Low mitigation scenarios since the AR4 – Global emission pathways and climate consequences

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Potsdam Real-time Integrated Model for probabilistic Assessment of emissions Paths

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Overview

- AR4 Scenarios
- Lower Scenarios
- Post AR4 – Lower Mitigation Scenarios
- Climate consequences and risk of exceeding temperature limits
- Conclusions

Potsdam
Real-time
Integrated
Model for probabilistic
Assessment of emissions
Paths

IPCC AR4 lowest stabilization range – 445-490 ppm CO_2 equivalent

CO_2-equivalent Stabilization level (2005 = 375 ppm CO_2-eq)	Global Mean temperature increase at equilibrium (ºC)	Global average sea level rise at equilibrium from thermal expansion only	Year global CO_2 emissions need to peak	Reduction in 2050 global CO_2 emissions compared to 2000
445 – 490	2.0 – 2.4	0.4 – 1.4	2000 – 2015	-85 to -50
Scenario category	Region		2020	2050
A-450 ppm CO_2-eq	**Annex I**		**-25% to -40%**	**-80% to -95%**
	Non-Annex I		Substantial deviation from baseline in Latin America, Middle East, East Asia 15-30% below business as usual (den Elzen and Höhne 2008)	Substantial deviation from baseline in all regions

SOURCE: TOP HALF OF TABLE FROM TABLE SPM.6 OF THE IPCC AR4 SYNTHESIS REPORT SUMMARY FOR POLICY MAKERS (IPCC 2007) AND LOWER HALF FROM BOX 13.7 OF IPCC WGIII (GUPTA, TIRPAK ET AL. 2007).

AR4 Fossil CO_2 reduction path for lowest scenarios

- AR4 Peak between 2000-2015
  - Six scenarios – two peak before 2010, 3 peak around 2010 and one peaks after 2010 and before 2020
- AR4 reduction by 2050 of 50-85% from 2000
  - Full range 43-89% for six scenarios.

Lower Scenarios: below 445 ppm CO_2 equivalent in 2100

- Nine scenarios – five Post AR4, 1 AR4, 3 AR4 revised
- Post AR4
  - IIASA/PBL Low scenarios IMAGE 2.6 W/m^2 scenario - revised from AR4
  - IIASA/PBL Low scenarios MESSAGE 2.6 W/m^2 scenario
  - ADAM Low Scenarios MERGE Model
  - ADAM Low Scenarios Poles Model
  - ADAM Low Scenarios REMIND Model
- AR4
  - AR4- IMAGE 2.6 W/m^2 scenario
- AR4 Revised Non-CO2 gases
  - AR4- Azar 350 ppm CO_2 - biomass energy carbon capture and storage –
  - AR4- Azar 350 ppm CO_2 - fossil fuel carbon capture and storage – Revised Non-CO2 gases
  - AR4- Azar 350 ppm CO_2 - no fossil fuel carbon capture and storage – Revised Non-CO2 gases

IMAGE and MESSAGE Scenarios Limiting GHG Concentration to Low Levels

- **Authors:** Shilpa Rao, Keywan Riahi, Elke Stehfest, Detlef van Vuuren, Cheolhung Cho, Michel den Elzen, Morna Isaac, Jasper van Vliet
  - International Institute for Applied Systems Analysis (IIASA), Austria
  - Netherlands Environmental Assessment Agency (PBL), Netherlands

- 450 ppm CO_2 equivalent stabilization scenarios - 2.6 W/m^2
  - Equilibrium temperature increase of ca 2.1^oC
  - IMAGE 2.6 updated from AR4
  - MESSAGE 2.6

IMAGE and MESSAGE Scenarios Limiting GHG Concentration to Low Levels

- Not attainable without negative emissions in energy sector – e.g. bio-energy with carbon capture
- Low levels attainable but **critically dependent** on several factors
  - Drastic, early and globally concerted mitigation and assumed that emission reductions implemented from 2013 and global peak by 2100
  - Rapid up-scaling and feasibility of large-scale bionergy, and availability of forest sinks
  - High rates of energy efficiency improvements
  - Availability of carbon capture and storage technologies

ADAM: **First assessment of low stabilisation scenarios**

- Investigated technological feasibility and implications of 400 CO_2 equivalent stabilization scenarios –(1.95 W/m^2)
  - Equilibrium temperature increase of ca 1.6^oC
- **Authors of the report:** Brigitte Knopf, Ottmar Edenhofer (PIK) (lead authors), Hal Turton (PSI), Terry Barker (4CM1R), Serban Scrieciu (4CMR), Marian Leimbach, (PIK), Lavinia Baumstark (PIK), Alban Kitous (Enerdata) (contributing authors)
- **Authors of the modelling results:** Lavinia Baumstark, Marian Leimbach (PIK, modelling with REMIND), Hal Turton, Bertrand Magné, Sokrates Kypreos (PSI, modelling with MERGE), Terry Barker, Serban Scrieciu (4CMR, modelling with E3MG), Alban Kitous, Elie Bellevrat (Enerdata, modelling with POLES)

ADAM Low Mitigation Scenarios - Models

- REMIND: Potsdam Institute for Climate Impact Research
- MERGE: Paul Scherrer Institute
- E3MG: Cambridge Centre for Climate Change Mitigation
- POLES: CNRS Universite Pierre Mendes, France

ADAM : **Report on first assessment of low stabilisation scenarios – Conclusions**

- All models can produce low stabilization targets
- Costs are moderate in all models
  - Ranging from cumulative gains of 1% of GDP to 1.7% losses compared to baseline to 2100
  - Lower to medium range of costs compared to AR4
- Technological flexibility is much lower compared to higher stabilization scenarios
  - Biomass, CCS, energy efficiency and demand side measures all play a very important role

