Atmospheric Modelling and Prediction

Satellite-derived emission trends: uncertainties and implications for atmospheric modelling

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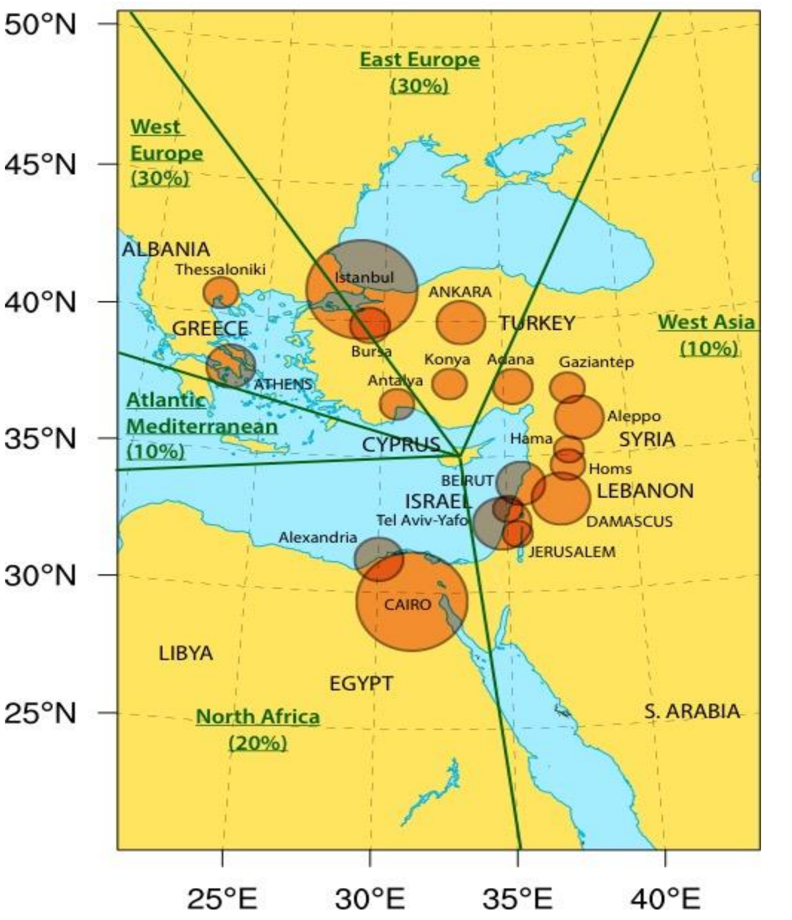
MOTIVATION

- Frequency of update of emission inventories 5-10 years
- Reporting data – proxies, older emission inventories
- Abrupt changes: unexpected socio-economic & geo-political factors



- Non-reporting countries, new facilities
- Understated magnitude of emissions
- Mass population moves: new emission sources, changes in land use

OBJECTIVE

- Utilize satellite information to timely update emission inventories more frequently than official global emission inventories compilation.

- Capture abrupt changes caused by unexpected factors or changes that do not comply with Representative Concentration Pathways.

- Identify missing sources in reported data or sources with higher magnitude of emissions than currently accounted for.

METHODOLOGY

CONCEPT: Satellite NO_2 Vertical Column Density (VCD) can be used to derive trends in emissions:

- Models are used to find a linear expression of the non-linear nature of relationship between emissions of NO_x and concentrations of NO_2 in the atmosphere

- β represents the ratio between the difference in NO_x emissions (ΔE/E) and the resulting change in modelled NO_2 VCD (ΔΩ/Ω)

