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WCRP Grand Challenge

Understanding and Predicting Weather and Climate Extremes

Lisa Alexander, Gabi Hegerl, Sonia Seneviratne, Xuebin Zhang

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Current Status

- Implementation plan Dec. 2014
  - 4 main extremes, 4 over arching themes
- Early successes
  - WCRP Summer School on Climate Extremes (Trieste, July 2014) and associated special issue
  - Workshop on GC-Extremes data requirements (Sydney, February 2015)
  - Workshop on Understanding, modeling and predicting weather and climate extremes (Oslo, October 2015)
  - Writing workshop – high impact paper (Jan 2016)

Driven largely by service needs

- From ***service perspective***: What are frequency and magnitudes of various impact-causing extremes in the near and long term?
- From ***science perspective***: How can we better understand the causes and mechanisms of variability and change in extremes, and improve the prediction of changes in extremes?
- Implementation needs to be focused

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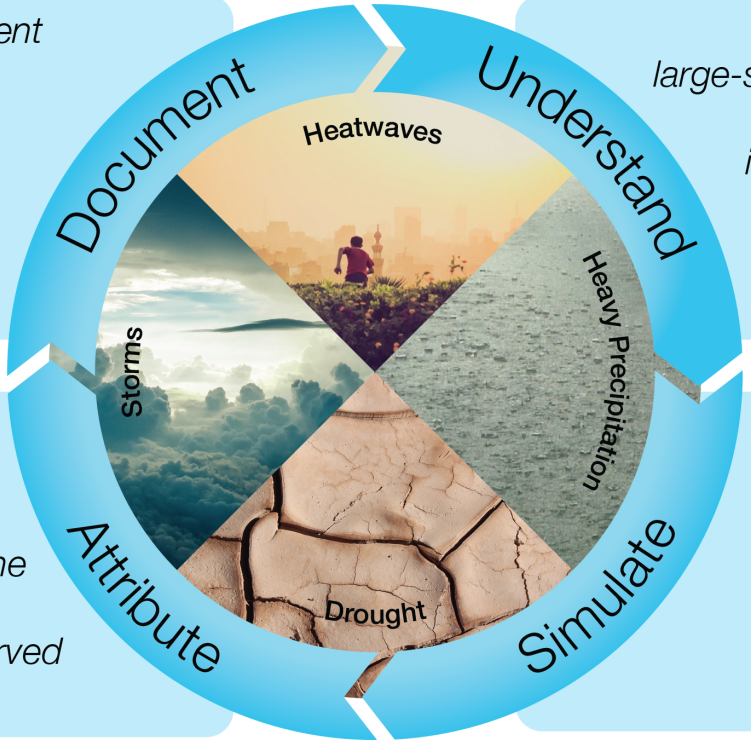
4 main extremes, 4 over arching themes

Are existing observations sufficient to underpin the assessment of extremes?

What are the relative roles of large-scale and regional or local-scale processes, as well as their interactions, for the formation of extremes?



How can we determine the contributors to observed extreme events and to changes in the frequency and intnesity of observed extremes?

Are models able to reliably simulate extremes and their changes, and how can this be evaluated and improved?

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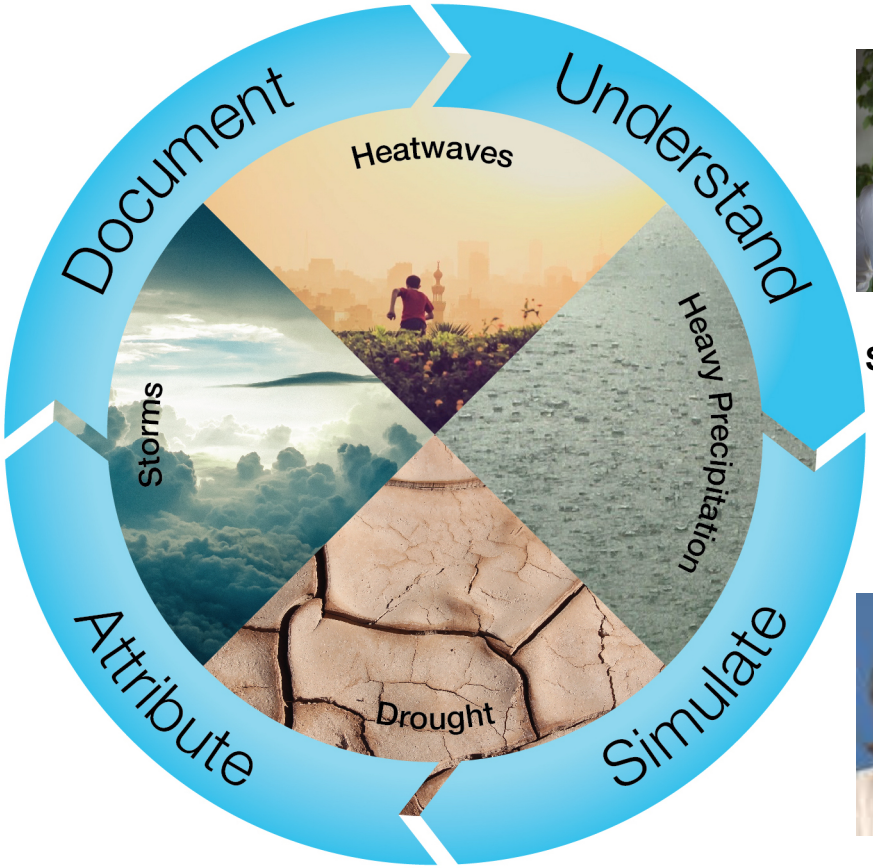
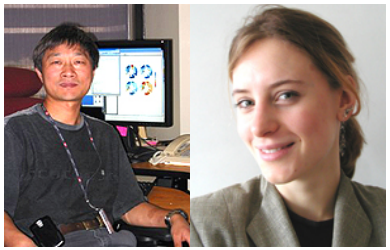
Leads

