WCRP Grand Challenge on Understanding and Predicting Weather & Climate Extremes

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Current Status

- Implementation plan Feb. 2015
  - 4 main extremes, 4 overarching 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)
  - Blocking workshop (with SPARC, Reading, April 2016)
  - Event attribution workshop (Banff, June 2016)
  - Workshop on Compound extremes (Zurich, April 2017)
  - Currently working on high-impact overview paper

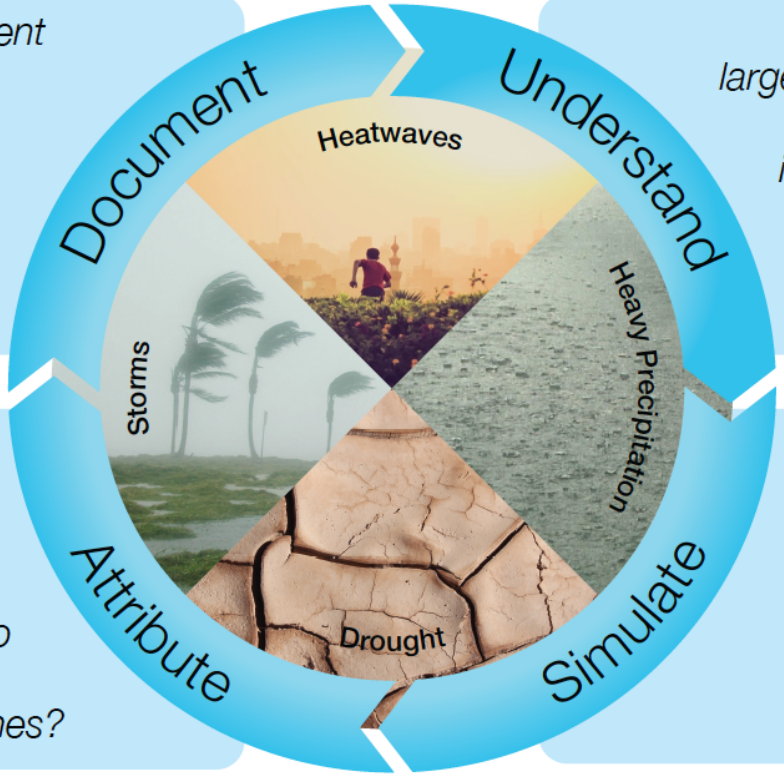
WCRP grand challenge on weather and climate extremes

- ***service perspective***: What are frequency and magnitudes of various impact-causing extremes in the near and long term?
- ***science perspective***: causes and mechanisms of variability and change in extremes, how to improve the prediction of change
- Implementation needs to be focused: areas with opportunity for rapid progress

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, regional and local scale processes, as well as their interactions, for the formation of extremes?



What are the contributors to observed extreme events and to changes in the frequency and intensity of the observed extremes?

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

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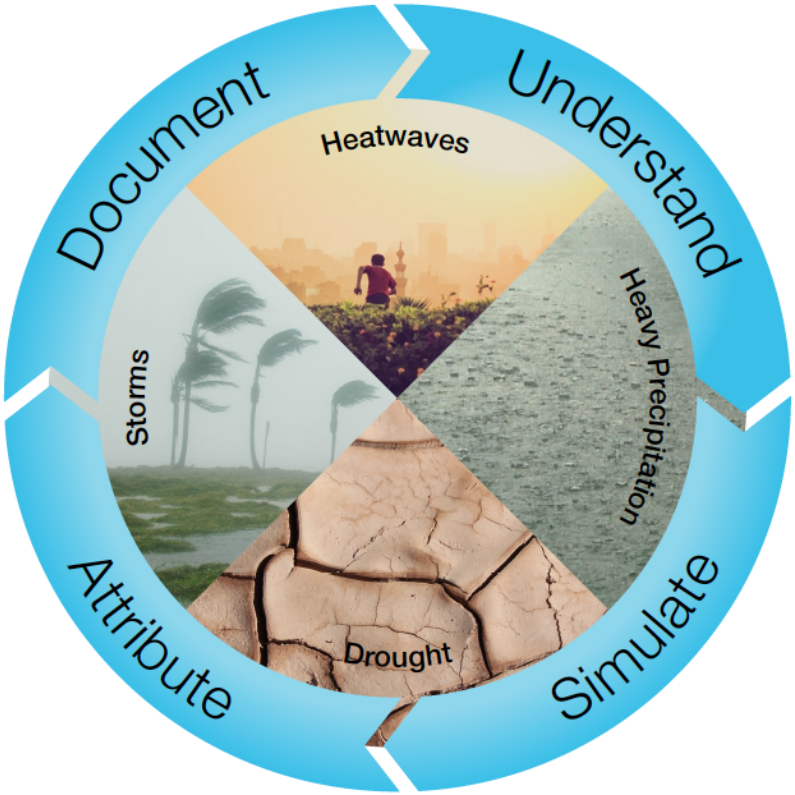
Leads

