Effect of Anthropogenic Climate Change on the Global Spatial Distribution of Tropical Cyclones over the Past 40 Years

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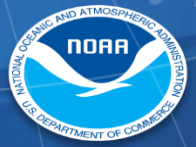
NOAA-GFDL



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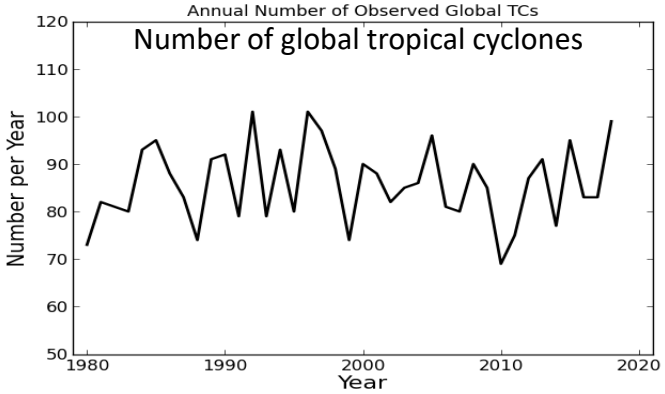
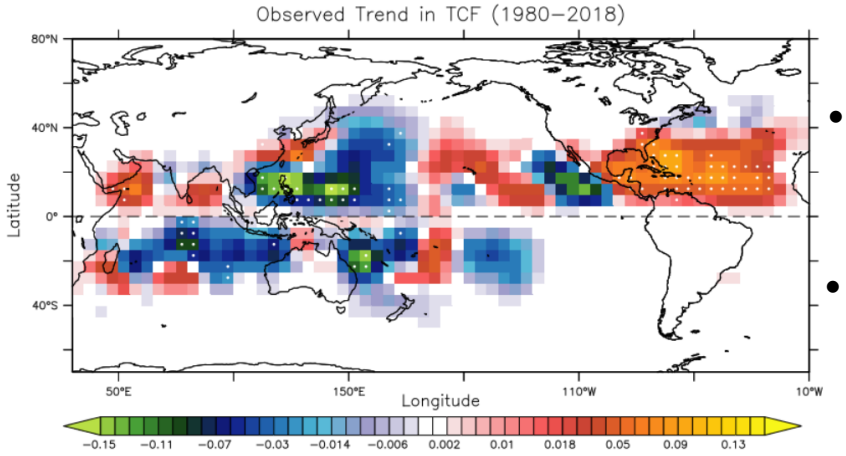
December 12, 2023

Trend in Global TC Activity (1980-2018)



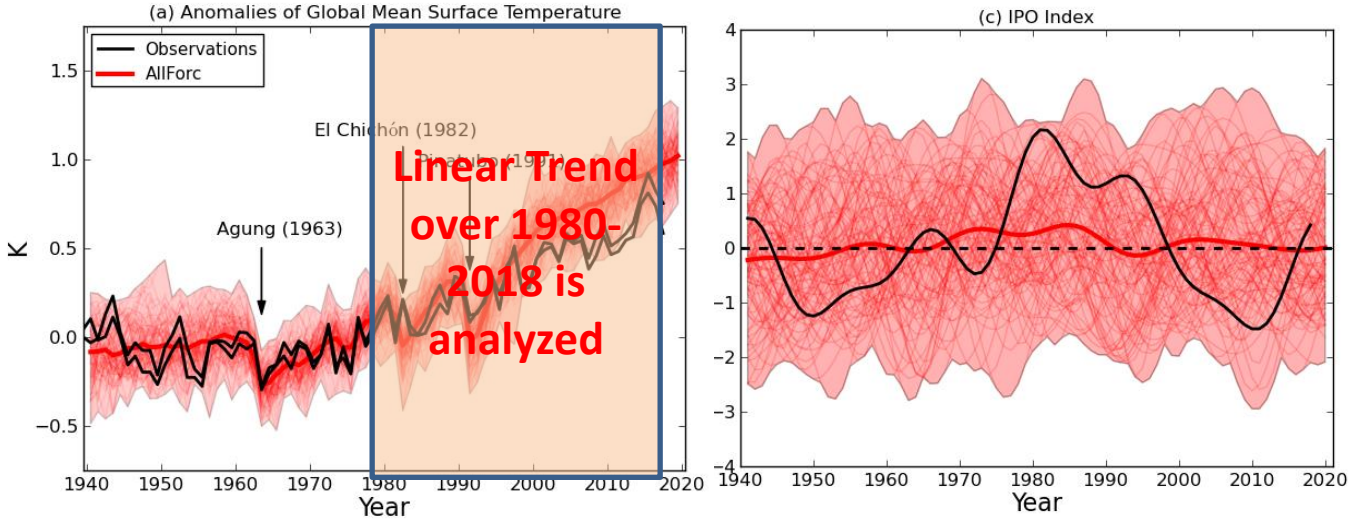


- No effect of global warming?
- Significant negative and positive trends depending on the region
- **Caused by external forcing or internal variability?**

