The 2°C climate policy goal: Chances & Challenges

DPG Regensburg 2016, March 9

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  Cost benefit versus cost effectiveness analysis
- Costs of the 2° target
- Solar radiation management: what could it add?
- The need for a more sophisticated interpretation of the 2° target

Two Lines of Argument behind Global Warming Mitigation Policies

- Collection of global warming-induced <u>explicitly projected impacts</u>

  → economic cost benefit framework

  – Given a weak data base on global warming damages:

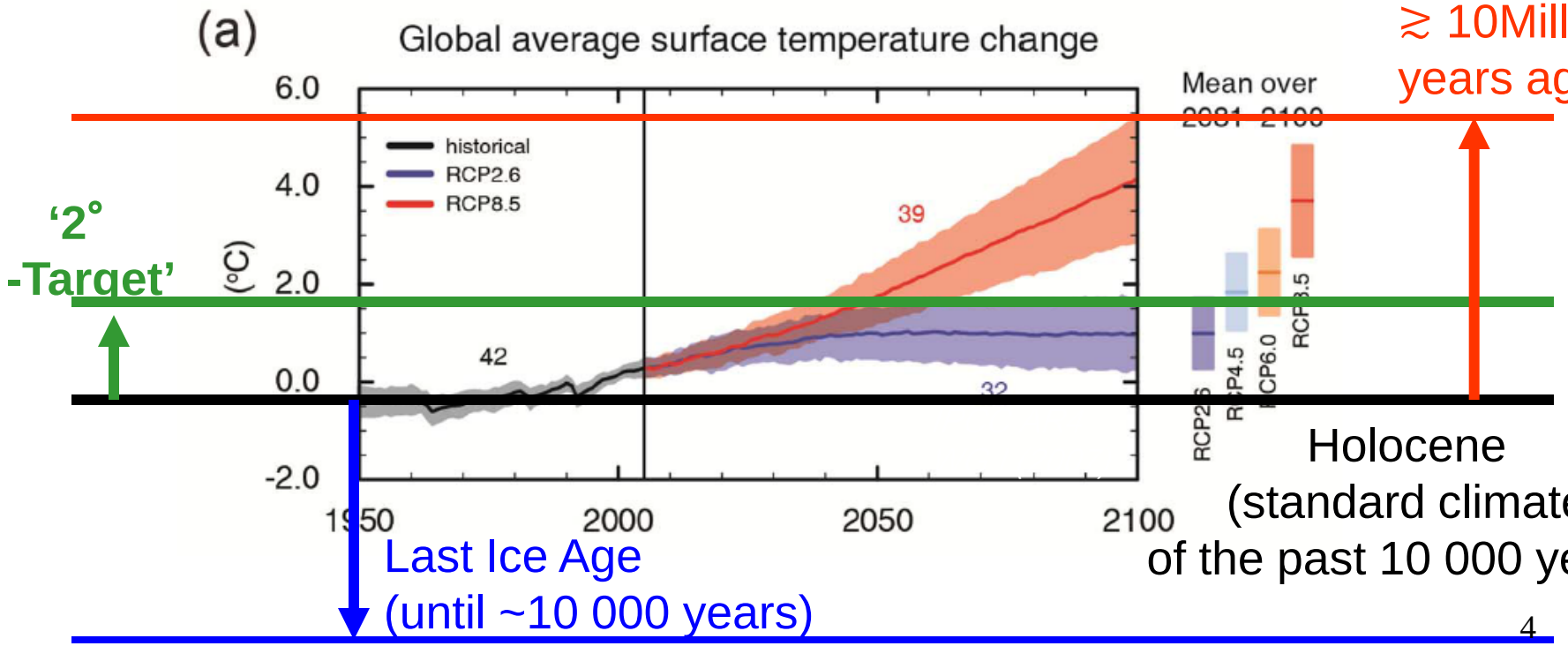
    → over the past 10 years, virtually any degree of immediate mitigation effort has been recommended as 'optimal'.