Lisa Alexander

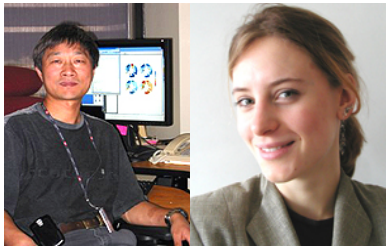
Ali Behrangi



Sonia Seneviratne

Olivia Martius

Robert Vautard



Xuebin Zhang

Fredi Otto

Gabi Hegerl

Jana Sillmann

Erich Fischer

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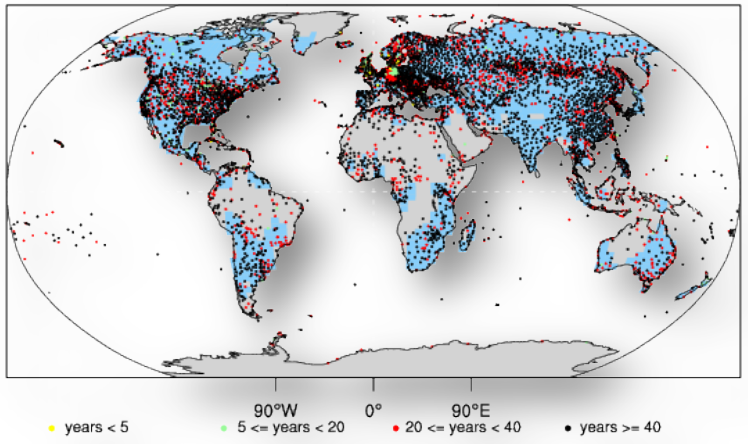
Theme: Document

Observations crucial for understanding change and evaluating models, but critical gaps exist in the amount, quality, consistency and availability, especially for extremes

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



Source: Westra et al. 2014, Rev. Geophys.

- 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
- *Also considers runoff observations*

