UNIVERSITÄT BERN

OESCHGER CENTRE
CLIMATE CHANGE RESEARCH

# Climatology III

**Fall Semester 2023 University of Bern**

**Prof. Stefan Brönnimann**
**Institute of Geography**
**Hallerstr. 12**
**3012 Bern**
**Office 503**

# Today's programme

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## Lecture

1. Info on this course
2. I introduce myself
3. You introduce yourselves
4. Organisation
5. Literature
6. Introduction

## Exercises

1. Introduction, Leistungskontrolle
2. Topics for presentations

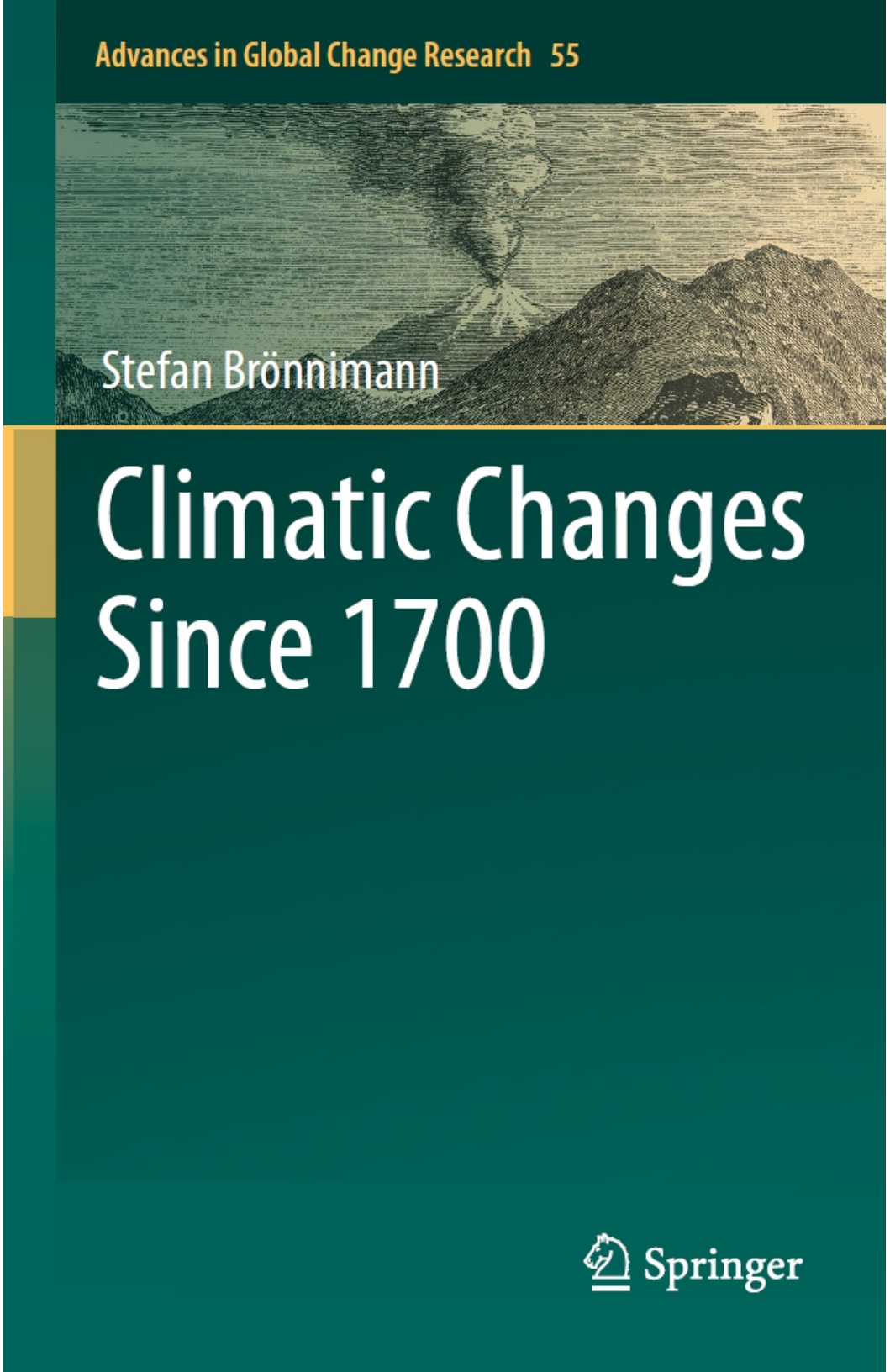
## On this course

- Suitable for MSc and PhD students
- Requirements: Atmospheric physics, Basic statistics
- 3 credit points
- Leistungskontrolle Poster (graded)
- Do homwework, hand in exercises (not graded)
- Exercises are in R (or Python)
- No exams

## Material

- e-learning material (CLIMANDES: https://boris.unibe.ch/74331/)
- e-learning material (www.weather-reconstruction.org)
- Additional reading (papers on ILIAS)
- My Slides

- **Mandatory reading:**
  Stefan Brönnimann: Climatic Changes Since 1700. Springer, 2015
- Recommended for repeating the basics:
  Dennis L. Hartmann: Global Physical Climatology, Academic Press, 2016

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Climatic Changes Since 1700 Fig. X


Download:
http://boris.unibe.ch/74331/

Online version:
http://giub-torrent.unibe.ch/climandes/E-LEARNING/

# Contact

Stefan Brönnimann
stefan.broennimann@giub.unibe.ch
Slow in replying e-mails

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# Climatology III

| |
|---|
| Introduction |
| Block I Data and Methods |
| Block II Processes: Internal variability |
| Block III Processes: External forcings |
| Block IV Climate history |
| Close-up meeting |

# Course overview

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| Date | Lecture | Exercises |
|---|---|---|
| 22.09.2023 | Introduction<br>Terms<br>Literature | Introduction<br>Organization |
| 29.09.2023 | Climate Data | Introduction R |
| 06.10.2023 | Climate Models | Climate Modeling |
| 13.10.2023 | Circulation of the northern extratropics and the stratosphere | Introduction Statistics |
| 20.10.2023 | Ocean-atmosphere coupling, ENSO | Statistics: Composites |
| 27.10.2023 | Tropical-extratropical coupling | Statistics: Correlation |
| 03.11.2023 | Volcanic and solar forcing | Statistics: Regression |
| 10.11.2023 | Greenhouse gas and aerosol forcing | Statistics: EOF |
| 17.11.2023 | (no class) | |
| 24.11.2023 | Climate of the last Millennium | Graphics and Design |
| 01.12.2023 | Climate from 1600 to 1850 | Individual work/help desk |

# Course overview

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| Date | Lecture | Exercises |
|---|---|---|
| 08.12.2023 | Climate from 1850 to 2000 | Individual work |
| 15.12.2023 | Climate since 2000 and future | Individual work |
| 22.12.2023 | Poster exhibit | no exercises |

## Climatology Research Group

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### Stefan Brönnimann

Climate data (historical data, methods)
Variability of global climate during the past 400 years
Variability of atmospheric circulation during the past 150 years
Extreme weather events during the past 150 years

Examples:
Effect of volcanic eruptions, solar variability and climate
El Niño, Hadley circulation, droughts, floods
Arctic climate variability, variability of the stratosphere

Plus: Urban climate

# Learning from past climate extremes

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"Dust Bowl" droughts,
USA, 1932-1938

Arctic warming 1915-1945

El Niño effects 1939-1942

# Learning from past climate extremes

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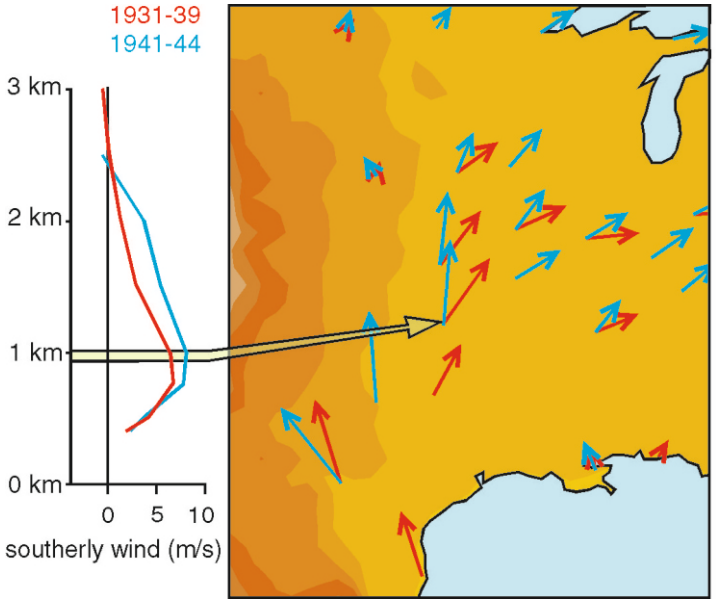
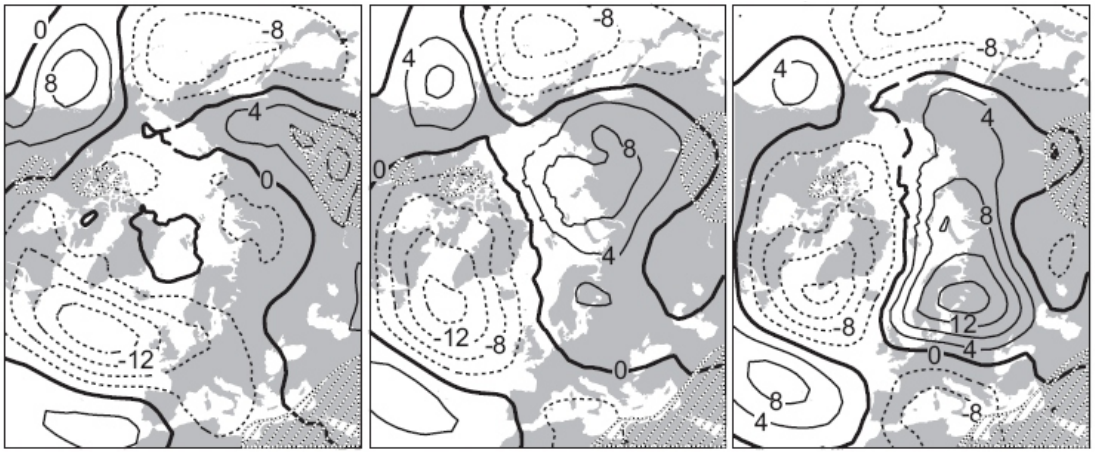
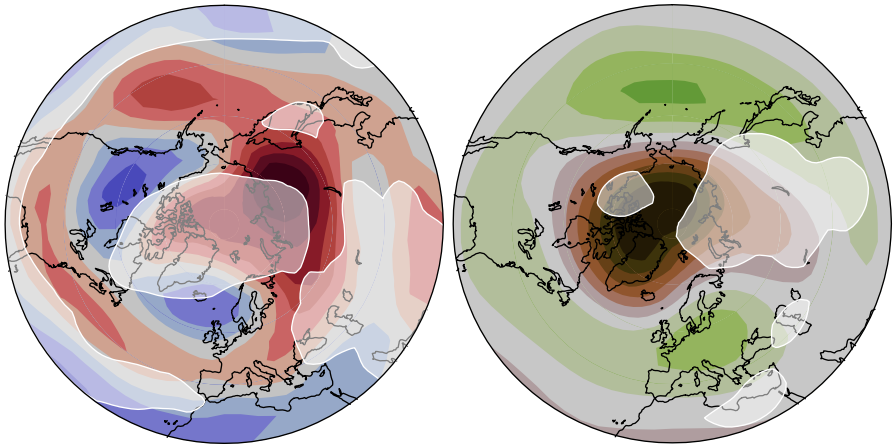
"Dust Bowl" droughts, USA, 1932-1938




