

From global to regional scale: Impact of road traffic emissions

Mariano Mertens^{1*}, Eleni Tsati¹, Astrid Kerkweg², Volker Grewe¹, Patrick Jöckel¹

¹ Institute for Atmospheric Physics, DLR, Oberpfaffenhofen, Germany

² Institute for Atmospheric Physics, University of Mainz, Germany

COSMO User Seminar 2015

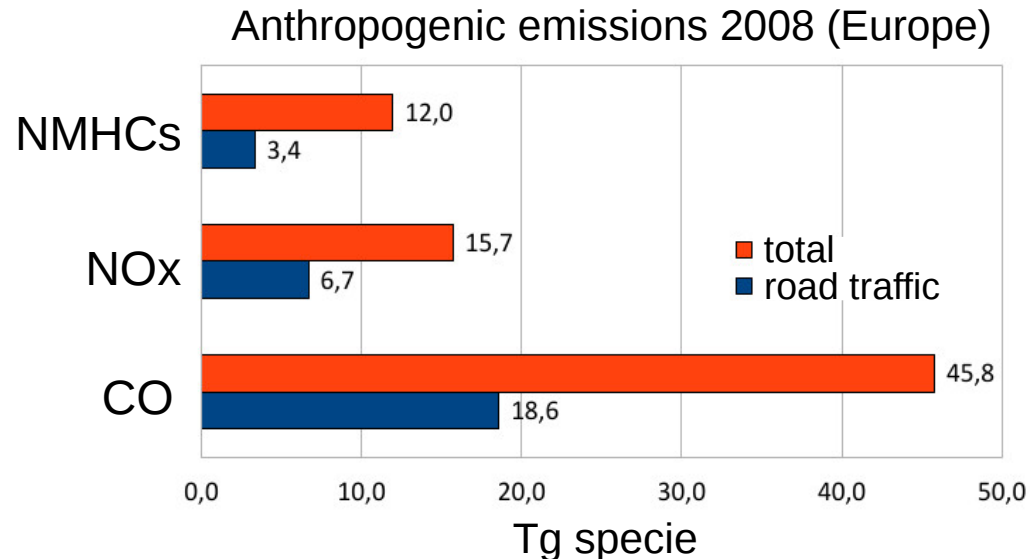
* Mariano.Mertens@dlr.de

Wissen für Morgen

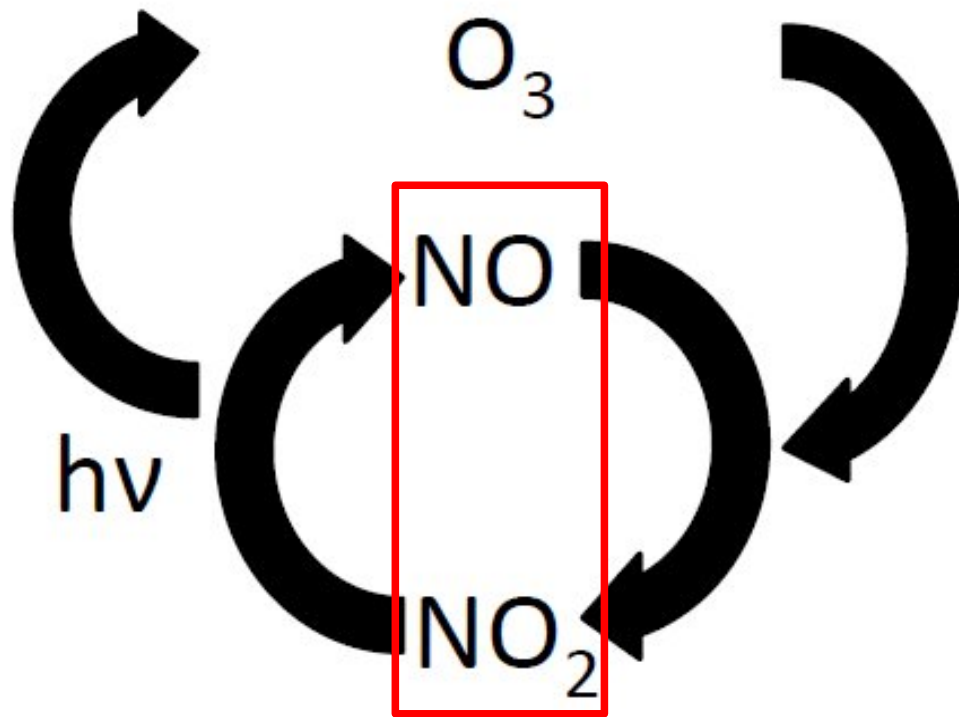


Getting serious - aim of this study

- What is the contribution of road traffic emissions on the production of ozone in the troposphere over Europe (Germany)?
 - Impact of different resolutions
 - Evaluation of mitigation strategies
- **Why ozone?**
 - Tropospheric ozone has noxious effects
 - Ozone acts as greenhouse gas in the troposphere