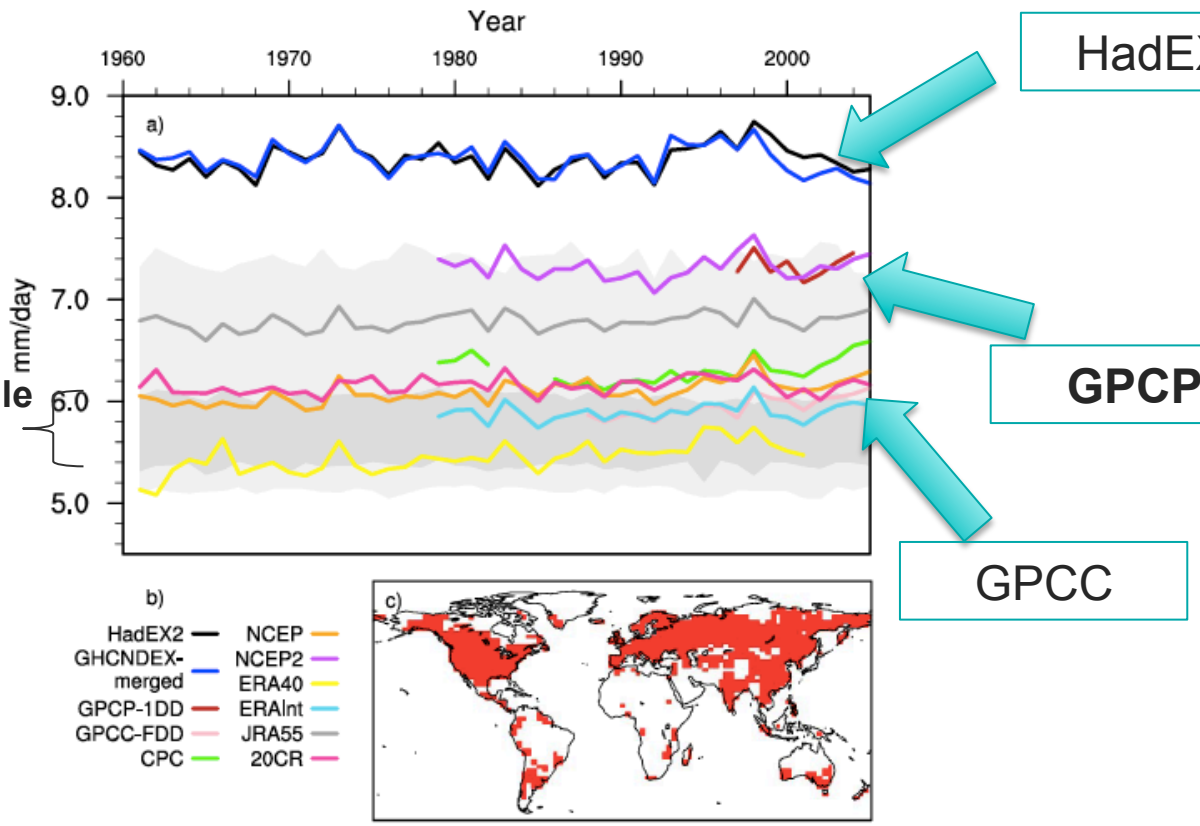
Theme: Document

The *dreary state* of precipitation observations

Full obs/ reanalyses **range**

Full CMIP5 range

Interquartile CMIP5 range



Source: Herold et al. 2016

~3mm/day difference

in annual estimates of daily precipitation intensity

Masked to where all datasets have data

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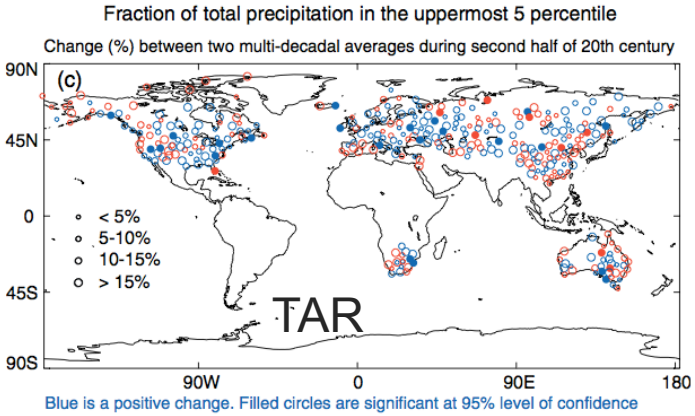
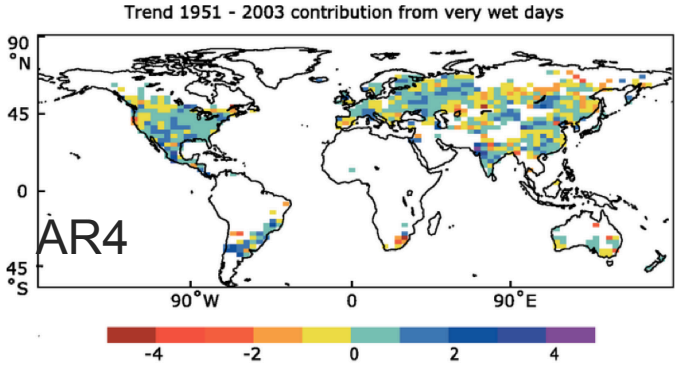
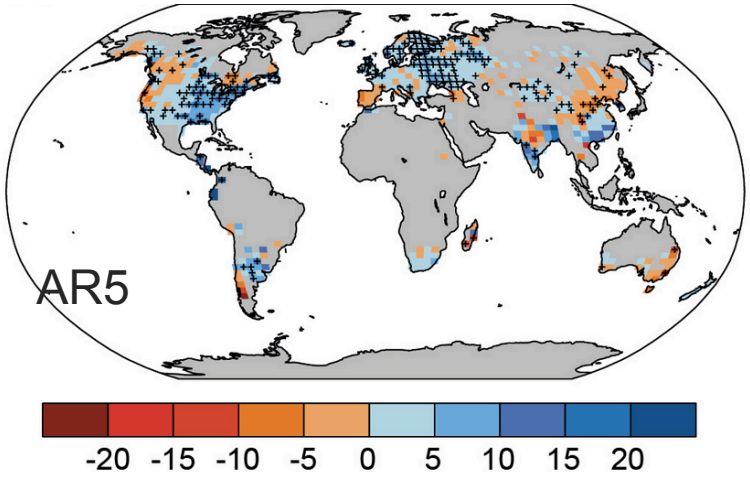
Theme: Document

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

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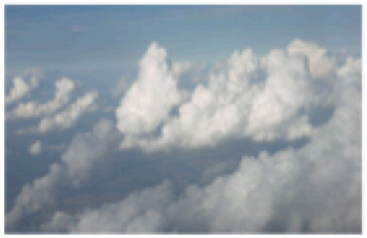
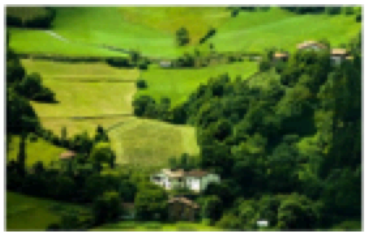
Theme: Understand

