Climate model assessment of changes in winter-spring streamflow timing over North America

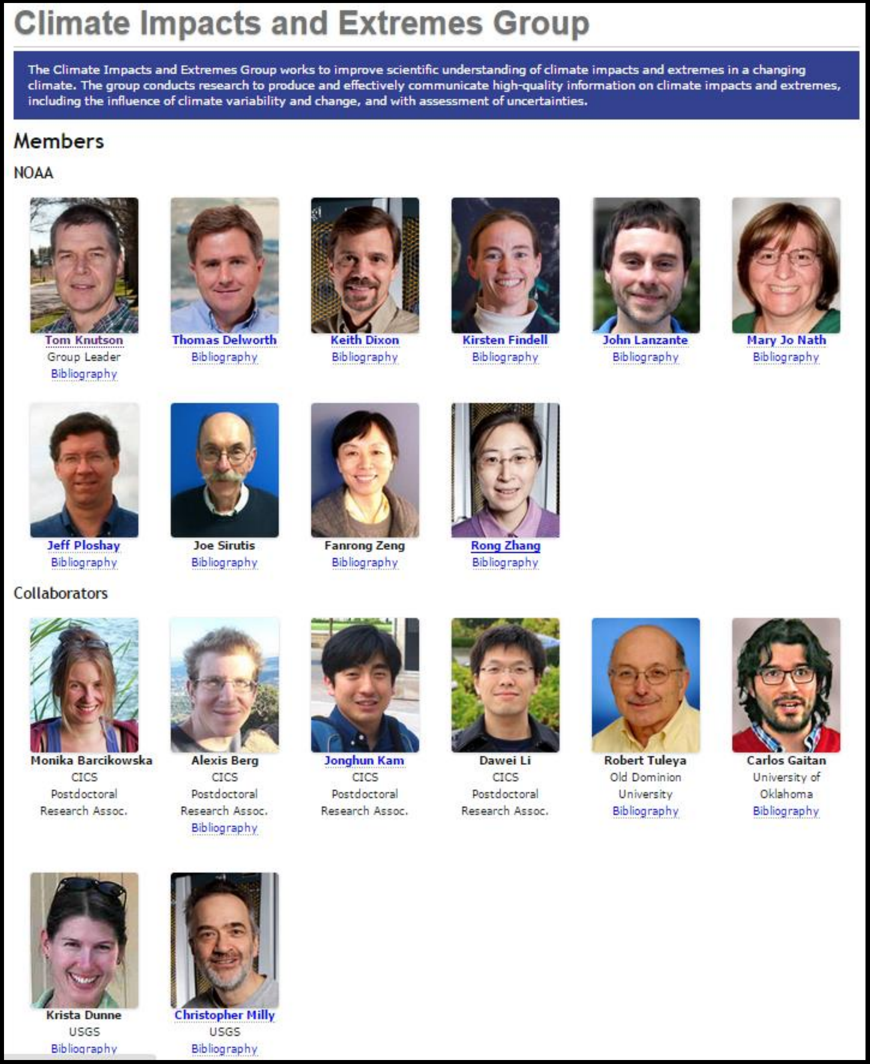
Jonghun Kam

Department of Civil, Construction, and Environmental Engineering,
The University of Alabama, Tuscaloosa

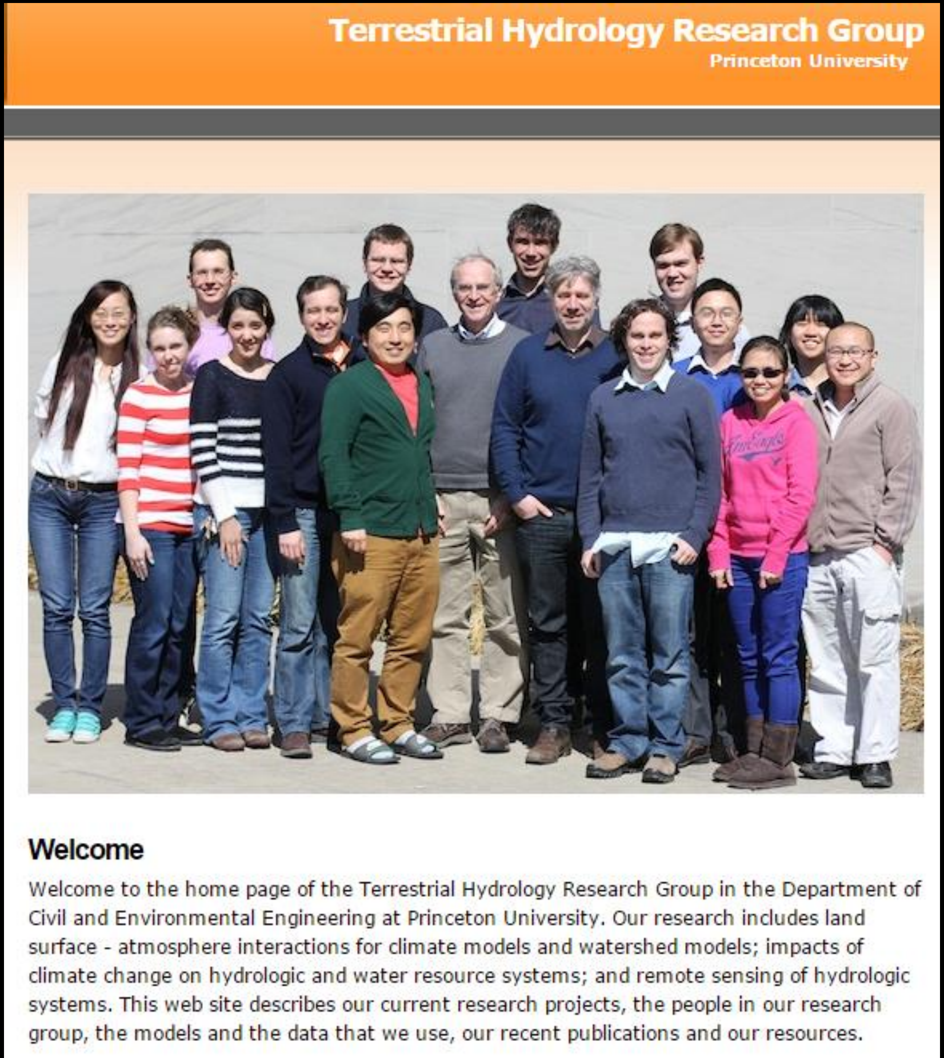
August 4, 2017

Short Biography

At GFDL/NOAA (Post-doc)



At Princeton U.(Ph.D)



