iLEAPS (integrated Land Ecosystem Atmosphere Processes)
Chairs: Eleanor Blyth (CEH) and Vinayak Sinha (IISER)

Complements GEWEX: Extreme climates, vegetation processes, soil biogeochemistry, wetlands.
Explicit focus on Society
Land-atmosphere interactions at a LONGER timescale

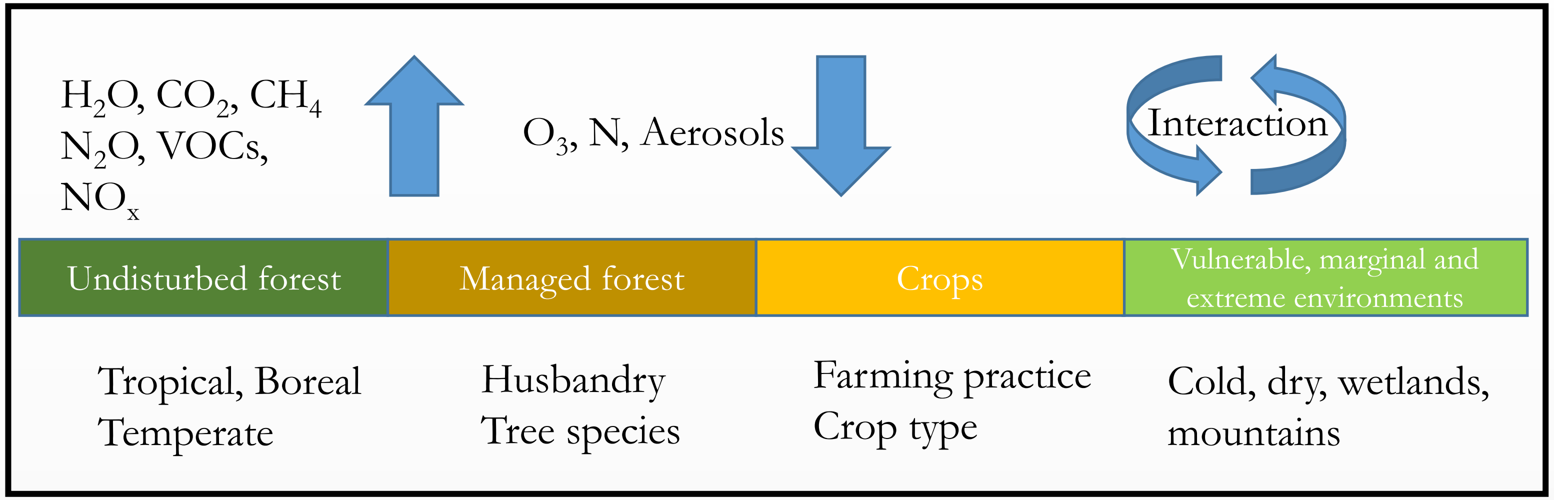
Motivation for the science. A metric by which we can measure our efforts. Can be applied to both GEWEX and iLEAPS (and all environmental science?)

Interactions between humans and nature

Extremes and how they are changing

Impacts of extremes on ecology and society

iLEAPS science



1. **Changing land-use and farming and forestry practice** affects the **atmospheric chemistry, air quality and climate**
2. Anthropogenic changes in **atmospheric chemistry** affects **plant productivity**
3. **Vulnerable and marginal ecosystems** will be affected by **changes in climate**
4. **Ecosystems** emit **short lived carbon** and its impact on the **atmospheric chemistry**

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Land-atmosphere interactions at the planetary and landscape scale

- Link Air Quality and Land
- Global Methane Budgets
- Role of permafrost warming on carbon budgets
- Aerosol impact on clouds
- Impact of ozone on crop production

Case Studies at CEH:

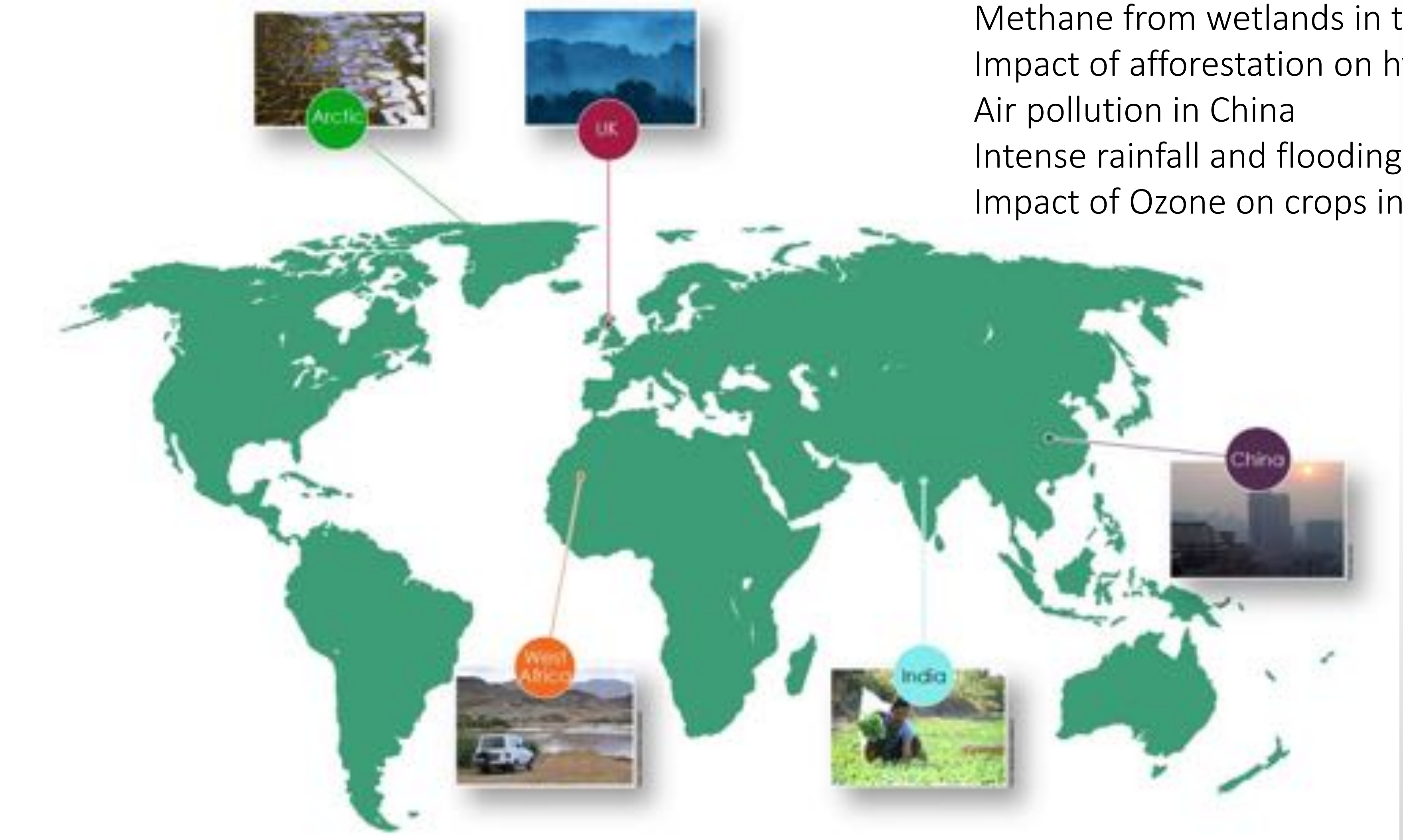
Methane from wetlands in the Arctic

Impact of afforestation on hydrology in the UK

Air pollution in China

Intense rainfall and flooding in West Africa

Impact of Ozone on crops in India



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Membership

IPO moved from Nanjing (China) to CEH in 2017
Recruited a Project Officer October 2017
700 on our mailing list
275 attended the conference in September 2017
Wide range of geographical spread of attendees

Regional Project Offices:

iLEAPS-Korea – Meehye Lee
iLEAPS-Japan – Tetsuya Hiyama
iLEAPS-China – Xuemei Wang

We are actively organising an iLEAPS-India
We are aiming to build an iLEAPS-Africa

We have a very active Early Career Scientist Network

Map of conference attendees

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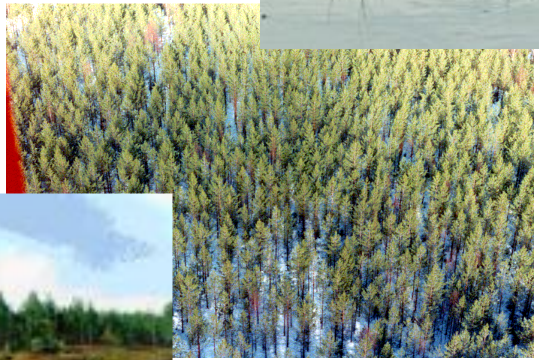
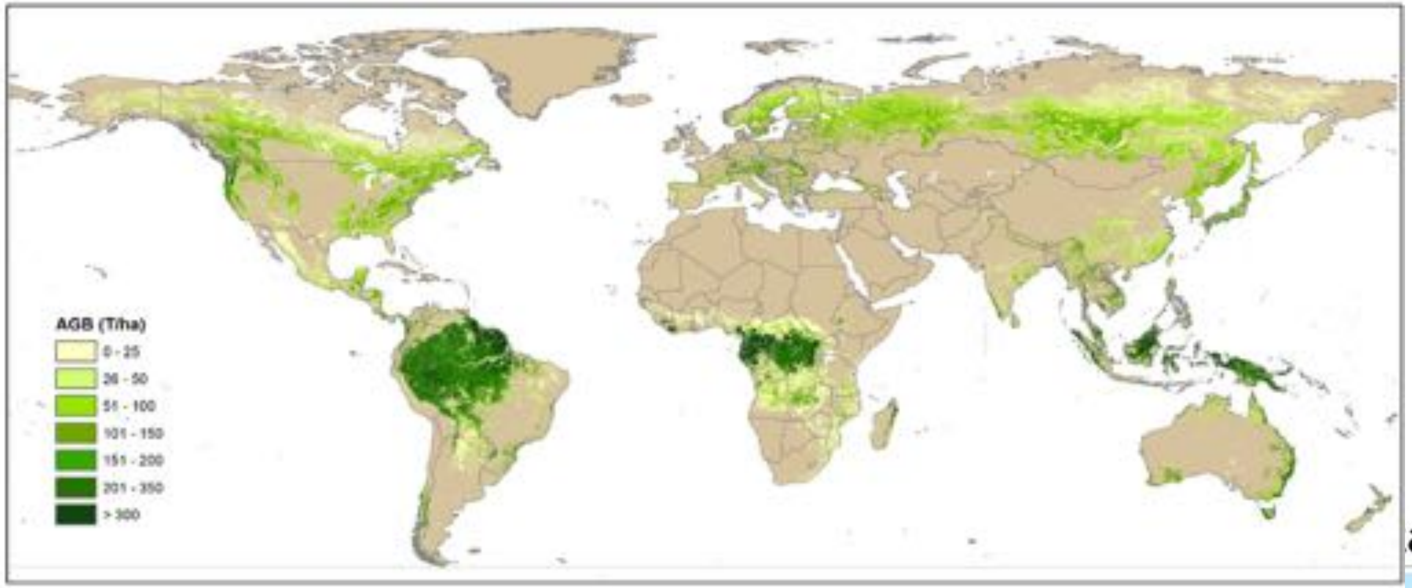
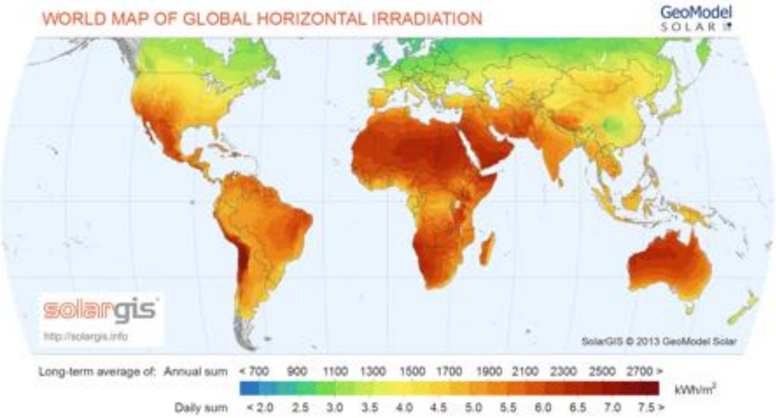
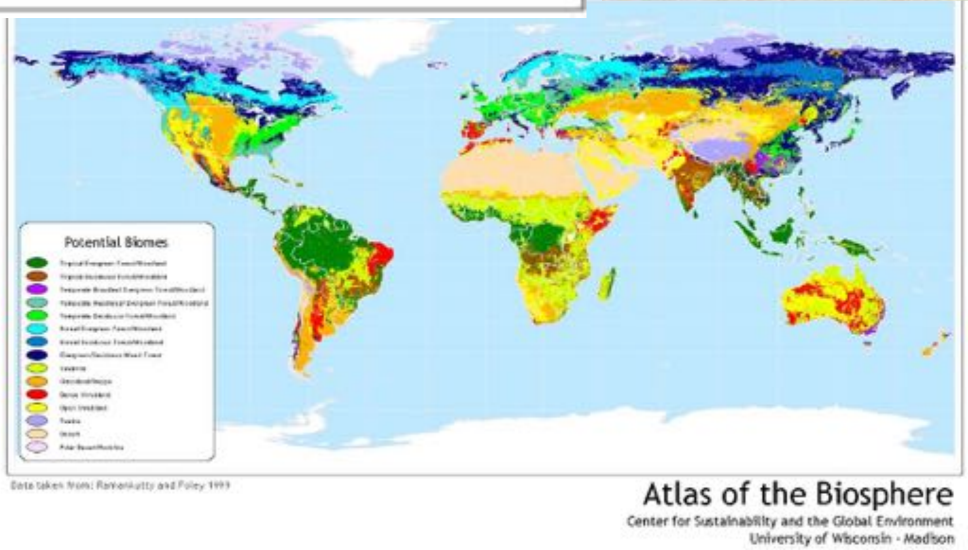
Link between Climate and Vegetation





