I don't know, are you sure you want to do this?

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Abstract. ...

1. Introduction

2. Sea level projections (PG)

2.1. Global sea level

Most climate models do not explicitly provide sea level as an output of the calculations. Rather, the IPCC AR5 report [*Stocker et al.*, 2013, ch. 13] combines the heat expansion of the ocean with temperature forced models for glacial melt, Greenland ice melt, and Antarctic ice melt and with land rise due to rebound from the last ice age. Judging from the supplementary material to *Stocker et al.* [2013, ch. 13], the uncertainty assessment is only based on the spread of the ensemble of temperature projections, not on the additional uncertainty in the ice models used.

We will instead use the empirical approach of Rahmstorf and collaborators [*Rahmstorf*, 2007; *Rahmstorf et al.*, 2011], employing the statistical modeling of *Bolin et al.* [2014] to relate global annual mean temperature anomalies [*Hansen et al.*, 2001] to global mean sea level anomalies [*Church and White*, 2011].

We then apply the estimated historical relationship to projected temperatures from the CMIP5 experiment [*Taylor et al.*, 2012] to obtain projected global annual mean sea level, taking into account the uncertainty in the statistical model as well as the spread of the temperature projection ensemble (see subsection 2.3).

2.2. Local sea level

In order to get from global sea level projections to local ones, it is important to note that sea level rise not is uniform over the globe. Glacial and land ice melting affect the local sea level differently depending on where the melted ice is located. Another major effect in Fennoskandia is the land rise due to isostatic rebound from the glaciers of the last ice age. Again, we will use historical data to relate global sea level to isostatically corrected local sea level using a time series regression model.

The local sea level projections are then obtained by first relating projected temperature to global sea level, and then relating the global sea level to the local one. Each climate model temperature projection yields a different local sea level projection.

2.3. Uncertainty assessment

Following the approach of *Guttorp et al.* [2014] we assess the uncertainty in the local sea level projections taking into account the variability between the climate projections used, the uncertainties in the regressions of global mean temperature on global mean sea level and of global on local sea level. We express the sea level projection uncertainty in terms of a confidence band that is simultaneously of the intended level for all projection years. This allows us, for example, to get a confidence band for the years when a given sea level rise is obtained.

2.4. Limitations of the sea level projections

The main assumption is using historical relationships in statistical projections of the type used in this paper is that there is no major change in how temperature relates to sea level, globally and locally. Among the factors that may invalidate this approach are changes in water storage on land (removing water from the oceans), excessive siphoning of groundwater (resulting in land subsidence), changes in the rates of glacial and land ice melt, and changes in Earth's gravitational field due to transfer of mass from land ice to ocean water. For example, the rate of ice melt on Greenland may suddenly increase substantially due to intense warming of both air and sea water. Our current climate models are not able to resolve the ice processes sufficiently to include such so called tipping points into the projections. Also, the IPCC scenarios do not include changes in water usage [*van Vuuren et al.*, 2011].

3. Decision tools (KdB, MD, TT)

3.1. Timing of adaptation measures

We consider adaptation decision making related to the timing of proactive adaptation measures. That is, the goal is to adapt to sea level rise before major damages occur. In a cost-benefit framework, an investment should be delayed as long as the benefits of delay (avoided investment costs) are greater than the associated costs (higher climate change damages) [*Fankhauser et al.*, 1999].

Fankhauser et al. [1999] describe a deterministic framework where an adaptation investment of C^0 now (at time $n = 0$) leads to unmitigated damage of d_0^0 in period 0, and a stream of partially mitigated damages d_t^0 in periods $t = 1, 2, \ldots$. If r is the discount rate, the net present value damage, D^0, associated with this investment is

$$D^0 = C^0 + d_0^0 + \frac{d_1^0}{1+r} + \frac{d_2^0}{(1+r)^2} + \cdots \tag{1}$$

In comparison, postponing the adaptation investment to time period $n = 1$ would lead to unmitigated damages in periods 0 and 1, and partially mitigated damages, d_t^1, thereafter. The delay would be preferable if

$$C^0 - \frac{C^1}{(1+r)} > (d_0^1 - d_0^0) + \frac{d_1^1 - d_1^0}{1+r} + \frac{d_2^1 - d_2^0}{(1+r)^2} + \cdots$$

Here, the expression on the left describes the benefits of the delay while the expression on the right describes the cost of the delay. In the simplest case, there is no change in investment costs ($C^0 = C^1 = C$) and the delay has no lasting effects beyond period 1 ($d_t^1 = d_t^0$ for $t > 1$). In this case, the comparison is between the expected return r earned on the captial while implementation is delayed and one addtional time period of unmitigated damage,

$$rC > d_1^1 - d_1^0.$$

3.2. Limitations of the decision framework

4. Case studies

4.1. Data (PG)

4.2. Timing of adaptation measures (KdB, TT)

A case study focusing on and comparing different cities in Norway.

4.3. Selection of adaptation measures(?) (MD)

A case study focusing on Denmark.

5. Conclusions

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