Natural VOC Sources and its Contribution to Air Quality in Europe

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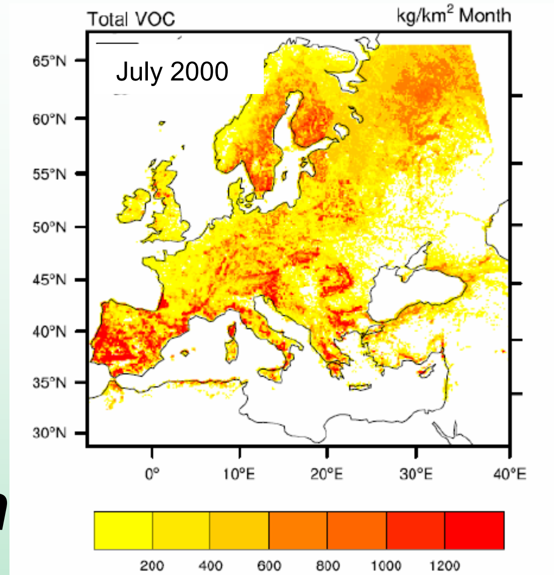
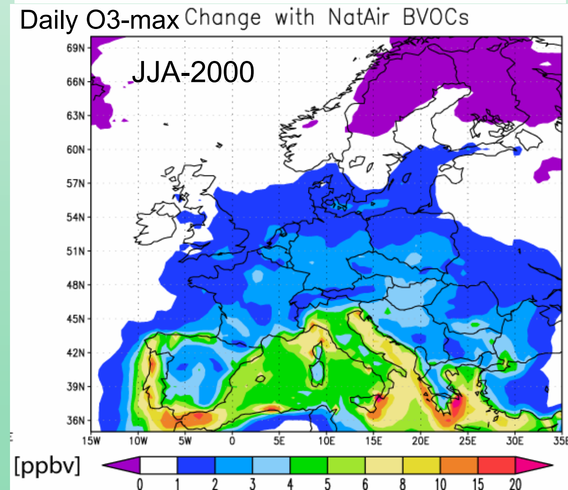




Natural VOC Sources and its Contribution to Air Quality in Europe

Outline

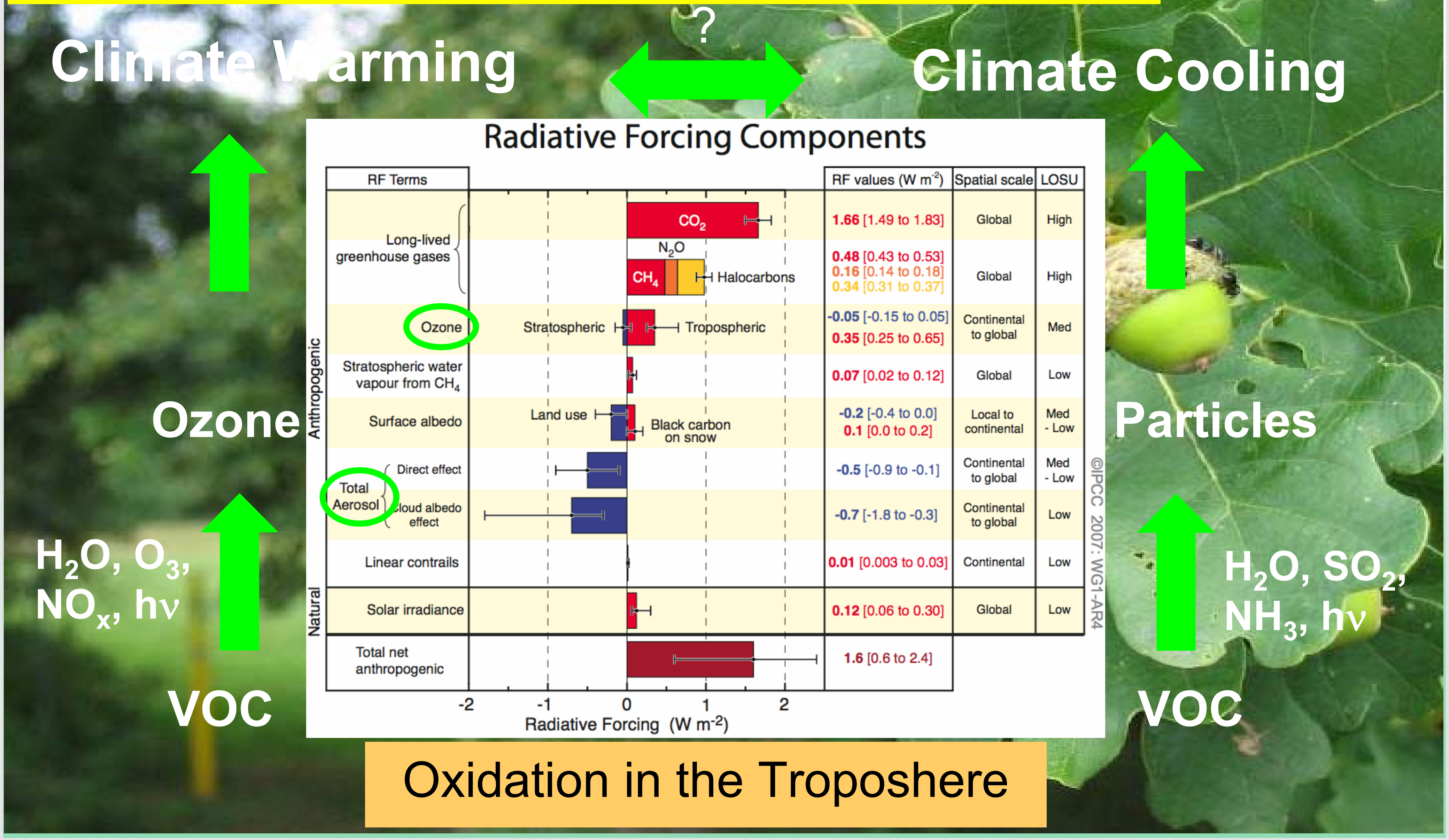
- **Motivation**
- **Modelling Platforms**
- **Natural VOC, Surface Ozone and PM**
- **Uncertainties**
- **Conclusions**

KIT – die Kooperation von Forschungszentrum Karlsruhe GmbH und Universität Karlsruhe (TH)

