The post-1984 step change in spring temperatures and spring onset in the Western U.S.A.: Proximal and distant drivers

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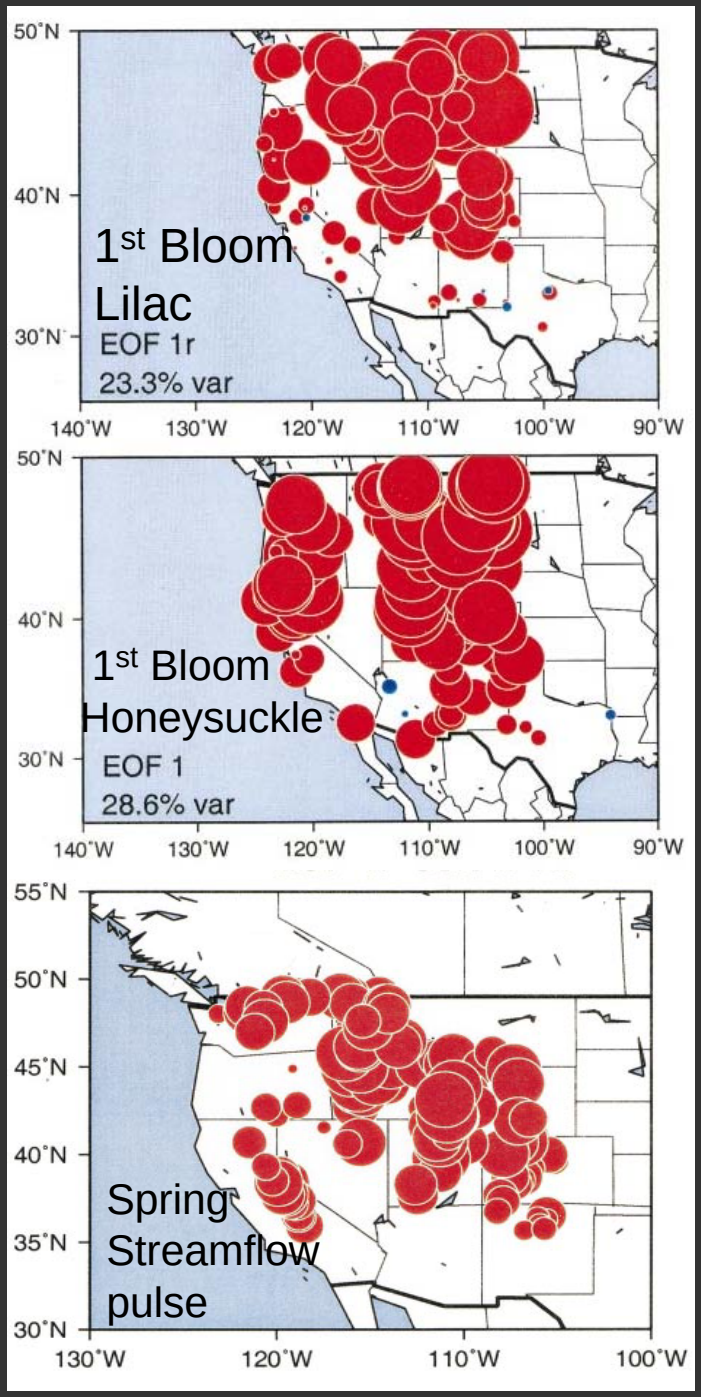
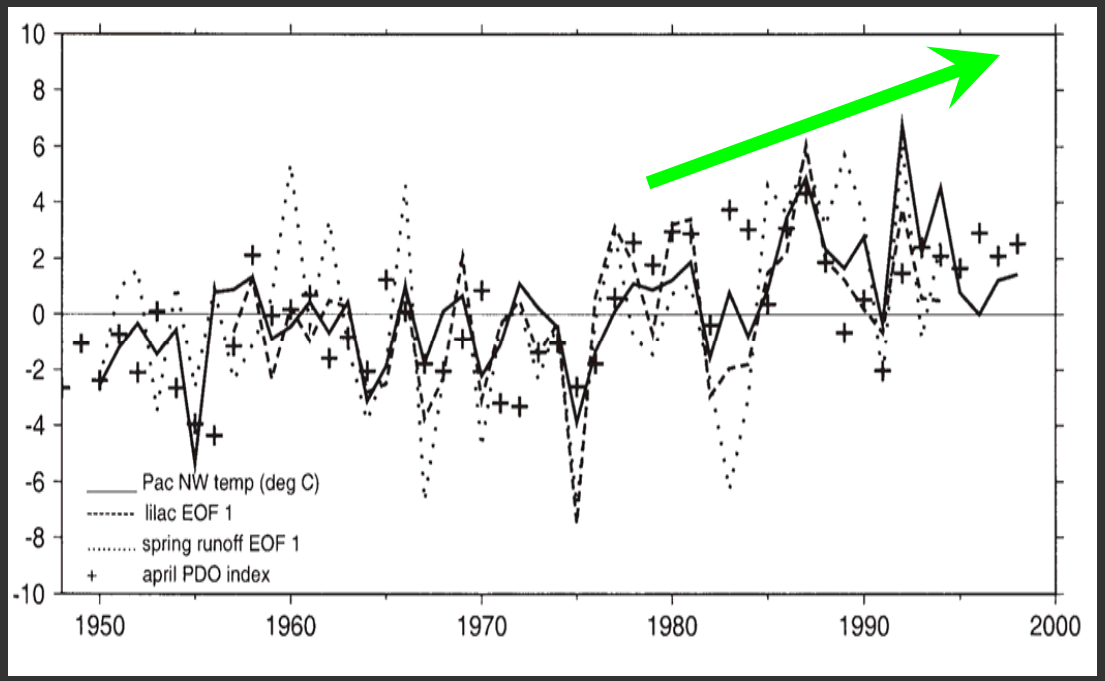


