Multi-year Predictability of Temperature and Precipitation Over Land

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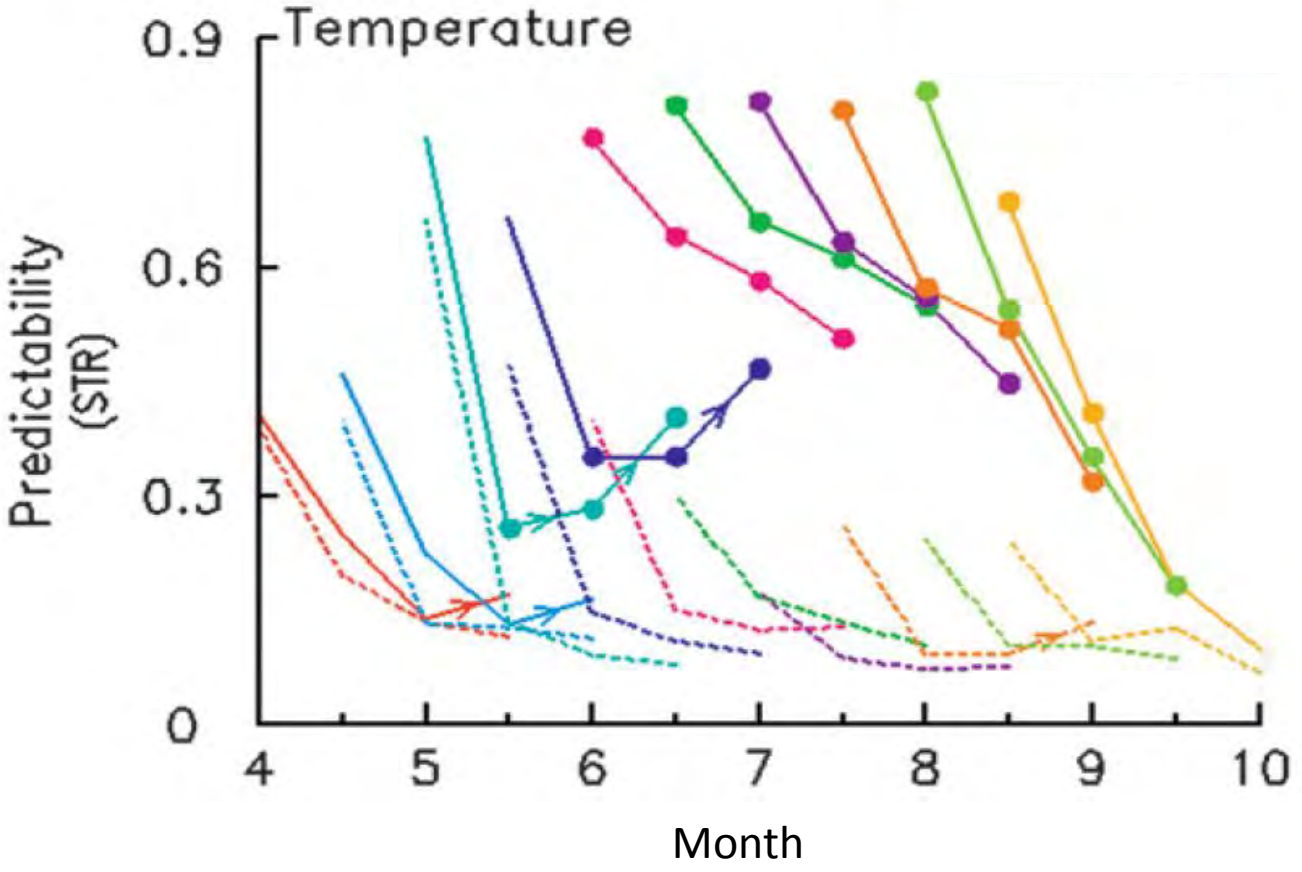
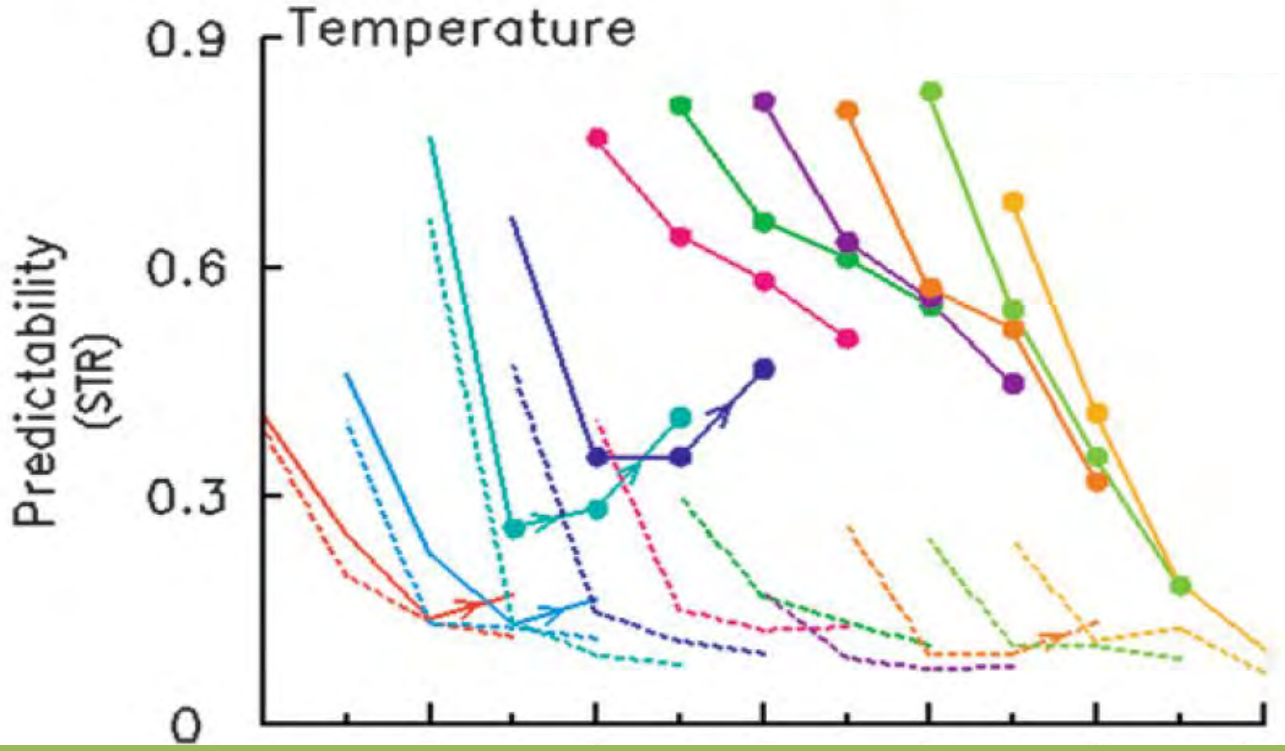
NTU, Taiwan, 2012