Large-Ensemble Experiments

AllForc: 1941-2018: Historical simulations by prescribing time-varying external forcing (green-house gases, aerosols, ozone, and volcanic forcing)

95 ensemble members: SPEAR_MED (30 members), FLOR (30 members), and FLOR-FA (35 members)

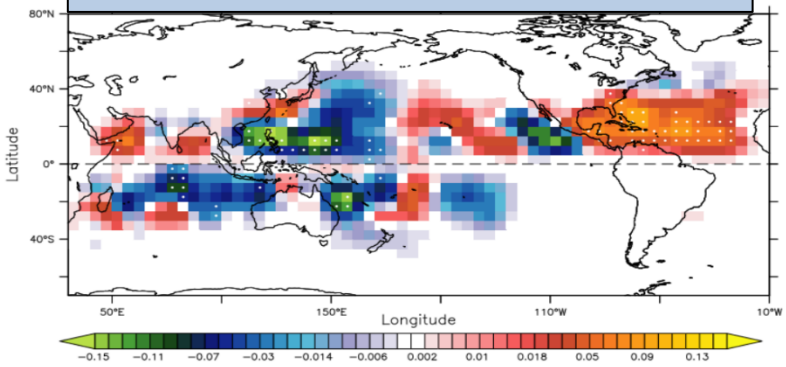


Each ensemble member shows different phase of internal variability.

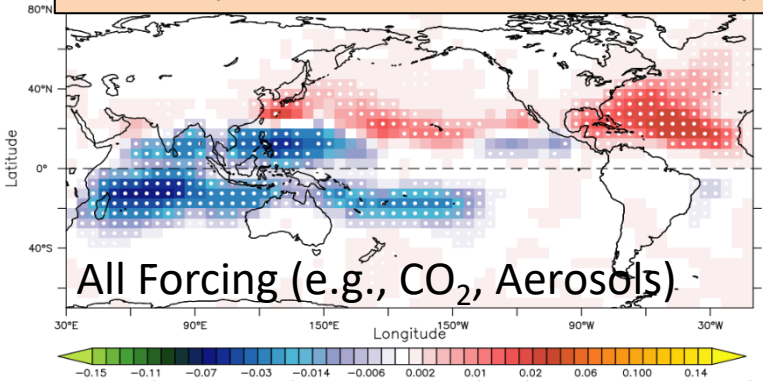
Internal variability can be canceled out by averaging the members.

Effect of External Forcing on the TCF Trend

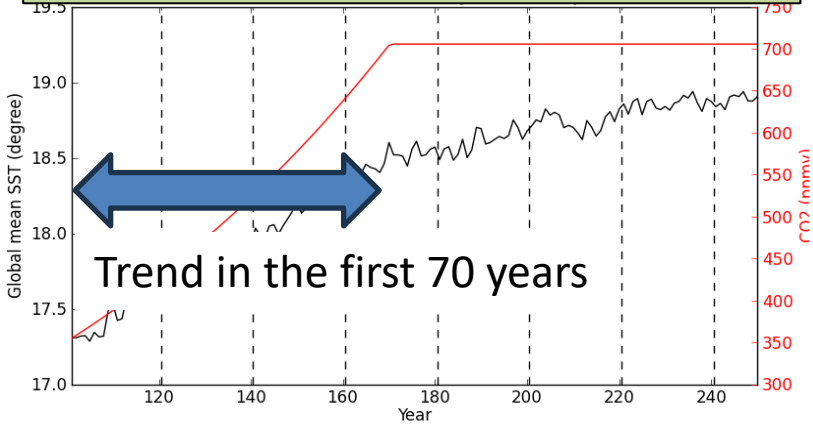
Observed Trend in TCF (1980-2018)



