Overview of CABLE activities

UM users workshop 2015

Rachel Law | CABLE coordinator

12 June 2015

OCEANS AND ATMOSPHERE FLAGSHIP
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Australian Government
Bureau of Meteorology

ARC CENTRE OF EXCELLENCE FOR CLIMATE SYSTEM SCIENCE

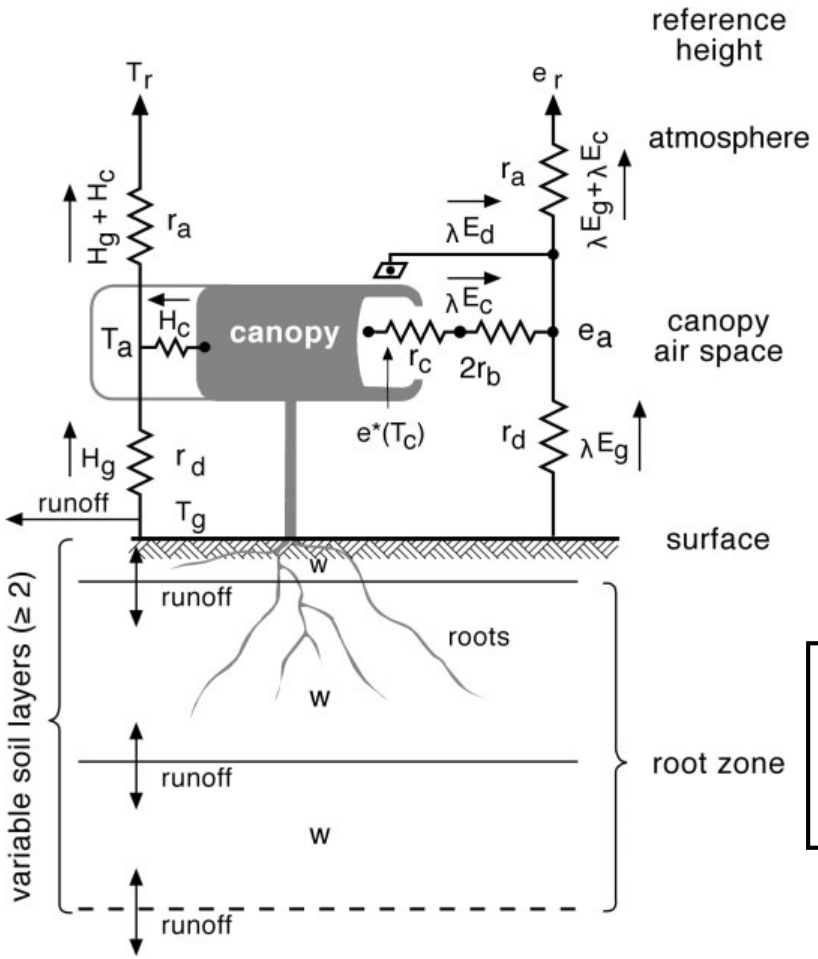
NCI

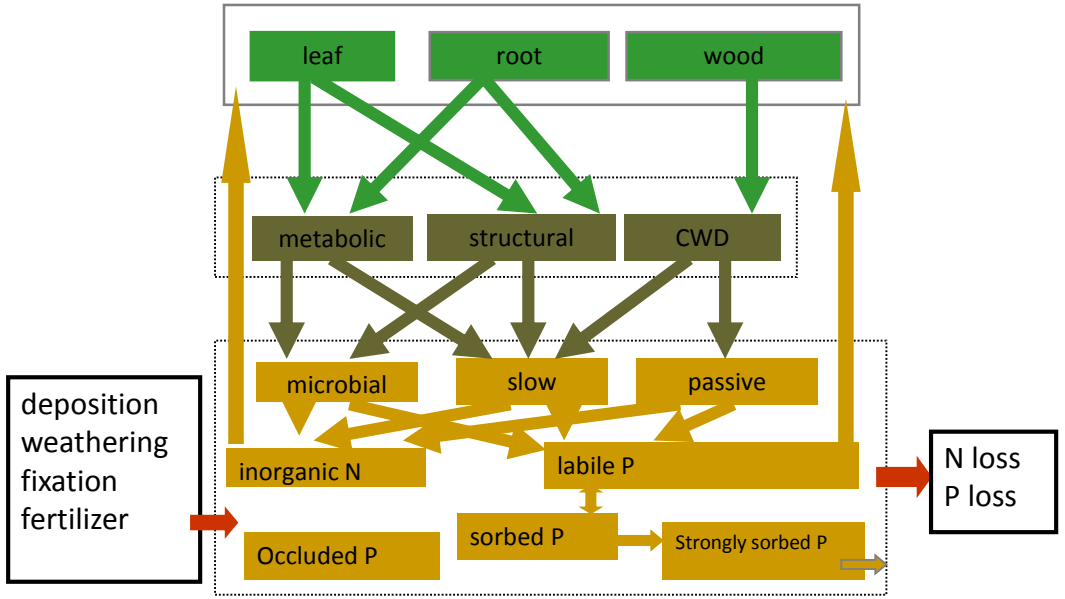
CSIRO

What is CABLE and who uses it?

- **C**ommunity **A**tmosphere **B**iosphere **L**and **E**xchange
- Australian community land surface model for stand-alone and online use
- Coupled to
  - global models: ACCESS (UM-atmosphere), CCAM, Mk3L
  - regional models: WRF (via NASA's Land Information System)
  - air pollution model: TAPM
- 88 registered users from 17 Australian and 24 overseas institutions
- Key groups
  - CSIRO, Melbourne: CABLE in ACCESS, model development, parameter estimation, global offline applications
  - CSIRO, Canberra: Australian continental applications, carbon and water budgets, linking CABLE to population dynamics
  - ARCCSS (UNSW), Sydney: ACCESS and offline applications, coupling to NASA LIS (and WRF), model development
  - BoM, Melbourne: CABLE in ACCESS for NWP

CABLE components





Biophysics (original CABLE) + **Biogeochemistry** (CASA-CNP) = **CABLE** (current)

CABLE timeline

1990: First land surface model developed in CSIRO.

1997: Another model - Soil Canopy Atmosphere Model (SCAM) -developed with an empirical photosynthesis model

1998: Two-leaf (sunlit, shaded) canopy model developed

2003: CSIRO Biosphere Model (CBM) developed

2006: CBM and SCAM combined to form CABLE version 1.0. Last released update v1.4b in Sep 2008.

2010: CASA-CNP, a global biogeochemical model of C, N and P developed

2012: CABLE2.0 released. CABLEv1.8 in ACCESS1.3 for CMIP5.

