AIR QUALITY IN A CHANGING CLIMATE

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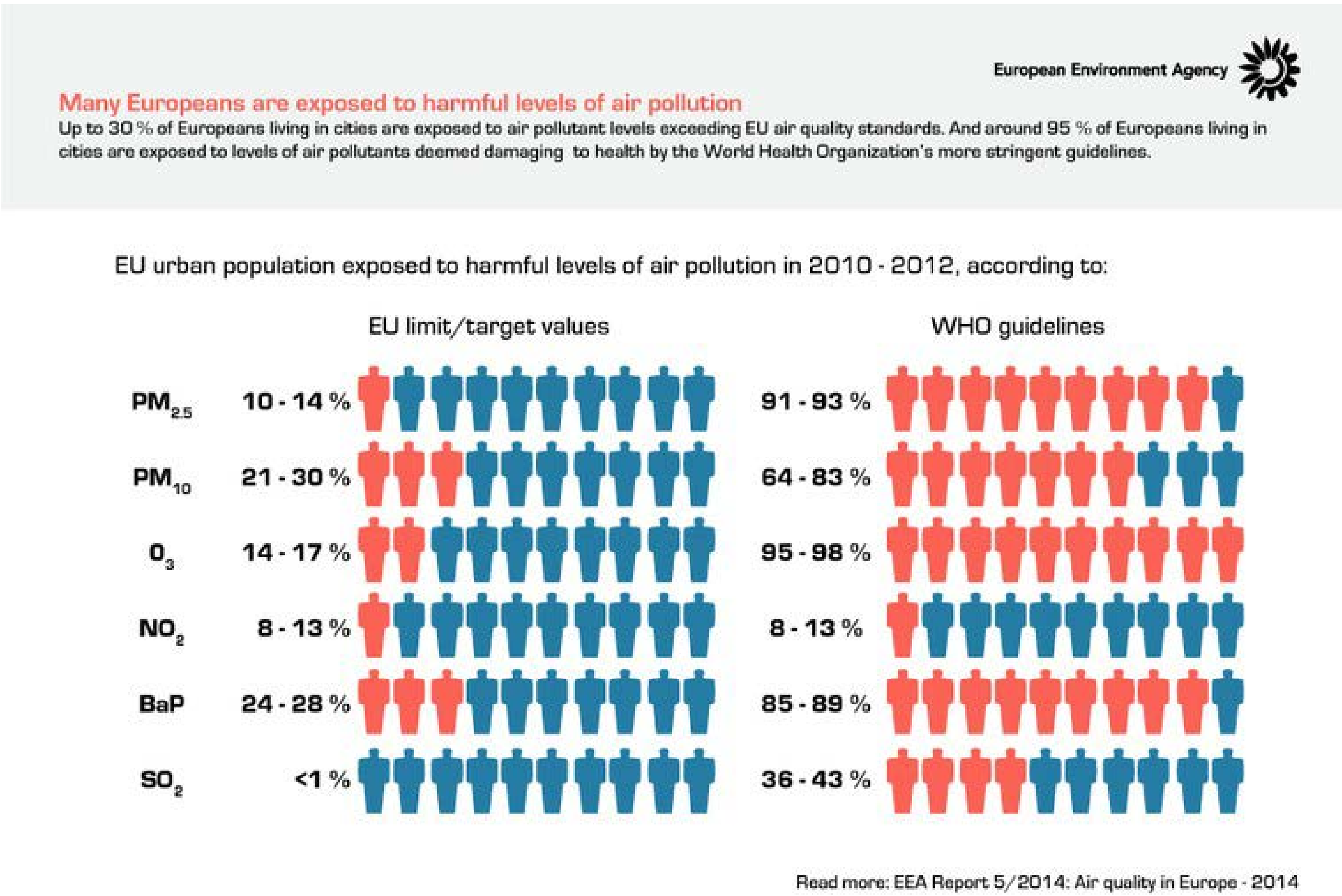
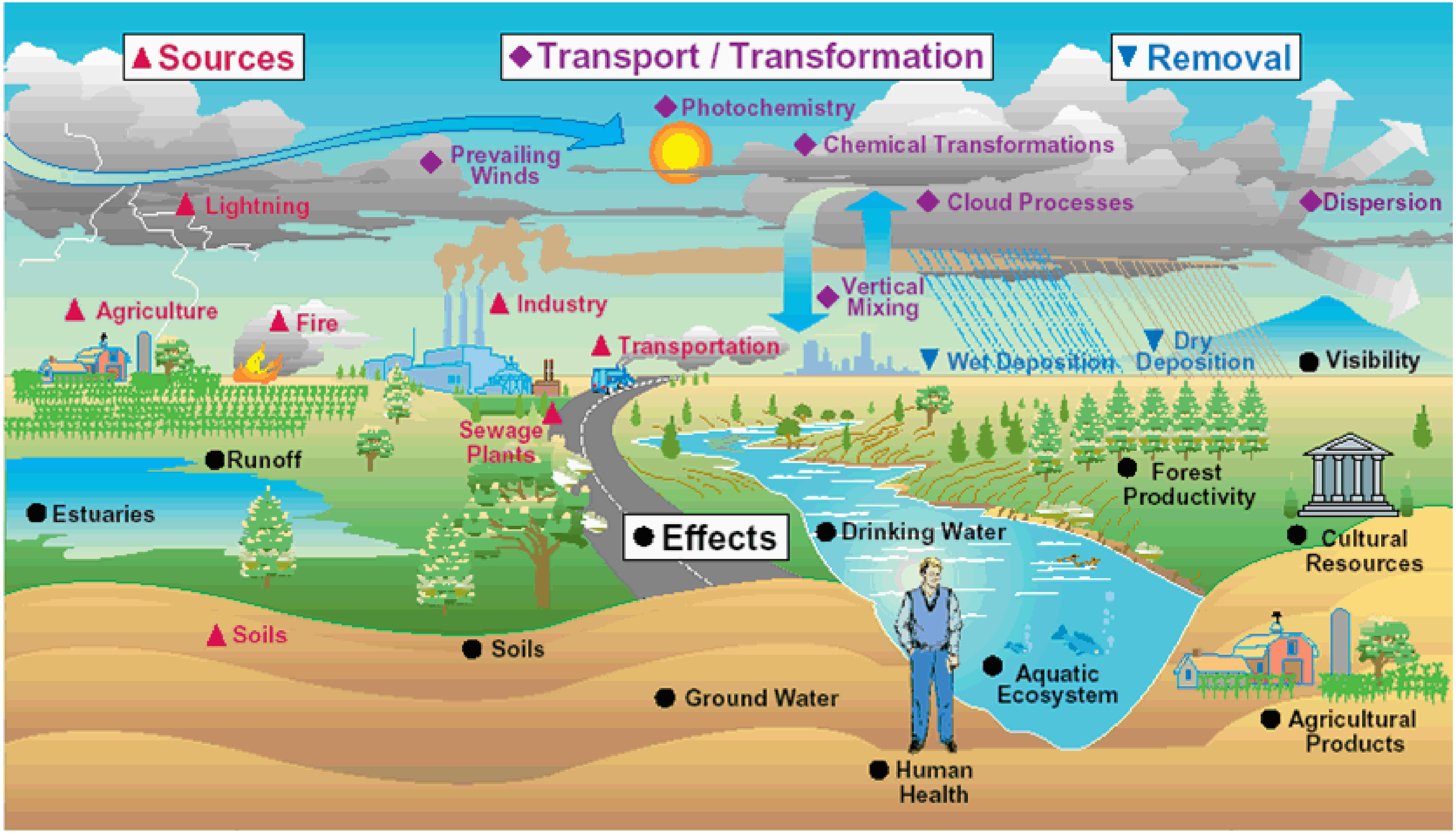
WHY STUDY AIR QUALITY?

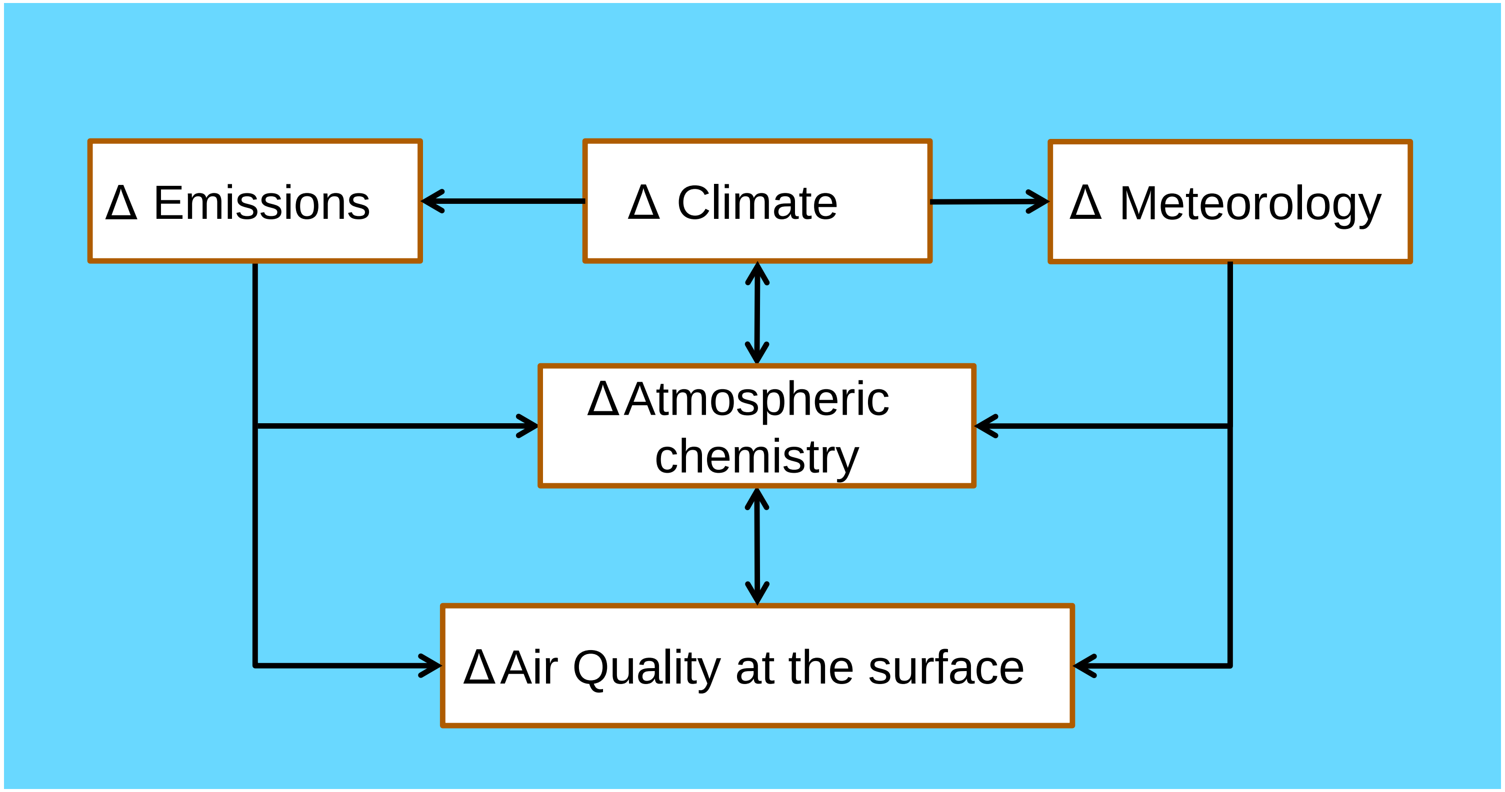


Adapted from EEA reporting,

AIR QUALITY PATHWAYS



AIR QUALITY IN A CHANGING CLIMATE



(after: Jacob and Winner, 2009)

