

Assessing regional and global variability from oceanographic time series

Susana Barbosa

INESC TEC, Porto, Portugal

Overview

Background

Data analysis concepts

Oceanographic variability - examples

Field measurements

Concluding remarks

Overview

Background

Data analysis concepts

Oceanographic variability - examples

Field measurements

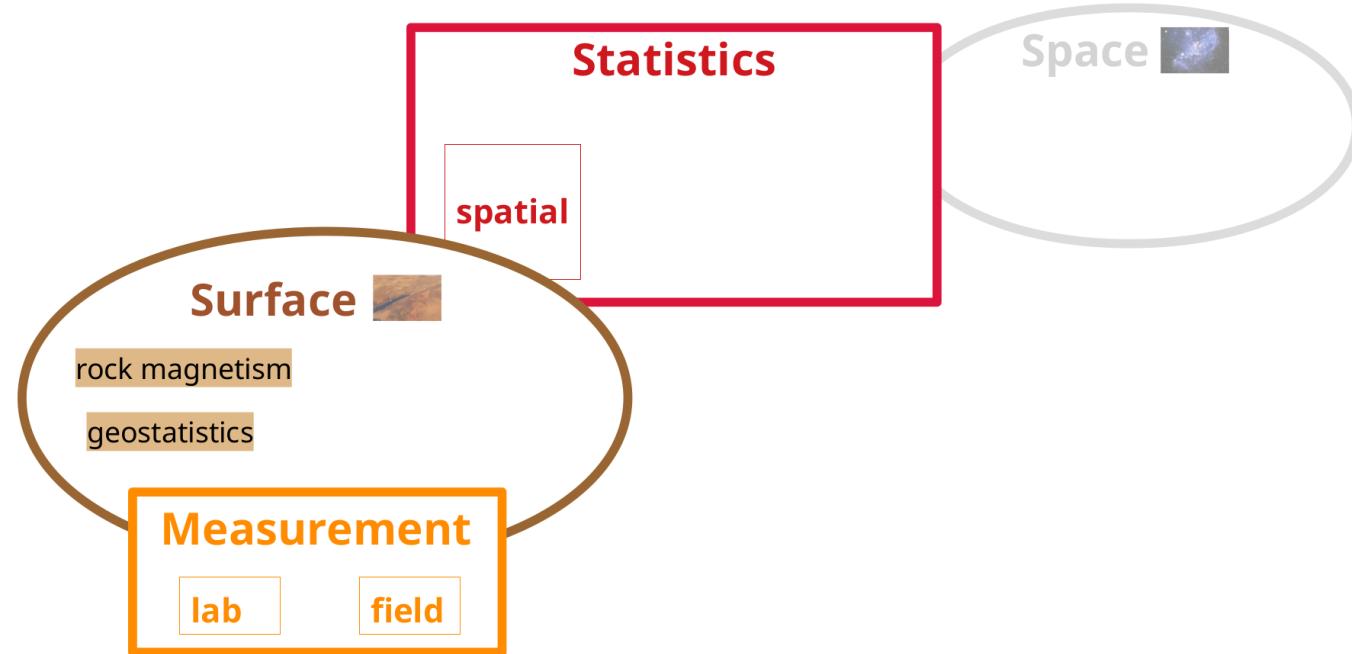
Concluding remarks

Background



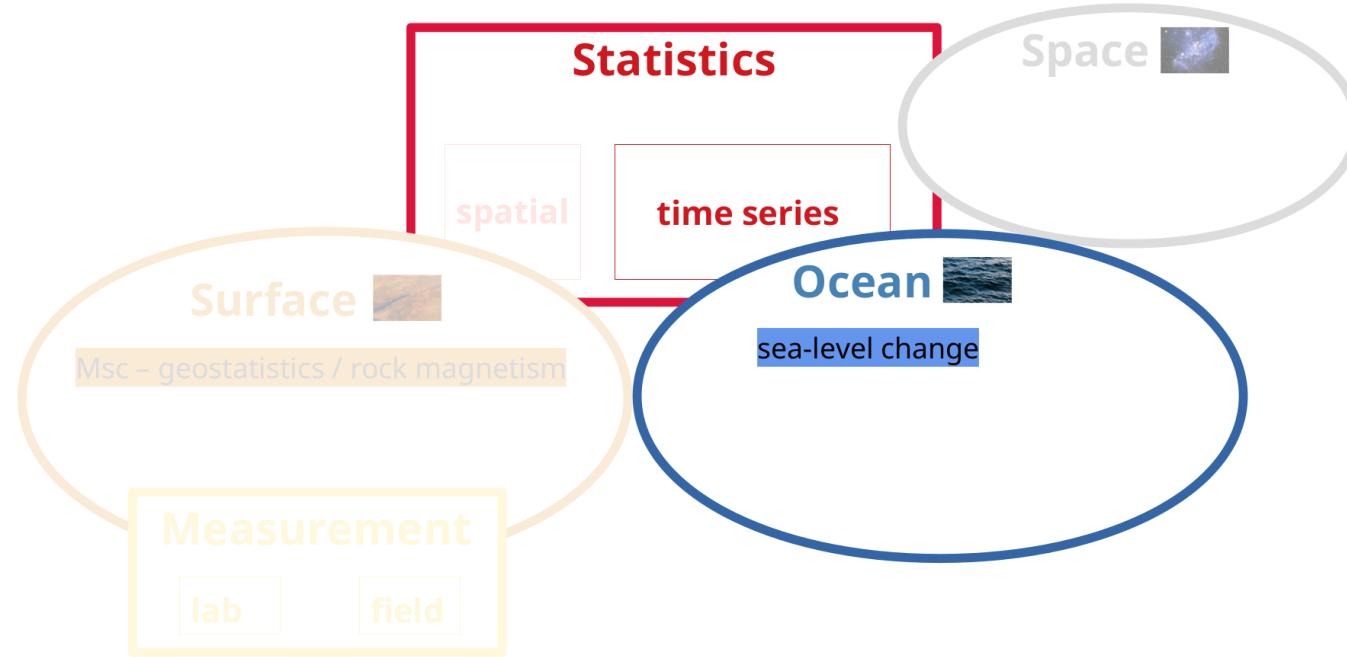
1st degree: Astronomy (physics / applied mathematics) [FCUP, 1998]

Background



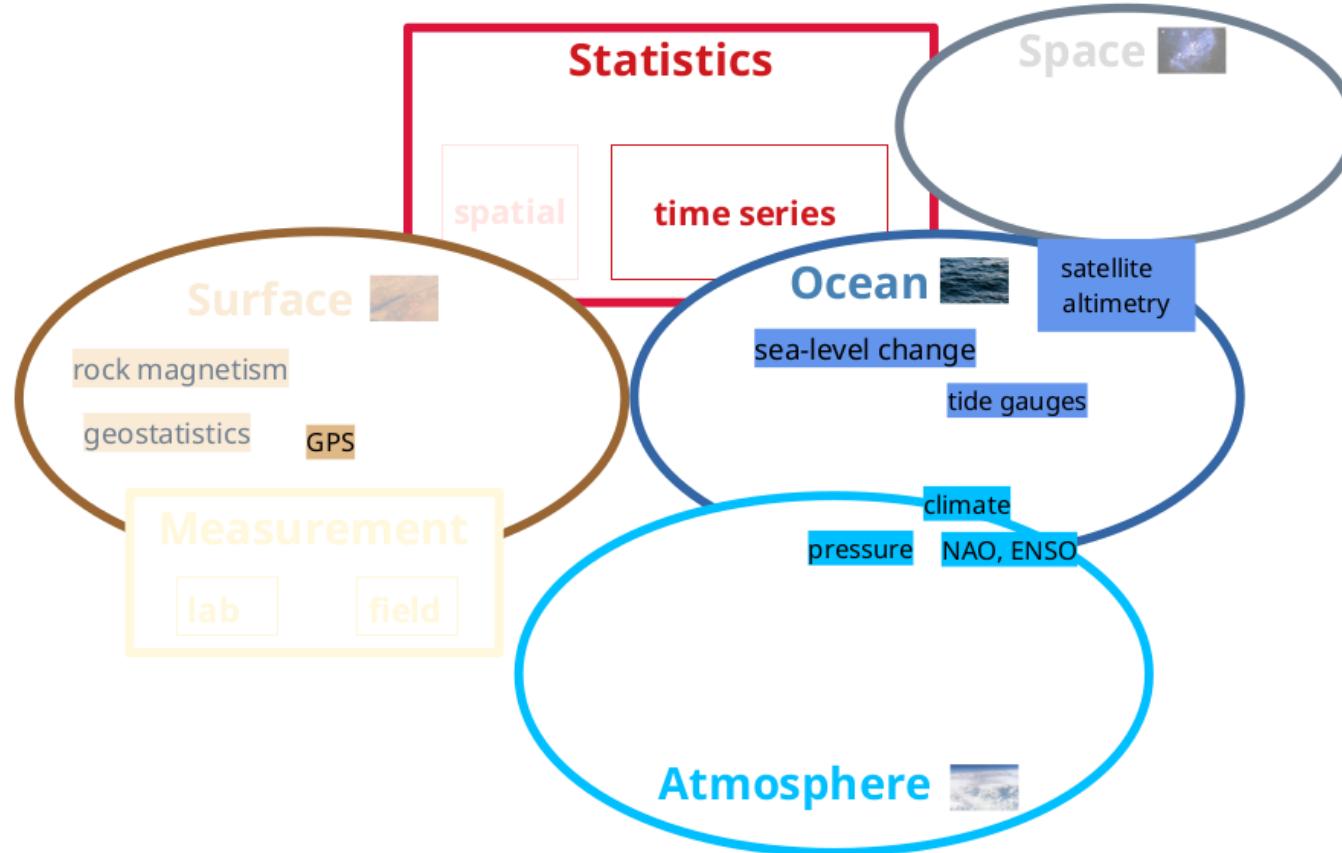
MSc: Geostatistical study of magnetic susceptibility data from Monchique complex [FEUP, 2000]

Background



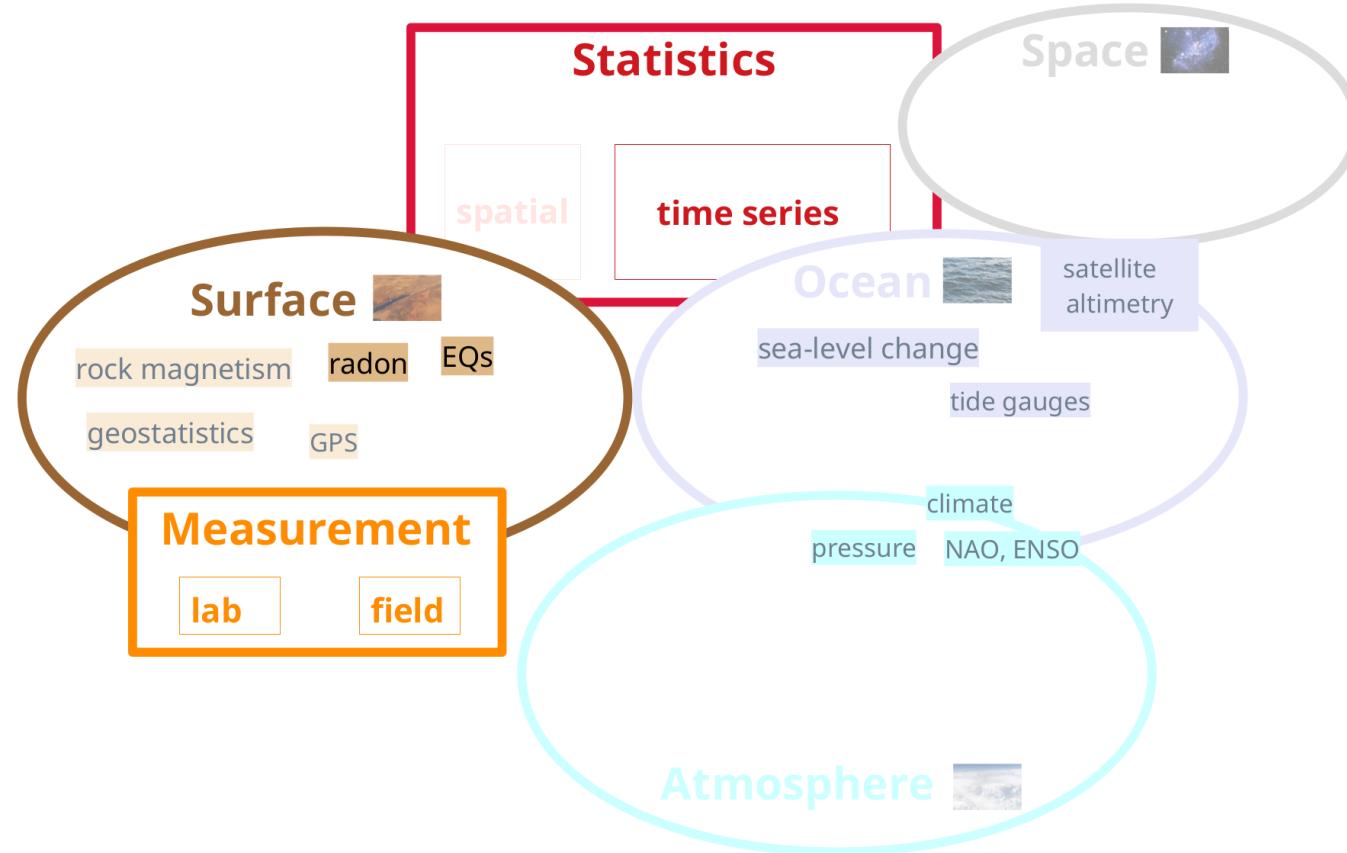
PhD: sea-level change in the NE Atlantic (satellite altimetry + tide gauges) [FCUP, 2006]

