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Climate and Atmosphere Research Center

Real-Time Air Quality Forecast over the Eastern Mediterranean with WRF/Chem

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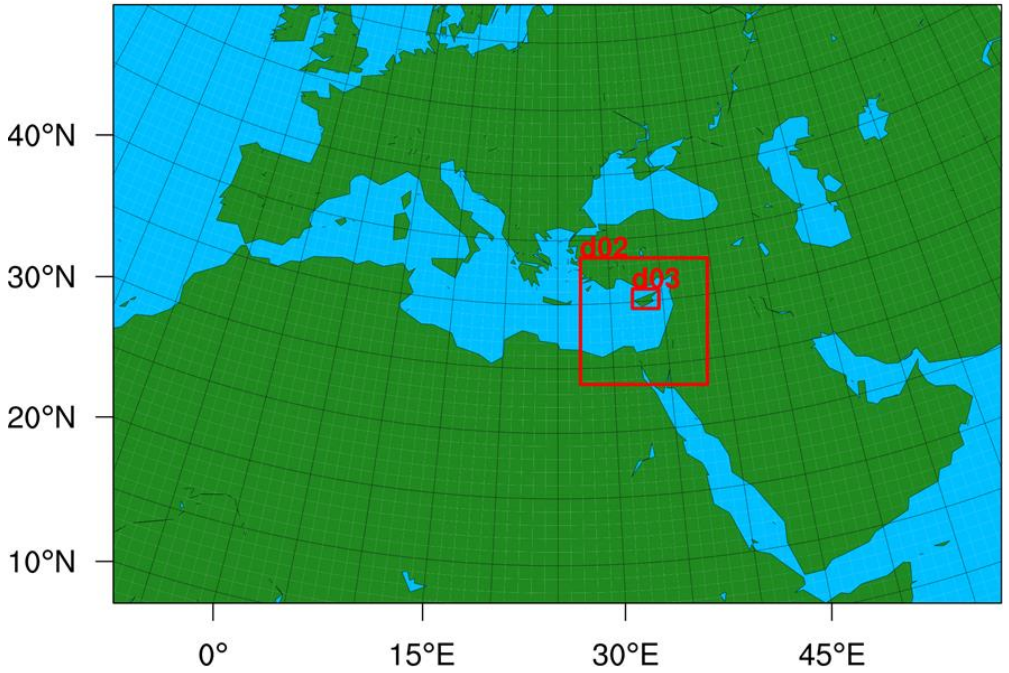
Introduction

- **WRF-Chem is used for daily, 3-day ahead air quality forecasts**
- 3 domains (1 way nested, 50km - 10km - **2km over Cyprus**)
- Extended outermost domain to include the major dust sources and minimize the impact of lateral boundary conditions

Model Domain



Lateral Boundary and Initial Conditions (LBC)

LBC	Source
Meteorology	Global Forecast System - GFS (3h, 0.5° x 0.5°)
Chemistry	WACCM global model (6h, 0.9° x 2.5°)

