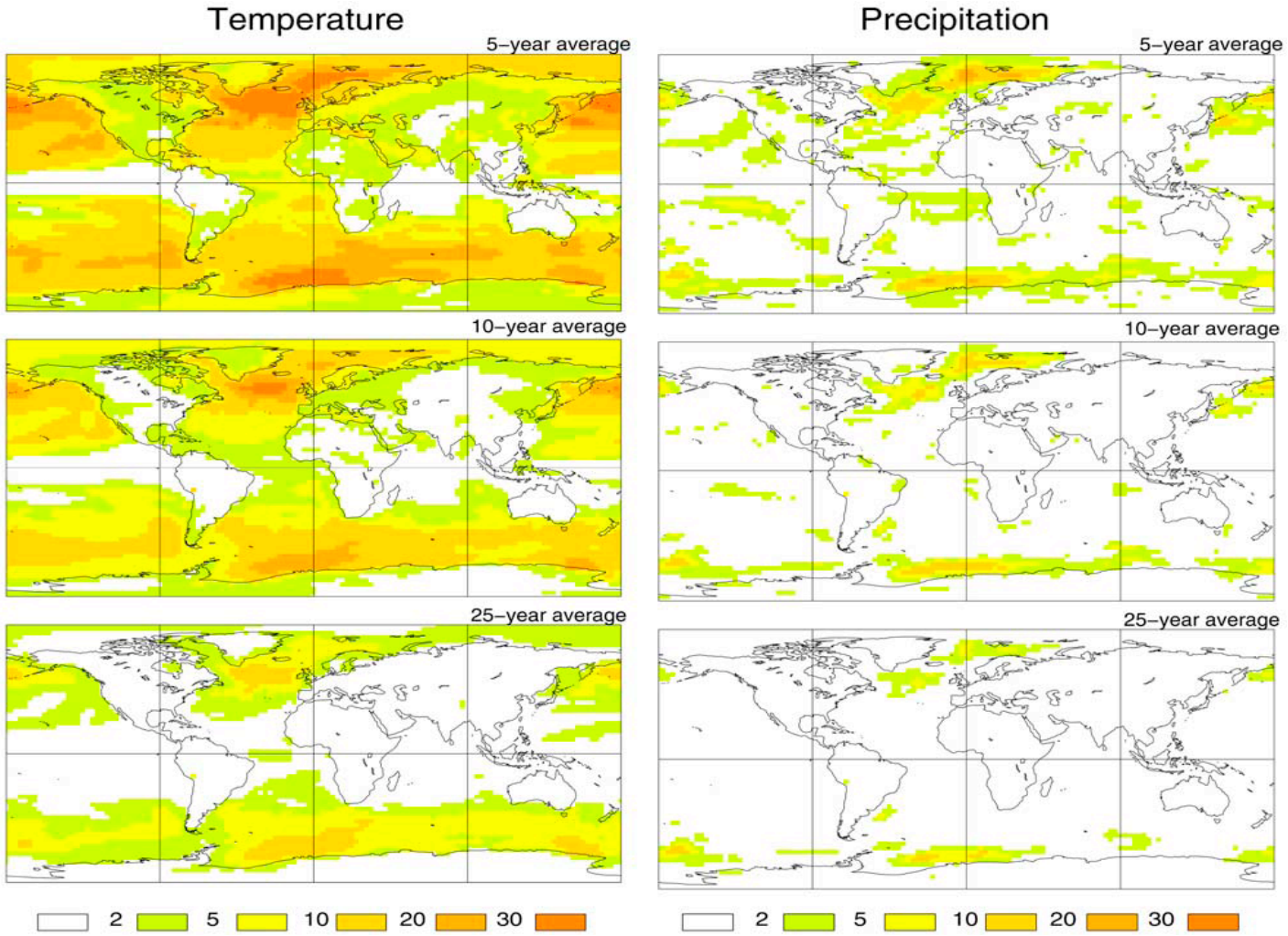
Detection of Multi-year Regional Predictability

Liwei Jia and Timothy DelSole

George Mason University

Motivation



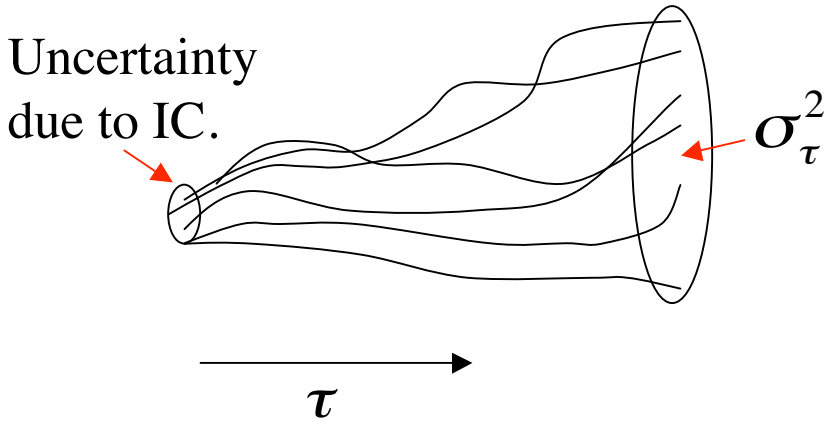
- Long-term predictability over oceans.
- Little predic. over land.
- Maximum predic. over land?

Potential predictability of temperature and precipitation.

Boer &Lambert, 2008, Geophys.Res. Lett.

Average Predictability Time (APT)

Predictability: A variable is predictable if its forecast distribution differs from the climatological distribution.



$$P = \frac{\sigma_{c\,\mathrm{lim}}^2 - \sigma_{forecast}^2}{\sigma_{c\,\mathrm{lim}}^2}$$

$$APT = 2\sum_{\tau=1}^{\infty} \frac{\sigma_{c\,\mathrm{lim}}^2 - \sigma_{forecast}^2}{\sigma_{c\,\mathrm{lim}}^2} = 2\sum_{\tau=1}^{\infty} P$$

Optimize APT

Find projection of the data that maximizes APT. Solution:

$$\left(2\sum_{\tau=1}^{\infty}(\Sigma_{c\,\mathrm{lim}} - \Sigma_{forecast})\right)q = \lambda\Sigma_{c\,\mathrm{lim}}q$$

- Eigenvalue gives the APT value.
- Time series of a single component is $q^T x$
- Each component with physical pattern $p = \Sigma_{c\,\mathrm{lim}}q$
- Resulting in a complete, uncorrelated set of components, ordered by their contribution to APT.

How to calculate APT with one ensemble member ?

