Fast response of East Asian precipitation to local and remote emission reductions during COVID-19

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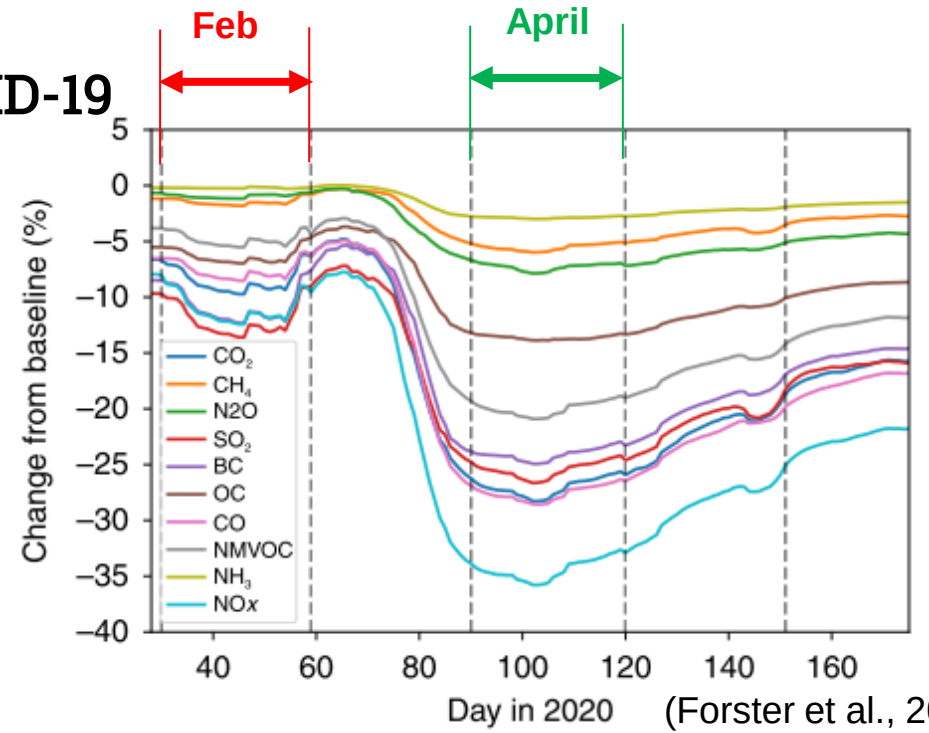
Background

Changes in emissions during COVID-19

Feb: **emission reductions over China**

April: **emission reductions outside China**

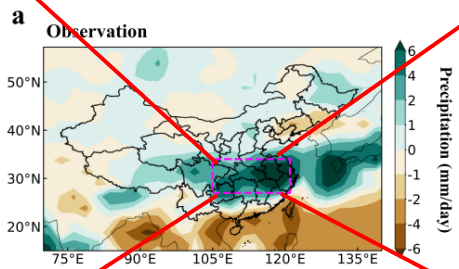


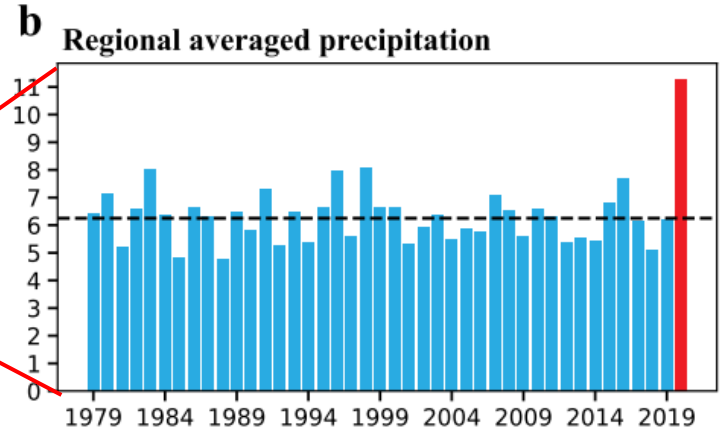
(Forster et al., 2020)

