6. Attributing causes of regional climate change 6.2 Global warming
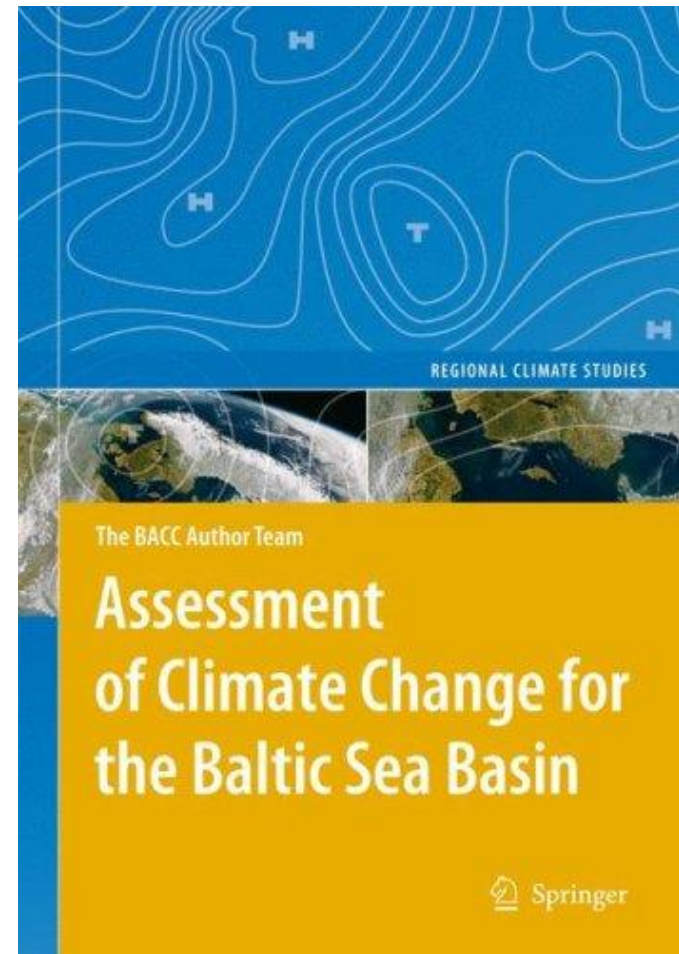
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Relevant statements in BACC I (2008)

- Introduction of philosophy of the detection and attribution (DnA) approach
- Lack of formal DnA studies for the Baltic area

REGIONAL CLIMATE STUDIES

The BACC Author Team

Assessment of Climate Change for the Baltic Sea Basin

Springer

Sub-chapter outline

6.2 Global warming

    6.2.1 Introduction and scope

    6.2.2 Processes causing global warming

    6.2.3 Causes of changes in temperature

    6.2.4 Causes of changes in circulation and the hydrologic cycle

    6.2.5 Causes of changes in the Baltic Sea

    6.2.6 Causes of climate change impacts

Sub-chapter outline

Redundancy?
Ch. 2 Paleoclimate

6.2 Global warming

    6.2.1 Introduction and scope

    6.2.2 Processes causing global warming

    6.2.3 Causes of changes in temperature

    6.2.4 Causes of changes in circulation and the hydrologic cycle

    6.2.5 Causes of changes in the Baltic Sea

   6.2.6 Causes of climate change impacts

6.2.1 Introduction and scope

- Approach in BACCII: Cascade of evidence
  - Formal detection and attribution studies of varying spatial scale (regional studies and global studies providing regional detail)
  - Consistency of recent observed and simulated changes Necessary but not sufficient criterion for attribution
- What is detection and attribution?
  - Detection: 'Observed change is significantly different from internal variability'
  - Attribution: 'What combination of external forcings explains best the detected change?'
- Why is regional DnA difficult?
  - Low signal-to-noise, model biases, additional forcings

