



SLOVAK
HYDROMETEOROLOGICAL
INSTITUTE



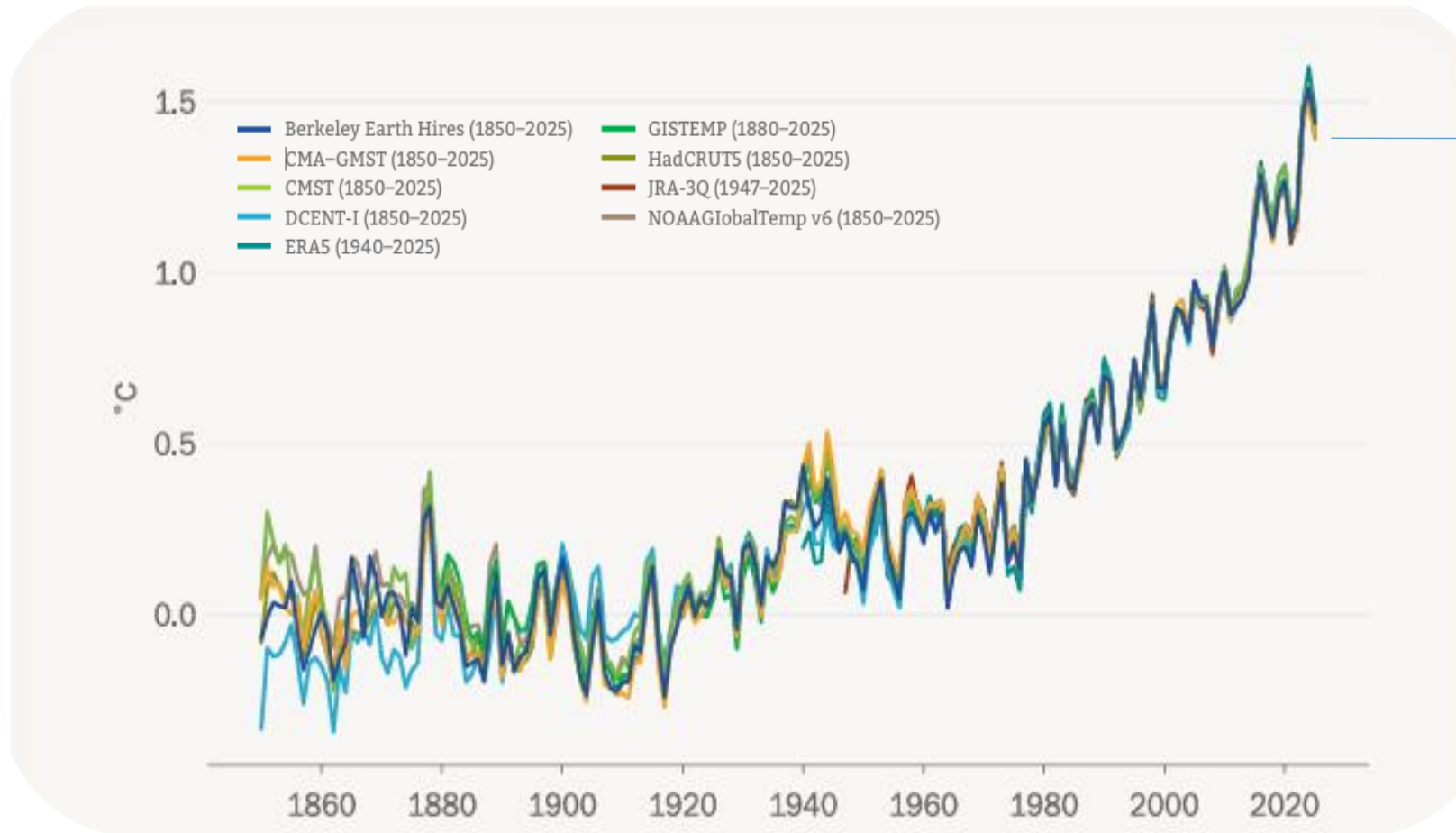
Climate Change in Slovakia:

Mechanisms, Observed Trends, and Future Projections

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Annual global mean temperature anomalies relative to pre-industrial (1850-1990) baseline shown from 1850 to 2025



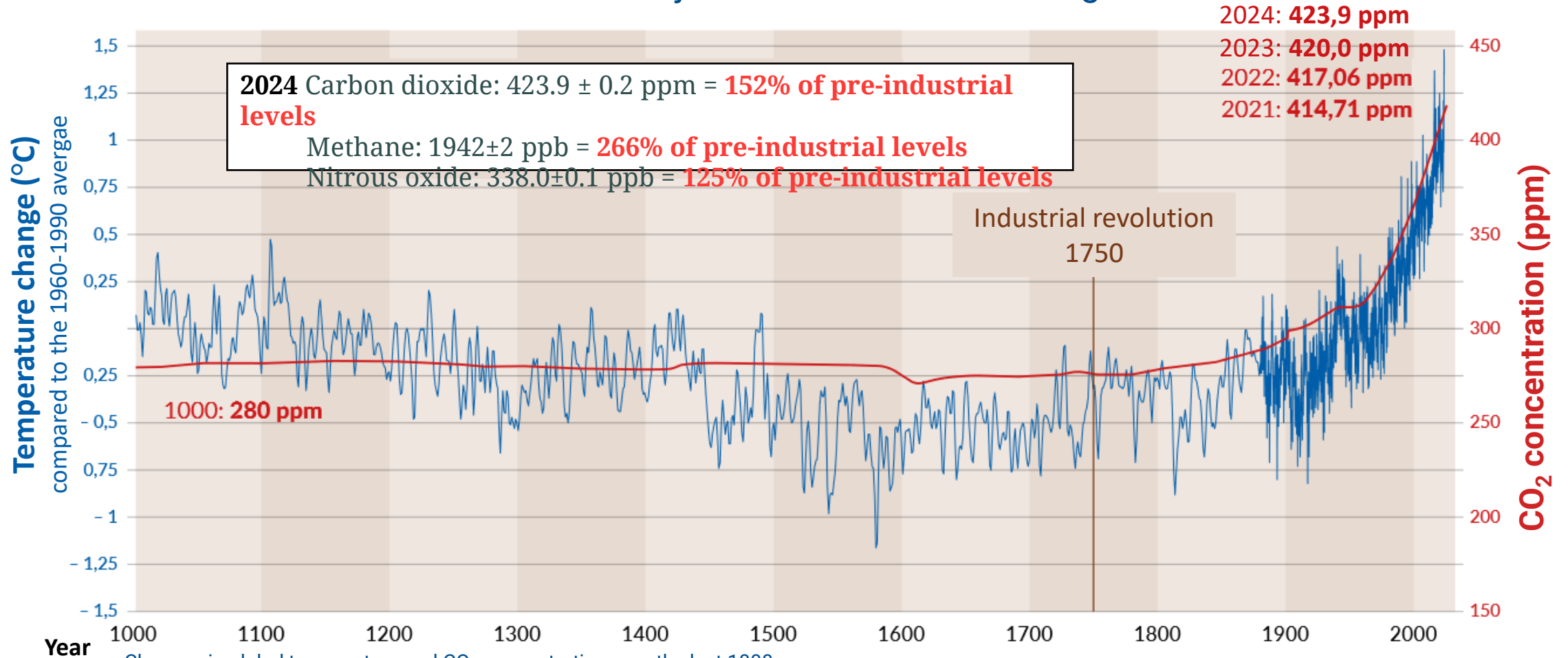
2025 was second or third warmest year on record.