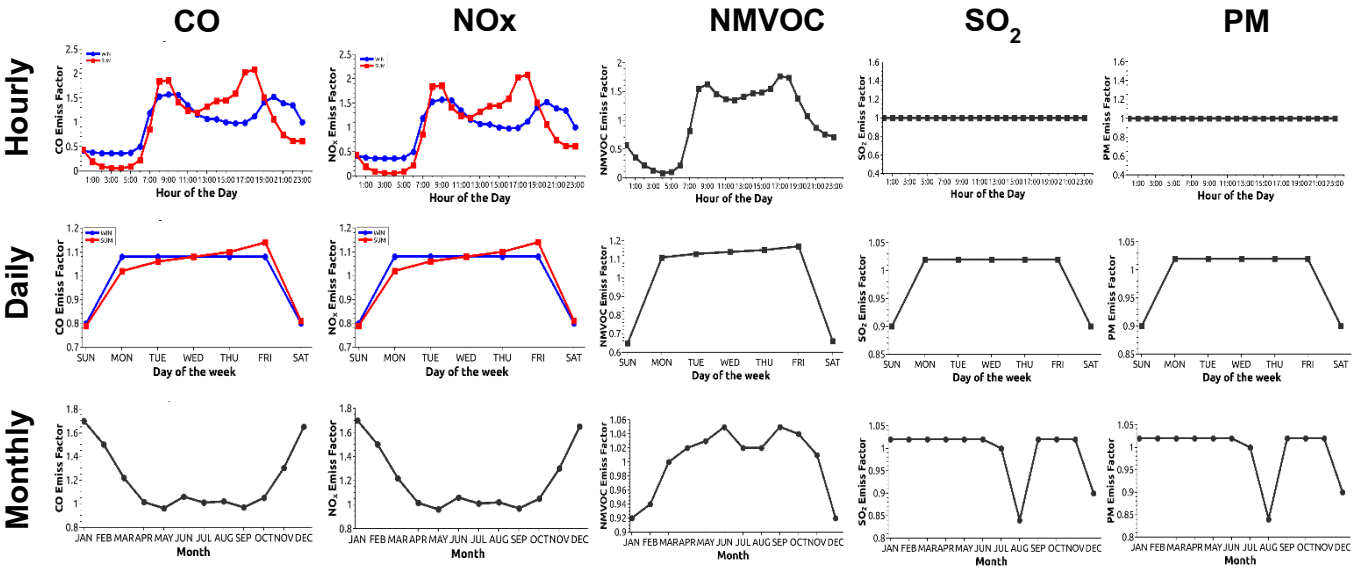
Emissions

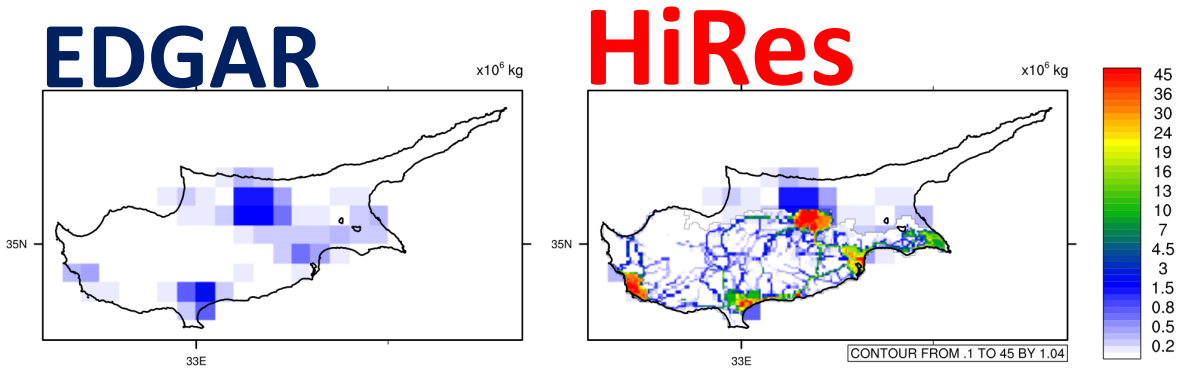
Emissions	Data/Scheme
Anthropogenic	EDGAR-HTAP v2 (monthly, 0.1° x 0.1°) (Janssens-Maenhout et al. 2010)
Biogenic	MEGANv2.1 Model (online, 0.5° x 0.5°) (Guenther et al. 2012)
Dust	GOCART (online) (Ginoux et al. 2001)
Sea-salt	GOCART (online) (Ginoux et al. 2001)

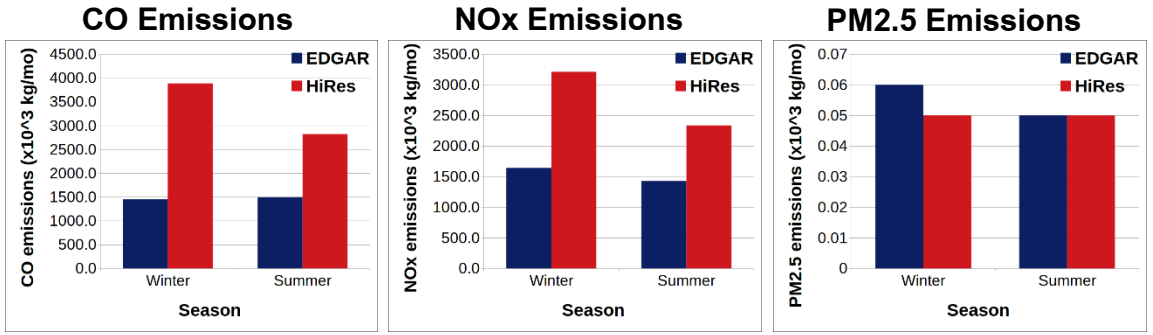
High Resolution Anthropogenic Emissions for Cyprus

- 1km x 1km emission inventory (Department of Labour Inspection – DLI, 2013 data)

- Markedly higher total CO and NOx emissions





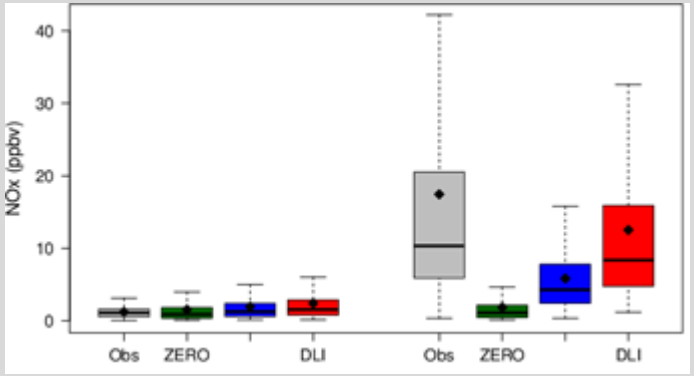


- Monthly, daily, hourly variation of emissions
  - Derived after LOTOS-EUROS (Schaap et al. 2005)
  - Factors calculated per species based on primary emission activity

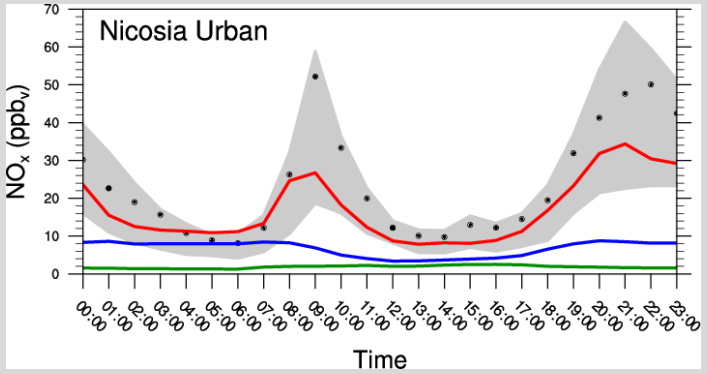
High Resolution Anthropogenic Emissions for Cyprus

