Impact of climate change on the Baltic Sea ecosystem

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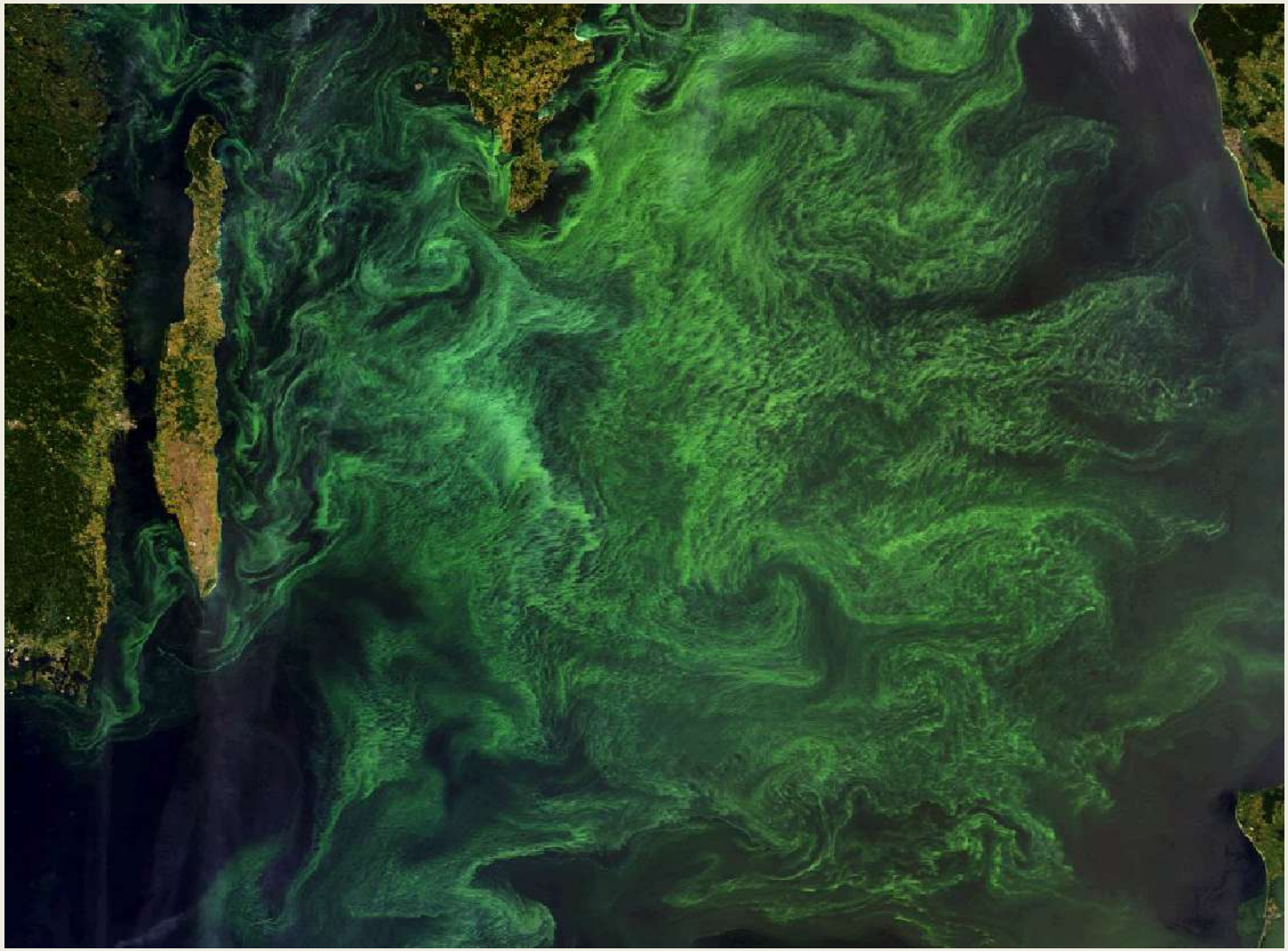
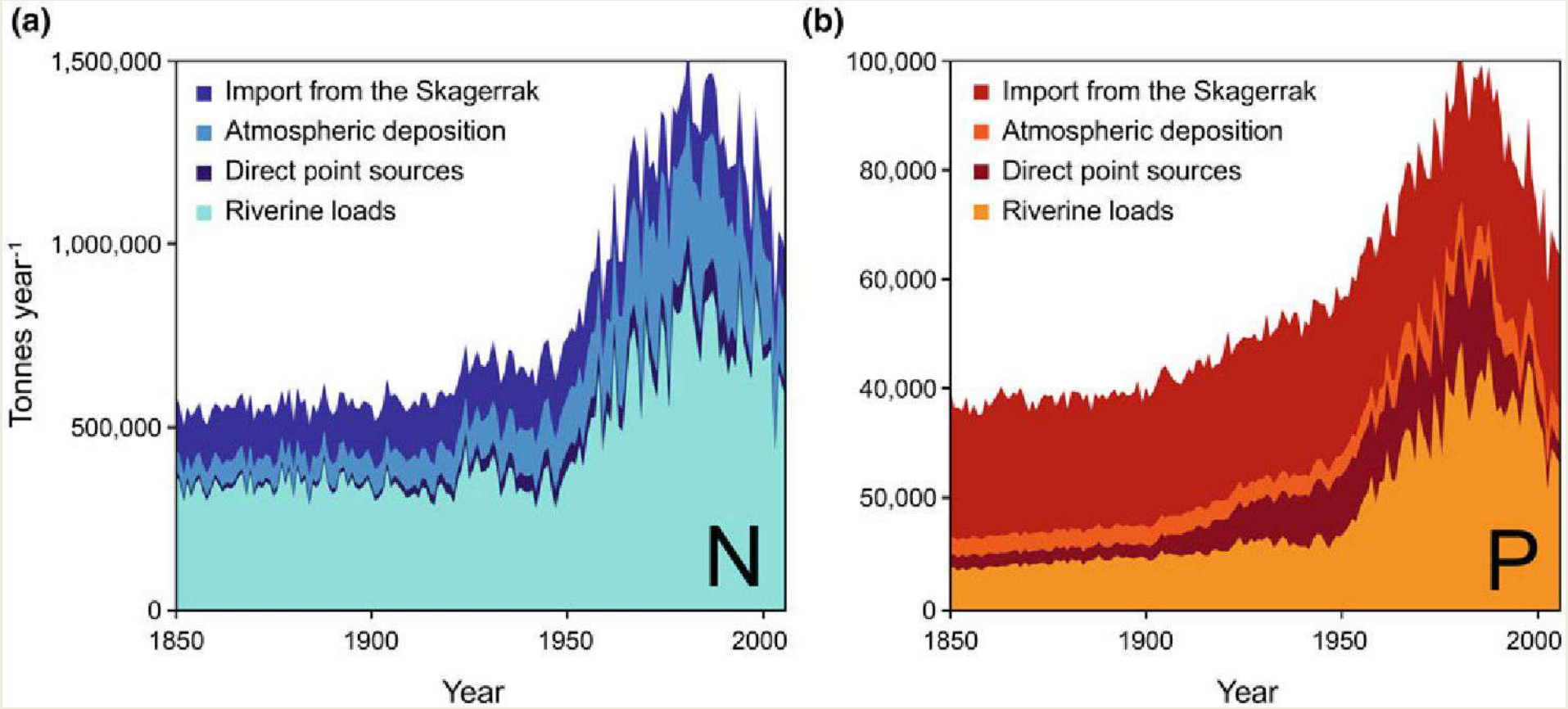
Cyanobacteria bloom



