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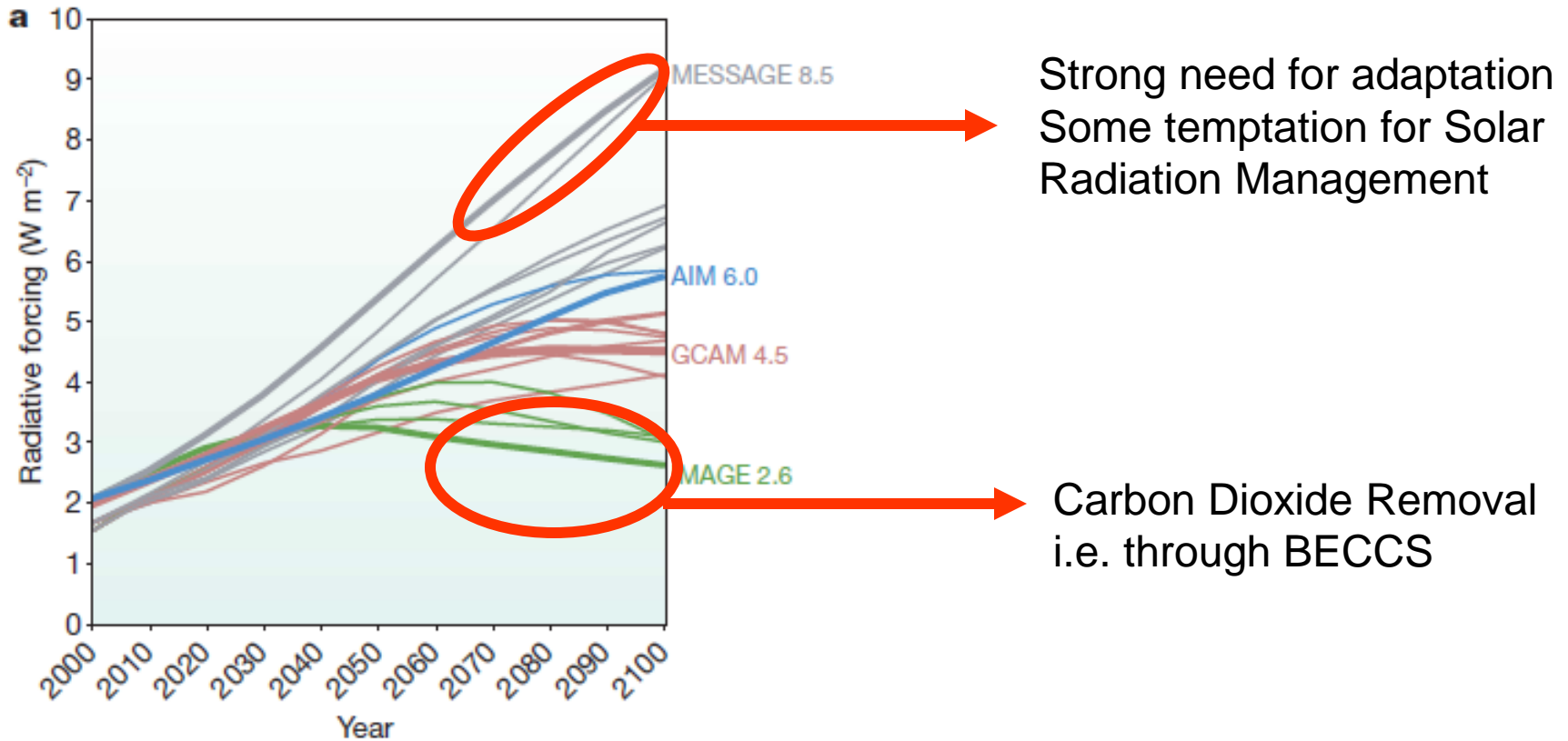
# The role of climate sciences and climate modelling in assessing solar radiation management

