The Community Atmosphere Land Exchange (CABLE) model:

Science/code: differences between CABLE1.4b and 2.0

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Australian Government
Bureau of Meteorology

The Centre for Australian Weather and Climate Research
A partnership between CSIRO and the Bureau of Meteorology

CSIRO

CABLE development from v1.4b to v2.0

The main areas of development:

- new science,
- new infrastructure i.e. svn repository for Cable,
- code modularisation,
- code consolidation in particular separation of so called core science code from interface routines,
- interface routines totally rewritten
- model benchmarking; offline/online,
- improvement to code robustness,
- new data sets

In parallel to the above major effort went into coupling CABLE to UM which turned out to be an exercise in replacing hardwired UM land surface scheme MOSES with CABLE.

CABLE development from v1.4b to v2.0

The main areas of development:

New/updated science include:

1) Inclusion of biogeochemistry (CASA-CNP) though not fully implemented
2) Resistance network approach to calculate screen level variables (INH)
3) Improvements to the seasonality of the fresh water influx into the ocean
4) More consistent formulations of heat and water fluxes to ensure an acceptable surface energy and water balance in long climate simulations
5) An improved root water extraction function
6) Revision for the calculation of canopy temperature
7) Hydraulic redistribution (optional, default OFF)

Resistance network approach to calculate screen level variables by Ian Harman

- The total resistance between the ground surface and the *Zref* is given by:

$$r_s + r_{ca} + r_{cb} + r_{cc}$$

where r_s is the resistance from the soil to the within canopy air temperature (eq.17, Kowalczyk et al. 2008) and r_{ca}, r_{cb}, and r_{cc} are the components of the canopy resistance network (eq.15).

- We approximate the screen level variables for temperature/humidity to be that value given by the appropriate position along the resistance network.

Mathematically, variable C which takes values C_s at the ground and C_{ref} at the reference level (z_{ref}) then the value of C at height z_{sc} above the ground, C_{sc}, is given by

$$C_{sc}(z_{sc}) = C_s + \left(C_{ref}(z_{ref}) - C_s \right) * r_{sc} \,/\, (r_s + r_{ca} + r_{cb} + r_{cc})$$

CABLE development from v1.4b to v2.0

Code restructure and modularisation,

- main cable routine ‘cable_cbm’ partitioned into a number of modules including:
  - cable_radiation,
  - cable_albedo,
  - cable_roughness,
  - cable_canopy,
  - cable_air

- cable_canopy module restructured and modularised into a number of routines:
  - define_canopy,
  - comp_friction,
  - within_canopy,
  - wetLeaf,
  - dryLeaf,
  - surf_wetness, latent_heat,
  - photosynthesis,
  - update_zetar,

Separation of so called core science from interface routines (for UM seven at present).

