ARC CENTRE OF EXCELLENCE FOR CLIMATE SYSTEM SCIENCE

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Impact of realistic land-surface initialisation on WRF-LIS-CABLE sub-seasonal forecast skill: preliminary results from GLACE-2

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Global Land-Atmosphere Coupling Experiment (GLACE)

- Aims to explore model land-atmosphere coupling through idealised experiments
  - Emphasis on soil moisture feedback on precipitation and air temperature
- Two key projects:
  - Quantify the sensitivity of the atmosphere to variations in the land surface (GLACE-1)
  - Identify how long a soil moisture anomaly is remembered into the forecast period (GLACE-2)

Why do GLACE?

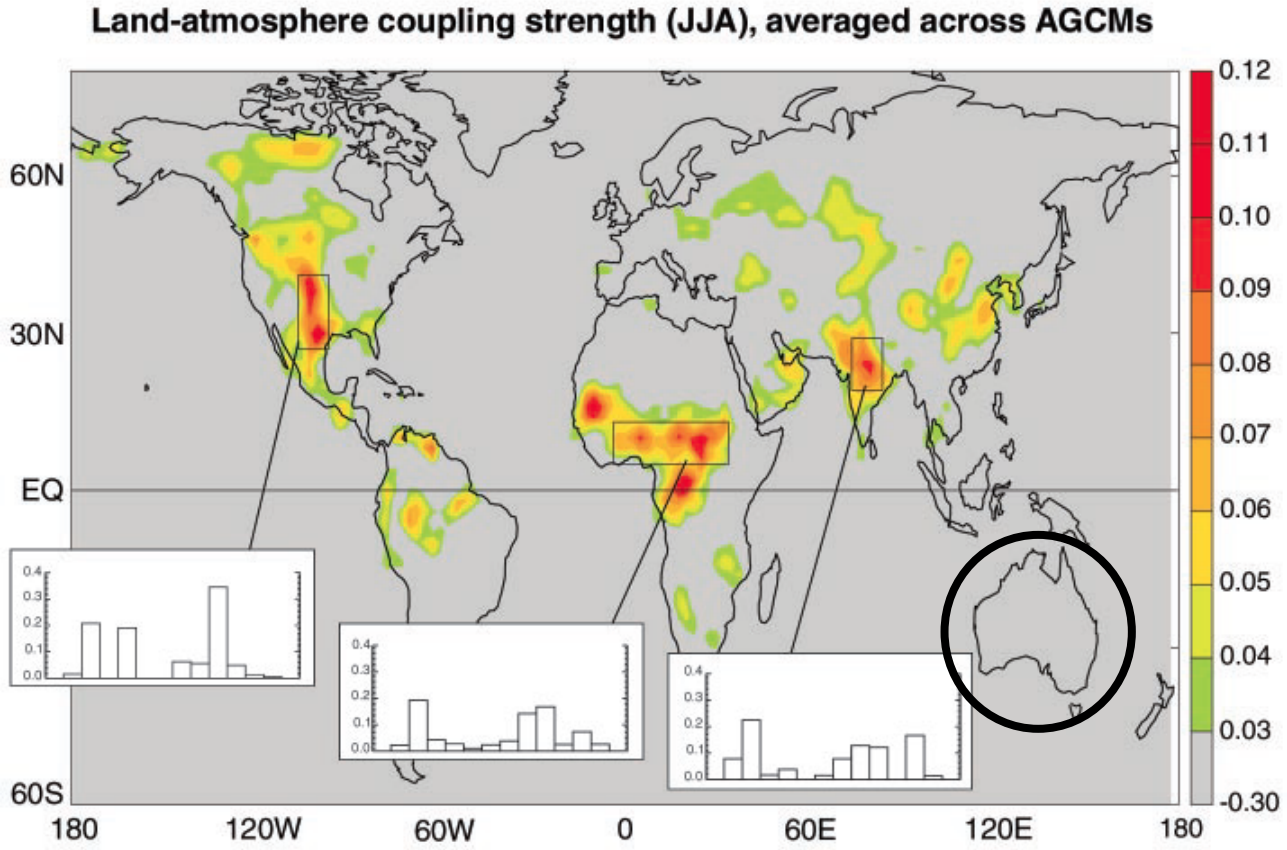


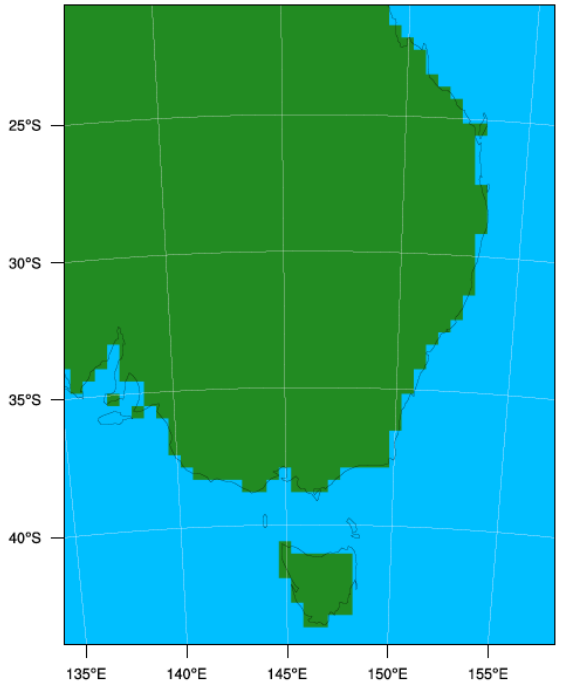
Figure 1. Koster et al 2004 Science

My aims

- To run GLACE for the Southern Hemisphere and evaluate the coupling strength of WRF-LIS-CABLE
- Do we get results that are comparable to the Northern Hemisphere?
- Is there a statistical impact on the model results by initialising the coupled WRF-LIS-CABLE system with equilibrated land surface states generated from offline LIS-CABLE simulations?

WRF-LIS-CABLE Configuration

- 50 km domain over SE Australia
- 38 atmospheric levels, 6 soil levels
- 5 patches per grid cell
- AVHRR LAI
- WRF physics:
  - Dudhia short-wave scheme