Cayan, D.R., Kammerdiener, S.A., Dettinger, M.D., Caprio, J.M. & Peterson, D.H., 2001: Changes in the onset of spring in the western United States. *Bull. Amer. Met. Soc.* 82: 399-415.



—— Pacific NW MAM temperature

------ Lilac EOF 1

..... Spring runoff EOF 1

\+ April PDO

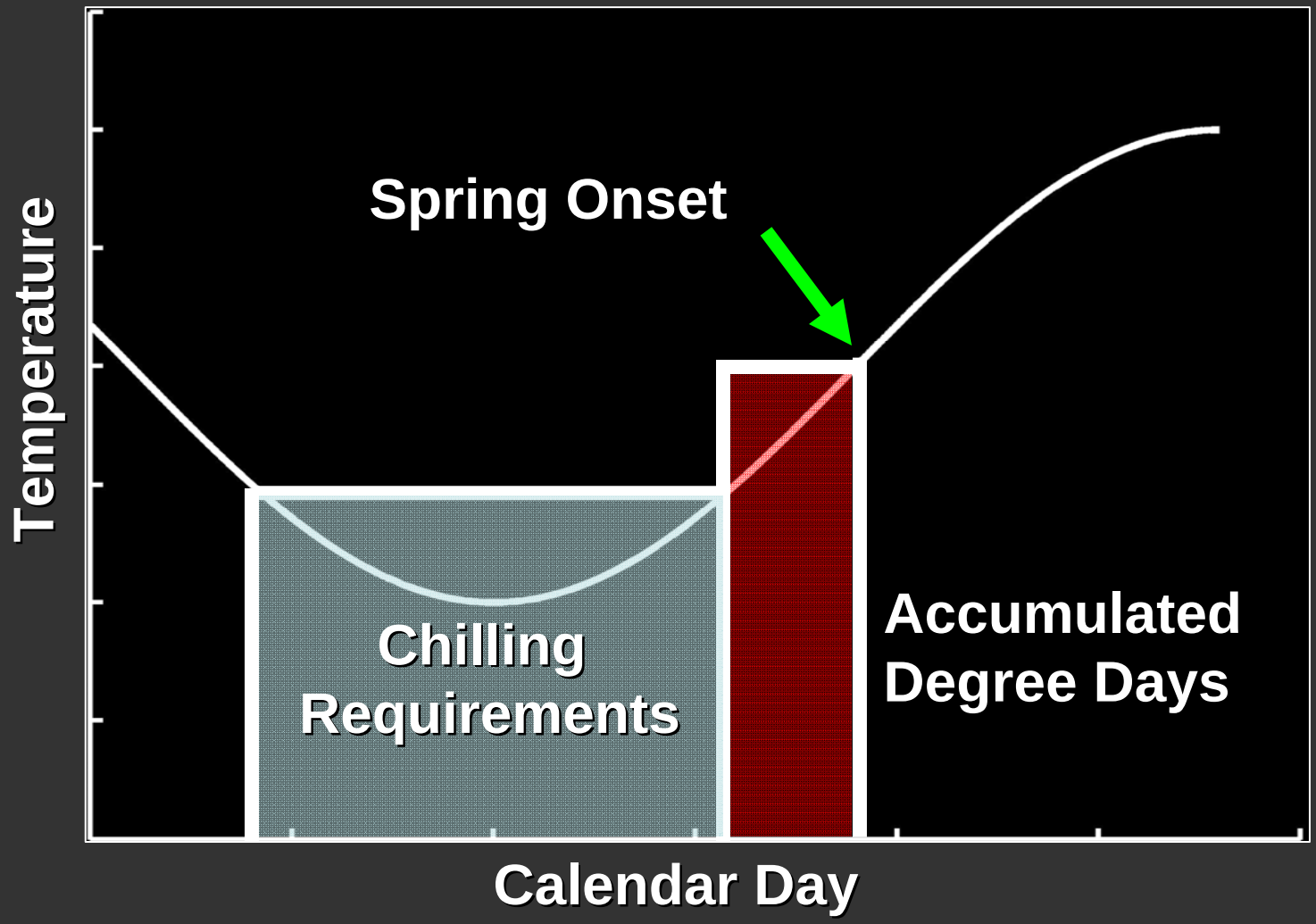
Phenological indices based on weather data and validated with lilac and honeysuckle observations made from 1957 to 2009

1. Can be generated at any location with daily max–min temperature time series, permitting broad scale analyses
2. Output is consistent over all areas, which may not be true for conventional data due to different species & event definitions