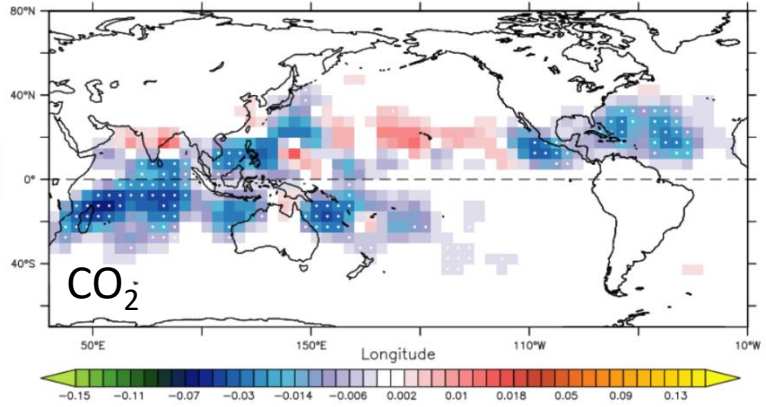
AllForc (95-member mean, 1980-2018)



Transient 2xCO_2 (3-member mean, 70 yrs)

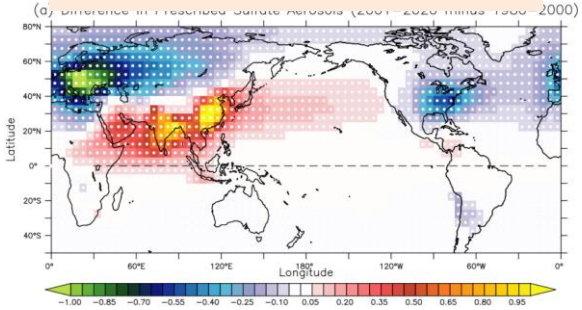


A similar spatial pattern with observations indicates marked influence of external forcing on global TCF.

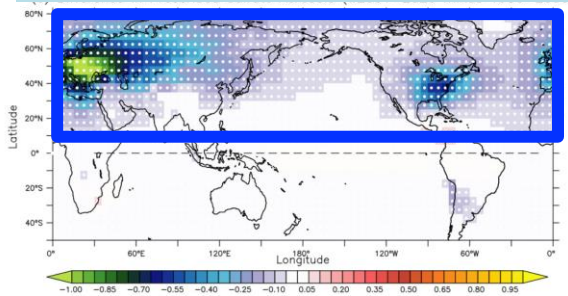


Effect of Aerosol Changes on global TCs

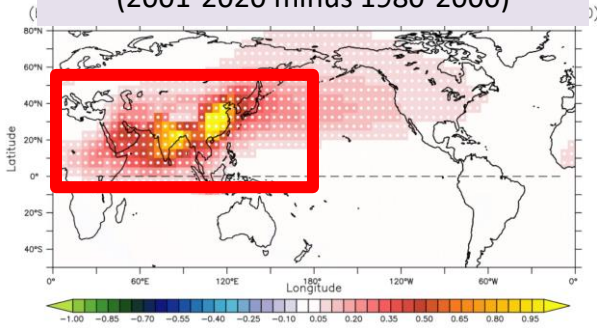
All Aerosol Changes
(2001-2020 minus 1980-2000)



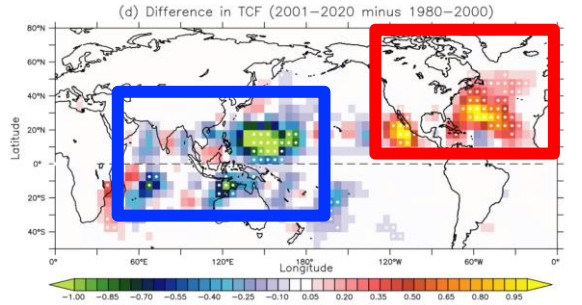
US-EURO Decreases
(2001-2020 minus 1980-2000)



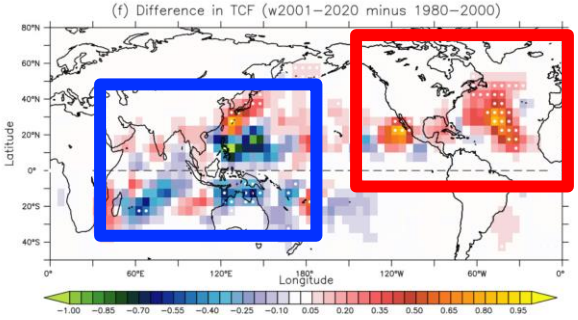
East Asia Increases
(2001-2020 minus 1980-2000)



