

Friday morning

BOG 2 Scientific advances since AR5

Key scientific advances since AR5

BOG 2 OBS

- Ensembles of observations now available (surface temperature, temperature, SSMI column water vapor, etc)
- Wider use of measurement proxies (mapping of models to observations)
- Availability of Obs4MIPs helped model development
- Longer records of novel satellite data – need to continue those into the future
- Better coordination between land use data developers and modelers
- Historical reanalysis & state estimates & ocean and coupled reanalysis
- Deep ARGO data
- Better understanding of Model forcings uncertainty:
 - Better understanding of volcanic impacts (beyond optical depth) → model forcing
 - Better understanding of uncertainties in Ozone data sets used to force models
- Making room for multiple explanations for model-obs differences

Key Scientific Advances Since AR5

BOG 3 CMIP Evaluation Tools

- We have maturing publically available open source CMIP evaluation tools that are currently being tested by reproducing CMIP5 evaluation results
- A subset of them will evaluate models as the output is published to ESGF for the DECK and CMIP6 historical simulations to provide early feedback to the modeling groups and wider community
- More community acceptance of the value of these open source evaluation tools and performance metrics and the value of standardized performance metrics.
- Quality controlled observational datasets now aligned with CMIP data structures (e.g. obs4mips, ana4mips) that have been developed through international collaboration for use in CMIP evaluation. This archive is growing.
- Traceability and provenance of models, evaluation codes, and datasets is increasingly appreciated and adopted.

Systematic Biases: Key Scientific Advances

BOG 5 Systematic Biases

CMIP3 to CMIP5 improvement primarily, but only anecdotal since CMIP5

- El Nino *
 - AMOC *
 - Low clouds ~*
 - Eastern boundary ocean areas *
 - Sea Ice – Arctic * / Antarctic
 - Ocean currents and sub-grid scale *
 - More comprehensive inclusion of BGC Ocean & Land*
 - Large model spread in Land BGC, but not ocean *
 - Atmospheric Blocking *
 - QBO*
 - Polar Vortex in HiTOP models*
 - IPO/PDO*
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- Monsoons, Double ITCZ, Cold tongue, Diurnal cycle, Dry bias over Amazon, Westerlies, SO warm bias

Key scientific advances since AR5?

BOG 6 Emergent Constraints

- Proliferation of proposed ECs since AR5 spanning Earth system
- A few have made their way into the confirmed and useful categories
- Deeper understanding of model spread including structural and parameterization uncertainties
- Recognition of the need for mechanistic understanding
- Classes of ECs have been identified: trend to trend, present day variability (temporal or spatial) to sensitivity, mean state to sensitivity (most 'proposed').

Key scientific advances since the AR5?

BOG 8 Weighting

- Beginning to recognise the limits of performance based weighting
- The emergence of interdependence based weighting schemes and recognition of their importance
- The understanding that PPEs and MMEs are not transitive
- The use of perfect models to perform out of sample testing
- Applying data assimilation approaches to paleo time series has advanced and has applications related to understanding decadal variability

Key Scientific Advances Since the

AR5 BOG 9 IMpacts

- Increased confidence in distributional effects
- Higher resolution models (some at ¼ degree)
 - Higher resolution atmosphere produces more realistic precipitation extremes
 - Higher resolution & richer forcing for land use, N fertilizer & irrigation (¼ degree)
 - Better resolution of hurricanes and circulation features
- New techniques for downscaling and bias correction
 - More organized and prominent work on empirical downscaling
 - More organized dynamical downscaling too
- Variable resolution models for focused study
- Focus on multivariate extremes
- Length of observational record is better
- Extreme event attribution (machinery ready to go for individual events)
- Much better links between impacts models to economics models (offline models)
- Formation of VIACS and links to CMIP6
- Embracing of probability/risk frameworks in the impacts community
- Increased exploration of emissions and climate space + one step to fully integrated IAM-ESM