

Statistical Analyses of Climate Events

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Extreme Event Attribution

- An extreme climate event occurs:
 - What is its probability (or return time)?
 - Has this probability changed (or will it) with time?
 - How can this change be described?
 - Is it related to climate change?

Several Approaches

- Large ensembles of climate simulations (~100000)
 - Weather@Home experiments (e.g. EUCLEIA project)
- Statistical and dynamical modelling and dependence to CC
 - Multi-physics & Euro-CORDEX ensembles
- Estimating the link with large scale
 - Conditional attribution to atmospheric circulation

Winter 2013/2014

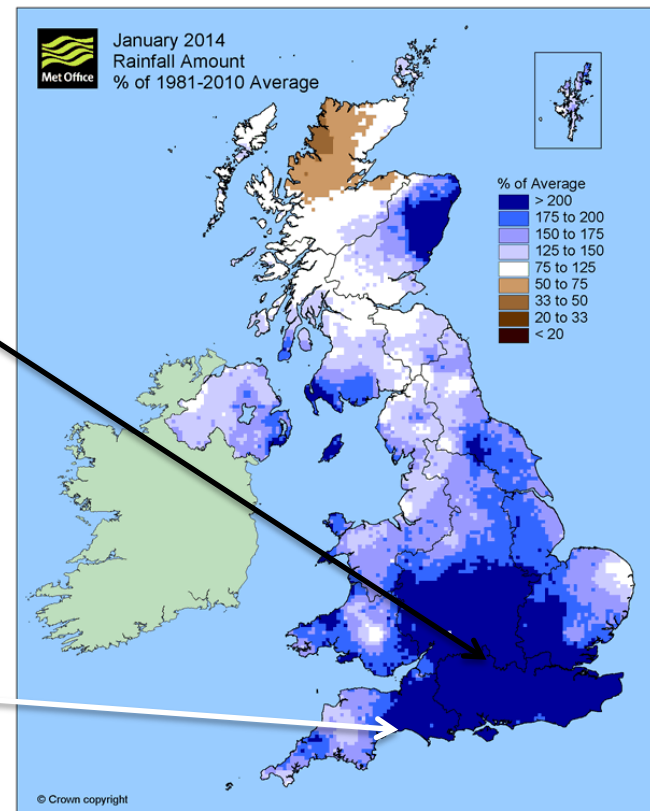
Did anthropogenic forcing affect the risk of the circulation, heavy precipitation and floods to occur in Southern England?



