Tipping elements, uncertainty and accountable decision making

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Horizon 2020 Programme

TIPPING POINTS IN THE EARTH SYSTEM

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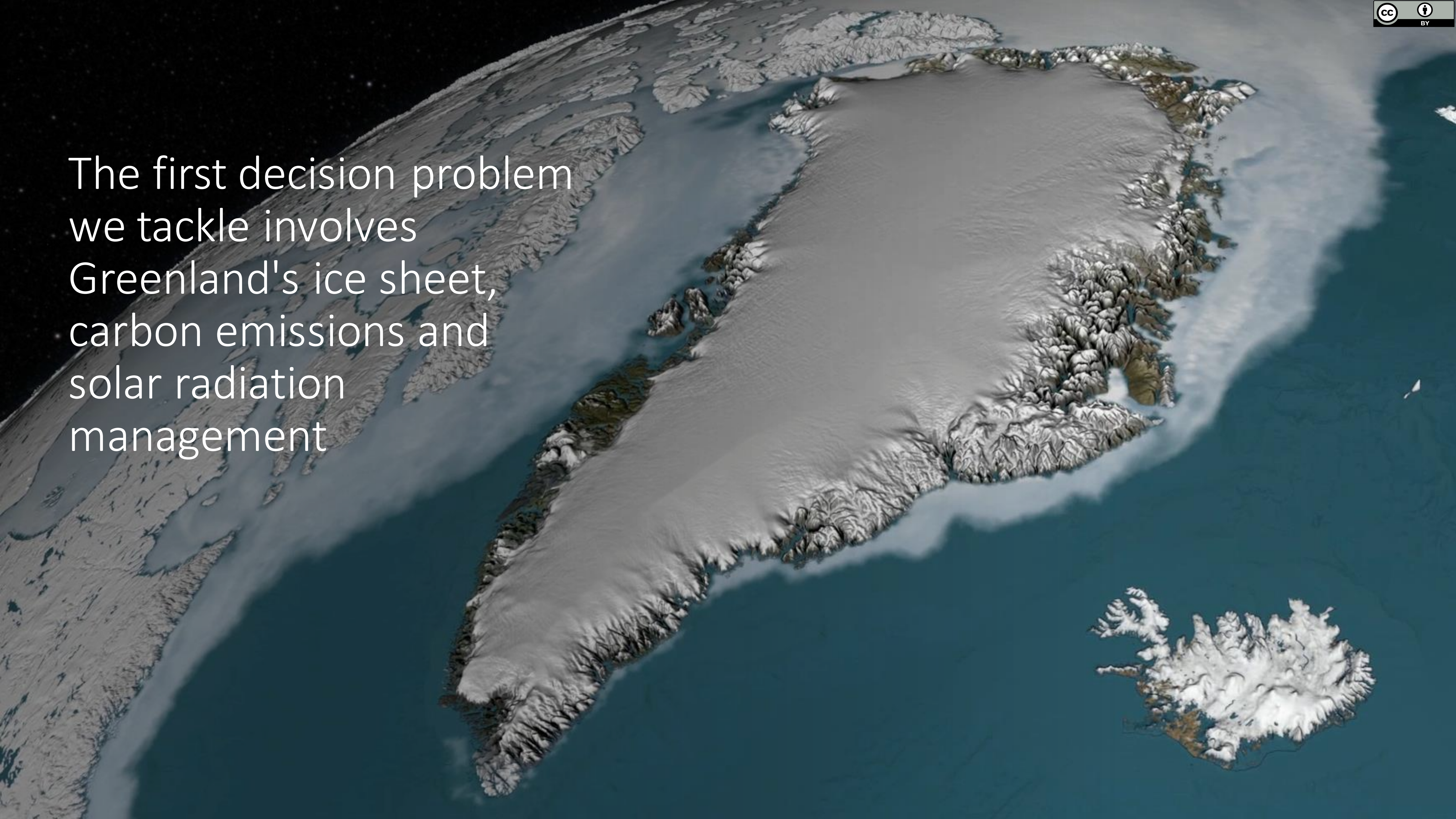
What do we do?