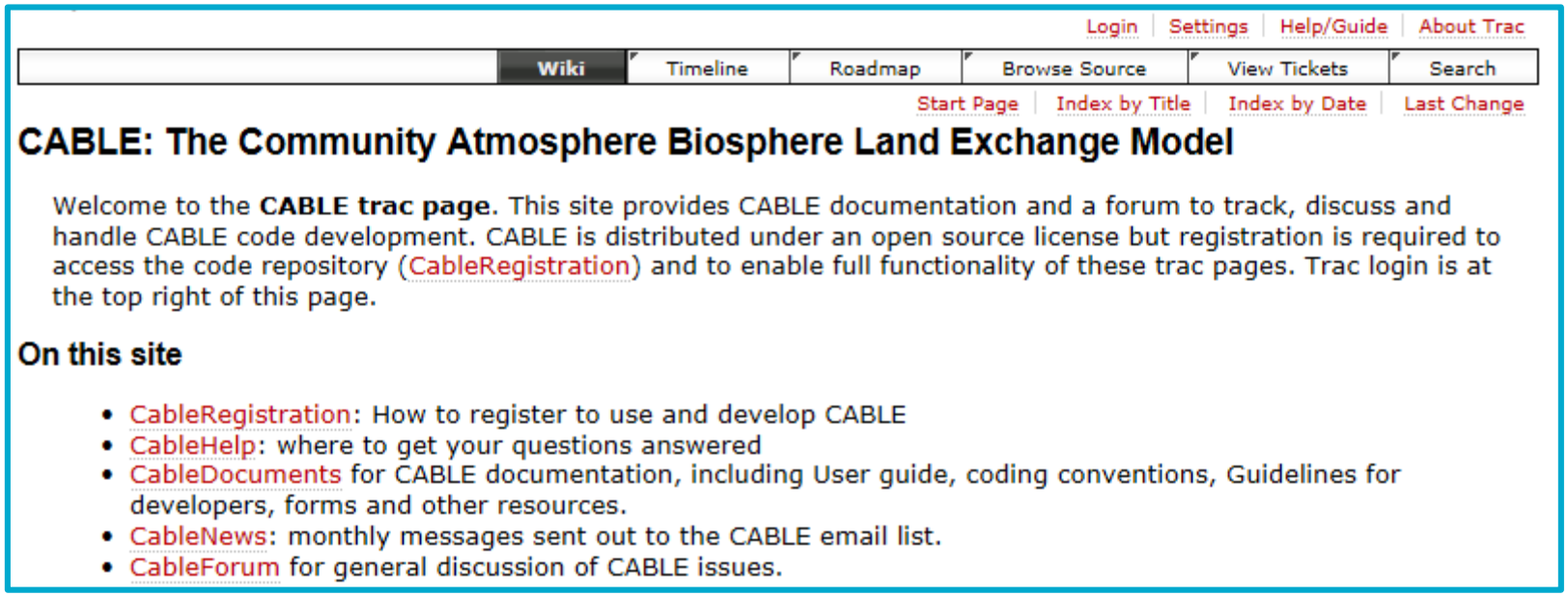
2014: CABLE2.2.3 in ACCESS-ESM1

Main technical documentation in

Kowalczyk et al., CMAR tech report, 2006;
Wang et al., BG, 2010; Wang et al., JGR, 2011.

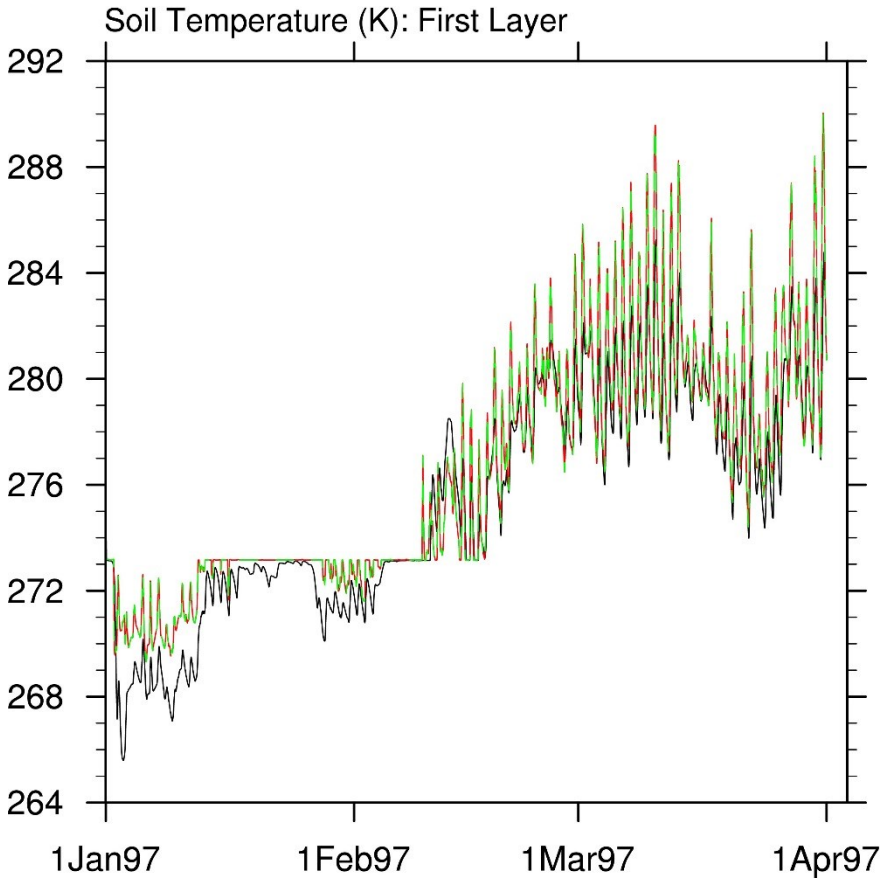
Code availability

- Open Source (BSD/MIT variant)
- Register to use CABLE repository
- Hosted at NCI (National Computational Infrastructure)
- Growing use of tickets for model development
- https://trac.nci.org.au/trac/cable/wiki



Technical activities

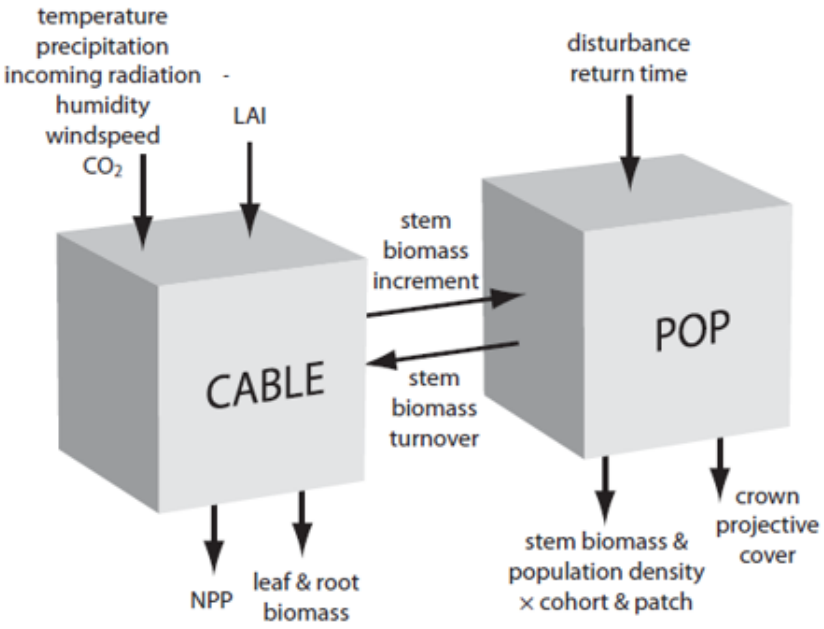
- CABLE via JULES
  - Single-site (L. Stevens)
    - Runs and very close to CABLE offline
  - Global offline (H. Zhang)
    - Runs, needs to be verified against CABLE offline
  - Coupled to UM8.5 for initial version of ACCESS-CM2 (J. Srbinovsky)
    - Crashes in first month
  - Coupled to UM10+ (M. Pryor)
    - Crashes in first timestep



L. Stevens

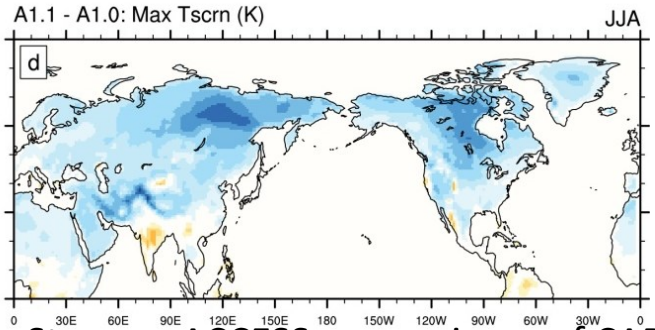
Technical activities

- Incorporation of alternate soil scheme: Soil Litter Isotope (SLI)
- Incorporation of POP: Population Orders Physiology – new capability for disturbance
- Currently offline applications only