The Oxford Mail

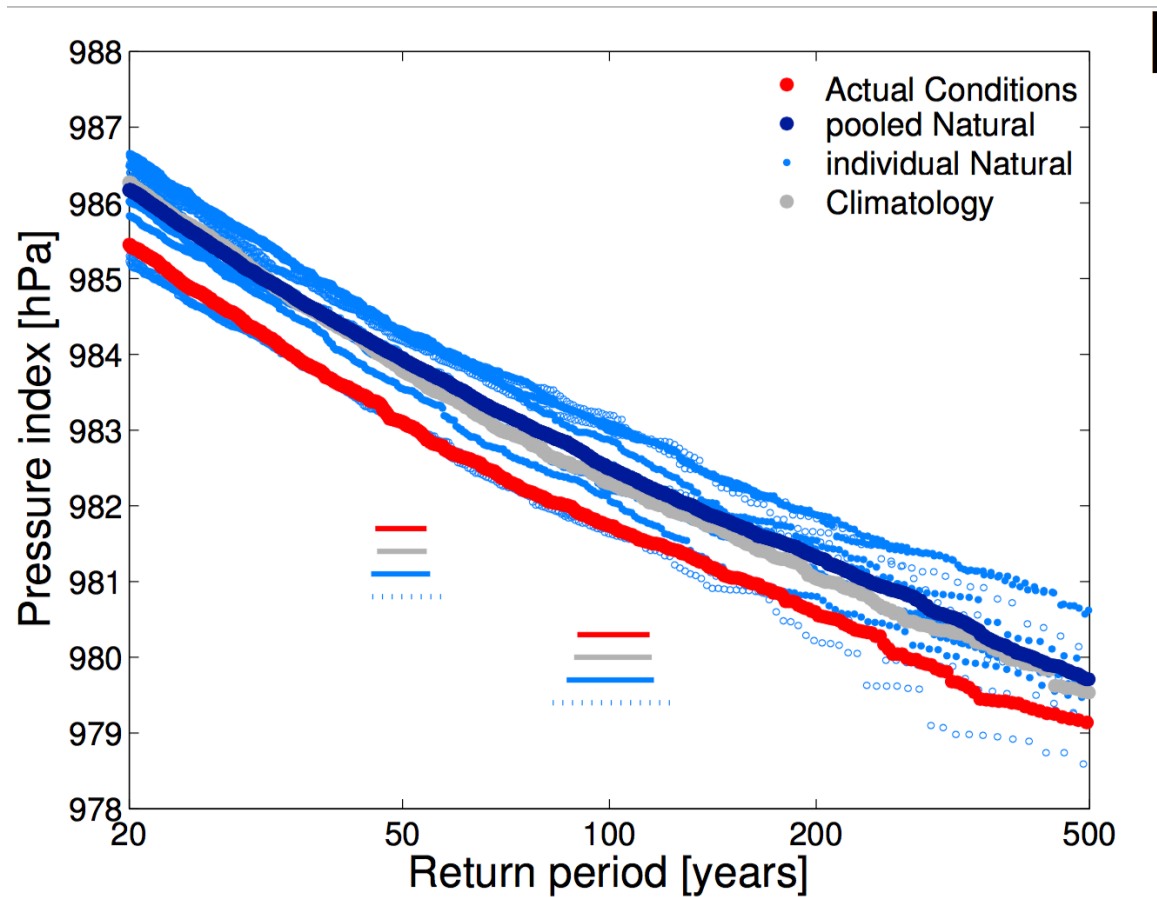


www.metoffice.co.uk



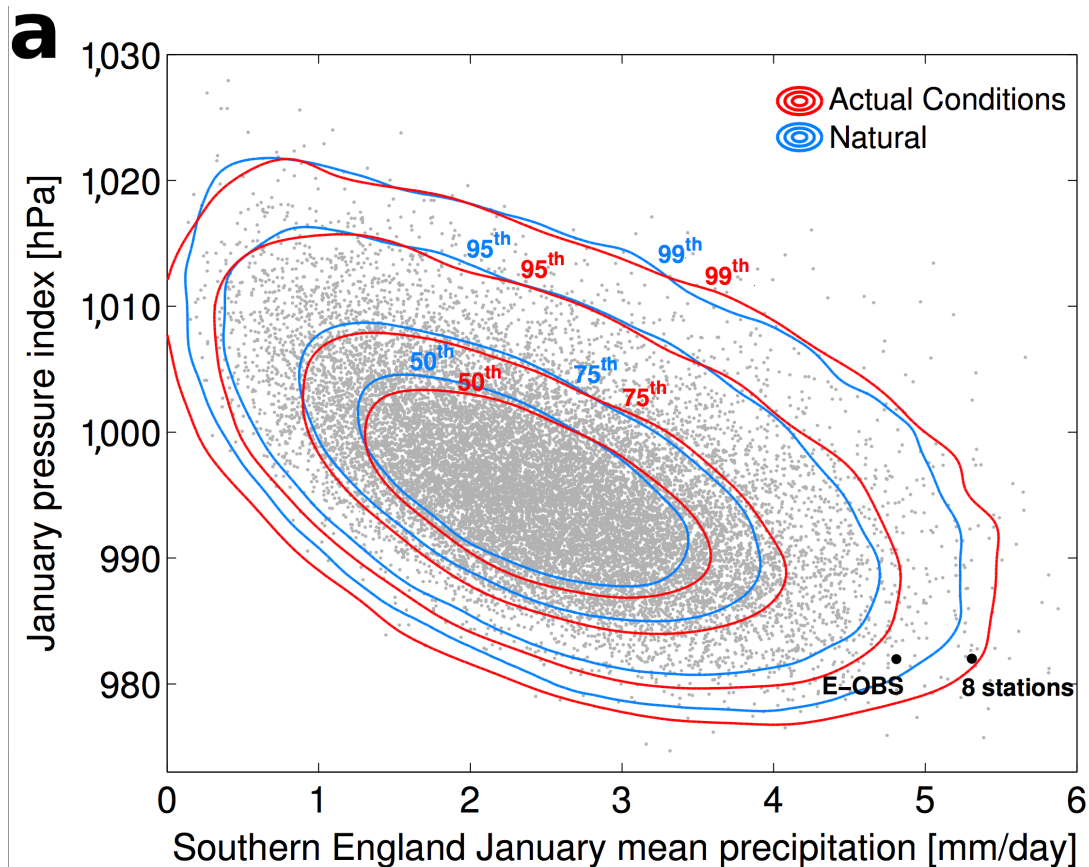
Results

- Pressure index: SLP at 20°W, 60°N



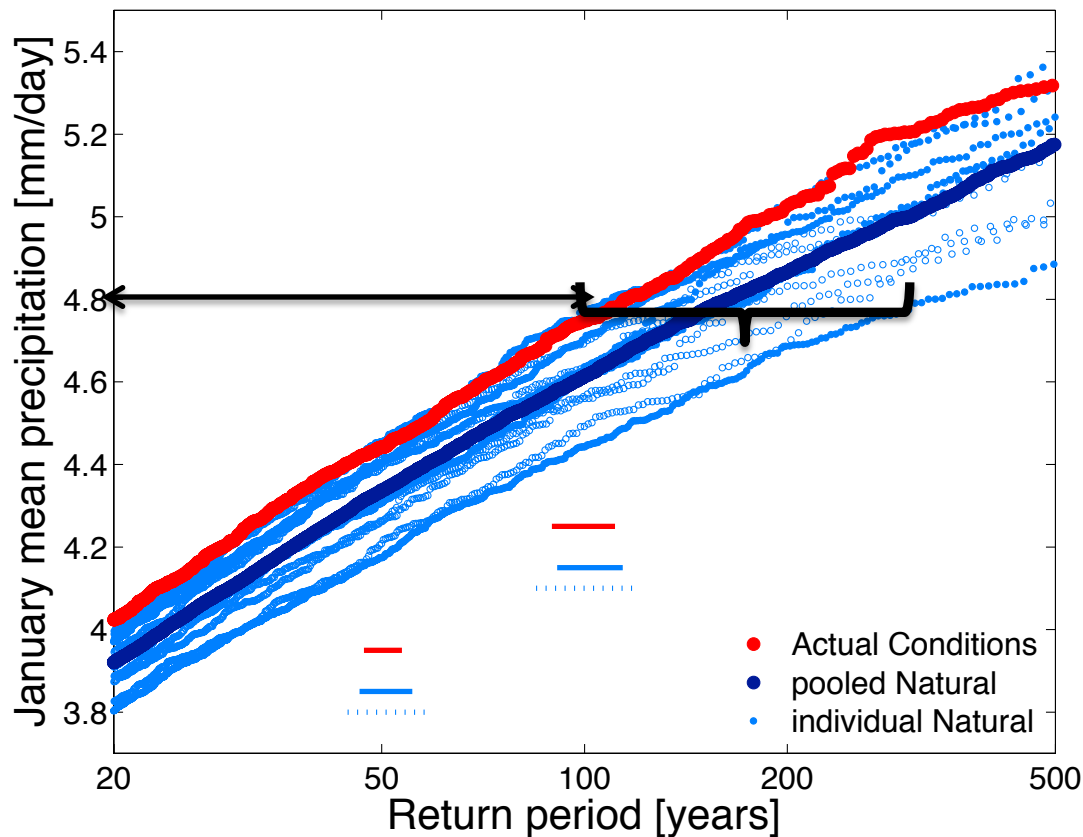
Schaller et al., Nature Climate Change, 2016

