Evaluating the Surface Climatology produced by two different LSMs in ACCESS

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17TH MODEL EVALUATION WORKSHOP: 19 MAY 2015

Setup & Motivation

Kowalczyk et. al. 2013

Australian Meteorological and Oceanographic Journal 63 (2013) 65–82

The land surface model component of ACCESS: description and impact on the simulated surface climatology

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(Manuscript received July 2012; revised March 2013)

The land surface component of the Australian Community Climate and Earth System Simulator (ACCESS) is one difference between the two versions of ACCESS used to run simulations for the Coupled Model Intercomparison Project (CMIP5). The Met Office Surface Exchange Scheme (MOSES) and the Community Atmosphere Biosphere Land Exchange (CABLE) model are described and compared. The impact on the simulated present day land surface climatology is assessed, in both atmosphere only and coupled model cases. Analysis is focused on seasonal mean precipitation and screen-level temperature, both globally and for Australia. Many of the biases from observations are common across both ACCESS versions and both atmosphere only and coupled cases. Where the simulations from the two versions differ, the choice of land surface model is often only a small contributor with changes to the cloud simulation also important. Differences that can be traced to the land surface model include warm biases with CABLE due to underestimation of surface albedo, better timing of northern hemisphere snowmelt and smaller seasonal and diurnal temperature ranges with CABLE than MOSES.

ACCESS1.3 (submitted to CMIP5)
- LSM: CABLE
- ATM: HadGem3(r1.1) with new atmospheric physics
- CLOUDS: PC2 scheme

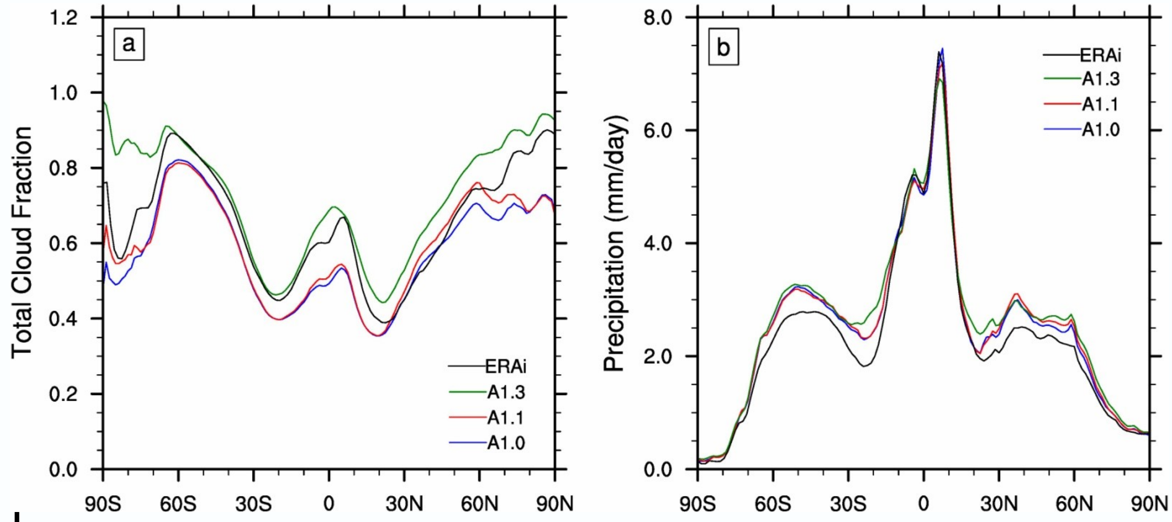
Using two 20 year ACCESS N96 AMIP simulations:

1. ACCESS1.0 (as submitted to CMIP5)
   - land surface model: MOSES
   - atmosphere: HadGem2(r1.1)
   - cloud scheme: Smith scheme
2. ACCESS1.1
   - land surface model: CABLE
   - atmosphere: HadGem2(r1.1)
   - cloud scheme: Smith scheme

