



Progress on hydrological modules in CABLE2

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Goals:

Add groundwater to facilitate hypothesis testing

Address two issues

ACCESS – Extremes

WRF – Large Winter time cold bias

Model improvements:

Runoff generation and infiltration

Subsurface Runoff

Groundwater Coupling

What remains the same:

Canopy processes (flux calculations)

Snow

Soil temperature

Infiltration

Limit flux into soil based on state of soil
Depends on surface layer moisture, ice, soil properties
For through fall over unsaturated soils:

$$q_{\text{infl,max}} = K_{\text{sat,srf}} F_{\text{infl}} \left[\theta, \theta_{\text{sat}}, \frac{\partial \psi}{\partial \theta} \right]$$

F_{infl} can be one of many functions
 $q_{\text{infl,max}}$ is the maximum infiltration

Surface Runoff

$$q_{\text{srf}} = F_{\text{sat}} q_{\text{thr}} + (1 - F_{\text{sat}})(q_{\text{thr}} - q_{\text{infl}}^{\text{max}})$$

F_{sat} : Fraction of Grid cell that is saturated

CABLE dumps water into first three soil layers until they were saturated

Runoff Based on TOPMODEL concepts

Subsurface Runoff: Topographic gradients drive subsurface fluxes

Horizontal transmissivity (i.e. conductivity) declines exponentially with Z_{∇}

Simplified parameterization:

$$q_{\text{sub}} = q_{\text{max}} e^{-fZ_{\nabla}}$$

Z_{∇} : Grid cell mean water table depth

f: Tunable parameter (~0.2)
Encapsulates slopes, grid dependant

Removed from same depth as the water table depth (soil or aquifer)

Same functional form for F_{sat}

$$F_{\text{sat}} = (1 - F_{\text{ice}}) F_{\text{sat,max}} e^{-fZ_{\nabla}} + F_{\text{ice}}$$

1D Conceptual groundwater model

Simple bucket model of mass conservation:

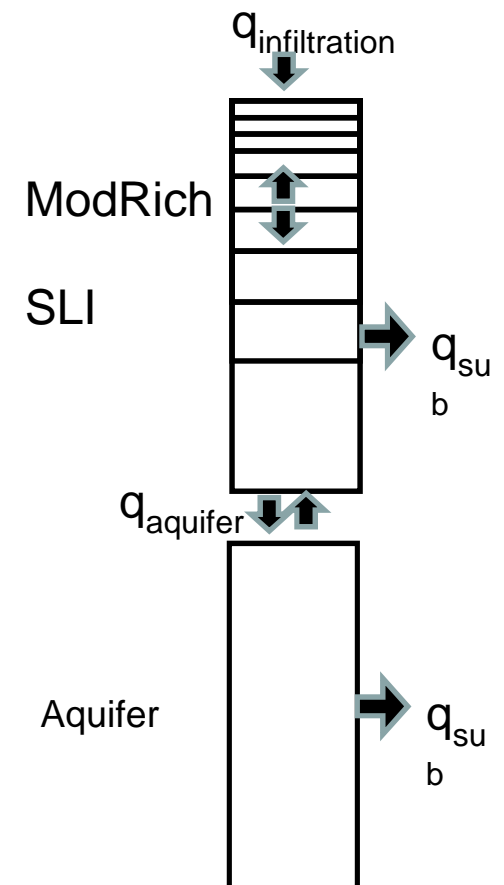
$$\frac{d\Theta_{gw}}{dt} = q_{aquifer} - q_{sub}$$

Provides bottom boundary condition for Richards Equation

Parameterize the fluxes using Z_{∇} , θ , K , and others

Limitations (of current implementation):

- No transfer between grid cells
- Subgrid scale fluxes from conceptual model
- Neglects groundwater coupling with
 - Stream flow
 - Flood plains
 - Anthropogenic removal



2D groundwater model: Explicit horizontal fluxes and Z_{\square} dynamics:

Model grid resolves topography driven fluxes

- Increasingly computationally viable
- Unknown aquifer and soil properties remain problematic

Common among hydrologists, used by at least 1 LSM

Simplifying Assumptions (Dupuit-Forchheimer)