Simplified ozone chemistry

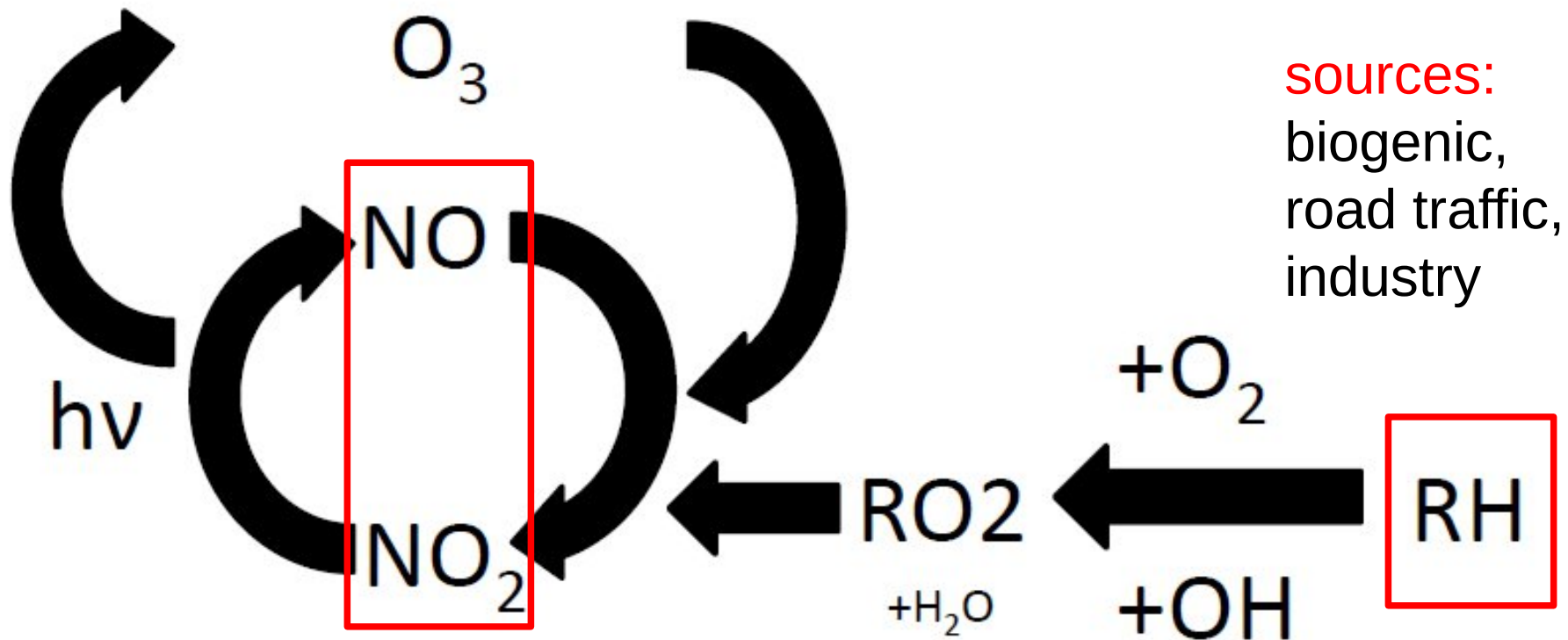


sources:

combustion (industry, road traffic),
lightning



Simplified ozone chemistry



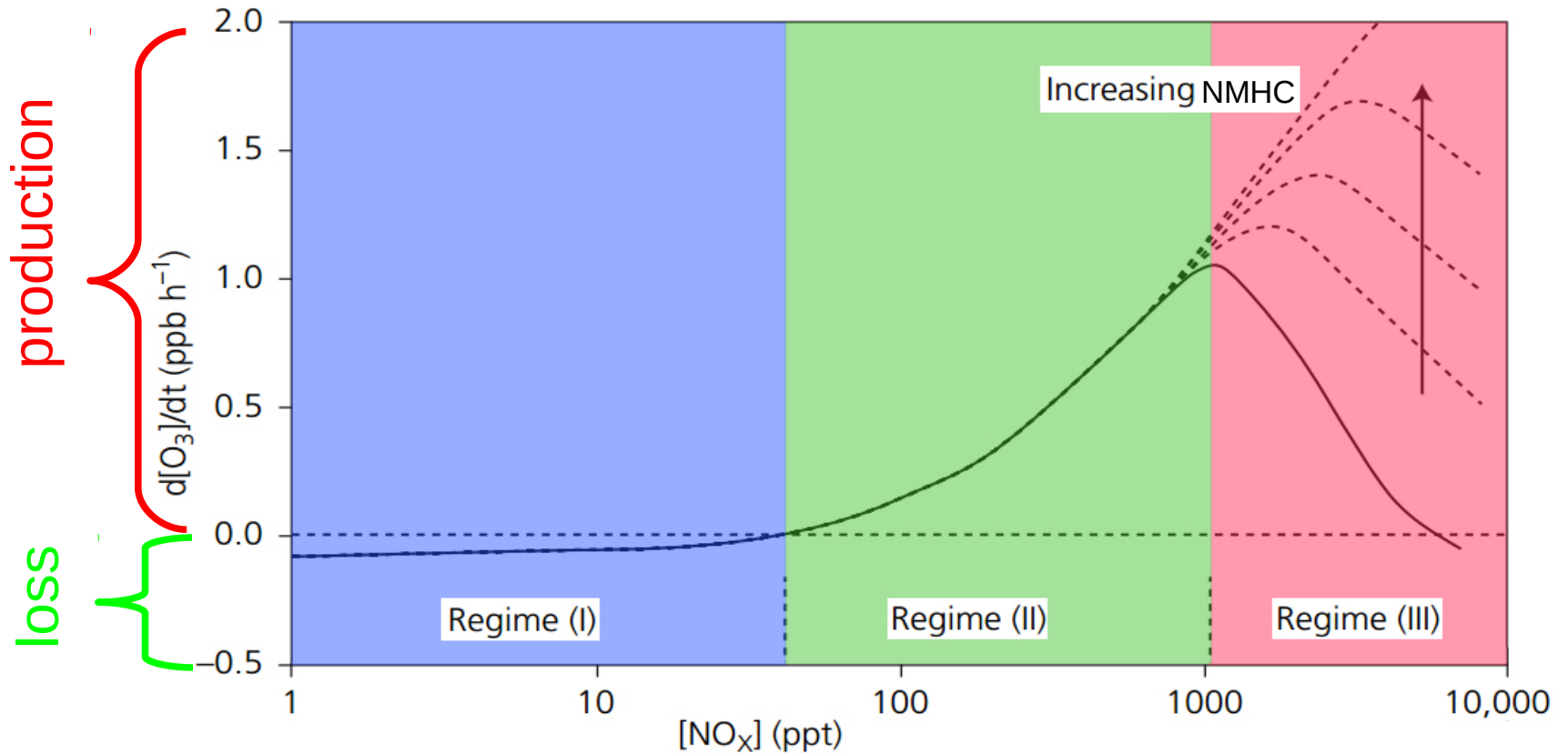
sources:
biogenic,
road traffic,
industry

sources:
combustion (industry, road traffic),
lightning



Ozone chemistry is strongly non linear

and therefore resolution can matter!