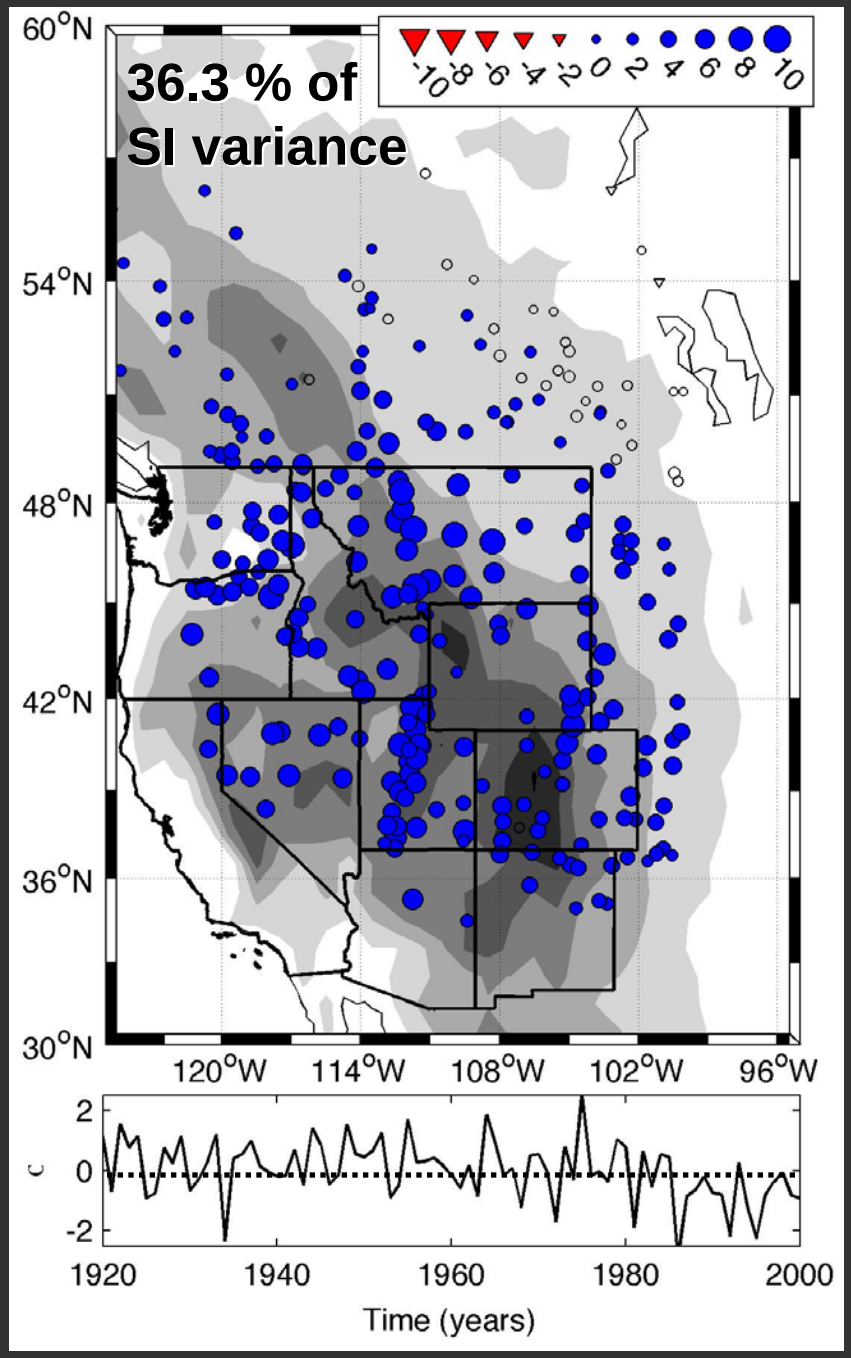
Schwartz, M. D., 1997: Spring Index Models: An Approach to Connecting Satellite and Surface Phenology. In *Phenology of Seasonal Climates*, H. Lieth and M. D. Schwartz, editors, pp. 23-38. Backhuys, Netherlands.

Schwartz, M. D., Ahas, R., & A. Aasa, 2006: Onset of Spring Starting Earlier Across the Northern Hemisphere. *Global Change Biology* 12: 343-351.

