

Ozone and CO budget over South Asia during the summer monsoon

GEOS-Chem model and IASI / IAGOS observations

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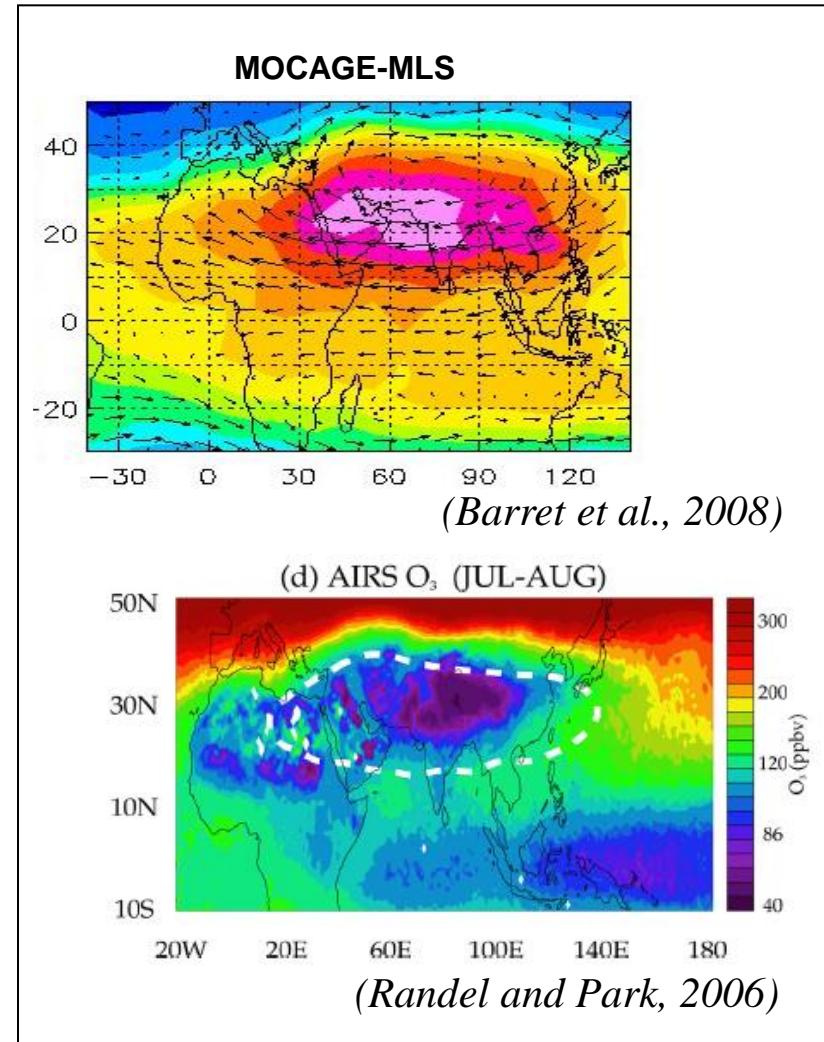
Outline

- **Asian Summer Monsoon**
 - ⇒ uplift of BL air masses to the UT
 - ⇒ increases levels of pollution tracers (CO)
 - ⇒ decreases levels of O₃
- **Asian Monsoon Anticyclone**
 - ⇒ Isolated UTLS region
 - ⇒ tropopause shifts to the north
 - ⇒ decreases levels of O₃