Lisa Alexander | Ali Behrangi



Sonia Seneviratne | Olivia Martius | Robert Vautard



Xuebin Zhang | Fredi Otto

Gabi Hegerl | Jana Sillmann | Erich Fischer

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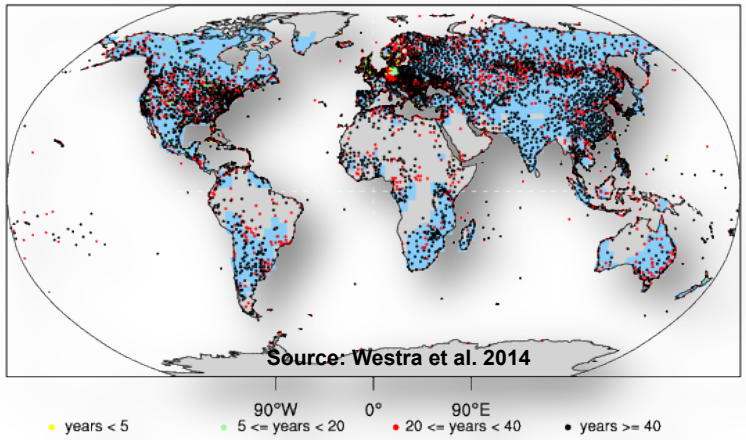
Document

Observations provide crucial underpinning but are often not well-constrained and critical gaps exist in the amount, quality, consistency and availability, especially for extremes

Sub-daily precip stations (HadISD) and SDII coverage (HadEX2)



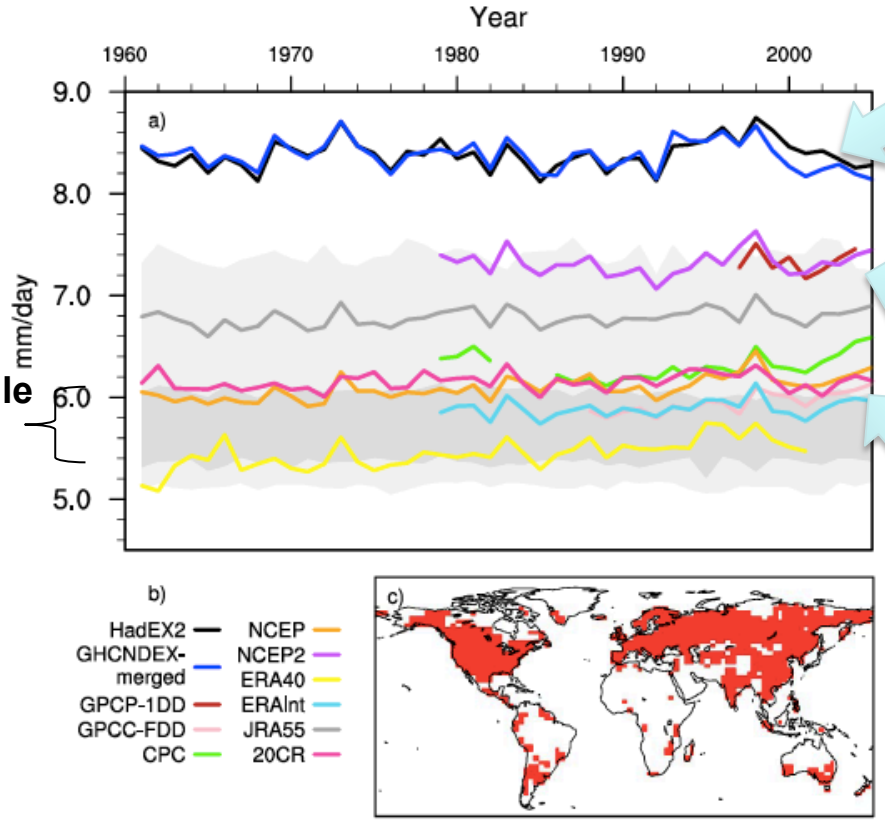
- Permanent destruction of old records
- More data undigitised than digitised (especially pre WWII)
- Many institutions unwilling or unable to exchange data
- Data quality and homogeneity

