THE DEVELOPMENT OF CLIMATE SCIENCE IN THE BALTIC SEA REGION: A CONTRIBUTION TO OXFORD RESEARCH ENCYCLOPEDIAS

Marstrand 1908 in the end of last Herring period with its fishing fleet

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Introduction

The Oxford Research Encyclopedias (OREs) offer overview articles written, peer-reviewed, and edited by leading scholars. One of the science area is Climate Science (Ed. Hans von Storch) generating now many interesting overview papers and Baltic Earth contributes by a number of papers related to climate change in the Baltic Sea region (Eds. Marcus Reckermann, Anders Omstedt). The following presentation is part of one such an overview paper (Omstedt, 2017).

http://oxfordre.com/

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Baltic Earth

From the 18th century to present some major regional climate related questions are:

1. Is the water sinking or land uplifted?
2. What can we learn from indirect or direct observations?
3. Are the marine resources unlimited?
4. Why is fishing success changing?
5. What can observations of winter condition teach us?
6. Why does winter climate change?
7. Is anoxic water natural or anthropogenic?
8. How will increasing CO_2 in the atmosphere influence the regional climate?
9. How will increasing CO_2 in the atmosphere influence the Baltic Basin?

1. Is the water sinking or land uplifted?

Seal rocks

The Celsius Rock has risen about 2 meters since 1731 a measure on sinking water in the Baltic Sea

1. Are the water sinking or land uplift?

Stone carved with runic text e.g.

Sigurds ristningen, Eskilstuna Sweden

Mälaren has risen about 5 meters during past 1000 years

Other examples are Hill forts (fornborgar)

1. Sinking water or land uplift?

Sinking? E.g Hiärne (1706), Celsius (1743), discussed in Ekman (2009)

Land uplift? E.g. Runeberg (1765) and Ferner (1765) argued that that land was rising

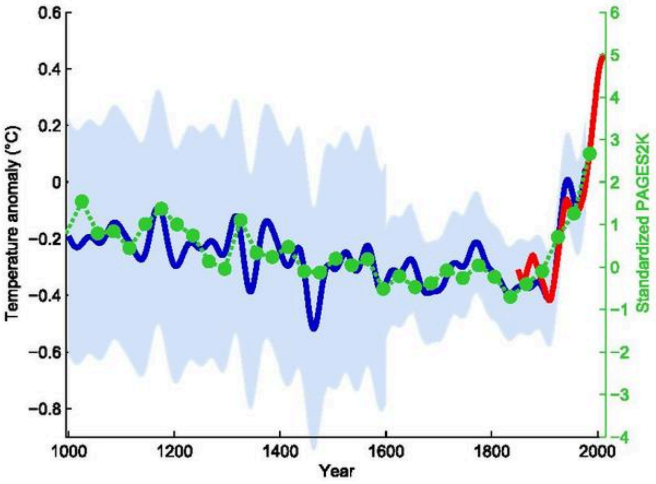
Discovery of the Ice Age? E.g. Esmark (1824) and Agassiz (1837) concluded that Norway and Swiss must have been covered by ice (huge blocks and moraines).

Sun-Earth orbital motions causing ice age? E.g. Adhe'mer (1842), Croll (1875), Milinkovic (1920)

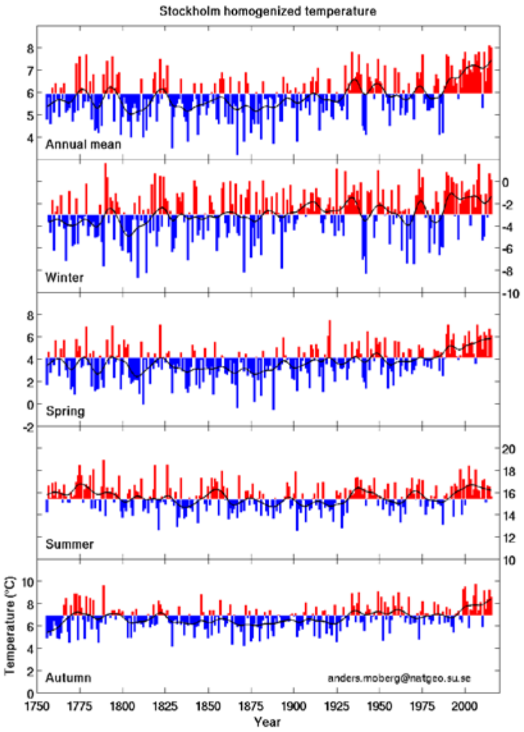
Postglacial uplift? Jamieson (1865, 1882)

