JULES biogeochemistry
Update on model developments

Module leaders: Mat Williams and Sarah Chadburn

Developments by: Joe McNorton, Nic Gedney, Eddy Robertson, Andy Wiltshire, Sarah Chadburn, Eleanor Burke, Doug Clark, Felix Leung and more...

Topics

- Wetland methane emissions
- Nitrogen scheme
- Soil carbon scheme
- JULES-ECOSSE-FUN
- Land use

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JULES wetland CH4 emissions model calibrated

using Bousquet et al. 2011 global anomaly variability estimates

FCH4= kCH4 fw ksubstrate Q10(Tsoil)(Tsoil-T0)/10

kCH4 = calibrated global constant

Q10(Tsoil)=calibrated Q10 function

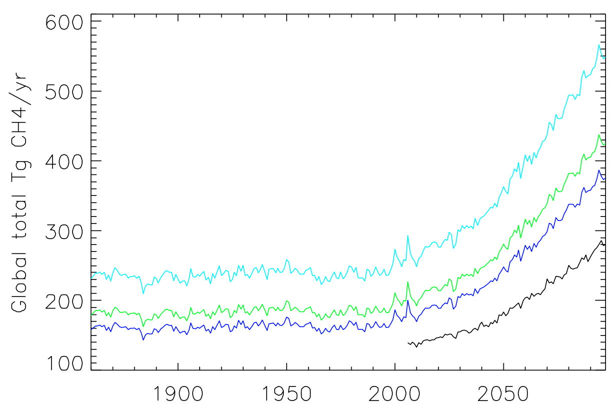
ksubstrate=obs soil carbon Cs, NPP or soil respiration

Future prediction (off-line HadGEM2-ES meteorology RCP8.54)

Calibrated param values:

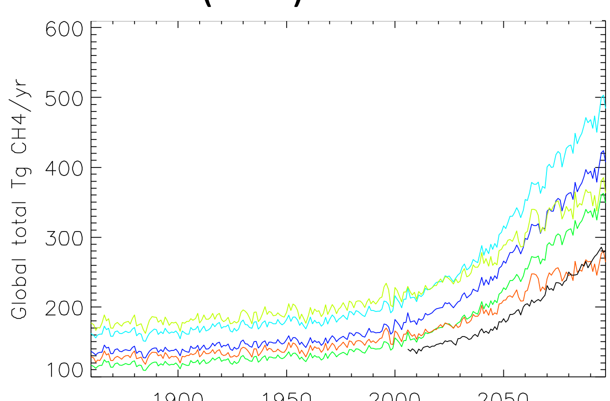
HadGEM2-ES:
~130TgCH4/yr, Q10=3.7, Cs (Zinke)
Latest JULES:
165TgCH4/yr, Q10=3.7, Cs (HWSD)
205TgCH4/yr, Q10=3.7, Cs (HWSD)
180TgCH4/yr, Q10=3.7, Cs (HWSD)

FCH4(Cs)



HadGEM2-ES:
~130TgCH4/yr, Q10=3.7, Cs (Zinke)
Latest JULES:
180TgCH4/yr, Q10=3.7, NPP
215TgCH4/yr, Q10=3.7, NPP
155TgCH4/yr, Q10=3.7, NPP
220TgCH4/yr, Q10=1.7, NPP
160TgCH4/yr, Q10=1.7, NPP

FCH4(NPP)



Summary:

- Large uncertainty in future wetland CH4
- Poor constraints on global total and Q10 temperature sensitivity are main drivers of uncertainty
- Wetland scheme (not shown) and substrate choice are less important