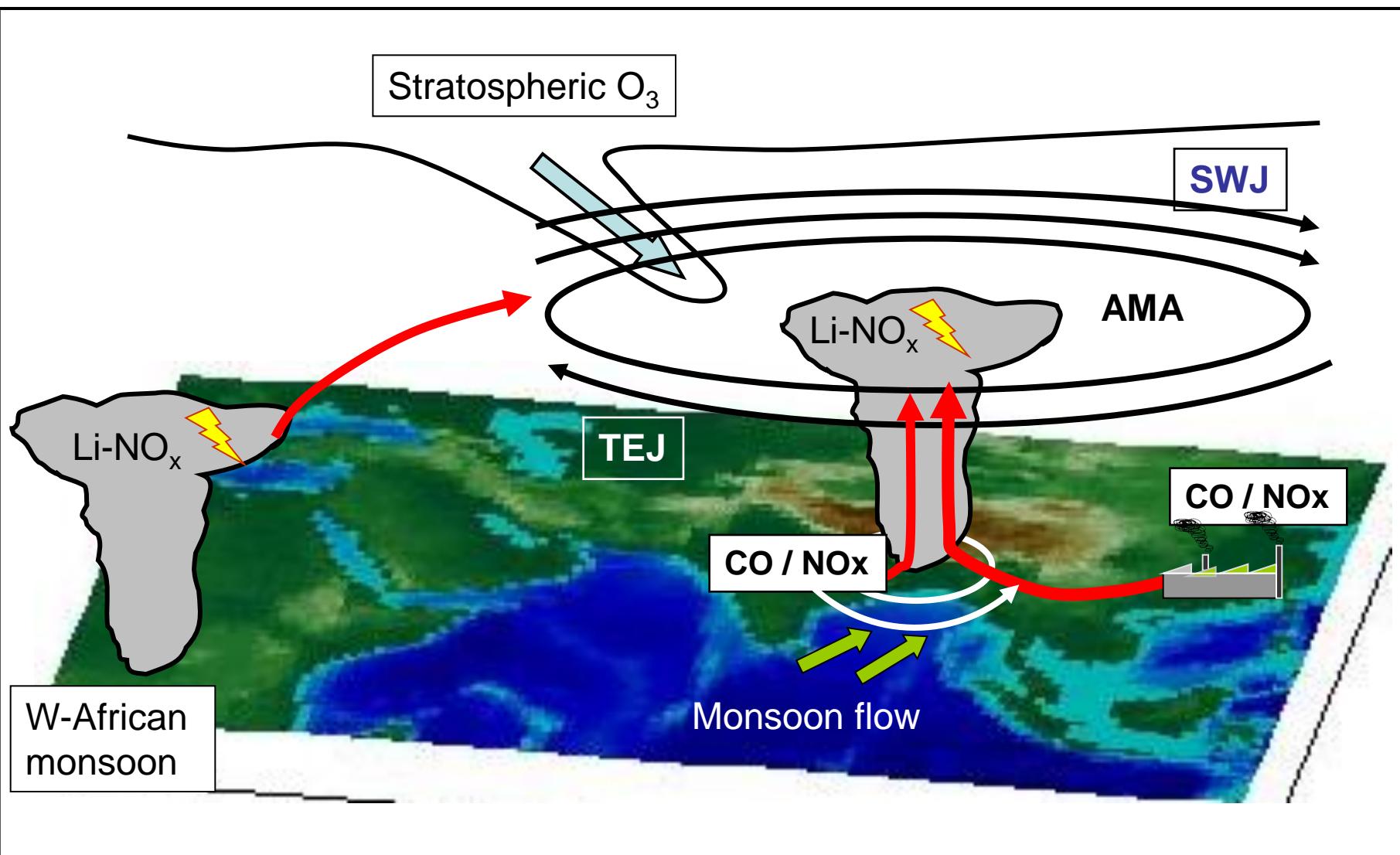
Uplift of O₃ precursors and LiNOx

- ⇒ increase O₃

Aim: Better characterize the CO and O₃ budget within the AMA

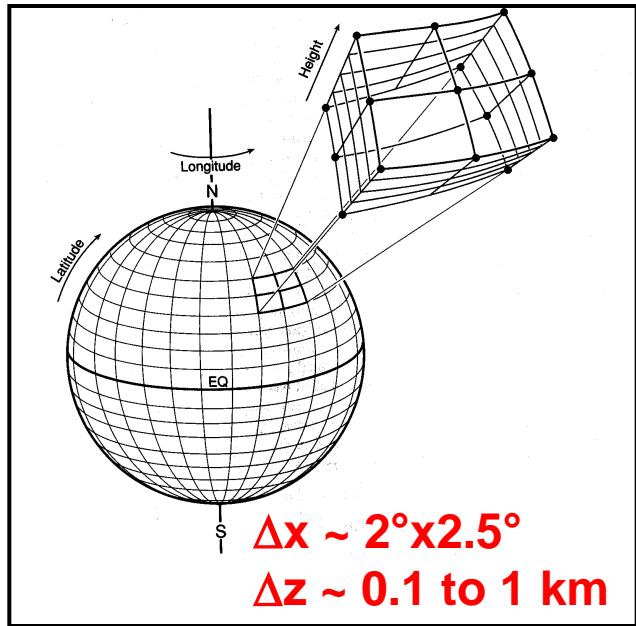


Processes driving UT O₃ during the monsoon



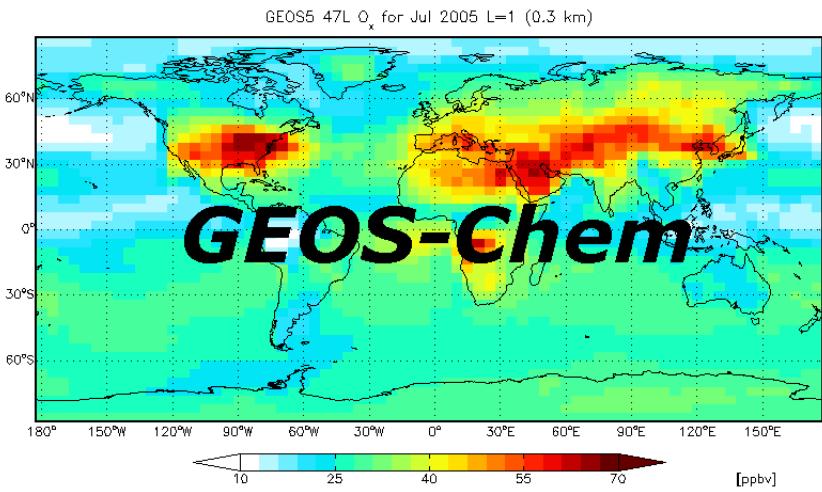
Atmospheric chemistry and transport simulations

GEOS-Chem



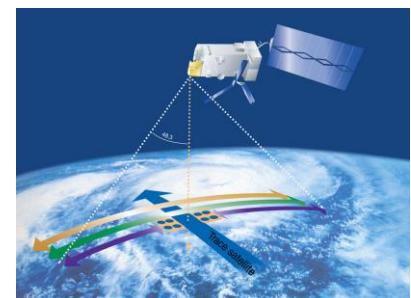
- Assimilated Meteorology (NASA GMAO)
- O₃-NO_x-VOC chemistry
- Interactive aerosol-chemistry
- Convection: modified Relaxed Arakawa Schubert scheme
- Linearized stratospheric chemistry (LINOZ)

- **Li-NOx:** CTH + injection profiles + LIS-OTD rescaling
- **BB:** GFED-3 inventory
- **Biogenics:** MEGAN model
- **Anthropogenic:** EDGAR + regional inventories (STREETS, BRAVO, EMEP...)

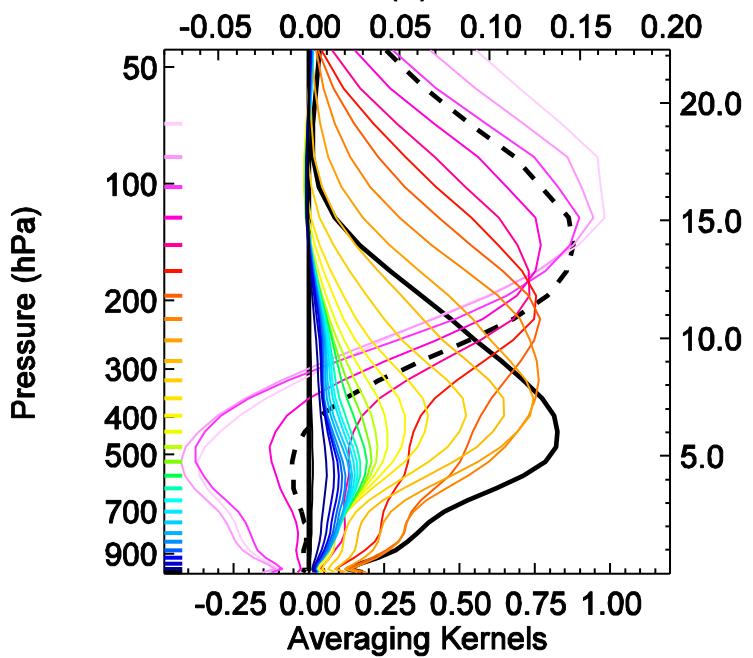


Satellite observations of the tropospheric composition IASI

- **Sensor:** nadir FTS / thermal IR (Metop-A, B and C 2006-?)
- **Objectives:** meteo sounding (T, RH) / chemistry (O_3 , CO...)
- **High spatio-temporal coverage:** twice daily / 12 km pixel
- **Retrieval:** **SOFRID** / Laboratoire d'Aérologie (RTTOV, 1DVar)

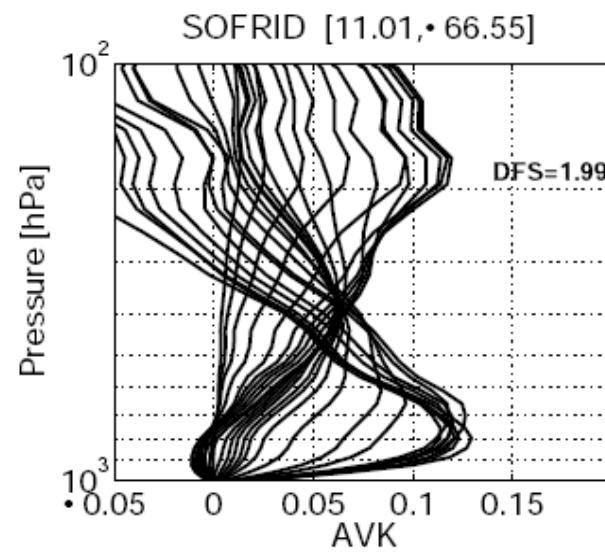


Ozone: DFS(*tropo*) = 2



(Barret et al., ACP, 2009)

