The impact of anthropogenic aerosol on the East Asian summer monsoon

Laura Wilcox[1,2] | Buwen Dong[1,2] | Rowan Sutton[1,2] | Ellie Highwood[2]

l.j.wilcox@reading.ac.uk

1. NCAS-Climate, University of Reading 2. Department of Meteorology, University of Reading

National Centre for Atmospheric Science
NATURAL ENVIRONMENT RESEARCH COUNCIL

The East Asian summer monsoon (EASM) has weakened considerably in recent decades. This results in a stagnation of the Mei-Yu front, causing a pattern of southern flooding and northern drought.
We investigate the possible mechanisms by which local and remote changes in anthropogenic aerosol may affect the strength of the EASM, and assess whether the 2014 northern drought can be attributed to anthropogenic forcing.

Preferred response to aerosol changes

- Atmospheric component of HadGEM2-ES
- Fast response to sudden switch on of European or Asian sulphur dioxide emissions

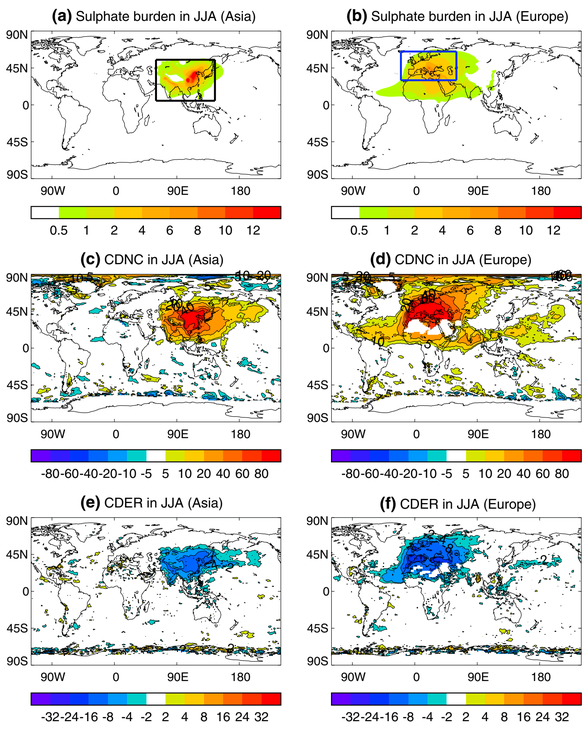

Figure 1: *The spatial patterns of (a, b) changes in sulphate aerosol burden (mg m-2), (c, d) percentage changes in cloud droplet number concentrations (CDNC), and (e, f) percentage changes in cluod droplet effective radius (CDER) in response to Asian and European sulphur dioxide emissions in June, July, and August. Boxes in (a, b) show where emissions were perturbed.*

- Large differences in aerosol and cloud changes over Asia in response to European and Asian emissions
- Very different responses in the radiation budget over Asia
- Aerosol emissions cause local cooling in both cases

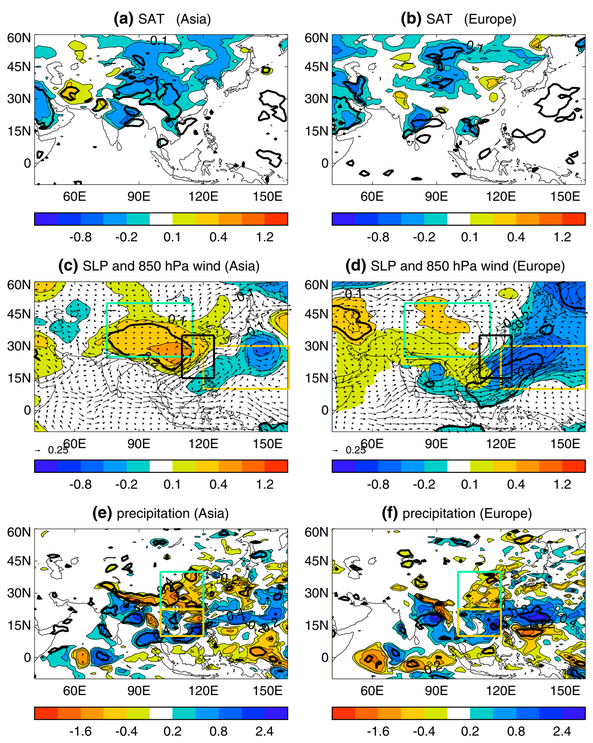

Figure 2: *The spatial patterns of changes in surface air temperature (SAT, °C), SLP (hPa) and 850 hPa wind (ms^{-1}), and precipitation (mm day^{-1}) in response to Asian and European sulphur dioxide emissions in June, July, and August. Thick black lines show where the changes are significant at the 10% level.*

