A proposed AeroCom model experiment on UTLS aerosols and connection to other international activities

https://wiki.met.no/aerocom/phase3-experiments

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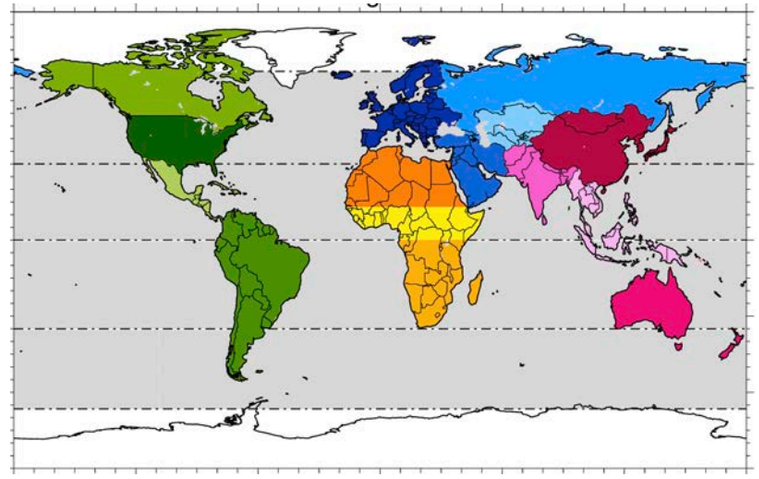
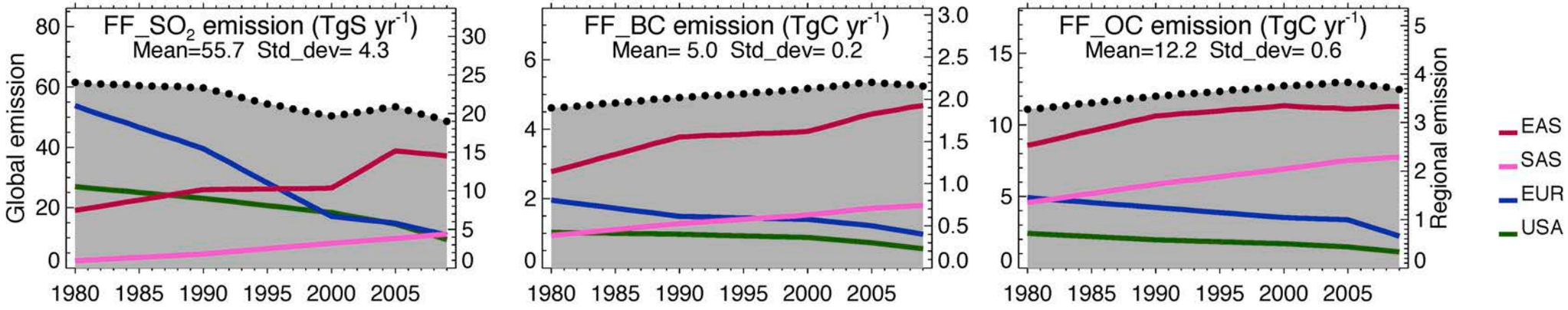
Introduction

- The origin and variability of aerosols in the upper troposphere/lower stratosphere have drawn considerable attention because the change of such aerosol could have long-term climate effects
- Recent observations seem to suggest that the stratospheric aerosol has been increasing in the past decade without major volcanic eruptions
  - Is the increase due to the Asian anthropogenic emission?
  - Or volcanoes?