adapted from:
The Royal Society,
Ground-level ozone in the 21st century

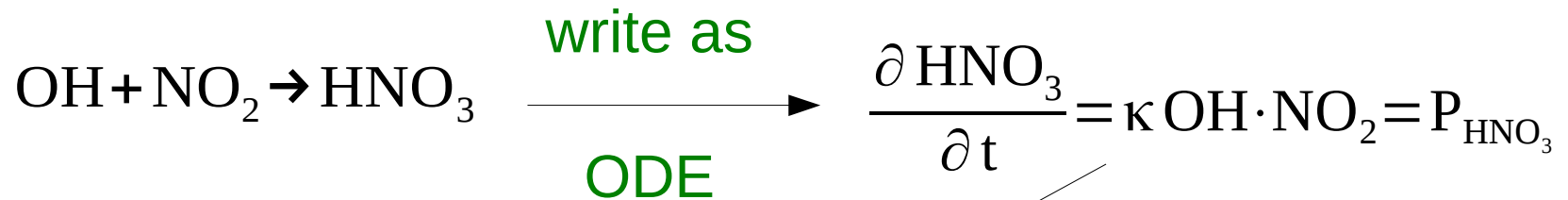
NO_x limited

NMHC limited



Quantify the contribution of sectors: the TAGGING method

- the basic idea (more details see Grewe, 2013):
 - track the reaction path of the species from different sources



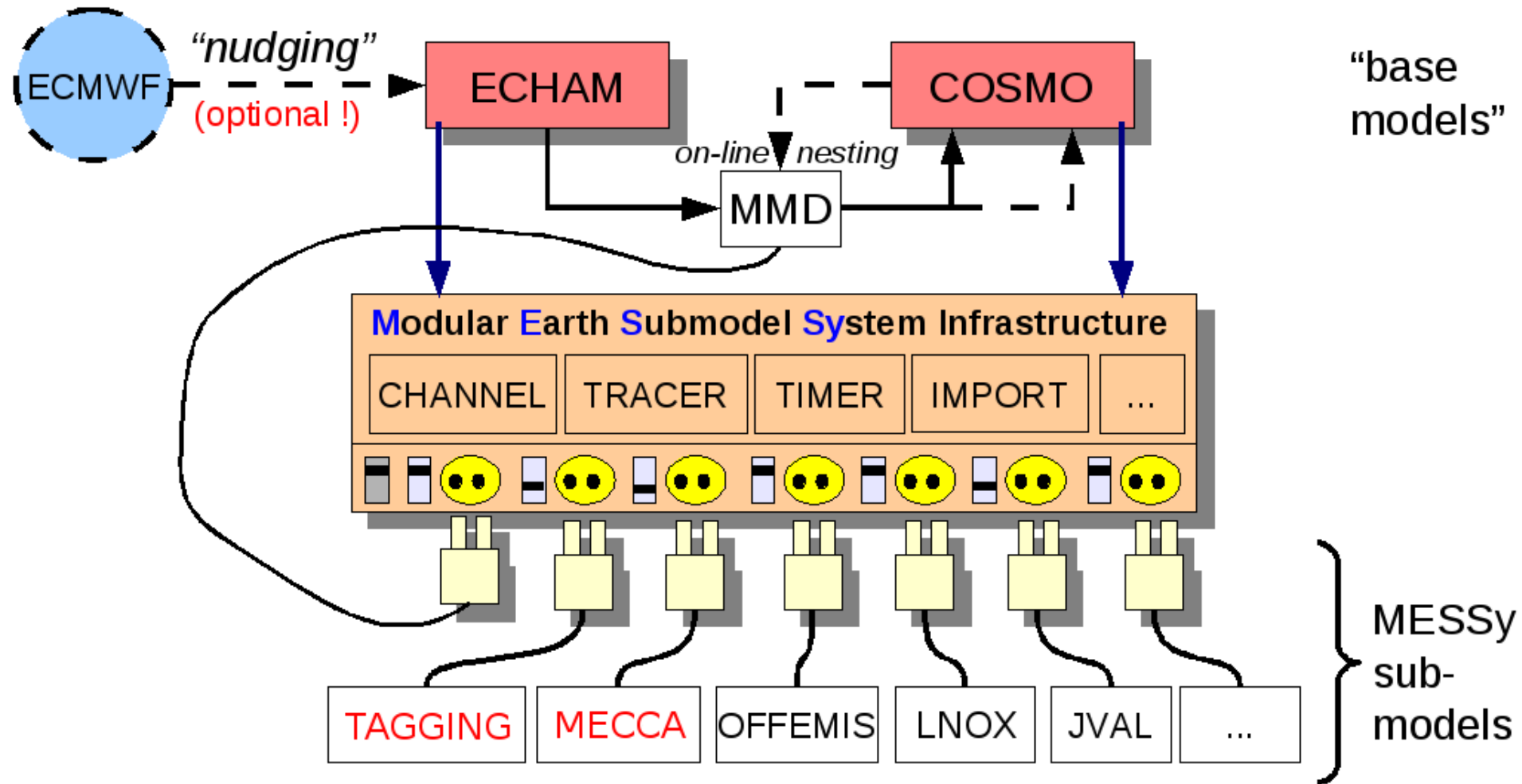
tag it!

$$\frac{\partial \text{HNO}_3^j}{\partial t} = \frac{1}{2} P_{\text{HNO}_3} \left(\frac{\text{OH}^j}{\text{OH}} + \frac{\text{NO}_2^j}{\text{NO}_2} \right)$$

