ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Eucleia

EUCLEIA: Attribution of climate change in observations and models

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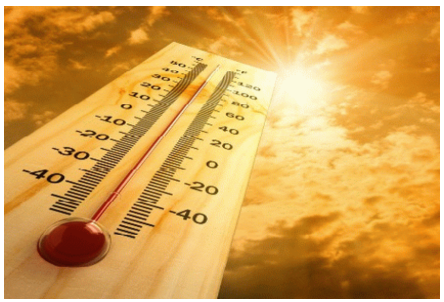
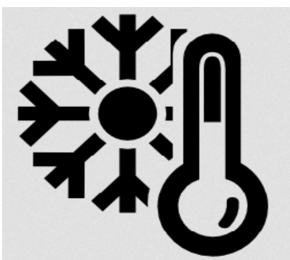
Contributions: P. Stott, UK Met Office; R. Vautard, LSCE; G.J. van Oldenborgh, KNMI; R. Orth, M. Hauser, M. Hirschi, N. Nicolai, ETH Zurich

CMUG Integration-6 Meeting, Munich, March 14, 2016

EUCLEIA: 3 year project under the FP7-SPACE Call, that brings together 11 European partners with an outstanding scientific profile in climate research:

The project aims to develop a quasi-operational attribution system, well calibrated on a set of test cases for European extreme weather, that will provide to targeted groups of users, well verified, well understood assessments on the extent to which certain weather-related risks have changed due to human influences on climate.



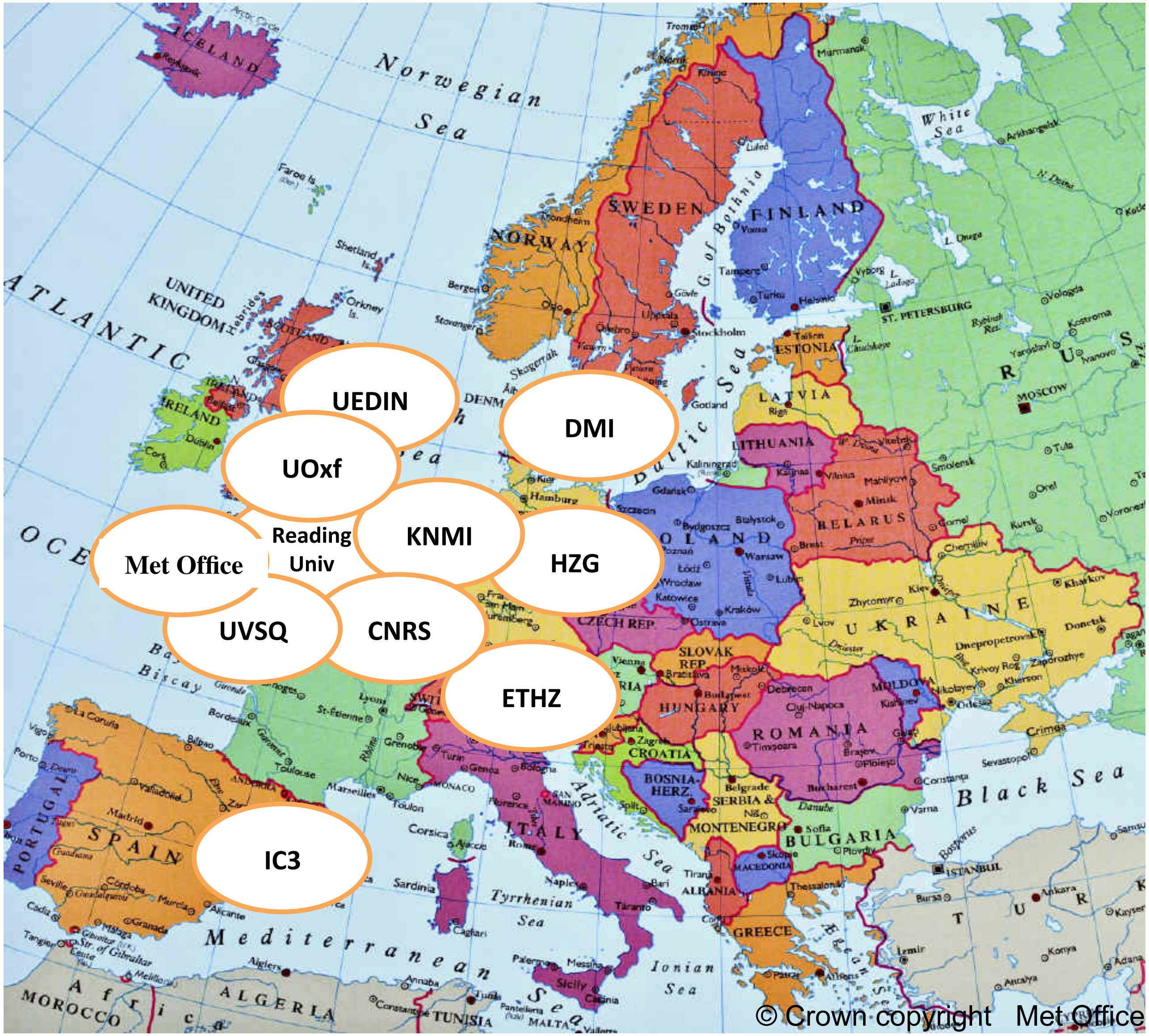


TEST CASES:

- ❑ Heat waves
- ❑ Cold spells
- ❑ Droughts
- ❑ Floods
- ❑ Storm surges

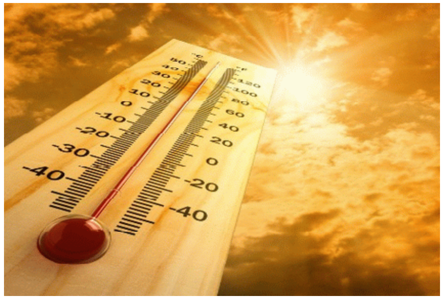
Project coordination:
UK Met Office
(P. Stott)

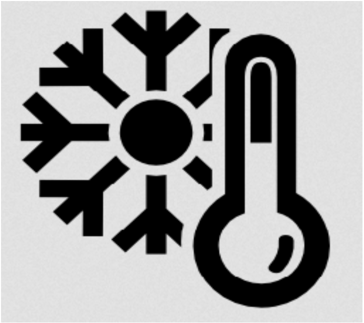
11 involved European institutions



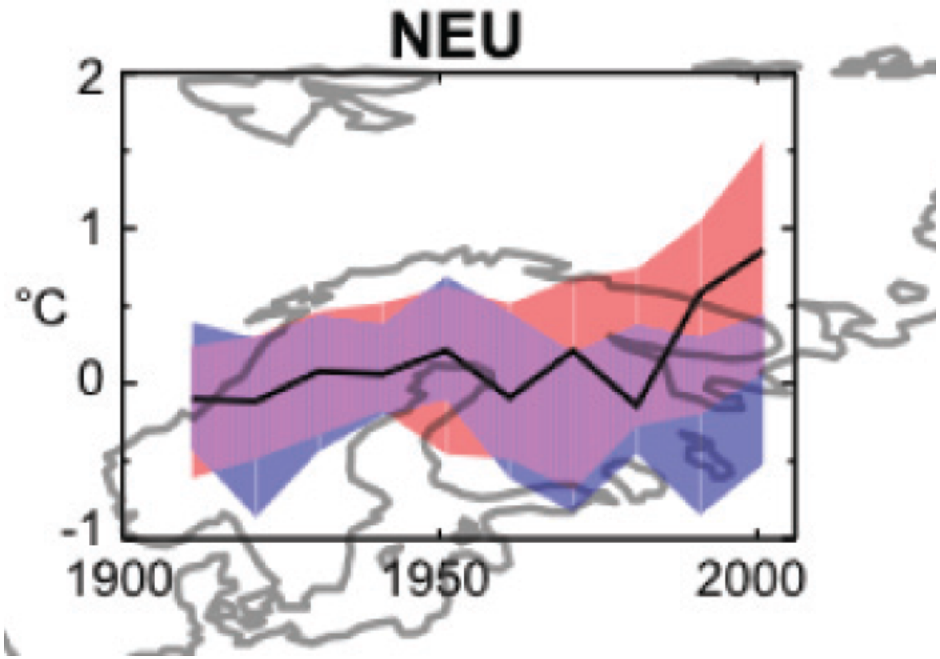
Objectives

1. Derive requirements from targeted user groups
2. Develop methods for event attribution including development of experimental designs and clear ways of framing
3. Identify key processes driving extreme events and develop methodologies for representing level of confidence in attribution results
4. Demonstrate the utility of the attribution system on a set of test cases of European weather and climate extremes
5. Deliver quasi-operational attribution assessments on a range of timescales in the aftermath of extreme events





