

Towards high resolution monitoring of atmospheric pollutants: Implications for the Eastern Mediterranean and the Middle East (EMME)

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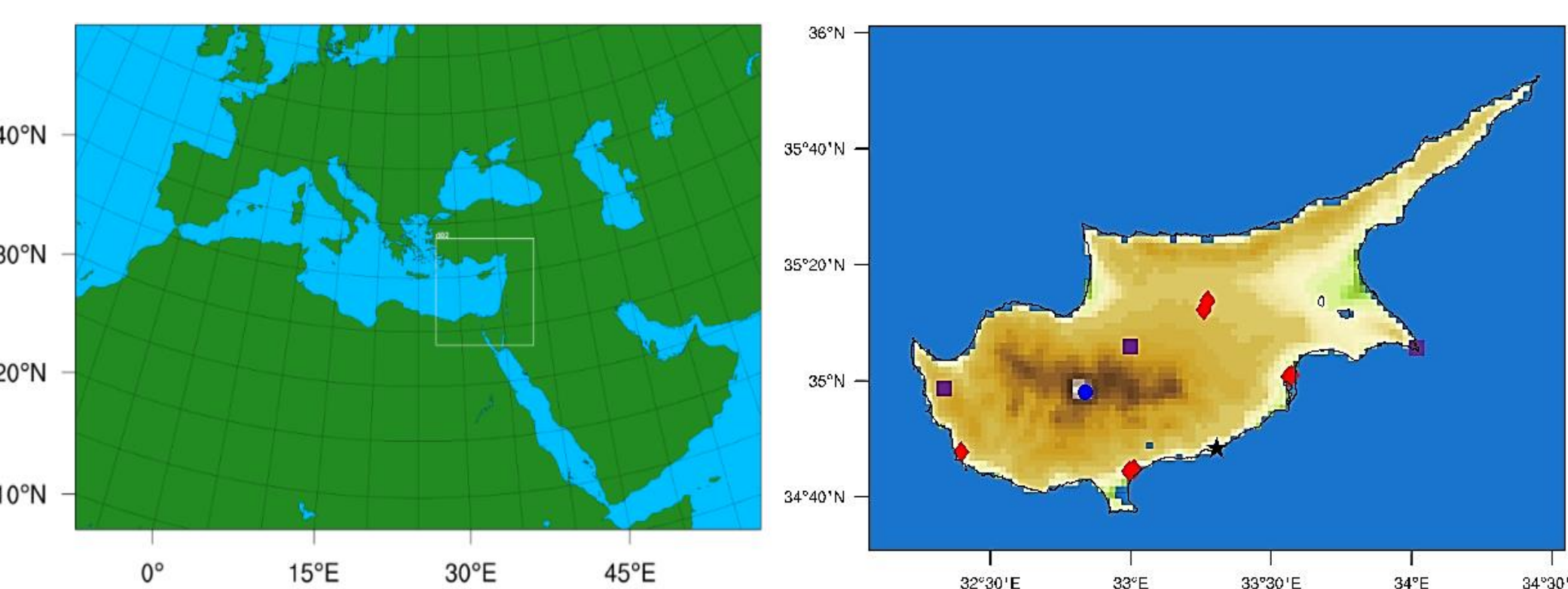
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MOTIVATION