**Olivier Boucher**

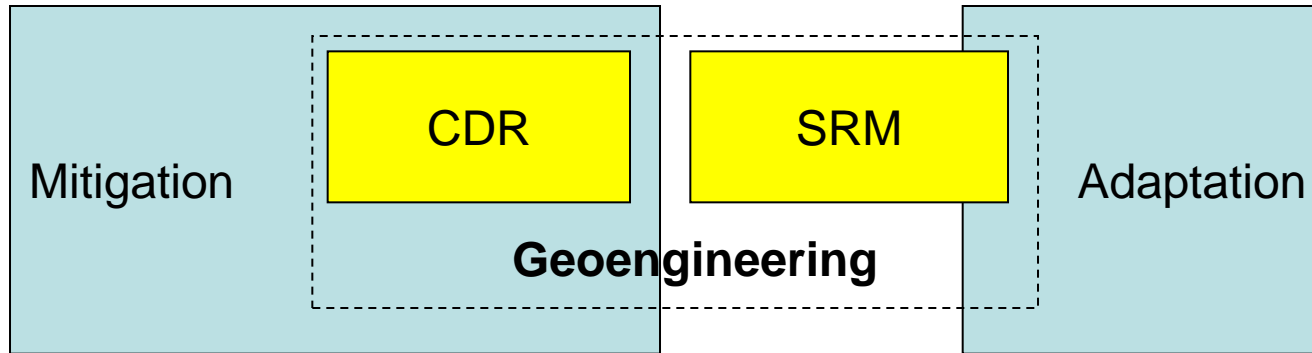
*Laboratoire de Météorologie Dynamique*

**11 October 2013**

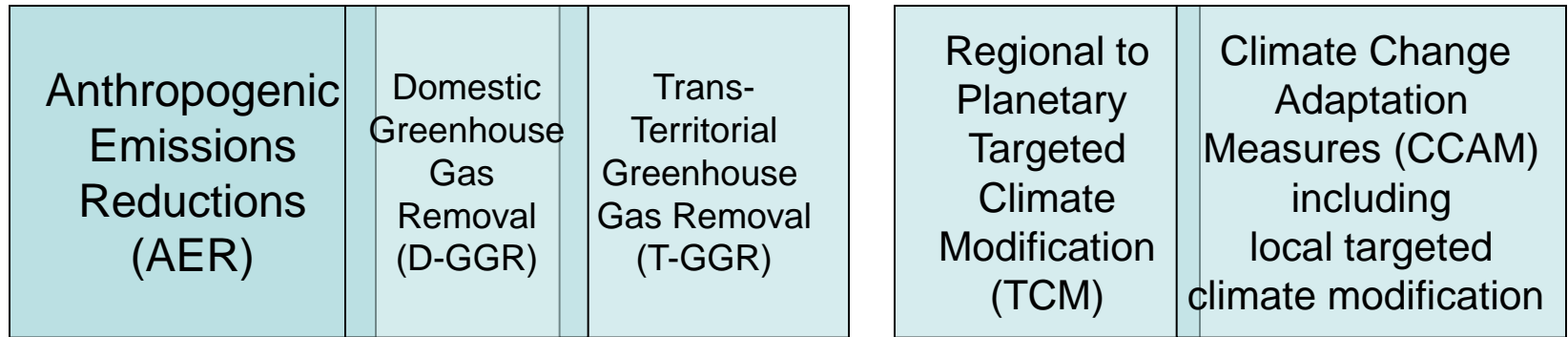
# RCP scenarios and geoengineering



**OLD**



**NEW**

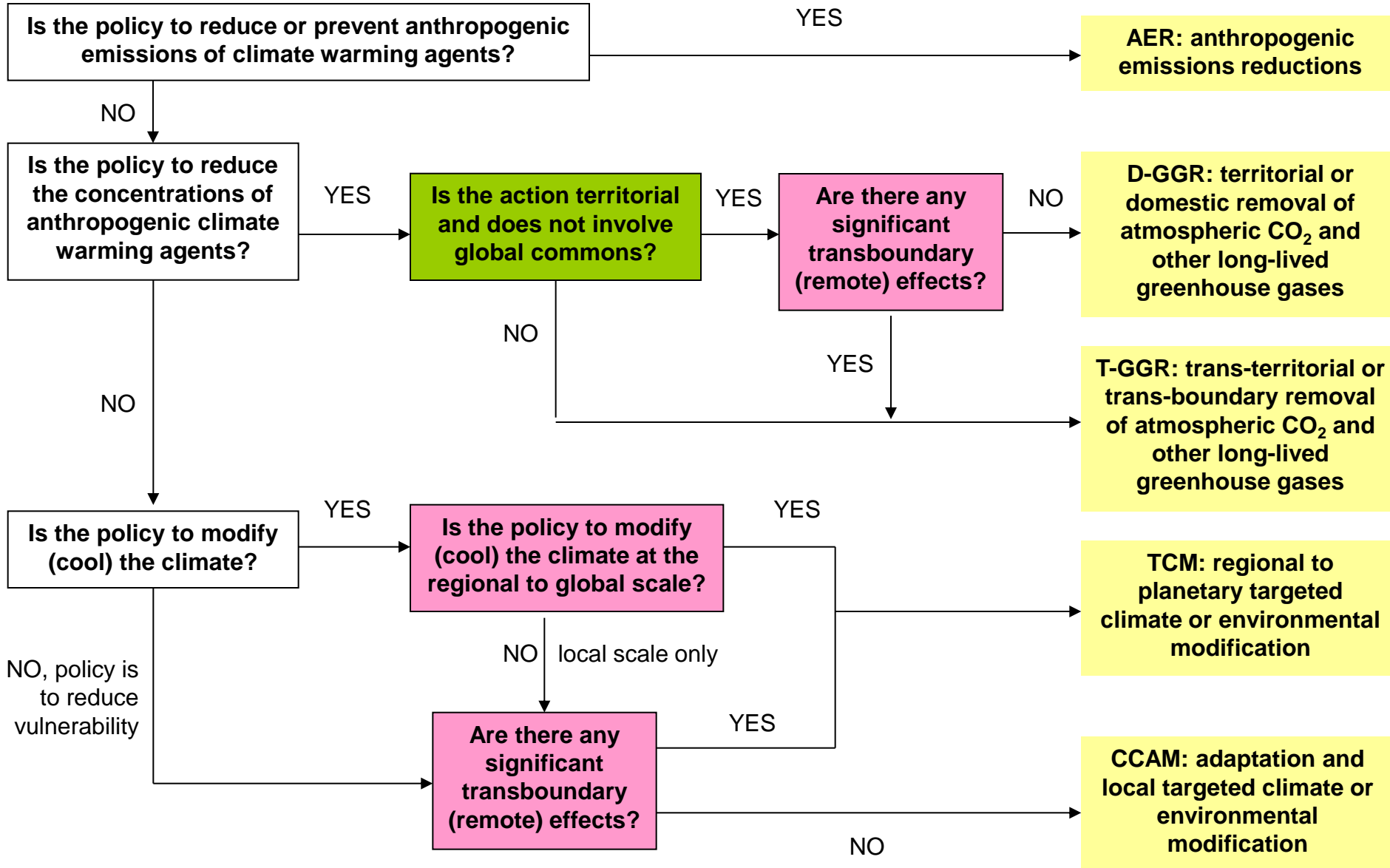


Scale &  
Intensity &  