atmosphere



greenhouse gases

oceans

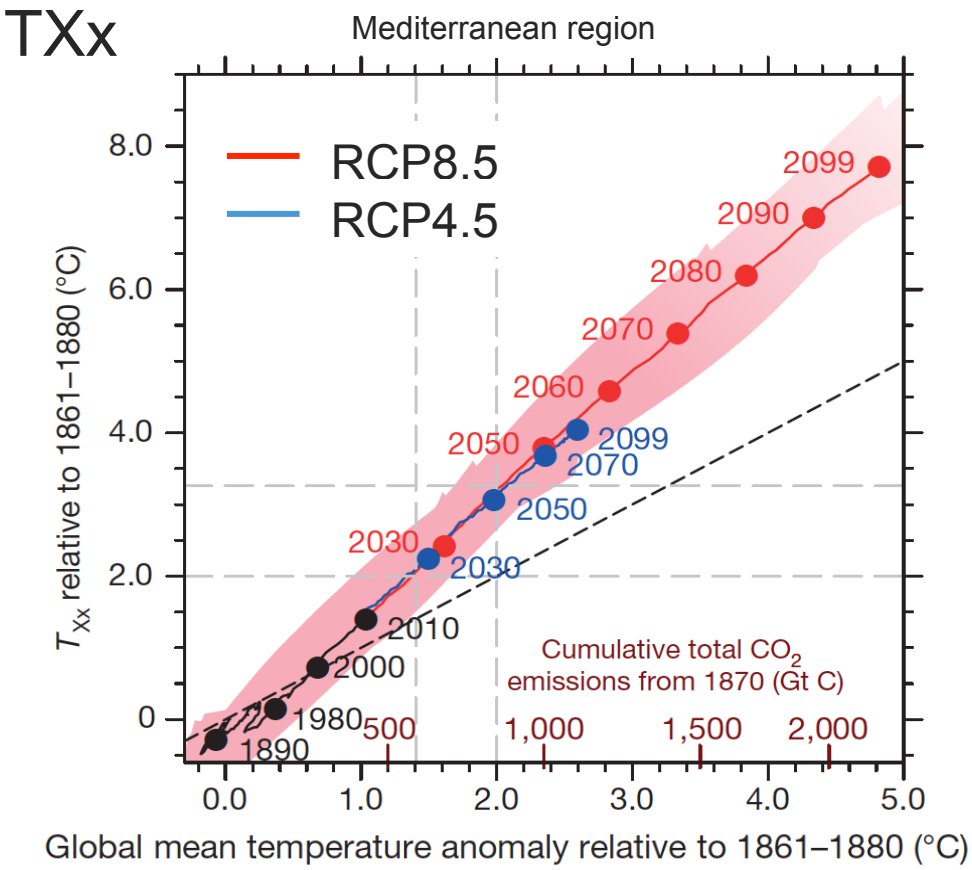


land

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

Theme: Understand

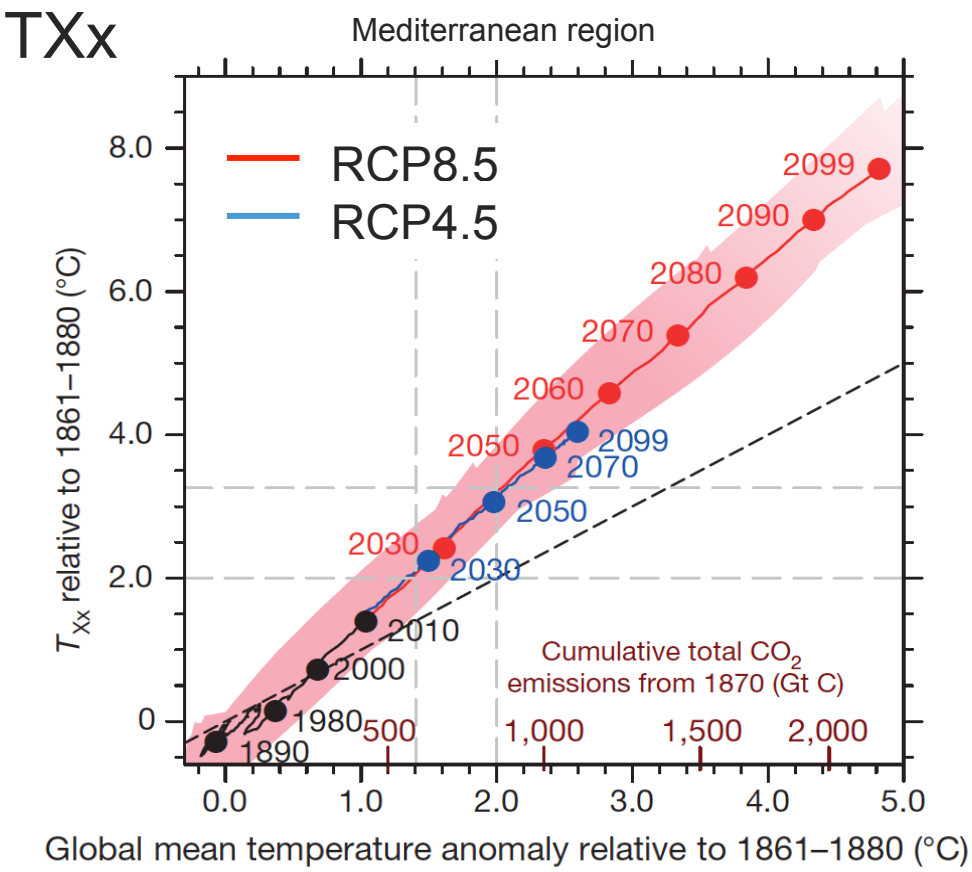
Understanding: Global scale vs regional scale drivers, role of land-atmosphere interactions



