Modelling Near-surface Ozone over South Asia –impacts on crops

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Why ozone modelling in South Asia?

- **Enhanced concentration of ozone is harmful to humans and vegetation**
- **Measurements of ozone are scarce in South Asia**
- **Models can be used to “fill the gap” between the measurements,**
  - **… and construct various indices related to ozone effects**
  - **… and investigate ozone chemistry, emission/climate scenarios etc.**
- **Models need to be tested against observations**

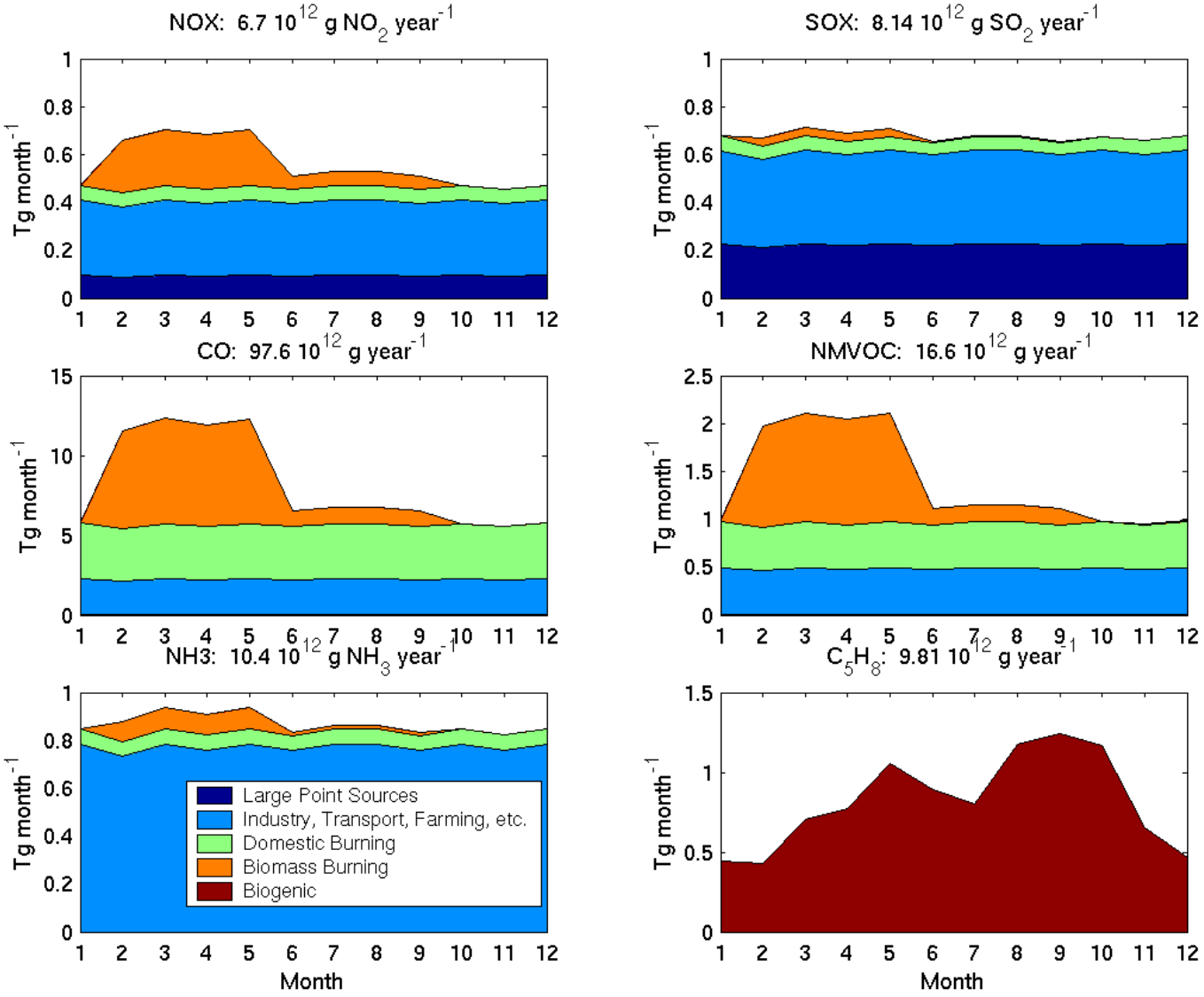
MATCH (Multiple-scale Atmospheric Transport and Chemistry) -model

- **Eulerian, three-dimensional, off-line model**
- **Driven by ERA-40 meteorology from ECMWF**
- **Horizontal resolution 0.5°×0.5°; 20 layers up to ~6 km**
- **Boundary conditions (O_3, CH_4, PAN, etc.) from measurements/climatology**
- **Meteorology and anthropogenic emissions valid for 12 months in 2000**

