### Influence of enhanced Asian NOx emissions on ozone in the Upper Troposphere and Lower Stratosphere (UTLS) in chemistry climate model simulations


#### Asian summer monsoon convection plays an important role in efficient vertical transport from the surface to the upper-level anticyclone.

#### In this paper, we investigate the potential impact of enhanced anthropogenic nitrogen oxide (NOx) emissions on the distribution of ozone in the UTLS using the fully-coupled aerosol chemistry-climate model, ECHAM5-HAMMOZ. Simulations for enhanced NOx emissions over India and China for observed trends were performed.

#### Model simulations show transport of NOx and ozone into the anticyclone and lower stratosphere.

**Fig:** Distribution anomalies of NOx (%) (top), anomalies of ozone production (ppt/day) (middle), anomalies of ozone RF (nW/m^2) (bottom).

- The model simulations with observed trend of NOx emission produce significant warming over the Tibetan Plateau and increase precipitation over India due to the strengthening of the monsoon Hadley circulation.

- However, further enhancement in NOx emissions over India results in large ozone production over IGP and TP. It induces a reversed monsoon Hadley circulation and negative precipitation anomalies.

### Potential impact of carbonaceous aerosol on the Upper Troposphere and Lower Stratosphere (UTLS) and precipitation during Asian summer monsoon in a global model simulation

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- The ECHAM6 HAM simulations show strong monsoon convection over the Bay of Bengal and the South China Sea and southern latitudes of the Himalayas lift the boundary layer carbonaceous aerosols into the anticyclone.

- Carbonaceous aerosol emission increases heating rate anomalies in the anticyclone by 0.02 - 0.03 K/day.

- Enhancement of carbonaceous aerosols produce significant warming in the mid/upper troposphere, enhances vertical velocities and thereby anomalies of cloud ice and ICNC in the UTLS.

- Anomalous warming over the TP induces the relative strengthening of the monsoon Hadley circulation and elicits enhancement in precipitation over India and northwest China.

**Fig:** Distribution of BC-OC (a) monthly vertical profile, (b) 1000hPa, (c) anomalies (avg:15.35N), (d) anomalies of temperature (avg:80-110E), (e) anomalies of ICNC (avg:15.35N) and (f) anomalies of cloud ice (avg:80-110E).

### Linkages of subtropical stratospheric intraseasonal intrusions with Indian summer monsoon deficit rainfall


- This paper reports that the subtropical stratospheric intrusion is likely to aid the development of longer spells of subdued rainfall during the Indian summer monsoon season.

- A deep stratospheric intrusion occurs due to RWB over NI and adjacent region during 10-18 June 2014.

- Intrusion traverses the NI along the subtropical westerly jet and sheds eddy.

**Fig:** Zonal and meridional potential vorticity (PV) averaged 25°N-40°N (top two), ozone mixing ratios (ppb) averaged 60°E-75°E (bottom two), (a) 10 June, (b) 12 June, (c) 14 June, (d) 16 June, (e) 18 June 2014.

- Intrusions spread dry, cold and ozone rich air in the UT (~500 hPa).

- It persisted until the end of June 2014.

- The stratospheric intrusion period is marked by an abrupt increase in static stability of the troposphere.

- Anomalously dry and cold upper troposphere weakens the north-south temperature gradient in the UT.

- This might have inhibited northward propagation of large scale convection and is responsible for India monsoon deficit during June 2014.

**Fig:** Distribution of PV at 350K level during 10-18 June 2014 (alternate day) indicating RWB.

**Fig:** Anomalies in daily temperature (K) at 400 hPa. Time-pressure cross section of anomalies in (a) temperature (K), (b) RH (%), (c) square of Brunt Vaisala frequency (per sec^4)(E-5).

- Comparison of simulated BC vertical profile, cloud ice and precipitation shows reasonable agreement with in situ and satellite measurements.