Scenario MIP activities and (preliminary) results

Osamu Nishiura, Tomoko Hasegawa, Shinichiro Fujimori, Ken Oshiro, Tatsuya Hanaoka, Kiyoshi Takahashi, Shotaro Mori, Koga Yamazaki and many others from IAM teams

AIM ASIA-PACIFIC INTEGRATED MODEL

National Institute for Environmental Studies, Japan

Coupled Model Intercomparison Project (CMIP)

What is CMIP?

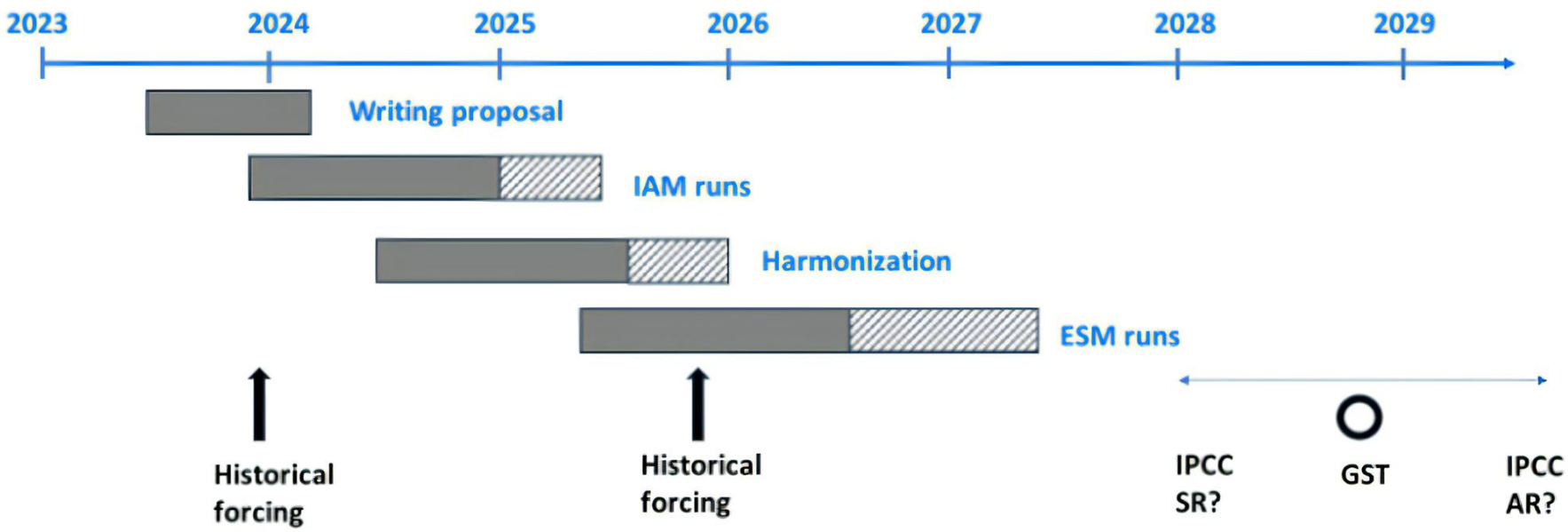
- CMIP is a project of the World Climate Research Programme (WCRP).
- CMIP develops experimental protocols to run Earth System Models (ESMs) and compare the simulation output.
- Comparing simulations helps to evaluate and improve models and provide a better understanding of past, present and future climates.

CMIP History

- In 1995, the WCRP Working Group on Coupled Modeling (WGCM) established CMIP.
- The number of participating models has significantly expanded since CMIP3 in 2005, with 136 models participating in CMIP6 in 2016.
- CMIP and its associated data infrastructure have become essential to the IPCC report and other climate assessments.
- CMIP7, the latest phase of CMIP, is under preparation.

