



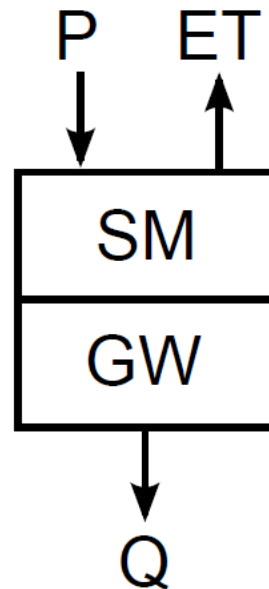
Runoff and Streamflow Data for Climate Extremes

Lukas Gudmundsson & Sonia I. Seneviratne
IACETH, Land-Climate Dynamics

Why care about **runoff/streamflow water on land?**

Impacts:

- Agriculture
- Public Water Supply
- Energy
- Flooding
- ...



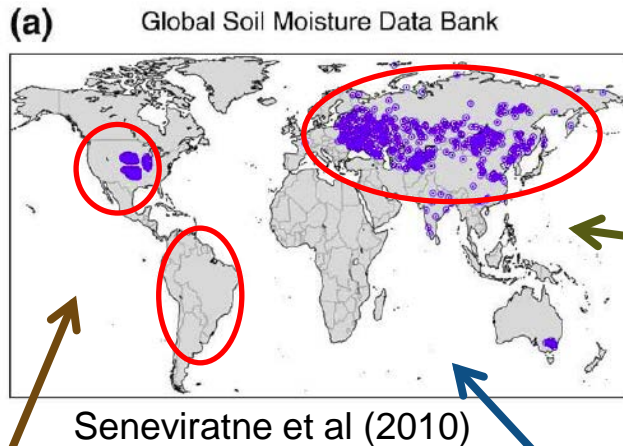
Processes:

- Land-atmosphere feedbacks
- Ecosystem processes
- Carbon Cycling
- ...

Note:

*Most Processes and Impacts are controlled by **storage variables***

Availability of in-situ observations: *Issues with storage variables, e.g: Soil Moisture*



