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Changes in air quality of Europe 1990 and 2020:
A modeling study

Harmo 15, 7 May 2013, Madrid

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Goals

LABOR FOR ATMOSPHERIC CHEMISTRY

Gothenburg Protocol

<i>first protocol</i>	<i>revised protocol</i>
signed in 1999	signed in 2012
<u>emissions to be reduced</u>	<u>emissions to be reduced</u>
SO ₂ (63%)	SO ₂ (59%)
NO _x (41%)	NO _x (42%)
NM VOC (40%)	NM VOC (28%)
NH ₃ (17%)	NH ₃ (6%)
	PM _{2.5} (22%)
target year 2010	target year 2020
reference year 1990	reference year 2005

2

Goals of the project

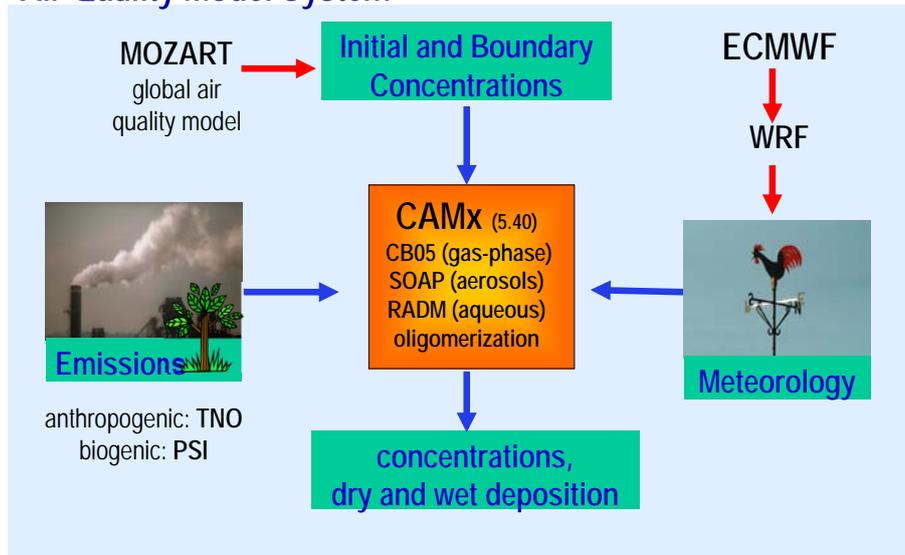
- How did the emission reductions since 1990 affect the air quality?



- What are the impacts of various emission scenarios in Europe within the framework of revised Gothenburg Protocol on air quality in 2020?

focus on PM, ozone damage indicators and nitrogen deposition

Air Quality Model System



CAMx: Comprehensive Air quality Model with extensions (ENVIRON)
WRF: Weather Research and Forecasting Model (NCAR)