Background

Record-breaking flood over the Yangtze River Basin (YRB) during summer (June-July) in 2020

(photo via Getty Images)





(Yang et al., 2022)

Emission Reductions during COVID-19 → ? → Regional Climate

Motivation

- **Emitting locations impact responses of precipitation to aerosol forcing**
- **Fast and slow response of precipitation to emission changes are different**

➢ **Fast response of precipitation over the YRB to emission reductions over China and the rest of the world in summer 2020?**

Model Simulations

- **CESM2.2-CAM6-Chem**
  - **Prescribed observed SST from 2015 to 2020**
  - **At 0.9°×1.25° horizontal resolution**
  - **10 ensemble members**
- **Emission scenarios in 2020**

a. **Reduced emission: COVID (Forster et al., 2020; Zheng et al., 2020)**
b. **Non-reduced emission: EXTRA (based on SSP2-4.5)**

Experiment Design

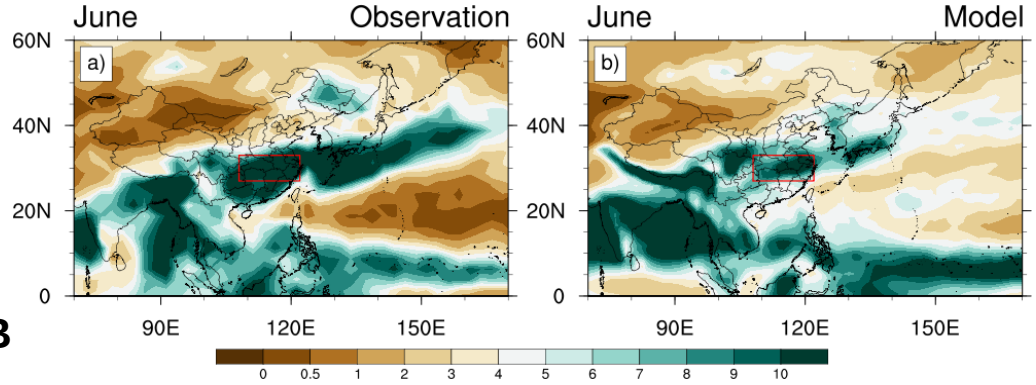
	Name	Local Emissions	Remote Emissions	Simulated year
		China	Rest of the World	
1	SSP	CEDS	SSP245	2015-2019
2	COVID	COVID	COVID	2020
3	NoCOV	EXTRA	EXTRA	2020
4	NoCOV_CN	EXTRA	COVID	2020
5	NoCOV_RW	COVID	EXTRA	2020

- COVID-NoCOV: impact of global emission reductions
- COVID-NoCOV_CN: impact of emission reductions over China
- COVID-NoCOV_RW: impact of emission reductions over the rest of the world

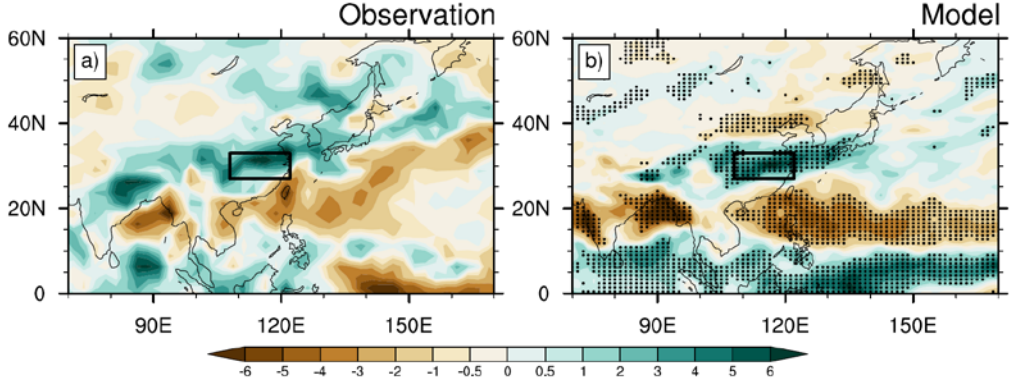
Evaluation of Simulated Precipitation

- The spatial pattern of precipitation is consistent with the observations.
- Dry bias in precipitation over the YRB and southern China in June 2020
- Significant increase in precipitation over the YRB

