KLIMATA MAINAS IETEKME UZ BALTIJAS REGIONA UDENU VIDI

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Baltijas regions kluvis siltaks

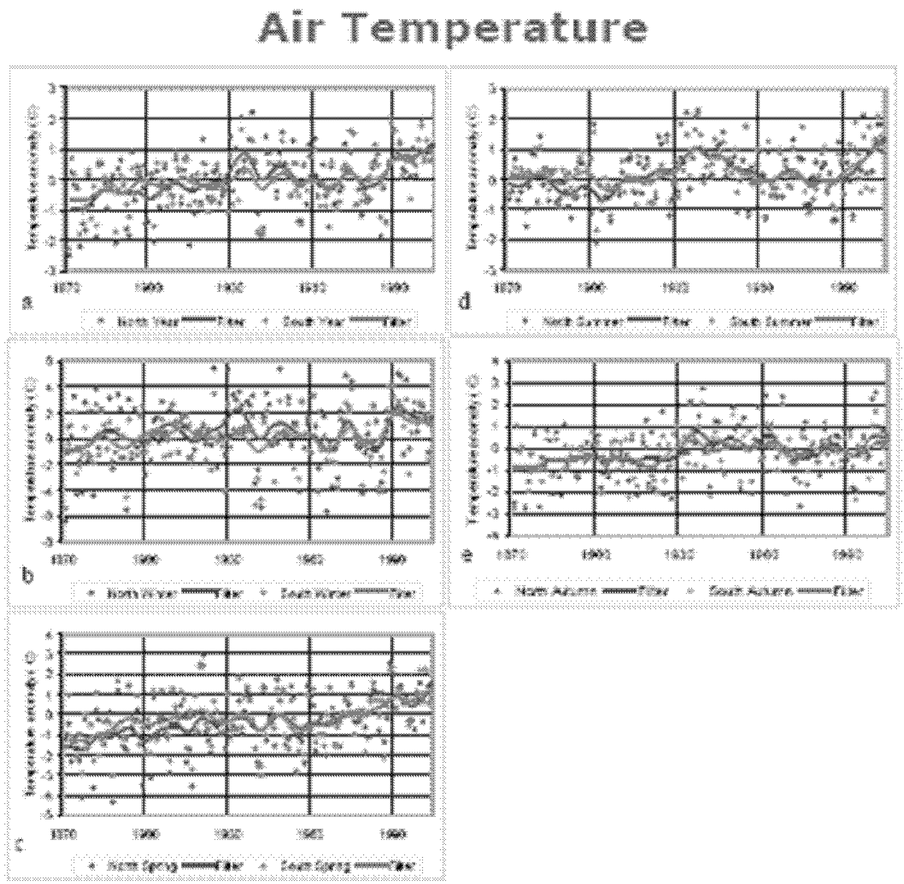


Fig. 1: Anomaly time series of annual and seasonal mean air temperature for the Baltic Sea catchment area from 1871 to 2004, calculated from 5° by 5° latitude, longitude box averages taken from the CRU dataset based on land stations (a=annual, b=winter (DJF), c=spring (MAM), d=summer (JJA), e=autumn (SON)). Blue colour comprises the area to the north of 60 °N, and red colour to the south of that latitude. The dots represent individual years, and the smoothed curves highlight variability on timescales longer than 10 years.

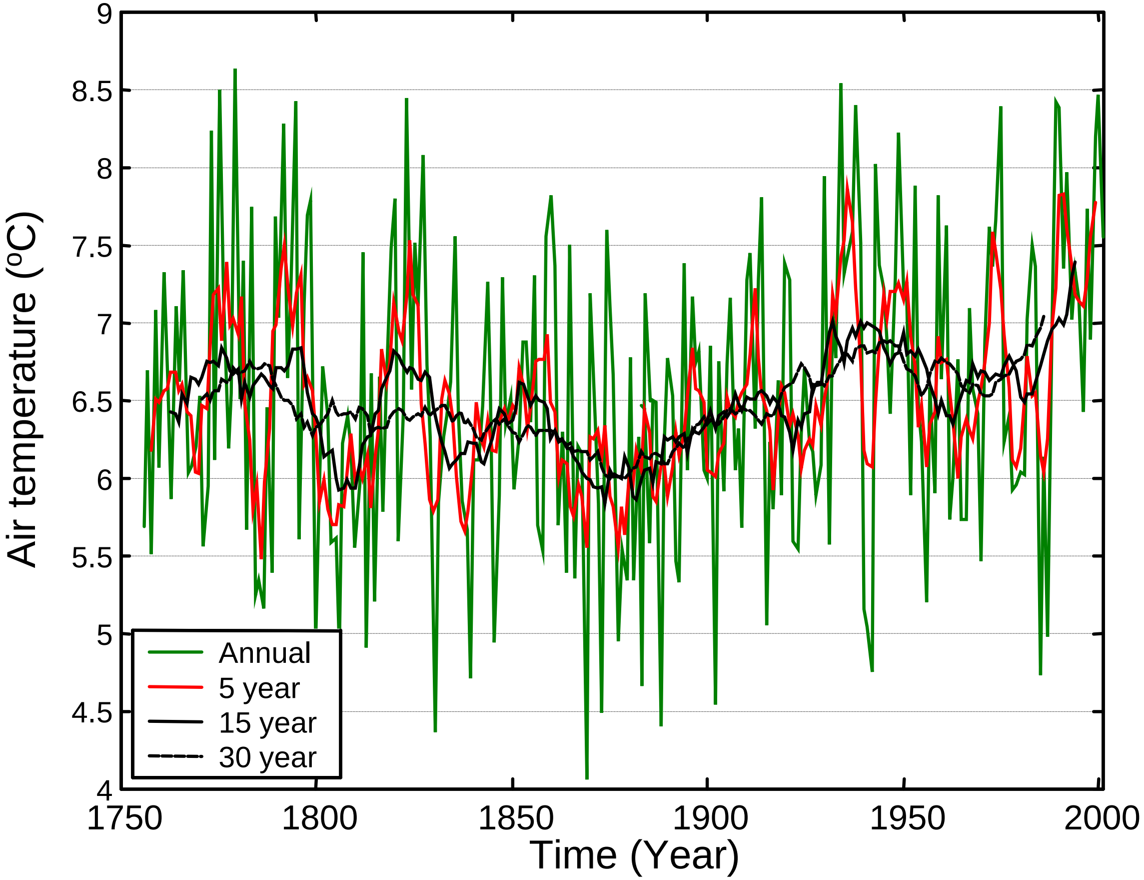
• Annual warming trends over the years 1871 to 2004 for the northern and southern Baltic catchment area, being 1.0 and 0.7 °C per 100 years, respectively, are somewhat larger than the trend for the entire globe.

• The warming has not occurred gradually. The longest measured temperature records from the Baltic area cover about 250 years. They show that there were warm periods during the latter half of the 18th century, and that the19th century was a relatively cool period.

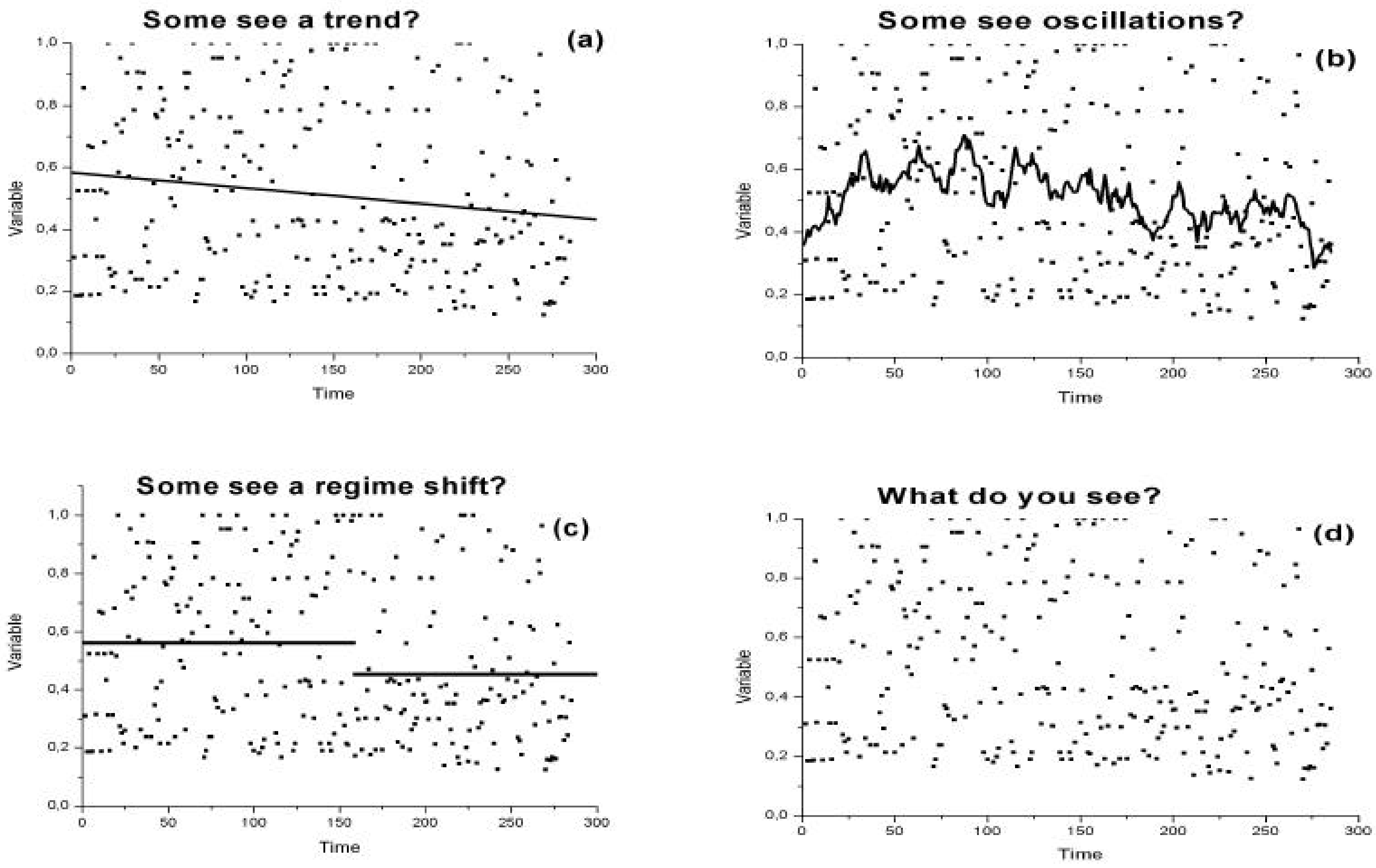
• In the annual mean temperatures, there was an early 20th century warming that culminated in the 1930s. This was followed by a smaller cooling that finished in the 1960s, and then another strong warming until the present day.

• Spring is the season showing the most linear and strongest warming, whereas wintertime temperature increase is intermittent but larger than in summer and autumn.

Problemas ar klimata statistiku



Problemas ar klimata statistiku



Vasaras kluvušas garakas, bet ziemas - isakas

Frost Days

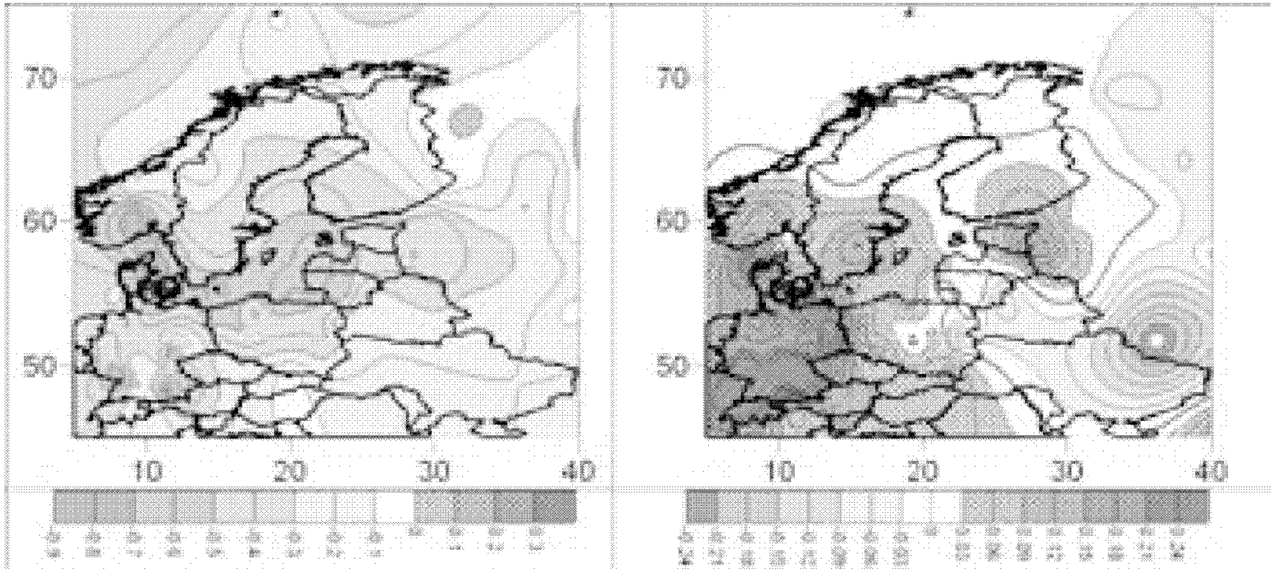


Fig. 2: Annual trends of frost days (on the left) and hot days (on the right), days/year. The ECA dataset for the period from 1951 to 2000 (Klein Tank et al., 2002a) and five Polish stations (Wibig and Głowicki, 2002) were used.

• A general tendency is that the climatic seasons in the spring half-year (e.g. spring, growing season, summer) start earlier, whereas the climatic seasons in the autumn half-year (e.g. autumn, frost season, winter) start later.

• Changes in extreme temperatures have broadly followed changes in mean temperatures. The number of frost days has decreased at the same time as the number of hot days has increased.