Model Domains

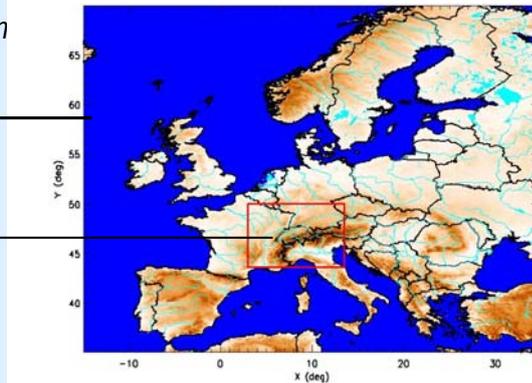
horizontal resolution

domain 1

0.250° x 0.125°

domain 2

0.083° x 0.042°



vertical resolution: 14 layers up to 7 km asl

5

Emission scenarios used in this study

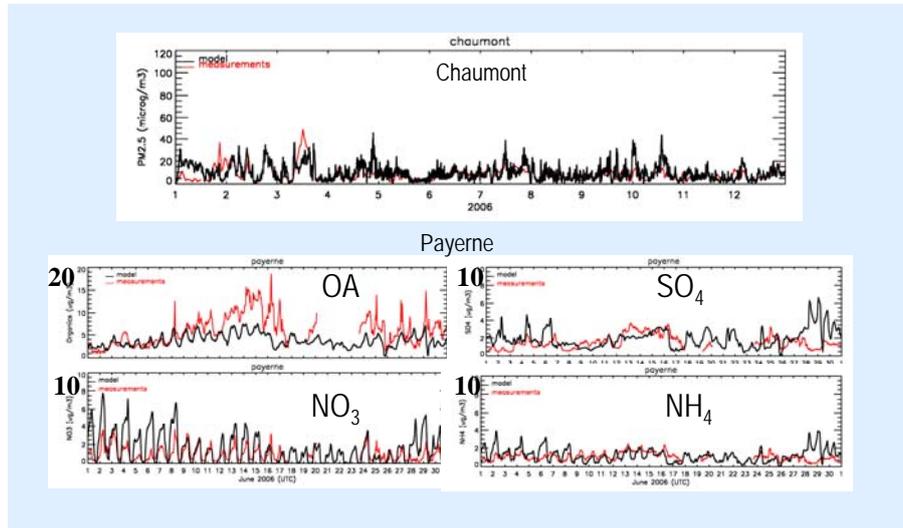
year	description
2006	Validation case
1990	Retrospective study
2005	Reference case RC*
2020	BL (baseline) *
2020	Mid*
2020	MTFR* (maximum technically feasible reduction)

* Annual data per country from IIASA calculated by GAINS, (CIAM4/2011)

GAINS: The Greenhouse Gas and Air Pollution Interactions and Synergies Model

6

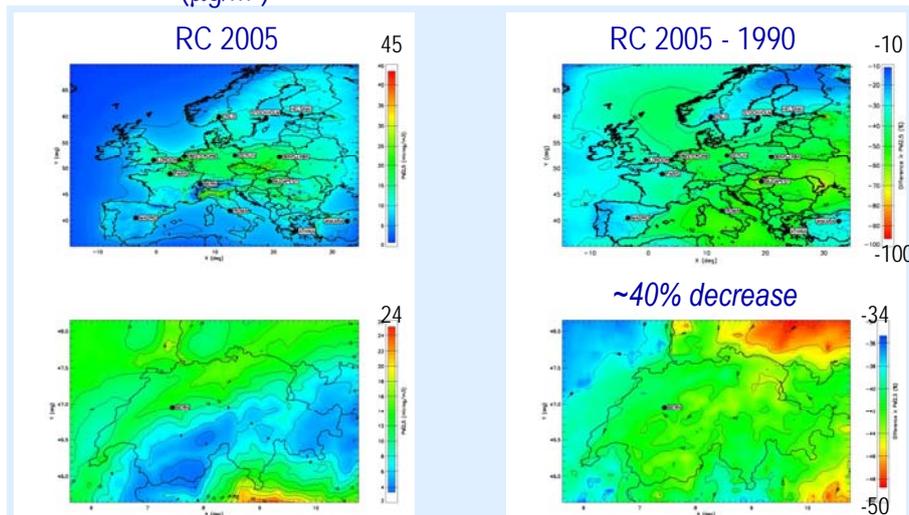
Comparison of modeled PM2.5 with measurements (2006)



7

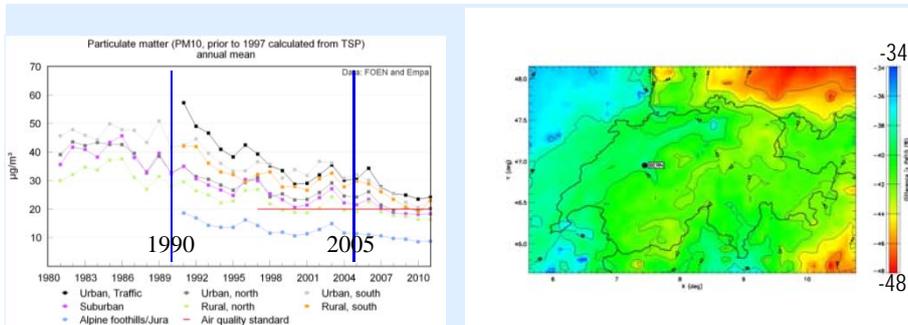
Annual average PM2.5
($\mu\text{g}/\text{m}^3$)