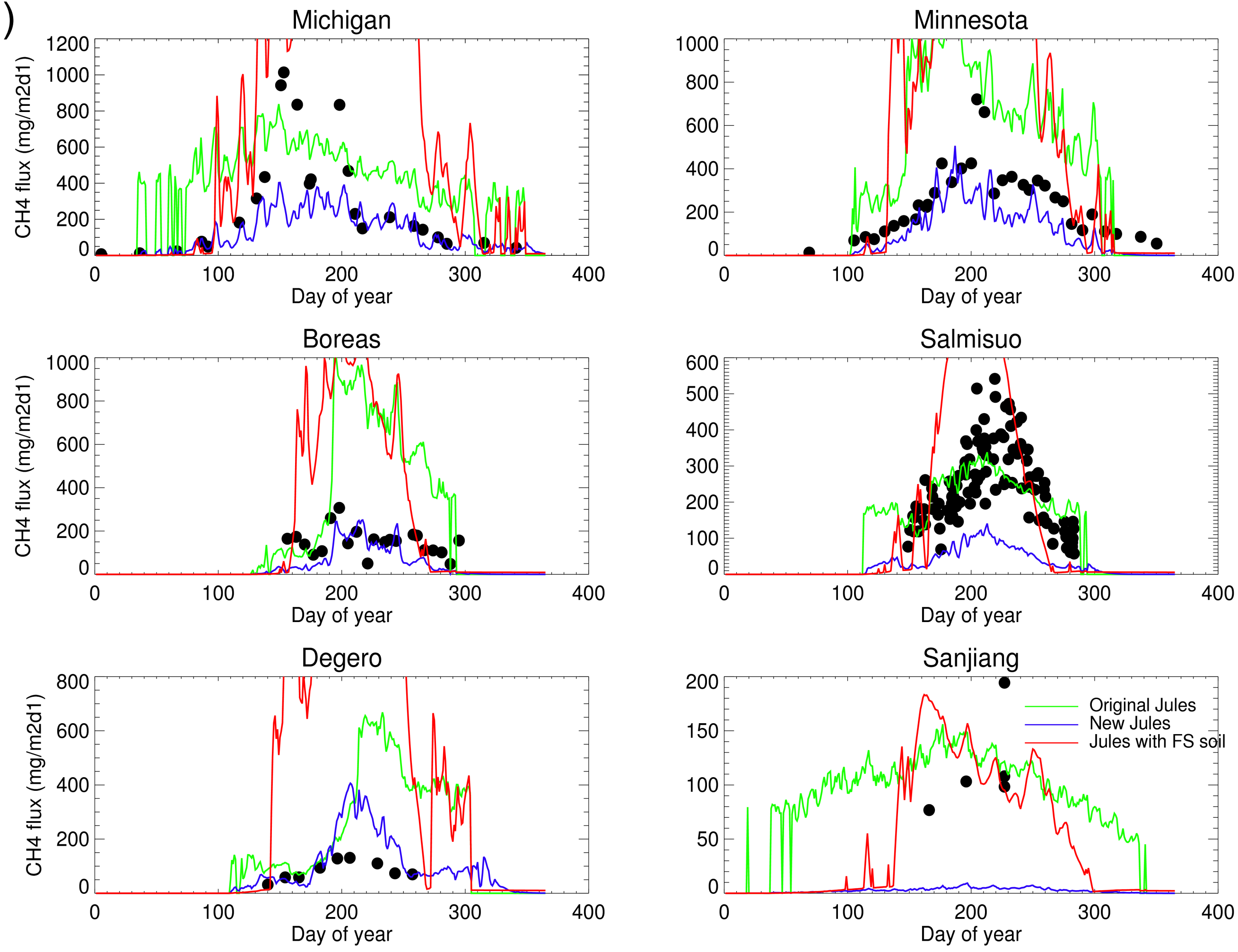
Nic Gedney

Wetland methane developments

Joey McNorton, Garry Hayman, Nic Gedney

Adding oxidation, transportation and CH4 pools to the wetland component of the model. This is largely based on previous work done with other land surface models (LPJ-Whyme & CLM4Me) and is currently being compared with flux measurements and atmospheric CH4 observations (using a 3D-Chemical Transport Model (TOMCAT)).