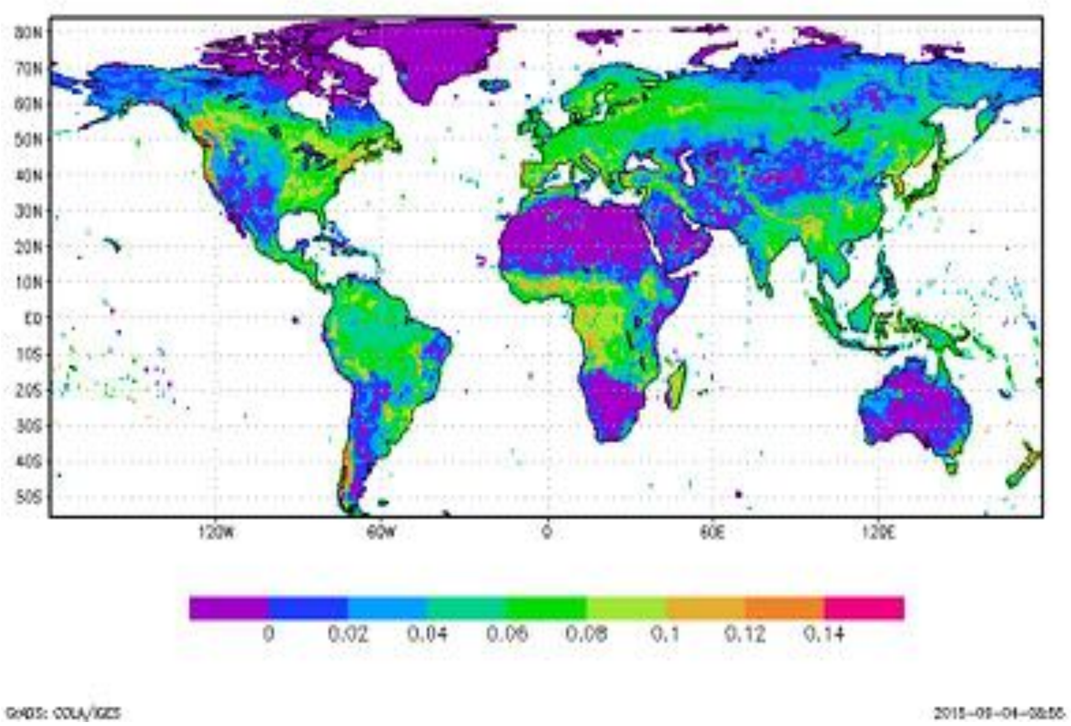




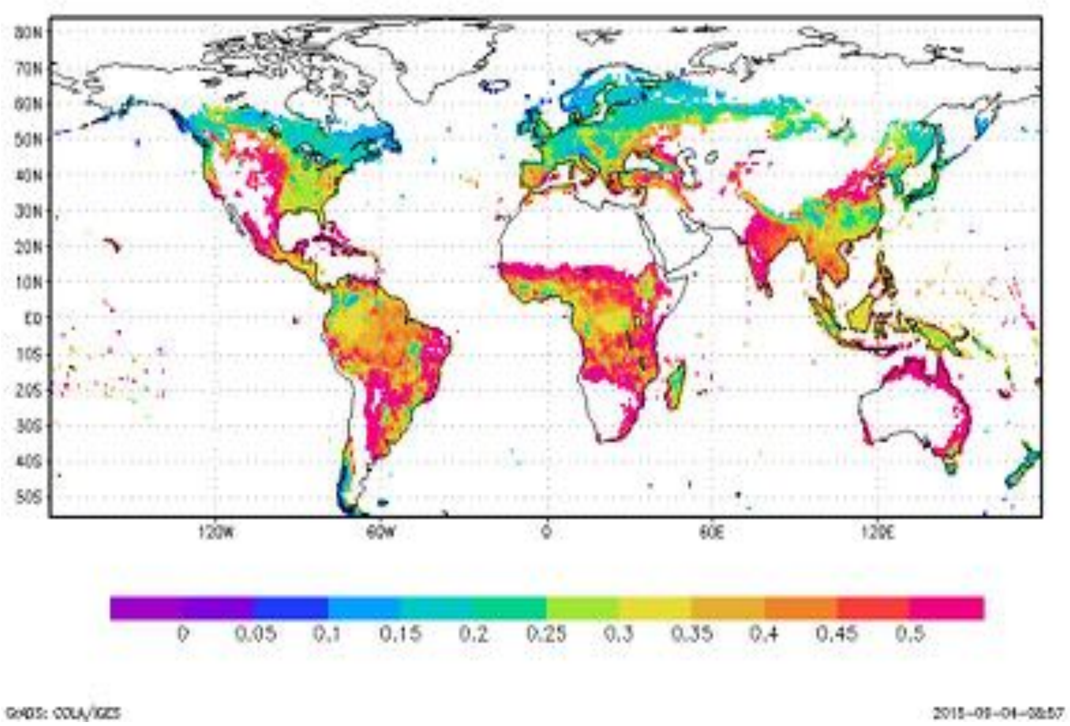
Fractional change in Quantity over one year with a double of CO_2

Rise in CO_2 results in reduced water loss

Transpiration reduced by about 10%:
shows similar response in Europe and Amazon



Photosynthesis increased by 10 to 40%:
shows smaller response in Europe than Amazon



Keenan et al, Nature, 2013. *Increase in forest water use efficiency as atmospheric carbon dioxide concentrations rise.*
Analysis of Flux-tower data at 21 sites suggests a substantial increase in water use efficiency in temperature and boreal forests of the Northern Hemisphere over the past 20 years.

