A Hierarchy of Large Ensemble Experiments for Risk Assessment of Extremes

FACTS
Facility for Climate Assessments

http://www.esrl.noaa.gov/psd/repository/facts

Why FACTS?

- Climate model simulations provide a useful mechanism for investigating the factors that give rise to extreme weather events
- FACTS provides multi-model, multi-forcing climate experiments to help understand and predict changes in climate and weather events.
- Experiments are designed to study the effects of real-time evolving factors on observed weather/climate extremes, including:
  - Modes of ocean variability (e.g. ENSO, PDO, AMO) and SST change in general
  - Arctic sea ice loss
  - Long term climate change

FACTS Datasets

- *Coupled and AMIP ensembles*
  - Coupled runs: NCAR-CESM1, CanESM2, GFDL-CM3
  - Historical AMIP runs: CAM4, CAM5 (low/high model top), ECHAM5, GFSv2, AM3, GEOS-5
  - 10-50 ensemble members per model/experiment
  - Output spans 1870-2018, updated annually to assist in near real-time assessments
- *Reanalysis/Observational Datasets*
  - 20CR, ERA-Interim/ERA5, JRA-55, MERRA 1&2, NCAR R1, GPCP, OISSTv2

Interactive Analysis and Visualization

- *Online quick look at the data*
  - Assess how model respond to different forcings
  - Compare different models in a same experimental forcing
  - Maps of climatology, anomalies, composites
  - Time series, PDFs, correlations
  - Download plot files for further analysis

Application of FACTS to Explore Causes of Extremes

Model simulations are essential for understanding causes for and predictability of extreme events. Large ensembles from historical coupled earth system models (CMIP) can identify impacts of observed radiative forcings. Large ensembles from atmospheric models (AMIP) can identify impacts of observed global sea surface temperature (SST) in addition to radiative forcing effects. The CMIP and AMIP ensemble spreads provide additional information on causality/predictability. The former indicates coupled ocean-atmosphere-land internal variability (for fixed radiative forcing); the latter indicates atmosphere-land internal variability (for fixed SST forcing). Two extreme events - using CESM and CAM5 large ensembles - are diagnosed below.

Case-1: The failure of expected rain in Southern California during 2015/16 El Nino

