A Review of the AR6 First Draft of IPCC Working Group I (WG1) Report

by

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I have two overarching comments on the WG1 draft report.

First, the terminology *"physical climate system"* is actually inaccurate as biogeochemical components of the climate system are included. One can discuss the physical comments of the climate system, but it is not correct to imply there is also a *"biological climate system".* Indeed, *"climate system"* is defined by the American Meteorological Society as *"the system, consisting of the atmosphere, hydrosphere, lithosphere, and biosphere, determining the earth's climate as the result of mutual interactions and responses to external influences (forcing)"* [http://glossary.ametsoc.org/wiki/Climate_system].

Thus the WG1 report is actually a report on the entire climate system. The header of 1.2.1 in Chapter 1, as one example, is not appropriate.

My recommendation is that the terminology *"physical climate system"* be changed to *"climate system"* everywhere in the report.

This inclusive view was also adopted in these assessment reports

National Research Council, 2005: Radiative forcing of climate change: Expanding the concept and addressing uncertainties. Committee on Radiative Forcing Effects on Climate Change, Climate Research Committee, Board on Atmospheric Sciences and Climate, Division on Earth and Life Studies, The National Academies Press, Washington, D.C., 208 pp. http://www.nap.edu/openbook/0309095069/html/

Kabat, P., Claussen, M., Dirmeyer, P.A., J.H.C. Gash, L. Bravo de Guenni, M. Meybeck, R.A. Pielke Sr., C.J. Vorosmarty, R.W.A. Hutjes, and S. Lutkemeier, Editors, 2004: Vegetation, water, humans and the climate: A new perspective on an interactive system. Springer, Berlin, Global Change - The IGBP Series, 566 pp. http://www.springer.com/us/book/9783642623738

but was not recognized even in the subsequent IPCC reports.

Secondly, in terms of the framing of the report, the inclusive approach would be to start with what is the spectrum of risks to society and the environment, and where does the human role in the climate system fit in. As we discussed in

Pielke Sr., R.A., R. Wilby, D. Niyogi, F. Hossain, K. Dairaku, J. Adegoke, G. Kallos, T. Seastedt, and K. Suding, 2012: Dealing with complexity and extreme events using a bottom-up, resource-based vulnerability perspective. Extreme Events and Natural Hazards: The Complexity Perspective Geophysical Monograph Series 196 © 2012. American Geophysical Union. All Rights Reserved. 10.1029/2011GM001086. http://pielkeclimatesci.files.wordpress.com/2012/10/r-3651.pdf and in the Preface to

Pielke Sr, R.A., Editor in Chief., 2013: Climate Vulnerability, Understanding and Addressing Threats to Essential Resources, 1st Edition. J. Adegoke, F. Hossain, G. Kallos, D. Niyoki, T. Seastedt, K. Suding, C. Wright, Eds., Academic Press, 1570 pp. http://pielkeclimatesci.files.wordpress.com/2013/05/b-18preface.pdf

there are two approaches – outcome vulnerability and contextual vulnerability. The former starts with a WG1 approach but, as a result, eliminates (at least certainly makes more difficult) a balanced assessment of risk. With contextual vulnerability, as we write in Pielke Sr et al 2012

"We discuss the adoption of a bottom-up, resource-based vulnerability approach in evaluating the effect of climate and other environmental and societal threats to societally critical resources. This vulnerability concept requires the determination of the major threats to local and regional water, food, energy, human health, and ecosystem function resources from extreme events including those from climate but also from other social and environmental issues. After these threats are identified for each resource, then the relative risks can be compared with other risks in order to adopt optimal preferred mitigation/adaptation strategies. This is a more inclusive way of assessing risks, including from climate variability and climate change, than using the outcome vulnerability approach adopted by the Intergovernmental Panel on Climate Change (IPCC). A contextual vulnerability assessment using the bottom-up, resource-based framework is a more inclusive approach for policy makers to adopt effective mitigation and adaptation methodologies to deal with the complexity of the spectrum of social and environmental extreme events that will occur in the coming decades as the range of threats are assessed, beyond just the focus on CO2 and a few other greenhouse gases as emphasized in the IPCC assessments."