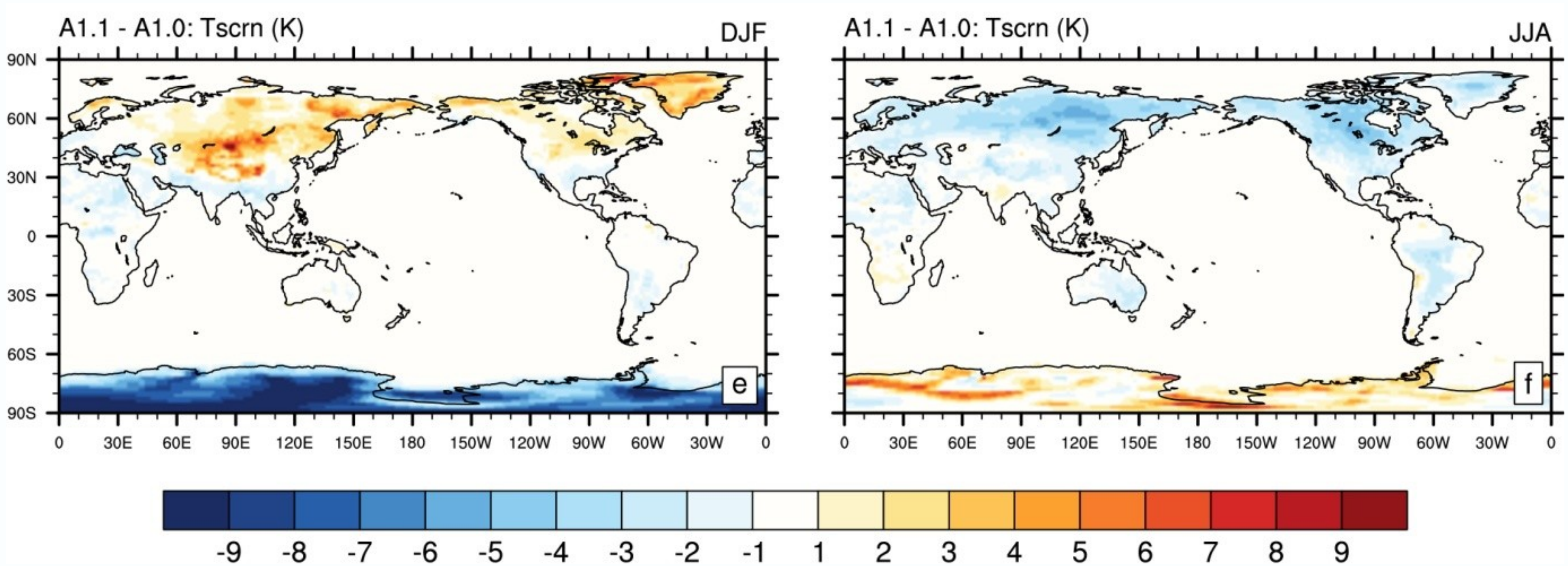
Motivation

continued …

Zonal Means →



Model Temp Difference ↓

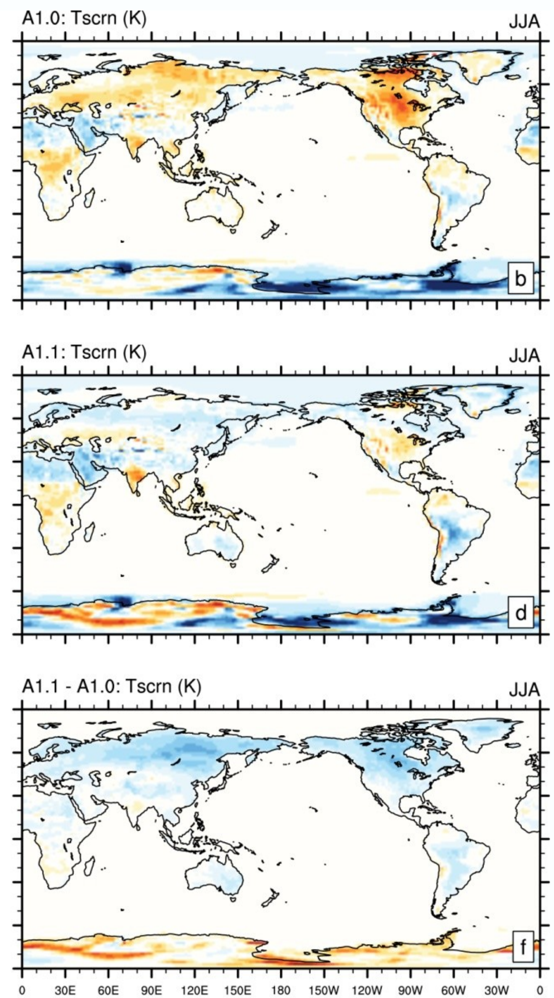


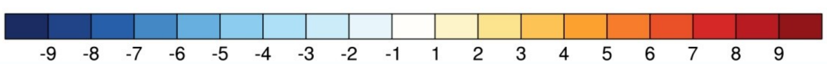
Boreal Summer (JJA)

