Summary of the Climate Dialogue on regional modelling

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Are regional models ready for prime time?

Climate models are vital tools for helping us understand long-term changes in the global climate system. Global climate projections for 2050 and 2100 have, amongst other purposes, been used to inform potential mitigation policies, i.e. to get a sense of how the climate system would be expected to evolve in response to different emission scenarios. The next logical step is to use models for adaptation as well, which requires a more regional approach. Stakeholders have an almost insatiable demand for future regional climate projections. These demands are driven by practical considerations related to freshwater resources, ecosystems and water related infrastructure, which are vulnerable to climate change.

Hundreds of studies have been published in the literature presenting regional projections of climate change for 2050 and 2100. The output of such model simulations is then used by the climate impacts community to investigate what potential consequences could be expected in the future, depending on the emission scenario. However several recent studies cast doubt whether global model output is realistic on a regional scale, even in hindcast[i].

The question in this dialogue was whether regional climate models are ready to be used for regional projections? Is the information reliable enough to use for medium to long term adaptation planning? Or should we adopt a different approach?

The following three participants joined this discussion: Bart van den Hurk of KNMI in The Netherlands who is actively involved in the KNMI regional climate scenario's, Jason Evans from the University of Newcastle, Australia, who is coordinator of Coordinated Regional Climate Downscaling Experiment (CORDEX) and Roger Pielke Sr. who through his research articles and his weblog Climate Science is well known for his outspoken views on climate modelling. For clarity, both Evans and Van den Hurk are actively involved in regional climate scenarios (decades into the future), Pielke is not.

For personal reasons Evans wasn't able to participate actively in the dialogue after the guest blogs and the first comments were published.

The Climate Dialogue

The key issue in this dialogue was whether regional climate scenarios for 2050 or 2100 are "good" or "reliable" enough to be used for e.g. infrastructural planning decisions on a regional and multidecadal scale. For example should we increase dikes along our rivers if climate projections indicate that extreme rainfall will likely increase in the coming decades?

Pielke's answer to this question is "no". Pielke wrote that "by presenting the global, regional, and local climate projections as robust (skillful) to the impacts and policy communities we are misleading them on the actual level of our scientific capability." And also (in his guest blog): "using the global climate model projections, downscaled or not, to provide regional and local impact assessment on multi-decadal time scales is not an effective use of money and other resources." PBL | 15

Evans has a different opinion as expressed in this comment: "In the end, climate models are our best tools for understanding how the climate system works. As climate scientists, we will continue to use these tools to improve our understanding of the climate system, and use our understanding of the system to improve these tools. Part of this includes exploring the impact of changing levels of

greenhouse gases on the climate by creating future climate projections." And in another comment he wrote: "So RCMs [Regional Climate Models] are not perfect but in many cases are good enough to be useful." Van den Hurk agreed with Evans by writing in his guest blog that: "RCMs can be of great help, not necessarily by providing reliable predictions, but also by supporting evidence about the salience of planned measures or policies."

So Evans and Van den Hurk are more positive than Pielke with respect to the central question in the title "Are regional climate models ready for prime time?" All discussants agree that models still have (a lot of) imperfections, also when simulating the past. For Evans and Van den Hurk model projections are nevertheless useful, for Pielke they are useless and he prefers other approaches.

Skill

A returning remark of Pielke was that models need to show "skill" in hindcast before it makes sense to use future projections. Skill is defined by Pielke as "an ability to produce model results for climate variables that are at least as accurate as achieved from reanalyses." where reanalysis data consists of a combination of observations and model output. This is often necessary to check model output against, because observations alone are not detailed enough to validate the models. Pielke continues: "The skill needs to be tested using hindcast runs against: i) the average climate over a multi-decadal time period and ii) CHANGES in the average climate over this time period." Pielke claimed models don't have this skill even back in time, so projecting them to the future makes no sense to him.

Van den Hurk didn't use this definition of skill. He wrote: "I don't know how to assess skill of decadal trends, and so do not require models to reproduce the past trends. A measure of skill of predictions thus should be that the observed climate trends fall within the range of an ensemble[ii] of hindcast predictions."

So the definition of Pielke is much stricter than that of Van den Hurk. Actually when asked about Pielke's definition, Van den Hurk agreed that models are not yet up to that task: "For predictions at the decadal time scale, as Roger identifies in his Type 4 application [i.e. climate scenarios], assessment of skill is actually barely possible. Even a perfect model can deviate significantly from past observed trends or changes, just because the physical system allows variability at decadal time scales; the climate and its trend that we're experiencing is just one of the many climates that we could have had."

So they disagreed on the operational definition of skill, but as Van den Hurk wrote: "I think we should conclude that we agree on the fact that on shorter (decadal) time scales GCM/RCM [Global Climate Models/Regional Climate Models, red] have shown little regional skill to predict/hindcast observed changes. But that does not necessarily imply that they are useless or have no skill on longer time scales." and "The purpose of a projection is to depict the possible (plausible) evolution of the system. To my opinion, the process of decision making is not dependent on the (quantitative) predictions provided by climate models, but by the plausibility that the future will bring situations to which the current system is not well adapted."

Pielke agreed "with the need to assess what is plausible", but said that the scientific community should be honest about the possibility that "the scenarios that you provide from PBL | 16

the downscaled models may fall outside the range of what actually could occur. If one insists, they could be included, but there should be a disclaimer given to the policymakers that these regional forecasts have not shown skill when tested in a hindcast mode."

Top down versus bottom up

For Pielke a more robust approach is to use historical, paleo-record and worst case sequences of climate events. "Added to this list can be perturbation scenarios that start with regional reanalysis (e.g. such as by arbitrarily adding a 1C increase in minimum temperature in the winter, a 10 day increase in the growing season, a doubling of major hurricane landfalls on the Florida coast, etc). There is no need to run the multi-decadal global and regional climate projections to achieve these realistic (plausible) scenarios." Pielke calls his approach the 'bottom up vulnerability approach' and contrasts this with the IPCC approach of first generating projections and then using these projections as input for impact models. This is what he would call the top down approach.

On the usefulness of the vulnerability approach Van den Hurk fully agreed with Pielke: "I fully embrace Pielke's plea for a system analysis that takes the vulnerability of the system as a starting point." but he also stressed that "from this kind of analyses, frequently the stakeholders are the participants that ask for support from (regional) climate models to illustrate the possible alternative future conditions." Van den Hurk thus argues that both approaches are complementary.

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[i] van Oldenborgh, G. J., Reyes, F. D., Drijfhout, S. S., & Hawkins, E. (2013). Reliability of regional climate model trends. Environmental Research Letters,8(1), 014055.
Anagnostopoulos, G. G., Koutsoyiannis, D., Christofides, A., Efstratiadis, A., & Mamassis, N. (2010). A comparison of local and aggregated climate model outputs with observed data. Hydrological Sciences Journal–Journal des Sciences Hydrologiques, 55(7), 1094-1110.
Stephens, G. L., L'Ecuyer, T., Forbes, R., Gettlemen, A., Golaz, J. C., Bodas-Salcedo, A., ... & Haynes, J. (2010). Dreary state of precipitation in global models. Journal of Geophysical Research: Atmospheres (1984–2012),115(D24).
Bhend, J., & Whetton, P. (2013). Consistency of simulated and observed regional changes in temperature, sea level pressure and precipitation. Climatic change, 118(3-4), 799-810.

[ii] An ensemble is a group of model simulations. This is done to get an idea of the average trend of the models under a given scenario.