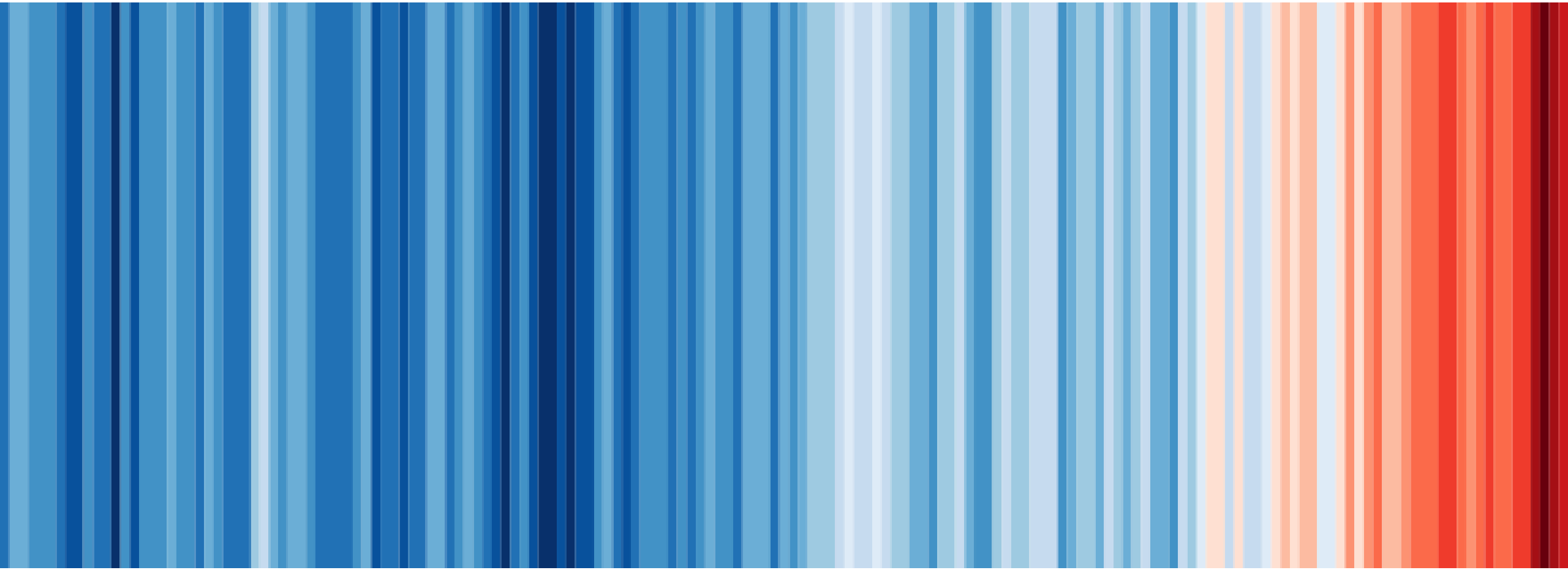
MUNI
SCI

03 Climatological data



Jan Řehoř, MSc, PhD

Content

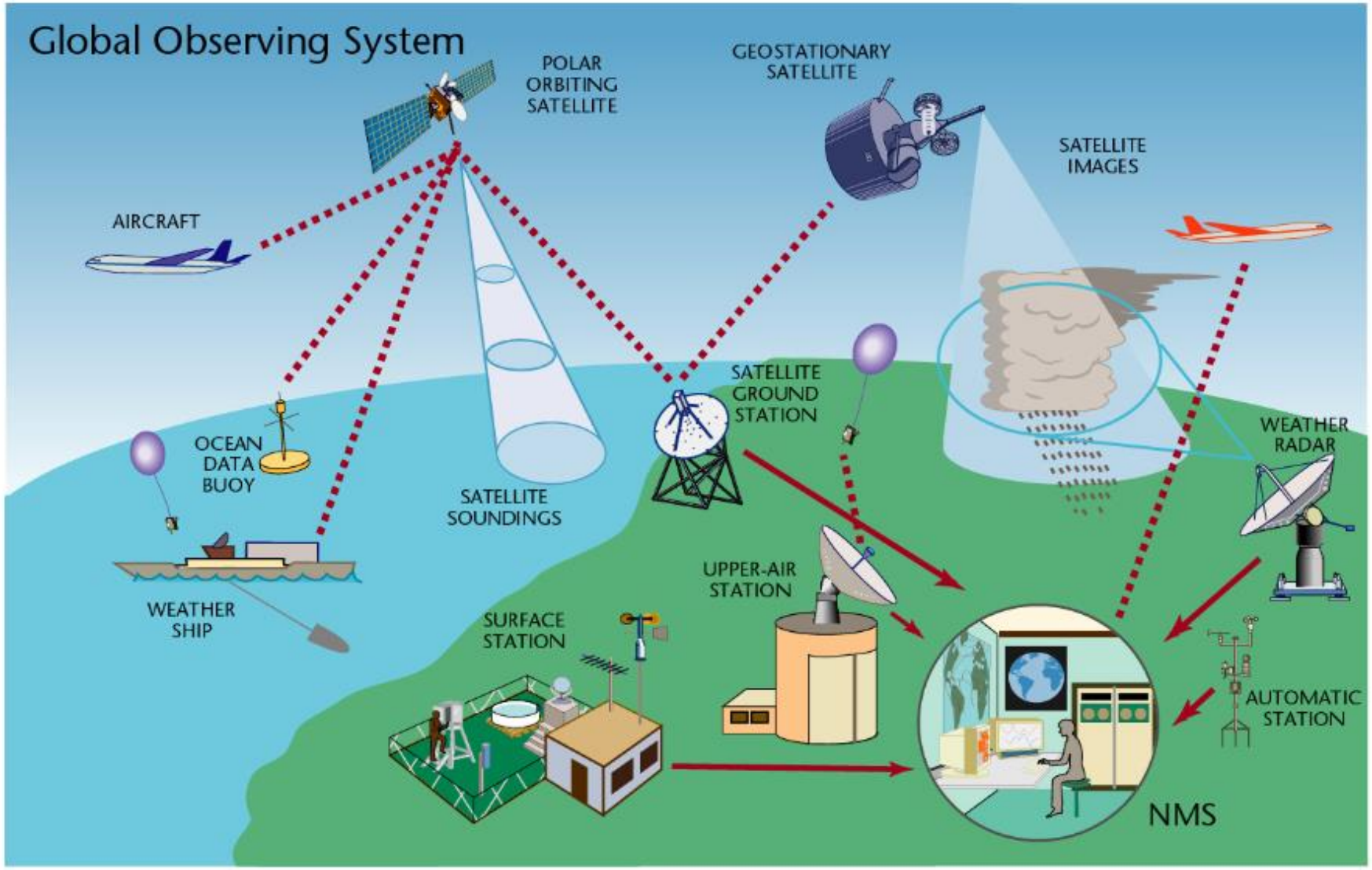
1. Global observing system
2. Atmospheric reanalysis
3. Climatological data sources
4. Climate data processing
5. Climate normals
6. Climate data visualization

Atmospheric data acquisition

- **Remote sensing**
  - Meteorological satellites (polar orbits / gestationary)
  - Weather radars
  - Lightning detection
  - Weather balloons – radiosondes
  - Aircraft

- **Surface weather observations**
  - Weather station (manual / automated weather station)
  - Ocean data buoys, ships, etc.

Global observing system



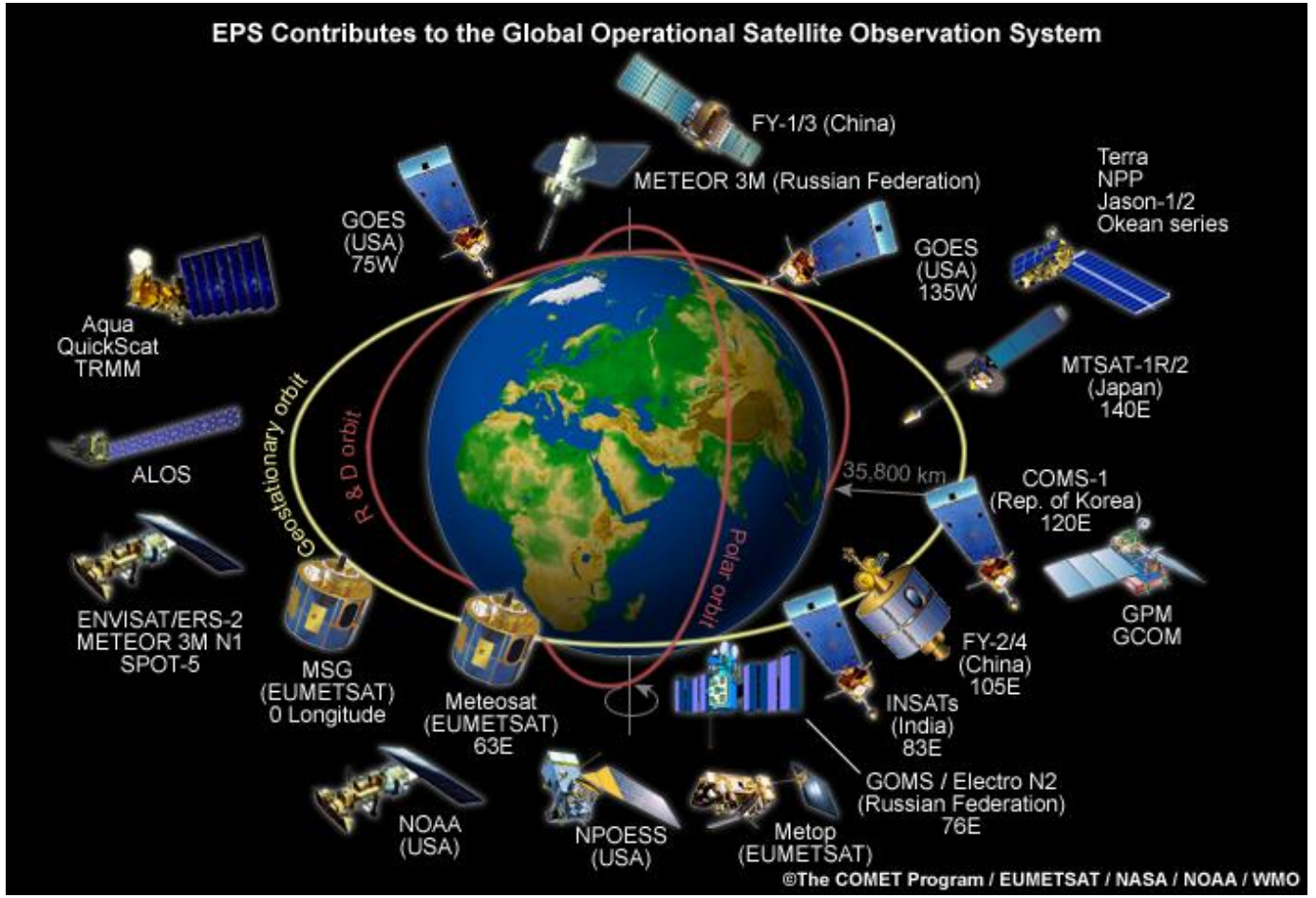
- remote sensing observations
- surface weather observations (in situ)

https://community.wmo.int/en/observation-components-global-observing-system

Observations from space – weather sattelites

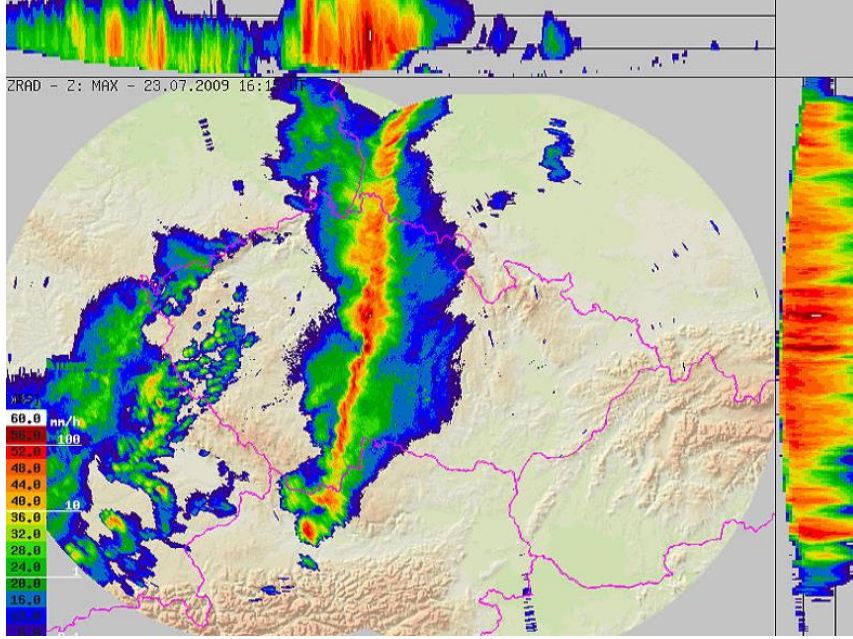
- Geostationary satellites
  - 35,785 km
  - Static position
- Polar orbiting satellites
  - Meridional tracks
  - Lower 100s of km

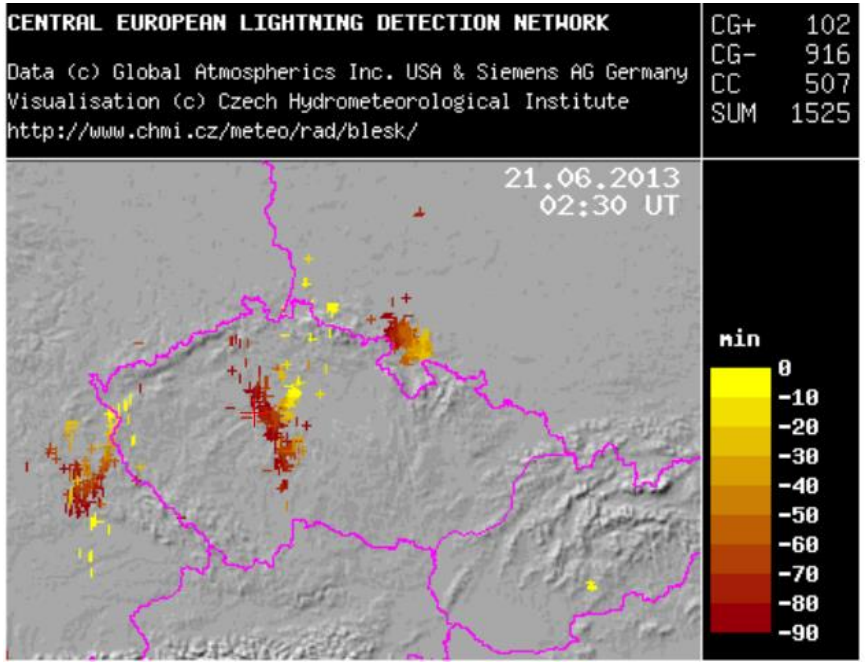
Category 5 Hurricane Iota seen from GOES-16 (GOES East) on November 16, 2020.



http://portal.chmi.cz/files/portal/docs/meteo/sat/data_jsmsgview.html ; https://www.metlink.org/resource/satellites/

Weather radars + lightning detection

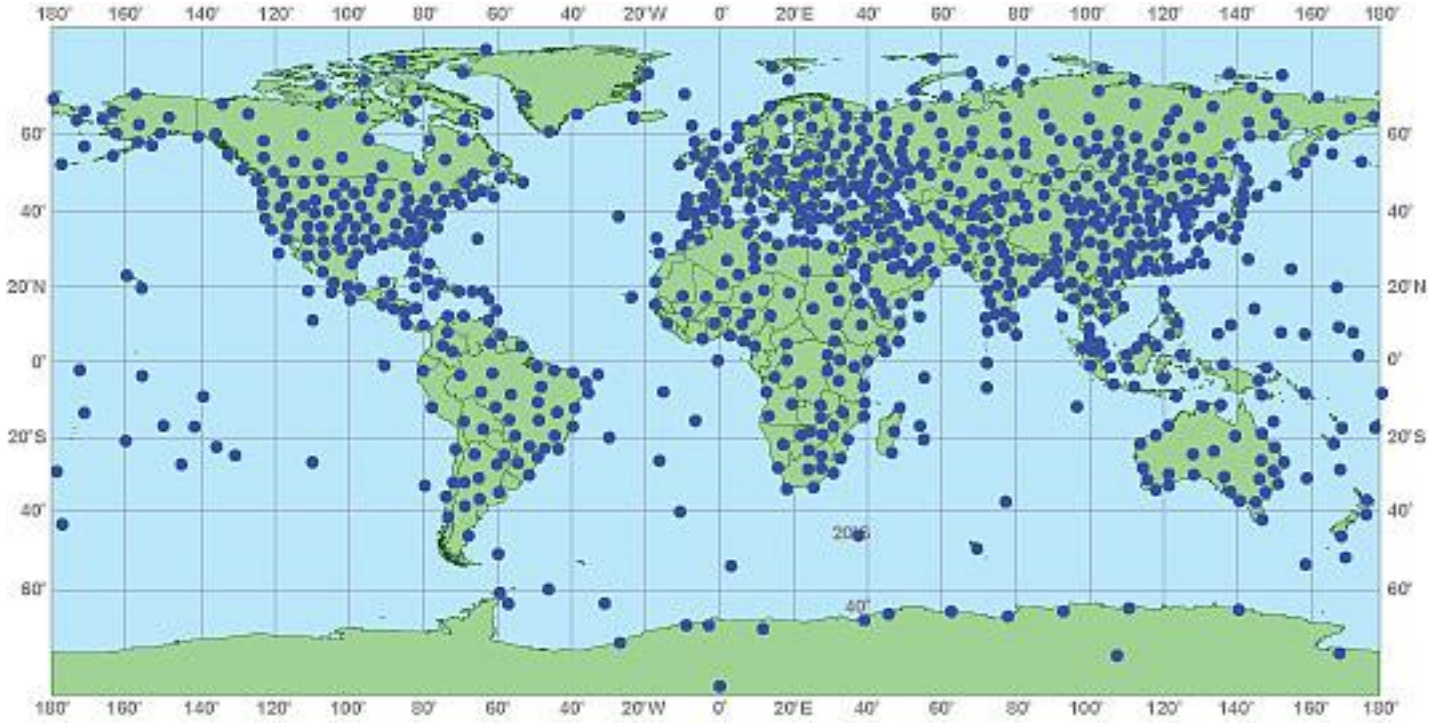




http://www.meteo-holesov.cz/zajpozo07.html

Weather ballons - radiosondes

- air temperature, air pressure, relative humidity, wind speed and direction (+ ozone, radioactivity)

