Update on GOCART Model Development and Applications

Aerocenter Annual Update

May 31, 2013

Dongchul Kim, GOCART group, and many collaborators

Contents

1. Emission

- Update of emission inventories for hindcast runs (A2-MAP) (*T. Diehl et al.*)
- Development of the dynamic dust source function for GOCART (*D. Kim et al.*)
- Constrain BB emission in GOCART using satellite AOD (*M. M. Petrenko et al.*)

2. Development

- Modeling nitrate in GMI and GOCART (*H. Bian et al.*)

3. Scientific Applications

- Multi-decadal variations of aerosol (*M. Chin., T. Diehl et al.*)
- Volcanic and anthropo. contributions to stratospheric aerosol (*M. Chin, T. Diehl et al.*)
- GOCART and GMI models participated in HTAP source-receptor experiments to assess the role of intercontinental transport (*H. Yu et al.*)
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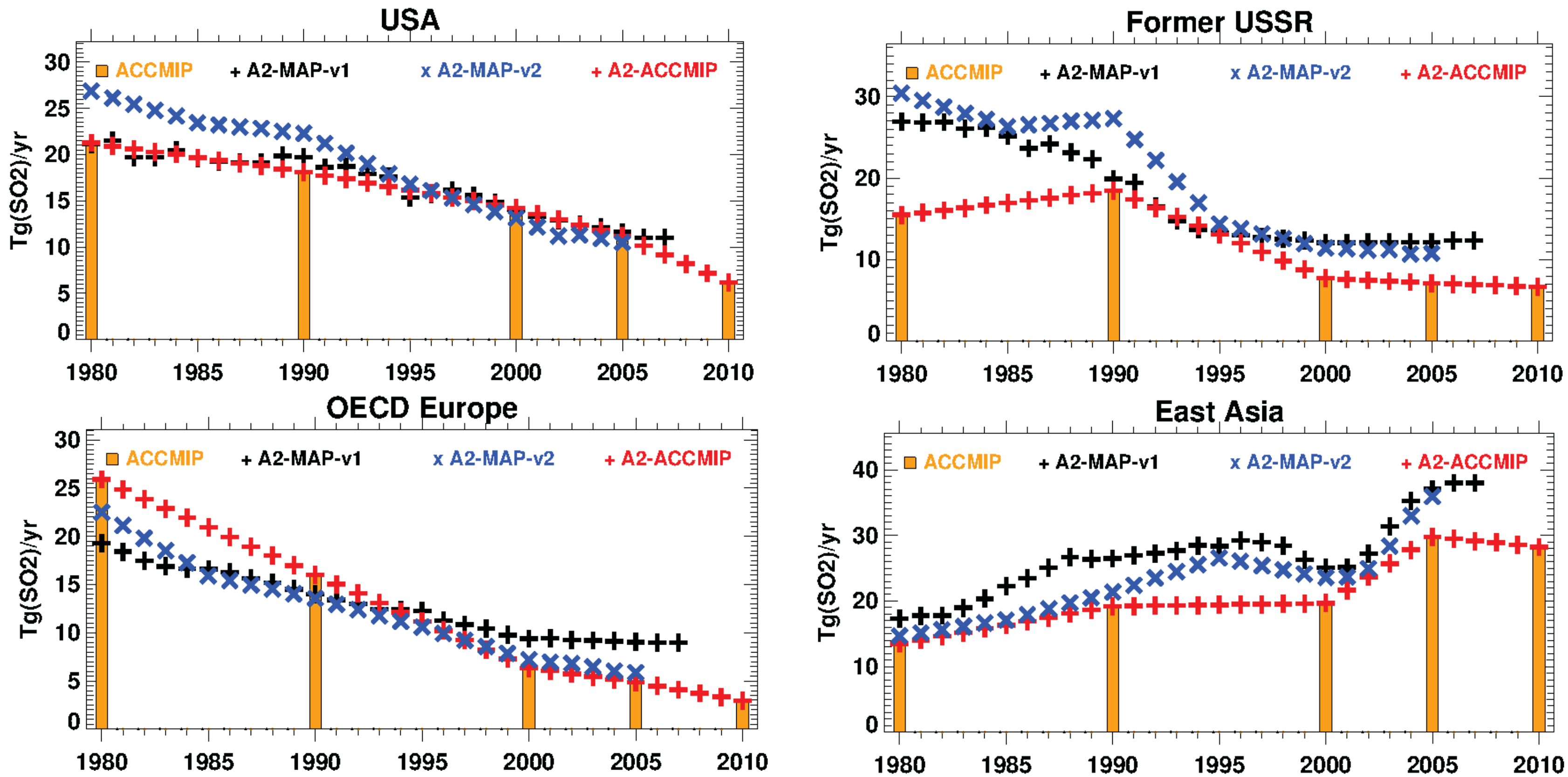
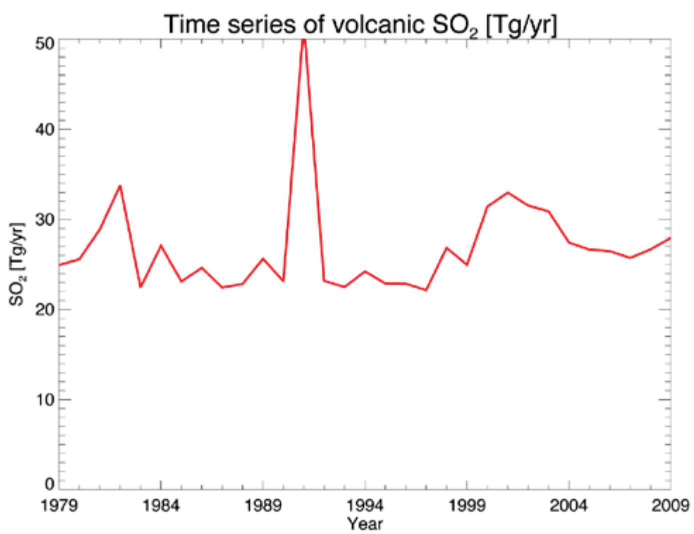
- Evaluation of multi-model aerosol over South Asia (*X. Pan et al.*)