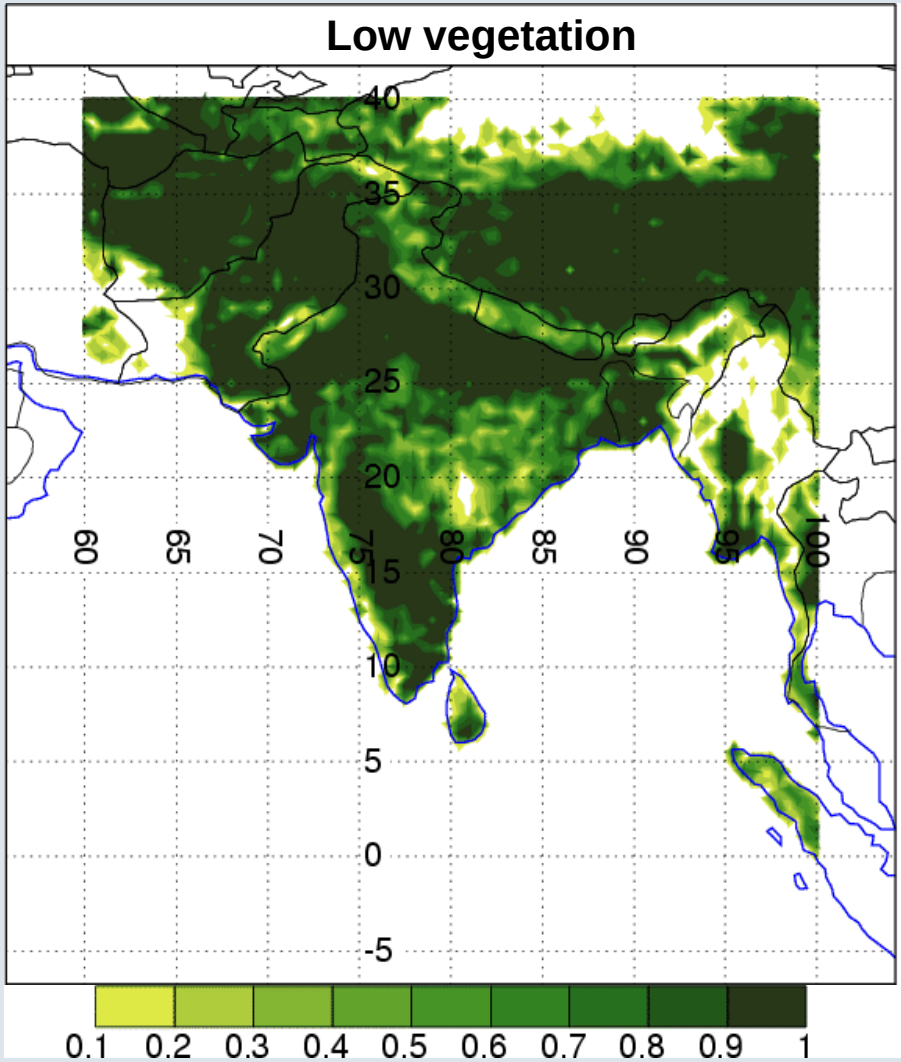
Emissions in model domain

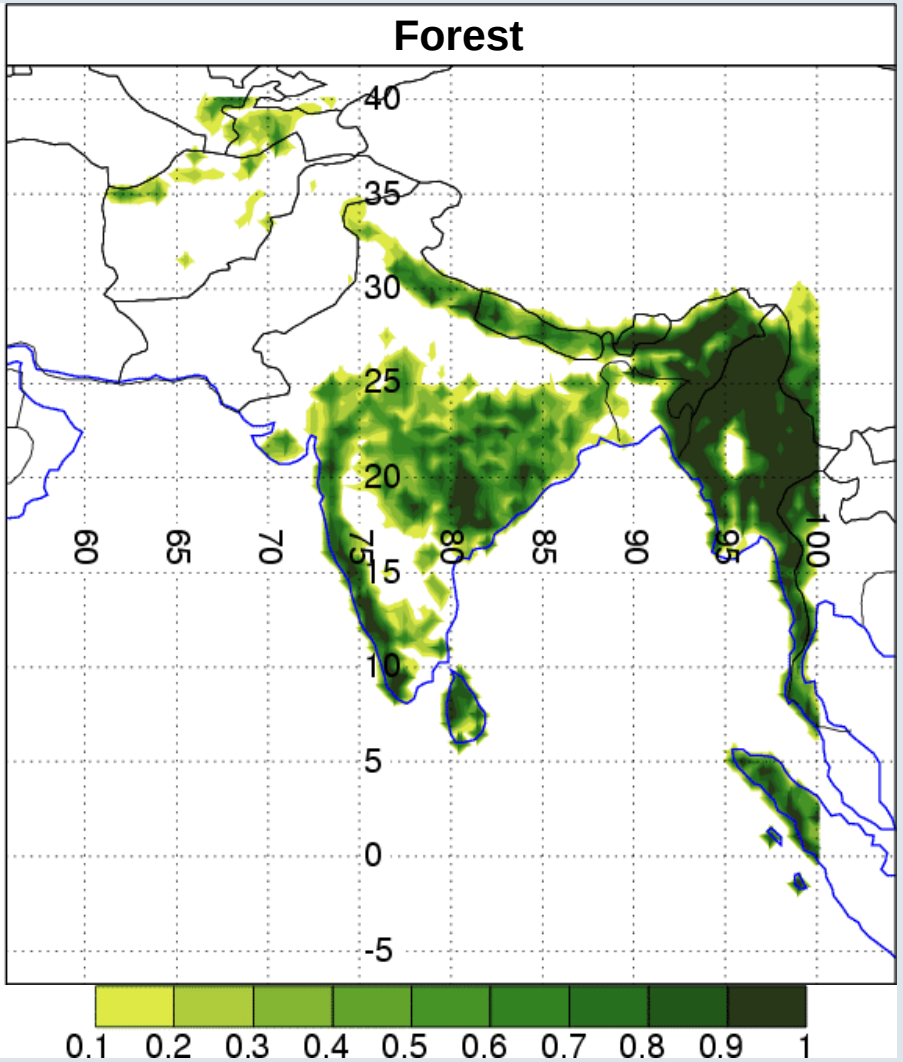
Anthropogenic (NO_X, SO_X, CO, NMVOC NH_3,) from Streets et al. (2003)

Biogenic C_5H_8 from Guenther et al. (1995)

