Confessions of a climate scientist – by Mototaka Nakamura

(English Version only, with arrangement & addition of titles by Robert J.Hopkirk)

The global warming hypothesis is an unproven hypothesis

A personal Introduction

Sometime in the early 1980' s when I was in high school, I became seriously concerned about the predicted "catastrophic global warming due to the increasing carbon dioxide in the atmosphere", after the talk of "a return of the glacial period" disappeared from the mass media. It eventually motivated me to study the atmospheric and oceanic sciences at the North Carolina State University in Raleigh, North Carolina, USA, and the Massachusetts Institute of Technology to become a climate scientist. From the very beginning, even before I began studying meteorology and oceanography, for some reason that I do not recall, I had believed the atmosphere, oceans, and ice (sea ice and quasi-permanent ice on land) to be the critically important components of the climate system, and studied the dynamics and thermodynamics of the atmosphere and oceans throughout my scientific career.

As I made advances in my study of the climate system and how it is represented by climate simulation models, however, my serious concern about the global warming gradually turned into skepticism on the global warming hypothesis and deep interests in complex mechanisms that generate variations and changes in climate at various time scales. From 1990 to 2014, I mainly worked on driving mechanisms of medium-scale, large-scale, and planetary-scale flows in the atmosphere and oceans and their interactions, material and heat transports by the atmosphere and oceans and their interactions, and cloud and precipitation mechanisms at the Massachusetts Institute of Technology, Georgia Institute of Technology, Goddard Space Flight Center, Jet Propulsion Laboratory, Duke University, University of Hawaii, and the Japan Agency for Marine-Earth Science and Technology. Recalling my time at these institutions, I identify my years at the MIT as the most important in forming the foundation of my scientific thinking. In particular, I was fortunate to be guided by Professor Alan Plumb, who helped me realize how important nonlinear fine-scale phenomena are in larger-scale processes and phenomena. In that respect, I was also very fortunate to be surrounded by talented scientists, in particular, Professors Glenn Flierl, John Marshall, Lorenzo Polvani, Larry Pratt, and Darryn Waugh, who generously provided me with their knowledge and insight in the fine-scale nonlinear geophysical fluid motions and their interactions with the larger-scale motions. I must also acknowledge Professor Vin Saxena, a cloud enthusiast, at the North Carolina State University, for imprinting me with the importance of crucial and complex roles of clouds in the climate system. Now, I must emphasize here that my skepticism on the "global warming hypothesis" is targeted on the "catastrophic" part of the hypothesis and not on the "global warming" per se. That is, there is no doubt that increased carbon dioxide concentration in the atmosphere does have some warming effect on the lower troposphere (about 0. 5 degrees Kelvin for a doubling from the pre-industrial revolution era, according to true experts), although it has not been proven that the warming effect actually results in a rise in the global mean surface temperature, because of the extremely complex processes operating in the real climate system, many of which are represented in perfunctory manner at best or ignored altogether in climate simulation models. I also want to emphasize that I am not negating the possibility of a major climate change as a result of the change as a result of the human activity, either catastrophic global warming or a return of severe glacial period (the real climate system that has a myriad of physical and biogeochemical processes is highly nonlinear, much more so than the toys used for climate predictions). I am simply pointing out the fact that it is impossible to predict with any degree of accuracy how the climate of this planet will change in the future. Aside from an obvious fact that we cannot predict future changes in the solar energy output, we just cannot predict, in any meaningful way, how the Earth' s climate will respond to the anthropogenic increase in the atmospheric carbon dioxide with the knowledge and technology that we currently possess. [Incidentally, I have never said or written that a glacial period is coming soon. Soon after my publicized comment on the coming 35- to 40-year period of minor cooling in the northern hemisphere, back in 2013, some web sites reported that I was predicting an imminent glacial period. I suspect that it was a typical smear tactic that attempted to discredit me by portraying me as a quack who makes outlandish claims. I only predicted a period of minor cooling in the northern hemisphere, primarily in the middle and high latitudes around the North Atlantic basin, based on records of cyclic temperature variations around the North Atlantic basin.] We also do not know for certain how the earth' s climate has changed in the past 100 years or longer, although we do know well how regional climate has changed in limited regions, such as Europe, North America, and some parts of Asia. A quasi-global observation system has been operating only for 50 years or so, since the advent of artificial satellite observation. Temperature data before then were collected over extremely small (with respect to the earth' s entire surface area) areas and, thus, have severe spatial bias. We have an inadequate amount of data to calculate the global mean surface temperature trend for the pre-satellite period. This severe spatial bias in reality casts a major uncertainty over the meaningfulness of "the global mean surface temperature trend" before 1980. There have been attempts to downplay the severity of this bias (e. g., Karl et al. 1995, Journal of Climate). But those attempts generally fail to acknowledge the significance of actual spatial and temporal variabilities in the surface temperature over the globe and have not addressed the problems in the accuracy of the global mean surface temperature trend in a satisfactory manner. I initially wrote this short book in Japanese with an aim to inform the Japanese public of the reality behind the rampant "global warming" references in the Japanese society, because of the absence of accurate description of the state of climate science revealed by climate experts in the Japanese language. While some real climate scientists in the USA and Europe have openly (and bravely, I might add) pointed out the serious flaws in the allegedly-proven hypothesis of "catastrophic global warming due to the anthropogenic carbon dioxide increase in the atmosphere", as far as I know, their voices have not been heard in the Japanese language at