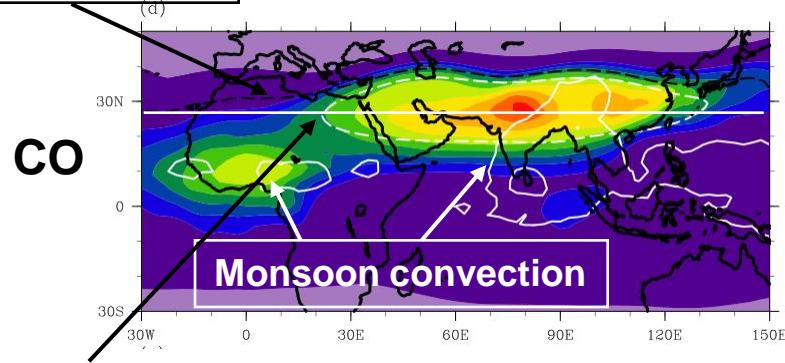
CO : DFS(*total*) = 2



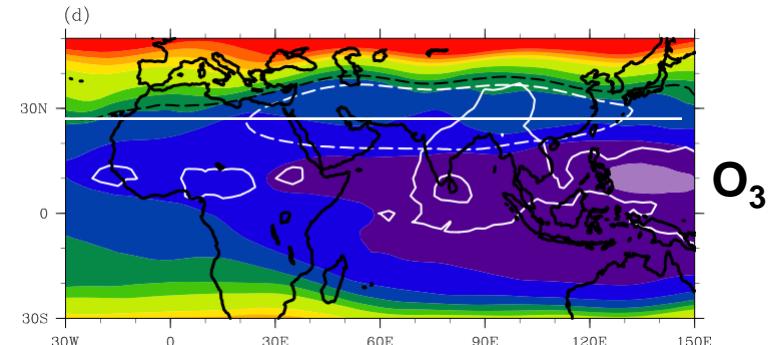
(de Wachter et al., ACP, 2012)

GEOS-Chem O₃ and CO distributions

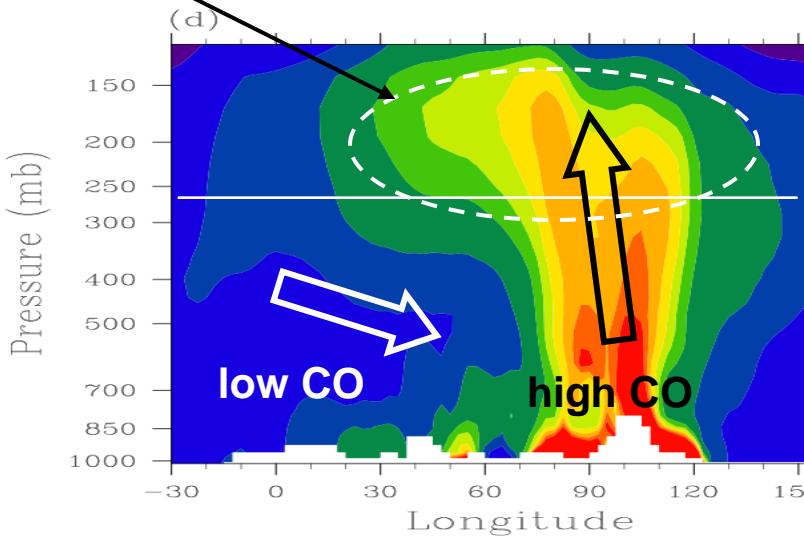
Tropopause



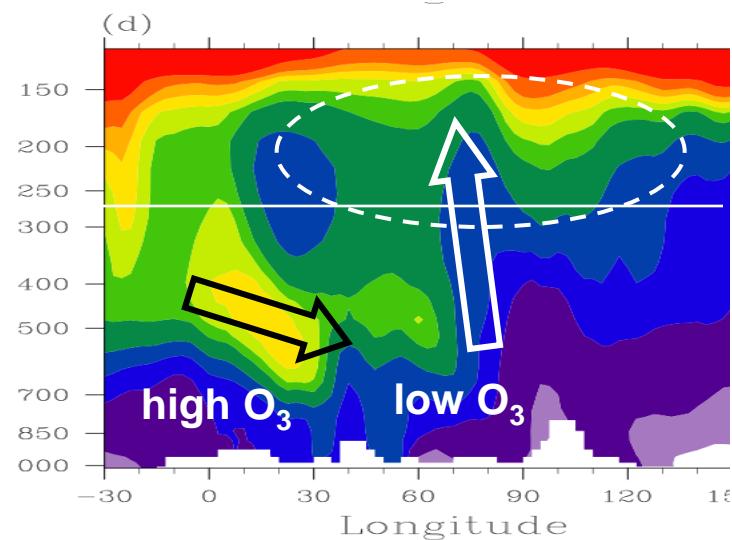
UT column (270-110 hPa)



AMA



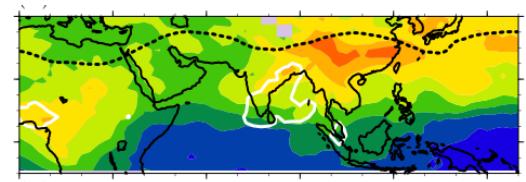
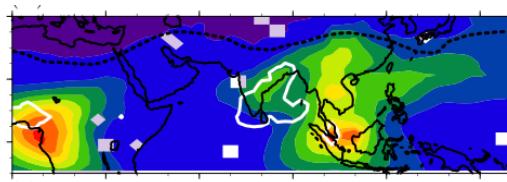
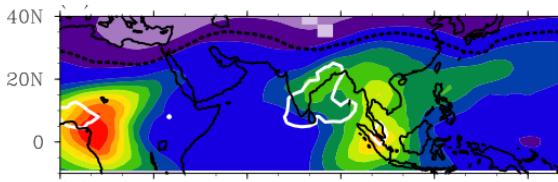
Longitude-P section @ 26°N



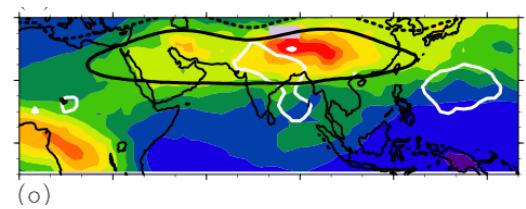
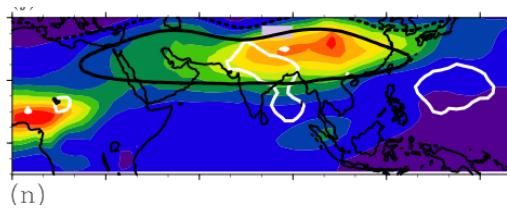
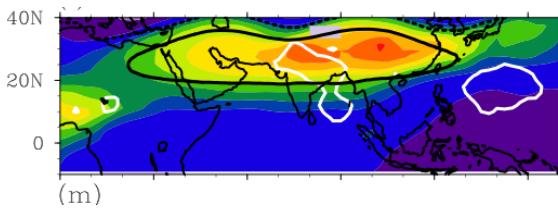
GEOS-Chem versus IASI: CO

UT CO column (270-110 hPa)

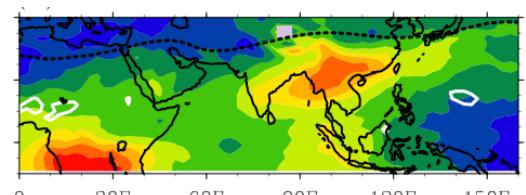
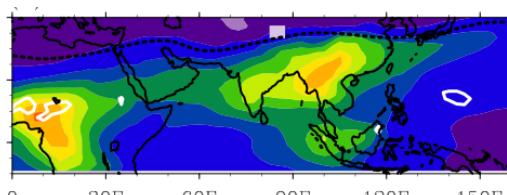
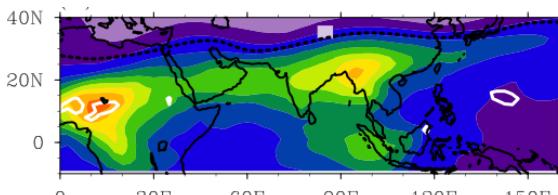
May



