



Biogenic Emissions over Europe in Past and Future Climate

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PRESENTATION OUTLINE



Biosphere-atmosphere-climate interactions



Modeling VOC emissions



Recent past (1979-2014)



Future Climate (2071-2100)



Take-home message

Introduction

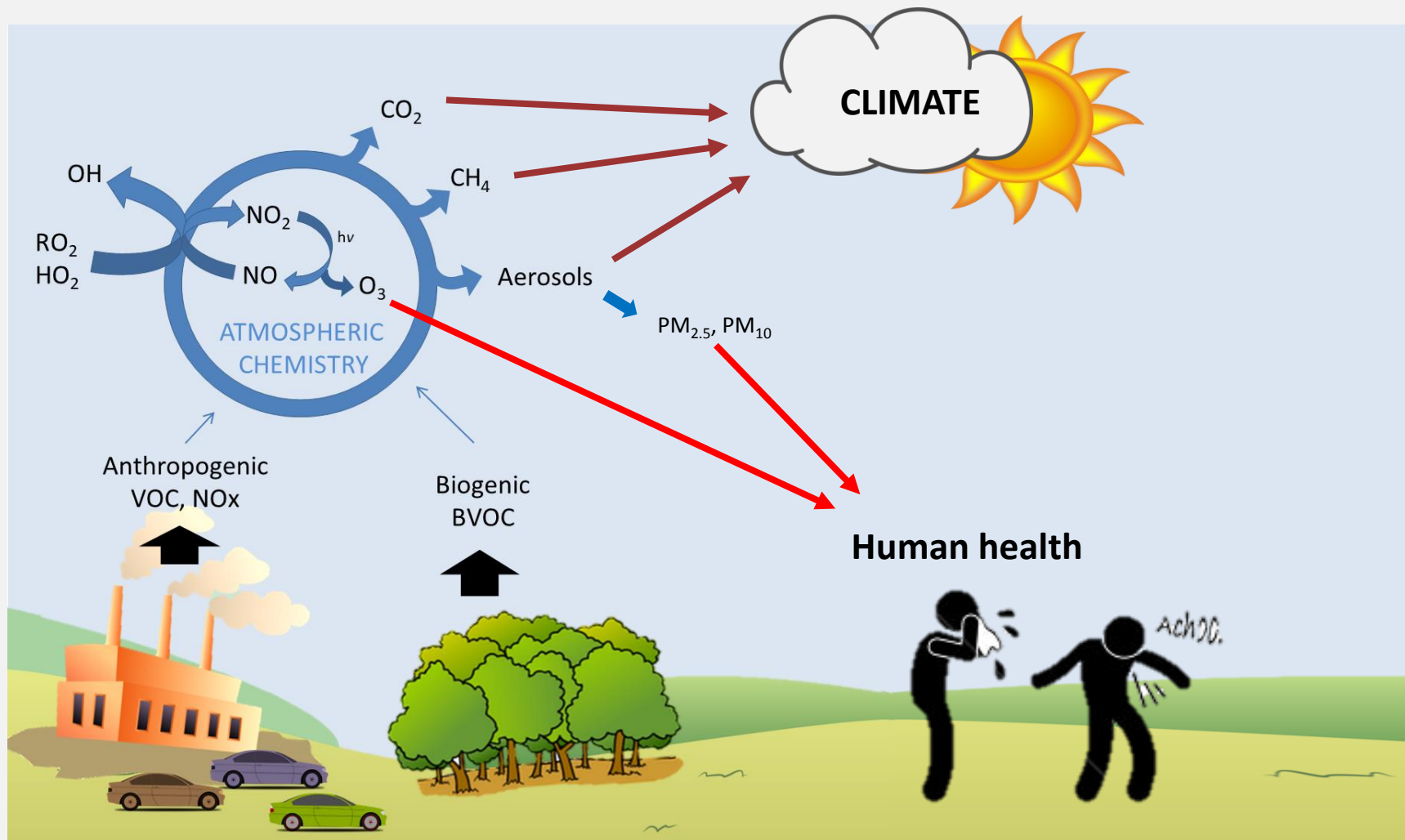
Isoprene