- 1km x 1km emissic
  Inspection – DLI, 2
- Markedly higher to

Implementation of the new high-resolution emission inventory:



Background



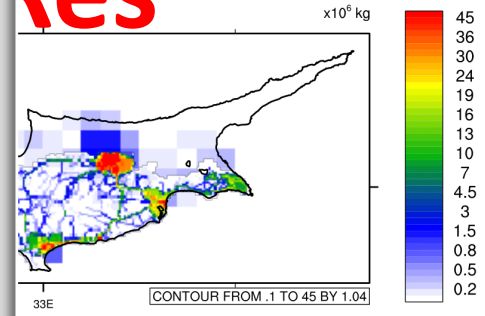
Urban

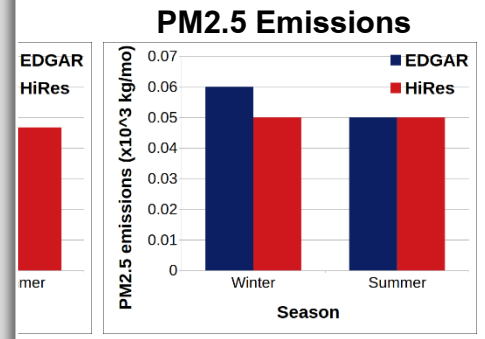
Nicosia diurnal profile

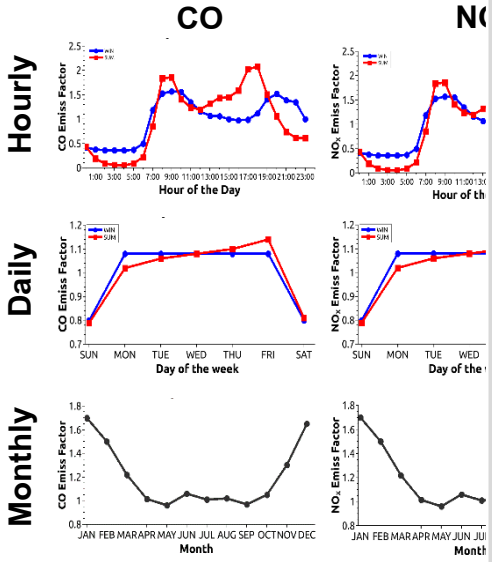
Observations ZERO EDGAR HiRes

- Up to 60% improvement in the estimation of the concentrations of atmospheric pollutants at the urban areas
- More accurate representation of the diurnal profile of the atmospheric pollutants

Res







of emissions

Schaap et al. 2005)