The *dreary state* of precipitation observations

Full obs/ reanalyses range

Full CMIP5 range

Interquartile CMIP5 range



HadEX2

GPCP

GPCC

~3mm/day difference

in annual estimates of daily precipitation intensity

Source: Herold et al. 2016

Masked to where all datasets have data

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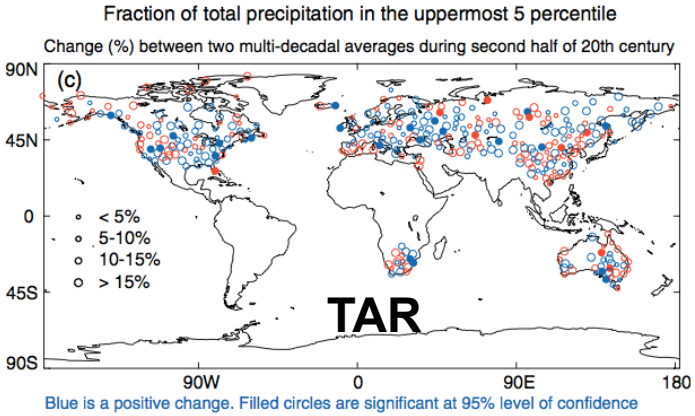
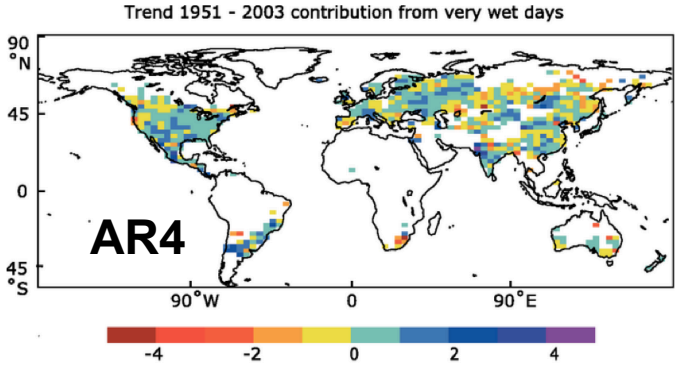
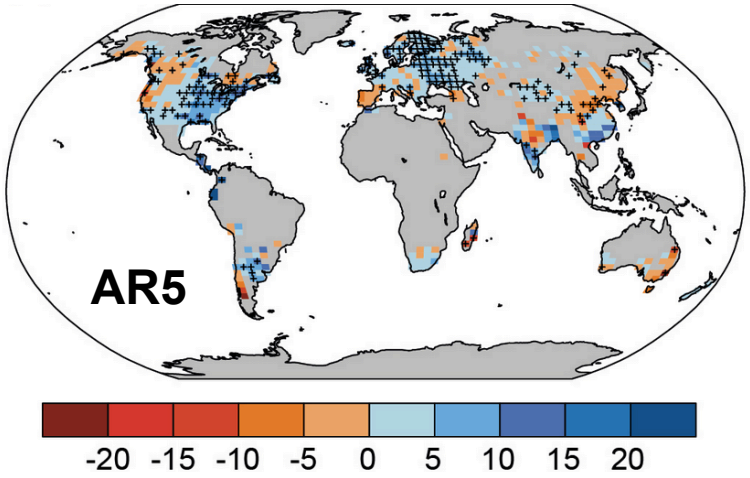
IPCC assessments – data improvements?