Recent past

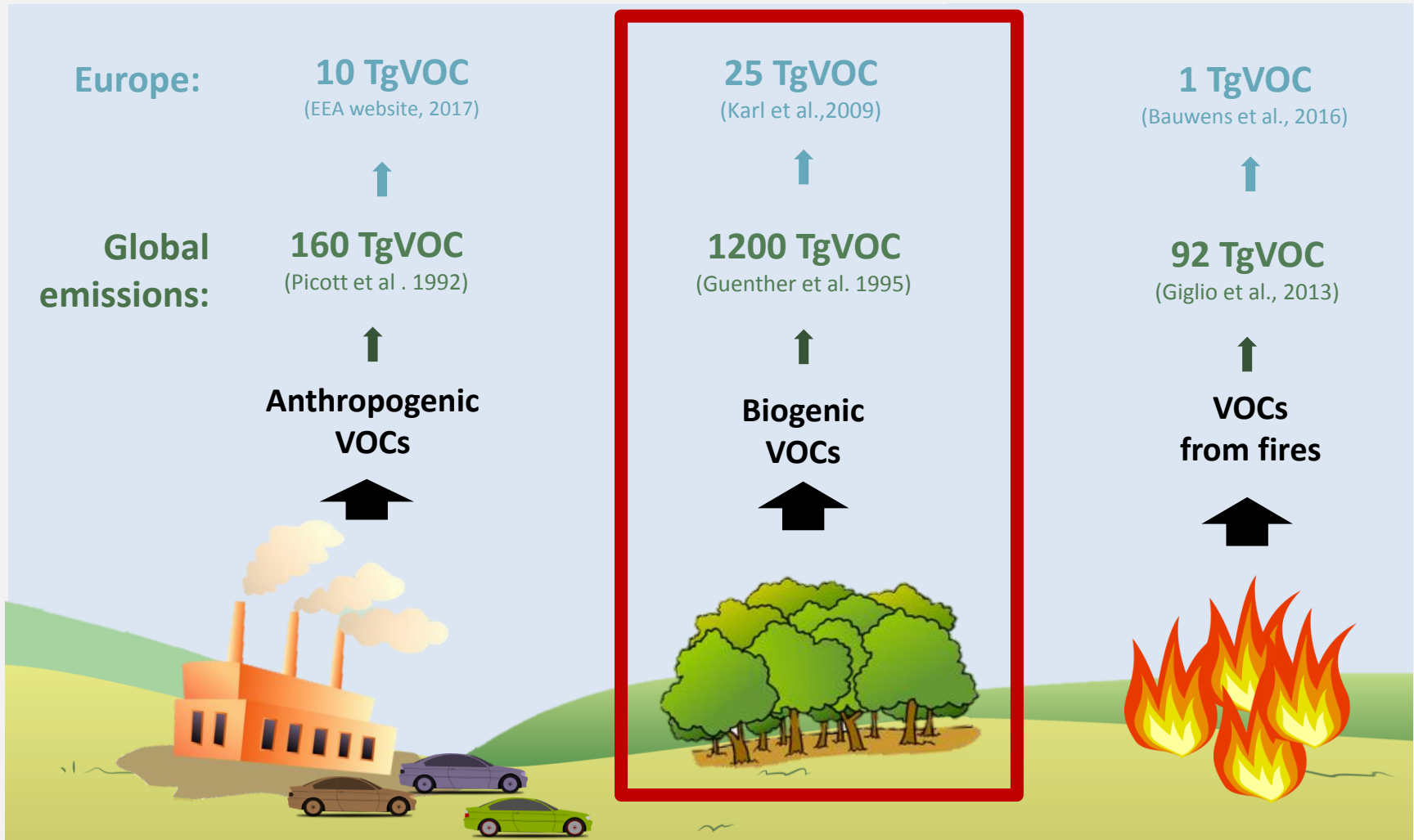
Future

Conclusions

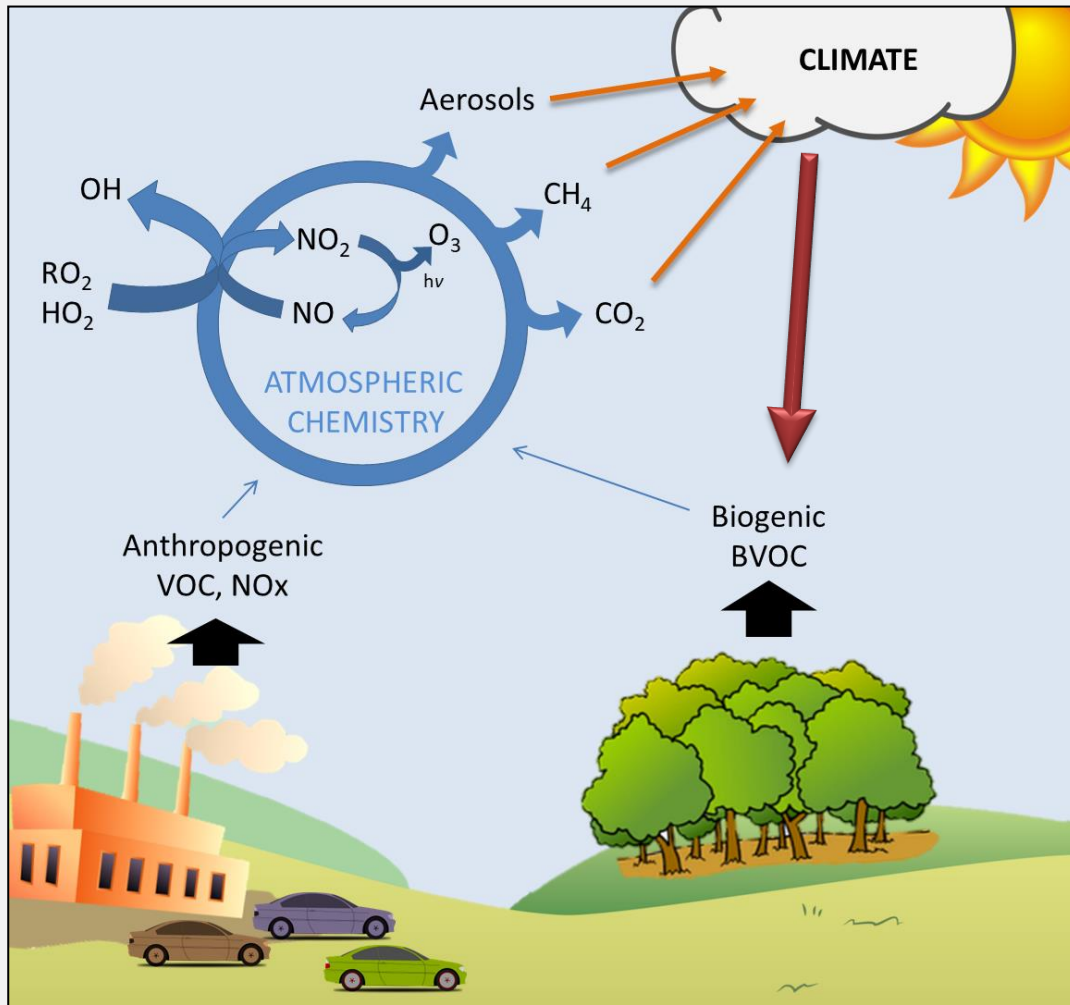
Chemistry, climate and human health



Origin of VOC emission sources



Biosphere-climate interactions



VOC emissions



Atmospheric
Chemistry

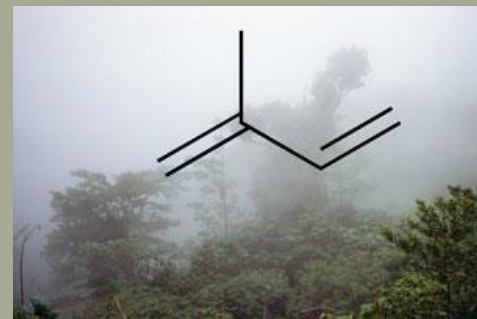
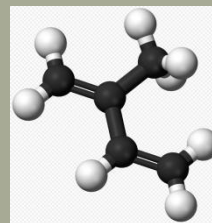