Ref. CMIP Overview - Coupled Model Intercomparison Project (https://wcrp-cmip.org/cmip-overview/#)

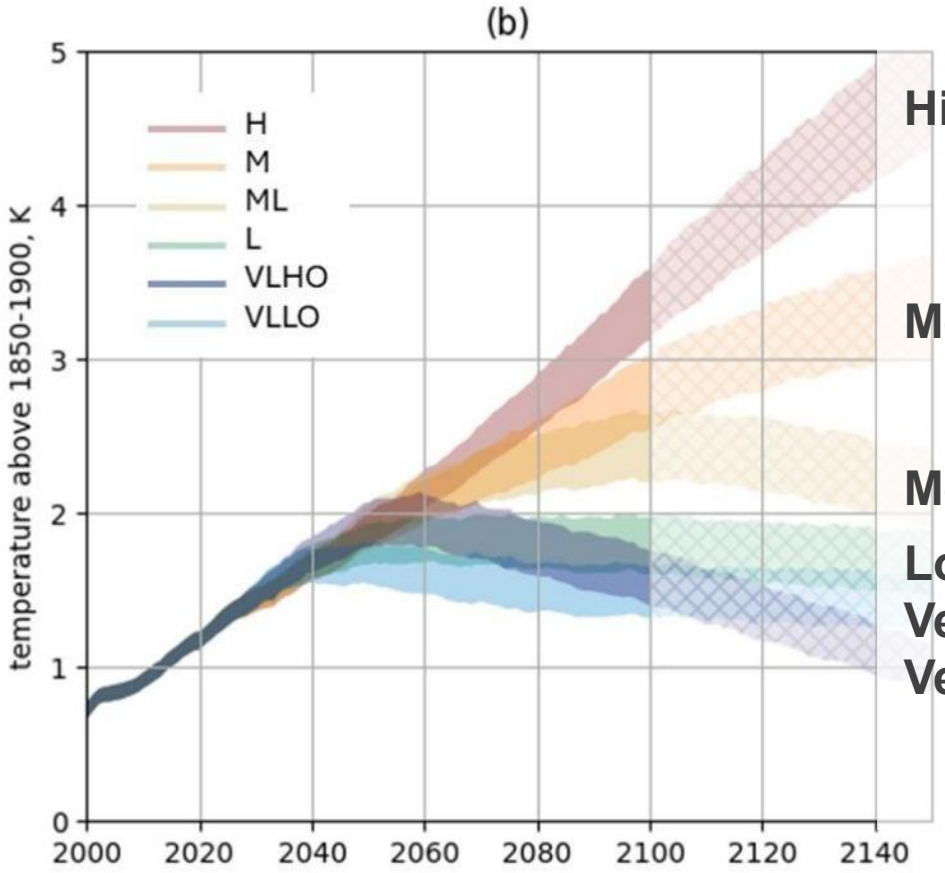
The Scenario Model Intercomparison Project (Scenario MIP)



ScenarioMIP workshop report, WCRP, 2023

- ScenarioMIP provides alternative futures of emissions and land use by which ESM simulations are driven.
- ScenarioMIP experiments integrate the climate science, integrated assessment modeling (IAM), and impacts, adaptation, and vulnerability (IAV) communities.
- In CMIP7, ScenarioMIP proposed a new set of scenarios, which covers a wide and plausible range.