These two approaches to vulnerability assessments should be discussed and both included in the report.

FOR CHAPTER 1

As Mike Hulme of the University of East Anglia writes of two views of the climate issue:

1) "*The overwhelming scientific evidence tells us that human greenhouse gas emissions are resulting in climate changes that cannot be explained by natural causes. Climate change is real, we are causing it, and it is happening right now."*

Or

2) "*The overwhelming scientific evidence tells us that human greenhouse gas emissions, land use changes and aerosol pollution are all contributing to regional and global climate changes, which exacerbate the changes and variability in climates brought about by natural causes. Because humans are contributing to climate change, it is happening now and in the future for a much more complex set of reasons than in previous human history."*

As Mike Hulme writes *"….these two different provocations – two different framings of climate change – open up the possibility of very different forms of public and policy engagement with the issue. They shape the response."* http://theconversation.edu.au/youve-been-framed-six-new-ways-tounderstand-climate-change-2119

The IPCC report focuses on the first view but does not present evidence and reasoning as to what the second view is essentially ignored.

FOR CHAPTER 1

Past IPCC WG1 reports did not highlight the hypothesis testing aspect of science e.g., see https://www.sciencebuddies.org/science-fair-projects/science-fair/steps-of-the-scientific-method

Ask a Question

Do Background Research

Construct a Hypothesis

Test Your Hypothesis by Doing an Experiment

Analyze Your Data and Draw a Conclusion

Communicate Your Results

As the IAC Review of the IPCC report in the section IPCC's Evaluation of Evidence and Treatment of Uncertainty http://reviewipcc.interacademycouncil.net/report/Chapter%203%20-%20IPCC%E2%80%99s%20Evaluation%20of%20Evidence%20and%20Treatment%20of%20Uncertainty.pdf wrote with respect to AR4

The IPCC uncertainty guidance provides a good starting point for characterizing uncertainty in the assessment reports. However, the guidance was not consistently followed in the fourth assessment, leading to unnecessary errors. For example, authors reported high confidence in statements for which there is little evidence, such as the widely-quoted statement that agricultural yields in Africa might decline by up to 50 percent by 2020. Moreover, the guidance was often applied to statements that are so vague they cannot be falsified. In these cases the impression was often left, quite incorrectly, that a substantive finding was being presented."

I do not see this shortcoming being adequately remedied in AR5, but encourage it be done in AR6.

There are three hypotheses that can be focused on with respect to the human role in the climate system. These are

Hypothesis 1: Human influence on climate variability and change is of minimal importance, and natural causes dominate climate variations and changes on all time scales. In coming decades, the human influence will continue to be minimal.

Hypothesis 2: Although the natural causes of climate variations and changes are undoubtedly important, the human influences are significant and involve a diverse range of first- order climate forcings, including, but not limited to, the human input of carbon dioxide (CO_2). Most, if not all, of these human influences on regional and global climate will continue to be of concern during the coming decades.

Hypothesis 3: Although the natural causes of climate variations and changes are undoubtedly important, the human influences are significant and are dominated by the emissions into the atmosphere of greenhouse gases, the most important of which is CO_2. The adverse impact of these gases on regional and global climate constitutes the primary climate issue for the coming decades.

These hypotheses are mutually exclusive. Thus, the accumulated evidence can only provide support for one of these hypotheses. The question is which one?

Hypotheses 2 and 3 are two different oppositional views to hypothesis 1. Hypotheses 2a and 2b both agree that human impacts on climate variations and changes are significant. They differ, however, with respect to which human climate forcings are important.

The hypotheses can be tested with respect to climate effects on important social and environmental resources such as drought, tropical cyclone intensity and so forth.