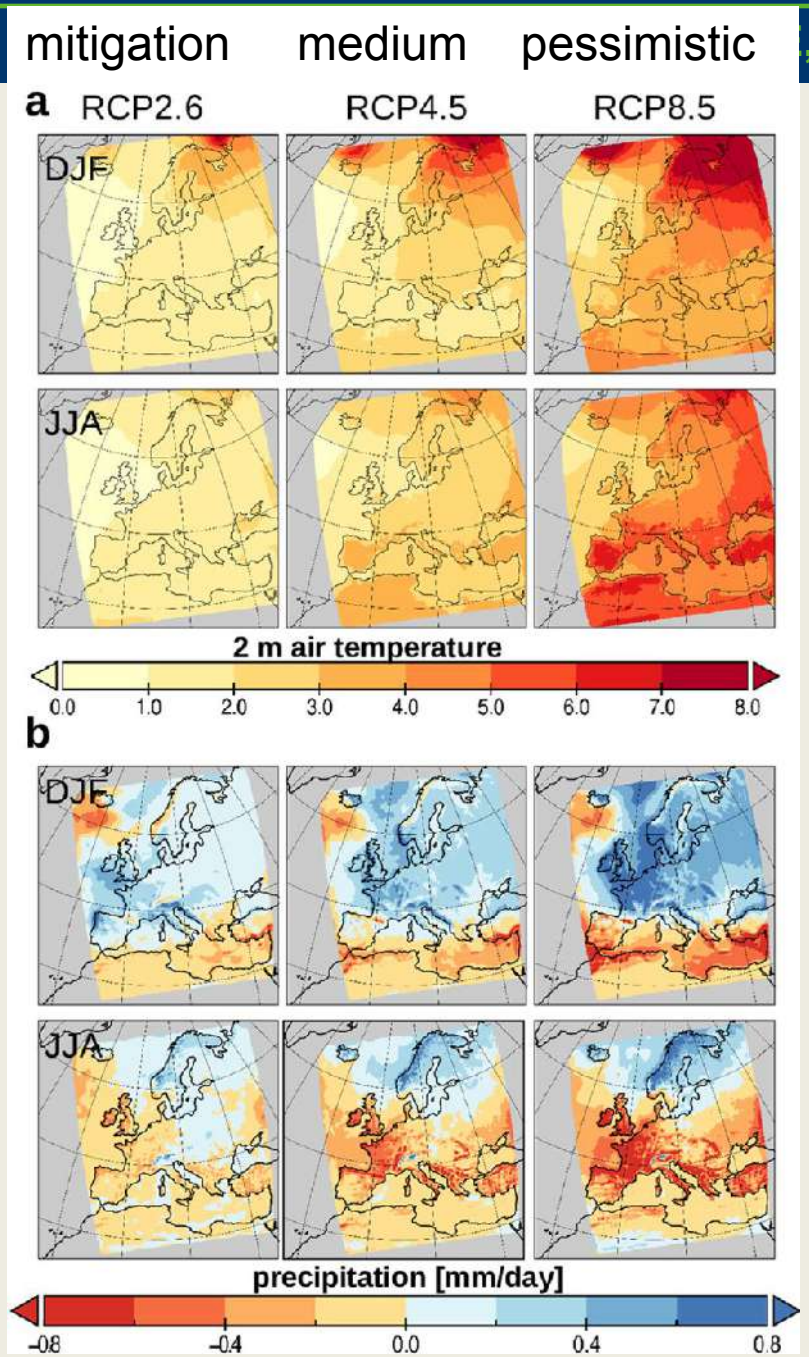
Nutrient inputs for nitrogen (N) and phosphorus (P)