Udens ezeros kluvis siltaks

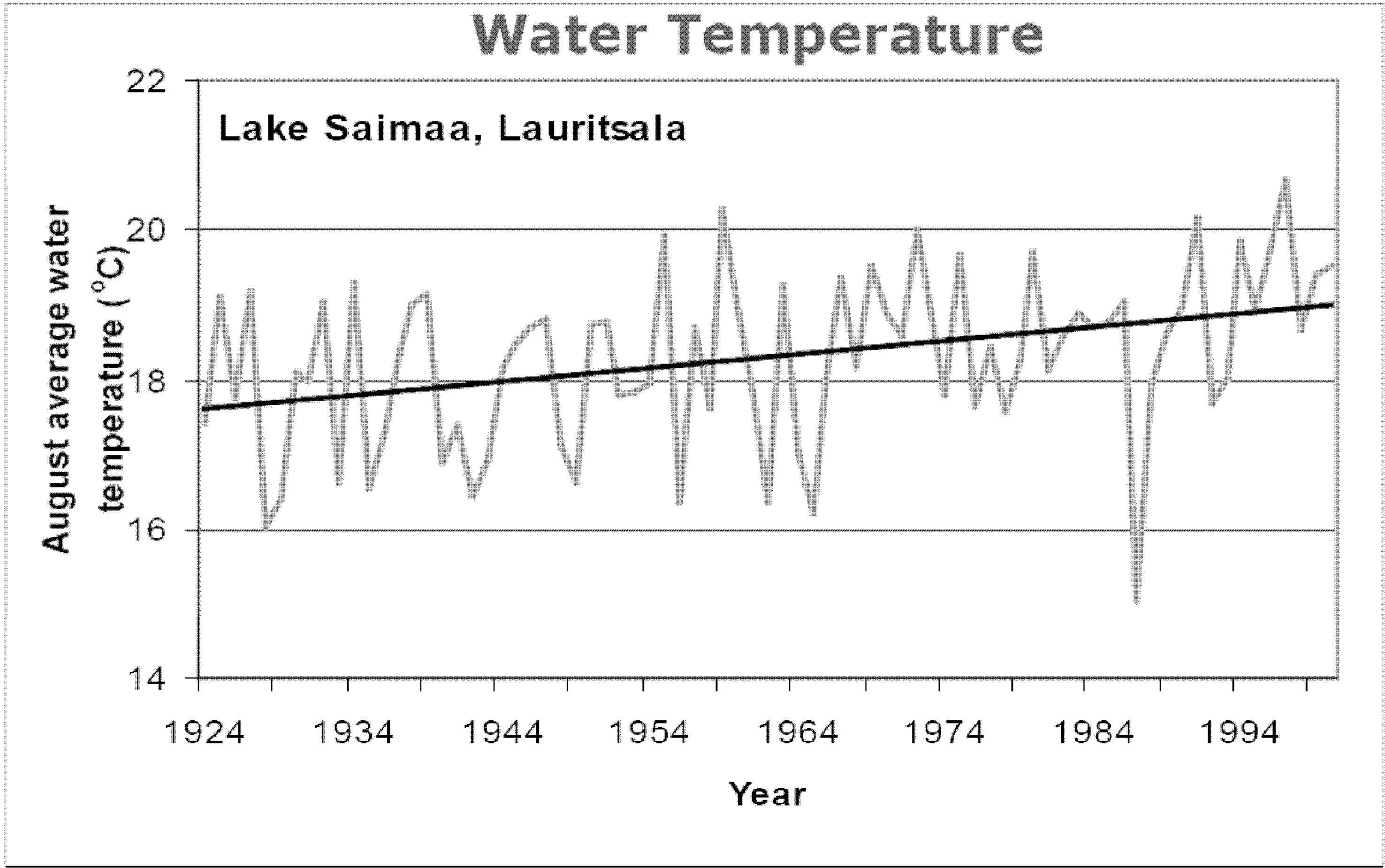


Fig. 3 The average water temperature in August in Lake Saimaa during 1924-2000.

Baltijas regions kļuvis mitrāks.

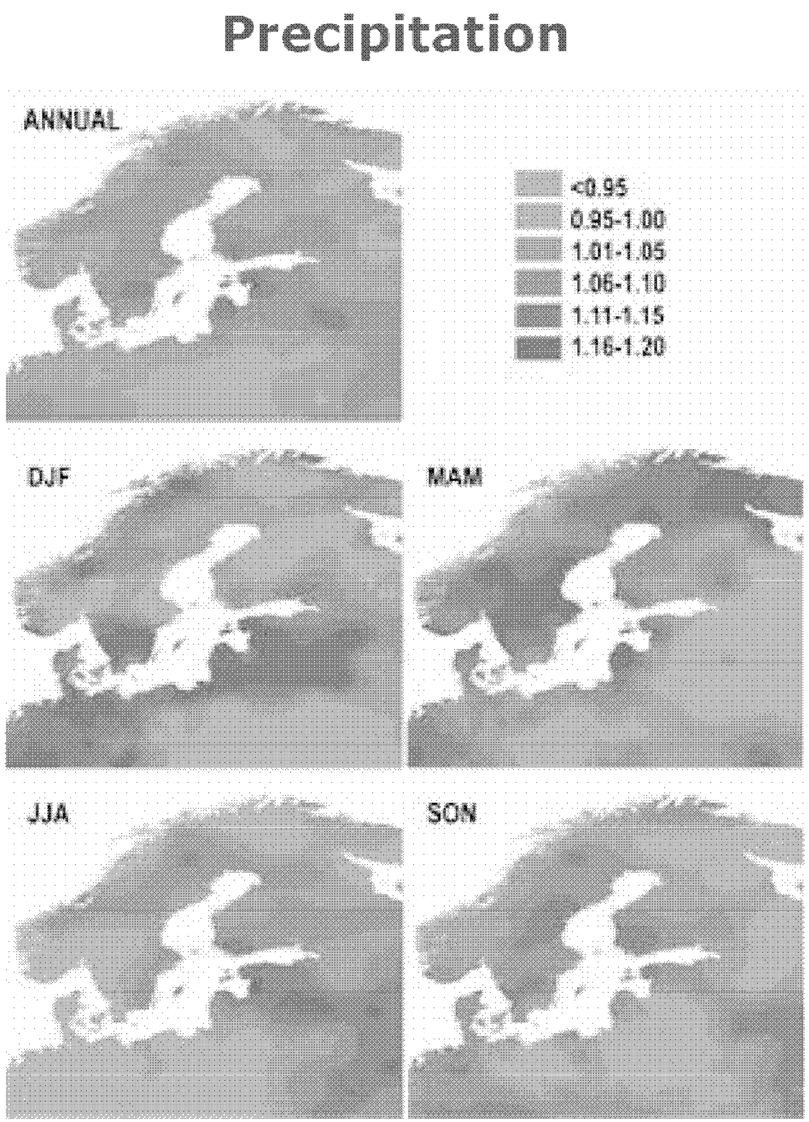


Fig. 4: Annual and seasonal precipitation ratios of the periods 1976-2000, relative 1951-1975. The darker the greenish colour, the stronger the increase in precipitatio Based on VASClimO data (Beck et al. 2005).

• Over the latter part of the 20th century, on average, northern Europe has become wetter, although, the increase in precipitation is not spatially uniform.

• Within the Baltic Sea basin, the largest increases have occurred in Sweden and the eastern coast of the Baltic Sea.

• Seasonally largest increases have occurred in winter and spring. Changes in summer are characterised with increases in the northern and decreases in the southern parts of the Baltic Sea basin.

• The long precipitation records covering 100 years or more show a clear increase in annual precipitation in Sweden and Denmark, while only weak increases are observed e.g. in the Baltic states, Finland and Poland. In Sweden, the long-term increasing trend arises mainly from the cold half-year.

• In wintertime, there is an indication that the number of heavy precipitation events has increased.

Palielinajusies upju notece ziema

Runoff

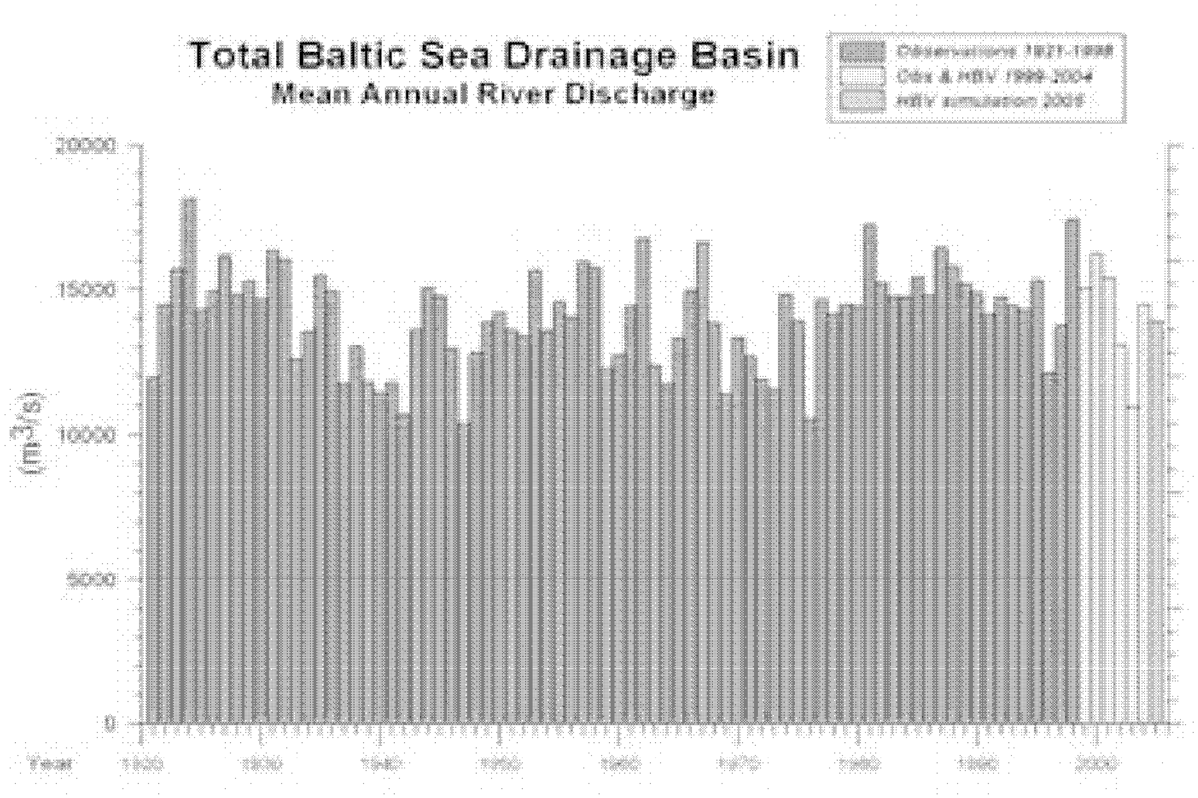


Fig. 1 Annual river runoff to the Baltic Sea for the period 1921-2005. (Prepared by Phil Graham).

- Positive trends in annual values of river runoff for 1920-2002 were detected for several rivers in Denmark, Southern Sweden and Lapland.
- In Russia, in some basins located south and southwest of the Gulf of Finland, annual runoff for 1978-2002 increased by about one third, compared to long-term values.
- Winter runoff from Finland into the Baltic Sea has increased at 785 m3 per second during the period 1912-2003.
- In the Russian part of the Baltic Sea basin, winter runoff has increased remarkably: 6-140% The increase of wintertime runoff has also been observed in Estonia, Latvia and in Belarus.

Ledstaves periods kluvis garaks.

•Ice melt timing in rivers in Russia occurs 15-20 days earlier than in the 1950s.

•Ice cover duration shows a strong negative trend in lakes in the northern part of the Polish Lowland (1961-2000), in lakes in Russia, and for some lakes in central and southern Finland since the middle of the 19th century.

Ice Cover

Fig. 4 Long-term changes in the ice cover duration in river Volkhov (prepared by V.Vuglinsky).

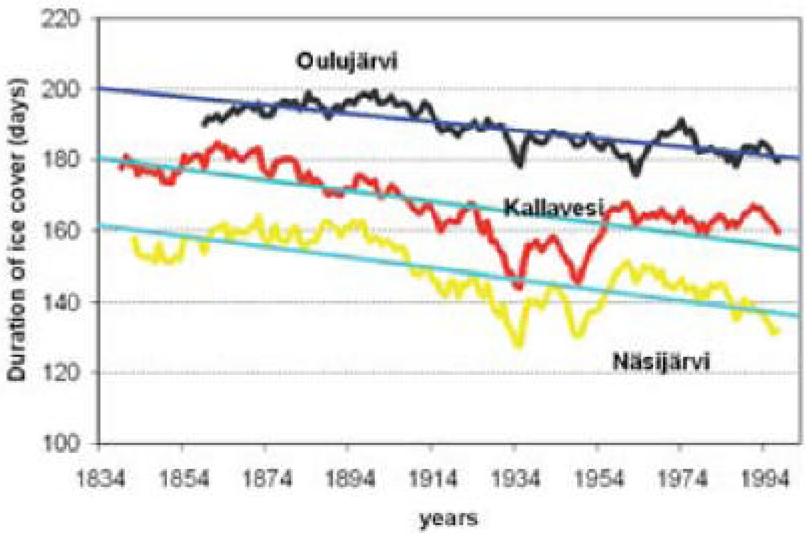


Fig. 5 Duration of the ice cover in Lake Näsijärvi, Lake Kallavesi and Lake Oulujärvi (11-year moving average). Finland (Korhonen, 2004).

Ledus kluvis planaks.

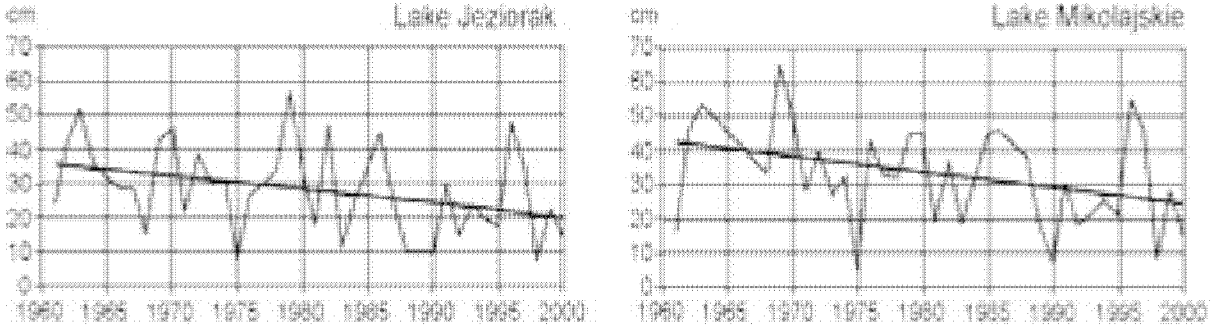


Fig. 6 Maximal ice cover thickness at two lakes in the Polish Lowland.

