GC Climate Extremes

Sonia Seneviratne, Graeme Stephens (GEWEX)

Task team co-chairs: Xuebin Zhang, Gabi Hegerl, Lisa Alexander (new)

Contributions to white paper: Francis Zwiers, Ron Stewart

Acknowledgements (material for presentation): Bob Adler, Jason Evans, Siegfried Schubert, Wouter Dorigo

GC Climate Extremes

Led by GEWEX, in consultation with CLIVAR

Co-chairs of task team (2013-2015): X. Zhang, G. Hegerl, L. Alexander (new)

White paper (February 2014): X. Zhang, G. Hegerl, S. Seneviratne, R. Stewart, F. Zwiers

GC Climate Extremes

New title: **Understanding and predicting weather and climate extremes**

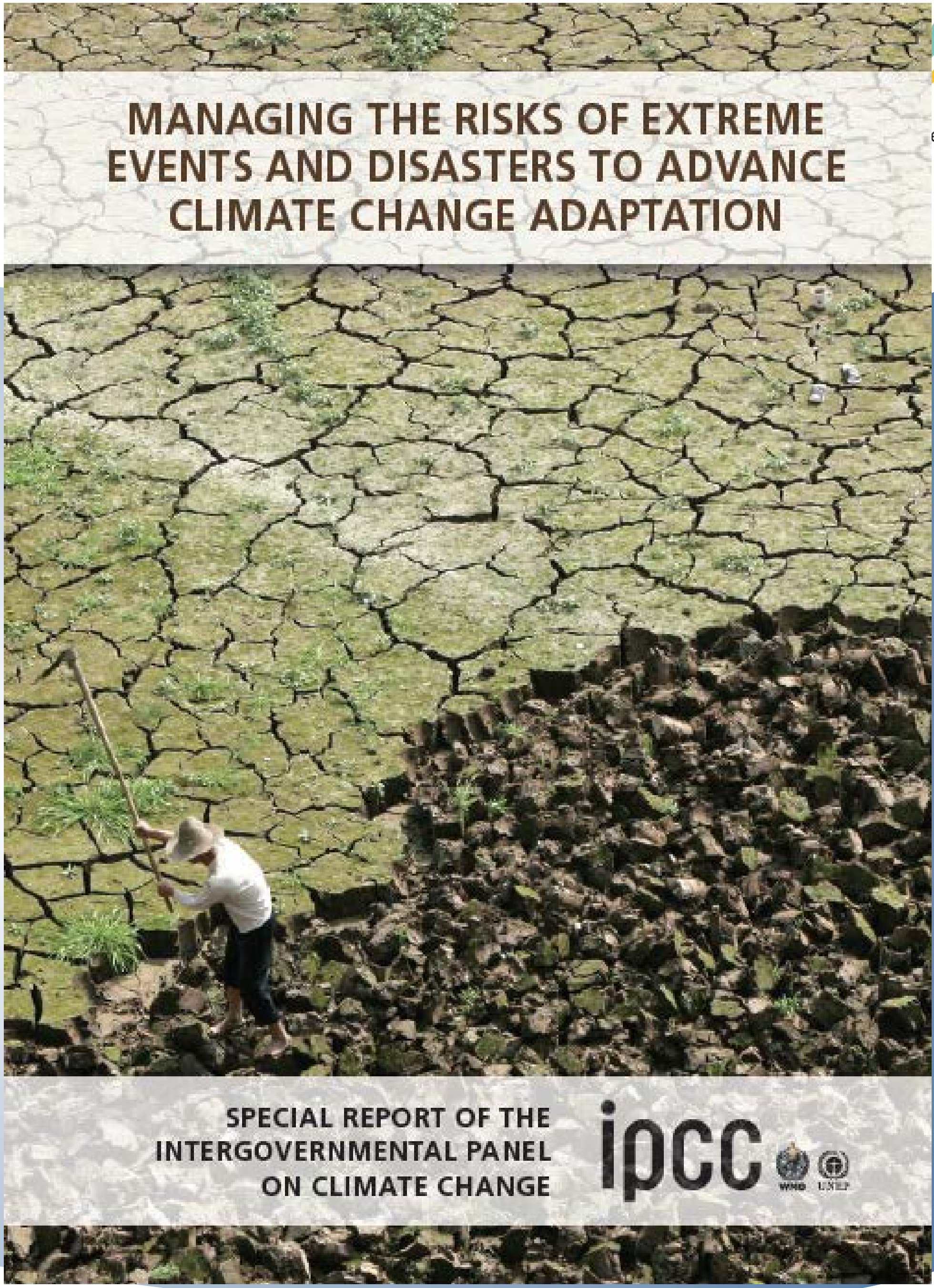
(Previous title “Science underpinning the prediction and attribution of extreme events” too narrow)

Current status

- White paper drafts circulated to CLIVAR and GEWEX SSGs in December 2013/January 2014
- Final draft posted February 2014
- Added a new member Lisa Alexander to task team co-chairs (jointly supported by GEWEX and CLIVAR co-chairs)
- White paper final draft circulated to US CLIVAR community for comments May 2014
- Currently developing more detailed implementation plan

What are climate extremes?

IPCC SREX report (2012)
Climate Extremes, or even a series of non-extreme events, in combination with social vulnerabilities and exposure to risks can produce climate related disasters



Many types of weather and climate extremes, different space/time scales

- Heat wave (days, over large region)
- Drought (year to decade or longer, continental)
- Major flood (days to month, over large region)
- Ice storm (day, over small region)
- Tornadoes (minutes and several kilometers)
- Marine storms (hours to days and thousand kilometers)

Identified 8 key scientific 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 *(GEWEX/CLIVAR/WGCM)*

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)*

5: factors contributing to the risk of a particular observed event *(ACE/ETCCDI/IDAG/CLIVAR)*

6: causes of drought changes in past and future *(GEWEX/CLIVAR/GDIS)*

7: predictability of changes in frequency and intensity of extremes at seasonal to decadal time scales *(WGSIP/CLIVAR/GEWEX)*

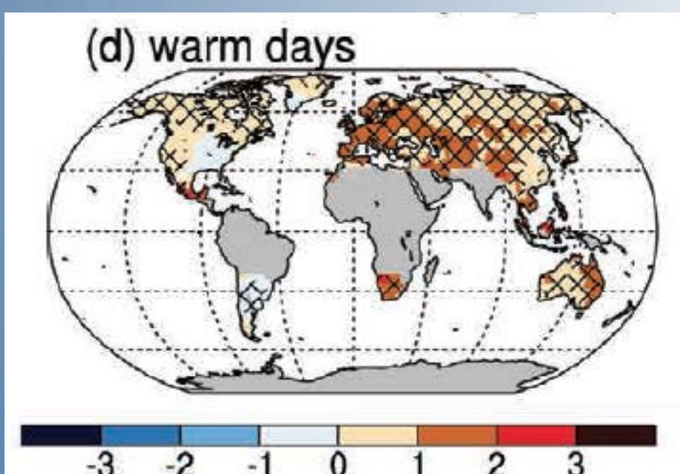
8: role of large-scale phenomena (monsoons, modes of variability) for past and future changes in extremes *(CLIVAR/GEWEX)*

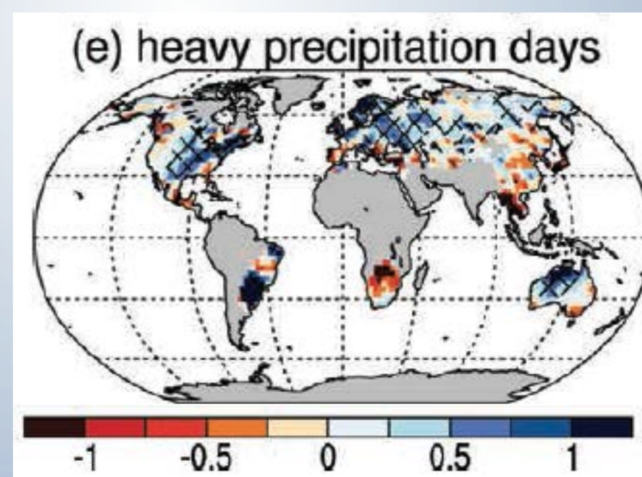
Improved observations

IN BOX
INSIGHTS and INNOVATIONS

Global Land-Based Datasets for Monitoring Climatic Extremes

BY M.G. DONAT, L.V. ALEXANDER, H. YANG, I. DURRE, R. VOSE, J. CAESAR





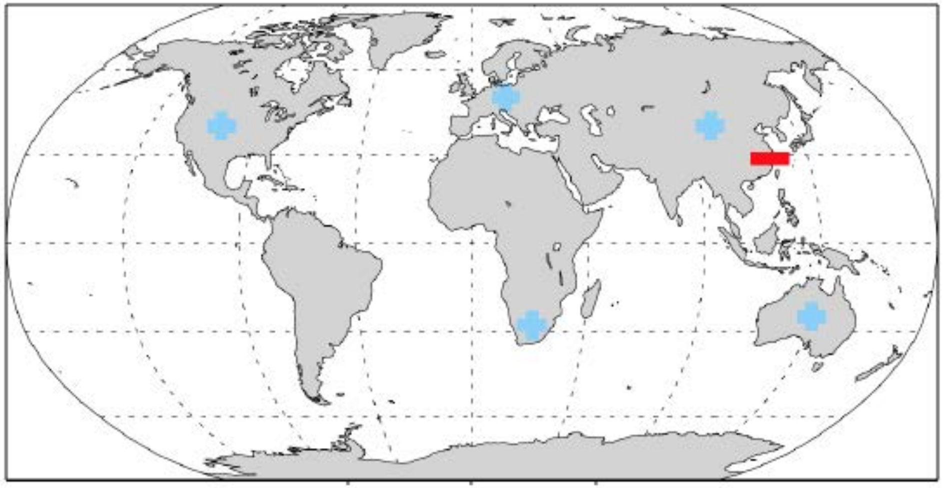
Donat et al. 2013, BAMS

Improved observations

Sub-daily precipitation Cross-cut project

- GHP: Review of sub-daily precipitation covering observations and modelling with focus on extremes (subm. to Rev. of Geophysics)
- While only limited regions of the globe have been studied, most show an increase in sub-daily extreme rainfall over the last few decades (but with regional and seasonal variations)