Jul



Oct



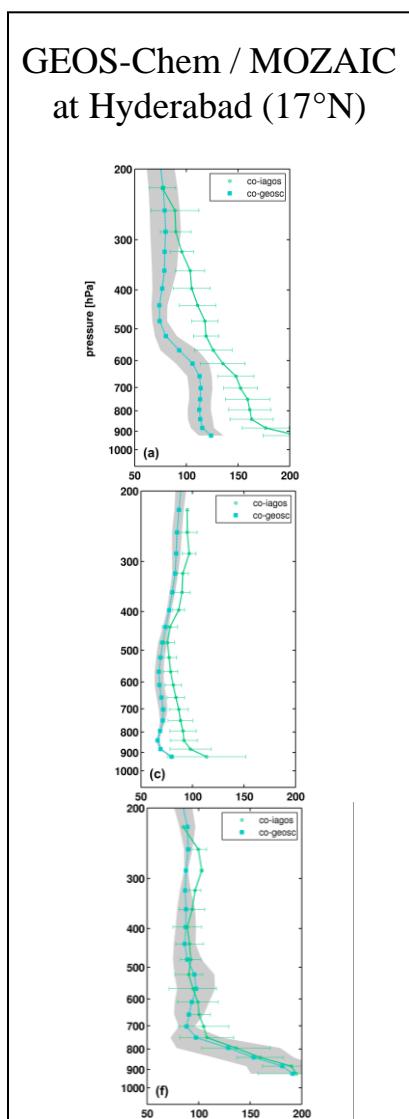
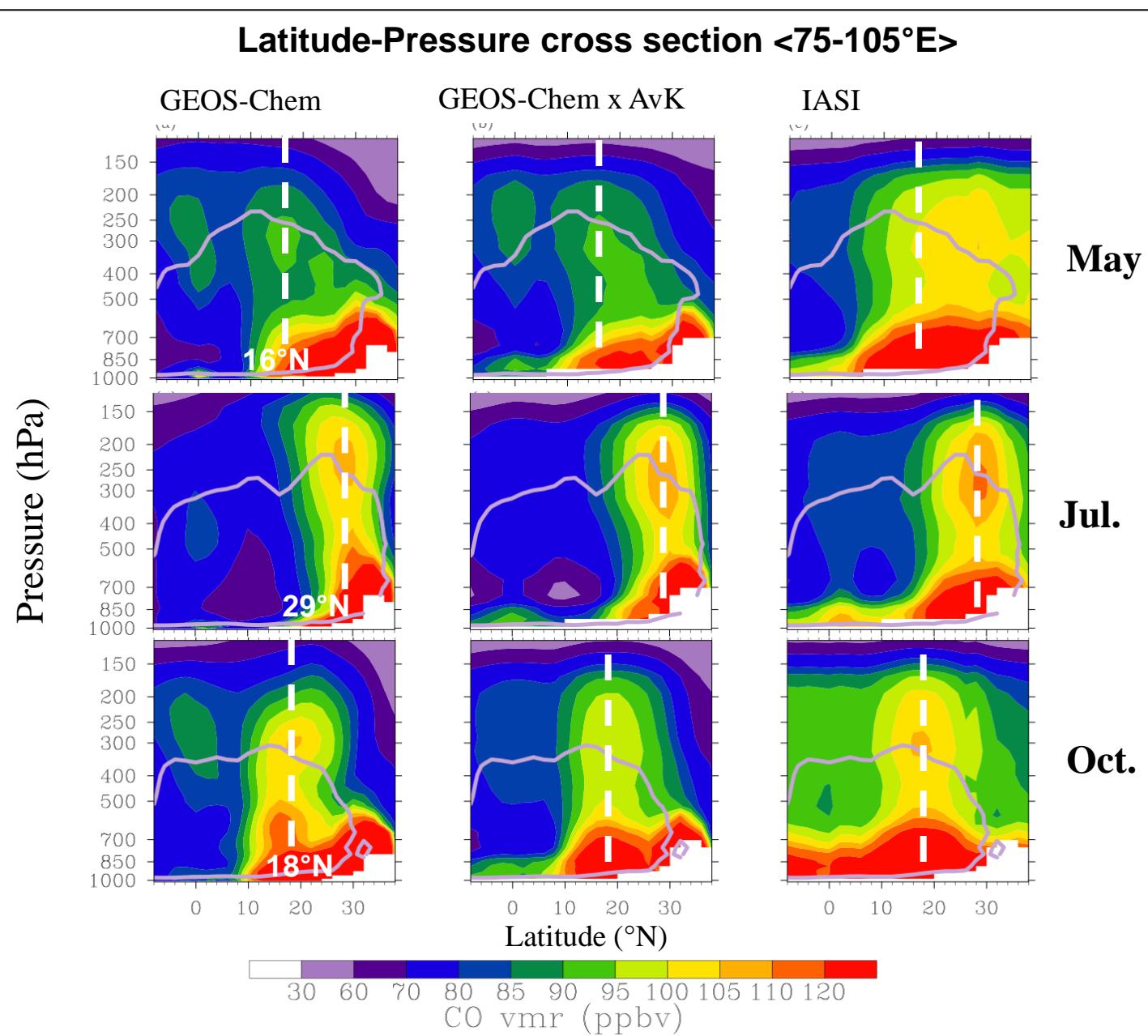
GEOS-Chem

GEOS-Chem*AvK

IASI

- ⇒ overall agreement between GC and IASI with Asian monsoon max.
- ⇒ GEOS-Chem underestimates UT CO relative to IASI

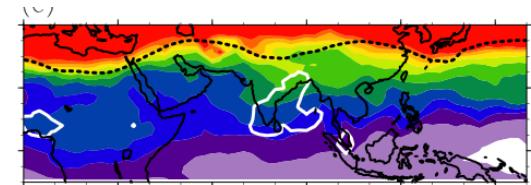
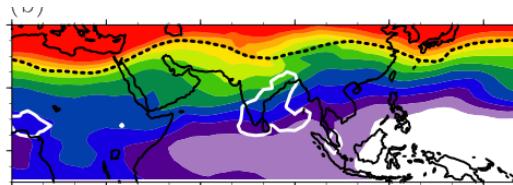
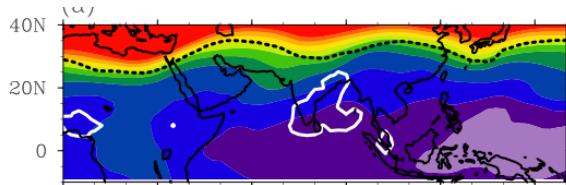
GEOS-Chem versus IASI: CO



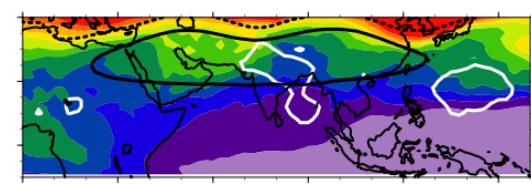
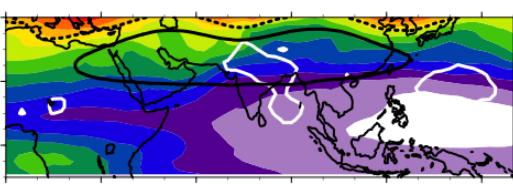
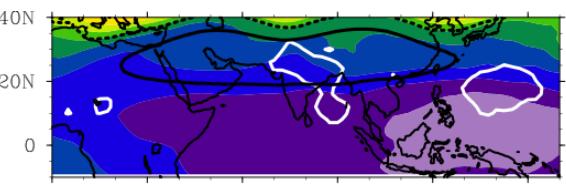
GEOS-Chem versus IASI: O₃

UT O₃ column (270-110 hPa)