Model skill can also be test using the hypothesis approach. Specially,

<u>The Framing Hypothesis</u>

Knowledge of CO_2 emissions into the atmosphere and resultant global averaged surface temperature anomaly are sufficient as the primary metrics to generate accurate and meaningful regional projections of changes in regional climate statistics.

This hypothesis claims that the accuracy of climate forecasts of changes in regional climate statistics emerges at time periods beyond a decade, when greenhouse gas emissions dominate over other human forcings, natural variability, and influences of initial value conditions. The hypothesis assumes that changes in climate are dominated by atmospheric emissions of greenhouse gases, of which CO_2 is the most important.

If this hypothesis is rejected, then multidecadal model forecasts incorporating detailed initial value conditions seeking to predict changes in regional climate statistics set an upper bound on the accuracy of climate projections based primarily on greenhouse gas emissions. According to this latter view, successful models must account for all important human forcings—including land surface change and management—and accurately treat natural climate variations on multidecadal time scales. If the Framing Hypothesis is rejected, these requirements significantly complicate the task of prediction.

Testing the hypotheses must be accomplished by using “hindcast” simulations that attempt to reproduce past climate behavior over multidecadal time scales. The simulations should be assessed by their ability to predict not just globally averaged metrics but changes in atmospheric and ocean circulation patterns and other regional phenomena (i.e., changes in regional climate statistics).

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FOR CHAPTER 3

There needs to be more discussion and assessment of the role of spatially heterogeneous human climate forcings in the report.

As written in

National Research Council, 2005: Radiative forcing of climate change: Expanding the concept and addressing uncertainties. Committee on Radiative Forcing Effects on Climate Change, Climate Research Committee, Board on Atmospheric Sciences and Climate, Division on Earth and Life Studies, The National Academies Press, Washington, D.C., 208 pp. https://www.nap.edu/read/11175/chapter/2

"*Regional variations in radiative forcing may have important regional and global climatic implications that are not resolved by the concept of global mean radiative forcing. Tropospheric aerosols and landscape changes have particularly heterogeneous forcings. To date, there have been only limited studies of regional radiative forcing and response.* "

As an example of how important this issue is, in the paper

Matsui, T., and R.A. Pielke Sr., 2006: Measurement-based estimation of the spatial gradient of aerosol radiative forcing. Geophys. Res. Letts., 33, L11813, doi:10.1029/2006GL025974. https://pielkeclimatesci.files.wordpress.com/2009/10/r-312.pdf

"Unlike GHG, aerosols have much greater spatial heterogeneity in their radiative forcing. The heterogeneous diabatic heating can modulate the gradient in horizontal pressure field and atmospheric circulations, thus altering the regional climate"

In that paper the spatial gradients of diabatic heating from aerosols was much more than an order of magnitude larger than that due to human greenhouse gas forcing. A similar large effect should be expected from land use change/land management.

Thus, this issue of spatial heterogeneity of human climate forcings needs to be better assessed. It is regional circulation patterns (e.g. ENSO, NAO, PDO, etc) that affect drought, flood and other weather patterns much more than that due to a global average surface temperature anomaly.

FOR CHAPTER 7

A self-regulation mechanism has been identified in the climate system, which to my knowledge, is properly assessed by the IPCC WG1 report. It is observed that the temperatures at 500 hPa are almost always bracketed between -42C and -3C in the northern hemisphere. The cold limit occurs despite these cold temperatures being reached in November even before the solstice is reached. On the warm limit, despite air being situated at times over hot dry tropical deserts, such as the Sahara, it does not get warmer than that value. The only exception is very limited, and is found in hurricanes where it can exceed 0C.

500 hPa is used as this is well recognized in synoptic meteorology as the best standard pressure level to assess synoptic weather patterns including extratropical cyclone development.