(Source: Savchuk et al., 2012)

Air temperature change in K

Precipitation change in mm/day



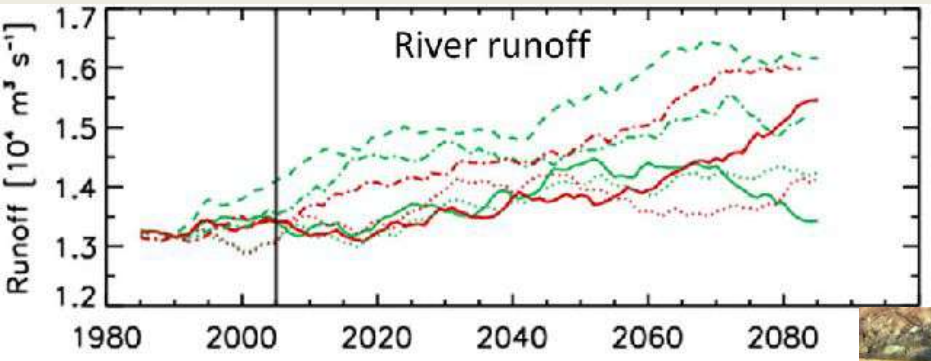
winter

summer

(Source: Gröger et al., 2021, Climate Dynamics)