Scenario narrative – Temperature pathways



ScenarioMIP-CMIP7 protocol paper, Van Vuuren et al., 2025

High (H): High emission scenario to explore potential high-end impacts

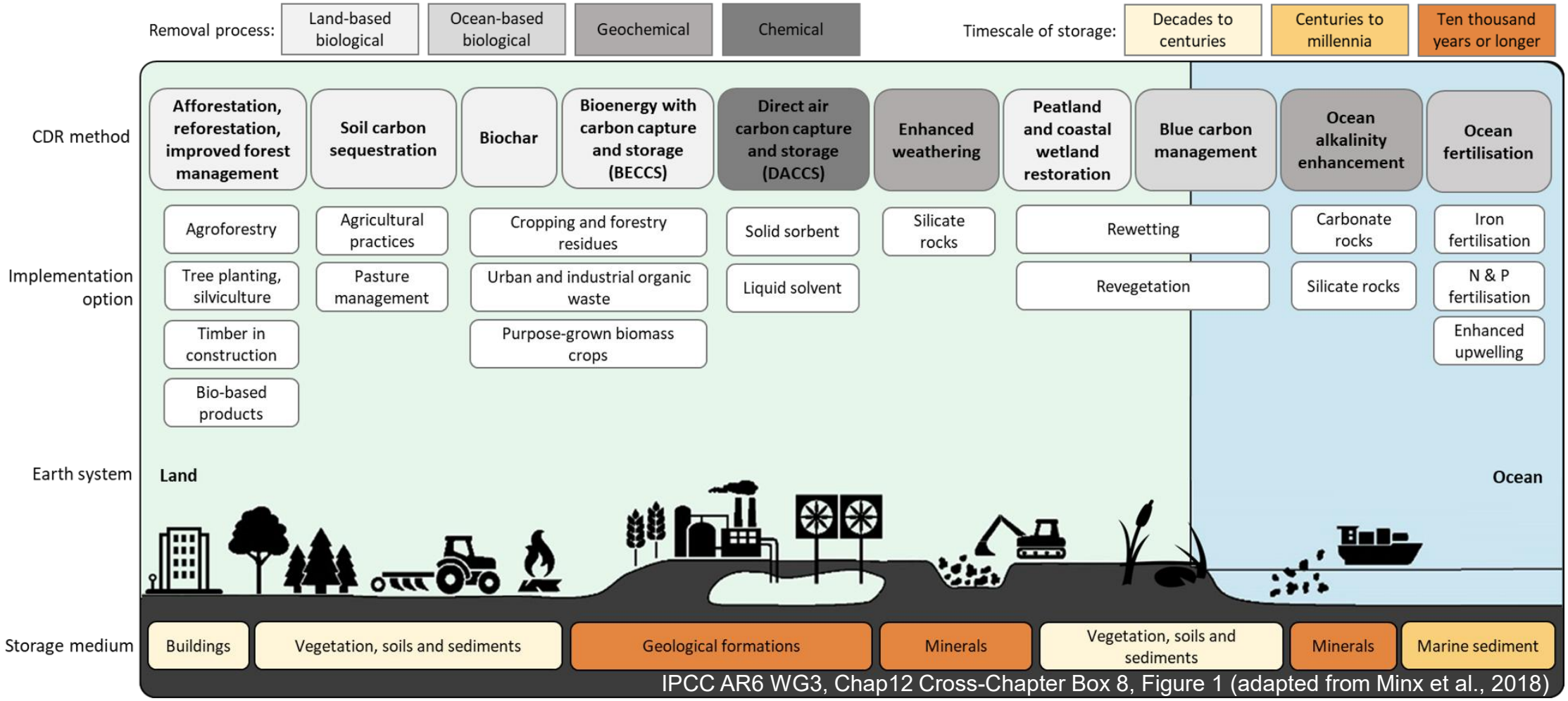
Medium (M): Medium scenario consistent with current policies

Medium-Low (ML): Delayed increase in effort after current policy

Low (L): Keep below 2C after NDCs
Very Low with Limited Overshoot (VLLO):1.5C with limited overshoot
Very Low after High Overshoot (VLHO):1.5C with high overshoot (>0.3C)

- Socio-economic assumptions are based on SSPs. (H:SSP3 or 5, M, ML, L, and VLHO:SSP2, VLHO:SSP1 or 2)
- In CMIP7, Seven IAMs quantified those scenarios, and one marker scenario will be selected for each scenario based on marker criteria.

Carbon dioxide removal (CDR)



IPCC AR6 WG3, Chap12 Cross-Chapter Box 8, Figure 1 (adapted from Minx et al., 2018)

- There are several type of CDR, each with different socio-economic and land use impacts.
- The policy intensity and future socioeconomic conditions will determine the type and amount of CDR which is one of the key elements of policy analysis and climate simulations.

