Assessment of local and regional air quality for Delhi, India within the South Asia-Cordex Domain

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Why there is a need for this study and what is the purpose ?

- One of the most populated cities in the world
- Long range transport and local air pollution are both effective
- Road vehicles contribute significantly

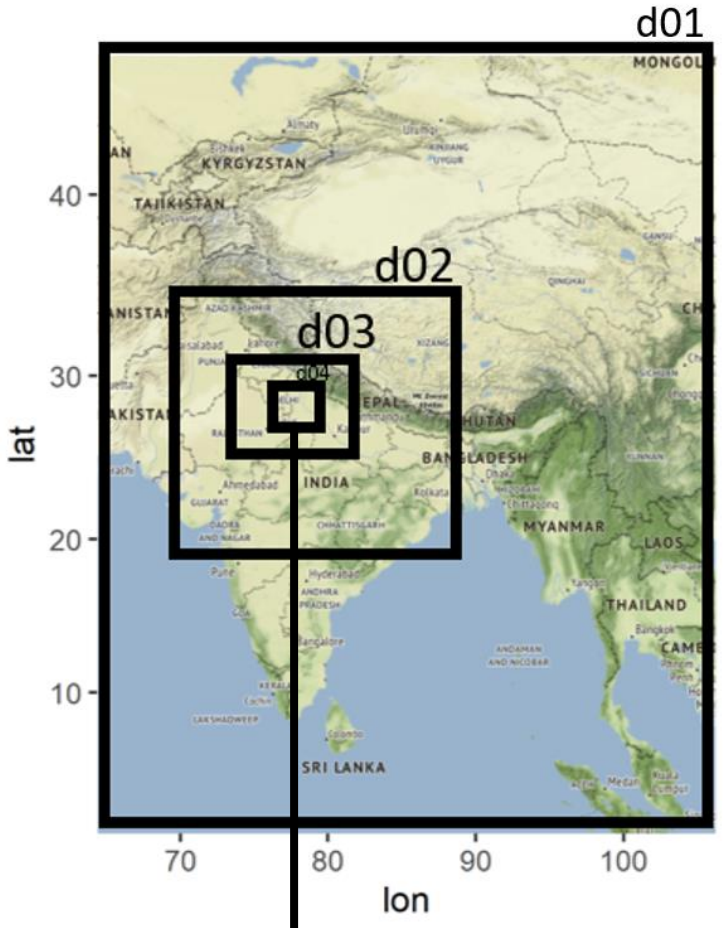
Purpose of this study :

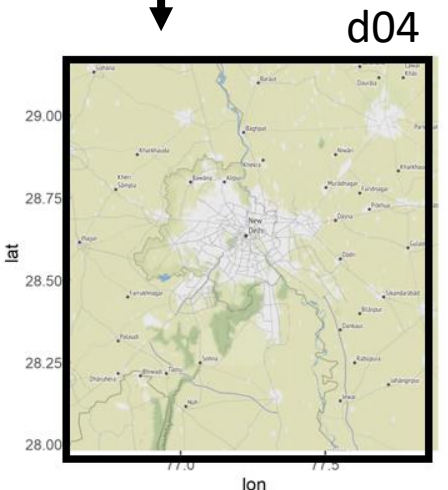
- Quantifying the contribution of road transport and other sources to AQ in Delhi
- How will meteorology and air quality change in 2050?