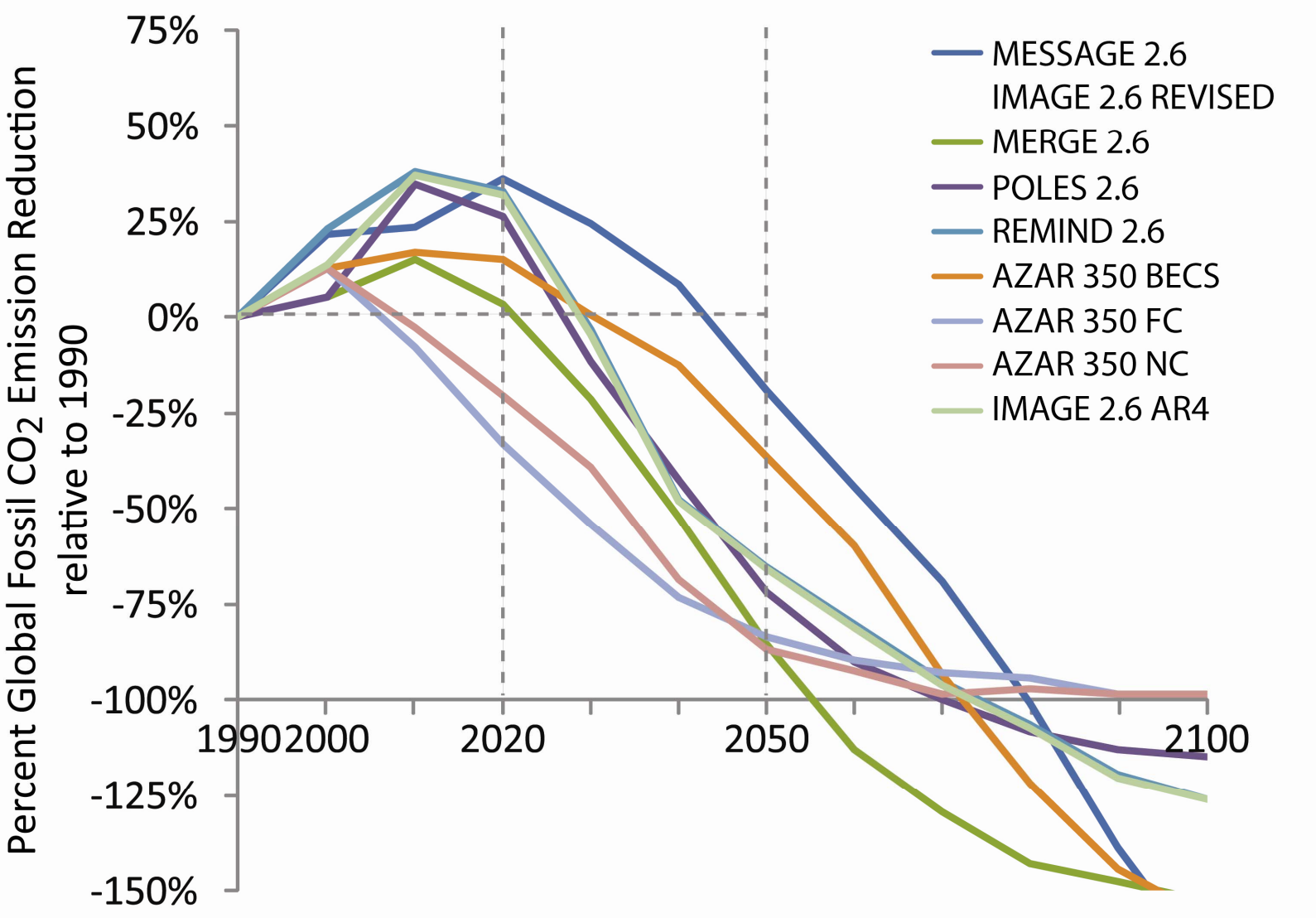
ADAM : **Report on first assessment of low stabilisation scenarios – Technology**

- POLES, REMIND, MERGE models require biomass and CCS, to achieve low stabilization level
  - All below 450 ppmv CO_2e by 2100
    - MERGE ca 400 ppmv CO_2e in 2100 and declining quickly
    - REMIND ca 440 ppmv CO_2e in 2100 and declining slowly
    - POLES ca 440 ppmv CO_2e in 2100 and declining slowly
- E3MG has a different model set up
    - Early investment in energy efficiency policies stimulate global economy
      - Biomass and CCS not needed
    - Above 460 ppm CO_2e in 2100 and increasing slowly