Forschungszentrum Karlsruhe in der Helmholtz-Gemeinschaft
IMK-IFU

Motivation

Biogenic VOC and Contribution to Climate Change



Oxidation in the Troposhere

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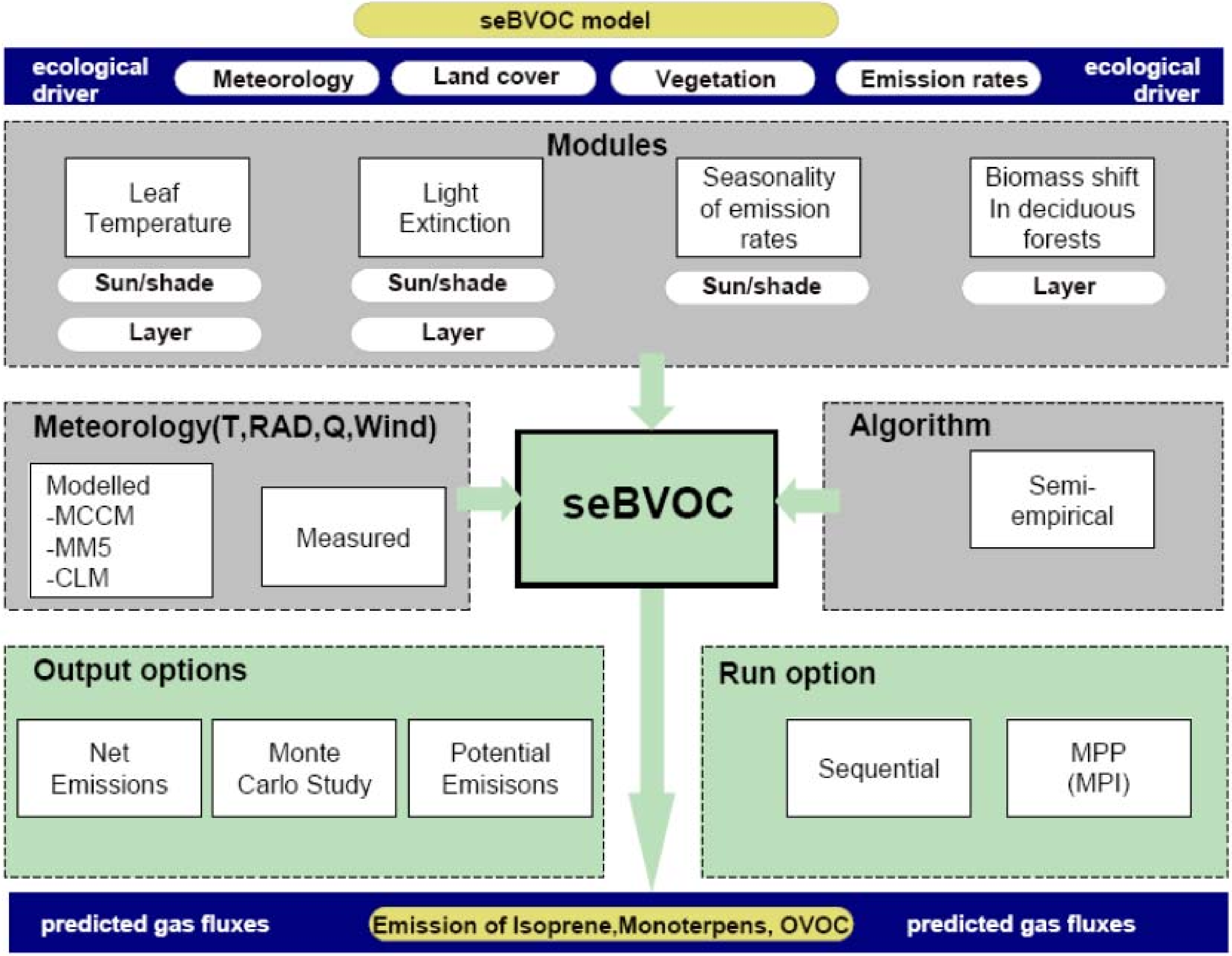
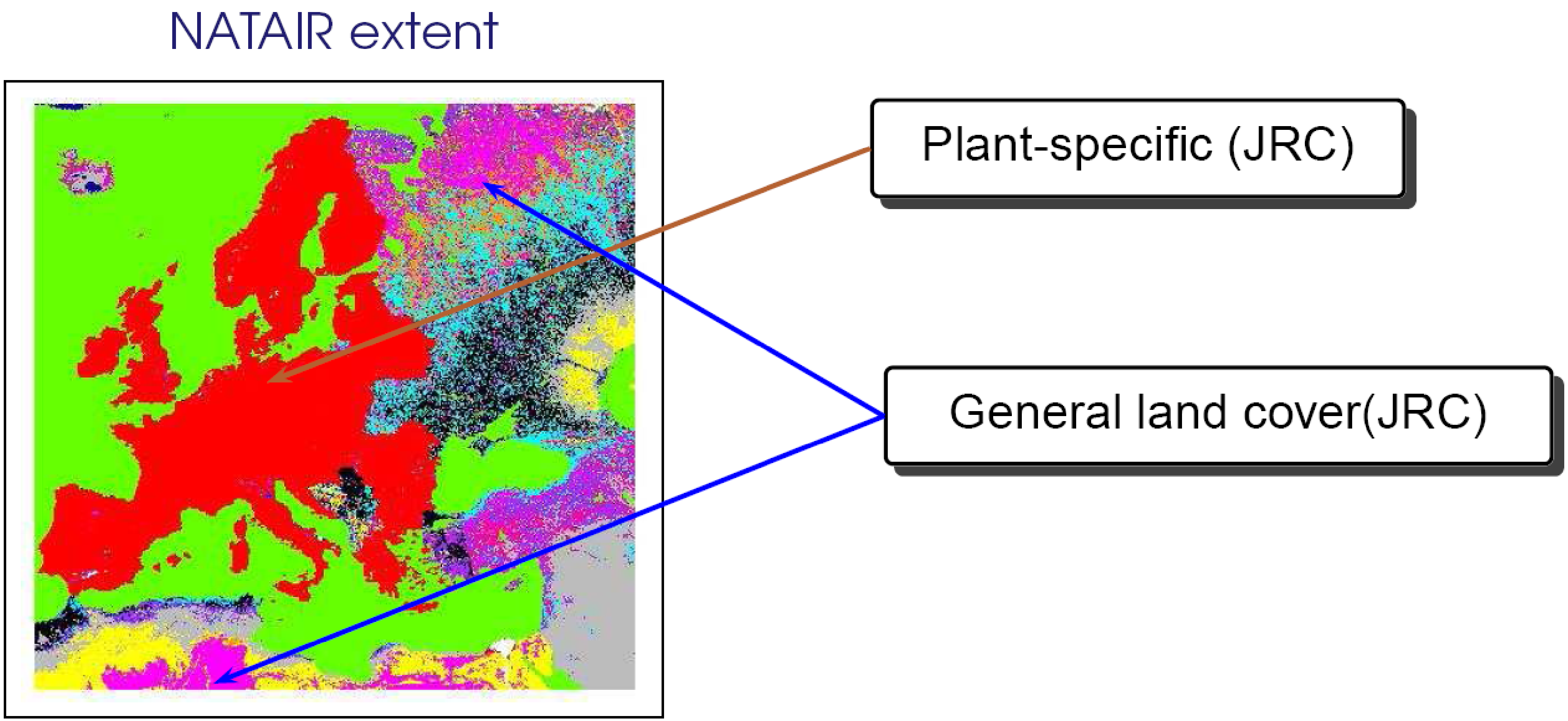
Tools: BVOC Model Platform



Tools: BVOC Model Platform

Land use data



Tools: BVOC Model Platform

Chemical Compound Split:

- isoprene
- monoterpenes:
  α-pinene, β-pinene, d-limonene, α-terpinene, γ-terpinene, camphene, Δ3-carene, myrcene, cymene, trans-β-ocimene, cis-β-ocimene, α-phellandrene, β-phellandrene, sabinene, 1,8-cineol, α-thujene, linalool,
- Sesquiterpene:
  β-caryophyllen,
- oxyVOC:
  methanol, ethanol, formaldehyde, acetaldehyde, acetone, formic acid, acetic acid.