Background



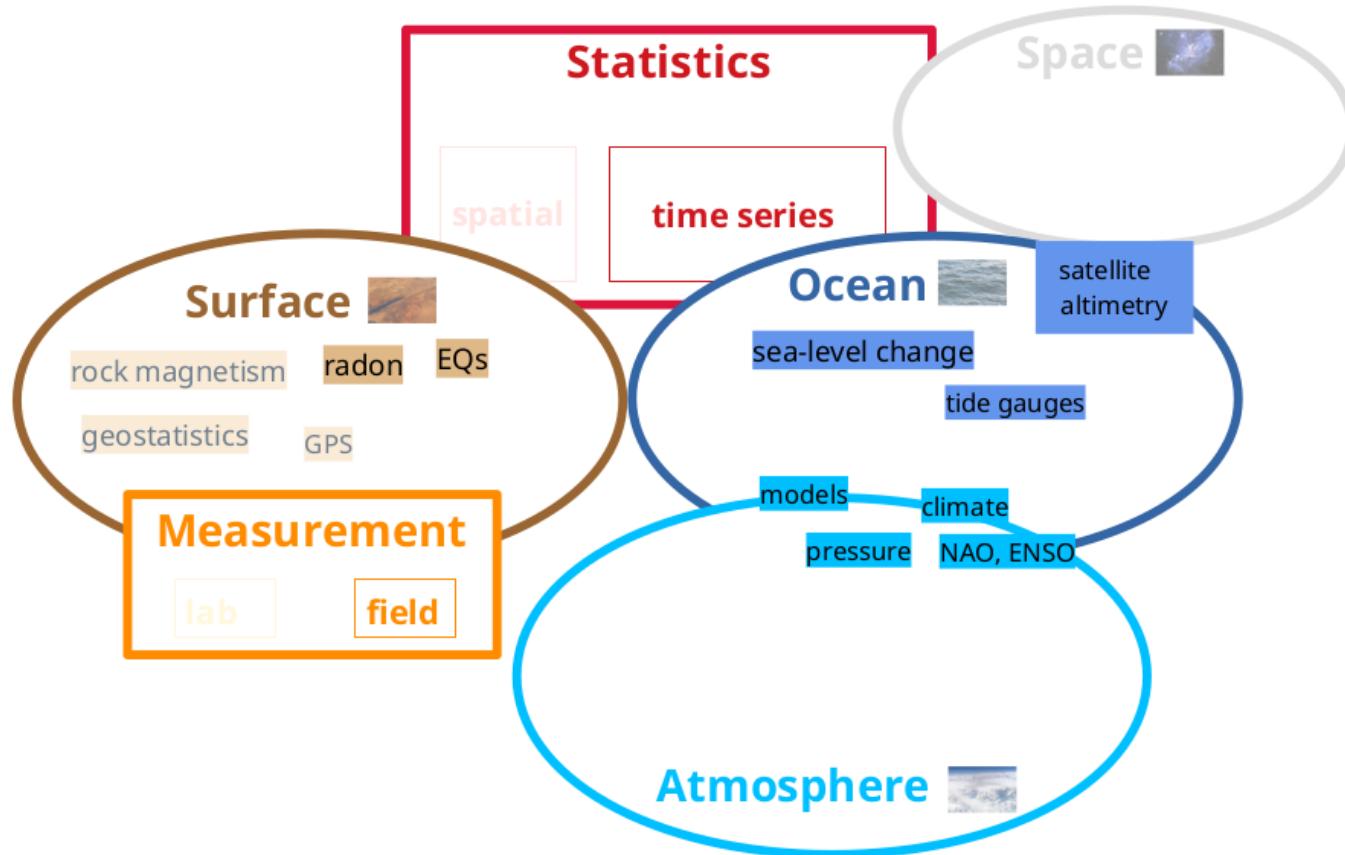
PhD: sea-level change in the NE Atlantic (satellite altimetry + tide gauges)[FCUP, 2006]

Background



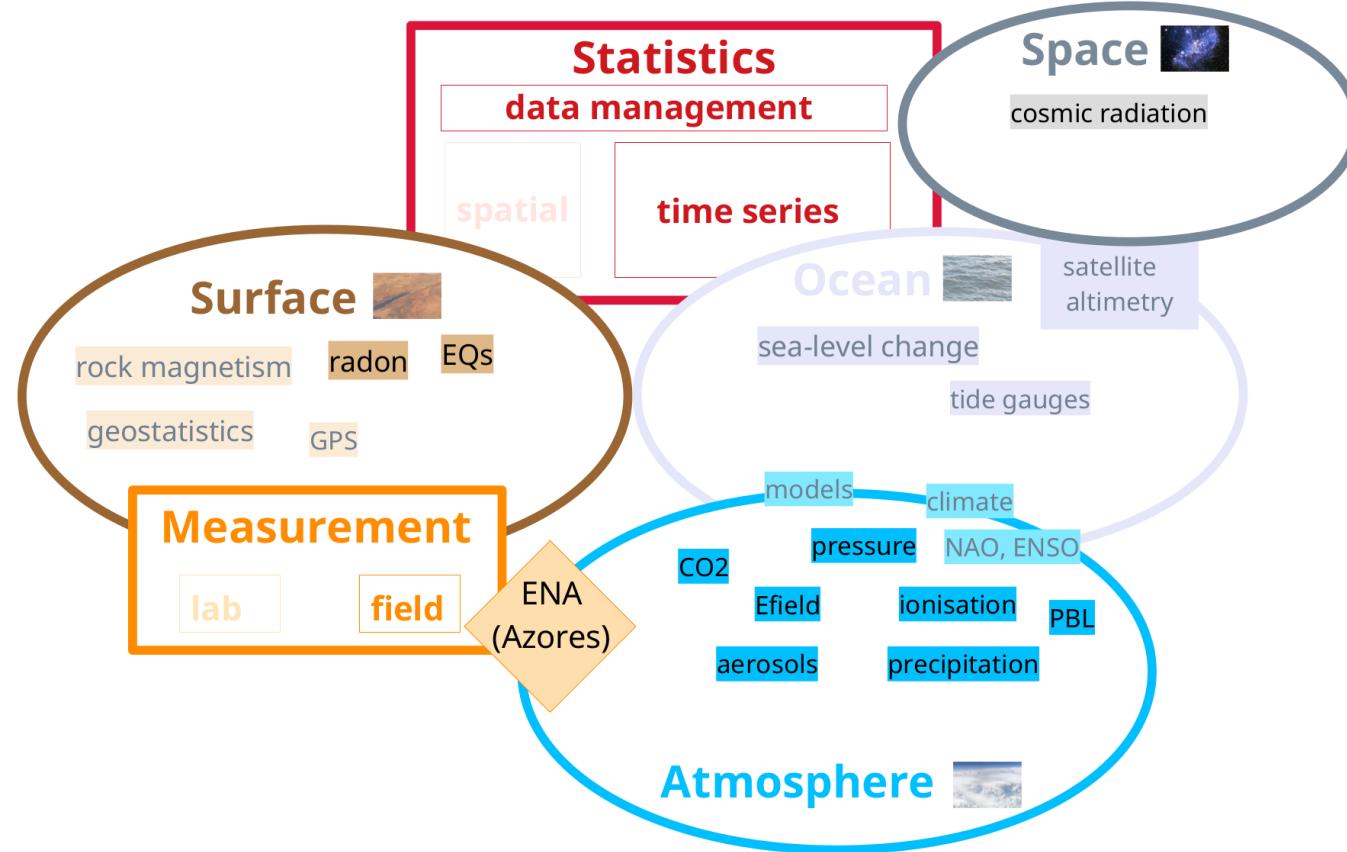
Postdoc: radon / environmental radioactivity [DTU/GSI, 2007-2009]

Background



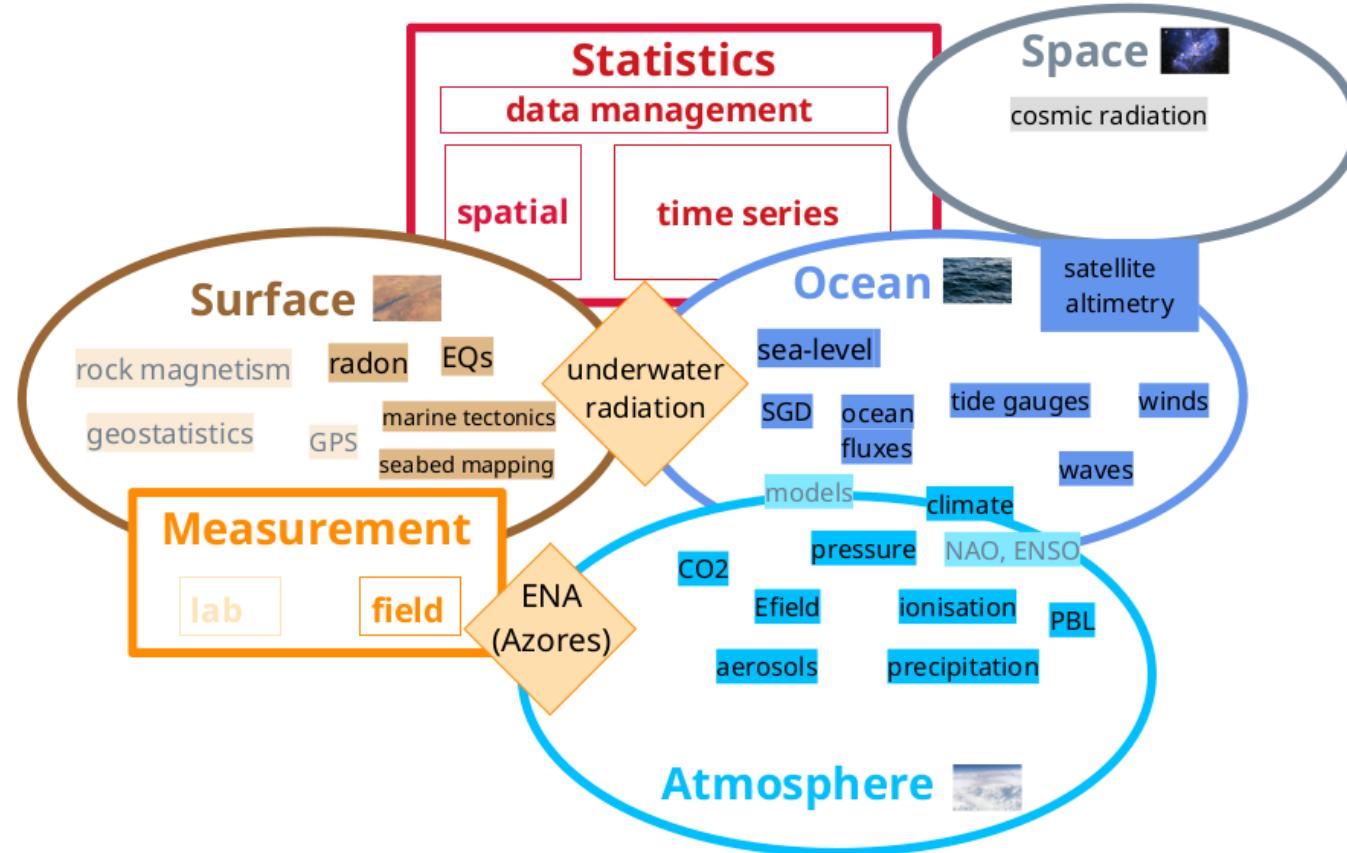
Senior researcher - IDL (University of Lisbon) [2009-2014]

Background



Senior researcher – INESC TEC (Porto) – space-atmosphere-surface interactions [2015-]

Background



Senior researcher – INESC TEC (Porto) – space-atmosphere-surface-hydrosphere

Overview

Background

Data analysis concepts

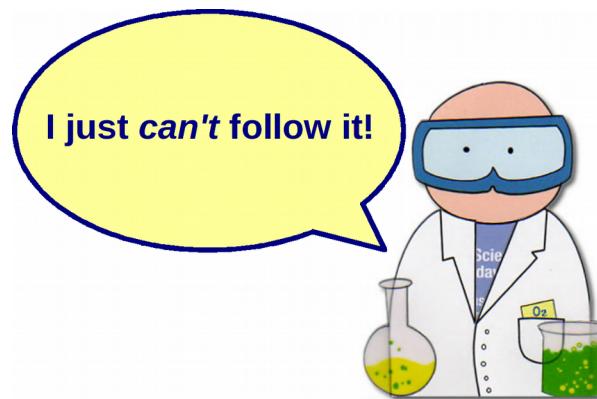
Oceanographic variability - examples

Field measurements

Concluding remarks

Data analysis concepts

Bad excuses NOT to use statistics...