No improvement in coverage between IPCC Assessments

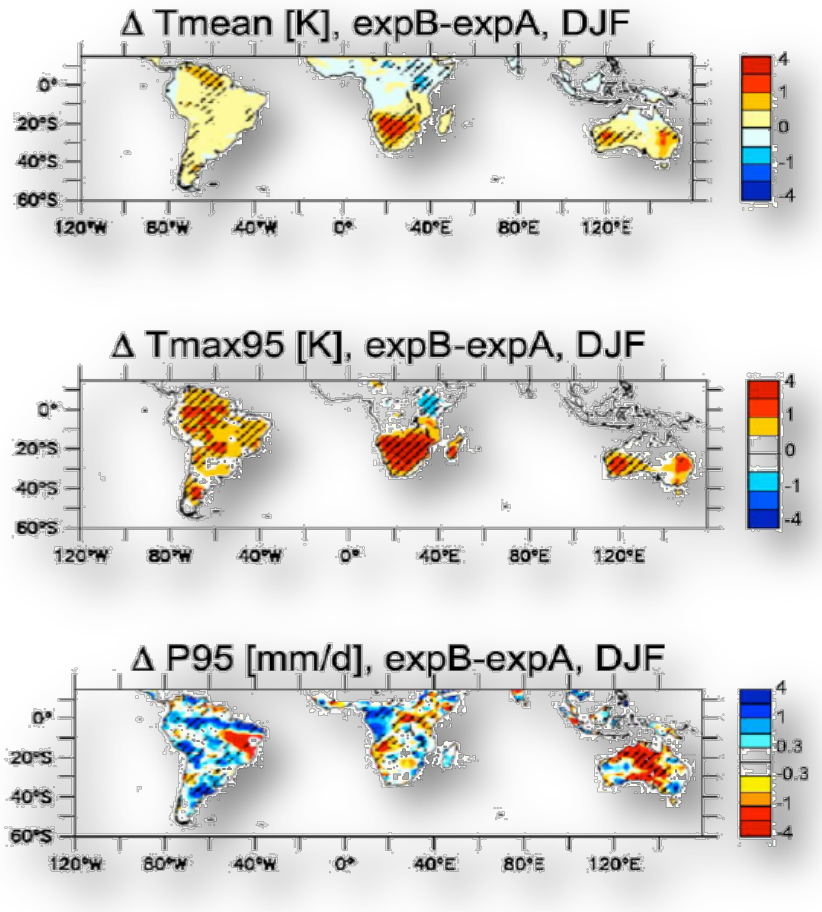


Big gains for small coordination effort between in situ, remote sensing, reanalysis communities

www.climdex.org

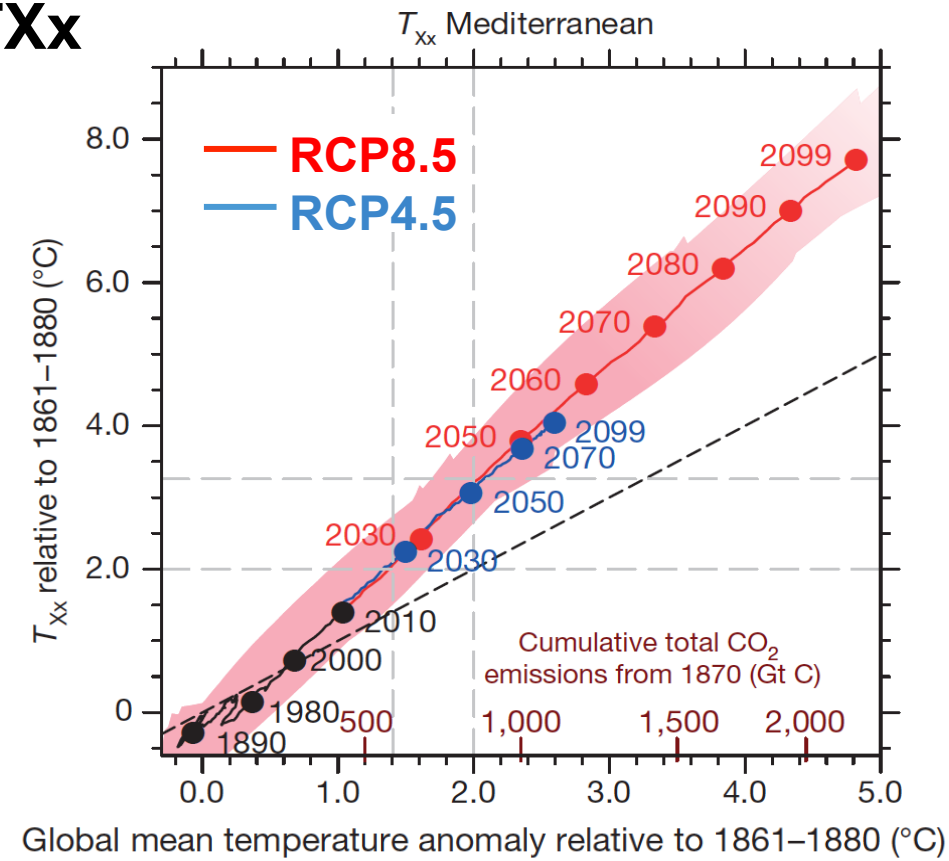
Understand

Interaction between large-scale phenomena (weather types, modes of variability) and regional-scale land-atmosphere feedbacks or forcing can be critical



