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Impacts of Northeast Monsoon cold surges on atmospheric composition in Southeast Asia

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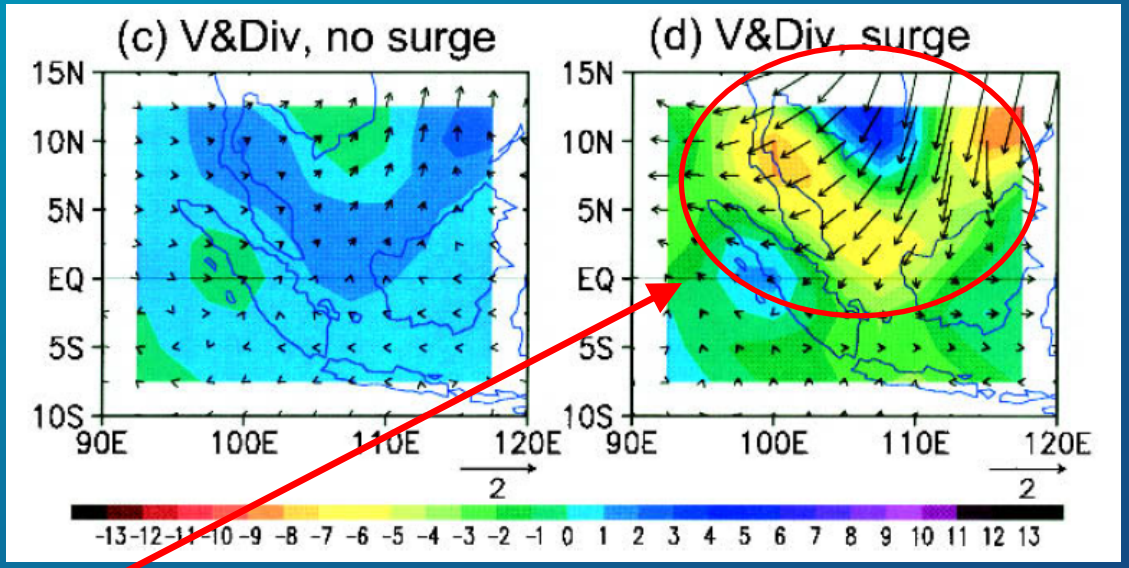
Outline

- Cold surges – brief intro; interest in 'downwind' impacts on atmospheric composition in SE Asia
- Role in transporting short-lived ozone depleting substances (ODS) to tropics (Oram, Ashfold et al., ACP, 2017)
- Cold surges and other monsoon flows transporting pollution to a tropical measurement site – Bachok, Malaysia
- Role in reducing air quality in tropical SE Asia (Ashfold et al., Atmos Environ, 2017)
- Further questions and opportunities for research