- Project data onto M principle components $x(t)$.
- Construct a linear regression model

$$x(t+\tau) = L_\tau x(t) + \varepsilon(t)$$

- The forecast variance is calculated from standard regression formula

$$\Sigma_f = \Sigma_c - L_\tau \Sigma_c L_\tau^T$$

where Σ_c is the covariance matrix of $x(t)$

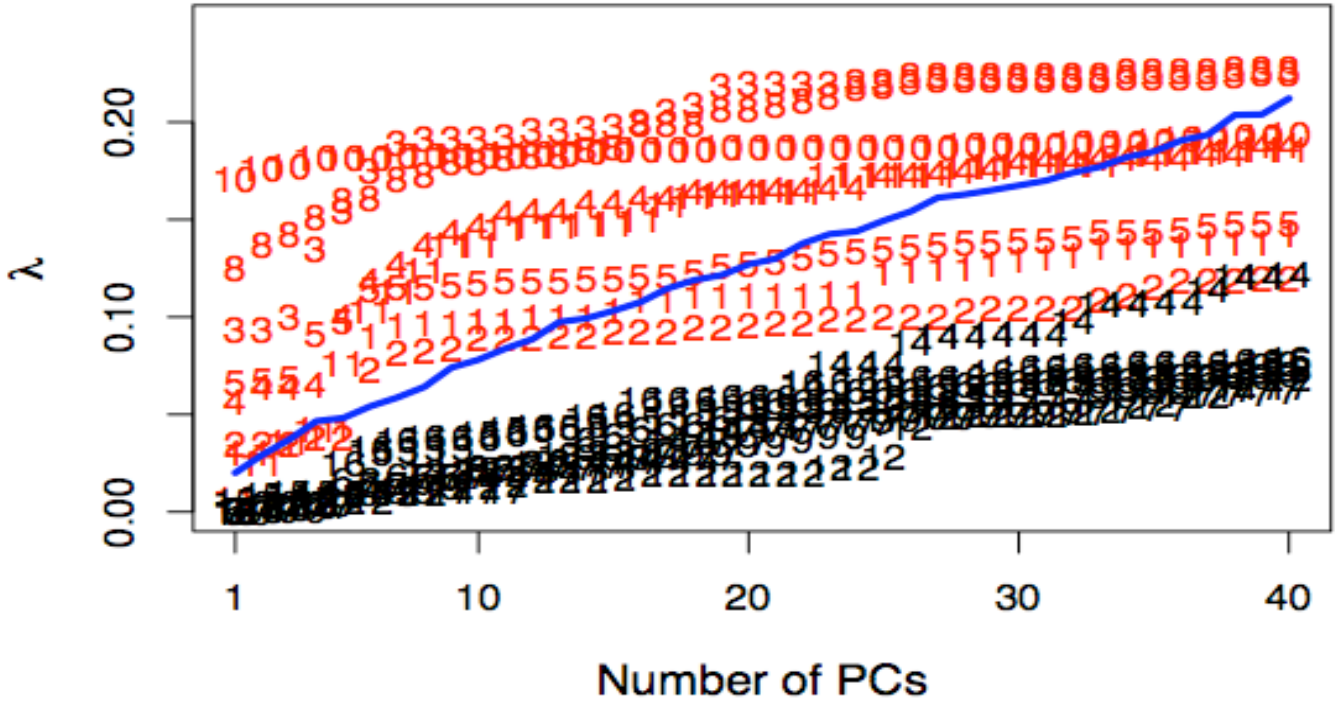
- Optimize APT using Σ_f and Σ_c .

Model data

- Output of IPCC/AR4/CMIP3 control runs.
- Selecting models based on trend and variance.
- Model grids are interpolated into common grid (72 x 36).

- Last 300 years of annual mean SAT and precipitation.
- First half data are training data, 2nd half are verification data.
- Selected model runs are pooled to create a multi-model data.
- 30 PC truncation, 20-year maximum lag.
- APT is applied to six individual continents.

Selecting models



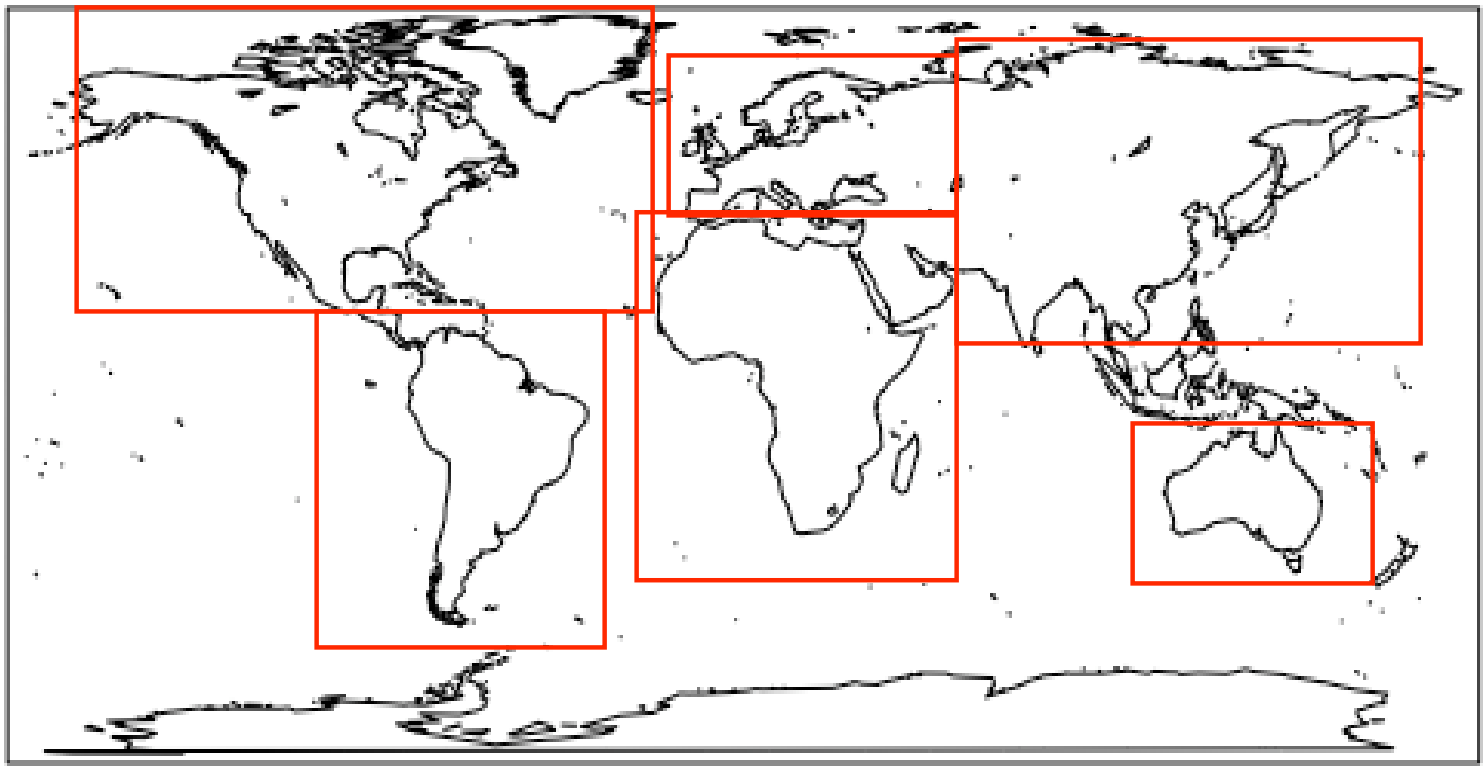
Fraction of variance explained by linear trend of global land SAT. Each number represents a particular model.

- Model GISS-ER model is omitted due to little variance.