- Joint distribution



Schaller et al., Nature Climate Change, 2016

- Increase in risk of heavy precipitation (FAR):
➤ 40% [0%:160%]



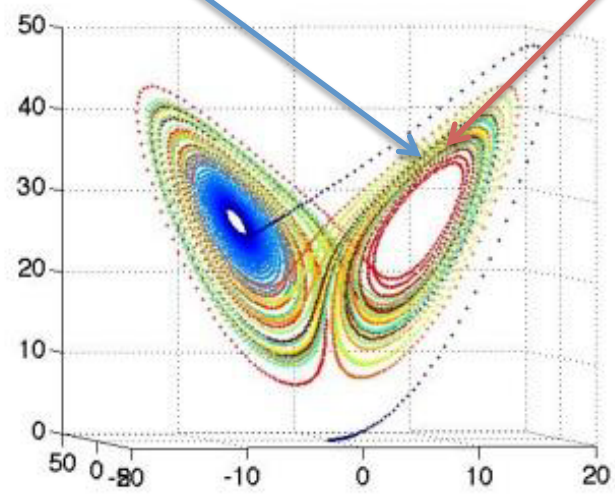
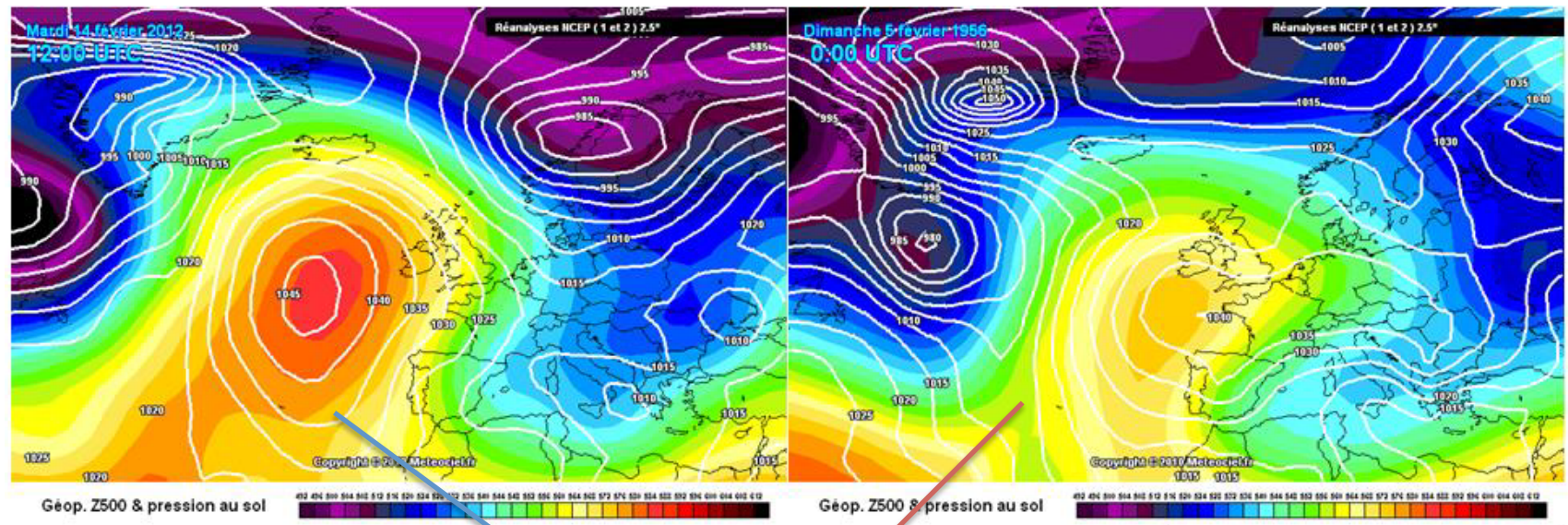
$$FAR = 1 - \frac{p_0}{p_1}$$