Short Biography

At Tuscaloosa, AL

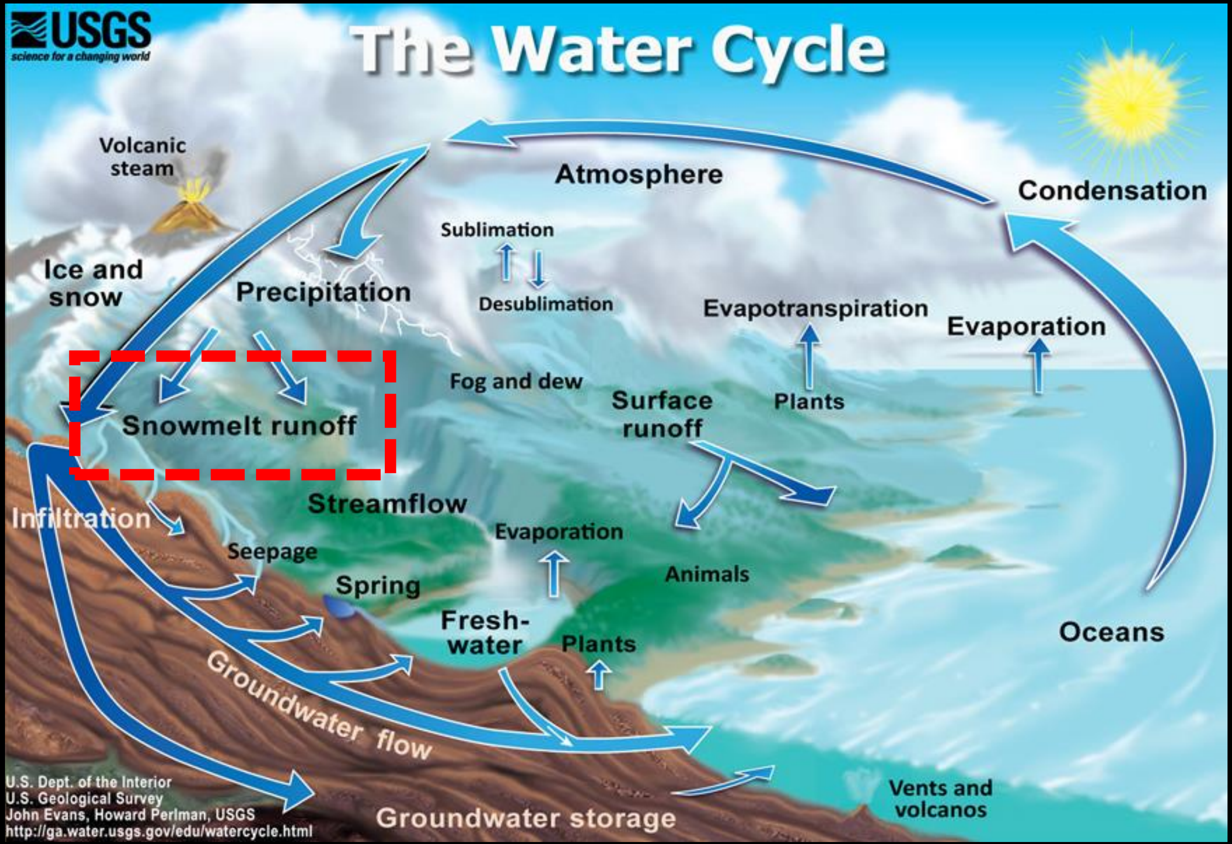
National Water Center/NOAA

2016 College Football Rankings - Week 11

AP Top 25

RK	TEAM	REC	PTS	TREND
1	Alabama (60)	9-0	1524	—
2	Michigan (1)	9-0	1432	—
3	Clemson	9-0	1408	—
4	Washington	9-0	1364	—
5	Louisville	8-1	1255	—

Global warming can change the hydrological cycle



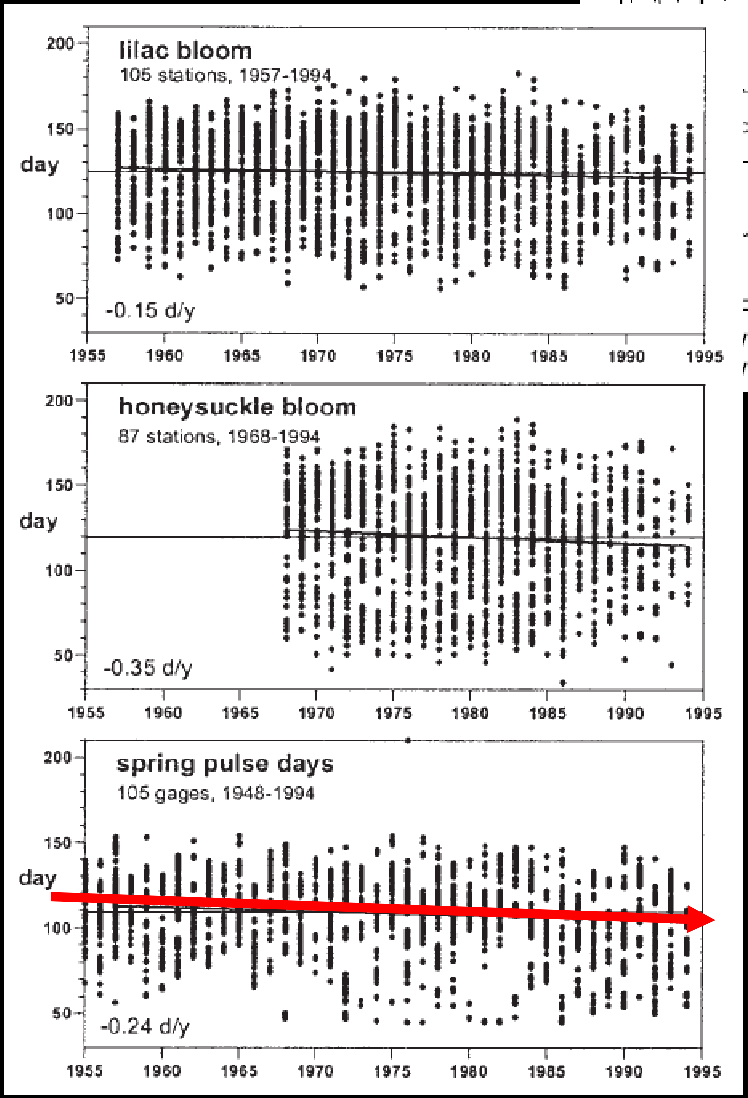
Over extratropical and mountainous regions,

- **Snowmelt runoff**
- Sensitive to surface temperature

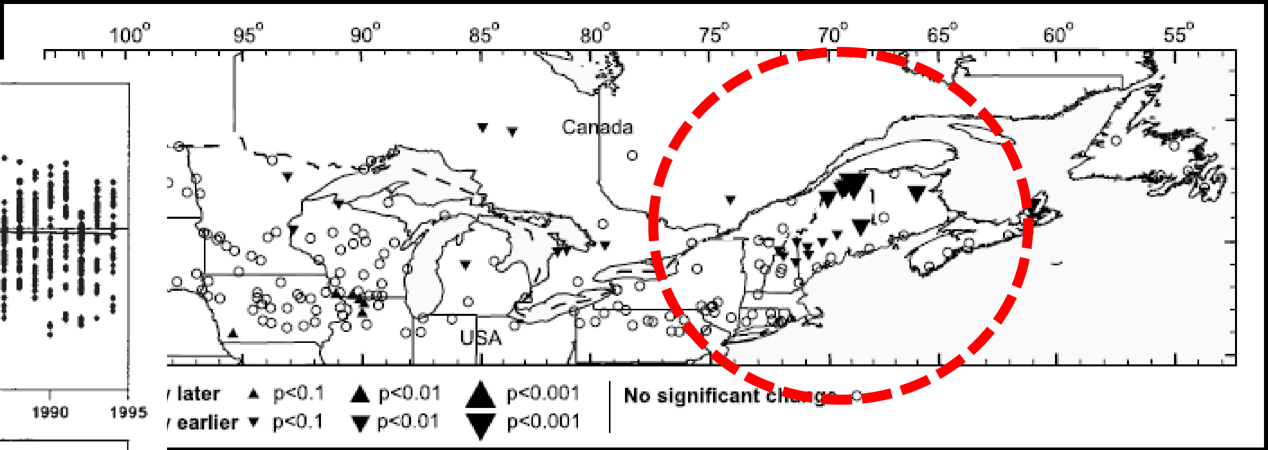
Impact of global warming,

- Increase winter-spring runoff due to early snow-melting processes
- Decrease summertime runoff due to lack of natural water storage
- Changes in peak streamflow timing

Changes in Timing of Winter-Spring Streamflows (1951-2000)



Cayan et al., BAMS, 2001



Hodgkins and Dudley, WRR, 2006

Over the U.S.,

- Advance the onset of spring
- Related to early snowmelt runoff
- Increase spring streamflows