GEWEX/GHP



Regional trends in observed sub-daily extreme rainfall based on published studies

(Westra et al., submitted)

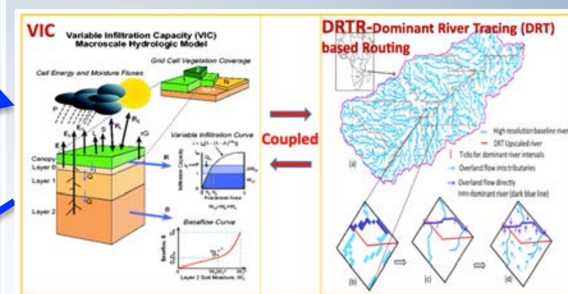
Improved observations

GEWEX/GDAP

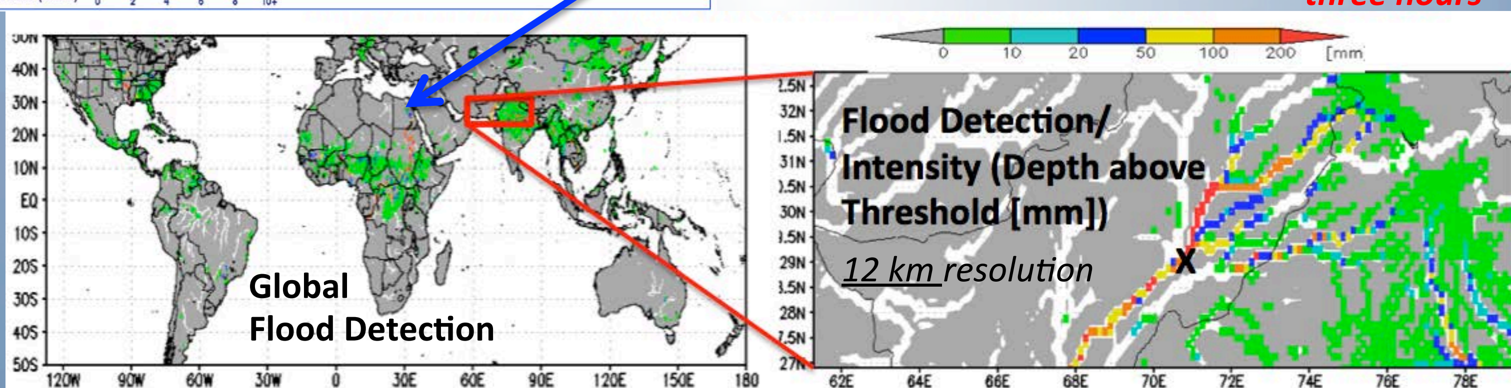
Global Flood Monitoring System (GFMS)

http://flood.umd.edu/

Global Real-time Flood Calculations Using Satellite Rainfall and Hydrological Models



TRMM/GPM rainfall into land surface and routing models for water depth and stream flow calculations compared to flood thresholds--every three hours



Indus River basin Aug. 20 2013

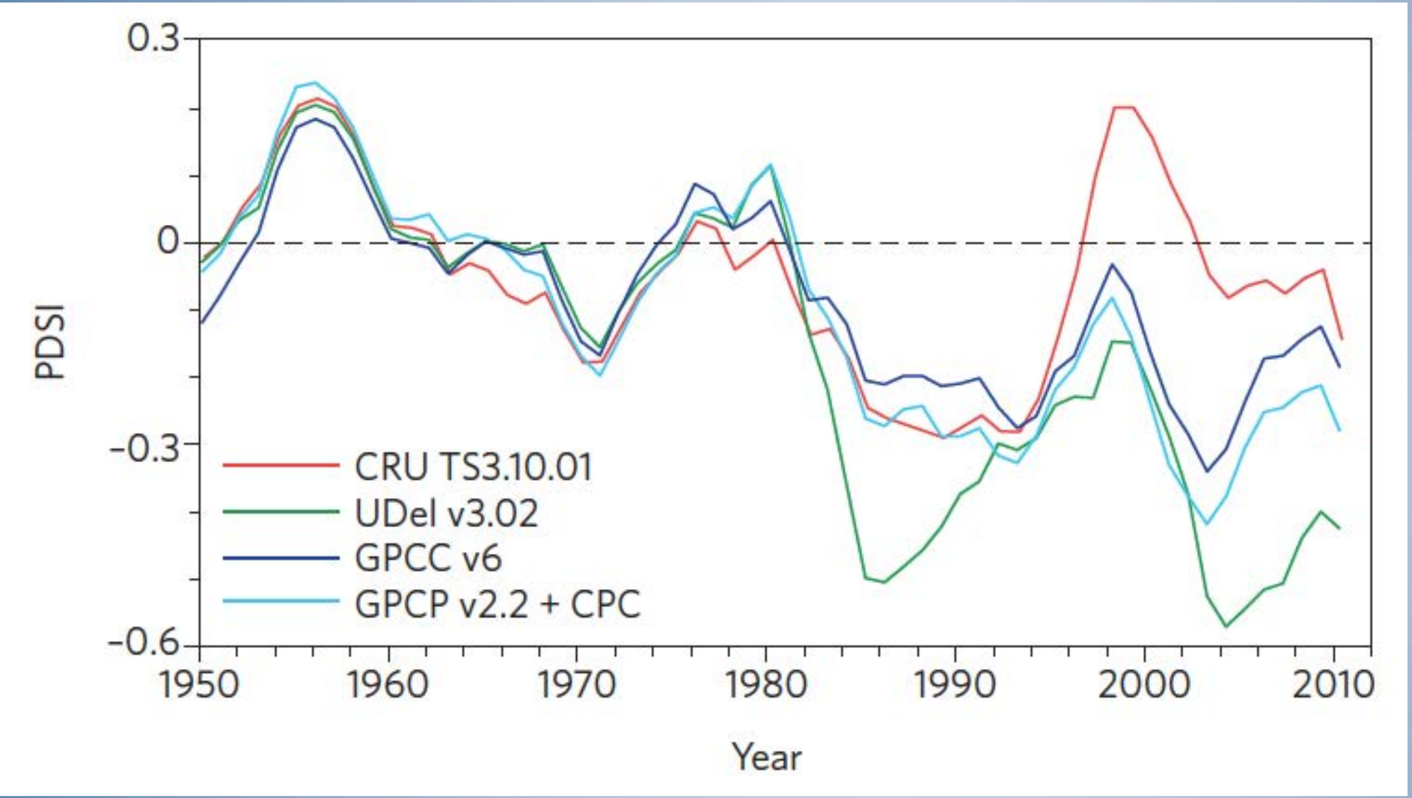
Wu, Adler et al., WRR 2014

Robert Adler/Huan Wu, U. of Maryland

Observations: Some challenges

World Climate Research Programme

Impact of uncertainties in precipitation datasets for global drought trends



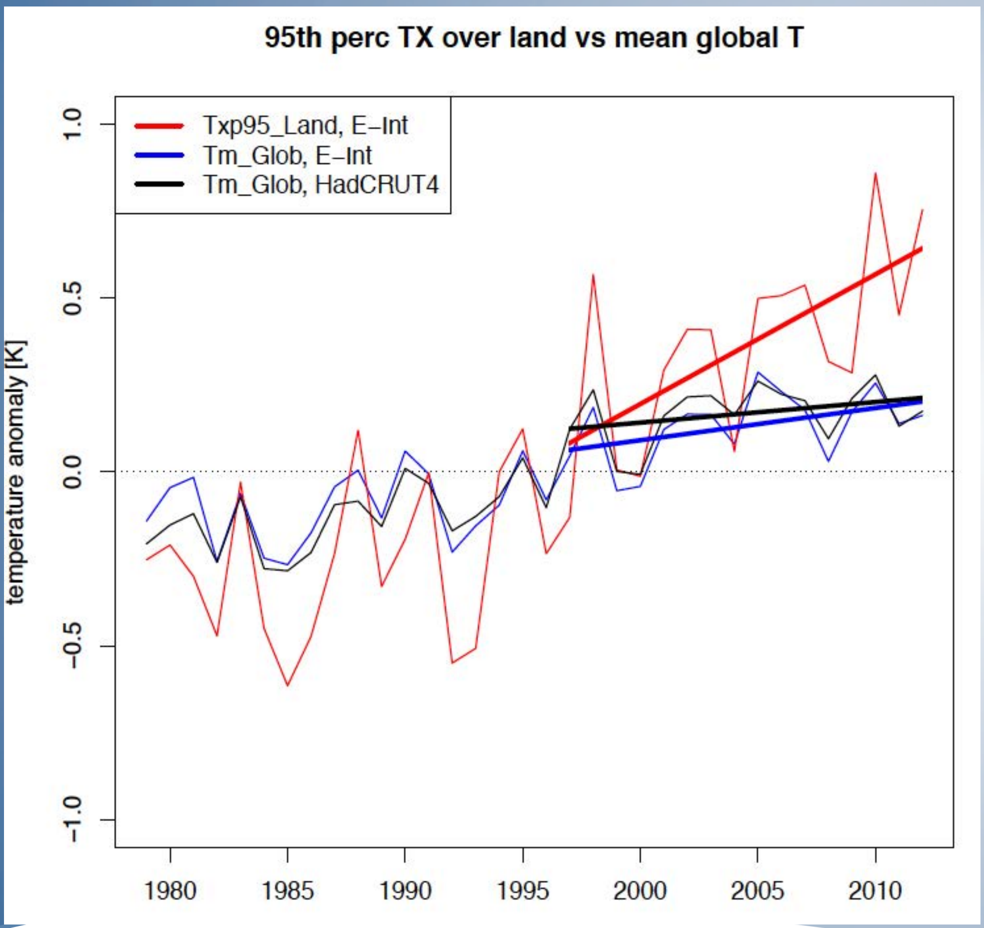
GEWEX/GDAP and GLASS

Trends in scPDSI (Penman-Monteith Epot)