Trans-territorial

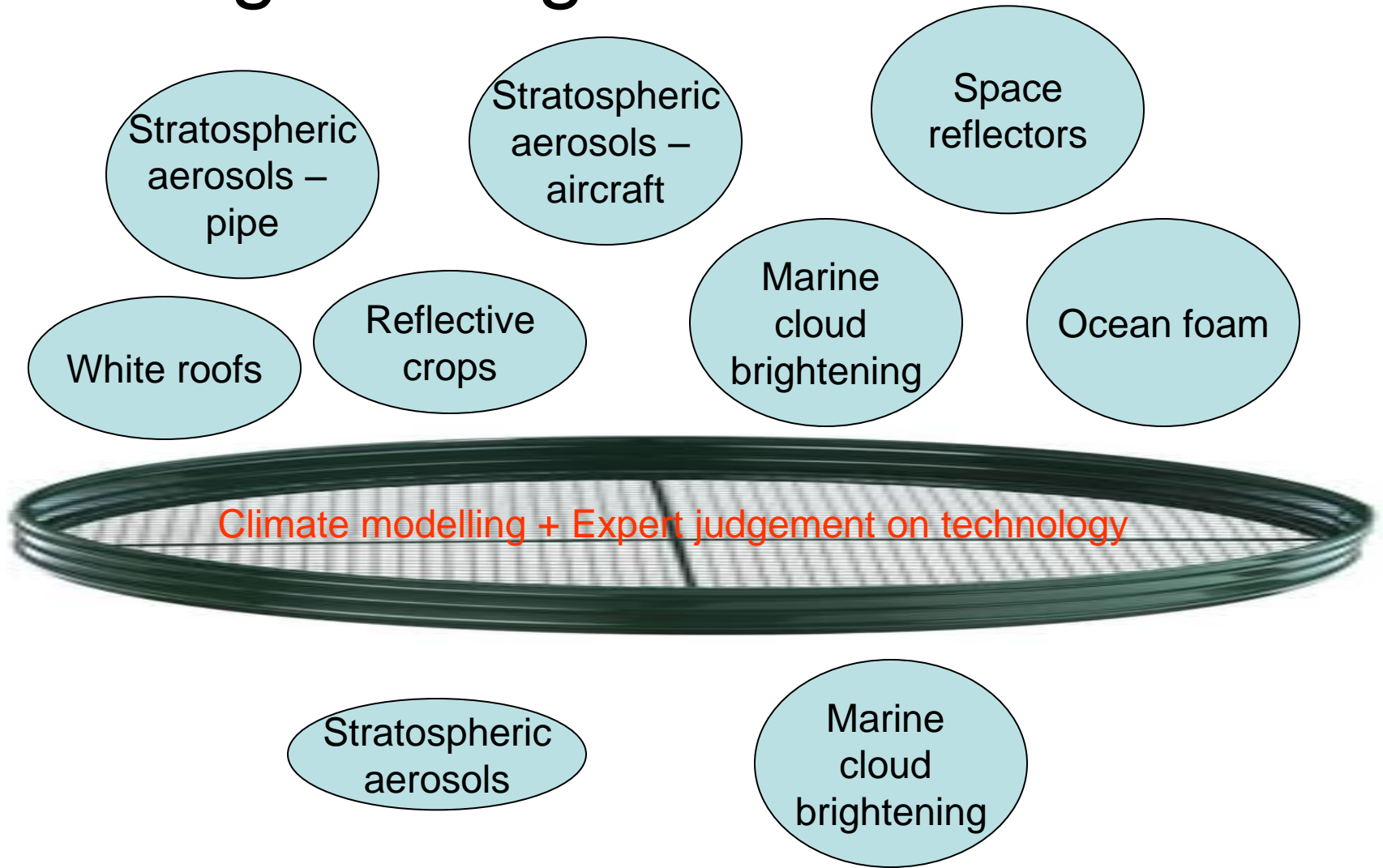


Scale &  
Intensity &  
Trans-territorial

# Categorizing a policy response to climate change

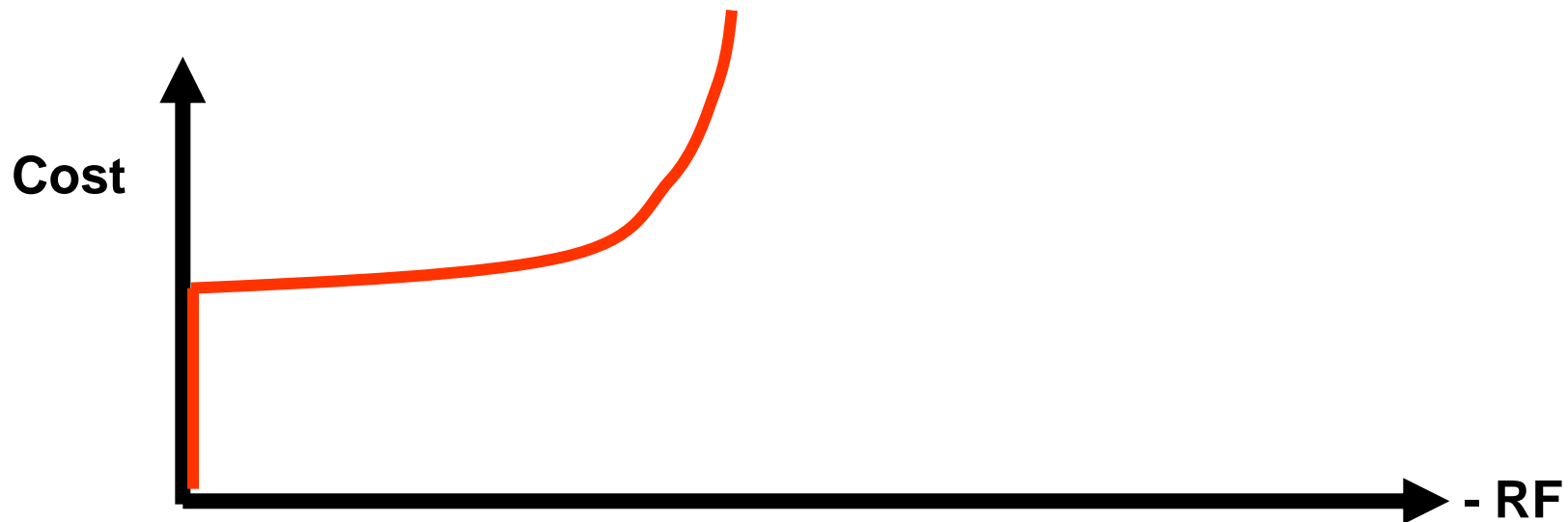
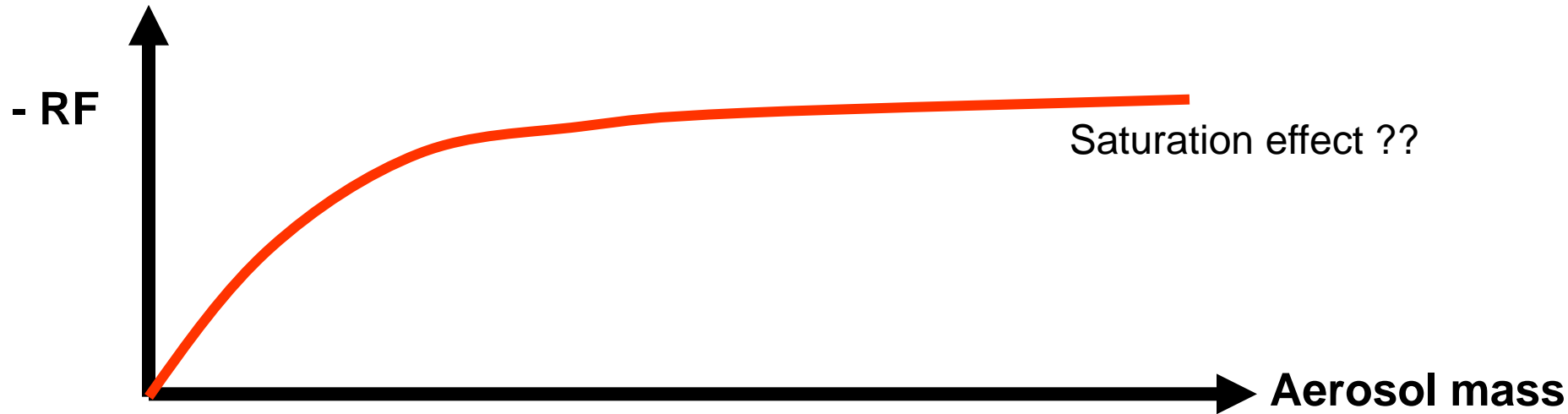


# Geoengineering research = idea sieve



➔ We