Baltic Earth:

Grand Challenges suggested for the new programme

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Baltic Earth

Earth System Science for the Baltic Sea Region

What is a Grand Challenge?

- Major research questions to be tackled in the next 3-4 years.
- Each Grand Challenge can have several specific research questions.
- Working groups should be identified to analyze the research gap and suggest plans to perform the research.
- Grand Challenges are to be identified within the Baltic Earth at conferences and by using assessments of existing research.
- The Working Groups should also aim at encouraging research as well as identify data collection needed.

Suggested Grand Challenges

→ **GC1: Salinity dynamics in the Baltic Sea.**

→ **GC2: Land-Sea biogeochemical feedbacks in the Baltic Sea region.**

→ **GC3: Natural hazards and extreme events as the key factor in understanding and predicting natural disasters in the Baltic Sea region.**

→ **GC4: Understanding sea level dynamics using new technologies (remote sensing).**

→ **GC5: Anthropogenic changes and how the Earth system of the Baltic Sea region is affected.**

→ **GC6: Understanding of regional/local variabilities of water and energy exchanges**

GC1: Salinity dynamics in the Baltic Sea
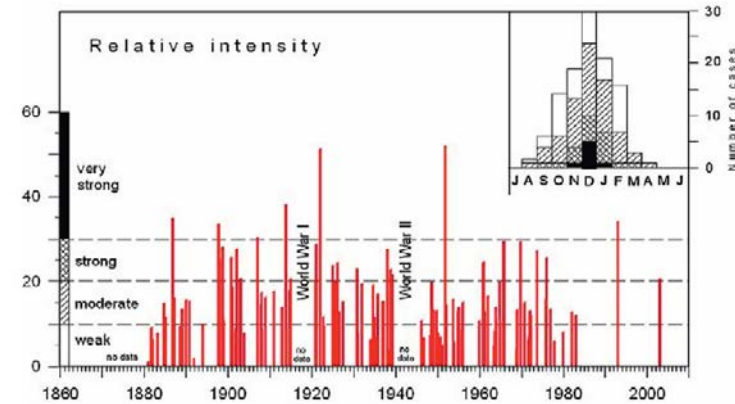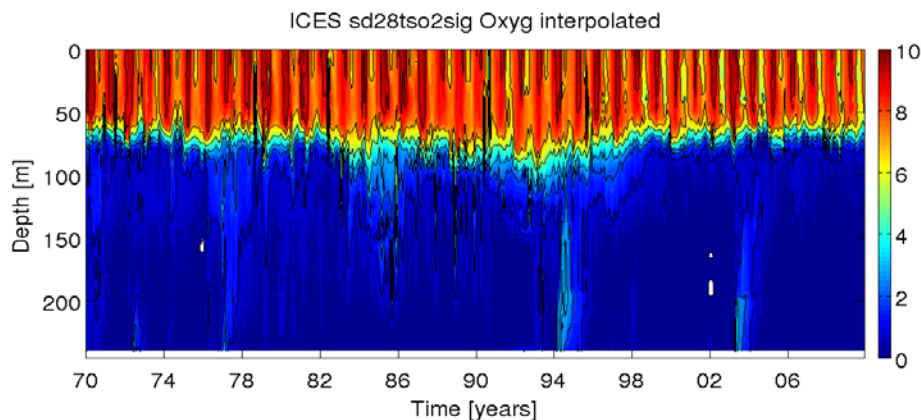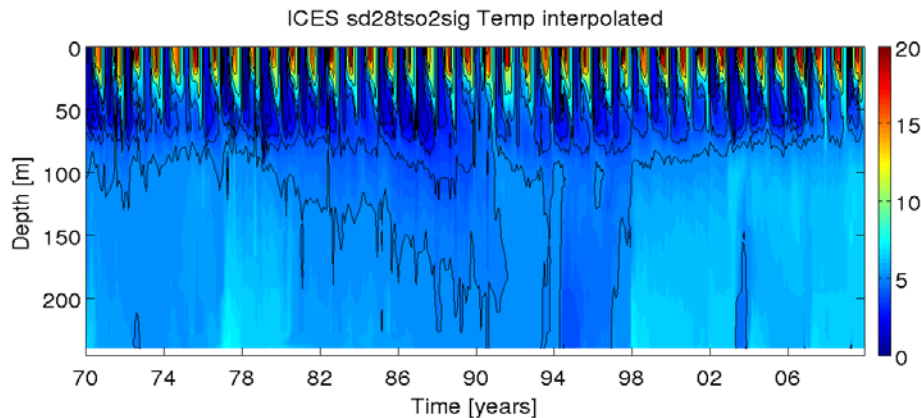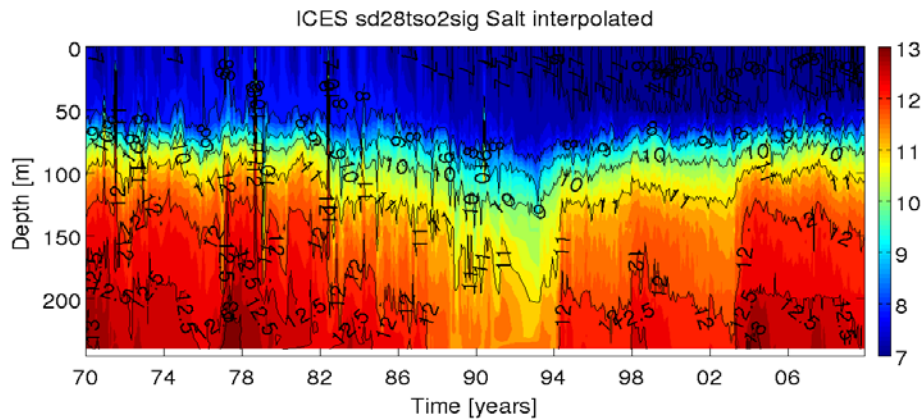## Andreas Lehman and Kai Myrberg

