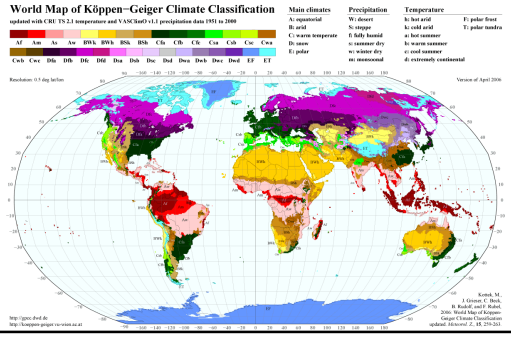
Methods in climatology

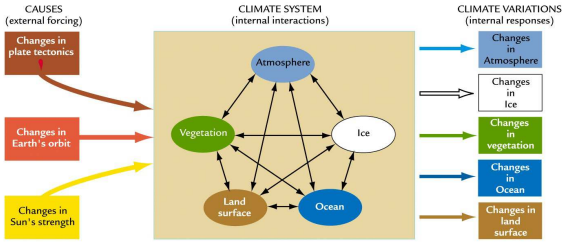
I. Introduction, data sources

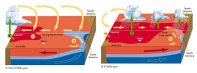
Climate and climatology

- Climate = weather statistics
- Climatology data – „average" of meteorological data
- Methods in climatology – descriptive statistics



Climate system





- Dynamic equilibrium
- Internal variability
- Positive/negative feedbacks
- Interactions on different time/space scales
- Non-linear relationships – small changes may cause big consequences

Contemporary climatology

- High complexity
- Stochastic nature of climate
- Dealing with uncertainty
- New data sources:
  - palaeoclimatology
  - satellite climatology
  - climate modelling

Rozměr klimatického systému, časová a prostorová proměnlivost klimatu

Složitost úplného klimatického systému i jeho subsystémů se odráží v značné časové a prostorové proměnlivosti hodnot meteorologických prvků a jejich klimatologických charakteristik

V praktických aplikacích se zabýváme částmi úplného klimatického systému. Popisujeme ho typickými hodnotami meteorologických prvků resp. jejich klimatologických charakteristik (rozměr globální, regionální, mezo, topo, mikro, rozměr hraničních vrstev).

Kategorie časové proměnlivosti klimatu

- sekulární
- interannuální
- sezónní
- interdiurní
- jiná (geologických dob, ….i řád minut)

Kategorie prostorové proměnlivosti klimatu

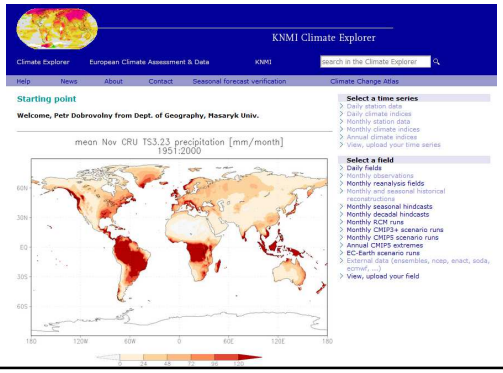
- globální
- regionální
- topická až chorická
- jiná

Climatology data sources

- Observations
  - stations (points)
  - fields (interpolated, remotely sensed)
  - meteorological variables
  - climate indices (e.g. NAO Index)
- Proxy reconstructions (also spatial)
- Reanalyses
- Hindcasts
- Model outputs (global, regional)

