



The
University
Of
Sheffield.



Quantifying and
Understanding
the Earth System



MODELING EMISSIONS OF VOLATILE ORGANIC COMPOUNDS FROM THE TERRESTRIAL BIOSPHERE

QUEST PROJECT

Juliette LATHIÈRE¹, David BEERLING¹
and Nick HEWITT²

¹University of Sheffield, ²University of Lancaster

Biogenic emissions in the Earth

80%
of Volatile Organic
Compounds emitted at the
surface ~ 1000 TgC/yr



Large chemical diversity:
alkenes, alcohols, ketones
isoprene, monoterpenes

Strong reactivity in the
troposphere:
Life times: several min to 1d
Ozone cycle, CO₂ and
secondary organic aerosols
formation

Sensitivity to environmental
conditions:
Radiation, temperature
Vegetation type, leaf surface,
leaf age
Soil moisture, CO₂ level

Model development

■ Emission model:

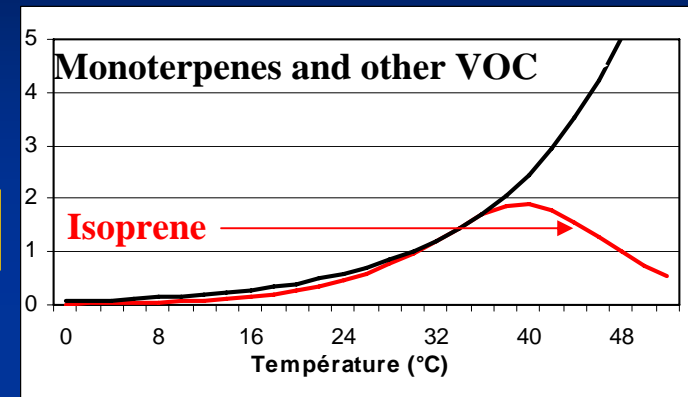
- Isoprene, monoterpenes and other organic compounds
- Flux calculation:

$$F = LAI * EF * F(\text{Temp}, \text{Rad}, \text{CO}_2, \text{leaf age}, \text{Soil moist})$$

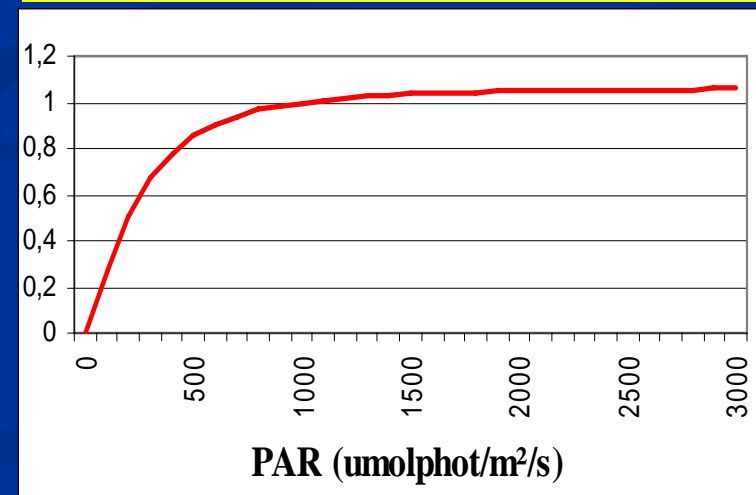
■ Influence of temperature and radiation

- Isoprene
 - Temperature and radiation
 - Leaf age, soil moisture and atmospheric CO₂
- Monoterpenes and other VOCs
 - Temperature

