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OESCHGER CENTRE
CLIMATE CHANGE RESEARCH

Allowable carbon emissions lowered under multiple climate and ecosystem targets

Fortunat Joos, Marco Steinacher, Thomas Stocker
Climate and Environmental Physics,
and Oeschger Centre for Climate Change Research,
University of Bern

"Climate change is one of the greatest challenges of our time"

Copenhagen Accord (2009)

1992 Rio Stabilization of greenhouse gas concentrations

1998 Kyoto Reduction of CO₂ emissions by 5%

2010 Cancún Limitation of warming below 2°C

UN Framework Convention on Climate Change (Art. 2):

... **stabilization of greenhouse gas concentrations** in the atmosphere at a level that would prevent **dangerous anthropogenic interference** with the climate system.

... should be achieved within a time frame sufficient to allow **ecosystems** to adapt naturally to climate change, to ensure that **food production** is not threatened and to enable economic development to proceed in a sustainable manner.

- ❖ UNFCCC: multiple targets
- ❖ How much CO₂ can we emit to meet a set of multiple climate targets?

Climate Targets

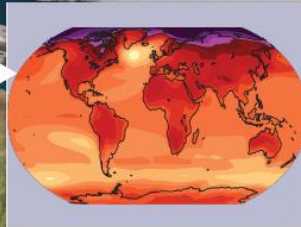
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CLIMATE TARGET 1

Limit global mean warming to (A) 2°C / (B) 3°C.



CLIMATE TARGET 2

Minimize the impact of ocean acidification on corals.

The loss of surface waters with favorable conditions for coral reefs ($\Omega_{\text{arag}} > 3$) should not exceed **75%** / **90%**.



CLIMATE TARGET 3

Limit ocean acidification in the Southern Ocean.

No more than **10%** / **25%** of surface waters should become corrosive to aragonitic shells of marine organisms.



CLIMATE TARGET 4

Limit the loss of carbon from cropland soils to 10% / 20%.



CLIMATE TARGET 5

Avoid decreases in food production. No more than **10%** / **20%** of the global cropland areas should suffer from a productivity loss of 10% or more.