Understanding: Global scale vs regional scale drivers, role of land-atmosphere interactions

TXx



(Seneviratne, Donat, Pitman, Knutti, and Wilby, 2016, Nature)

Understanding: Global scale vs regional scale drivers, role of land-atmosphere interactions

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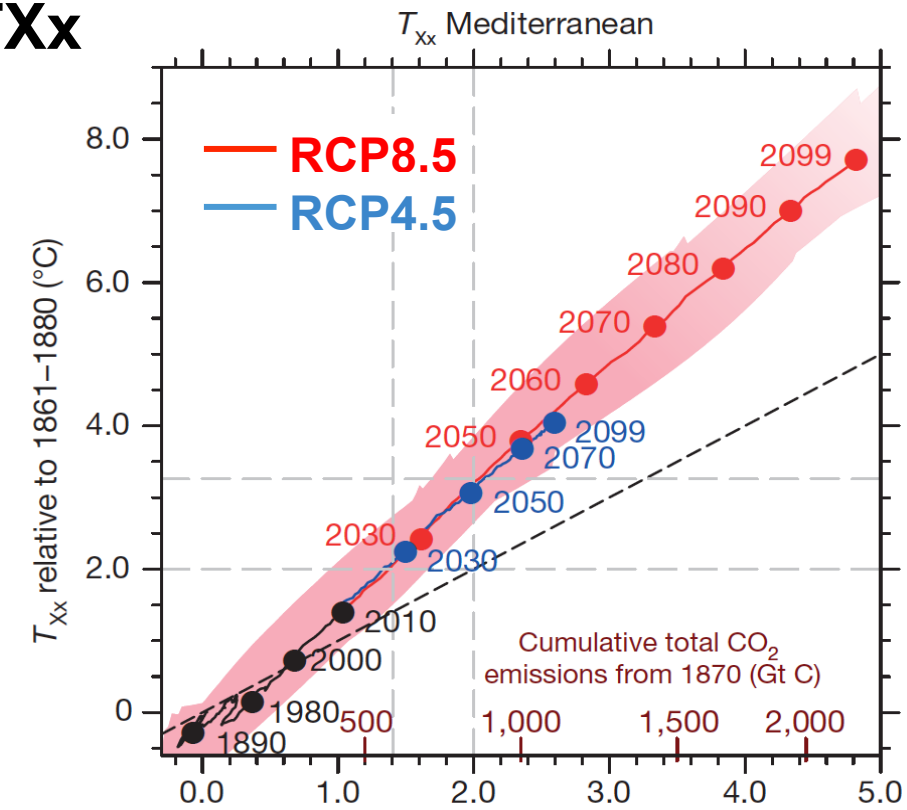
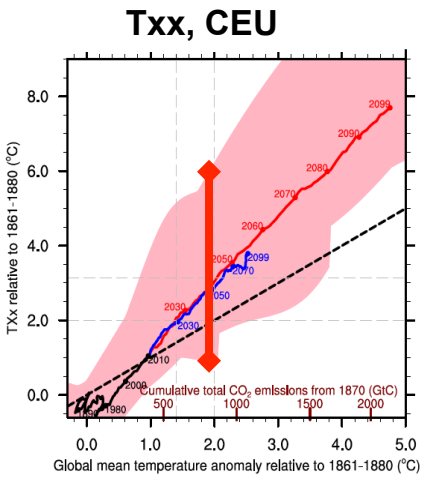
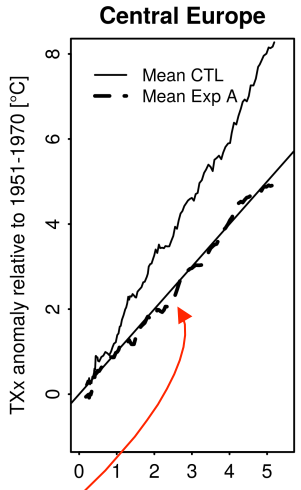


(Seneviratne, Donat, Pitman, Knutti, and Wilby, 2016, Nature)





