Biogenic Fluxes: Module Update

Garry Hayman and James Weber

Covers the exchange of trace gases between the land surface and atmosphere

- Emission (or release) to the atmosphere from the land surface
- Deposition (or uptake) to the land surface from the atmosphere

Specific topics

- **Emissions of biogenic VOCs (isoprene, terpenes, acetone, methanol)**
- **Atmospheric deposition**

- *Emissions of CH_4 from wetlands (also hydrology and soil biogeochemistry modules)*
- *Emissions of trace atmospheric species from biomass burning (with fire module)*

Biogenic VOCs

James Weber (U. Reading)

- Using isoprene column observations from satellites to assess UKESM performance
- Investigating impact of changing modelled land cover, atmospheric chemistry and emission factors on model performance
- Exploring the use of machine learning to derive “top-down” iBVOC emission factors for isoprene to compare to traditional “bottom-up” approach
- Presentation later today (Day 2) on bullet points 1 and 3

- Also involved in two studies on marine isoprene sources
- Developing an online emission parameterisation for marine isoprene which could involve treating chlorophyll or phytoplankton as a PFT

Emma Sands (PhD Student at University of Edinburgh)

- Using aerosol optical depth from satellite measurements to investigate isoprene emission factors

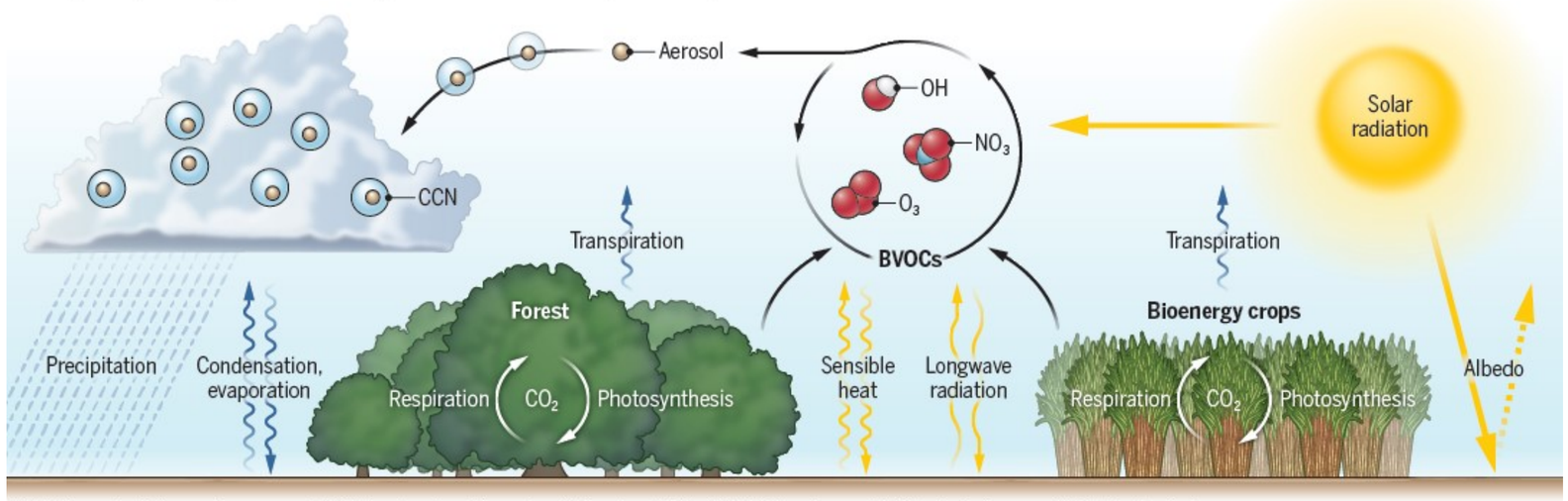
Biogenic VOCs

Publications

- Chemistry-albedo feedbacks offset up to a third of forestation's CO_2 removal benefits (Weber et al., 2024, https://doi.org/10.1126/science.adg6196)
- Forestation is not an easy fix (Hayman, 2024: https://doi.org/10.1126/science.adn7026). Perspective article on above

How forests and bioenergy crops affect the Earth system

There are many coupled land and atmospheric processes, such as albedo, photosynthesis, and the release of BVOCs by vegetation, that have been included in recent ESMs. ESMs are used to investigate the effects of forests and bioenergy crops on the surface climate and carbon cycle. Although forestation increases CO_2 uptake, this can be partially offset by attendant changes in albedo and atmospheric composition.



