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

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Short Biography

At GFDL/NOAA (Post-doc)

Climate Impacts and Extremes Group

The Climate Impacts and Extremes Group works to improve scientific understanding of climate impacts and extremes in a changing climate. The group conducts research to produce, and effectively communicate, high quality information on climate impacts and extremes, including the influence of climate variability and change, and with assessment of uncertainties.

Members

NOAA
- Emma Kinter
- Thomas Delworth
- Keith Dixon
- Kirsten Findell
- John Lanzante
- Mary Jo Roth

Collaborators
- Hana Hu
- Alex Lin
- Xiao Chen
- Mark Cary
- Robert Tokay
- Carlos Gallant

At Princeton U. (Ph.D)

Terrestrial Hydrology Research Group
Princeton University

Welcome

Welcome to the home page of the Terrestrial Hydrology Research Group in the Department of Civil and Environmental Engineering at Princeton University. Our research includes land surface - atmosphere interactions for climate models and watershed models; impacts of climate change on hydrologic and water resource systems; and remote sensing of hydrologic systems. This web site describes our current research projects, the people in our research group, the models and the data that we use, our recent publications and our resources.
Short Biography

At Tuscaloosa, AL

National Water Center/NOAA

2016 College Football Rankings - Week 11
AP Top 25

<table>
<thead>
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<th>RK</th>
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Global warming can change the hydrological cycle

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

Over extratropical and mountainous regions,

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

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)

Hodgkins and Dudley, WRR, 2006

Cayan et al., BAMS, 2001
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

Europe Region Annual Surface Temperature Anomalies Through 2014

Relative to 1881-1920 mean. CMIP5 Historical/RCP4.5 experiments

- CMIP5 All-Forcing Indiv. Ens. Members
- CMIP5 All-Forcing Ensemble Mean (25 models)
- Observations (HadCRUT4)
- CMIP5 Natural Forcing Ensemble Mean (10 models)

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):
Longer records but fewer gage stations?

80 years (1933-2012; black)

50 years (1951-2000; green)
WSCT Climatology and Elevation Map: Obs. vs CMIP5
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

Region 3

A_N: Insensitive to anthropogenic forcings
A_n: Sensitive to anthropogenic forcings

End year
(with a common start year, 1933)
Sliding Trend Analysis of WSCT: 8 Regions

Y-Axis Labels:
- \( a_n \): Inconsistent with ALL- and NAT- Forcing
- \( A_n \): Consistent with ALL-Forcing but not with NAT-Forcing
- \( A_N \): Consistent with ALL- and NAT-Forcing
- \( a_N \): Consistent with NAT-Forcing but not with ALL-Forcing

Number of GCMs (Max: 9 GCMs)
Summary

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

2. Marginal evidence for a detectable anthropogenic influence was found in the mountainous western U.S./southwestern Canada and in extreme northeastern U.S./Canadian Maritimes and in extreme

3. In the mountainous western U.S./southwestern Canada, a recent shift toward later streamflows has rendered the full-record trend toward earlier streamflow insignificant.

4. In extreme 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.
Increased Drought and Pluvial Risk over California due to Changing Oceanic Conditions

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

References:
WSCT Inter-annual Variability: Obs. vs CMIP5

(c) Std. Dev. of WSCT (1951-2000, OBS)
(d) Std. Dev. of WSCT (1951-2000, 9 climate models)
Impact of downscaling
Future Changes in WSCT from Downscaled CMIP5

WSCT Changes in 2006-2050 (16 downscaled GCMs)

WSCT Changes in 2056-2099 (16 downscaled GCMs)
Temperature dominant vs Rainfall dominant?

Observation (1951-2000)
Ensemble Mean (18 CGMs: 1951-2000)
Ensemble Mean (17 GCMs(RCP8.5): 2006-2050)
Ensemble Mean (17 GCMs(RCP8.5): 2056-2100)