It was approximately 1.43 ± 0.13 °C warmer than the pre-industrial (1850-1900) average.

According to the latest IPCC report (March 2023), global temperatures have increased by 1.1°C compared to 1850-1900.

Source: World Meteorological Organization, 2026

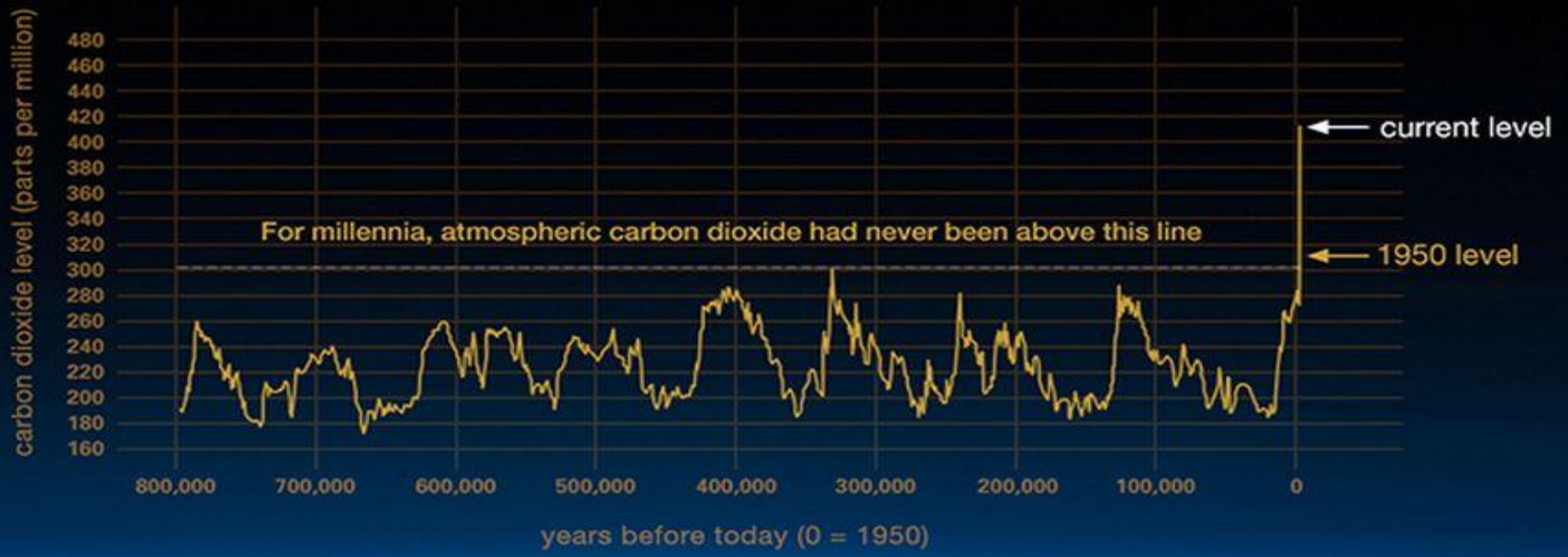
Increasing levels of greenhouse gases, like carbon dioxide, in the atmosphere due to human activities are a major driver of climate change.



Changes in global temperature and CO₂ concentration over the last 1000 years

Source: Zmena klímy a rašeliniská, Inštitút aplikovanej ekológie DAPHNE 2024;

World Meteorological Organization, 2026

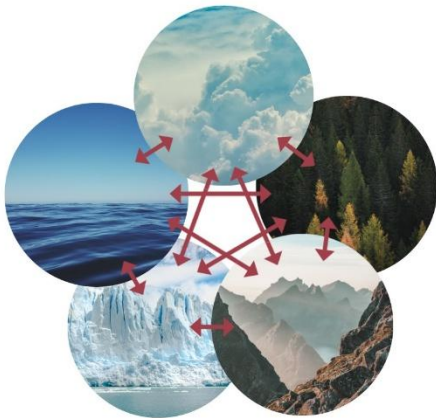


climate.nasa.gov

As greenhouse gases are trapping more heat in the Earth system, the balance of energy incoming and outgoing is changing.

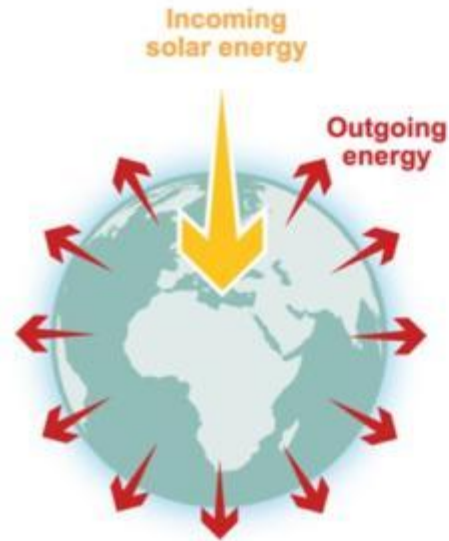
As the trapped energy accumulates, it raises temperatures on land and in the ocean and leads to melting glaciers and ice sheets.

Around 90% of the extra heat trapped by greenhouse gases is absorbed by the ocean, causing it to warm and affecting marine life, weather patterns, and sea levels.

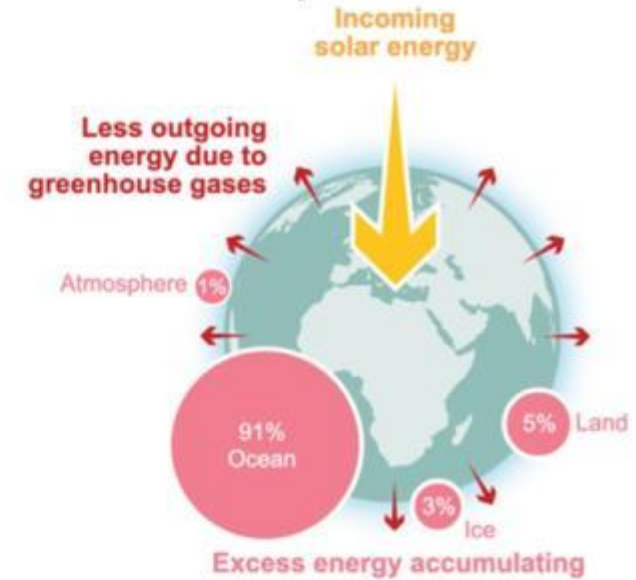


Because the components of the climate system are closely interconnected, changes in land, ocean, and atmospheric temperatures also affect other meteorological variables.

