Recognizing distinctiveness of SSP3-7.0 for use in impact assessments

Hideo Shiogama[1], Shinichiro Fujimori[2], Tomoko Hasegawa[3], Michiya Hayashi[1], Yukiko Hirabayashi[4], Tomoo Ogura[1], Toshichika Iizumi[5], Kiyoshi Takahashi[1], and Toshihiko Takemura[6]

[1]National Institute for Environmental Studies, Japan

[2]Kyoto University

[3]Ritsumeikan University

[4]Shibaura Institute of Technology

[5]National Agriculture and Food Research Organization

[6]Kyushu University

NIES

Dramatic changes have occurred in mitigation policy factors worldwide

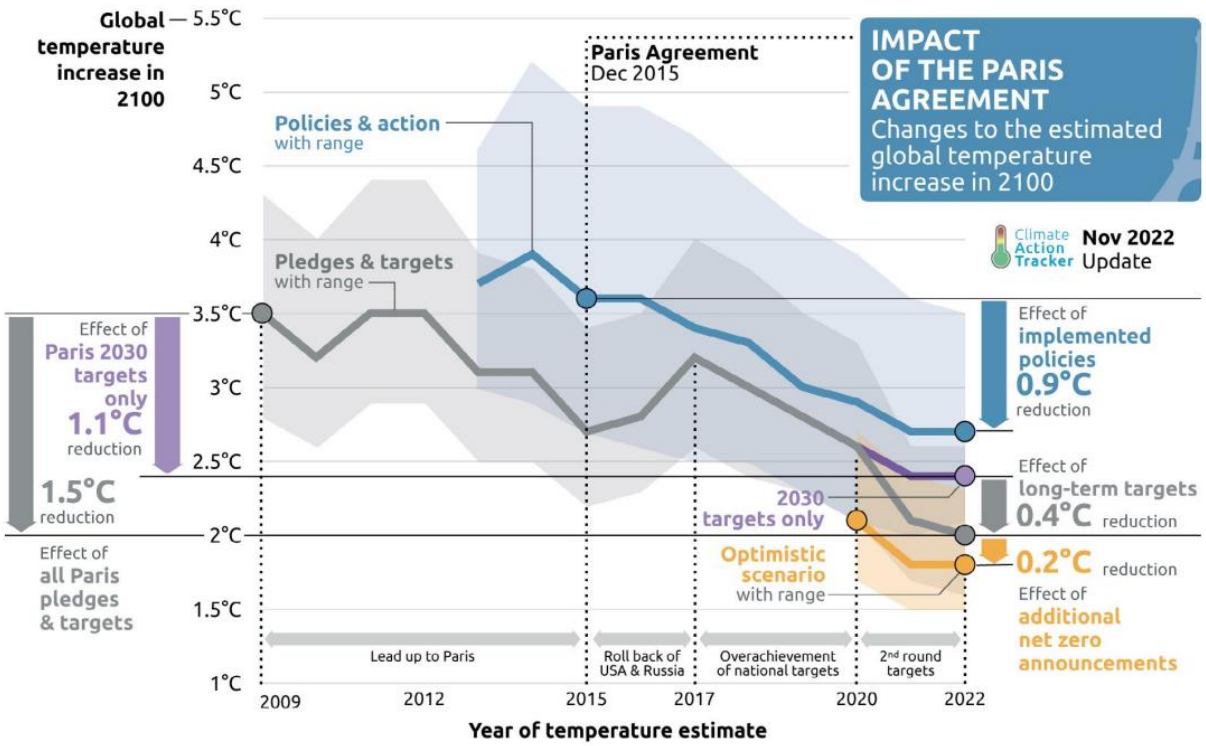
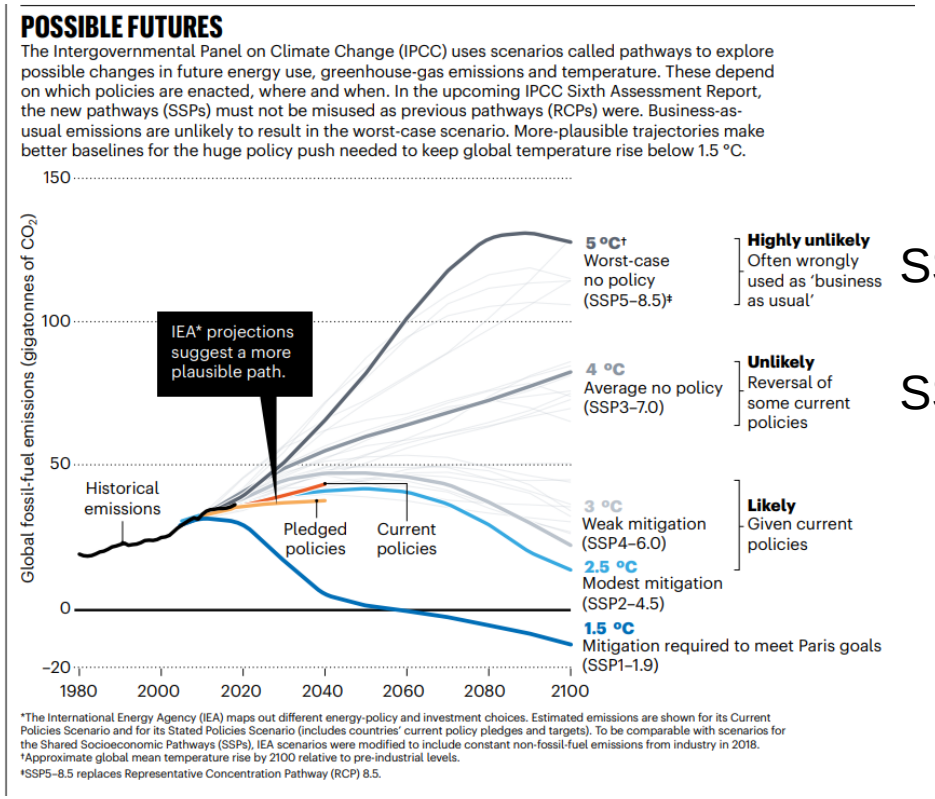