Change (%) in PM2.5
between 1990 and 2005



8

Change (%) in average PM10 between 1990 and 2005

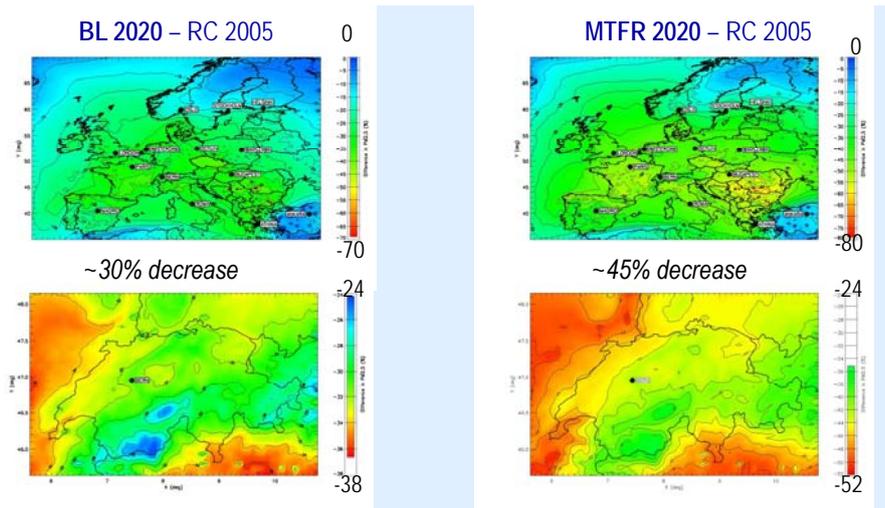


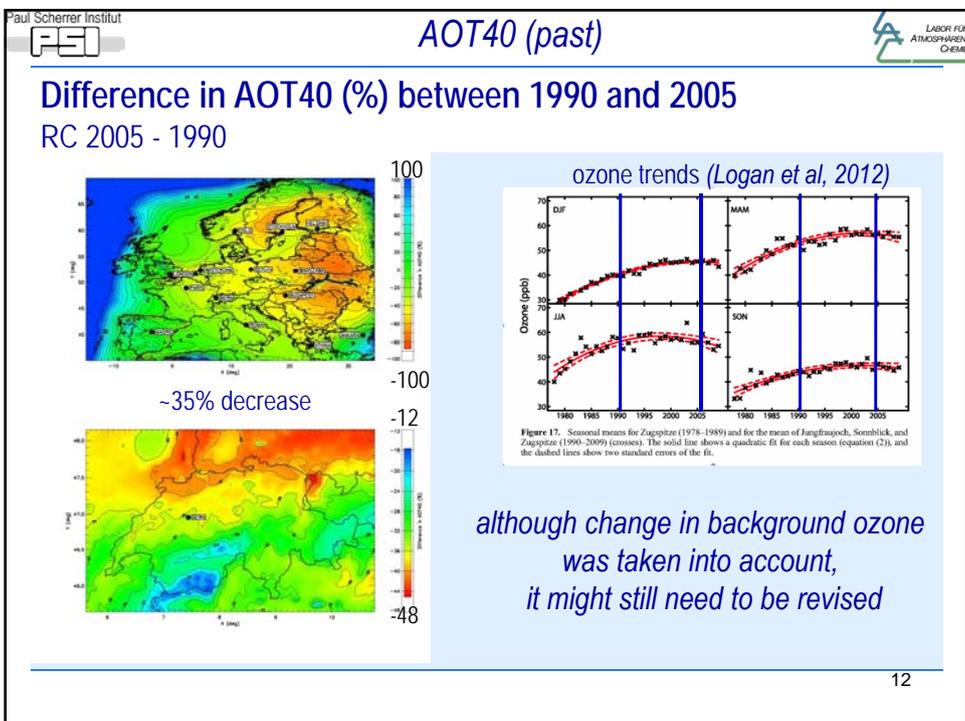
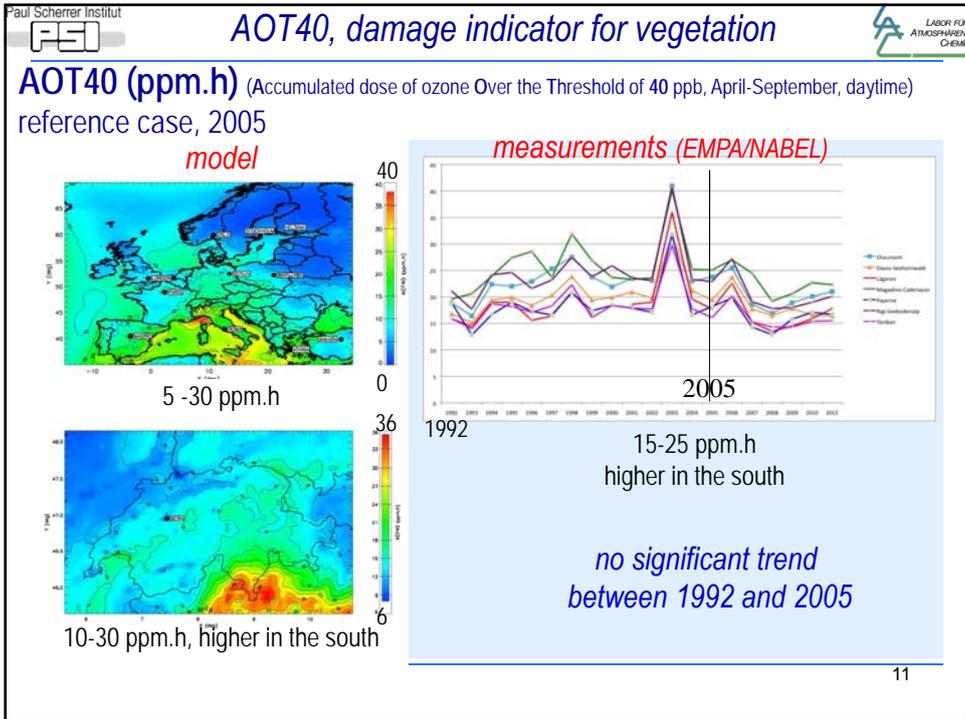
measurements: 30-50% decrease