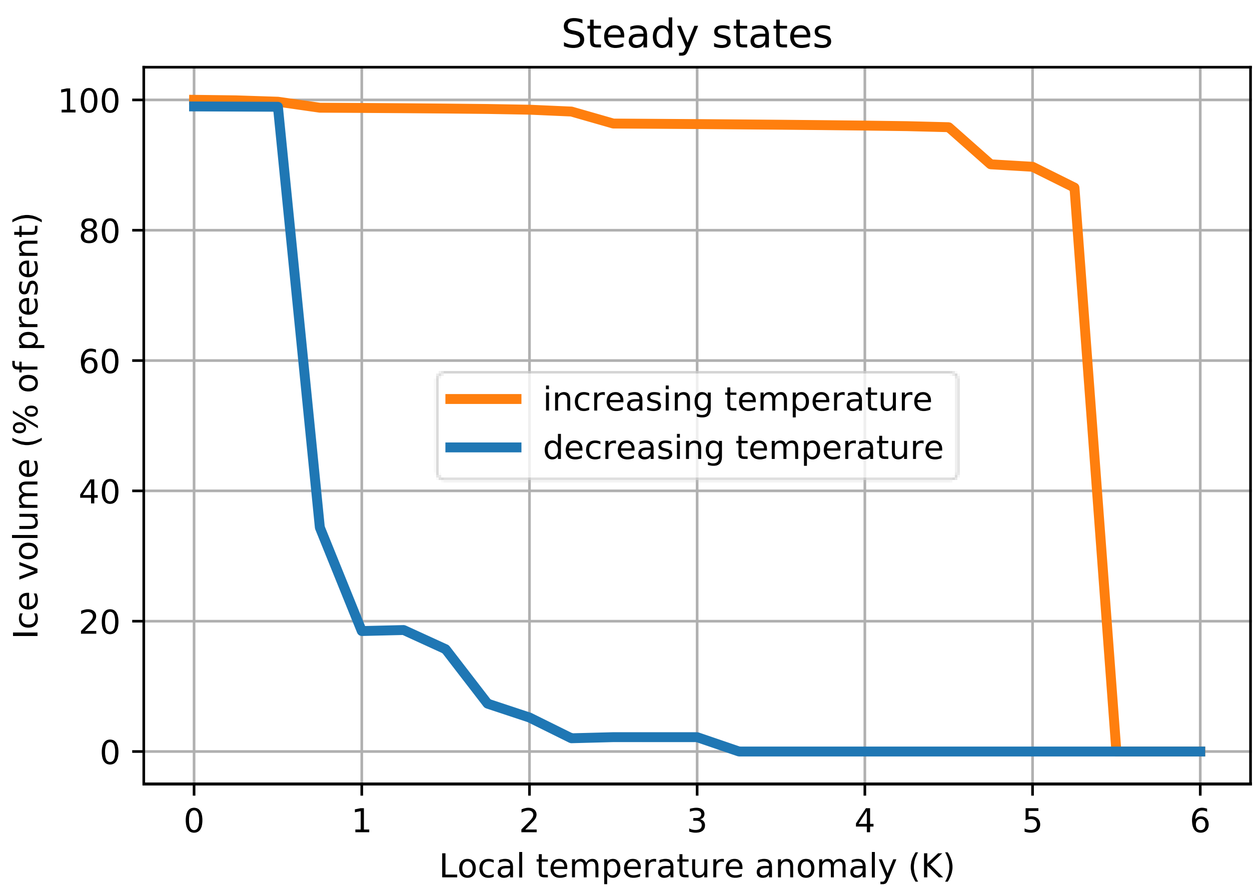
We provide **accountable policy advice**
for urgent and relevant decision problems
in the context of climate change


The first decision problem we tackle involves Greenland's ice sheet, carbon emissions and solar radiation management

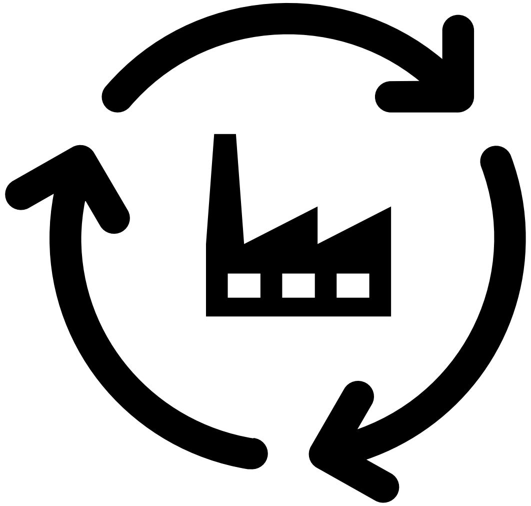
Greenland's ice sheet has an irreversible tipping point

Greenland's ice sheet **can** melt due to global warming if a critical threshold temperature is trespassed

Greenland's ice sheet equilibrium states



We model the evolution of Greenland's ice sheet using a simplified ice sheet model, GRANTISM. See Ref. [1].



Carbon cycle

Many different processes, with a variety of timescales, take part in the carbon cycle.

We simulate the carbon cycle using a simple model called BEAM, see Ref. [2].

BEAM correctly captures the range of timescales relevant from policy to ice dynamics and it is robust against changes in emission scenarios.

Emission decisions made today **can** inevitably take us to a world without Greenland's ice sheet in a few centuries to millennia.

Solar radiation management

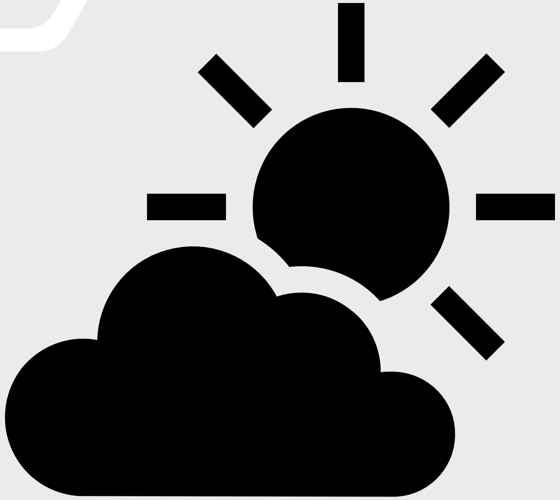
The injection of aerosols into the atmosphere **can** reduce the global average temperature.

Beware!!!

- Aerosols don't last long in the atmosphere.
- They don't "fix" all CO_2 related problems.
- They might come with unknown and unwanted secondary effects.

Can they help in a decarbonisation transition or in avoiding tipping points?

See Ref. [3] for a related problem.