Anthropogenic emission

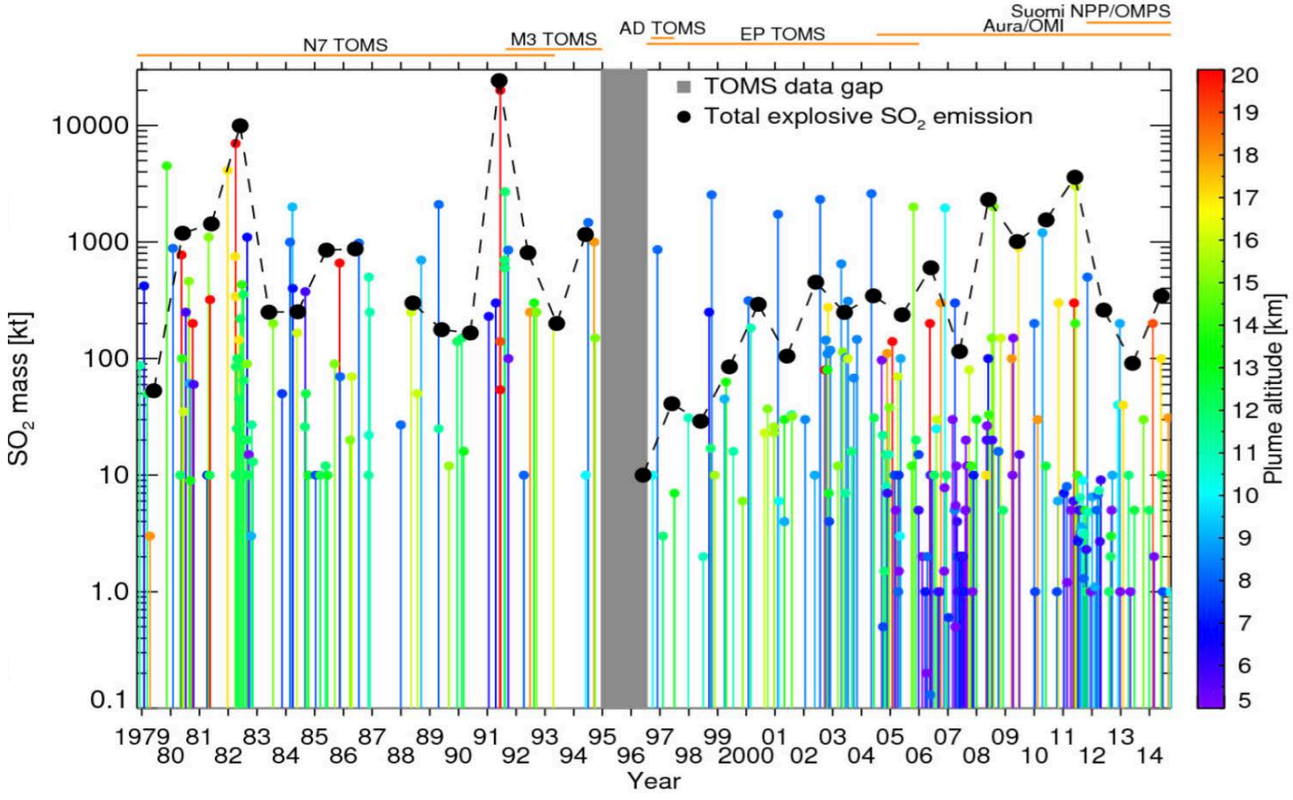
- Anthropogenic SO_2 (and other pollutants as well) emissions in East Asia and South Asia have increased significantly in the last decade
- EAS emission is much higher than SAS
- The question is: How efficient the transport is to lift surface pollution to the UTLS?





(Figures from Chin et al., 2014)

Volcanic SO_2 emission



SO_2 emission from eruptive volcanoes from 1979 to 2014. Data source: Carn et al., 2015.

