Document 12

Item of business :

Climate Change Response (Zero Carbon) Amendment Bill

Submission name :

Barbara McKenzie

Comments

SUBMISSION TO THE CLIMATE CHANGE RESPONSE (ZERO CARBON) AMENDMENT BILL.

There is no logic to the "Zero Carbon" bill whatsoever. It flies in the face of all serious scientific evidence - its only function appears to be to please the UN bureaucracy and the elite foundations which are affiliated with and exert considerable influence over that bureaucracy.

HUMAN GENERATED CO2 IS NOT CAUSING GLOBAL WARMING

There is no evidence that CO2 causes global warming. Ice core data indicates that CO2 levels lag warming by hundreds of years, rather than driving it. See e.g. Mudelsee (2001, attached), who found that "over the full 420,000 year Vostok history CO2 variations lag temperature by 1,300 years ± 1000".

Studies show that the warming period which began in the 1970s, and was the reason for abandoning alarmist claims of a new ice-age in favour of "global warming", eased off around 1998, and scientists are predicting a worrying cooling, even a mini-ice age.

In any case:

Of total CO2 levels human activity is responsible for 3-5% of atmospheric CO2, while New Zealand's contribution is about 0.1%. Nothing will be achieved by NZ going "zero carbon" when other bigger countries are focused on development and improving their citizens' quality of life - it is pure grandstanding. At the same time New Zealand is squandering its credibility which would be better spent drawing attention to real environmental issues.

METHANE

Undermining New Zealand's dairy industry on the back of the climate hoax is another government target. 0.00017% of atmosphere is methane. Sheahen and Allison (attached) show that methane and nitrous oxide (reputedly responsible for about half of New Zealand s emissions) are virtually irrelevant as contributors to any global warming effect.

As they point out, methane is an unstable gas which oxidises quickly in atmosphere. It occupies less than 2PPM of the atmosphere, and its absorption bands almost completely overlap with H2O. Even a very large increase in CH4 would have almost no impact on climate.

MELTING ICECAPS AND SEA LEVEL RISE.

It is claimed that the because of anthropogenic global warming, the ice caps are melting, causing a dramatic rise in sea level.

The claims of icecaps melting away are clearly nonsense: while Western Antarctic is experiencing melting due to the large number of volcanoes that have recently become active, this is more than offset by the ice accumulating in Eastern Antarctica (see eg Oct. 31, 2015, NASA Study: Mass Gains of Antarctic Ice Sheet Greater than Losses). A NZ expedition to Antarctica in the summer of 2017-18 found that the Ross Ice Shelf was freezing rather than melting.

As for the predictions of London and Manhattan disappearing under the waves: numerous studies show that the sea has been rising by one or two millimetres per year for some time, but that the rise has decelerated since the 1950s. See eg Holgate (attached):

"The rate of sea level change was found to be larger in the early part of last century (2.03 ± 0.35 mm/yr 1904 1953), in comparison with the latter part (1.45 ± 0.34 mm/yr 1954 2003)."

Australia's Bureau of Meteorology established 12 sea-level gauges on Pacific Islands from 1992. The gauges show no increased rate of sea rise, in fact no or minimal rise at all, in some cases a negative result. (See eg the BOM Pacific Country Report, Vanuatu, graph for all countries p. 9.)

The bogus claims of dramatic sea level rise are especially concerning, as councils are using them to justify changes to building codes and planning regulations. See for example the article by David Kear, former Director of the DSIR (attached). Kear observed that the Ohope Council was making decisions on the assumption that there was a landward inundation, ignoring evidence from residents and experts alike that the coastline had a net seawards movments.

ENVIRONMENTAL IMPLICATIONS

The government hopes to replace fossil fuels with "renewable" energy provided by, for example, windfarms despite the environmental impacts: the threat to birds, bats and human health, and the blighting of the rural landscape. The environmental implications of a greater use of batteries, in both production and disposal, are being ignored

Despite the fact that a large part of New Zealand is already forested, the governmment has a policy of growing planting trees a year, hoping that two thirds will be native, ie one third will be pinus radiata. Most of this will be on fertile pasture, so although dairy farming is 49% of our economy, we will be replacing dairy with pine, which is hostile to flora and fauna and renders the land infertile.

LOCAL AND NATIONAL GOVERNMENTS ARE MAKING DECISIONS ON THE BACK OF A MANIFEST FRAUD

The weakness of the climate alarmist position should be apparent by the nature of the arguments of adherents, which are based on extravagant predictions never fulfilled, fraudulent or over heated data, cherry-picking, bogus claims of consensus, and much reference to the views of teenage girls. The narrative is driven by the UN's IPCC, which from its inception has had a brief to assume anthropogenic climate change, and has consistently produced reports whose conclusions have been highly criticised even by those scientists invited to make submissions.

Since at least 2007 New Zealand's top scientists have opposed the UN's climate narrative: people like the former Director-General of the DSIR David Kear, Augie Auer (emeritus professor and former chief meteorologist with the MetService), and Dr Vincent Gray, who made a great many submissions to the IPCC. New Zealand governments have consistently ignored their advice.

The function of the climate fraud is to achieve global governance by the owners of the narrative. For decades the United Nations has produced reports, whether on environment, climate, or governance, which have urged high-density urbanisation, the elimination of private property and increased power to the corrupt UN bureaucracy, and always proposing a greater role for elite foundations such as Rockefeller, Gates etc. It is hard to believe that those politicians in the Labour and Green Parties who have made "climate" their cause are unaware of this agenda.

On the back of a manifest fraud, New Zealand politicians are hell-bent on ruining our environment, our way of life and our economy.

Recommendations

1) The government's plans to destroy the New Zealand economy, environment and way of life on the basis of pseudo-science be abandoned.

2) The government focus on genuine environmental issues, and

3) Consider how it will face the Maunder Minimum, i.e. a climatic cooling, which is predicted.

Global Warming, Reducing Emissions a Very Expensive Approach to a Non Problem : Dr Jock Allison, ONZM, FNZIPIM, October 2018

With all the present hysteria about global warming and the need to commence drastic emissions reductions within 12 years, there is still no convincing scientific evidence that atmospheric CO_2 is the cause of warming. While clearly the world has warmed a little, this has been expected, as it is coming out of a little ice age.

Emeritus Professor from MIT, Richard Lindzen a few days ago at a public meeting in the UK said "the currently popular narrative, is that the climate, a complex multifactor system, can be summarized in just one variable, the globally averaged temperature change, and is primarily controlled by the 1-2% perturbation in the energy budget due to a single variable – carbon dioxide – among many variables of comparable importance.

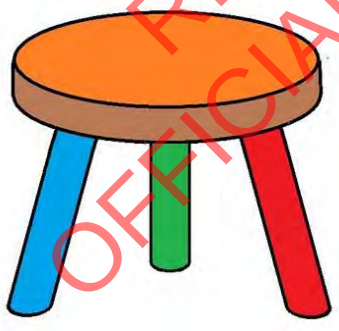
This is an extraordinary pair of claims based on reasoning that borders on magical thinking".

Three recent lines of research show global warming cannot be confidently attributed to human emissions. First, that methane and nitrous oxide are virtually irrelevant re climate change (half of New Zealand's assessed emissions).

Second, CO_2 doesn't stay in the atmosphere for very long – a half-life of 10 years, not the 200+ years asserted by the IPCC. Third, that within the "Climate Models" used by the Intergovernmental Panel on Climate Change (IPCC) and many other researchers there is a fatal error that causes them to overestimate the effect of doubling atmospheric CO_2 by three times.

Thus, the billions and billions of dollars of expenditure worldwide over the past 35 years, and the push for international unanimity to reduce the level of CO_2 in the world's atmosphere has largely been wasted.

SUMMARY: There are three legs to this stool and it is pretty hard to knock any of them over on the basis of science.



BLUE: Water vapour is the main Greenhouse Gas; methane and nitrous oxide are irrelevant, human CO_2 causes some minor warming (Allison & Sheehan 2018)

RED: Anthropogenic (human) CO_2 has a half-life of only 10 years in the atmosphere, not more than 200+ years espoused by the IPCC (Berry, 2018)

GREEN: The IPCC models, which predict 3.6 degrees C warming, + or minus 1.2 degrees (as a result of doubling atmospheric CO_2) are wrong. The correct figure is less than one third of this, 1.0 degree + or minus 0.2 degrees (Monckton et al., 2018). Monckton talks about this in a video (https://www.youtube.com/watch?v=kcxcZ8LEm2A). A lay summary is attached.

1. Allison & Sheahen 2018

Recently Tom Sheahen and I published a paper in the New Zealand Institute of Primary Industry Management Journal on the topic of the effectiveness of Greenhouse Gases (GHG), https://www.nzipim.co.nz/Folder?Action=View%20File&Folder_id=120&File=The%20Journal%20September%202018.pdf It is the first paper in the journal.

A simpler representation of the work is an article published in Dairy News, 18 September 2018: https://www.ruralnewsgroup.co.nz/dairy-news/dairy-general-news/water-blamed-as-big-planet-warmer .

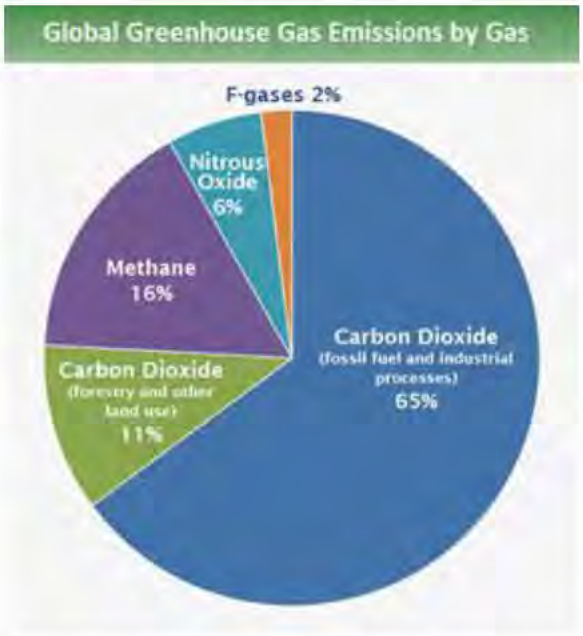
The main points …

My co-author Tom Sheahen is a distinguished PhD in Physics who Chairs the United States Science and Environmental Policy Project (https://www.heartland.org/about-us/who-we-are/tom-sheahen), and we have been advised in the preparation of the paper by two distinguished Professors of Physics at American universities: Will Happer, an emeritus Professor of Physics at Princeton, who has just been appointed to the White House as a Scientific Advisor (http://www.sciencemag.org/news/2018/09/trump-adds-physicist-will-happer-climate-science-opponent-white-house-staff); Professor William van Wijngaarden of York University in Canada (http://www.physics.yorku.ca/index.php/who-we-are/all-faculty/62-wijngaarden) has also been a valuable advisor on atmospheric physics.

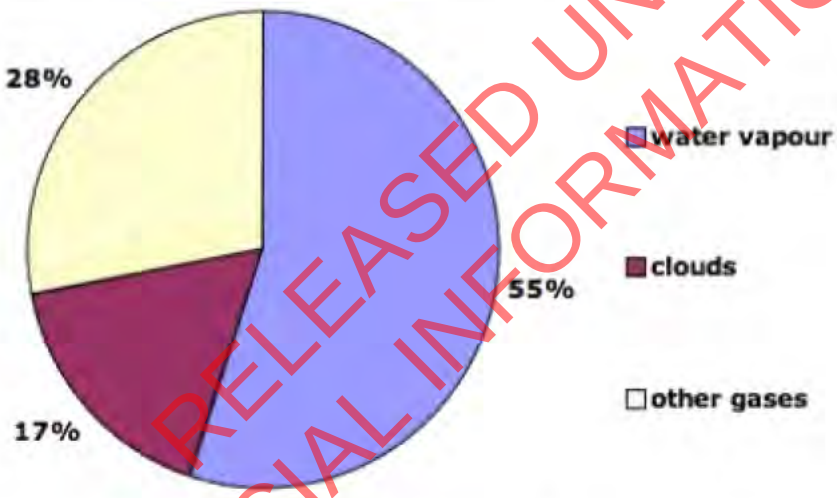
Our paper is most important because …

a. Water vapour is the most important GHG, and even the IPCC accepts water vapour is responsible for more than 70% of the Greenhouse Effect, (as defined in AR4 - the 4th IPCC report most estimates of the importance of water vapour estimate it at more than 90%).

Breakdown of the 'natural' greenhouse effect by contributing gas



As usually presented, without water vapour



With water vapour included, from a 1992 IPCC Report.

From the figure above, it is clear that water vapour is the main GHG (water vapour + clouds). The IPCC computer models conveniently "park" the water vapour to one side and then assume that the water vapour as a "feedback "amplifies the effect of the other GHGs by about 3 times. The facts are that the water vapour molecules are evenly mixed throughout the lower atmosphere, and absorb radiation coming back from the Earth's surface in all the same areas as do the other GHGs.

b. The Greenhouse Gases, water vapour (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4) are similar size molecules and have an absorptive capacity within the same order of magnitude (none is 10 times or more effective as any other as a heat absorber).

c. The concentration of water vapour is very small at the poles to about 4% in the tropics. We have taken a for-example of 15,000 ppm in our paper, a conservative assumption. CO_2 is 410 ppm, methane 1.8 ppm, and nitrous oxide 0.3 ppm. (Yes, a Greenhouse Gas of only 1.8 ppm is supposedly responsible for 35%+ of New Zealand's total emissions?

d. The Global Warming Potentials (GWP, or estimated heating potential compared with CO2 = 1) estimated by the IPCC of CO_2 = 1, Methane = 28, and nitrous oxide 265 – 300. This is clearly nonsense. Tom Sheahen addresses this in "How to Deceive With Statistics : Distortions With Diminutive Denominators" see https://www.americanthinker.com/articles/2018/01/how_to_deceive_with_statistics_distortions_due_to_diminutive_denominators.html . The IPCC ignores water vapour as a participant in the competition to absorb photons of heat radiated back from the Earth. Rather, in their models they consider this is a positive feedback that amplifies the effec of the other GHGs by 2 or 3 times.

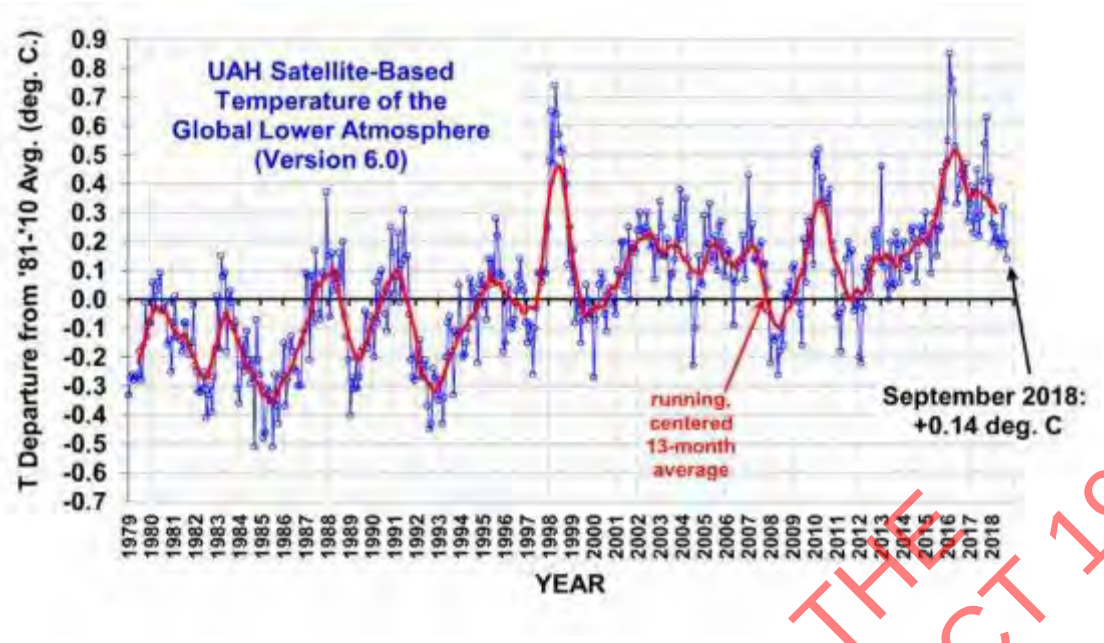
e. The Earth is not heating up. There has been some warming as we come out of the Little Ice Age. Over the past couple of decades (see https://judithcurry.com/2015/12/17/climate-models-versus-climate-reality/) this is the most accurate measure of temperature, the lower atmosphere, which unlike the surface temperature records:

i) covers almost the whole globe, unlike the land based temperature records, which cover about 25% of the globe only.

ii) doesn't have the biases of the predominantly "urban"-based temperature records that have the well-known UHI (Urban Heat Island) effects from the build-up of heat in concrete, asphalt etc., which makes nights warmer in urban areas

iii) is not subjected to continued corrections, many of which have years later been imposed in statistical treatment of surface station data that has accentuated warming trends.

The trophospheric temperature from satellites and balloons is in the figure below. Apart from two significant EL Nino spikes in 1998 and 2016, temperatures are not rising (http://www.drroyspencer.com/).



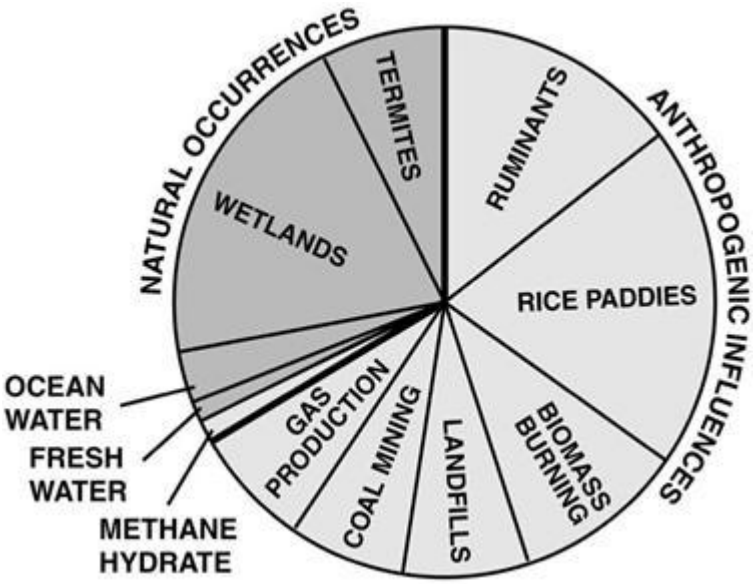
The IPCC Computer Models are clearly not working, they are running very hot. From February 2016 to September 2018, the atmospheric temperature has dropped by 0.7 degrees C.

f. Methane and nitrous oxide are able to absorb heat only in an area of the electro-magnetic spectrum where there isn't a huge amount of heat emitted from the earth, and where there is almost total saturation of water vapour (remember methane 1.8 ppm versus water vapour 15,000 ppm).

We conclude, therefore, that particularly methane and nitrous oxide (reputedly responsible for about half of New Zealand's emissions) are virtually irrelevant as contributors to any global warming effect. These gases should therefore be removed from New Zealand's GHG Inventory.

This is very important information, particularly when our politicians say they want any policy to be "evidence based", and yet they are convinced that global warming / climate change is real, and that humans cause it. Clearly this is incorrect.

New Zealand scientists Andy Reisinger and Harry Clark from the Agricultural Greenhouse Gas Research Centre at Palmerston North (AGGRC) have been publishing information contendingthat methane from livestock can be responsible for up to 20% of the world's warming. Methane from ruminants is only about 16% of all the methane going into the atmosphere – see pie chart below.



Sources of atmospheric methane. Ruminants are cattle, sheep, goats, etc. 2/3 of the total is due to human activities.
https://www.giss.nasa.gov/research/features/200409_methane/

In New Zealand we seem to be concentrating on this gas which our paper, (Allison & Sheahen, 2018) is shown to be almost irrelevant in GHG effect in the atmosphere. New Zealand concentrating on this gas and modelling and then planning the reductions that need to be made to have various effects in the future is meaningless:

a) The way the GWP value are calculated is scientifically unsound, and the derivation of the high values have been discredited a a result of faulty calculation.

b) The putative reductions required for methane from cattle in New Zealand come from only 16% of total methane emissions on the planet. If we consider that cattle make up about 85% of total world ruminant emissions, and the developed countries make up about 25% of the total numbers. With the USA removed from the numbers , because it isn't in the Paris Accord, this reduces the rest of the developed world to about 14% of the total. New Zealand has about 1% only of the world's cattle and 2.6% of the world's sheep. About 75% of the world's cattle and sheep are in undeveloped countries, which under the Paris Accord are not expected to significantly reduce emissions until after about 2030, or at such time that each country has developed sufficiently to raise the standard of living of its population to a level that would deem it to be classified as "developed".

   Many undeveloped countries will have a lower share of total ruminant emissions due to their smaller animals, than the bigger, more productive animals in developed countries. However, such recognition could bring New Zealand's total ruminant emissions up to perhaps a maximum of only 3% of world ruminant emissions. This is about 3% of 16%, or 0.48% or 1/200th of the world's methane going into the atmosphere (see above pie chart for other sources of methane).

So, making allowances for ruminant emissions in New Zealand when no such recognition of 65% to 70% or more of total world ruminant emissions is being made, let alone financially accounted for,

will likely have significant negative effects on all economic indicators in our economy. All this achieved without having any possible effect on the world's warming and or climate. This can be recognised as only "virtue signalling". Potentially, New Zealand will be paying billions of dollars or spending billions of dollars on other activities to alleviate a tiny percentage of world ruminant emissions, when most flocks and herds will not only, not be measured, but also will not be allowed for in other country commitments.

The world will be unable to reduce emissions anyway?

The effectiveness of the world in reducing CO_2 emissions since the Kyoto Protocol negotiations started, is sobering considering the heroic assumptions now being made by the IPCC with regard to what the world might achieve in GHG reductions in the future, required so temperature increases of 1.5 or 2 degrees C respectively, might be avoided.

From 1990, the baseline date for Kyoto, the world's total human emissions increased by 60% to 2013, were then pretty stable in 2014, 2015 and 2016, but increased again by 1.6% in 2017. Under the Paris 2015 Accord, "Developing Countries", which are now responsible for 62% of the world's emissions, are allowed to keep developing while they improve standards of living for their populations. China has signalled it will double emissions by 2030 (+29.5% of world emissions now), and India has signalled it will increase 3X by the same date (+13 6%). The other undeveloped countries can be expected to increase total world emissions by at least 10% by 2030. On such a scenario the world is looking at about 55% in world emissions from the presently designated undeveloped countries by 2030.

Further, with the USA out of the Paris Accord (14.5%), that leaves 23.5% of presently estimated emissions for the developed countries who are supposed to be on rigorous emissions reductions scenarios. Not to mention also they are supposed to proportionately support a $US100 billion Green Climate Fund each year from 2020. This will not happen.

Clearly the path to mostly renewable energy by 2030 or 2050 is not achievable. The world is still relying on fossil fuels which still makes up more than 80% of total world energy use. Further, the academic IPCC reports never factor in the beneficial effects of CO_2, or take note that perhaps half of the world's food is produced with the help of fossil fuel derived fertilisers.

All of this shows just how removed from reality governmental bureaucrats, politicians and scientists are when promoting the huge reductions in the world's emissions in a much shorter timeframe be it 2030, or 2050.

If we take these data on achievement above back to our very small parish here in New Zealand with supposedly only 0.17% of the world's emissions, the spending of up to $36 billion by 2030 on climate change doesn t seem to make much sense from any viewpoint.

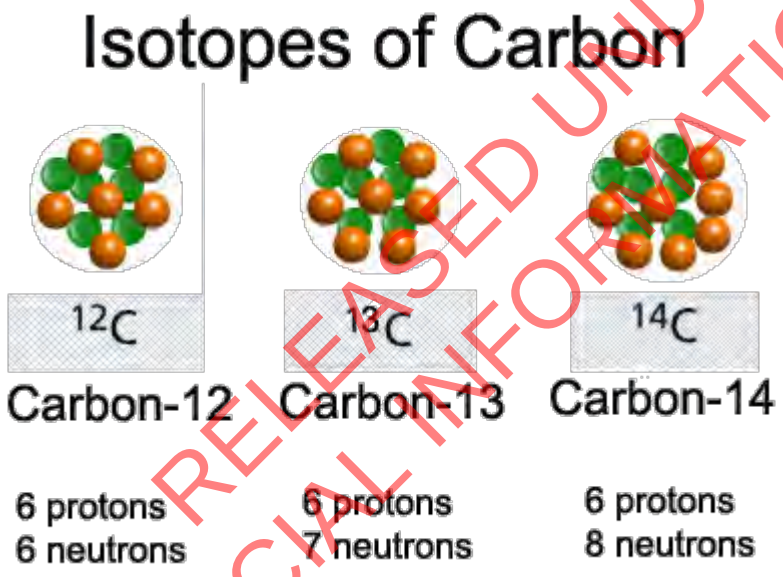
https://www.newsroom.co.nz/2017/12/07/66415/paris-agreement-could-cost-nz-36b Anything we will spend on "climate change" will be a total waste of money (which, as a country below halfway down the OECD's income / capita tables, we don't have). Further, the developed countries that are the most bullish about the need to take action about climate change – the EU, for example – are all already falling behind their ambitious GHG reduction targets.

2. The next big thing in Climate Change Research

There is a fatal flaw in Climate Change Research regarding the human effects on the percentage atmospheric CO2 and how long CO_2 stays in the atmosphere : Dr Ed Berry has had a distinguished career in climate physics see https://edberry.com/exb/dr-ed-berry/

The IPCC, the United Nations and most governments throughout the world are certain that human-produced CO_2 is the reason for the increasing levels of atmospheric CO_2, and that this is the main reason for increasing world temperature. Nothing could be further from the truth.

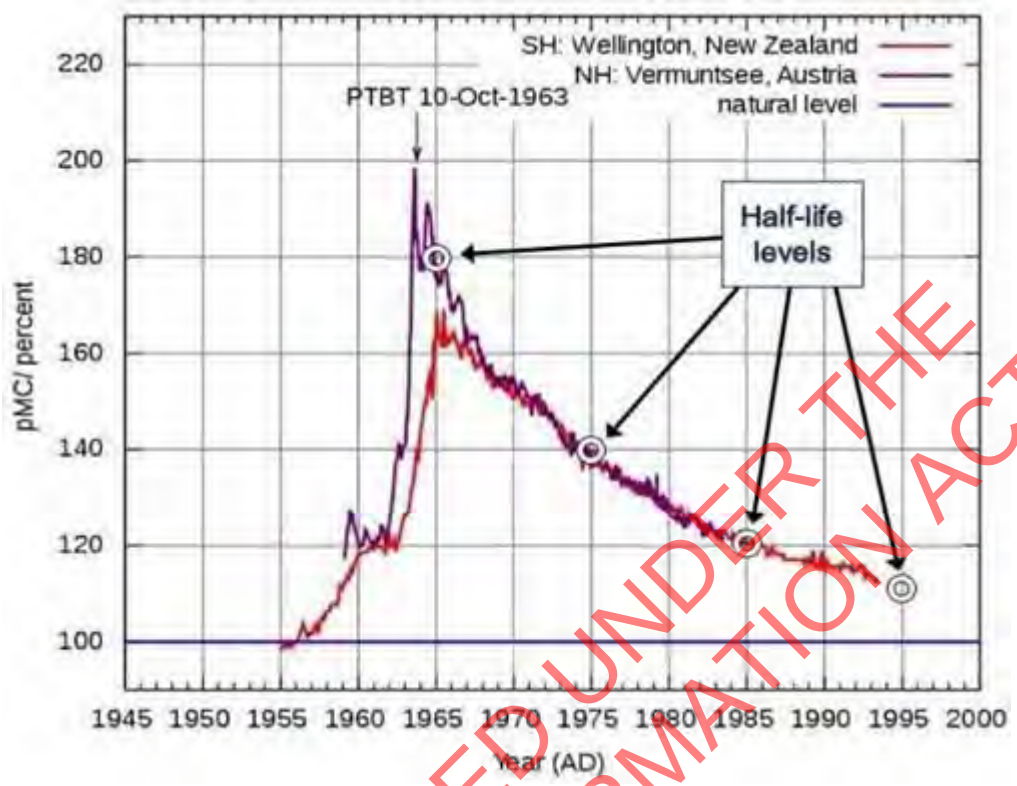
Dr Berry has developed a model for the flows of CO_2 in the atmosphere, based on the decay / disappearance rates of radioactive C14 CO_2 in the atmosphere after all the nuclear testing in the Pacific and elsewhere. These data are the only data available on real labelled CO_2 in the atmosphere. The rate of disappearance of C14 CO_2 in the atmosphere tells us something about the normal C12 CO_2 (note: carbon has a molecular weight of 12, with 6 neutrons and 6 protons in the nucleus, while C14 has 6 protons and 8 Neutrons formed as a consequence of nuclear explosions in the atmosphere. . See diagram below).



C14, in the atmosphere as C14 CO_2, will react chemically and physically in exactly the same way as the normal carbon in the atmosphere C12. Therefore, C12 CO_2 has the same half-life (rate of disappearance) from the atmosphere as the C14 CO_2. Also, there is no way to differentiate between the CO^2 from human activities, i.e. burning fossil fuels, and all other human activities (less than 5% of all the CO_2 going into the atmosphere at any time) and the 95% + of CO_2 from natural sources also going into the atmosphere.

In the years when there were a lot of nuclear tests going on, particularly in the Pacific (1946 to 1962), there was an increase in C14 in comparison with C12 (the carbon in CO_2), in the atmosphere. C14 is an isotope and has a molecular weight of 14 from the addition of two additional neutrons to the nucleus of the C atom, this being caused by the atomic explosions in the atmosphere.

(https://edberry.com/blog/climate-physics/agw-hypothesis/preprint-a-fatal-flaw-in-global-warming-science/)

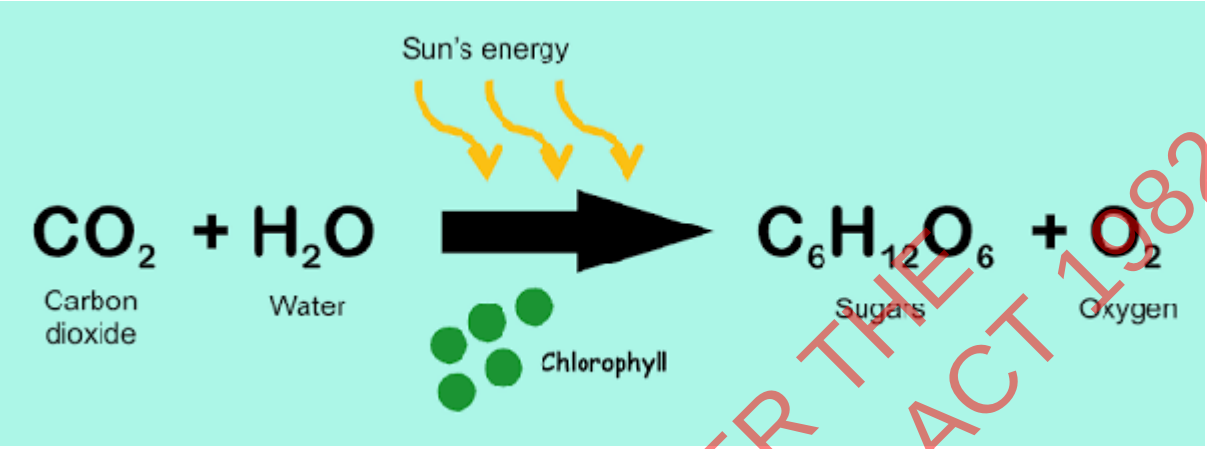


The above figure shows C14 data before and after the above-ground atomic bomb tests. The natural concentration of C14 CO_2 is defined as 100%. The pMC percent scale is "percent of modern carbon" where "modern carbon" means the level in 1950. The white circles mark the half-life times.

The graph shows that the concentration of C14 CO_2 halves every 10 years. (This is atmospheric C14 CO_2, not be confused with the radio-active half-life of C14 carbon of 5730 years). Now C14 CO_2 and C12 CO_2 (the normal stuff we have in the atmosphere) react identically chemically and physically in the atmosphere. This if C14 CO_2 is disappearing from the atmosphere at the rate illustrated in the graph, then so too will the other CO_2 in the atmosphere. Reisinger & Clark (AGGRC) have been getting a lot of publicity recently regarding the warming effect of methane in particular. They contend that CO_2 added to the atmosphere from the days when the level was about 280 ppm, (supposedly 1850, although not well defined) all comes from human activities. This is also the assumption made by the UN and the IPCC.

CO_2 is, in effect, plant food, and the higher the concentration in the atmosphere, the faster plants grow, and also with greater water use efficiency. The chemical equation is shown below:

Photosynthesis in plants which use atmospheric CO_2, water and sunlight to synthesise sugars



For most of geological time, CO_2 levels in the atmosphere have been much higher than the present day. A level of more than 150ppm is required for plants to grow at all, and as the concentration increases, plants grow faster. If the level of atmospheric CO_2 was to double, then plant growth worldwide would increase by about 30%. Significant "greening" can be observed worldwide already from space – a result of the 45% increase in atmospheric CO_2 since pre-industrial times. This is an outstanding result for the Earth, not the impending disaster of rising CO_2 widely promoted.

It is generally agreed that only 5% of CO_2 added to the atmosphere during each specified time period is from human sources (probably a bit less).

The graph of C14 CO_2 disappearing from the atmosphere shows that the concentration halves every 10 years. Under the principle of "equivalence", C14 behaves in the same way as C12 CO_2, so there is nothing to suggest that human CO_2 (which is C12 CO_2) will react or behave chemically or physically any differently from naturally occurring CO_2 does. Further, it is not possible to differentiate between human CO_2 and the other naturally occurring CO_2.

This is a very different situation from that which the IPCC claims (including New Zealand scientists advising the Government). The IPCC claims:

a) **all of the rise in atmospheric CO_2 from 280 ppm (pre-industrial, about 1850) to 410 ppm today is due to human activities**
b) **the half-life of CO_2 (i.e. C12 CO_2 which makes up about 99% of the CO_2 in the atmosphere) is 200+ years or more, often quoted to be more than 1,000 years**
c) **15% of human CO_2 will stay in the atmosphere forever**

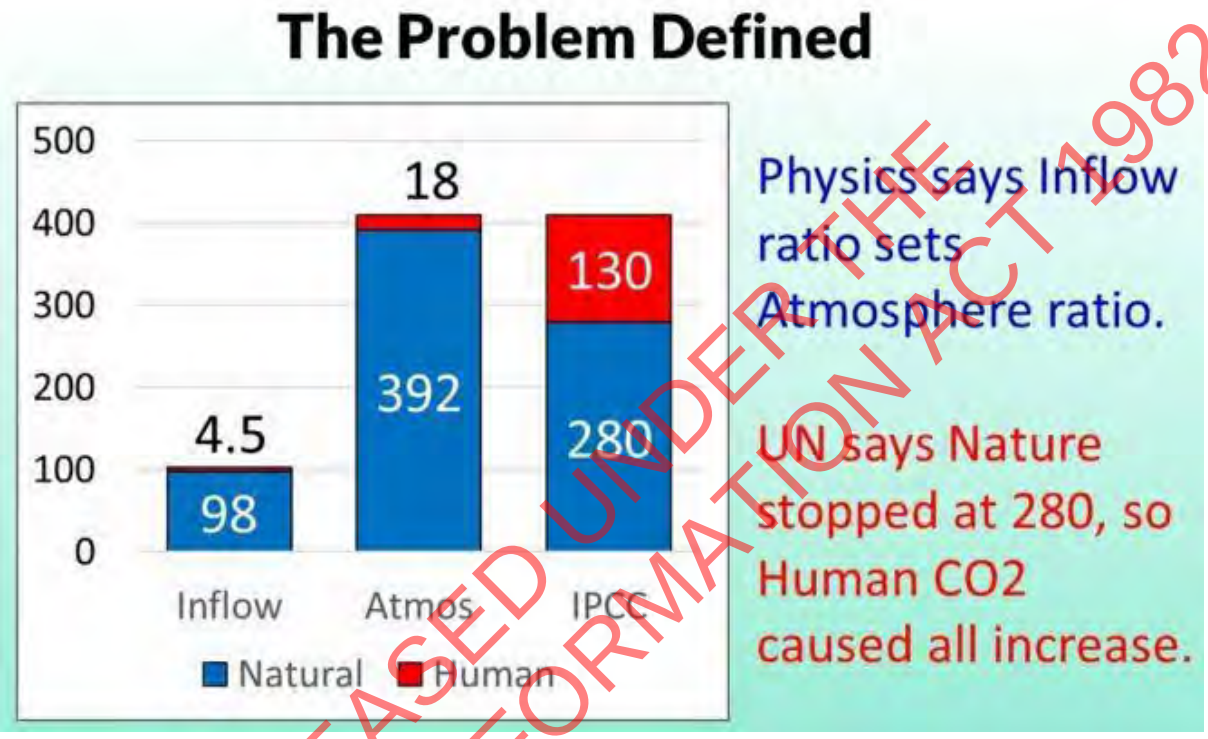
These are all wrong.

The latest science from Dr Ed Berry (https://edberry.com/wp-content/uploads/Climate/EdwinBerryPortoSep7Final.pdf) shows that as a result of applying the climate physics embodied in the C14 decay graph above, human CO_2 cannot be responsible for all of

the CO_2 increase in the atmosphere since pre-industrial times. The result of the accepted equivalent half-life of C14 CO_2 results in the calculation of only 18ppm in the atmosphere being derived from anthropogenic (human derived) CO_2.

On this basis, therefore, human CO_2 cannot possibly be the "control knob" of global warming. Any efforts to diminish atmospheric CO_2 cannot be expected to have any demonstrable effect on the climate.

The calculated levels of CO_2 from the decay rates defined from the study of the C14 after nuclear testing gives the results illustrated in the graph below:



So, the human activity-derived CO_2 in the atmosphere presently is 18ppm, not the 125ppm from human activity from 1850 as the IPCC contends. These data concerning rates of disappearance from the atmosphere are the only such data published, and show that:

a) **human-derived CO_2 emissions at only 18ppm, can make little difference to the atmosphere**
b) **reductions of the human-derived emissions will not make anything but a miniscule effect on temperature – they are a complete waste of time**
c) **so, human-derived CO_2 emissions into the atmosphere are of little significance to temperature, i.e. global warming / climate change / climate disruption**

3. IPCC Climate Models Overestimate Warming by Three Times :

The third part of this three-legged stool is work that Christopher Monckton and a few others have been doing re the "Climate Models" used by the IPCC and others to predict future temperature rises.

A lay summary of the work it attached with this paper. A more technical paper is available if required.

Lord Monckton has over several years been working on what might be wrong with these Models. He found .....

a) the IPCC estimate that Equilibrium Climate Sensitivity (from the doubling of atmospheric CO_2) is 3.6 degrees C + or minus 1.5 degrees C,

b) after allowing for the omission in the IPCC models (as Monckton put it "they forgot about the sun" - in fact the feedback to the incoming solar radiation), the ECS is only 1 degree C + or minus 0.2 degrees C. So no problem. The problem of climate change has disappeared. An increase in temperature of another one degree, most of which we have had already is really quite beneficial.

If it is accepted that the Global Warming / Climate Change / Climate Disruption scare is over then a very large number of jobs, established science institutions, governmental departments and university departments, plus the finance to run these is at stake worldwide, will be at risk, so a big kickback can be expected. Lord Monckton presented the results at an International Conference in Portugal in July 2018 and has submitted the paper for publication in a climate science journal. A more detailed Monckton et al paper can be supplied on request. .

JOCK ALLISON AND THOMAS P. SHEAHEN

GREENHOUSE GASES – A MORE REALISTIC VIEW

The contributions of water vapour (H_2O), carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) to the warming of the atmosphere are reviewed. Water vapour and clouds are responsible for 80-90% or more of the greenhouse gas (GHG) effect. CO_2 has a finite influence. However, contrary to the common assertions, the contribution of methane and N_2O to world's total emissions is negligible. We therefore conclude that expensive attempts to reduce human emissions can have negligible effects only on regional and world temperature.

Therefore, the generally accepted effects of CH_4 and N_2O as infrared-absorbing GHGs, causing about 50% of the total New Zealand emissions, must therefore be urgently reassessed, and to a lesser extent the quantitative role of CO_2. It is therefore suggested that CH_4 and N_2O be removed from New Zealand's Greenhouse Gas Inventory, and that the supporting case for such treatment be prepared for negotiation with our international partners towards eventual withdrawal from the Paris 2015 Climate Agreement.

