Development of JULES in the UKESM and LOCATE projects

Douglas Clark
with material from several other people

JULES science meeting, Exeter, June 2017

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NERC LTS-M projects

JULES is being developed in two NERC-funded LTS-M projects.

LTS-M = Long Term Science, Multiple NERC Centres
These projects will run 2016-2021 and involve several NERC centres.

The projects:

UKESM: UK Earth System Modelling

http://www.jwcrp.org.uk/research-activity/ukesm.asp

LOCATE: Land Ocean Carbon Transfer

http://locate.ac.uk

UKESM: UK Earth System Modelling

The UKESM project is a collaboration between NERC and the Met Office to develop, apply and support community use of the next generation of UK Earth System Models.

Partners: NCAS (lead), MetOffice, NOC, CEH, NCEO, PML, BAS.

CEH activities include:

- 2 people in the “core team”
- Model evaluation, including via NCEO
- Model development (towards UKESM2, c.2021)

UKESM: JULES developments

CEH JULES development considers:

- Soil biogeochemistry
- Atmospheric deposition (surface-atmos exchange)
- Plant physiology

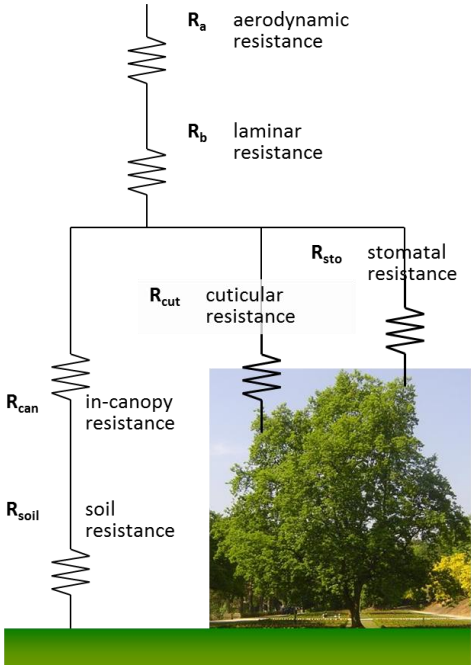
UKESM: JULES developments

Soil biogeochemistry
(Douglas Clark, Emma Robinson)

- Ongoing development of the ECOSSE model of C and N
- Possible future activities include
  plant uptake of N (e.g. FUN)
  soil P (links to LOCATE, see later).

UKESM: JULES developments

Atmospheric deposition (Garry Hayman and others)



- Atmospheric dry deposition is represented using a conventional resistance approach in the UKCA atmospheric chemistry module
- Community consultation and workshop to build consensus (deposition needed for land, ocean and cryosphere)
- CEH will develop and test an offline deposition module
  - Include current UKCA deposition schemes
  - Include scheme used in the EMEP CTM; considered to represent the current state-of-knowledge.

UKESM: JULES developments

Plant physiology
(Becky Oliver, Lina Mercado)

Improving the temperature response of photosynthesis:

- Implemented Medlyn model for stomatal conductance and Farquahar model for photosynthesis.
- Investigating effects of thermal adaptation (spatial variation of temperature response of Vcmax and Jmax) and acclimation (temporal variation).

Possible future work:

- Sensitivity to O_3 dependent on LMA (thick leaves are more resilient)

Interlude

LOCATE (Land Ocean Carbon Transfer)

The LOCATE project aims to quantify and model the transfer of terrigenous organic matter from land to sea.

Partners: NOC (lead), CEH, PML, BGS and others.

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PML Plymouth Marine Laboratory

CEH activities include:

- Extensive field and experimental campaigns across GB
- Modelling at:
  - catchment-scale (CASCADE)
  - GB-scale (LTLS-IM)
  - continental/N.Atlantic-scale (JULES)