Meier & Kauker, 2003
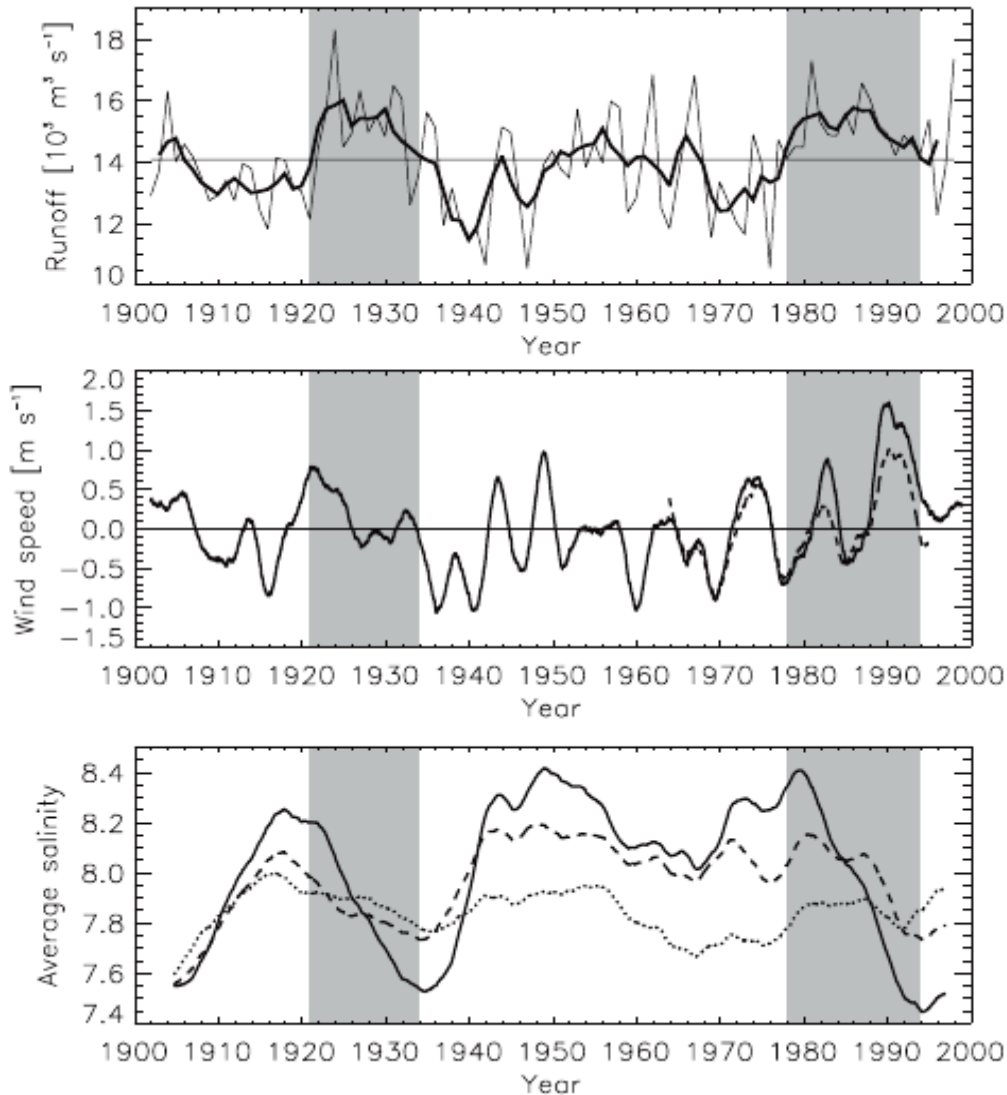
Salinity is an elementary factor controlling the ecosystem of the Baltic Sea

BACC 2008:

- no long-term trend in the mean salinity for the 20th century

- half of the decadal variability is explained by the accumulated river runoff

- the remaining decadal variability is explained by the zonal wind fluctuations

GC1: Salinity dynamics in the Baltic Sea

ICES sd28tso2sig Salt interpolated

ICES sd28tso2sig Temp interpolated

ICES sd28tso2sig Oxyg interpolated

Major Baltic Inflows, Matthäus & Franck, 1992

Salinity dynamics in the sub-basins of the Baltic Sea is more complex, and it controls the oxygen distribution in the deep basins.