A1.0 - ERAi

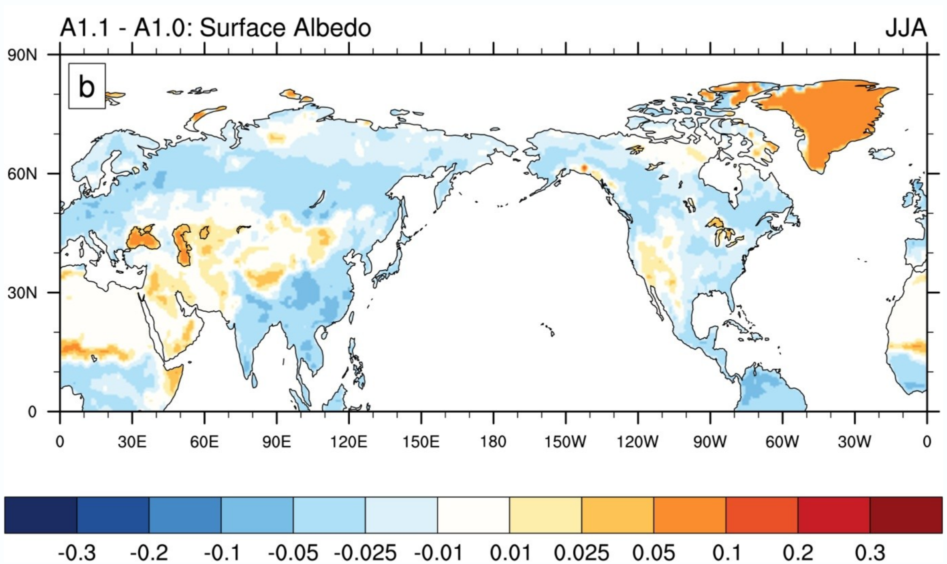
A1.1 - ERAi

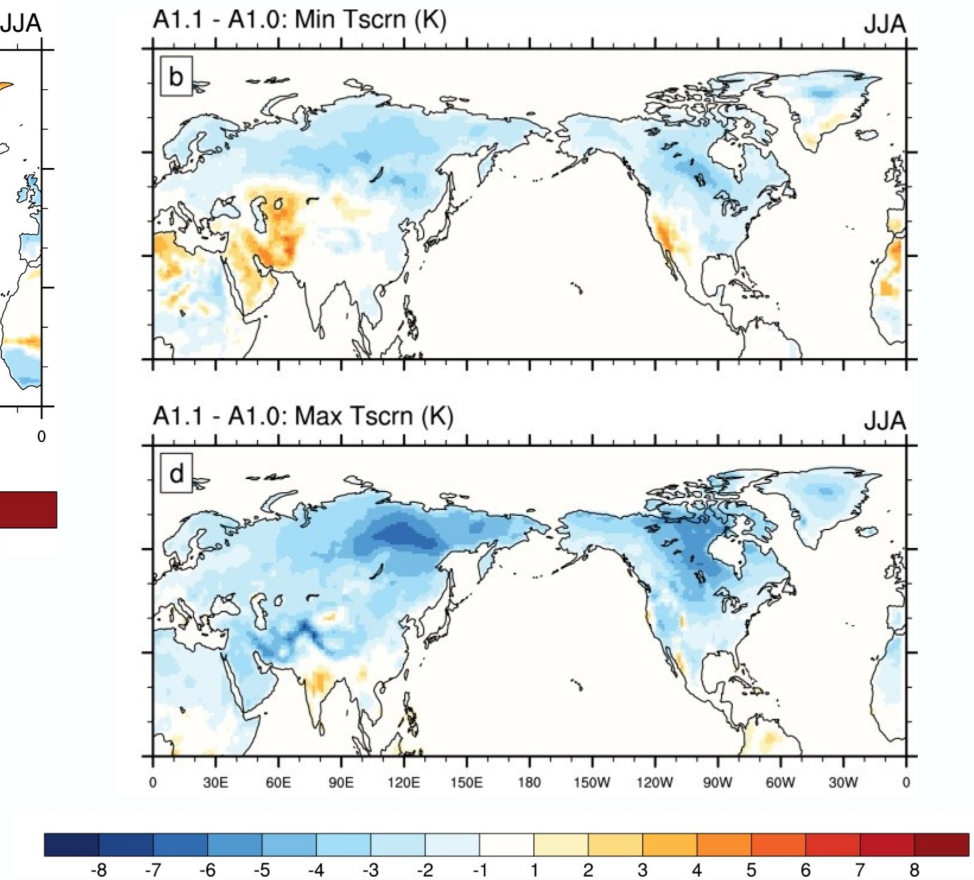
A1.1 – A1.0





Albedo and Min & Max Temperature

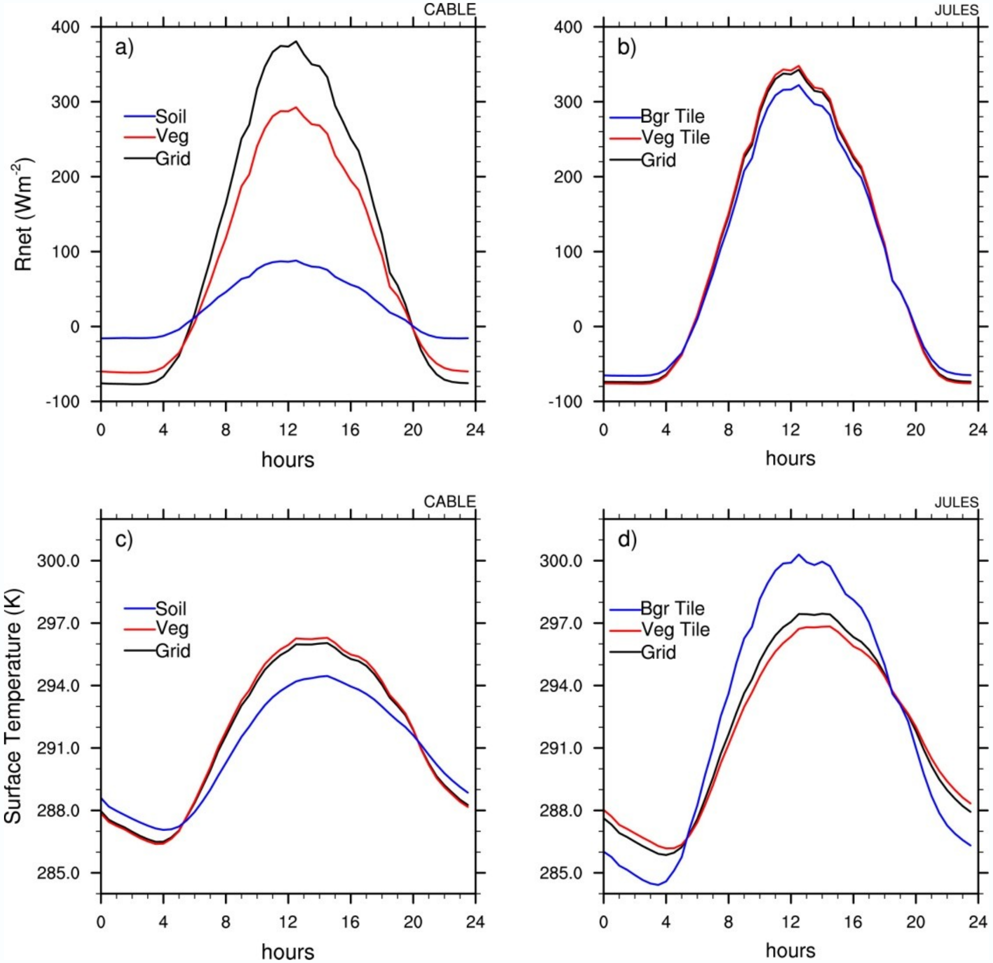


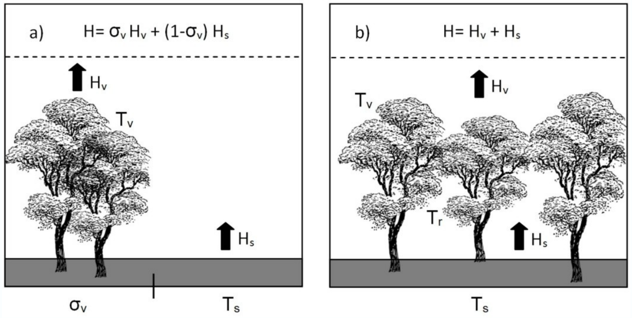