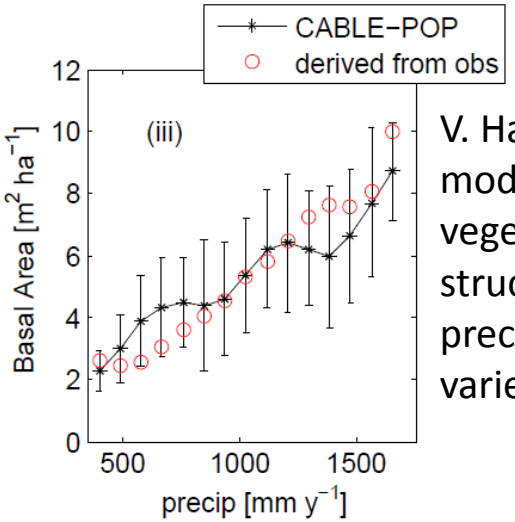


*Haverd et al. 2013
Geophysical Research Letters 40: 5234-5239

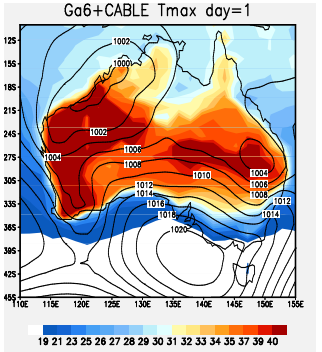
Science activities

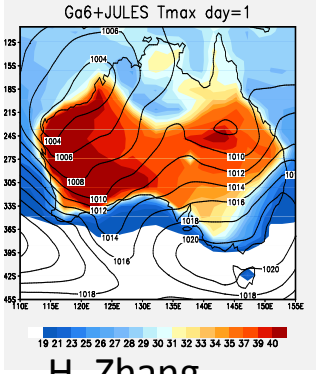


L. Stevens, ACCESS comparisons of CABLE vs MOSES

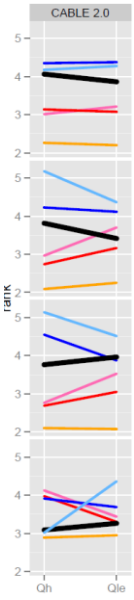


V. Haverd, modelling vegetation structure as precipitation varies

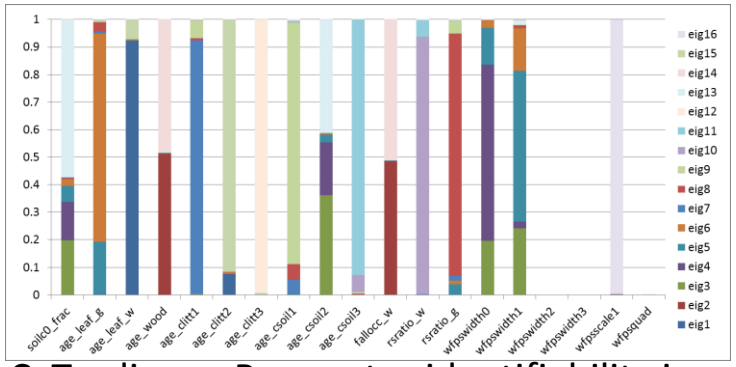




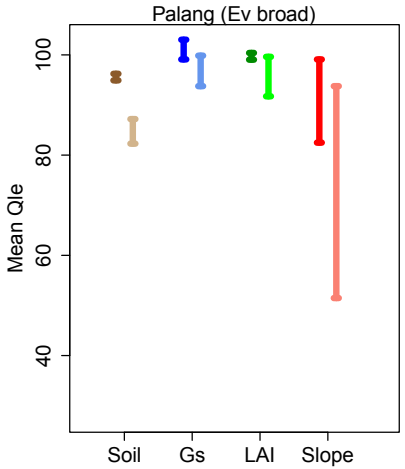
H. Zhang, Transpose-AMIP test with GA6+CABLE, GA6+JULES



N. Haughton, PLUMBER analysis



C. Trudinger, Parameter identifiability in CASA-CNP



A. Ukkola, Sensitivity of latent heat to model parameters

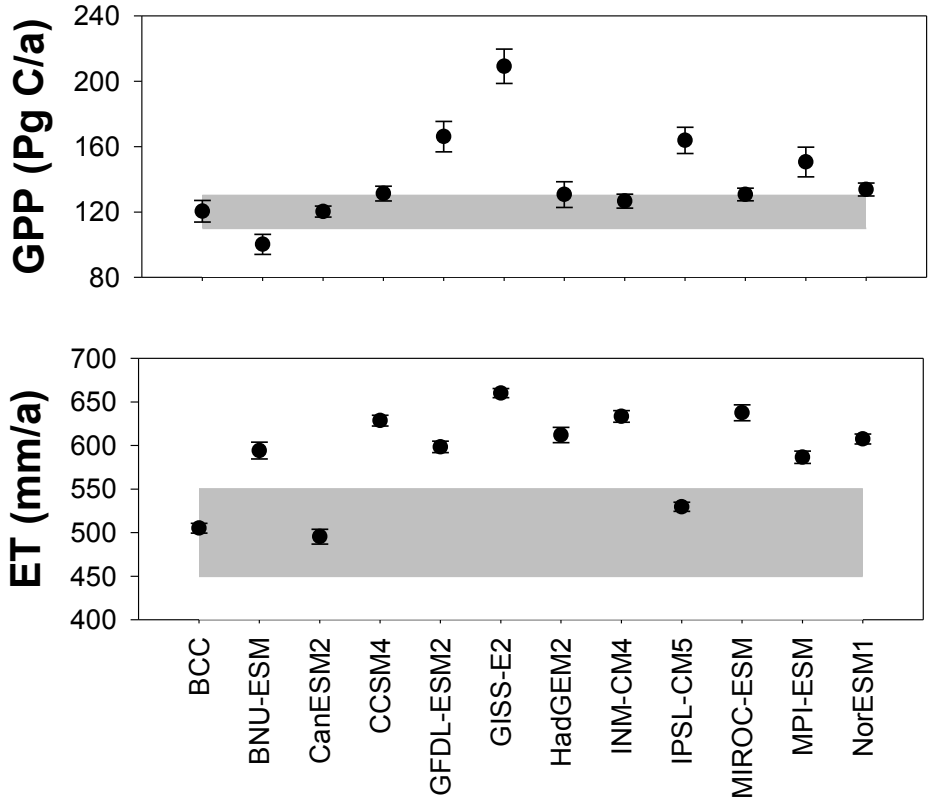
https://trac.nci.org.au/trac/cable/wiki/VideoMay2015

Sensitivity analysis and parameter estimation

Jianduo Li and Ying-Ping Wang

Beijing Normal University and CSIRO

Why parameter estimation?



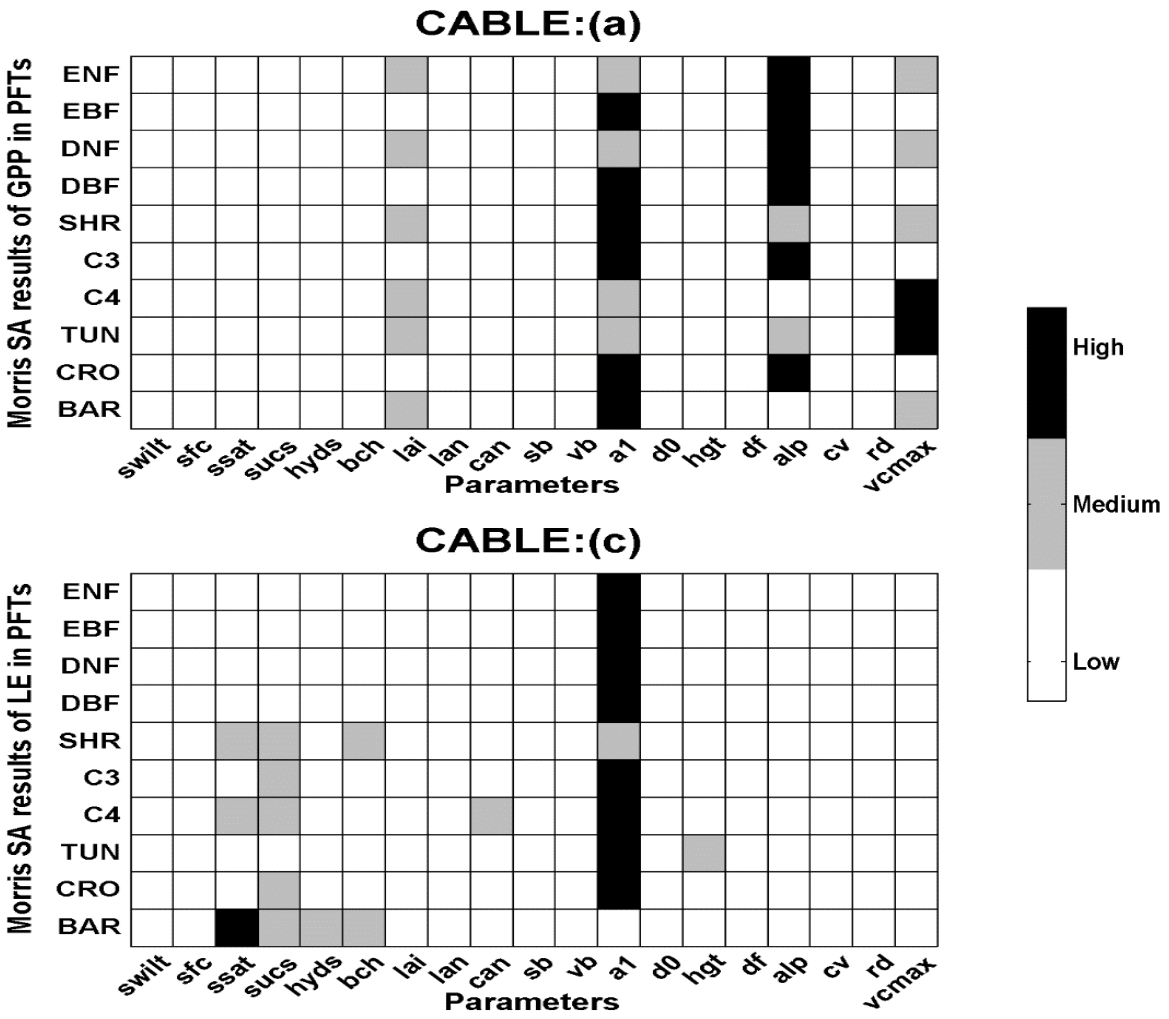
Modelled GPP and ET compared to Fluxnet-derived estimates (Jung et al, 2011) (grey bar)

- Most CMIP5 ESMs do not match global present-day Global Primary Production (GPP) and Evapotranspiration (ET)
- Difficult to diagnose errors in coupled simulations
- Difficult to directly compare land surface model components
- Could parameter tuning improve simulation?