Major players are:

- Major Baltic Inflows
- Sub-basin water exchange
- Circulation and advection
- Net precipitation and runoff
- Turbulent mixing

GC2: Land-Sea biogeochemical feedbacks in the Baltic Sea region.
Gregor Rehder, Karol Kulinski, Ben Smith
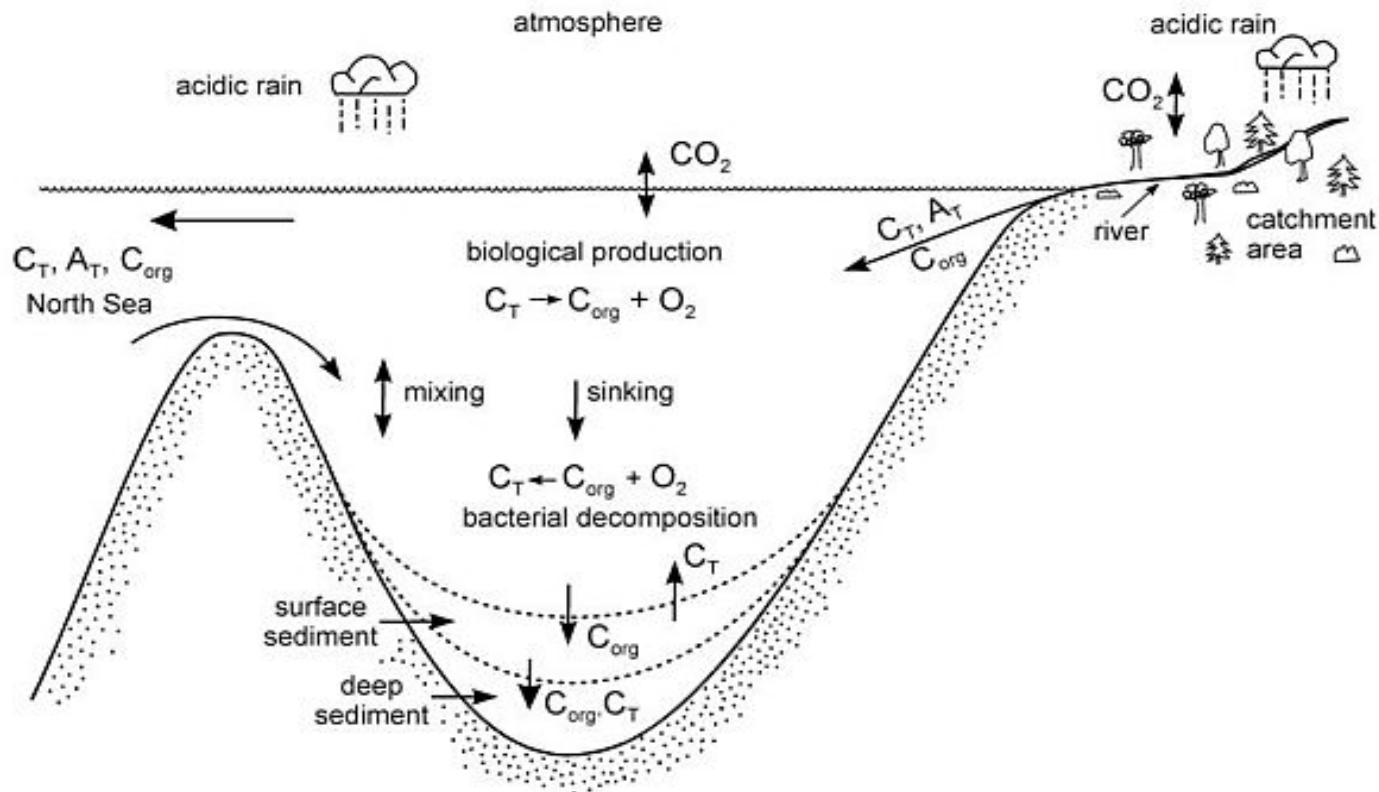
1) Scientific problems: euthrophication, acidification

2) We have a lot of experimental data and sophisticated model tools

3) But there is lack of process understanding – process parametrizations are missing

GC2: Land-Sea biogeochemical feedbacks in the Baltic Sea region.

Suggested specific questions:

a) control of nitrogen fixation,

b) control of production after nitrate depletion caused by the spring bloom

c) bioavailability of N,P inputs,

d) terrestrial inputs as a forcing for biogeochemical processes

e) influence of DOM on the acid-base system,

f) burial of organic carbon in sediments

g) these are examples - the list is not closed.

GC3: Natural hazards and extreme events in the Baltic Sea region.
Anna Rutgersson, Jaari Haapala

- Meteotsunami: a long tsunami-like wave of meteorological origin
- Destructive in extreme cases, but only locally
- Occur in shallow seas with suitable topography

1) Focus:

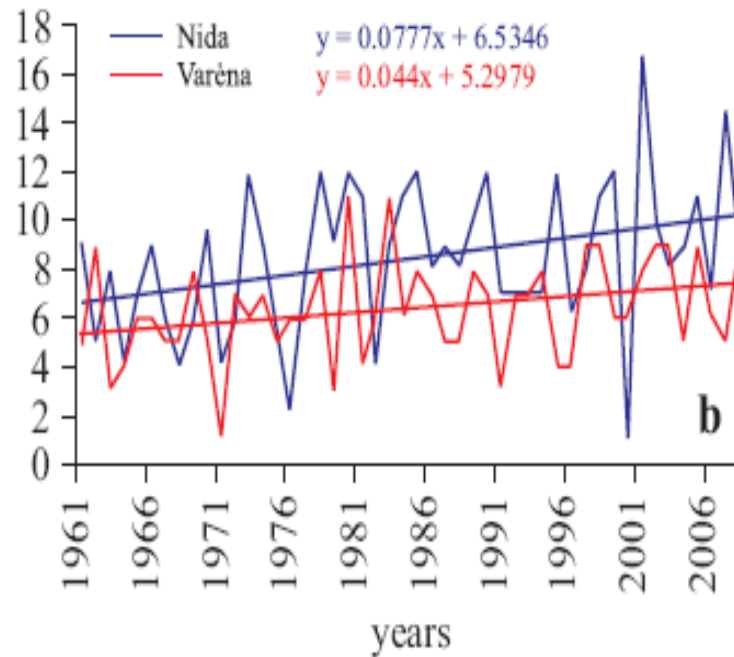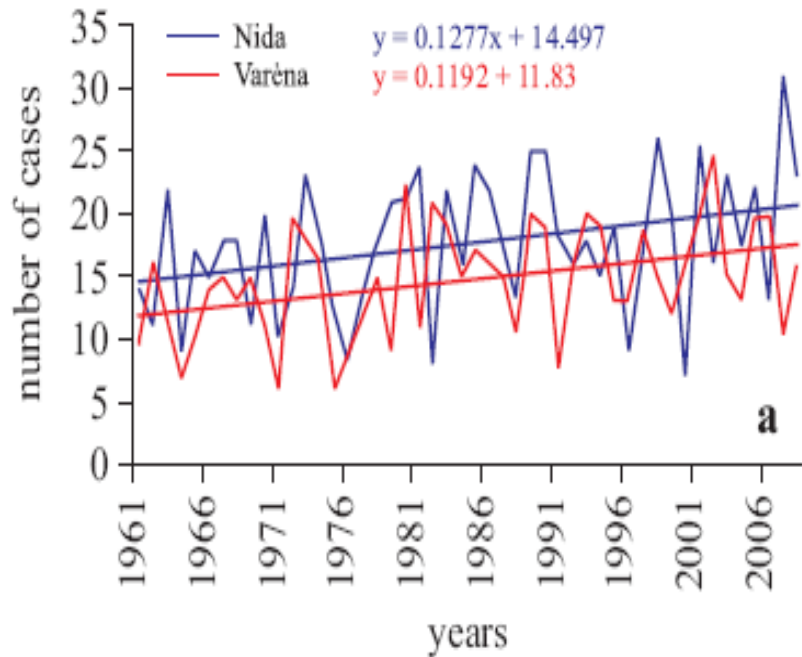Frequency and predictability of extreme hydrometeorological events.

2) Importance:

Infrastructure, safety, ecoystems.

Rissaga in Ciutadella harbor, Menorca

# GC3: Natural hazards and extreme events in the Baltic Sea region.

Number of days with heavy precipitation in Lithuania. (Rimkus et al 2011).

Suggested specific questions:

a) Changes in Atmospheric circulation in the NH and the impact on extremes.

b) Response of marine processes to changes in extremes and variability.

c) Monthly to seasonal prediction systems and probabilistic estimates of the extremes.

d) How vulnerable is drinking water security to hydrometeorological extremes

e) How will the carbon cycle of the Baltic region respond to changes in extreme.