$$\beta = \frac{\Delta\Omega/\Omega}{\Delta E/E} \qquad \text{Eq. 1}$$

INVERSE REPRESENTATION KEEPING

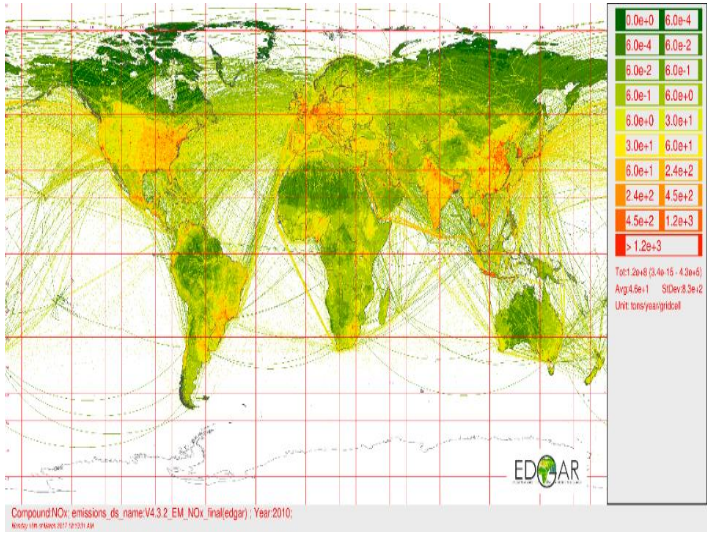
THE CONSTANT PART IN THE

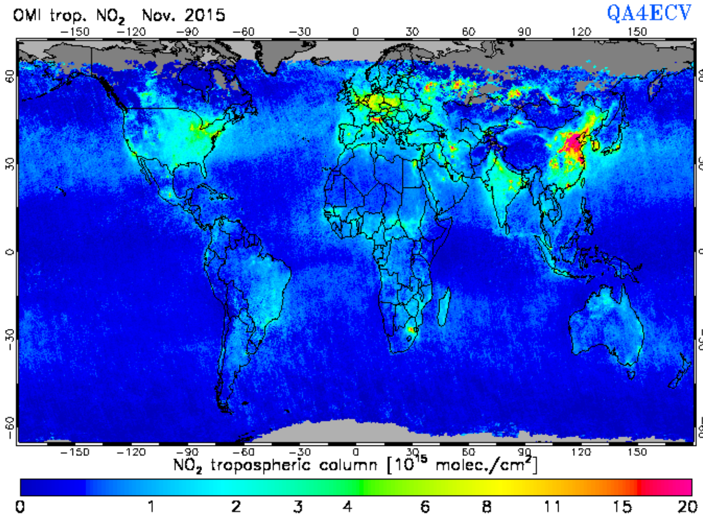
DENOMINATOR PLACE (ΔE/E)

β >(<) 1 near (downwind of) sources

$$Ey = Ex\left(1 + \frac{\Omega y - \Omega x}{\Omega x * \beta}\right) \qquad \text{Eq. 2}$$

TOOLS





- Weather Research and Forecasting model coupled with Chemistry with initial and boundary chemical conditions from MOZART-4/GEOS-5, online Emissions of Gases and Aerosols From Nature (MEGAN) and mineral dust and sea salt emissions, meteorological conditions from NCEP Global Forecast System (GFS) reanalysis data ($0.5^o x 0.5^o$ grid spacing)

- Anthropogenic emissions from EDGAR-HTAPv2 for CO, Nox, NMVOC, NH3, SO2, BC/OC and PMs with monthly speciation only until 2010 and based on reporting data or pre-existing inventories

