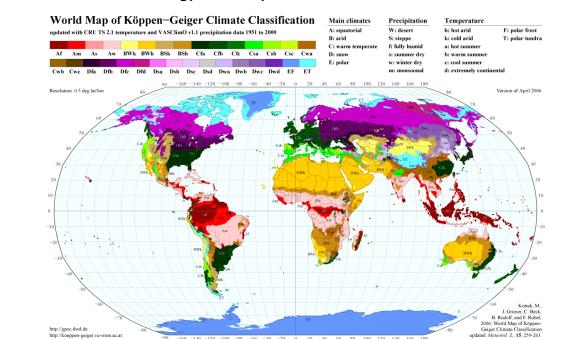


Methods in climatology

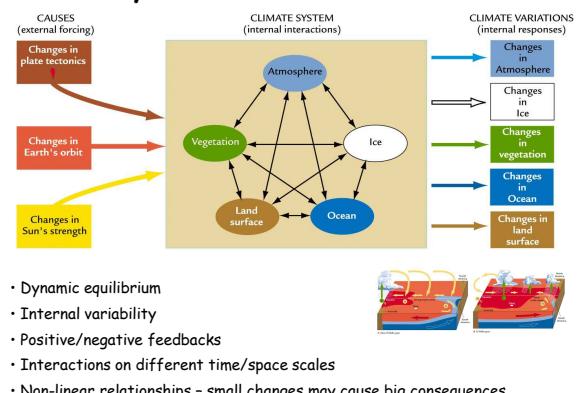
I. Introduction, data sources



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

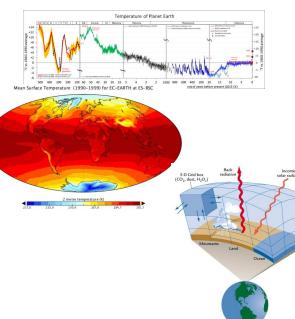


Climate system



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 odraží 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 hranících vrstev).

- sekulární
- interannuální
- sezónní
- interdiurní
- jiná (geologických dob, Řad minut)

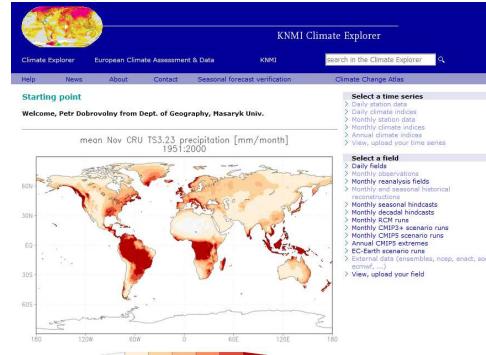
- globální
- regionální
- topická až chorická
- jiná

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)

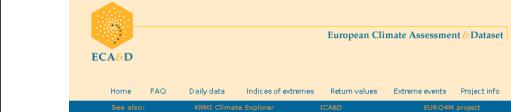
Data sources - some examples

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



Další zdroje dat

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



Home

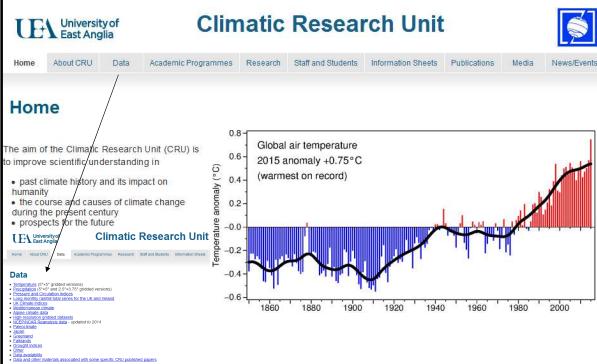
Welcome to the website of the European Climate Assessment & Dataset project. Presented is information on changes in weather and climate extremes, as well as the daily dataset needed to monitor and analyse these extremes. ECA&D was initiated by the ECN in 1998 and has received financial support from the EURECNET and the European Commission.

What's new?