Schaller et al., Nature Climate Change, 2016

Ongoing Research Questions

- For a given atmospheric pattern, has the probability distribution of temperature/precipitation changed?
 - Thermodynamic response
- Are there trends in the atmospheric circulation?
 - Dynamical response

Analogue and Recurrences



Two analogue maps correspond to close points in phase space

(Courtesy of D. Faranda)

Circulation analogues (1)

- *Reference* database **R**, containing consistent pressure (SLP and/or geopotential heights), temperature, precipitation etc. data during a reference period of observations
 - E.g. Reanalysis data for a fixed period, climate model control simulation
- *Target* dataset **T**, with only pressure data (SLP or geopotential height)
 - E.g. Observation during a period outside of the reference

Circulation analogues (2)

- We want to *infer* the value of climate variables (e.g. T, Prec., Wind speed) in the dataset **T**, from information in the database **R**.
- For each day in **T**, find best analogues of pressure in **R**.
 - Minimize distance (Euclidean, Mahalanobis...)
 - Maximize spatial correlation (rank)
- **Statistical properties of analogue T, Prec...?**
 - “Copies” of T, Prec.

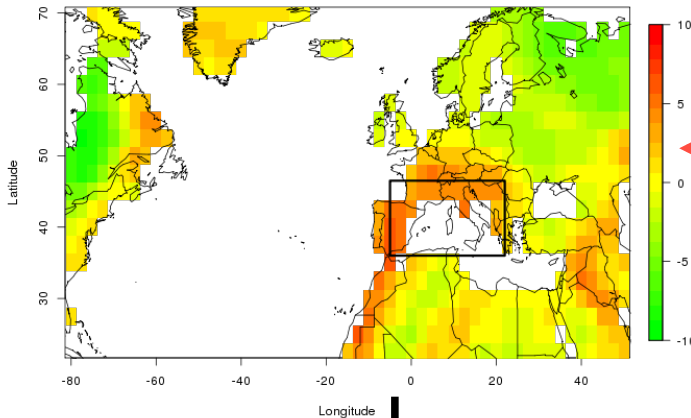
Circulation analogues (3)

- Use of daily sea-level pressure (SLP) from NCEP reanalyses
- For all days between Jan. 1st 1948 and Nov. 20th 2017, pick the 20 days within 30 calendar days but different year with the closest SLP:
 - largest correlation (rank or linear)
 - Smallest Euclidean distance
- Determine temperature, precipitation of analogue days