Spring Index

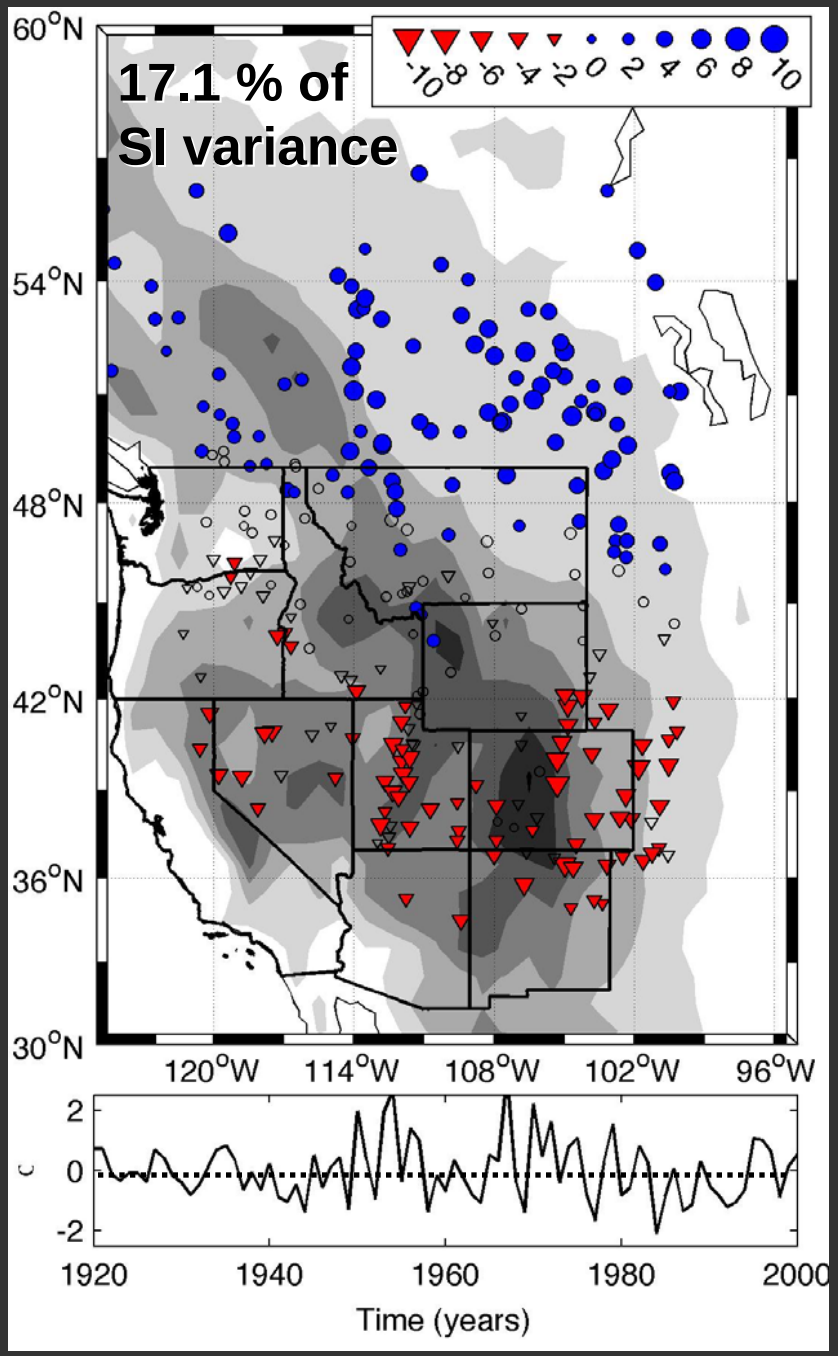


PCA on SI & then regressing PC1 onto original data



Ault, Macalady, Pederson, Betancourt & Schwartz (in review) *Quaternary International*

PCA on SI & then regressing PC2 onto original data



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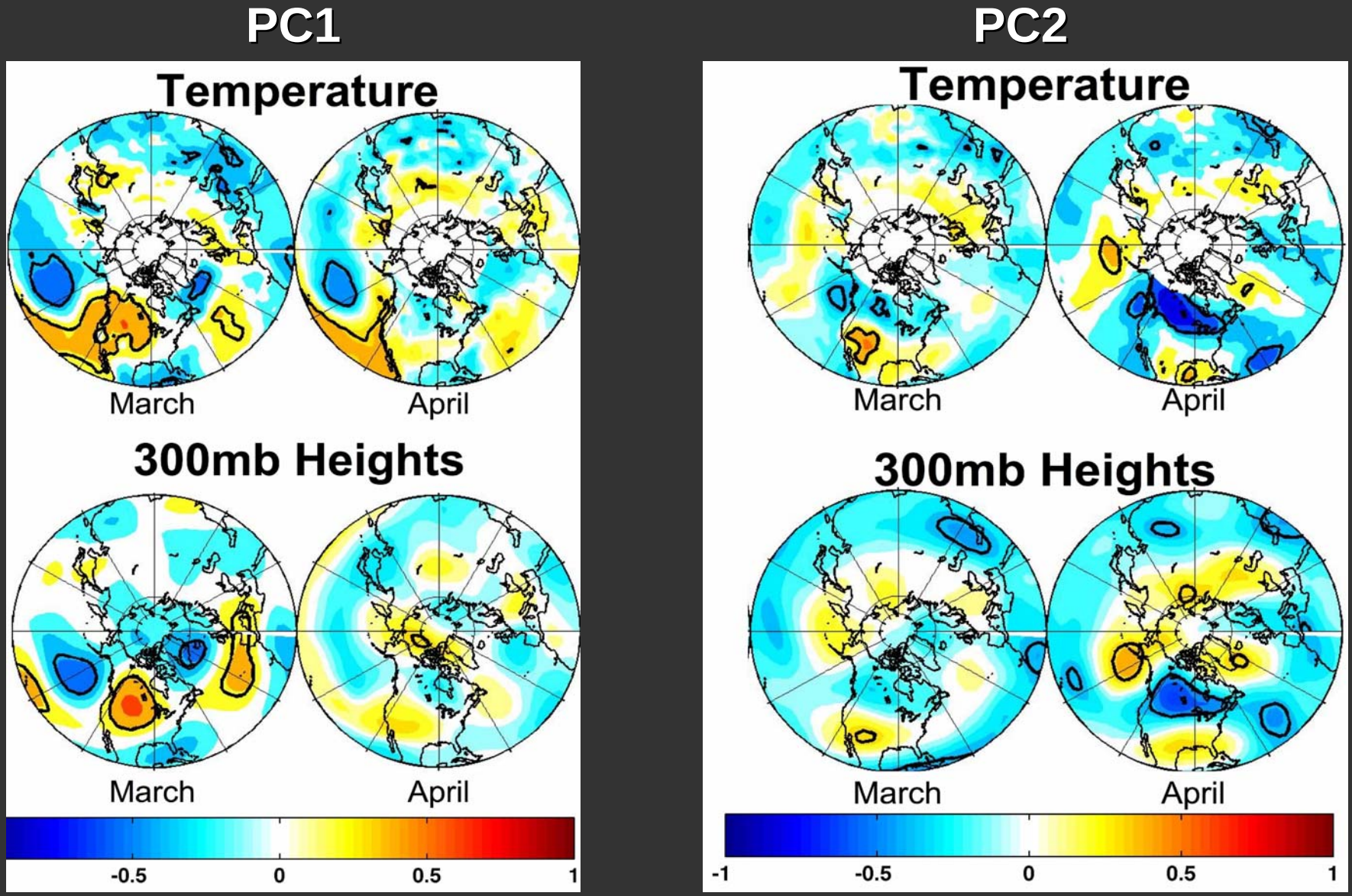
Correlations between PC1 and PC2 of SI with March and April temperature and 300mb geopotential heights



