

Drought Research at GFDL:

Aridity, Land Use, Precipitation Trends and more

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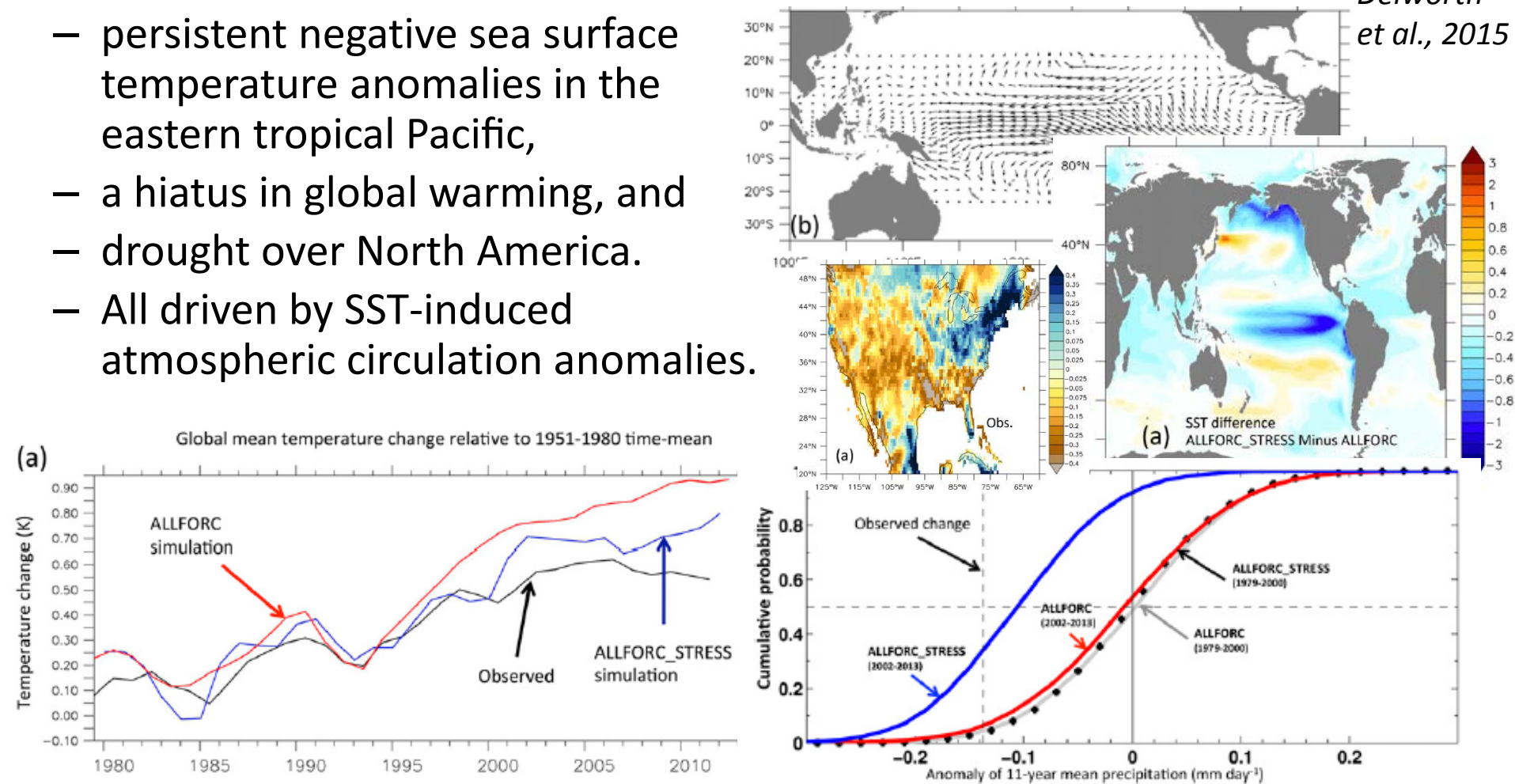


A Link Between the Hiatus and Drought in NA

- Observed tropical Pacific wind stress anomalies from 2002-12 inserted into coupled models lead to:

- persistent negative sea surface temperature anomalies in the eastern tropical Pacific,
- a hiatus in global warming, and
- drought over North America.
- All driven by SST-induced atmospheric circulation anomalies.