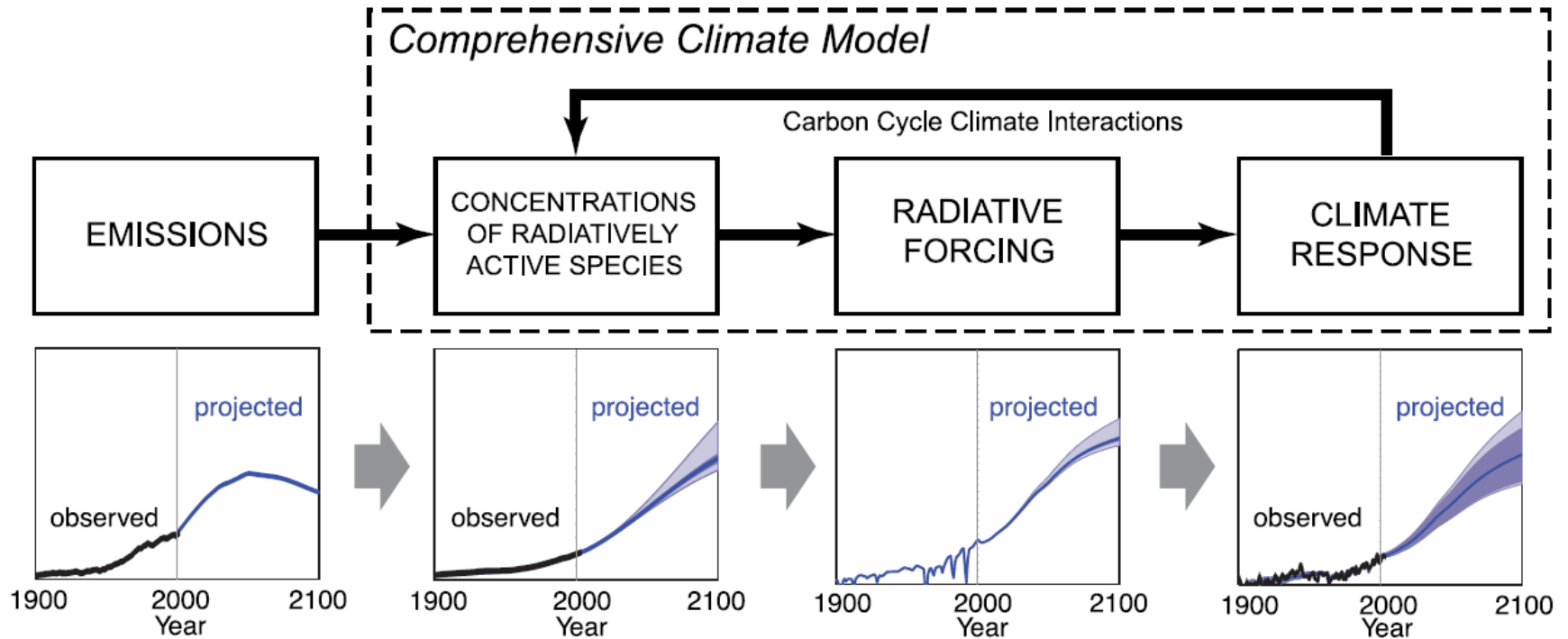


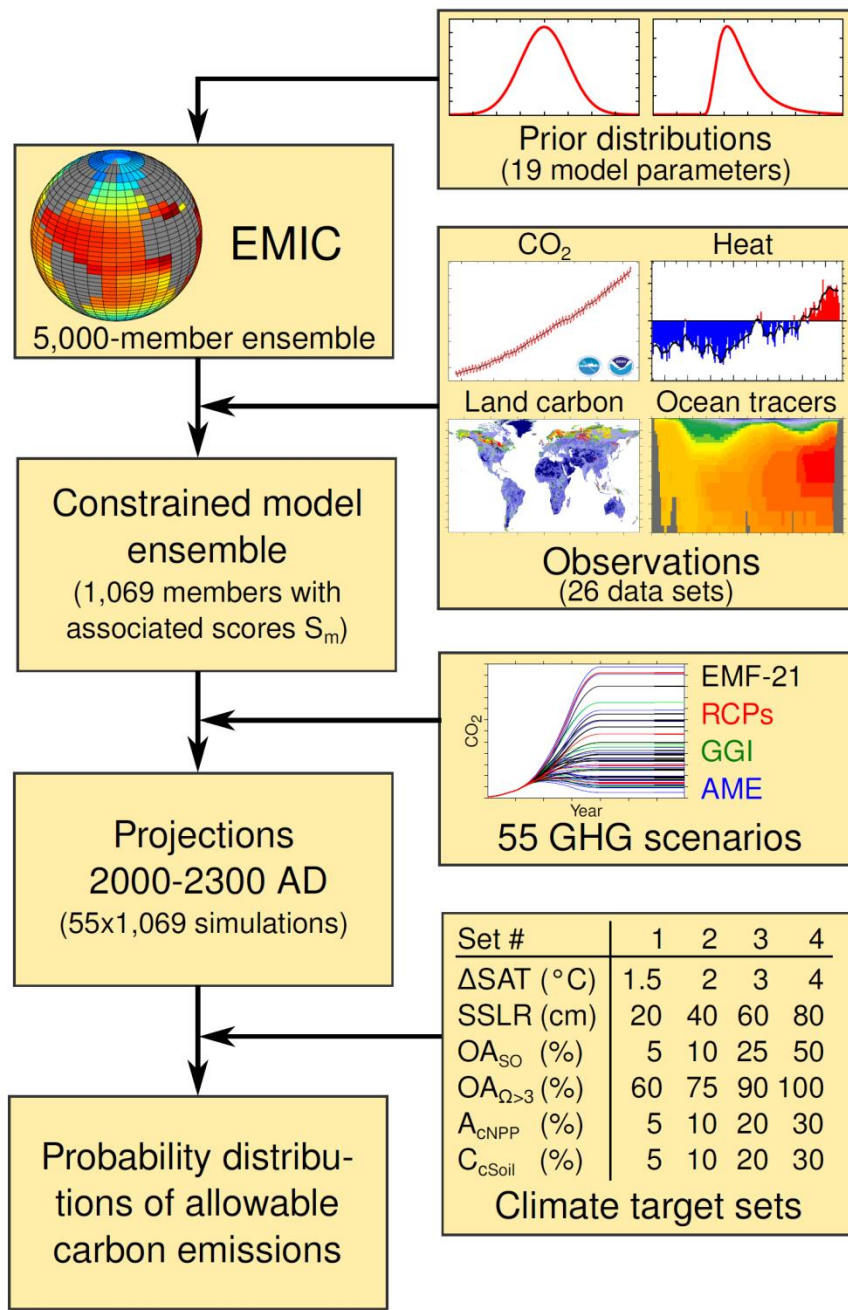
CLIMATE TARGET 6

Limit sea level rise due to thermal expansion to 40 cm / 60 cm.