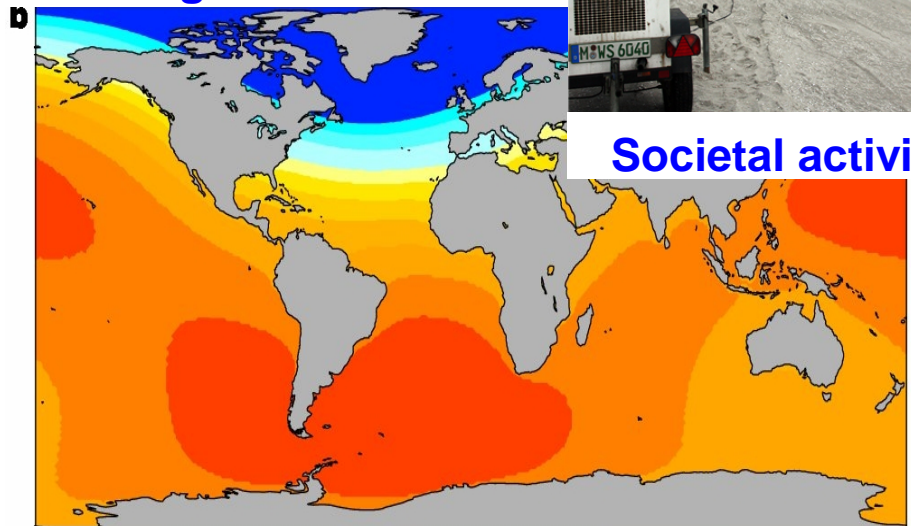# GC4: Understanding sea level dynamics using remote sensing.
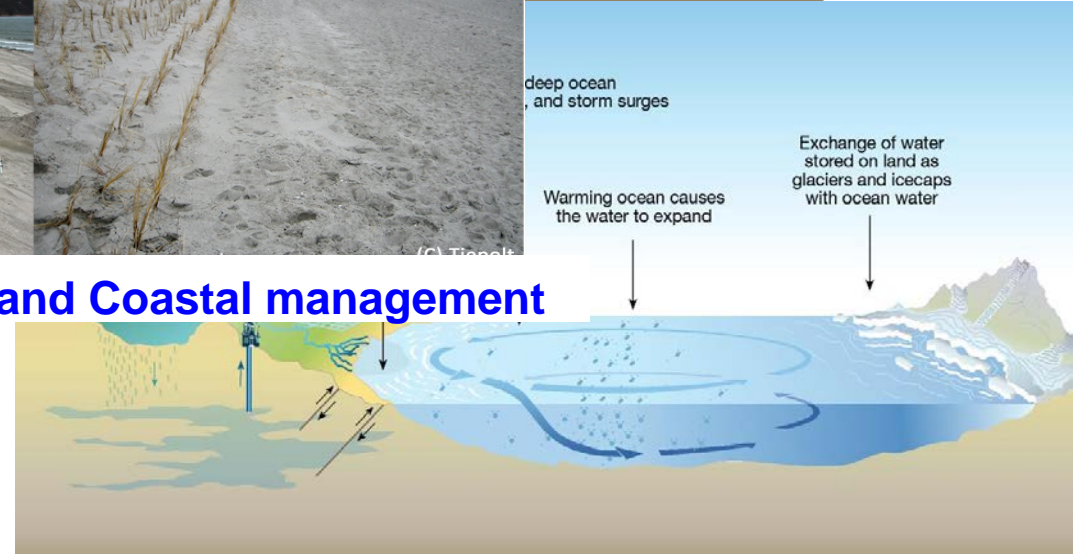## Eduardo Zorita, Anders Omstedt
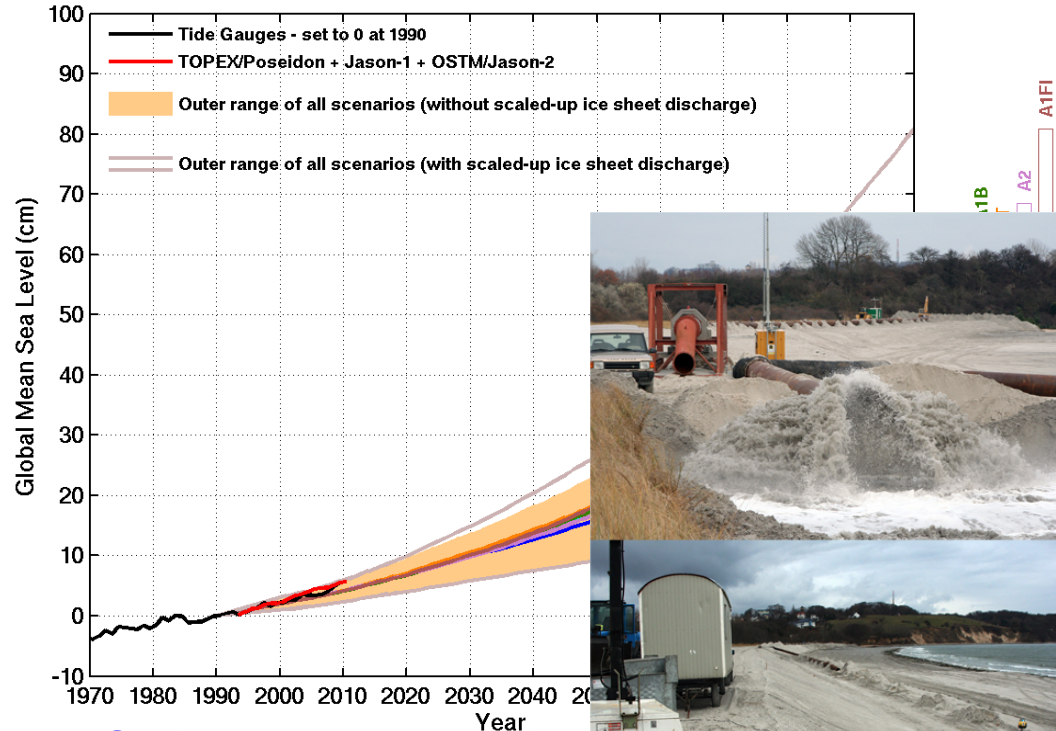