CABLE development from v1.4b to v2.0

- Changes required for CMIP5 simulations with ACCESS1.3

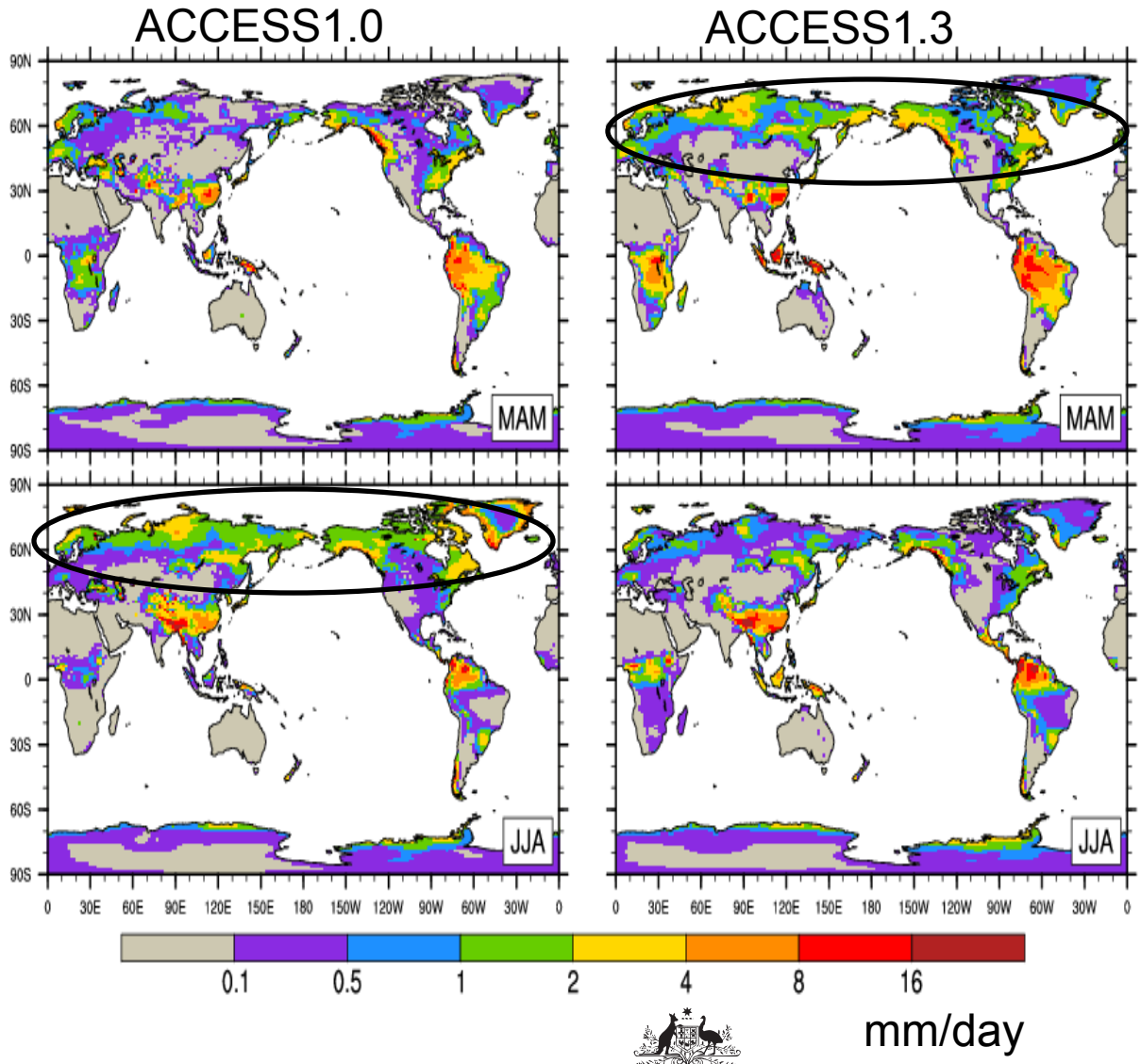
UM changes

- Change number of vegetation types
- Change number of soil layers
- Keep parts of MOSES (e.g. sea-ice)
- Link UM and CABLE variables (pack/unpack)
- Allow for tiled soil and snow

CABLE development

- Multiple vegetation types per grid-cell
- Code revision: canopy, screen temperature
- Simpler albedo for 3 hourly radiation
- Partitioning of runoff and glacier capping
- Surface energy and water balance

Runoff: northern spring and summer



Warmer winter/ spring temperatures in ACCESS1.3 lead to earlier snow-melt and runoff

Sources of errors in the model

The main areas of development: improvement to code robustness

- simplifications in the mathematical/physical model
  (the effects of such errors are difficult to estimate)
- errors in given input data and surface parameters
  (examples include unrealistic soil albedo or LAI, etc…)
- human errors (one has to devise a set of routine checks to evaluate the credibility of the results, for example whether energy and mass are conserved)

- truncation error

Examples include:

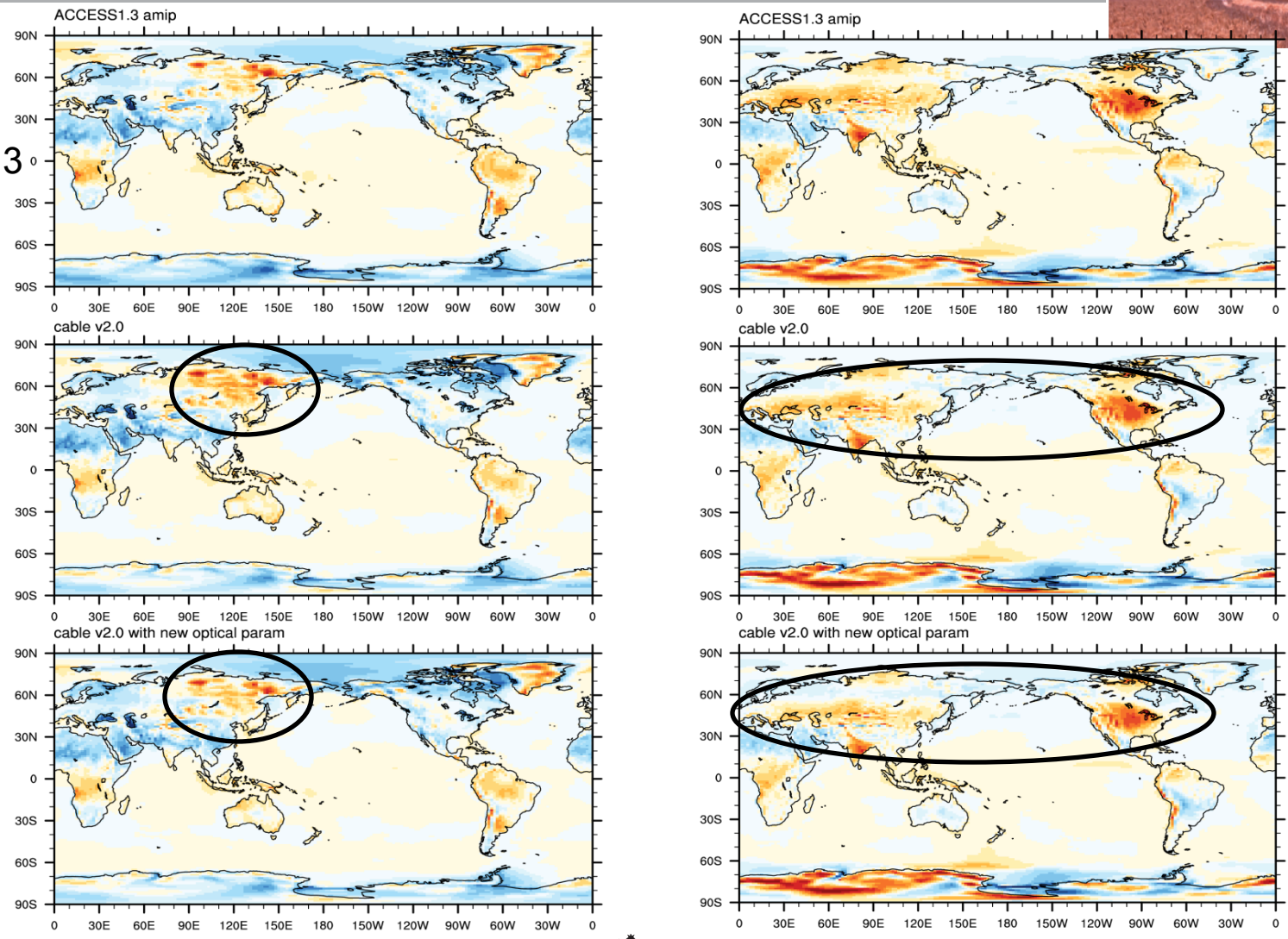
- *limiting iteration process*
- *discretization errors*
  - *transformation of a differential equation to a system of nonlinear equations*
  - *approximation of highly nonlinear function with linear function,*

ACCESS benchmark, atmosphere-only, 20 years
Seasonal screen level temperature bias