HNO3 formed by sector j



MECO(n) model system

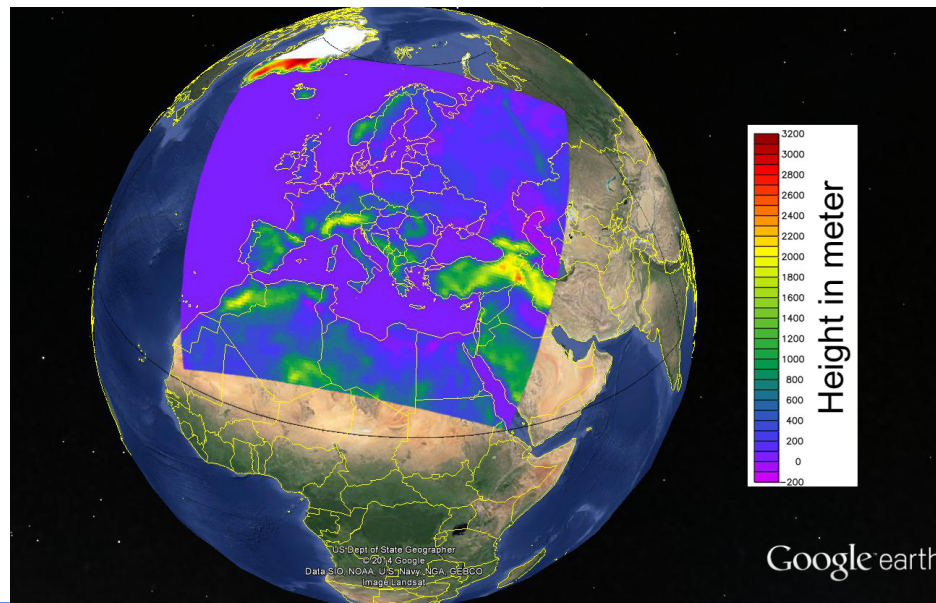


Kerkweg & Jöckel, 2012



Setup

- MECO(1)
- based on the REF-C1SD setup for ESCiMo consortia simulations¹
- T42L31ECMWF for EMAC
 - Nudged with ECMWF operational analysis data
- 0.44° x 0.44° COSMO/MESSy nest over Europe
- MECCA and TAGGING running regionally and globally
- LNOX and biogenic emissions calculated globally, transformed to region
- anthropogenic emissions based on MACCity² database (0.5° resolution)



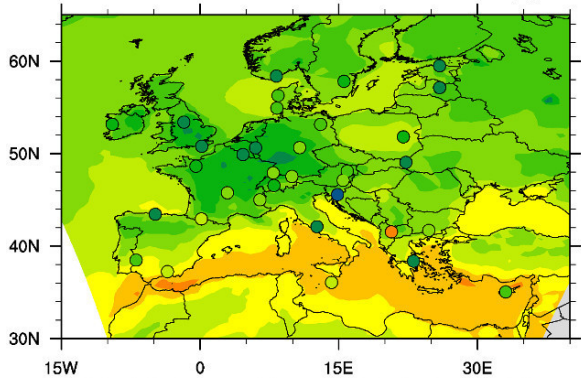
¹ <http://www.pa.op.dlr.de/~PatrickJoeckel/ESCiMo/>

² eccad.sedoo.fr

Comparison of ground level ozone 06/08 and 12/08

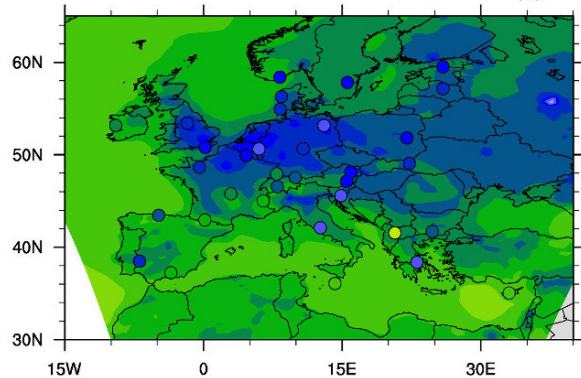
ground level ozone concentration - 6/2008

$\mu\text{g}/\text{m}^3$



ground level ozone concentration - 12/2008

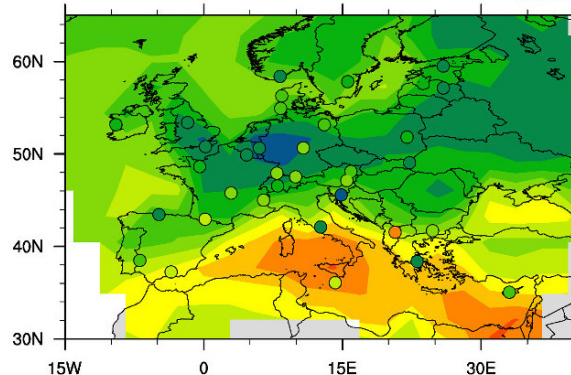
$\mu\text{g}/\text{m}^3$



COSMO/MESSy

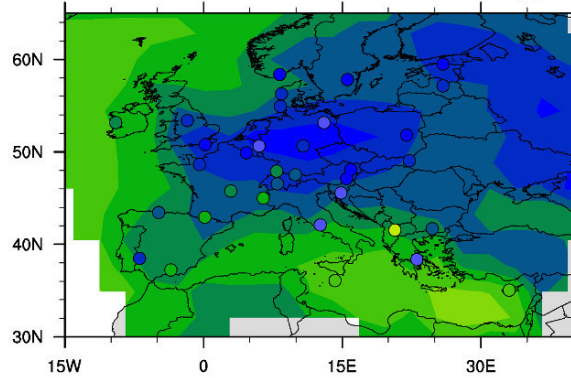
ground level ozone concentration - 6/2008

$\mu\text{g}/\text{m}^3$

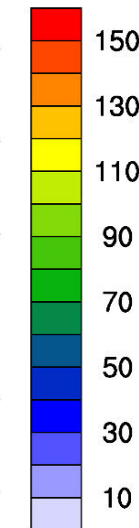


ground level ozone concentration - 12/2008

$\mu\text{g}/\text{m}^3$



EMAC



$\mu\text{g}/\text{m}^3$

Overall positive ozone bias.

COSMO/MESSy:
Too high concentrations (due to several reasons) in North-Eastern Europe.