  - Yonsei University PBL scheme
  - Kain-Fritsch cumulus scheme
  - WRF Single Moment 5-class microphysics
  - Rapid Radiative Transfer Model long-wave scheme



The GLACE-2 Methodology

- Two parallel series of simulations
  - Each simulation runs for 60 days
- 10 start dates on 15-day interval over 10 years
  - 1 Oct, 15 Oct, 1 Nov … 15 Feb
  - 1986 – 1995 (GSWP-2 period)
  - 10 member ensemble forecast
    - Initialised 1 day apart
- Each series has 100 10-member ensemble forecasts, each with a duration of 60 days

The GLACE-2 Methodology

- Series 1: Equilibrated Land Surface
  - Land surface initialisation
    - Run LIS-CABLE offline for 4 years
  - Meteorological dataset used for land initialisation
    - MERRA land reanalysis
  - Run coupled WRF-LIS-CABLE
    - Using the equilibrated states from the LIS-CABLE offline simulations for the surface IC
    - Use ERA-Interim for atmospheric IC and BC

The GLACE-2 Methodology

- Series 2: Cold Start – No equilibration
  - NO offline LIS-CABLE
  - Coupled WRF-LIS-CABLE simulations as cold start
    - ERA-Interim as atmospheric BC and soil moisture IC for consistency
- Series 2 is identical to Series 1 in EVERY way except that Series 2 does not benefit from realistic soil moisture initialisation from the LIS-CABLE offline simulations
- What one expects to see is that the two series will eventually converge