Figure 5: Impact of the Paris Agreement on the estimated global warming increase in 2100. Figure shows the estimates of the Climate Action Tracker from 2009-2022 for 'pledges and targets' and 'policies & action'.[6]

Climate Action Tracker (2022)



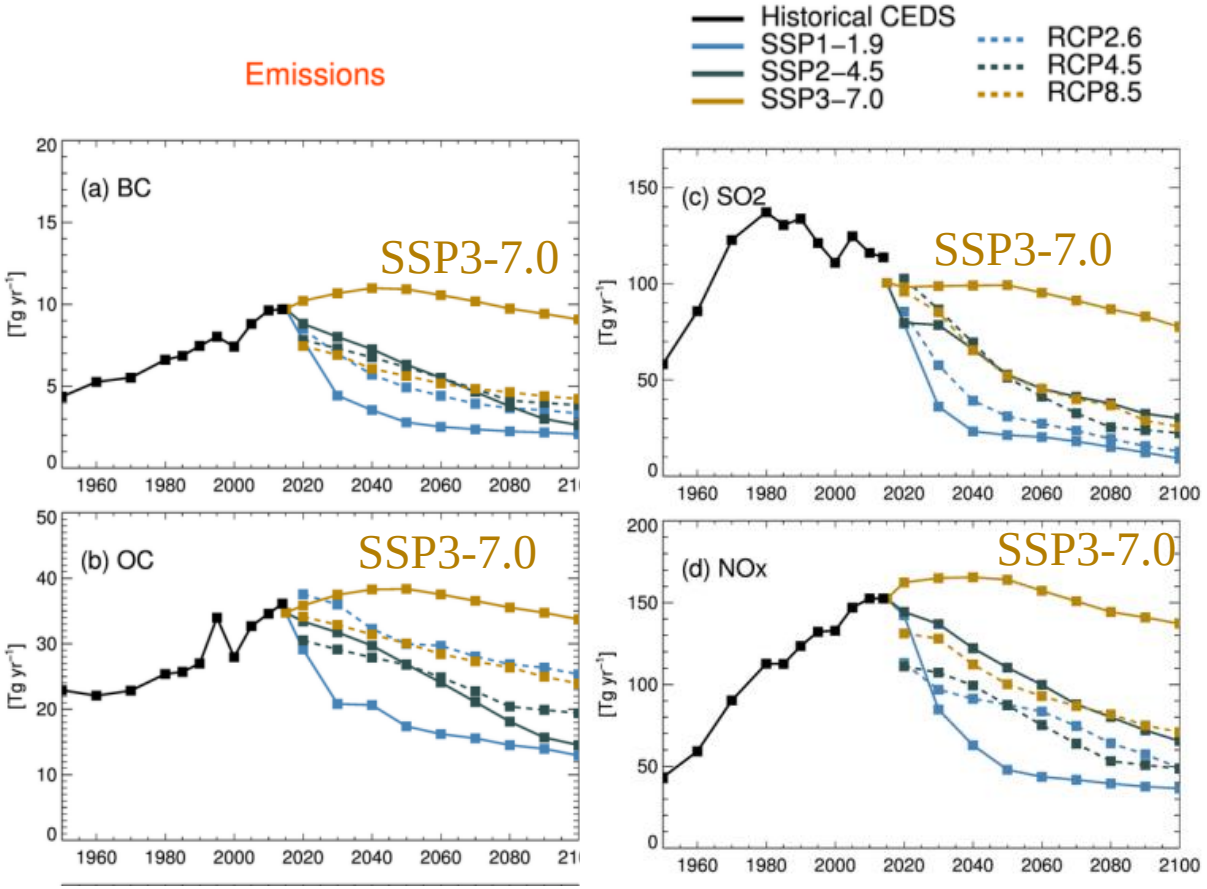
SSP5-8.5

SSP3-7.0

Hausfather and Peters (2020, Nature)

- Mitigation efforts after the 2015 Paris Agreement have made the upper-end scenario of the future GHG concentration (SSP5-8.5) highly unlikely.
- Therefore the second highest scenario (SSP3-7.0) has recently received attention as an alternative high-end scenario for impact studies.
- However, we are concerned about that IAV researchers do not well recognize the 'distinctiveness' of SSP3-7.0

Distinctive high aerosol emission



Lund et al. (2017, ACP)