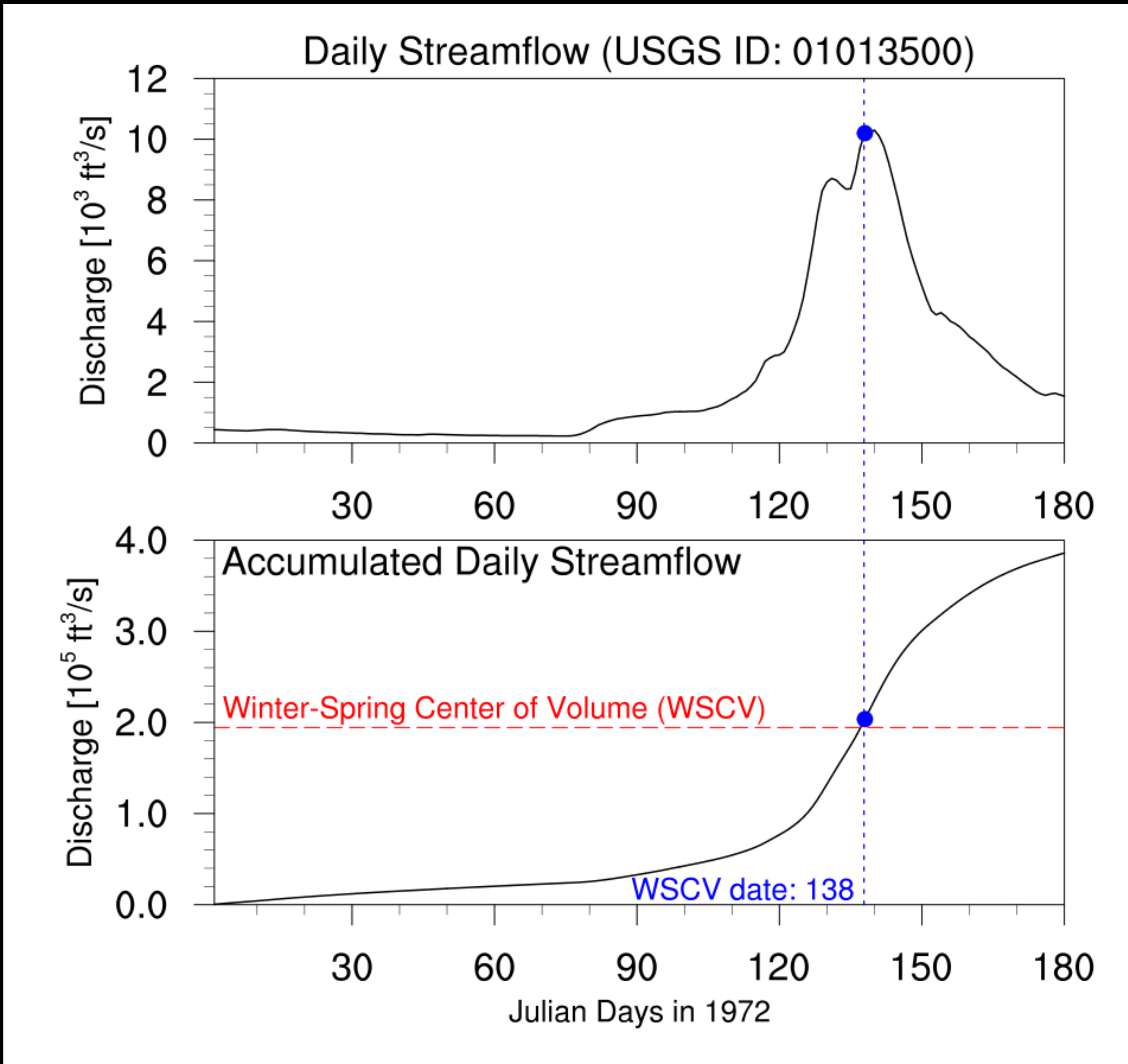
Adverse effects:

- Flash Flood (mid-winter ice jam)
- Drought (lack of natural water storage)
- Ecological impacts (salmon survival rate, blooming season)

1. Changes in timing of winter-spring streamflow over North America is still detectable?

2. What are key drivers of the changes in timing of spring-winter streamflow? Global warming or internal (multi-decadal) variability?

How to Define Timing of Winter-Spring Streamflows



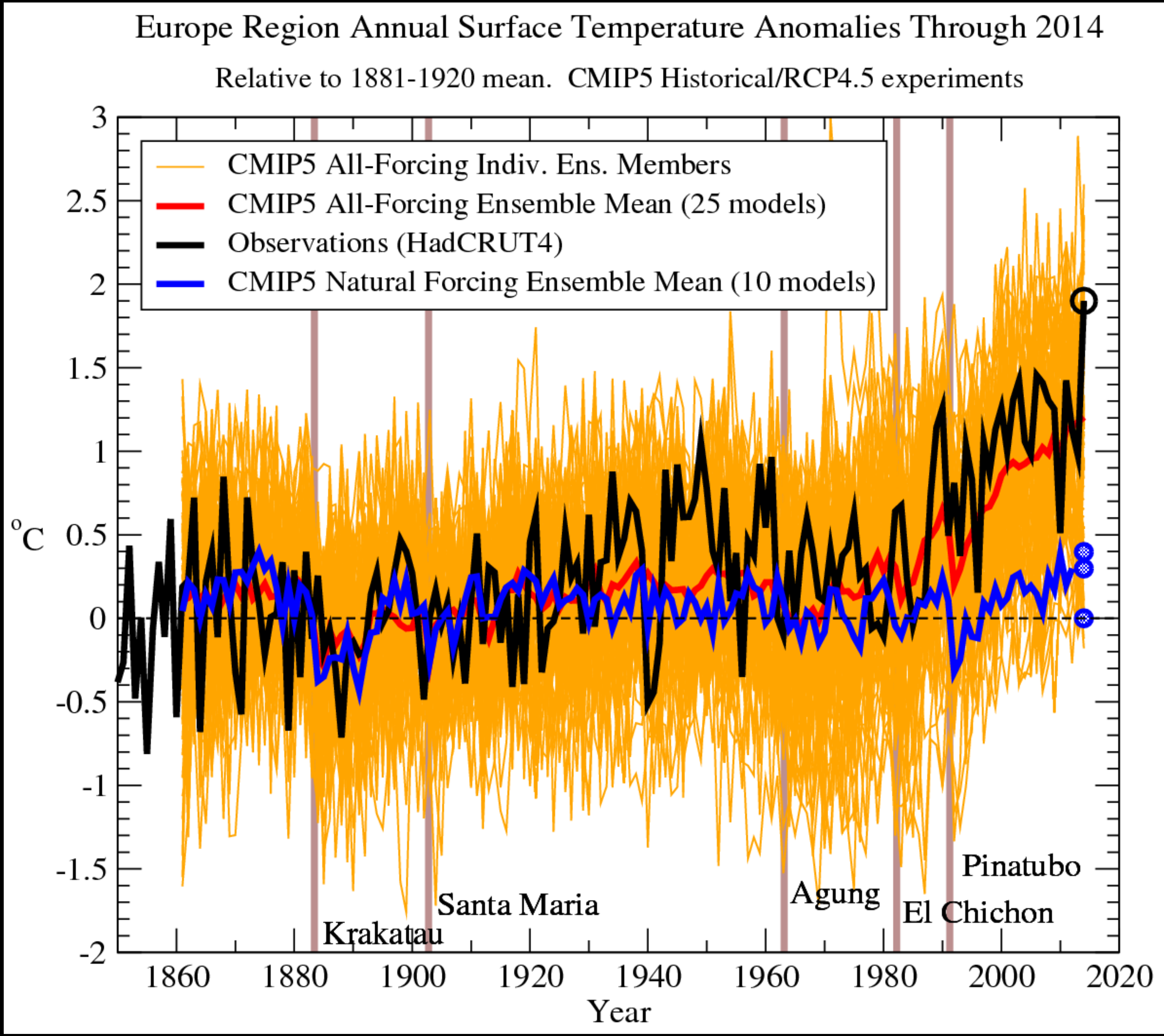
Winter-Spring Center of Volume:

- Half of accumulated daily discharge volume from the start to the end of a year or season.
- Accumulating period: January through June of a calendar year

Winter-Spring Time of Center Volume:

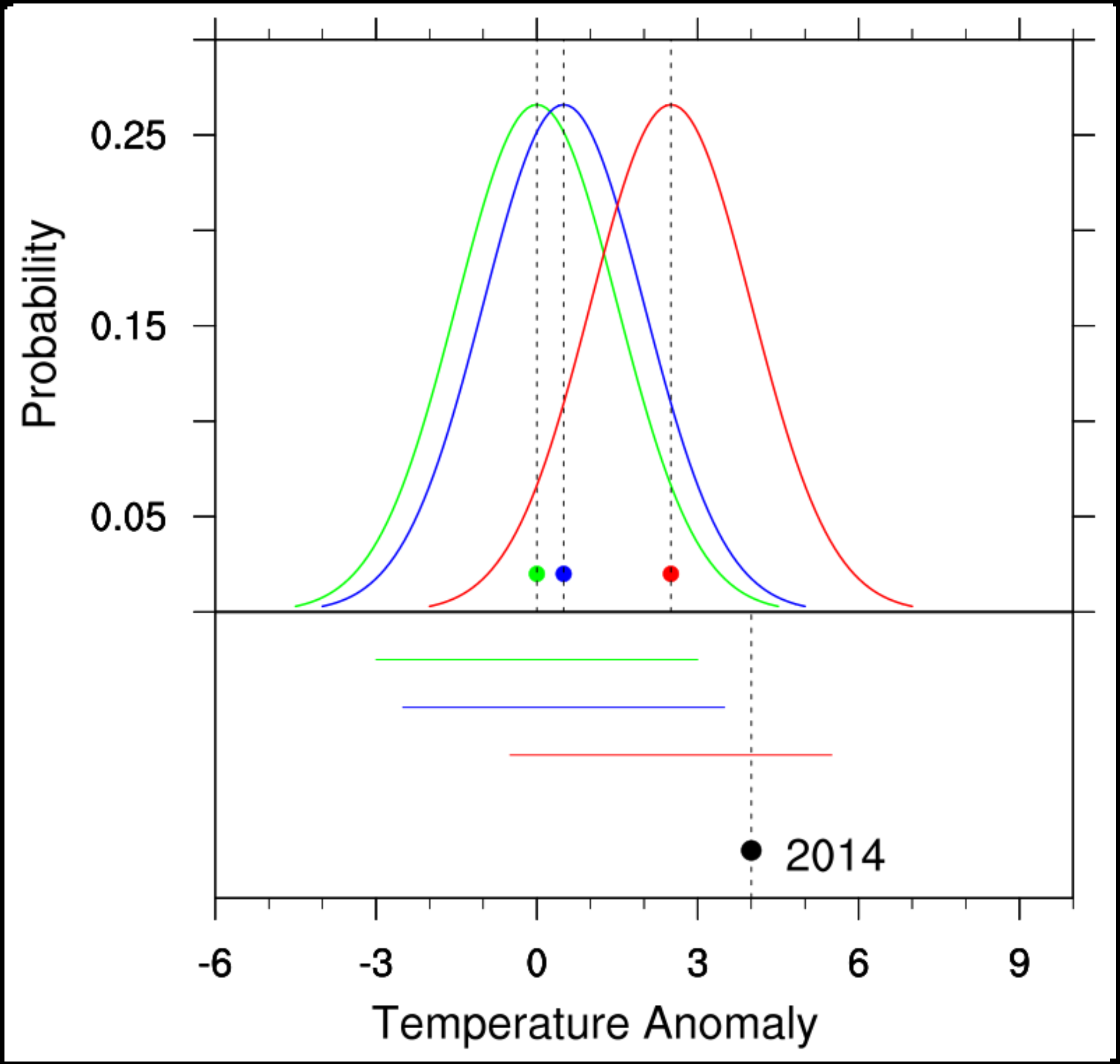
- the first date by which winter-spring center of volume or more passes by a gauge station

Climate Model Experiment Design: CMIP5



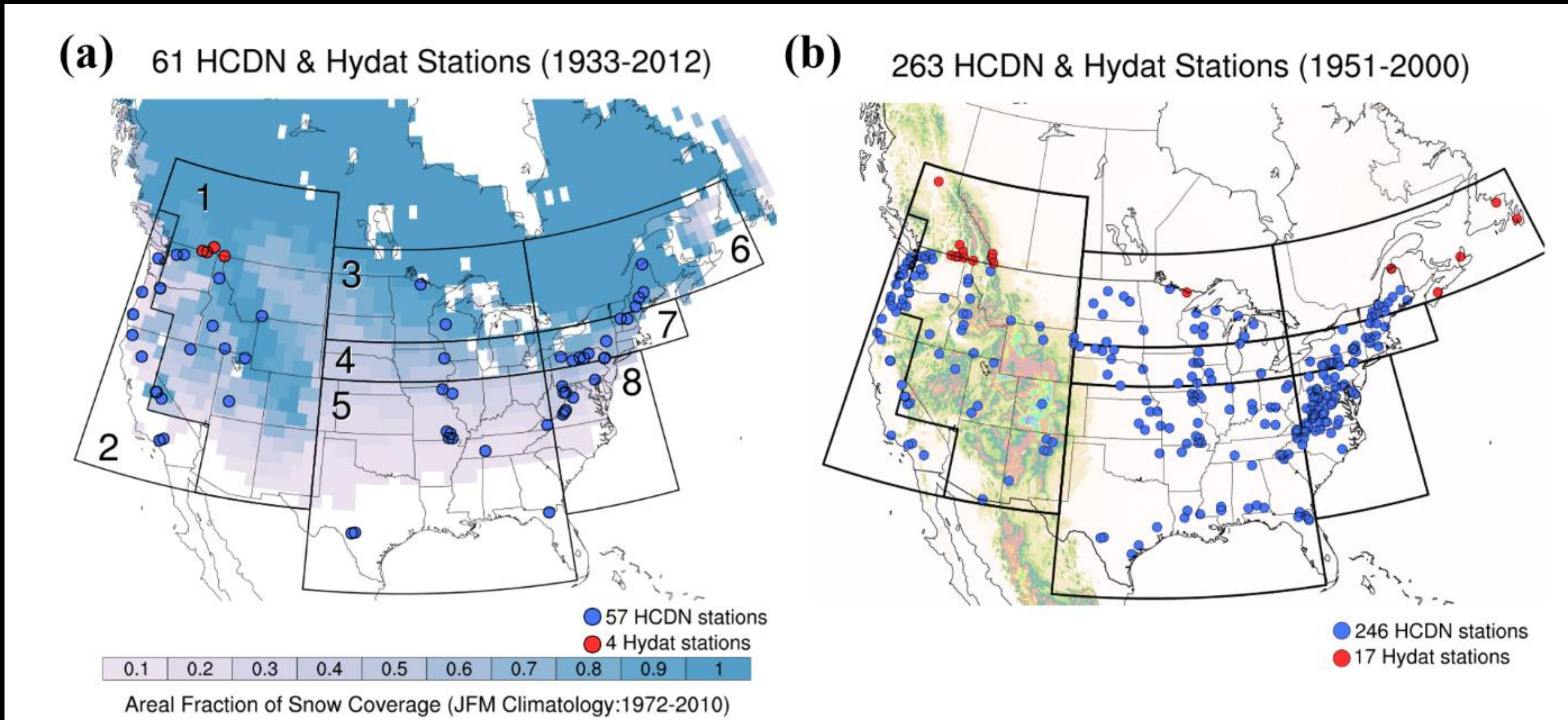
Kam et al., BAMS, 2015

Detection and Attribution of Anthropogenic Influence



Obs
piCont (unforced)
historicalNat (natural forcing)
Historical (natural forcing + anthropogenic forcing)

Observed and Simulated Monthly Runoff Data



Monthly discharge records: USGS HCDN and HYDAT (Canada) stations

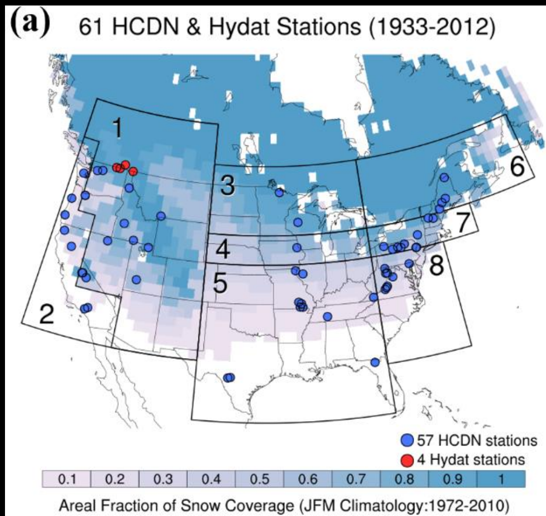
Winter-spring Streamflow Center Time (WSCT):

$$WSCT = \frac{0.5*q_1+1.5*q_2+2.5*q_3+3.5*q_4+4.5*q_5+5.5*q_6}{\Sigma_{i=1}^{6} q_i} \text{ [months] Eqn. 1}$$

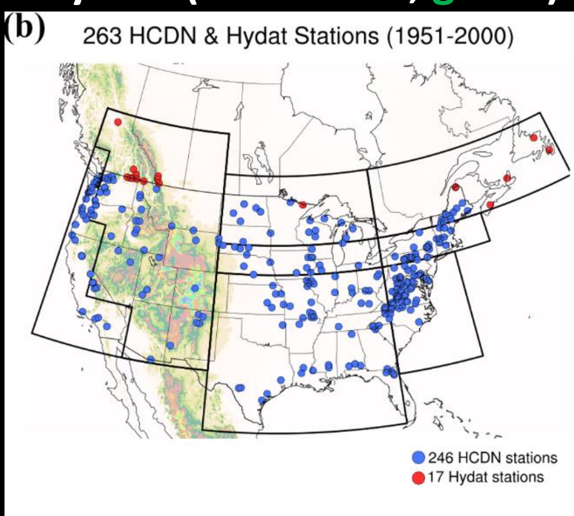
$$= \frac{\Sigma_{i=1}^{6}(t_i-0.5)q_i}{\Sigma_{i=1}^{6} q_i} * \left(\frac{181\ days}{6\ month}\right) \text{ [DOY] Eqn. 2}$$