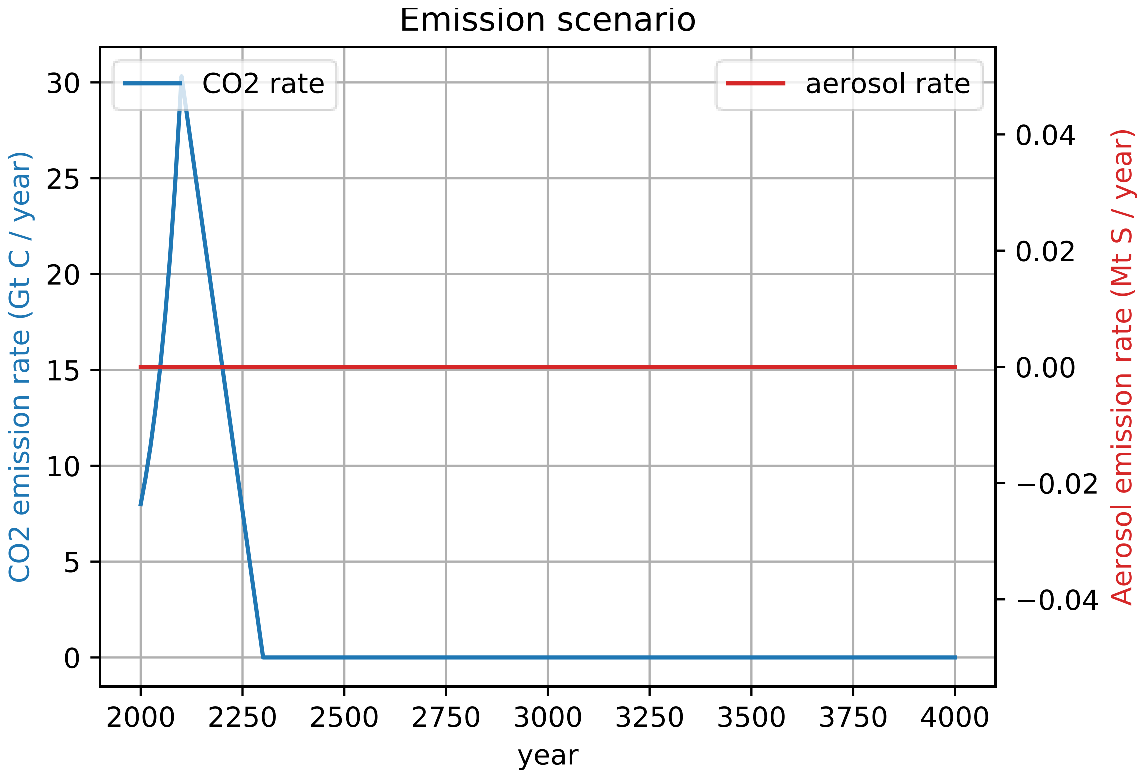
A2 followed by decarbonisation

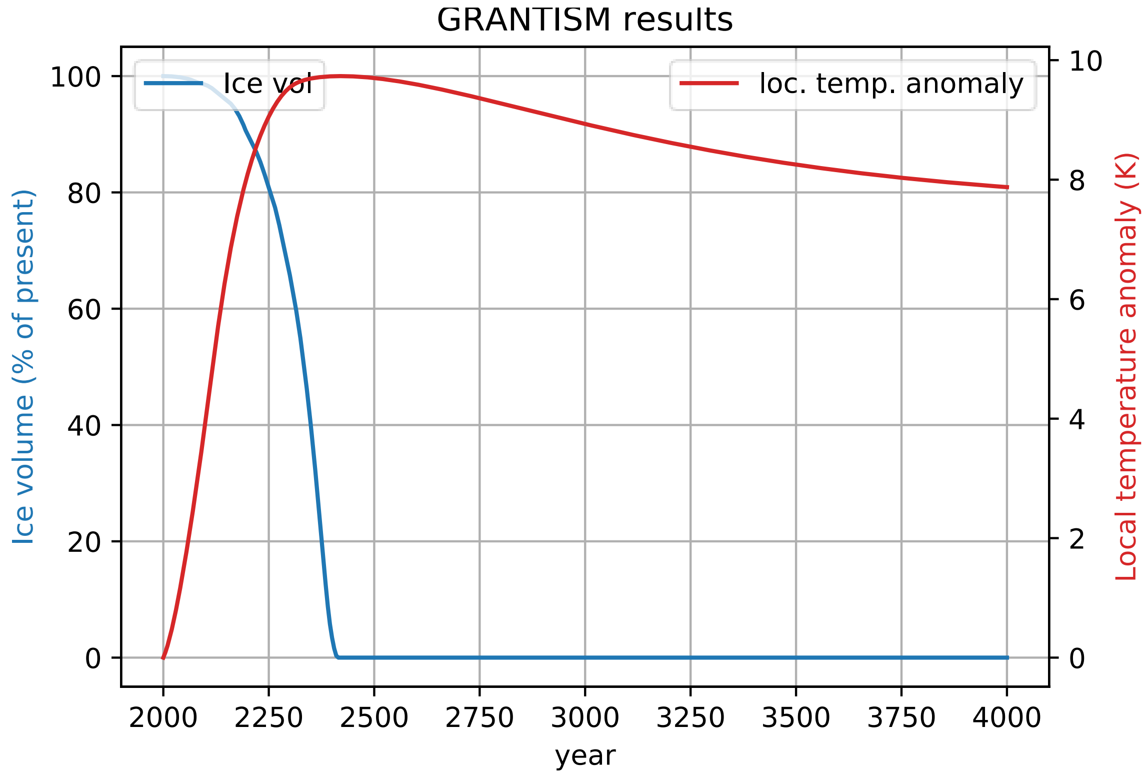
Consider a carbon emission scenario in which we continue business as usual until 2100 and then decarbonise from 2100 to 2300

Can solar radiation management help prevent the melting of Greenland's ice sheet?