Lower Scenarios: Emissions summary

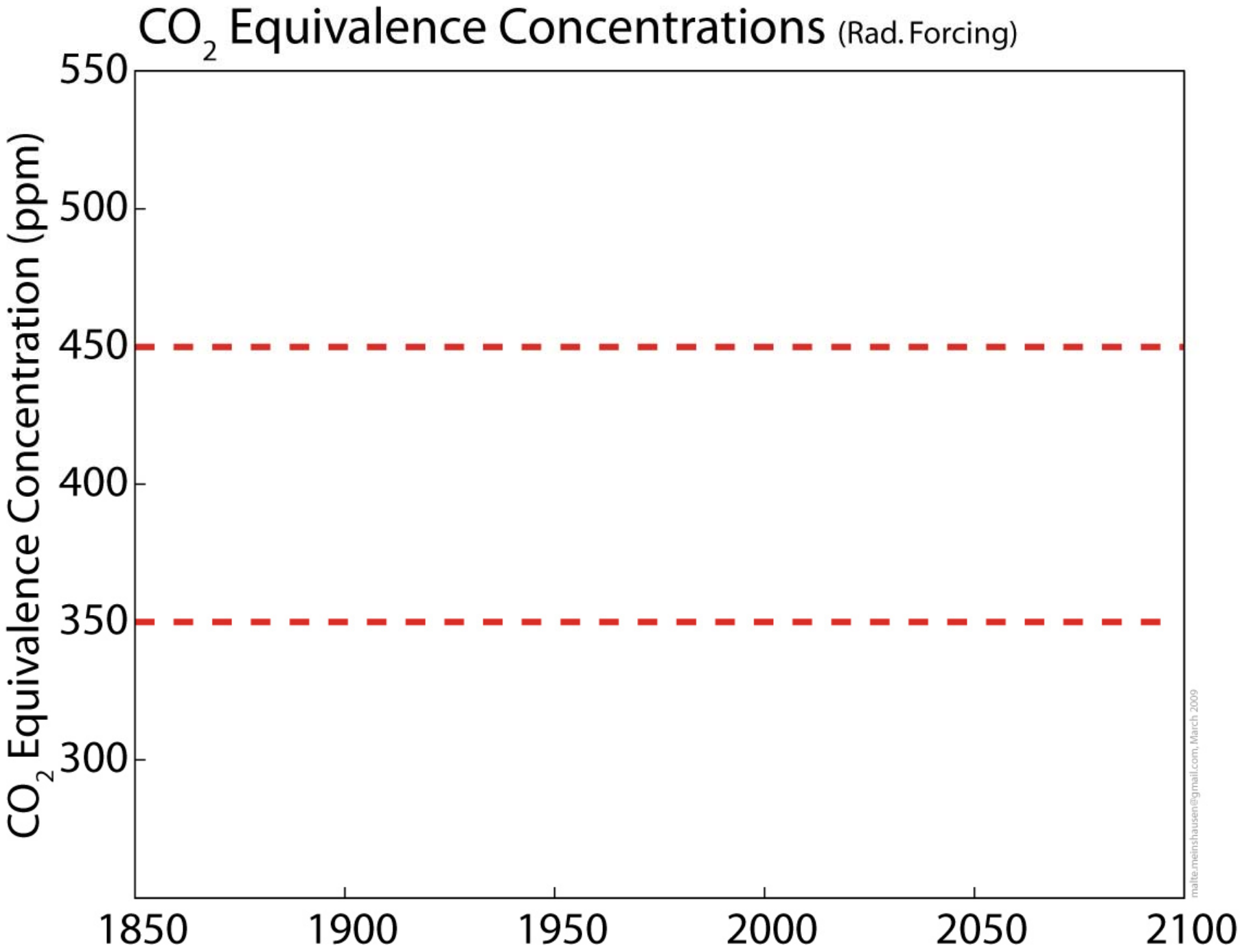
SCENARIO	Peak year Industrial CO_2	Industrial CO_2 reductions in 2050 from 2000	Total GHG reductions 2050 from 1990
Azar revised 350 ppm CO2 stabilization with biomass energy carbon capture and storage	2010	45%	15%
Azar revised 350 ppm CO2 stabilization with fossil fuel carbon capture and storage	2000	85%	50%
Azar revised 350 ppm CO_2 stabilization with no fossil fuel carbon capture and storage	2000	90%	50%
AR4-IMAGE 2.6 W/m2	2010	70%	50%
IIASA/PBL Low scenarios IMAGE 2.6 W/m2 scenario - revised from AR4	no data	no data	50%
IIASA/PBL Low scenarios MESSAGE 2.6 W/m^2 scenario	2020	35%	5%
ADAM Low Scenarios MERGE Model	2010	85%	65%
ADAM Low Scenarios Poles Model	2010	75%	55%
ADAM Low Scenarios REMIND Model	2010	85%	65%

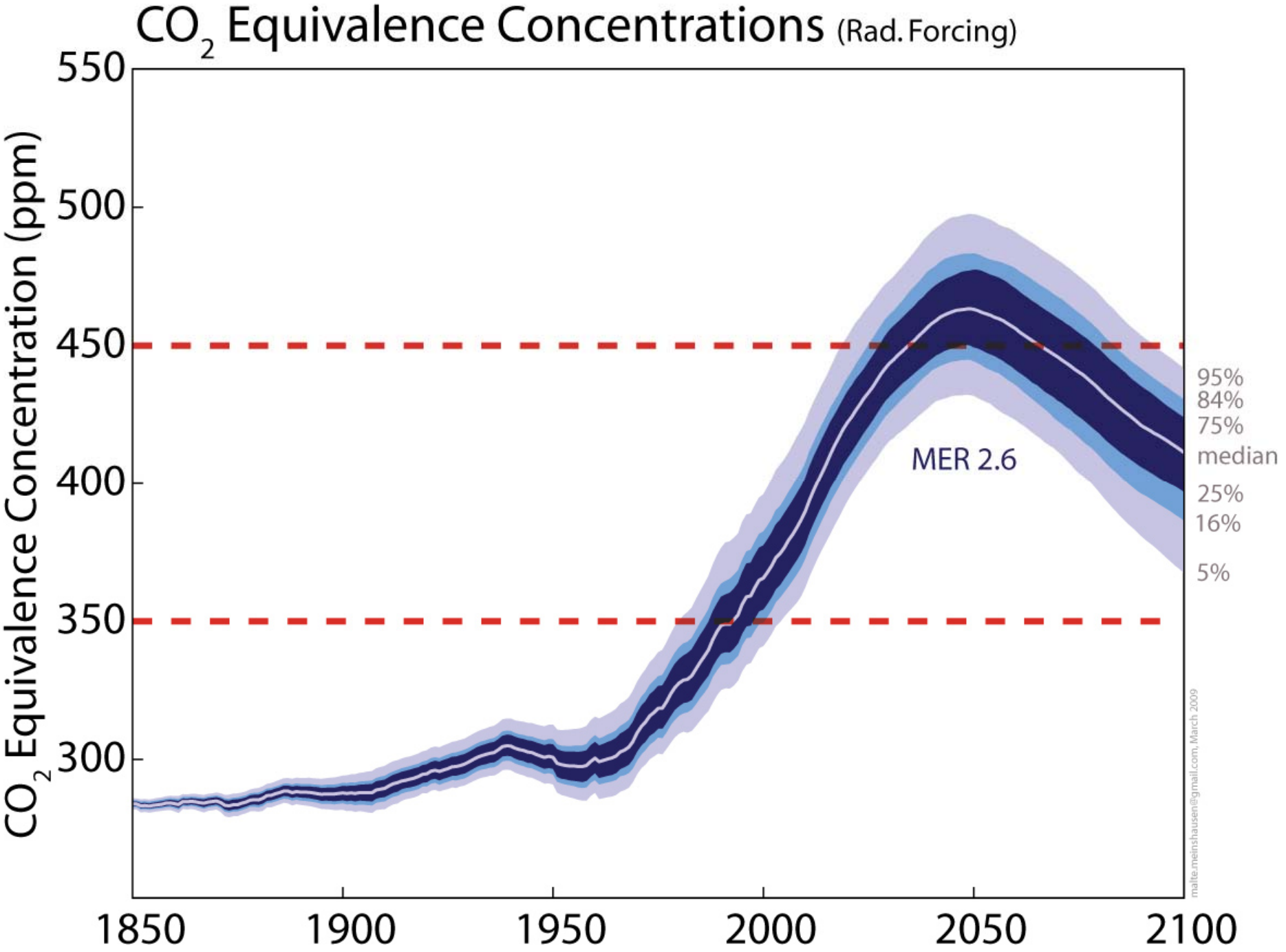
Low Scenarios - Global Fossil CO_2 reductions relative to 1990 (%)