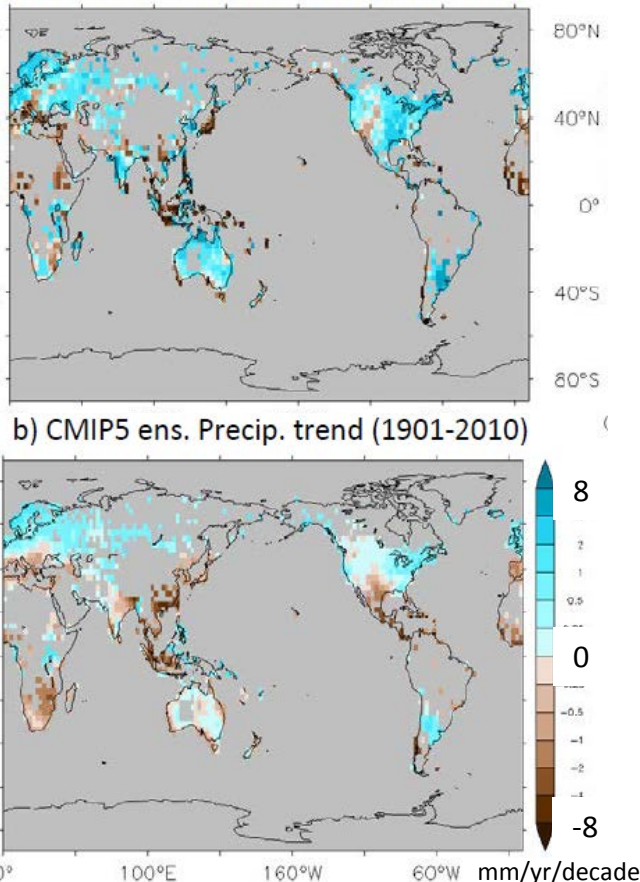
Delworth et al., 2015



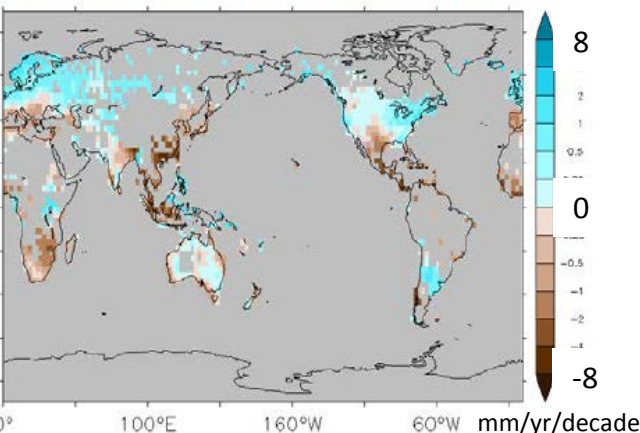
Historical precipitation trends

- **Observed precip trends: increases in extratropics**
- **Models: statistically consistent in 58% of area analyzed**

a) Obs. (GPCC) Precip. trend (1901-2010)