Climate



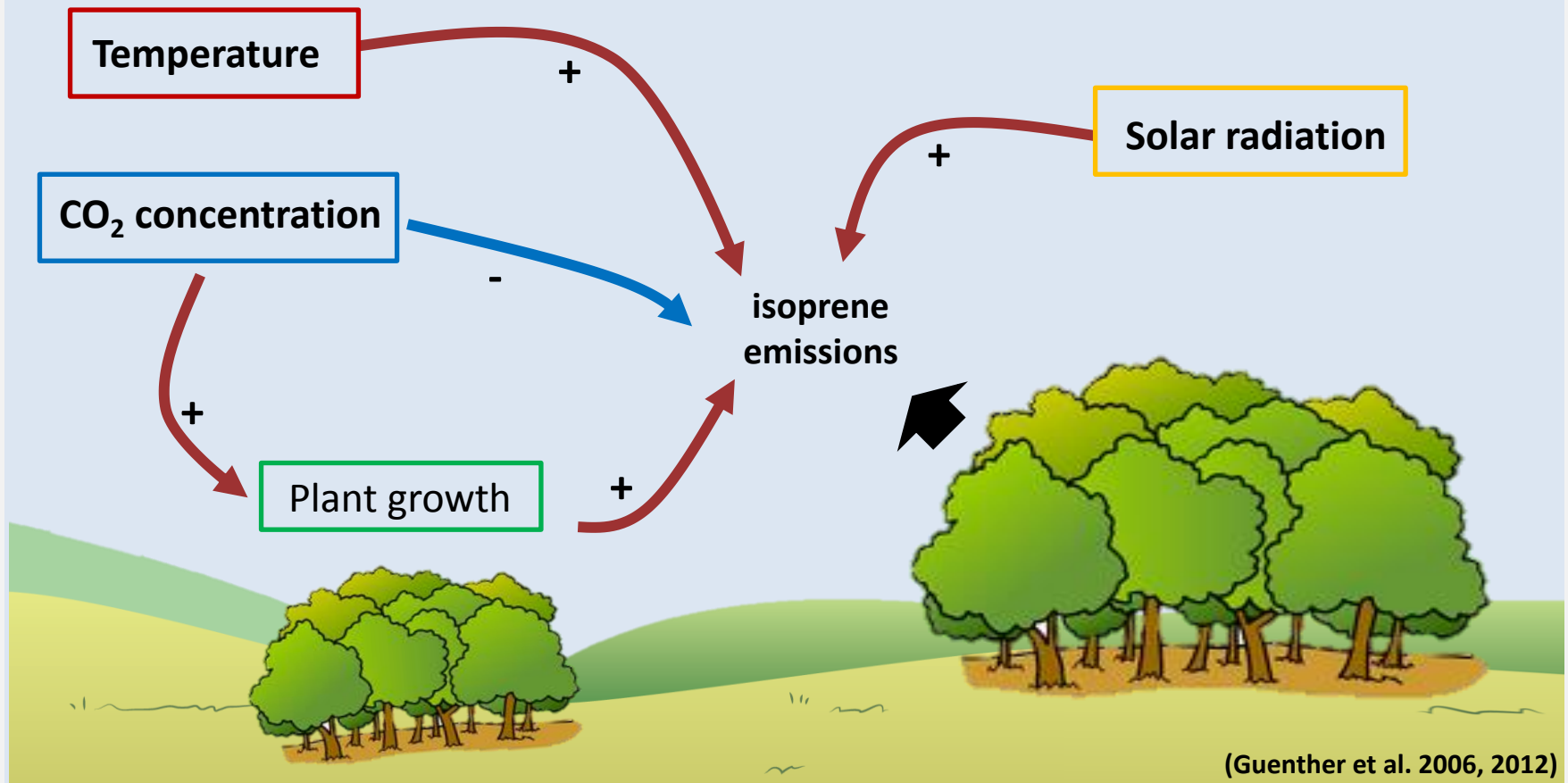
(CLIMATOLOGICAL) PARAMETERS DRIVING ISOPRENE EMISSIONS

- Isoprene is the most abundantly emitted biogenic VOC
- Highly reactive : $+OH$, $+O_3$, $+NO_3$, its degradation in the atmosphere is still not fully understood
- Oxidation by OH leads to ozone formation under polluted conditions : Source of secondary organic aerosols → impact on health, negative climate forcing
- Central in chemistry-biosphere-climate interactions
- Model isoprene emissions using MEGAN



The MEGAN model

$$\text{Isoprene Flux} = \varepsilon \cdot C_{CE} \cdot \gamma_P \cdot \gamma_T \cdot \gamma_{CO_2} \cdot \text{LAI} \cdot \gamma_{age}$$



The MOHYCAN canopy model

$$\text{Isoprene Flux} = \varepsilon \cdot C_{CE} \cdot \gamma_P \cdot \gamma_T \cdot \gamma_{CO_2} \cdot LAI \cdot \gamma_{age}$$