Frank et al, Nature Climate Change, 2015. *Water Use efficiency and transpiration across European forests during the Anthropocene.*
Data (δ13 C tree ring) over 20C suggests increase of WUE of 14 (broadleaf) and 22 (conifer)%

Linked Transpiration and Photosynthesis

FUTURE CLIMATE

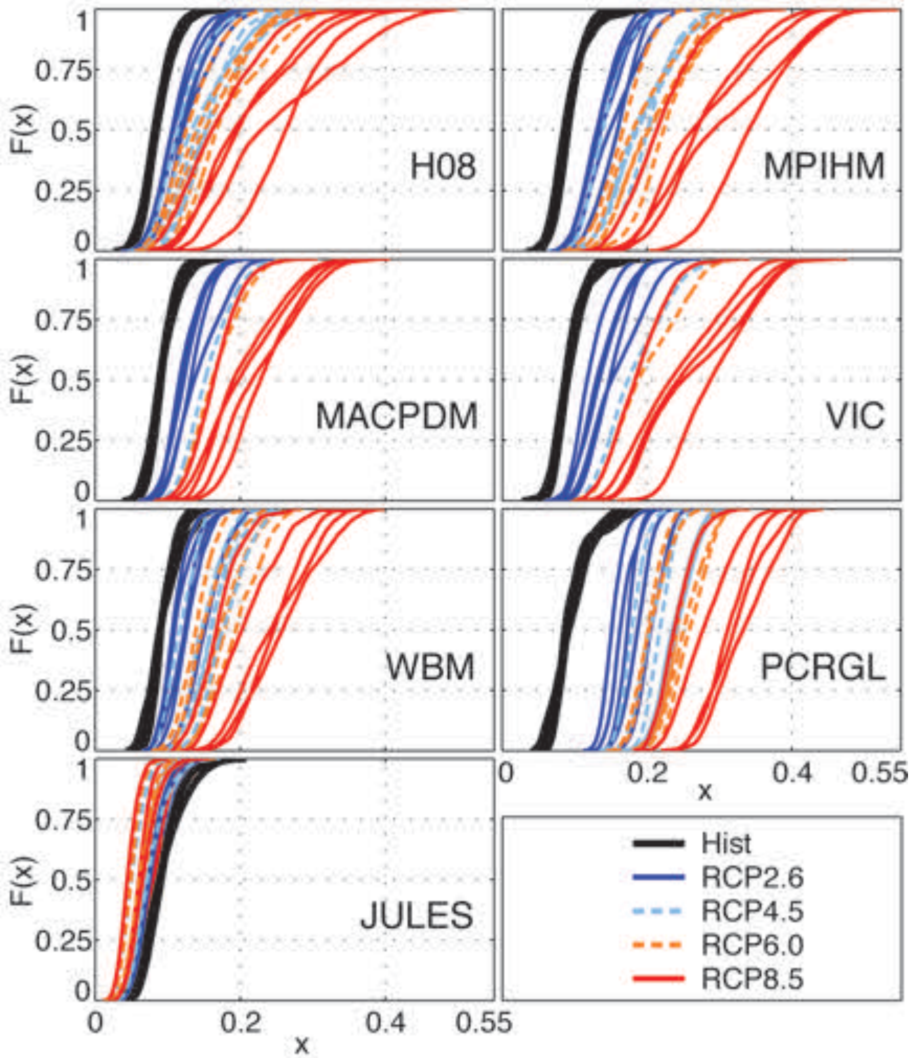
Future food production, future freshwater availability, future biodiversity depends on this relationship

For example: Impact of CO_2 fertilisation:

- x: proportion of land under ‘drought’ at the same time
- F(x): cumulated time this happened.

For JULES the maximum land over under drought is 20% (0.2) and is reached under historical climate; for H08 maximum drought extent is ~ 55%

When JULES is run without dynamic CO2, the maximum land area under drought is 40%.



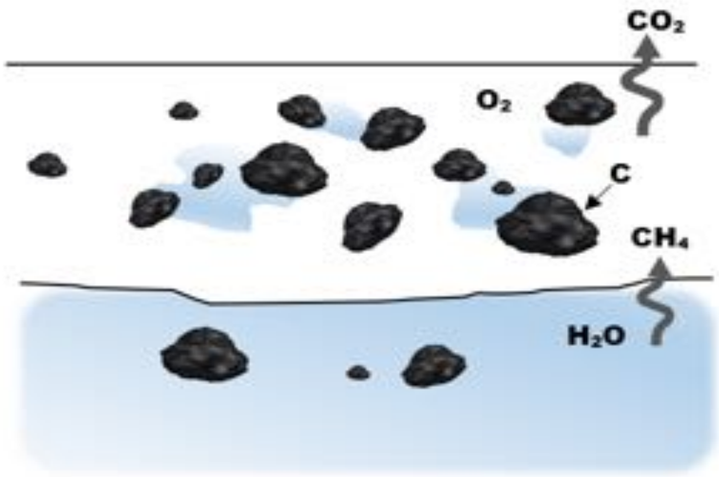
Prudhomme, C., et al. (2013) Hydrological droughts in the 21st century, hotspots and uncertainties from a global multimodel ensemble experiment. PNAS