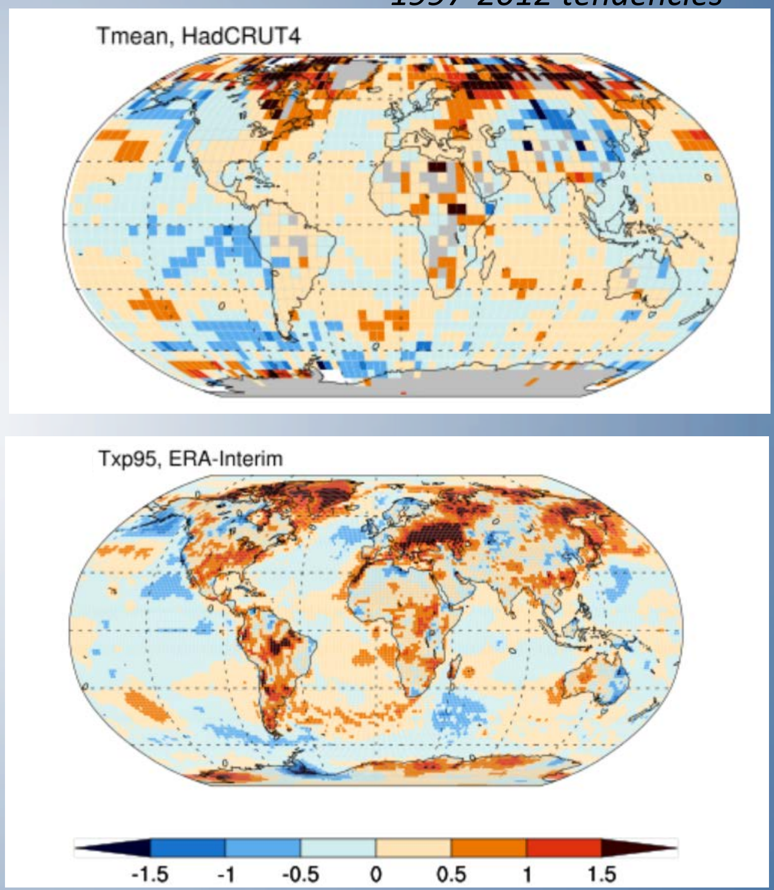
Trenberth et al. 2013, Nature Clim. Ch.

Observational data: Recent trends

No pause in increase of hot temperature extremes



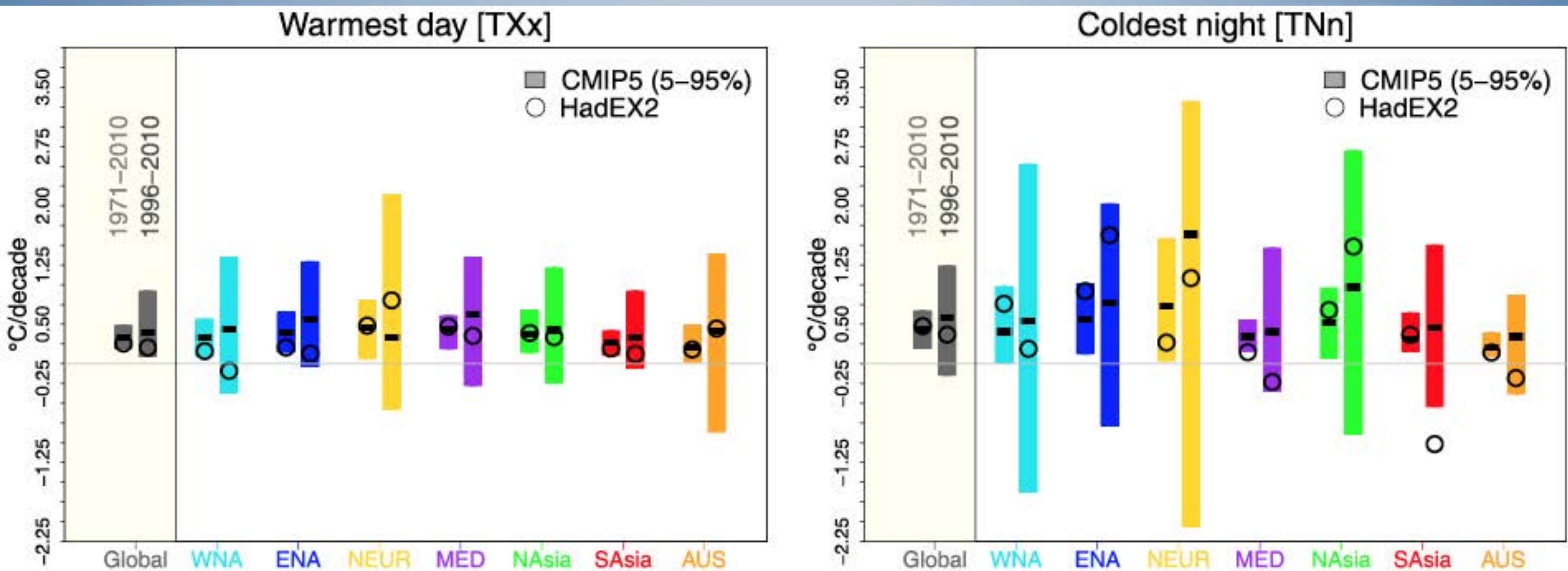
1997-2012 tendencies



(Seneviratne et al. 2014, Nature Clim. Ch.)