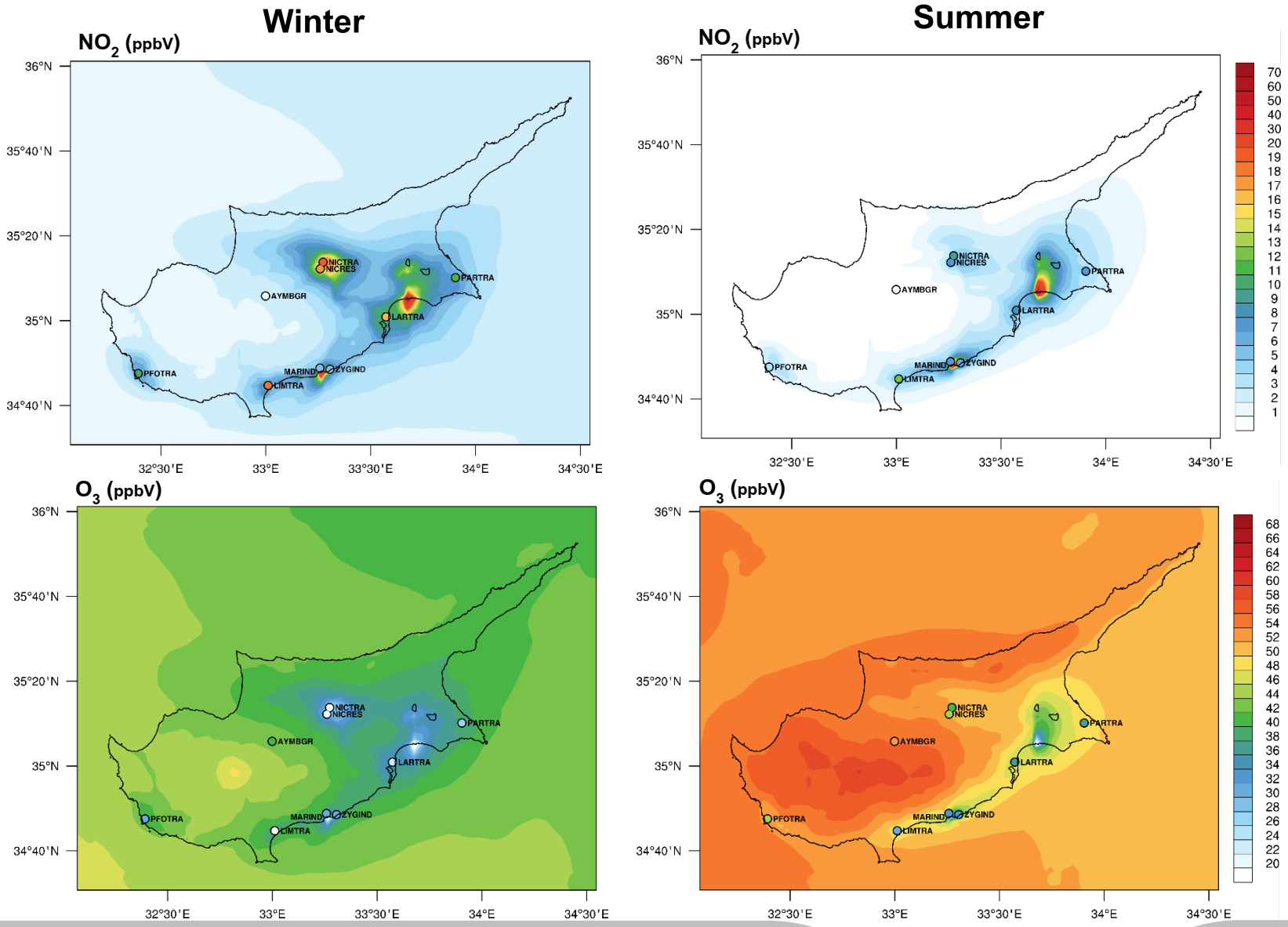
based on primary emission

Operational Air Quality Forecasting Evaluation

- Ran in forecast mode* for the winter (January, February, December) and summer (June, July, August) of 2020
- Compared to observational data from ground stations over Cyprus (Background, Residential, Traffic, Industrial)
- Compared to CAMS forecasts

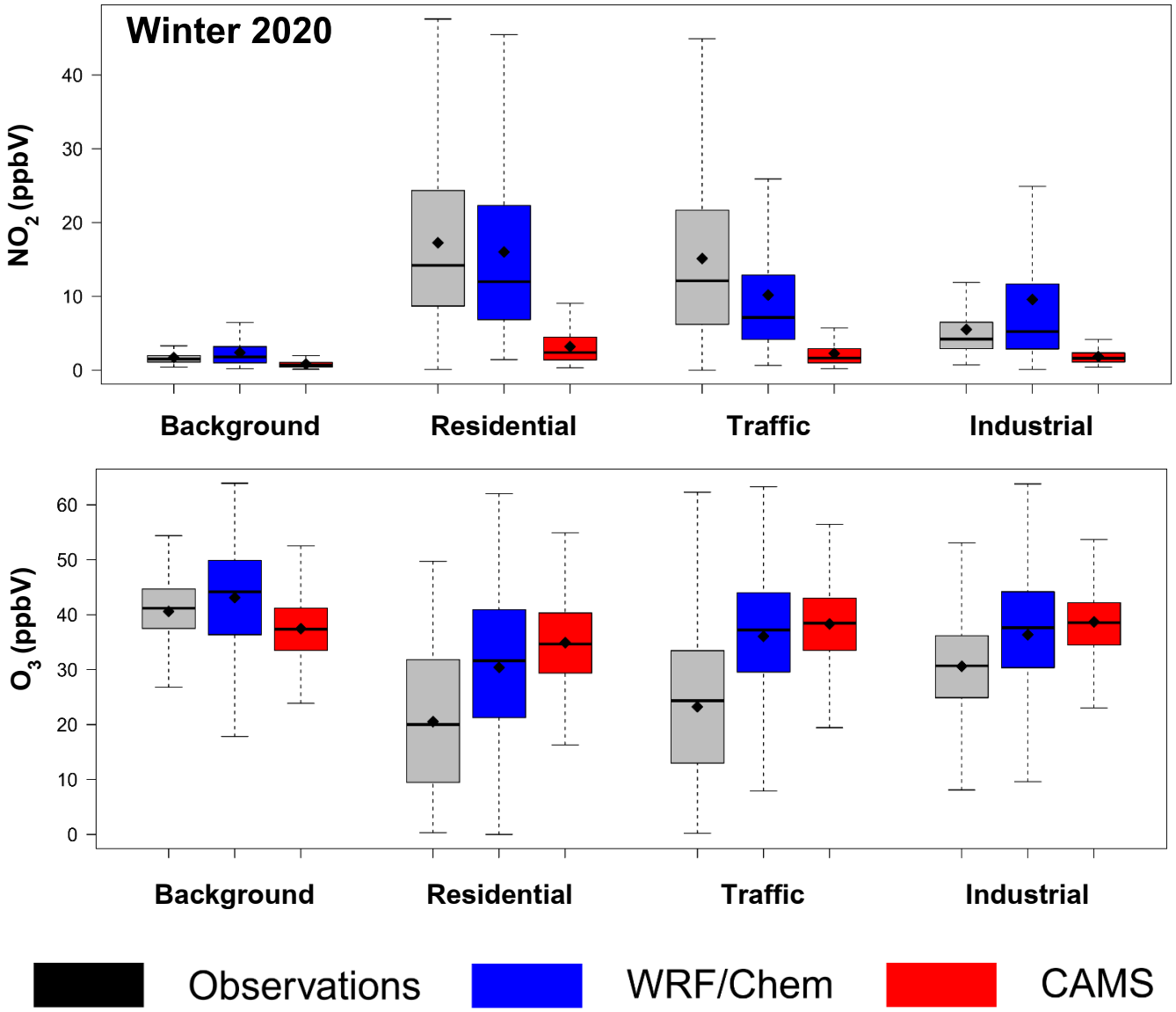
* Forecast data for boundary conditions (GFS, WACCM) are available online