After Milinkovic (1920) made his mathematical contribution in explaining the Earth movement around the Sun, new studies could better relate climate change to orbital periods and ice periods. Periodic behavior in time series become popular studies.

2. What can we learn from indirect or direct observations?



Green dots show the 30-year average of the new PAGES 2k reconstruction. The red curve shows the global mean temperature, according HadCRUT4 data from 1850 onwards. In blue is the original hockey stick of Mann, Bradley and Hughes (1999) with its uncertainty range (light blue). Graph by Klaus Bitterman. http://thinkprogress.org/climate/2013/07/08/2261531/most-comprehensive-paleoclimate-reconstruction-confirms-hockey-stick/



Stockholm air temperature. Homogenization important. From Anders Moberg: http://bolin.su.se/data/stockholm/air_temperature.php

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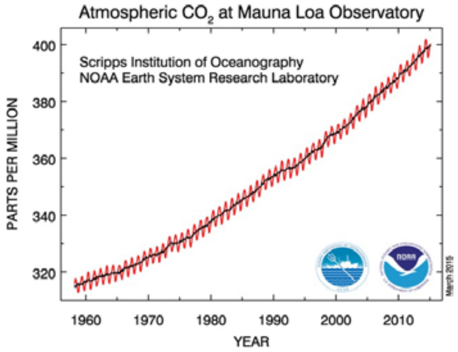
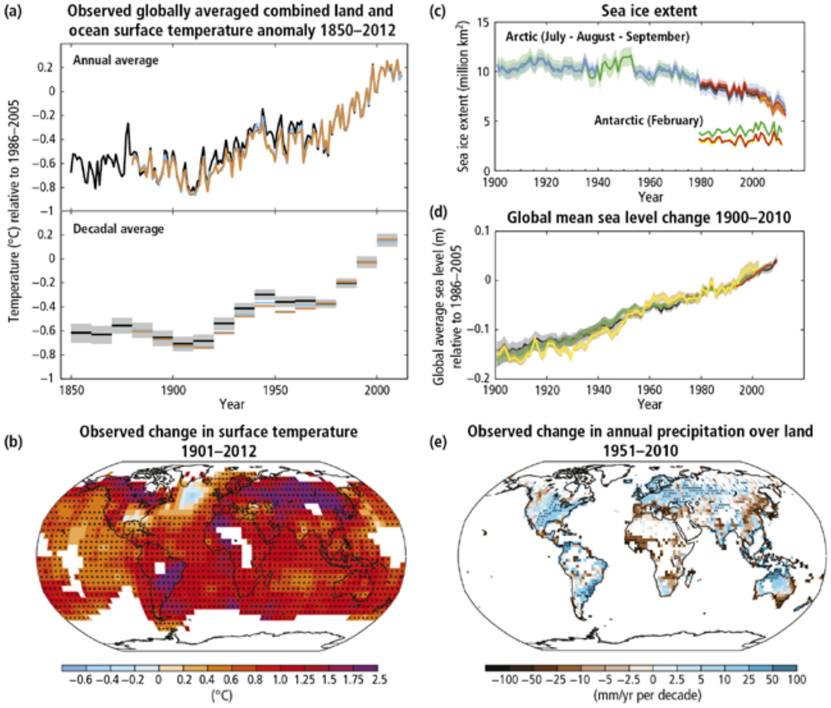
2. What can we learn from indirect or direct observations?