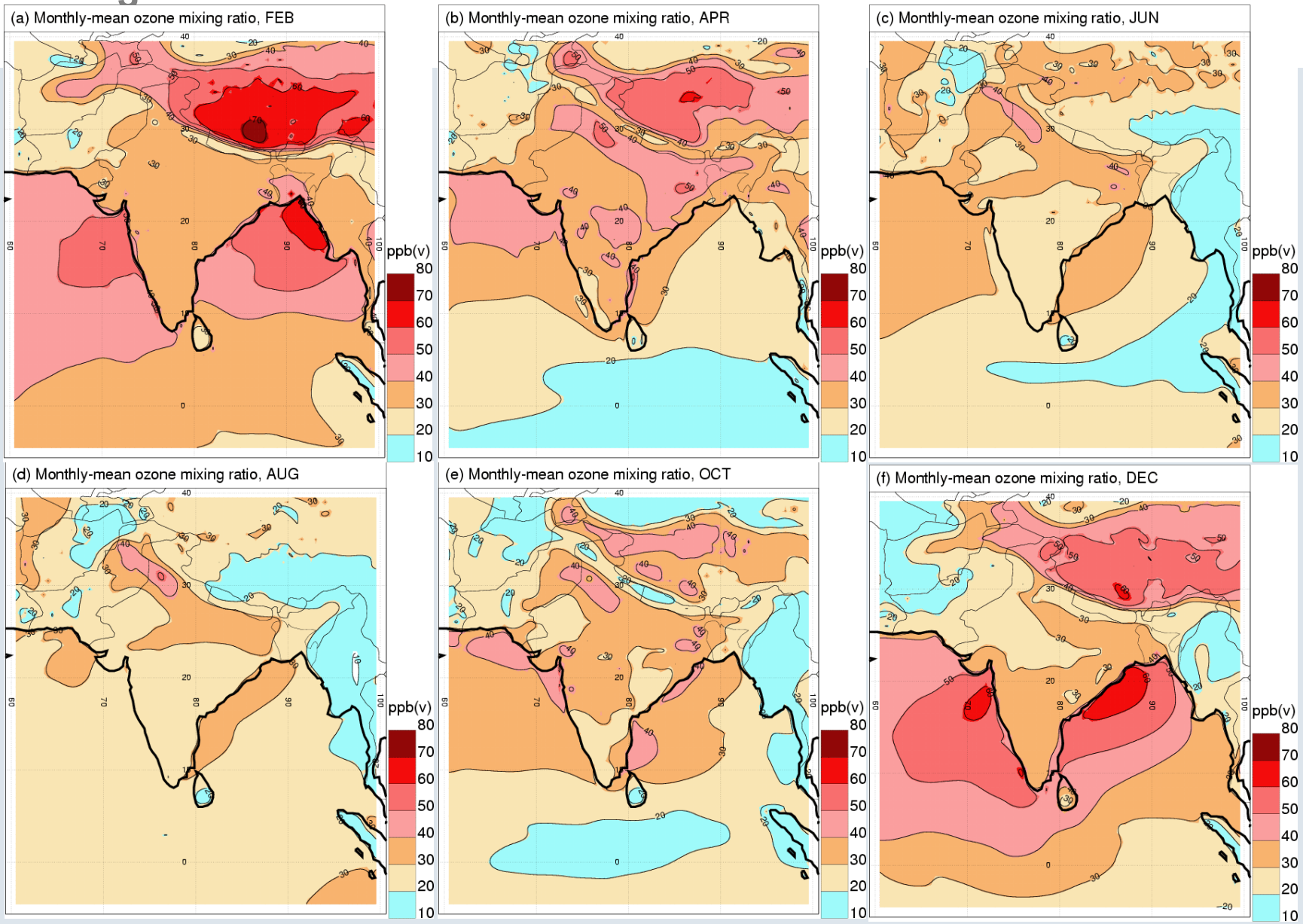


Four surface types: (1) low vegetation; (2) forest; (3) dry land; (4) ocean

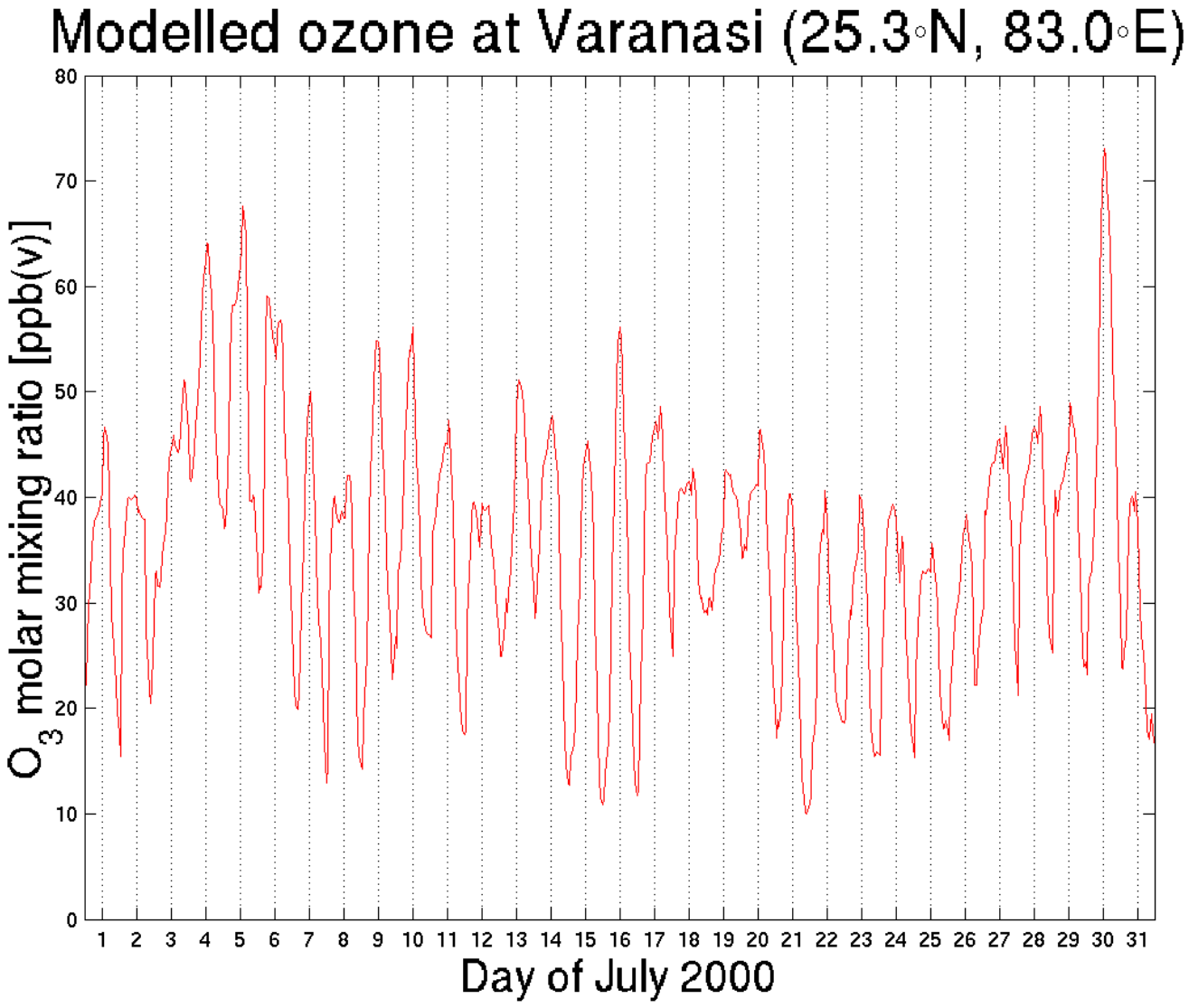




Modelled monthly-mean (24h) near-surface O_3 concentrations across South Asia



Modelled ozone concentration at a site in India in July 2000 (hourly values)

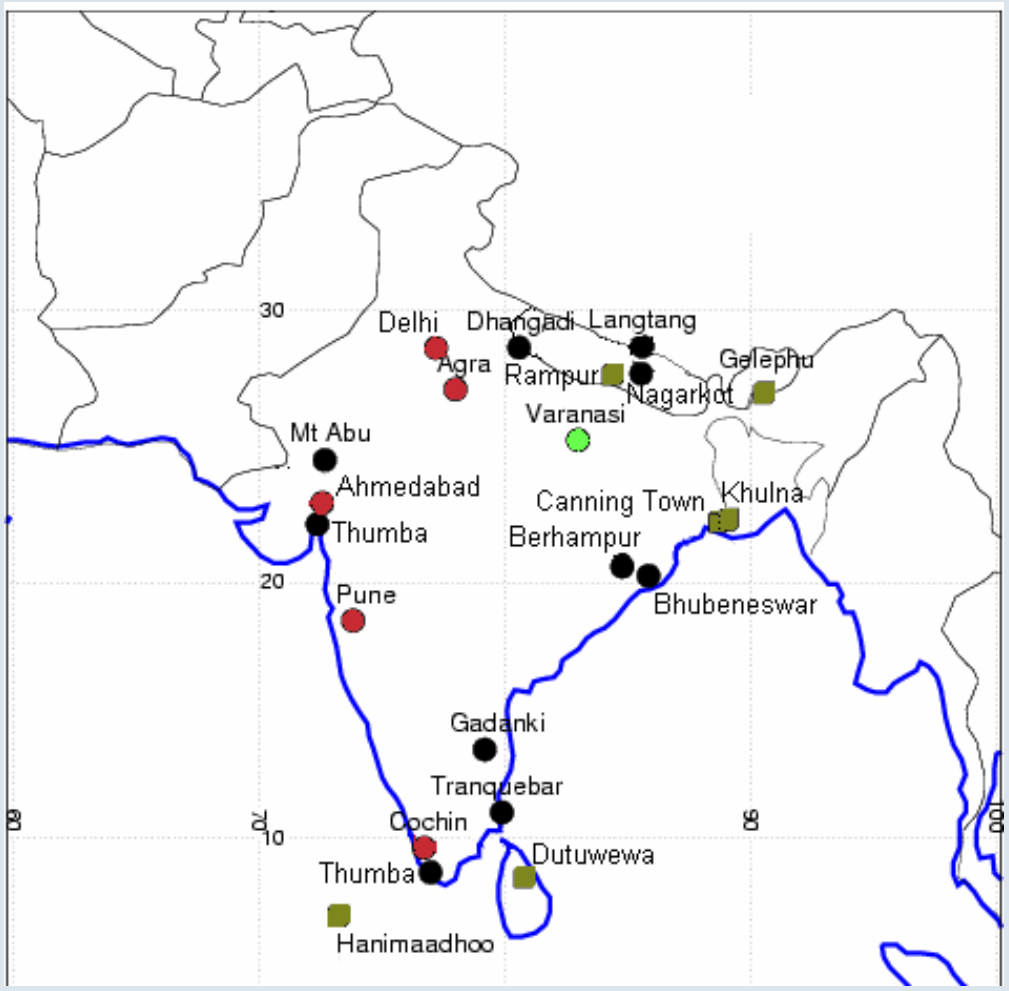


Available ozone data in South Asia

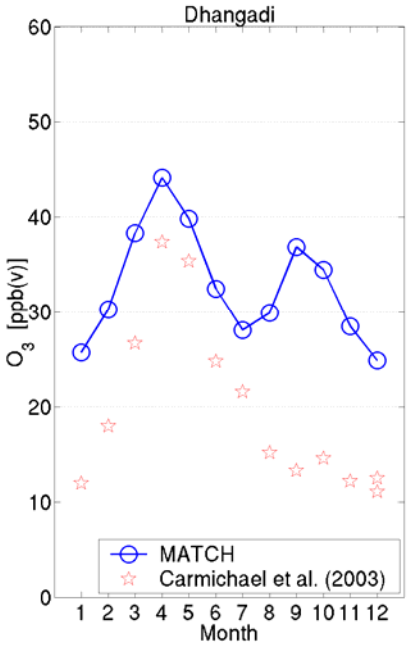
Collected by different methods over > ~10 years