Updated emission inventories for hindcast runs (A2-ACCMIP)





- A2-ACCMIP emissions derived from decadal ACCMIP emissions for latest hindcast ; A2-MAP emissions based on Streets et al. (BC, OC) and EDGAR 4.1 (SO2)
- Volcanic emissions compiled from Smithsonian database, TOMS, OMI, and other sources
- Anthropogenic inventories agree on general trends, but large differences for some years in some regions

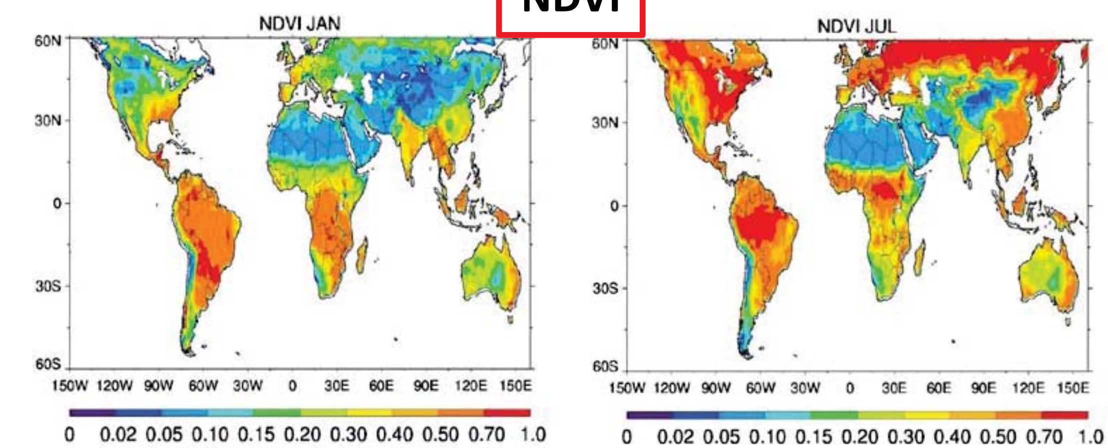
Diehl et al. (2012)

Development of the Dynamic Dust Source Function for GOCART

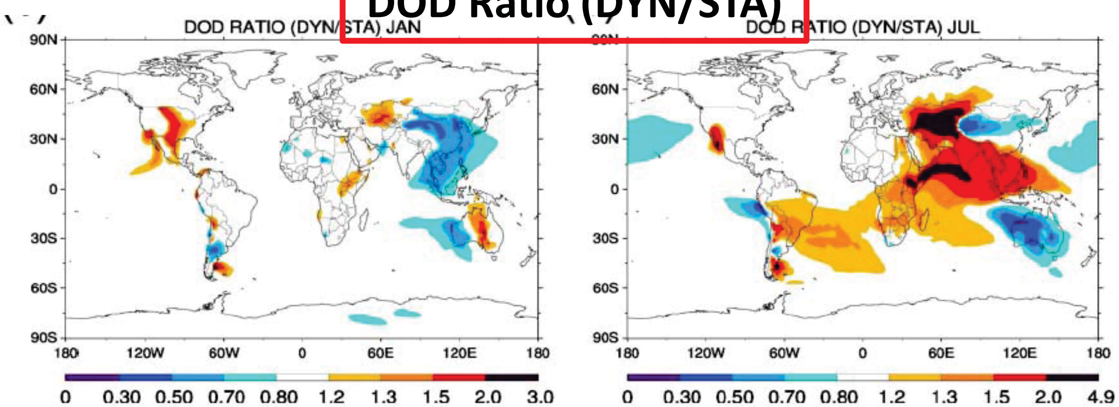
$$E_p = C \times S \times s_p \times u^2{}_{10} \times (u_{10} - u_t), \; if \, u_{10} > u_t$$

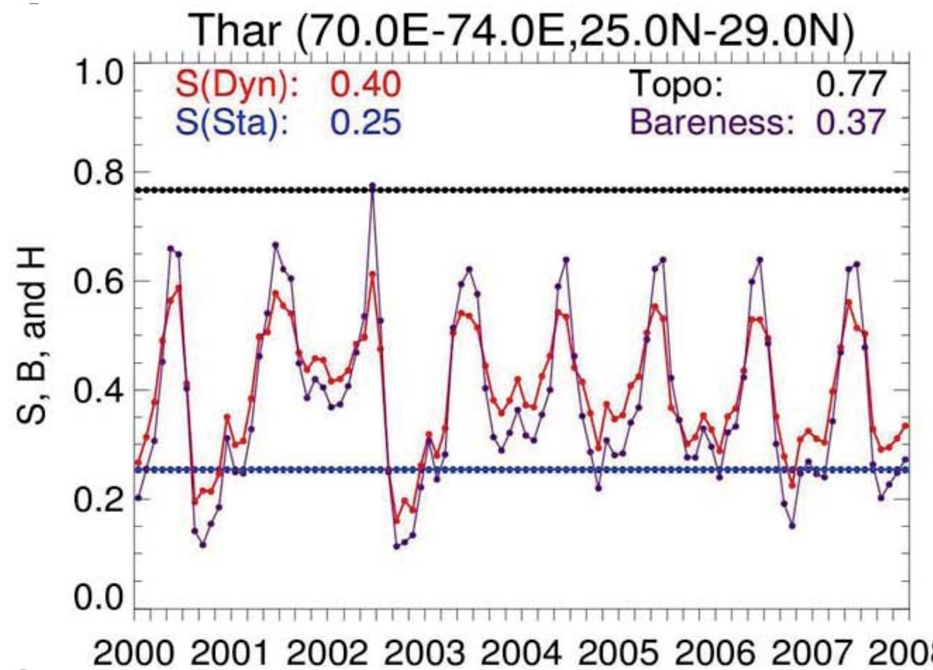
where C is a dimensional factor (1 μg s^2 m^{-5}), S is the dust source function or probability of dust uplifting with a value between 0 and 1, s_p is the fraction of size group p within the soil [*Tegen and Fung*, 1995], u_{10} is the 10 m wind speed (m s^{-1}), and u_t is the threshold velocity of wind erosion as a function of dust density, particle diameter, and surface wet-

NDVI



DOD Ratio (DYN/STA)





- A global dynamic source function has been developed for GOCART using the AVHRR-NDVI 8km.
- One half of 22 analyzed deserts are seasonality in their bareness.
- We found a clear and significant effect of the new dynamic dust source on seasonal variation of dust emission and dust optical depth near the source regions.