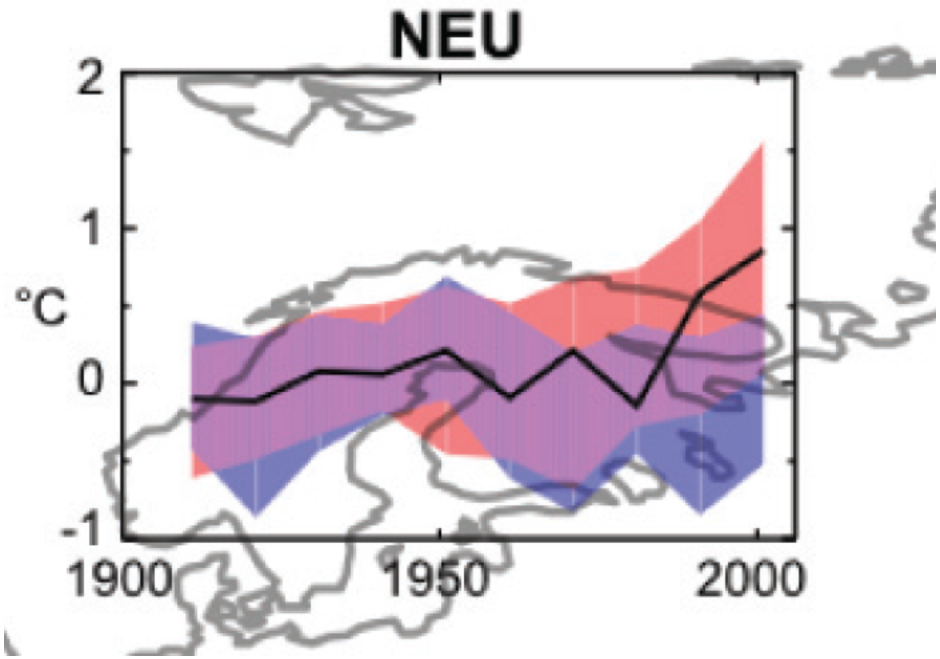
Detection and attribution of climate trends (e.g. temperature)



(IPCC AR4, Hegerl et al. 2007; see also IPCC AR5, Bindoff et al. 2013)

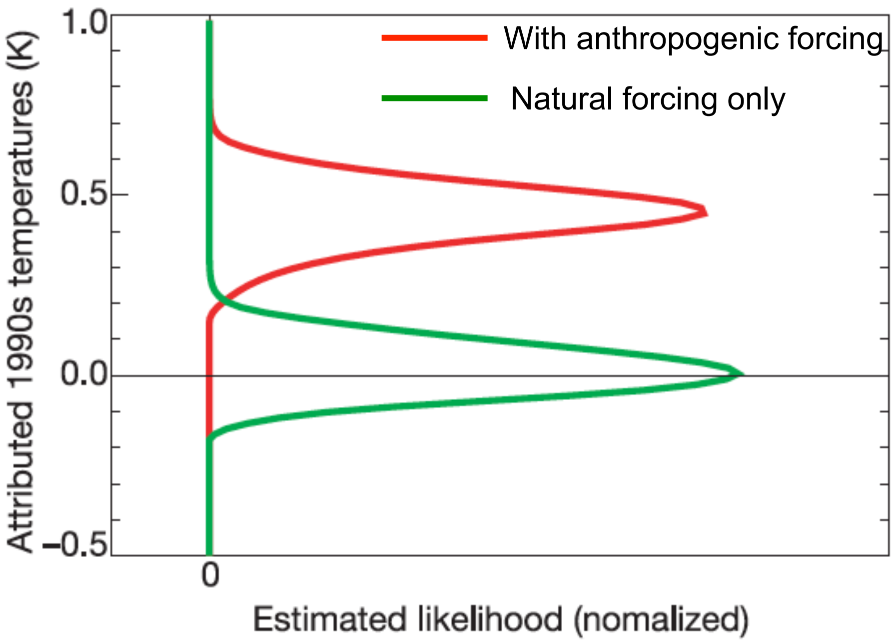
What is attribution?

Detection and attribution of climate trends (e.g. temperature)



(IPCC AR4, Hegerl et al. 2007; see also IPCC AR5, Bindoff et al. 2013)

Attribution of single events (or rather class of events!)



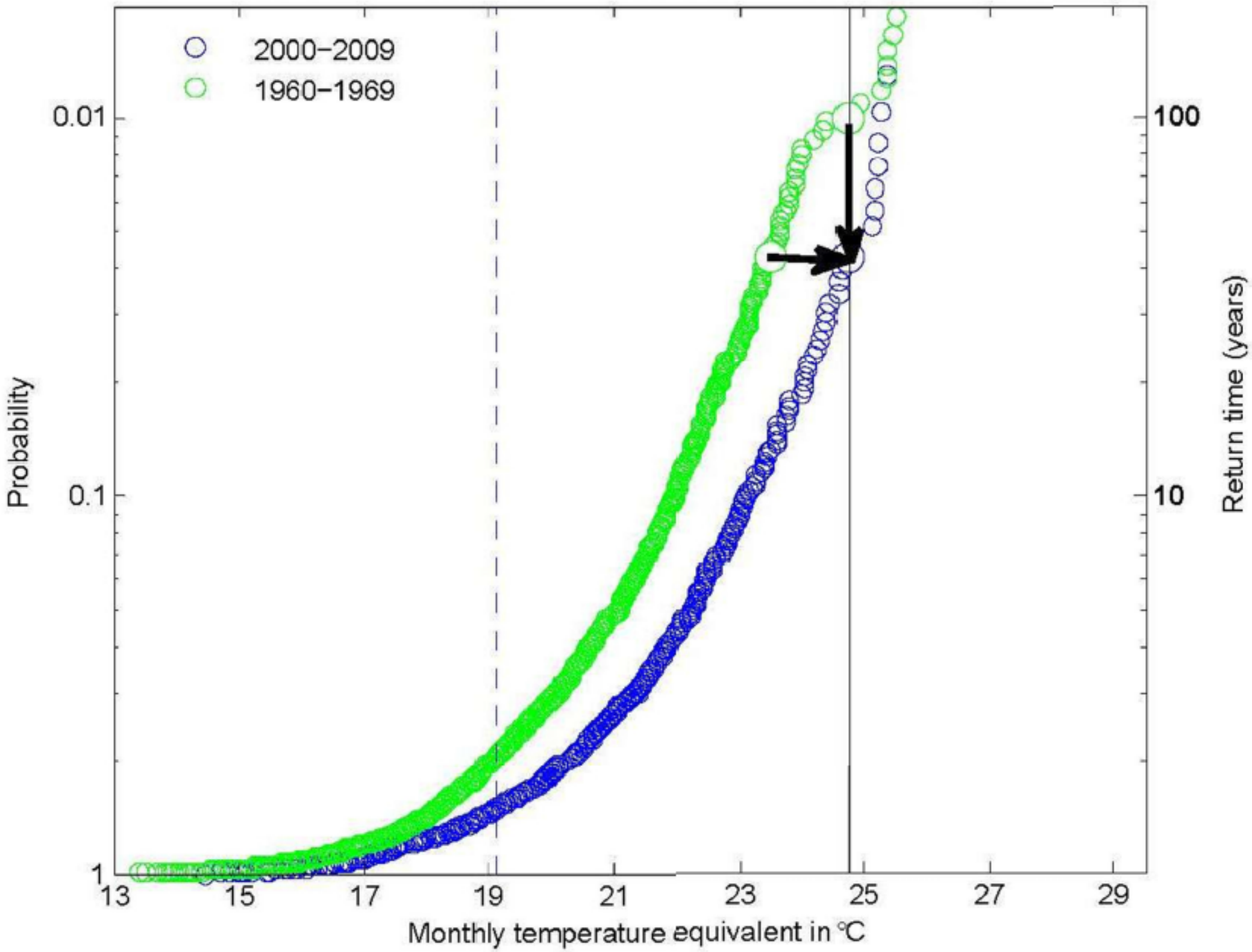
(after Stott et al. 2004, Nature; see also Allen 2003, Nature)

Event attribution:

Attributing difference in probability of occurrence or intensity of given classes of events (e.g. above set threshold) due to anthropogenic forcing vs natural forcing only

NB: Statements depend very much on framing (addressed question)

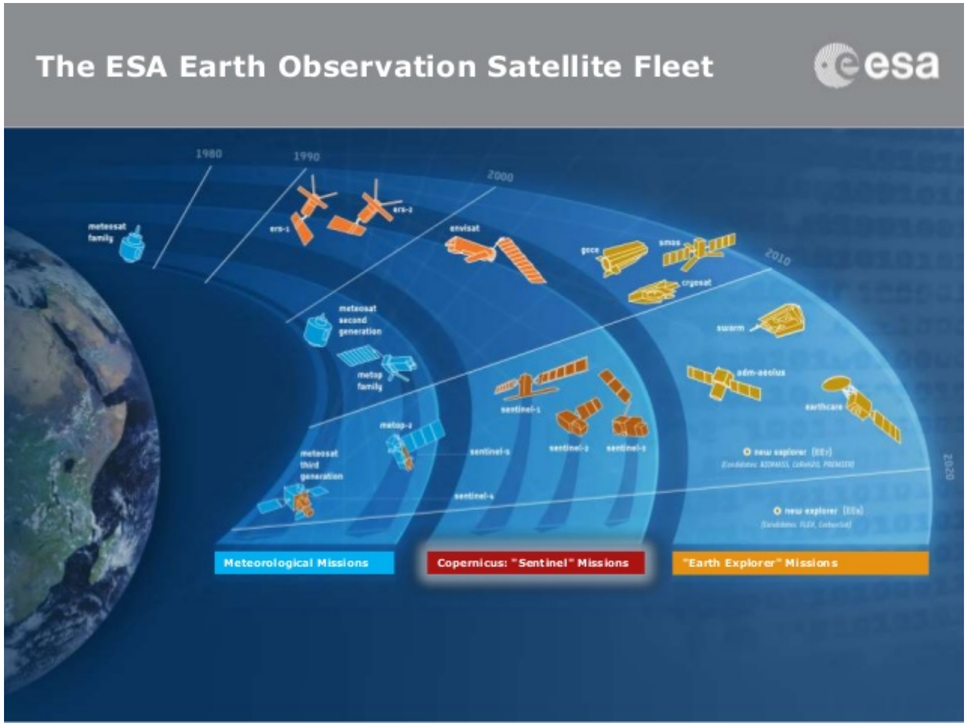
Probability of occurrence of 2010 Russian heatwave: Frequency vs Intensity



(NRC report, 2016, based on Otto et al. 2012, GRL)