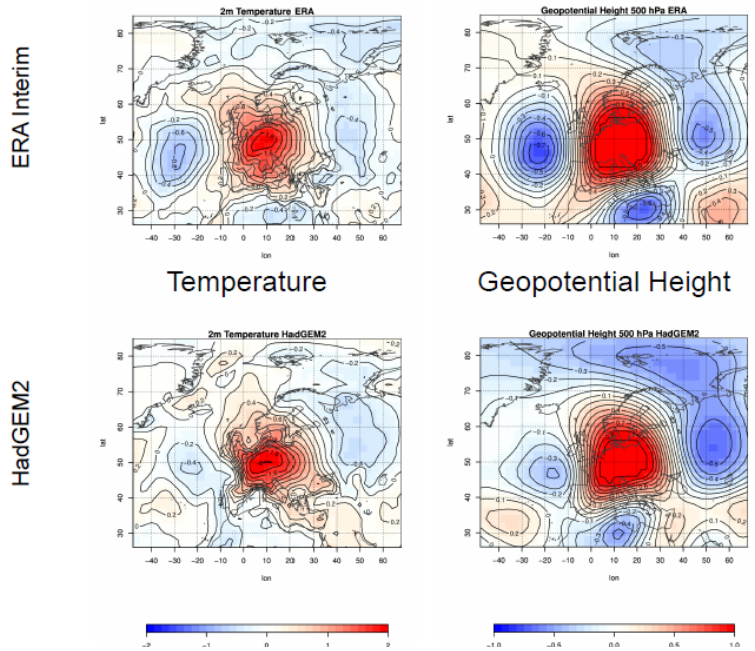
Soil moisture set to present-day conditions

(Vogel, ETH Zurich)

Simulate

To understand types of events that current GCMs and RCMs can credibly simulate and to identify key processes for weather and climate extremes that can be credibly simulated to improve prediction of large scale phenomena (weather types, modes of variability)

Composites of warm summer events



Source: Krueger et al. 2015

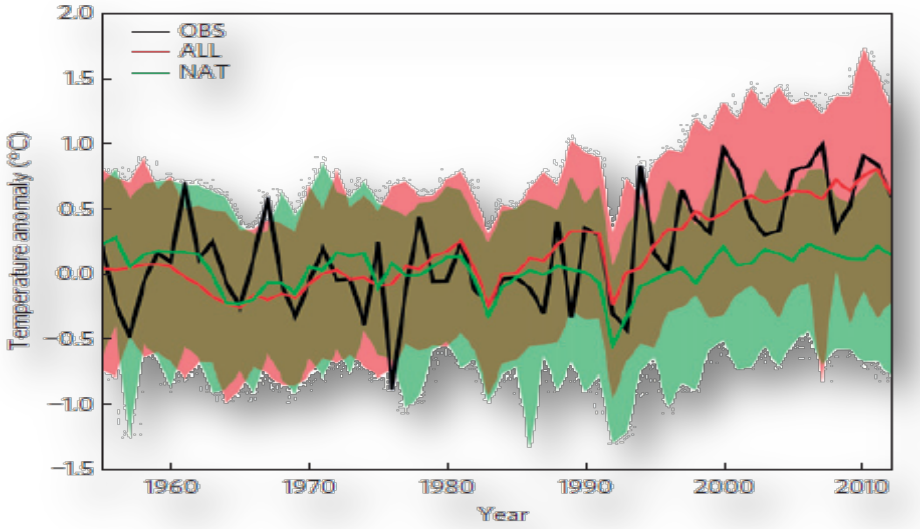
Simulating Extremes

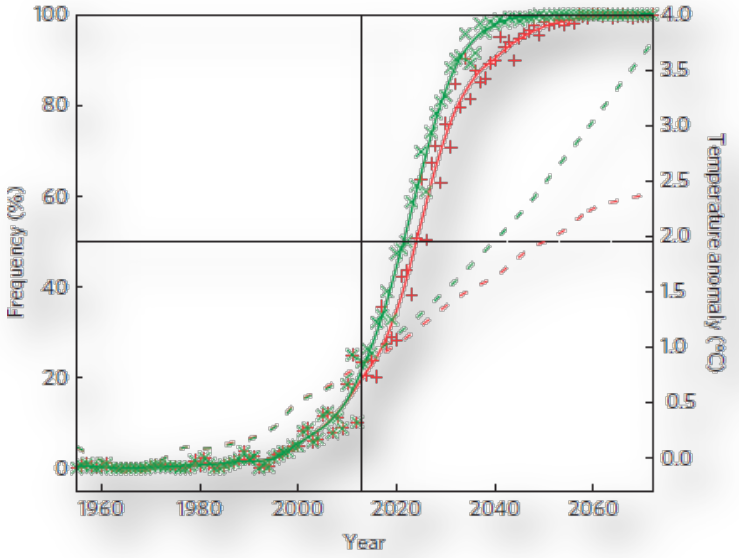
- Different issues between small-scale short-lived extremes (heavy precipitation, wind storms) and large-scale long-lived extremes (heatwaves, droughts)
- High-resolution more critical for first kind of extremes
- Land processes strong constraint for 2nd kind of extremes