Data sources – some examples

Climate Explorer https://climexp.knmi.nl/

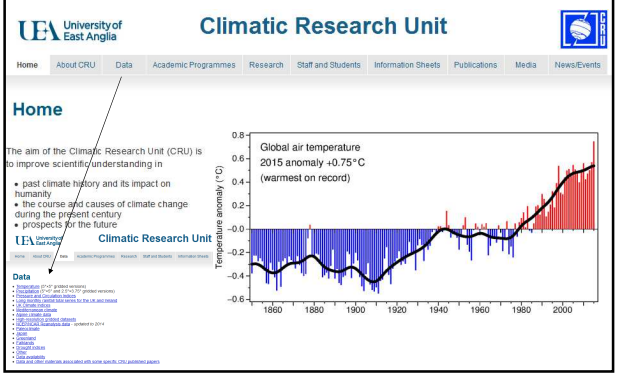


Další zdroje dat

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

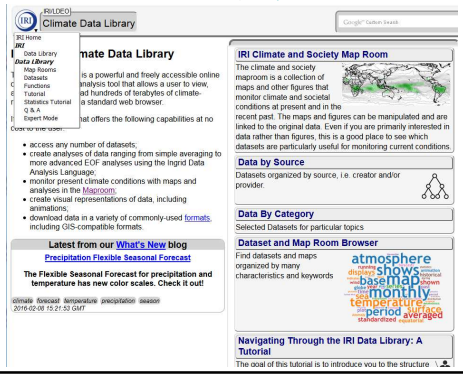
Další zdroje dat

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



Další zdroje dat

IRI/LDEO Climate Data Library http://iridl.ldeo.columbia.edu/



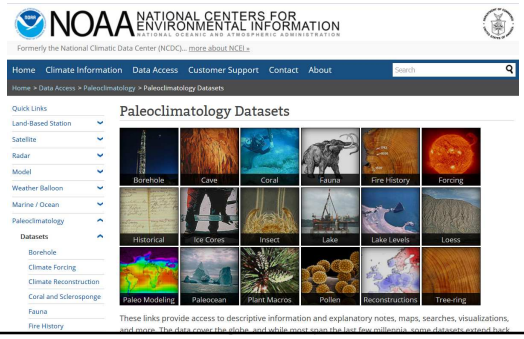
Další zdroje dat

BADC – The British Atmospheric Data Centre
http://badc.nerc.ac.uk/home/index.html

Další zdroje dat

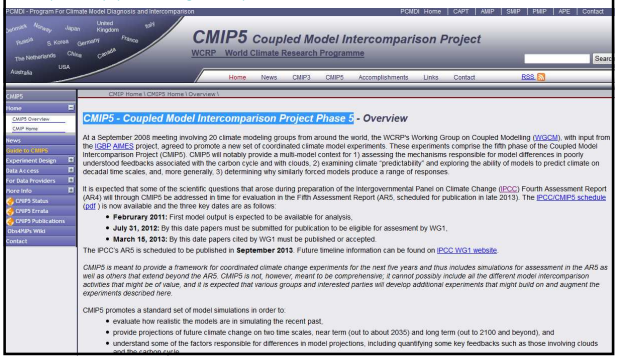
NOAA – National Centers for Environmental Information

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



Další zdroje dat

CMIP5 - Coupled Model Intercomparison Project Phase 5
http://cmip-pcmdi.llnl.gov/cmip5/

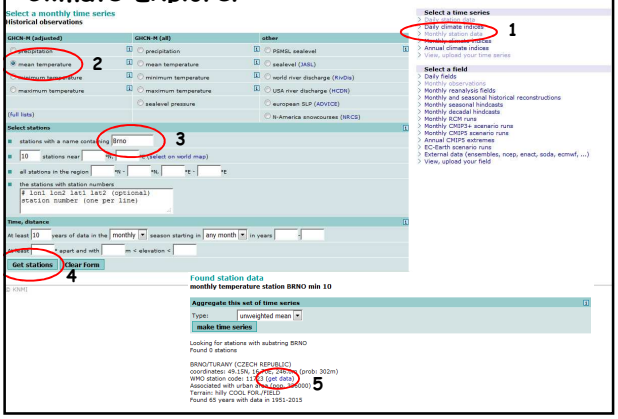


Climate Explorer

- rozhraní pro přístup k velkému množství dat
- nástroj pro analýzu klimatických dat
- možnost analýz vlastních datových souborů

Climate Explorer

Výběr řady průměrných měsíčních teplot vzduchu z Brna, Tuřan



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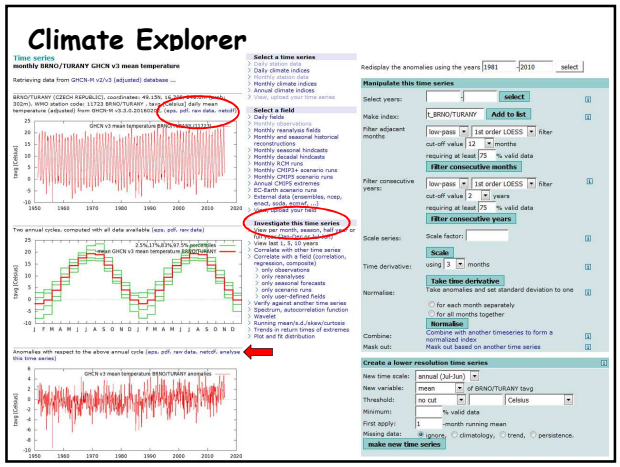