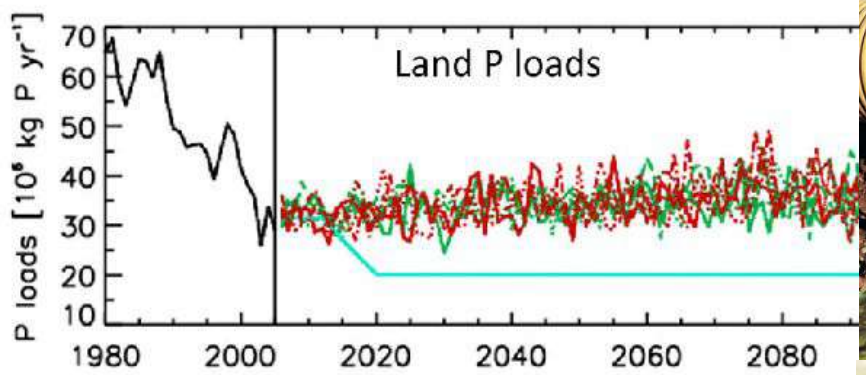
winter

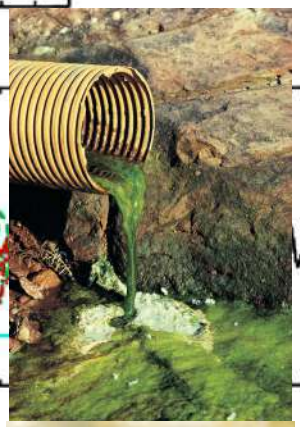
summer

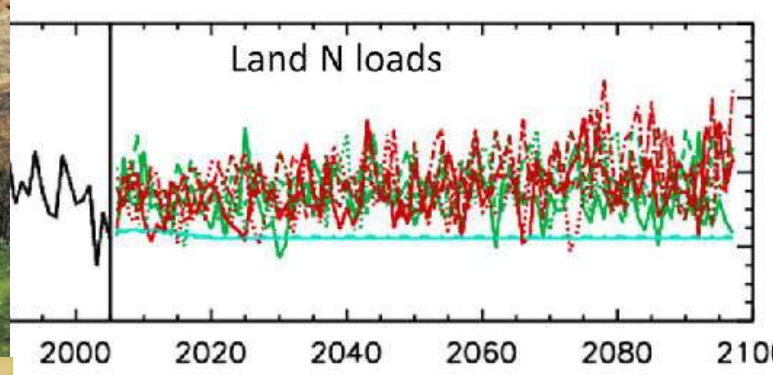


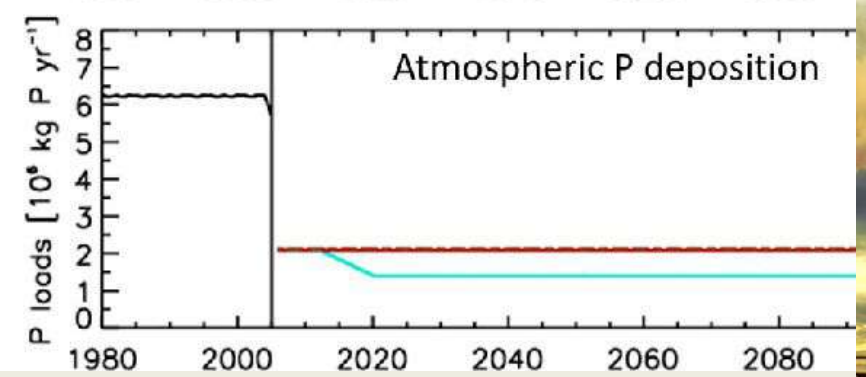
RCP 4.5, BSAP
RCP 8.5, BSAP
RCP 4.5, REF
RCP 8.5, REF
Historical data

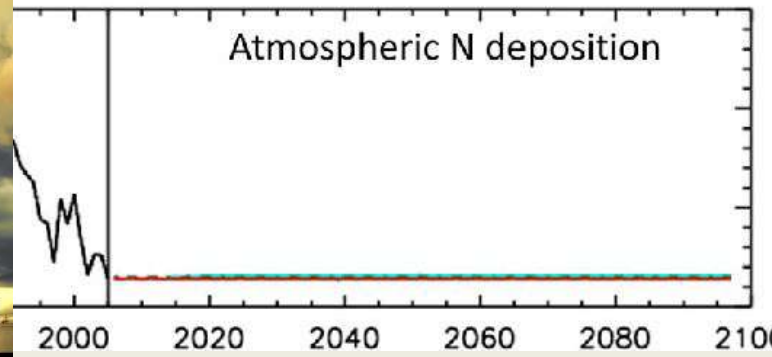
BSAP = Baltic Sea Action Plan
REF = Reference loads
RCP 4.5 = medium
RCP 8.5 = pessimistic



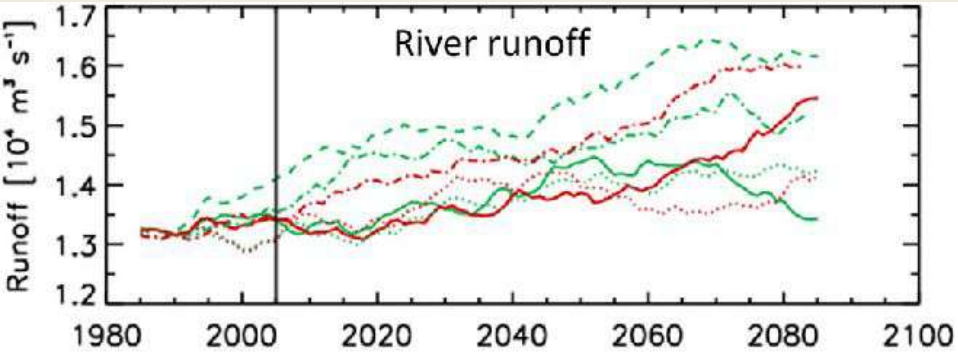








(Source: Meier et al., 2021)



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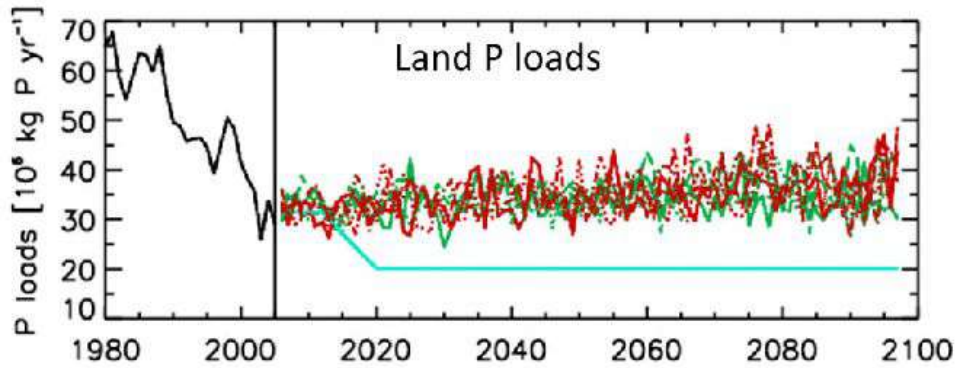