The database is updated until Dec 31, 2015.
19 February 2016 - The January 2016 update has been delayed until March 2015 due to technical problems.
December 2015 - 2015 is the joint warmest year on record. It has been very slightly warmer than 2014, which used to be exceptionally warm December.
November 2015 - The Spanish Meteorological Service Aemet now updates its stations each month. The latest update in November 2015 - The Czech HydroMeteorological Institute CHMI has shared 65 new stations and updates these monthly.
October 2015 - E-OBS version 12.0 has been released.
[All news items](#)

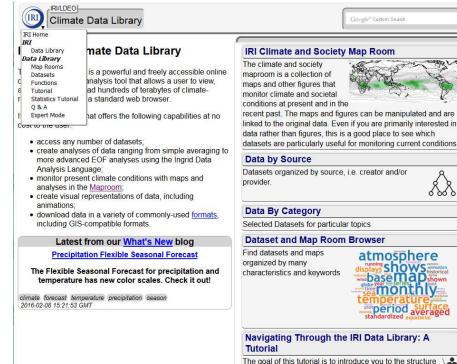
Další zdroje dat

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



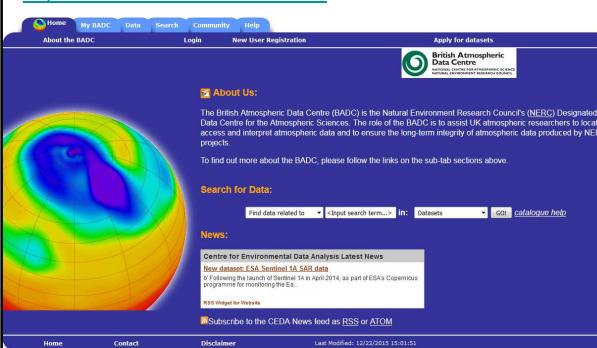
Další zdroje dat

IRI/LDEO Climate Data Library <http://iri.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/>

At a September 2010 meeting involving 20 climate modeling groups from around the world, the WCRP Working Group on Coupled Modelling (WGCM), with input from the GFDL AMIP project, agreed to provide a new set of coordinated climate model experiments. These experiments comprise the fifth phase of the Coupled Model Intercomparison Project (CMIP5). CMIP5 will notably provide a multi-model context for 1) assessing the mechanisms responsible for model differences in poorly understood feedbacks associated with the carbon cycle and with clouds; 2) examining climate "predictability"; and exploring the ability of models to predict climate on seasonal time scales, and more generally forced models to simulate a range of responses.

It is expected that some of the scientific questions that arise during the development of the intercomparison will be addressed in the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4) with CMIP5 being addressed in time for evaluation in the Fifth Assessment Report (AR5, scheduled for publication in late 2013). The [IPCC-CMIP5 website](#) (IPCC) is now available, and the three key dates are as follows:

- February 2011: All CMIP5 data must be available for analysis.
- July 31, 2012: By this date papers must be submitted for publication to be eligible for assessment by WG1.
- March 15, 2013: By this date papers cited by WG1 must be published or accepted.

The IPCC AR5 is scheduled to be published in [September 2013](#). Future climate information can be found on [IPCC WG1 website](#).

CMIP5 is meant to provide a framework for coordinated climate change experiments for the next years and thus includes simulations for assessment in the AR5 as well as others that are beyond the AR5. CMIP5 is not, however, meant to be comprehensive. It cannot possibly include all the different model intercomparison experiments that may be of value, and it is expected that various groups and interested parties will develop additional experiments that might be run on augment the experiments described here.

CMIP5 promotes a standard set of model simulations in order to:

- evaluate how realistic the models are in simulating the recent past.
- provide projections of future climate change on time scales, near term (out to about 2030) and long term (out to 2100 and beyond), and
- understand some of the factors responsible for differences in model projectors, including quantifying some key feedbacks such as those involving clouds and land vegetation.

Climate Explorer



KNMI Climate Explorer

Please register as a user so that I can track usage of the system, and mail you if I find bugs. If you have already registered, just give me your e-mail address and I will add you to the system. You can log in later. You also have the option to upload your own data. If you upload your own data and use large datasets (e.g. monthly historical reconstructions) you can't use the system until you have finished. You also have the option to upload your own data.