We investigated this issue in these papers

Chase, T.N., B. Herman, R.A. Pielke Sr., X. Zeng, and M. Leuthold, 2002: A proposed mechanism for the regulation of minimum midtropospheric temperatures in the Arctic. J. Geophys. Res., 107(D14), 10.10291/2001JD001425. http://pielkeclimatesci.wordpress.com/files/2009/10/r-246.pdf

Tsukernik, M., T.N. Chase, M.C. Serreze, R.G. Barry, R. Pielke Sr., B. Herman, and X. Zeng, 2004: On the regulation of minimum mid-tropospheric temperatures in the Arctic. Geophys. Res. Letts., 31, L06112, doi:10.1029/2003GL018831. http://pielkeclimatesci.wordpress.com/files/2009/10/r-270.pdf

Herman, B., M. Barlage, T.N. Chase, and R.A. Pielke Sr., 2008: Update on a proposed mechanism for the regulation of minimum mid-tropospheric and surface temperatures in the Arctic and Antarctic. J. Geophys. Res.-Atmos., 113, D24101, doi:10.1029/2008JD009799. http://pielkeclimatesci.wordpress.com/files/2009/10/r-339.pdf

Chase, T. N., B. M. Herman, R. A. Pielke Sr., 2015: Bracketing mid-tropospheric temperatures in the Northern Hemisphere: An observational study 1979 - 2013. J. Climatol. Wea. For., 3,2, http://dx.doi.org/10.4172/2332-2594.1000131.

The IPCC WG1 should report on this issue, as it provides a negative feedback on the atmosphere warming due to added greenhouse gases. Unless 500 hPa can warm above this cold limit, for example, extratropical cyclones and other polar front dynamics will not change much.

FOR CHAPTER 9

In assessing ocean heat content changes, in addition to presenting as zetajoules, it should be shown in terms of rate of heating (i.e. in Watts per meter squared). As I discussed in

Ellis et al. 1978: The annual variation in the global heat balance of the Earth. J. Geophys. Res., 83, 1958-1962. https://pielkeclimatesci.files.wordpress.com/2010/12/ellis-et-al-jgr-1978.pdf

Pielke Sr., R.A., 2003: Heat storage within the Earth system. Bull. Amer. Meteor. Soc., 84, 331-335. https://pielkeclimatesci.files.wordpress.com/2009/10/r-247.pdf

This flux can be used to estimate the top of the atmosphere radiative imbalance. In addition to presenting the observed data, the model predictions of this flux of heat into the ocean should be presented.

Comment on land portion of surface temperature data

While the ocean heat change should be the primary metric to assess climate system heat changes (global warming and cooling), to the extent that the global average surface temperature is used, there needs to be a more thorough discussion of uncertainties which include

1. Height of the temperature data from the observing sites. In light winds at night, trends vary depending on height in the surface layer [Lin, X., R.A. Pielke Sr., R. Mahmood, C.A. Fiebrich, and R. Aiken, 2015: Observational evidence of temperature trends at two levels in the surface layer. Atmos. Chem. Phys. Discuss., 15, 24695–24726, doi:10.5194/acpd-15-24695-2015 https://www.atmos-chem-phys.net/16/827/2016/acp-16-827-2016-discussion.html
2. Concurrent trends in absolute humidity can affect the dry bulb temperature trend. The dry bulb is only part of the heat per unit volume (of kg) in the surface air, as discussed in Pielke Sr., R.A., C. Davey, and J. Morgan, 2004: Assessing "global warming" with surface heat content. Eos, 85, No. 21, 210-211. https://pielkeclimatesci.files.wordpress.com/2009/10/r-290.pdf A concurrent long-term drying trend, for example, such as from land use change can result in elevated dry bulb temperatures even though the actual heat in the air has not changed or even fallen. A trend of increasing absolute moisture in the air (such as due to irrigation) can increase the trend in warming that is interpreted by just using the dry bulb temperature.
3. The use of a global average surface anomaly to diagnose global warming neglects that outgoing surface temperature depends exponentially on the actual temperature to the 4^{th} power. Thus an increase of 1C has more of an effect at warming surface temperatures. This does affect quantitatively the actual rate of radiative feedback. This issue is discussed in Pielke Sr., R.A., C. Davey, D. Niyogi, S. Fall, J. Steinweg-Woods, K. Hubbard, X. Lin, M. Cai, Y.-K. Lim, H. Li, J. Nielsen-Gammon, K. Gallo, R. Hale, R. Mahmood, S. Foster, R.T. McNider, and P. Blanken, 2007: Unresolved issues with the assessment of multi-decadal global land surface temperature trends. J. Geophys. Res., 112, D24S08, doi:10.1029/2006JD008229. https://pielkeclimatesci.files.wordpress.com/2009/10/r-321.pdf