Arctic warming 1915-1945




El Niño effects 1939-1942

# ...for the present

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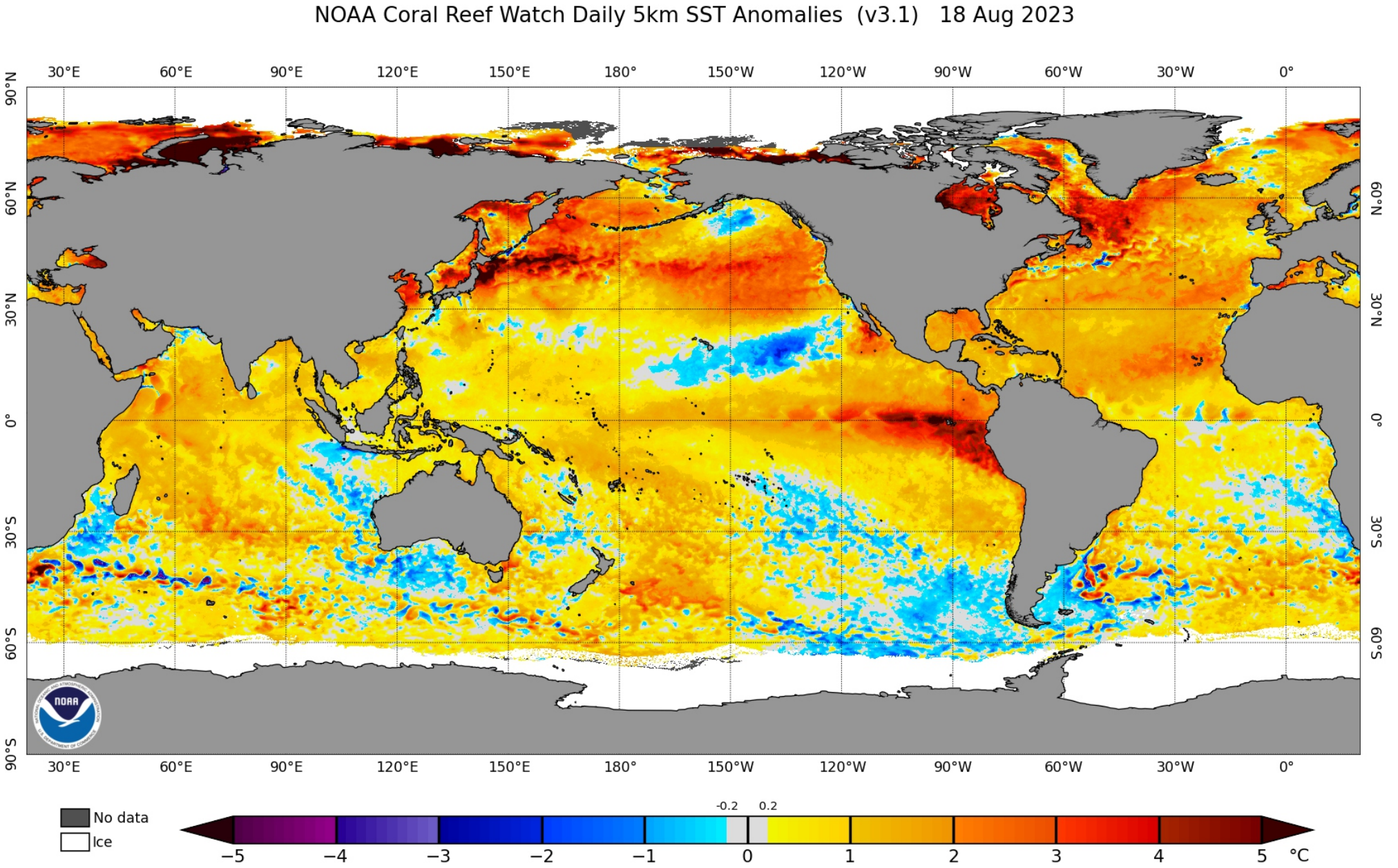

# Learning from past weather extremes

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Blizzard,
USA,
Nov. 1940

Flooding, Switzerland, June 1910

Storm, UK, Dec 1879

# Learning from past weather extremes

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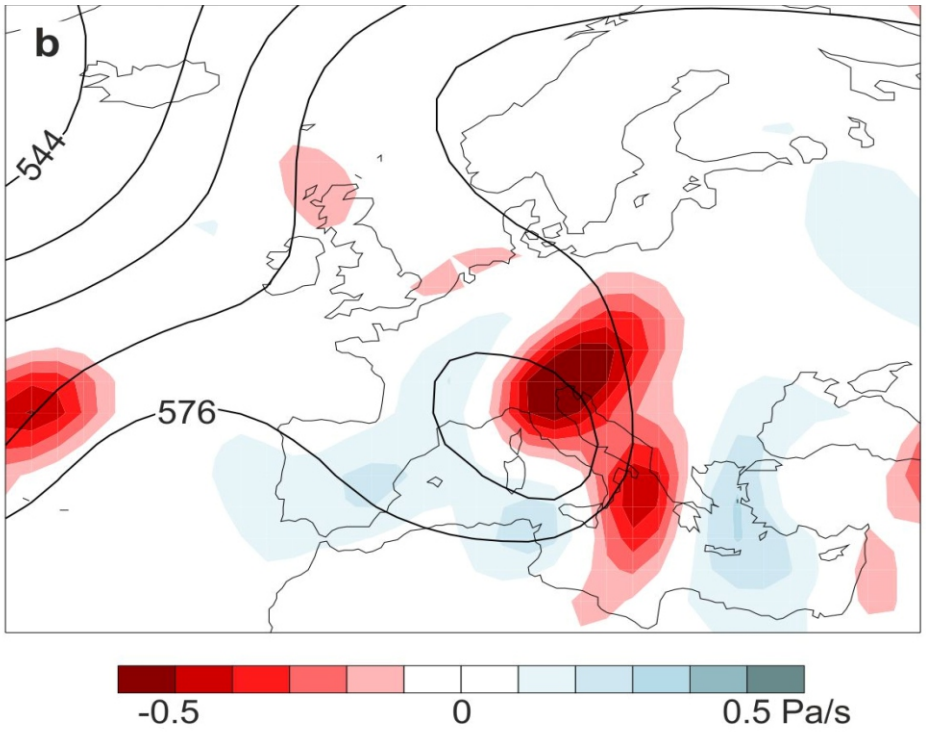
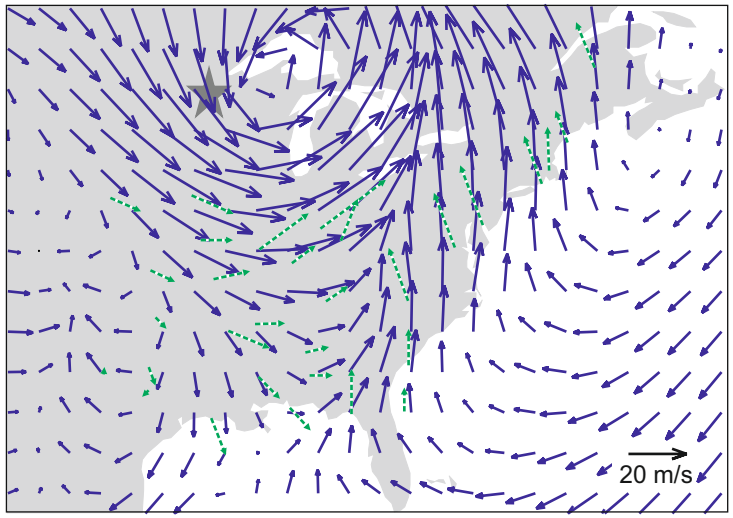
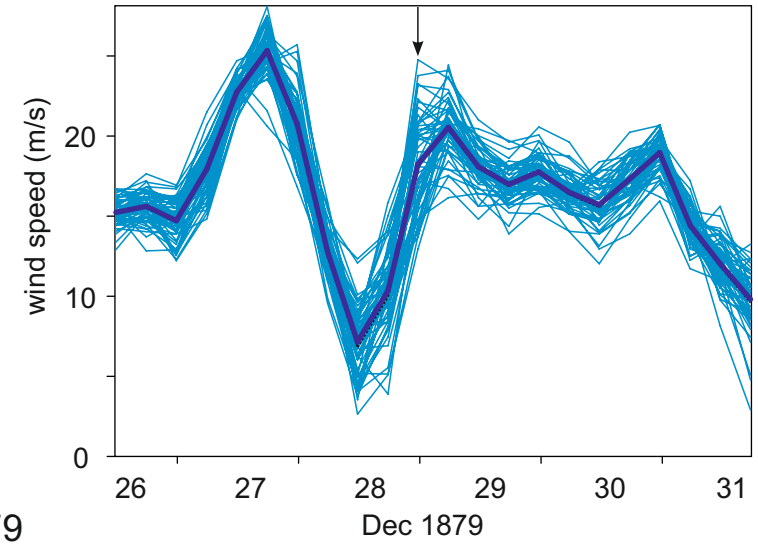
Flooding, Switzerland, June 1910