- Volcanic emissions release SO_2 usually at higher altitudes than anthropogenic emissions to have a more direct influence in the UTLS

Objectives

- Compare and evaluate the model simulated aerosol composition, amount, and variability in the UTLS regions
- Examine the origins of aerosols in the UTLS region (e.g., roles of convective transport, chemistry, and direct injection)
- Assess the contributions of anthropogenic and volcanic emissions to the decadal variations of UTLS aerosols
- Coordinate with other community model experiments/analysis, in particular the SPARC/Stratospheric Sulfur and its Role in Climate (SSiRC) and the IGAC/Atmospheric Chemistry and Asian Monsoon (ACAM)

Model simulations

- Years: 1998-2012 (descope: 2003-2012)
- AGCM preferred, CTM or GCM with nudged winds are OK
- Emissions:
  - Anthropogenic emission: ACCMIP (Granier et al., 2011)
  - Biomass burning emission: GFEDv4
  - Volcanic emission: OMI-based sporadically erupting volcanic emission (Carn et al., 2015) + continuously erupting volcanic emission (Andres and Kasgnoc, 1998)
  - Sulfate from OCS oxidation
  - Other emissions: model-dependent

Model simulations (cont'd)

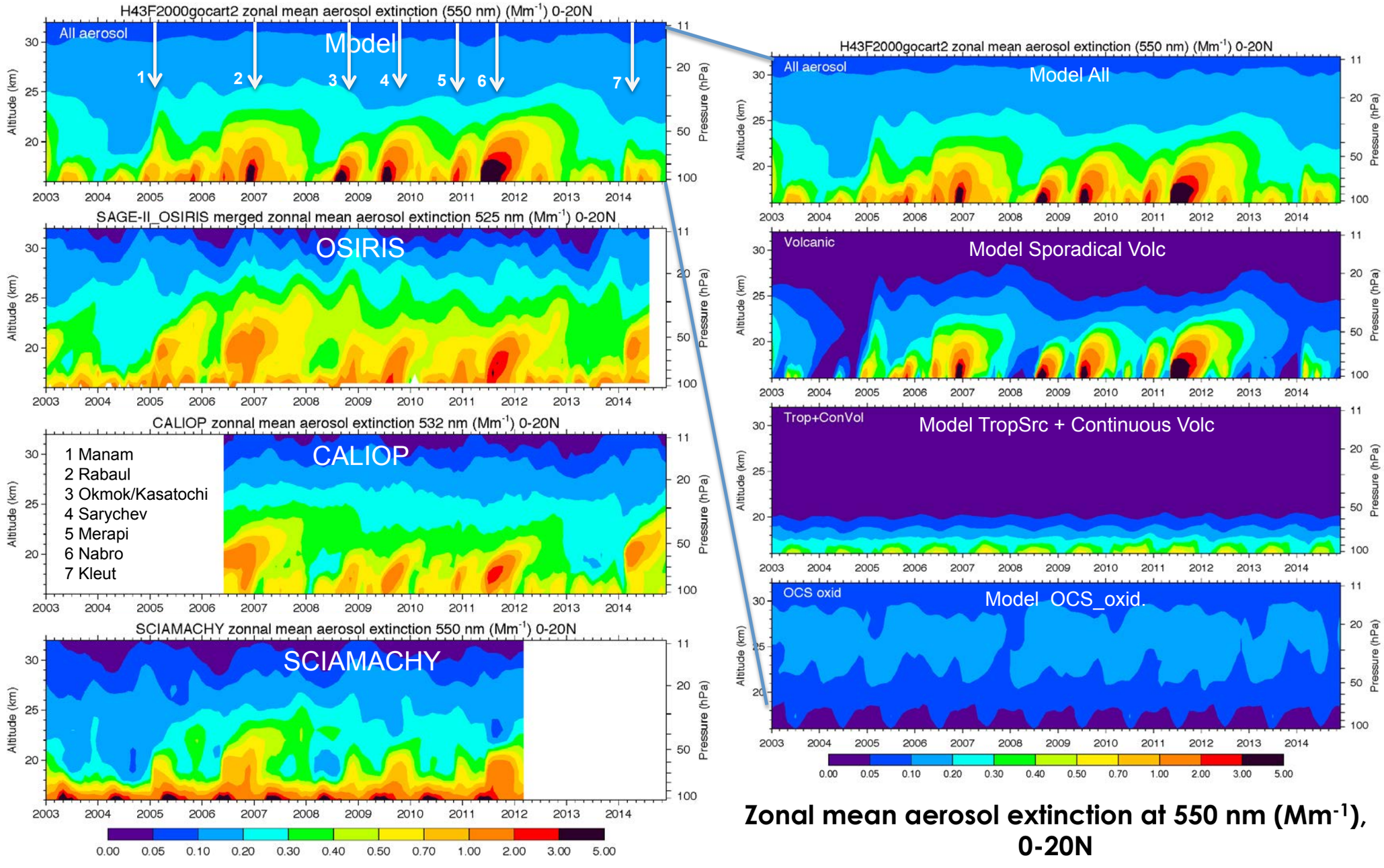
- Model experiments:
  - BASE: simulation with all emissions
  - VOL0: simulation with no volcanic emissions
  - FIR0: simulation with no fire emissions
  - ANT0: simulation without anthropogenic emissions in
    - A): global
    - B): South Asia
    - C): East Asia
- Transport tracer: CO with prescribe emission and 50-day decay time
- Output: monthly, 3-D concentrations and 550 nm extinctions
- Others (TBD)