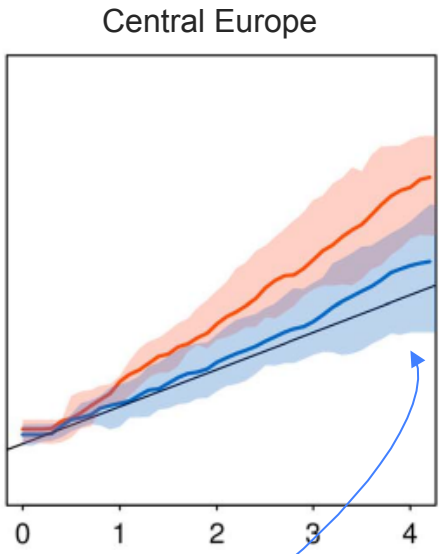
Source: Seneviratne et al. 2016, Nature

Theme: Understand

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



Source: Seneviratne et al. 2016, Nature

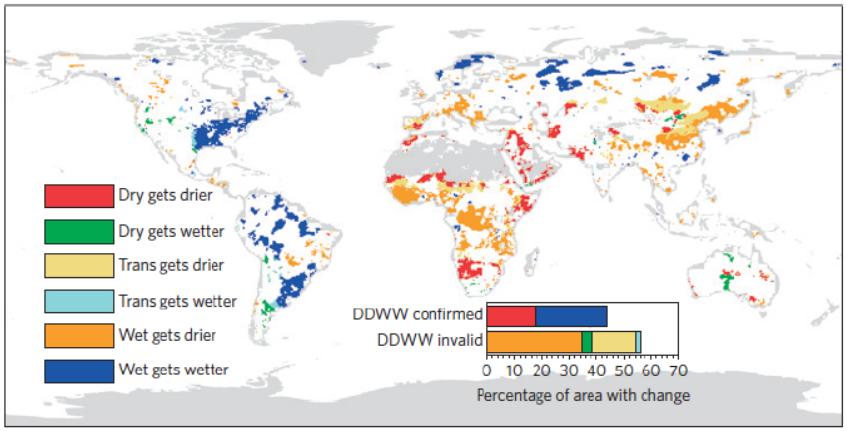


Source: Vogel et al. 2017, GRL

Theme: Understand

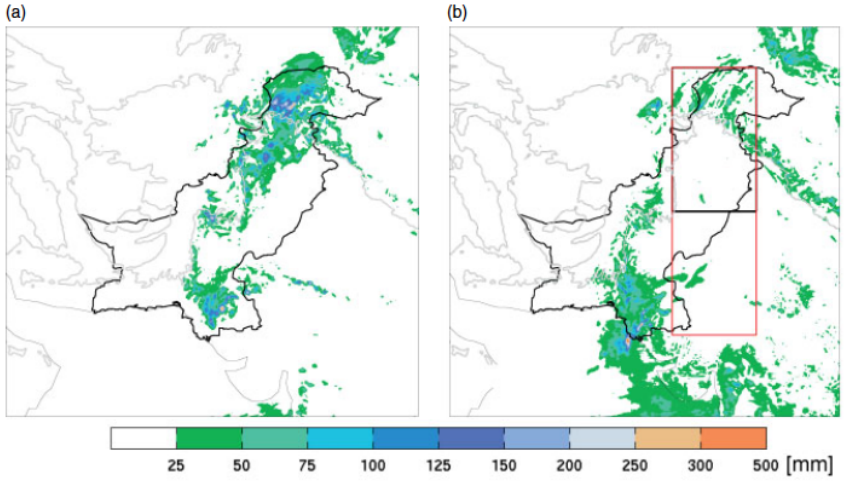
Understanding: Global scale vs regional scale drivers, role of land-atmosphere interactions

Analysis of observed robust drying trends (from 1948-1968 to 1985-2005): No support for "dry gets drier, wet gets wetter" paradigm



