



Synergistic use of chemistry-transport modelling and satellite observations for air pollution control.

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Bremen, 15-16 May 2013

“Pollution studied by REmote Sensing of Conurbations/megacities and Retrieved from observations made by Instrumentation on space BasEd platforms - PRESCRIBE”



What do we want to know?



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the levels of pollution



the drivers (sources) of pollution



If promised actions were taken



Can it be done better

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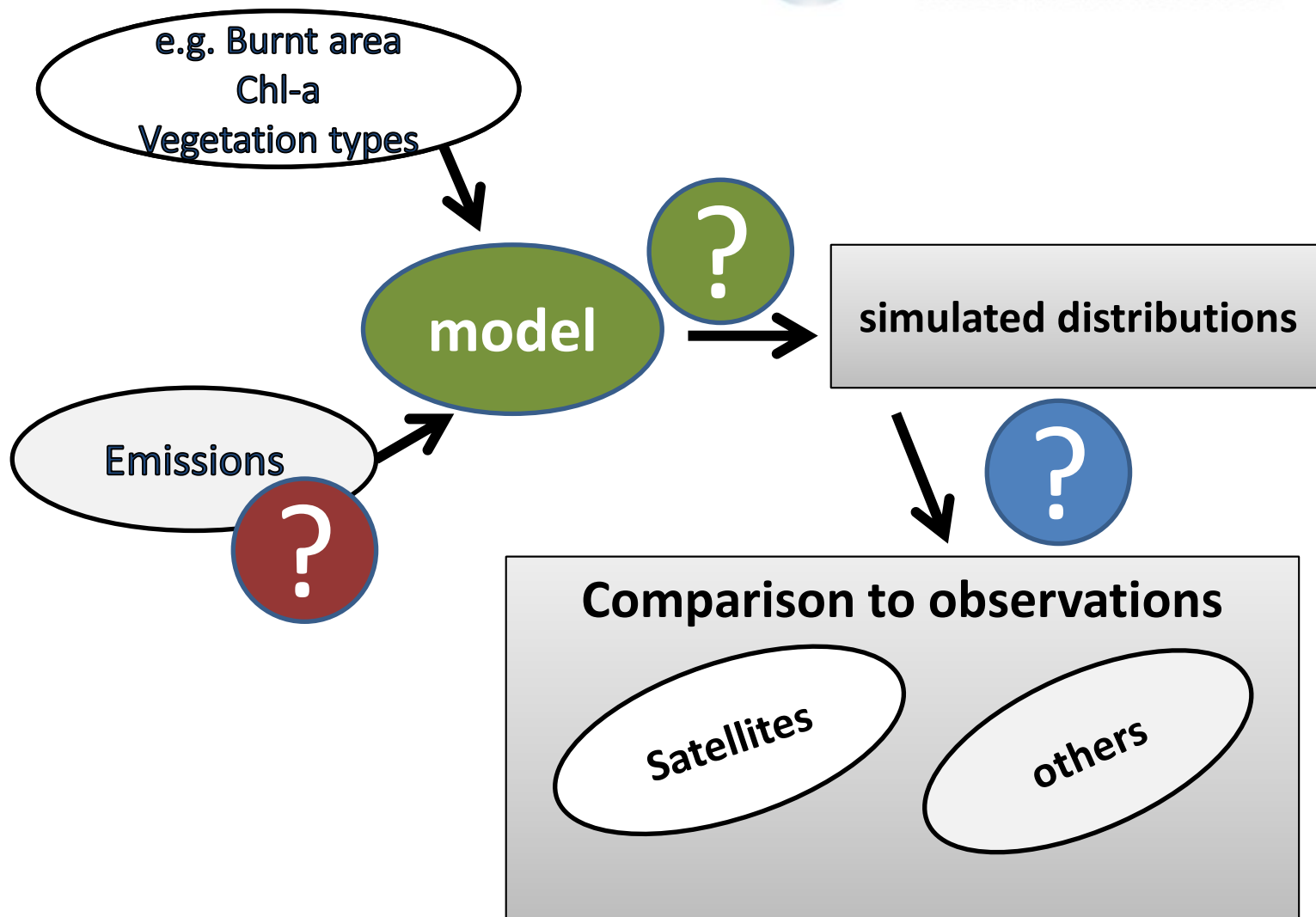


Forward approach



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What models ?



global



Mesoscale



What resolution ? Spatial/temporal





What model constituents?



gases



aerosols



clouds

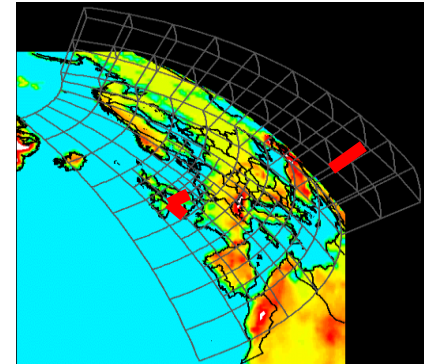


Global 3-d chemistry-transport modeling

- global 3-d Chemistry Transport Model TM4-ECPL
VOC /NO_x/oxidants chemistry & all major aerosol components including primary & secondary OC, coupled with ISORROPIA II.

Myriokefalitakis et al., ACP, 2008 (glyoxal), Advances in Meteorology 2010 (marine OA), ACP, 2011 (multiphase chemistry, oxalate); Tsigaridis and Kanakidou, AE, 2007 (future SOA) ; Kanakidou et al., GBC, 2012 (ON,OP deposition)

3 lon x 2 lat x 34 levels (6x4x34 levels)



- Present day simulations :
anthropogenic CITYZEN/ CIRCE/ ECLIPSE/ ACCMIP, biomass burning gfedv2/gfedv3, biogenic emissions MEGAN
- Past simulations: *no anthropogenic, 10% biomass burning*
- Future simulations: *anthropogenic BAU for 2050 – ECLIPSE/CIRCE*
- *ECMWF meteorology (operational / ERA-iterim)*