- Precautionary principle

  – beyond certain regimes knowledge too poor to systematically evaluate the impacts

One possible interpretation of the Precautionary Principle:

Avoid Historic Dimension of Temperature Rise



Held, 2015

The 2°-Target as an Amalgam of Both

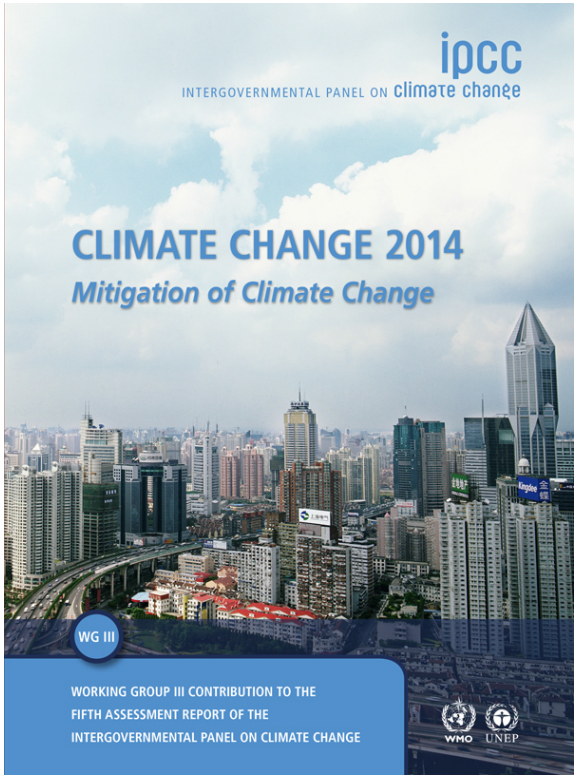
- Acknowledges known impacts
- Adds a precautionary component
- *Condenses information for political discourse ('academically informed political target')*
  - *Analogous to a speed limit*
  - *Does* not *indicate a phase transition or bifurcation of the climate system at 2°.*

A Key Question in the last IPCC Report

- **When** to invest **how much** into **what energy** technology, given a climate target (limit *T* to 2° C), to minimize costs?
  - 'Cost effectiveness analysis'

- Options:
  - Renewable sources
  - Energy efficiency
  - Carbon capture & sequestration (CCS)
  - Nuclear

Cost of Mitigation?



IPCC AR5 WGIII (April 2014) assessed ~1000 energy-economic scenarios, published since AR4 (2007)

Economic Welfare Effects of 450ppmeq (~2° C) Target?

- Economic reference case:

  Scenario without climate damages and without climate policy
- This is characterized by global economic growth of 1,6 - 3 % / year.

- 2°-oriented scenarios compatible with continued global economic growth.
- Annual growth rate reduced by 0.06 %- points .

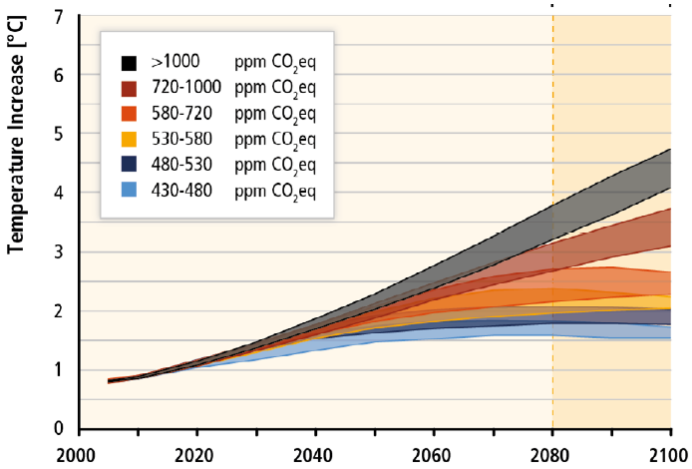
- Hereby avoided warming-induced net damages not yet included.

- *(After IPCC AR5 WGIII SPM)*

- 2° target '~insurance premium against unpredictable warming damages'