all. Furthermore, as far as I know, none of the Japanese climate scientists have talked about the flaws and the true state of climate science. So, I felt that I needed to publish a concise description of the flaws and possible reasons behind the "global warming" hysteria/ propaganda with some personal anecdotes that may shed a light on the sorry state of climate science. Incidentally, I used the word "confession" in the title of the book just to make it sound somewhat sensational in a hope to attract a larger number of readers. I have been openly expressing my skepticism since 1990' s and, so, it is not really a "confession". I apologize for this bit of promotion tactic. I was not going to write an English version of this book, as I believe that most of the important contents of this book have been already known by many enlightened people in the USA and Europe and I generally dislike doing anything that I consider redundant. Nevertheless, since I have received some requests from non-Japanese people for its English version, and since I have found that the original contents and nuances in the Japanese version are often not accurately presented when translated into other languages by software, I have decided to write only certain important contents in English also. The English contents, by the way, are not translation of the Japanese contents, as I dislike translating in general. So, the English contents are products of my spontaneous writing in English from scratch and are not designed to match the Japanese ones part to part. Please be assured, however, that the crux of the English contents is the same as that of the Japanese version. For better or worse, I have more-or-less lost interest in the climate science and am not thrilled to spend so much of my time and energy in this kind of writing beyond the point that satisfies my own sense of obligation to the US and Japanese tax payers who financially supported my higher education and spontaneous and free research activity. So, please expect this to be the only writing of this sort coming from me. I am confident that some honest and courageous true climate scientists will continue to publicly point out the fraudulent claims made by the "mainstream climate science community" in English. I regret to say this, but I am also confident that docile and/ or bought-up and/ or incompetent Japanese climate researchers will remain silent until the "mainstream climate science community" changes its tone, if ever. I believe that the serious problems with the "global mean surface temperature trend" before 1980 that I describe in the Japanese version have long been known among many enlightened people in the USA and Europe and, thus, will not bother to repeat it in English. I will elaborate only on two serious flaws in climate simulation models used for climate change predictions that I know as an expert: a fatally serious flaw in the oceanic component of the models and grossly oversimplified and problematic representations of the atmospheric water vapor, the most important greenhouse gas, in the atmospheric component of the models, which has been previously revealed to the public in English by other experts such as Professor Richard Lindzen. Needless to say, the climate models treat the solar energy output as a constant, which is a blatantly obvious fatal flaw for predicting climate changes that needs not to be described any further. Even if we were only to attempt to predict the response of climate to the projected increase in the atmospheric carbon dioxide concentration, however, these models are inadequate to produce any meaningful prediction. There are many other gross simplifications employed in climate prediction models that are likely to be fatal for making any meaningful climate prediction. One of them is, for example, a complete lack of meaningful representation for changes in aerosols that act as cloud condensation nuclei. I do not touch on these biogeochemical topics even in the Japanese version either, since I am not an expert on them. I do not plan to write the rest of the contents in English, since I consider them non-essential and/ or speculative and/ or widely known among enlightened people with English proficiency. Before concluding the introduction, let me state unambiguously that I am all for environmental conservation, contrary to what some people might think about me. I do support the idea of reducing oil and gas consumption, based on a simple fact that there are limits to those resources (unless the rate of generation is greater than the rate of consumption) and also on a fact that there are human health problems caused by the use of those resources, not based on the unproven hypothesis of the global warming. It is also widely believed that fossil resources have been a major factor in many serious geopolitical problems that have killed or injured many, many millions of lives in the past. I believe that globally reduced dependence on the fossil resources would also reduce the probability of conflicts and wars. Let' s reduce the oil and gas consumption by globally declaring eternal zero tax on any activity related to renewable or sustainable energy resources, rather than imposing nonsensical and immoral carbon tax on harmless carbon dioxide, shan' t we? I would happily support a constructive and productive approach of that kind. I am convinced that such a global policy will entice millions of companies, probably including large oil and coal companies, and hundreds of millions of people throughout the world to actively participate in the development, promotion, and use of renewable or sustainable energy. Can you imagine how much healthy economic growth and fossil-based energy use reduction we would attain with such a global policy? Eternally zero tax and no government fees on investment, sale, consumption, profit, income, etc., so long as they are related to renewable or sustainable energy. It sounds good to me. I hope that it also sounds good to those who are urging governments to take actions to reduce the carbon dioxide emission. It would be the policy of the least resistance (from the public, but probably not from governments and climate researchers) and the highest efficiency to achieve their goal, the reduction of carbon dioxide emission, regardless of its meaningful (meaningless) ness. I challenge those who believe in the "catastrophic global warming" and are screaming at their governments to do something about it to push their governments and various supposedly-non-profit organizations, such as the UN and IMF, to pursue a policy that would most efficiently reduce the carbon dioxide emission and also benefit the people, rather than a policy of legalized robbery/ fraud, carbon tax. Those who refuse to accept this challenge are, in my opinion, hypocrites with ulterior motives. Please find the English contents attached as an appendix at the end.