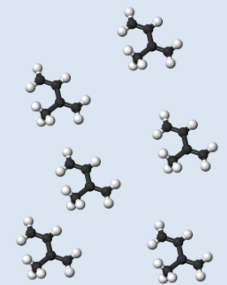
Temperature

Solar radiation

Relative humidity

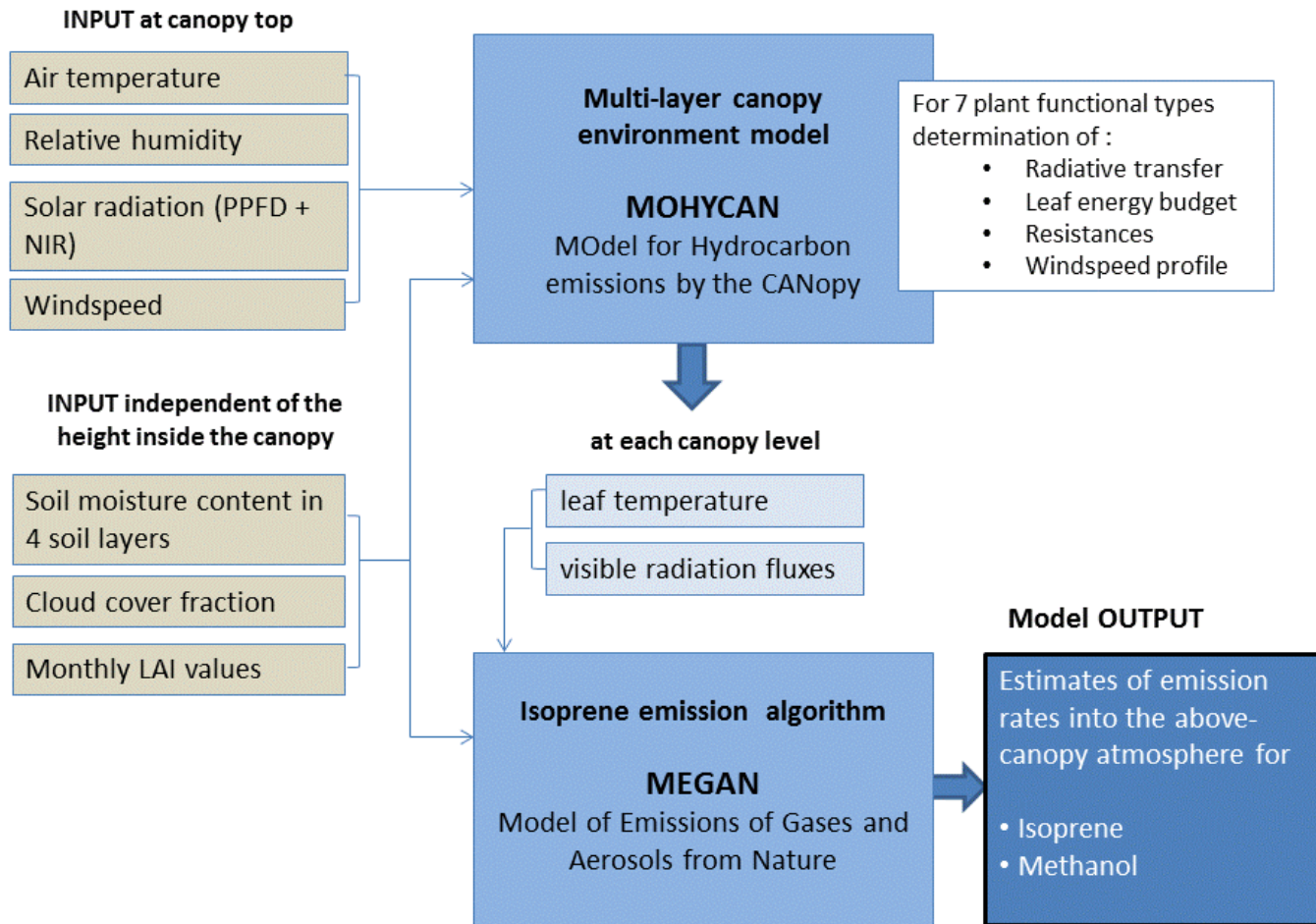
Wind speed

Isoprene



Müller et al., 2008

The MEGAN-MOHYCAN model



Müller et al., 2008
Stavrakou et al., 2014

Input in MEGAN-MOHYCAN

Recent past (1979-2014)

- Climate data:
 - ERA-Interim ECMWF (Dee et al., 2011)
 - Solar radiation data from observations (Sanchez-Lorenzo et al., 2015)
- Vegetation
 - Fixed PFT map from MEGAN
 - LAI from MODIS or before 2003 calculated based on temperature

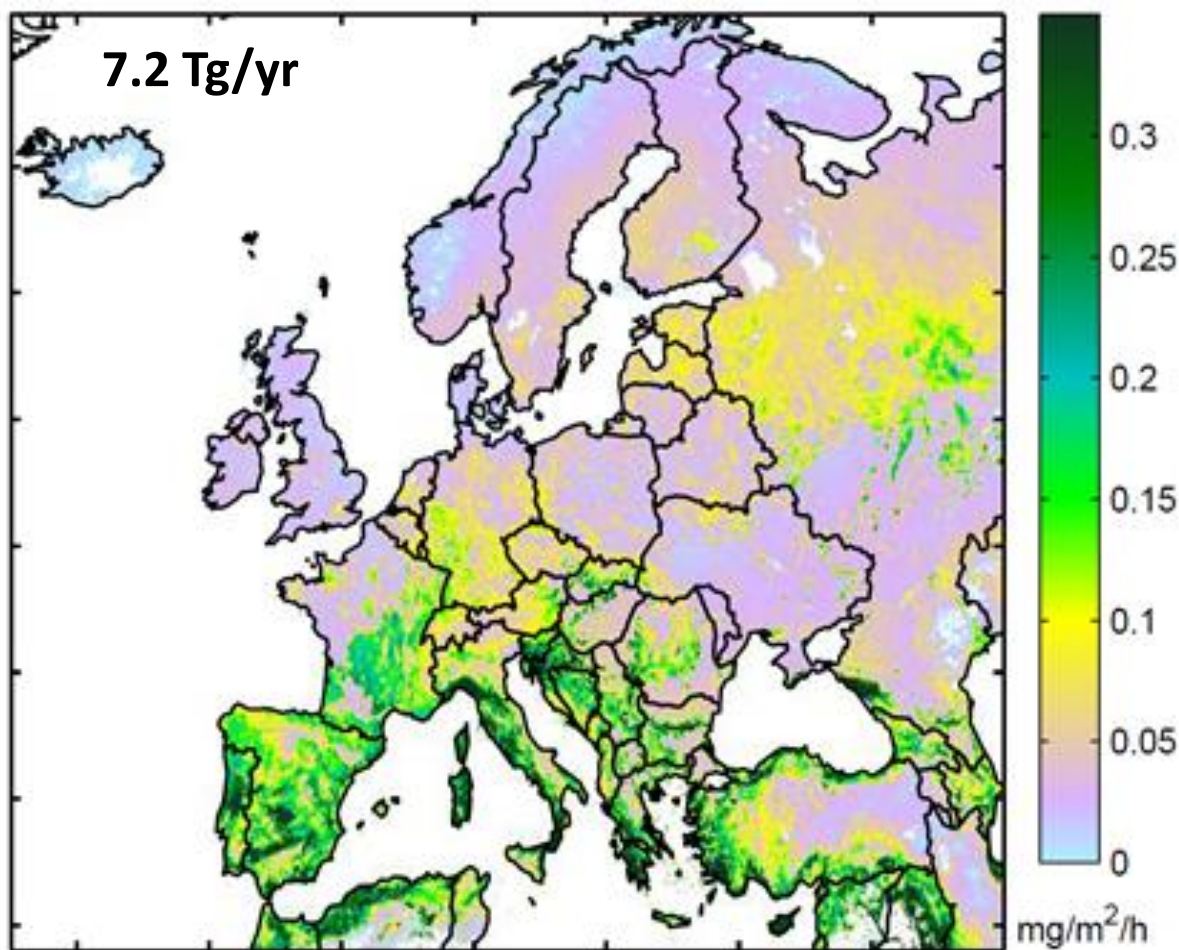
End-of-century



- Climate data
 - Projections from ALARO (Giot et al., 2016)
 - RCP2.6, RCP4.5 and RCP8.5
- Vegetation
 - Fixed PFT map from MEGAN
 - LAI fixed or increased to account for CO₂ fertilization (Zhu et al. 2016)