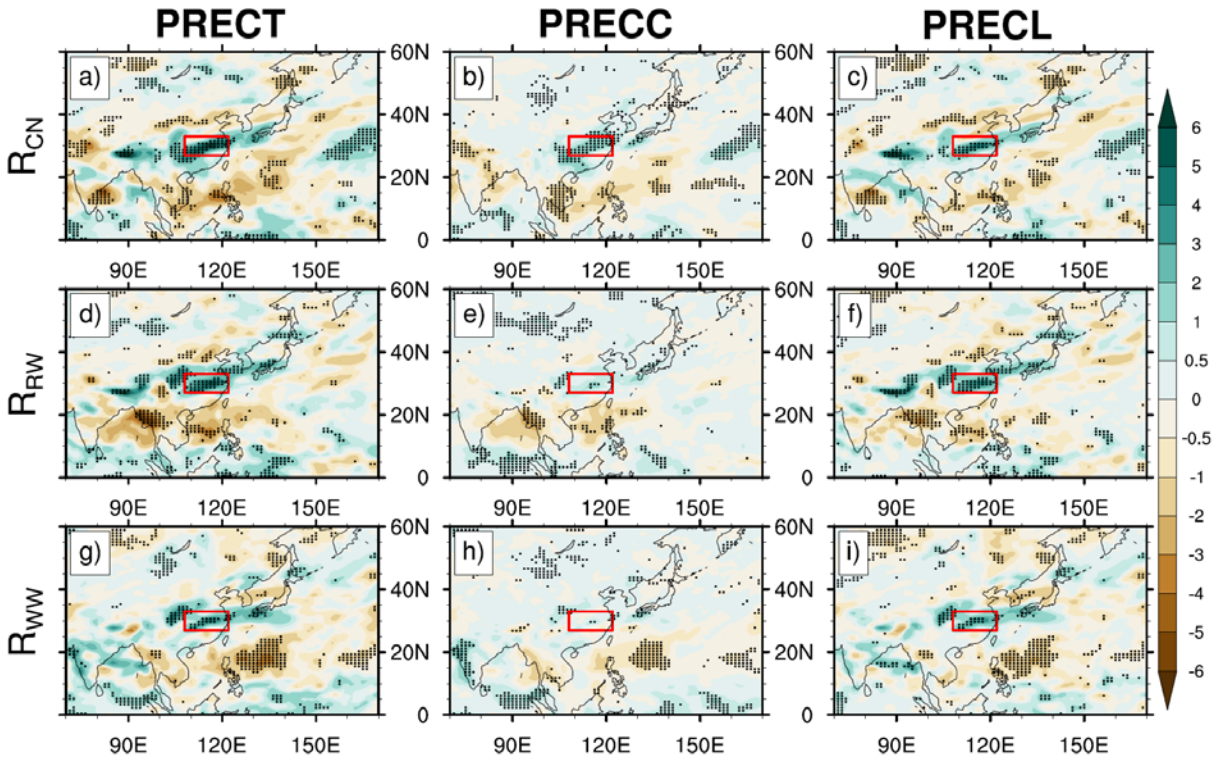
Precipitation in 2020



2020 - 2015~2019 mean



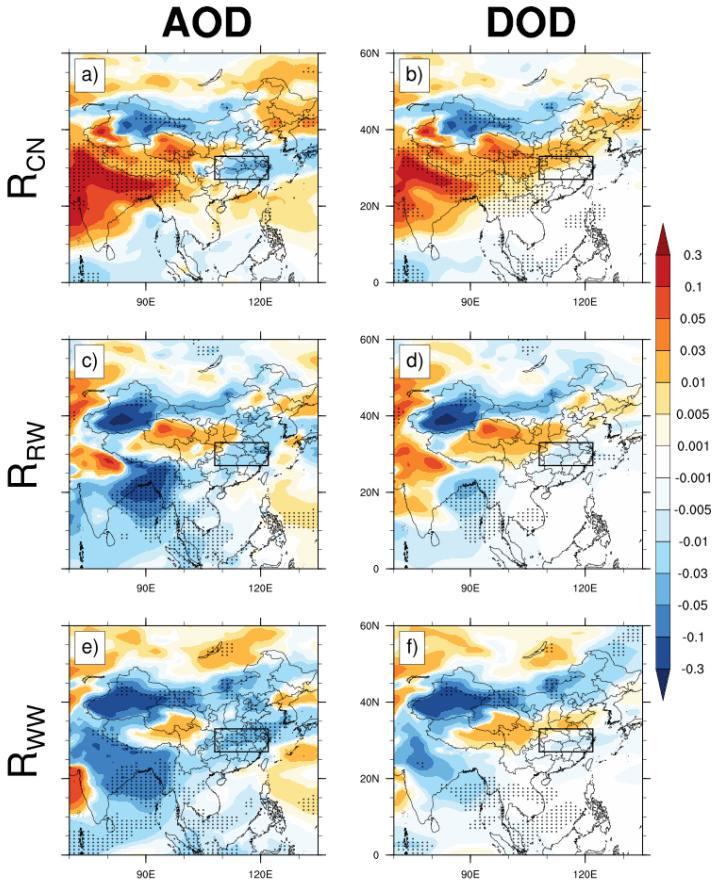
Fast Precipitation Response to Emission Reductions in June