Lower Scenarios: Concentration temperature and risk

SCENARIO	CO_2e in 2100	°C increase in 2100	Probability of exceeding 2°C	Probability of exceeding 1.5°C
Azar revised 350 ppm CO2 stabilization with biomass energy carbon capture and storage	415	1.5	25%	75%
Azar revised 350 ppm CO2 stabilization with fossil fuel carbon capture and storage	410	1.3	5%	40%
Azar revised 350 ppm CO_2 stabilization with no fossil fuel carbon capture and storage	410	1.4	5%	45%
AR4-IMAGE 2.6 W/m2	445	1.6	30%	75%
IIASA/MNP Low scenarios IMAGE 2.6 W/m^2 scenario - revised from AR4	445	1.6	30%	75%
IIASA/MNP Low scenarios MESSAGE 2.6 W/m^2 scenario	440	1.7	50%	95%
ADAM Low Scenarios MERGE Model	405	1.4	15%	60%
ADAM Low Scenarios Poles Model	440	1.6	25%	90%
ADAM Low Scenarios REMIND Model	440	1.6	30%	75%


CO_2 Equivalence Concentrations (Rad. Forcing)
CO_2 Equivalence Concentration (ppm)
550
500
450
400
350
300
1850
1900
1950
2000
2050
2100
malte.meinshausen@gmail.com, March 2009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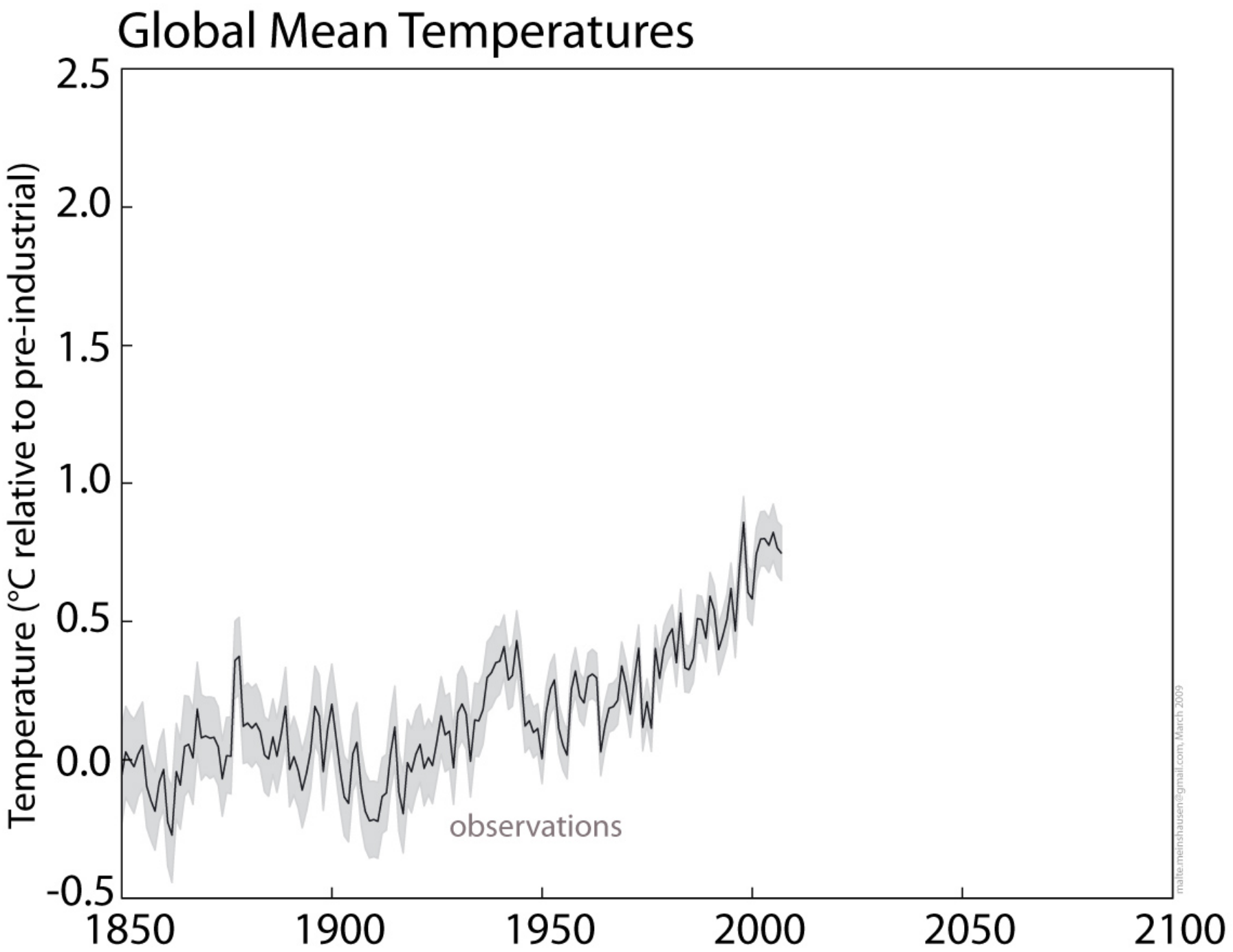
CO_2 Equivalence Concentration (ppm)
550
500
450
400
350
300
1850
1900
1950
2000
2050
2100
MER 2.6
95%
84%
75%
median
25%
16%
5%
malte.meinshausen@gmail.com, March 2009