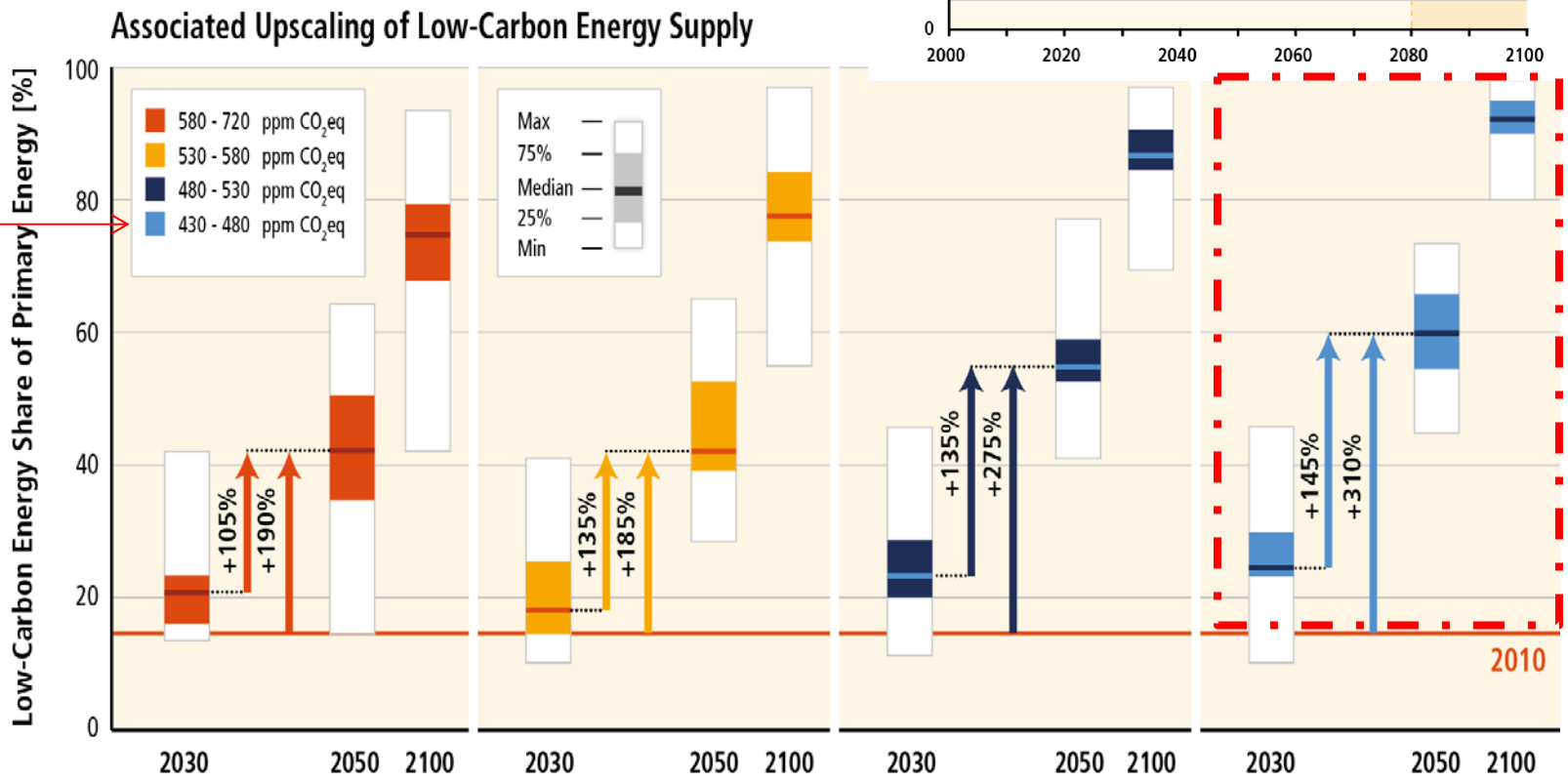
Cost efficient compliance with 2°-target by upscaling of low-emission energy technologies