AIR QUALITY

Emissions
(natural + anthropogenic)

Air Quality
Pollutant concentrations

- Temperature, e.g. biogenic volatile organic compounds (10% per °C)
- Wind, e.g. Dust suspension, Sea salt
- Soil moisture (natural Emissions)
- Anthropogenic activities e.g. Heat/cool, renewable/fossil energy

AIR QUALITY

Emissions
(natural + anthropogenic)

Dynamics
(horizontal + vertical Transport)

Air Quality
Pollutant concentrations

- Wind (speed, direction), e.g. Advection
- Boundary layer parameter (PBL, Stability), e.g. vertical Transport, Deposition

AIR QUALITY

Emissions
(natural + anthropogenic)

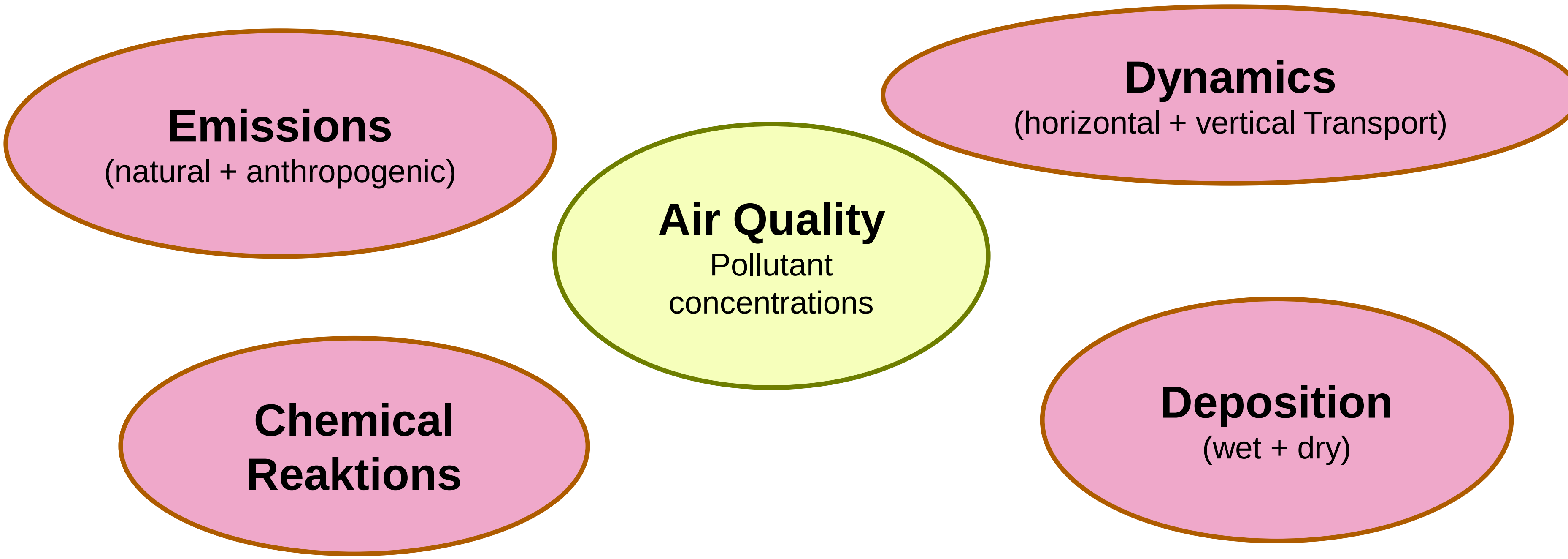
Dynamics
(horizontal + vertical Transport)

Air Quality
Pollutant concentrations

Chemical Reactions

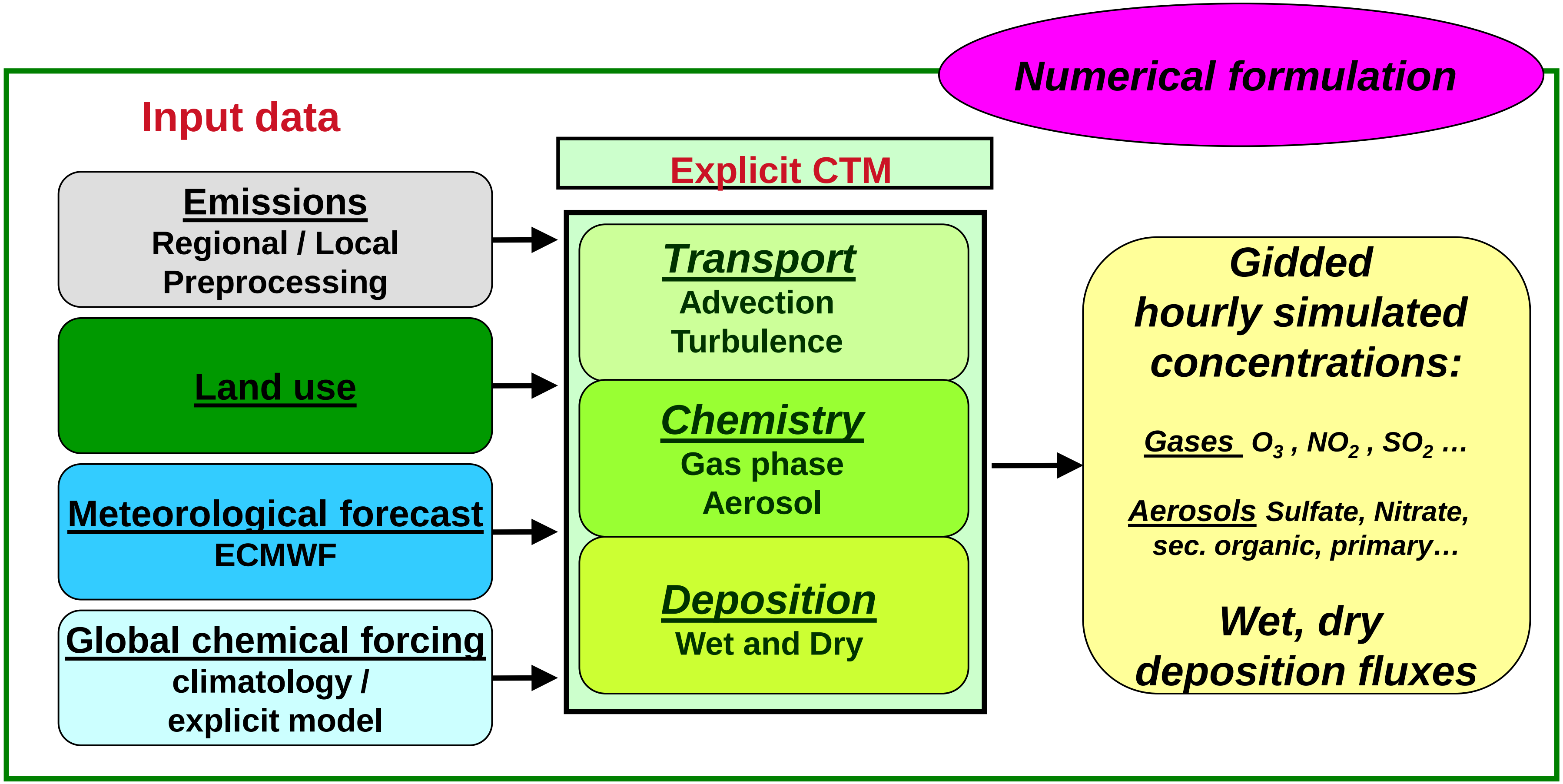
- Temperature, e.g. reaction rates, equilibrium semi-volatiles
- Radiation, e.g. photochemistry (Ozone)
- Clouds, e.g. Production of sulfate in cloud water

AIR QUALITY

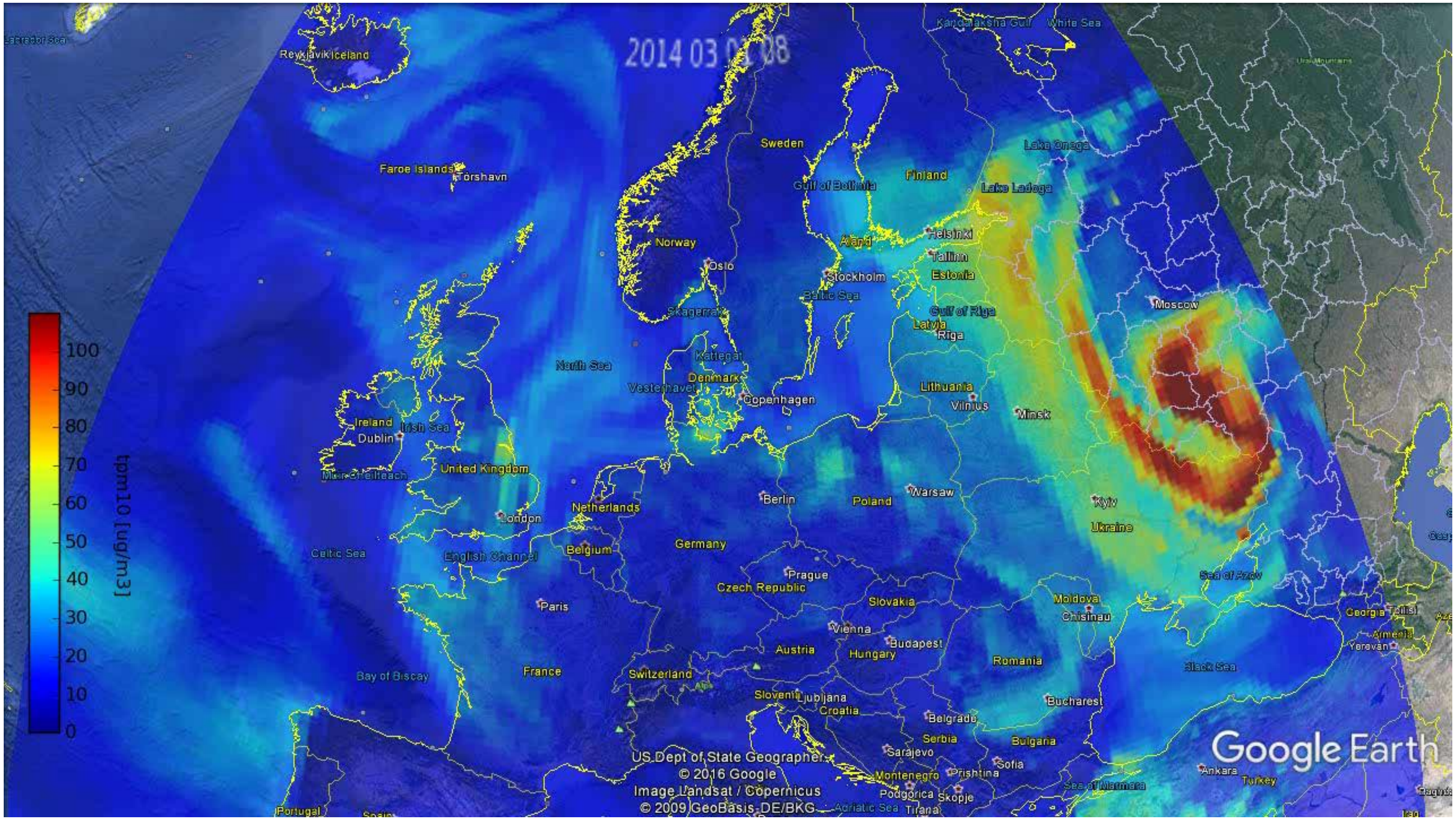


- **Dry Deposition:** Boundary layer parameter (Turbulence, atmospheric stability), soil moisture for stomatal conductance
- **Wet Deposition:** Precipitation (Intensity, Variability), Cloud parameter (CLWC, Coverage)