Kim et al. (2013)

Using satellite AOD to constrain BB emissions in the GOCART model

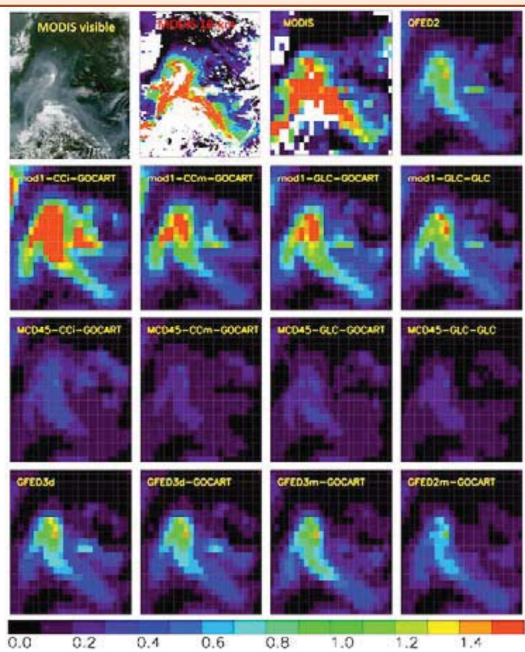
1. Currently 13 biomass burning (BB) emission options are available

$$E(BB) = F \times C \times A$$

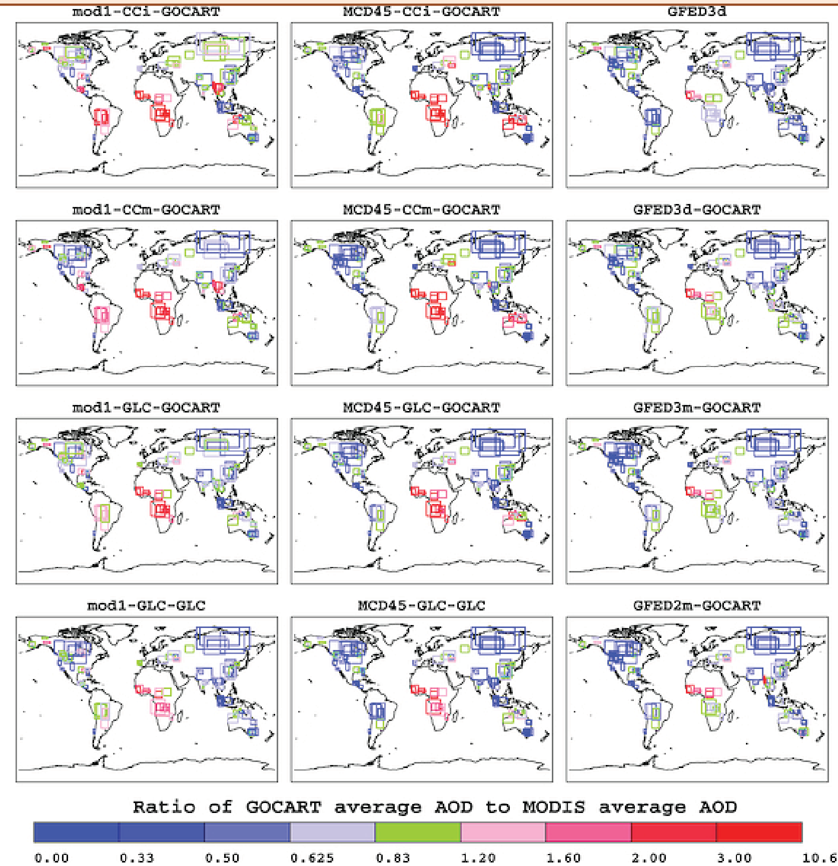
F=Emission factor
C=Fuel consumption
A= Area burned

: Different data sources (MODIS, GFED2, GFED3, CCi, GLC, etc..) result 13 different options!

2. A fire case study shows large diversity in AODs with MODIS AOD and GOCART simulations



3. Regional dependency in AOD for different options against MODIS AOD using 124 fires

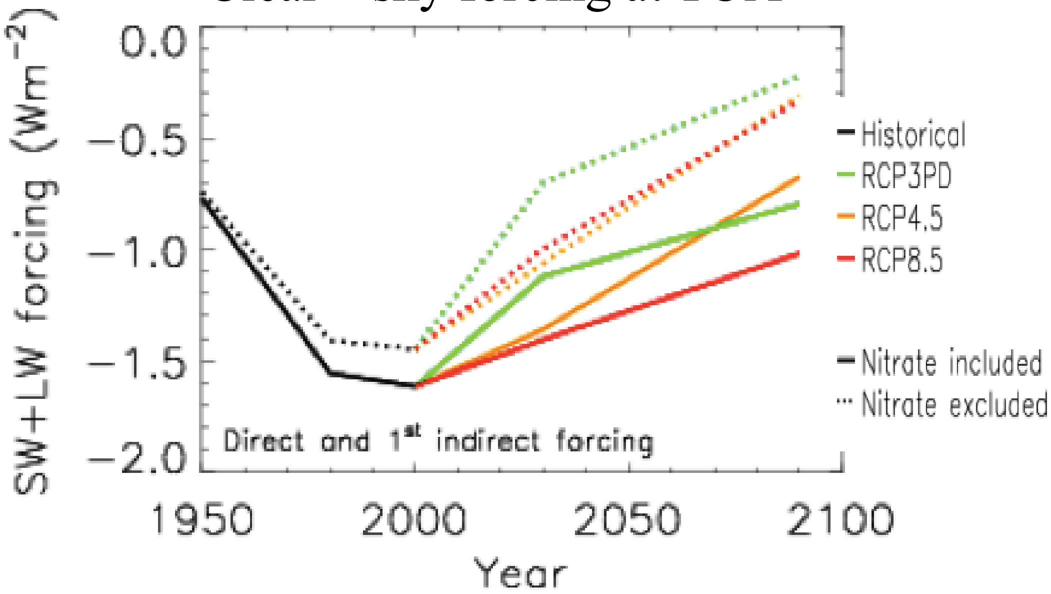


- This work shows consistent regional bias compared to MODIS AOD, depending on biomass burning emission options.
- Future goal is to improve the agreement between modeled and observed biomass burning aerosol.