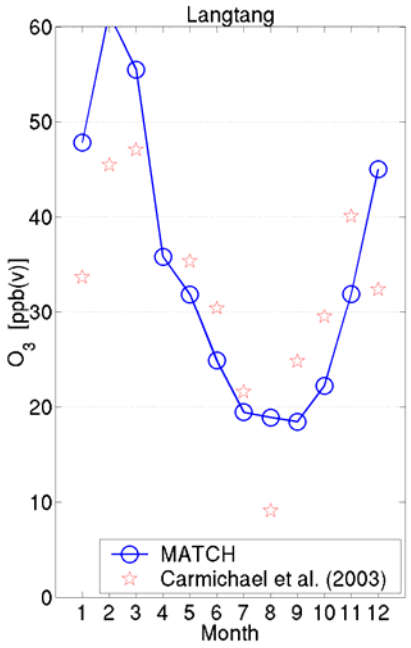
- Urban/suburban
- Malé site
- Rural background
- APCEN site

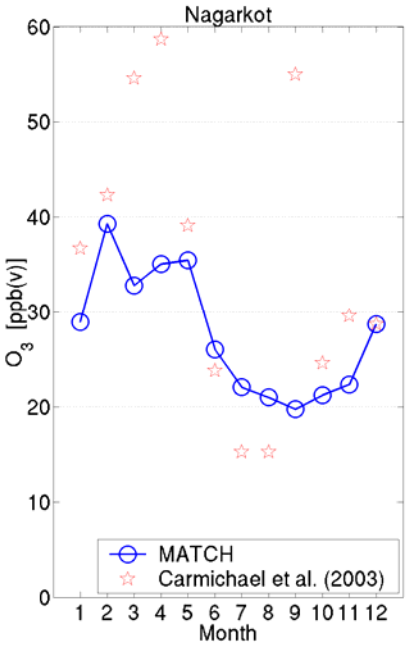
A few urban stations purposely omitted in current compilation

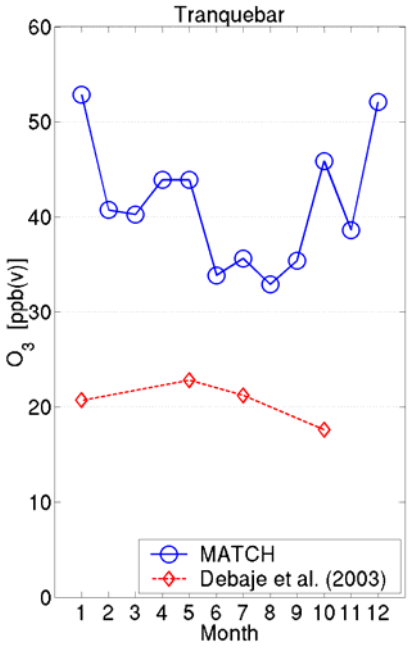


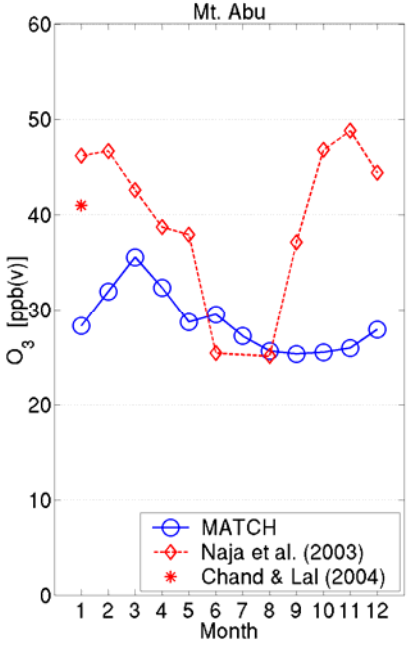
Monthly-mean O_3 at rural stations in South Asia