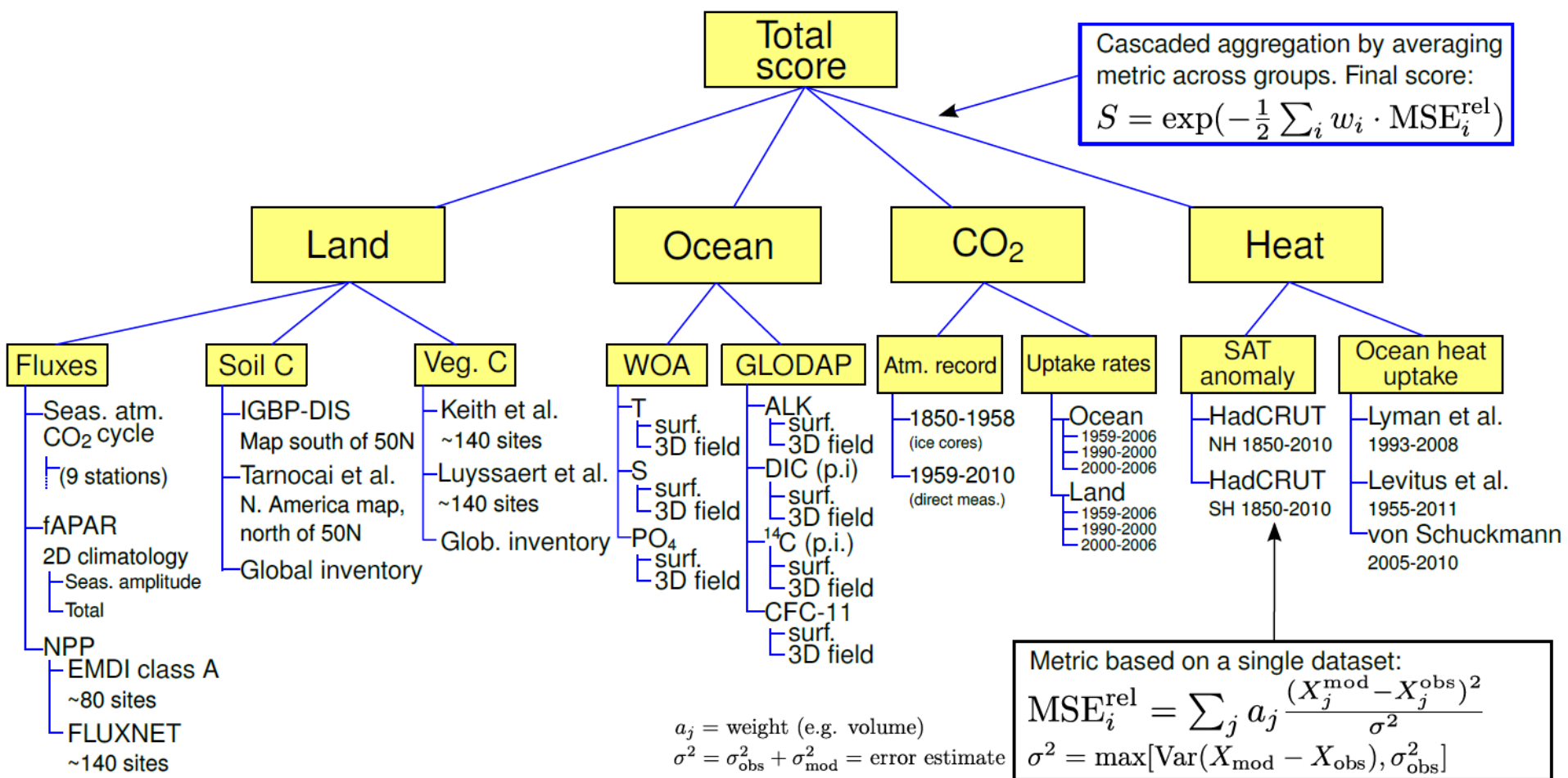
From emissions to climate system response