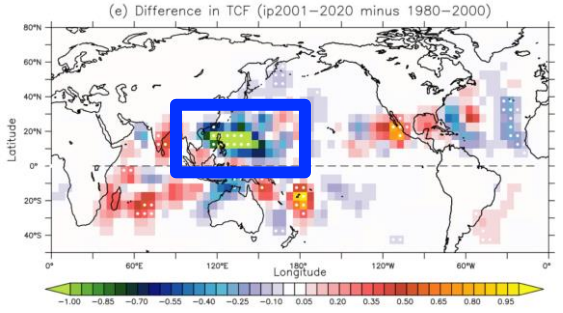
Simulated TCF Changes by All Aerosol
(2001-2020 minus 1980-2000)



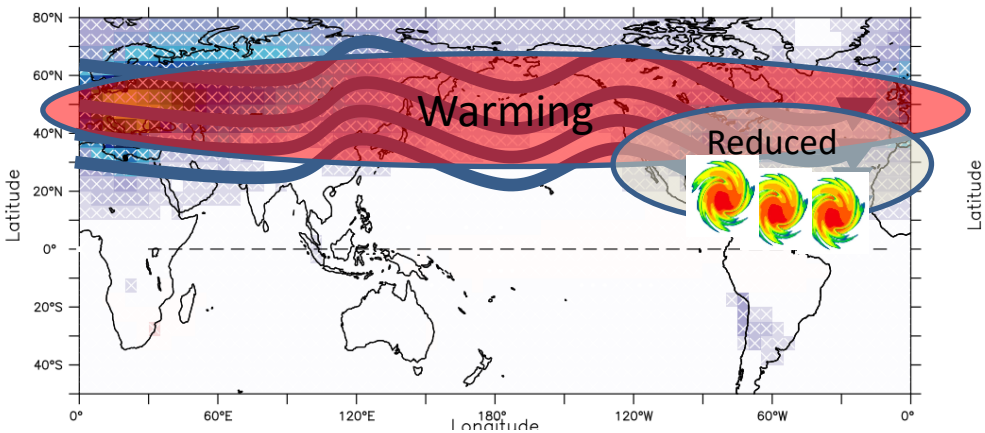
Simulated TCF Changes by US-EURO Decreases
(2001-2020 minus 1980-2000)

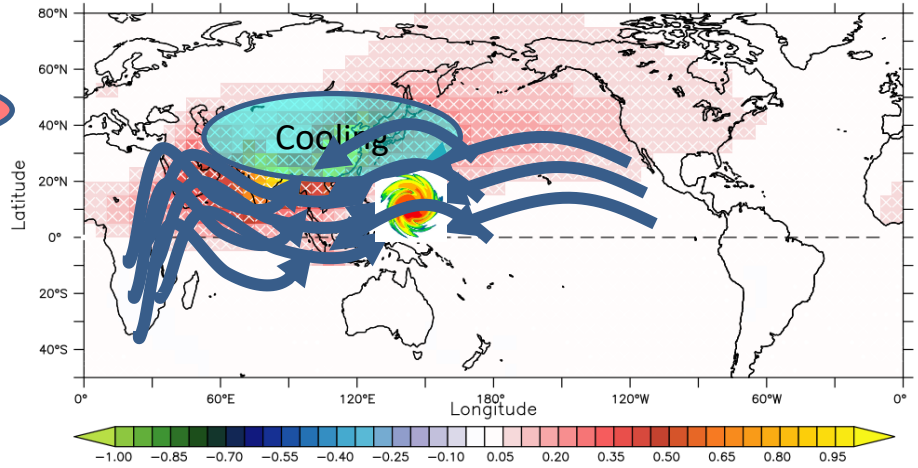


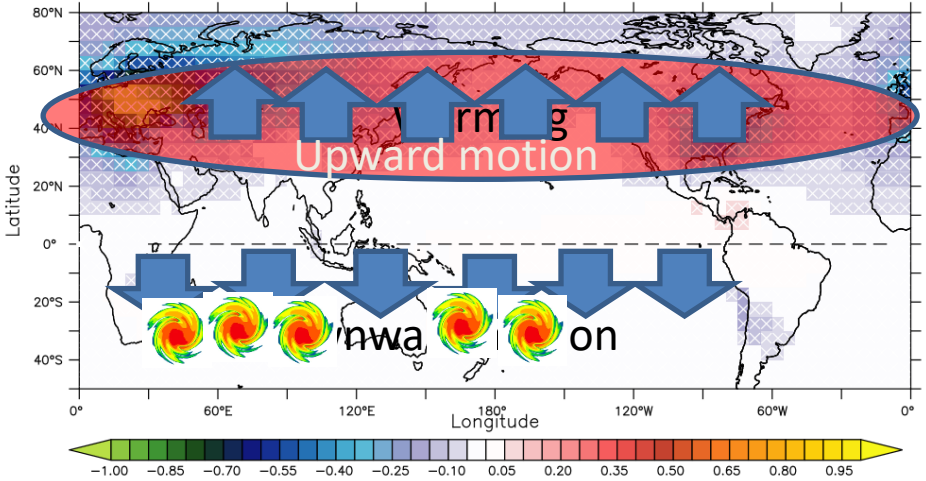
Simulated TCF Changes by East Asia Increases
(2001-2020 minus 1980-2000)