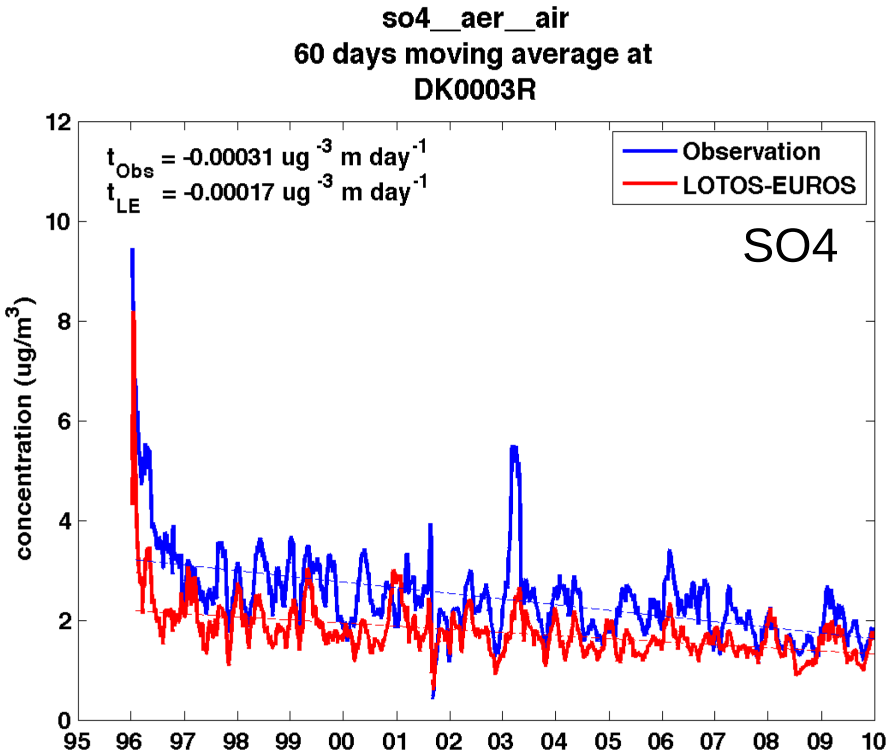
LOTOS-EUROS – CHEMISTRY TRANSPORT MODEL OF INTERMEDIATE COMPLEXITY

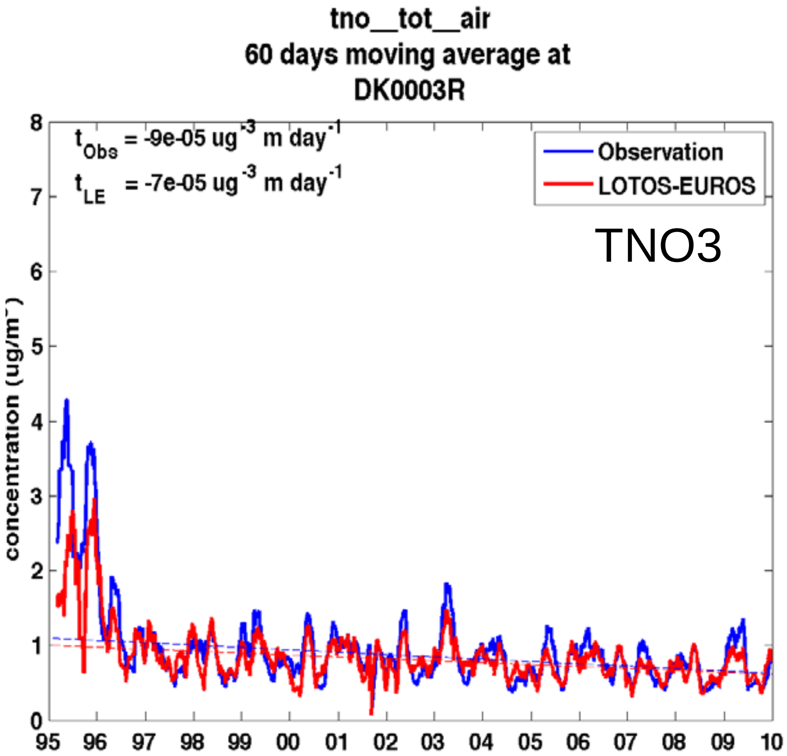


MOVIE OF MODELLED PARTICULATE MATTER



COMPARISON TO LONG TERM OBSERVATION DATA, E.G DENMARK

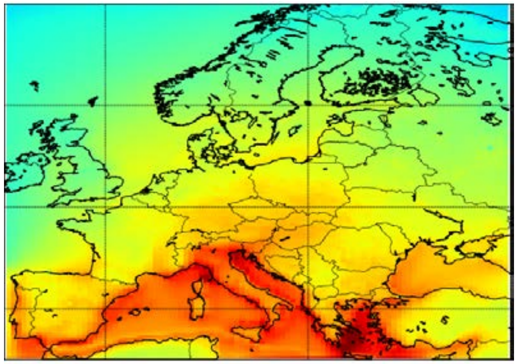




CLIMATE SCENARIOS FOR OZONE AND PM10 FOR 2050

- „**Downscaling**“ of climate change scenarios of GCMs using the CTM LOTOS-EUROS and RCM RACMO
- Comparison of 20 year periods for 1989–2009 and 2041–2060
- Focus: **Ozone und PM10**
- Anthropogenic emissions taken constant for 2005 (MACC 2005)

Zeitraum	Randbedingungen (RACMO)	Name
1989-2009	ERA-interim	RACMO_ERA
1970-2060	ECHAM5 A1B	RACMO_ECHAM
1970-2060	MIROC A1B	RACMO_MIROC

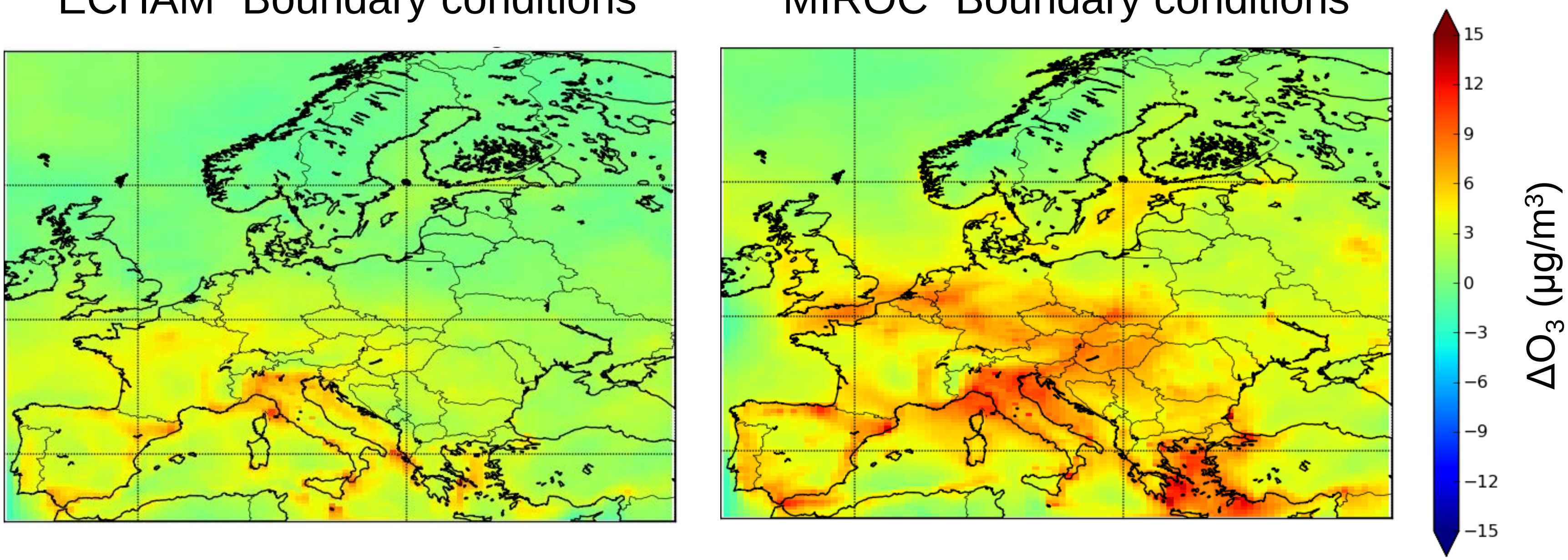


Horizontal resolution 0.5°x0.25°

Manders et al., 2012 (Atmos. Chem. Phys.)

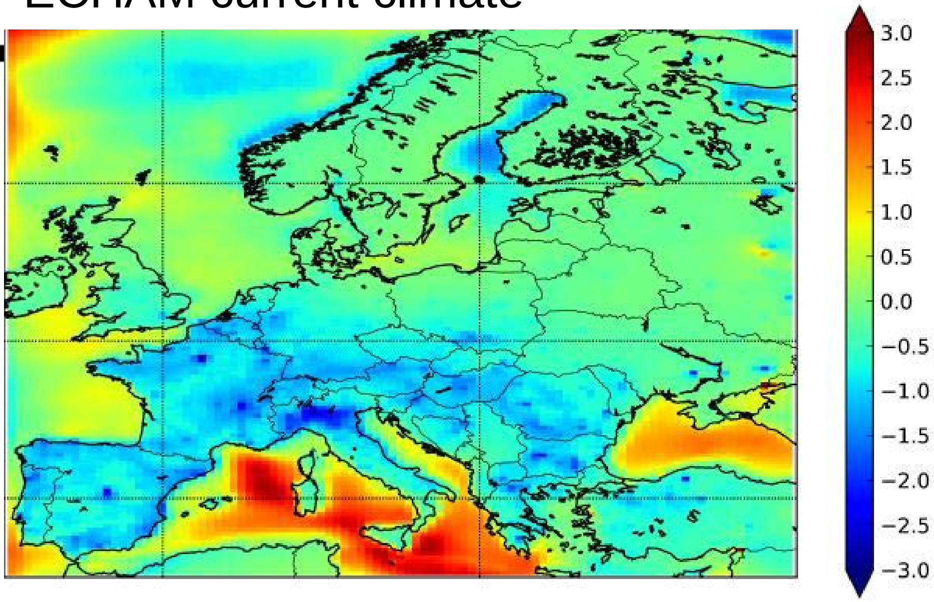
CHANGE IN AVERAGE DAILY MAXIMUM OZONE IN SUMMER AT CONSTANT EMISSIONS