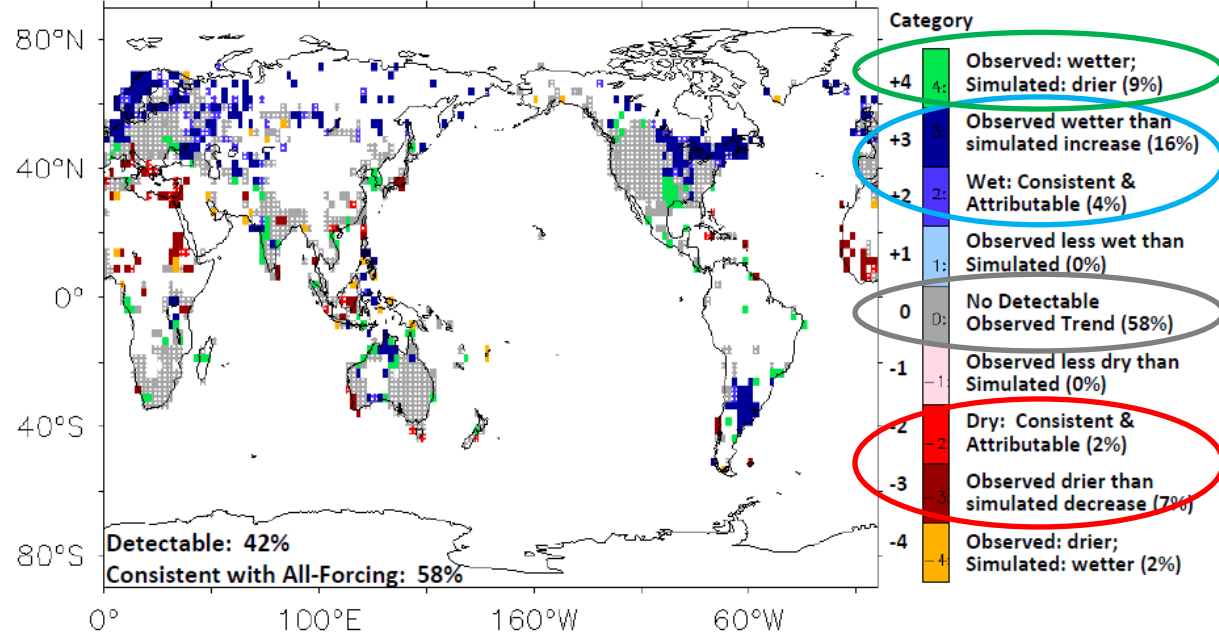


b) CMIP5 ens. Precip. trend (1901-2010)



- Detectable wetting, at least partially attributable: 20% of area
 - Detectable drying, at least partially attributable: 9% of area
 - Also 9%: obs are wetter and models are drier
- Could mean these models might overestimate future drought risk*

c) Precipitation trend assessment (1901-2010)