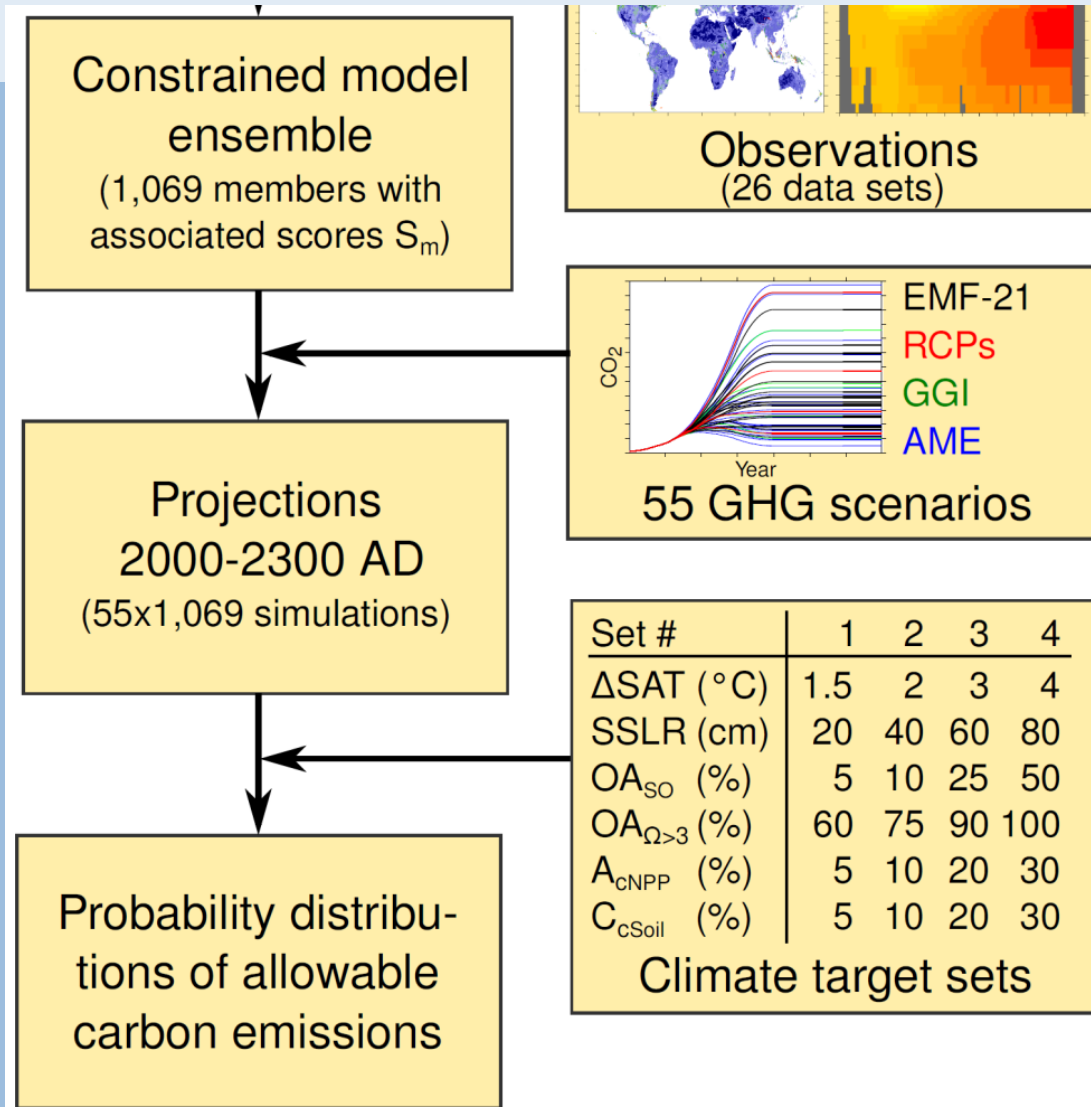


- Bayesian approach of model calibration
- definition of climate targets of comparable stringency
- probabilistic determination of climate system response

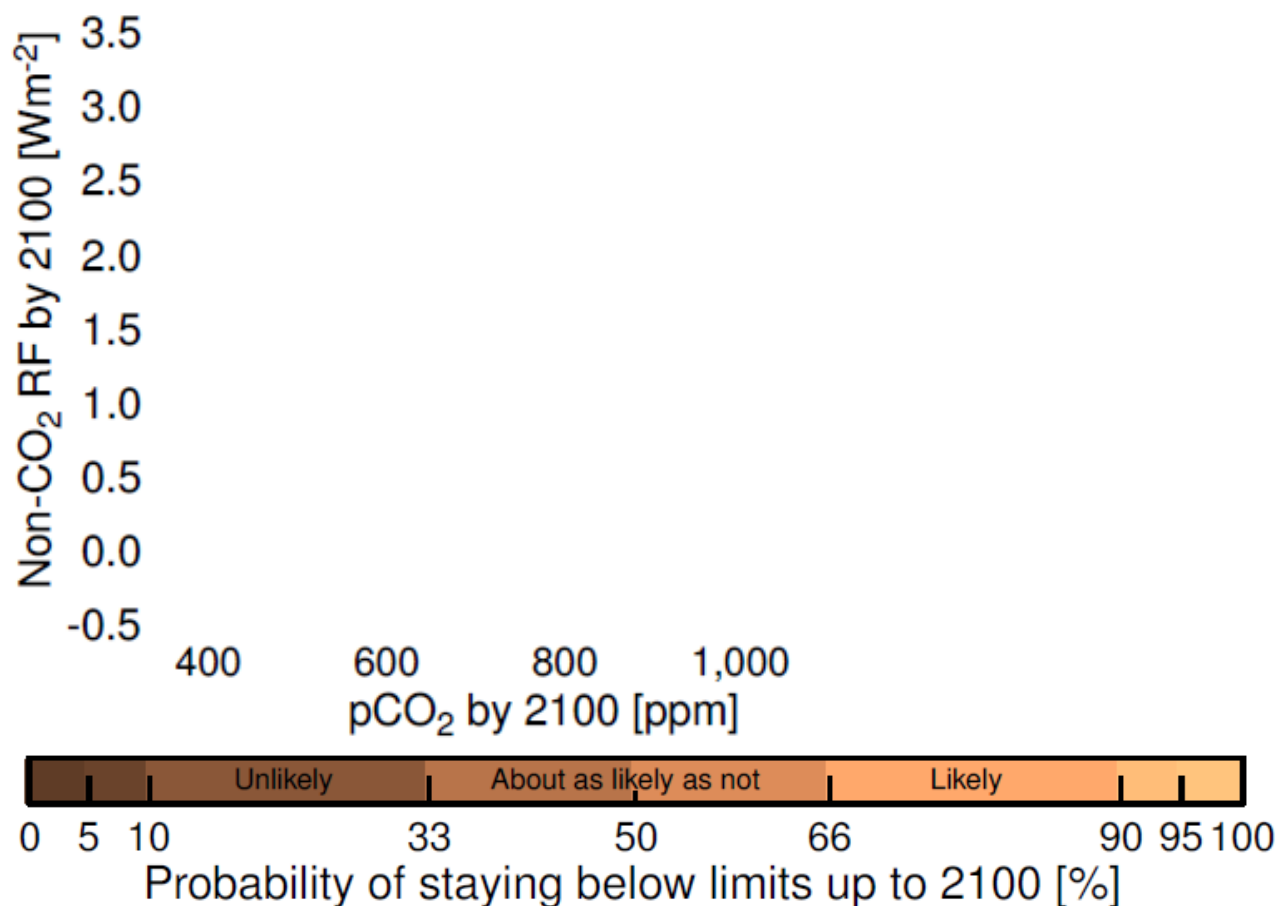
Observational constraints and model skill