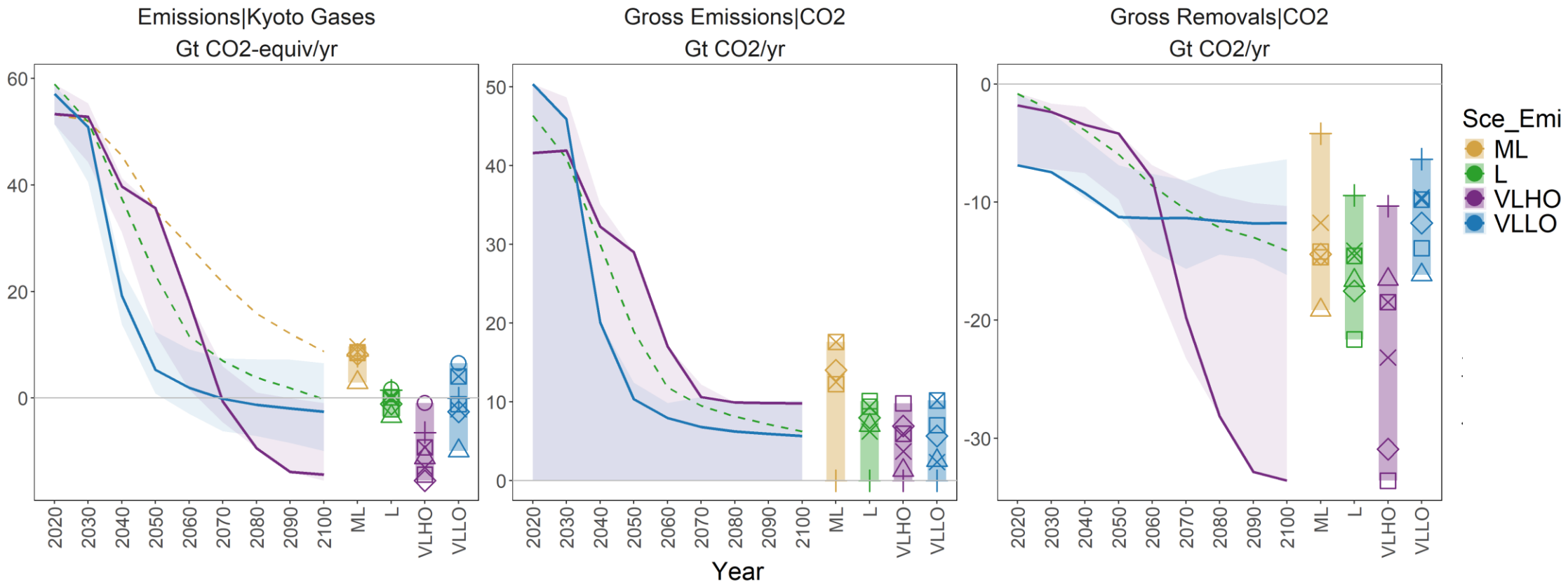
Scenario narrative – Marker criteria for CDR and Sustainability

- The narrative for Scenario MIP includes a description of CDR implementation and sustainability indicators related to CDR.
- Bellow table shows marker criteria for CDR and used for the scenario vetting and marker selection.

Criteria	Only VLLO	Only VLHO	All
CDR total volume (i)VLLO<VLHO, (ii)VLLO<=L			X
VLHO needs to be sufficiently different from other scenarios, in terms of CDR		X	
Rapid deployment of land-based CDR in VLLO within sustainability limits	X		
Keeping geological storage within **modest** technological limits (around 11200Gt in cumulative)			X
Keeping geological storage within **strong** sustainability limits in VLLO (around 5.0Gt/year)	X		
Near-term plausibility of CCS (4.3Gt/year in 2040 and 7.0Gt/year in 2050)			X
Sustainability of biomass and BECCS use (biomass ~ 100-150 EJ) in VLLO	X		
Biodiversity implications through BII or other biodiversity indicator / Natural land area			X
Rapid convergence of efforts in VLLO (Carbon price)	X		

