Atmospheric Rivers From a Hierarchy of Climate Simulations

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Motivation and Science Questions

- Atmospheric rivers (ARs) transport over 90% of atmospheric moisture across subtropical boundaries to midlatitude destinations globally, and are a main cause of flooding in many regions.
- How well can climate models simulate ARs? What are the sources of uncertainty?
- What are the thermodynamical and dynamical modulations of AR in a warmer climate?

Approach

- Perform and analyze a set of aquaplanet and AMIP experiments:
  - Community Atmosphere Model (CAM) with the HOMME and MPAS dynamical cores at resolution between 30 km – 220 km with CAM4 physics.
- Analyze CMIP5 simulations of historical and future climate.
- ARs are defined as:
  - IWV > 2 cm, with 80% of moisture below 800 hPa
  - Length > 2000 km and width < 1000 km
  - Wind speed > 10 m/s, U, V > 0 and Latitude > 20°N

Atmospheric Rivers in Aquaplanet Simulations

- AR frequency decreases with increasing model horizontal resolution.
- AR frequency is higher in HOMME than MPAS.

Atmospheric Rivers in AMIP Simulations

- AR frequency in APE runs

Atmospheric Rivers in CMIP5 Simulations

- AR detected based on IVT > 85th percentile, IWV > 2 cm, and elongated > 2000 km.
- Evaluate the dynamical and thermodynamical modulation on AR frequency by rescaling Q and winds.

Summary

- AR frequency is sensitive to model resolution and dynamical core.
- Thermodynamics: total precipitable water and moisture profile.
- Dynamics: Subtropical jet location.
- AR frequency increases manifold under RCP8.5.
- Thermodynamics (water vapor) effect dominates the dynamical (wind) effect in the ARs response, with positive dynamical contribution in Alaskan coast in spring.
- Large uncertainties in the winter time AR projection off the Californian coast are a result of uncertainty in predicting the eastern North Pacific jet stream response.

Column integrated precipitable water

Ratio of low-level to total precipitable water

850 hPa zonal winds

850 hPa zonal wind structure

Atmospheric Rivers in AMIP Simulations

Jet location shifts poleward and jet strength weakens with increasing resolution.

Southeast Pacific AR frequency

Changes in AR pathways

Uncertainty in projecting AR changes and jet stream position are related.