Improving models

ETCCDI/CLIVAR

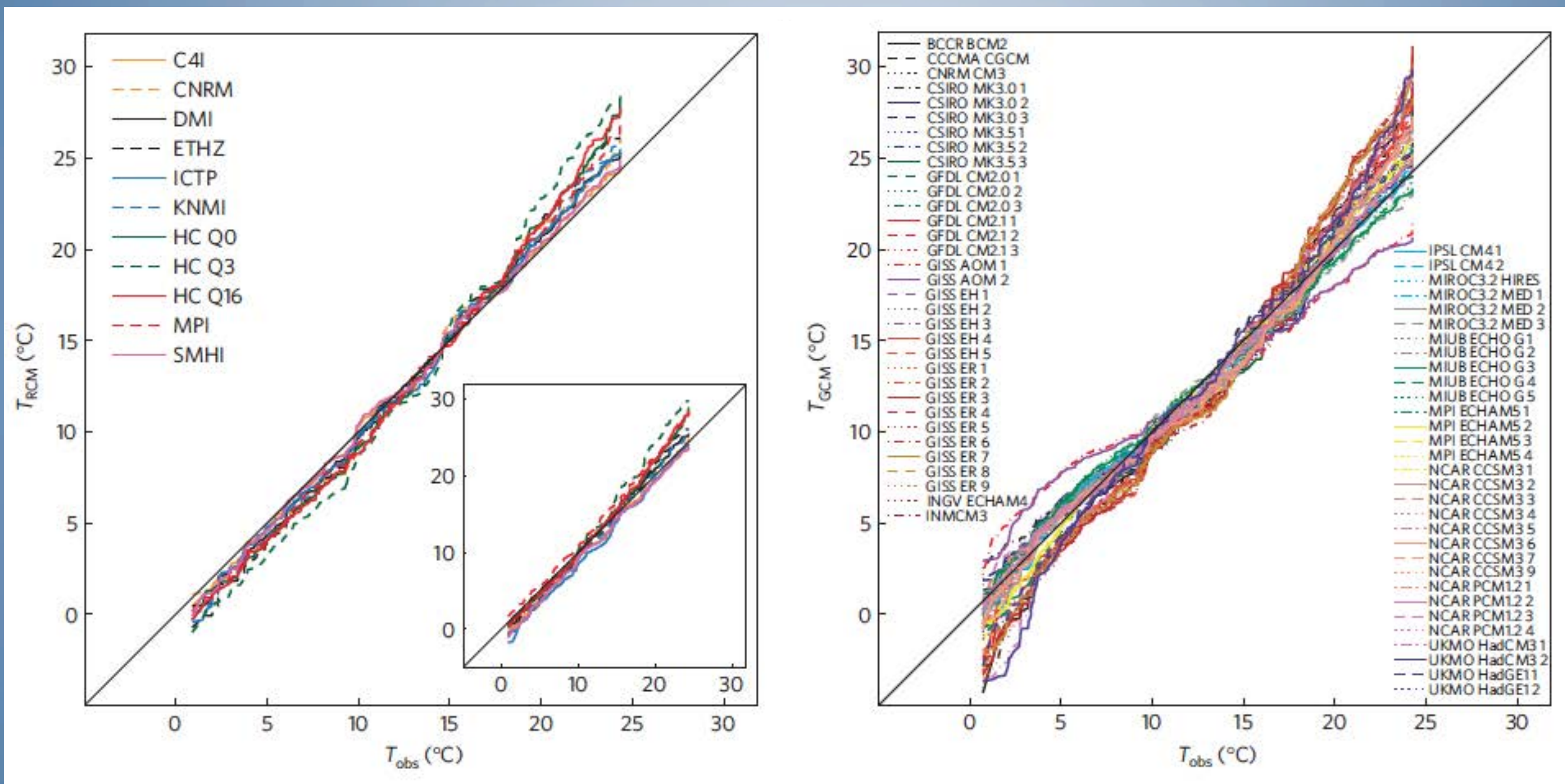


Sillmann et al. 2014, ERL

World Climate Research Programme

Improving models

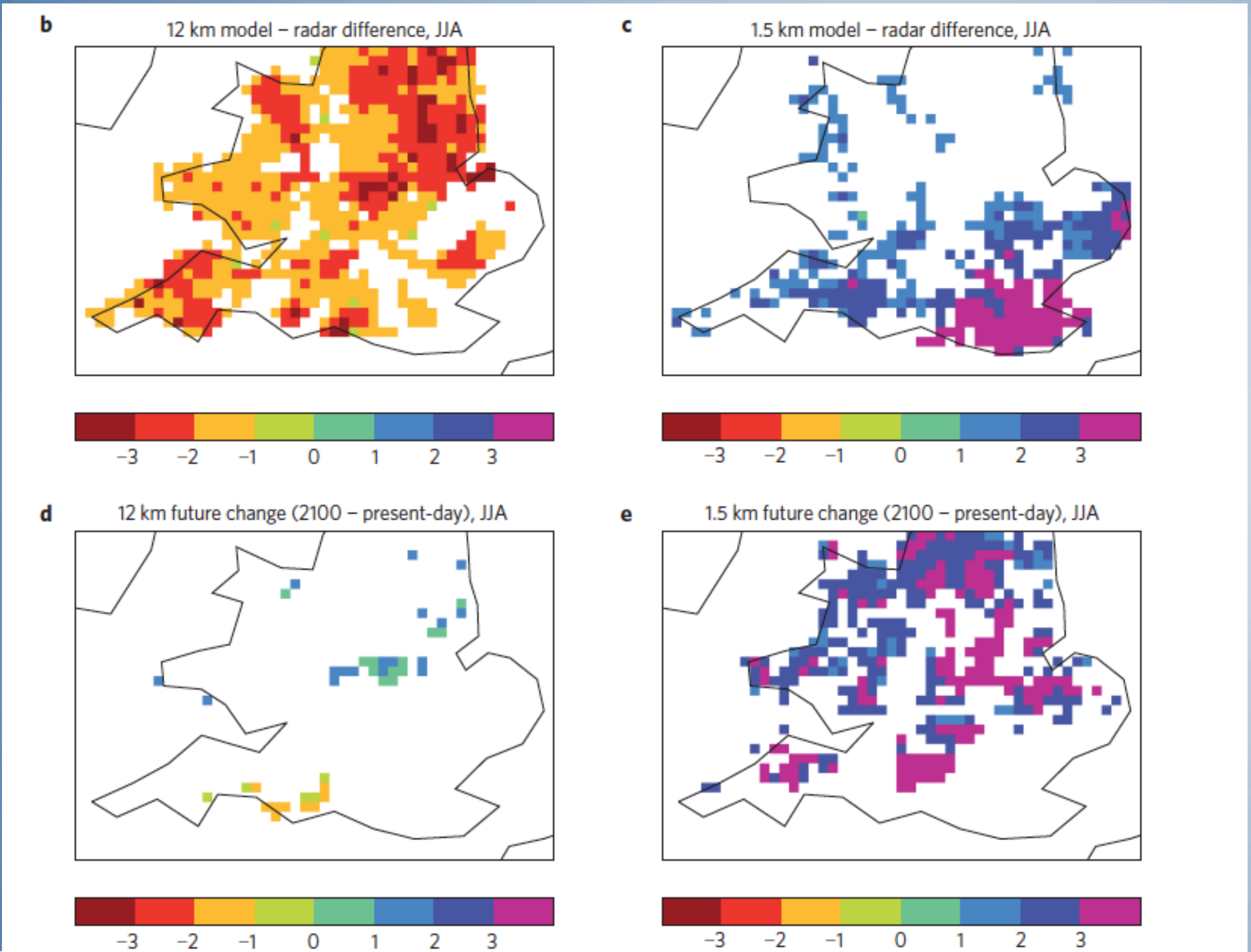
Climate models overestimate highest temperatures in the Mediterranean



Boberg and Christensen 2012, Nature Clim. Ch.

Improving models

Impact of model resolution for simulating heavy precipitation

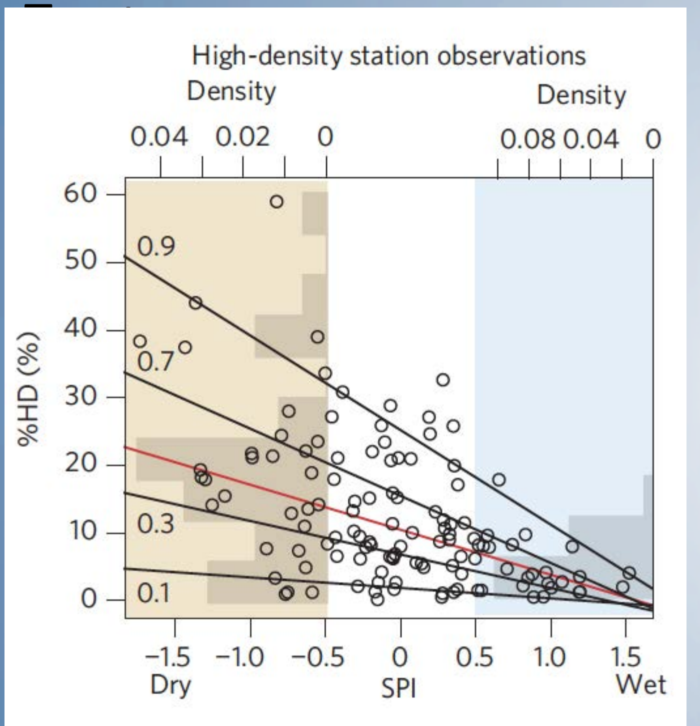


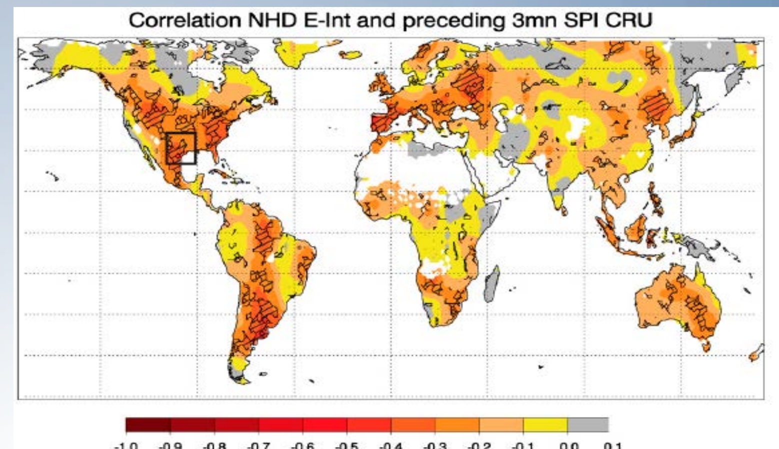
Kendon et al. 2014, Nature Clim. Ch.