The glyoxal issue



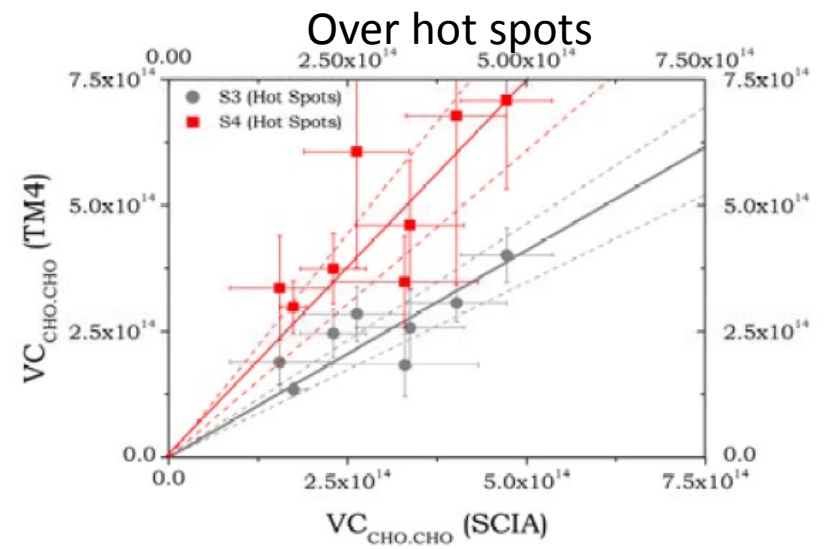
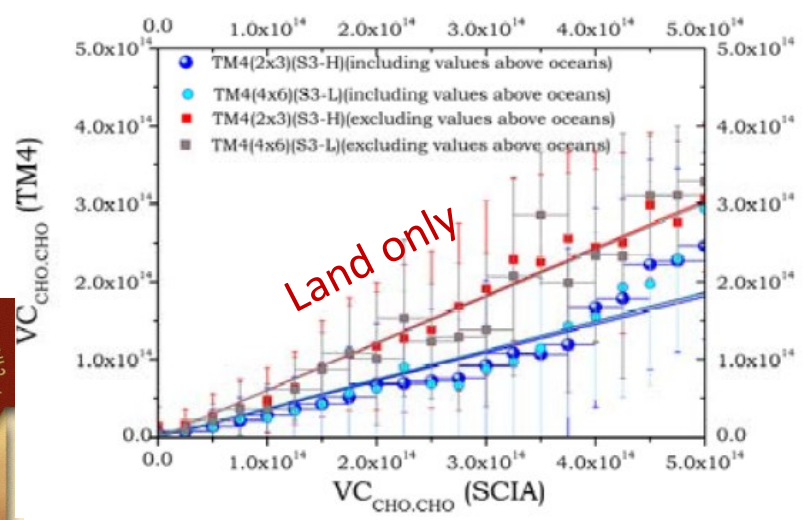
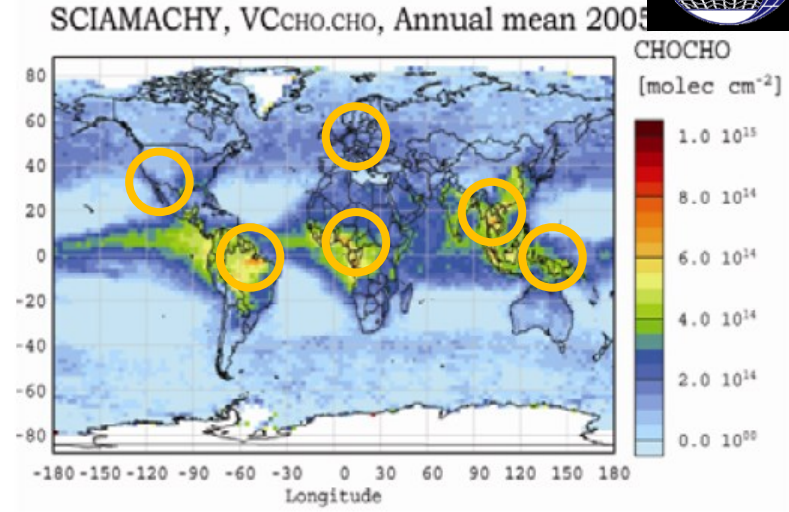
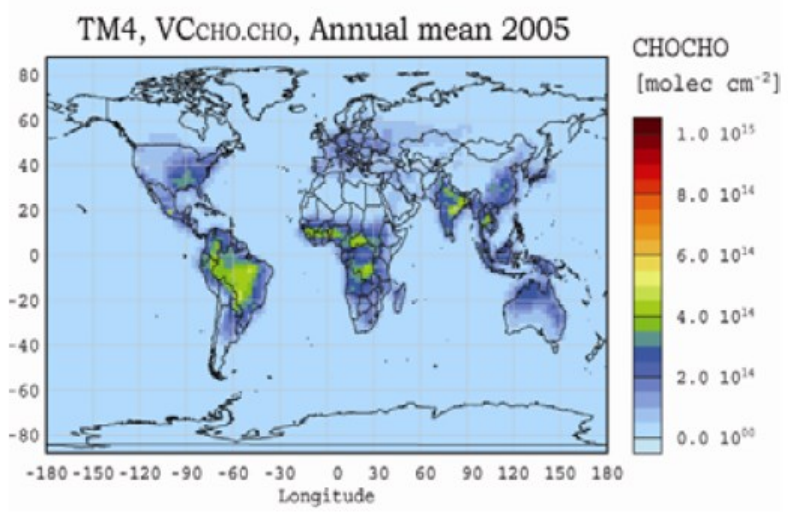
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Myriokefalitakis et al ACP 2008

