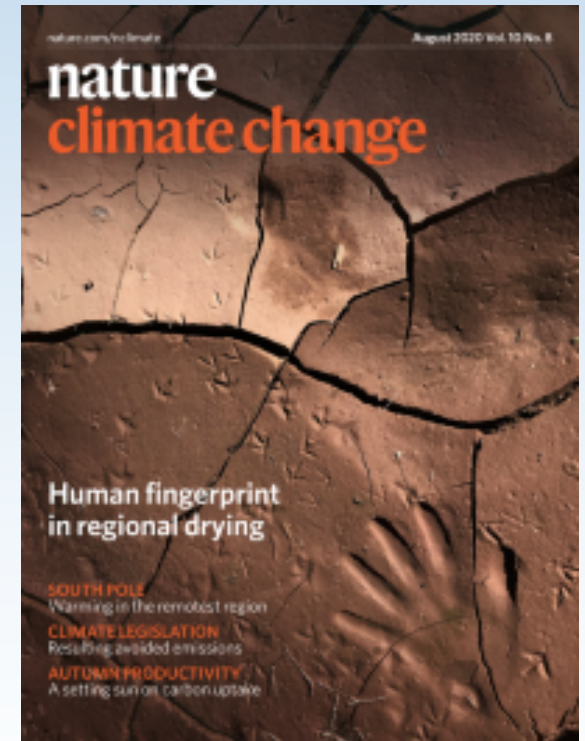


Can we disentangle the impact of changes in greenhouse gases and aerosols on recent decadal changes in hydroclimate?

Céline Bonfils, Benjamin Santer, John Fyfe, Kate Marvel, Thomas Phillips, Susan Zimmermann, Stephen Po-Chedley

- Can we explain why arid conditions are spreading worldwide? Or why the western U.S. is getting increasingly arid since the 1980s while the African Sahel has recovered from its prolonged drought?
- CMIP5 historical runs, reanalyses, and a novel method accounting for the spatio-temporal variations in aerosols
- **Main Finding** : Like musical instruments contributing to two songs playing simultaneously out of a noisy background, we found that since 1950, GHG and anthropogenic aerosols have influenced, together, global changes in temperature, precipitation and regional aridity in two distinct ways.

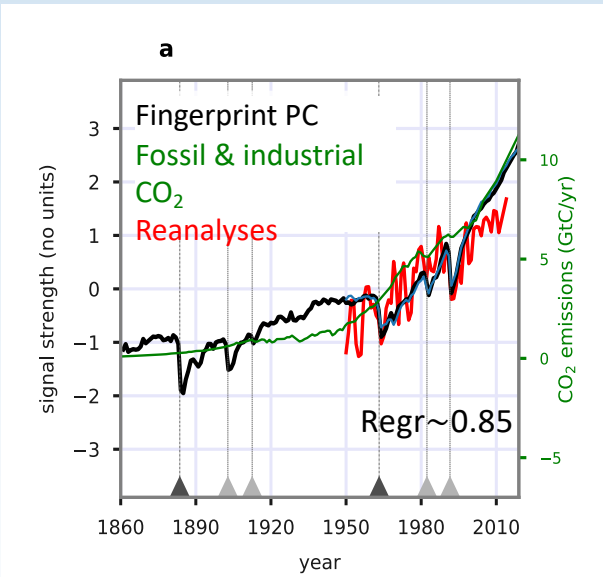


Bonfils, et al., Human influence on joint changes in temperature, rainfall, and continental aridity. *Nature Climate Change*, 10, 726–731 (2020). <https://doi.org/10.1038/s41558-020-0821-1>