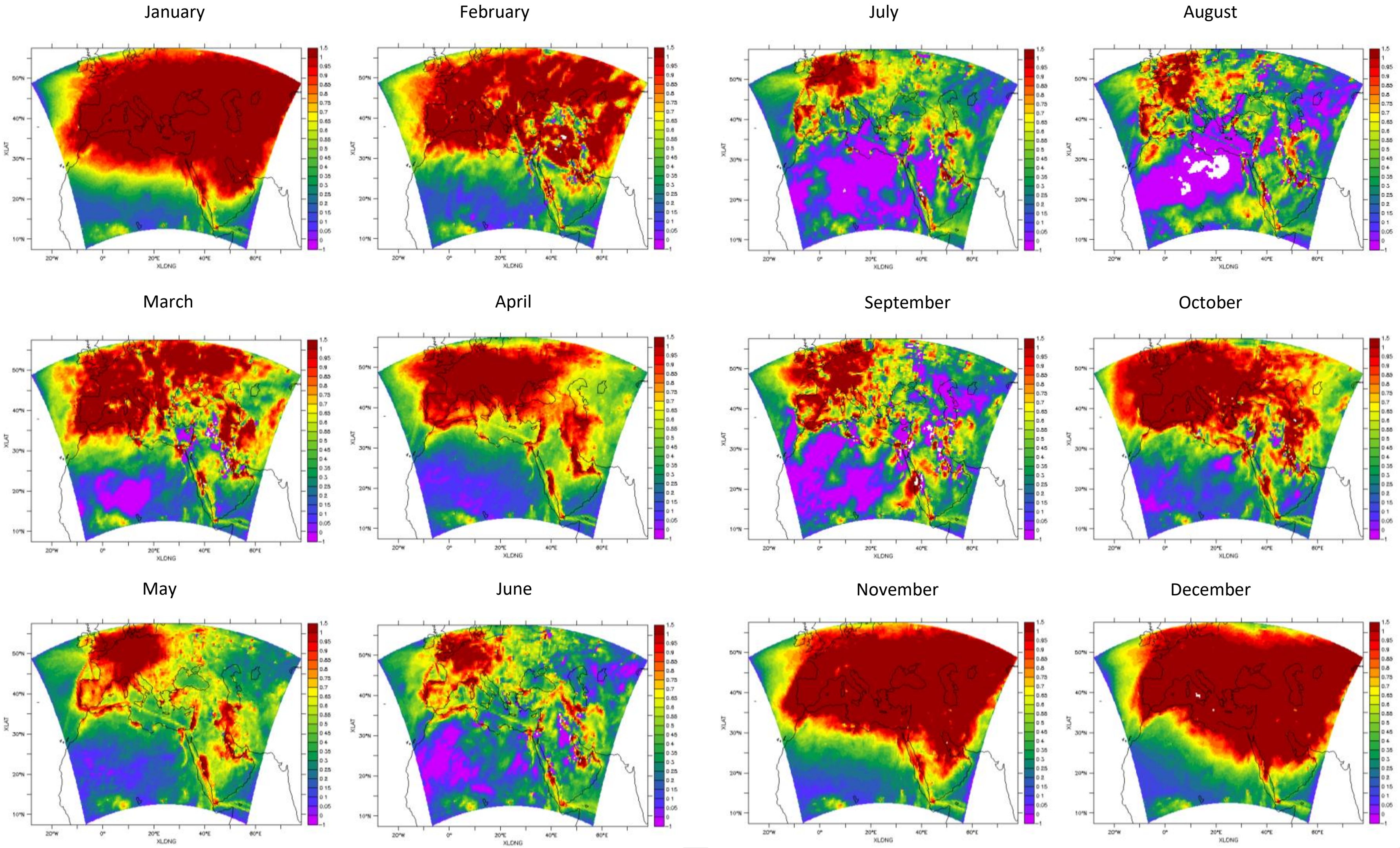
- QA4ECV Project: Quality Assurance for Essential Climate Variables for Tropospheric, stratospheric and total NO2 column densities from 1996-2015 and OMI, GOME-2(A), SCIAMACHY and GOME (community algorithm)

RESULTS – REGIONAL SCALE

Summer-time spatial variation is more pronounced – more clear depicting of chemistry paths and VOC availability.

Summer-time uncertainties of the beta factor are lower owing to the fast reaction rates due to enhanced photochemistry (increased sun intensity) that lead to a reduced lifetime of NO2 in the atmosphere, smoothing out the impact of the emission reductions on beta.

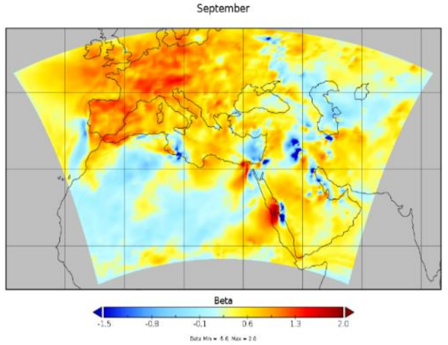
$$\frac{\Delta E}{E} = 30\% \text{ and } 15\%$$

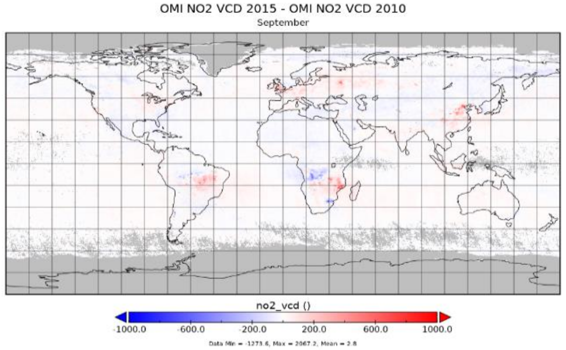


Pronounced differences:

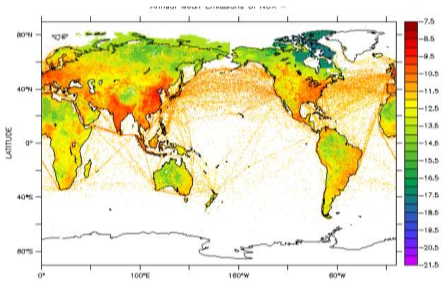
- Areas where population movements occurred (North Africa, Lebanon etc)
- In regions with high industrial activities (Israel, Gulf region).
- Over Benelux countries, Germany, northern part of Italy and several locations in Eastern Europe (Poland) that might be associated with increases in primary emissions due to transport, coal power plants and other industrial facilities.
- In the EMME region two major urban conglomerates (Athens and Istanbul) exhibit noticeable differences.