Cold surges

Major form of variation during Northeast (NH winter) monsoon

Asian high pressure centres move SE-ward accompanied by cold air mass



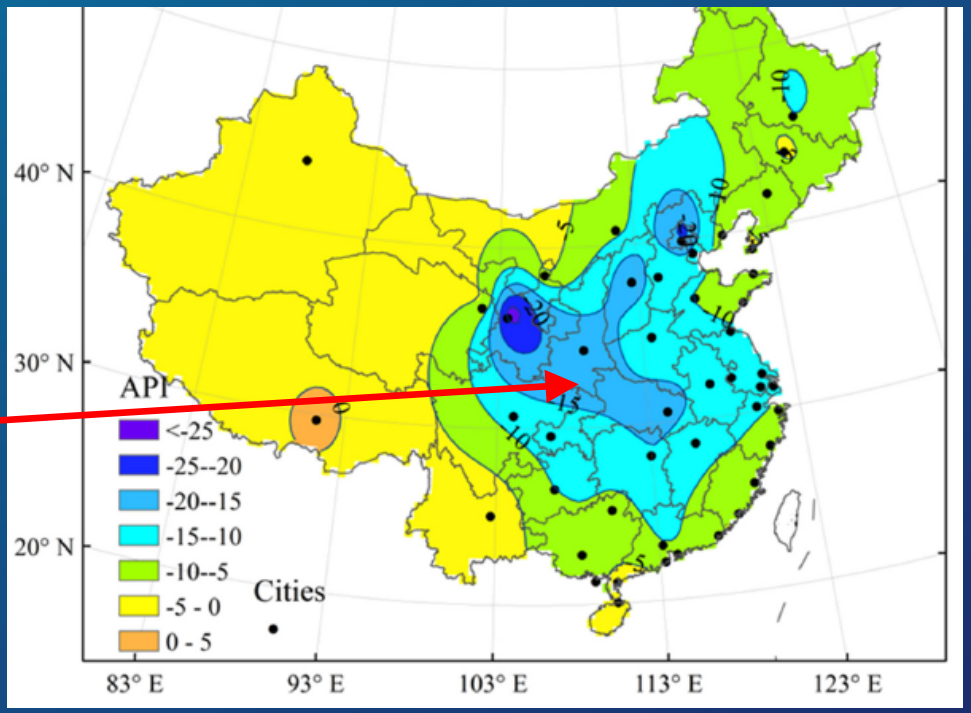
Strengthen winds from N in SCS

Enhance tropical convection

Chang et al., MWR, 2005

Can considerably improve air quality (decrease API) over mainland China

Wang et al., Atmosphere, 2016

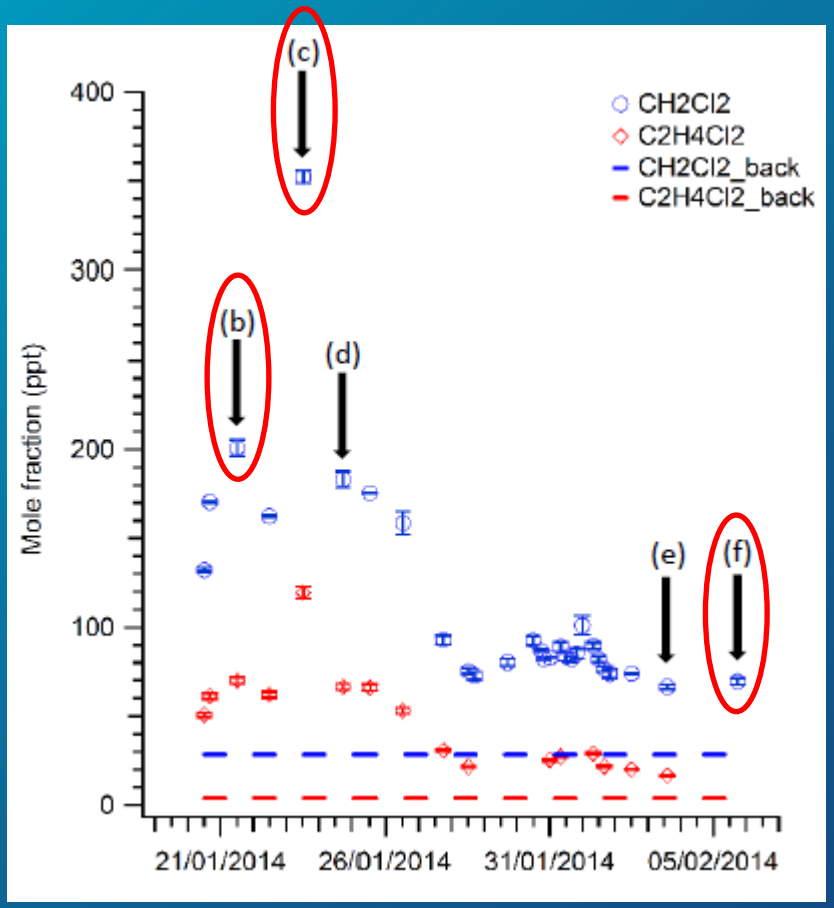


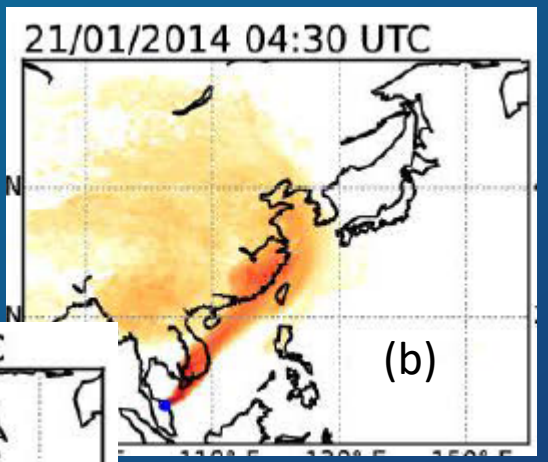
Pollution goes elsewhere?