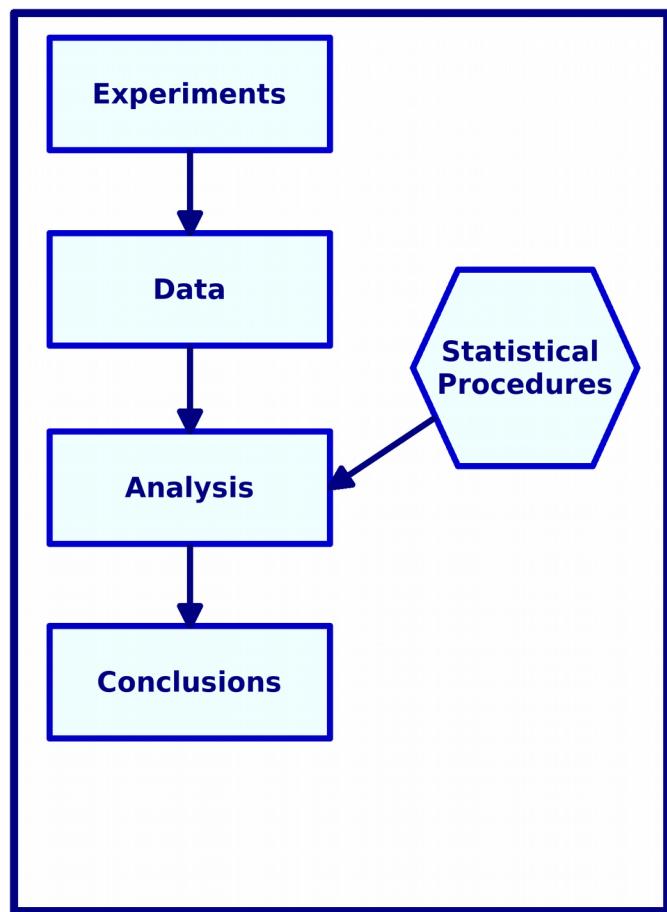
Data analysis concepts

Bad excuses to use statistics...



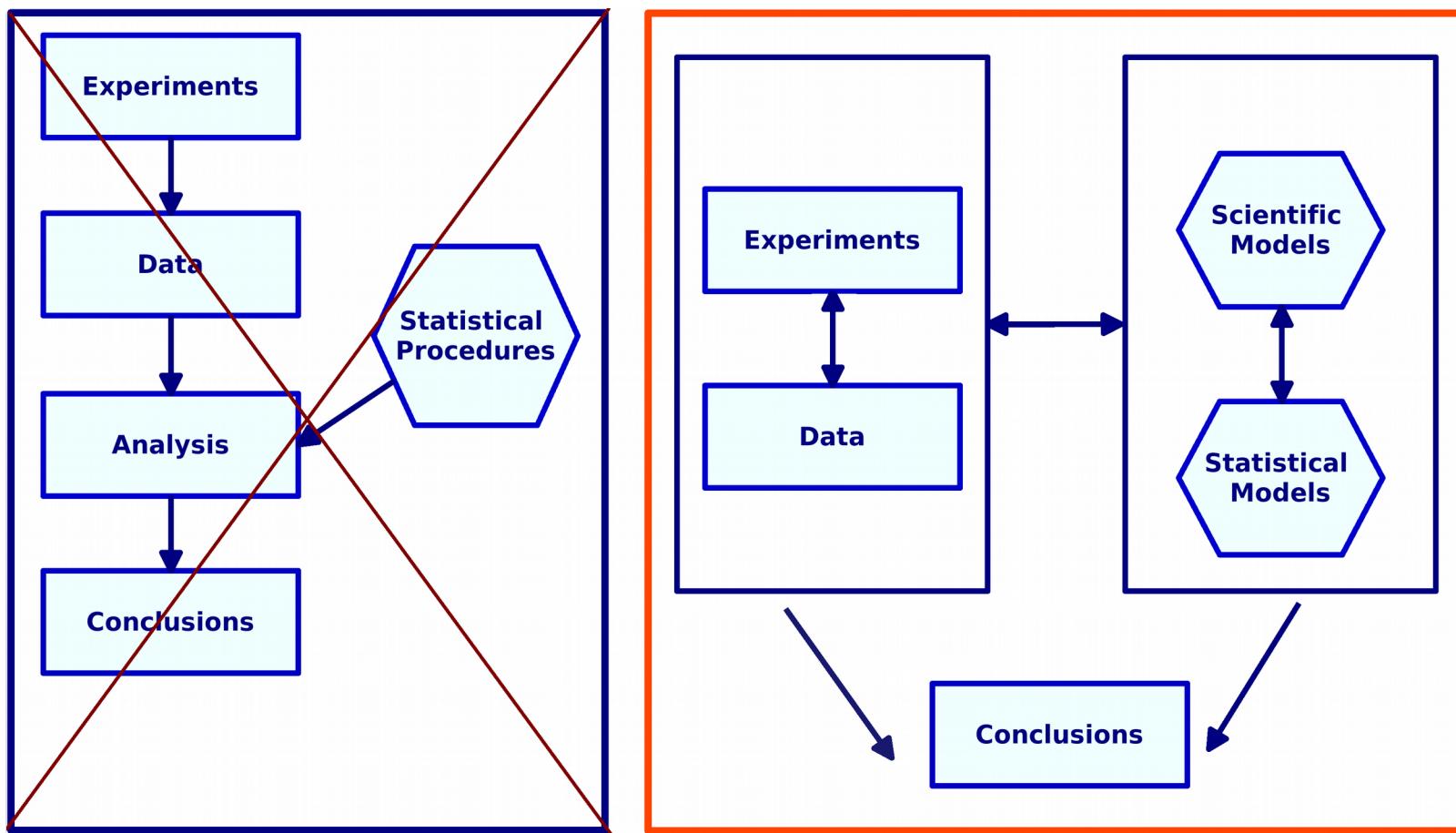
Data analysis concepts

"Statistics is a way to get information from data. That's it!" [G. Keller]



Data analysis concepts

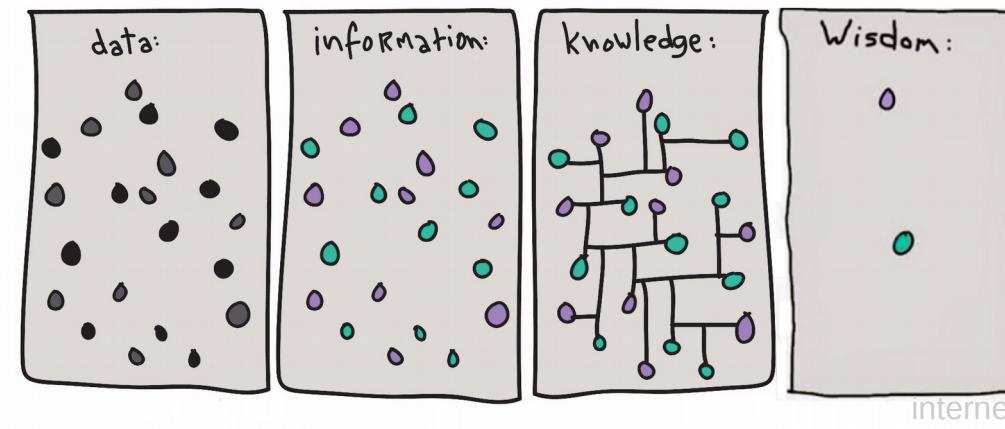
"Statistics is a way to get information from data. That's it!" [G. Keller]



Data analysis concepts

"Statistics is a way to get information from data. That's it!" [G. Keller]

... from data to information... **CONTEXT**



Analysis of a problem

instead of

Analysis of data

Overview

Background

Data analysis concepts

Oceanographic variability - examples

Field measurements

Concluding remarks

Oceanographic variability - examples

Example I - multi-scale behavior & correlation

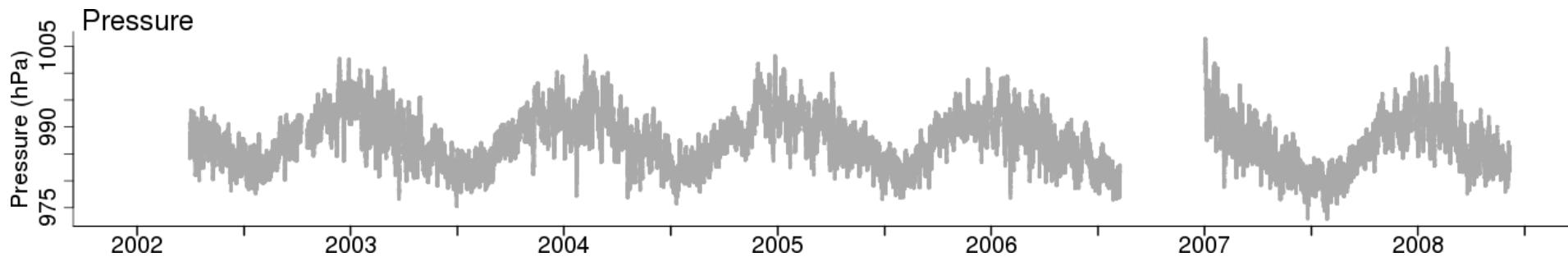
Example II - trends

Example III - seasonality

Multi-scale behavior & correlation

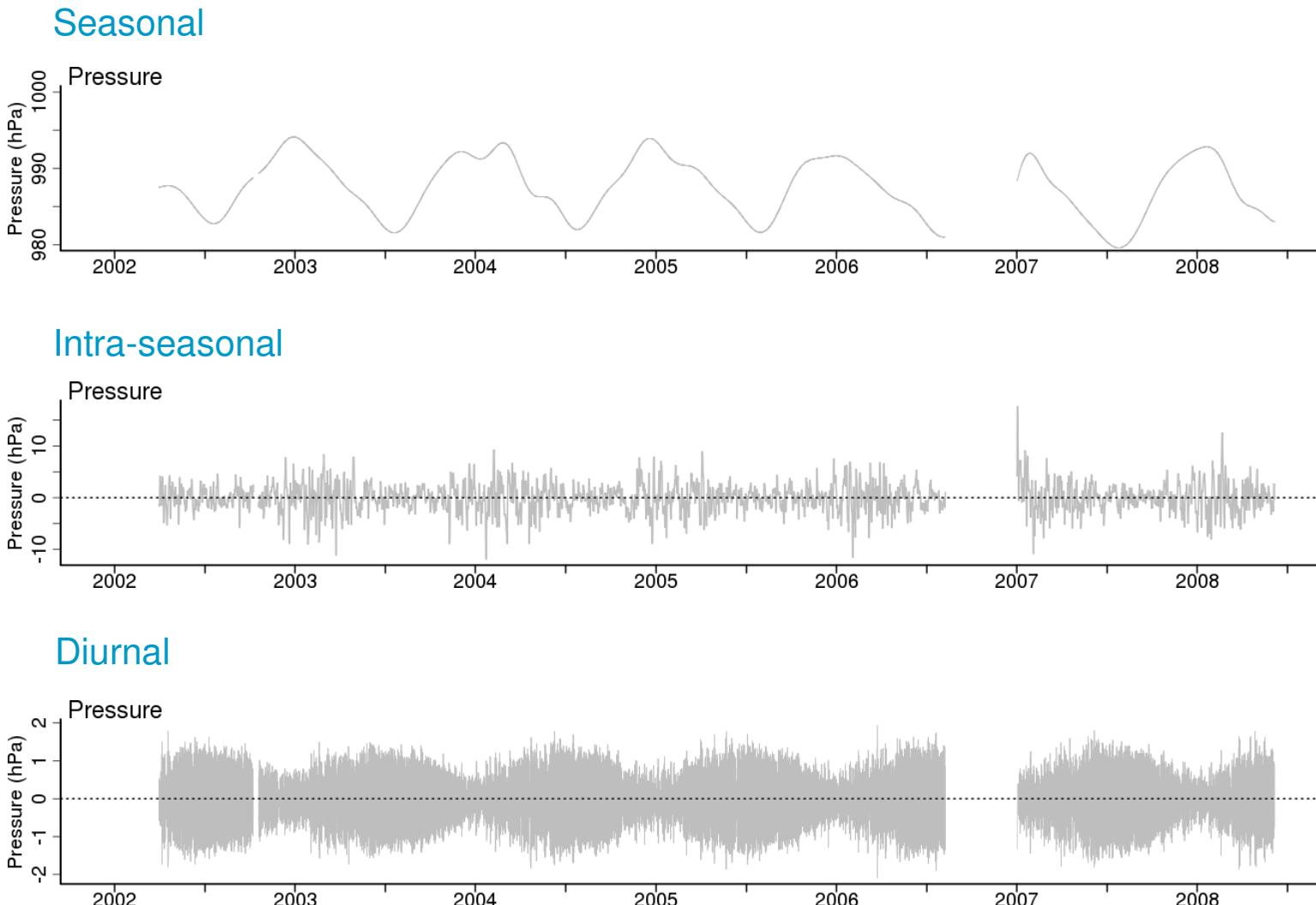
“Recent” problem → computer’s driven: meteorological vs climatological perspectives