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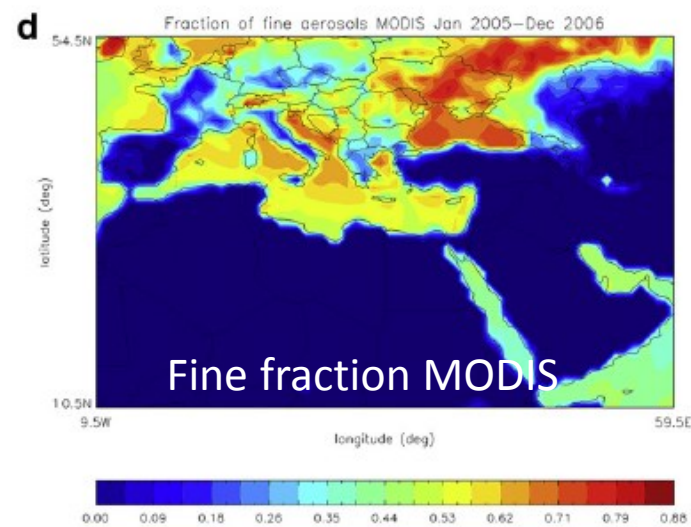
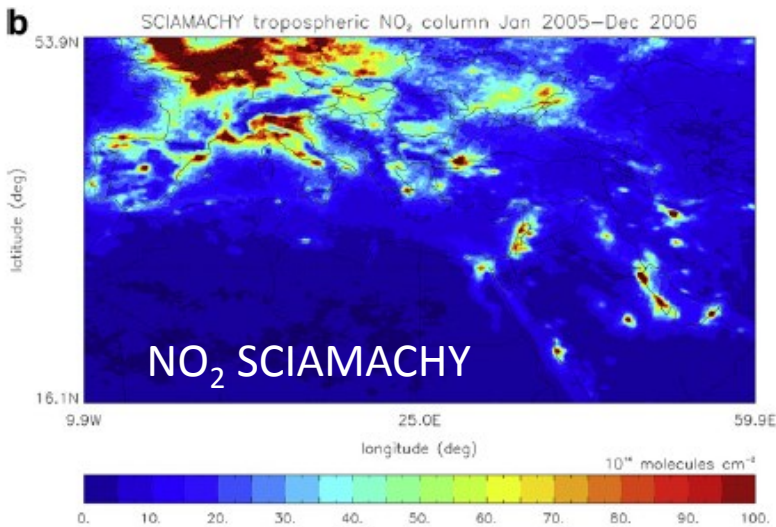
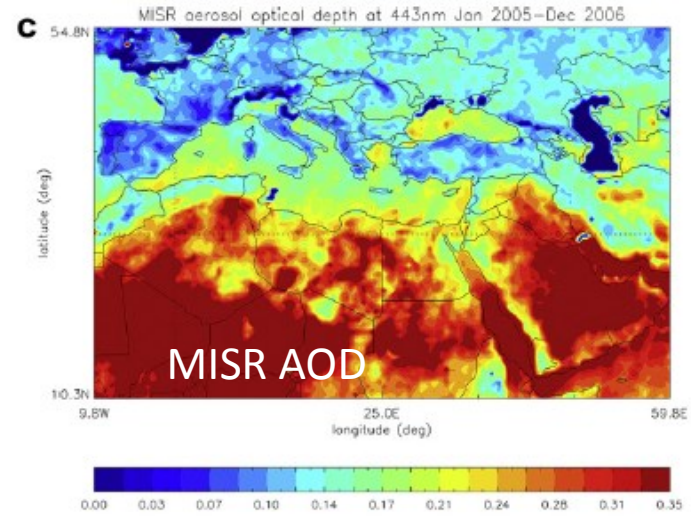
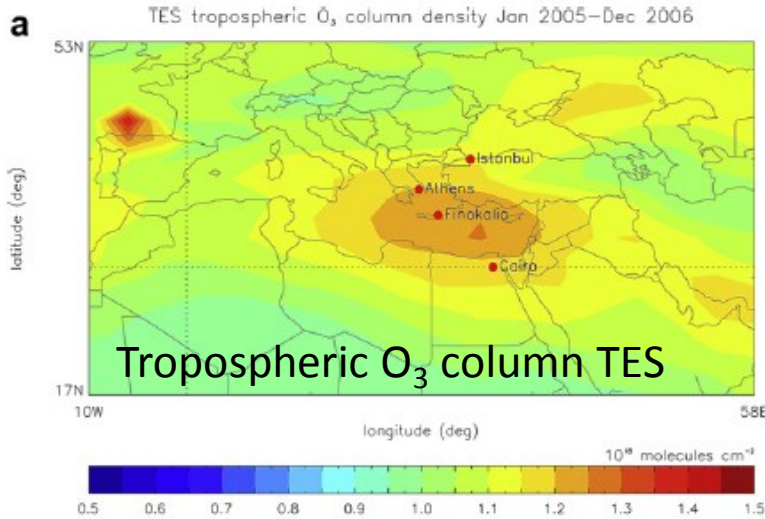


Hot spot East Mediterranean



Receptor and chemical cooker of transported pollution

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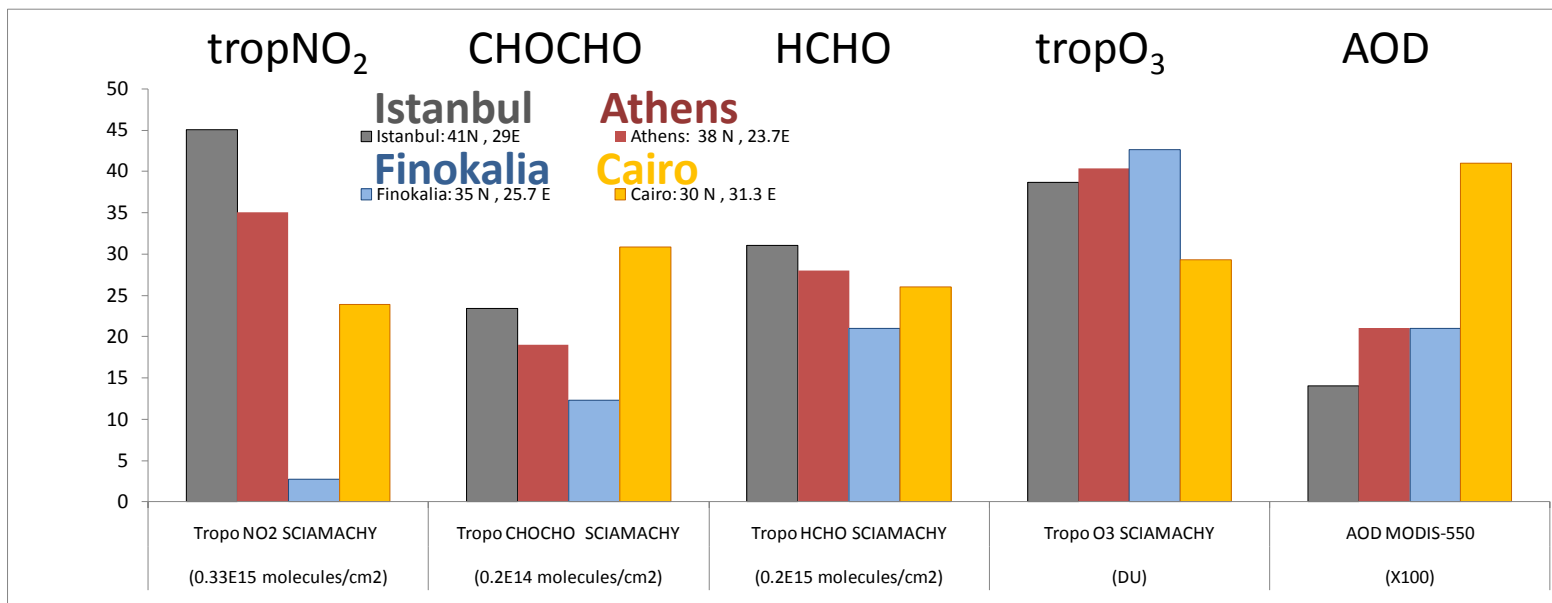