Selected models

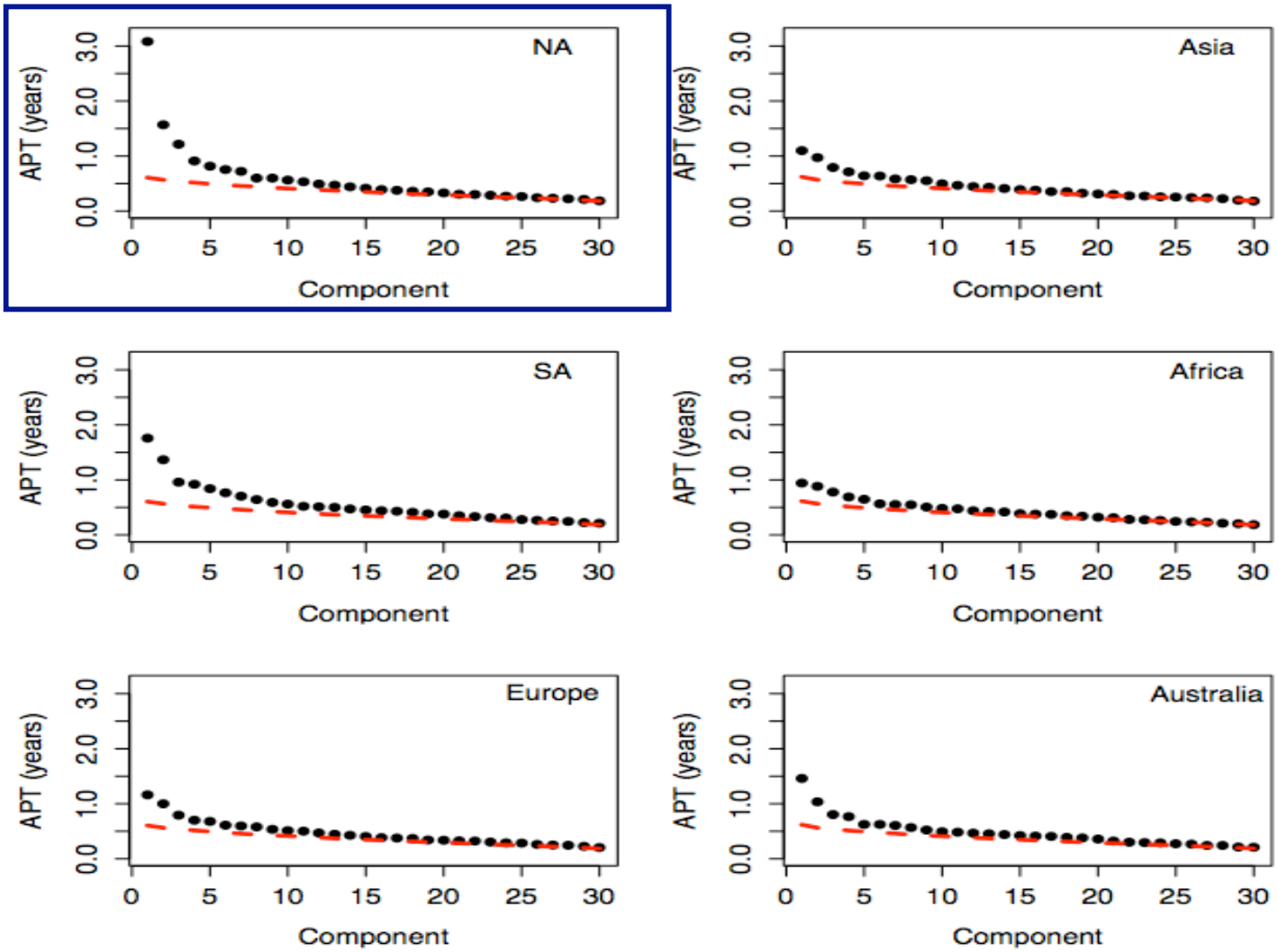
Model Name	Institute/Country
1. GFDL-CM2.0	(GFDL,USA)
2. GFDL-CM2.1	(GFDL,USA)
3. IPSL-CM4	(France)
4. MIROC3.2(medres)	(Japan)
5. ECHO-G	(Germany/Korea)
6. MRI-CGCM2.3.2	(Japan)
7. CCSM3	(NCAR,USA)
8. UKMO-HadCM3	(UK)