A2+decarbonisation scenario with no aerosol injection

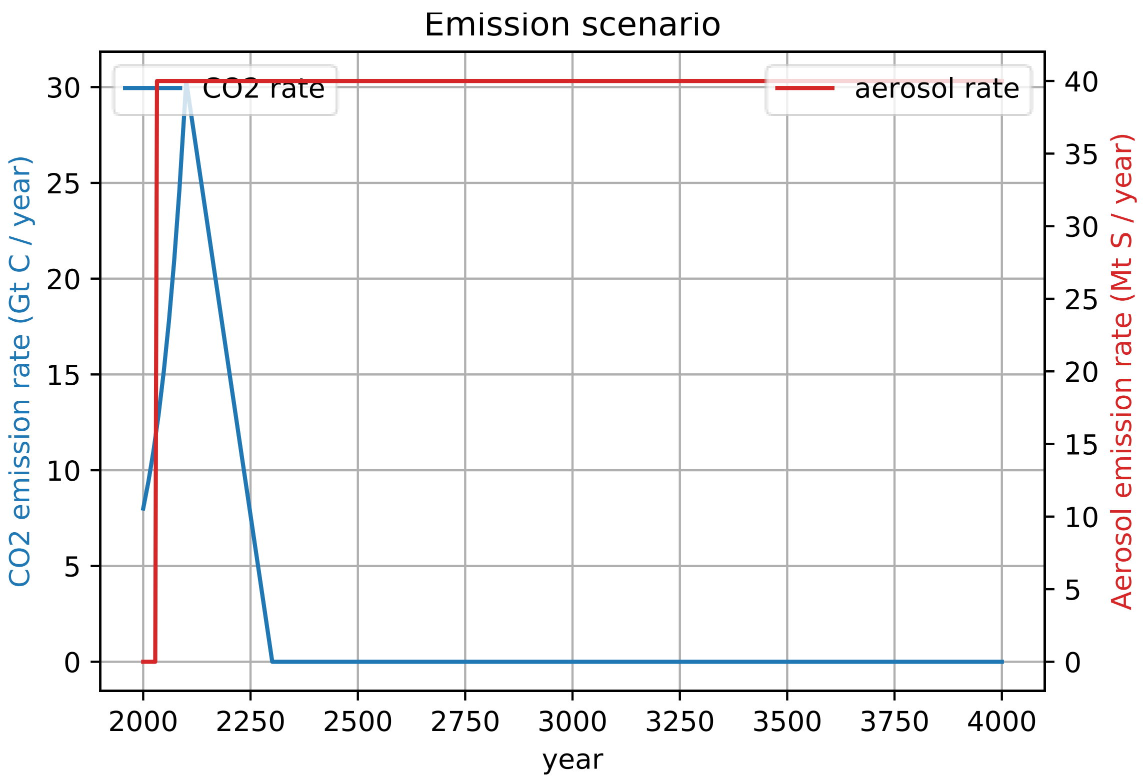
Greenland melts quickly, but the costs and uncertainties related with aerosols are avoided...