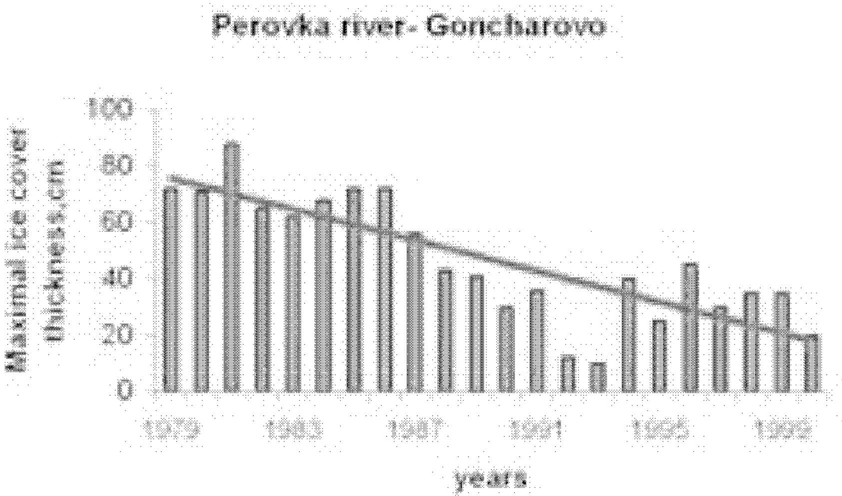


Fig. 7 Long-term changes in maximal ice cover thickness at river Perovka, European Russia.

- Maximum ice cover thickness decreased in Polish and Russian lakes (Fig. 6).
- Maximum ice cover thickness decreased by 15-20% in Russian rivers by the end of the 20th century (Fig. 7).
- Maximum ice cover thickness mostly increased in eastern and northern Finland and decreased in southern Finland.

Sniegs nokust atrak.

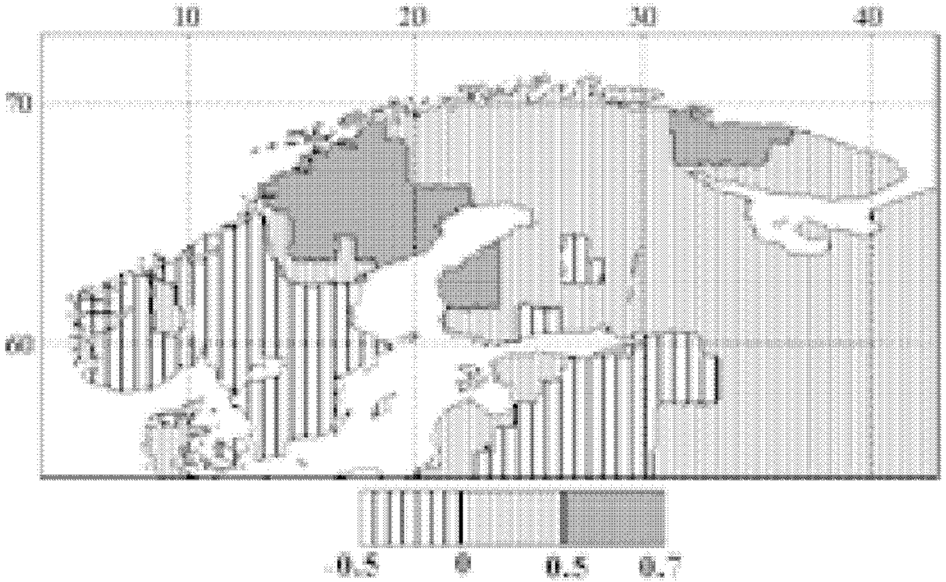


Fig. 9 Spatial variability of trends of the duration of snow cover (days per year) 1936-2000 (Kitaev et al, 2005)

- Snow cover duration in Latvia decreased on average by 12 days during 1945-1996, but at a statistically significant level only at three stations. Permanent snow cover in Lithuania in the last decades of the 20th century tends to occur earlier and to disappear earlier than in the middle of the century. Duration of snow cover in Estonia decreased during the recent 4 decades by more than 1 day per year. In Poland, snow cover duration decreased by -4 days/10 years and depth - by -13 cm/10 years.

Juras udens temperatura praktiski nav mainijusies.

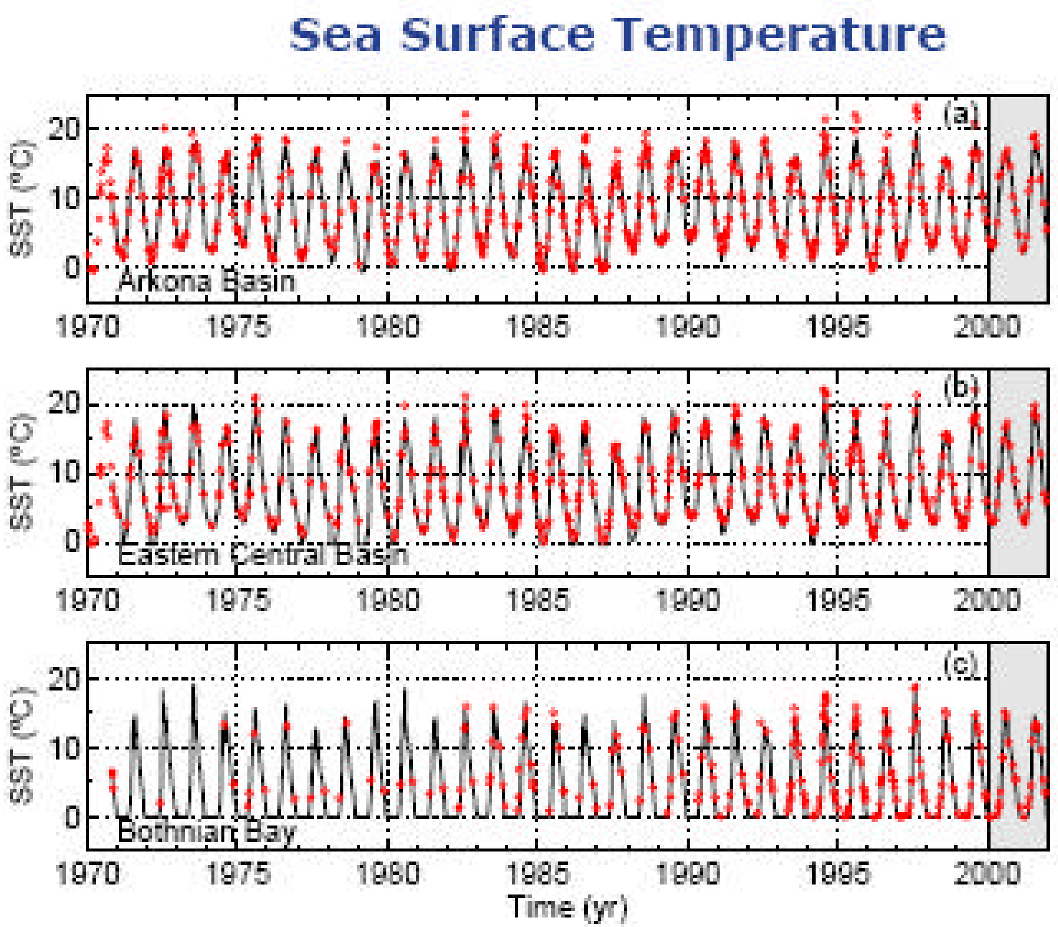
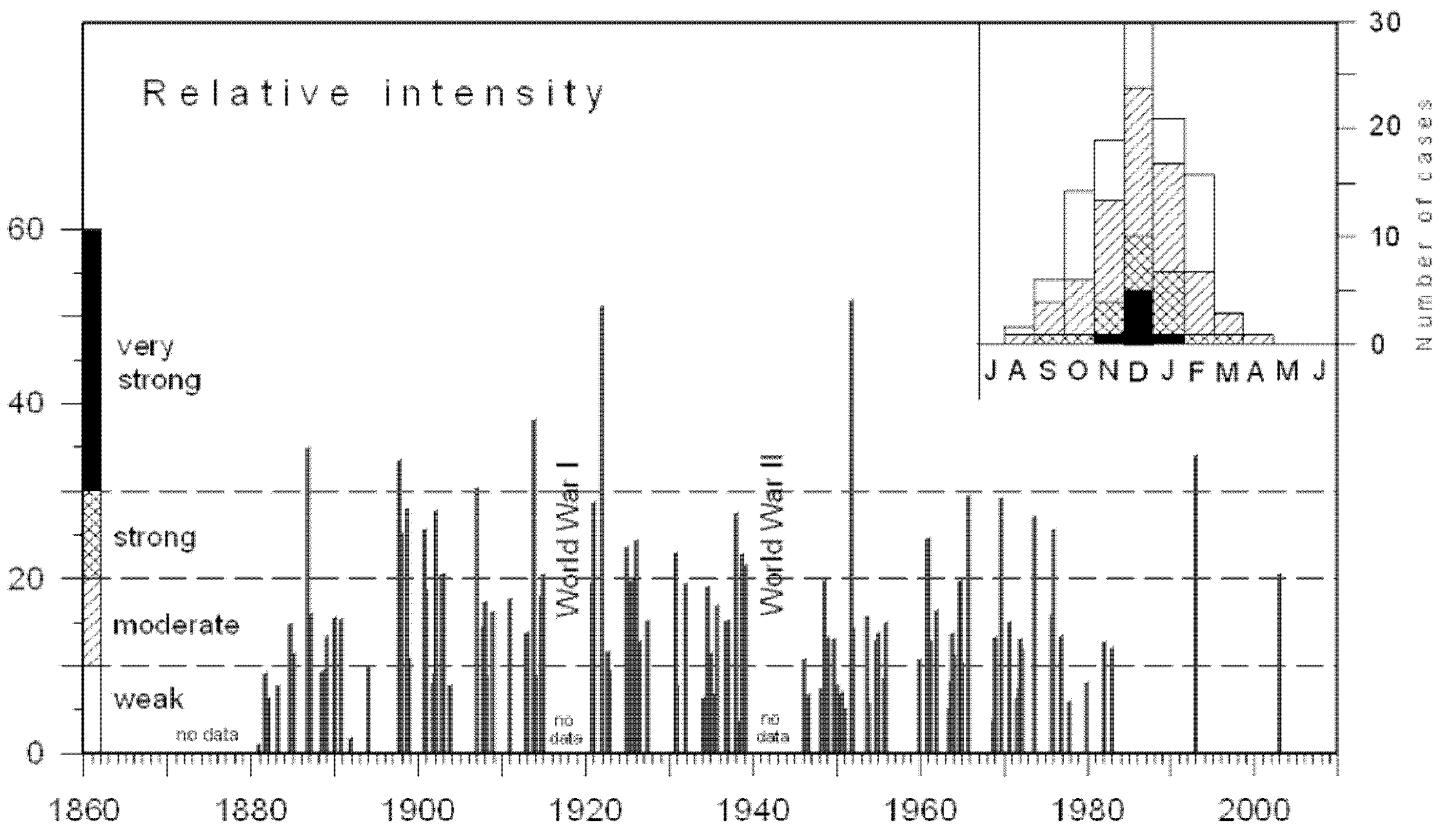


Fig. 1: Time series of sea surface temperature (SST) in 3 different Baltic Sea basins and annual mean. in 3 different Baltic Sea basins and annual mean. Baltic Sea heat loss. From Omstedt and Nohr (2004).

- There are indications that the integrated heat content has not increased in response to increased air temperature during the past three decades. This may be explained by changes in the heat exchange caused by simultaneous changes in cloudiness and wind speeds.

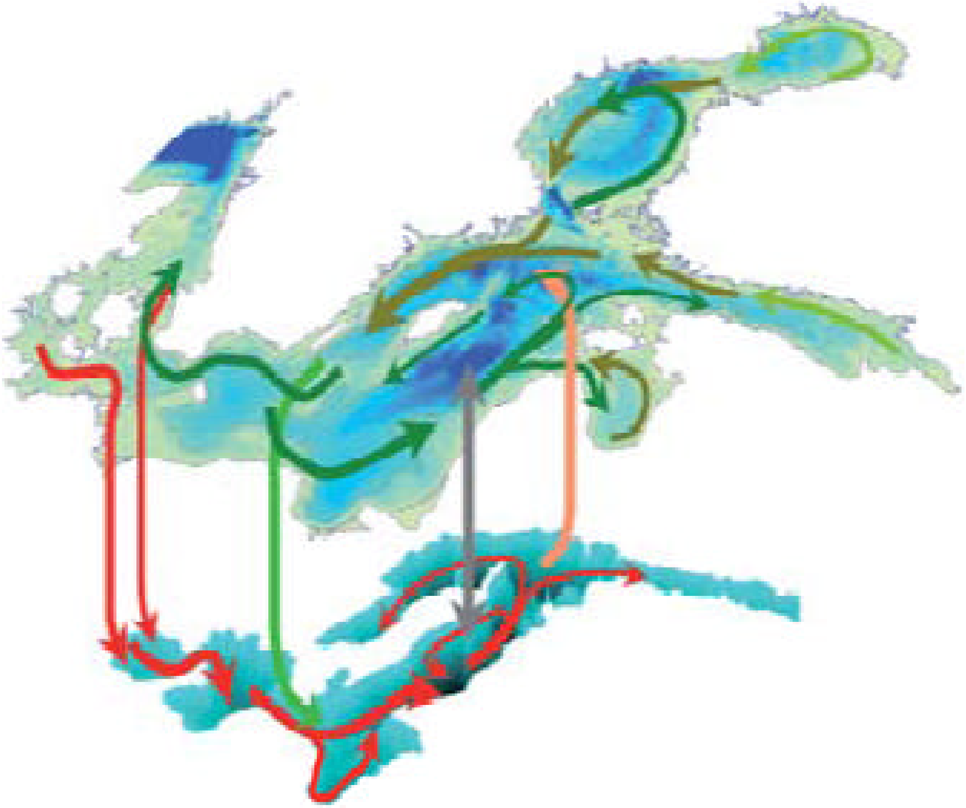
- The heat content of the Baltic Sea varies signifi cantly on decadal time scales, but no signifi cant trends have been found for the period from 1958 until now.

Specigas sala udens ieplūdes klust retakas



Major Baltic inflows (MBIs) between 1880 and 2005 and their seasonal distribution (upper right) shown in terms of their relative intensity (Matthäus and Franck, 1992; Fischer and Matthäus, 1996; supplemented and updated by BACC).

Specigas sala udens iepludes klust retakas



- Vajaka sala udens ieplude dzilakajos slanos
- Pastiprinata saldudens ieplude virskarta

Major current patterns in the Baltic Sea. Saline water is entering the Baltic Sea through the Danish Straits, while freshwater is supplied by numerous rivers.

Udens salums virskarta: nav izteiktas tendences...