Stable climate: in balance



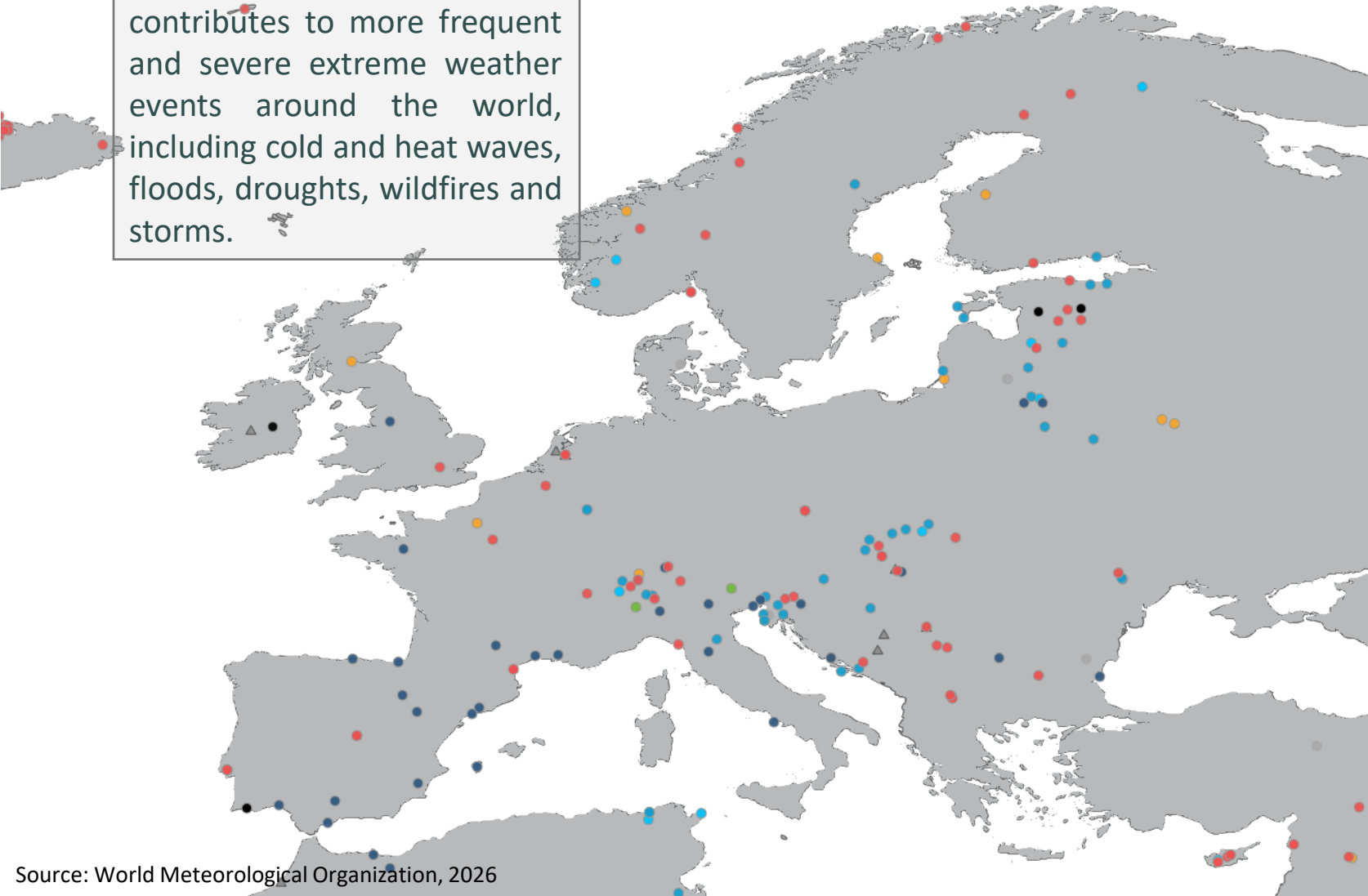
Today: imbalanced



Source: World Meteorological Organization, 2026

Extreme Events Map 2025

Rising global temperatures contributes to more frequent and severe extreme weather events around the world, including cold and heat waves, floods, droughts, wildfires and storms.



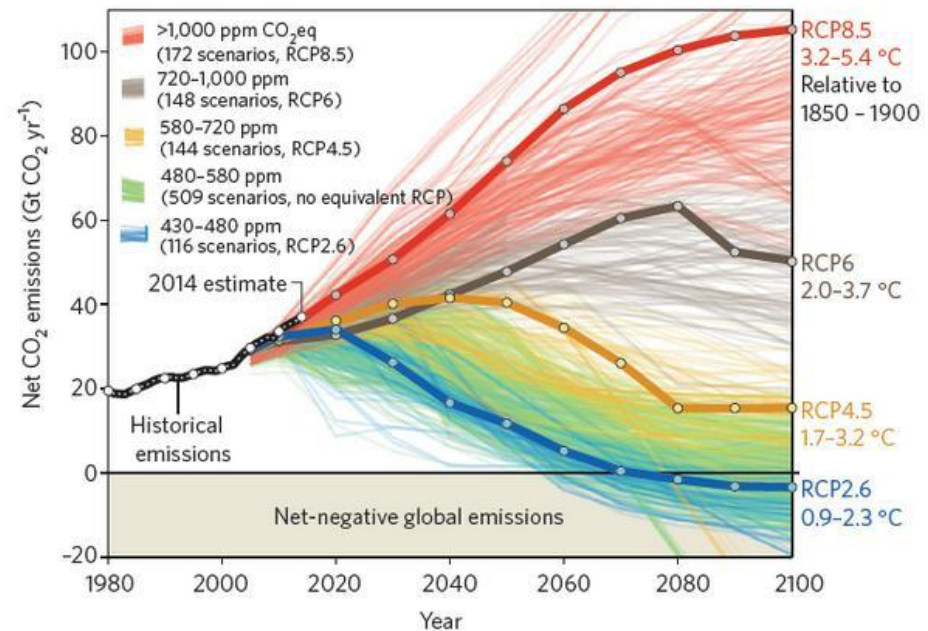
●	Heat wave
●	Drought/Dry spell
●	Wild land fire/Forest fire
●	Flood
●	Thunderstorms/Squall lines
●	High seas/Rogue waves
●	Rain/wet spell
●	Hail
●	Cold wave
●	Snowstorm
●	Snow
●	Wind
●	Pollen pollution/polluted air
●	Fog/Haze/Smog
●	Dust storm/Sandstorm
●	Landslide/mudslide & debris flow
●	Tropical cyclone
●	Extra-tropical cyclone
●	Tornado
●	Lightning
▲	Other
●	Other

Scenarios of Climate Change

Representative Concentration Pathways (RCPs) are greenhouse gas concentration trajectories adopted by the IPCC for climate modeling.