Predictability of Land Surface Temperature



Guo, Dirmeyer and DelSole, *GRL*, 2012

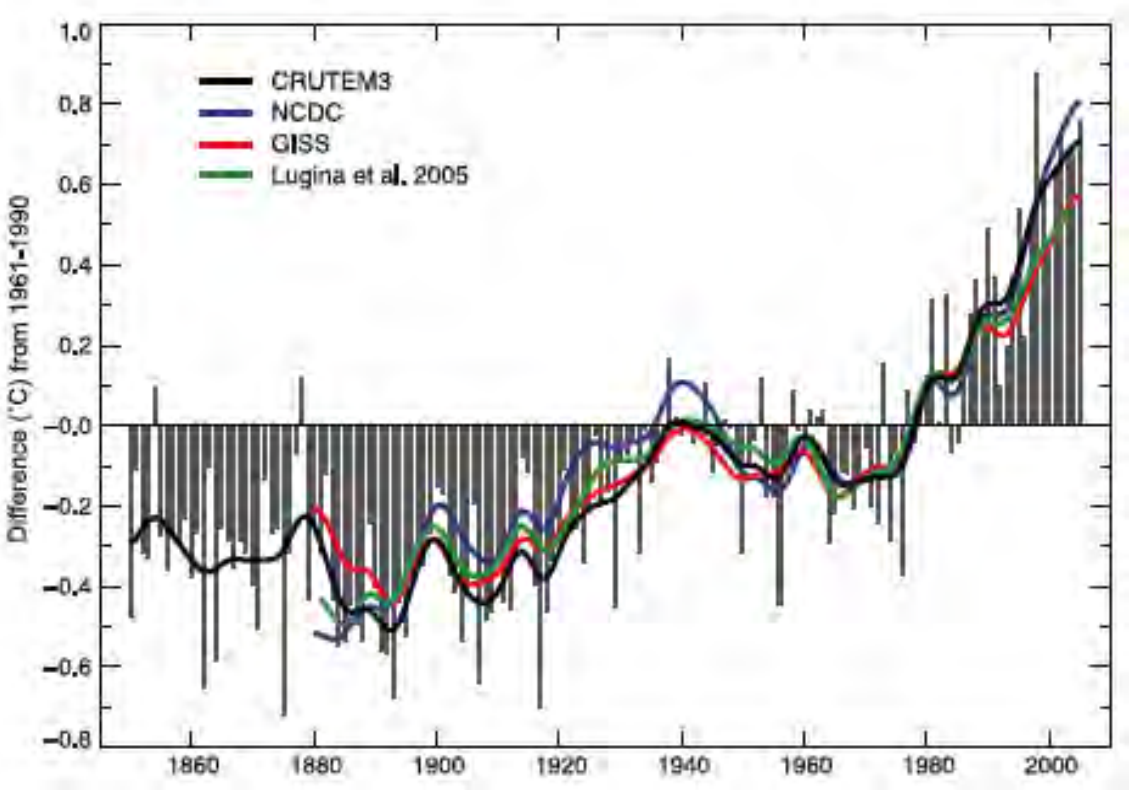
Predictability of Land Surface Temperature



Can we find components over land that are predictable beyond seasons?

Guo, Dirmeyer and DelSole, *GRL*, 2012

Observed Land Surface Temperature Change



Global land-surface temperature anomalies, relative to 1961-1990 mean (IPCC AR4).

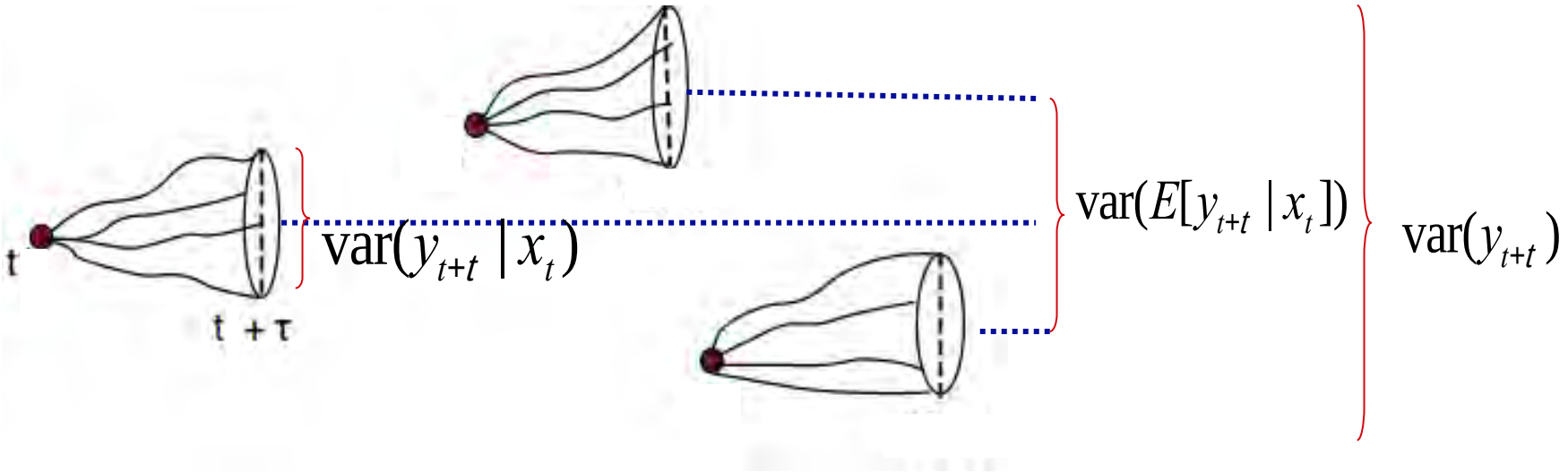
Previous Studies on Predictability

- Decadal predictability over oceans (Boer, 2004; Pohlmann et al., 2004; Collins et al., 2006, DelSole et al., 2011).

- Multi-year predictability over land on continental scales (Jia and DelSole, 2011).

Assess land predictability in new CMIP5 dataset.