Preliminary results: (The three lines are old JULES, new JULES and new JULES with fully saturated soils)



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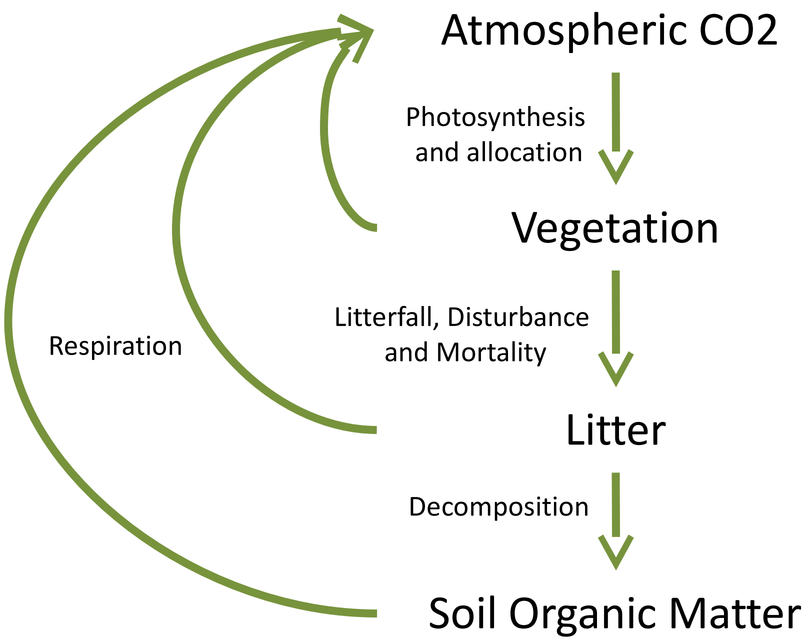
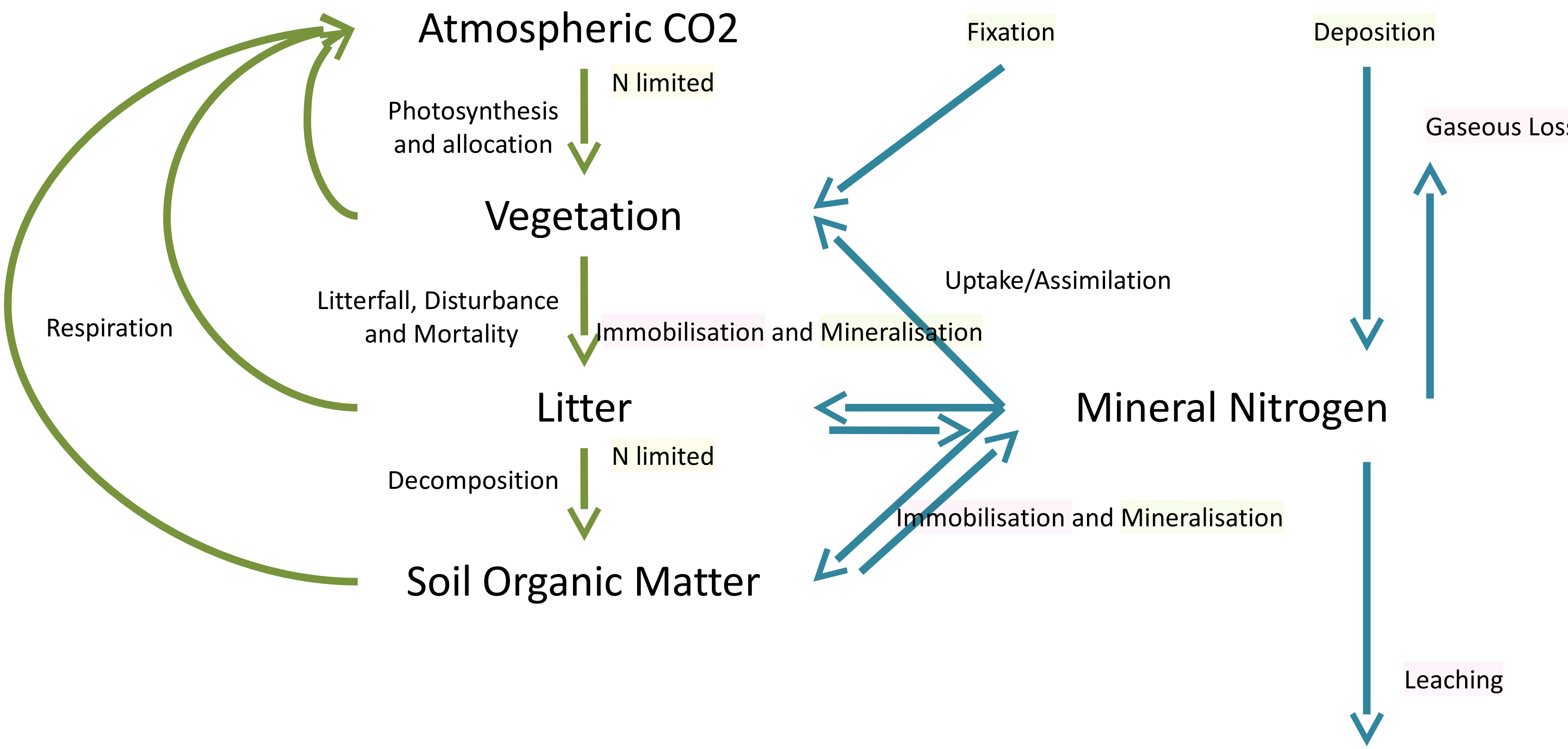
Terrestrial Carbon Cycle