Photo credit :https://www.intelligenttransport.com

Modelling configuration for predicting present air quality

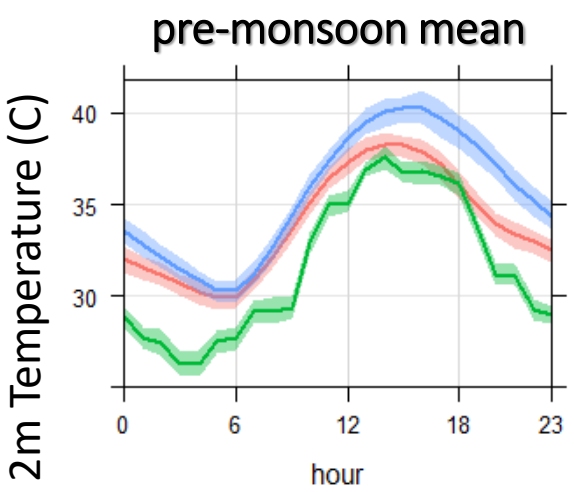
- With WRF 4.2.1 and CMAQ 5.3.2 models
- Resolutions of four nested domains :
  - Domain #1 : 45 km (South Asia Cordex)
  - Domain #2 : 15 km (India)
  - Domain #3 : 5 km (Larger Delhi Area)
  - Domain #4 : 1.6 km (Delhi)
- For year 2018
- Several options were used in WRF model optimizing stage; including LULC data sensitivities (ISRO vs MODIS), PBL schemes (YSU vs ACM2).
- EDGAR v5.0 emission inventory (for 2015)
- Cam-Chem initial and boundary condition data
- Run #1 (BL) → BASELINE runs (no change in the EDGAR emission inventory)
- Run #2 → SCENARIO (no road transport emissions in Domain #3)

