Met Office activities

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SRNWP working day, ECMWF

5th September 2011

Overview

- JULES
- Benchmarking
- Current work
- Current potential with JULES
- Future plans

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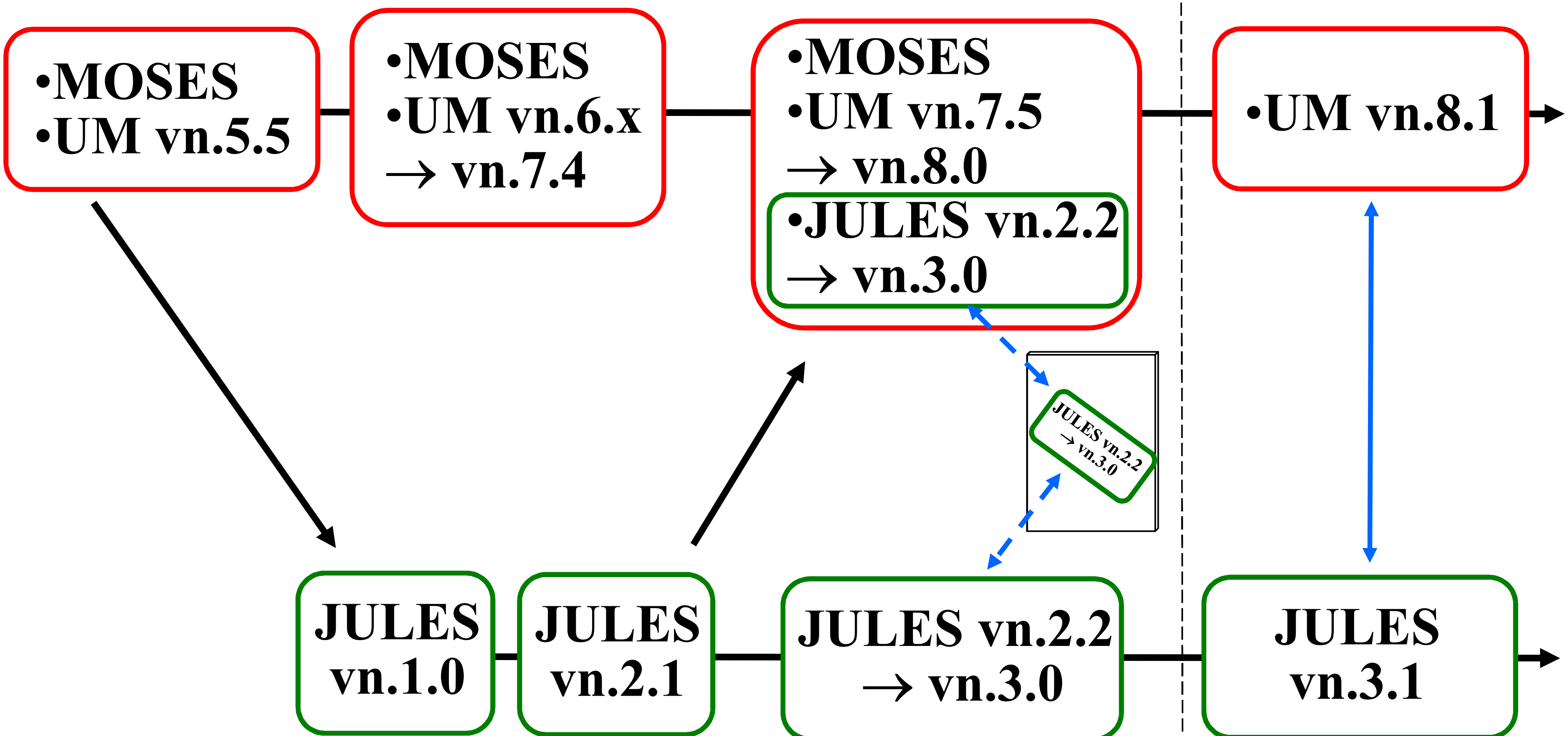
Joint UK Land Environment Simulator (JULES)

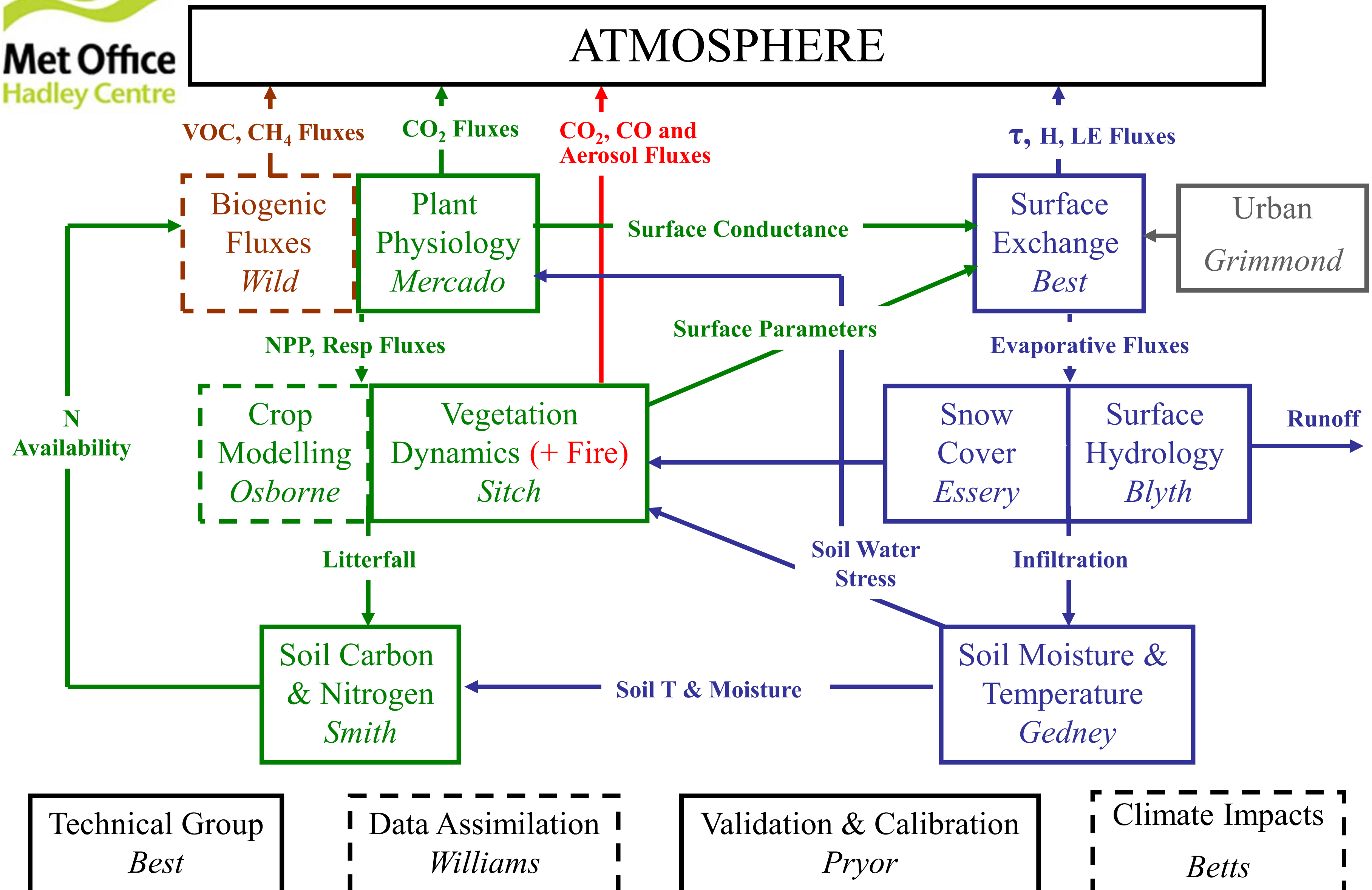
Best et al. (2011). The Joint UK Land Environment Simulator (JULES), model description –Part 1: Energy and water fluxes, Geosci. Model Dev., 4, 677–699, doi:10.5194/gmd-4-677-2011.