High regional O₃ build up during transport



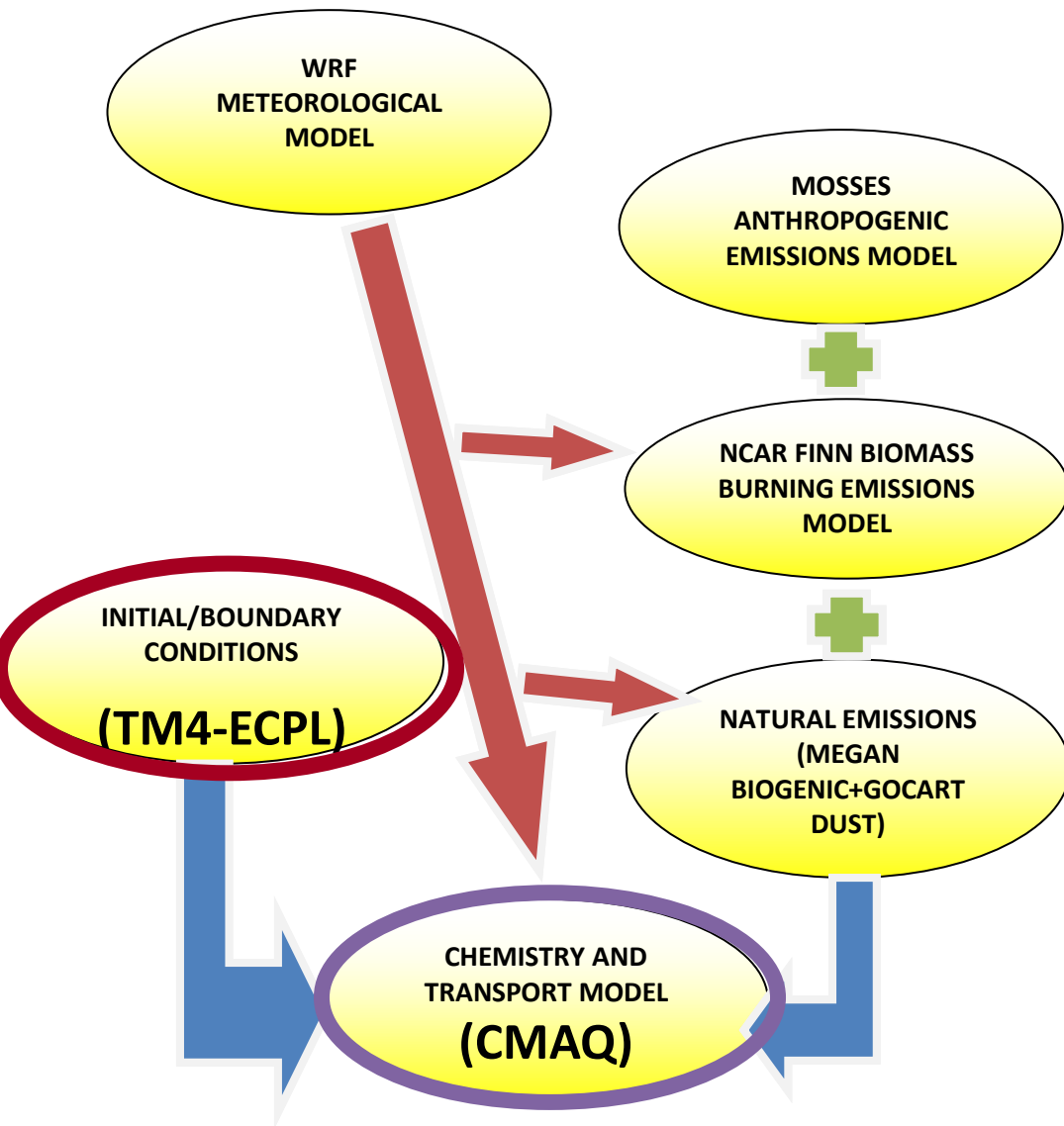
Environmental Chemical Processes Laboratory, Chemistry Dep.
 Univ of Crete, Heraklion, Greece
<http://ecpl.chemistry.uoc.gr>
 mariak@chemistry.uoc.gr
 Maria Kanakidou



2003-2009

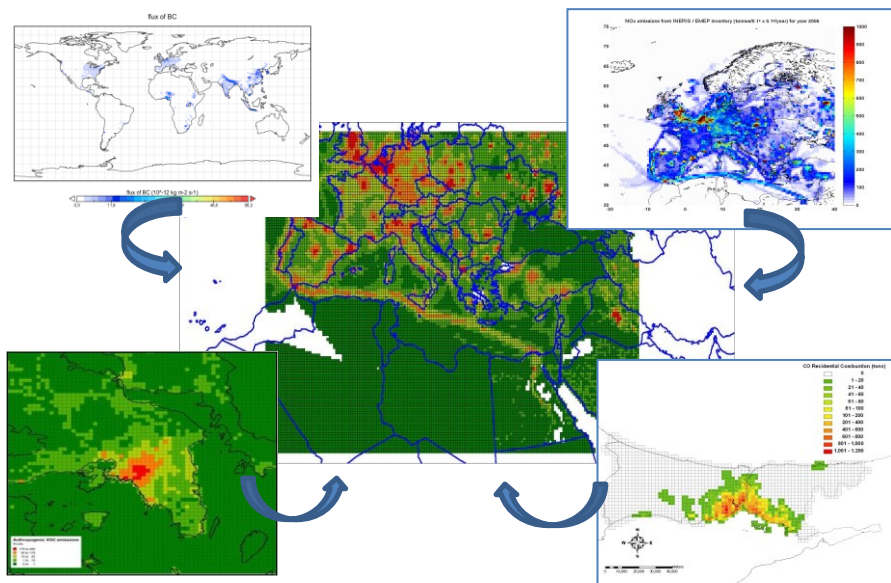
2000-2008

METHODS – MODEL CONFIGURATION



- **CMAQ**
- 171×123×23 grid cells
- 30 km horizontal resolution
- Vertical extent ~16 km (23 layers)
- CB-V chemical mech (*Yardwood et al., 2005*)
- AERO5 aerosol mechanism (*Foley et al., GeosciModDev, 2010*)
- Monthly mean boundary conditions (**TM4-ECPL: *Myriokefalitakis et al., ACP, 2011***)
- Model setup: **WRF/CMAQ *Im and Kanakidou, ACP, 2012***

EMISSIONS in CMAQ



ANNUAL SECTORAL N EMISSIONS

Emission Sectors (tons/yr)	NO _x	NH ₃
Anthropogenic	2E+07	6E+06
Biogenic	2E+02	
Biomass Burning	2E+03	9E+02