Forecast Evaluation: NO_2 & O_3



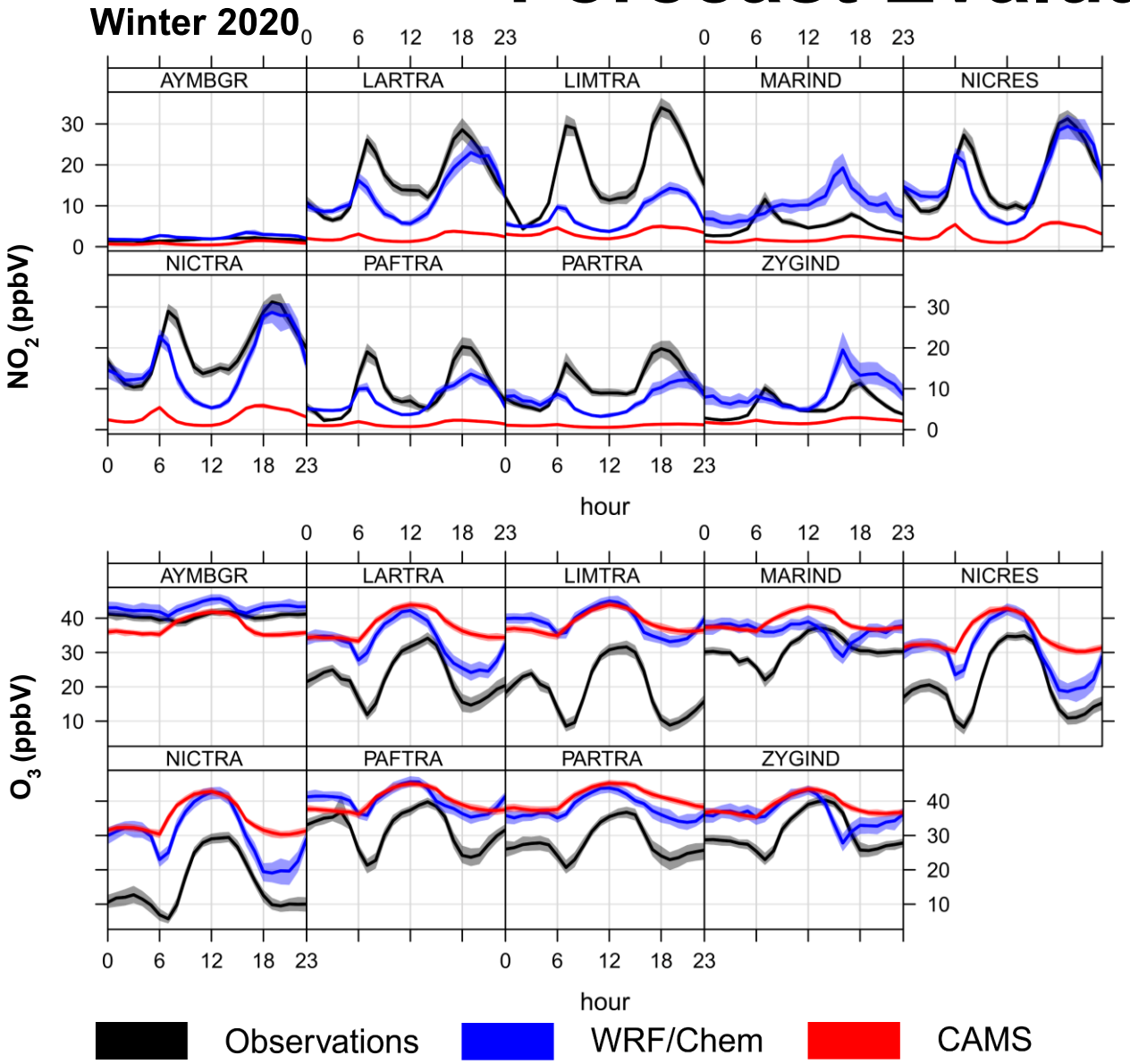
- **Higher NO_2 mixing ratios:**
  - During winter
  - **Near the urban centers**, the locations of the power generation stations, and the eastern part of the island
  - Reduces **O_3 mixing ratios** with respect to background
- The whole island population is exposed to O_3 above 40ppbV during winter and 55ppbV during summer
- O_3 exceedance episodes during the summer

Forecast Evaluation: NO_2 & O_3



- **Compared to CAMS: improved NMB** for WRF/Chem at the residential and traffic stations by up to **90% (13 ppbV) in for NO_2** and up to **30% (5 ppbV) for O_3**
- Industrial stations: Overestimation of NO_2 by WRF/Chem
  - Investigating emissions height (chimneys) and boundary layer height