A large amount of blended meteorological and proxy data become freely available. Trends in time series become popular since 1980th as indicator of anthropogenic climate change

IPCC 2013

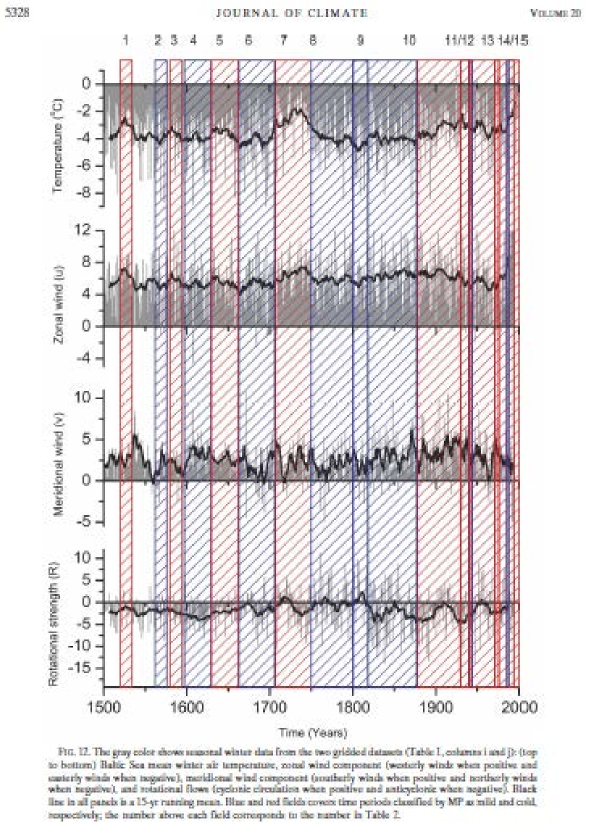
3. Are the marine resources unlimited?

In 19th century larger research vessel cruises mapping the Seas. Increasing concern about fish stock variability. Last decades - growing number of studies analysing regime shifts in time series and major concern of high fishing pressure.

ICES started in 1902

4. Why is the fishery success changing?

Bohuslän herring periods:
1. End of 10th to early 11th century
2. End of 11th to early 12th century
3. End of 12th to mid13th century
4. End of 13th to mid14th century
5. Mid 15th century
6. 1556-1590
7. 1660-1680
8. 1747-1809
9. 1877-1906



