Large Scale Circulation Patterns Associated With North American Short-term Temperature and Precipitation Extreme Events

aka: The Extremes WG

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US CLIVAR 2014 Summit Report

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Problem

Short-term extreme events in temperature and precipitation have a large societal impact but are difficult to analyze because:

•they are rare

•they require daily or higher frequency data since they are not well captured in monthly data

•daily data are not fully available or hard to access in CMIP output

•key data (such as the vertical profile of moisture over oceans) have inaccuracies or are poorly resolved (like the low level jet in the central US)

•they happen while climate change and natural variability are occurring

Science Plan Research Challenges

- Decadal variability and predictability
- Climate extremes
- Polar climate
- Climate and ocean carbon/biogeochemistry

Subset (short timescale extremes) of this challenge

Focus

To make focus narrow enough for progress within WG framework:

•North American region

•Short term (approx. 1 to 5 days)

•Temperature (heat waves and cold air outbreaks) and Precipitation (emphasizing processes other than hurricanes, which has its own working group)

•Events associated with Large Scale Meteorological Patterns (LSMPs): synoptic to continental-scale circulations that are large enough to be well-captured by observations and models, and to have some prediction and down-scaling potential. These patterns are defined by the extreme events, rather than in terms of known modes (ENSO, MJO, NAO, etc.) though such modes may play a role

Approach

Why emphasize large-scale patterns*?

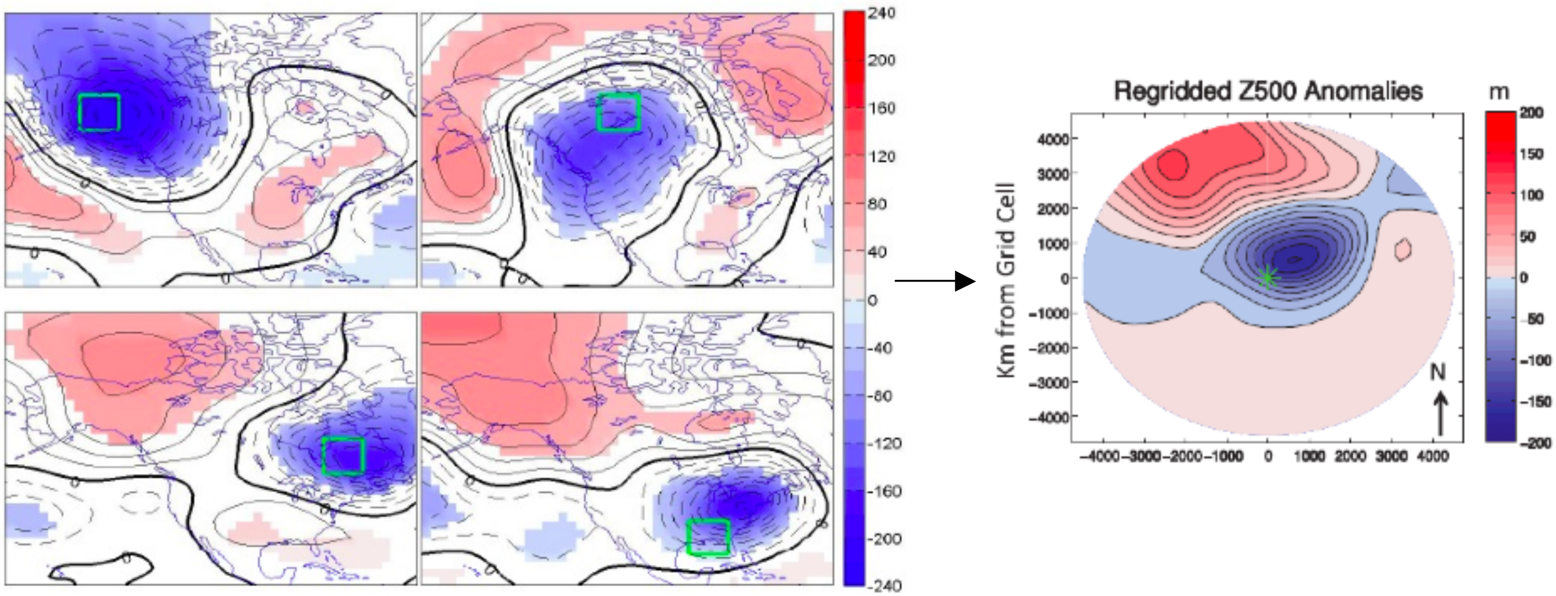
- Focus on dynamics we can resolve in many different datasets
- Particularly, allow for assessment of model dynamics
- Set up for downscaling

*WG Lingo: Large-Scale Meteorological Pattern (LSMP)

Example of Large-Scale Pattern

RUTGERS

Composite Z_{500} anomalies for January Tx5



Composites based on temperature distribution at the locations of the green boxes.
Shading indicates anomalies are statistically significant at 5% level based on t-test.

