July 2026

THE BALTIC CLIMATE SCHOOL

Climate change and the Baltic Sea: Impact on hydrology, coastal morphology and shipping

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Klaipėda University

2026 07 07

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them.

Coalition Clean Baltic

What is Climate?

- *“Climate is what we expect, weather is what we get.” Mark Twain*
- *“Weather is one football game, climate is the history of the National Football League.” @MikeNelson247 via @CC_Yale*
- *“Climate tells you what clothes to buy, weather tells you what clothes to wear.” – middle school student*

World Meteorological Organisation (WMO)

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Climate in a narrow sense is usually defined as the "average weather", or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years.

GFS 2m Temperature (°C)

Init 2026/07/04 00Z | f090 Valid Tue 18Z, Jul 07, 2026

ClimateReanalyzer.org

Climate Change Institute | University of Maine

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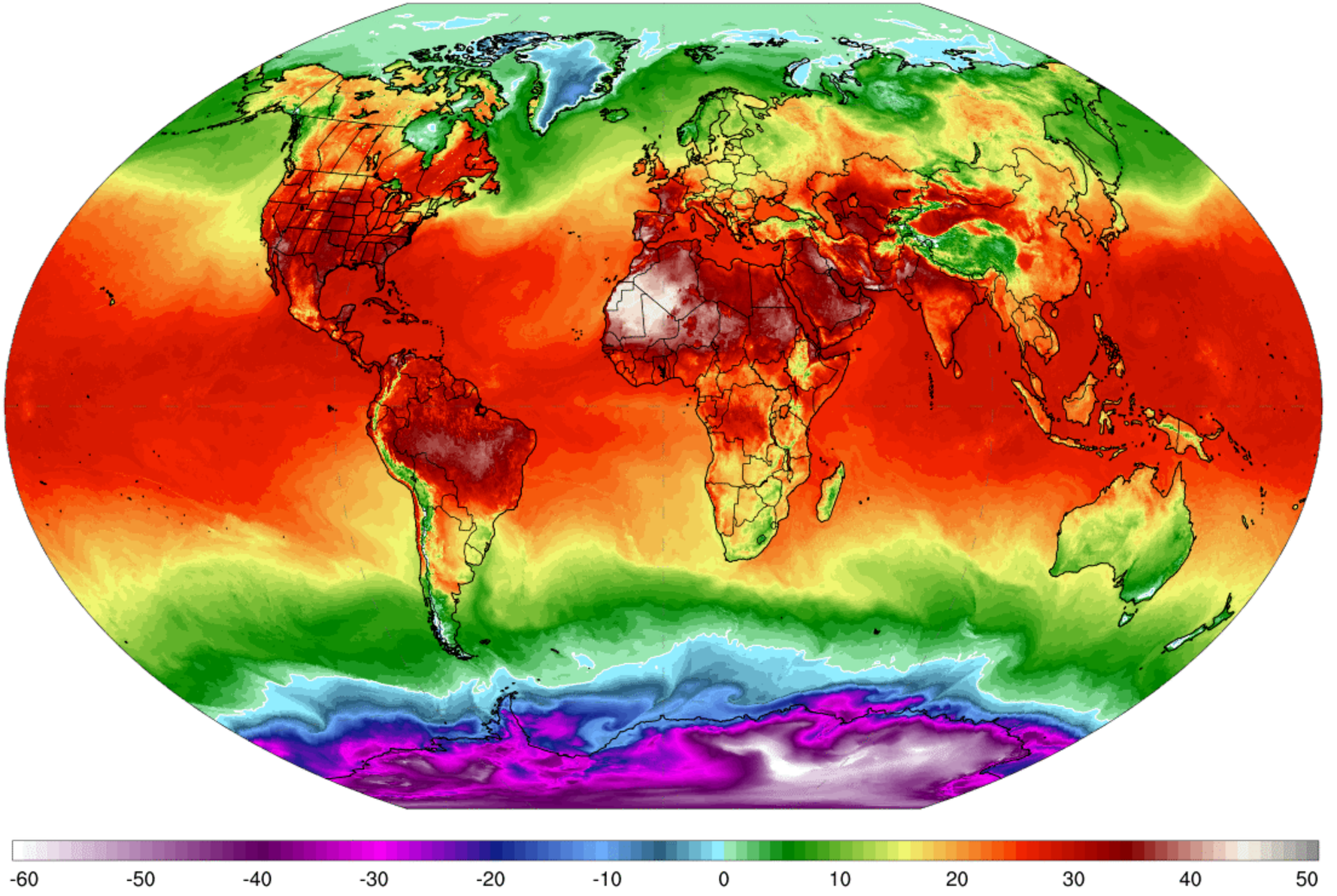

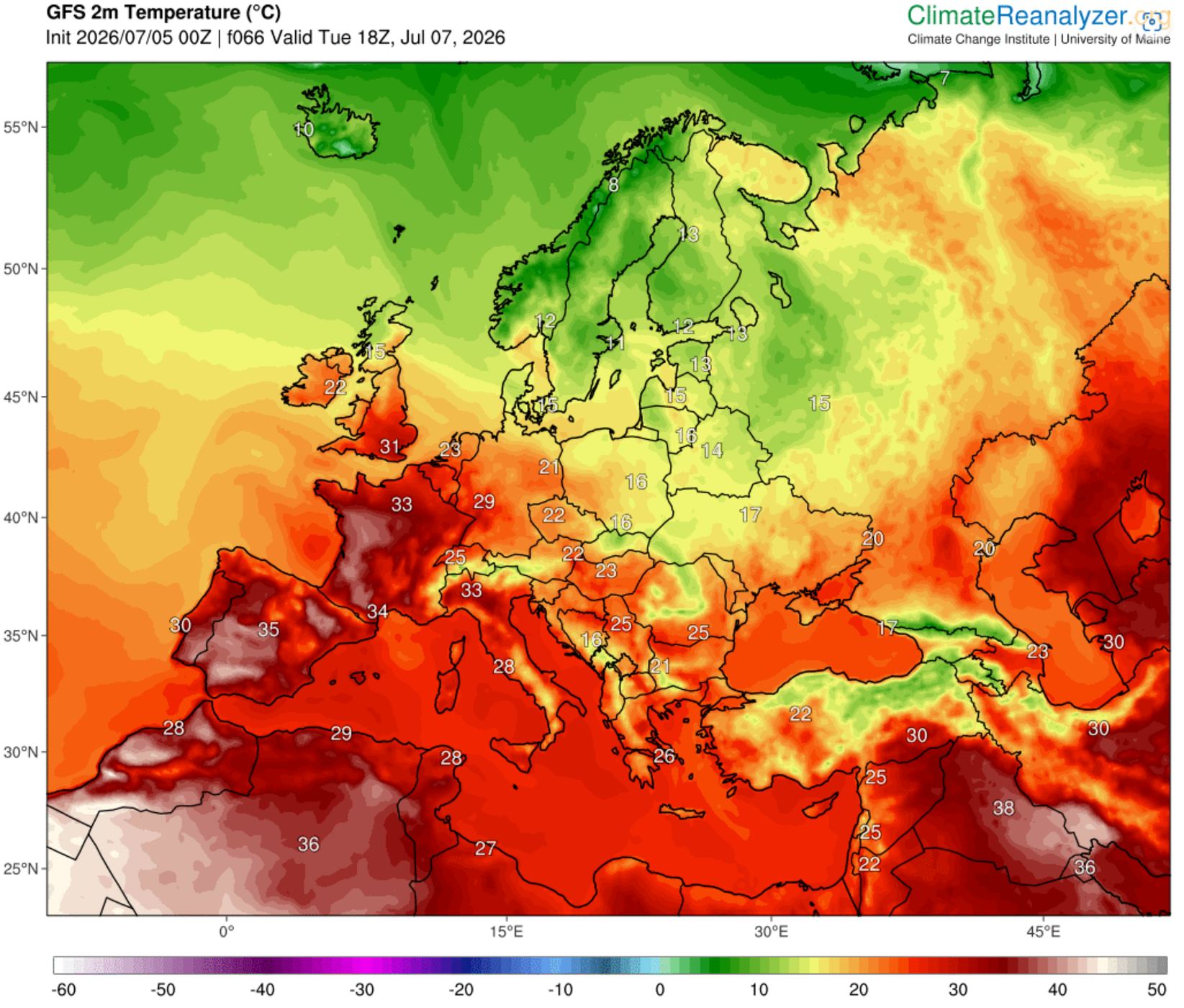

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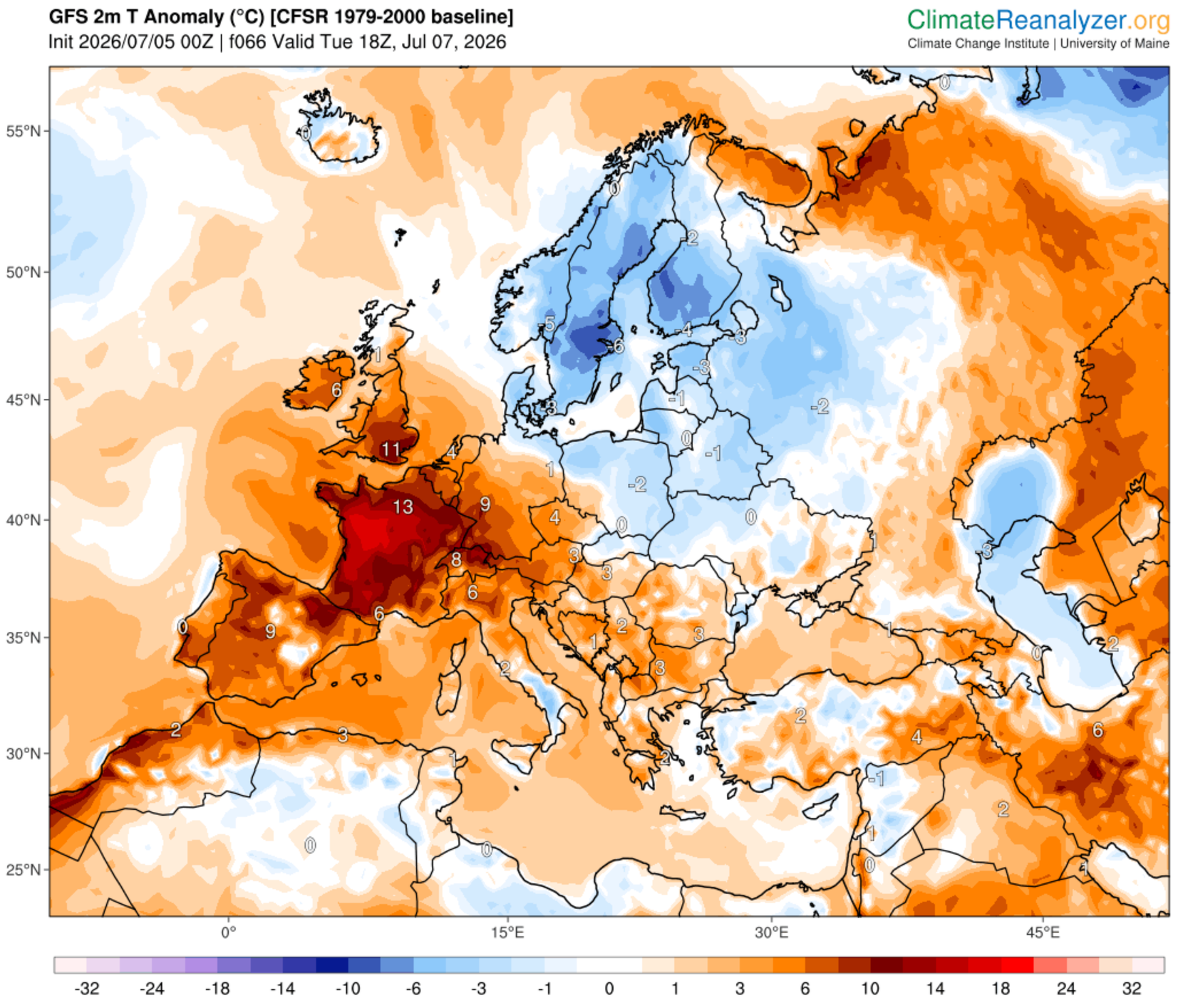

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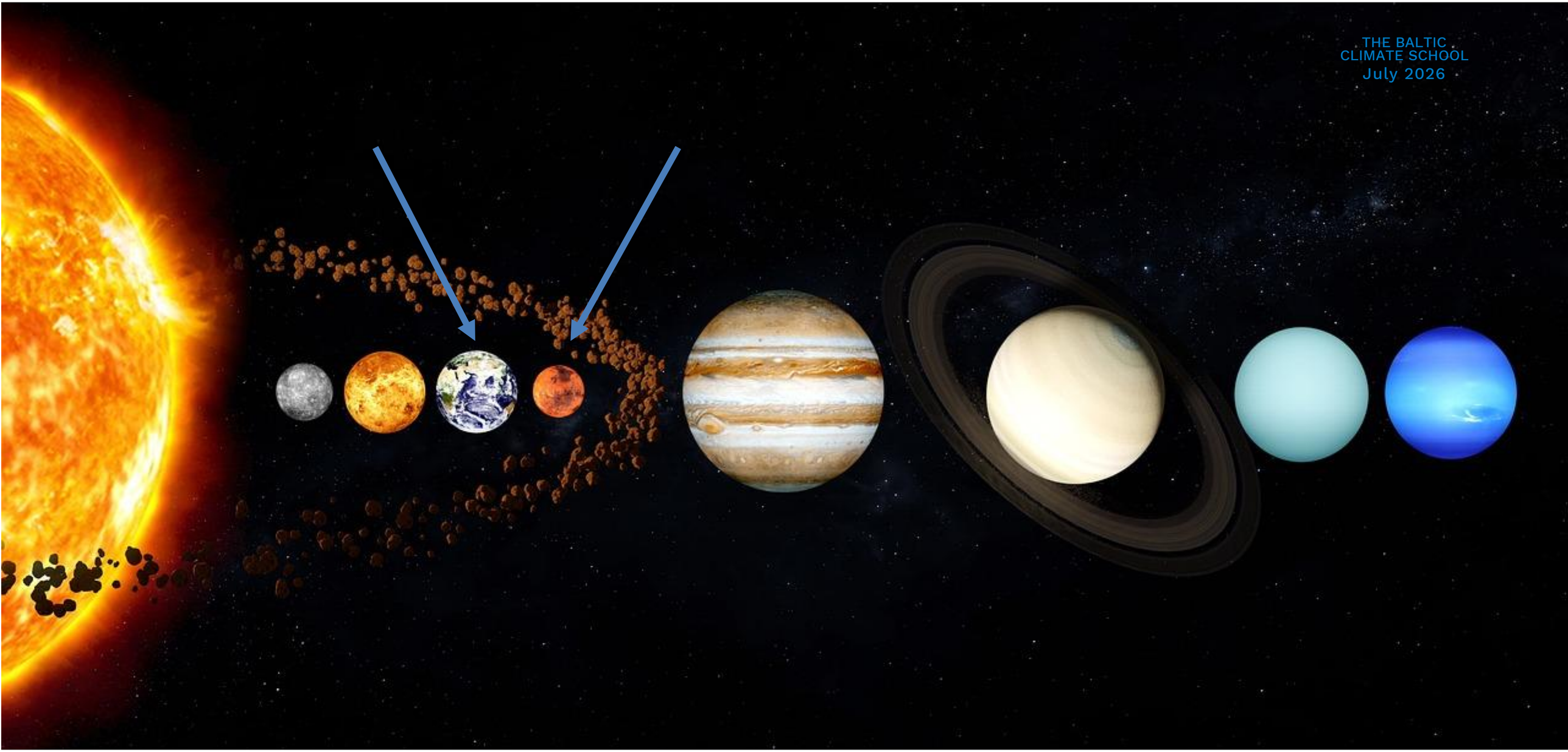
THE BALTIC
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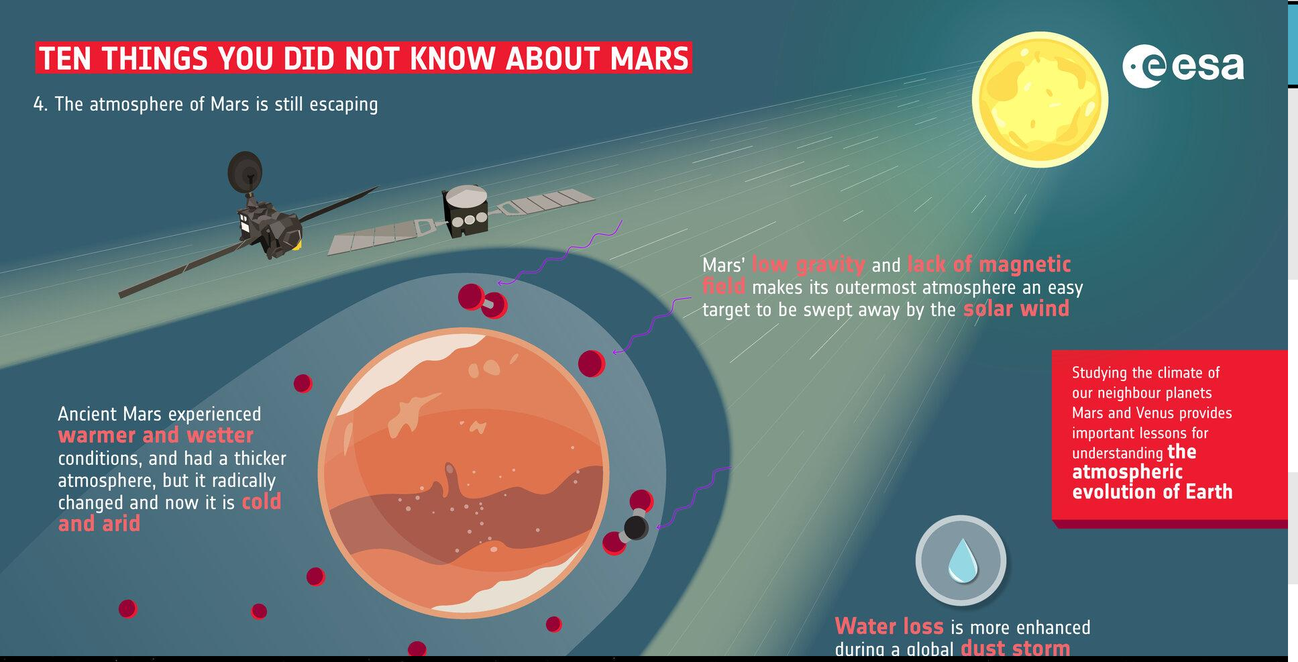
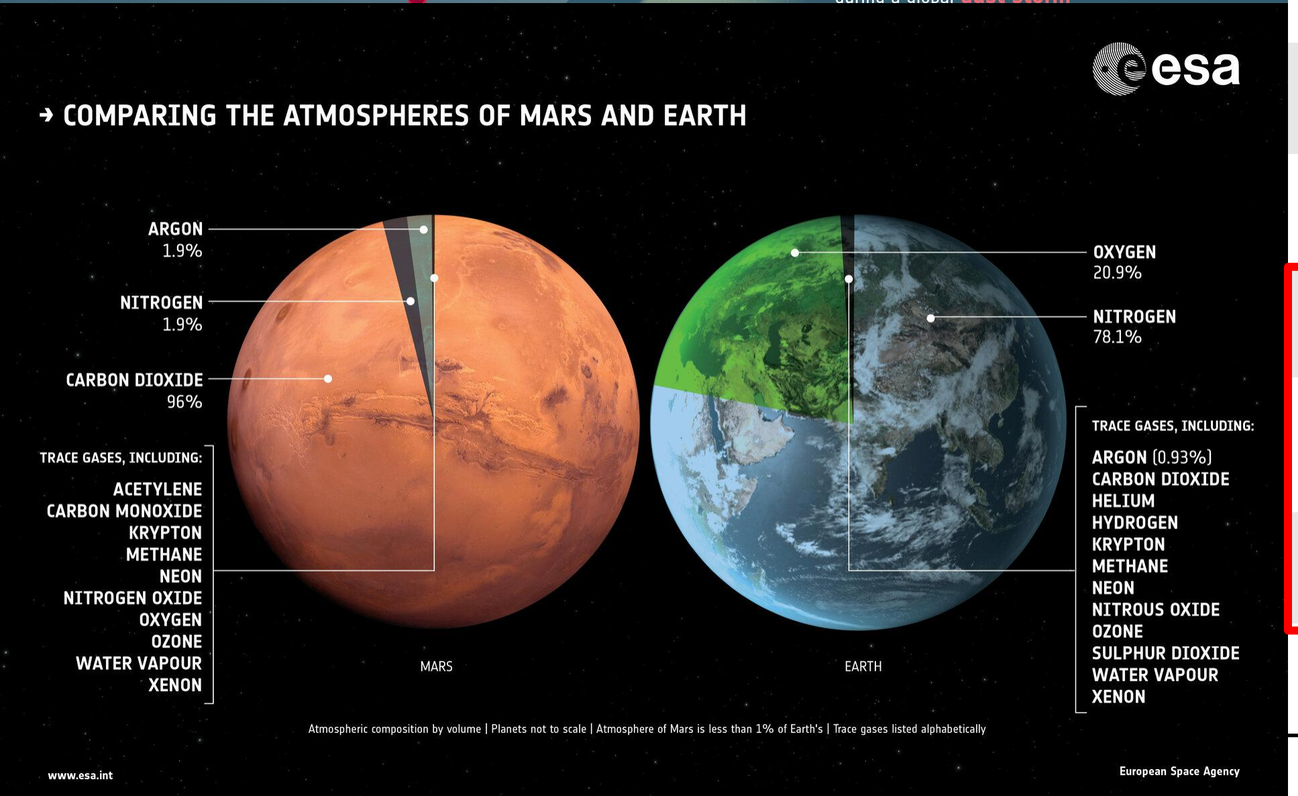
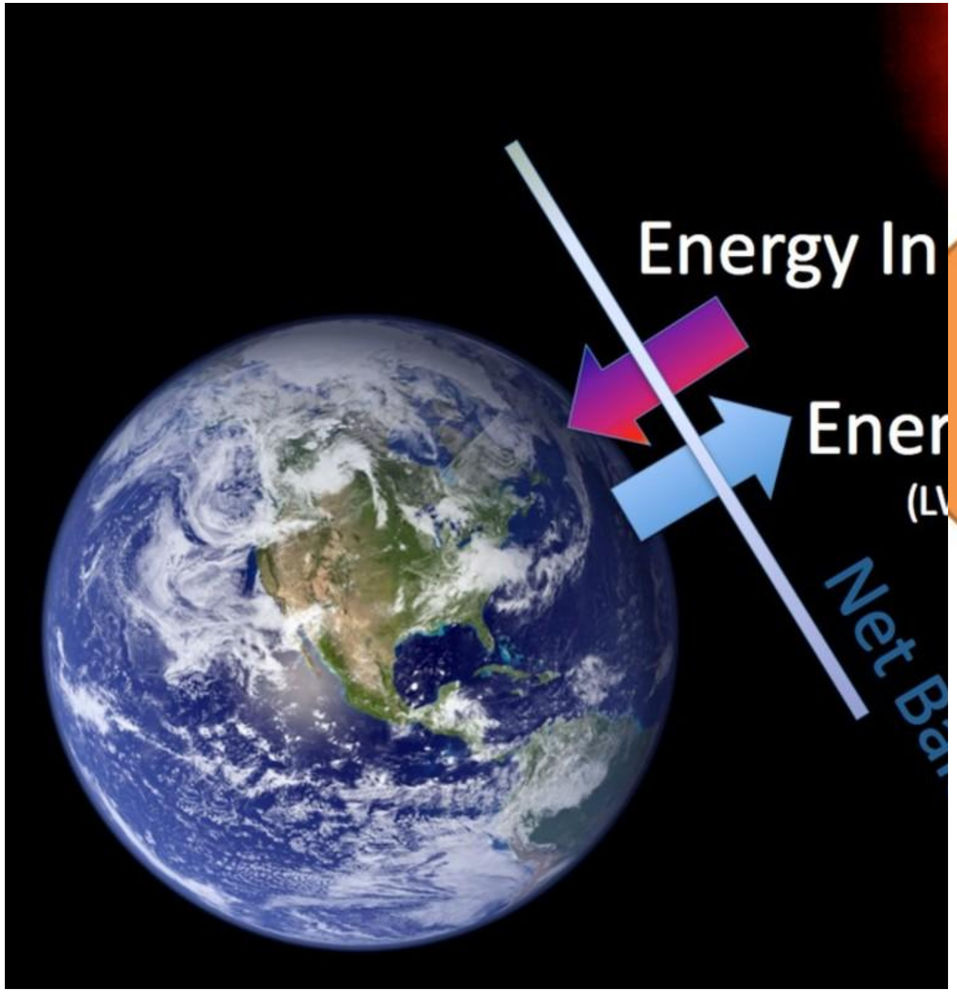


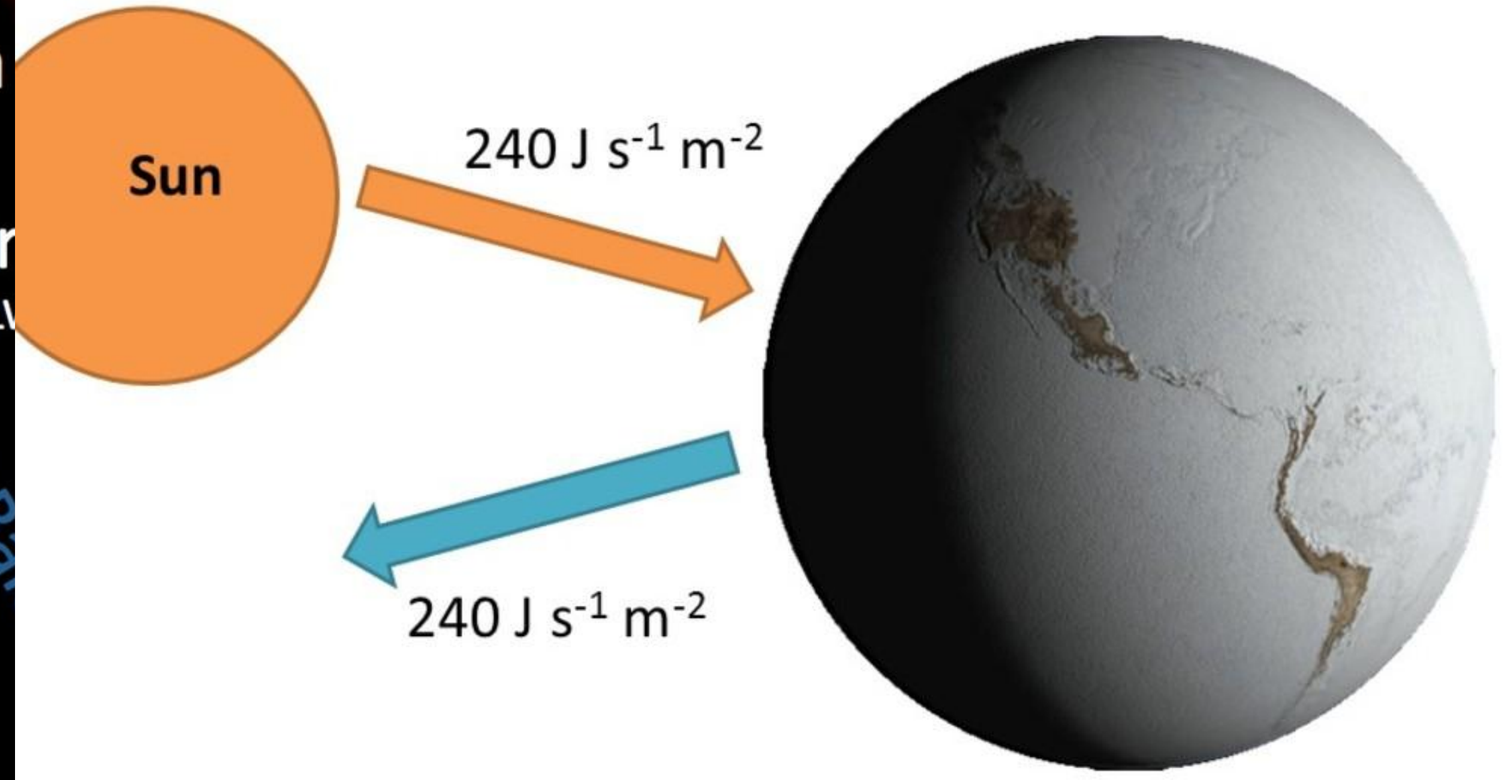


	Earth	Mars
Average Distance from Sun	150 million km	229 million km
Average Speed in orbiting Sun	29.8 km/s	23.3 km/s
Diameter	12 755 km	6 791 km
Tilt of Axis	23.5 deg	25 deg
Length of Year	365.25 d	687 d
Length of Day	23 h 56 min	24 h 37 min
Mass	4.3*10^24 kg	6.4*10^23kg
Gravity	9.81 kg*m/s^2	3.68 kg*m/s^2
Pressure	1013 hPa	6-8 hPa
Moon	1	2