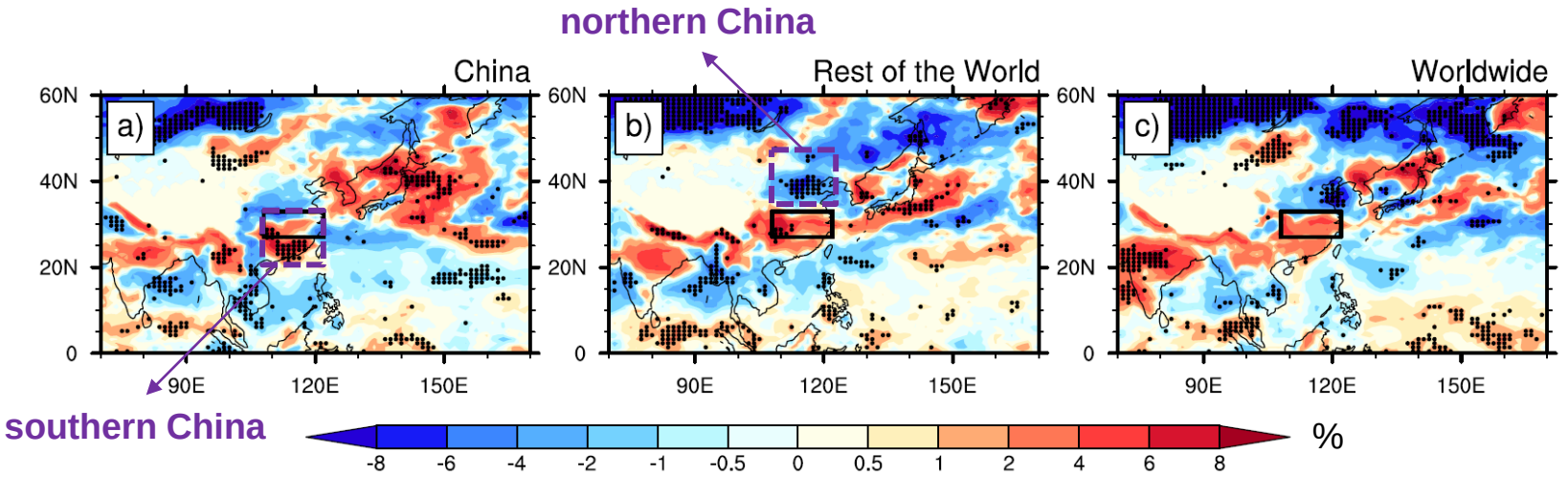
- stronger convective precipitation with reduced emissions over China
- stronger large-scale precipitation with reduced emissions outside China