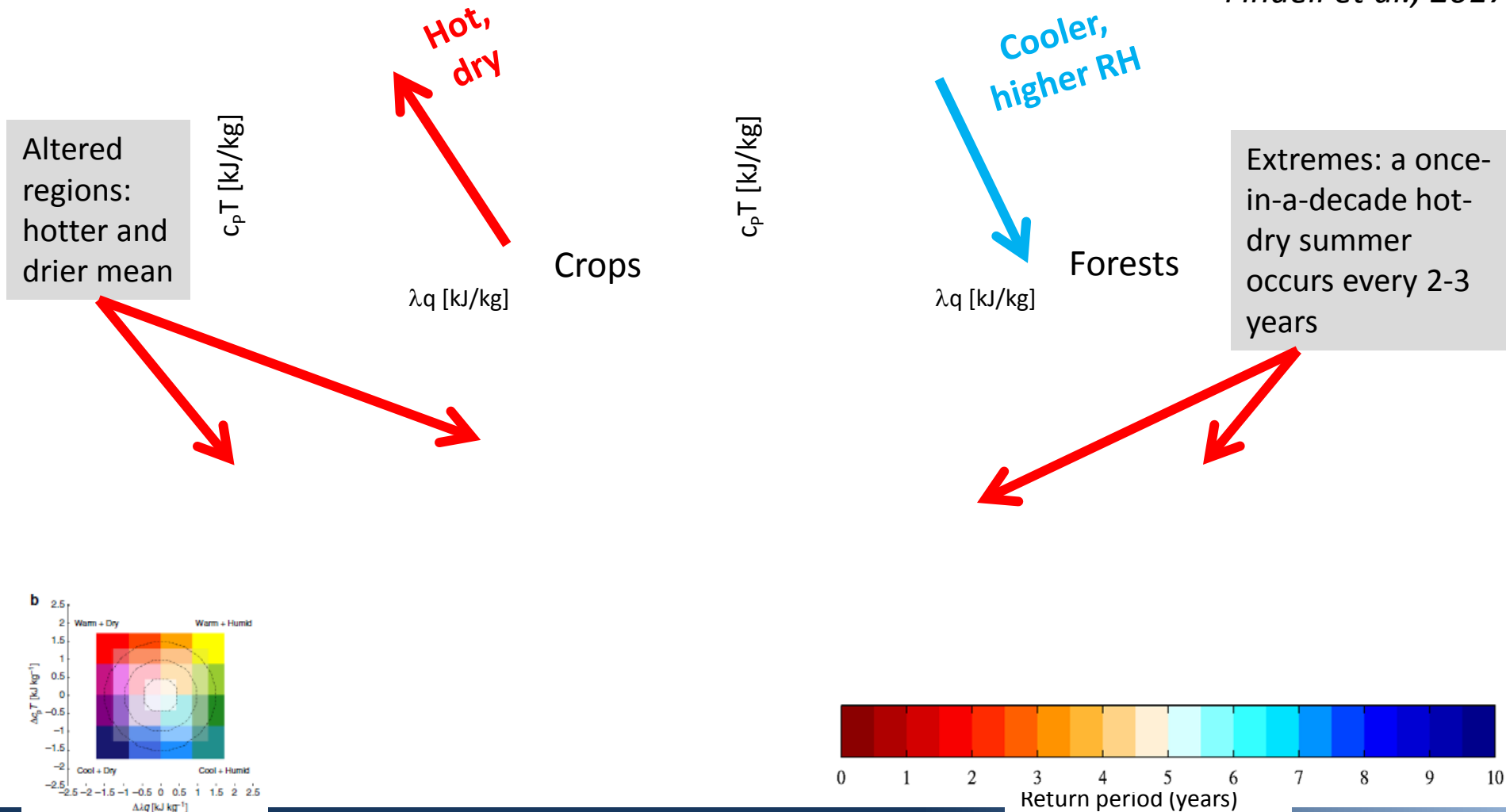


Knutson and Zeng, submitted

Anthropogenic LULCC and Hot/Dry Summers

- ESM2G: *historical versus potential vegetation simulations*

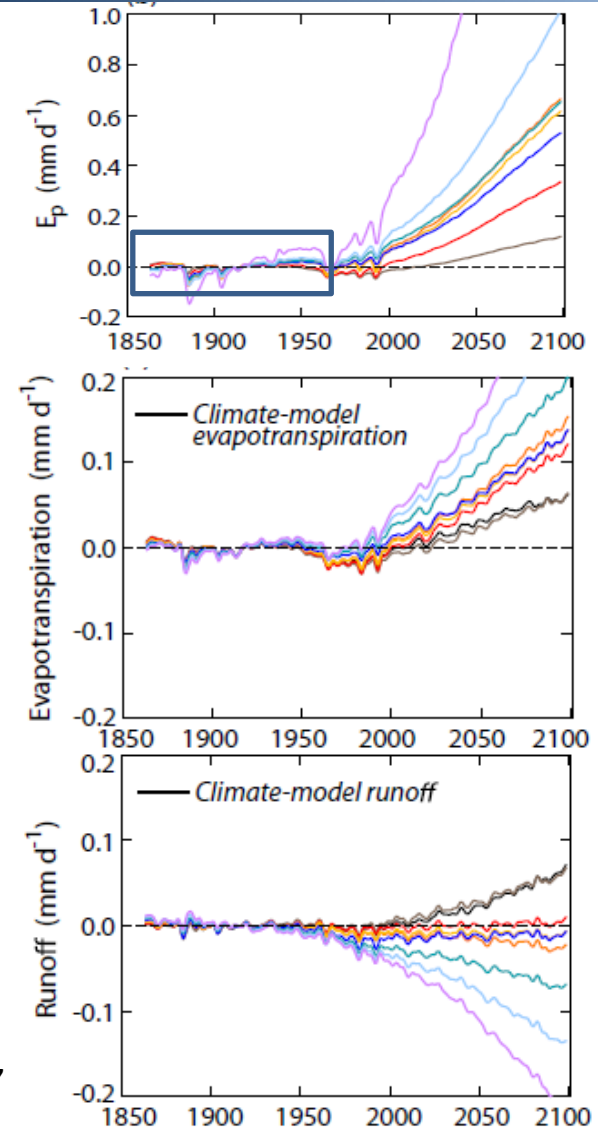
Findell et al., 2017



Potential ET and Future Drought

- Potential Evapotranspiration (PET):
 - the ET rate when the surface is well-supplied with water.
- Many empirical methodologies
 - developed during the 1940s-1970s
 - rely heavily on temperature
 - don't account for changes in stomatal conductance with increased CO₂
 - Calculated off-line; used to estimate *ET*
- Studies relying on off-line PET estimates overestimate recent and future drying