Clark et al. (2011). The Joint UK Land Environment Simulator (JULES), model description –Part 2: Carbon fluxes and vegetation dynamics, Geosci. Model Dev., 4, 701–722, doi:10.5194/gmd-4-701-2011.

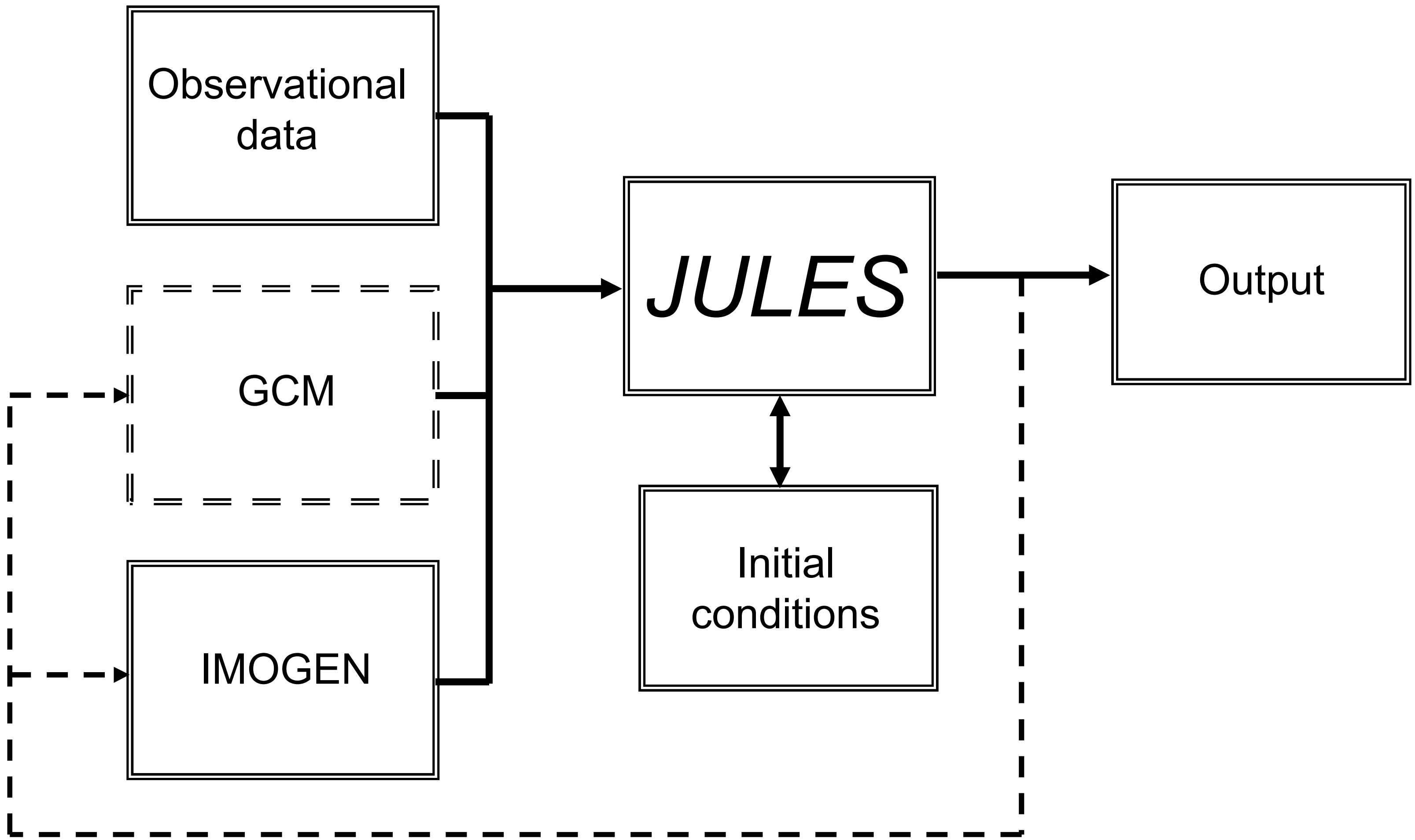
JULES / UM timeline



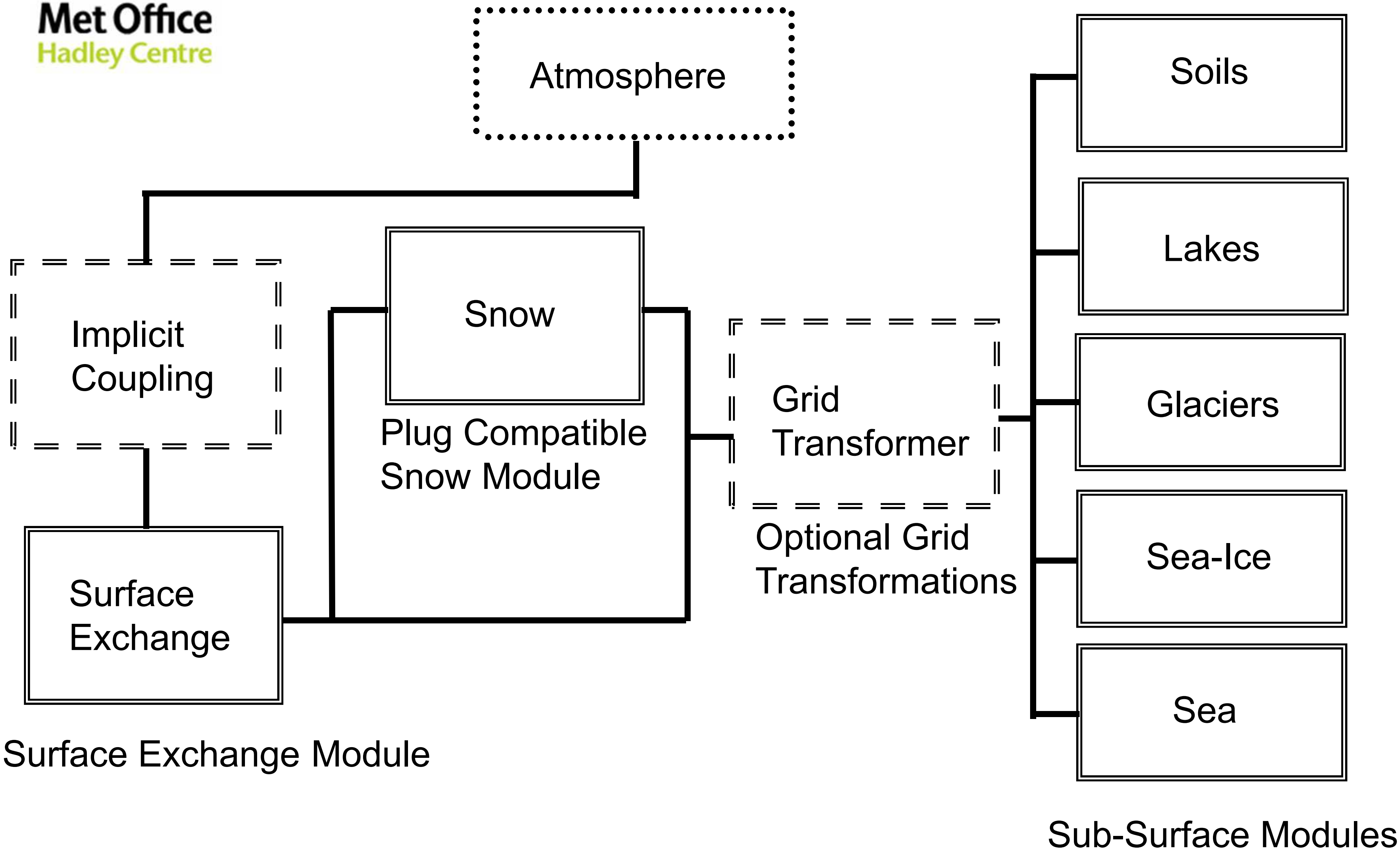
JULES Module Structure



Multiple forcing framework



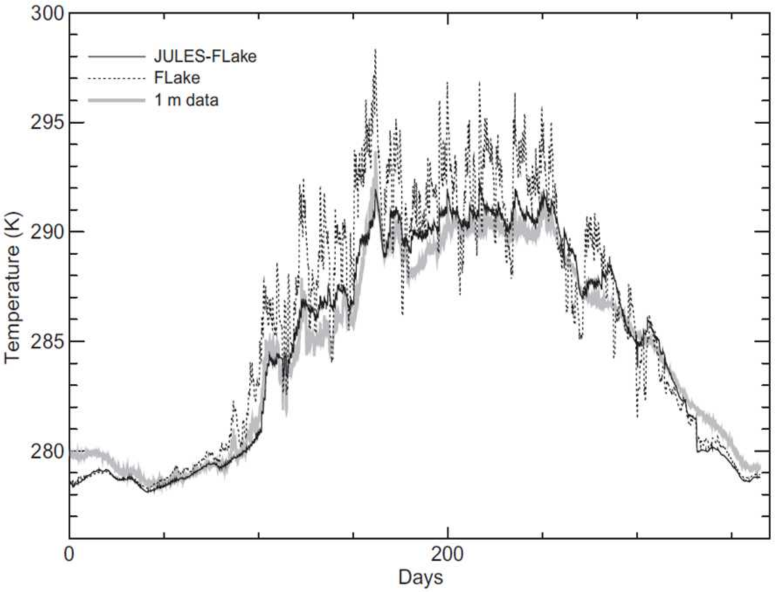
Flexibility for modular structure



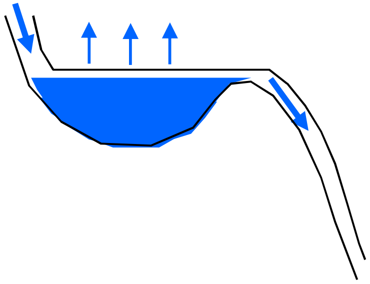
FLake

- Adjustments to standard FLake
  - ➢JULES surface exchange
  - ➢Coupled via surface heat flux