Petrenko et al. (2012)

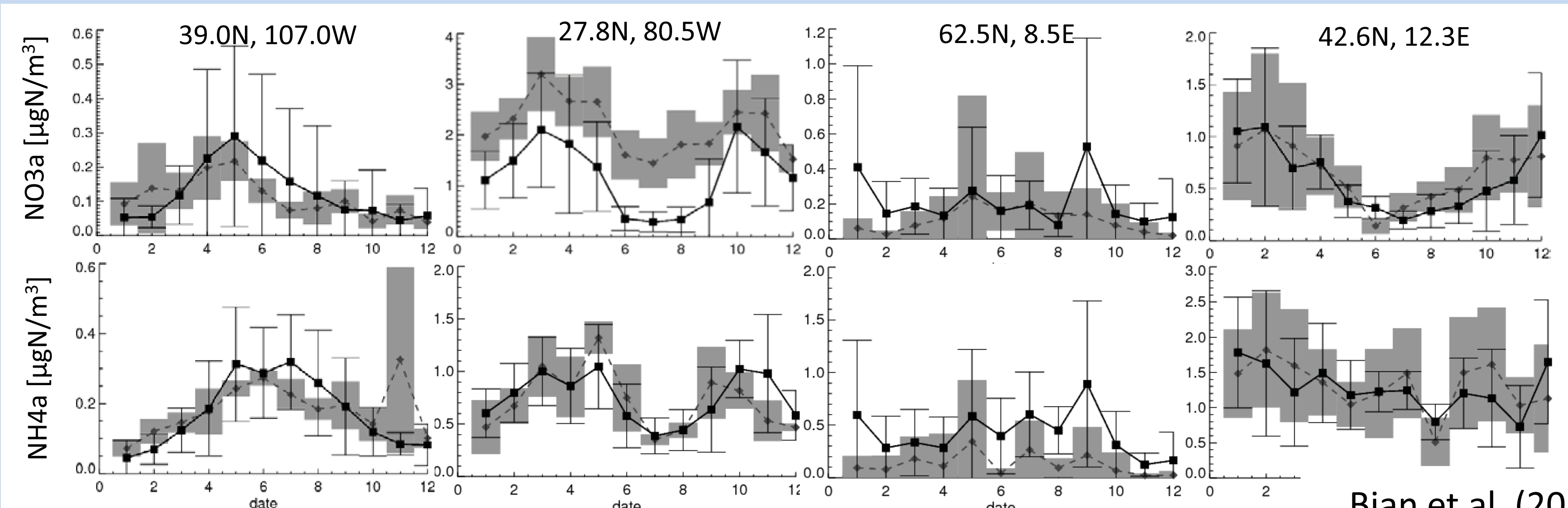
Modeling Nitrate in GMI and it will to be implemented to GEOS5-GOCART (1)

Clear – sky forcing at TOA



- The nitrate contribution is substantial, about 1/4 to 1/3 to that of sulfate.
- As other air pollutants are decreased nitrate will be more important in next century.
- Model suggests stronger negative forcing in the next century due to the nitrate (Belluin et al., 2010).

NO3 and NH4 simulation: compare with surface measurement in US and Europe

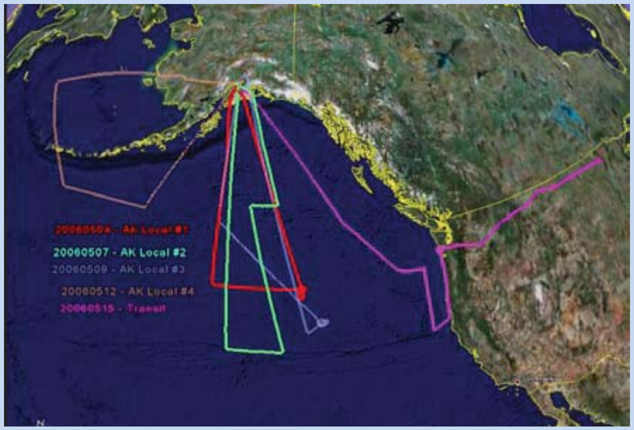


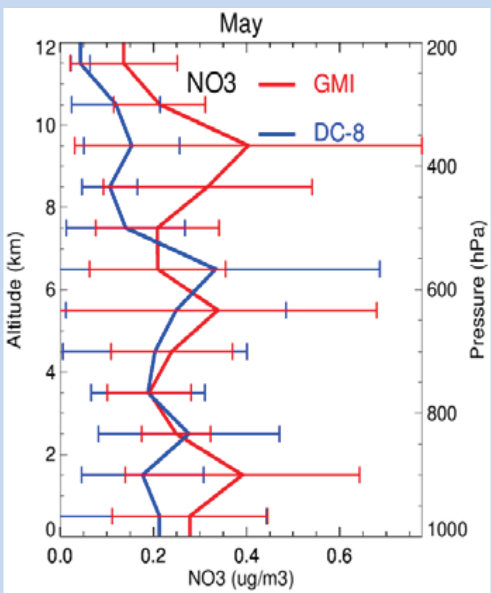
Bian et al. (2013)

Modeling Nitrate in GMI and it will to be implemented to GEOS5-GOCART (2)