Example – daily atmospheric pressure



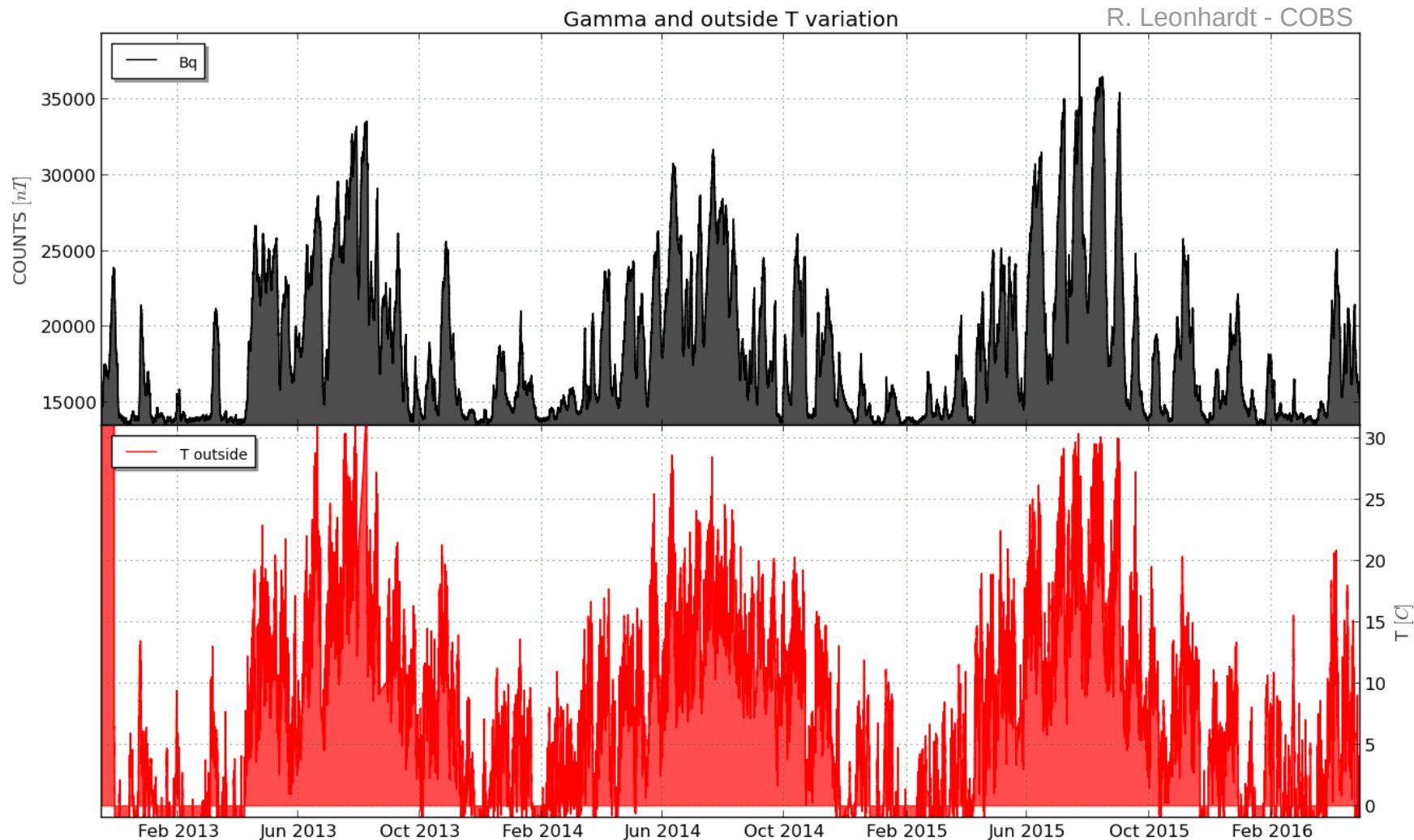
Multi-scale behavior & correlation

Example – daily atmospheric pressure



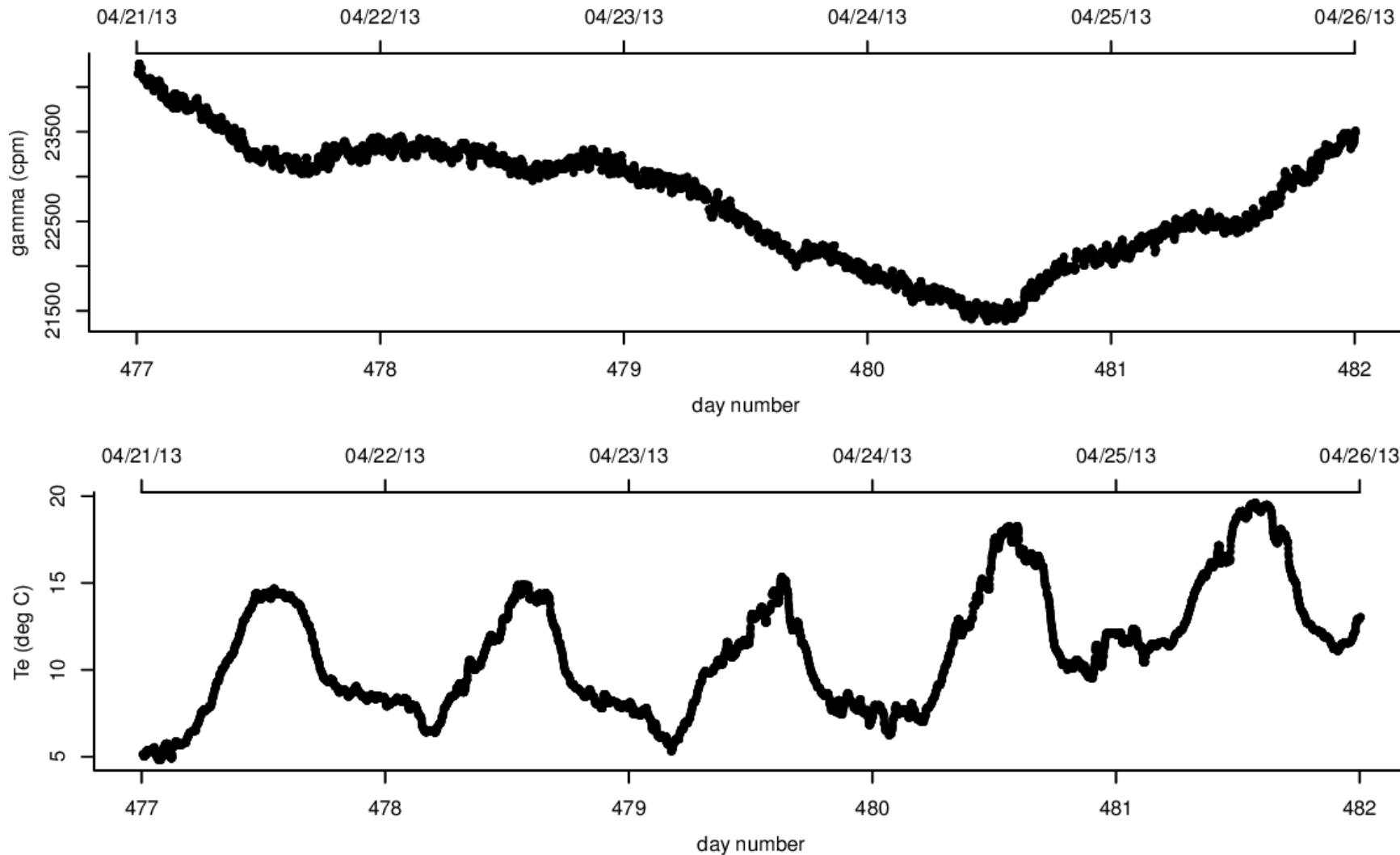
Multi-scale behavior & correlation

Example – gamma radiation & temperature



Multi-scale behavior & correlation

Example – gamma radiation & temperature

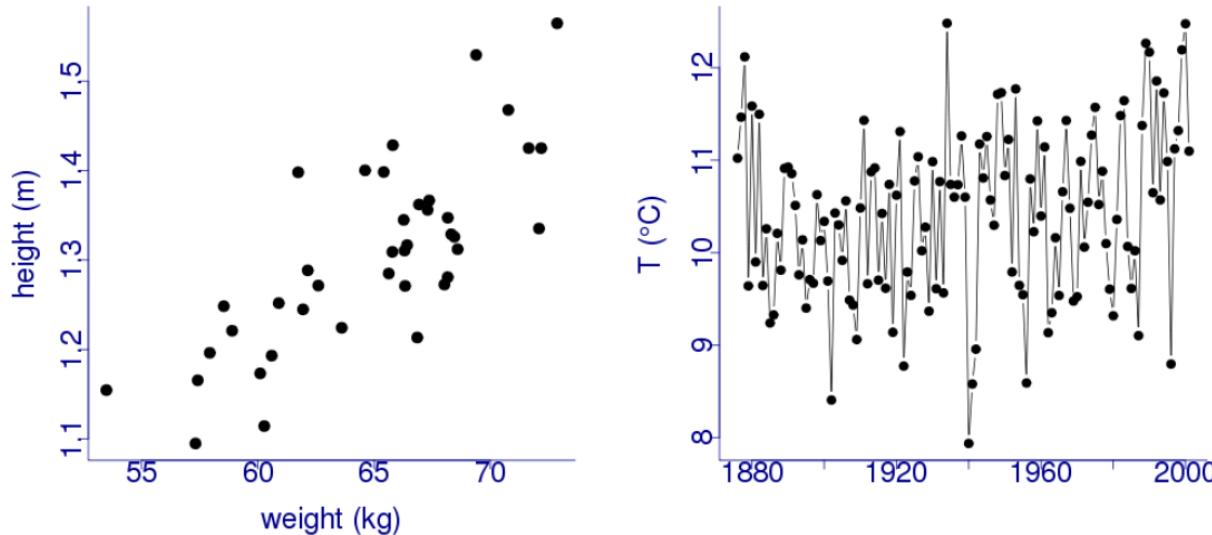


Multi-scale behavior & correlation

The correlation issue in time series

It is fairly familiar knowledge that we sometimes obtain between quantities varying with the time (time-variables) quite high correlations to which we cannot attach any physical significance whatever, although under the ordinary test the correlation would be held to be certainly "significant". [Yule, 1925, address to the Royal Statistical Society]

independent vs time series (dependent data)



The causality fallacy

...fireworks always scare the dragon and save the moon...



Oceanographic variability - examples

Example I - multi-scale behavior & correlation

Example II - trends

Example III - seasonality

Trends

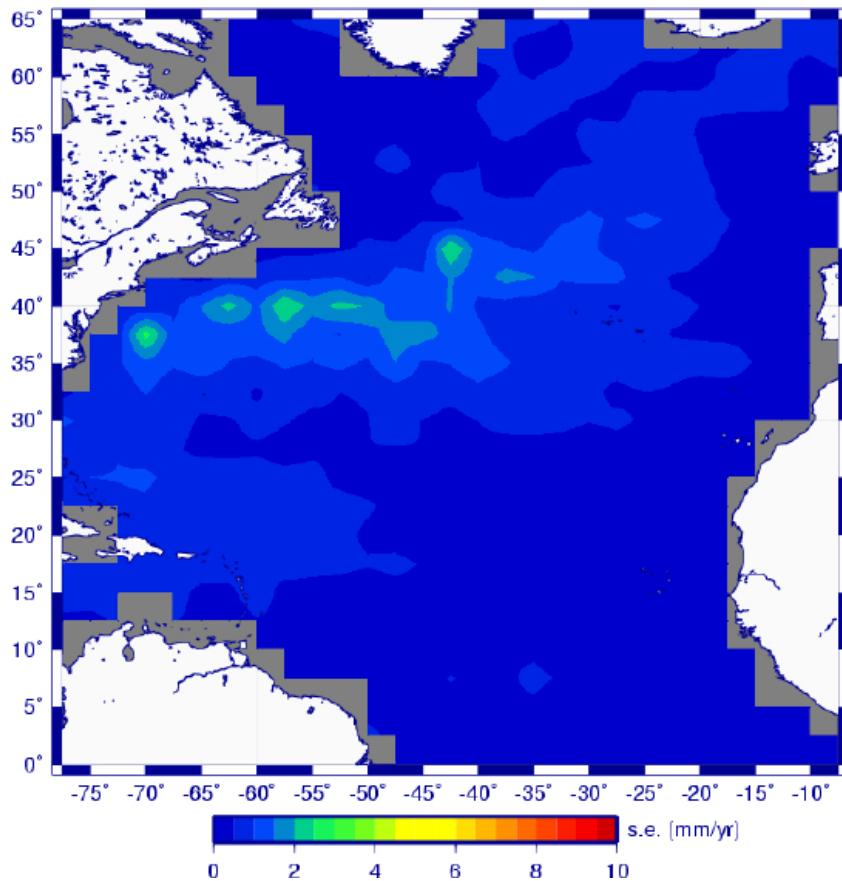
Two different issues:

- estimation of linear trends
 - * trends in the mean
 - * trends in other quantiles
- interpretation of trends
 - * deterministic vs stochastic trends
 - * long-range dependence

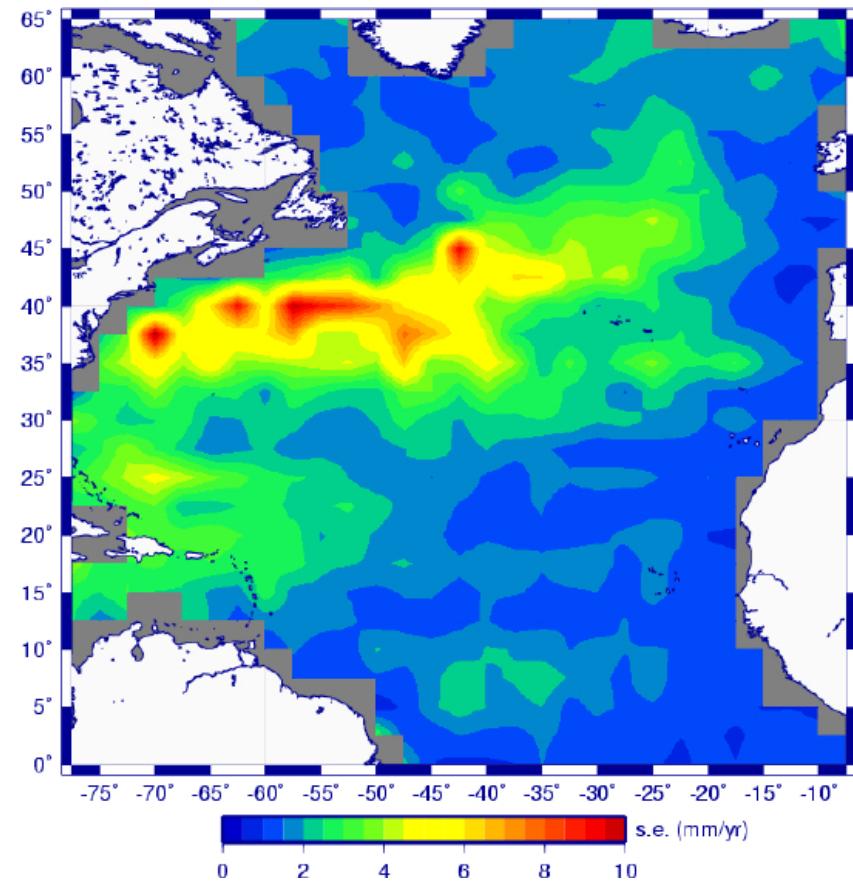
Trends – estimation (mean)