Climate =
Heat energy balance + Atmosphere

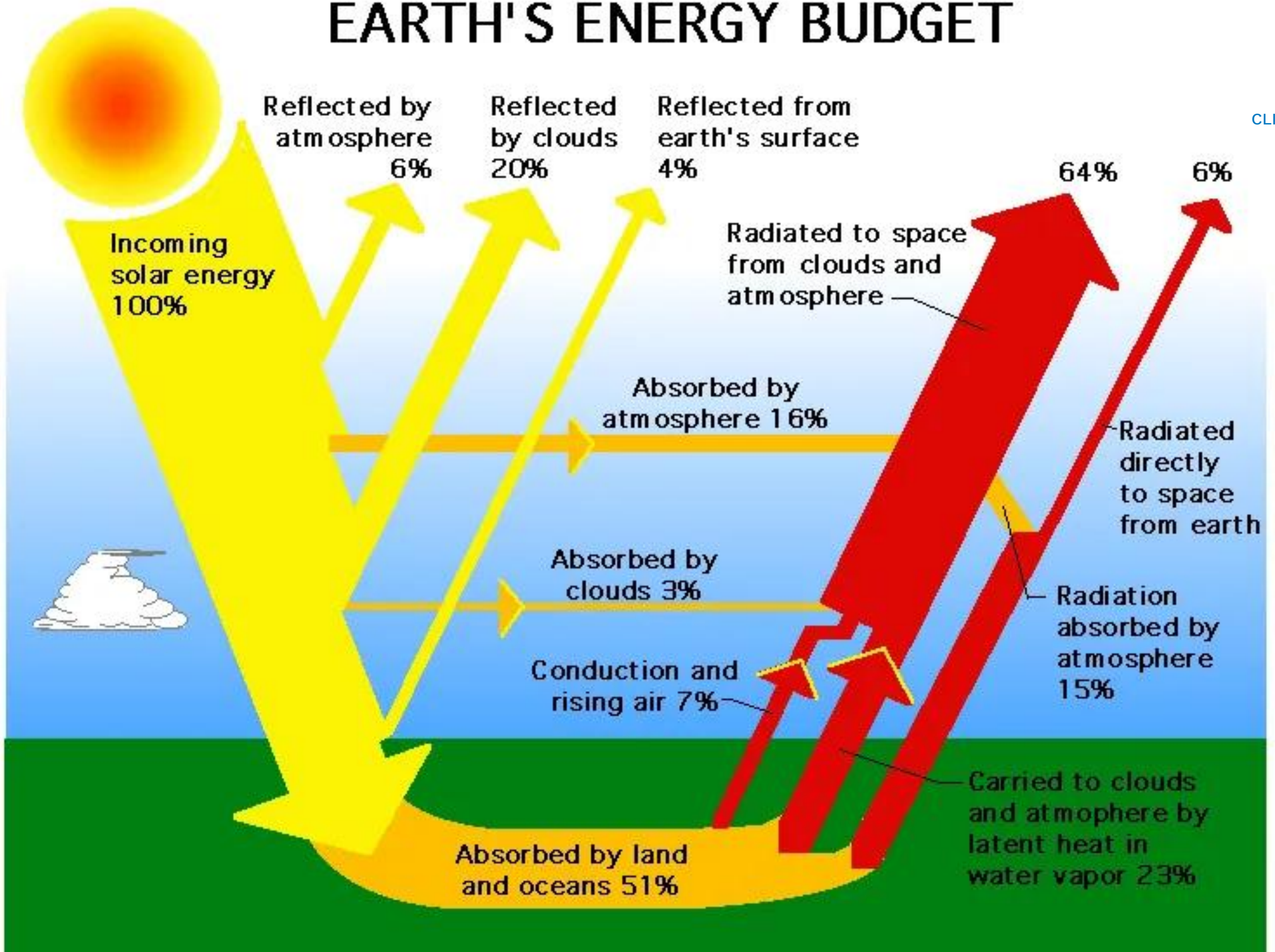


If there were no atmosphere…

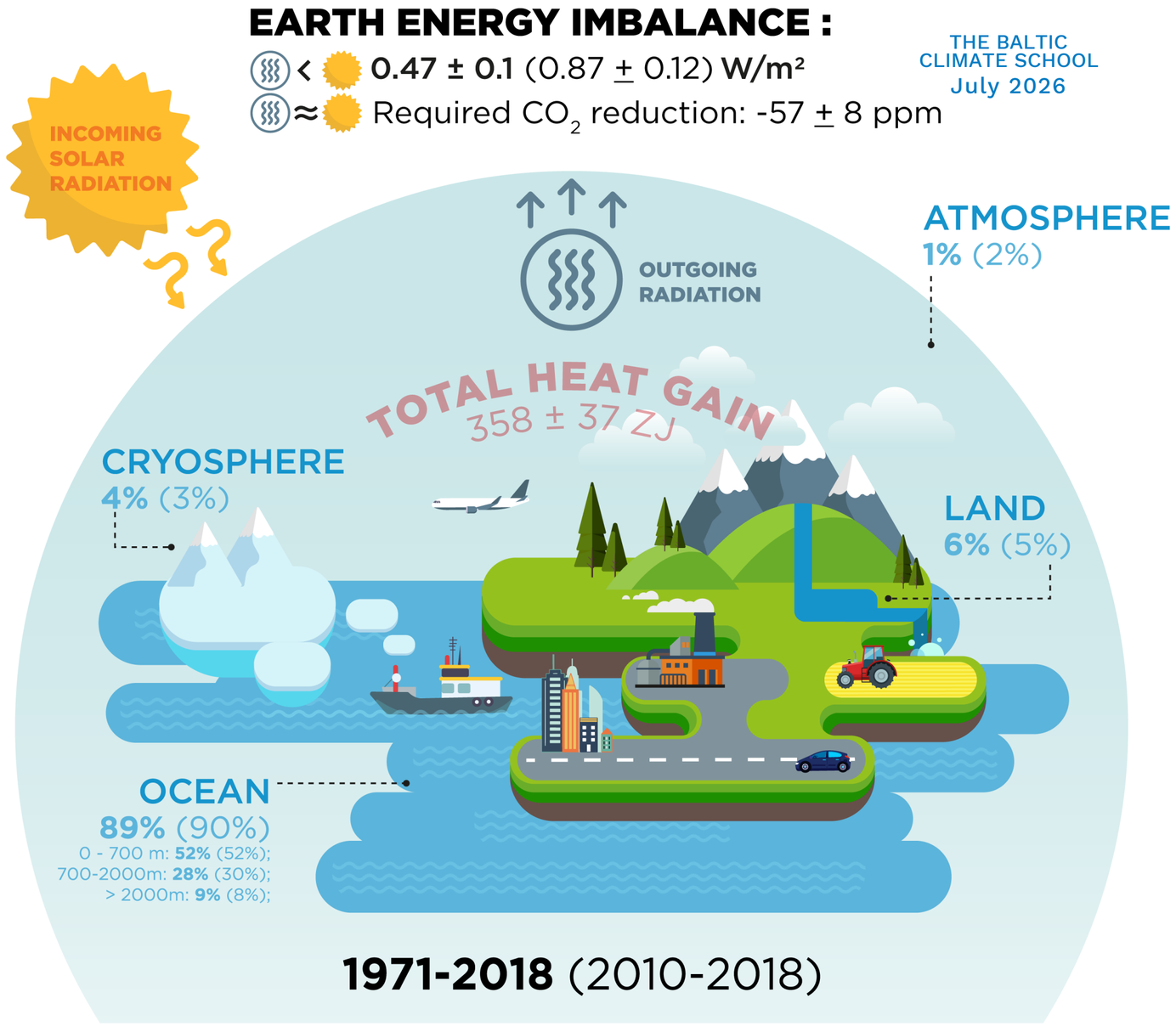


The earth would be 255 K (-18°C)

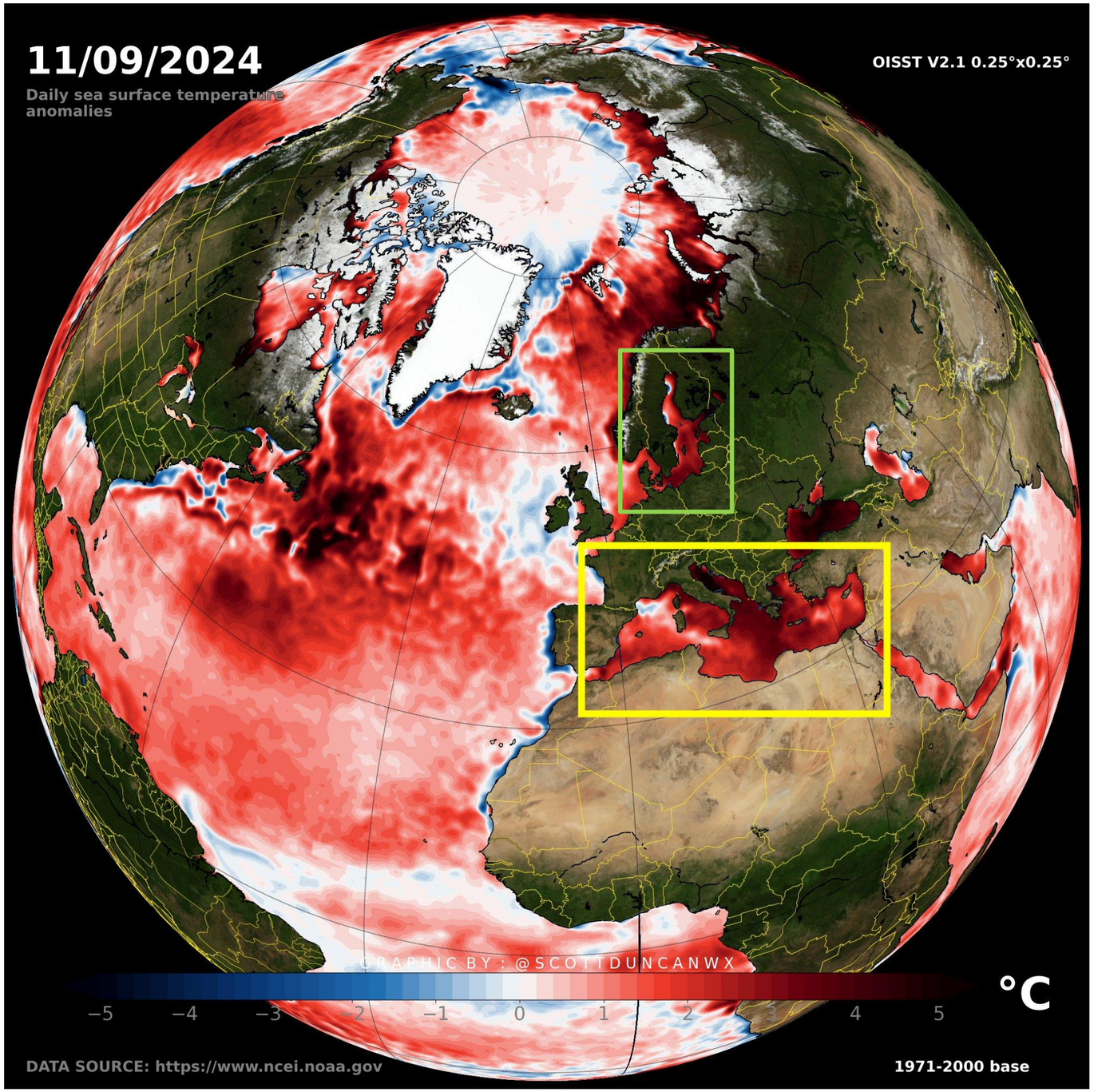
EARTH'S ENERGY BUDGET



Where heat is accumulated?



(von Schuckmann et al., 2023)



Scott Duncan:

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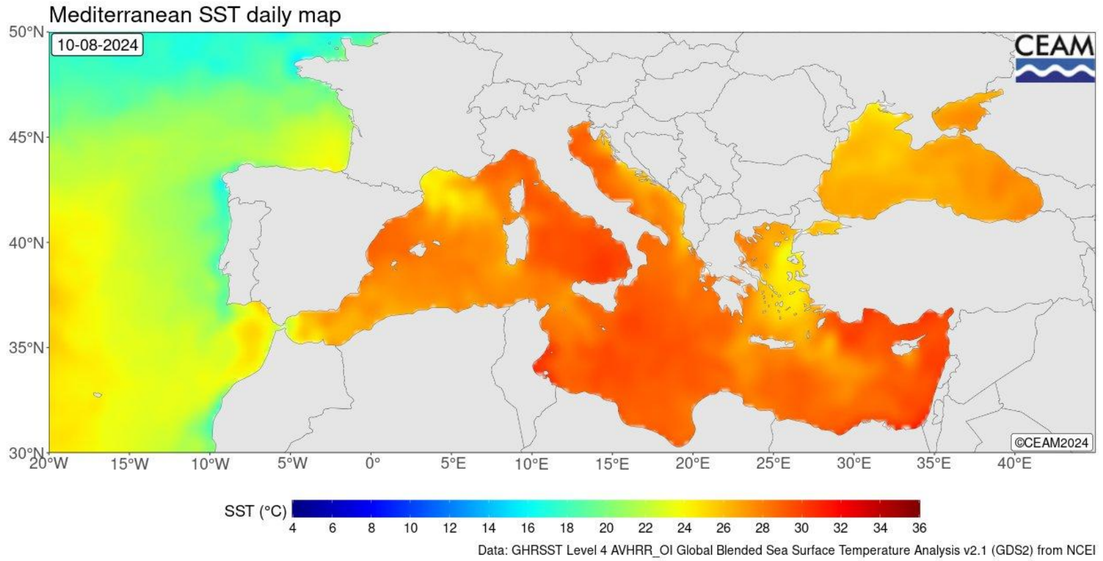
July 2026

It is official. The Mediterranean sea surface temperature has just set a new heat record. The average sea surface temperature just hit a staggering +28.15°C. 18 out of the top 20 hottest days for the Mediterranean sea surface have been observed in the last 13 months alone.



https://www.ceam.es

Copernicus EU
4 val. · 🌐

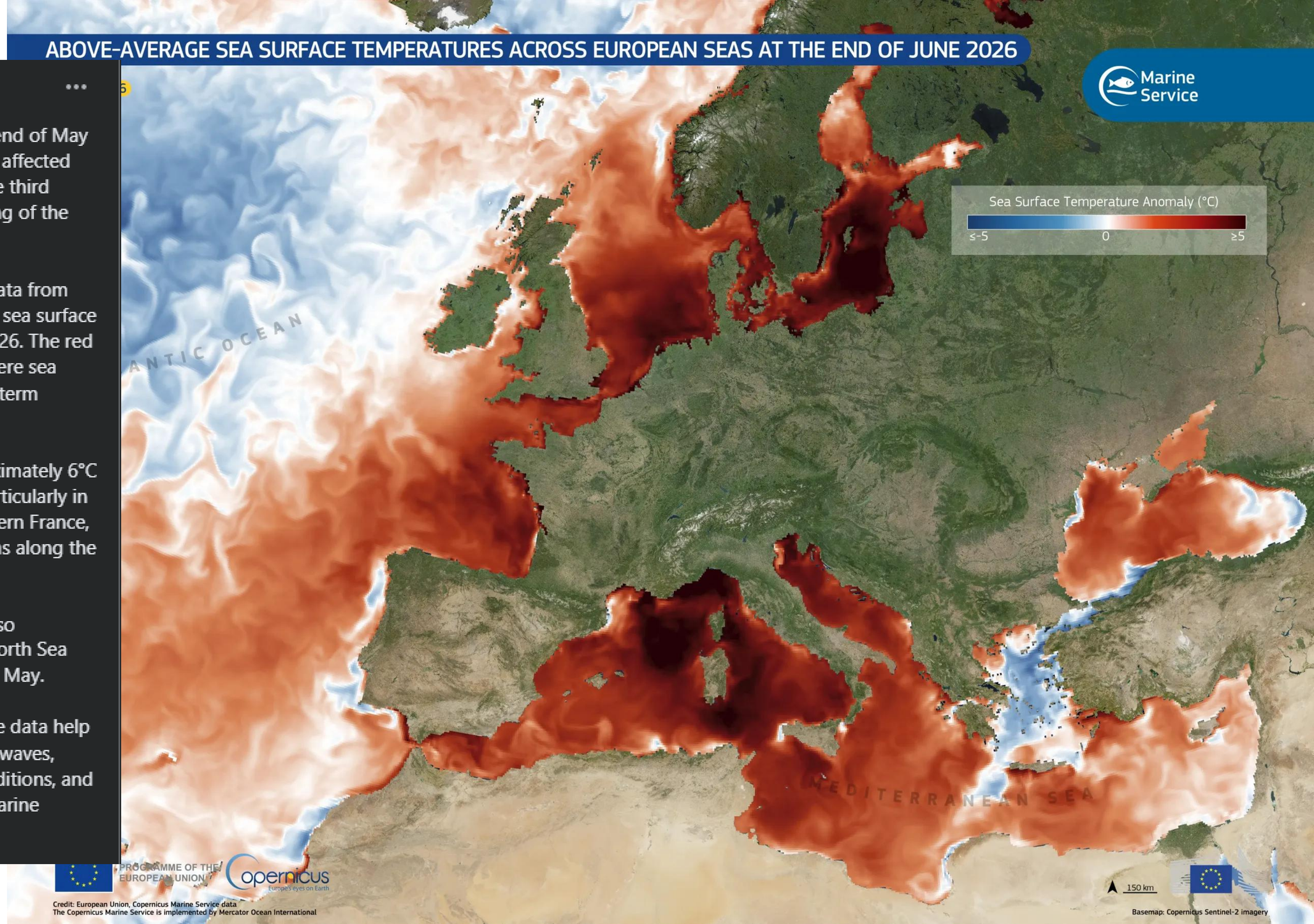
🌊 After the marine heatwave of the end of May 2026, the intense temperatures which affected western and central Europe during the third decade of June caused further warming of the surrounding seas.

🌡️ This data visualisation, based on data from the Copernicus Marine Service, shows sea surface temperature anomalies on 29 June 2026. The red and dark red tones 🔴 show areas where sea surface temperatures above the long-term average were recorded.

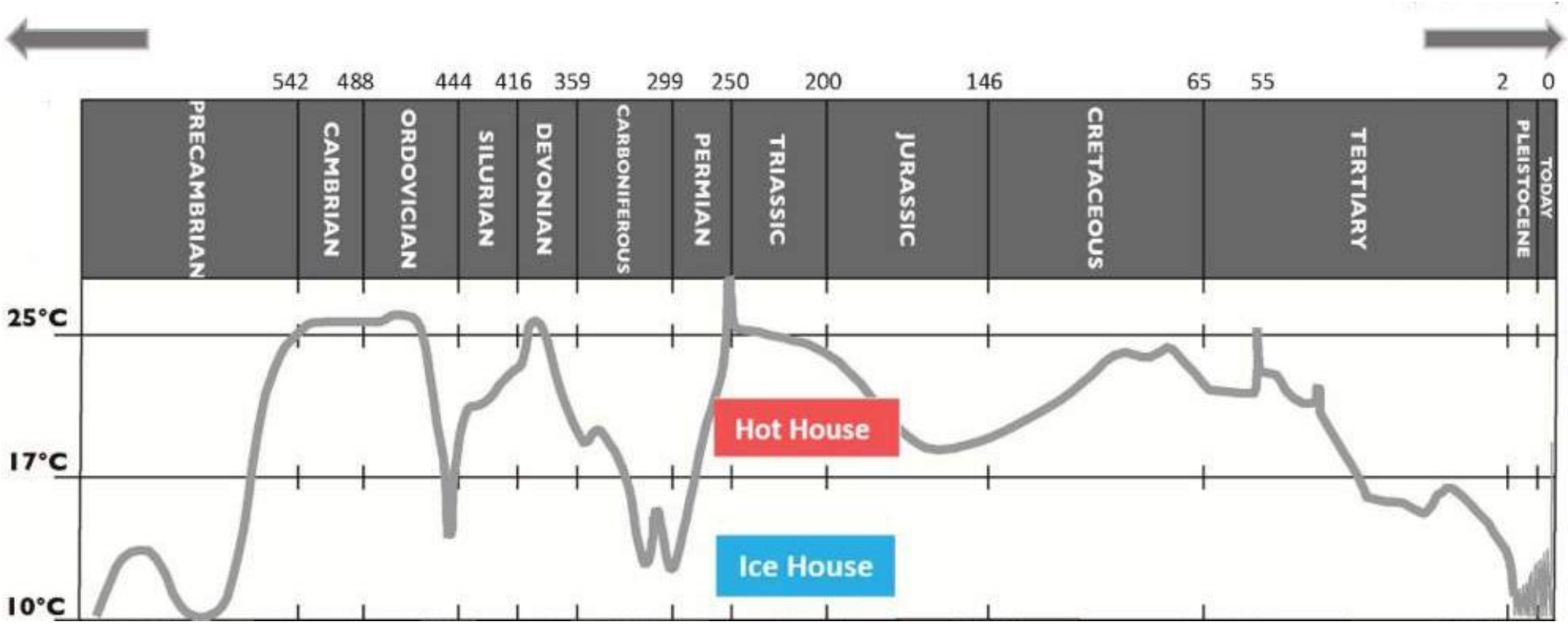
The largest anomalies reached approximately 6°C in the western Mediterranean Sea, particularly in the Gulf of Lion off the coast of southern France, and in the Ligurian and Tyrrhenian seas along the western coast of Italy.

Sea surface temperature anomalies also increased markedly in the southern North Sea and the Baltic Sea compared with late May.

🛰️ The **#CopernicusEU** Marine Service data help track the development of marine heatwaves, support the assessment of ocean conditions, and the monitoring of potential risks to marine ecosystems globally.

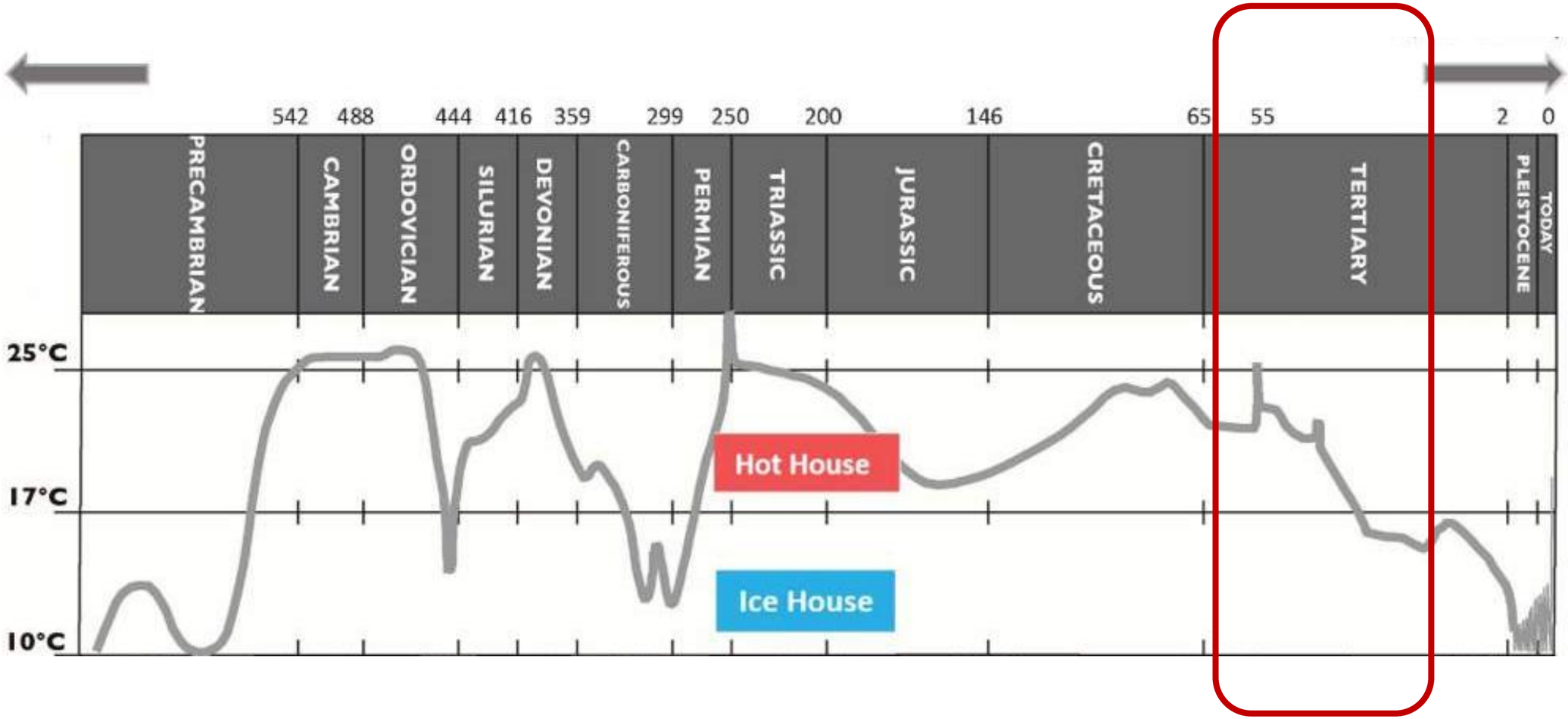



Earth climate was stable?



2 billion years ago...

- Over the last 2 billion years, the Earth's climate has changed alternately: the Ice House has replaced the Hot House. During the "greenhouse" period, the planet has a lot of liquid water, while during the "glacial" period, the climate is cold enough to support large amounts of ice, sometimes covering the entire planet.
- **Dr. C. R. Scotese, of the University of Texas; http://www.scotese.com/climate.htm**



2 billion years ago...

- The last transition between these phases occurred about 55 million years ago, when the temperature reached its thermal maximum, followed by the long cooling period we are currently experiencing.
- **Dr. C. R. Scotese, of the University of Texas; http://www.scotese.com/climate.htm**

500 000 – 100 000 years ago

- Between 500,000 and 100,000 years ago, there was a period of hot and cold fluctuations. Arctic ice samples show that over several hundred thousand years, large layers of ice covering parts of North America and Europe have melted in several temperature spikes, each occurring approximately every 100,000 years. This is how we get closer to the last 10,000 years.

photo: *NASA's Goddard Space Flight Center/Ludovic Brucke*

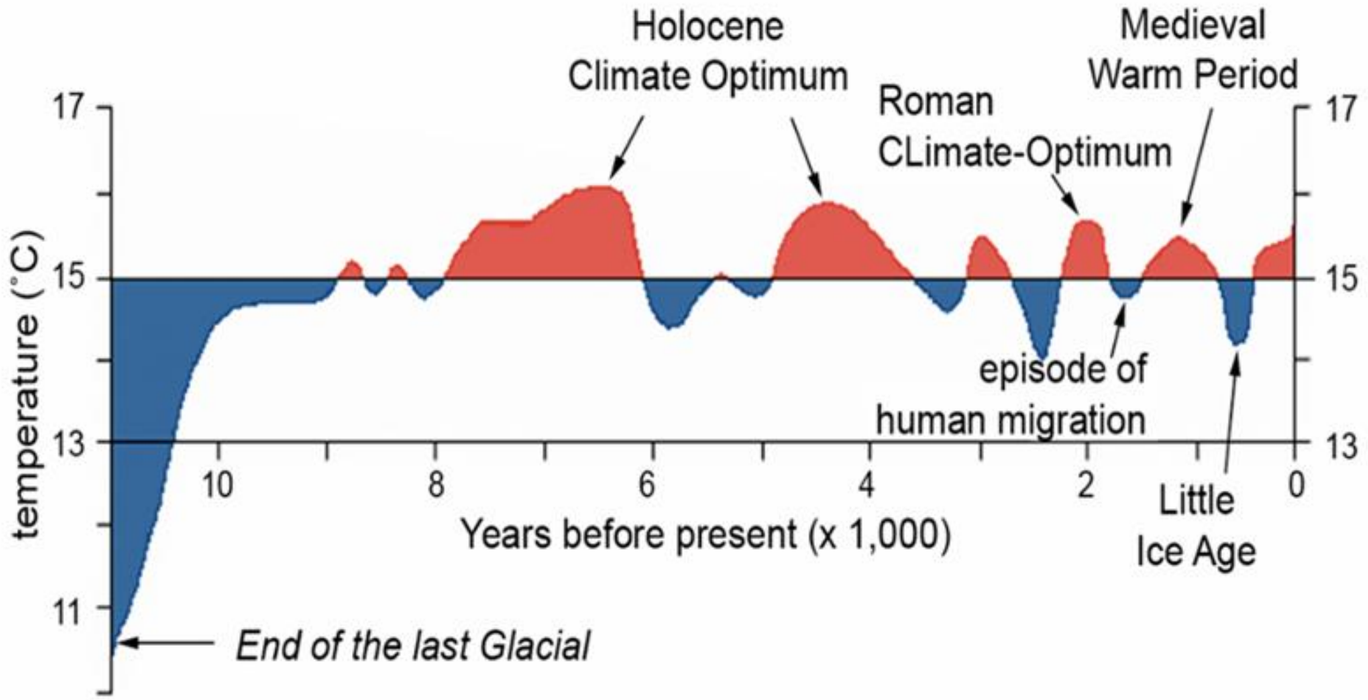
10,000 years ago up to this day

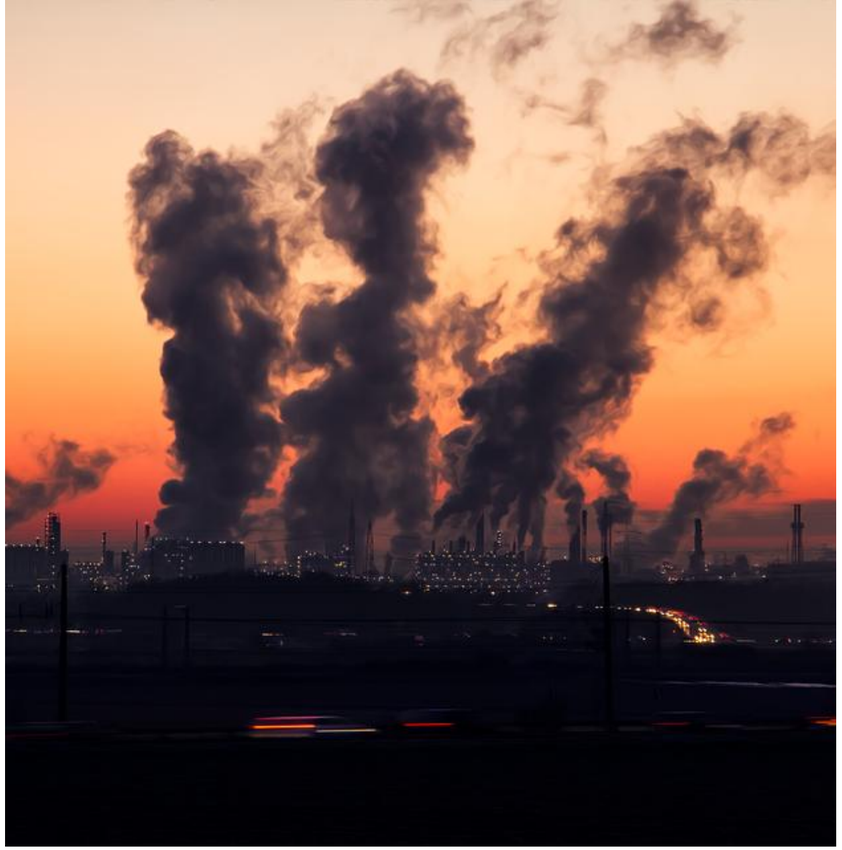
- The last 10,000 years have been known as the Holocene. They were uniquely stable and warm. Sea levels stabilized at current levels about 7,000 years ago. This allowed the development of human civilization.

- Although the temperature was relatively stable compared to previous periods, there have still been minor climate changes in recent climate history, such as a sudden / short-term drop in temperature between 1600 and 1850, called the Little Ice Age.