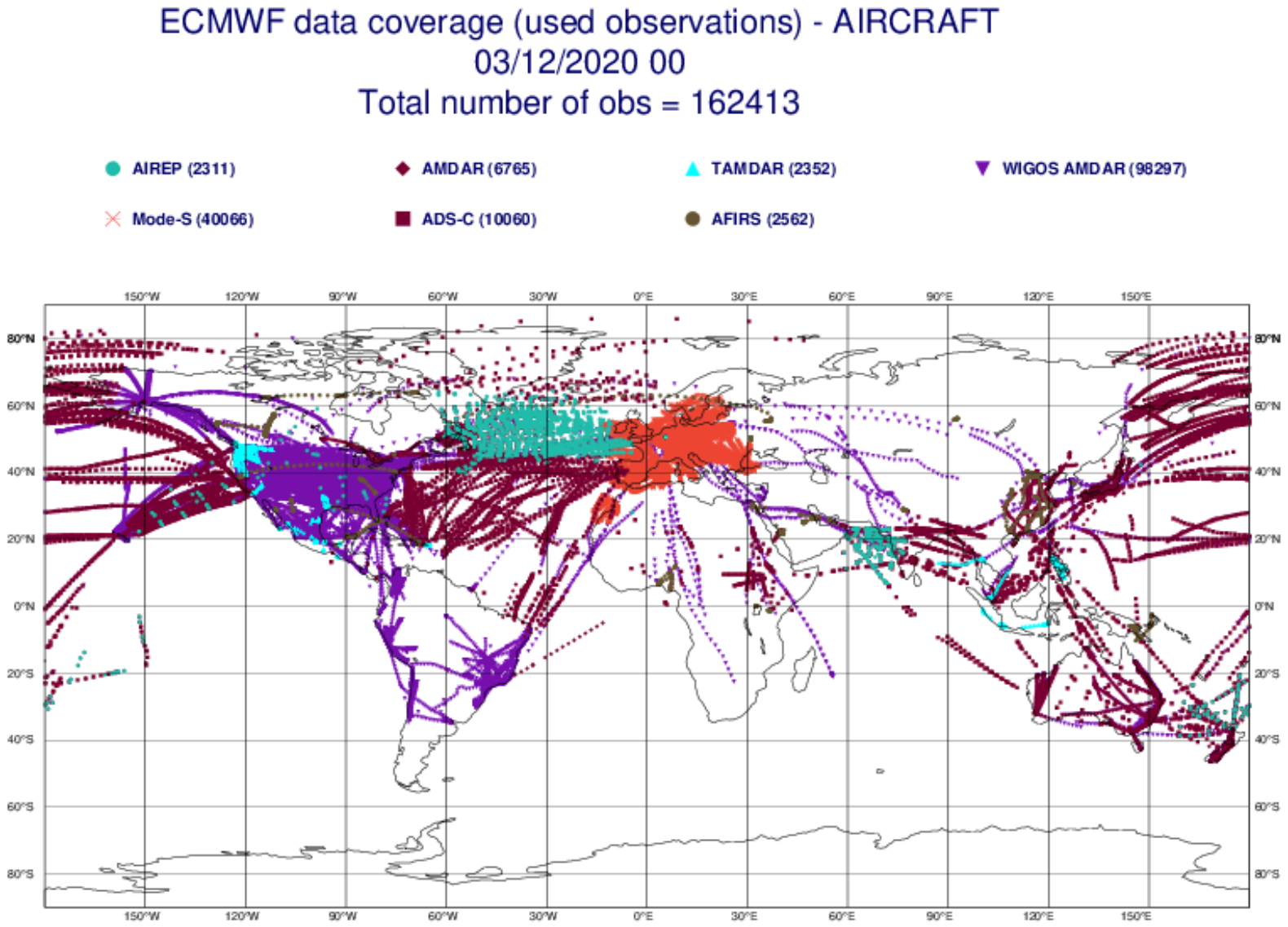


https://www.noaa.gov/jetstream/upperair/radiosondes

http://portal.chmi.cz/files/portal/docs/meteo/oa/ptu_grafy.html

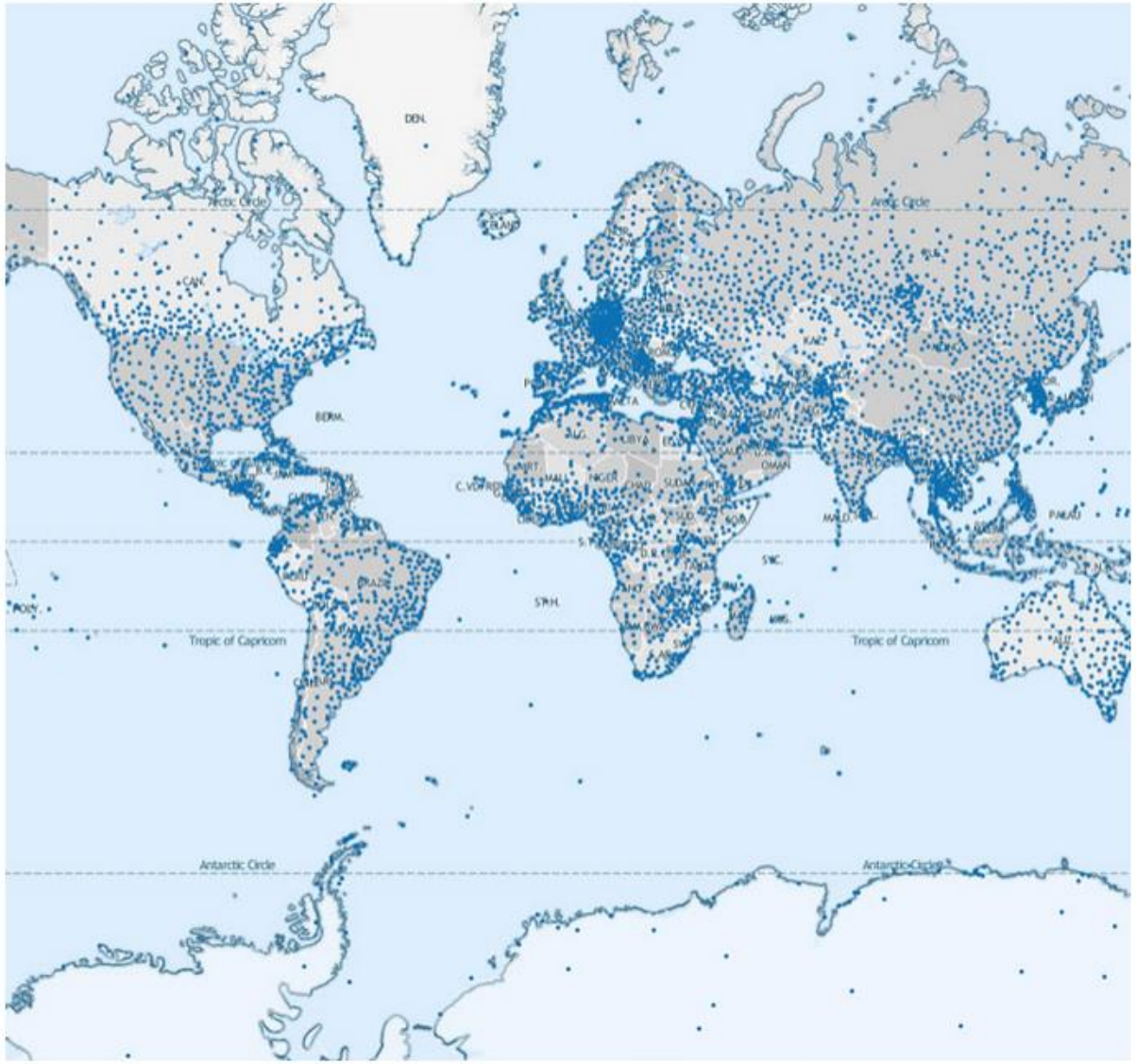
Aircraft-based observations

- upper-air monitoring of the atmosphere
- vertical profiles of temperature, wind, (and moisture)

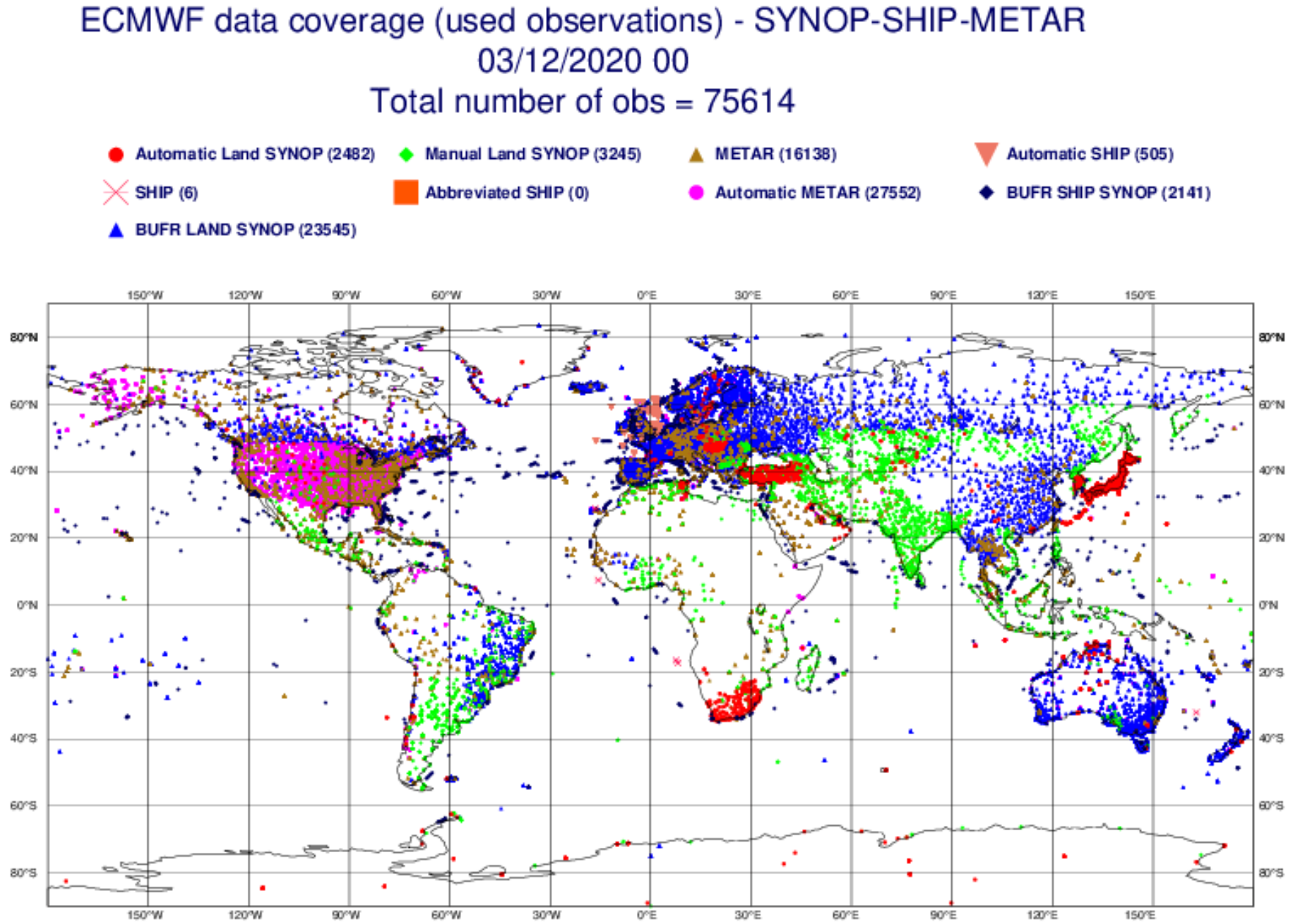


Surface observations – meteorological stations

- basic meteorological elements and weather phenomena
- 11,000+ profecion stations on earth