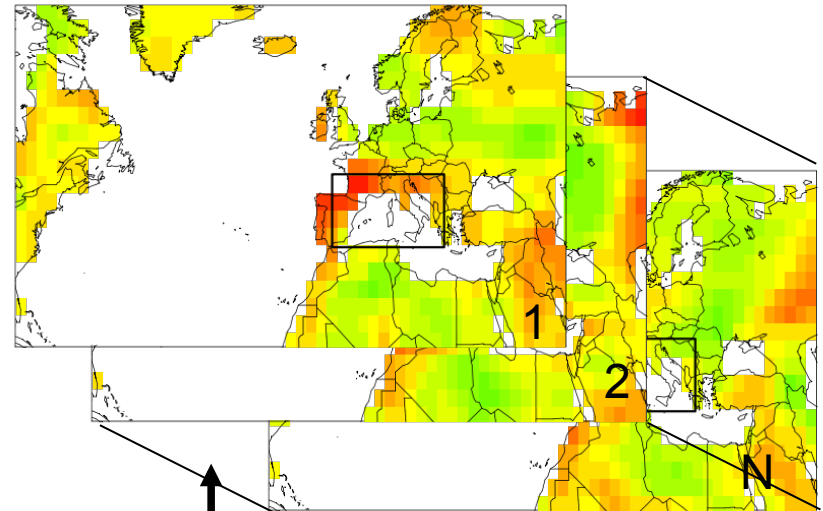
Procedure

Climate observable
(Temperature)

Day d ,
Year y

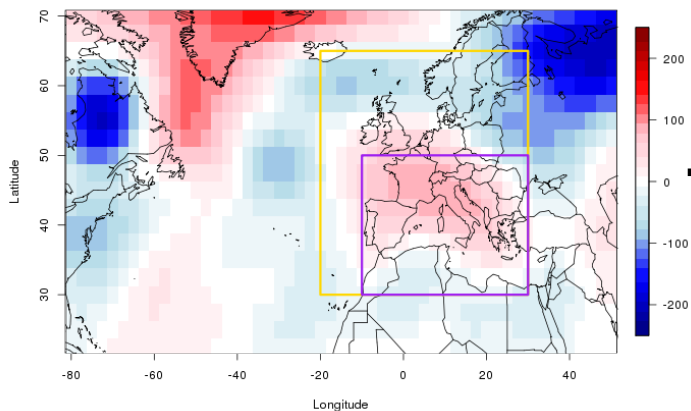


?



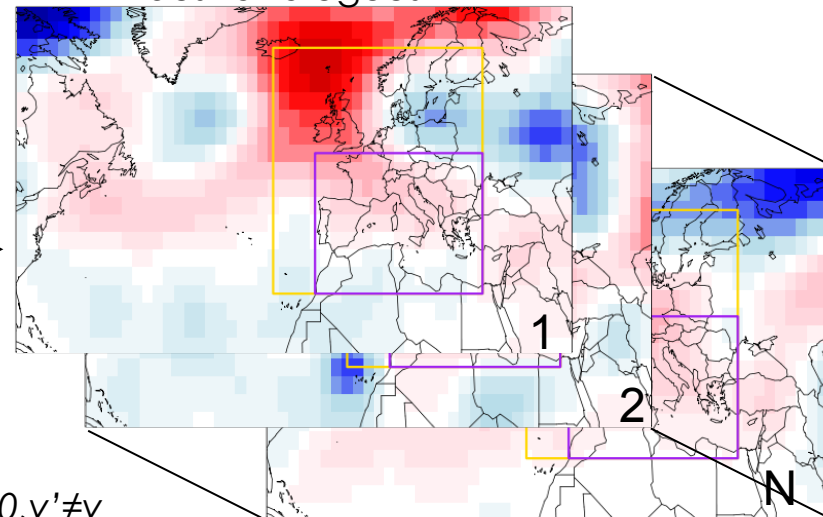
Corresponding circulation
(Z500 detrended)