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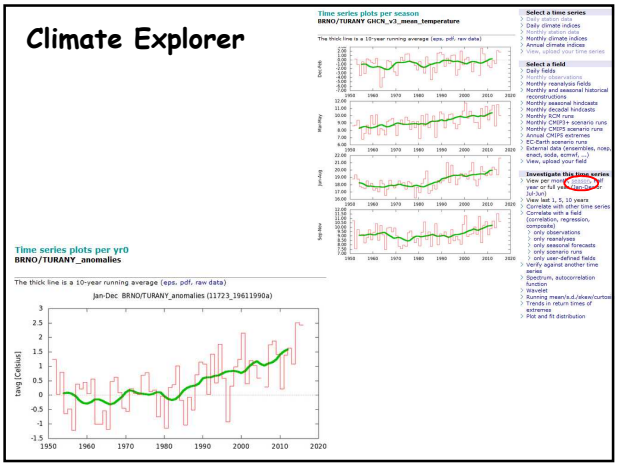
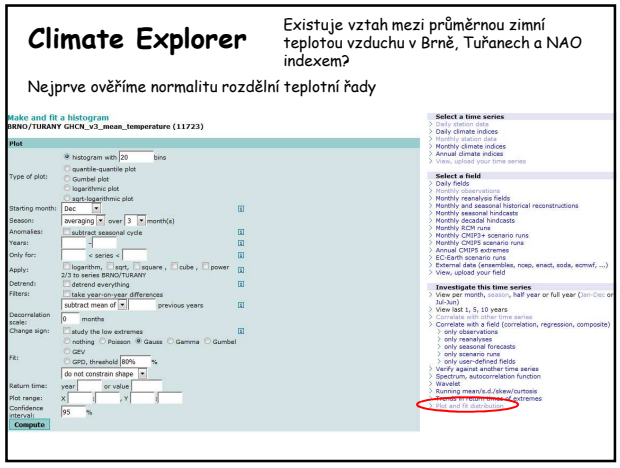


Climate Explorer

Existuje vztah mezi průměrnou zimní teplotou vzduchu v Brně, Tuřanech a NAO indexem?

Nejprve ověříme normalitu rozdělní teplotní řady



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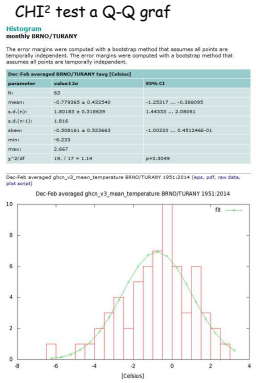
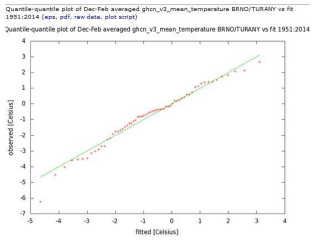
CHI² test a Q-Q graf





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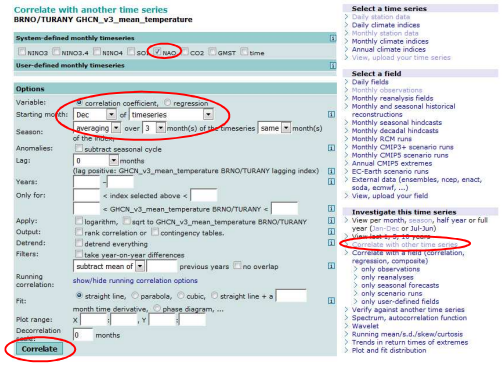

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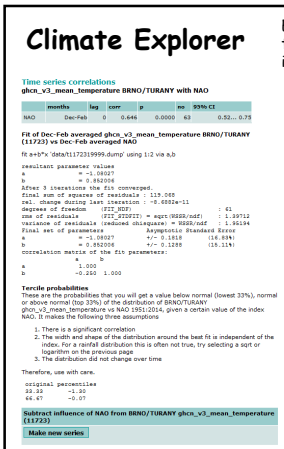
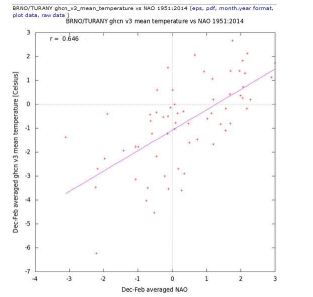
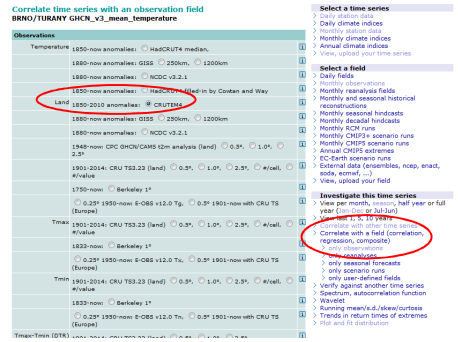




Climate Explorer

Jaká je prostorová reprezentativnost brněnské teplotní řady?