Example: North Atlantic sea-level - linear trend uncertainty*

* assuming independent data
(no serial dependence)

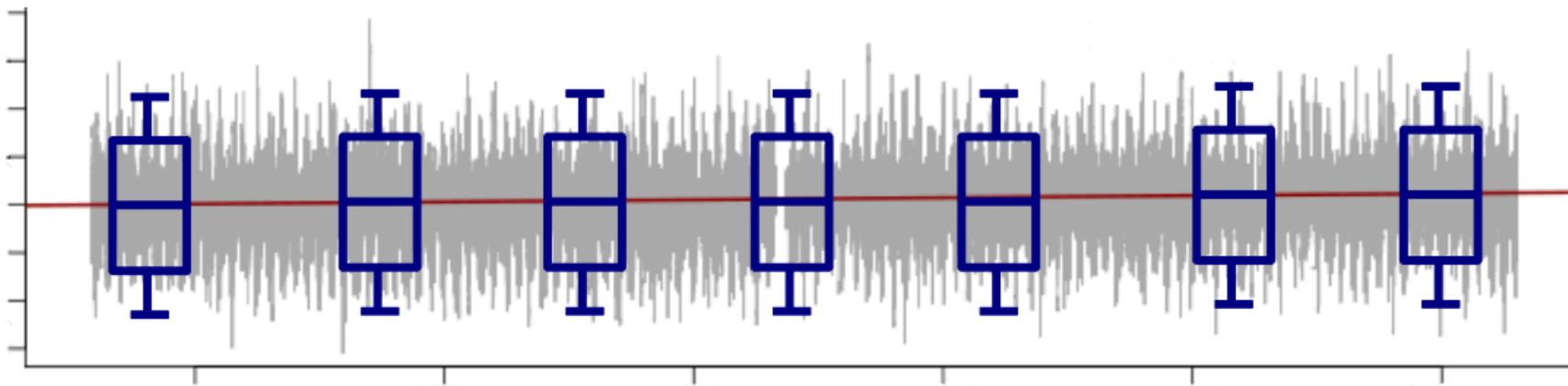


* assuming time series data
(AR(1) serial dependence)



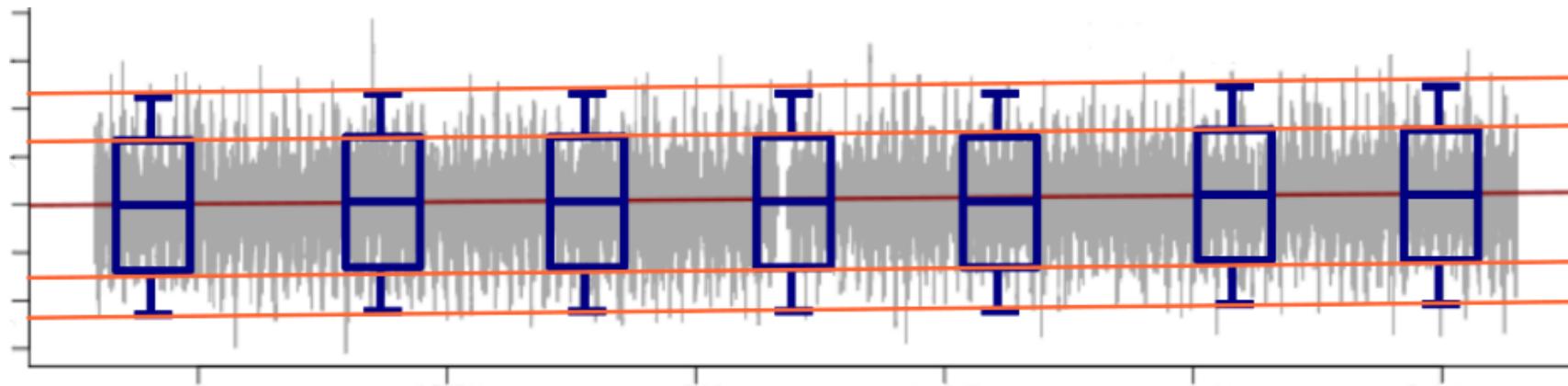
Trends – estimation (quantiles)

Linear regression assumption: normality, constant distribution



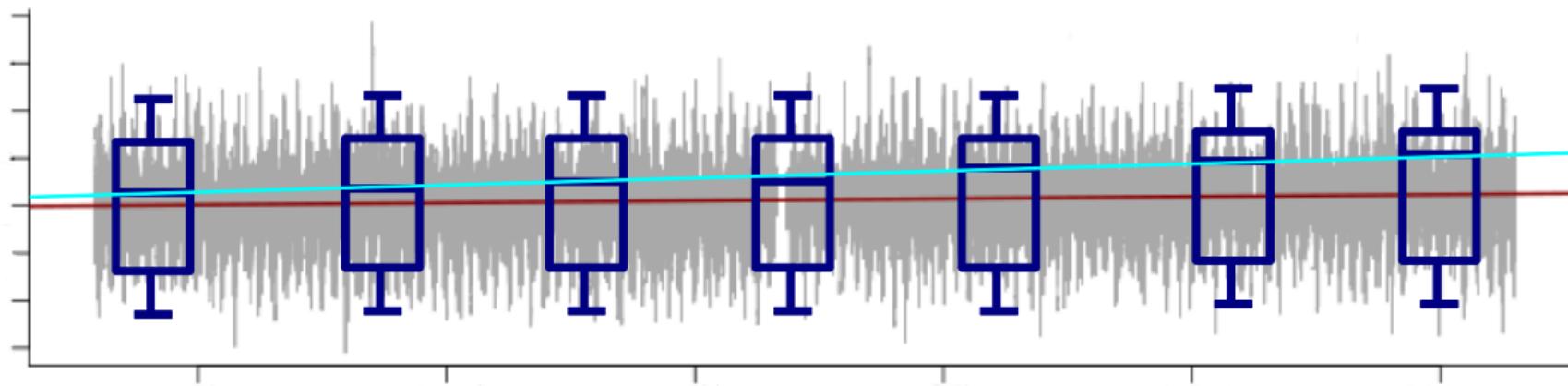
Trends – estimation (quantiles)

Linear regression assumption: normality, constant distribution



Trends – estimation (quantiles)

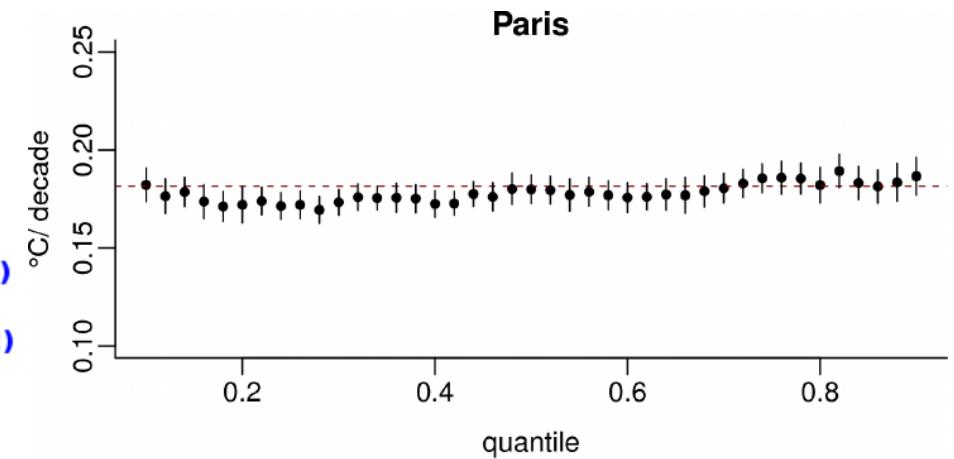
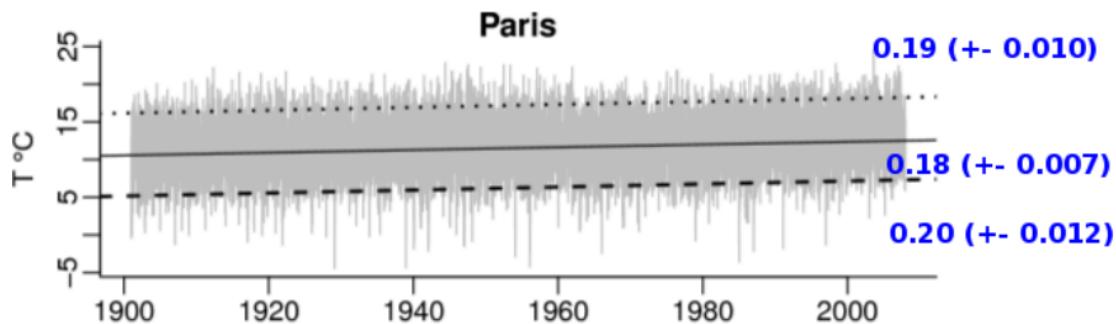
Linear regression assumption: normality, constant distribution



"Everyone believes in the [Gaussian] law of errors, the experimenters because they think it is a mathematical theorem, the mathematicians because they think it is an experimental fact" (H. Poincaré)

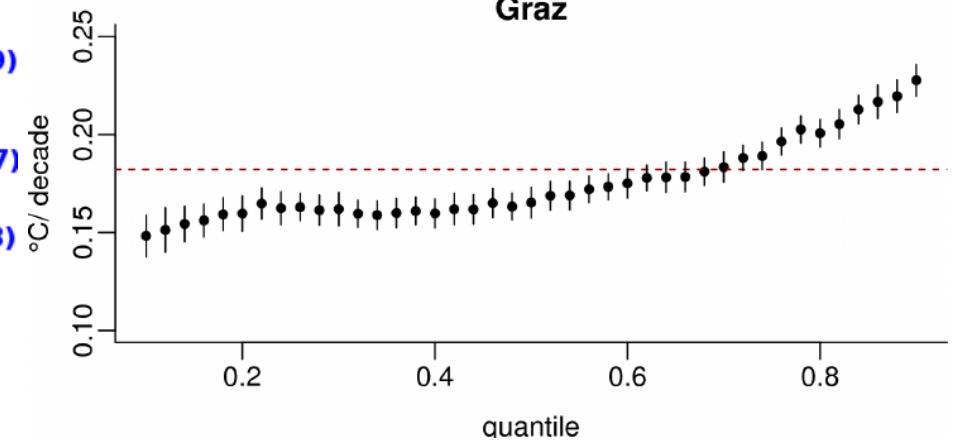
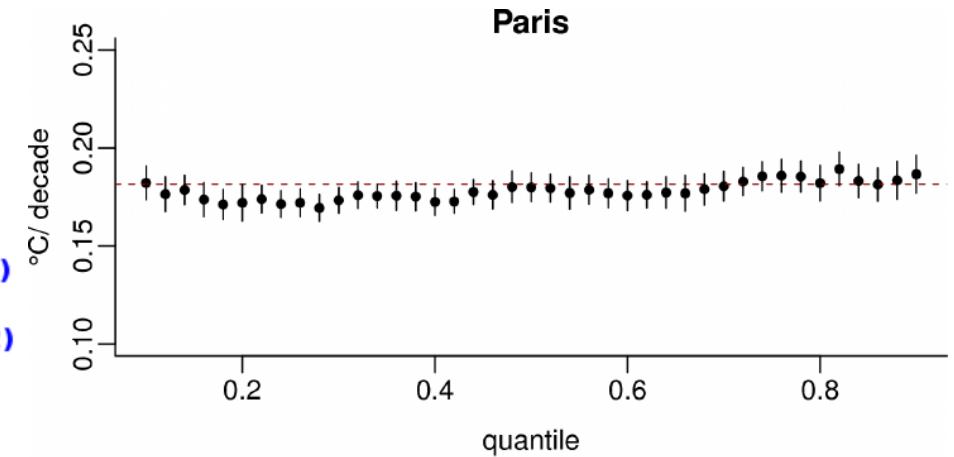
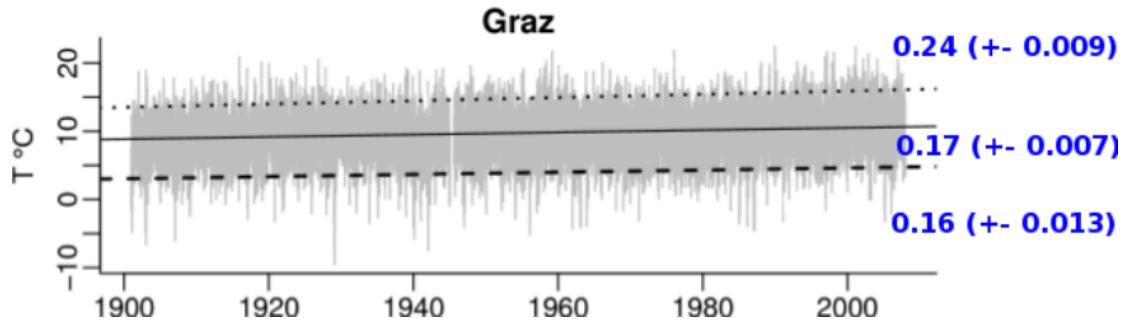
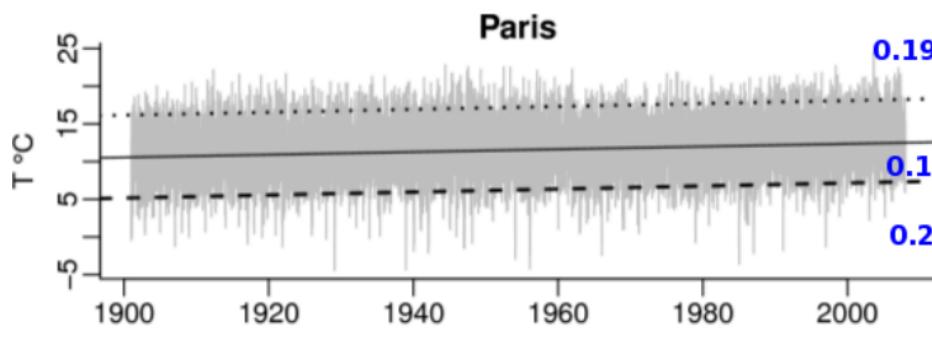
Trends – estimation (quantiles)