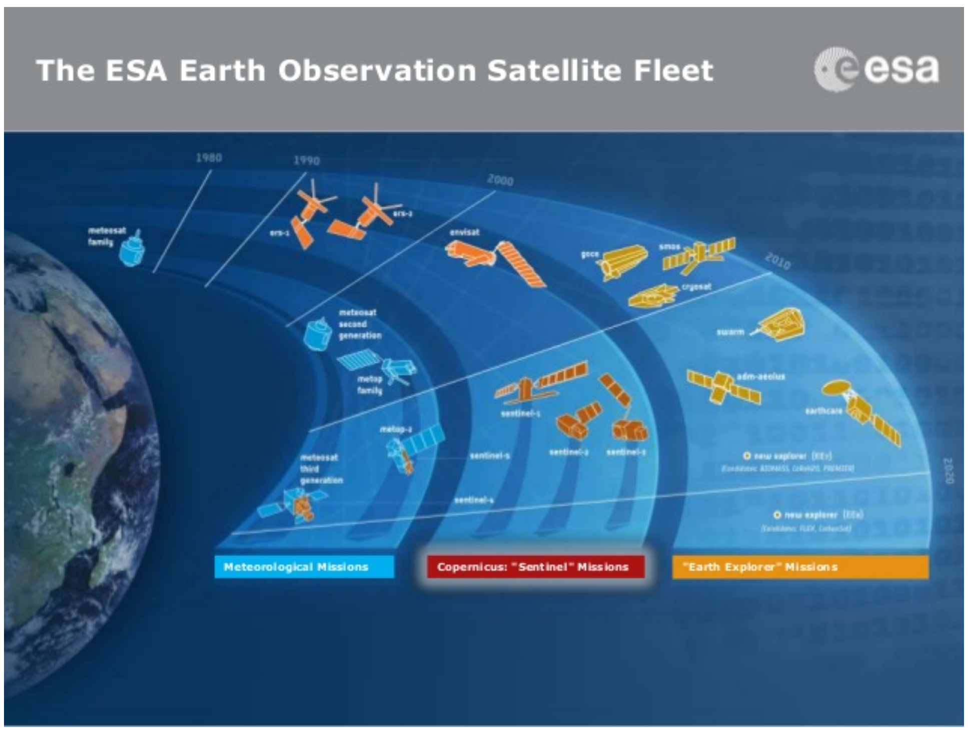
Using satellite-based records in event attribution

- Model validation
- Detecting trends
- Near real-time availability



Using satellite-based records in event attribution

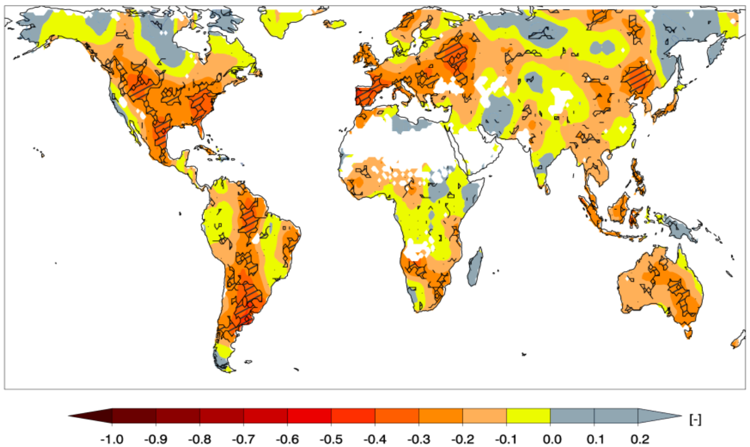
- Model validation: Seasonal and interannual dynamics
- Detecting trends: Often difficult!
- Near real-time availability: Often difficult!



Soil moisture: Relation to extremes

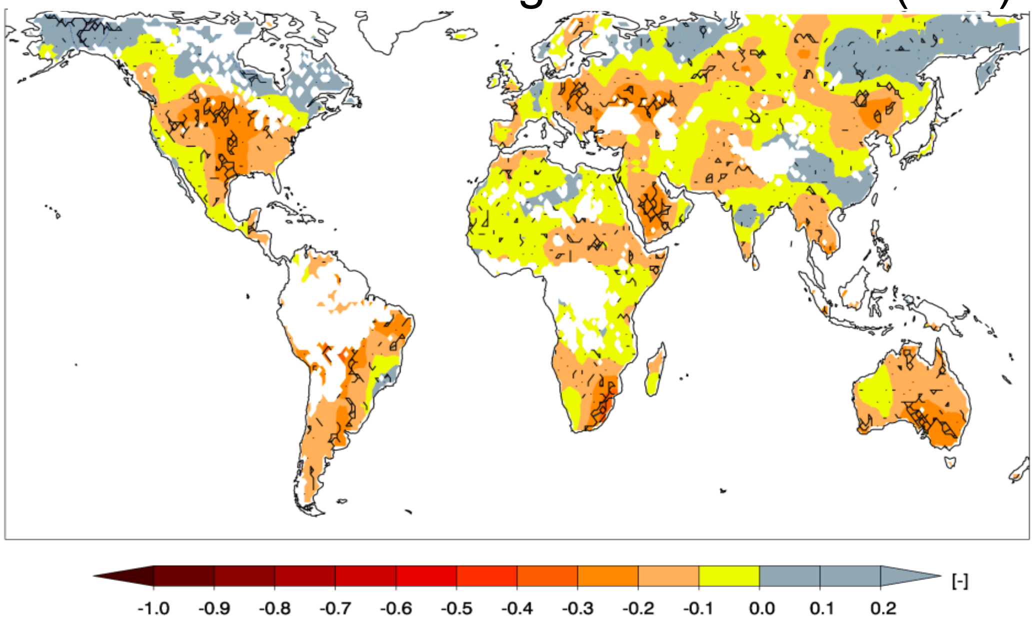
Lag correlations between moisture deficits in preceding 3 months and number of hot days in hottest month

SPI CRU



(Mueller and Seneviratne 2012, PNAS)

Merged satellite SM (CCI)

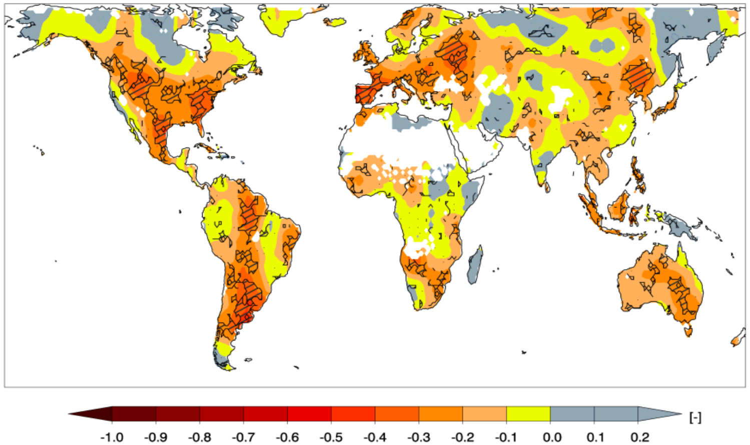


(Hirschi et al. 2014, RSE)

Similar regions of soil moisture-temperature coupling found with satellite retrieved surface soil moisture as with ground observations, but coupling less strong

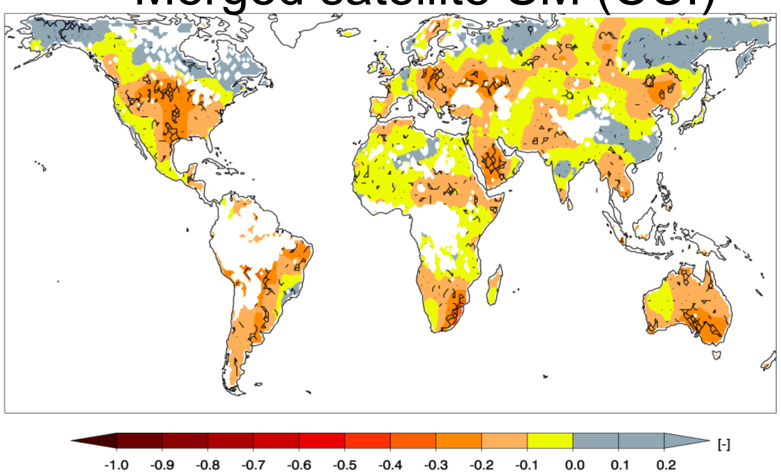
Soil moisture: Validating climate relationships

SPI CRU



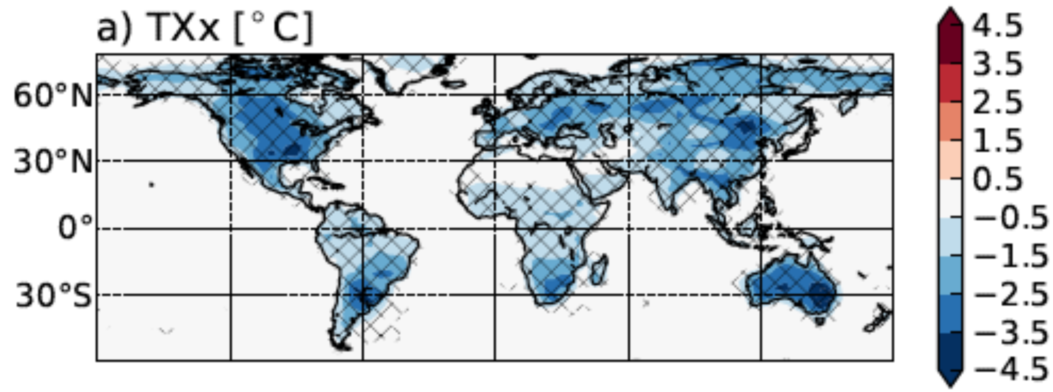
(Mueller and Seneviratne 2012, PNAS)