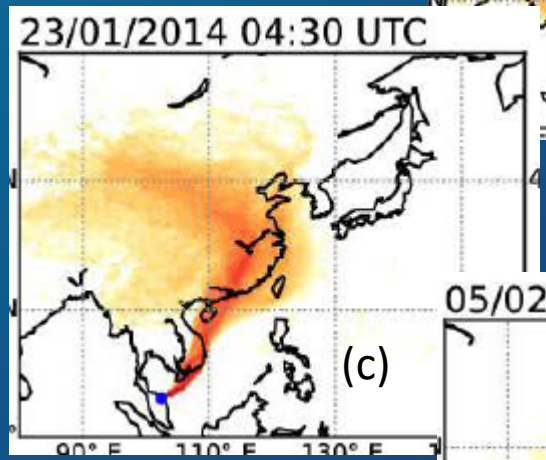
Cold surges – transport of short-lived ODS

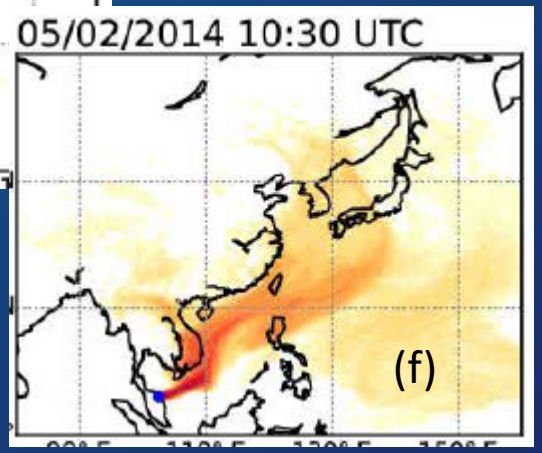
Observations at **Bachok**, on E coast of Peninsular Malaysia, Jan-Feb 2014