Global Mean Temperatures
Temperature (°C relative to pre-industrial)
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
1850
1900
1950
2000
2050
2100
observations
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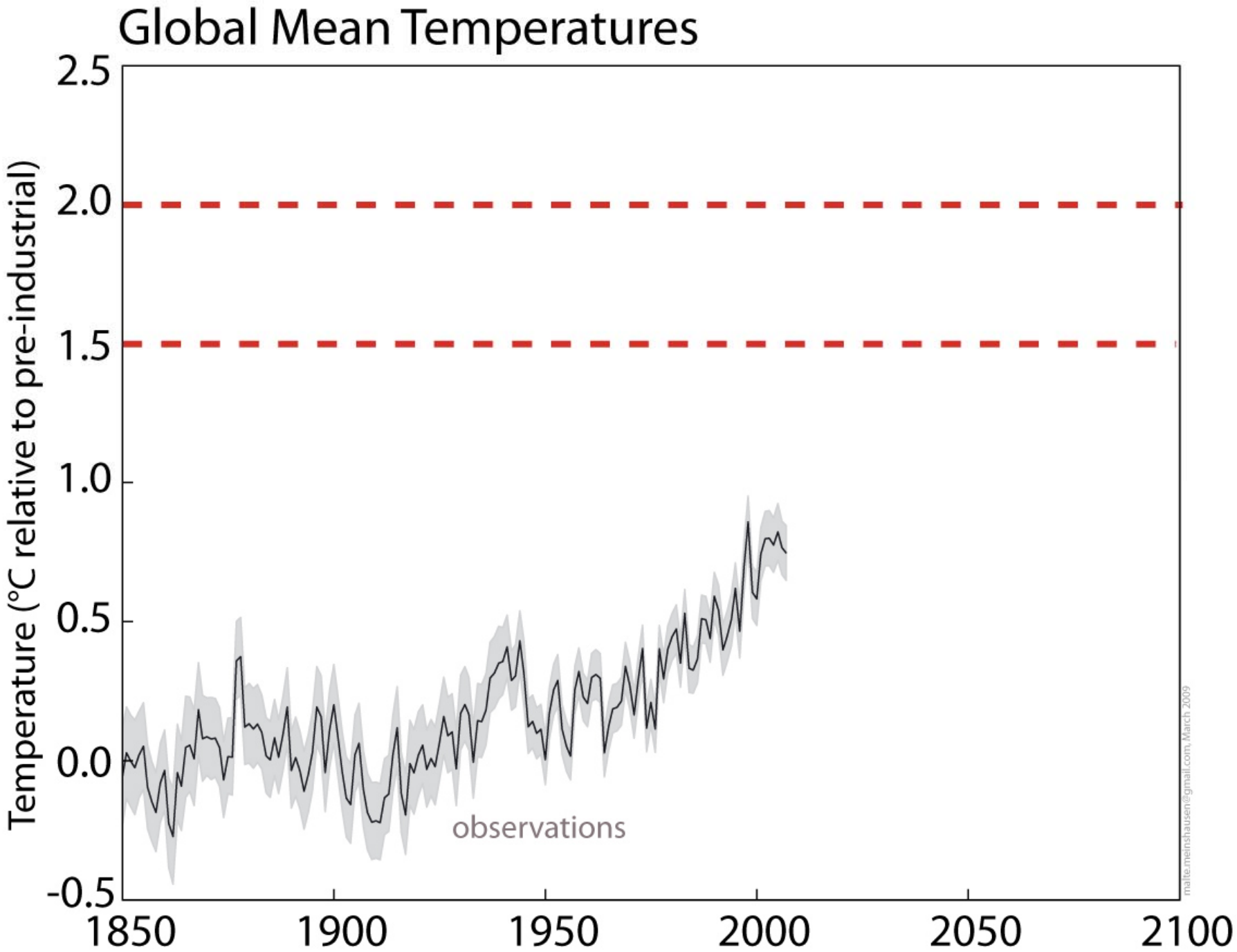