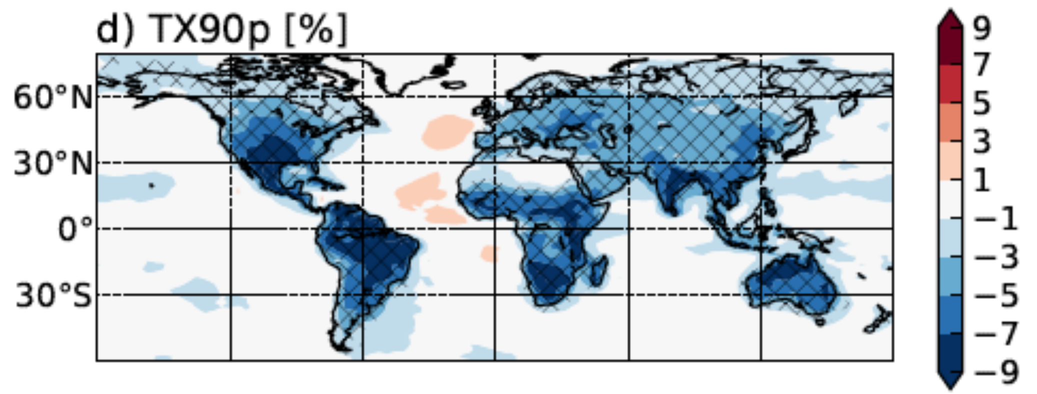
Merged satellite SM (CCI)



(Hirschi et al. 2014, RSE)

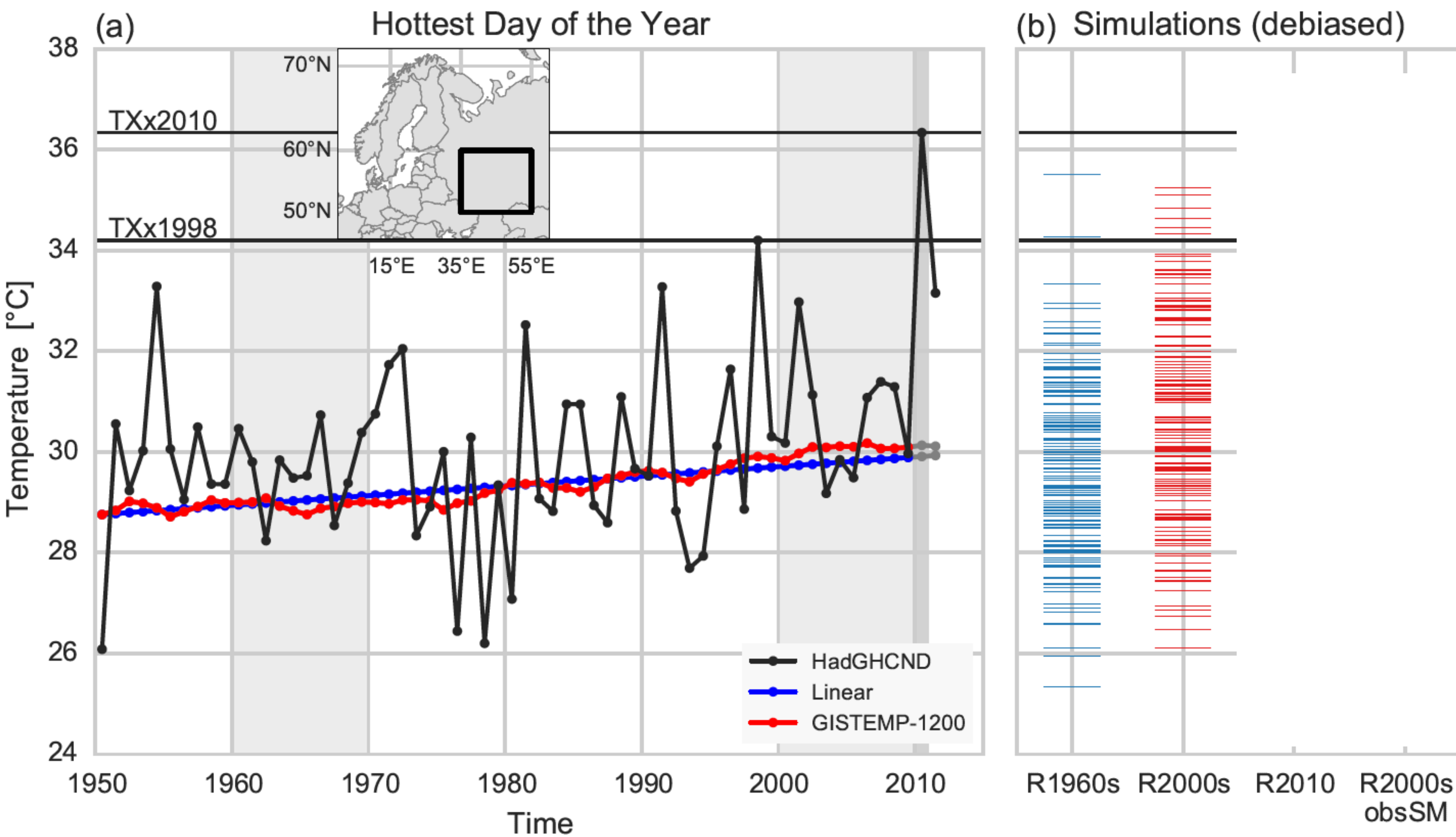
Climate models: Impact of removing soil moisture variability in present climate





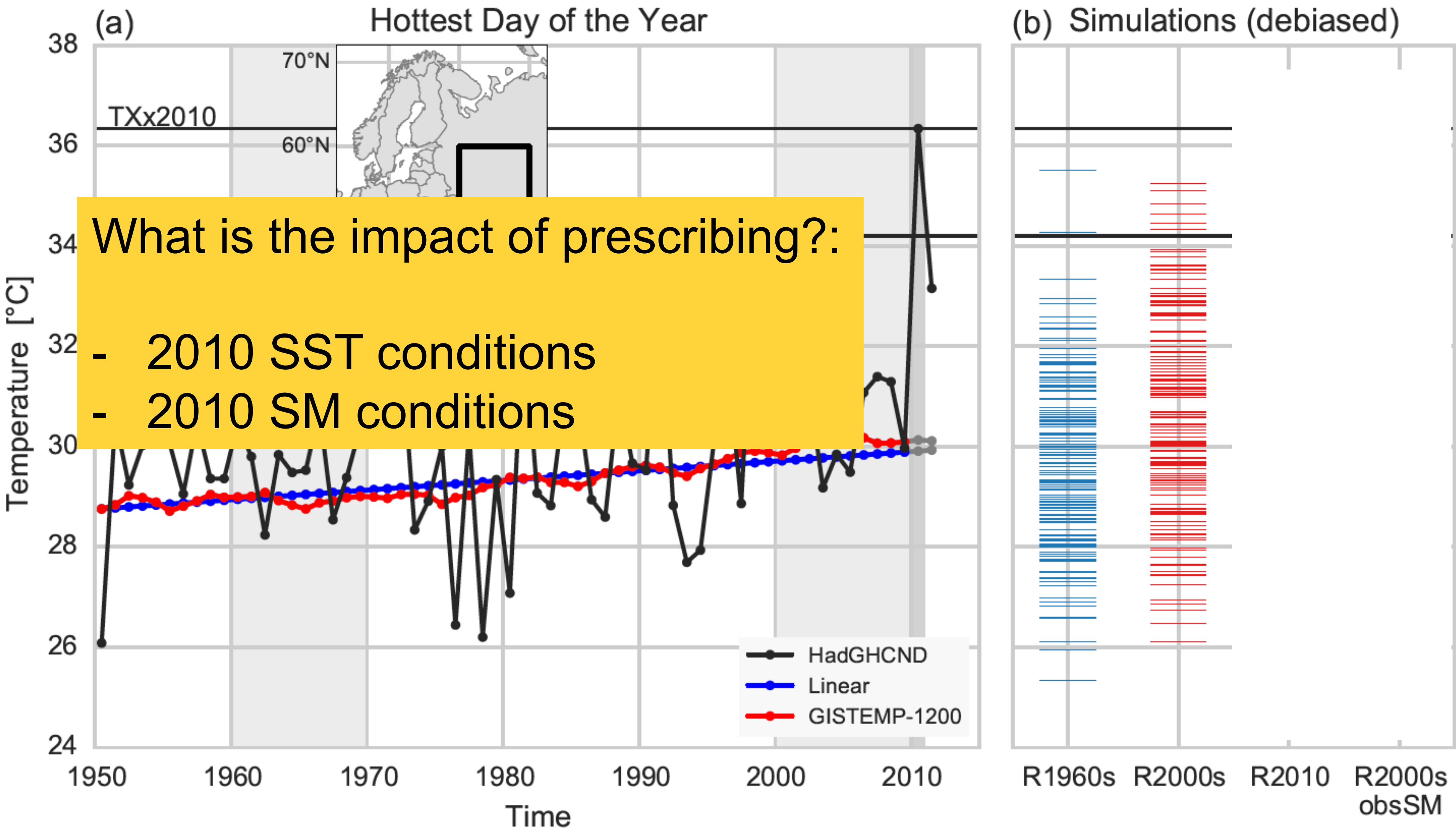
(Lorenz et al., in press, JGR; based on simulations of GLACE-CMIP5 experiment, Seneviratne et al. 2013, GRL)

Attribution: 2010 Russian heatwave



(Hauser et al. GRL, in press)