Changes in AOD due to Emission Reductions in June

- **Decreased AOD over northern and southern China**
- **This is mainly associated with decrease in anthropogenic AOD**



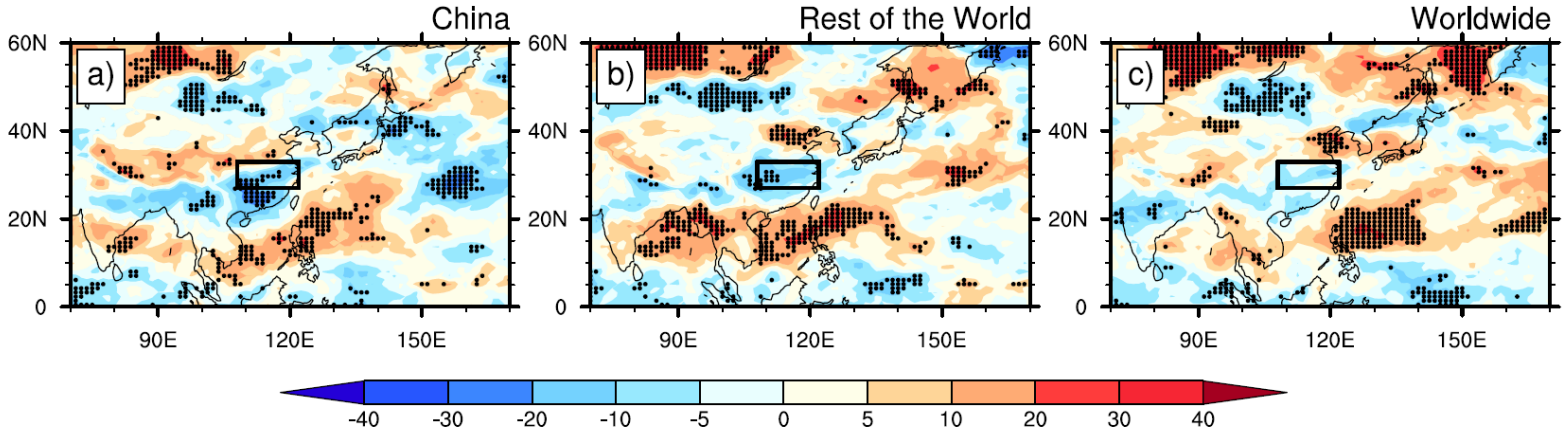
Changes in Low-Cloud fraction due to Emission Reductions in June



- **A decrease in low-cloud fraction over the northern China, mainly caused by emission reductions outside China**

- **An increase in low-cloud fraction over the southern China, which is associated with enhanced vertical motion and atmospheric stability**