Eriksson et al 2007

Baltic Earth

5. What can observations of winter condition teach us?

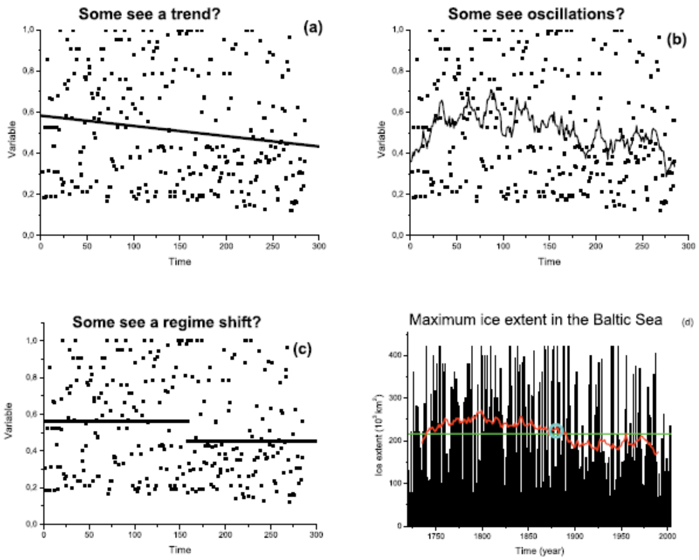
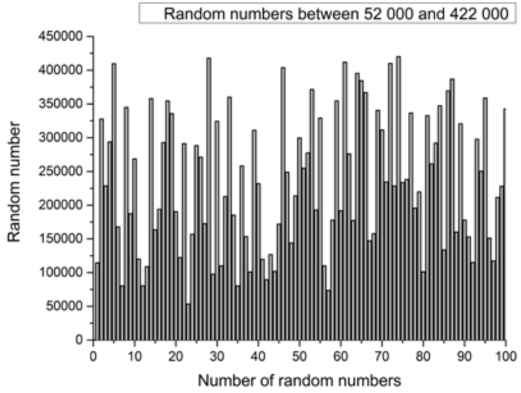
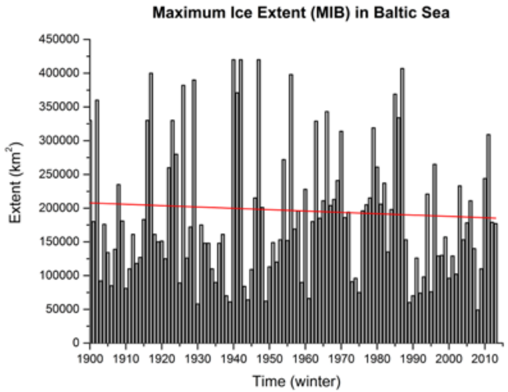


Fig. 1.13. Climate change can be detected by trends, oscillations and jumps or regime shifts. In this figure the same data sets is used and normalised (Figs. **a–c**). The original data set is illustrated in Fig. (**d**), for details see Omstedt and Chen (2001)

BACC I 2008





Omstedt 2015

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6. Why does the winter climate change?