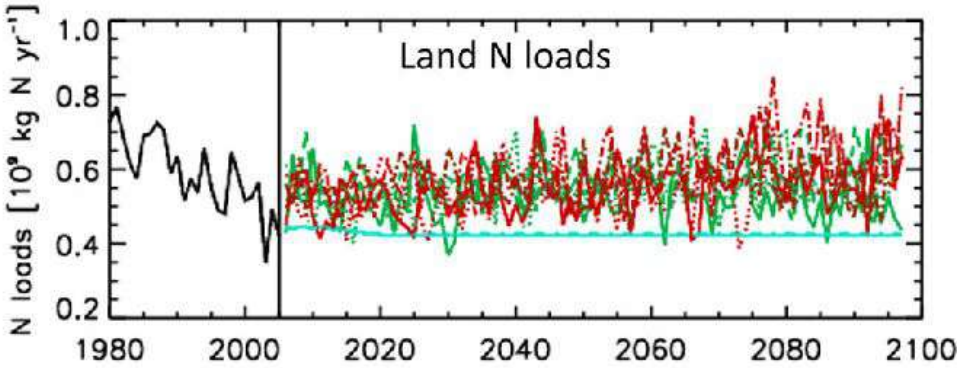

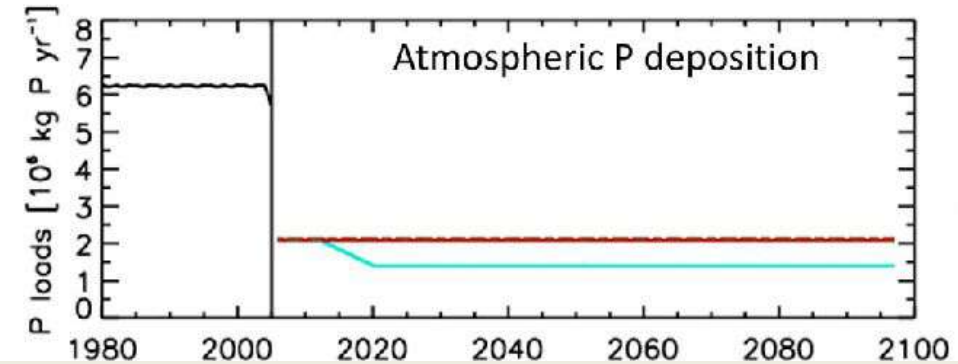

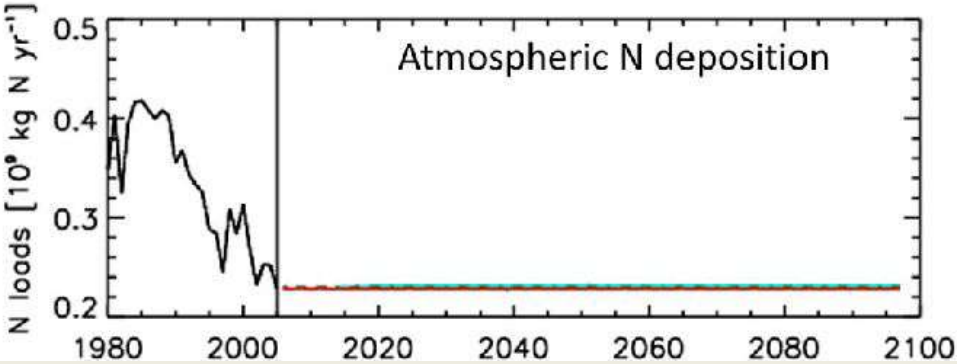

(Source: Meier et al., 2021)