d, y



Similar to

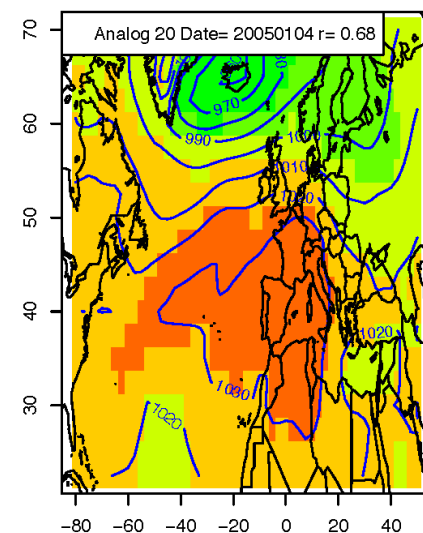
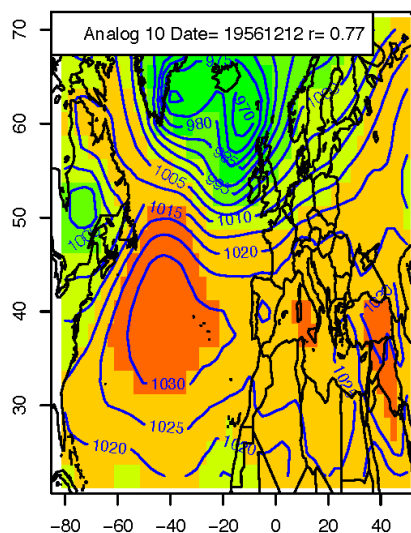
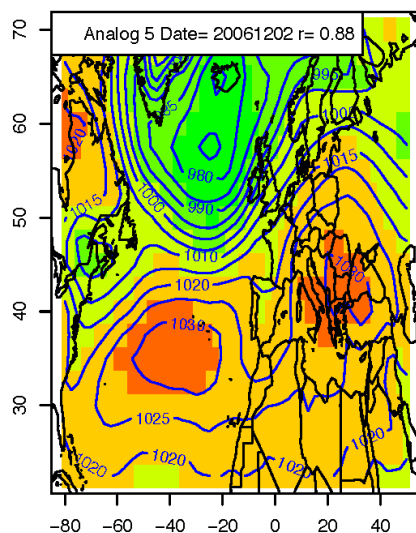
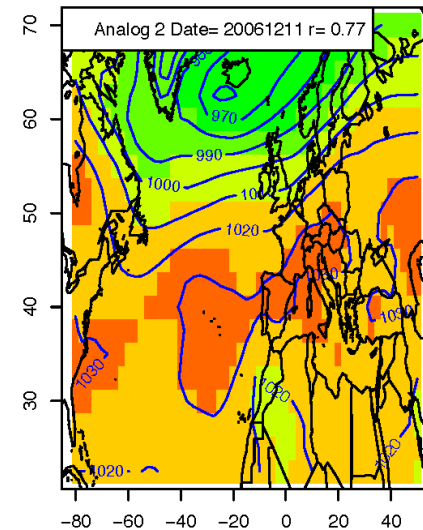
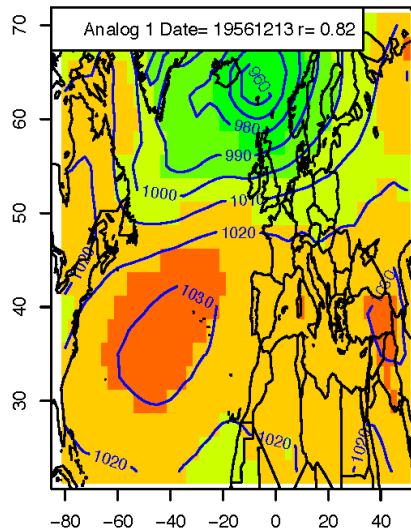
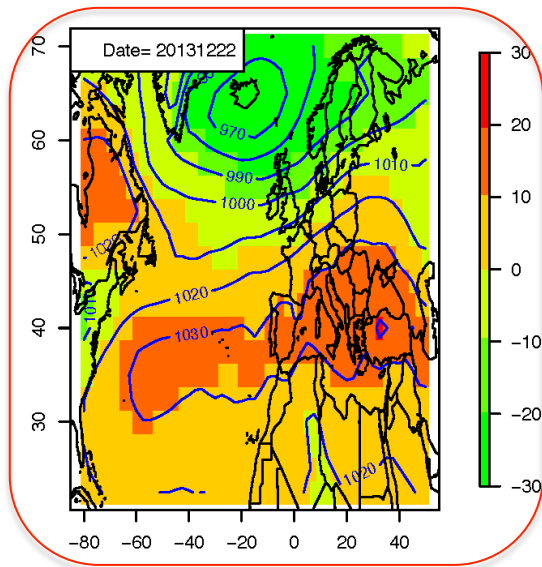
N best analogues



$d \pm 30, y' \neq y$

(Courtesy of A. Jézéquel)

Storm Dirk (22 Dec. 2013)