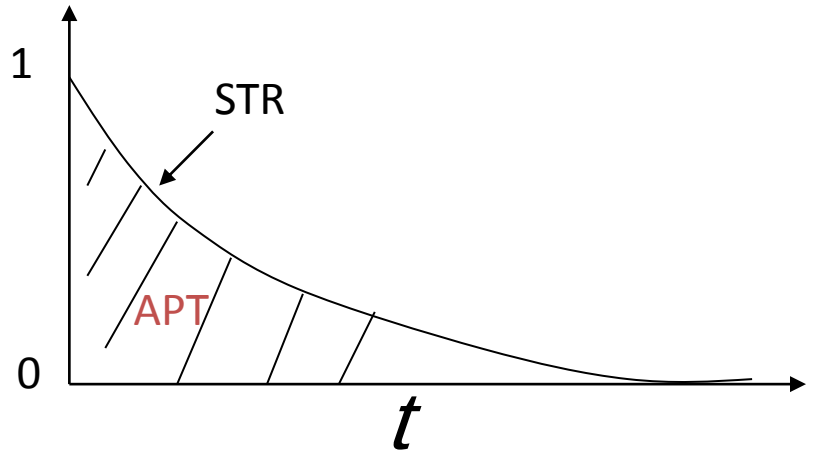
Illustration of Unforced Predictability



Average Predictability Time

Measure of predictability: $$STR(t) = \frac{\mathrm{var}(E[y_{t+t} \mid x_t])}{\mathrm{var}(y_{t+t})}$$

$$APT = 2 \int_0^{\infty} STR(t)\,dt$$



DelSole and Tippett, *J. Atmos. Sci.*, 2009

Maximizing APT

- We seek a linear combination of variables that maximizes APT

$$2\,\grave{Q}^{¥}\,S_{signal}q = /\,S_{total}q$$

  - Eigenvalues give the APT values.
  - Time series of a single component is $q^T y$
  - Regression pattern of a component is $p = S_{total}q$
  - Yields a complete, uncorrelated set of components, ordered by their contribution to APT.

Derive APT with One Ensemble Member

- Project data on the first few principal components.
- Construct a linear regression model.

$$y(t+t) = L_t x(t) + \epsilon(t)$$

- Derive multiple correlation for each component from regression model.

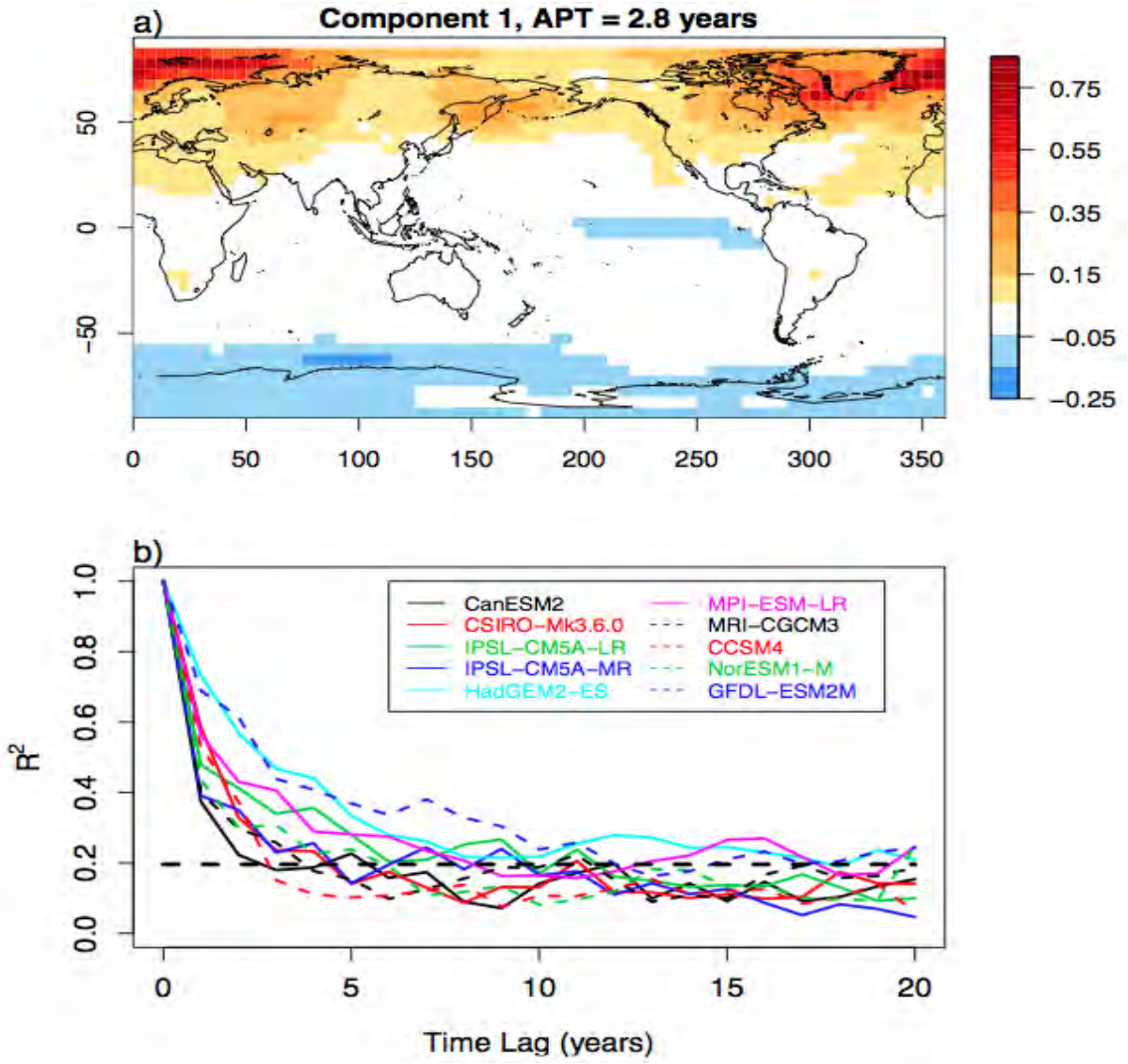
$$APT = 2 \int_0^{\infty} R^2(t)\,dt$$

Model Data

- CMIP5 pre-industrial control runs with fixed external forcing.
- Reject model outliers in trends and variances.
- 10 models were selected.
- Model grids are interpolated to common grid (72 x 36).