EMISSIONS/VCD
Relationship Per month

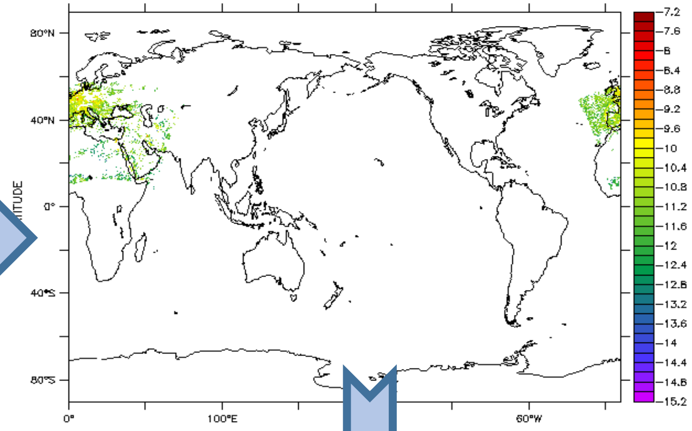




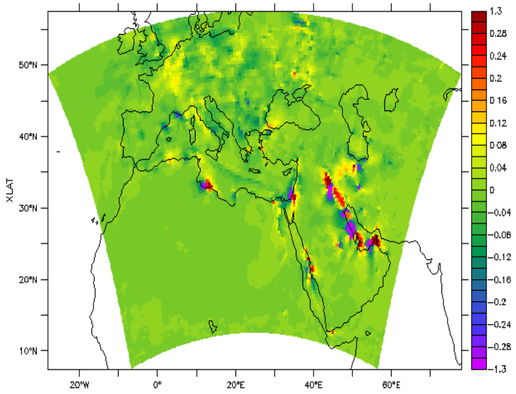
EMISSIONS per month

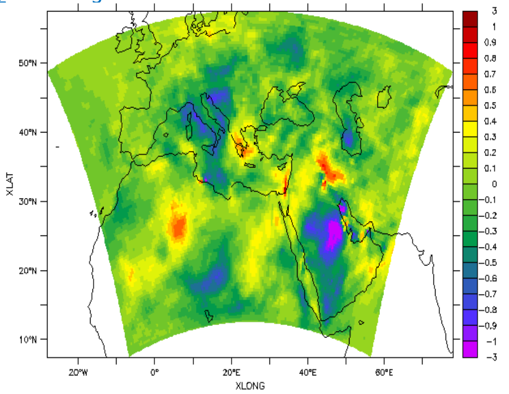


UPDATED MONTHLY EMISSIONS



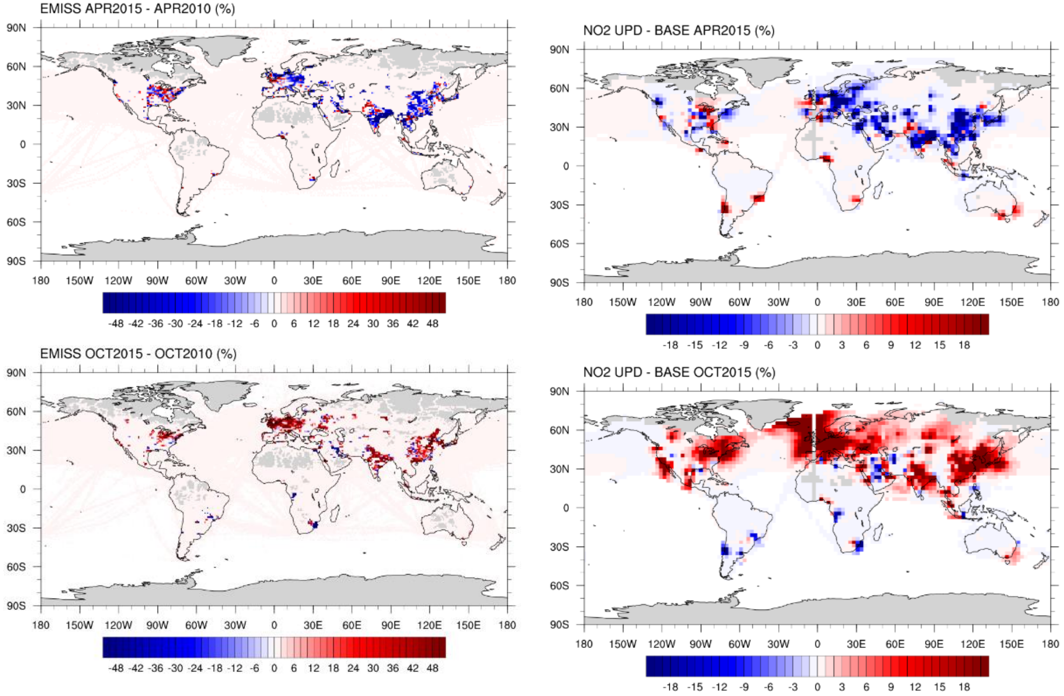
DIFFERENCE IN NO_2 and O_3



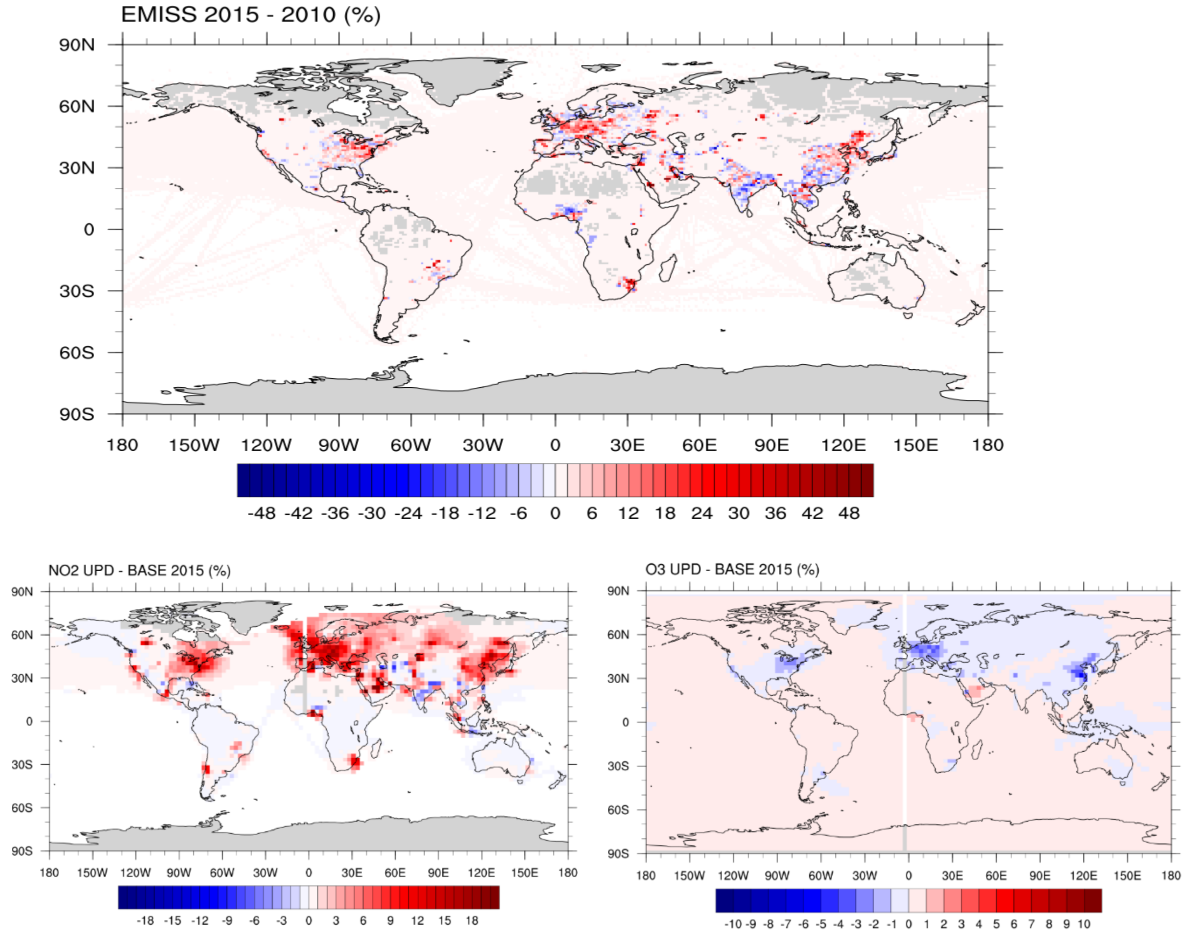


RESULTS – GLOBAL SCALE

Monthly change (%) in emissions - concentrations



Annual change (%) in emissions – concentrations of NO_2/O_3



- NO_2 trends (from 2010 to 2015) are positive for Europe and North Africa (enhancement of emissions in 2015 compared to 2010), while India has lower emissions fluxes in 2015.
- Over Asia there are two distinct zones with opposite emission trend signs (North-East and South-West areas) with the south-west region following the negative trend pattern of the Indian region.

Thank you!