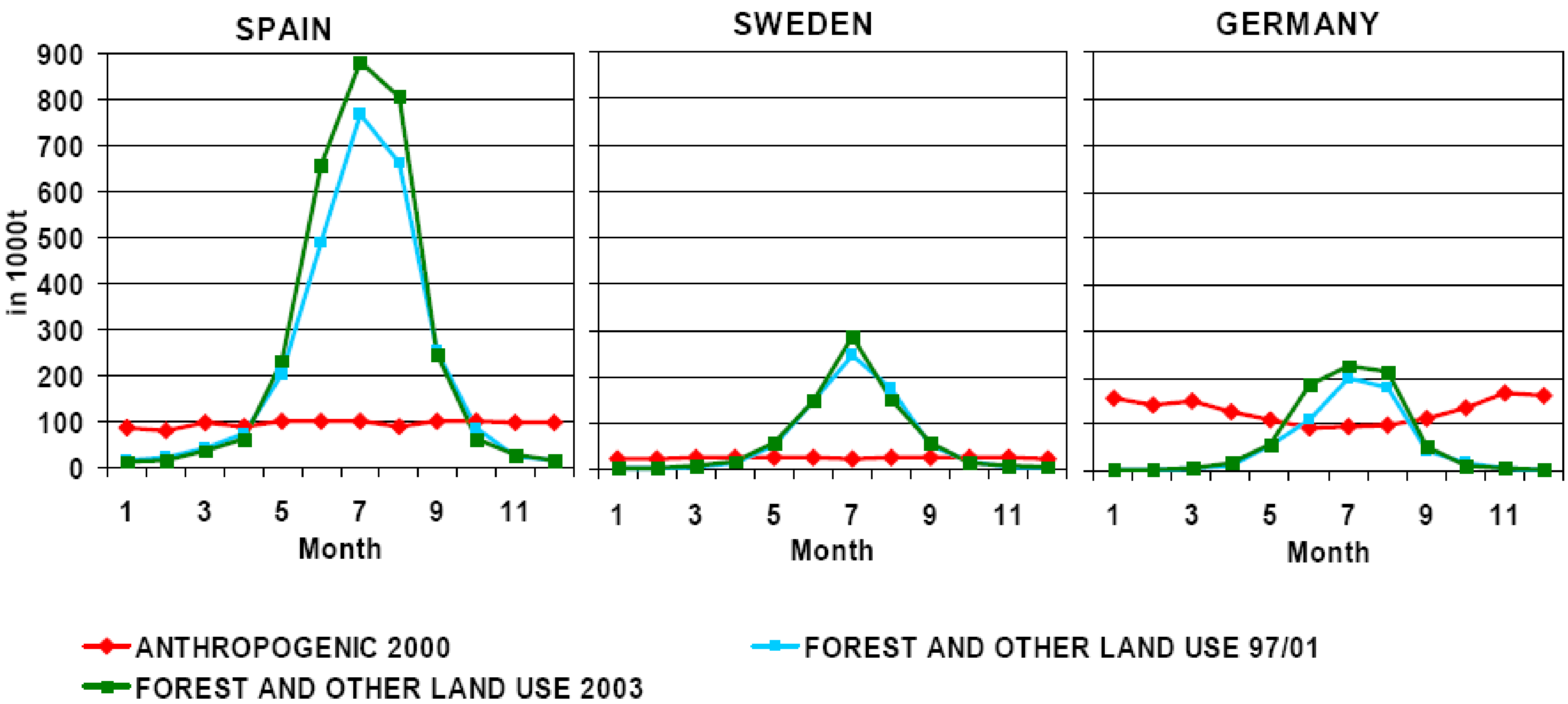
Tools: Chemical Model Platform

The Chimere Chemistry-Transport Model

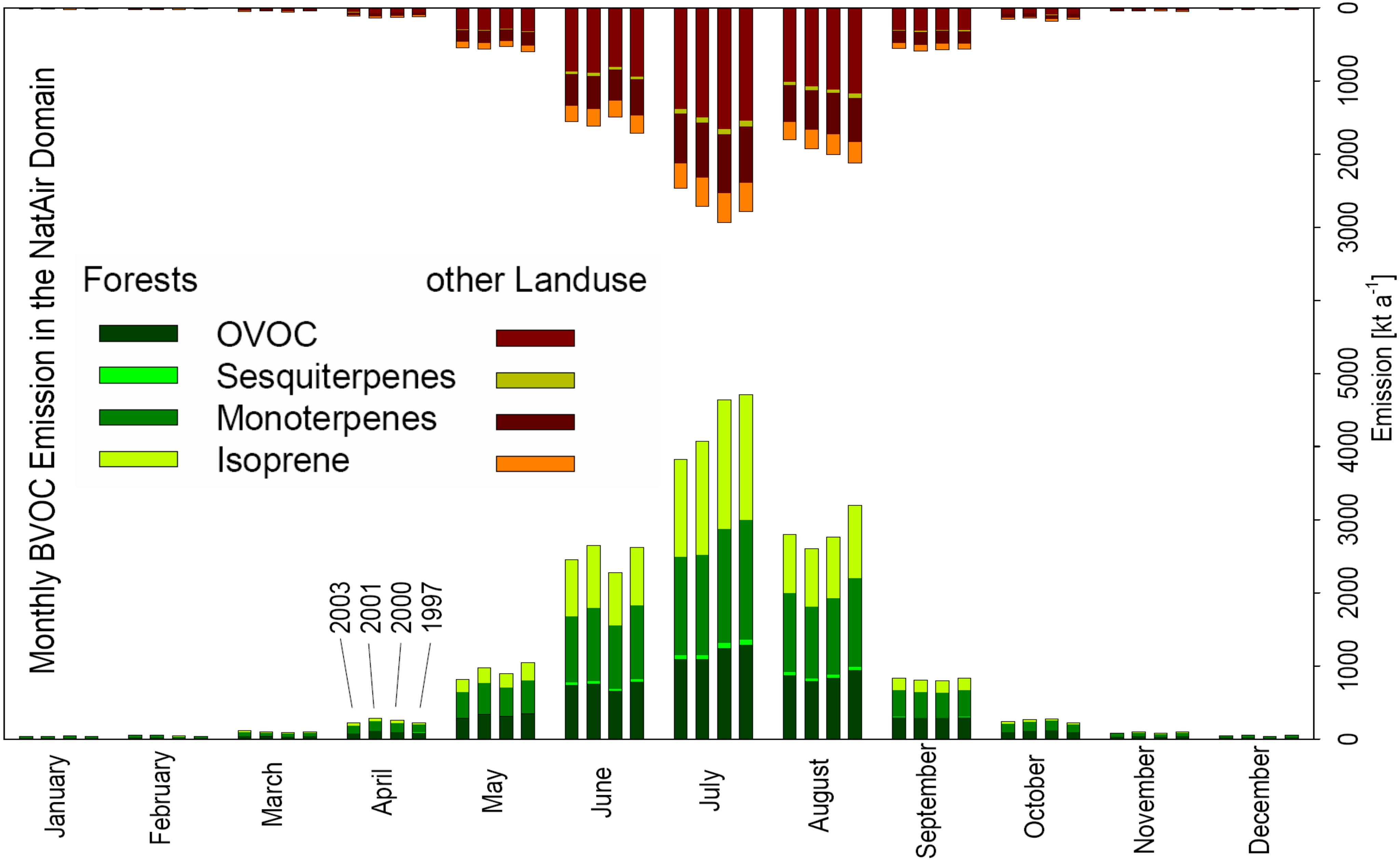
http://www.lmd.polytechnique.fr/chimere

- METEO: MM5 forced by ECMWF (European Centre for Medium-Range Weather Forecasts) analyses by nudging
- DOMAIN: 0.5°x0.5°over Europe
- EMISSIONS
  - Anthropogenic: gas and PM10 (EMEP), EC+OC (Lab. Aérologie)
  - Natural/bio: VOC and NO (NatAir), dust, sea salt,
- BOUNDARY COND.: climatology gas (LMDzINCA, coupled Climate-Chemistry Model) and aerosol (GOCART, Goddard Chemistry Aerosol Radiation and Transport Model)
- CHEMISTRY: full MELCHIOR (Derognat, 2003) (>80 species, >300 reactions, aerosols)

BVOC Emissions vs. Anthro Emissions

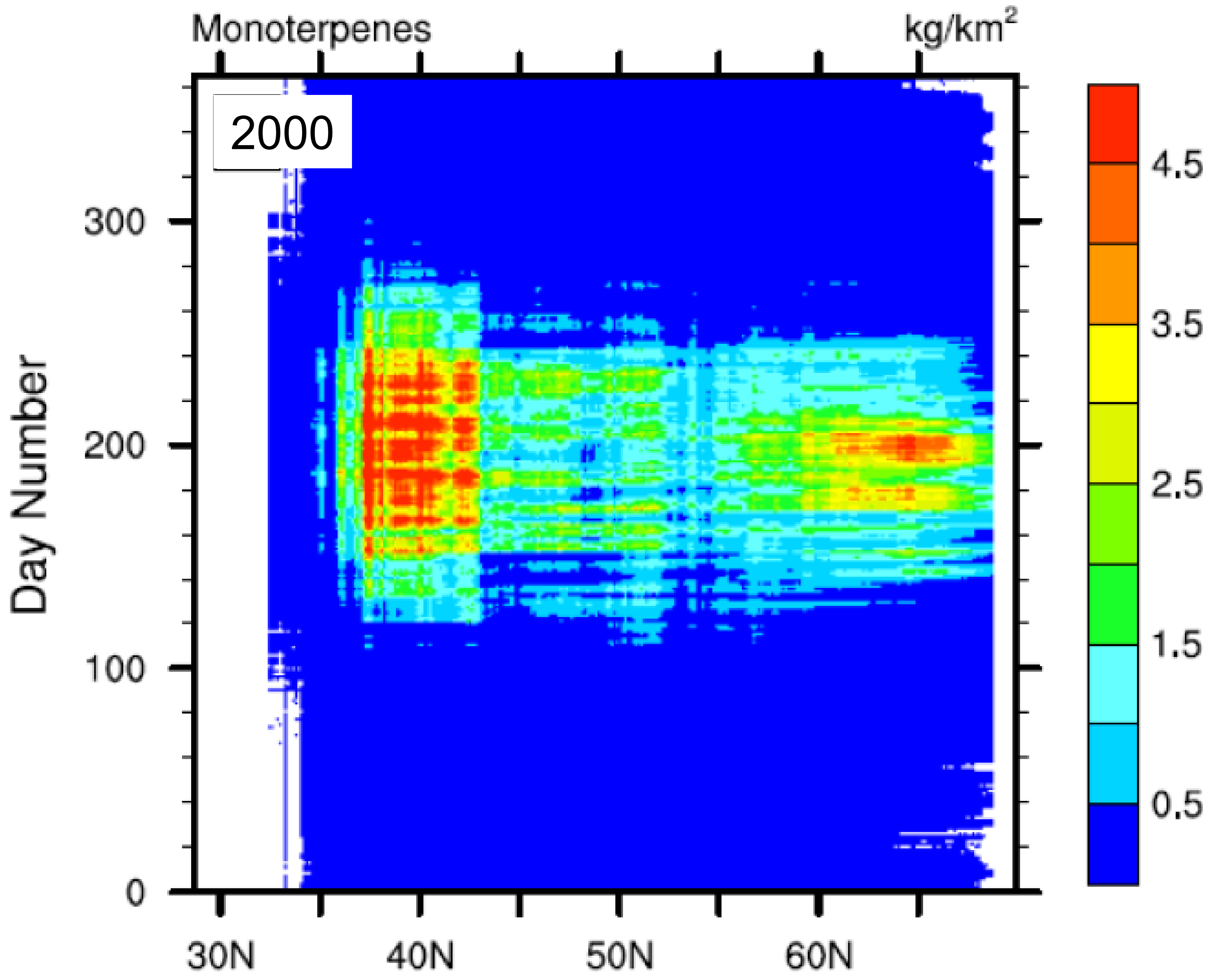


BVOC Emission Split and Annual Variations



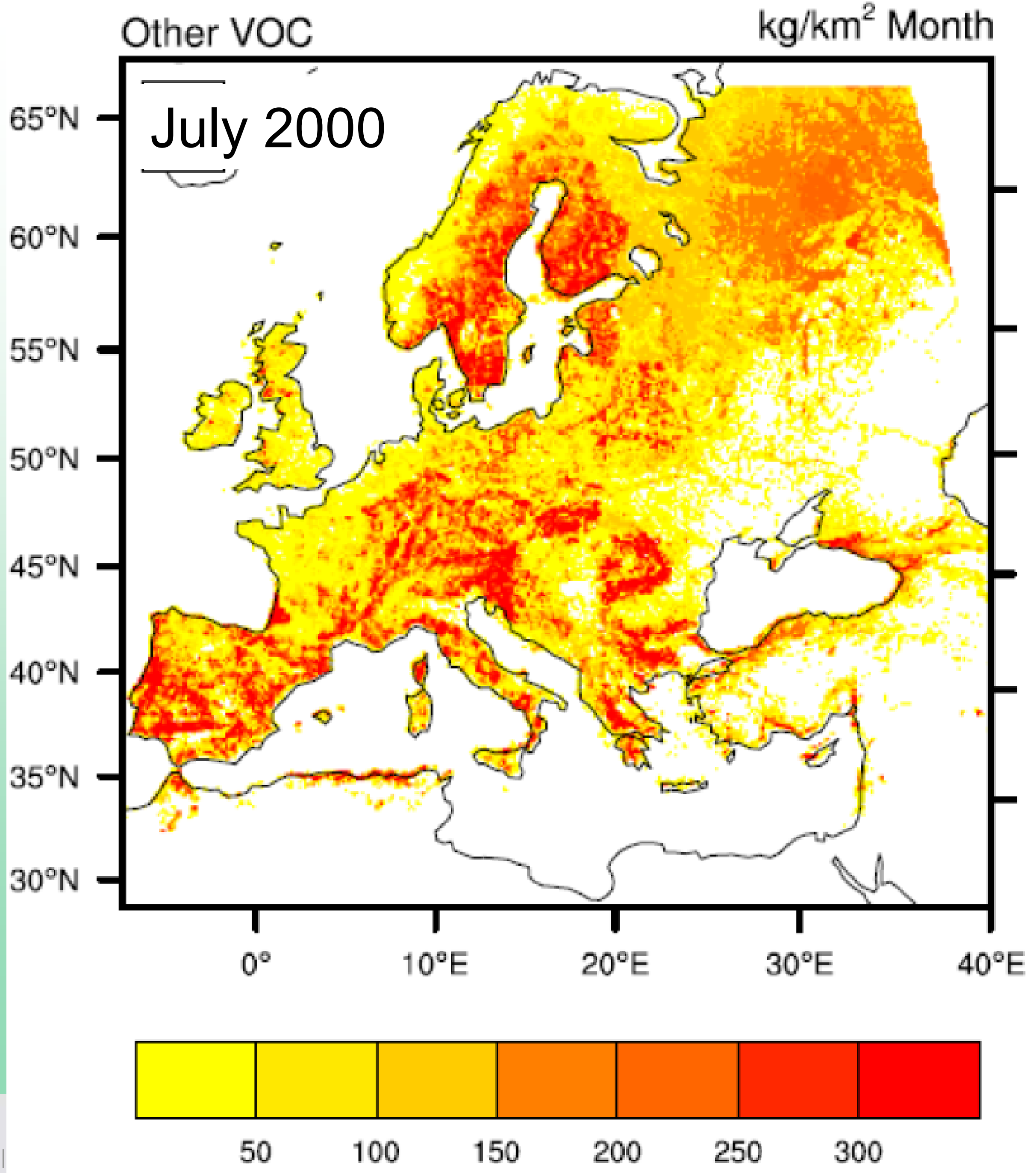
(Steinbrecher, Smiatek et al. 2008)