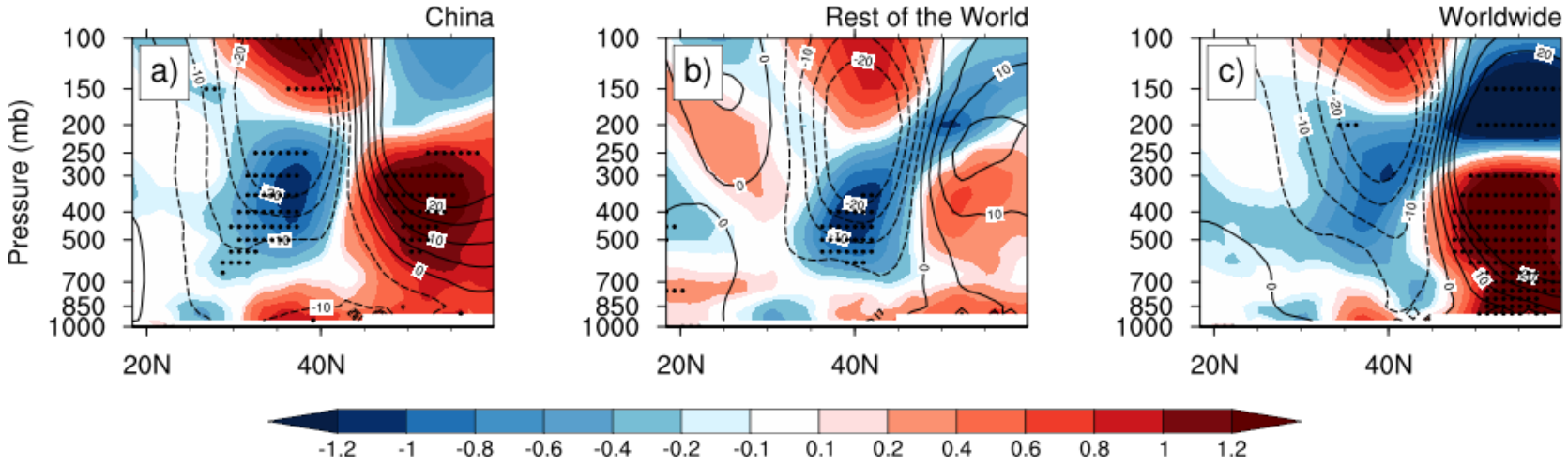
Changes in Surface Radiation due to Emission Reductions in June



- **An increase in net solar radiation at surface over northern China due to decreased aerosol and low-cloud, mainly caused by emission reductions outside China**

- **A decrease in net solar radiation at surface over southern China due to increased low-cloud**

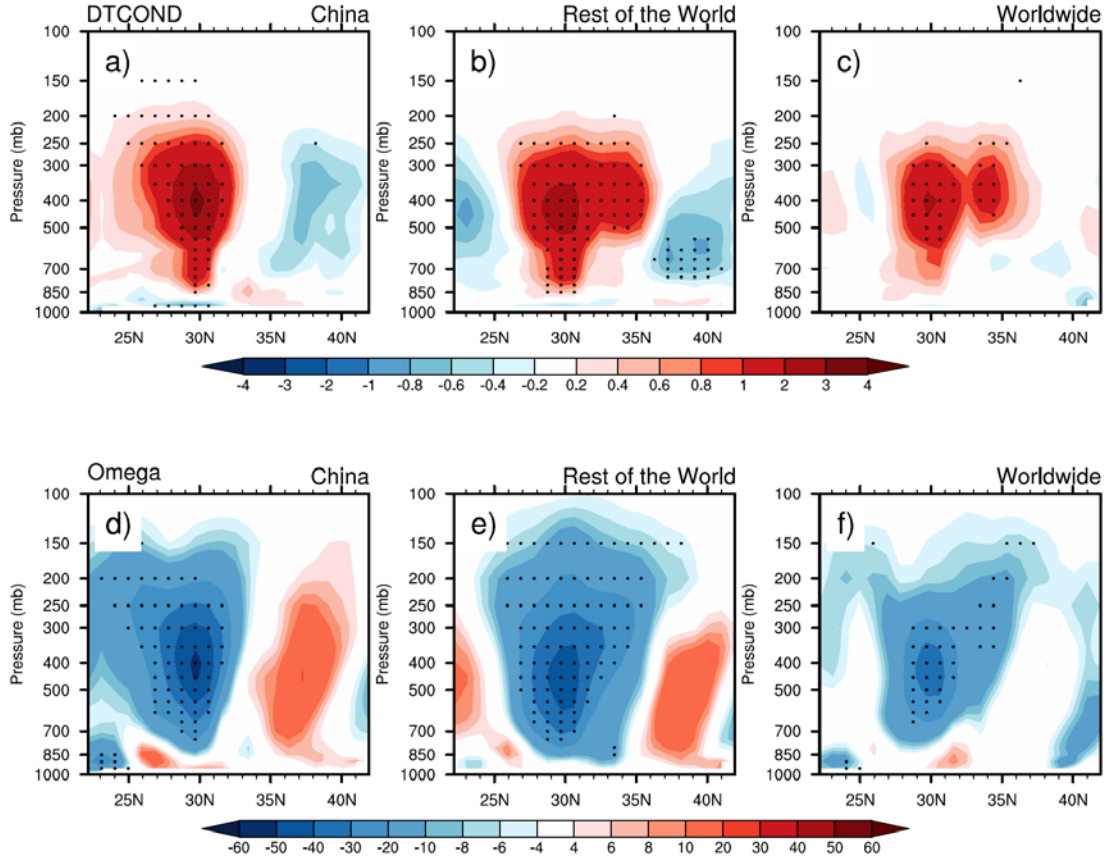
Changes in Circulation due to Emission Reductions in June