Register or log in

E-mail address: [your e-mail address] Name: [your real name (only first name)] Institute: [your institution (only first name)] [register/log in](#)

Select a time series

Daily climate indices
Monthly mean
Monthly seasonal historical reconstructions
Monthly seasonal historical
Monthly decadal
Monthly CHIPI+ scenario runs
Monthly CHIPI+ scenario
Annual CHIPS extremes
EC-Earth scenario runs
External data (ensemble, ncep, reanalysis, cmip3, cmip4, cmip5, ...)
View, upload your time series

Select a field

Daily fields
Monthly mean
Monthly seasonal fields
Monthly seasonal historical reconstructions
Monthly seasonal historical
Monthly decadal
Monthly CHIPS scenario runs
Monthly CHIPS scenario
Annual CHIPS extremes
EC-Earth scenario runs
External data (ensemble, ncep, reanalysis, cmip3, cmip4, cmip5, ...)
View, upload your field

Select a year

Redisplay the anomalies using the years [1981-2010] [select](#)

Manipulate this time series

Select years: [\[\] select](#) Make index: [\[\] BRNO/TURANY](#) [\[\] select](#) Filter adjacent months: low-pass: [\[\] 1st order LOESS](#) [\[\] filter](#) cut-off value: [\[\] 12 months](#) requiring at least [\[\] 75 % valid data](#)

Filter consecutive years: low-pass: [\[\] 1st order LOESS](#) [\[\] filter](#) cut-off value: [\[\] 2 years](#) requiring at least [\[\] 75 % valid data](#)

Scale series: Scale factor: [\[\]](#) Time derivative: Take time derivative: [\[\]](#) Normalise: [\[\]](#) Compose: [\[\]](#) Mask out: [\[\]](#)

Time derivative: Take time derivative: [\[\]](#) Normalise: [\[\]](#) Compose: [\[\]](#) Mask out: [\[\]](#)

Normalise: [\[\]](#) Compose: [\[\]](#) Mask out: [\[\]](#)

Create a lower resolution time series

New time scale: [\[\]](#) New variable: [\[\]](#) Mean: [\[\]](#) of: [\[\]](#) BRN/TUR/NAO [\[\] Celsius](#) Threshold: no out: [\[\]](#) % valid data Minimum: [\[\]](#) First apply: [\[\]](#) month running mean Missing data: [\[\] ignore](#), [\[\] climatology](#), [\[\] trend](#), [\[\] persistence](#) [\[\] make new time series](#)

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

Climate Explorer

Select a monthly time series

Historical adjustments

GRCH-M (adjusted)

1. **mean temperature** (selected)

2. **minimum temperature** (selected)

maximum temperature

(full lists)

Select stations

3. **stations with a name containing 'Brno'** (selected)

10 stations near **Brno** (selected on world map)

all stations in the region: **Brno** (selected)

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 []

Get stations [Clear form](#) 4. [Found station data](#)

Found station data: monthly temperature station BRNO min 10

Aggregate this set of time series

Type: unweighted mean [make time series](#)

Found for stations with substring BRNO

Found for stations with substring TURANY

BRNO/TURANY (CZECH REPUBLIC) coordinates: 49.15N, 16.4E elevation: 492m Associated with urban area: [Brno](#) (see data) 5. Found 50 years with data in 1951-2015

Climate Explorer

Time series plots per season

BRNO/TURANY GRCH_v2_mean_temperature

The thick line is a 10-year running average (eps, pdf, raw data)

Time series plots per yr

BRNO/TURANY_anomalies

The thick line is a 10-year running average (eps, pdf, raw data)

Jan-Dec BRNO/TURANY_anomalies (33723_19511990a)

Time series plots per yr

BRNO/TURANY_anomalies

The thick line is a 10-year running average (eps, pdf, raw data)

Jan-Dec BRNO/TURANY_anomalies (33723_19511990a)

Investigate this time series

1. **histogram with 20 bins** (selected)

2. **scatter** (selected)

3. **line** (selected)

4. **time series** (selected)

5. **plot and fit distribution** (selected)

6. **return times** (selected)

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364. **return times of extremes** (selected)

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389. **return times of extremes** (selected)

390. **return times of extremes** (selected

Climate Explorer

CHI² test a Q-Q graf

Histogram
BRNO/TURANY

The error margins were computed with a bootstrap method that assumes all points are temporally independent. The error margins were computed with a bootstrap method that assumes all points are spatially independent.