List of publications:

Doctoral thesis Characteristics of potential vorticity mixing by breaking Rossby waves in the vicinity of a jet. (Doctor of Science in Meteorology, Massachusetts Institute of Technology, 1994) (Publications with review)

1. The effects of flow asymmetry on the direction of Rossby wave breaking. Nakamura, M. and R. A. Plumb, J. of Atmos. Sci., 51, 2031-2045 (1994).

2. Destabilization of the thermohaline circulation by atmospheric eddy transports. Nakamura, M., P. H. Stone, and J. Maroztke, J. of Climate, 7, 1870-1882 (1994).

3. Effects of the ice-albedo and runoff feedbacks on the thermohaline circulation. Nakamura, M., J. of Climate, 9, 1783-1794 (1996).

4. The role of high- and low-frequency dynamics in the blocking formation. Nakamura, H., M. Nakamura, and J. L. Anderson, Mon. Wea. Rev., 125, 2074-2093 (1997).

5. On modified rotational and divergent eddy fluxes and their application to blocking diagnoses. Nakamura, M., Quart. J. Roy. Meteor. Soc., 124, 341-352 (1998).

6. On the eddy isopycnal thickness diffusivity of the Gent-McWilliams subgrid mixing parameterization. Nakamura, M. and Y. Chao, J. of Climate, 13, 502-510 (2000).

7. Characteristics of three-dimensional quasi-geostrophic transient eddy propagation in the vicinity of a simulated Gulf Stream. Nakamura, M. and Y. Chao, J. of Geophys. Res., 105, 11, 385-11, 406 (2000).

8. Diagnoses of an eddy-resolving Atlantic Ocean model simulation in the vicinity of the Gulf Stream. Part I: Potential vorticity. Nakamura, M. and Y. Chao, J. of Phys. Oceanogr., 31, 353-378 (2001).

9. Diagnoses of an eddy-resolving Atlantic Ocean model simulation in the vicinity of the Gulf Stream. Part II: Eddy potential enstrophy and eddy potential vorticity fluxes. Nakamura, M. and Y. Chao, J. of Phys. Oceanogr., 32, 1599-1620 (2002).

10. A simulation study of the 2003 heat wave in Europe. Nakamura, M., T. Enomoto, and S. Yamane, J. of the Earth Simulator, 2, 55-69 (2005).

11. Potential vorticity and eddy potential enstrophy in the North Atlantic Ocean simulated by a global eddy-resolving model. Nakamura, M. and T. Kagimoto, Dynamics of Atmospheres and Oceans, 41, 28-59 (2006).

12. Transient wave activity and its fluxes in the North Atlantic Ocean simulated by a global eddy-resolving model. Nakamura, M. and T. Kagimoto, Dynamics of Atmospheres and Oceans, 41, 60-84 (2006). and

13. Dominant anomaly patterns in the near-surface baroclinicity and accompanying anomalies in the atmosphere and oceans. Part I: North Atlantic basin. Nakamura, M. and S. Yamane, J. of Climate, 22, 880-904 (2009).

14. Dominant anomaly patterns in the near-surface baroclinicity and accompanying anomalies in the atmosphere and oceans. Part II: North Pacific basin. Nakamura, M. and S. Yamane, J. of Climate, 23, 6445-6467 (2010).

15. Quasigeostrophic transient wave activity flux: Updated climatology and its role in polar vortex anomalies. Nakamura, M., M. Kadota, and S. Yamane, J. of Atmos. Sci., 67, 3164-3189 (2010).

16. Impacts of SST anomalies in the Agulhas Current System on the climate variations in the southern Africa and its vicinity. Nakamura, M., J. of Climate, 25, 1213-1229

17. Greenland Sea surface temperature change and accompanying changes in the northern hemispheric climate. Nakamura, M., J. of Climate, 26, 8576– 8596 (2013)

18. Impacts of the Oyashio temperature front on the regional climate. Nakamura, M. and T. Miyama, J. of Climate, 27, 7861-7873 (2014)

Appendix: Serious flaws in climate "forecasting" models

1. What can the present models tell us about the climate?

Before pointing out a few of the serious flaws in climate simulation models, in defense of those climate researchers who use climate simulation models for various meaningful scientific projects, I want to emphasize here that climate simulation models are fine tools for studying the climate system, so long as the users are aware of the limitations of the models and exercise caution in designing experiments and interpreting their output. In this sense, experiments to study the response of simplified climate systems, such as those generated by the "state-of-the-art" climate simulation models, to major increases in atmospheric carbon dioxide or other greenhouse gases are also interesting and meaningful academic projects that are certainly worth pursuing.

So long as the results of such projects are presented with disclaimers that unambiguously state the extent to which the results can be compared with the real world, I would not have any problem with their use. The models just become useless pieces of junk or worse (worse, in a sense that they can produce gravely misleading output) only when they are used for climate forecasting. All climate simulation models have many details that become fatal flaws when they are used as climate forecasting tools, especially for mid- to long-term (several years and longer) climate variations and changes. These models completely lack some of critically important climate processes and feedbacks and represent some other critically important climate processes and feedbacks in grossly distorted manners to the extent that makes these models totally useless for any meaningful climate prediction.