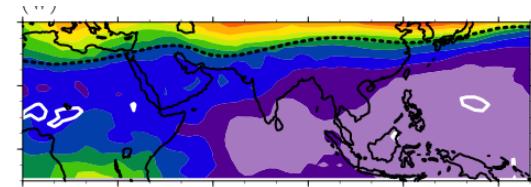
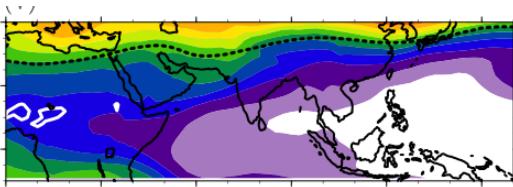
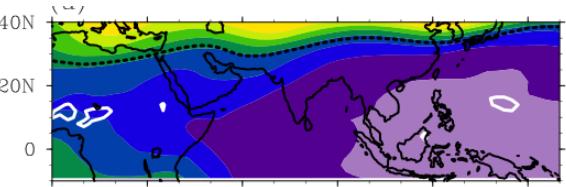
May



Jul



Oct



GEOS-Chem

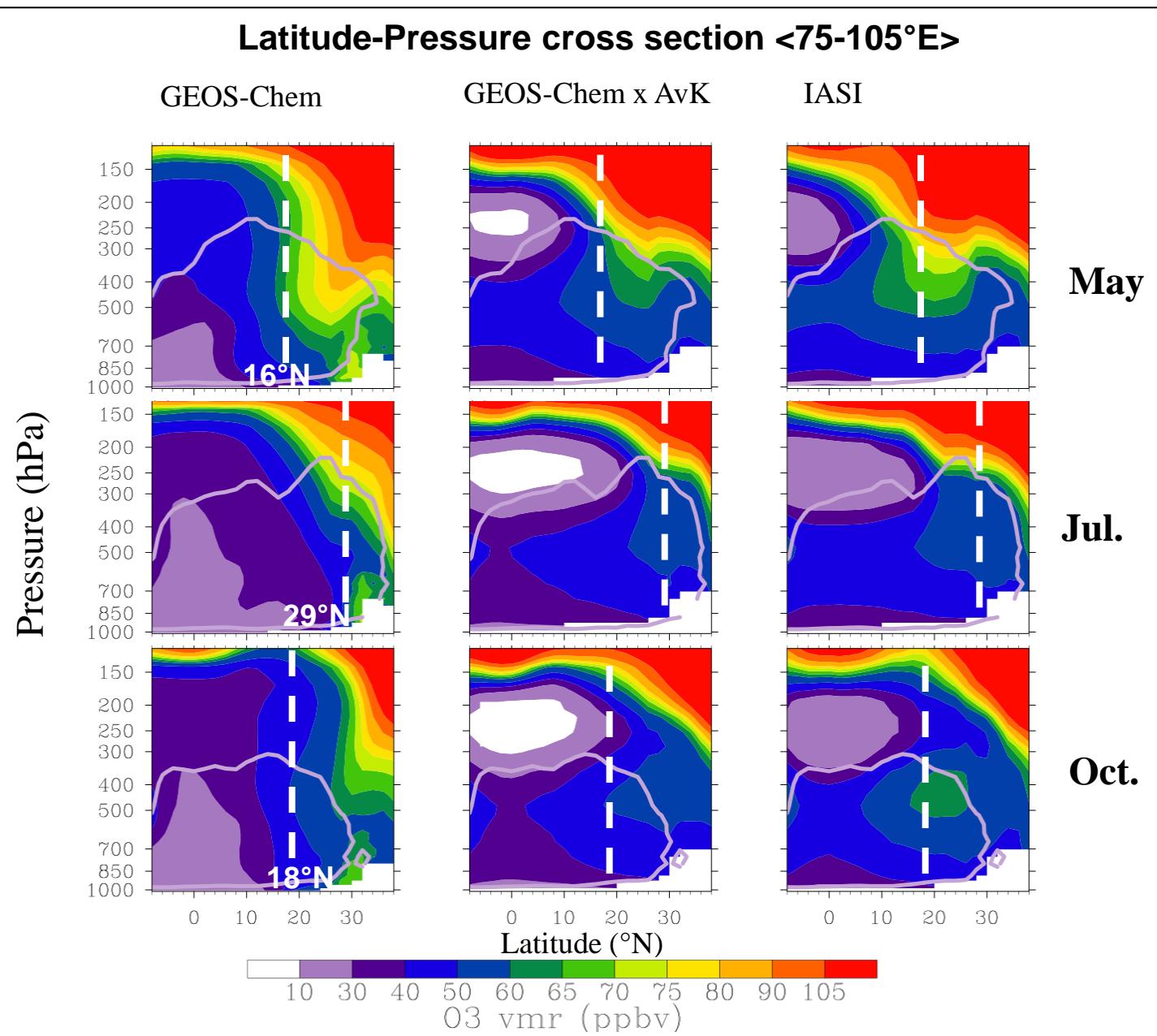
GEOS-Chem*AvK

IASI

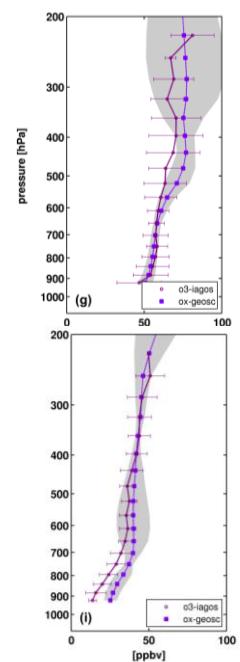
⇒ general agreement: strato. - tropo., W-Pacific min., S-Atlantic max.

⇒ GEOS-Chem overestimates UT O₃ relative to IASI

GEOS-Chem versus IASI: CO

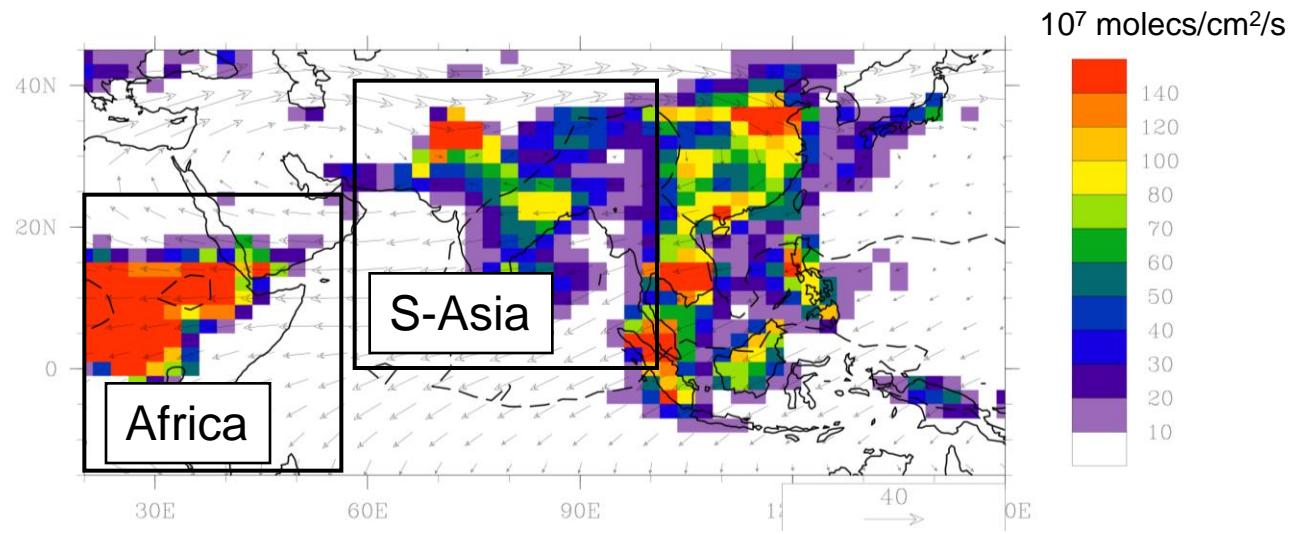


GEOS-Chem / MOZAIC
at Hyderabad (17°N)