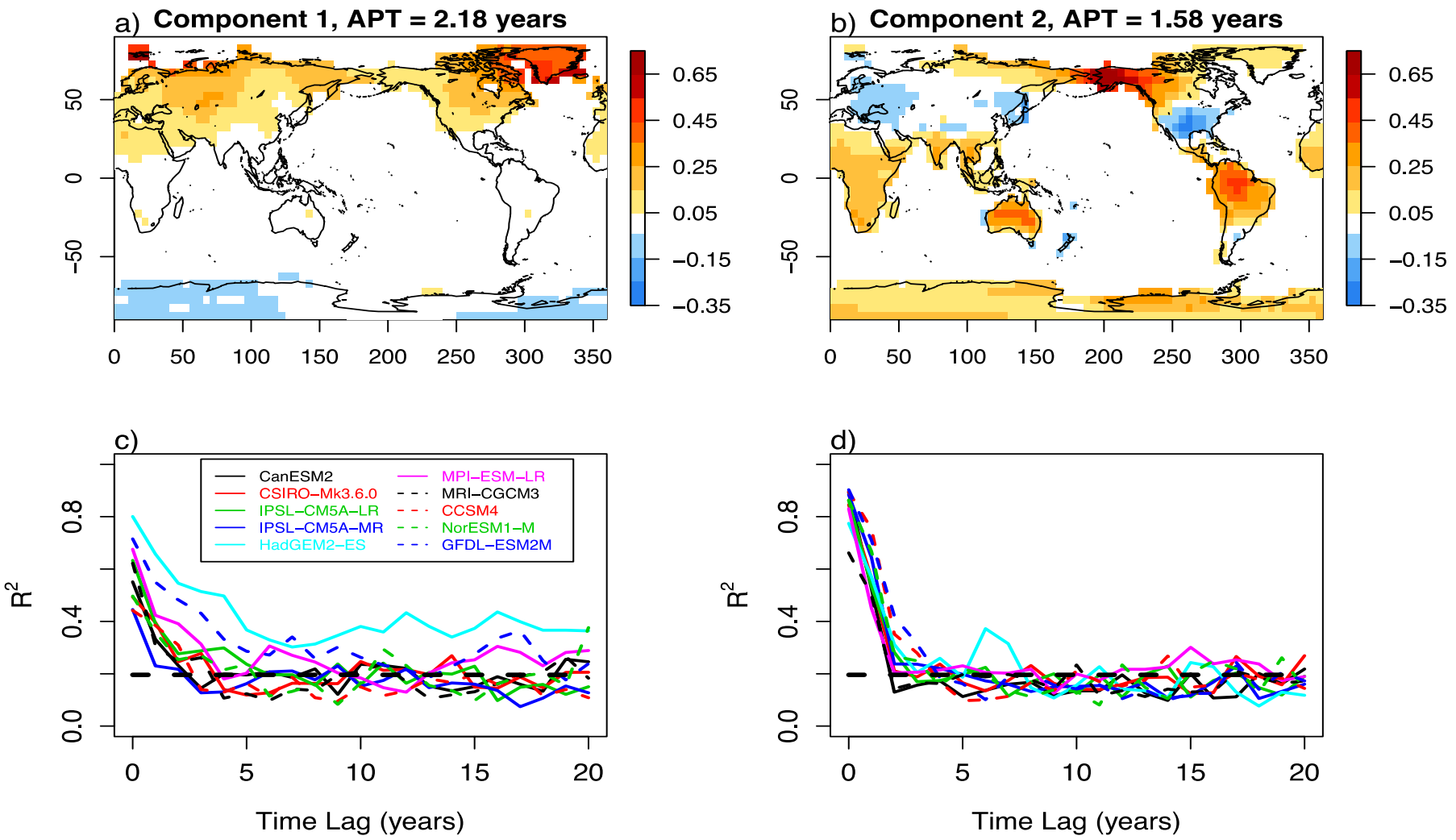
- Last 300 years of annual mean temperature, precipitation.
- First 150 years as training, the second 150 years as verification.
- Selected model runs are pooled to create a multi-model data of 1500 years for training and verification separately.
- 20 PCs, 20-year time lags.