Attribution: 2010 Russian heatwave

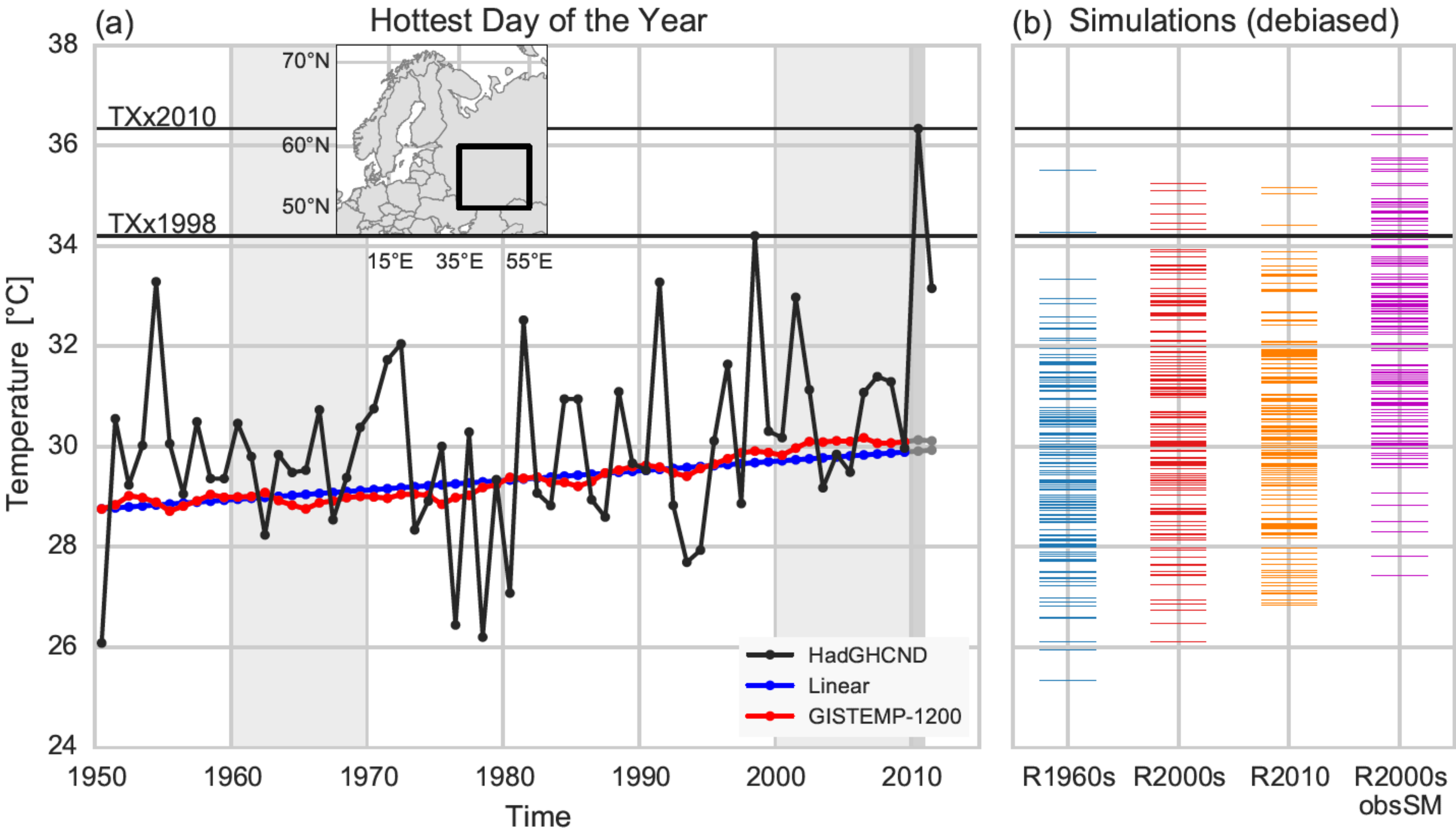


What is the impact of prescribing?:

- 2010 SST conditions
- 2010 SM conditions

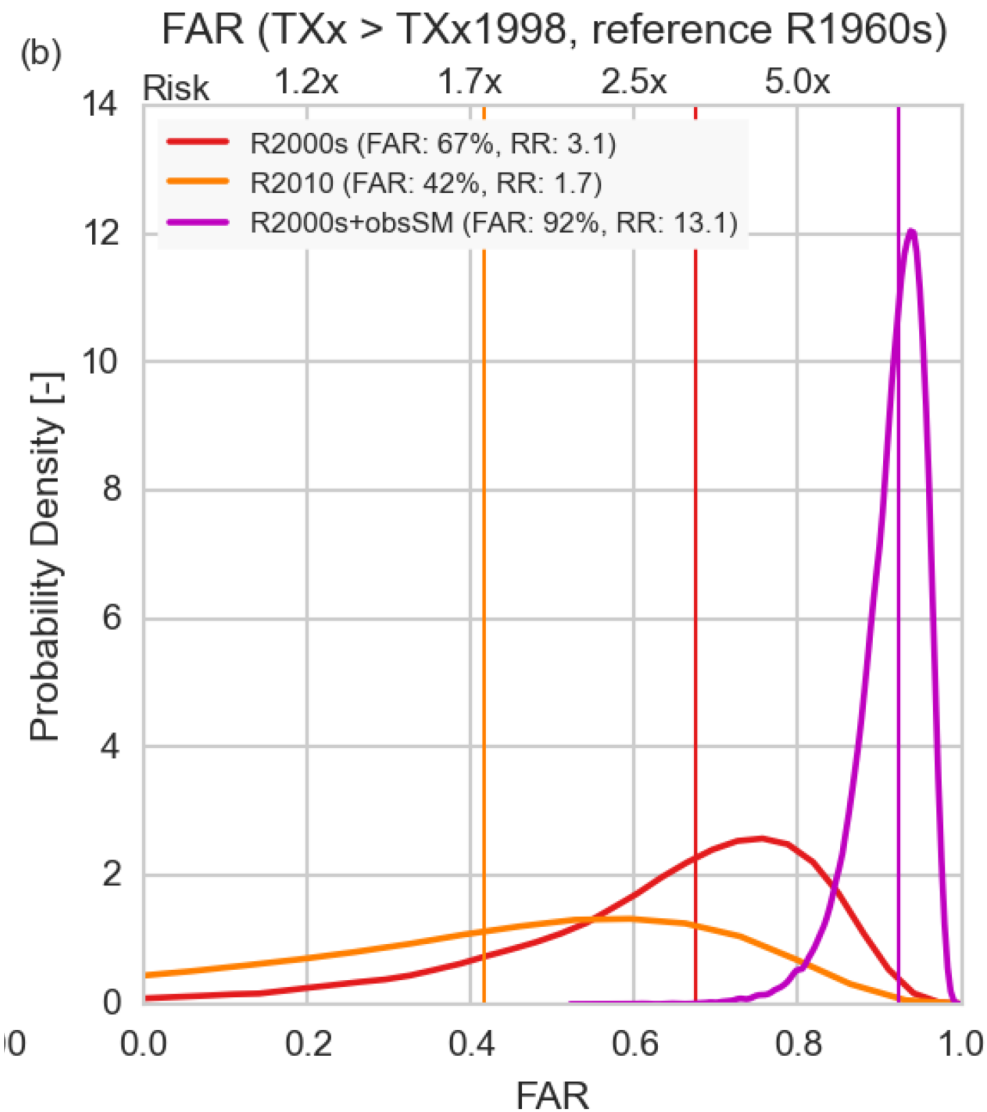
(Hauser et al. GRL, in press)

Attribution: 2010 Russian heatwave



(Hauser et al. GRL, in press)

Attribution: Increase in risk



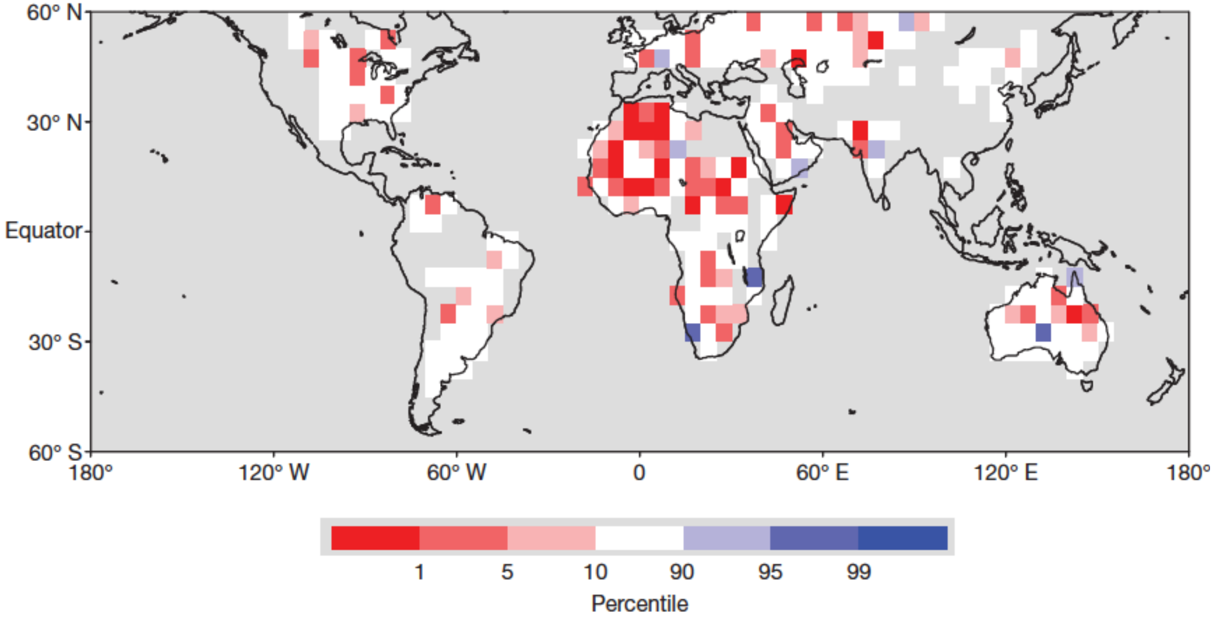
Compared to historical conditions (1960s):

- 2010 SST increased risk of >1998 by ~1.7
- Anthropogenic forcing (general warming) increased risk of >1998 by ~3
- Soil moisture conditions + anthropogenic forcing increased risk by ~13 (but largely induced by internal climate variability!)