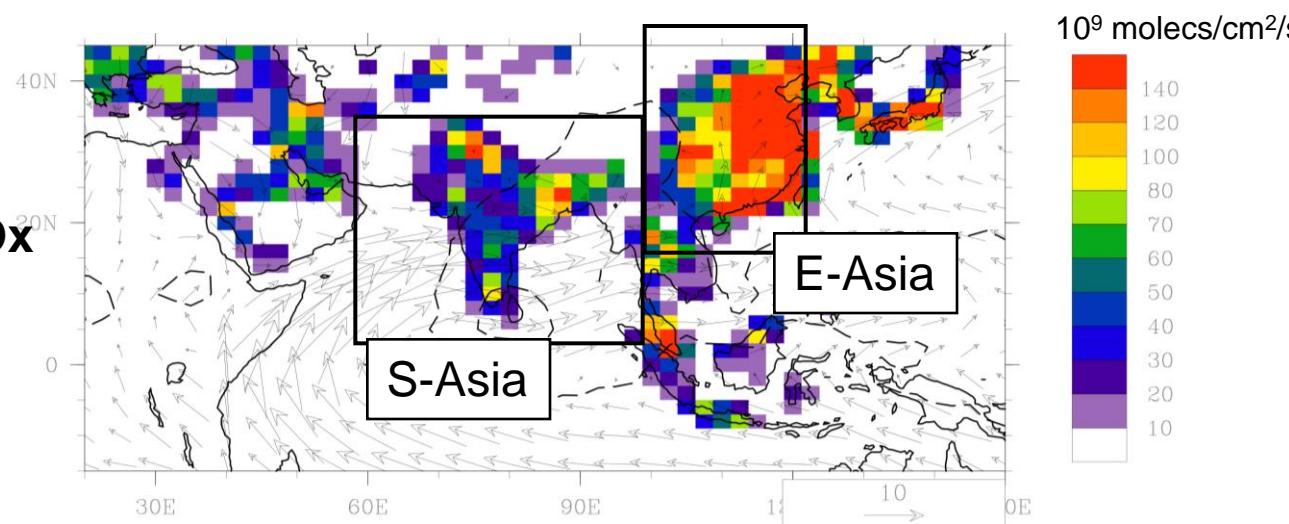


O₃ and CO budget with GEOS-Chem Sensitivity simulations

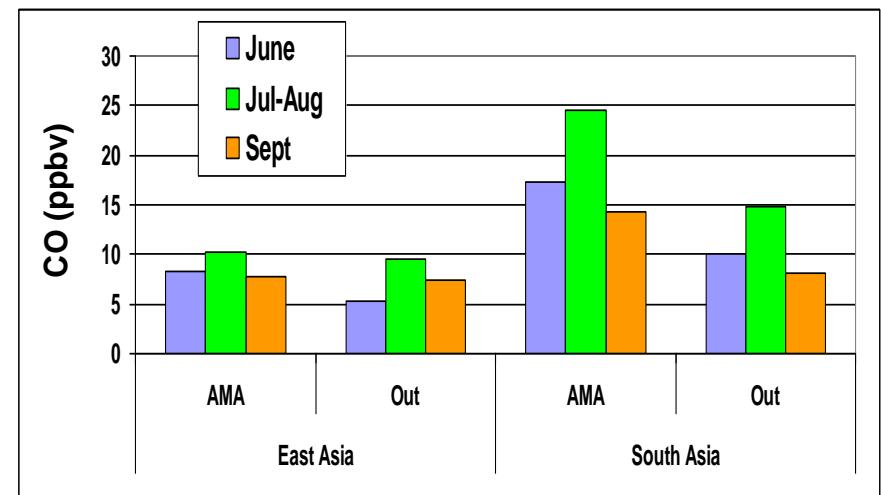
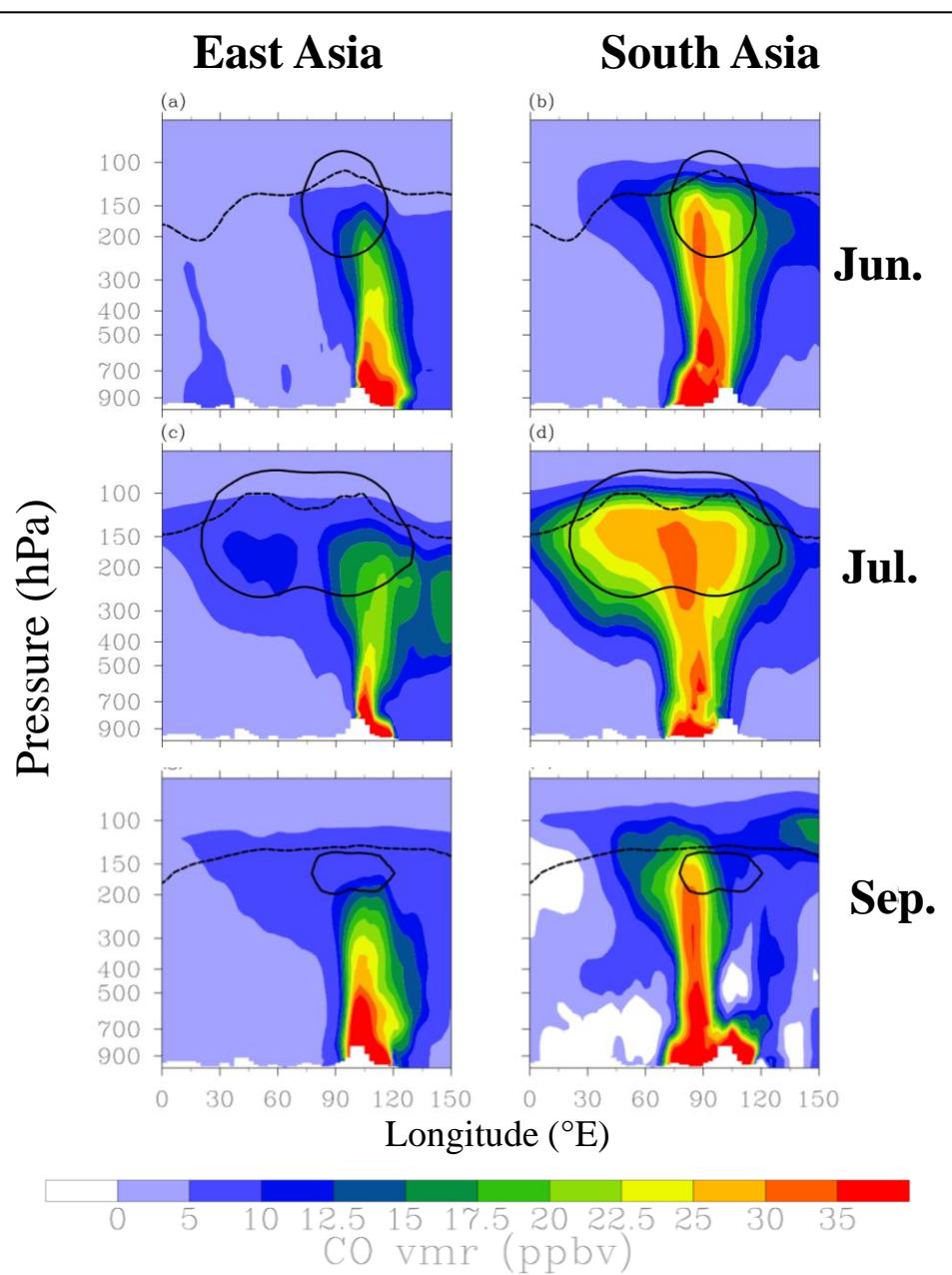
LiNOx