Instrumentation

- Different principles
- Heterogeneous technology

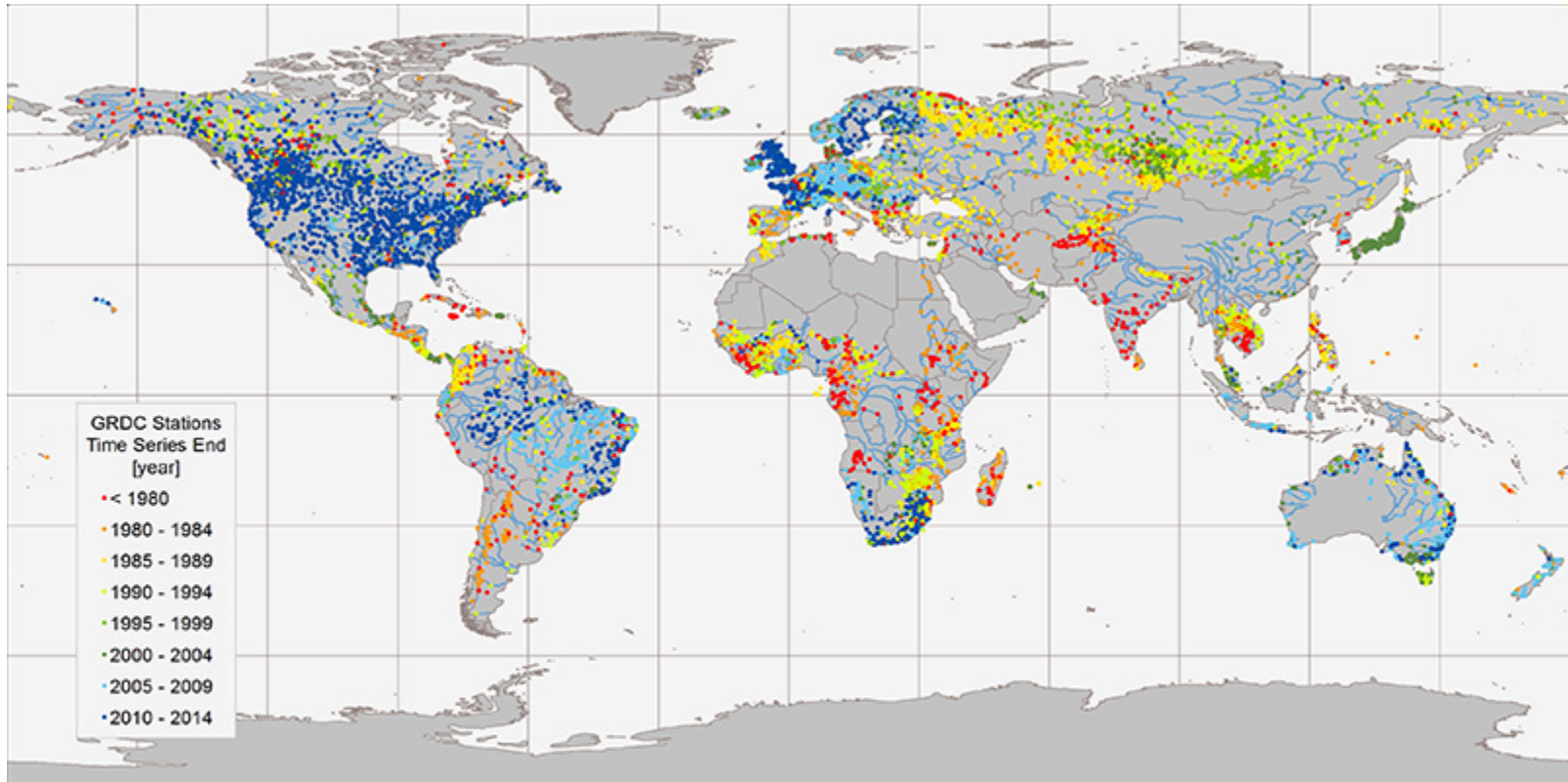
Spatial coverage

- Irregular station density
- Sparse observation networks

Temporal coverage

- Large regional differences
- Short time series

Availability of in-situ observations: *Runoff & Streamflow: most complete coverage*



9011 GRDC stations with monthly data, incl. data derived from daily data (Status: 18 Dec 2014)
Koblenz: Global Runoff Data Centre, 2014.



Typical Data Providers

- **The Global Runoff Data Center (GRDC)**
 - Large number of series
 - No regular updates
 - No «full» data base access (copy right restrictions)
- **Regional and national collections**
 - e.g. the USGS, European Water Archive (EWA)
 - Heterogeneous updating policies
 - Large differences in data-access (open access vs. restricted)

Question 1:

How to best integrate observations from different data providers.

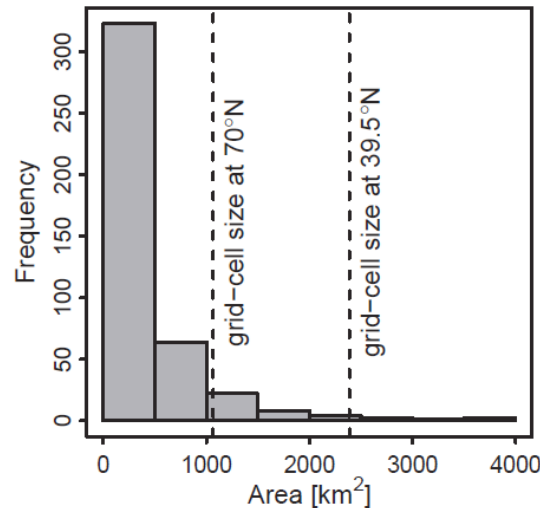
Particularities of runoff & streamflow data:

(1) *Spatial Localization*

Many Small Catchments



■ Grid Cell ● Station



Few Continental River Basins



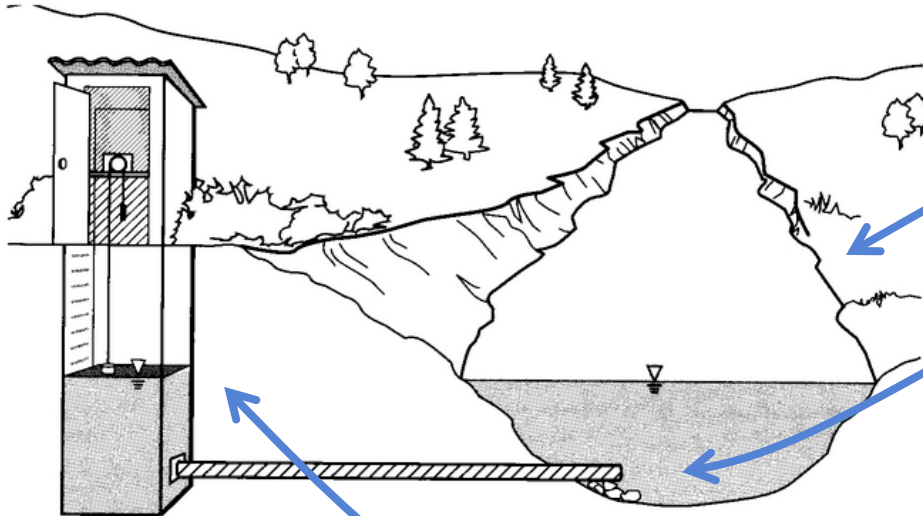
Question 2:

What does the differences between small head water catchments and continental scale river basins imply?

Particularities of runoff & streamflow data:

(2) Observing Systems

https://www.utdallas.edu/~brikowi/Teaching/Field_Methods/sanders-1998_fig3-15.jpg



Floods:
«over-flow» issues

Low-flows:
Often decreased resolution

Stage-height Discharge relation:
Uncertainties in rating-curves

Question 3:

Can quality control procedures be developed that help to classify the credibility of observations from heterogeneous observing systems

Particularities of runoff & streamflow data: (3) *Changes in the catchment*

Engineering



Wikimedia Commons / 663highland / CC BY 2.5

Land Use Change



NASA / Wikimedia Commons

Question 4:

How to treat inhomogeneities caused by catchment-engineering and land use change; can we detect the and differentiate between them automatically?

Runoff & streamflow based indices for extremes

(1) *Extreme Events*

Characterizing events with un-usual amounts of water

- Block Statistics (e.g. annual, monthly)
 - maxima / minima
 - Percentiles
- Values above / below a threshold
- Excess / deficit volumes
 - Volume of water that exceeds or is below a threshold
- Complex indices for specific applications
 - E.g. minimum series smoothed with an moving average.

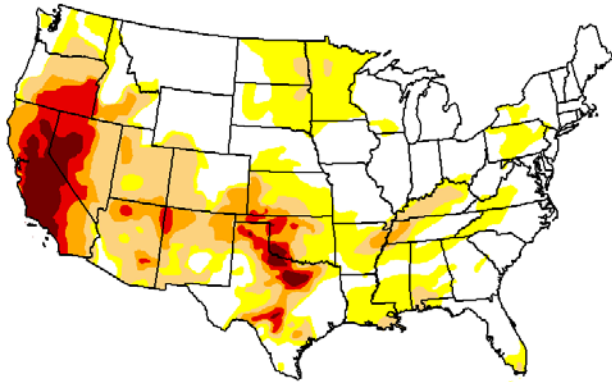
Question 5:

A plethora of extreme-indices are in use in hydrology; Which ones to use and why?

Runoff & streamflow based indices for extremes

(2) Extreme Episodes

US Drought Monitor Feb 17, 2015



Droughts: *prolonged episodes* of limited water availability

Often quantified through:

- Standardized anomalies of water-balance variables
- «Drought Indicators» (SPI) can easily be applied to streamflow data.