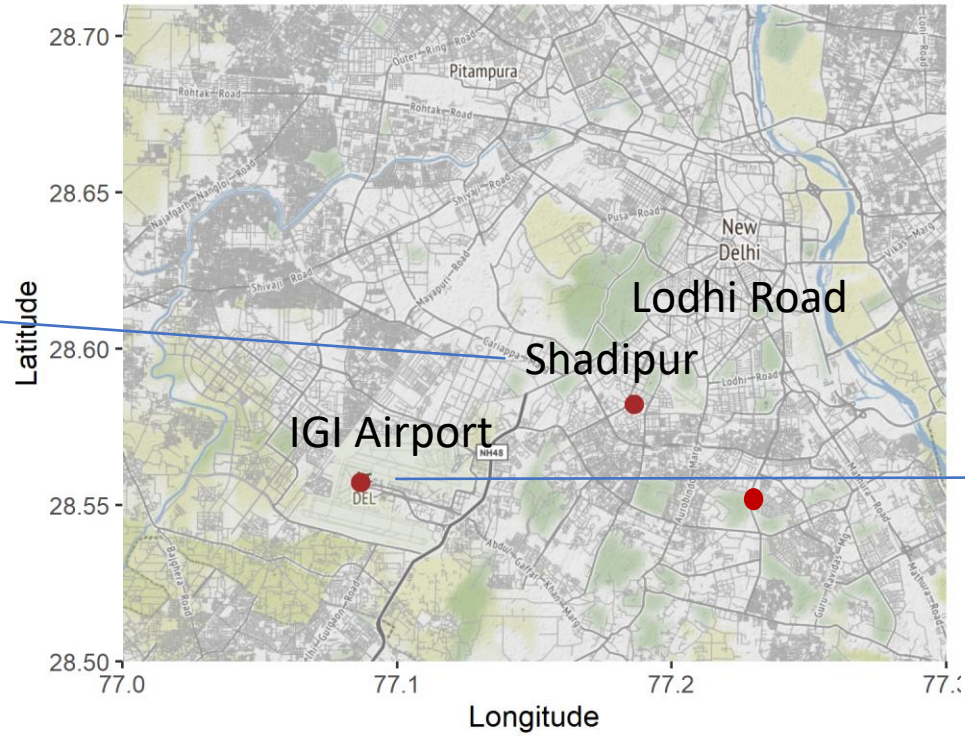




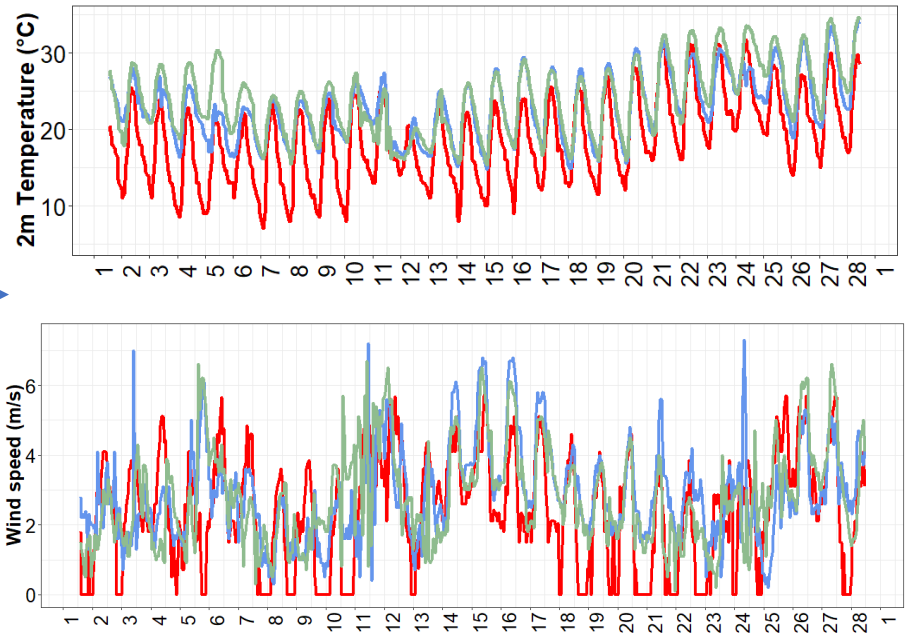
Performance of the WRF model

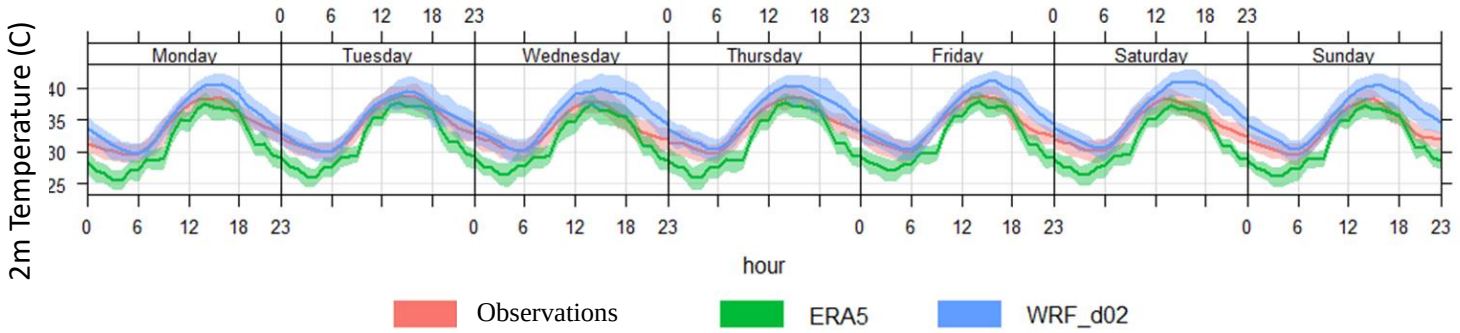
Diurnal and daily evolution of modelled and observed 2m Temperature for Shadipur station for April, May and June 2018





Hourly time series of modelled (d02) and observed for IGI Airport station for February 2018 with two different LULC data (ISRO and MODIS)





Observations — ISRO LULC - MODIS LULC

* Observations are from NOAA.