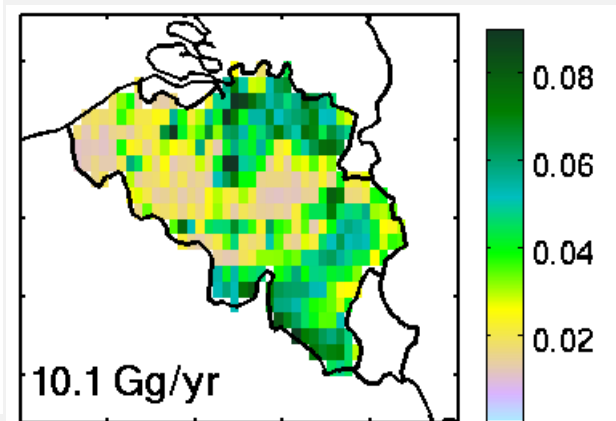
(Bauwens et al., 2017)

Isoprene emission distribution



Strong emissions in:

- Warm regions
- Regions with strong emitters
- Densely forested regions



(Bauwens et al., 2017)

WHAT IS THE IMPACT OF CHANGING CLIMATE ON ISOPRENE EMISSIONS ?

Introduction

Isoprene

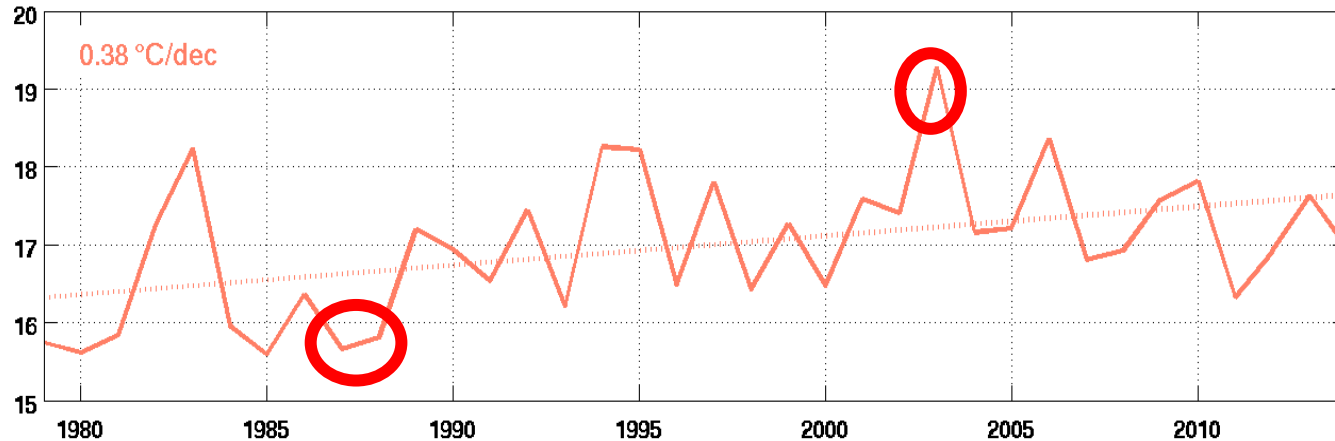
Recent past

Future

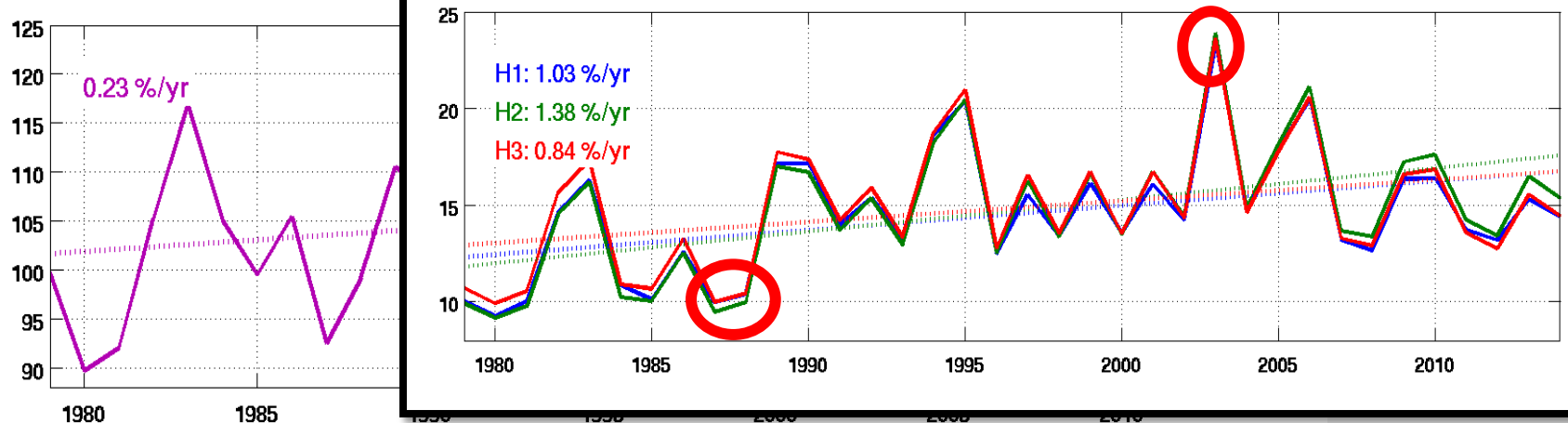
Conclusions

Isoprene emissions in Belgium

Mean summer temperature over Europe (°C)



Annual Isoprene emission over Belgium (Gg/yr)



HOW WILL ISOPRENE EMISSIONS EVOLVE IN FUTURE ?