Most Predictable Component of SAT



Jia and DelSole, *GRL*, 2012

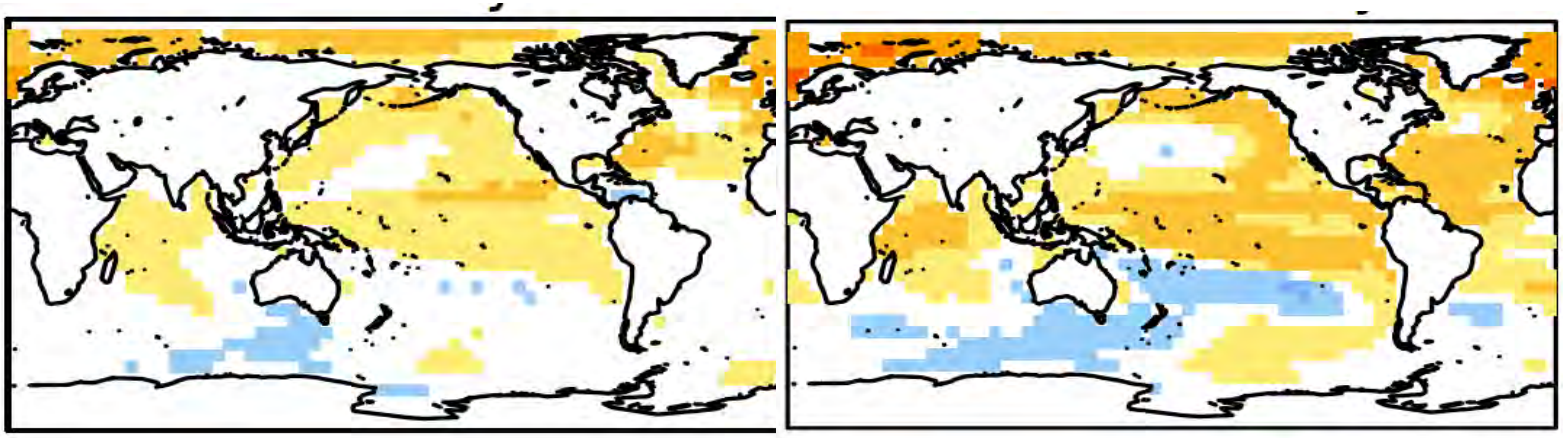
Predictable Components of SAT over Land

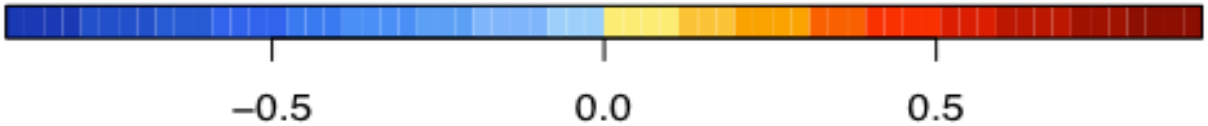


Correlation of SAT over Oceans with Predictable Components

Ocean leads 3 yrs

Ocean leads 1 yr





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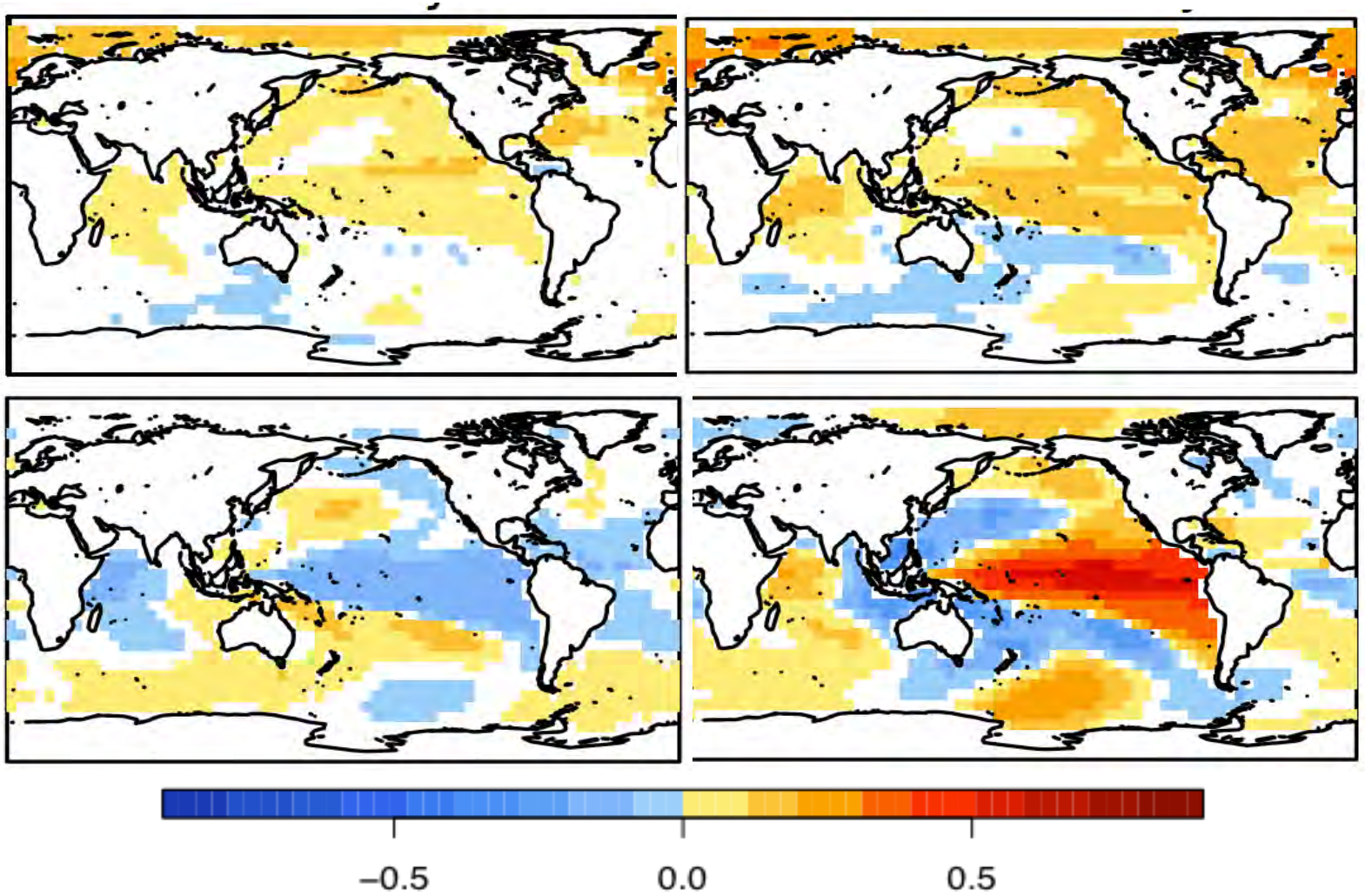
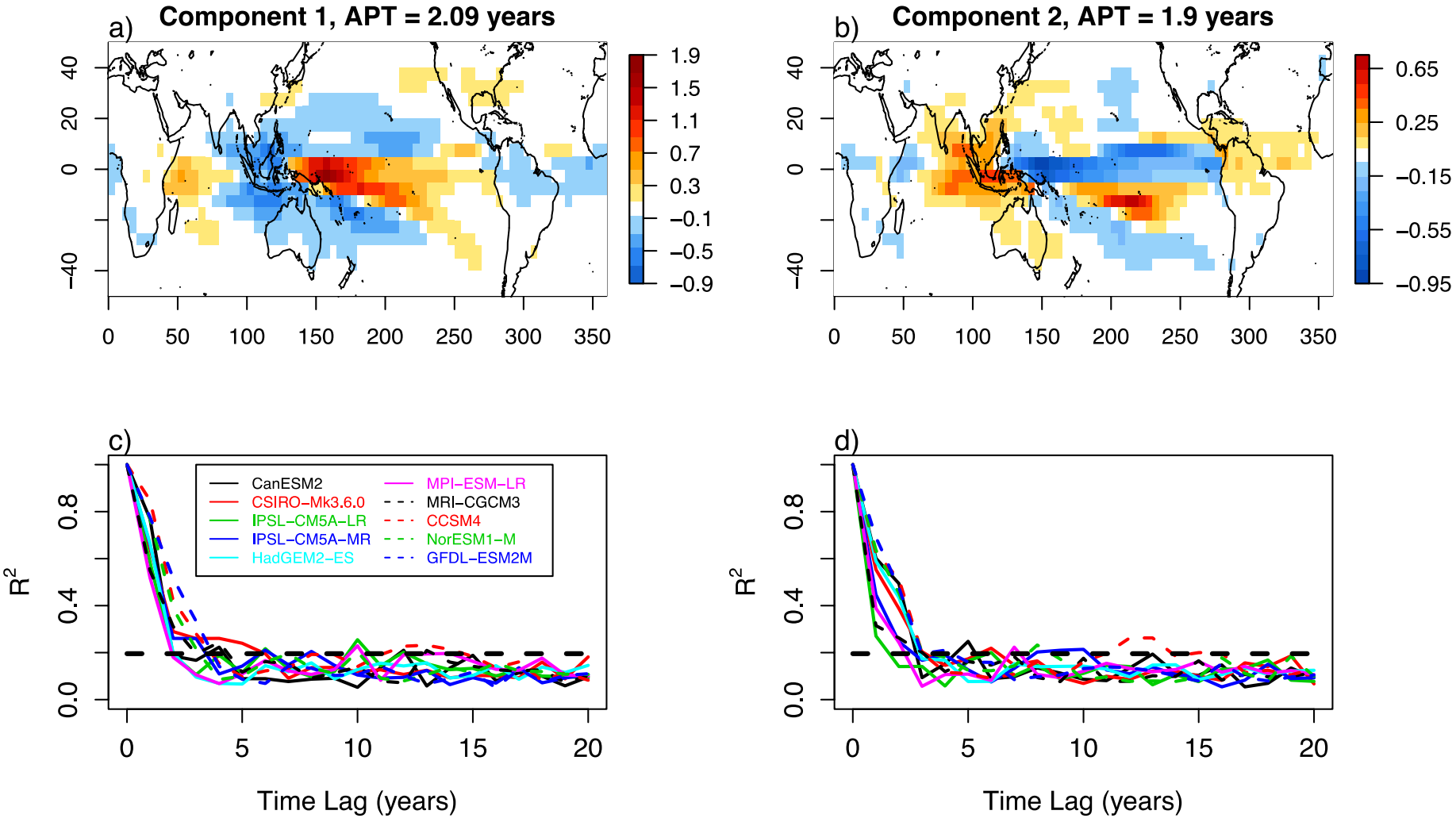
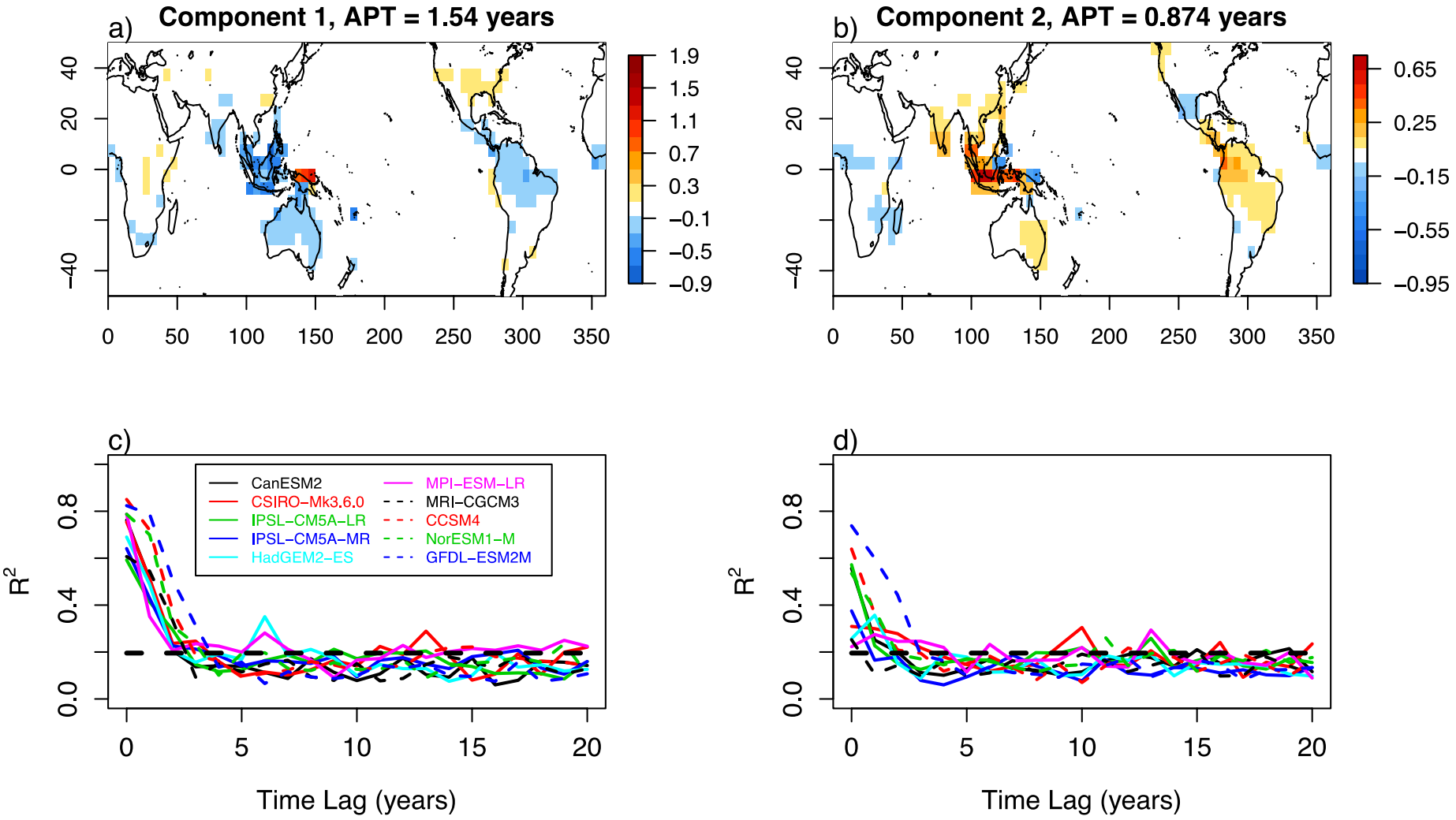