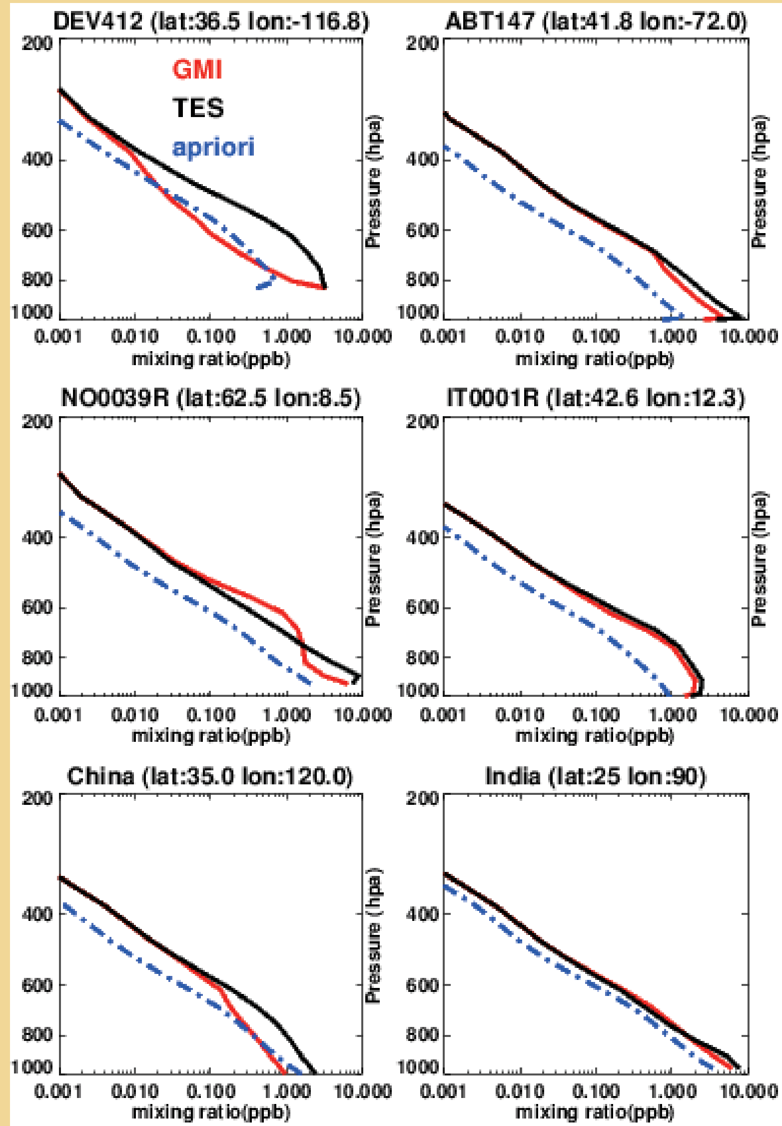
Compare with aircraft measurements

(INTEX-B Anchorage, Alaska campaign during May, 2006)





Vertical profile of NH3 from TES & GMI (annual mean in 2006)



Bian et al. (2013)

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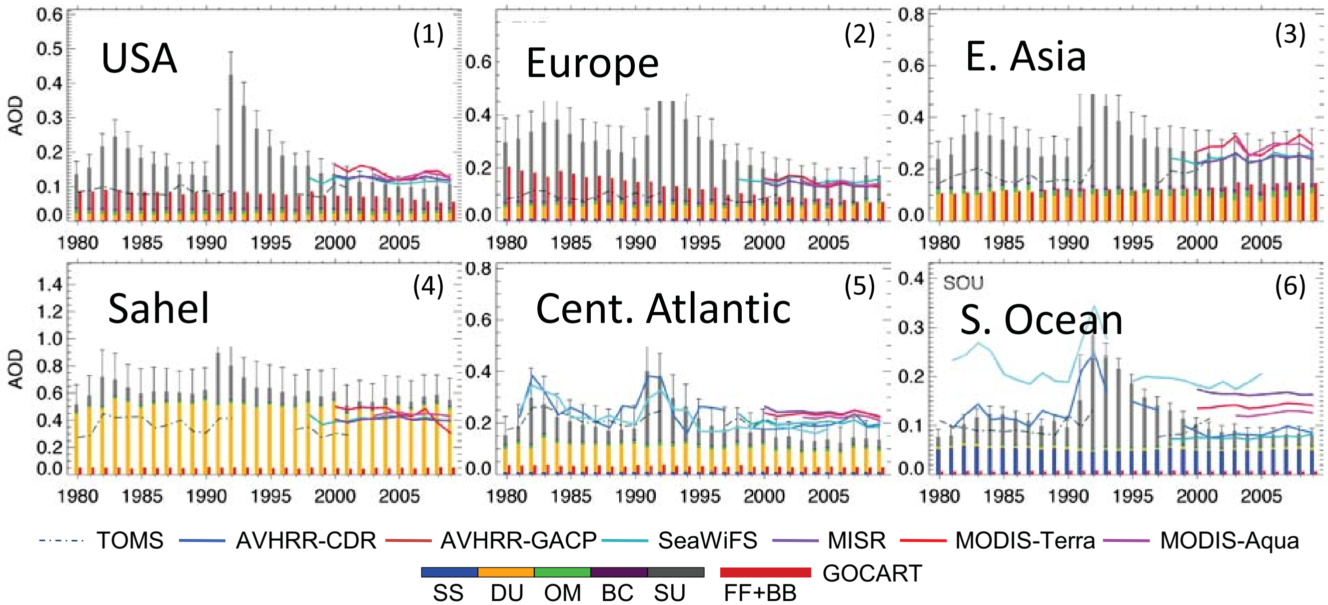
Multi-decadal variations of aerosols from 1980 to 2009: Global and regional trends