Introduction

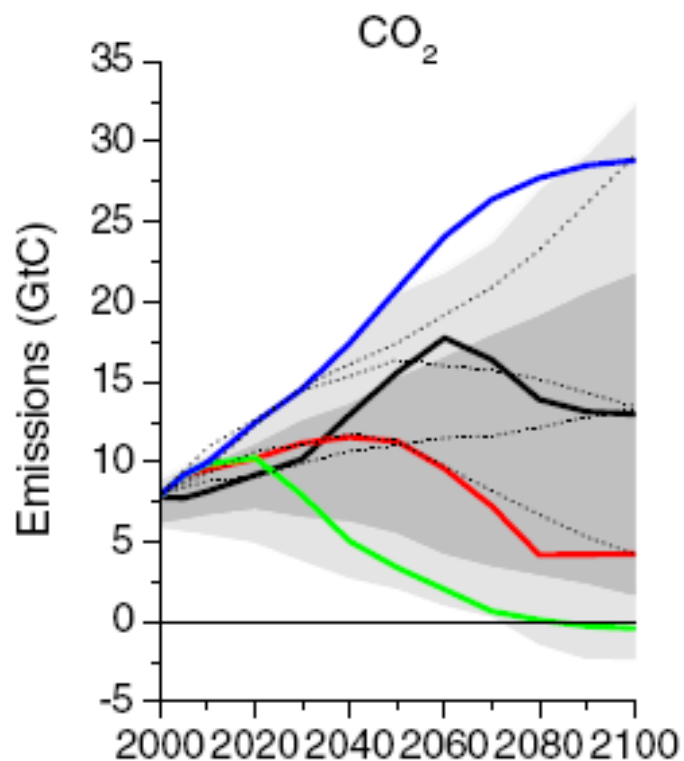
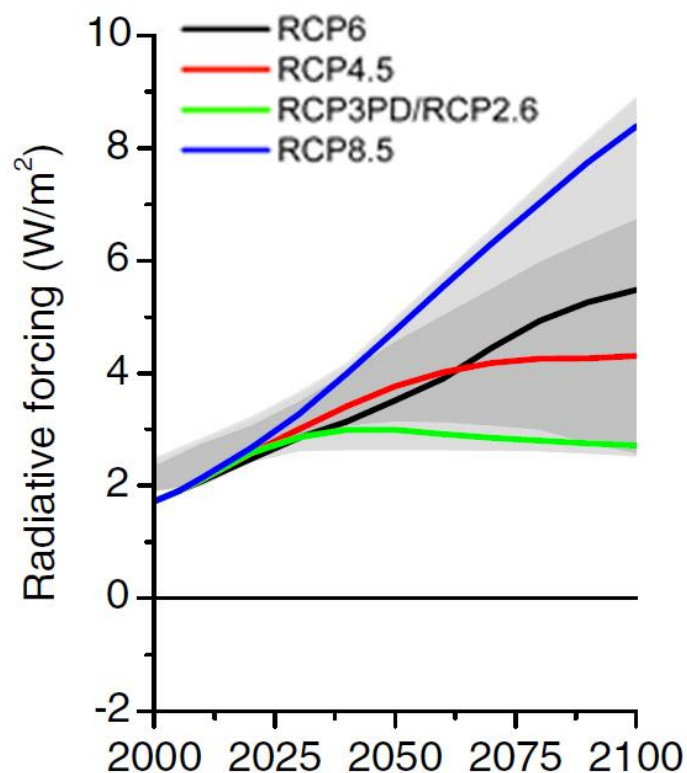
Isoprene

Recent past

Future

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Future climate forced by RCP-scenarios