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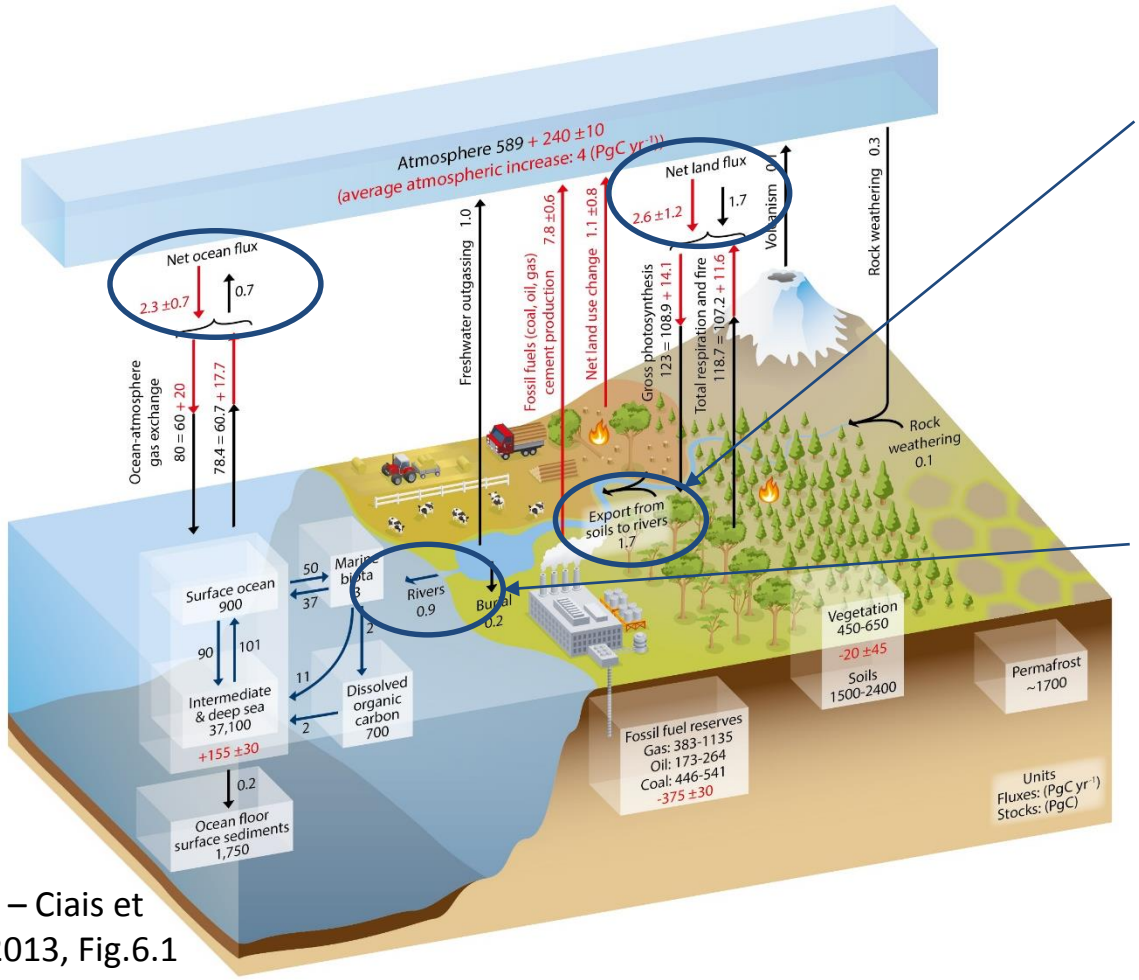
LOCATE: motivation



IPCC – Ciais et al., 2013, Fig.6.1

C exported from soils to rivers (~1.7 PgC yr^{-1}) is of the same order as uptake of anthropogenic C by either land (2.6±1.2) or ocean (2.3±0.7 PgC yr^{-1}).

- It's a significant flux.

Roughly half of that (0.9 PgC yr^{-1}) is exported to the coastal oceans.

- There is substantial processing in aquatic environments.

The export is of (very approx.) equal amounts of DOC, DIC and particulate C.

Note: Aquatic environments are also important in the terrestrial N cycle!