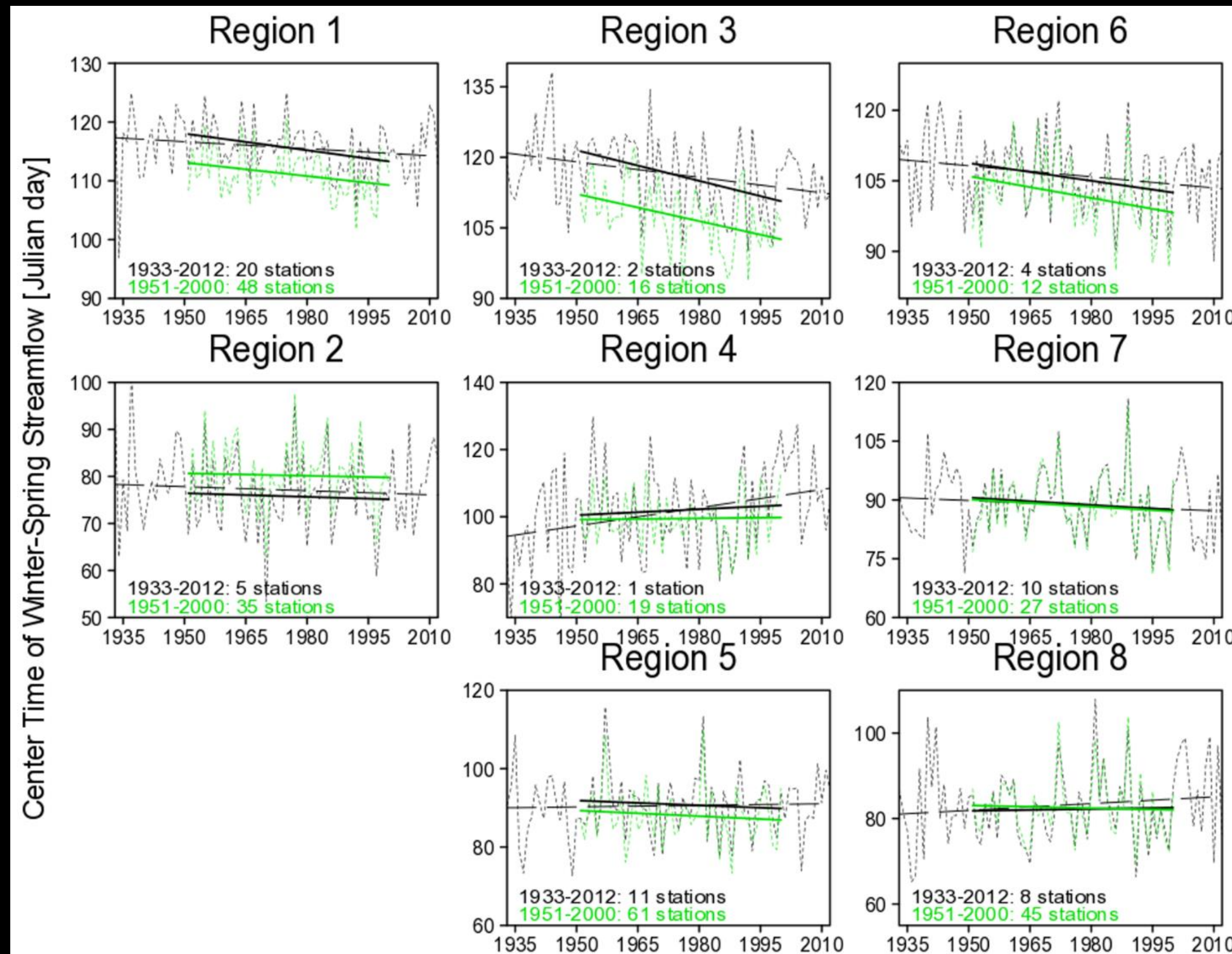
Longer records but fewer gage stations?

80 years (1933-2012; black)

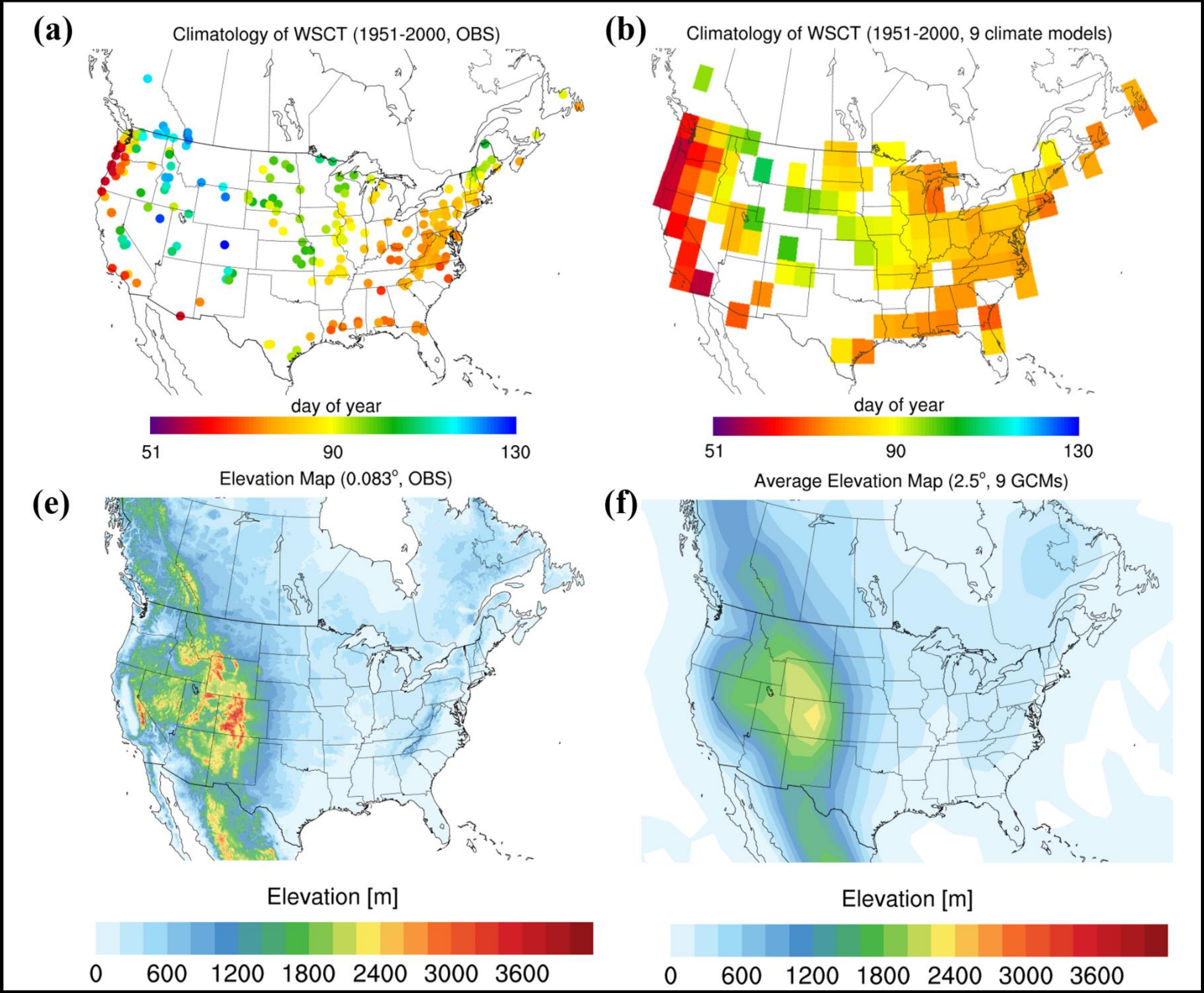


50 years (1951-2000; green)