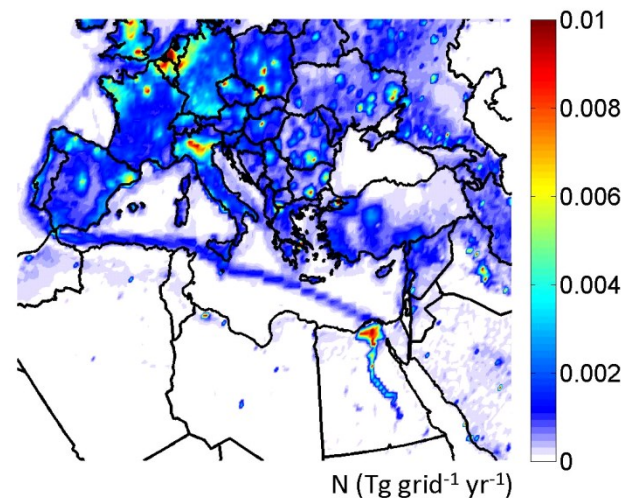
Im et al. (2013) Atmospheric deposition of nitrogen and sulfur over Europe with focus on the Mediterranean and the Black Sea *AtmEnv. Under Review*

Anthropogenic Emissions

- INERIS 10 km inventory for Europe
- CIRCE global emissions for remaining parts around the Mediterranean and Asia (*Pozzer et al., ACP, 2012*)
- 2 km emissions for Istanbul (*Markakis et al., APR 2012*) and Athens (*Markakis et al., WASP & APR, 2010*)

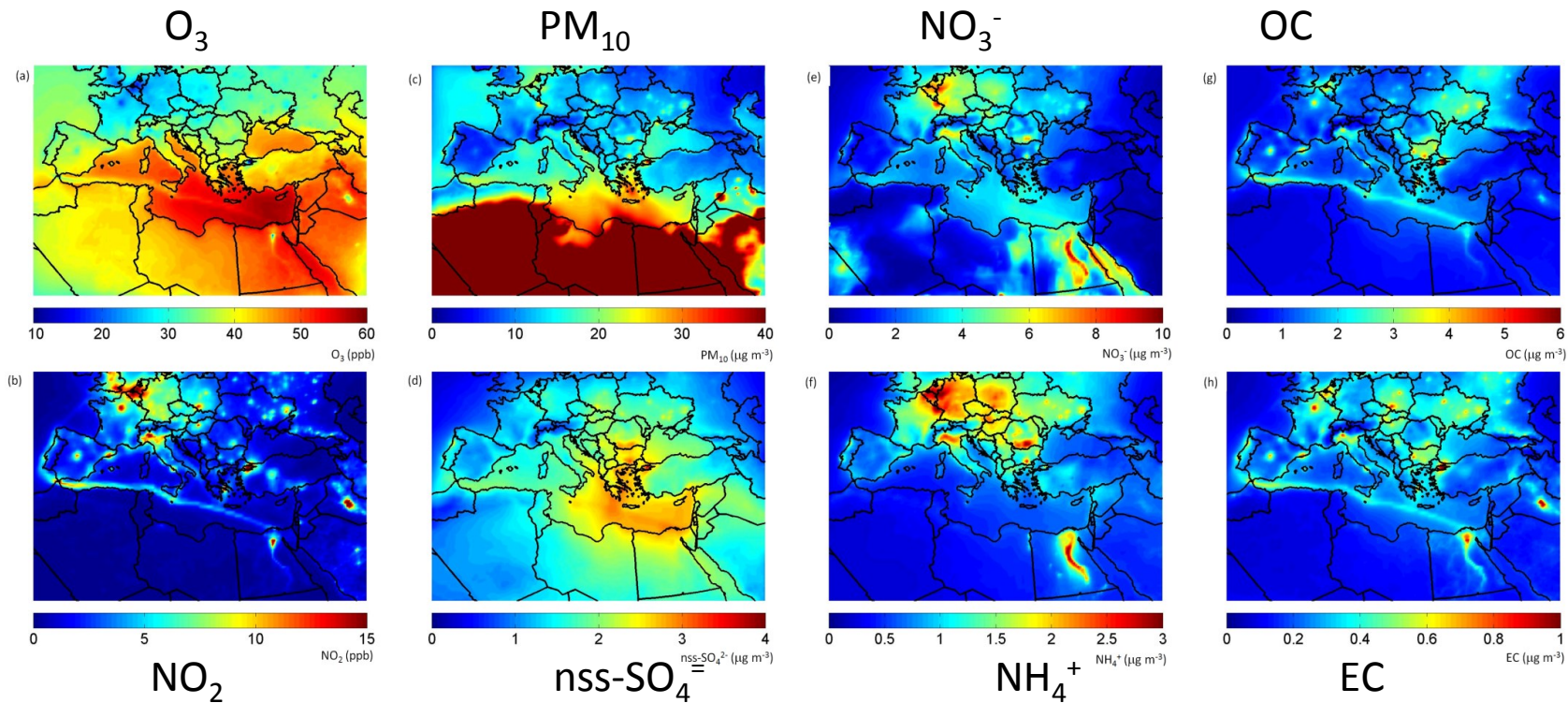


ANNUAL TOTAL N EMISSIONS





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WRF-CMAQ 2008 simulations started in the frame of the CITYZEN project
Im et al submitted to STOENV





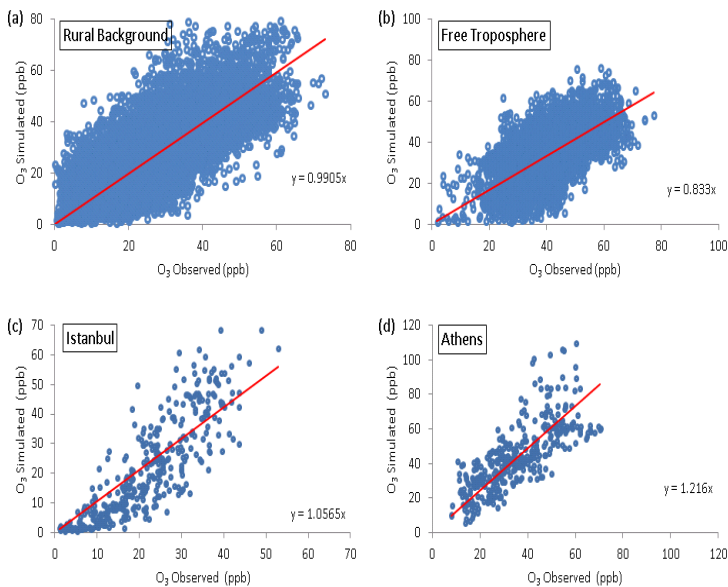
Model evaluation against ground based observations