Li et al. unpublished data

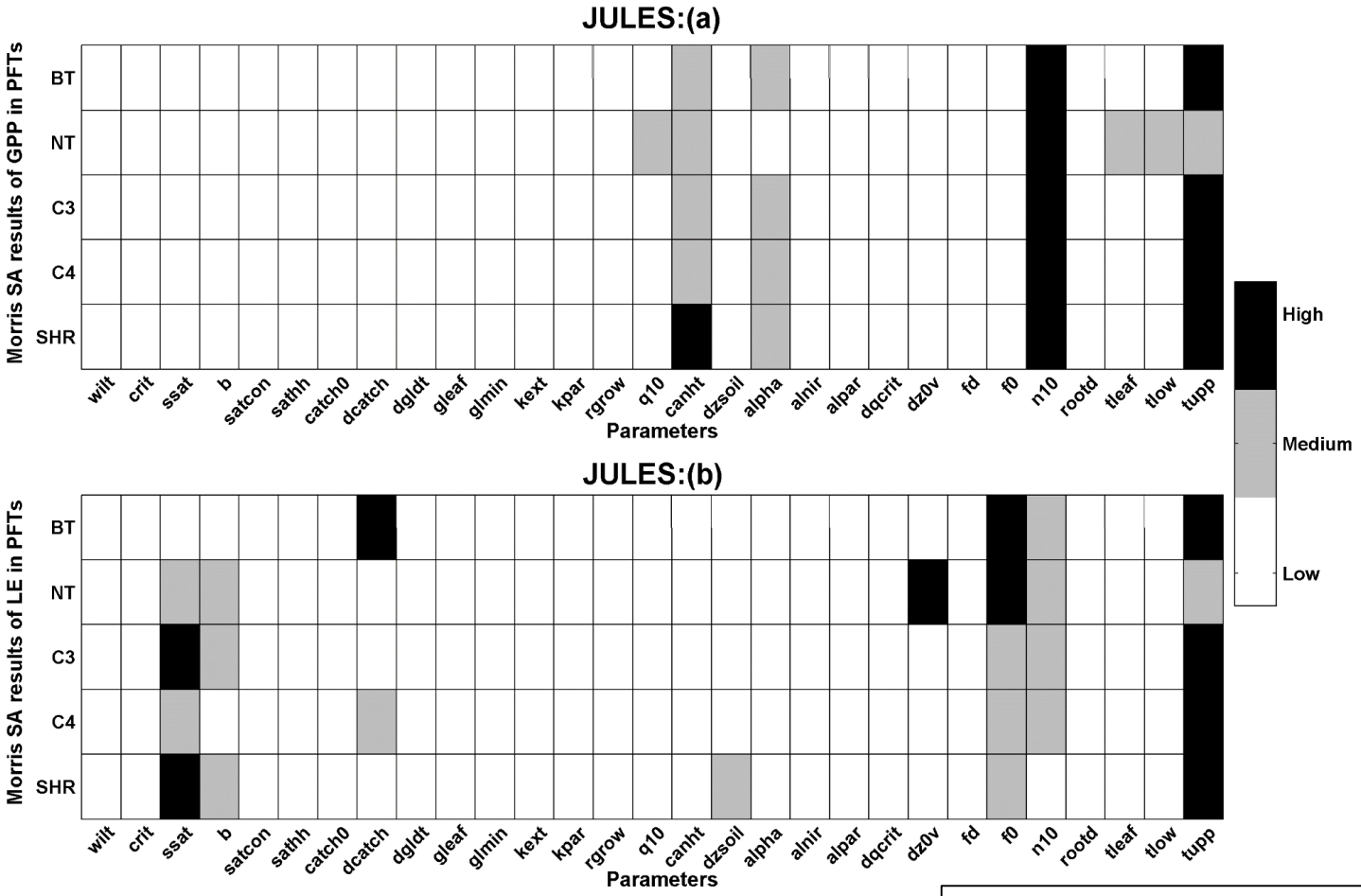
Sensitivity analysis - CABLE

Morris method:
Offline simulations for 1990



Li et al. unpublished data

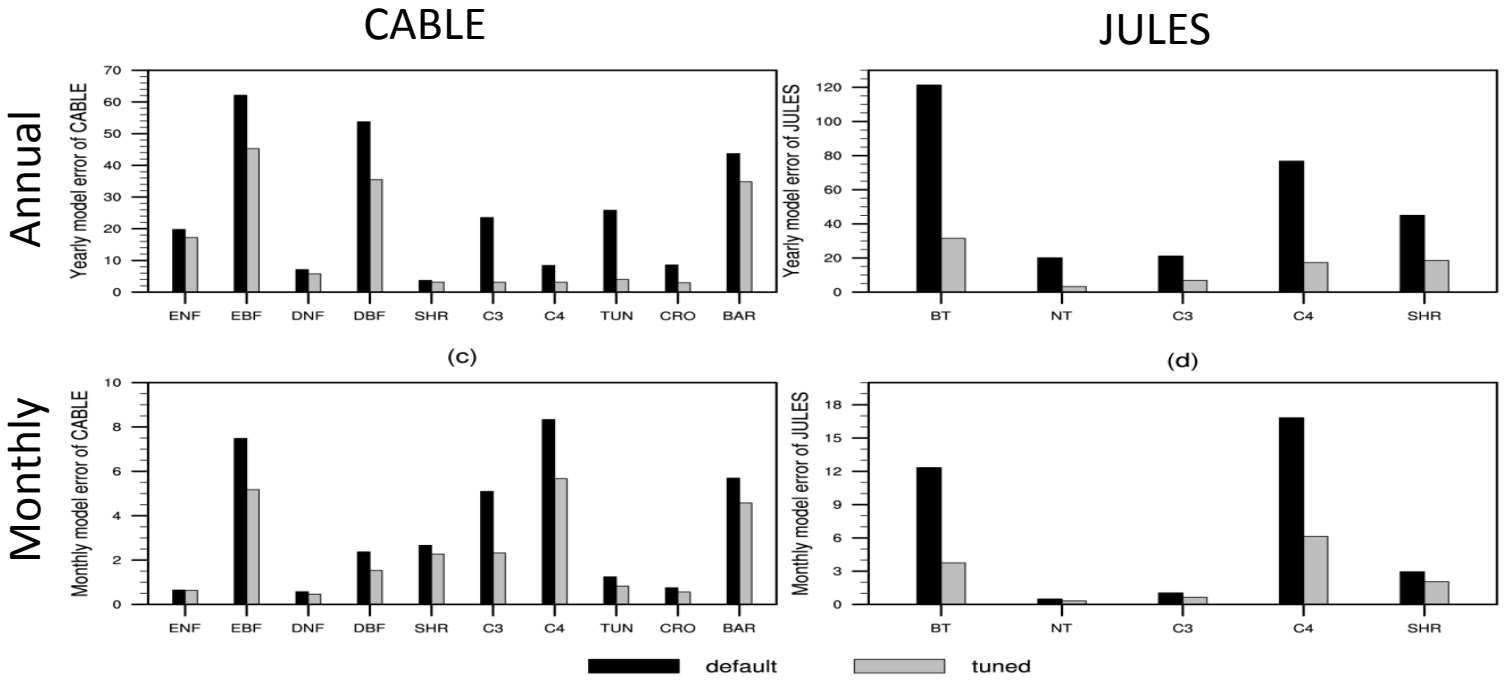
Sensitivity analysis - JULES



Li et al. unpublished data

Impact of tuning sensitive parameters

Combined error in GPP and LE by vegetation type before/after parameter tuning



Offline simulation, 1982-2005

Substantial reduction in errors for tuned parameters.