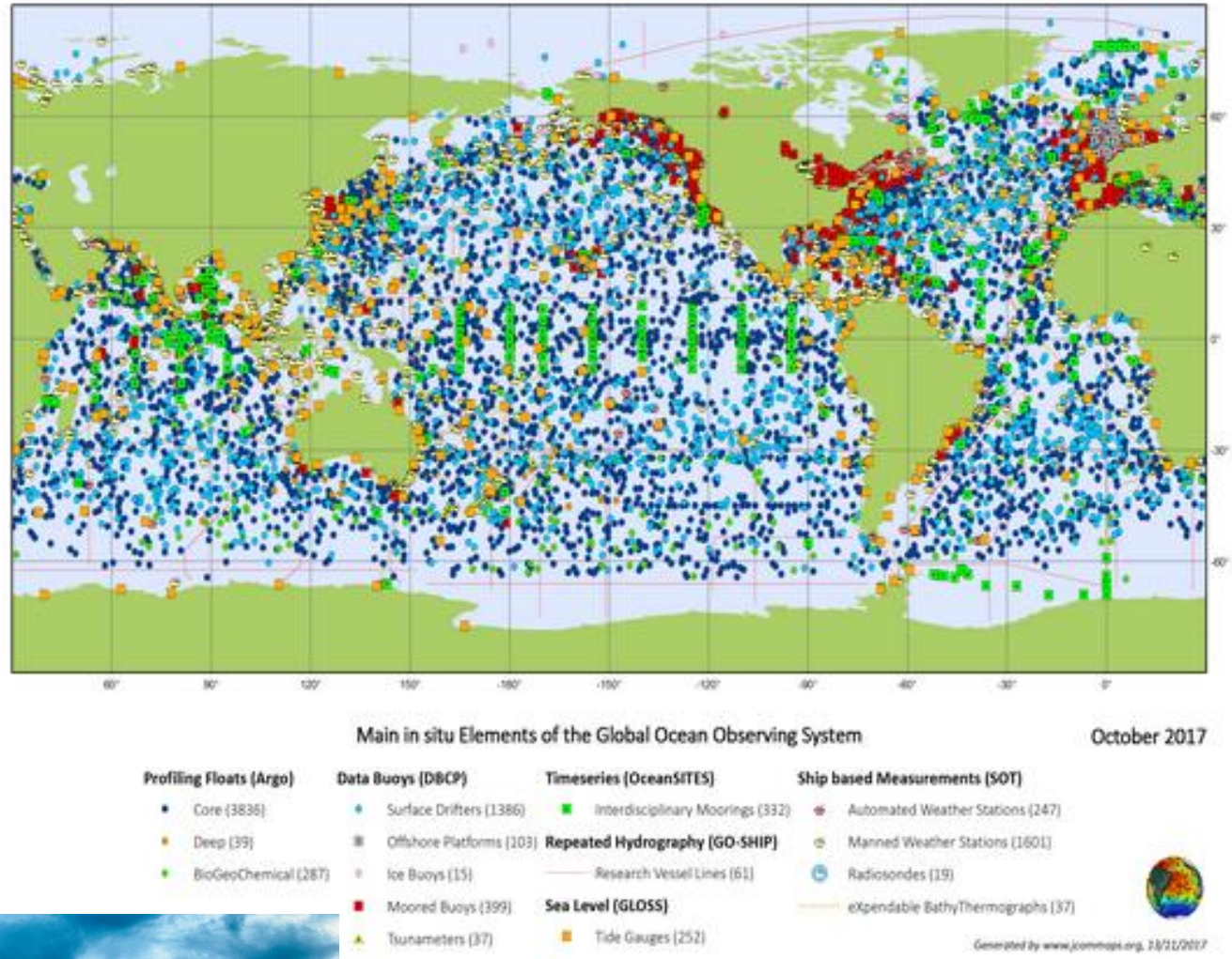


Surface observations – meteorological stations

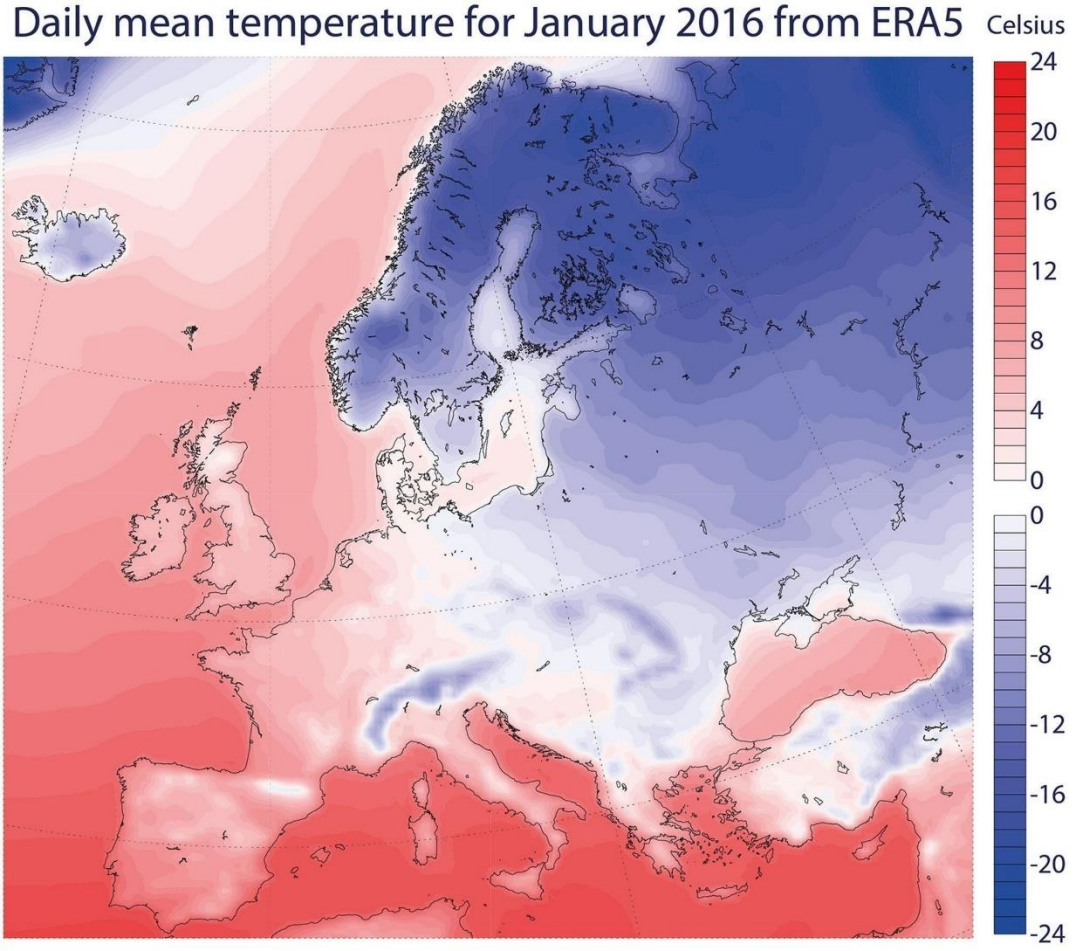


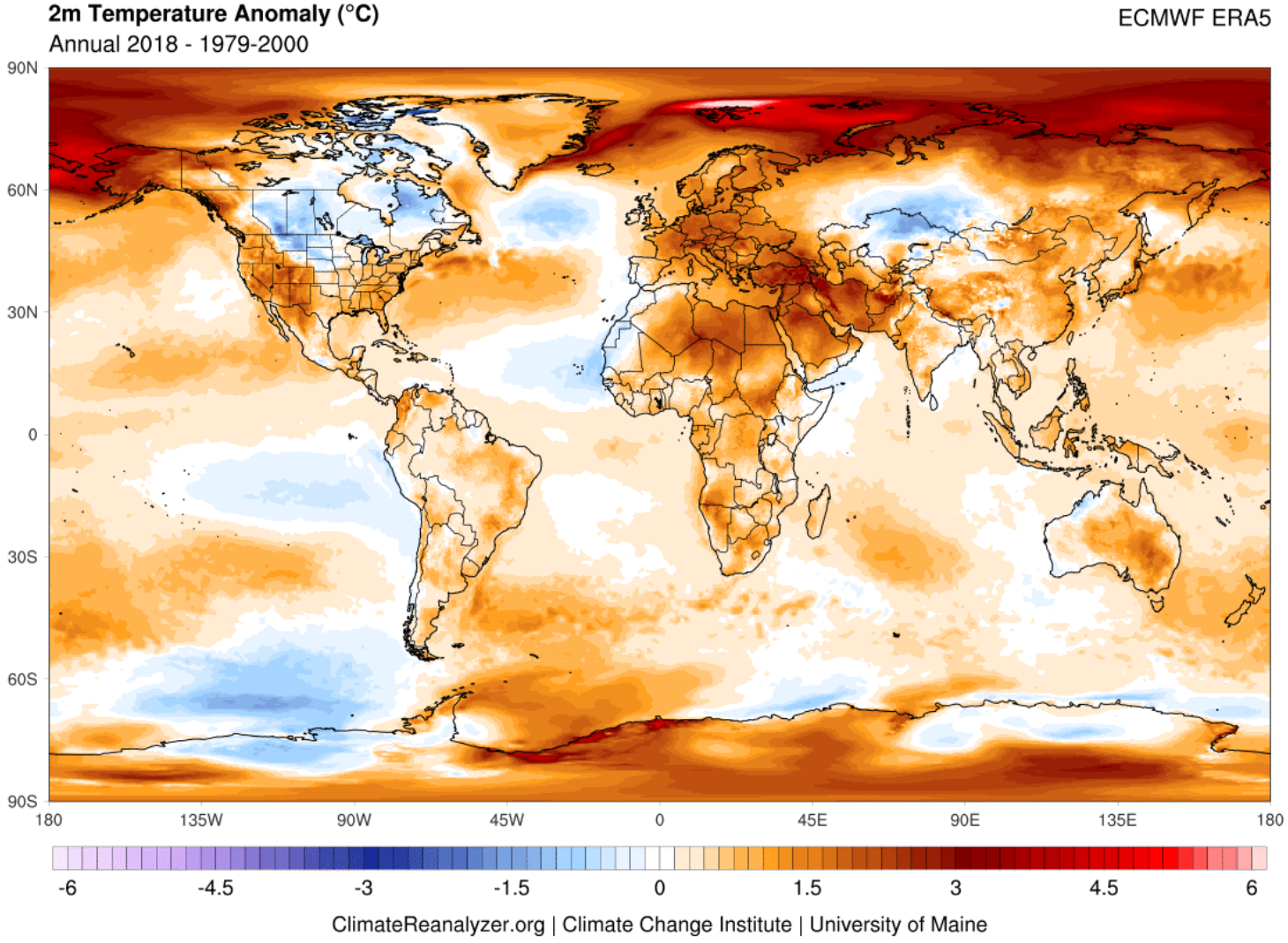
Marine observations

- ships
- moored and drifting buoys
- stationary platforms



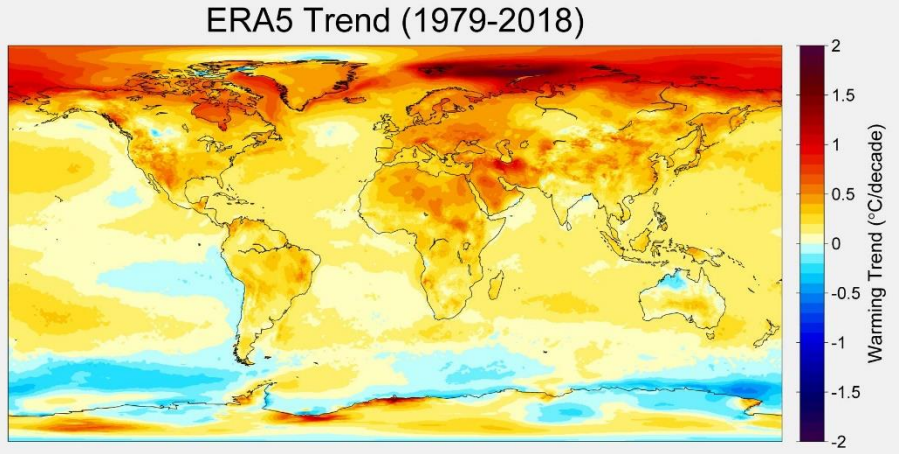
Atmospheric reanalysis





Atmospheric reanalysis

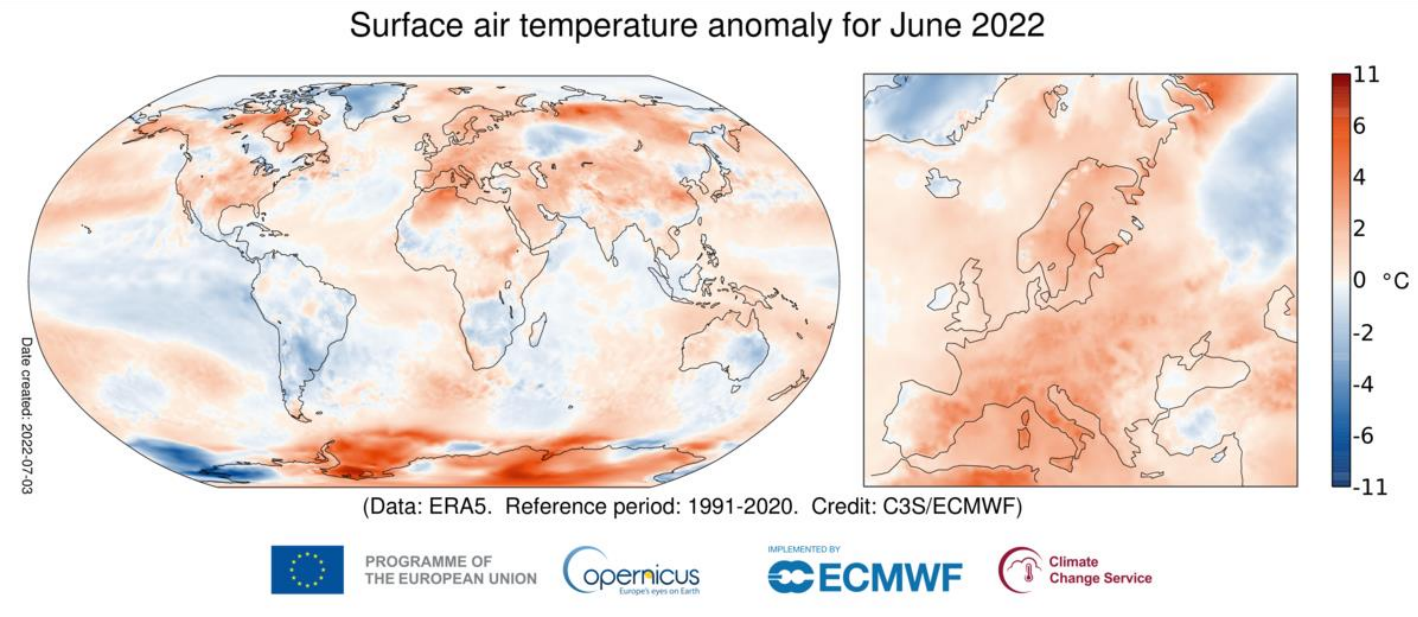
- **Numerical atmospheric model**, similar to numerical **weather forecast models** or **climate models** (GCMs)
- Applied to **already elapsed** time period
- **Assimilation** of measured data:
  - meteorological stations
  - satellite data (since the late 1970s)
  - ballons, ships, aircraft, buoys, ...

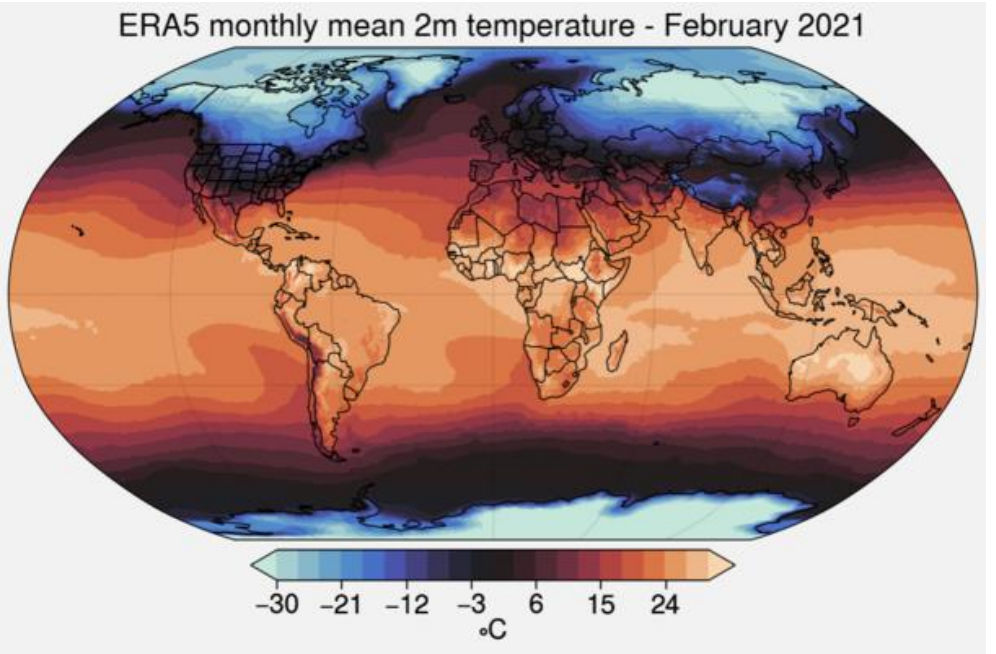


- **Data quality control** - elimination of problematic values
- Last decades: several **millions** of values assimilated at each step
- Rapid decline in the amount of data available for assimilation towards the past

Atmospheric reanalysis – advantages

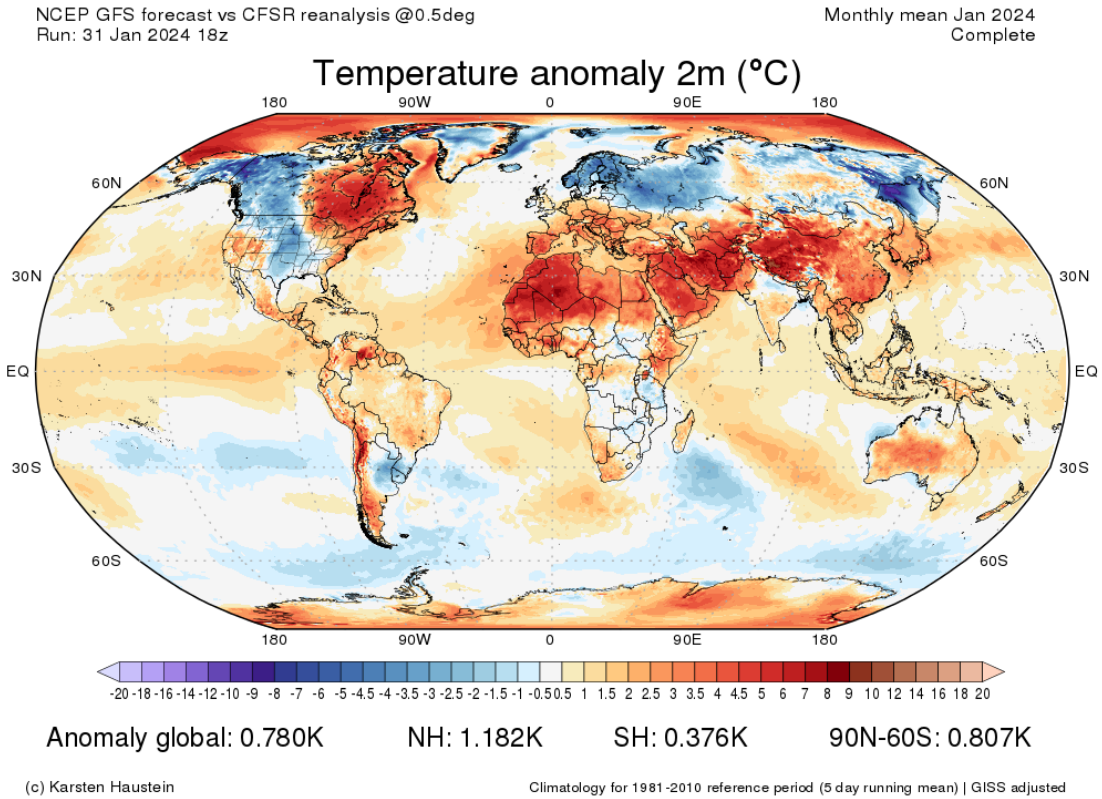
- Data calculated for regions with **low measurement density / absence of measurements**
  - ➢ Areas with minimum surface stations
  - ➢ Vertical atmospheric layers – minimum amount of measurements
- Calculation of variables which are **not or sparsely measured**
- **Global product** for several decades, same resolution for all regions