Domain of six continents



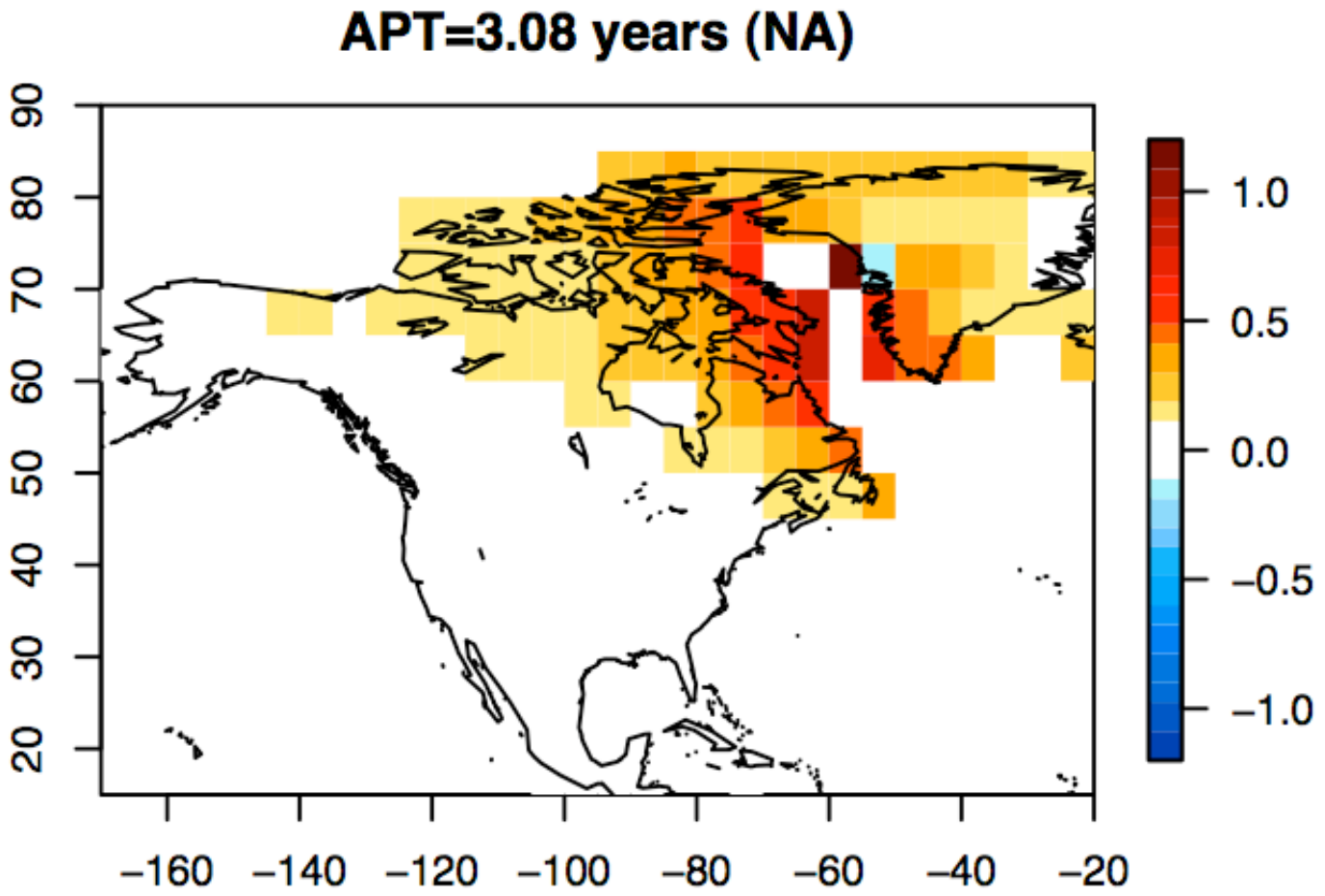
APT analysis of SAT

APT values of SAT in six continents

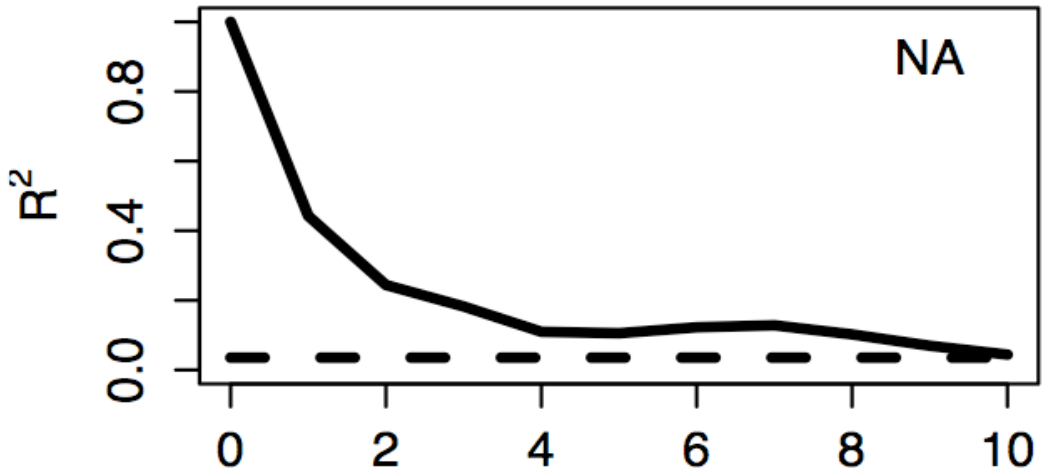


- First 5 or so are significantly different from white noise (predictable).
- Largest APT values are found in North America.

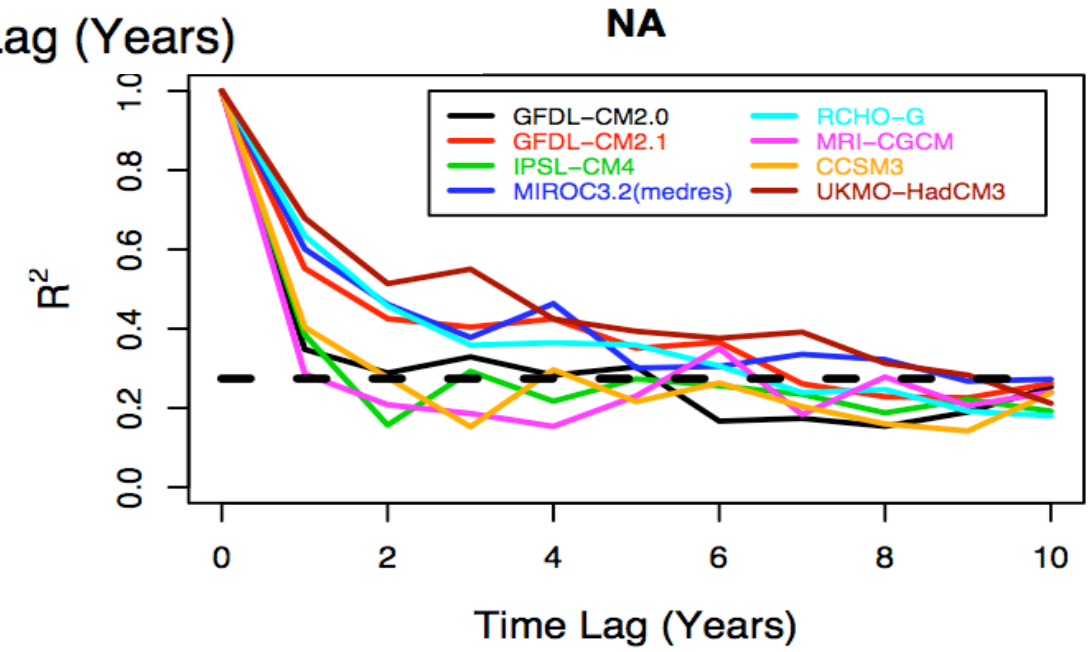
Spatial pattern of the first component (C1)