I myself used to use climate simulation models for scientific studies, not for predictions, and learned about their problems and limitations in the process. I, with help of some of my former colleagues, even modified some details of these models in attempts to improve them by making some of grossly simplified expressions of physical processes in the models less grossly simplified, based on physical theories. So, I know the internal workings of these models very well. I find it rather bewildering that so many climate researchers, many of whom are only "so-called climate researchers" in my not-so-humble opinion, appear to firmly believe in the validity of using these models for climate forecasting. I have observed that many of those climate researchers who firmly believe in the global warming hypothesis view the climate system in a grotesquely simplified fashion: many of them view the climate system as a horizontally homogeneous (no variations in the north-south and east-west directions) or zonally homogeneous (no variations in the east-west direction) system whose dynamics are dominated by the radiative-chemical-convective processes, smooth vertical-north-south motions in the atmosphere, and stationary oceans, and completely neglect the geophysical fluid dynamics, an extremely important and strong factor in the maintenance of the climate and generation of climate variations and changes. So, in their view, those climate simulation models that have ostensible 3 D flows in the atmosphere and oceans may be more than good enough for making climate predictions. They are not good enough. Incidentally, I never liked the term, "model validation", often used by most climate researchers to describe the action of assessing the extent to which the model output resembles the reality. They should use a more honest term such as "model assessment" rather than the disingenuous term, "model validation", and evaluate the model performance in an objective and scientific manner rather than trying to construct narratives that justify the use of these models for climate predictions.

The most obvious and egregious problem is the treatment of incoming solar energy — it is treated as a constant, that is, as a "never changing quantity". It should not require an expert to explain how absurd this is if "climate forecasting" is the aim of the model use. It has been only several decades since we acquired an ability to accurately monitor the incoming solar energy. In these several decades only, it has varied by 1 to 2 Watts per square meters. Is it reasonable to assume that it will not vary any more than that in the next hundred years or longer for forecasting purposes? I would say "No". One can stop here and proclaim that we can never predict climate changes because of our inability to predict changes in the incoming solar energy.

2. The Task of Representing Oceanic Movement

Nevertheless, for the sake of providing some useful pieces of information that can help countervail rampantly bold claims such as "We can correctly predict climate changes that are attributable only to increasing atmospheric carbon dioxide to assess the human impact on the climate", I will describe two problematic aspects of climate simulation models below. I also hear somewhat less bold claims such as "These models can correctly predict at least the sense or direction of climate changes that are attributable only to increasing atmospheric carbon dioxide." I want to point out a simple fact that it is impossible to correctly predict even the sense or direction of the change of a system when the prediction tool lacks and/ or grossly distorts important nonlinear processes, feedbacks in particular, that are present in the actual system. "Mickey Mouse" calculations of oceanic actions (To the Disney: I apologize for using the beloved character' s name in this way but found this slang expression perfect for the nuances that I have in mind. I'd be happy to change the expression to something else if this bothers you.)