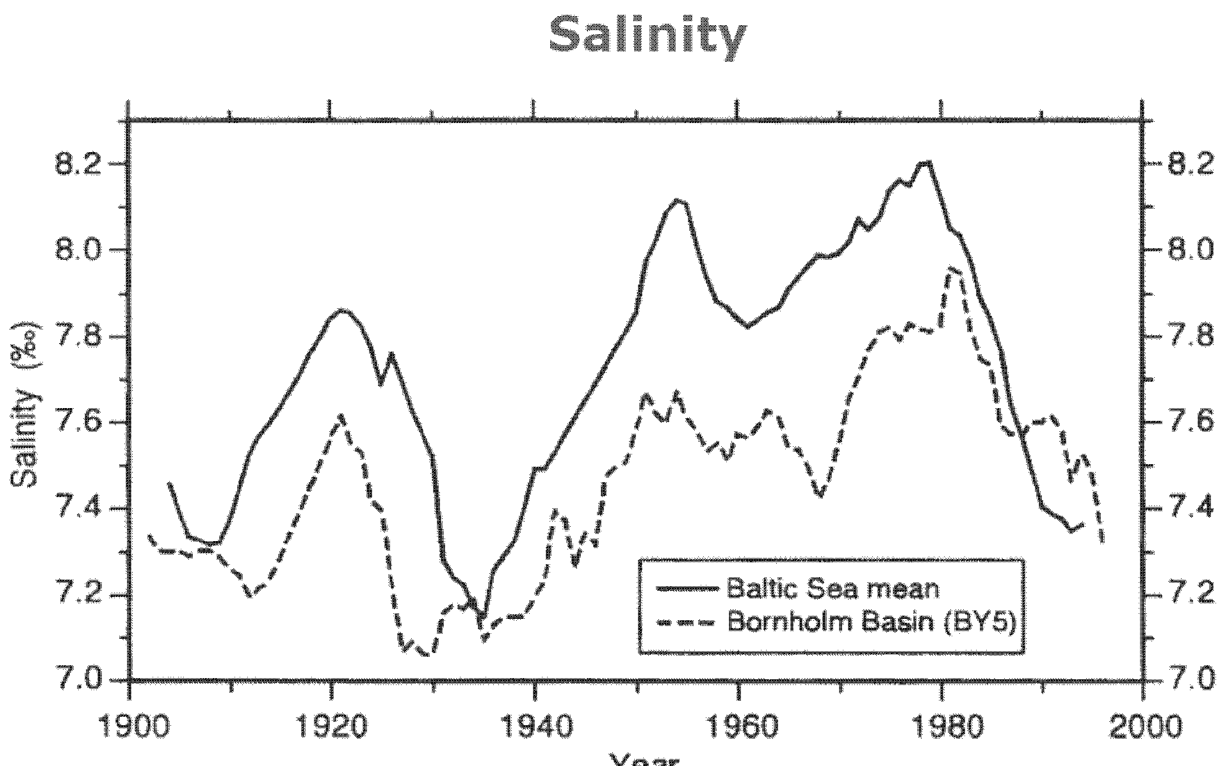
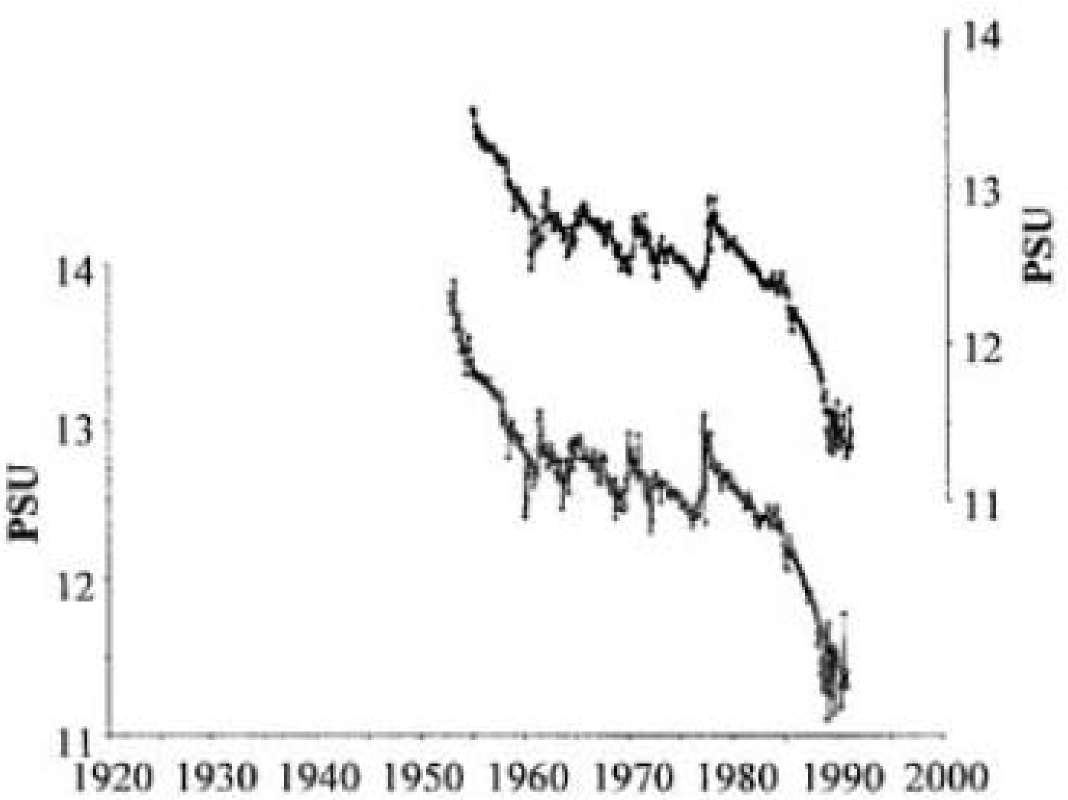


Fig. 2: Five-years running mean of spatially averaged salinity of the Baltic Sea and the surface salinity in the Bornholm Basin. From Winsor et al. (2001).

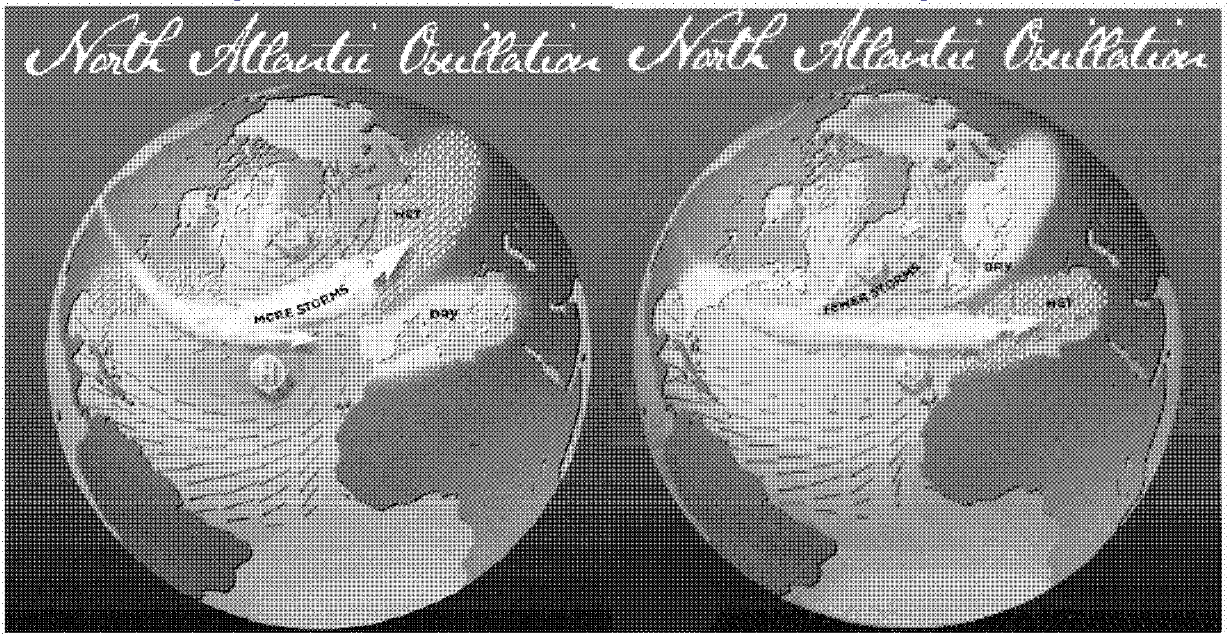
- Changes in the salinity of the Baltic Sea are essentially determined by variations in freshwater supply, which is primarily river runoff, and variations in wind speeds altering the exchange with the Ocean.
- The response is quite slow since the time scale of salinity changes set by the residence time is about 33 yrs.
- Observations show that the spatially averaged salinity has varied with about +/- 0.5 during the 20th Century, but there is no trend in the data.

Dziluma: izteikta saluma samazinašanas

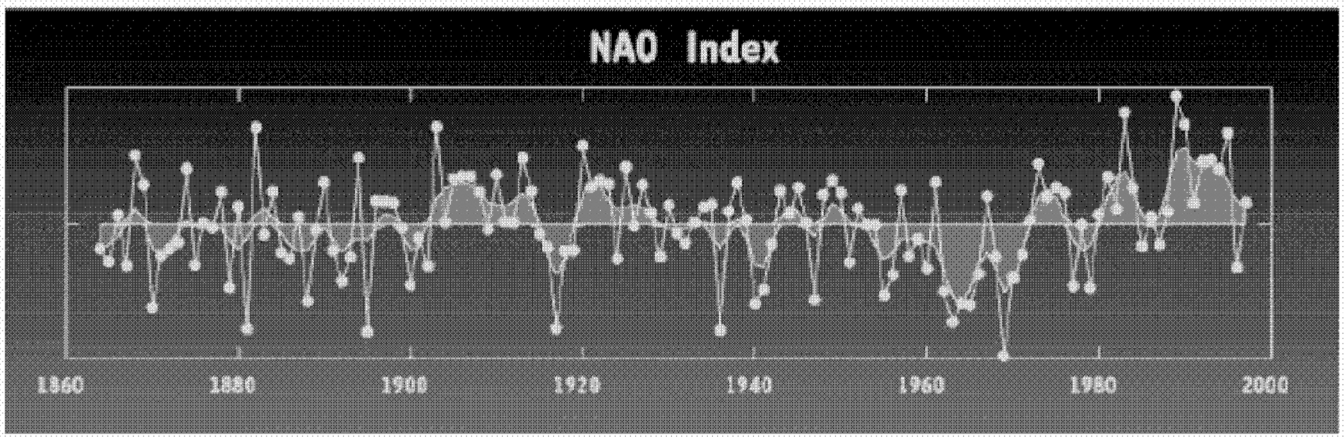


Modeled (top curve) and observed (lower curve) salinity changes in Baltic Sea deep water off Gotland at 200m depth. The response of the deep water salinity is related to the total freshwater runoff to the Baltic Sea (after Hänninen J., Vuorinen I., and Hjet P., 2000).

Ziemelatlantijas oscilacija: NAO (N-Atlantic Oscillation)



Positive NAO Index phase. Negative NAO Index phase



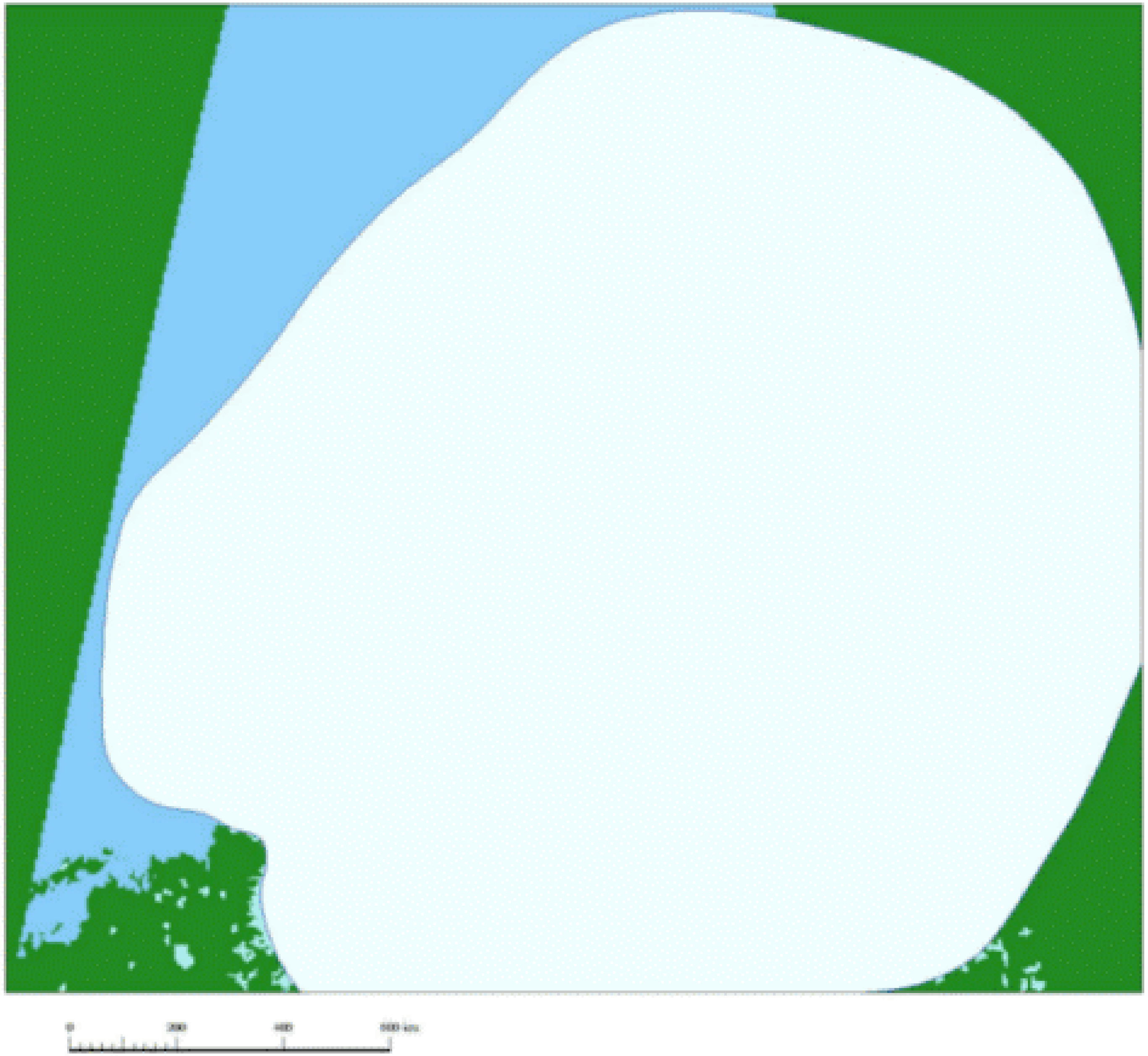
The North Atlantic Oscillation (NAO) is the main source of inter-annual climate variability in the North Atlantic region. The NAO is the difference between two persistent sets of contrasting air pressures: high pressure over the Azores and low pressure over Iceland. A large pressure gradient (positive NAO) results in a strong westerly air flow on a more northerly track over the eastern North Atlantic and Europe; this brings warm, wet winters to all of Europe except the southern part.

