来世紀ゼロエミッションによるCO_2濃度安定化
ー気候安定化への新しい排出シナリオの可能性ー

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Stabilization of the CO_2 concentration via zero-emission in the next century

- Possibility of new emission pathway to stable climate–

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Themes of the Symposium today

- To clarify scientific basis of climate change mitigation strategy / current arguments on emission reduction

- To look for shared emission reduction strategy by all nations

Current arguments on climate change mitigation (GHG emissions reduction) strategy

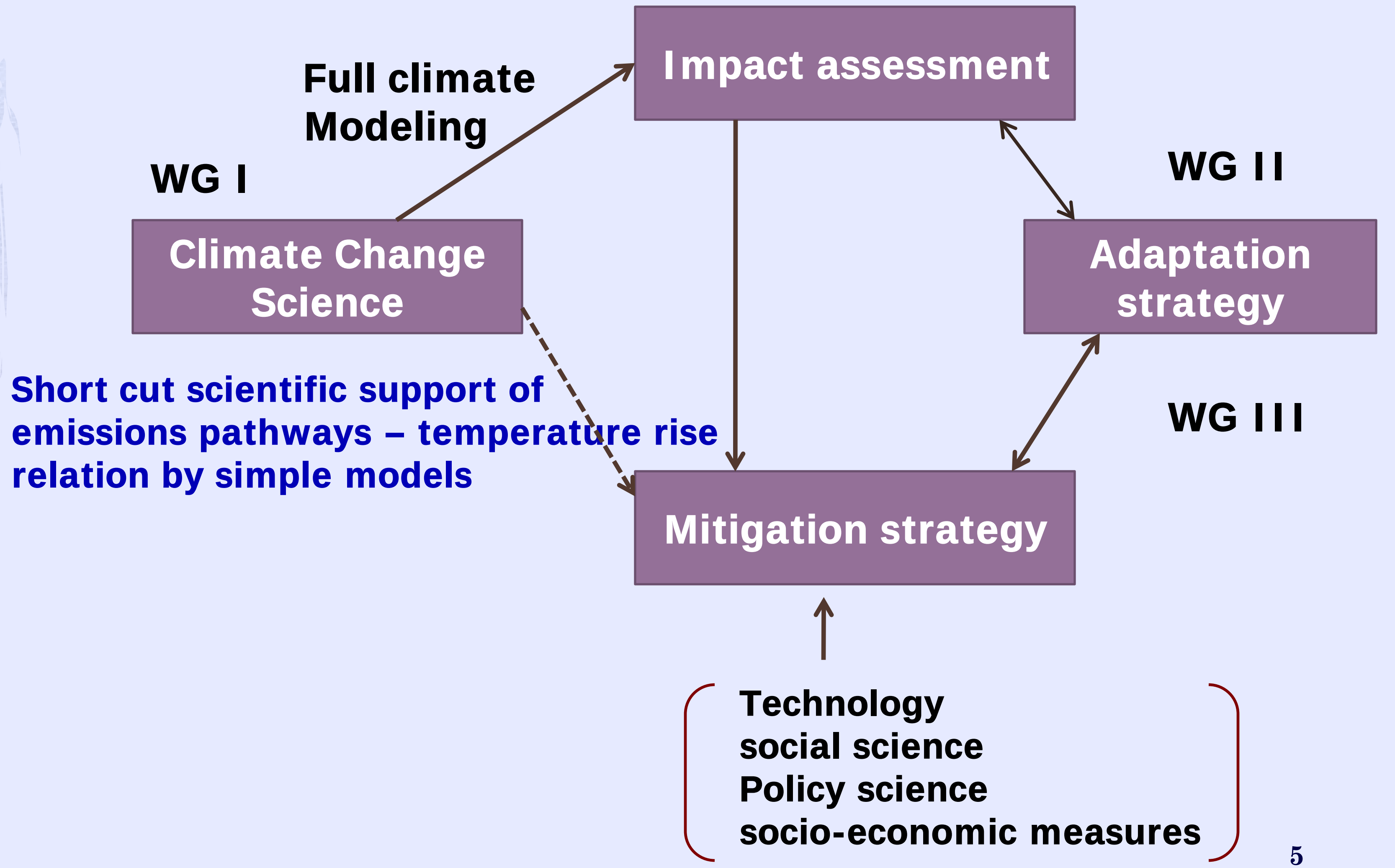
In order to keep the global mean temperature rise
less than 2℃ above pre-industrial state
for avoiding dangerous climate change,
the world's emissions of GHGs (CO_2) must be reduced to 50% of the present (2000) emissions by the year 2050

European Union, G8 Summit Declaration 2007, 2008

(   ) : specification after IPCC WGIII AR4

—— comes from 2 ~ 3°C above 1980 – 1999 average
equivocally 2.5 ~ 3.5°C above pre-industrial level
in IPCC WGII AR4

Scientific basis of climate change mitigation (GHG emissions reduction) strategy



Outline

- Reexamination of traditional “stabilization” concept

  → Equilibrium stabilization via zero emission

- Comparison of two types of stabilizations (CO_2 only)
- Reconsideration of the current emission reduction strategy “50% emission reduction by 2050”

  (A problem in the scientific basis of the strategy)

- Application of zero-emission stabilization for practical climate change mitigation

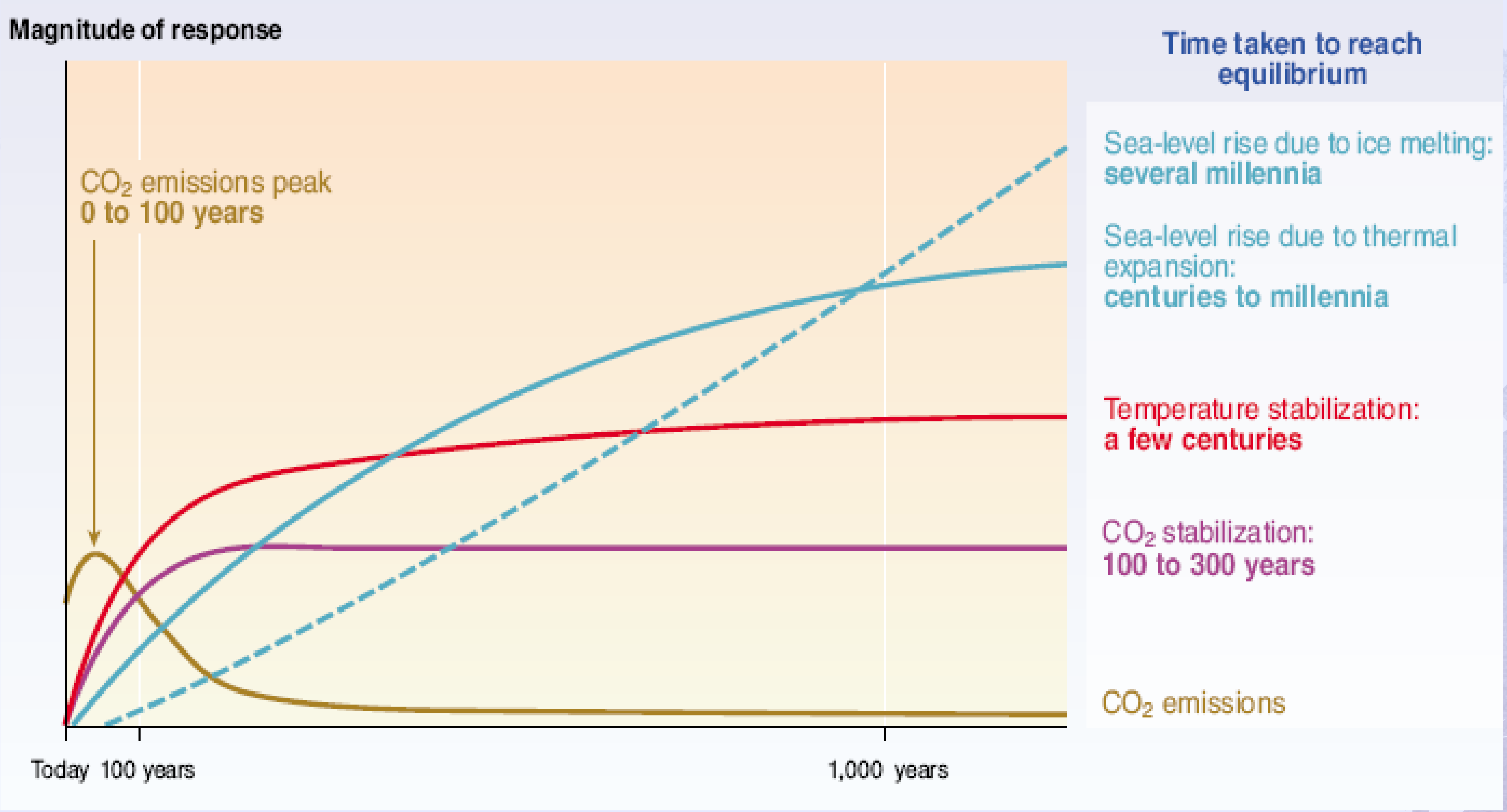
  Proposal of a new emission pathway Z650

- Discussion on the emission pathway Z650 from socio-economic viewpoints (Dr. Koki Maruyama)

Reexamination of traditional “stabilization” concept

従来の“安定化”概念の再検討

Schematic picture to show "stabilization" IPCC TAR Synthesis Report (2001)



Basic properties of the traditional stabilization

- CO_2 (generally GHG) concentration is held constant (at a target level) after the stabilization is realized.
- Emissions pathways