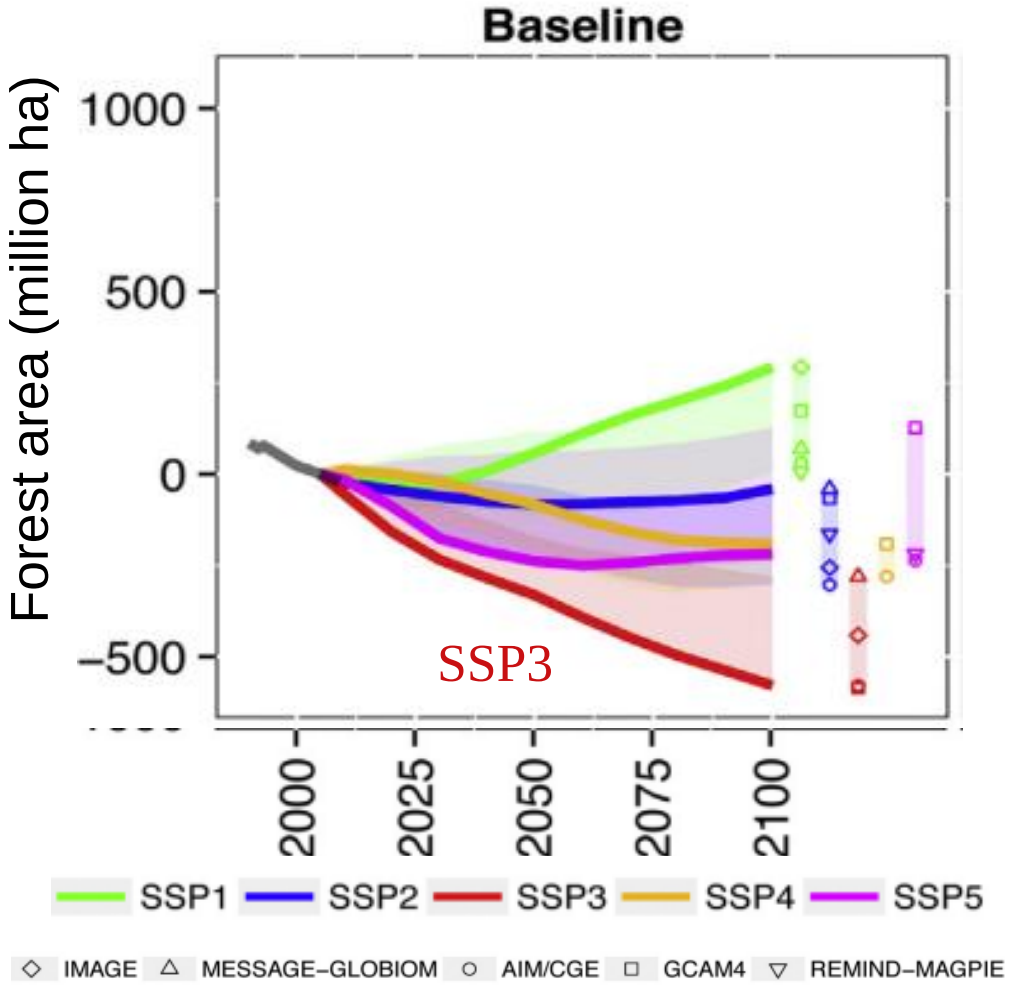
- Aerosol emissions increase or change little in SSP3-7.0 due to the assumption of a lenient air quality policy, while they decrease in the other SSP-RCPs of CMIP6 and all the RCPs of CMIP5.
- This distinctive high-aerosol-emission design of SSP3-7.0 was intended to enable AerChemMIP to investigate the consequences of continued high levels of aerosol emissions on climate.

Table 2. ScenarioMIP experimental design.

Scenario name	Forcing category	2100 forcing[1] ($W m^{-2}$)	SSP	Use by other MIPs[2]
Tier 1[3]				
SSP5-8.5	High	8.5	5	C[4]MIP, GeoMIP, ISMIP6, RFMIP
SSP3-7.0	High	7.0	3	AerChemMIP, LUMIP
SSP2-4.5	Medium	4.5	2	VIACS AB, CORDEX, GeoMIP, DAMIP, DCPP
SSP1-2.6	Low	2.6	1	LUMIP

O'Neill et al. (2016, GMD)

Distinctive large decreases in forest area



- Decreases in forest area were also substantial in SSP3-7.0, unlike in the other SSP-RCPs.
- This design enables LUMIP to analyse the climate influences of extreme land-use and land-cover changes.

Table 2. ScenarioMIP experimental design.

Scenario name	Forcing category	2100 forcing[1] ($W m^{-2}$)	SSP	Use by other MIPs[2]
Tier 1[3]				
SSP5-8.5	High	8.5	5	C[4]MIP, GeoMIP, ISMIP6, RFMIP
SSP3-7.0	High	7.0	3	AerChemMIP, LUMIP
SSP2-4.5	Medium	4.5	2	VIACS AB, CORDEX, GeoMIP, DAMIP, DCPP
SSP1-2.6	Low	2.6	1	LUMIP

O'Neill et al. (2016, GMD)