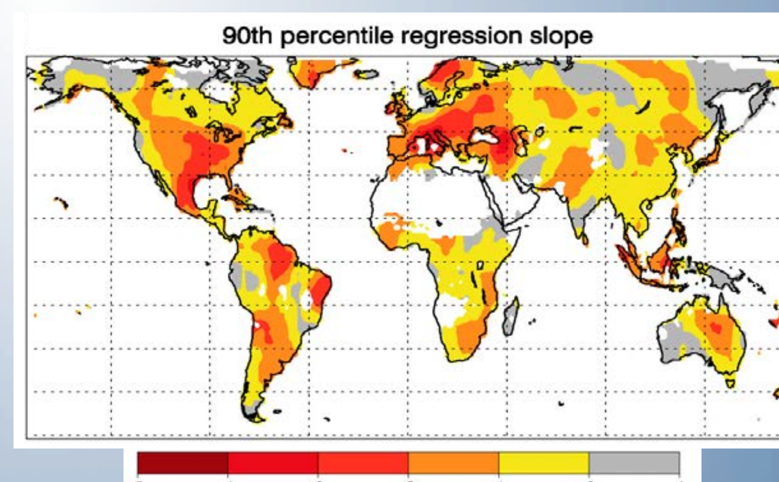
Mechanisms: Land-climate interactions

GEWEX/GLASS

Impacts of surface moisture limitations for





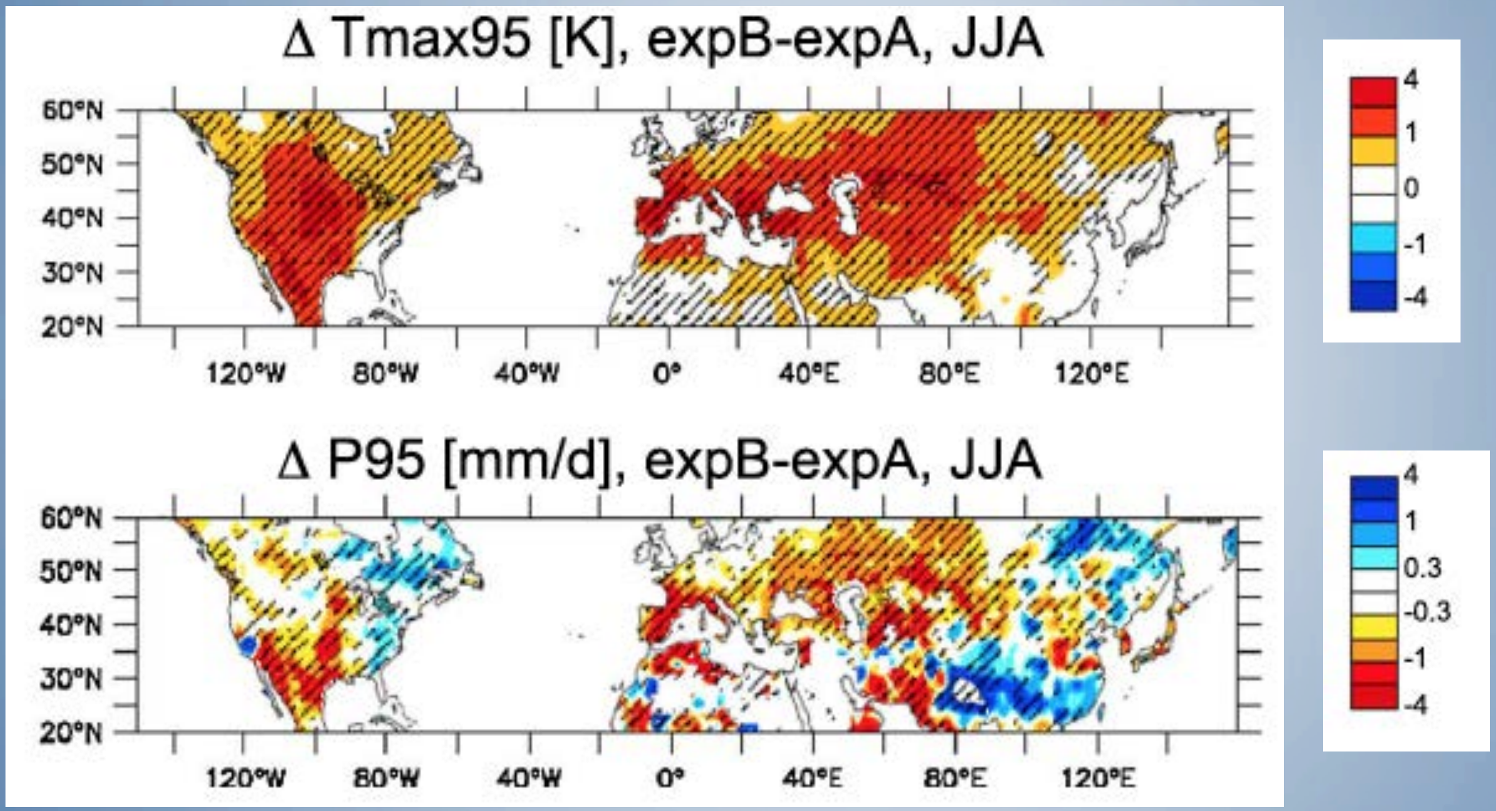


Hirschi et al. 2011, Nature Geo.; Mueller and Seneviratne 2012, PNAS

Mechanisms: Land-climate interactions

GEWEX/GLASS

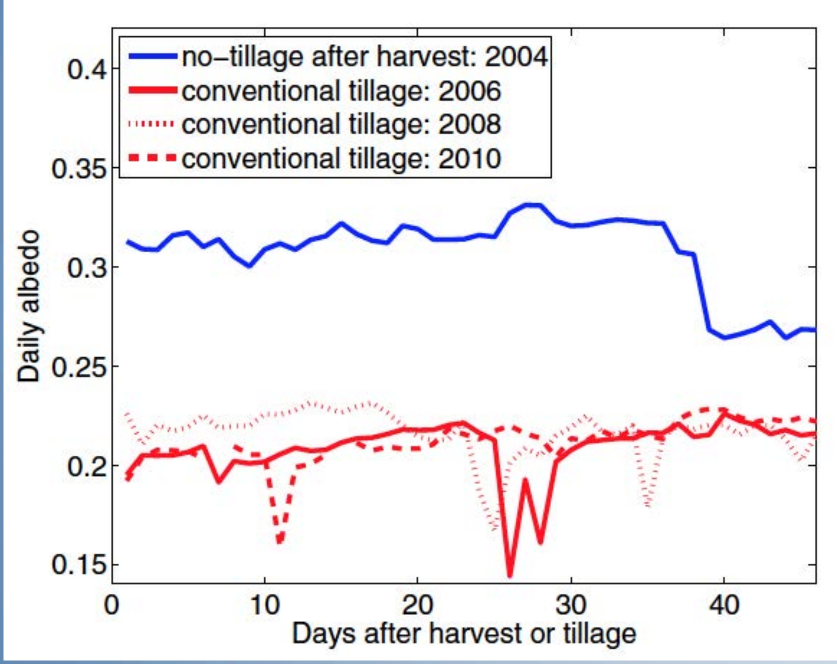
Contribution of mean soil moisture change to change in T and P extremes (late 21st century-late 20th century): GLACE-CMIP5