  - ➢Thermal conductivity calculated from FLake temperature gradients
- Issues to be addressed
  - ➢Conservation of energy during snow and ice melt
  - ➢Conservation of water for climate applications

Windermere, 2007



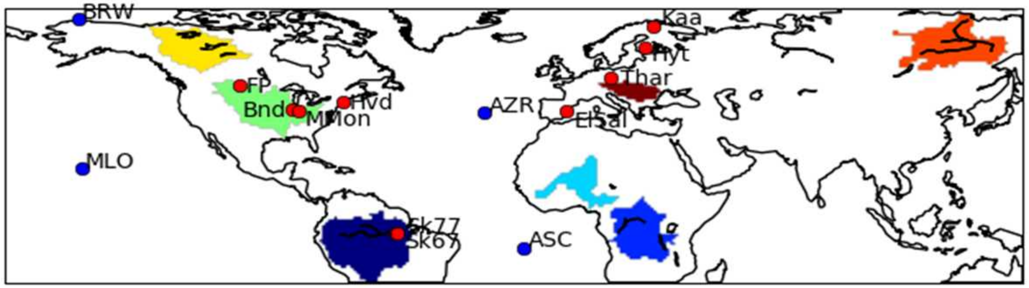
1m buoy T v surface T

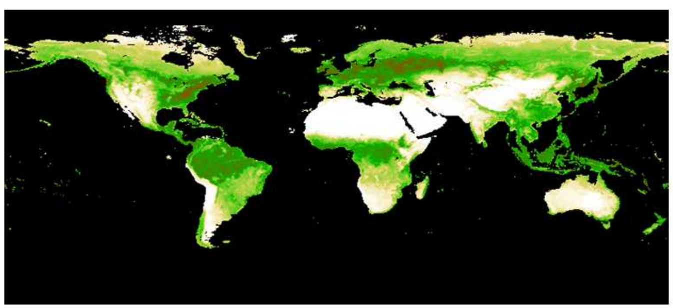


Benchmarking

JULES benchmarking: 1

Map showing 4 Atmospheric CO2 concentration stations
10 FLUXNET stations
7 rivers basins

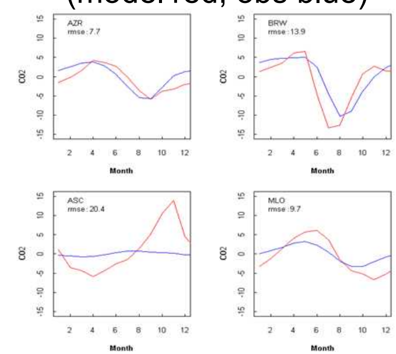




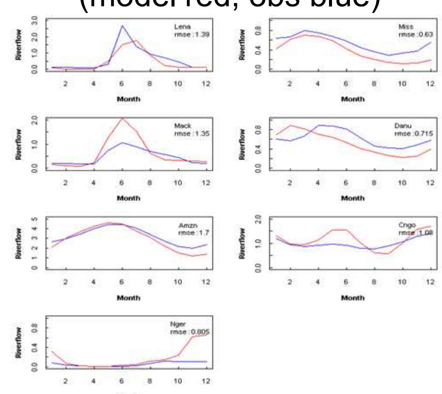
20 years of NDVI data
(co Sietse Los, Swansea)