Negative NAO results in colder, drier winters in Northern Europe.

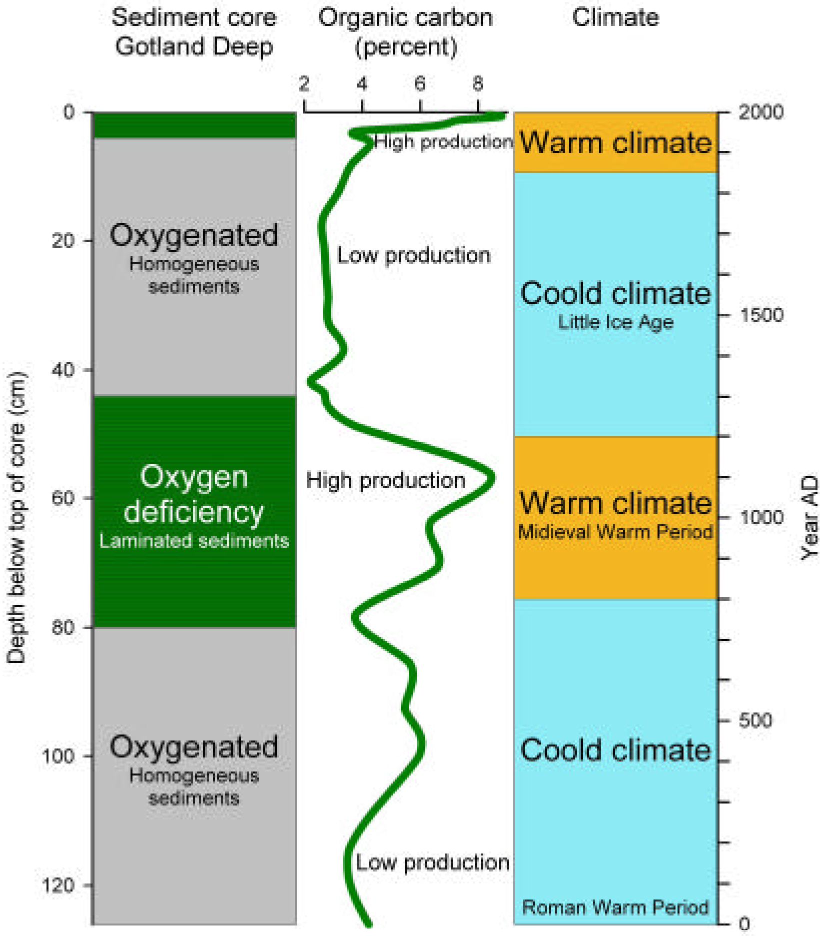
It is not known whether there is a link between the NAO and the increasing concentrations of greenhouse gases in the atmosphere.

Baltijas juras attistaba: A.Omstedt

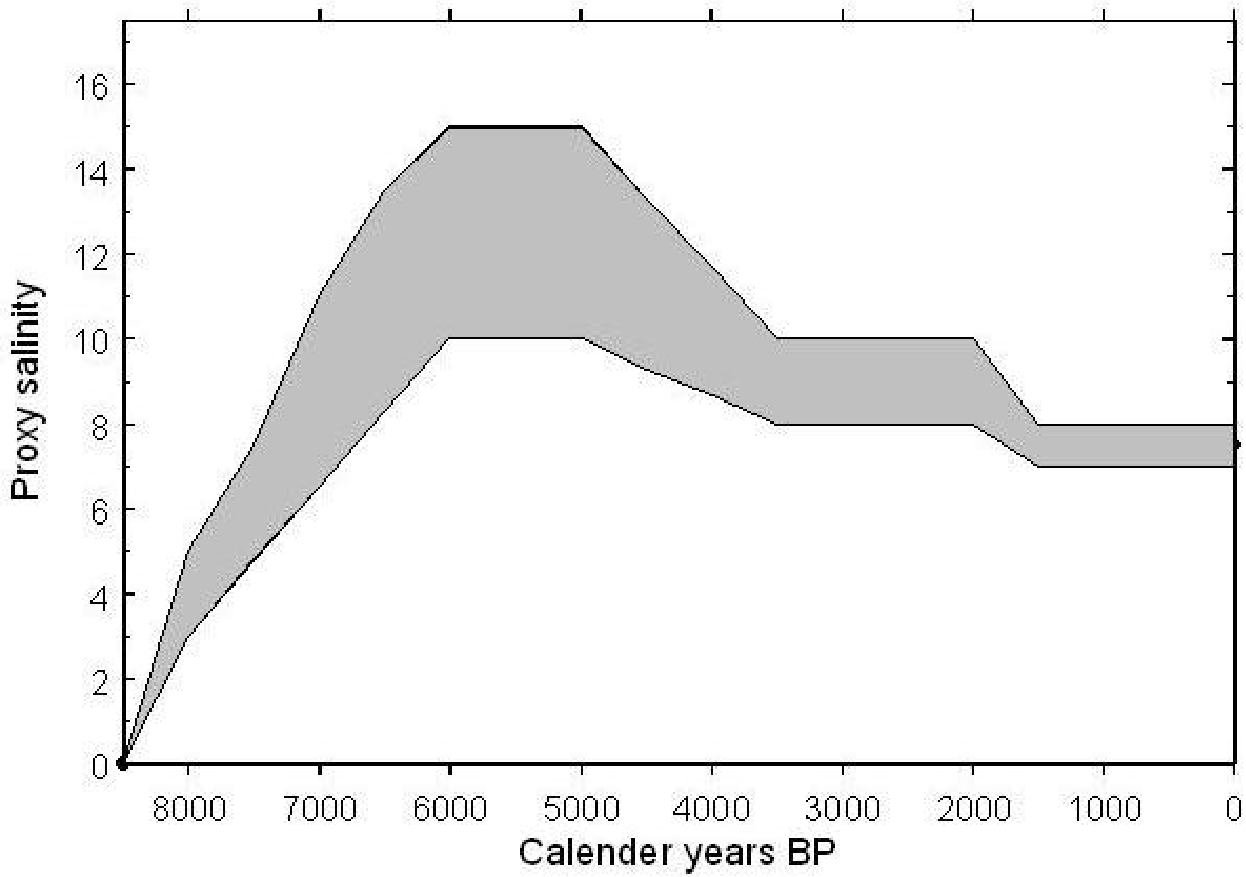
21000 BP



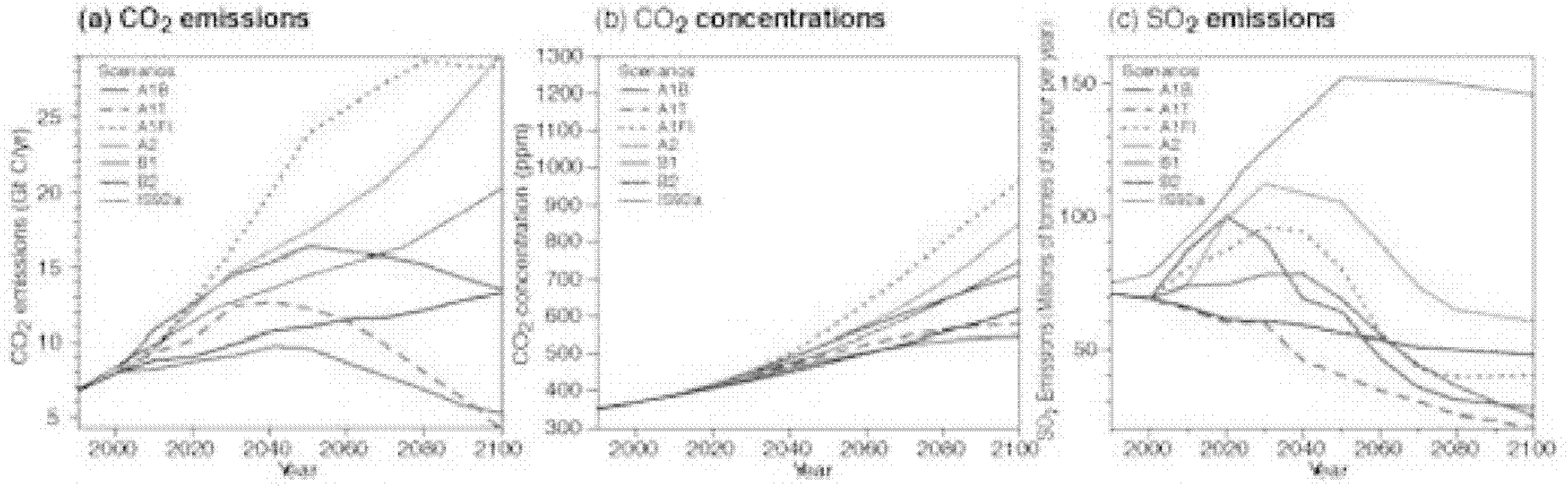
Ko var uzzinat no Baltijas jurasnogulumiem: Thomas Andreen



Baltijas juras udens salums pagatne: Gustafsson & Westman, 2002



Nakotnes scenariji.



<u>REALISTISKIE</u>

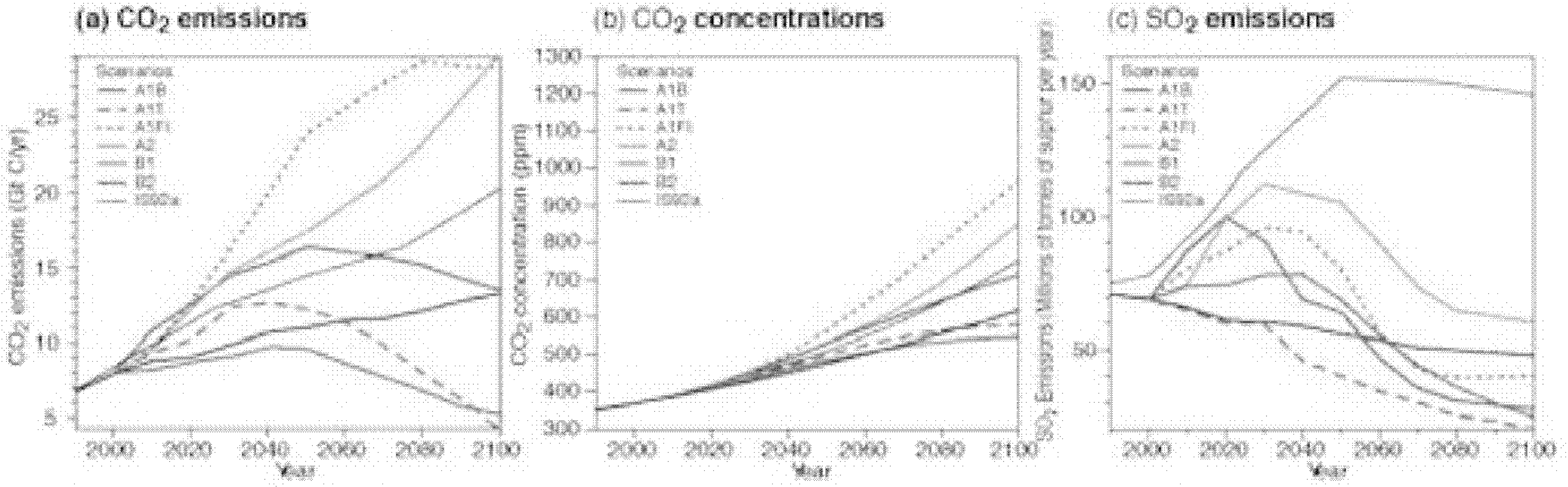
A1 - very rapid economic growth and efficient international co-operation. New innovations are distributed to developing countries faster than today. Increasing economic wellbeing leads to decreasing fertility in the developing world, and the global population peaks at about 8.7 billion in the year 2050 and declines thereafter.

A1FI - energy production remains highly dependent on fossil fuels throughout the century;

A1T - rapid shift toward non-fossil energy sources.

A1B - an intermediate case between A1F1 and A1T

Nakotnes scenariji.

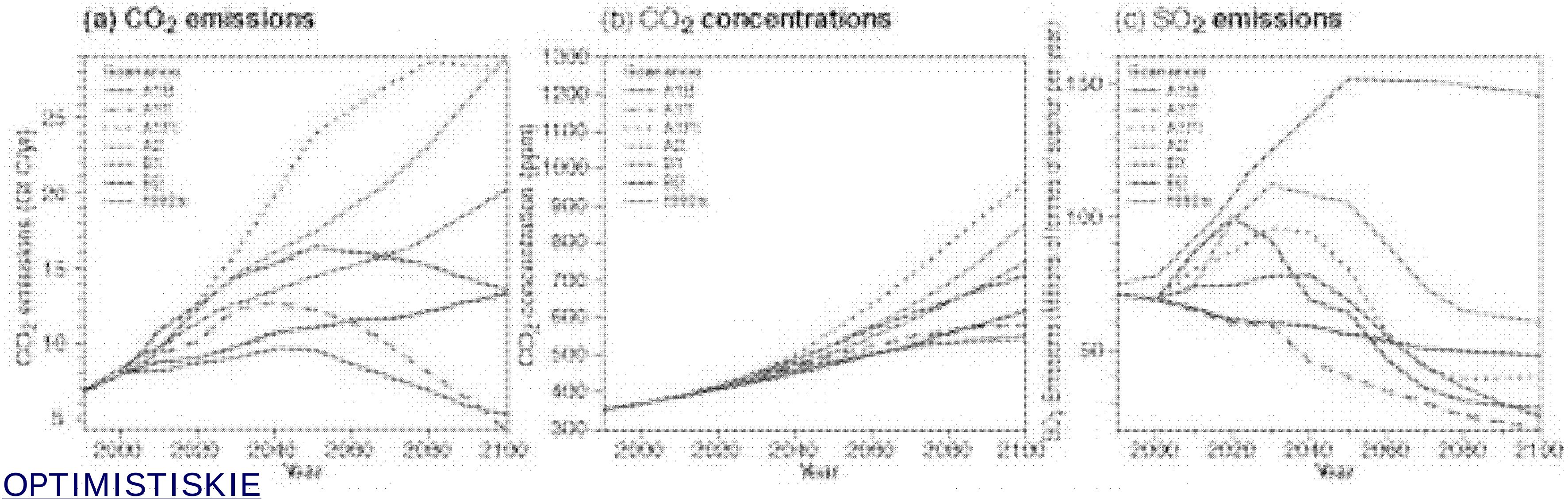


KONSERVATIVAIS

A2 - world is characterized by economic blocks that are more inclined to defending their own special interests than to co-operating with each other. As a result, economic growth is slower than in A1, particularly in the developing world. The distribution of new environmentally efficient technologies to the developing world is also slower. The global population increases continuously, reaching 15 billion in the year 2100.
Although the per capita economic growth is relatively slow, the increasing population and slow introduction of non-fossil energy sources lead to a large increase in GHG emissions.