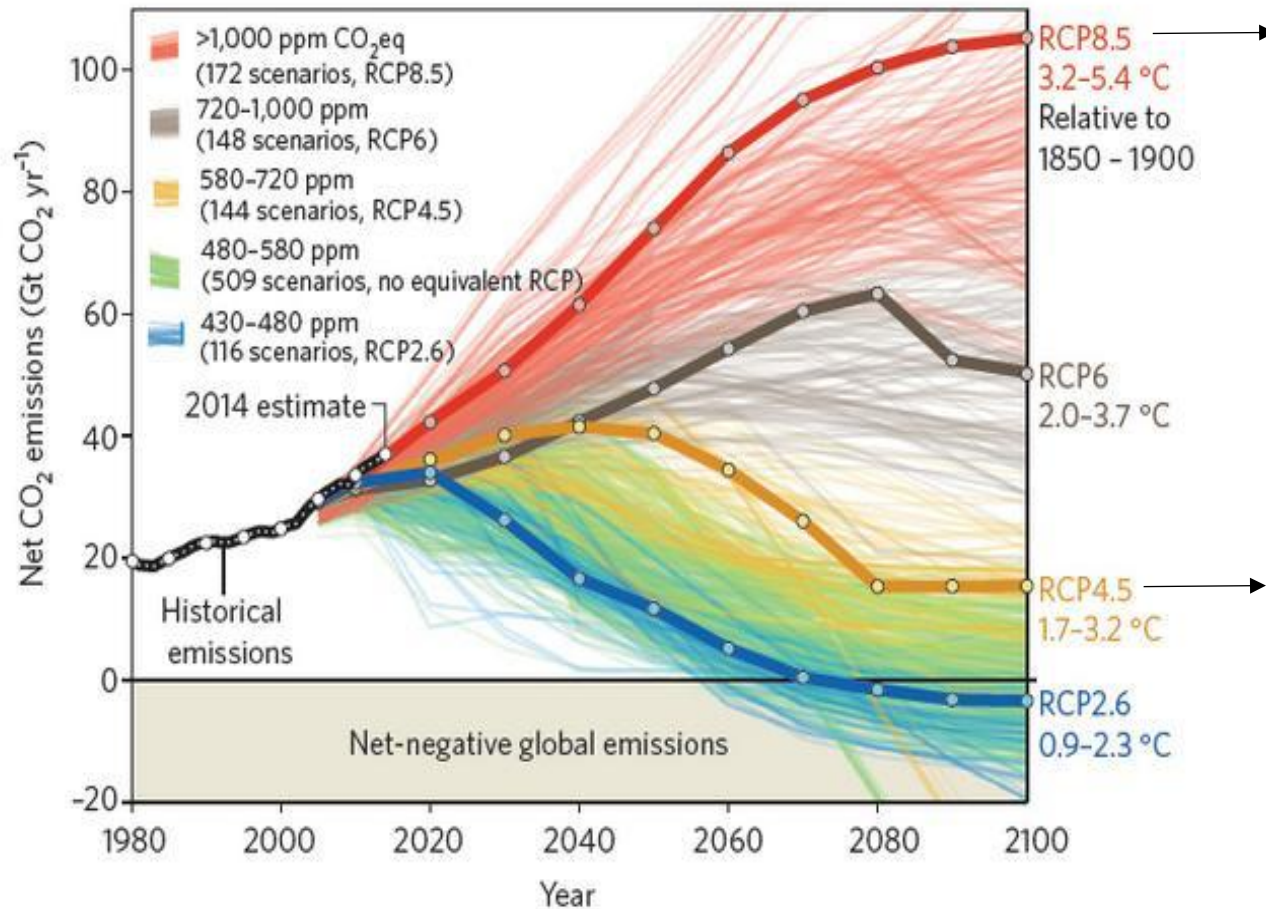
The future pathways shows the different „what if?“ results from different combinations of assumptions about:

- Population growth
- Economic activity
- Energy intensity
- Socio-economic development
- Land use change
- Climate policy



Source: <https://andthetheresphysics.wordpress.com>

Sources: <https://climatedata.ca/resource/emissions-scenarios-rcps/>

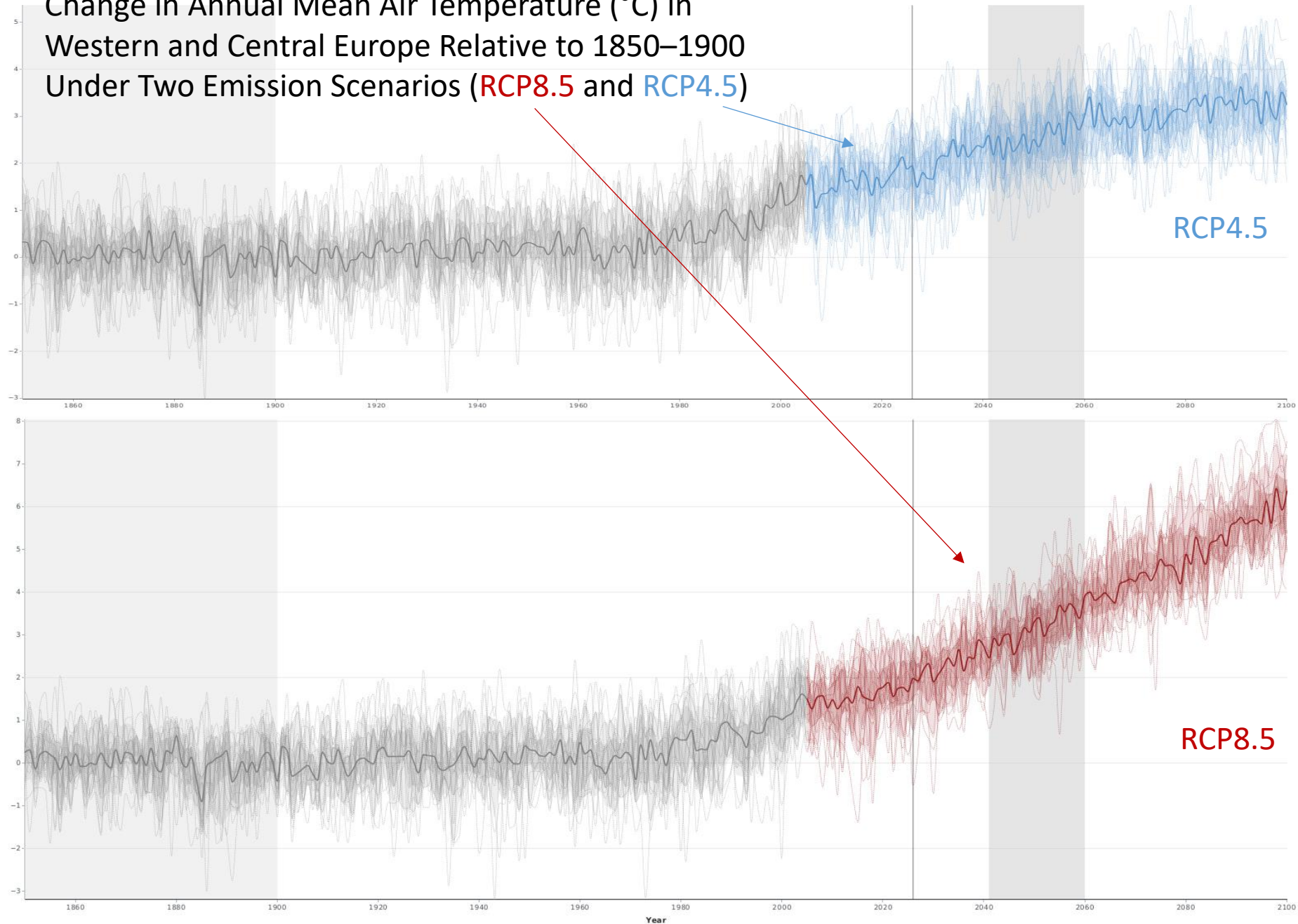


RCP 8.5; the high emissions scenario
 Future where there are few restrictions on emissions. Emissions continue to increase rapidly through this century, and only stabilize by 2250.

RCP 4.5; a medium emissions scenario
 Future with included measures to limit human-caused climate change. This scenario requires global carbon emissions to stabilize by end of the century.