NAME air histories connect elevated CH_2Cl_2 etc. to cold surges









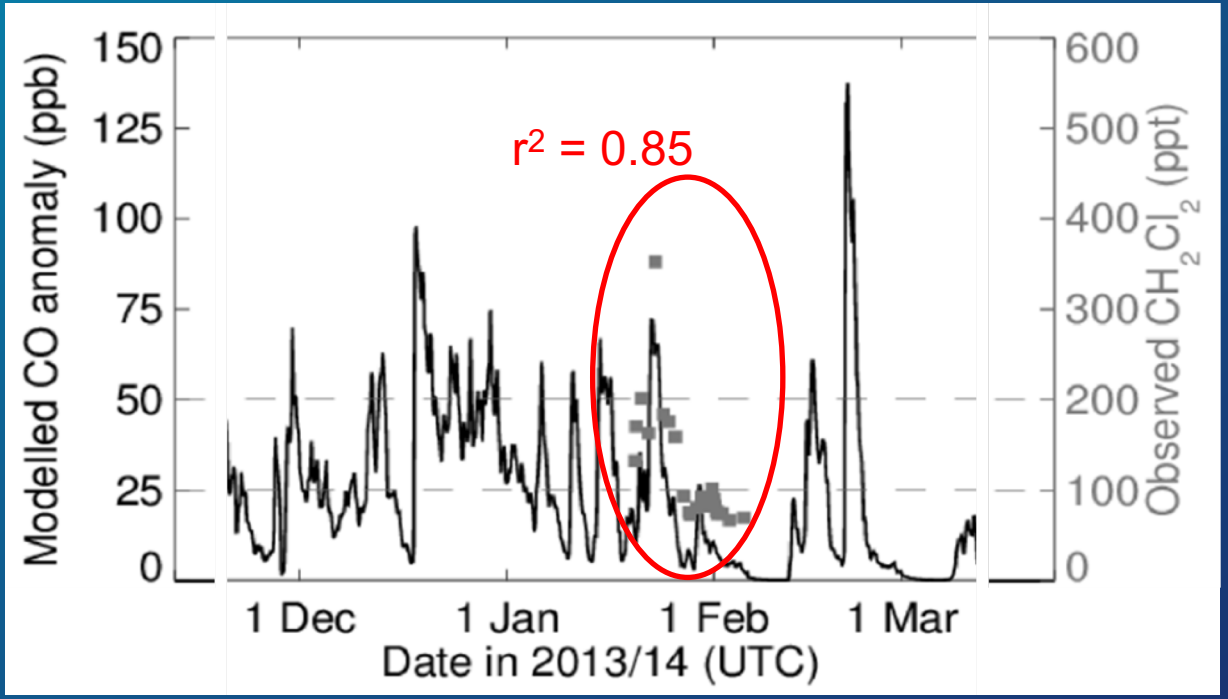
Oram, Ashfold et al., ACP, 2017

Cold surges – transport of short-lived ODS

To further explore how cold surges transport E Asian emissions …

Generate modelled anomaly at Bachok combine 1) emission sensitivity information from NAME with 2) emissions inventory for “industrial” CO

- explains observed variations in CH_2Cl_2 well
- shows the short period of observations is not unusual



Oram, Ashfold et al., ACP, 2017

This paper also presented evidence for cold surges driving enhanced pollutant uplift → Cl towards stratosphere

