Intra-Seasonal to Inter-annual (ISI) Climate Predictability in a changing climate

-Effect of realistic land surface initialization

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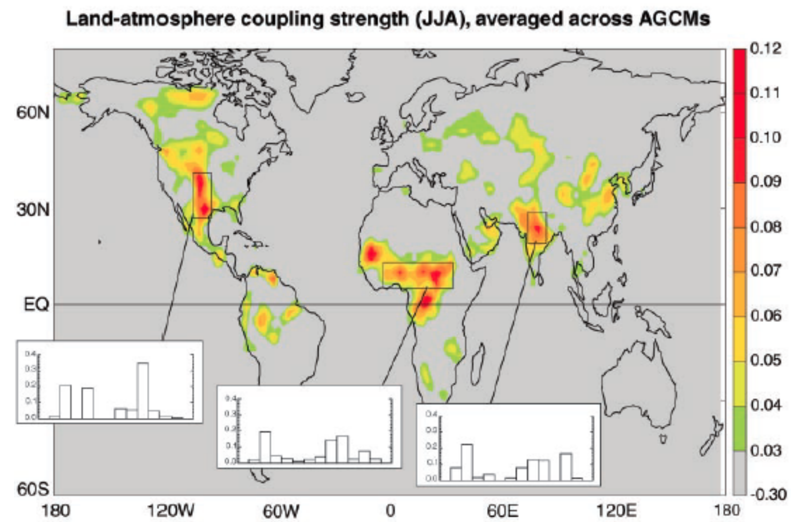
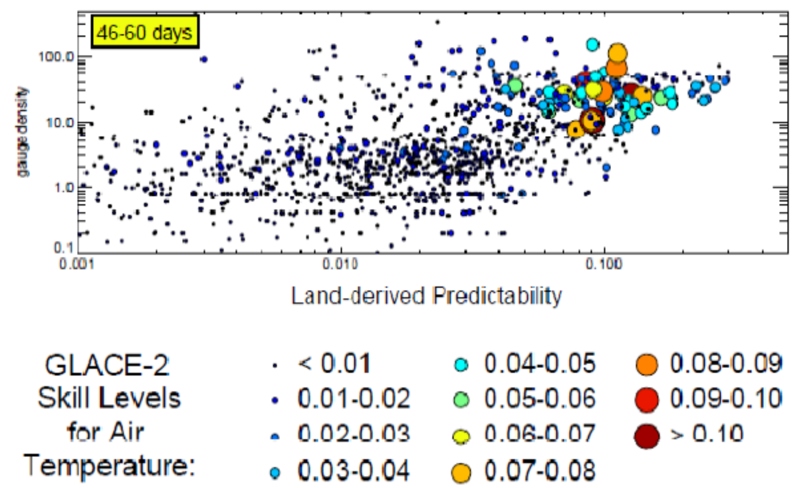
Motivation

1. Memory stored in the land surface (e.g. soil moisture) to affect ISI climate predictability (GLACE1 and GLACE2 experiments, e.g. Koster et al., 2004 and 2010)

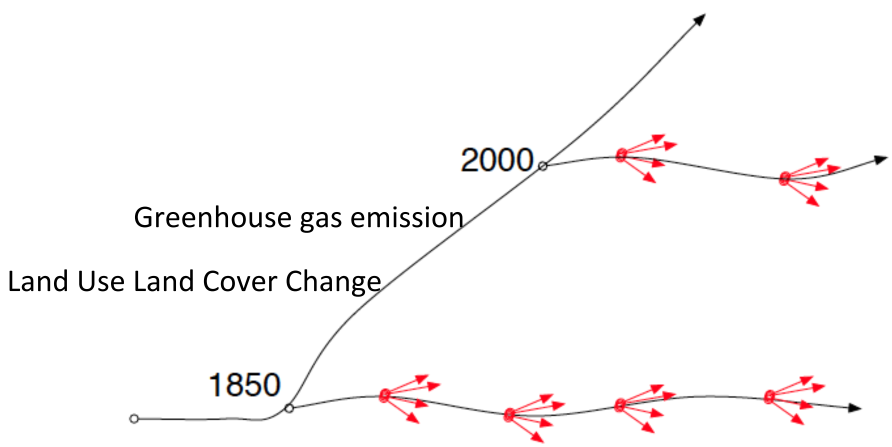


2. Limitations: (a) observation quality issues (Koster et al., 2011); (b) Inter-model variability (Pitman et al., 2009); **(c) effects of climate change including land use land cover change**