GHG=Green-house gases

Nakotnes scenariji.

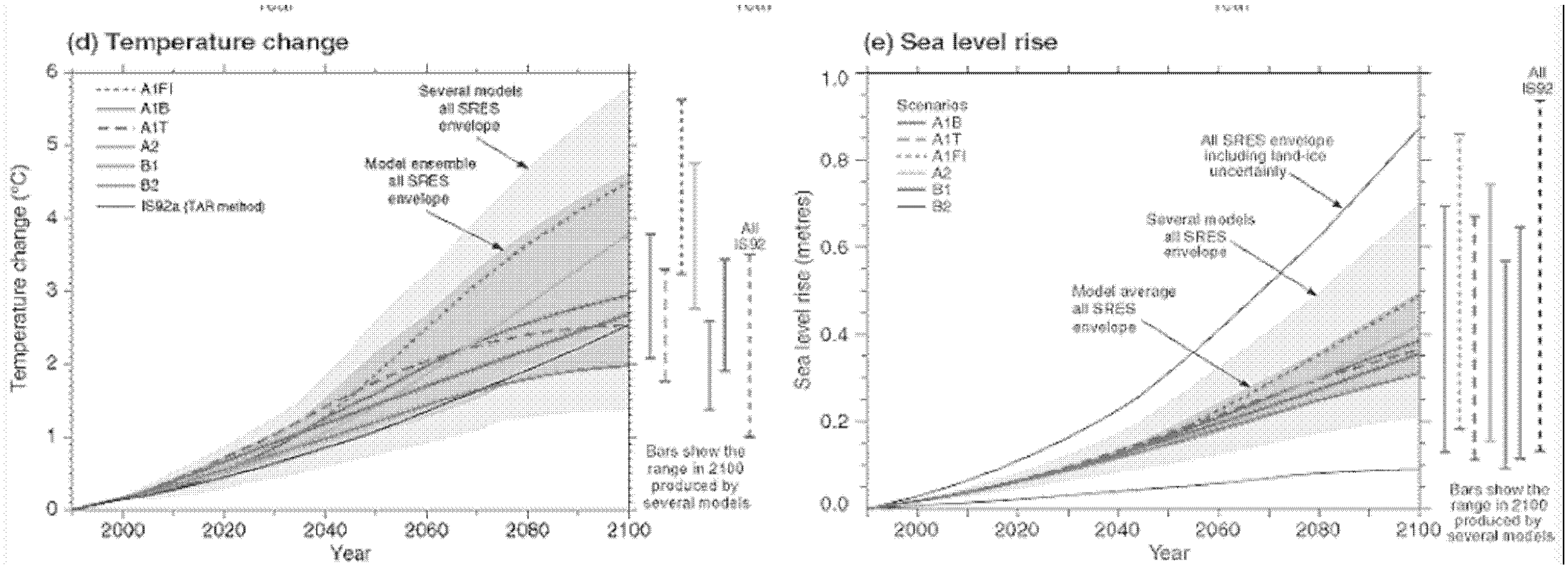


OPTIMISTISKIE

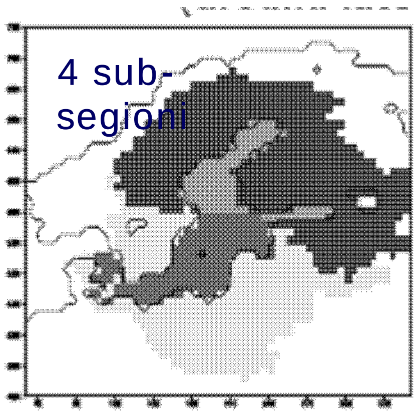
B1 - efficient international co-operation and rapid distribution of new technologies; same evolution of global population as for A1. Technological development is driven more strongly by environmental values and social equity than in the A1 and A2. Economic growth is slightly slower, and the gap between the developing and the industrialized world decreases more slowly than in A1, but the introduction of clean and resource-effi cient technologies is faster. Rapid change in economic structures toward a service and information society. GHG emissions are reduced below the present-day level by the end of the 21st century.

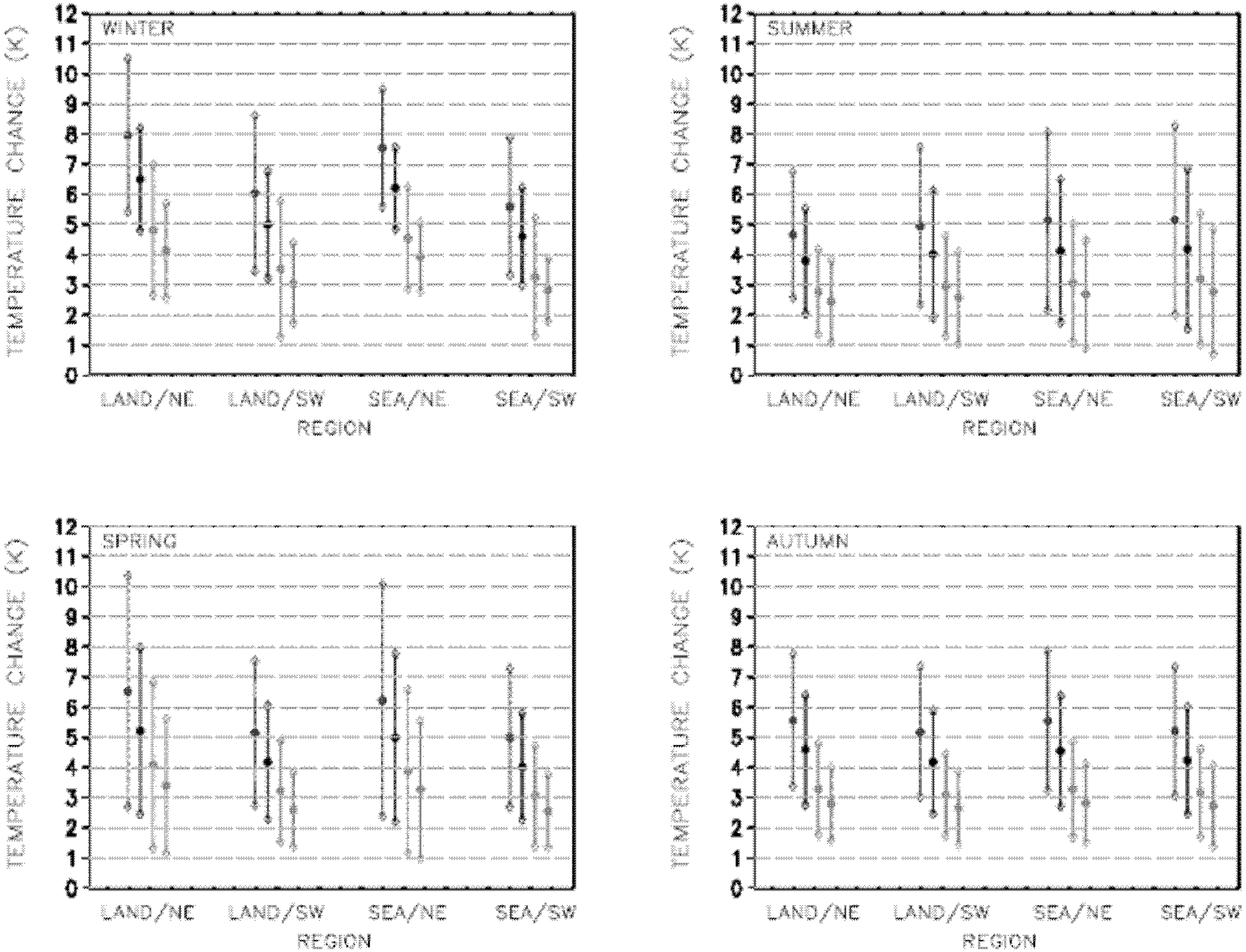
B2 – Hybrid of A2 and B1. International co-operation is less effi cient and the distribution of new technologies is slower than in A1 and B1. The global population increases less rapidly than in A2, reaching 10.4 billion by the year 2100. Development of environmentally friendly technologies slower than in B1. GHG emissions continue to grow throughout the 21st century, although at a substantially slower rate than in the A2 and A1FI scenarios.

Kas no ta iznak...



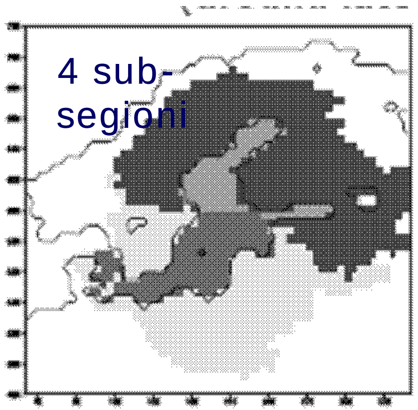
Baltijas klimats 21 g.s. beigas: <u>gaisa temperatura</u>

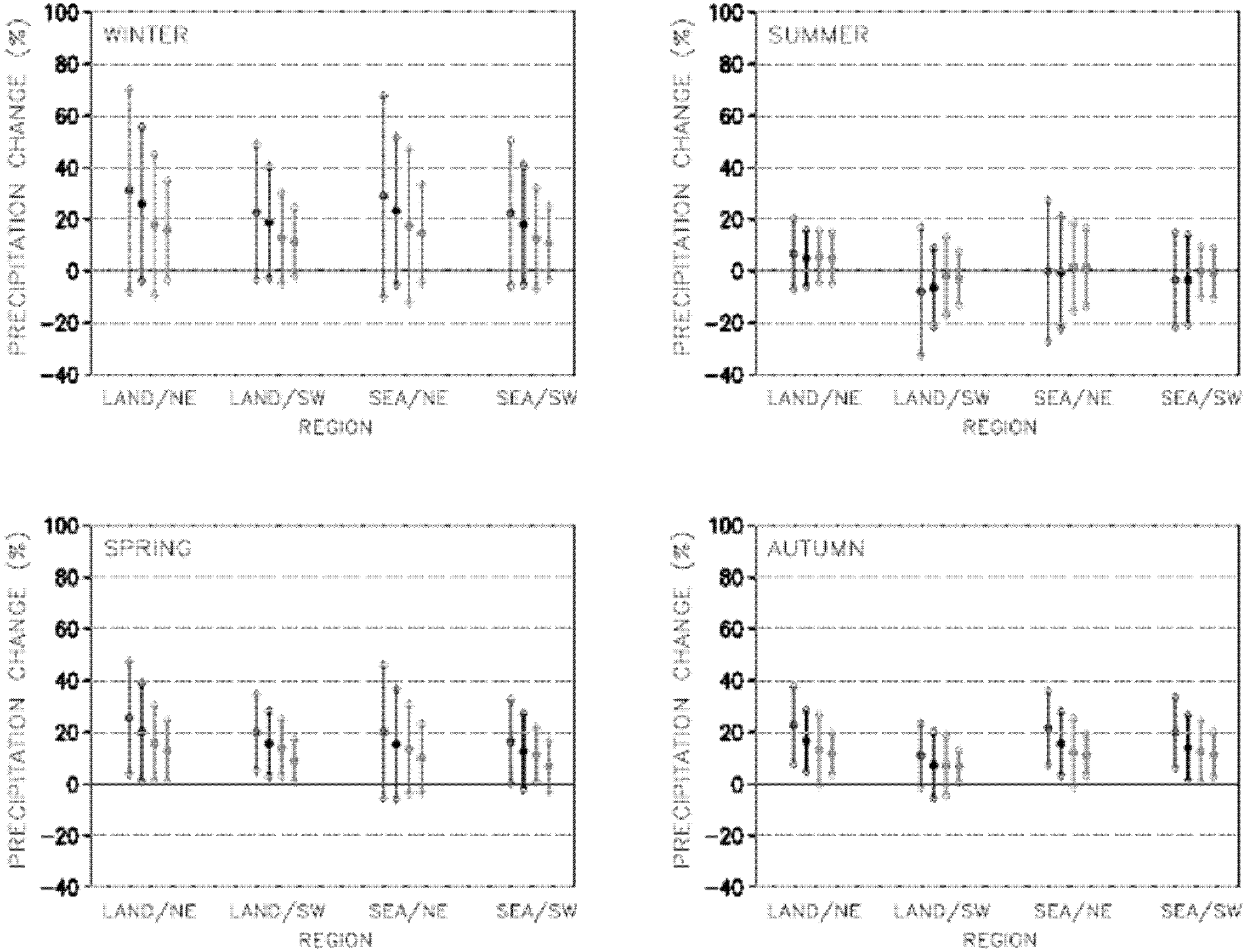




Seasonal GCM-driven 95% probability intervals of temperature change (vertical bars) from 1961–1990 to 2070–2099 for four sub-regions (defined in Figure 11), derived from SRES-forced simulations performed with six GCMs. Intervals are given separately for the A1FI (red), A2 (black), B2 (blue), and B1 (green) scenarios. The dot in the centre of the bar denotes the median of the interval.