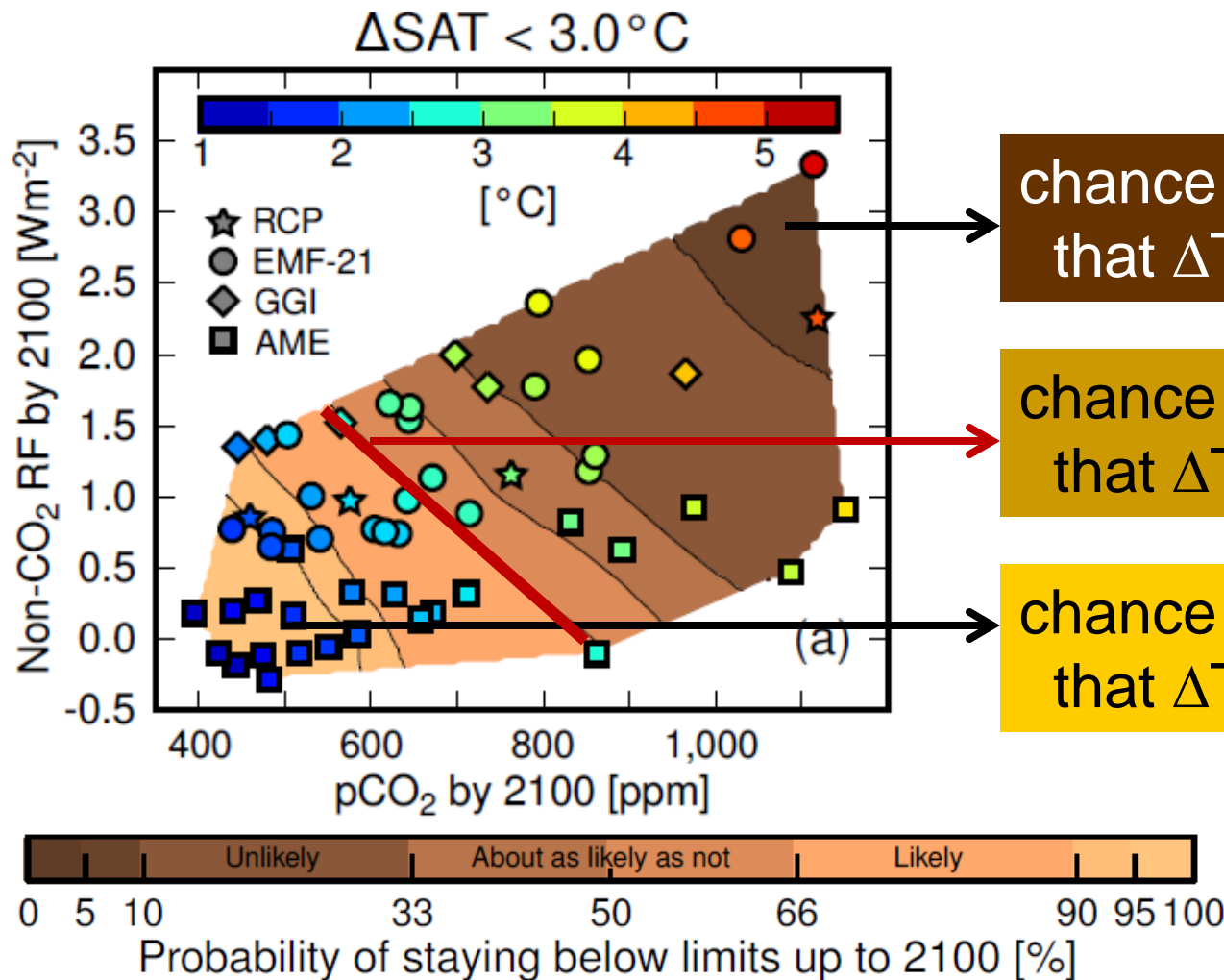
Bayesian approach from emission to response