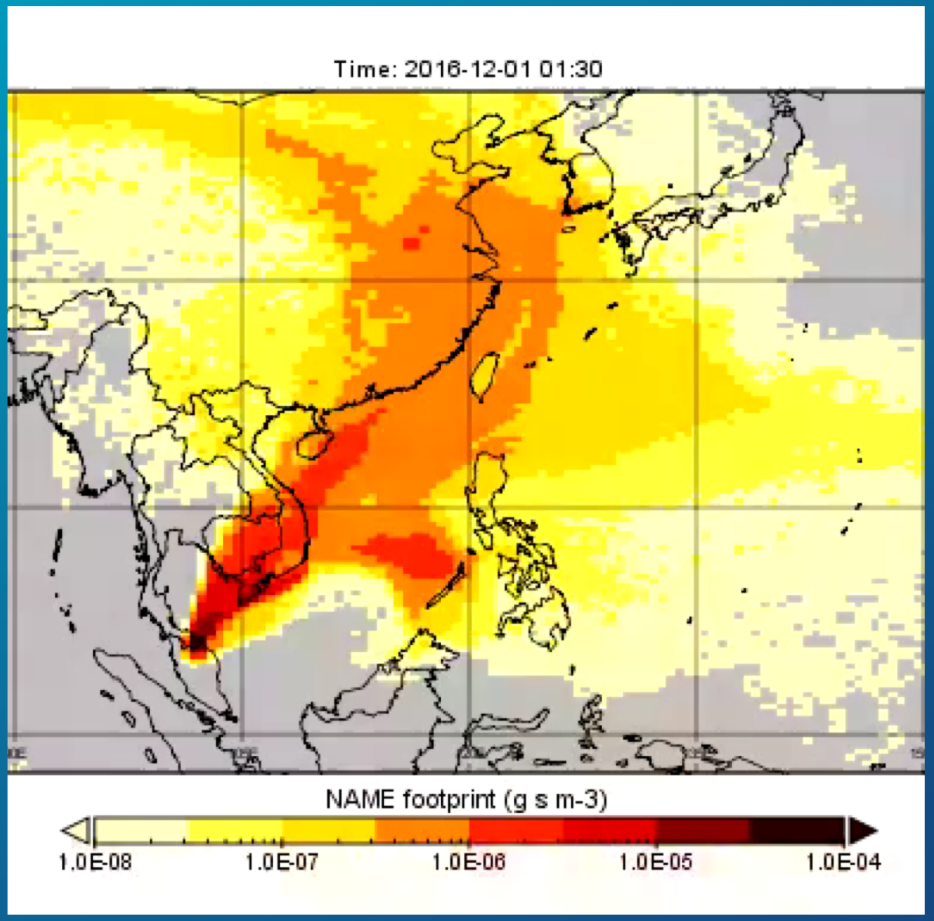
Cold surges and monsoon flows at Bachok

Using same method, example animations for Dec 2016

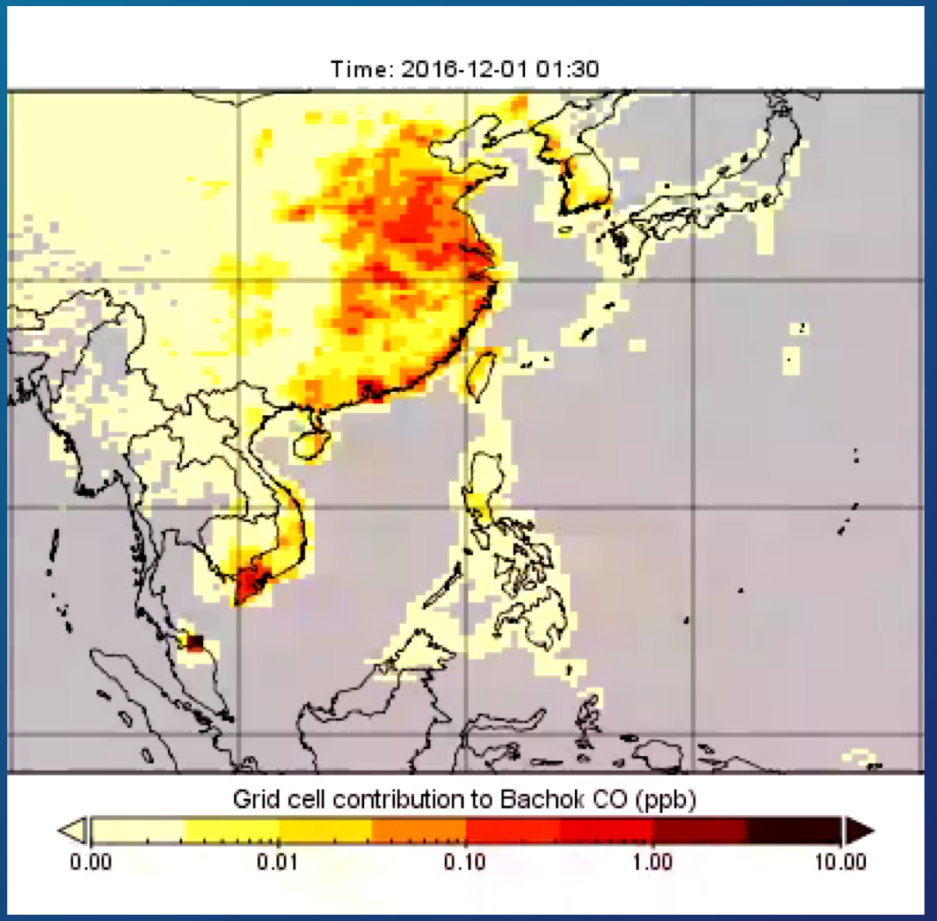
Bachok site exposed to emissions from across E and SE Asia

Where is air coming from?

(NAME air mass history, or “footprints”)



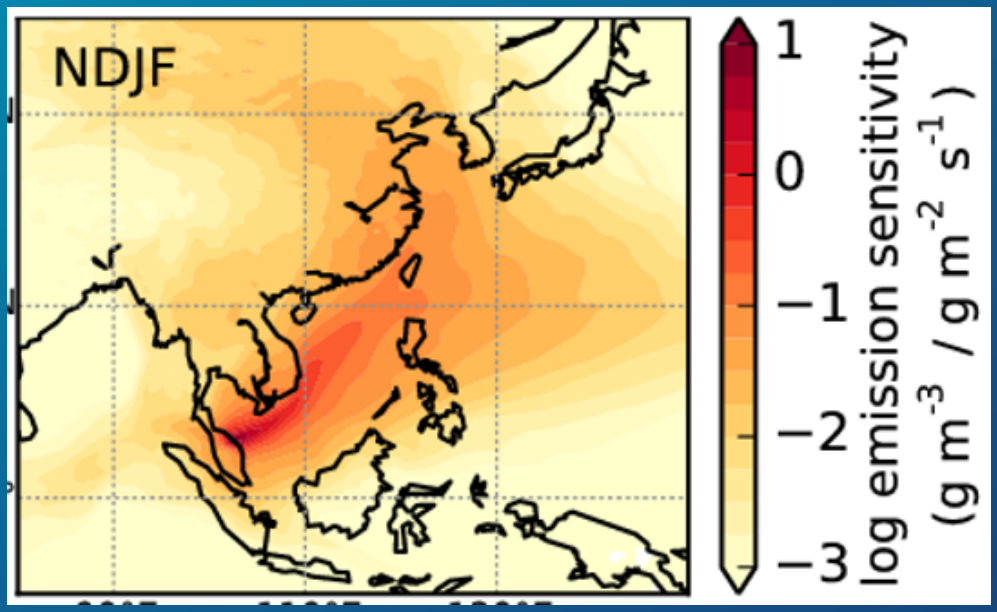
Exposure of air mass to pollutant (industrial CO) emissions