**Anthropo.
CO and NOx**



AMA CO budget



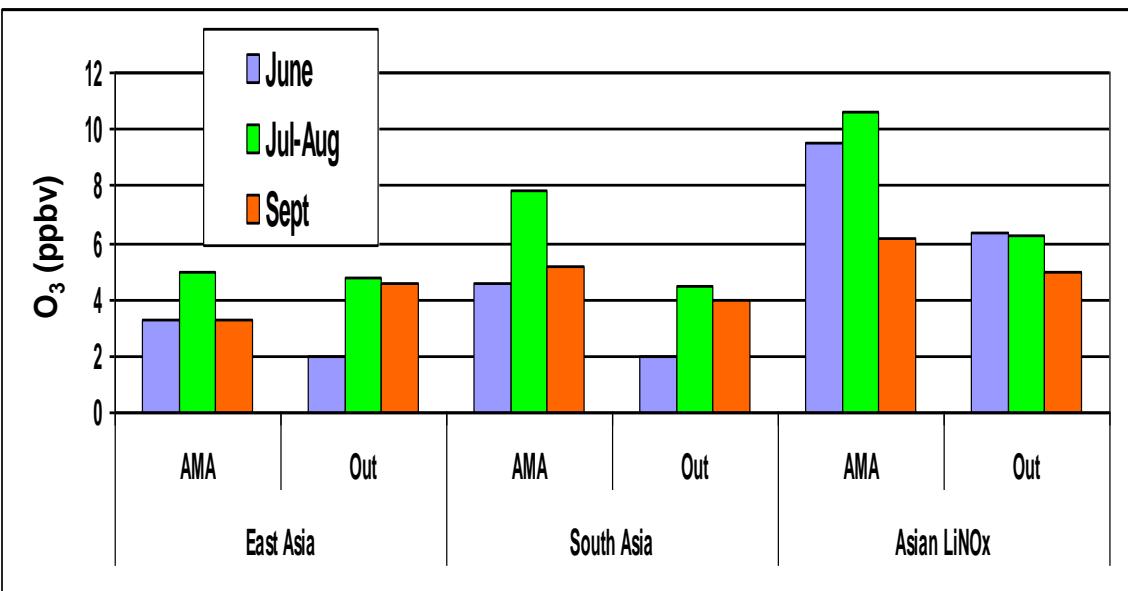
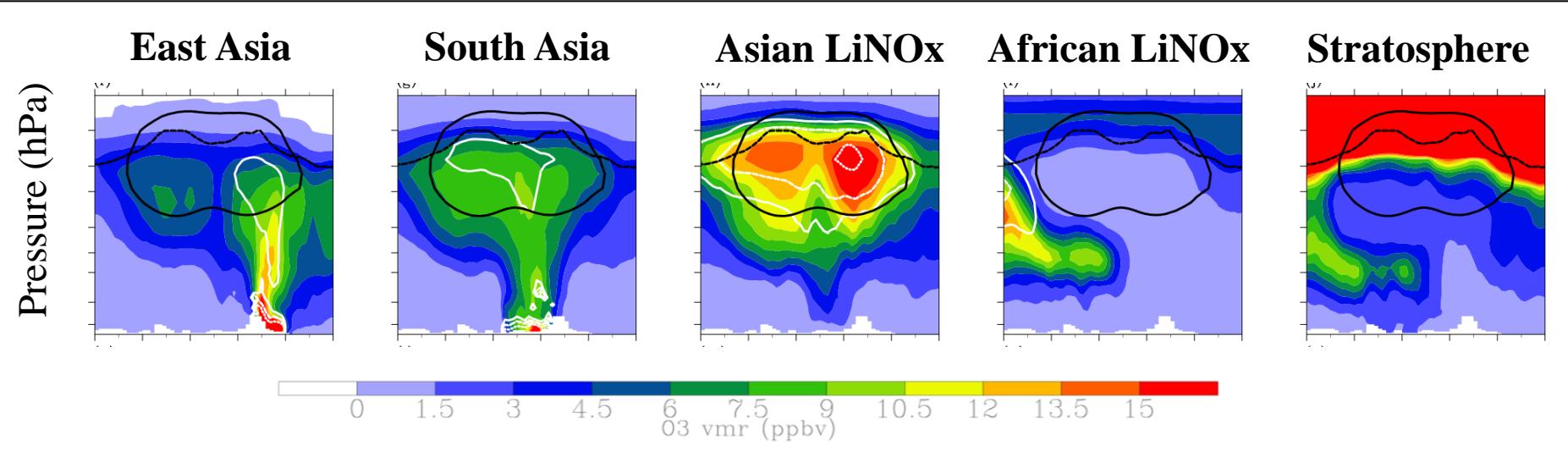
East Asia

- Lower contribution
- Inside ~ outside AMA
=> Convection not collocated with emissions

South Asia

- Largest contribution
- Inside AMA >> outside AMA
=> Convection collocated with emissions