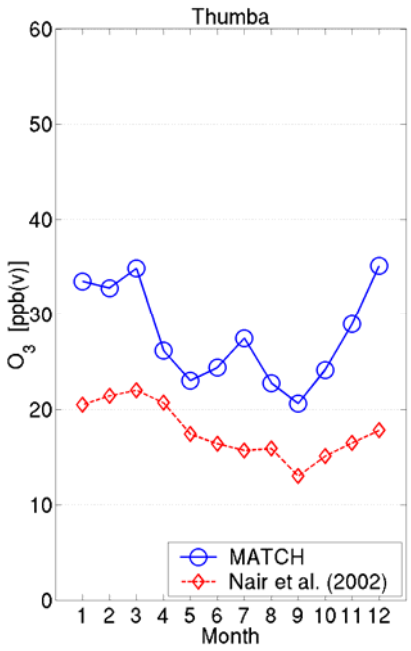


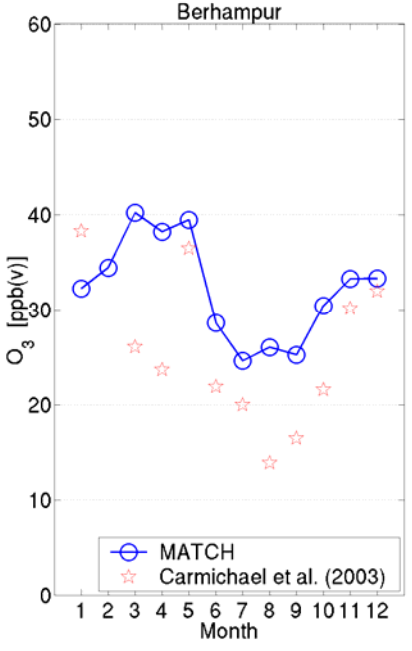


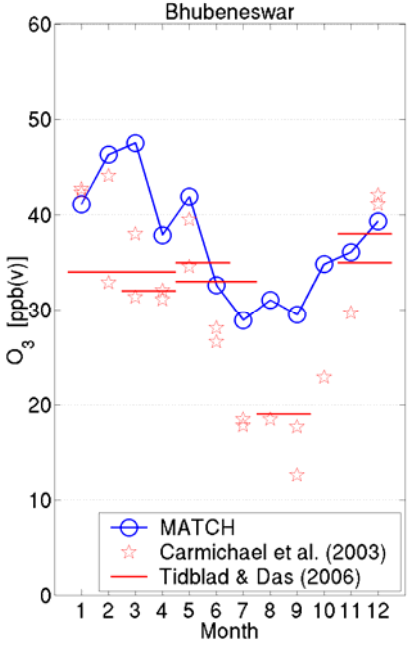




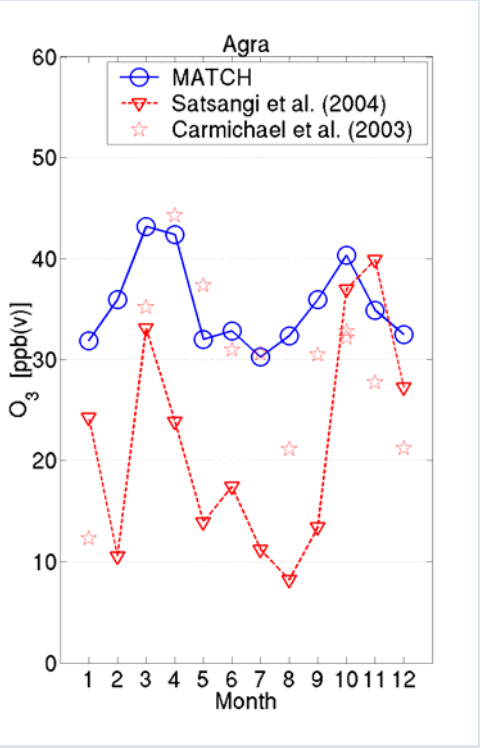


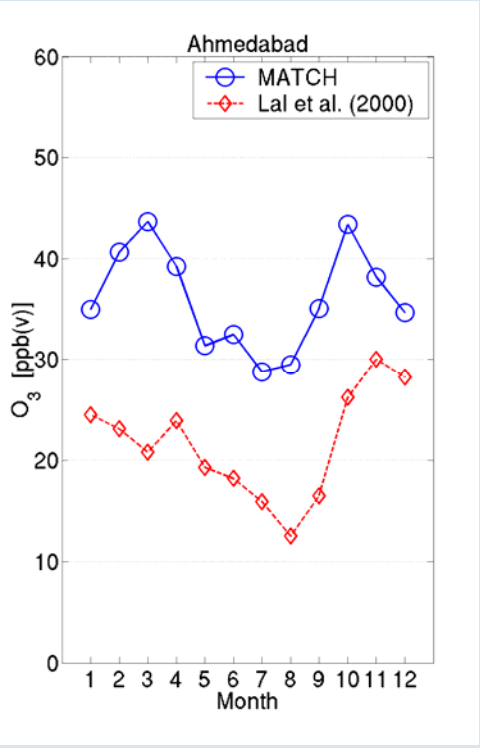


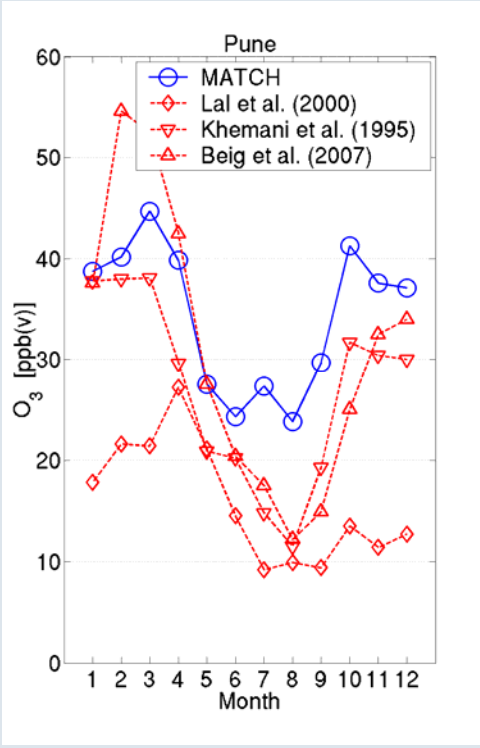


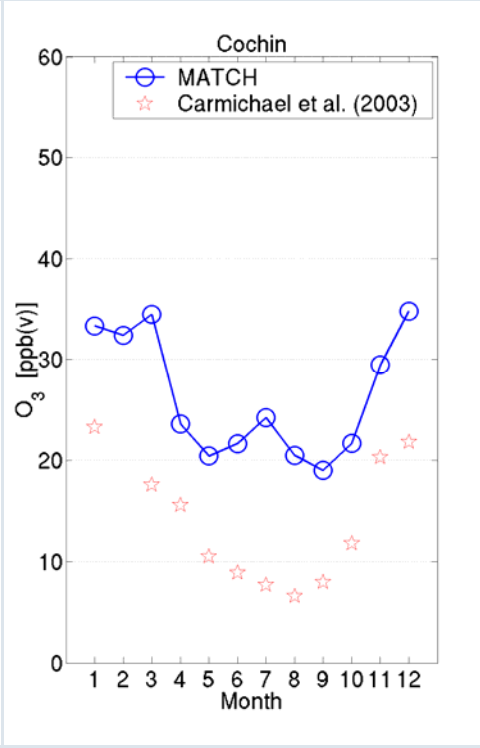