Data for model evaluation

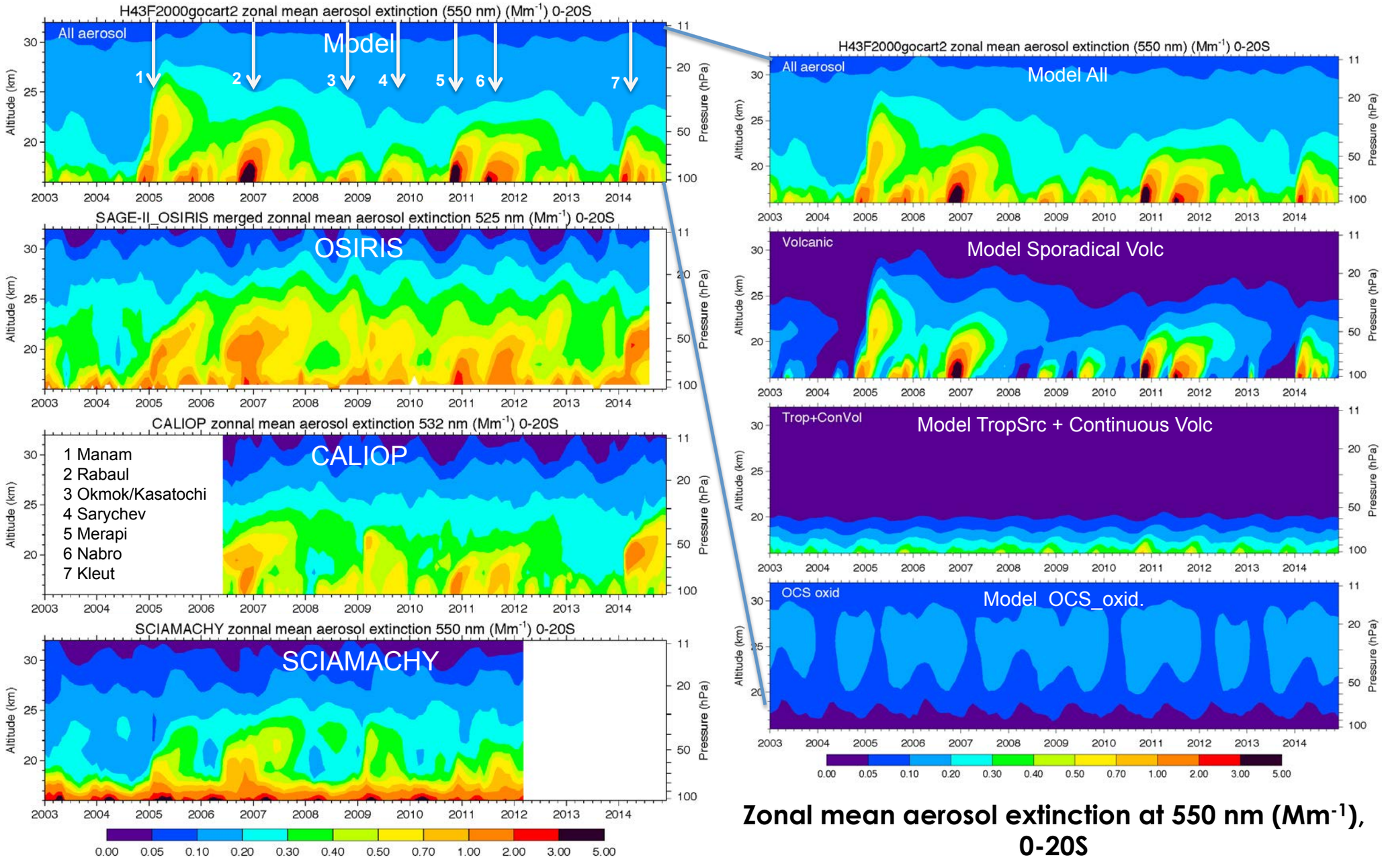
- Satellite:
  - OSIRIS: UTLS aerosol extinction, 2001-present
  - CALIOP: UTLS aerosol extinction, 2006-present
  - SCIAMACHY: UTLS aerosol extinction, 2003-2012
  - GOMOS: UTLS aerosol extinction, 2003-2012
  - MIPAS: strat SO2, 2003-2012
  - OMI: column SO2, 2006-present
- Aircraft:
  - CARIBIC: 200-200 hPa, aerosol S and C concentrations, 2004-present
  - HIPPO: Pacific, 0 km–UT, BC concentrations, 201x-201x
  - ATom: Pacific, Atlantic, Southern Ocean, 0 km-UT, aerosol species, 2016-2018
  - Other (ICARTT, INDEXB, ARCTAS, TC4…)