ACCESS1.3

CABLE2.0

CABLE2.0 revised optical properties



Dec/Jan/Feb

Jun/Jul/Aug

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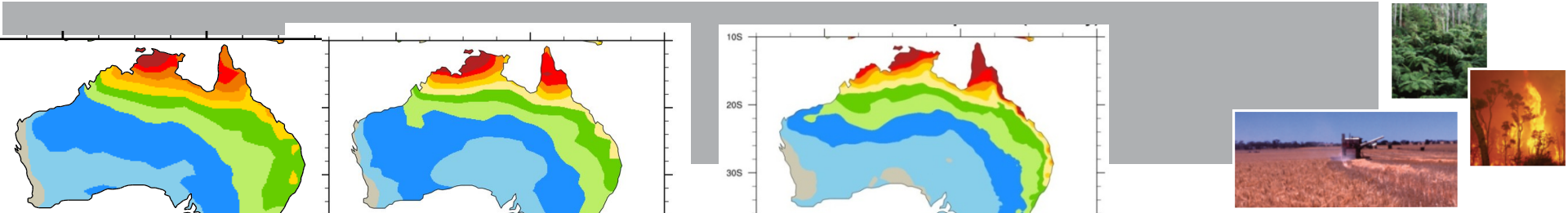
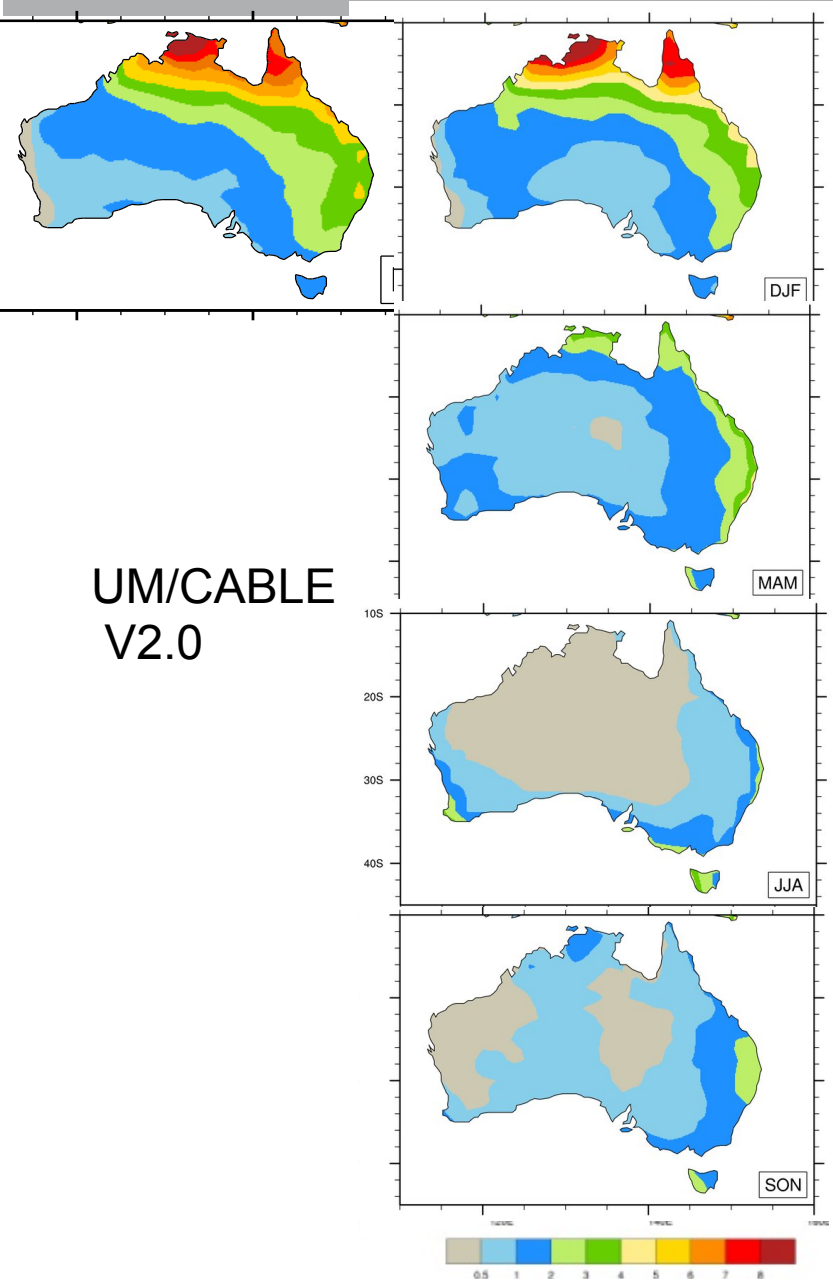
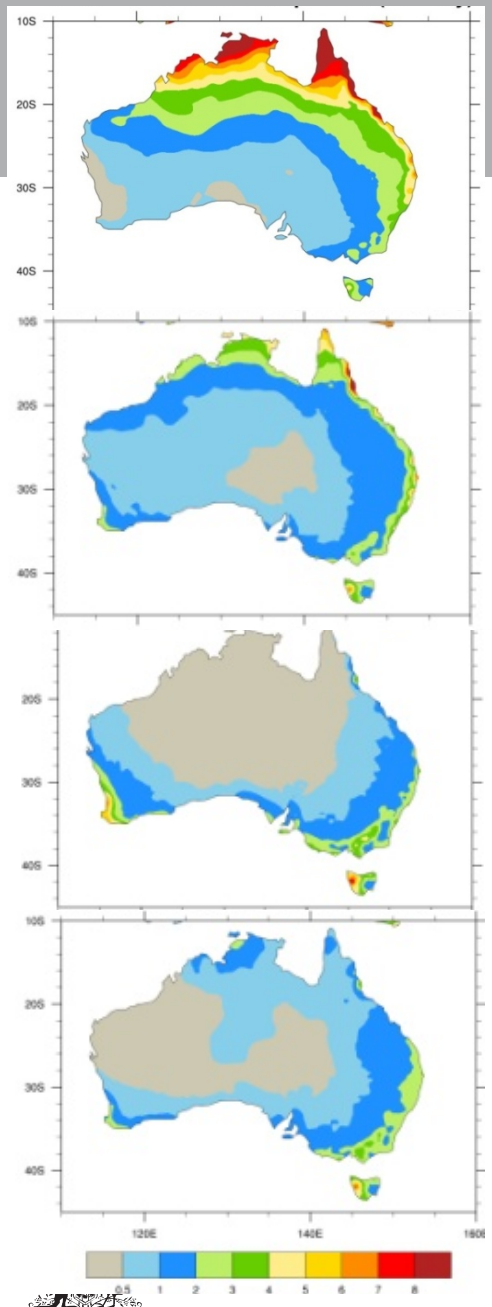