Results of JULES vn.2.1.2 for atmospheric CO2 concentrations, river flow and LAI

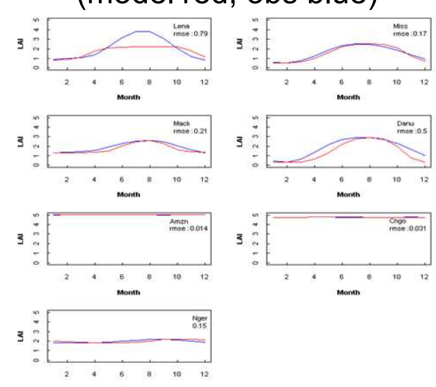
CO2 concentration
(model red, obs blue)



River Flow
(model red, obs blue)



LAI
(model red, obs blue)



JULES benchmarking: 2

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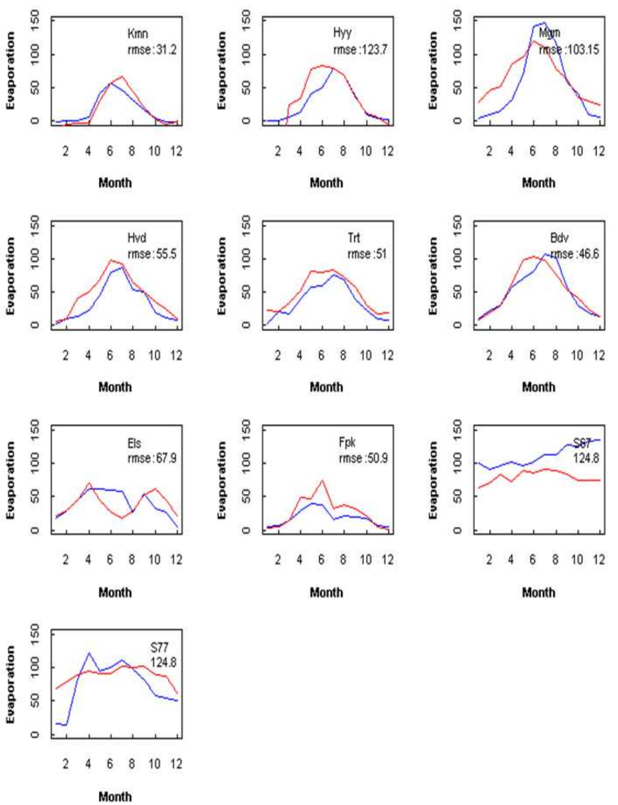
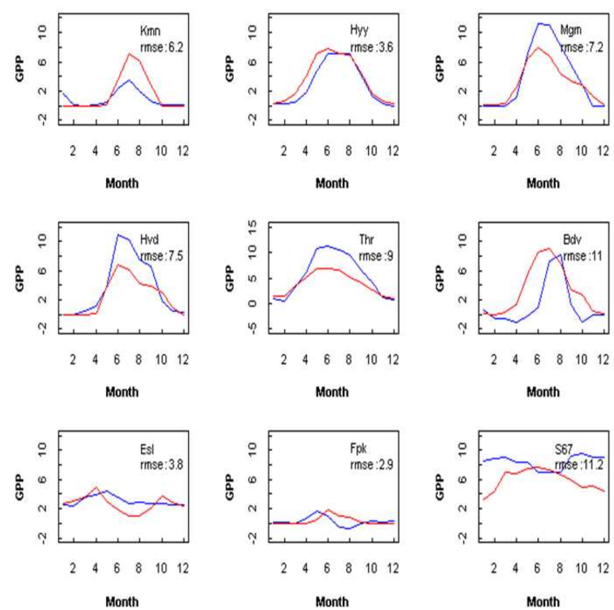
Comparison of JULES vn.2.1.2 against 10 (9 for CO_2) Fluxnet Sites

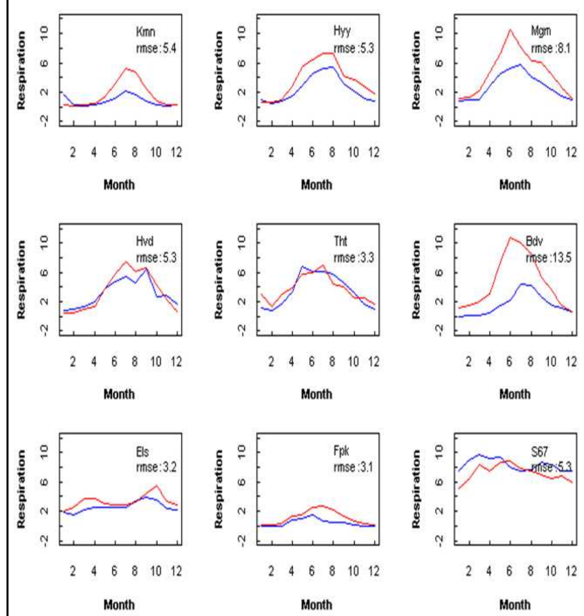
Normalised Evaporation
(model red, obs blue)



Photosynthesis
(model red, obs blue)

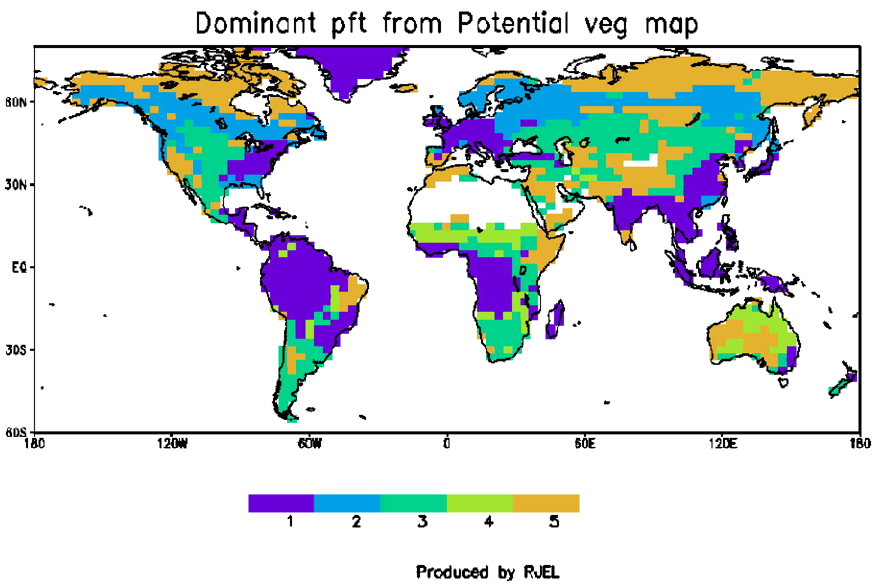


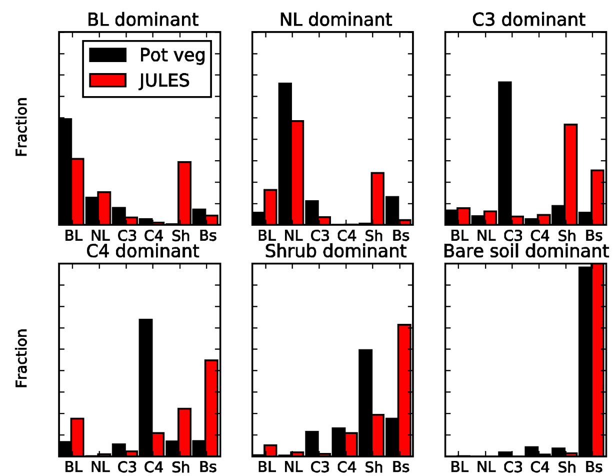
Respiration
(model red, obs blue)