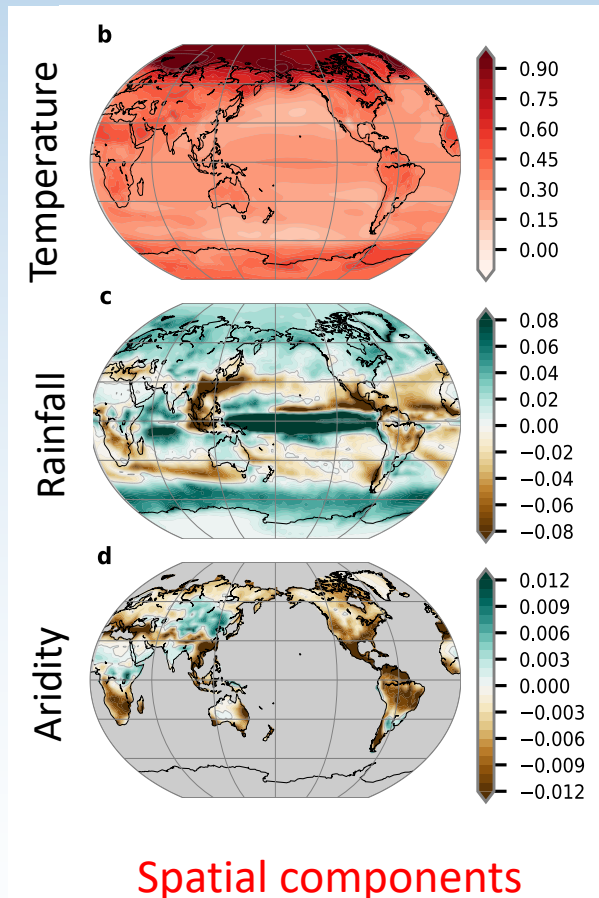
The first mechanism influencing the joint changes in T, P and aridity is loud and clear

93.6% of time-space variance

This mechanism increases over time (black line) and is present in reanalyses (red line)



Temporal component



Spatial components

global warming

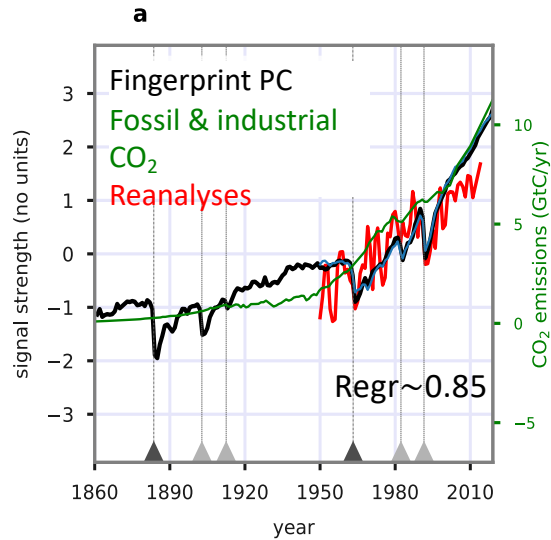
intensified wet-dry patterns

progressive large-scale continental aridification

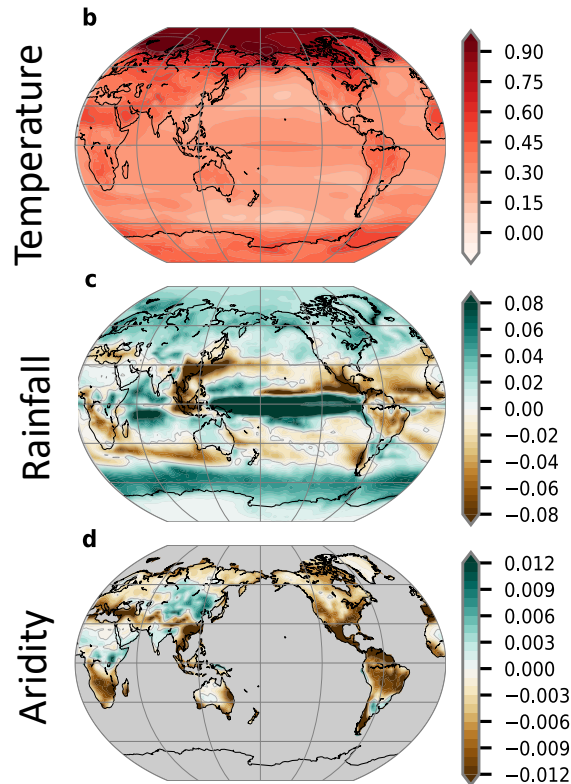
The first mechanism influencing the joint changes in T, P and aridity is loud and clear