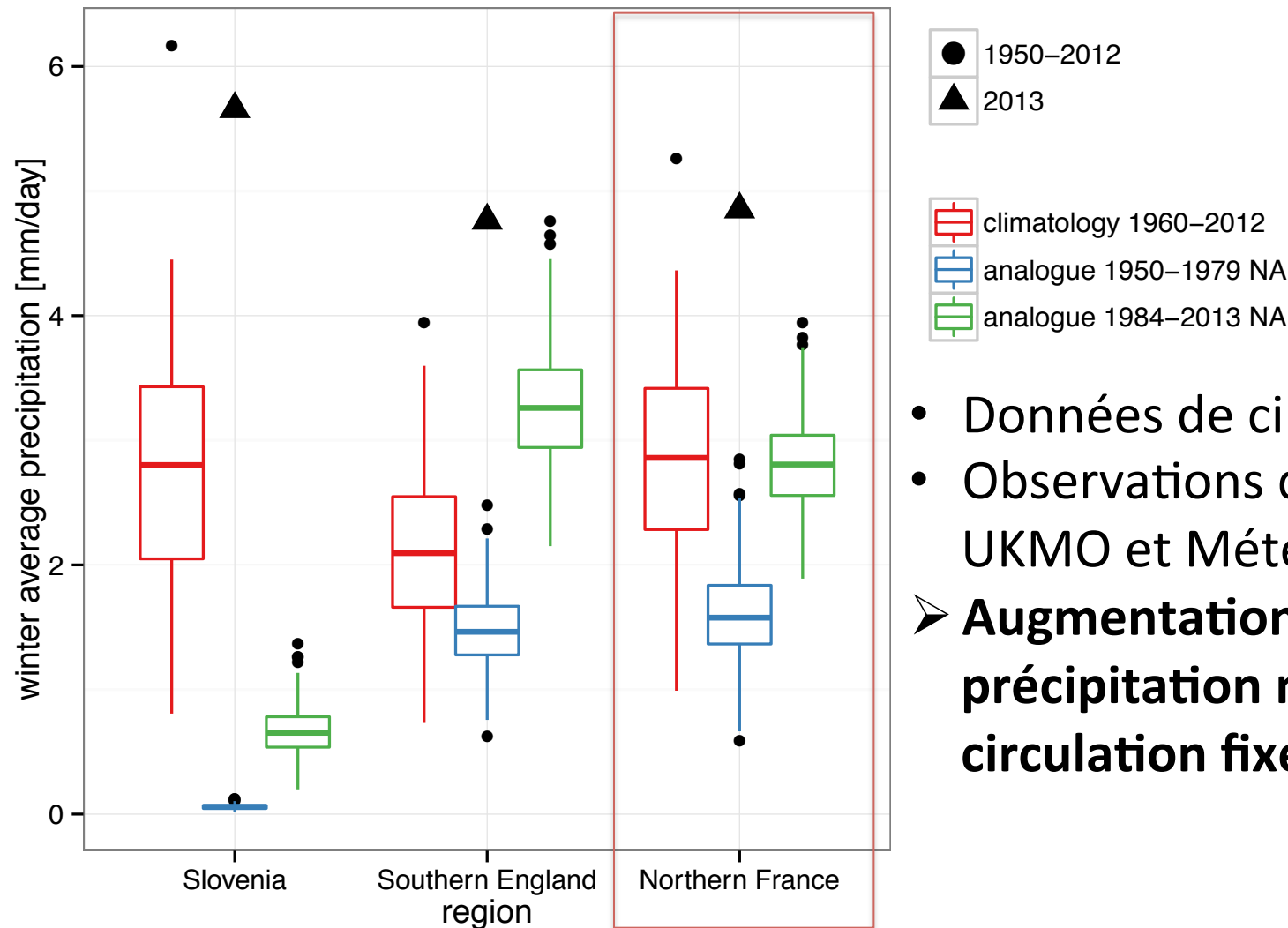


Uchronic probabilities

Probability distribution of temperature/precipitation for the same circulation, but without human activities.

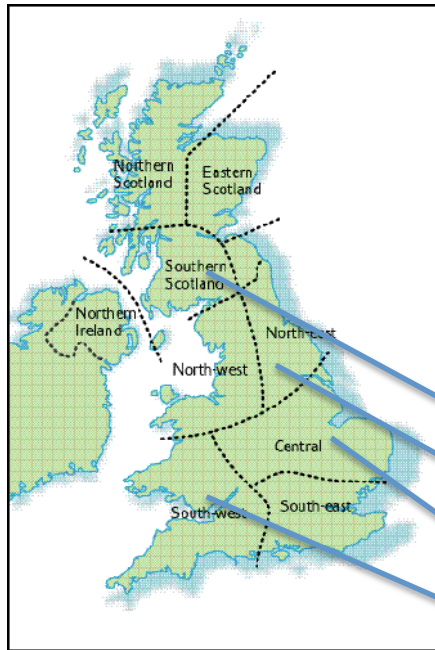
- Simulating monthly (or seasonal) temperature from analogues of circulation
 - Random sampling of analogues from two different periods
 - Estimating the distribution of possible temperatures for atmospheric sequences that are close to the observed ones.