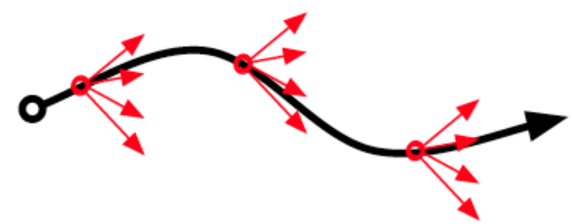


Experiment Design

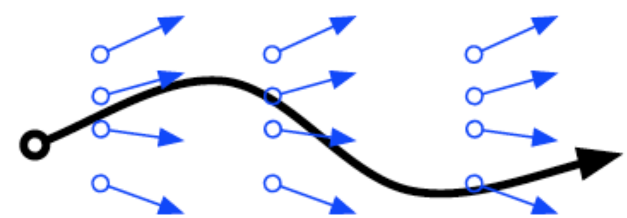
1. Model – **CCSM4**, land+ocean+atmosphere+sea ice; CLM with CN component active
2. Perfect twin experiment methodology – long control model runs (50 years) are taken as observations
3. Two sets of parallel experiments – (a) Pre-industrial scenario [1850], and (b) Present scenario [2000] – [a third set with RCP8.5 state at 2095 is now underway]
4. Fifteen cases spawned for predictability experiments with 14 members ensemble each for realistic (previous 7 days @ 0.5 days, SPPY) and unrealistic land surface ***initialization*** (same day of a different year, LPPY) – 5 El Niño, 5 La Niña, 5 Neutral
5. 90 days predictability experiments with May 1, June 1, July 1, and Dec 1 initial conditions



Overall Experiment Design



Realistic Land Perturbation (SPPY)



Unrealistic Land Perturbation (LPPY)

Predictability Metric

For a given scenario (say 1850) let Ocean+Atmosphere (*OA*) and Land+Ocean+Atmosphere (*LOA*) ***initial conditions*** experiments be modeled respectively as:

$$y_{e_1 n}^{OA} = \mu^{OA}{}_n + \varepsilon_{e_1 n}^{OA}$$

$$y_{e_2 n}^{LOA} = \mu^{LOA}{}_n + \varepsilon_{e_2 n}^{LOA}$$

Where e_1 = 1, 2, …14 (ensemble size of LPPY exp.)
e_2 = 1, 2, …14 (ensemble size of SPPY exp.)
n = 1, 2, …15 (number of cases [years])
μ = mean value (signal)
ε = error term (noise)

The Null Hypothesis (H0) is: $\mu_1^{OA} = \mu_1^{LOA}, \quad \mu_2^{OA} = \mu_2^{LOA}$ …and $\mu_{15}^{OA} = \mu_{15}^{LOA}$