LowC Energy Share of Primary Energy: Factor 4 2010 → 2050



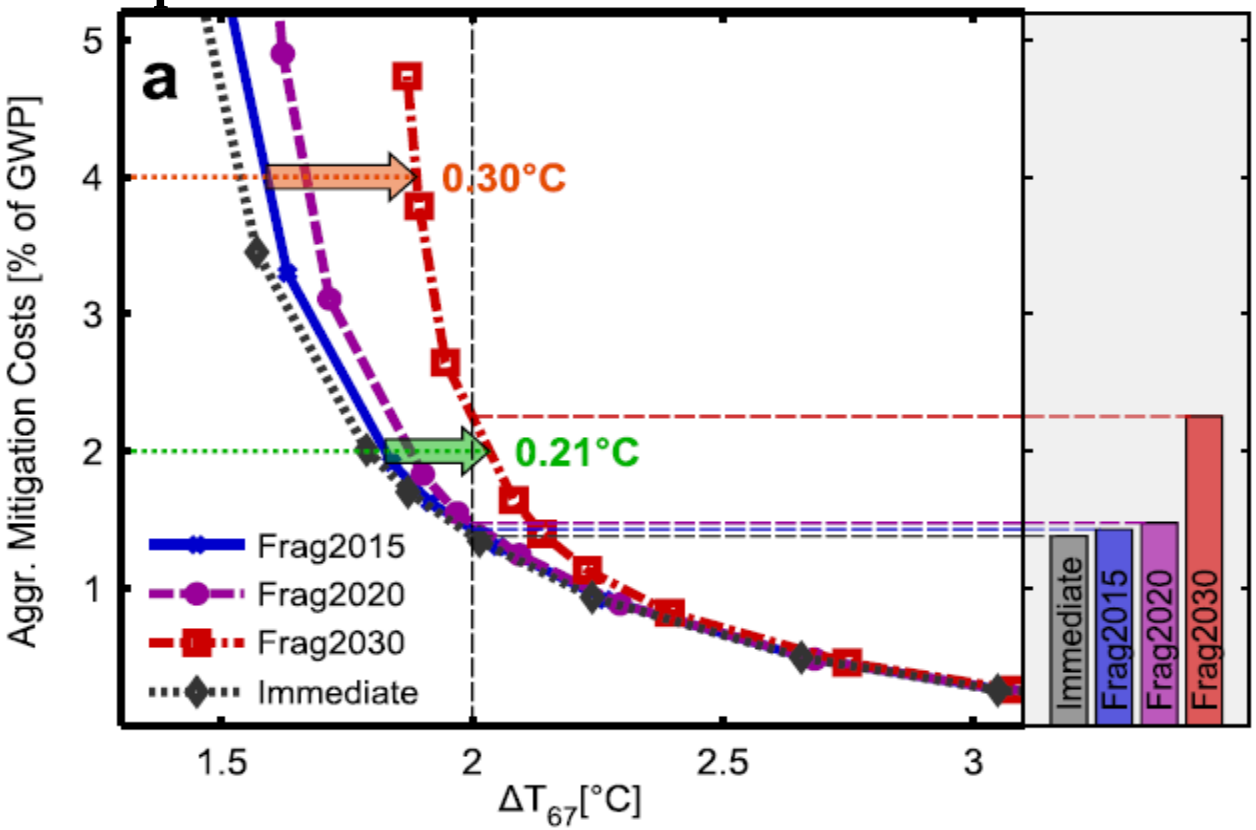
IPCC AR5 WGIII, Figure SPM.4.

2°-compatible



Effects of Delay of Climate Policy
(as against immediate collective implementation of cost effective solution)

Temperature-Cost Trade-Off Curve and the Effect of Timing



(after Luderer et al. (2013, ERL))

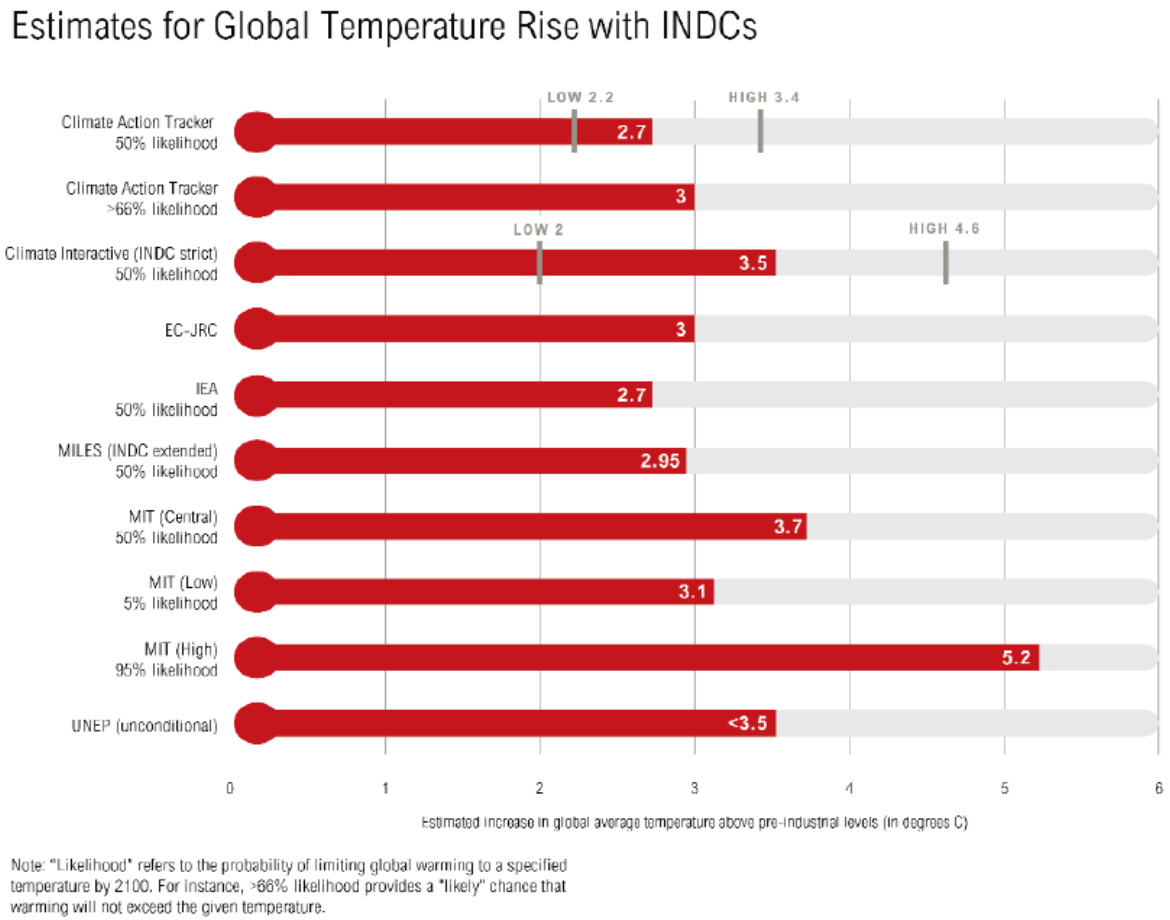
Bar chart indicates costs to reach 2°-guard rail for different delay scenarios