Rainy winter 2013/2014

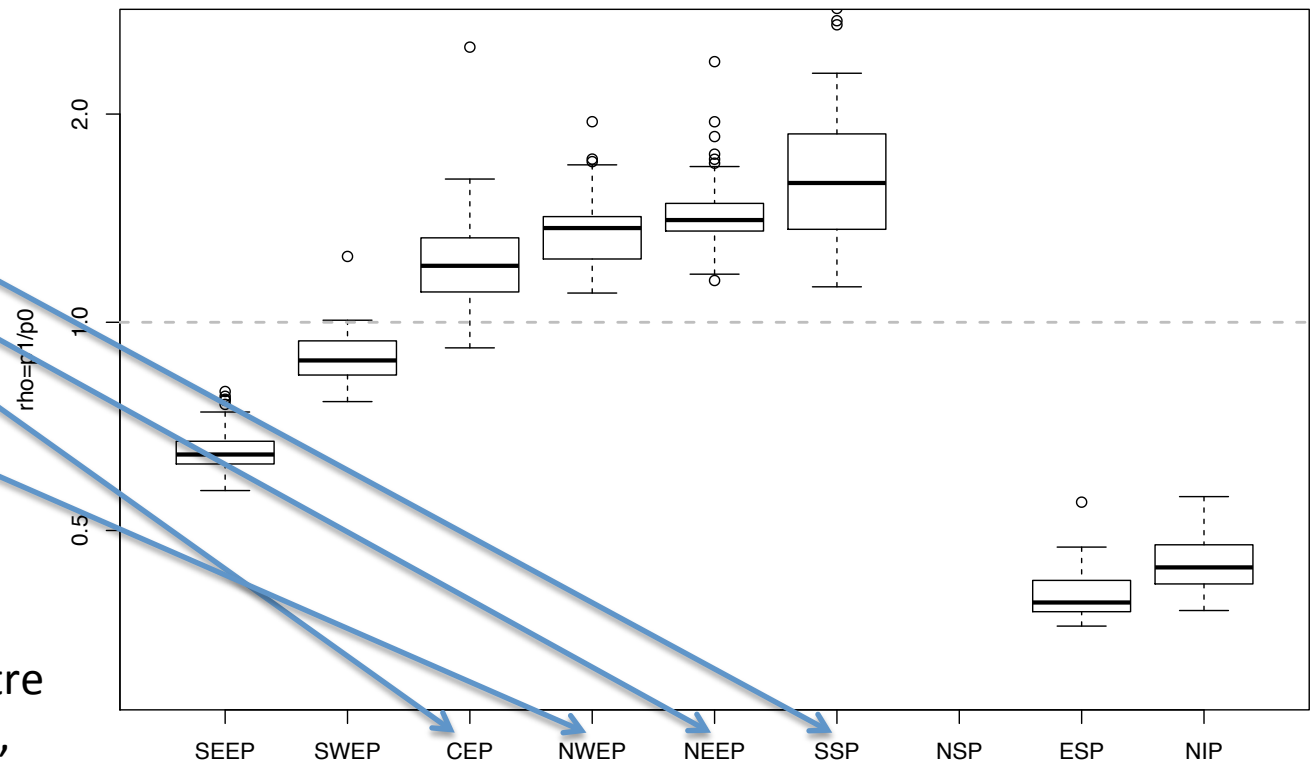


- Données de circulation NCEP
- Observations de température UKMO et Météo-France
- **Augmentation de la précipitation moyenne, à circulation fixée**

Rainy 2012 summer in UK



Augmentation de la probabilité de forte précipitation estivale entre 1930-1971 et 1971-2012, pour une circulation cyclonique



(Wilcox et al., Clim. Dyn., 2017)

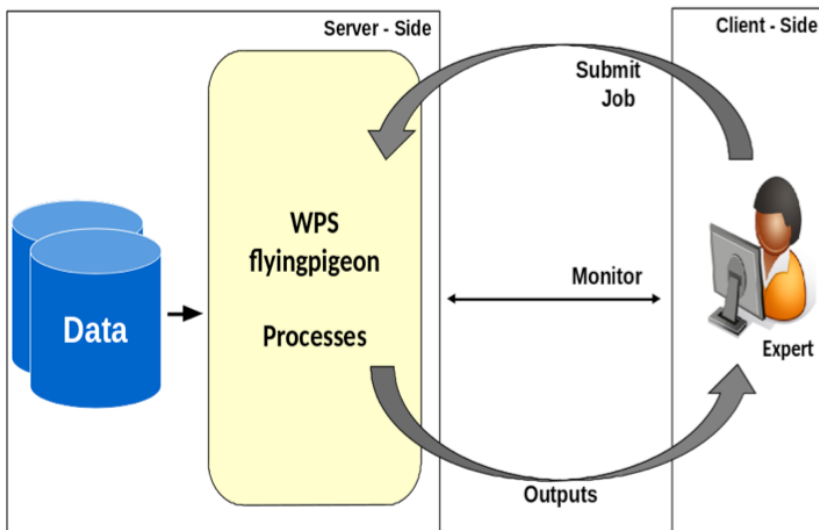
Today's Exercise

- Circulation in January 2018
 - Storms Carmen, Eleanor, Frederieke
- Is it exceptional?
- Use of SLP analogues from NCEP

A tool for fast analyses

Open source WPS: blackswan

Analogue viewer



Diagnostics statistiques sur des bases de données multiples (CMIP, CORDEX, réanalyses)