Annual AOD variations from 1980 to 2009 – Model and Satellites

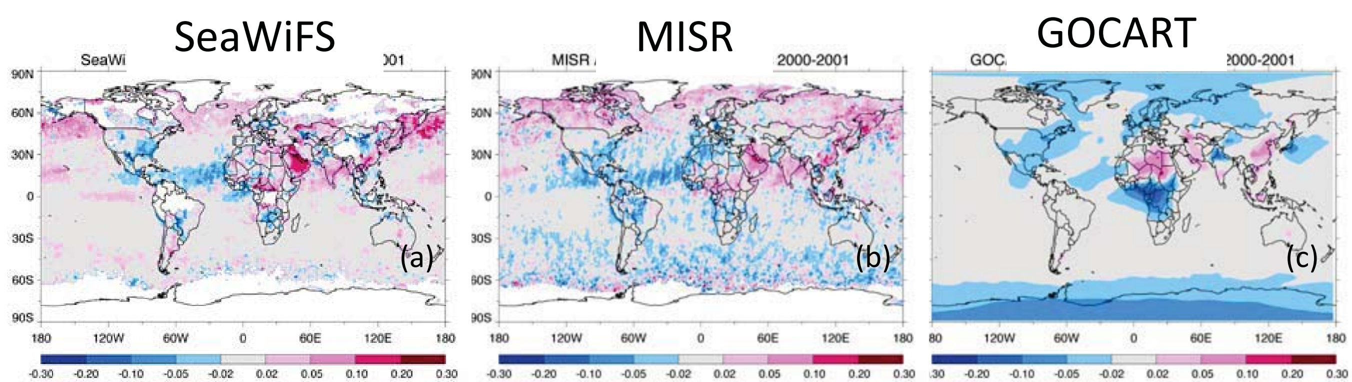
Polluted Region - Anthrop.

Remote Region - Natural



Aerosol emission & AOD have been greatly changed over different regions in period.

Differences in AOD: (2008-2009) minus (2000-2001)



The aerosol trends over polluted regions are controlled by emissions, but over remote regions they are also controlled by climate variability.

Chin et al. (2013)

Volcanic and anthropogenic contributions to stratospheric aerosol trends

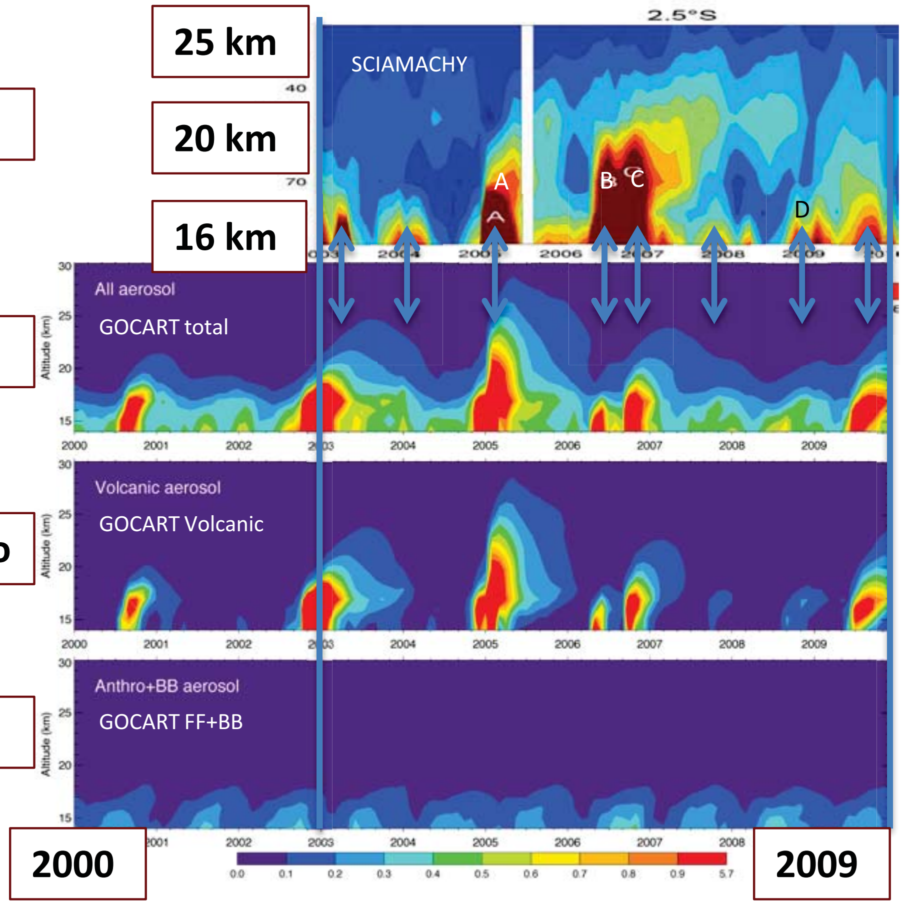
Stratospheric aerosol extinction vertical profiles (2.5S)