UM/CABLE V2.0





BoM observations

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Eva Kowalczyk

CABLE trac page: https://trac.nci.org.au/trac/cable/
CABLE email list: https://lists.csiro.au/mailman/listinfo/cable-users

Thank you

www.cawcr.gov.au

The ACCESS model

Two model versions of ACCESS have been used to contribute simulations to CMIP5

Both use the atmospheric component of ACCESS the UK Met Office Unified Model (UM).

- ACCESS1.0 model configuration uses HadGEM2(r1.1) atmospheric physics (Davies et al., 2005; Martin et al., 2011) and the Met Office Surface Exchange Scheme (MOSES).

- ACCESS1.3 uses new atmospheric physics similar to that described in Hewitt et al. (2011) and CABLE

Two main differences:

1) the choice of the PC2 cloud scheme (Wilson et al. 2008)
2) MOSES replaced by CABLE

ACCESS land scheme configurations

	MOSES in ACCESS1.0	CABLE in ACCESS1.3
Canopy formulation	one big leaf model canopy placed beside bare ground	two leaf model (sunlit and shaded leaves) canopy placed above the ground
Grid Tiles	9 surface types (5 vegetated) with 9 tiles used in each grid cell	13 surface types (10 vegetated) with up to 5 tiles used in each grid cell
Soil	4 layers, no subsurface tiling	6 layers, subsurface tiling
Snow	1 layer	3 layers

Kowalczyk et al., The land surface model component of ACCESS: description and impact on the simulated surface climatology, submitted to AMOJ.

