Atlantic Origin of Recent Decadal Trends in Meridional Thermal Gradient and Global Monsoon

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1. Background

Literature pointed out a systematic enhancement of Global Monsoon (GM) since 1979 (Wang et al. 2013). External forcing drives long-term changes in GM system (e.g. past and future changes). In addition to well-mixed GHGs, anthropogenic aerosols lead to the long-term GM weakening since the 1950s (Polson et al. 2014). However, trend in anthropogenic aerosol forcing is not substantial since 1979.

Recent decadal trends in tropical basin-scale SST can also drive the decadal GM variability. In our study, individual triggering factors (Atlantic, Indian and Pacific Oceans) for the GM trend are examined by series of ocean-temp assimilation experiments.

2. Data & Metohd

CESM tropical ocean T assimilation runs

Model: CESM1 (~2° in atm, ~1° in ocn)

Control run: Basin-wide ocean mixed-layer T restored to clim

Trend run: Adding obs T trend (1979-2012)

Similar to Li et al. (2016)

- **Atl**: Atlantic assimilation
- **IO**: Indian Ocean
- **Pac**: Pacific Ocean
- **tAtl**: Tropical Atlantic assimilation
- **tPac**: Tropical Pacific Ocean

12 ensemble in each run

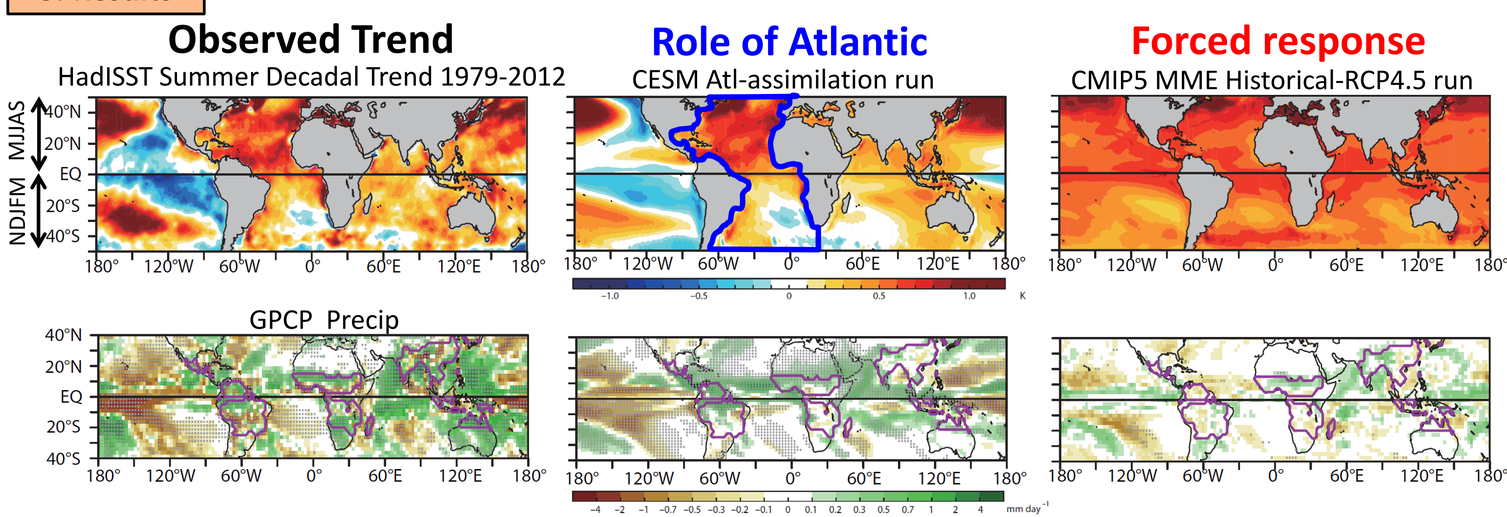
CMIP5 multi-model ensemble

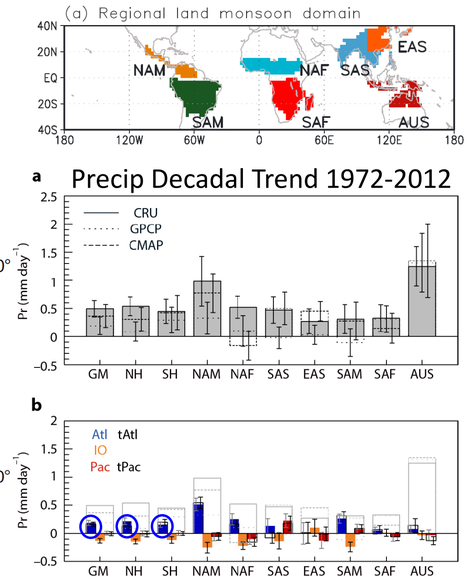
24 CGCMs Historical+RCP4.5 run (1979-2012)