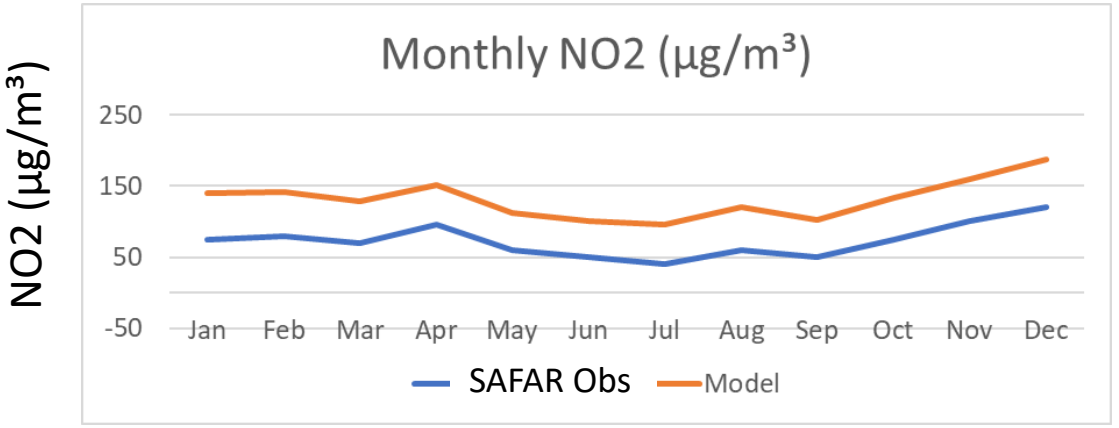
CMAQ model performance

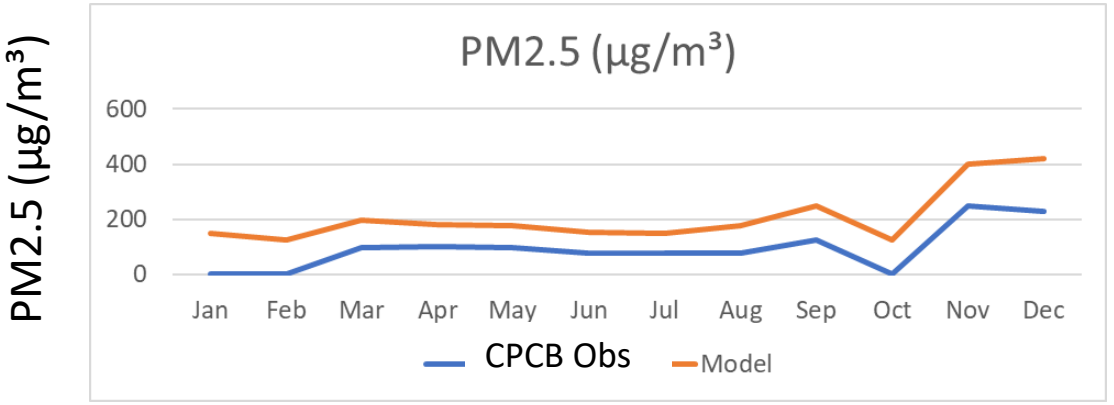
- Diurnal signal is suppressed in multi-year averaged run.
- Long term signal is still being captured.
- Observations are lacking - need for more observations.

Observations from:

1. SAFAR observations
2. CPCB (Central Pollution Control Board of India)

Comparison of monthly mean time series predicted by CMAQ model with observations for Delhi

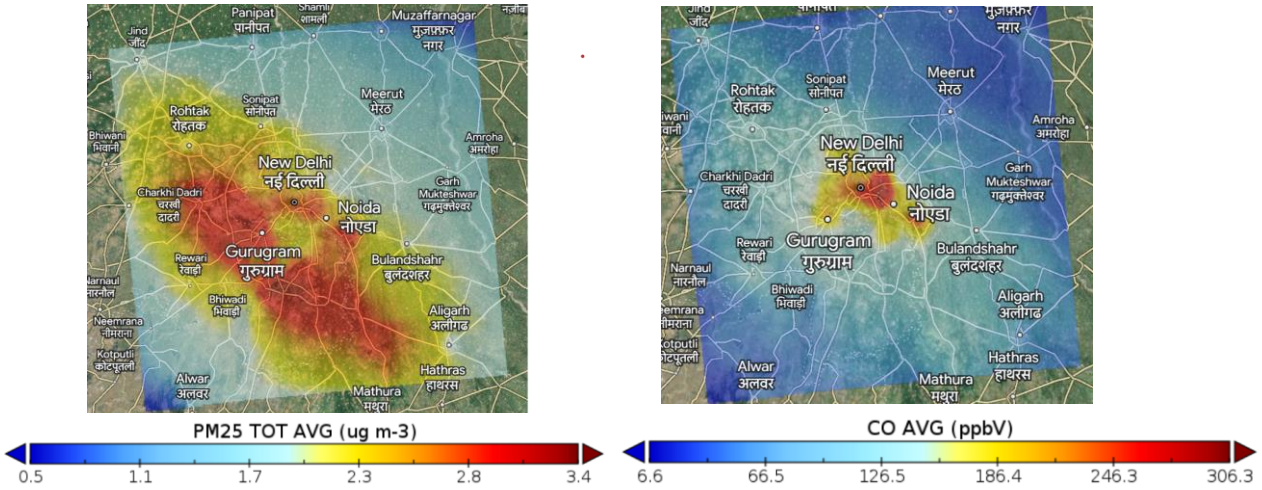




* No PM2.5 observations for January, February and October 2018.