- Z_{\square} is relatively flat with a hydrostatic saturated zone
- Horizontal fluxes & K invariant with respect to z

Solves for the thickness of the saturated layer:

Darcy's Law: $q_{\text{sub}} = -kh \nabla_{xy} [h]$ h : thickness of saturated zone
 xy : horizontal direction

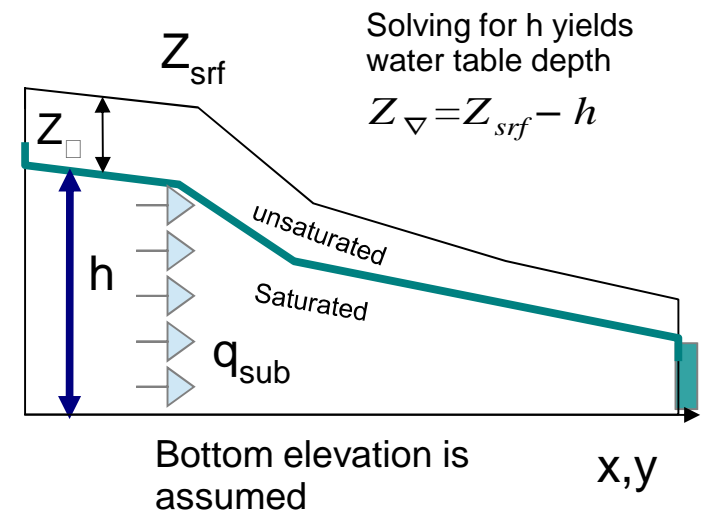
Conservation of mass:
$$\frac{\partial h}{\partial t} = \frac{\partial}{\partial x} \left[-kh \frac{\partial h}{\partial x} \right] + \frac{\partial}{\partial y} \left[-kh \frac{\partial h}{\partial y} \right]$$

Simplified 2D simplified equation for groundwater dynamics (i.e. Z_{\square})

Explicit horizontal transport between grid cells

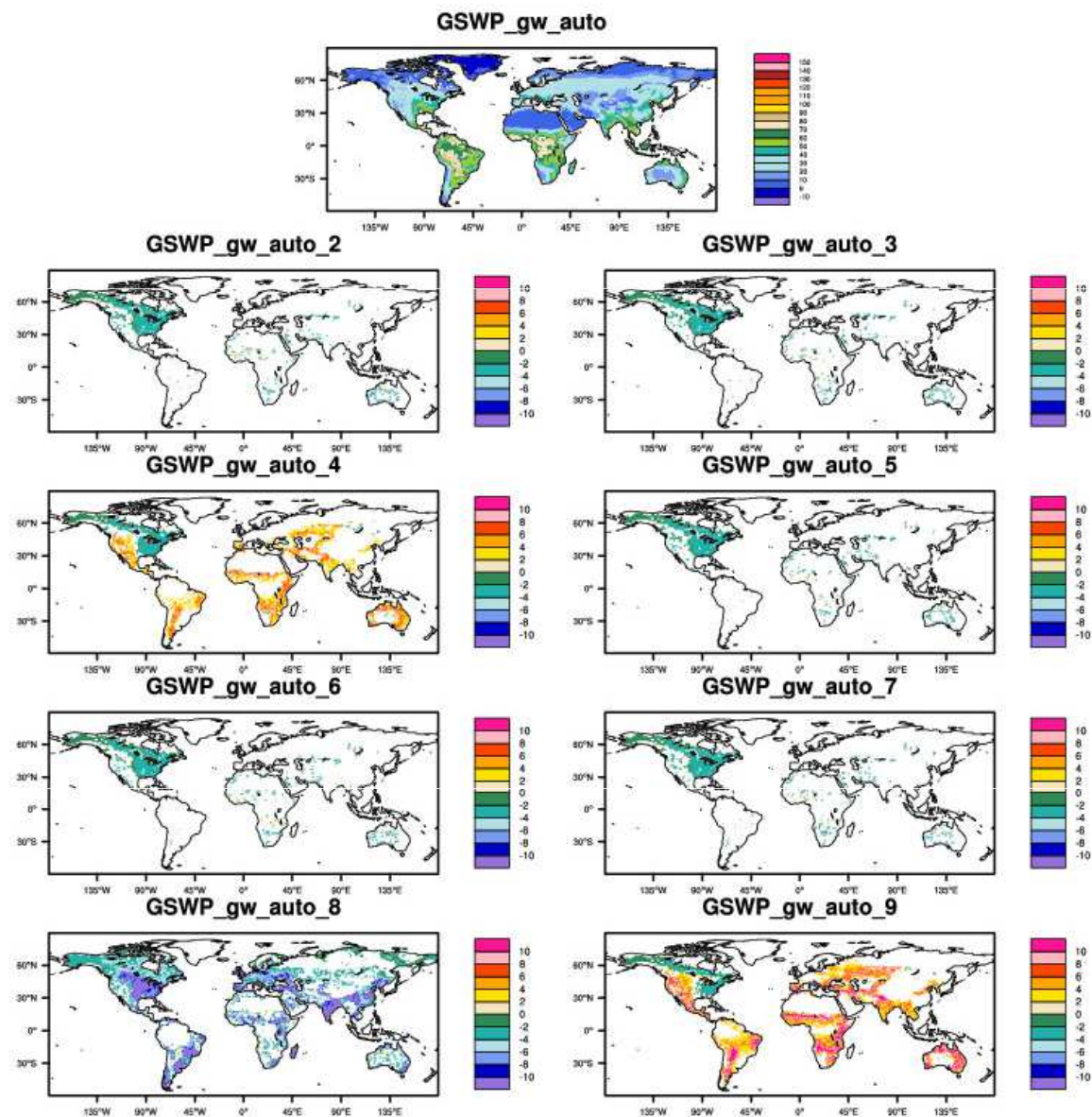
Computationally expensive compared to 1D models