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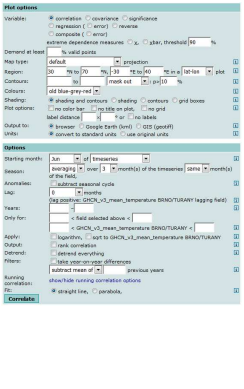
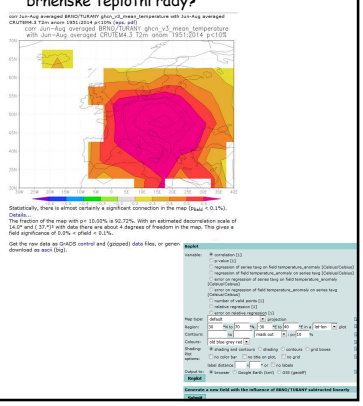
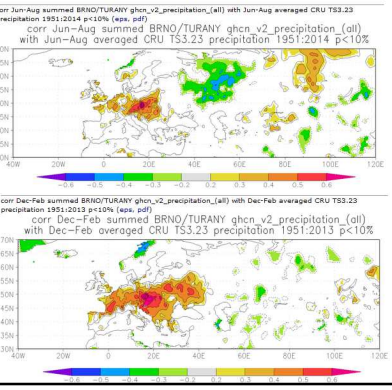




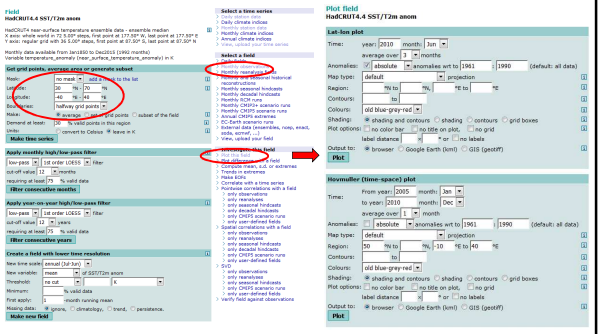
Climate Explorer

- prostorová korelace - srážky
- telekonekce



Climate Explorer

Analýza polí meteorologických prvků / klimatologických charakteristik



Climate Explorer

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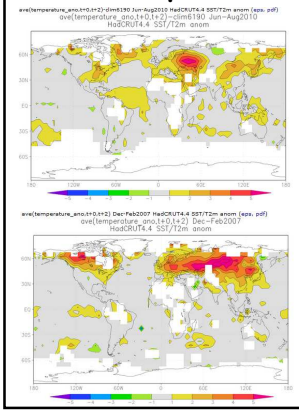
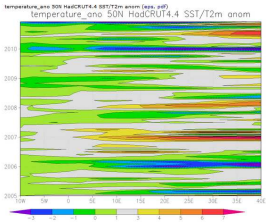
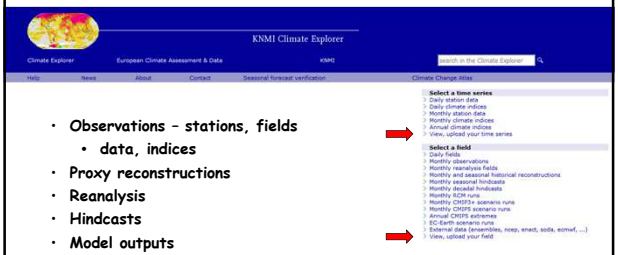