JULES benchmarking: 3

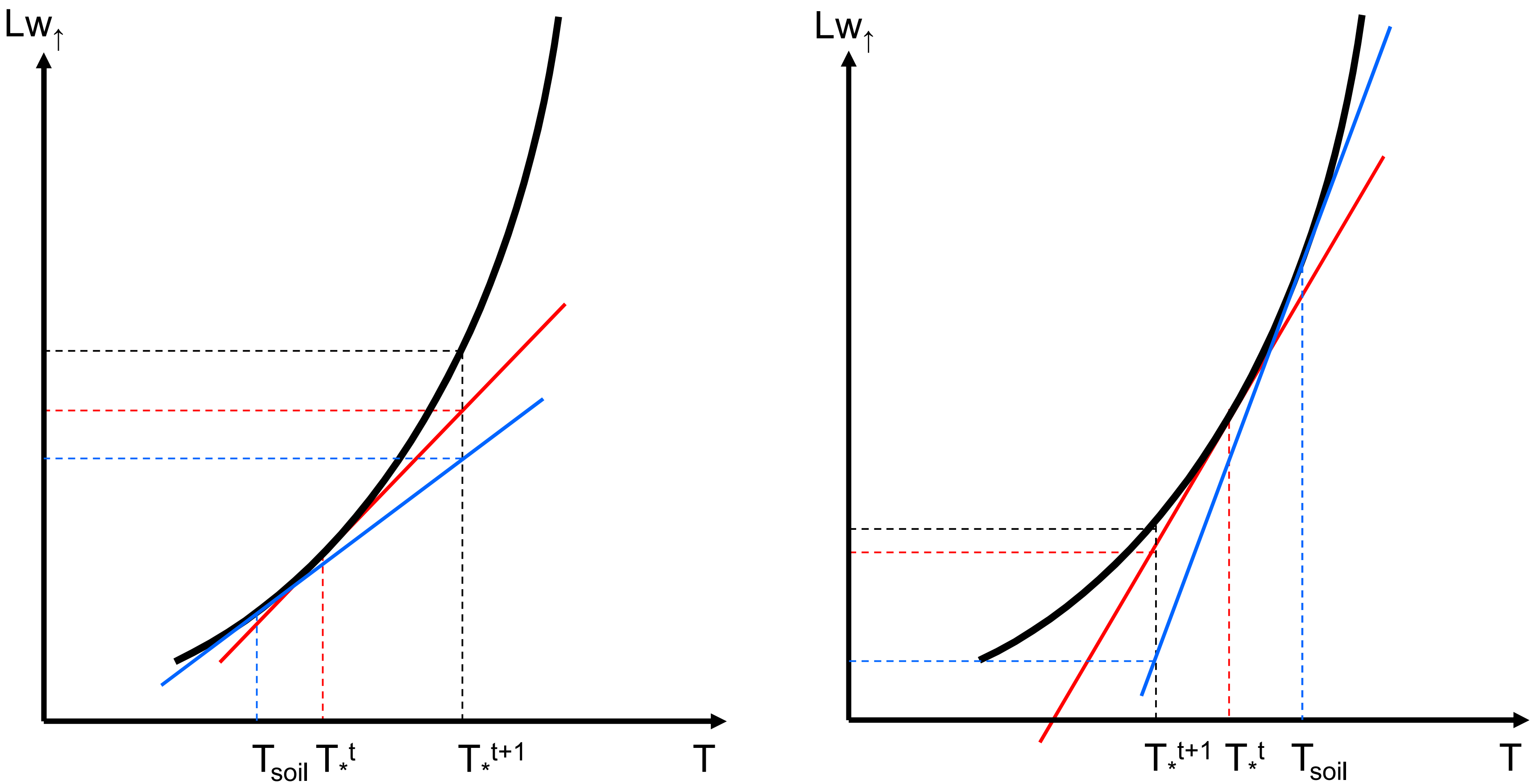
Comparison of JULES vn.2.1.2 predicted land cover with SAGE (Ramankatty and Foley, 1999) map of potential land cover