Impact of temperature

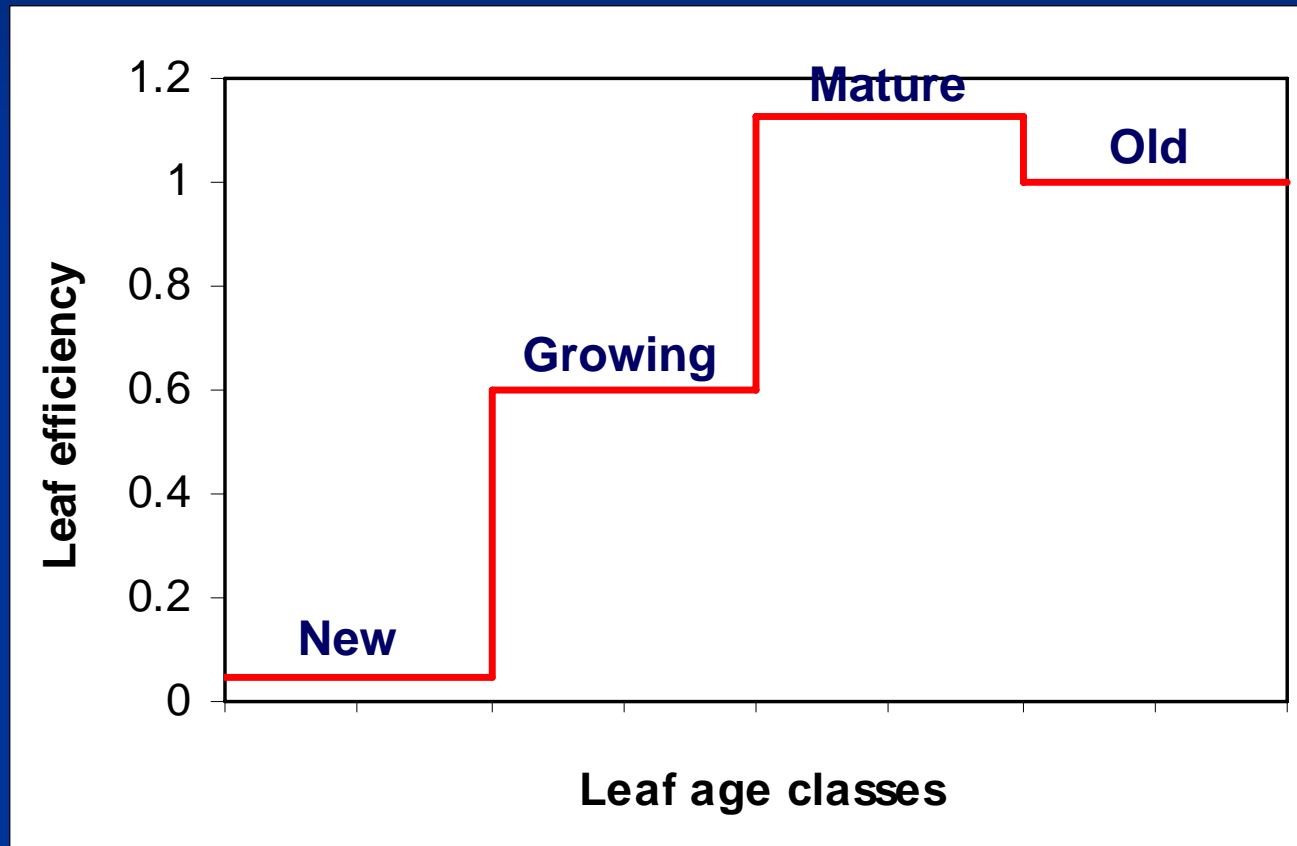


Impact of radiation



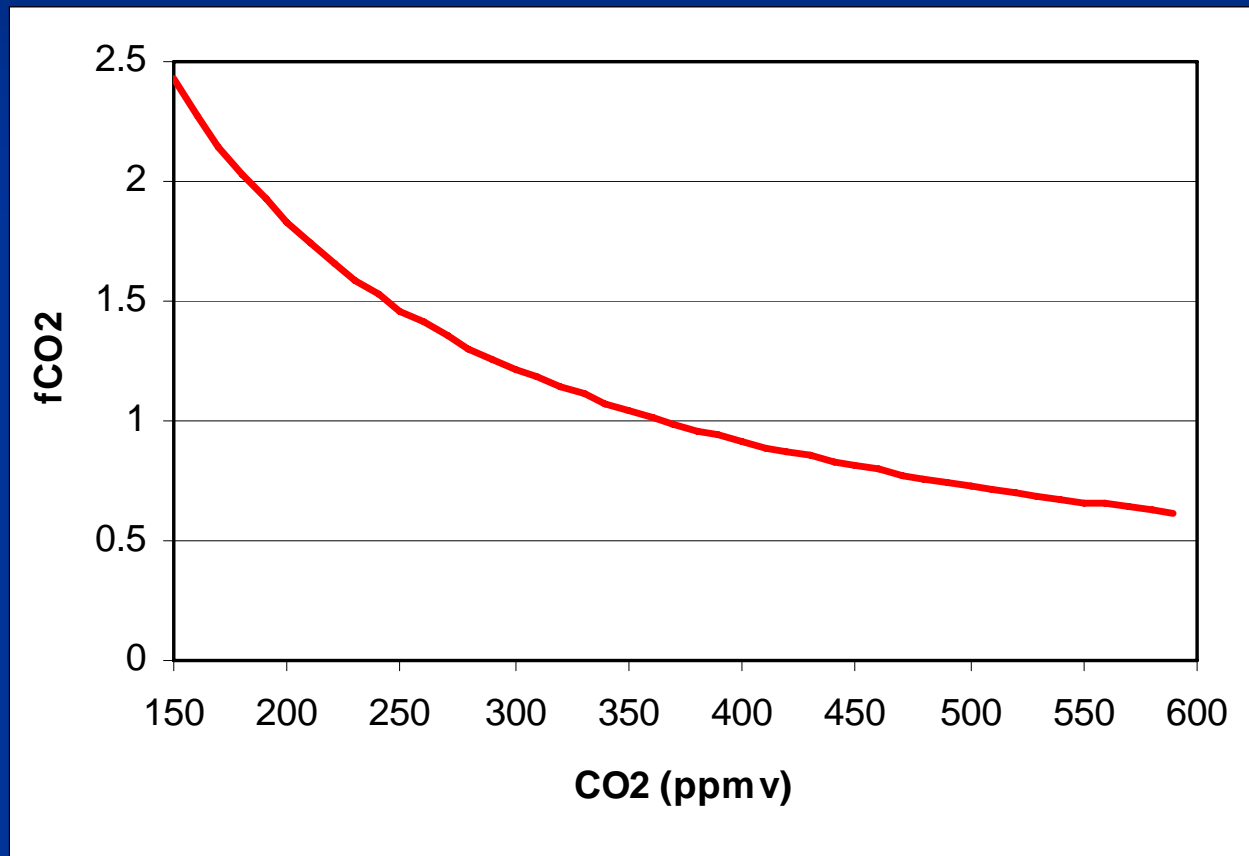
Model development: Isoprene

- Leaf age: 4 classes and varying efficiency



Model development: Isoprene

- Atmospheric CO₂ (Possel et al. 2005)



Scenarios for the Future

- Vegetation model: Sheffield DGVM, potential vegetation maps
- Climate: CRU (present-day)
and LMDz general circulation model (anomalies for 2050)

Inputs description			Results (TgC/yr)		
Climate	Vegetation map	CO ₂ level for isoprene	Isoprene	Monoterpenes	Other VOCs
Present	Potential present	366 ppmv	540	107	224
2050	Potential present	366 ppmv	719 (+33%)	134 (+25%)	275 (+23%)
2050	Potential 2050	366 ppmv	801 (+48%)	167 (+56%)	350 (+56%)
2050	Potential 2050	532 ppmv	552 (+2%)		