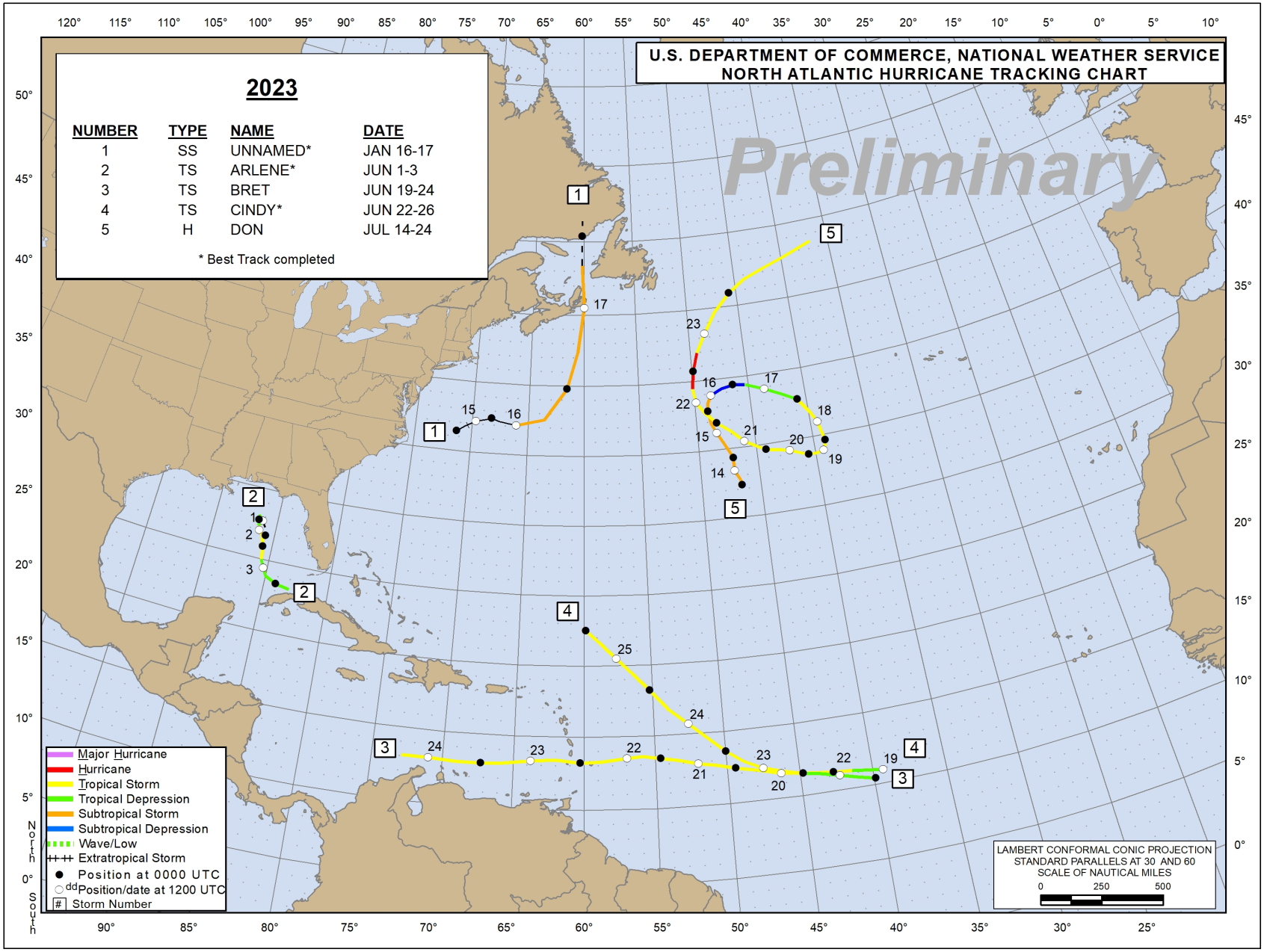

Blizzard, USA, Nov. 1940




Storm, UK, Dec 1879

# ...for the present





# Climate data

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Methods:
- Data rescue
- Reconstruction/Assimilation
- Modeling

$$\bar{x}^{a} = \bar{x}^{b} + \mathbf{K}(y - \mathbf{H}\bar{x}^{b})$$

$$\mathbf{P}^{a} = (\mathbf{I} - \mathbf{K}\,\mathbf{H})\,\mathbf{P}^{b}$$

$$\mathbf{K} = \mathbf{P}^{b}\mathbf{H}^{T}(\mathbf{H}\mathbf{P}^{b}\mathbf{H}^{T} + \mathbf{R})^{-1}$$

# Your turn!

Write down your main expectations

# Learning goals

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The goal of this course is to understand variations and disturbances of the global climate system and apply the concepts for understanding past and present climate variations.

Students will be able to summarize and present a scientific problem and will have the necessary basis for a MSc thesis in climate data analysis.

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# Large-scale climate variability

## Introduction

# Climate is all about variability!

# Air temperature at sunrise at a particular location

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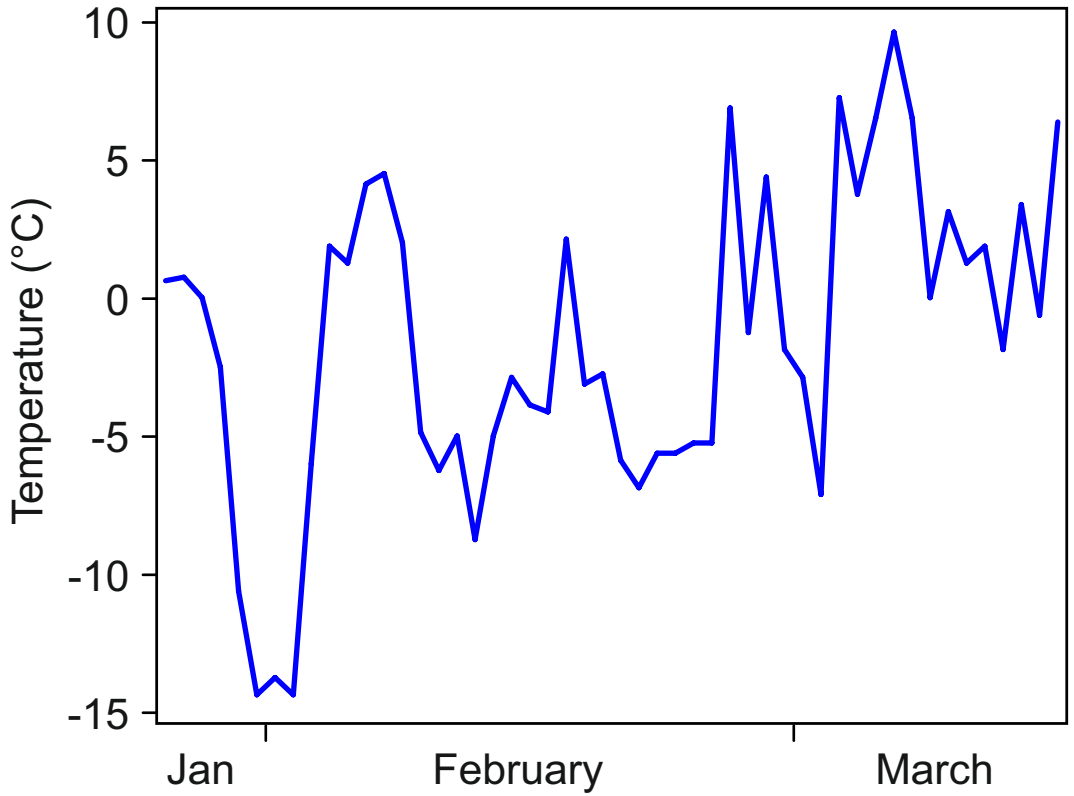


Climatic Changes Since 1700 Fig. 1.1

# Surface air temperature on a particular day

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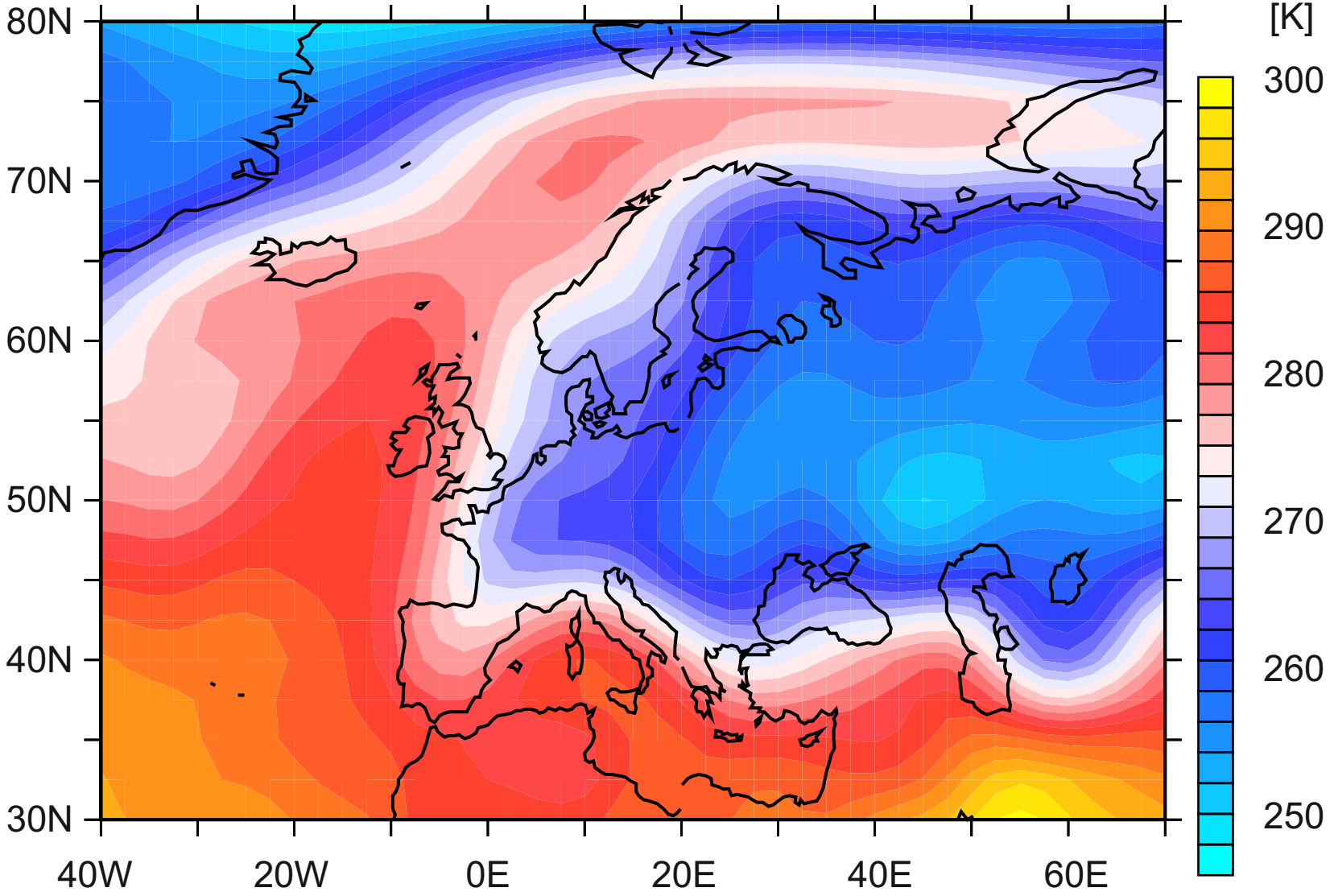