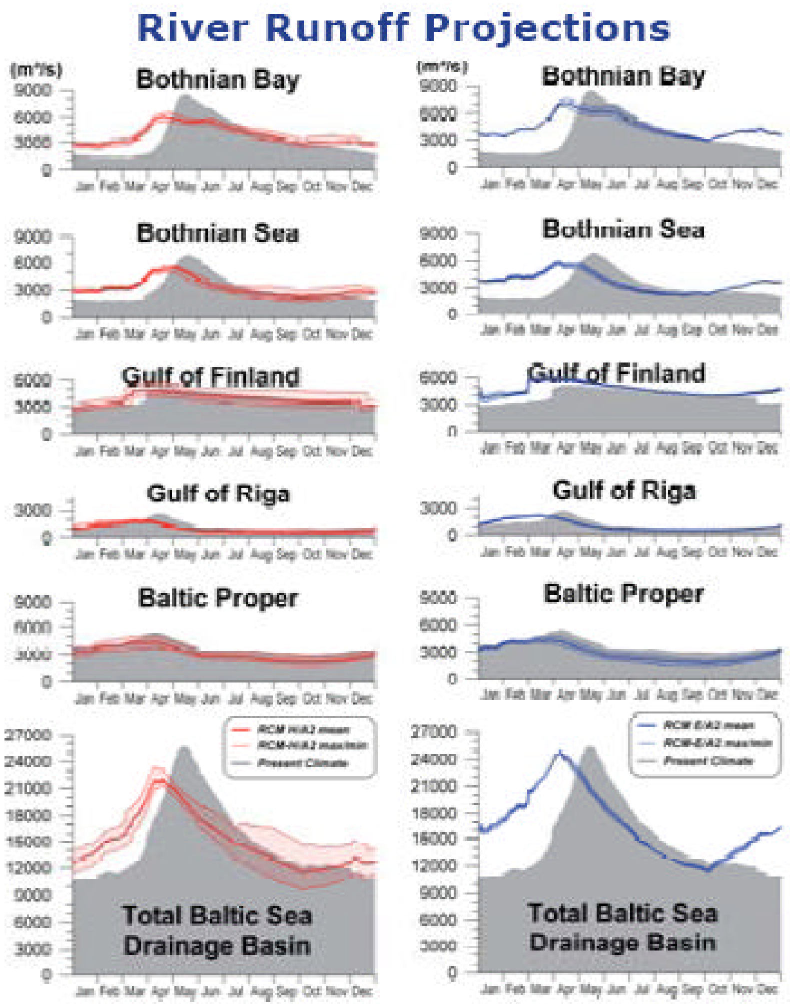
Baltijas klimats 21 g.s. beigas: <u>nokrišni</u>





Seasonal GCM-derived 95% probability intervals of precipitation change in percent. Intervals are given separately for the A1FI (red), A2 (black), B2 (blue), and B1 (green) scenarios. The dot in the centre of the bar denotes the median of the interval.

Baltijas klimats 21 g.s. beigas: <u>saldudens noplude</u>



Mean river discharge from HBV-Baltic for RCM-A2 scenarios, driven by HadAM3H (left; 10 RCMs) and ECHAM4/OPYC3 (right; 2 RCMs). The scenarios represent future climate for the period 2071-2100 compared to the control period 1961-1990. (Adapted from Graham et al., 2006b.)

River runoff is projected to increase in the north and decrease in the south with distinct changes in seasonal variation.

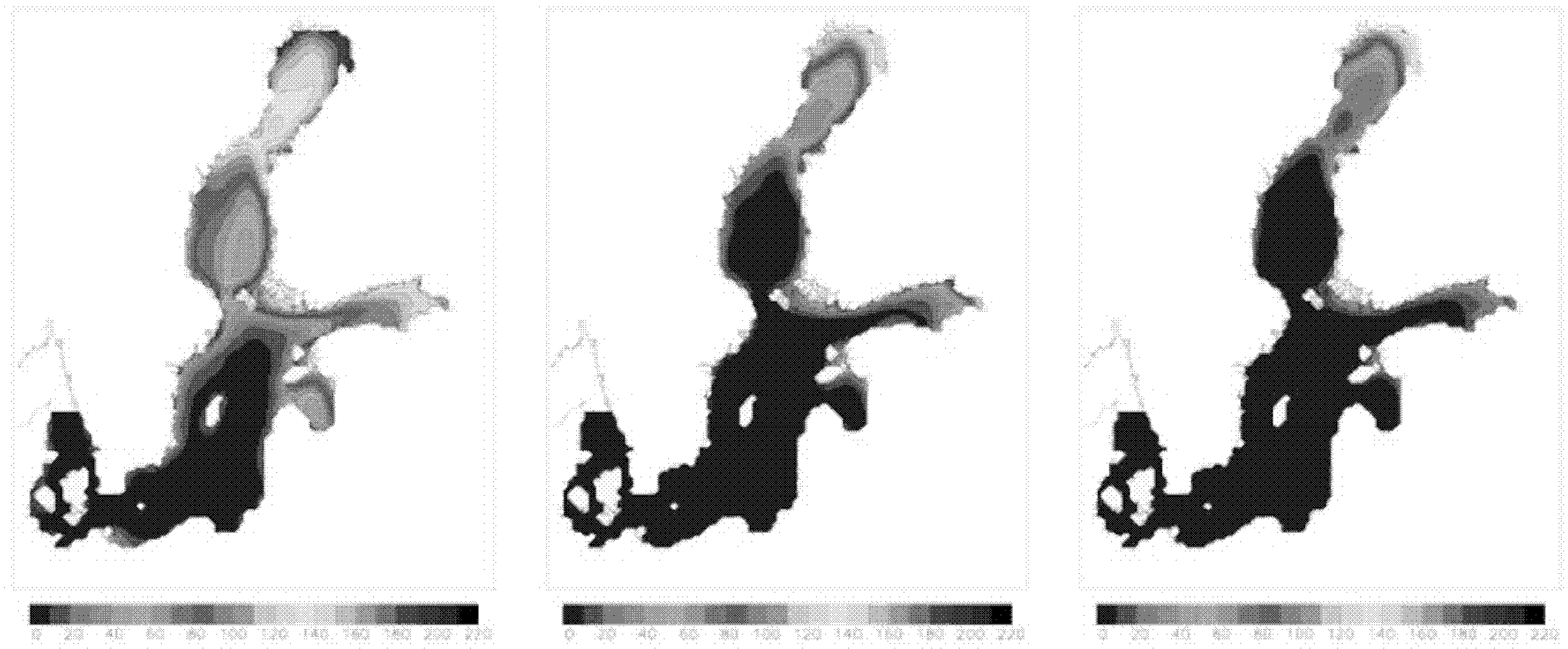
- Annual river runoff would increase in the northernmost catchments of the Baltic Sea basin and decrease in the southernmost catchments.

- Projected summer river runoff shows a decrease of as much as 20%, while winter runoff shows an increase of up to 50%, on average for the total basin.

- The projected occurrence of medium to high river runoff events shows a higher frequency.

- The projected magnitude of high runoff events shows no pronounced increase on the large scale.

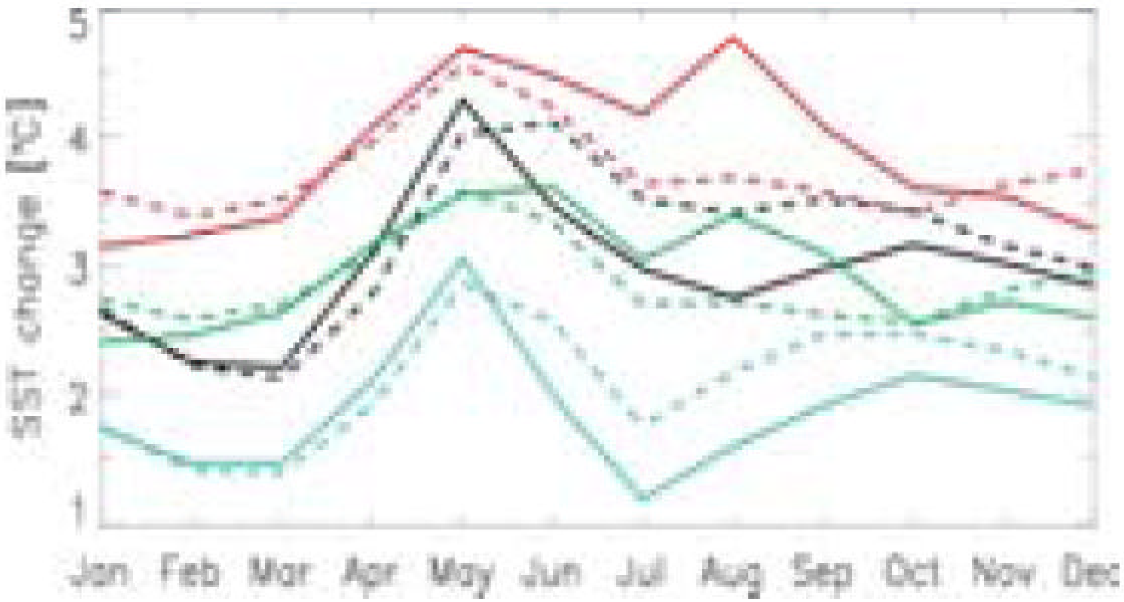
Baltijas klimats 21 g.s. beigas:
<u>udens temperatura un ledus</u>



Mean number of ice days averaged for regional downscaling simulations of HadAM3H and ECHAM4/OPYC3: control (left panel), B2 scenario (middle panel), and A2 scenario (right panel). (Figure adopted from Meier et al., 2004a.)

Ice extent in the sea would decrease by some 50 to 80%.
Average salinity of the Baltic Sea is projected to decrease between 8 and 50%, but uncertainty for this is large.
Risk for coastal inundation would increase most along the eastern and southern shores of the Baltic Sea.

Baltijas klimats 21 g.s. beigas: <u>udens temperatura un ledus</u>



Mean monthly sea surface temperature change: RCAO-H/B2 (blue solid line), RCAO-H/A2 (black solid line), RCAO-E/B2 (green solid line), and RCAO-E/A2 (red solid line). Dashed lines denote the corresponding RCO scenarios. (From Meier, 2006.)

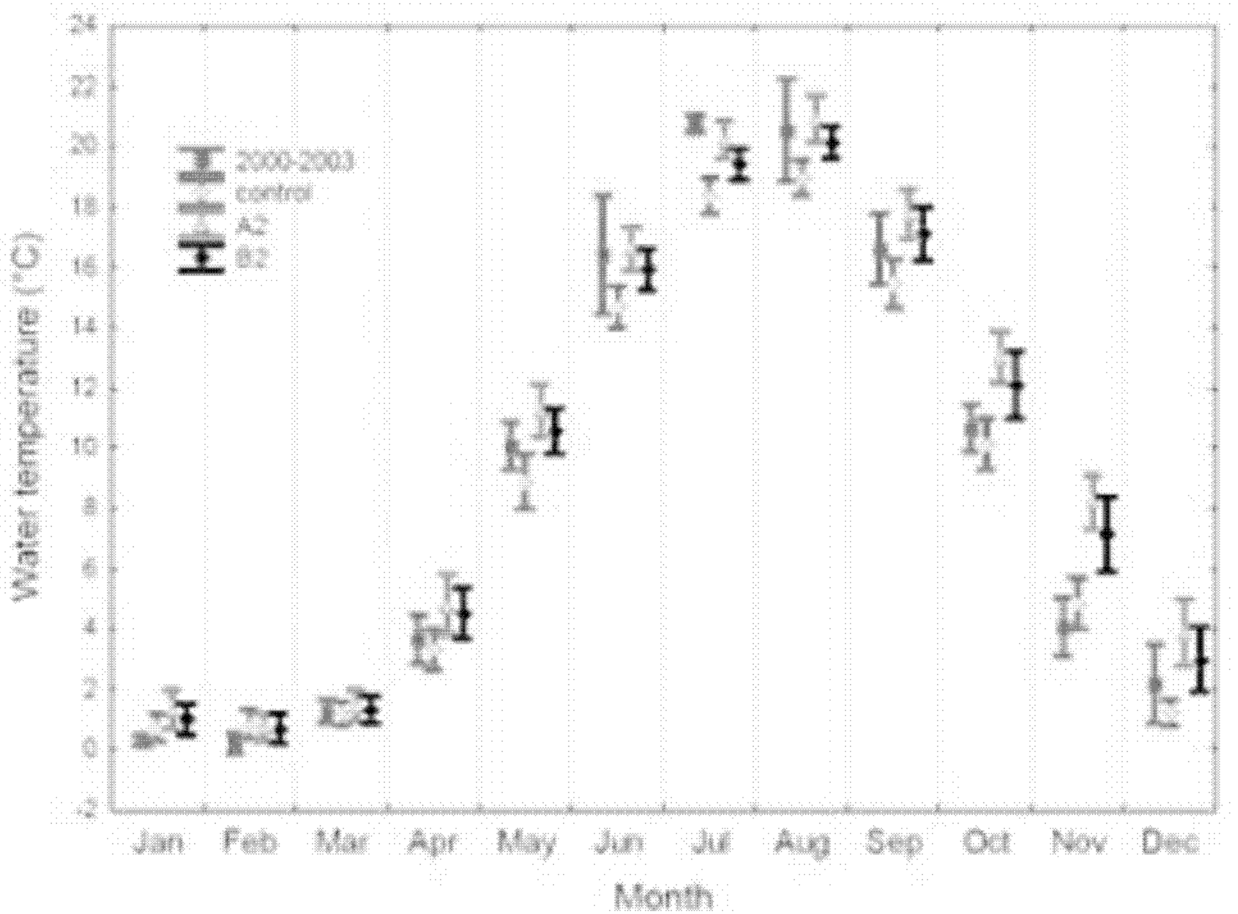
Mean annual sea surface temperatures are projected to increase by some 2 to 4ºC.

Sauszemes ekosistemas: parmainas jau jutamas

Mean rate of change (days per year) in date of leaf unfolding in birch (Betula pendula) from the southern and eastern Baltic coasts over the period 1951-1998. Source: Ahas et al. 2002.

- Advancement of spring and summer phases by 5-20 days over the last 50 years in many plant species;
- Delay of autumn phases by 5-30 days over the last 50 years in some plant species;
- Growing season extended by ca. 20 days over the last 50 years in many plant species
- Cold-limit range boundary shifts tracking isotherm migration for some plant and animal species
- Reduced migratory distances, changed migratory direction, increasing proportion of non-migrating individuals in some birds and other migratory species
- Treeline advance, mainly due to increased height growth in extant individuals, in the Fennoscandian mountains
- Land areas of the Baltic Sea basin are currently a net sink for CO2 from the atmosphere;
- Permafrost melting may be causing a shift towards a greater proportional coverage of wet habitats in tundra;
- possible consequences include increased methane release and accentuated greenhouse forcing.

Saldudenu ekosistemas 21.g.s. beigas: udens temperaturas celšanas



Mean and range of monthly water temperatures simulated for Lake Erken, Sweden for a control period, 1960-1990, and under two alternative RCM-generated climate scenarios for 2071-2100. The simulated temperatures may be compared to observed temperatures for the warm-summer period 2000-2003.

Saldudenu ekosistemas 21.g.s. beigas:

Impacts of increased water temperatures.

•Warmer water temperatures combined with longer stratified and ice-free periods in lakes may accelerate eutrophication, particularly in the western and southern Baltic Sea Basin. Shallow lakes and littoral zones may be particularly vulnerable.

•Cold-water fi sh species may be extirpated from much of their current range while cool- and warmwater species expand northwards.

Impacts of altered lake nutrient status and N:P ratios

•Increased remineralisation and higher diffusion rates of nutrients in warmer water is expected to increase nutrient availability, especially in lakes with longer water residence times.