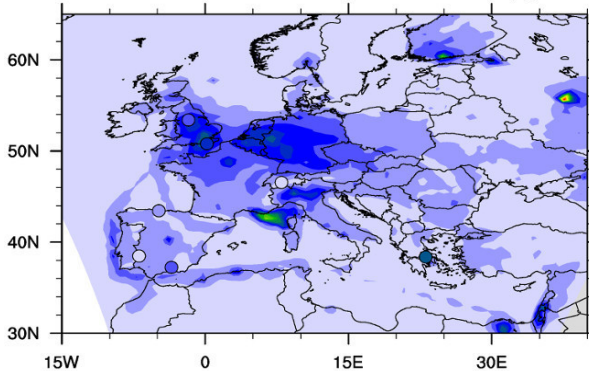
observation data from ebas.nilu.no



Comparison of ground level NO_x 06/08 and 12/08

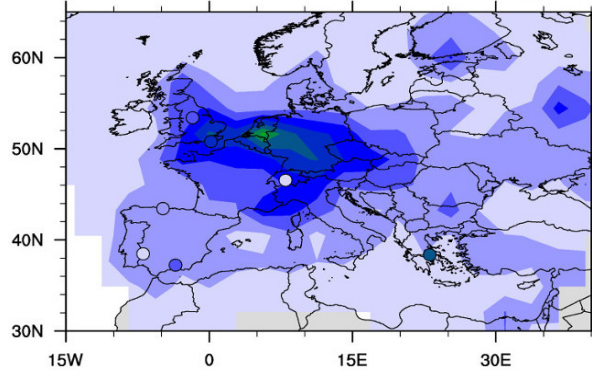
ground level NO_x concentration - 6/2008

µg N/m³



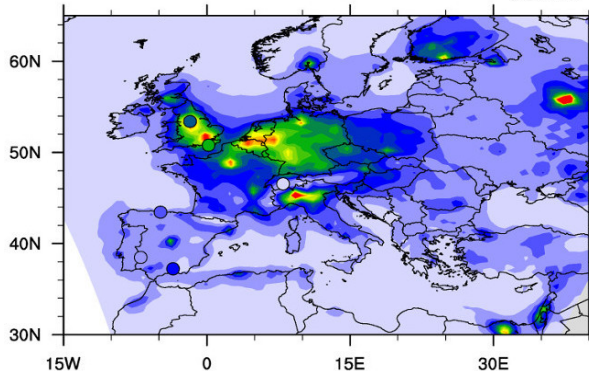
ground level NO_x concentration - 6/2008

µg N/m³



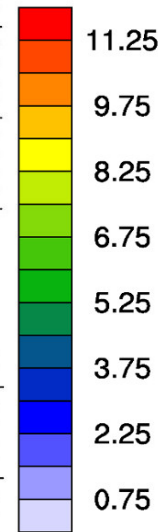
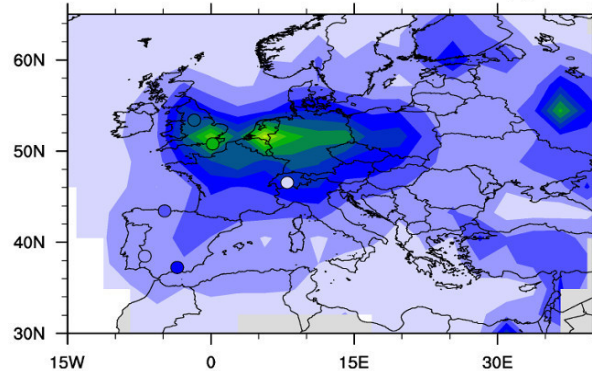
ground level NO_x concentration - 12/2008

µg N/m³



ground level NO_x concentration - 12/2008

µg N/m³



µg N/m³

COSMO/MESSy captures finer structures much better.

Too high concentrations near source regions (too high emissions!).