Introduction

The rotating planet earth is warmed by incoming sunlight in the daytime and cooled by outgoing infrared radiation at night *(Figure 1A)*.

The planet never actually reaches equilibrium. The real atmosphere contains a varying percentage of water vapour (dry air is an idealised concept found only in the laboratory). The principal atmospheric gases N_2 and O_2 have no role in cooling.

The black body curves shown in *Figure 1B* are displaced in wavelength (shifted horizontally), depending on temperature. Molecules radiating from different altitudes will do so at corresponding temperatures.

The cooling process involves multiple steps: heat from the surface is radiated back, absorbed by the various GHGs (mainly water vapour), and transported upward by the convection of moist air to the upper troposphere, where clouds form. Throughout this journey from the surface molecular collisions, emission and re-absorption of radiation continues. The 'greenhouse effect' is attributed to gases that absorb and emit solar electromagnetic energy in a particular part of the electro-magnetic spectrum – ultraviolet (UV), visible, infrared light. The final cooling step (emission to space) takes place via infrared radiation leaving the upper troposphere and stratosphere.

The down-going radiation from the sun is in the UV and visible light part of the spectrum (0.1 to 1.2 microns wavelength), and here there is some interception of energy by clouds and a little by water vapour. There is virtually no effect of the GHGs, CO_2, CH_4, and N_2O at the wavelength of the incoming radiation from the sun.

All of the upgoing thermal radiation is in the 3 to 70 micron range of the spectrum, where the GHGs have some effect in absorbing the up-radiated heat from the earth's surface. This will be discussed in greater detail later.

Computer models used by the IPCC and many climate scientists attempt to account for all these mechanisms, and make future predictions about planetary conditions, especially temperature.

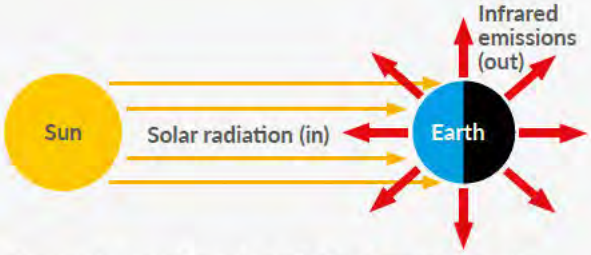


Figure 1A : Incoming solar radiation (energy) in and infrared emissions out

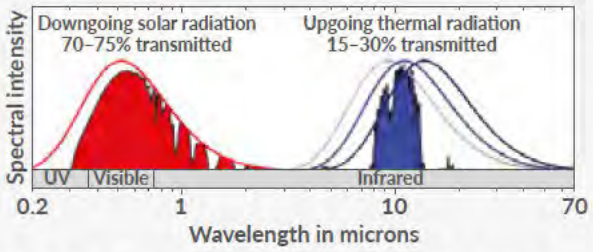


Figure 1B : Incoming solar radiation (energy) at 0.2 to 3 microns and outgoing thermal radiation at 3 to 70 microns

The IPCC concentrates mainly on anthropogenic (human) emissions, and ignores natural contributions of the GHGs from the planet and the ubiquitous water vapour, both of which also must be included in any sensible consideration of the effects on world temperature.

GHGs and their contribution to global warming (aka climate change and more recently 'climate disruption') are of national interest in view of the 2015 Paris Climate Agreement, and the commitments New Zealand has made to reduce emissions of these gases in the future. In addition to the known GHGs, ozone is recognised for its protective effect against UV radiation from space and will not be discussed further. CH_4 and N_2O make up almost half of New Zealand's assessed GHG emissions, but are insignificant in comparison with CO_2.

Mistakenly, water vapour is not included in any assessments of GHG effects by the Intergovernmental Panel on Climate Change (IPCC), a crucial omission. The IPCC concentrates mainly on anthropogenic (human) emissions, and ignores natural contributions of the GHGs from the planet and the ubiquitous water vapour, both of which also must be included in any sensible consideration of the effects on world temperature.

The potential effectiveness of GHGs in influencing temperature depends essentially on five factors:

1. The capability of individual molecules to absorb or radiate heat.
2. Their relative concentration in the atmosphere.
3. Whether each can actually absorb effectively (as heat is radiated to and from the earth) depends on both the location of their spectral bands and the energy distribution of the earth's outgoing radiation.
4. Competition for absorption by and between other gases.
5. Phase change of water, evaporation, condensation and precipitation.

These factors will be discussed in turn.

Capability of individual molecules

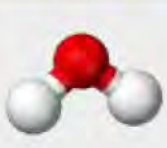
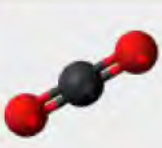
In the 1860s, John Tyndall demonstrated that some atmospheric and other gases absorbed heat from black body radiation. He reported that CH_4 and N_2O both absorbed about four times as much heat as carbonic acid, the original name for CO_2. While his observations were not truly quantitative, this estimated value is many times less than indicated by the adopted Global Warming Potential (GWP) figures from the IPCC) – see values in *Table 1*.

GWP is a calculated ratio that the IPCC uses to estimate how much heat a GHG absorbs in the atmosphere (IPCC AR5, pp. 210-216). It compares the amount of heat trapped by a very small amount of the gas in question to the same additional very small amount of the comparator gas, CO_2 in this instance. This value for 'radiative forcing' is supposed to estimate the relative capability of a GHG molecule to have an effect on warming in comparison with one molecule of CO_2. GWP is a concept promulgated by the IPCC and is accepted (by governments) as the basis for the calculation of their country GHG inventories. More of that later.

The individual molecules of CO_2, H_2O and N_2O are similar in structure. Their relative concentrations in the atmosphere are in *Table 1* – CO_2 is now 410 ppm.

The GWP values are from the 2007 IPCC AR4 report. In 2013, the IPCC adjusted the GWP for CH_4 up to 28 and for N_2O downwards to 265. Effectively these values are almost certainly wrong because of the faulty conceptual approach embedded in the very definition of GWP. Recent reports also emphasise that the treatment of reputedly

Table 1: Atmospheric parameters of GHGs

	WATER	CARBON DIOXIDE	METHANE	NITROUS OXIDE
				
Atmospheric concentration	0.01–4%*	385 ppm	1797 ppb	322 ppb
Rate of increase	N/A	1.5 ppm/yr	7.0 ppb/yr	0.8 ppb/yr
Atmospheric lifetime	Very short 1–5 days	Variable 5–200 yr	12 yr	120 yr
Global Warming Potential (GWP)	N/A†	1	21	310

**The amount of water vapor in the air varies according to temperature and density of air (usually ~1–3% of troposphere*
† Water vapor levels vary strongly according to region, so rates of change and warming potential cannot be assessed

long-lived gases such as CO_2 in the same way as short-lived gases (such as CH_4, 12 years) is not environmentally credible (Allen et al., 2018). This same approach must also be considered for N_2O because the half life of this gas in the atmosphere is about half that for CO_2. Allen et al.'s (2018) approach if adopted may reduce CH_4's assessed effect by about three-quarters, or New Zealand's calculated emissions by about 30%. Quite evidently, the 'official' GWP numbers asserted by the IPCC are unreliable and controversial.

Recent calculations (Happer & van Wijngaarden, unpublished data) clearly show that the absorptive capability of individual molecules of the GHGs is not as widely different as the GWP values might suggest *(Table 2)*.

Table 2: Calculated heat absorptive capability of individual GHG molecules relative to CO_2 with a concentration change of zero to one ppb, at the tropopause (11 km) or the top of the atmosphere

CAPABILITY TO ABSORB HEAT IN COMPARISON WITH CO_2 = 1		
Gas	Top of atmosphere	Tropopause
CO2	1	1
CH4	0.19	0.22
N2O	0.54	0.66
H2O	0.084	0.14

Table 2 shows that the capability of the individual molecules to absorb heat (radiative forcing) is of the same order of magnitude. This seems reasonable since the molecular structure of the four molecules is not enormously different. Also, the absorptive value differences between the molecules is very similar to what Tyndall found in the 1860s.

This refutes the popular notion and the IPCC's claim that CH_4 and N_2O are much more powerful GHGs than CO_2. The reason for this is that the assumed radiative forcing for CO_2 is much more strongly saturated than the other gases *(Figure 2)*.

Because of this saturation additional CO_2 above 400 ppm has a miniscule effect on warming in comparison with additions to the very low unsaturated concentrations for N_2O and CH_4. However, the comparative effects of CH_4 and N_2O on warming are derived with no cognisance of any competitive effects of water vapour throughout the atmosphere, or the fact that there is very little energy transfer from the earth at the frequency on the electromagnetic spectrum at which these trace gases might have an effect. More of this later.

Relative concentration of GHGs in the atmosphere

Omitting water vapour, the major gas components of a 'dry' atmosphere are nitrogen (N_2), oxygen (O_2) and argon (Ar), at 78.1%, 20.9% and 0.92% by volume, respectively, all of which do not absorb heat. This leaves 0.1% by volume for the remaining gases. CO_2 at 400 ppm is the largest of the trace gases. CH_4 and N_2O are very small, just traces in effect, 1.7 and 0.3 ppm, respectively *(Table 1)*.

But the real atmosphere is not dry. Water vapour is widely variable: a very low percentage at the poles, but up to 4% in the tropics. For the purposes of comparisons and discussion in this article, we have assumed it is 1.5% or 15,000 ppm. Of course, any amount of atmospheric water vapour will proportionately reduce the percentage of all the other gases.

Further the amount of anthropogenic CO_2 (human induced) produced each year is less than 5% of the total CO_2 entering the atmosphere. Now, how are these gases supposed to cause all of the warming the world has experienced since the Little Ice Age (LIA)? In the teaching and scientific literature the estimates vary.

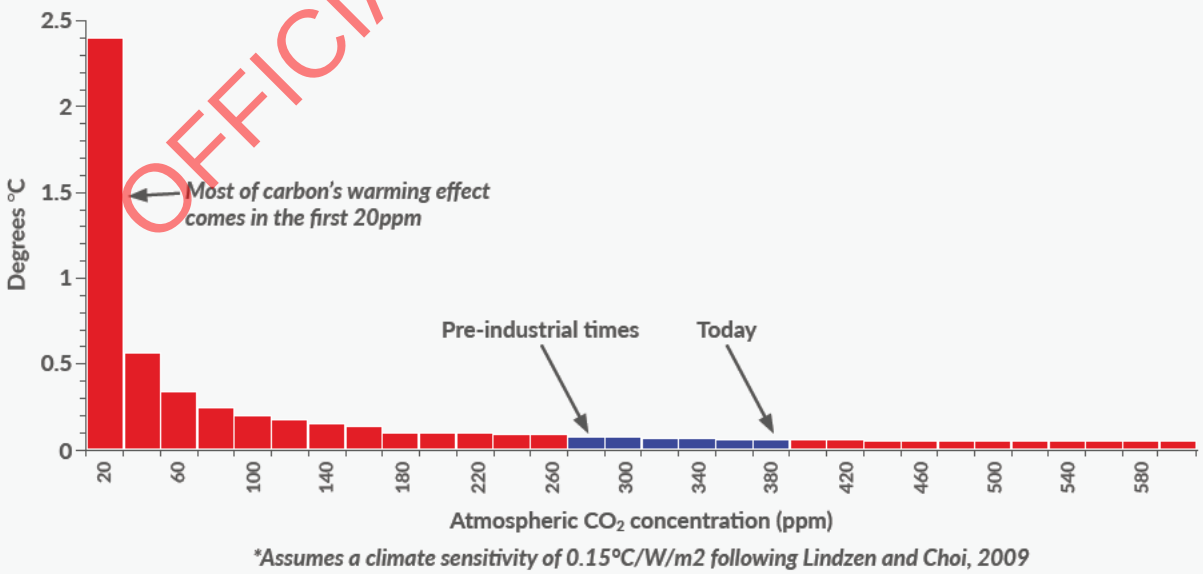


Figure 2: Increasing levels of CO_2 cause less and less warming effect
Source: Adapted from Lindzen & Choi (2009). This relationship is the basis of the MODTRAN atmospheric model, University of Chicago.

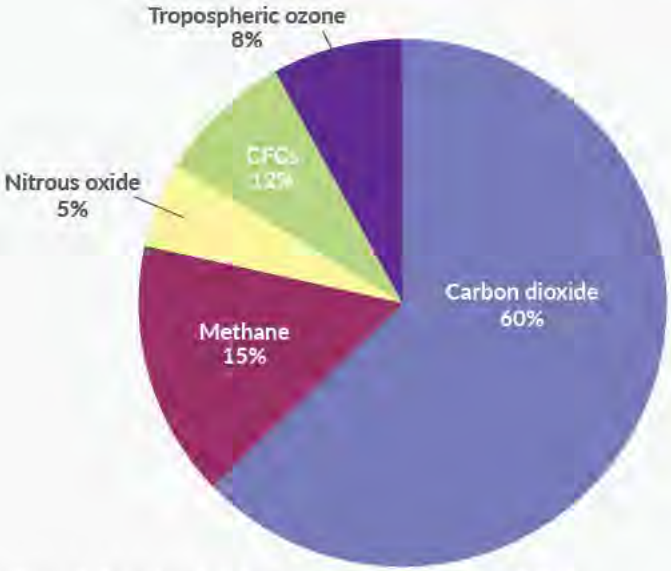


Figure 3: Putative global warming effects of selected GHGs
Source: http://eesc.columbia.edu/courses/ees/slides/climate/g_effect.gif

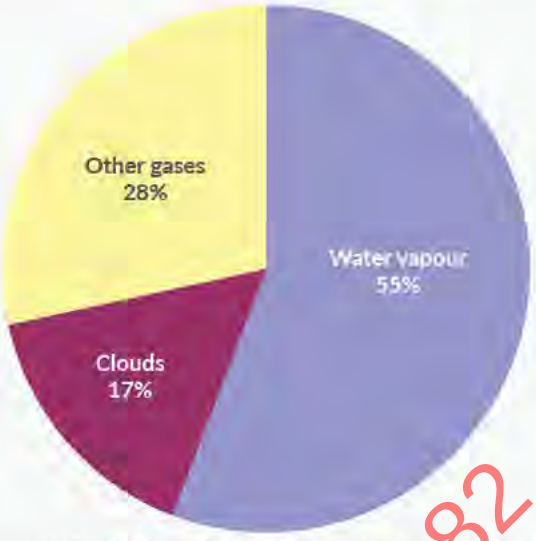


Figure 4: Breakdown of the 'natural' greenhouse effect by contributing gas. As halocarbons are industrial gases they are not represented here
Source: IPCC Report (1992)

Of all the CO_2 going into the atmosphere each year, 5% or less is anthropogenic, in comparison with CH_4, about 40% of which is from natural sources, and similarly estimates of naturally occurring N_2O are about 60%.

The estimates in *Figure 3* above suffice for the discussion. CO_2 is generally regarded as causing about 60% of the warming from GHGs, CH_4 15%, and N_2O about 5%. Clearly the 'agricultural gases', although at very minor concentrations in the atmosphere, are estimated as being major causes of the total warming effect on the world from GHGs.

A common representation of the effect of the relative effects of the GHGs is in *Figure 3*, which 'conveniently' eliminates the dominant effect of water vapour.

The 2013 IPCC Report, AR5 (Physical Science Basis, Chapter 8, p. 666) states: 'Water vapour is the primary GHG in the earth's atmosphere. The contribution of water vapour to the natural greenhouse effect relative to that of CO_2 depends on the accounting method, but can be considered to be approximately two to three times greater.' Further, the IPCC's 1992 report indicates that water vapour accounts for 55% of the total GHGs effect, and that clouds account for a further 17% *(Figure 4)*.

Many scientific assessments consider that the total effect of water vapour is more like 90%, much more than the 72% suggested by the IPCC. Even at a value of 72% for water vapour, the proportion of the GHG effect on the world temperature, which international governments are ambitiously seeking to diminish through the reduction of the GHGs going into the atmosphere, is far less than conveyed in communications to the general public through official channels or the media.

Of all the CO_2 going into the atmosphere each year, 5% or less is anthropogenic, in comparison with CH_4, about 40% of which is from natural sources, and similarly estimates of naturally occurring N_2O are about 60%. It is frequently claimed that without the anthropogenic contribution of CO_2 the amount of natural CO_2 being released into the atmosphere would equal the amount of CO_2 being absorbed each year by the biosphere, and mankind is blamed for the absence of the balance.

Governments rely heavily on the IPCC's reports and claims about GHGs causing or threatening to cause dangerous warming. As shown above, however, the IPCC's reports fail to provide the complete picture, especially about water vapour. The IPCC relies on General Circulation Models (GCMs) to predict future temperatures, and when run with and without GHGs, to estimate mankind's contribution to warming. Because water vapour added to the atmosphere is present there for only a few days it is not incorporated into the models. Instead, the assumptions in the GCMs are that water vapour operates as a 'positive feedback', which amplifies the effects of the GHGs by two to three times.

This indicates an assumption that H_2O does not operate in a direct way as do other GHG molecules in the atmosphere. This contention is made in spite of the fact that water vapour molecules are always present. All of the GHG molecules are well mixed throughout the atmosphere, albeit with water vapour at differing percentages (i.e. humidity). In this situation, all GHG molecules absorb, lose and re-absorb photons of energy. Thus, some radiant heat from the earth's surface is reflected back.

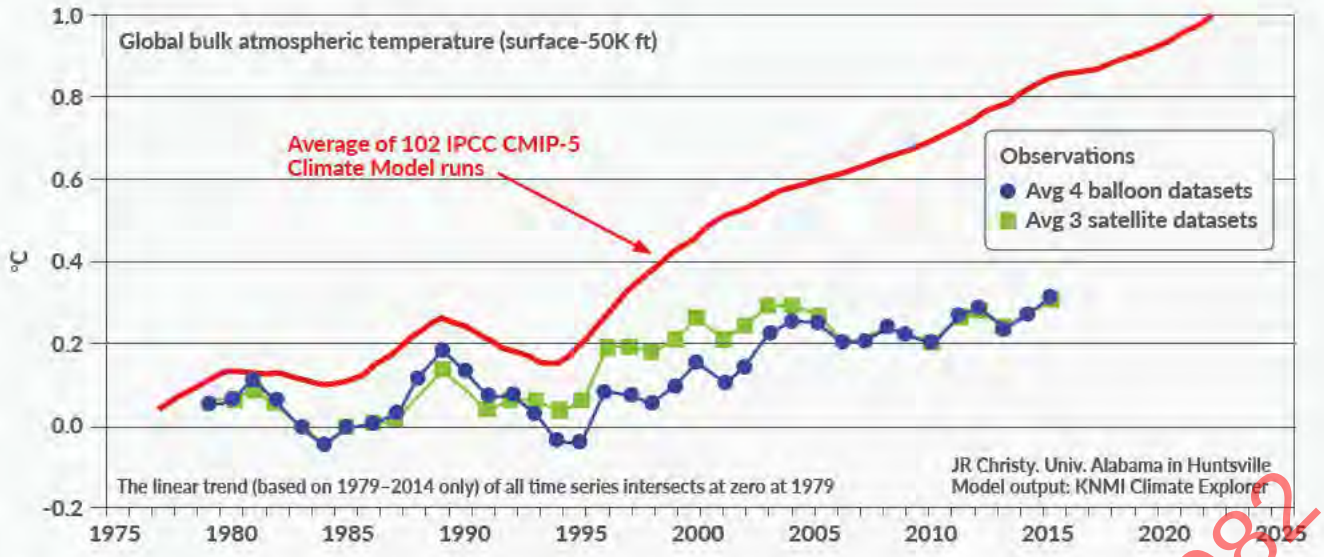


Figure 5: Climate models predicted temperature compared to actual
Source: Christy et al. (2016)

There has been no significant increase in the world's temperature in the last couple of decades, the well-known and accepted 'pause'

There is no logic for the removal of water vapour molecules from consideration in the dynamic situation where all of the GHGs participate in exchanging photons of energy radiating outward from earth. This is particularly relevant in a situation where there is such a high concentration of water vapour in comparison with the other GHGs. As noted previously, many scientific assessments specify that water vapour is the most important GHG and responsible for 80% to 90% of the greenhouse effect.

The IPCC dismisses any possible role of variations in solar output, such as the solar wind interacting with the earth's magnetic field or variations in sunspot activity.

Temperature

The fact is that the world's temperature is not increasing at anything like the rate projected from the GCMs of the IPCC. The 'feedback' from water vapour amplifying the actual temperature effect of CO_2 by two to three times, as expected in the IPCC models, is not evident at least for the last two decades. Clearly the climate models are running hot, which is shown in *Figure 5*.

The data are lower stratosphere measurements from satellites (green) and radiosondes on balloons (blue). These are the most accurate temperature data available, covering most of the world (including the oceans); not suffering from the Urban Heat Island (UHI) effects, from poor siting of climate stations in urban areas, or allowances for the heat build up, particularly at night from asphalt, shelter and other heat stores. Adjustments of past surface temperature records have also often resulted in apparent amplification of recent warming.

There has been no significant increase in the world's temperature in the last couple of decades, the well-known and accepted 'pause'. Over this short time there has been about one-third of all human GHG emissions ever, and the concentration of atmospheric CO_2 has increased more than 10%. Apart from some variation up and down, the mean temperature has not shifted much, certainly not at the rate suggested by the IPCC models. This is good evidence that CO_2 is not the main driver of the world's temperature and/or does not have a major effect on the world's temperature.

Heat absorption activity range of GHGs over the total electromagnetic spectrum

The ability of the GHGs to absorb and emit radiation has been investigated extensively. In the daytime incoming radiation from the sun spans wavelengths from 0.2 to 3 microns. CO_2 has a small absorption band centred at 2.8 microns, which can absorb some incoming radiation. At this same wavelength water vapour is 100% saturated, so its 15,000 ppm versus 400 ppm substantially diminishes any minor effect CO_2 might have on incoming heat. We conclude therefore that there is little effective absorption of incoming radiation by CO_2. Far more important is that the central stratosphere (~50 km) is warmer than the tropopause because ozone absorbs UV energy.

Water vapour does have two significant absorption peaks and some smaller ones in the 0.2 to 3 micron range of the spectrum which will be responsible for some absorption of incoming radiation. The outgoing radiation of heat from the earth is in the 4 to 70 micron range of

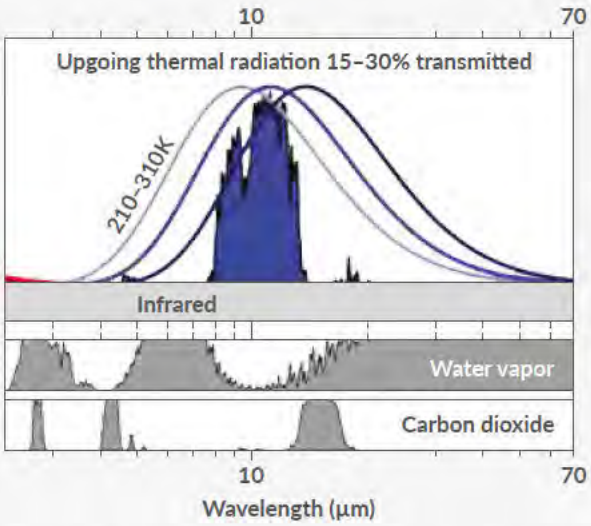


Figure 6A: Upper : Absorption of outgoing radiation from the earth's surface in the 2 to 70 micron range of the spectrum. Lower : Two panels show the absorption-saturation by H_2O and CO_2 in various spectral regions

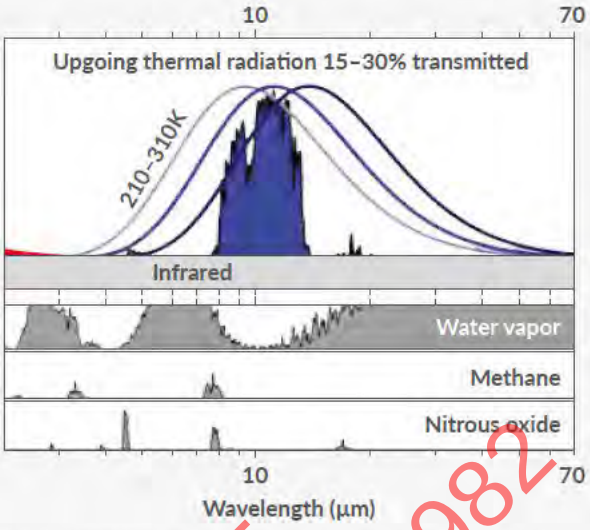


Figure 6B: Upper same as 6A. Lower bands: Absorption peaks for H_2O, CH_4 and N_2O across the infrared. The absorption bands of CH_4 and N_2O are quite narrow

the electro-magnetic spectrum (peaking around 10-15 microns), as shown in *Figures 6A* and *6B*. Absorption bands for CO_2, CH_4 and N_2O are indicated. The water vapour bands are dominant. Note that CO_2 does not compete with CH_4 and N_2O for heat radiated back from the earth, at any specific wavelength, only water vapour. Their roles are completely independent of each other.

One very important point that stands out in *Figures 6A* and *6B* is that water vapour absorbs over a very broad region of the spectrum. In contrast, CH_4 and N_2O absorb only in narrow bands. This means that H_2O captures much, much more of the radiant energy.

CO_2 has three main bands of infrared absorption: 1.8 to 2 microns, 4 to 5 microns and 12 to 18 microns. At the position of the first two bands where CO_2 is able to absorb there is hardly any energy being radiated by the earth anyway *(Figure 1A)*, and thus CO_2 is not effective as a GHG in those bands. The 12 to 18 micron band is the main place where CO_2 absorbs outgoing radiation. Absorption and emission from this band of CO_2 remains a major factor even up into the high stratosphere – above 50 km.

For CH_4 and N_2O, *Figure 6B* shows narrow absorption peaks in the 7 to 8 micron range; these are their only relevant bands. At the other minor absorption peaks for these gases there is very little energy emitted by earth into that spectral region.

In this discussion 15,000 ppm is taken for the atmospheric concentration of water vapour. This is 38 times the concentration of CO_2, and a much bigger concentration difference in comparison with those of CH_4 and N_2O. We know the individual capability of the GHG molecules is of the same order of magnitude *(Table 2)*. We also know the projected warming is not happening, *(Figure 5)* and that the GWP metrics presently used by the IPCC to classify the various GHGs as to their respective effects on warming are defective. The suggested treatment of a new way for CH_4 to get an environmentally credible metric (Allen et al., 2018) is a case in point.

Further, Sheahen (2018) has pointed out the mathematical illogicality of using the slope of a saturated gas (CO_2) as the divisor of the numerator (the top number in a fraction). If any number is divided by another number (the divisor), which is close to zero, then the quotient (the result) becomes a large number itself. This is the simple situation in the calculation of the GWP. A normal numerator (the number related to the absorption by CH_4 or N_2O) is divided by the very low number, the slope of the CO_2 absorption curve. This ridiculous situation produces a huge quotient (purported value for GWP).

CH_4 and N_2O at their tiny concentrations in the atmosphere absorb radiated heat at the earth's surface and in the trophosphere – in small, narrow bands. While this happens, water vapour (a GHG of similar absorptive capacity) is at concentrations thousands of ppm higher than these GHGs. The sequence of absorption, collisions (with N_2 and O_2), emissions and more collisions combines to carry energy away, and that process is dominated by H_2O and CO_2. That mechanism completely truncates the effectiveness of CH_4 and N_2O as GHGs.

Further, Ollila (2014) suggested that the present assessment of the effectiveness of the various GHGs was badly flawed, referring to an analysis from the Harvard-Smithsonian Centre for Astrophysics (2014), which noted that the total contributions of GHGs up to 120 km in altitude were H_2O 82.2%, CO_2 11%, O_3 5.2%, CH_4 0.8% and N_2O 0.8%. This assessment agrees with many other estimates in the scientific literature that suggest that water vapour is the main GHG,

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and 82% being higher than the IPCC's estimate of 72% mentioned above. Clearly, the main GHG is water vapour and there is not a great deal that can be done about the control of this gas.

Other energy transfer mechanisms that must be examined simultaneously

There is an important factor that is often overlooked with one of these GHGs, namely water, which has the additional ability to change phase (evaporate, condense, and precipitate) which the others cannot. These properties also act to provide cooling mechanisms for the earth.

If the planet heats up for any reason, the oceans (which are 70.9% of the earth's surface) will heat up slightly, water will evaporate, and the atmosphere will increase in humidity. Then convection carries the moist air to the cooler upper troposphere, where water changes phase back again, deposits its heat at high altitudes and forms clouds. More clouds reflect heat back to the earth. Further, in the daytime clouds will reflect back or absorb about 30% of the incoming sunlight. This is a built-in cooling effect, a 'negative' feedback. Again, this casts doubt on the IPCC contention that water vapour provides strong positive feedback that amplifies the warming effect of CO_2.

Increasing the concentration of CO_2 in the atmosphere is not such a potential warming problem for the world as frequently promoted in the scientific literature, by governments and the media. Clearly water vapour is the dominant GHG. CO_2 becomes less and less effective (at a logarithmic rate) as its atmospheric concentration increases. Thus, there is limited opportunity for additional CO_2 to cause heating, as previously illustrated in *Figure 2*.

There is agreement that increasing CO_2 in the atmosphere causes some warming; the relevant discussion is about how much? There is also general agreement that doubling the CO_2 levels in the atmosphere from 'pre-industrial' levels of about 280 ppm might increase global temperatures by up to 1°C. Just how much of the temperature rise is due to expected warming as the earth comes out of the Little Ice Age (LIA), i.e. natural variation, and how much is due to an increase in CO_2 levels is impossible to determine.

High altitude absorption

The observed temperature and GHG concentration data are pertinent close to the earth's surface and through much of the trophosphere where water is the dominant GHG. At higher altitudes water is largely frozen out and the dominant absorber becomes CO_2. At higher stratospheric altitudes water vapour is in the few ppm range, with CO_2 and CH_4 still at their lower trophospheric values. In the lower stratosphere the oxidation of CH_4 to H_2O and CO_2 begins to occur. Consequently, CH_4 always remains less than half the concentration of water vapour.

In the stratosphere the ambient temperature is below minus 30°C, and so the energy peak of outgoing radiation has shifted further out into the infrared, leaving even less energy in the 7 micron zone. Again, CH_4 has no significant role as an absorber of infrared energy. Ultimately, the cooling of the planet takes place from the stratosphere and upper troposphere as gases emit radiation into space.

CO_2 participates in this process, but CH_4 does not. CO_2 does not compete with CH_4 or N_2O to absorb radiation from the earth; CO_2 absorbs at different frequencies. Nevertheless, the effect of water vapour in the atmosphere overwhelms the role of CO_2; H_2O is known to provide about 33°C worth of greenhouse effect warming (IPCC, AR4 & AR5). That suggests that reducing atmospheric CO_2 by reducing human emissions has little potential to reduce temperature, much less to control climate. Presently, anthropogenic CO_2 is less than 5% of all the CO_2 going into the atmosphere, and as the temperature increases (as it has in the last millennium) the ocean will heat up and 'outgas' CO_2. Of course, this will also contribute to the atmospheric concentration.

Benefits of CO_2

There is a huge scientific literature about the benefits of additional CO_2 in the atmosphere; it is in fact the gas of life. The fact that many refer to this gas and the increasing levels in the atmosphere, even the adding any of it to the atmosphere, however small, as 'carbon pollution' is illustrative of a misinformed and alarmist media and a misinformed general public.

Already the increase in atmospheric CO_2 from 280 to 400+ ppm from 1850 to 2018 is responsible for probably more than a 15% increase in plant growth, and the 'greening' of the the earth is well recognised. Adding additional CO_2 to the atmosphere will increase crop, pasture and forest growth. In fact a doubling of the level of CO_2 in the atmosphere would most likely result in about 30% increase in plant growth, a result which would be a terrific boon towards food production for an increasing world population.

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Are the present IPCC Estimates of GWP for the various GHGs realistic?

It is clear that the warming effect of CH_4 and N_2O is limited due to their molecular structure, their concentration in the atmosphere, and the minor amount of energy falling within their very narrow absorption bands. They are ineffective GHGs.

There are four serious discrepancies regarding our present political assessment of the effectiveness of CH_4 and N_2O as GHGs:

1. The similar molecular structure to CO_2 and H_2O, N_2O and CH_4 result in their individual capability to absorb radiating heat from the earth of a similar order of magnitude.
2. There are very tiny amounts of CH_4 and N_2O in the atmosphere.
3. The earth emits very little energy in the energy band where both CH_4 and N_2O can absorb radiation.
4. The absorption bands of CH_4 and N_2O are narrow and small, thus these molecules are unable to materially contribute to the dominant role of water vapour in the heat transfer process.

These factors drive the potential impact of these gases down to vanishingly small values. Based on the information presented we conclude that the GWP value of 25 (and rising) for CH_4, and between 265 and 310 for N_2O, is incorrect. Such an error, if followed through to financial commitment according to the United Nations Framework Convention on Climate Change (UNFCCC) and the 2015 Paris Agreement will have very serious negative effects on the New Zealand economy, not to mention all other countries. All of this would be promulgated with an indiscernible effect on temperature or climate. Thus, the generally accepted GHG effects of CH_4 and N_2O, almost 50% of the total New Zealand emissions, must be seriously questioned, and to a lesser extent the quantitative role of CO_2. Water vapour is the dominant GHG.

We assert therefore that the GWP values of both CH_4 and N_2O are vastly overstated by the IPCC, and therefore by member governments of the UNFCCC. Consequently, it is suggested that these gases be removed from New Zealand's Greenhouse Gas Inventory, and that the supporting case for such treatment be prepared for negotiation with our international partners.

Further, there is a much bigger prize at stake. CO_2 has such a small part to play in global warming/climate change, with no more than 20% of the total greenhouse (heating of the earth) effect and probably a lot less than that and the effects of CH_4 and N_2O are trivial. This means that there is an urgent need to stop all this expensive concentration on 'climate change' and be rid of the naivety of assuming that human beings can control and/or stabilise the climate.

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Further reading

For those who wish to read further on the topic of global warming we recommend a small (and free) book availabe on Google, *Why Scientists Disagree About Global Warming: The NIPCC Report on the Consensus* (2nd Edn).

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Pacific Country Report

Sea Level & Climate:
Their Present State

Vanuatu

December 2010

PACIFIC COUNTRY REPORT
ON
SEA LEVEL & CLIMATE: THEIR PRESENT STATE

VANUATU

December 2010

Executive Summary

● A SEAFRAME gauge was installed in Port Vila, Vanuatu, in January 1993. It records sea level, air and water temperature, atmospheric pressure, wind speed and direction. It is one of an array designed to monitor changes in sea level and climate in the Pacific.

● This report summarises the findings to date, and places them in a regional and historical context.

● The sea level trend to date is +5.7 mm/year but the magnitude of the trend continues to vary widely from month to month as the data set grows. Accounting for the precise levelling results and inverted barometric pressure effect, the trend is +4.9 mm/year. An older gauge at Port Vila operated from 1977-1982.

● Variations in monthly mean sea level include a moderate seasonal cycle and were affected by the 1997/1998 El Niño.

● Variations in monthly mean air and water temperature include pronounced seasonal cycles and were likewise affected by the 1997/1998 El Niño.

● A number of destructive Tropical Cyclones (TC) have passed near Vanuatu since the SEAFRAME was installed. In particular TC Prema caused damage to the SEAFRAME in March 1993.

● The SEAFRAME at Port Vila, Vanuatu has recorded 37 separate tsunami events since its installation. The largest tsunami signal of trough-to-peak height 77 cm was recorded after an earthquake of magnitude Mw7.5 that occurred near Vanuatu on 26th November 1999. Vanuatu is prone to tsunamis and two in particular have caused loss of life and damage to property in the period since installation.

Contents

	Page
Executive Summary	2
1. Introduction	4
2. Regional Overview	5
2.1. Regional Climate and Oceanography	5
2.2. Sea level datasets from SEAFRAME stations	8
2.2.1. Vertical datum control of SEAFRAME sensors	10
2.2.2. Inverted barometric pressure effect	11
2.2.3. Combined net rate of relative sea level trends	12
2.3. Sea level datasets from additional stations	14
2.4. Satellite altimetry	17
3. Project Findings to Date – Vanuatu	19
3.1. Extreme events	19
3.1.1. Tropical cyclones	19
3.1.2. Tsunamis	22
3.2. SEAFRAME sea level record and trend	32
3.3. Additional sea level records and trend	34
3.4. Predicted highest astronomical tide	36
3.5. Monthly mean air temperature, water temperature, and atmospheric pressure	37
3.6. Precise Levelling Results for Vanuatu	40
Appendix	
A.1. Definition of Datum and other Geodetic Levels at Port Vila, Vanuatu	41

1. Introduction

As part of the AusAID-sponsored South Pacific Sea Level and Climate Monitoring Project ("Pacific Project") for the FORUM region, in response to concerns raised by its member countries over the potential impacts of an enhanced Greenhouse Effect on climate and sea levels in the South Pacific region, a **SEAFRAME** (**Sea** Level **F**ine **R**esolution **A**coustic **M**easuring **E**quipment) gauge was installed in Port Vila, Vanuatu, in January, 1993. Aside from an inoperative 10-month period following damage caused by tropical cyclone Prema in March 1993, the gauge has been returning high resolution, good scientific quality data since installation.

SEAFRAME gauges not only measure sea level by two independent means, but also a number of "ancillary" variables - air and water temperatures, wind speed, wind direction and atmospheric pressure. There is an associated programme of levelling to first order, to determine shifts in the vertical of the sea level sensors due to local land movement. A Continuous Global Positioning System (CGPS) station was installed in Vanuatu in September 2002 to determine the vertical movement of the land with respect to the International Terrestrial Reference Frame.

When change in sea level is measured with a tide gauge over a number of years one cannot be sure whether the sea is rising or the land is sinking. Tide gauges measure relative sea level change, i.e., the change in sea level relative to the tide gauge, which is connected to the land. To local people, the relative sea level change is of paramount importance. Vertical movement of the land can have a number of causes, e.g. island uplift, compaction of sediment or withdrawal of ground water. From the standpoint of global change it is imperative to establish absolute sea level change, i.e. sea level referenced to the centre of the Earth, which is to say in the terrestrial reference frame. In order to accomplish this, the rate at which the land moves must be measured separately. This is the reason for the addition of CGPS near the tide gauges.

2. Regional Overview

2.1. Regional Climate and Oceanography

Variations in sea level and atmosphere are inextricably linked. For example, to understand why the sea level at Tuvalu undergoes a much larger annual fluctuation than at Samoa, we must study the seasonal shifts of the trade winds. On the other hand, the climate of the Pacific Island region is entirely ocean-dependent. When the warm waters of the western equatorial Pacific flow east during El Niño, the rainfall, in a sense, goes with them, leaving the islands in the west in drought.