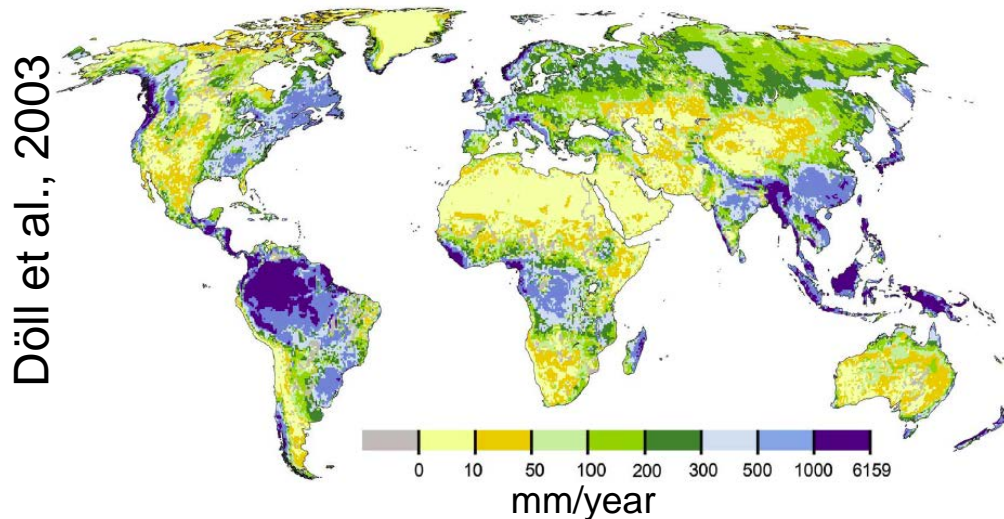
Question 6:

Should extreme episodes in runoff & streamflow be quantified through standardized indices or is it important to keep physical units intact



SCI: Standardized Climate Indices such as SPI, SRI or SPEI

Open Challenge: How to derive observational runoff grids



Most common approach:

- Re-analysis driven LSM
- Under-utilize observations
- No data-assimilation (state updating)

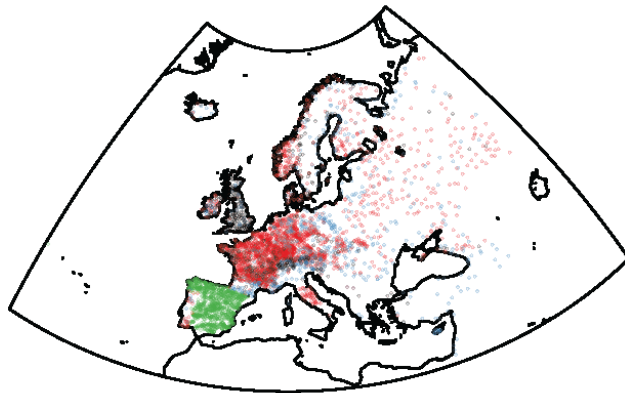
Question 7:

What approaches should be used to produce continental/global observation-based estimates? Which alternatives do exist?

European Case-study:

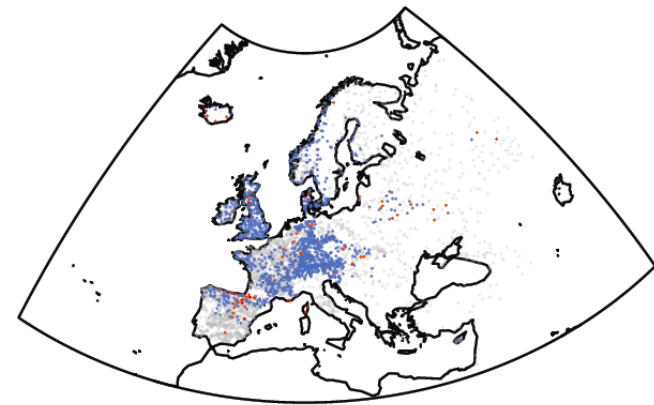
(1) Data Collection & Quality Control

Data Sources



- Source Data Base
- EWA
 - GRDB
 - Spain
 - EWA and GRDB

Homogeneous stations

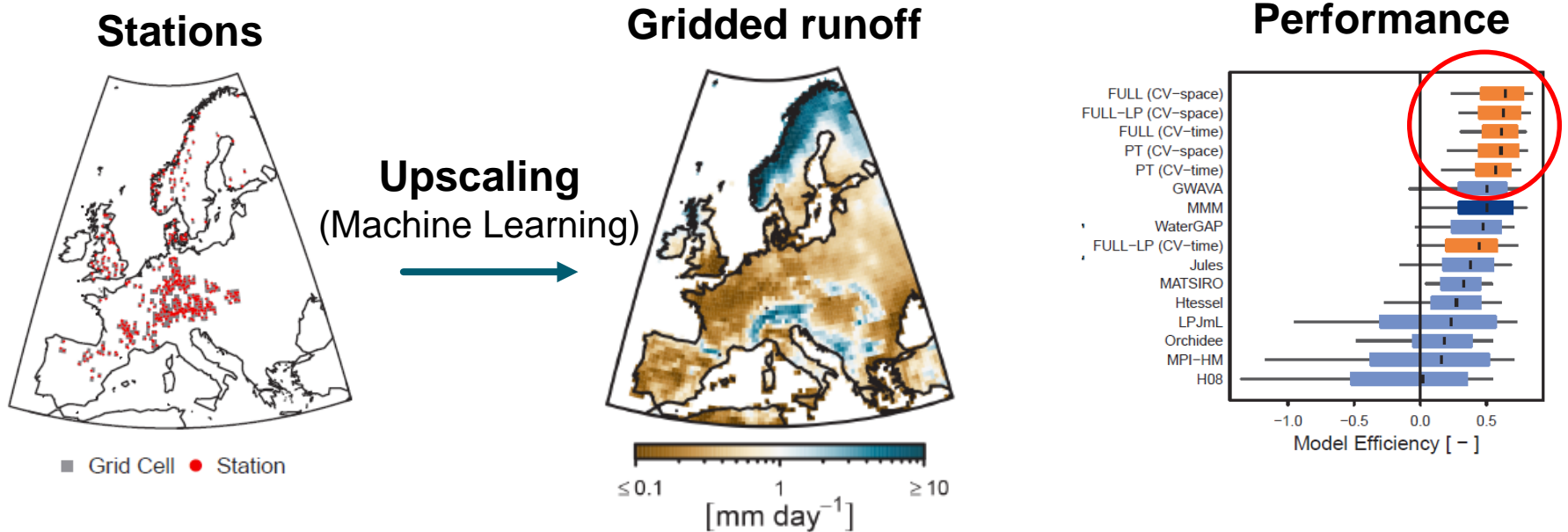


- Usefull
- Suspect
- Not sufficient data in 1971– 2005 or catchment ara > 5000 km2

data-base merging:
using statistical record-linkage

Quality control & homogeneity testing:
Following EAC&D recommendations

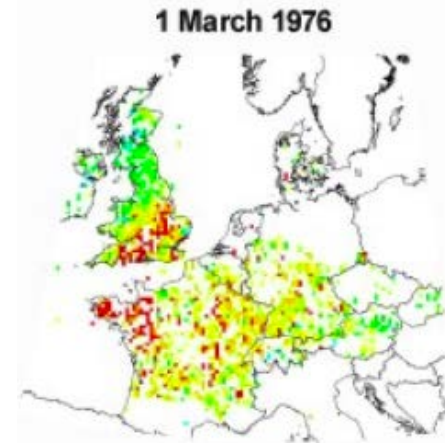
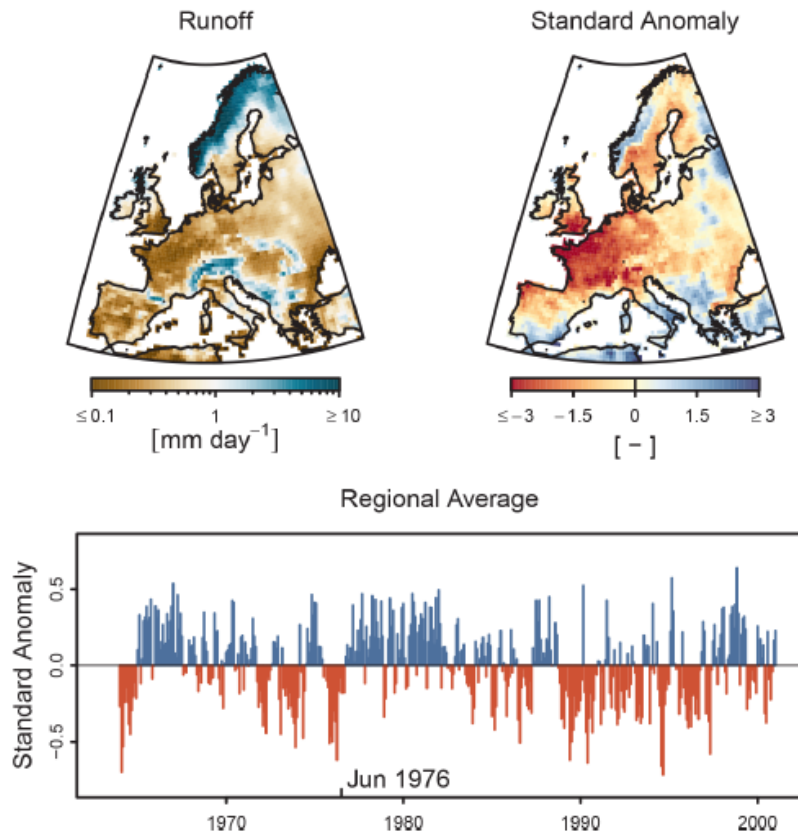
European Case-study: (2) Statistical Upscaling