COSMO/MESSy

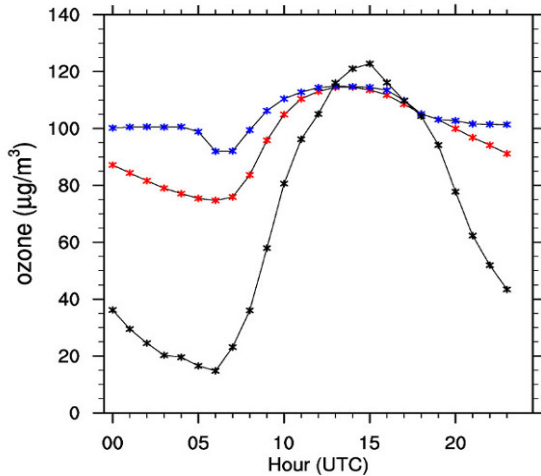
EMAC

observation data from ebas.nilu.no

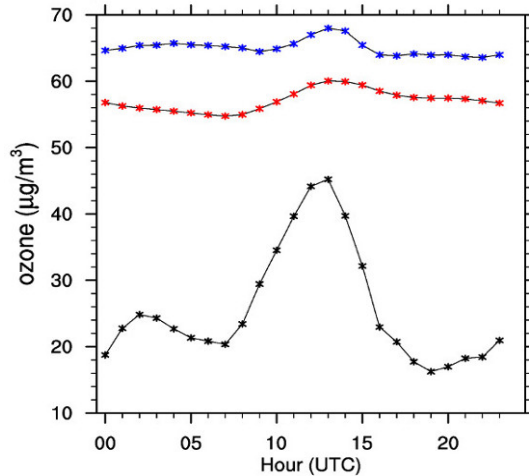


Monthly averaged diurnal cycle of ozone

diurnal cycle of ozone 6/2008 at MON



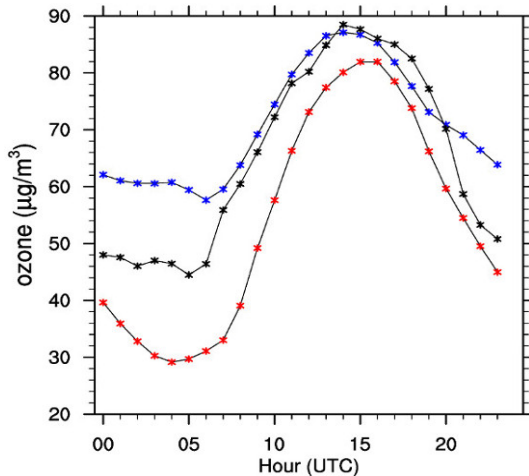
diurnal cycle of ozone 12/2008 at MON



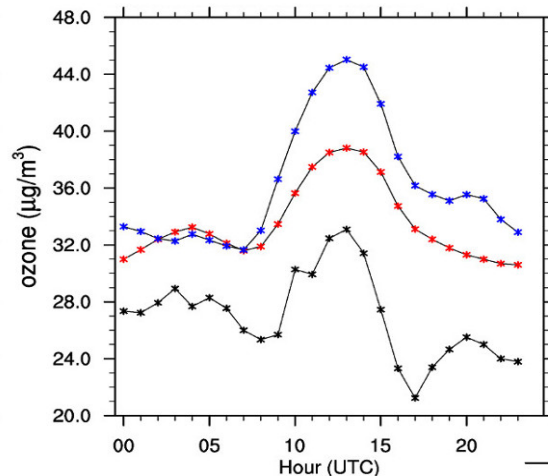
Montelibretti, Italy

Loss over night
(dry deposition) is
underestimated

diurnal cycle of ozone 6/2008 at eupe



diurnal cycle of ozone 12/2008 at eupe



Eupe, Belgium

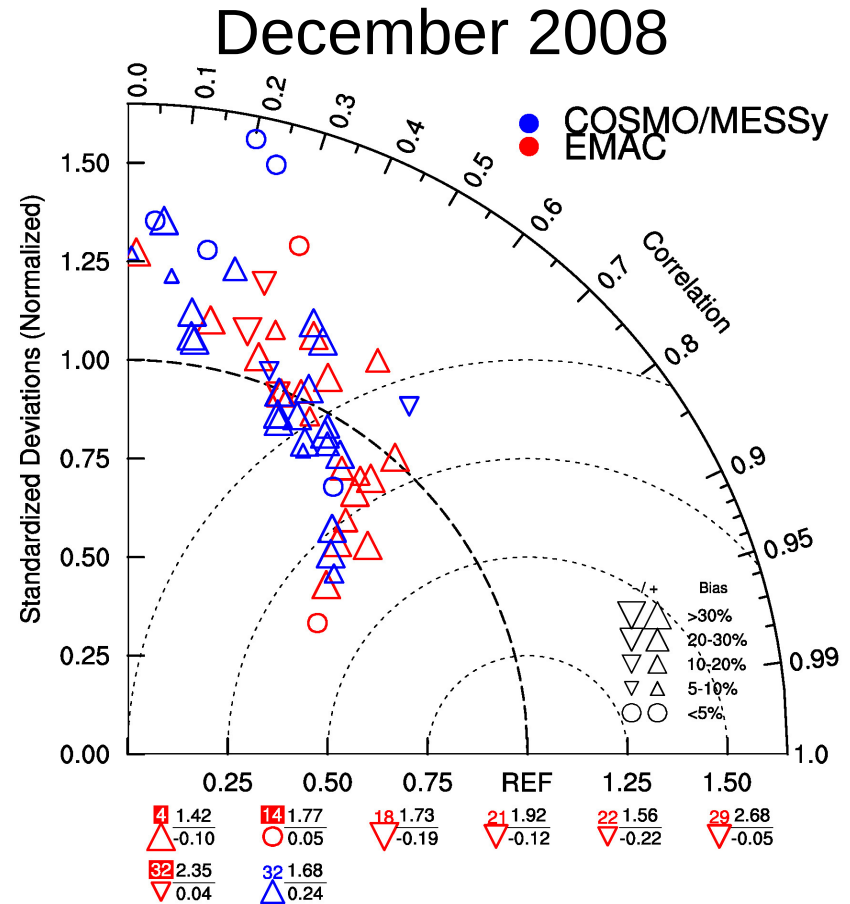
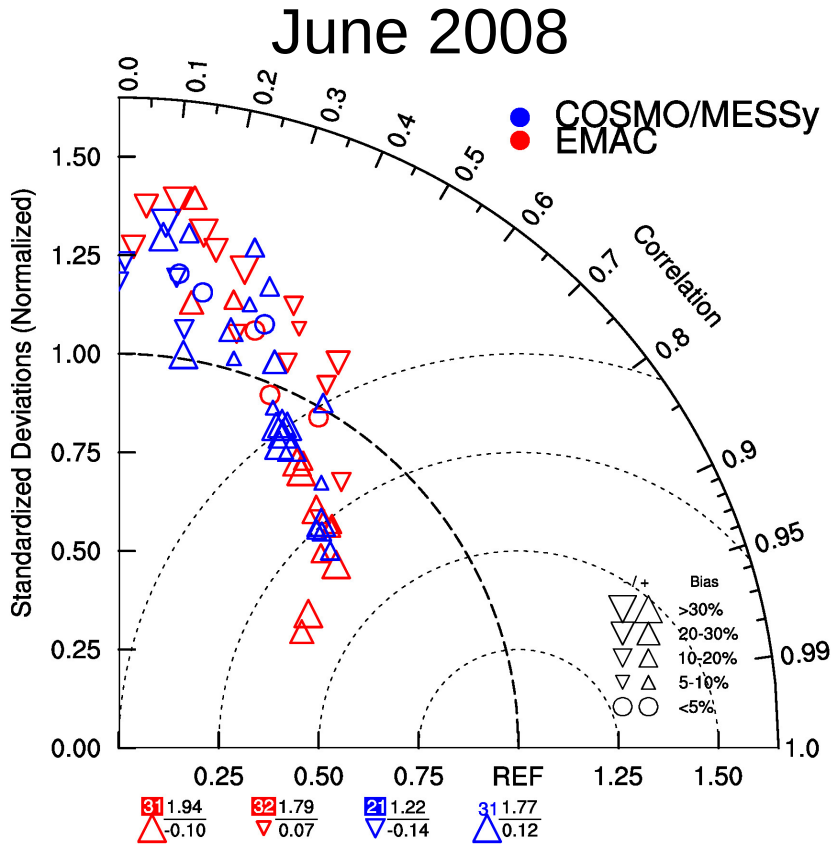
observation data from ebas.nilu.no