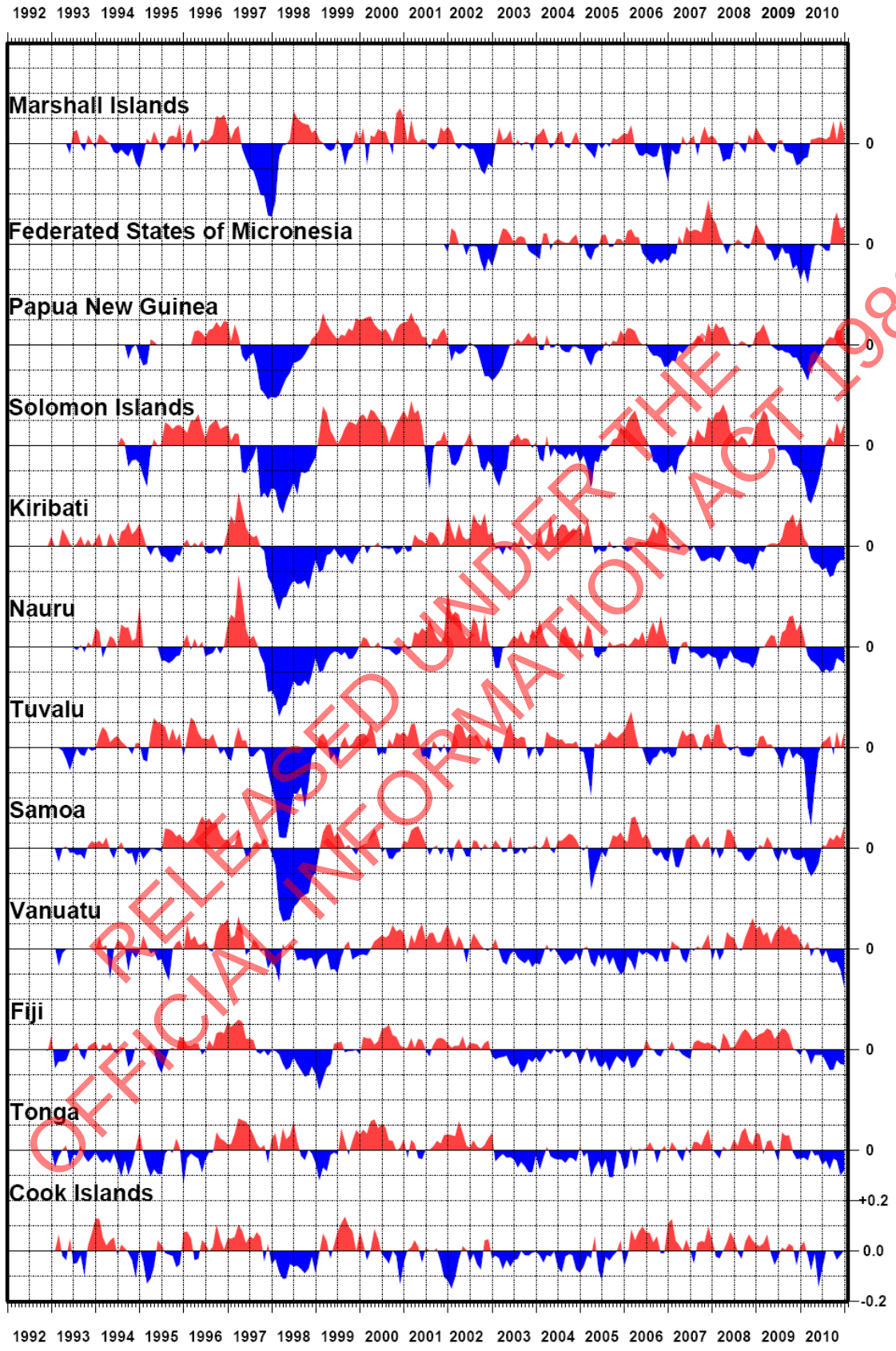
Compared to higher latitudes, air temperatures in the tropics vary little throughout the year. Of the SEAFRAME sites, those furthest from the equator naturally experience the most extreme changes – the Cook Islands (at 21°S) recorded the lowest temperature, 13.1°C, in August 1998. The Cook Islands regularly fall to 16°C while Tonga (also at 21°S) regularly falls to 18°C in winter (July/August).

Table 1. Range in air temperatures observed at SEAFRAME stations

SEAFRAME location	Minimum recorded air temperature (°C)	Mean recorded air temperature (°C)	Maximum recorded air temperature (°C)
Cook Islands	13.1	24.2	32.0
Tonga	15.3	24.2	31.4
Fiji (Lautoka)	16.6	26.0	33.9
Vanuatu	15.2	25.1	33.3
Samoa	18.7	26.6	34.3
Tuvalu	22.4	28.5	33.7
Kiribati	22.2	28.2	32.9
Nauru	19.6	28.0	33.0
Solomon Islands	20.1	26.8	34.5
Papua New Guinea	21.5	27.3	32.0
Marshall Islands	20.9	27.7	32.6
FSM	22.6	27.6	31.8

The most striking oceanic and climatic fluctuations in the equatorial region are not the seasonal, but interannual changes associated with El Niño. These affect virtually every aspect of the system, including sea level, winds, precipitation, and air and water temperature. Referring to Figure 1, we see that at most SEAFRAME sites, the lowest sea level anomalies appeared during the 1997/1998 El Niño. The most dramatic effects were observed at Marshall Islands, PNG, Solomon Islands, Nauru, Kiribati, Tuvalu and Samoa. PNG, Solomon Islands, Tuvalu and Samoa lie along a band that meteorologists refer to as the “South Pacific Convergence Zone (SPCZ)”. The SPCZ is a zone of Trade Wind convergence that extends southeastward from the equator and can sometimes be identified as a cloud band in satellite pictures.

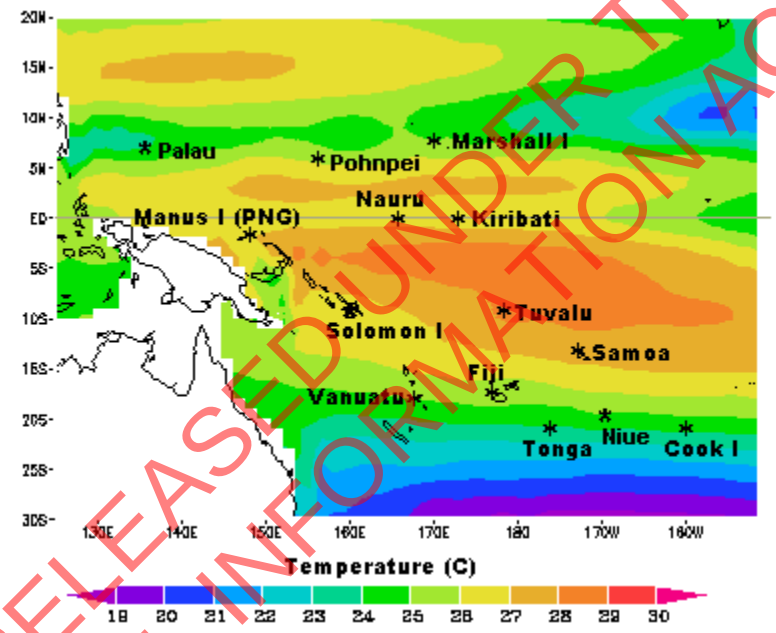
Figure 1. Sea level anomalies* at SEAFRAME sites



* Sea level "anomalies" have had tides, seasonal cycles and trend removed from the sea level observations.

Most Pacific Islanders are very aware that the sea level is controlled by many factors, some periodic (like the tides), some brief but violent (like cyclones), and some prolonged (like El Niño), because of the direct effect the changes have upon their lives. The effects vary widely across the region. Along the Melanesian archipelago, from Manus Island to Vanuatu, tides are predominantly diurnal, or once daily, while elsewhere the tide tends to have two highs and two lows each day. Cyclones, which are fuelled by heat stored in the upper ocean, tend to occur in the hottest months. They do not occur within 5° of the equator due to the weakness of the "Coriolis Force", a rather subtle effect of the earth's rotation. El Niño's impact on sea level is mostly felt along the SPCZ, because of changes in the strength and position of the Trade Winds, which have a direct bearing on sea level, and along the equator, due to related changes in ocean currents. Outside these regions, sea levels are influenced by El Niño, but to a far lesser degree.

Figure 2. Mean surface water temperature

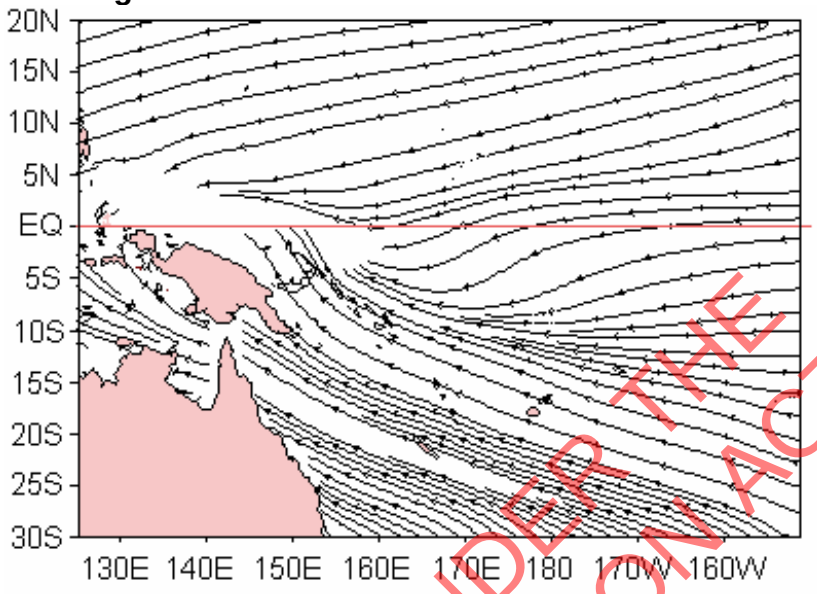


Note the warm temperatures in the SPCZ and just north of the equator.

The convergence of the Trade Winds along the SPCZ has the effect of deepening the warm upper layer of the ocean, which affects the seasonal sea level. Tuvalu, which is in the heart of the SPCZ, normally experiences higher-than-average sea levels early each year when this effect is at its peak. At Samoa, the convergence is weaker, and the seasonal variation of sea level is far less, despite the fact that the water temperature recorded by the gauge varies in a similar fashion. The interaction of wind, solar heating of the oceanic upper layer, and sea level, is quite complex and frequently leads to unexpected consequences.

The streamlines of mean surface wind (Figure 3) show how the region is dominated by easterly trade winds. In the Southern Hemisphere the Trades blow to the northwest and in the Northern Hemisphere they blow to the southwest. The streamlines converge, or crowd together, along the SPCZ.

Figure 3. Streamlines of mean surface wind



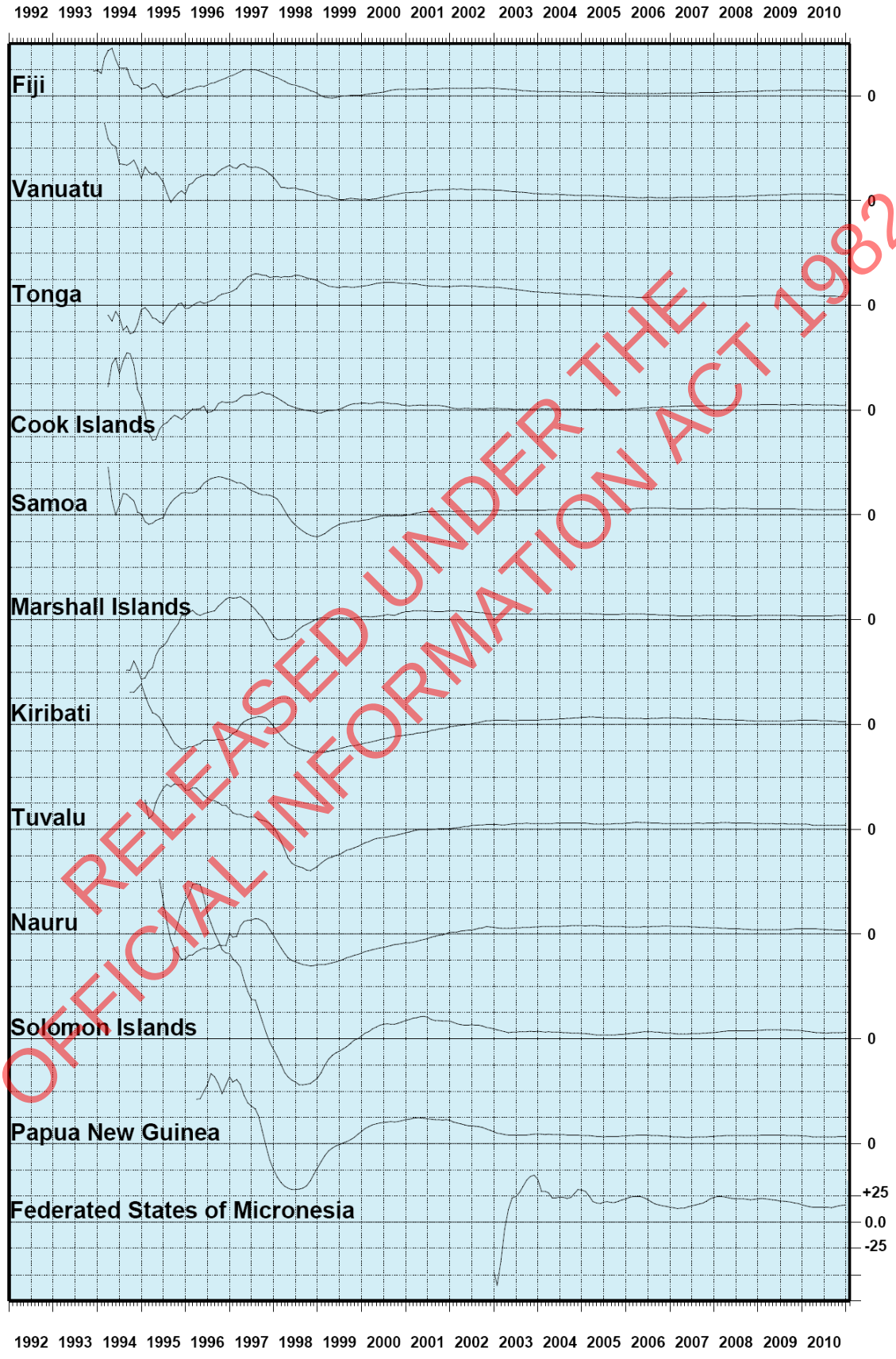
Much of the Melanesian subregion is also influenced by the Southeast Asian Monsoon. The strength and timing varies considerably, but at Manus Island (PNG), for example, the NW monsoon season (winds from the northwest) runs from November to March, while the SE monsoon brings wind (also known as the Southeast Trade Winds) from May to October. Unlike many monsoon-dominated areas, the rainfall at Manus Island is distributed evenly throughout the year (in normal years).

2.2. Sea Level Datasets from SEAFRAME stations

A key objective of the South Pacific Sea Level and Climate Monitoring Project (SPSLCMP) is to provide an accurate long-term sea level record. SEAFRAME stations were installed from 1992 onwards to provide precise relative sea level measurements. The SEAFRAME stations undergo regular calibration and maintenance and are levelled against a network of land-based benchmarks to maintain vertical datum control. The SEAFRAME observations are transmitted via satellite and are processed using specific quality control procedures.

The project's data collection program has been operating for a relatively short period with regards to long-term climate change and therefore the sea level trends are still prone to the effects of shorter-term ocean variability (such as El Niño and decadal oscillations). As the data sets increase in length the linear trend estimates will become increasingly indicative of the longer-term secular changes and less sensitive to large annual and decadal fluctuations. Figure 4 shows how the sea level trends from SEAFRAME stations have evolved from one year after installation to the present. These trends are expected to continue to stabilise, as is demonstrated by Figure 6.

Figure 4. Evolution of relative sea level trends (mm/year) at SEAFRAME stations. The trends continue to stabilise as the length of record increases.



2.2.1 Vertical datum control of SEAFRAME sensors

Precise levelling of the height of the SEAFRAME sea level sensor relative to an array of land-based benchmarks is undertaken by Geosciences Australia every eighteen months where possible. The precision to which the survey must be performed is dependent on the distance K_m (km) between the SEAFRAME sensor benchmark and the primary tide gauge benchmark (TGBM) and forms part of the project's design specifications.

The precise levelling program enables the vertical stability of the SEAFRAME stations to be monitored. Referencing the sea levels to land is especially important if the SEAFRAME needs to be replaced or relocated, or is displaced by a boat or large storm waves. The rates of vertical movement of the gauges relative to the TGBM (determined by fitting a straight line to the survey results after accounting for any adjustments to tide gauge zero) that are contributing to the observed sea level trends are listed in Table 2. Substantial subsidence of the tide gauges at Samoa and Cook Islands is occurring at rates of –0.9 mm/year and –0.7 mm/year. Subsidence is also occurring at Marshall Islands, FSM, Solomon Islands and Tonga. The tide gauges at Fiji and Nauru are rising with respect to the tide gauge benchmark at rates of +0.6 mm/yr and +0.2 mm/yr. The rates of vertical tide gauge movement are used to correct the observed rates of sea level change relative to the land-based primary tide gauge benchmark.

Table 2. Distance (km), required survey precision (mm), number of surveys and the rate of vertical movement of the SEAFRAME relative to the TGBM.

Location	K_m (km)	$\pm 2\sqrt{K_m}$ (mm)	Number of Surveys	Vertical movement (mm/year)
Cook Is	0.491	1.4	10	-0.7
FSM	0.115	0.7	4	-0.4
Fiji	0.522	1.4	11	+0.6
Kiribati	0.835	1.8	12	+0.0
Marshall Is	0.327	1.1	11	-0.5
Nauru	0.120	0.7	12	+0.2
PNG	0.474	1.4	10	-0.0
Samoa	0.519	1.4	10	-0.9
Solomon Is	0.394	1.3	6	-0.3
Tonga	0.456	1.4	11	-0.4
Tuvalu	0.592	1.5	11	-0.1
Vanuatu	1.557	2.5	10	+0.1

Continuous Geographical Positioning Systems (CGPS) stations have also been installed on all of the islands where SEAFRAME gauges are located. The purpose of the CGPS program is to close the final link in establishing vertical datum control – that is, to determine whether the island or coastal region as a whole is moving vertically with respect to the International Terrestrial Reference Frame. Early estimates of the rates of vertical movement are being calculated by Geosciences Australia but continued monitoring is necessary before long-term results emerge from the CGPS time series data. The latest CGPS information for the project is available from Geosciences Australia at http://www.ga.gov.au/geodesy/slm/spslcmp/

2.2.2. Inverted barometric pressure effect

Atmospheric pressure is another parameter that can potentially influence local measurements of relative sea level rise. Atmospheric pressure is also known as barometric pressure because it is measured by a barometer. The 'inverse barometer effect' refers to the sea level response to changes in barometric pressure, whereby a 1 hPa fall in barometric pressure that is sustained over a day or more typically causes local sea levels to rise about 1 cm (within the area beneath the low pressure system).

Scientific interest in accounting for the inverse barometer effect in sea level measurements arises because it is not directly related to global sea level rise due to global warming. Changes in barometric pressure does not cause changes in global ocean volume (because the oceans being a liquid are incompressible), but they can cause sea level to rise in some places and fall in other places due to shifting weather patterns. Global warming on the other hand does cause changes in ocean volume (and hence global sea level rise) due to the expansion of the oceans as they warm and the addition of land-based ice-melt.

Trends in barometric pressure over a period of time will cause changes in relative sea level. A 1 hPa/year decrease (increase) in barometric pressure for example would on average cause a 1cm/yr (or 10 mm/year) increase (decrease) in relative sea level. Estimates of the contribution to relative sea level trends by the inverse barometer effect at all SEAFRAME sites over the period of the project are listed in Table 3.

Table 3. Recent short-term barometric pressure trends expressed as equivalent sea level rise in mm/year based upon SEAFRAME data to December 2010.

Location	Installed	Barometric Pressure Contribution to Sea Level Trend (mm/yr)
Cook Is	19/02/1993	-0.2
FSM*	17/12/2001	-0.8
Fiji	23/10/1992	0.7
Kiribati	02/12/1992	0.3
Marshall Is	07/05/1993	0.0
Nauru	07/07/1993	0.4
PNG	28/09/1994	1.3
Samoa	26/02/1993	0.2
Solomon Is	28/07/1994	-0.3
Tonga	21/01/1993	0.4
Tuvalu	02/03/1993	0.2
Vanuatu	15/01/1993	0.9

*The trend at FSM is from a comparatively short series and therefore varies considerably.

2.2.3. Combined net rate of relative sea level trends

The effects of the vertical movement of the tide gauge platform and the inverse barometer effect are removed from the observed rates of relative sea level change and presented in Table 4 and Figure 5. The net sea level trends are positive at all sites, which indicates sea level in the region has risen over the duration of the project. The sea level rise is not geographically uniform but varies spatially in broad agreement with observations taken by satellite altimeters over a similar timeframe. The differences in the net sea level trends amongst the stations are largely due to regional oceanographic and geodynamic factors, excluding FSM where the trend is considerably large because it is derived from a shorter record than the other sites.

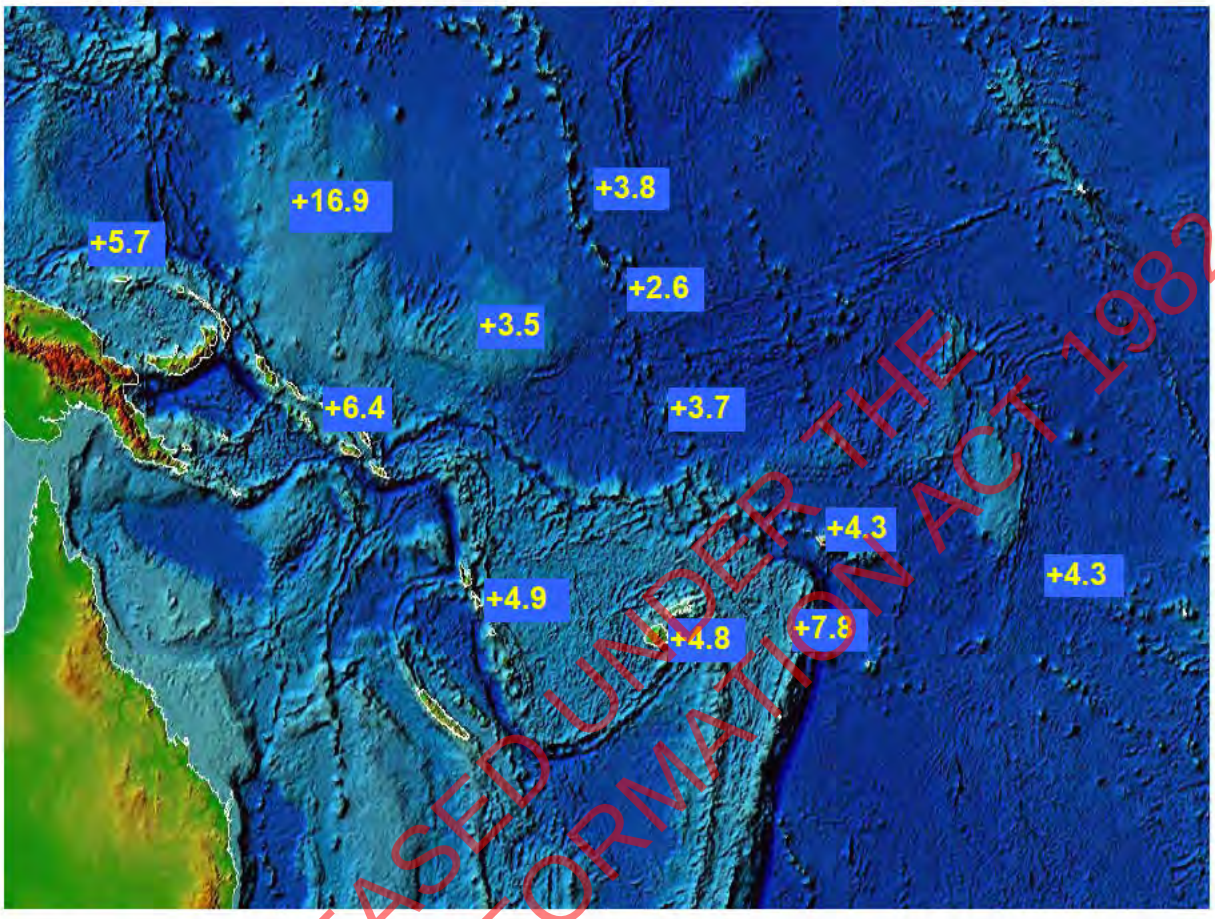
The net relative sea level trend at Tonga is larger than its neighbouring sites Fiji, Samoa and Cook Islands. Investigations that involve differencing of the sea level timeseries at Tonga from those of other stations suggest the sea level datum at Tonga is reasonably stable prior to 1996 and after 1998 but there is evidence of around 5cm of subsidence between 1996 and 1998. The impact of a tug boat occurred during this time but the precise levelling results show this collision caused less than 1cm of subsidence. Unfortunately, the CGPS station at Tonga was installed by Geosciences Australia at a later time (February 2002), and therefore it is difficult to determine whether additional subsidence is related to seismotectonic activity along the Tonga trench.

Table 4. The net relative sea level trend estimates as at December 2010 after the inverted barometric pressure effect and vertical movements in the observing platform relative to the primary tide gauge benchmark are taken into account.

Location	Installed	Sea Level Trend (mm/yr)	Barometric Pressure Contribution (mm/yr)	Vertical Tide Gauge Movement Contribution* (mm/yr)	Net Sea Level Trend (mm/yr)
Cook Is	19/02/1993	4.8	-0.2	+0.7	4.3
FSM**	17/12/2001	16.5	-0.8	+0.4	16.9
Fiji	23/10/1992	4.9	0.7	-0.6	4.8
Kiribati	02/12/1992	2.9	0.3	-0.0	2.6
Marshall Is	07/05/1993	4.3	0.0	+0.5	3.8
Nauru	07/07/1993	3.7	0.4	-0.2	3.5
PNG	28/09/1994	7.0	1.3	+0.0	5.7
Samoa	26/02/1993	5.4	0.2	+0.9	4.3
Solomon Is	28/07/1994	6.4	-0.3	+0.3	6.4
Tonga	21/01/1993	8.6	0.4	+0.4	7.8
Tuvalu	02/03/1993	4.0	0.2	+0.1	3.7
Vanuatu	15/01/1993	5.7	0.9	-0.1	4.9

*The contribution is the inverse rate of vertical tide gauge movement
** The sea level trend at FSM is derived from a comparatively short data record.

Figure 5. Map of region showing net relative sea level trends (in mm/year) after subtracting the effects of the vertical movement of the platform and the inverse barometric pressure effect, utilising all the data collected since the start of the project up to the end of December 2010.



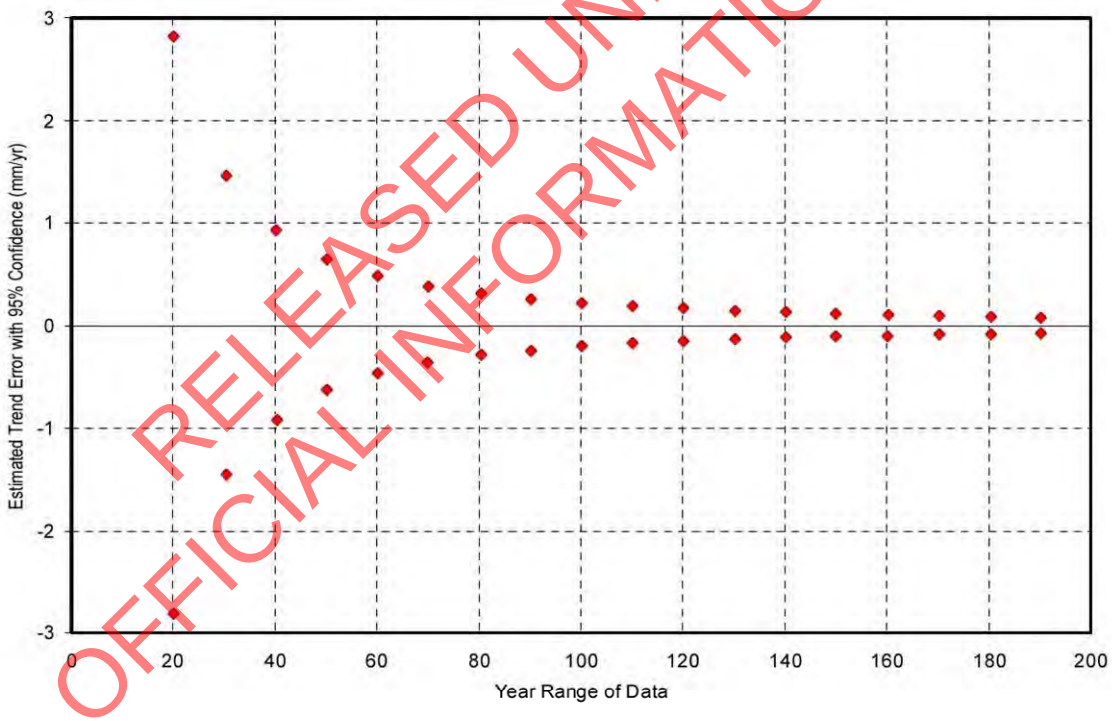
The net relative sea level measurements are important in terms of the local effects and adaptation strategies required on individual islands. Continued CGPS monitoring of the vertical motion of these islands will, in time, allow sea level trends to also be expressed in an absolute reference frame that will improve our understanding of the regional and global effects of climate change.

2.3. Sea Level Datasets from Additional Stations

Additional sea level data sets for the Pacific Forum Region are available from the Joint Archive for Sea Level (JASL). This archive was established in 1987 to supplement the University of Hawaii Sea Level Centre data holdings with contributions from other agencies. The research quality datasets available from the JASL may be accessed online at http://uhslc.soest.hawaii.edu/uhslc/jasl.html

Sea level in the Pacific Forum region undergoes large inter-annual and decadal variations due to dynamic oceanographic and climatic effects such as El Niño, and this 'noise' affects estimates of the underlying long-term trend. In general, sea level trend estimates are more precise and accurate from longer sea level records as is shown in Figure 6. Sea level records of less than 25 years are thought to be too short for obtaining reliable sea level trend estimates. A confidence interval or precision of 1 mm/year should be obtainable at most stations with 50-60 years of data on average, providing there is no acceleration in sea level change, vertical motion of the tide gauge, or abrupt shifts due to seismic events.

Figure 6. 95% Confidence Intervals for linear mean sea level trends (mm/year) plotted as a function of the year range of data. Based on NOAA tide gauges with at least 25 years of record[1].



The annual mean sea levels and relative sea level trends for the additional JASL sea level data sets are shown in Figure 7. The datasets are of different lengths covering different periods of time, and therefore different periods of climatic and sea level change. Many of the datasets are too short to provide reliable trend estimates. At some islands there are multiple sea level records, but joining them together can be problematic. They are archived separately on the Joint Archive for Sea Level

1. Zervas, C. (2001) Sea Level Variations of the United States 1854-1999. NOAA, USA.

because they either originate from different tide gauge locations or they have unrelated tide gauge datums.

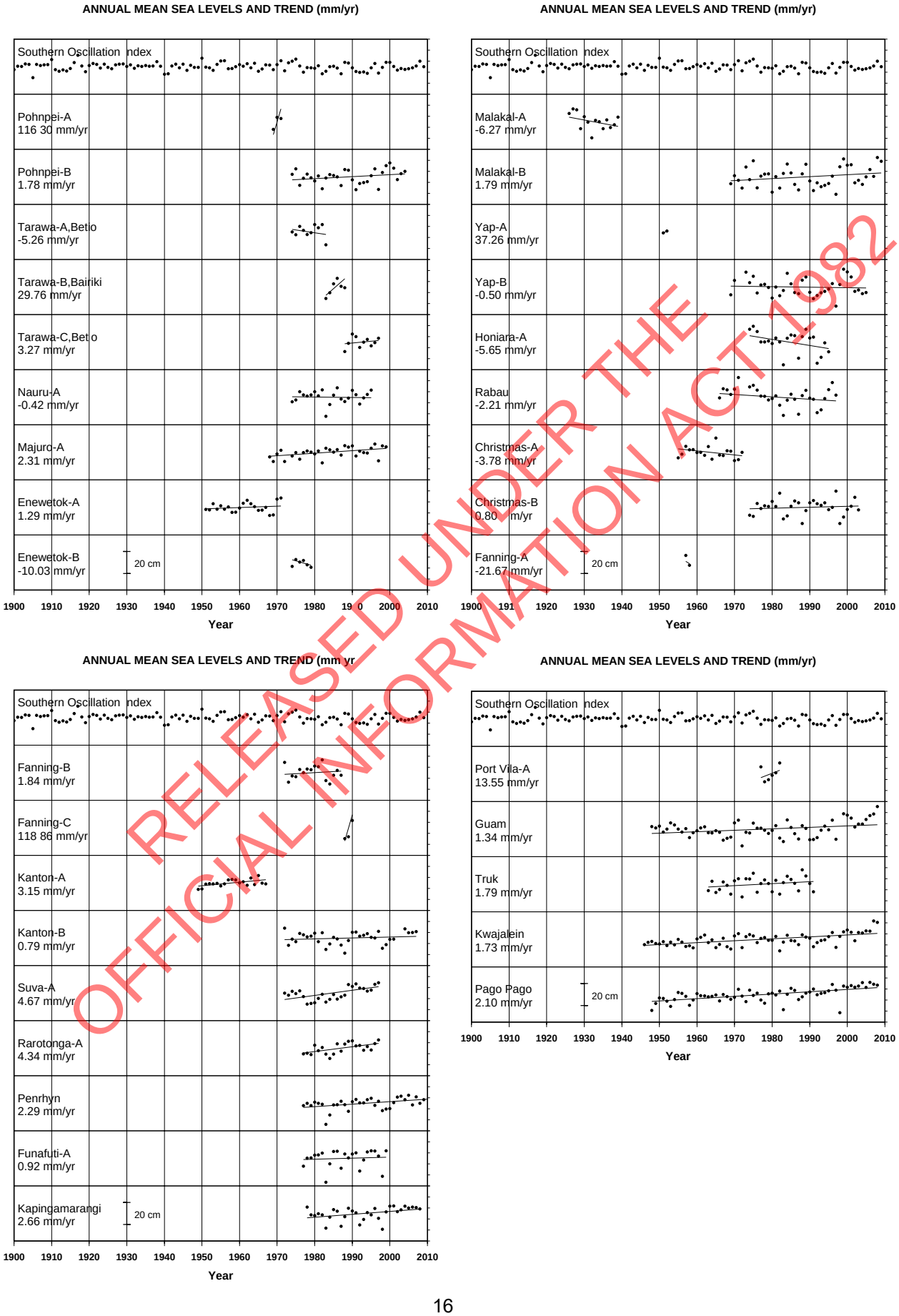
Diverse climatic and oceanographic environments are found within the Pacific Islands region. Different rates of vertical land movement are likely at different stations. Many of the historical tide gauges were designed to monitor tides and sea level variability caused by El Niño and shorter-term oceanic fluctuations rather than long-term sea level change, and therefore lack the required level of instrumental precision and vertical datum control. All of these factors potentially affect the rates of relative sea level change that are listed in Table 5. The overall mean trend from stations with more than 25 years of data is 1.3 mm/year, bearing in mind this is a very simple average that is based on datasets of different lengths that span different time periods.

Table 5. Sea level trends for additional Pacific Forum data holdings on the Joint Archive for Sea Level.

JASL	STATION	COUNTRY	START DATE	END DATE	SPAN (years)	TREND (mm/yr)
001a	Pohnpei-A	Fd St Micronesia	1-Jan-69	31-Dec-71	3	116.3
001b	**Pohnpei-B**	**Fd St Micronesia**	**1-Jan-74**	**31-Dec-04**	**1**	**1.8**
002a	Tarawa-A,Betio	Rep. of Kiribati	1-Jan-74	31-Dec-83	10	-5.3
002b	Tarawa-B,Bairiki	Rep. of Kiribati	1-Jan-83	31-Dec-88	6	29.8
002c	Tarawa-C,Betio	Rep. of Kiribati	1-Jan-88	31-Dec-97	10	3.3
004a	Nauru-A	Rep. of Nauru	1-Jan-74	31-Dec-95	22	-0.4
005a	**Majuro-A**	**Rep. Marshall I.**	**1-Jan-68**	**31-Dec-99**	**32**	**2.3**
006a	Enewetok-A	Rep. Marshall I.	1-Jan-51	31-Dec-71	21	1.3
006b	Enewetok-B	Rep. Marshall I.	1-Jan-74	31-Dec-79	6	-10.0
007a	Malakal-A	Rep. of Belau	1-Jan-26	31-Dec-39	14	-6.3
007b	**Malakal-B**	**Rep. of Belau**	**1-Jan-69**	**31-Dec-09**	**41**	**1.8**
008a	Yap-A	Fd St Micronesia	1-Jan-51	31-Dec-52	2	37.3
008b	**Yap-B**	**Fd St Micronesia**	**1-Jan-69**	**31-Dec-05**	**37**	**-0.5**
009a	Honiara-A	Solomon Islands	1-Jan-74	31-Dec-95	22	-5.7
010a	**Rabaul**	**Papua New Guinea**	**1-Jan-66**	**31-Dec-97**	**32**	**-2.2**
011a	Christmas-A	Rep. of Kiribati	1-Jan-55	31-Dec-72	18	-3.8
011b	**Christmas B**	**Rep. of Kiribati**	**1-Jan-74**	**31-Dec-03**	**30**	**0.8**
012a	Fanning-A	Rep. of Kiribati	1-Jan-57	31-Dec-58	2	-21.7
012b	Fanning B	Rep. of Kiribati	1-Jan-72	31-Dec-87	16	1.8
012c	Fanning-C	Rep. of Kiribati	1-Jan-88	31-Dec-90	3	118.9
013a	Kanton-A	Rep. of Kiribati	1-Jan-49	31-Dec-67	19	3.2
013b	**Kanton-B**	**Rep. of Kiribati**	**1-Jan-72**	**31-Dec-07**	**36**	**0.8**
018a	**Suva-A**	**Fiji**	**1-Jan-72**	**31-Dec-97**	**26**	**4.7**
023a	Rarotonga-A	Cook Islands	1-Jan-77	31-Dec-97	21	4.3
024a	**Penrhyn**	**Cook Islands**	**1-Jan-77**	**31-Dec-10**	**34**	**2.3**
025a	Funafuti-A	Tuvalu	1-Jan-77	31-Dec-99	23	0.9
029a	**Kapingamarangi**	**Fd St Micronesia**	**1-Jan-78**	**31-Dec-08**	**31**	**2.7**
046a	Port Vila-A	Vanuatu	1-Jan-77	31-Dec-82	6	13.6
053a	**Guam**	**USA Trust**	**1-Jan-48**	**31-Dec-08**	**61**	**1.3**
054a	**Truk**	**Fd St Micronesia**	**1-Jan-63**	**31-Dec-91**	**29**	**1.8**
055a	**Kwajalein**	**Rep. Marshall I.**	**1-Jan-46**	**31-Dec-08**	**63**	**1.7**
056a	**Pago Pago**	**USA Trust**	**1-Jan-48**	**31-Dec-08**	**61**	**2.1**

The mean trend for datasets that span more than 25 years (bold font) is 1.3 mm/yr.
Data from JASL as at March 2011.

Figure 7. Annual mean sea levels and linear sea level trends (mm/year) for additional stations on the Joint Archive for Sea Level.



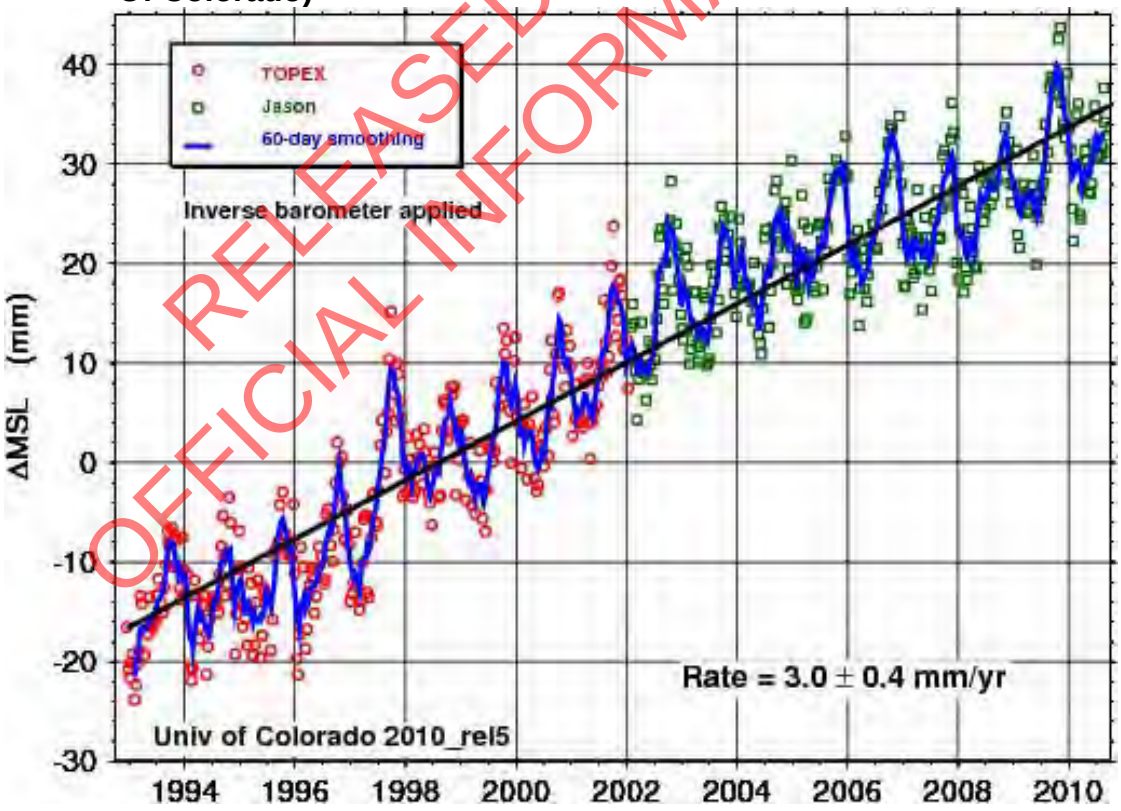
2.4. Satellite Altimetry

Satellite altimetry is technology that allows the height of the sea surface to be measured from satellites orbiting the earth. Satellite altimeters such as Topex/Poseidon and the follow-up missions Jason1 and Jason2 have provided a global record of sea level beginning in late 1992. Although the time interval between successive sea level measurements of the same position on earth is 10 days, the spatial coverage is particularly useful for mapping sea surface anomalies and monitoring development of basin scale events such as El Niño.