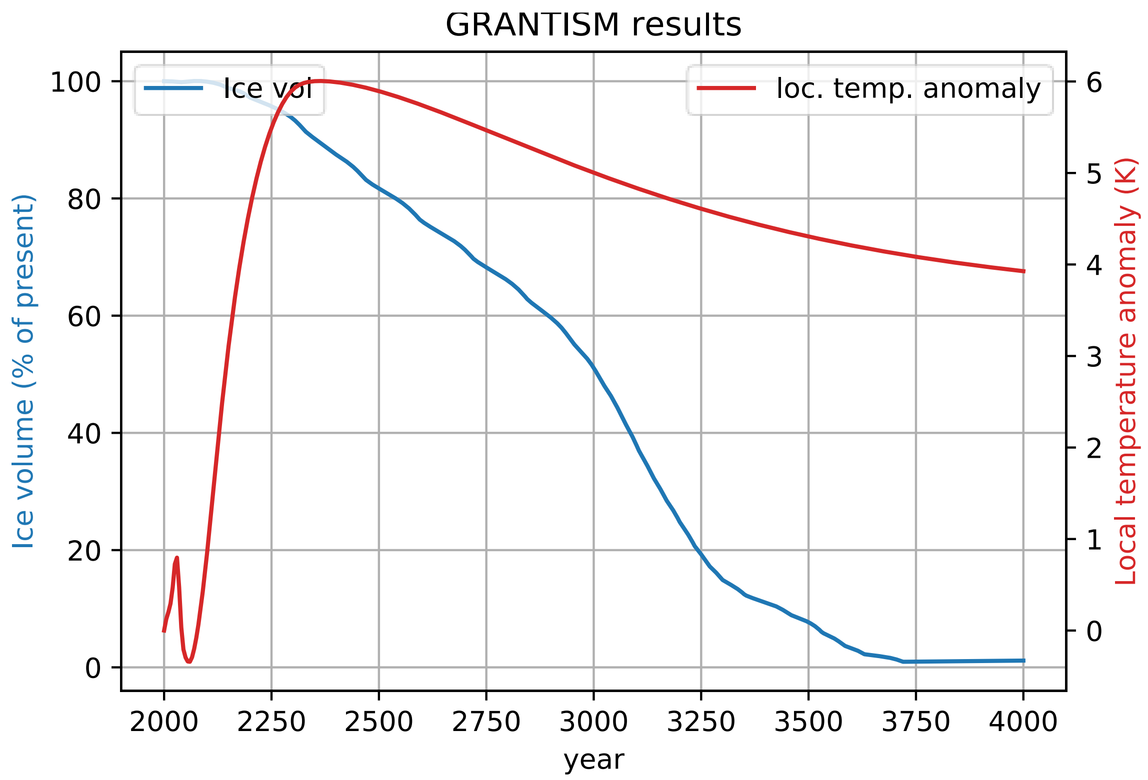




A2+decarbonisation scenario with indefinite medium aerosol injection

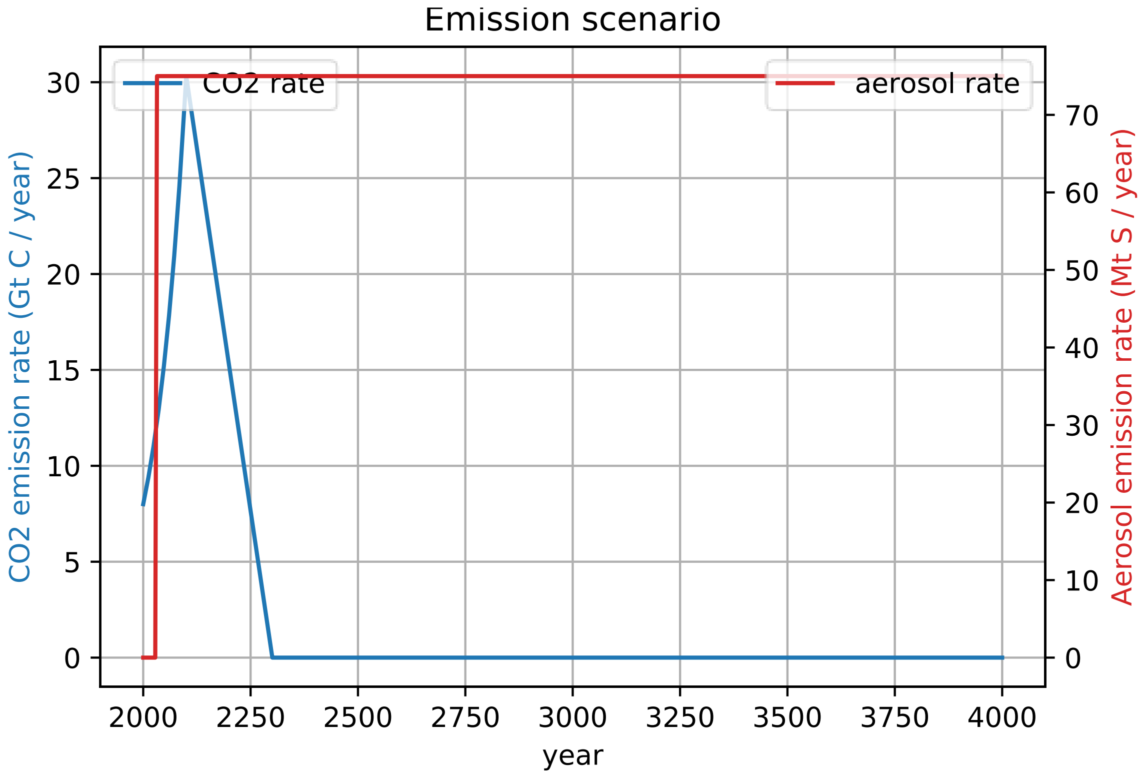
An intermediate but indefinite aerosols injection delays the melting of Greenland...