Climate change and the human history

Northern Hemispheric temperature reconstruction for the past 10,000+ years





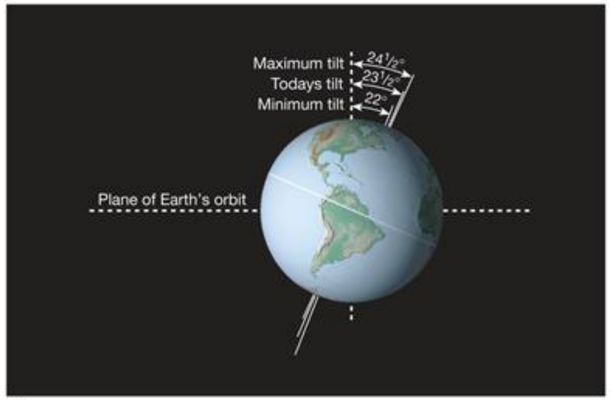
Main reasons for the natural climate change

- Change in solar radiation (energy);
- Volcanic activity;
- CO2 cycle.

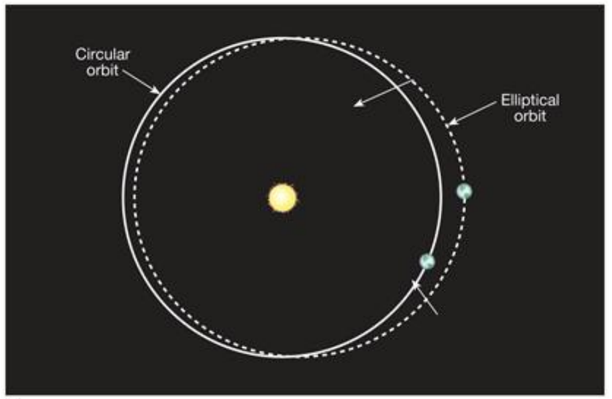
Change in solar radiation (energy);

- Earth orbit changes;
  - Milankovic cycles:
  - Orbital shape;
  - Earth axis displacement angle;
  - Precession of the earth's axis.

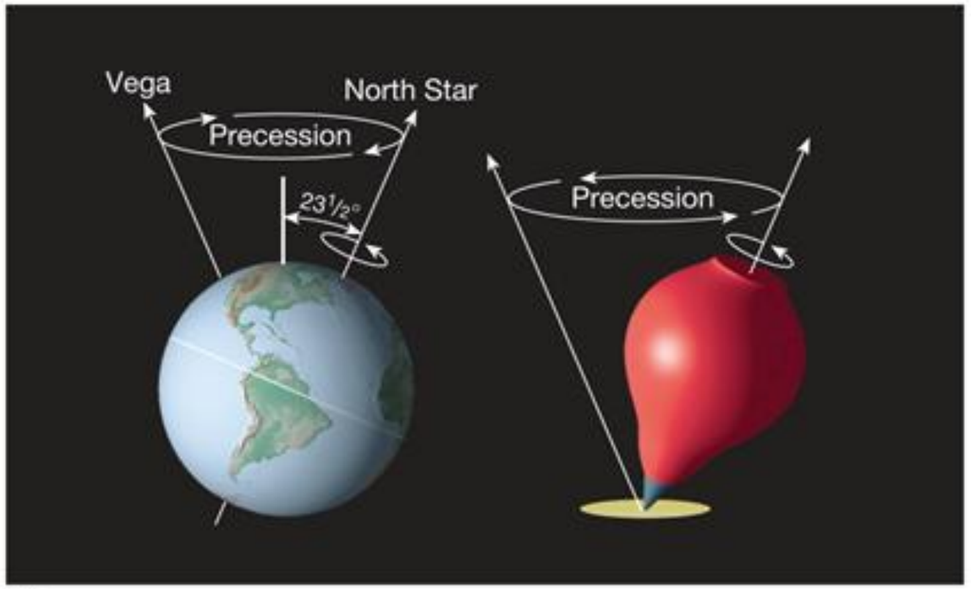
There is little evidence to link changes in solar activity to climate change.



(b)



(a)



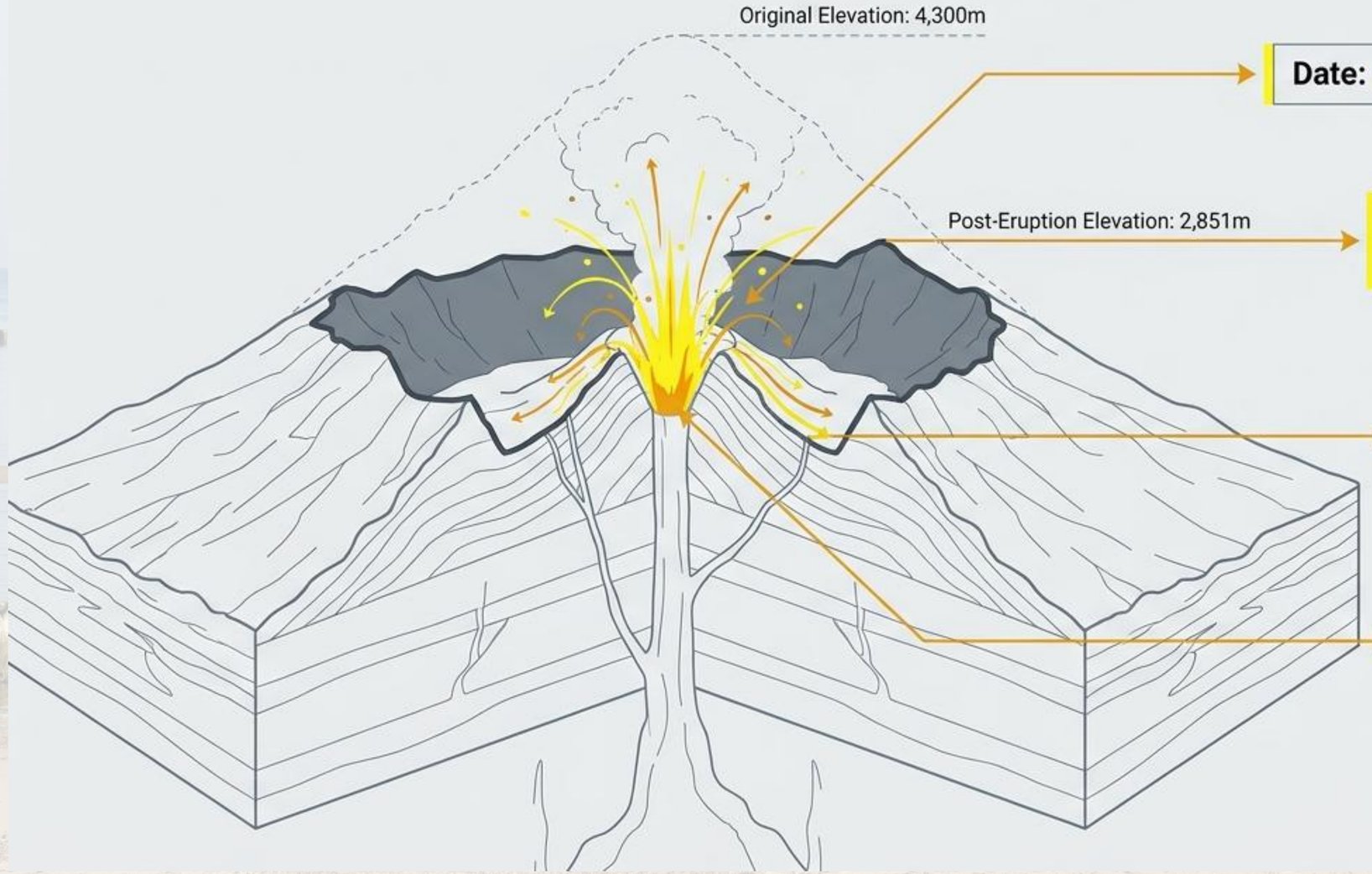
(c)

Volcanic activity;

Volcanic emissions (aerosols) can block solar radiation Need many eruptions in a short time Eg: Mt.Pinatubo eruption in 1991, cooled the atmosphere around it from 0.1-0.3 0C for 3 years.

Ground Zero: Mount Tambora

Sumbawa, Indonesia

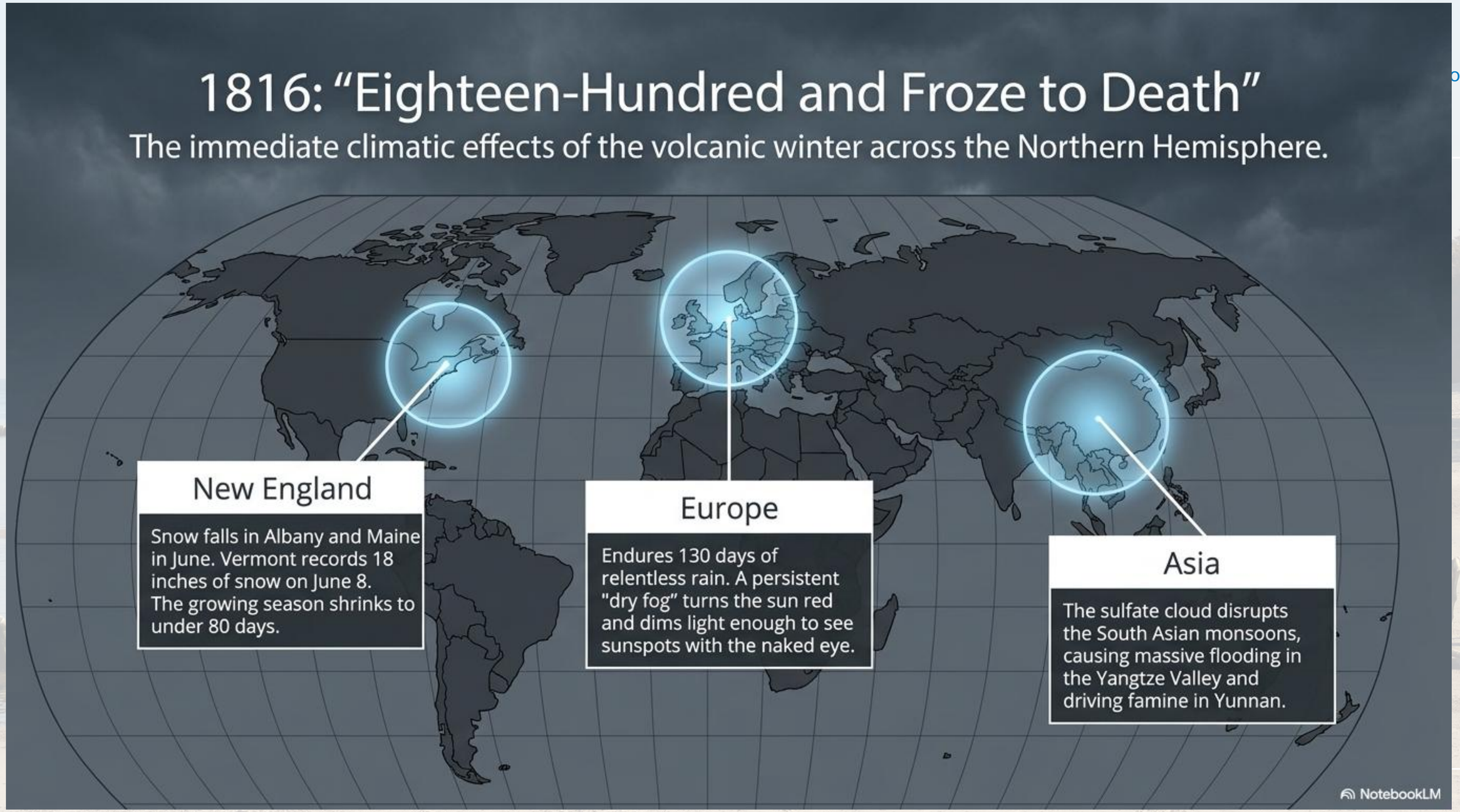


Date: April 10, 1815 (The Climax)

Volume: 37–45 km³ of dense rock blasted into the sky.

Explosive Force: 33 gigatons of TNT (heard 3,352 km away).

Immediate Toll: 10,000 direct deaths from pyroclastic flows and tsunamis.


1816: “Eighteen-Hundred and Froze to Death”
The immediate climatic effects of the volcanic winter across the Northern Hemisphere.
New England
Snow falls in Albany and Maine in June. Vermont records 18 inches of snow on June 8. The growing season shrinks to under 80 days.
Europe
Endures 130 days of relentless rain. A persistent "dry fog” turns the sun red and dims light enough to see sunspots with the naked eye.
Asia
The sulfate cloud disrupts the South Asian monsoons, causing massive flooding in the Yangtze Valley and driving famine in Yunnan.
NotebookLM

The Human Cost: The Great Subsistence Crisis

And all hearts were chill'd into a selfish prayer for light.
— Lord Byron, Darkness (1816)

1. Agriculture

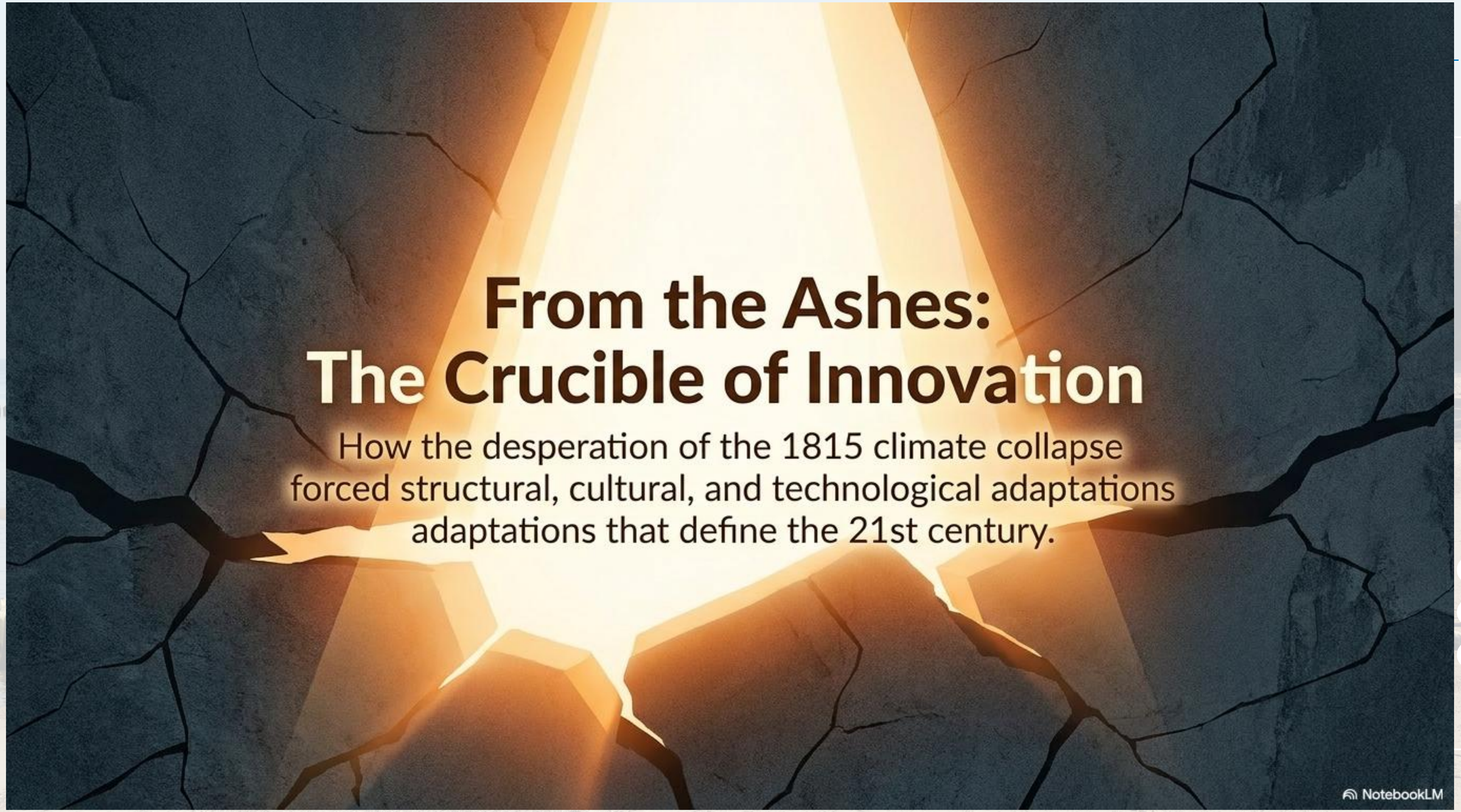
Frosts destroy corn and oat harvests. Famine sweeps the globe. Vermonters survive on hedgehogs and nettles; Chinese peasants eat white clay.

2. Health

Disrupted weather patterns birth a deadly new strain of Cholera in Bengal (1817). Starving refugees spread Typhus across Ireland and Europe. Total death toll exceeds 100,000.

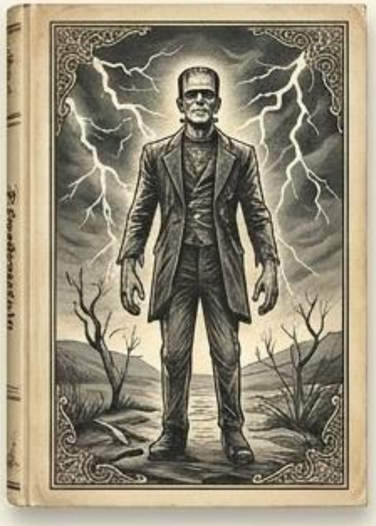
3. Society

1817 is dubbed "The Year of the Beggar". In America, ruined New England farmers flee west, triggering "Ohio Fever" (population surges from 230k to 400k).


From the Ashes:
The Crucible of Innovation
How the desperation of the 1815 climate collapse
forced structural, cultural, and technological adaptations
adaptations that define the 21st century.
NotebookLM

The Dark Summer of Literature

Lake Geneva, Switzerland, 1816.
A party of English tourists is trapped indoors by 130 days of unceasing rain and plunging temperatures. They pass the time writing ghost stories.



Mary Shelley's Frankenstein

The creature—wandering, despised, and suffering from the elements—mirrors the starving, typhus-infected climate refugees roaming Europe.

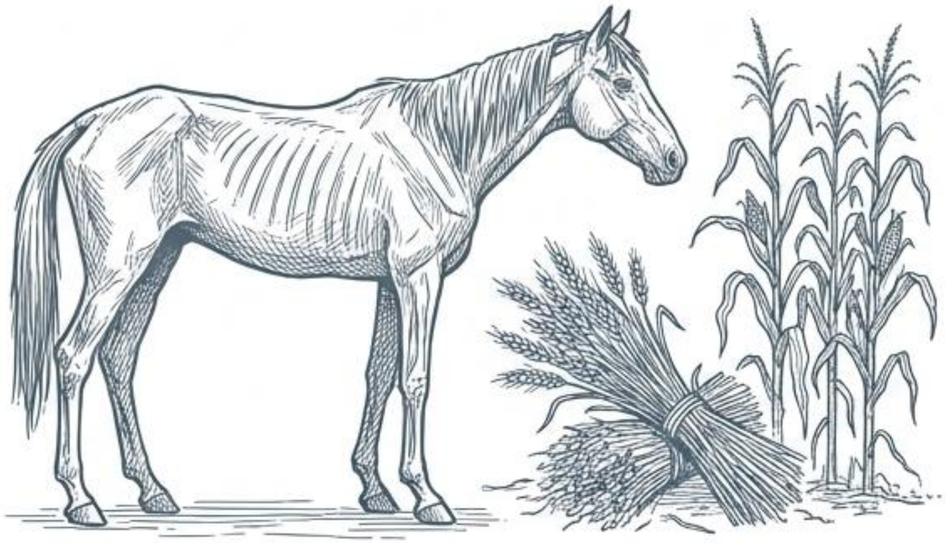
John Polidori's The Vampyre & Byron's Darkness

Apocalyptic themes emerge from days where "fowls went to roost at noon," birthing modern gothic horror and sci-fi.

The Birth of the Bicycle

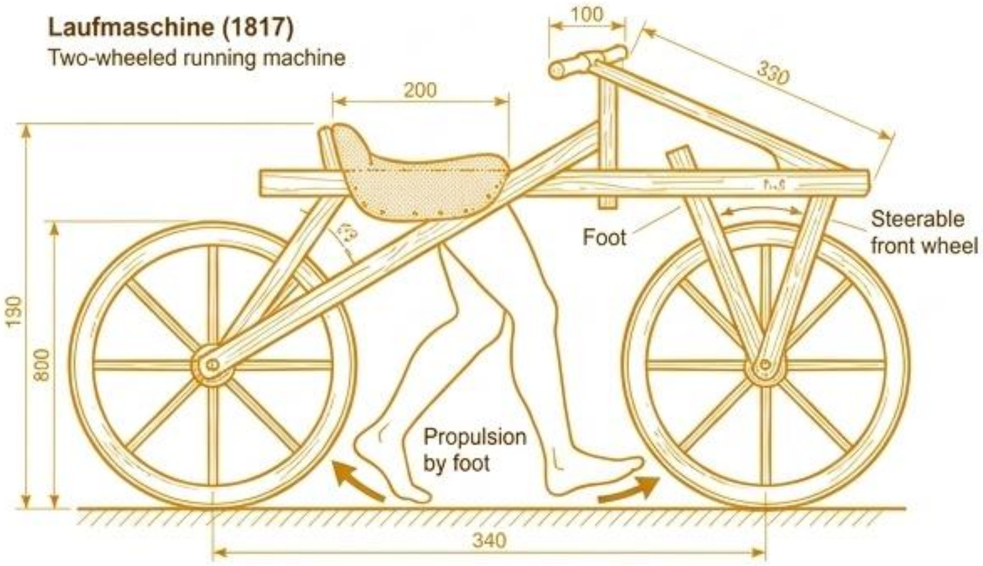
Mechanical invention born directly from an environmental supply-chain crisis.

The Supply Chain Fails



The oat harvest fails completely. Tens of thousands of horses starve or are slaughtered across Europe. The primary mode of human transport is eliminated.

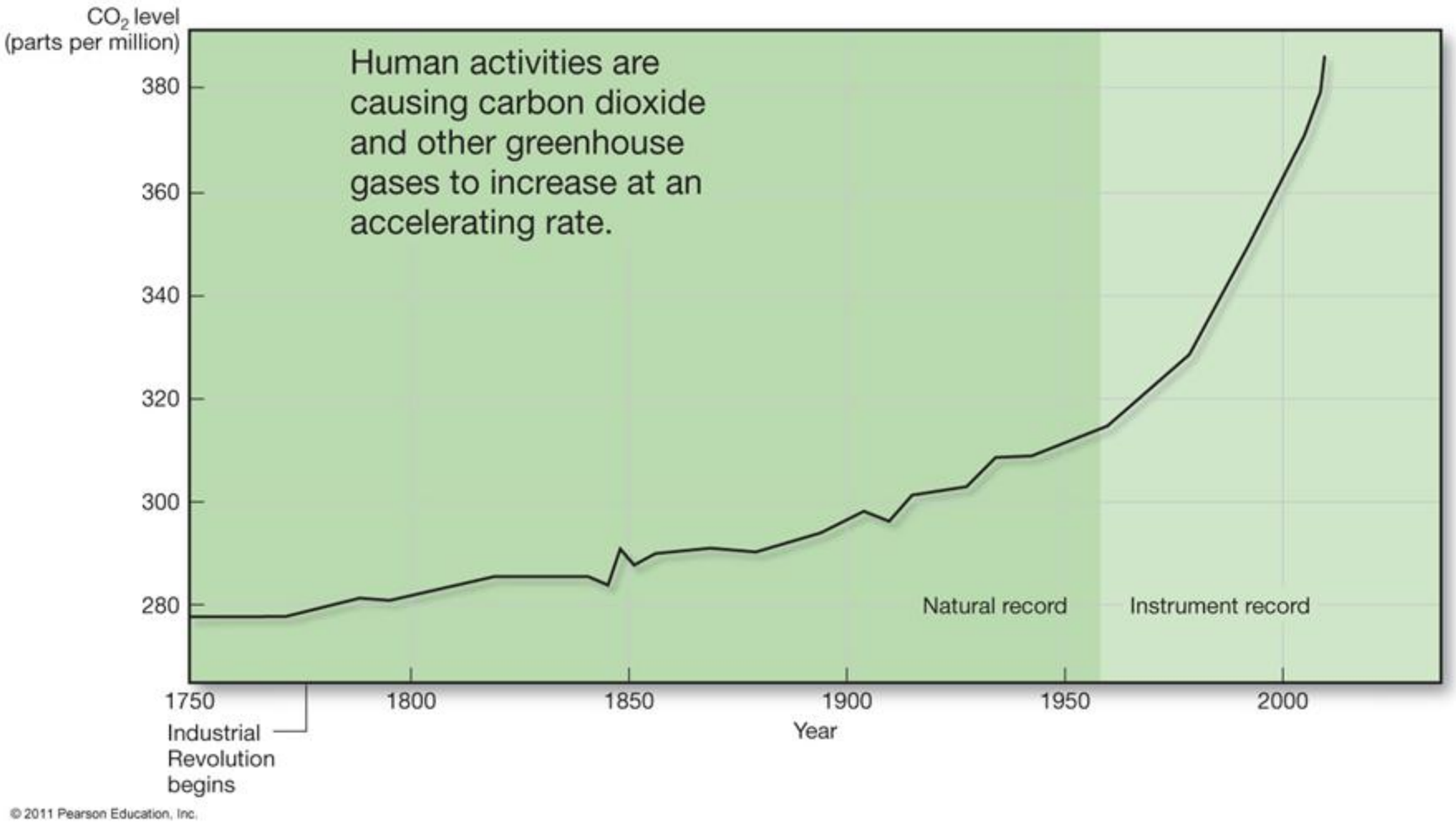
The Mechanized Replacement



Karl Drais invents the "Dandy Horse" in 1817. Propelled by human feet pushing against the ground, it achieves speeds of 10 mph. It is the direct predecessor to the modern bicycle.

CO2 cycle

The increase in carbon dioxide, along with other greenhouse gases in the Earth's environment, disrupted the natural carbon cycle in nature, which had a direct impact on the Earth's climate.



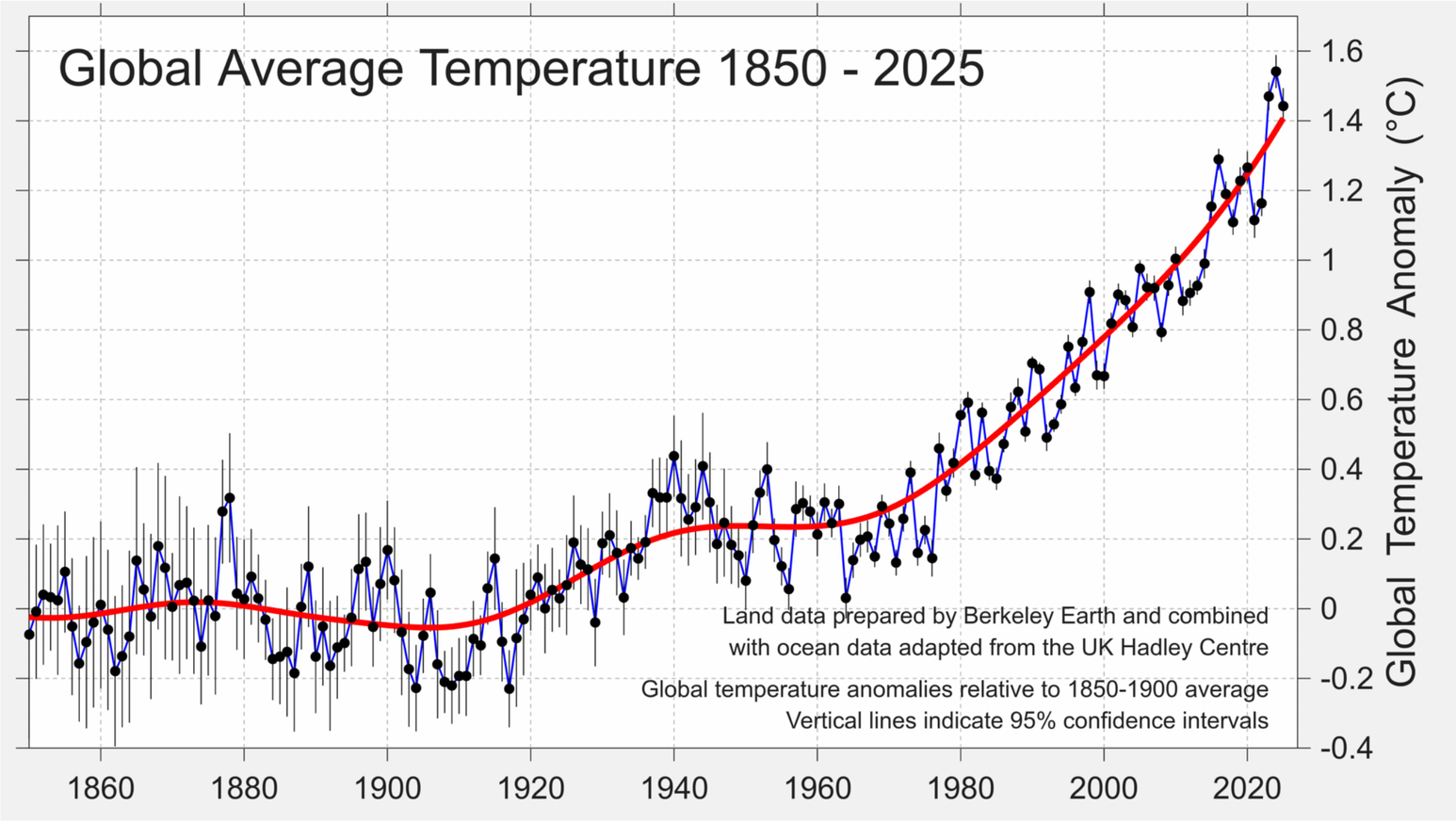
What is climate change?