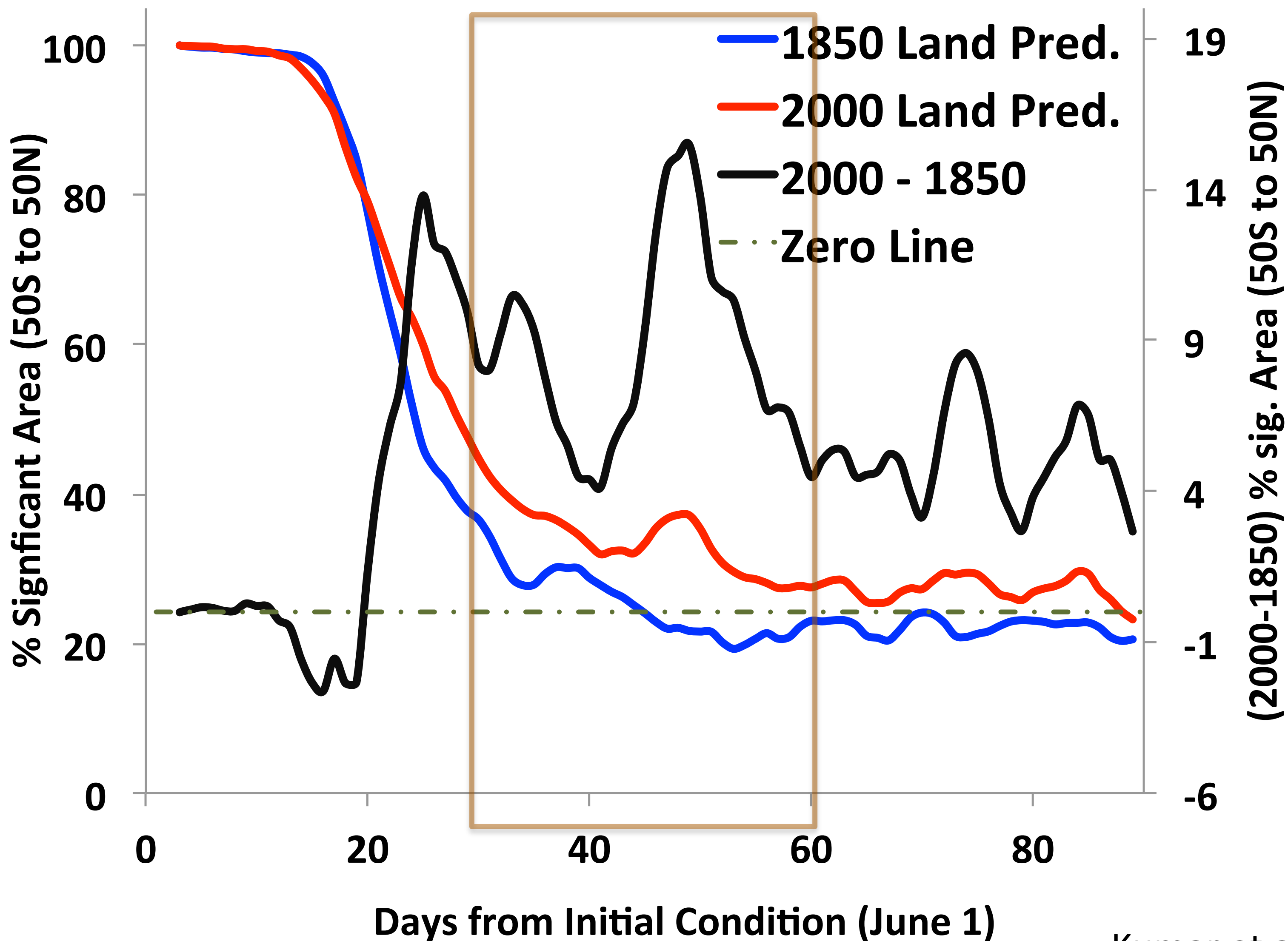
For rejection of the null hypothesis i.e. ~ for statistically significant land driven climate predictability:

$$\frac{\sum_n (y_{\cdot n}^{LOA} - y_{\cdot n}^{OA})^2}{S_{pooled}^2} * \frac{E_1 E_2}{N(E_1 + E_2)} \geq F_{N, N(E_1+E_2-2)}^{0.05}$$

Where dot(.) indicates that corresponding index has been averaged; and

S_{pooled}^2 is the total variance of the noise term for *OA* and *LOA* conditions