Effect of Aerosol Changes on global TCs

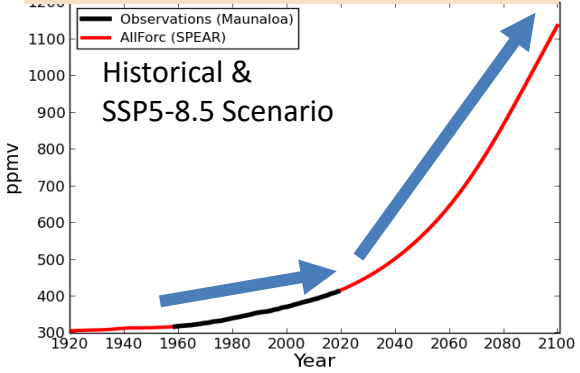




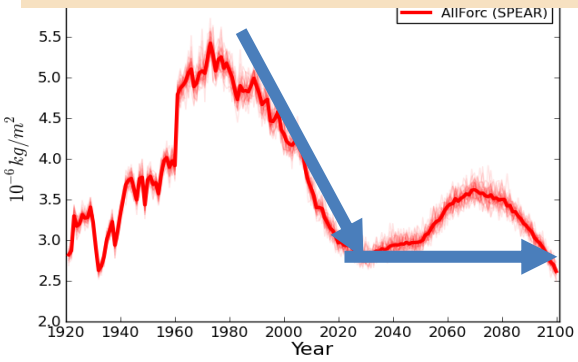


Future Projections

Global Mean CO_2 Concentration

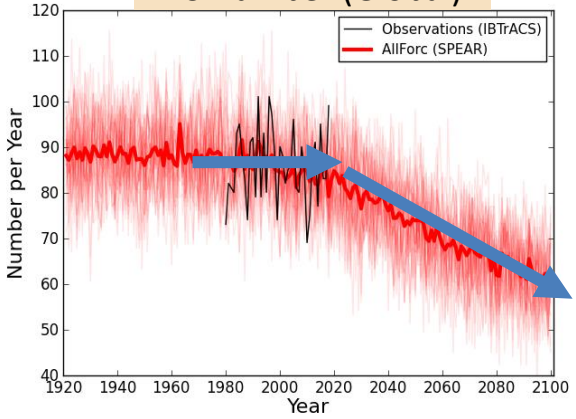


Sulfate Aerosols over North Atlantic

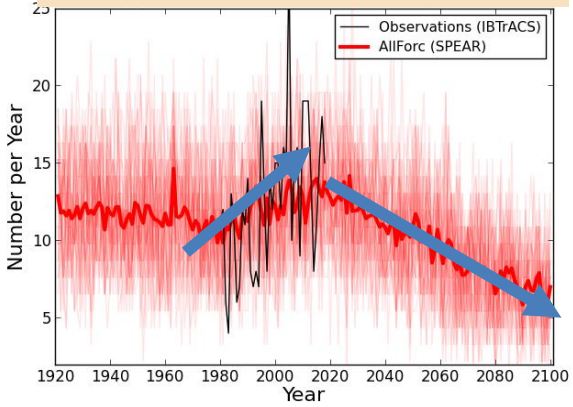


The 30-member SPEAR projects decreased global TC number toward the end of this century due to increased CO_2.

TC Number (Global)



TC Number (North Atlantic)



The decreased aerosols may be the important factor for the increased TCs over the North Atlantic over 1980-2020.

TC number of North Atlantic is also projected to decrease in the future due to the dominant effect of increased CO_2.

Summary

- Observed Trends in Global TCF (1980-2018)

External forcing (CO_2, Aerosols) played an important role.

- Anthropogenic Aerosols

Decreased aerosols from Europe & US -> More TCF in the North Atlantic
Fewer TCF in the Southern Hemisphere
Increased aerosols from East Asia -> Fewer TCF in the western North Pacific

- Future

Decreasing TCF trends in global (including North Atlantic) owing to the dominant effect of CO_2 increases.