Source: <https://andthentheresphysics.wordpress.com>

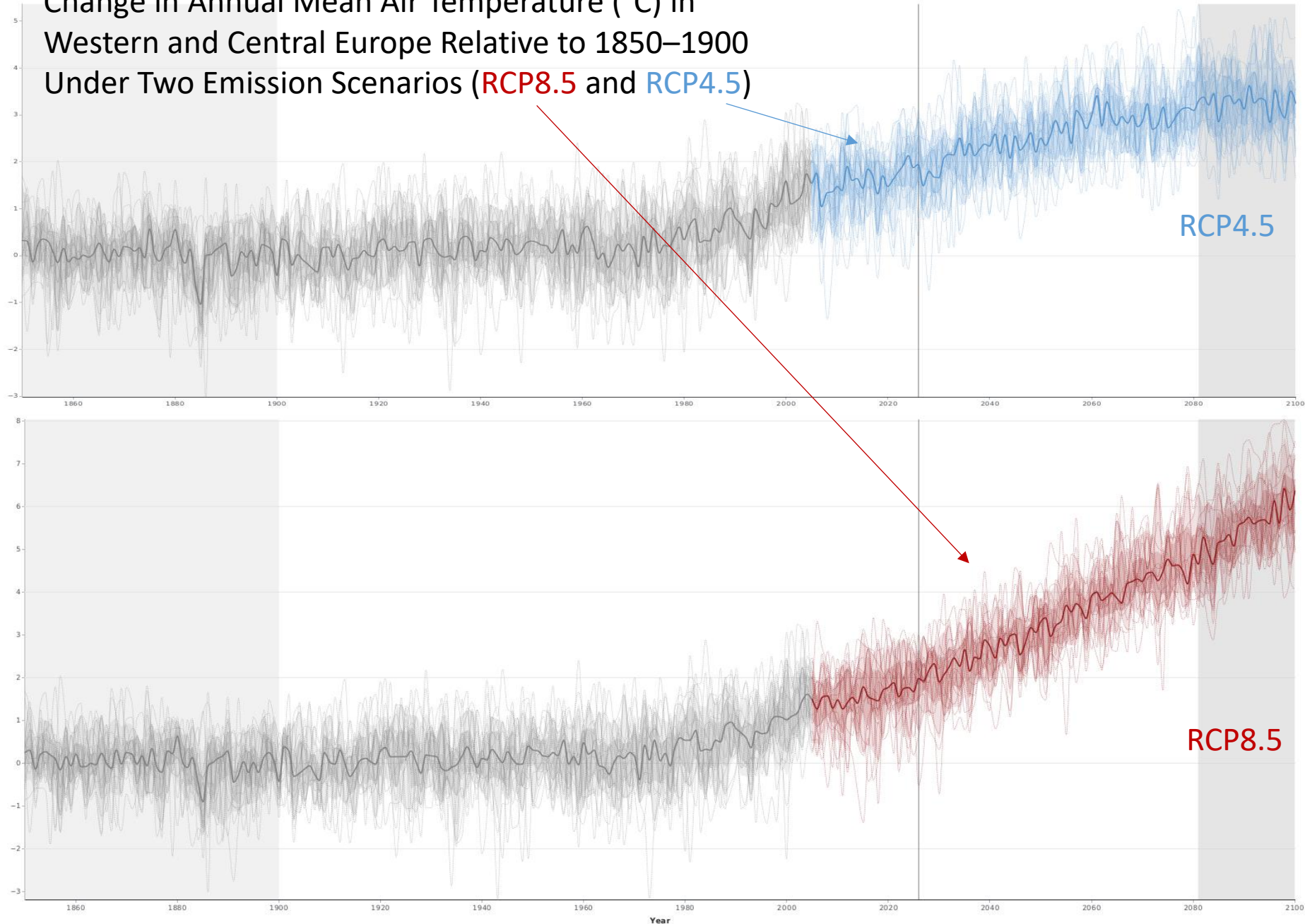
Change in Annual Mean Air Temperature (°C) in Western and Central Europe Relative to 1850–1900 Under Two Emission Scenarios (RCP8.5 and RCP4.5)



Dotted/Solid line: Model/P50 (Median)
Light/Dark shadow: P10 to P90/ P25 to P75
Light/dark box: Baseline/Selected period



Change in Annual Mean Air Temperature (°C) in Western and Central Europe Relative to 1850–1900 Under Two Emission Scenarios (RCP8.5 and RCP4.5)



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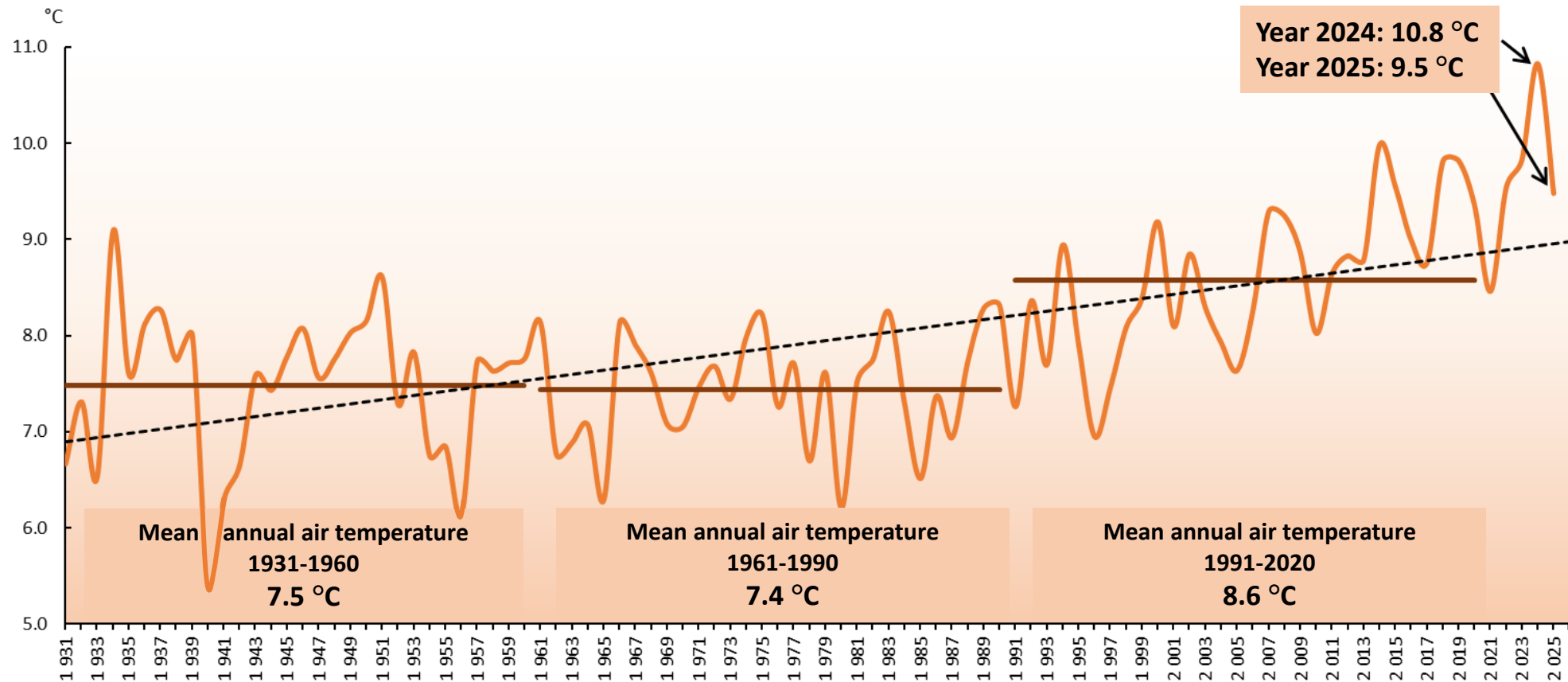