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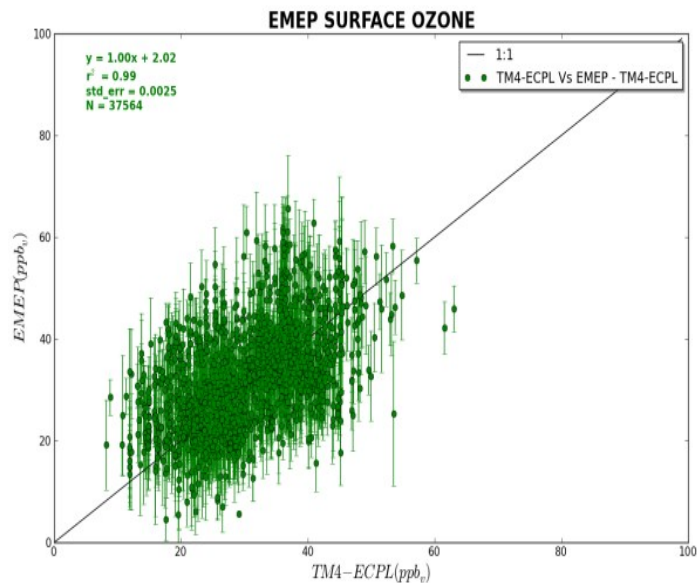
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WRF/CMAQ 2008



Im et al submitted to STOENV 2013

TM4-ECPL 2008



Myriokefalitakis et al to be submitted





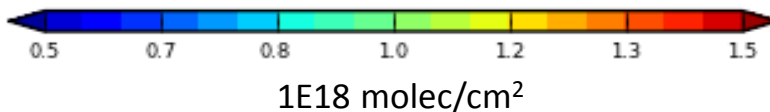
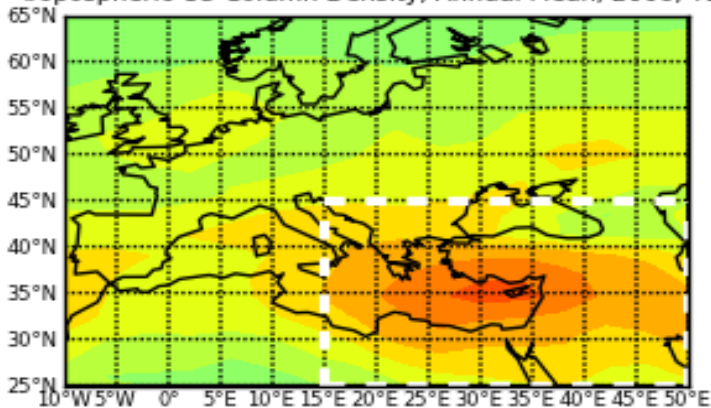
Tropospheric O₃ 2008



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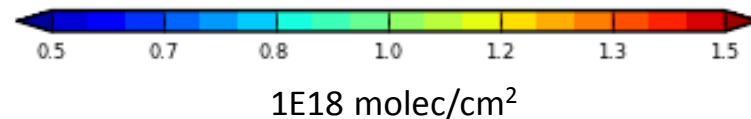
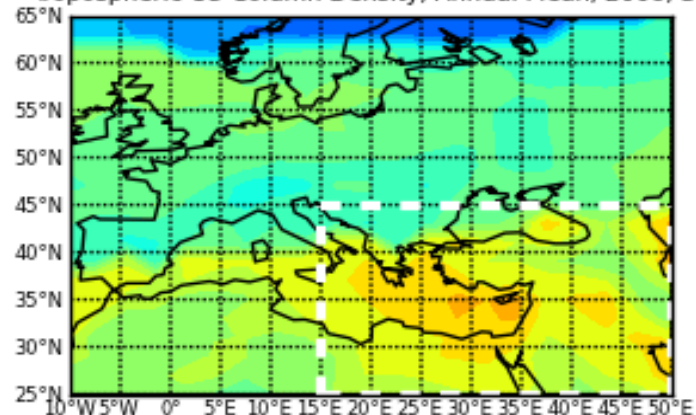
TES 2008 (Giovanni NASA product)

Tropospheric O₃ Column Density, Annual Mean, 2008, TES

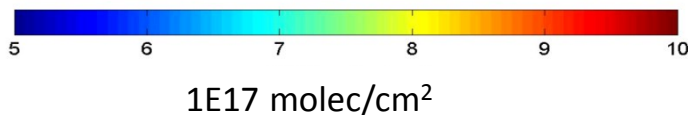
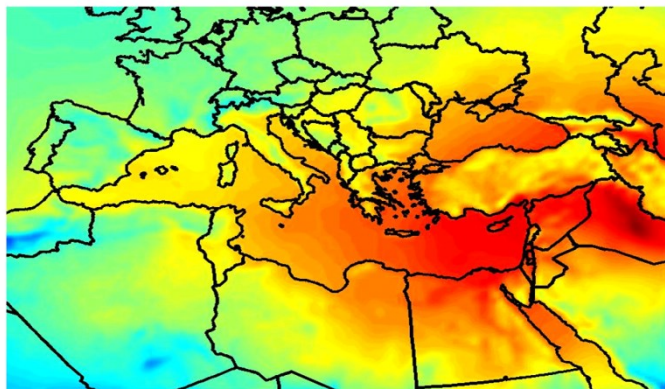


TM4-ECPL 2008

Tropospheric O₃ Column Density, Annual Mean, 2008, 50



CMAQ 2008



Issue the tropopause level

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Vertical Column Density NO₂ 2008

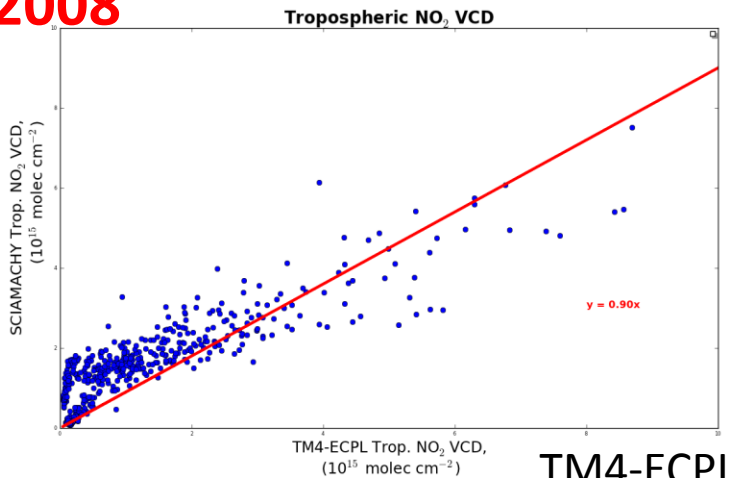


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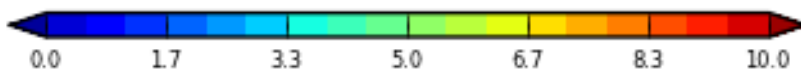
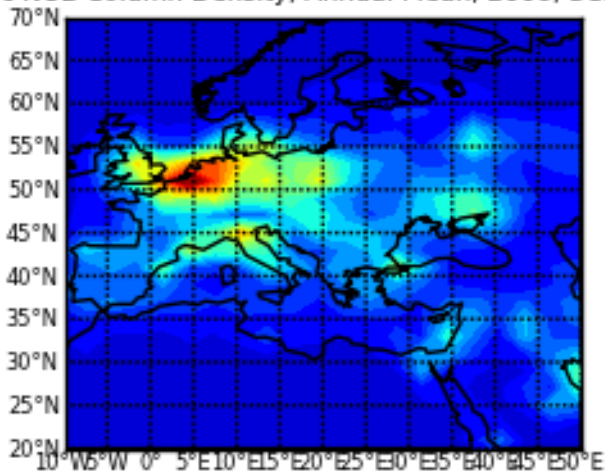
SCIAMACHY