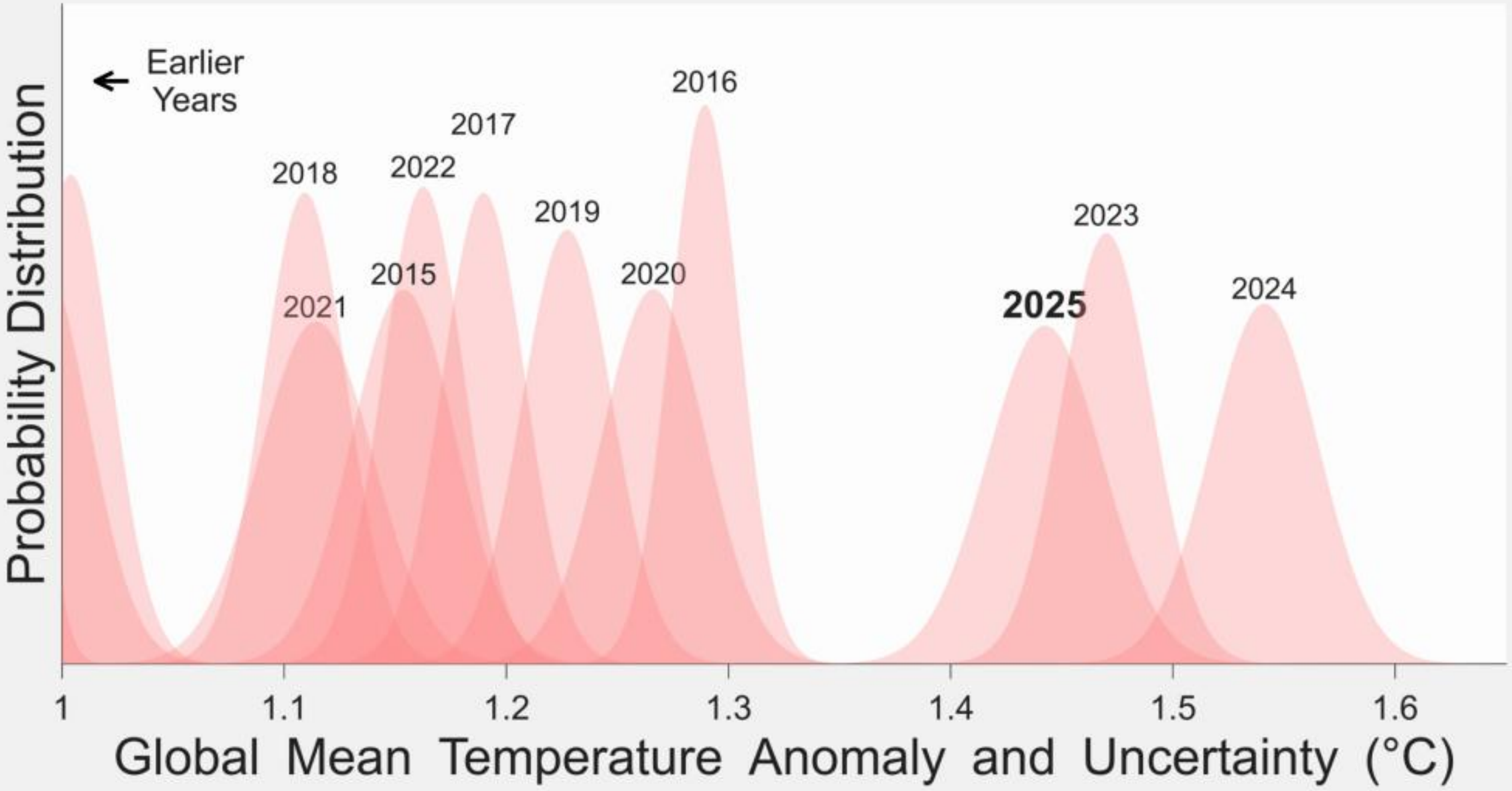
A **significant, unusual** change in the climate of a certain region:

- mean temperature;
- precipitation;
- storminess.

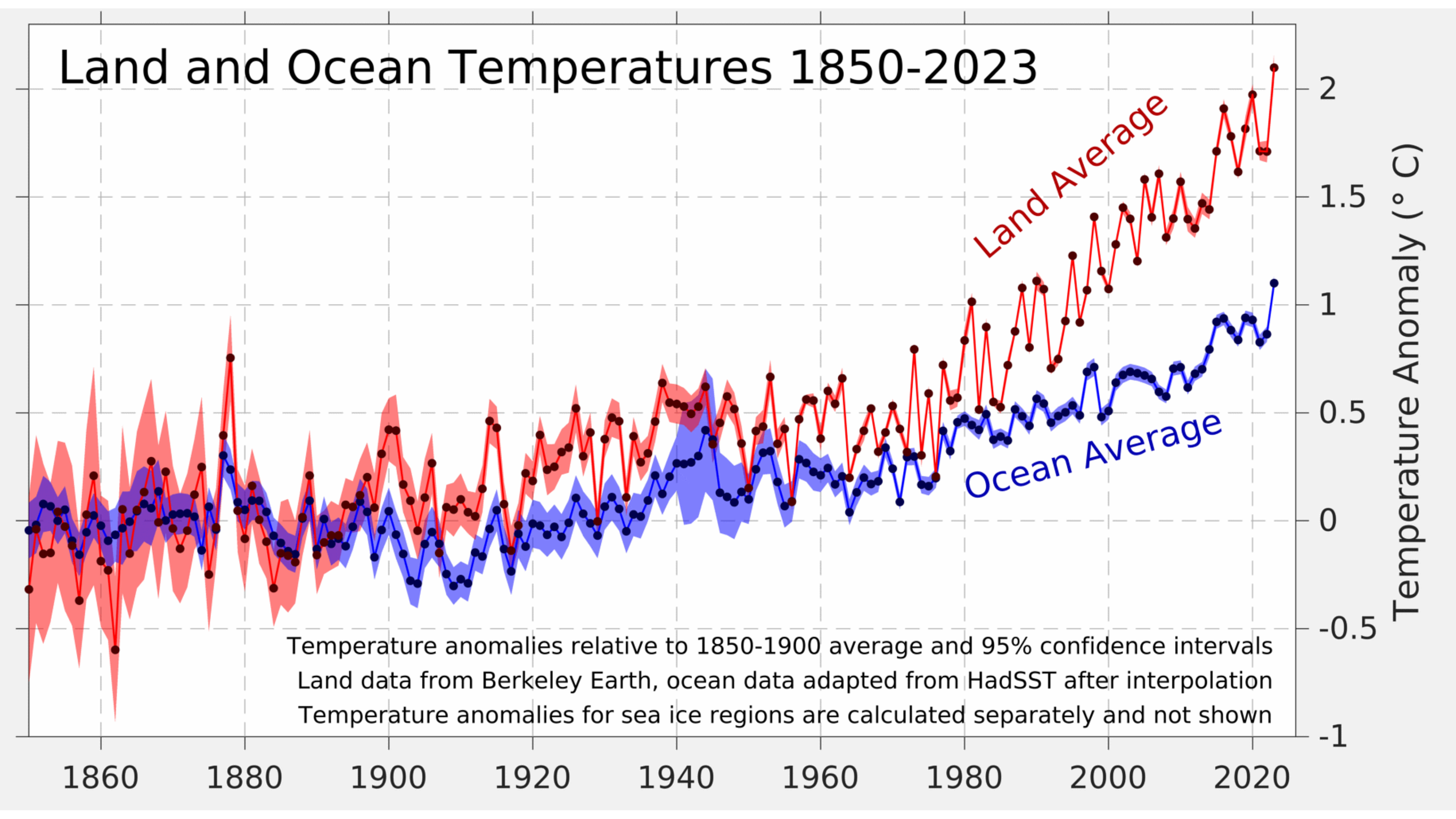
Temperature

- Since the 18th century, temperatures have risen by more than 1.20C;
- Since 1970, the annual average temperature has increased by 0.10C every 5-6 years;
- *2020 is the second warmest year since 1850, after 2016. (difference 0.0220C).*
- According to: http://berkeleyearth.org/global-temperature-report-for-2020/





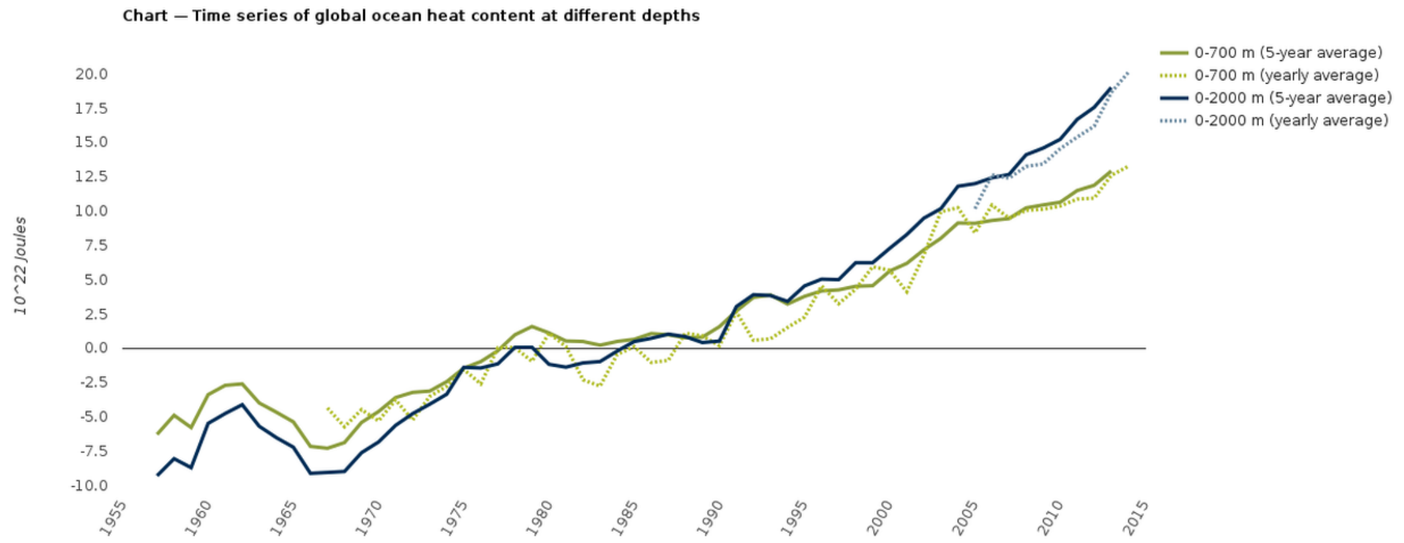
Based on Berkeley Earth's estimates of the global annual average temperature increase relative to 1850-1900.
Each year's individual uncertainty is shown, but does not include the systematic uncertainty in the baseline.


Land and Ocean Temperatures 1850-2023
Land Average
Ocean Average
Temperature anomalies relative to 1850-1900 average and 95% confidence intervals
Land data from Berkeley Earth, ocean data adapted from HadSST after interpolation
Temperature anomalies for sea ice regions are calculated separately and not shown
Temperature Anomaly (° C)
2
1.5
1
0.5
0
-0.5
-1
1860
1880
1900
1920
1940
1960
1980
2000
2020

The amount of heat in the ocean

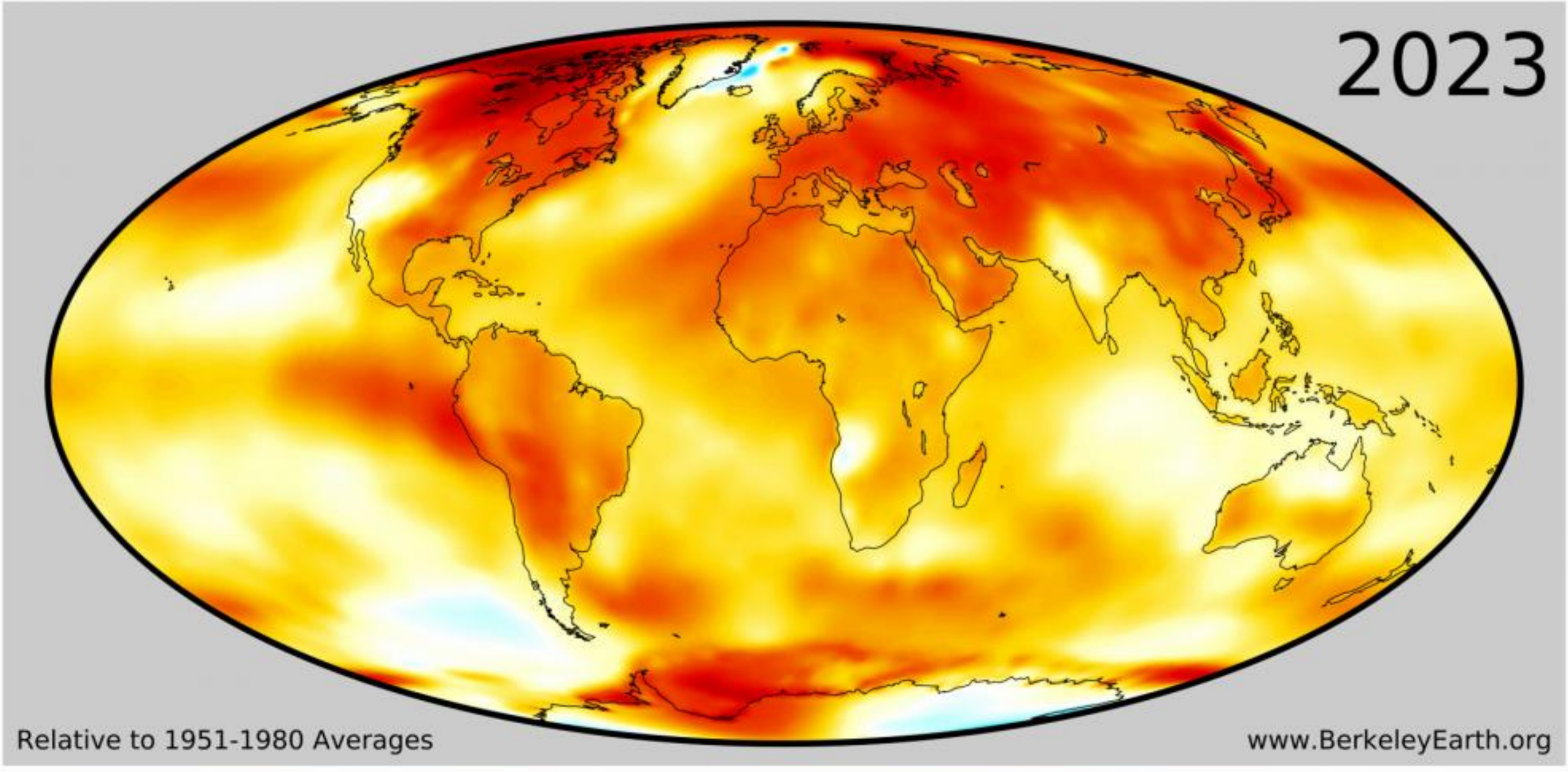
- More than 90% of the energy retained by greenhouse gases goes to the oceans. Surface temperatures have risen slowly as the oceans absorb excess energy in the climate system.
- The heat of the upper (0–700 m) ocean layer accounted for 64% of the total heat consumption.
- Recent observations also show warming of the deeper ocean layers (between 700-2000 m and deeper 3000 m).

https://www.eea.europa.eu/data-and-maps/daviz/global-heat-content-0-700m-2#tab-chart_3



This figure describes the change in global ocean heat content for the upper 700 m and the upper 2000 m of the ocean, both as annual average and as 5-year average. Ocean heat content is defined as the change in heat content of an oc
relative to a reference period (here: 1955 to 2006). The length of the time series differs depending on the ocean layer and the smoothing period.

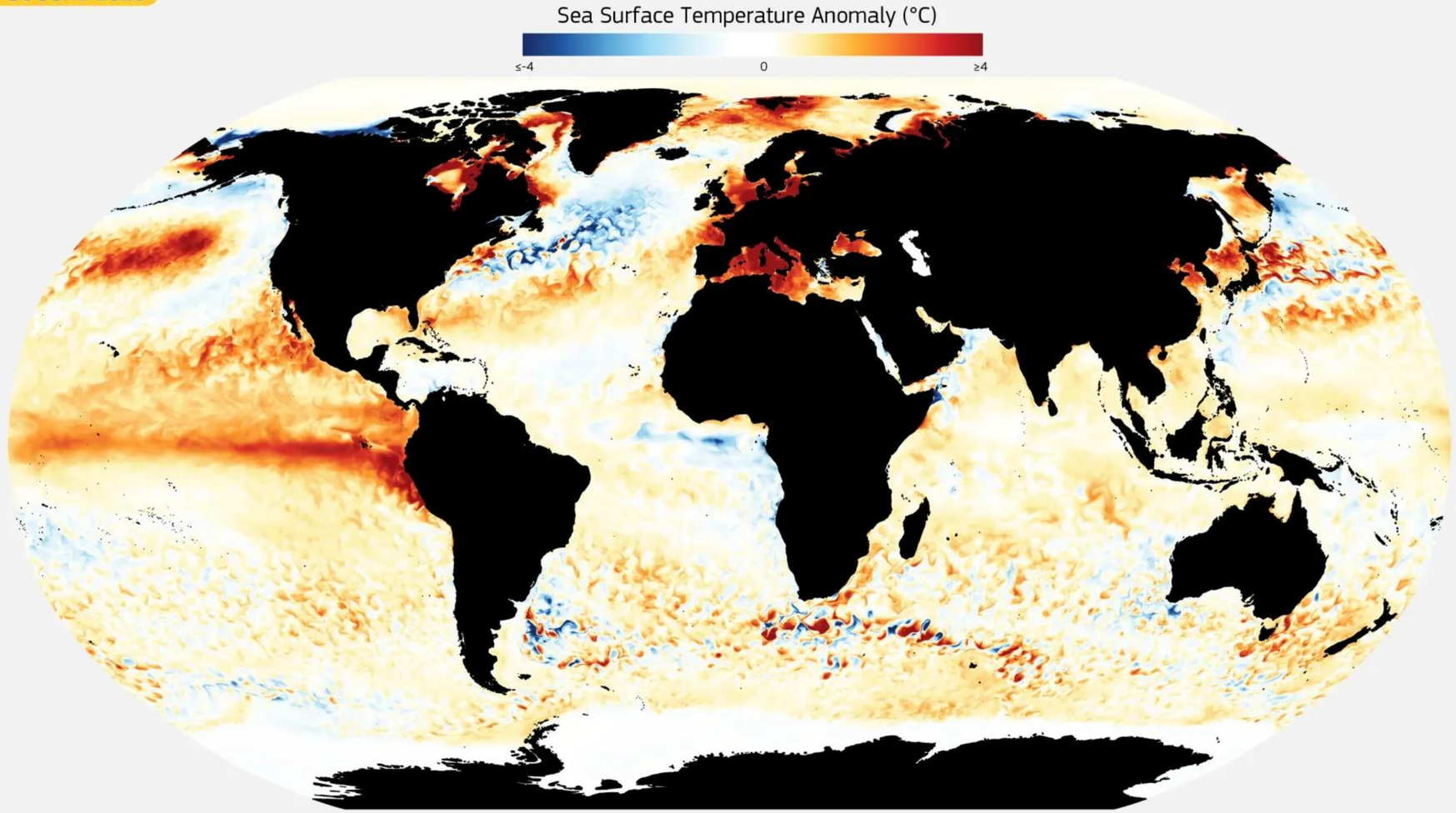
Data sources:
Global Ocean Heat and Salt Content provided by National Oceanic and Atmospheric Administration (NOAA)


2023
Relative to 1951-1980 Averages
www.BerkeleyEarth.org
-6
-4
-2
-1
-0.5
0
0.5
1
2
4
6
Temperature
Anomaly (° C)

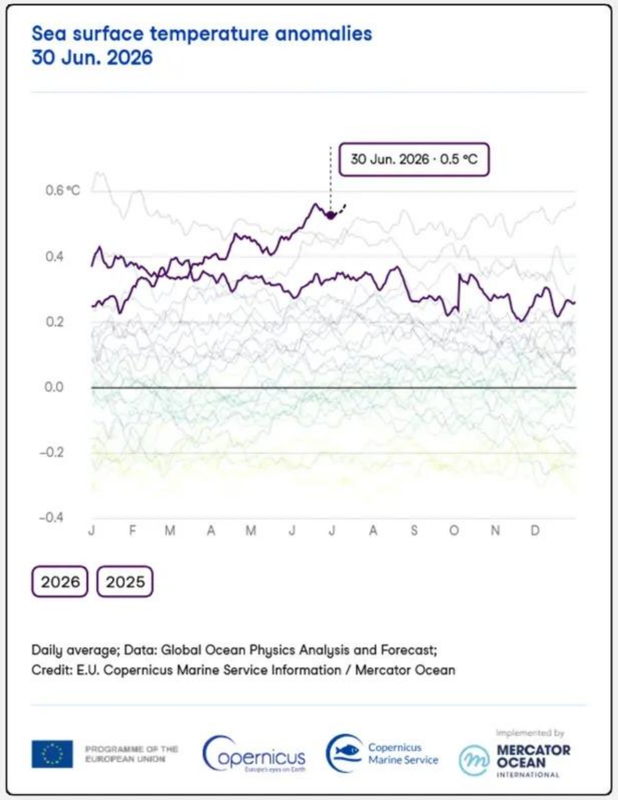
SEA SURFACE TEMPERATURE ANOMALY OF THE GLOBAL OCEAN

30 JUNE 2026

Marine Service



Sea Surface Temperature Anomaly Map



Sea Surface Temperature Anomaly Time Series

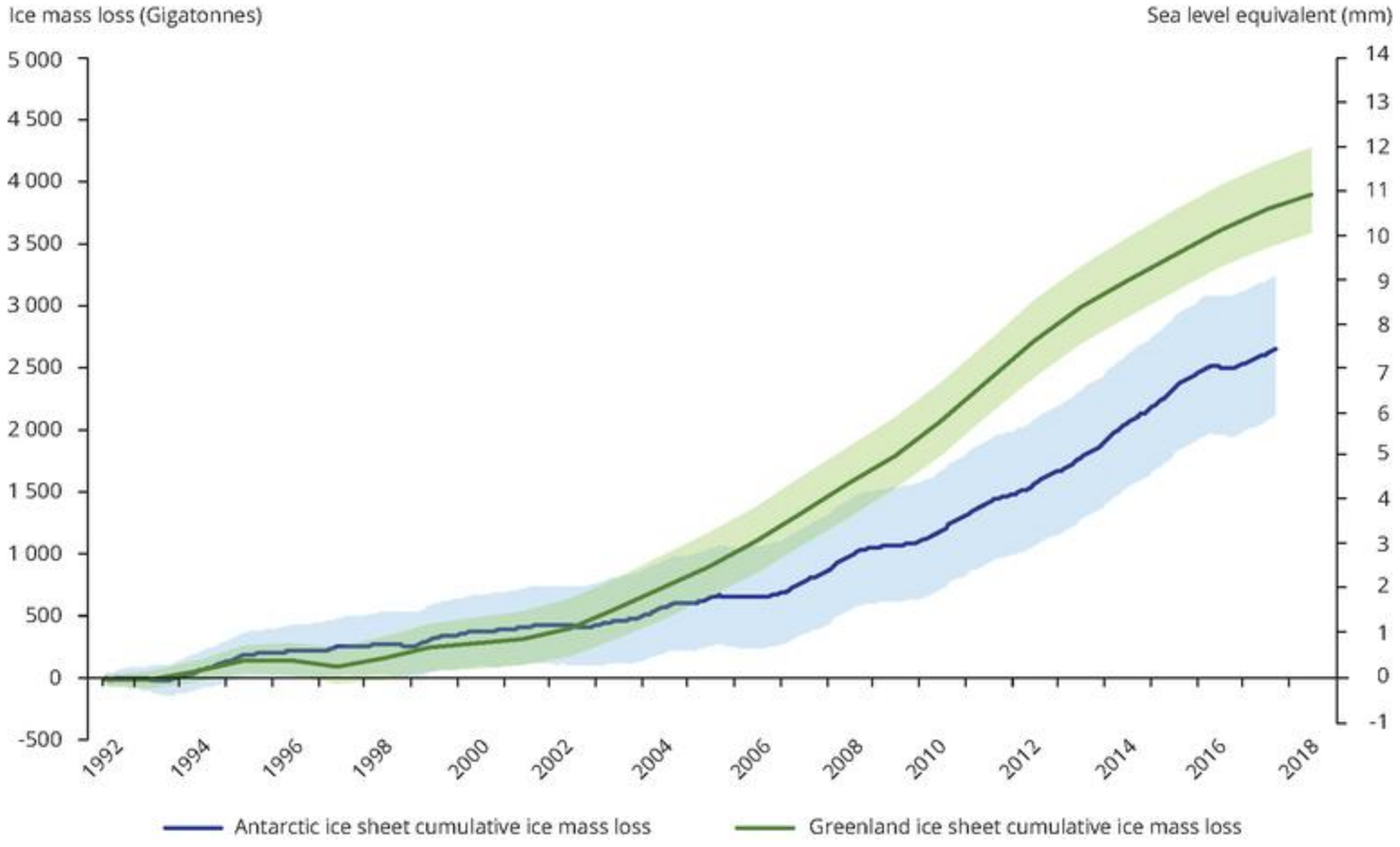
PROGRAMME OF THE EUROPEAN UNION
Copernicus
Europe's eyes on Earth

Credit: European Union, Copernicus Marine Service data
The Copernicus Marine Service is implemented by Mercator Ocean International

Ice

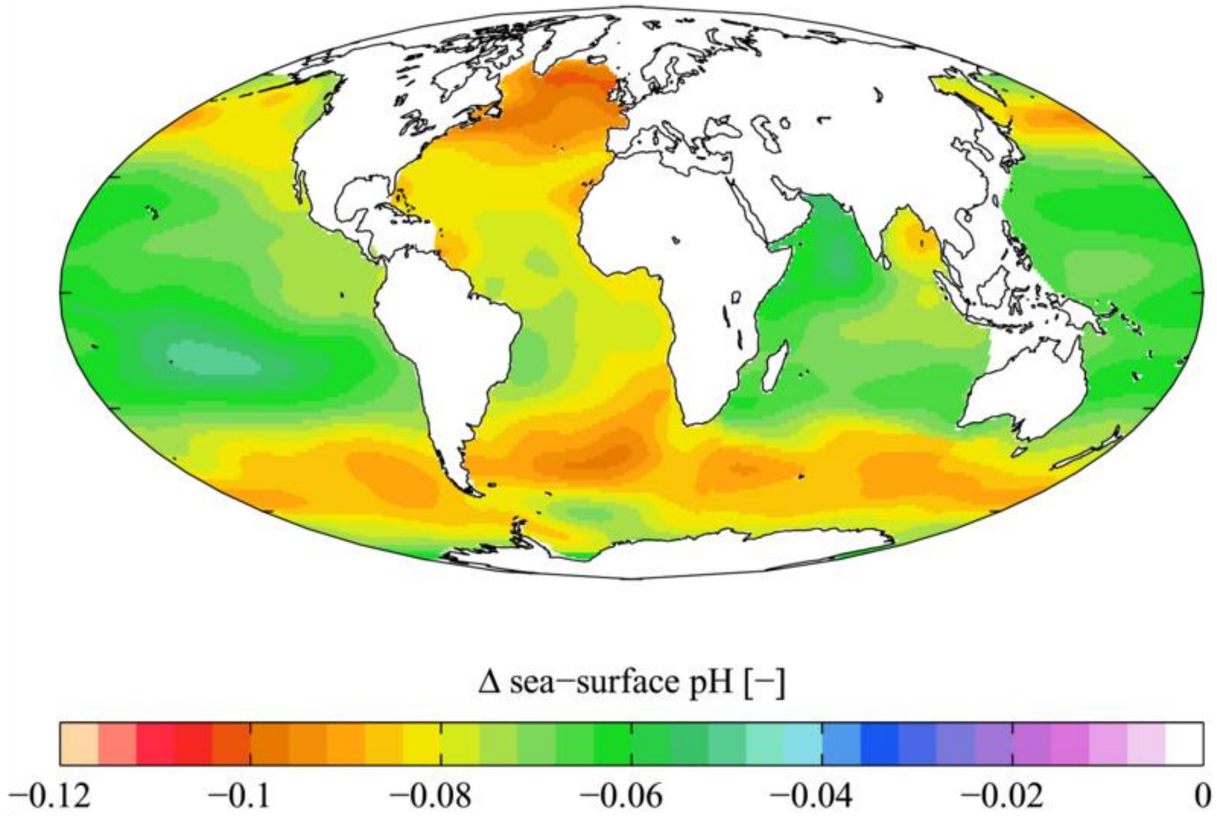
- The scale and volume of Arctic sea ice is declining rapidly.
- Every year since 2007. until 2018 The amount of Arctic summer sea ice was lower than in any previous year since the emergence of satellite data in 1979.
- The largest ice bodies are the Greenland and Antarctic ice sheets since 1992. loses large amounts of ice.

https://www.eea.europa.eu/data-and-maps/figures/cumulative-ice-mass-loss-from



Acidification of the oceans

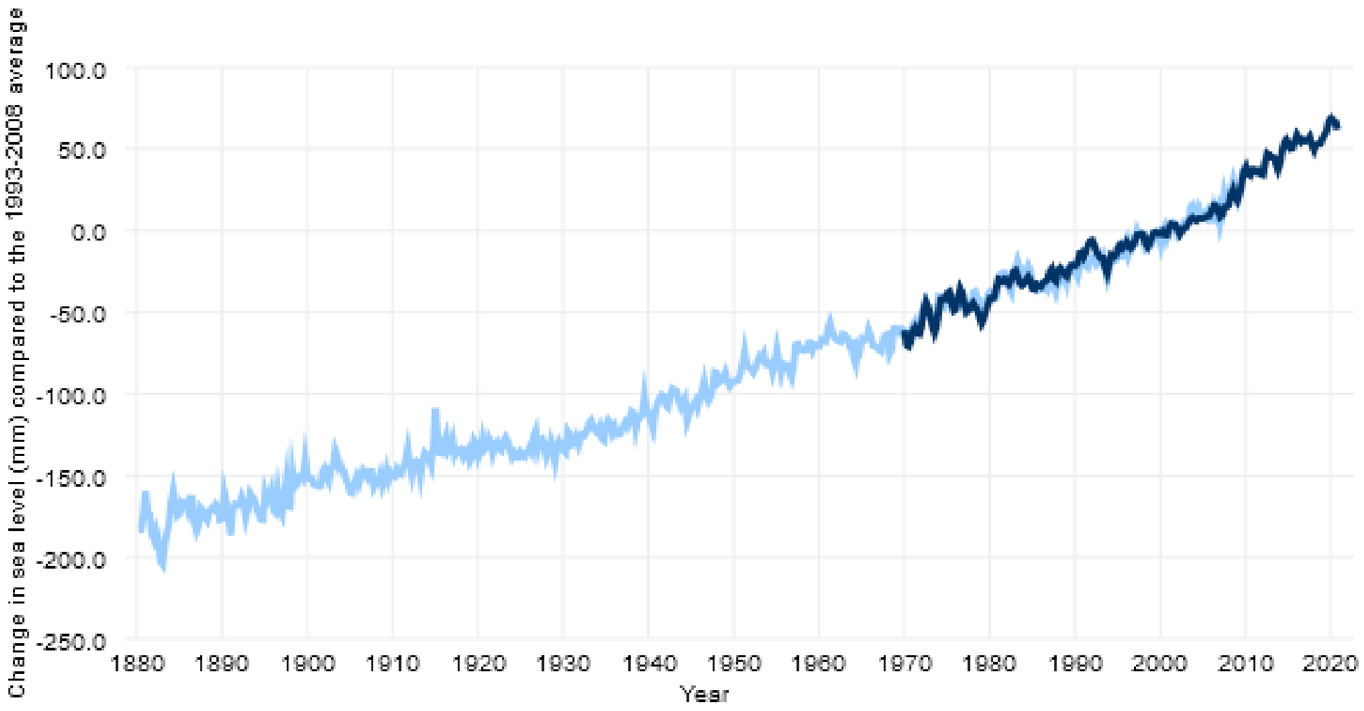
- Over the last decade, the oceans have absorbed about 25% of anthropogenic CO2. The absorbed CO2 reacts with seawater and causes ocean acidification.
- The pH of the ocean surface dropped from 8.2 to below 8.1 due to increased atmospheric CO2 concentrations. This decrease corresponds to a 30% increase in ocean acidity.
- In recent decades, ocean acidification has occurred 100 times faster than in the previous 55 million years.