- × — Observations
- * — COSMO/MESSy
- * — EMAC



Taylor diagrams for ground level ozone

COSMO/MESSy and EMAC show similar skills

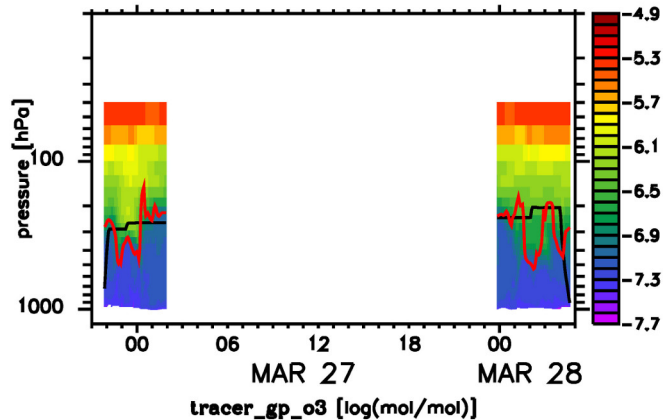


observation data from ebas.nilu.no

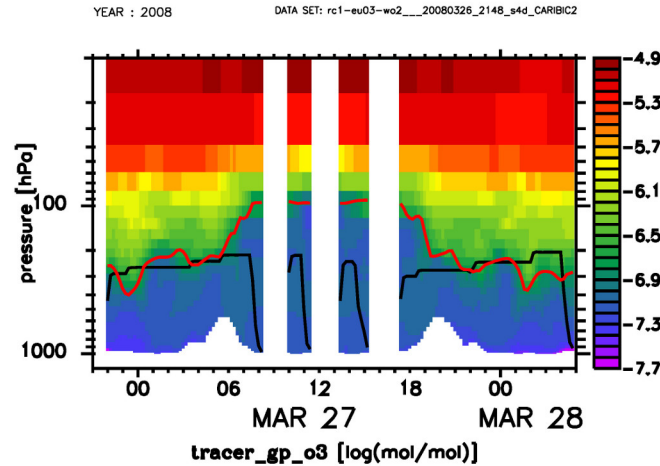


Comparison with CARIBIC observations

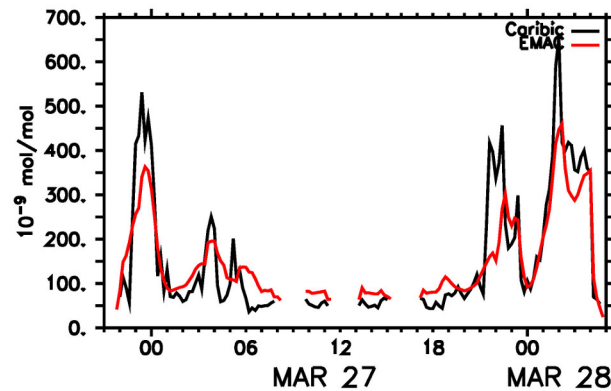
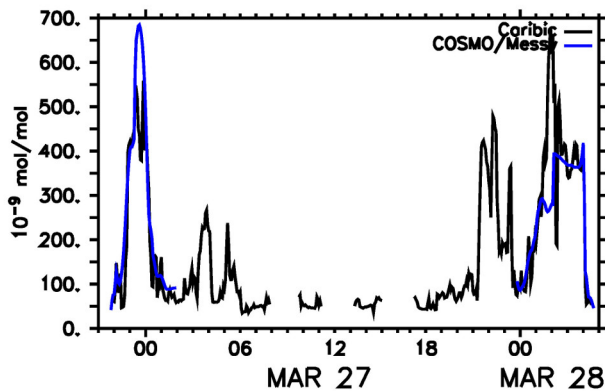
COSMO/MESSy



EMAC



CARIBIC flights
224 – 227



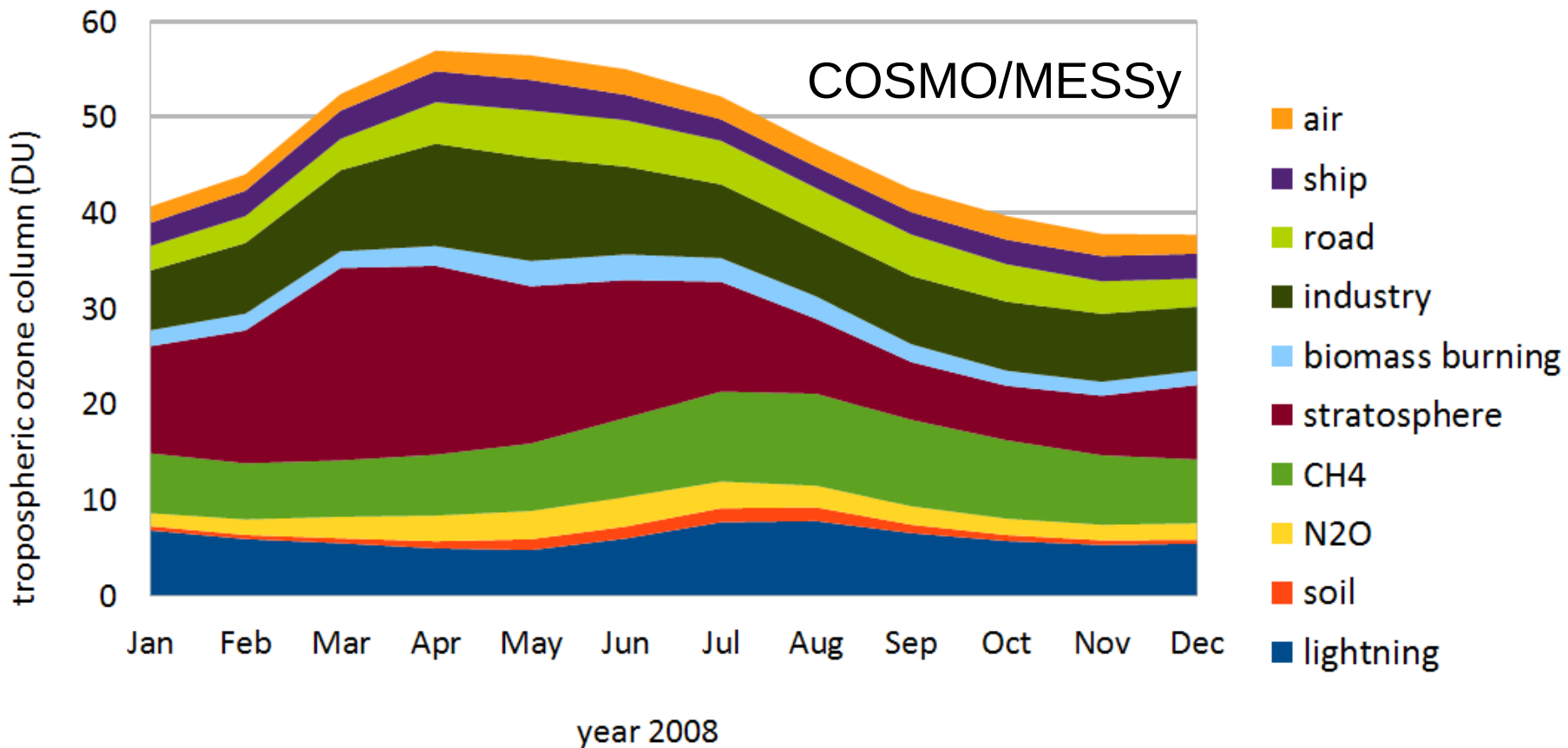
Frankfurt (Main)
Guangzhou, China
Manila, Philippines
and back