- TRIFFID Current Carbon Cycle Model
- Simulates Changes in Carbon Stores under Climate Change
- Missing the role of Nitrogen availability on carbon assimilation and turnover of soil carbon

Coupled Terrestrial Carbon-Nitrogen Cycle

Andy Wiltshire et al.



- Extended to include terrestrial Nitrogen Cycle
- Availability of N limits assimilation of Carbon and Turnover of soil Carbon

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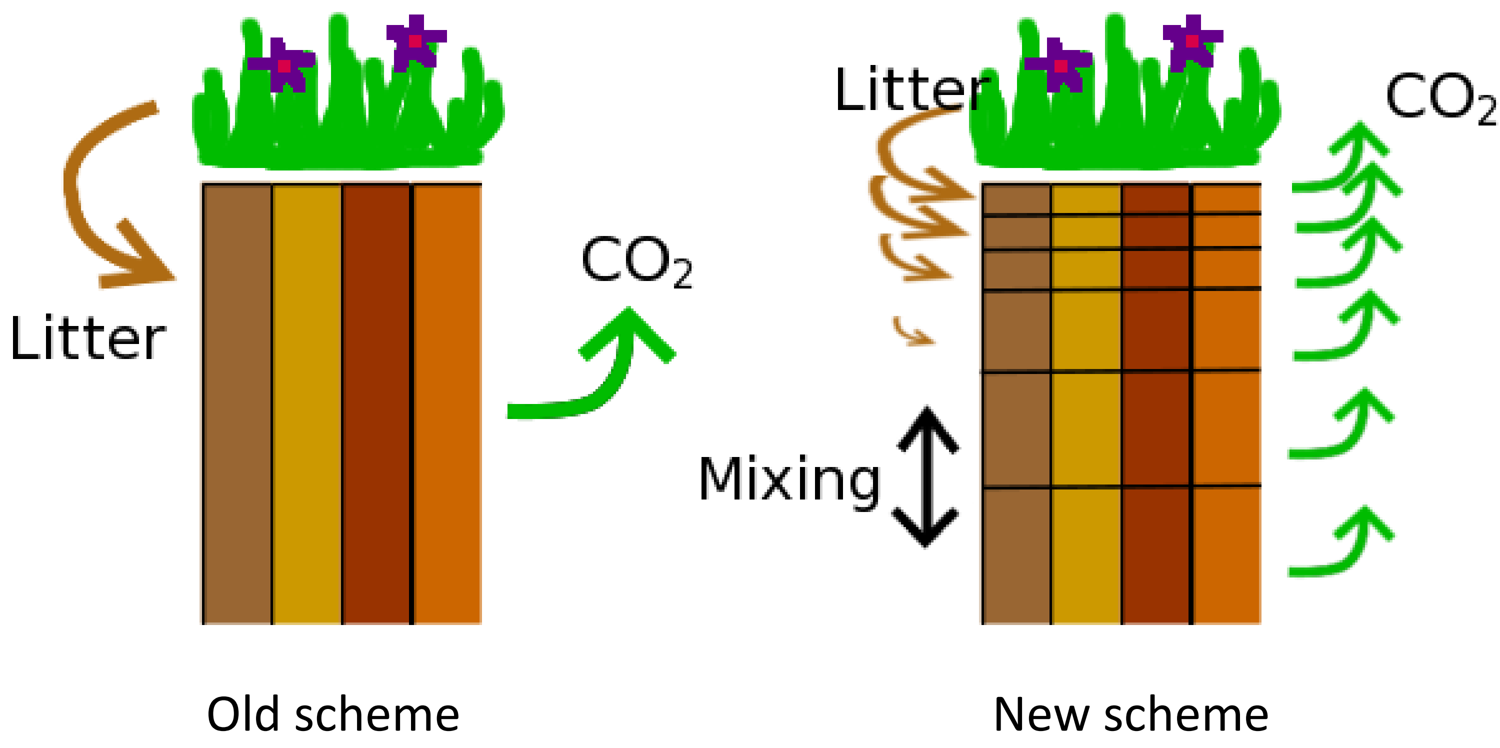
Vertically discretised soil carbon

