Black swans and butterflies: analogues of atmospheric circulation

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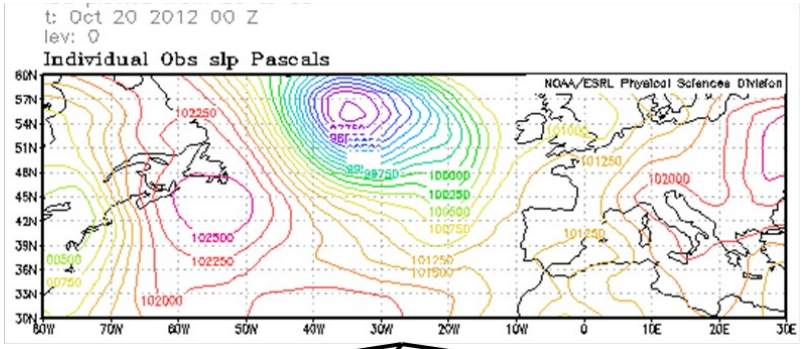
Motivations

- Study climate events and relate them to large-scale atmospheric circulation
- If there is a climate attractor, how to measure a qualitative alteration?
  - Link with forcings (solar, volcanoes, GHG…)
- Detection, attribution and emergence?

Project summary

Flow Observation or simulation



WP2

Determination of best analogues

Database 1

Database 2

…

Database N

Data-mining computer infrastructure

Detection & Attribution

WP3b

Probability of analogues

WP1

Attractor deformation

WP3a

Eg: Black swans

Emergence of new regimes

Who & what

- WP1: mathematics and statistics of circulation analogues
  - How do we measure rarity and emergence in chaotic systems?
  - PY, P. Naveau, M. Vrac & 1 PhD + 1 Postdoc
- WP2: Engineering of analogue computation
  - Compilation of databases
  - Continuous time assessments
  - PY & 1 engineer
- WP3: Applications to climate change
  - Last millennium, future, D&A
  - PY, R. Vautard & 1 PhD + 1 postdoc
- Administration
  - PY & J. Bazire

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, model control simulation
- *Target* dataset **T**, with only pressure data (SLP or geopotential height)
  - E.g. Observation during a period outside of the reference

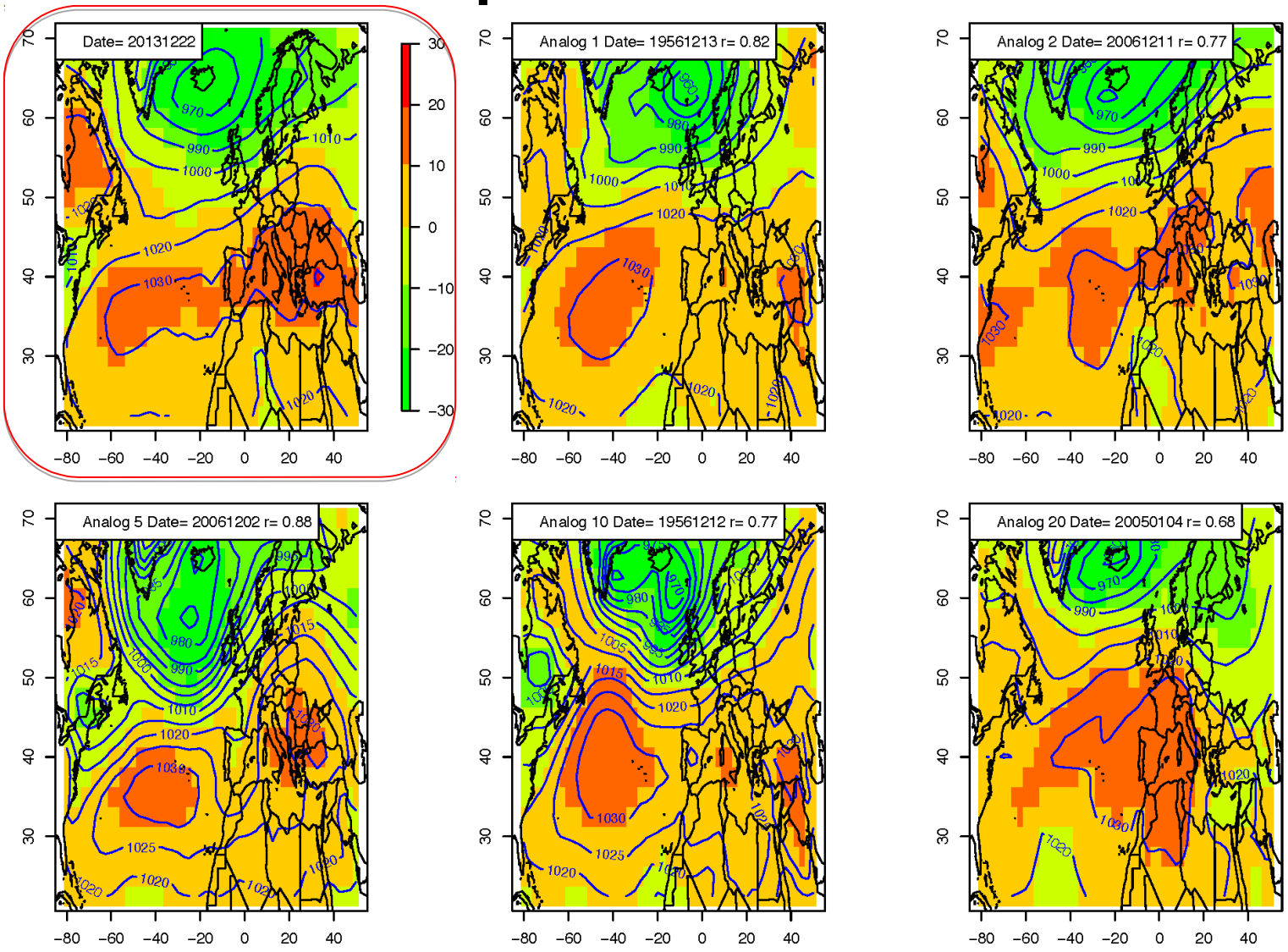
Circulation analogues (2)