Climatic Changes Since 1700 Fig. 1.1

# Process view of climate: Scales in Atmospheric Processes

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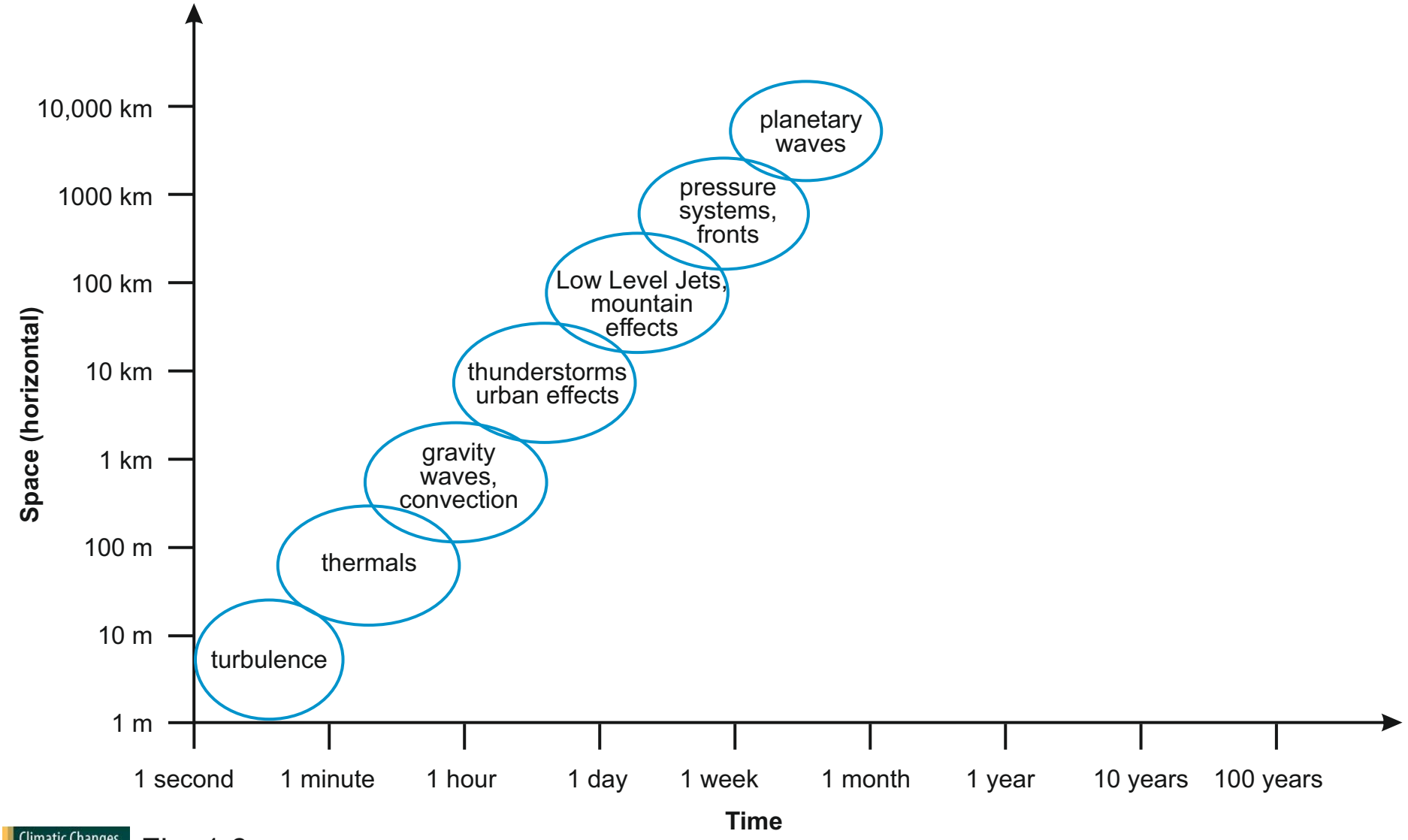
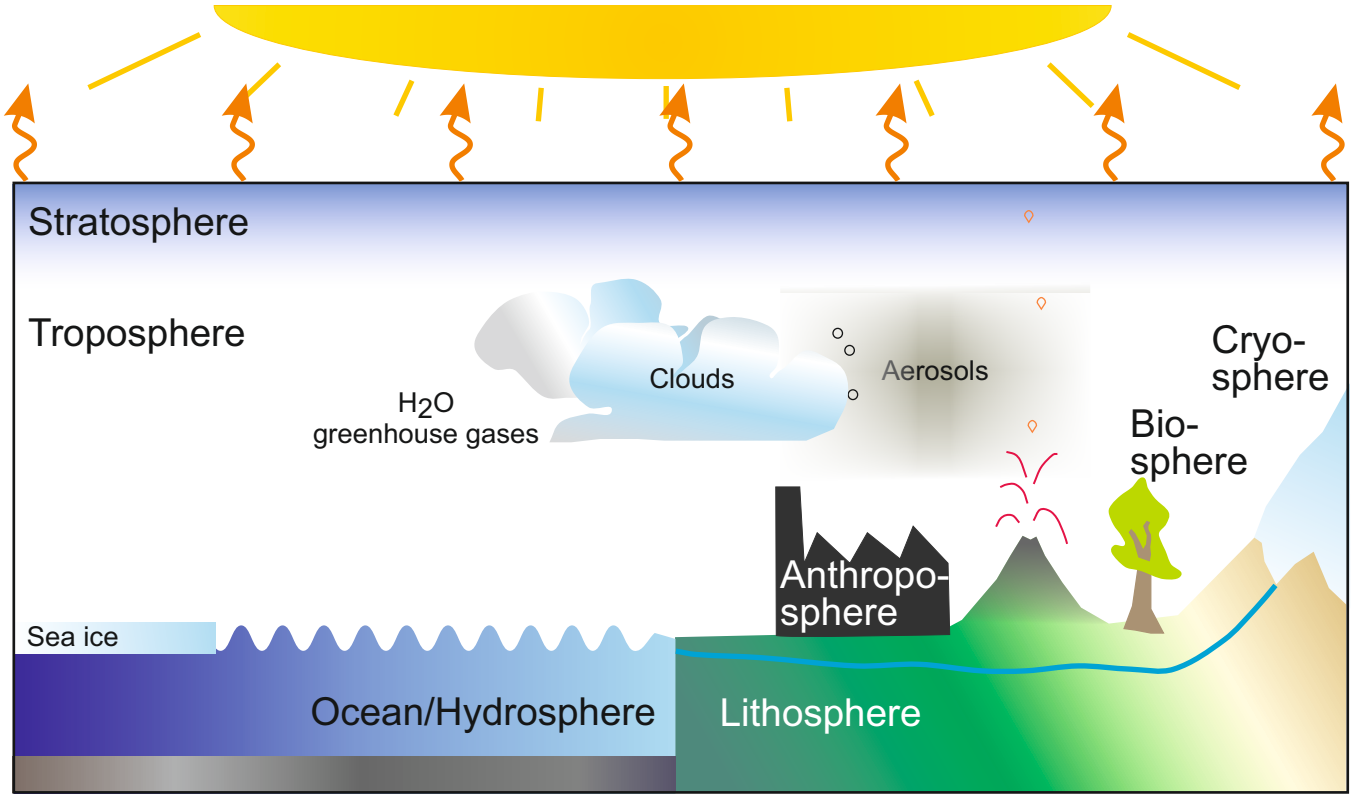



Climatic Changes Since 1700 Fig. 1.6

# Process view of climate: The climate system

Fluxes of energy, mass, momentum
Storage of energy, mass
External input of energy