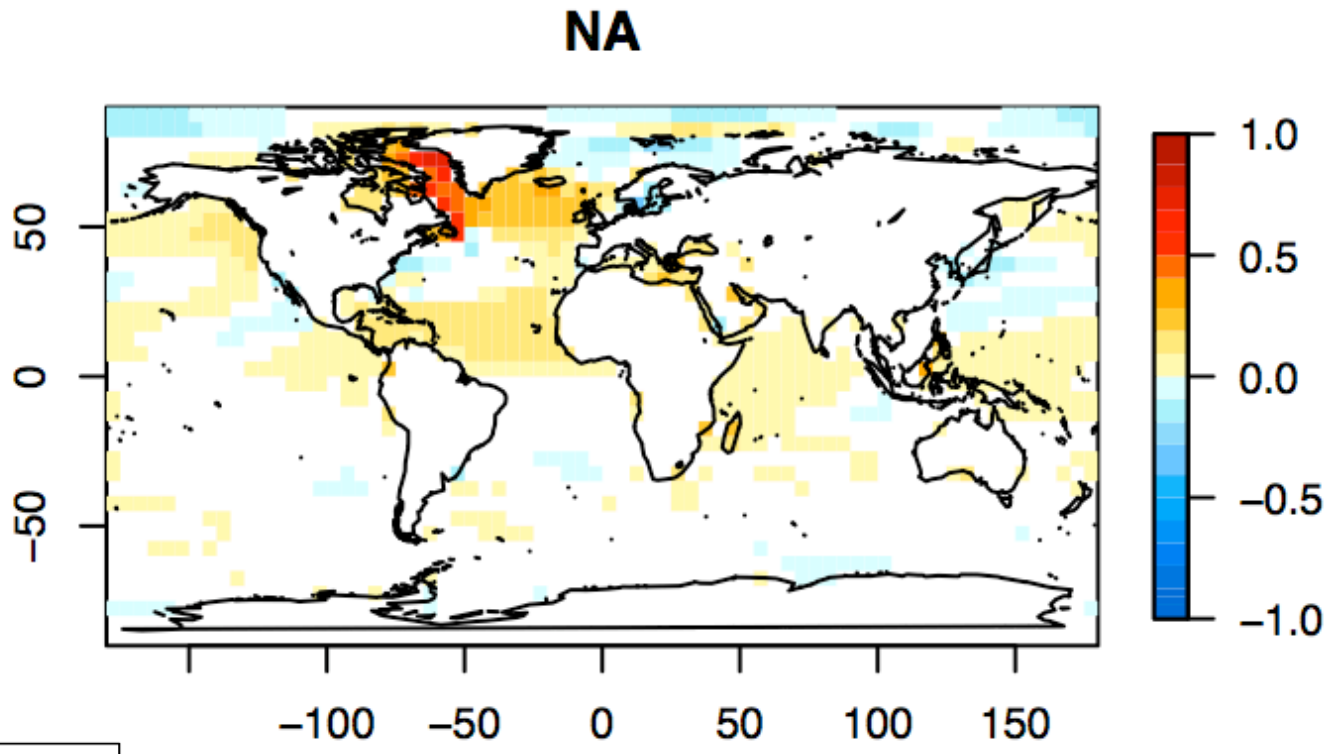
Multiple correlation of C1 in NA

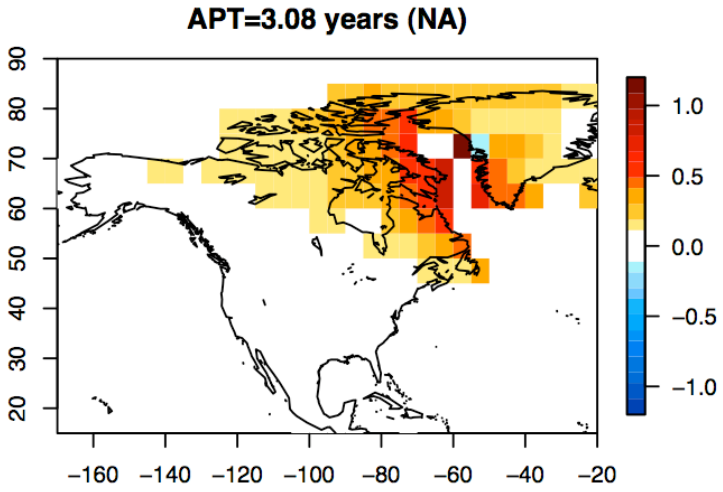


$$APT = 2\sum_{\tau=1}^{\infty} R_{\tau}^{2}$$

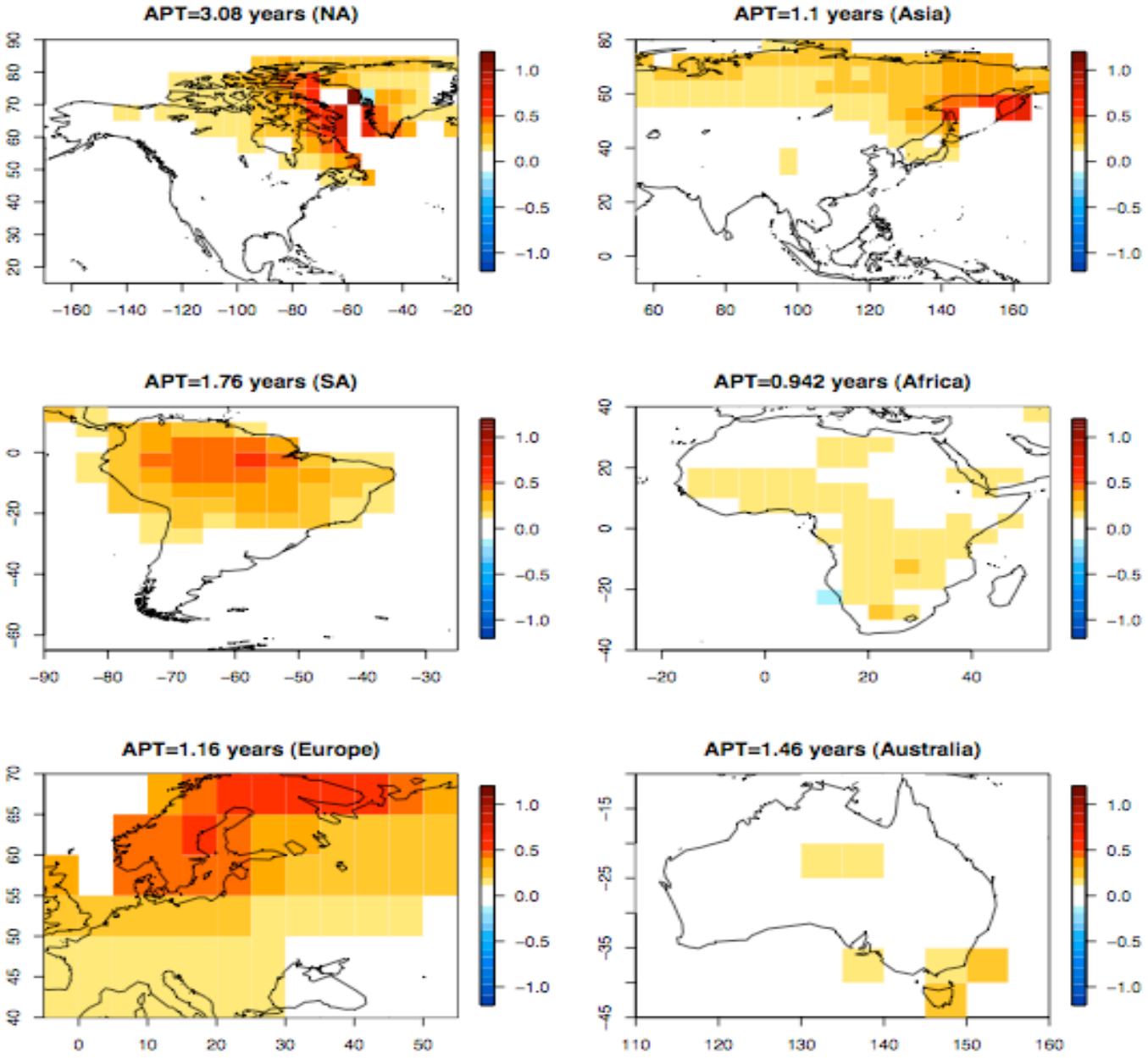


Correlation pattern of SST with SAT in NA

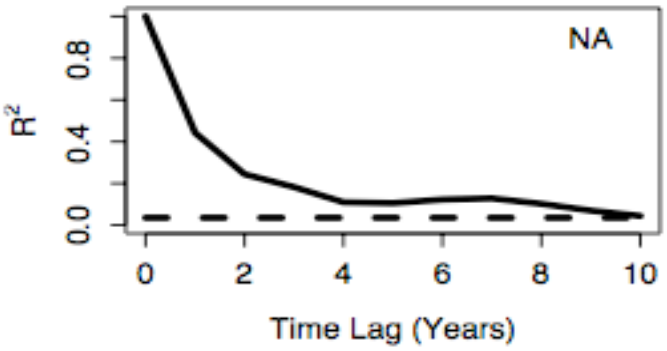


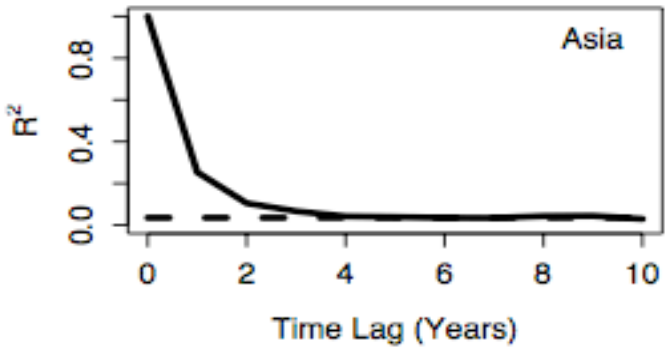


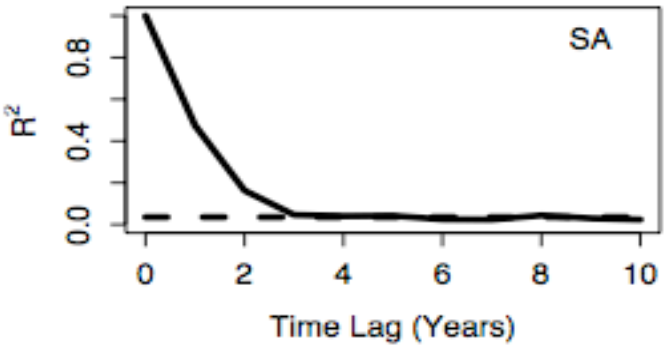