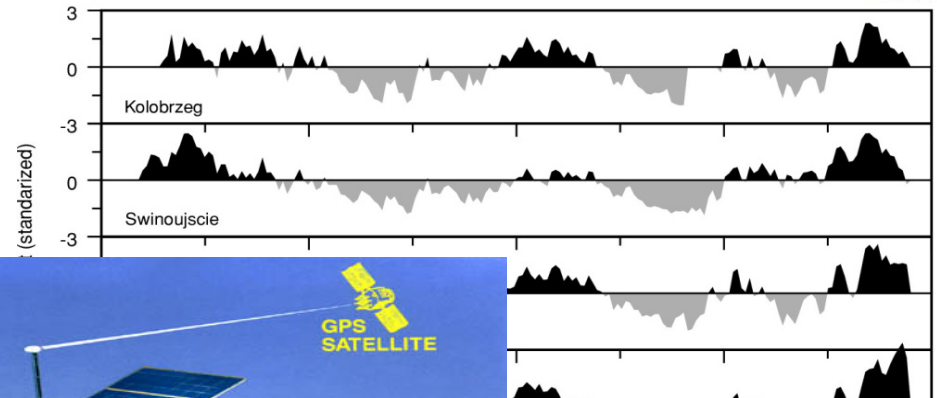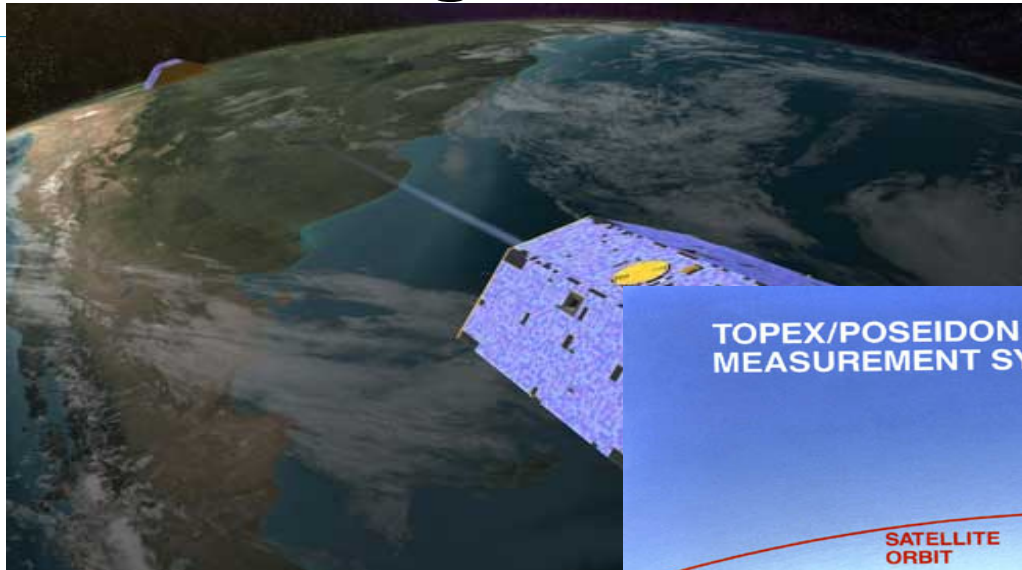**Melting and crustal deformation**
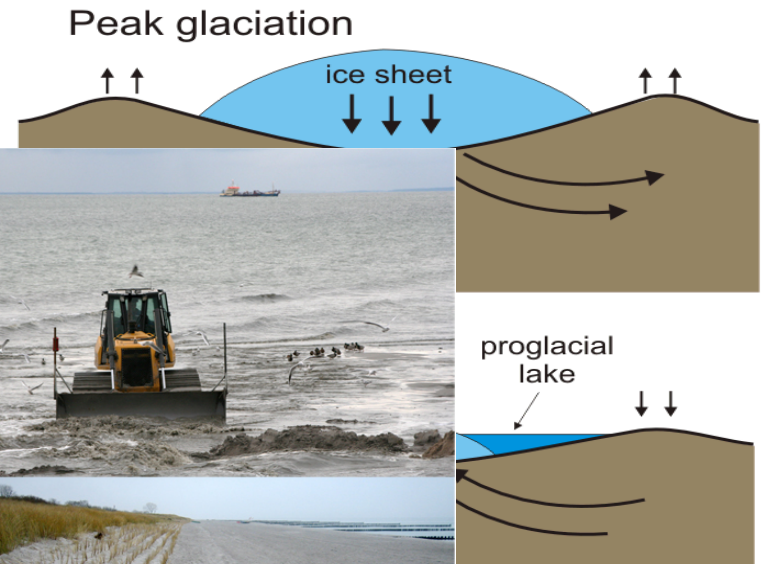
Self-gravitational effec