Source: <https://www.bbc.com/news/world-europe-17847682>



Observed Trends, and Future Projections for Slovakia

Observed trend in spatially averaged annual air temperature in Slovakia since 1931



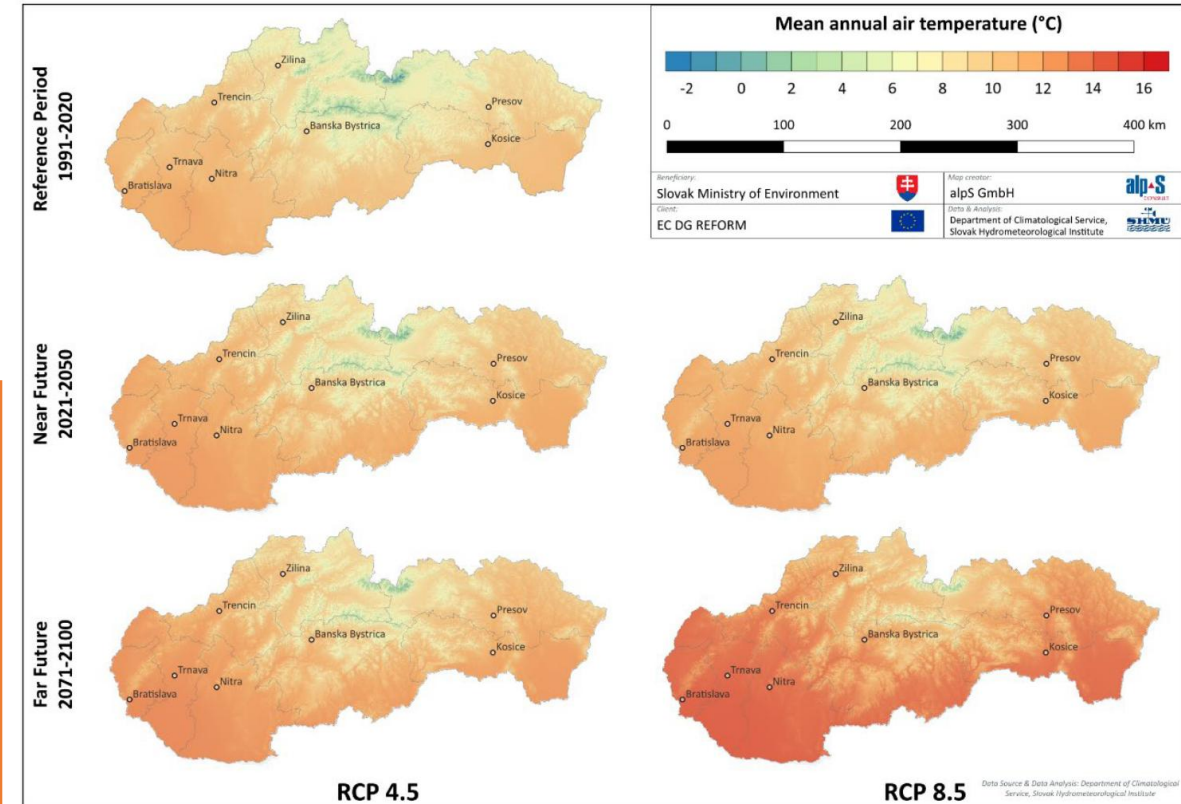
Scenarios of air temperature and related characteristics

We are expecting fewer

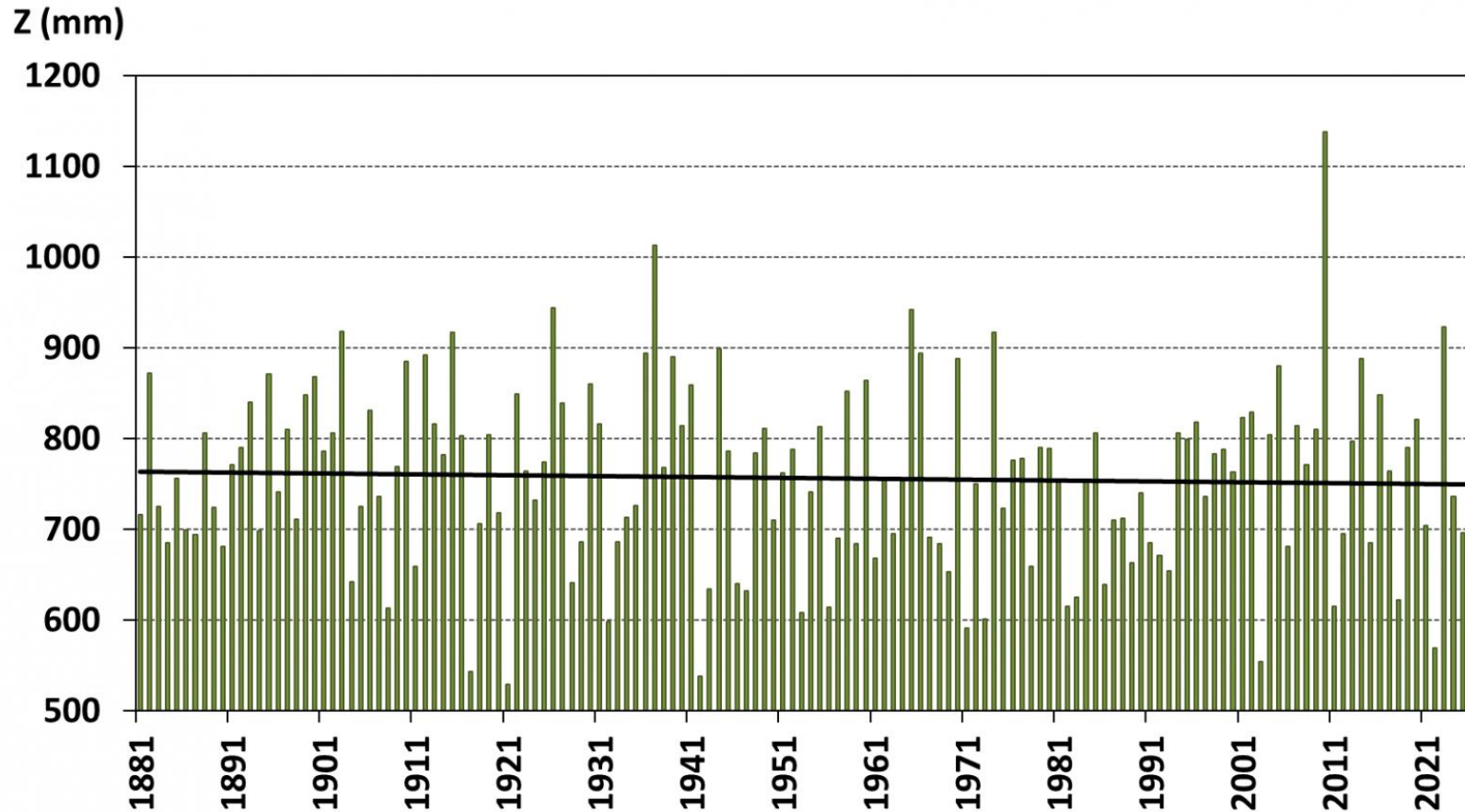
- Ice days (daily $T_{max} < 0\text{ }^{\circ}\text{C}$)
- Frost days (daily $T_{min} < 0\text{ }^{\circ}\text{C}$)
- Heating days