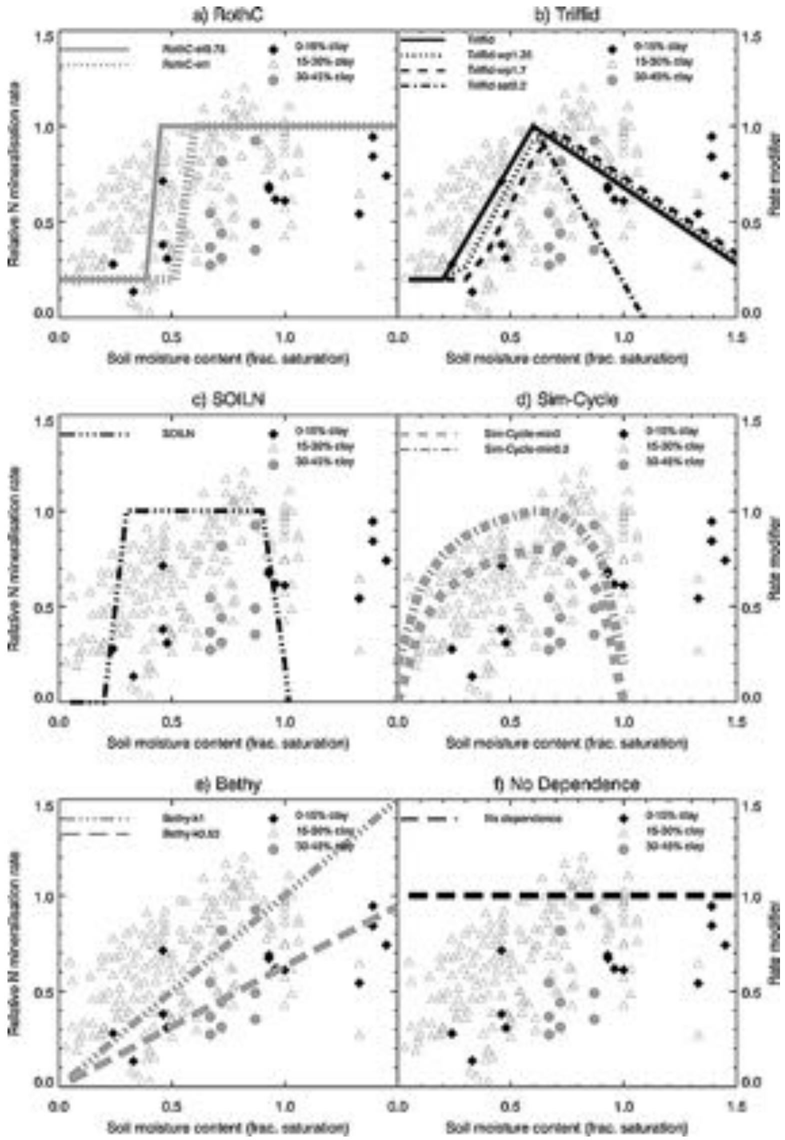
Soil microbial-physics interaction

Soil Carbon being seen as possible way to mitigate the fossil fuel emissions. There is a new initiative called '4 per mille' (1000 in French - shown as 4‰) aimed to show that agricultural soils might absorb this amount of carbon.

Microbes can only access the carbon if they have transport to get there (some water) and if they have some oxygen to breathe (not too much water).

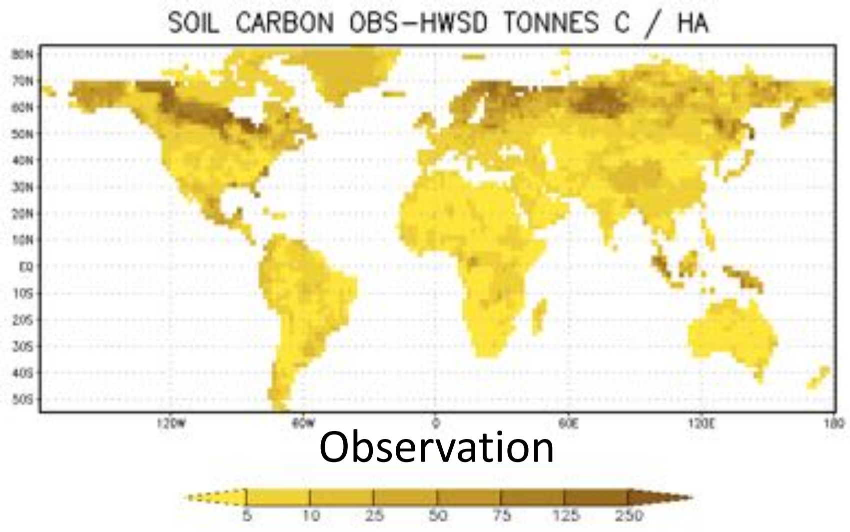
Like all living organisms, they also have an optimum temperature range.



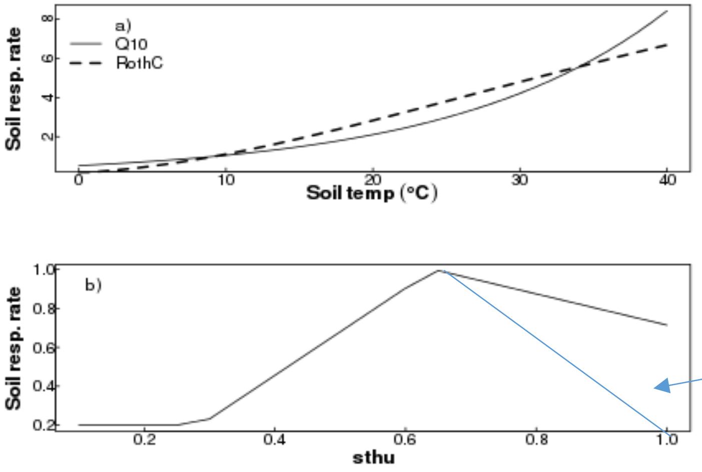


Direct soil moisture controls of future global soil carbon changes: An important source of uncertainty. Falloon et al. Global Biogeochemical Cycles
[Volume 25, Issue 3,](#) GB3010, 22 JUL 2011