Note: No carbon output submitted to CMIP5 from either version of ACCESS

MOSES

CABLE

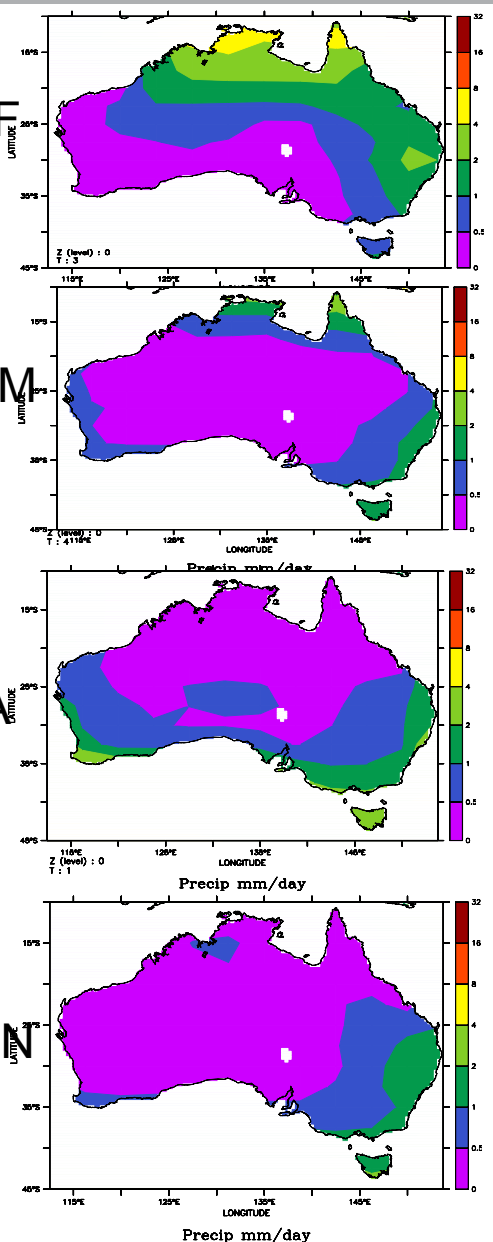
BoM

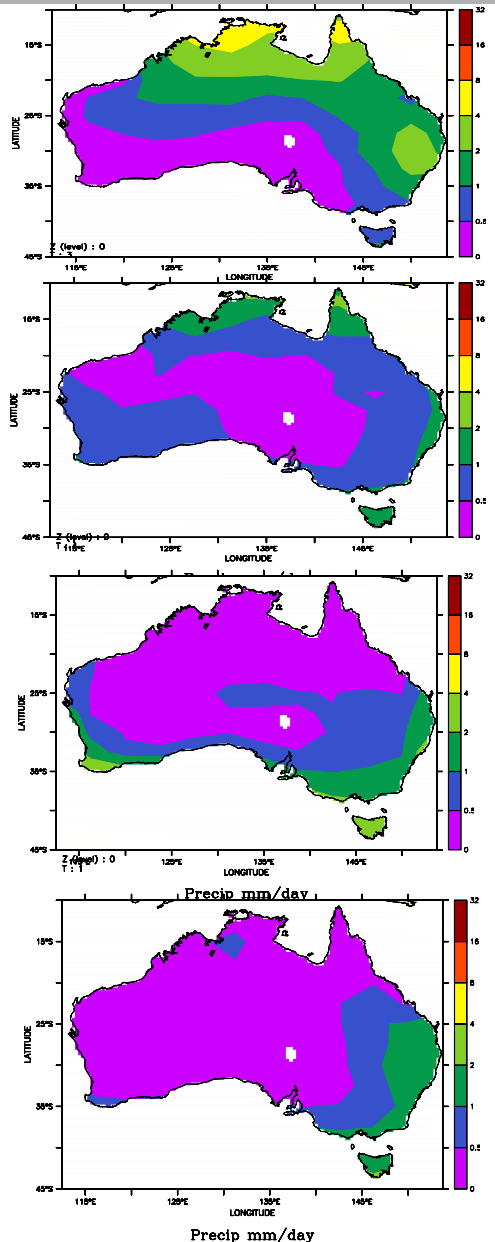
DJF

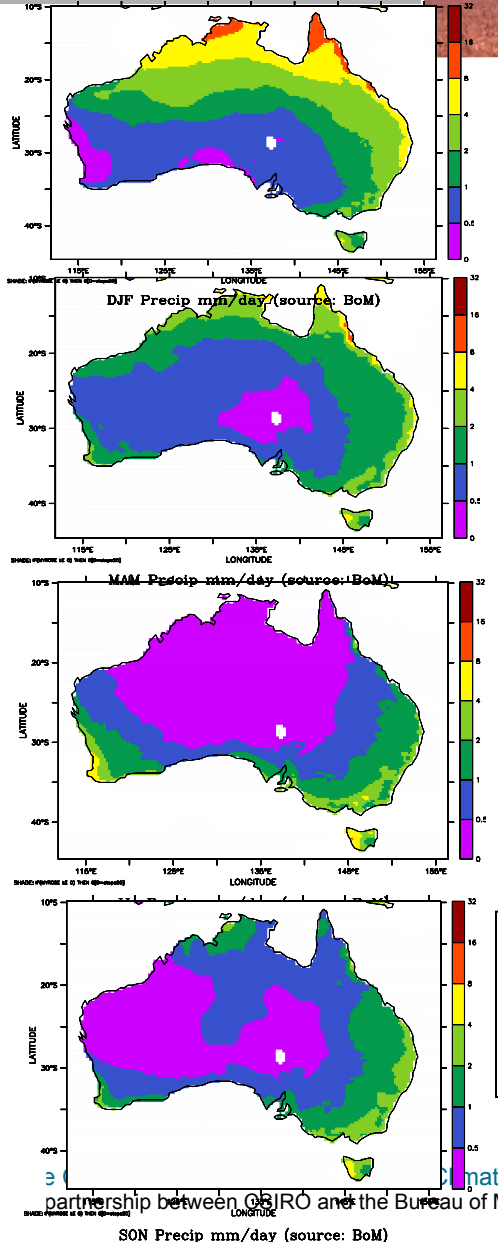
MAM

JJA

SON







Seasonal rainfall over Australia

The CABLE land surface model

Role of land surface models

- Provide boundary conditions at the land-air interface
  - e.g. albedo, surface T, heat and moisture fluxes
- Partition rainfall into runoff and evaporation
  - River runoff as an input to the oceans
- Update state variables which affect surface fluxes