Results: (a) Temperature Predictability in boreal Summer



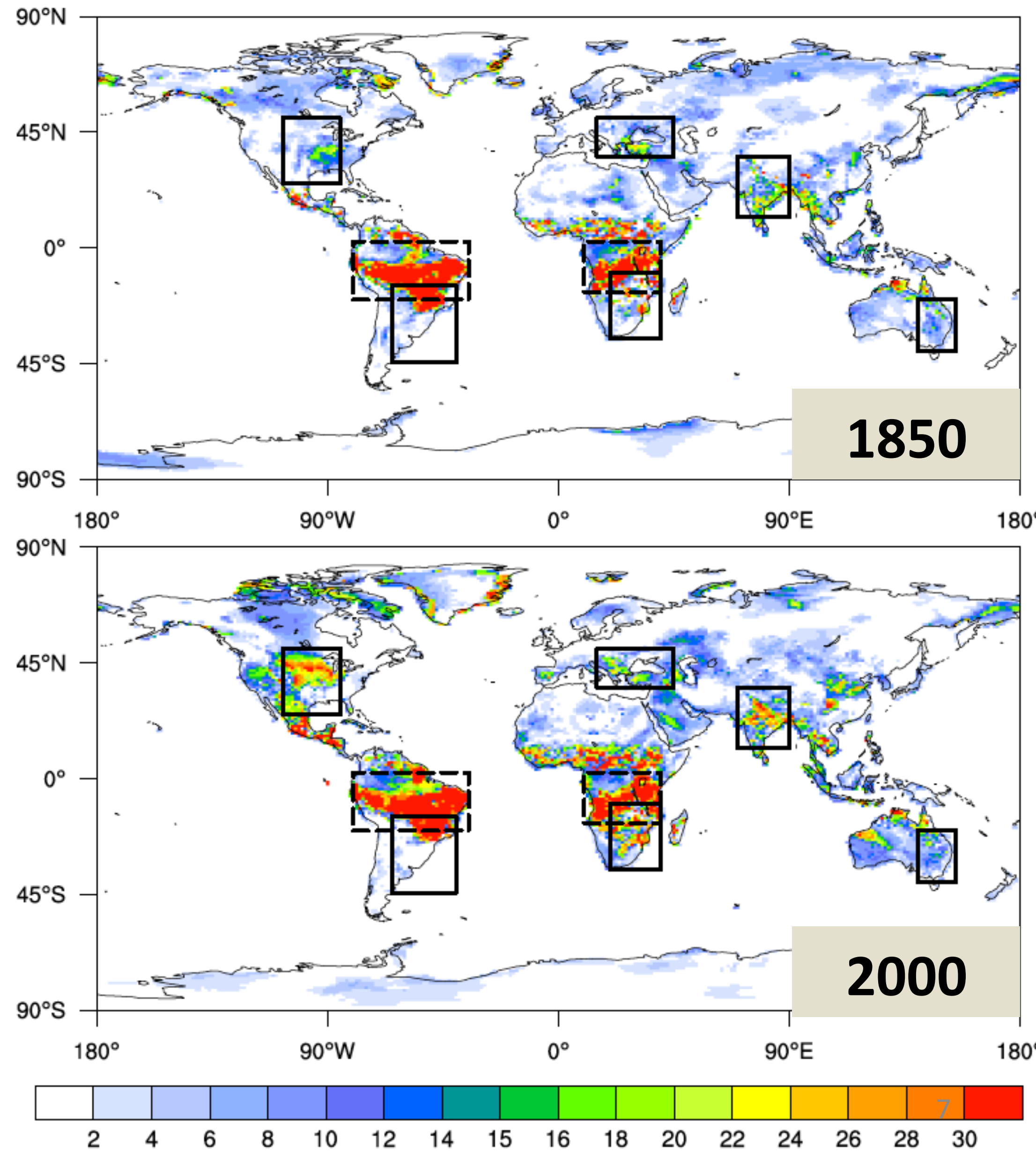
Kumar et al. (in prep.)