TM4-ECPL

SCIAMACHY in 3x2 deg 2008

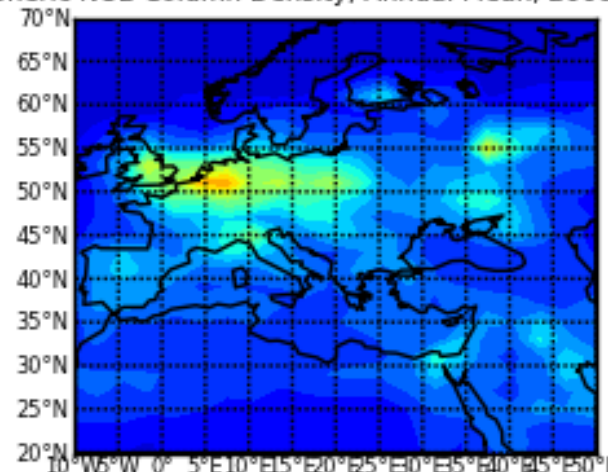
Tropospheric NO₂ Column Density, Annual Mean, 2008, SCIAMACHY (



1e15 molec/cm²

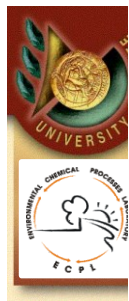
TM4-ECPL in 3x2 deg 2008

Tropospheric NO₂ Column Density, Annual Mean, 2008, TM4-ECPL



1e15 molec/cm²

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Vertical Column Density NO₂ 2008

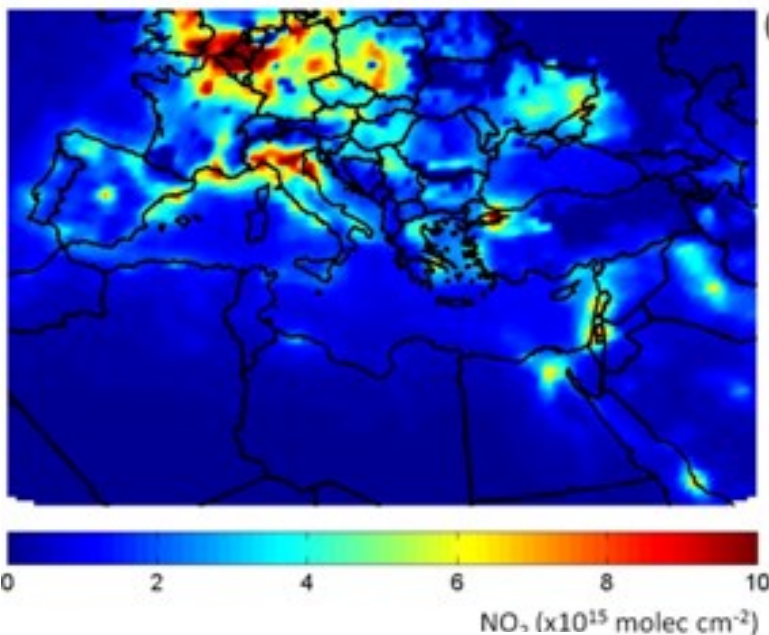


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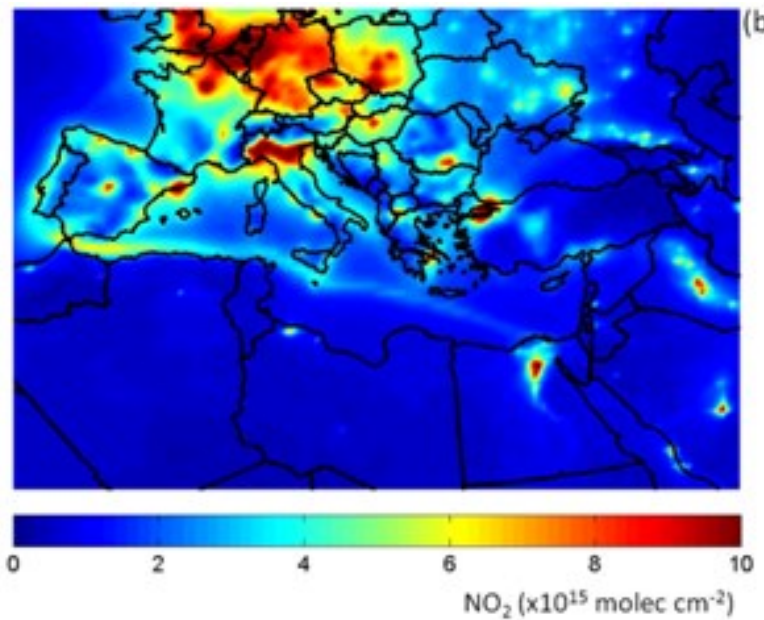
SCIAMACHY 2008



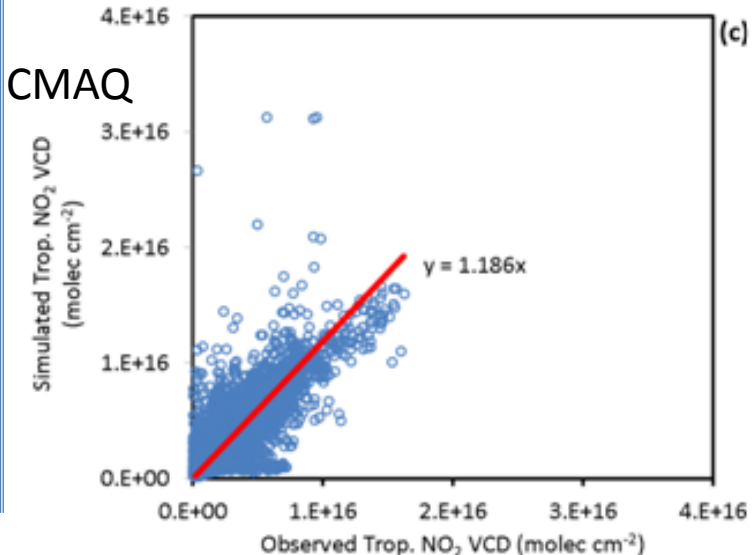
(a)

30x30km

CMAQ 2008



(b)



(c)

SCIAMACHY

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Relatively good agreement but ...