We are expecting more

- summer days (daily $T_{max} \geq 25\text{ }^{\circ}\text{C}$)
- tropical days (daily $T_{max} \geq 30\text{ }^{\circ}\text{C}$)
- Tropical nights (minimum night temperature $\geq 20\text{ }^{\circ}\text{C}$)
- Days with heat stress
- Heat waves
- Cooling days



Observed trend in spatially averaged annual precipitation totals in Slovakia since 1881



Changes in annual precipitation totals are not significant.

Observed Changes in Precipitation Patterns

- Declining contribution of snowfall to total winter precipitation.
- Increasing contribution of heavy convective rainfall to total summer precipitation.

Scenarios of precipitation



These hypothetical sponges become 7% larger with each degree of warming. In turn, the absorptive capacity of the sponges increases such that they can soak up more water (analogous to increased evaporation over wet surfaces), as will their propensity to yield increasingly large volumes of water if wrung out with sufficient force (analogous to increasingly heavy downpours of precipitation when atmospheric conditions are otherwise conducive).

Source: Swain et al., 2025

The water-vapour-holding capacity of the atmosphere increases exponentially in response to a linear increase in temperature by about 7% per 1°C.

- Increase in potential evapotranspiration
- Increase in extreme precipitation

Annual precipitation is projected to increase by approximately 10–15% by 2100, with larger increases in winter and in northern regions of Slovakia, while summer precipitation may decrease.

Days with daily precipitation totals >40 mm are projected to increase across Slovakia. In 2020–2050, these events may occur in low-lying areas of southwestern Slovakia with a return period of 1–2 years. By the end of the century, their frequency is expected to increase by ~30%.



Despite the decrease in total snowfall, many places in Slovakia may experience more frequent intense snowfall (in line with increasing extremes). Wet and heavy snowfall will also be more frequent.

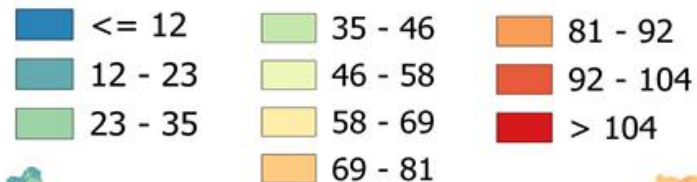
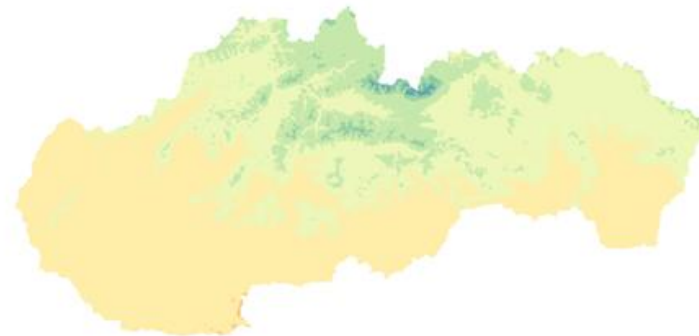
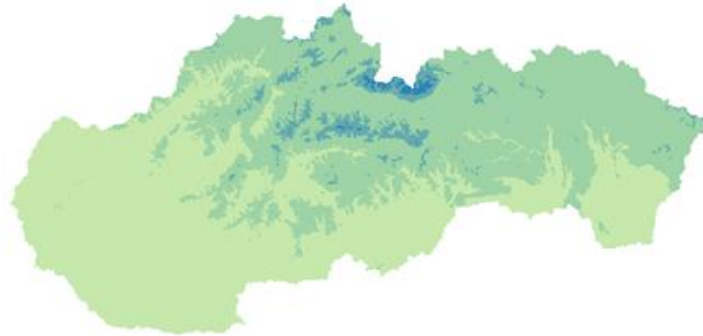
Reference evapotranspiration

Difference in mean annual reference evapotranspiration (mm) between 1991–2020 and 2021–2060 (left) and between 1991–2020 and 2061–2100 (right).

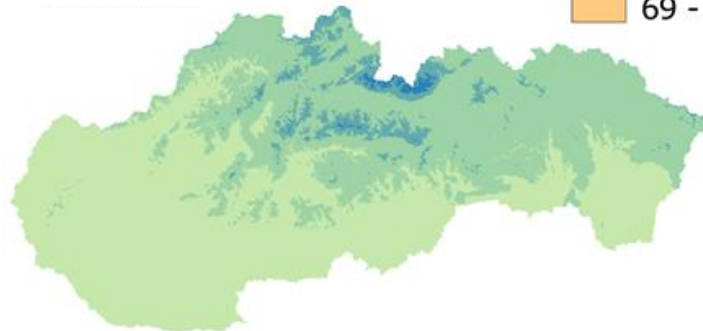
(2021-2060) - (1991-2020)

(2061-2100) - (1991-2020)

RCP 4.5



RCP 8.5



Reference evapotranspiration

The evapotranspiration rate from a standardized vegetated surface under well-watered conditions, representing atmospheric water demand.

Due to rising air temperatures, an increase in reference evapotranspiration is expected across the entire territory of Slovakia.

