

## WORKSHOP REPORT: WATER IN THE CLIMATE SYSTEM

KERRY EMANUEL, DAN ROTHMAN (LORENZ CENTER), SANDRINE BONY, TED SHEPHERD, ADAM SOBEL AND BJORN STEVENS (GRAND CHALLENGE)

### SUMMARY

At the initiative of MIT's Lorenz Center, a workshop on *Water and Climate* was held at the MIT Endicott Center, near Boston, from Feb 10-12, 2014. This was the first Lorenz Center Workshop and the ideas and topics it explored were coordinated with the WCRP Grand Challenge on *Clouds, Circulation and Climate Sensitivity*. The workshop consisted of twenty-six short (20 min) invited presentations and extended discussions. An emphasis was placed on articulating fundamental issues in a way that would make them accessible to scholars in the physical sciences (e.g., Math, Physics, Chemistry) but not currently working on problems in climate science. Presentations were focused on the troposphere, but included contributions related to geomorphology, statistical physics, oceanography, and the stratosphere. In addition to the invited speakers, PhD candidates and postdocs from the area were invited to attend. There was a strong turnout from MIT and Harvard, bringing the number of participants to about fifty.

Five hours of formal discussion were spread over the two and a half days of the workshop, during which the themes in the talks were explored. Discussion sessions were held in one hour blocks, with ca 20 min at the outset reserved for PhD candidate and postdoc questions. The format was very successful in involving these younger scientists. Although the workshop's primary purpose was intellectual exchange, some broader issues emerged as presented below.

**Opportunities:** The workshop emphasized the importance of encapsulating key aspects of the behavior of complex systems (as observed for Earth, or simulated by comprehensive climate models) in more idealized frameworks as a means of advancing the science more efficiently. In this context, radiative convective equilibrium emerged as an exciting problem, in part because it is very relevant to the behavior of the full system and applicable to the full model hierarchy. In this spirit, the core projects of WCRP should focus more on the question of what can be left out of, rather than what can be put into, complex models.

**Challenges:** Several workshop participants noted that a troubling trend is the development of complex and comprehensive climate models that are too singularly focused on the most complex representation of the climate system possible, at the expense of the ability to configure such models to solve more idealized problems. More emphasis on using such models to solve idealized problems would be helpful in advancing understanding in a way that is directly traceable to the more comprehensive models, which in the long term is crucial for improved prediction. It would also influence how the models are designed and hence their broader utility and relevance for the academic community. This point merits further discussion by the WCRP, perhaps through its modelling advisory council.

## WORKSHOP PRESENTATIONS (AND PRESENTORS)

- (1) Convection
  - Some theoretical questions about convective parameterization – Isaac Held
  - New developments related to gross moist stability – David Raymond
  - Can a bulk plume represent the effect of aqueous-phase reactions in shallow cumuli? – Zhiming Kuang
  - Sensitivity of deep convection to free-tropospheric humidity in a hierarchy of models – Gilles Bellon
  - Large-scale structures in moist atmospheric convection – Antonello Provenzale
- (2) Water Vapor, Clouds, and Climate
  - Radiative Convective Equilibrium (RCE) – Bjorn Stevens
  - Radiative-Convective Instability – Kerry Emanuel
  - Self-Aggregation of Convection in RCE – Caroline Muller
  - Water vapor as an active scalar – Adam Sobel
  - On the role of convective aggregation in climate: observational and modeling perspectives – Sandrine Bony
  - Stratospheric water vapor and climate – Ted Shepherd
- (3) Moisture and Weather
  - A near-global CRM study of moisture and tropical atmospheric predictability – Chris Bretherton and Marat Khairoutdinov
  - The Pliocene Permanent El Nino and Atmospheric Superrotation– Eli Tziperman
  - Towards a theory for free-tropospheric relative humidity – David Romps
  - Weather Regimes and a Stochastic/Deterministic Strategy for Ultra-High Resolution Simulation of Earths Water Cycle – Tim Palmer
  - The role of mid-tropospheric humidity in tropical cyclone genesis and intensification – Brian Soden
- (4) Potpourri
  - Freshwater transport in the coupled ocean-atmosphere system: a passive ocean – John Marshall
  - Bistability of the climate around the habitable zone: a thermodynamic investigation – Valerio Lucarini
  - The abrupt seasonal transition of the Northern Hemisphere general circulation: mechanisms and future changes – Tiffany Shaw
  - Aridity and the Branching of River Networks – Dan Rothman
  - A symmetric energy balance as a macroscopic constraint on Earths climate? – Graeme Stephens
  - Regional feedback patterns and regional climate predictability – Gerard Roe
- (5) Precipitation and Climate
  - Contrasting responses of mean and extreme snowfall to climate change – Paul O’Gorman
  - Variability and Change in Our Water: Some Results from Climate Model Ensembles – Susan Solomon
  - Coupling Climate to Clouds, Land-use, Precipitation and Snow – Alan Betts
  - Rapid adjustments of precipitation to climate forcings - are they real and what can we learn from them? – Piers Forster