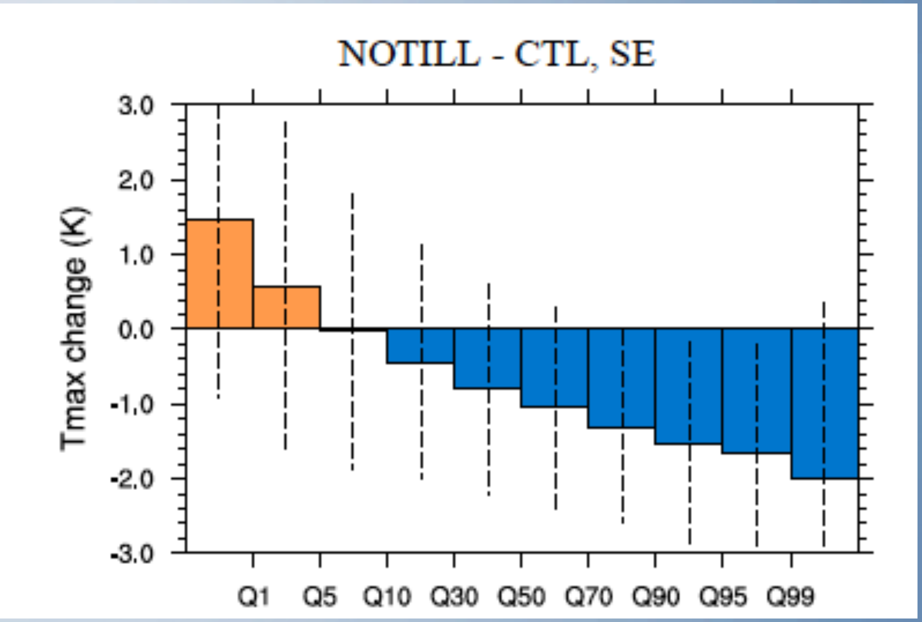


Seneviratne et al. 2013, GRL

Mechanisms: Land-climate interactions

Impacts of land management on temperature extremes: No-till farming

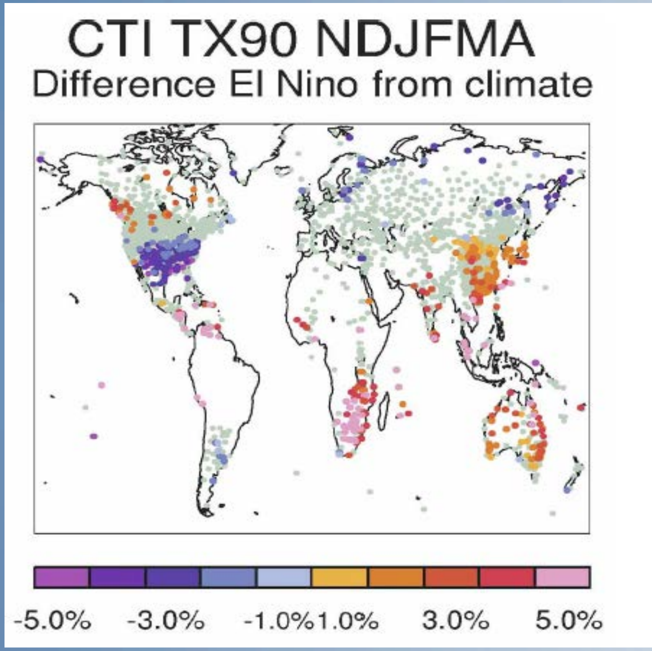


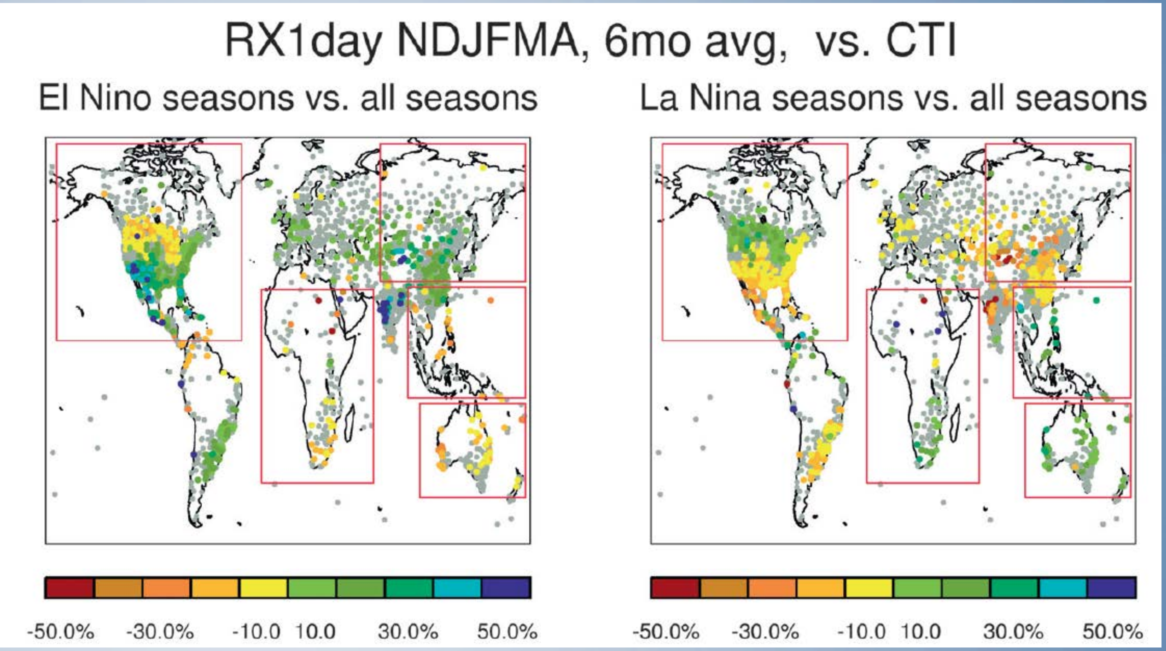


Davin et al. 2014, PNAS

Mechanisms: Large-scale drivers

CLIVAR/ETCCDI



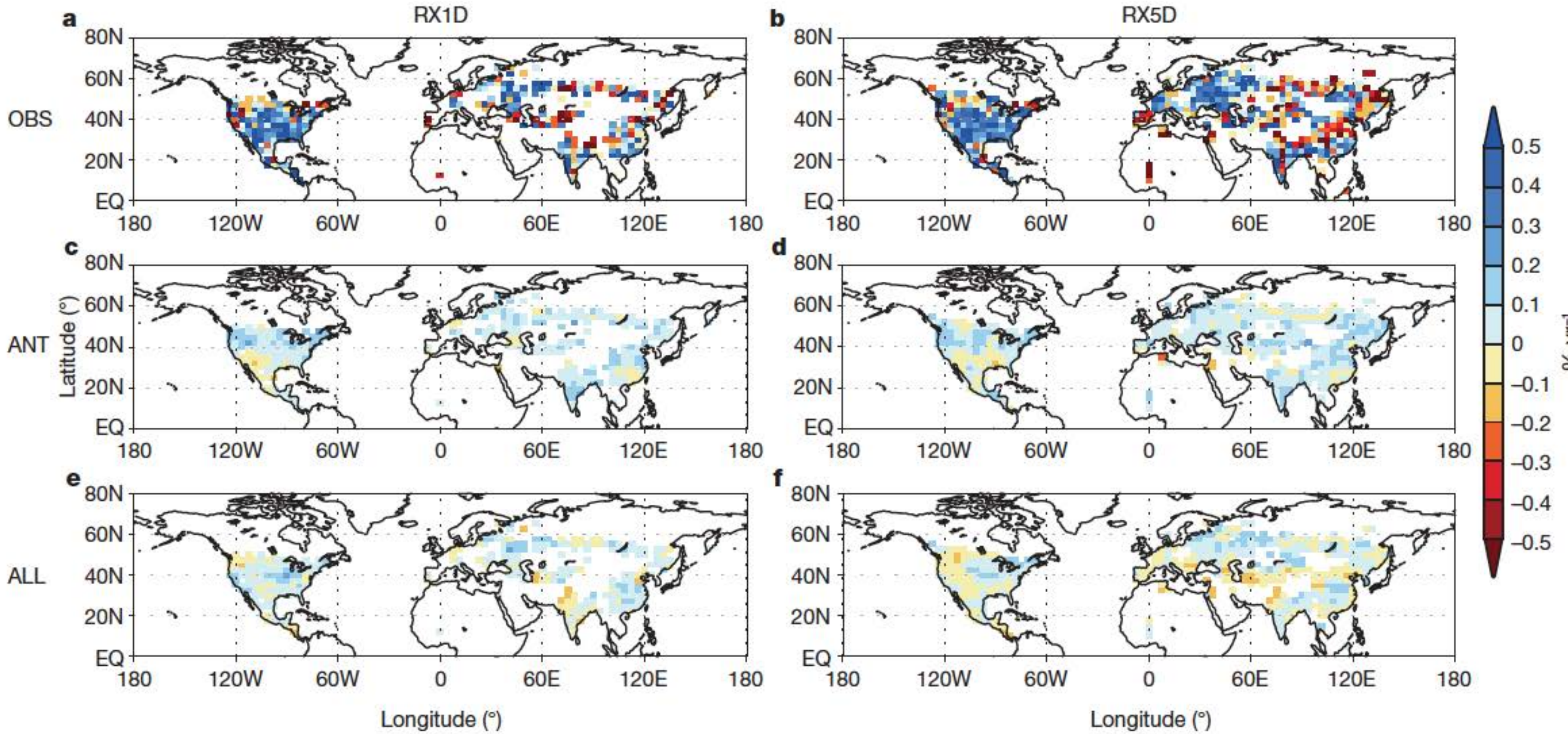


Kenyon and Hegerl 2008, J.Clim; Kenyon and Hegerl 2010, J.Clim.

External forcings vs internal variability

ETCCDI/CLIVAR

Trends in precipitation extremes (1951-1999)

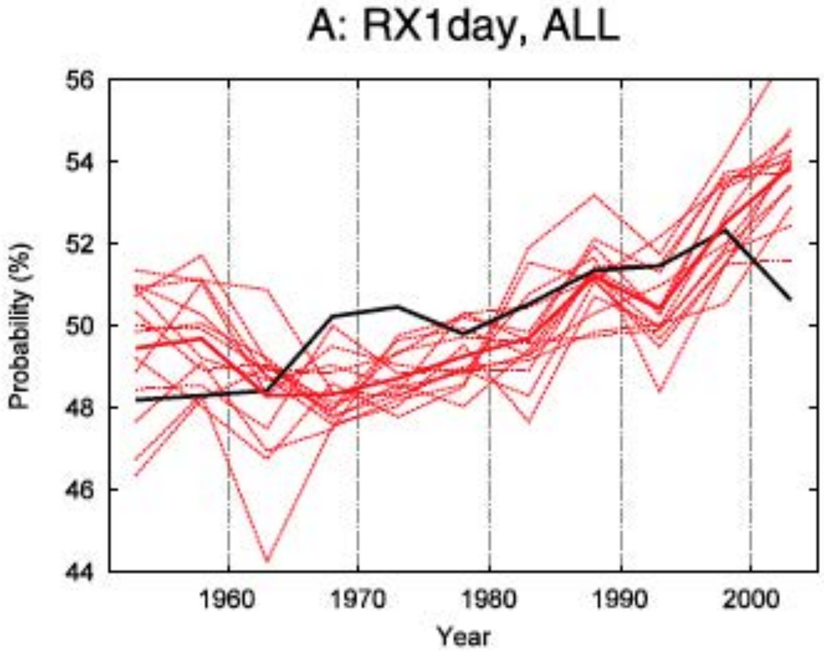


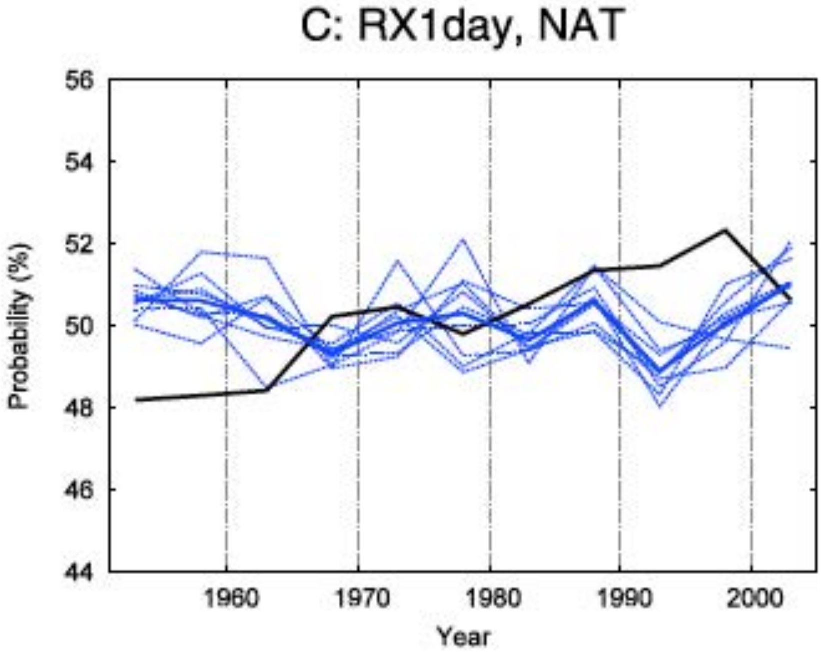
Min et al. 2011, Nature

External forcings vs internal variability

ETCCDI/CLIVAR

Trends in heavy precipitation in Northern Hemisphere Land (1951-2005)

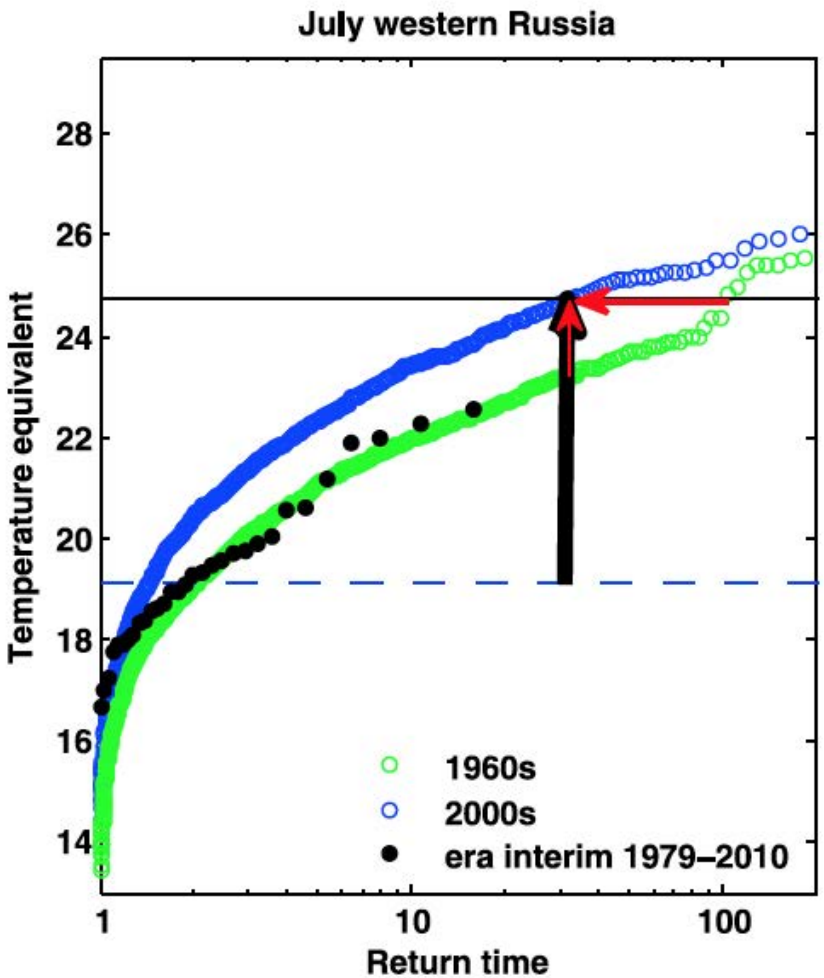




Zhang et al. 2013, GRL

Event attribution

ACE / ETCCDI



Contradictory statements on attribution of Russian heat wave:

- Dole et al. 2012, GRL: Event mainly due to natural internal atmospheric variability
- Rahmstorf and Coumou 2010, PNAS: 80% probability that 2010 event would not have occurred without global warming

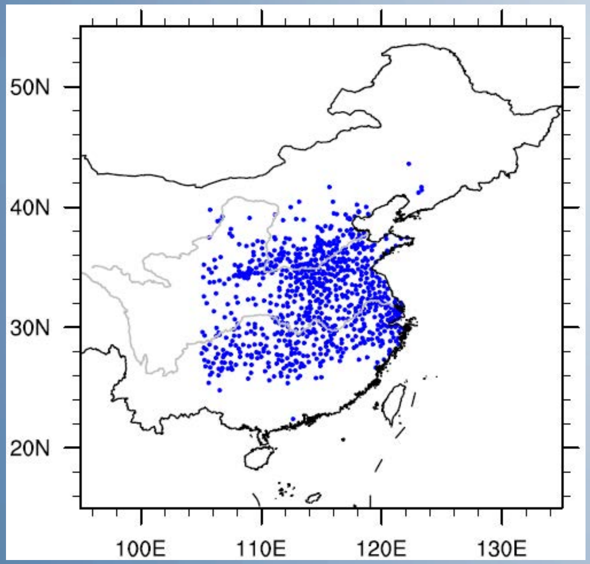
Otto et al. 2012, GRL: Two perspectives are complementary

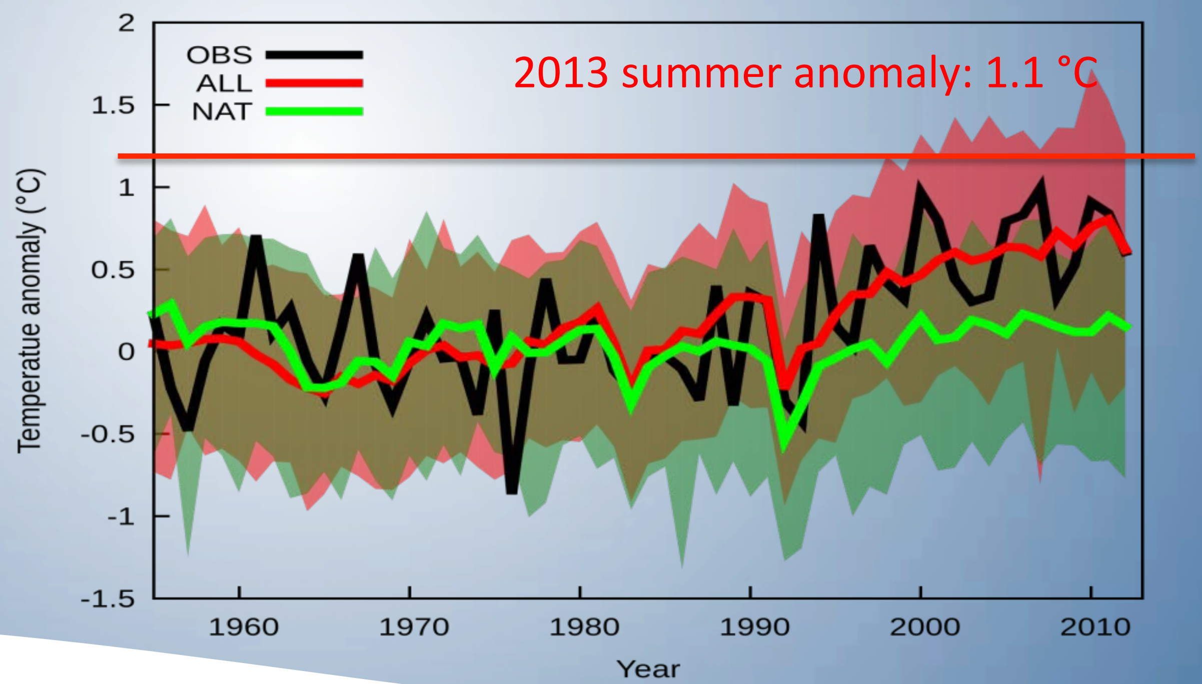
Otto et al. 2012, GRL

Event attribution
Eastern China 2013 Summer Heatwave

- Broader event attribution, putting event into historical perspective
- Hottest summer since obs network established in 1950s
- Anthropogenic influence increased the likelihood of the extreme warm 2013 summer by 60-fold (every 4.5 yrs vs every 270 yrs)