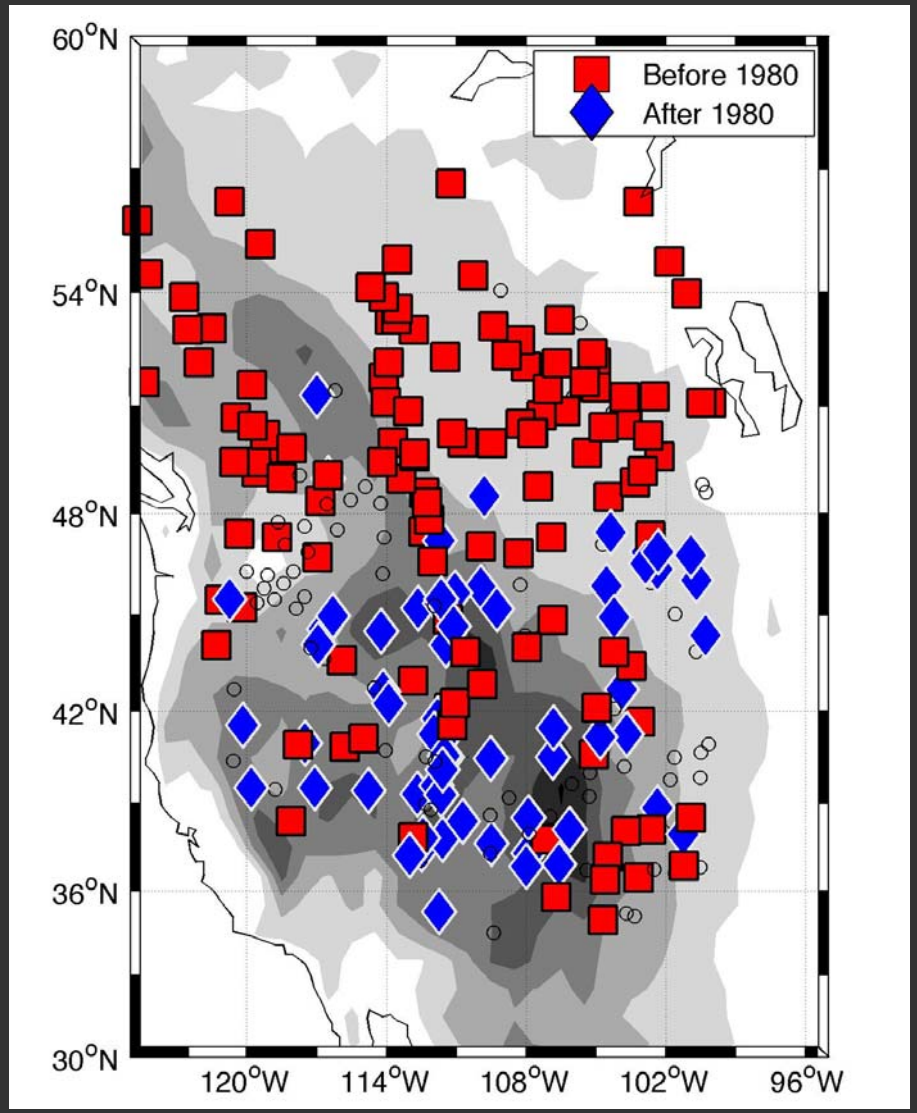
1. Spring onset in the West has two modes of spatial variability, one west-wide (PC1) & one a N-S dipole (PC2)