FOR CHAPTER 12

The report provides extensive discussion and results from downscaled multidecadal climate projections. Yet, there is essentially no skill in predicting changes in regional climate statistics when the models are run in hindcast for the last few decades. Example of papers who document this inability were reported on in

Pielke Sr., R.A., R. Wilby, D. Niyogi, F. Hossain, K. Dairaku, J. Adegoke, G. Kallos, T. Seastedt, and K. Suding, 2012: Dealing with complexity and extreme events using a bottom-up, resource-based vulnerability perspective. Extreme Events and Natural Hazards: The Complexity Perspective Geophysical Monograph Series 196 © 2012. American Geophysical Union. All Rights Reserved. 10.1029/2011GM001086. http://pielkeclimatesci.files.wordpress.com/2012/10/r-3651.pdf

Indeed, as discussed in

Pielke Sr., R.A., and R.L. Wilby, 2012: Regional climate downscaling – what's the point? Eos Forum, 93, No. 5, 52-53, doi:10.1029/2012EO050008. http://pielkeclimatesci.files.wordpress.com/2012/02/r-361.pdf

there are four types of downscaling. The

Type 1 downscaling is used for short-term, numerical weather prediction. In dynamic type 1 downscaling the regional model includes initial conditions from observations. In type 1 statistical downscaling the regression relationships are developed from observed data and the type 1 dynamic model predictions.

Type 2 dynamic downscaling refers to regional weather (or climate) simulations [e.g., Feser et al., 2011] in which the regional model's initial atmospheric conditions are forgotten (i.e., the predictions do not depend on the specific initial conditions) but results still depend on the lateral boundary conditions from a global numerical weather prediction where initial observed atmospheric conditions are not yet forgotten or are from a global reanalysis. Type 2 statistical downscaling uses the regression relationships developed for type 1 statistical downscaling except that the input variables are from the type 2 weather (or climate) simulation.

Downscaling from reanalysis products (type 2 downscaling) defines the maximum forecast skill that is achievable with type 3 and type 4 downscaling.

Type 3 dynamic downscaling takes lateral boundary conditions from a global model prediction forced by specified real world surface boundary conditions such as seasonal weather predictions based on observed sea surface temperatures, but the initial observed atmospheric conditions in the global model are forgotten. Type 3 statistical downscaling uses the regression relationships developed for type 1 statistical downscaling except using the variables from the global model prediction forced by specified real-world surface boundary conditions.

Type 4 dynamic downscaling takes lateral boundary conditions from an Earth system model in which coupled interactions among the atmosphere, ocean, biosphere, and cryosphere are predicted Other than terrain, all other components of the climate system are calculated by the model except for human forcings, including greenhouse gas emissions scenarios, which are prescribed. Type 4 statistical downscaling uses transfer functions developed for the present climate, fed with large scale atmospheric information taken from Earth system models representing future climate conditions. It is assumed that statistical relationships between real-world surface observations and large-scale weather patterns will not change. Type 4 downscaling has practical value but with the very important caveat that it should be used for model sensitivity experiments and not as predictions. Type 4 downscaling is what is reported on in the IPCC WG1 report.