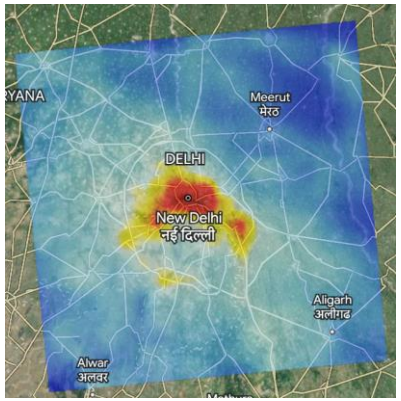
Contribution of road transport to the air quality of Delhi (annual mean of BASELINE-SCENARIO)

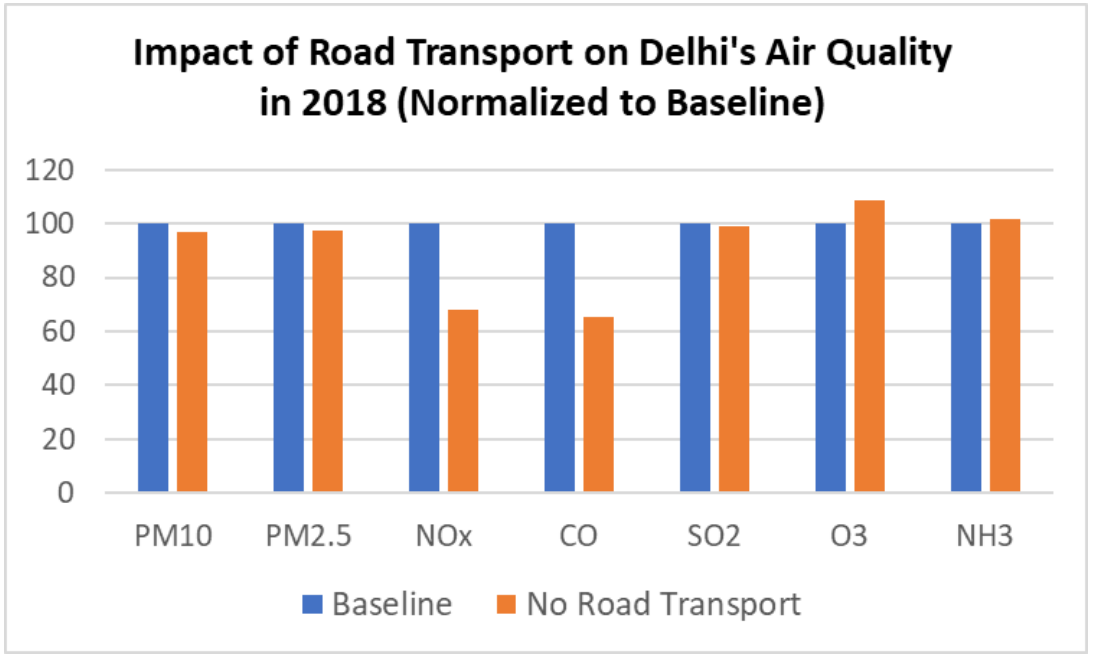
$PM_{2.5}$



CO

NOx





- Other sources eg LRT dominates
- Vehicles contributed
  - around 3-4% of the PM concentration
  - Significantly (~30-40 %) to NOx and CO
- SO2 is mostly industrial
- A nonlinear O3 increase due to NOx decrease