  ① increase following the current trend ↗

  ② turn to decline ↗↘

  ③ drastic emission reduction ↘

  ④ declining speed slows down →

  ⑤ small near constant emission continues →

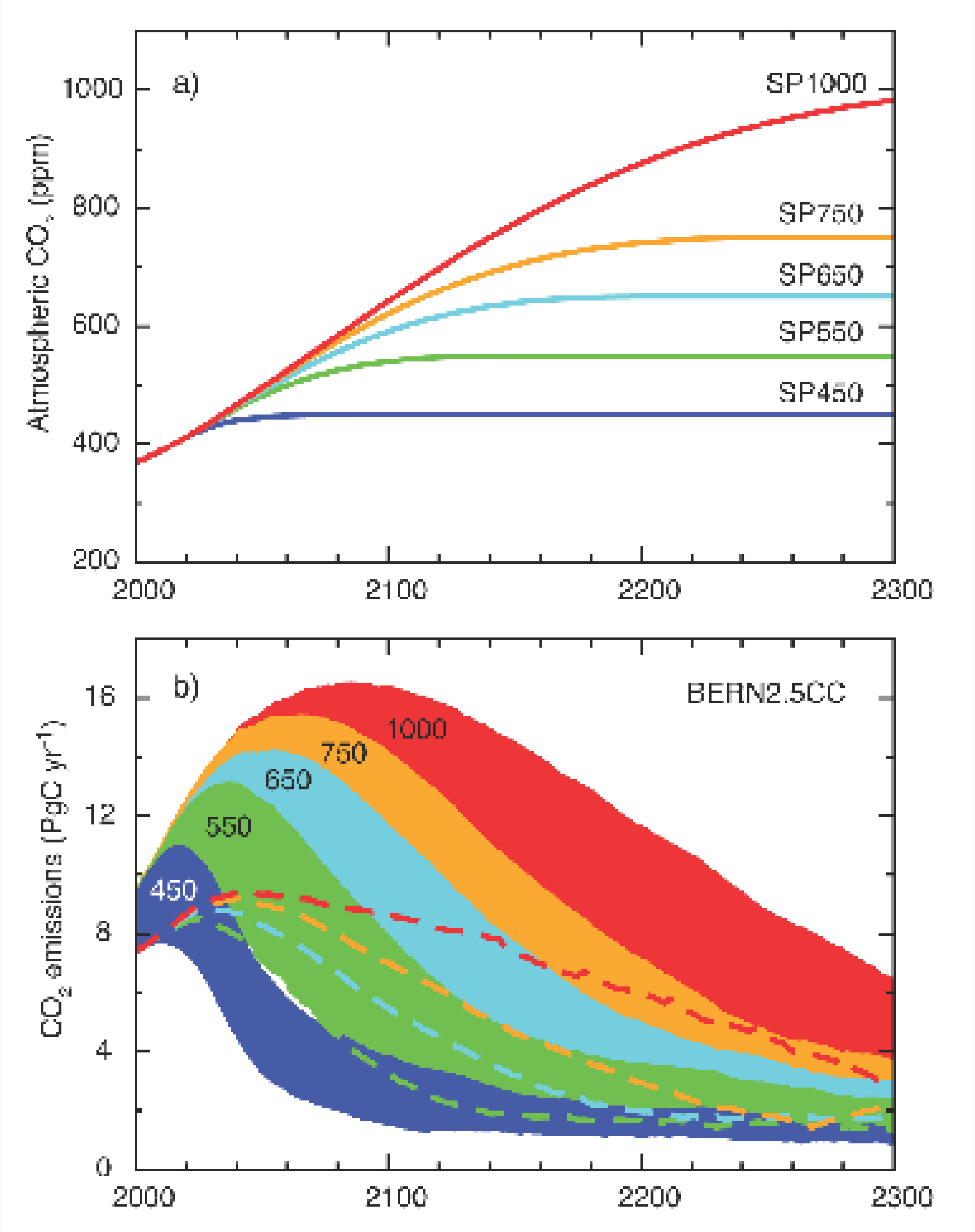
- Temperature increase continuously toward the targeted equilibrium value. However, it takes many centuries.

  (At the beginning of stabilized state 65 ~ 70% of the final △T)

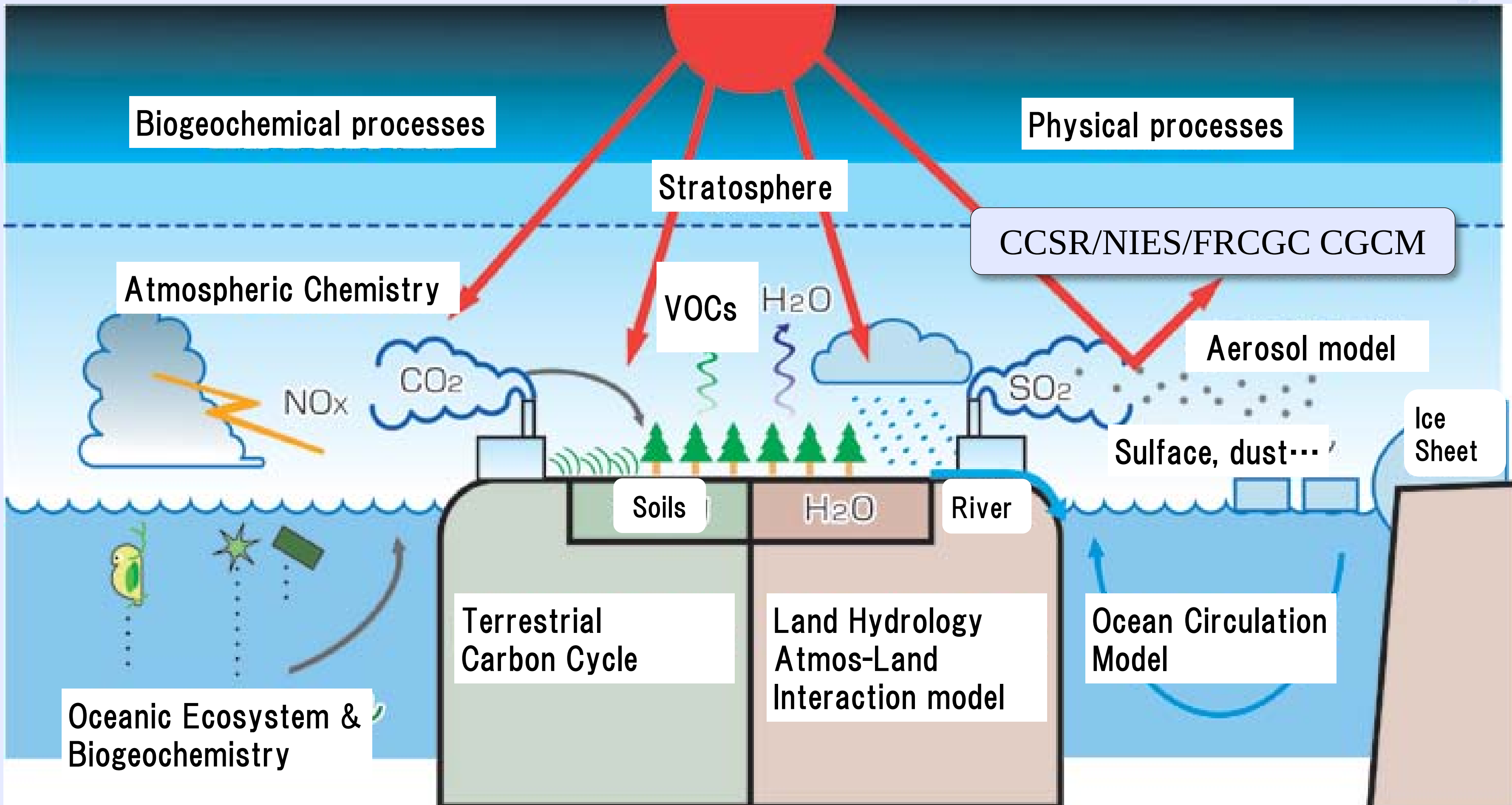
- Even under stabilized state sea level rises continuously by thermal expansion and ice sheet melting

  (Under the constant higher (than present) temperature)

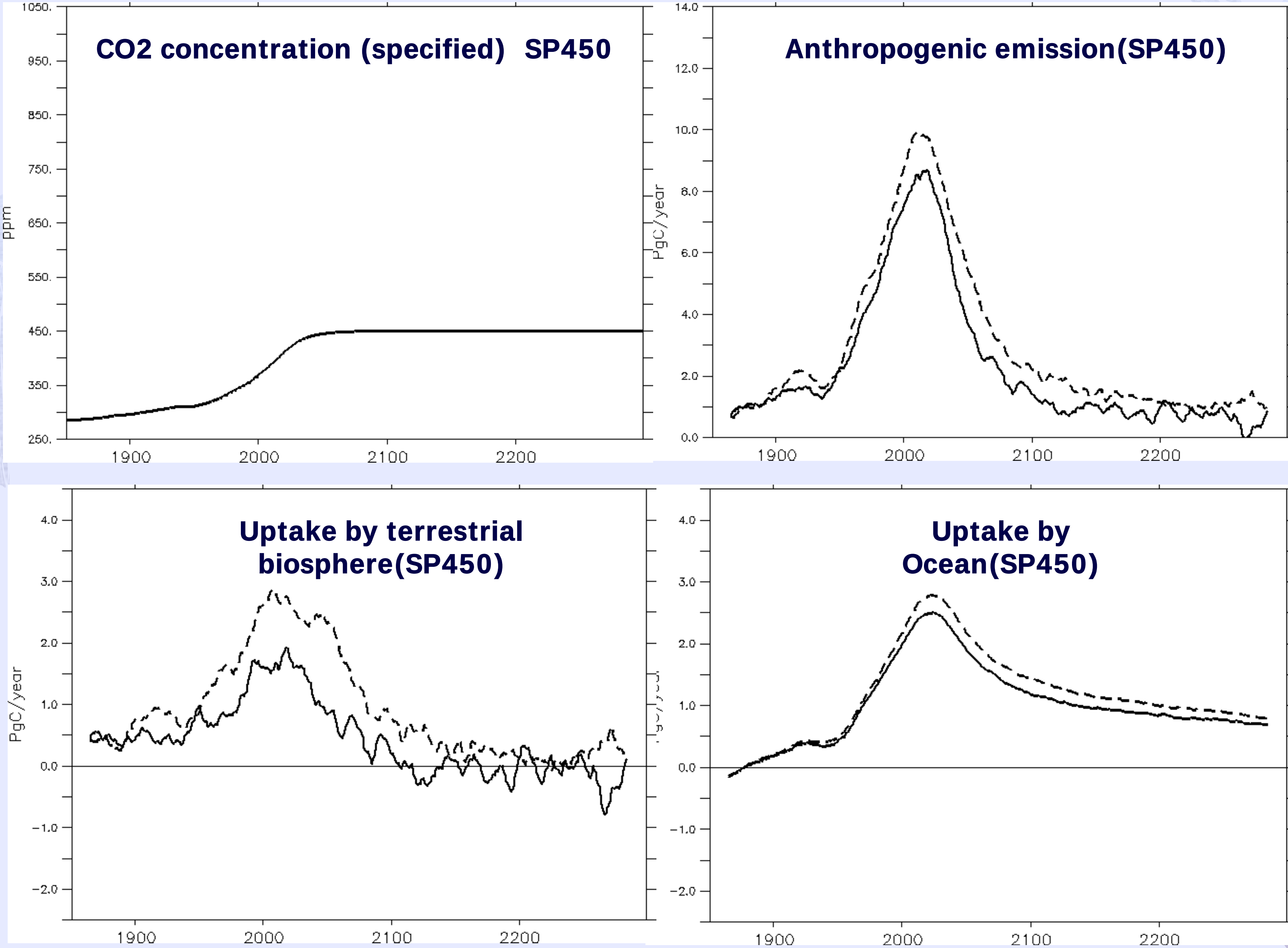
Stabilization pathways from IPCC TAR (Reproduced in AR4)

