Detection of anthropogenic influence on the historical evolution of annual extreme rainfall

Céline Bonfils (LLNL), Shiheng Duan, Stephen Po-Chedley, Margot Bador, Benjamin Santer, Ray Shi, Gavin Madakumbura

Overview

Models consistently project an intensification of extreme rainfall. Yet, detecting such a change in observational records is hard:

- Large internal climate variability
- Limited coverage of observational records / Large model uncertainty

Superimposed on the background noise of natural climate variability, extreme rainfall events are impacted by the combined influence of:

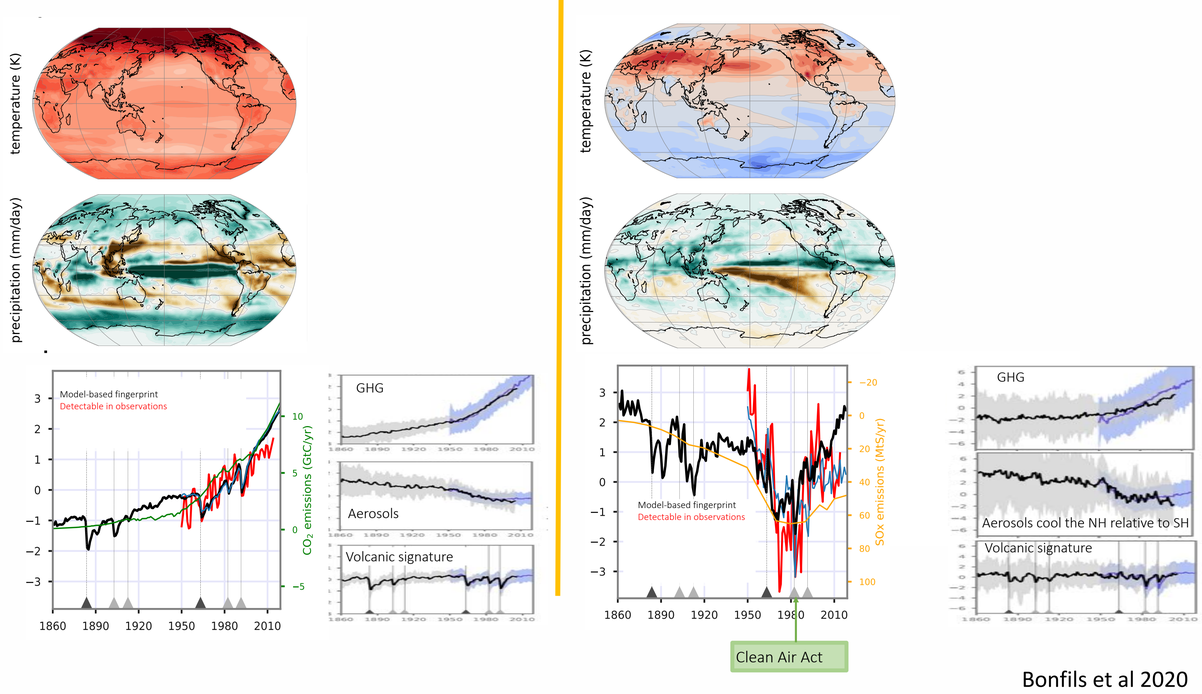
- Human-induced increase in GHG emissions
- Particulate pollution from North America, Europe then from India and Asia
- Occasional volcanic eruptions.

Most studies detecting changes in extreme rainfall in observations did not focus on the the role of aerosol and volcanic forcings.

Pattern-based fingerprinting can help disentangle the role of aerosols and GHG on the hydroclimate

A global warming and intensification of the wet-dry rainfall patterns

An aerosol-driven inter-hemispheric temperature contrast governing the ITCZ position



Bonfils et al 2020

Strategy

Detection and attribution

- 200+ CMIP6 historical + PIControl runs
- REGEN 1950 – 2016
- Method: pattern-based fingerprinting method

Model evaluation of time-varying signals

- ECS (Zelinka et al): role of climate sensitivity
- HighResMIP: role of horizontal resolution

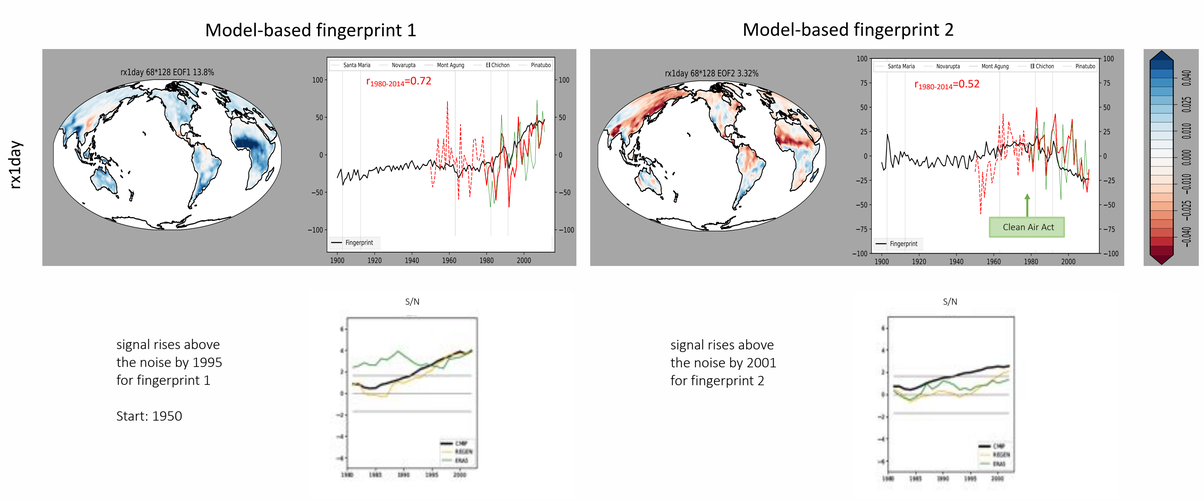
ForceSMIP activity

- Isolating the forced response from an individual realization
- CMIP6 / ForceSMIP ensembles
- Methods: Pattern-based fingerprint, Unet

Variables

- Rx1day (Annual maximum 1-day precipitation)

Can we also disentangle the impacts of aerosols and GHG on the historical changes in extreme rainfall?