Soil and groundwater properties are poorly constrained due to limited observations



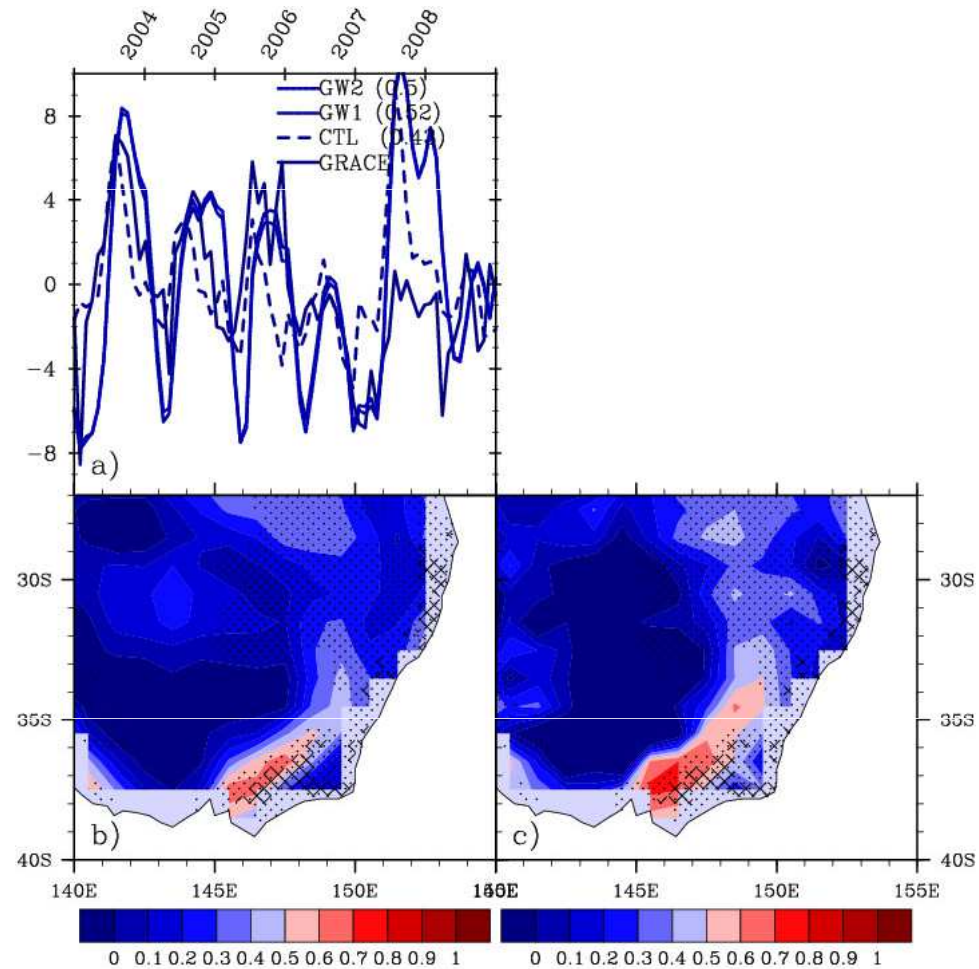


Offline parameter sensitivity: GSWP CABLE-2.1.2 + GW



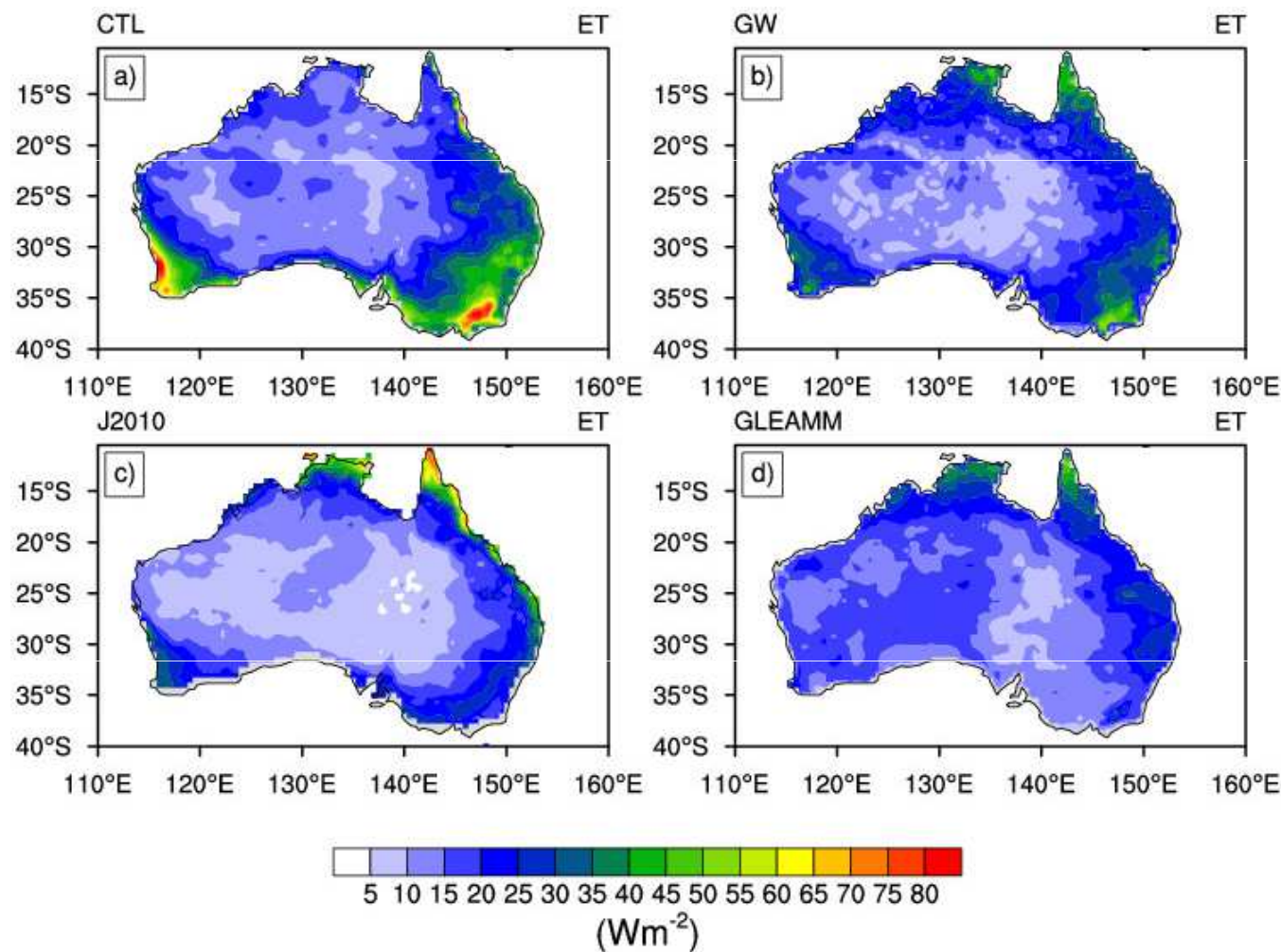