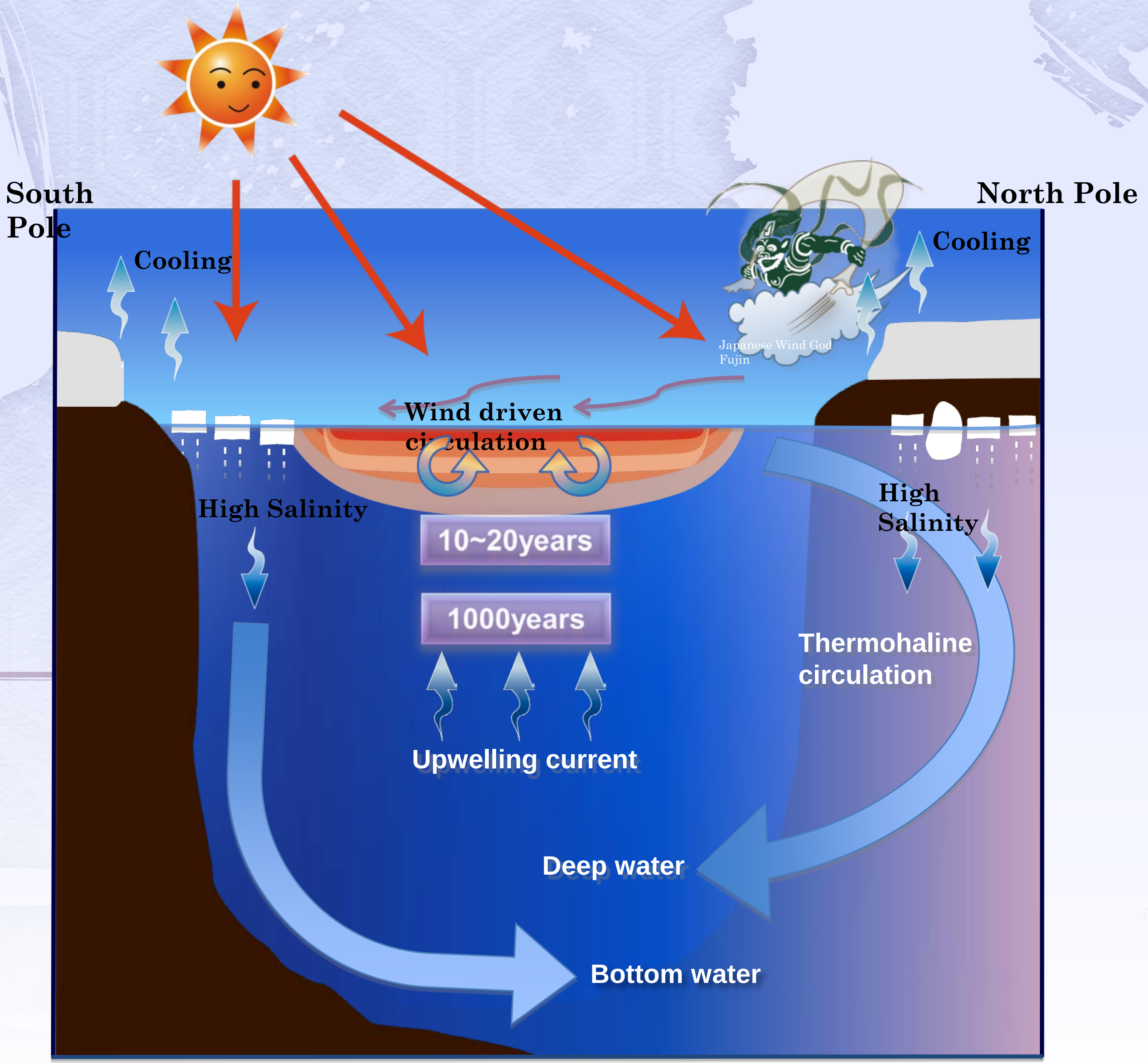


Schematic picture of global environment system (earth system)

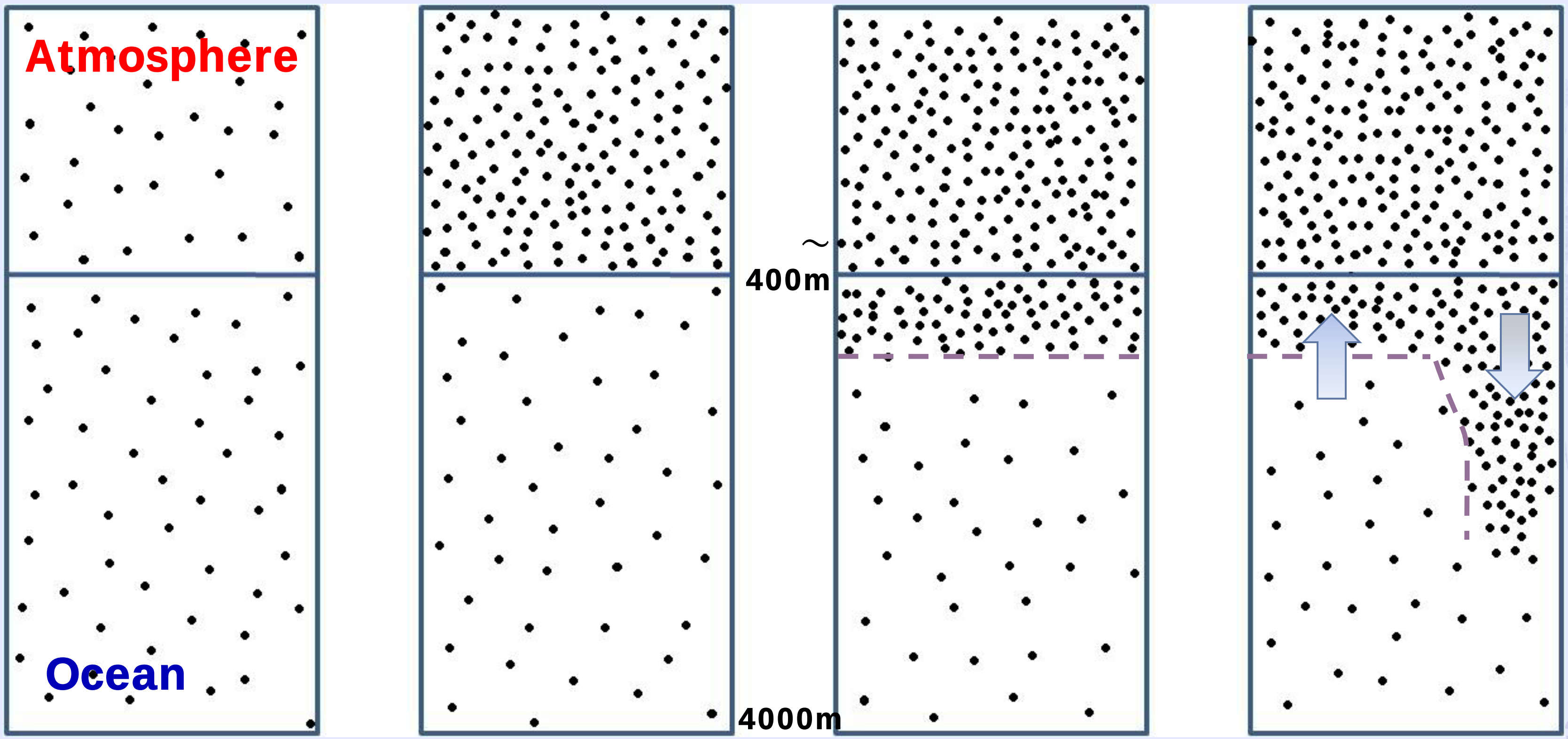


Carbon budget at 450ppm Stabilization




South Pole
North Pole
Cooling
Cooling
Japanese Wind God Fujin
Wind driven circulation
High Salinity
High Salinity
10~20years
1000years
Thermohaline circulation
Upwelling current
Deep water
Bottom water

Schematic picture of the oceanic uptake of CO_2



Pre-industrial equilibrium state

Increase in the atmosphere

(～20years) Subsurface layer equilibrates

(1,000y <) Gradually spreads into deep ocean

Naïve question on the traditional stabilization

Why does the world (human society) stop or slow down the emission reduction after accomplishment of drastic reduction?

Why / for what purpose emissions of a small but significant amount (10 ~ 20% of the peak) continue over many centuries and millennia?

There may be no need for continued small emissions

It is merely a consequence of inverse calculation from "stabilization = constant concentration".
Continuous emissions are needed to keep the CO_2 concentration at the target level against the natural uptakes
➡ Emission keeping stabilization.

It is very strange to keep anthropogenic emissions to maintain the higher concentration/temperature against natural recovery effects

New concept of Zero-emission stabilization

By continuing the efforts of emissions reduction “without slowing down”, the emissions can be reduced to levels sufficiently lower than the natural uptake (at the originally intended stabilized state) = 10~20%

➡ (practically) zero-emission

Then the once elevated CO_2 concentration will turn to decline towards final equilibrium.

The temperature rise also turns to decrease and continues to decrease very slowly (0.3^{o}C per century).

The final state (after about a millennium) is a stable stationary state similar to pre-industrial era but with higher CO_2 concentration and higher temperature.