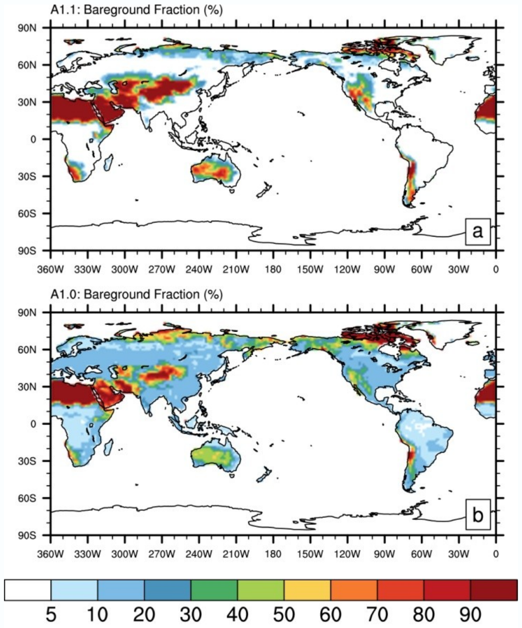
Above 30°N exc. Greenland		*JJA*	
	A1.0	***A1.1***	***A1.1 – A1.0***
Screen Temperature (°C)	19.02	16.95	-2.07
- Maximum	24.11	21.36	-2.75
- Minimum	13.40	12.30	-1.10