Cold surges and monsoon flows at Bachok

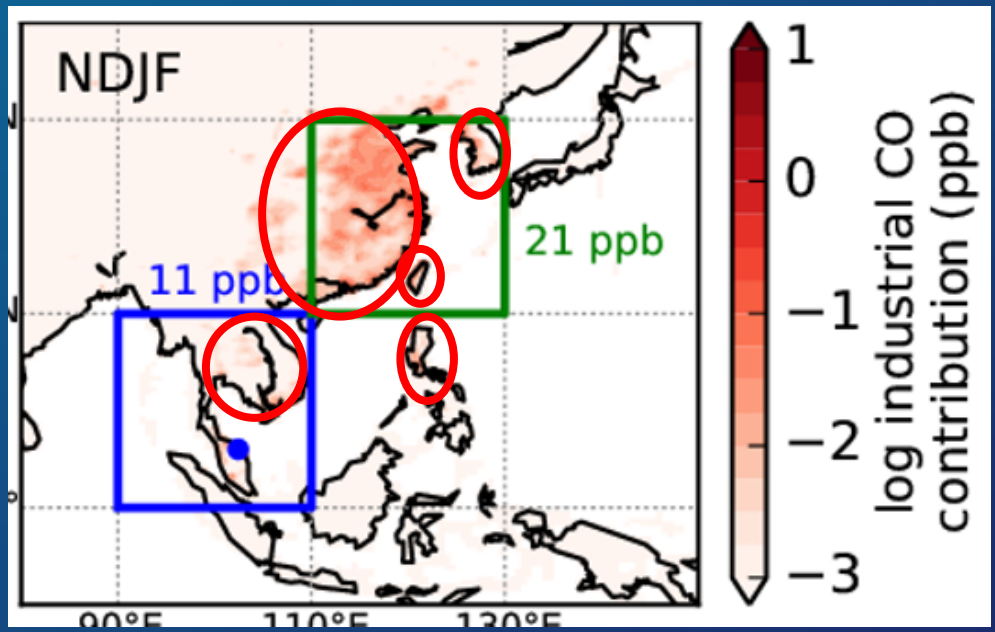
Time averages for monsoon season – Nov-Feb (NDJF)

NAME air mass history ("footprint")