Australia 0.25x0.25 CABLE-2.1.2 + GW offline



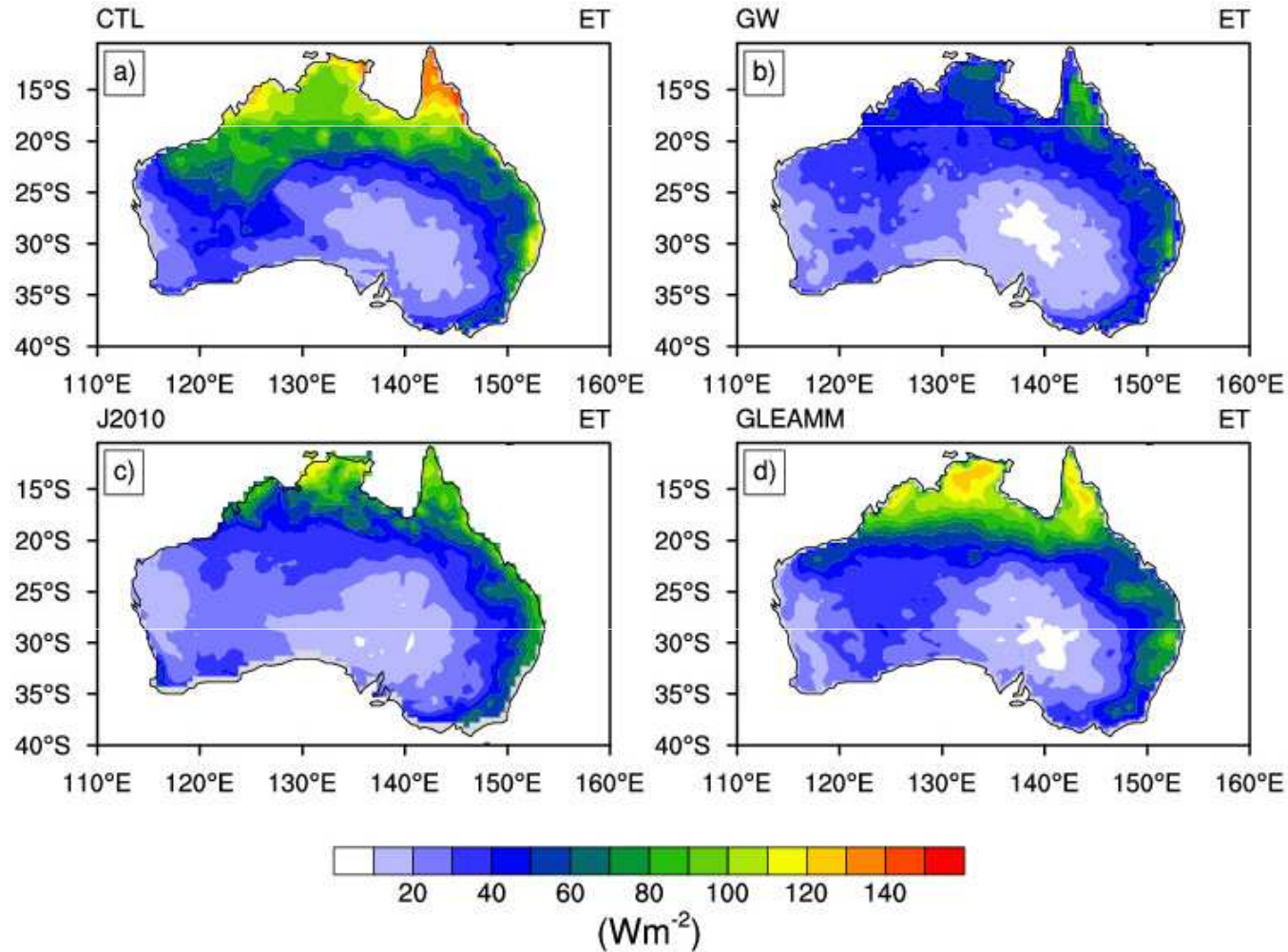


Australia 0.25x0.25 CABLE-2.1.2 + GW offline



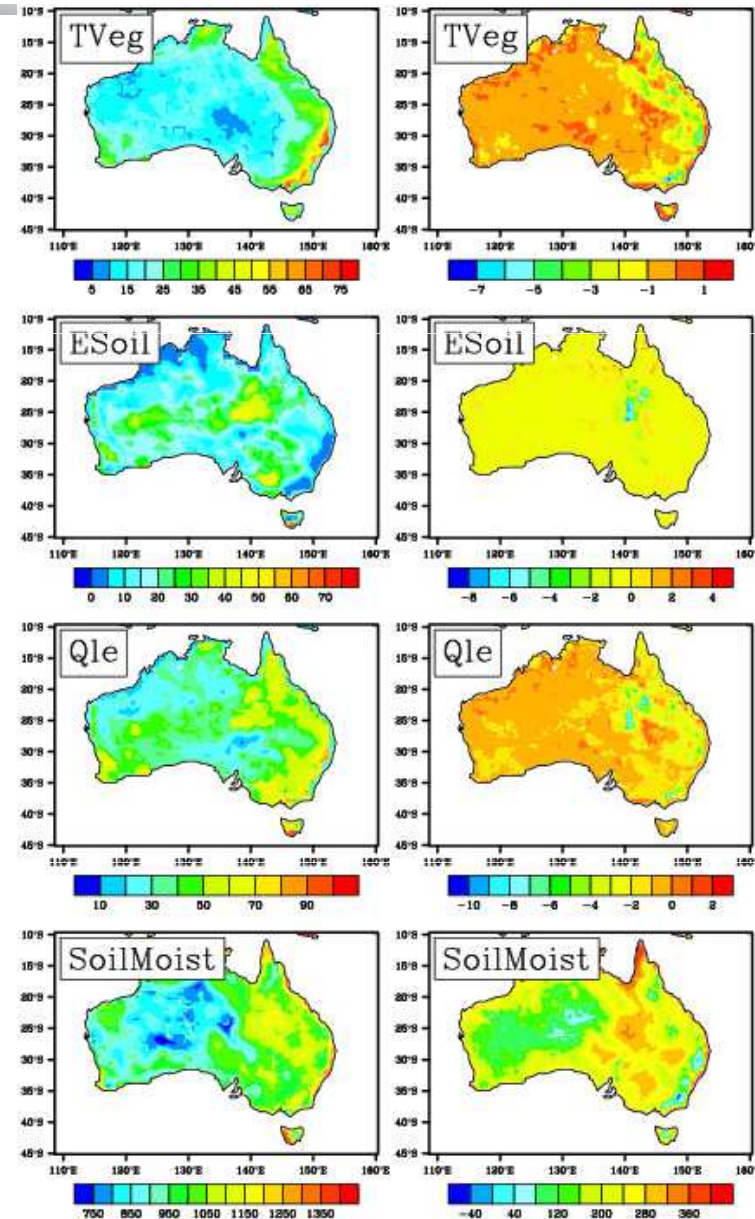


Australia 0.25x0.25 CABLE-2.1.2 + GW offline





Australia 0.25x0.25 CABLE-2.1.2 + GW + 2D Lateral Transfer





GW:

Nail down choice of parameters to give good Australian ET for both summer and winter
Non-hydro tuning?

2DGW

Simulations at high resolution (0.05 degrees) while sampling parameter space

Coupled:

LIS-WRF - Claire

Running. Finished spinup. Initial results promising

ACCESS - Ruth

Bug hunting. Hopefully running soon