SCIAMACHY

GOCART - all

GOCART - volcano

GOCART - FF+BB



Time series of zonal and monthly averaged extinction

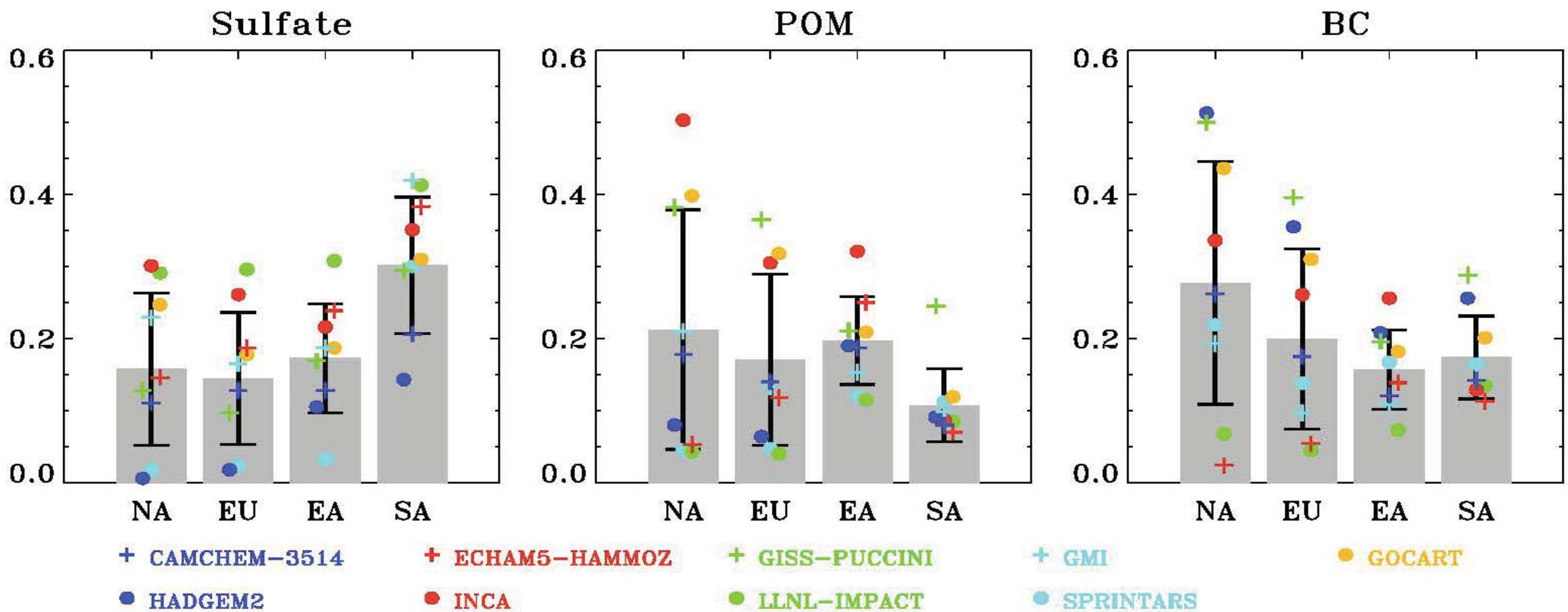
Major volcanic eruptions:
A. Manam (Jan 2005, 4°S)
B. Soufriere Hills (May 2006, 16°N)
C. Tavurvur (Oct 2006, 4°S)
D. Sarychev Peak (July 2009, 48°N)

- Without major explosive volcanic eruptions (i.e., at the magnitude of El Chichon or Pinatubo), numerous volcanic eruptions frequently perturb the stratospheric “background” aerosols.
- The model suggests that the increase of Asia pollution contribute to the stratospheric aerosol, but they are mostly confined in the lower stratosphere with organized seasonal cycles and is much less than volcanic aerosols.

Chin et al. (AMS meeting)

GOCART and GMI models participated in HTAP source-receptor experiments to assess the role of intercontinental transport

AOD fractional contribution of foreign aerosol import via intercontinental transport (for man-made aerosols)



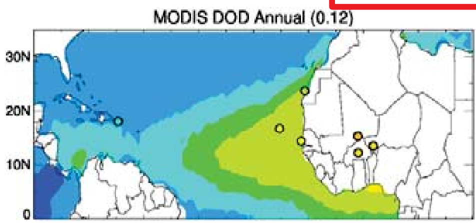
NA – North America ; EU – Europe ; EA – East Asia ; SA – South Asia

- ❑ The 9-model median fraction ranges from 10% to 30%, depending on region and species. But model spread is large.