model : ~40% decrease

good agreement

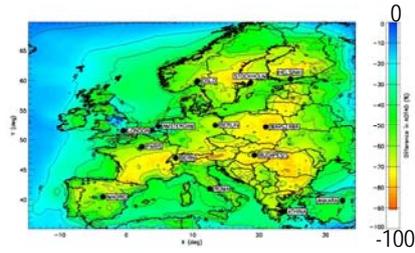
Change (%) in average PM2.5 between 2005 and 2020



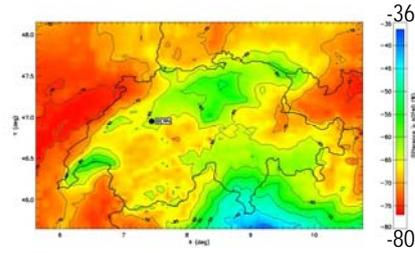


Difference in AOT40 (%) between 2005 and 2020
BL 2020 - RC 2005

European Domain



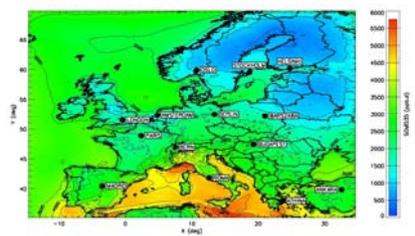
Swiss Domain



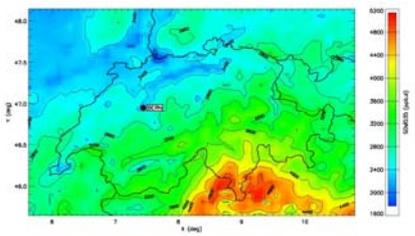
~60% decrease

SOMO35 (ppb.d) (Sum of Ozone Means Over 35 ppb, 8-hr running, entire year)
reference case, 2005

European Domain



Swiss Domain

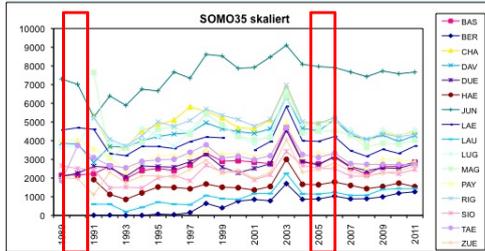


1000 – 5000 ppb.d

Comparison with measurements in Switzerland

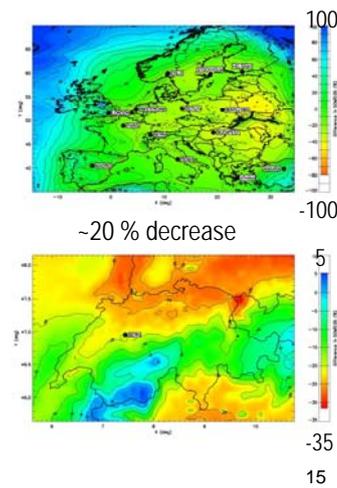
measurements

SOMO35 (ppb.d) trends in Switzerland (from FOEN)



sensitive to background ozone

modelled change 2005-1990



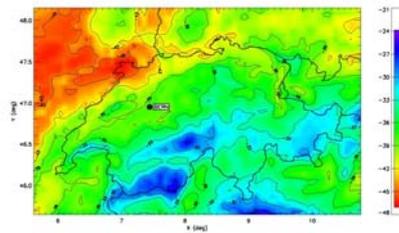
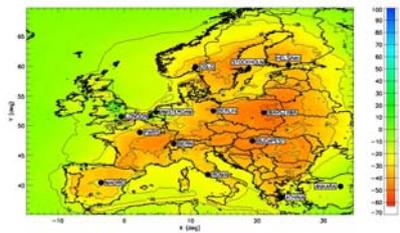
15