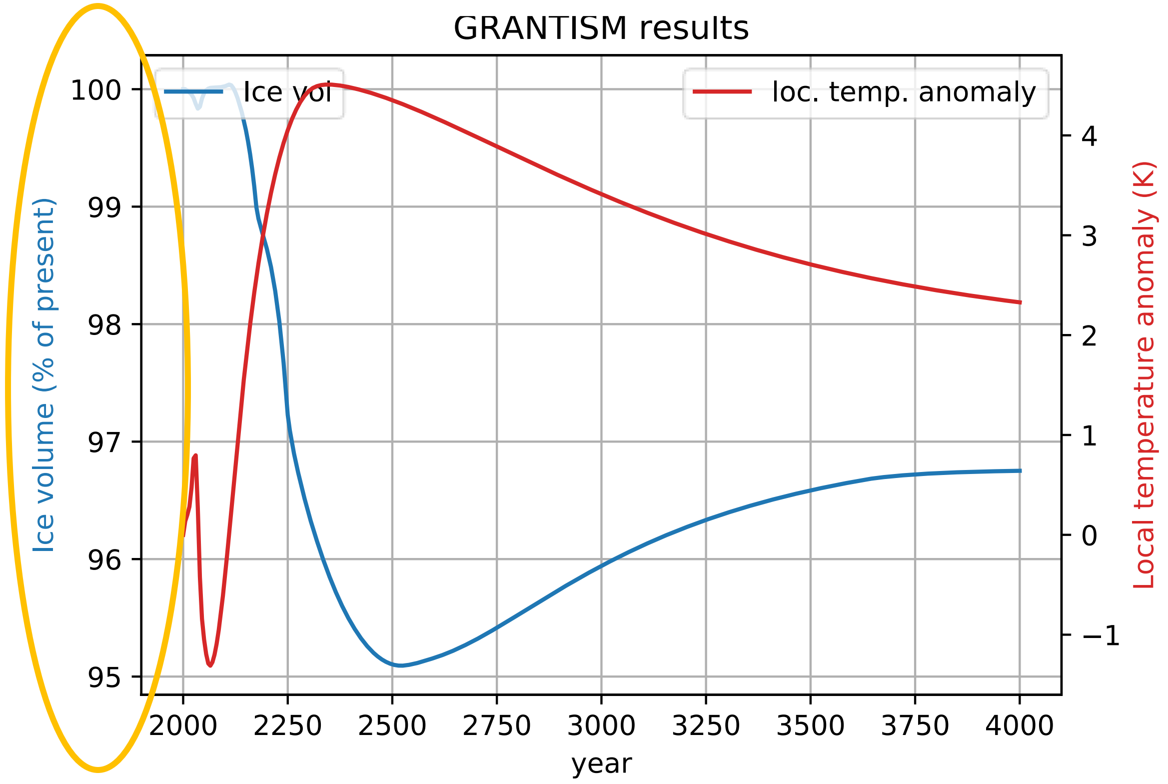




A2+decarbonisation scenario with indefinite high aerosol injection

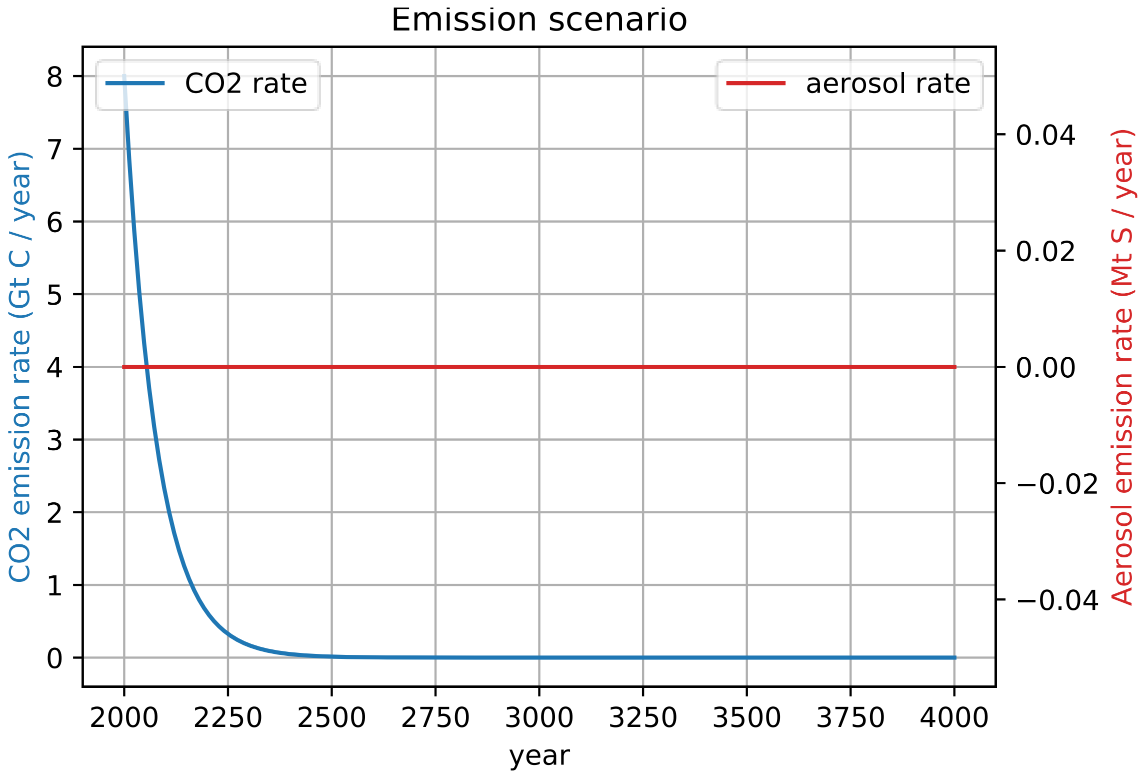
In this case aerosols save Greenland, but... they need to be emitted for more than 2000yrs...
What if at some point, we must stop because of unexpected secondary effects? Is this too risky?