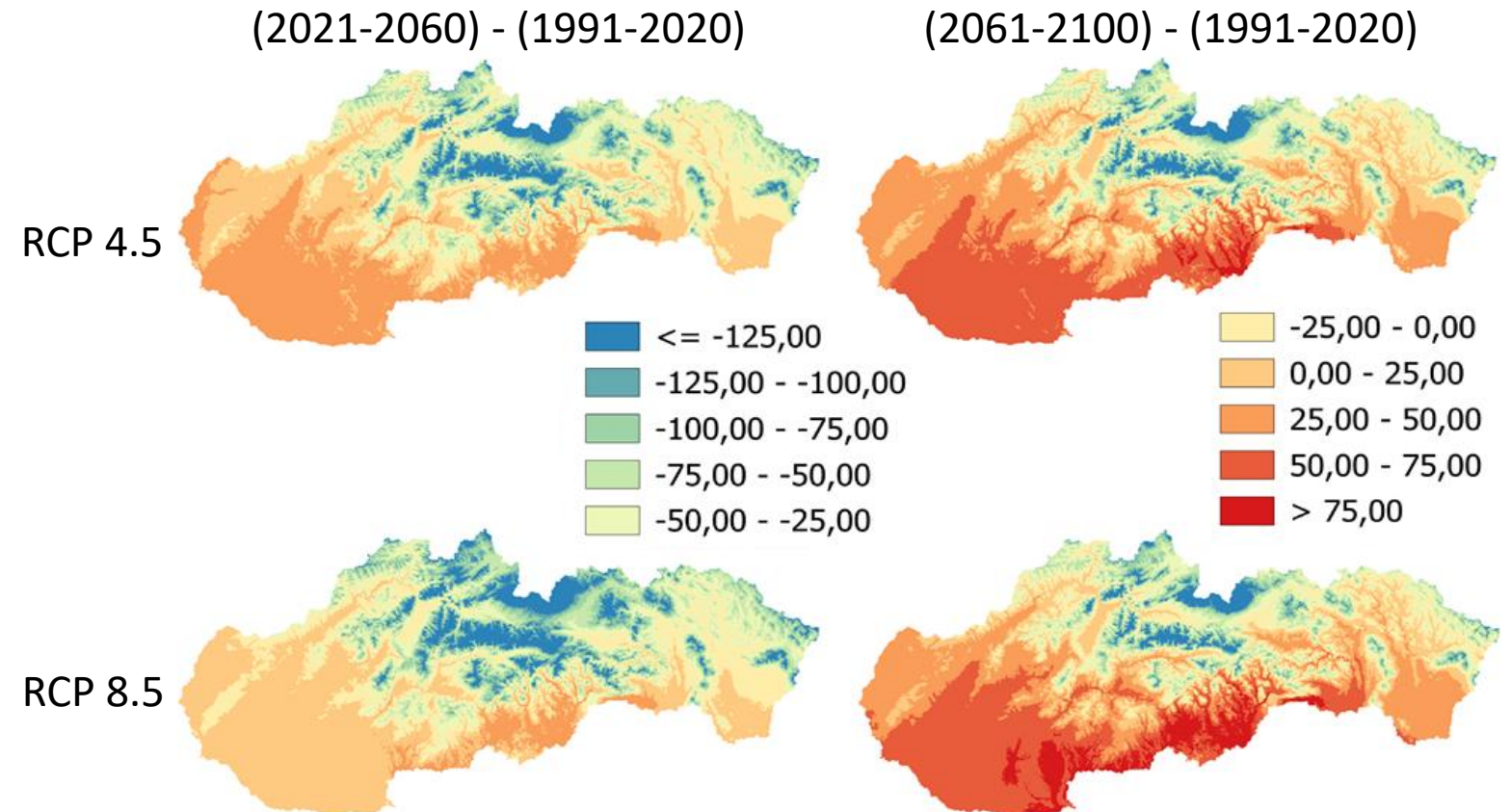
Drought

Water balance

The difference between reference evapotranspiration and precipitation.

The frequency of drought is expected to increase most significantly in the western part of the country (Danubian Lowland and Záhorská Lowland), as well as in the southern areas of central Slovakia, southwestern and southern parts of central Slovakia. Drought intensity is also projected to increase here.

Change in mean annual water balance (mm) between 1991–2020 and 2021–2060 (left) and between 1991–2020 and 2061–2100 (right):



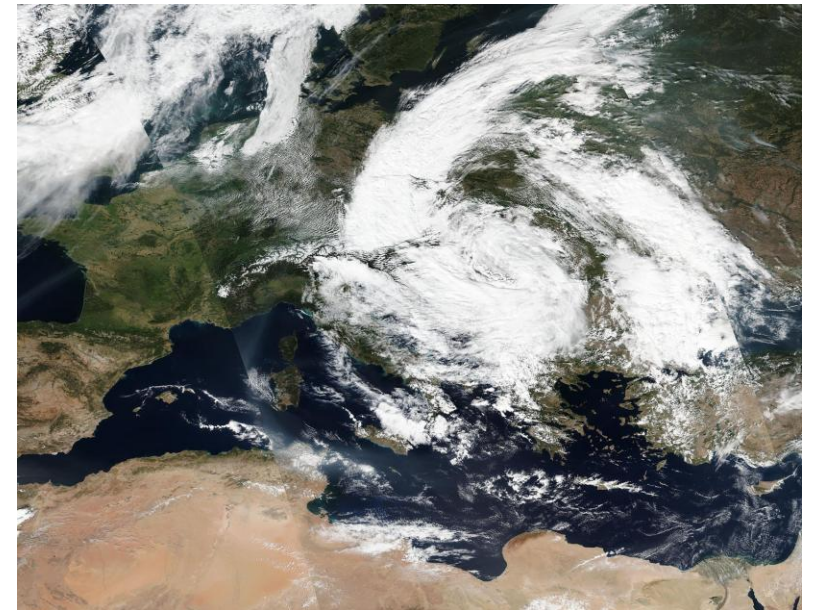
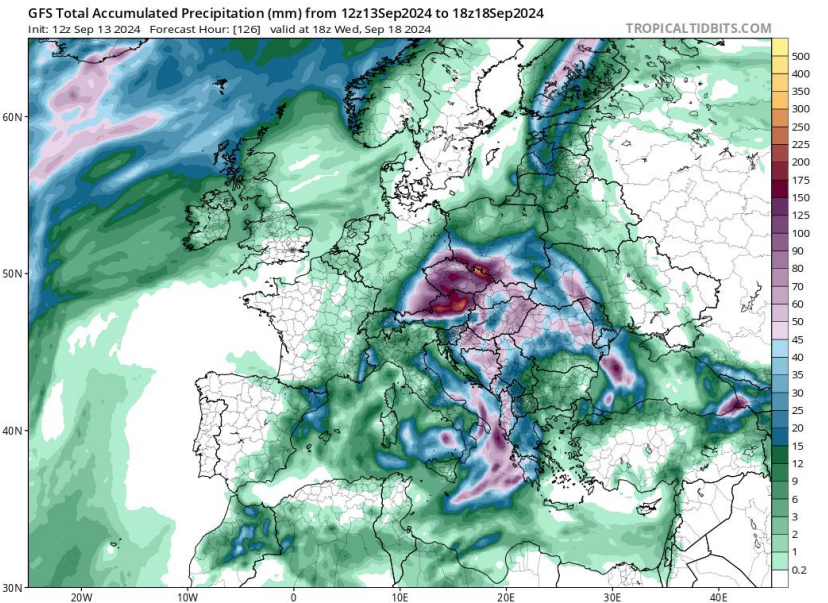
Case study: Storm Boris

Between **Friday, 13 and Monday, 16 September 2024**, a low-pressure system named Boris brought record-breaking rainfall to central Europe leading to severe flooding in parts of Austria, Czechia, Slovakia, Poland, Romania and Hungary. The flooding caused widespread damage and disruption with costs estimated in the billions of euros. Sadly, the loss of 27 lives was reported and many people will have been left with mental health issues due to the trauma they experienced.

In this case, extreme precipitation totals followed a preceding dry episode in the region, representing a rapid transition between two contrasting extremes.

According to Athanase et al. (2024), Storm Boris produced approximately 9% more precipitation due to anthropogenic warming. The area affected by extreme rainfall exceeding 100 mm was about 18% larger than it would have been without climate change.

This intensification was supported by **increased atmospheric moisture**: key source regions for the storm, including the Eastern Mediterranean and the Black Sea, are warming at an accelerated rate.



Useful links



Download Spatial Data on Future Climate Projections for Slovakia

<https://arcgis.shmu.sk/portal/apps/sites/#/katalog/pages/b076fa21e3e24847b090ea0a9dcc8446>



Klima Adapt

<https://www.klima-adapt.sk>



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