Now, let me pound on the first of the two problematic details of climate simulation models mentioned earlier: erroneous representation of actions of oceanic motions that have spatial scales of a few hundred kilometers or smaller. I use the word "erroneous" here to convey a message of "doing something wrong" to the readers, but emphasize that there is nothing anyone can do about it intellectually and that it can be remedied only by increasing the resolution of climate simulation models from the typical 1 ˚ x 1 ˚ or lower to 0. 1 ˚ x 0. 1 ˚ or higher in longitude and latitude. It is simply an issue of limited computer resources and is not an issue of our limited knowledge of the ocean dynamics and thermodynamics. In that sense, it may be eliminated in the future by the development of quantum computers. One might ask "Why do we have to care so much about the oceans when we are talking about the temperature of the atmosphere?" Oceanic flows play extremely important roles in climate. They are much slower than atmospheric flows, but transport extremely large amount of heat due to the large heat storing capacity of water. The oceanic heat storing capacity is so much greater than that of the atmosphere to the extent that one can say that the atmosphere does not store any heat at all in comparison to the ocean. The oceanic flows transport a vast amount of heat all over the world, slowly releasing the heat to the atmosphere in the cooler regions and maintaining relative warmth in those regions. Oceanic flows are driven primarily by the atmosphere, but actually work together with the atmosphere (and the land mass, to be precise) to form the large-scale atmospheric and oceanic circulation patterns and storm generation patterns, thereby forming what is known as "the Earth' s climate". Thus, their variations cause major anomalies in the atmosphere also. An obvious example of regions that greatly benefit from the oceanic heat transport is the western Eurasia. The great Gulf Stream and its downstream branches have kept the western Eurasia relatively warm for centuries. Variations in the Gulf Stream and/or its downstream branches bring climatic anomalies around the North Atlantic basin, not to mention the western Eurasia. Without going into details, I simply state here that they play far more important roles than the atmosphere in generating climatic variations of time scales longer than a few years. Without the oceanic flows, climatic variations would be much simpler than otherwise. Needless to say, it is absolutely vital for any meaningful climate prediction to be made with a reasonably accurate representation of the state and actions of the oceans. In particular, oceanic flows that play important roles in poleward transports of heat and salt and generation of the so-called thermohaline circulation must be represented reasonably accurately, because of very long timescales (tens to hundreds of years) associated with the thermohaline circulation. (A thesis research advisor of mine, Professor Lindzen, whom I greatly respect, may still disagree with me on this issue and may admonish me by saying "How do you know?!" Well, yes, scientific evidence for the importance of the thermohaline circulation is not as robust as the believers would like it to be. Nonetheless, there are many pieces of supporting evidence that have convinced me and many others of its existence and its important roles in the global and regional climate.) This is so because of the thermohaline circulation' s role in one of the most important feedbacks that determine the course of the Earth' s climate, the ice-albedo feedback. Large-scale oceanic flows driven by wind also play important roles in the poleward transport of heat and interact with the ice-albedo feedback, but presumably do not contribute to long-term (beyond, say, the 50year cycle) climate variations and changes as much as the thermohaline circulation. (However, I point out that the large-scale wind-driven flows are not completely separable from the thermohaline circulation in reality and should not be ignored.) Albedo is a fancy term for the planetary reflectivity of the solar radiation. The ice-albedo feedback, in an extremely simplified fashion, works like this: lower temperature in the middle- and high-latitude regions results in more ice and snow cover in the regions, thereby increasing the albedo of the regions, which in turn further lowers the temperature in the regions and increases the ice and snow cover, and vice versa. In other words, it is a vicious cycle that tends to change middle- and high-latitude climate, given a minor perturbation in the region' s temperature and/ or albedo, in the direction nudged by the initial perturbation. This process plays the dominant role in the major warming in high-latitude regions produced by climate simulation models in scenarios of increasing atmospheric carbon dioxide. Without a reasonably accurate representation of the ice-albedo feedback, it is impossible to make any meaningful prediction of climate variations and changes in the middle- and high-latitudes and, thus, the entire planet. One might argue that it wouldn't matter in a very long run, if the carbon dioxide emission continues to increase. It does matter, because the terrestrial and oceanic biogeochemical processes that control the atmospheric carbon dioxide concentration are dependent on the temperature, among other factors, and are highly nonlinear. Needless to say, oceans interact with the atmosphere in complex ways and generate short-, medium-, and long-term variations in weather patterns and climate. These variations, especially those in the middle- and high-latitudes, are actually integral parts of climate changes of much longer time scales. These variations may appear to be cyclical individually but can exert non-cyclical effects on the climate system due to a myriad of feedbacks, an important one of which is the aforementioned ice-albedo feedback, among all the components of the system. The oceanic flows, thus, can exert very strong impacts on variations and changes in climate through their enormous heat transport of their own and also through their strong influence on the atmospheric heat transport. I stress here again that the ocean is one of the most important components of the climate system and that it is absolutely crucial to represent the state and actions of oceans reasonably accurately in climate models if the models are to be used for any meaningful prediction.

