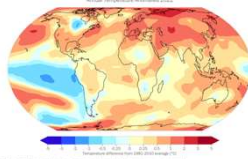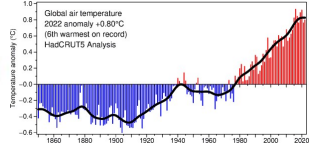# Global change research methods
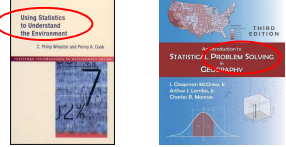
I. Climate data on global change

Petr Dobrovolný

dobro@sci.muni.cz

Motivation

Global air temperature variability in space and time

The main goal is to provide an overview of suitable data sources and the basic principles of methods that can be used to study global change

---

The course introductory notes

- Special attention will be given to the **demonstration and explanation** of selected statistical methods and techniques.
- Students will conduct their **own analyses** of the data provided.
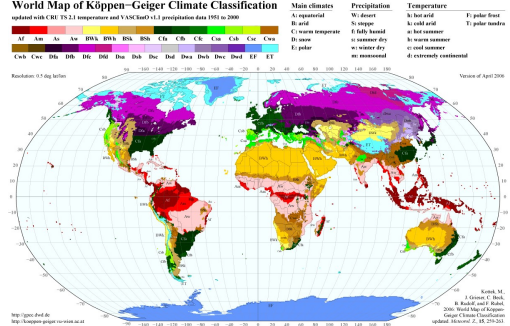- **Practical part** will use either internet resources or the R programming environment

- Very basic knowledge of **descriptive statistics** is assumed
- **Written test** at the end of the whole course
- **All materials available in IS** (Information system – Study materials)

The first lecture contents

1. Introductory terms
2. Selected data sources on climate change
3. Climate Explorer (CE)
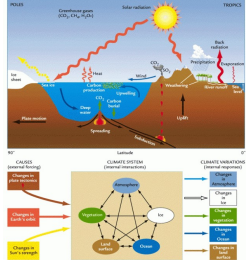4. Introductory statistics in CE

A traditional view of climatology

- **Climate = weather statistics**
- **Data in climatology** – arithmetic means of meteorological measurements
- **Methods in climatology** – descriptive statistics
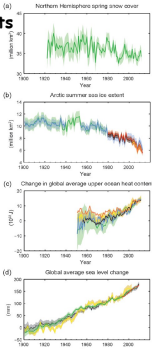
Contemporary climatology

- **The climate system** – several components.
- Positive and negative **feedbacks between components**
- External and internal climate drivers (**forcings**)
- Internal climate variability

The climate system is changing

https://www.e-education.psu.edu/earth530/content/l3_p3.html

https://www.temperaturerecord.org/

Contemporary climatology

Traditional and new sub-disciplines of climatology are given a new dimension in the current global change:

- **Data assimilation, re-analysis**
  - https://epic.awi.de/id/eprint/25075/1/DA_overview.pdf
- **Atribution analysis**
  - **World Weather Attribution – Exploring the contribution of climate change to extreme weather events**
  - https://www.worldweatherattribution.org/
- **Urban climatology**
  - Urban Climate Change Research Network
  - https://uccrn.ei.columbia.edu/
- „**Open climate science**" - Climate-lab book
  - http://www.climate-lab-book.ac.uk/about/

Contemporary climatology

Among other things, it is typical for contemporary climatology:

- **High complexity** of the studied phenomena in time and space

- Their **stochastic nature** (some phenomena do not have a clear cause, there is internal climate variability)

- It uses its own methodology with a strong statistical basis

- It deals with defining **uncertainties**, it can only give a probabilistic statement about a number of phenomena

- Climatology is **not an experimental science** (it does not have a "laboratory"). At a given time and place, only one realization of the course of the weather is available.