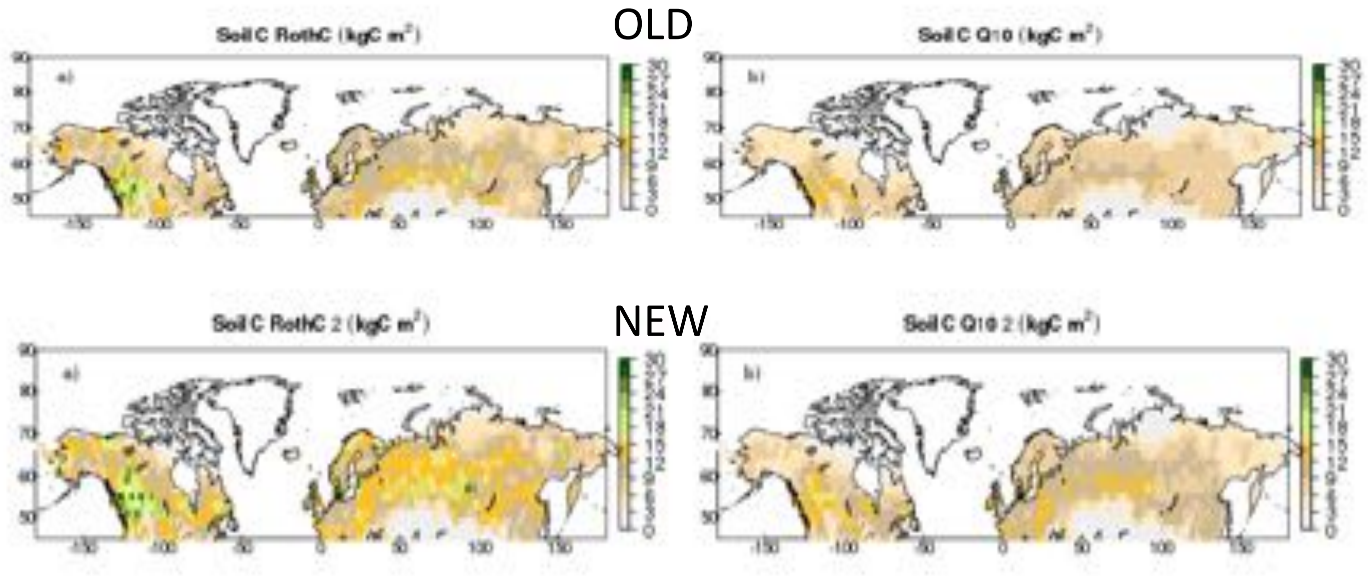
Soil microbial-physics interaction

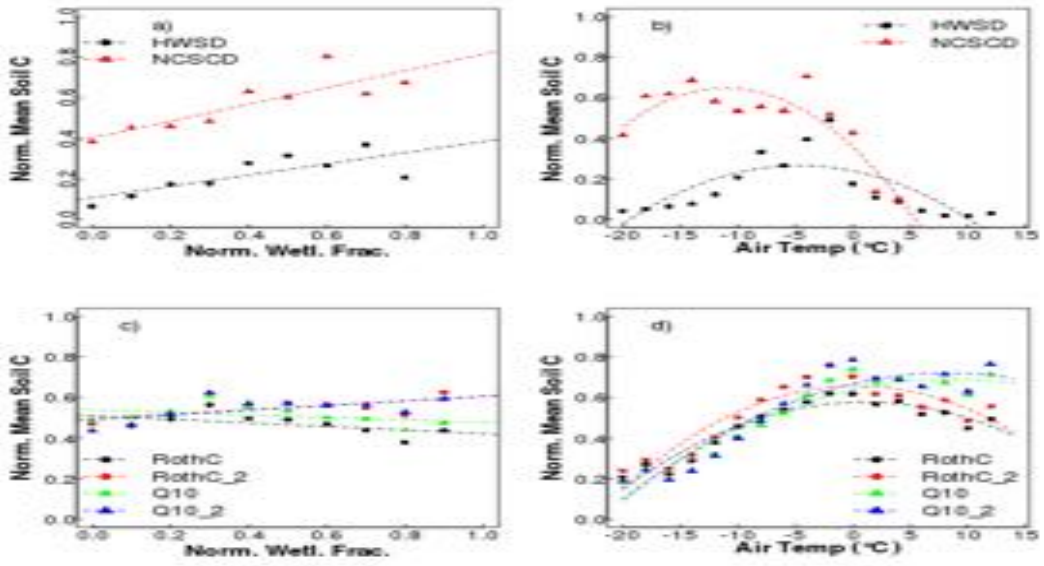


Observation



New soil moisture function





Interception

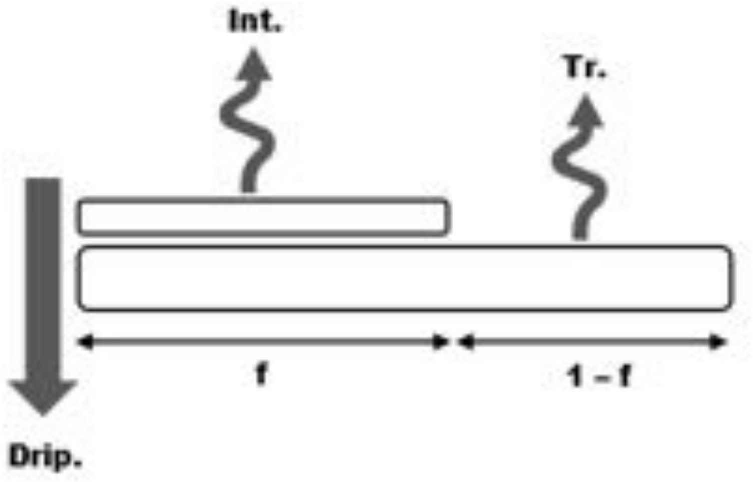
The interception is the water that never reaches the soil.

It is a function of rainfall amount, rainfall intensity and vegetation type.

In JULES, the throughfall T_f, is calculated assuming an exponential distribution of rainfall intensity across the area:

$$T_f = P\left(1 - \frac{C}{C_m}\right) exp\left(-\frac{\varepsilon C_m}{P\Delta t}\right) + P\frac{C}{C_m}$$

where P is the rainfall (mm), C (mm) is the amount of rainfall stored on the leaves, C_m (mm) is the maximum capacity and ε is a tuning factor.



Evaporation from the wet canopy occurs at a higher rate than transpiration.

Plays a large role in the UK water budget – and affects the trends in rivers and soil moisture

Report from Forestry commission based on data from CEH. Interception as much as **35% of rainfall**

Penman (Potential) Evapotranspiration (PEt): The total loss of water by evaporation from an actively growing, short, green (grass) crop that is never short of soil water (see Alternative land cover).

annual rainfall is typically lost by interception[1] from conifer stands, compared with 10–25% for broadleaves (Calder *et al.*, 2003). These percentages remain remarkably constant over a wide range of total rainfall (Figure 2).

Transpiration rates, on the other hand, vary little between the two forest types, with annual losses mainly falling within a relatively narrow range of 300–350 mm (Roberts, 1983). Recent work in southern England, however, has found higher annual transpiration losses for broadleaves of 360–390 mm (Harding *et al.*, 1992). Therefore if both interception and transpiration are considered together, and assuming an annual rainfall of 1000 mm, conifers could be expected to use some 550–800 mm of water compared with 400–640 mm for broadleaves.

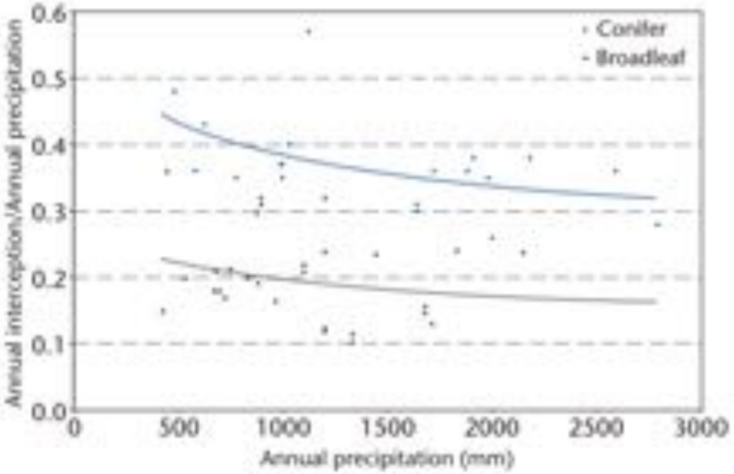


Figure 2

Comparison of interception ratios for conifers and broadleaves.