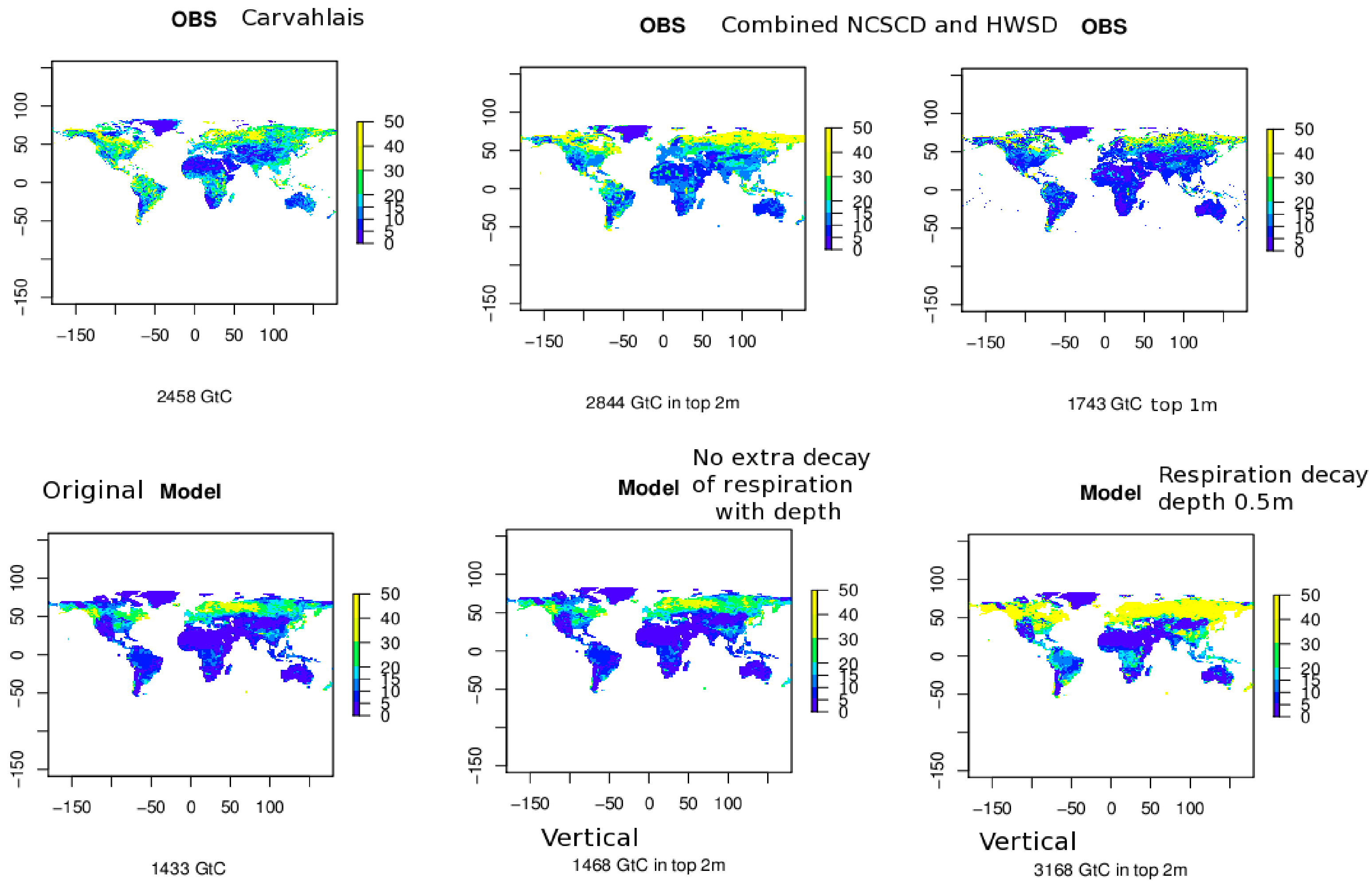
Sarah Chadburn, Eleanor Burke.