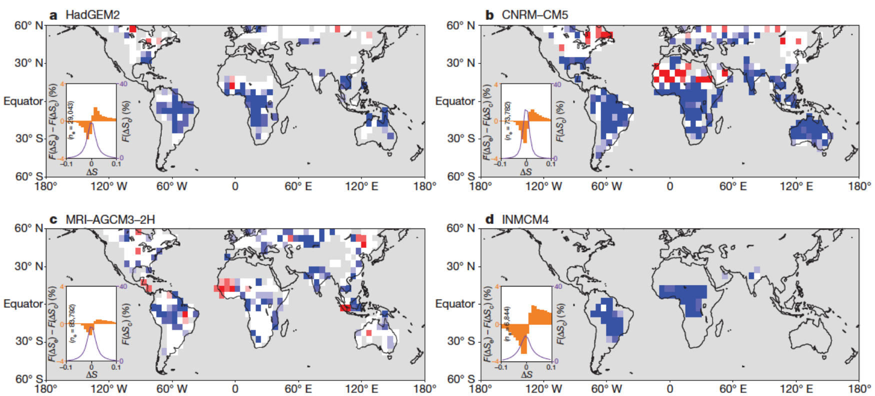
(Hauser et al. GRL, in press)

Soil moisture: Validating climate relationships

Soil moisture-precipitation feedbacks



Negative spatial feedback in observations (satellite-based datasets)



Climate models show wrong relationship…

(Taylor et al. 2012, Nature)

Soil moisture: Validating climate relationships

ARTICLE

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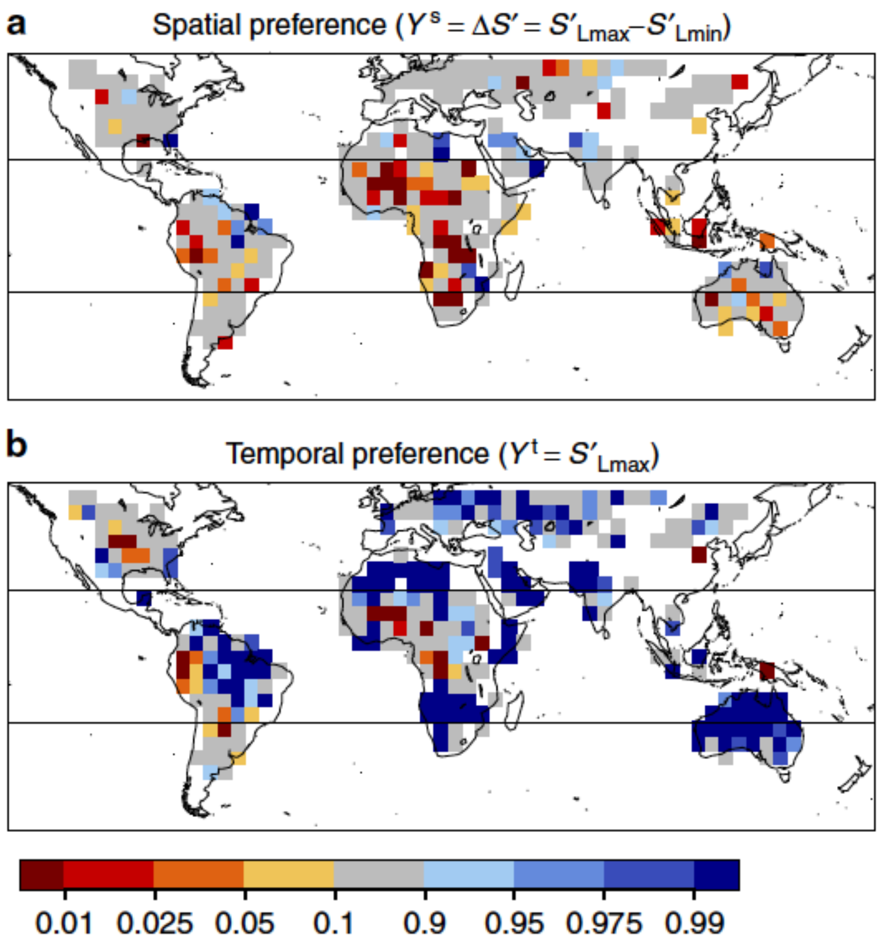
DOI: 10.1038/ncomms7443

OPEN

Reconciling spatial and temporal soil moisture effects on afternoon rainfall

Benoit P. Guillod[1,†], Boris Orlowsky[1], Diego G. Miralles[2,3], Adriaan J. Teuling[4] & Sonia I. Seneviratne[1]

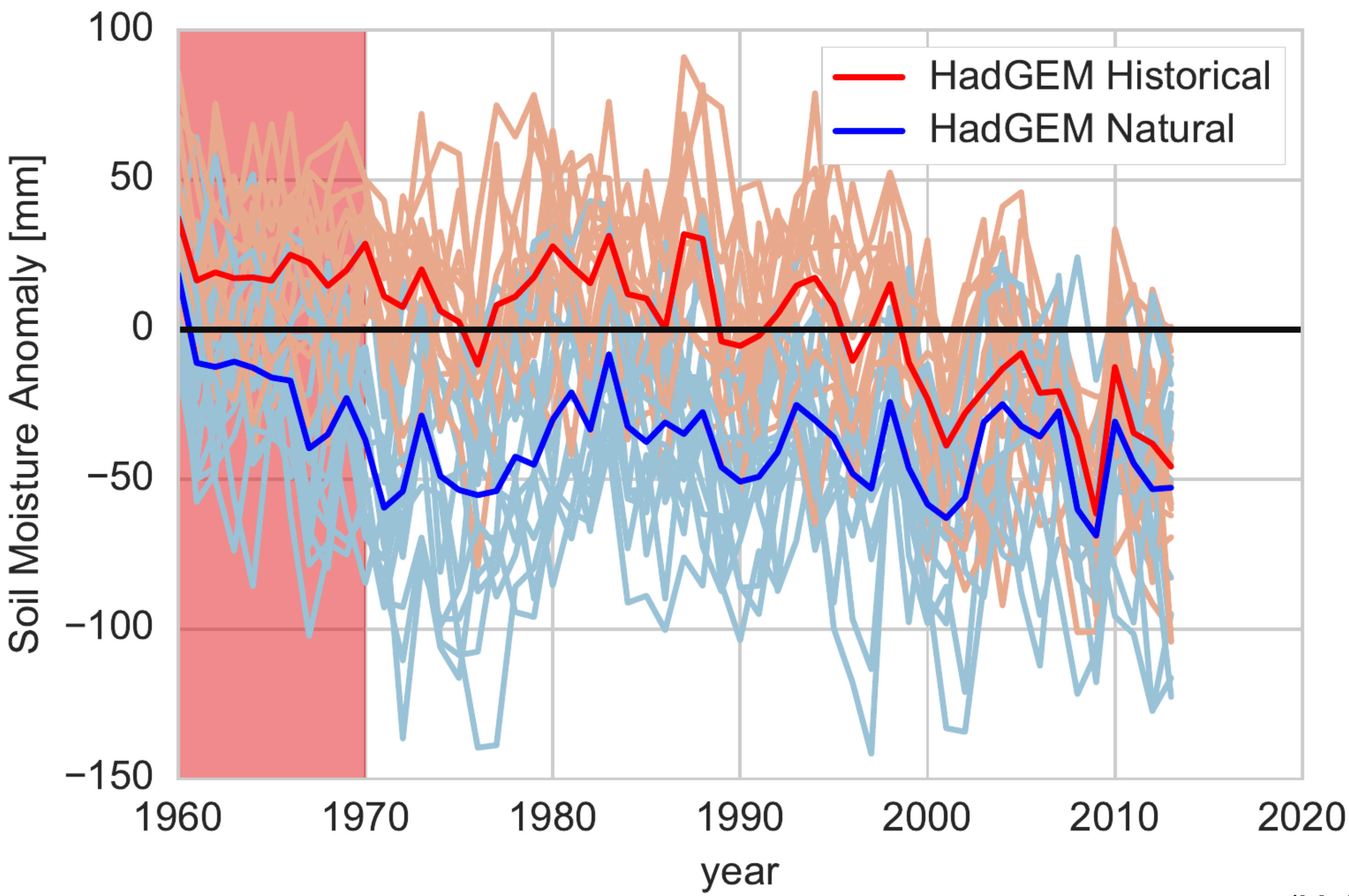


Precipitation: CMORPH, PERSIANN

Land conditions (soil moisture, ET): GLEAM, AMSR-E

(Guillod et al. 2015, Nature Communications)