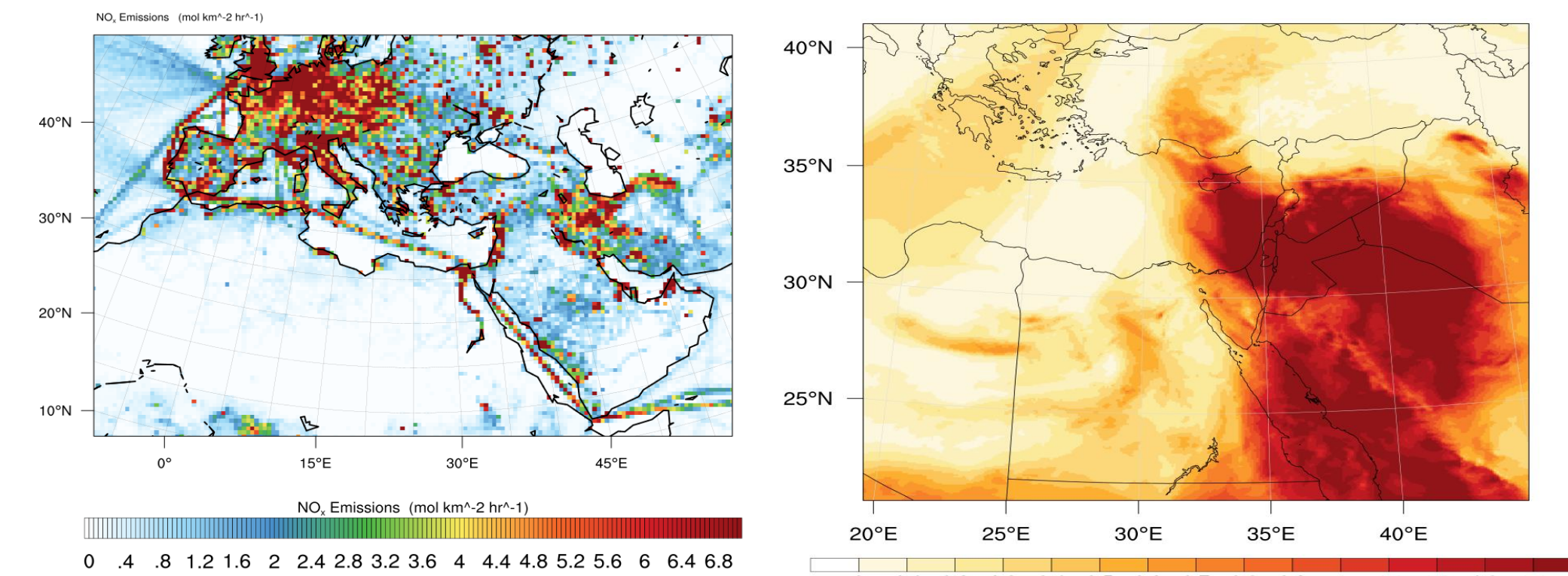
Satellite data can contribute to accurate assessment of atmospheric composition, with the use of modelling systems, by improving representation of emissions and IC/BC conditions.
Emission trends: Low frequency of update of emission inventories - Reporting data, proxies, older emission data - Abrupt changes: unexpected socio-economic and geo-political factors
Missing sources: Non-reporting countries, new facilities - Understated magnitude of emissions - Mass population moves: new emission sources, changes in land

Model and Data Description

Model Domain: Two nested domains with horizontal resolution of 50km and 10km.