Societal activities and Coastal management

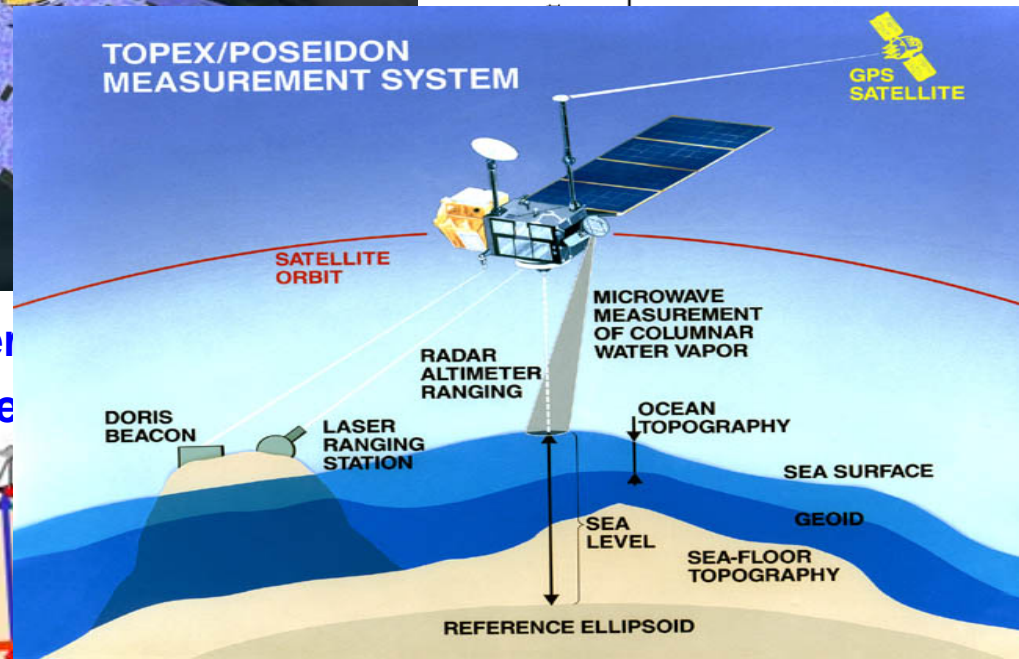**Regional drivers**

GC4: Understanding sea level dynamics using remote sensing.

GRACE (Gravitation recover... experiment), water integrate...

...standing multidecadal

Measuring not only coastal sea-level
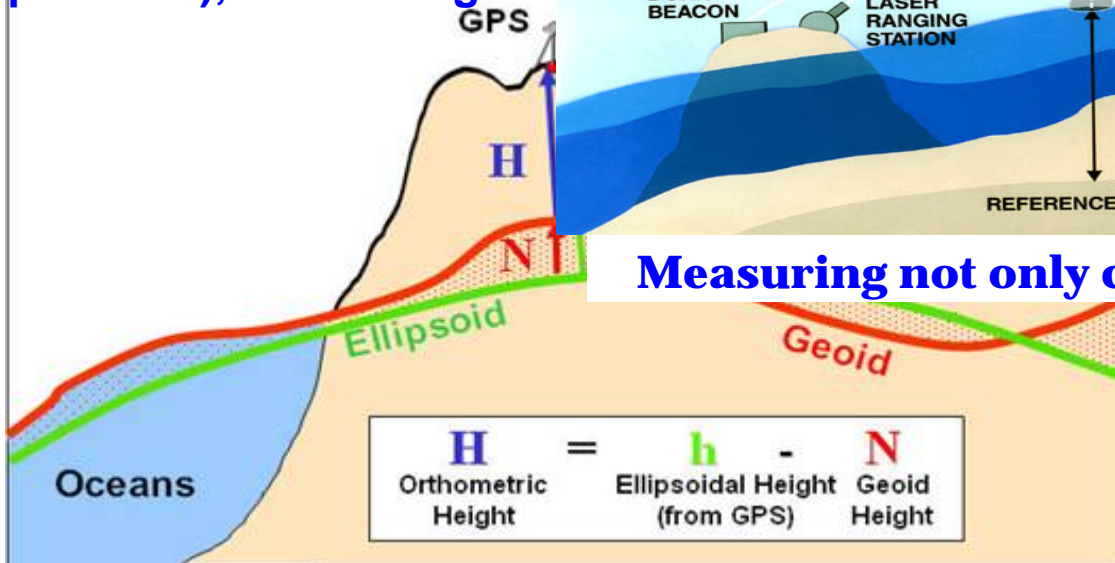
Measuring crust deformation by GPS
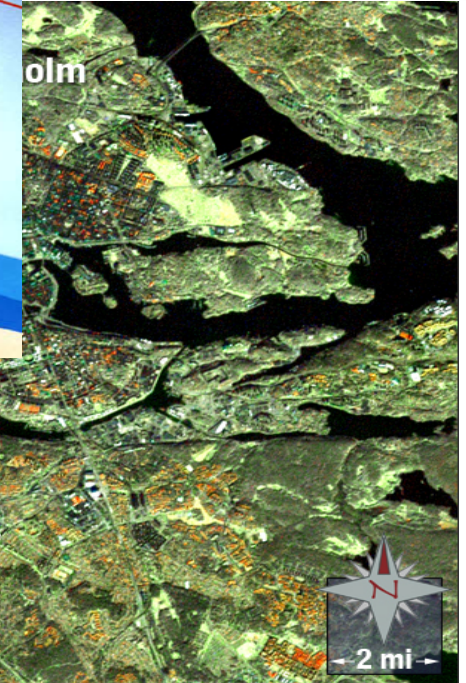
Landsat: Measuring the coastal morphology

TOPEX/POSEIDON MEASUREMENT SYSTEM

GPS SATELLITE

SATELLITE ORBIT

RADAR ALTIMETER RANGING

MICROWAVE MEASUREMENT OF COLUMNAR WATER VAPOR

DORIS BEACON

LASER RANGING STATION

OCEAN TOPOGRAPHY

SEA SURFACE

GEOID

SEA LEVEL

SEA-FLOOR TOPOGRAPHY

REFERENCE ELLIPSOID

Kolobrzeg

Swinoujscie

GPS

H

N

Ellipsoid

Geoid

Oceans

$$H = h - N$$

Orthometric Height = Ellipsoidal Height (from GPS) − Geoid Height

GC5: Anthropogenic changes and impact on Earth system of the Baltic Sea region.
Hans von Storch

A natural extension to understanding the dynamics of the Baltic Sea region earth system is to then understand how humans impact and affect these dynamics.