Spatial pattern of C1 in each continent

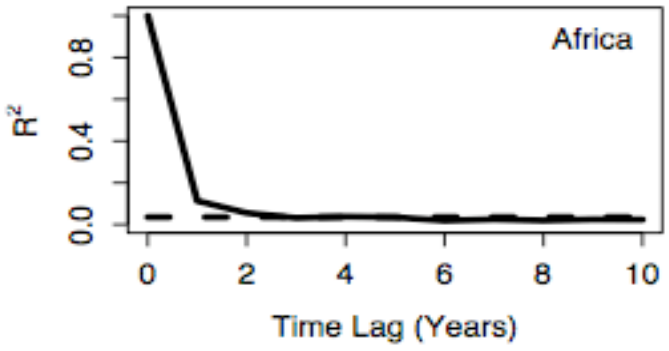


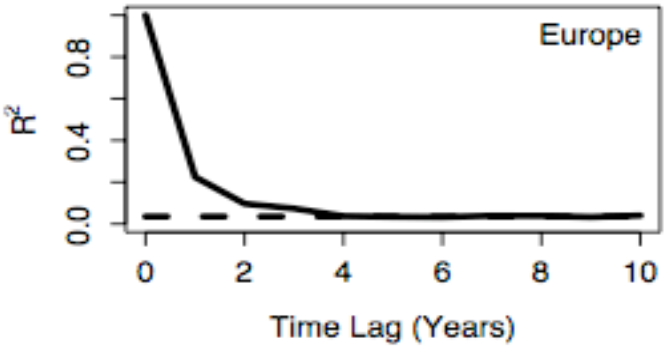
Squared multiple correlation of C1

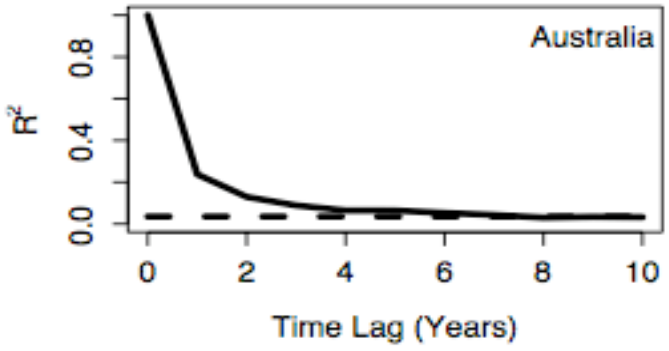




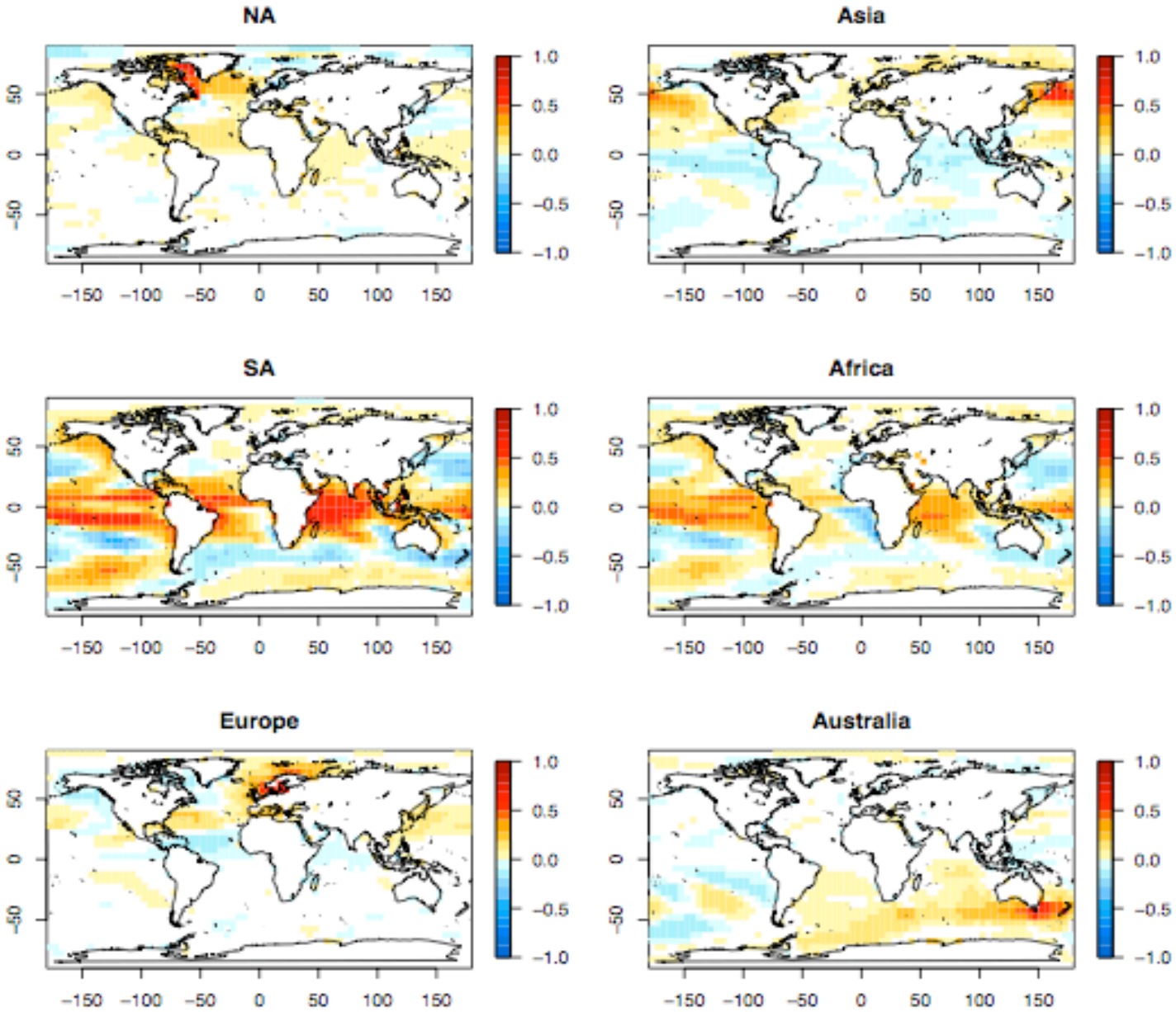






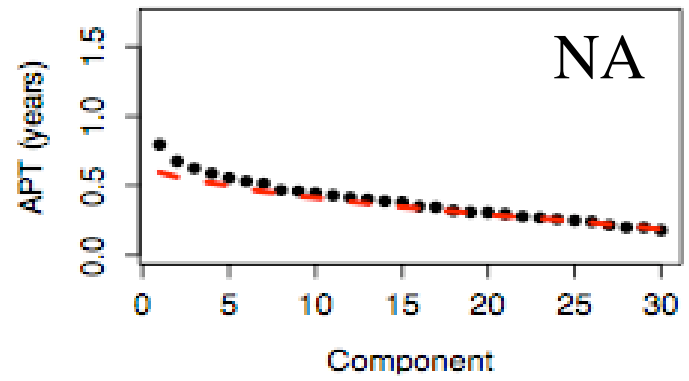


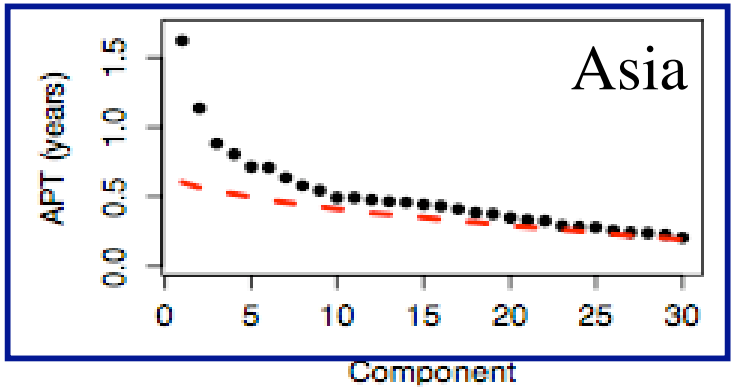
Correlation Pattern of SST with C1 of SAT