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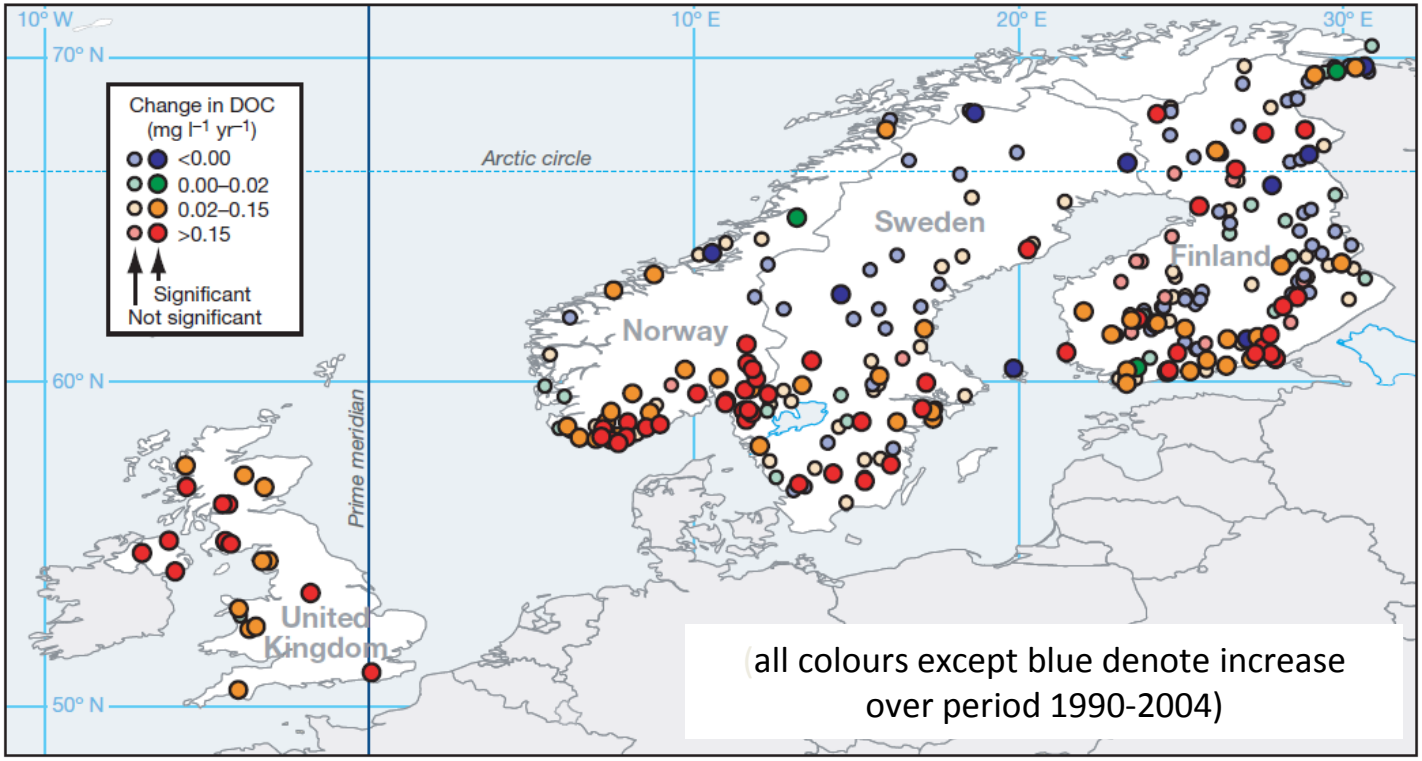
LOCATE: motivation

Riverine DOC fluxes throughout northern Europe have doubled over past 25 years due to anthropogenic activities



Monteith et al., 2007

LOCATE: overarching objectives

- To quantify the fate of terrigeneous organic matter (tOM) from soils to the ocean, with particular focus on estuaries and coastal waters.