Climatic Changes Since 1700 Fig. 1.4

# Process view of climate: The climate system

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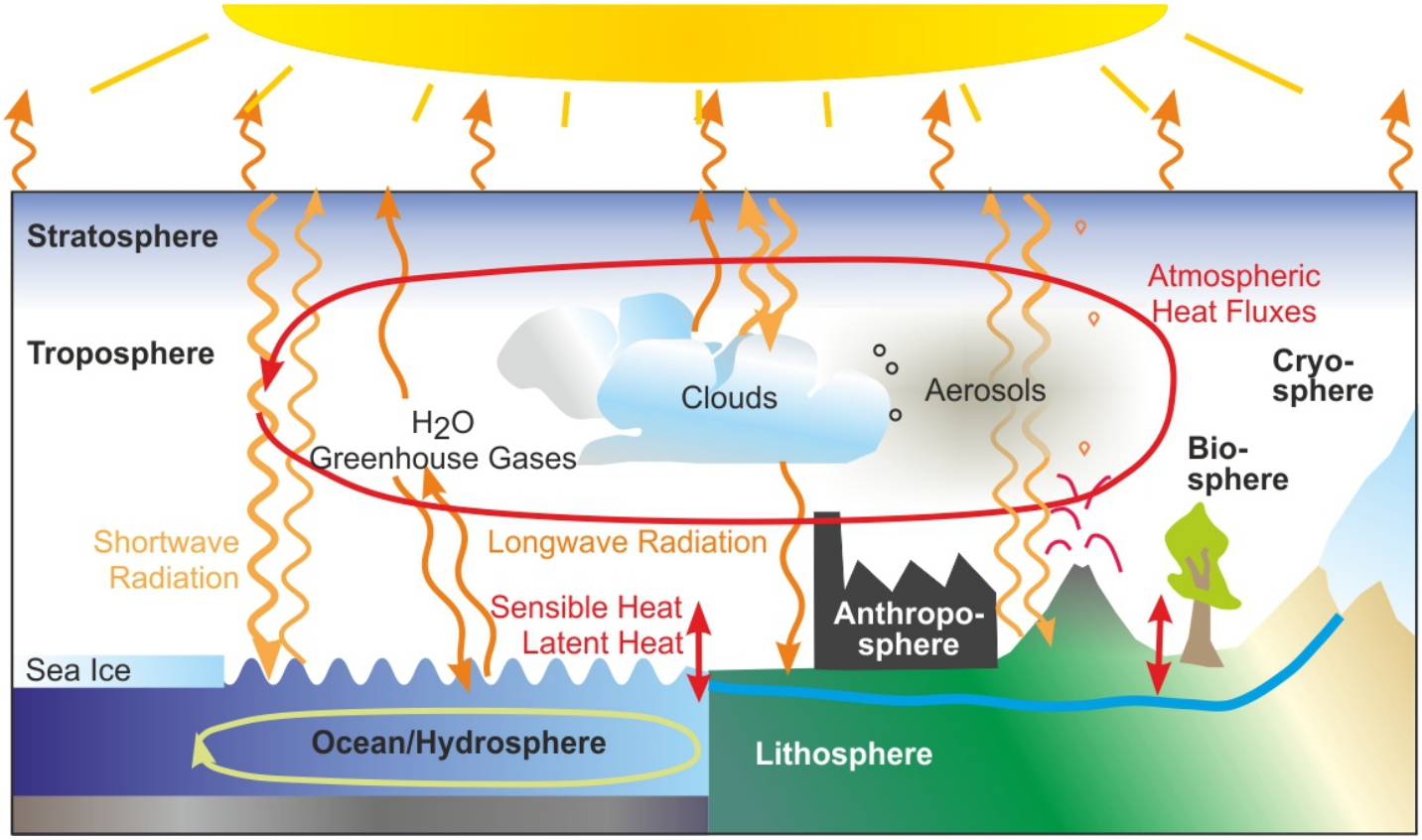
Fluxes of energy, mass, momentum
Storage of energy, mass
External input of energy




Climatic Changes Since 1700 Fig. 1.5

# Process view of climate: The climate system

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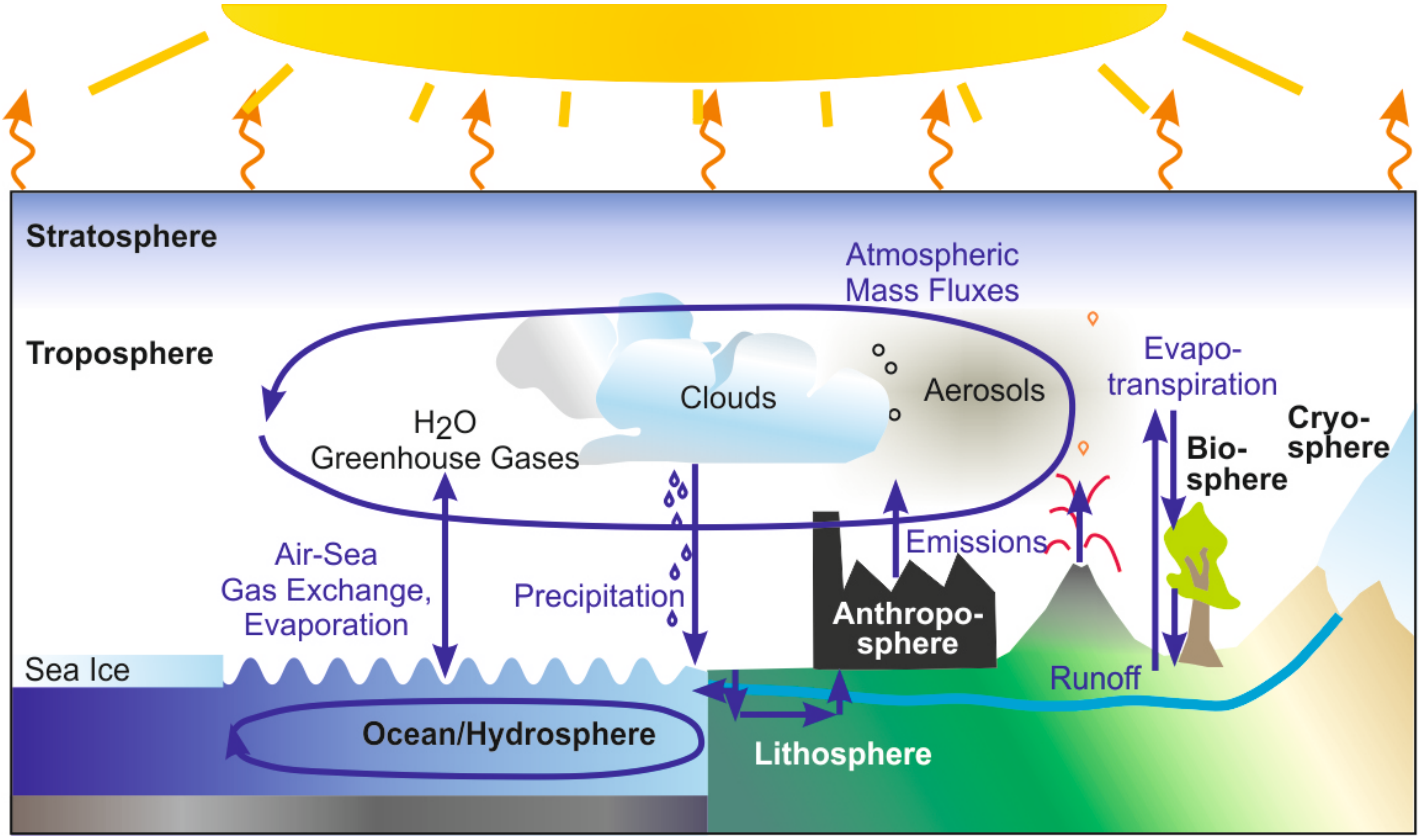
Fluxes of energy, mass, momentum
Storage of energy, mass
External input of energy




Climatic Changes Since 1700 Fig. 1.5

# Process view of climate: The climate system

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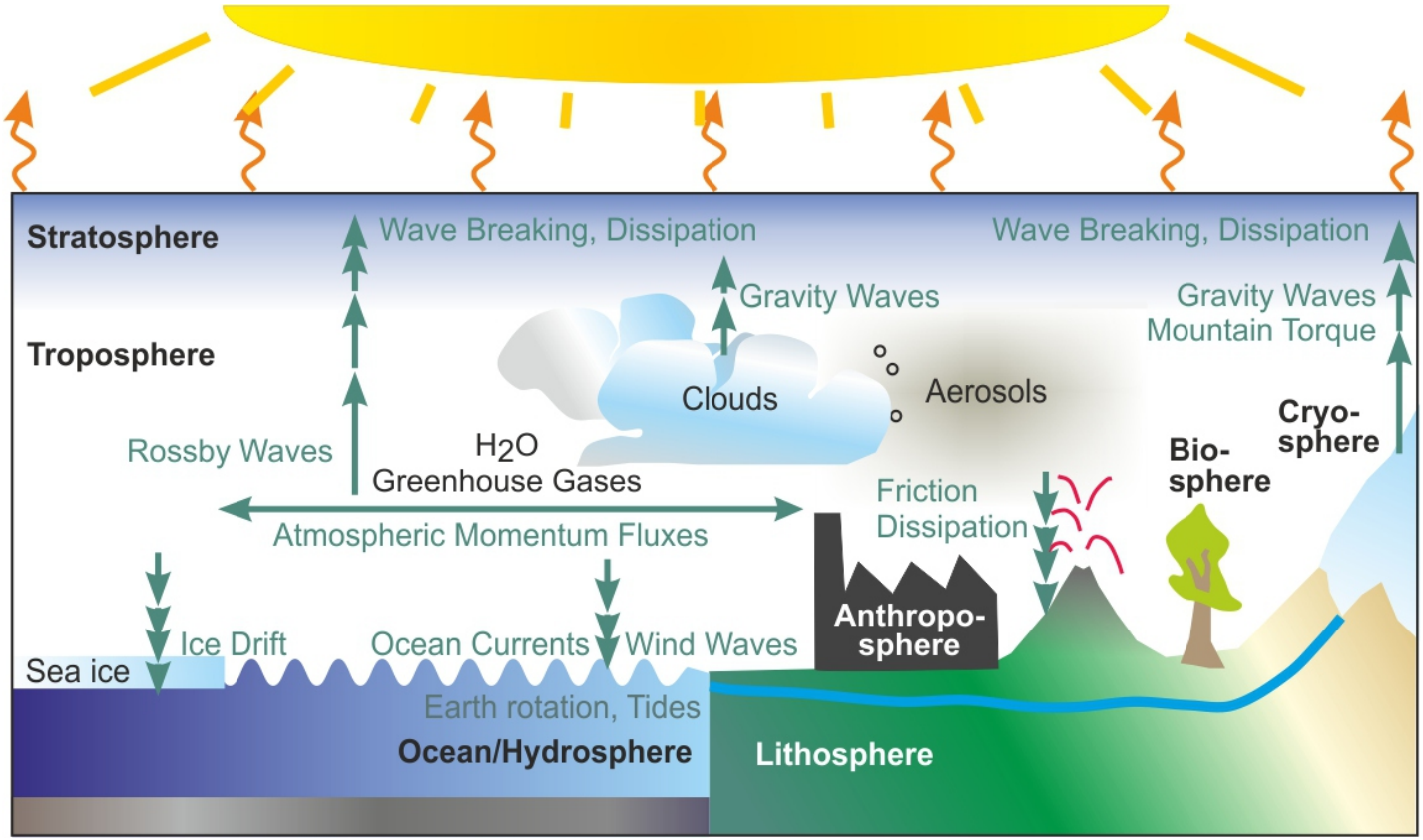
Fluxes of energy, mass, momentum
Storage of energy, mass
External input of energy