The GLACE-2 Methodology

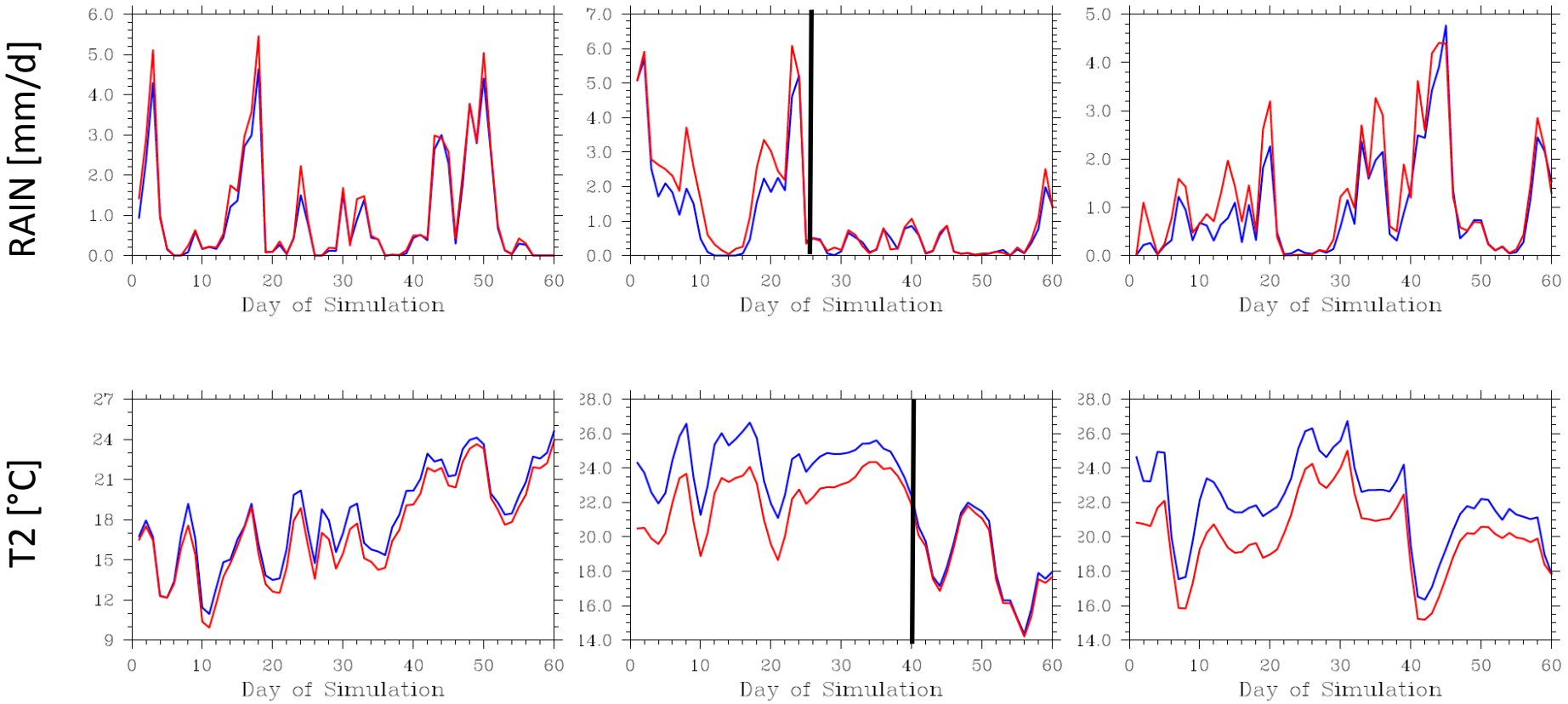
- Compute 15-day averages for all simulations
- For now only look at the 15-day averages corresponding to DJF
- For each ensemble forecast, split the 15-day averages into the four different lead times
- For each lead time, collate the 15 day averages to create time series over the 10 years