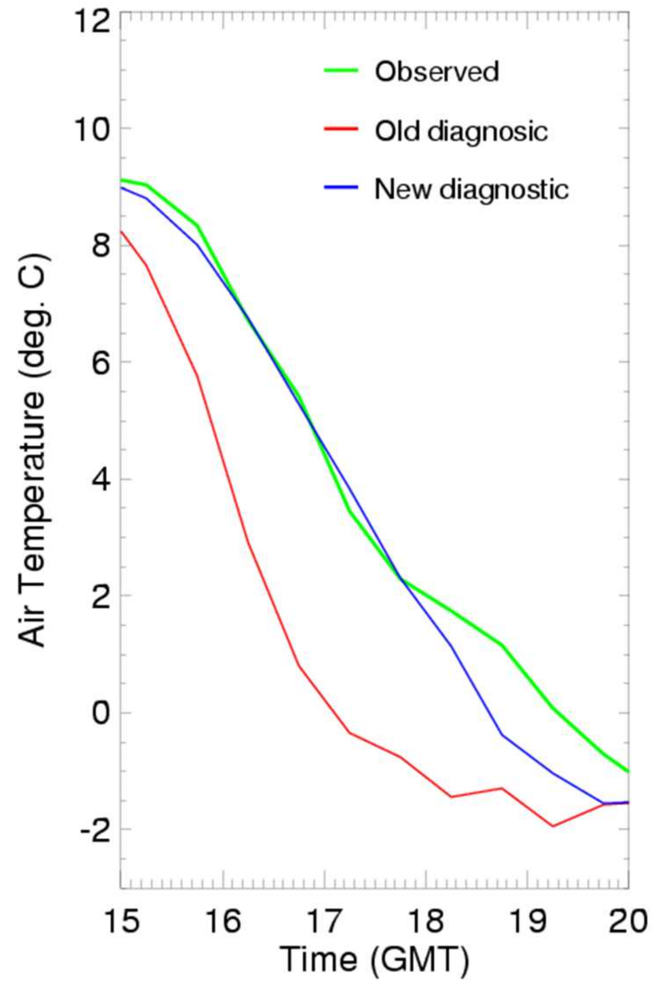
Current work

JULES implemented into operational models in neutral configuration



Screen level diagnostic

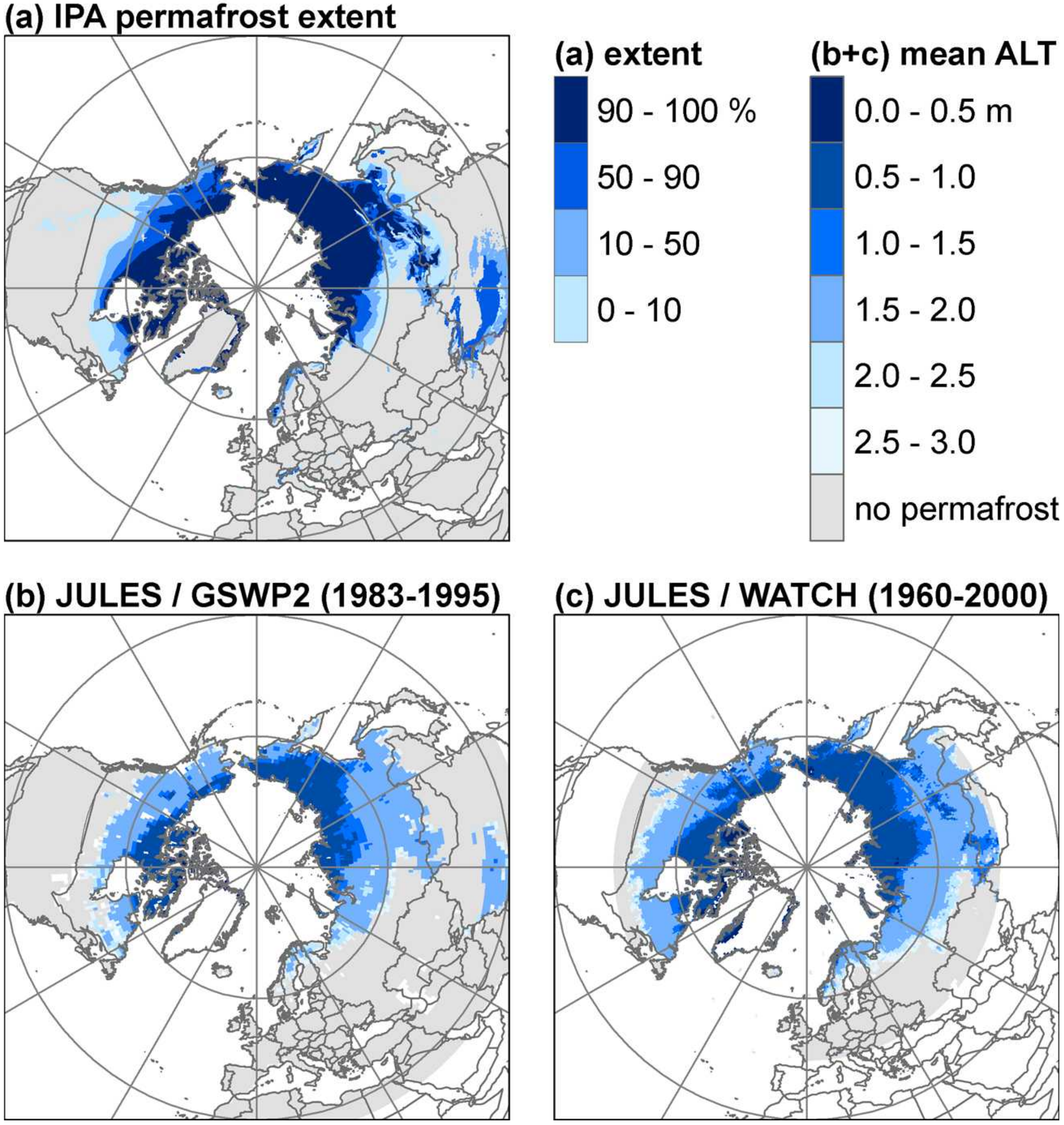
- Forecaster complaints about large (up to 5K) cold bias errors around evening transition in very calm clear conditions in winter/early spring
- Detailed study showed that surface layer up to first model level not in turbulent equilibrium -> MO theory not good assumption
- Temperature profile dominated by radiative cooling for winds O(1 ms^{-1})
- New diagnostic parametrization of radiative cooling from detailed modelling study
  - ➢ Merges back towards standard MO theory as wind increases
  - ➢ Only applied during evening transition
    - ❖ Impacts on data assimilation scheme



Courtesy of John Edwards

Permafrost

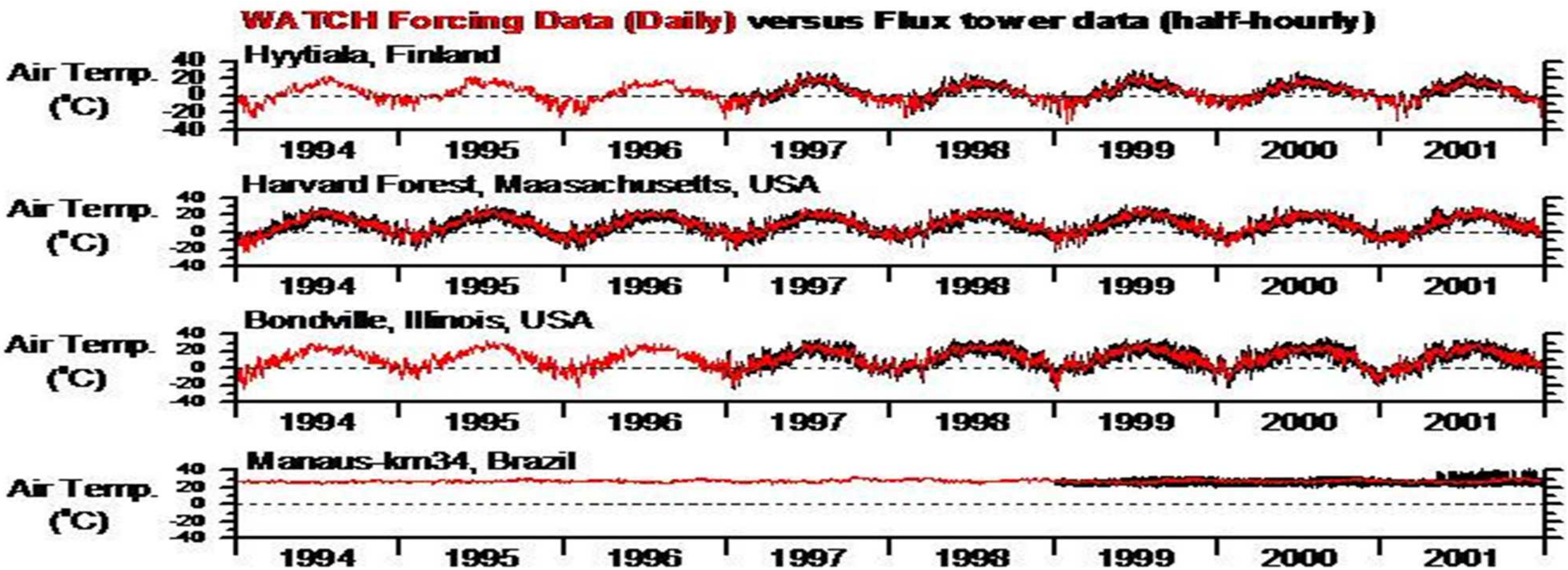
- Can simulate physical extent of permafrost
- Issues with soil moisture drainage affecting soil temperatures
- Need to include biophysical processes (such as CO_2 or CH_4 release)