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Temperature (°C relative to pre-industrial)
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-0.5
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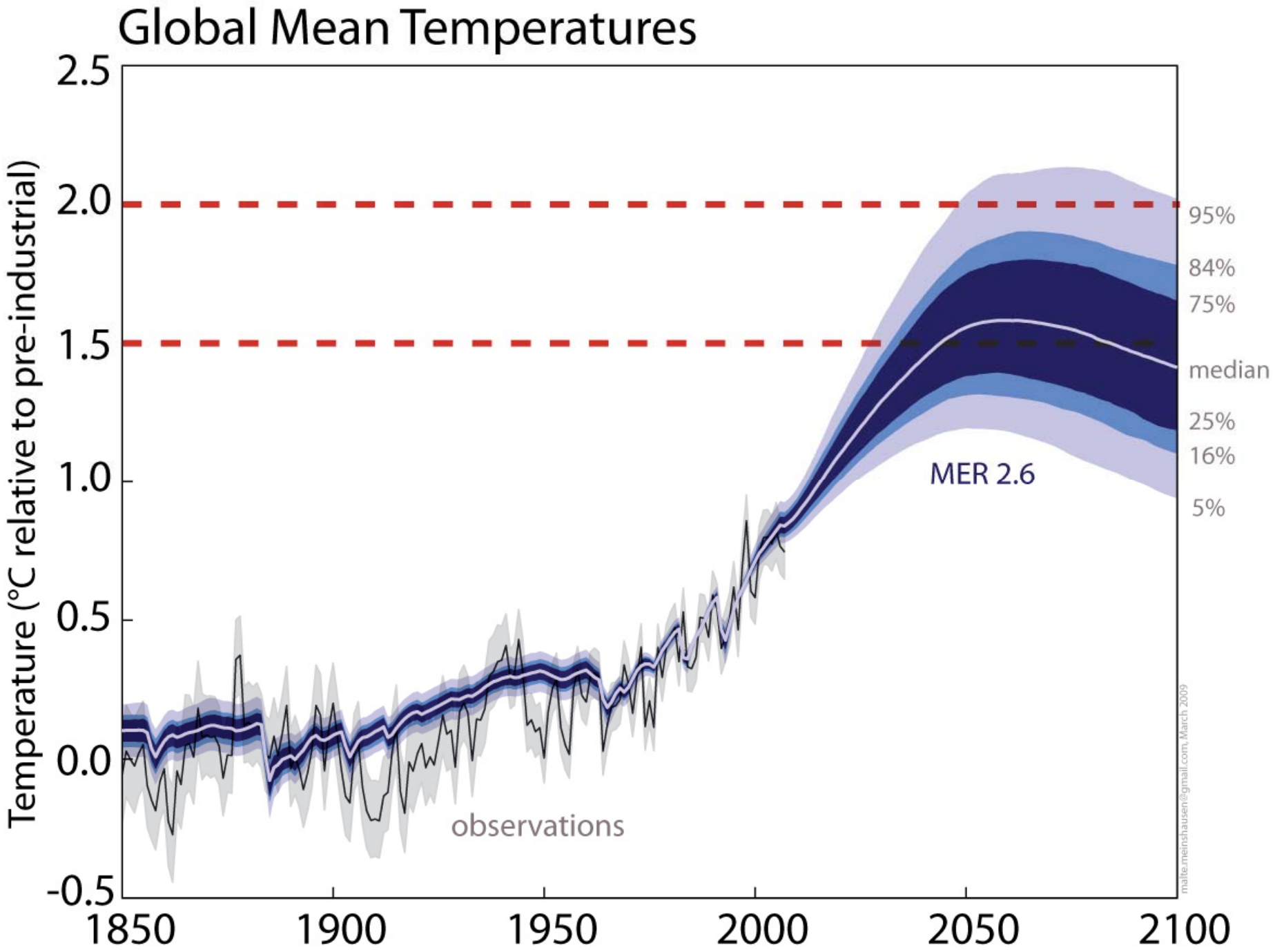
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2.0
1.5
1.0