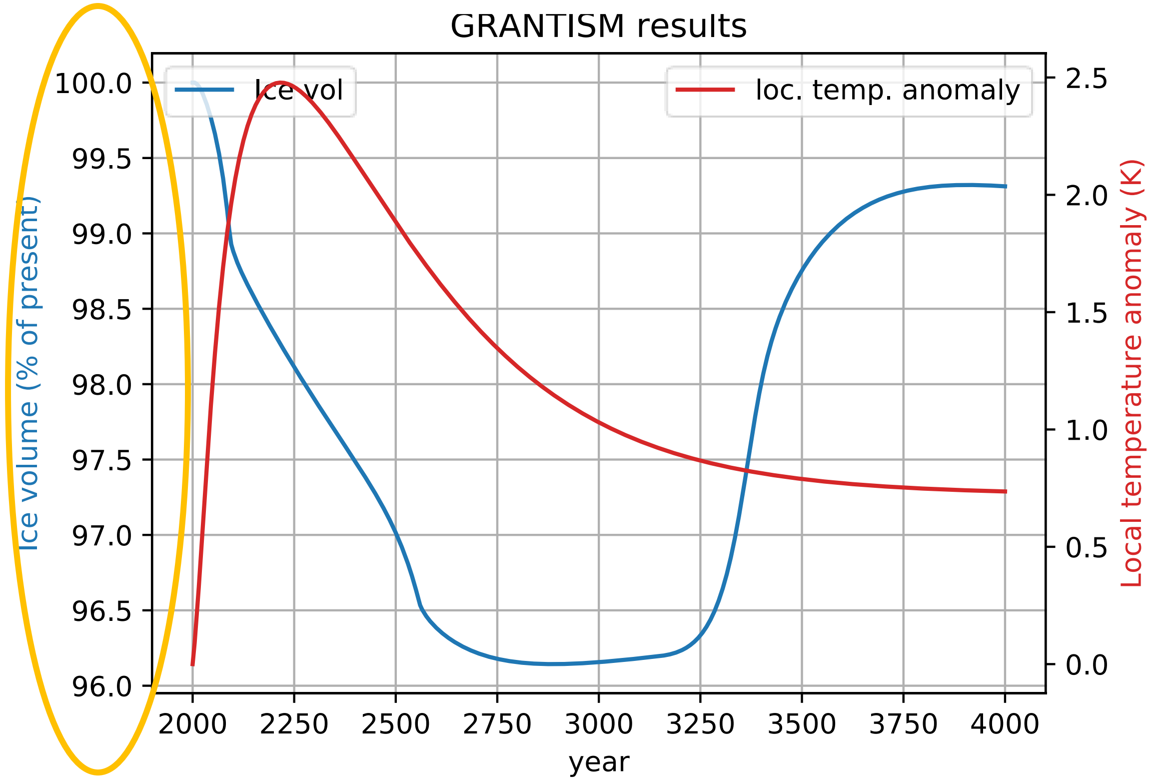


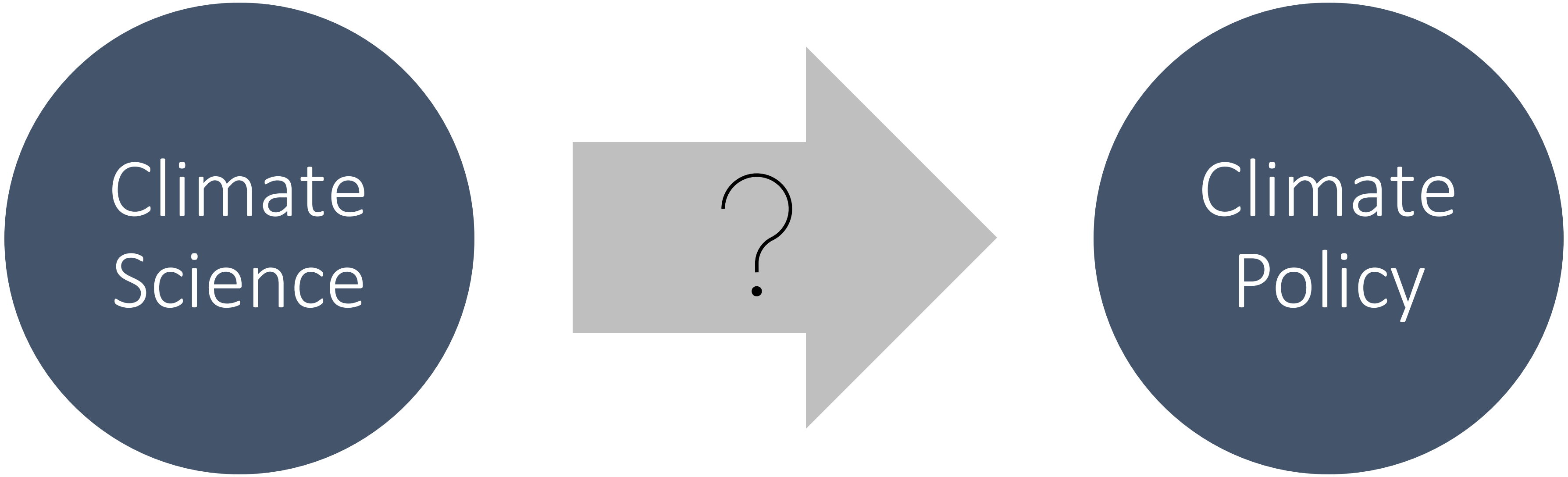


Is it just better to go for fast decarbonisation with no aerosol injection?

Here Greenland is also safe but… Is this option too costly for humanity?