Monthly-mean O_3 at selected urban/suburban stations in South Asia

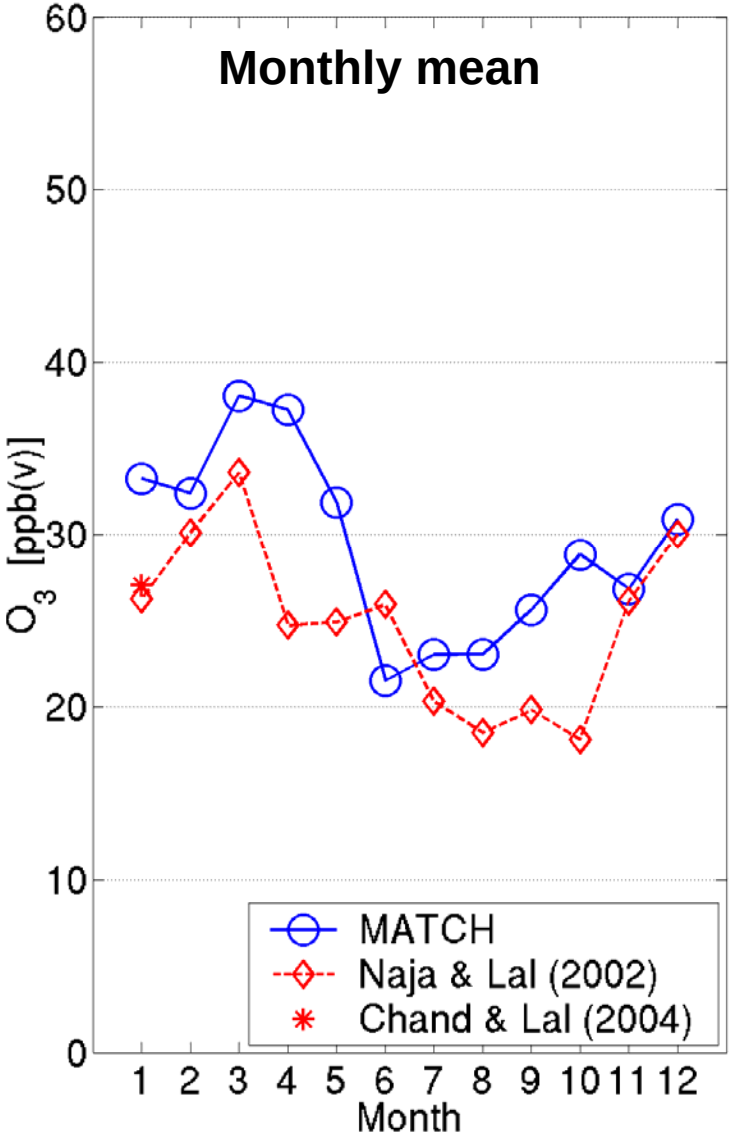




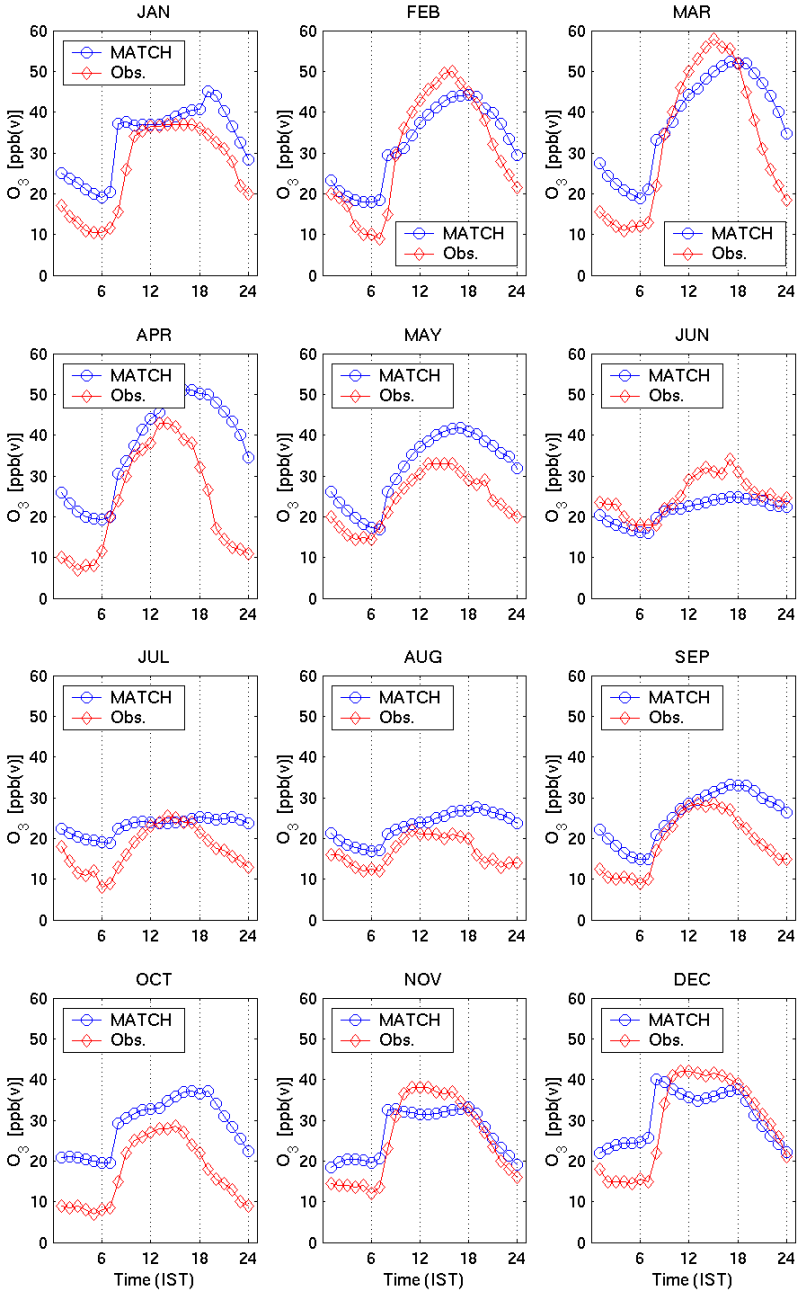




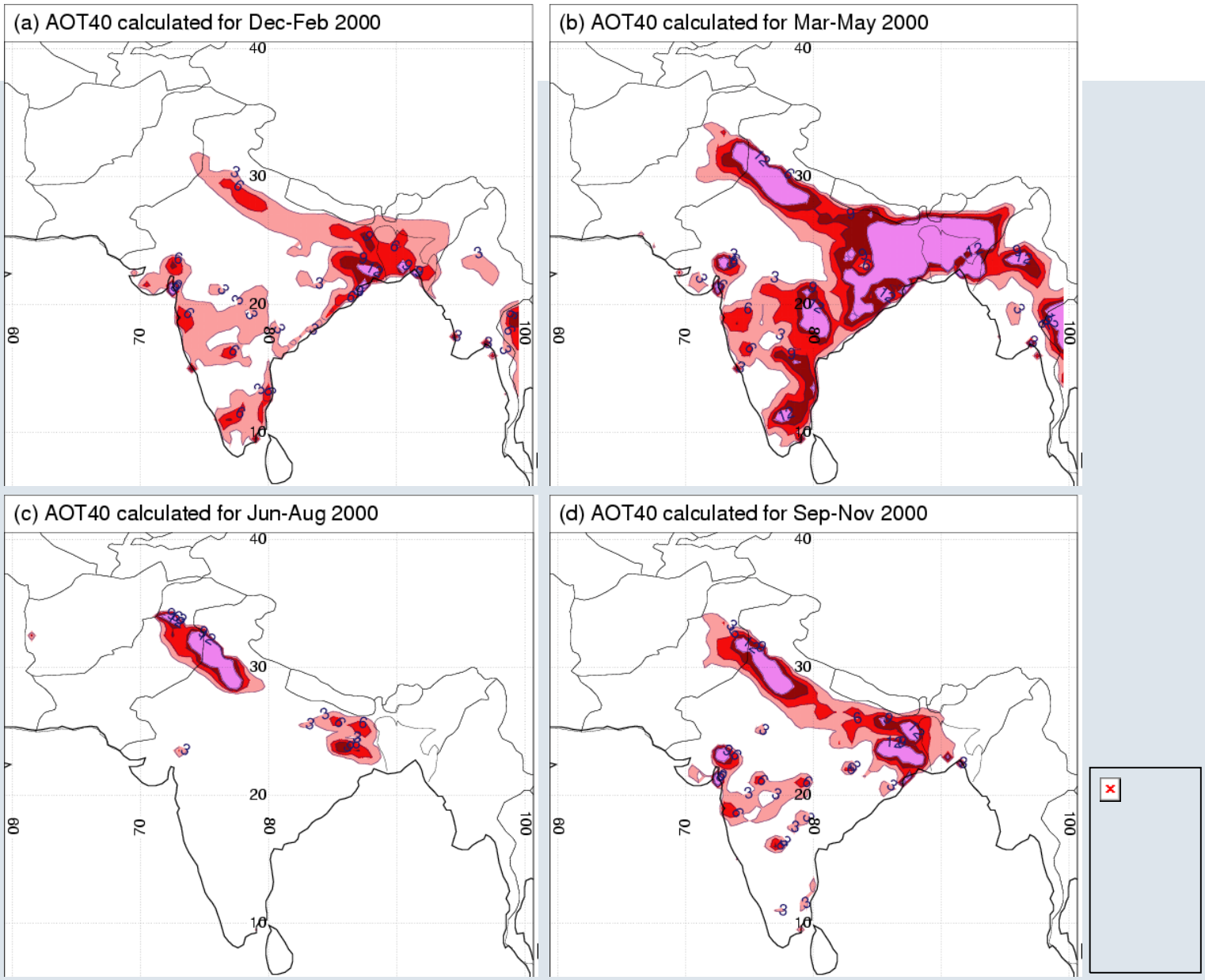
Model performance at Gadanki



Average diurnal cycle

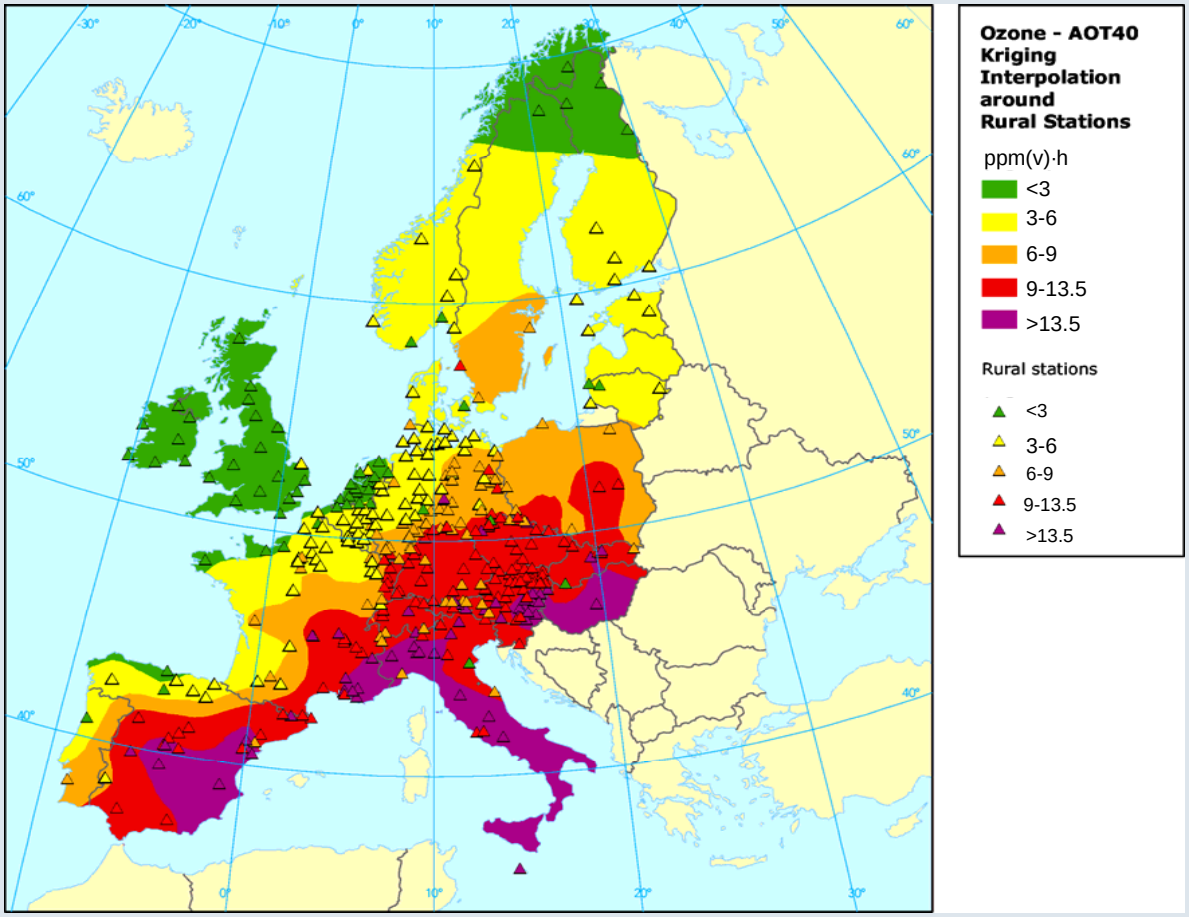


Calculated three-month AOT40 over land

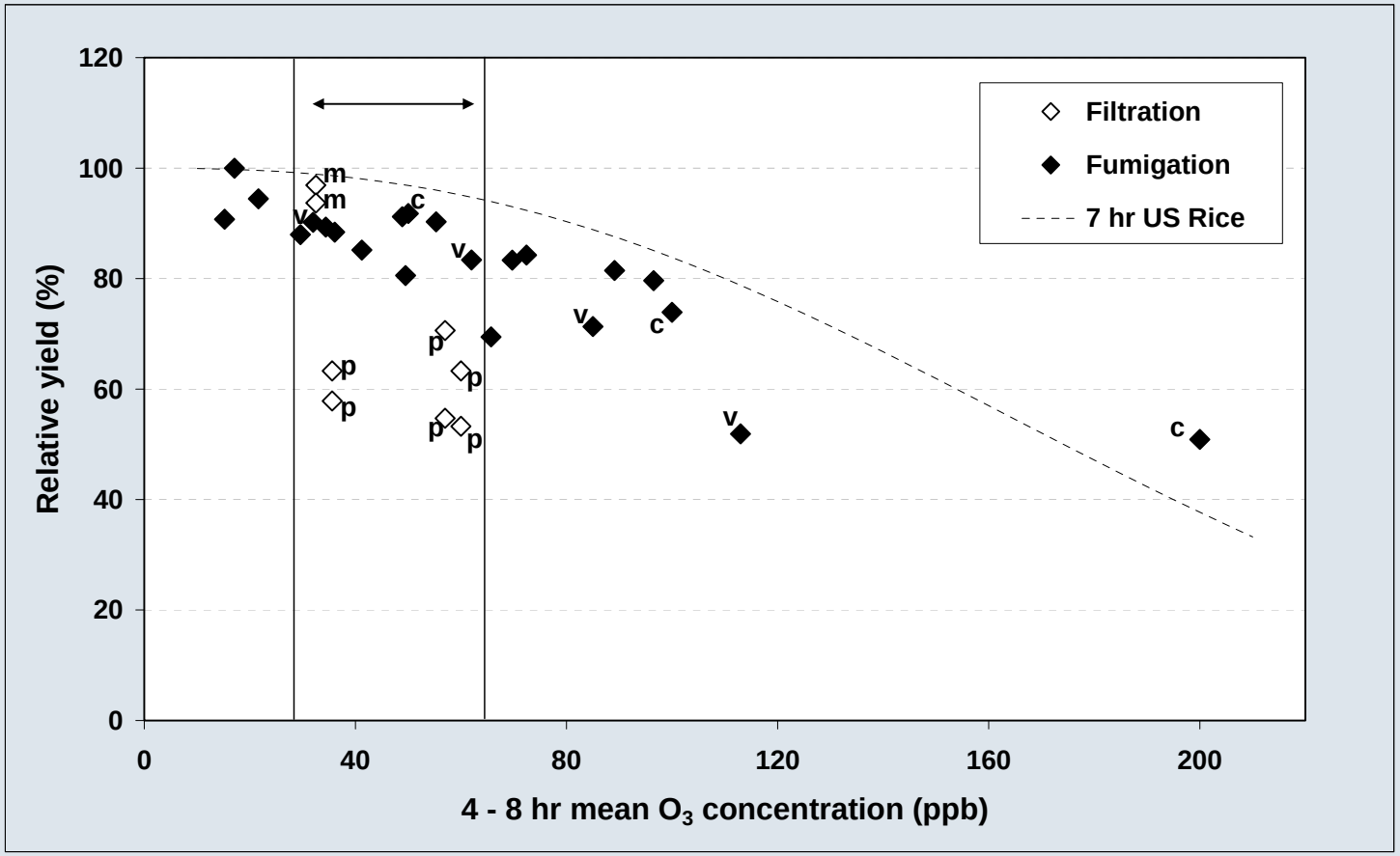


Three-month AOT40c in Europe based on measurements

Exposure above AOT40 target values for vegetation around rural ozone stations (EEA member countries), 2002



Asian rice yield loss data against 4-8 hr growing season mean O_3 exposure. US (Adams et al., 1989) dose-response relationship for rice is also shown.