maximum 21st century temp. (prob.: 67%)

Delay beyond 2030: no solution available any more!

Conference of the Parties (COP) 21, Paris, 2015

- Reduction of increase of emissions 2030-2010 by 50% $\Rightarrow$ global mean temperature?



Our Research Question in a DFG-SPP Project on Climate Engieering

Assuming compliance with the 2° target:

How would the optimal portfolio of mitigation options change

if we added sulphur aerosol injection to the portfolio ?

Key assumptions:

- For the assessment of SRM (low cost option) risks of side effects are key.
- Side effects of SRM are as difficult to project as impacts effects of global warming.
- Can we utilize the target-approach here as well?

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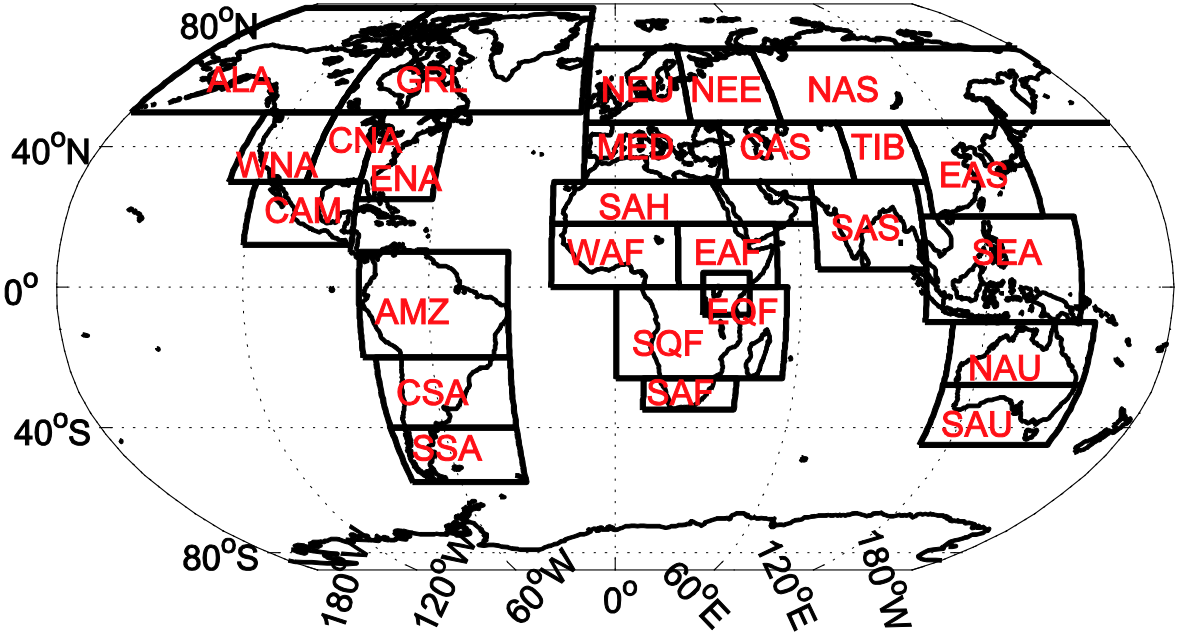
- For the assessment of SRM (low cost option) risks of side effects are key.
- Side effects of SRM are as difficult to project as impacts effects of global warming.
- Can we utilize the target-approach here as well?
- Note: SRM destroys the correlation between global mean temperature and regional impacts.
- Regional climate impacts must explicitly be projected by regional modelling.
- Then targets concerning regional climate changes.