may also find some technique that is interesting maybe not so much as climate geoengineering, but relevant for adaptation to climate change

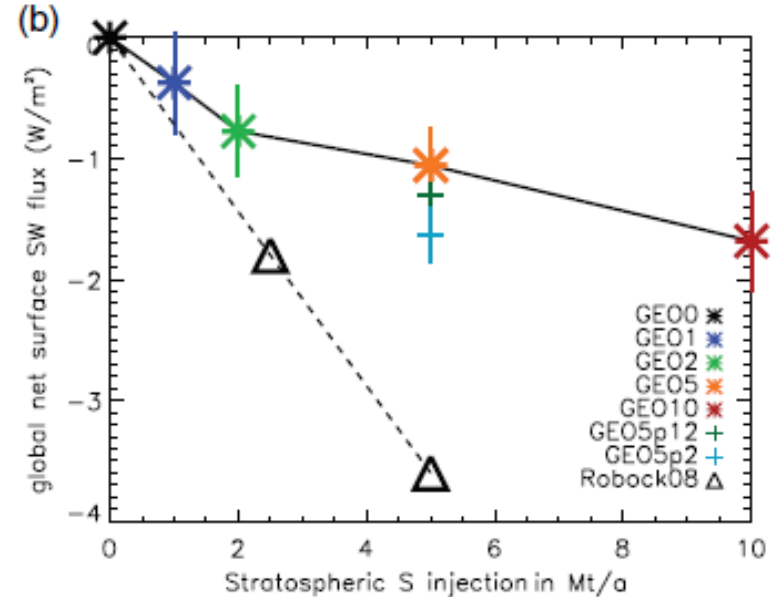
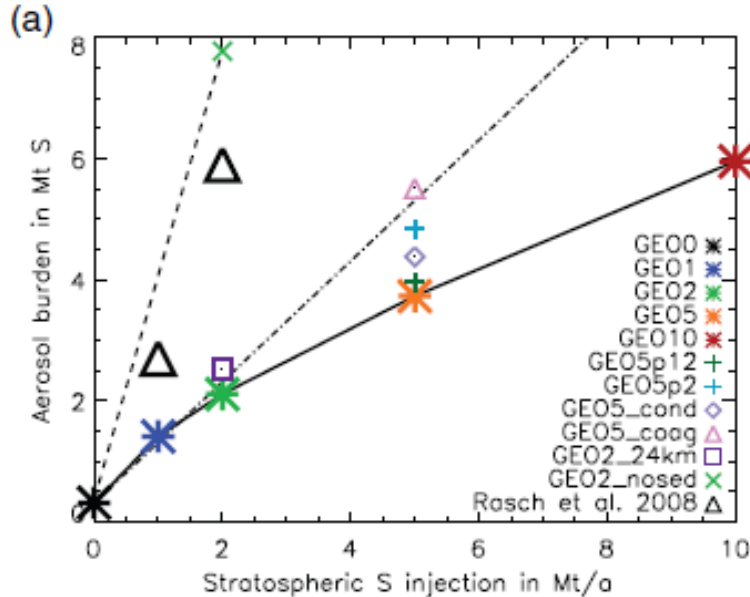
# What is the upper bound for stratospheric aerosol injection?