“ECHAM” Boundary conditions   “MIROC” Boundary conditions

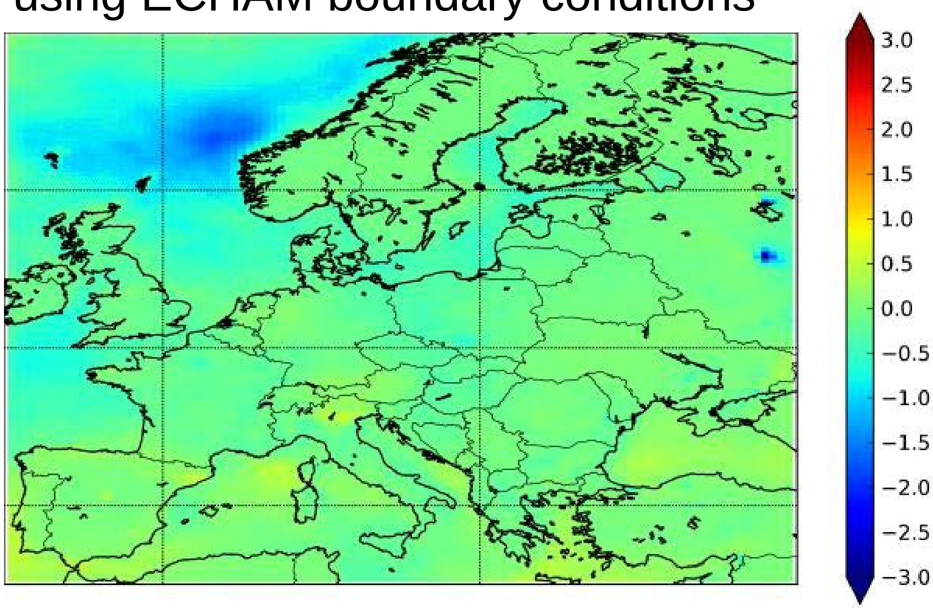


- Increase of the average daily maximum ozone (Sommer) of 5–10 µg/m³ in parts of central and southern Europe
- Low increase in northern and eastern Europe
- The differences indicate **high uncertainties** between models but the direction is consistent

Bias between ERA-interim and ECHAM current climate

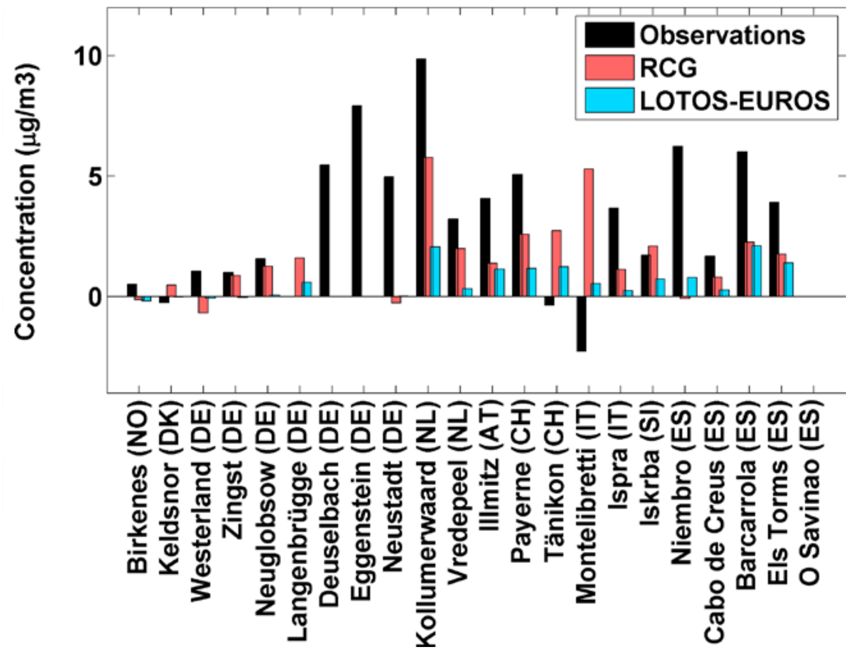


Climate change induced difference using ECHAM boundary conditions



PM IS A CHALLENGE

Summer 2003 PM10 concentration change (µg/m³)



Mues et al., 2012 (Atmos. Environ.)

BUT EMISSIONS WILL NOT BE CONSTANT...

What will be the combined impact of:

- **An increase of bioenergy plantations**
- **EU's air quality policy**
- **Climate change**

on health damage from ground based ozone?

SCENARIO STUDY APPROACH

PRIMES energy scenarios for Europe

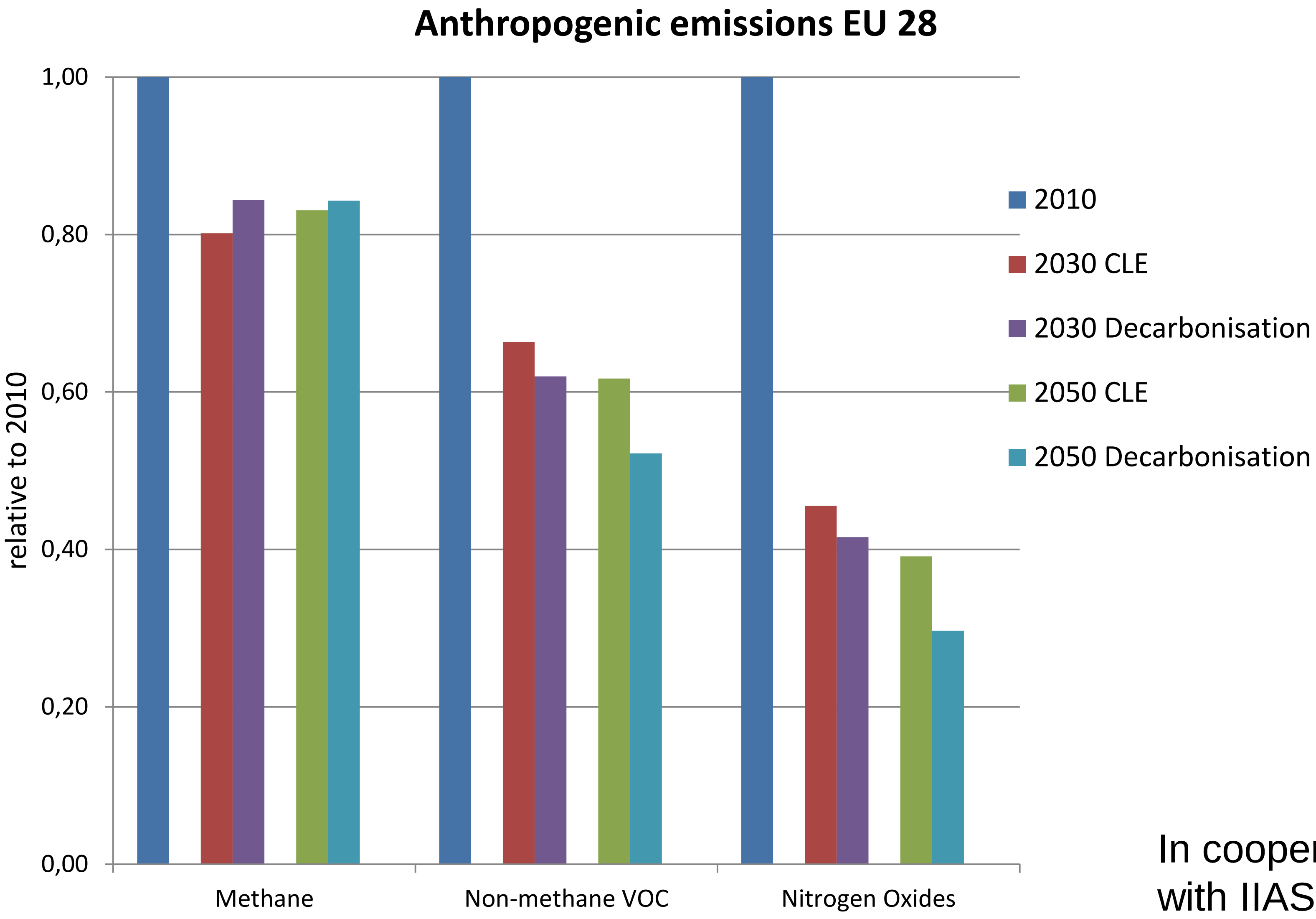
- Current legislation (CLE)
- Decarbonization scenario + efficiency measures