Because real-world observational constraints diminish from type 1 to type 4 downscaling, uncertainty grows as more climate variables must be predicted by models rather than obtained from observations. Thus, the regional projections presented in the IPCC WG1 report are based on regional mulitdecadal climate predictions which have little if any skill.

The further tests to assess skill should include testing the following two hypotheses. The first argues that the accuracy of climate forecasts emerges only at time periods beyond a decade, when greenhouse gas emissions dominate over other human forcings, natural variability, and influences of initial value conditions. The hypothesis assumes that changes in climate are dominated by atmospheric emissions of greenhouse gases, of which CO2 is the most important. It represents the stance of the draft WG1 IPCC report.

A second hypothesis is that multidecadal forecasts incorporating detailed initial value conditions and regional variation set an upper bound on the accuracy of climate projections based primarily on greenhouse gas emissions. According to that view, successful models must account for all important human forcings—including land surface change and management—and accurately treat natural climate variations on multidecadal time scales. Those requirements significantly complicate the task of prediction.

Testing the hypotheses must be accomplished by using “hindcast” simulations that attempt to reproduce past climate behavior over multidecadal time scales. The simulations should be assessed by their ability to predict not just globally averaged metrics but changes in atmospheric and ocean circulation patterns and other regional phenomena.

In the last IPCC WG1 report this was accomplished and presented in two separate chapters. Chapter 11 is titled Near-term climate change: projections and predictability” while Chapter 12 is titled “Long term climate change: projections, commitments and irreversibility”. Annex 1 “Atlas of global and regional climate projections” presents results based on Chapter 12.

However, the literature clearly shows that Type 4 downscaling such as in Chapter 12 and the Annex cannot be any more skillful than shown in Chapter 11. The AR5 WG1 report ignored the implications of Chapter 11 and this mistake should not be perpetuated in AR6 WG1. To assume that skill, somehow, emerges for time periods longer than a decade using Type 4 downscaling (or from the global models themselves) is not supported by scientific evidence.

FOR CHAPTER 12

The term “resolution” is used erroneously throughout the entire IPCC WG1 report. What is really meant is “grid increment”. The reason this is important is that in utilizing output from the models the actual spatial resolution is less than implied by the use of “resolution” as used in the report. While the modelers themselves know this is jargon shorthand for grid increment, users of the information will not generally know this.

This issue is discussed in these articles.

Pielke, R.A., 1991: A recommended specific definition of "resolution", Bull. Amer. Meteor. Soc., 12, 1914. http://pielkeclimatesci.files.wordpress.com/2009/09/nt-27.pdf

Pielke Sr., R.A., 2001: Further comments on "The differentiation between grid spacing and resolution and their application to numerical modeling''. Bull. Amer. Meteor. Soc., 82, 699 http://pielkeclimatesci.wordpress.com/files/2009/10/r-241.pdf

Laprise, R., 1992: The resolution of global spectral models. Bull. Amer. Meteor. Soc., 9, 1453-1454. https://pielkeclimatesci.files.wordpress.com/2009/09/nt-27a.pdf

Sea Ice

While there is extensive discussion of sea ice areal extent and change over time in the WG1 report, there is no quantification of seasonal start of spring melt and the start of the fall freeze up. This weblog post is the only work I am aware of on this subject.

Temporal Trends In Arctic and Antarctic Sea Ice Maximum and Minimum Areal Extents
https://pielkeclimatesci.wordpress.com/2009/09/09/temporal-trends-in-arctic-and-antarctic-sea-ice-maximum-and-minimum-areal-extents/

The conclusion was (up to 2007)

The time of occurrence of the maximum and minimum sea ice coverage in the Arctic showed slight trends towards occurring earlier in the year, although not significant. In the Southern Hemisphere, the trends were smaller and also not significant, but the time of ice maximum was becoming later, contrary to the other three trends.

This analysis should be extended up to the present.