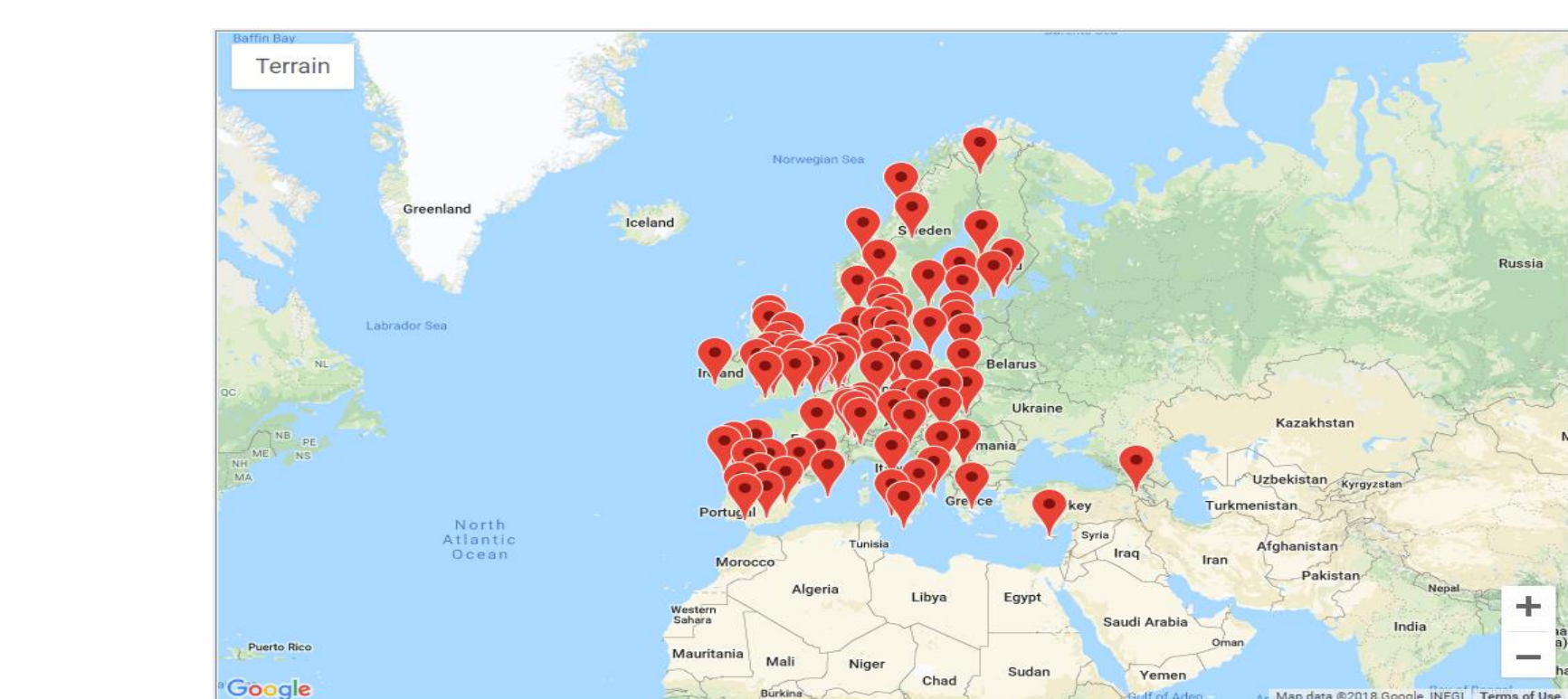
Emissions: On-line biogenic emissions (MEGAN2.1). GOCART model using AFWA for desert dust emissions. EDGAR-HTAP (Emission Database for Global Atmospheric Research for Hemispheric Transport of Air Pollution) V2 for anthropogenic emissions (Reference year 2010).



Model Configuration: Physical and chemical schemes:

Atmospheric Process	Scheme
Cloud microphysics	Morrison double moment
Cumulus parameterization	Grell 3D
Land-surface physics	Noah Land Surface Model
Longwave radiation	RRTM scheme
Shortwave radiation	RRTM scheme
Photolysis	Fast-J Photolysis
Planetary boundary layer	Yonsei University PBL

Observations: Scarce monitoring from ground based observations in the region. Initial tests included comparison of model results against hourly observations from eight ground stations operated by the Cyprus Department of Meteorology.



There is an ever-growing need for regional collaboration and coordination on both surface monitoring and network establishment and use of satellite data for update and/or validation of emission inventories (reported or developed).

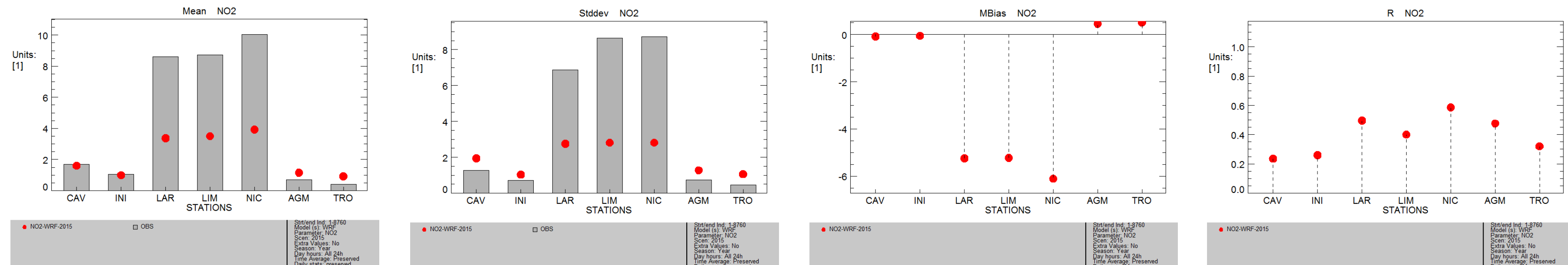
Acknowledgements

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Disclaimer:

The view expressed herein can in no way be taken to reflect the official opinion of the European Space Agency.