Example: air temperature



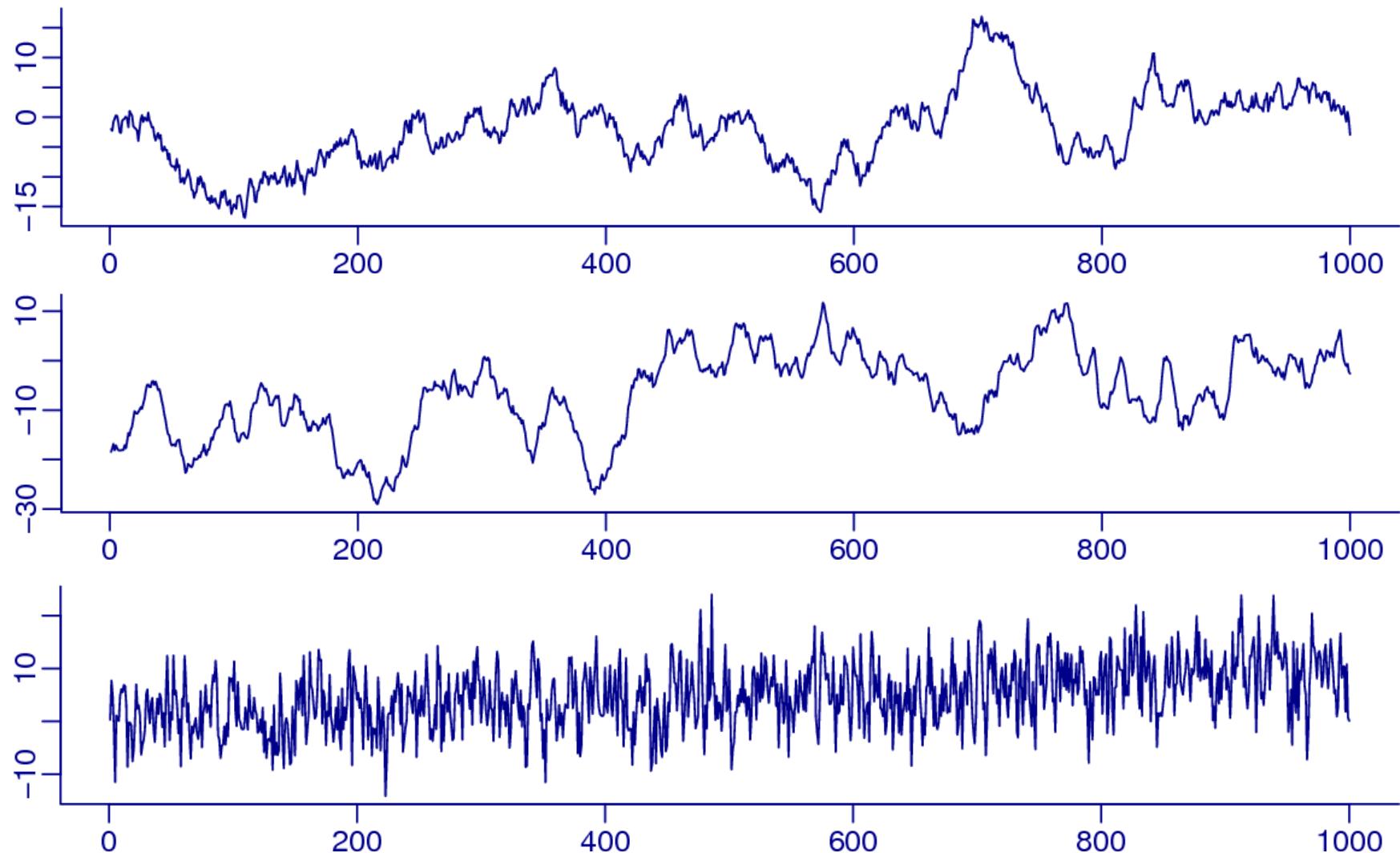
Trends – estimation (quantiles)