Satellite altimeters have an accuracy of several centimetres in the deep ocean, but they are known to be less accurate in shallow coastal regions and therefore are no replacement for in-situ tide gauges. Tide gauges are needed to calibrate the satellite altimeters and provide accurate and more frequent sea level measurements in specific locations where reliable tide predictions and real time monitoring of extreme sea levels is of prime importance.

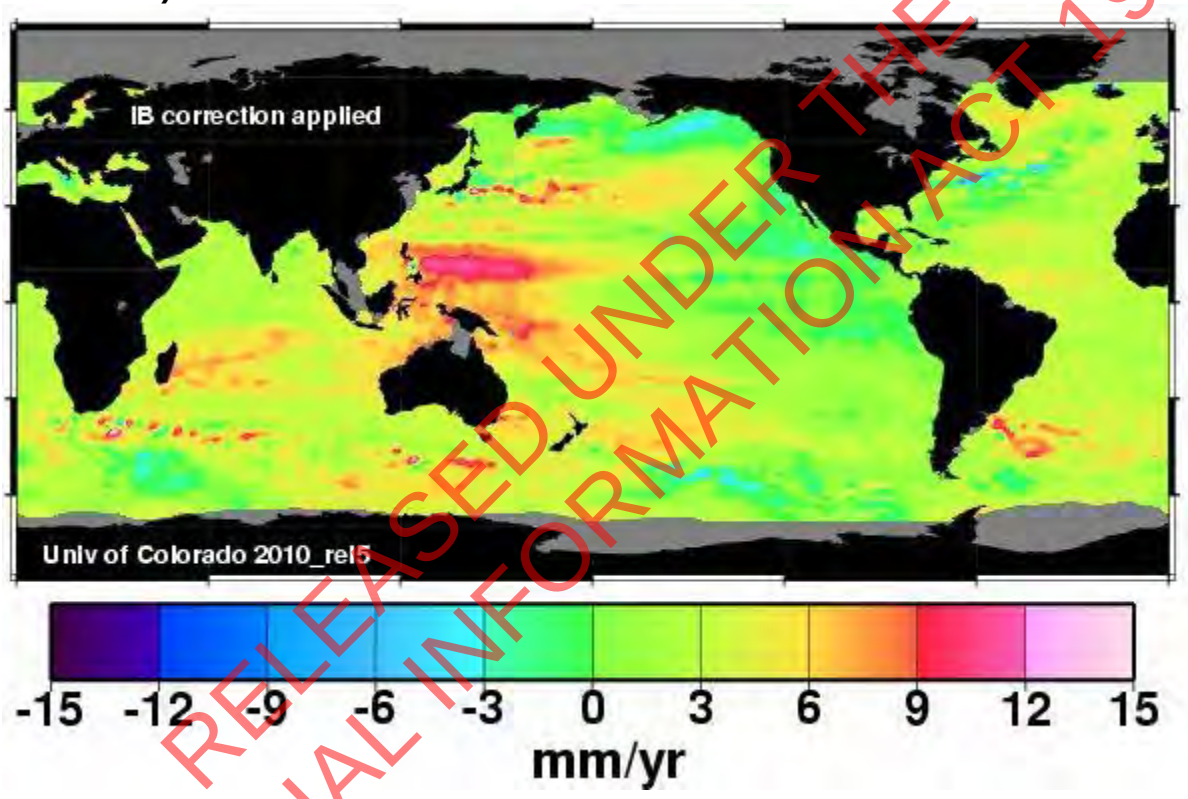
Information about global sea level change derived from satellite altimeters is available from the University of Colorado at http://sealevel.colorado.edu/. Sea level data collected by Topex/Poseidon and Jason show that global mean sea level has risen at a rate of 3.0 +/- 0.4 mm/yr since late 1992 (Figure 8).

Figure 8. Global Mean Sea Level Change Measured By Satellite Altimeters between 1992 and 2010. (Figure Courtesy Of University Of Colorado)



However, global mean sea level change during this time has not been geographically uniform (Figure 9) and continued monitoring is necessary. For example, sea level has risen at relatively high rates across the southwest Pacific but it has risen at relatively low rates across the northeast Pacific and has even fallen in some areas, illustrating basin-wide decadal variability in the Pacific Ocean. The satellite altimetry data has a similar length of record to the South Pacific Sea Level Monitoring Project SEAFRAME stations. The sea level trends from SEAFRAME stations (Table 4) are mostly higher than the global average rate, but this is consistent with higher rates in the southwest Pacific measured by satellite altimeters shown in Figure 9.

Figure 9. Regional Rates of Sea Level Change from 1992 to 2010 as measured by satellite altimeters. (Figure courtesy of University of Colorado)



This section has provided an overview of aspects of the climate and sea level of the South Pacific Sea Level and Climate Monitoring Project region as a whole. The following section provides further details of project findings to date that are relevant to Vanuatu.

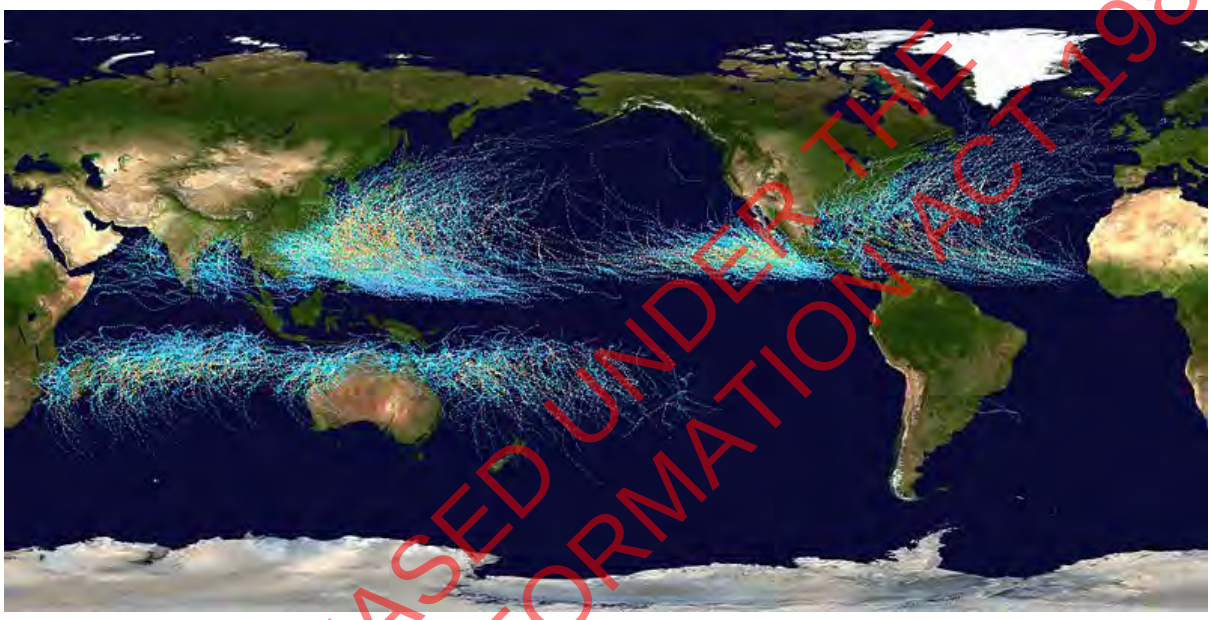
3. Project findings to date - Vanuatu

3.1 Extreme Events

3.1.1. Tropical Cyclones

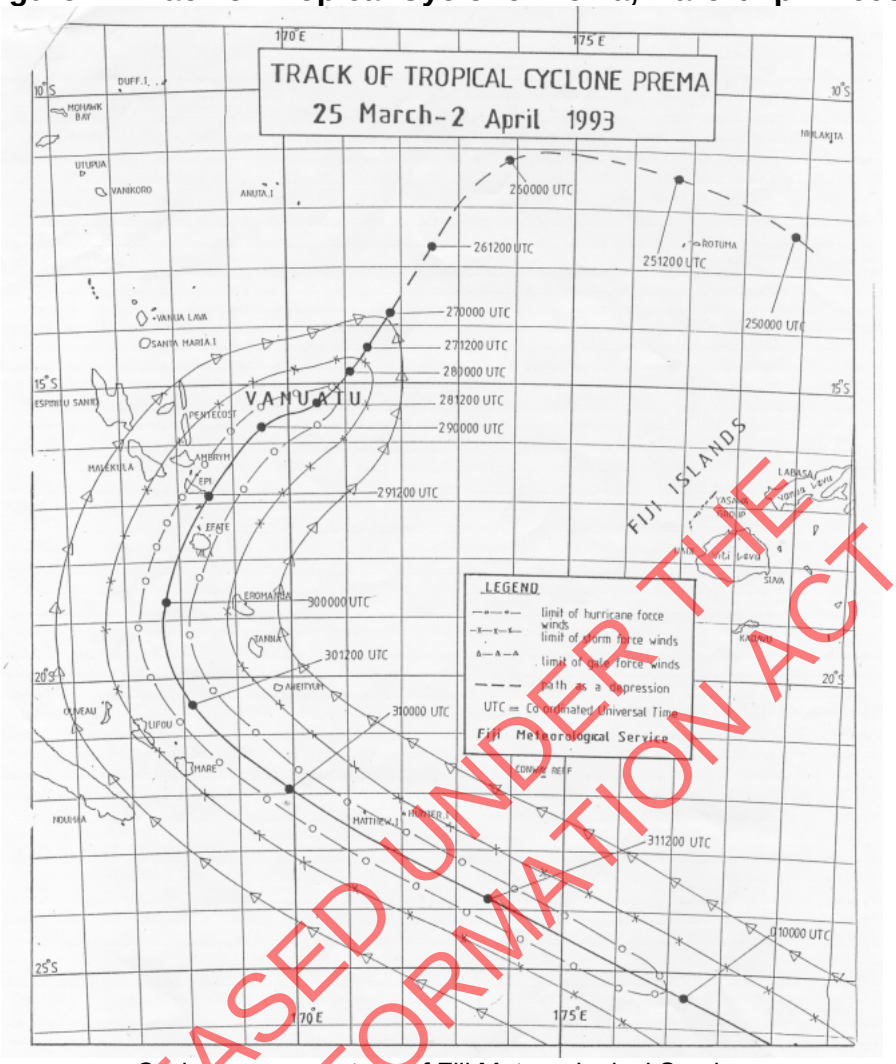
Vanuatu is situated in the southwest Pacific in an area that historically experiences tropical cyclones as shown in Figure 10.

Figure 10. Global Tropical Cyclone Tracks between 1985 and 2005 (Figure courtesy of Wikipedia)



A number of destructive tropical cyclones have passed near Vanuatu since the SEAFRAME was installed, and three in particular have come close enough to Port Vila to be recorded as very low pressures. TC Prema, on 29 March 1993, TC Paula (Category 3), on 2 March 2001 and TC Ivy (Category 4) on 26 February 2004 have all caused considerable damage. One consequence of TC Prema was that the SEAFRAME was damaged and inoperative for ten months.

Figure11. Track of Tropical Cyclone Prema, March/April 1993



Cyclone map courtesy of Fiji Meteorological Service

Figure 12. Track of Tropical Cyclone Paula, February/March 2001

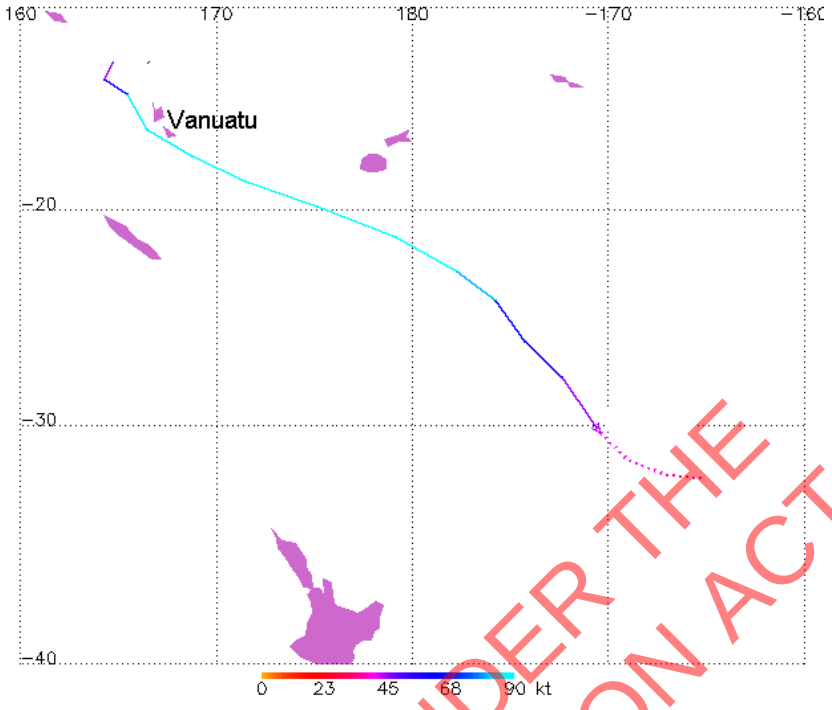
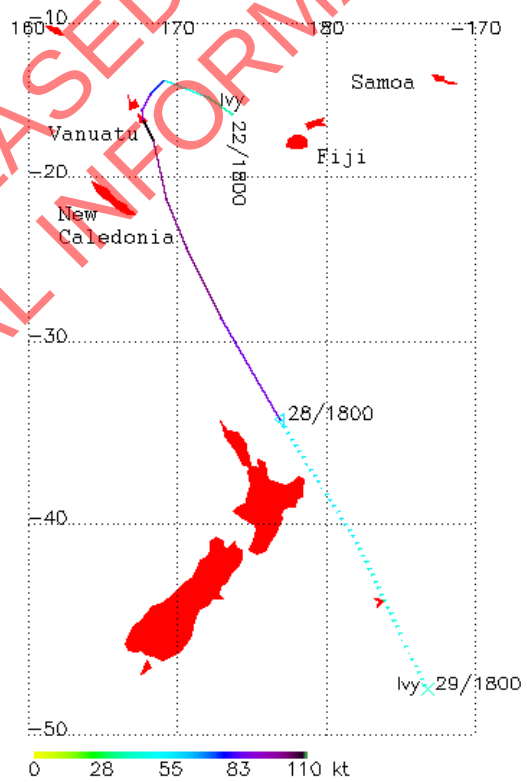


Figure 13. Track of Tropical Cyclone Ivy, February 2004

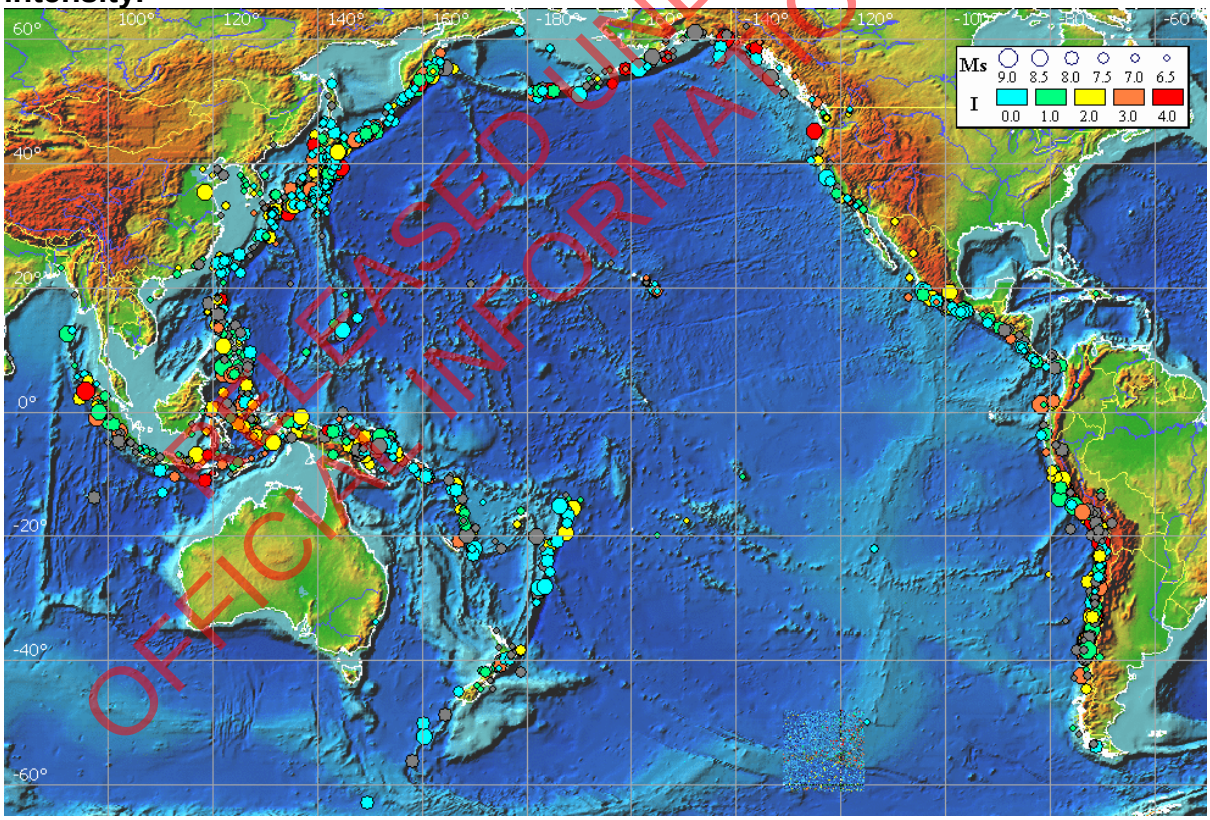


3.1.2. Tsunamis

A tsunami is a series of waves generated by an impulsive disturbance such as an undersea earthquake, coastal or submarine landslide, volcanic eruption, or asteroid impact. Tsunamis are most commonly generated along tectonic plate margins where earthquakes and volcanoes are found. Due to their association with seismic events tsunamis are also referred to as *seismic sea waves*. The term *tidal wave* is incorrect, as tsunamis have nothing to do with gravitational tide generating forces. Tsunami waves may be barely discernible in the open ocean but as they propagate into shallow coastal waters their size may increase significantly.

Figure 14 shows the sources of historical tsunami events listed in the *Integrated Tsunami Database for the Pacific and the Eastern Indian Ocean*[1]. A number of tsunamis have been generated in the South Pacific Sea Level and Climate Monitoring Project region. The SEAFRAME tide gauge network provides important real time tsunami monitoring capability in the region and contributes toward the tsunami warning system for the Pacific Ocean.

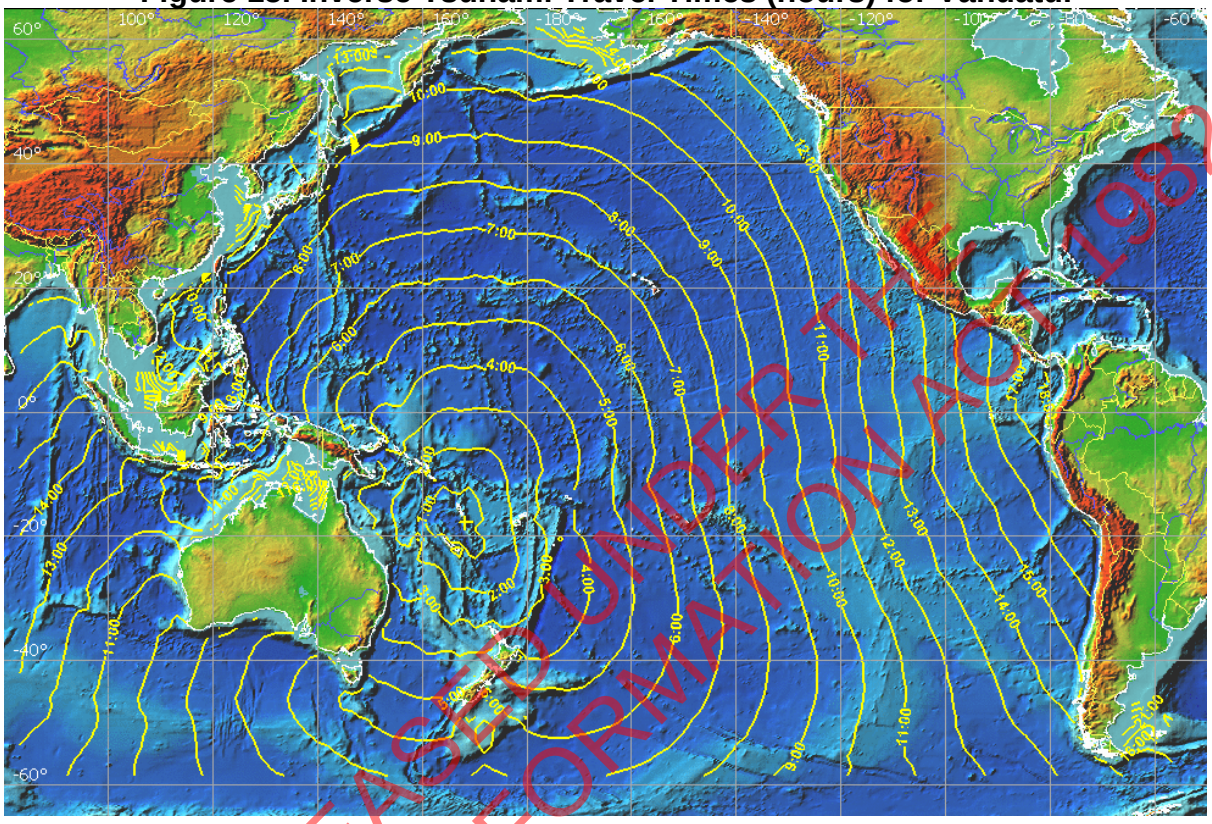
Figure 14. Historical Tsunami Events in the Pacific and Eastern Indian Ocean. Circle size indicates earthquake magnitude and colour indicates tsunami intensity.



[1] ITDB/PAC (2004) Integrated Tsunami Database for the Pacific, Version 5.12 of December 31, 2004. CD-ROM, Tsunami Laboratory, ICMMG SD RAS, Novosibirsk, Russia.

The historical record reveals that tsunamis have been observed at Vanuatu from sources including Vanuatu, Loyalty Islands, Indonesia, Chile and Peru. Figure 15 shows the inverse tsunami travel time chart for Vanuatu. This chart may be used to provide an estimate of the time taken for a tsunami to arrive at Vanuatu from any source location.

Figure 15. Inverse Tsunami Travel Times (hours) for Vanuatu.



Since its installation in 1993, the SEAFRAME tide gauge at Vanuatu has detected 37 separate tsunami events. The non-tidal sea levels (3-minute averages recorded every 6 minutes) for each of these events are presented in Figures 16a-16g. Also shown (as vertical dotted lines) are tsunami arrival times, which have been computed independent of the observations by tsunami travel time software using the earthquake location as input.

The tsunamis detected by the SEAFRAME at Vanuatu include local, regional and transoceanic tsunamis. In fact the Vanuatu SEAFRAME has recorded the most number of tsunami events and also tends to observe larger signals in comparison to other stations in the network.

A number of local tsunamigenic earthquakes have occurred in the Vanuatu region since the SEAFRAME was installed, ranging in magnitude from Mw7.1 to Mw7.7. Two of these events produced the largest tsunamis to be recorded on the SEAFRAME. The first was a magnitude Mw7.5 earthquake on 26 November 1999 that occurred 140 km to the northwest of Port Vila. A tsunami was generated which caused destruction on Pentecost Island where maximum tsunami heights reached 6m. The tsunami claimed 3 lives, although many were saved when some residents

recognised an impending tsunami as the sea began to recede and managed to warn people to seek higher ground. The peak to trough tsunami signal on the Port Vila SEAFRAME was around 0.9 m for the 1-minute sea level data, or 0.77m for the 3-minute sea level data recorded every 6 minutes. The tsunami arrival coincided with low tide, which resulted in dangerously low sea levels 23 cm below the lowest astronomical tide.

The second event was an earthquake of magnitude Mw7.2 on the 2nd of January 2002 that occurred 100 km west of Port Vila, Vanuatu. Several people were injured and there was widespread damage on the island of Efate. Access to the wharf was blocked by rockslides. The SEAFRAME tide gauge at Port Vila recorded the tsunami wave that followed, whose peak to trough height reached 80 cm for the 1-minute data, or 74cm for the 3-minute data stream.

A number of regional tsunamis have also been detected by the SEAFRAME emanating from sources including Samoa, Loyalty Islands, Tonga, Solomon Islands and Irian Jaya. Larger transoceanic tsunamis have also been observed generated from far-field earthquake sources including Kuril Islands (in the northwest Pacific), Peru, Chile, Mexico, Andreonof Islands and as far as Sumatra, Indonesia in the Indian Ocean.

Figure 16a. Tsunami signals (m) recorded by the SEAFRAME at Port Vila, Vanuatu since installation.

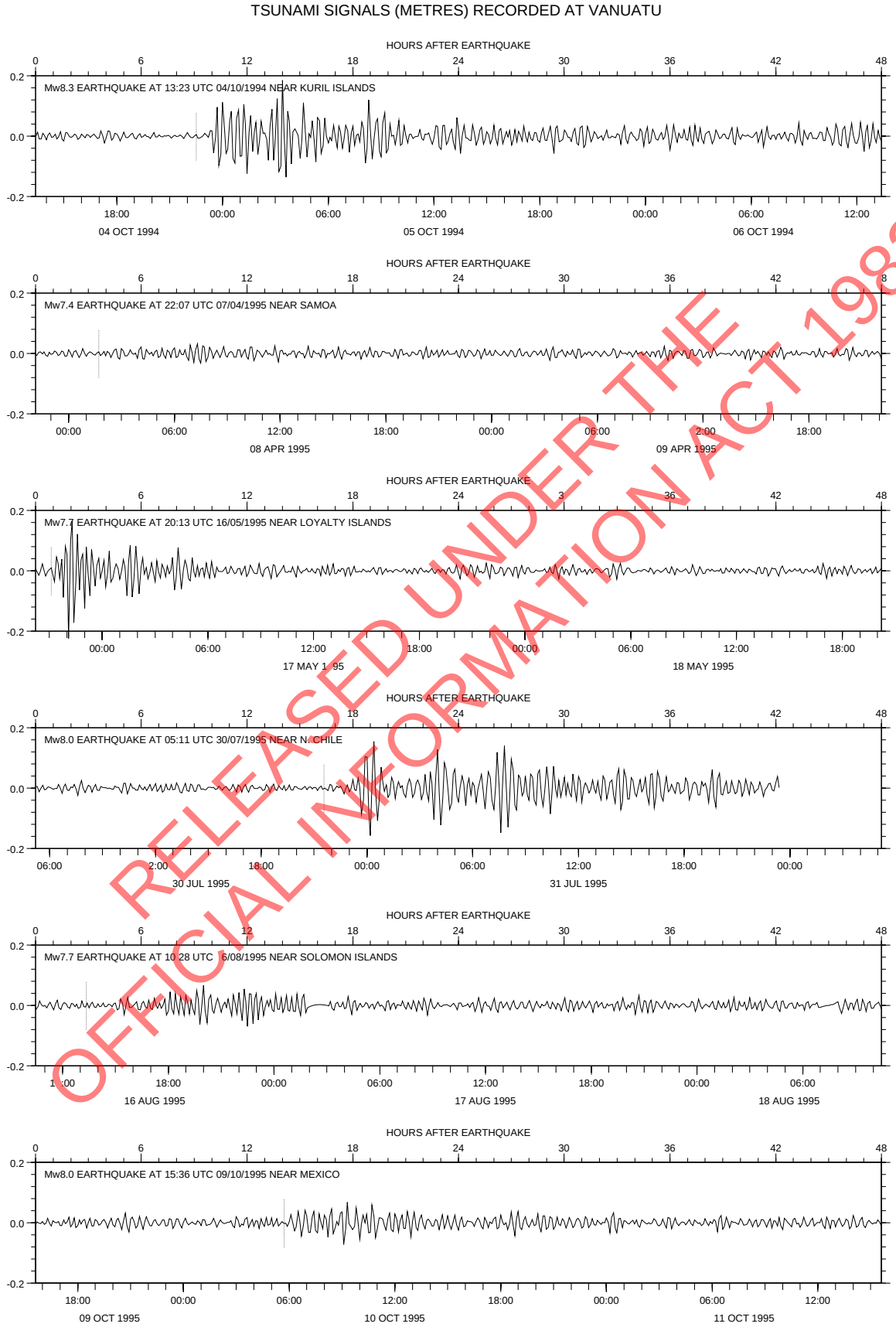


Figure 16b. Tsunami signals (m) recorded by the SEAFRAME at Port Vila, Vanuatu since installation.

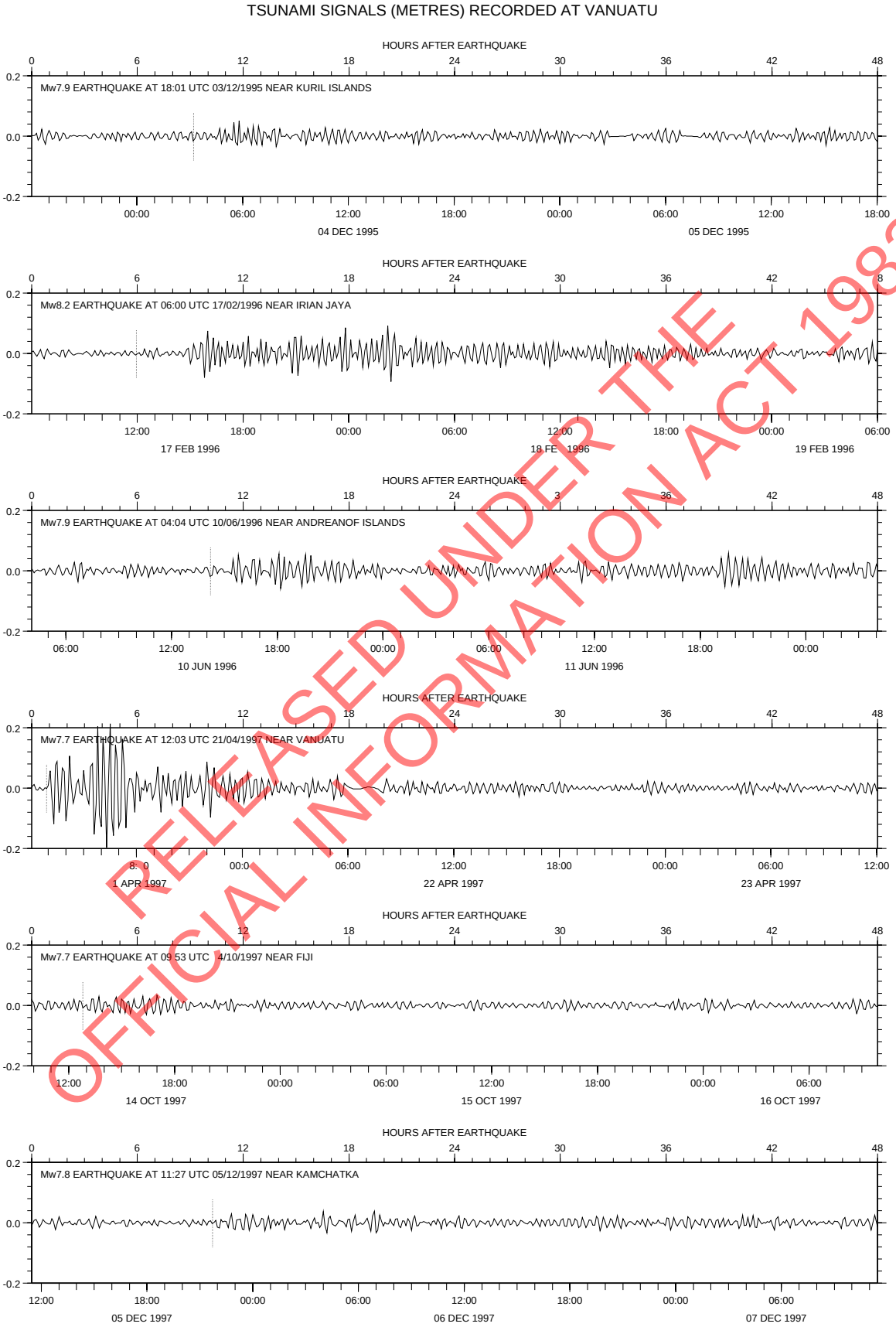


Figure 16c. Tsunami signals (m) recorded by the SEAFRAME at Port Vila, Vanuatu since installation.

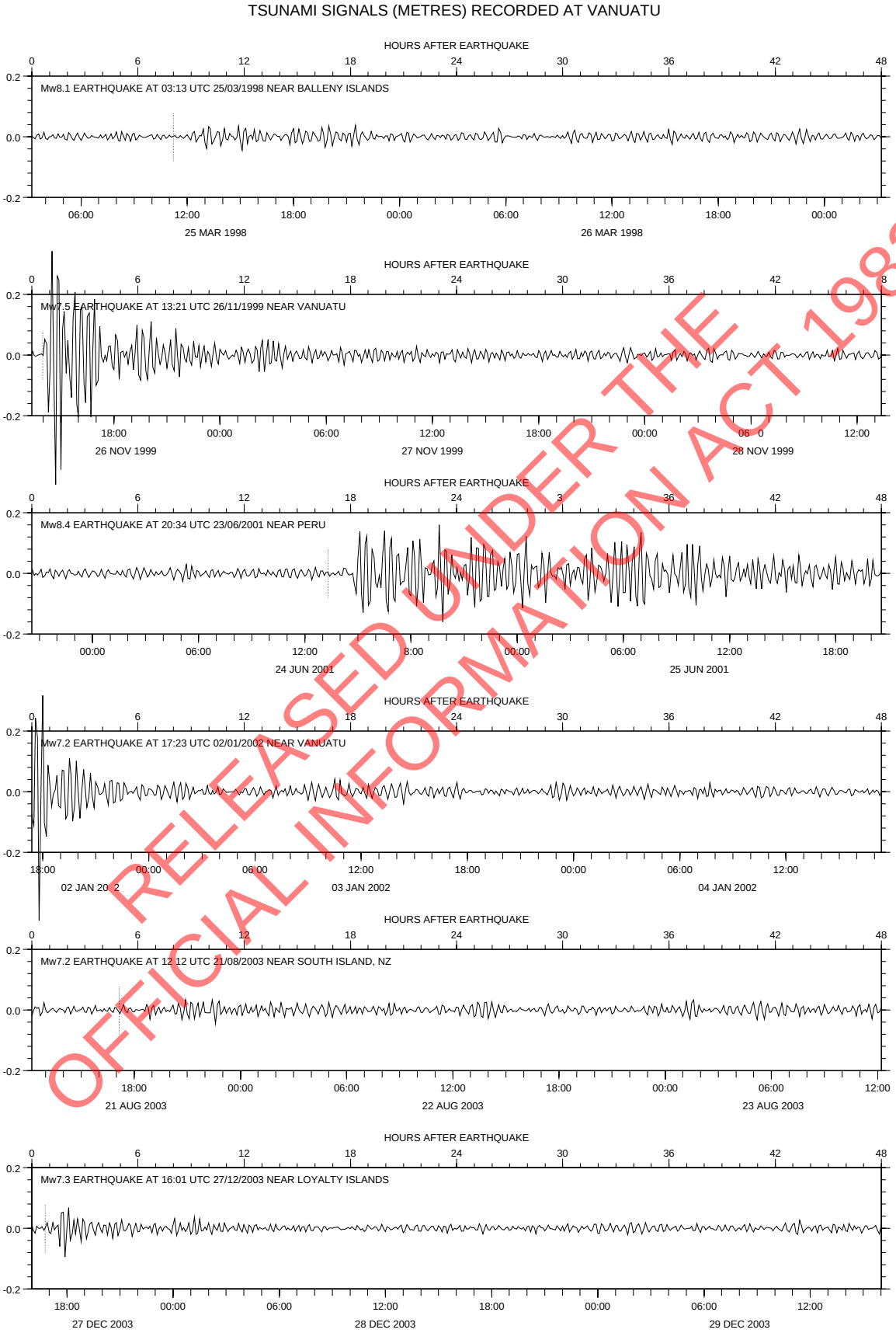


Figure 16d. Tsunami signals (m) recorded by the SEAFRAME at Port Vila, Vanuatu since installation.

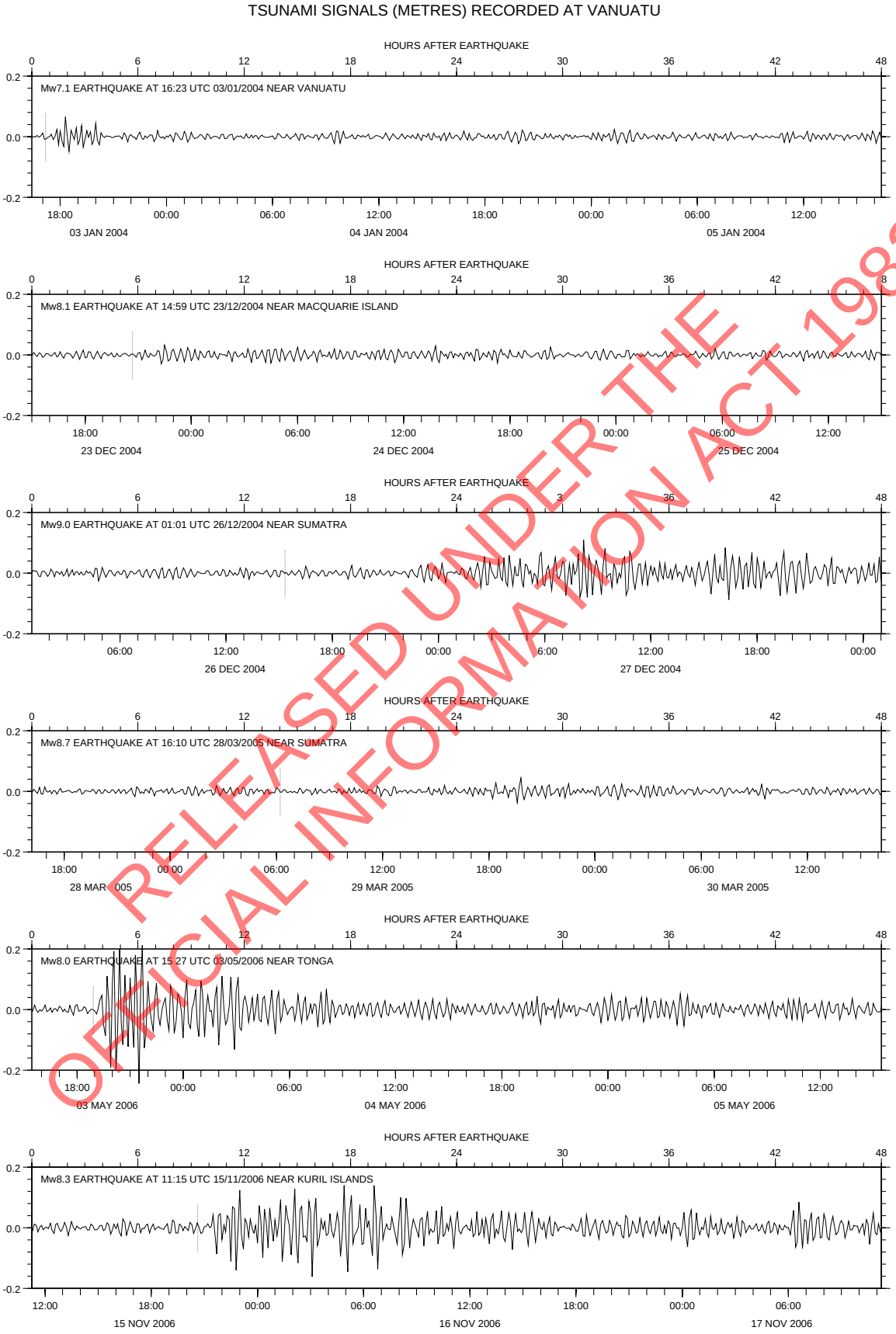


Figure 16e. Tsunami signals (m) recorded by the SEAFRAME at Port Vila, Vanuatu since installation.