Model Evaluation

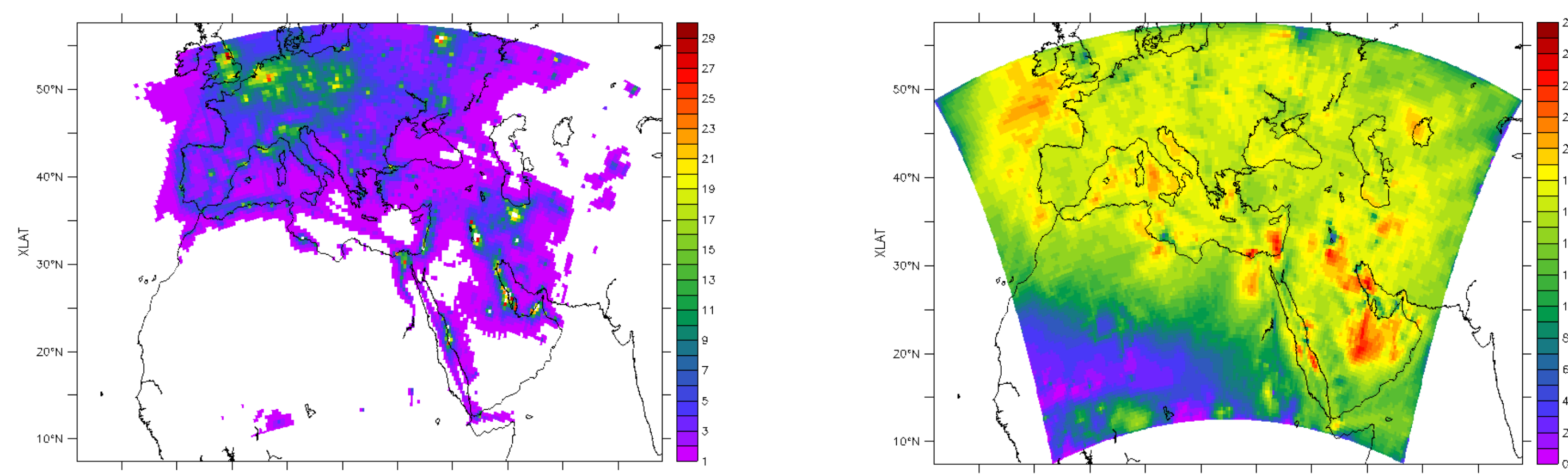


Modeled and observed NO2 concentrations: Statistical metrics over background and rural stations in Cyprus (Kushta et al., 2018)

- ❖ EMME is receptor of pollution from long range transport (LRT) from three continents (Europe, Africa and Asia) therefore its pollution landscape is a mixture of local and remote activities.
- ❖ The model represents well the pollution levels in background stations (transport and background) but underestimates rural concentrations that is an indicator of understated emission fluxes.
- ❖ It is anticipated that the use of an up-to-date (simulation used 2010 reference year emission data) high resolution and temporally resolved (diurnal to seasonal) emission inventory encompassing ground-based and satellite information and an accompanying model configuration with similar grid spacing can help capture the magnitude of emission fluxes and ozone levels in urban areas.