Dec-Feb averaged ghm_v3_mean,temperature	BRNO/TURANY	
parameter	Value (Std. Err.)	95% CI
mean	-0.779345 ± 0.055454	-1.25517 ± -0.308695
s.e.(z)	1.8018 ± 0.136039	1.40283 ± 2.08981
skew	-0.000144 ± 0.000144	-0.000144 ± 0.000144
kurt	3.007 ± 0.000144	2.996 ± 0.000144
max	2.667	2.667
x ² /df	16. / 17 = 1.4	= 0.3249

Dec-Feb averaged ghm_v3_mean,temperature BRNO/TURANY 1951-2014 (noo, off, raw data, plus weight)

Dec-Feb averaged ghm_v3_mean,temperature BRNO/TURANY 1951-2014 ft

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

Quantile-quantile plot of Dec-Feb averaged ghm_v3_mean,temperature BRNO/TURANY vs ft 1951-2014 (noo, off, raw data, plus weight)

Quantile-quantile plot of Dec-Feb averaged ghm_v3_mean,temperature BRNO/TURANY vs ft 1951-2014

Climate Explorer

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

Correlate with another time series

BRNO/TUŘANY GHCN_V3_mean_temperature

System-defined monthly timeseries

NINCO NINCO-3.4 SOI NAO CO2 GMST time

User-defined monthly timeseries

Options

Variable: correlation coefficient, regression

Starting month: Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

Seasons: all seasons over [3] (months) of the timeseries same [month(s)] of the previous year

Anomalies: subtract seasonal cycle

Leg: 0 months

Years: lag position: $\text{GHCN}_V_3\text{-mean_temperature BRNO/TUŘANY lagging index}$

Only for: <input checked="" type="checkbox"/> index selected above <input checked="" type="checkbox"/> $\text{GHCN}_V_3\text{-mean_temperature BRNO/TUŘANY}$

Apply: right to $\text{GHCN}_V_3\text{-mean_temperature BRNO/TUŘANY}$ left to $\text{GHCN}_V_3\text{-mean_temperature BRNO/TUŘANY}$ contingency tables.

Output: raw data correlation matrix scatter plot

Detailed: detailed everything

Filters: latest year-on-year difference

Running correlations: subtract mean of [3] previous years no overlap show/hide running correlation options

Fit: straight line + parabola cubic straight line + a month time derivative phase diagram, ...

Plot range: 0 months

Decomposition: Correlate

Select a time series

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

Search a field

Daily fields Monthly observations Monthly Climate Fields Monthly seasonal historical Monthly seasonal forecast Monthly seasonal hindcasts Monthly decadal hindcasts Monthly decadal forecasts Monthly extremes Annual CMIP5 extremes Annual CMIP6 extremes External data (ensembles, nope, enact, scad, zoom, ...)

View, upload your field

Investigate this time series

View per month, season, half year or full year View per decade Correlate with a data (correlation, regression, comparison) Correlate with others (time, ...) only reanalysis only observational forecasts only scenario runs Correlate with daily fields Verify against another time series View spectrum Running means/std./skew/kurtosis Trend analysis Plot of extremes Plot fit and distribution

Climate Explorer

Time series correlations
ghcn_v3_mean_temperature BRNO/TURANY with NAO

months	lag	corr	p	no	95% CI	
MAO	Dec-Jan	0	0.644	0.0000	63	0.52..0.75

Fit of Dec-Feb averaged ghcn_v3_mean_temperature BRNO/TURANY vs MAO

```
fz=xts(x=dat$MAO,y=dat$TURANY,order=1) fit=lm(y~fz)
```