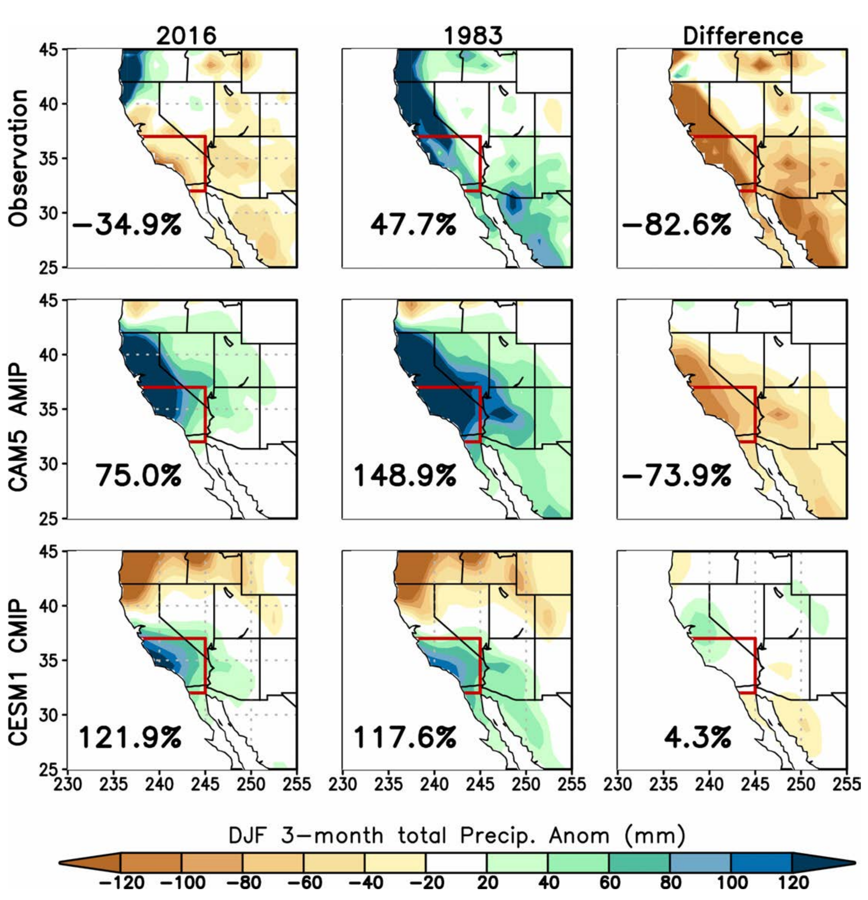

Fig.1

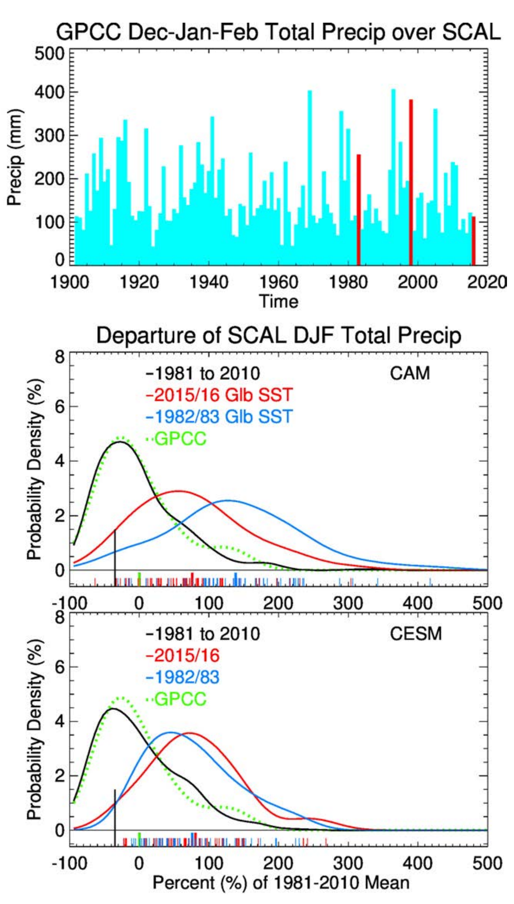

Fig.2

Heavy rains had occurred in Southern California (SCAL) during both the strong El Nino winters of 1982/83, and 1997/98, but unexpectedly failed to arise during the winter of 2015/16. Here we ask if human induced climate change (CC) has altered ENSO teleconnections to SCAL rainfall? The 40-member CESM-LENS runs, contrasting 2016 and 1983 winters, indicate that human induced CC had little significant impact on heavy rain risks in 2015/16 compared to 1982/83 (Fig 1,2 bottom). The 40-member CAM5 AMIP-LENS runs indicate that the particular global 2015/16 global SSTs were much less effective in generating heavy seasonal rains compared to 1982/83 (fig1,2 middle). Nonetheless, the observed drier than normal winter of 2015/16 is reconciled with internal dynamics and not forced signals as revealed by the CESM and CAM5 PDF spreads. (Quan et al, 2017, *BAMS EEE;* Zhang et al, 2017, *J. Climate*)

Case-2: The flash drought over Northern US in the summer of 2017

The rapid onset of drought over Northern US in spring and summer of 2017 (fig.3 top) was mainly due to the failure of rains. The drought was characterized by two features: record low precipitation and near-record rapid decline of soil moisture. Mechanisms behind these features are explored by the CESM and CAM5 large ensembles. Both models indicated human impact would cause a small but significant increase of May to July precipitation in this region (fig.4 right), suggesting that the low precipitation is of atmospheric internal variability; and both models indicated increased risk of more reduced soil moisture (fig.4 left) due to increased air temperature and evapotranspiration at surface (not shown), suggesting higher risk of severe drought in this region (fig.3 bottom) due to the global warming . (Hoell et al, 2018, *BAMS EEE)*