Source: Greve et al. 2014, Nature Geoscience

Land moisture sources strong contributor to 2010 Pakistan flood-inducing rainfall events



Source: Martius et al. 2013, QJRMS

Theme: Understand

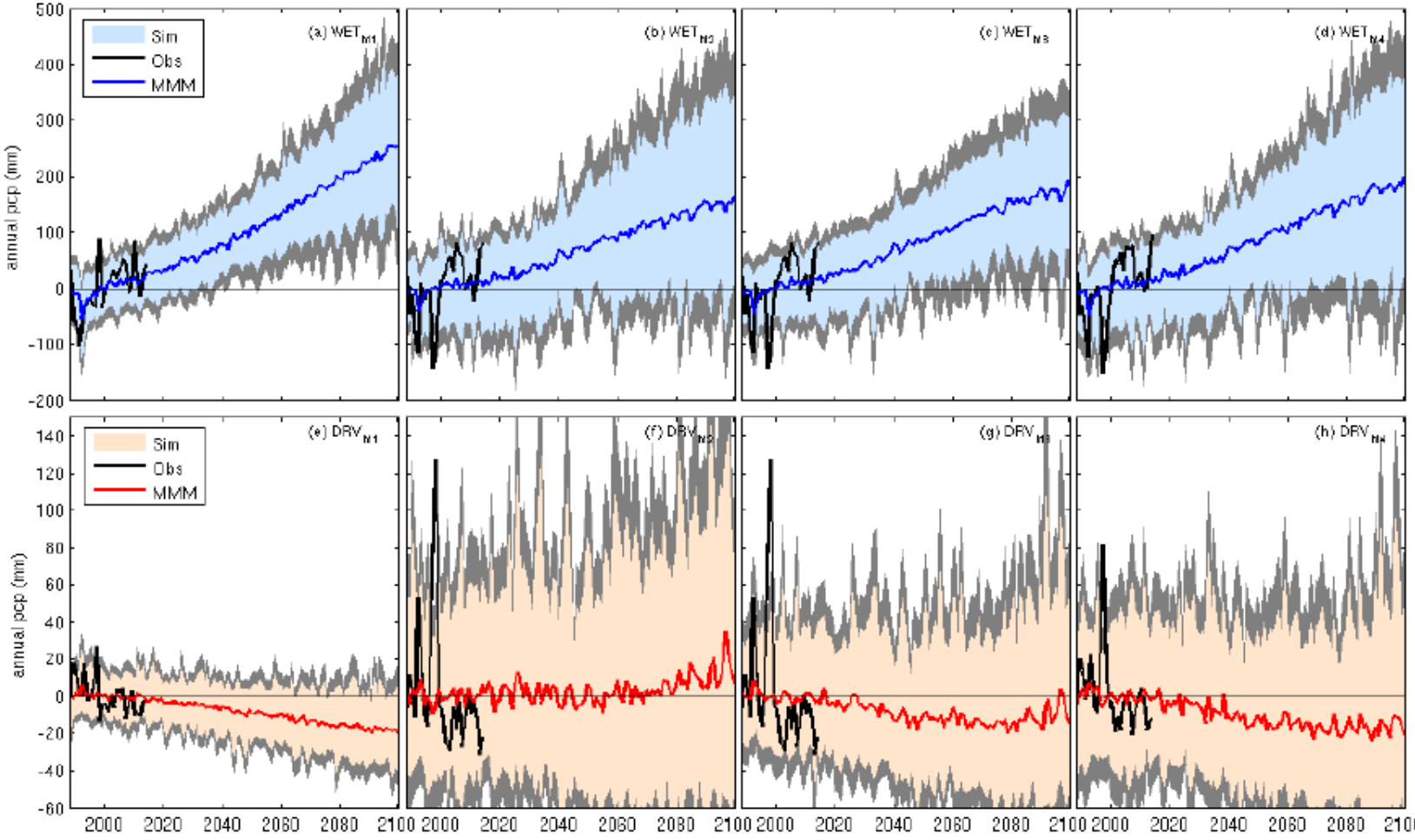
Wet vs dry for model evaluation

M1: model climatology & moving regions

M2: obs climatology & fixed annual regions

M3: model climatology & fixed annual regions

M4: obs climatology & fixed seasonal regions



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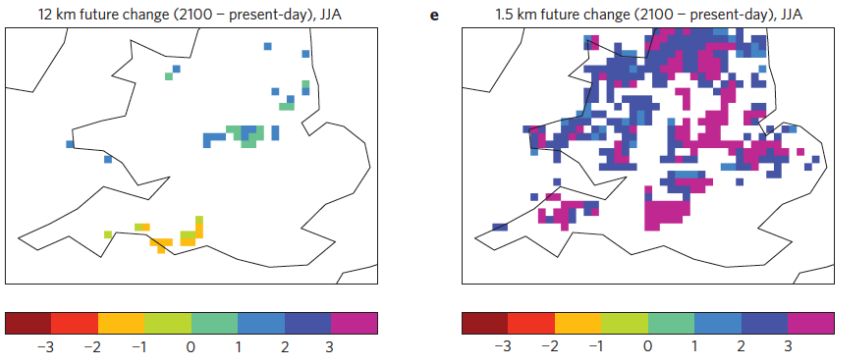
Theme: Simulate

