Atmospheric Rivers From a Hierarchy of Climate Simulations

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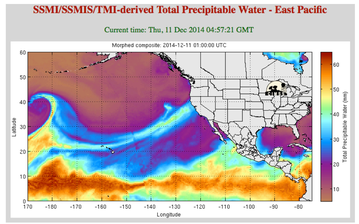
Motivation and Science Questions

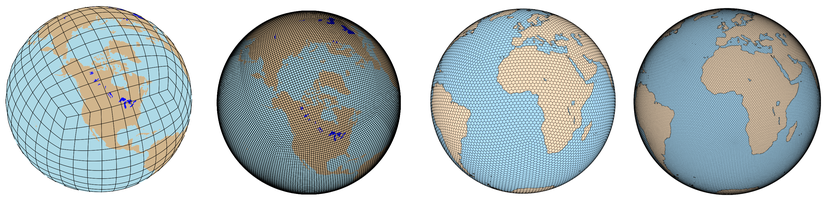
- Atmospheric rivers (ARs) transport over 90% of atmospheric moisture across subtropical boundaries to midlatitude destinations globally, and are a main cause of flooding in many regions
- How well can climate models simulate ARs? What are the sources of uncertainty?
- What are the thermodynamical and 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 > 20ºN

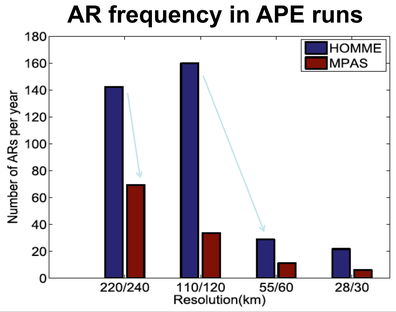
HOMME: Cubed sphere | **MPAS: Voronoi grid**



Atmospheric Rivers in Aquaplanet Simulations

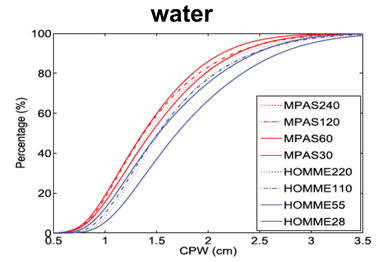
- AR frequency decreases with increasing model horizontal resolution
- AR frequency is higher in HOMME than MPAS

AR frequency in APE runs

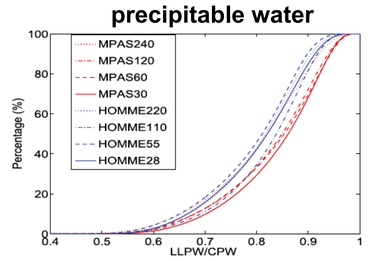


(Hagos et al. JCLIM, 2015)

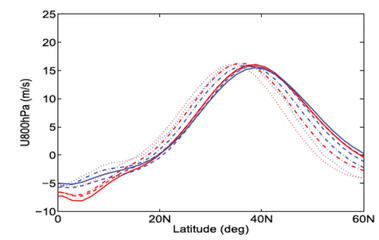
Column integrated precipitable water



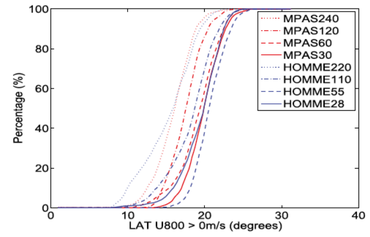
Ratio of low-level to total precipitable water



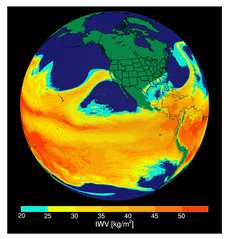
850 hPa zonal winds



850 hPa zonal wind structure

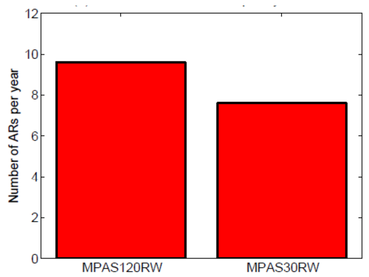


Atmospheric Rivers in AMIP Simulations

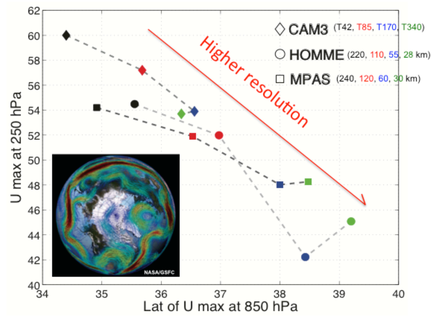


(Lu et al. JCLIM)