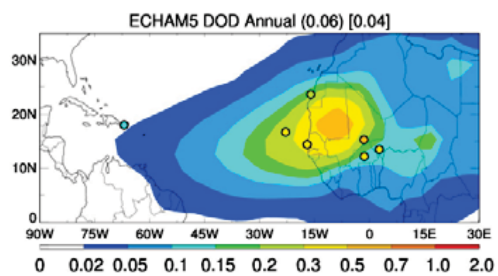
Yu et al., JGR 2013

Comparisons of models and satellite observations for transatlantic dust

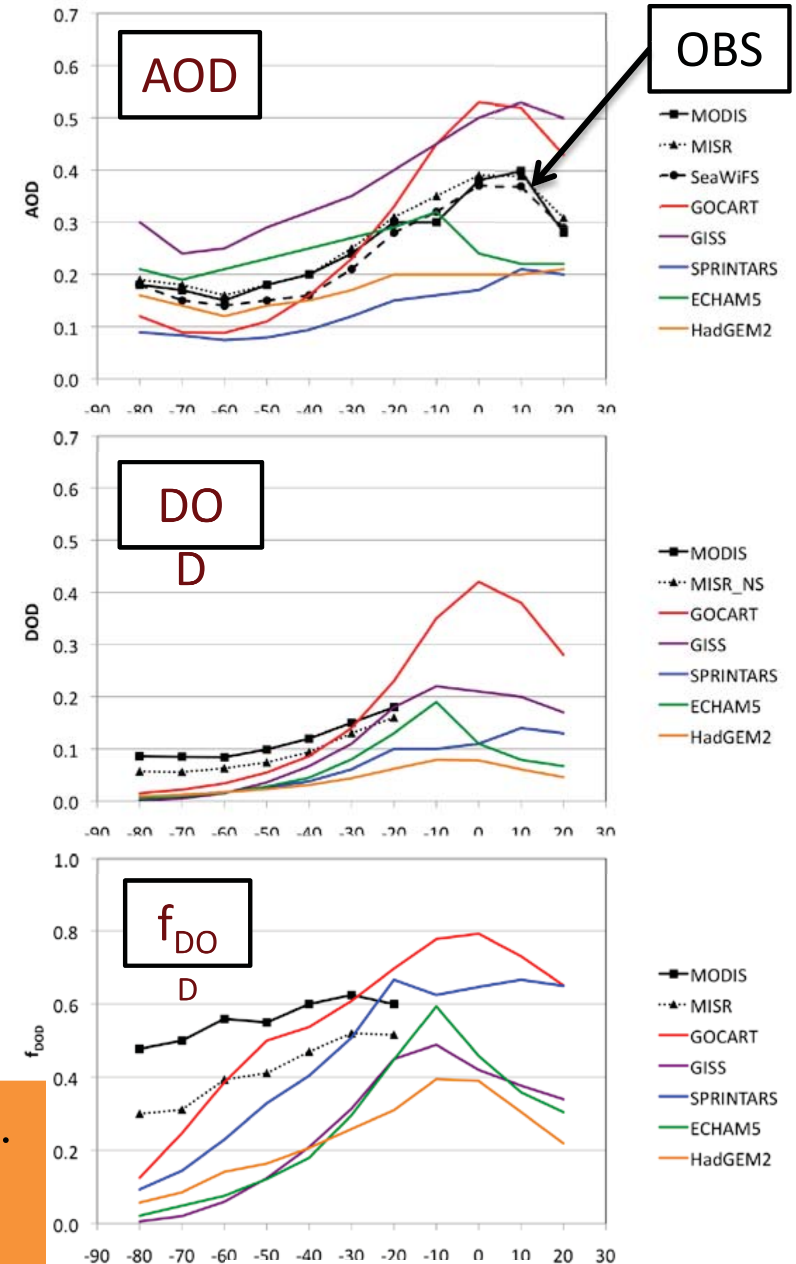
Satellite DOD



Model DOD



Longitudinal gradient (0-35N)



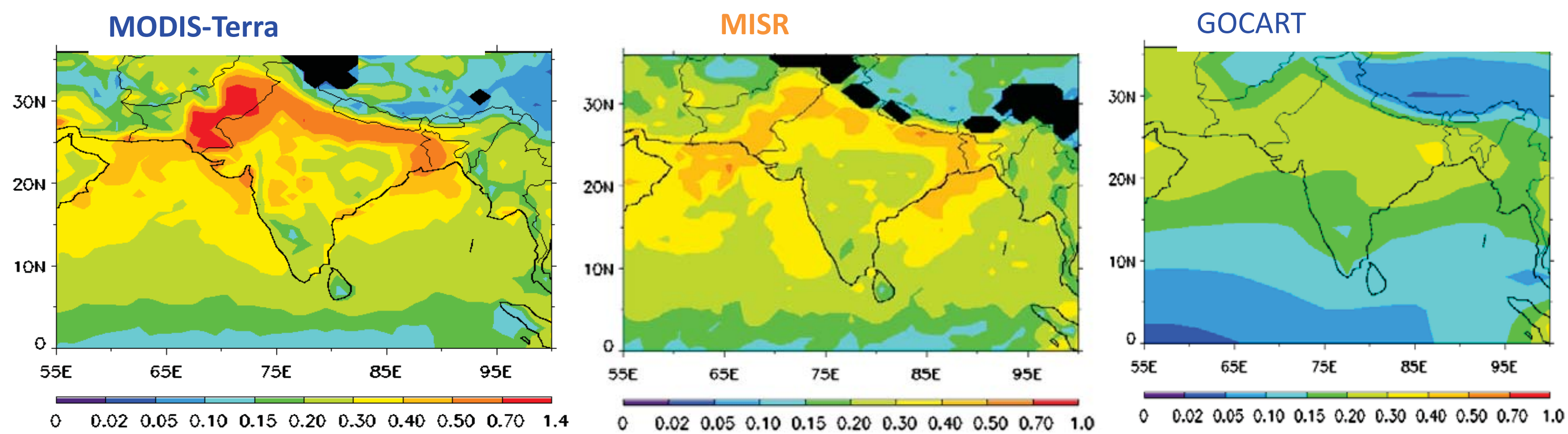
Longitude

- Unlike to AOD, model DODs are too lower than OBS.
- Also the longitudinal gradient of f_{DOD} in most models including GOCART are too strong than OBS.

Kim et al. (2012)

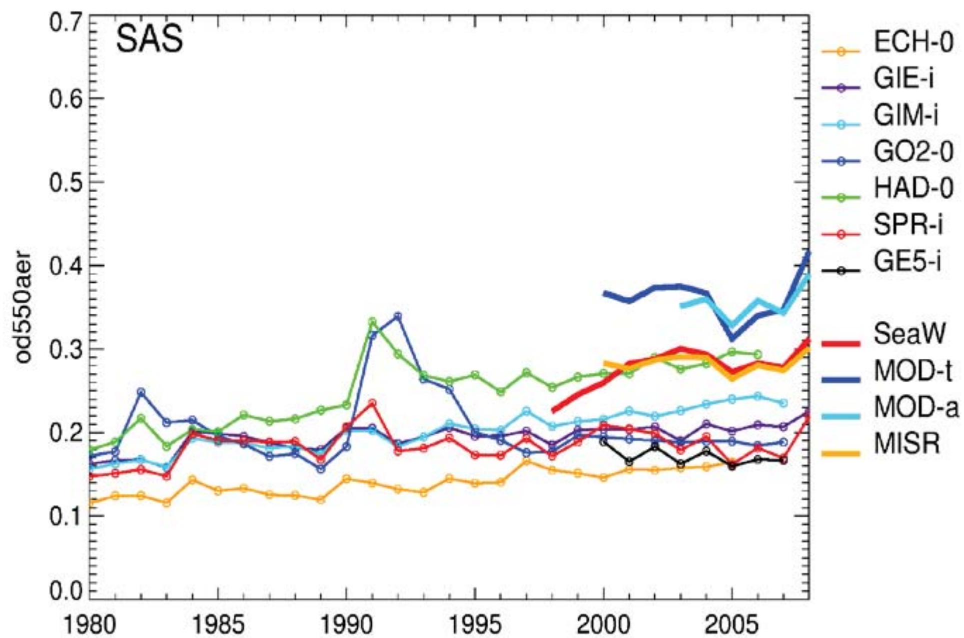
Evaluation of multi-model aerosol simulations over South Asia

Annual Mean AOD For 2006



- Representing the high AOD belt over the northern India is challenging for many current global chemical transport models, including NASA GOCART and GISS models.
- Averaged over entire South Asia, 6 out of 7 models underestimated the annual mean AOD about 30% compared to MISR, indicating an incorrect regional contribution towards the global mean radiation forcing estimation.

Annual mean AOD for 1980-2008



Pan et al. (2013)

End