Climatic Changes Since 1700 Fig. 1.5

# Process view of climate: Scales in atmospheric and oceanic processes

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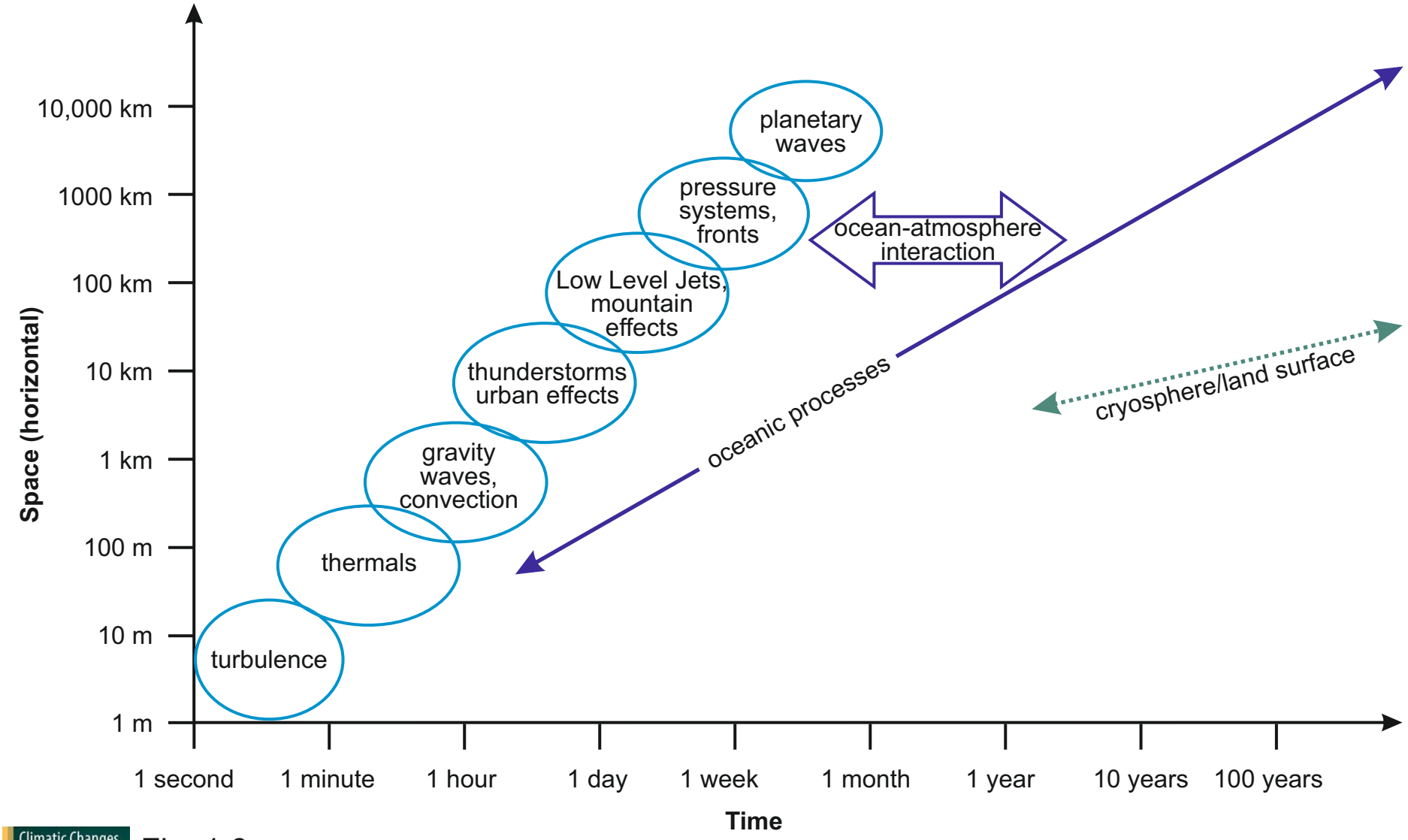


Climatic Changes Since 1700 Fig. 1.6

# Process view of climate: Scales in climate mechanisms

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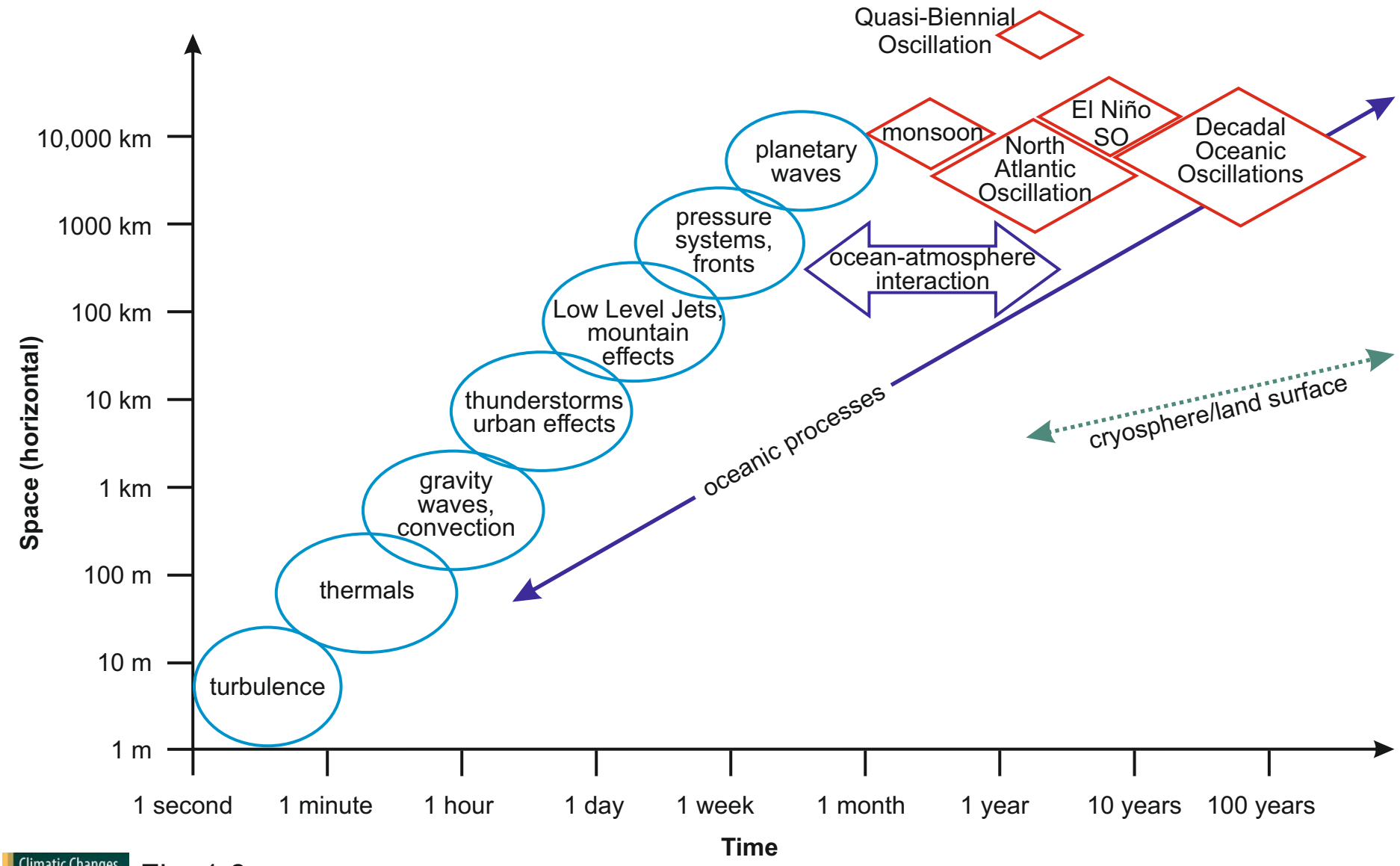


Climatic Changes Since 1700 Fig. 1.6

# Process view of climate: Scales of external influences

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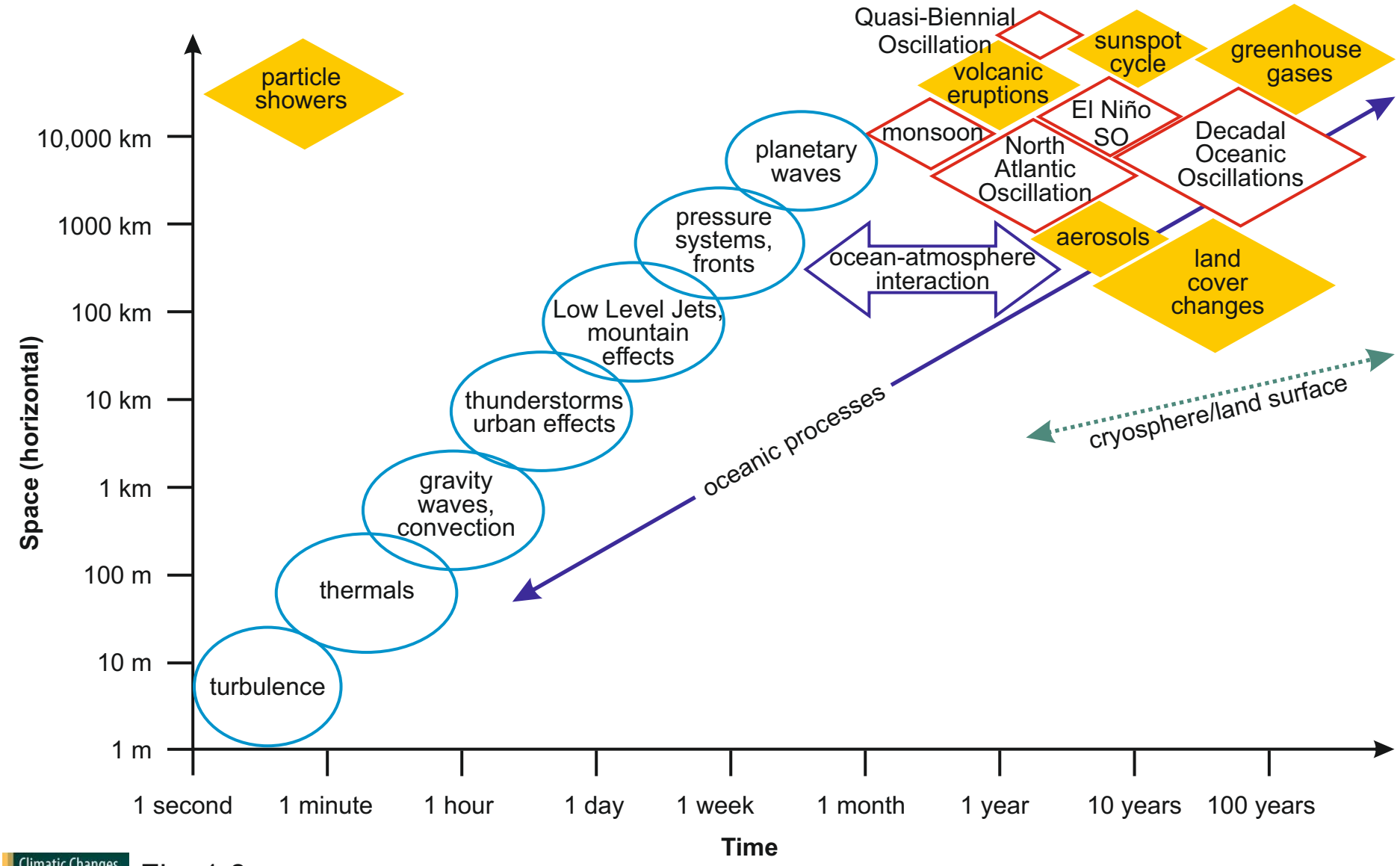