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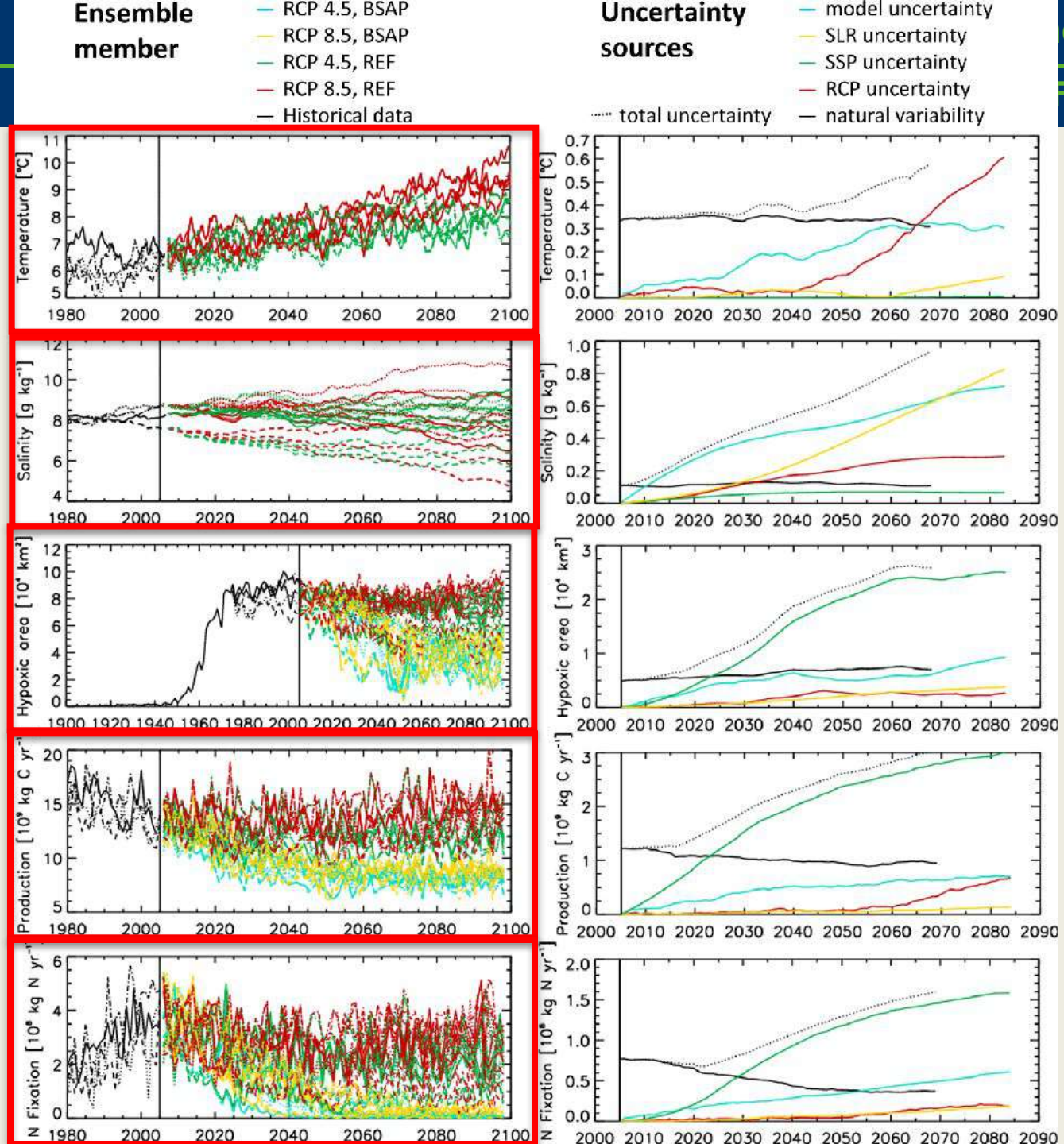

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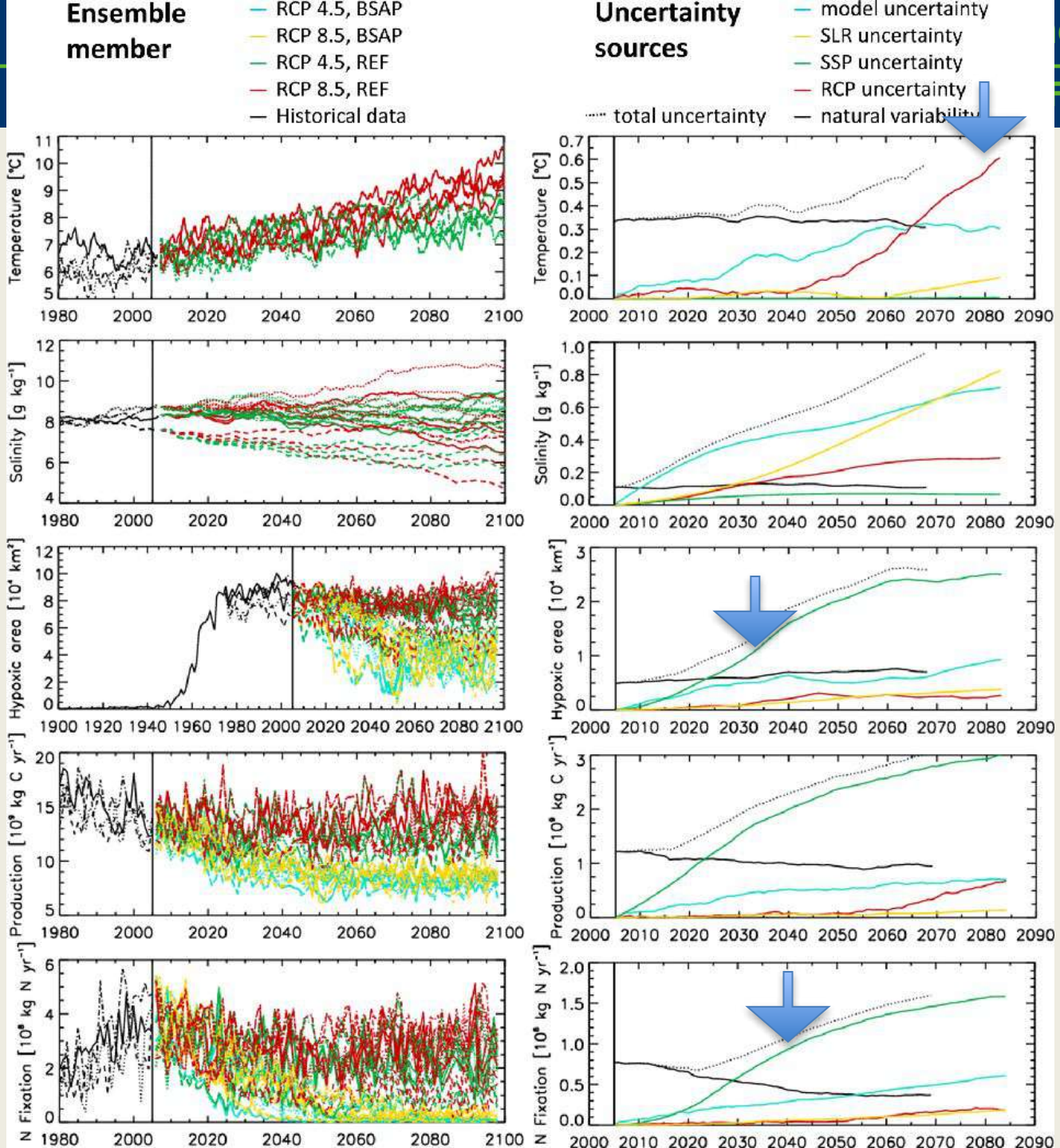