  - e.g. snow cover, soil moisture, soil T, veg. cover, Leaf Area Index

CABLE includes

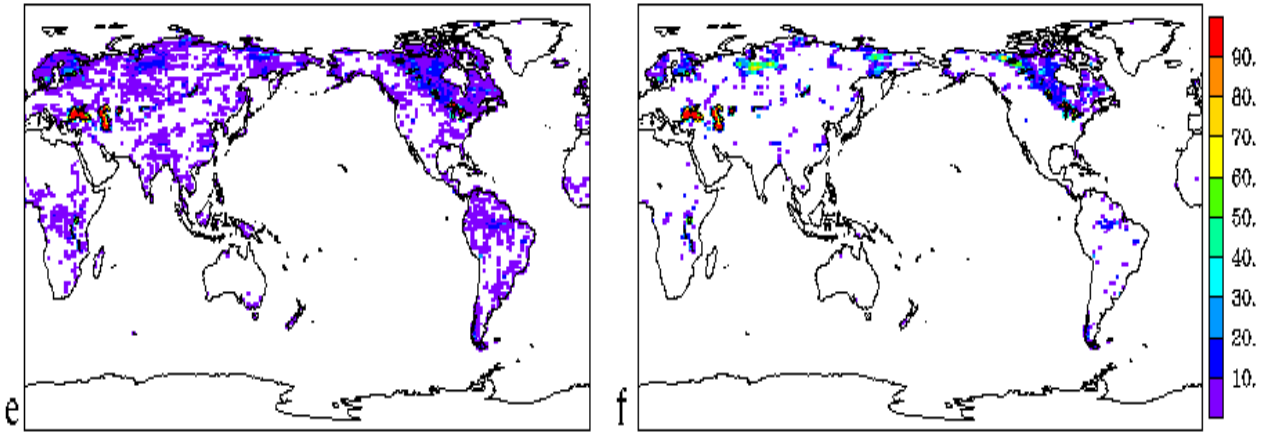
- Biophysical component
  - Surface radiation transfer (direct beam/ diffuse, visible, NIR and thermal, sunlit/ shaded leaves)
  - Canopy turbulence
  - Two-leaf canopy
  - Six soil and three snow layers
- Biogeochemical component
- Land use and land use change
  - Patch representation of surface heterogeneity
  - No vegetation competition and succession

Vegetation distribution

MOSES

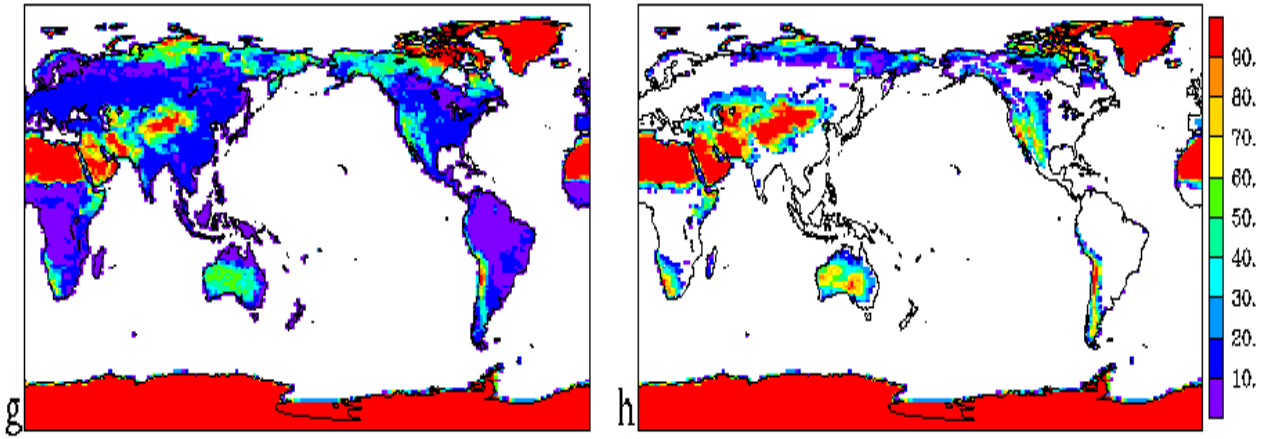
CABLE

Lakes & wetland 'Water'