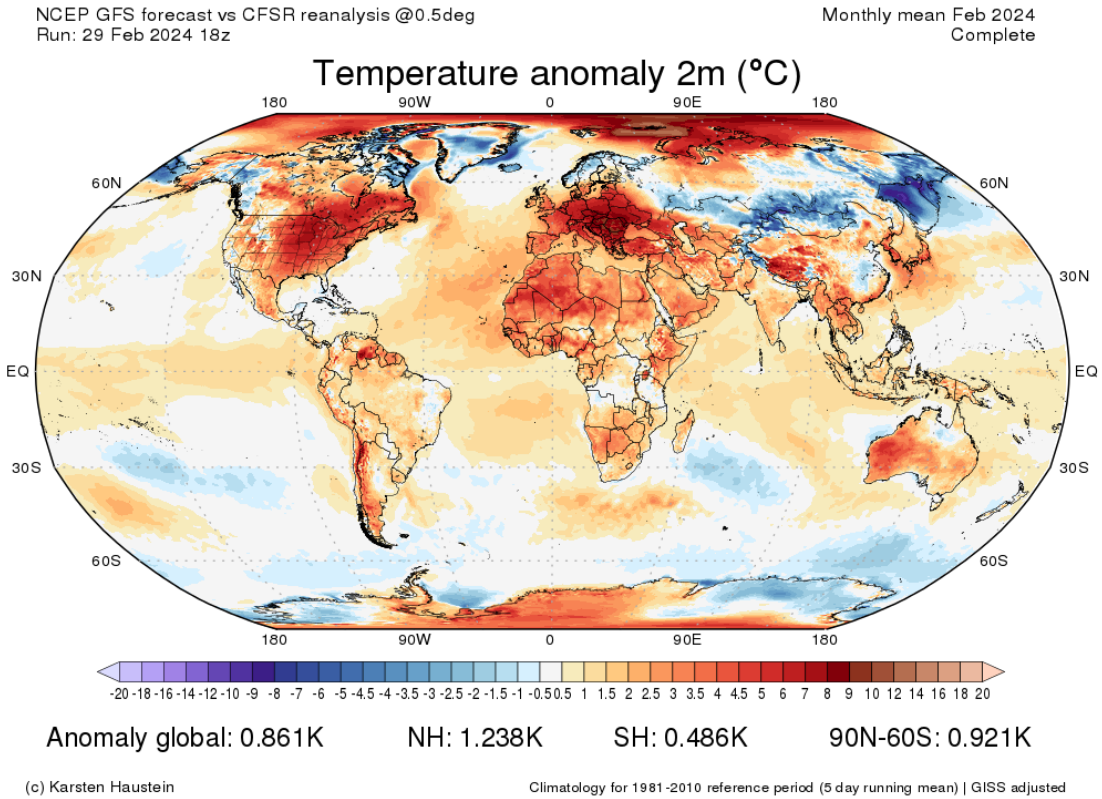




Atmospheric reanalysis – disadvantages

- Lower **spatial resolution** (better for the newest products)
- Spatiotemporal inconsistency in number of assimilated data
- Specific problems from weather forecasting models transferred to reanalysis





Atmospheric reanalysis – available products

- NCEP/NCAR (National Centers for Environmental Prediction / National Center for Atmospheric Research)
- 1948–2024 (developer in 1995 but updated), resolution 2.5 x 2.5 °
- NOAA 20th-Century: 1836–2014 (longest global reanalysis)

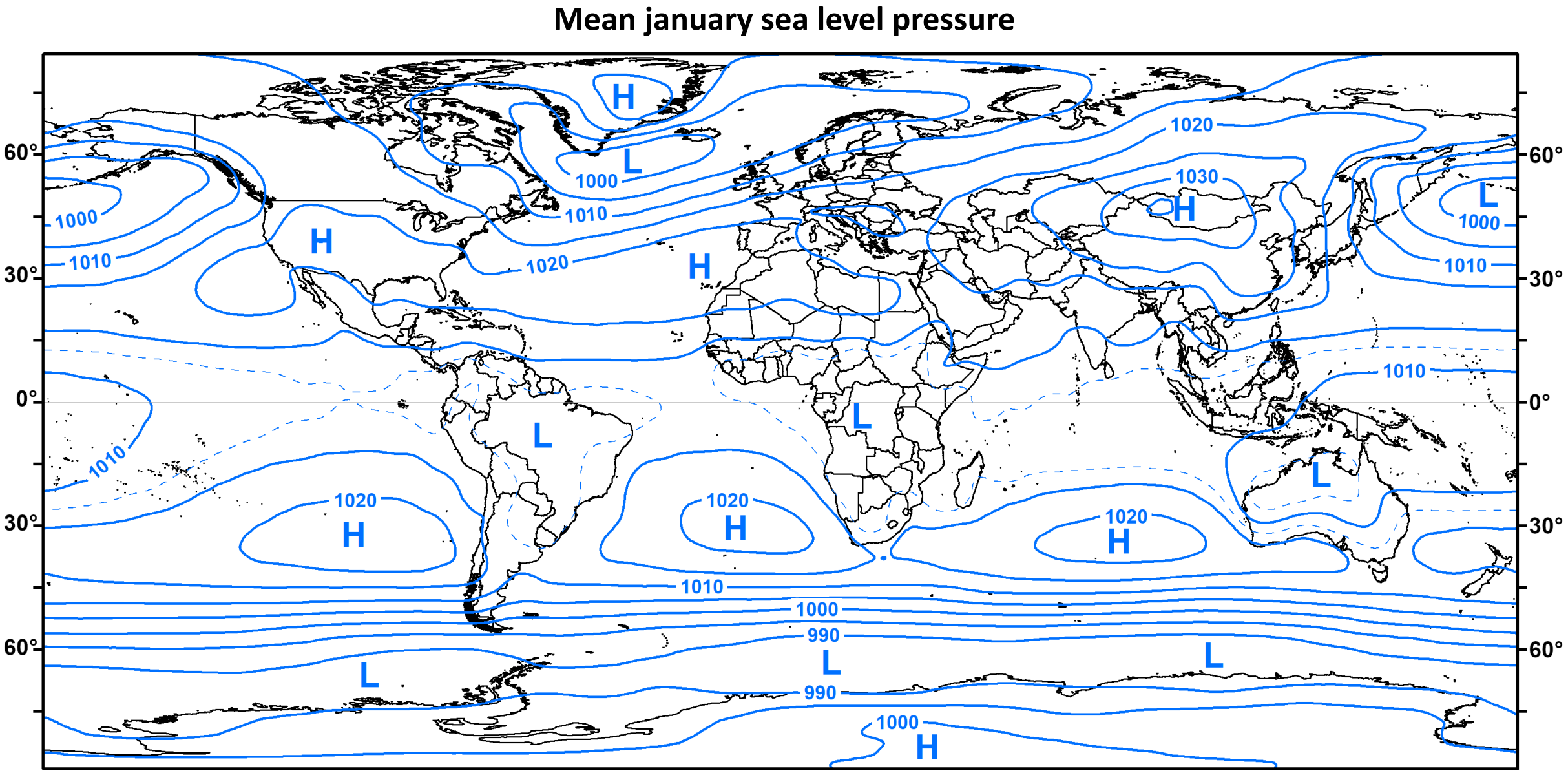
ECMWF (European Centre for Medium-Range Weather Forecasts):

- **ERA5:** 1940-2024 (updated constantly), **0.25 x 0.25 °** resolution
- **ERA5-Land:** land-surface version of ERA5, **0.1 x 0.1 °** resolution (ca 9 km)
- ERA-20C/CERA-20C: 1901-2010, 1.125 x 1.125 °,
- ***Regional reanalyses***:

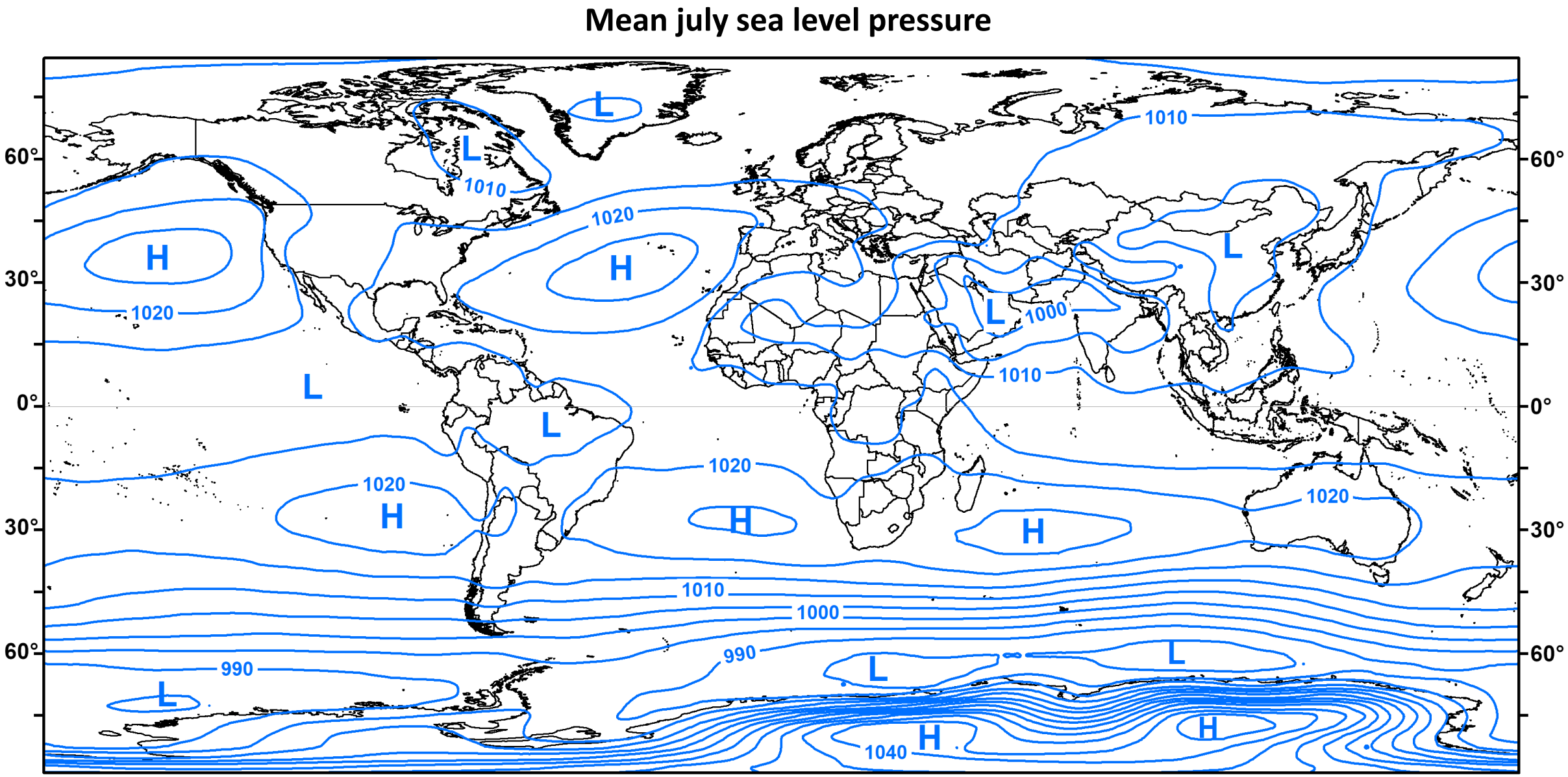
➢UERRA/MESCAN-SURFEX, CARRA

➢**CERRA + CERRA-Land:** Europe since 1984, **0.05 x 0.05 °** (cca 4.5 km

Atmospheric reanalysis – usage



Atmospheric reanalysis – usage



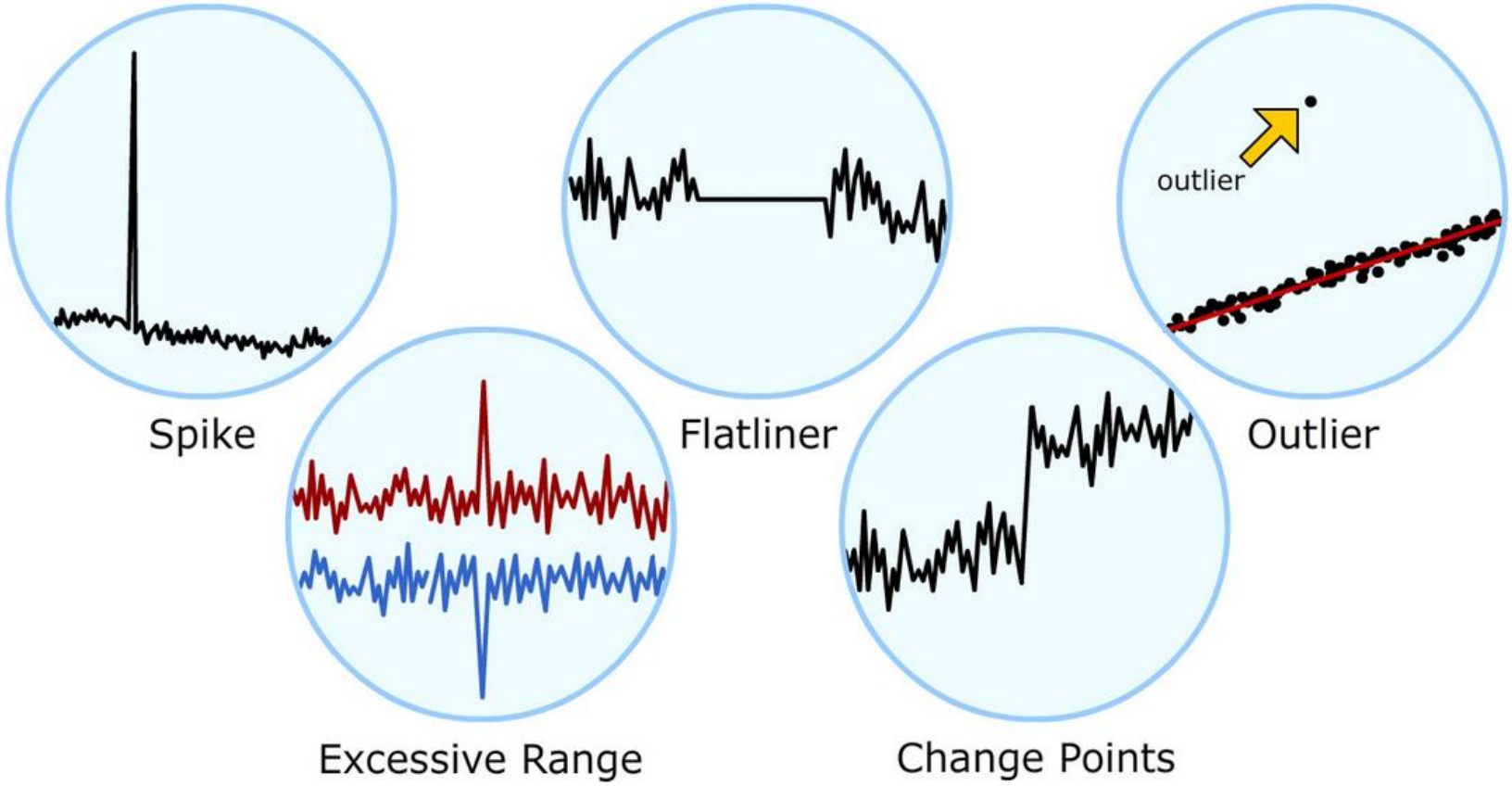
Climatological data sources

- **National weather services**
- **Global / continental databases:**
  - ***CRU*** – global station-based gridded data: https://crudata.uea.ac.uk/cru/data/hrg/
  - ***Climate reanalyzer*** – various types of data: https://climatereanalyzer.org/
  - ***ECA&D*** database – European in-situ measurements https://www.ecad.eu/
  - ***E-OBS*** – gridded data from ECA&D https://cds.climate.copernicus.eu/cdsapp#!/dataset/insitu-gridded-observations-europe?tab=overview
- **Data from atmospheric reanalyses:**
  - Copernicus climate services (C3S): https://cds.climate.copernicus.eu
  - ECMWF database: https://apps.ecmwf.int/datasets/
  - NCEP/NCAR data: https://psl.noaa.gov/data/gridded/data.ncep.reanalysis.html
- Data download via R programming:
  - https://www.rdocumentation.org/packages/RNCEP/versions/1.0.10/topics/NCEP.gather
  - https://dominicroye.github.io/en/2018/access-to-climate-reanalysis-data-from-r/

Climate data processing

Look at your data!