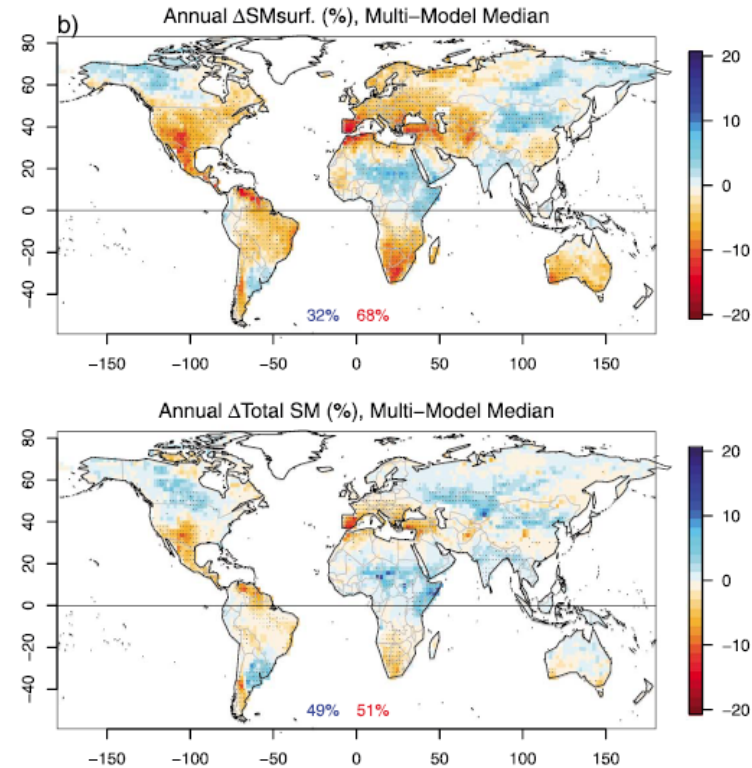
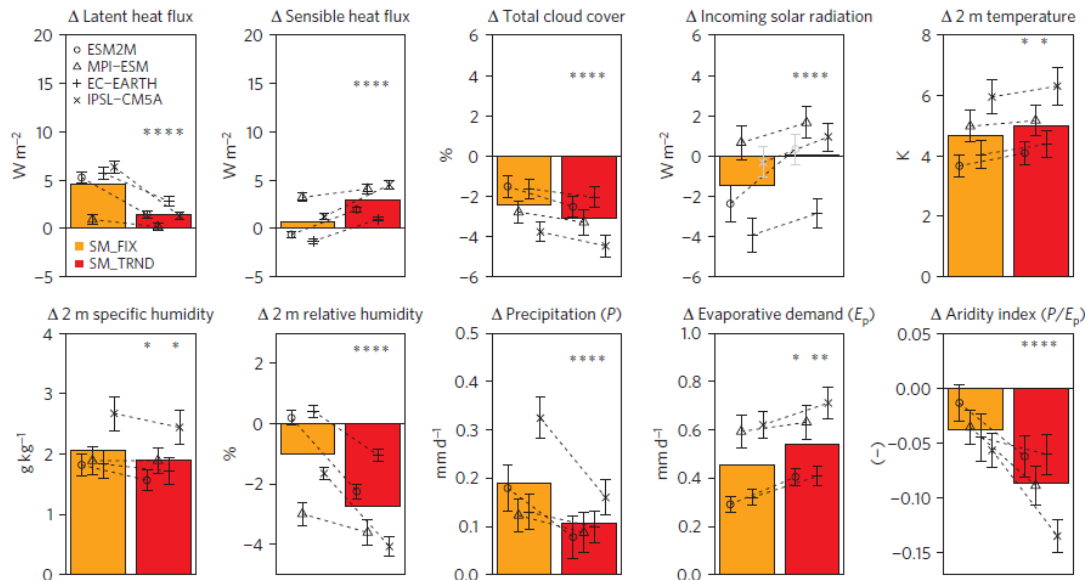
Milly and Dunne, 2016, 2017



Future Soil Moisture and Aridity

- Estimates of future aridity often based on surface soil moisture
- Deeper SM in CMIP5 models is more consistent with expected changes in precip--not as dire!

Berg et al., 2016, 2017



- Land-atmosphere feedbacks amplify future aridity increase over land

Drought-relevant research at GFDL

- Understanding the recent decadal drought in California
- Detection and attribution of historical precip trends
- Anthropogenic LULCC has led to more frequent hot/dry summers in altered regions
- Many estimates of future drought vulnerability have been overstated due to
 - Overestimates in future evaporative demand, and
 - Reliance on surface rather than deeper soil moisture.
 - Future drought and aridity projections should be determined directly from climate models, not off-line metrics like PET.
- Land surface processes amplify future aridity driven by large-scale changes.