Questions & Answers Part 2

Please type your questions in the Question Box. We will try our best to get to all your questions. If we don't, feel free to email Alexander Ruane (alexander.c.ruane@nasa.gov) or Brock Blevins (brock.blevins@nasa.gov).

Question 1: Could you elaborate more about the NOAA heat index? Was the threshold > 41?
Answer 1: The NOAA Heat Index is a combination of temperature and relative humidity, for example capturing that warm temperatures with high humidity may feel hotter even than higher temperatures with low humidity. The NOAA Heat Index has been connected with physiological responses, although the exact thresholds of key responses is still the subject of some research. HI>41C is used here; some National Weather Service locations use HI>39C instead – potentially due to local tolerance and expectations. Further research is ongoing to connect this (and similar metrics) to specific activities and vulnerable populations.

Question 2: I intend to use the CMIP6 SSP-RCPs to explore future water and food scenarios. Where and how can I get some training, resources and working knowledge on selecting and downscaling (statistical or dynamic) CMIP6 climate pathways and GCMs?
Answer 2: CMIP6 SSP-RCPs are a good choice for the most up-to-date projections and scenarios. This training is intended to provide you with the types of characteristics you might look for and the questions you might ask to understand which projection set is most applicable. We note several projections sets in the call, but acknowledge that there are many more under production and others are available. We cannot evaluate them all and cannot know your particular context (e.g., resources available, adaptations or risk management planned, decisions informed), but hopefully the approaches described here will make the process of selection more clear. ISIMIP and AGMIP are relevant to those apps.

Question 3: Do we need to bias adjust the dataset, even if we are using the latest NEX-GDDP CMIP6 datasets? If the same is needed, are there any free of cost softwares for bias adjustments?

Answer 3: NEX-GDDP already has included bias-adjustment, so you would not need to perform additional bias adjustment unless you had reason to believe that you could improve upon what NEX-GDDP has already done (e.g., if you have a new observational dataset that provides critical local information). Tools exist, Climate 4R, for example. ISIMIP has tools too.

Question 4: Are these packages for different impact modeling freely available?
Answer 4: Communities like ISIMIP and the Agricultural Model Intercomparison and Improvement Project (AgMIP) foster applications of climate projection sets using impact models. Many of these models are freely available but require training and expert application.

Question 5: As of today, which is more advantageous to use between CMIP5 CORDEX (high resolution) and new CMIP6 GCM (low resolution) for regional impacts/vulnerability/adaptation?
Answer 5: *This depends on your application*. Of course we are looking forward to seeing CORDEX simulations using CMIP6 outputs, but in the meantime an application would need to weigh the importance of high-resolution information in your domain and decision context. It would also be useful to examine differences between CMIP5 and CMIP6 projections in your region to see how model improvements have changed the key messages in climate projection for your region of interest. It can take longer to run the dynamically downscaled approaches. Comparing the 2 in your region will be advantageous.

Question 6: Some of the newest generation of models from CMIP6 are 'too hot' and project climate warming in response to carbon dioxide emissions that might be larger than that supported by other evidence. Has there been any work to improve projections to be more consistent with AR6 assessments?
Answer 6: In this training we discuss how we might use subsets of the climate model ensemble to reflect uncertainties in climate responses for the so-called 'hot' models.

Question 7: For multiple models, how is the year of crossing GWL (Global Warming Levels) established? Is a multi-model ensemble used to determine GWL? Year of crossing a GWL (eg. 1.5 degC warming) may be different for each GCM.
Answer 7: The questioner is correct in pointing out that each ESM and scenario will have a particular crossing point for a given GWL. We typically use a moving window of

at least 20 years to understand transient global temperatures (rather than selecting the first year where temperatures exceed a GWL). CMIP6 and IPCC authors have published tables on crossing points for each ESM and scenario (see Hauser et al. 2019, doi:10.5281/zenodo.3591807). Once crossing points have been determined for each ESM/scenario, it is possible to create ensembles that represent each GWL.

Question 8: Kindly state the four CMIP6 SSP-RCP scenarios that are available in NASA Earth Exchange (NEX) GCMs.
Answer 8: Many NEX-GDDP-CMIP6 models provide climate data for the SSP1-2.6, SSP2-4.5, SSP3-7.0 and SSP5-8.5 scenarios, but please note that not every ESM in NEX provides data for all four scenarios; certain ESMs are only available for high-priority scenarios.