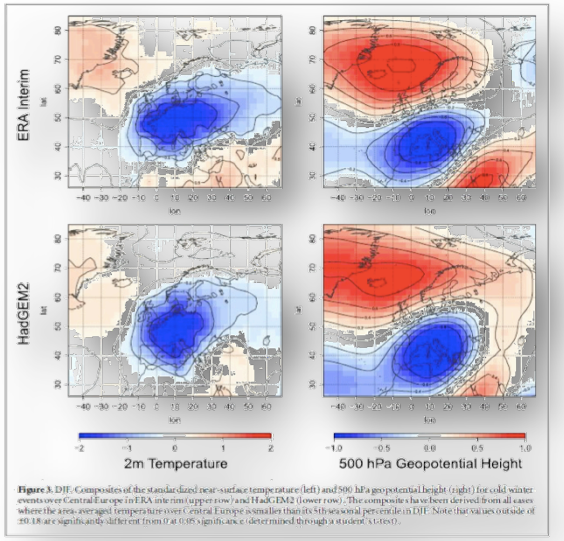
Do the models simulate extreme events for the right reason?

How to use both statistical methods for tails and knowledge about mechanisms/storylines?

What phenomena are GCM and RCM simulations credible for and how can simulations be improved?



Source: Kendon et al. 2014, Nature Climate Change



Source: Krueger et al. 2015, ERL

Theme: Simulate

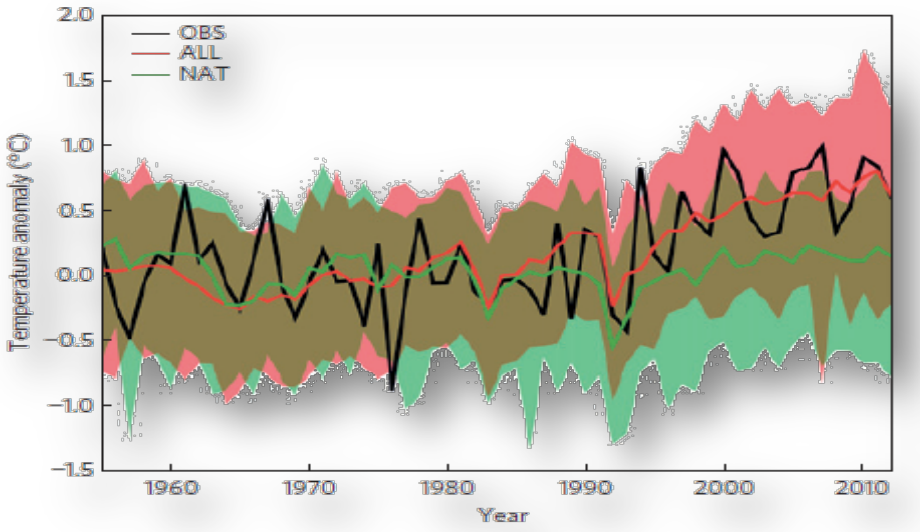
Simulating Extremes

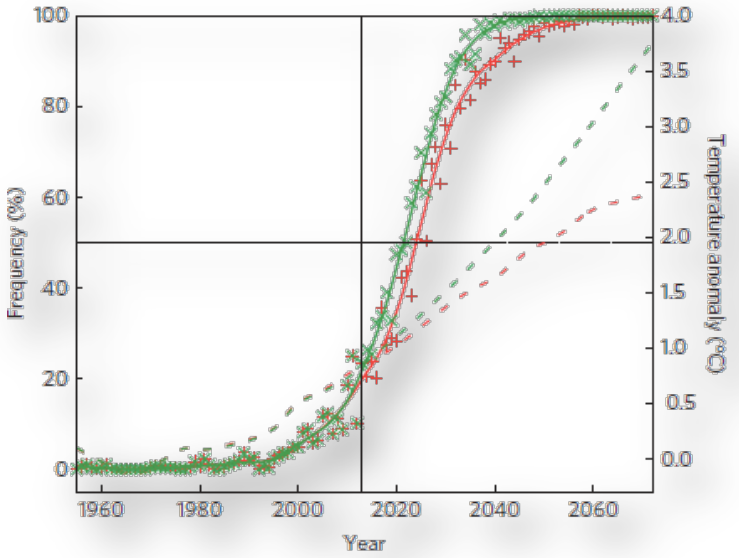
- Different issues between small-scale short-lived extremes (heavy precipitation, wind storms) and large-scale long-lived extremes (heatwaves, droughts)
- High-resolution more critical for first kind of extremes
- Land processes strong constraint for 2nd kind of extremes; uncertain in models
- Uncertainty in circulation response to forcing affects both