Predictable Components of Precipitation



Predictable Components of Land Precipitation



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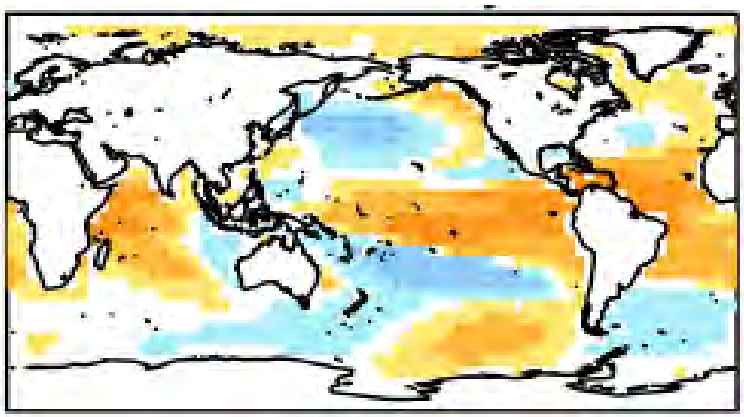
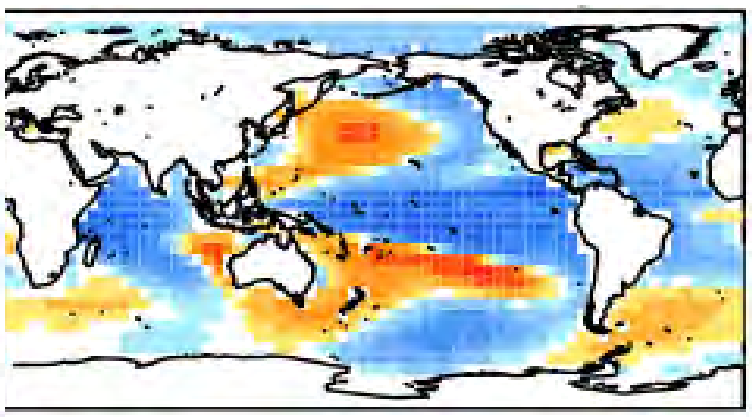
Ocean leads 2 yrs