Courtesy of Eleanor Burke

Historical terrestrial water cycle

- Land forcing dataset from 1900 – 2001 (WFD)
- Multi-model ensemble for historical terrestrial water cycle
- Planned extension to near current day (WFDi)
- Multi-model and multi-forcing dataset comparison



Courtesy of Graham Weedon

Data assimilation

Recent developments

- use interpolated global snow cover/depth analysis in regional NAE model (but not UK models)
- allow soil temperature updating beneath snow (but without melting)
- introduce new LAI climatology (more recent MODIS data)
- new SST climatology used at points unresolved by OSTIA analysis (lakes)

(operational since July 2011)

Further improvements

- migrate to EUMETSAT's updated ASCAT soil wetness processing (completed mid-August 2011)
- increase weight given to ASCAT soil wetness data (operational autumn 2011)
- adopt improved correlation scales for screen-level analysis used in soil moisture nudging (operational autumn 2011)
- update UM soil moisture climatology used within ASCAT assimilation for latest JULES version
- continuous soil properties rather than 3 discrete classes

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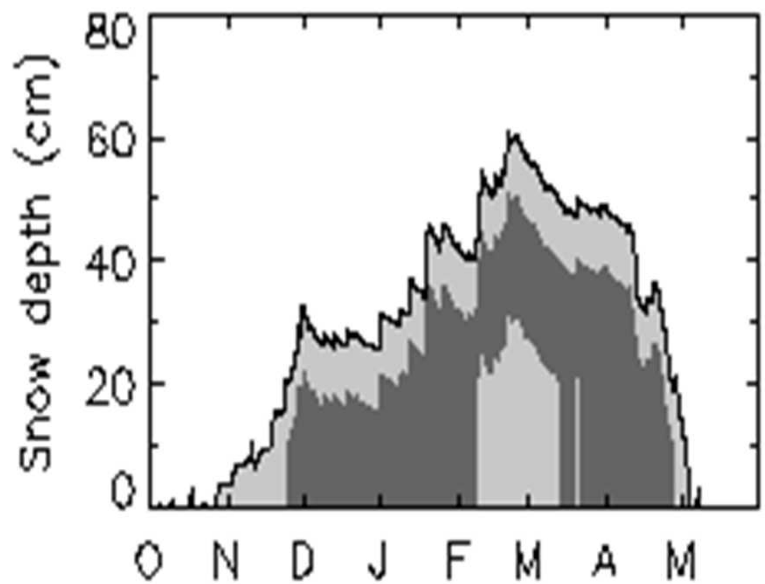
Current potential with JULES

Multi-layer snow scheme

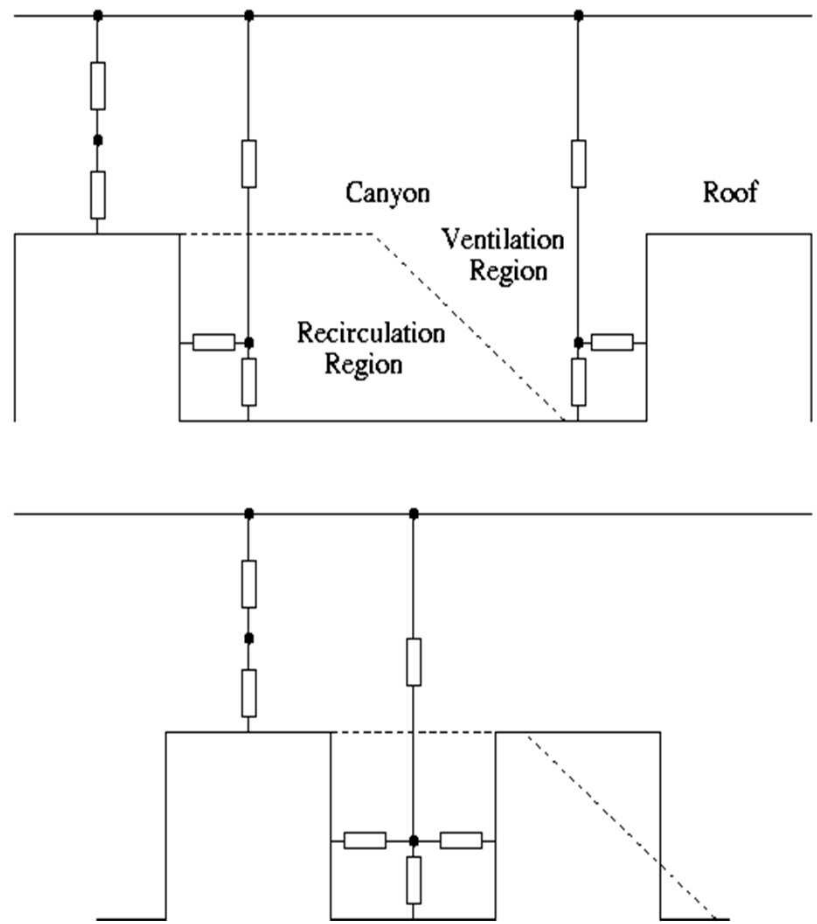
- User defined number of layers
- Layers change according to depth of snow
- Liquid and Solid stored



Best et al., 2011

Urban schemes

- 1 tile urban scheme
- 2 tile urban scheme
- MORUSES
  - ➢Parameters depend upon morphology
  - ➢Aerodynamic resistance dependent upon flow regime