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EN CLIME

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https://helcom.fi/wp-content/uploads/2021/09/Baltic-Sea-Climate-Change-Fact-Sheet-2021.pdf

Revised version September 2024

Direct parameters	Categorization
Air temperature*	Energy cycle
Water temperature*	Energy cycle
Large scale atmospheric circulation	Energy cycle
Sea ice*	Energy cycle
Solar radiation	Energy cycle
Salinity and saltwater inflows*	Water cycle
Stratification	Water cycle
Precipitation*	Water cycle
River run-off*	Water cycle
Carbon Uptake and Storage Potential	Carbon and nutrient cycles
Acidification	Carbon and nutrient cycles
Riverine nutrient loads and atmospheric deposition	Carbon and nutrient cycles
Sea level*	Sea level and wind
Wind*	Sea level and wind
Waves*	Sea level and wind
Sediment transportation*	Sea level and wind

Indirect parameters	Categorization
Oxygen	Carbon and nutrient cycles
Microbial community and processes	Biota and ecosystems
Benthic habitats	Biota and ecosystems
Coastal and migratory fish	Biota and ecosystems
Pelagic and demersal fish	Biota and ecosystems
Waterbirds	Biota and ecosystems
Marine mammals	Biota and ecosystems
Non-indigenous species	Biota and ecosystems
Marine protected areas (MPAs)	Biota and ecosystems
Nutrient concentrations and eutrophication	Biota and ecosystems
Ecosystem function	Biota and ecosystems
Biofouling	Biota and ecosystems
Harmful Algal Blooms	Biota and ecosystems
Offshore wind farms	Human activities
Coastal protection	Human activities
Shipping	Human activities
Tourism	Human activities
Fisheries	Human activities
Aquaculture	Human activities
Marine Litter	Human activities
Blue carbon storage capacity	Services
Marine and coastal ecosystem services	Services

Water temperature 2021

Author

Energy cycle

Linked parameters:

Description

As air temperature increases, also water temperature rises[1]. Starting at the surface, the heat spreads downward through different processes and may warm up even the deep water of the Baltic Sea. The ocean plays an important role for the climate because by far the largest amount of the heat from global warming is stored in the oceans. Due to their huge heat capacity, oceans respond slowly, and moderate temperature increases in the atmosphere. Oceans are also important in providing moisture to the atmosphere, the more the warmer the water is.

What is already happening?

Mean change: Marginal seas around the globe have warmed faster than the global ocean[2], and the Baltic Sea has warmed the most of all marginal seas[2]. Average surface-water temperature increased by +0.59°C/decade for 1990-2018[3] and between +0.03 and +0.06°C/decade for 1856-2005 in northeastern and southwestern areas, respectively[4].

Extremes: With reference to 2020, the summer of 2018 was the warmest on instrumental record in Europe, and also the warmest summer in the past 30 years in the southern half of the Baltic Sea[5], with surface-water temperatures 4-5°C above the 1990-2018 long-term mean. The heat wave has also been recorded in bottom temperatures[6].

What can be expected?

Mean change: Global ocean temperatures are rising at accelerating rates[7,8]. Scenario simulations for the Baltic Sea project a sea surface temperature increase of 1.1°C (0.8-1.6°C, RCP2.6) to 3.2°C (2.5-4.1°C, RCP8.5)* by the end of this century compared to 1976-2005[9-12]. In all scenarios, sea surface temperature changes at the end of the century significantly exceed natural variability.