Attribute

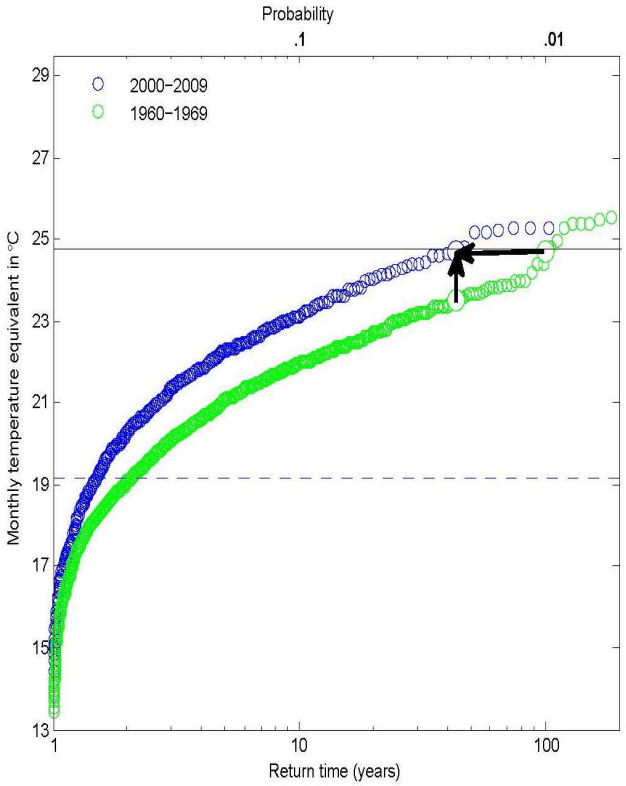
A key challenge is to understand the extent to which humans are responsible for changes in extremes and the likelihood of individual extreme weather events

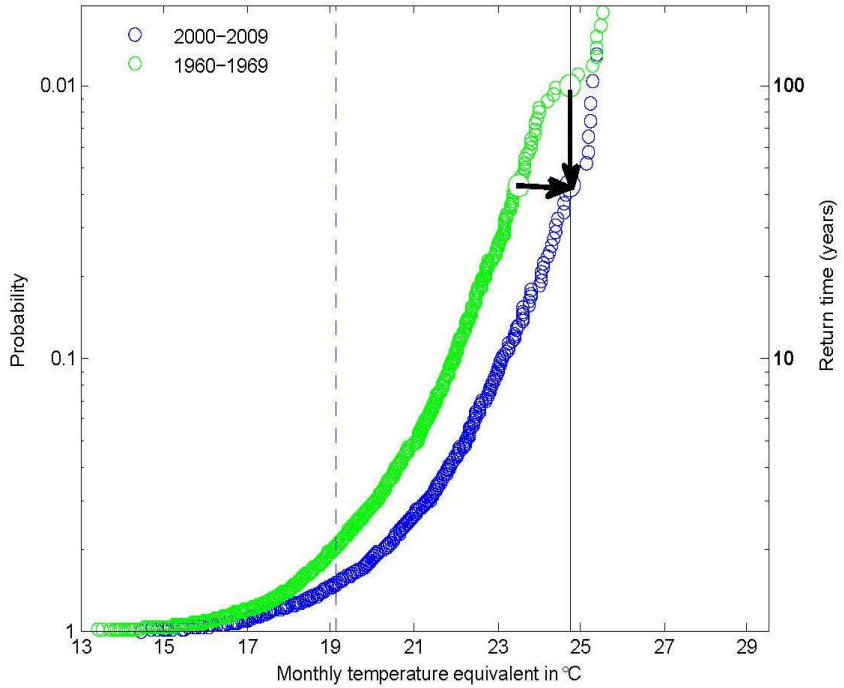
2013 Summer East China Heatwave





Attribute – framing is essential





Different ways to describe effect of anthropogenic climate change on July heat waves over Western Russia (from NRC report 2016; adapted from Otto et al., 2012)

Early Successes:
WCRP-ICTP summer school

236 applications for 35 places. About half of the attendees from developing countries.