Ocean leads 0 yr



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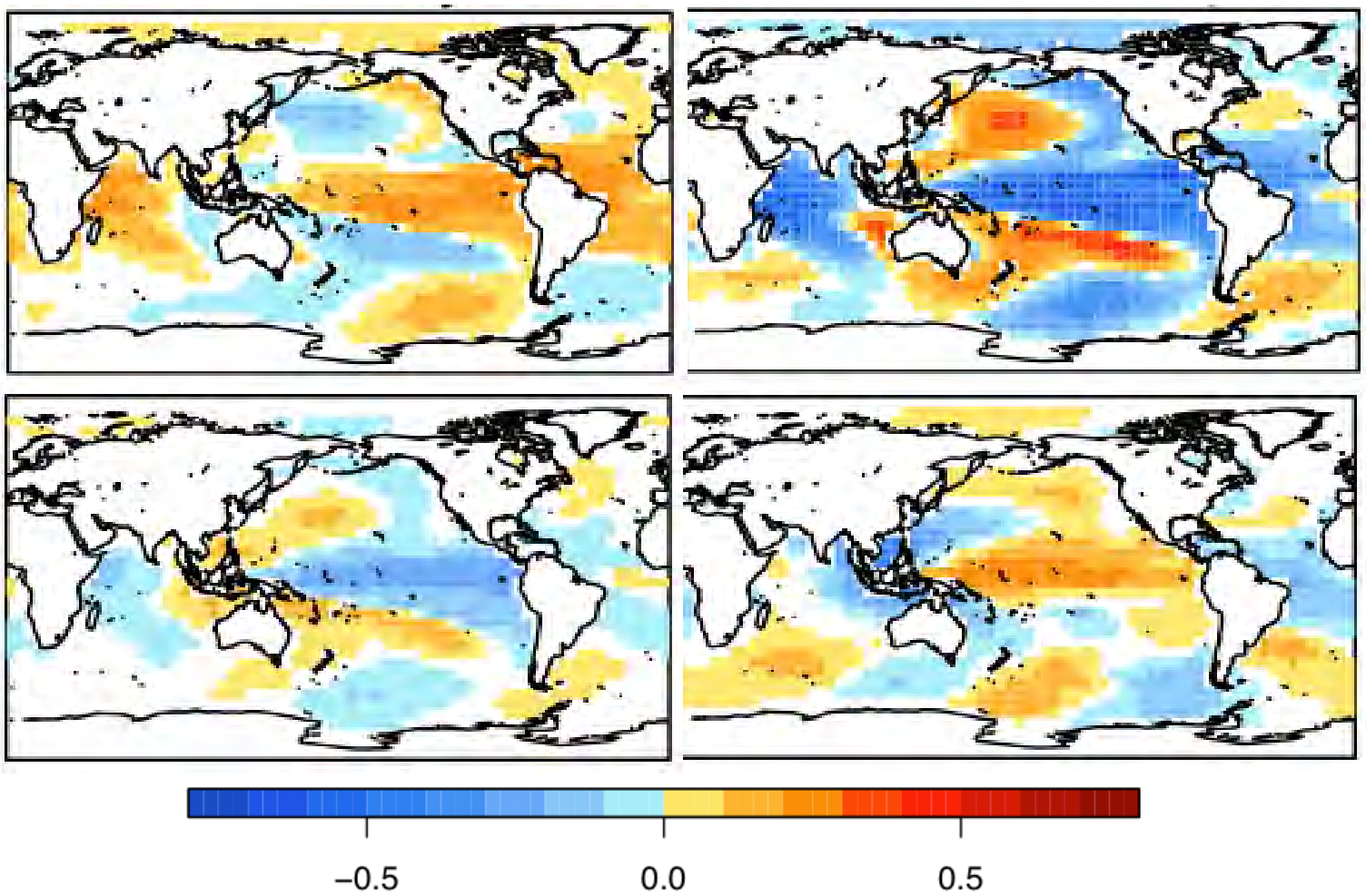


Summary

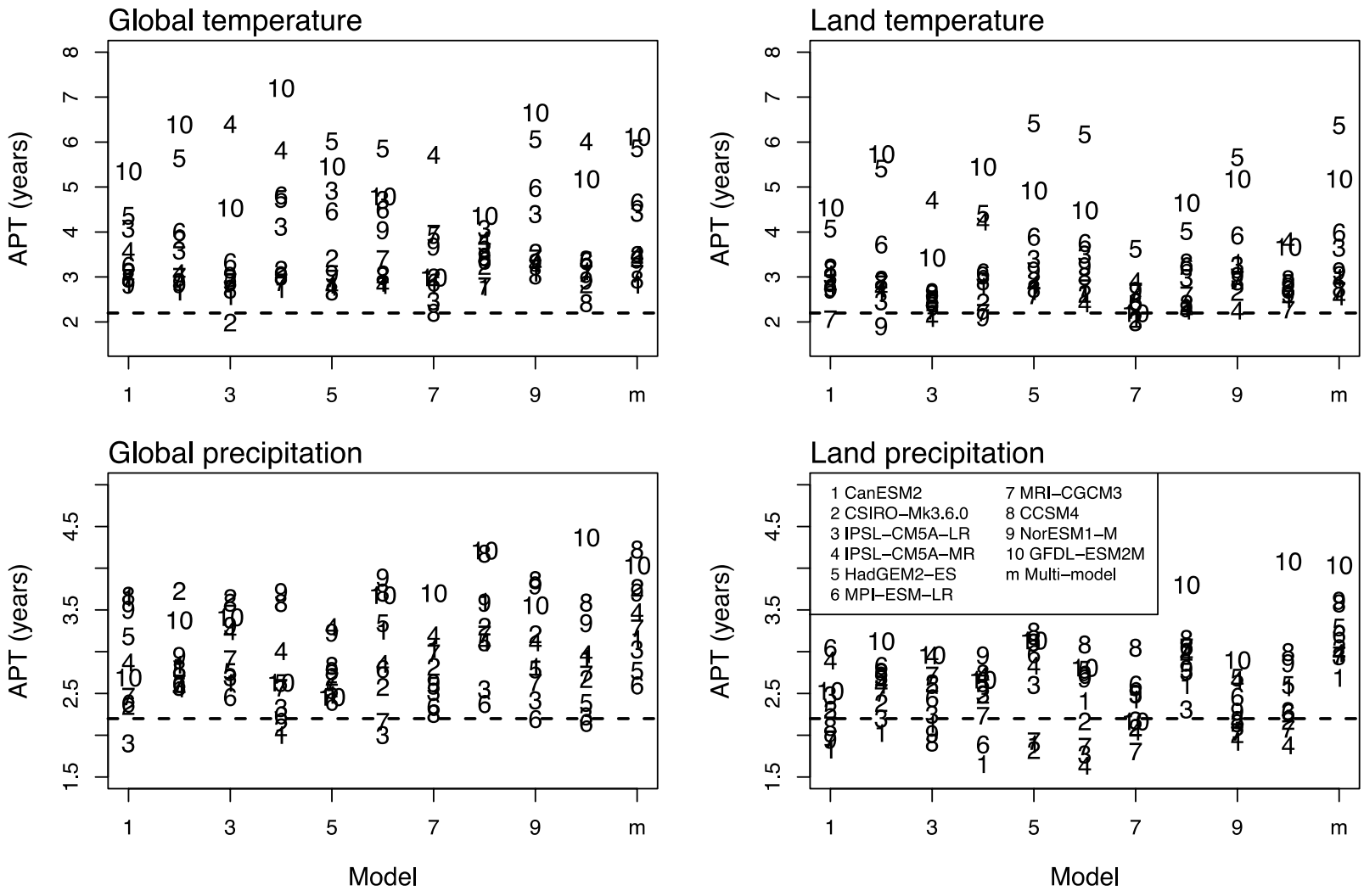
- Explicitly identified space-time structure of predictable temperature and precipitation over land on multi-year scales.