Offline Hyytiala Simulation: 2002/2005*

Grid has 1 tile — Grid has 2 tiles



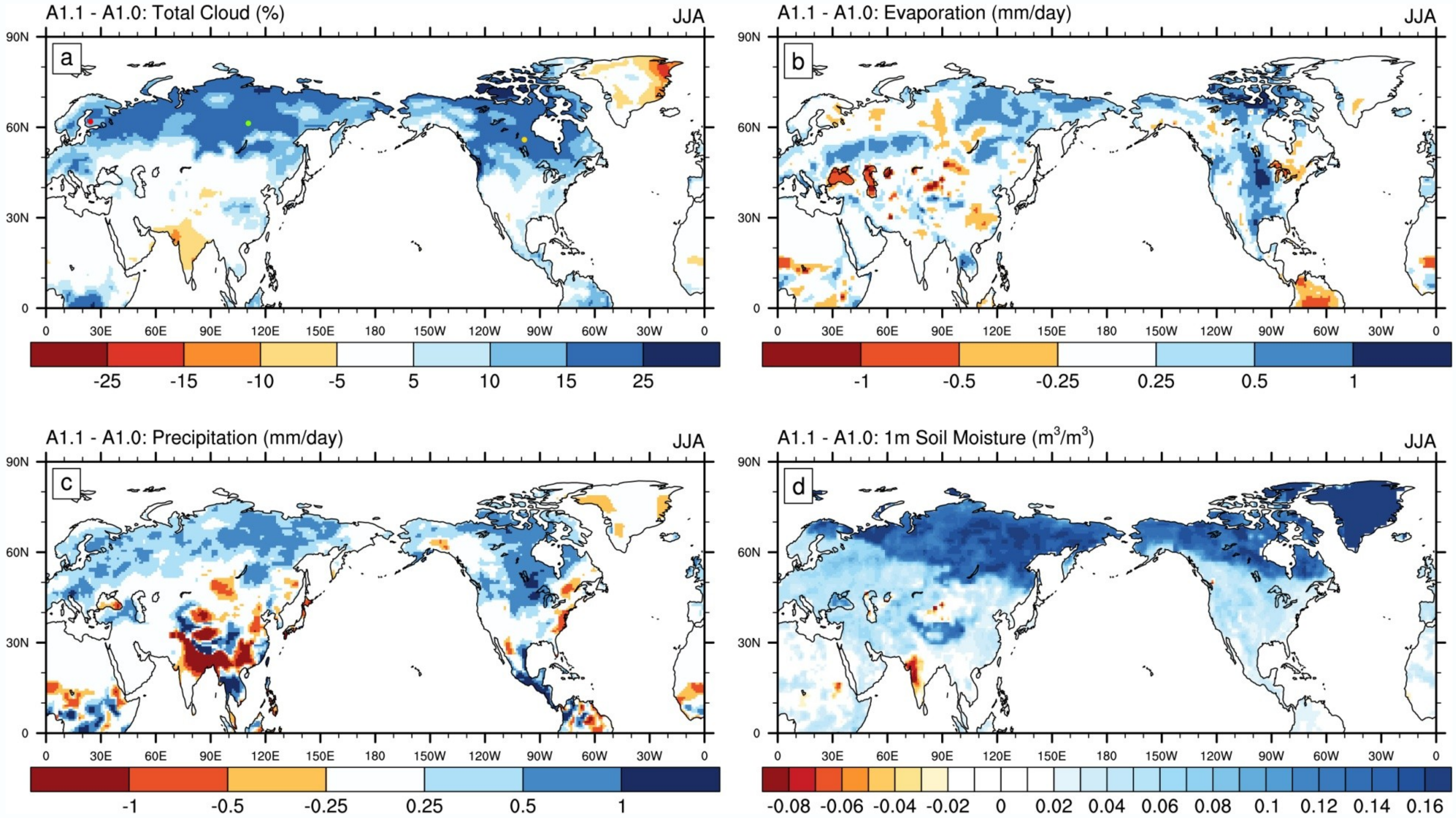




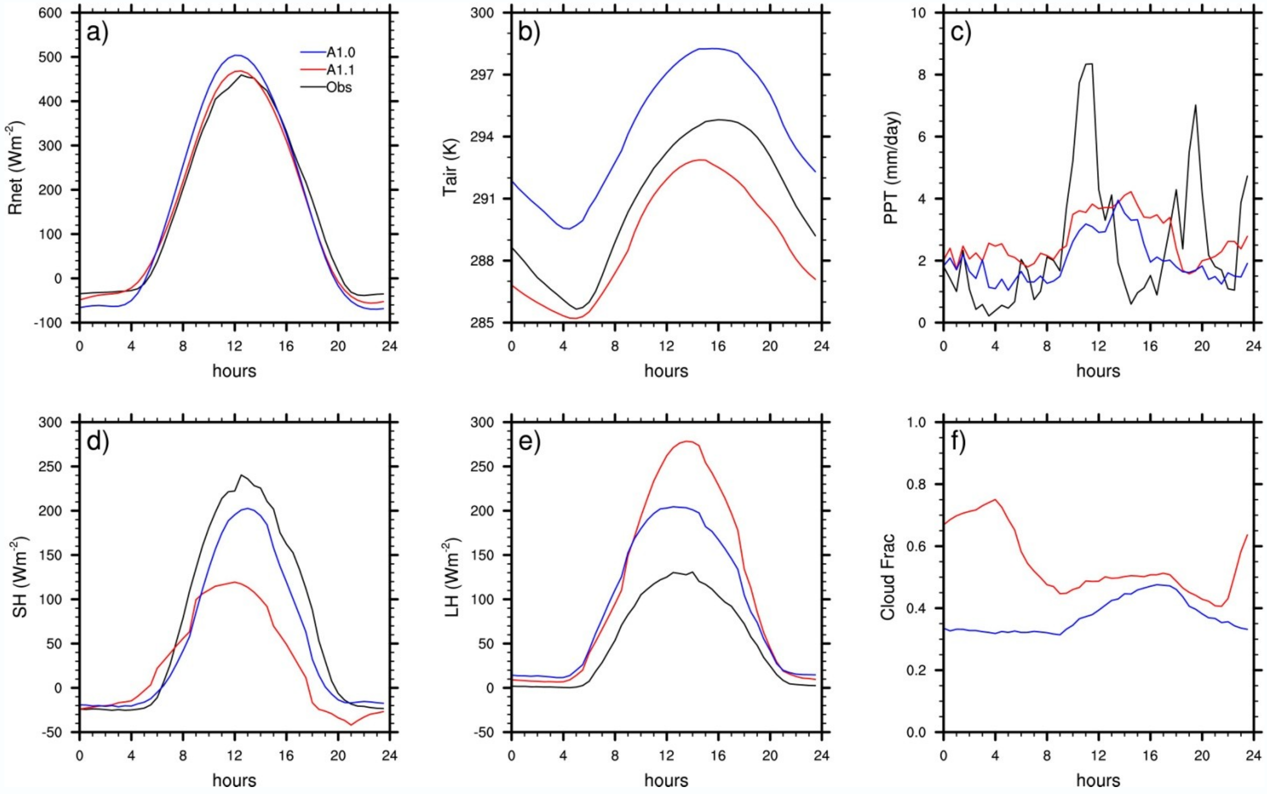
- In CABLE, soil under canopy is cooler than the canopy.
- In JULES, the bareground tile temperature is higher than the canopy tile temp.