Climate researchers used to downplay the significance of interactions between the large-scale atmosphere and oceans in the middle and high latitudes, based on many experiments using coarse-resolution climate simulation models that are hopeless in capturing the atmospheric response to the underlying oceanic temperature structures and analyses of these experiments with mostly linear statistical methods in simple frameworks. They had missed important factors in the large-scale atmosphere-ocean interactions in the extra-tropics (middle and high latitudes) — importance of the spatial position of the westerly jet stream with respect to the areas of large horizontal temperature gradient (contrast) in the oceans and high horizontal resolutions required for capturing effects of the oceanic temperature structures — and grossly underestimated the oceanic impacts on the large-scale atmospheric states. I was not convinced at all by their argument that the extra-tropical atmosphere-ocean interactions are not as significant as those in the tropics and managed to reveal a tiny tip of this huge iceberg in publications 13, 14, 16, 17, and 18 in the list of my publications. I would argue that the interactions that involve areas of oceans with significant downward motions, e. g., Greenland Sea and Labrador Sea, are the most difficult to simulate with models because of the significant roles played by non-hydrostatic dynamics in the oceans that are not calculated in climate models. In the real oceans, the most energetic part of the flows that does the most of mixing and transport of heat and various materials is of small- to medium-scales, roughly in a range from a few kilometers to a few hundred kilometers. This part of the oceanic flows is explicitly calculated and represented reasonably well in ocean simulation models that have a horizontal resolution of 0. 1 ˚ x 0. 1 ˚ or higher in longitude and latitude. It is not, however, calculated in oceanic component of climate simulation models that have been used for predictions, since these models have horizontal resolutions of 0. 5 ˚ x 0. 5 ˚ or coarser. In those models, only the net effects of this important part of the oceanic flows are estimated by parametric representations that derive the net effects from the large-scale state of the ocean that can be explicitly calculated by the models. I hate to say this, because I know well how much of serious efforts have been put into improving these parametric representations (I spent hundreds of hours in vain myself), but all of these parametric representations, even the best of them, are Mickey Mouse mockeries when compared with the reality. In the real oceans, just like in the atmosphere, the smaller-scale flows often tend to counteract the effects of the larger-scale flows. So, small- to medium-scale motions exert ensemble effects on the larger-scale state in such a way that they "tighten" the larger-scale fields of flows, temperature, and salinity when and where the larger-scale flows tend to "loosen" the larger-scale fields. I found this situation occurring roughly half of the time in realistic ocean simulation output. In the oceanic component of the climate prediction models, these smaller-scale flows are required to be "diffusive" on the larger-scale fields and always tend to "loosen" the larger-scale fields. In other words, the models force the smaller-scale flows to be diffusive even when and where the smaller-scale flows should decay and transfer "energy" (strictly speaking, "energy" is not the correct word, but the best choice to help the reader grasp the picture) up to the larger-scale flow and act in an anti-diffusive manner. Of course, since the effects of the smaller-scale flows are anti-diffusive about half of the time, this strictly-diffusive representation of the effects of the smaller-scale flows results in a grotesque distortion of the mixing and transport of momentum, heat, and salt, thereby making the behavior of the climate simulation models utterly unrealistic. Not only is the strictly diffusive qualitative aspect of the representations wrong, but also the quantitative aspect of the representations, the strength of mixing and transport, is an ad hoc "model tuning tool". Parameters that determine the strength of mixing and transport by the smaller-scale flows are selected to "tune" the model without adhering to numbers estimated from observations or high-resolution model output. That is, the selection of the parameter values is a poor engineering process to "make the model appear to work" rather than a scientific process. The models are "tuned" by tinkering around with values of various parameters until the best compromise is obtained. I used to do it myself. It is a necessary and unavoidable procedure and is not a problem so long as the user is aware of its ramifications and is honest about them. But it is a serious and fatal flaw if it is used for climate forecasting/prediction purposes. I used to hear moronic statements such as "The model manages to produce large-scale oceanic states that resemble the observed and, so, should be good enough for climate predictions." from some ocean modelers. It is nonsense. Even if the best compromise so obtained from the tuning looks very close to the observation, the models' behaviors are guaranteed to be grotesquely unrealistic, since the tuning requires other aspects of the models to be extremely distorted in order to counterbalance the distortion associated with the Mickey Mouse representations described above. (The atmospheric modeling community has been well aware that the models must capture the average large-scale state and variations around it in order for them to be useful for any meaningful prediction.) The oceanic component used in those climate models does not generate realistic variability at all, perhaps except for the El Nino in the tropics. Thus, changes and variations in climate predicted by those models are completely meaningless even if they were tuned to reproduce the current climate very accurately. By the way, none of the climate simulation models used for predictions can reproduce the current climate accurately despite the heavy tuning efforts by climate researchers. The models are tuned to produce the "best compromise" and used for various experiments. The root cause of this intractable problem lies on the fundamental requirement for the models to run without failing. It is simply impossible to make these models represent the net effect of the smaller-scale flows in any realistic manner. (I have presented and discussed this issue in publications 6, 7, 8, 9, 11, and 12 in the list of my publications.)

Hopefully, quantum computers will eliminate this problem in the future. However, when the computers become so much more powerful than the present supercomputers and acquire a capability to run super-high resolution climate simulation models, climate researchers will most likely encounter serious difficulty in tuning the models to their liking and in interpreting the simulation results, since the realistic oceanic flows will undoubtedly introduce into the models realistic feedbacks between smaller-scale flows and larger-scale flows in the oceans, and, if a similarly high resolution is used for the atmospheric models as well, also complex interactions between the extra-tropical atmosphere and oceans. Those feedbacks and interactions will generate much higher complexity in slowly- and very-slowly-evolving aspects of the simulated climate and will confuse many of the climate researchers who are used to seeing grotesquely simplified and smoothed behaviors of the climate system in climate simulations conducted thus far. The real or realistically simulated climate system is far more complex than an absurdly simple system simulated by the toys that have been used for climate predictions to date and will be insurmountably difficult to deal with for those naive climate researchers who have zero or very limited understanding of geophysical fluid dynamics. I understand geophysical fluid dynamics just a little, but enough to realize that the dynamics of the atmosphere and oceans are absolutely critical facets of the climate system if one hopes to ever make any meaningful prediction of climate variations and changes.

I want to emphasize, however, that elimination of the problem described above alone WILL NOT make the climate simulation models fit for making meaningful predictions, although it will make the models extremely useful tools to study dynamics of the atmosphere-ocean system, because of a myriad of other important processes that are inadequately represented or ignored in climate simulation models.