GAINS
Anthropogenic emissions

GLOBIOM
Land use change

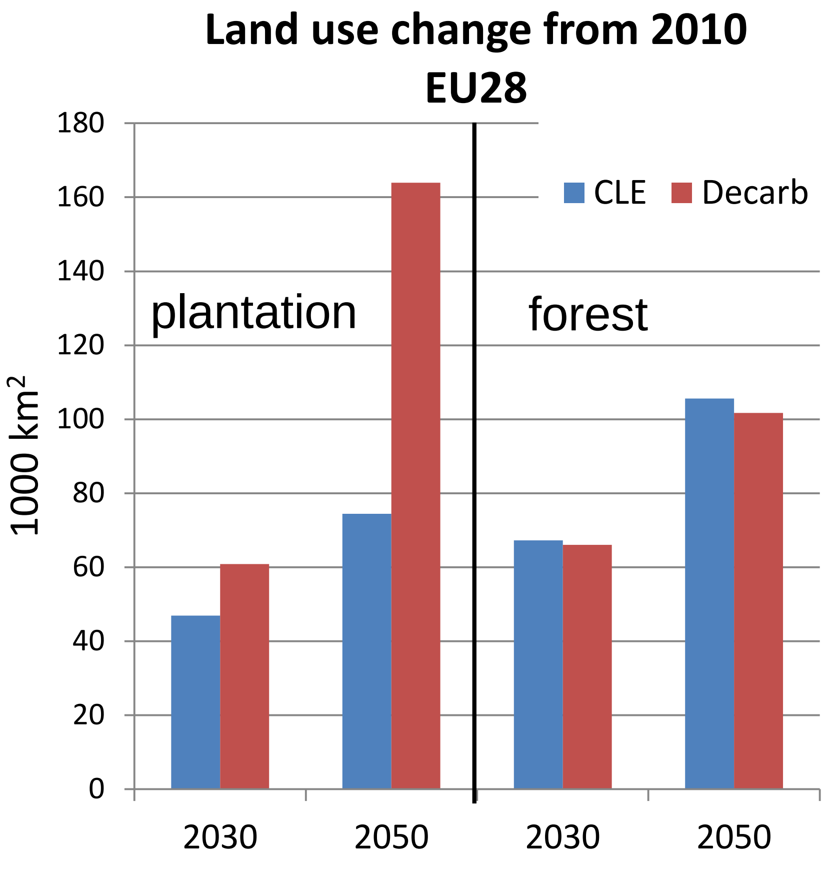
LOTOS-EUROS
Ground level ozone

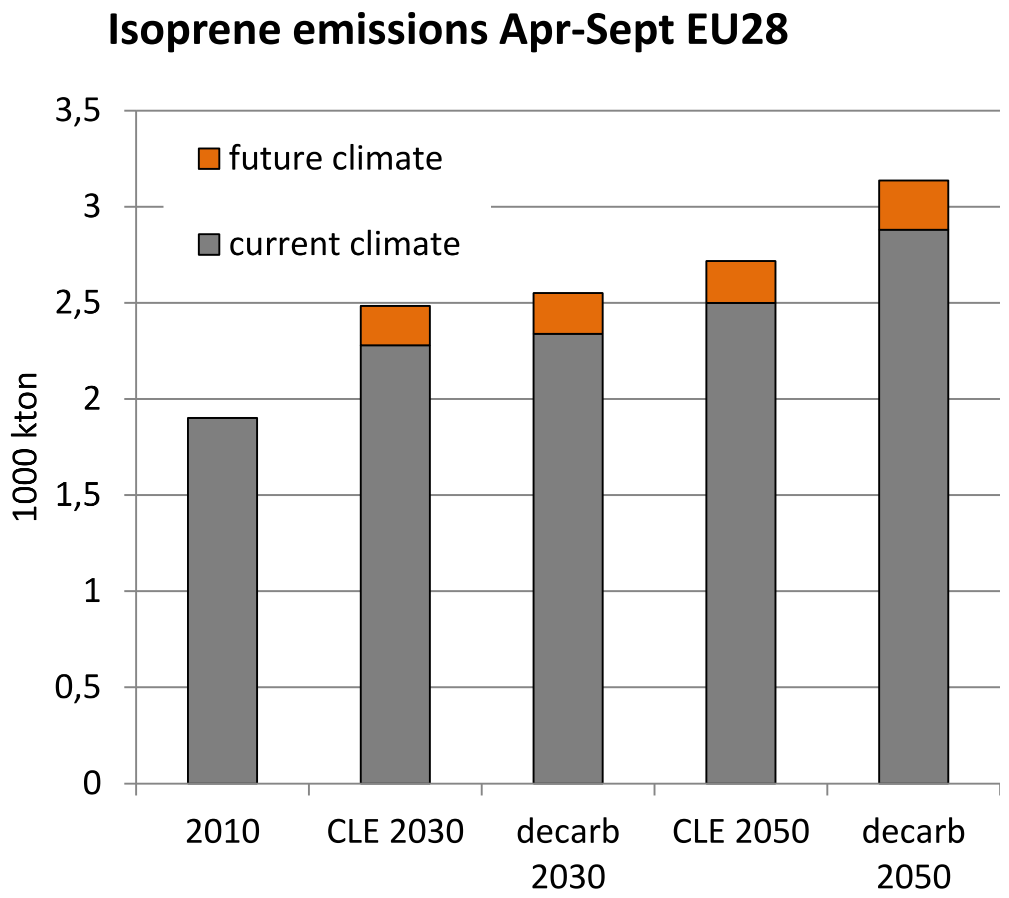
ANTHROPOGENIC EMISSION CHANGE



In cooperation with IIASA

LAND USE AND ISOPRENE EMISSION CHANGE





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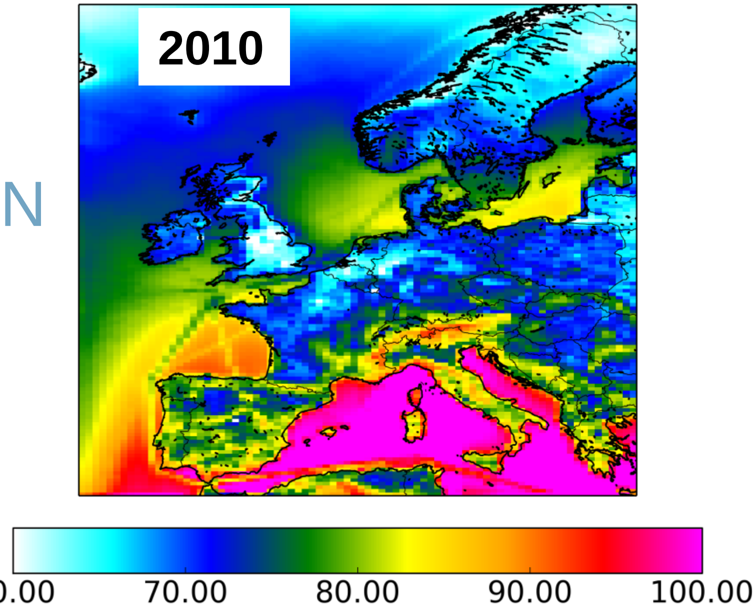
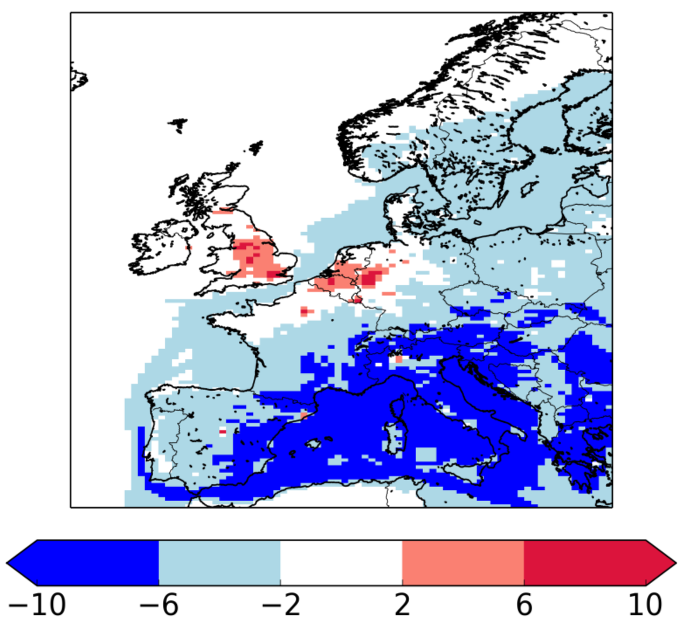
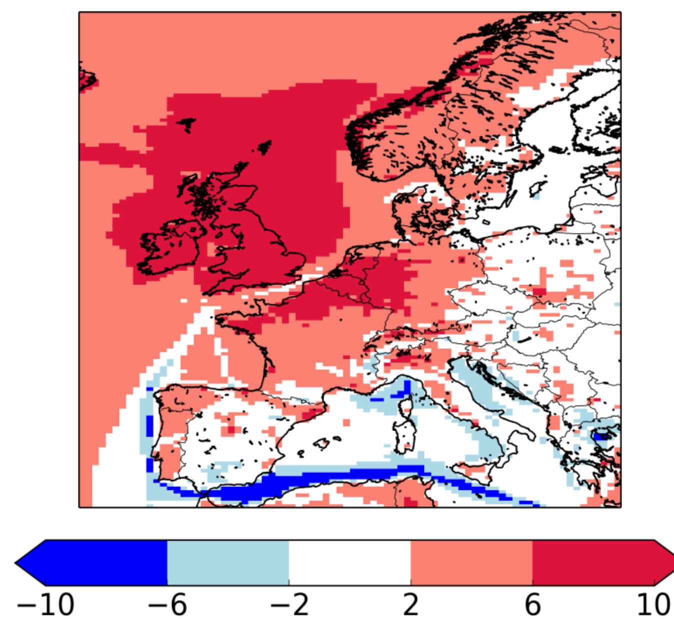
GROUND LEVEL OZONE CONCENTRATION



2050 decarbonisation current climate

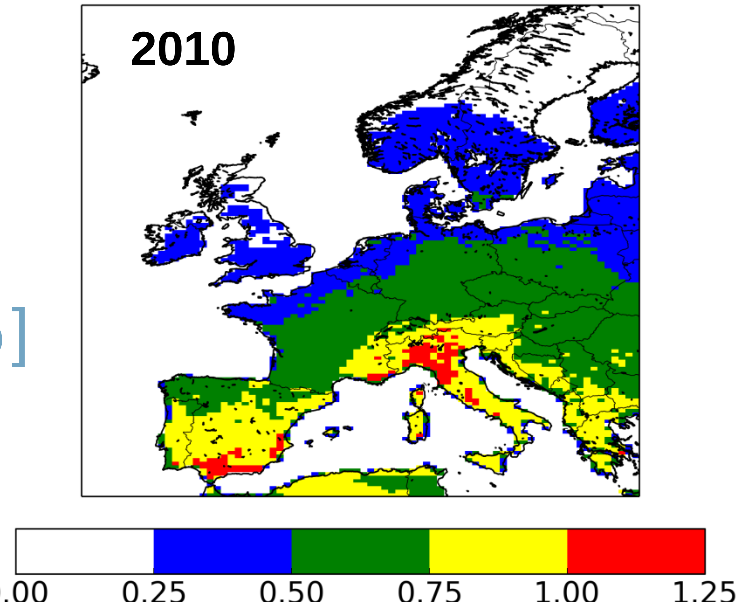


2050 decarbonisation future climate

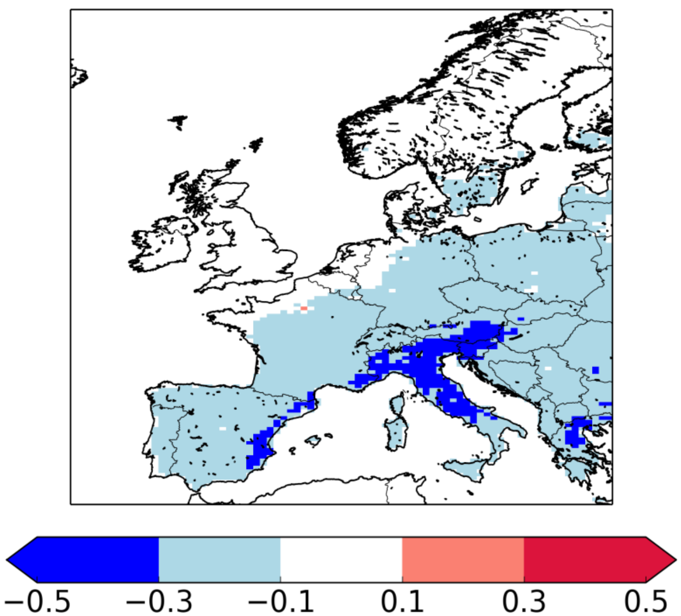


[µg/m^3]

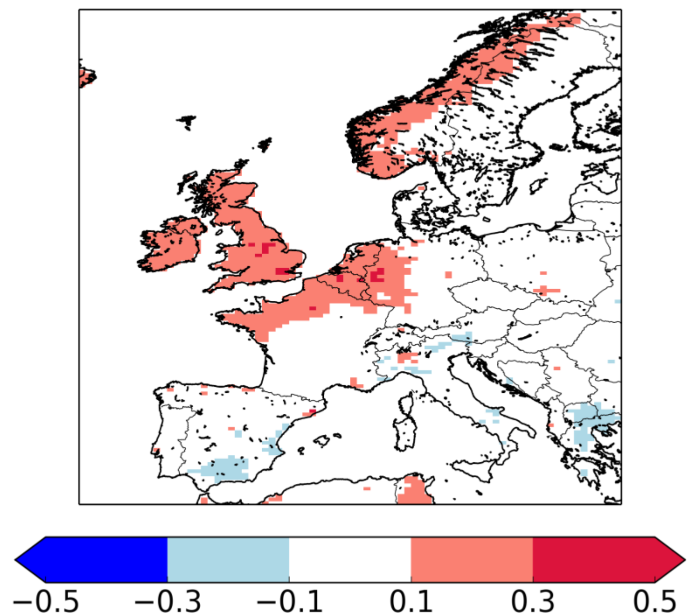
RELATIVE RISK, ALL CAUSE MORTALITY [%]