Climatic Changes Since 1700 Fig. 1.6

# Statistical view of climate: Interannual variability - locally and global

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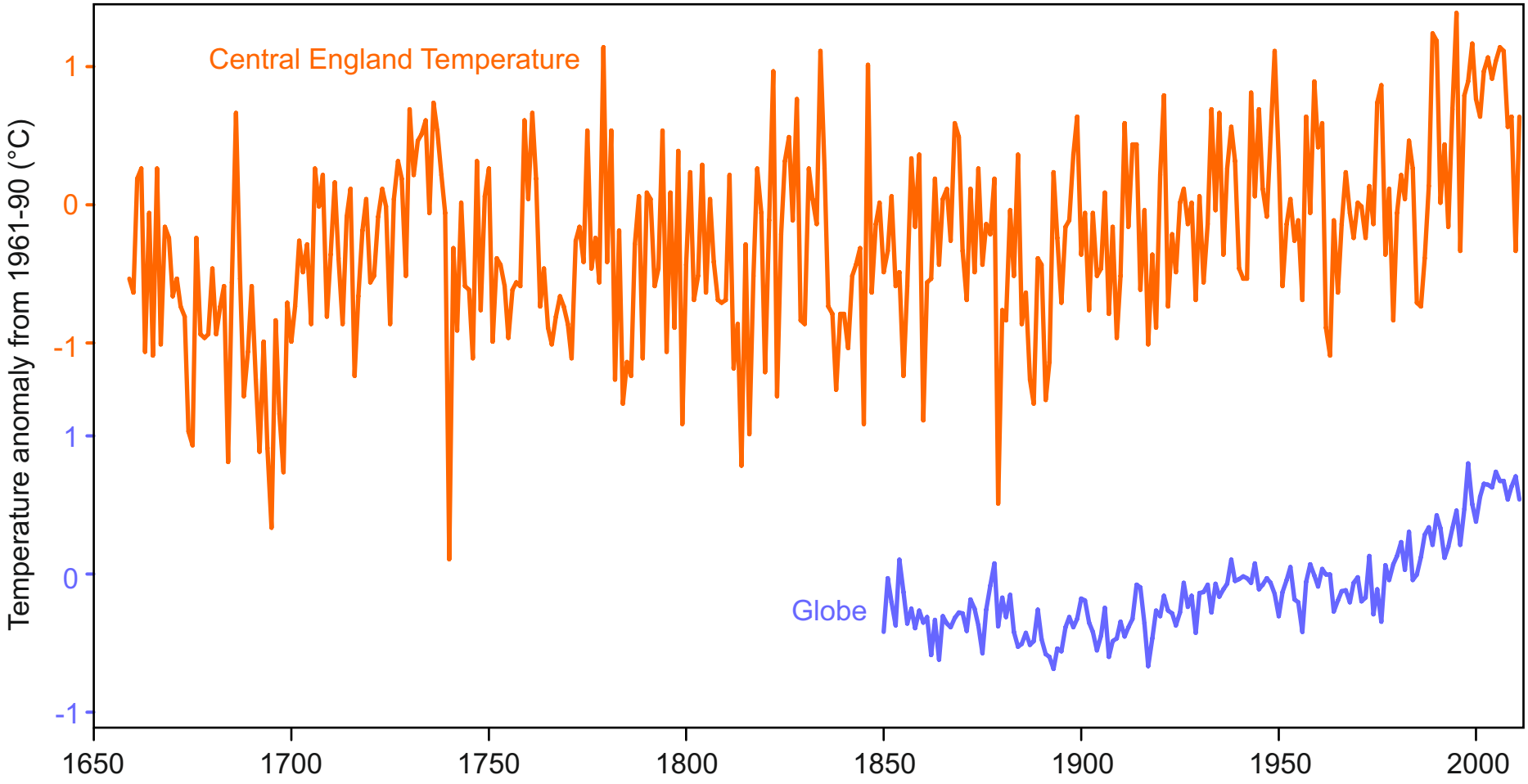


Climatic Changes Since 1700 Fig. 1.2

# Statistical view of climate: 1979-2010 temperature trends as a function of area

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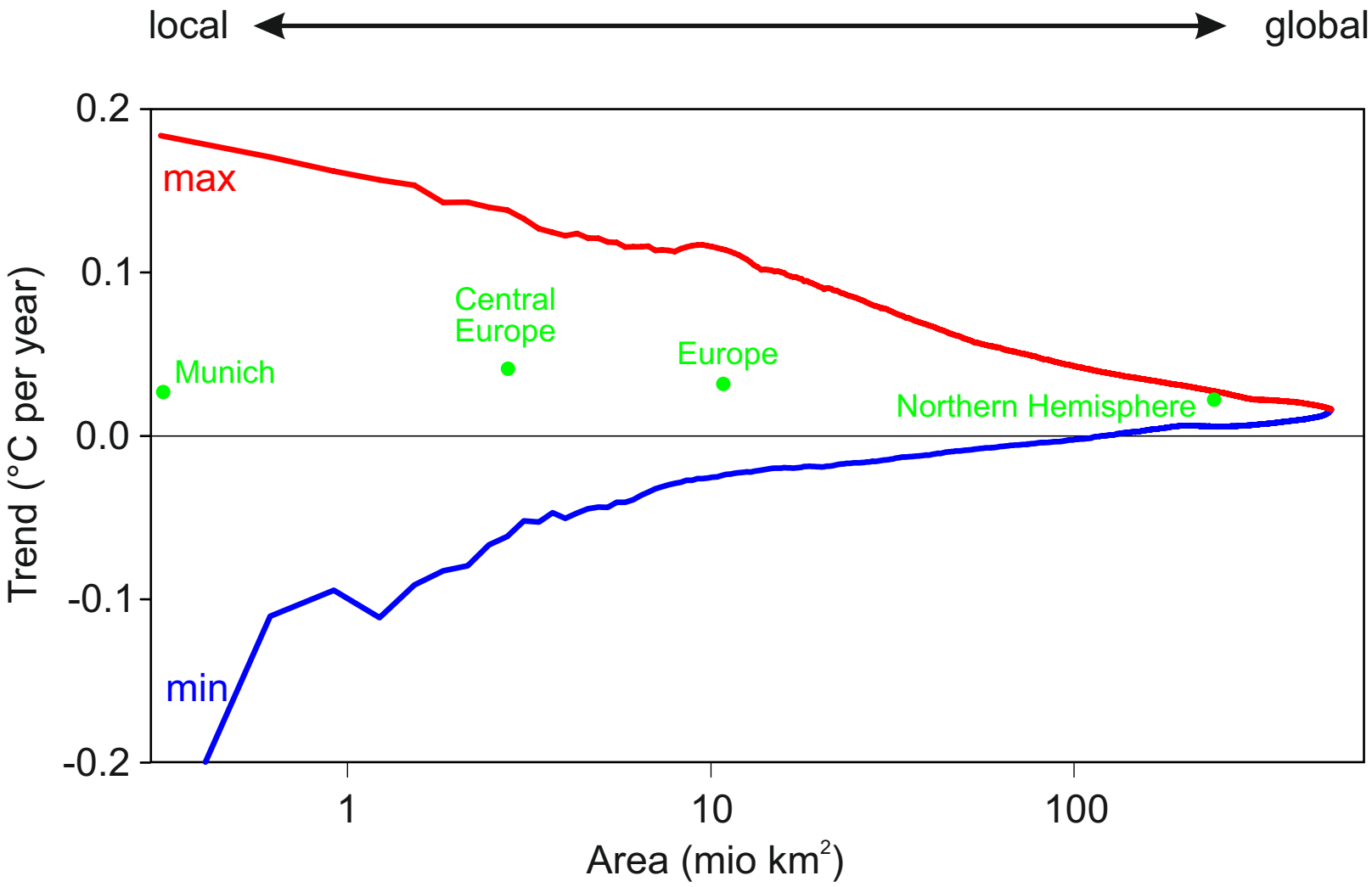