AMA O₃ budget



Anthropogenic

- Similar to CO
- South Asia > East Asia

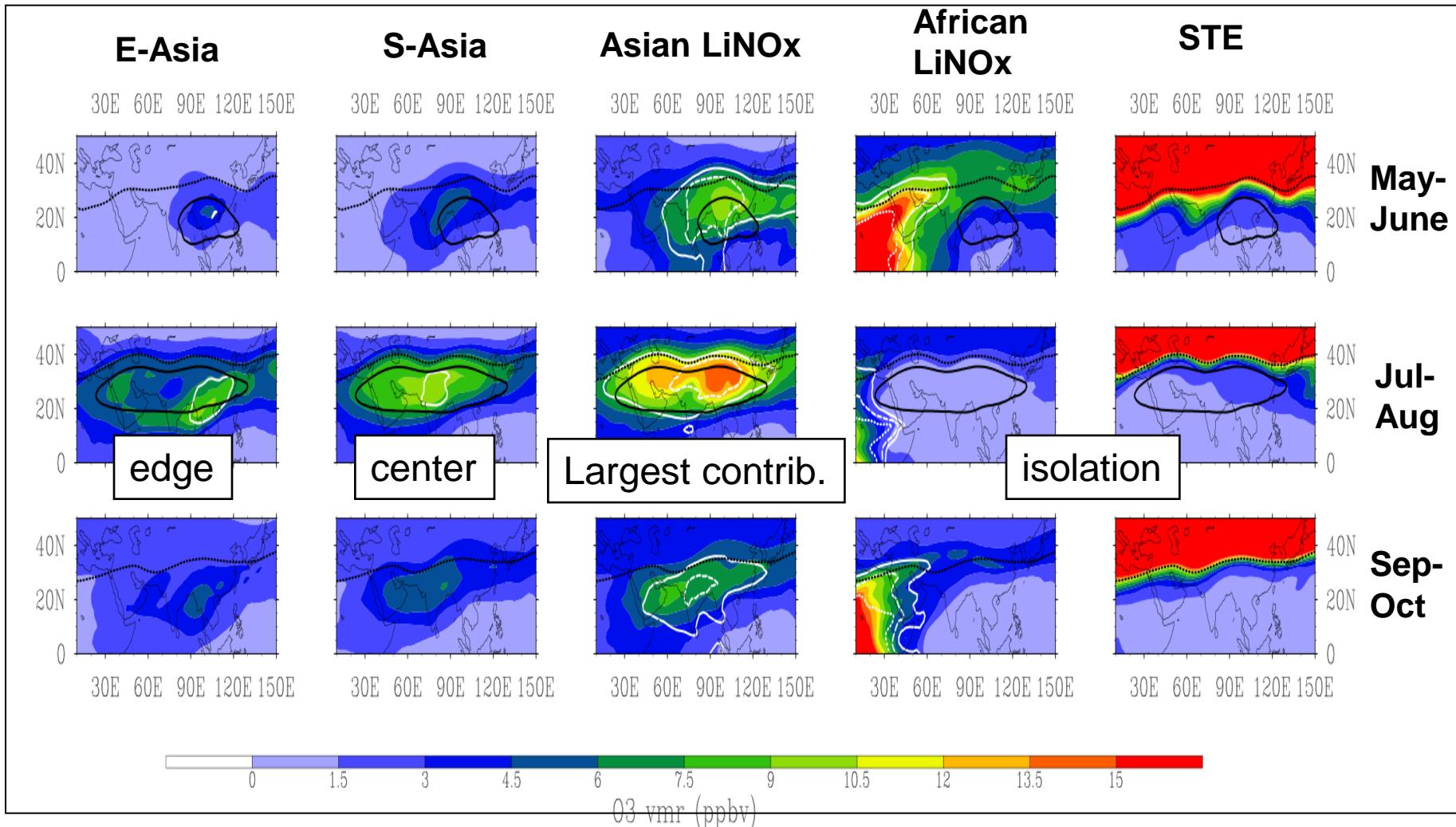
LiNOx

- Asian LiNOx: largest contribution
- NOx with high O₃ prod. eff. directly into the AMA
- African LiNOx: subside below the strato.

O₃ budget with GEOS-Chem

Overview in the UT

ΔO_3 @ 200 hPa



Remark: Indonesia Anth. and African BB NOx = negligible impact.

Conclusions and perspectives

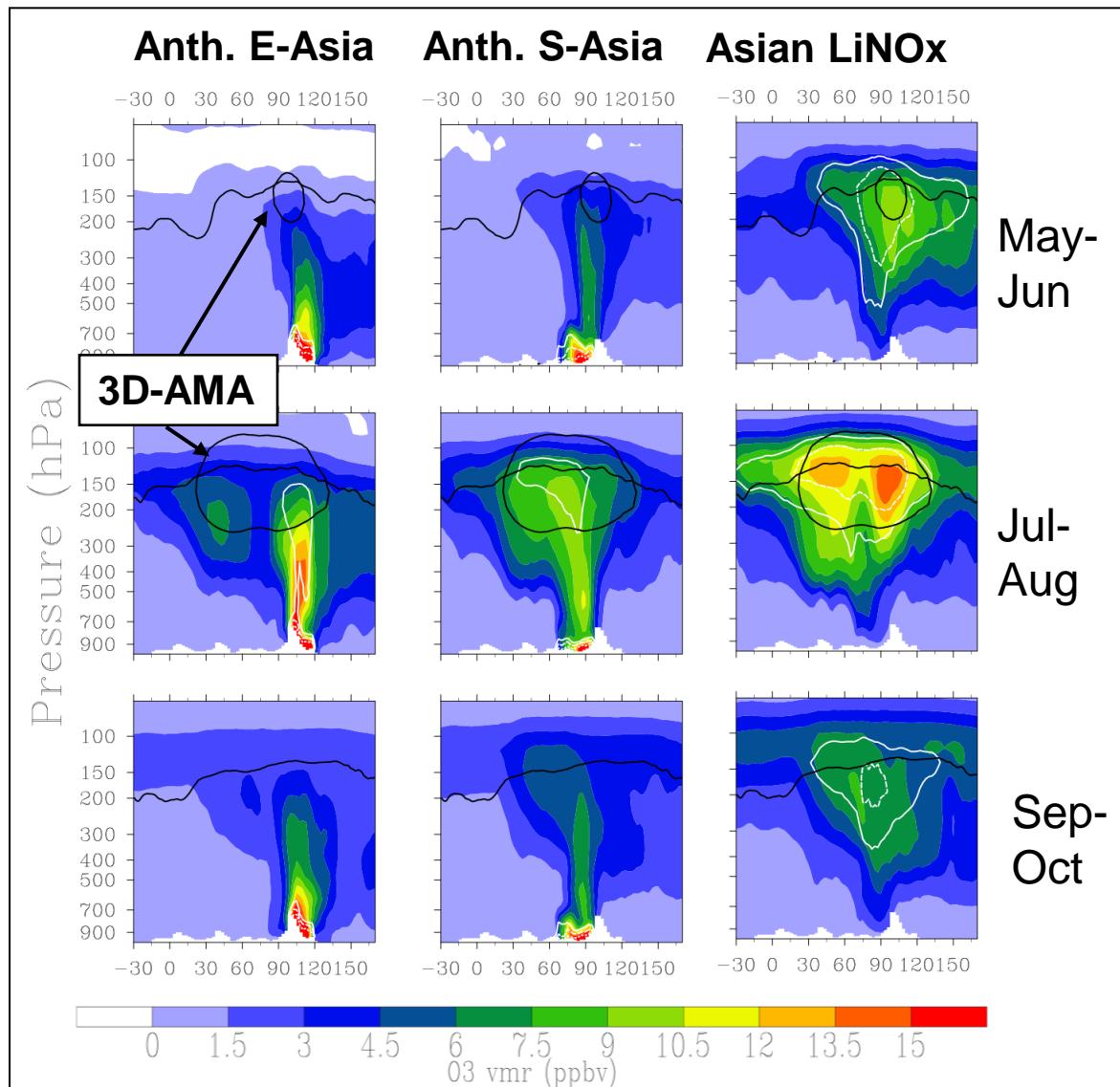
- **GEOS-Chem validation over Asia**
 - Good representation of CO convective uplift but general underestimation of CO relative to IASI / IAGOS
 - General agreement for O₃ within Asian UT with North-South gradient and GC captures the West-East gradient of mid-tropo. O₃
 - IASI enables the detection of UT CO convective latge enhancements
- **AMA CO/O₃ budget**
 - S-Asia largest contributor to CO increase: sources+convection+AMA
 - Important increase of O₃ within the AMA relative to neighbouring regions
 - Main O₃ contributors are S-Asian anth. NOx (<9 ppbv) and LiNOx (<15 ppbv)
 - O₃ produced by STE and African LiNOx are subsiding below the AMA and impact Middle East mid. Tropo.
- **Perspectives**
 - Look at UT interannual variability with IASI 9 years data
 - Characterize intrasesonnal distributions and « anomalies »
 - Determine the transport pathways and origins of these anomalies

O₃ budget with GEOS-Chem Regional NOx sources

Pre and post-monsoon:
low convection = low UT O₃ production

Monsoon:

- Regional sources produce O₃ within the AMA
- S-Asia more efficient than E. Asia: location/convection
- LiNOx largest contributor: high O₃ production efficiency



O_3 budget with GEOS-Chem Remote sources

- **pre-monsoon** = largest impact of African LiNOx and STE over S-Asia

-Monsoon:

- Remote sources have little impact on O_3 within the AMA = isolation
- African LiNOx and STE impact middle East mid-tropo trough subsidence below the AMA

- **post-monsoon**: lowest impact of STE and African LiNOx