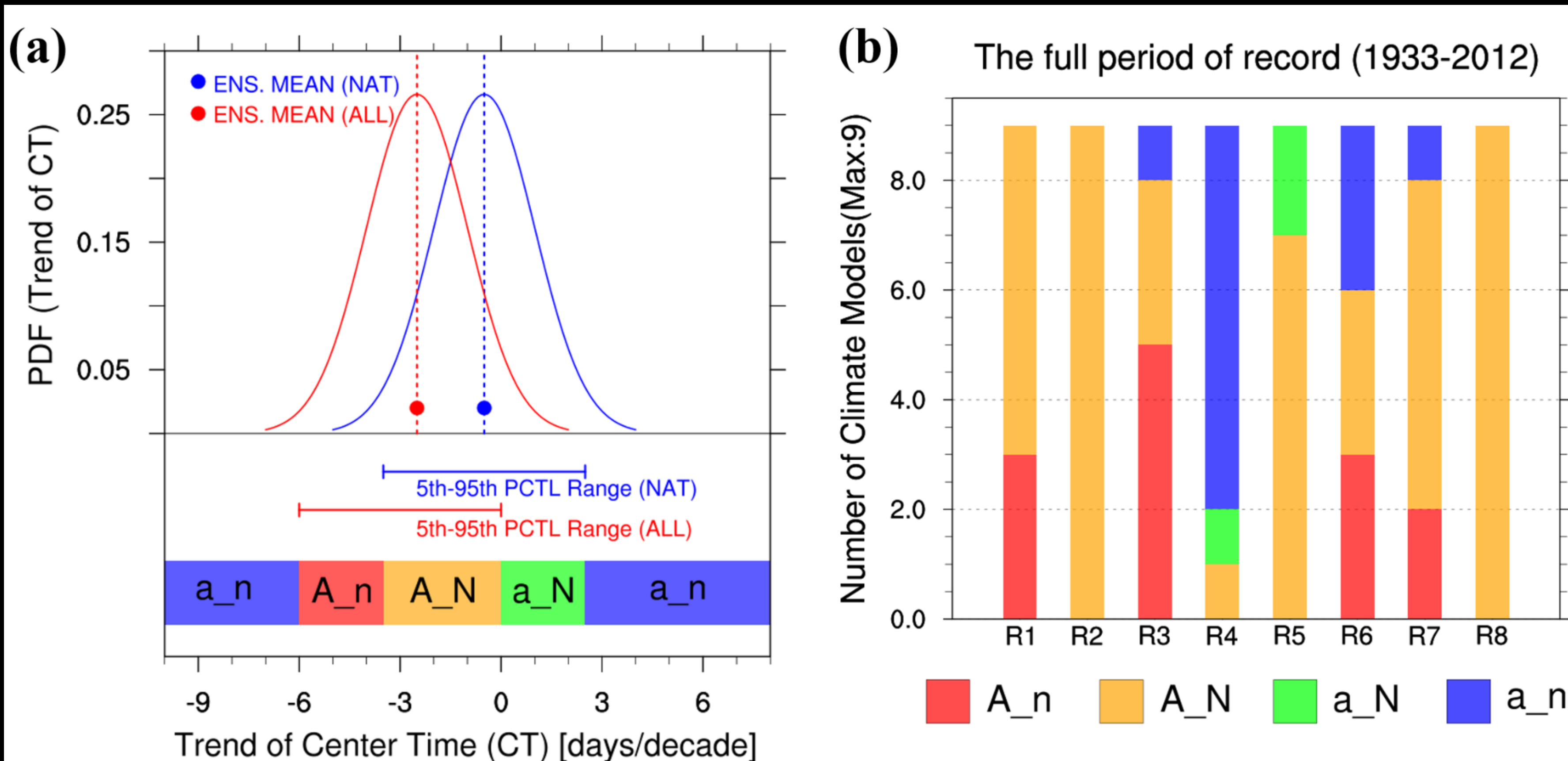




WSCT Climatology and Elevation Map: Obs. vs CMIP5



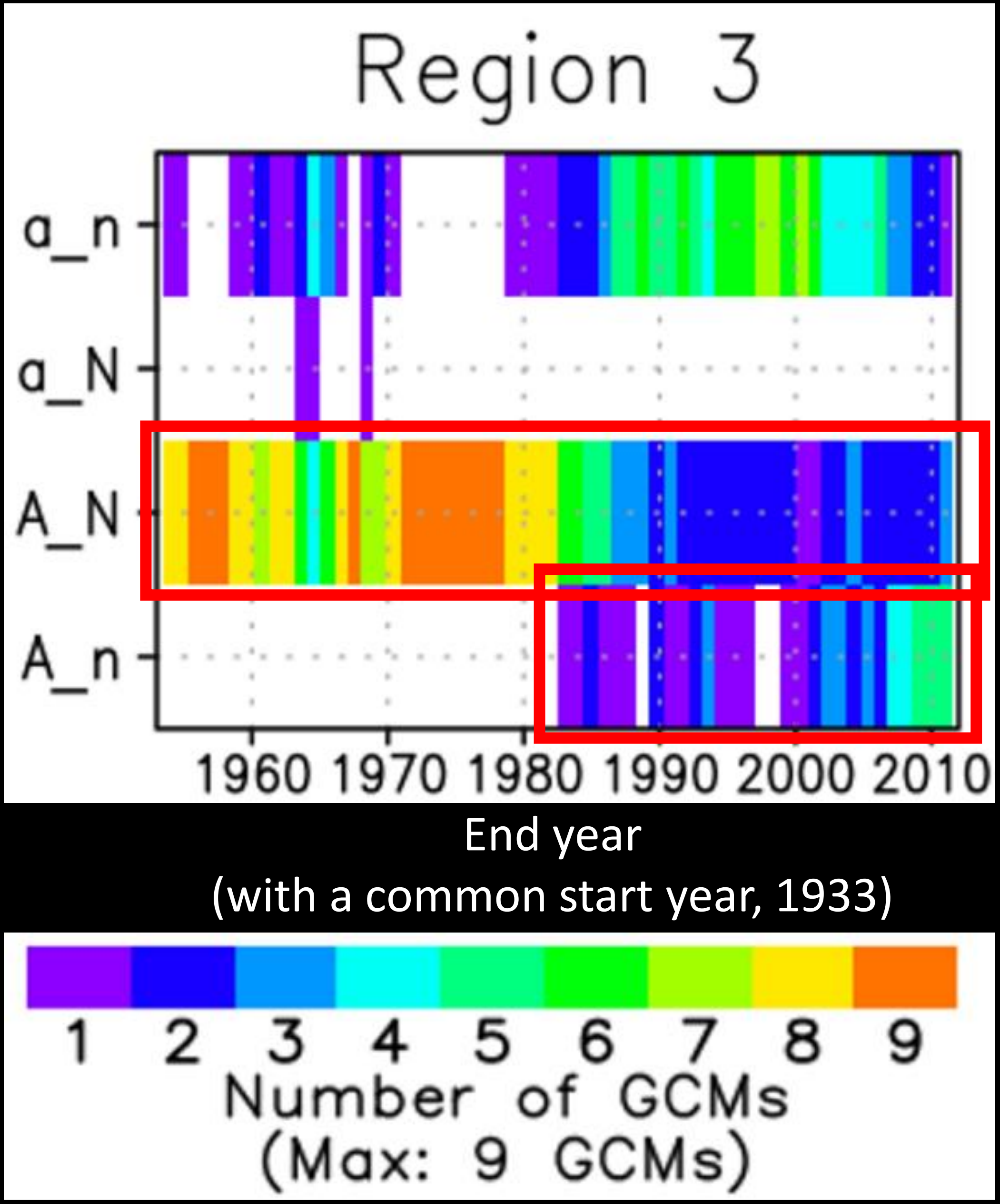
Detection and Attribution of Changes in WSCT



Definition of a robust evidence for detectable anthropogenic influence: five of nine models are in **A_n**.

The robust evidence are found in R3.