3. Water Vapor – the ad hoc treatment of water in the atmosphere

Another major contributor to the predicted major global warming is water vapor, the most important greenhouse gas in the Earth' s atmosphere. Actually, a large portion of the major global warming predicted by those climate prediction toys is attributed to increases in the atmospheric water vapor concentration, not the increased atmospheric carbon dioxide. The atmospheric water vapor plays a crucial role in the climate system in several ways. Most of the people who have studied the global warming issue probably know about its strong greenhouse effect, that is, its role as a radiation absorber/ emitter. Its radiative forcing in the present climate dwarfs that of the atmospheric carbon dioxide. The enhanced warming effect of its changes predicted by the climate simulation models also dwarfs that of the projected carbon dioxide increase. So, predicting changes in the radiative forcing associated with the atmospheric water vapor accurately is essential for any meaningful prediction of climate changes. But the fact is this: all climate simulation models perform poorly in reproducing the atmospheric water vapor and its radiative forcing observed in the current climate. This difficulty stems from, among several major factors, large spatial and temporal variations in the water vapor concentration. Unlike other trace greenhouse gases in the atmosphere, water vapor plays a critical and active role in atmospheric motions of all scales and directions and readily changes its phase from gas to liquid (water) or solid (ice), and vice versa. Energy release/absorption associated with these phase changes is one of the most important factors that drive the climate system. Since water and ice can be removed from the atmosphere by precipitation, accurately simulating atmospheric motions that bring these phase changes is a prerequisite for reasonably accurate simulation of climate, not to mention prediction of climate variations and changes. It is a basic knowledge to anyone who has studied the weather at any level that formation of cloud and precipitation are mostly associated with vertical motions of the atmosphere. The atmospheric water vapor actually plays an active role in these vertical motions as well and is not a passive tracer gas, which complicates the issue further. Needless to say, reasonably accurate computation of the vertical motions and effects of the vertical motions on water vapor is absolutely essential if one hopes to calculate the atmospheric water vapor distribution with reasonable accuracy. Here is an important fact: climate simulation models cannot calculate the vertical motions and only diagnose a miniscule portion of the vertical motions from changes in the large-scale state of the atmosphere which is calculated by the models. In order to allow the models to calculate the vertical motions, we must remove the so-called "hydrostatic approximation" from the climate models, which would require an enormous enhancement in the computational power. It is simply not feasible, probably not even with the advent of quantum computers. So, then, how do they come up with the water vapor distribution in a vertical atmospheric column? The models use various parametric representations that estimate the water vapor profiles from the large-scale atmospheric state that can be calculated by the models. All but one of these parametric representations are ad hoc and rely on major simplifying assumptions that are not justifiable when scrutinized against the reality. They have only a few parameters that can be used to "tune" the performance of the models and utterly unrealistic. I had many discussions on this topic with Professor Nilton Renno during my graduate student days when he was my office mate and became very much intrigued by the ramifications of these parametric representations in climate simulation. Most of these parametric representations employ procedures that adjust the atmospheric water vapor content in a vertical column by using as references certain smooth profiles derived from averaging relative humidity profiles over the globe or over very large areas and over very long periods of time, and have nothing to do with instantaneous physical processes. They do offer a major benefit for scientific research because one wishes to simplify unknown or intractably complex aspects of a system as much as possible in order to focus on the topic of research for scientific investigation. However, they are detrimental for making reliable forecasts or predictions. In the case of increasing atmospheric carbon dioxide, the use of relative humidity as the variable of control target creates artificially forced extra warming arising from the increase in the maximum water vapor content in the atmosphere, as the maximum water vapor that can be contained in the atmosphere increases exponentially with temperature. Now, relative humidity is a percentage ratio of the water vapor contained in the atmosphere to the maximum water vapor amount that can be contained in the atmosphere at a given temperature and pressure. So, if a model were to have the same relative humidity regardless of changes in other aspects of the atmosphere, then, for a minor warming caused by an increased amount of carbon dioxide, the artificially imposed condition on the relative humidity would generate some extra warming due to an increase in the water vapor amount, which would tend to further raise the atmospheric temperature and water vapor content, creating a vicious cycle between the atmospheric water vapor and temperature. This positive feedback itself is not fictitious. But, in climate models, it is artificially enforced to operate without interference by other feedbacks that exist in the real climate system and is very likely to be exaggerated. It is this feedback that generates major increases in the surface temperature when the atmospheric carbon dioxide is increased in climate simulation models. The vertical profile of the atmospheric water vapor produced by these parametric representations do not compare well at all with the observation, except when averages over a large area or over a long period are compared. One might think that the parametric schemes work fine for climate simulation, if such averages compare well with the observation, since the target of the simulation is not the daily forecasts. They do not, because of the nonlinear relationship between the water vapor concentration and its warming effect, which I will discuss a little more in detail later. As far as I know, the only physics-based parametric representation of water vapor content usable in climate simulation models is the so-called "Emanuel scheme", developed by Professor Kerry Emanuel. The scheme is based on solid physical theories and has a number of parameters whose values are constrained to some degree by observational data and/ or theories. So, the Emanuel scheme is far superior to others in theory, but still suffers from limitations that arise from simplifying assumptions and a lack of sufficient observational data to constrain the value of the parameters. I liked it the best among all parametric representation methods available for vertical motions and precipitations in climate models, and attempted to improve it by making one of its parameters ("precipitation efficiency", if I recall it correctly) a variable that depends on the vertical shear in the