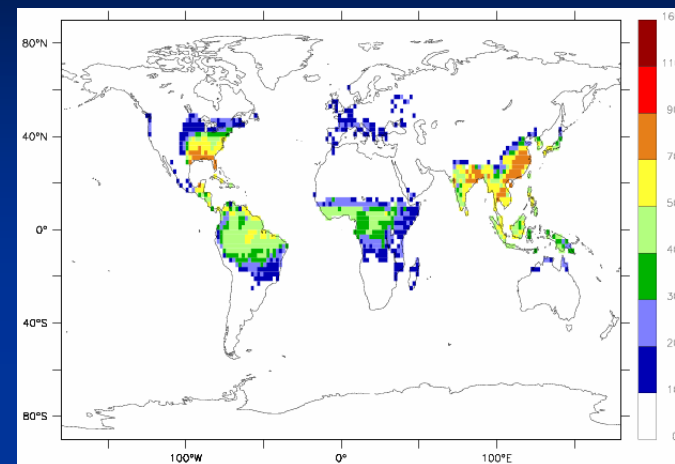
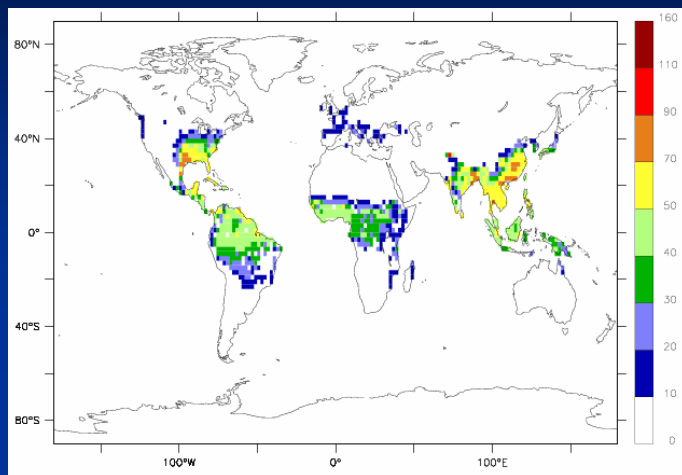
→ Taking into account the impact of CO₂ on isoprene emissions has a strong counteracting effect compared to the impact of climate and vegetation changes.

Future emissions (July mgC/m²/day)

PRESENT-DAY

2050

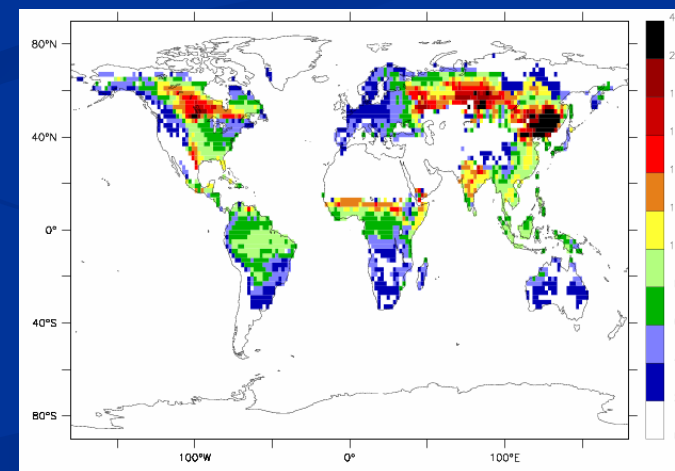
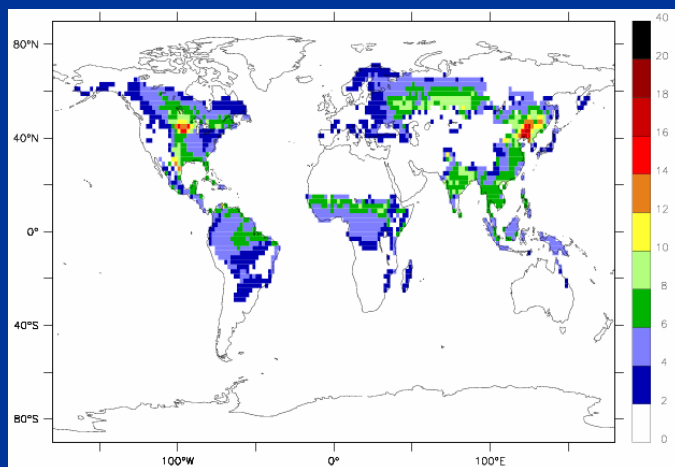
Isoprene



540 TgC/yr

552 TgC/yr

Monoterpenes



107 TgC/yr

167 TgC/yr

Next steps

- **VALIDATION**

- On-site measurements
- Evaluate isoprene emissions against satellite datasets

- **IMPACT ON TROPOSPHERIC CHEMISTRY**

- John Pyle, Oliver Wild, Rachel Pike
- Scenarios for preindustrial, present-day and 2100 (UM and UKCA models)

Next steps

- **USE INPUT FROM JULES...**
 - Vegetation fraction, leaf area index
 - Soil moisture, (leaf age)
 - Minimum number of PFTs
 - **Broadleaf trees**
 - **Fineleaf evergreen trees**
 - **Fineleaf deciduous trees**
 - **Shrubs**
 - **Grasses**
 - **Crops**