Forecast Evaluation: NO_2 & O_3

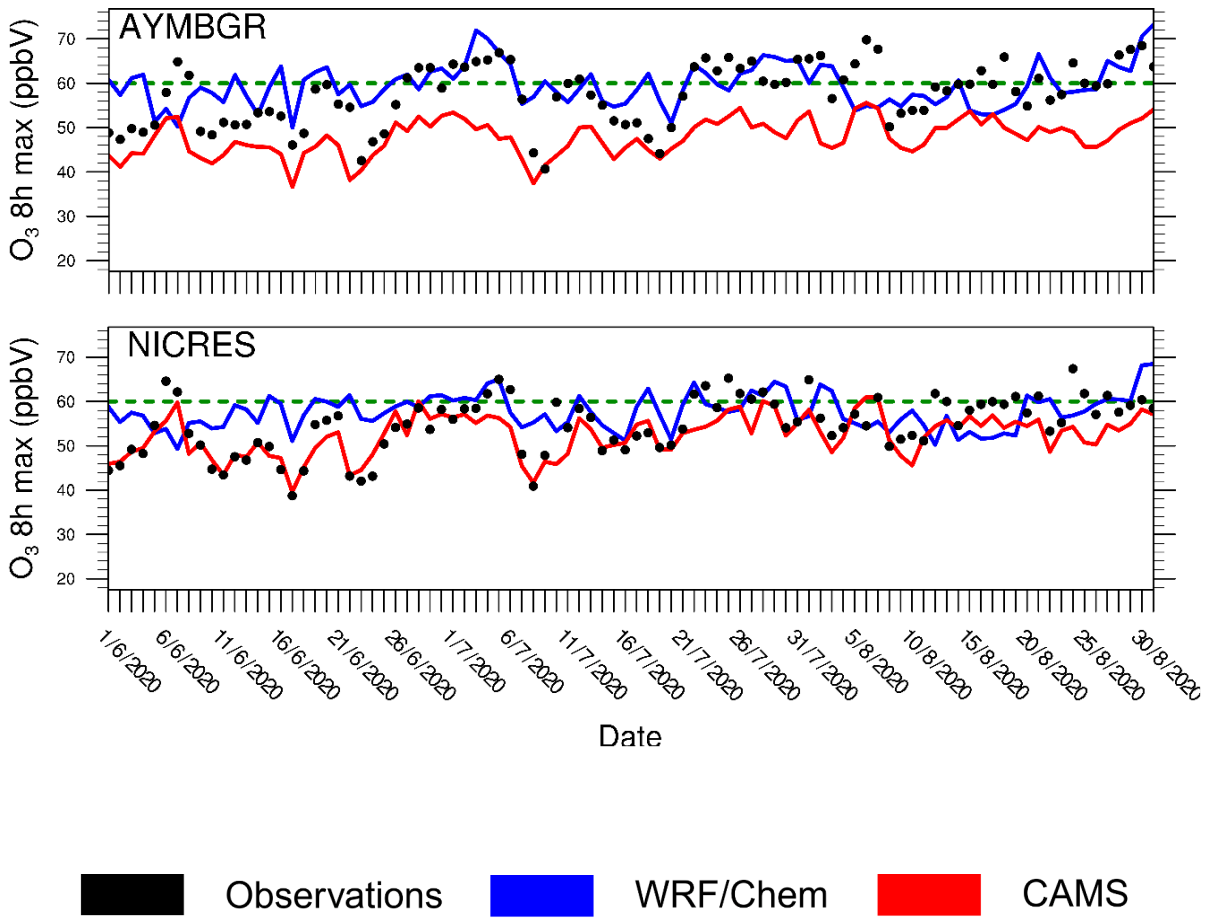


- More **accurate representation of the diurnal profile of NO_2** mixing ratios by WRF/Chem **at the residential and traffic stations** (morning and evening peaks)

- Decreases in O_3 mixing ratios <u>are captured **only** by the WRF/Chem</u> due to increase in NOx concentrations