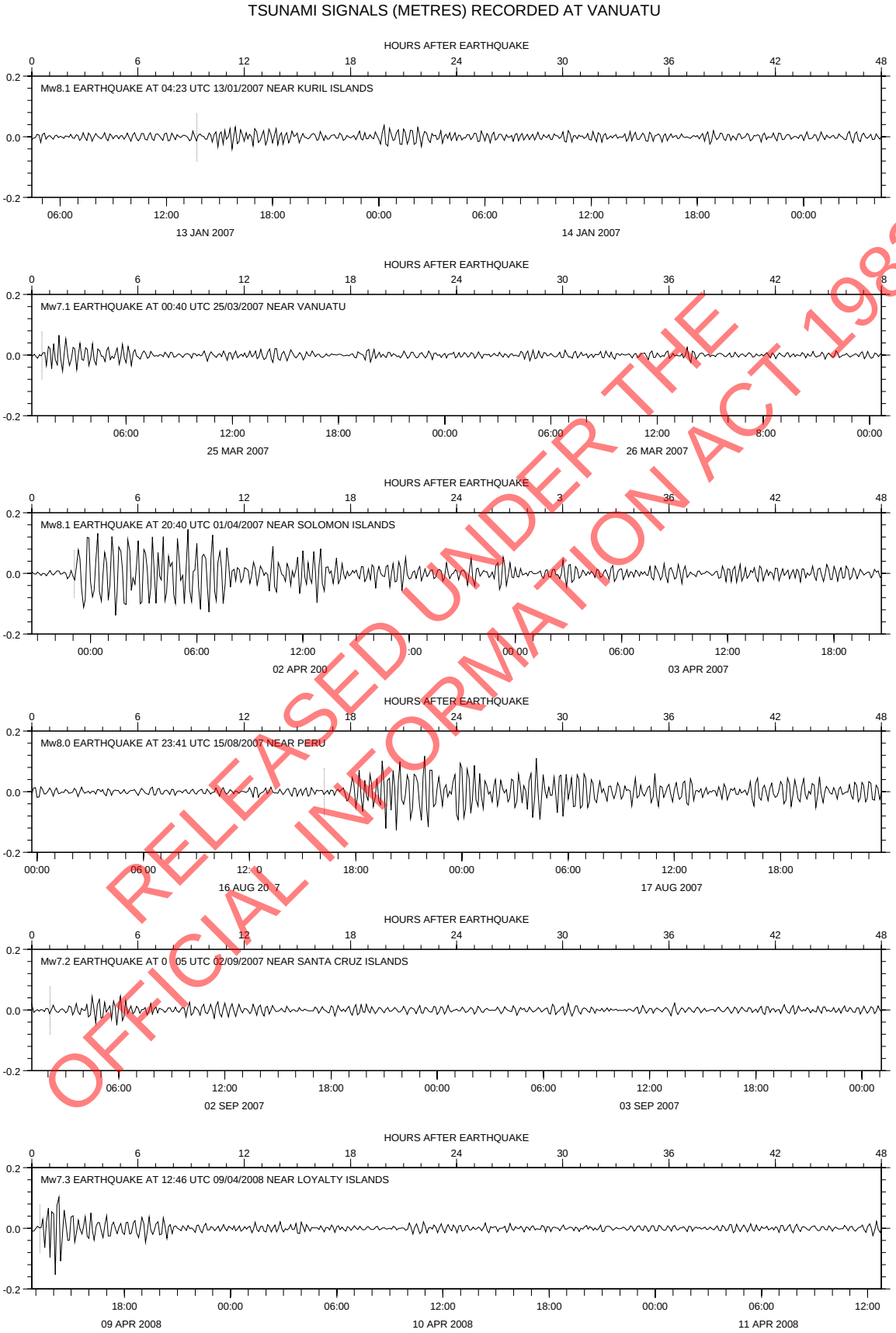


Figure 16f. Tsunami signals (m) recorded by the SEAFRAME at Port Vila, Vanuatu since installation.

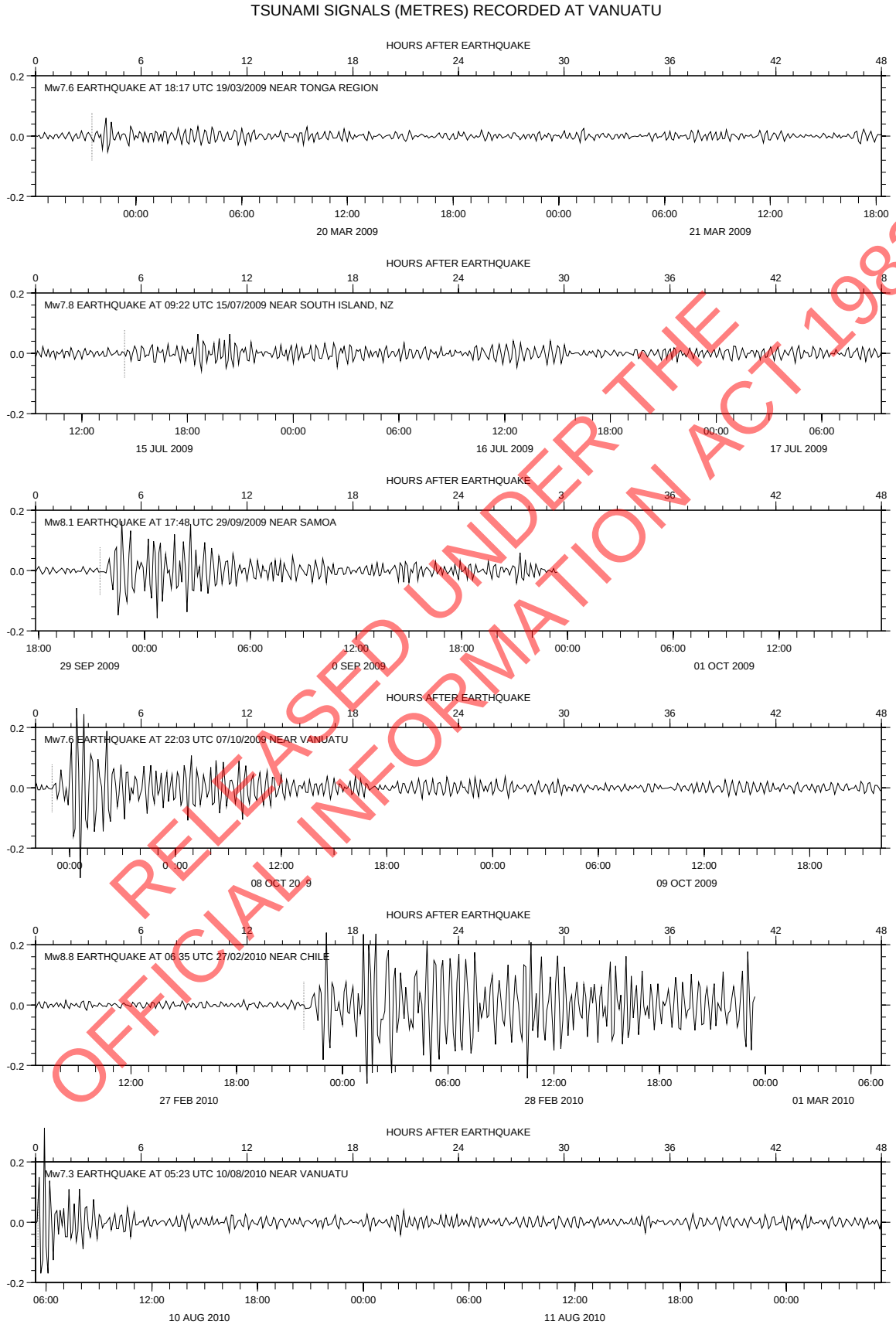
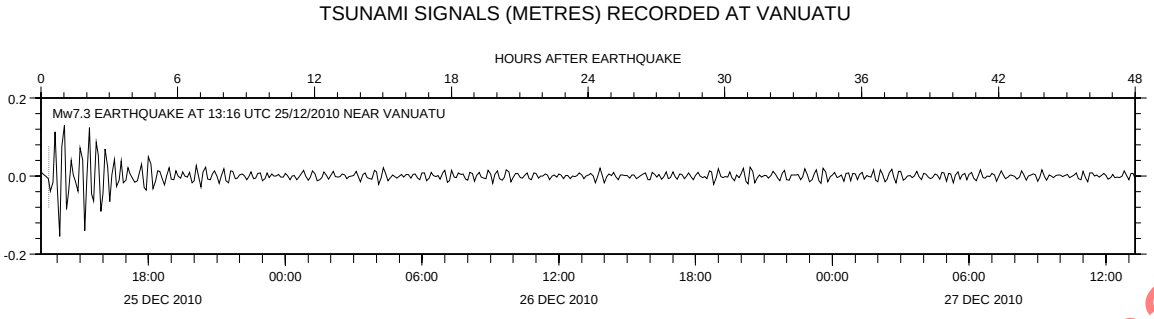


Figure 16g. Tsunami signals (m) recorded by the SEAFRAME at Port Vila, Vanuatu since installation.



3.2. SEAFRAME sea level record and trend

A fundamental goal of the Project is to establish the rate of sea level change. It has been recognised since the beginning that this would require several decades of continuous, high quality data. The preliminary findings are being provided, but caution should be exercised in interpreting this information. Figure 6 shows that confidence in trend estimates improve as more data becomes available.

As at December 2010, based on the short-term sea level rise analyses performed by the National Tidal Centre using the Port Vila SEAFRAME data, a rate of **+5.7 mm per year** has been observed. Accounting for the inverted barometric pressure effect and vertical movements in the observing platform, the net sea level trend is **+4.9 mm per year**. By comparison, the Intergovernmental Panel on Climate Change (IPCC) in its Fourth Assessment Report (IPCC AR4, 2007) estimates that global average long-term sea level rise over the last hundred years was of the order of 1 to 2 mm/yr.

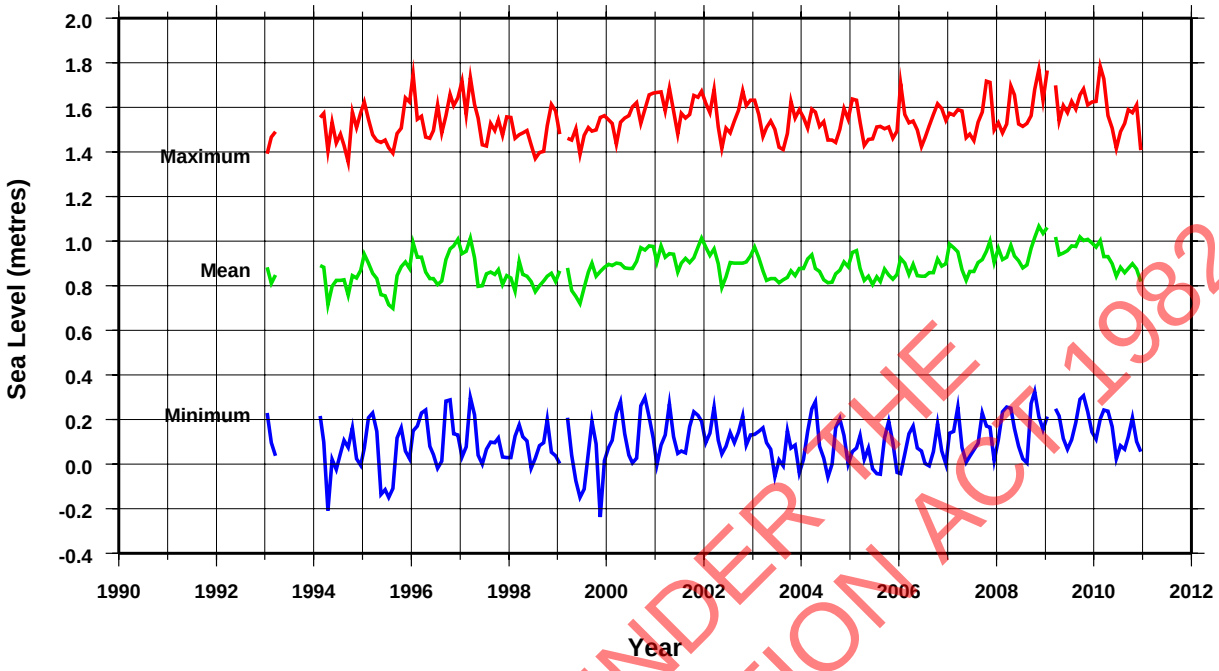
Figure 4 shows how the trend estimate has varied over time. In the early years, the trend appeared to indicate an enormous rate of sea level rise. Later, due to the 1997/1998 El Niño when sea level fell about 12 cm below average, the trend dropped substantially. Given the sea level record is relatively short, it is still too early to deduce a long-term trend.

The sea level data recorded since installation is summarised in Figure 17. The middle curve (green) represents the monthly mean sea level. The upper and lower curves show the highest and lowest values recorded each month. Unlike many of the SEAFRAME sites, sea level at Port Vila did not experience a dramatic decrease in 1998 as a result of El Niño, although it did disrupt the normal seasonal cycle and produced a negative sea level anomaly. Port Vila is relatively far from the equator, where El Niño signals are most pronounced.

By inspection of the monthly maxima (red curve) it appears that Vanuatu, like Fiji, the Cook Islands, Tonga and Tuvalu, experiences highest sea levels near the start of the year. At mid-year, the highest sea levels are typically about 20 cm less than when at the maximum. However, this pattern does not occur every year. The mean sea level over the duration of the record is 0.887 metres, with a maximum of 1.785 metres on 28th of February 2010 (as a result of tsunami waves arriving following the Mw8.8 earthquake off Chile), and a minimum of -0.237 metres on 26th of November 1999 due to the arrival of a tsunami at low tide.

Figure 17

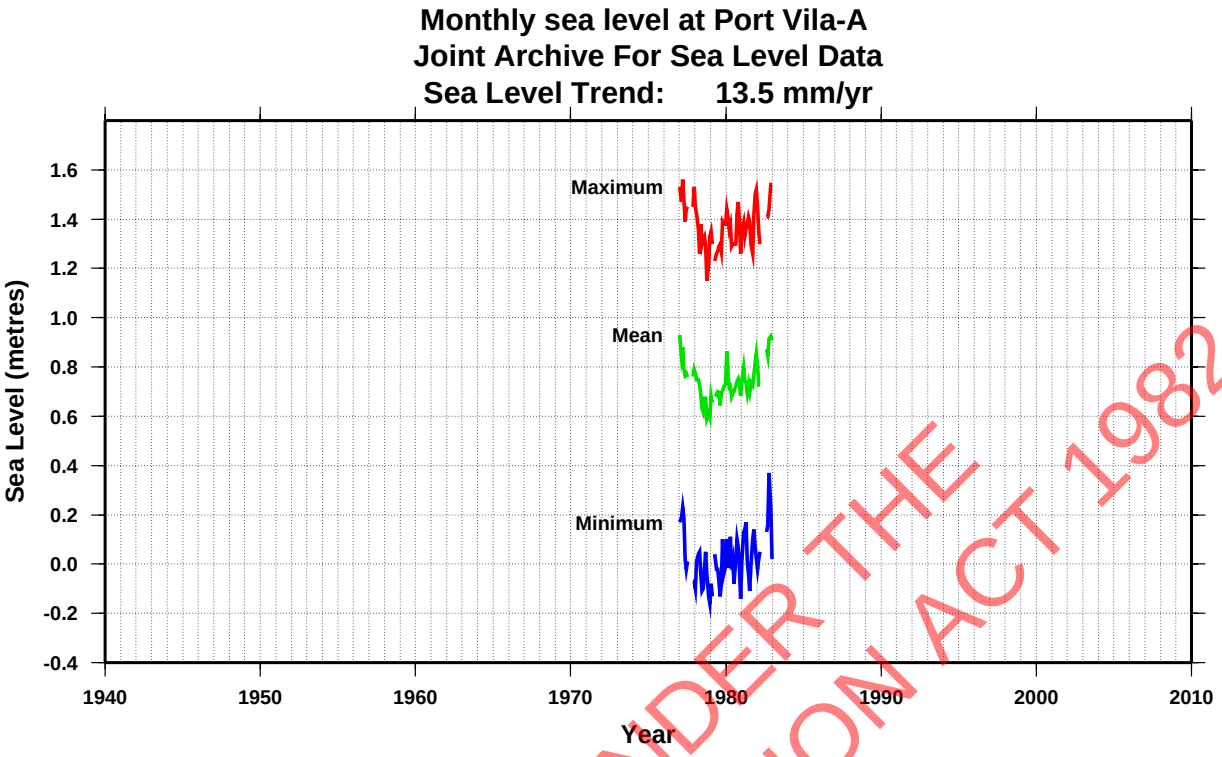
Monthly sea level at Port Vila, Vanuatu
SEAFRAME gauge



3.3. Additional sea level records and trend

An additional sea level record for Vanuatu is available from the Joint Archive for Sea Level for Port Vila, where a tide gauge operated from 1977 to 1982. The monthly sea level data from this station is shown in Figure 18, but the relative sea level trend of +13.5 mm/year is large since it is derived from a very short record. Older tide gauges such as these were primarily designed for monitoring tides and shorter-term oceanic fluctuations such as El Niño rather than long-term sea level monitoring which requires a high level of precision and datum control.

Figure 18

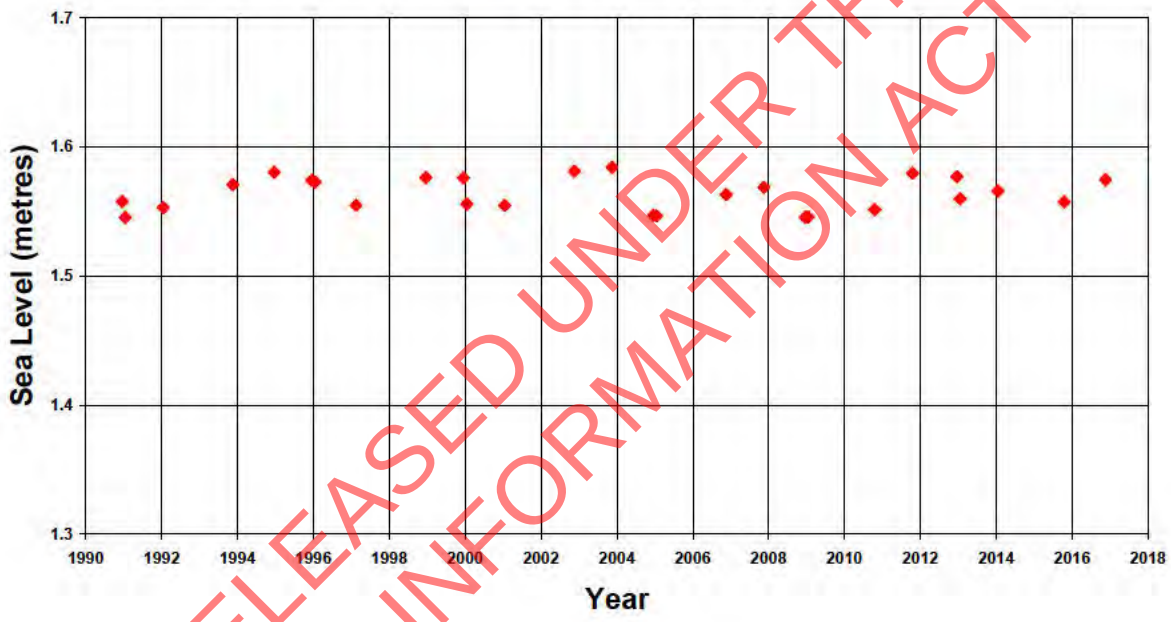


3.4. Predicted highest astronomical tide

The component of sea level that is predictable due to the influence of the Sun and the Moon and some seasonal effects allow us to calculate the highest predictable level each year. The highest astronomical tide is the highest sea level that can be predicted under any combination of astronomical conditions, including the proximity of the earth to the sun and the moon. Figure 19 shows that the highest predicted level (1.58 m) over the period 1990 to 2016 was at 17:28 Local Time on 24 November 2003.

Figure 19

Predicted highest tide each year for Port Villa

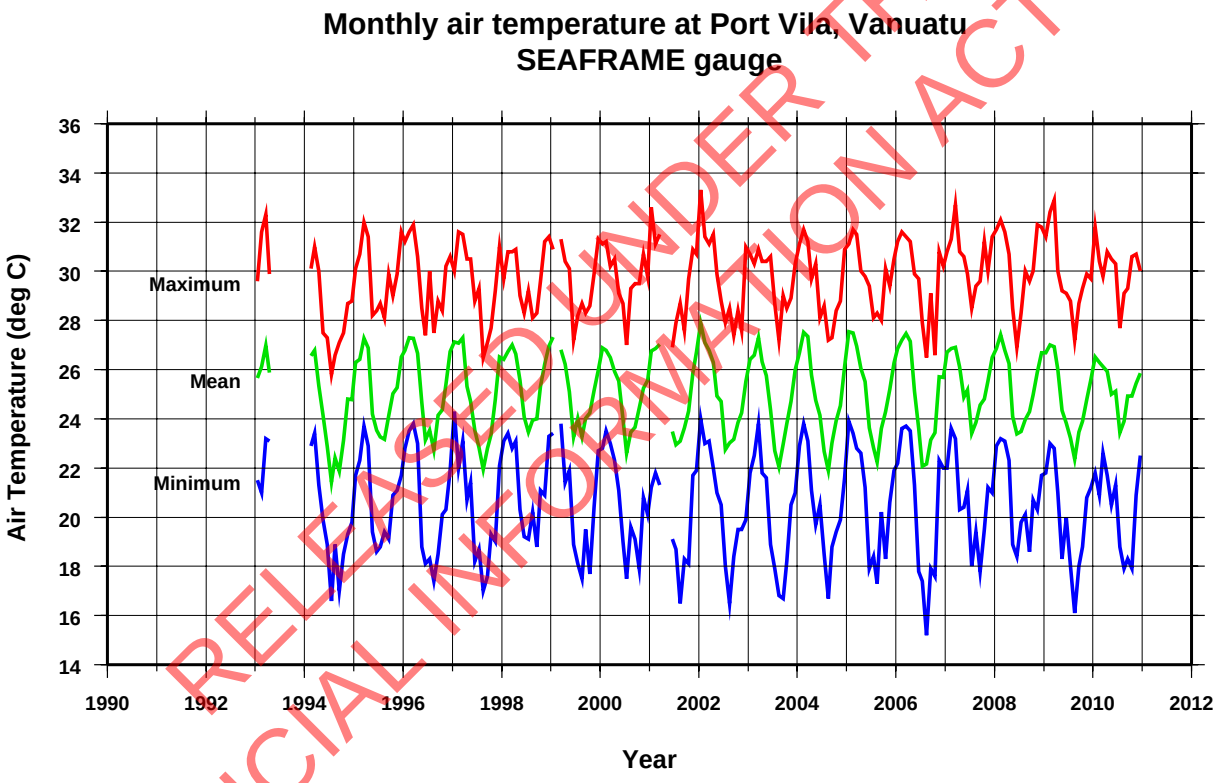


3.5. Monthly mean air temperature, water temperature and atmospheric pressure

The data summarised in Figures 20-22 follows the same format as the monthly sea level plot: the middle curve (green) represents the monthly mean, and the upper and lower curves show the highest and lowest values recorded each month.

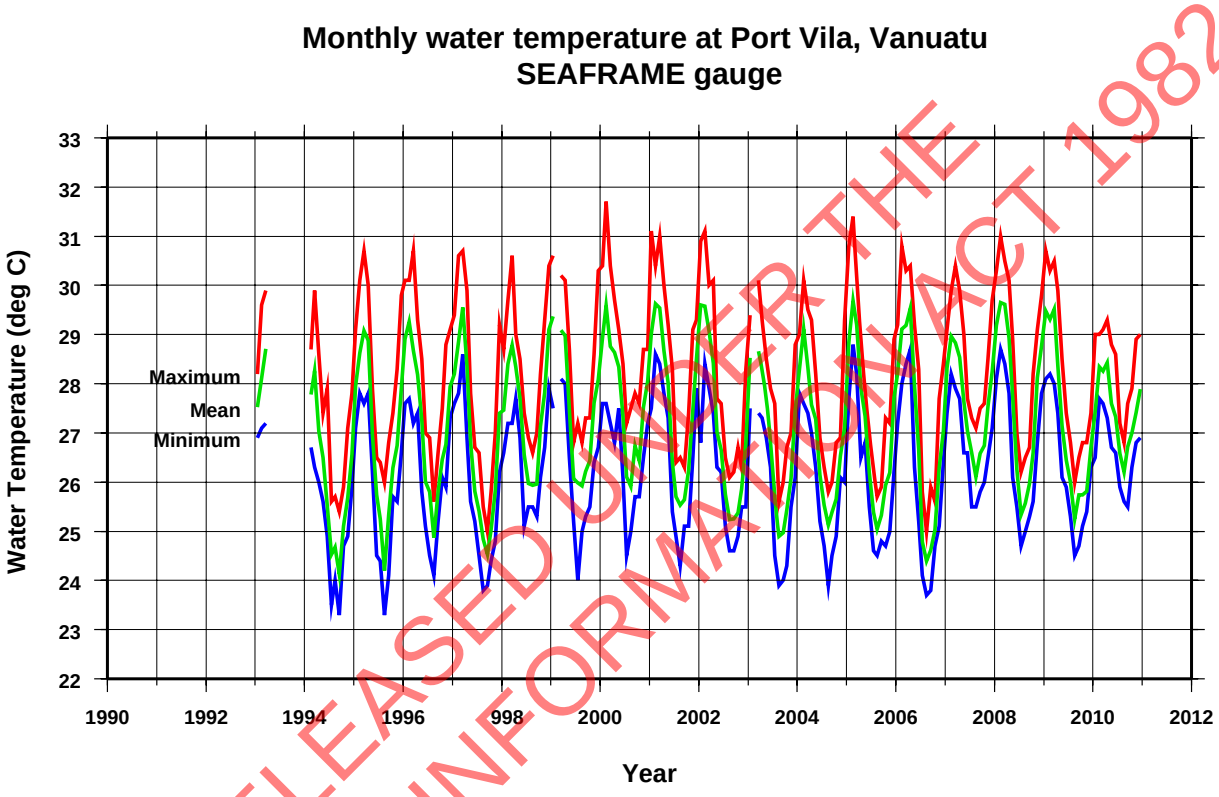
Compared to the more equatorial sites, Port Vila undergoes much greater seasonal temperature variations. The summertime highs are normally recorded in January or February. The mean air temperature over the duration of the record is 25.1°C. The minimum air temperature of 15.2°C was reached on 10th of August 2006, and a maximum of 33.3°C was reached on 24th of January 2002.

Figure 20



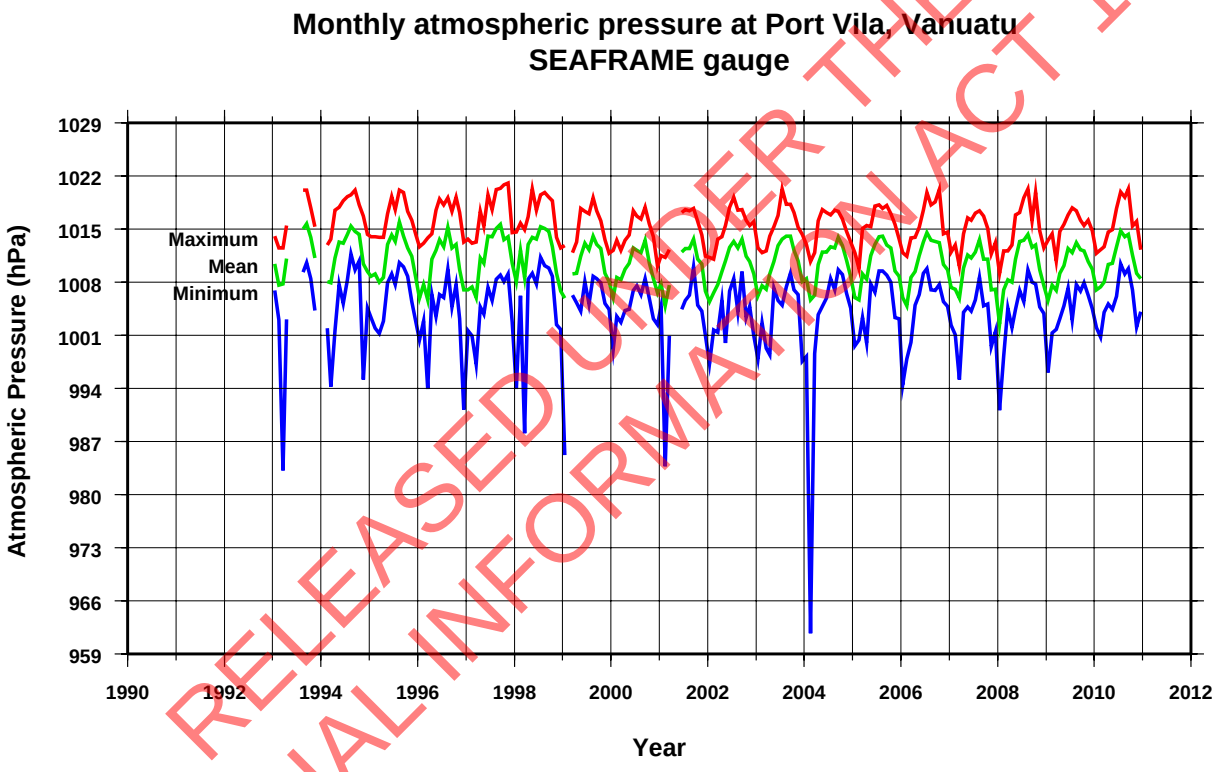
Water temperature also undergoes seasonal oscillations, which are virtually in phase with those of air temperature. Interestingly, in several years the maxima in air and water temperature come a month or two after the sea level maxima. The mean water temperature over the duration of the record is 27.2°C. The maximum water temperature of 31.7°C was recorded on 15th of February 2000, and the minimum of 23.3°C recorded on 8th of September 1994.

Figure 21



The sea level also responds to changes in barometric pressure. As a rule of thumb, a 1 hPa fall in the barometer, if sustained over a day or more, produces a 1 cm rise in the local sea level (within the area beneath the low pressure system). The seasonal (summertime) high sea levels at Port Vila are highly correlated with low barometric pressure systems. This is particularly the case for the very low pressure events (cyclones), most of which coincide with the highest sea levels for the year (since summer is also cyclone season). The mean barometric pressure over the duration of the record is 1010.6 hPa. The highest pressure recorded was 1021.1 hPa on 10th of November 1997, while the lowest was 961.7 hPa on 26th of February 2004 as a result of Tropical Cyclone Ivy.

Figure 22



3.6. Precise Levelling Results for Vanuatu

While the SEAFRAME gauge exhibits a high degree of datum stability, it is essential that the datum stability be checked periodically by precise levelling to an array of deep-seated benchmarks located close to the tide gauge. For example, a wharf normally supports the SEAFRAME, and wharf pilings are often subject to gradual vertical adjustment, which in turn can raise or lower the SEAFRAME.

Precise levelling is carried out on a regular 18-monthly cycle between the SEAFRAME Sensor Benchmark and an array of at least six deep benchmarks. The nearest stable benchmark is designated the "Tide Gauge Benchmark (TGBM)", and the others are considered the "coastal array".

Figure 23 summarises the most important survey information being the movement of the SEAFRAME Sensor benchmark relative to the TGBM, as well as recent movement relative to the CGPS station. The graph does not include the results for the other benchmarks on the coastal array. The first two surveys in 1993 and 1994 are not shown because in 1995 the SEAFRAME Sensor benchmark was repositioned and a new zero value established after damage to the installation. Each survey is plotted relative to the 1995 survey, thus in 1997 the SEAFRAME Sensor benchmark had *risen* relative to the TGBM by 1.5 mm. An earthquake in January 2002 caused a substantial fall of the SEAFRAME sensor but the sea level record has been corrected for this. Over the duration of the project the SEAFRAME Sensor has risen at an average rate of +0.1 mm/year.

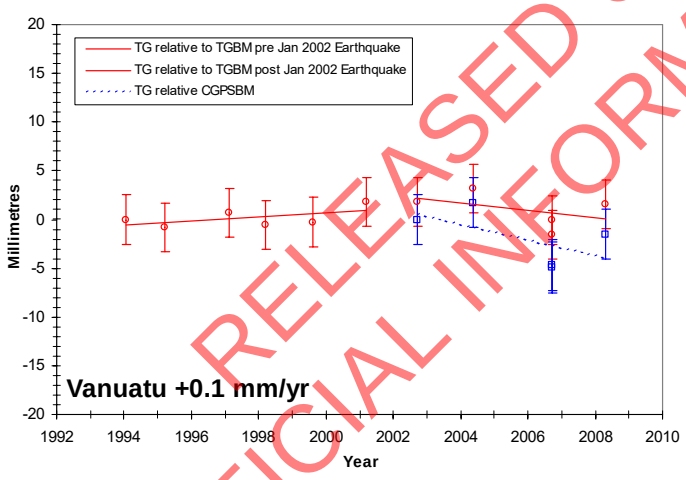


Figure 23. Movement of the SEAFRAME Sensor relative to the Tide Gauge Bench Mark and CGPS station.

Levelling of SEAFRAME Sensor benchmark. Photo credit: Steve Turner, NTC.

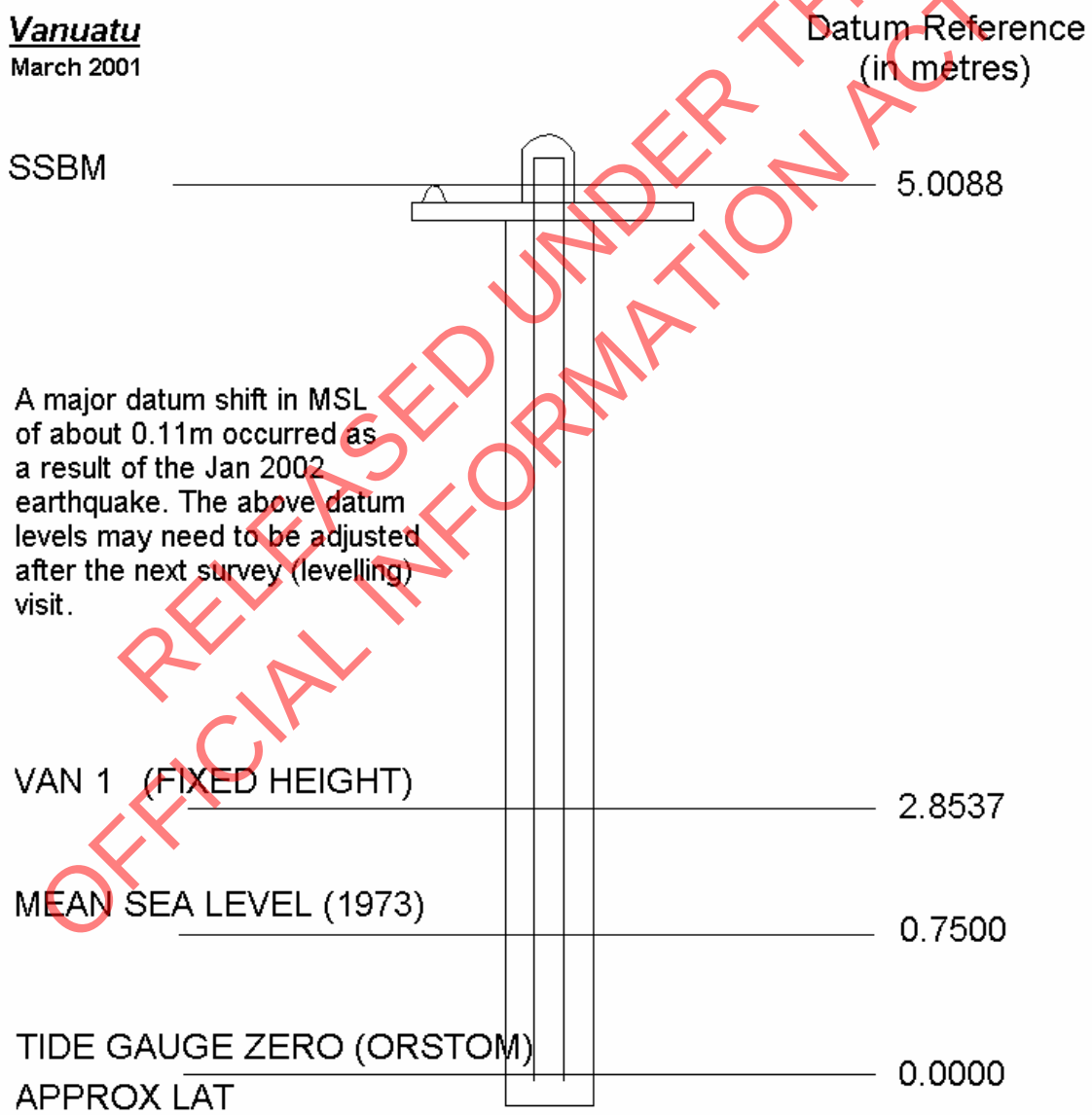
Appendix

A.1. Definition of Datum and other Geodetic Levels at Port Vila, Vanuatu

Newcomers to the study of sea level are confronted by bewildering references to "Chart Datum", "Tide Staff Zero", and other specialised terms. Frequent questions are, "how do NTC sea levels relate to the depths on the marine chart?" and "how do the UH sea levels relate to NTC's?".

Regular surveys to a set of coastal benchmarks are essential. If a SEAFRAME gauge or the wharf to which it is fixed were to be damaged and needed replacement the survey history would enable the data record to be "spliced across" the gap, thereby preserving the entire invaluable record from start to finish.

Figure 24



The word “datum” in reference to tide gauges and nautical charts means a reference level. Similarly, when you measure the height of a child, your datum is the floor on which the child stands.

Where possible, “sea levels” in the NTC data are normally reported relative to “Chart Datum” (CD), thus enabling users to relate the NTC data (such as shown in the figure above) directly to depth soundings shown on marine charts – if the NTC sea level is +1.5 metres, an additional 1.5 metres of water may be added to the chart sounding. At Port Vila, “LAT” (see below) provides an “equivalent” datum.

Mean Sea Level (MSL) in Figure 24 is the average recorded level at the gauge over the year 1973. The MSL at Port Vila is 0.75 metres above CD.

Lowest Astronomical Tide, or “LAT”, is based purely on tidal predictions over a 19 year period. In this case, LAT is 0.0 metres, meaning that if the sea level were controlled by tides alone, the sea level reported by NTC would drop to 0.0 metres just once in 19 years.

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Human CO_2 Emissions Have Little Effect on Atmospheric CO_2

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Abstract: The United Nations *Intergovernmental Panel on Climate Change* (IPCC) agrees human CO_2 is only 5 percent and natural CO_2 is 95 percent of the CO_2 inflow into the atmosphere. The ratio of human to natural CO_2 in the atmosphere must equal the ratio of the inflows. Yet IPCC claims human CO_2 has caused all the rise in atmospheric CO_2 above 280 ppm, which is now 130 ppm or 32 percent of today's atmospheric CO_2. To cause the human 5 percent to become 32 percent in the atmosphere, the IPCC model treats human and natural CO_2 differently, which is impossible because the molecules are identical. IPCC's Bern model artificially traps human CO_2 in the atmosphere while it lets natural CO_2 flow freely out of the atmosphere. By contrast, a simple Physics Model treats all CO_2 molecules the same, as it should, and shows how CO_2 flows through the atmosphere and produces a balance level where outflow equals inflow. Thereafter, if inflow is constant, level remains constant. The Physics Model has only one hypothesis, that outflow is proportional to level. The Physics Model exactly replicates the 14C data from 1970 to 2014 with only two physical parameters: balance level and e-time. The 14C data trace how CO_2 flows out of the atmosphere. The Physics Model shows the 14 CO_2 e-time is a constant 16.5 years. Other data show e-time for 12CO_2 is about 4 to 5 years. IPCC claims human CO_2 reduces ocean buffer capacity. But that would increase e-time. The constant e-time proves IPCC's claim is false. IPCC argues that the human-caused reduction of 14C and 13C in the atmosphere prove human CO_2 causes all the increase in atmospheric CO_2. However, numbers show these isotope data support the Physics Model and reject the IPCC model. The Physics Model shows how inflows of human and natural CO_2 into the atmosphere set balance levels proportional to their inflows. Each balance level remains constant if its inflow remains constant. Continued constant CO_2 emissions do not add more CO_2 to the atmosphere. No CO_2 accumulates in the atmosphere. Present human CO_2 inflow produces a balance level of about 18 ppm. Present natural CO_2 inflow produces a balance level of about 392 ppm. Human CO_2 is insignificant to the increase of CO_2 in the atmosphere. Increased natural CO_2 inflow has increased the level of CO_2 in the atmosphere.