Modelling configuration for the future meteorology and air quality

Meteorology Model

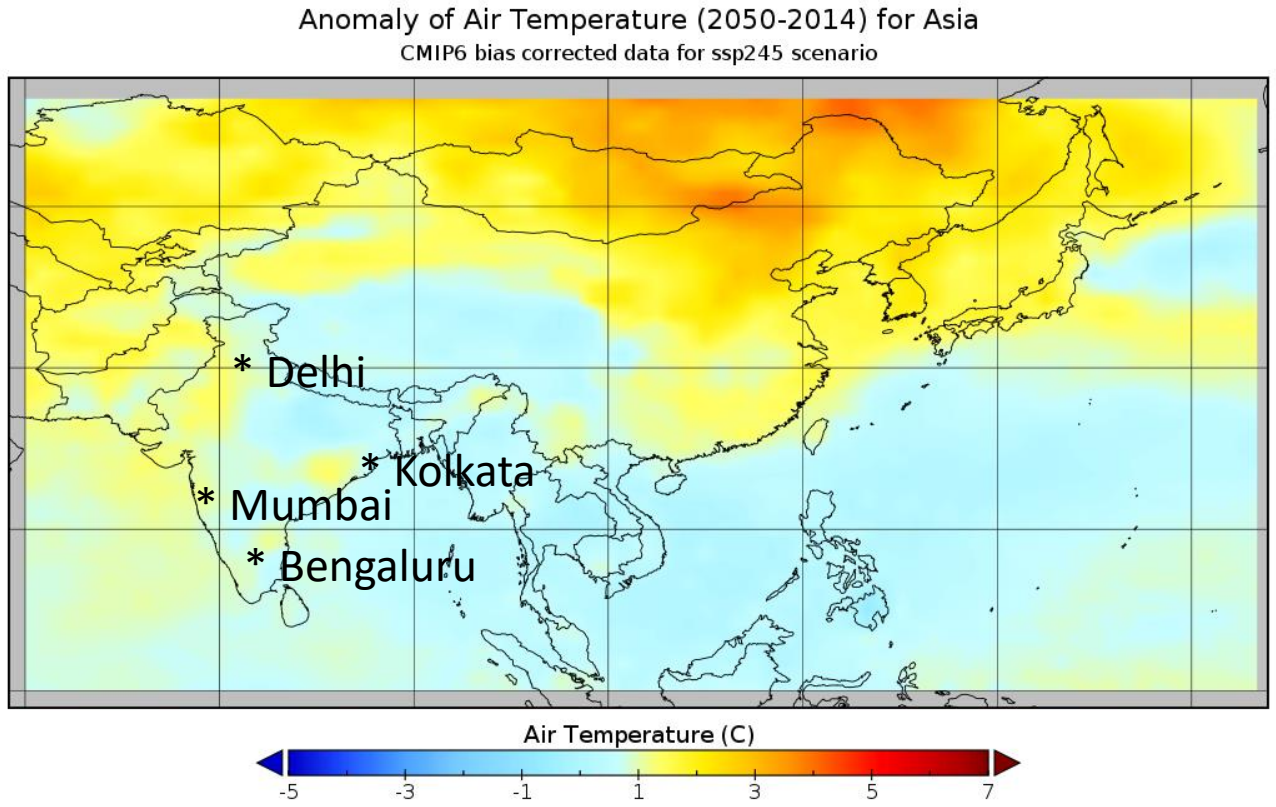
- WRF v4.2.1
- South Asia Cordex domain
- 27 km grid resolution
- 2015 (representative of 2011-2020) and 2050 (representative of 2046-2055)
- With daily initialization and grid nudging option
- The WRF model simulations were driven by bias-corrected Coupled Model Intercomparison Project Phase 6 (CMIP6) data, using a dynamical downscaling method.

Air Quality Model

- CMAQ v5.3.2
- Selected future scenario for India → SSP2.4.5 (Middle of the Road) Scenario
- Averaged meteorology approach incorporated
- Future land use land cover, initial and boundary conditions
- Future emissions data for India, spanning ten years; SMoG-India v1 2050 hypothetical emissions dataset provided by the Indian Institute of Technology, Bombay for the NERC project.
- Comparison between present (2011-2020) and future (2046-2055) air quality