2. Influence shifts from March (PC1) to April (PC2)

3. Correlations of PC1 and PC2 with known climate modes may provide spring onset forecasting skill

4. How much of this is natural variability vs. climate change?

Changes in mean SI



before 1980

45° N

after 1980

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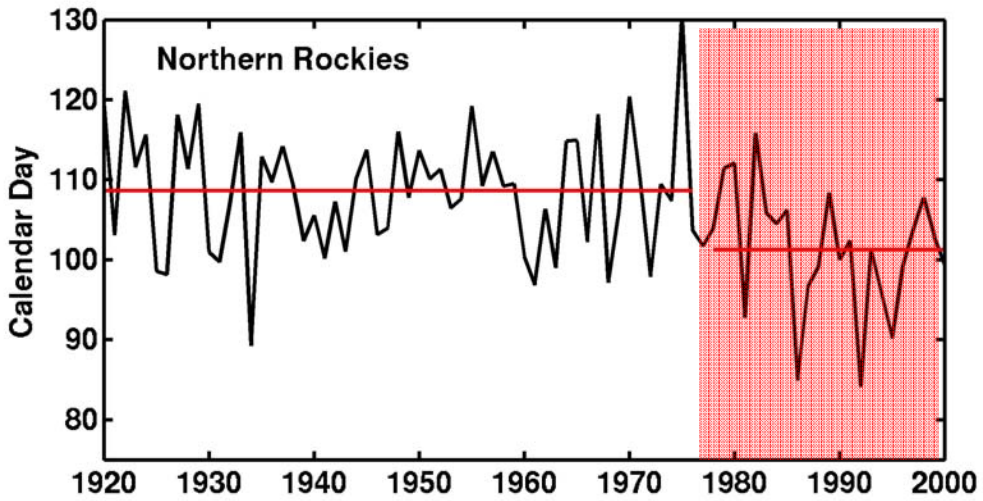
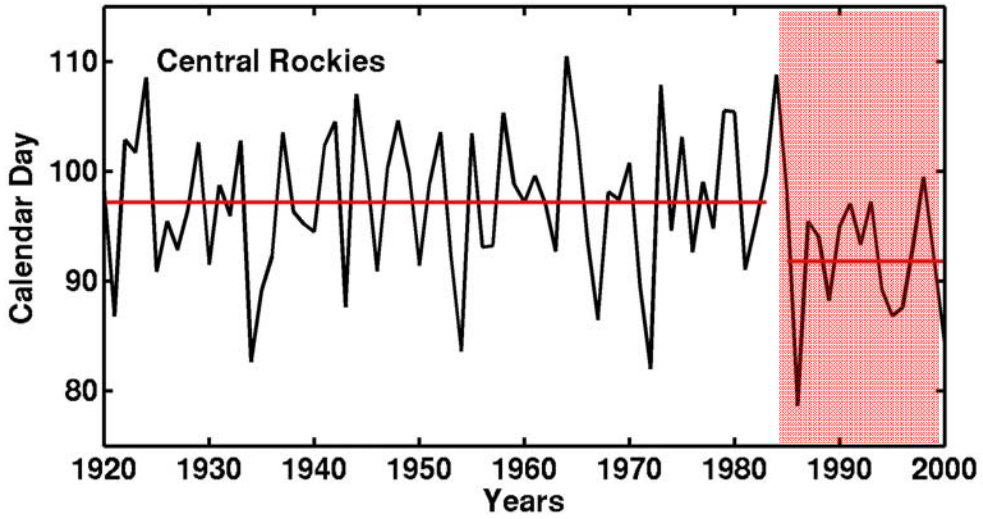
Spring Index