Difference in SOMO35 (%) between 2005 and 2020

BL 2020 - RC 2005

European Domain

Swiss Domain



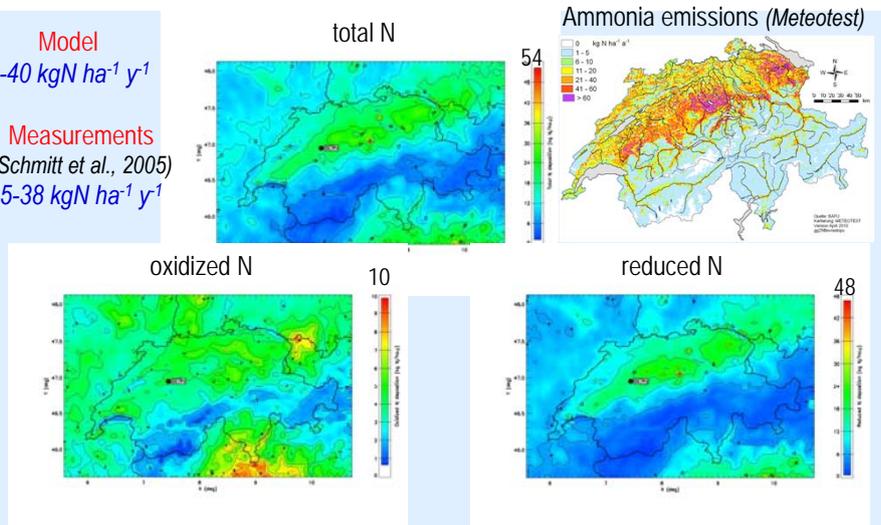
-40% decrease

16

Nitrogen Deposition ($\text{kg N ha}^{-1} \text{y}^{-1}$) reference case, 2005

Model
5-40 $\text{kg N ha}^{-1} \text{y}^{-1}$

Measurements
(Schmitt et al., 2005)
5-38 $\text{kg N ha}^{-1} \text{y}^{-1}$

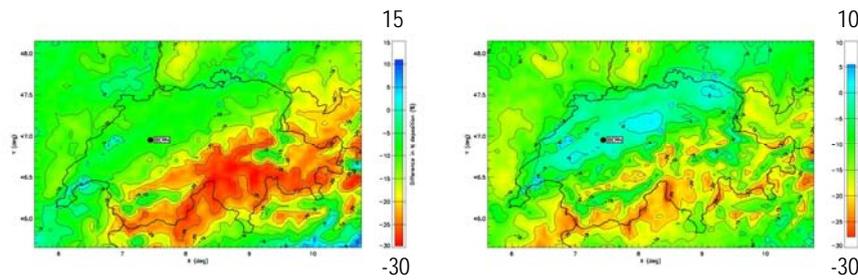


17

Difference in Nitrogen Deposition (%)

RC 2005 - 1990

BL 2020 - RC 2005



~10 % decrease in the north
~25% decrease in the south

no significant change in the north
~15% decrease in the south

18

Conclusions

PM: The model could reproduce the relative changes of about 40% in annual average concentrations of PM between 1990 and 2005.

Assuming the baseline scenario for 2020, ~30% decrease in PM_{2.5} is expected in Europe.

Ozone damage indicators: AOT40 and SOMO35 could be modelled reasonably well for the reference year, but their trends cannot be confirmed by measurements. These results indicate their sensitivity to the background ozone levels which need to be revised.

Assuming constant background ozone concentrations over Europe after 2005, AOT40 and SOMO35 were predicted to decrease significantly until 2020.

Nitrogen deposition in Switzerland: Good model performance. Fraction of reduced N species is larger in the north due to high NH₃ emissions.

Nitrogen deposition decreased by about 25% since 1990 and further decreases were predicted for 2020 in the south mainly due to reduction of oxidized species.

19

Acknowledgements

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