93.6% of time-space variance

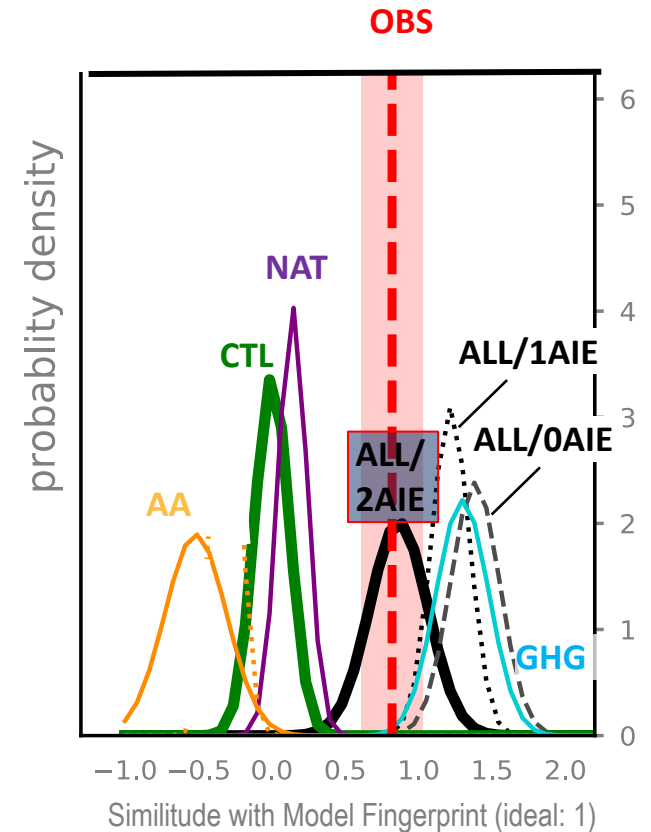
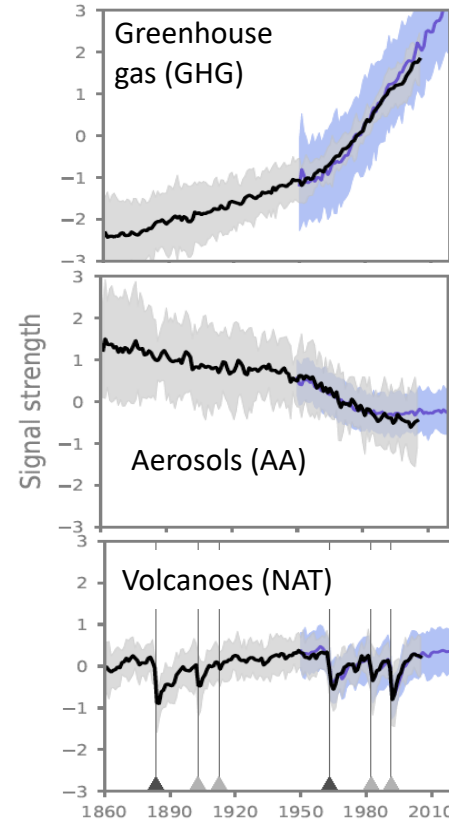
This mechanism increases over time (black line) and is present in reanalyses (red line)



Temporal component



Spatial components

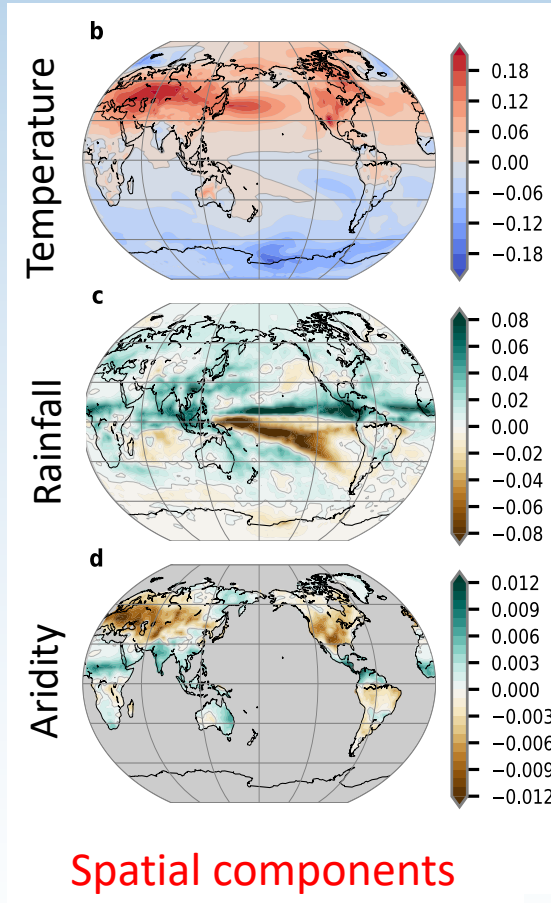
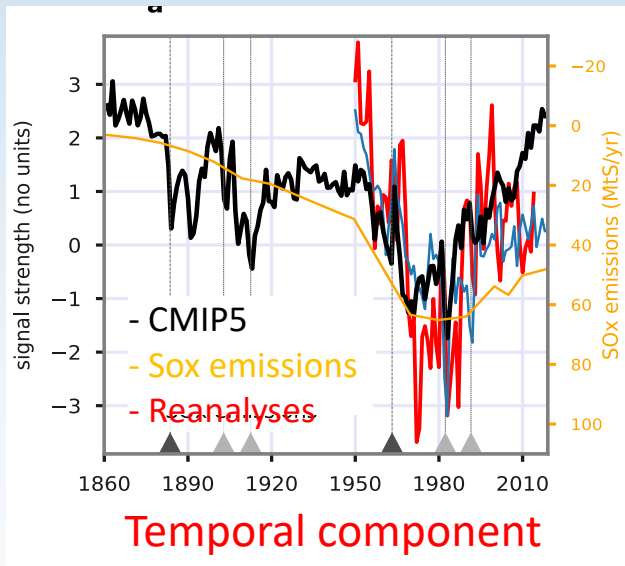