- **Numerical models** play the role of "laboratory" in climatology

---

Data sources in contemporary climatology

- Meteorological observations and measurements
  - Stations point measurements
  - spatial fields (remote sensing, interpolation)
  - Meteorological variables, e.g. eir temperature
  - climatological characteristics, e.g. number of tropical days
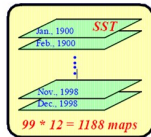 - climate indices, e.g. ENSO Index

- Model outputs (global, regional, local)
- Reanalyses
- Paleoclimatology proxy reconstructions

satellite climatology
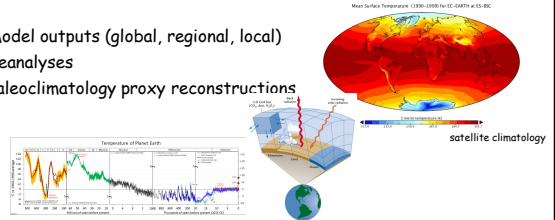
Data sources in climatology

- In most cases, data sources have a **multidimensional** character
- This requires the use of special data formats (**NetCDF**)

Jan. 1900   SST
Feb. 1900
⋮
Nov., 1998
Dec., 1998
99 * 12 = 1188 maps

PANOPLY

http://www.giss.nasa.gov/tools/panoply/.

Climate Explorer

https://climexp.knmi.nl/

KNMI Climate Explorer

Climate Explorer   European Climate Assessment & Data   KNMI

Help   News   About   Contact   Seasonal forecast verification   Climate Change Atlas

Starting point

Welcome, Petr Dobrovolný from Dept. of Geography, Masaryk Univ.

mean Nov CRU TS3.23 precipitation [mm/month]
1951-2000

Select a time series
- Daily station data
- Daily climate indices
- Monthly station data
- Monthly climate indices
- Annual climate indices
- View, upload your time series

Select a field
- Daily fields
- Monthly observations
- Monthly reanalysis fields
- Monthly and seasonal historical reconstructions
- Monthly seasonal hindcasts
- Monthly decadal hindcasts
- Monthly RCM runs
- Monthly CMIP3+ scenario runs
- Monthly CMIP5 scenario runs
- Annual CMIP5 extremes
- EC-Earth scenario runs
- External data (ensembles, ncep, enact, soda, ecmwf, ...)
- View, upload your field

Climate Explorer

- **interface to access large amounts of data**
- **a tool for climatological data analysis**
- **the possibility of analyzing own data files**

https://climexp.knmi.nl/registerform.cgi

WORLD METEOROLOGICAL ORGANIZATION
European Climate Assessment & Dataset   KNMI
Climate Explorer

Home   Help   News   About   World weather   Effects of ENSO   Climate Change Atlas

Home » Register or log in

Register or log in

Please register as a user so that I can trace usage of the system, and mail you if I find bugs. If you have already registered just give your e-mail address to log in. The service is also available anonymously, but some features (notably the ability to define your own indices, to upload your own data and to use large datasets) are then disabled. As a registered user many forms remember your settings for a few days.

Register / Log in
E-mail address dobro@sci.muni.cz
Name   your real name (only first time)
Institute   your institution (only first time)

register/log in

Select a time series
- Daily station data
- Daily climate indices
- Monthly station data
- Monthly climate indices
- Annual climate indices
- View, upload your time series

Select a field
- Daily fields
- Monthly observations
- Monthly reanalysis fields
- Monthly and seasonal historical reconstructions
- Monthly seasonal hindcasts
- Monthly CMIP3+ scenario runs
- Monthly CMIP5 scenario runs
- Annual CMIP5 extremes
- Monthly CMIP6 scenario runs
- Monthly CORDEX scenario runs
- Attribution runs
- View, upload your field

Climate Explorer

Selection of average monthly air temperatures from Brno, airport

Select a monthly time series
Historical observations

GHCN-M (adjusted)
- precipitation **2**
- mean temperature
- maximum temperature

GHCN-M (all)
- precipitation
- mean temperature
- minimum temperature
- maximum temperature
- sealevel pressure

other
- PSMSL, sealevel
- sealevel (JASL)
- world river discharge (RivDis)
- USA river discharge (HCDN)
- european SLP (ADVICE)
- N-America snowcourses (NRCB)