Water level since 1880

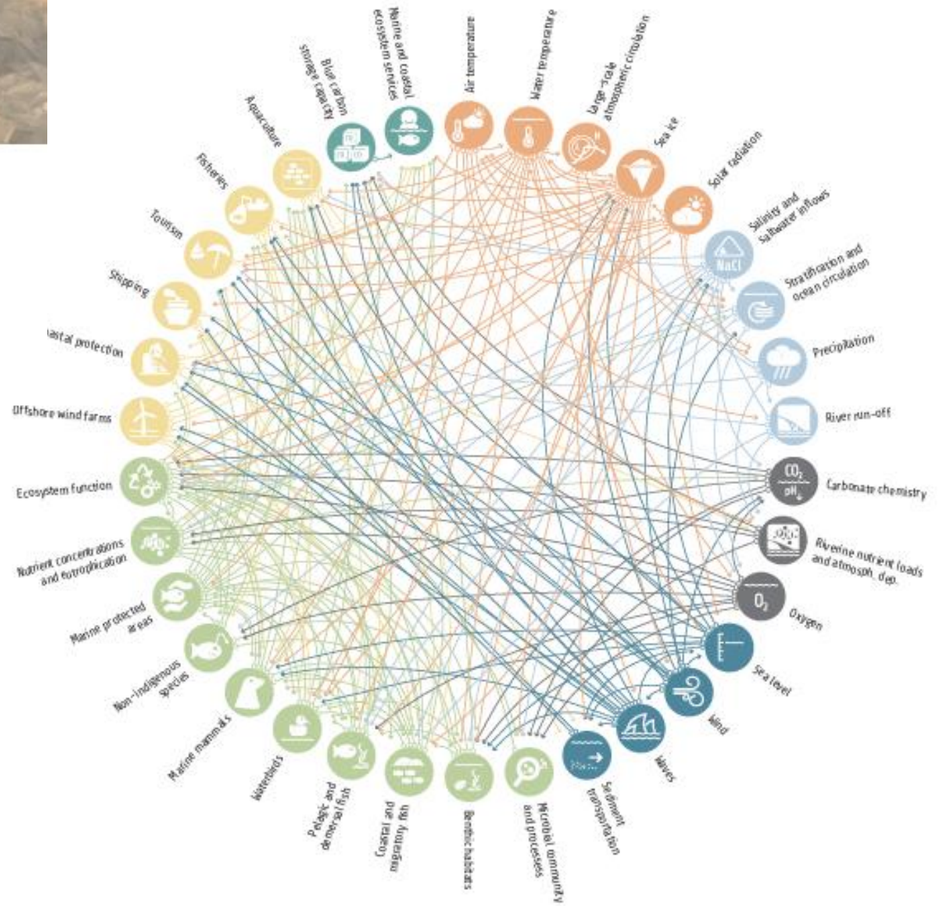
- Average global sea level in 2016 It was the highest annual average since the beginning of the measurements in the 19th century. end.
- The rate of sea level rise since 1993, when measurements from satellites appeared, is 3 mm per year.
- 2018 Total sea level change since 1993 was 78 mm. .

https://www.climate.gov/news-features/understanding-climate/climate-change-global-sea-level

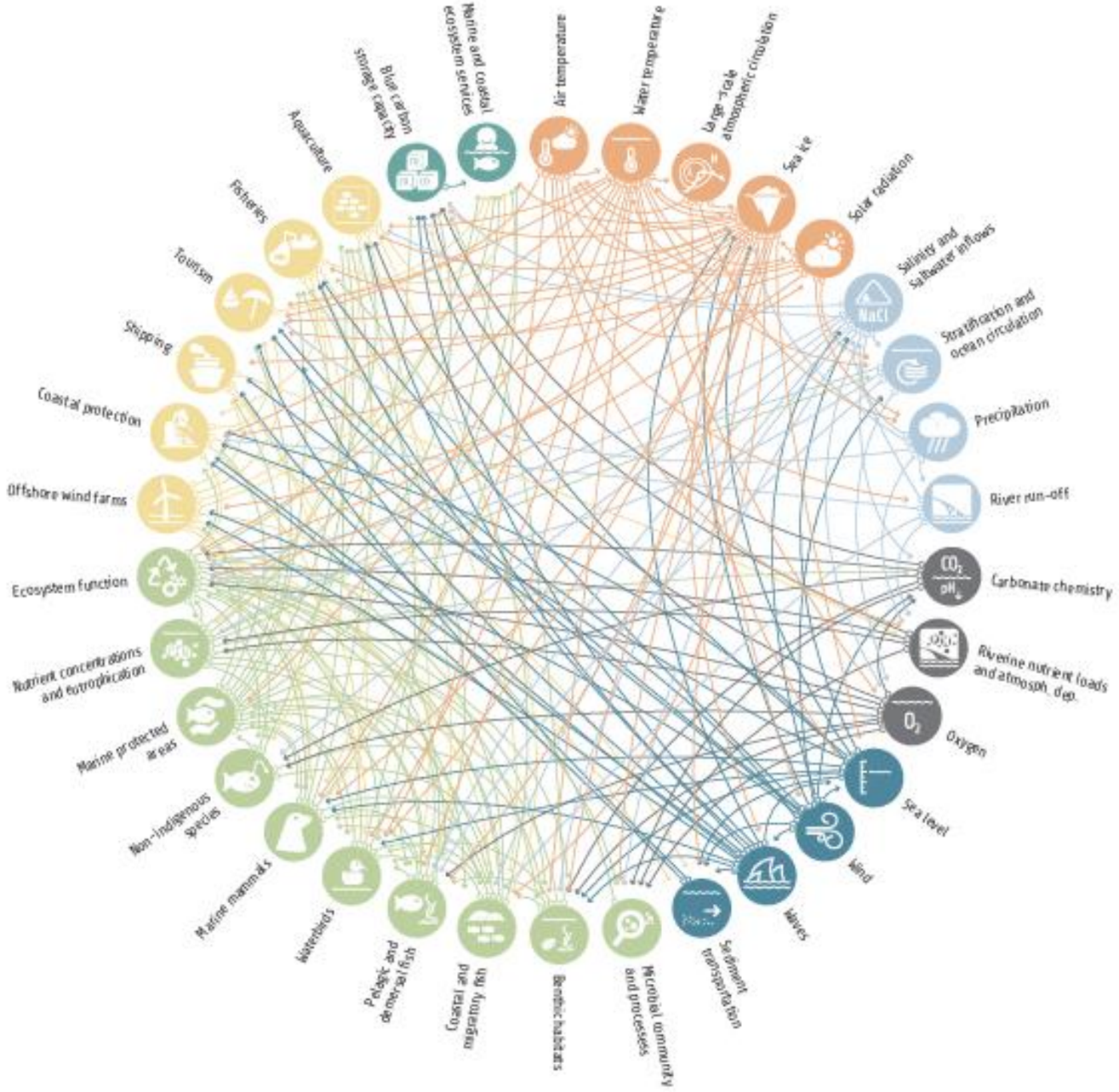


CLIMATE CHANGE

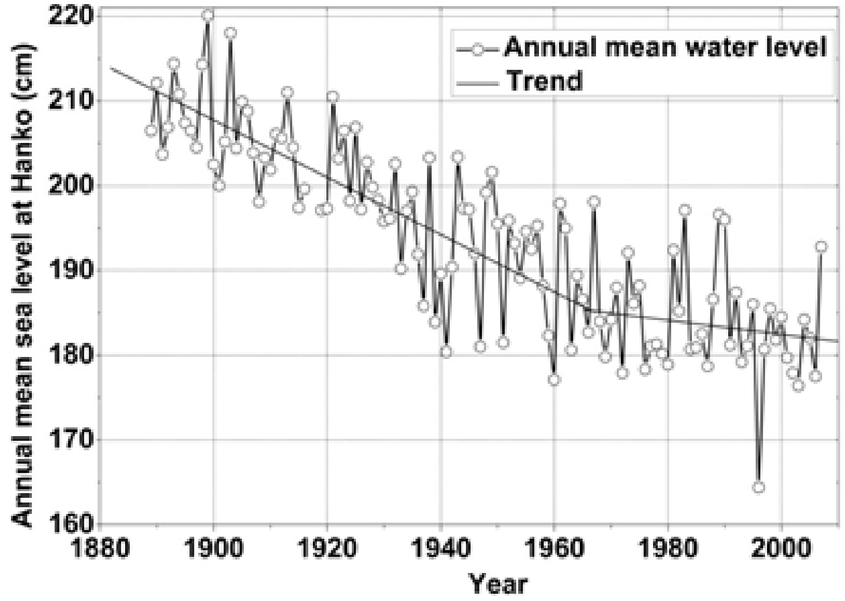
How is climate change affecting the Baltic Sea?

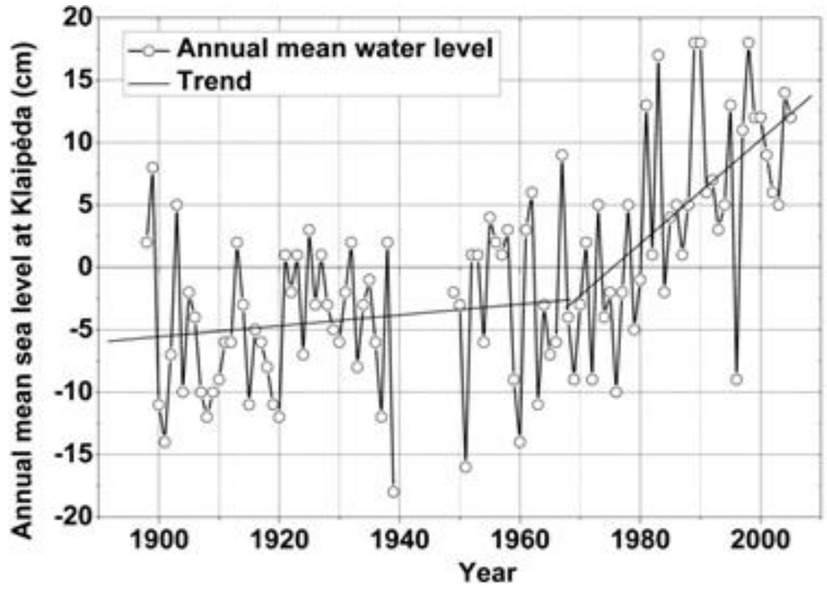


- [Climate change – State of the Baltic Sea – Third HELCOM holistic assessment]

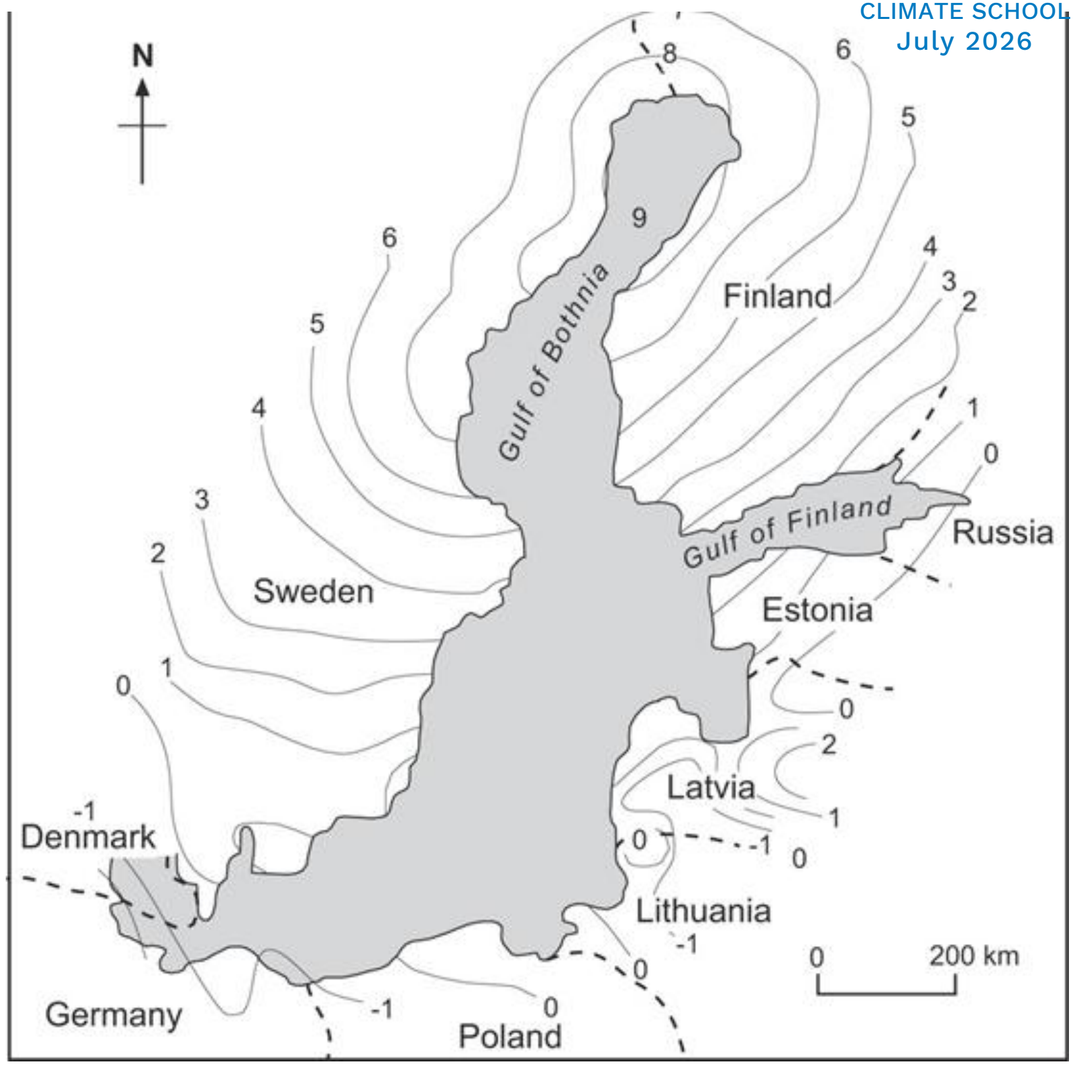

Air temperature
Water temperature
Large-scale atmospheric circulation
Sea ice
Solar radiation
Salinity and Saltwater inflows
Stratification and ocean circulation
Precipitation
River run-off
Carbonate chemistry
Riverine nutrient loads and atmosph. dep.
Oxygen
Sea level
Wind
Waves
Sediment transportation
Microbial community and processes
Benthic habitats
Coastal and riverine run-off
Pelagic and demersal fish
Waterbirds
Marine mammals
Non-indigenous species
Marine protected areas
Nutrient concentrations and eutrophication
Ecosystem function
Offshore wind farms
Coastal protection
Shipping
Tourism
Fisheries
Aquaculture
Blue carbon storage capacity
Marine and coastal ecosystem services

SWL changes in BS



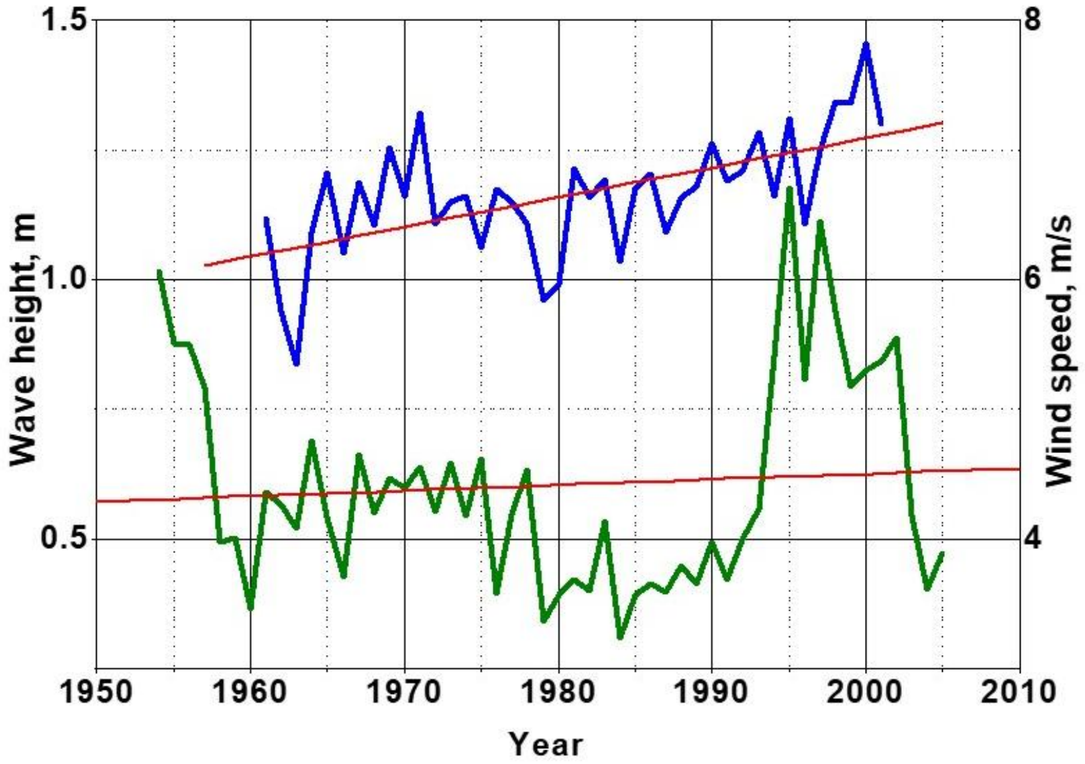


Land upllift



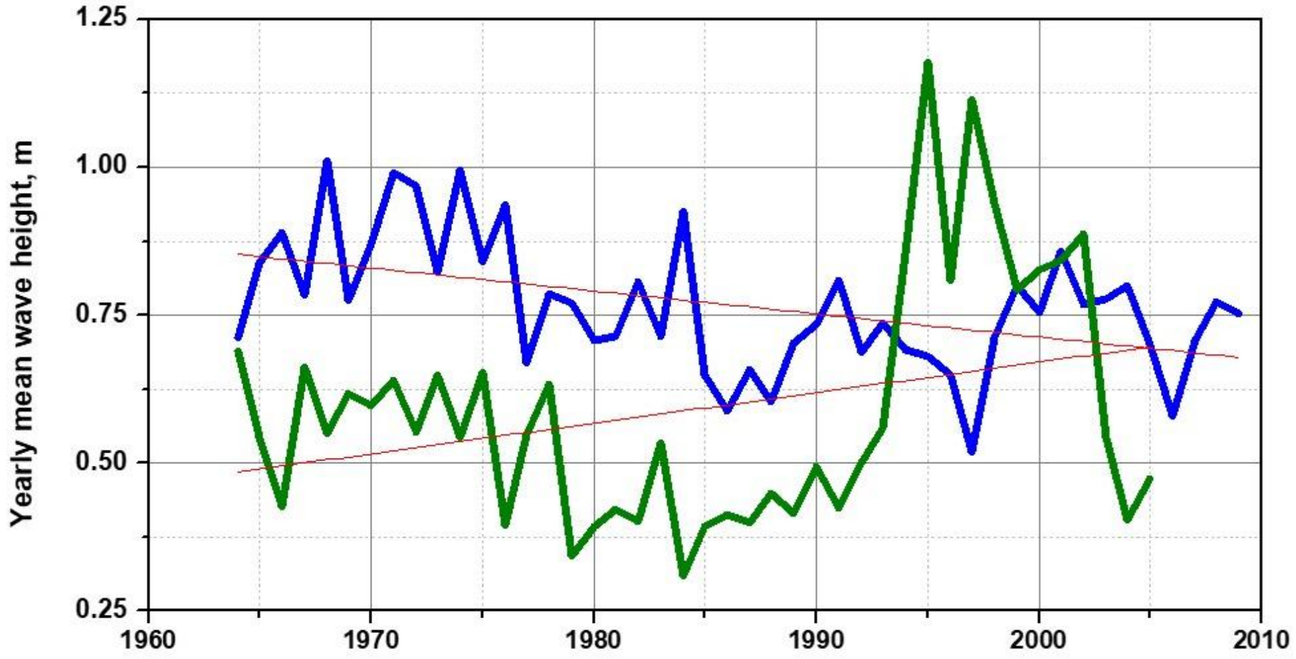
Storminess

- Wind speed Utö
- Wave height Vilsandi



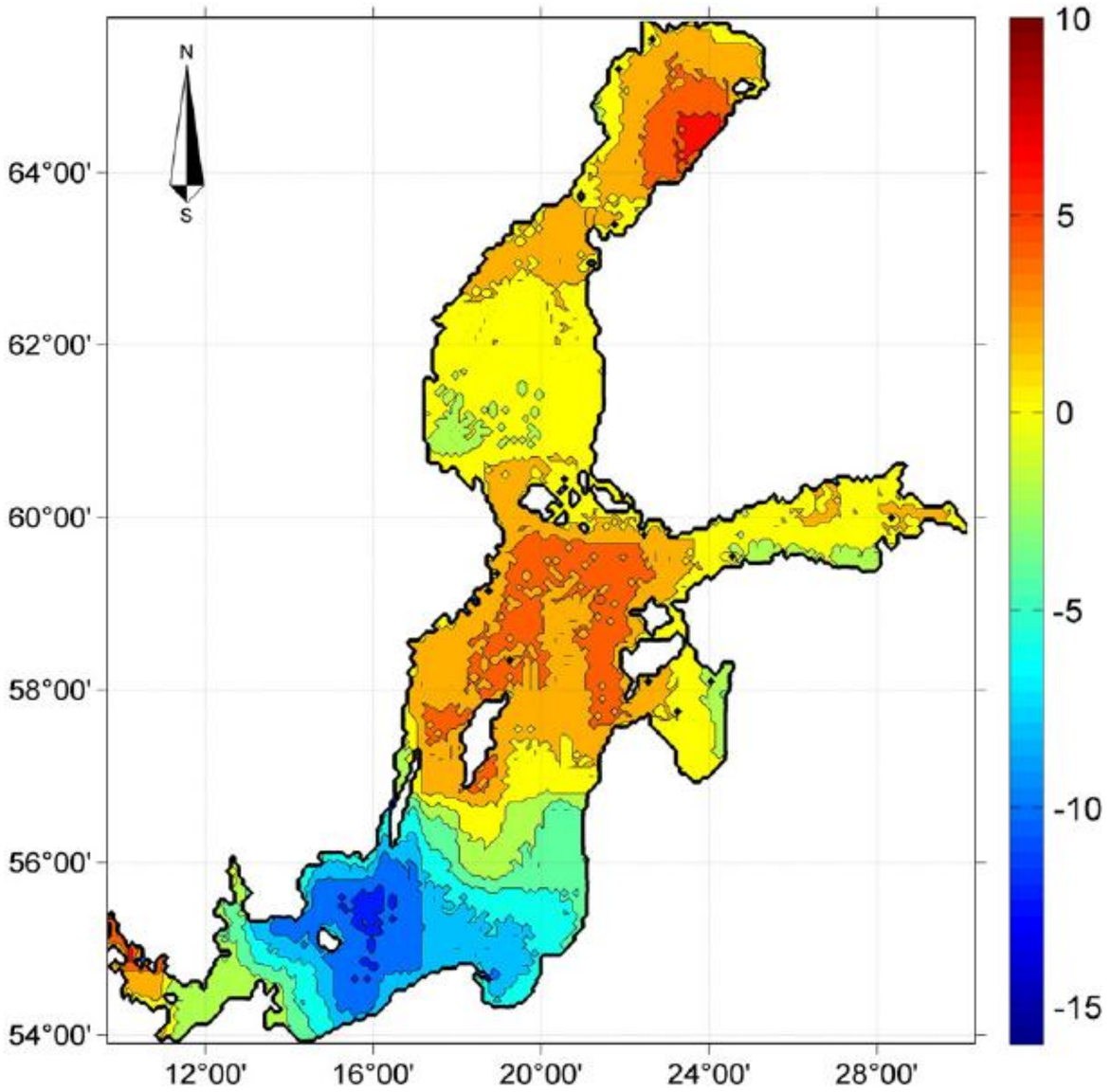
Annual mean wave height

- Wave height Klaipėda
- Wave height Vilsandi



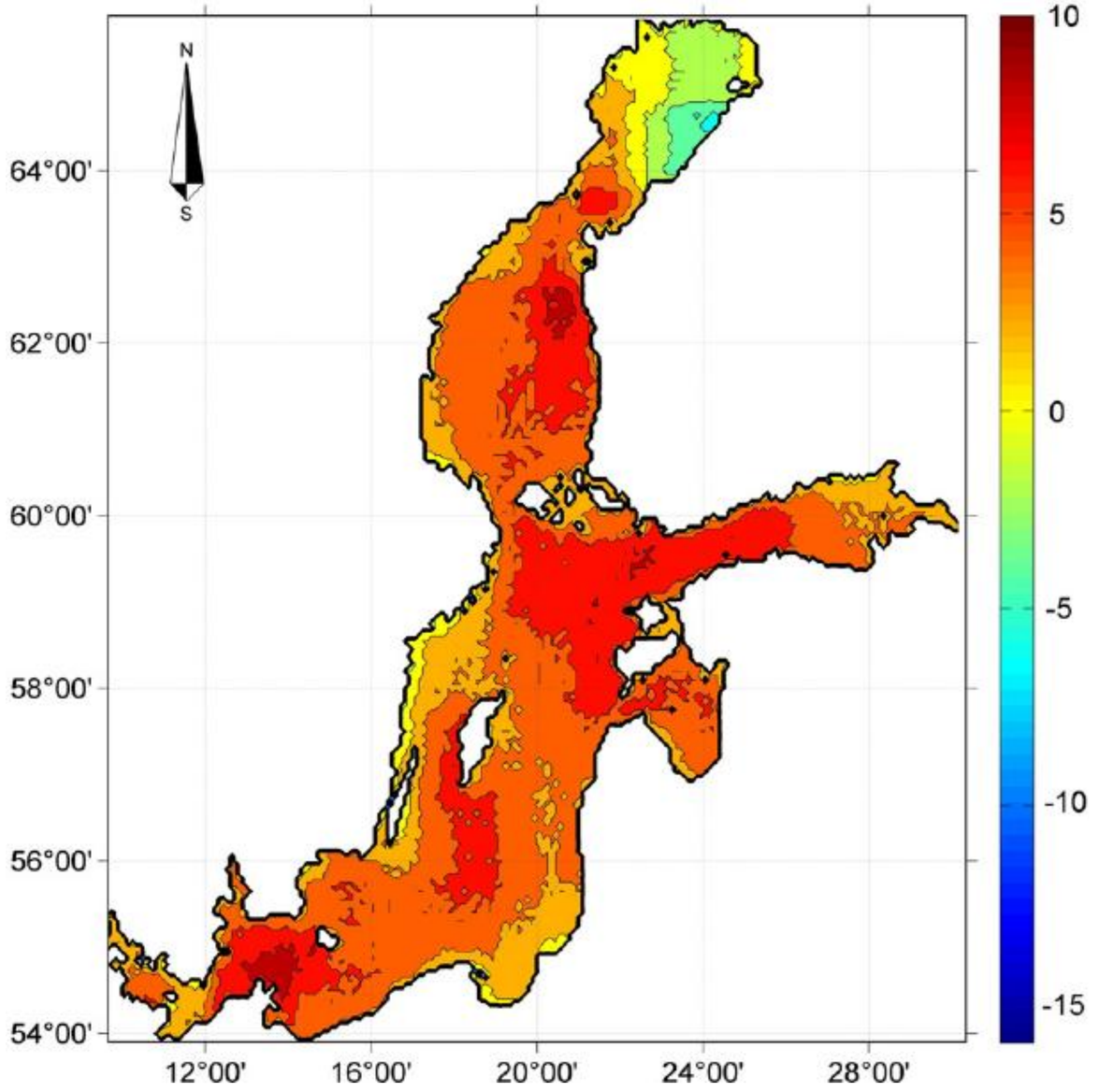
Modelled wave 1970 – 1979

Changes in wave height, cm.