Sliding Trend Analysis of WSCT: An Example

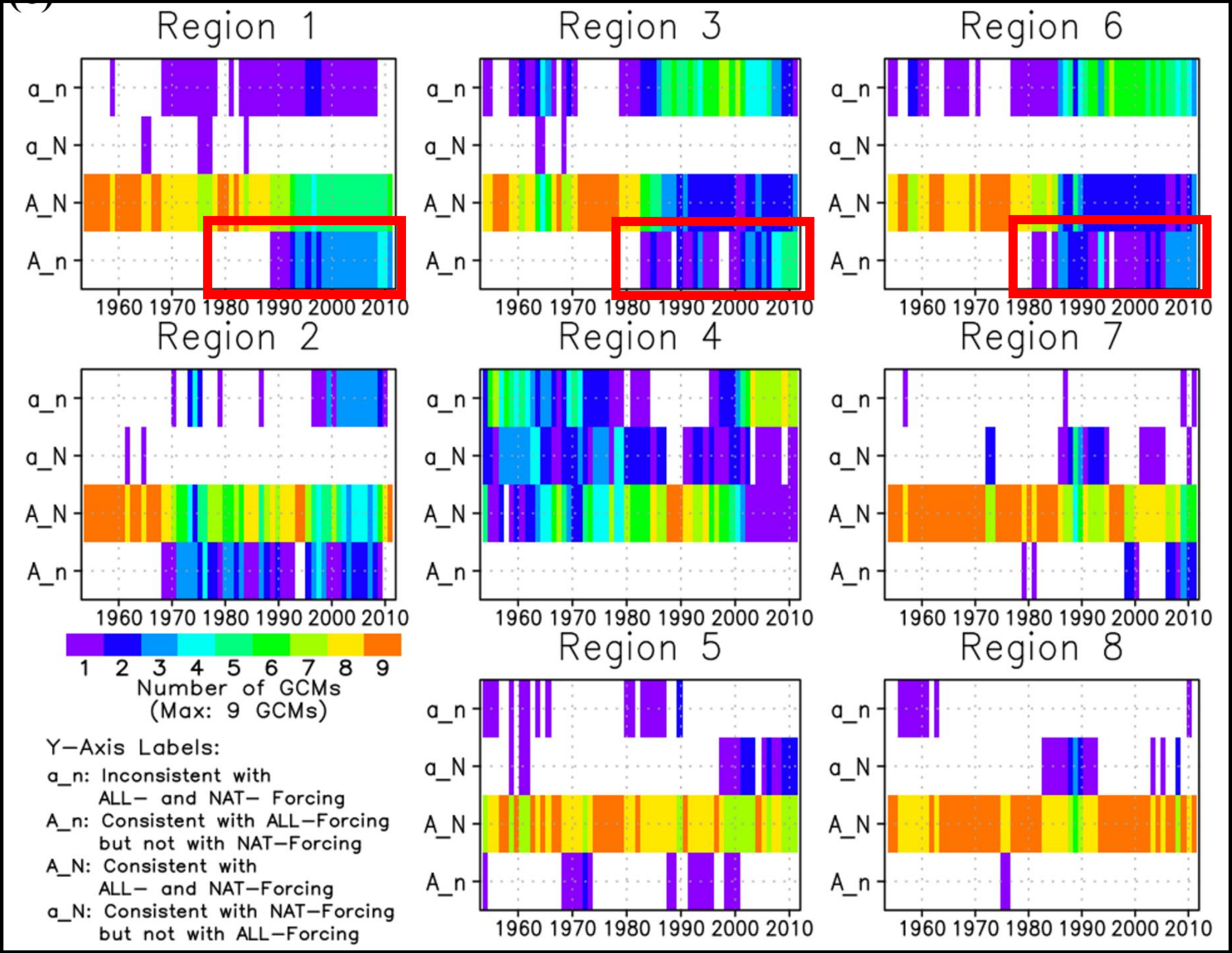


End year
(with a common start year, 1933)

A_N: Insensitive to anthropogenic forcings

A_n: Sensitive to anthropogenic forcings

Sliding Trend Analysis of WSCT: 8 Regions



Summary

1. The most robust evidence for detectable anthropogenic influence (five of nine models) is in north-central U.S., where streamflows ha[illegible]en coming earlier.

2. Marginal evidence for a detectable anthrop[illegible] was found in the mountainous western U.S./sout[illegible]da and in extreme northeastern U.S./Canadian Ma[illegible]

3. In the mountain[illegible]/southwestern Canada, a recent shift toward later [illegible] rendered the full-record trend toward earlie[illegible] significant.

4. [illegible]treme northeastern U.S./Canadian Maritimes, the forced responses from several models are inconsistent with the detectable observed earlier streamflow

Take-Home Message: North-central U.S. is more vulnerable for drought and flood in next decades likely due to the anthropogenic influence.

Question?

Increased Drought and Pluvial Risk over California due to Changing Oceanic Conditions

JONGHUN KAM AND JUSTIN SHEFFIELD

Department of Civil and Environmental Engineering, Princeton University, Princeton, New Jersey

(Manuscript received 10 December 2015, in final form 18 August 2016)

J. Climate 2016

References:

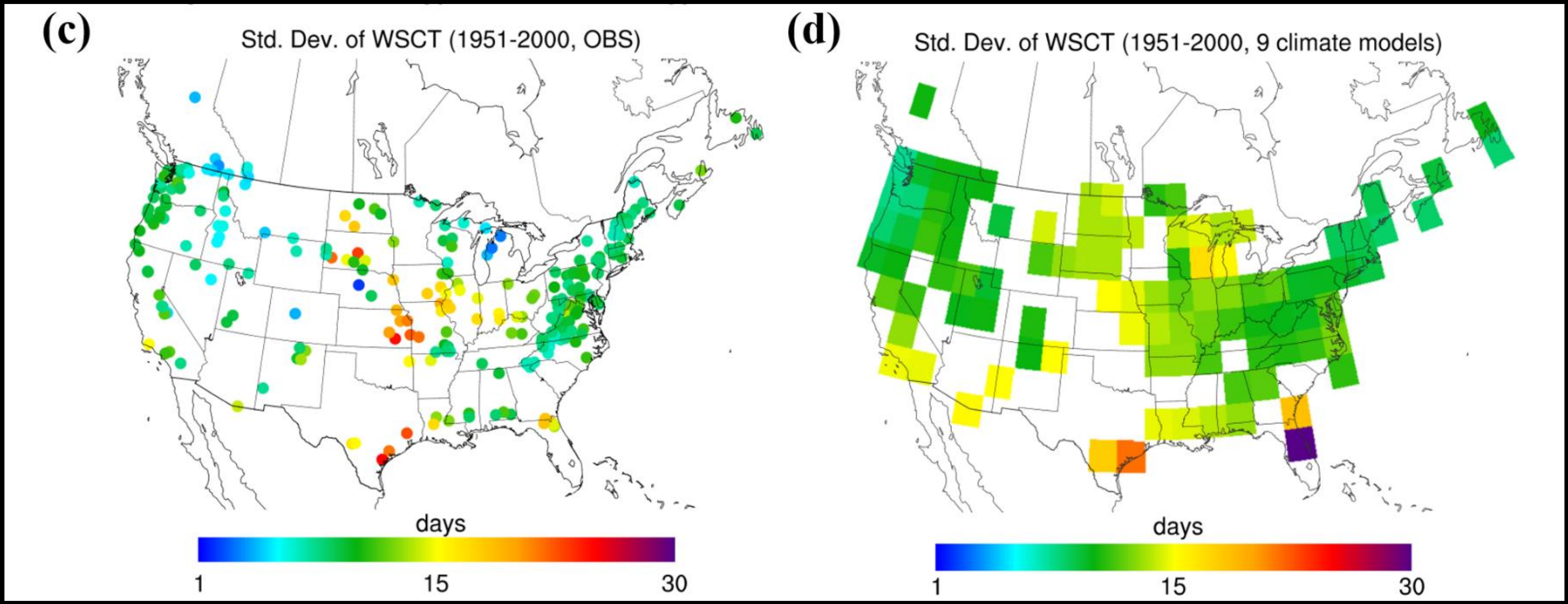
Kam et al., Record annual-mean warmth over Europe, the northeast Pacific, and the northwest Atlantic during 2014: Assessment of anthropogenic influence, Bull. Amer. Meteor. Soc., 96, S61-S65 (2015).

Kam, J., T. R. Knutson, and P. C. D. Milly, 2016, Climate model assessment of changes in winter-spring streamflow timing over North America. (in review)