horizontal wind. I had the modification implemented in the Atmospheric model For the Earth Simulator (AFES) by a colleague of mine at the Earth Simulator Center in 2003 or 2004. The modification, to my disappointment, did not improve the model performance significantly. It was only one of a number of parameters used in the scheme. I suppose that making only one of them a function of the large-scale state was not enough to make a substantial impact on the model' s performance. So, reproducing the observed vertical profiles of the atmospheric water vapor reasonably realistically is an insurmountable task for all climate models, which is to say that the models are not capable of simulating the vertical radiative forcing profiles with reasonable accuracy. The ad hoc treatment of the vertical water vapor distribution is not the only major problem associated with this most important greenhouse gas. Methods to calculate its horizontal distribution are laced with a grave problem also. It is rooted in the treatment of effects of sub-grid (too small to be calculated explicitly in climate models) motions on the water vapor. The climate simulation models can calculate most of the important part of the horizontal wind. This fact makes the atmospheric component of the climate models much better than the oceanic component, as the transports of materials and heat in the atmosphere are explicitly calculated. However, in order for the models to operate without failing, fine structures and sharp boundaries between areas of high and low concentration of materials and temperature must be eliminated, that is, smoothing of all fields are required. This "smoothing" is accomplished by a procedure called "diffusion" that is designed to mimic the effects of sub-grid wind on the concentration fields and forces materials and heat to "seep out" from areas of higher concentration to adjacent areas of lower concentration. The greater is the gradient (difference per unit distance) in the concentration, the larger is the amount of this "seeping out". In the real atmosphere, this diffusion is observed in some cases but not always. The water vapor field, in particular, is often observed to have very sharp boundaries between areas/ layers of high concentration and areas/ layers of low concentration. The diffusion in the models results in artificial spatial smoothing of the water vapor field by artificially moving some water vapor from areas of greater amount to smaller amount. This procedure is designed to conserve the total amount of water vapor, but produces artificial net warming effect via the nonlinear characteristic of greenhouse effect — the smaller the amount of a particular greenhouse gas there is to begin with, the greater is the accompanying additional warming effect due to an addition of some amount of the greenhouse gas. The following analogy may help some readers understand it. Suppose there are two persons living next to each other, one with a saving of $ 1, 000, 000, 000 and the other with a saving of $ 1, 000. The former gives $ 500 to the latter. The shedding of $ 500 is not a major psychological "cooling" to the former, but the addition of $ 500 to the latter is a major psychological "warming". Well, this may not be an apt analogy in a scientific sense but may give some people an easier reference to think about this effect. Isn' t this artificial warming effect via the diffusion augmented in simulation of the "atmospheric carbon dioxide doubling scenario"? I did not get a chance to examine the question myself, but suspect that it is, because of the artificially fixed reference relative humidity. This diffusive smoothing is enforced in the vertical direction as well, producing artificial movement of water vapor from layers of greater amount to adjacent layers of smaller amount. The vertical diffusion of water vapor, however, has very complicated effects on the radiative forcing profile of an atmospheric column and is not clear to me if it is contributing to artificial warming at the surface. Clouds, consisting of immeasurable numbers of very, very small liquid water droplets, also have the greenhouse effect, but have significant cooling effects due to their light scattering properties as well. Clouds' role in the global climate is extremely important and extremely complex, to say the least. Ad hoc representations of clouds in climate models may be the greatest source of uncertainty in climate prediction. A profound fact is that only a very small change, so small that it cannot be measured accurately with the currently available observational devices, in the global cloud characteristics can completely offset the warming effect of the doubled atmospheric carbon dioxide. Two easy examples of such a change is an increase in the area covered by clouds and a decrease in the average size of cloud particles with a concomitant increase in the number of cloud particles, which can occur when the number of cloud condensation nuclei increases. Reasonably accurate representation of cloud is one of the most difficult and important tasks in climate simulations. Accurate simulation of cloud is simply impossible in climate models, since it requires calculations of processes at scales smaller than 1 mm. So, clouds are represented with parametric methods in climate models. Are those methods reasonably accurate? No. If one seriously studies the properties of clouds and processes involved in cloud formation and dissipation and compares them with the cloud treatment in climate models, one would most likely be flabbergasted by the perfunctory treatment of clouds in the models. The parametric representations of clouds are ad hoc and are tuned to produce the average cloud cover that somewhat resembles that seen in the current climate. Can we, or should we, expect them to simulate the cloud coverage and properties in the "doubled atmospheric carbon dioxide" scenario with reasonable accuracy? No. I am aware that some sophisticated cloud models have been developed in recent years. Unfortunately, however, regardless of the degree of sophistication they achieve, the net effect of clouds in the future climate cannot be predicted meaningfully without knowing how the presence of super tiny particles in the atmosphere that are essential to cloud formation changes in the future, which is practically impossible.

Closing Remarks

The take-home message from the above discussion is this: all climate simulation models, even those with the best parametric representation scheme for convective motions and cloud, suffer from a very large degree of arbitrariness in the representation of processes that determine the atmospheric water vapor and cloud fields. Since the climate models are tuned arbitrarily to produce the time-averaged atmospheric water vapor field and cloud coverage that best resemble the observed climatological ones, but still fail to reproduce the observed fields (especially miserably when the instantaneous field and temporal variability are examined), there is no reason to trust their predictions/ forecasts. With values of parameters that are supposed to represent many complex processes being held constant, many nonlinear processes in the real climate system are absent or grossly distorted in the models. It is a delusion to believe that simulation models that lack important nonlinear processes in the real climate system can predict at least the sense or direction of the climate change correctly.