Does offline impact carry over to coupled applications without unintended negative impacts on simulation?

Li et al. unpublished data

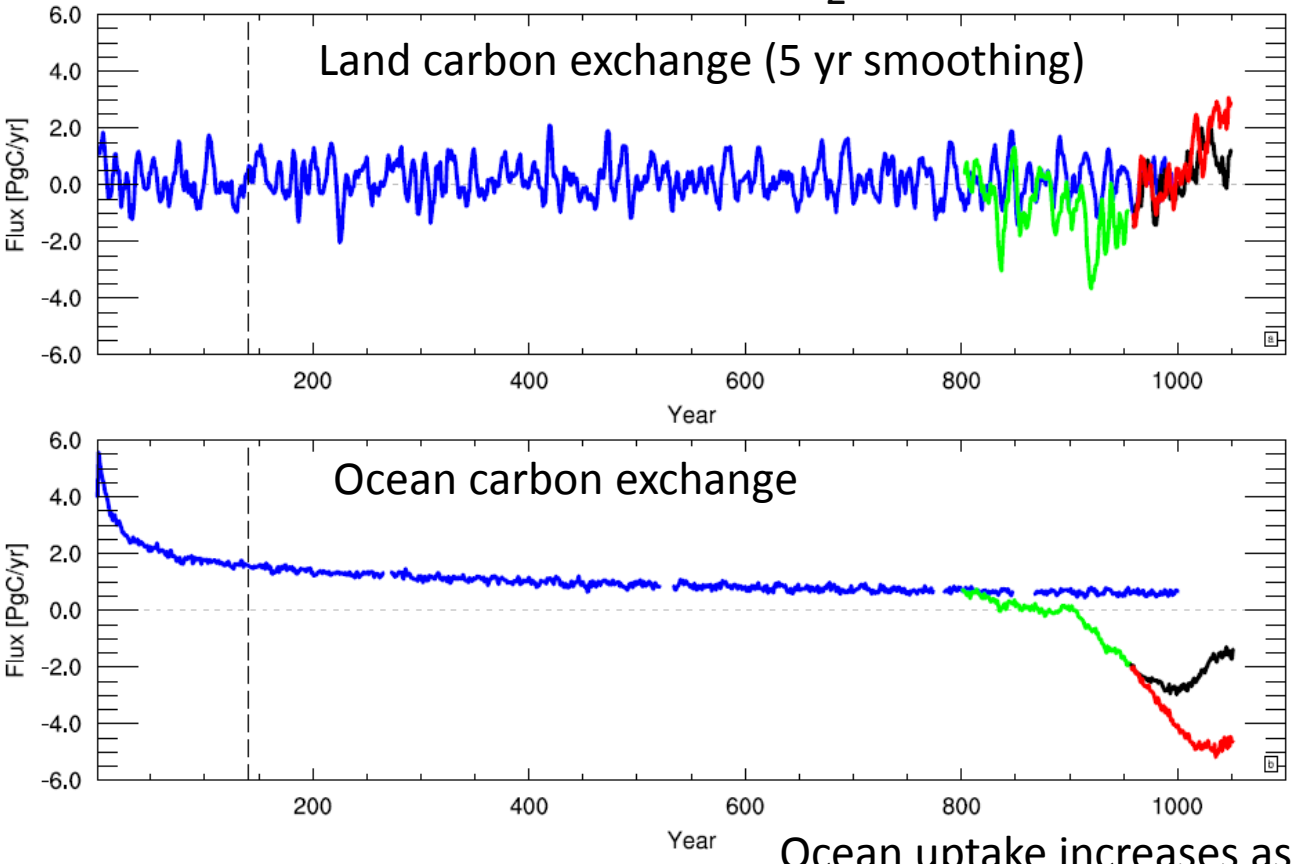
CABLE in ACCESS-ESM1

Tilo Ziehn and Rachel Law
CSIRO

(and acknowledging R. Matear, A. Lenton, M. Chamberlain for ocean carbon)

ACCESS-ESM1 simulations

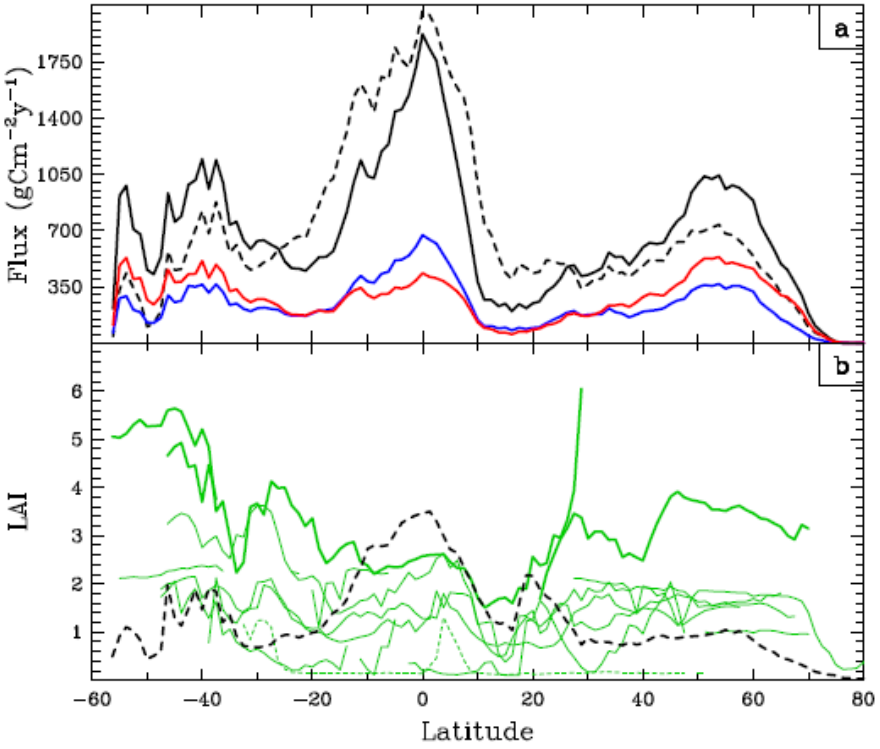
Prescribed atmospheric CO_2



- 1000 yr pre-industrial simulations completed. Long spin-up for carbon cycle. (Blue)
- Historical simulations (green)
- Future scenarios: RCP4.5 (black) RCP8.5 (red)

Ocean uptake increases as CO_2 increases,
Land initially uptake then source to atmosphere