Probability of staying below 3°C in the scenario space



Probability of staying below 3°C in the scenario space

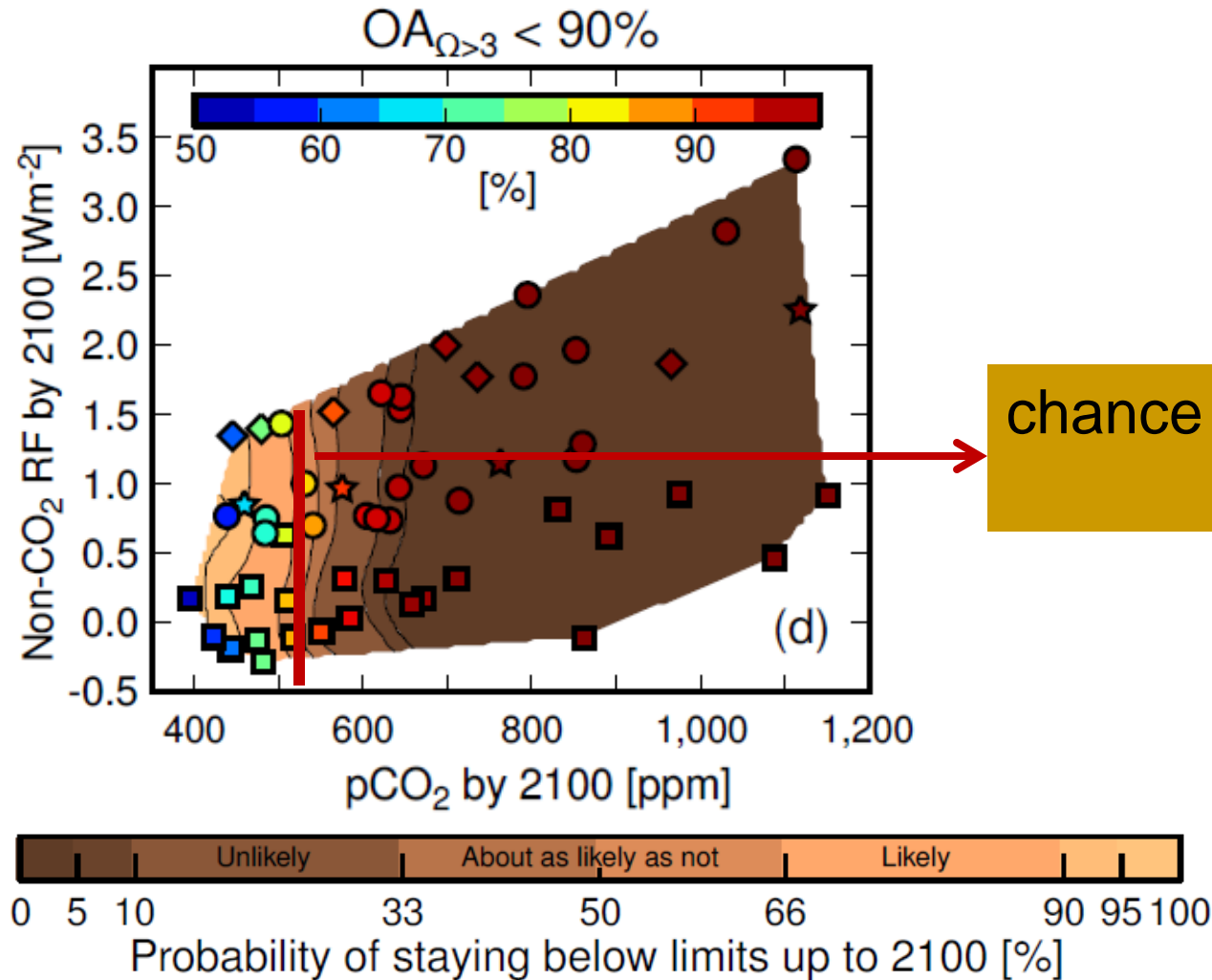


chance < 5%
that $\Delta T < 3^{\circ}C$

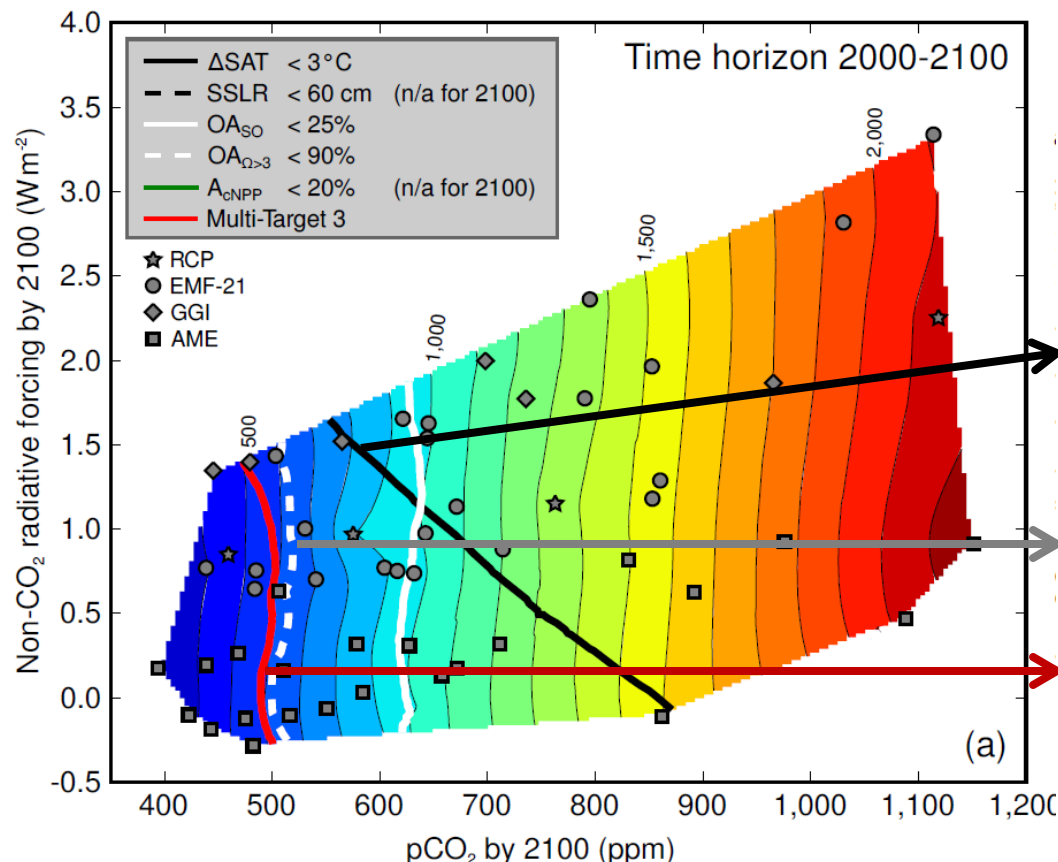
chance = 66%
that $\Delta T < 3^{\circ}C$