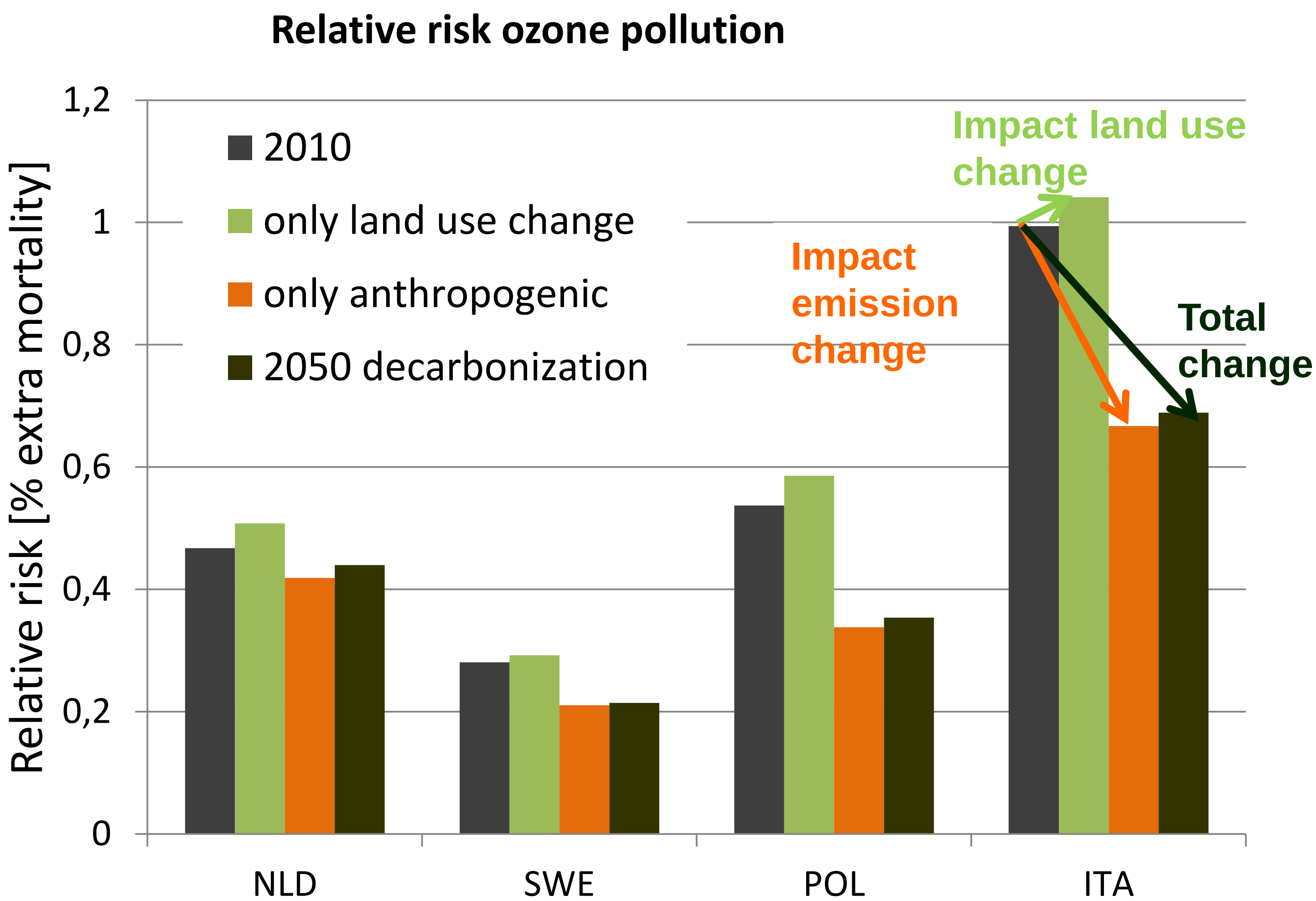
2050 decarbonisation current climate



2050 decarbonisation future climate



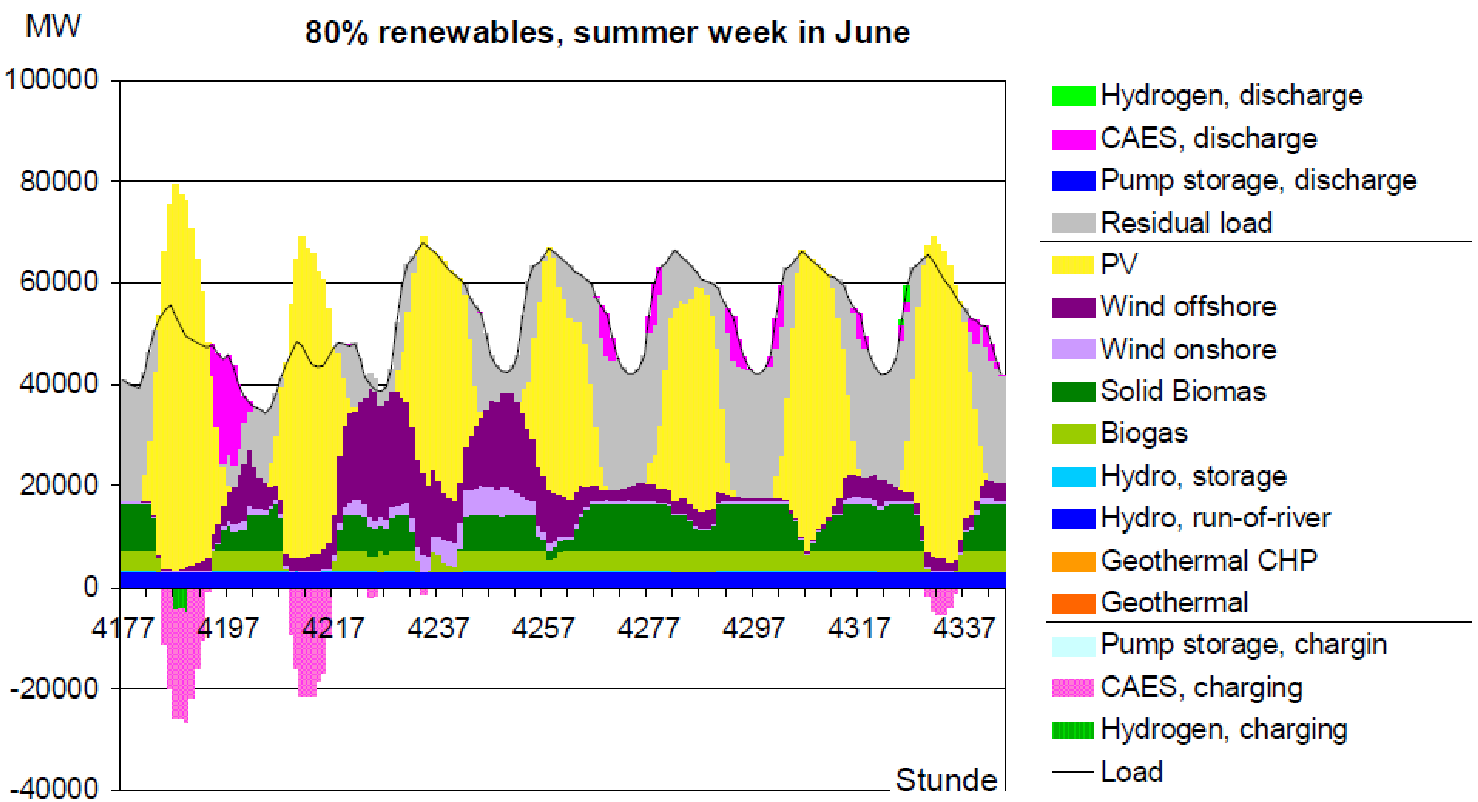
DECOMPOSITION: WHAT DETERMINES EFFECT?



CONCLUSIONS

- Damage to health from ozone pollution is likely to decrease in 2030 / 2050 if climate remains as today
- The difference between the energy pathways is small
- Impact of anthropogenic emission change far outweighs impact of land use change
- Climate change may be a more important driver of ozone concentrations than the change in anthropogenic emissions and land use change unless very strong emission reductions are achieved

DO CURRENT SOURCE RECEPTOR MATRICES HOLD FOR LARGE SCALE IMPLEMENTATION OF RENEWABLES?



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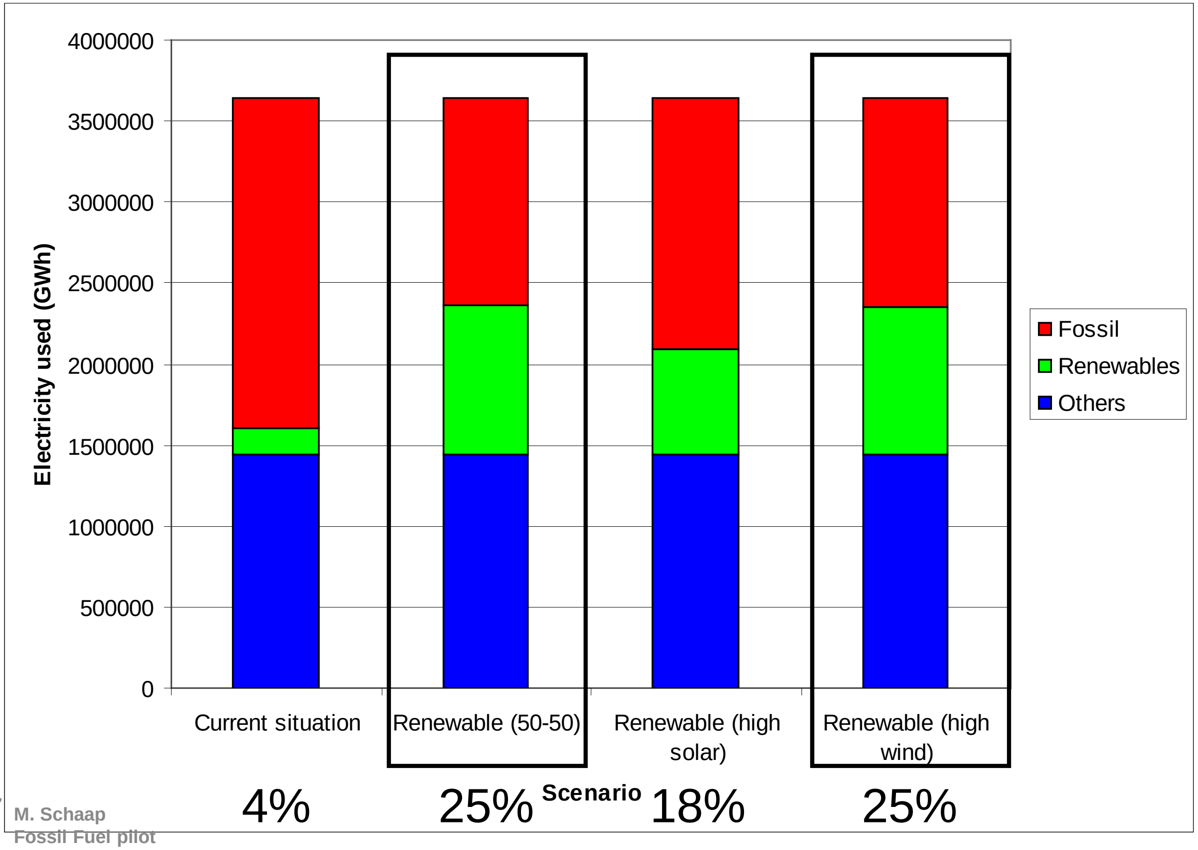
SCENARIOS