- **Quality control**



https://www.climate.gov/media/5719

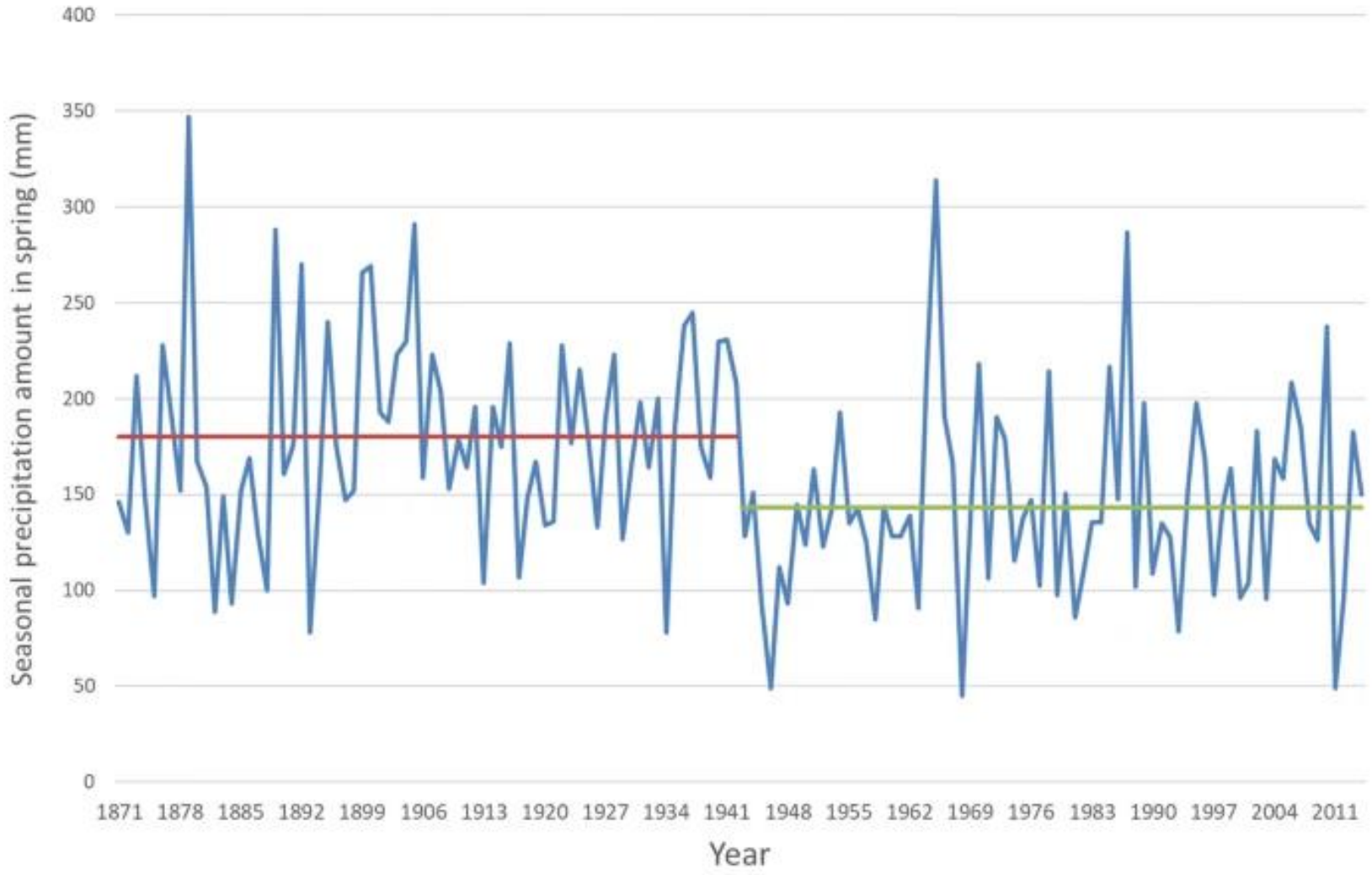
Climate data processing

- **Homogenization**
  - ➢ Done to the temporal variations in the adjusted data reflect only the variations due to climate processes

Possible **sources of inhomogeneities** in station data**:**

- Sheltering and exposure
- **Daily mean** calculations, observation hours and daylight-saving times
- **Units** of observed elements
- **Urbanization** and land-use changes
- Automatization of stations / new types of instruments
- **Quality control** and data recovery procedures, etc.

Climate data processing – homogenization



Significant change points and downward shifts in the mean in the precipitation amounts for spring (1871–2014)

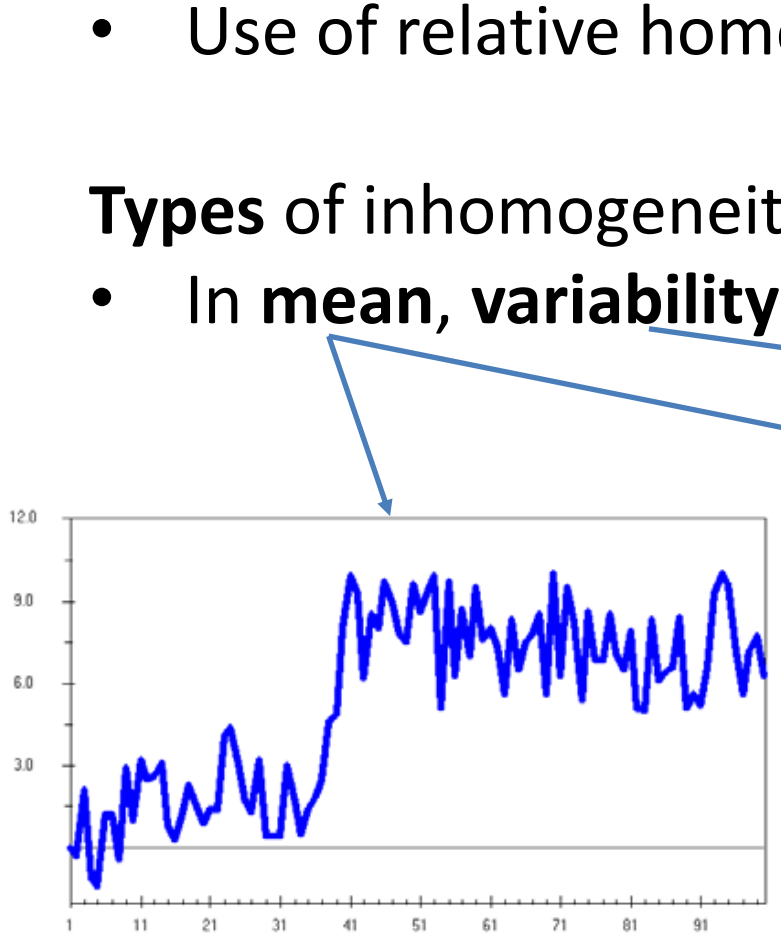
Climate data processing – homogenization

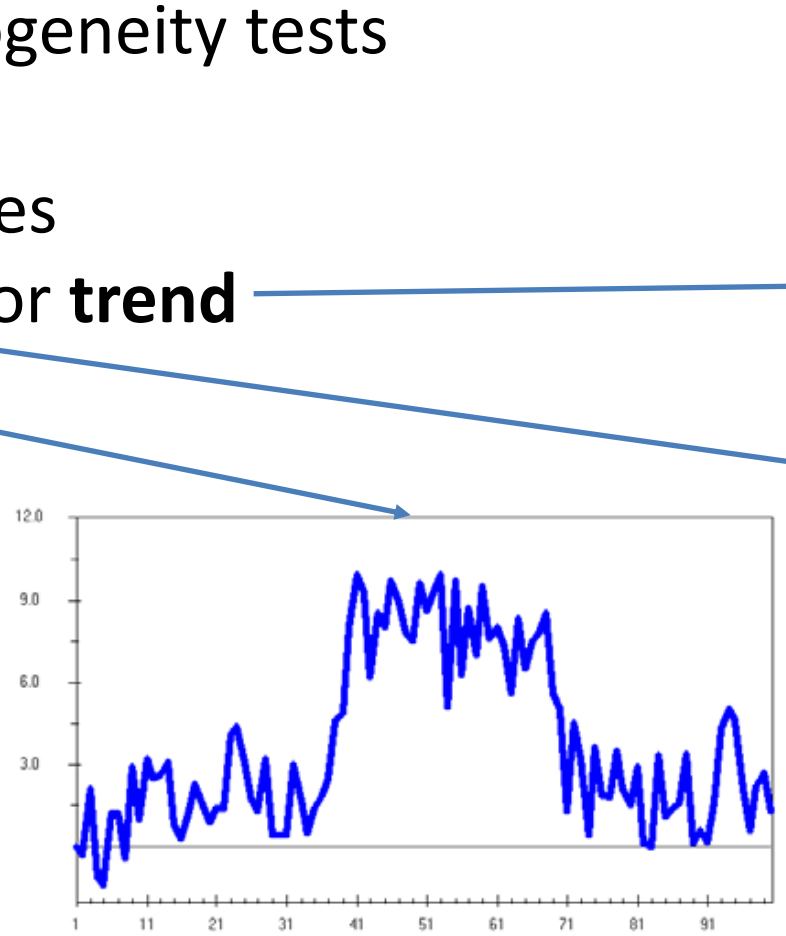
Methods

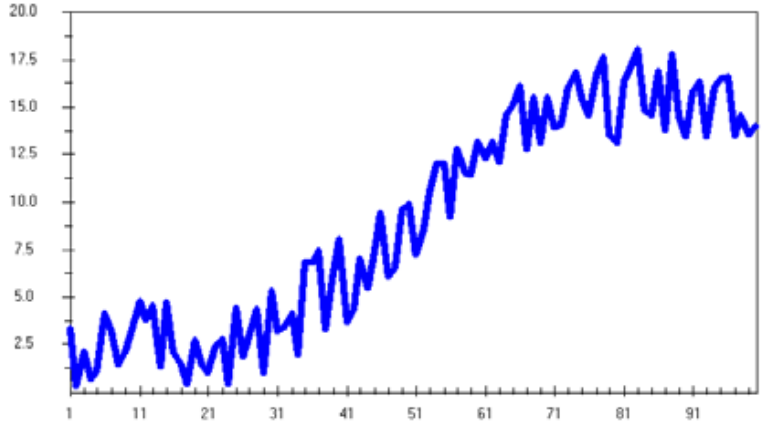
- Comparison of the tested station with surrounding stations
- Use of differences between the reference-tested series
- Use of relative homogeneity tests

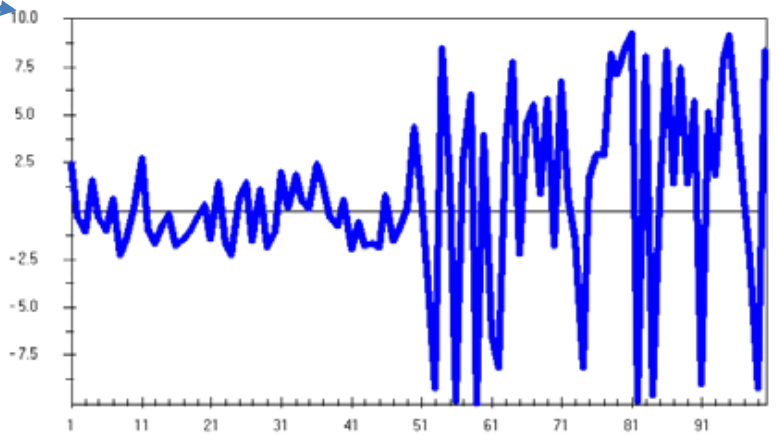
Types of inhomogeneities

- In **mean**, **variability** or **trend**









Climate normals

- **Normal (reference) period** – meteorological parameters are analysed for **30-year** (or different) periods

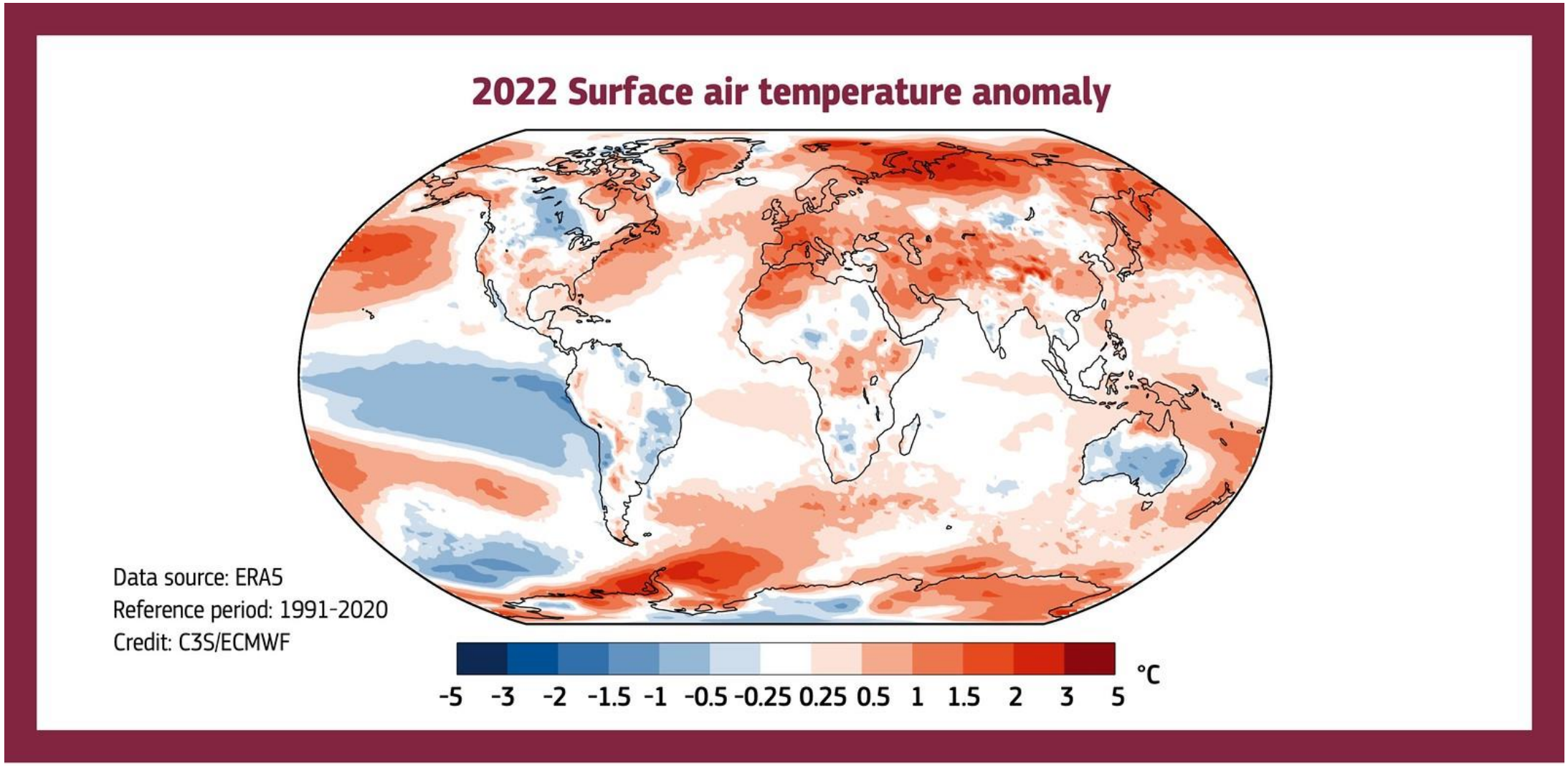
- Arguably the shortest period for **climate variables** calculation
- **Climate normals** – the mean values of climate variables for these periods
- Different locations can be **compared** with one another

- Recent normals: **1991–2020**, **1961–1990**, 1931–1960, …
- Irregular normals: 1981–2010, …

- Other notable **reference periods:**
  - **„preindustrial period“ 1850–1900**

Climate normals

Temperature anomalies,
normal period: 1991–2020



PROGRAMME OF THE EUROPEAN UNION

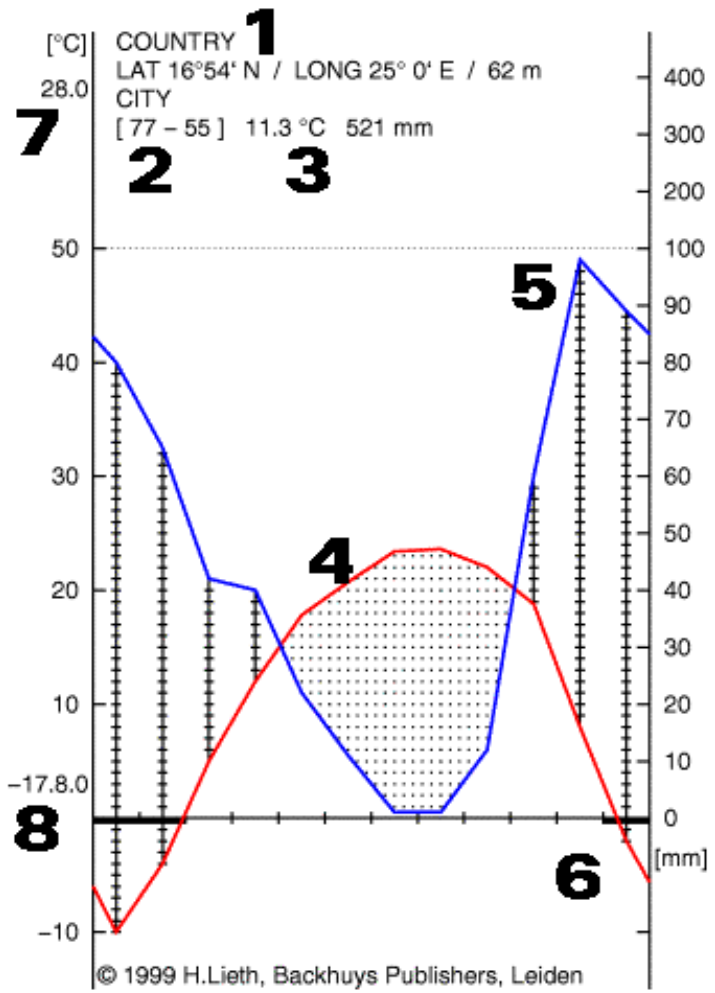
Copernicus Europe's eyes on Earth

IMPLEMENTED BY ECMWF

Climate Change

Climate charts (diagrams)