Upscaling monthly runoff from small catchments

- Based on re-analysis data and machine learning regression
- Good overall performance of the upscaling model (**orange**)

European Case-study: (3) Drought Assessment



Zaidman et al., 2002

1976:

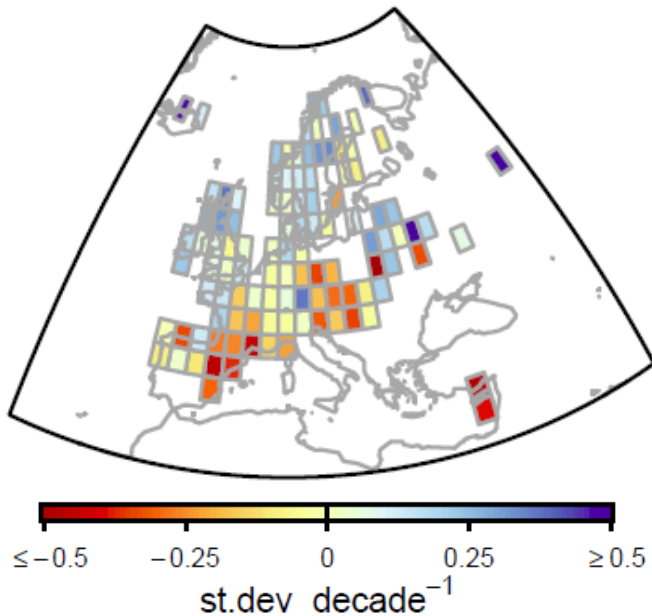
One of the driest years in the record

- The newly derived grid captures reported anomalies well.

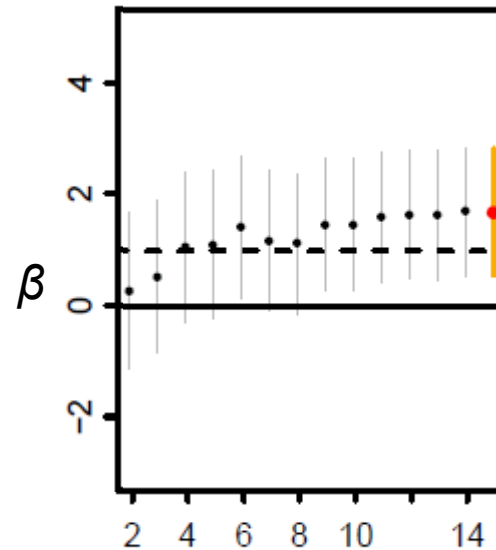
European Case-study:

(4) Trends and climate-change

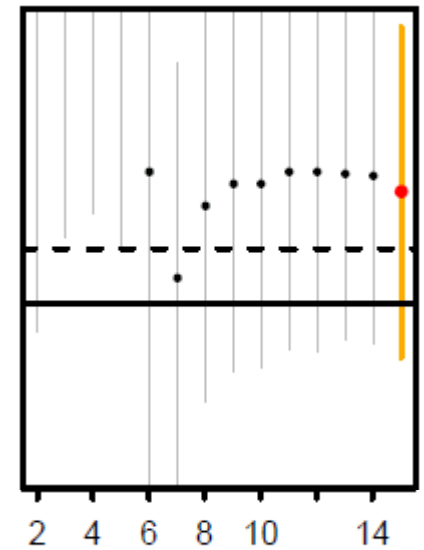
Runoff Trends



Historical Forcing



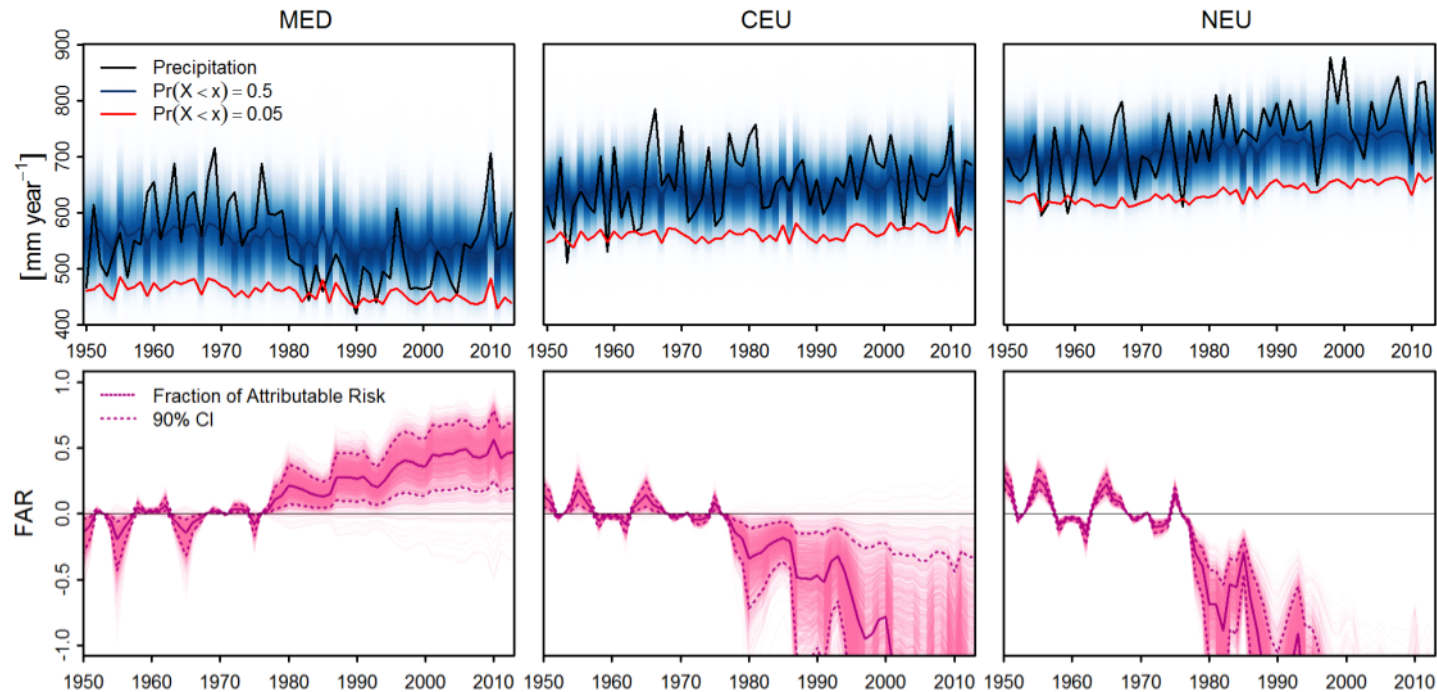
Natural Forcing



Changes in European runoff are very likely linked to anthropogenic climate change

European Case-study:

(5) Trends in Drought Frequency (Precipitation)



Regional precipitation: a conditional on *NAO* and *global temperature anomalies*

- Fixed global temperature anomalies: estimate of natural variability
- **Drought frequency, significantly related to global temperature**

What are your Questions...?

- 1) How to best integrate observations from different data providers?
- 2) What does the differences between small head water catchments and continental scale river basins imply?
- 3) Can quality control procedures be developed that help to classify the credibility of observations from heterogeneous observing systems
- 4) How to treat inhomogeneities caused by catchment-engineering and land use change; can we detect the and differentiate between them automatically?
- 5) A plethora of extreme-indices are in use in hydrology; Which ones to use and why?
- 6) Should extreme episodes in runoff & streamflow be quantified through standardized indices or is it important to keep physical units intact
- 7) What approaches should be used to produce continental/global observation-based estimates? Which alternatives do exist?