•Reduced N:P ratios combined with higher temperatures may shift phytoplankton community structure towards species with higher temperature optima, including cyanobacteria, and pose risks for deteriorated drinking water quality.

Impacts on lake biogeochemistry

•Dissolved organic carbon loads in runoff from boreal and subarctic catchments may increase or decrease in the future in conjunction with changes in soil temperature, water table depth, discharge and seasonal runoff distribution.

•Increased influxes of humic substances to lakes would increase light attenuation, with negative impacts on lake periphyton and benthic (deepwater) communities, while potentially increasing the contribution of boreal lakes to regional CO2 emissions and climate forcing.

Saldudenu ekosistemas 21.g.s. beigas: lauksimnieciba un eitrofikacija

Changes in climate patterns and related runoff regimes can signifi cantly infl uence nutrient losses from catchments:

•Changes in the timing of seasonal and annual events (spring runoff, autumn low fl ow, ice and snow cover etc.)

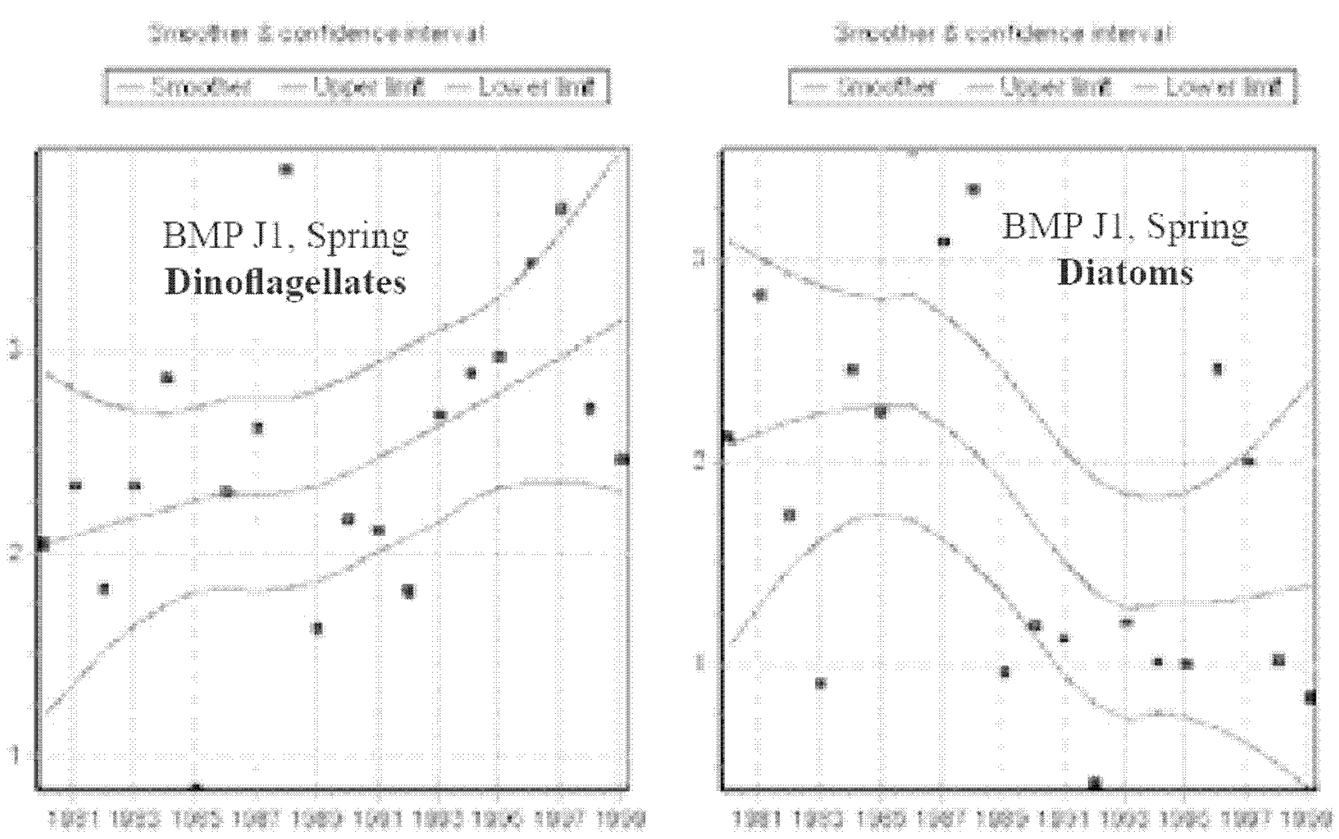
•Frequency and severity of extreme events (floods, droughts, erosion)

•Shorter periods of frozen surfaces and increased numbers of freezethaw cycles will lead to more intensive leaching during winter from arable land, especially in northern areas.

•Southern areas may become more vulnerable to rainstorms and fl ood events, with severe effects on agricultural activities in former floodplain areas, as well as nutrient losses.

•Responses of nutrient losses to climate change will be faster and more direct in small agricultural catchments; internal material cycles will lead to more complicated dynamics in large catchments.

Juras ekosistemas 21.g.s. beigas:
biologiskas daudzveidibas un produktivitates izmainas



Biomass and species composition of phytoplankton is expected to change as a consequence of climate change, recent changes in long term records (1981 – 1999) show the extent of variation (Wasmund and Uhlig, 2003).

Juras ekosistemas 21.g.s. beigas:
biologiskas daudzveidibas un produktivitates izmainas

Bacteria

•Increase in temperature stimulates metabolic processes: Implication for the functioning of marine system, Global consequences for the carbon cycle

Phytoplankton

•Warming will inhibit cold water species;
•Warming will enhance warm-water species;
•Reduced ice cover and earlier stabilization of the water column will shift the start of spring bloom;
•Biomass and species composition will change;
•Increase in cyanobacteria blooms.

Zooplankton

•Salinity controls the Baltic Sea biodiversity, also in zooplankton;
•Temperature change affects growth and reproduction;
•Decreasing salinity, increasing eutrophication, temperature and stratification favor the microbial loop;
•Shift in abundance affects growth and condition of the most important fish stocks.

Benthos

•Particle sedimentation, resuspension rates, current velocity, temperature, salinity and oxygen conditions contribute to uneveness in distribution;
•Biomass increase due to increased deposition of organic material (increased primary production due to eutrophication).

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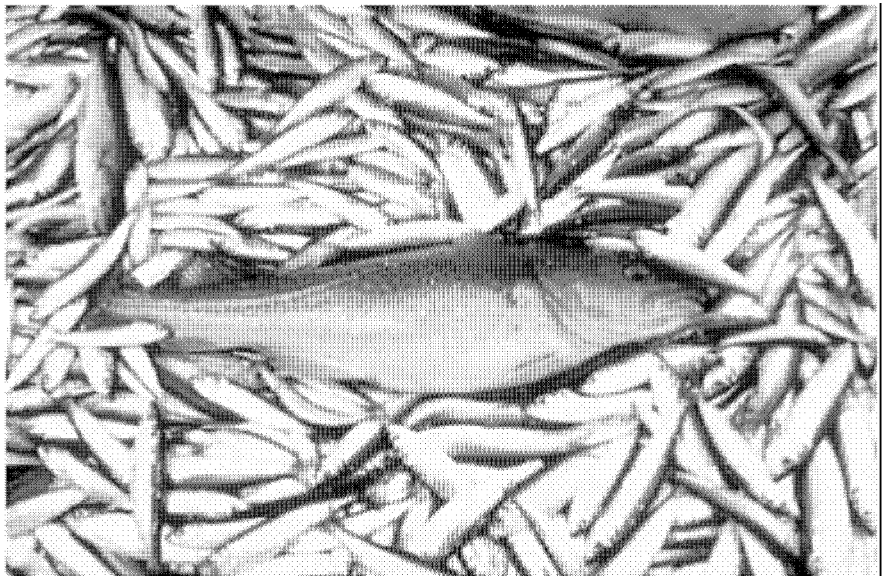
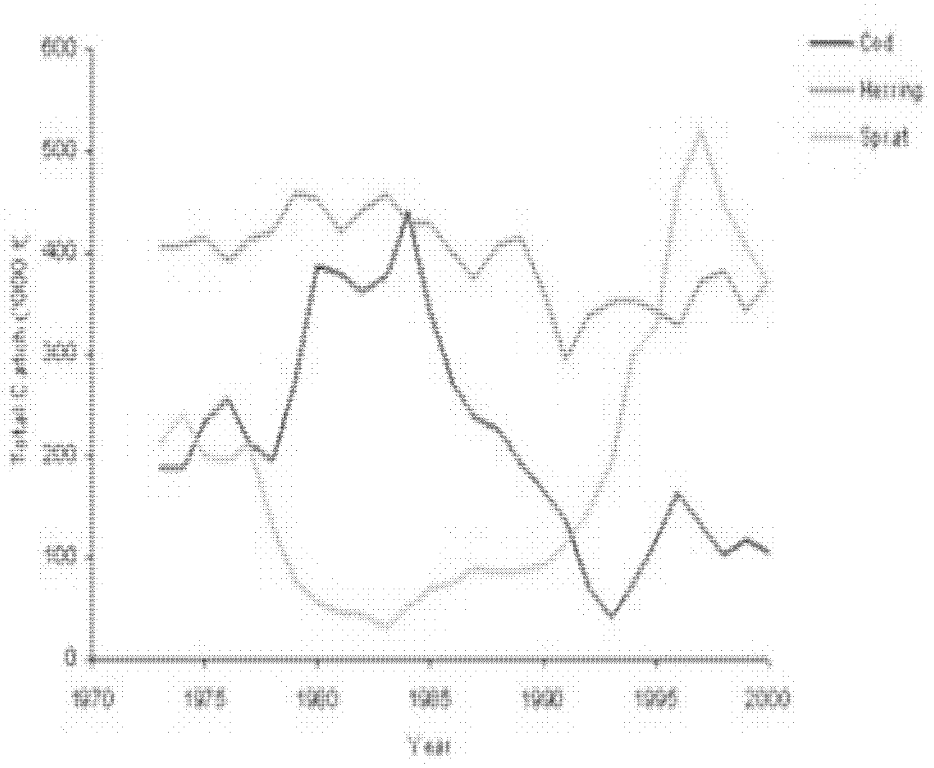


Cod, herring and sprat are the predominant pelagic fi sh species in the Baltic. Photo: Juha Kääriä.



Sprat stocks have increased, possibly due to decreased predation by cod or increased crustacean zooplankton, or both.

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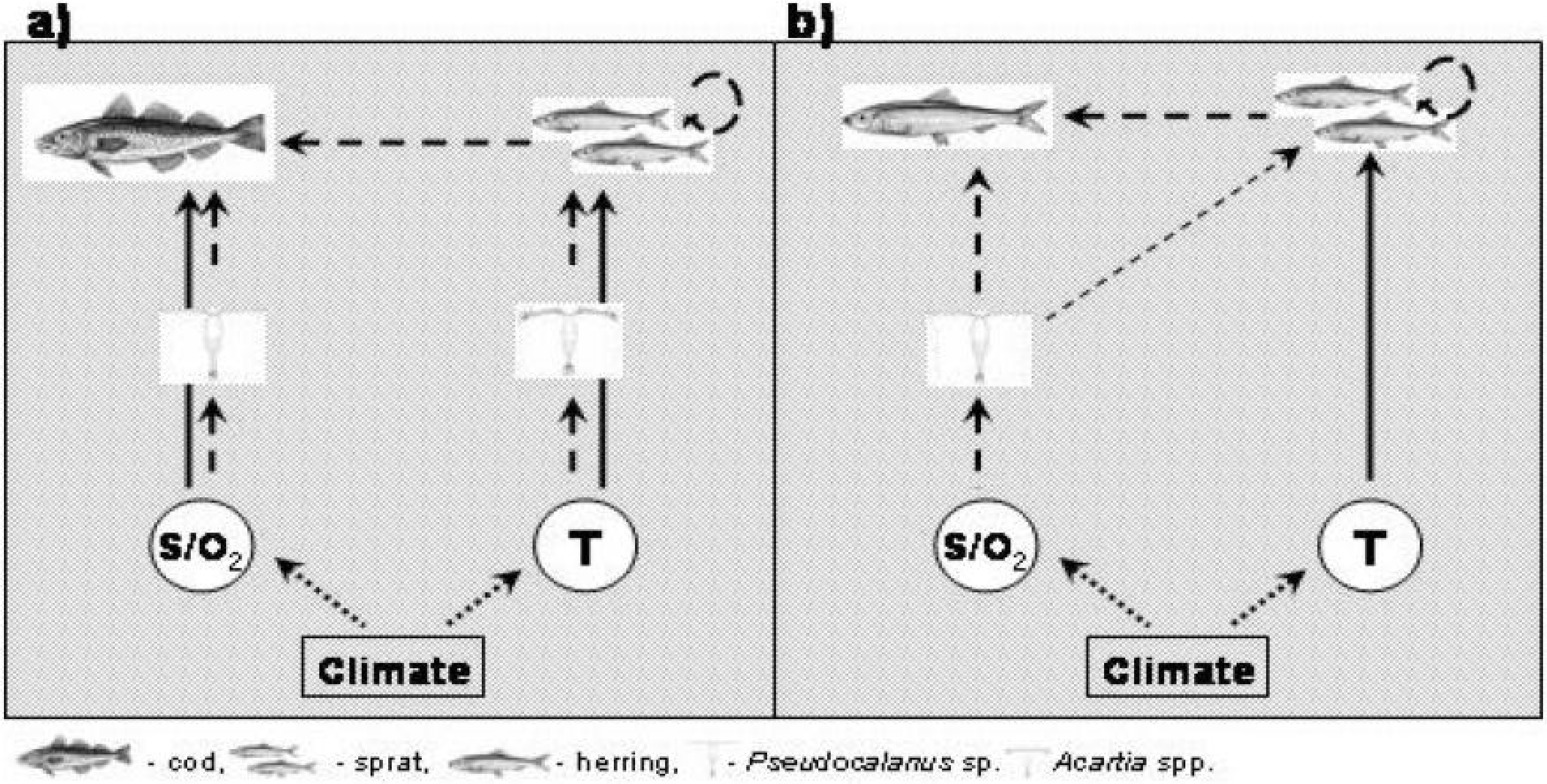

Conceptual model of climate effects on (a) recruitment and (b) growth of Baltic fish stocks. Dotted arrows: effect of climate on hydrography; dashed arrows: indirect effects; solid arrows: direct effects; S: salinity; O2: oxygen; T: temperature.

The present clupeid-dominated regime in the Baltic fish community would be stabilized with the climate change.

Harbor porpoise is the only cetacean species in the Baltic.
Photo: Antti Halkka.