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1850
1900
1950
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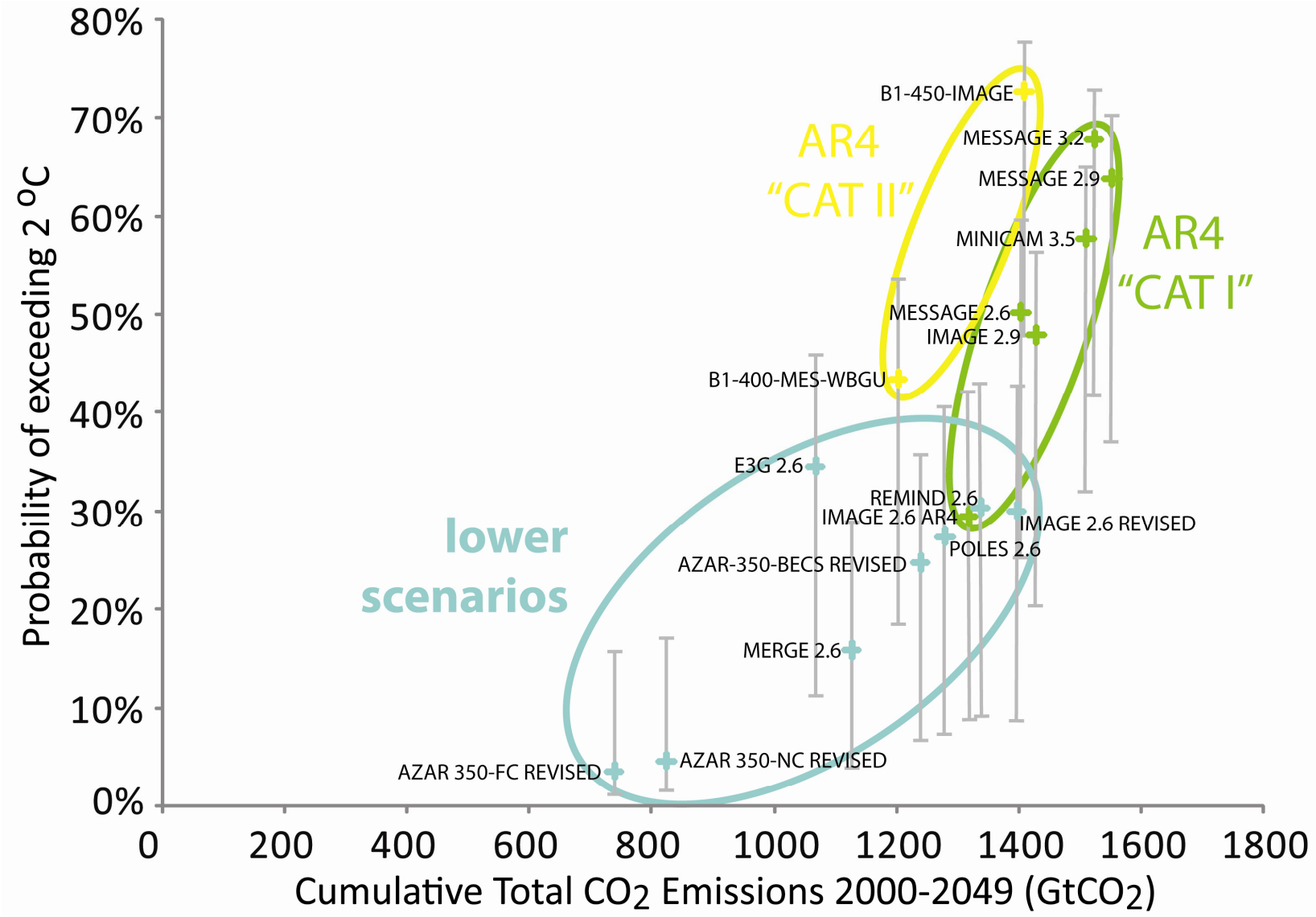
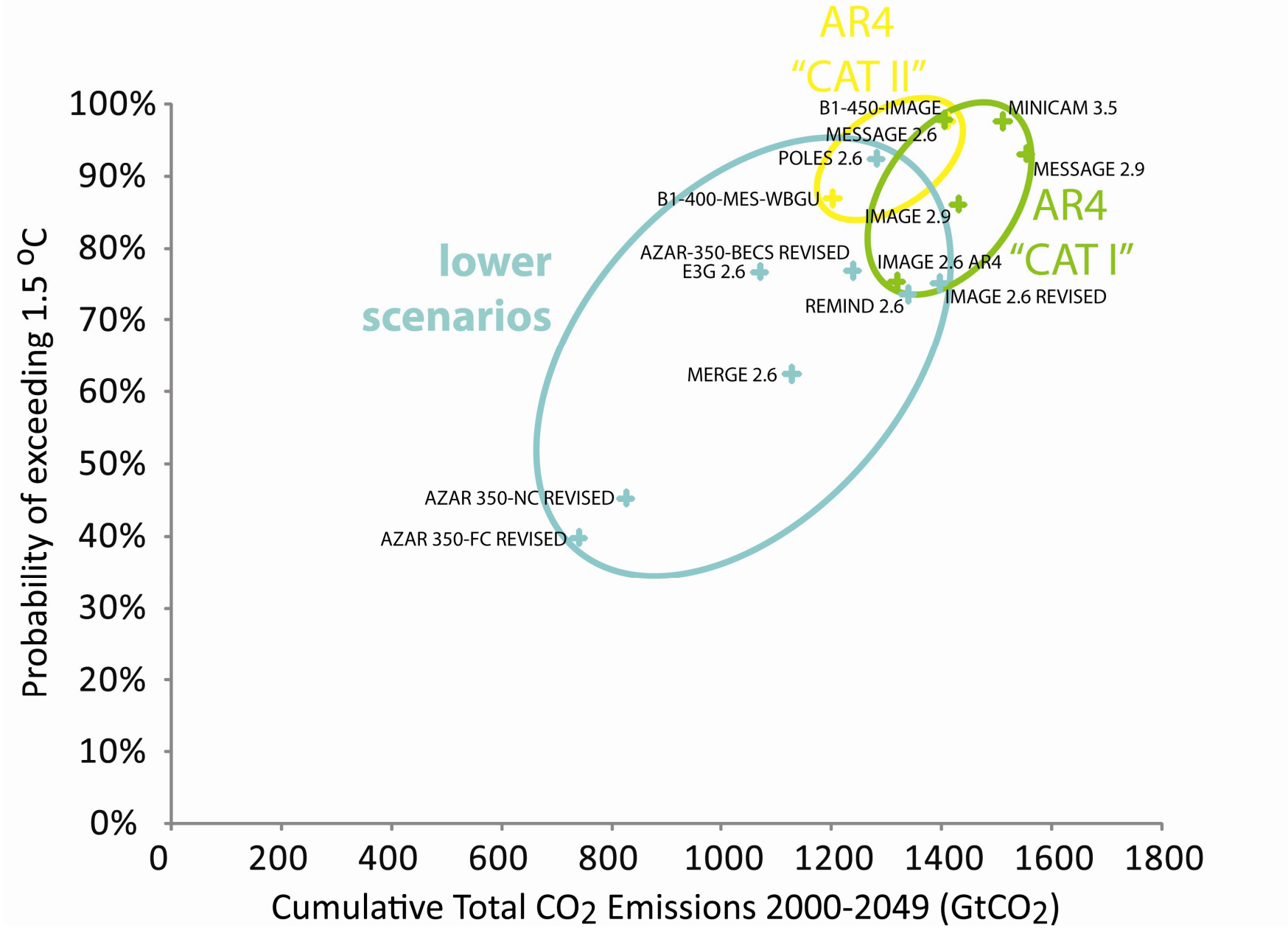
2050
2100
95%
84%
75%
median
25%
16%
5%
MER 2.6
observations
malte.meinshausen@gmail.com, March 2009