- **Atmospheric cooling over the sea (10~20N) and warming over the land (40~60N) increase the land-sea thermal contrast**

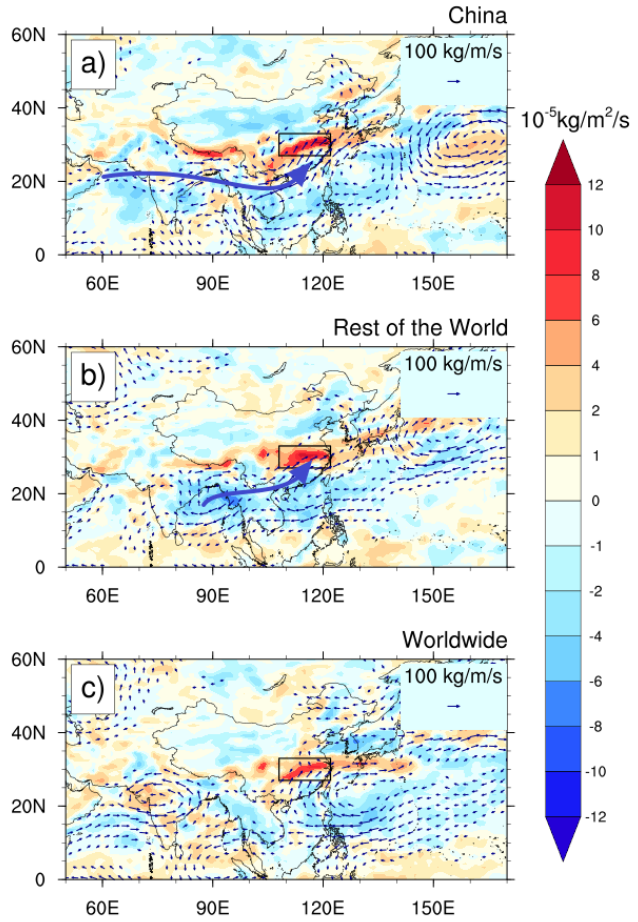
Changes in Vertical Motion due to Emission Reductions in June

- **Enhanced diabatic heating due to condensation**
- **Stronger ascending over the YRB**
- **Reduced emissions over China cause the strongest ascending around 30N**



Changes in Moisture Transport due to Emission Reductions in June

- **Enhanced moisture transport and convergence over the YRB**
- **Local reduced emissions over China enhance moisture transport from the Arabian sea to the YRB**
- **Remote reduced emissions outside China enhance moisture transport from the Bay of Bengal to the YRB**



Conclusions/Implication

- **Local reduced emissions over China lead to stronger convective precipitation, while remote emission reductions outside China cause stronger large-scale precipitation.**

- **AOD and low-cloud fraction decrease over northern China due to emission reductions, enhancing solar radiation at surface and land-sea thermal contrast. The vertical motion and moisture convergence are enhanced over the YRB.**

- **The local and remote emission reductions lead to different anomalous ascending motion and moisture transport path.**

- **The nonlinearity in the response to aerosol forcing from local and remote regions requires international collaboration across countries when addressing the regional impact of climate change.**

Thanks