Continued…

Number of days out of 30 in which SPPY signal is significantly different from LPPY signal for 31 to 60 days temperature predictability using June 1 initial conditions

Maximum Value: 30
Minimum Value: 0

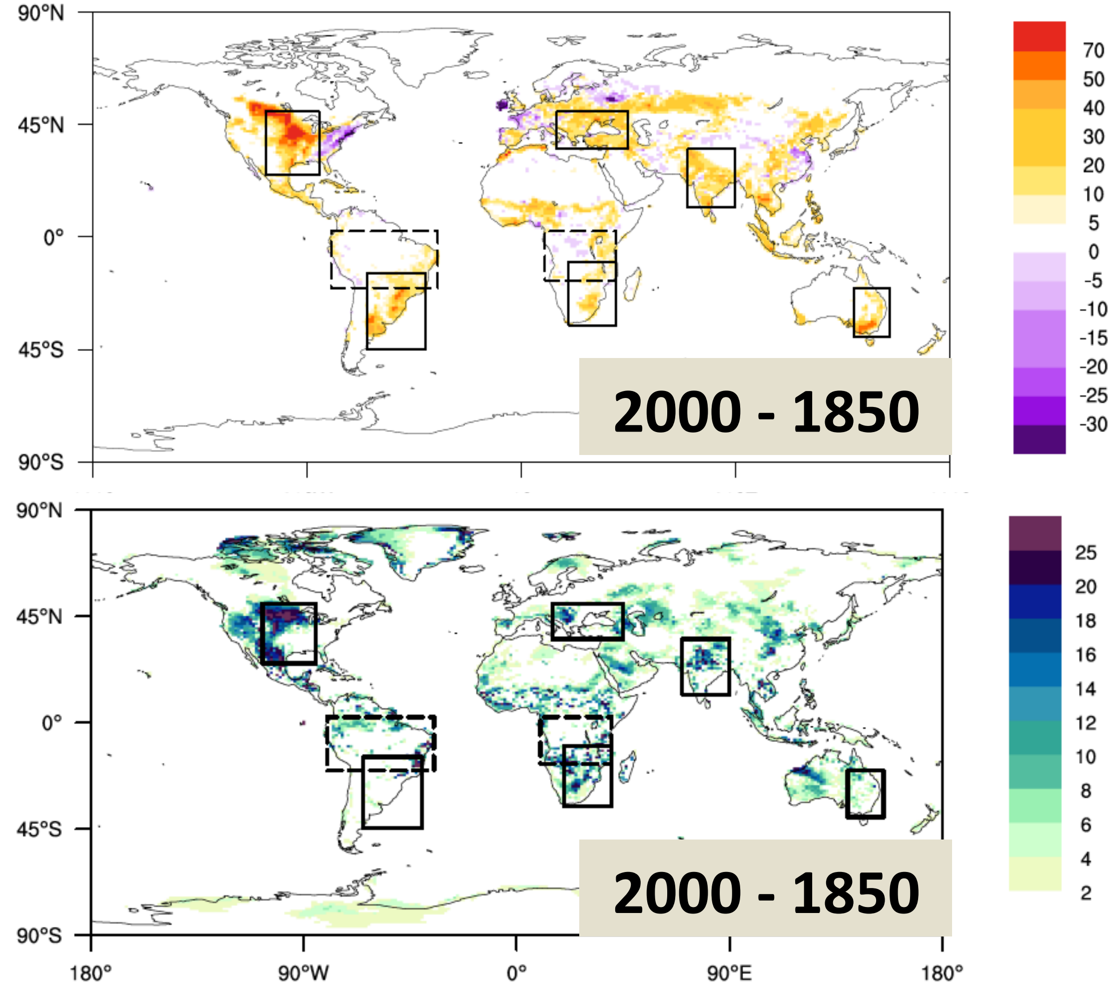
Ocean data is masked out



Results: (b) Effects of land cover change

Land Use Land Cover Change [Crop cover change, % of grid cell]