- brief summaries of average climatic variables and their time course



1 Country name, station location and elevation, station name

2 Period of observation of temperature (77 years) and precipitation (55 years)

3 Annual average of temperature and annual precipitation sum

4 (red) Temperature curve

5 (blue) Precipitation time series

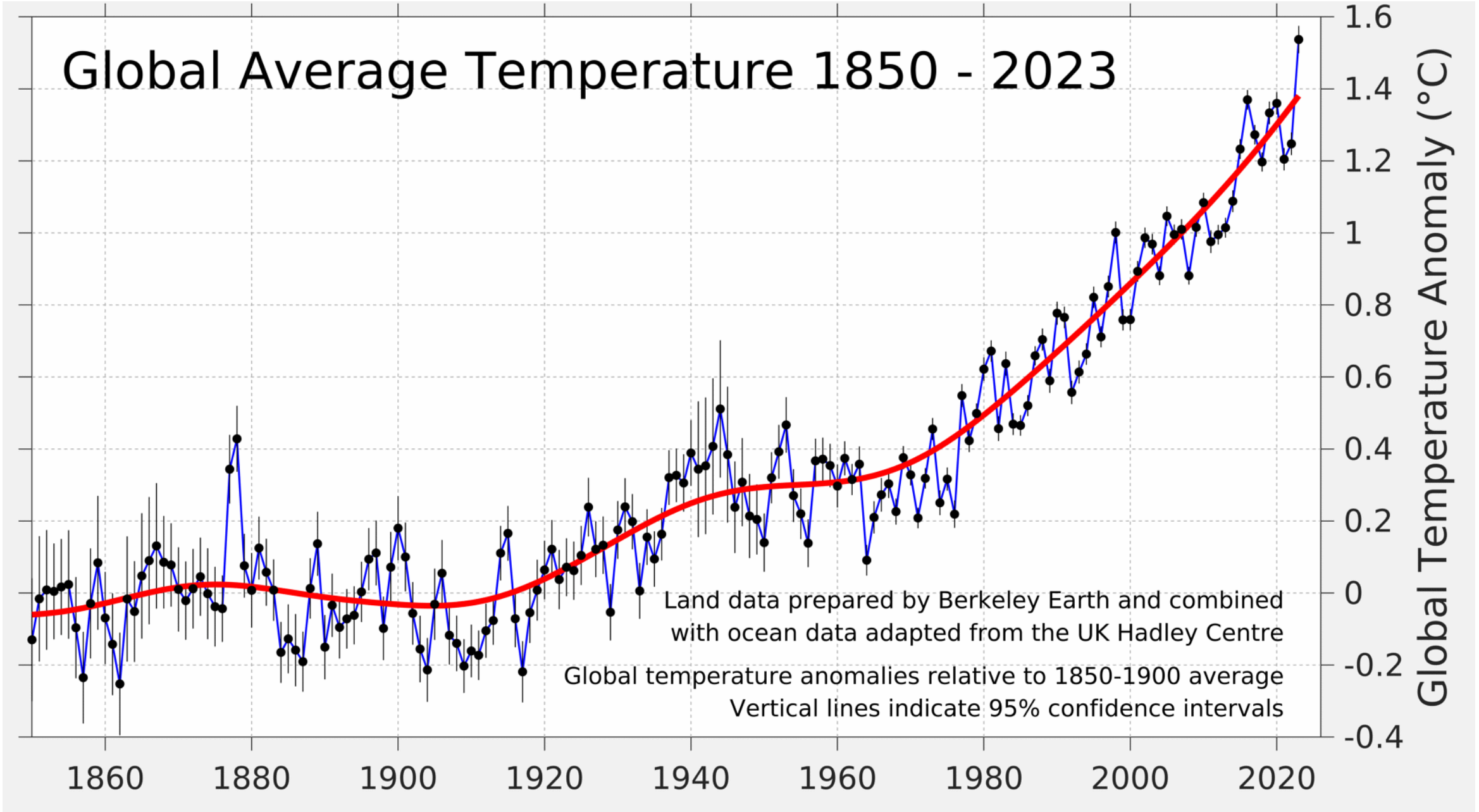
6 Indication of frost periods

7 Mean daily max. temperature of the warmest month

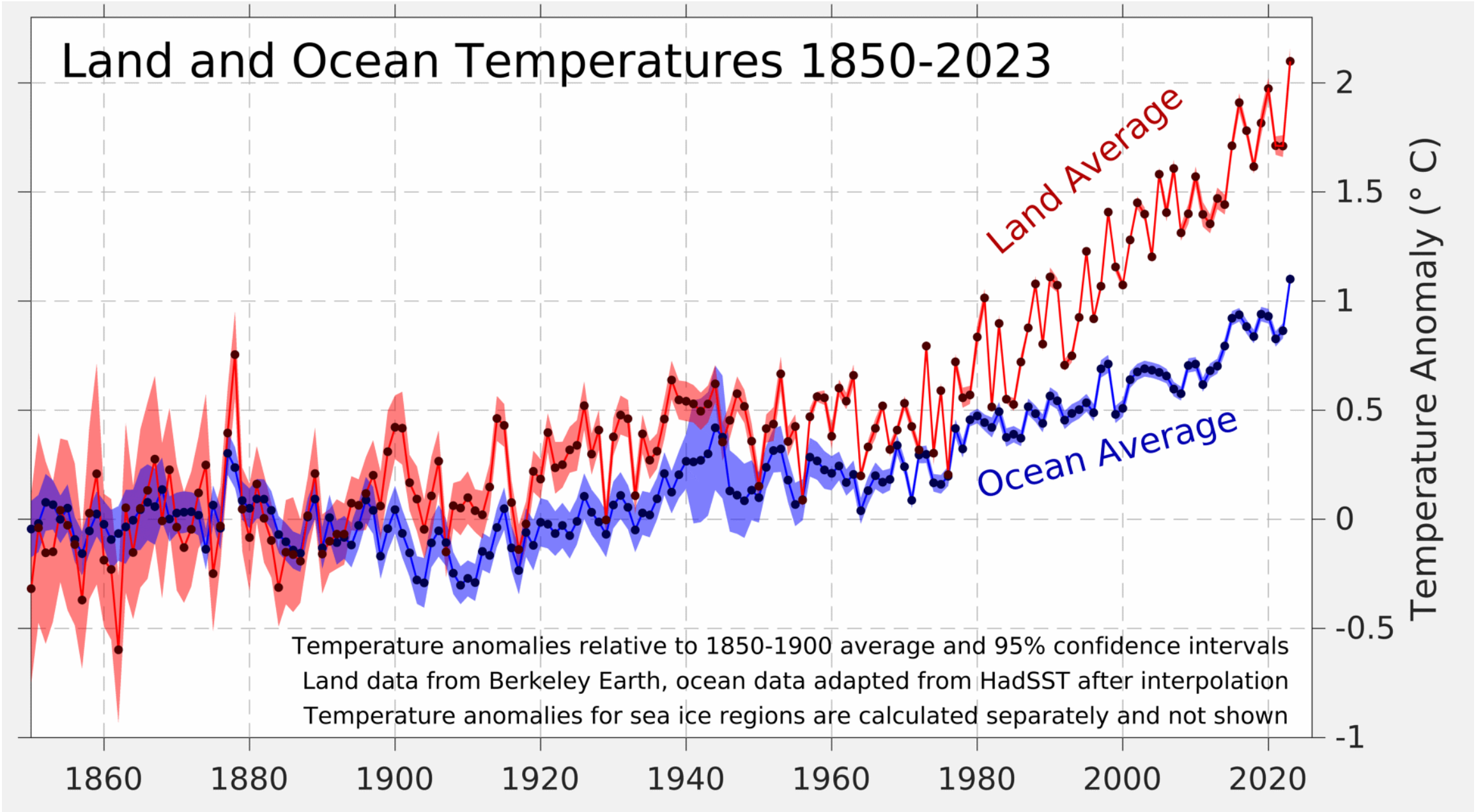
8 Mean daily min. temperature of the coldest month

https://zoolex.org/page/walter/

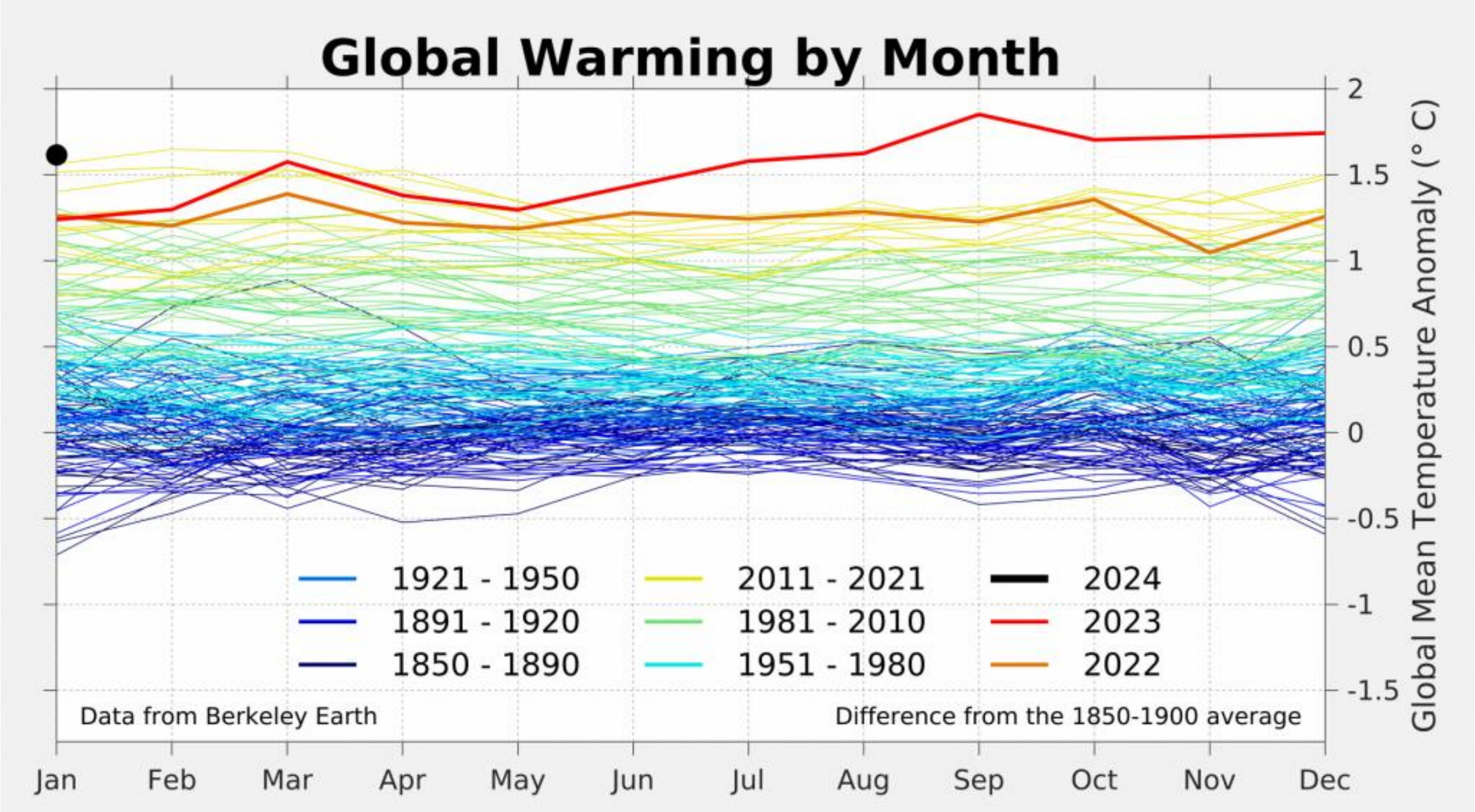
Climate data visualization – climate change



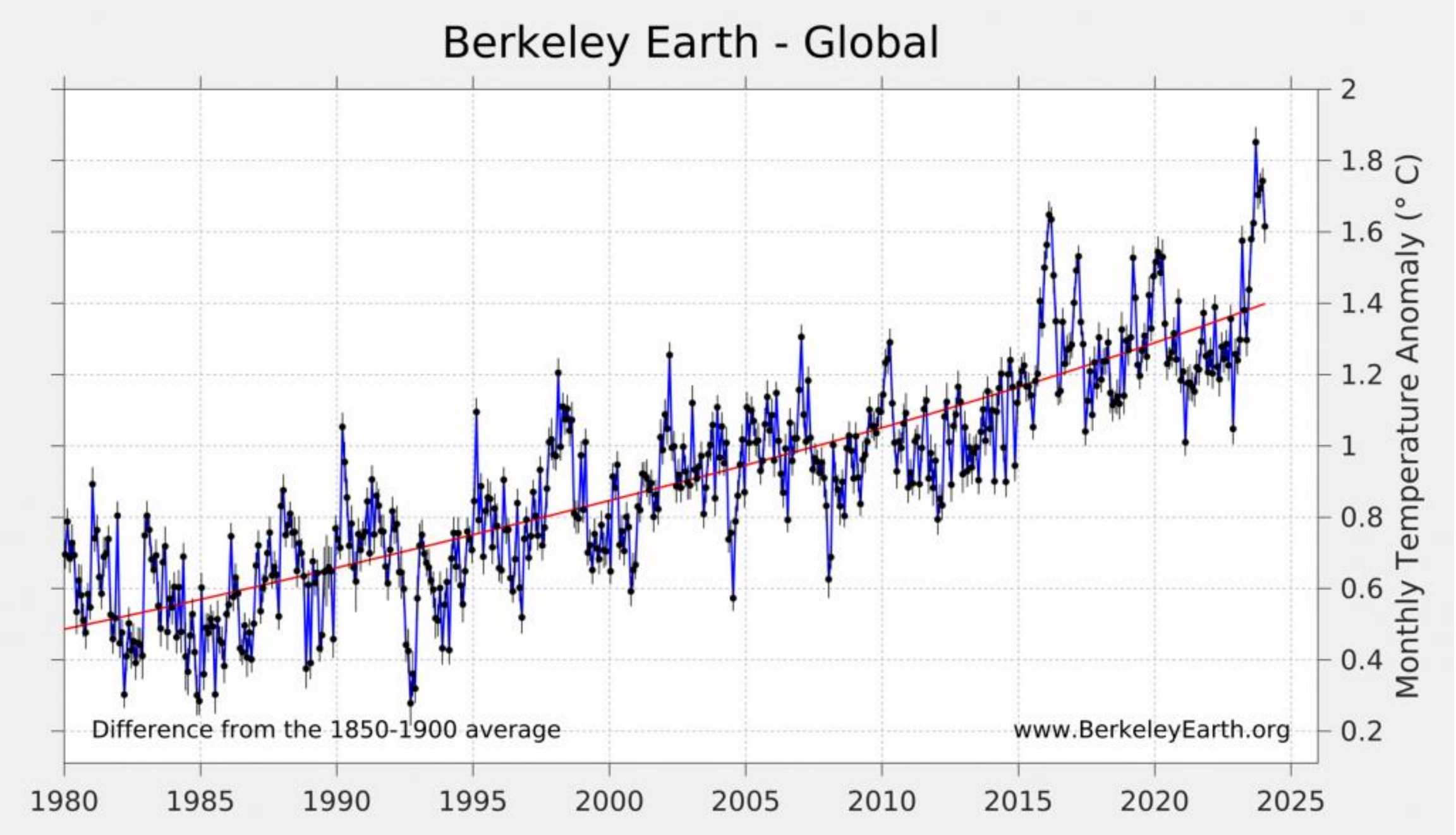
Climate data visualization – climate change