Record summer Tmean



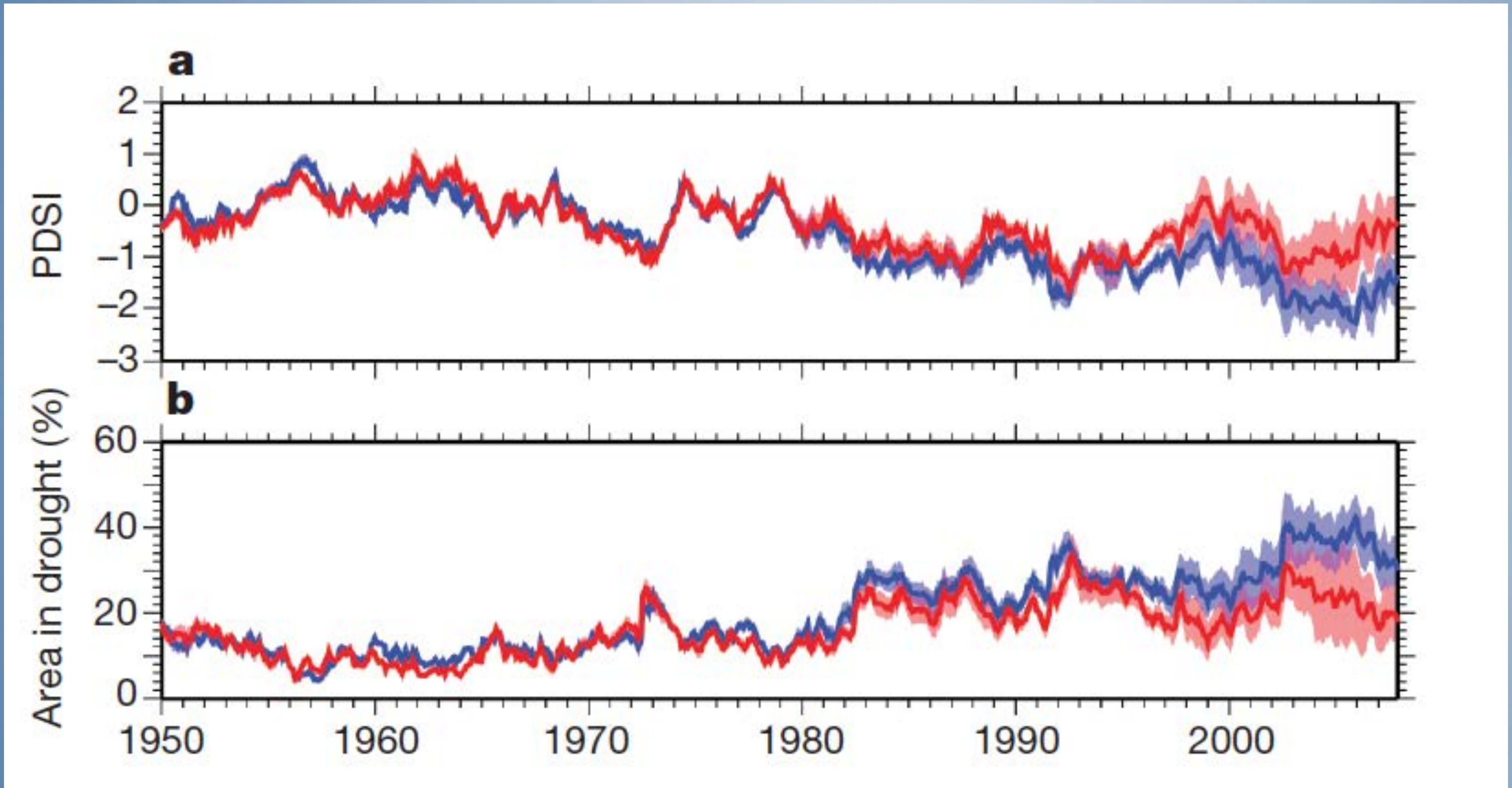


Sun et al. 2014

Causes of drought changes

GEWEX/CLIVAR/GDIS

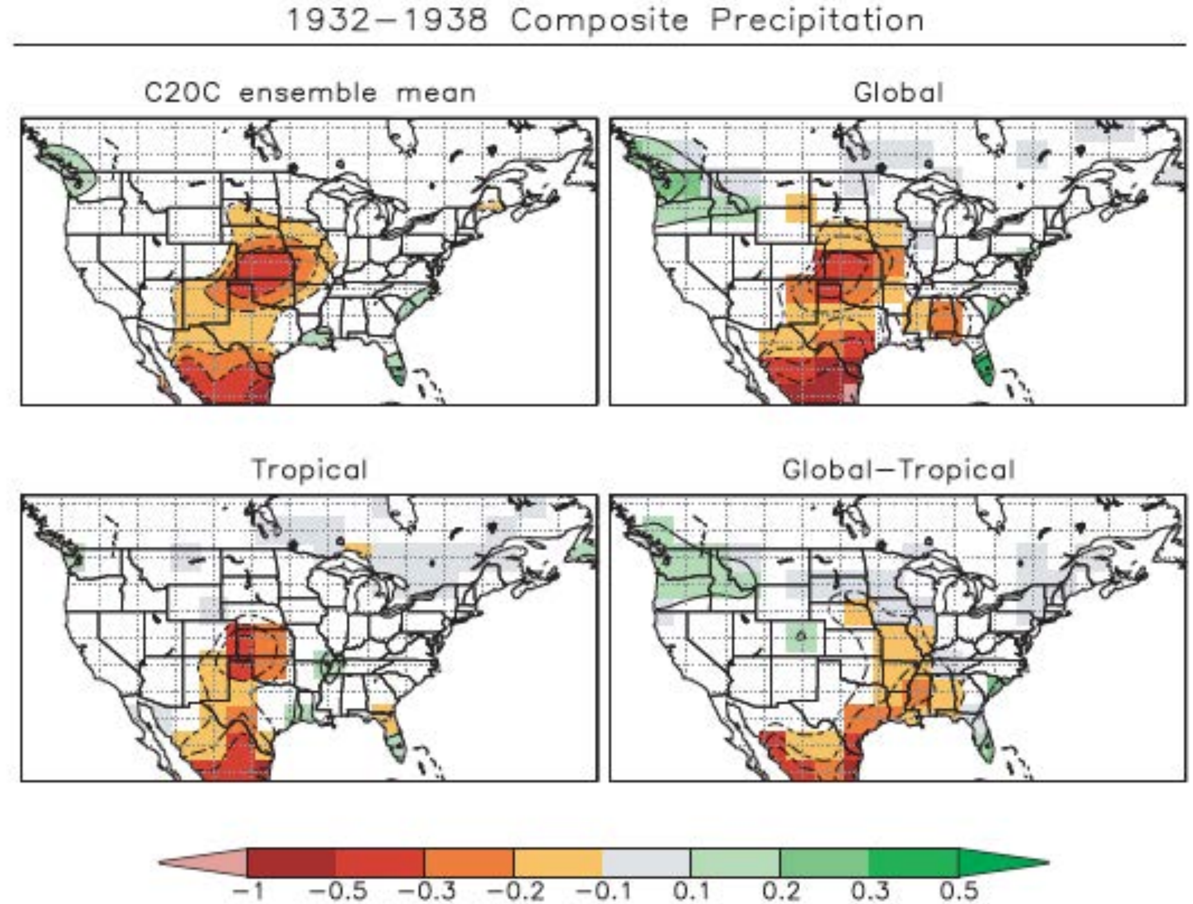
Representation of potential evapotranspiration is critical for assessing long-term trends in agricultural drought



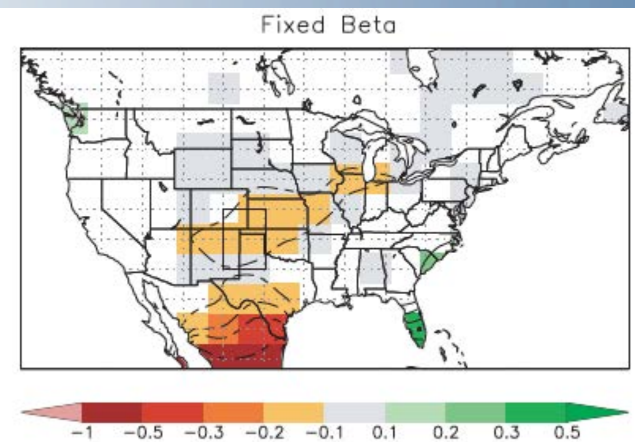
Sheffield et al. 2012, Nature

Causes of drought changes

GEWEX/CLIVAR/GDIS

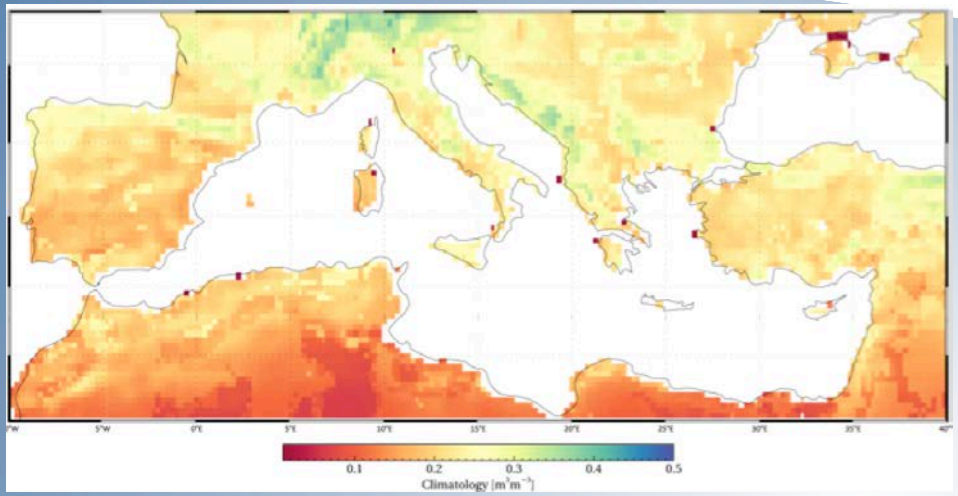


US dust bowl: SST vs land-atmosphere effects on droughts

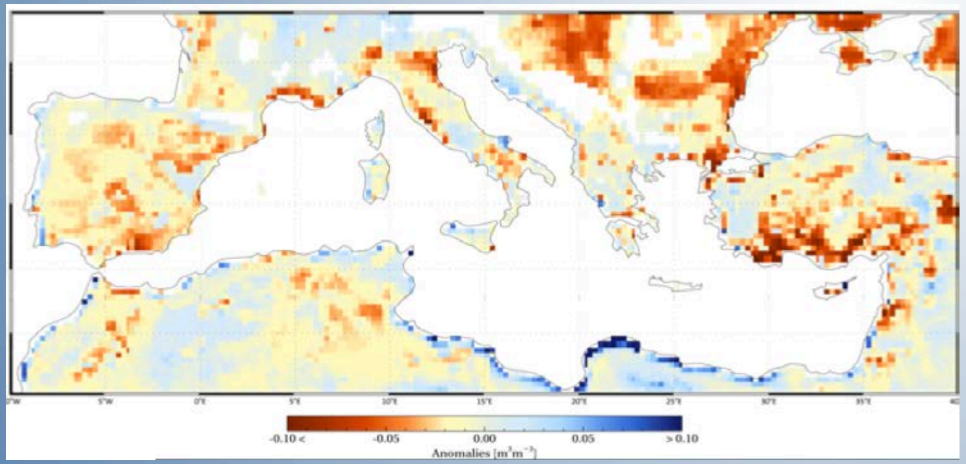


Schubert et al. 2004, Science

Soil moisture drought: RS-based estimates



Climatology



2012 anomalies

NB: Nice new data but some issues to carefully evaluate (inconsistencies in time, regional artefacts)

(Slide: W Dorigo)

Opportunities

- The **recognition of the importance of and the societal needs** to the understanding and prediction of weather and climate extremes by WCRP and world climate research community at large
- Recent **substantial advances in modelling** (including but not limited to model resolution)
- **Advances in the understanding** of the physical mechanisms leading to extremes
- Increased **efforts to extend the historical observational record**, including planned climate quality reanalyses over longer historical periods
- Expected **improvements in remote sensing products**, which now often extend long enough to document trends and sample extremes and have a higher temporal and/or spatial resolution
- Recent **world-wide coordinated efforts to attribute the causes of individual extremes**, and other research activities already underway and planned

Strategies and activities

- A **WCRP-led international symposium on climate extremes in 2017/18** to exchange progress in the community and to identify future research needs. This should be as widely promoted as possible so that the community has a target to meet (like IPCC)
- Prompt **WCRP-wide coordination of extreme related research** activities and communicate new findings to key organizations including WMO, GEO, Future Earth, as well as contribute to Global Framework on Climate Services
- Foster **actionable research** for accelerating exchange across the community **(datasets, software, reference articles)**
- Prompt the Grand Challenge through **major international conferences** such as AGU, EGU, IUGG, etc., by organizing special symposia on climate extremes
- **Train next generation leaders** through targeted training workshops
- Organize 2-3 workshops over the next 1-2 years to bring the appropriate communities together to make significant progress in **strategic areas**

GC Climate Extremes

WCRP World Climate Research Programme

Implementations

- **Two sessions related to extremes research at GEWEX Science Conference (July 2014, The Hague, Netherlands)**
  - Modeling, predicting, and attributing climate extremes (Hegerl, Scaife, Seneviratne)
  - Observations and changes in climate extremes (Zhang, Stewart, Zolina)
- **Sessions within PanGEWEX and PanCLIVAR meetings**
- **WCRP summer school on extremes (ICTP, July 2014, Trieste)** Organization: F. Zwiers, S. Seneviratne (and substantial support from R. Boscolo, A. Pirani)

GC Climate Extremes

Implementations (continued)

- Potential **data workshop in Australia** (Lisa Alexander, UNSW, Australia) some funding confirmed, details/scope TBD, early 2015)
- Potential **process workshop in Oslo** (Jana Sillmann, Cicero center, Norway) (some funding from Norway confirmed, details to be developed, spring or fall 2015)
  - dynamical and physical processes (e.g., large-scale modes of variability, blocking anticyclones, land-atmosphere feedbacks, monsoons) affecting weather and climate extremes
  - representation of these processes in models,
  - development of statistical methods and tools to incorporate this information into the evaluation of model performance and the prediction of climate extremes

Summary and outlook: GC Extremes

Vibrant research field, potential for interactions between several WCRP projects, panels and GCs

Detailed implementation plan to focus on ca. 5-6 projects of high potential for return (concrete outcomes, high relevance) – Discussion at the Hague before Pan-GEWEX and Pan-CLIVAR meetings