chance > 95%
that $\Delta T < 3^{\circ}C$

Probability that less than 90% of surface water with $\Omega_{\text{Aragonite}} > 3$ disappears



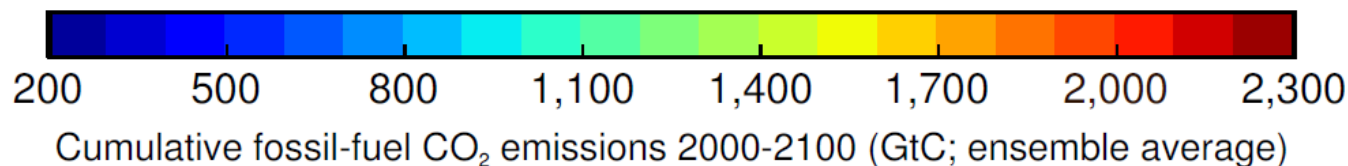
Allowable 21st century fossil-fuel CO₂ emissions to not exceed limits with 66% probability



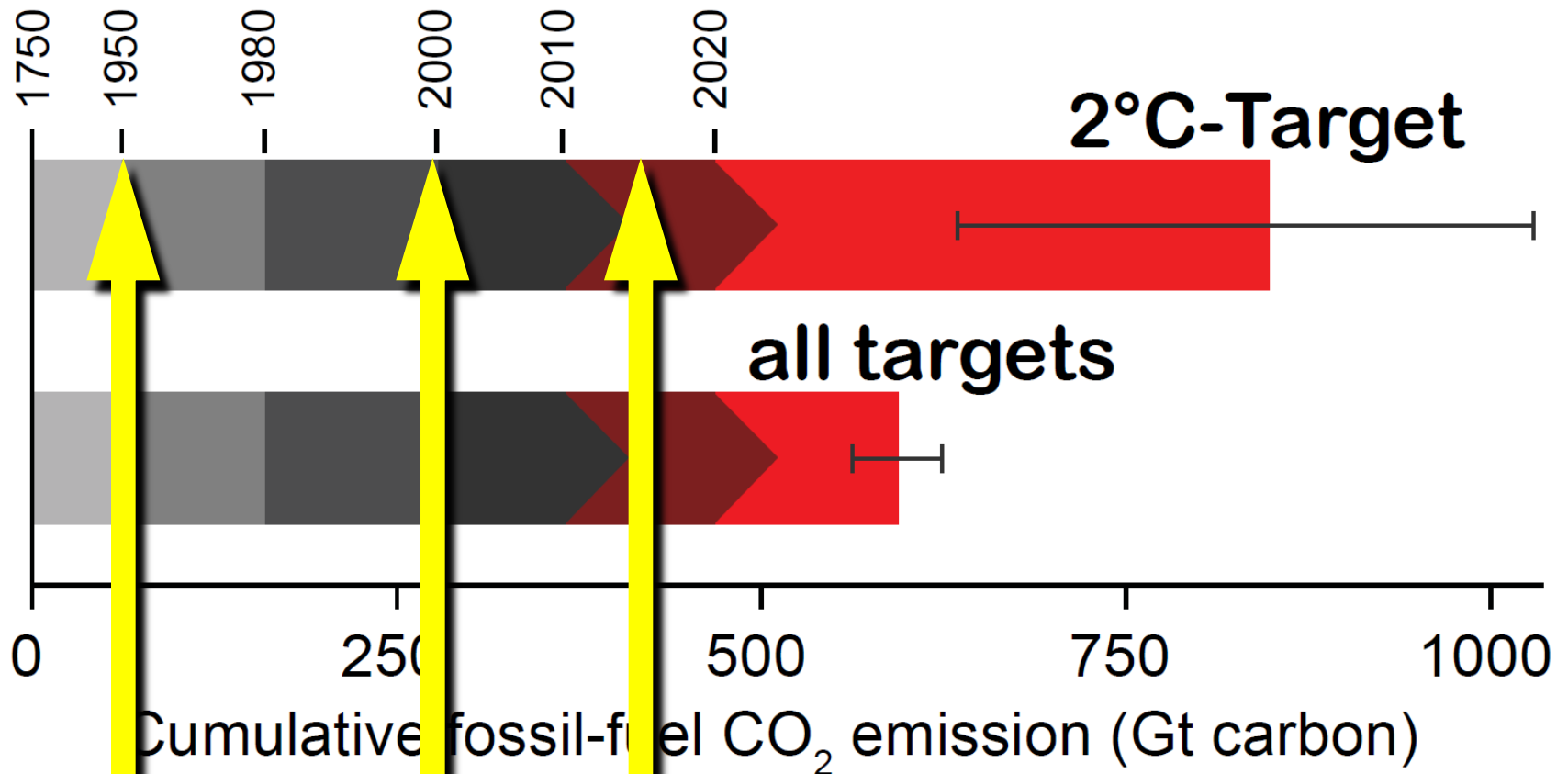
Temp. Target (3°C)