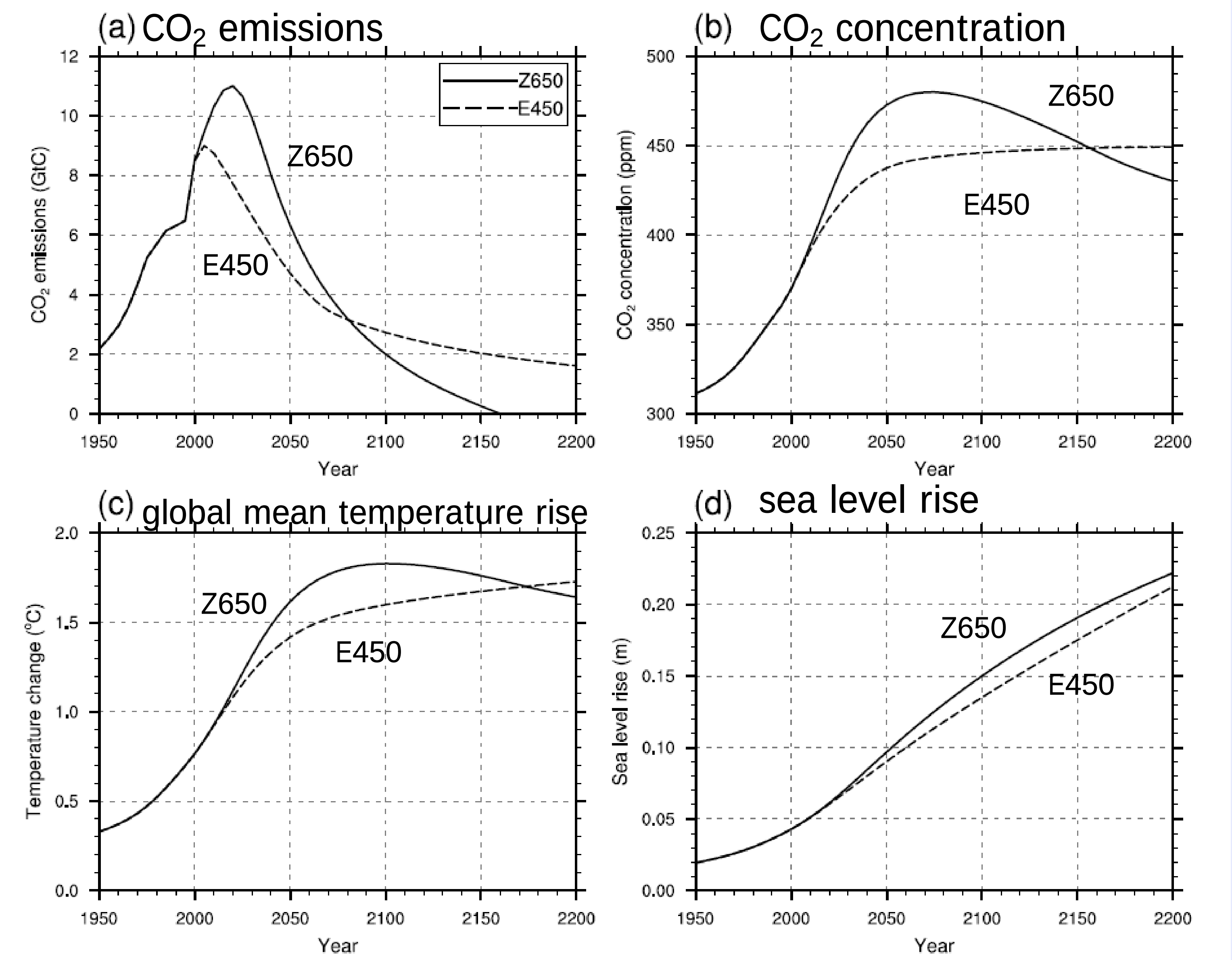
Comparison of the two stabilizations

2種の安定化の比較

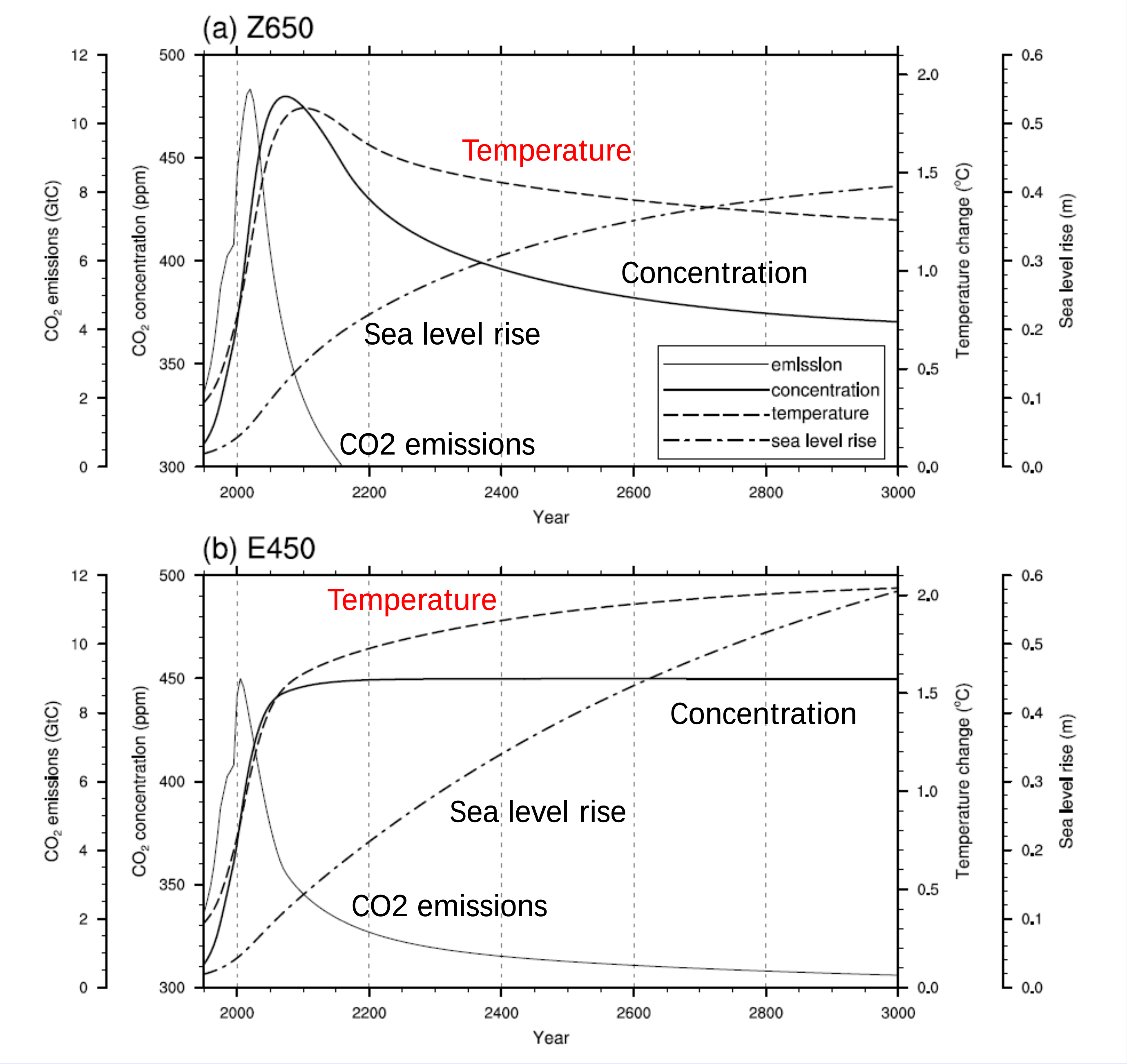
Projection calculations by use of a simplified carbon cycle/climate model based on NICCS

"Nonlinear Impulse response model of the coupled Carbon Cycle Climate System" developed at Max Planck Institute(2001)

Characteristics of Z650(bold line) and E450(dashed line)



Long-term characteristics of Z650 (a) and E450 (b)



Results of the comparison Z650 and E450

Until 2200

•CO_2 concentration in Z650 temporarily overshoot above 450ppm to reach480ppm, but the temperature rise remains below 2℃ (max 1.8℃)

•CO_2 concentration in E450 increases continuously to reach almost 450ppm by 2100 but the temperature rises rather slowly.

At 2050 440ppm (94% of increase) △T ~ 1.4℃ (70%)

At 2200 450ppm △T ~ 1.8℃(90%)

Longer time scale

•CO_2 concentration in Z650 slowly decreases after peaking (480ppm) down to ~370ppm at 3000;

Temperature rise also decrease to ~1.3℃ at 3000

•CO_2 concentration in E450is held constant at 450ppm

Temperature rises steadily to reach 2.1℃ at 3000.

The emissions in the near future (21st century) are much larger for Z650 than E450.