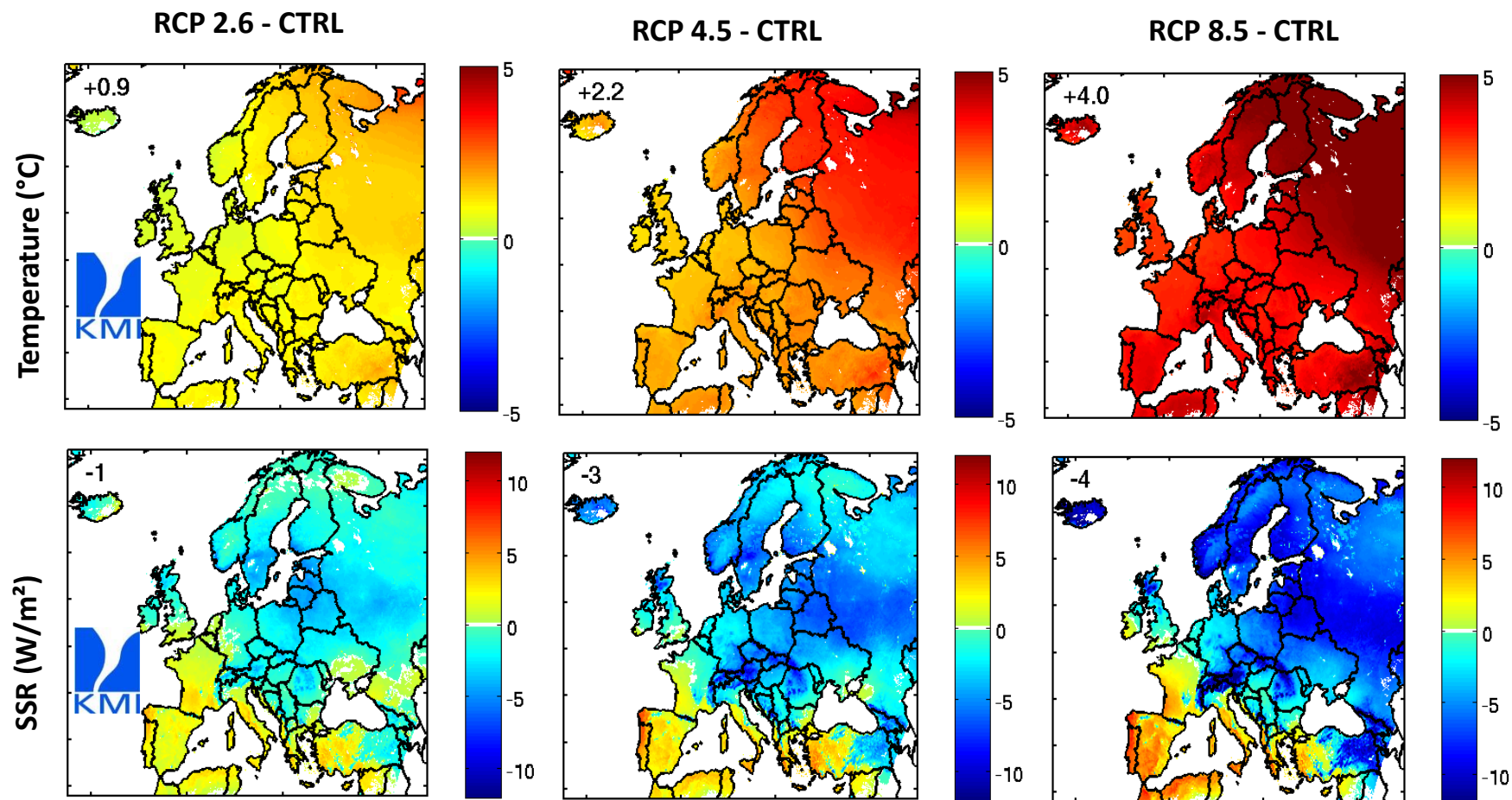
RCP 8.5: emissions continue to rise

RCP 4.5: emissions in peak around 2040, then decline

RCP2.6: strong emission reduction after 2020

Van Vuuren et al., 2011

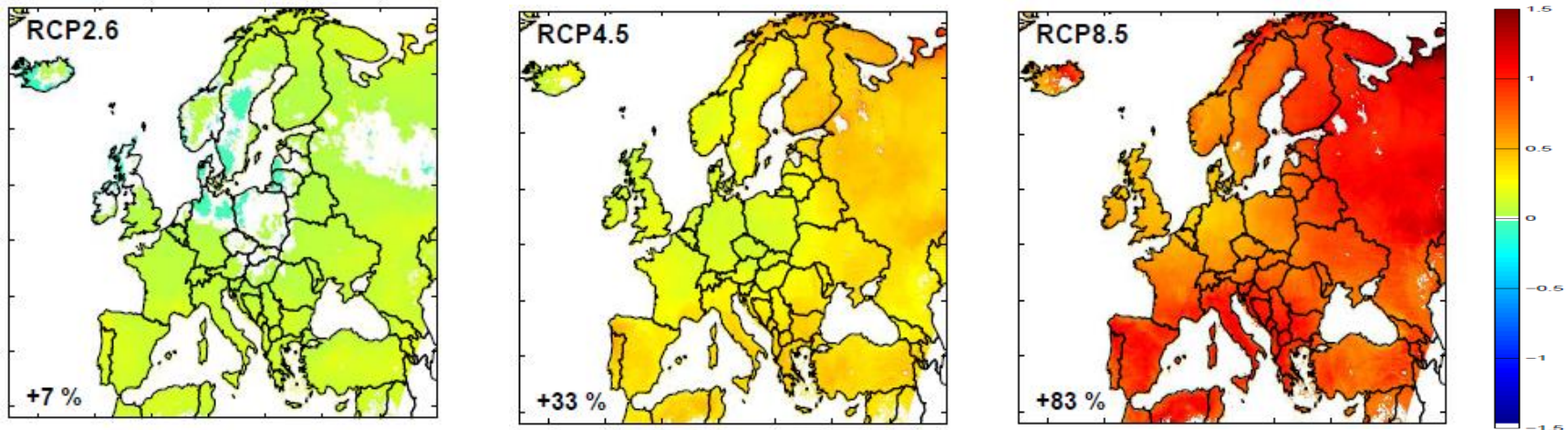
Future climate change based on ALARO



Giot et al. 2016

Climate impact on isoprene

Isoprene emission increment compared to recent past (in %)



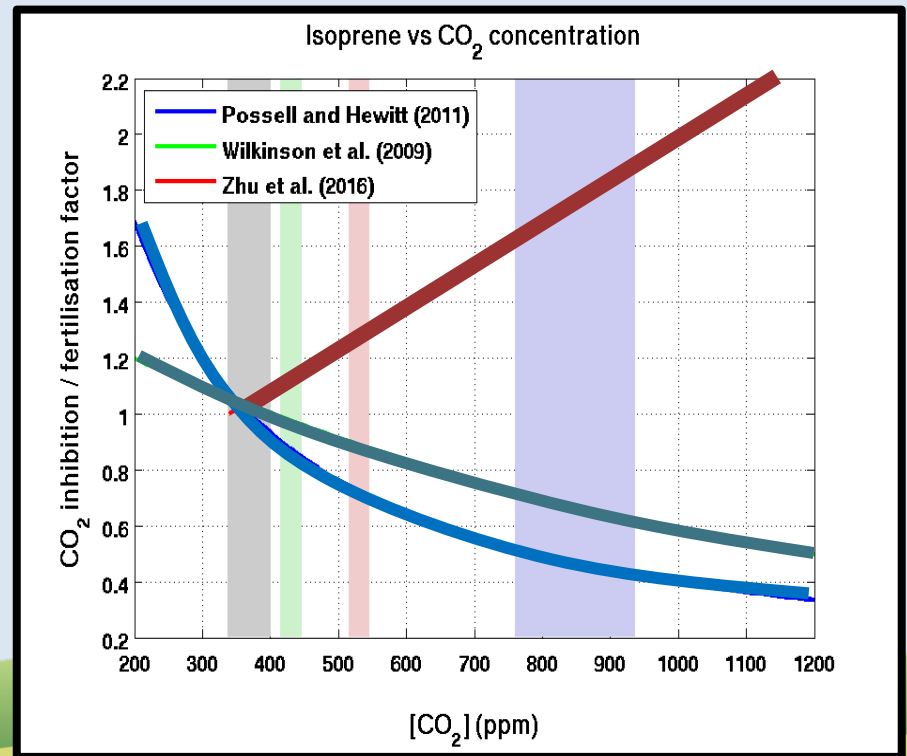
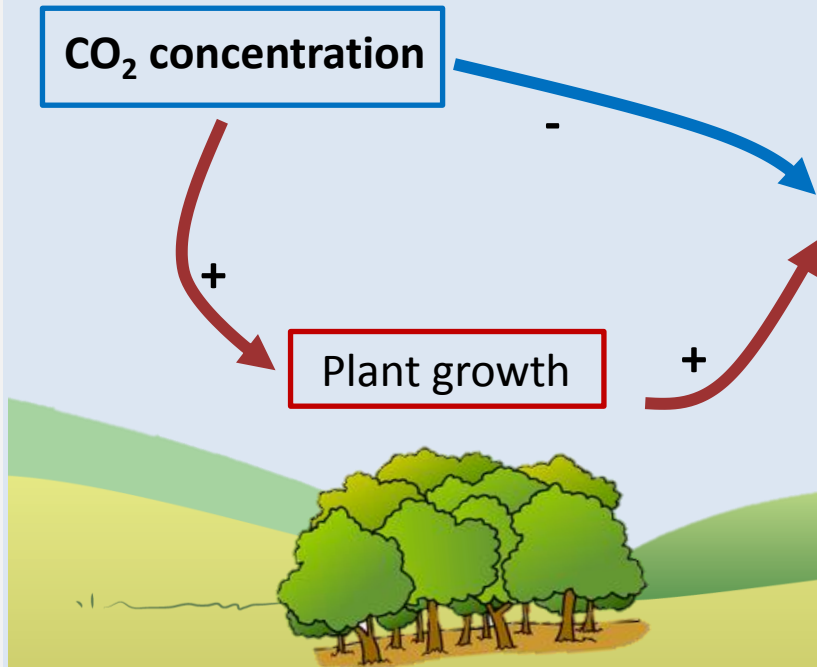
When considering **only climate** changes
isoprene emissions will **increase by 7% to 83%**
by the end of this century