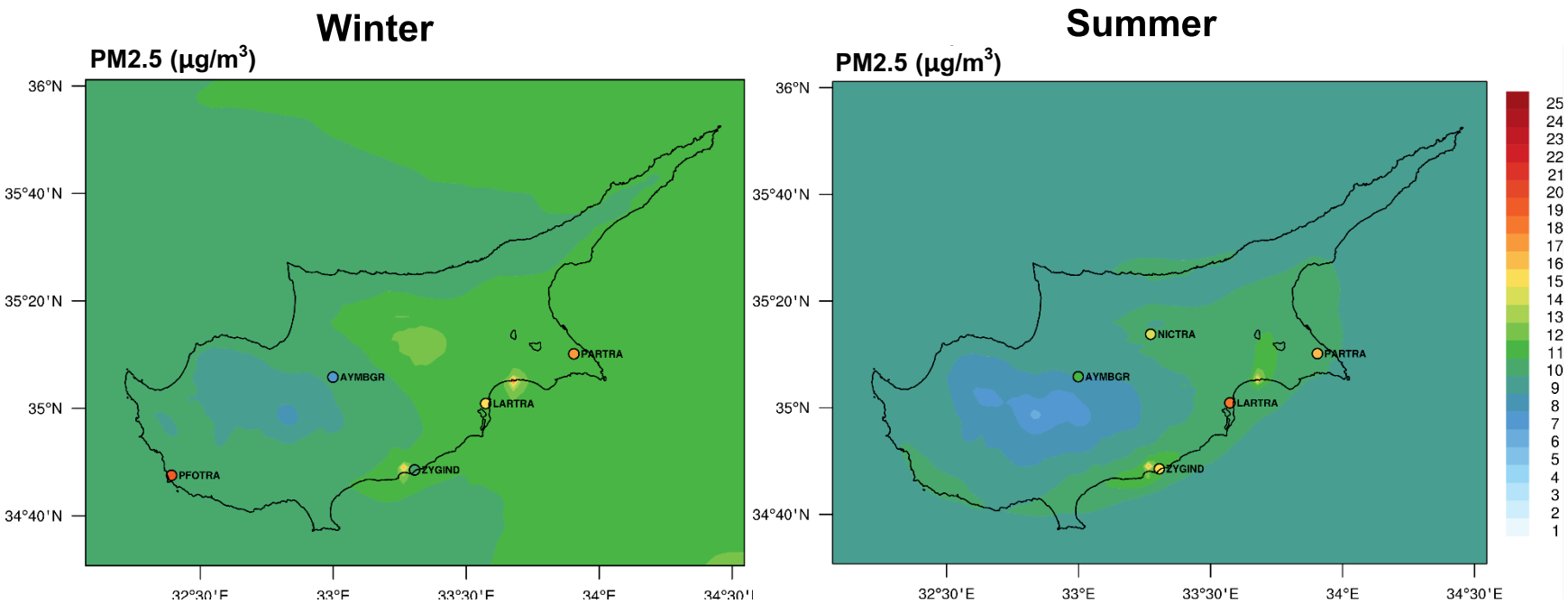
O_3 daily maximum 8 h average

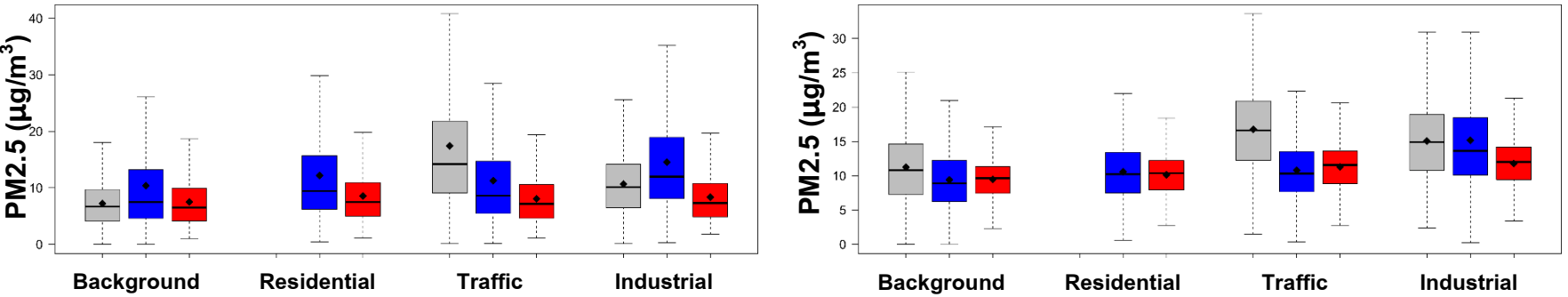
Summer 2020



- **Background station:**
  - 35 exceedances (EU, 2008)
  - 22 exceedances have been successfully predicted by WRF-Chem
  - No exceedances predicted by CAMS
- **Residential station:**
  - 20 exceedances
  - 7 exceedances have been successfully predicted by WRF-Chem
  - 2 exceedances have been successfully predicted by CAMS
- False alarms by the WRF-Chem due to overestimation (15%) in O_3 concentrations