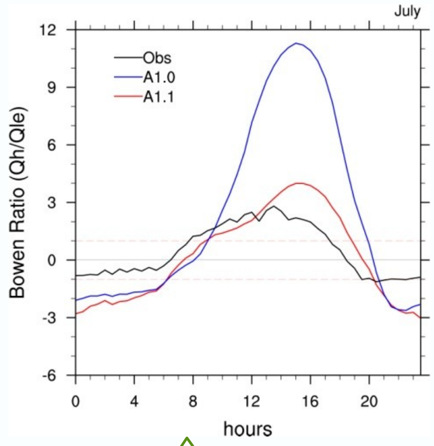
*Mean July diurnal cycles for 2002-2005

Components of the Water Cycle



Mean July Diurnal Cycle: Boreas, Canada

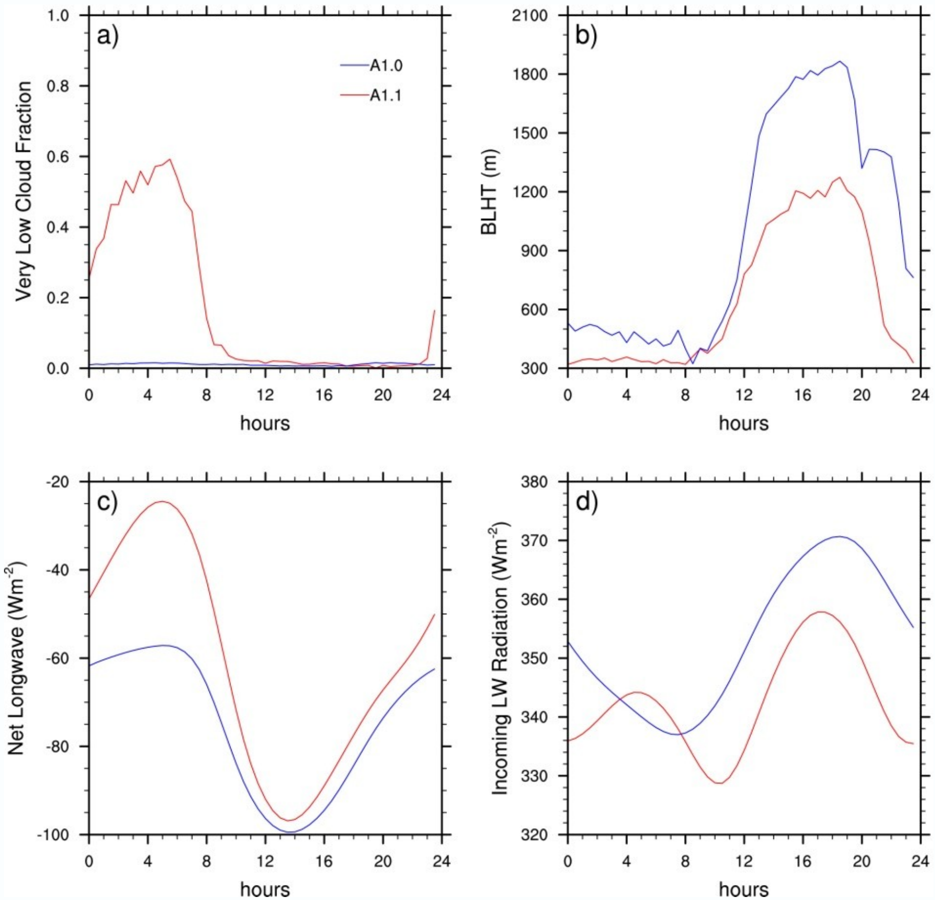




The mean of 42 sites from PALS*

*PALS: the Protocol for the Analysis of Land Surface models

Mean July Diurnal Cycle continued...*



- The large cloud fraction overnight in A1.1 is due to the presence of fog (a).
- Radiative cooling in the A1.1 simulation reduces the boundary layer height due to the generation of a temperature inversion (b).
- The fog increases the incoming longwave radiation at the surface (c) and (d).

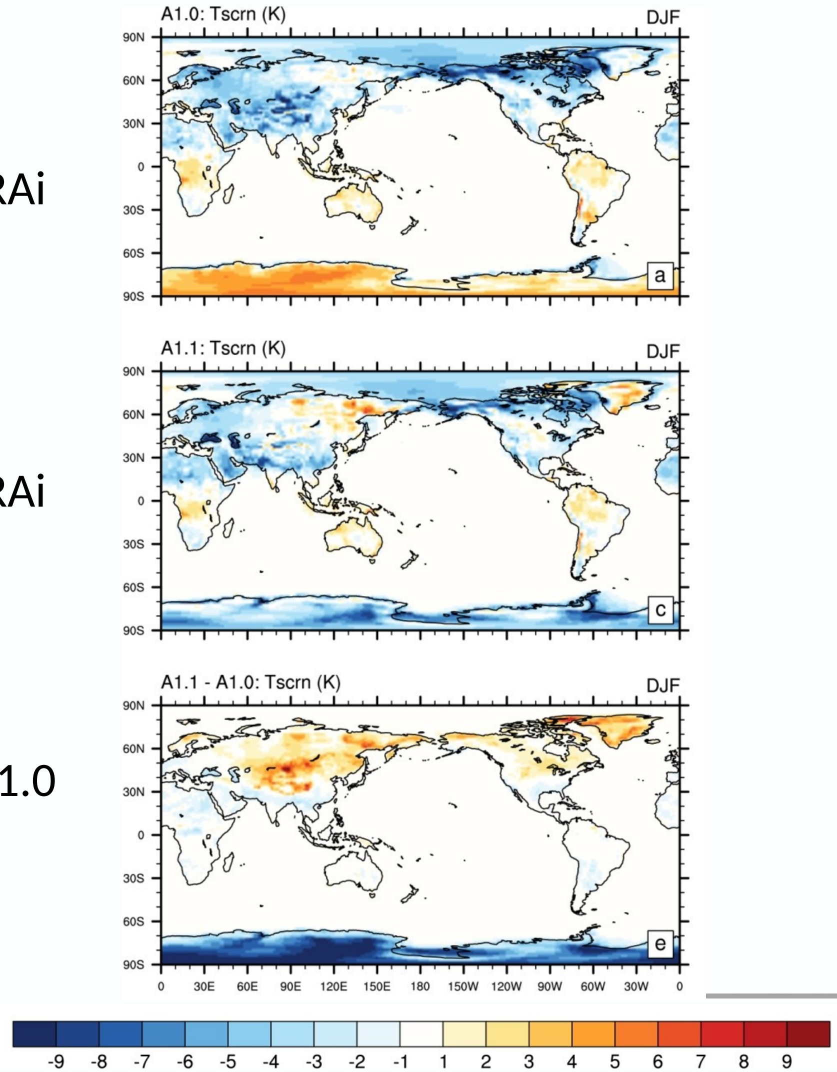
*Mean July diurnal cycle for 1 year simulation

Boreal Winter (DJF)