BVOC Emission and Geographical Variation



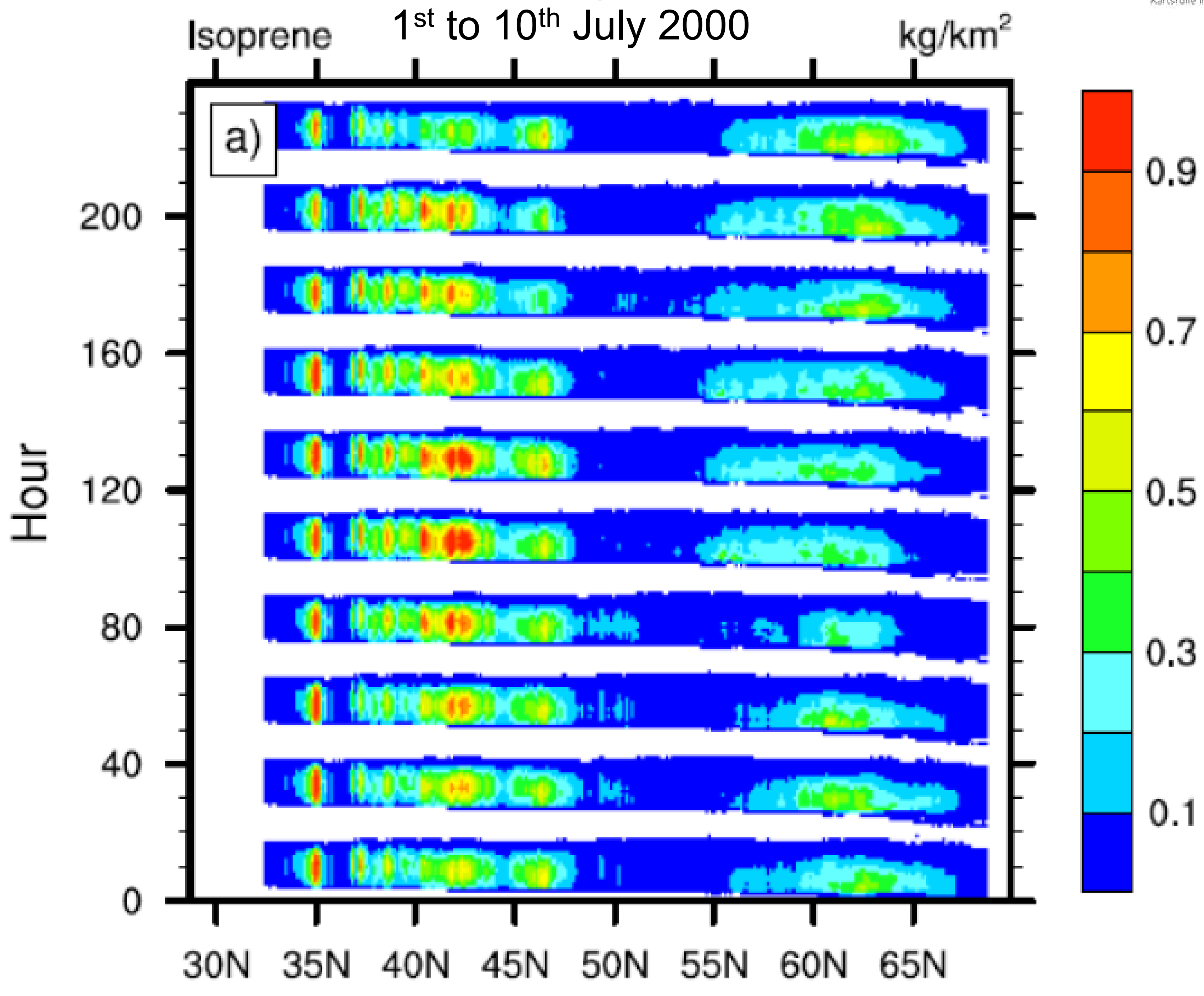
(Steinbrecher, Smiatek et al. 2008)

BVOC Emission and Geographical Variation



(Steinbrecher, Smiatek et al. 2008)