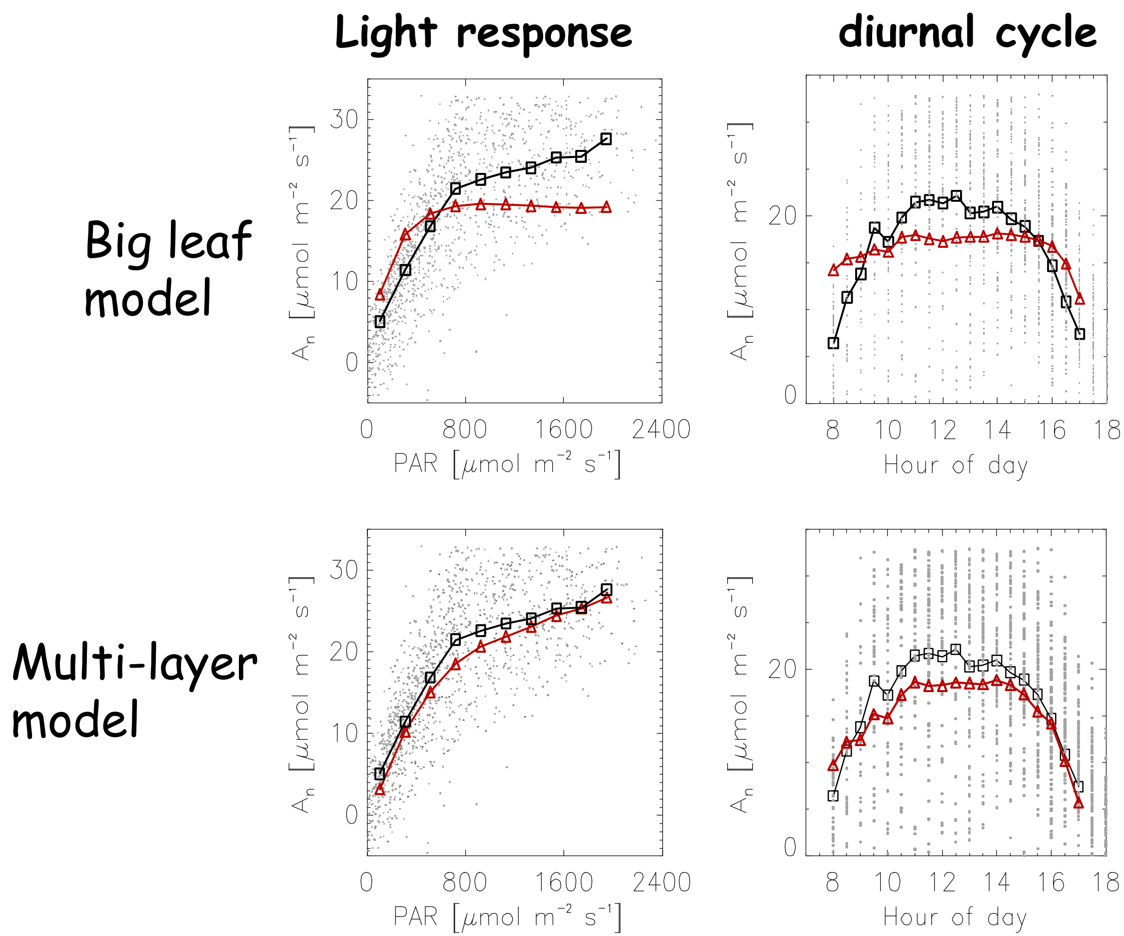
Best et al., 2011

Radiation interception

- Distribution of radiation through vegetation canopy
- Inclusion on nitrogen availability
- Impact of direct/diffuse radiation

A_n = net carbon uptake

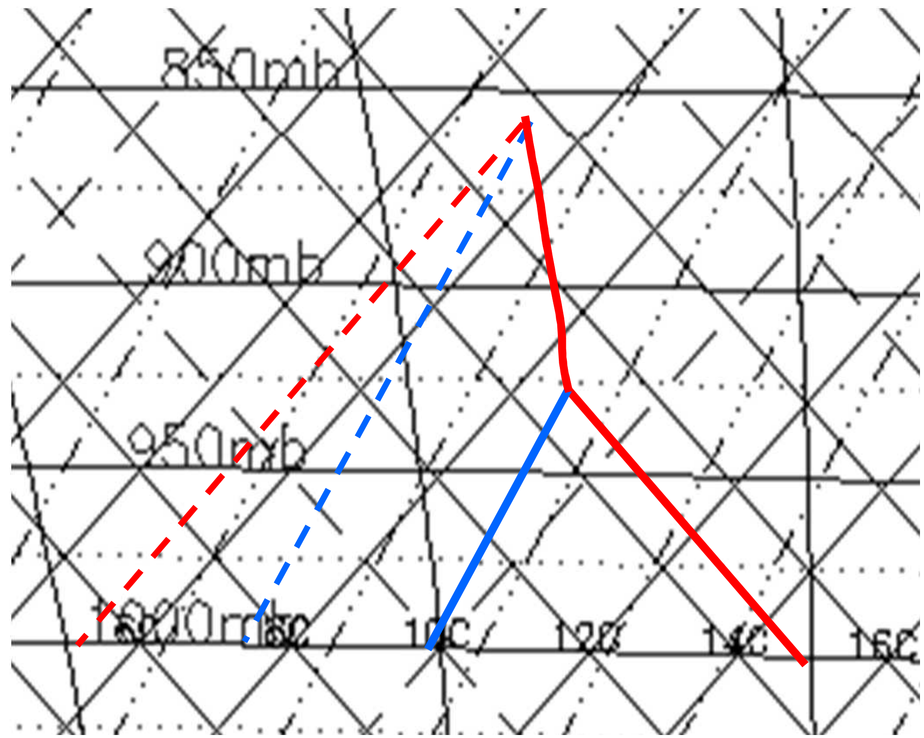
= Total photosynthesis (GPP) – leaf respiration



Courtesy of Lina Mercado

Flexible tiles

- 1 tile -> 9 tiles for Global model
- More flexible definitions for tiles
- Elevation bands for tiles



Future plans

Planned JULES developments

JULES version	New science	Timescale
3.1	Flake New I/O interface Full JULES repository Removal of mirror in UM at next subsequent UM release	Summer 2011
3.2	Crops TRIP Irrigation MEGAN	Autumn 2011
3.3	ECOSSE FUN	Easter 2012
3.4	ED	End 2012

Data assimilation plans

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Needs for a new system

- improve propagation of surface information to deeper layers
- introduce multivariate increments
- cater for complex indirect satellite measurements
- analysis variable priorities: soil moisture, soil temp, snow depth, albedo, LAI
- contain computational cost
- run uncoupled from NWP model with driving data for years

Development plan

- Initial development of EKF as implemented at ECMWF and Meteo-France (develop in ’11-’12)
- add new observations & variables e.g. LST, snow depth
- each operational NWP model to have its own coupled EKF (implement in ’12-’13)
  - including seasonal prediction system
- Move on to EnKF
  - engage with potential Australian Research Council proposal on EnKF land DA for ensemble ppn forecasting (2012-2015)
  - explore use of EnKF with NASA Land Information System (LIS)
  - consistent with direction of Met Office atmospheric DA strategy

Key science areas to address over next 5 years

Area	Goal
Hydrology	*Understand changes and impacts of the terrestrial water cycle on timescales from minutes to centuries and spatial scales from kilometres to 100s of kilometers, leading to improved predictions of the water and energy cycles and near surface meteorology*
Earth System Science	*Quantify the uncertainty and improve our best estimates of land surface state in future weather and climate through the impact of the terrestrial components of the Earth System, to improve predictions of the carbon, energy and water cycles along other greenhouse gases, aerosols and near surface meteorology*
Predictability	*Understand the impact of predictability of the land state on the predictability of weather and climate at timescales from minutes to centuries, leading to improved constraints on uncertainty in predictions of the water, energy and carbon cycles and near surface meteorology*
Data Assimilation	*Obtain the best estimates of current and past land surface states and fluxes, to improve predictions of the water, energy and carbon cycles and near surface meteorology*
Urban	*Understand the interaction and impact of weather and climate on urban environments, leading to improved predictions of the energy, water and carbon cycles and near surface meteorology*

Questions