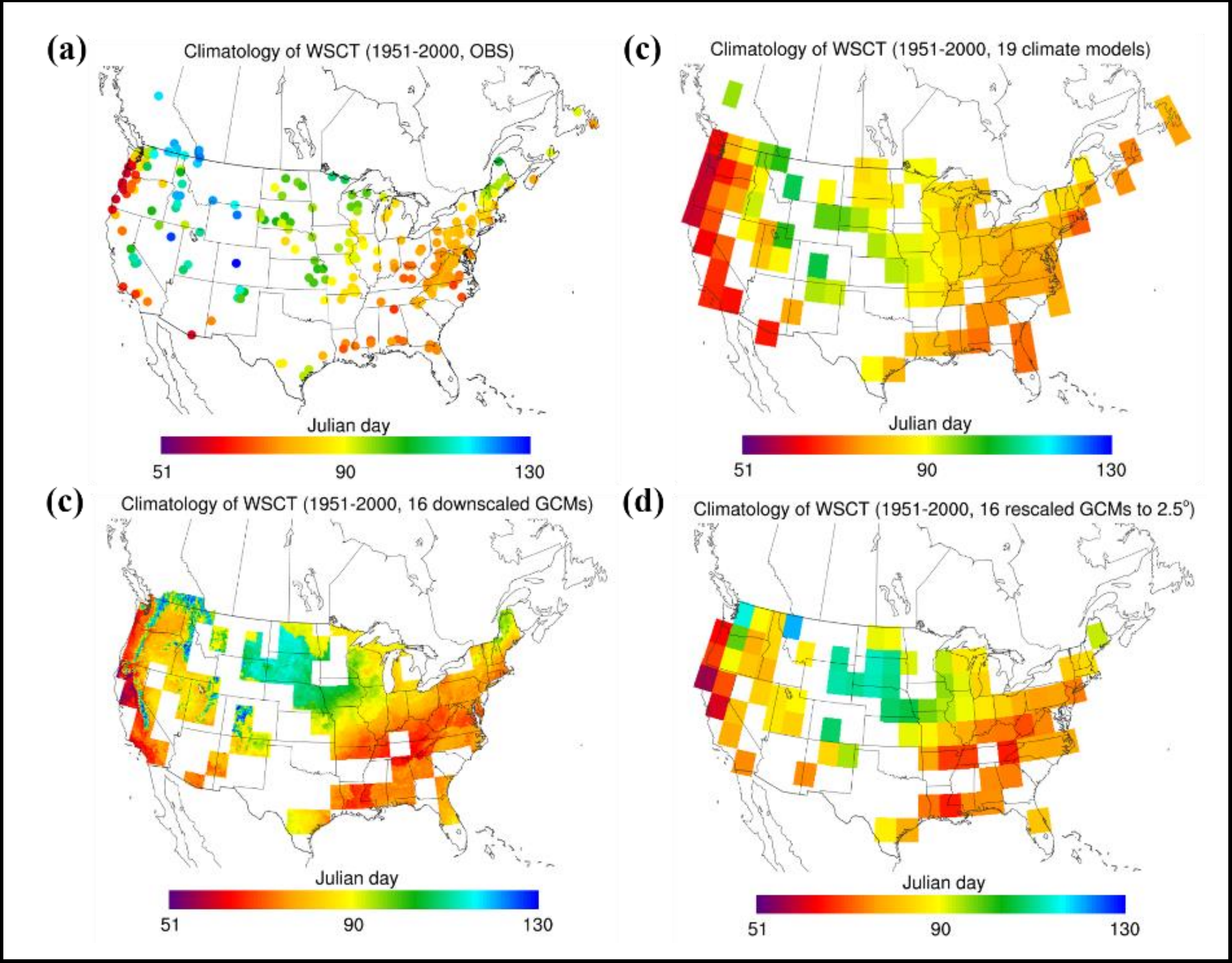
Cayan, D. R., Kammerdiener, S. A., Dettinger, M. D., Caprio, J. M. & Peterson, D. H., Changes in the Onset of Spring in the Western United States. Bulletin of the American Meteorological Society 82, 399-415 (2001).

Hodgkins, G. A. & Dudley, R. W., Changes in the timing of winter-spring streamflows in eastern North America, 1913-2002. Geophysical Reserch Letters 33, L06402 (2006).

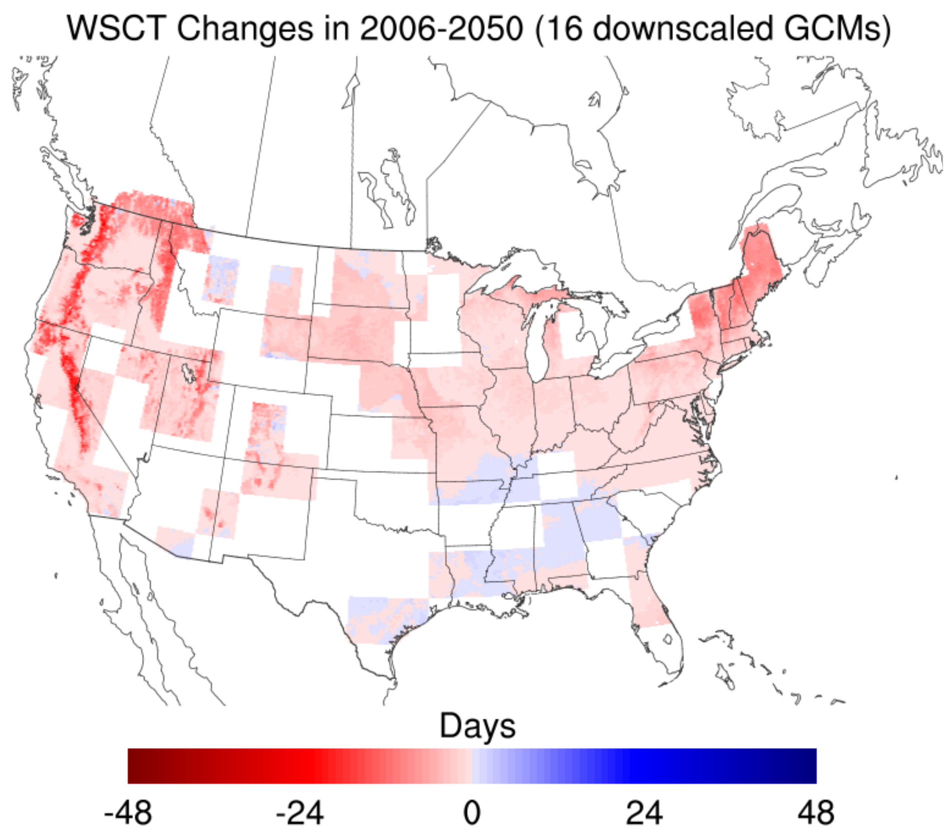
WSCT Inter-annual Variability: Obs. vs CMIP5

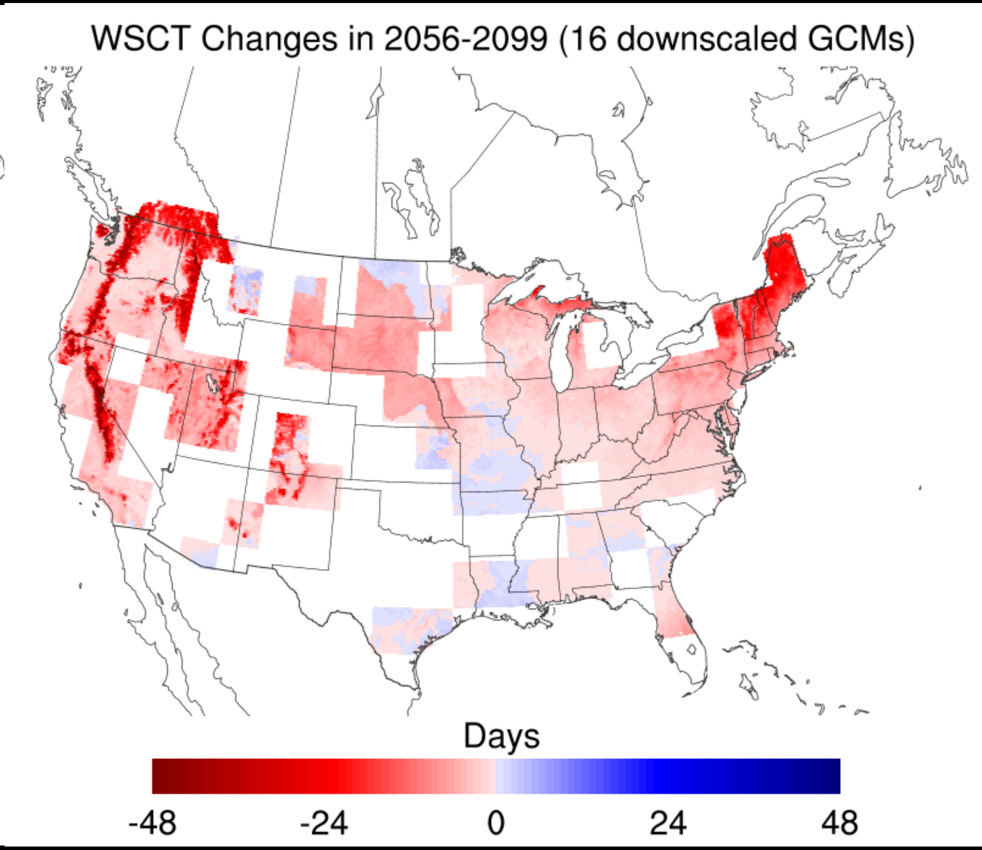


Impact of downscaling



Future Changes in WSCT from Downscaled CMIP5





Temperature dominant vs Rainfall dominant?