The GLACE-2 Methodology

- For each series (S1 and S2) you have one time series for each lead time
- Using these time series we compute correlations between WRF-LIS-CABLE and AWAP for:
  - Precipitation
  - Mean, maximum and minimum air temperatures
- Take the difference between the S1 and S2 correlations to evaluate the change

Results: Initialisation Examples

Blue = With land surface equilibration (S1); Red = Without land surface equilibration (S2)



Results: S1 minus S2

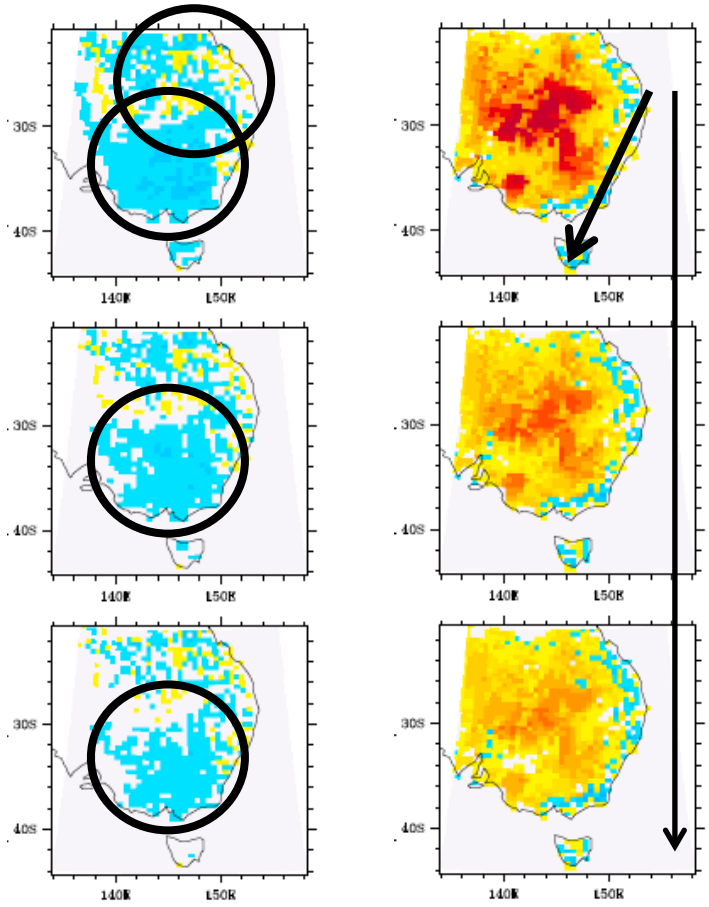
RAIN [mm/d]

T2 [°C]