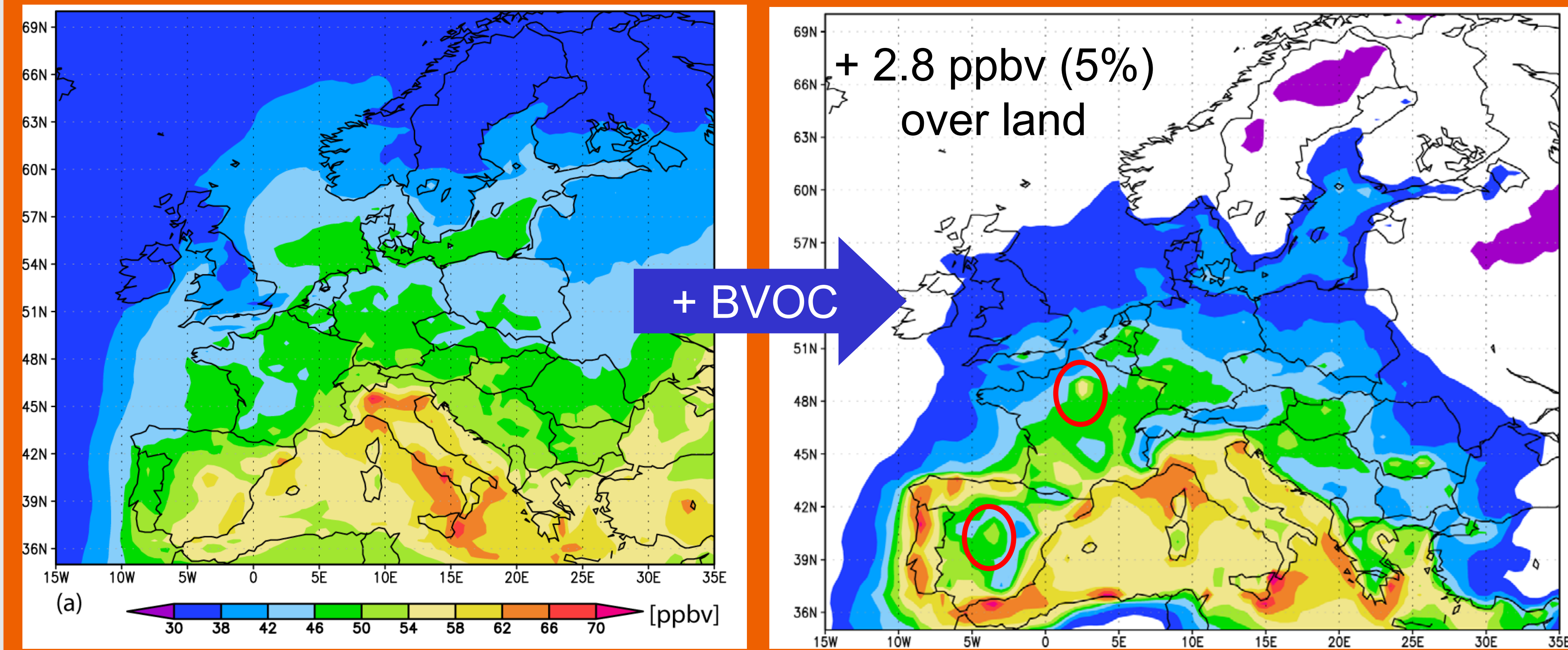
BVOC Emission and Daily Variation



Biogenic VOC and the Atmosphere

NatAir Emissions and Air Quality in Europe in JJA 2003 with CHIMERE

Average O_3 daily max AVOC emissions only | ΔO_3 daily max + BVOC emissions

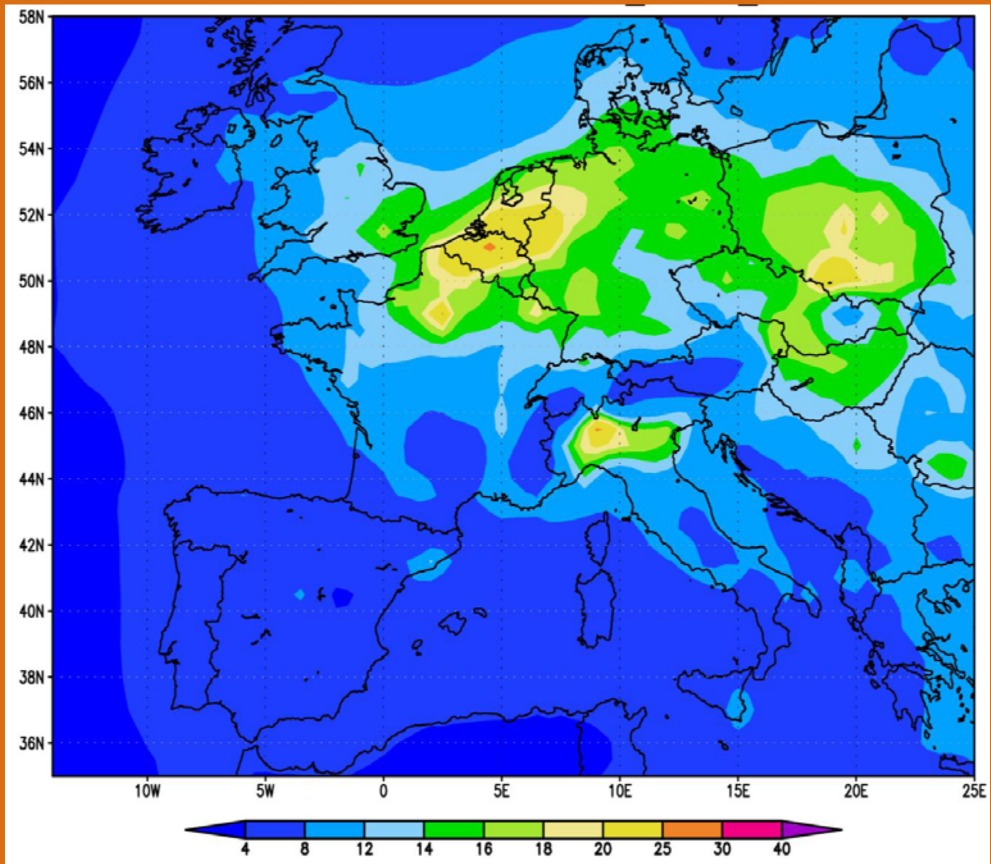


- Large impact in Southern Europe, in Portugal > 15 ppbv
- Large impact also around major metropolitan areas (Curci, Beekmann et al. 2008)

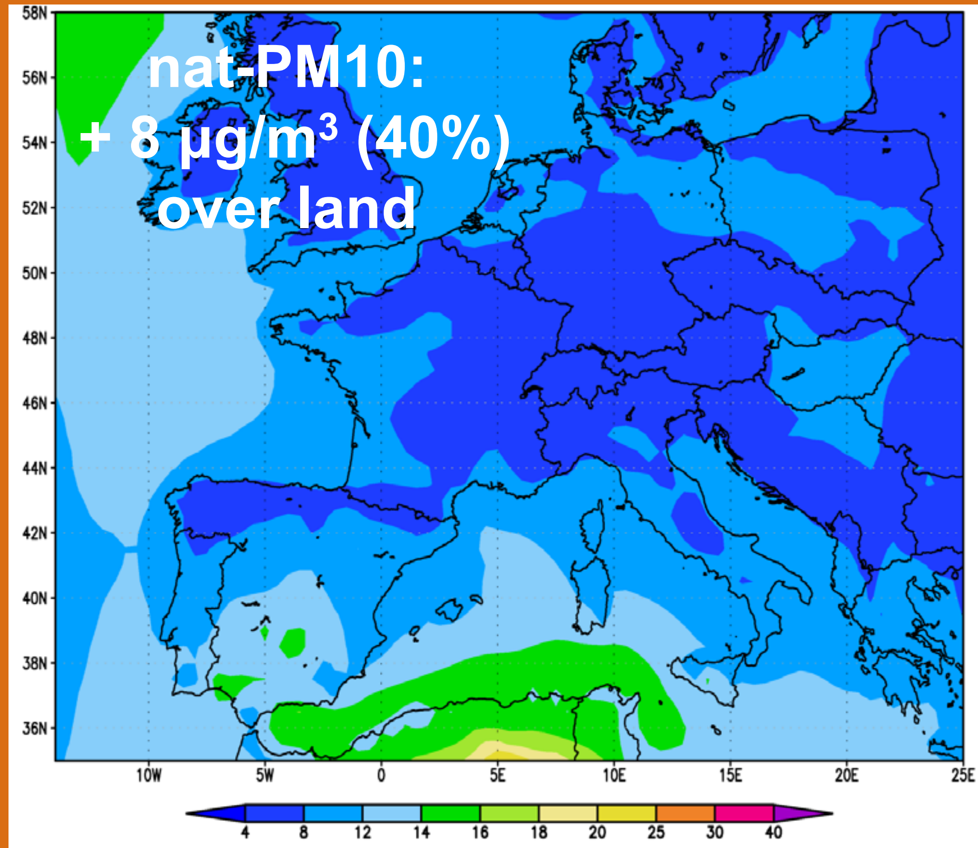
PM10 in the Atmosphere

NatAir Emissions and Air Quality in Europe in 2003 with CHIMERE

Anthropogenic PM10



Natural/Bio PM10

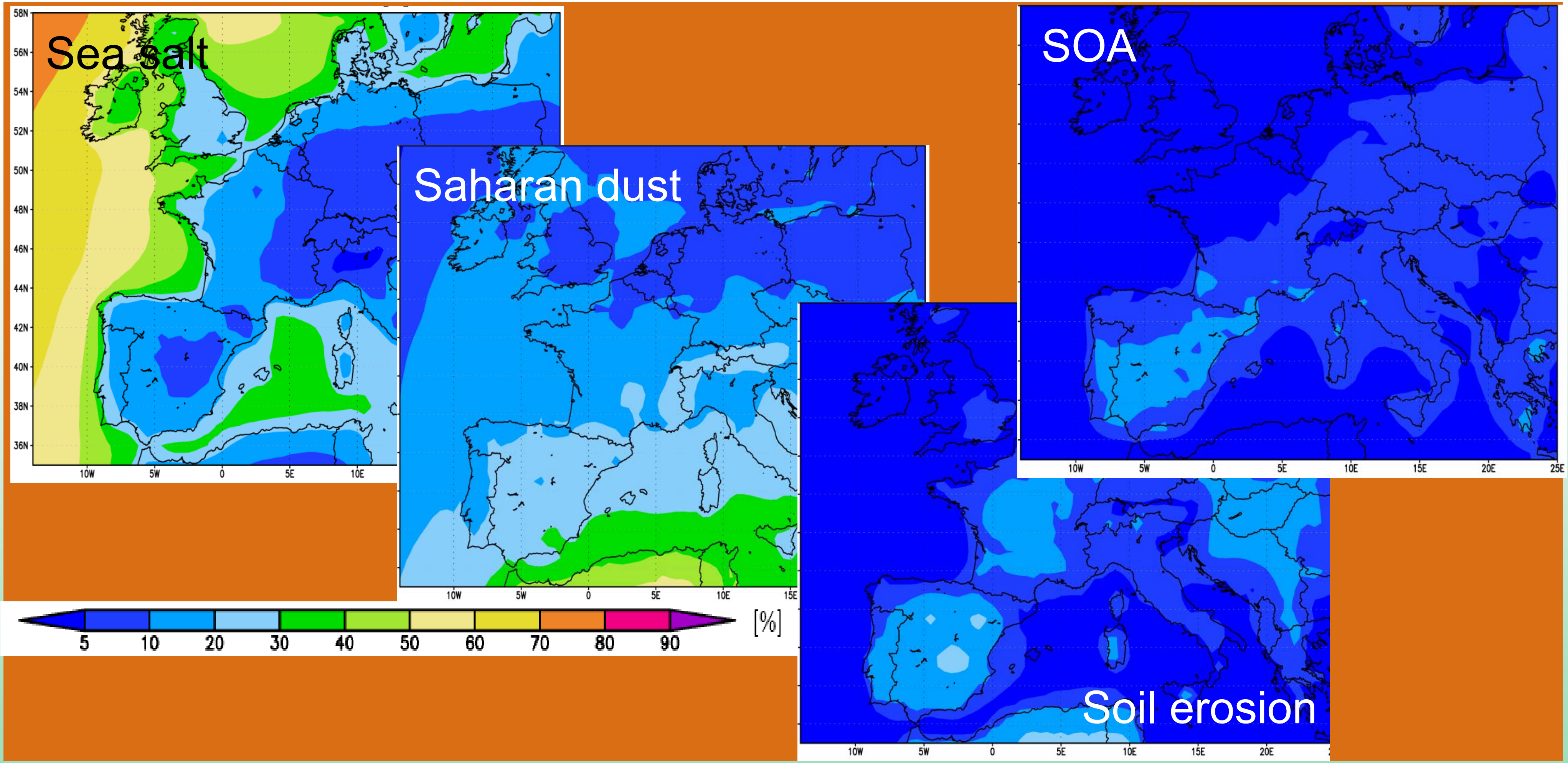


- **Large impact in Southern Europe, > anthropoginc PM10**
- **Largly decoupled from anthropoginc PM10**

(Curci, Beekmann et al. 2008)