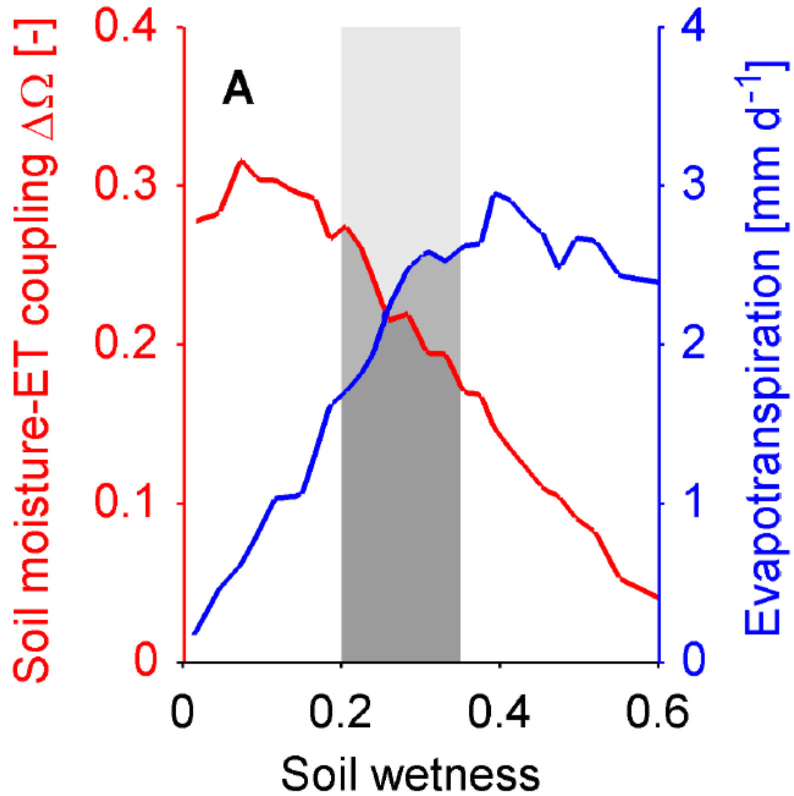
Change in land driven climate predictability [temperature, June 1 ICS, 31 to 60 days]



Areas of increased land driven climate predictability coincides with the agricultural expansion in the Northern Hemisphere

Kumar et al. (in prep.)

Soil moisture-ET coupling



Koster et al. (2004), GLACE1
Seneviratne et al., 2010