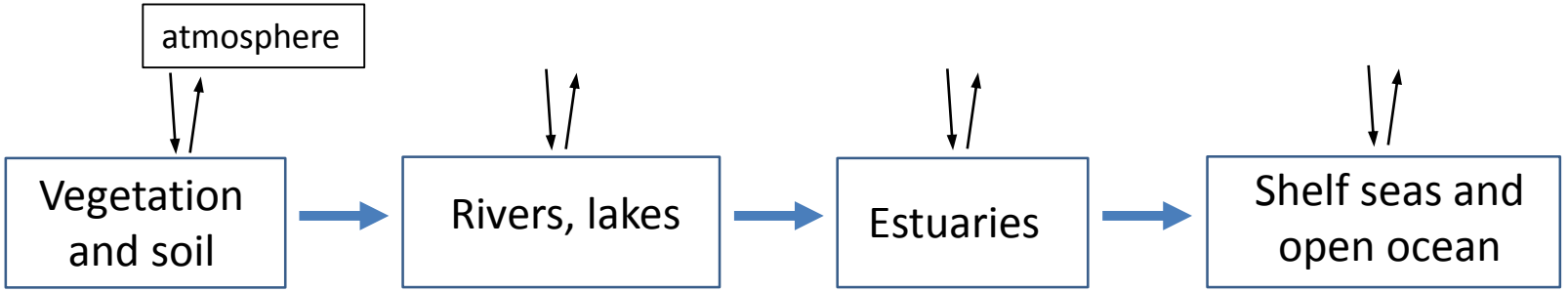
- To quantify and understand the loss processes in estuarine environments.

- To build a new model of terrigeneous organic matter cycling valid in marine and fresh waters, and use it to predict the future evolution of the land ocean carbon flux.

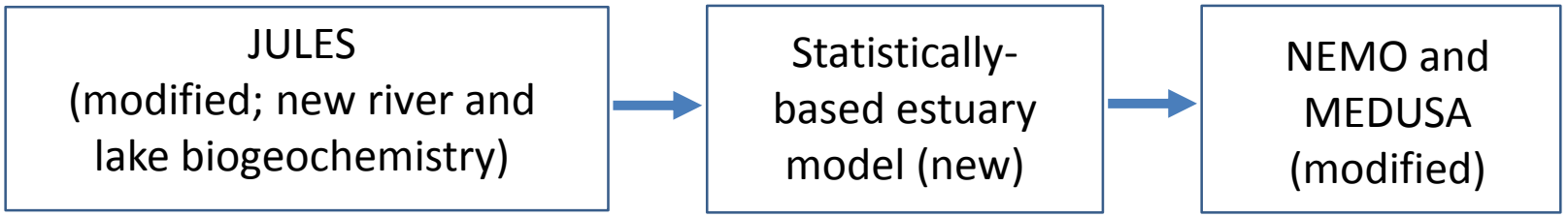
  i.e. consistent treatment of tOM from land to sea

LOCATE: large-scale modelling

We want to understand the fate of organic material as it passes through these domains:

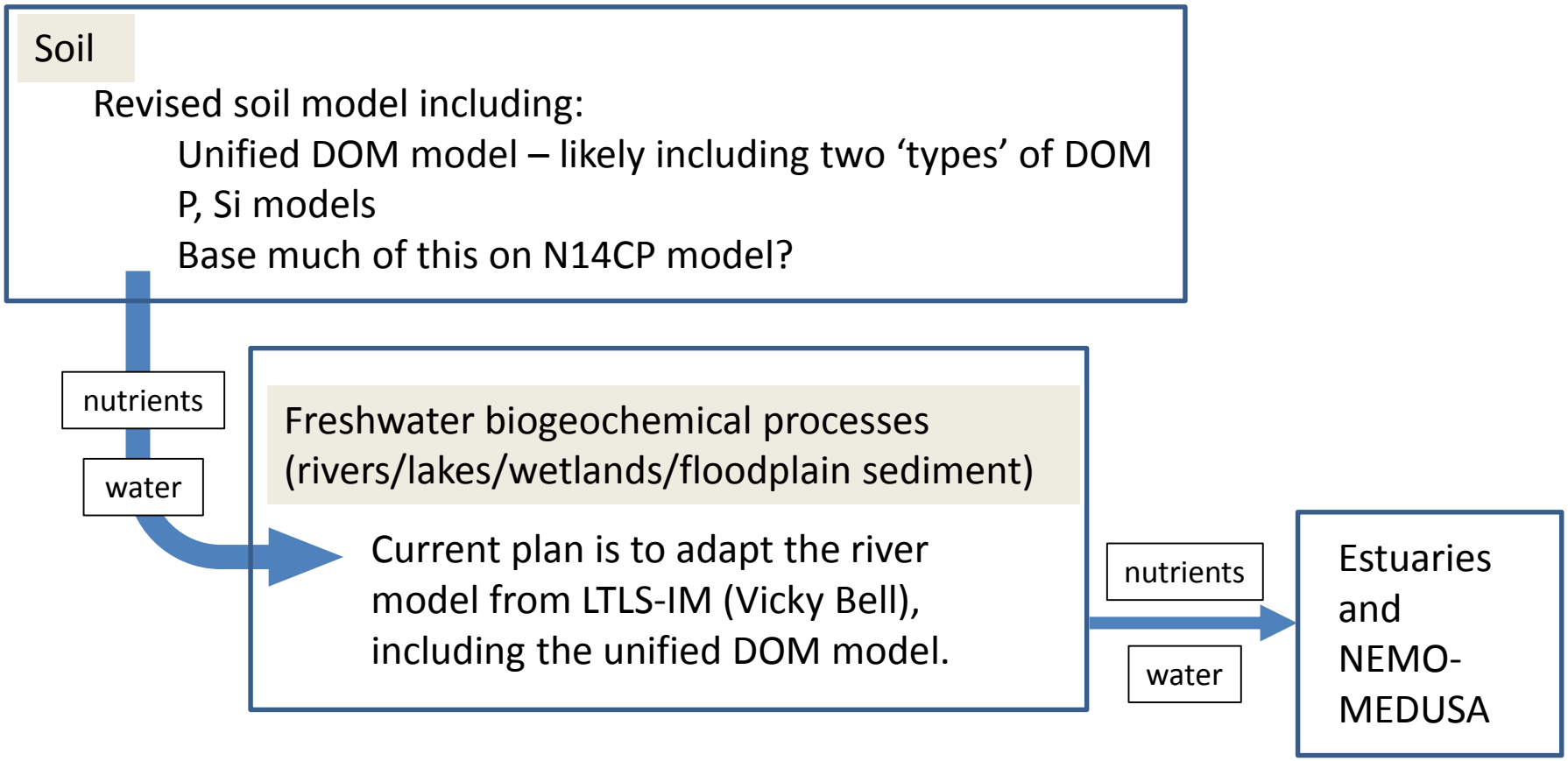


We will use a chain of models (asynchronous, 1-way coupling):



New components and functionality will be developed with UKESM2 in mind.

LOCATE: JULES development

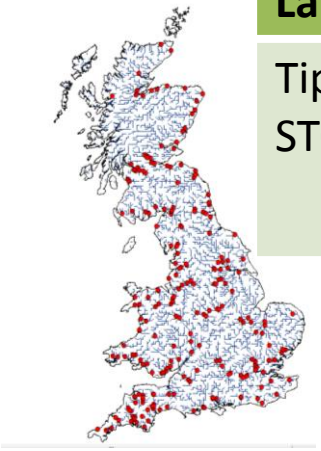


LOCATE: river and lake models

The LTLS river and lake models (Vicky Bell, Ed Tipping, et al.) are:

relatively complex, with several state variables

and has only been run for GB on a 5km grid.

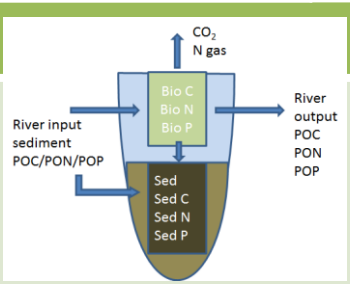


LTLS Riverine processes

- Denitrification
- Organic matter decomposition
- Oxidation of ammonia
- Degassing
- pH
- Chlorophyll growth

Lake model

Tipping et al., STOTEN, 2016



Pictures from Vicky Bell, CEH.

We need to run globally at ESM resolutions (~1°).
Are simplifications possible?

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LOCATE: JULES short term plans

- Investigate modelling of river temperature
  Likely have to represent advection

- Keep an eye on the development of the unified DOM model
  This will have to be made consistent with the JULES soil model – possibly adopt bits of N14CP?

- Plan for adoption of the river model from LTLS-IM

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UKESM1.0: new science from JULES

What's new in JULES for UKESM1.0
(that is, this is the first time these are in the UK's ESM):

- 9 PFTs, with generalised competition
- Trait-based plant physiology
- Crops and pasture
- Lack of Nitrogen can limit plant growth
- BVOC emissions