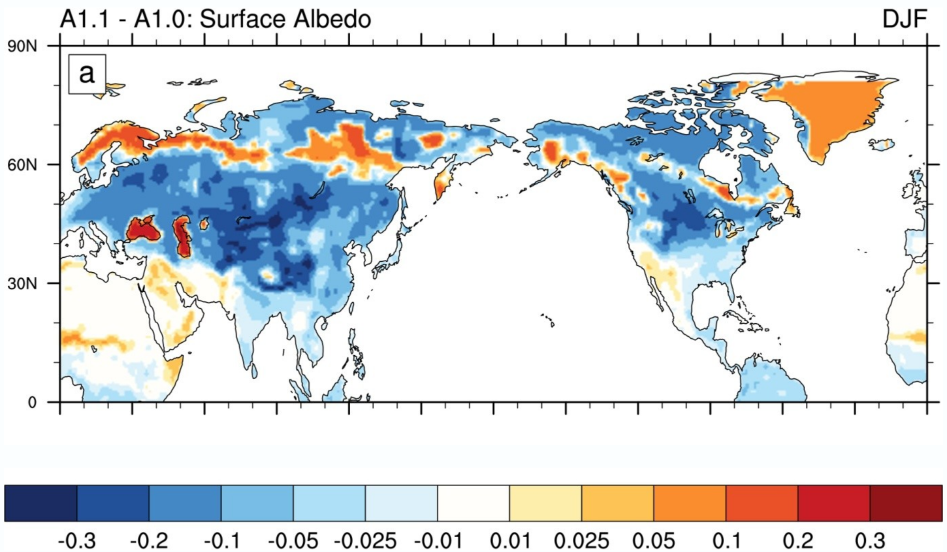
A1.0 - ERAi

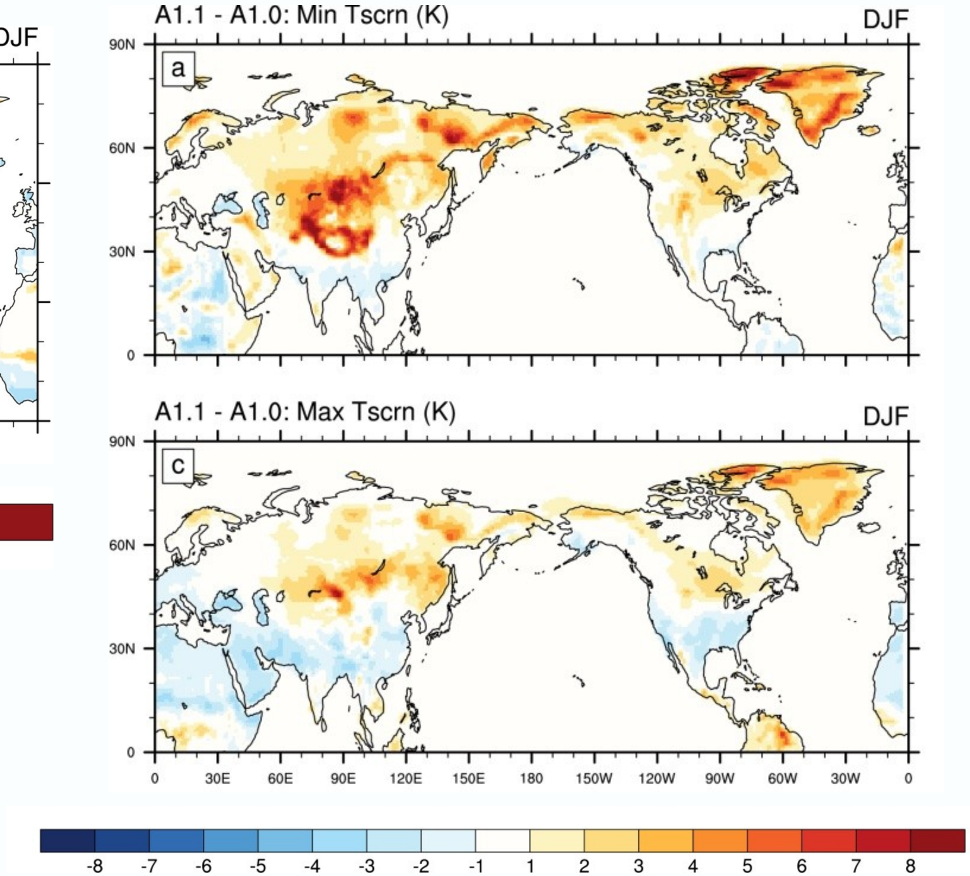
A1.1 - ERAi

A1.1 – A1.0



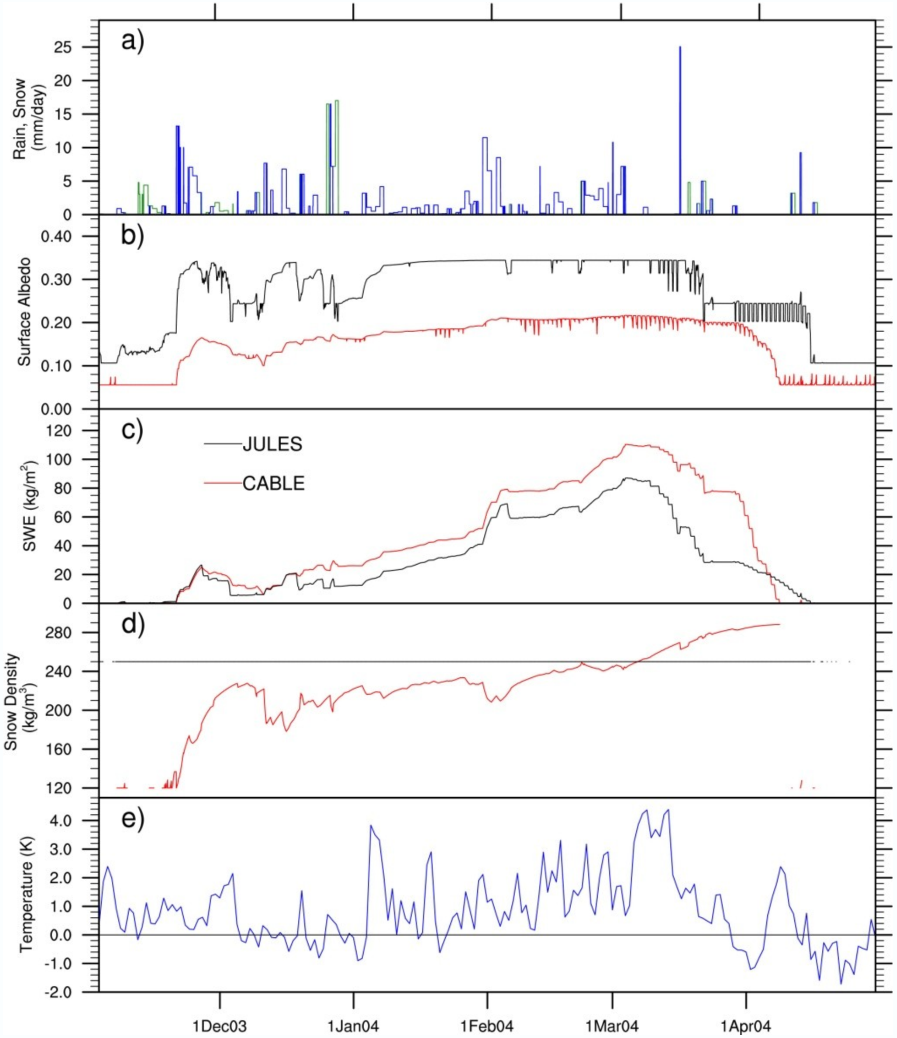
Albedo and Min & Max Temperature





Above 30°N exc. Greenland	*DJF*		
	A1.0	***A1.1***	***A1.1 – A1.0***
Screen Temperature (°C)	-13.30	-12.19	1.11
- Maximum	-9.59	-9.27	0.32
- Minimum	-16.73	-14.99	1.74