Reconsideration of the current emissions reduction strategy “50% reduction by 2050”

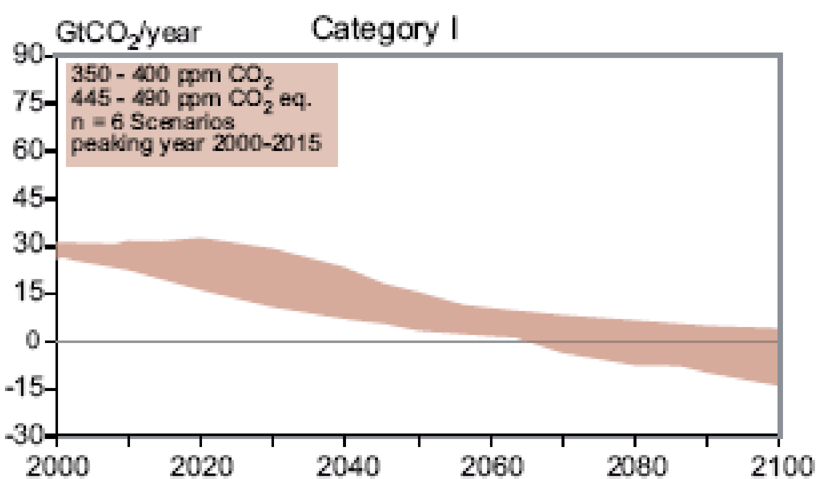
現在議論されている「2050年までにCO_2(温室効果ガス)排出50%削減」の再検討

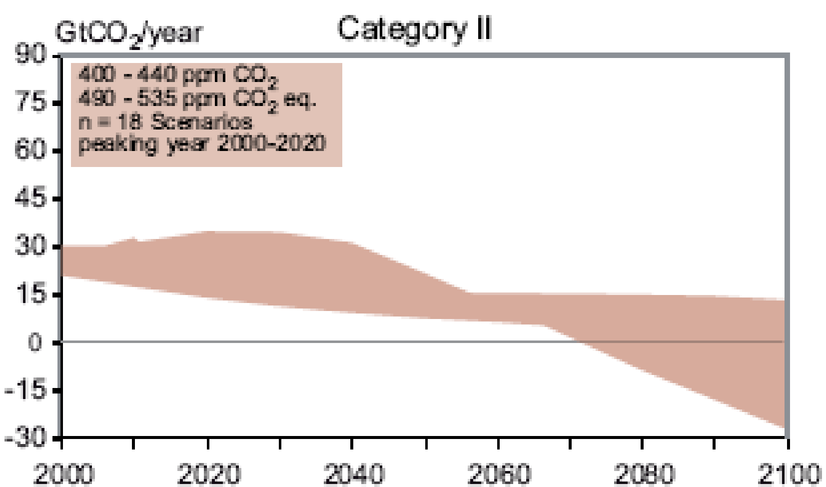
Scientific basis of the 50% emissions reduction by 2050

IPCC WG III AR4(2007):Category I Scenarios

Table SPM.5: *Characteristics of post-TAR stabilization scenarios [Table TS 2, 3.10]*[a)]

Category	Radiative forcing (W/m^2)	CO_2 concentration[c)] (ppm)	CO_2-eq concentration[c)] (ppm)	Global mean temperature increase above pre-industrial at equilibrium, using "best estimate" climate sensitivity[b), c)] (ºC)	Peaking year for CO_2 emissions[d)]	Change in global CO_2 emissions in 2050 (% of 2000 emissions)[d)]	No. of assessed scenarios
I	2.5-3.0	350-400	445-490	2.0-2.4	2000-2015	-85 to -50	6
II	3.0-3.5	400-440	490-535	2.4-2.8	2000-2020	-60 to -30	18
III	3.5-4.0	440-485	535-590	2.8-3.2	2010-2030	-30 to +5	21
IV	4.0-5.0	485-570	590-710	3.2-4.0	2020-2060	+10 to +60	118
V	5.0-6.0	570-660	710-855	4.0-4.9	2050-2080	+25 to +85	9
VI	6.0-7.5	660-790	855-1130	4.9-6.1	2060-2090	+90 to +140	5
						Total	177





Motivation (Our expectation)

Under Z-stabilization, more emissions are permissible in the near future (21st century) compared with the (traditional) E-stabilization with the same temperature rise constraint.

➡

There may be emissions pathways of Z-stabilization type to allow more than 50% at 2050 with the 2℃ temperature upper limit.

Comparison of CO_2 emissions in two types of stabilization pathways with the 2℃ temperature rise constraint under multi-gases conditions.

マルチガスを考慮した昇温2℃以内となる2種の安定化排出経路の比較

Indentifying two emission pathways for the comparison

E-stabilization

Representative Concentration Pathway (RCP)
developed by Integrated Assessment Modeling Consortium (IAMC)
New package of emission/concentration scenarios for AR5

RCP 2.6 Stabilization target 2.6 Wm^{-2} → 450ppm CO_2-eq

(RCP 3PD Almost the same but negative CO_2 emissions 2080-2100)

Z-stabilization

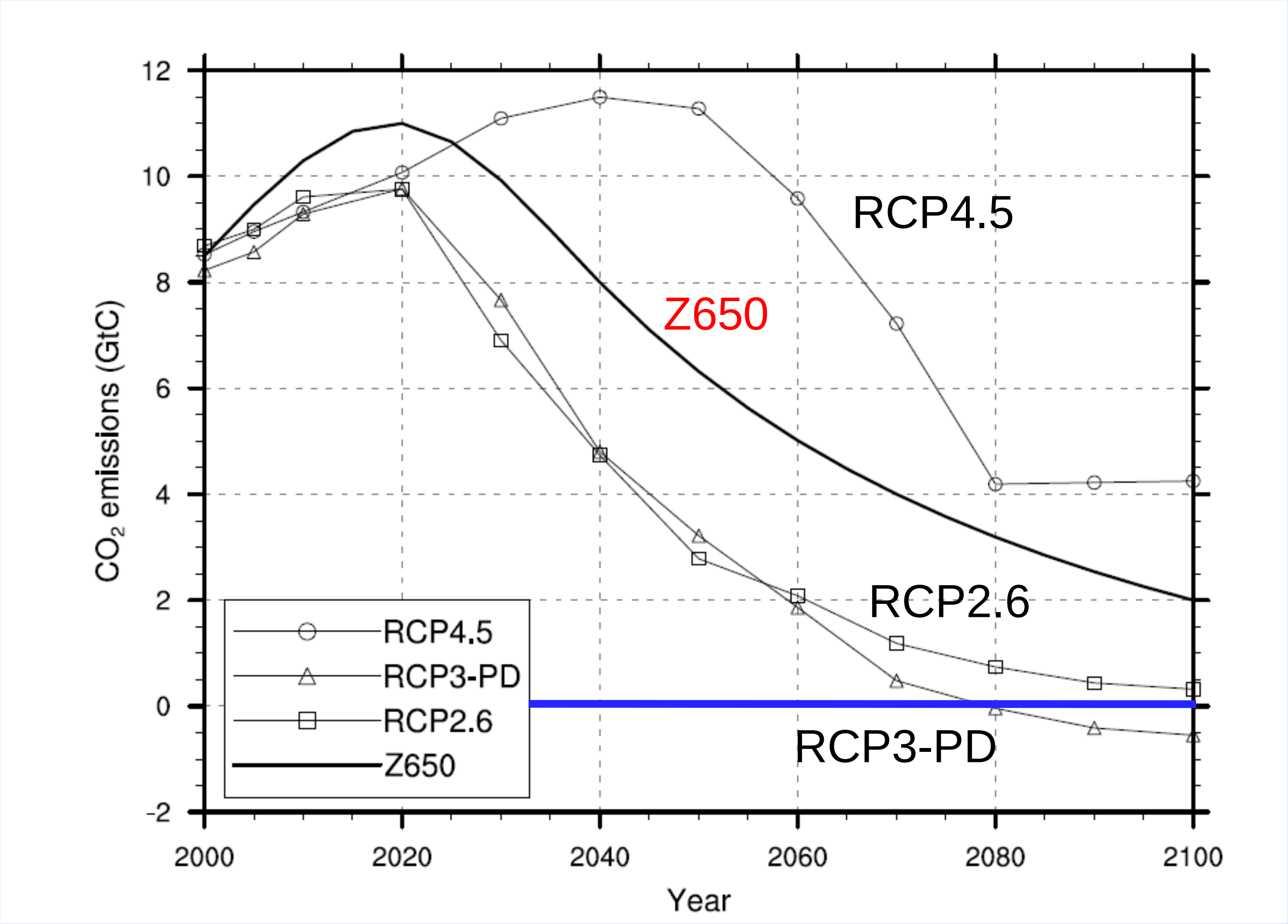
Z650 The maximum temperature ~1.8℃ at 2100

Modify the CO_2 concentration/emissions pathways to make the temperature peak below 2℃ including radiative forcings due to other GHGs and aerosols

Radiative forcings of other gases and aerosols to be included common to the two pathways

Originally taken from RCP 2.6 → smooth idealized form

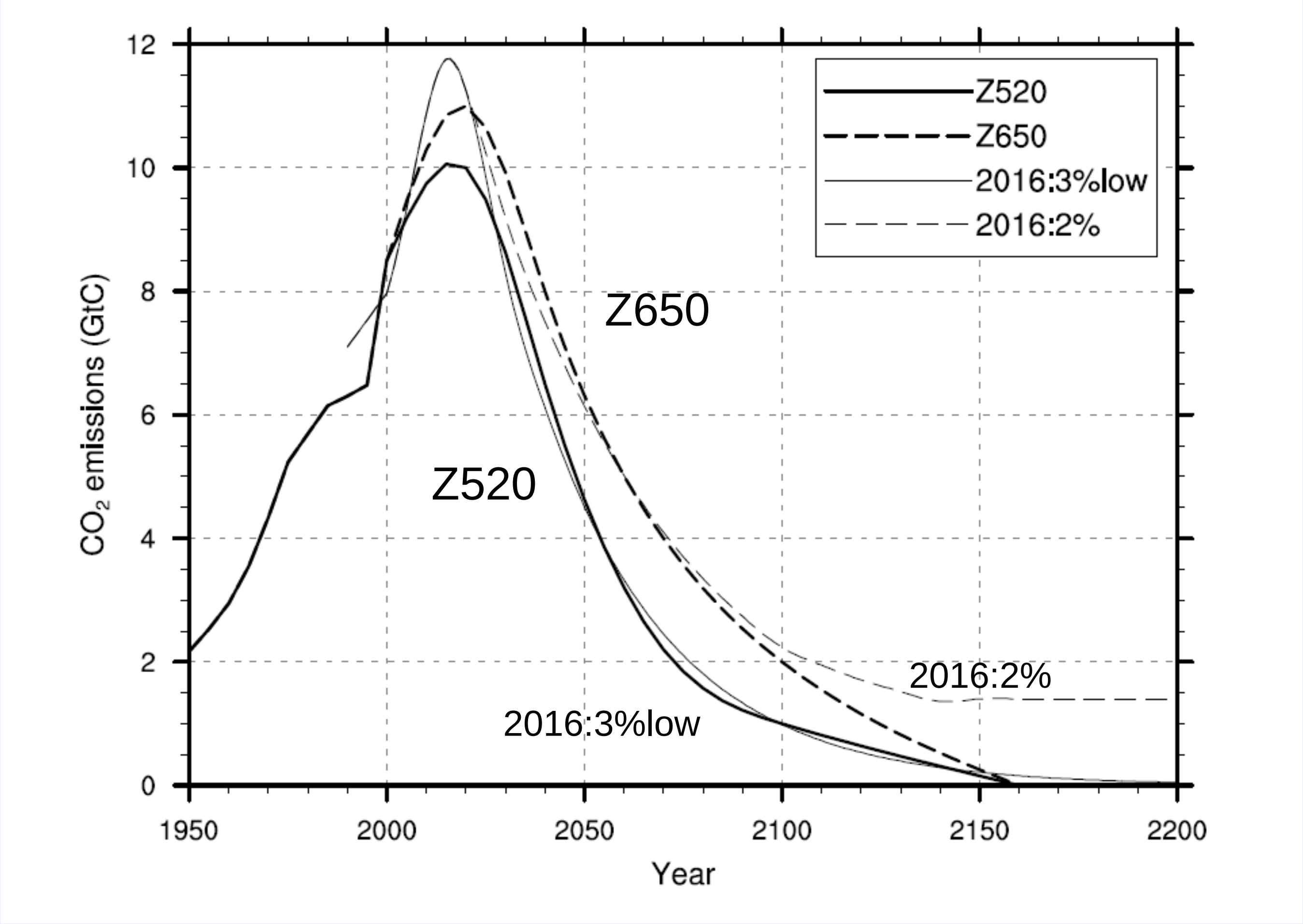
CO_2 emission pathways ;RCP 2.6, RCP3-PD, RCP 4.5 and Z650(our case)