From Tony Broccoli's workshop Presentation

Objectives

•Assess and synthesize existing knowledge based on the links between Large Scale Meteorological Patterns (LSMPs) and short-term temperature and precipitation extremes

•Identify key questions and knowledge gaps

•Establish a methodology and research protocols for using the LSMP approach to analyzing extremes in observations and model output

•Provide a preliminary assessment of the ability of current models to reproduce the correct relationship between extremes and LSMPs for North America.

Key Questions

- Is our current understanding of temperature and precipitation extremes sufficient to assess whether current climate models accurately reproduce the dynamics of these events?

- How do we improve our understanding of these extremes?

- How do we assess confidence in projections of changes in extreme events given current uncertainties and knowledge limits?

Membership

Regular committee members

Richard Grotjahn – Co-Chair (UC Davis)
Mathew Barlow – Co-Chair (UMASS Lowell)
Robert Black (Georgia Tech
Joshua Xiouhua Fu (U. Hawaii)
Alexander Gershunov (Scripps; UC San Diego)
William Gutowski (Iowa St. Univ.)
Rick Katz (NCAR)
Arun Kumar (CPC NCEP/NOAA)
Lai-Yung (Ruby) Leung (PNNL, Washington)
Young-Kwon Lim (NASA GSFC)
Russ S. Schumaker (Colo. St. Univ.)
Michael Wehner (LBL, California)

International Members

Tereza Cavazos (CICESE, Mexico)
John Gyakum (McGill U., Canada)

Contributing Members

Anthony Barnston (IRI Columbia U)
Michael Bosilovich (GMAO, NASA/GSFC

Main Activities

- Workshop in Berkeley, August 2013
- Workshop report, with detailed recommendations
- Contributed to CLIVAR Science Plan
- CLIVAR Variations issue
- 2 survey papers (in progress)

Main Conclusions

1. Analyzing the large-scale meteorological patterns (LSMPs) associated with short-term extreme events is a very useful for analyzing the dynamics and can provide a basis for down-scaling.

2. Understanding and predicting extremes requires interaction between researchers in these different topical areas:

-Extreme value statistics,
-observations,
-synoptic-dynamics
-modeling, and
-application sectors

The Berkeley workshop facilitated interaction amongst experts in the first four areas, and there was much interest in follow-on activities that also involved the fifth.

Primary Recommendations (1)

- Need to improve our dynamical understanding of observed short-term extremes

- The LSMP approach provides a very effective structure in which to advance this work from its present early stage

- Models' representations of extremes must be evaluated in terms of how well the model reproduces the synoptic-dynamics of the extremes (simply put: does the model have the right distribution for the right reason?)

- Develop new indices (beyond ETCCDI) that incorporate the synoptic-dynamics of extreme events. Develop metadata such as location, date, and intensity information for events.

Primary Recommendations (2)

- Expand or supplement CMIP database to include more daily and higher frequency fields, in a more easily accessible fashion (e.g. preprocessing of data prior to downloading)

- Foster more collaboration between different programs working on various aspects of extremes (from different topical areas, different regions, etc.)

- See also the detailed list in workshop report

Suggested Next Steps

•Fund additional work on the synoptic-dynamics of extremes both fundamental understanding but also to develop more informative indices and tests of simulation skill.

•Encourage modeling groups to assess model simulation of extremes in terms of the synoptic-dynamics

•Hold regular workshops on short-term extremes that mix researches and stakeholders in the five topical areas. Include both broad topics (to encourage wide interaction) and specific questions (such as developing particularly useful indices and definitions)

•Continue to improve observations over land and ocean regions, especially the three dimensional structure of moisture

Relevance to Science Plan

CLIVAR Goals:

•Understand the role of the oceans in observed climate variability on different timescales.

Coupled variability has strong influence on LSMPs

•Understand the processes that contribute to climate variability and change in the past, present, and future.

LSMP approach useful for understanding dynamics

•Better quantify uncertainty in the observations, simulations, predictions, and projections of climate variability and change.

•Improve the development and evaluation of climate simulations and predictions.

LSMP approach useful for evaluating models

•Collaborate with research and operational communities that develop and use climate information.

Many different efforts on extremes could benefit from collab./coord.

Specific research challenge: Climate and extreme events (science plan section 5.2)