(full list)

Select stations
- stations with a name containing Brno **3**
- 10 stations near   °N °E (select on world map)
- all stations in the region °N - °N, °E - °E
- the stations with station numbers
  # lon1 lon2 lat1 lat2 (optional)
  station number (one per line)

Time, distance
At least 10 years of data in the monthly   season starting in any month   in years
at least   apart and with   m < elevation <

Get stations   Clear Form **4**

Select a time series
- Daily station data
- Daily climate indices **1**
- Monthly station data

Select a field
- Daily fields
- Monthly observations
- Monthly reanalysis fields
- Monthly and seasonal historical reconstructions
- Monthly seasonal hindcasts
- Monthly decadal hindcasts
- Monthly RCM runs
- Monthly CMIP3+ scenario runs
- Monthly CMIP5 scenario runs
- Annual CMIP5 extremes
- External data (ensembles, ncep, enact, soda, ecmwf, ...)
- View, upload your field

Found station data
monthly temperature station BRNO min 10

Aggregate this set of time series
Type: unweighted mean

Looking for stations with substring BRNO
Found 0 stations

BRNO/TURANY (CZECH REPUBLIC)
coordinates: 49.15N, 16.43E, 246m (probi: 302m)
WMO station code: 11723 (get data)
Associated with urban area (pop. 90000) **5**
Terrain: hilly COOL FOR./FIELD
Found 65 years with data in 1951-2015

Climate Explorer – analysis example

What is the spatial representativeness of the Brno temperature series?

Climate Explorer – analysis example

Climate Explorer as a data source

- **Observations – stations, fields**
  - **data, indices**
- **Proxy reconstructions**
- **Reanalysis**
- **Hindcasts**
- **Model outputs**
  - RCM
  - CMIP5

Climate Explorer as a data source

Reanalyses

- Reanalysis is an **objective** analysis of meteorological data applied backwards to the data and is also referred to as a method of physically consistent ("correct") interpolation.

- It links meteorological measurements and observations (unevenly spaced, less frequent in the past) with a numerical prediction model that provides a "physically consistent" state of the atmosphere.

- The connection is realized statistically (e.g. similar to LSM) with the use of the assimilation method (joining/linking) of data.

- Unlike weather forecasting, in which the forecast model is constantly evolving, reanalysis is performed using a uniform approach – the used assimilation scheme does not evolve (it is so-called "frozen"). This enables the use of reanalyses, for example, in the study of climate change.

- Outputs from reanalyses may also contain variables for which measurements are not available for the given period.

- Current reanalyses cover the entire Earth three-dimensionally (in several layers), usually with a 6-hour step

- In terms of time, some are available for the entire 20th century, also developing in paleoclimatology

Reanalyses

- Climate Explorer provides a simple interface allowing access to reanalyses at daily or monthly resolution
- It also enables their visualization and basic processing

Illustrative video
https://www.youtube.com/watch?v=FAGobvUGl24

Further info
https://reanalyses.org/

https://www.ecmwf.int/en/research/climate-reanalysis

World Weather

Climate Change Atlas

Climate Change Atlas

Temperature Czech Rep. Jun-Aug AR5 CMIP5 subset. On the left, for each scenario one line per model is shown plus the multi-model mean, on the right percentiles of the whole dataset: the box extends from 25% to 75%, the whiskers from 5% to 95% and the horizontal line denotes the median (50%).

Climate Change Atlas

IPCC WGI Interactive Atlas

https://interactive-atlas.ipcc.ch/

Another data sources

European Climate Assessment & Dataset project http://www.ecad.eu/ **(ECA&D)**

Another data sources

Copernicus Climate Change Service https://climate.copernicus.eu/

Another data sources

Climatic Research Unit (CRU) http://www.cru.uea.ac.uk/

Another data sources

NOAA – National Centers for Environmental Information

https://www.ncdc.noaa.gov/