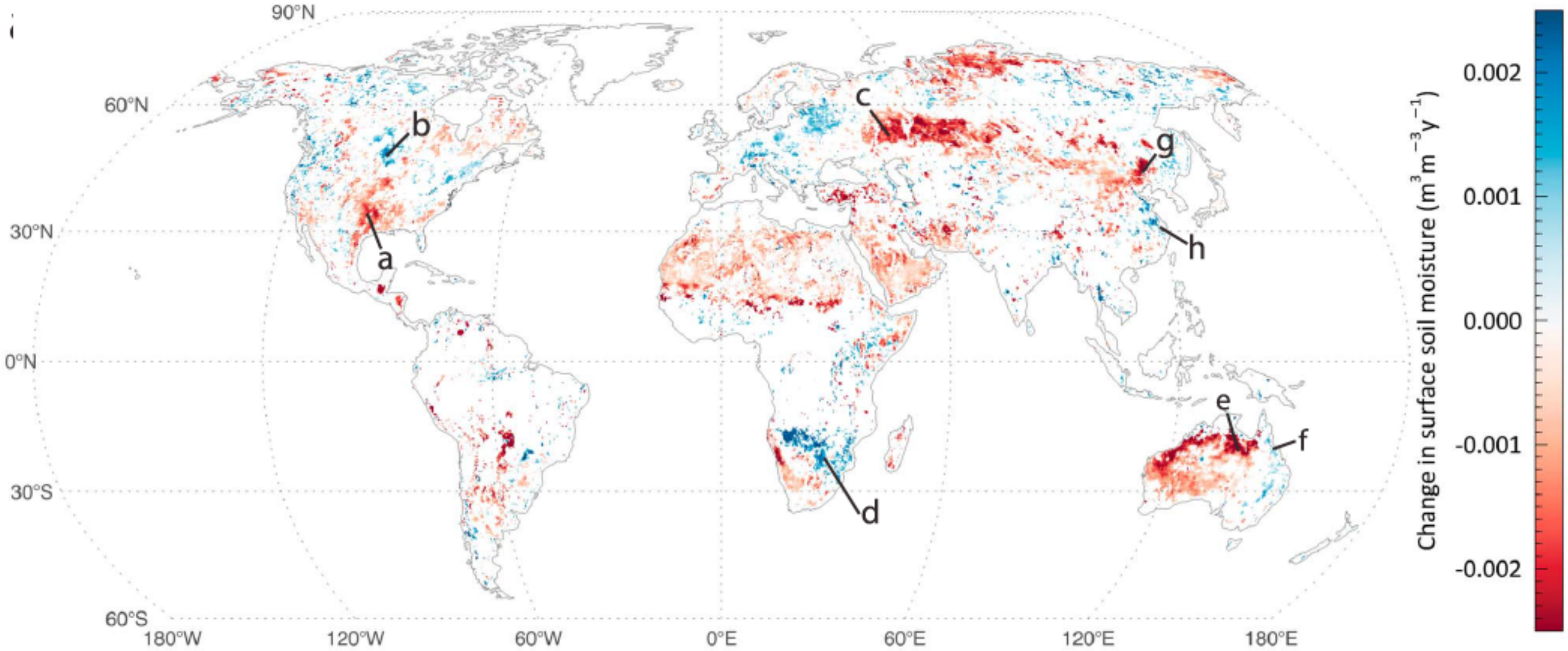
Impact of anthropogenic forcing on soil moisture content?
(preliminary analyses of HadGEM simulations)



(M. Hauser, ETH Zurich)

Evaluating global trends (1988–2010) in harmonized multi-satellite surface soil moisture

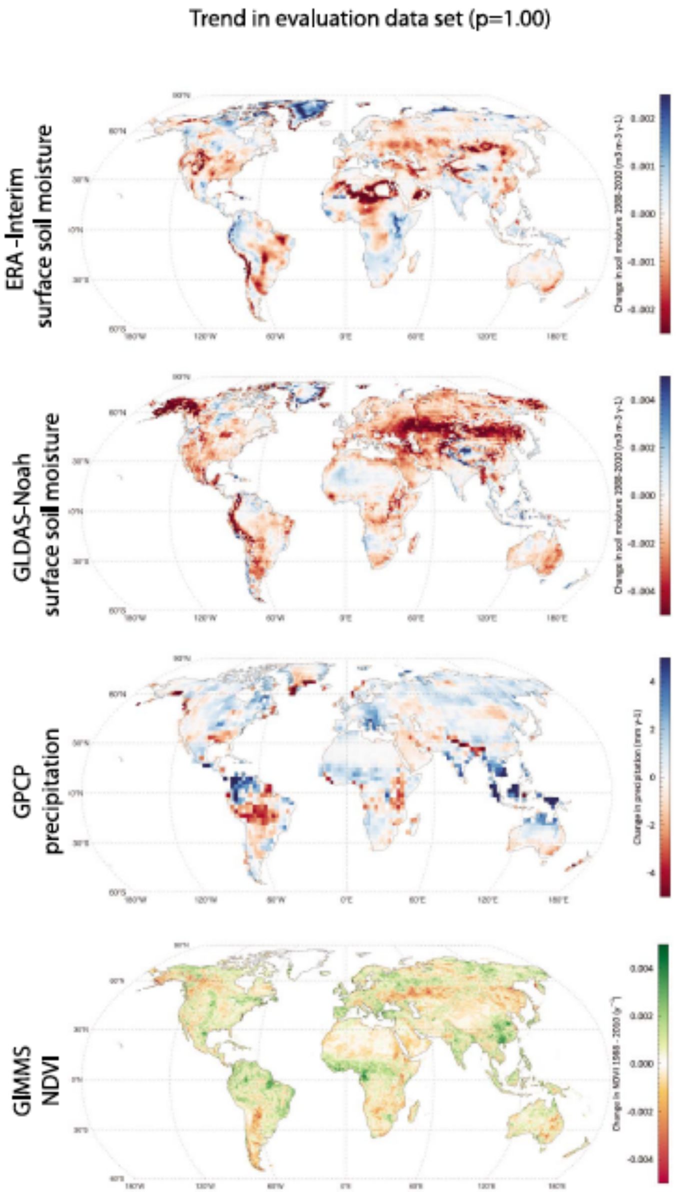
Wouter Dorigo,[1] Richard de Jeu,[2] Daniel Chung,[1] Robert Parinussa,[2] Yi Liu,[3,4] Wolfgang Wagner,[1] and Diego Fernández-Prieto[5]



Issue: Should we trust these trends?

(Dorigo et al. 2012, GRL)

Soil moisture trends?



[21] Despite the promising results, the reader should be aware of the limitations and uncertainties of the merged dataset. SM-MW relies on sensors with differences in temporal resolution and coverage, spatial resolution, observation principle, sensor calibration, center frequencies, band width, and radiometric accuracy. In addition, the performance of the retrieval algorithms is sensitive to topography, surface water, and vegetation while retrievals entirely fail for dense vegetation. Therefore, our future research will focus on

Need to carefully assess satellite-based data records when considering trends

For many analyses, even 30 years is still too short (need an estimate of pre-industrial conditions)

(Dorigo et al. 2012, GRL)

Droughts: Detecting robust trends

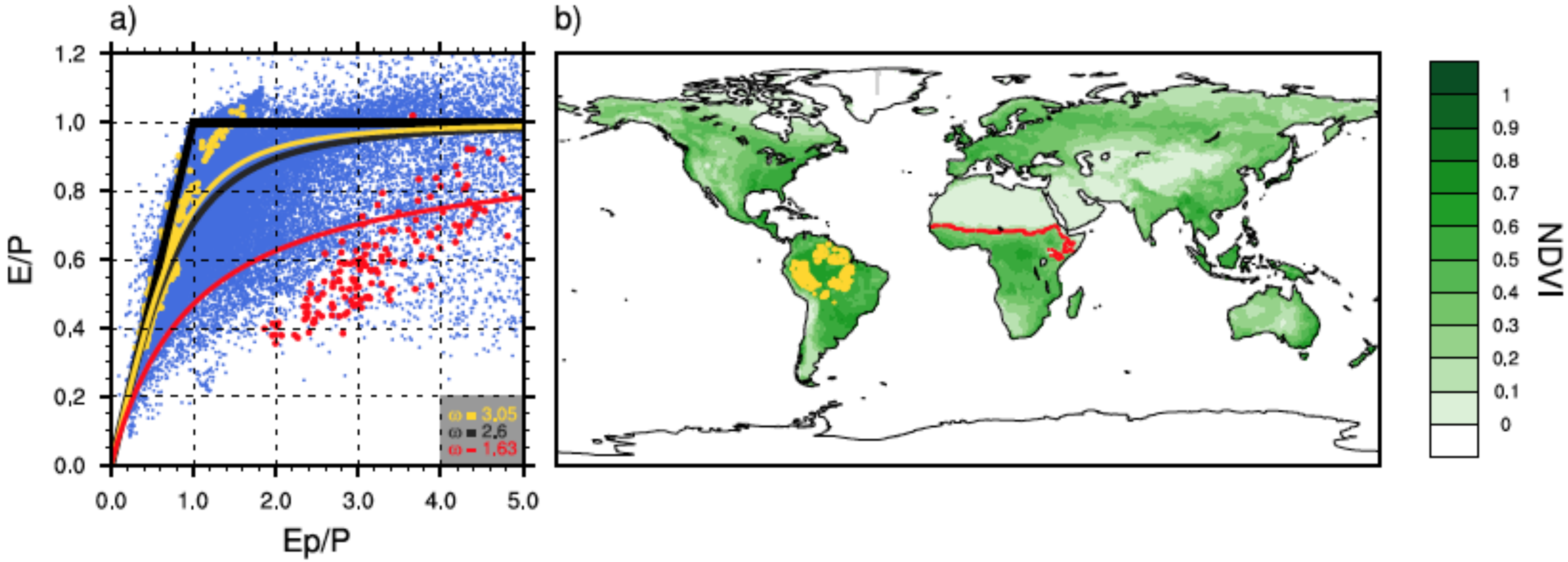
LETTERS
PUBLISHED ONLINE: 14 SEPTEMBER 2014 | DOI: 10.1038/NGEO2247
nature geoscience

Global assessment of trends in wetting and drying over land

Peter Greve[1,2*], Boris Orlowsky[1], Brigitte Mueller[1†], Justin Sheffield[3], Markus Reichstein[4] and Sonia I. Seneviratne[1*]