- 40 days after emissions, the response to Asian and European aerosols looks similar over Asia
- Cold, dry anomaly over Europe in response to emissions there is advected into Asia, while Asian emissions cause local cooling

- European and Asian aerosol emissions both cause cooling over Asia
- This cooling weakens the land-sea contrast and the EASM
- A weakened EASM results in a pattern of southern flooding and northern drought
- The similarity 40 days after emission indicates a preferred response

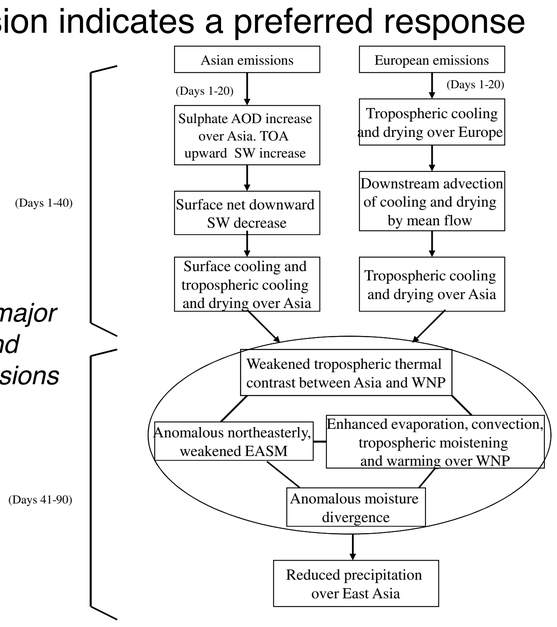

Figure 3: *Schematic diagram illustrating the major processes of the EASM responses to Asian and European anthropogenic sulphur dioxide emissions*

A preferred response of the EASM to regional aerosol changes suggests that both Asian and European emissions may have contributed to the observed weakening of the EASM.

Northeast Asia drought: JJA 2014

- 2014 drought occurs in the context of over a decade of summer drought in the region: an extreme case of a decadal pattern
- Weakened EASM and a pattern of southern flooding and northern drought

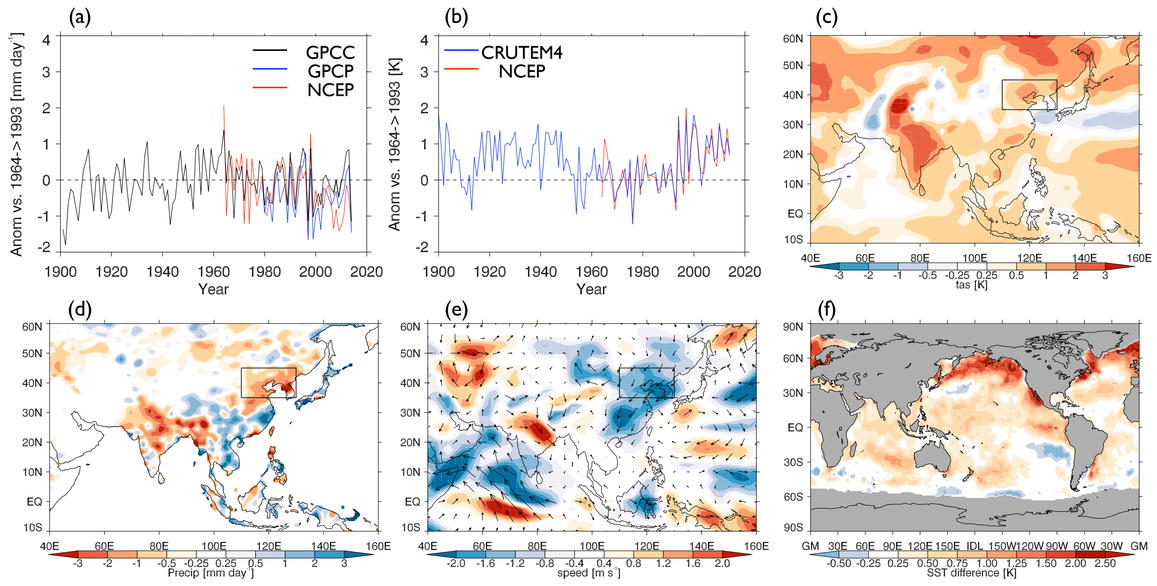

Figure 5: *(a) JJA precipitation anomalies over northeast Asia. The northeast Asia region is indicated by the boxes in panels (c)–(e).(b) JJA temperature anomalies over northeast Asia. (c) 2014 near-surface temperature anomalies (NCEP–NCAR). (d) 2014 precipitation anomalies (GPCC). (e) 2014 850-hPa wind anomalies (NCEP-NCAR). (f) 2014 SST anomalies (HadISST). Anomalies are relative to 1964–93.*