Keywords: Carbon Dioxide, CO_2, Climate Change, Anthropogenic

1. Introduction

The U.S. Global Change Research Program Climate Science Special Report (USGCRP) [1] claims,

This assessment concludes, based on extensive evidence, that it is extremely likely that human activities, especially emissions of greenhouse gases, are the dominant cause of the observed warming since the mid-20th century.

The United Nations Intergovernmental Panel on Climate Change (IPCC) [2] Executive Summary claims human emissions caused atmospheric CO_2 to increase from 280 ppm in 1750, to 410 ppm in 2018, for a total increase of 130 ppm.

IPCC and USGCRP claim there are "no convincing alternative explanations" other than their theory to explain the "observational evidence."

This paper presents a "convincing alternative explanation" that explains the data. A simple physics model explains the required first step of human-caused climate change: how human CO_2 changes atmospheric CO_2.

For simplicity, this paper uses levels in units of ppm (parts per million by volume in dry air) and flows in units of ppm per year. GtC (Gigatons of Carbon) units are converted into CO_2 units in ppm using:

$$1 \text{ ppm} = 2.12 \text{ GtC}$$

Authors who support the USGCRP [1] and IPCC [2, 3]

include Archer et al. [4], Cawley [5], Kern and Leuenberger [6], and Kohler [7].

Authors who conclude human CO_2 increases atmospheric CO_2 as a percentage of its inflow include Revelle and Suess [8], Starr [9], Segalstad [10], Jaworoski [11, 12], Beck [13], Rorsch, Courtney, and Thoenes [14], Courtney [15], Quirk [16], Essenhigh [17], Glassman [18], Salby [19-22], Humlum [23], Harde [24, 25], and Berry [26, 27].

2. The Science Problem

IPCC [2, 3] says nature emits about 120 GtC from land and 90 GtC from ocean for a total of 210 GtC per year. This is equivalent to about 98 ppm per year of natural CO_2 that flows into the atmosphere. IPCC admits its estimates of "gross fluxes generally have uncertainties of more than ±20%."

Boden [28] shows human CO_2 emissions in 2014 were 9.7 GTC per year, or 4.6 ppm per year. So, IPCC agrees that human inflow is less than 5% and nature is more than 95% of the total CO_2 inflow into the atmosphere. Yet IPCC assumes nature stayed constant since 1750 and human CO_2 causes 100 percent the increase in atmospheric CO_2 above 280 ppm, which today is 130 ppm or 32 percent of 410 ppm.

The Physics Model concludes the percent of human CO_2 in the atmosphere equals the percent of human CO_2 in the inflow.

Figure 1 shows how the predictions of the Physics Model and IPCC model differ regarding the composition of human CO_2 in the atmosphere.

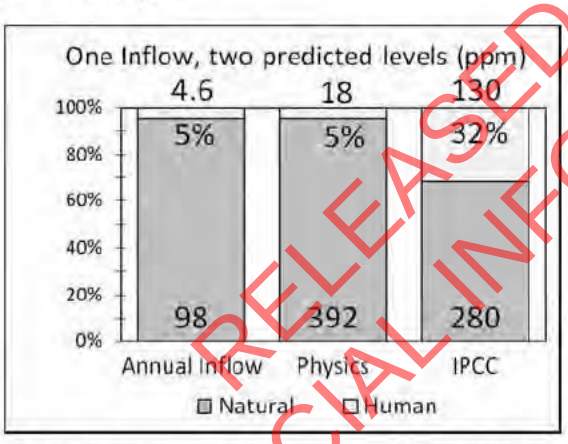

Figure 1. *The IPCC agrees the inflow of human CO_2 is less than 5 percent. The Physics Model says the percent of human CO_2 in the atmosphere equals the percent of its inflow. IPCC claims human CO_2 adds all atmospheric CO_2 above 280 ppm, which is now 32 percent of the total.*

If the IPCC model is correct, then the effect of human CO_2 emissions on atmospheric CO_2 is 100 percent. If the Physics Model is correct, then human CO_2 emissions do not cause climate change.

3. The Physics Model

3.1. How CO_2 Flows Through the Atmosphere

IPCC states, and much of the public believes, human emissions "add" CO_2 to the atmosphere. IPCC's view is the atmosphere is a garbage dump where human CO_2 is deposited and mostly stays forever.

However, nature must treat human and natural CO_2 the same because their molecules are identical. Nature has had millions of years to "add" to atmospheric CO_2. If nature's CO_2 "adds" to atmospheric CO_2, the CO_2 in the atmosphere would be much higher than it is today.

Therefore, natural and human CO_2 do not "add" CO_2 to the atmosphere. Both natural and human CO_2 "flow through" the atmosphere. As CO_2 flows through the atmosphere, it raises the level of atmospheric CO_2 just enough so CO_2 outflow equals CO_2 inflow. Nature balances CO_2 in the atmosphere when outflow equals inflow.

You pump air into a tire or inner tube that has a leak. As you pump air into the tube, air leaks out of the tube. The faster you pump air in, the faster air leaks out. If you pump air into the tube at a constant rate, the air pressure in the tube will find a level where outflow equals inflow.

River water flows into a lake or a pond and flows out over a dam. If inflow increases, the water level increases until outflow over the dam equals inflow from the river. Then, the water level will remain constant so long as inflow remains constant. The river does not "add" water to the lake. Water "flows through" the lake and finds a balance level where outflow equals inflow.

Similarly, human and natural CO_2 flow through the atmosphere. The inflow creates a balance level that remains constant so long as inflow remains constant.

3.2. Physics Model System Description

Figure 2 shows a bucket of water as an analogy to CO_2 in the atmosphere. Water flows into the bucket at the top and flows out through a hole in the bottom. An outside source (faucet) controls the inflow.

The water level and the hole size control the outflow. No matter what the inflow, the level and the size of the hole control the outflow. Inflow only serves to set a balance level.

This paper uses e-time rather than "residence" time because there are many definitions of residence time. E-time has a precise definition: the time for the level to move (1 – 1/e) of the distance from its present level to its balance level. The balance level is defined below.

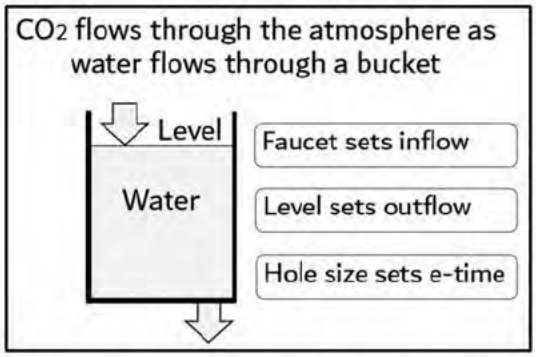

Figure 2. *A bucket of water is an analogy to the Physics Model for atmospheric CO_2. Water flows through the bucket as CO_2 flows through the atmosphere.*

The bucket analogy provides insight into e-time. If the hole in the bucket gets smaller, e-time increases. If the hole in the bucket gets larger, e-time decreases. The hole is an analogy to the ability of the oceans and land to absorb CO_2 from the atmosphere.

Figure 3 shows the Physics Model system for atmospheric CO_2. The system includes the level (concentration) of CO_2 in the atmosphere and the inflow and outflow of CO_2.

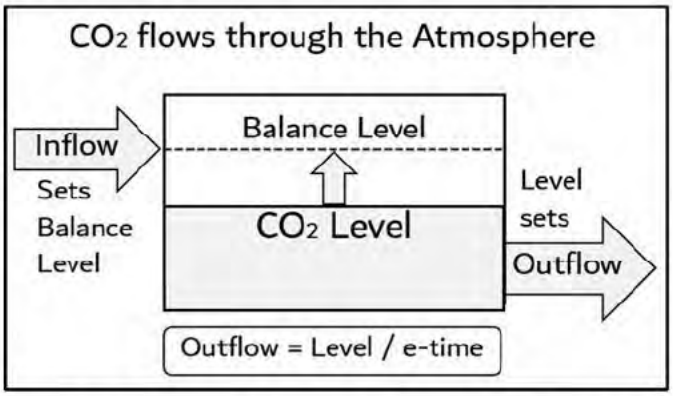

Figure 3. *The Physics Model system for atmospheric CO_2. Inflow and Outflow determine the change in level. The only hypothesis is Outflow = Level / e-time.*

The Physics Model applies independently and in total to all definitions of CO_2, e.g., to human CO_2, natural CO_2, and their sums, and to $12CO_2$, $13CO_2$, and $14CO_2$, and their sums.

The Physics Model is complete. It is not necessary to add separate inflows for human and natural CO_2 to the Physics Model. Just use a copy of the Physics Model for each CO_2 definition desired.

The Physics Model does not need to describe the details of the external processes. Inflow, outflow, and e-time include all the effects of outside processes. If the Physics Model were connected to land and ocean reservoirs, it would behave exactly as derived in this paper.

Kohler [7] claims Harde's [24] model and therefore the Physics Model is "too simplistic" and "leads to flawed results for anthropogenic carbon in the atmosphere."

Kohler is wrong. There is no such thing as a system being "too simplistic." A system should be as simple as possible to solve a problem. The Physics Model shows how inflow, outflow, and e-time affect the level of CO_2 in the atmosphere. The IPCC model cannot do this.

3.3. Physics Model Derivation

A system describes a subset of nature. A system includes levels and flows between levels. Levels set flows and flows set new levels. The mathematics used in the Physics Model are analogous to the mathematics used to describe many engineering systems.

The Physics Model derivation begins with the continuity equation (1) which says the rate of change of level is the difference between inflow and outflow:

$$dL/dt = Inflow - Outflow \quad (1)$$

Where

L = CO_2 level (concentration in ppm)

t = time (years)

dL/dt = rate of change of L (ppm/year)

Inflow = rate CO_2 moves into the system (ppm/year)

Outflow = rate CO_2 moves out of the system (ppm/year)

Following the idea from the bucket of water, the Physics Model has only one hypothesis, that outflow is proportional to level:

$$Outflow = L \ / \ Te \quad (2)$$

where *Te* is the "e-folding time" or simply "e-time."

Substitute (2) into (1) to get,

$$dL/dt = Inflow - L \ / \ Te \quad (3)$$

One way to replace *Inflow* in (3) is to set dL/dt to zero, which means the level is constant. Then *Inflow* will equal a balance level, *Lb*, divided by e-time. However, a more elegant way to replace *Inflow* is to simply define the balance level, *Lb*, as

$$Lb = Inflow * Te \quad (4)$$

Equation (4) shows how *Inflow* and *Te* set the balance level. Substitute (4) for *Inflow* into (3) to get,

$$dL/dt = -(L - Lb) \ / \ Te \quad (5)$$

Equation (5) shows the level always moves toward its balance level. At this point, both *L* and *Lb* are functions of time. *Te* can also be a function of time.

In the special case when *Lb* and *Te* are constant, there is an analytic solution to (5). Rearrange (5) to get

$$dL \ / \ (L - Lb) = -dt \ / \ Te \quad (6)$$

Then integrate (6) from *Lo* to *L* on the left side, and from 0 to *t* on the right side [29] to get

$$\text{Ln}\ [(L - Lb) \ / \ (Lo - Lb)] = -t \ / \ Te \quad (7)$$

where

Lo = Level at time zero ($t = 0$)

Lb = the balance level for a given inflow and *Te*

Te = time for *L* to move (1 – 1/e) from *L* to *Lb*

e = 2.7183

The original integration of (6) contains two absolute values, but they cancel each other because both *L* and *Lo* are always either above or below *Lb*.

Raise e to the power of each side of (7), to get the level as a function of time:

$$L(t) = Lb + (Lo - Lb) \exp(-t/Te) \quad (8)$$

Equation (8) is the analytic solution of (5) when *Lb* and *Te* are constant.

The hypothesis (2) that outflow is proportional to level creates a "balance level." Equation (4) defines the balance level in terms of inflow and e-time.

Figure 4 shows how the level always moves toward its

balance level according to (5). While outflow is always proportional to level, inflow sets the balance level.

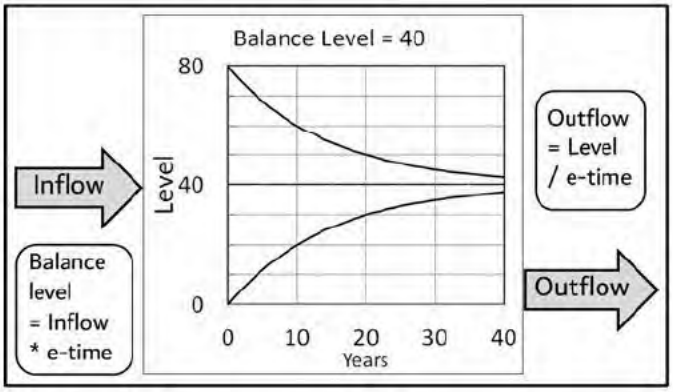

Figure 4. *Inflow sets the balance level. The level at any time t determines the outflow. Level always moves toward the balance level, whether the level is above or below the balance level.*

The Physics Model shows how CO_2 flows through the atmosphere. CO_2 does not "stick" in the atmosphere. A higher inflow merely raises the balance level. Then the level will rise until outflow equals inflow, which will be at the balance level.

3.4. Physics Model Consequences

All equations after (2) are deductions from hypothesis (2) and the continuity equation (1).

Equation (4) shows the balance level equals the product of inflow and e-time. Using IPCC numbers, and subscripts "p" to mean human (or people) and "n" to mean natural, the balance levels of human and natural CO_2 are 18.4 and 392 ppm:

$$Lbp = 4.6 \text{ (ppm/year)} * 4 \text{ (years)} = 18.4 \text{ ppm} \quad (9)$$

$$Lbn = 98 \text{ (ppm/year)} * 4 \text{ (years)} = 392 \text{ ppm} \quad (10)$$

The ratio of human to natural CO_2 is 4.6%. The percentage of human CO_2 to total CO_2 is 4.5%. Both are independent of e-time:

$$Lbp \ / \ Lbn = 4.6 \ / \ 98 = 4.6\% \quad (11)$$

$$Lbp \ / \ (Lbn + Lbp) = 4.6 \ / \ 102.6 = 4.5\% \quad (12)$$

Equation (9) shows present human emissions create a balance level of 18 ppm, independent of nature's balance level. If nature's balance level remained at 280 ppm after 1750, then present human emissions would have increased the CO_2 level 18 ppm from 280 ppm to 298 ppm.

Equation (10) shows present natural emissions create a balance level of 392 ppm. The human contribution of 18 ppm brings the total balance level to 410 ppm, which is close to the level in 2018.

Equation (11) shows the ratio of human to natural CO_2 in the atmosphere equals the ratio of their inflows, independent of e-time.

Equation (12) shows the percentage of human-produced CO_2 in the atmosphere equals its percentage of its inflow, independent of e-time.

Figure 5 illustrates these Physics Model conclusions when e-time is 4 years.

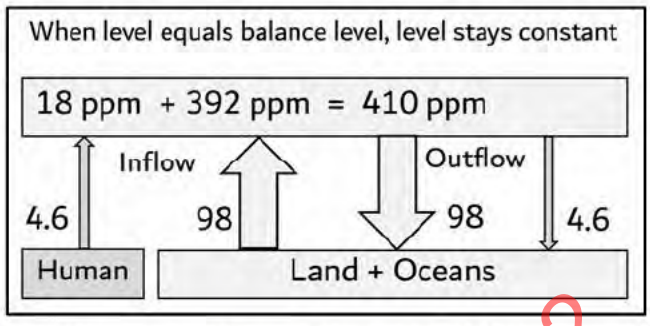

Figure 5. *For an e-time of 4 years, the human inflow of 4.6 ppm per year sets a balance level of 18 ppm, and the natural inflow of 98 ppm per year sets a balance level of 392 ppm. When the level equals the total balance level of 410 ppm, outflow will equal inflow and level will be constant.*

Equations (9) and (10) support the key conclusions of Harde [24, 25]:

Under present conditions, the natural emissions contribute 373 ppm and anthropogenic emissions 17 ppm to the total concentration of 390 ppm (2012).

4. The IPCC Bern Model

4.1. IPCC Bern Model Origin

In 1992, Siegenthaler and Joos [30] created the original Bern model. Their Figure 1 connects the atmosphere level to the upper ocean level, and the upper ocean level to the deep and interior ocean levels. They used 14C data to trace the flow of $12CO_2$ from the atmosphere to the upper ocean and to the deep and interior oceans. Using some physics constraints, they attempted without success to fit three versions of their model to available data.

Earlier, in 1987, Maier-Reimer and Hasselmann [31] used an ocean circulation model connected to a one-layer atmosphere to reproduce the main features of the CO_2 distribution in the surface ocean. They applied a mathematical curve fit to represent their conclusions. Their curve fit used a sum of four exponentials with different amplitudes and time constants, as in today's Bern model.

The use of four exponentials by [31] seems to result from their reconnection of both the deep and interior ocean levels directly to the atmosphere level. Such reconnection would be a serious modelling mistake. Other papers followed the model developed by [31].

Archer et al. [4] found the four-exponential models "agreed that 20–35% of the CO_2 remains in the atmosphere after equilibration with the ocean (2–20 centuries)."

Joos et al. [32] compared the response of such atmosphere-ocean models to a pulse emission of human CO_2. All the models predicted a "substantial fraction" of pulse would remain in the atmosphere and ocean for millennia.

The conclusions of [4, 30, 31, 32] must be questioned because:

1. Agreement among models does not prove they are

accurate.

2. All models treat human and natural CO_2 differently, which violates physics.
3. All models assume human CO_2 causes all the increase in atmospheric CO_2, which violates physics.
4. All models partition human CO_2 inflow into four artificial bins, which is unphysical.
5. All models lack a valid physics model for atmospheric CO_2.

Segalstad [10] notes that the models like [31] do not allow CO_2 to flow out of the atmosphere in linear proportion to the CO_2 level. Rather they use a non-linear constraint on the outflow that contradicts physics and chemistry.

Segalstad [10] concludes the alleged long residence time of 500 years for carbon to diffuse to the deep ocean is inaccurate because the 1000 GtC of suspended organic carbon in the upper 75 meters of the ocean can sink to the deep ocean in less than one year. That gives a residence time of 5 years rather than 500 years.

The IPCC Bern model that evolved from models like [31] artificially partitions human CO_2 into four separate bins. The separate bins prevent human CO_2 in one bin from moving to a bin with a faster e-time. This is like having three holes of different sizes in the bottom of a bucket and claiming the smallest hole restricts the flow through the largest hole.

The IPCC Bern model is unphysical. It begins with the assumption that human CO_2 causes all the increase in atmospheric CO_2. Then it creates a model that supports this assumption.

The Bern model fails Occam's Razor because it is unnecessarily complicated.

4.2. IPCC Bern Model Derivation

The Joos [33] Bern model is an integral equation rather than a level equation.

It is necessary to peer inside IPCC's Bern m del. To deconstruct the integral version of the Bern model, let inflow occur only in the year when "t-prime" equals zero. Then the integral disappears, and the Bern model becomes a level equation.

The Bern level equation is,

$$L(t) = Lo\,[A_0 \quad A_1 \exp(-t/T_1) + A_2 \exp(-t/T_2) + A_3 \exp(-t/T_3)] \qquad (13)$$

Where

t = time in years

Lo = level of atmospheric CO_2 in year $t = 0$

$L(t)$ = level of atmospheric CO_2 in year t

and the Bern TAR standard values, derived from curve-fitting the Bern model to the output of climate models, are,

$A_0 = 0.150$

$A_1 = 0.252$

$A_2 = 0.279$

$A_3 = 0.319$

$T_1 = 173$ years

$T_2 = 18.5$ years

$T_3 = 1.19$ years

The A-values weight the four terms on the right-hand side of (13):

$A_0 + A_1 + A_2 + A_3 = 1.000$

In (13), set t equal to infinity to get,

$$L = A_0\ Lo = 0.152\ Lo \qquad (14)$$

Equation (14) predicts a one-year inflow that sets Lo to 100 ppm, followed by zero inflow forever, will cause a permanent level of 15 ppm.

The four terms in (13) separate human (but not natural) CO_2 into 4 bins. Each bin has a different e-time. Only one bin allows human CO_2 to flow freely out of the atmosphere. Two bins trap human CO_2 for long times. One bin has no outflow and traps human CO_2 forever.

Figure 6 shows the size of the four Bern-model bins in percent and the amount of human CO_2 that remains in the atmosphere 8 years after an artificial pulse of human CO_2 enters the atmosphere.

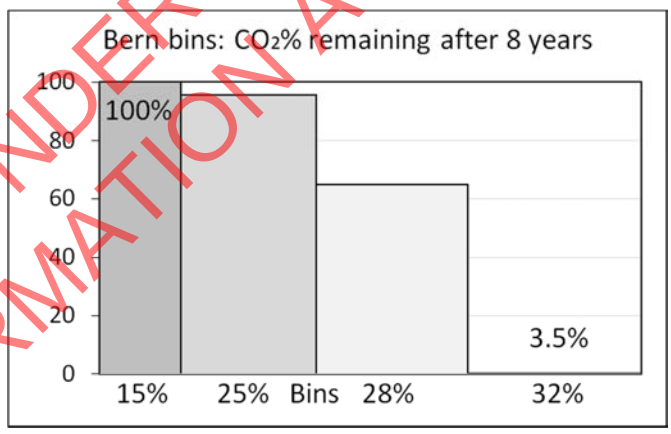

Figure 6. *The percent of human CO_2 left in each Bern model bin after 8 years.*

Bern (13) predicts 15 percent all human CO_2 entering the atmosphere stays in the atmosphere forever, 25 percent stays in the atmosphere almost forever, and only 32 percent flows freely out of the atmosphere.

4.3. How IPCC Gets 32 Percent

The burden of proof is upon the IPCC to explain how 5 percent human inflow becomes 32 percent in the atmosphere. IPCC cannot change the inflow. Therefore, IPCC must change the outflow. The IPCC Bern model restricts the outflow of human CO_2 while it lets natural CO_2 flow freely out of the atmosphere. The IPCC Bern model incorrectly treats human CO_2 differently than it treats natural CO_2. By doing so, it artificially increases human CO_2 in the atmosphere to 32 percent and beyond.

IPCC assumes its Bern model applies to human but not to natural CO_2. That assumption is unphysical because CO_2 molecules from human and natural sources are identical. All valid models must treat human and natural CO_2 the same.

If applied to natural CO_2, the Bern model predicts 15

percent of natural CO_2 sticks in the atmosphere. Then in 100 years, 1500 ppm of natural CO_2 sticks in the atmosphere. This clearly has not happened. Therefore, the Bern model is invalid.

For you mathematicians:

It is simple to prove the Bern model is unphysical. Take the derivative of (13) with respect to time. It is impossible to get rid of the exponential terms because the Bern model has more than one time constant in its exponentials. The Bern model dL/dt does not correspond to a physics formulation of a problem.

By contrast, it is straightforward to take the time derivative of the Physics Model (8) and reproduce its dL/dt form of (5).

The Physics Model began as a rate equation, as all physics models should. The Bern model began with a curve fit to an imaginary scenario for a level rather than as a rate equation for a level. The Bern model does not even include a continuity equation.

5. Theories Must Replicate Data

5.1. The 14C Data

The above-ground atomic bomb tests in the 1950s and 1960s almost doubled the concentration of 14C in the atmosphere. The 14C atoms were in the form of CO_2, called $14CO_2$.

After the cessation of the bomb tests in 1963, the concentration of $14CO_2$ decreased toward its natural balance level. The decrease occurred because the bomb-caused 14C inflow became zero while the natural 14C inflow continued.

The 14C data are in units of D14C per mil. The lower bound in D14C units is -1000. This value corresponds to zero 14C inflow into the atmosphere. In D14C units, the "natural" balance level, defined by the average measured level before 1950, is zero, 1000 up from -1000. [34]

Hua [34] processed 14C data for both hemispheres from 1954 to 2010. Turnbull [35] processed 14C data for Wellington, New Zealand, from 1954 to 2014. After 1970, $14CO_2$ were well mixed between the hemispheres and $14CO_2$ in the stratosphere were in the troposphere. The 14C data from both sources are virtually identical after 1970.

14C is an isotope of 12C. Levin et al. [36] conclude the C14 data provide "an invaluable tracer to gain insight into the carbon cycle dynamics."

5.2. Physics Model Replicates the 14C Data

The Physics Model (8) accurately replicates the $14CO_2$ data from 1970 to 2014 with e-time set to 16.5 years, balance level set to zero, and starting level set to the D14C level in 1970.

Figure 7 shows how the Physics Model replicates the 14C data.

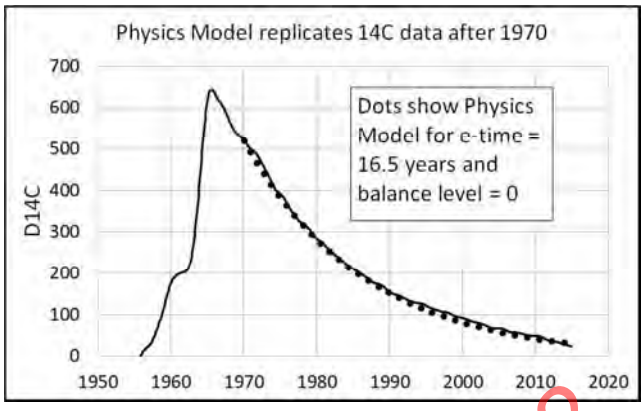

Figure 7. *The 14C data from Turnbull [35] using 721 data points. The dotted line is the Physics Model replication of the data.*

The Physics Model is not a curve fit with many parameters like the Bern model. The Physics model allows only 2 parameters to be adjusted: balance level and e-time, and they are both physical parameters. It is possible that the data would not allow replication by the Physics Model.

The replication of the 14C data begins by setting the Physics Model to the first data point in 1970. Then it is a matter of trying different balance levels and e-times until the model best fits the data. Although there is room for minor differences in the fit, the best fit seems to occur when the balance level is zero and e-time is 16.5 years.

The replication of the 14C data by the Physics Model has significant consequences. It shows the 14C natural balance level has remained close to zero and e-time has remained constant since 1970. If the e-time had changed since 1970, it would have required a variable e-time to make the Physics Model fit the data.

5.3. $12CO_2$ Reacts Faster Than $14CO_2$

Isotopes undergo the same chemical reactions but the rates that isotopes react can differ. Lighter isotopes form weaker chemical bonds and react faster than heavier isotopes [37].

Because $12CO_2$ is a lighter molecule than $14CO_2$, it reacts faster than $14CO_2$. Therefore, its e-time will be shorter than for $14CO_2$.

Equation (4) shows e-time equals *Level* divided by *Inflow*. Using IPCC numbers, e-time for $12CO_2$ is about 400 ppm divided by 100 ppm per year, or 4 years. Also, IPCC [3] agrees $12CO_2$ turnover time (e-time) is about 4 years. Segalstad [10] calculated 5 years for e-time.

Figure 8 shows the Physics Model (8) simulation of $12CO_2$ using an e-time of 4 years. For comparison, Figure 8 shows the 14C data from Hua [34] and the Physics Model replication of $14CO_2$ data with an e-time of 16.5.

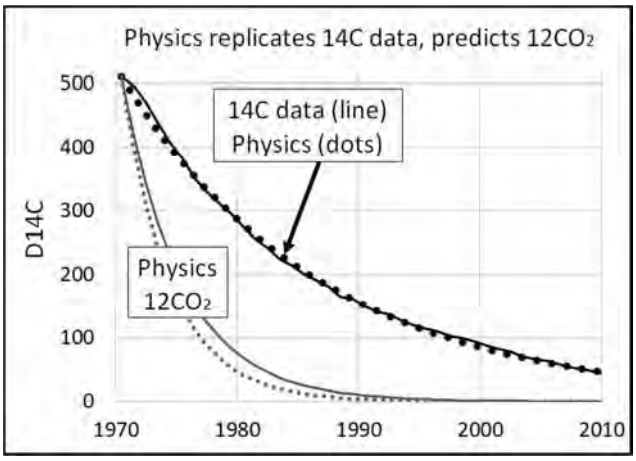

Figure 8. *This plot uses the 14C data from Hua [34] from 1970 to 2010. Hua data is in mid-years, so the fit begins in 1970.5. The Physics Model (dotted line) replicates the 14CO₂ data with an e-time of 16.5 years. The Physics Model simulates 12CO₂ for an e-time of 4 years (dotted line) and 5 years (solid line).*

5.4. IPCC Model Cannot Simulate 12CO₂

The Bern model claims to predict the outflow of $12CO_2$. Therefore, the Bern model should come close to predicting the outflow of $12CO_2$ as calculated by the Physics Model that replicates the 14C data.

Figure 9 shows the Bern model (13) predictions. The IPCC Bern model begins with a short e-time, then increases its e-time. The increased e-time causes the Bern line to cross the 14C line and thus conflicts with the 14C data. The Bern model traps 15 percent of human CO_2 in the atmosphere forever.

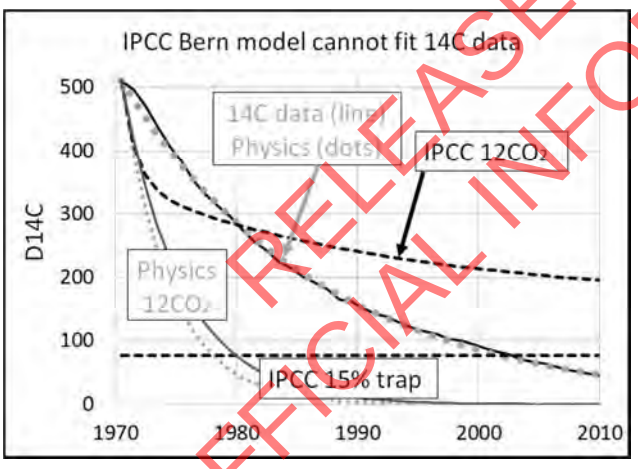

Figure 9. *The IPCC Bern model (dashed lines) is not consistent with the 12CO₂ simulation or with 14CO₂ data. The Bern model includes a trap for 15 percent of human CO₂.*

The IPCC Bern model is not just a failure to simulate data. The Bern model is a functional failure. It's e-time increases significantly with time when 14C data show e-time is constant. The only way the Bern model can increase with time is by using its history as a reference.

Figure 10 shows how the IPCC Bern model cannot even replicate itself when it is restarted at any point in its simulation.

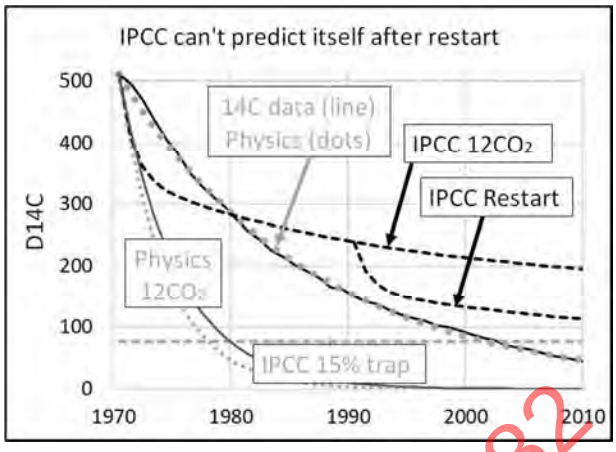

Figure 10. *The Bern model (dashed lines) cannot even replicate itself after a restart.*

The IPCC Bern model cannot continue its same prediction line if it is restarted at any point. The Bern model cannot properly restart because it depends upon its history, which makes it an invalid model.

A restart deletes the Bern model's history. This forces the Bern model to create a new history. In the real world, molecules do not remember their history. Molecules only know their present. Therefore, the IPCC Bern model fails the most basic test for a physical model.

Revelle and Suess [8] used 14C data to calculate correctly that human CO_2 would increase atmospheric CO_2 by only 1.2 percent as of 1957, based for an e-time of 5 years.

5.5. IPCC's Buffer Theory is Invalid

IPCC [3] claims:

> *The fraction of anthropogenic CO_2 that is taken up by the ocean declines with increasing CO_2 concentration, due to reduced buffer capacity of the carbonate system.*

Buffer capacity is the ability of the oceans to absorb CO_2.

Kohler et al. [7] claim human (but not natural) CO_2 has reduced the "buffer capacity" of the carbonate system:

> *The rise in atmospheric and oceanic carbon content goes along with an increase in the Revelle factor, a phenomenon which is already measurable. This implies that the oceanic uptake of anthropogenic carbon will become slower if we continue to increase anthropogenic CO_2 emissions. This is already seen in all CHIMP5 model simulations.*

Kohler's last sentence exhibits circular reasoning when it claims a model can prove what has been fed into the model.

All IPCC models use the buffer factor myth instead of Henry's Law to conclude human CO_2 causes all the rise in atmospheric CO_2 [10].

The problem for Kohler and IPCC is data. Where are the data that support their claim? They have only their models. Models are not data. Models must make predictions that replicate data. Their models cannot replicate data.

Ballantyne et al. [38] found "there is no empirical evidence" that the ability of the land and oceans to absorb atmospheric CO_2 "has started to diminish on the global scale."

The 14C data are the most accurate way to measure changes in the Revelle factor and "buffer capacity." Reduced buffer capacity, if it existed, would increase e-time. The 14C data prove e-time has been constant since 1970. Therefore, IPCC's buffer capacity has been constant.

IPCC's buffer capacity claim is absurd because it assumes only human CO_2 reduces the buffer capacity while natural CO_2 outflow does not. IPCC treats human and natural CO_2 differently, which is impossible.

Kohler [7] claims lower buffer capacity affects only $12CO_2$, not $14CO_2$. That claim violates chemistry and physics. Segalstad [10] previously showed Kohler's claim is impossible because "chemical and isotropic experiments show the equilibrium between CO_2 and water is obtained within a few hours."

The IPCC Bern model is based upon the invalid assumption that human CO_2 decreases buffer capacity.

5.6. Isotope Data Support the Physics Model

IPCC [3] writes:

> *Third, the observed isotropic trends of 13C and 14C agree qualitatively with those expected due to the CO_2 emissions from fossil fuels and the biosphere, and they are quantitatively consistent with results from carbon cycle modeling.*

Human fossil-fuel CO_2 is "14C-free" and the 14C balance level has decreased. IPCC [3] and Kohler [7] claim this proves human CO_2 caused all the rise in atmospheric CO_2.

But neither IPCC nor Kohler argue with numbers. Let's do the calculations to compare the results from both models with the data. IPCC [2] says human CO_2 comprises 32 percent of atmospheric CO_2 while the Physics Model (12) says human CO_2 is less than 5%. The question is whether the available isotope data support or reject either of the models.

RealClimate [39] says the 13C/12C ratio for human CO_2 is about 98 percent of the ratio in natural CO_2, and the 13C ratio has declined about 0.15 percent since 1850. RealClimate says this proves human CO_2 caused all the increase in atmospheric CO_2 since 1850.

Human CO_2 causes the new balance level of D14C and 13C/12C to be:

$$Lb = Ln\ Rn + Lh\ Rh \qquad (15)$$

Where

Lb = the new balance level (of D14C or 13C/12C)

Ln = the natural balance level (D14C = 0; 13C/12C = 100%)

Lh = the human balance level (D14C = –1000; 13C/12C = 98%)

Rn = the fraction of natural CO_2

Rh = the fraction of human CO_2

The Physics Model predicts for D14C:

$$Lb = (0)\ (0.955) + (-1000)\ (0.045) = -45 \qquad (16)$$

The IPCC model predicts for D14C:

$$Lb = (0)\ (0.68) + (-1000)\ (0.32) = -320 \qquad (17)$$

The Physics Model predicts for 13C/12C:

$$Lb = (100)\ (0.955) + (98)\ (0.045) = 99.91 \qquad (18)$$

The IPCC model predicts for 13C/12C:

$$Lb = (100)\ (0.680) + (98)\ (0.320) = 99.36 \qquad (19)$$

The 14C data

The Physics Model (16) predicts human CO_2 has lowered the balance level of 14C from zero to –45. The IPCC model (17) predicts human CO_2 has lowered the 14C balance level to –320.

Figure 11 compares the Physics and IPCC predicted levels for human CO_2 in the atmosphere.

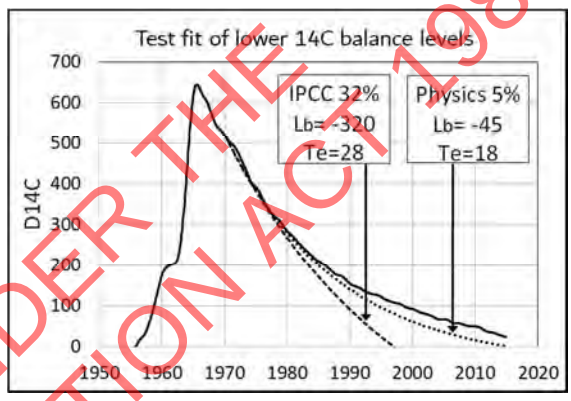

Figure 11. *The dotted lines show the Physics Model calculation for a balance level of –4. The dashed line shows the Physics Model calculation for the IPCC predicted balance level of -320.*

Figure 11 shows the Physics Model result of 5 percent human CO_2 in the atmosphere matches the 14C data much better than the IPCC model of 32 percent of human CO_2 in the atmosphere.

In summary, the 14C data support the Physics Model and reject the IPCC model.

The 13C data

The Physics Model (18) predicts human CO_2 has lowered the 13C ratio by 0.09. The IPCC model (19) predicts human CO_2 has lowered the 13C ratio by 0.64.

Figure 12 compares the Physics and IPCC predictions of the 13C/12C ratio to Real Climate's numbers.

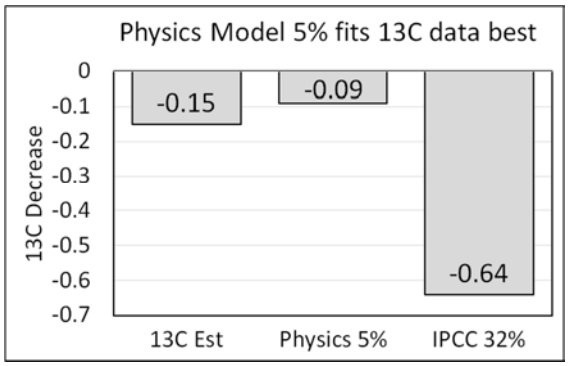

Figure 12. *Real Climate [39] says the 13C ratio has decreased by 0.15 since 1750. Physics predicts a decrease of 0.09 and IPCC predicts a decrease of 0.64.*

There seem to be no error bounds in the available 13C data. Nevertheless, even without error bounds the 13C data do not support the IPCC model over the Physics Model. So, the IPCC argument fails.

Segalstad [10] calculated similar results using permil units. He concluded the isotope data show human CO_2 cannot be more than 4 percent of atmospheric CO_2.

5.7. Mauna Loa Data

Some scientists argue that a viable CO_2 model must replicate the Mauna Loa CO_2 data. The Physics Model can simulate the Mauna Loa data for atmospheric CO_2 as well as any other model.

Spencer [40] has a model that fits the Mauna Loa data. Spencer assumes like the IPCC that the natural level of CO_2 is fixed at 280 ppm and human CO_2 causes all the increase in atmospheric CO_2. His model has many variables available to adjust so a fit to the Mauna Loa data is guaranteed.

The significance of the fit by the Physics Model is that it comes with physical constraints that the other models do not have. The Physics Model e-time must be 4 years and natural CO_2 must be 95 percent of atmospheric CO_2.