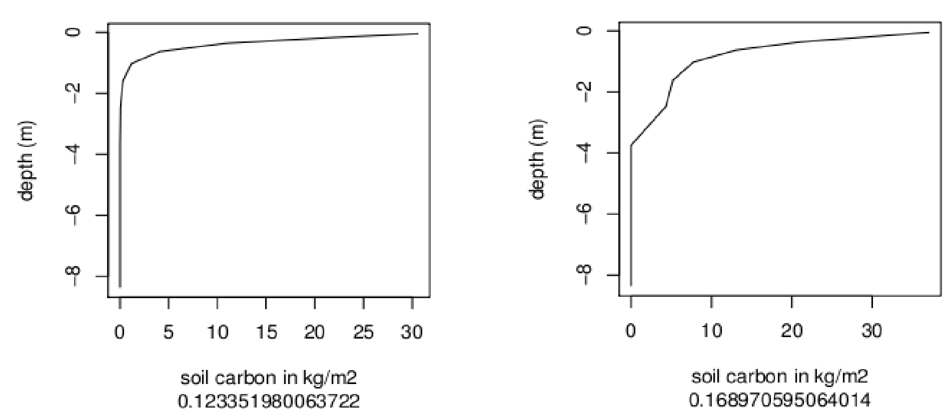
Need a vertical profile of carbon to include deep stored carbon in JULES.

- Discretised RothC as a set of pools in every soil layer. Respiration depends on temperature/moisture in the appropriate layers.
- Added vertical mixing terms (bio- and cryoturbation)
- Added vertical profile of litter inputs and addition depth-dependent controls on respiration.



Vertically discretised soil carbon: global distribution





Also: Initial results show improved soil respiration compared with observations.

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JULES-ECOSSE-FUN: update

Doug Clark et al.

Adding the ECOSSE model of soil C and N cycling
the FUN model of plant N uptake. - Alternative to carbon and nitrogen models already described; has vertical profile of carbon + nitrogen cycle.