Extremes: The RCP4.5 and RCP8.5 scenarios project more tropical nights over the Baltic Sea, increasing the risk of record-breaking water temperatures[13].

Knowledge gaps

For the projection of water temperatures in the Baltic Sea, regional climate models are needed. However, the effect of aerosols in regional climate models has not been investigated. More knowledge on natural variability of Baltic Sea temperature and its connection to large-scale patterns of climate variability is needed. The occurrence of marine heatwaves is projected to increase. However, their potential to affect the ecosystem in the Baltic Sea is not well known.

Policy relevance

Water temperature has profound effects on the marine ecosystem. Climate change mitigation is the only way to counteract temperature increase. The best adaptation response available is to reduce environmental pressures to the Baltic Sea, thus building climate change resilience. The protection of marine areas where the temperature increase is expected to be lower, so-called climate refuges, focuses on areas where climate change impacts are not contributing to multiple stressors[14,15]. These could become a last outpost for species affected by climate change.

Harmful Algal Blooms 2024

Authors
Biota and ecosystems

Linked parameters:

Links to main policies:

Description

Harmful algal blooms (HABs) are occurrences of mostly microscopic algae, including cyanobacteria, with negative impacts on the environment and human health. HABs may be mass occurrences, but some cause problems at low cell densities. HABs are often favoured by high nutrient concentrations, stratified water, low wind speed, and high water temperatures [1]. Harmful effects include the production of toxins causing various poisoning syndromes in humans, fish kills, and oxygen depletion, with ecosystem wide consequences [2]. In the Baltic Sea, 42 HAB species have been documented [3]. Cyanobacterial blooms cause surface scums and enhance bottom water anoxia [2, 4, 5]. Their toxins accumulate in zooplankton, mussels, fish, and waterfowl [6, 7]. Toxins of harmful (dino-)flagellates may cause toxic syndromes in humans, marine mammals, birds [8] and fish [9, 3].

What is already happening?

The frequency and extent of cyanobacterial blooms have increased in the past decades, and now blooms are formed even in the northernmost basins [10, 11]. An increase in nitrogen fixing cyanobacteria in the Bothnian Sea is likely related to enhanced phosphate input from the central Baltic Sea, in relation to nitrogen availability. This trend is considered a result of freshening of surface water and increasing SST [10, 12]. The toxic warm water dinoflagellates Alexandrium ostenfeldii and A. pseudogonyaulax increasingly cause blooms associated with high concentrations of toxins [13, 14] which can accumulate at higher trophic levels [4, 8]. Mass occurrences of Karlodinium veneficum, Prymnesium parvum, and Pseudochattonella spp. have led to fish kills in coastal waters [9, 15, 16].

What can be expected?

Warming climate favours cyanobacteria [17] and will generally lead to range expansion of warm-adapted harmful taxa into and within the Baltic Sea [17, 18]. New physical and chemical conditions will affect spatial distribution patterns, prolong the bloom "window" [19] and promote selection toxic genotypes [20]. Motile dinoflagellates and haptophytes can take advantage of climate driven stratification and will increasingly cause blooms and toxicities. Ever more extensive blooms of N fixing cyanobacteria will intensify bottom water hypoxia, and further fuel the vicious circle [2]. Nevertheless, modelling studies suggest that implementation of the Baltic Sea Action Plan (BSAP) can eventually diminish hypoxia, and extreme cyanobacteria blooms and respective biogeochemical consequences will no longer occur [18, 21, 22].

Other drivers

Many of the toxic bloom forming cyanobacteria and dinoflagellate species produce resting stages to survive periods of unsuitable growth conditions [23]. Such seed banks anchor and stabilize populations of HAB species in a new habitat [24] and thus support climate driven invasion and establishment of new HAB taxa in the Baltic Sea [25].

Knowledge gaps

Harmful algae species respond to changes in the environment either by changing habitat or by adapting to new conditions [17]. It is not well understood yet, how these evolutionary and physiological adaptation processes work and how they affect growth and toxicity of HAB species under climate change conditions. In addition, it is not clear how HAB species will respond to reductions of inorganic nutrient loads [3], as many of them are mixotrophs and able to utilize organic nutrient sources [26]. Little is known yet, on how reduction of nutrient loads will interact with complex climate change conditions.

Policy relevance

HABs affect human health directly through their potent toxins which can cause life threatening poisoning syndromes. When toxins accumulate in shellfish, fish, and molluscs they threaten food safety severely and cause large economic losses to aquaculture and fisheries [27]. High biomass blooms reduce the quality of bathing water significantly and therefore impact the recreational value of bathing and boating. Once established, HABs are practically impossible to remove, but their frequency and extent can be affected by combating eutrophication. A climate service for cyanobacteria blooms in the Baltic combining observations and modelling has been proposed [28].

Thank you very much for your attention!