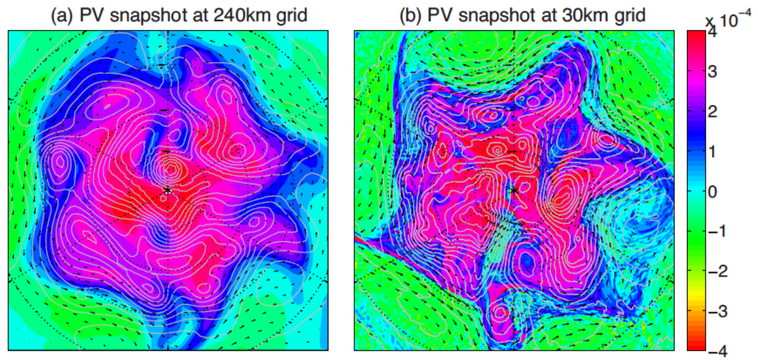
Southeast Pacific AR frequency



Jet location shifts poleward and jet strength weakens with increasing resolution

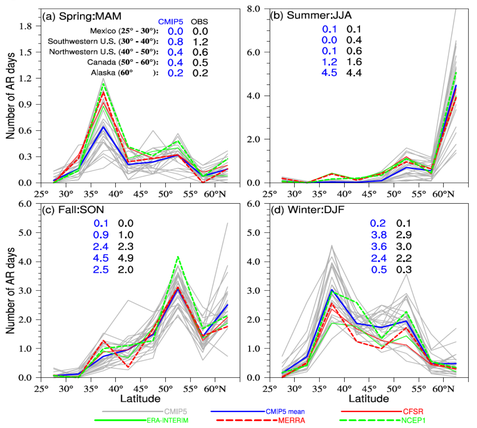


(a) PV snapshot at 240km grid | (b) PV snapshot at 30km grid



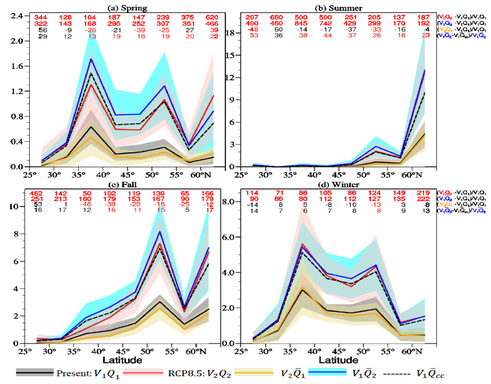
Atmospheric Rivers in CMIP5 Simulations

- AR detected based on IVT > 85th percentile, IWV > 2 cm, and elongated > 2000 km

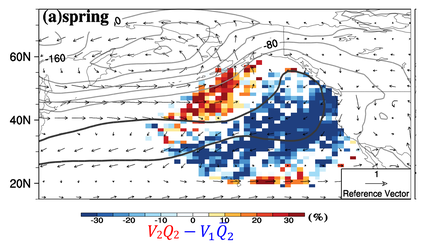


(Gao et al. 2015 GRL)

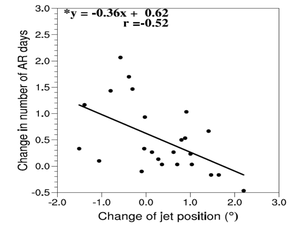
- Evaluate the dynamical and thermodynamical modulation on AR frequency by rescaling Q and winds



Changes in AR pathways



Uncertainty in projecting AR changes and jet stream position are related



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 manyfold 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

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