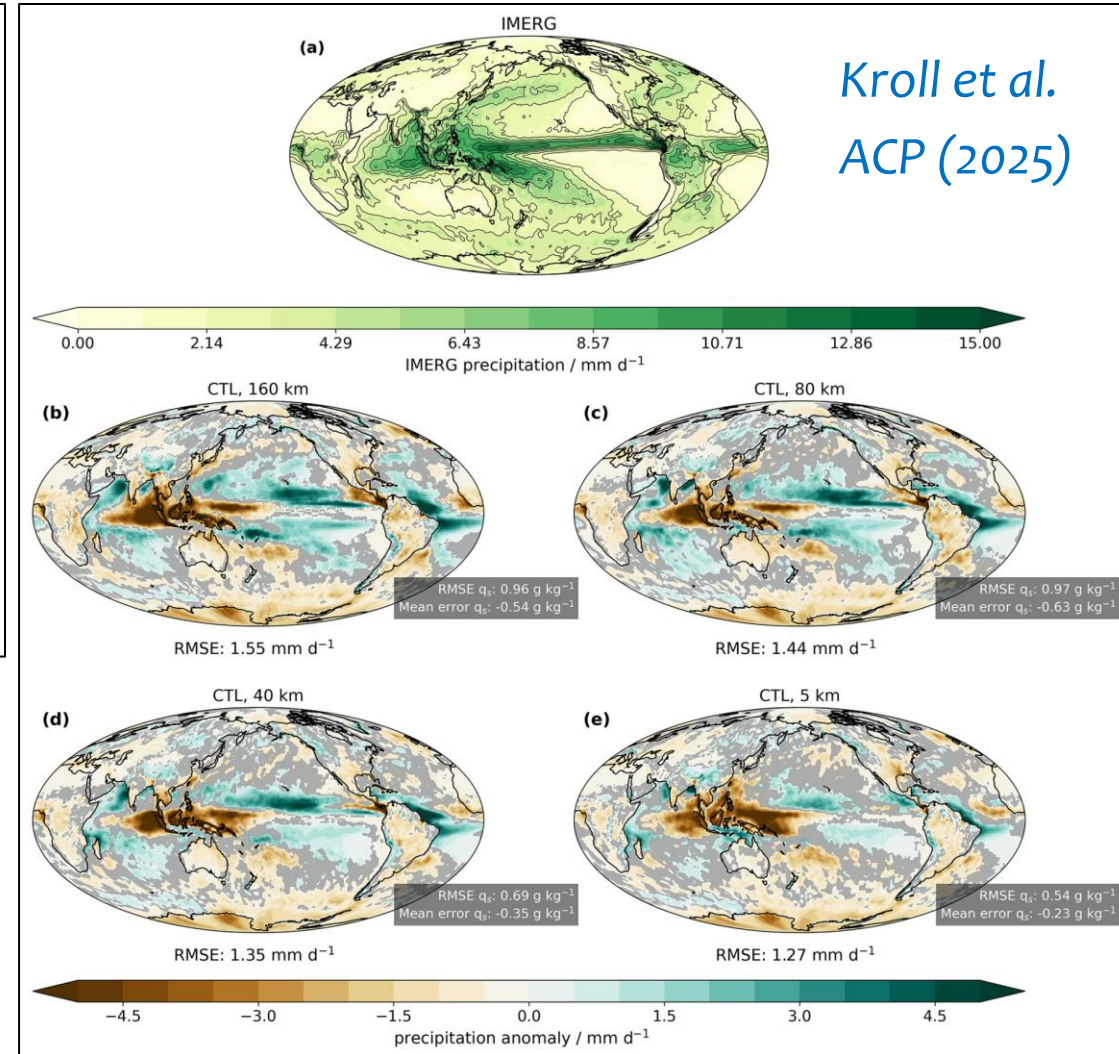
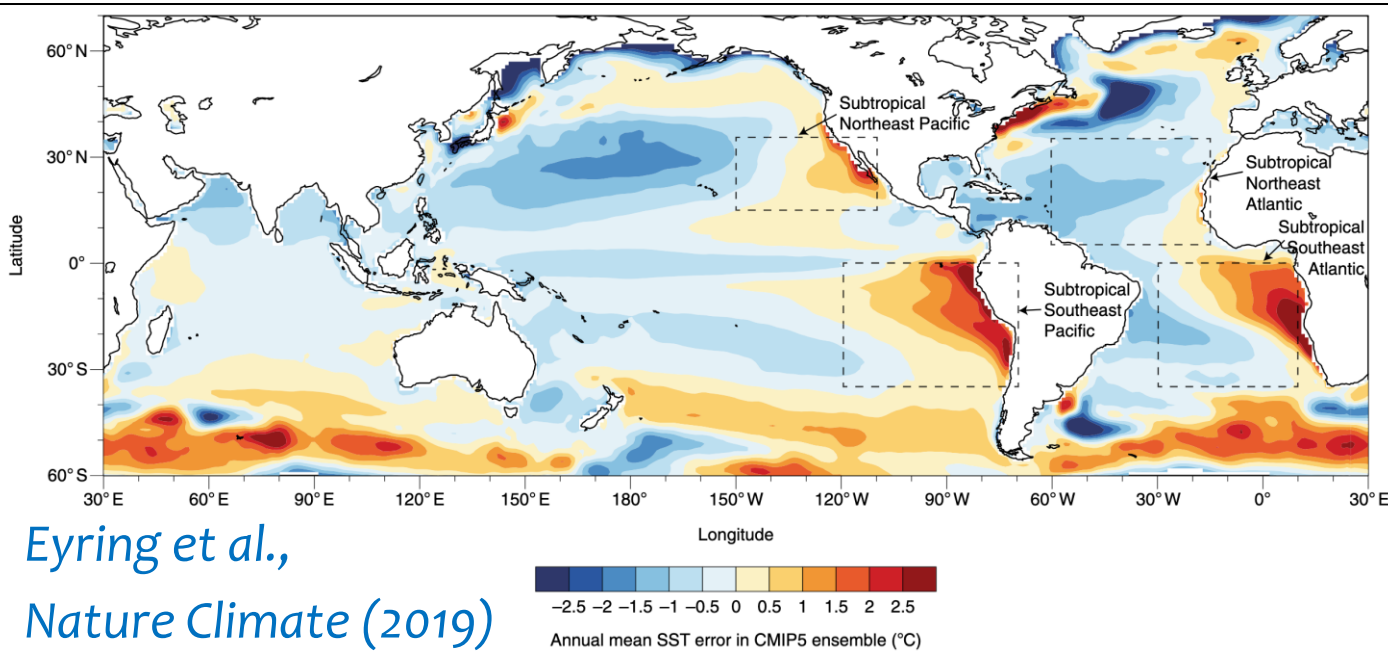


Earth's Hydrosphere: A grand-challenge simulation problem

Annual mean SST error from the CMIP5 multi-model ensemble

Precipitation bias in a resolution hierarchy of climate model simulations



Lessons:

1. Resolution alone will not improve climate model biases
2. Parameterization and rigorous model calibration (e.g., via inversion/data assimilation/hybrid ML) remains essential
3. **NASA can lead the way developing ESMs that learn from data and use NASA's (and others') observational assets**