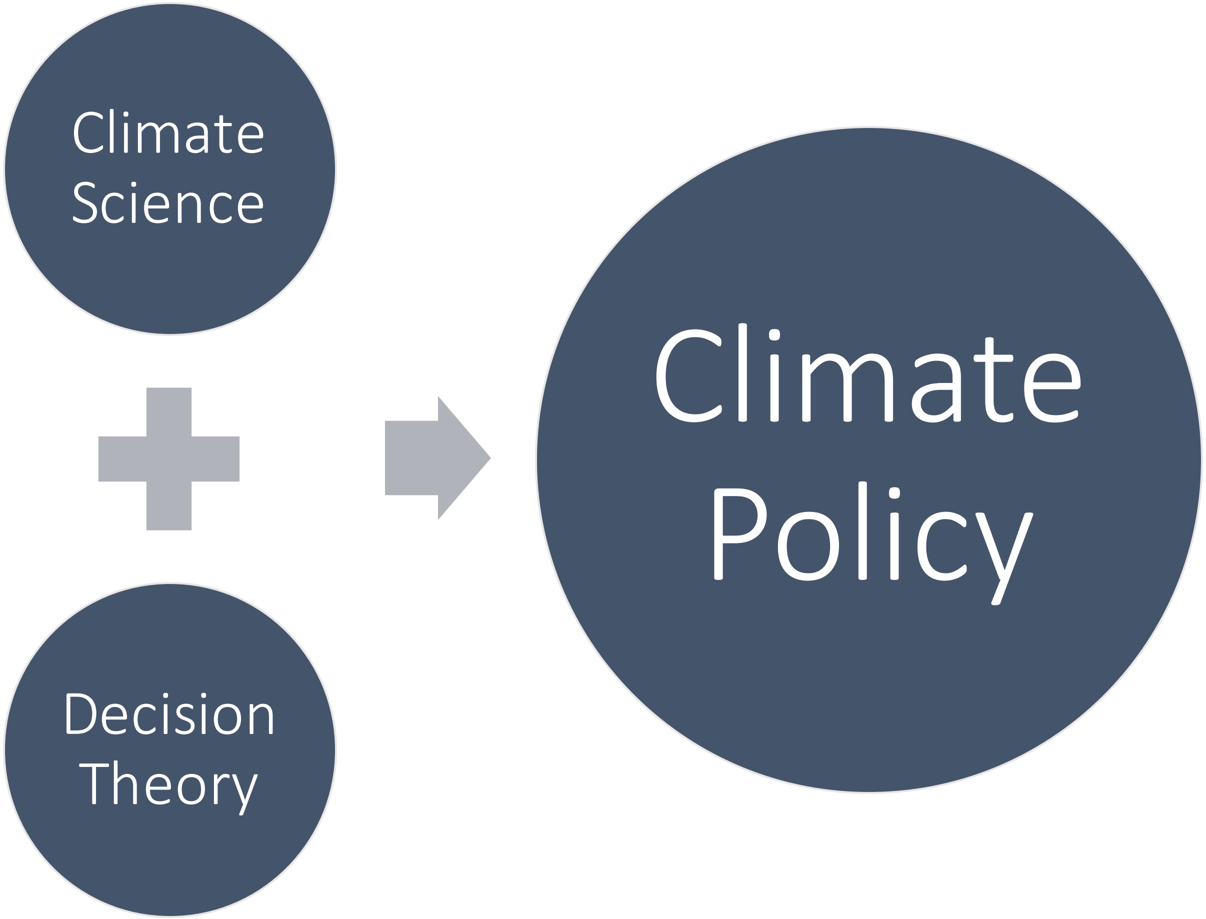


Filling the gap: we know the science but... how do we provide policy advice?

It is not obvious how to directly translate the results of climate research into accountable policy advice.

Decision theory has proven itself very relevant for policy advice, see Ref. [4].

We apply decision theory methods to decision problems in climate.



It is important to keep in mind that…

… there are many judgement calls to be made when posing a decision problem.

What simplifications are we making?
The decision problem needs to remain tractable while capturing enough to be relatable to realistic situations.

What policy options will be available to the policy maker?
Will those options change over time?

How much do we trust the models we consider?
We can't do actual experiments!

What are the criteria for optimality?
Do we consider a discount rate?

Are there uncertain or unknown parameters?
Do we want to consider all of them?

… and there are also a lot of uncertainties

Uncertainties on climate parameters: climate sensitivity, aerosol forcing, tipping points, …

When will solar radiation management become available? …if it will at all.

Are there secondary effects of solar radiation management that we have missed?

How do unexpected catastrophes (wars, pandemics, natural disasters, …) affect the implementation of policies?

The solutions to a decision problem,
i.e., optimal policies,
will inevitably depend on those
judgement calls and uncertainties.

Quantifying the sensitivity of optimal policies
to such judgement calls and uncertainties
is a very important goal for our project.

Formally **verified** methods

- We don't want to add extra uncertainty to the problem through the methods employed in solving the decision problem.
- For such urgent problems we should use methods that give us the **correct** result with 100% confidence.
- The formally verified methods introduced in Botta et. al. 2017 and applied in Botta et. al. 2018 to an emission decision problem, make this possible. See Refs. [5,6].
- By applying those formally **verified** methods we obtain **accountable** optimal policies.
- And we quantify, unequivocally, the effects of judgement calls and uncertainties into accountable optimal policies.

Join the EGU chat!

We are applying the formal methods introduced in Botta et. al. 2017 , see Ref. [5], to the solar radiation management decision problem explained in the beginning.

We are currently working on the specification of the problem and **any comments and remarks are very much welcome!**

References

[1] F. Pattyn, “GRANTISM: An ExcelTM model for Greenland and Antarctic ice-sheet response to climate changes,” Comput. Geosci., vol. 32, no. 3, pp. 316–325, 2006.

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[3] K. G. Helwegen, C. E. Wieners, J. E. Frank, and H. A. Dijkstra, “Complementing CO2 emission reduction by solar radiation management might strongly enhance future welfare,” Earth Syst. Dyn., vol. 10, no. 3, pp. 453–472, 2019.

[4] M. Webster, “Incorporating Path Dependency into Decision-Analytic Methods: An Application to Global Climate-Change Policy,” Decis. Anal., vol. 5, no. 2, pp. 60–75, 2008.

[5] N. Botta, P. Jansson, and C. Ionescu, “Contributions to a computational theory of policy advice and avoidability*,” J. Funct. Program., no. September, 2017.

[6] N. Botta, P. Jansson, and C. Ionescu, “The impact of uncertainty on optimal emission policies,” Earth Syst. Dyn., vol. 9, no. 2, pp. 525–542, May 2018.