Question 9: Among GCMs, RCMs, CORDEXs, which one is the best for impact modeling and should we include all those models in an ensemble to produce robust scenarios?
Answer 9: Some considerations: Using direct GCM outputs is potentially problematic given the effects of biases that may interact with biophysical or engineering tolerance thresholds in the impacted system. CORDEX is an effort to create an ensemble of Regional Climate Models (RCMs) with dynamically downscaled results. These may also need bias-adjustment before application. The extent to which you are able to use each of these (and potentially add bias-adjustment) depends on your resources and the decision contexts you have in mind. Regional modeling is particularly attractive if your domain has substantial fine-resolution heterogeneity (e.g., steep mountains, coastlines and strong land use patterns) or if you are looking at basin-scale interactions (e.g., for river flows and water resources).

Question 10: CMIP6 can provide 10 km resolution across the globe. But we might need 1 km resolution for impact models at the watershed basin scale. Which downscaling methods are most appropriate for that purpose?
Answer 10: CMIP6 are closer to 100km spatial resolution. There are a number of dynamical and bias-adjustment techniques that can help you reach a finer resolution scale, as described in this training. We do not attempt to inventory and rank all of them here, but hope that the questions and characteristics we highlight here will empower your selection. It is also important to note that some regions may not have adequate observational data to justify such fine-scale data, and it may also prove overwhelming

to have so much data when you factor in the number of models and scenarios in question.

Question 11: What does 'Global 0.5-degree domain' mean in ISIMIP? I don't quite understand what it is used for. Where can I download the data I need? I apply Python in my research.
Answer 11: ISIMIP data are available over the whole globe, and the horizontal resolution is 0.5 degrees latitude and longitude (~50 km). ISIMIP data can be downloaded from the online repository here.

Question 12: Are there any reference data of 30 meter resolution (temp and precip) possibly other variables so that CMIP6 can be biased corrected to 30 meter resolution?
Answer 12: Similar to question 10 above, bias-adjustment and dynamical downscaling would be needed to reach this resolution, but I would encourage extreme caution in attempting to chase such fine resolution that might not be supported by high quality observational data or models. Reaching finer resolutions does not necessarily mean that the results are useful if the process ends up introducing additional bias in observational uncertainty.

Question 13: Can we use reanalysis data as observation data and check if the projections are reasonable? That is, if I wanted to know today's and future rainfall for a particular county, would reanalysis data be sufficient? Can recommendations be made for which reanalysis data to use?
Answer 13: Reanalysis are efforts to assimilate huge # of observations into weather models and can be very useful when local observations are not so available. Bias, bc reanalysis to not assimilate observations.

Question 14: For the Ruane and Mcdermid paper, is this showing the biases of using one model, or adaptation method if the area is more cold or hot? Could you give another example of the model democracy problem? / Can you explain or expand on why the Model democracy method is not a good approach, again?
Answer 14: In that set of projections in Ames, Iowa, USA, that was more uncertainty across the projections. We looked at hotter/ drier scenarios, etc.

Question 15: You mentioned several times models that convey storylines. Storylines can have different meanings depending on the target audience/stakeholders. Could you please elaborate?
Answer 15: Storylines are a wide category. When selecting storylines, keep in mind the caveats.

Question 16: Regarding a general overview of the possible climate changes, if I want to reduce my dataset sample size by selecting only one ensemble (member) per model, which considerations would one want to keep in mind in the selection process?
Answer 16: In many cases there are groups of ensemble members and smaller submitted sub monthly or daily. There is alot published on this, but be sure not to confuse a projection with a prediction.

Question 17: (1) for the models you presented, are they open to the public, open-non-commercial? (2) NEX-GDDP-CMIP6 - what are the positives and negatives of using this dataset?
Answer 17: (1) Yes largely open and available, some have restrictions. (2) Key Characteristic slide on NEX-GDDP-CMIP6.

Question 18: During my research using CORDEX datasets and calculating indices using Climpact, it took a large memory storage, processing power and remarkably long time (extracting indices from historical data took about 7-10 hours for 30 years data for one model). Could you please recommend any way that I could improve on handling data, storage, etc.?
Answer 18: A big issue with downscaling data. Use a high performance computer, if accessible, also look to see if other groups have performed similar analysis.

Question 19: *EL Modelo ISIMIP , involucra multiples sectores, varios escenarios , 11 variables. Me dá la impresióm que es el más completo? Es de uso libre?*
[Eng] The ISIMIP Model involves multiple sectors, several scenarios, 11 variables. It gives me the impression that it is the most complete? Is it free to use?
Answer 19: Free to use, yes. They like to know who is accessing it though. Not the most complete but it has been designed to allow impact modeling on top of it. Comparing your sector impact modeling to other sectors impacts.