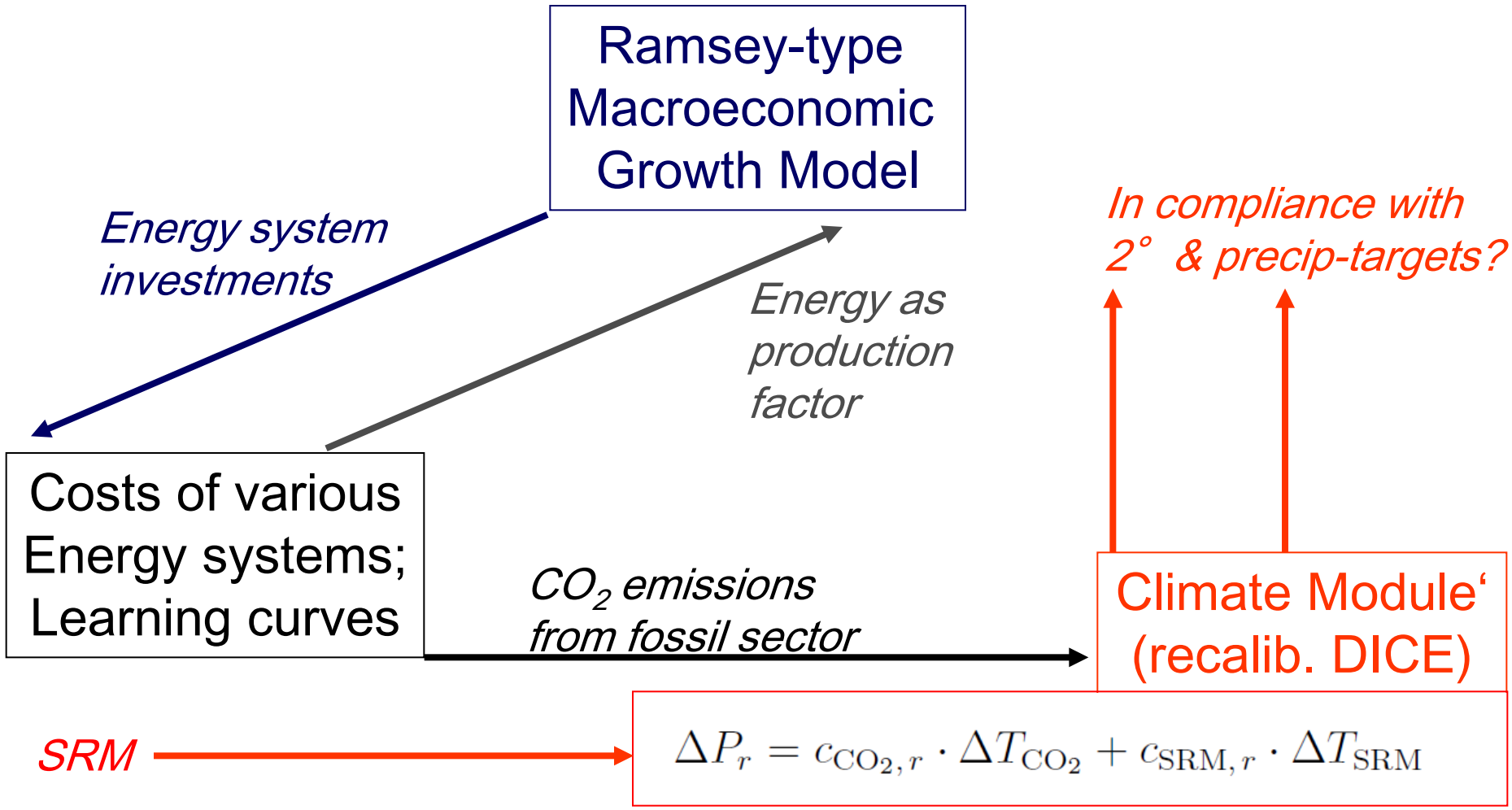
‘G0 Scenario’: Requesting Precipitation-Guardrails for 26 Giorgi Regions



(from Giorgi & Bi, 2005)