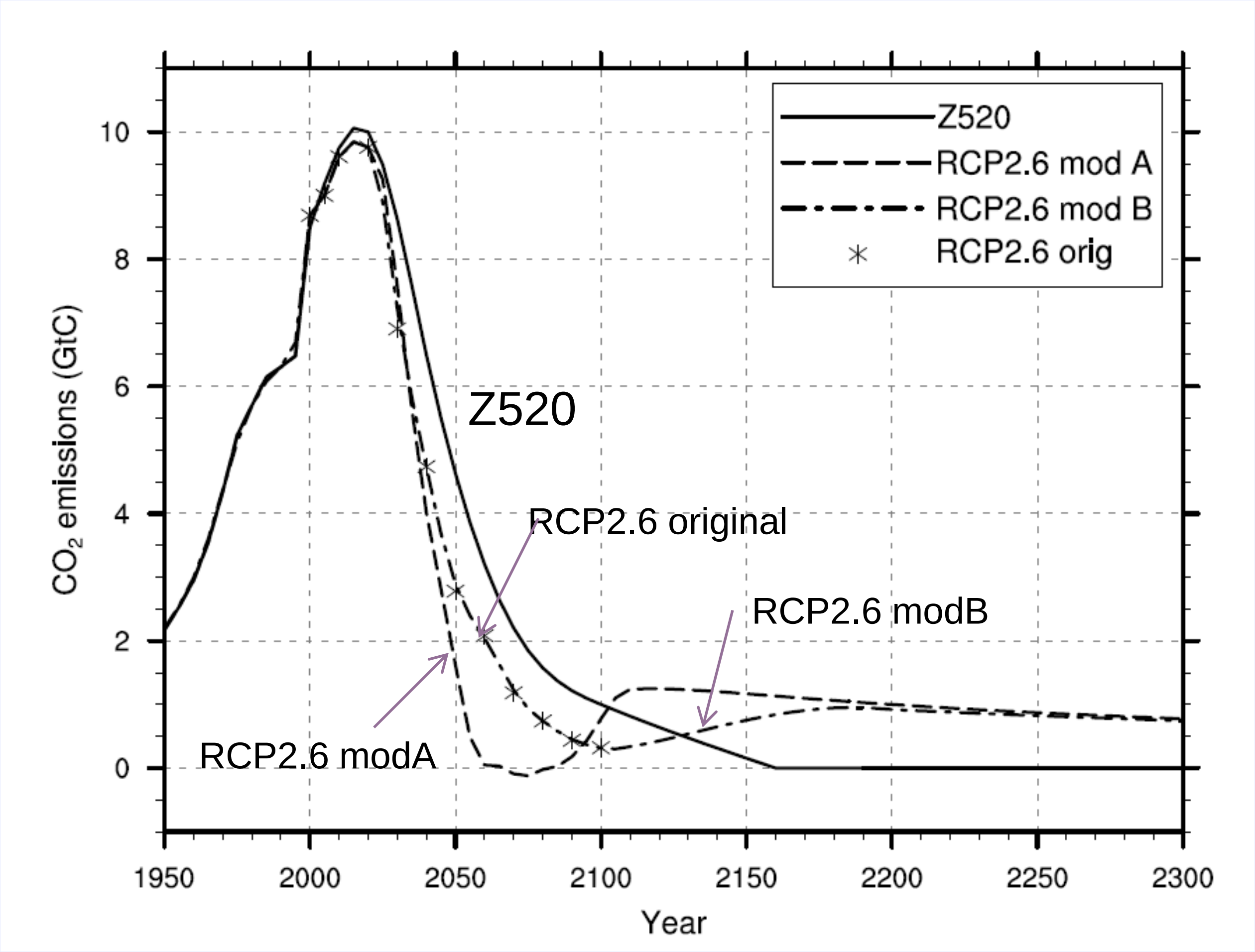
(Source) RCP Database (version1.0)
IIASA Homepage (http://www.iiasa.ac.at/web-apps/tnt/RcpDb)

CO_2 emissions in Z520, Z650

comparison with Z650 and UKCCC 2016:3% low, 2016:2% pathways

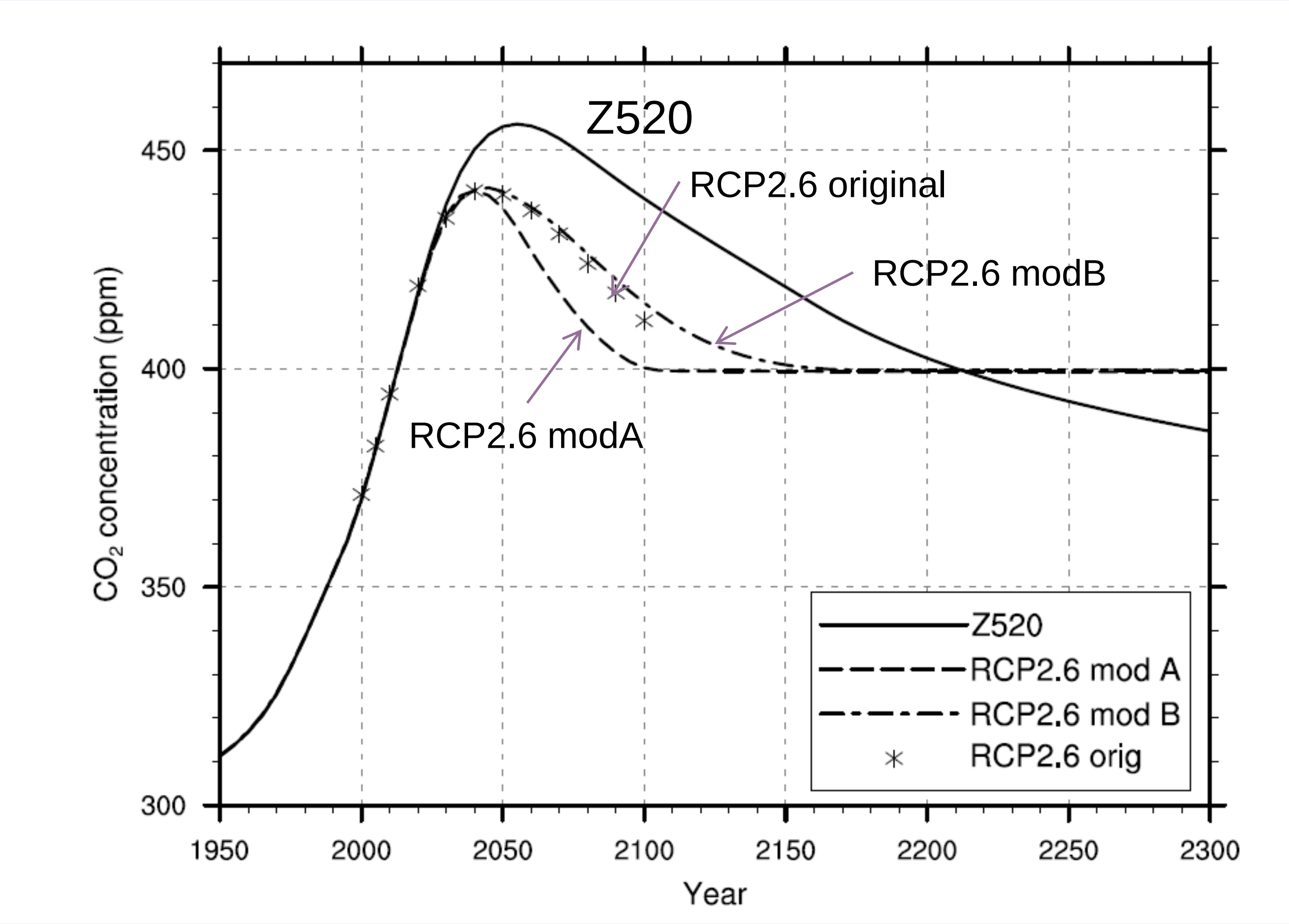


Comparison of the two CO_2 emission pathways
Z520 vs RCP2.6 (with 2 modified version)