Work in the last year includes:

- Global runs and analysis of C and N budgets
- Various bug fixes
- Implemented an alternative N uptake model (based on Wania/Gerber)
- Testing response to fertilisation by CO2 (FACE) and N (forest sites)
- Looking to improve linkage with TRIFFID demand/budget for N.

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NERC SCIENCE OF THE ENVIRONMENT

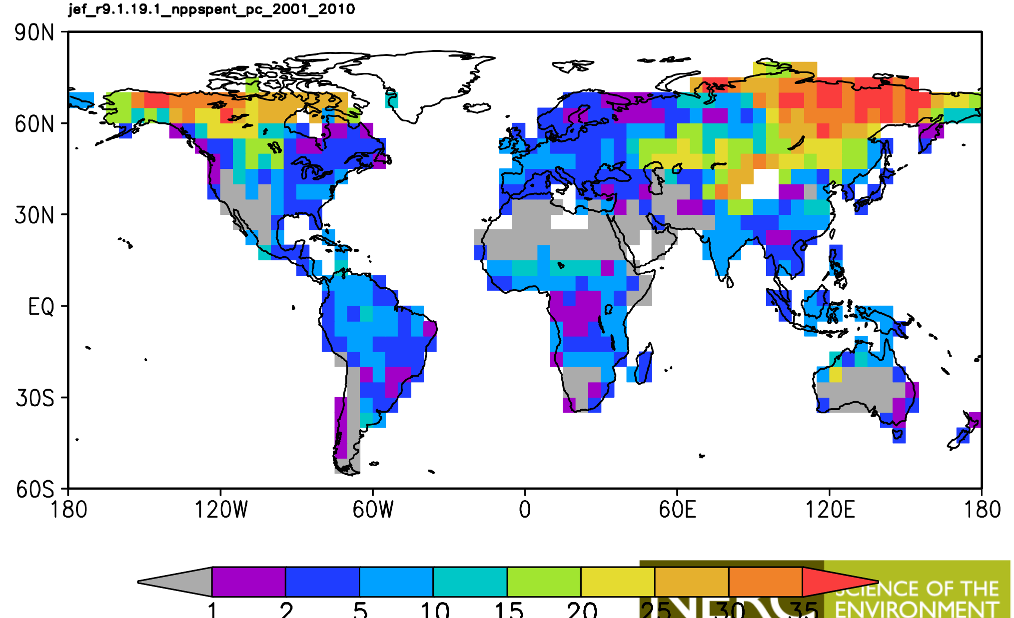
Ongoing and future work

- Move to latest version prior to getting onto the trunk.
- Tuning/calibration (including more work on N fertilisation data)

  Some current issues are
  - FUN currently can increase fixation in 2xCO2 experiments to such an extent that veg is rarely limited by availability of N
  - Soil emissions of N2O are rather high.

Example of modelled % NPP spent acquiring N.

N is limiting mainly at high latitudes.



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SCIENCE OF THE ENVIRONMENT

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Land Use Developments

Eddy Robertson

New approach to land use transitions:

• Extra PFTs to represent crops, physiology is calculated as for the natural PFTs

• A fraction of crop litter is removed to represent a harvest carbon flux (this will improve soil carbon dynamics.)

• Crop and natural PFTs do not compete with one another

• TRIFFID used to determine distribution of crop PFTs within agricultural fraction, ensuring crop distribution is consistent with climate

• Each natural PFT has a disturbed fraction, allowing specific PFTs to be replaced by agriculture