6.2.2 Processes causing global warming …

- Very broad-brush overview of processes causing global warming and their contributions to 20th century warming
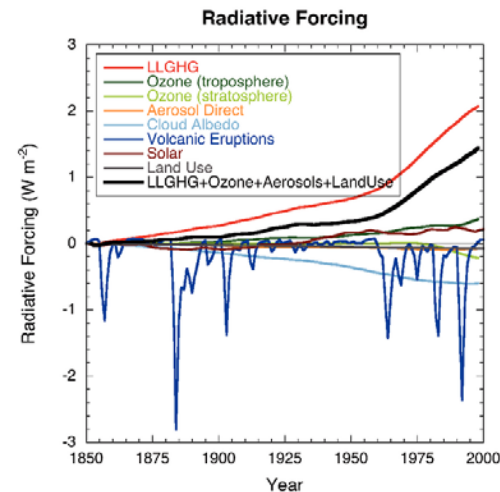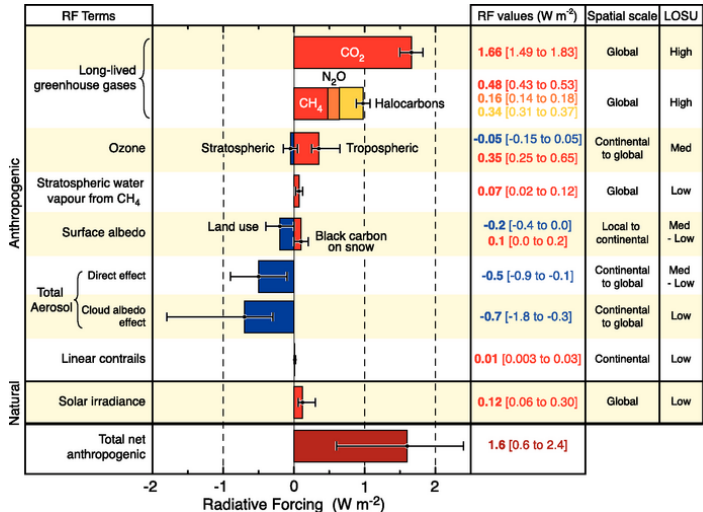
- How we can use the different spatio-temporal patterns of the response to discriminate influences

6.2.3 Causes of changes in temperature

- Formal DnA studies detect anthropogenic warming
  - Marginal detectability of warming in Baltic Sea area. Results often dependent on details of analysis, e.g.
    - Anthropogenic influence has increased the likelihood of very warm summers (Jones *et al.,* 2008)
    - Mixed evidence for increasing frequency of very warm seasons (Stott *et al.,* 2011)
  - + Global analyses, paleo-records, consistency, clustering of records
- Temperature extremes
  - External influence is detectable in warmest night but not other indicators, consistent with anthropogenic forcing, not attributable
- Caveats because circulation changes (e.g. NAO) are not yet fully understood → robust for warming in summer

6.2.4 Causes of changes in circulation …

- Global circulation changes detectable, but simulations underestimate magnitude of observed northern hemispheric circulation changes (e.g. NAO)

- Mixed evidence for storminess
  - Geostrophic wind from SLP suggests late 20th century increase is not unusual
  - Northern hemisphere storminess detectable but simulations underestimate change
  - Increase in storminess in 20th century reanalysis (Donat *et al.*, 2011)

6.2.4 … and the hydrological cycle

- Global warming signal in precipitation is less clear (CC-response modulated by circulation changes, short-term forcings more important)

- Evidence for detectable human influence on precipitation globally, in the Arctic and on precipitation extremes

- Observed regional changes inconsistent with (stronger than) simulated anthropogenic response

- Changes in 'hydrologic variables' such as streamflow and snow potentially detectable but no formal assessment available

6.2.5 Changes in the Baltic Sea

- Warming detected and attributed in world oceans (not including the Baltic Sea)
- Reconstructions suggest that recent warming in the Baltic is not unusual in the light of historic changes
- Salinity changes difficult to detect due to complex (episodic) interaction with North Sea
- Sea ice would lend itself for detection and attribution – no formal assessment so far

- Not quite sure whether there is enough material to justify a separate sub-section

6.2.6 Causes of climate change impacts

- Pitfalls and caveats when trying to attribute change in complex 'sociobiogeophysical' systems

- Outline of potential ways forward following IPCC experts:
  1. **Single-step attribution:** using modelling set up to quantify influence of all relevant drivers and uncertainties
  2. **Multi-step attribution:** Attribute changes in atmospheric parameters, attribute changes in impacts (to certain atmospheric parameters) and quantify overall uncertainty
  3. **Associative pattern attribution** (Rosenzweig *et al.,* 2008)

- Most examples for Baltic Sea area lack regional focus or quantification of uncertainties

The take-home message

We do understand regional warming

- Anthropogenic signal emerging at the regional scale with first successful detection and attribution of warming
- Detectability still marginal

We do not understand non-thermal changes (e.g. circulation)

- Underestimate circulation and precipitation changes
- Conflicting evidence, data issues