Assessment of simulation

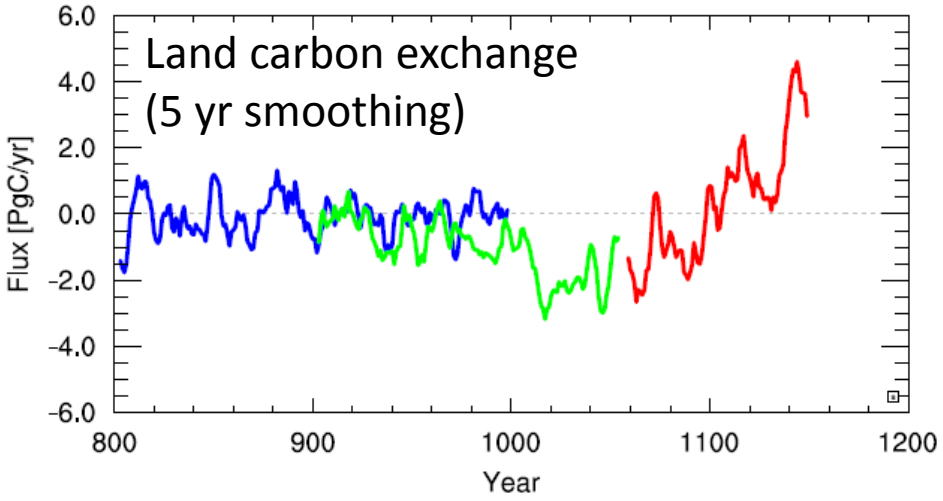


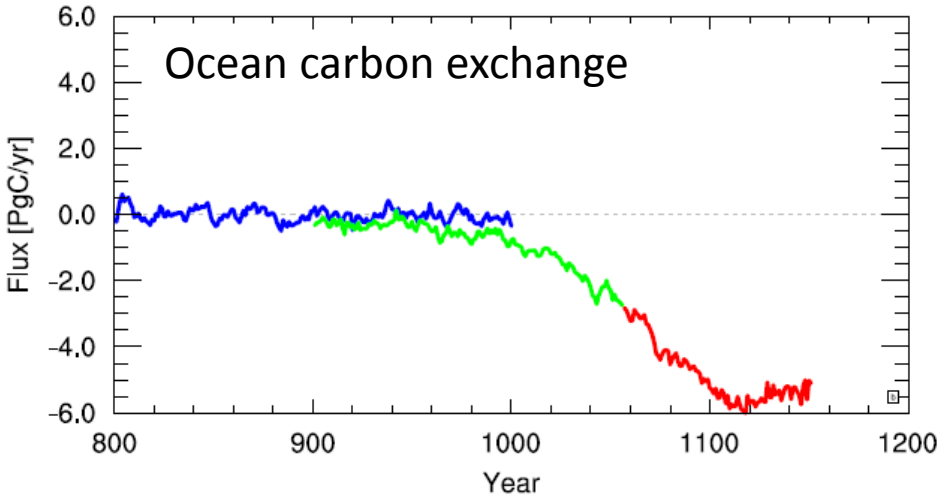
Zonal mean GPP (black) and respiration (blue – plant, red – soil).
Prescribed LAI (dash), prognostic LAI (solid)

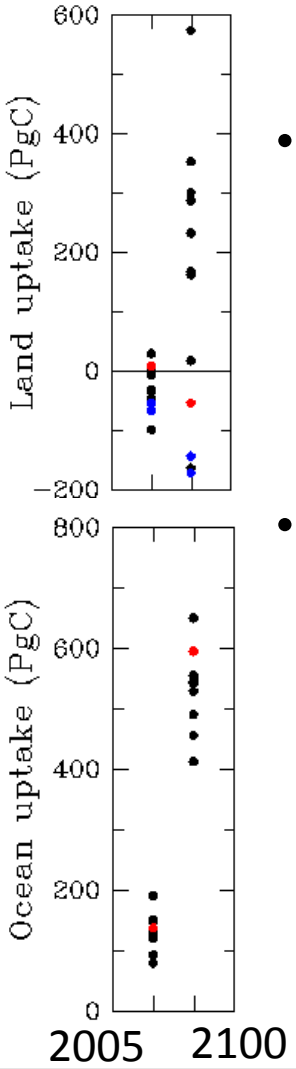
Zonal mean simulated LAI (all vegetation types – green) and prescribed LAI (black)

The carbon cycle in the Australian Climate and Earth System Simulator (ACCESS-ESM1). 1. Model description and pre-industrial simulation (Law et al.) and 2. Historical simulations (Ziehn et al.). For Geoscientific Model Development.

Emissions-driven simulations

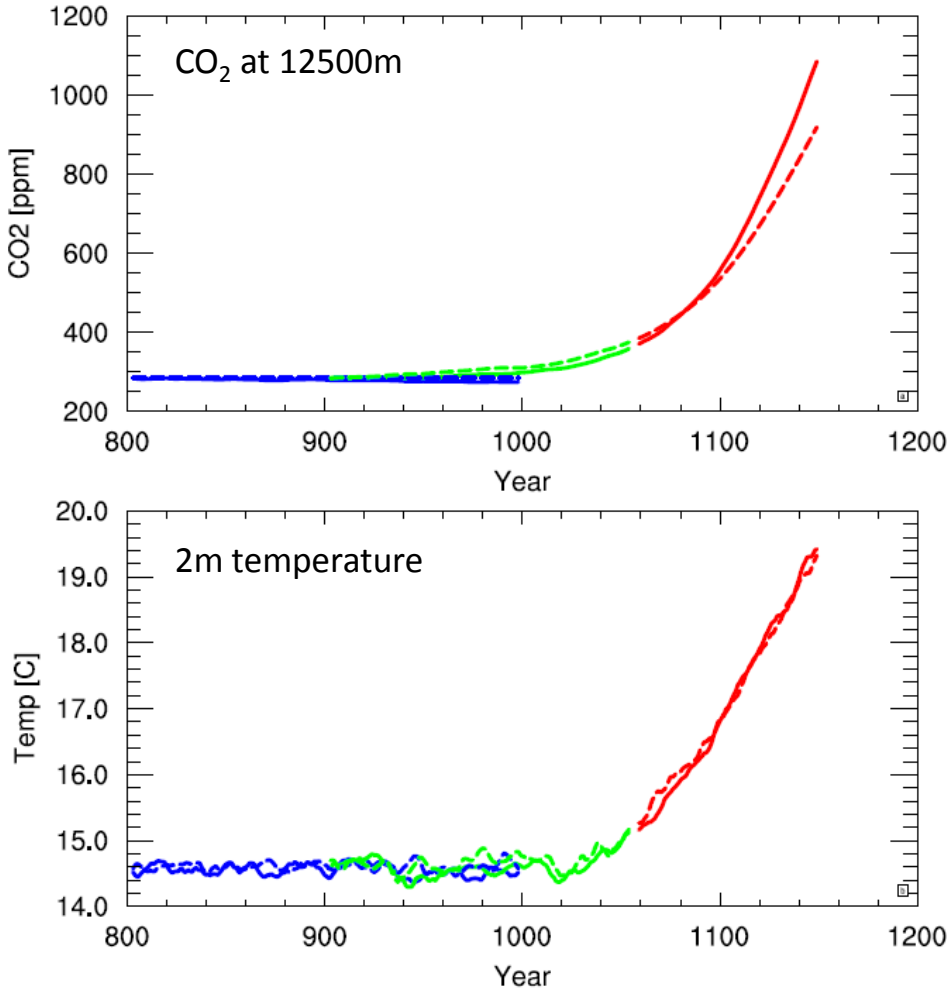






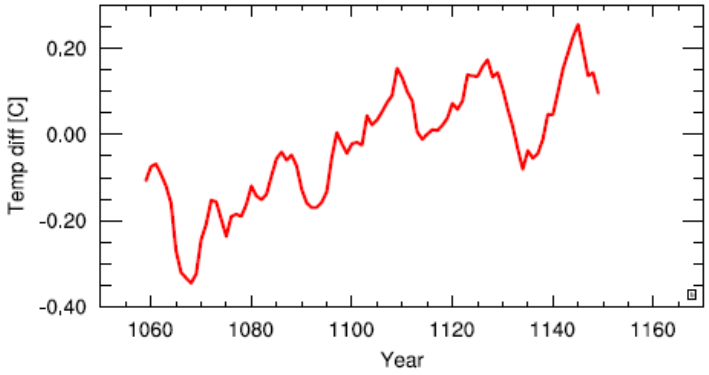
- Total land and ocean uptake in 2005 and 2100 from ACCESS (red) is in the range of other CMIP5 models (black, blue)
- Land uptake in 2100 at lower end of range with other models that include nutrient limitation (blue)

Impact on CO_2 and temperature



Interactive carbon cycle leads to higher atmospheric CO_2 in 2100 (positive climate-carbon feedback) and warmer temperatures

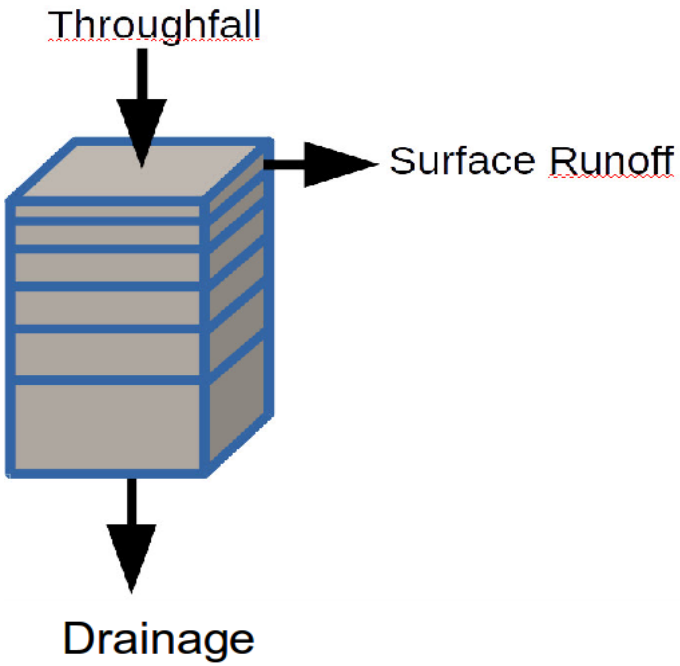
Temperature difference
(with – without interactive CO_2)