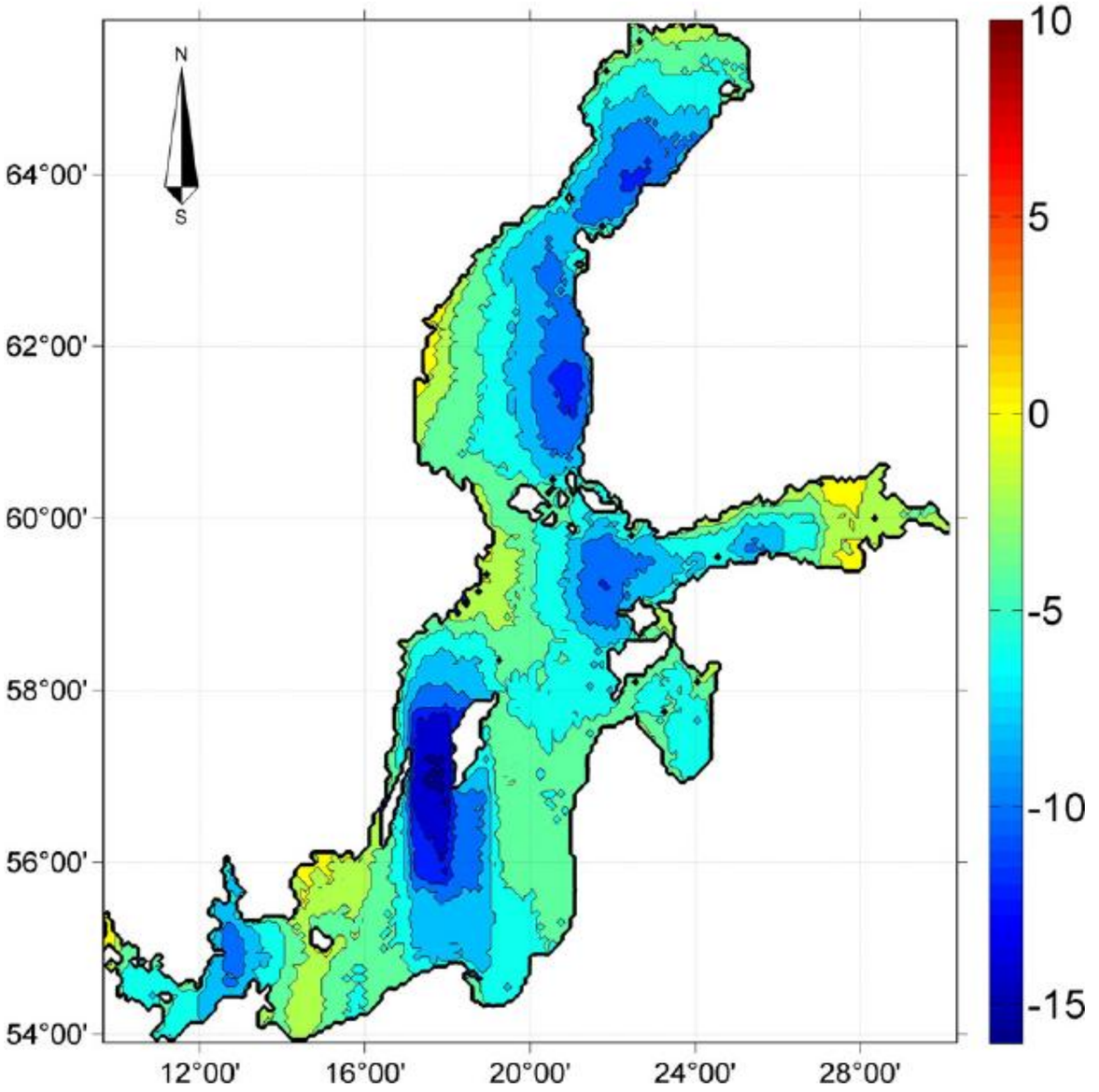
(Soomere and Räämet, 2015).

Modelled wave 1980 – 1989 Changes in wave height, cm.



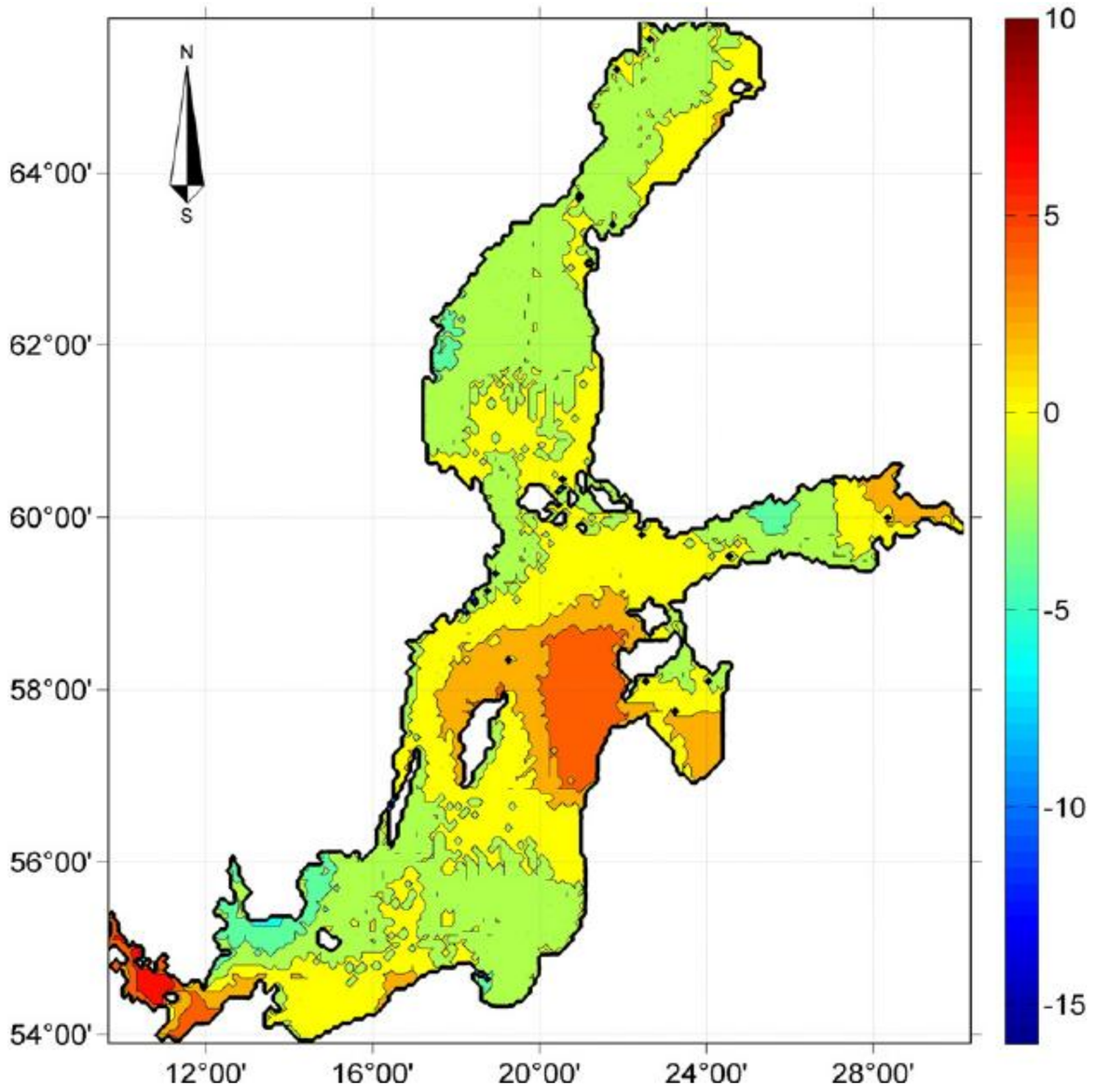
(Soomere and Räämet, 2015).

Modelled wave 1990 – 1999 Changes in wave height, cm.



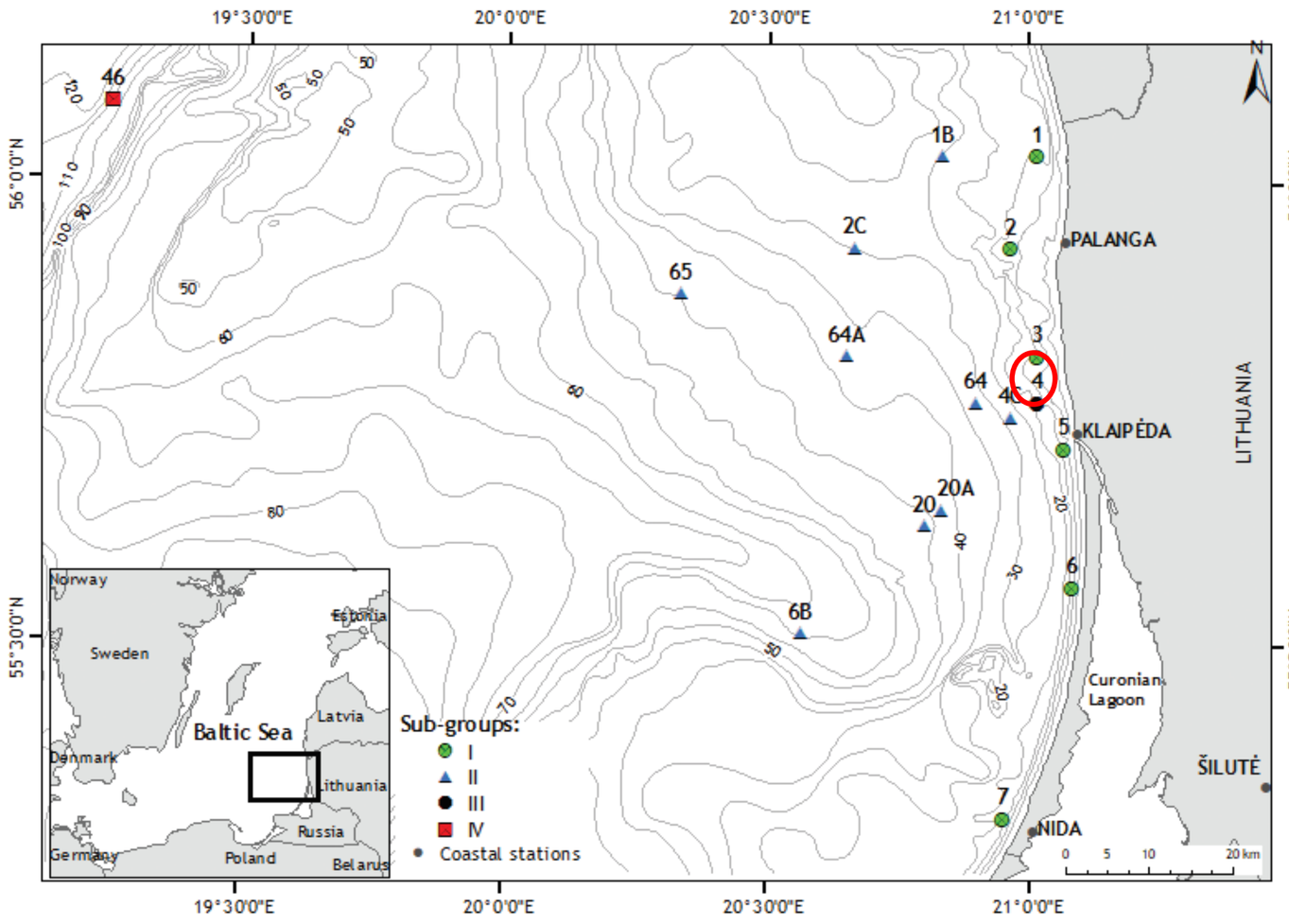
(Soomere and Räämet, 2015).

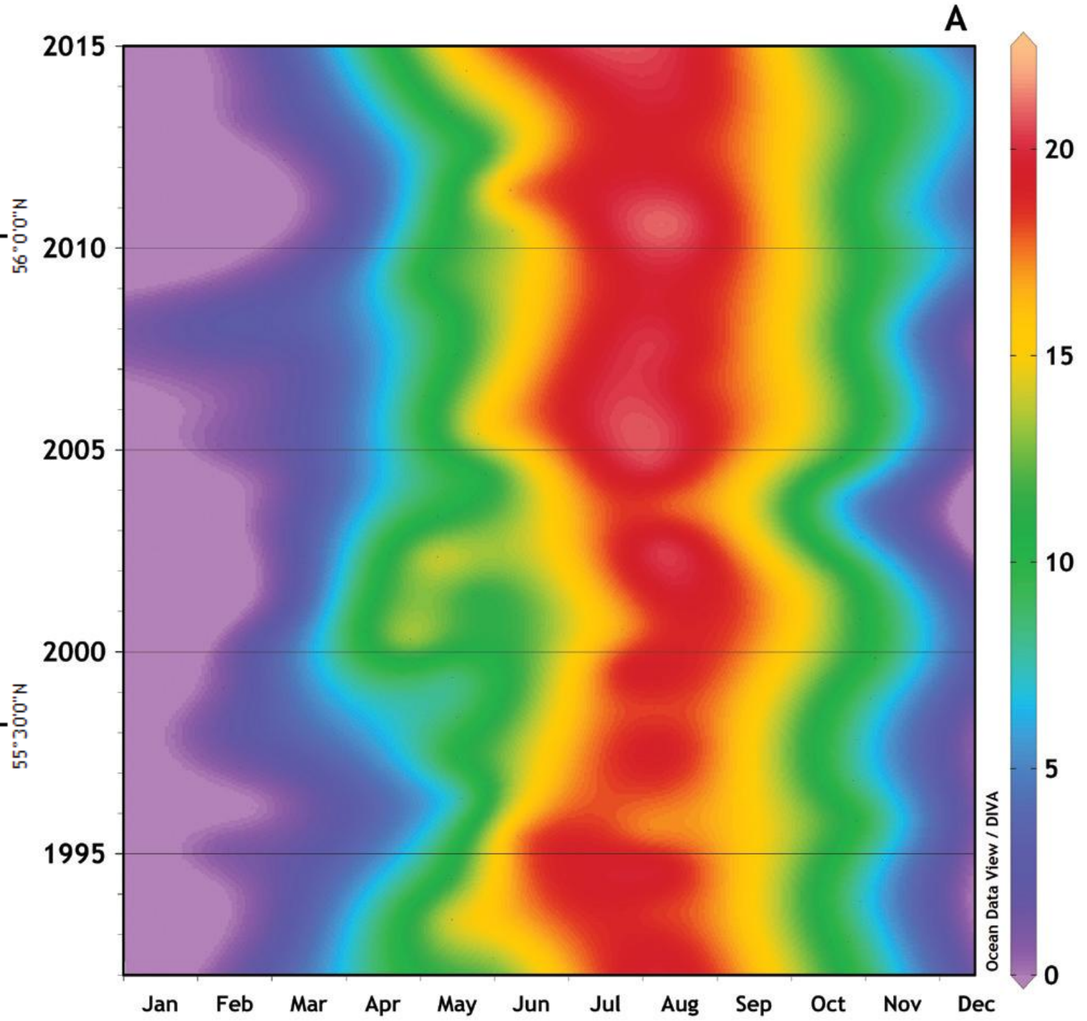
Modelled wave 2000 – 2007
Changes in wave height, cm.



(Soomere and Räämet, 2015).

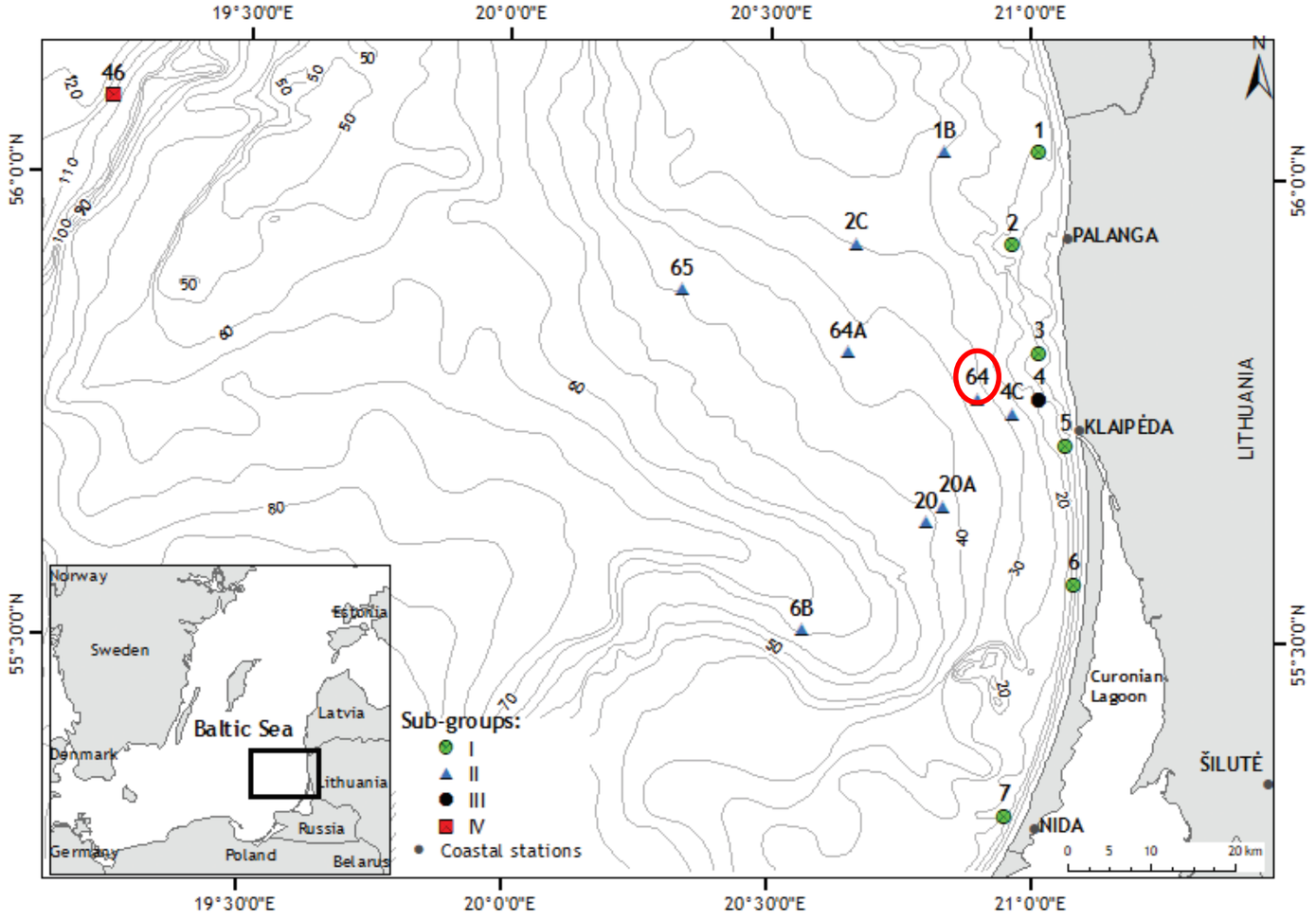
Temperature change at station 4

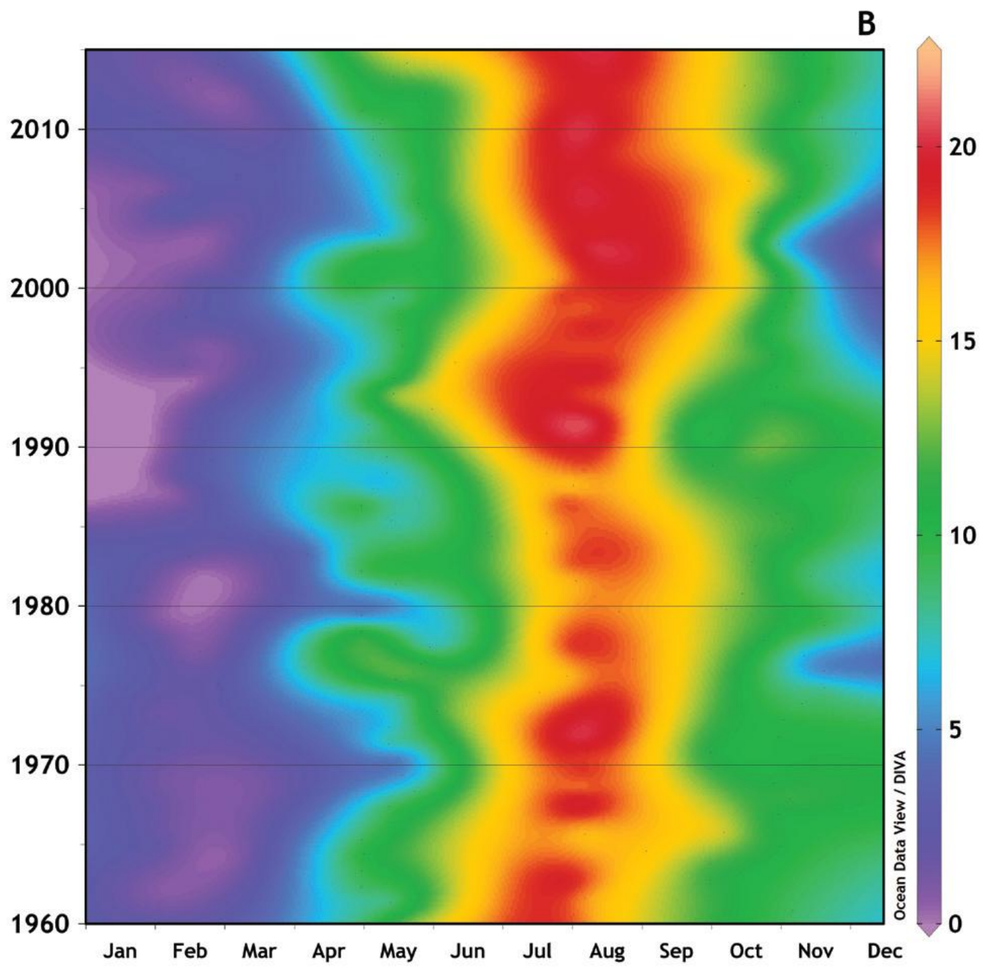




(Rukšenienė ir k.t. 2017)

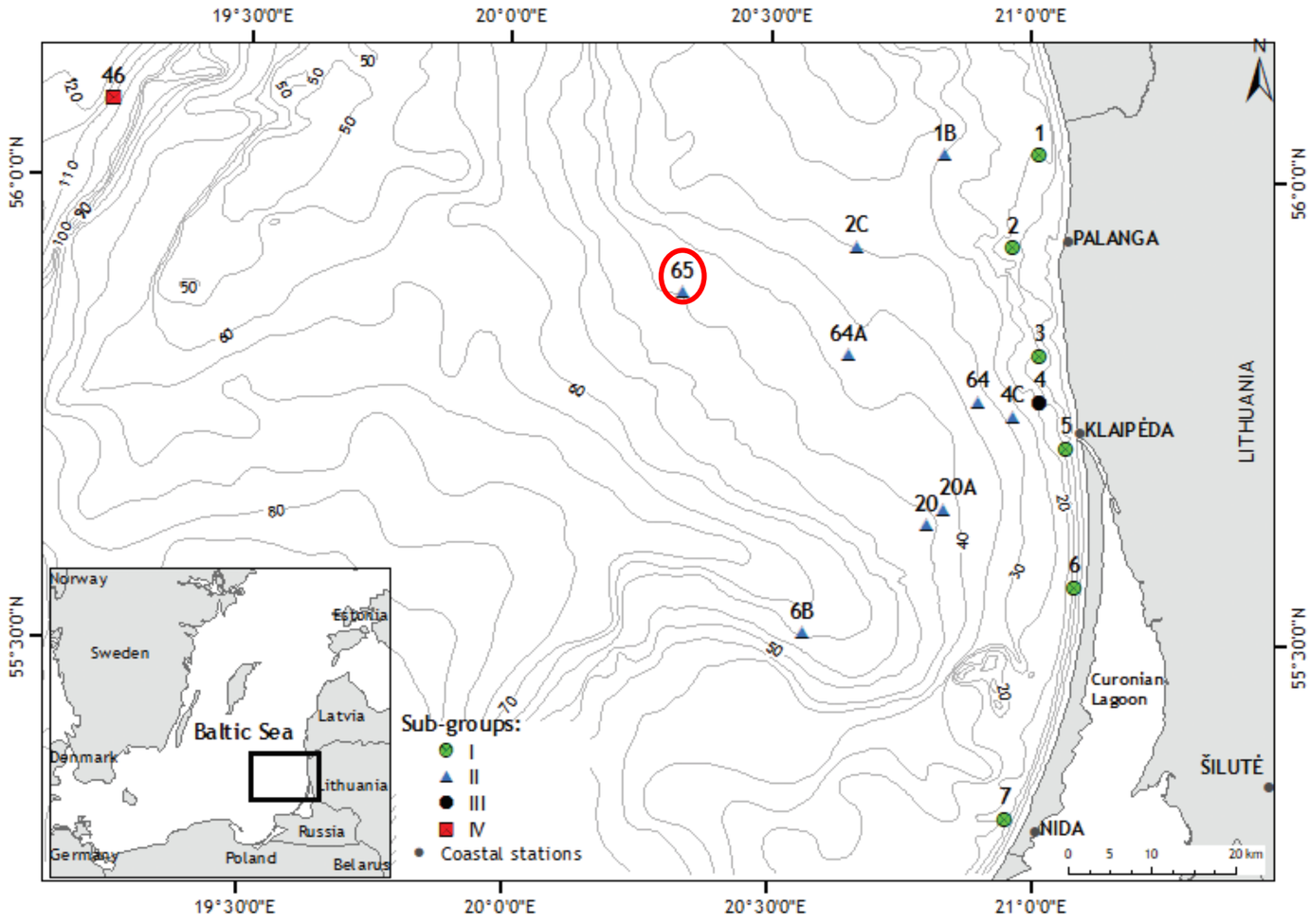
Temperature change at station 64

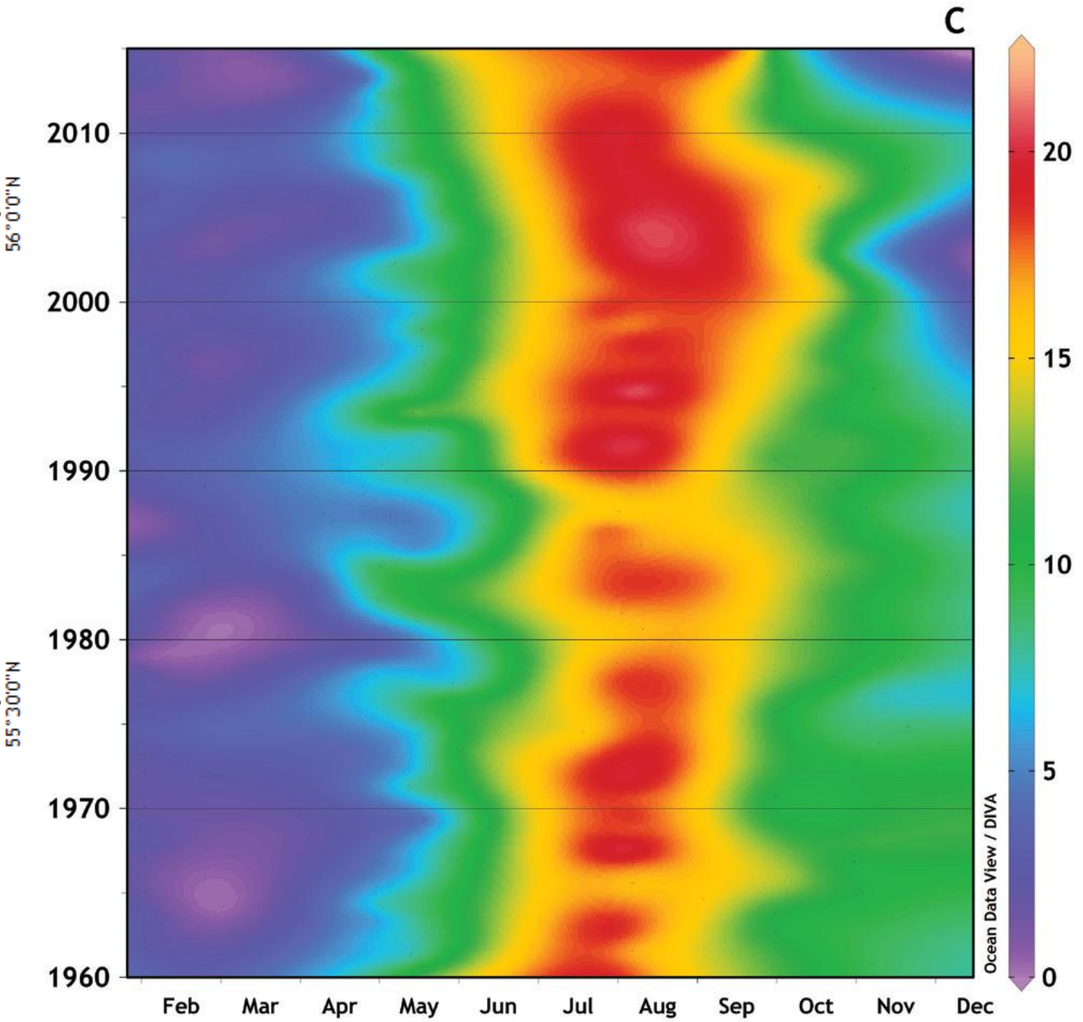




(Rukšenienė ir k.t. 2017)