Exposure of air mass to pollutant (industrial CO) emissions

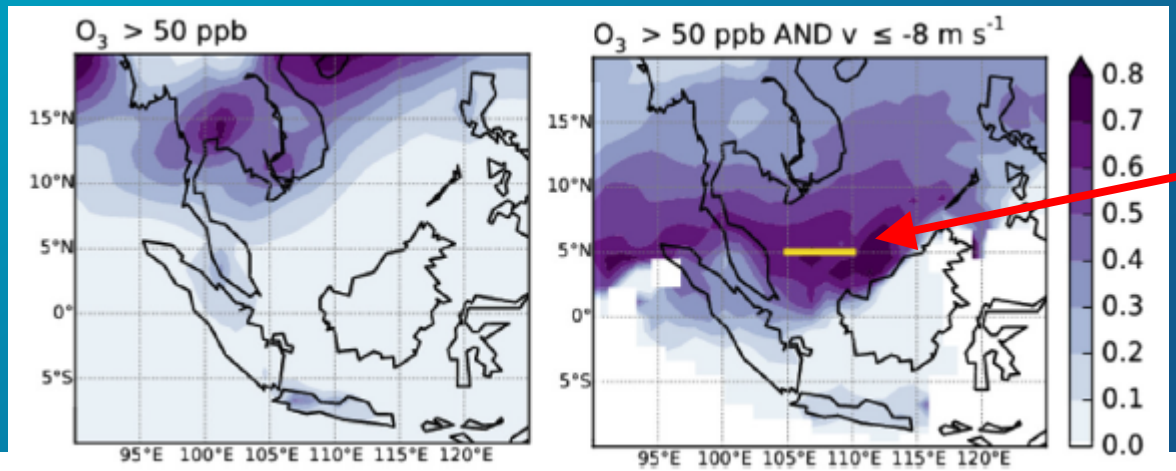
Exposed to (i.e. downwind of) parts of Thailand, Cambodia & Vietnam, much of E China, Taiwan, Korean Peninsula, N Philippines …



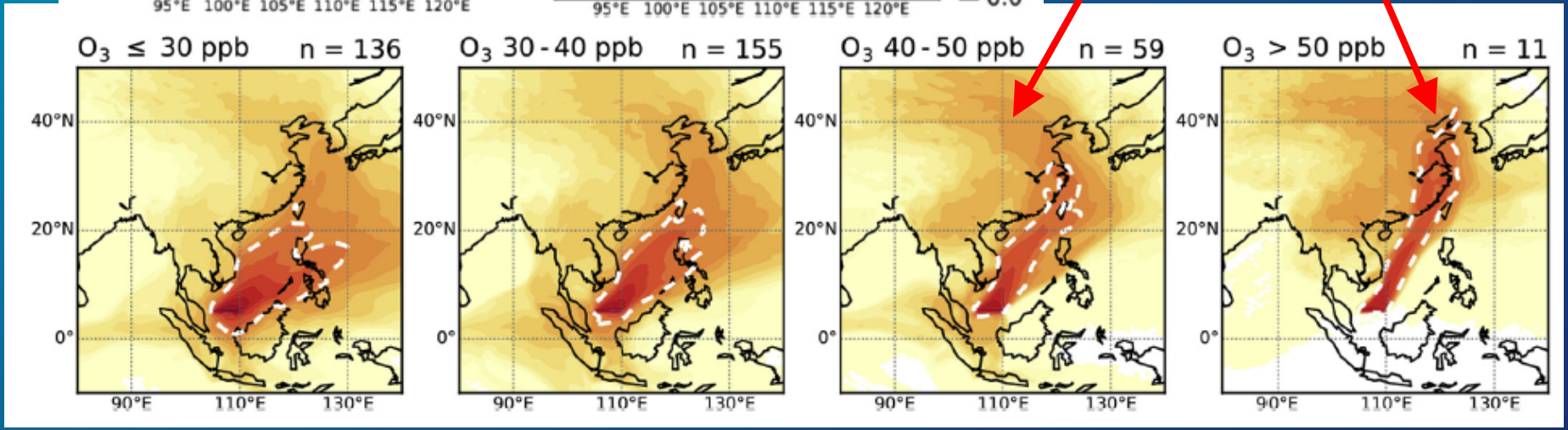
Cold surges and air quality in tropical SE Asia

Cold surges when MACCRA O_3 > 50 ppb across much of South China Sea

NAME air history composites reveal cold surge circulation on high O_3 days



Very probable that high O_3 days (>50 ppb) occur during cold surges



Ashfold et al., Atmos Environ., 2017

Summary

- Cold surges a prominent feature of NH winter Asian monsoon
- Important mechanism for regional redistribution of pollutants
- Cold surges transport short-lived ODS to deep tropics and, through strengthening tropical convection, create a pathway for uplift of these pollutants towards the stratosphere
- Appear to have a significant influence on wider atmospheric composition in tropical SE Asia … but so far influence described fairly generally …
  - How do different source regions and sectors contribute to pollution transported within cold surges (and NE monsoon more generally) and affecting air quality (e.g. O_3) in tropical SE Asia?
  - How do pollutants transported over long ranges interact with local emissions (e.g. in KL, Singapore)?