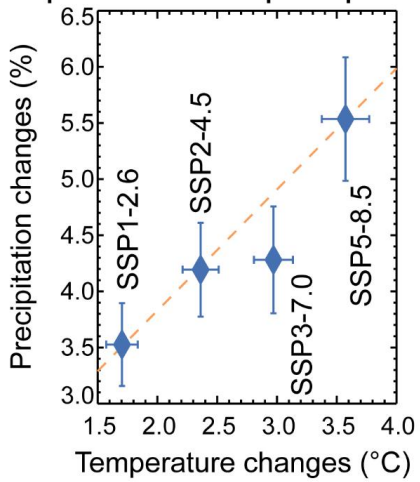
Out of the blue

- The IAM community (Prof. S. Fujimori), who developed the SSP-RCPs, did not anticipate the limelight on SSP3-7.0 for IAV studies because
  - SSP3-7.0 was the distinctive scenario
  - there were low (SSP1-2.6), medium (SSP2-4.5) and high (SSP5-8.5) scenarios available for investigation of scenario uncertainties in impact assessments.
- The IAM community also expected that the influences of extreme scenarios of aerosols and land-use land-cover change on climate were small,
  - but there was no evidence supporting that assumption.

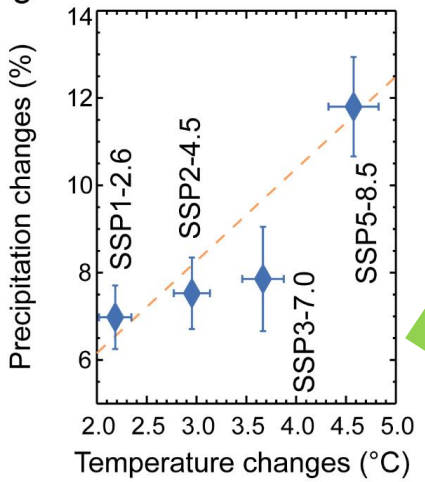
- At least, we can demonstrate notable effects of the distinctive aerosol emissions in SSP3-7.0 on climate projections.

Aerosols can efficiently reduce precipitation increases in SSP3-7.0

(a) Changes in the global mean temperature and precipitation

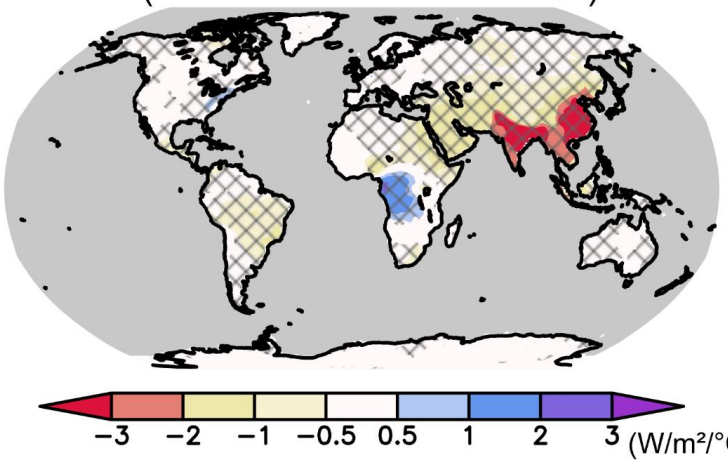


(b) Changes in temperature and precipitation averaged over the selected land region

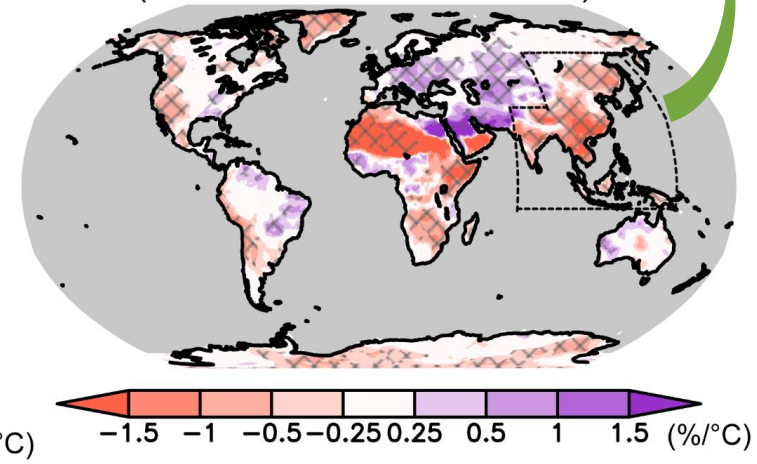


Selected area averages

(c) Diff. of downward SW radiation sensitivity (SSP3-7.0 minus SSP5-8.5)