# What is the upper bound to the cooling by stratospheric aerosol injection?

## Technological and physical limits

- o aerosol size is increasingly difficult to control as the emission rate increases
- o competition between the SW and LW radiation effects of aerosols
- o possible modification of high-level clouds



Heckendorn et al., ERL, 2009

## Climatic limits

- o side effects become larger as the forcing increases
- o the risks of geo-engineering and its termination become larger as the forcing increases

# What is the upper bound to the cooling by marine cloud brightening ?

Injected aerosol simulations

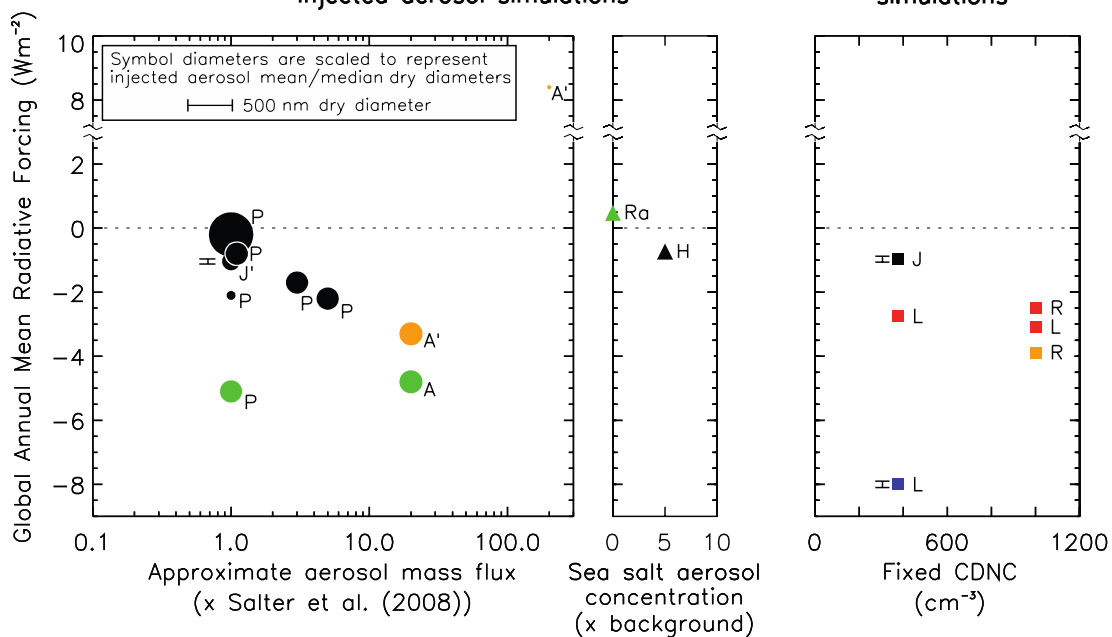
Fixed CDNC simulations

## Physical limits

- o non-linear microphysical and radiative processes that response to the aerosol size

- o surface area of clouds that are susceptible to brightening

- o evaporative cooling in the injected sea salt plumes



=> new GeoMIP experiments

### Publications:

A = Alterskjær et al. (2012)  
 A' = Alterskjær and Kristjánsson (2013)  
 H = Hill and Ming (2012)  
 J = Jones et al. (2009)  
 J' = Jones and Haywood (2012)  
 L = Latham et al. (2008)  
 P = Partanen et al. (2012)  
 R = Rasch et al. (2009)  
 Ra = Rap et al. (2013)

### MCB Injection Area:

<10% of Earth's surface  
 10–20% of Earth's surface  
 20–50% of Earth's surface  
 >50% of Earth's surface  
 All model low-level marine cloud (unspecified %)