Obs & Reanalysis

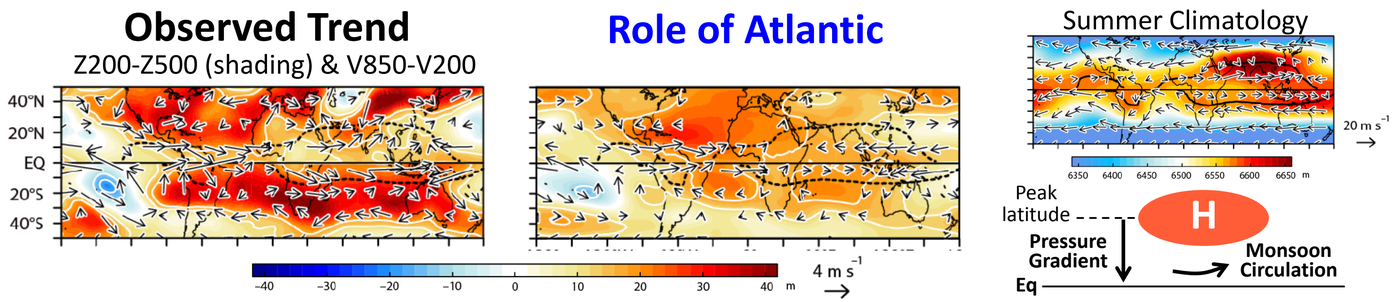
GPCP, CMAP, CRU TS v3.23, ERA-I

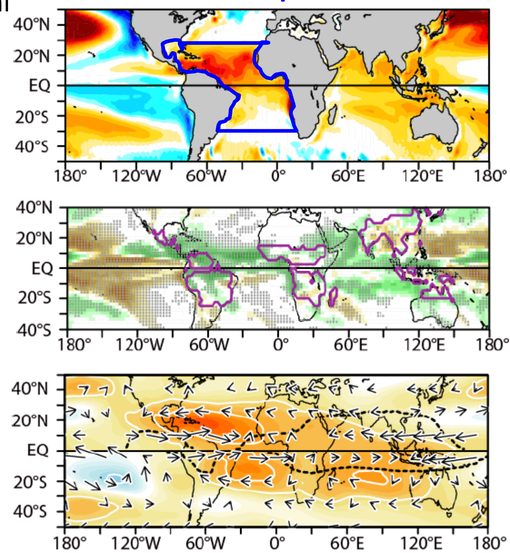
3. Results





Atlantic Ocean temp assimilation results in quite similar global SST trend to the observation. The warmer tropical Atlantic leads to subtropical anticyclone and stronger meridional thermal gradient over the North and South American Monsoon (NAM, SAM), and North African Monsoon (NAF) regiions. These enhanced meridional thermal gradient are consistent with the observed intensifications of GM and monsoon precipitation.





Major parts of the Atlantic effect are attributed to tropical Atlantic

Summary

The recent intensified GM is largely "Atlantic origin" (except South Asia)

North Atlantic warming → Intensified meridional thermal gradient, stronger monsoon circulation & rainfall

Further questions

Not the Atlantic but the Pacific is active for the intensified South Asian monsoon. Why?

The cause of the North Atlantic warming: Internal? Natural forcing? Aerosols? GHG?

References

Li, X., S.-P. Xie, et al. (2016) Atlantic-induced pan-tropical climate change over the past three decades. *Nature Clim. Change*, **6**, 275–279.

Polson, D., et al. (2014) Decreased monsoon precipitation in the Northern Hemisphere due to anthropogenic aerosols. *Geophys. Res. Lett.*, **41**, 6023–6029.

Wang, B., et al. (2013) Northern Hemisphere summer monsoon intensified by mega-El Nino/southern oscillation and Atlantic multidecadal oscillation. *PNAS*, **110**, 5347–5352.

We need sustained observations over African and Asian monsoon regions that are essentially required for decadal climate variability studies