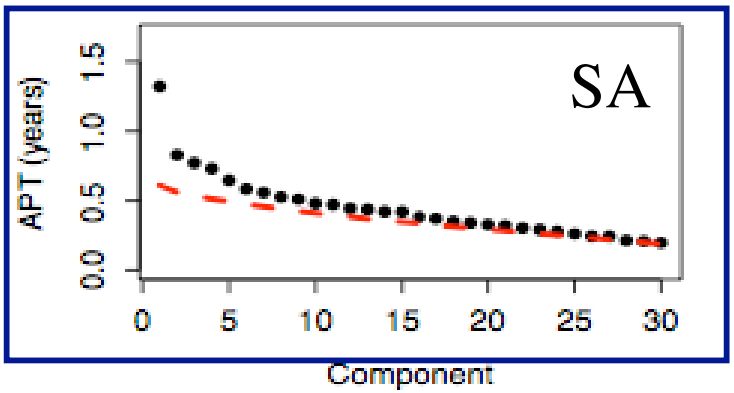


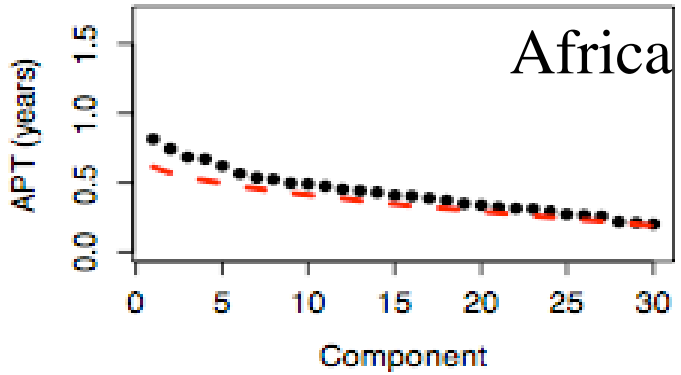
APT analysis of precipitation

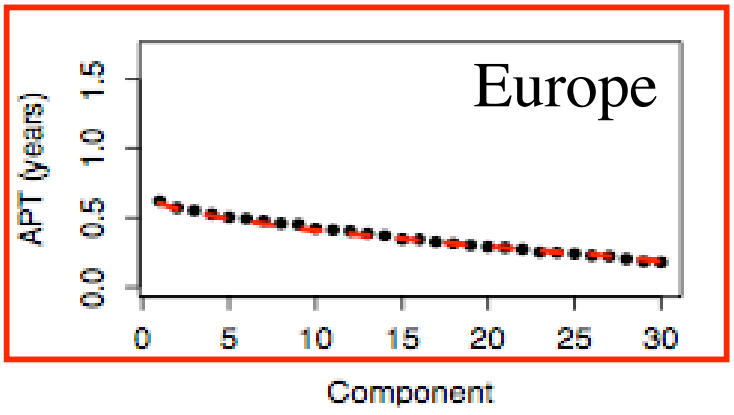
APT of precipitation in 6 continents

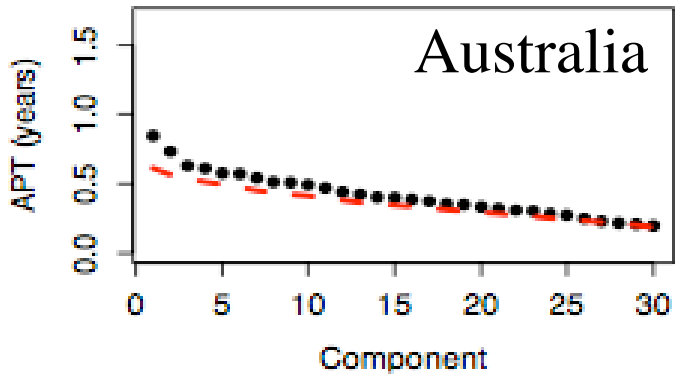




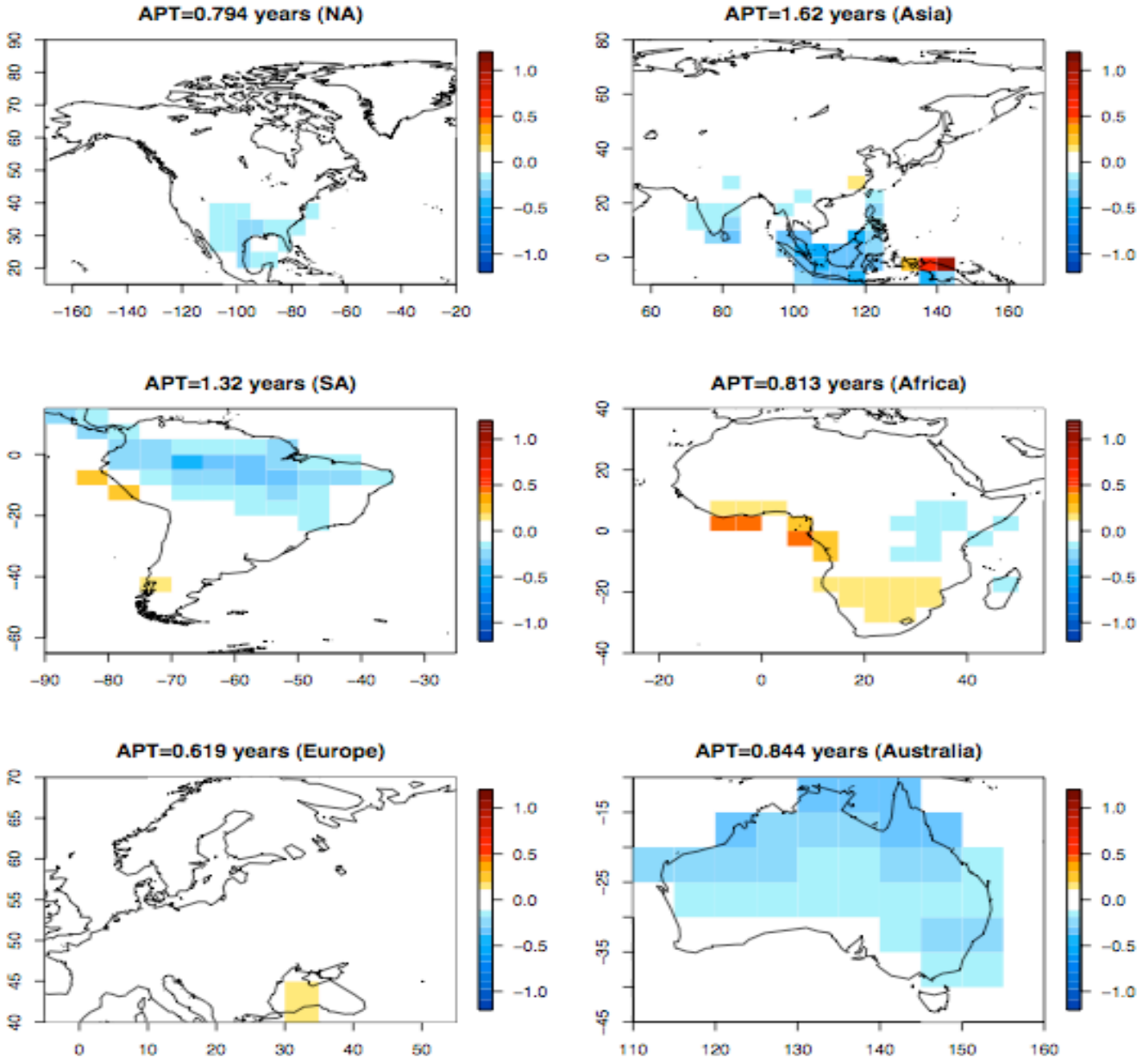




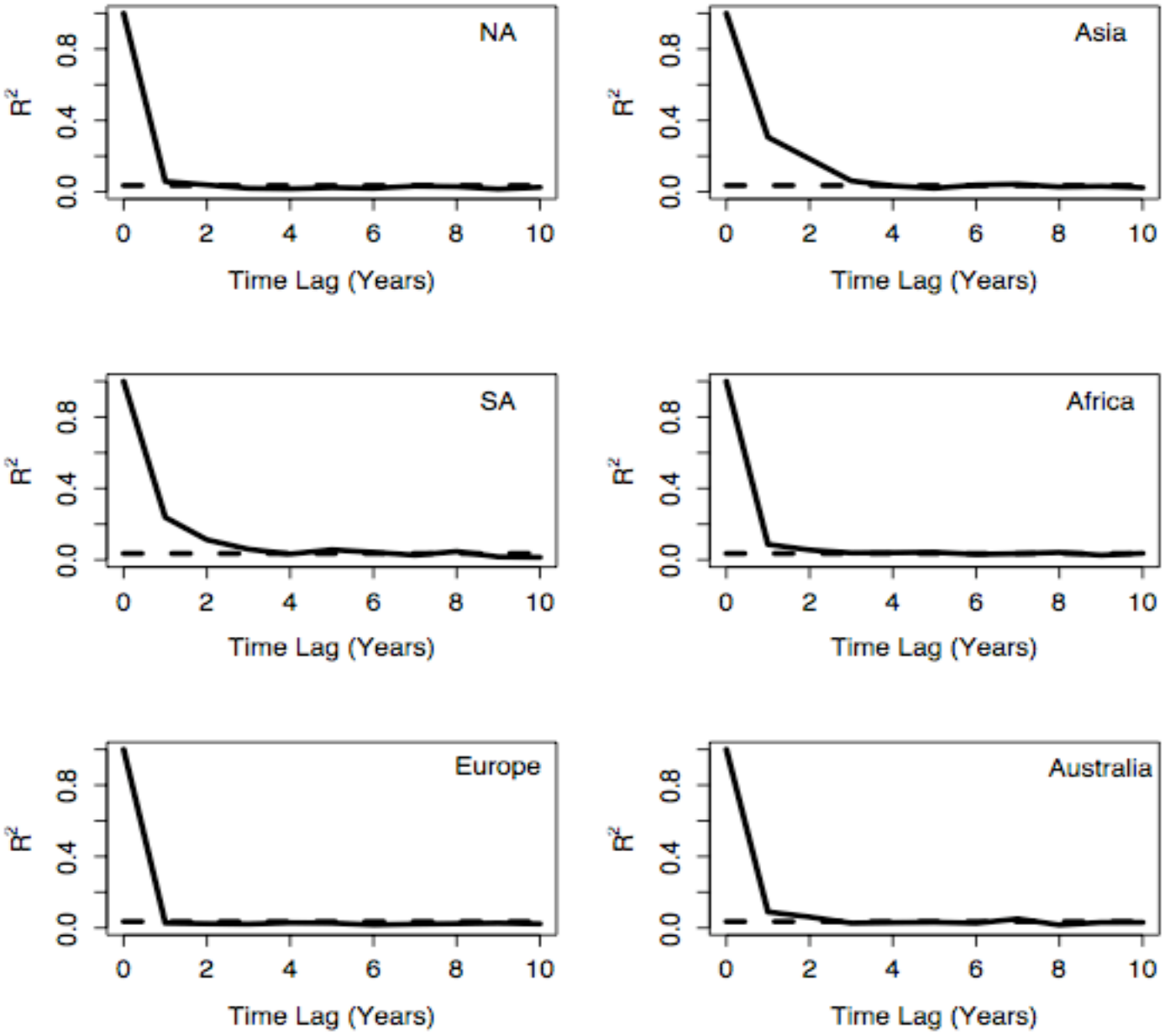




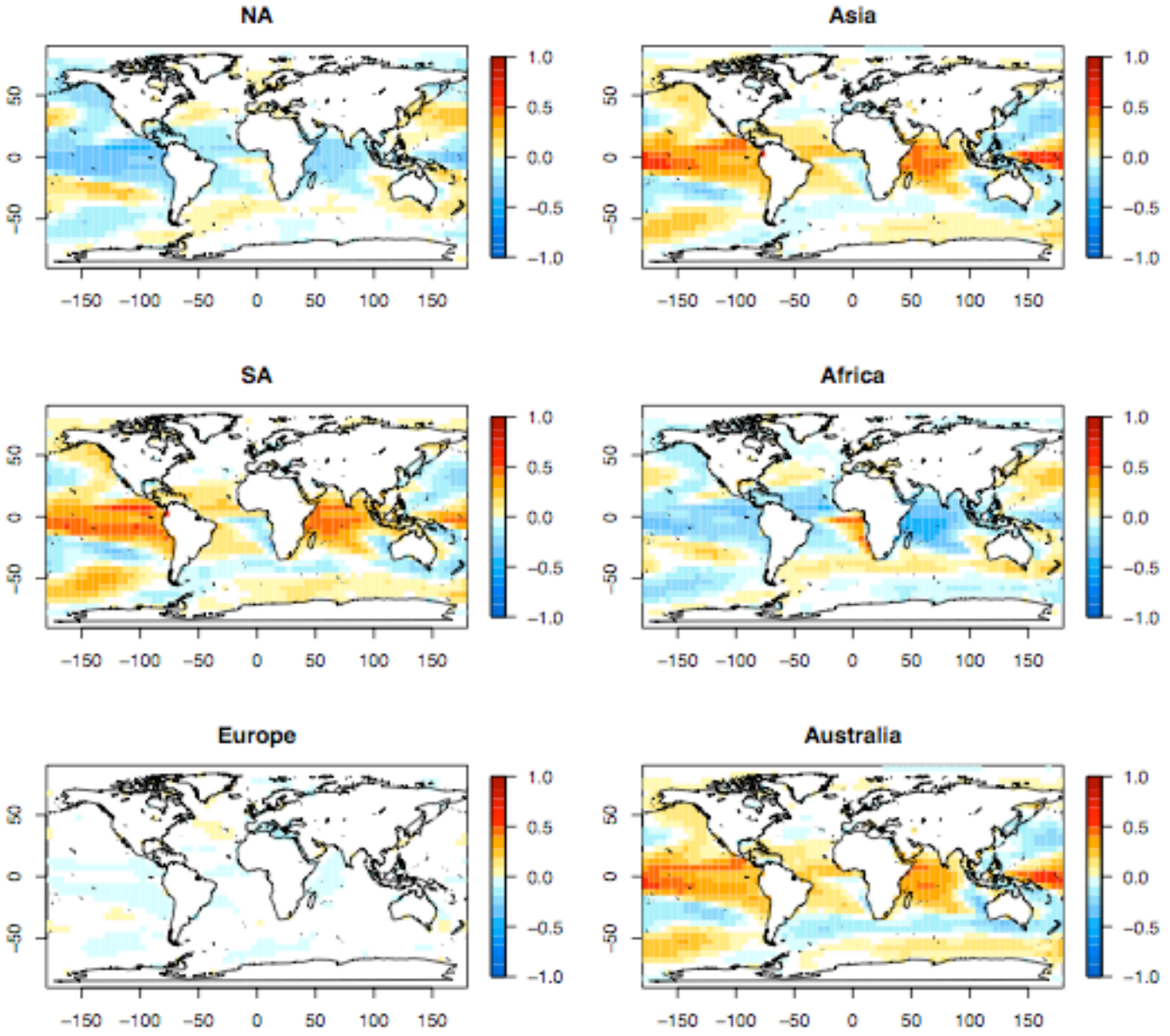
Spatial pattern of C1 of precipitation



Squared multiple correlation of C1



Corr. Pattern of SST with C1of precip.



Summary

- Applied a new method (APT) to detect optimal predictable components of regional SAT and precipitation.
- **Decadal predictability of SAT** in northeast of NA and Greenland and it is related to SST in North Atlantic.
- **Multi-year predic. of SAT** in other 5 continents.
- **Multi-year predic. of precip**. in 6 continents except in Europe and are ENSO-related.