Error bars ( $\pm 1$  standard deviation) indicated to the left of data points



# How much confidence do we need in climate models? **Mitigation**

← Climate change is bad  
Precaution principle

Perceived risk is low →

Mitigation cost is high →

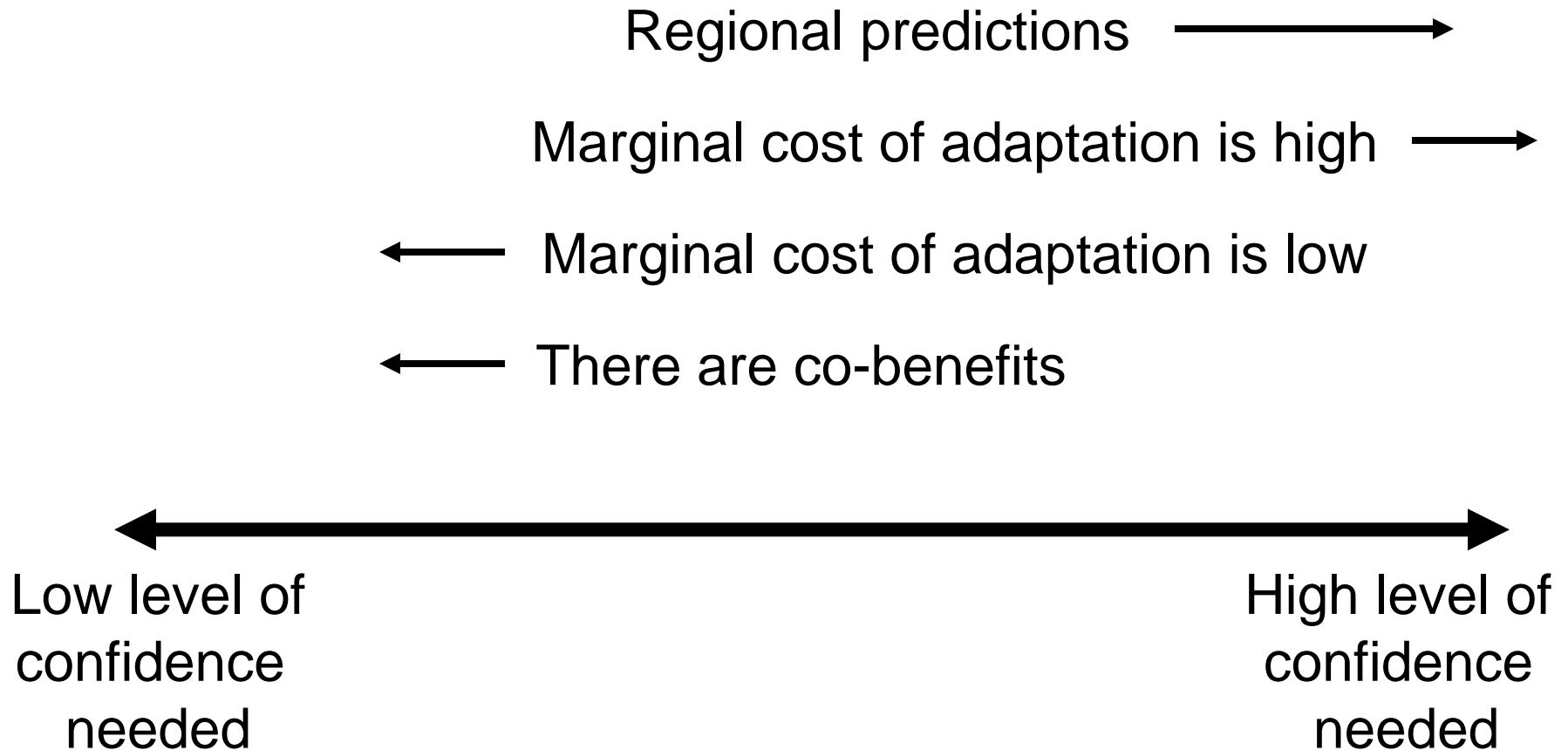
← There are co-benefits

Some mitigation measures  
relies on climate predictions →  
(e.g. some renewables, REDD, afforestation)