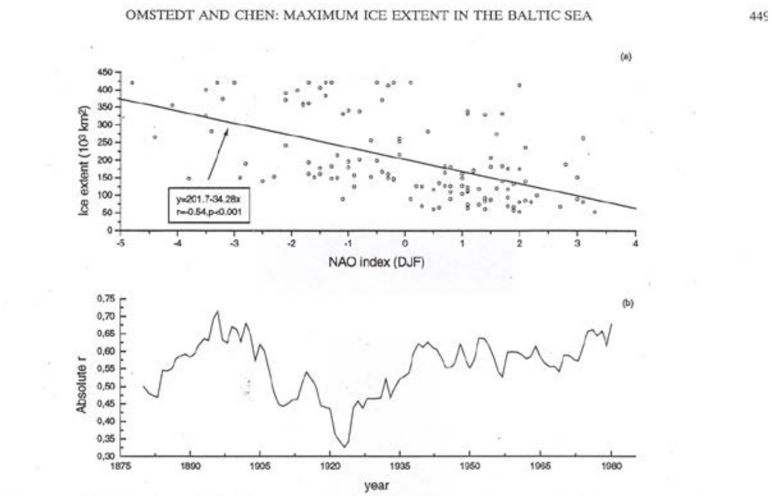


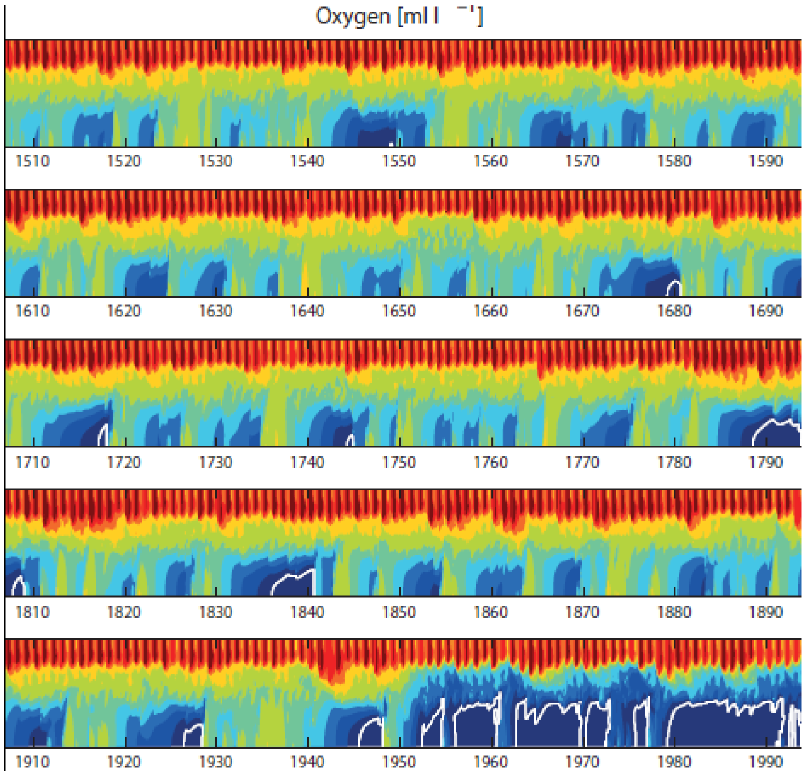
Figure 4. (a) Scatterplot and (b) 31 year moving correlation between the seasonal NAO_i and the annual maximum ice extent. The line in Figure 4a indicates the least squared fit given by the equation in Figure 4a.

Changes in large scale atmospheric circulation essential in the Baltic region. Characterizing the complex atmosphere with just one "golden" parameter and to relate these parameters with other single observations such as ice or fish abundance periods seems questionable.

20th century a growing need for system understanding and coupled atmosphere-ocean-land models.

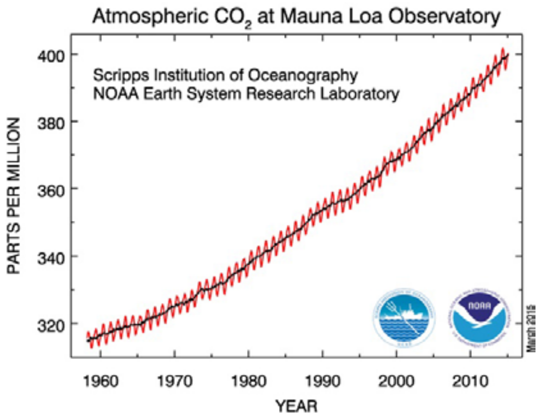
7 Is anoxic bottom water natural or caused by human?

Extent of hypoxic and anoxic bottom water based on observations, SMHI



Model simulation (Hansson and Gustafsson, 2011)

8. How will increasing atmospheric carbon dioxide concentrations influence the regional climate?



BACC II (2015) some results in short:

- Warming is going on and will continue.
- Plausible that this warming is partly related to antropogenic factors.
- Climate signal related to warming, ice and snow later to water cycle components.

9. How will increasing atmospheric carbon dioxide concentrations influence the Baltic Sea?

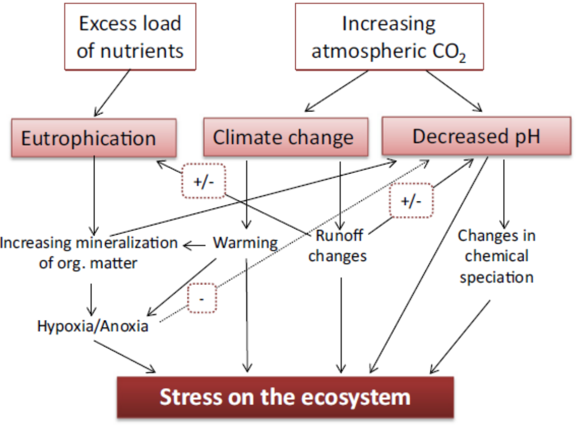


Fig. 9. Flowchart of the impact and interconnectivity of the effects from increased nutrient loads and atmospheric CO_2.