Figure 13 shows how the Physics Model fits the Mauna Loa data.

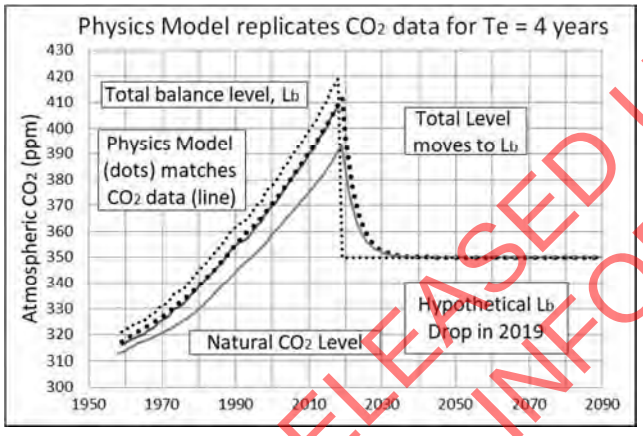

Figure 13. *The Physics Model replicates the Mauna Loa data with an e-time of 4 years and the requirement that natural CO_2 is 95 percent of atmospheric CO_2.*

In Figure 14, the total balance level is the sum of natural and human balance levels. The balance level continues to rise. Level follows the balance level with a lag of about 4 years (the e-time), after the year 2000. This lag keeps the level about 10 ppm below the its balance level. Human CO_2 adds to the natural level to produce the total level, about 15 ppm above the natural level.

In 2019, the balance level in Figure 14 is artificially reset to 350 ppm to test how fast the CO_2 level moves to the new balance level. The total CO_2 level falls to its new balance level of 350 ppm in about 10 years. No CO_2 remains stuck in the atmosphere.

5.8. Ice-core Data

IPCC claims "the observational CO_2 records from ice cores … show that the maximum range of natural variability about the mean of 280 ppm during the past 1000 years was small."

Using this invalid claim, IPCC assumes natural CO_2 emissions remained constant within about one percent. IPCC's invalid claim about ice-core data is the basis of IPCC's invalid claim that human CO_2 causes all the increase in atmospheric CO_2 above 280 ppm. This increase is presently 130 ppm or 32 percent.

Siegenthaler and Joos [30] observed that ice-core data show natural CO_2 increased by 17 ppm or 6 percent before 1900, when human CO_2 emissions totaled only 5 ppm. These ice-core data contradict IPCC's claim that natural CO_2 emissions stayed constant after 1750.

Jaworoski [12] explains why ice-core data do not properly represent past atmospheric CO_2. He concludes nature produces 97 percent of atmospheric CO_2.

Proxy ice-core values for CO_2 remained low for the past 650,000 years [10, 12]. If these ice-core values represent atmospheric CO_2, then atmospheric CO_2 did not cause any of the global warming in the last 650,000 years. And if CO_2 did not cause global warming in the past, then the IPCC has lost its claim that CO_2 causes present global warming [12].

Leaf stomata and chemical data prove the historical CO_2 level was much higher than derived from ice cores [12]. There is no evidence that the pre-industrial CO_2 level was 280 ppm as IPCC assumes.

Beck [13] reconstructed CO_2 from chemical data show the level reached 440 ppm in 1820 and again in 1945.

IPCC's claim that human CO_2 produces all the increase in atmospheric CO_2 above 280 ppm is invalid. In science, when data contradict a theory, the theory false. The IPCC, however, ignores how its theories contradict data.

6. Theories Must Be Logical

6.1. IPCC's Response Times Fail Physics

The Physics Model e-time has a precise definition: e-time is the time for the level to move (1 – 1/e) of the distance to its balance level.

Segalstad [10] observes IPCC [3] uses many definitions of lifetime — like residence time, transit time, response time, e-folding time, and adjustment time — in its quest to prove human CO_2 remains in the atmosphere for hundreds of years. Many investigators, from 1957 to 1992, have calculated the e-time of atmospheric CO_2 is about 5 years [10].

IPCC [3] defines "adjustment time (*Ta*)" as:

The time-scale characterising the decay of an instantaneous pulse input into the reservoir.

Cawley [5] defines "adjustment time (*Ta*)" as:

The time taken for the atmospheric CO_2 concentration to substantially recover towards its original concentration following a perturbation.

The word "substantially" is imprecise.

Cawley follows IPCC to define "residence time (*Tr*)" as:

The average length of time a molecule of CO_2 remains in the atmosphere before being taken up by the oceans or terrestrial

biosphere.

Some authors use "residence time" to mean "e-time" but other authors, such as Cawley and IPCC, have a different meaning for residence time. This paper uses e-time because its definition is precise.

In summary, IPCC uses two different response times when it should use only e-time:

1. When the level is far from its balance level (which can be zero), IPCC thinks e-time is an *adjustment* time because the level is moving rapidly toward its balance level.
2. When the level is close to its balance level, IPCC thinks e-time is a *residence* time because "molecules" are flowing in and out with little change in level.

Figure 14 illustrates how e-time relates to IPCC's adjustment and residence times.

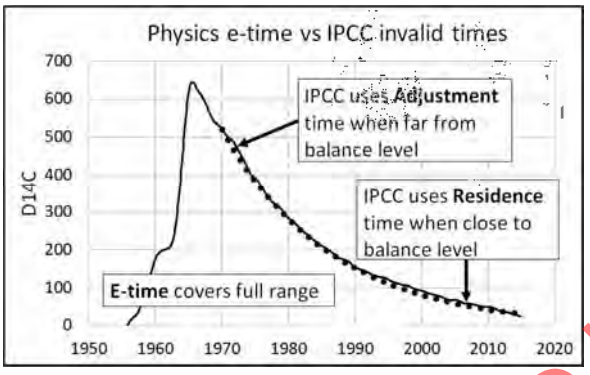

Figure 14. *E-time covers the full range of movement of level to a balance level. IPCC [3] adjustment and residence times apply to only each end of the range.*

IPCC defines "turnover time (*Tt*)" as:

The ratio of the mass M of a reservoir (e.g., a gaseous compound in the atmosphere) and the total rate of removal S from the reservoir: Tt = M/S.

IPCC's turnover time seems to be the same as e-time except "removal" is not the same as outflow. Near the balance level, IPCC sometimes interprets "removal" to mean the difference between outflow and inflow.

IPCC says when outflow is proportional to level (the Physics Model hypothesis) then adjustment time equals turnover time. IPCC claims:

In simple cases, where the global removal of the compound is directly proportional to the total mass of the reservoir, the adjustment time equals the turnover time: Ta = Tt.

The Physics Model's replication of the 14C data shows the $14CO_2$ outflow is proportional to level. Therefore, by IPCC's own definition, adjustment time equals e-time equals residence time.

IPCC says in further confusion:

In more complicated cases, where several reservoirs are involved or where the removal is not proportional to the total mass, the equality T = Ta no longer holds.

Carbon dioxide is an extreme example. Its turnover time is only about 4 years because of the rapid exchange between atmosphere and the ocean and terrestrial biota.

Although an approximate value of 100 years may be given for the adjustment time of CO_2 in the atmosphere, the actual adjustment is faster initially and slower later on.

IPCC agrees $12CO_2$ turnover time (e-time) is about 4 years. IPCC claims adjustment time is "fast initially and slower later on" which is why its Bern model cannot replicate the 14C data in Figure 9.

The 14C data show the e-time for $14CO_2$ is 16.5 years. This e-time is the upper bound for $12CO_2$ e-time. The IPCC claim of hundreds of years is based on IPCC's misunderstanding of e-time.

Unfortunately, there are many different definitions of residence time. Therefore, this paper uses e-time with its exact definition.

6.2. IPCC's First Core Argument Is Illogical

The IPCC [2] first core argument notes that human emissions from 1750 to 2013 totaled 185 ppm while atmospheric CO_2 increased by only 117 ppm. These numbers are OK. But IPCC claims this proves human CO_2 caused all the increase in atmospheric CO_2 above 280 ppm. IPCC's logic is faulty.

Figure 15 shows the IPCC first core argument.

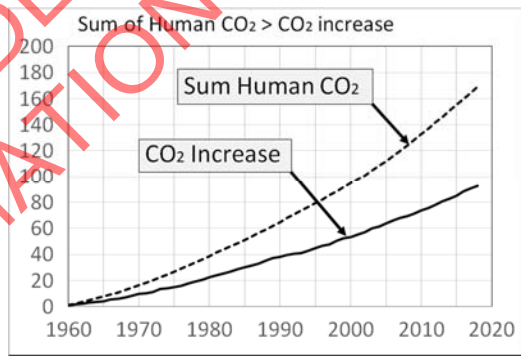

Figure 15. *The sum of human CO_2 year-by-year is larger than the increase in atmospheric CO_2.*

However, the fact that the sum of human emissions is greater than the increase does not prove human CO_2 caused the increase. The IPCC argument omits natural CO_2 which totaled about 6000 ppm during the same period, much larger than the sum of human CO_2.

Figure 16 shows the plot when the sum of natural CO_2 is included.

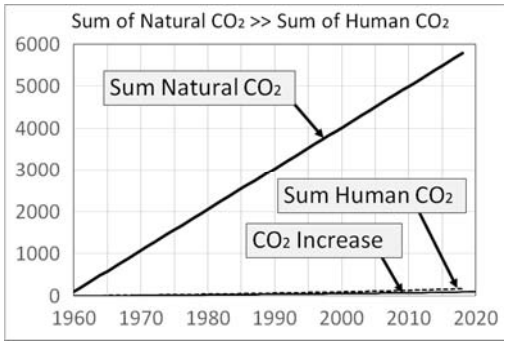

Figure 16. *The sum of natural CO_2 compared to the sum of human CO_2 and the increase in CO_2.*

The sum of natural CO_2 from 1959 to 2018 is 5700. The sum of human CO_2 over the same period is 170 ppm which is 3 percent of the natural CO_2 sum. IPCC's whole case depends upon its incorrect assumption that nature did not vary more that 3 percent since 1959 or since 1750. At the same time, IPCC admits it does not know nature's CO_2 emission within 50 percent.

The fundamental error in this IPCC argument is discussed in Section 3.1. The sums of inflows do not matter because inflows do not "add" to atmospheric CO_2. Inflows set balance levels. The human effect on the total balance level is less than 5 percent.

6.3. IPCC's Second Core Argument Is Illogical

IPCC [2] claims nature has been a "net carbon sink" since 1750, so nature could not have caused the observed rise in atmospheric carbon dioxide. Please refer to Figure 5 that shows the inflow and outflow of atmospheric CO_2.

Of course, nature is a "net carbon sink" because nature absorbs human CO_2 emissions. However, absorption of human CO_2 has no bearing whatsoever on how much natural CO_2 flows into the atmosphere. Nature can set its inflow as it pleases, no matter how much human inflow nature absorbs. The 98-ppm natural flow can double or reduce to one-half while nature continues to absorb the outflow of the human addition to atmospheric CO_2. So, the IPCC argument is absurd.

The Physics Model shows how CO_2 inflows set balance levels in atmospheric CO_2. At the balance level, outflow will equal inflow. No CO_2 gets trapped in the atmosphere.

6.4. Key IPCC Paper Makes Serious Errors

Kohler [7] uses Cawley [5] to "prove" the IPCC case. But Cawley fails physics and statistics.

Cawley [5] is a key paper for the IPCC theory. Cawley claims human CO_2 caused all the increase of atmospheric CO_2 above the 280 ppm in 1750. But Cawley's attempted proof fails physics.

Figure 17 shows three of Cawley's equations.

$$F_e = k_e C + F_e^0. \quad (3)$$

$$\frac{dC_A}{dt} = -\frac{C_A F_e}{C} \quad (7)$$

$$\frac{dC_N}{dt} = F_i^0 - \frac{C_N F_e}{C} \quad (8)$$

Figure 17. *Equations from Cawley [5].*

Cawley's equation (3) attempts to do the same job as Physics Model (2), namely, to represent how level sets outflow. But Cawley adds to his equation (3) a second term that represents a steady-state outflow that is independent of level. Cawley's added term is fictitious because his first term on the right side of his equation (3) is the true source of all outflow. As a result, all Cawley's equations after his (3) are wrong, which makes his whole paper wrong.

Cawley's equation (7) should include his Fa for human inflow. His equations (7) and (8) should omit his arbitrary Fe for outflow and set outflow equal to level (his C) divided by his residence time. His residence time is also inaccurate as shown in Section 6.1.

6.5. Statistical Correlation

Cawley [5] argues,

Lastly, the rise in atmospheric carbon dioxide closely parallels the rise in anthropogenic emissions ... which would be somewhat of a coincidence if the rise were essentially natural in origin!

IPCC [3] writes:

Second, the observed rate of CO_2 increase closely parallels the accumulated emission trends from fossil fuel combustion and from land use changes.

IPCC incorrectly claims this proves human CO_2 causes the increase in atmospheric CO_2.

A standard scientific test for the non-existence of cause and effect is to show the correlation of the assumed cause with the assumed effect, is zero.

For the IPCC to argue that human CO_2 causes climate change, the IPCC must show that the correlation of human emissions with the increase in atmospheric CO_2 is significantly greater than zero.

Proper statistics requires a detrended analysis of a time series to conclude cause and effect. Munshi [41] shows the "detrended correlation of annual emissions with annual changes in atmospheric CO_2" is zero. Chaamjamal [42] extended Munshi's calculations and found the correlations are zero for time intervals from one to five years.

Therefore, the standard statistical test for cause and effect proves human CO_2 is insignificant to the increase in atmospheric CO_2.

The ratio of annual change in atmospheric CO_2 to annual human CO_2 emissions that Munshi [41] tested is IPCC's "airborne fraction". Therefore, IPCC's airborne fraction has no useful meaning.

An estimate of the airborne fraction is about 2.5 ppm/year divided by 5 ppm/year, or 0.5. Since the increase in level is caused by an increase in natural CO_2 emissions, the airborne fraction has little physical meaning, and it would go to infinity if human emissions stopped.

7. Conclusions

The IPCC model and the Physics model compete to describe how human CO_2 emissions add to atmospheric CO_2. Both models agree that the CO_2 inflow into the atmosphere is less than 5 percent human CO_2 and more than 95 percent natural CO_2.

The IPCC model concludes that human CO_2 causes all the increase in atmospheric CO_2 above 280 ppm; that 15 percent of all human CO_2 emissions stays in the atmosphere forever; that 53 percent stays for hundreds of years; and only 32 percent flows freely out of the atmosphere like natural CO_2.

The Physics Model treats human CO_2 and natural CO_2 the

same because their CO_2 molecules are identical. The Physics model makes only one hypothesis: CO_2 outflow equals the level of CO_2 in the atmosphere divided by e-time.

The Physics Model concludes that inflow sets a balance level equal to inflow multiplied by e-time, and that continuing inflow does not continue to increase atmospheric CO_2. Rather inflow sets a balance level where outflow equals inflow and continuing inflow will not further increase the level of atmospheric CO_2 beyond the balance level.

The proper test of two theories is not to claim the IPCC theory explains "observational evidence." The proper test is the scientific method: if a prediction is wrong, the theory is wrong.

The 14C data following the cessation of the atomic bomb tests show how the level of CO_2 in the atmosphere returns to its balance level after inflow decreases. All valid models of atmospheric CO_2 must be able to replicate the 14C data.

The Physics Model exactly replicates the 14C data after 1970. This replication shows the e-time for $14CO_2$ is 16.5 years and that this e-time has been constant since 1970. The replication shows the Physics Model hypothesis — that outflow equals level divided by e-time — is correct.

The IPCC Bern model cannot replicate the 14C data. Its curve crosses the 14C data curve. The Bern model cannot even replicate itself if it is restarted at any point. This failure proves the IPCC Bern model does not have the mathematical structure for a valid model.

If natural CO_2 is inserted into the Bern model, as physics requires, the Bern model predicts that 15 percent of natural CO_2 inflow sticks in the atmosphere forever, which contradicts data and proves the Bern model is invalid.

The Physics Model concludes that the ratio of human to natural CO_2 in the atmosphere equals the ratio of their inflows independent of e-time, and that the e-times for both human and natural CO_2 are the same. Usin IPCC data, the e-time for $12CO_2$ is about 4 years.

The ratio conclusion means human CO_2 adds only about 18 ppm and natural CO_2 adds about 392 ppm to today's CO_2 level of 410 ppm. If all human CO_2 emissions stopped and natural CO_2 emissions stayed constant, then the level of atmospheric CO_2 would fall only to 392 ppm in about 10 years. Nothing would be gained by stopping human CO_2 emissions. There are no long-term effects of human CO_2 emissions. Continued constant CO_2 emissions do not add more CO_2 to the atmosphere. Continued constant CO_2 emissions simply maintain the balance level.

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Author's Contributions

The author declares he is the only contributor to the research in this paper.

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GLOBAL WARMING *alias* CLIMATE CHANGE

[*the* NON-EXISTENT, *incredibly expensive,* THREAT TO US ALL, *including to our* GRANDCHILDREN]

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INTRODUCTION

"Climate Change" has become an important international topic - one might almost say religion. It began life as "Global Warming".

So very many people, including politicians and "news people", appear to have been overwhelmed by it, and have led others to believe, and follow the doctrine.

It has sponsored a good deal of international co-operation, which can only have been good.

However, the cost of "Combating Carbon" has been extremely high, and the debt and economic consequences are being passed on to present citizens, and, worse still, to future generations, including all our grandchildren.

This booklet attempts to raise, in citizens' minds, questions regarding the enormous sums of money and effort being wasted on this topic.
Is it soundly based?
Will it "do good" or "do bad" for ordinary citizens?
Do those promoting it deserve our attention?

This booklet suggests that Global-Warming-alias-Climate-Change, as proposed by "Global Warmers" makes no sense. You, as the reader, must judge that for yourself - not to help the writer of this booklet, but to help you and your family.

Do you think after reading all this that the proponents are absolutely reliable?

Should you add your voice to those against it, or at least talk to your councillors and members of parliament and see how they feel?

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THE ANCIENT ACCEPTABLE VIEW

Our Earth's climate is highly variable, and records show clearly that it always has been so. Animals and plants have had no option but *to accept what comes*, and to adapt life in *ways that suit best*. Evolution gave some help by introducing "*the Survival of the Fittest*"

Humans found early that their discussion and understanding were helped by a belief in some extraneous source being the cause of recorded changes of climate - perhaps with divine power. This booklet uses "Mother Nature" in that role to avoid wordy explanations.

Humans discovered that they could ameliorate climatic effects with buildings, clothing *and the rest*, and even create "microclimates" through windbreaks, forest clearing, artificial lakes, fossil fuel burning, *and the rest*. However, no-one originally thought seriously that man could change the basic influences to our climate – our Sun our Earth's rotation, the total quantity of our Planet's water, *and the rest*. Mother Nature is able to change all such things (and has been doing so for some 3,000,000,000 years), *but we are not*.

THE NEW BELIEF - THE NEW PROBLEM

Introduction

That ancient and acceptable view was amended in the minds of some people whom I call the "Global Warmers". I've heard nothing convincing about their so-called "Science"; but what they publish convinces me that it's close to nonsense. The most convincing evidence against it comes mostly from the Global Warmers themselves.

In this booklet, the beliefs of "Global Warming", and "Climate Change" have initial capital letters. That contrasts with natural warming, or natural changing of climate - indicated by lower case initial letters. The idea of a human cause is much less than 300 years old.

My interest in our changing climate and sea level

During fieldwork for a PhD thesis[c] I found a coastal exposure of soft sandstone at Ohuka Creek, south of Port Waikato. There were Pliocene fossils of marine shellfish *below* an extensive horizontal bedding plane. *Above* that plane were more fossils, but of cool-loving[a] plants. A finger could show the exact location of the abrupt change to the cooler climate at the onset of the first of the world-wide Pleistocene glaciations [Ice Ages]. Ice formed widely at the ultimate expense of sea water, so sea level fell. At Ohuka, sea bed had become land. Such changes are rarely seen in a continuous sequence, so I recorded it in a 1957 scientific paper[b]. That resulted in my joining an informal world-wide Group researching changing sea levels.

Most interest then was about the rate of sea level rise as the Earth warmed following the "Little Ice Age". That cool period, from about 1500 to 1700 AD, halted wine-making in England and taro cropping in New Zealand. Our Group determined the rate of sea level rise in many different World regions, from widely-available readings of tide gauges (less variable than those of thermometers). The average for us all was 125 mm/century ("***125***" here). Hence it would take 8 centuries for sea level to rise 1m – no serious threat to us.

Global Warming Dawns Subsequently, I attended many international science conferences representing DSIR, NZ or Pacific Nations. I noted the words "Global Warming" appearing increasingly in paper titles, and sensed a growing number of adherents. Those latter arranged a first-ever "Conference on Global Warming" in Vienna in 1985. Unlike most such meetings, where a communiqué summarising achievements was released on the final day, the full results of this one were delayed for over 2 years.

When they did appear (front page, *NZ Herald*, two days before Christmas 1987) a *World Declaration* included "Overseas scientists have estimated that the seas around New Zealand will rise by up to 1.4 m in the next 40 years". That article concentrated on the massive consequent problems, caused by our carbon dioxide (CO_2) emissions, but gave no adequate supporting science. That rate of rise was equivalent to ***3,500*** mm/century, 28 times faster than our ***125.*** Hence we stupidly ignored it, thinking no-one could possibly believe it. But the World did believe, and the Global Warming mirage was born. Had ***3,500*** been true, sea level should have risen by almost 1 m by today – it hasn't, not even closely.

This showed unambiguously that those "Overseas Scientists" were not true scientists. They ignored a most important basic rule of true science "*Thou shall not publish Science without first checking it.* A check against local tide gauges would have shown how wrong *1.4 m in 40 yrs* was; *they simply hadn't bothered to check.* That was a **First Grave Error.**

Australian government scientists were concerned about the effects on Pacific Island nations by any sea level rise of around ***3,500*** mm/century, and launched a project to determine the correct figure at that time. They announced the result at the 1992 meeting of SOPAC – a geoscientific organisation of South Pacific nations. Their figure was ***122*** mm/century, confirming the order of magnitude of our group's ***125*** average value.

Fooling the World The Global Warmers persisted with their use of pseudo-science and made further predictions. Understandably they too all proved wrong. At conferences I began to hear, regardless of the science involved, when a speaker wished to "rubbish" some scientific idea or research, he/she stated that conclusion firmly, and followed it by "*Just like Global Warming*". Clearly the Global Warmers heard that too. They didn't change their pseudo-science, but cleverly changed the name to 'Climate Change". [*One can disprove warming*, but the words *change of climate* can't be proved wrong].

The United Nations became interested – major sea level rise could cause havoc in low-lying areas or island groups. They established an *Intergovernmental Panel for Climate Change (IPCC)* and invited nations to send delegates. Not surprisingly those chosen were almost entirely Global Warmers, because *they clearly knew something about it.* But to do them credit the Panel members acted a little more like true scientists than those earlier.

They accepted that "*1.4 m in 40 yrs*" was wrong and re-evaluated it as "*0.49 m by 2100"*, [roundly a century ahead]. Thus they dropped ***3,500*** down to ***500*** mm/century – to 14% of the original. The cause remained unchanged – our CO_2 emissions to the atmosphere. In no other human activity would those involved retain a belief when the most crucial item involved was found to be 86% wrong ***by themselves.*** That was a **Second Grave Error.**

In spite of that, the World was taken in. Politicians were able to promise to save us from the consequences, and the Media had an unending "Field Day". It wasn't that people necessarily believed, but they lacked the courage to risk that it might come true, and that they might have to bear the terrible consequences that had been so forcibly promised.

The New Errors The new value of "0.49 m by 2100" became widely accepted. In New Zealand, District Councils were instructed by Government Departments, like Conservation and Environment, and by Regional Councils, that they must take full account of the risk that "0.49" implied for a sea level rise by 2100. Councils had to consider that in the same way as earthquake and volcanic risk. Yet that "0.49" value doesn't stand up to the most simple scientific scrutiny.

First, the rate is four times faster than the current sea level rise, as indicated by regional, widely-available tide gauges; *second*, no reason was given for quadrupling the value, and *third*, good science interprets "0.49" in this sense as being deliberately different from 0.48 and 0.50. Thus that effectively claims that those who determined that value know, for sure, where sea level will be a century ahead to ±5 mm. That was, and is, patently absurd

These were the **Third, Fourth & Fifth Grave Errors**

Further Damning Disclosures The United Nations appointed me personally to their UNCSTD **C**ommittee which assists small countries with their ability regarding **S**cience and **T**echnology **D**evelopment. Three or so of us would go to a central city to talk and discuss their options with delegates from regional countries. On one occasion we met in Prague, to assist countries on both sides of the "Iron Curtain". While there, we were invited to visit the World's only "Institute for Global Warming". It was founded and funded incredibly by the USA and Soviet Union jointly, at the height of their "Cold War" in an attempt to fund something "for the good of Mankind", rather than "for armaments". Some of its staff could have attended the 1985 Conference, and helped create the 1987 *World Declaration.*
I took the opportunity of asking to see copies of the documents that had been brought to that 1985 Meeting in neutral Austria. Several attendees brought their estimates for sea level rise due to Global Warming. The values, converted to mm/century, ranged from ***500*** minimum to ***3,500*** maximum. There can be no doubt that, to ensure that their 1987 World Declaration made the greatest impact, they published the maximum value - contravening the most sacred rule of acceptable science *Thou shall not publish items for monetary, political, or personal gain that are not clear un-biased un-inflated truths.*

The fact that "up to" was used, might be allowed in non-scientific areas, but not in Science. If World Media had distorted the message, the Warmers should immediately have denied what was wrongly claimed, and ensured that the proper statement got equal publicity. Using a maximum value for greatest effect was the **Sixth (and Worst) Grave Error.**

OLD SCIENTIFIC CONCLUSIONS ON CLIMATE IGNORED

19th Century science posed a important question. Why is our Earth's average temperature significantly higher than that calculated from the then-recent determinations of our Sun's distance and its radiation? Knowing my interests in climate, DSIR librarians found me a publication in German that answered that puzzle early. It had Scandinavian author(s), if I remember correctly. Its answer was that the CO_2 in our atmosphere acts like glass in a glasshouse. Both change the optical physical nature of the Sun's infra-red rays [that carry the warmth to us] such that they

may enter, but cannot then leave. *So we are warmed by the heat trapped below our CO_2; like the glasshouse below its glass.*

I surmise that the Global Warmers, along with Al Gore, noted correctly that CO_2 keeps us warm, but thought wrongly that *more* would make us *warmer*. The analogy with glass is important. Horticultural experiments long ago found that more (thicker) glass does not cause more warming, so more CO_2 probably doesn't either. The effect is like that of polarising spectacles, where the change takes place as light *begins* passing through the lenses. Thickness makes no difference. Polarisation is either 100%, or not at all.

A coincidence timed the Little Ice Age's end with the Industrial Revolution's start. The Warmers blamed the undoubted warming on the latter – ignoring the glasshouse evidence.

THE NEW CLIMATE REGIME

NIWA The National Institute of Water & Atmospheric Research (NIWA) retains New Zealand climate records. It has a history of persuading successive governments that Global Warming and Climate Change are both real. It often encouraged media headlines like *"We are Getting Warmer"*, when any news item sugges ed any higher temperature. Science progresses by new concepts and ideas being aired freely for scientific scrutiny. That has sometimes taken centuries to be completed. Although I don't agree with some of NIWA's views, it is proper that they should be aired for discussion, as in this booklet.

One announcement (that surely originated from NIWA) was very important to me and all citizens, and was a credit to NIWA itself. At the close of 2007, it stated that the decade just finishing was the warmest since New Zealand records began. The announcement added that, of those 10 years, 1998 was the warmest ever since records began. I was grateful to NIWA, and concluded that 2007 was no warmer than 1998, and probably cooler. I could assume therefore that warming at our ***125*** rate finished in 1998. In the roundest of figures, the Little Ice Age lasted for some 200 years. There would be no conflict with accepting that the following warming should similarly last for some 200 years.

As always in Science one seeks confirmation whenever possible. I have seen many items that lead to that same view of "no warming since 1998". The best was a written debate in the *Imperial Engineer* of autumn 2008. [*That scientific journal is produced for engineering graduates of Imperial College, London – arguably UK's top university in engineering.*] The debate was on whether Humans were to blame for current changes of climate. Prof Joanna Haigh blamed Humans, Lord Monckton blamed Mother Nature. The only point on which they both agreed was that there had been no warming since 1998. That confirmed NIWA's statement perfectly, along with several comparable pronouncements.

My conclusion is that warming since the Little Ice Age's end is now almost certainly finished. That was supported further by NIWA's release at the end of 2012, concerning the Eastern Bay of Plenty. Their report was that 2012 had been drier *and colder* than 2011. Citizens also notice that warming seems to be over. Skiing seasons are extended, winter fires are needed earlier, and some of us travelling overseas have been asked by those from Queensland, even Hawaii, whether we in New Zealand feel colder generally – *as they do*. I conclude that the New Zealand climate has not been warming since 1998.

THE AFFECTS ON CITIZENS

Astronomical Cost of Major Measures to Combat a Non-Existent Threat:
Politicians and the Media have listened to the proponents of Global-Warming-Climate-Change, but don't seem to have made any critical assessment of it all. Perhaps they were bemused by the Global Warmers constantly naming themselves and associates as "Scientists". As has been shown, those people disregarded the basic rules of true Science. Their political and media audiences innocently believed the statements ***- which contained grave errors***.

Innocents in politics and the media were badly mis-led. They gladly supported projects to combat the non-existent threat of Global-Warming-Climate-Change. The projects were ***unnecessary*** because there was no threat*;* ***extremely costly*** in money time and effort; ***full of praise*** *where ridicule was deserved* ***misleading*** *about benefits & options; and a*bove all ***diversionary*** away from today's real problems.

A huge international bureaucratic industry was born - with Cabinet Ministers, government departments, company sections, travel, conferences, treaties, carbon credits, and carbon trading, and very much more. The challenge was often heard that we must curb our carbon emissions or sacrifice our grandchildren's well-being. In truth, those children were being saddled with a gigantic debt to pay for everything encompassed by the Warmers' "carbon footprints", including the salaries and expenses of the loudest proponents.

Perhaps the saddest part has been that the essential and innocent gas, carbon dioxide, has been demonised and criminalised. It is essential in creating plant growth using chlorophyll and photo-synthesis. It is thus **essential for our very existence**. Crops grow better in a CO_2-enriched and warmer atmosphere, when heated by an old-fashioned vertical kerosene heater. It gives off "carbon emissions" that are valuable to us all.

Costs and Dangers of Local Measures to combat the Non-Existent Threat:
Local authorities were compelled to adop measures designed to combat the non-existent threat. Typically maps were drawn showing the coastline's position now, and in the year 2100 with intermediate zone(s), assuming that sea level would rise 0.49 m in the next 100 years. Onerous restrictions have been emplaced within the zones that were thus defined.

Many regions have vast quantities of sand transported by rivers to their coast, released by the erosion of hills and mountains, continuously raised by Mother Nature. Their coastline extends seawards steadily. Citizens in such regions have long noted (with surveys and photos) that the coastline has a net ***seawards*** movement. It contrasts with many Councils' imposed belief in "0.49" which demands ***landwards*** movement ("inundation").

Councils seem unable to accept their citizens' constant and loud protests about all this. They seem to feel that higher authorities insist that they must ignore such views. It is not just (a) the absurdity of restrictions about where houses may be erected (only inland of certain lines), etc.; or (b) the increasing costs to those building their first home. At the other end of the scale there are enforced dangers; a requirement for higher floor levels, leading to more steps, with unnecessary risks to elderly folk falling, when using them.

The fact that sea level is no longer rising is a new extra factor for councils to ignore. In the example of Ohope Beach, a Commission of enquiry, set up by Council, backed the Council's view of ***landwards*** inundation. That rejected all citizens' factual

evidence of ***seawards*** net movement for periods ranging from 50 to 5,000 years. Council also rejected the advice, supporting the Citizens, by one who was highly qualified in engineering and science and had had long and successful experience in coastal work.

Much worse, the Council's own appointed consultants provided an additional report based on every coastal survey for which a record was available**. It showed a "retreat of the sea" [seaward shoreline movement, or accretion] at the only three Ohope sites, of 0.30-0.94 m/yr over 130 years** ***that was still ongoing in 2008. Clearly neither Council nor Commission had bothered to read that critical report, written by highly regarded consultants, who had been appointed for this project by the Council itself.***

The widespread obsession with Global-Warming-Climate-Change, in opposition to all factual evidence, is quite incredible. It leads to unfair treatment of some citizens, and a massive bill for all, for nothing useful. When will citizens revolt effectively against such callous disregard for their observations and wishes, by those who are essentially their elected employees? When will the perpetrators examine the basis of their ideology, and realise that it's based on unfounded unscientific beliefs, not on confirmed, widely-available investigations by real scientists who abide by the moral standards of their profession?

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What Humans Contribute to Atmospheric CO_2: Comparison of Carbon Cycle Models with Observations

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Abstract: The Intergovernmental Panel on Climate Change assumes that the inclining atmospheric CO_2 concentration over recent years was almost exclusively determined by anthropogenic emissions, and this increase is made responsible for the rising temperature over the Industrial Era. Due to the far reaching consequences of this assertion, in this contribution we critically scrutinize different carbon cycle models and compare them with observations. We further contrast them with an alternative concept, which also includes temperature dependent natural emission and absorption with an uptake rate scaling proportional with the CO_2 concentration. We show that this approach is in agreement with all observations, and under this premise not really human activities are responsible for the observed CO_2 increase and the expected temperature rise in the atmosphere, but just opposite the temperature itself dominantly controls the CO_2 increase. Therefore, not CO_2 but primarily native impacts are responsible for any observed climate changes.

Keywords: Carbon Cycle, Atmospheric CO_2 Concentration, CO_2 Residence Time, Anthropogenic Emissions, Fossil Fuel Combustion, Land Use Change, Climate Change

1. Introduction

Following the interpretation of the Intergovernmental Panel on Climate Change (IPCC) the inclining atmospheric CO_2 concentration over recent years is assumed to result almost exclusively from anthropogenic emissions, and as a consequence of the greenhouse effect this increase is made responsible for the rising temperature over the Industrial Era (see, 5th Assessment Report, AR5 [1]). These predictions are based on more or less refined theoretical models of the carbon cycle and their comparison with observations. But good agreement between calculations and observations is only a necessary, not sufficient prerequisite for reliable simulations, they must also be in conformity with all natural causalities. Because of the expected far reaching consequences of anthropogenic carbon on future climate changes this was motivation enough to critically scrutinize the main assumptions used in these carbon cycle models.

In this contribution we consider three theoretical approaches, which find favor with the IPCC and predominantly focus on the influence of human activities caused by Land Use Change (LUC) (see e.g., Le Quéré et al. [2]; CICERO [3]) and the Fossil Fuel Emissions (FFE) (CDIAC [4]), while environmental effects are supposed to have been constant over the last 270 yr. We show that the main consequence of isolating the anthropogenic carbon cycle from the natural cycle is to introduce a new time scale, the adjustment time, which differs significantly from the residence time, the latter characterizing the natural uptake of CO_2 from the atmosphere by extraneous reservoirs.

We compare respective simulations of these approaches with actual observations at Mauna Loa (Keeling et al. [5]; AR5 [1] Chap.6-Fig.6.3, p. 476), and we contrast them with our alternative description of the atmospheric carbon cycle (Harde [6]), which is based on a first order absorption process for the full cycle with only one time scale, the residence time, and additionally including temperature dependent natural variations of the emission and uptake of CO_2.

We do not model carbon in the complete Earth-Atmosphere System, we only focus upon CO_2 in the atmosphere, which is controlled by the governing Conservation Law.

Based on this fundamental relation of mass conservation and a first order absorption process, we show that human activities have a minor influence on the CO_2 increase in the

atmosphere, while the main contribution has to be explained by natural effects, particularly the temperature, which is responsible for more than 85% of the CO_2 increase since the Industrial Revolution. Therefore, not CO_2 but primarily native impacts control any observed climate changes.

2. Physical Concept

The basis of our considerations is the balance for the influx of CO_2 into the atmosphere and the outflux from the atmosphere to extraneous reservoirs, by which the CO_2 concentration C in the atmosphere is controlled. This can well be compared with a swimming pool (see also Salby [7]) with an influx f_{in} and an outflux f_{out}, for which the changing amount of water dm_W in the pool over the time interval dt is given by the difference of these fluxes:

$$\frac{dm_W}{dt} = f_{in} - f_{out} \,. \tag{1}$$

From a simple flux consideration we get the average turnover or residence time τ_R it takes to completely exchange the water in the pool. Under steady state conditions for $f_{in} = f_{out}$ then the total amount of water in the pool m_W is exchanged within

$$\tau_R = \frac{m_W}{f_{in}} = \frac{m_W}{f_{out}} \,, \tag{2}$$

and the other way round is this an important measure for the outflux rate

$$f_{out} = \frac{m_W}{\tau_R} \,. \tag{3}$$

In the same way as for the pool we can consider the balance for atmospheric CO_2 with a total emission rate $e_T(t)$ of CO_2 from the surface to the atmosphere, and reversely a total absorption rate $a_T(t)$ of the extraneous reservoirs (Figure 1). Generally the influx can be split into natural emissions with a rate $e_N(t)$ and an additional anthropogenic emission rate $e_A(t)$, which on its part results from fossil fuel emissions and land use changes. The outflux is determined by temporary or continuing absorption of CO_2 by oceans and the land. Incidentally the total absorption rate $a_T(t)$ is also separated into a fraction $a_N(t)$, characterizing an uptake that can be addressed to the amount of natural emissions, and another contribution, $a_A(t)$, caused by the additional anthropogenic emissions. This results in a total mass balance, the Conservation Law:

$$\begin{aligned} \frac{dC(t)}{dt} &= \frac{dC_N(t)}{dt} + \frac{dC_A(t)}{dt} = e_T(t) - a_T(t) \,, \\ &= e_N(t) + e_A(t) - a_N(t) - a_A(t) \end{aligned} \tag{4}$$

which governs the atmospheric CO_2 concentration.

Generally all these fluxes are changing with time and also depend on the actual concentration $C(t)$, which virtually may be considered to consist of a time dependent fraction $C_N(t)$, caused by native emissions, and of a time dependent anthropogenic portion $C_A(t)$, with $C(t) = C_N(t) + C_A(t)$. Thus, usually this equation has to be solved numerically.

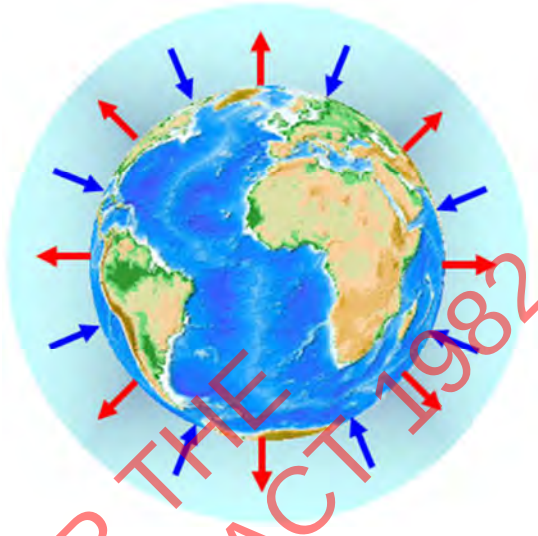

Figure 1. *Emissions of CO_2 from the surface to the atmosphere (Red Arrows) and absorption of CO_2 by the surface (Blue Arrows).*

In analogy to the pool example it follows that an exchange of CO_2 in the atmosphere takes the time

$$\tau_R = \frac{C(t)}{e_T(t)} = \frac{C(t)}{a_T(t)} \,, \tag{5}$$

the so called residence time of CO_2 in the atmosphere, and the absorption rate is

$$a_T(t) = \frac{C(t)}{\tau_R} \,. \tag{6}$$

With (4) we do not model the carbon cycle in the complete Earth-Atmosphere System (EASy). That would require a wider analysis, accounting for processes within extraneous systems and exchanges between them. Our analysis focuses upon CO_2 in the atmosphere, which is controlled by the governing conservation law. Incidentally this physical law is characterized as a flawed one-box description (see e.g., Köhler et al. [8]), because a single balance equation - so the argument - does not account for details in other reservoirs, systems that are extraneous to the atmosphere. As will be shown, such interpretation is confused. With the inclusion of surface fluxes e_T and a_T, which account for influences on the atmosphere, the balance equation (4) entirely determines the evolution of CO_2. Details of extraneous systems, which are largely unobservable, are then irrelevant.