Most stringent single target

Multiple targets



Allowable emission budget for multiple climate targets

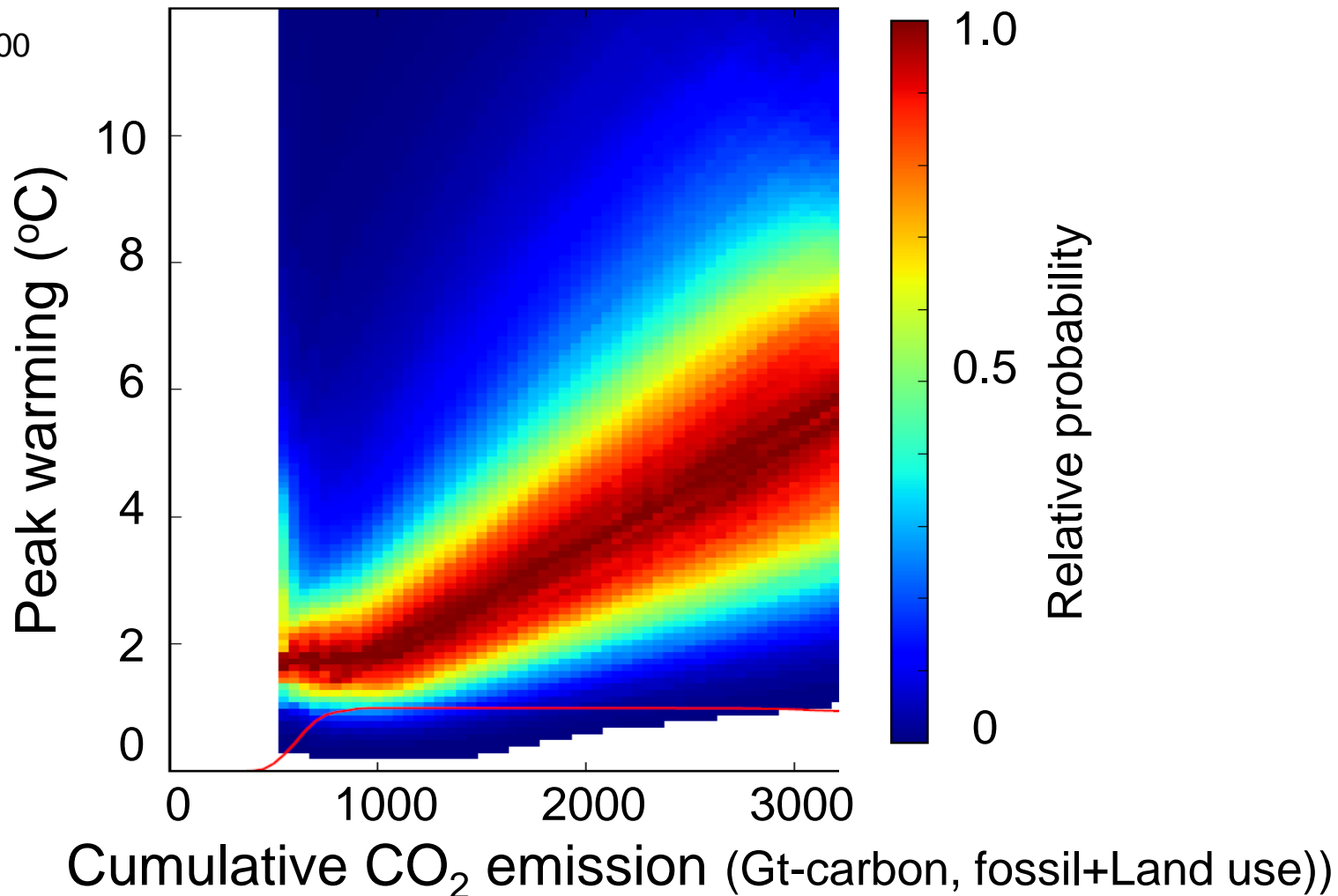




- ❖ **Article 2 of the UNFCCC** cannot be encapsulated by one single "one-size-fits-all" climate target;
- ❖ **Multiple targets** require even deeper emission cuts;
- ❖ **Mitigation of CO₂ emissions** appears to be a prerequisite to allow ecosystems to adapt to ocean acidification;
- ❖ **Climate targets become unreachable** when emissions reductions are delayed, or remain insufficient.

Warming scales with accumulated CO₂ emissions

Period:
1800-2300



Emission Gap in 21st century for target set 2