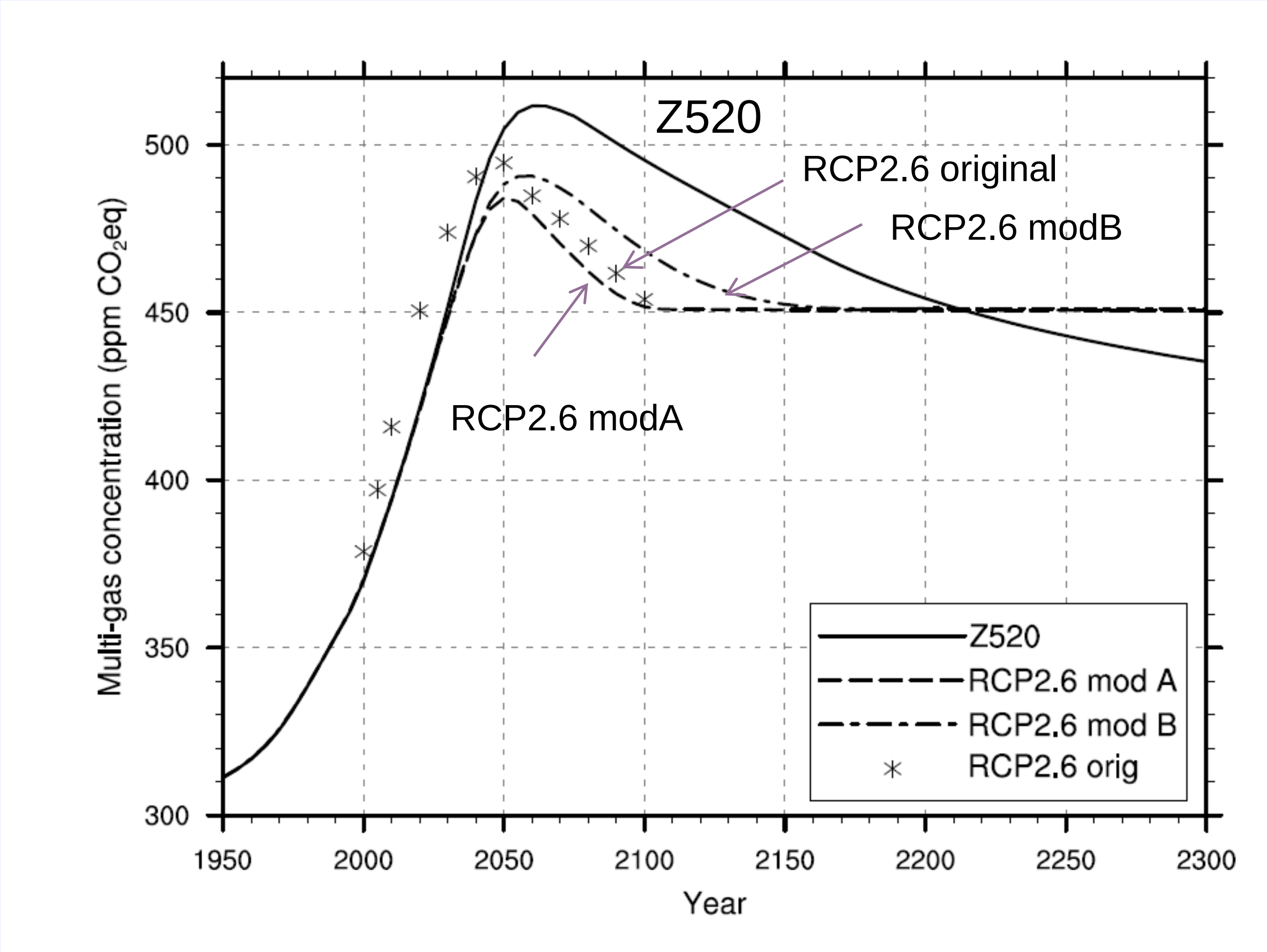


Results of projection calculations until 2300 based on the CO_2 emissions pathways; Z520 and RCP 2.6

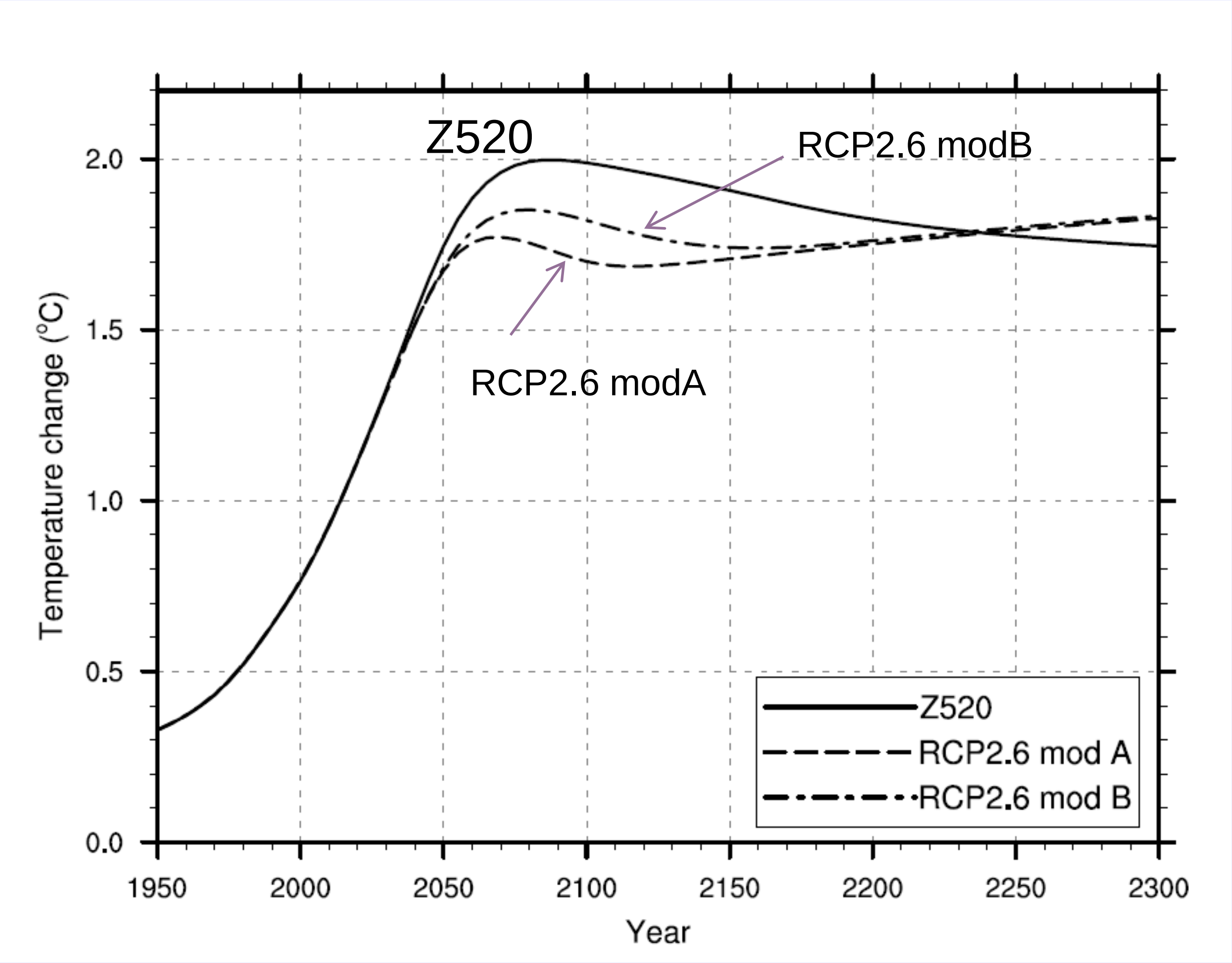
CO_2 concentration pathways of Z520 and RCP 2.6



Total CO2 equivalent concentration pathways



Temperature rises for Z520 and RCP 2.6



Comparison of Z520 and RCP 2.6 (mod B)

	Z520	**RCP2.6 (mod B)**
Total emissions 2000 – 2100	520GtC	430GtC
Emissions at 2050 (Relative to 2000)	6.43GtC/y (54%)	2.8GtC/y (33%)
Maximum CO_2 Concentration	460ppm (at ~ 2060)	400ppm (after 2150)
Maximum total CO_2 eq concentration	515ppm (at ~ 2060)	450ppm (after 2150)
Maximum temperature rise	2.0℃ (~ 2080)	1.8℃ (at 2070 and 2300)
Temperature rise at 2300 and onward	1.7℃ ↘	1.8℃ ↗

Motivation (Our expectation)

Under Z-stabilization more emissions are permissible in the near future (21st century) compared with the (traditional) E-stabilization with the same temperature rise constraint.

→

There may be emissions pathways of Z-stabilization type to allow more than 50% at 2050 with the 2℃ temperature upper limit.

How about the “50% emissions reduction by 2050” strategy

Z520 vs RCP 2.6

Larger emissions expected for Z520 than RCP 2.6

Yes, total emissions in 21st century :

520GtC vs 430GtC

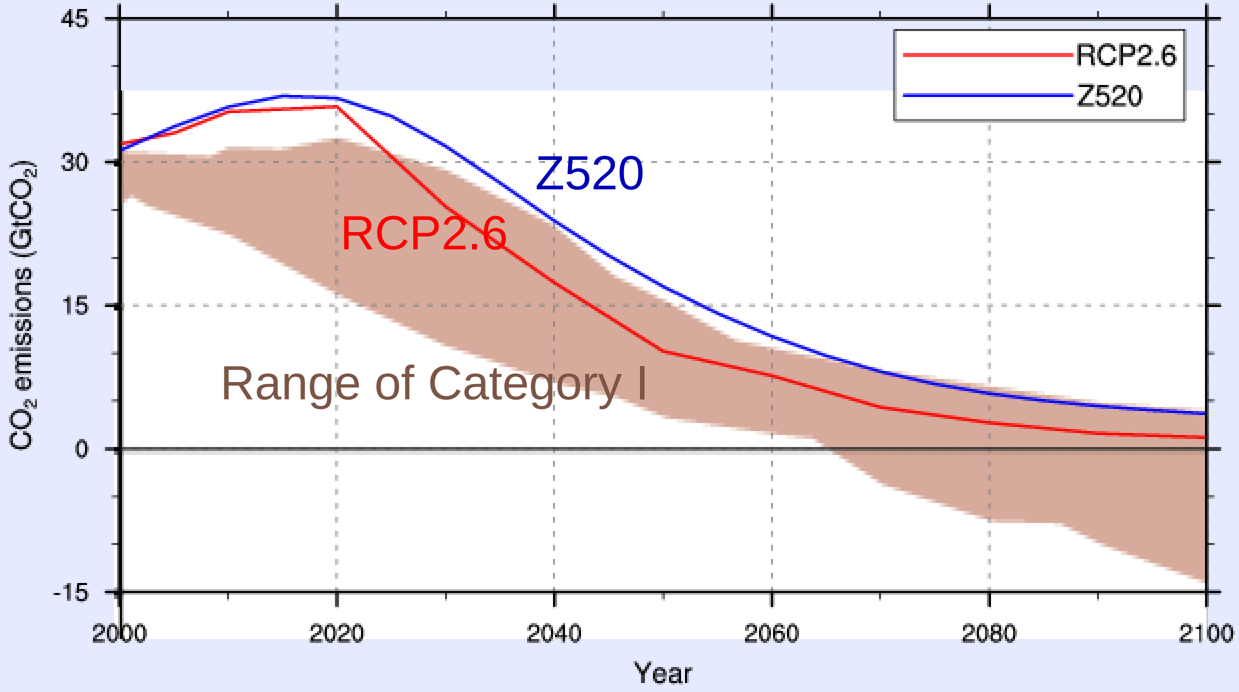
But the emissions at 2050 is 54% of the 2000 emissions. slightly above 50%

Little difference from Category I

While for RCP 2.6 emissions at 2050 : 33% of the 2000 emissions

Why?   RCP 2.6 is not a representative of category I?