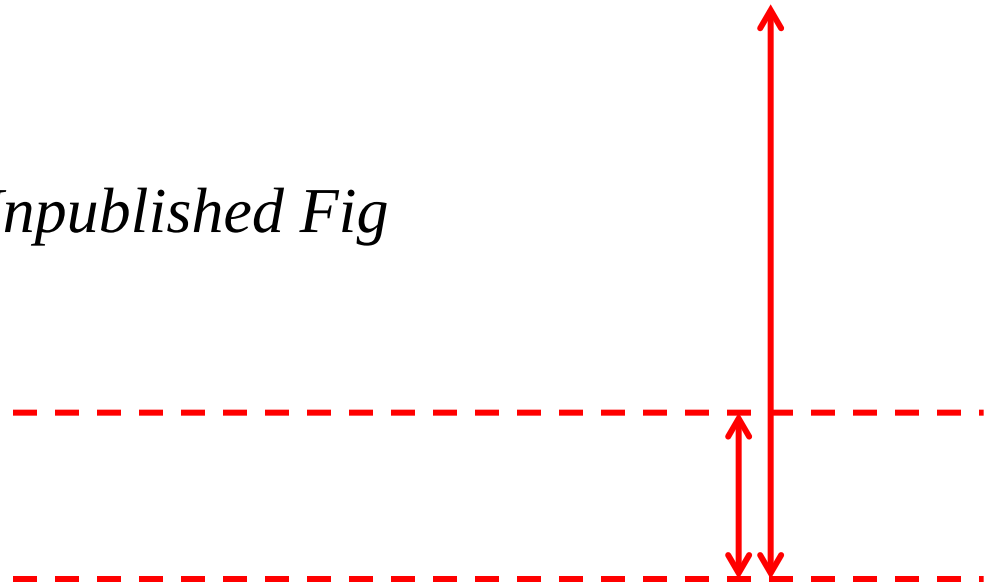
‘What kind of precip change would a region have accepted under a 2° target?’

Costs of Climate Targets?
Our Model Setup including SRM



Economic effects (~consumption changes); also successively ignoring threshold-sensitive regions

w/o SRM; with SRM



Unpublished Fig

About 1/3 of costs of 2° target could be saved through SRM

Stankoweit et al., 2015, EGU

Difference plot:
Economic gain by sacrificing precipitation guardrail for just another Giorgi region

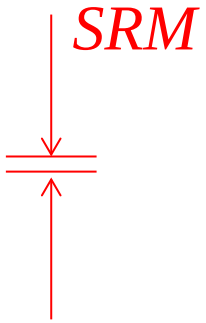
Unpublished Fig

Stankoweit et al., 2015, EGU

Attribution of Temperature rise to CO_2 and SRM

CO_2

Unpublished Fig



SO_2

Stankoweit et al., 2015, EGU

Summary on SRM

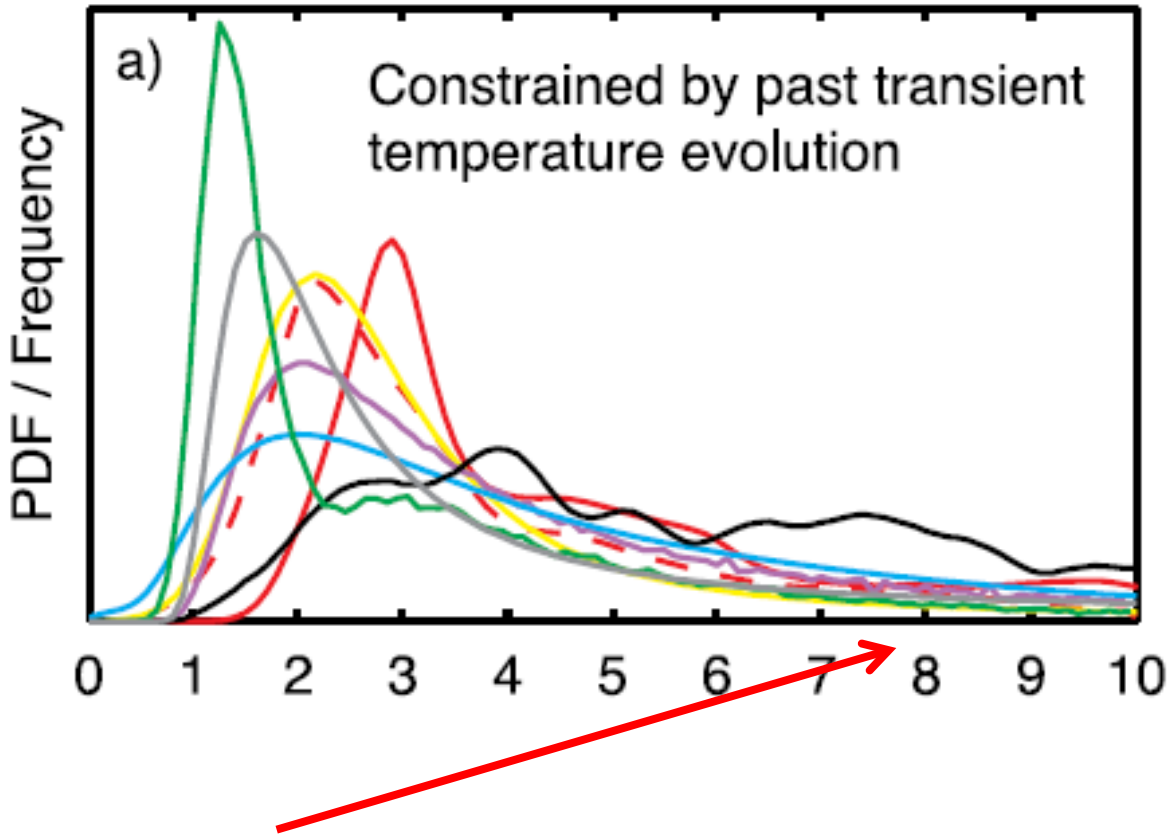
- **The SRM option ‘sulphur aerosol injection’ added to a cost effectiveness analysis of the 2° -target.**
- **Target-based approach extended to constraining SRM-induced precipitation pattern changes:**
- **Then (‘only’ / ‘still’) 1/3 of costs of the 2° -target could be saved through SRM & investment in mitigation delayed by ~decade.**
- **If climate in all regions to be 2° compatible: contribution of SRM only ~0.2° C!**