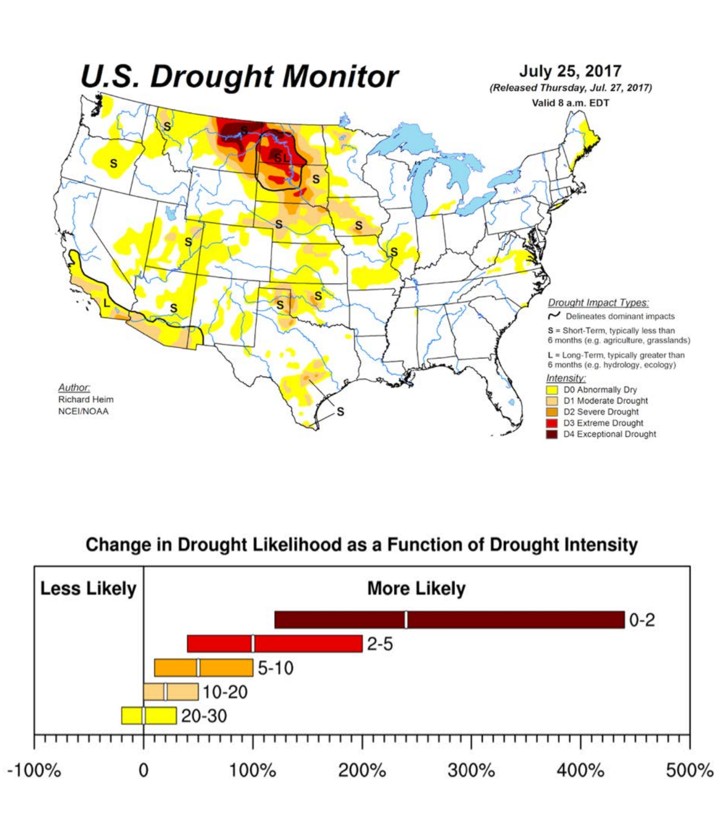

Fig.3

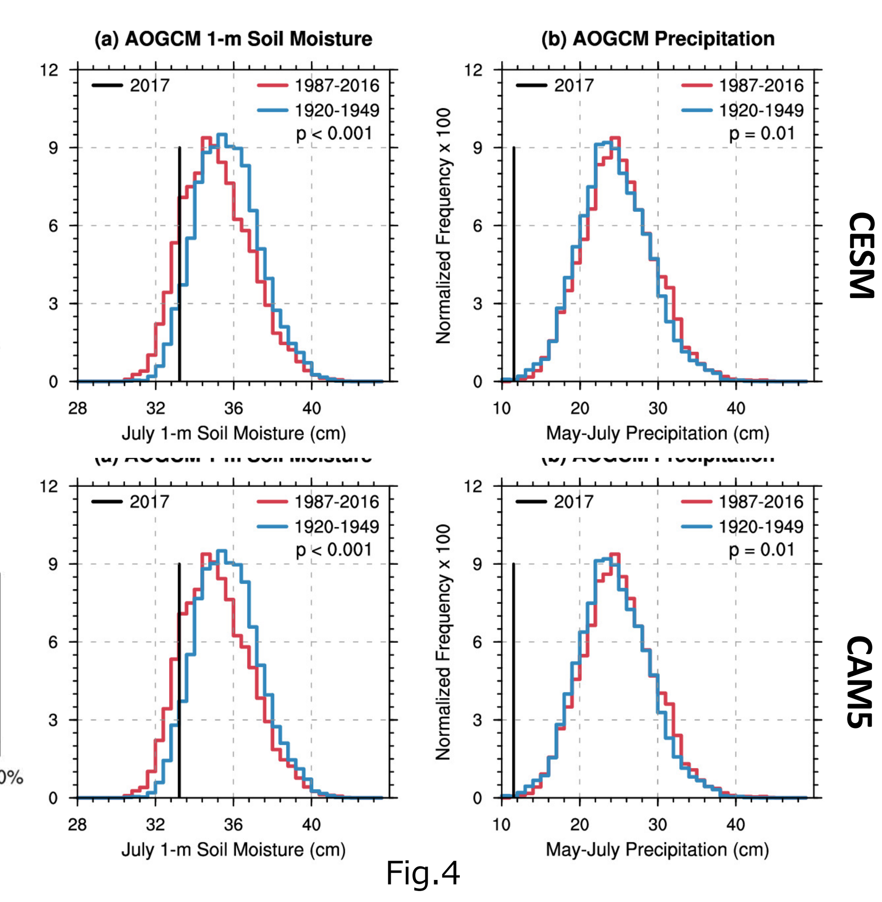

Fig.4

Quan, XW, M. Hoerling, J. Perlwitz, D. Murray, J. Eischeid, A. Hoell
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