Theme: Attribute

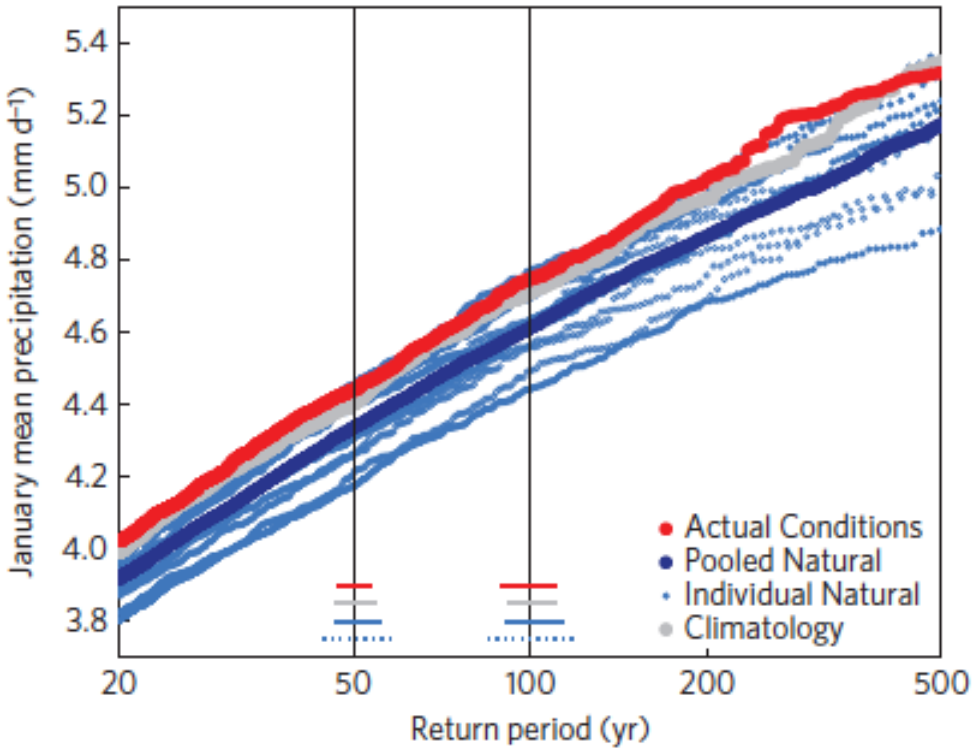
A key challenge is to understand the extent to which humans are responsible for changes in extremes and the likelihood of individual extreme weather events

2013 Summer East China Heatwave





Theme: Attribute



Source: Schaller et al. 2016, Nature Climate Change

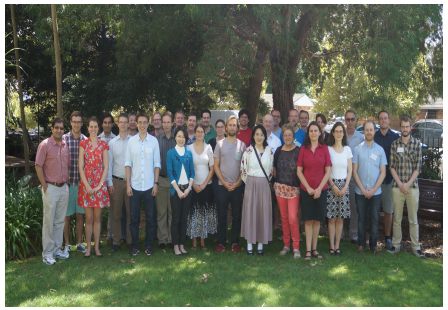
Estimate changing risk due to human influence, e.g:

Human influence on 2014 southern England winter floods

Activities

Early successes

2014 WCRP summer school (Trieste, Italy) & journal special issue



2015 Workshop on data requirements (Sydney, Australia)

2015 Workshop on understanding & simulating extremes (Oslo, Norway)

2016

- Blocking workshop (UK, with SPARC)
- Data Rescue workshop, Ireland
- High-impact weather, USA (with WWRP)
- 13th International Meeting on Statistical Climatology and Statistics and D&A meeting, Canada
- Banff workshop (statistical aspects of extremes)

2017-2018

- Workshop on compound extremes, Switzerland (April 2017)
- Perspective paper in progress by grand challenge team
- 2018 OSC on Climate Extremes and Water Availability

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
- Target date for major results from on-going activities (publications)

GC extremes and 3 out-of-the-box science questions

- The GC extremes has a high relevance to all three questions
- “How does weather change with climate”: Weather we care about is extreme weather, this is the core of the GC
- “How does climate influence habitability”: Habitability is strongly affected by changes in climate extremes (heatwaves, droughts, storms, floods), also core topic
- “Where does the carbon go?”: Climate extremes affect carbon uptake, in particular related to potential changes in drought occurrence in vegetated regions (e.g. Amazon)

Thank you!

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