late spring

early spring

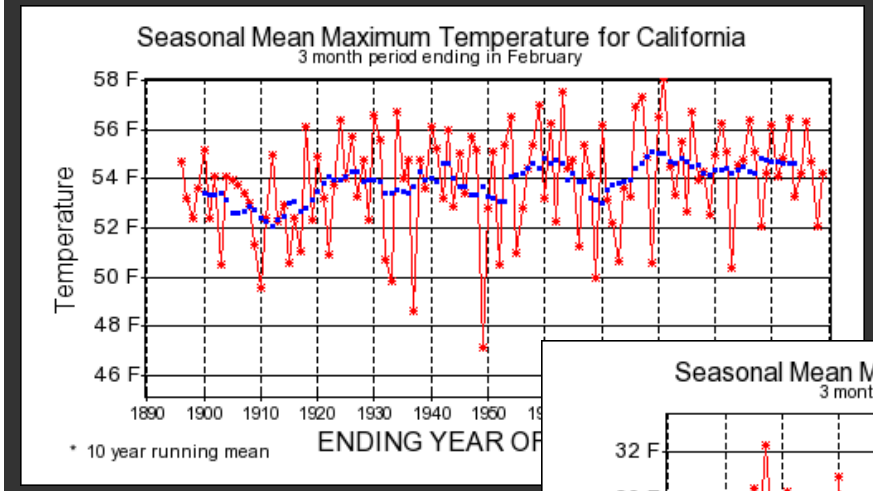


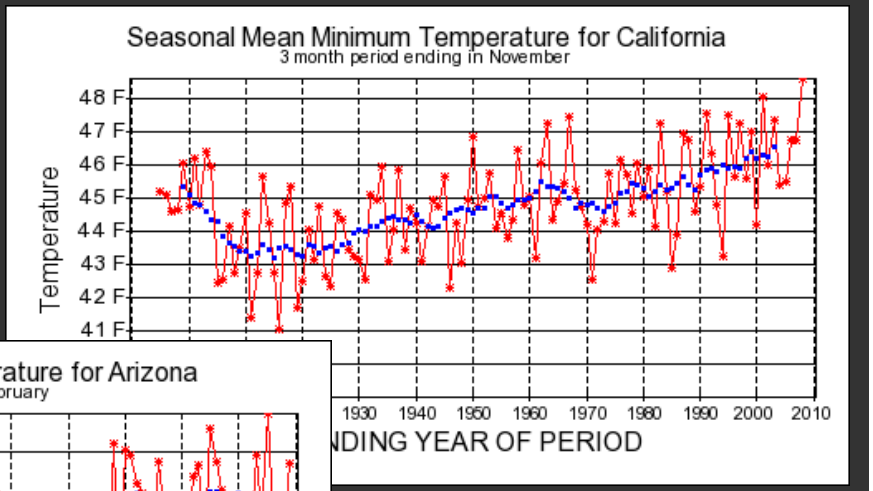
late spring

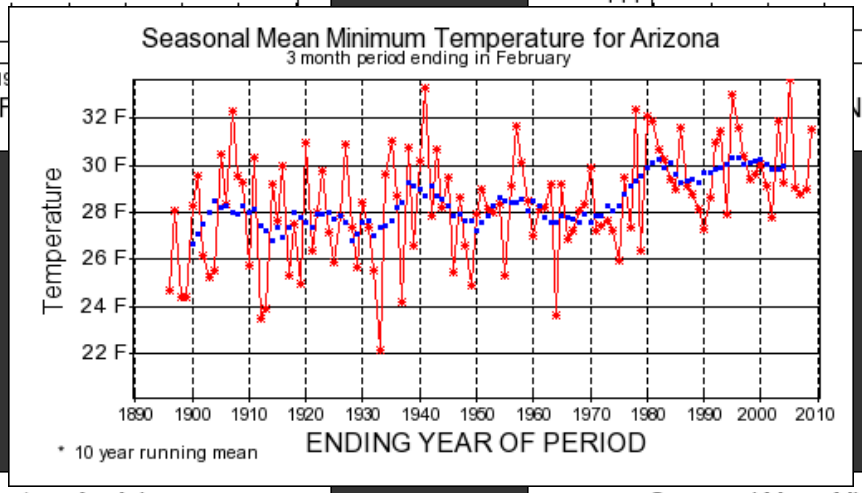
early spring

Ault, Macalady, Pederson, Betancourt & Schwartz (in review) *Quaternary International*

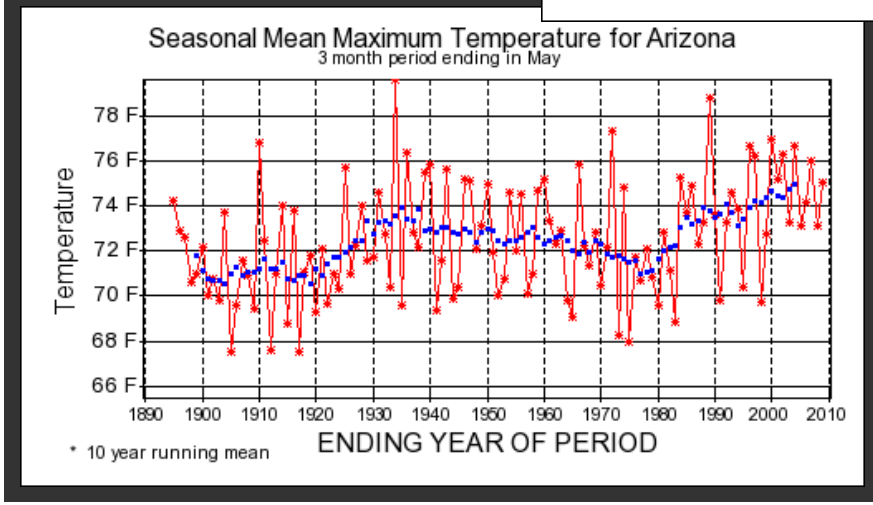
Seasonal mean maximum and minimum temperatures