- The observed signal cannot be explained by noise, volcanic, AA or GHG forcing alone
- It is best captured by all forcings together, and best captured by models with a more complete representation of aerosol indirect effects

The second mechanism is more subtle

2.2% of time-space variance

This mechanism has a complex temporal behavior captured in the reanalyses.



Pronounced interhemispheric T contrast

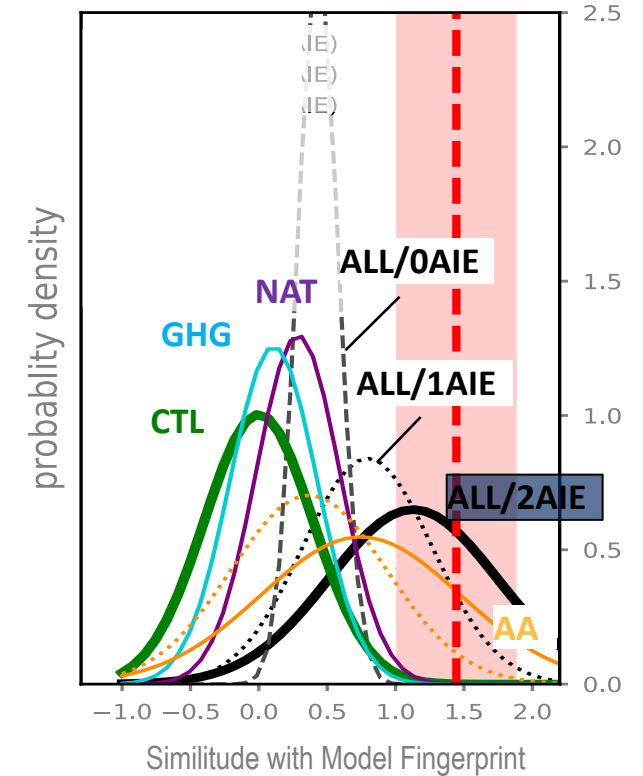
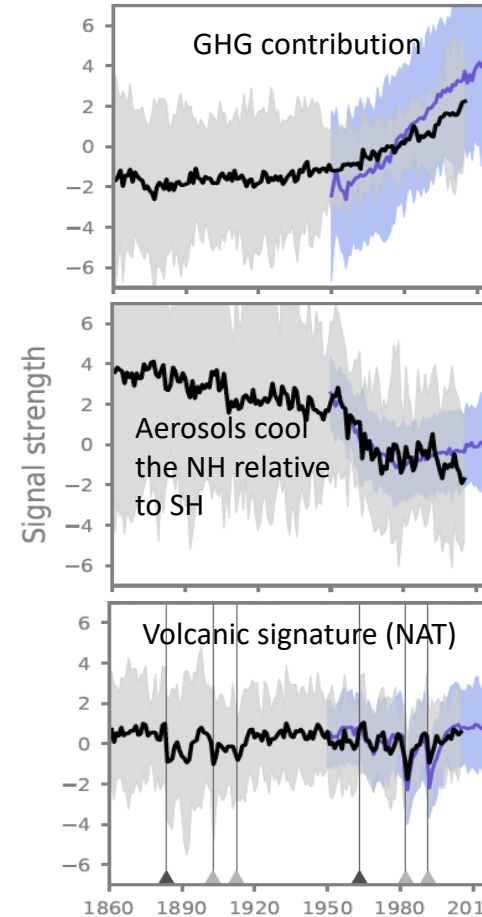
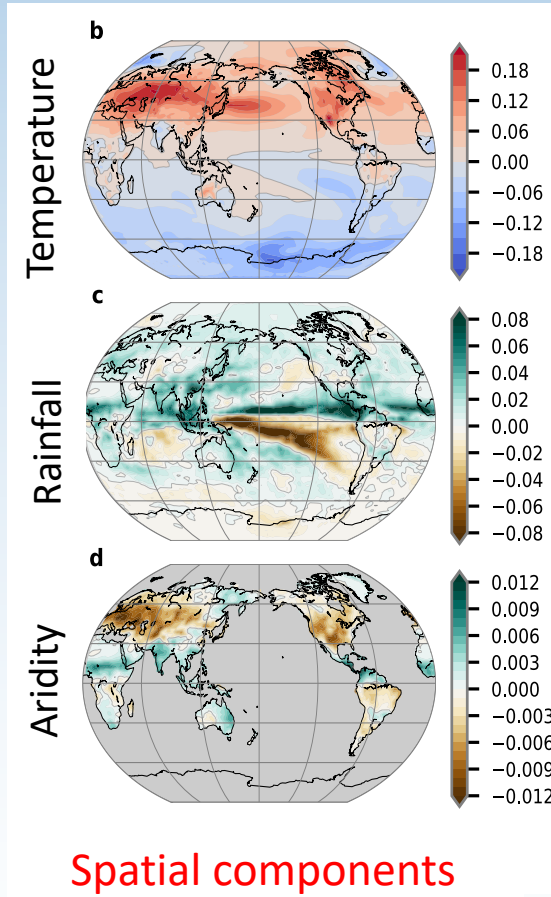
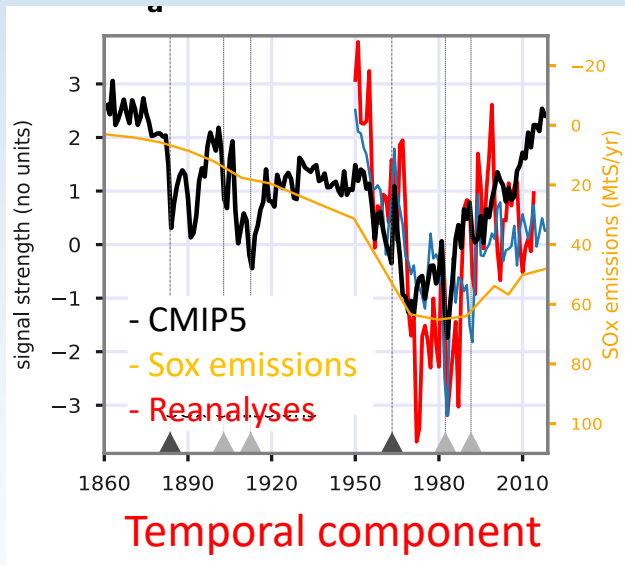
shift in ITCZ location

Change in aridity in California, the Sahel, and India

The second mechanism is more subtle

2.2% of time-space variance

This mechanism has a complex temporal behavior captured in the reanalyses.



- The observed signal cannot be explained by noise, volcanic, AA or GHG forcing alone
- It is best captured by all forcings together, and best captured by models with a more complete representation of aerosol indirect effects

Description of Challenges and Current Research in RGMA

- **Gaps in Current Research:** Better separation of direct and indirect aerosols effects on climate
- **Future Directions:** confirm CMIP5 results with CMIP6 models
- **Short Term (3- 5 years) Research Goals:** Better understanding of the decadal climate response to evolving aerosol emissions. Investigate potential forced changes in modes of variability.
- **Long Term (10 years) Research Goals:** Enhance the decadal-scale prediction skills of the climate state and extremes from both oceanic and nonoceanic drivers.