Jutterström et al, 2014

BACC II (2015) some results in short:

- A variety effects on terrestial and marine ecosystems.
- Warming will reduce sea-ice, increase surface temperature, reduce ………..
- Most probably the Baltic Sea will become more acid in the future.

New developments:

- Earth System Science
- Multiple drivers
- Detection and attributions

Summary

- Why the water is sinking around the Baltic Sea coasts could not be solved until the idea about post glacial up lift and the thermal history of the Earth were better understood open up for analyzing periodic behavior in time series

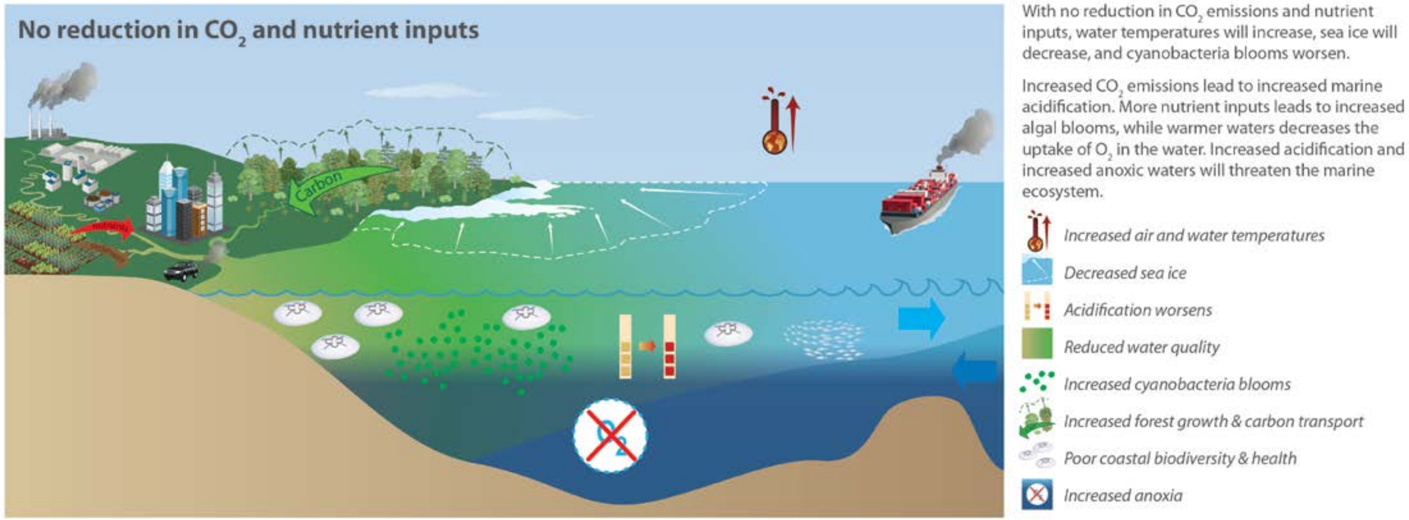
- Herring and sardine fishing success and failure lead to investigations about fishery and climate but also the realization that fishery itself have strongly negative effects on the marine environment and need for international assessment efforts. Regime shift studies popular in the biological community

- The increasing amount of anoxic deep water in the Baltic Sea caused debates about what is natural and what is caused by man and the scientific outcome from these debates forms now the base for international management efforts in reducing the leakage of nutrients from land.

- Observed increase in atmospheric CO_2 and effects on global warming has focused the climate debate on trends and generated a series of international and regional assessments and research programs that have considerable improved our understanding of climate and environmental changes adding more efforts in Earth System Science where both climate and environmental factors are analyzed together.

- Climate and biogeochemical data may display stochastic behavior and with few observations this can easily be interpret as oscillations, trends or regime shifts. Correlation between different observations can give high correlations during some periods but not during others. Simplified statements based on poor amount of observations are misleading and common in science.

Future lacking successfull managements



Thanks for your interests!