Fit of Dec-Feb averaged ghcn_v3_mean_temperature BRNO/TURANY vs MAO

fit=xts(x=dat\$MAO,y=dat\$TURANY,order=1) fit=lm(y~fz)

residuals versus fitted values

DATOS(TURANY) ghcn_v3_mean_temperature vs MAO 1951/2014 (text, zdf, monthyear format, plot data, raw data)

TURANY(ghcn_v3_mean_temperature vs MAO 1951/2014)

Final set of parameters : Asymptotic Standard Error

estimate	standard error	t-value	p-value
0.892027	0.000000	44.11	0.1298
correlation matrix of the fit parameters:			
a	b		
1.000	-0.205		

These probabilities are the probabilities that you will get a value below (lower 33%), normal or above normal (top 33%) of the distribution of BRNTURANY given the estimated value of the index NAO. It makes the following three assumptions

1. The width and shape of the distribution around the fit is independent of the value of the index NAO.
2. The logit transformation is often not true, try selecting a sort of logarithm on the previous page.
3. The distribution did not change over time

There were 63 observations

critical percentiles

critical percentile	value
22.22	-1.00
44.44	-0.70
66.67	-0.40

Subtract influence of NAO from BRNO/TURANY ghcn_v3_mean_temperature (11723)

Make new series

Climate Explorer

- prostorová korelace - srážky
- telekonekce

corr Jun-Aug summed BRNO/TURANY ghcn_v2_precipitation_(all) with Jun-Aug averaged CRU TS3.23 precipitation 1951-2014 p<10% (eos, pdf)

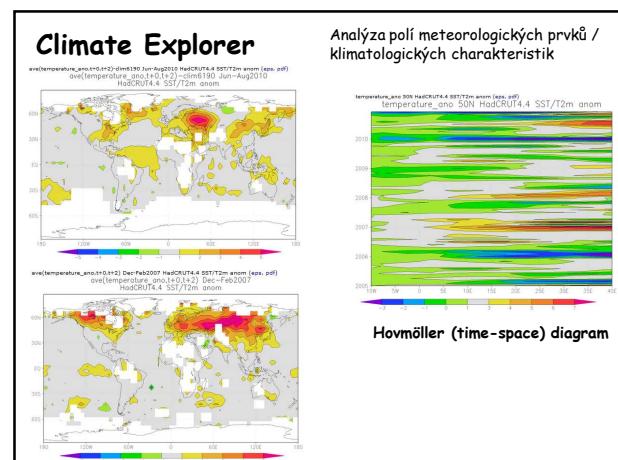
corr Jun-Aug summed BRNO/TURANY ghcn_v2_precipitation_(all) with Jun-Aug averaged CRU TS3.23 precipitation 1951-2014 p<10%

70N
60N
50N
40N
30N
40W 20W 0 20E 40E 60E 80E 100E 120E

corr Dec-Feb summed BRNO/TURANY ghcn_v2_precipitation_(all) with Dec-Feb averaged CRU TS3.23 precipitation 1951-2013 p<10% (eos, pdf)

corr Dec-Feb summed BRNO/TURANY ghcn_v2_precipitation_(all) with Dec-Feb averaged CRU TS3.23 precipitation 1951-2013 p<10%

70N
65N
60N
55N
50N
45N
40N
35N
30N
40W 20W 0 20E 40E 60E 80E 100E 120E



Climate Explorer - datové zdroje



KNMI Climate Explorer

Climate Explorer European Climate Assessment & Data KNMI Search in the Climate Explorer Search

Help News About Contact Seasonal forecast verification Climate Change analysis

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

Selected field series
• Daily station data
• Daily climate indices
• Monthly station data
• Monthly climate indices
• Monthly climate extremes
• View, upload your time series
Select a field
• Daily station data
• Monthly observations
• Reanalysis
• Reanalysis fields
• Monthly and seasonal historical reconstructions
• Monthly historical
• Monthly decadal hindcasts
• Monthly projections
• Monthly CHIRPS+ seasons runs
• Monthly CHIRPS projections
• Annual CHIRPS extremes
• CHIRPS
• External data (ensembles, ncep, enak, sode, ecmwf, ...)
View, upload your field