A special issue of "Weather and Climate Extremes" with 7 articles led by students

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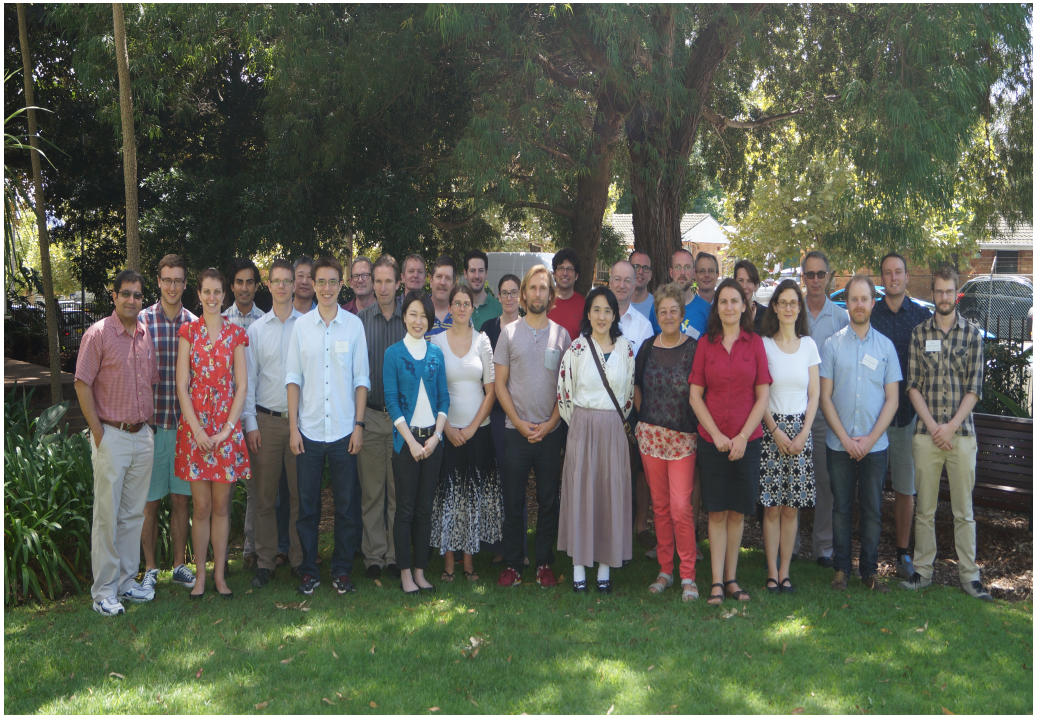
Workshop on GC-Extremes Data Requirements



Improving the collation, dissemination and quality of observations and assessing what new observations are required for extremes

Representation from major international data centres

Deliverables set over the next 3 years

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Workshop on Understanding, simulating and predicting extremes

Identified key issues in simulation of extremes

Distinguishing between small-scale extremes (heavy precipitation, wind) and large-scale extremes (droughts, heatwaves), which require different approaches

First planning for ExtremEX experiments

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Planned 2016 activities

2016: Planned workshops:

- Blocking, UK (with SPARC)
- E3S conference, Germany
- Data Rescue workshop, Ireland
- High-impact weather, USA (with WWRP)
- 13th International Meeting on Statistical Climatology and Statistics and D&A meeting, Canada (including meeting on framing event attribution question)
- Banff workshop (statistical aspects of extremes)
- Extremex workshop (late 2016 or early 2017)

IDAG 2016: Paper writing meeting (overview article planned in high-impact journal; contact taken with Nature Geoscience)

WCRP Open Science Conference on Climate extremes and Water availability, 2018

- Co-sponsored by Extremes GC, Water availability GC and GEWEX
- A milestone for the climate research community to report their progress
- Major input for the 6th Assessment
- Possible local host identified (Environment Canada)

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Thank You

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White paper: 8 key questions

1. Improved quality of ground-based and remote-sensing based datasets for extremes *(GEWEX: GHP and GDAP)*
2. Improved models for simulations of extremes *(WCRP-wide theme)*
3. Interactions between large-scale drivers and regional-scale land surface feedbacks affecting extremes *(GEWEX: GLASS)*
4. Role of external (e.g. anthropogenic) forcings vs internal variability for changes in intensity and frequency of extremes *(ETCCDI/IDAG/CLIVAR*

White paper: 8 key questions

5. Factors contributing to the risk of a particular observed event *(ACE/ETCCDI/IDAG/CLIVAR)*
6. Causes of drought changes in past and future *(GDIS/ GEWEX/CLIVAR)*
7. Predictability of changes in frequency and intensity of extremes at seasonal to decadal time *scales (WGSIP/ CLIVAR/GEWEX)*
8. Role of large-scale phenomena (monsoons, modes of variability) for past and future changes in extremes *(CLIVAR/GEWEX Monsoon panel)*

ExtremEX experiment (theme Understand)

(coordination: S.I. Seneviratne, R. Vautard, O. Martius)

- **Investigation of 2010-2015 extremes**
- Sensitivity experiments assessing relative role of drivers:
  - **Atmospheric circulation patterns, sea surface temperatures, soil moisture**
  - Anthropogenic vs Pre-industrial conditions