Example: air temperature



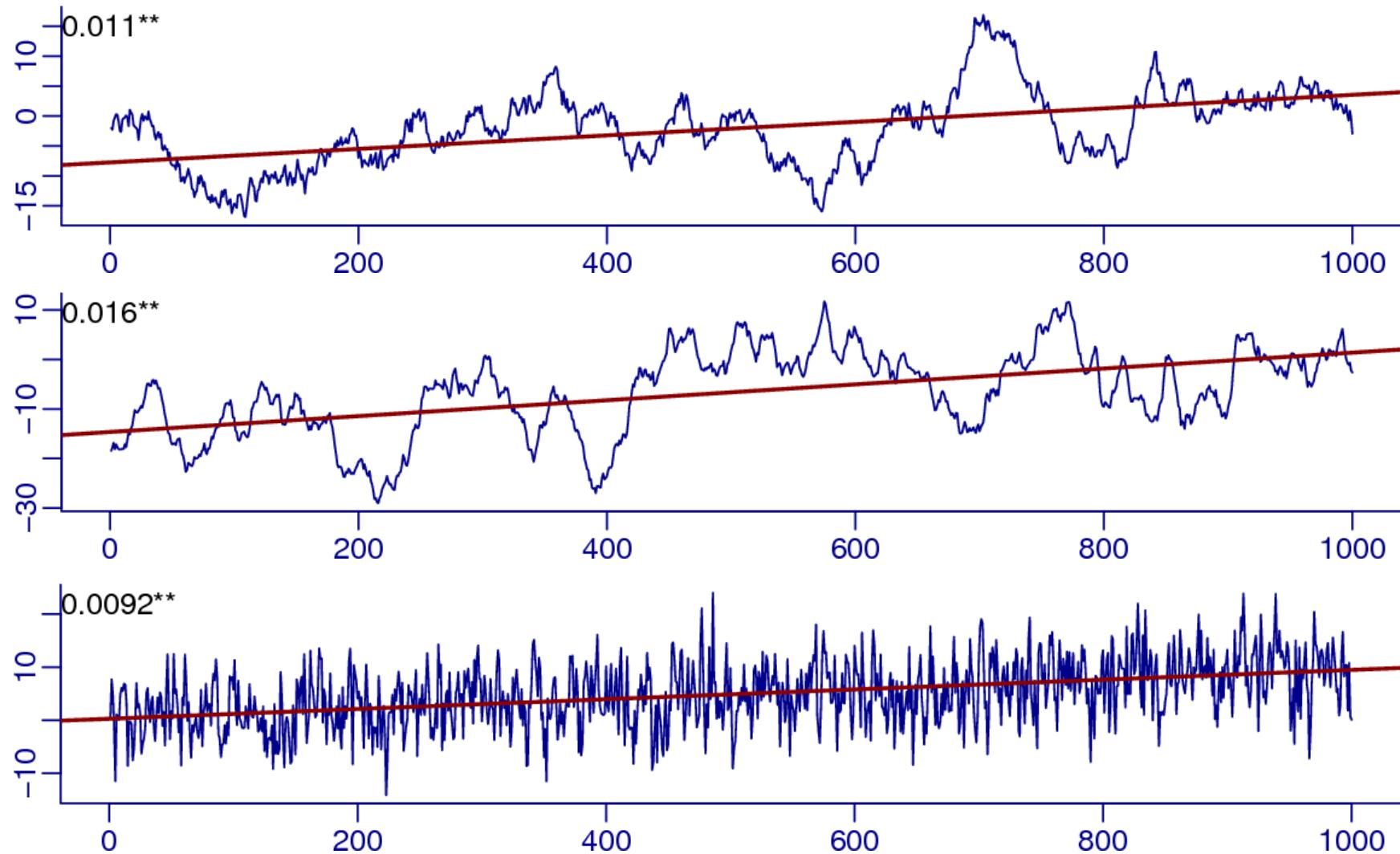
Trends – interpretation

Example: simulated time series



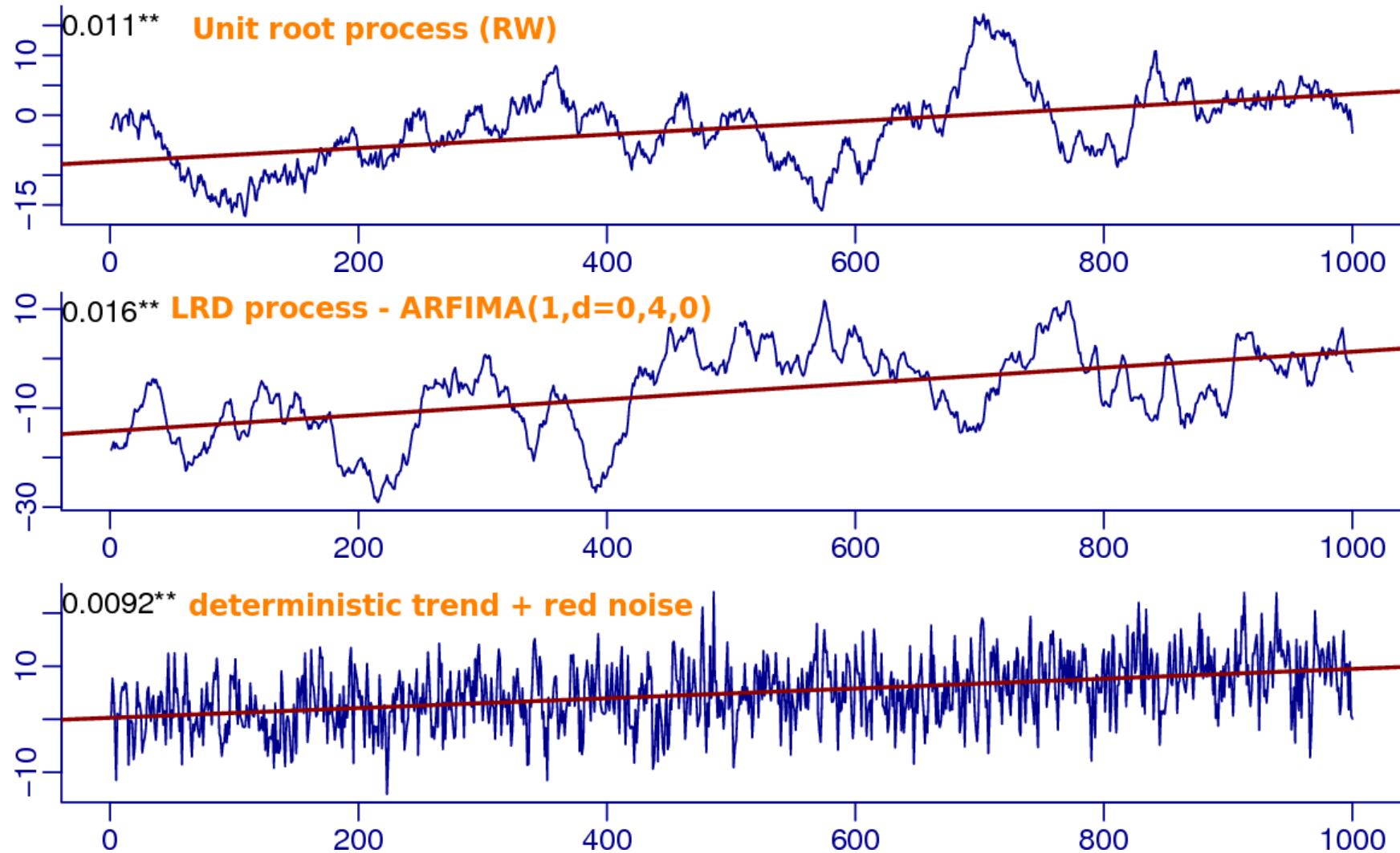
Trends – interpretation

Example: simulated time series



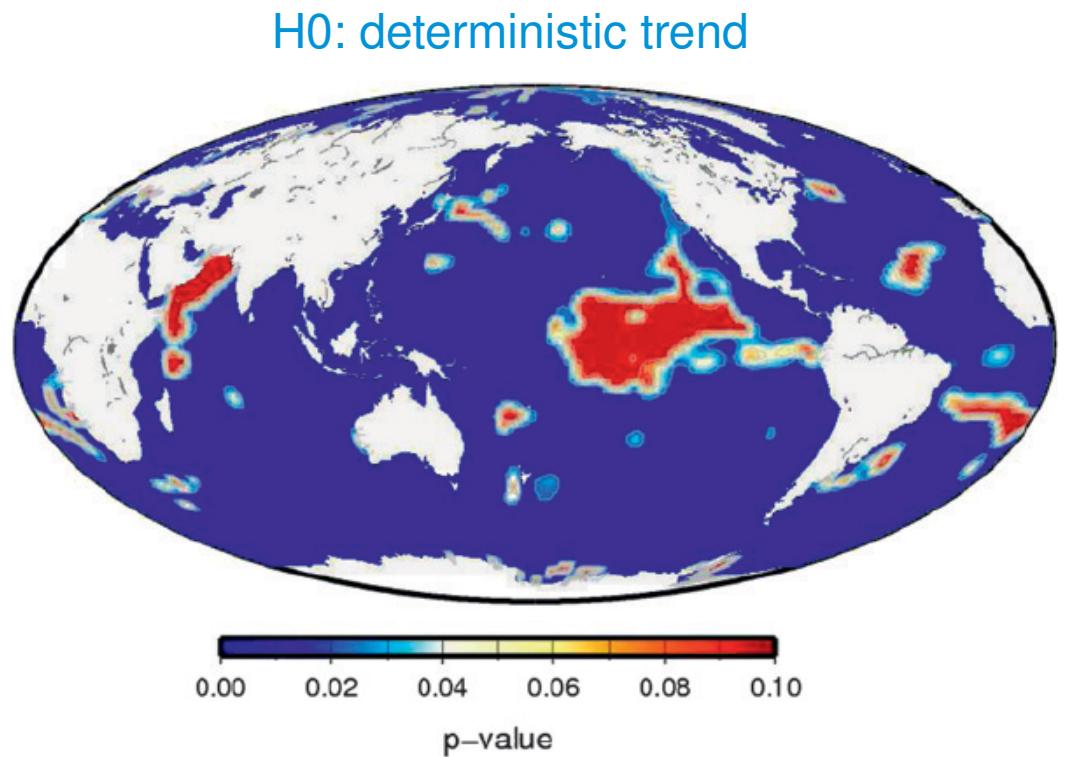
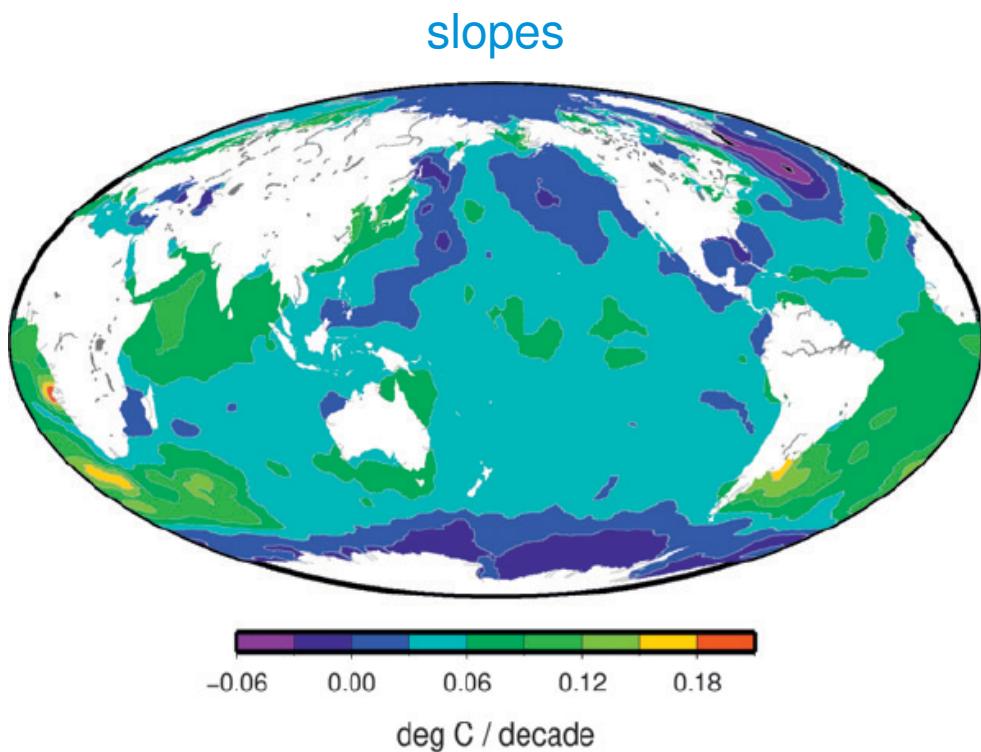
Trends – interpretation

Example: simulated time series



Trends – interpretation

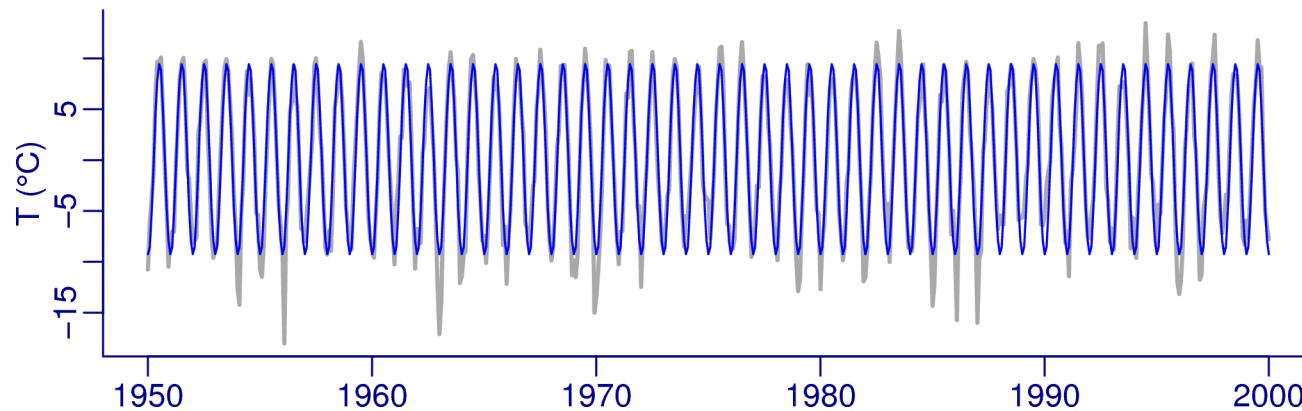
Example: SST (Sea Surface Temperature)



Seasonality

Classical perspective

- regular, constant
- uninteresting, “boring”
- needs to be removed to see “interesting things” in the data
- easy (to extract, model understand)



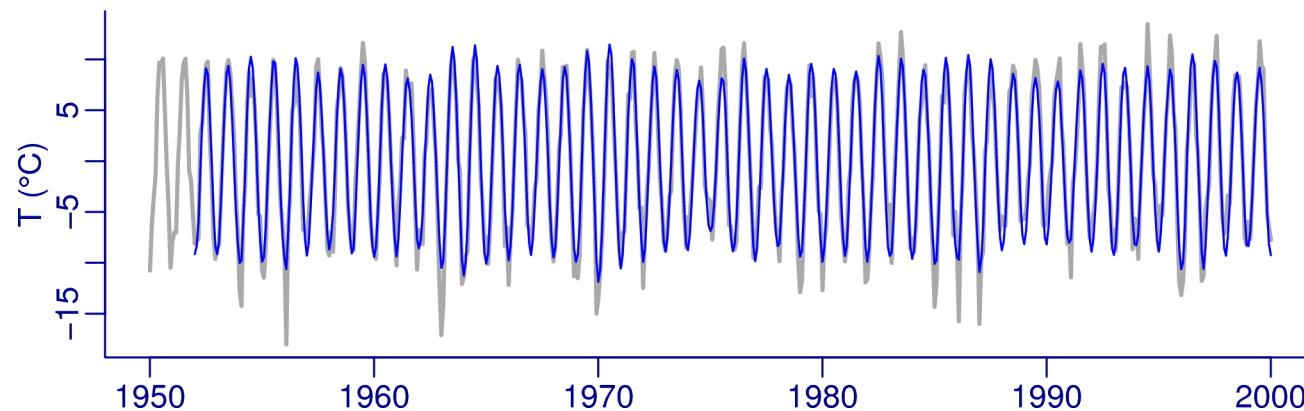
Seasonality

Classical perspective

- regular, constant
- uninteresting, “boring”
- needs to be removed to see “interesting things” in the data
- easy (to extract, model understand)

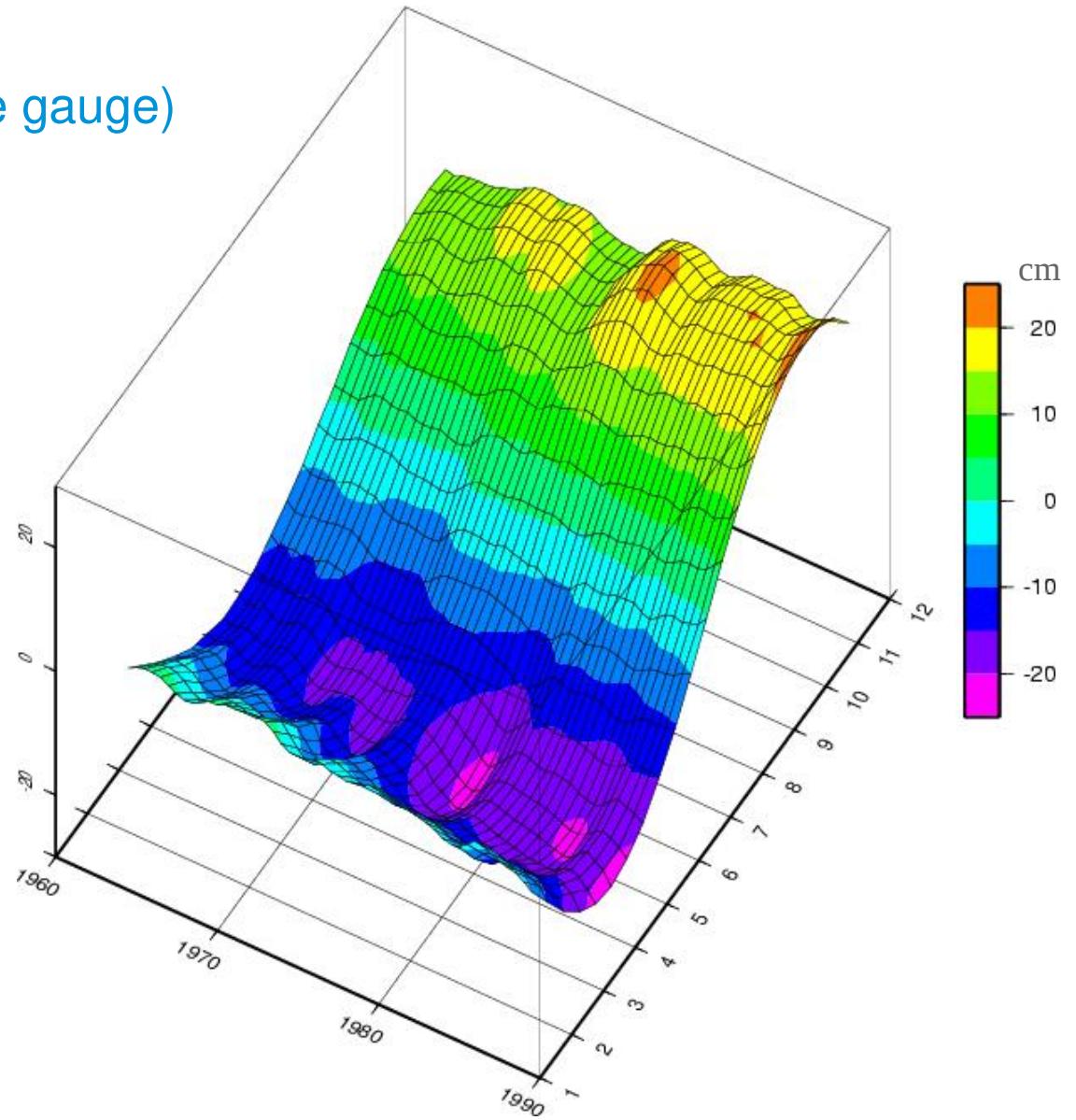
“Modern” perspective

- changing, non-constant
- interesting, relevant
- needs to be described, quantified, predicted
- difficult (to extract, model understand)



Seasonality

Example – sea-level (Cascais tide gauge)