Atmospheric CO_2 is fully described by this single equation for a reason. It follows from the 3-dimensional continuity equation, the physical law that governs the global distribution of atmospheric CO_2. In flux form, the continuity equation is given by

$$\frac{\partial c}{\partial t} + \nabla \cdot (\boldsymbol{v}\, c) = c \nabla \cdot \boldsymbol{v} \,, \tag{7}$$

where the local CO_2 concentration c is transported with velocity $\boldsymbol{v}$. When integrated over the volume of the atmosphere and subjected to the divergence theorem, (7) reduces to the governing balance equation (4) for globally averaged CO_2.

If this would be flawed, then so would be the fundamental physical law from which it follows.

The anthropogenic emissions $e_A(t)$ as the sum of the Land Use Change (LUC) (see e.g., Le Quéré et al. [2]; CICERO [3]) and the Fossil Fuel Emissions (FFE) (CDIAC [4]) are displayed in Figure 2. While LUC (Red-Brown) almost stays constant over the last 170 years, FFE (Blue) is rapidly increasing over recent years.

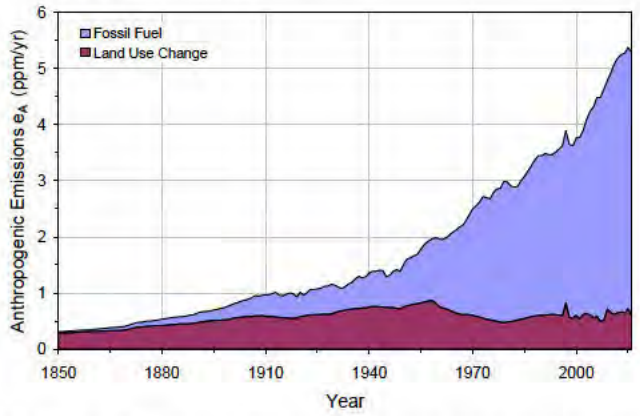

Figure 2. *Total anthropogenic emissions $e_A(t)$ due to land use change (Red-Brown) and fossil fuel emissions (Blue). Data from Le Quéré et al. [2] and CDIAC [4] displayed as stacked representation.*

Figure 3 shows again the total anthropogenic emissions (Red Squares) together with the temperature anomaly $\Delta T(t)$ (Blue Triangles) of the global annual station temperature data from the Goddard Institute for Space Studies (GISS) [9].

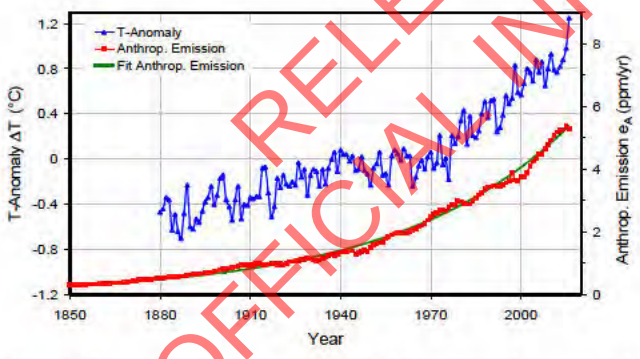

Figure 3. *Anthropogenic emissions $e_A(t)$ (Red Squares) with exponential fit (Green Graph) and global temperature anomaly (GISS-data, Blue Triangles).*

The anthropogenic emissions can be well approximated by an exponential of the form

$$e_A(t) = e_{A0} \cdot (e^{(t-t_0)/\tau_e} + b) \tag{8}$$

with parameters: $e_{A0} = 0.026\ ppm/yr$, $\tau_e = 50\ yr$, $t_0 = 1750\ yr$ and $b = 4$. The integral over the emission rate agrees within a few ‰ with the integral of the estimated observations.

On first glance the almost synchronous evolution of the fossil fuel emissions and temperature anomaly looks to be a strong indicator for the human influence as the driving force for a globally increasing temperature. But a closer look already reveals some systematic discrepancies, particularly between 1940 and 1970, where the emissions are further increasing, while the temperature stagnates or even slightly decreases. This has to be considered in some more detail, in particular by directly comparing model calculations of the CO_2 increase, based on the fossil fuel emissions and land use change, with the actual observations at Mauna Loa since 1958 (Keeling et al. [5]; AR5 [1] Chap.6-Fig.6.3, p. 476).

Therefore, in this contribution we first investigate the carbon cycle based on the IPCC's assumptions that the human emissions are the dominant cause of the CO_2 increase, before we extend the balance to the full carbon cycle also including natural variations with their temperature dependence (see also: Harde [6]; Salby [7], [10, 11]).

3. Anthropogenic Carbon Cycles

To explain the CO_2 increase over recent years and to predict its further progression, the IPCC assessment reports emanate from equation (4), but they are using some restricting assumptions (see AR5 [1] Chap.6), which can be summarized by the following statements:

1. Before 1750 and in first approximation also before 1850 steady state conditions are presupposed with a CO_2 concentration of $C_{N0}(1750) \approx 280\ ppm$, which is determined by constant natural emission and absorption rates $e_{N0} = a_{N0}$ of about $93\ ppm/yr$ (AR5 [1] Chap.6-Fig.6.1).
2. At this concentration and with these fluxes it follows from (5) an average residence time τ_R (at pre-industrial times: τ_{R0}) of CO_2 in the atmosphere of

$$\tau_{R0} = \frac{C_{N0}}{e_{N0}} = \frac{C_{N0}}{a_{N0}} = 3.0\ yr. \tag{9}$$

Note: The same result is found from (4) for the in- and outfluxes in equilibrium and with an absorption rate equivalent to (6), which is scaling proportional to the concentration C_{N0}:

$$\frac{dC_{N0}}{dt} = e_{N0} - a_{N0} = e_{N0} - \alpha_{R0} \cdot C_{N0} = e_{N0} - \frac{C_{N0}}{\tau_{R0}}, \tag{10}$$

with $\alpha_{R0} = 1/\tau_{R0}$ as the absorptivity and τ_{R0} now as the e-folding residence time.

3. It is assumed that an increasing CO_2 concentration over the last 170 years is almost exclusively caused by anthropogenic emissions from fossil fuel combustion and land use change, while the natural emissions over this period are supposed to have been the same as in pre-industrial times.
The increasing concentration is attributed to only partial re-absorption of the anthropogenic emissions, from

which a fraction, the so-called Airborne Fraction $AF = \Delta e_A/e_A$, is assumed to remain in the atmosphere. Then

$$\Delta e_A(t) = AF \cdot e_A(t) \tag{11}$$

is the non-absorbed portion, which cumulates in the atmosphere and

$$a_A(t) = e_A(t) - \Delta e_A(t) = e_A(t) \cdot (1 - AF) \tag{12}$$

represents the absorbed fraction of the anthropogenic emissions. Actually the IPCC emanates from an airborne fraction of $AF = 44\%$ (AR5 [1] Chap.6, p. 495; Le Quéré et al. [12]).

4. To account for a changing uptake of extraneous reservoirs with increasing atmospheric concentration the absorption is supposed to consist of a series of different exponential decay terms representing the uptake of the different reservoirs with different time constants. This absorption is considered to be proportional to the human emissions, not the actual concentration C (see (12)).

Based on these assumptions more or less sophisticated approaches are known to explain the increasing CO_2 concentration in the atmosphere. Three of them will be briefly characterized and discussed in this contribution. They all emanate from the same basic concept to isolate the natural carbon exchange between atmosphere and extraneous reservoirs and only to consider the anthropogenic cycle.

3.1. Constant Airborne Fraction

With a constant natural emission and absorption rate over the Industrial Era ($e_{N0} = a_{N0}$) and also a constant airborne fraction over this period the balance equation (4) reduces to the simple form

$$\frac{dC(t)}{dt} = \Delta e_A(t) = AF \cdot e_A(t) \tag{13}$$

and changes synchronously with $e_A(t)$. The concentration as a function of time is found by simply integrating (13) over the Industrial Era:

$$C(t) = C(1750) + AF \cdot \int_{1750}^{t} e_A(t')\, dt' \cdot \tag{14}$$

From the carbon budget over the last 270 years we derive an airborne fraction of $AF = 42\%$ (see Le Quéré et al. [2], Table 9). Then, with an initial concentration of $C(1750) = C_{N0} = 280$ *ppm* this results in a progression as shown in Figure 4 (Green Line), which for the last 60 yr can directly be compared with measurements (Blue Diamonds) at Mauna Loa (Tans & Keeling [13]). This comparison shows generally too high concentrations, particularly for past periods. This might be caused by a too large initial concentration in 1750, but also the slope does not fit very well. More likely is a too large emission rate, especially due to LUC, which anyway is only known with an accuracy of about $\pm 50\%$.

A surprisingly good agreement can be found with an anthropogenic emission rate $e'_A(t)$, which as average over the considered period is reduced by *0.21 ppm/yr*, and using an airborne fraction of 48% (Green Crosses), 6% larger than the average fraction over the Industrial Era. The smooth shape of the fits is the result of an integration over the full anthropogenic emissions since 1750, where the soft increase of the curves is dominated by the 'average' emission rate, while even larger emission events are strongly flattened.

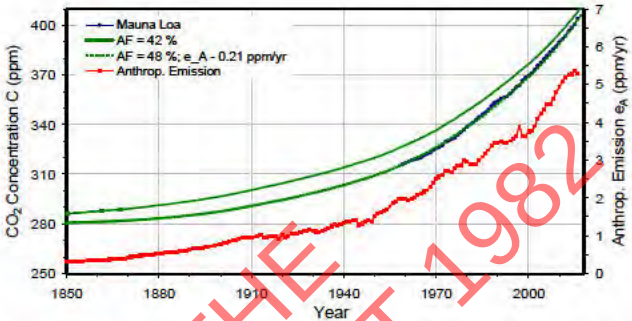

Figure 4. *Calculated CO_2 concentration with an airborne fraction of 42% (Green Line) compared with observations at Mauna Loa (Blue Diamonds). A simulation with AF = 48% and reduced emissions is plotted as Green Crosses. Also shown are the anthropogenic emissions $e_A(t)$ (Red Squares).*

3.2. Bern Model

A more advanced approach to describe the carbon cycle, is the so-called Bern Model of CO_2 absorption (e.g., Joos et al. [14]), a prototype of similar treatments in other models. It distinguishes between different sinks on different time scales and assumes a multi-exponential decay to re-equilibrate after a perturbation, e.g., caused by a transient spike of CO_2 added to the atmosphere. Using the five-term fit to the Bern carbon cycle model (Joos et al. [14]; Hansen et al. [15, 16]) the adjustment following a δ-pulse perturbation Δe_P from equilibrium emission e_{eq} is supposed to be:

$$\begin{aligned} R(t) &= (e(t) - e_{eq})/\Delta e_P \\ &= 0.18 + 0.14 \cdot e^{-t/420} + 0.18 \cdot e^{-t/70} \cdot \\ &\quad + 0.24 \cdot e^{-t/21} + 0.26 \cdot e^{-t/3.4} \end{aligned} \tag{15}$$

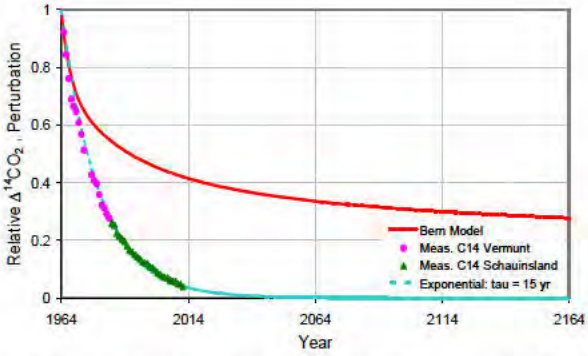

Figure 5. *Decay of perturbation predicted by the Bern Model (Red Graph) as calculated from (15). Also shown is the observed ^{14}C decay (Circles and Triangles) and an exponential fit with a decay time $\tau = 15$ yr (Dashed Blue).*

Figure 5 shows the adjustment of the relative perturbation $R(t)$ over 200 yr (Red). Also displayed is the observed $^{14}CO_2$ decay at Vermunt and Schauinsland (Levin et al. [17]) after the

stop of the atomic bomb tests, shown as relative fractionation-corrected ‰-deviation $\Delta^{14}CO_2$ from the Oxalic Acid standard. This decay is well represented by a single exponential with a decay constant of only 15 yr (Dashed Blue). Almost identical $\Delta^{14}CO_2$ decays of 16.5 yr can be found from the data of Hua et al. [18] and Turnbull et al. [19].

For calculating the atmospheric CO_2 concentration by the Bern Model (e.g., Joos [14]), the emission of anthropogenic CO_2 into the atmosphere is considered as a series of consecutive pulse inputs. Then the atmospheric CO_2 concentration $C(t)$ at time t is assumed to be the sum of earlier emissions $e_A(t')$ at time t' multiplied by the fraction, now a time dependent airborne fraction, which is still available in the atmosphere after the time $t - t'$ and which is given by the pulse response function $R(t - t')$ of (15). With an anthropogenic emission rate, which can well be approximated by (8) (see Figure 3), it follows:

$$\begin{aligned} C(t) &= C(t_0) + \int_{t_0}^{t} e_A(t') \cdot R(t-t') \cdot dt' \\ &= C(t_0) + e_{A0} \cdot \left[c_e \cdot e^{-(t-t_0)/\tau_e} - c_0 - c_1 \cdot e^{-(t-t_0)/\tau_1} \right. \\ &\quad - c_2 \cdot e^{-(t-t_0)/\tau_2} - c_3 \cdot e^{-(t-t_0)/\tau_3} \\ &\quad \left. - c_4 \cdot e^{-(t-t_0)/\tau_4} + 0.18 \cdot b \cdot (t-t_0) \right] \end{aligned} \qquad (16)$$

with:

$$c_e = 0.18 \cdot \tau_e + 0.14 \cdot \tau_{e1} + 0.18 \cdot \tau_{e2} + 0.24 \cdot \tau_{e3} + 0.26 \cdot \tau_{e4};$$

$$c_0 = 0.18 \cdot \tau_e - b \cdot (0.14 \cdot \tau_1 + 0.18 \cdot \tau_2 + 0.24 \cdot \tau_3 + 0.26 \cdot \tau_4);$$

$$c_1 = 0.14 \cdot (\tau_{e1} + b \cdot \tau_1); \quad c_2 = 0.18 \cdot (\tau_{e2} + b \cdot \tau_2);$$

$$c_3 = 0.24 \cdot (\tau_{e3} + b \cdot \tau_3); \quad c_4 = 0.26 \cdot (\tau_{e4} + b \cdot \tau_4);$$

$$\tau_{ei} = \tau_e \cdot \tau_i / (\tau_e + \tau_i); \quad \tau_e = 50\,yr; \quad \tau_1 = 420\,yr;$$

$$\tau_2 = 70\,yr; \quad \tau_3 = 21\,yr; \quad \tau_4 = 3.4\,yr; \quad b = 4;$$

This approach also presupposes an equilibrium CO_2 concentration C_{eq} in 1750 of $C_{eq} = 280$ *ppm*, and it excludes any further variations in the natural emission rate over the Industrial Era.

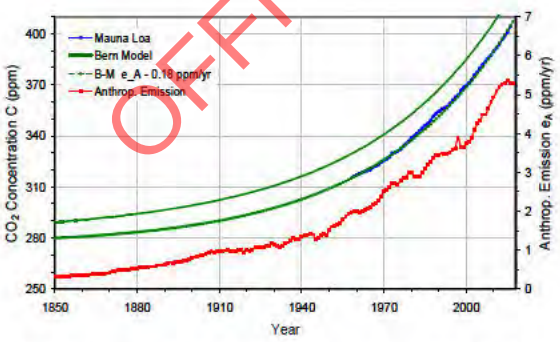

Figure 6. *Comparison of the Bern Model (Green Graph) with the Mauna Loa data (Blue Diamonds). A simulation with reduced emission $e_A(t)$ - 0.18 ppm/yr is displayed as Green Crosses. Also shown are the original data of anthropogenic emissions $e_A(t)$ (Red Squares).*

The calculated atmospheric CO_2 concentration as given by (16) is displayed in Figure 6 (Solid Green). The Bern Model shows the same tendency of too large calculated concentrations as this was already found for the much simpler model of constant airborne fraction (AF Model).

With a reduced average anthropogenic emission rate, in this case of *0.18 ppm/yr*, again a very good agreement with the Mauna Loa data can be observed.

But from basic causalities there exist some fundamental problems with the AF and the Bern Model:

1. Additional emissions to the atmosphere even at a constant rate will never attain a new equilibrium.
2. These emissions will further accumulate in the atmosphere, in the Bern Model 18%, in the simple AF Model even 48%, emissions which will stay for ever in the atmosphere.
3. This is a consequence of the defect, that these models essentially add up additional emissions deviating from pre-industrial times, and they only consider partial uptake, which is scaling *proportional with the emission rate* – and not with the concentration.
4. The Bern Model uses different time scales for the uptake, although the ^{14}C-decay shows a single exponential decay of only 15 yr or shorter.
5. Even natural year-to-year variations of only 1%, El Niños and volcanic activities comparable or even larger than the human emissions, will cumulate in the atmosphere, since only additional emissions but not adequate sinks are considered in these models.

To avoid some of these deficits another class of models uses a first order absorption process, but applies this only to concentration changes $C_A(t)$ caused by anthropogenic emissions.

3.3. Absorption Scales with Concentration

Since the anthropogenic absorption rate $a_A(t)$, by presumption, is proportional to the man-made emission rate $e_A(t)$ (see Eq.(12)) and this rate on its part directly determines the anthropogenically induced fraction of the CO_2 concentration $C_A(t)$, in analogy to (6) or (10) we infer:

$$a_A(t) = e_A(t) \cdot (1 - AF) \Rightarrow \frac{C_A(t)}{\tau_A}, \qquad (17)$$

which converts the absorption term in (4) to a first order process scaling proportional to the anthropogenic fraction $C_A(t)$ of the concentration (for a similar approach see e.g.: Siegenthaler & Sarmiento [20]; Dietze [21]; Cawley [22]; Lüdecke & Weiss [23]). For $e_{N0} = a_{N0}$ this results in the balance equation:

$$\frac{dC(t)}{dt} = \frac{dC_A(t)}{dt} = e_A(t) - \frac{C_A(t)}{\tau_A} = e_A(t) - \frac{C(t) - C_{N0}}{\tau_A} \qquad (18)$$

with τ_A as the respective absorption time of molecules in the atmosphere, which in the IPCC terminology controls the

'adjustment' of the atmosphere only due to anthropogenic emissions. From Figure 4 and with (17) we can estimate this 'adjustment' time, which for C_A = *(393-280) ppm = 113 ppm*, e_A = *4.7 ppm/yr* (all values averaged over 10 years from 2007-2016, see Le Quéré et al. [2], Table 7) and the fitted *AF = 48%* from Figure 4 gives

$$\tau_A = \frac{C_A(t)}{e_A(t)(1-AF)} = 46\,yr \cdot \tag{19}$$

Numerical integration of (18) with this 'adjustment' time, with the given emission rate $e_A(t)$ and a native concentration C_{N0} = *280 ppm* is shown in Figure 7 (Green Line). For a corrected emission rate $e'_A(t)$ = $e_A(t)$ - *0.3 ppm/yr* and the 'adjustment' time from (19) also this accounting scheme (Green Crosses) gives good agreement with the observations at Mauna Loa (Blue Diamonds). This absorption time is almost identical with an adjustment time of 48 yr as derived from a simple flux calculation presented in Harde [6], Eq. (9).

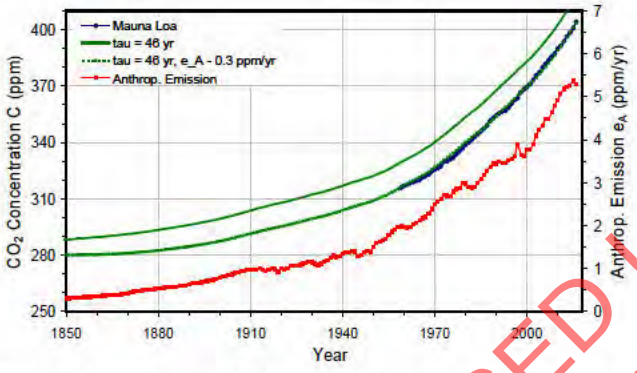

Figure 7. *Calculation of the CO_2 concentration for an adjustment time τ_A = 46 yr (Green Line) and comparison with observations at Mauna Loa (Blue Diamonds). A simulation with reduced emissions is displayed as Green Crosses. Also shown are the anthropogenic emissions $e_A(t)$ (Red Squares).*

3.4. Influence of Native Effects

So, with the right parameters all investigated approaches can reproduce the observations at Mauna Loa very well. But all these models are based on different hypotheses and boundary conditions, some of them are even in contradiction to each other. Therefore, only one or none of them may be right. Good conformity with observations alone is not a sufficient criterion for testing the validity of a model, it must also be in agreement with basic physical principles. They alone can give us the physically consistent explanations for a carbon cycle, which is dominated by more than 95% of native emissions and underlies continuous environmental impacts. It is also evident that this cycle is governed by the same principles at paleoclimatic times as today with human emissions.

Thus, for the further considerations it seems reasonable first to concentrate on three basic questions:

1. *How could nature be in equilibrium before the Industrial Era?*

Some climate scientists consider the natural carbon exchange as a closed cycle, which happened in this way unaffected over thousands of years without larger variations. But when looking to the glacial and interglacial periods or only to the Holocene we have to recognize that the atmospheric CO_2 concentration was always varying over longer and shorter periods. Slow variations per se are no sign of non-equilibrium, they can also result from varying emission strengths over time. But an adaptation to such natural variations is not possible, when emissions are only cumulating, as this is assumed in the AF and Bern Models for *anthropogenic* emissions, which never come to equilibrium. Thus, an adaptation to volcanic activities, temperature variations or even to the seasonal variations requires an absorption process for the *native* cycle, which behaves more or less proportional to the respective concentration $C_P(t)$ at pre-industrial times, in a similar way as considered in the 3rd model for the anthropogenic emissions.

So, it is close by to presuppose also a first order process for the native cycle, and the respective balance equation for pre-industrial times then assumes the form, analogous to (10):

$$\frac{dC_P(t)}{dt} = e_P(t) - \frac{C_P(t)}{\tau_{RP}} \tag{20}$$

with $e_P(t)$ as the emission rate and τ_{RP} as the residence time at pre-industrial times. Equilibrium is achieved when the left side of (20) is zero. Then the residence time becomes τ_{RP} = $C_P(t)/e_P(t)$.

The same relation was found from the simple flux model with a residence time τ_{R0} = *3 yr* at 1750. Such a residence or absorption time for the natural cycle is in good agreement with the observed seasonal variations and is also supported by the ^{14}C-decay as will be discussed in detail in subsection 5.7.3.

When CO_2 concentrations were continuously changing in pre-industrial times we also have to inquire:

2. *Can the natural cycle really be assumed to have been constant over the last 270 yr?*

Almost every day we recognize natural phenomena and processes in form of significant perturbations or variations, e.g., volcanic eruptions, earthquakes, El Niño - La Niña events, internal and external oscillations, global warming or seasonal variations.

All these phenomena have a direct influence on the naturally caused fraction $C_N(t)$ of CO_2 in the atmosphere. Therefore, the balance for the natural cycle also over the Industrial Era has to be expressed explicitly by a time dependent emission rate $e_N(t)$ and also a time dependent residence time $\tau_R(t)$. The latter can slightly be affected by internal or external variations, but should not significantly deviate from pre-industrial times or 1750. Otherwise the balance must obey the same principal relation as in pre-industrial times with:

$$\frac{dC_N(t)}{dt} = e_N(t) - \frac{C_N(t)}{\tau_R(t)}. \tag{21}$$

Finally we have to ask:

3. *Can the anthropogenic cycle be considered separately from a natural cycle?*

From the preceding discussion one may conclude that the total balance equation for the respective models looks like

$$\begin{aligned}\frac{dC(t)}{dt} &= \frac{dC_N(t)}{dt} + \frac{dC_A(t)}{dt} \\ &= \left(e_N(t) - \frac{C_N(t)}{\tau_R(t)}\right) + \begin{cases} e_A(t)\cdot AF & AF\,Model \\ e_A(t)\cdot R(t'-t) & Bern\,Model \\ e_A(t) - C_A/\tau_A & 1.\,Order\,Mod. \end{cases}\end{aligned} \tag{22}$$

In all cases is this equation controlled by two or more independent time scales, a fast scale with $\tau_R \approx 3\ yr$ for the absorption of natural emissions and a slow scale with an infinite decay for 48% of emissions in the AF Model, with 5 decay times for different sinks in the Bern Model, and an adjustment time of 46 yr in the 3rd model, all for the adaptation of the atmosphere to additional anthropogenic emissions.

At least here it gets obvious that naturally and human emitted molecules cannot be treated differently. As long as no saturation in the uptake is observed, which is not the case (see Appendix A), an additional emission by humans must underlie the same absorption process as the natural emissions. A separation is in startling contradiction to the Equivalence Principle, and as a consequence of this principle only one absorption time, τ_R, with the same absorption behavior for human and native emissions must exist.

4. Complete Carbon Cycle

The preceding considerations show that a realistic analysis of the CO_2 exchange between the atmosphere and its adjacent reservoirs has also to include natural variations due to temperature effects or temporal events. It has also to consider a common absorption of all natural and human contributions, which are scaling proportional to the apparent CO_2 concentration and which are represented by one unique decay time (see also: Essenhigh [24]; Salby [7, 10]; Harde [6]; Berry [25]).

We summarize the main deviations from the previously discussed accounting schemes by the following fundamental principles:

1. Changes in the natural carbon cycle, which are due to a continuous temperature increase over the Industrial Era, are included in the balance equation (4) by a temperature dependent term for the natural emissions and also a term for the temperature dependent absorption.
2. Perturbations from an equilibrium concentration C_{eq} due to natural changes or additional anthropogenic emissions are compensated for or controlled in the carbon cycle by an absorption rate, which changes proportional to the actual concentration C (first order process, see Eq. (6)).
3. Molecules emitted to the atmosphere can have a number of different sources, natural and man-made sources, but (up to now) they have only common natural sinks in form of the oceans and continents, which do not differentiate between the native or anthropogenic origin.
4. There exists no evidence that the absorption was suddenly saturating and the residence time τ_R jumping up by one or two orders of magnitude from τ_{R0} to τ_A, when the atmospheric concentration exceeded a level of *280 ppm*. τ_R can only have changed continuously from pre-industrial to present times from 3 to 4 yr, synchronously with the atmospheric concentration and in agreement with (5) and (9).
5. The observed exponential decay of ^{14}C in the atmosphere after the stop of the atomic bomb tests in 1963 is a strong indication for a first order absorption process of CO_2 by land and oceans with a unique time constant determined by the gross flux of CO_2 from the atmosphere to the reservoirs (see Figure 5). Only such an absorption ensures that the carbon cycle can stabilize and react adequately on any temporal perturbations like seasonal variations or volcanic activities.
6. For parallel absorption processes by the oceans, by the biosphere or rock weathering the absorptivity α is given as the sum of the individual channels α_i with $\alpha_R = \alpha_1 + \alpha_2 + \ldots + \alpha_N$ and $\tau_R = 1/\alpha_R$. The uptake is not restricted by the slowest process as assumed in the Bern Model, but by the sum of all processes with one unique absorptivity α_R for all molecules. The reciprocal of α_R is the residence time τ_R of CO_2 in the atmosphere.

These principles are incorporated in a balance equation, the General Conservation Law, which on the one side includes temperature dependent and, thus, time dependent natural and anthropogenic emissions, and on the other side considers a temperature dependent unique residence time τ_R, which describes the collective or net absorption of all molecules. It does not differentiate between a residence or adjustment time:

$$\frac{dC(t)}{dt} = e_N(T(t)) + e_A(t) - \frac{C(t)}{\tau_R(T(t))}. \tag{23}$$

In first order the natural emission rate and the residence time can be assumed to increase linearly with the temperature anomaly ΔT:

$$\begin{aligned} e_N(T(t)) &= e_{N0} + \beta_e \cdot \Delta T(t) \\ \tau_R(T(t)) &= \tau_{R0} + \beta_\tau \cdot \Delta T(t) \end{aligned}. \tag{24}$$

β_e and β_τ are the temperature coefficients of the natural emission and the absorption time. In the general case of a saturating uptake by the extraneous reservoirs τ_R will additionally change with C. But up to now any unequivocal saturation effects cannot be identified (see Appendix A).

With the temperature anomaly $\Delta T(t)$ and the anthropogenic emissions $e_A(t)$ as represented in Figure 3, Eq.(23) can be solved numerically.

Figure 8 shows the simulated CO_2 concentration in the atmosphere (Green Graph) over a time period 1880 - 2016, for which reliable temperature data are available (GISS [9]), whereas the direct CO_2 measurements at Mauna Loa (Blue Diamonds) started not before 1958. The temperature data were used as moving average over ±5 yr. We achieve good

agreement with the observations for a natural emission rate e_{N0} = *93.3 ppm/yr*, τ_{R0} = *3 yr* (both in agreement with (9)) and temperature coefficients β_e = *10 ppm/yr/°C* and β_τ = *0.37 yr/°C*. Similar good results are obtained with larger β_e (up to *24 ppm/yr/°C*) and smaller β_τ ($\rightarrow 0$) or vice versa with β_τ (up to *0.74 yr/°C*) and smaller β_e ($\rightarrow 0$). Thus, we have to assert that as long as the natural and anthropogenic emission rates and at least one of the temperature coefficients are not more accurately known, we can only determine a combination of these parameters, not their absolute values.

Figure 8 also displays a simulation for which the anthropogenic emissions were set to zero (Magenta).

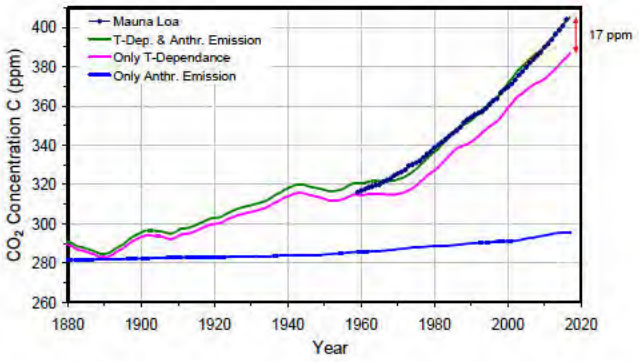

Figure 8. *Calculated CO_2 concentration with temperature-dependent emission and absorption (Green). Compared against the observed record of CO_2 from Mauna Loa (Blue Diamonds). Simulation without anthropogenic emissions (Magenta), and only human activities (Blue).*

The difference between both curves results from the human activities. These graphs evidently show that, based on (23), the anthropogenic contribution to the observed CO_2 increase over the last 150 years is significantly less than the natural influence. So, as an average over the period 2007- 2016 the anthropogenic emissions were contributing not more than 4.3% to the total concentration of 393 ppm and thus, their fraction to the atmospheric increase since 1750 of 113 ppm is not more than 17 ppm or 15%. The dominating contribution with 85% is determined by natural influences, in Figure 8 represented as difference of the Magenta Graph to the 280 ppm grid-line.

The pure anthropogenic contribution to the atmospheric concentration, which would result without temperature effects, is shown by the Blue Graph on a constant background of 280 ppm. With a residence time of τ_{R0} = *3 yr* human emissions cannot contribute more than 14.5 ppm, and with an increasing τ_R over the Industrial Era due to the temperature influence it will slightly increase to 17 ppm, as displayed by the difference between the Green and Magenta Graphs (see red arrow). *At equilibrium the relative contribution of human activities to the total CO_2 concentration is always determined by the anthropogenic to the total emission rate, independent of the actual residence time* (Eq.(23); Harde [6], Eq.(14)).

Note, a simulation without anthropogenic emissions, but slightly increased temperature coefficients (β_τ = *0.48 yr/°C* or β_e = *13.3 ppm/yr/°C*) lifts the Magenta curve to coincide almost exactly with the Green graph. Thus, the observed evolution at Mauna Loa could also be reproduced without involvement of $e_A(t)$, contrary to the IPCC interpretations.

Up to now we were only considering the seasonally averaged CO_2 measurements, but it is also worthwhile to look closer to the monthly data at Mauna Loa (see Keeling et al. [5]; AR5 [1] Chap.6-Fig.6.3, p. 476) as displayed in Figure 9 (Magenta Diamonds). The "sawtooth" curve is an obvious indication for the direct variation of the CO_2 emission and uptake rates, driven by the solar activity and the temperature over the seasons. Generally this modulation is attributed to the greater land mass on the Northern Hemisphere, where the uptake by photosynthesis predominantly occurs during the growing season, while CO_2 release by heterotrophic processes is more dominant over the other seasons.

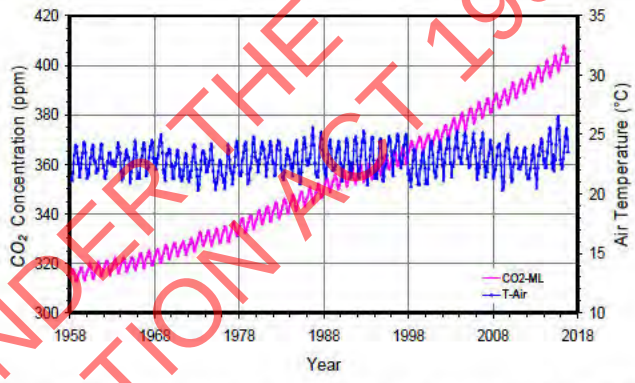

Figure 9. *Monthly time series of measured CO_2 concentration at Mauna Loa (Magenta Diamonds) and air temperature record at Hawaii (Blue Triangles).*

However, apparently also local effects have a direct influence on this record. Figure 9 shows also the monthly averaged air temperature at Hawaii (Blue Triangles) with seasonal variations of 3 - 4°C (NOAA [26]). Almost synchronous changes are found for the sea surface temperature (NOAA [27]). The CO_2 concentration follows these temperature variations with a delay of 6 - 7 months (see also Salby [7]).

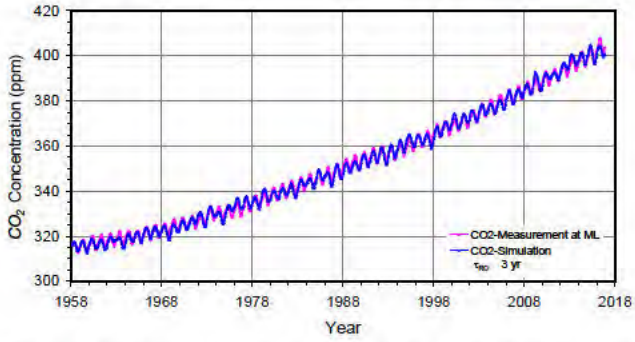

Figure 10. *Monthly CO_2 concentration integrated from the balance equation with temperature-dependent emission and absorption and an initial residence time of 3 years (Blue Triangles). Compared against the observed record of CO_2 from Mauna Loa (Magenta Diamonds).*

A calculation with human emissions included and using the modulated air temperature anomaly $\Delta T(t)$ at Hawaii (NOAA [26]) is shown in Figure 10 (Blue Diamonds). This excellent

agreement with the monthly Mauna Loa CO_2 measurements (Magenta Diamonds) is obtained by applying a linear response of the natural emissions to the modulated temperature anomaly, and assuming a residence time with an initial value of $\tau_{R0} = 3\ yr$ and an averaged slightly nonlinear temperature increase $\Delta T^{1.5}(t)$, which accounts for the nonlinear response of oceanic emissions and the uptake of CO_2 (see Subsection 5.6). It should be mentioned that the averaged air temperature at Hawaii is distinguished by a quite linear increase over time. Therefore, different to Figure 8 also smaller deviations at about 1970 are completely disappearing.

A detailed analysis of the Mauna Loa curve (Salby [7, 10, 11]) and independent cross-correlation investigations of thermally induced emission (Humlum et al. [28]) indicate that the actual absorption time of 3-4 yr, as derived from (9) and based on the IPCC's own estimates, may even be significantly shorter, as short as only 8–12 months, this at least over the vegetation growths' periods on land and in oceans, but also in areas such as the North Atlantic with cold downwelling waters. Under such conditions, in the same way as the residence time is getting shorter, the total emission rate gets larger (generally the most uncertain parameter of the guessed rates). As the admixture of human generated CO_2 is given by the percentage of anthropogenic to total emissions, also this fraction further decreases. So, with an absorption time of $\tau_{R0} = 1\ yr$ and a total emission rate of $e_T = 298\ ppm/yr$ the anthropogenic emissions of $4.7\ ppm/yr$ do not contribute more than 1.6% or 6 ppm to the atmospheric CO_2. However, for a more conservative assessment and in agreement with the IPCC's estimates (AR5 [1], Chap.6-Fig. 6.1) we further emanate from conditions as derived from the simulations of Figures 8 and 10 with $\tau_{R0} = 3\ yr$.

5. Discussion

All presented schemes for simulating the atmospheric CO_2 concentration are based on the balance equation considering the fluxes from extraneous reservoirs to the atmosphere and vice versa. However, as widely used in the literature, the approaches in Section 3 restrict these fluxes on anthropogenic emission-absorption cycles, whereas natural emissions and their uptake are supposed to be the same since 270 years, and thus, any changes in these fluxes are simply disregarded in the total balance. In addition, two of these approaches use a unilateral balance for this cycle, only controlled by the influxes and independent of the actual atmospheric concentration. These deficits have some fatal consequences in the further interpretation of the carbon cycle.

5.1. New Time Scale

Sole consideration of anthropogenic fluxes is identical with the introduction of a new time scale for the uptake of man-made emissions (see subsection 3.4). Since these emissions and also their changes are more than one order of magnitude too small to explain directly the observed concentration changes over recent years, carbon-cycle models just introduce an additional buffer factor, the 'adjustment' time. Such new time scale ensures a sufficiently long cumulation time of the molecules in the atmosphere to attain a concentration level, which is in agreement with the observations. But it looks quite dubious that 280 ppm, equivalent to the environmental fraction, are exchanged with extraneous reservoirs within 3-4 yr, and for about 45% of additional human emissions an accumulation over thousands of years in the atmosphere is assumed.

Effectively represents an 'adjustment' time τ_A nothing more than an amplification factor for the anthropogenic emission rate to fit with the observations. This is obvious for the approach described in subsection 3.3 (see Eqs.(18) and (19)), where the integrated net flux is proportional to $e_A(t)$ and τ_A. But implicitly this is also concealed in the other two schemes.

In the case of a constant airborne fraction the adjustment' time for the fraction $\Delta e_A = AF \cdot e_A(t)$, cumulating in the atmosphere, is even infinite. Under such conditions already any additional constant emission contributes to a linear increase of the concentration, whereas any changes in the emission rate only slightly affect the further shape of this increase. In such case - with an infinite lifetime of additionally emitted molecules in the atmosphere and a given emission rate for FFE from CDIAC [4] and for LUC from Le Quéré et al. [2] (see Figure 2) - AF is now the only free parameter controlling the size and steepness of the concentration growth rate (see (14)).

From a simple balance of the increasing concentration and the total emissions we derive a value for AF of 42%. A realistic model then should reproduce the observations with this airborne fraction. But our previous simulations (see Figure 4) showed that this does not fit in size and shape. The discrepancy would even further increase, when additional natural emissions due to a globally increasing temperature have to be considered. Good consistency can only be found with a reduced anthropogenic emission rate and a further adapted AF.

In the more elaborate Bern Model not only one, but even five new time scales are introduced. This is expressed by the response function with its five decay times (see (15)). While the last term in (15) is similar to the decay described by the residence time τ_R, the others shall represent the limited uptake by different extraneous reservoirs with different time constants, one also infinite. A simulation with this response function, which is equivalent with a time dependent airborne fraction, reproduces quite well the general trend of the increasing concentration (see Figure 6), but in direct analogy to 3.1 and 3.3 satisfactory agreement with the free-air measurements at Mauna Loa is only obtained when reducing the official anthropogenic emissions and neglecting any additional natural emissions.

5.2. First Order Absorption Process

Approaches 3.1 and 3.2 use a quite exceptional definition for the in- and outfluxes between the atmosphere and adjacent reservoirs. The respective absorption rates are considered to be independent of the actual atmospheric concentration, instead they are supposed to scale in direct proportion to the