$$\text{Isoprene Flux} = \varepsilon \cdot C_{CE} \cdot \gamma_P \cdot \gamma_T \cdot \gamma_{CO_2} \cdot LAI \cdot \gamma_{age}$$

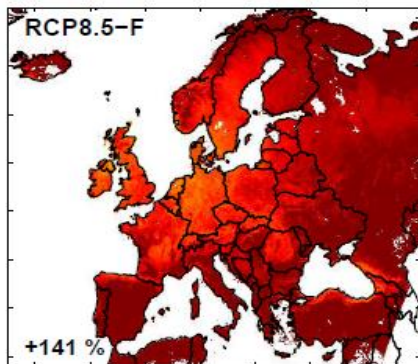
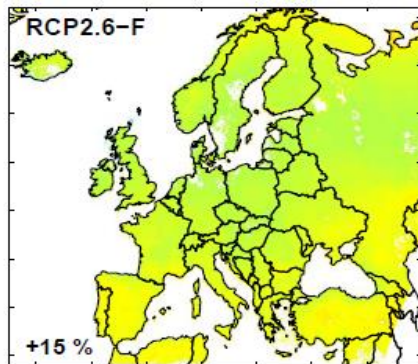
vens et al., 2017

CO₂ and isoprene

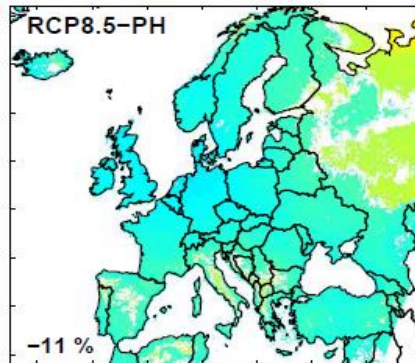
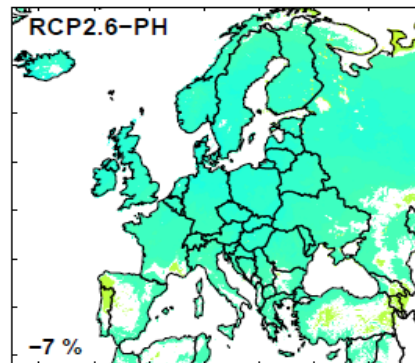
$$\text{Isoprene Flux} = \varepsilon \cdot C_{\text{CE}} \cdot \gamma_P \cdot \gamma_T \cdot \gamma_{\text{CO}_2} \cdot \text{LAI} \cdot \gamma_{\text{age}}$$



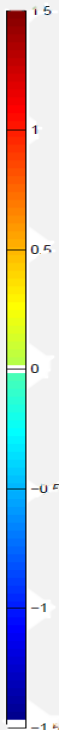
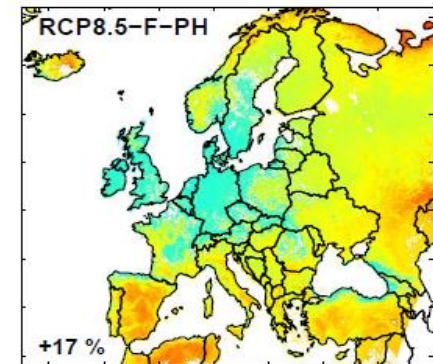
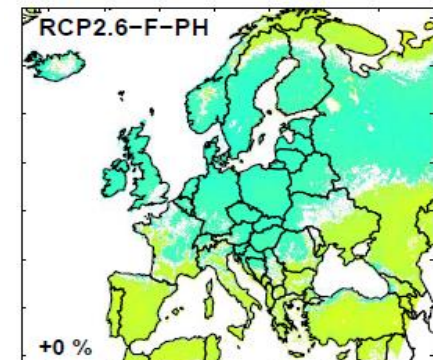
CO₂ fertilization



CO₂ inhibition



Combined



When considering climate changes together with CO₂ fertilization and CO₂ inhibition isoprene will **increase by 0 to 17%** by the end of the century.

Bauwens et al., 2017

Take-home message

- VOC emissions play a key role for climate and human health
- Changing climate has an impact on BVOC emission, and isoprene is the most important BVOC
- We used the MEGAN-MOHYCAN model to calculate isoprene emissions in the recent past (1979-2014) and future (2070-2100)
- During 1979-2014 isoprene emissions increased by 1%/year in response to the changing climate
- Future projections using ALARO model output suggest an increase of isoprene emissions by 7-83% for the end-of-the-century depending on the scenario
- Rising CO₂ levels lead to, on the one hand, emission inhibition, and, on the other, to fertilization. These effects are still highly uncertain.

THANK YOU FOR YOUR ATTENTION
TIME FOR QUESTIONS

Introduction

Isoprene

Recent past

Future

Conclusions