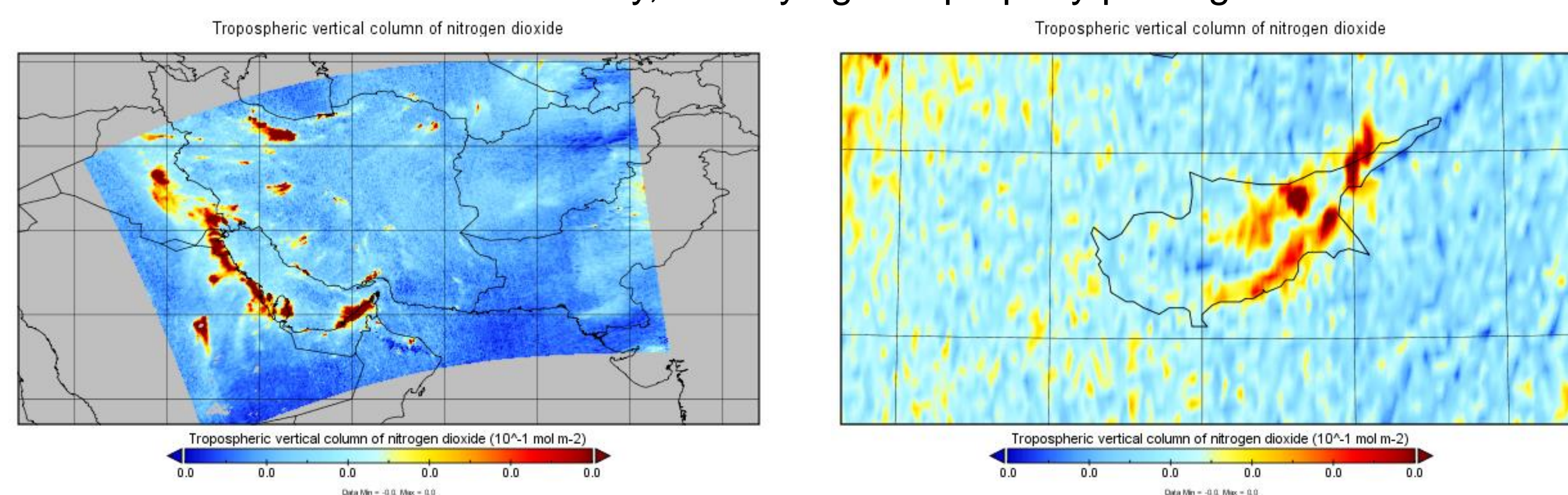
Timely update of emissions with the use of satellite data

- ❖ Satellite observations of tropospheric NOx columns can act as indicators of changes in NOx emissions
- ❖ Quantify the response of tropospheric NO₂ columns to changes in NOx emissions with the use of a chemical transport model, by applying fixed reduction to NOx emissions and determining the ratio (Lamsal et al., 2011):
$$\Delta E/E = \beta * \Delta \Omega / \Omega$$
Where $\Delta \Omega$ is the change in simulated tropospheric NO₂ columns driven by the change in emissions ΔE .



NO2 near ground concentrations from the control run and difference (percentage) due to the reduction of emissions by 15% in the perturbed run

- ❖ Monthly β values are used to translate changes in satellite tropospheric NO₂ columns to changes in monthly NOx emissions. Aggregating to yearly values, the annual changes in NOx emissions will be combined with NOx emission inventories and produce updated emission values.
- ❖ β tends to be > 1 in remote regions where an increase in NOx emissions decreases NOx lifetime (feedback on O₃ and OH). In polluted regions β tends to less than one since an increase in NOx emissions consumes OH.
- ❖ A simulation at higher resolution might better resolve nonlinear NOx chemistry and heterogeneous emission sources with more pronounced spatial variation of β .
- ❖ Currently only long term satellite data can be used (i.e. OMI). In the future TROPOMI will enhance any related activity due to the better resolution and sensitivity, identifying and properly placing emission sources in EMME.



Sentinel 5 Precursor NO2 VCD over Arabian Gulf (left) and Cyprus (right)

Data downloaded from <https://s5phub.copernicus.eu/dhus/#/home> and visualized with the PANOPLY tool www.giss.nasa.gov/tools/panoply

Conclusions

- ❖ Satellite data can prove very efficient at monitoring composition and timely update emission inventories.
- ❖ EMME region needs comprehensive utilization of satellite EO information for both current situation and future changes that, as seen until now, differ greatly from current formal emission scenarios of (RCPs).
- ❖ Space monitoring represent unique added value for pollutants derived from natural/anthropogenic phenomena of episodic nature like dust storms, fires and volcano, AND episodic changes caused by human intervention, including armed conflicts or economic recession periods.

References

- ❖ Kushta et al., 2018: Performance evaluation of the WRF-Chem model with the FAIRMODE benchmarking methodology, Air Quality, Atmosphere and Health, 1-14, DOI 10.1007/s11869-018-0631-z
- ❖ Lamsal et al., 2011: Application of satellite observations for timely updates to global anthropogenic NOx emission inventories. Geophysical Research Letters 28, L05810.--

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