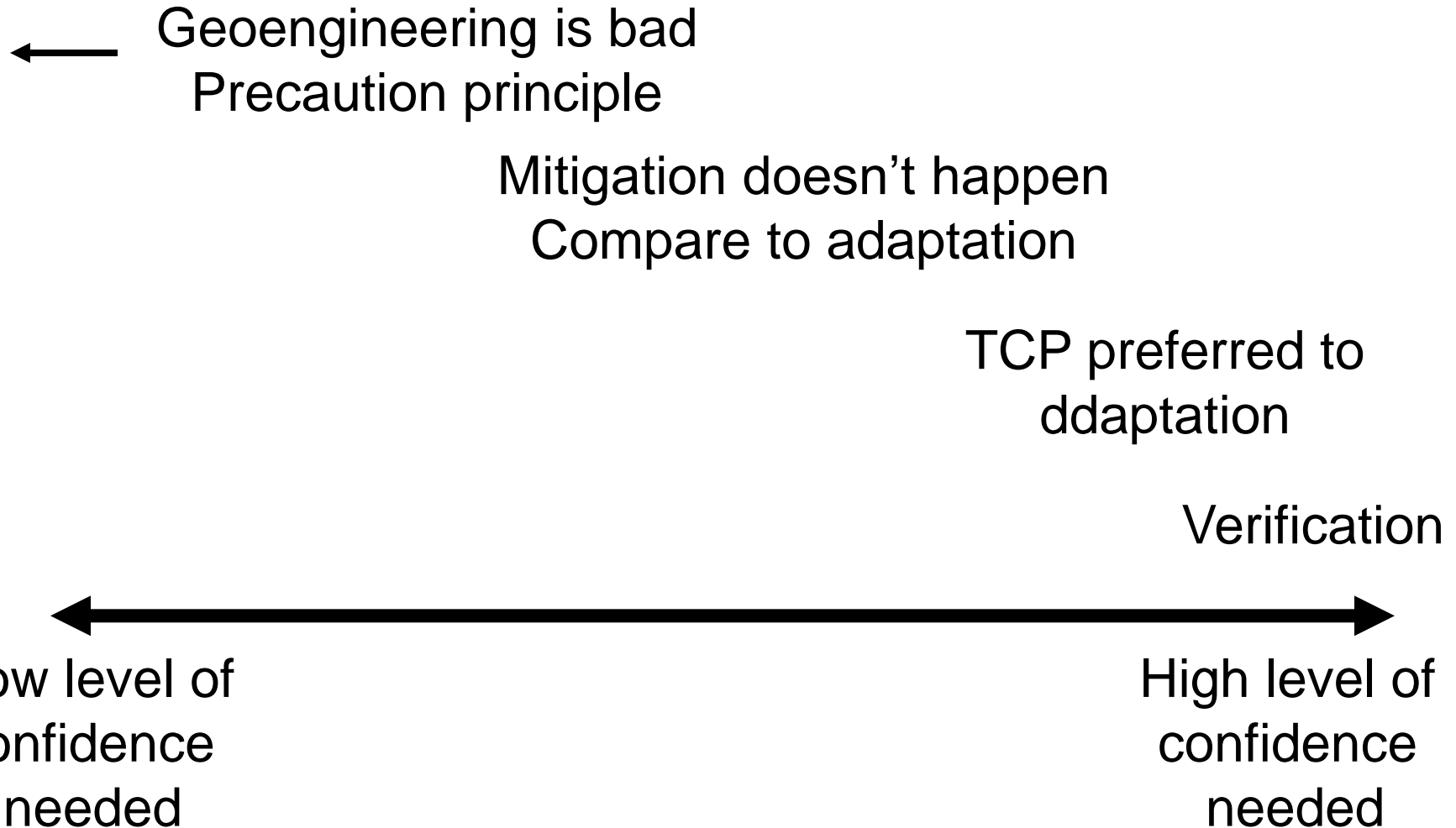
←  
Low level of  
confidence  
needed

→  
High level of  
confidence  
needed

# How much confidence do we need in climate models? **Adaptation**



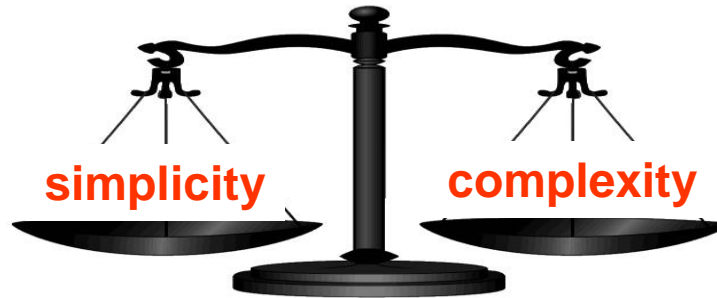
# How much confidence do we need in climate models? TCM



# How to frame research in Targeted Climate Modification?

- What is the upper bound of RF by TCM?  
What is the lower bound for TCM side effects?
- How to optimize a TCM scheme to maximize efficiency / minimize side effects / minimize departure to pre-industrial or present-day climate?

# Modelling dilemma: simplicity vs complexity



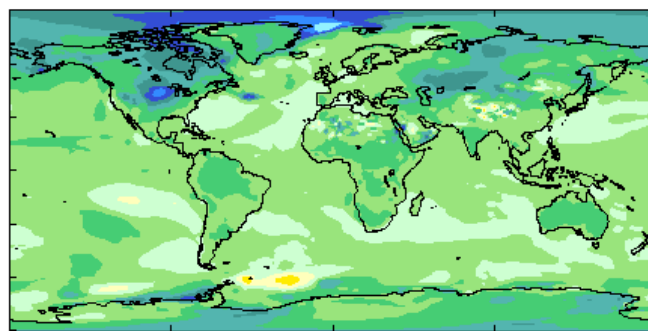
- Early stages of research
- Bound impacts
- Assess potential
- Back of the envelope calculations

- Many subtle effects
- Climate system complex
- More side-benefits of geo-engineering research

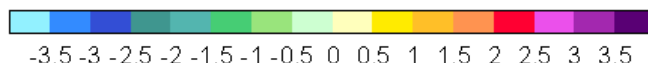
# What baseline for comparing geoengineered climate?

(d) Temperature Change ( $^{\circ}\text{C}$ )

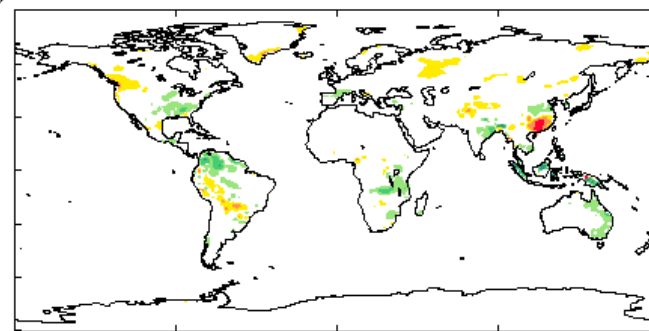
Geoengineered  
minus  
non-geoengineered  
  
=> effectiveness



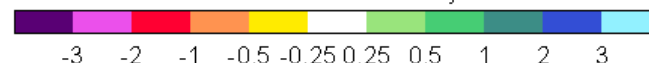
Mean =  $-0.83\text{ K}$



(e) Precipitation Change ( $\text{mm}/\text{day}$ )

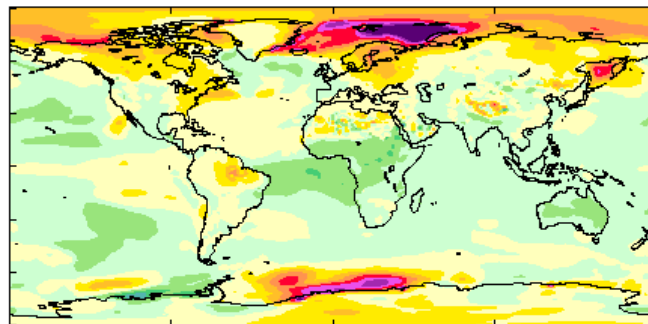


Mean =  $-0.001\text{ mm day}^{-1}$

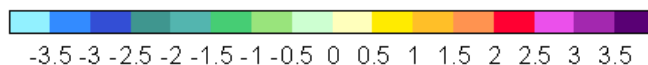


(f)