PM10 in the Atmosphere

Fractional contribution of natural/bio sources to PM10 in 2003

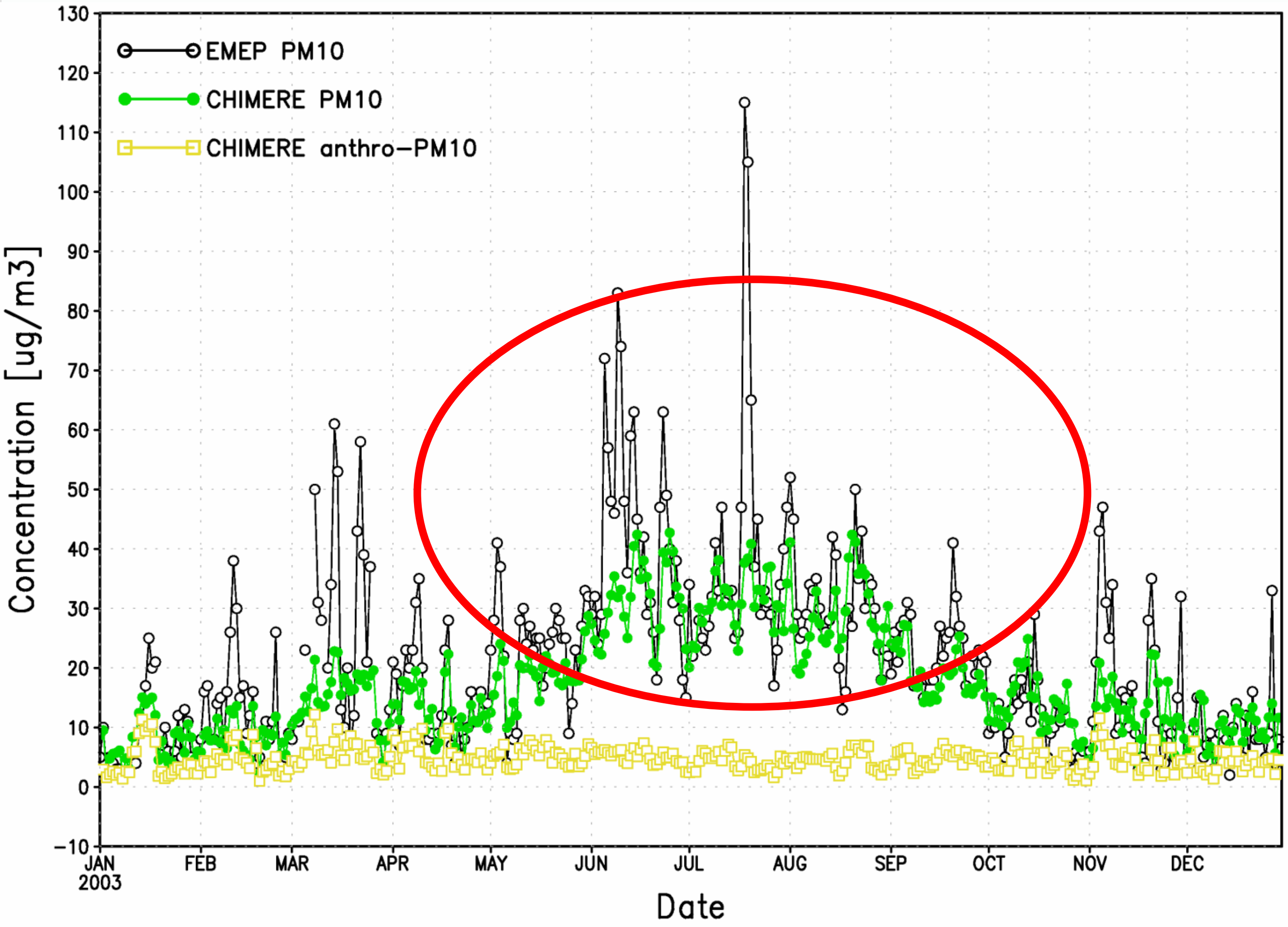


- PM10 sea salt up to 40% of PM10 at coastal sites.
- Saharan dust >20% in Southern Europe.
- Secondary Organic Aerosols (SOA) <10%, except in Spain.

(Curci, Beekmann et al. 2008)

PM10 in the Atmosphere

Simulation and Observation in Southern Spain (La Cartuja) in 2003

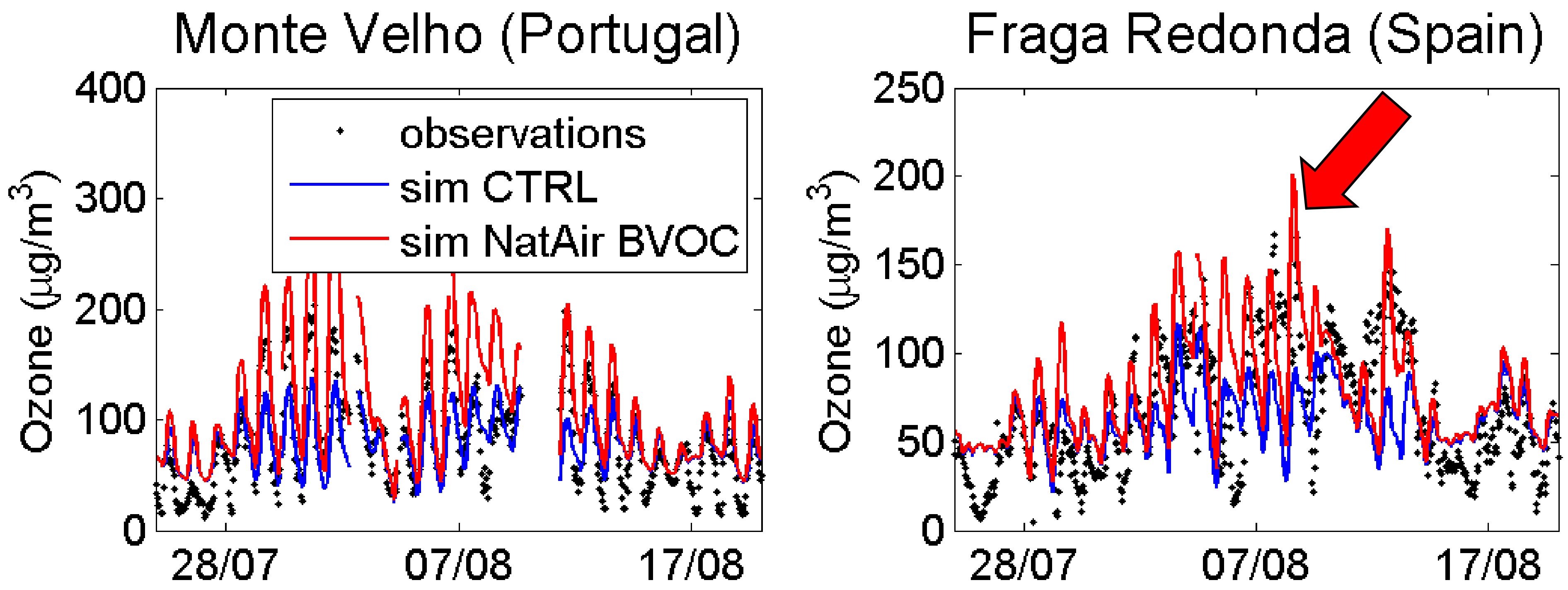


Very large contribution in Southern Spain: **up to 35 µg/m³ (>80%)** during summer due to SOA from BVOC oxidation

(Curci, Beekmann et al. 2008)

Ozone in the Atmosphere

Simulations vs. Observations



Very large episodic contribution of BVOC to hourly ozone: **up to 100 µg/m³(~50 ppbv)** for one extreme case in Spain during August 2003!

Uncertainties: O_3 and PM10
Simulations vs. Observations

Performances:
against 2003 EMEP ground based measurements

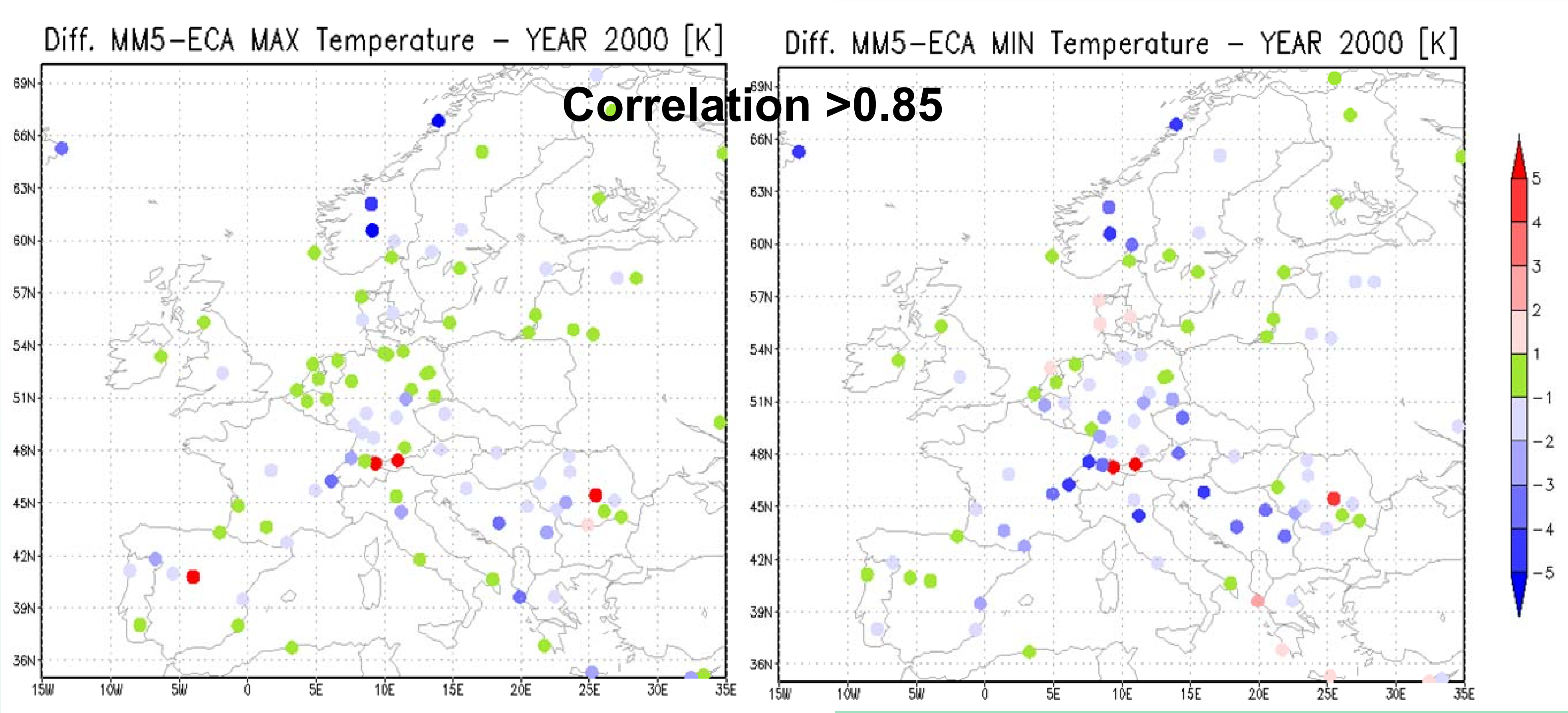
- O_3: 1-h: bias +5 ppbv, RMSE 20 ppbv, correlation 0.75
- PM10: 24-h: bias -0.3 µg/m^3, RMSE 10 µg/m^3, correlation 0.65