Soil hydrology upgrade

Mark Decker
ARC Centre of Excellence for Climate System Science

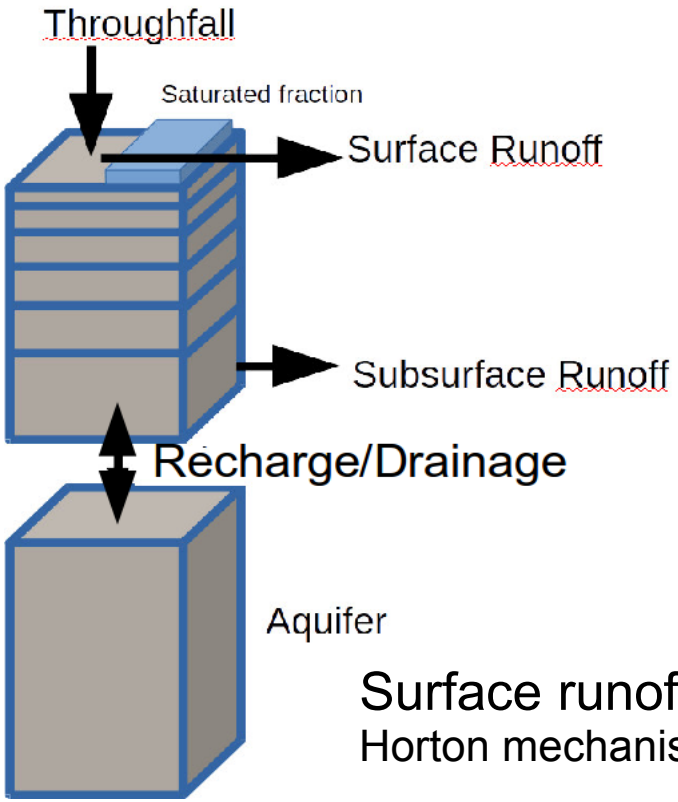
CABLE Soil Hydrology



Surface runoff: Only when top layers nearly saturated

Subsurface runoff: Only vertical drainage

New Soil Hydrology: SSGW

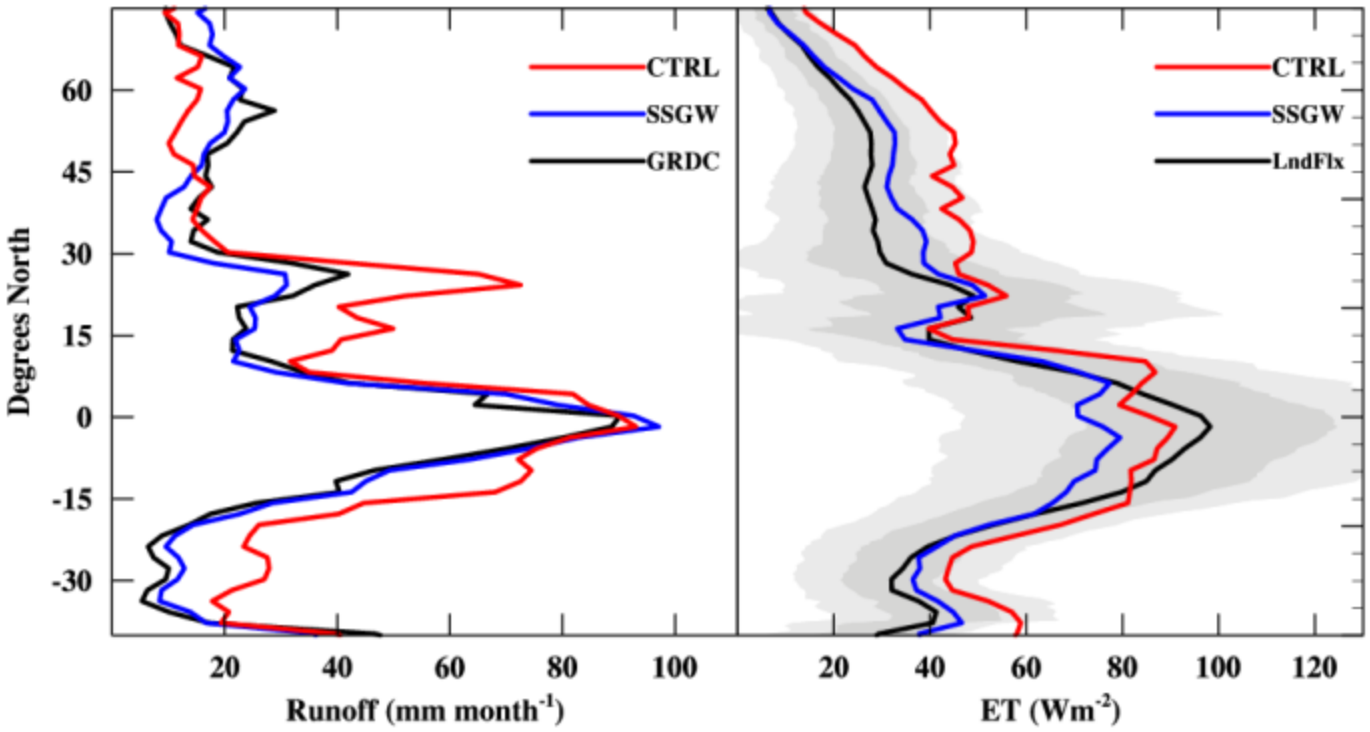


Surface runoff: Dunne and Horton mechanisms

Subsurface runoff: Topographically driven

Mean 1986-1995 runoff

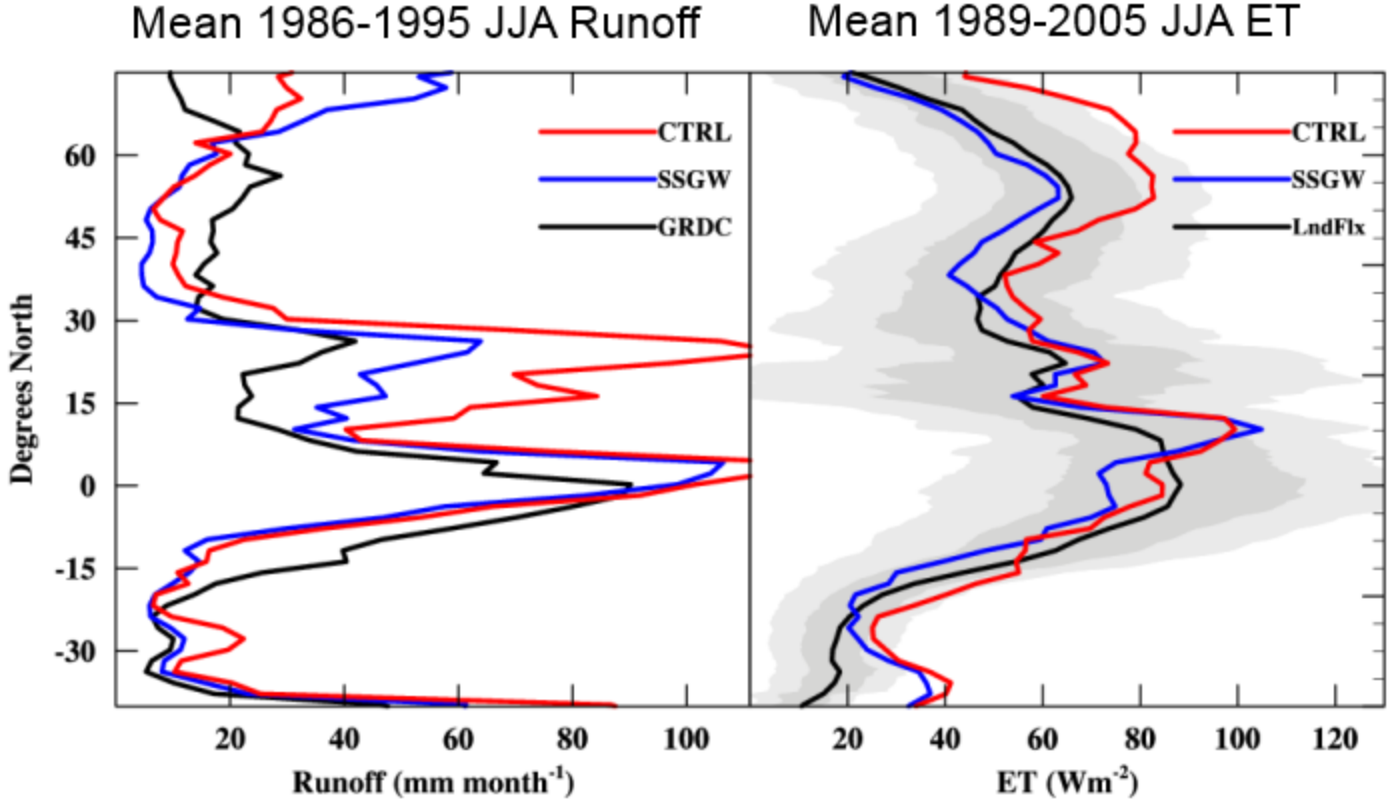
Mean 1989-2005 ET



- Global offline simulation
- 0.5x0.5 degree
- GSWP3 forcing
- 1901-2010

Zonal mean (left) runoff (mm month^{-1}) and (right) ET (W m^{-2}) as a function of latitude (using 2 degree bins).