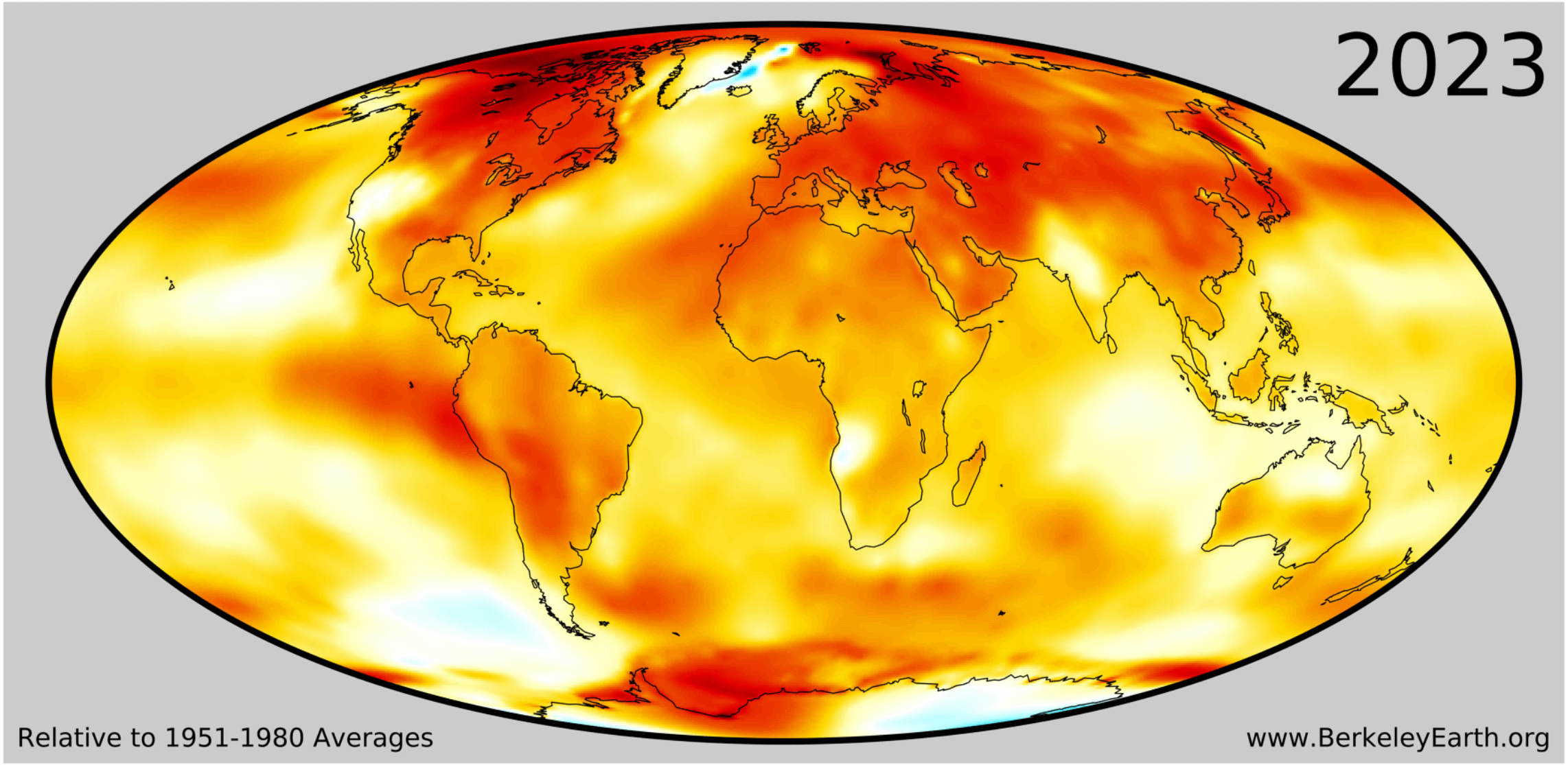
Climate data visualization – climate change



Climate data visualization – climate change

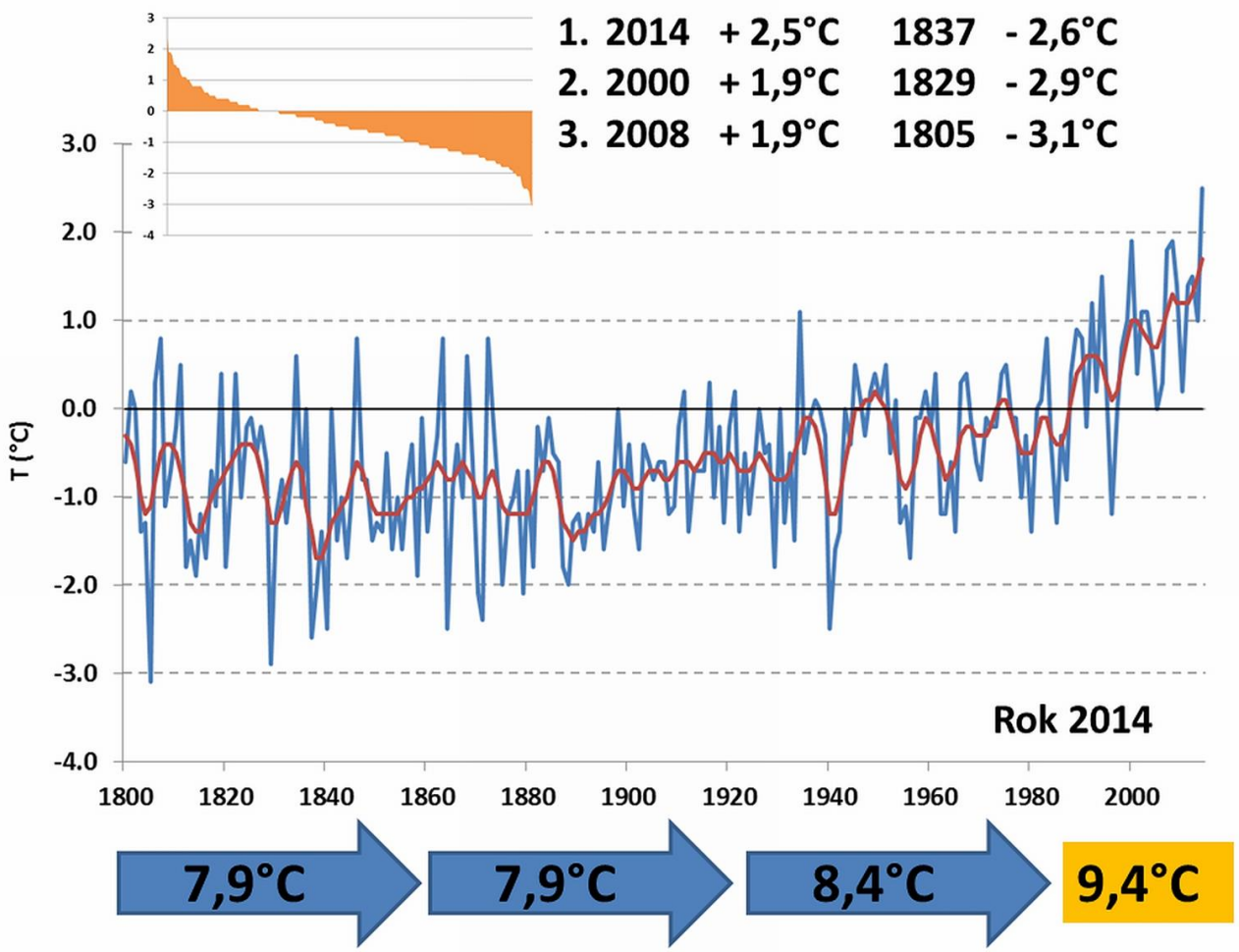


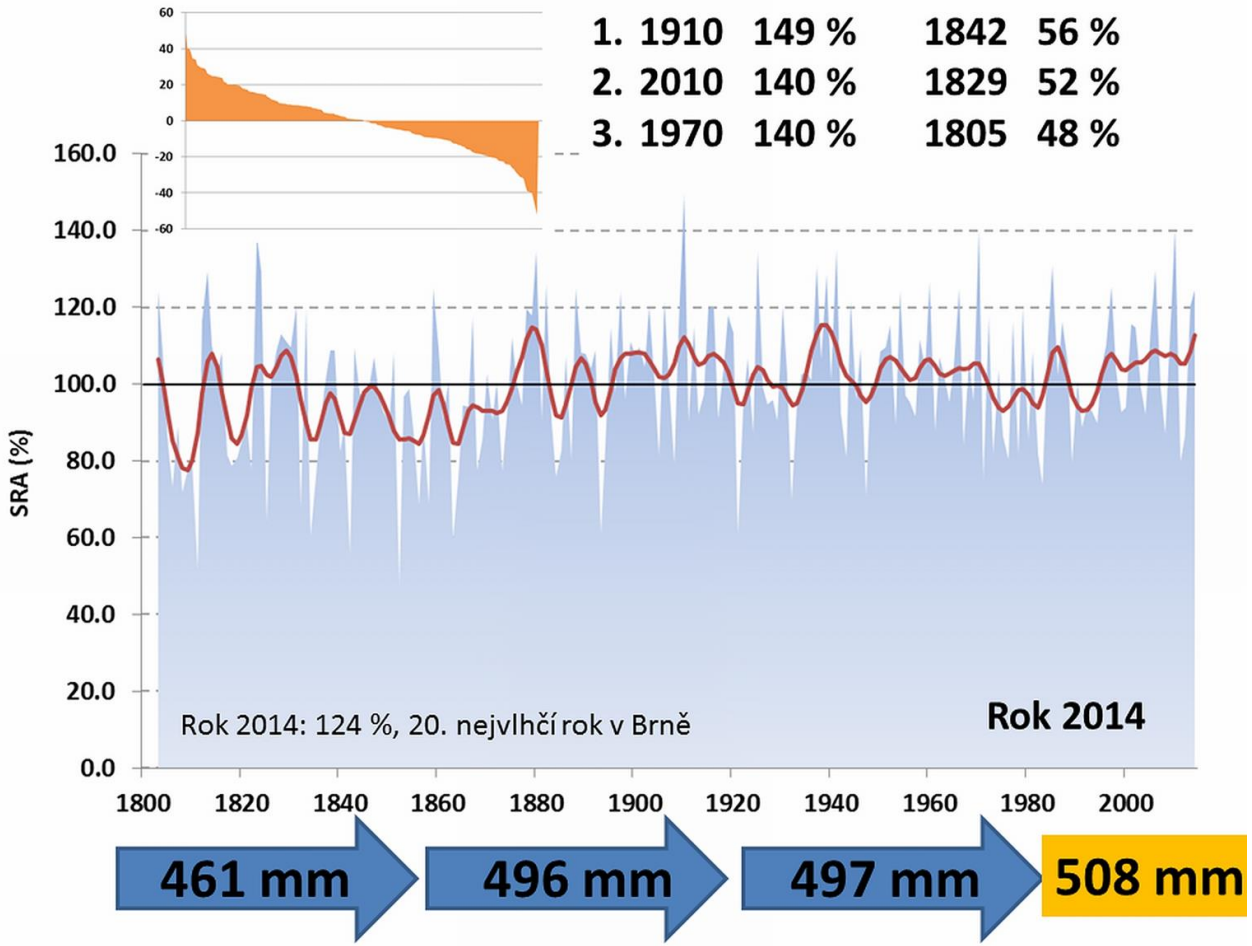
Climate data visualization – climate change



Climate data visualization – climate change

Temperature and precipitation series for the Czech Republic

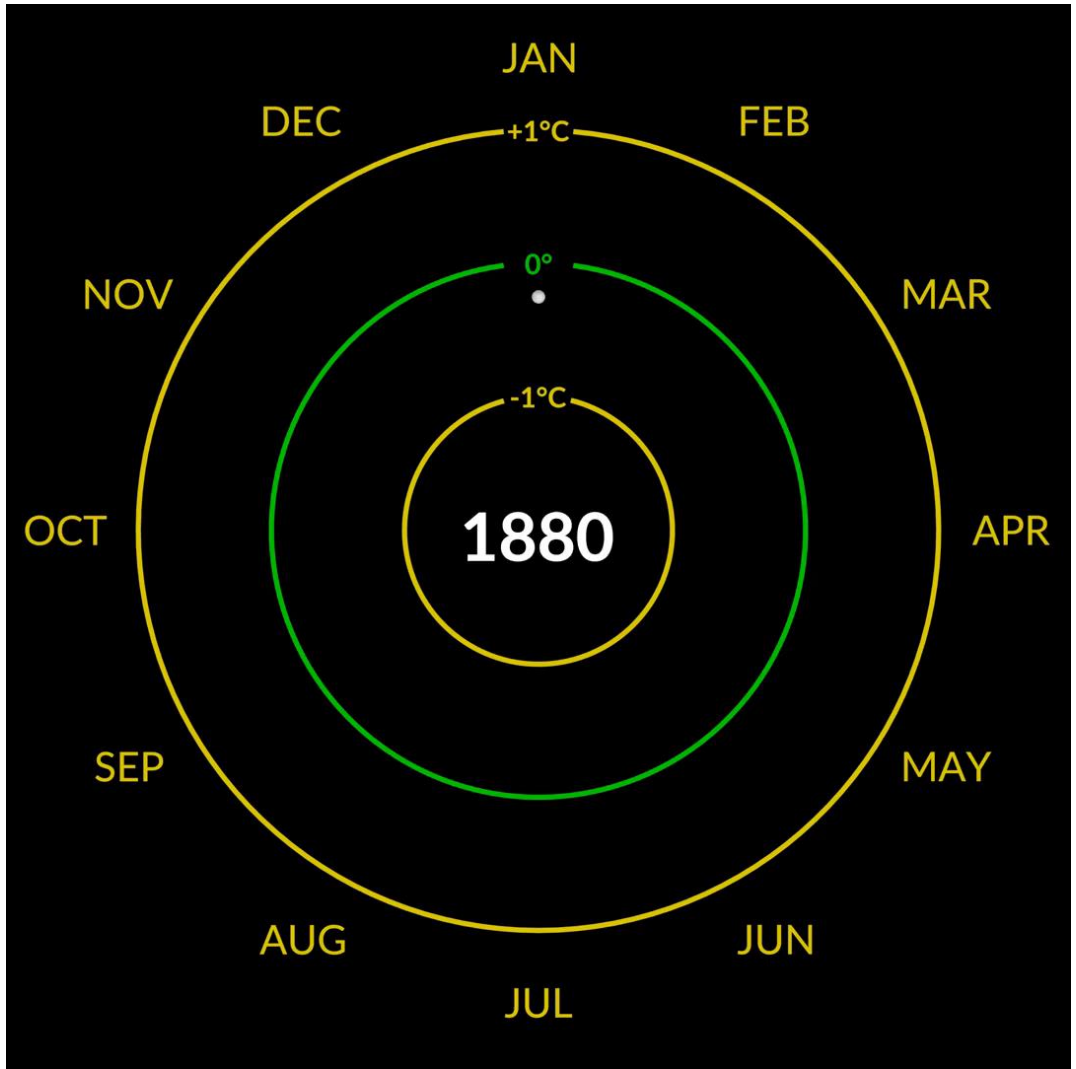




http://www.infomet.cz/index.php?id=read&idd=1422394809

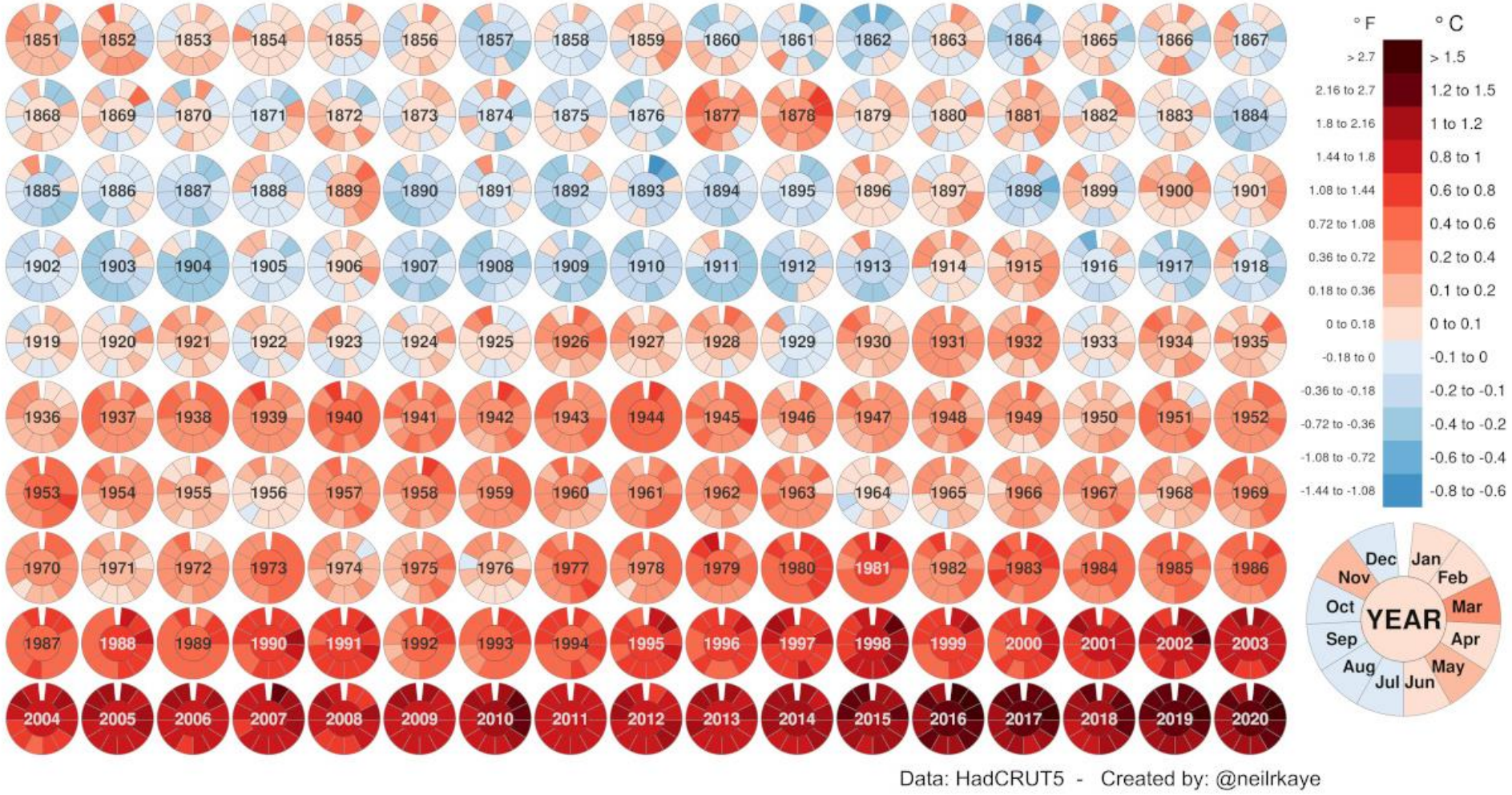
Climate Spiral (created by NASA)