16-30 Days

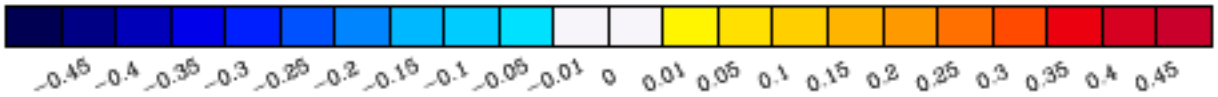
31-45 Days

46-60 Days



Results: GLACE-2 Diagnostic

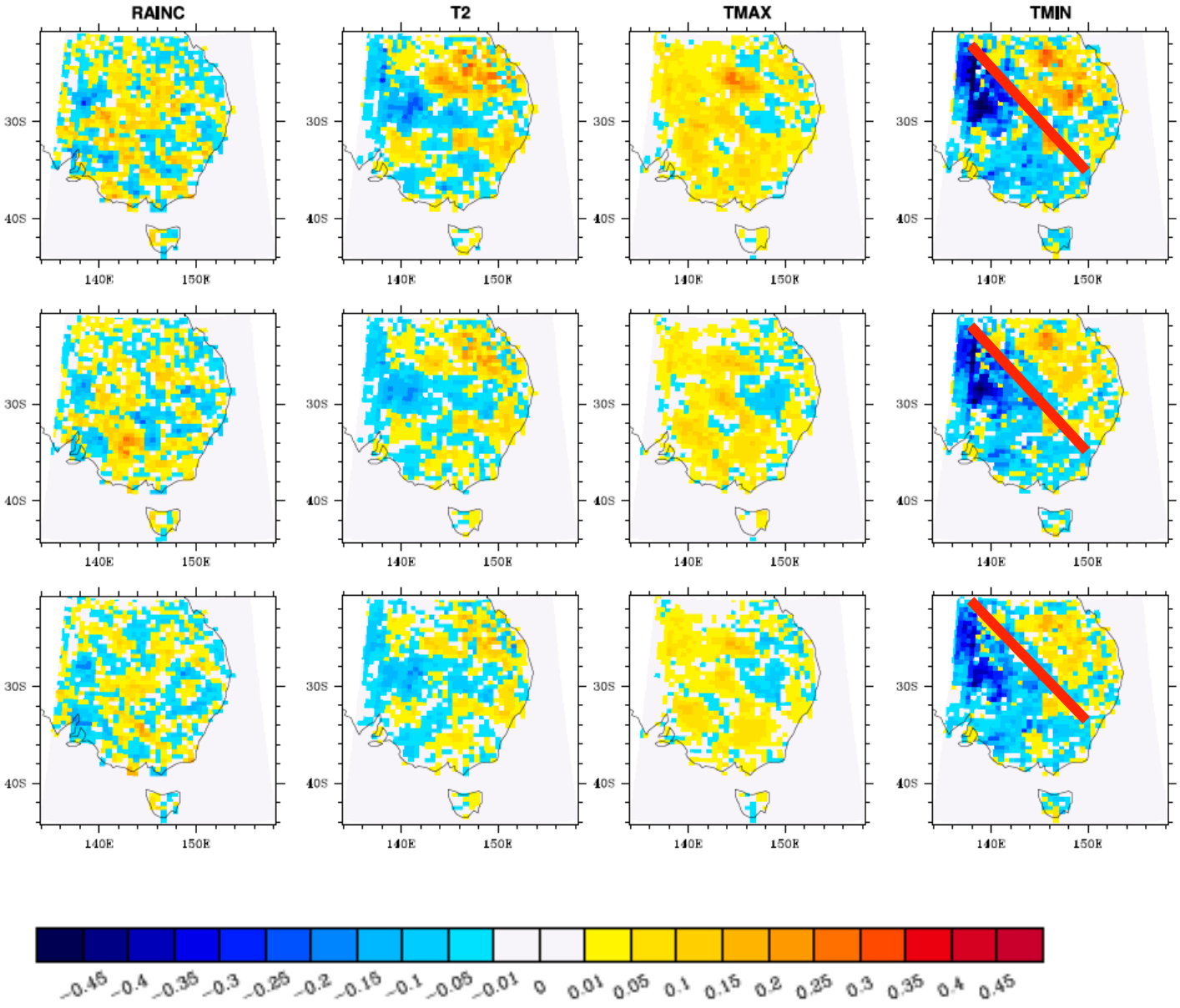
- S1 = With equilibrated land surface states
- S2 = Without equilibrated land surface states
- GLACE2 Diagnostic: $(R_{S1})^2 - (R_{S2})^2$
- Red: $R_{S1} > R_{S2}$ GAIN
- Blue: $R_{S1} < R_{S2}$ LOSS



16-30 Days

31-45 Days

46-60 Days



Concluding Remarks

- The two parallel series with and without land surface equilibration tend to converge but at different stages across the start dates
- Greatest impact on air temperature, with the biggest gains for T_{MAX}
- Unusual result for T_{MIN}
- Future analysis to identify dependence of results on land cover, albedo, initial soil moisture anomaly
- What next? GLACE-1