- The leading 2 components of land temperature are predictable for 2-20 years depending on model.

- Predictability of land temperature arises from the persistence of temperature over oceans and ENSO.

- The leading 2 components of land precipitation are predictable for 2-4 years, and are correlated with ENSO.

Sensitivity of Predictability to Models



CanESM2	Canadian Centre for Climate Modelling and Analysis
CSIRO-Mk3.6.0	Commonwealth Scientific and Industrial Research Organisation in collaboration with the Queensland Climate Change Centre of Excellence (Australia)
IPSL-CM5A-LR	Institut Pierre-Simon Laplace (France)
IPSL-CM5A-MR	Institut Pierre-Simon Laplace (France)
HadGEM2-ES	Met Office Hadley Centre (UK)
MPI-ESM-LR	Max Planck Institute for Meteorology (MPI-M) (Germany)
MRI-CGCM3	Meteorological Research Institute (Japan)
CCSM4	National Center for Atmospheric Research (USA)
NorESM1-M	Norwegian Climate Centre
GFDL-ESM2M	Geophysical Fluid Dynamics Laboratory (USA)

Drivers for Multi-year variability

- **Internal dynamics of climate system (e.g., air-sea interactions, slowly-varying climate components).**

  - unforced predictability

- External forcing (e.g. CO2, volcano).

  - forced predictability

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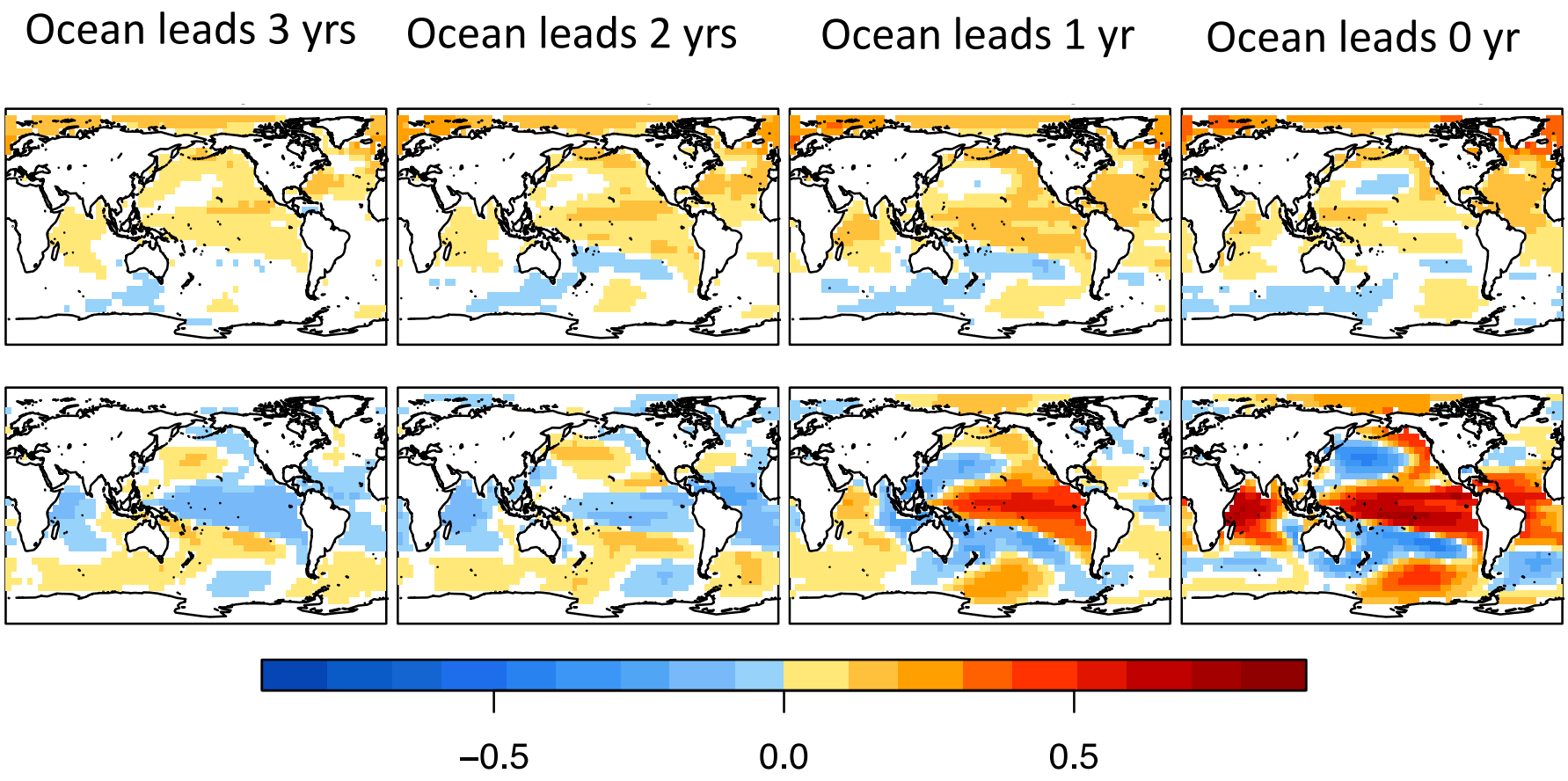

Correlation of SAT over Oceans with Predictable Components