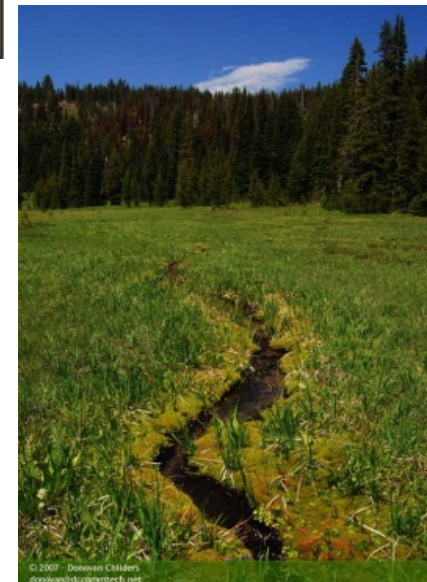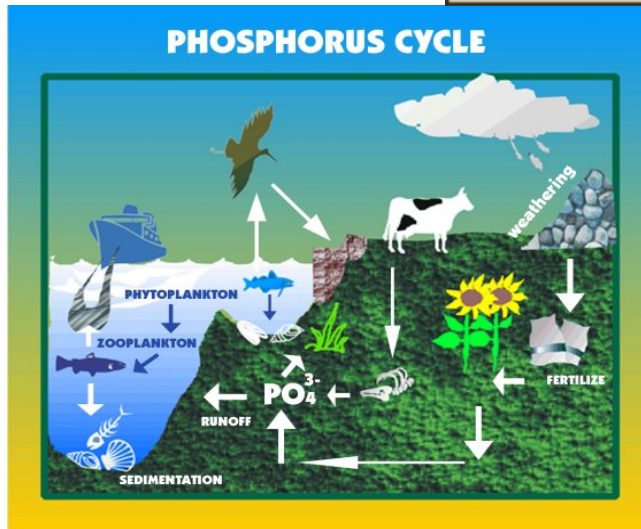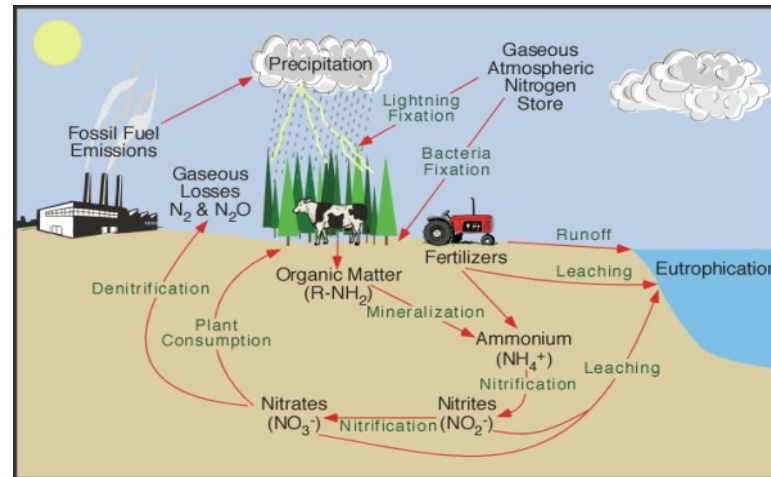# GC5: Anthropogenic changes and impact on Earth system of the Baltic Sea region.

Focus Points

1. ***Describing anthropogenic forcings and their development in time in earth system models*** - Anthropogenic change can be complex and unpredictable, yet to take into account anthoprogenic factors in earth system models requires simplifications of anthropogenic behaviour and change

2. **Attribution of observed changes to the correct anthropogenic drivers** – The physical and biogeochemical cycles of the earth system are complex and it can difficult to attribute changes in nutrients, for example, to a single factor.

3. **Simulation and validation of simulations of changes to anthropogenic drivers**. - simulation models make assumptions regarding the effects of anthropogenic drivers on various parts of the earth system. There remains large scope to verify such assumptions against the effects of historical anthropogenic changes

GC6: Understanding of regional/local variabilities of water and energy exchanges.
Franz Berger, Sergey Zhuravlev

This BALTIC Earth grand challenge contributes to the WCRP grand challenges and the GEWEX science questions and continues some efforts of the past Baltic Sea Experiment BALTEX.

The key activities are:

- *The observation of atmospheric processes*, characterization of uncertainties of ABL processes, the observation of atmospheric exchange processes from surface to the top of the Atmosphere at different climate scales for various spatial scales.

- *The diagnosis of natural variability of energy and water components,* which includes changes in extremes.

GC6: Understanding of regional/local variabilities of water and energy exchanges.

The key activities continued:

- *The improved description and modelling of atmospheric processes*
to simulate the regional/local energy and water cycle with parameterizations
considering e.g. an improved understanding of cloud-aerosol-feedback
mechanisms, of cloud processes and of atmospheric boundary layer processes.

- *The extended and continuous evaluation of atmospheric processes*
with conventional meteorological/hydrological observations, with
surface based and satellite based remote sensing.

- *The modelling/prediction of short- and long-term water and energy
exchanges* of the past century and of the future century to provide a
significant service to the people of the Baltic Sea region.

Work of WGs

- Continue the discussion of identifying GCs at workshops and meetings.
- Define a research plan identifying research needs.
- Writing review paper, stating present knowledge and research needs.
- Pursue the research by research applications.

Are these the Grand Challenges?

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