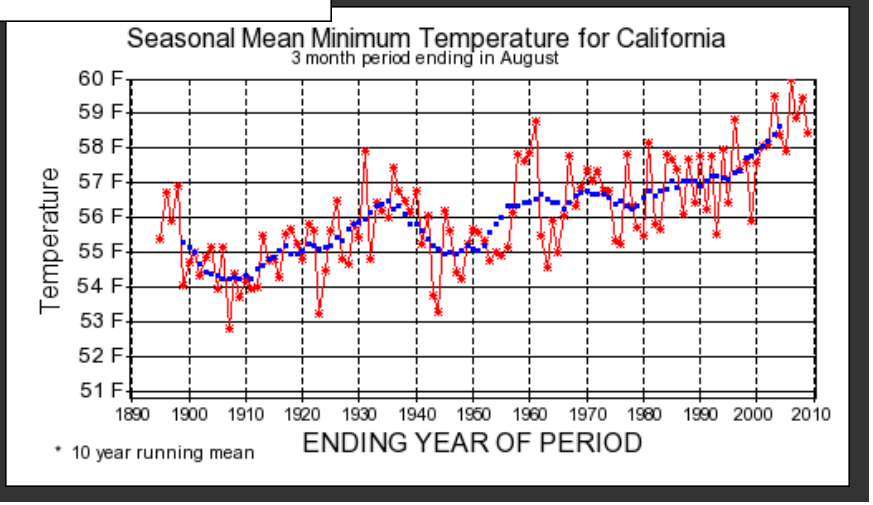




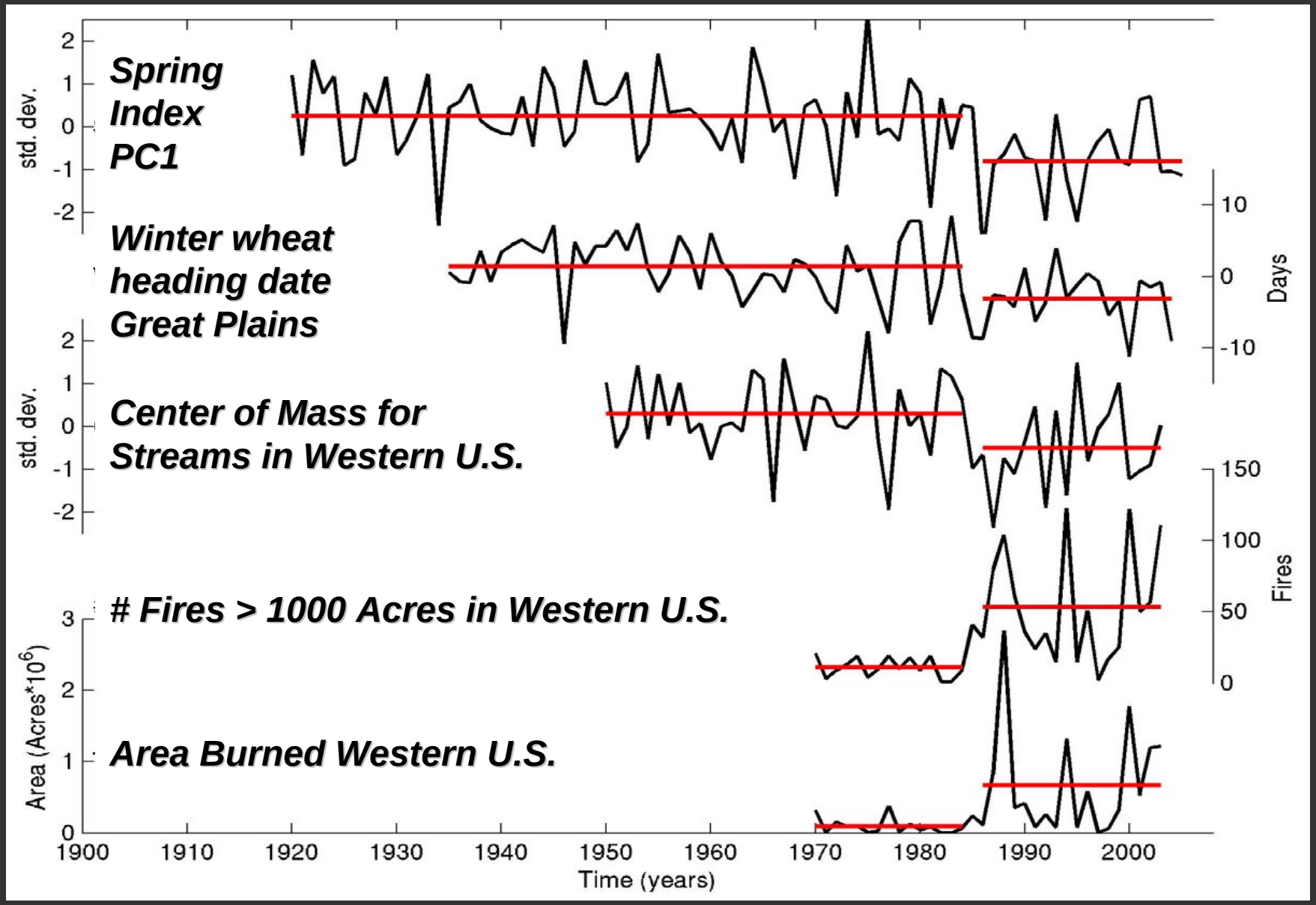


WestMap





Step (?) change in timing of spring onset, wheat headings, center of mass, fire frequency and area burned



1. Datasets must extend back past late-1970s and mid-1980s climate shifts to see most of spring advance

2. Climate has been, and will likely be, a bumpy ride

   - non-stationarity *AND* discontinuity

3. How much of this is natural variability vs. climate change?

4. Can we build institutional capacity to absorb climate shifts that drive significant impacts?