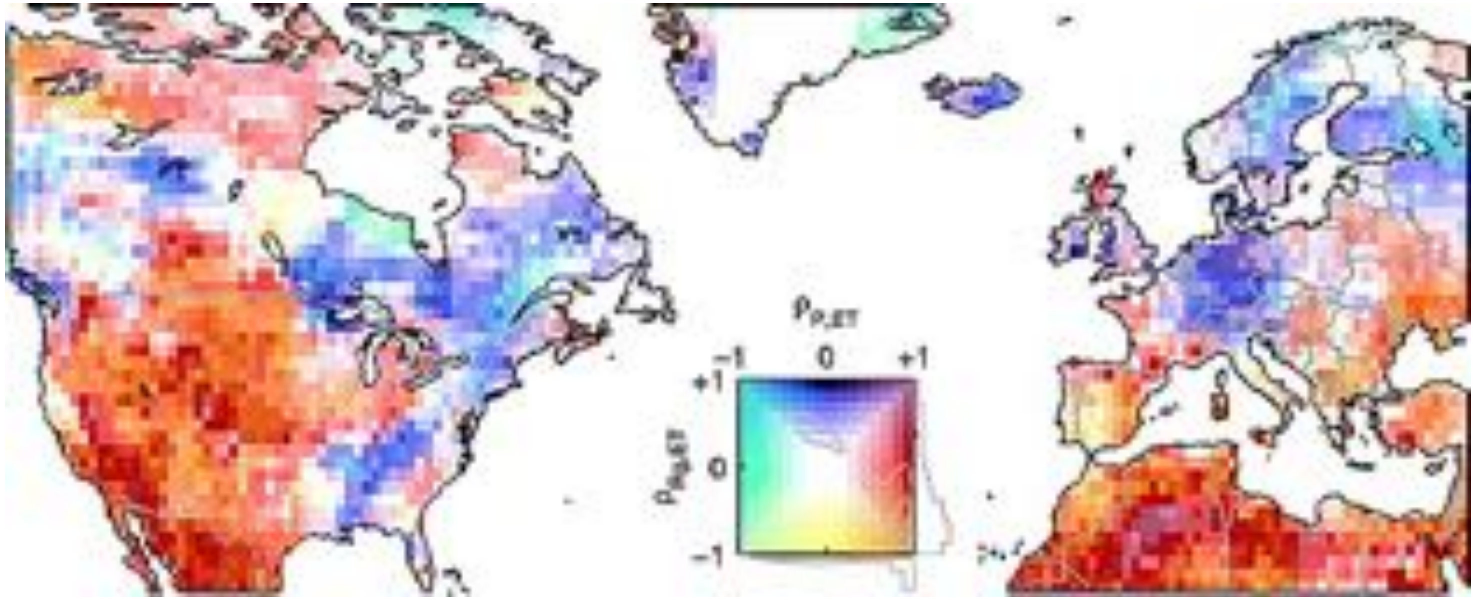
[1]Rainfall and evaporation are usually expressed as an equivalent depth of water in mm across the land surface. The addition or loss of 1 mm of water to/from an area of 1 m² of ground is equivalent to a total volume of 1 litre. Similarly, 1 mm of rainfall or evaporation to/from 1 ha is equivalent to 10 m³ or 10 000 litres of water.

Interception

Here, Teuling et al (2009) show how the evaporation correlates with different environmental drivers: radiation and precipitation

Usually precipitation is important in dry areas (red) and radiation in wet areas (blue).

An exception seems to be the west of Scotland.



Multi-model analysis of controls on yearly evapotranspiration. Correlation between yearly evapotranspiration and global radiation ($\rho_{Rg,ET}$), respectively precipitation ($\rho_{P,ET}$), for the period 1986–1995.

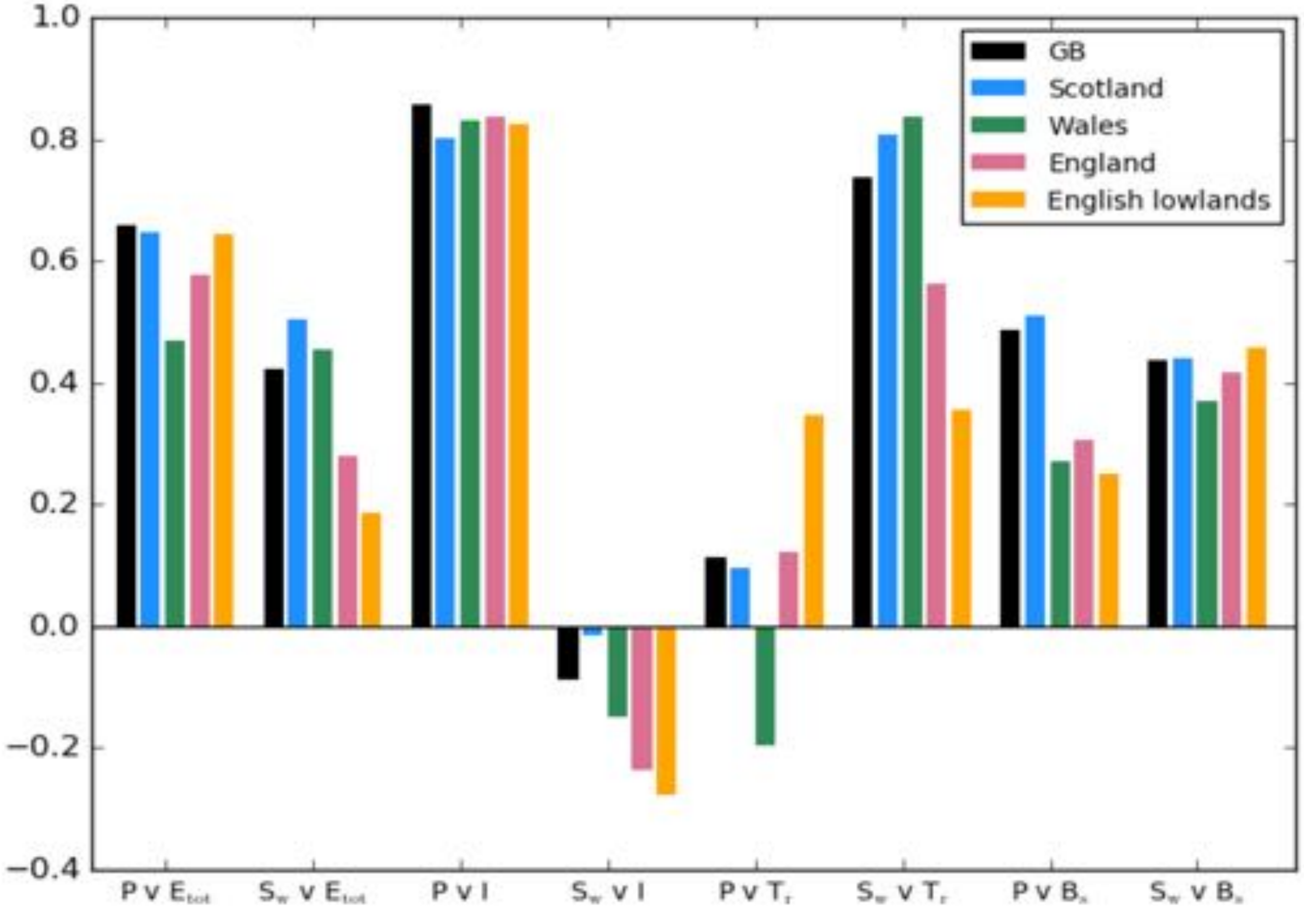
Teuling et al, A regional perspective on trends in continental evaporation. GRL, 2009