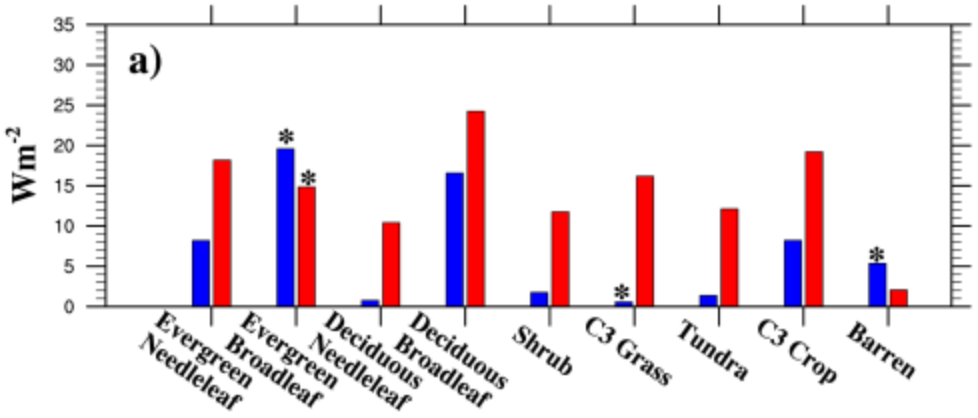
Northern Hemisphere Summer (JJA)



Zonal mean JJA (left) runoff (mm month^{-1}) and (right) ET (W m^{-2}) as a function of latitude (using 2 degree bins).

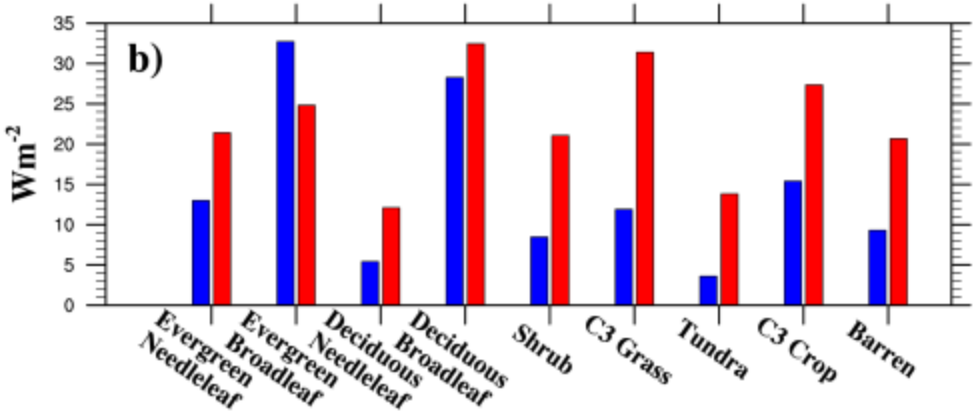
Evapotranspiration by vegetation type compared to Landflux synthesis product

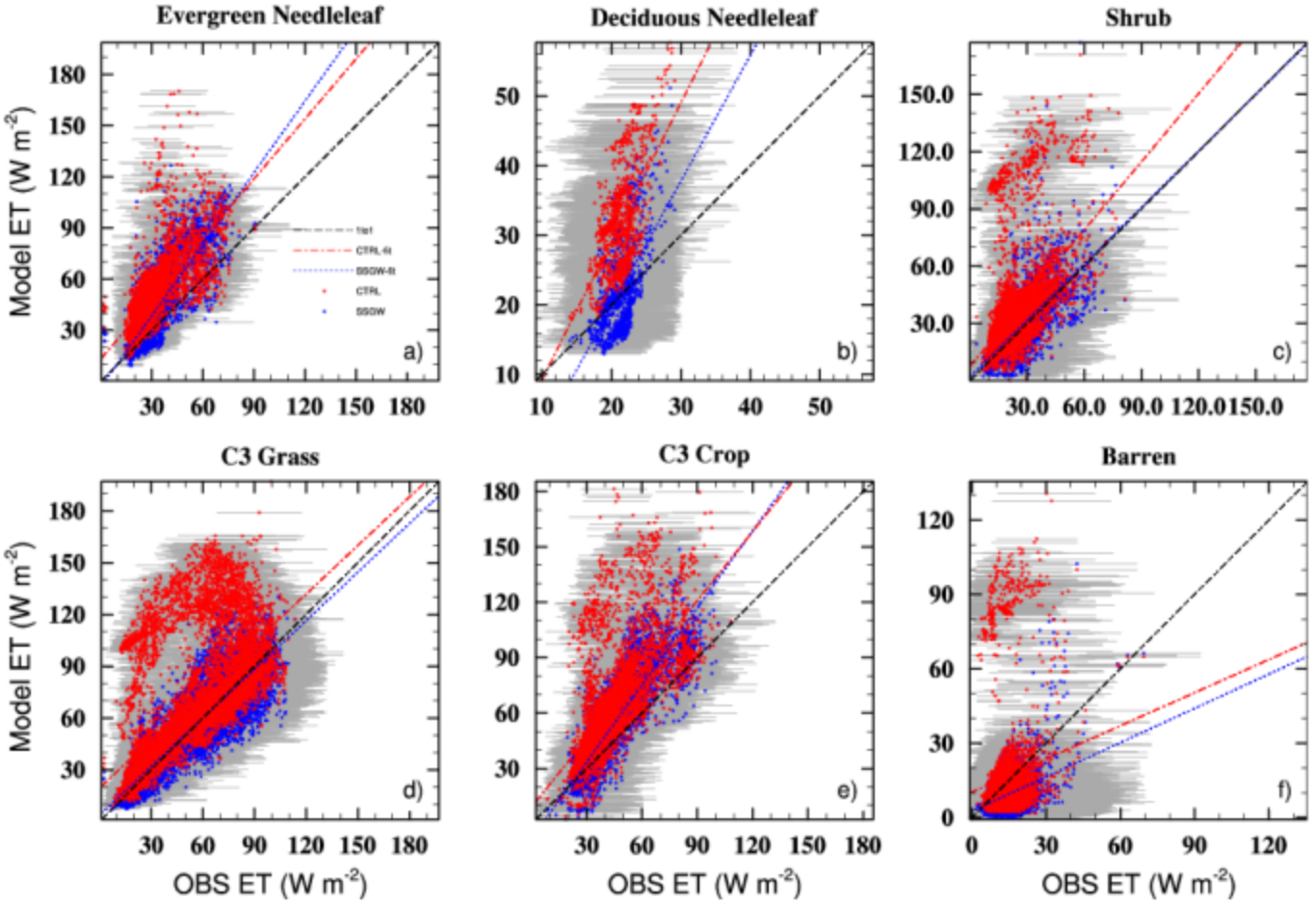
Absolute Bias
* negative bias



SSGW – blue
CTRL - red

Root Mean Square Error





Simulated vs Landflux ET for 6 example vegetation types and least squares regression line

CTRL – red
SSGW – blue

Grey bars: ±1 σ error estimate from LandFlux.

Summary

- CABLE used for many applications
- Publications using CABLE: https://trac.nci.org.au/trac/cable/wiki/CablePublications
  - 2014 – 23 listed
  - 2015 – 8 listed
- Ongoing challenges
  - Sharing developments across applications
  - Code management
  - CABLE via JULES

Thank you

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