(d) Diff. of precipitation sensitivity (SSP3-7.0 minus SSP5-8.5)



No IAV studies have investigated how these distinct changes in shortwave radiation and precipitation in SSP3-7.0 can affect impact assessments

- Whereas the global mean temperature warming is greater in SSP-RCPs with larger GHG emissions, the increases in the global mean precipitation of SSP3-7.0 are similar to those of SSP2-4.5. Large aerosol emissions in SSP3-7.0 suppress future increases in precipitation.
- For changes in downward shortwave radiation at the surface per degree global warming, differences between SSP3-7.0 and SSP5-8.5 are large in eastern, southeastern and southern Asia due to the higher aerosol emissions in SSP3-7.0 in those areas. Negative anomalies of downward shortwave radiation affect the surface energy balance, resulting in suppression of evapotranspiration and precipitation.
- Future increases in precipitation are lowered around those areas in SSP3-7.0 and are similar to those in SSP2-4.5, whereas temperature increases are larger in SSP3-7.0 than in SSP2-4.5.

Recommendations

For the IAV community

- It is useful to compare impacts per degree global warming between SSP3-7.0 and SSP5-8.5 to investigate the effects of aerosols on impacts.
- Although SSP5-8.5 was recently labelled the “unlikely worst case scenario”, RCP8.5 was used as the upper-end scenario before the Paris Agreement. Therefore, we can examine the possible benefits of mitigation efforts after the Paris Agreement by comparing the CM and impact model simulations under SSP5-8.5 and those under the other SSP-RCPs.

For the IAM community

- ScenarioMIP is now discussing the scenario design for CMIP7.
- We recommend excluding scenarios with extreme policies of aerosols and land-use land-cover changes from Tier 1 of ScenarioMIP/CMIP7 and instead including them in AerChemMIP and LUMIP.

Shiogama, H., S. Fujimori, T. Hasegawa, M. Hayashi, Y. Hirabayashi, T. Ogura, T. Iizumi, K. Takahashi & T. Takemura (2023) Important distinctiveness of SSP3-7.0 for use in impact assessments. *Nature Climate Change*, 13, 1276–1278. https://doi.org/10.1038/s41558-023-01883-2

ssp370-lowNTCF of AerChemMIP
(a variant of SSP3-7.0 with a cleaner air quality policy except for methane)

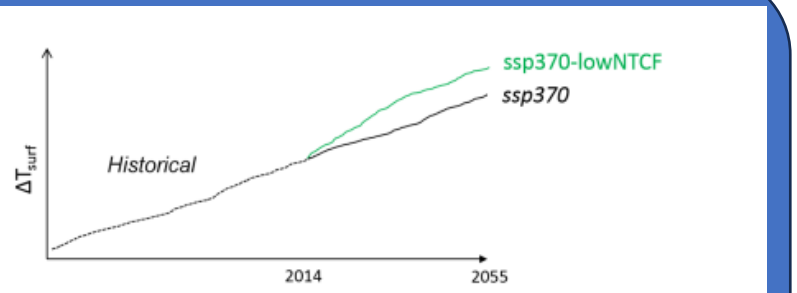


Figure 1. Schematic of future coupled-ocean simulations based on the SSP3-7.0 scenario.

Collins et al. (2017, GMD)

The 2015-2050 linear trends of precipitation under SSP3-7.0 are lower than those under SSP3-7.0-lowNTCF.

The median values of the reduction rate are 39% and 53% for the global mean and selected area mean precipitation trends, respectively.

Unfortunately, the end time of ssp370-lowNTCF was set to the middle of this century (not 2100).