- 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)

Analogues of circulation

- What is a good analogue? (***butterflies***)
  - Hypothesis of recurrent patterns in a phase space to be defined
  - Probability distribution of distances of analogues
- Cases without analogues (***black swans***)
  - Extremes of the probability distribution of distances
- Re-construction of 3D field from the constraint on a boundary of the domain?

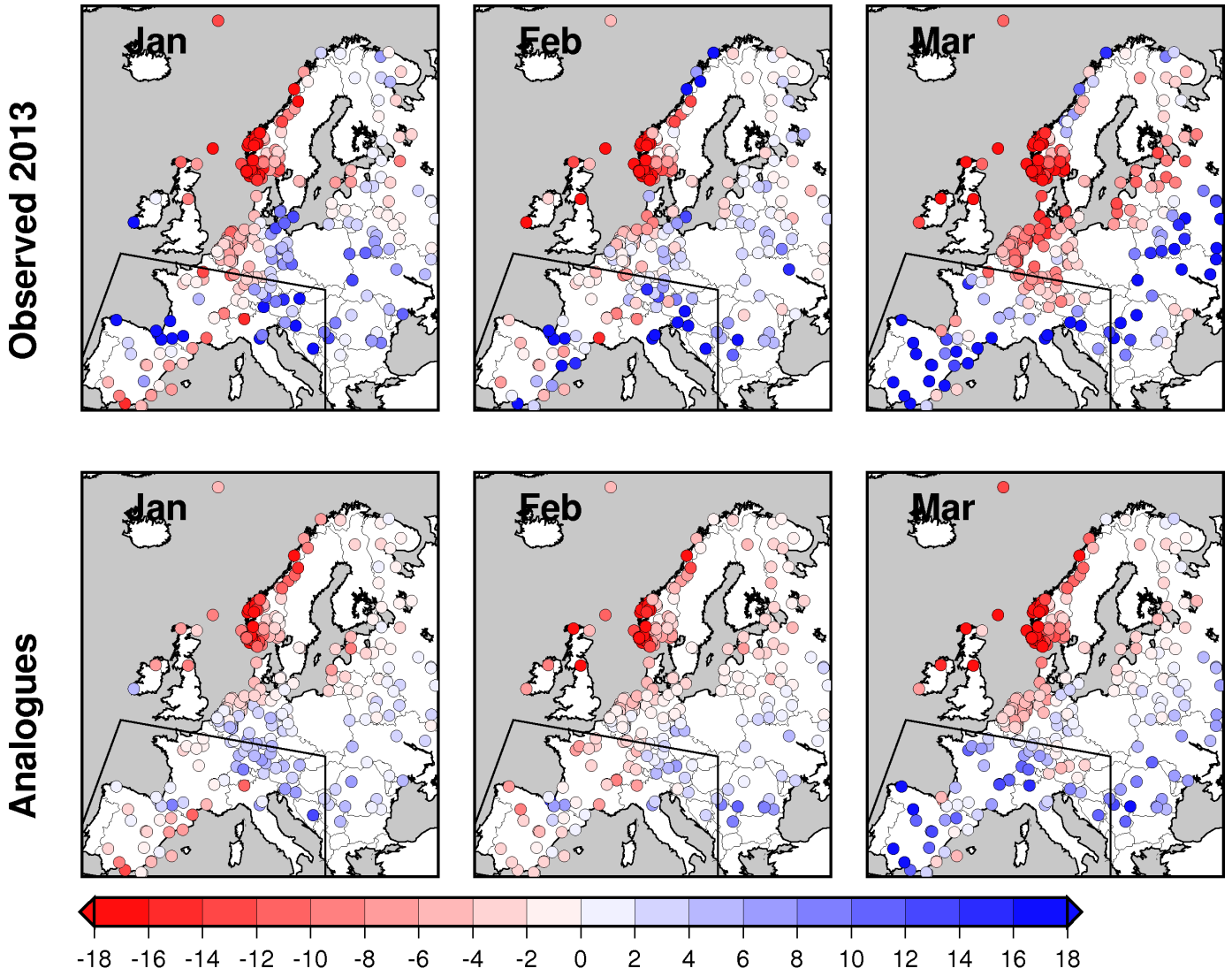
Example: Storm Dirk



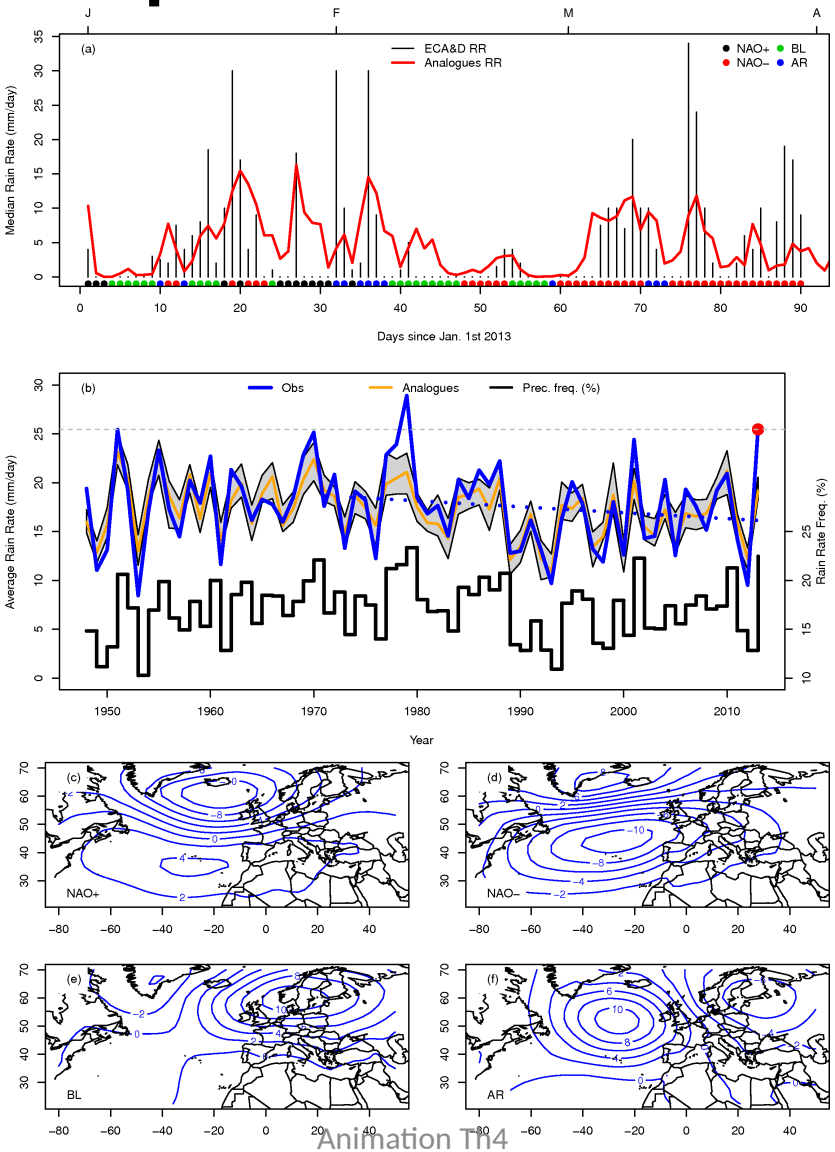
Meteorological analogues

- Average daily temperature (TN) anomaliesor precipitation (RR) over Europe
  - ECA&D database
- Compute the median temperature for 10 circulation analogue days
  - Analogue temperature or precipitation & spread of analogues

Example: Winter 2013



Example: Winter 2013



Conclusion & Perspectives

- Flexible approach to investigate the likelihood of some extreme events from atmospheric variability
  - Special issues of the BAMS (2012, 2013, 2014)
- Analysis of the probability of “black swans” (i.e. events with no analogues in the past)
- Simulation of catalogues of extreme events (e.g. storms):
  - 1000 samples out of 30 years of observations

ESTIMR Project Mapping

- D&A, assessment of extremes in Europe in continuous time
  - Copernicus
- Methodologies to analyze rare events, last 1k, future, Europe, America, Asia
  - ERC
- Extremes in France, past 1k, future, present
  - Fr. Min. Envir.

X-treme scope

LSCE

A2C2
Atmospheric flow Analogues for Climate Change

Thank you