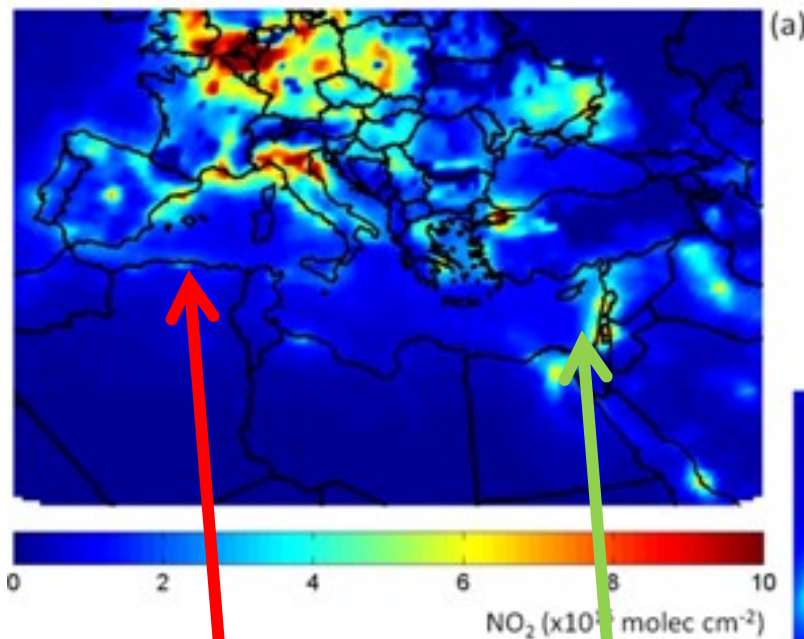


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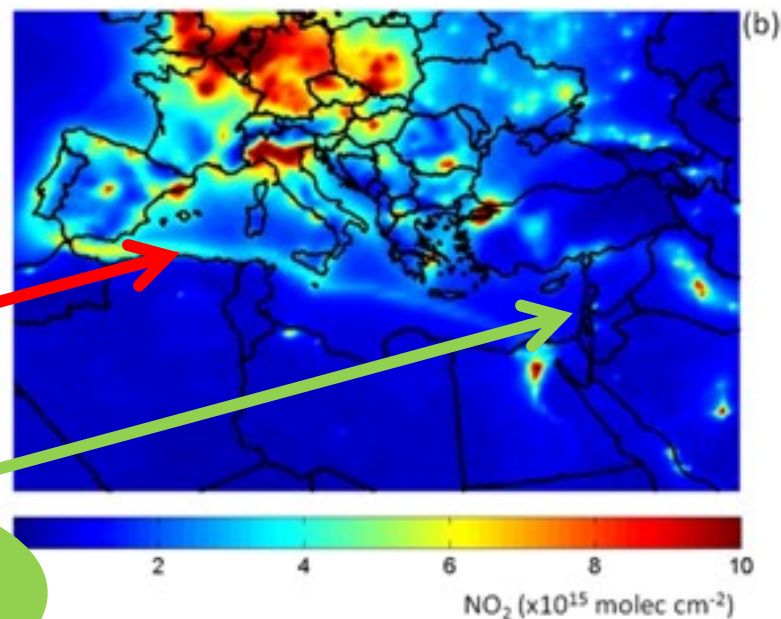


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SCIAMACHY 2008



CMAQ 2008



Shipping track ??

Lebanon + Israel hot spots





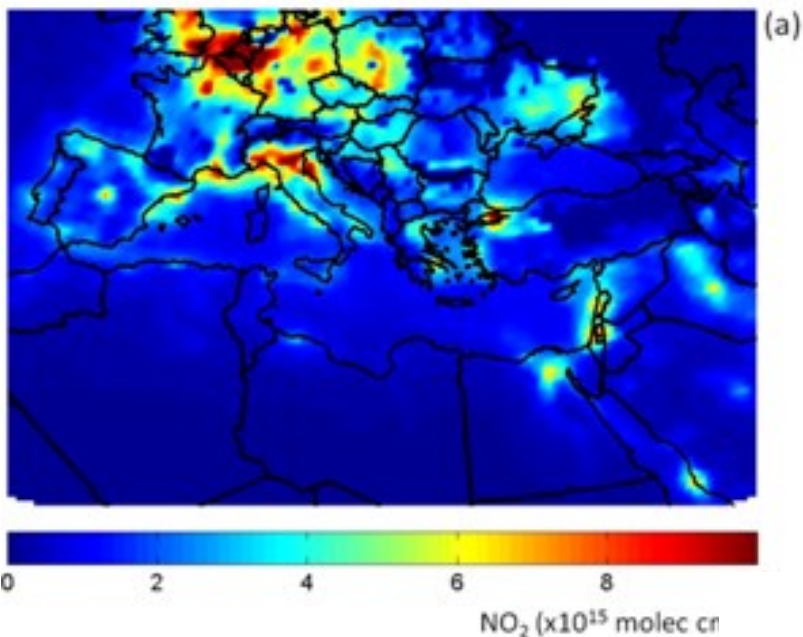
Relatively good agreement but ...



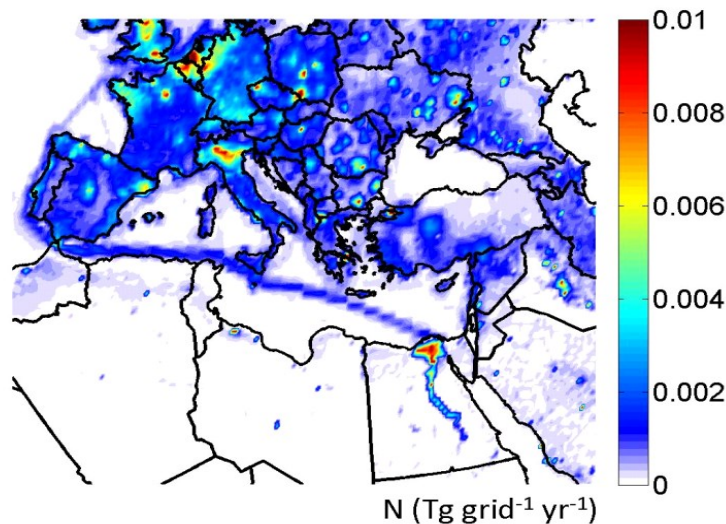
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SCIAMACHY 2008



ANNUAL TOTAL N EMISSIONS



- Clouds next to shipping routes?
- Emission deficiencies ?

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The way forward



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- ✓ Satellites and models provide consistent global pollutant distributions
- ✓ Together can provide information in emission inventory deficiencies
- ✓ inverse modeling → provide emission estimates
- ✓ 'cloud masking of pollution'
- ✓ Vertical profiles and tropopause definition (O_3)
- ✓ To resolve air pollution high spatial and temporal resolution is needed

Thank you

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