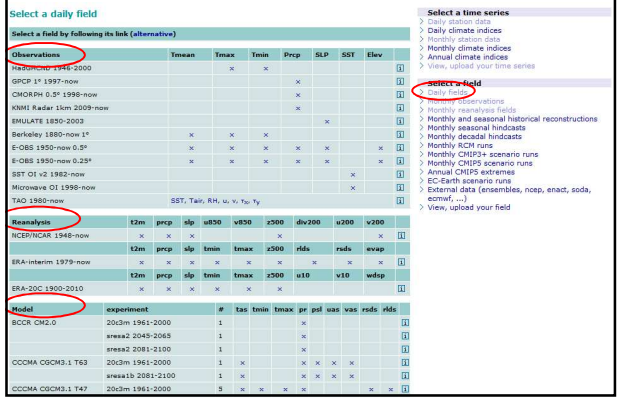
Hovmöller (time-space) diagram

Climate Explorer – datové zdroje



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

Climate Explorer – datové zdroje



Data sources - reanalyses

- **Reanalysis** is a scientific method for developing a comprehensive record of how weather and climate are changing over time. In it, observations and a numerical model that simulates one or more aspects of the Earth system are combined objectively to generate a synthesized estimate of the state of the system.
- A reanalysis typically extends over several decades or longer, and covers the entire globe from the Earth's surface to well above the stratosphere.
- Reanalysis products are used extensively in climate research and services, including for monitoring and comparing current climate conditions with those of the past, identifying the causes of climate variations and change, and preparing climate predictions.
- Information derived from reanalyses is also being used increasingly in commercial and business applications in sectors such as energy, agriculture, water resources, and insurance.

https://reanalyses.org/

- NCEP/NCAR Reanalysis
- ECMWF re-analysis (ERA-40, ERA-Interim)

https://reanalyses.org/atmosphere/comparison-table

Data sources - reanalyses

Reanalysis a systematic approach to produce data sets for climate monitoring and research. Reanalyses are created via an unchanging ("frozen") data assimilation scheme and model(s) which ingest all available observations every 6-12 hours over the period being analyzed. This unchanging framework provides a dynamically consistent estimate of the climate state at each time step. The one component of this framework which does vary are the sources of the raw input data. This is unavoidable due to the ever changing observational network which includes, but is not limited to, radiosonde, satellite, buoy, aircraft and ship reports. Currently, approximately 7-9 million observations are ingested at each time step. Over the duration of each reanalysis product, the changing observation mix can produce artificial variability and spurious trends. Still, the various reanalysis products have proven to be quite useful when used with appropriate care.

Global data sets, consistent spatial and temporal resolution over 3 or more decades, hundreds of variables available; model resolution and biases have steadily improved Reanalyses incorporate millions of observations into a stable data assimilation system that would be nearly impossible for an individual to collect and analyze separately, enabling a number of climate processes to be studied Reanalysis data sets are relatively straightforward to handle from a processing standpoint (although file sizes can be very large)

Observational constraints, and therefore reanalysis reliability, can considerably vary depending on the location, time period, and variable considered The changing mix of observations, and biases in observations and models, can introduce spurious variability and trends into reanalysis output Diagnostic variables relating to the hydrological cycle, such as precipitation and evaporation, should be used with extreme caution

Data sources - hindcasts (backtesting)

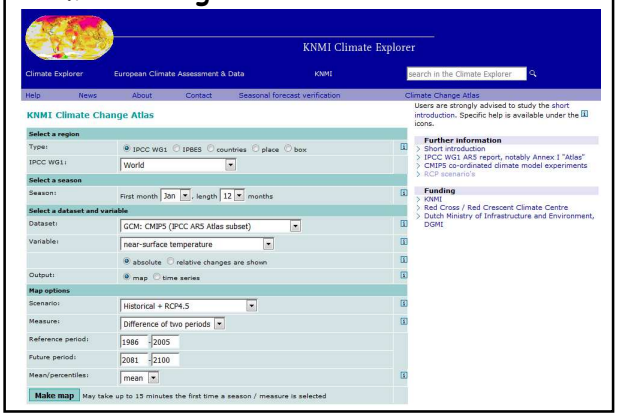
- testing a predictive model using existing historic data
- a statistical calculation determining probable past conditions
- hindcasting usually refers to a numerical model integration of a historical period where **no observations have been assimilated**. This distinguishes a hindcast run from a reanalysis.

http://www.oceanweather.com/research/HindcastApproach.html

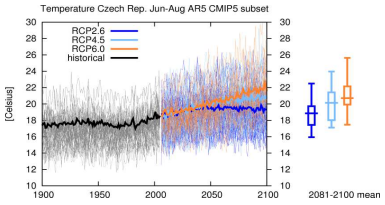
Data sources – Model simulations

- CMIP5 – Coupled Model Intercomparison Project
- RCM - ENSEMBLES

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%).