Comparison of Z520 and RCP2.6 emissions with Category I



Answer to the question

In IPCC WG III AR4 (Table SPM 5);

- All member scenarios of category I fail to represent rapid increase of the CO_2 emissions in the earliest period 2000 – 2030. Near constant emissions were assumed contradicting the actually observed emission.
- "50% reduction of the 2000 emissions at 2050" for stabilization at 450ppm CO_2-eq (2°Ctemp rise) was deduced from irrelevant scenario studies.
- It must have been "1/3 (66% reduction) of the 2000 emissions at 2050" as long as the E-stabilization pathways are concerned.
- By extending pathways to include Z-stabilization type the said emission reduction strategy can have scientific basis.

Search for emission pathways of Z-stabilization type for application to practice

Characteristics of Z-stabilization

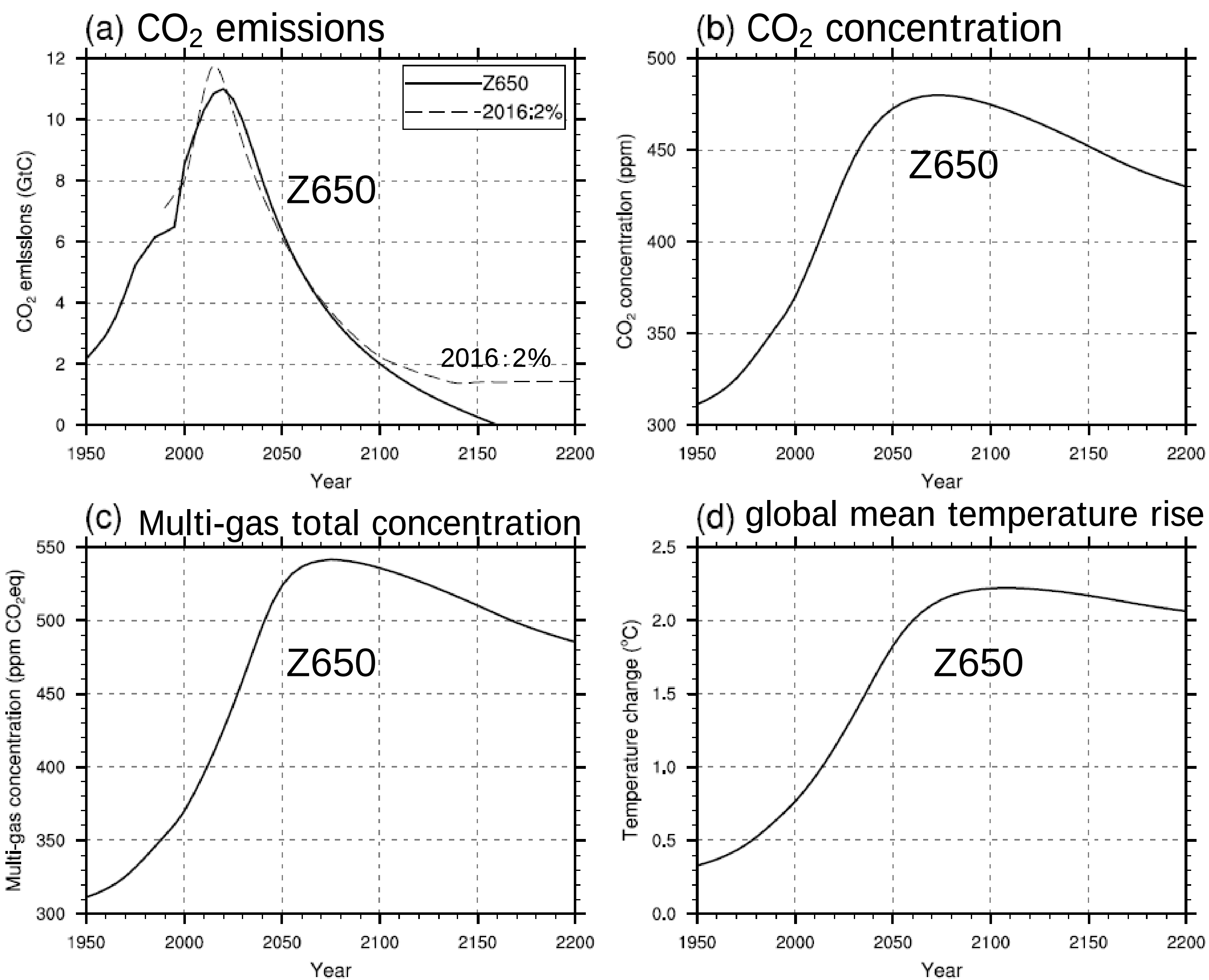
- Larger emissions are permissible in near future compared with E-stabilization (with the same temperature constraint).
- The peak temperature appears temporarily (short period).
- Final equilibrium temperature rise is lower than E-stabilization. → free from long-term risks (sea level rise)

In the case of E-stabilization, the target temperature lasts for any long period. → continuous sea level rise

➡ For a limited period temperature rise above the upper limit may not be dangerous for climate system.

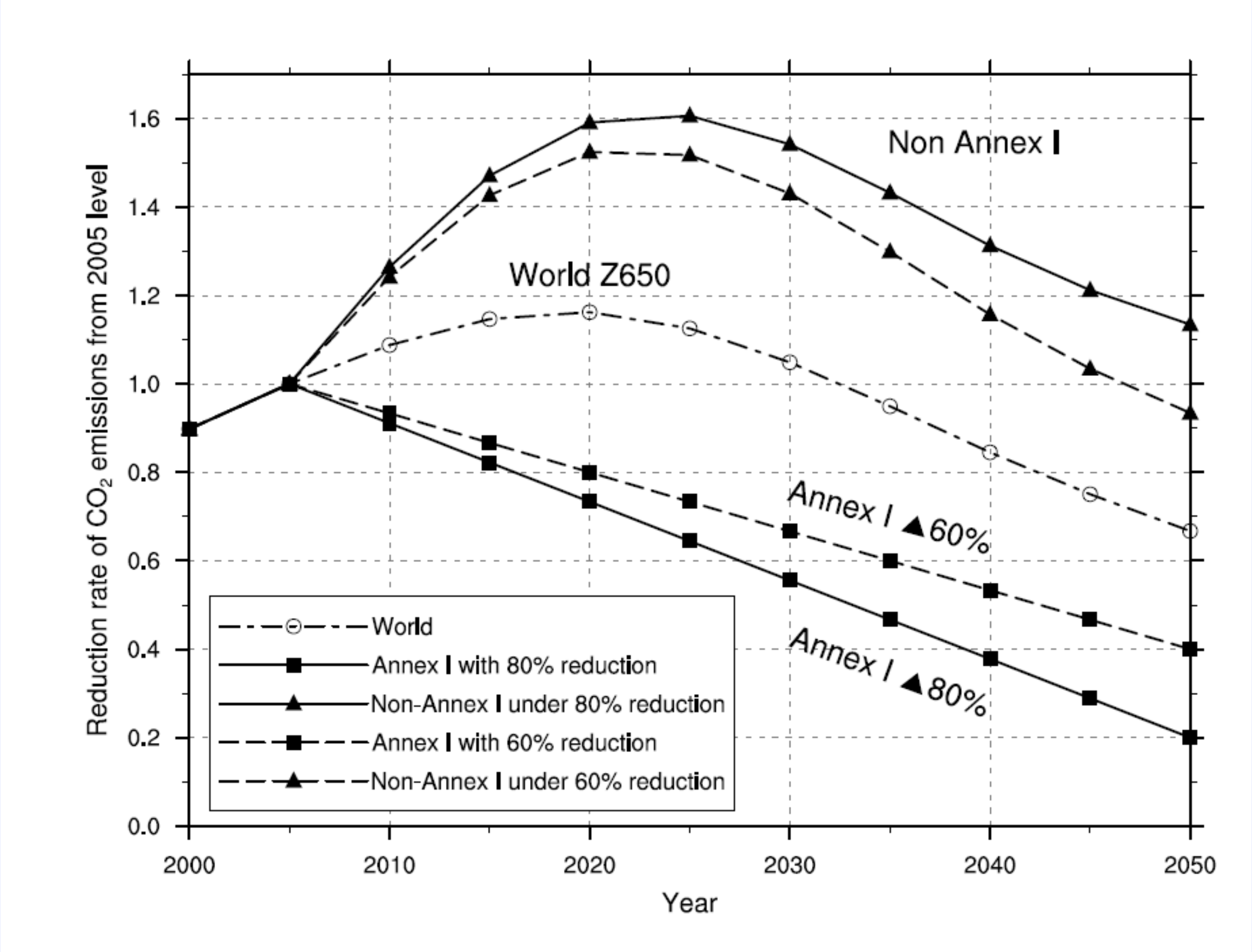
Z650 peak temperature rise in CO_2 only case is 1.8℃

Projections until 2200 for Z650 under realistic conditions (including other gases effects)



Socio-economic implications of Z650

Larger emissions can be allocated to Non-Annex I countries



Summary

- Traditional stabilization concept is questioned as a target or measure of climate change mitigation.

- In a newly proposed zero-emission stabilization(Z-stabilization), the CO2 emissions are reduced to zero, and thereafter the concentration and temperature rise decrease toward final equilibrium status.

- In the Z-stabilization, the emissions in the 21st century are larger compared with the E-stabilization case.

- In the Z-stabilization, the maximum temperature appear in a limited period so that the upper limit of temperature rise may be a little relaxed.

- Z650 stabilization pathway which gives a large total emissions in the 21st century was investigated. It has potential to respond to socio-economic application.