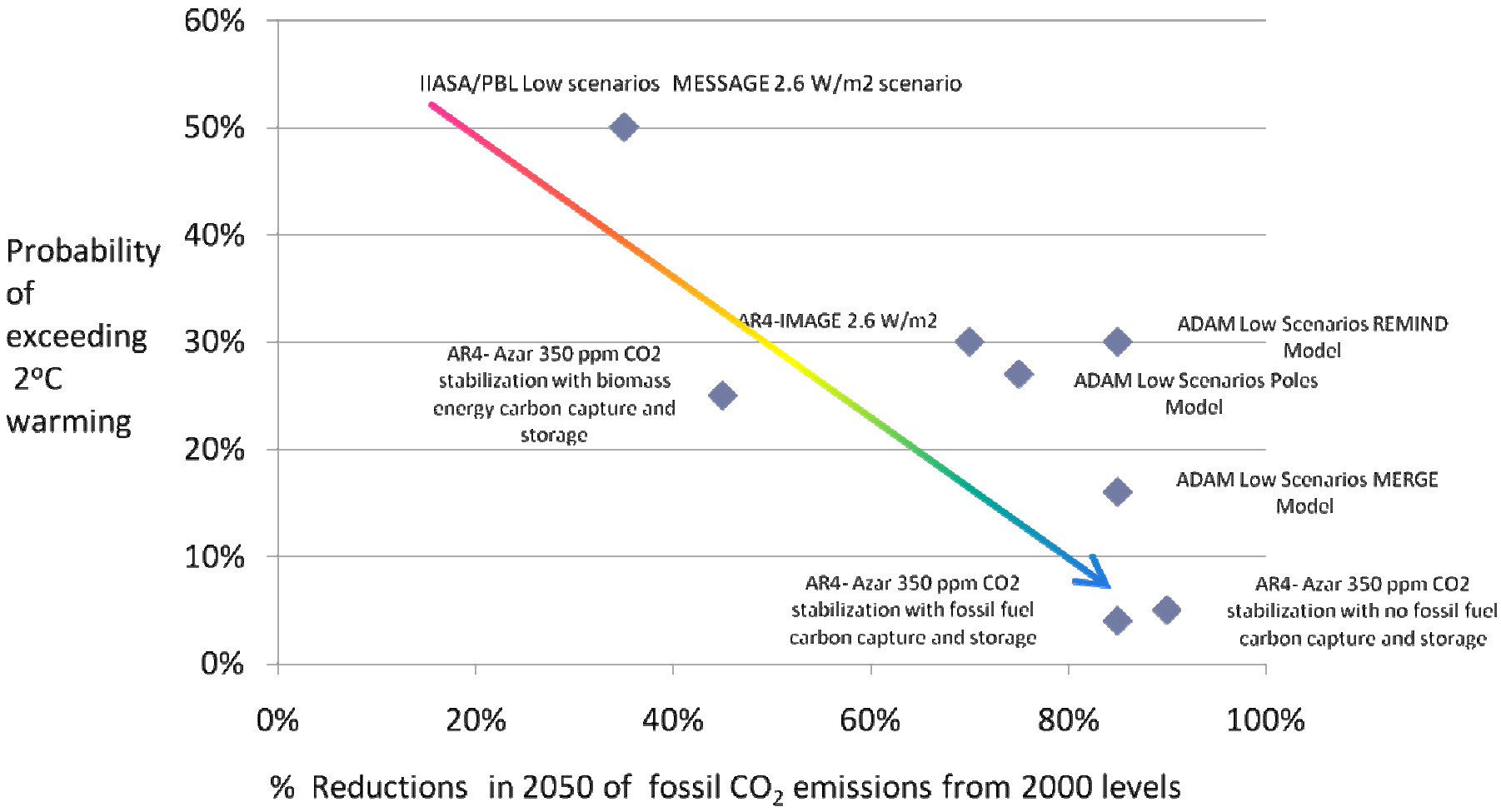
Probability of exceeding 2°C



Probability of exceeding 1.5°C



2050 Fossil CO_2 reductions and risk of exceeding 2°C



Conclusions

- Lower scenarios show
  - 2°C warming limit can be achieved with higher probability than shown for lowest category AR4 stabilization scenarios
  - Fossil CO_2 emissions peak before 2020
  - Fossil CO_2 emissions reduced 35-90% by 2050 from 2000 levels (6 out of 8 scenarios 70-90%)
- Further work is needed on higher probability pathways for that 1.5°C warming level

Thank you.
Further information
www.primap.org
www.climateanalytics.org

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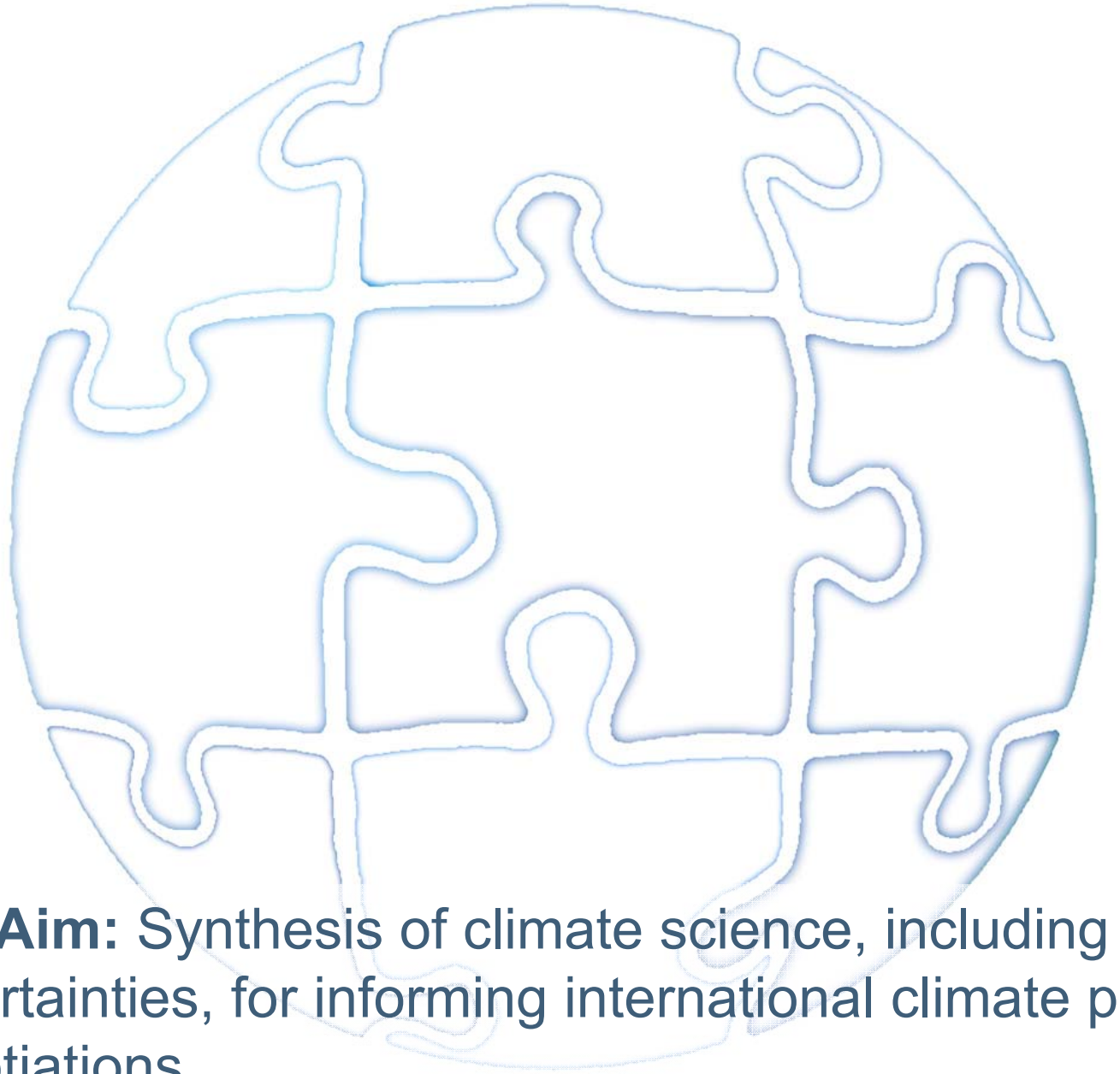

Our Aim: Synthesis of climate science, including its uncertainties, for informing international climate policy negotiations.