Towards a softer Interpretation of the 2° Target

- **2° target does not indicate a bifurcation, but delivers orientation for negotiations.**
- **Probabilistic interpretation (e.g. 66% compliance) due to long tails of climate sensitivity.**

Targets & Decision under Uncertainty

Infinitely-tailed distribution of climate sensitivity



IPCC AR4 WGI

Infinite tails:

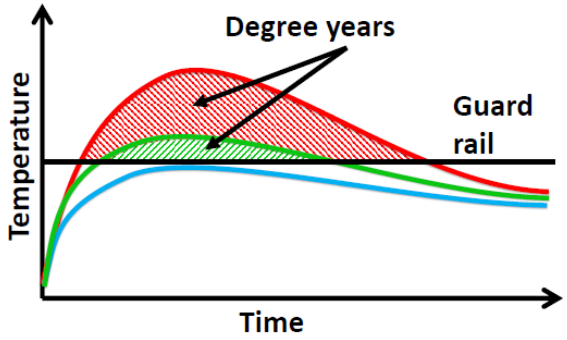
For any temperature limit we can find a CS-value such that the limit is transgressed.

Towards a softer Interpretation of the 2° Target

- **2° target does not indicate a bifurcation, but delivers orientation for negotiations.**
- **Probabilistic interpretation (e.g. 66% compliance) due to long tails of climate sensitivity.**
- **If we allow for the inclusion of anticipated future learning, even a probabilistic target, yet lexicographic decision-framework too strict.**
  - Decision-theoretic criticism of target-based approach since the 70ies
  - → **'cost risk analysis' (CRA)**

How much mitigation is desirable?

Cost Risk Analysis (CRA):
A hybrid decision analytic tool



Present-day mitigation costs

Risk of trespassing temperature limit

Cost-Risk-Analysis trades off risk of trespassing

$$\mathbf{Max}_{\{C(t)\}}\, W := \int \left\{ \int \left(U(C(t)) - b\, R(T(C(t), \gamma))\, p(\gamma)\, d\gamma \right\} e^{-rt}\, dt \right.$$

Schmidt et al., 2011

Risk-of-transgression function 'R(.)' chosen such that

- Non-threshold-type nature of 2° target is complied to
  - Still strive for mitigation in case 2° are transgressed
- Max. conservative for $T \rightarrow \infty$

$\Rightarrow$ *Above threshold linear risk function .*

Neubersch et al., 2014

Results from CRA / Summary (I)

- Uncertainty in climate sensitivity requires a hybrid decision instrument of cost effectiveness and cost benefit analysis.
  - Climate targets then less absolute.
  - The expected value of perfect climate information could be on the order of hundreds of billions € / year under a 2° target (on average 1/3 of mitigation costs saved – Neubersch et al., 2014).
  - 1st half of 21st century action similar to IPCC's deterministic scenarios – potentially lower costs from learning (Neubersch et al., 2014).
- The new tool does also allow for extrapolating the value system of the 2° target into a future in which compliance with the target might become impossible – less mitigation than for strict target (Roth et al., 2015).

Summary (II)

- In an idealized economy, the 2° target is compatible with continued economic growth.
  - The corresponding reduction of growth rate is 1-2 orders of magnitude smaller than the very growth rate (IPCC, AR5, WGIII (2014)).
- Solar radiation management does not come with a significant potential if 2°-compatible regional climates are to be preserved (Stankoweit et al., 2015).