- HadGEM3-A driven with observed GHG, anthropogenic aerosol, and sea surface temperature (SST) patterns

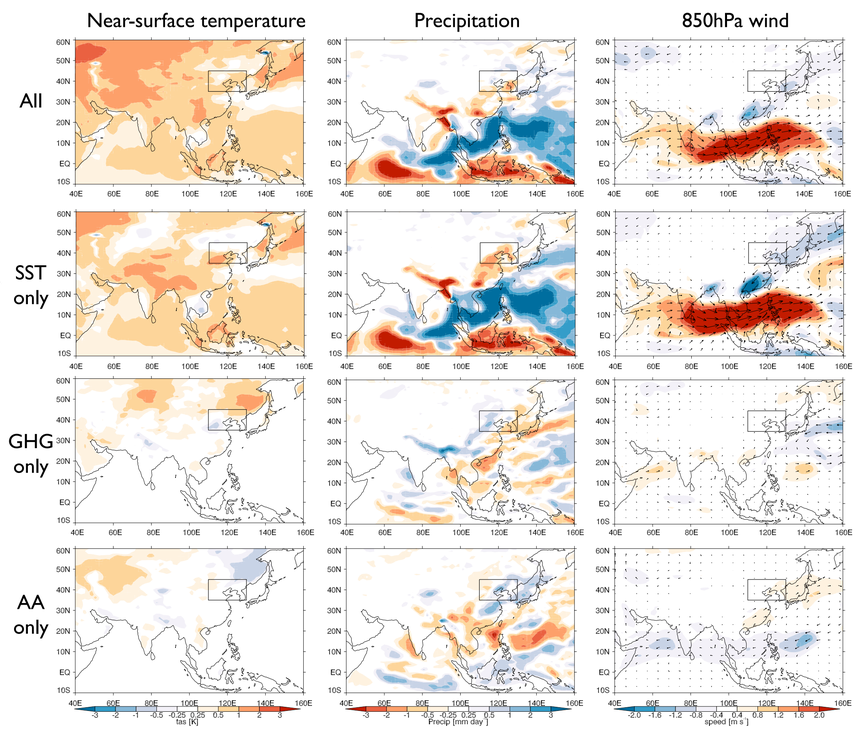

Figure 5: *HadGEM3-A responses to summer 2014 forcings, relative to the 1964–93 mean.*

- Model response is primarily determined by the response to SST changes

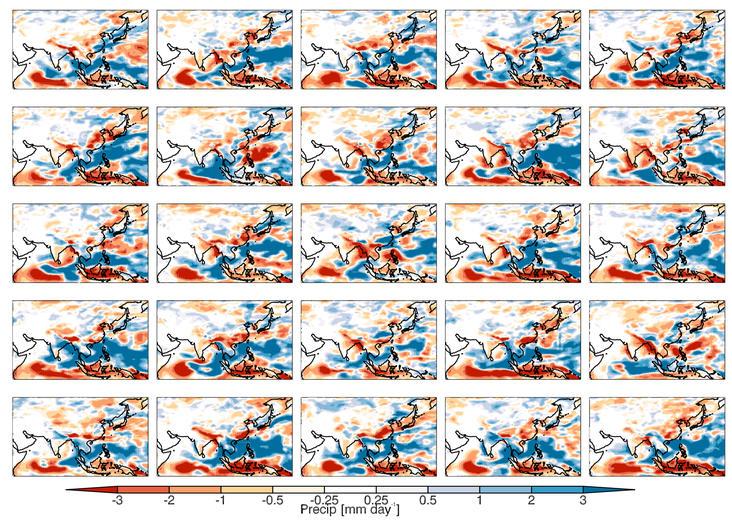

Figure 6: *Individual realisations of 2014 precipitation anomalies (mm day-1) relative to 1964-93 from the all-forced HadGEM3-A simulation.*

- No single model ensemble member is able to reproduce the observed 2014 precipitation pattern, so no definitive attribution statements can be made

Our work shows the mechanisms by which anthropogenic aerosol could have contributed to the observed weakening of the East Asian summer monsoon, but suggests that model biases need to be reduced in order to enable successful attribution of individual extreme precipitation events.

Learn more:

Dong et al., (2015), *Climate Dynamics*, DOI:10.1007/s00382-015-2671-5.
Wilcox et al., (2015), *BAMS*, DOI:10.1175/BAMS-D-15-00123.1.