Climatic Changes Since 1700 Fig. 1.3

# Statistical view of climate:
# NH temperature trends as a function of time period

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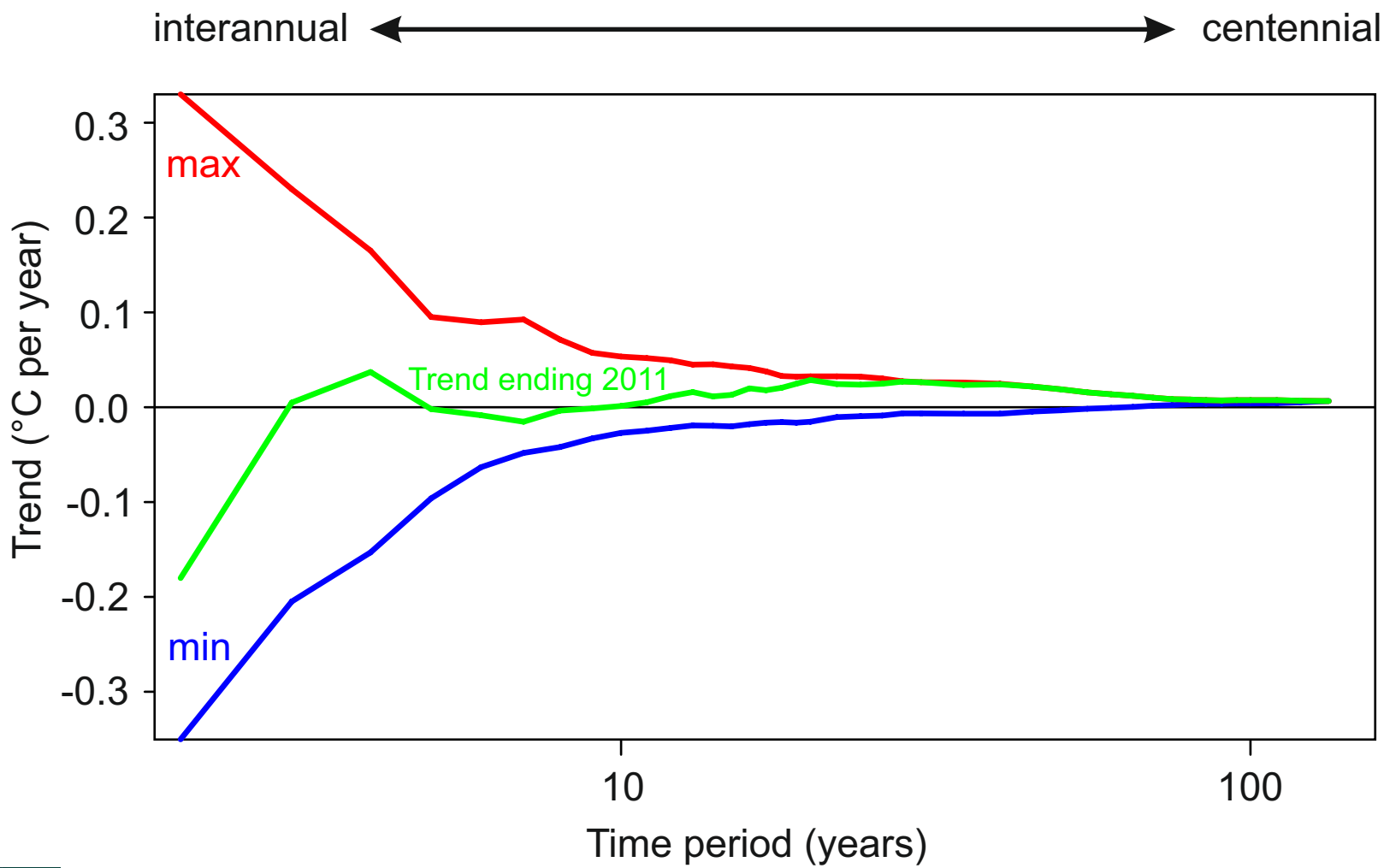


Climatic Changes Since 1700 Fig. 1.3

# Large-scale climate variability
# Process and statistical view of climate

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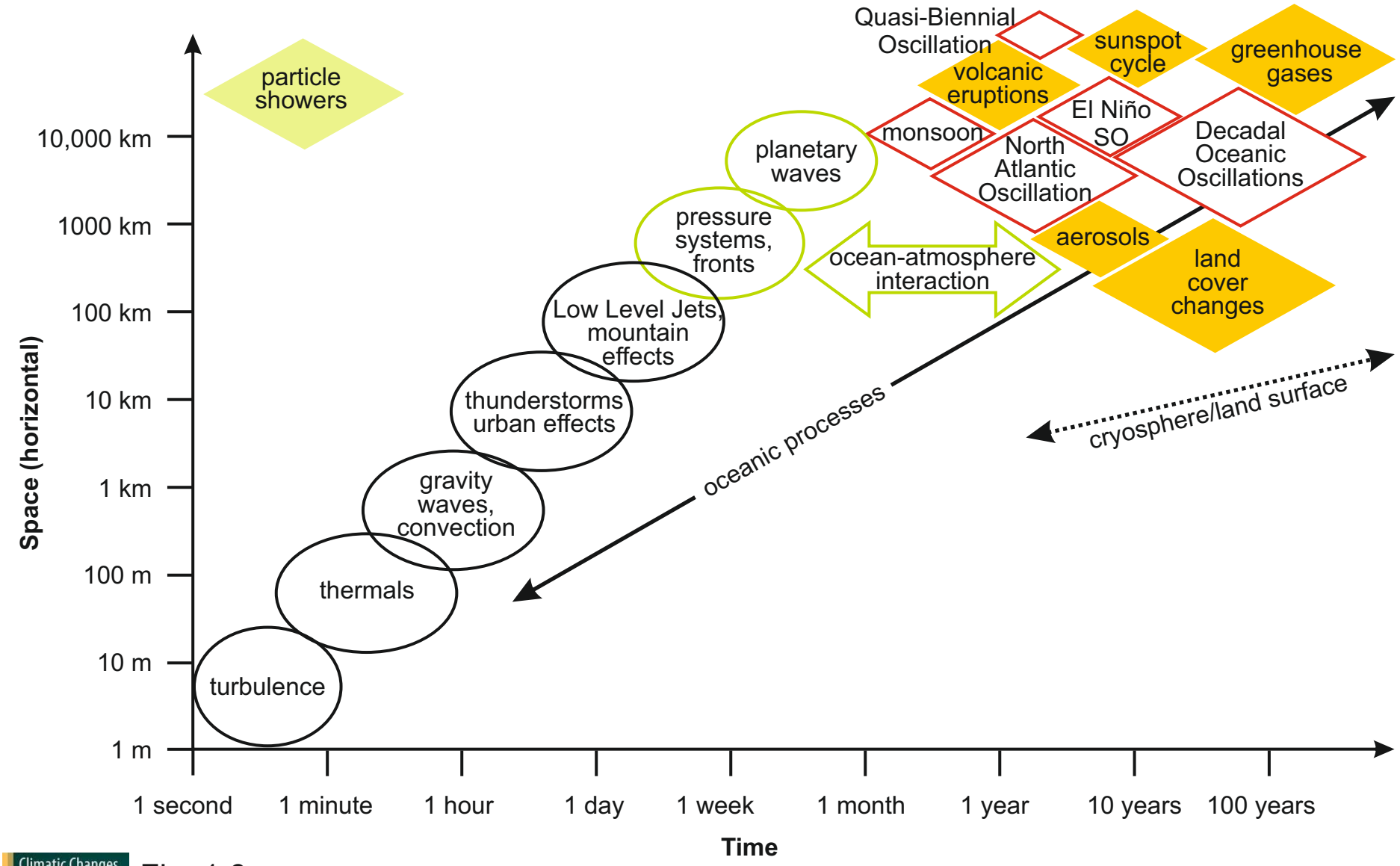


Climatic Changes Since 1700 Fig. 1.6

# What is climate variability?
# What are climate variations?

In the context of this course, large-scale climate variations denote:
A departure of climate from its mean state on
a continental to hemispheric scale
over a year up to several decades.

# Large-scale climate variability

## Exercises

Exercises on the material covered in the presentation

Bring your own computer

Install R or use Python

Use common data set (ModE-RAHires -> Introduction follows)

**Learning goals:**

Acquire some important skills in climatology: Data, statistics, programming
Comprehend what it means to work with real data and model data
Deepen topics of the course on the example of one topic
Comprehend the main theoretical concepts
Discuss the state of the literature
Phrase a problem in a statistical way
Solve a statistical problem in R

Graded individal Assigments in statistics/R (30% of grade)

Preparation for you work on the poster

# Programme of Exercises

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| Date | | |
|---|---|---|
| 22.09.2023 | Assignments (Poster) | |
| 29.09.2023 | Introduction to R, ClimeApp | |
| 06.10.2023 | Climate Modeling | R |
| 13.10.2023 | Introduction Statistics | |
| 20.10.2023 | Statistics: Composites | R/ClimeApp (assignment) |
| 27.10.2023 | Statistics: Correlation | R/ClimeApp (assignment) |
| 03.11.2023 | Statistics: Regression | R/ClimeApp (assignment) |
| 10.11.2023 | Statistics: EOF | R |
| 17.11.2023 | (no class) | |
| 24.11.2023 | Q&A | |
| 01.12.2023 | Graphics and Design | |

Assignment are for next week

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# ModE-RA and subproducts

Global montly 3-D data back to 1420

Off-line assimilation of instrumental data, documentary data, and proxies into a large ensemble of climate model simulations
(Data assimilation)

20 ensemble members, you get the ensemble mean

Update of version used in the book (Brönnimann 2015)

Important data on ILIAS (ensemble means of temperature, sea-level pressure, precipitation, 500 hPa height)

**Not yet published. Very nice interface to the data set: ClimeApp http://climeapp-modera.unibe.ch:3838/**

**Task: Analyse a case study OR compare with an independent seires OR perform simple statistical analyses (suggested topics on ILIAS)**

**Your contribution is important!**

## Poster: What you have to do

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- Read relevant papers
- If applicable, do own analyses using model simulations provided
- Present a poster with the literature research and your results
- Create a handout (1-2 pages)
- Present 5 Min. during the display

## Groups of two

# Poster

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- A0 portrait
- Visually appealing
- Well structured
- Conclusions highlighted
- Fully referenced

## Grading



- **Individual R assignments (30%)**

- **Poster in groups (70%), of which:**

- **Formal aspects (50%):** Graphical concept, structure, clarity, amount of material, references

- **Scientific aspects (50%):** Correctness, completeness, logical structure, argumentation.

# Mitglied werden lohnt sich

- Netzwerk
- Vorträge
- Exkursionen
- Publikationen
- Veranstaltungen

Jahresbeitrag Studierende: 25 CHF

stefan.broennimann@giub.unibe.ch

Geographische Gesellschaft Bern

03.10.2023: **150 Jahre Geographische Gesellschaft Bern** (mit Film)

17.10.2023: **Feldkurse 2023**
Studierende berichten über die beiden zweiwöchigen Feldkurse des Geographischen Instituts im Sommer 2023.

31.10.2023: **Nachaltige Raumentwicklung**
Ueli Seewer, Vizedirektor ARE
Vera Götze, seit 2020 Doktorandin am GIUB
moderiert durch Barbara Keller, Alpines Museum

14.11.2023 (im Alpinen Museum): **«Geographie-Gespräch»**
Simone Schmid, Drehbuchautorin
Simon Bärtschi, Chefredaktor BZ/Bund
Katrin Schneeberger, Direktorin Bundesamt für Umwelt
moderiert durch Susan Thieme