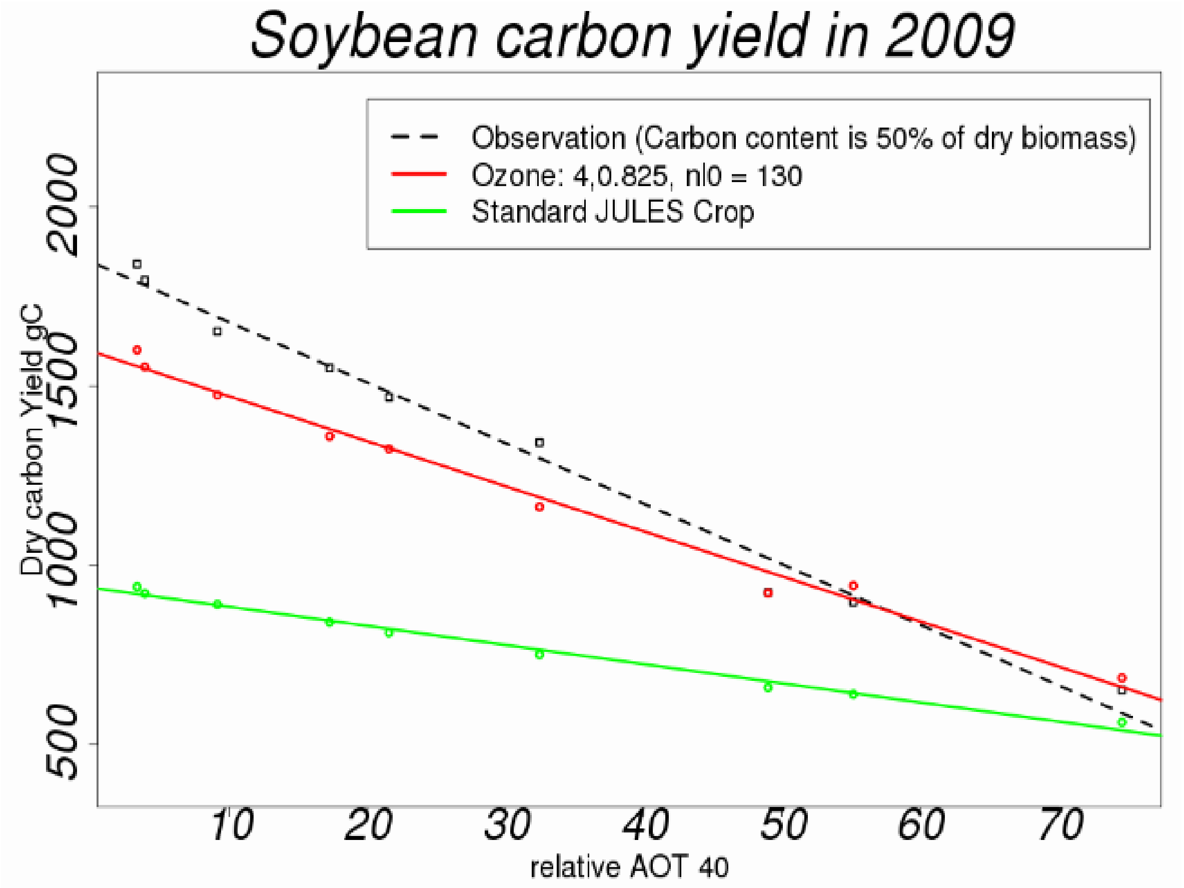
• PFT-specific disturbed fraction allows comparison of “grasses-first” land use change versus “trees-first” land use change. If historical driving data has this information there can be a more accurate representation of historic land use changes.

• PFT-specific disturbed fraction allows representation of gross land use changes (instead of just net changes).

Sensitivity of JULES-CROP to tropospheric ozone

Felix Leung

JULES-crop is evaluated against the Soybean Free Air Concentration Enrichment experiment in Illinois, USA. JULES-Crop default parameters gives a very low yield for soybean. Top leaf nitrogen and quantum efficiency is tuned up to increase productivity. Dark respiration is tuned down to reduce total respiration and increase net primary productivity.



Calibrated model result of effect of ozone (AOT40) on soybean yield

JULES-crop is more sensitive to the presence of ozone than the increase AOT40 of ozone. The calibration will be applied in regional model and eventually will be coupled with Earth System Model to quantify feedbacks between coupled climate-crops and atmospheric chemistry. The project will thus help to build a state-of-the-art impact assessment model, and contribute to a more complete understanding of the impacts of climate change on food production.