Climate Explorer - datové zdroje											
Select a daily field											
Select a field by following its link (alternative)											
Observations											
	Tmean	Tmax	Tmin	Pcp	SLP	SST	Elev				
HadISST1.1: 1946-2000		x	x								
GHCN: 1.5t 1997-now					x						
CHORR: 0.5t 1998-now					x						
KMID: HadISST 2009-now					x						
CMAP: 1850-2000						x					
Berkely: 1880-2010 t ⁴	x	x	x								
E-OBS: 1550s-now t ⁵	x	x	x	x	x	x		x			
ECS: 1550s-now t ⁵	x	x	x	x	x	x		x			
SET-OI v2 1985-now						x					
Microwave OI: 1990-now						x					
TAO: 1860-now				SST, Tair, RH, u _t , v _t , Tg, Ty							
Reanalysis											
	t2m	prcp	slp	u850	v850	z500	div200	u200	v200		
NCEP/NCAR: 1948-now	x	x			x			x	x		
	t2m	prcp	slp	tmin	tmax	z500	rlds	rsds	ewav		
ERA-interim: 1979-now	x	x	x	x	x	x	x	x	x		
	t2m	prcp	slp	tmin	tmax	z500	u10	v10	wdwp		
ERA-20C: 1900-2010	x	x	x	x	x	x	x	x	x		
Model											
	experiment	#	tas	tmin	tmax	pr	psl	vas	vas	rlds	rlds
BCCR CM2.0	203cm 1941-2000	1	x								
	stress2 2040-2065	1	x								
	stress2 2081-2100	1	x								
COCMA CGCM3.1 T63	203cm 1961-2000	1	x		x	x	x	x	x		
	stress2 2081-2100	1	x		x	x	x	x	x		
CCCM4 CGCM3.1 T47	203cm 1961-2000	5	x	x	x			x	x		

Data sources - reanalyses

- **Reranalysis** is a scientific method for developing a comprehensive record of how weather and climate are changing over time.
 - 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.
 - Reranalyses 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.
 - A reranalysis typically extends over several decades or longer, and covers the entire globe from the Earth's surface to well above the stratosphere.
 - NCEP/NCAR Reranalysis
 - ECMWF re-analysis (ERA-40, ERA-Interim)

<https://reanalyses.org/>

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

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>

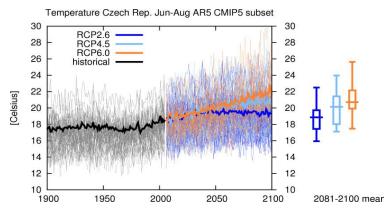
Data sources - Model simulations

- CMIP5 - Coupled Model Intercomparison Project
- RCM - ENSEMBLES

Climate Change Atlas

The screenshot shows the KNMI Climate Explorer interface with the 'Climate Change Atlas' section selected. The interface includes a search bar, navigation links (Help, News, About, Contact, Seasonal forecast verification), and a 'Climate Change Atlas' header with a small sun icon. The main area contains several dropdown menus and input fields for selecting a region (IPCC WG1, IPBES, countries, place, box), season (first month Jan to length 12 months), dataset (GCM: CMIP5 (IPCC AR5 Atlas subset)), variable (near-surface temperature), and output type (map or time series). There are also sections for scenario selection (Historical + RCP4.5), measure (Difference of two periods), reference period (1986-2005), future period (2081-2100), and mean/percentiles (mean). A 'Make map' button is at the bottom.

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

The screenshot shows the KNMI Climate Explorer interface with the 'Climate Change Atlas' section selected. The main area displays a map of Europe with color-coded contours representing precipitation changes. A legend at the bottom indicates values from -2 to 2 mm/dy. The map shows significant spatial variability, with higher increases in the northern and central parts of the continent. The interface includes the same navigation and selection options as the previous screenshot.