v Vietnam

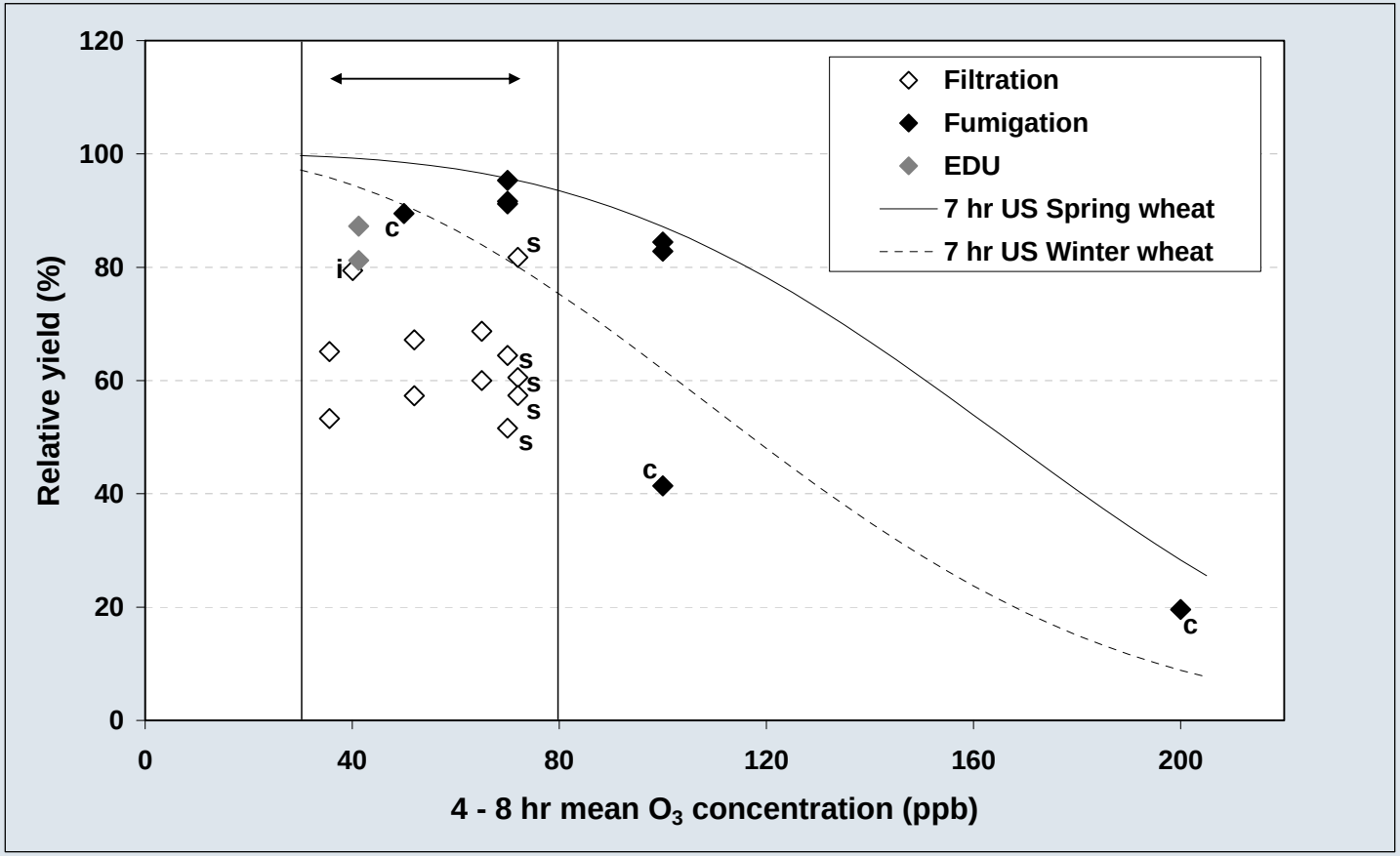
p Pakistan

c China

m Malaysia

All other studies conducted in Japan

Asian wheat yield loss data against 4-8 hr growing season mean O_3 exposure. North American dose-response relationships (winter wheat: NCLAN, Lesser et al., 1990; spring wheat: Adams et al., 1989).



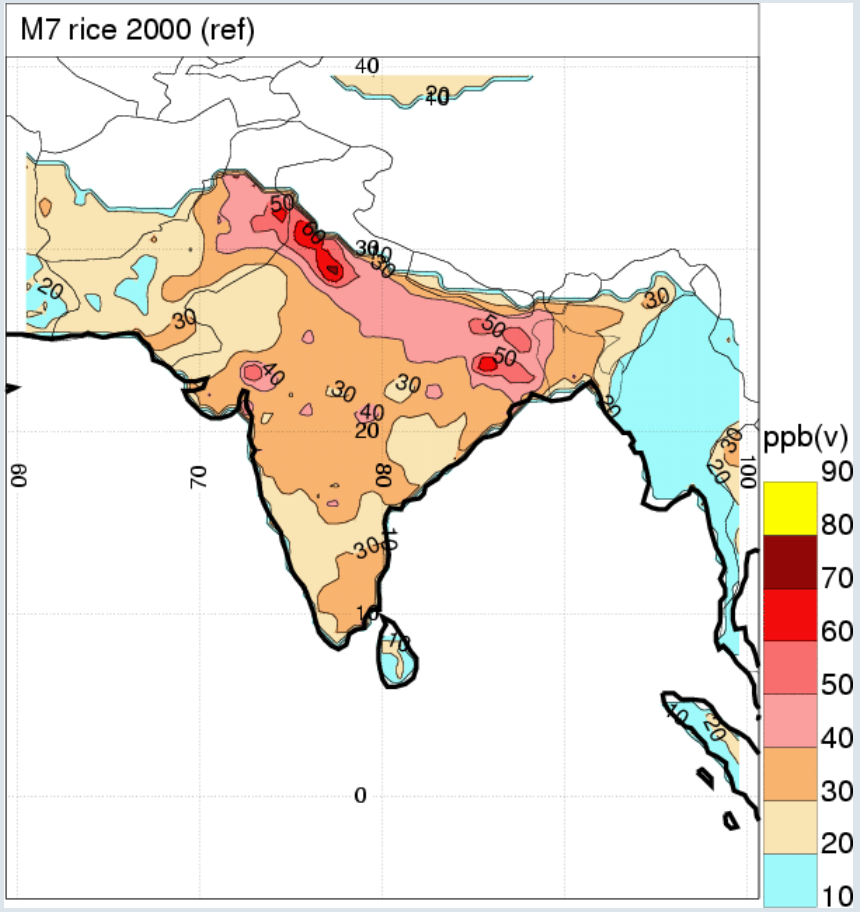
s spring wheat

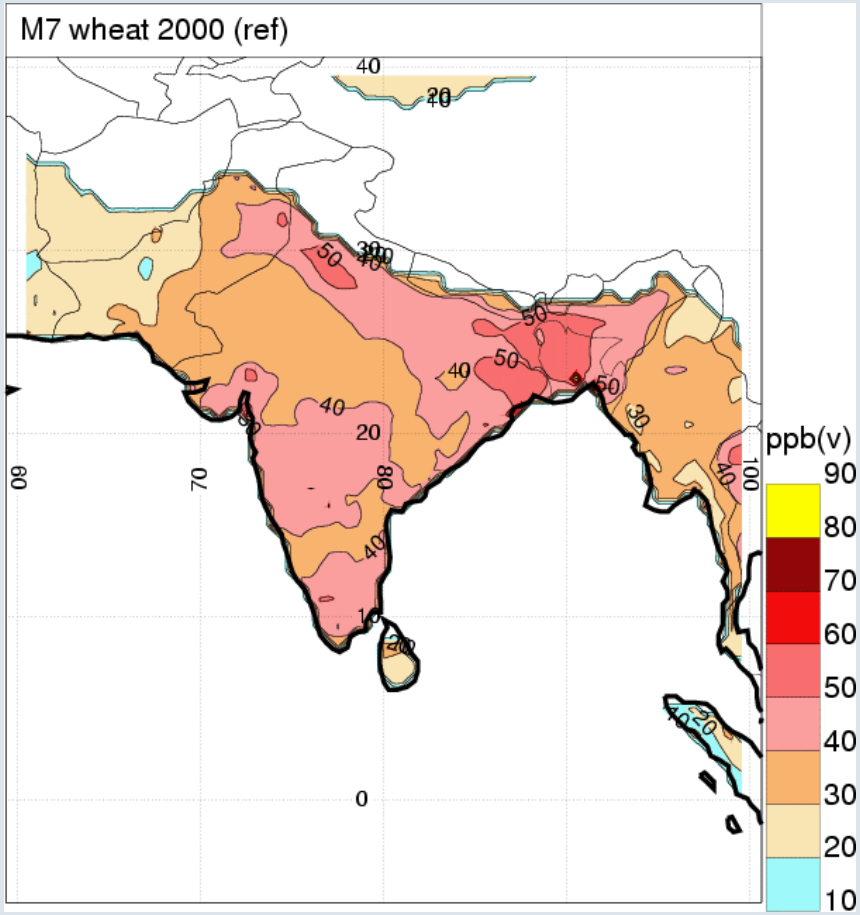
c China

i India

All other studies conducted in Pakistan

M7 calculated for the 3-month *growing season* of rice and wheat





Summary/Conclusions

Modelled *and* measured monthly-mean, near-surface, ozone concentrations show a seasonal trend in South Asia; lowest in June-August, highest in December-April

MATCH overestimates ozone measurements collected at coastal- and urban sites, reasonably good (?) at inland continental sites

MATCH can be used to map, e.g., AOT40 over large areas during different conditions

Calculated AOT40, and M7 is often higher than thresholds assumed to be harmful to vegetation in Europe

Recent studies indicate that Asian crops are more sensitive to O_3 than in Europe and N. America

References

Engardt, M. 2008. *Modelling of near-surface ozone over South Asia.* **J. Atmos. Chem.** 59, 61-80. DOI:10.1007/s10874-008-9096-z.

Emberson, L., Bueker, P., Ashmore, M.R., Mills, G., Jackson, L., Agrawal, M., Atikuzzaman, M.D., Cinderby, S., Engardt, M., Jamir, C., Kobayashi, K., Oanh, N.K., Quadir, F. and Wahid, A. 2009. *A comparison of North American and Asian exposure-response data for ozone effects on crop yields.* **Atmos. Environ.** doi:10.1016/j.atmosenv.2009.01.005