- Define scenarios with different contribution of solar (PV) and wind



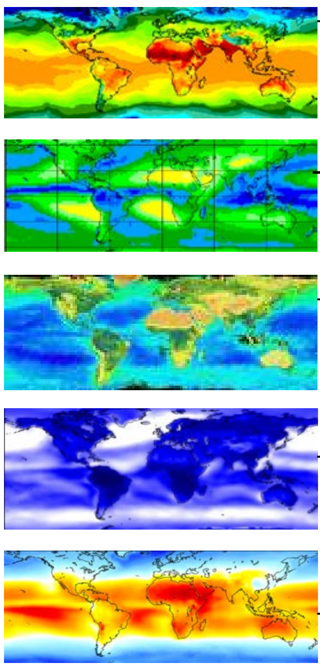
Major assumptions:

1. No exchange between countries
2. No storage of electricity

Under these assumptions, solar (PV) capacity is not sufficient to supply the necessary electricity at the requested time

Assessment of technology impact in energy supply systems

Renewable power generation potentials



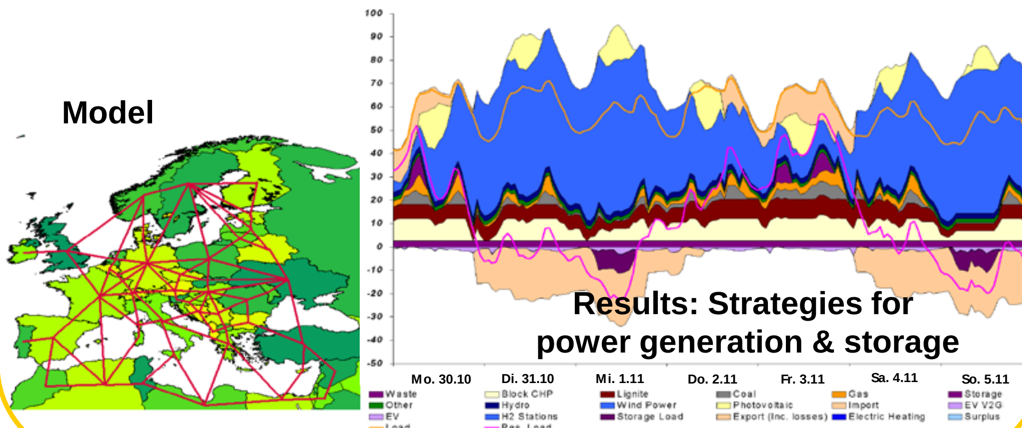
DC - Transmission
Overhead lines or earth cables

AC - Transmission
Simplified representation of the current high voltage grid

Optimisation module REMix

Least-cost power supply, spatially and temporally explicit

Model



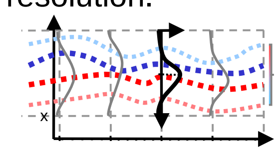
Power demand

Heat demand

Flex. CHP-operation:
- heat storage
- Peak load boilers

Electric vehicles

BEV/EREV: different charging strategies, V2G.
Battery capacity of the vehicle fleet in temporal resolution.



FCEV: flexible on-site H_2-generation

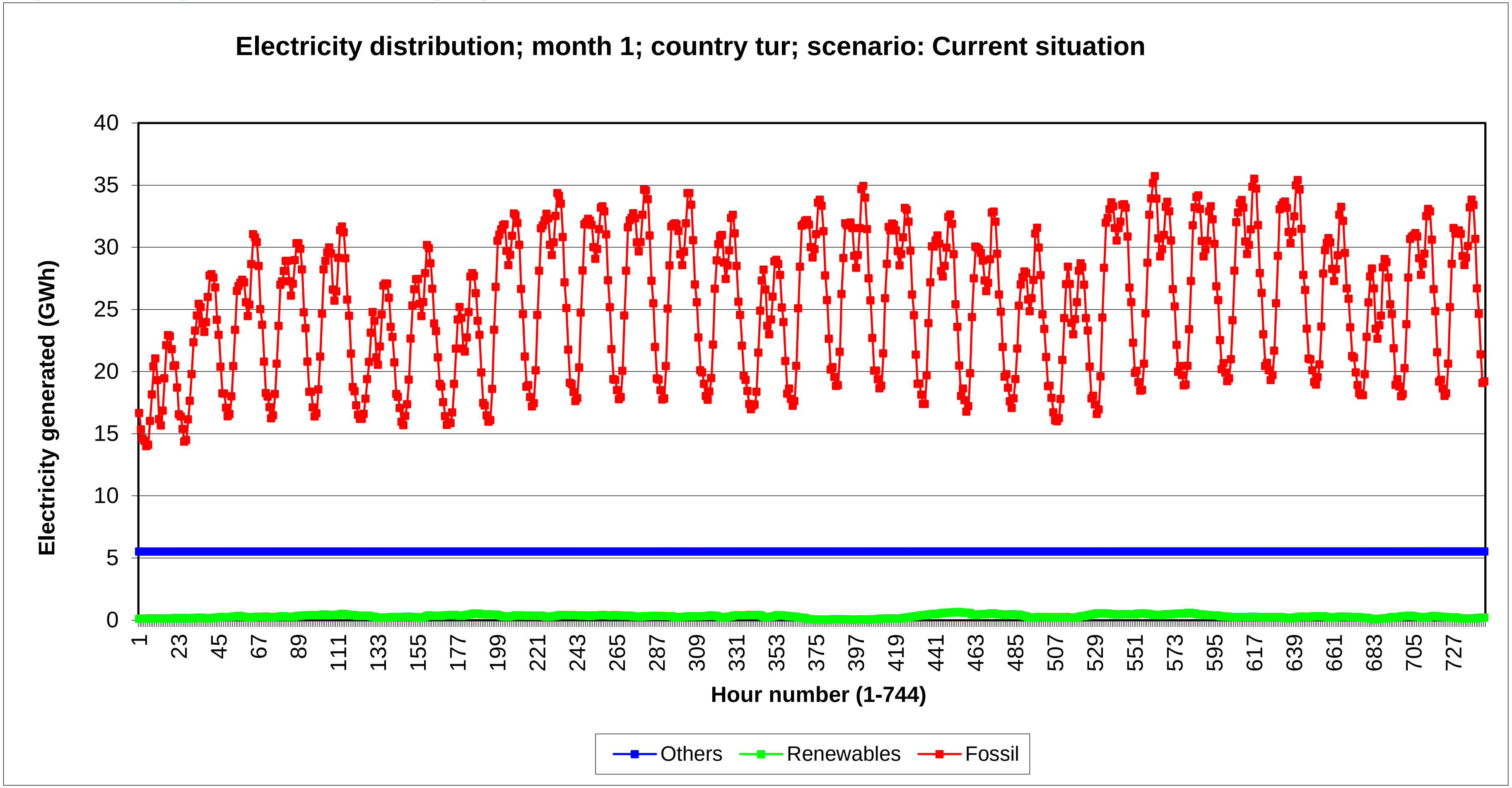
Conventional power plants
Nuclear, coal
CCGT, gas

Storage
Pumped hydro
Compressed Air Energy Storage
Hydrogen

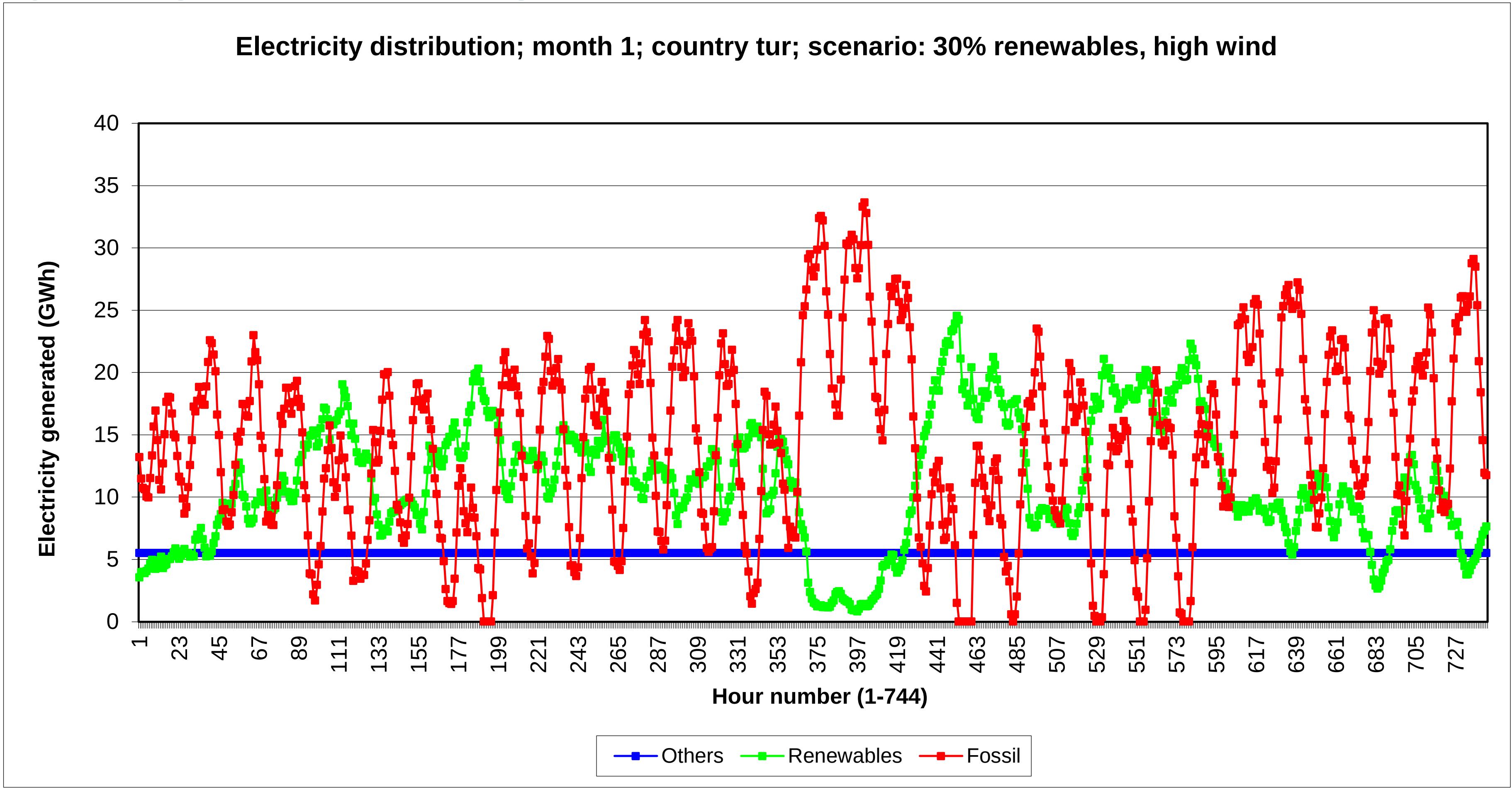
Demand Side Management
Industry & households
(ongoing research)