Offline Hyytiala Simulation: 2003/2004*



With the same forcing (a), CABLE has a lower albedo (b) but a higher snow amount (c) than JULES because of the following:

Cable albedo:

$$\alpha_s = f(snow\ depth, snow\ density, zenith\ angle, soot, snow\ temperature)$$

Jules albedo:

$$\alpha_s = f(snow\ depth, temperature)$$

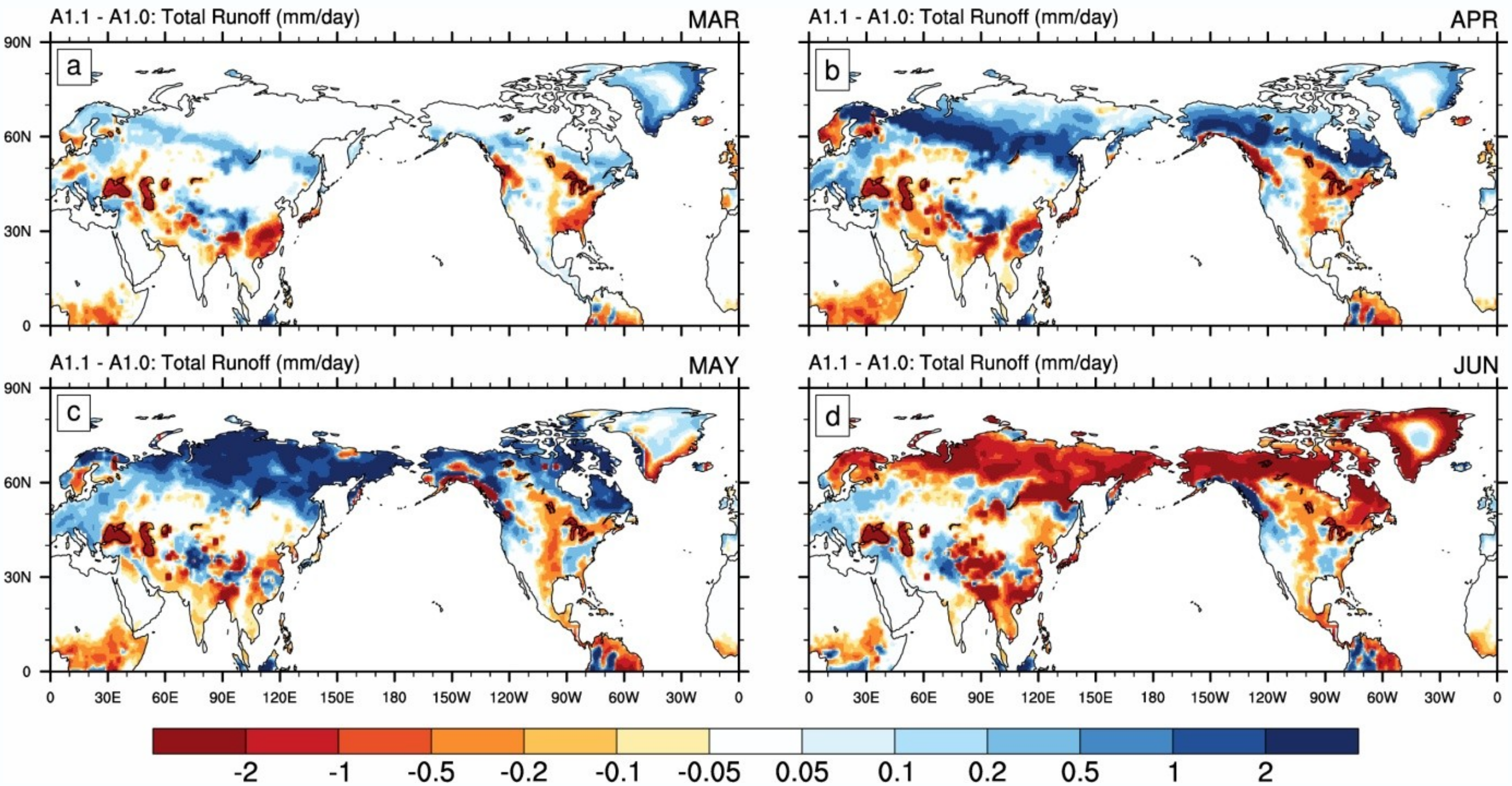
$$\alpha_s = \begin{cases} \alpha_{cds} & T_* < T_m - 2 \\ \alpha_{cds} + 0.3(\alpha_o - \alpha_{cds})(T_* - T_m + 2) & T_m - 2 < T_* < T_m \end{cases}$$

- the temporal evolution of snow density (d) and thermal conductivity which acts to age the snowpack
- freezing of liquid water on the snowpack

The temperature difference is shown in (e).

*Timeseries for the 2003/2004 winter season

Consequence: Total Runoff



- Runoff peaks approximately a month earlier in A1.1 than A1.0. This is because A1.1 runoff emerges as surface runoff whereas A1.0 runoff emerges as drainage.

Summary

- Cooler summer temperatures in the NH are attributed to two factors; the representation of the canopy in CABLE with the vertical placement of vegetation above the ground allowing for aerodynamic and radiative interaction between the canopy and the ground below. Cooler summer temperatures are also attributed to larger evapotranspiration fluxes and larger cloud cover fraction.

- Warmer winter temperatures over the snow covered areas of mid and high latitudes are attributed to the parameterization of cold climate processes in CABLE. These include; liquid precipitation freezing within the snowpack which delays the building of snow pack in autumn and accelerates snow melting in spring, prognostic snow density increasing through the winter lowering diurnally resolved snow albedo and variable snow thermal conductivity which is low in early winter preventing heat loss and increases with passage of time allowing more heat to enter the ground.

Questions

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