Examples with GEOS-5 AGCM model simulations

- GEOS-5 AGCM with modules of GOCART + StratChem + OCS, ACCMIP and Carn emissions, 2003-2012 (Valentina Aquila)
- Comparisons of zonal averaged UTLS aerosol vertical profiles with satellite data
- Comparisons of S and C aerosol concentrations with CARIBIC data
- Monsoon convective transport

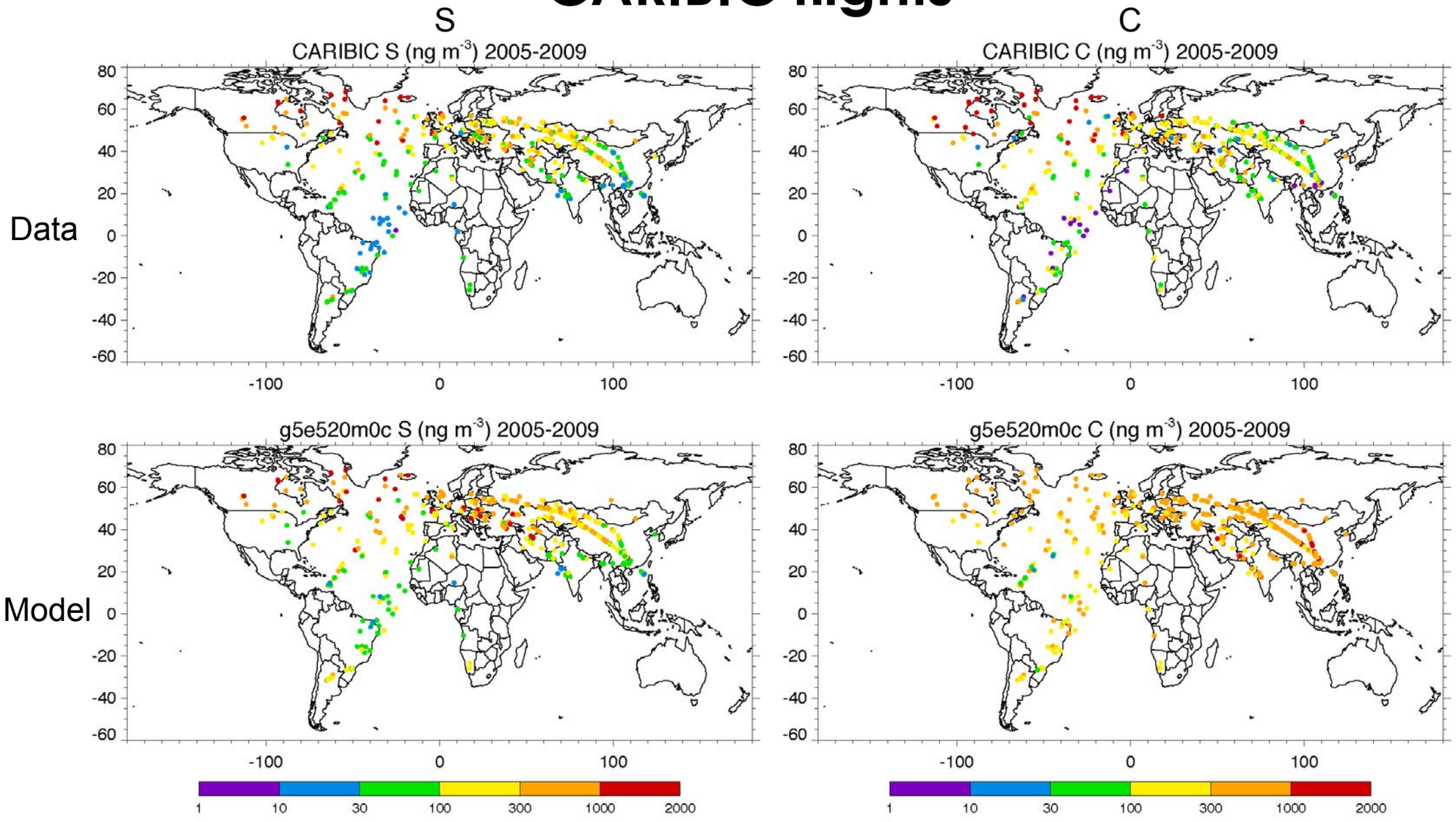


Zonal mean aerosol extinction at 550 nm (Mm^{-1}), 0-20N



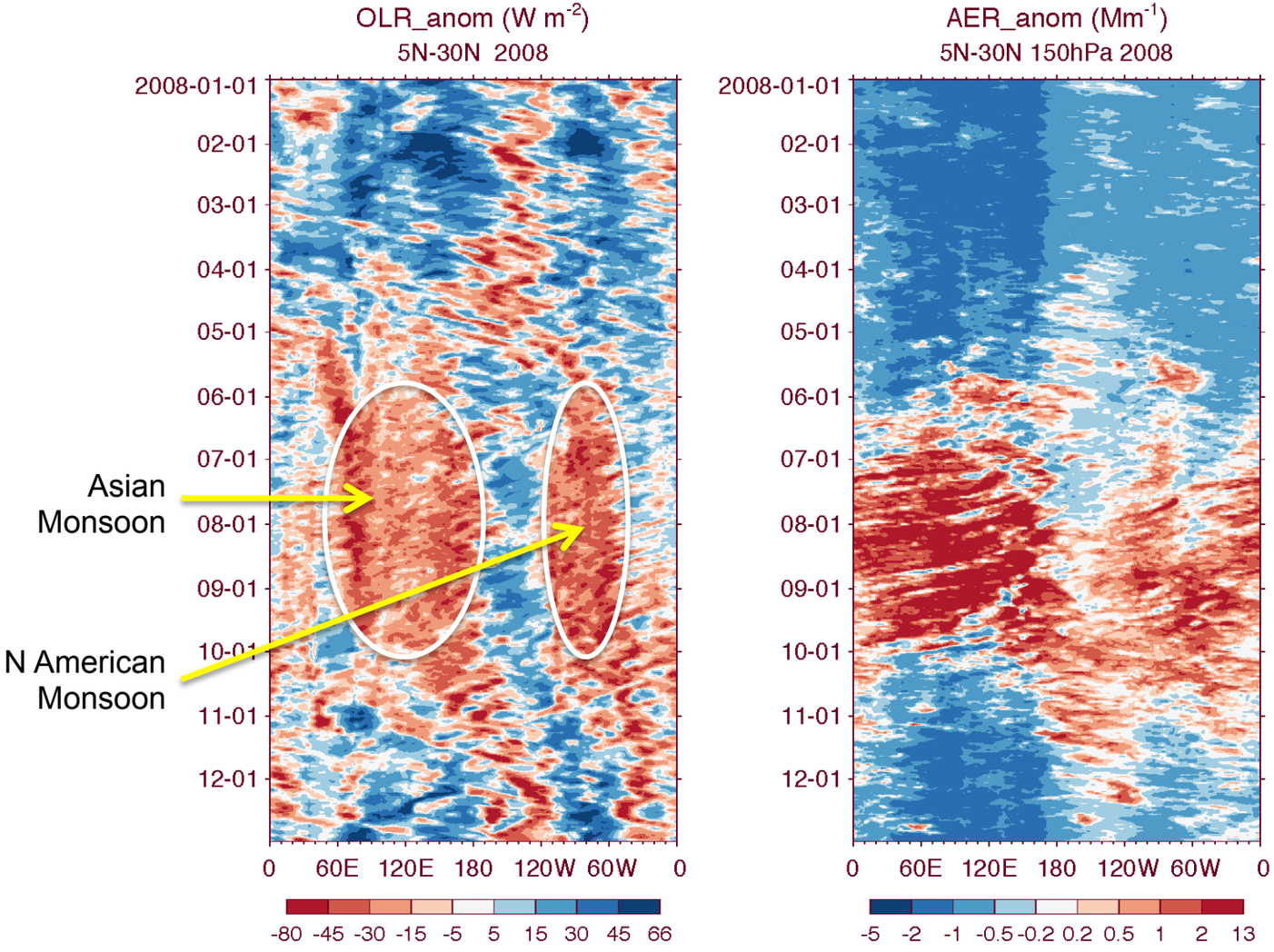
Zonal mean aerosol extinction at 550 nm (Mm^{-1}), 0-20S