BVOCs, biogenic volatile organic compounds; CCN, cloud condensation nucleus; CO_2, carbon dioxide; ESM, Earth system model; NO_3, nitrate; O_3, ozone; OH, hydroxyl radical

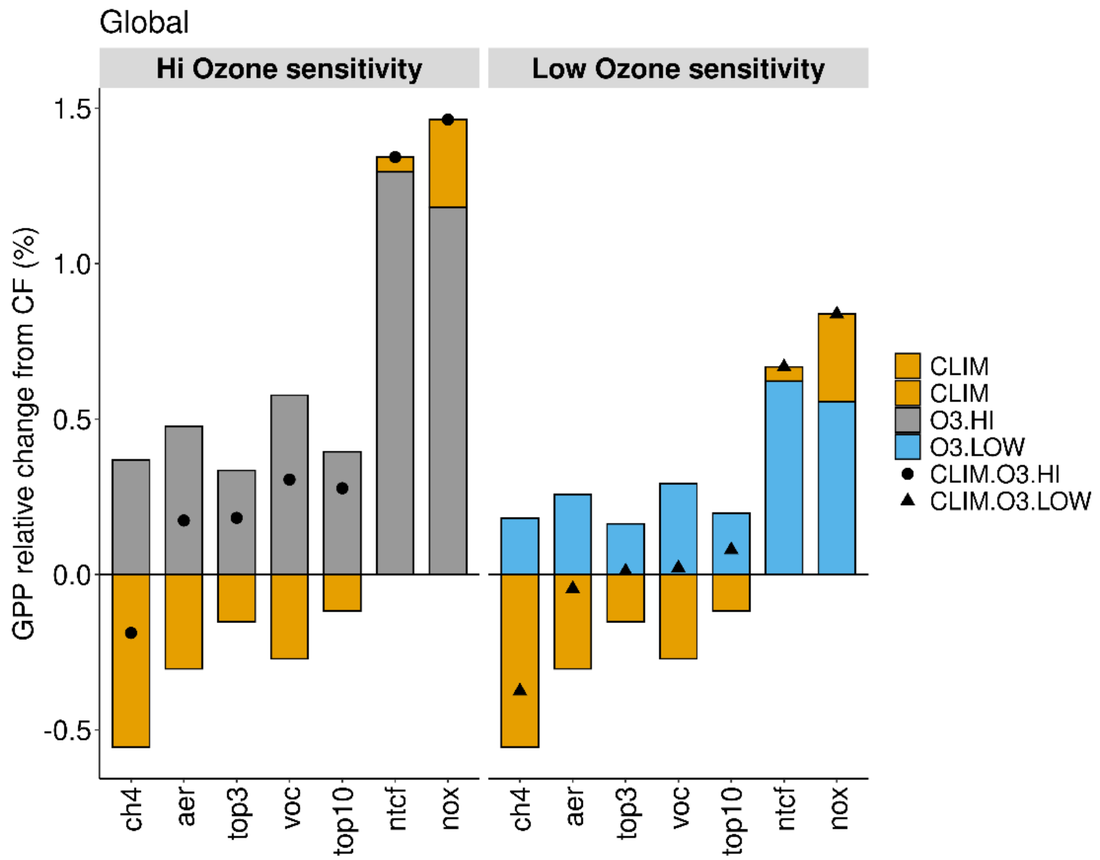
- Atmospheric isoprene measurements reveal larger-than-expected Southern Ocean emissions (Ferraci et al., 2024: https://www.nature.com/articles/s41467-024-46744-4)

Uptake of Ozone

Garry Hayman and Becky Oliver (UKCEH)

- With Vegetation module

- Contributing to the Methane Pledge study led by the Met Office
- Using offline JULES ES runs to investigate ozone vegetation damage from different emission control scenarios
- Not enabled in UM-coupled JULES and hence UKESM
- Presentation later today



Uptake of hydrogen

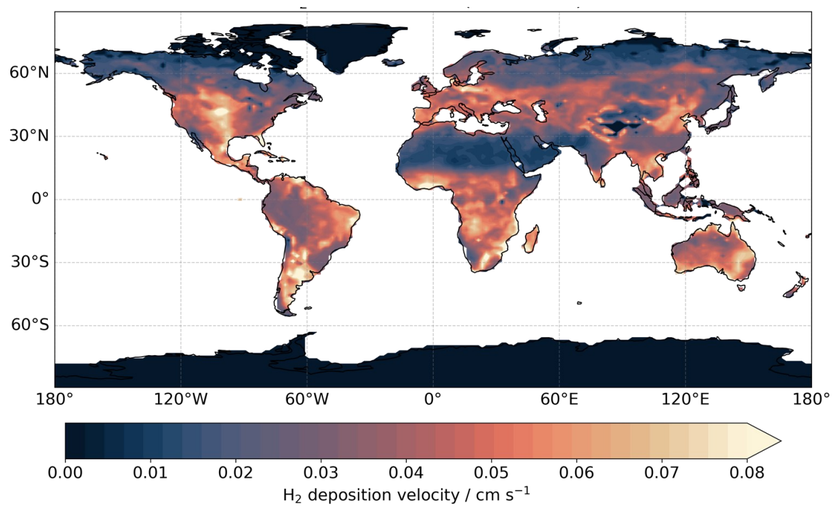
Megan Brown and Alex Archibald (U. Cambridge)