4 P datasets, 11 Ep datasets, 7 ET datasets
(1948-68 vs 1985-2005)

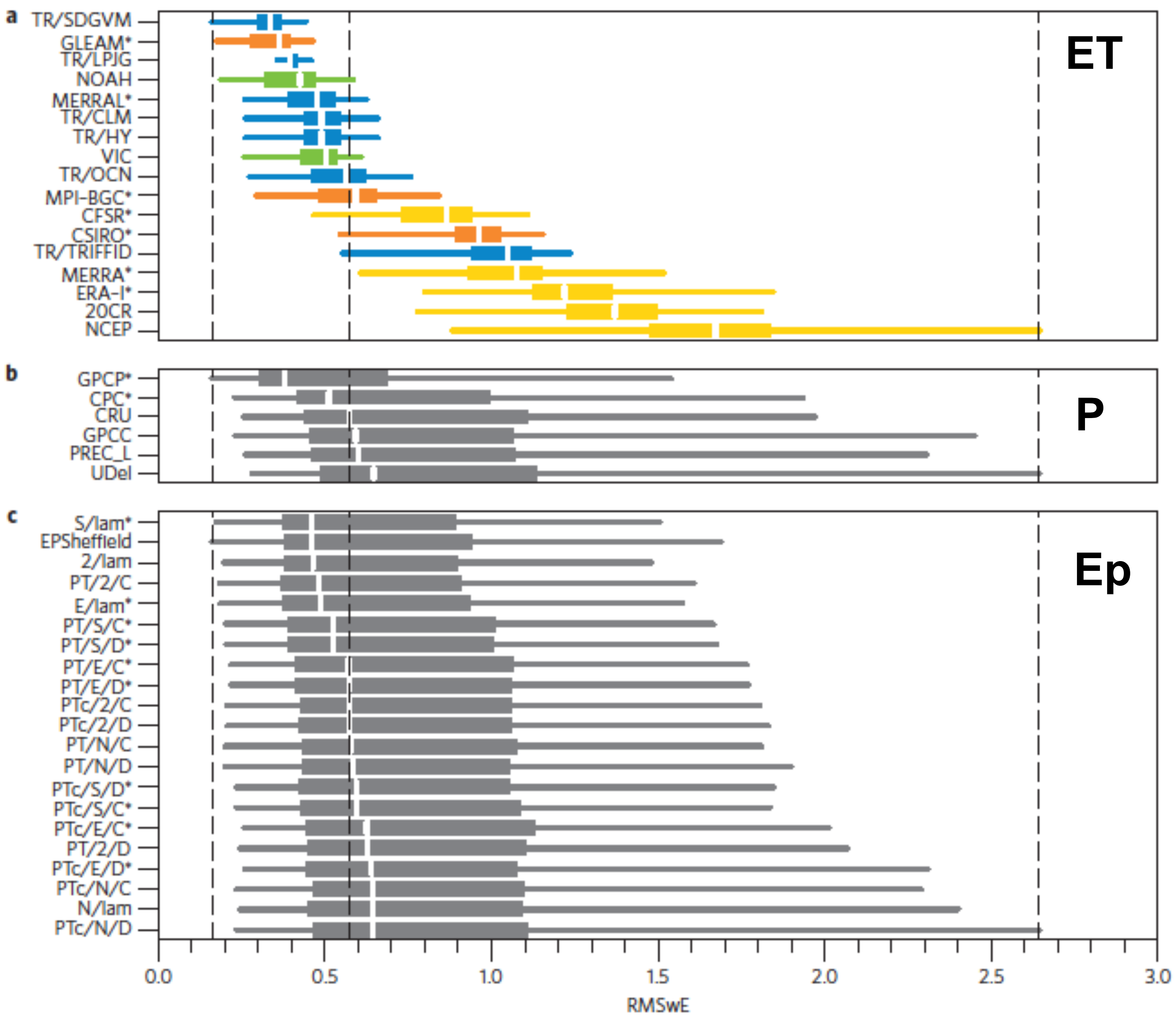
(Greve et al. 2014, Nature Geoscience)



$$\frac{E}{P} = 1 + \left(\frac{E_p}{P}\right) - \left(1 + \left(\frac{E_p}{P}\right)^{\omega}\right)^{\frac{1}{\omega}}$$

(Budyko 1956, Fu et al. 1981)

Droughts: Detecting robust trends

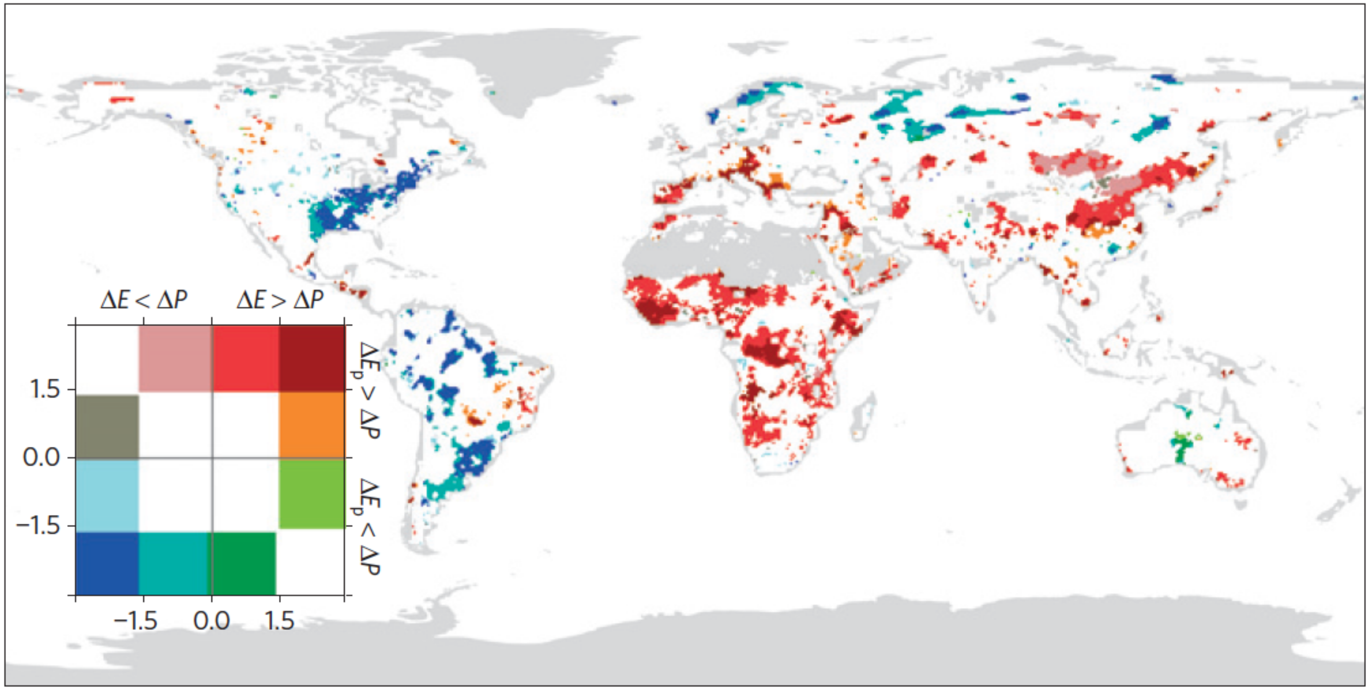


4 P datasets,
11 Ep datasets,
7 ET datasets

Largest uncertainty in ET! (related to soil moisture limitation and other plant physiological effects)

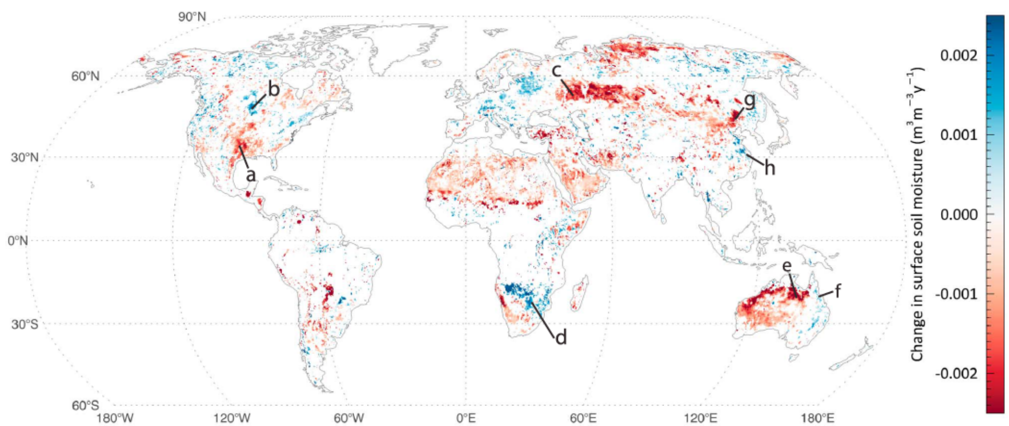
(Greve et al. 2014, Nature Geoscience)

Droughts: Detecting robust trends



Long-term hydrological changes (1948-68 vs 1985-2005)

(Greve et al. 2014, Nature Geoscience)



CCI soil moisture trends 1988-2010

(Dorigo et al. 2012, GRL)

Conclusions (1/2)

- Climate event attribution is a quickly expanding area of climate research
- Large demand from the media and public
- Satellite-based products can usefully contribute to this field of research, with some caveats
- Assessments currently on-going within FP7 EUCLEIA project

Conclusions (2/2)

- Contributions of satellite-based products:
  - Provide constraints on processes and mechanistic relationships (e.g. soil moisture-precipitation/temperature feedbacks, land cover effects on climate)

- Some issues to keep in mind:
  - Length and homogeneity of datasets (affect assessment of trends)
  - Near real time availability

- From CCI/CMUG community: Review providing assessment on suitability of CCI products for trend evaluation and near real time attribution?