Uncertainties: Temperature

BIAS

MAX TEMP **MIN TEMP**

Correlation >0.85



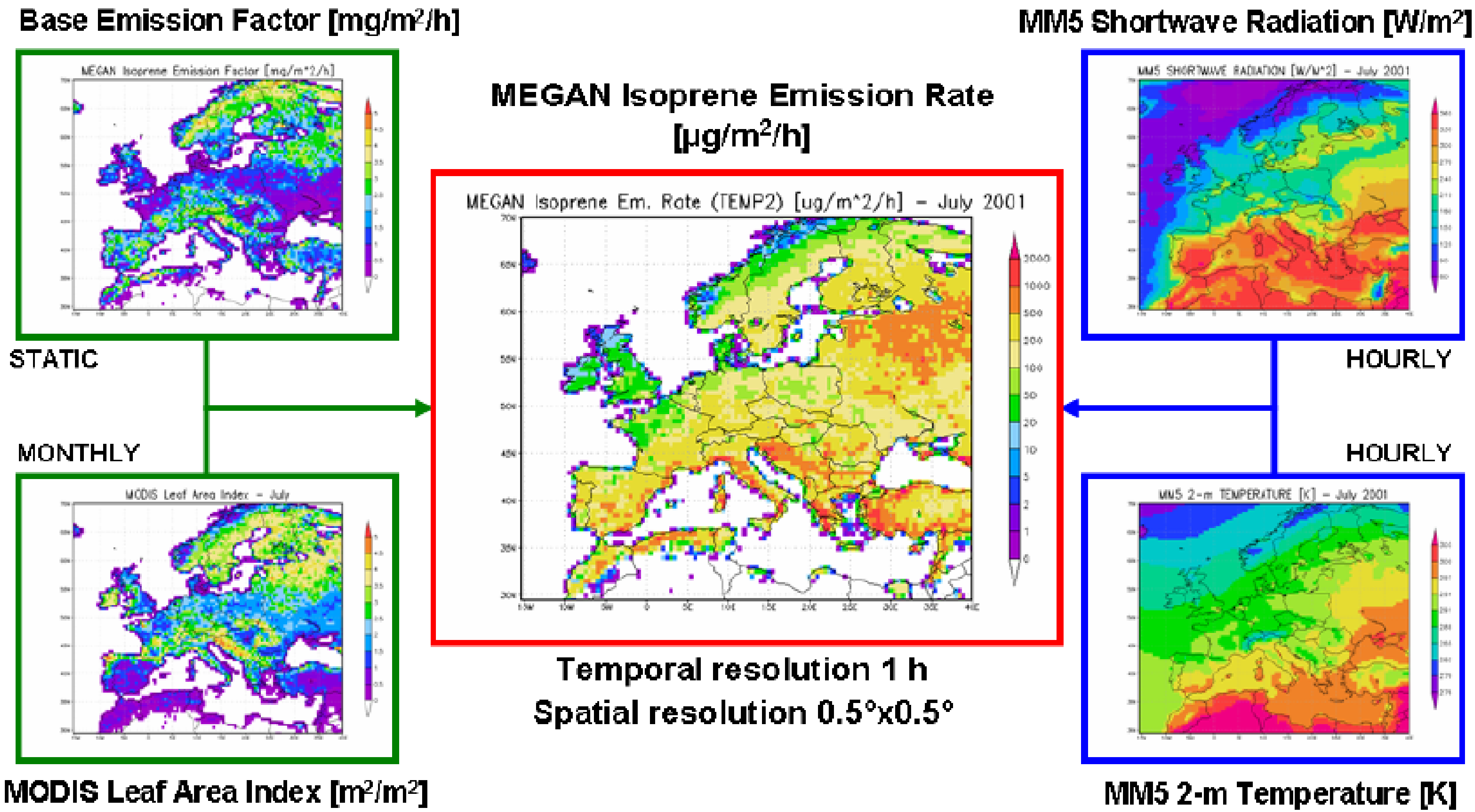
Temperatures slightly underestimated

MAX generally better than MIN

European Climate Assessment & Dataset (ECA&D) project (http://eca.knmi.nl/)

Uncertainties: BVOC Emission

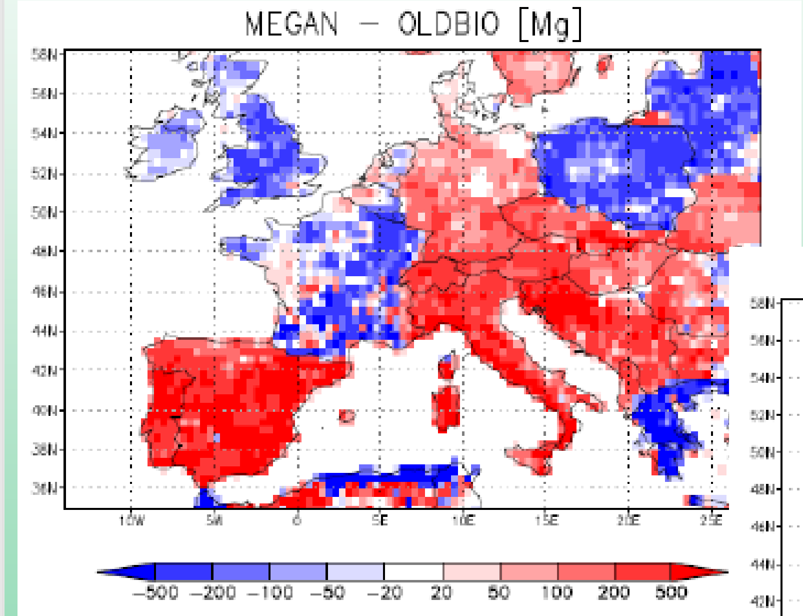
Model inter-comparison: MEGAN (Guenther 2007), OLDBIO (Simpson et al. 1999)

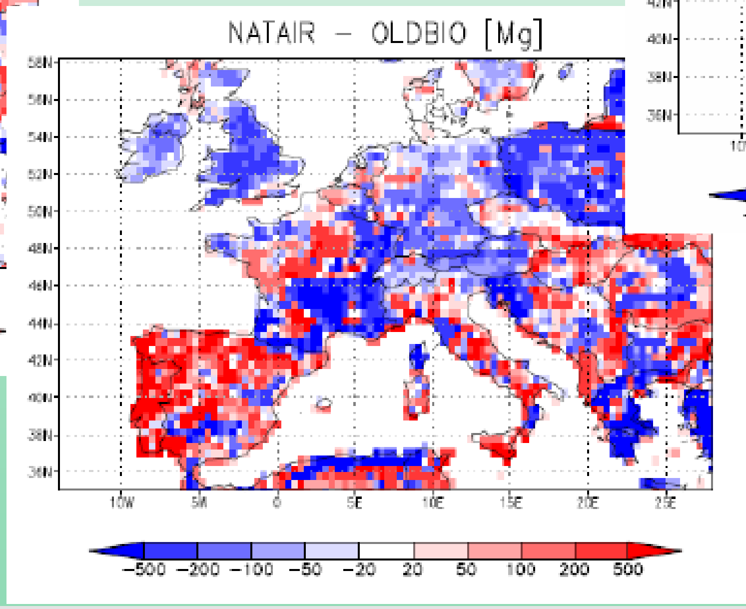


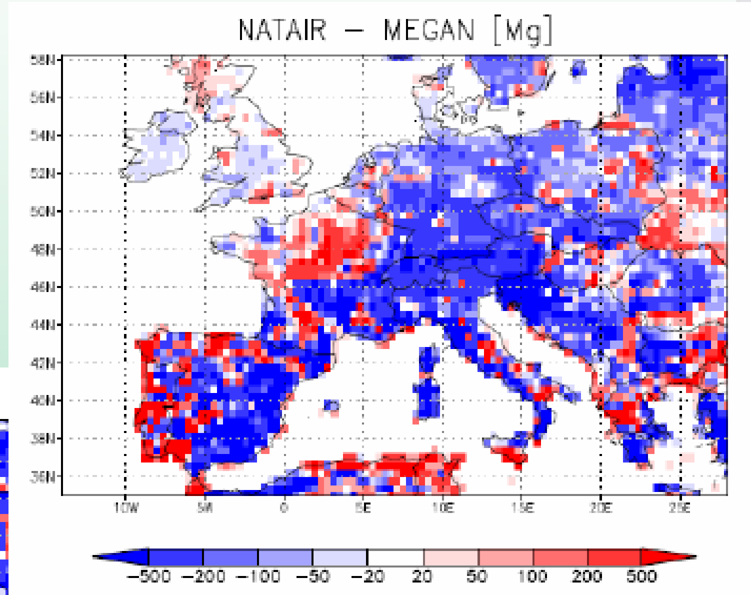
Uncertainties: BVOC Emission

Model inter-comparison: MEGAN (Guenther 2007), OLDBIO (Simpson et al. 1999); NatAir (this approach):