- A necessary condition but not sufficient condition for land driven climate predictability
- Dirmeyer (2011) combined ET sensitivity with soil moisture variability

$$I_\Phi = s_w \beta_\Phi$$

Where I_Φ ET sensitivity to soil-moisture variability

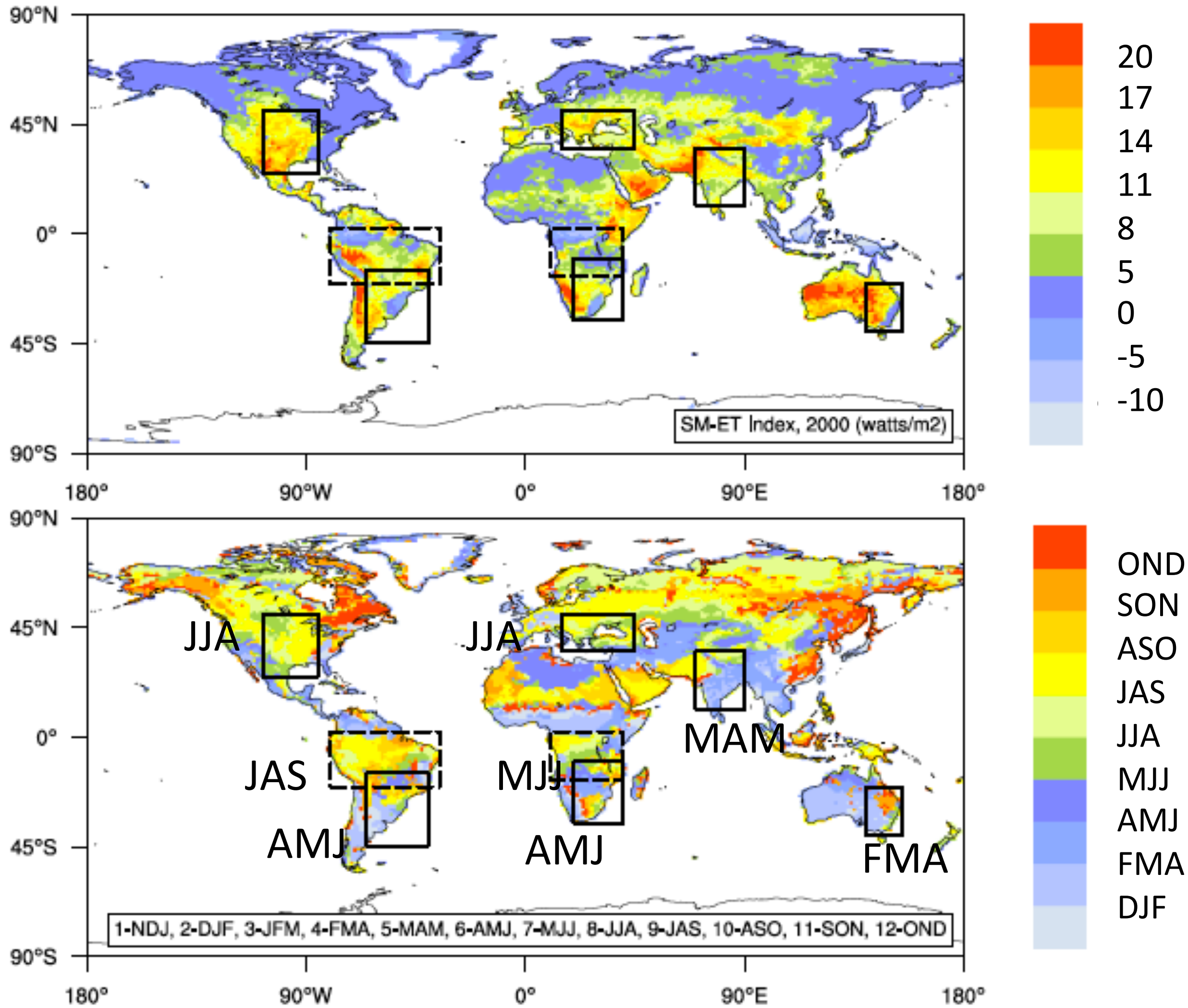
β_Φ Linear regression slope of ET on soil moisture w