Overview

Background

Data analysis concepts

Oceanographic variability - examples

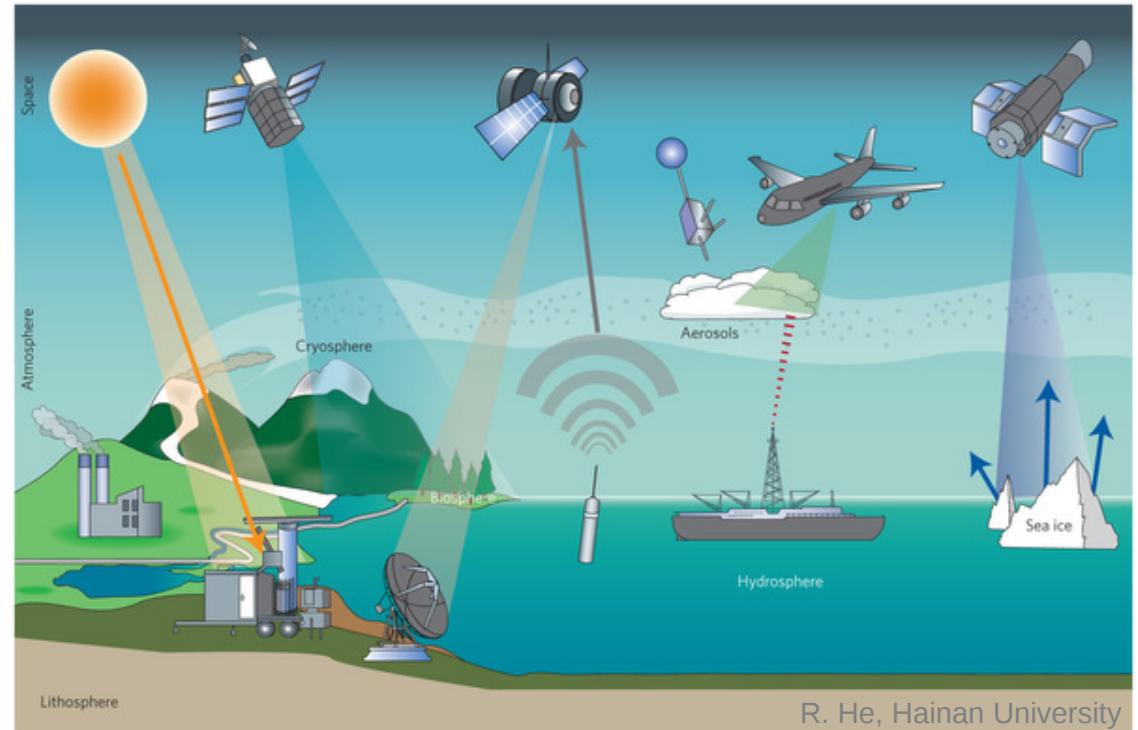
Field measurements

Concluding remarks

Notes on field measurements



human-intensive, analogic, daily (or +)
single-site, single-domain



digital, high-resolution (sub-hourly)
multi-site, multi-variable, multi-domain

Notes on field measurements

progress in scientific understanding << technology



Radon & gamma radiation

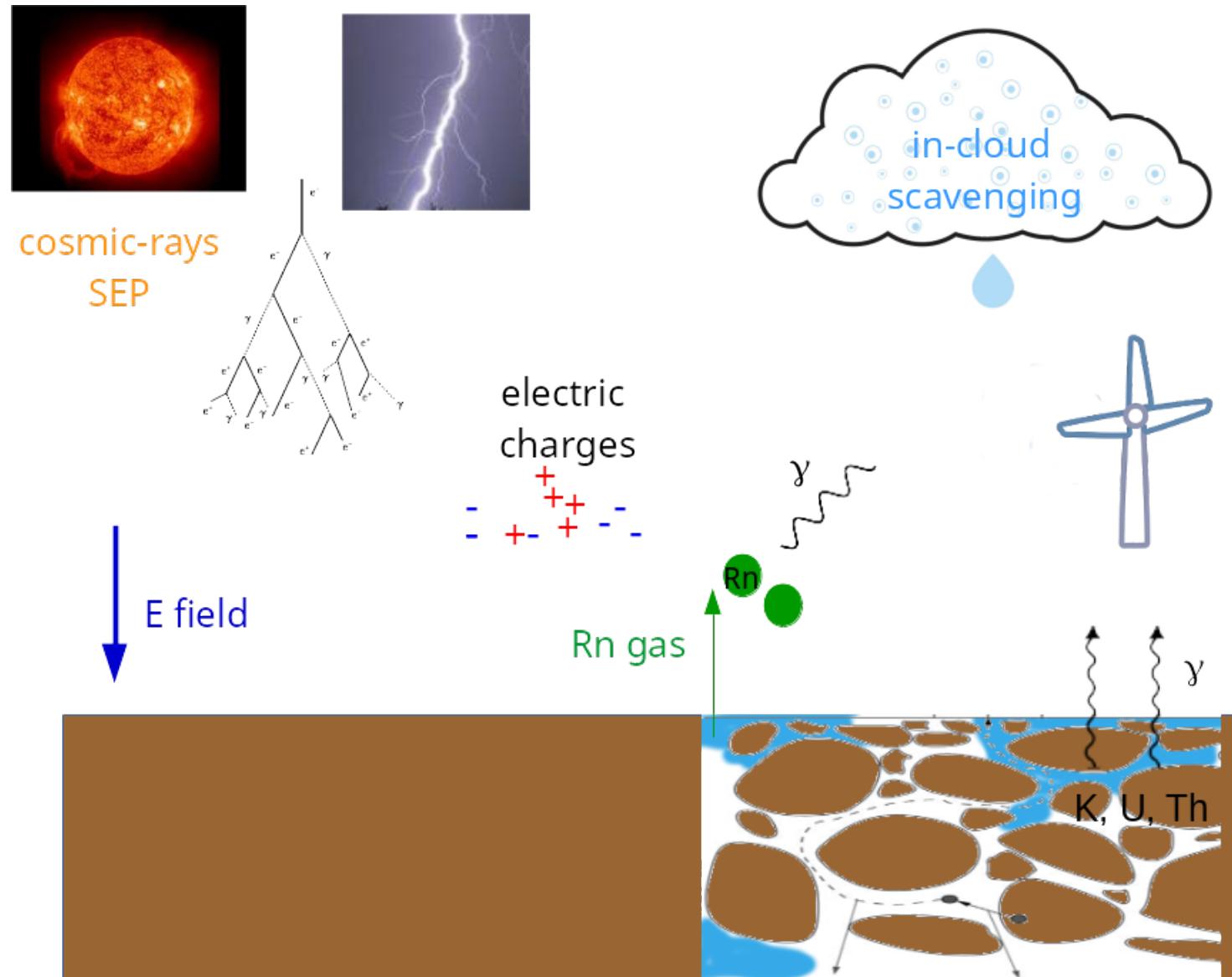
Radon (Rn-222)

- ubiquitous in nature (soil, water, air)
- gas (highly mobile)
- noble element (non-reactive)
- short half-life (3.8 days)
- radioactive (measurable by alpha / gamma)

Applications:

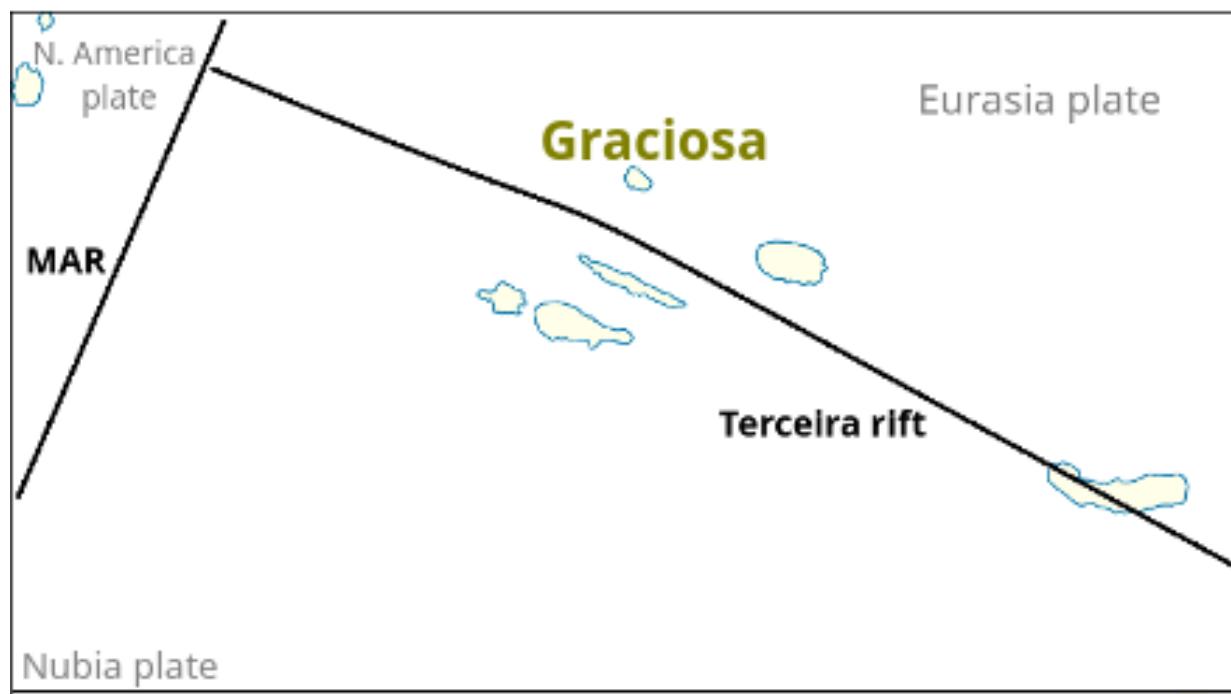
- atmospheric stability / air mass trajectories
- tectonic features / buried faults / earthquakes (??)
- volcanic degassing / hydro-thermal environments
- GHG fluxes / ocean fluid migration (CO₂, CH₄)
- groundwater / submarine groundwater discharge / offshore freshwater

Radon & gamma radiation



Environmental radioactivity field campaigns

The gamma radiation monitoring campaign – ENA – Azores [2015-2018, 2020] 0€



Precipitation type & cloud microphysics \leftrightarrow aerosols \leftrightarrow gamma

Earthquakes \leftrightarrow gamma radiation \leftrightarrow soil moisture

Environmental radioactivity field campaigns

The RELECT campaign – Hyytiälä (ICOS/SMEARII) (Finland) [2017] (6 k€)

Radon (in soil, alpha) + gamma (in air) + atmospheric electric field



balloelectric ion production \leftrightarrow precipitation \leftrightarrow gamma

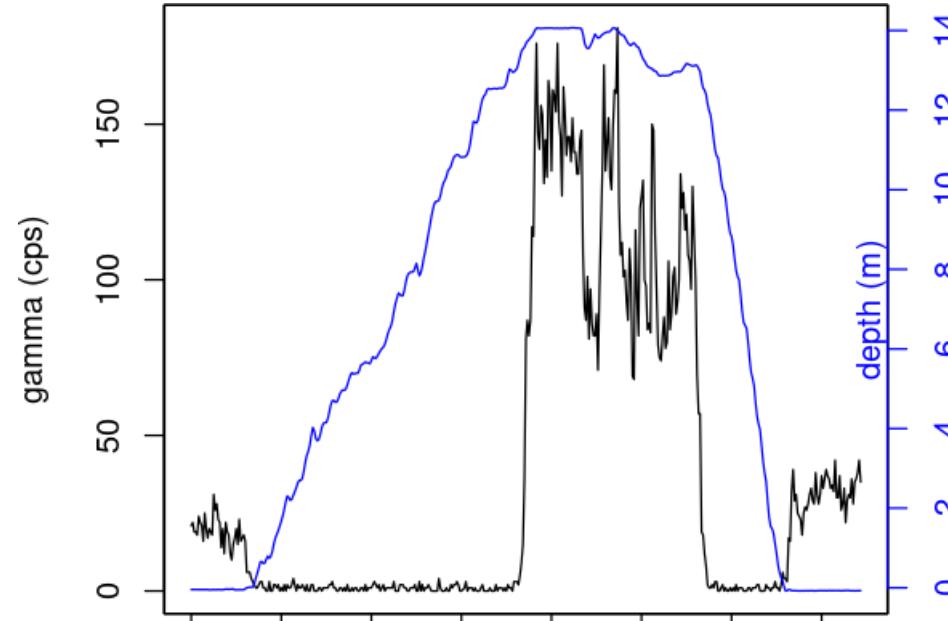
gamma radiation \leftrightarrow soil moisture

electric field \leftrightarrow gamma radiation \leftrightarrow solar activity (September 2017)

soil radon concentration \leftrightarrow soil moisture \leftrightarrow snow

Environmental radioactivity field campaigns

Underwater gamma radiation



sea bed mapping / underwater faults

submarine groundwater discharge / fluxes (CH₄,...)

FAIR & OPEN data

[Home](#) / Organizations / INESC TEC / Gamma radiation monitoring at ...

Gamma radiation monitoring at the Azores ENA-ARM station (Graciosa Island)

Followers 0

Organization



INESC TEC
The Institute for Systems and Computer Engineering, Technology and Science – INESC TEC is an Associate Laboratory with over 30 years

Dataset **Groups** **Activity Stream**

Gamma radiation monitoring at the Azores ENA-ARM station (Graciosa Island)

Gamma-ray total counts in counts/minute (cpm), every 15-minutes, from the Gamma Radiation Monitoring campaign at the ENA site (Graciosa, Azores). Data were collected to study the temporal variability of the progeny of the noble gas radon (Rn-222), aiming to examine how it is influenced by meteorological conditions and its association with the atmosphere's ionization and aerosols concentration.

This dataset has Jupyter notebook for visualization.

Data and Resources

 **dataGRM_ENA**
Time series of gamma total counts every 15-minutes.

 **GRM-ENA**
Dataset notebook.

[atmosphere](#) [environmental radio...](#) [gamma radiation](#)

**Radon data from ENVRIplus TNA campaign
SELECT at SMEAR II – HYYTIÄLÄ multi-disciplinary RI platform**

Followers 0

Organization



INESC TEC

Dataset **Groups** **Activity Stream**

Radon data from ENVRIplus TNA campaign SELECT at SMEAR II – HYYTIÄLÄ multi-disciplinary RI platform

Radon concentration measurements (in Bq/m³) every 2-hours.

Data and Resources

 **RadonSoil_week25**
Measurements of radon concentration every 2-hours for week 25 (2017, ISO week...)

 **RadonSoil_week26**
Measurements of radon concentration every 2-hours for week 26 (2017, ISO week...)

 **RadonSoil_week27**
Measurements of radon concentration every 2-hours for week 27 (2017, ISO week...)

[Explore](#) [Explore](#) [Explore](#)

Concluding remarks

- multi-disciplinary perspective (problems / data & measurements / statistics)
- data management (FAIR / Open data) [part of the job description]
- field measurements [*"you can do anything, not everything"*]
- from data to big data: challenging opportunity
 - * methodological advances required (scaling, correlation,...)
 - * focus on understanding (data → knowledge)