Range for isoprene July 2003 modelling domain:
1124 Gg (NatAir) – 1446 Gg (MEGAN)



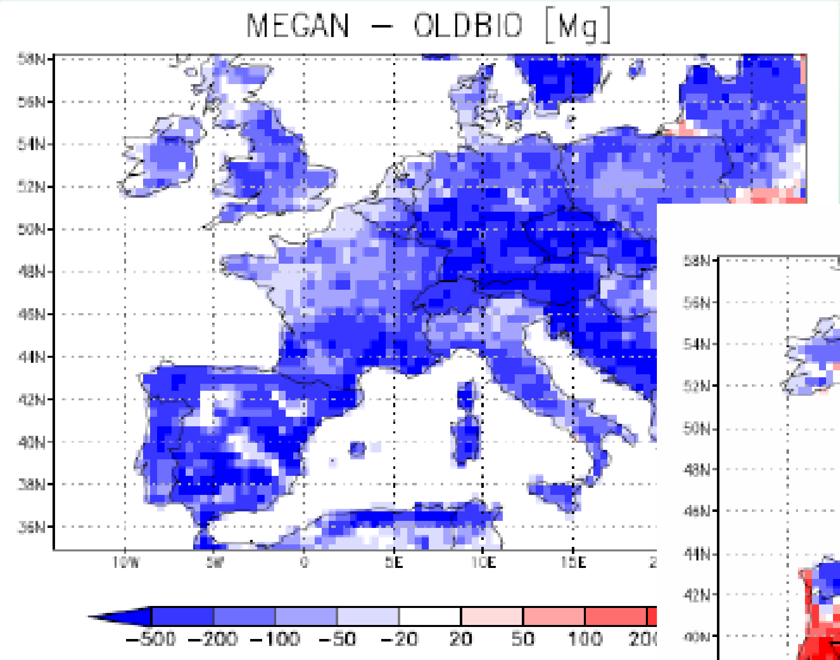


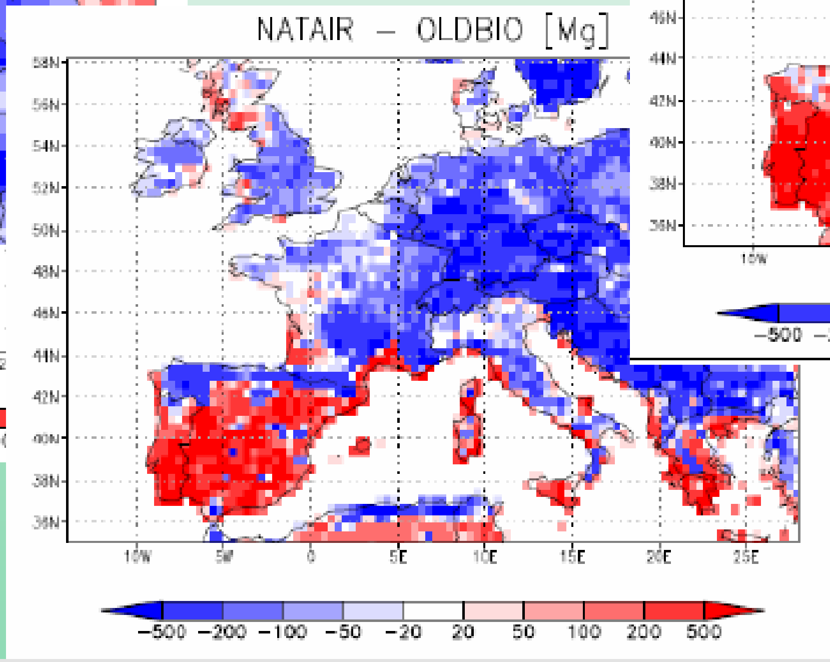


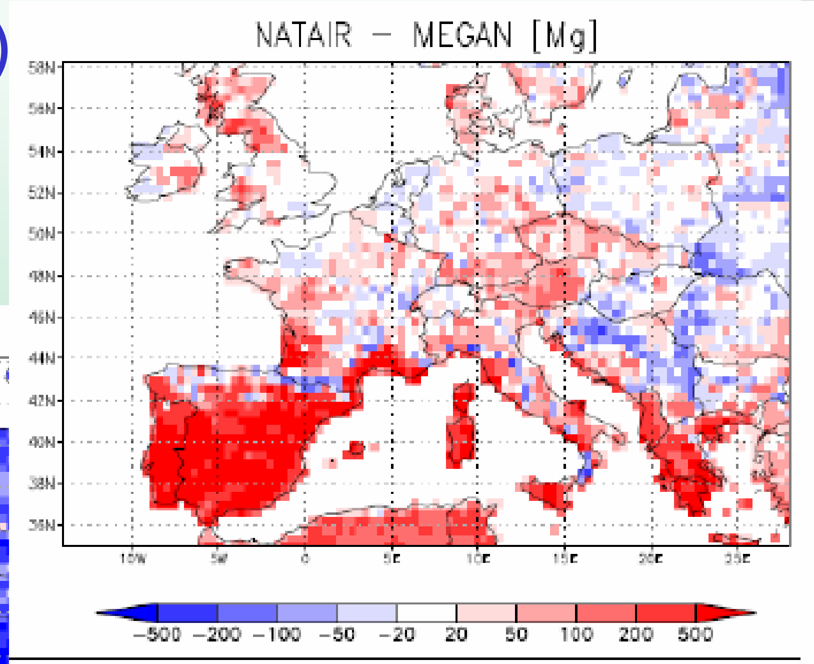
Uncertainties: BVOC Emission

Model inter-comparison: MEGAN (Guenther 2007), OLDBIO (Simpson et al. 1999); NatAir (this approach):

Range for monoterpenes July 2003 modelling domain:
338 Gg (MEGAN) – 1112 Gg (OLDBIO)





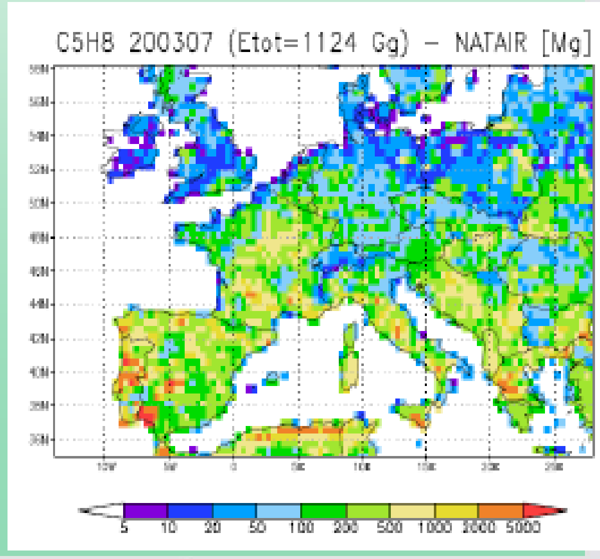


Uncertainties: BVOC Emission

Model inter-comparison: MEGAN (Guenther 2007), OLDBIO (Simpson et al. 1999); NatAir (this approach):

- For isoprene and monterpenes the uncertainty for the emission estimates based on different landuse schemes is ± 500 Mg per grid cell (approx. 0.6 Mg per km^2 per month)

- Which is in the order of the estimated emission for some areas



Conclusions

- The emission estimate presented may serve as an improved basis - despite the remaining uncertainties - for investigating the effect of biogenic emission on air quality in a world of increasingly reduced anthropogenic VOC emissions due to the emission control directives adopted.
- BVOC emissions may become even more important in regional air chemistry of the atmosphere in the future, as
- not only higher temperatures result in higher VOC emissions, but also
- an increased land area of agro-forests with high VOC emitters, e.g. *Eucalyptus, Poplar* or palm trees planted for building CO_2 sinks and producing biomass for fuel production.

Conclusions cont.

Therefore further efforts are needed in:

- improving the land use database by including more areas with plant species-specific information with high spatial resolution
- studying the impact of additional emission-modulating factors identified, e.g. CO_2, ozone, drought, pests on the source strength and VOC species profile emitted.
- validating and further improving emission models by flux studies in key ecosystems that also include economic plants (e.g. plants used in bio-fuel production).

Conclusions cont.

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- We evaluated the impact of natural/biogenic sources on O_3 and PM10 using a regional CTM (CHIMERE) for the year 2003
- The impact of BVOC on O_3 is on average 2.8 ppbv (5%) for the summer 2003
- The impact on PM10 of natural sources is on average 8 µg/m^3 (40%) for the year the 2003

Conclusions cont.

KIT Karlsruhe Institute of Technology

- maximum impact of BVOC is observed in Southern Europe, particularly the Iberian Peninsula
- „Bio-O_3“ is coupled with anthropogenic NO_x, while „bio-PM10“ is not
- in the extremely hot summer of 2003 the impact of BVOC oxidation results in up to 100 ppbv O_3 and 35 µg/m^3 PM10 in Spain

Will this be common during the 21st century?

Conclusion Final

Far better an approximate answer to the right question,
which is often vague,
than an exact answer to the wrong question,
which can always be made precise.
John W. Tukey, 1962

In that sense:
All the best and thank you for listening