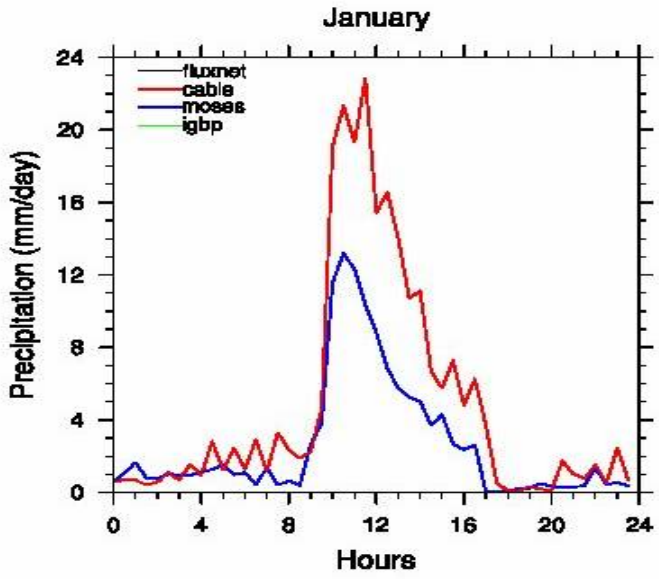
% of grid-cell

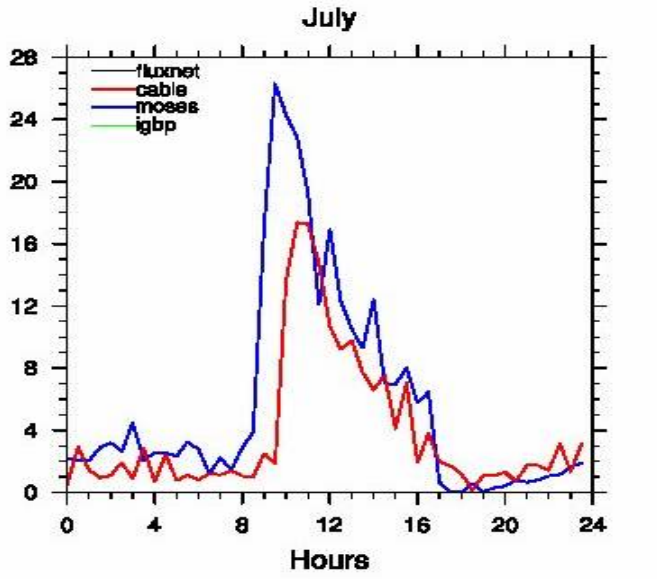
Bare ground & permanent ice

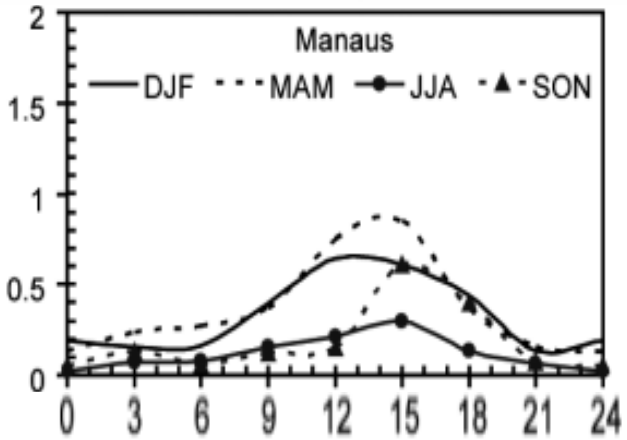


% of grid-cell

Mean diurnal precipitation at Manaus (old version of UM/CABLE)







Mean rain rate (mm /hour) in each season DJF, MAM, JJA,SON. (Angelis et al. 2004)