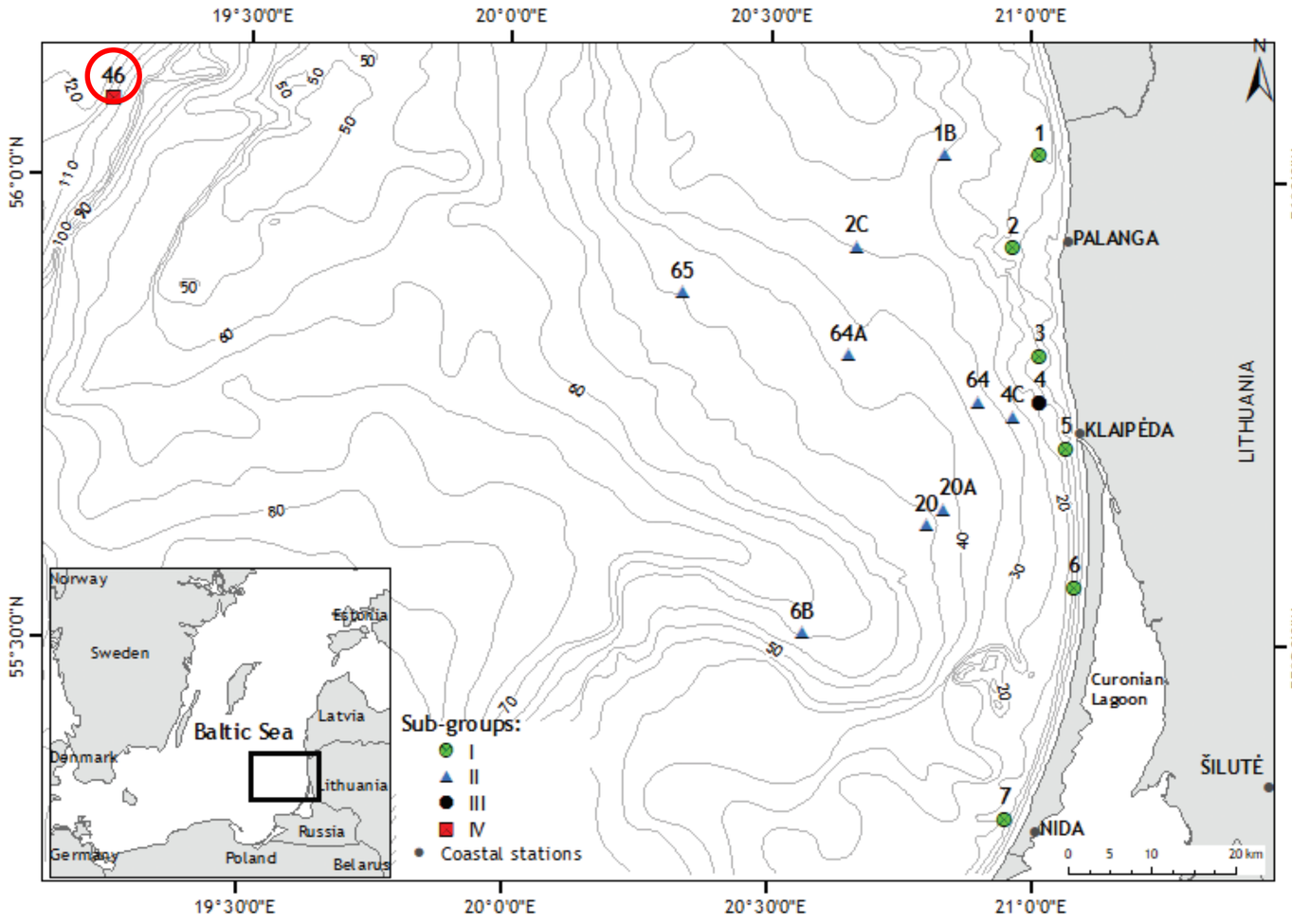
Temperature change at station 65

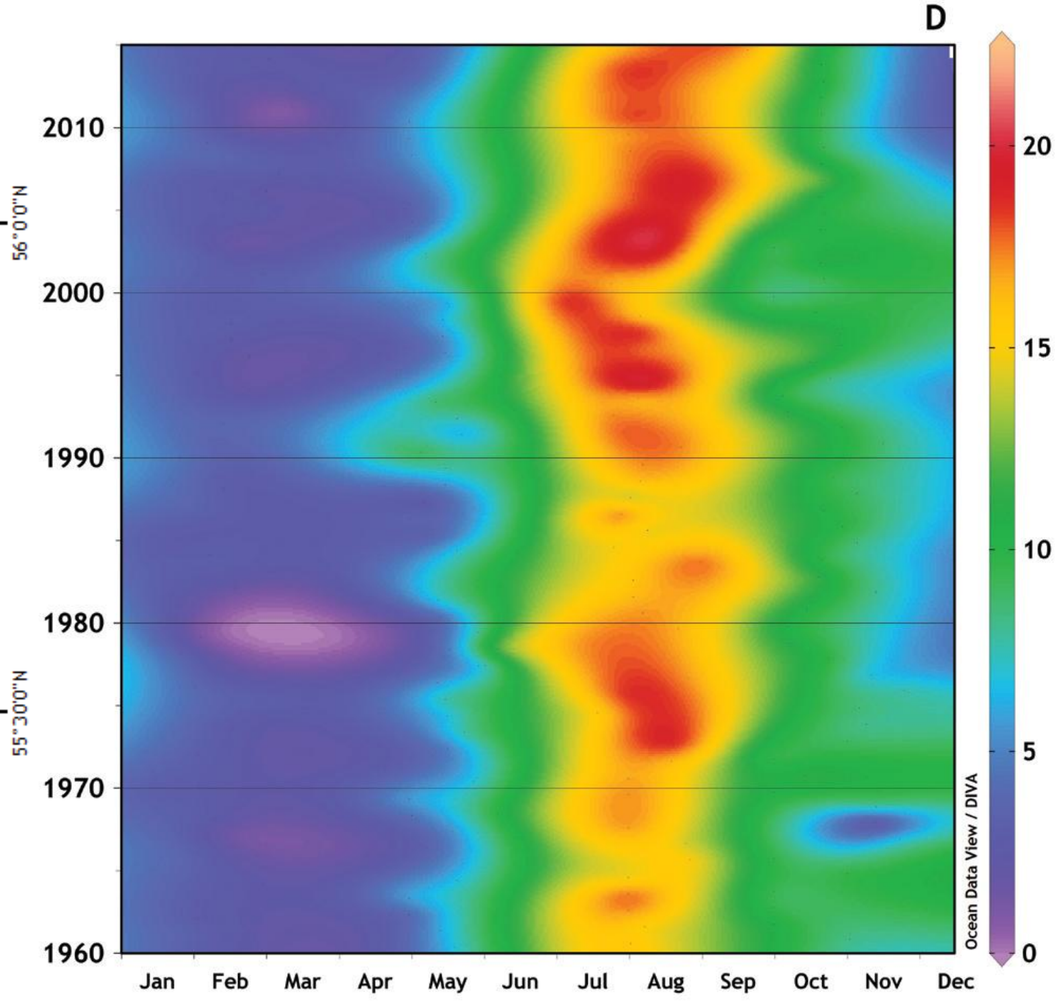




(Rukšenienė ir k.t. 2017)

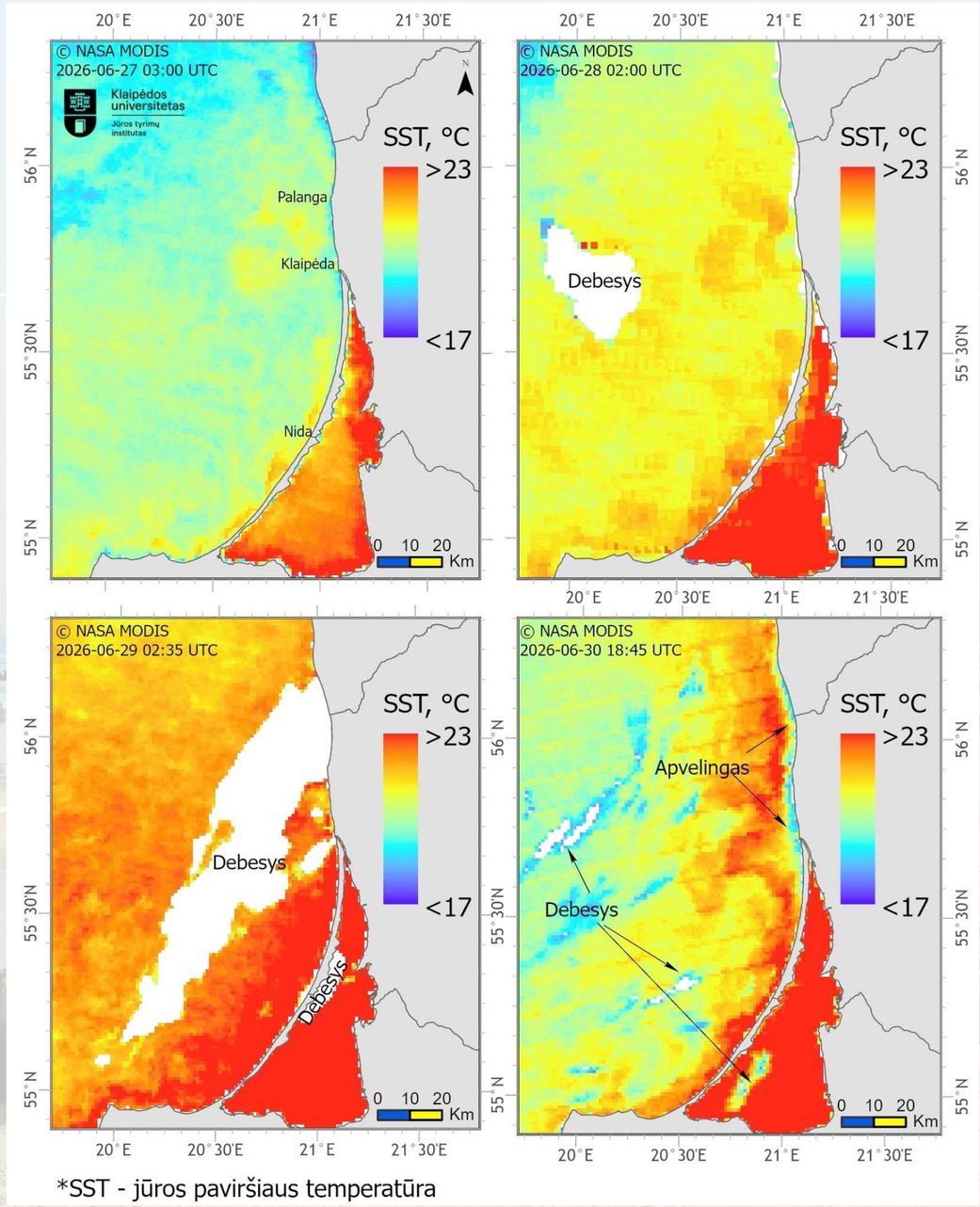
Temperature change at station 46





(Rukšenienė ir k.t. 2017)

THE BALTIC
CLIMATE SCHOOL
July 2026



*SST - jūros paviršiaus temperatūra

Curiosity of :Phd Inesa Servaite, dr. Toma Dabulevičienė

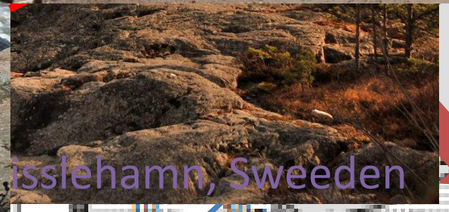
ltic

Valgerand, E

Finland
Hanko, Timo

Valgerand, Estija

Finland
Kemiö Ölmos. Elokuun loppumyrsky. 2016.



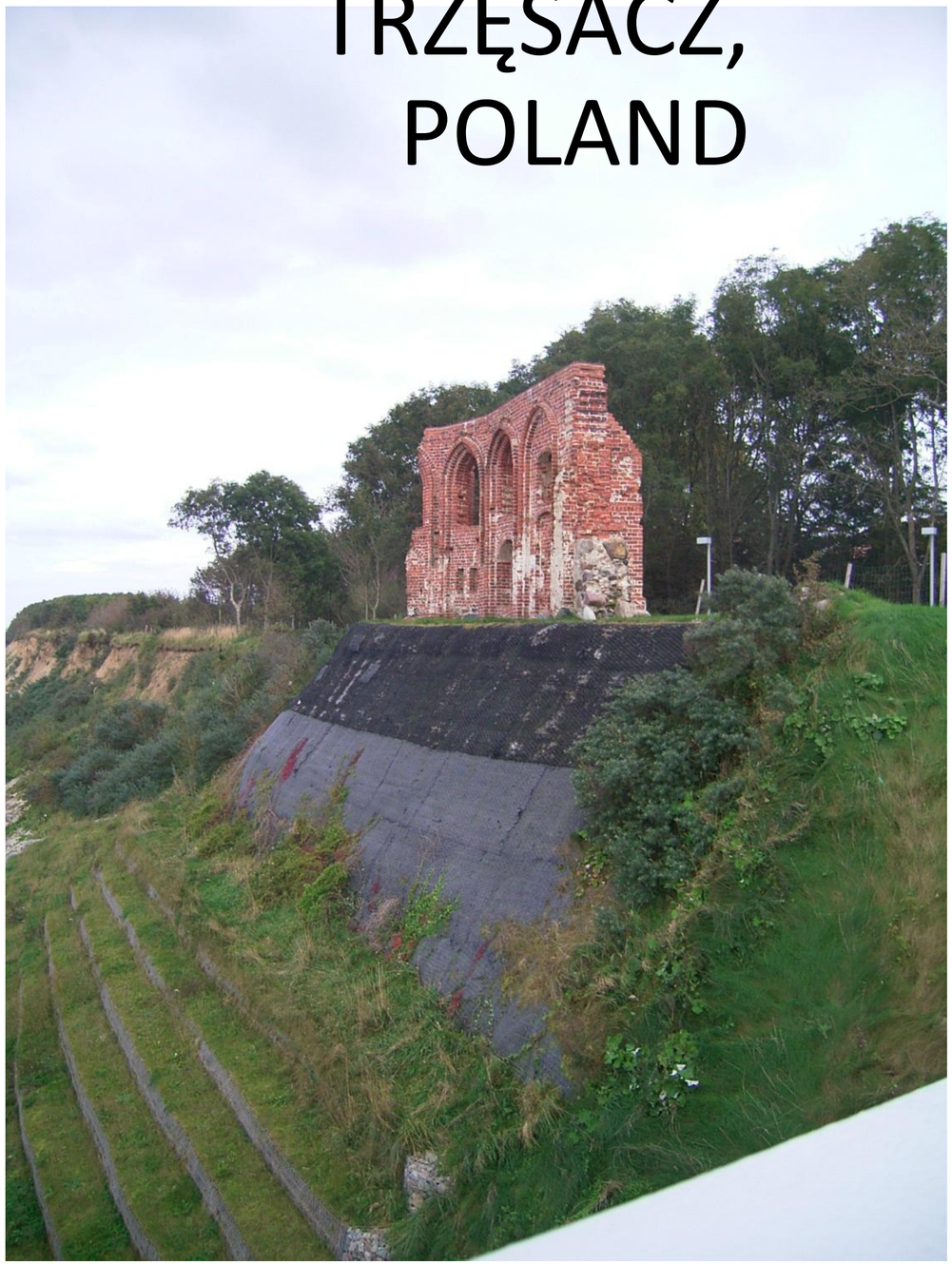
sslehamn, Sweeden

Latvija, Rugumu

Olando kepurė, aut. Tomas Ruginis

Jeppojos Fortas

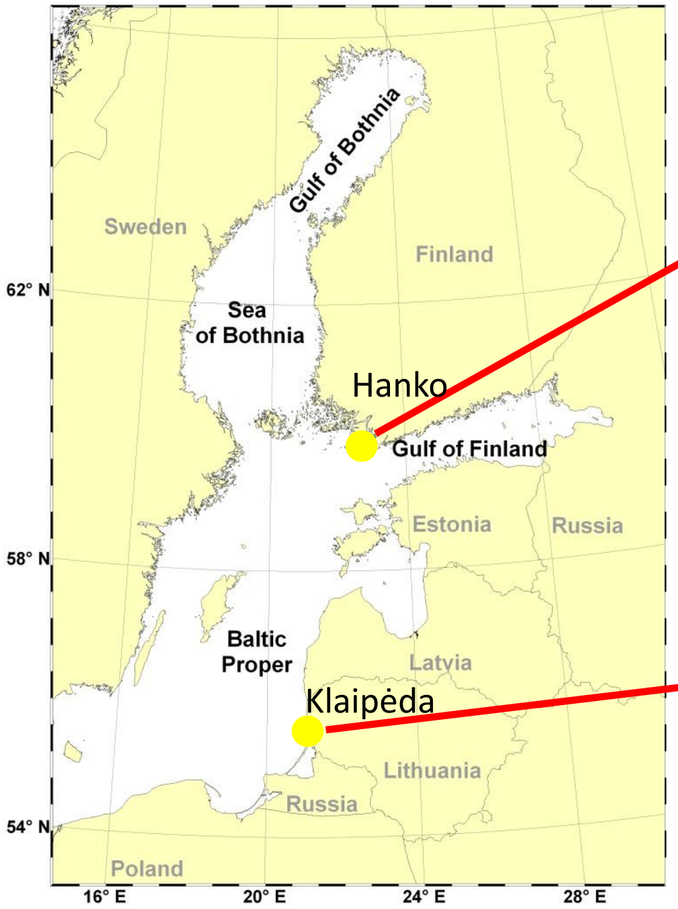
TRZĘSACZ, POLAND

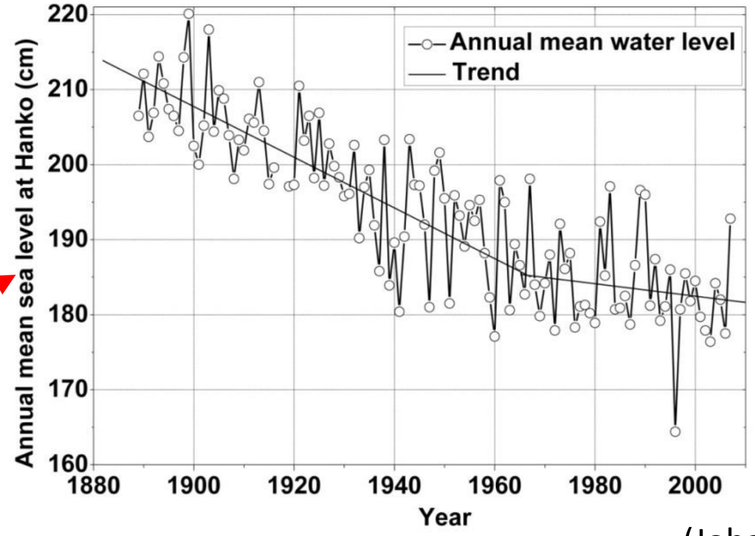


http://www.wybrzeze-rewalskie.pl/atrakcje/ruiny.html

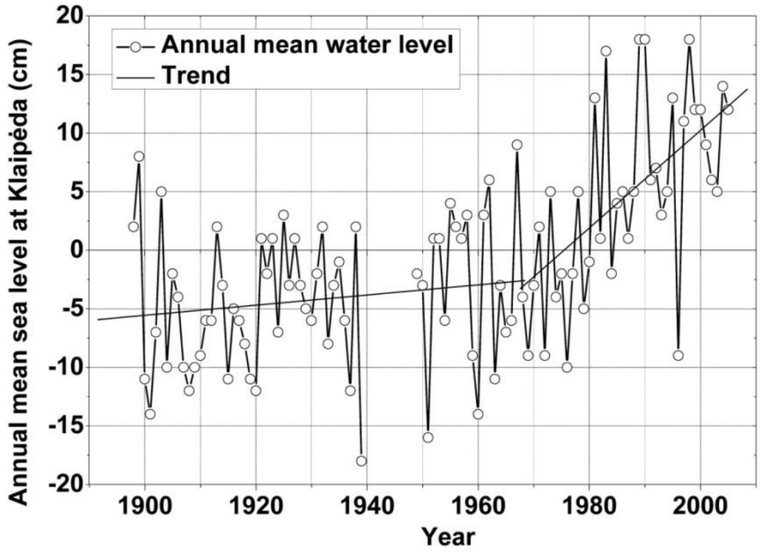
1935

Sea water level rise





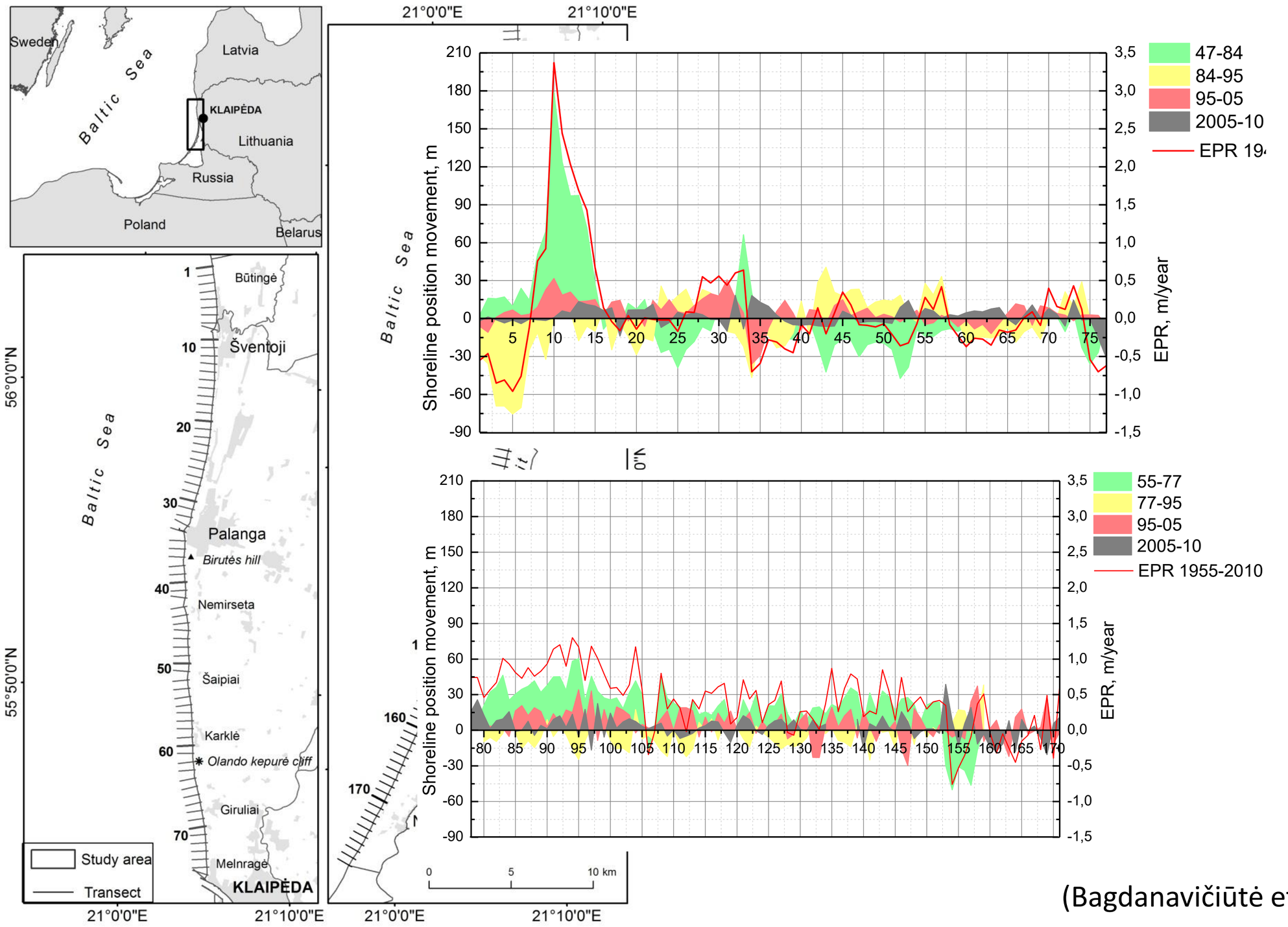
(Johansson *et al.* 2004)



(Dailidienė *et al.* 2006)

2009 AUGUST

2011 February

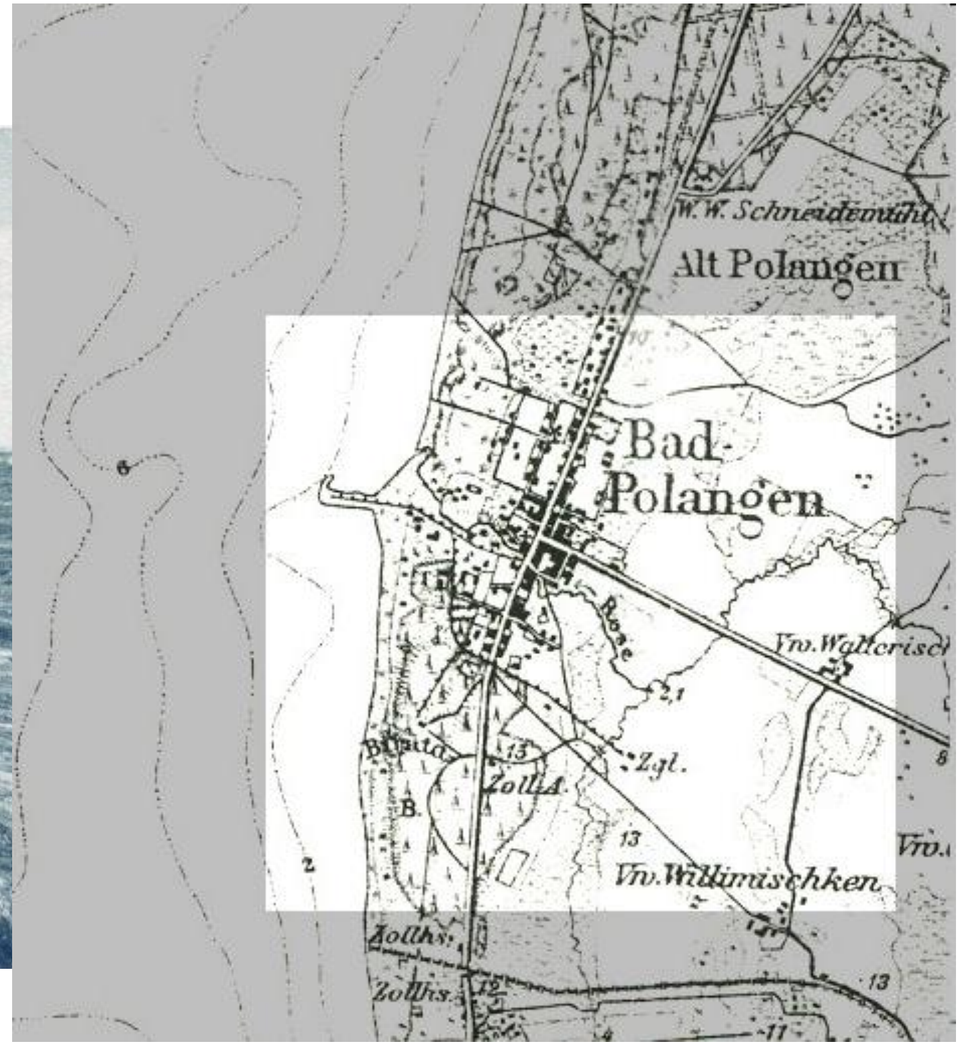


(Bagdanavičiūtė et al. 2012)

PALANGA

PALANGA

J. Tyszkiewicz tiltas 1888

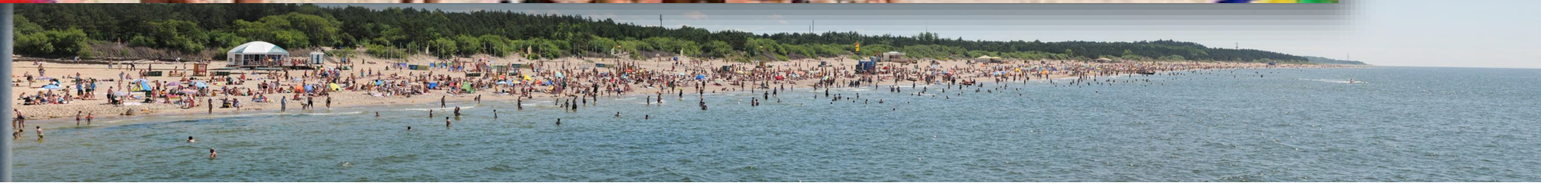


1888–1910 kranto linija pasitrauke nuo jūros per 500 žingsnius (0.7 km) (Karwowski 1913), iki 1947 papildomai pasitrauke 100 m. (Žilinskas *et al.* 2000)

PALANGA

XX. begining

Paulina Mongirdaitė



Lietuvos ži

LIETUVOJE KOMENTARAI IR DEBATAI TYR

Žinios gyvai | Pinigai | Spo

Miestas | Vilnius | Kaunas |

Miestas / Klaipėda

Pajūrį sekmac nuplautas Pal

GALERIJA: Uraganinis vėj

GALERIJA: Didžiulės bang

Vėjas pajūryje sekmadie

Naktį į pirmadienį uraga

LIETUVOJE

Jūra jau išplovė milij

Autorius: **Denisas NIKITENKA**
06:03 Rugpjūčio 24 d. 2012

Baltijos jūros srovės jau atliko savo juodą dar

Vasarotojai neilgai džiaugėsi kaip

Vakarų Lietuva

Palangoje – avarinė situacija (10)

2017-07-04, 17:38 **Rūta Pukenė, DELFI** Spausdinimo versija | Pasidalink A+ A-

Patinka 21 žmonės (-ių) tai mėgsta. Būk pirmas iš savo draugų.

Palangos pajūris antradienį.

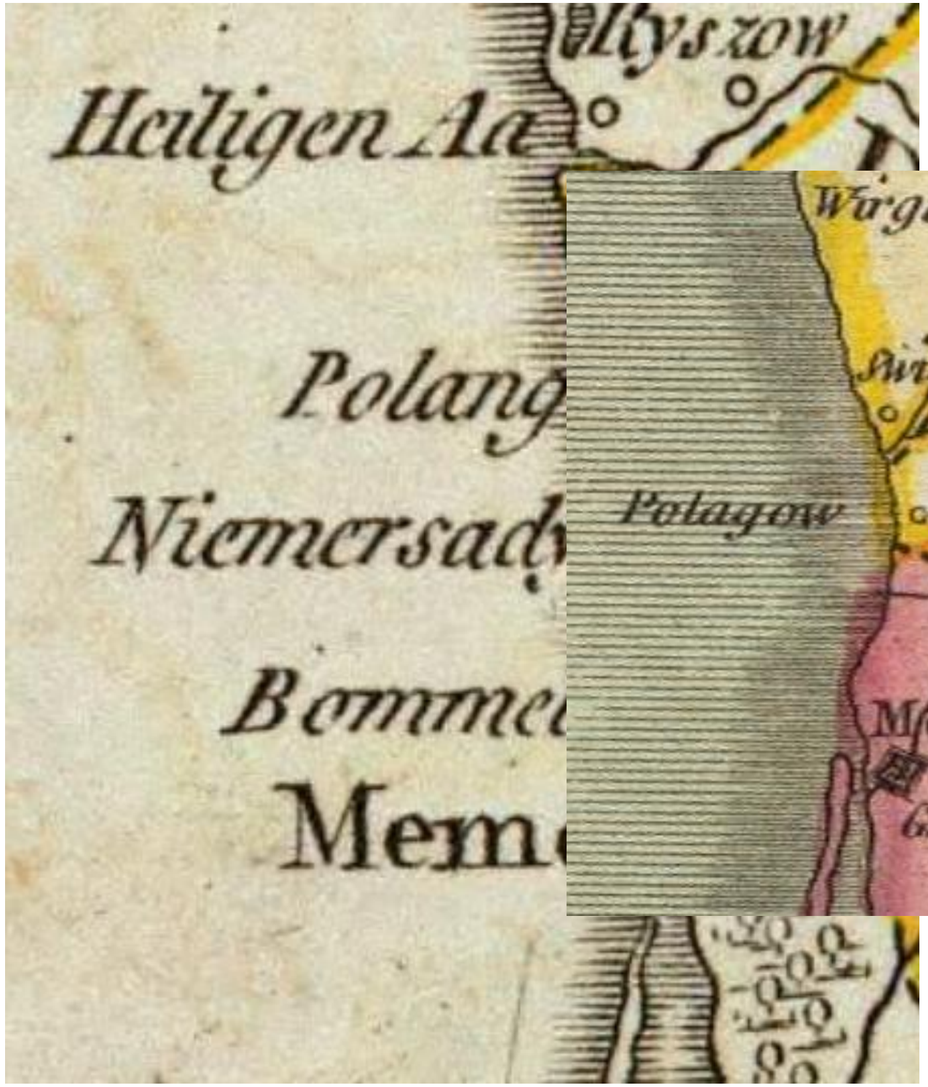
© Orijaus Gasanovo nuotr.