Forecast Evaluation: PM2.5

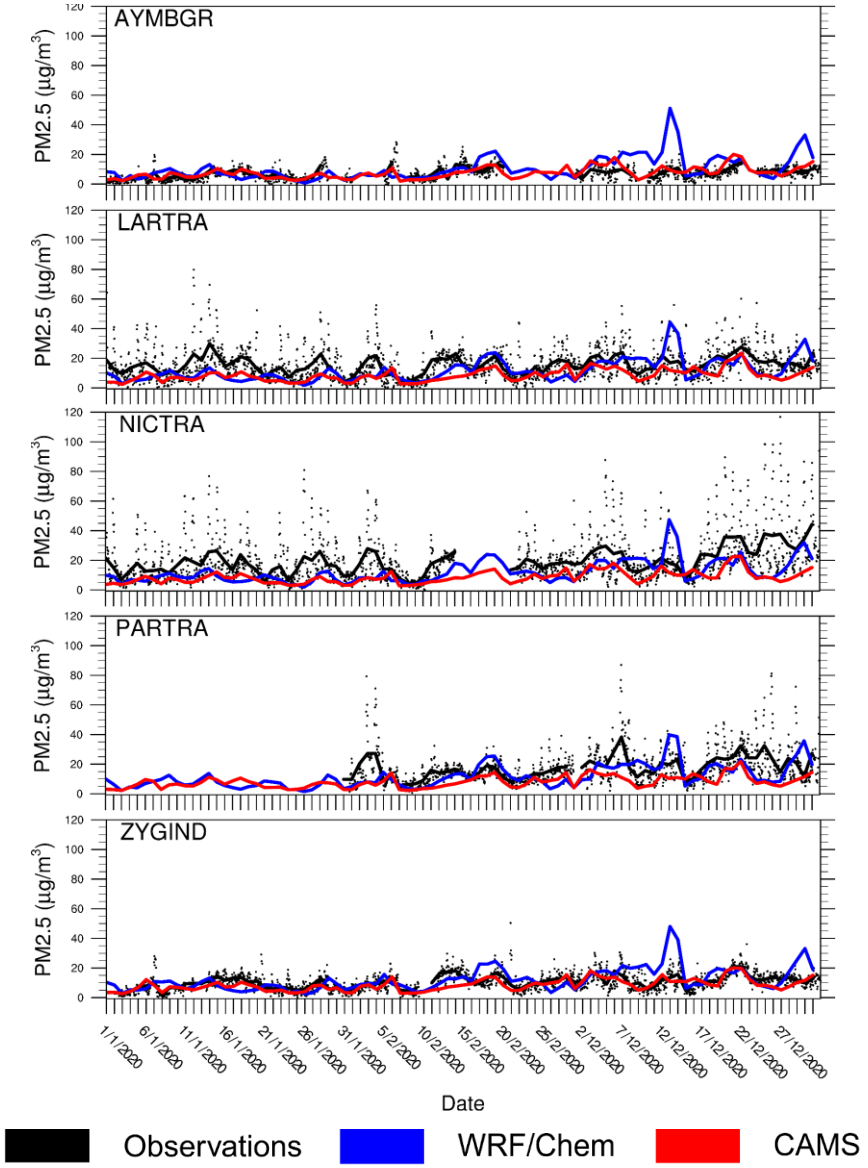


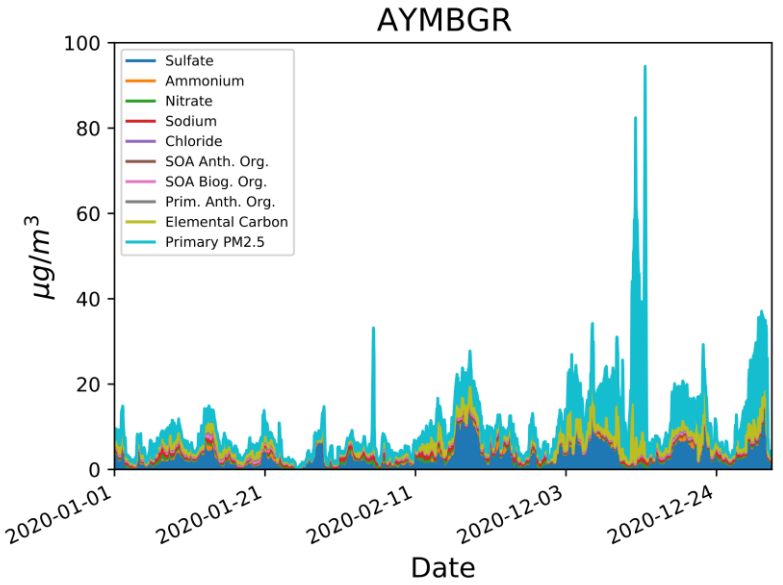


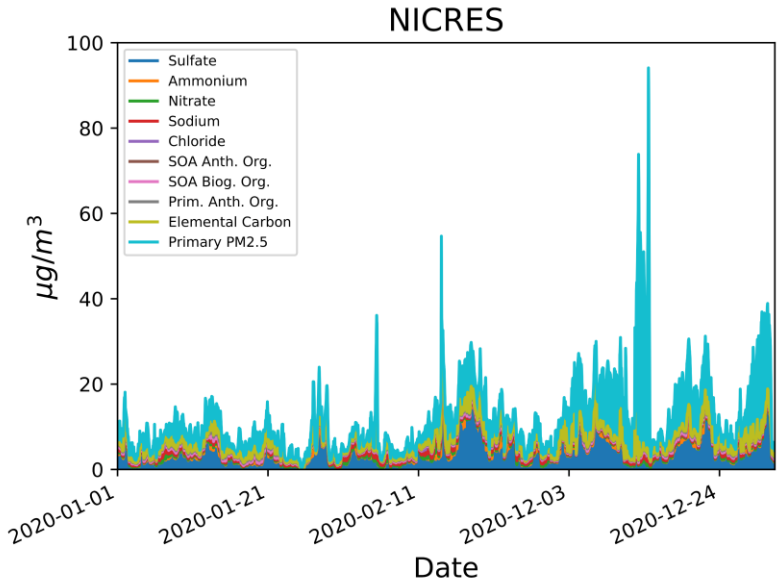
Observations WRF/Chem CAMS

- Similar behavior by WRF/Chem and CAMS during the summer
- Equivalent performance to CAMS
- Overestimation of background PM2.5 concentrations during winter

Forecast Evaluation: PM2.5







- Increased sulfate aerosol concentrations
- Increased concentrations of primary PM2.5 aerosols (includes fine dust particles)

Conclusions

- Employed WRF/Chem to produce accurate air quality forecasts over the Eastern Mediterranean
- By improving the spatial and temporal resolution of the emissions we see improvement of skill in the representation of the magnitude and the diurnal profiles of atmospheric pollutants, especially near the urban centers where the majority of population lives
- Up to 90% (13 ppbV) improvement in NO_2 and 30% (5 ppbV) in O_3 forecast accuracy
- WRF-Chem predicts the O_3 exceedances with higher accuracy compared to CAMS
- WRF-Chem and CAMS have similar performance in terms of forecasting the PM2.5 concentrations
- Regional, coupled online air quality can provide improved real-time air quality forecasts, at least for short-lived species or species that undergo photochemical reactions, compared to the state-of-the-art global chemical transport models

References

- Georgiou, G. K., Kushta, J., Christoudias, T., Proestos, Y., and Lelieveld, J.: Air quality modelling over the Eastern Mediterranean: Seasonal sensitivity to anthropogenic emissions, Atmos. Environ., 222, 117119, https://doi.org/10.1016/j.atmosenv.2019.117119, 2020.

- Georgiou, G. K., Christoudias, T., Proestos, Y., Kushta, J., Pikridas, M., Sciare, J., Savvides, C., and Lelieveld, J.: Evaluation of WRF-Chem model (v3.9.1.1) real-time air quality forecasts over the Eastern Mediterranean, Geosci. Model Dev., 15, 4129–4146, https://doi.org/10.5194/gmd-15-4129-2022, 2022.

Thank you for you attention!!!