Thanks to the CARIBIC-Team for the measurement data

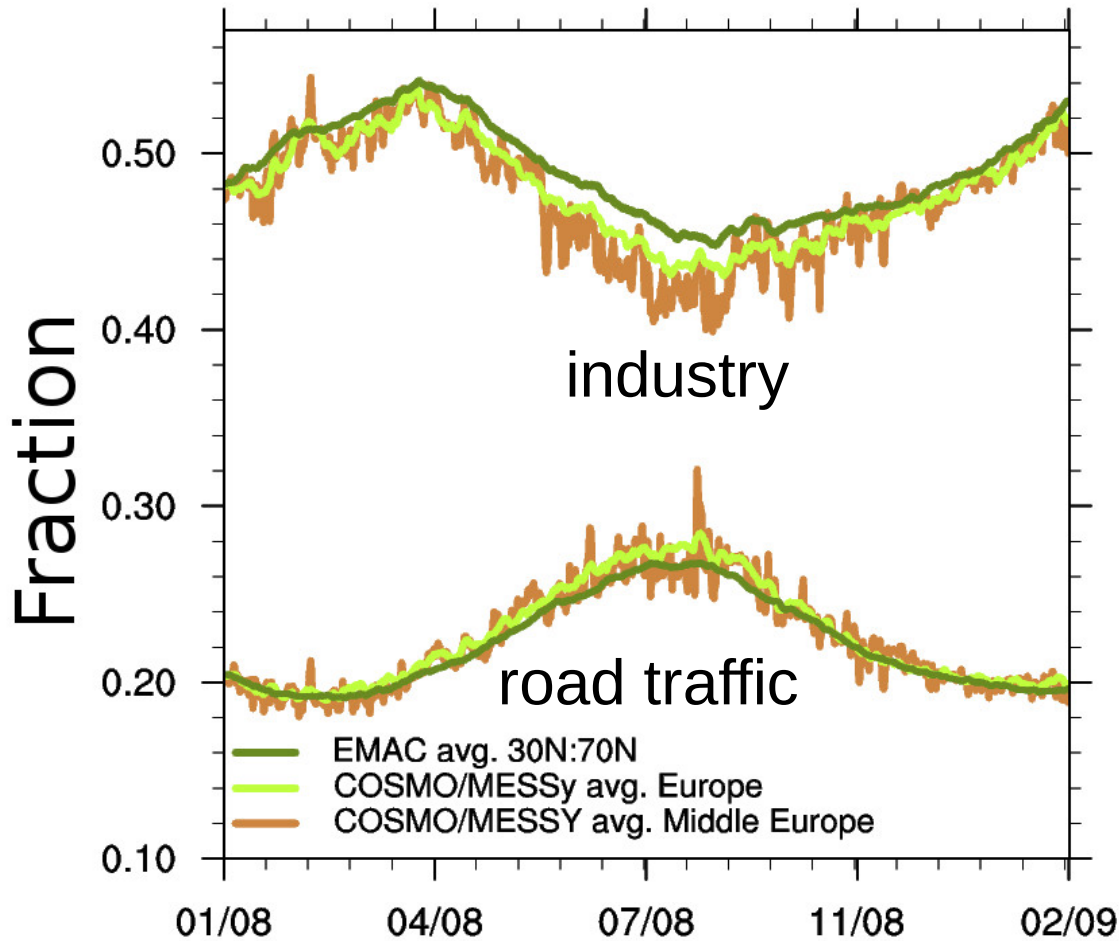


Contributions to the tropospheric ozone column over Europe

More than 1/3 of the tropospheric ozone over Europe has a anthropogenic origin



Contribution to tropospheric ozone by anthropogenic emissions



Fraction of the contribution from industry and road traffic are anti-correlated, as industry emissions have a minimum during the summer.

Contribution of industry in Europe slightly lower than for global 30N:70N average.



Summary

- COSMO/MESSY successfully evaluated with respect to tropospheric chemistry (mainly ozone)
 - Dry deposition parametrization must be enhanced in the future
 - Higher resolution reveals much more details (alpine regions, shiptracks or highly polluted areas (like the Po basin))
 - **Keep in mind:** Capabilities of higher resolution in COSMO/MESSy (better resolved emission datasets, on-line calculated biogenic and lightning NO_x emissions) not considered here.
- TAGGING diagnostic allows us to quantify the contribution of different sectors to the tagged species (e.g. ozone, carbon monoxide etc.)