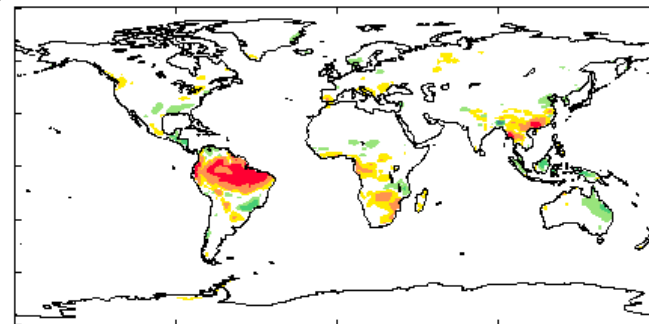
Geoengineered  
minus  
present-day  
  
=> residual effects



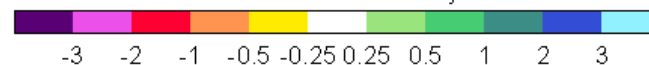
Mean =  $+0.01\text{ K}$



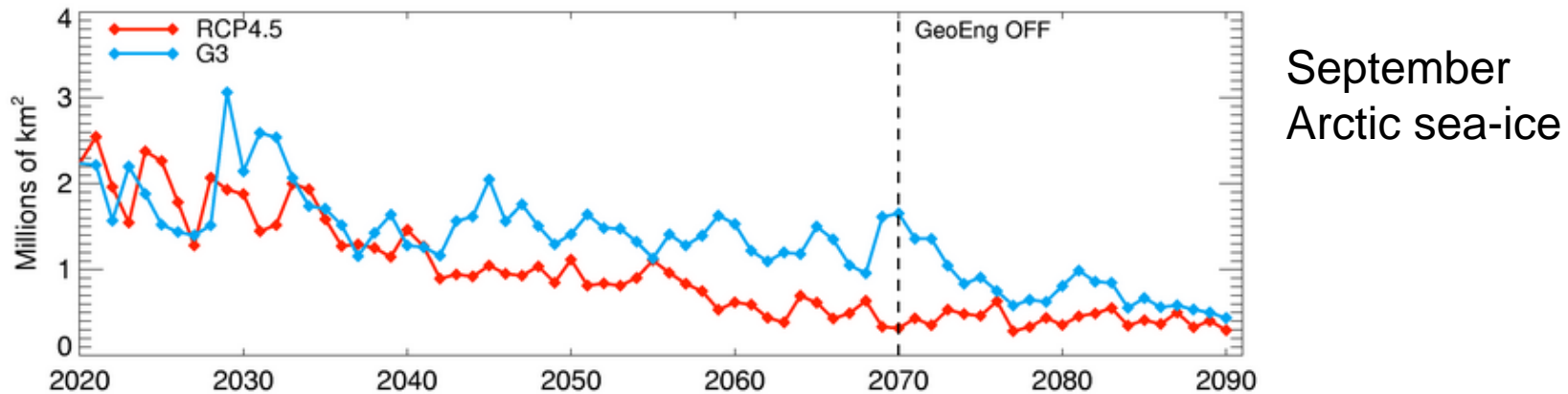
(g)



Mean =  $-0.065\text{ mm day}^{-1}$



# Detection of climate changes in a geoengineered world

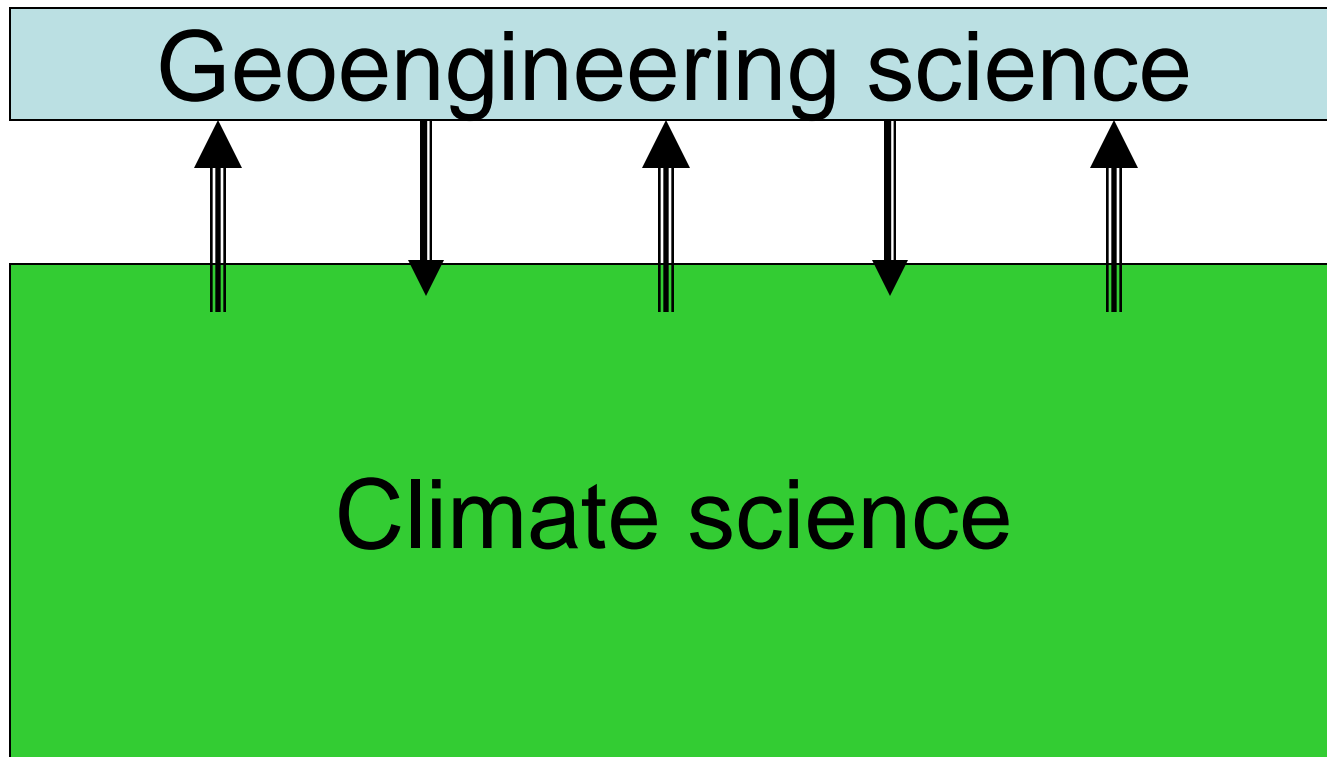


Climate variability is large...

It wouldn't be possible to tell that geoengineering has a positive impact on Arctic sea ice before 2050.

- ➔ TCM difficult to verify on variables other than T
- ➔ Some residual effects would be lost in variability

# Climate science vs. Climate geoengineering science



Example: Haywood et al., Asymmetric forcing from stratospheric aerosols impacts Sahelian rainfall, Nature Climate Change, 2013.



End

Questions?