Comparisons of CMIP6 and WRF predictions

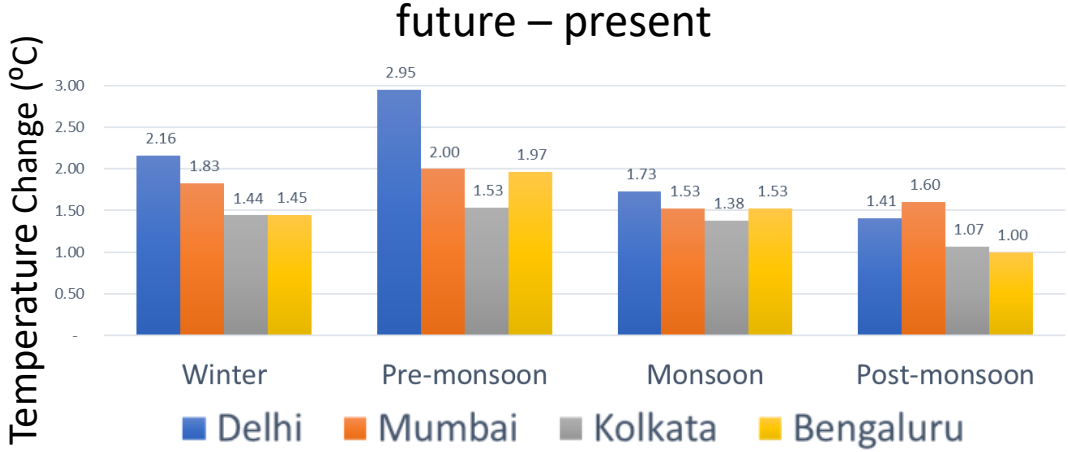
Anomaly plot from CMIP6 bias corrected model for Asia for "future – present"



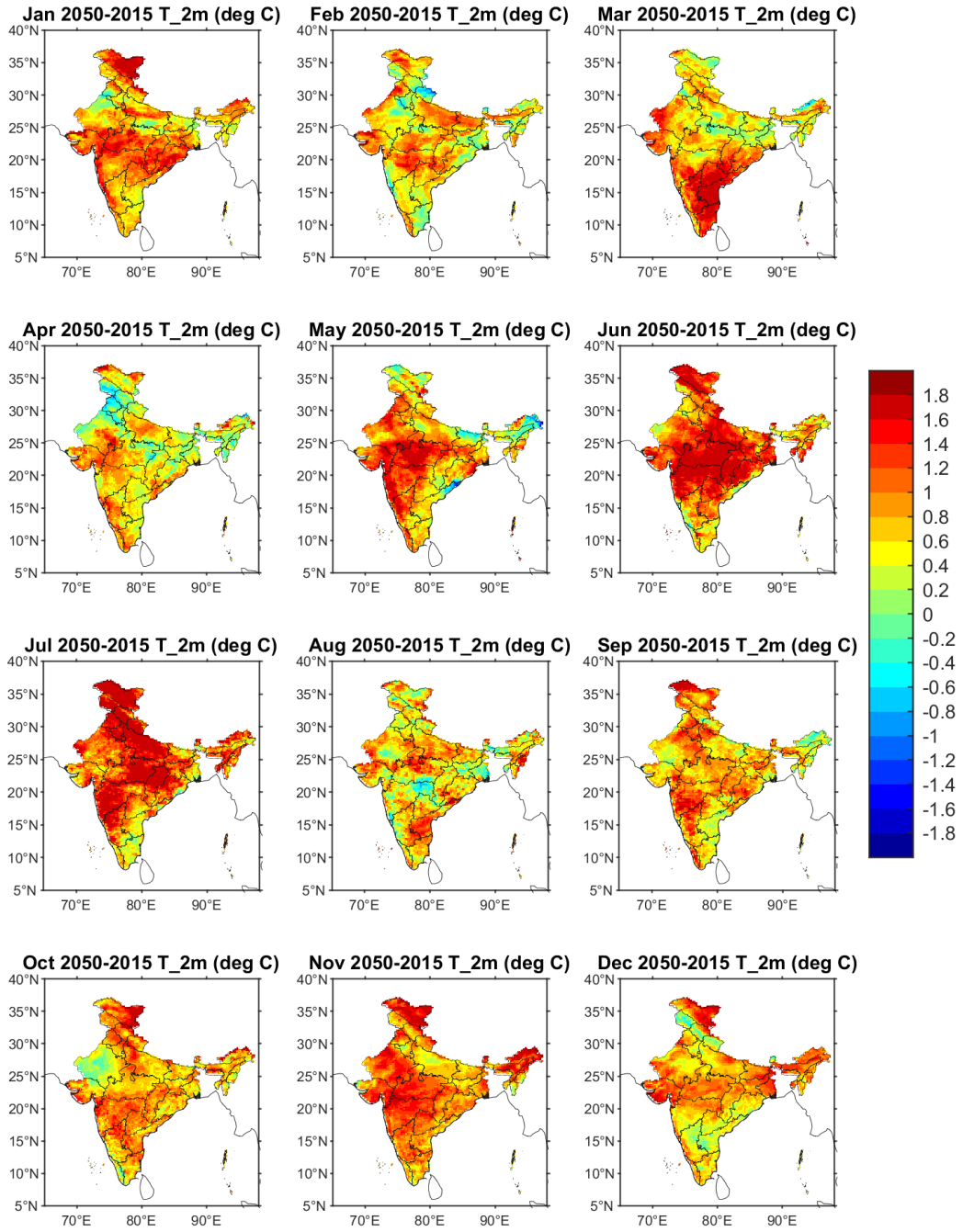
Mean Air Temperature increase in 2050 for India:

→1.0 ^{o}C with ssp245 (middle-of-the-road) scenario

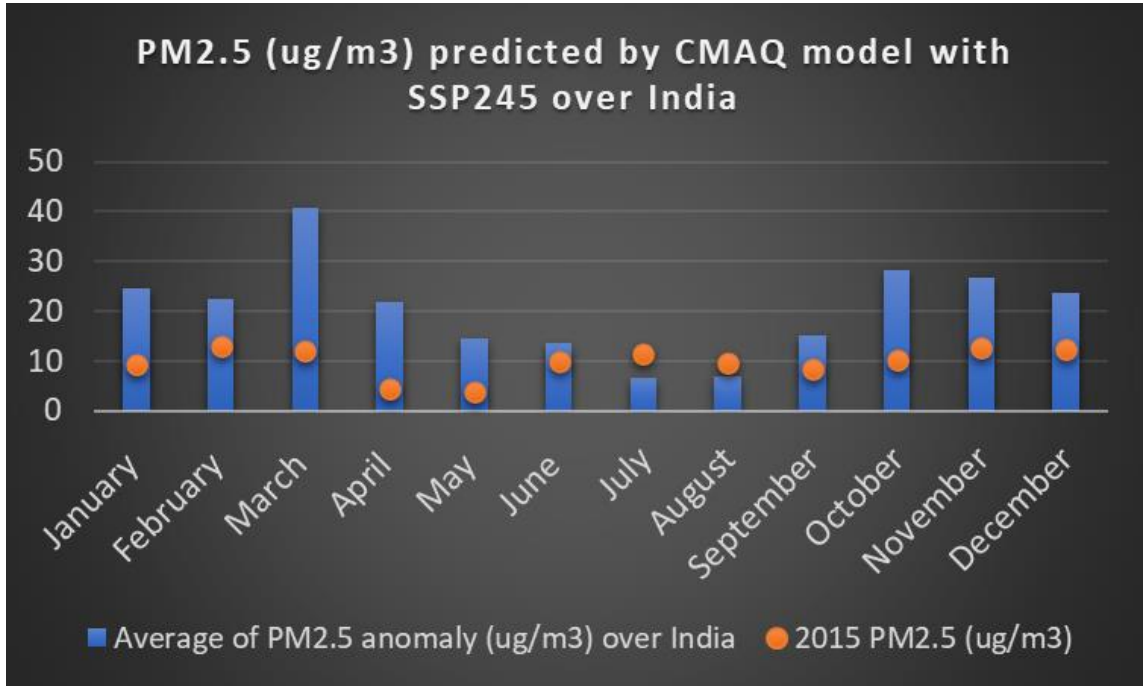
WRF predictions for the selected four regions in India for "future – present" with bias corrected CMIP6 Asia data



- Delhi anomaly is highest for the winter and pre-monsoon
- On average 1.7 ^{o}C annual temperature increase in 2050 in those 4 regions.
- Even with the middle-of-the-road scenario, cities such as Delhi will have higher projected temperatures in India



Histogram of monthly means of T2 and PM2.5 anomalies (2050-2015) over India predicted by WRF-CMAQ model with SSP245 scenario



Conclusions

- The use of ten-year averages around the desired year provided insights into monthly changes in climate and air quality parameters.
- LRT is the main source for PM where road transport is significant for CO, NO_x for Delhi.
- Future projections show T2 anomaly of around 2C by 2050 and significant increases in PM2.5 possibly due to LRT and dust for Indian urban cities, especially for Delhi.
- This study is being extended through the Horizon Europe project, FOCI for Asia and other regions including Europe, Africa and Latin America

Thanks for listening

Questions ?

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