Interception

We calculated the correlation of annual evaporation and its components against Short wave radiation (sun) and precipitation (rain).

The results showed (again) a surprisingly high correlation for total evaporation with rain in Scotland (blue bar).

This can be explained by the high correlation of Interception, coinciding with high rainfall rates in this region.



iLEAPS supports development of tools to progress and inform the science:

- Monitoring: Experiments and long term trends

FACE experiments, Soil moisture monitoring

- Observations: field scale and satellite, new field campaigns

Fluxnet Data, using new SIF data,

- Models: Process understanding, research and operations

Land surface models

Land Surface Models

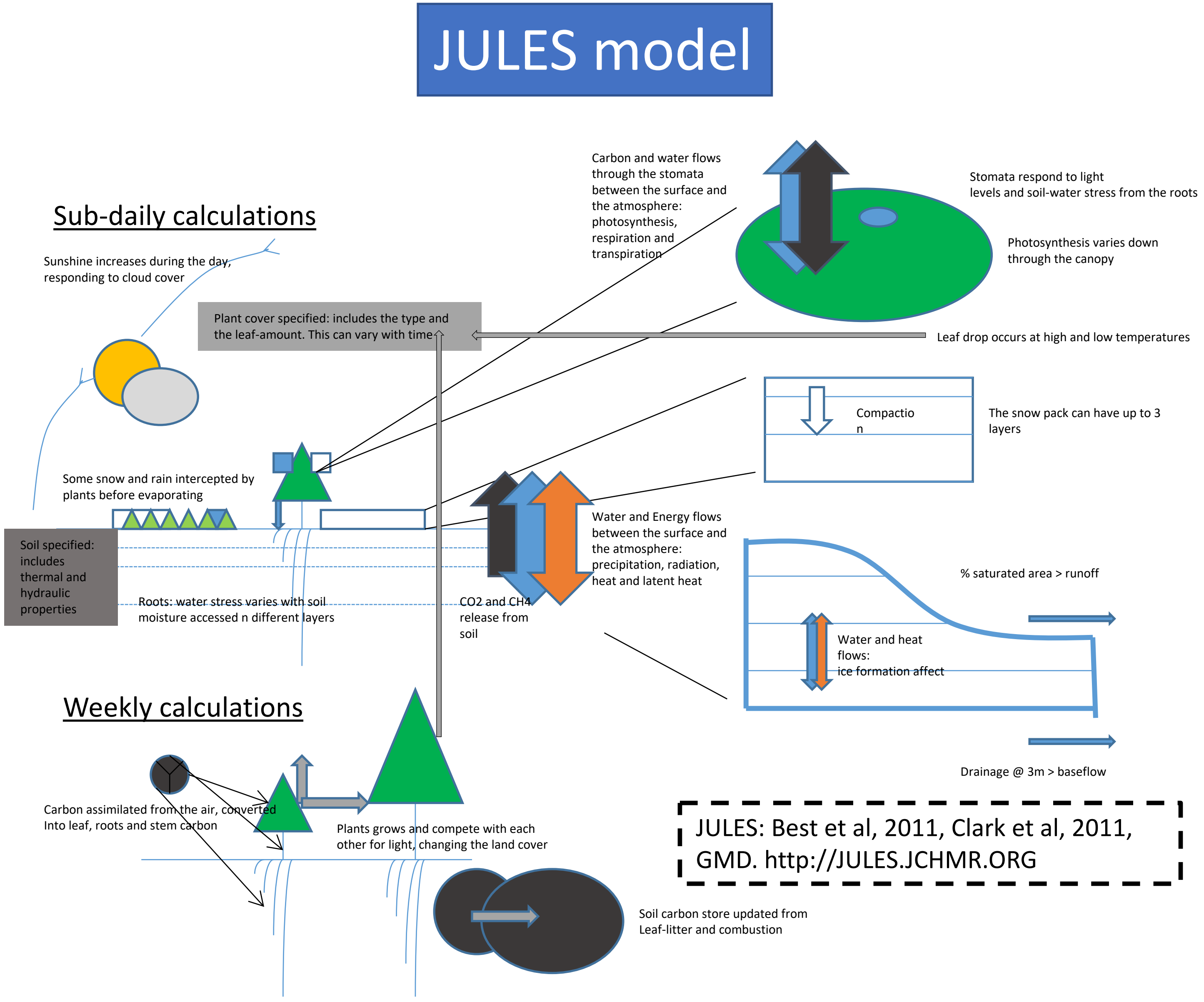
Represent our best understanding of the links between the energy and water processes and other aspects of the land surface.

Water and carbon are linked.

The discipline could be called ‘Land System Science’

We should aim to represent Nature in all her finest and necessary complexity.

We should also bring in the humans!



JULES: Best et al, 2011, Clark et al, 2011, GMD. http://JULES.JCHMR.ORG

Extremes – are they changing?

- Huge effort ($$££€€₳¥¥) put into forecasts

- We should put a similar effort into understanding the past so we can understand if the extremes are *changing.*
- Very important for Engineering, Insurance, Operational hydrology, policy

- Water community: GSWP3 – global land reanalysis. Not available for current year
- Carbon Community: TRENDY – global carbon reanalysis up to current year (but not very good rainfall)

- Perhaps we should bring these together?

Future Collaborations:

- Joint Land Surface Modelling Summit. Oxford, 2020
- Joint workshop on using the PLUMBER2 data, or the FACE data?
- Focus on Water Use Efficiency and interception.
- Join up the water and carbon community to analyse the LS3MIP results in terms of extremes