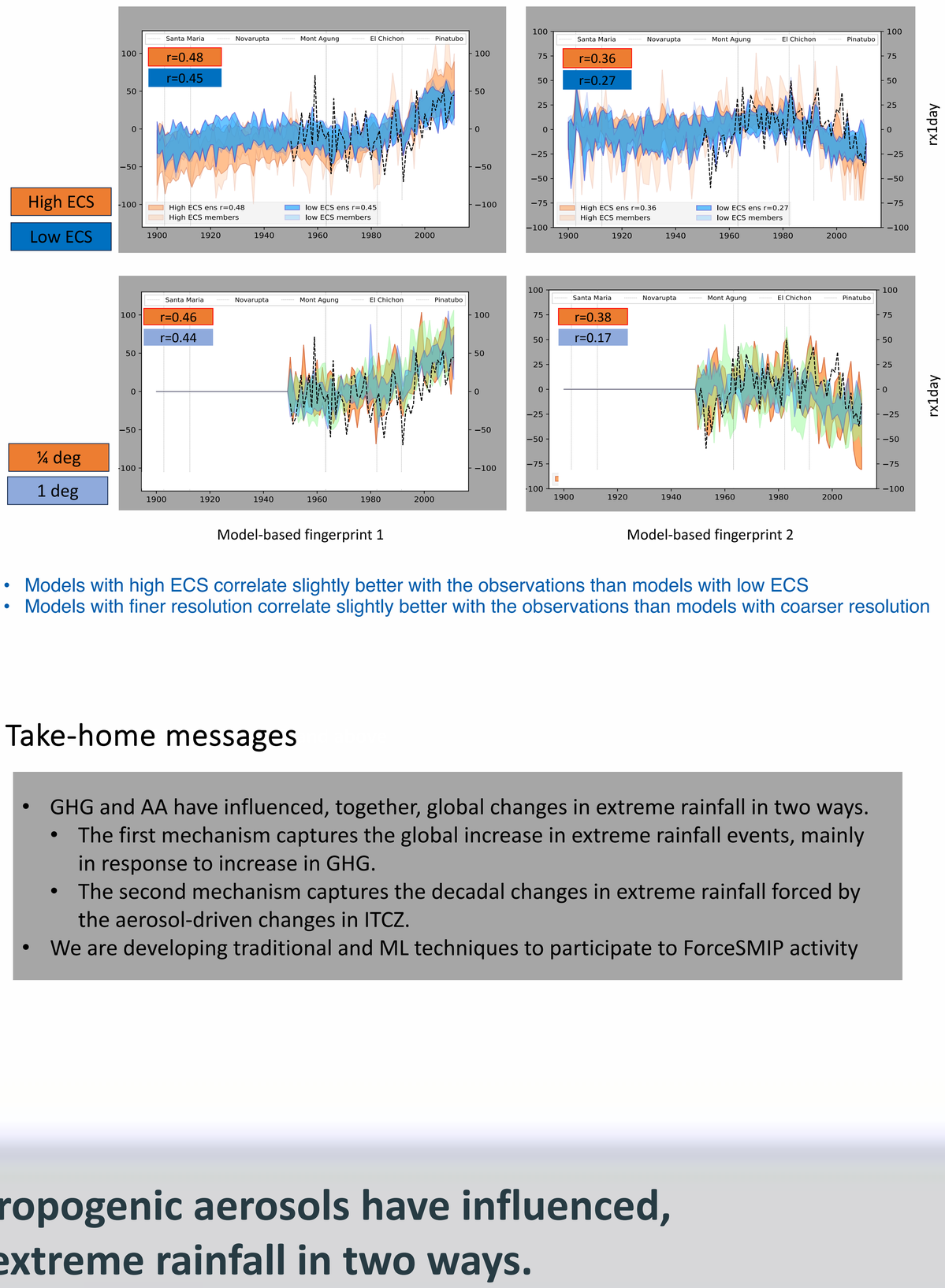
signal rises above the noise by 1995 for fingerprint 1

Start: 1950

signal rises above the noise by 2001 for fingerprint 2

- Global increase in extreme rainfall is mainly GHG-driven, with a clear volcanic signature
- Decadal variability in extreme rainfall mainly driven by the interhemispheric T change and the shift in ITCZ
- Both fingerprints are detectable in the changes derived from observations
- Similar results are reached when using ForceSMIP runs (credit to S. Duan)
- Detectability is reached when signal trends are compared to unforced trends

Role of ECS and horizontal resolution (rx1day)



- Models with high ECS correlate slightly better with the observations than models with low ECS
- Models with finer resolution correlate slightly better with the observations than models with coarser resolution

Take-home messages

- GHG and AA have influenced, together, global changes in extreme rainfall in two ways.
  - The first mechanism captures the global increase in extreme rainfall events, mainly in response to increase in GHG.
  - The second mechanism captures the decadal changes in extreme rainfall forced by the aerosol-driven changes in ITCZ.
- We are developing traditional and ML techniques to participate to ForceSMIP activity

The changes in greenhouse gases and anthropogenic aerosols have influenced, together, global changes in annual extreme rainfall in two ways.

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