Palangoje šiuo metu esantis žurnalistas ir DELFI kelionių ambasadorius Orijus Gasanovas pasidalijo vaizdais, kuriuose matyti skęstantis paplūdimys.

„Lietingas oras Palangos paplūdimyje yra mažiausia problema. Didesnė problema, kad nebeliko paties paplūdimio. Griūna barai, tuoj paskęs naujasis viešasis tualetas ir persirengimo būdelės“, – tokią žinią jis pranešė savo feisbuko paskyroje.

WHY???

history



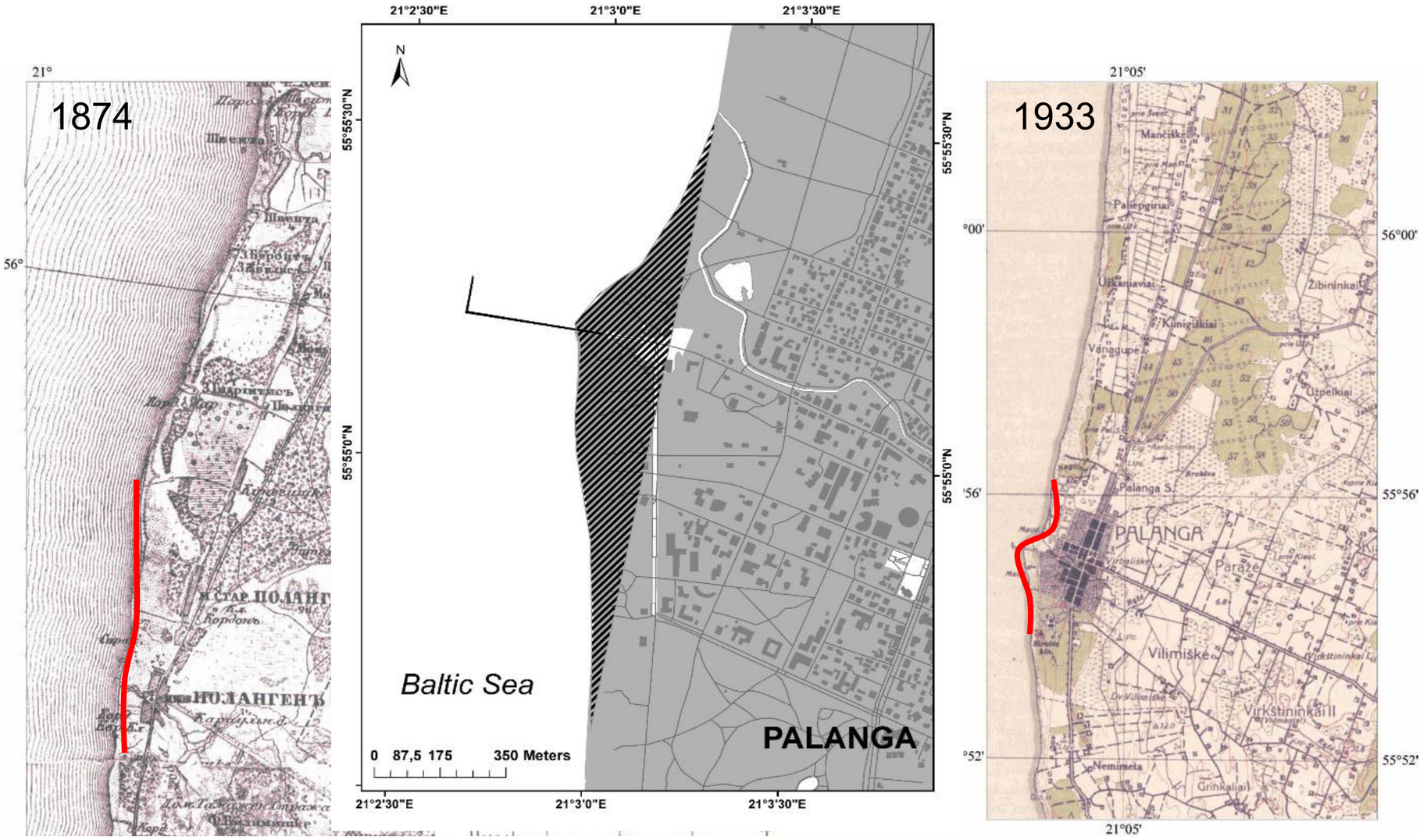
1787

1790

1799

1855

Shoreline changes



(The History Museum of Lithuania Minor)

SHORELINE CHANGES

Nothing last forever

Palanga pier 1956 m.

New bridge1998

The hurricane “Anatoly“

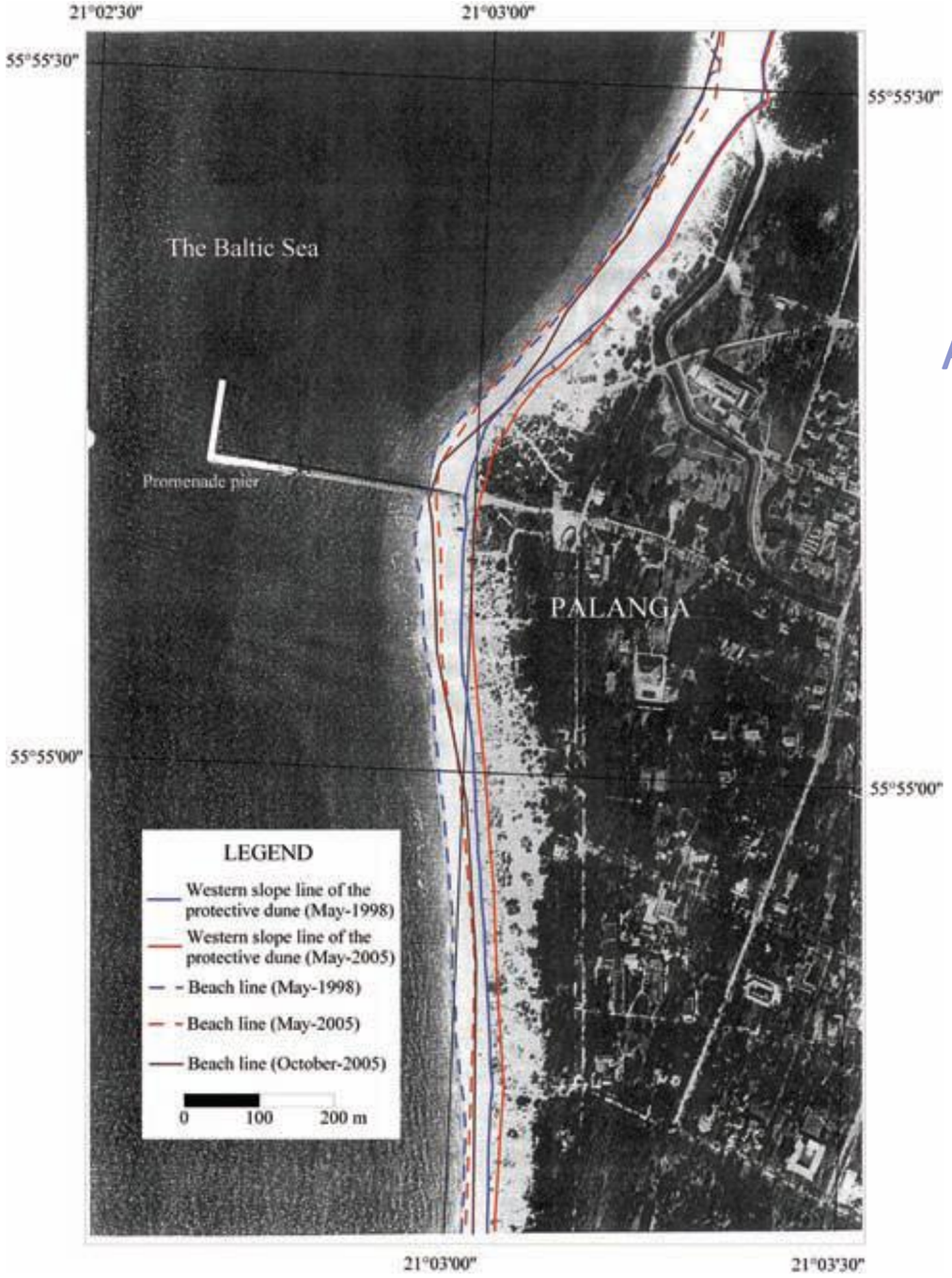
- 4 –5 December 1999;
- SW, S wind 40 m/s;
- The total of 3.94 million m³ of sand was washed out from the Lithuanian coast:
  - –1.94 million m³ from the Curonian spit coast;
  - –2.00 million m³ from the continental coast;

Palanga beaches and the pier after the hurricane “Anatoly“

THE BALTIC
CLIMATE SCHOOL
July 2026

The protective foredune near the promenade pier in Palanga lost over 20 m of its width.

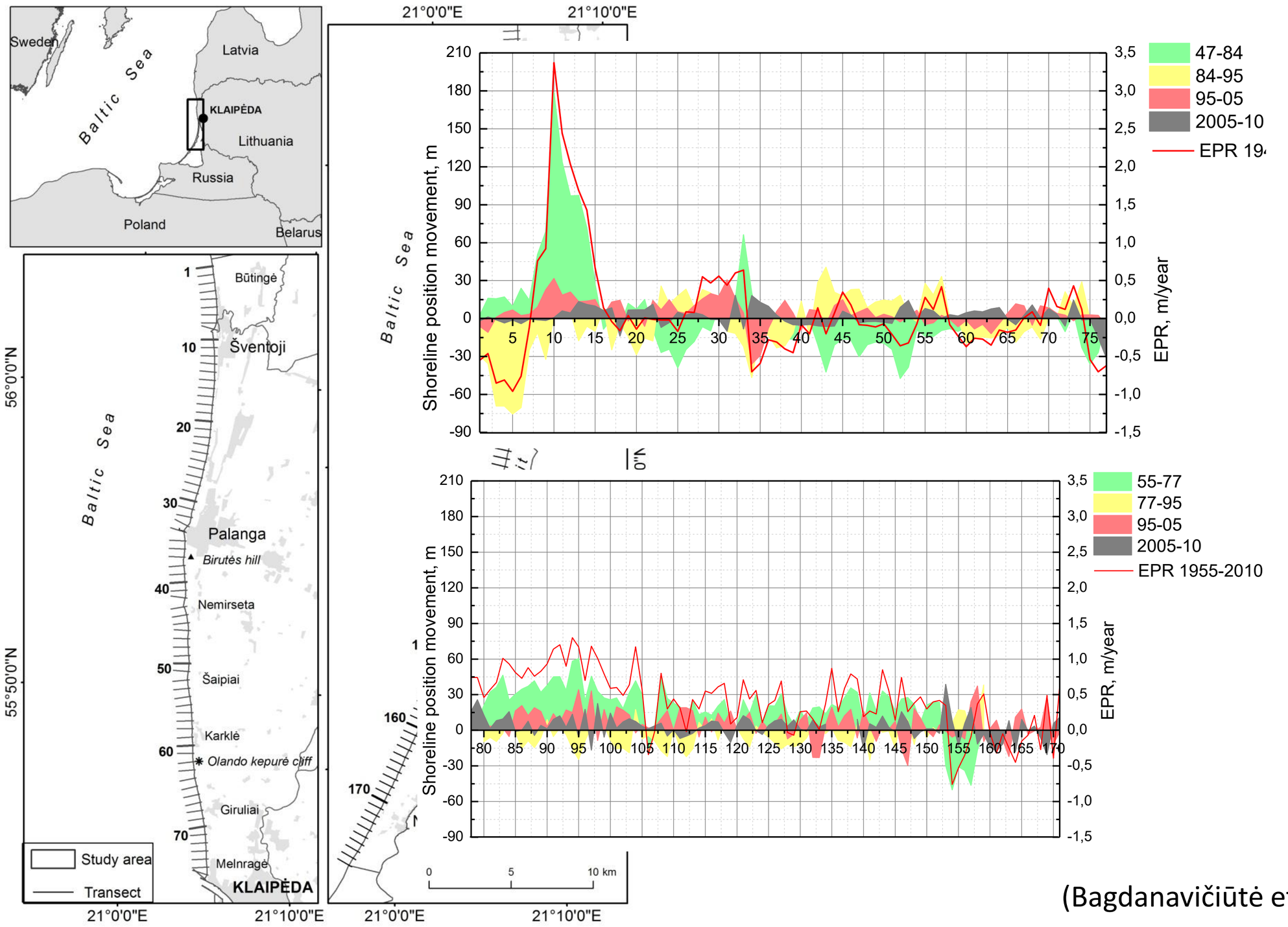
The groyne reconstruction, May 2000



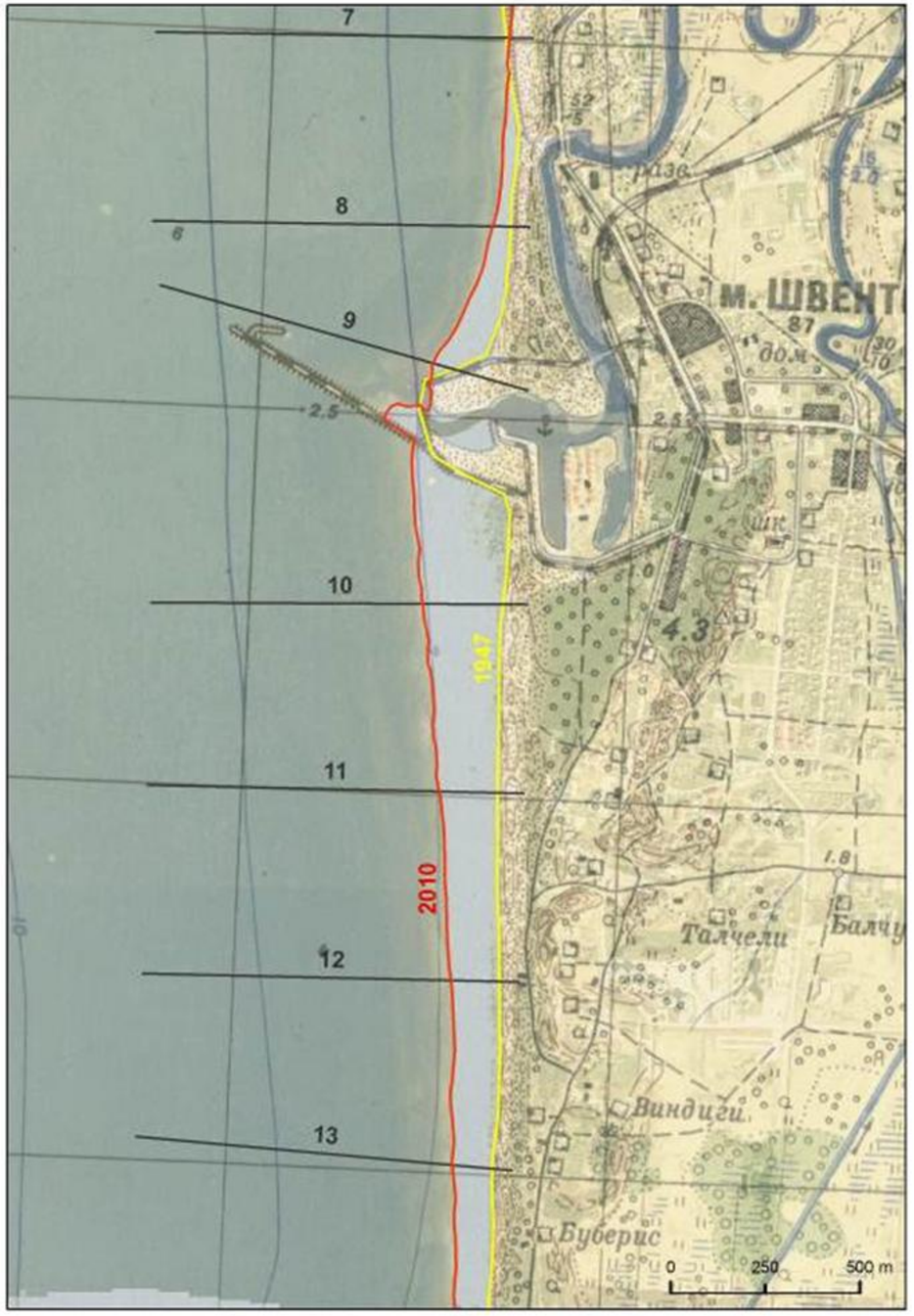
A digitized aerial photograph of the Baltic coast near Palanga (spring, 1998) supplemented with the situation of spring and autumn, 2005.

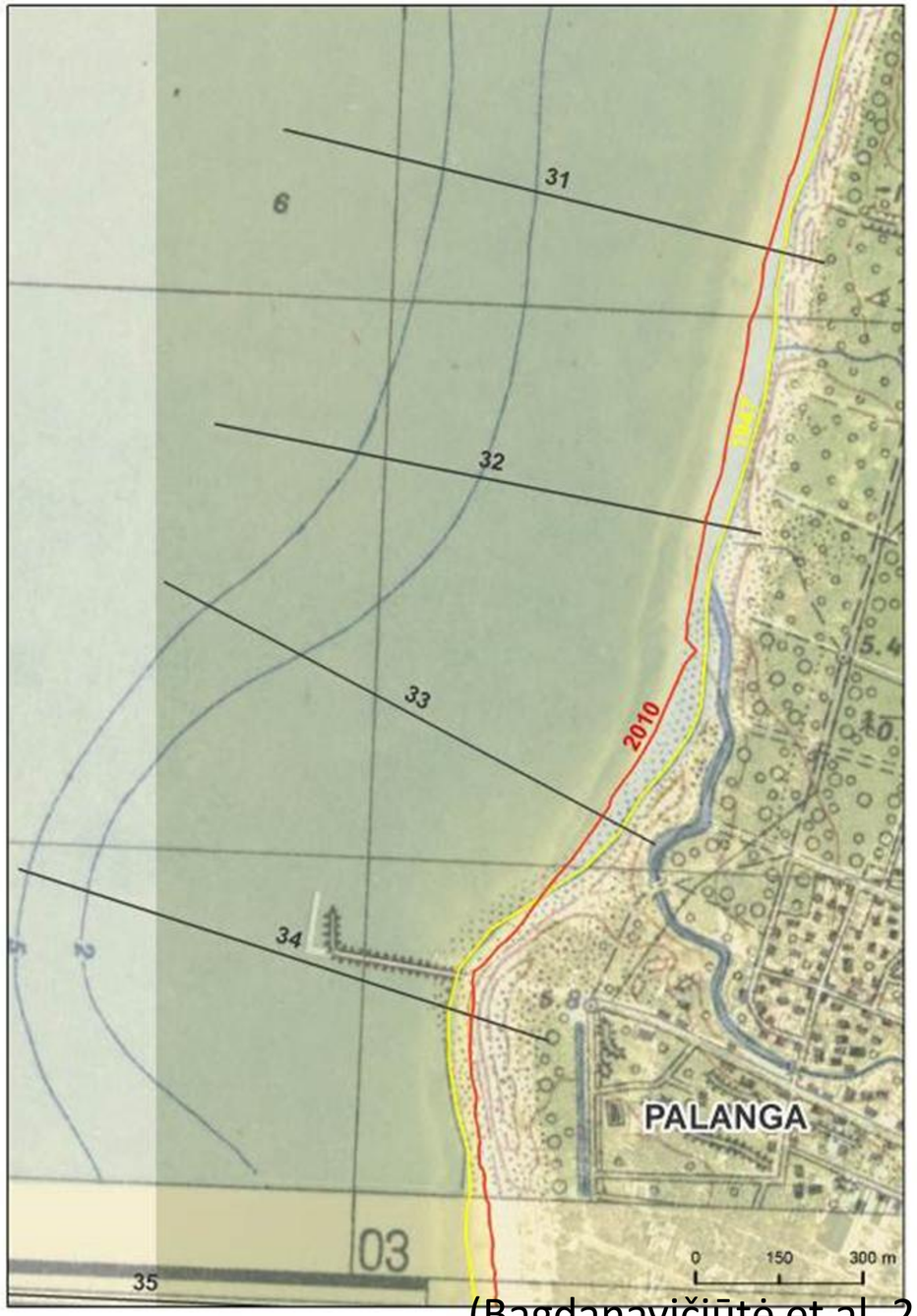
(Dubra 2006)


CAT

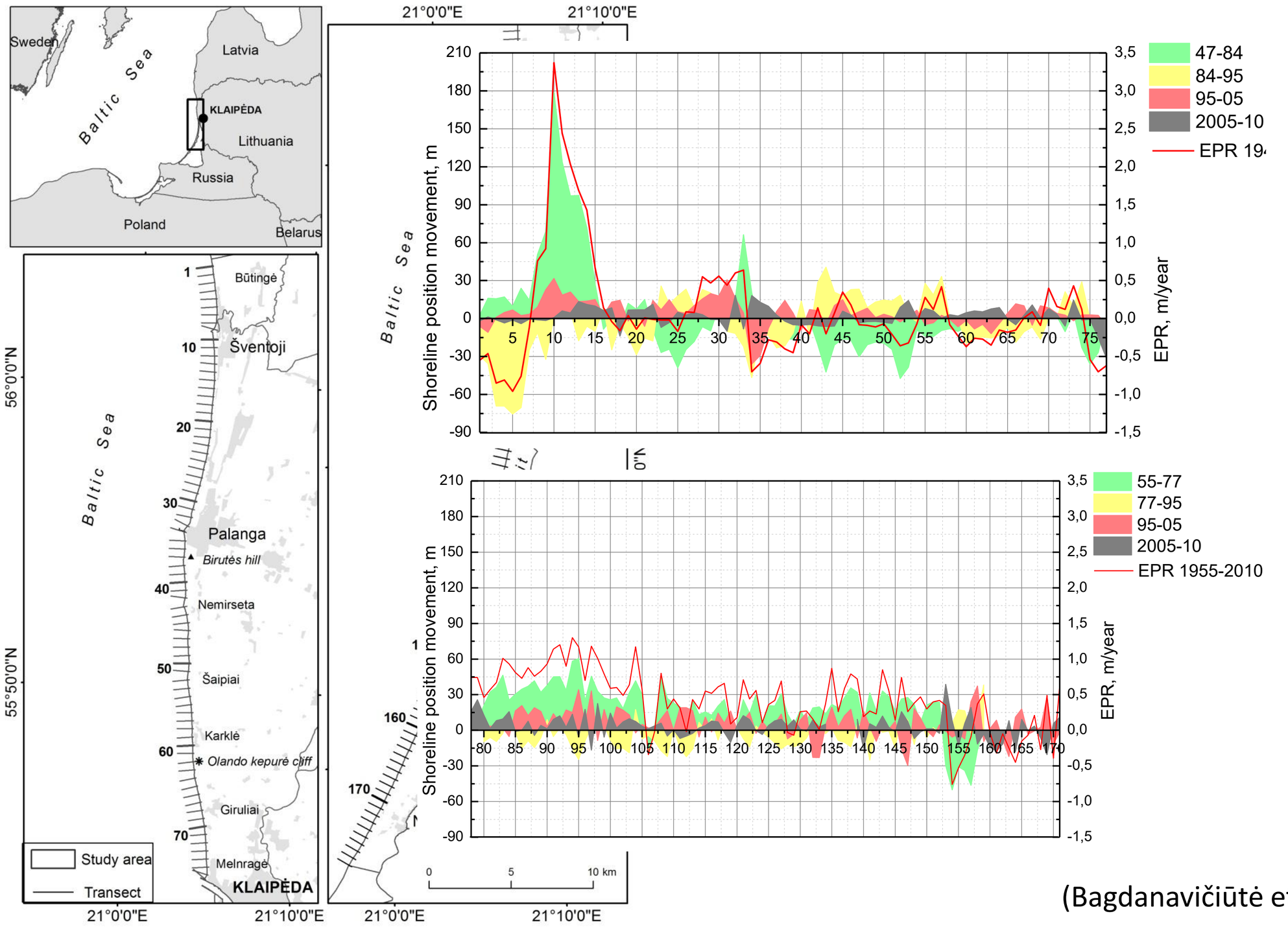


(Bagdanavičiūtė et al. 2012)



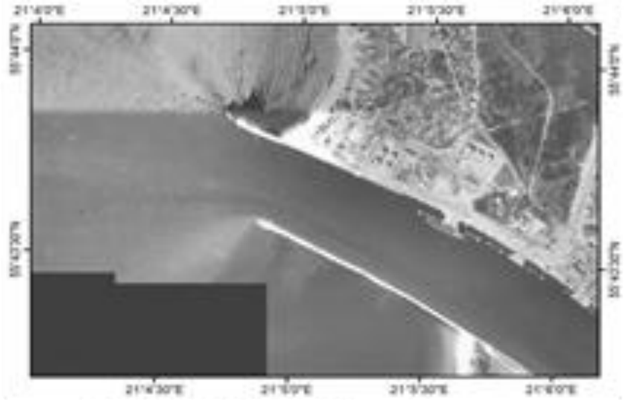


(Bagdanavičiūtė et al. 2012)



(Bagdanavičiūtė et al. 2012)

Port of Klaipeda Jetties



Reconstruction of the Klaipeda port jetties in 2002 and increasing anthropogenic activity at this coast section has disturbed the natural course of the nearshore sediment transport.

Klaipėda | TREČIADIENIS 2018 09 12 | PRANEŠK NAUJIENĄ | SKELBIMAI | HOROSKOPAI | 17° ORŲ PROGNOZĖ

MIESTAS | LIETUVA | VERSLAS | PASAULIS | SPORTAS | KRIMINALAI | SVEIKATA | GRAŽI DIENA | LAISVALAIKIS IR KU

KL.lt > Klaipėda / Miesto pulsas / Ekstremalai jūroje gaudė bangas

Ekstremalai jūroje gaudė bangas

2018-08-15 17:28:00 | Milda Skiriutė

Spausdinti Teksto dydis:

Ekstremalai jūroje gaudė bangas Vytauto Liaudanskio nuotr.

Laisvadienis savaitės viduryje pajūryje nelepino orais. Dangų temdė debesys, o Baltijos jūroje siautė audra. Vėjas pradžiugino ekstremalių pramogų mėgėjus.

/ilniausdiena/Vartotoju zona/lukas.s/_g0e6228.jpg?itok=0x94BIF_

Coastal erosion positive sign:

There was more action next the wave breaker. Here the wind and the waves are enjoyed by extreme sports enthusiasts - kites of power and surfing fans. There were also curiosities that were watching the entertainers.

http://klaipeda.diena.lt/naujienos/klaipeda/miesto-pulsas/ekstremalai-juroje-gaude-bangas-876586

Photos: Tomas Ruginis, Tarmo Soomere

17:45 **An intensive upwelling event of hypoxic water at the southern Baltic Sea coast in September 2025 – a rare phenomenon or quite common?**

Naumann M, Sass M, Krebs B, Neubert S, Mars R, Thiele O, Bukowski C, Voss M, Holtermann P

An intensive upwelling event of hypoxic water at the southern Baltic Sea coast in September 2025 – A rare phenomenon or quite common?

Michael Naum

Bukowski [2], Uv

[1] Leibniz Institut

* E-mail: micha

Large-scale up
is known about
Sea generally
and phosphoru
accumulation o
of oxygen-depl
is consumed o
as permanently
some of which
can have a stro
of fish and ben
question is the
and whether th
from the Warne

DETAILS | RELATIONS

Limnology and Oceanography Bulletin
Volume 28, Issue 4
Nov 2019
Pages 117-151

Article

Baltic Sea Hypoxia Takes Many Shapes and Sizes

View article page

Jacob Carstensen, Daniel J. Conley

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https://doi.org/10.1002/lob.10350

ISSN 1539-607X

eISSN 1539-6088

Received 20 September 2019

article

Baltic Sea Hypoxia Takes Many Shapes and Sizes

Jacob Carstensen and Daniel J. Conley

ABSTRACT

The Baltic Sea is naturally prone to hypoxia, but the frequency and extent have increased multifold over the last century. Hypoxia manifests itself as perennial in the open central part, seasonal at the entrance area, and episodic at many coastal sites, and the expression of hypoxia is largely driven by differences in bottom water residence times and stratification patterns. Enhanced nutrient inputs from land and atmosphere are the main drivers of expanding hypoxia in the Baltic Sea although deoxygenation has also been exacerbated by increasing to increasing nutrient inputs from land and atmosphere (Carstensen et al. 2014a).

Today, the Baltic Sea constitutes the largest man-made "dead zone" in the world, totaling almost 70,000 km^2 (Fig. 2a). Whereas this huge "dead zone," equivalent to the 1.5 times the area of Denmark or three times the area of Maryland, has received attention among scientists and in the public, it is less known that the entrance area of the Baltic Sea, the Danish Straits, and several hundred Baltic coastal ecosystems also suffer from hypoxia (Conley et al. 2011). The development of hypoxia in these moves upward during periods with more frequent inflows, whereas it is gradually eroded during periods of low inflows. However, there have been decade long periods of stagnation generally caused by large freshwater inflows and high mean zonal wind speeds. One such stagnation period occurred from around 1973 to 1993 (Fig. 2a). During this period, the halocline was eroded downward by more than 10 m (Carstensen et al. 2014a). Thus, the existing hypoxic water is not removed by saltwater inflows but merely displaced to other areas where it may affect benthic fauna and nutrient

Take home messages

The climate is changing;

The causality of climate change is not 100% clear;

How strongly the climate changes depends on which period we compare with;

Don't believe everything the media says.

July 2026

THE BALTIC CLIMATE SCHOOL

THANK YOU

Prof.dr. Loreta Kelpšaitė-Rimkienė

loreta.kelpsaite-rimkiene@ku.lt

Coalition Clean Baltic