Question 20: On slide 56, you mentioned that there are new bias adjustment techniques that are able to maintain the nonstationary temporal trends. Any chance you can share the reference to these techniques? Would you recommend these bias adjustment techniques be used to downscale the daily climate projections to the sub-daily durations using observations for the water resources applications?
Answer 20: Lange et al., 2019: Trend-preserving bias adjustment and statistical downscaling with ISIMIP3BASD (v1.0)
https://gmd.copernicus.org/articles/12/3055/2019/
We are not recommending specific climate projection sets within this training, but features in this climate dataset make it appealing for water resource applications although we also caution about the overall coarseness of this dataset which may need further downscaling for some applications.

Question 21: Can these modeling tools help to model future global energy distribution in the terrestrial and extraterrestrial environments?
Answer 21: This is an example of looking for climate projection sets that have 'applications-ready' variables for energy applications and applications in the oceans. Some climate projection sets provide more energy budget components to facilitate this type of analysis.

Question 22: Are you aware of studies that have assessed tolerance thresholds for ecosystems services globally?
Answer 22: I cannot recommend specific studies, but would recommend the questioner examine IPCC WGII Chapters 2 and 3 for ecosystem vulnerability, impacts and adaptation.

Question 23: You mentioned the importance of close engagement with stakeholders in the decision making process. Do you think it's possible to import the information from the local level to the decision making process?
Answer 23: IPCC WGI Chapter 10 and Chapter 12 show examples of how decision makers can interact with the design and provision of climate information for applications. WGII Chapter 17 also includes examples of adaptation services.

Question 24: Regarding climate geoengineering- the solar radiation management is one of the new scenarios upcoming. Are these models helpful in modeling solar radiation management (SRM)?

Answer 24: Geoengineering scenarios may also be of interest for some applications. For these you may look to the GEOMIP simulations in CMIP6 and ongoing work to understand how geoengineering storylines affect climatic impact-drivers and applications decision making around the world.

Question 25: What are your thoughts on selecting observational baseline datasets to use with projections for comparison and bias correction? For example, if using LOCA data in the US, should Livneh always be used as the baseline dataset (since it's what LOCA was developed with), or should other observational datasets like PRISM or daymet be considered based on accuracy for the specific region of interest?
Answer 25: Analysis of future impacts often need to be compared with corresponding impacts in the current period. By using the same underlying climate dataset in both periods we can better isolate the signal of climate change and its effects on the system we are looking at. When using an observational dataset for bias-adjustment it is also important to note that the process may not be perfect, thus it is cleaner to use the bias-adjusted historical climate period from a model than to use the observational dataset itself. This gives ua a validation period. That tells us about bias adjustment.

Question 26: Are there coordinated downscaling projects for marine climate data? Something like CORDEX for marine variables (SST, OA, etc)?
Answer 26: I am not aware of such a dataset, but there is certainly a vibrant ocean modeling community that has regional models.

Question 27: Are you aware of studies that have assessed tolerance thresholds for ecosystem services (or one ecosystem service) globally? Or are these thresholds usually not analyzed at global scale?
Answer 27: This is not my area of expertise but I know that there are many such studies. See Section 12.3 in the AR6 WGI CH12. In many cases thresholds are species and biome specific. Also, Rocky Mountain Pikas are famously sensitive to temperatures. Pest and disease connections may also be useful here (temp dependent).

Question 28: Can you review how to assess "hot models"?
Answer 28: How to use hot models, or select from ensembles. Each model has published the equilibrium sensitivity ot tables with those #s within them.

Question 29: When using an ensemble of models, what should be considered when determining which models to include in a study so that results aren't biased? Would this process be similar to the methods used in the study you referenced on temperature and precipitation in Ames, Iowa?
Answer 29: If you have a subset of models, look at the sensitivities so you are not collecting hot or cool models. Example: if you are in a region and there is a dif in hist trends and projected trends, you may want to introduce storylines that
That could be due to internal variability.

Question 30: So far there is no, or few, downscaled data forced with CMIP6 (e.g., from CORDEX). In what context should I prioritize spatial resolution (Downscaled forced with CMIP5) over updated global model projections (global CMIP6)?
Answer 30: We would love to have CMIP6 cordex, but until then.
Bias adj comes faster than the downscaled region-specific features. Compare the 2 outputs to see where the differences are.

Question 31: What would be the better relation between spatial resolutions and downscaling, and bias-adjustment approaches? For example, for a scale 1:XXXXX it's possible to use XXXX meters of spatial resolution with downscaling of XXX model.
Answer 31: It depends on the obs dataset and how well you know them. Sparse obs or short time periods, you may need to deal with the lower spatial resolution. But regional variability should also be considered. Bias vs dynamical downscaling,

Question 32: What will be maximum scale information for use in these models? For example, for basin management the ideal resolution is 1:25.000, but it is complex to find historical information for modeling.
Answer 32: You are correct, historical information is the challenge before we start talking about projections.