s_w Standard deviation of daily soil moisture w for a given month

Results: (c) seasonal influence on land driven climate predictability

Three months Seasonal Maximum

I_Φ



Season for maximum I_Φ

Calculated from 50 years control experiments in 2000 scenario

Kumar et al. (in prep.)

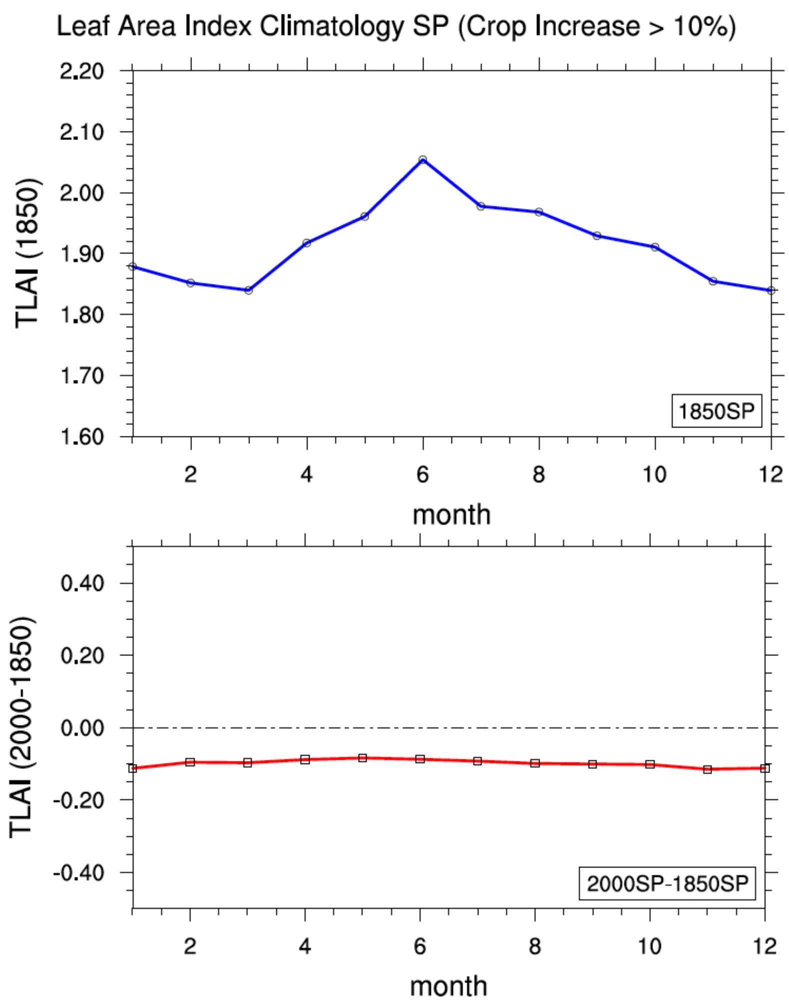
Conclusions

1 We found higher land driven climate predictability in 2000 scenario compared to 1850 scenario

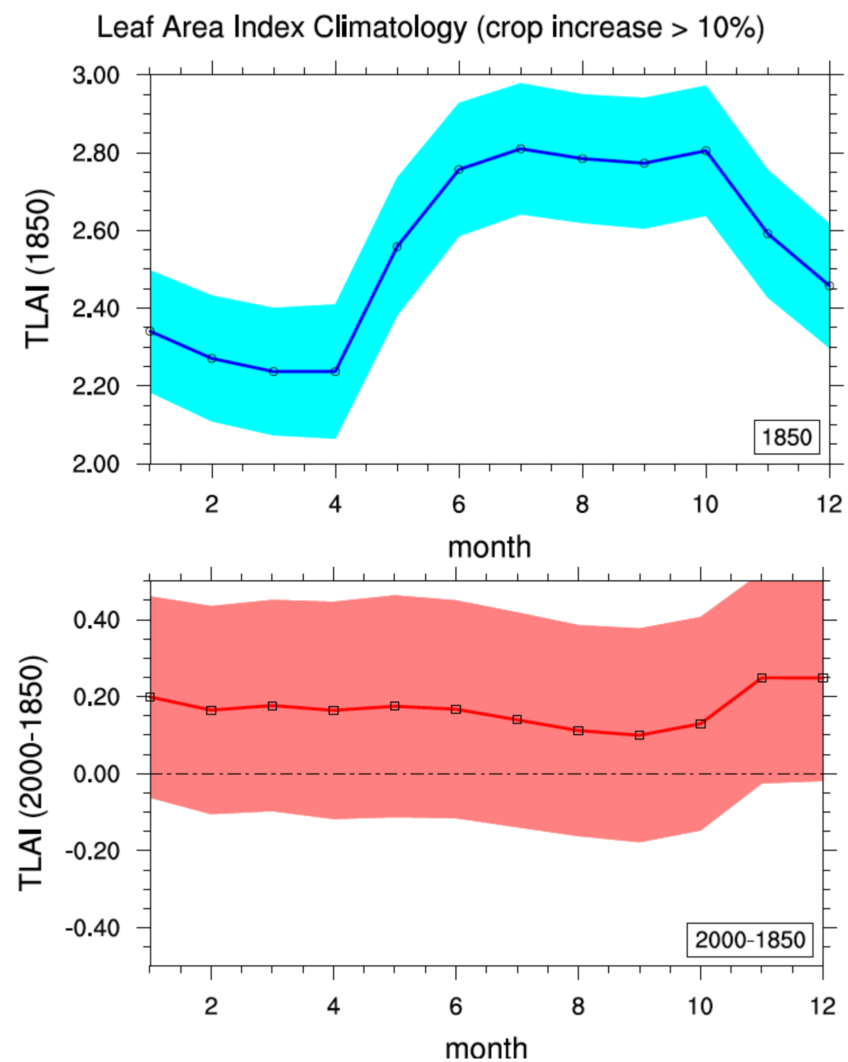
2 Area of higher land driven climate predictability coincided with the land cover change in the Northern Hemisphere

3 Season play an important role in land driven climate predictability, which is significant corresponding to the maximum I_{Φ} season

Outstanding issue



SP Phenology



CN Phenology

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