- monthly global temperature anomalies (changes from an average) between the years 1880 and 2022



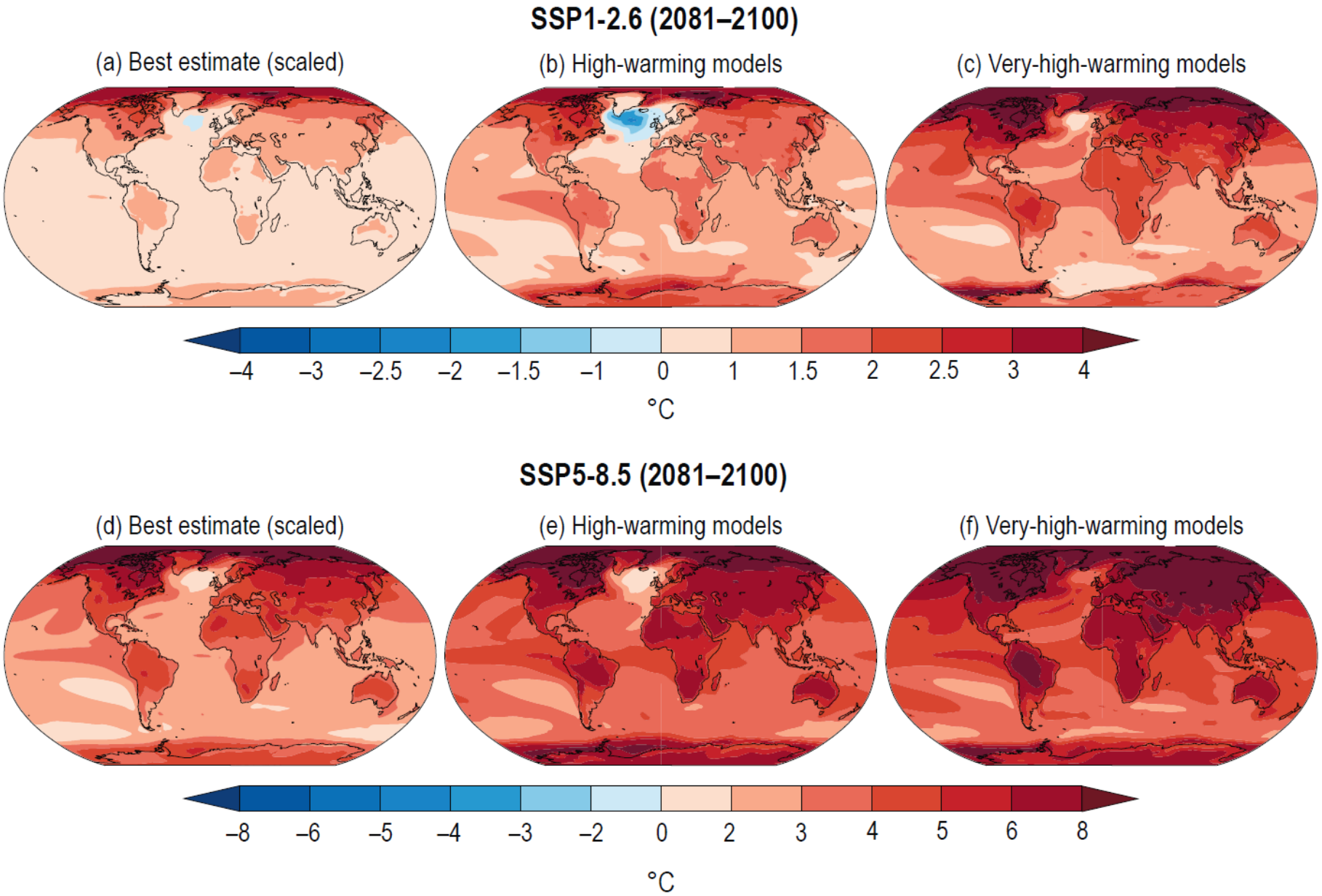
Monthly global mean temperatures 1851 2020

(compared to 1850-1900 averages)



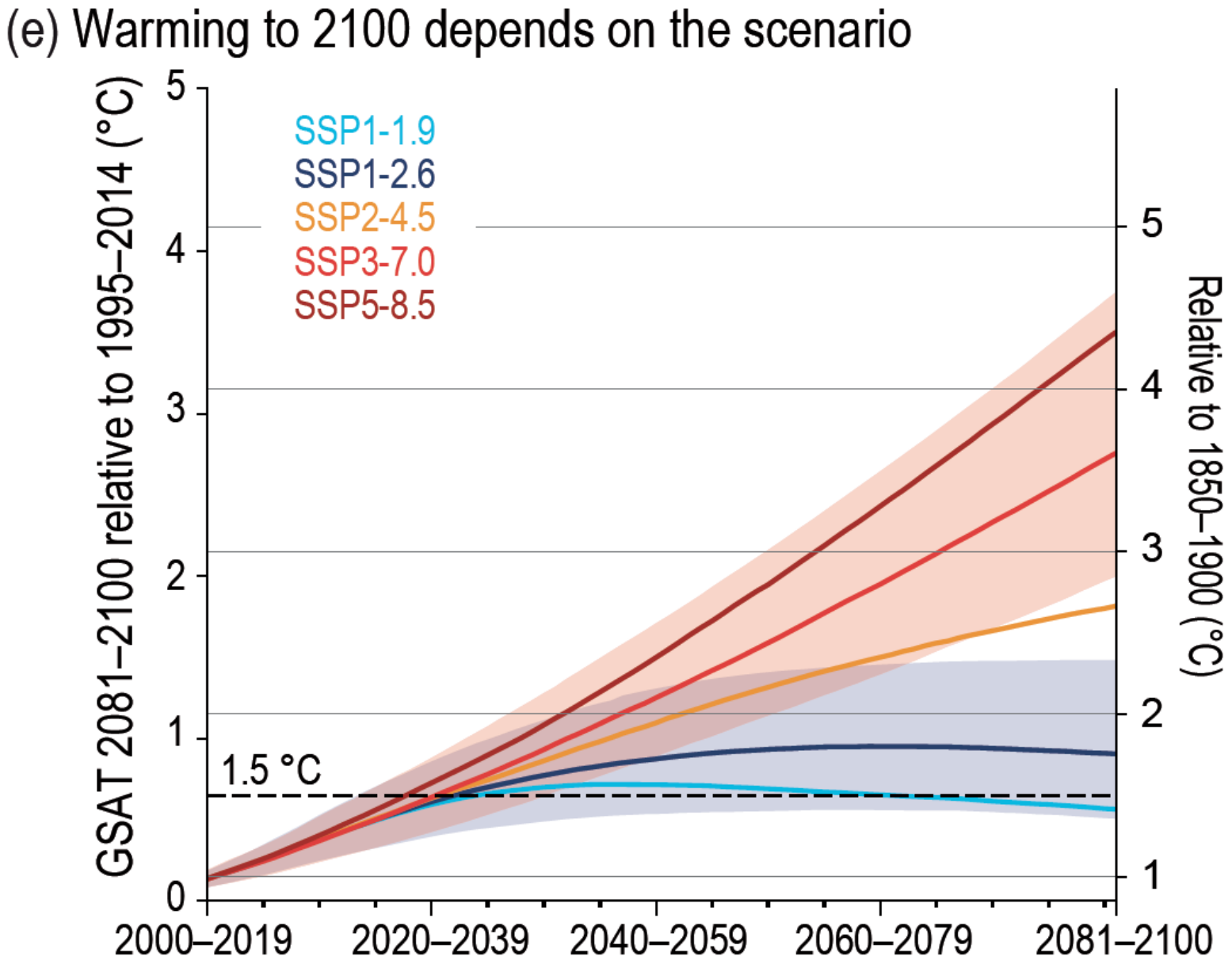
https://www.visualcapitalist.com/global-temperature-graph-1851-2020/

Climate data visualization – climate models



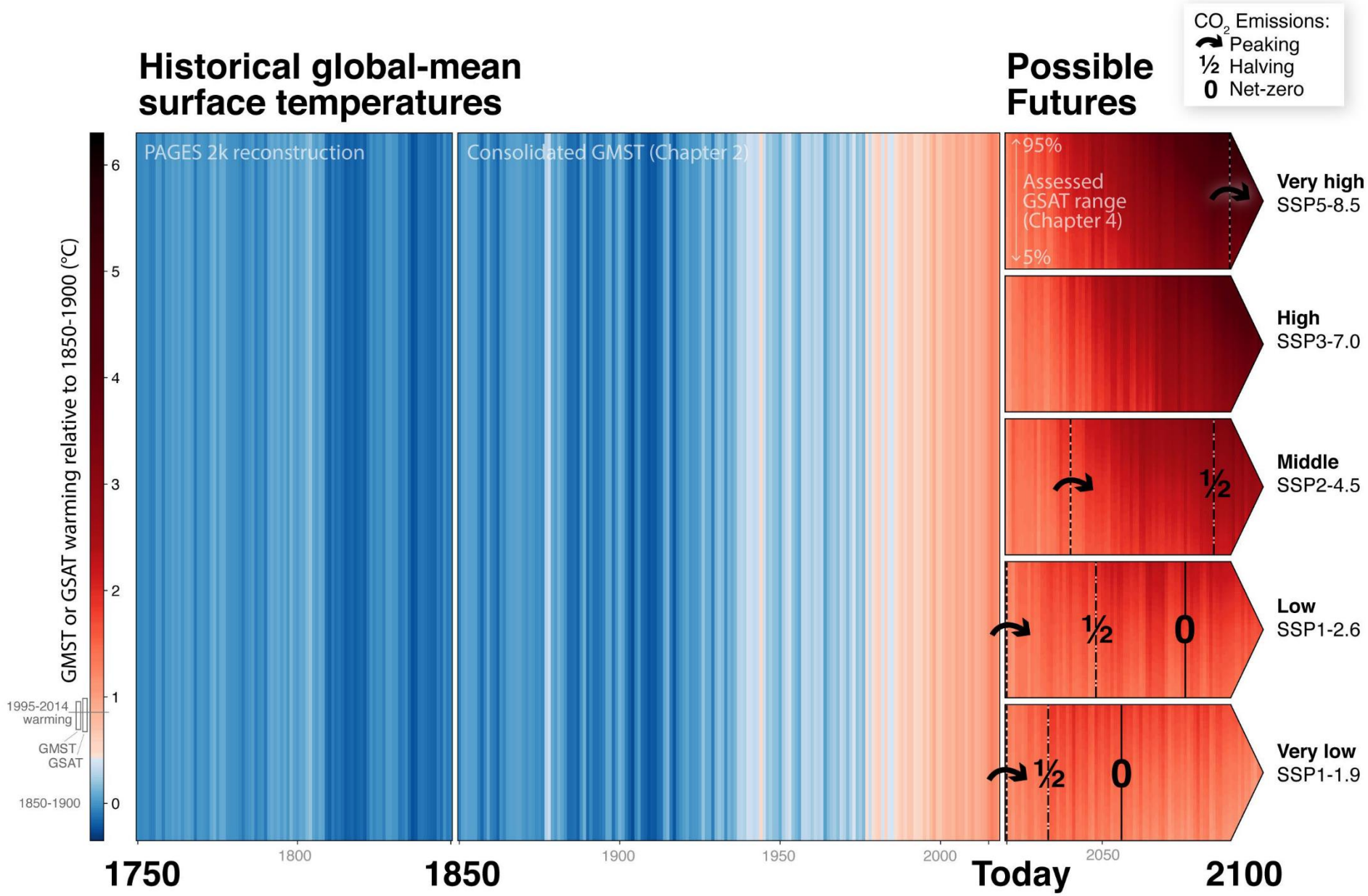
IPCC, 2022

Climate data visualization – climate models



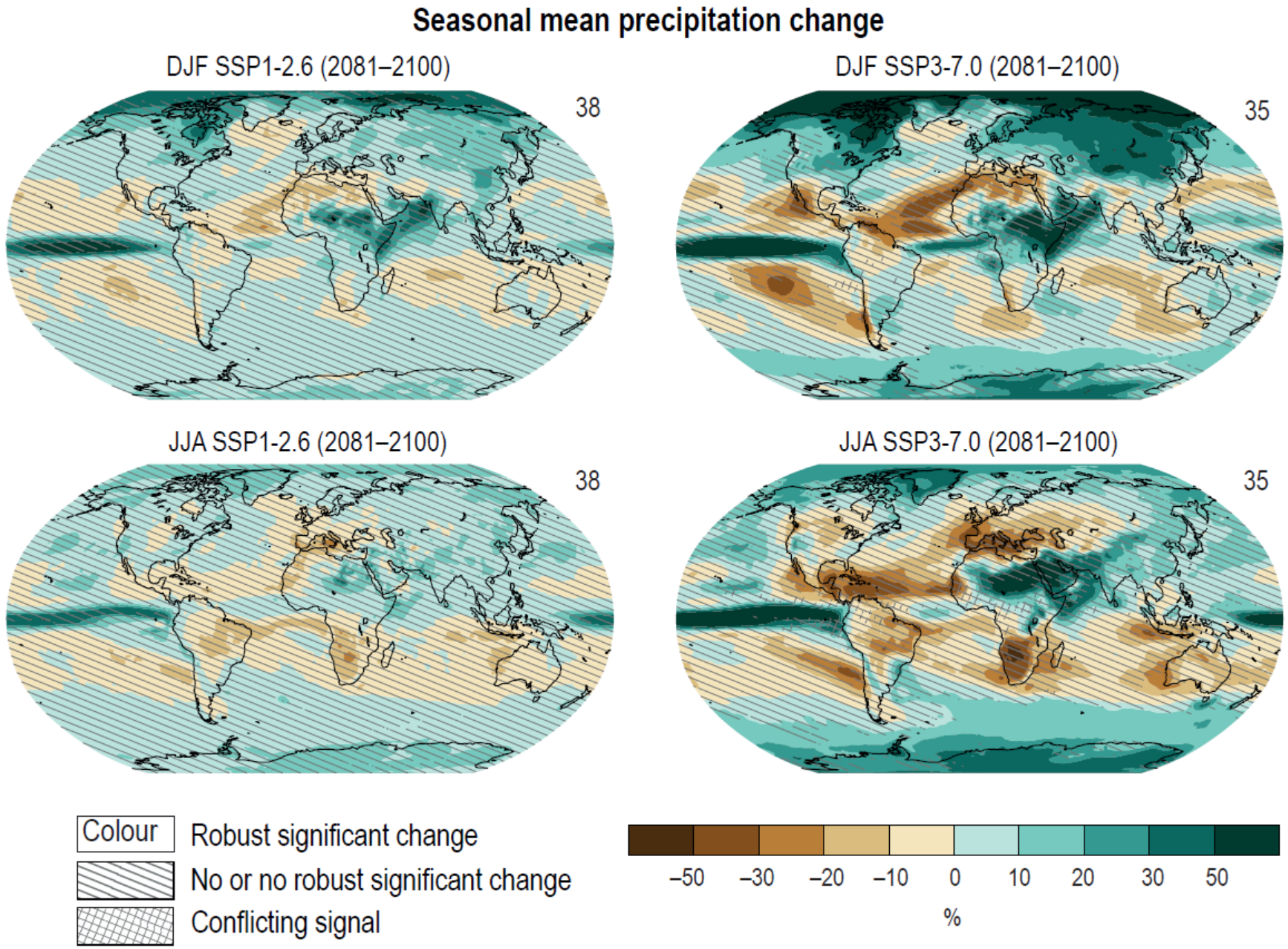
IPCC, 2022

Climate data visualization – climate models



IPCC, 2022

Climate data visualization – climate models



IPCC, 2022

Thank you for your attention