Aerosol S and C concentrations en-route of CARIBIC flights

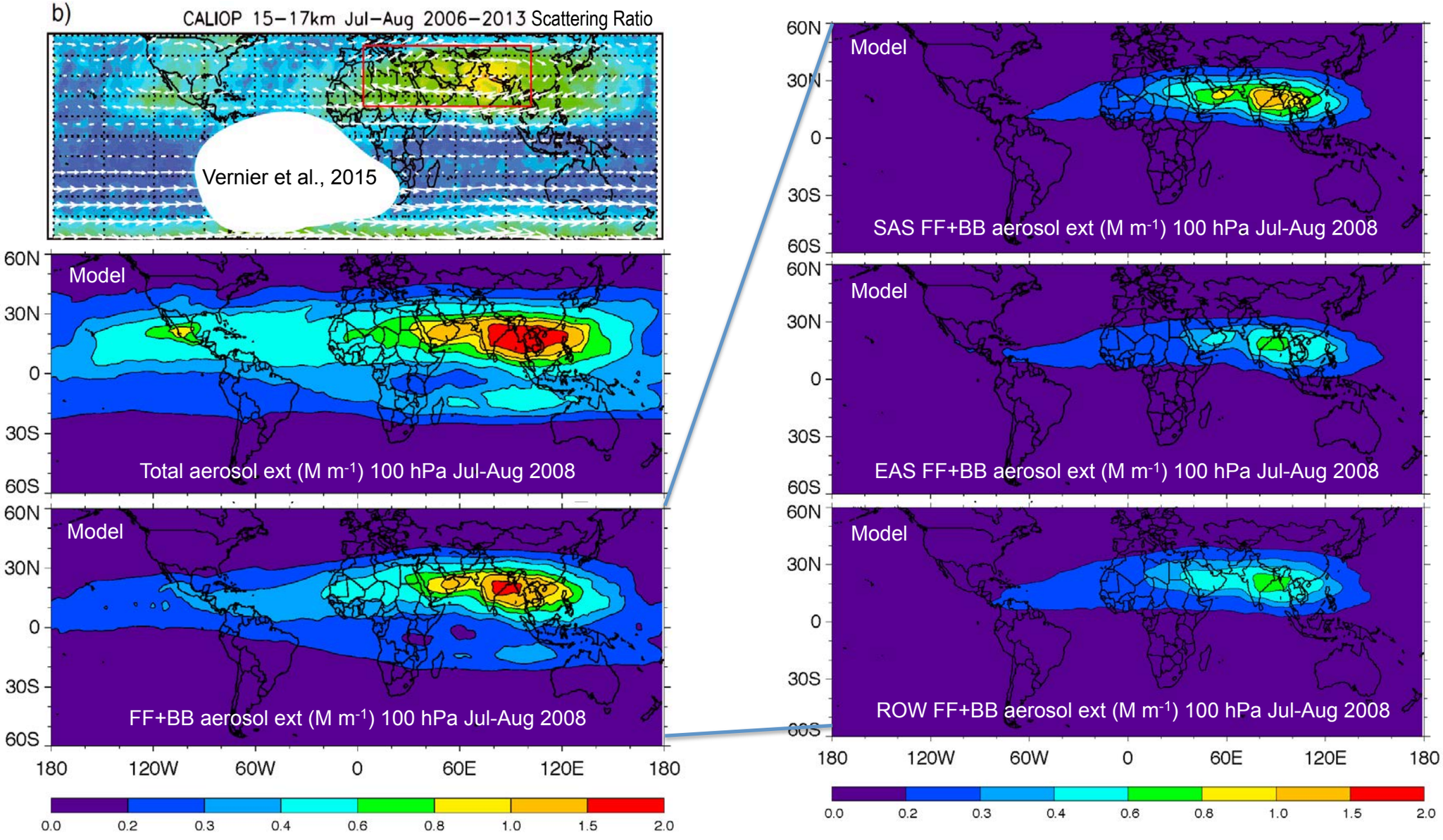


Seasonal variations of deep convective transport: Average OLR and UT aerosol anomaly, 5-30N

- In the subtropical northern hemisphere, the most pronounced convective features are the Asian summer monsoon and the North American summer monsoon
- The monsoon convections pumps aerosols to the upper troposphere, even though the convection always associated with heavy rainfall
- Composition of UT aerosol varies from year to year depending on the variation of aerosol sources



Aerosol at 100 hPa



Connections to SSiRC and ACAM

- SPARC/SSiRC was initiated in 2012 with the goal of reducing uncertainties in the properties of stratospheric aerosol and assessing its climate forcing
  - Interactive Stratospheric Aerosol Model Intercomparison Project (ISA-MIP) proposed 4 model experiments, with the MITAR (model intercomparisons of transient record) most relevant to AeroCom
  - ISA-MIP is seeking collaborations with AeroCom
  - Chapman Conference in 2018 on SSiRC has been proposed to AGU
- SPARC-IGAC/ACAM started in 2013 with themes of interactions between atmospheric chemistry, aerosol-cloud interactions and Asian monsoon and UTLS response to the Asian monsoon transport
  - ACAM would like to engage CCMI and AeroCom communities on modelling and analysis related to ACAM
  - Biannual workshop; next one will be in June 2017 in Guangzhou, China

- Please seriously consider doing the UTLS experiment!
- It could be combined with other proposed model experiments to have “one stone kills multiple birds”
- Feedbacks and suggestions are appreciated