What did we learn from the latest generation of climate models?

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What did we learn from the latest generation of climate models?

Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system. Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions. (6, 11–14)



Climate projections Why are they uncertain?







Economic scenarios

Model structure Parameters

Variability

Distance to observations

Surface temperature and precipitation



Knutti et al., GRL 2013

Model performance My model is the best...

- An infinite number of metrics can be defined.
- Many metrics are dependent.
- Observation datasets and their uncertainty matters.
- The concept of a "best model" is ill-defined.
- There may be a best model for a particular purpose, where "best" measured in a specific way. But determining that is hard.





Relating model performance to projections





Dec-Feb surface temperature (°C)

Temperature bias







Temperature bias (°C)

Warming









Dec-Feb warming 2080-2100 (°C)

Climate model genealogy Models are not independent



Edwards, WIRE 2011

Climate model genealogy Models are not independent

Dissimilarity for surface temperature and precipitation



Knutti et al., GRL 2013

Climate model genealogy Models are not independent



Natural variability Important but often ignored

PREDICTING CLIMATE CHANGE Vital Details of Global Warming **Are Eluding Forecasters** Decision-makers need to know how to prepare for inc

"First of all, there are the uncertainties inherent in the regional model itself. Then there are the global model's uncertainties at the regional scale, which it feeds into the regional model."

gerous" effects set in. And nothing at effects expected in the next several decades.



either suffer severe droughts more frequently,

projections of future climate according to

Kerr, Science 2011

Limits of predictability Warmest and coolest of 40 realizations



Limits of predictability Wettest and driest of 40 realizations



Deser et al., Nature Climate Change 2012

Robust projections through aggregation even for extreme events



Fischer, Beyerle and Knutti, Nature Climate Change 2013

Are we making progress? Projections are robust, uncertainties remain



Old

New

Are we making progress? June-August precipitation projections



Knutti and Sedlacek, Nature Climate Change 2012

Long term water cycle term projections Some things are more certain than others



Long term water cycle projections Affected variables and people



Conclusions, and open questions

- Models are getting "better" at things we observe, but model spread is not reduced for projections.
- Models are always wrong. They can only be adequate for purpose. But what is adequate, and what is the purpose?
- Model performance varies but it's hard to translate that into weights. Direct verification is impossible.
- Model sampling is neither systematic nor random.
- Models are not independent. Model spread is not an uncertainty.
- Natural variability puts irreducible limits for model evaluation and uncertainty quantification.
- Despite all that, many large scale projections are very robust.