DLR

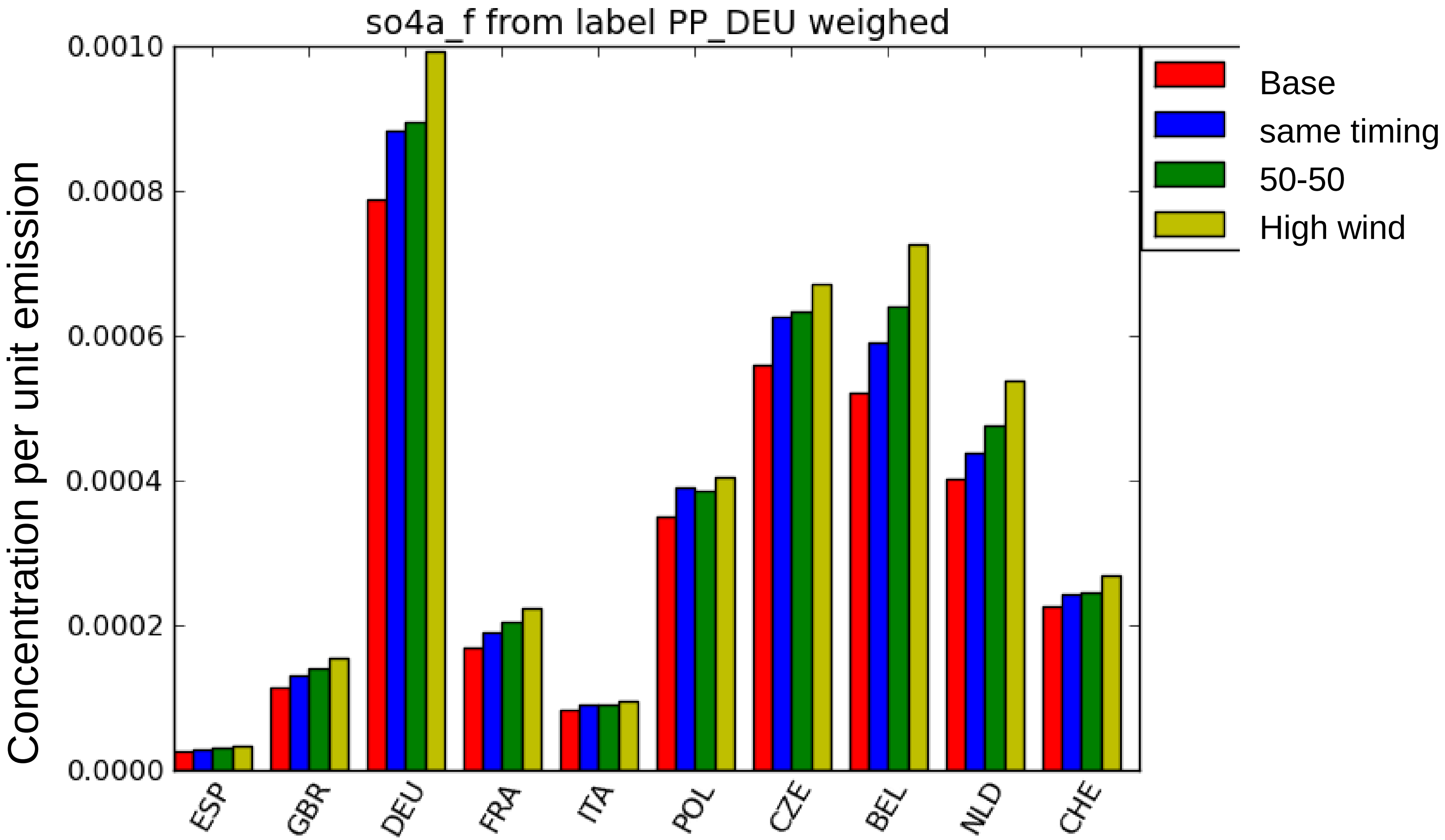
ELECTRICITY DEMAND TURKEY – JANUARY - CURRENT



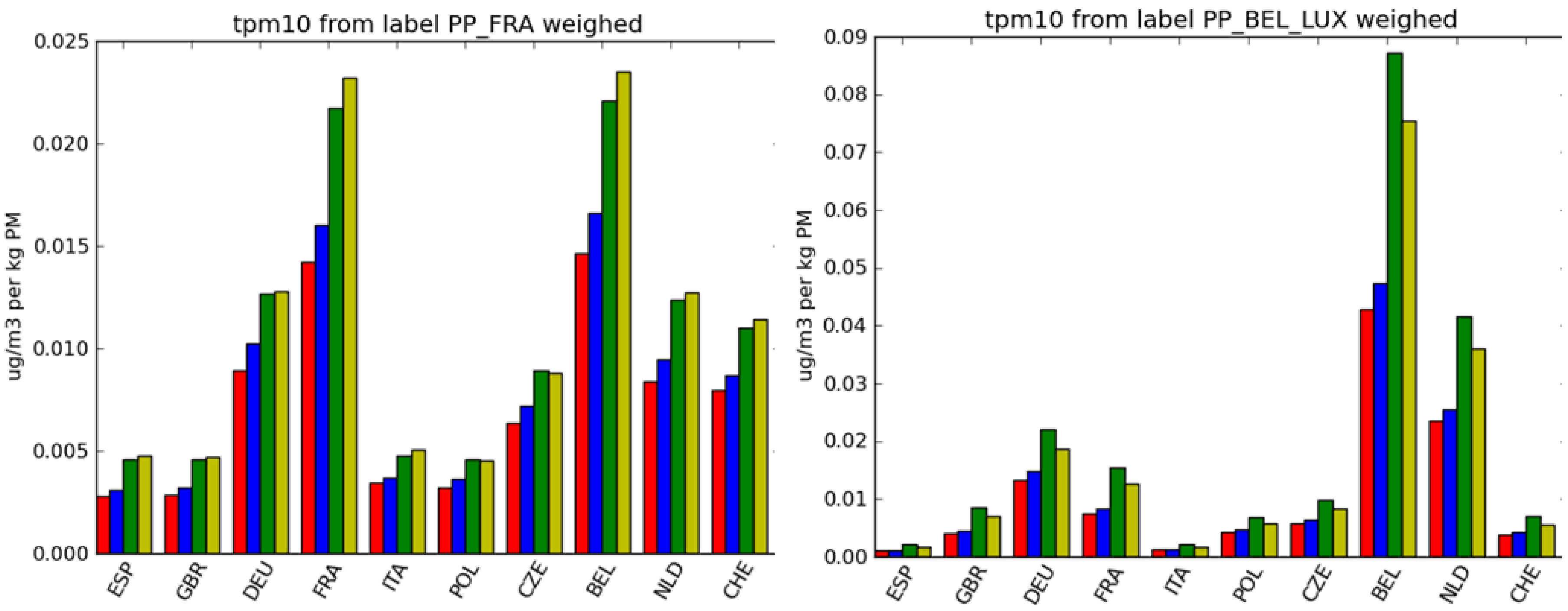
ELECTRICITY DEMAND TURKEY – JANUARY – HIGH WIND



Impact on sulphate concentrations – CZE and DEU



WE SEE THE SAME FOR OTHER POLLUTANTS, E.G. NO2, PM10



CONCLUSIONS

- The impact of changing **emission variability for renewable energies** may be significant during the transition phase to a society based on renewable energy resources.

- In general, the meteorological and **climate impact on anthropogenic emissions** is largely neglected in current modelling approaches and needs to be accounted for,


THANK YOU FOR YOUR ATTENTION
Take a look:
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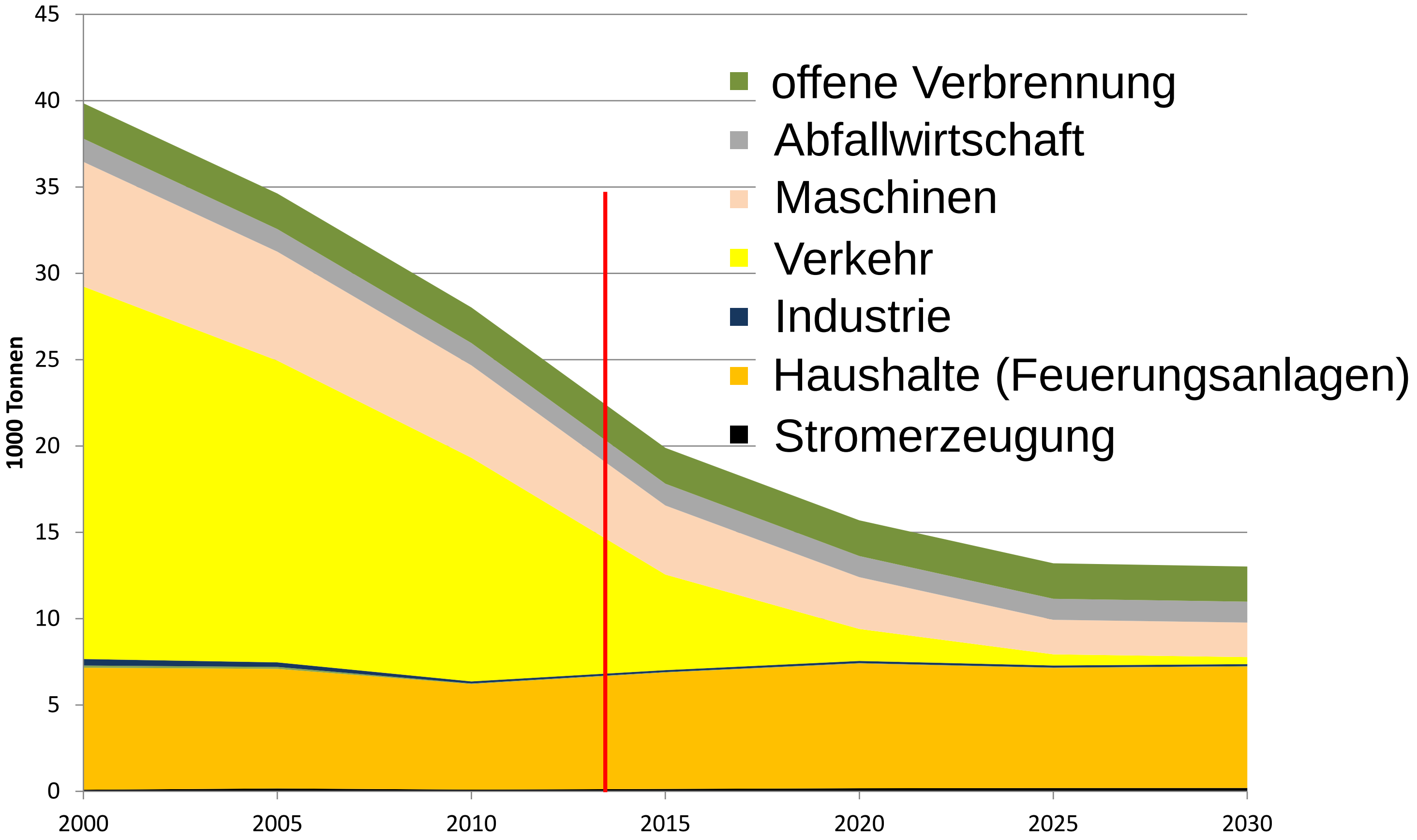
RUßQUELLEN IN DEUTSCHLAND

IIASA Prognose für die europäische Kommission (TSAP)



(Courtesy of M. Amann)