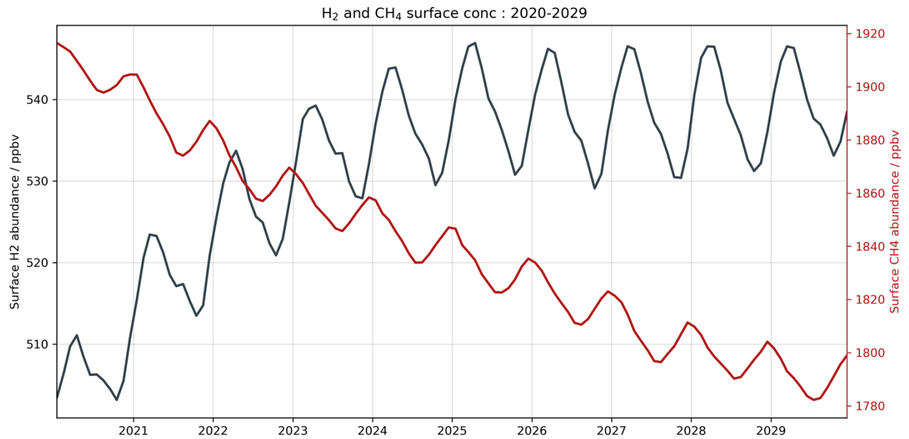
- One of 3 projects funded under the NERC call "Environmental response to hydrogen emissions"
- New two-layer H_2 deposition scheme introduced into UKCA (and in time into JULES)
- Uses soil properties from JULES
- Tested offline with multiple CMIP6 models
- Tuned to UKCA and works interactively in model, produces surface H_2 concentration of ~510 ppbv

Soil:
Total porosity
Soil moisture
Soil Carbon Content
Soil type
Temperature

Atmosphere:
Pressure

Snow depth





UK Centre for Ecology & Hydrology

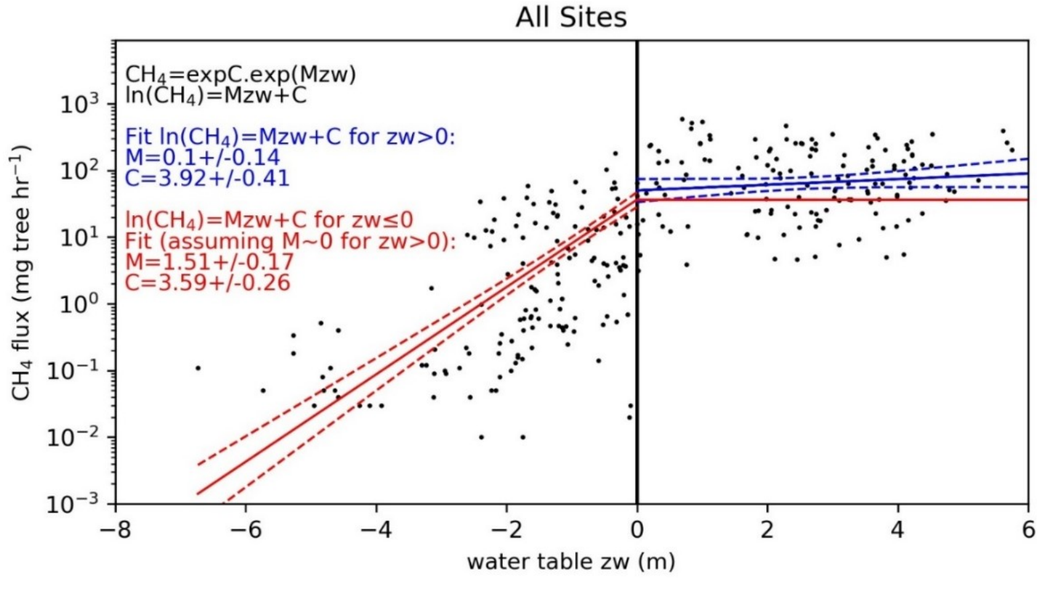
Other

Nic Gedney (Met Office) & Carolina Duran Rojas (U. Exeter)

- With Hydrology & Soil Biogeochemistry modules

Pangala et al. (2017, Nature, https://doi.org/10.1038/nature24639)

- Trees provide route for CH_4 release
- Large emissions from Amazon floodplain trees



Gauci et al. (2021, Phil. Trans. Royal Society A, https://doi.org/10.1098/rsta.2020.0446)

- Emissions from non-flooded wetlands in the Amazon floodplain
- Vegetated-mediated CH_4 code into the JULES trunk

Scale up – JULES inundation & water table model:

Amazon trees:
- Non-inundated ~3 Tg CH_4 yr^{-1}
- Total ~19 Tg CH_4 yr^{-1}

Total "wetlands"
- Total ~43 Tg CH_4 yr^{-1}