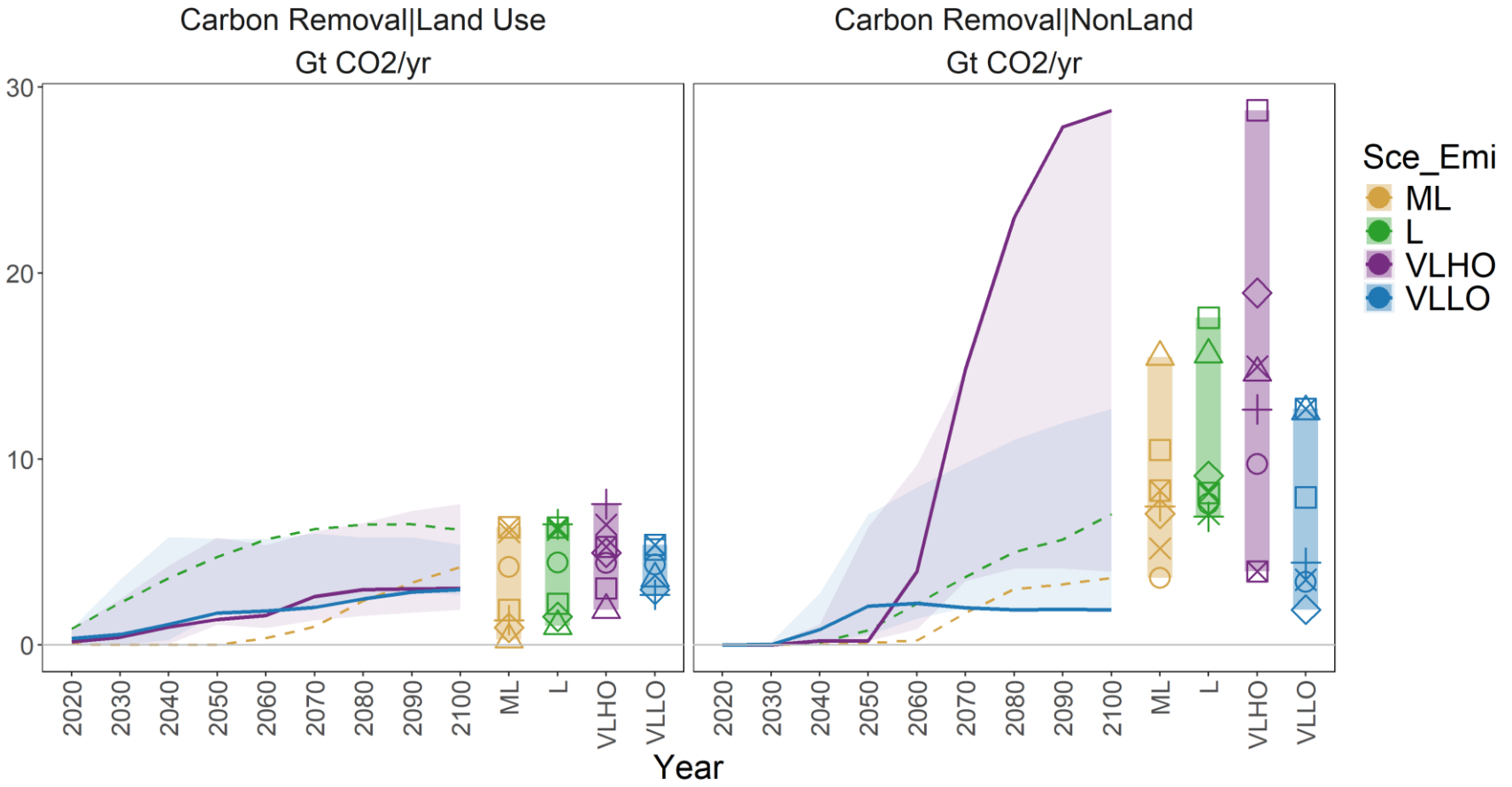
(Preliminary) Results associated with CDR

Emissions and removals



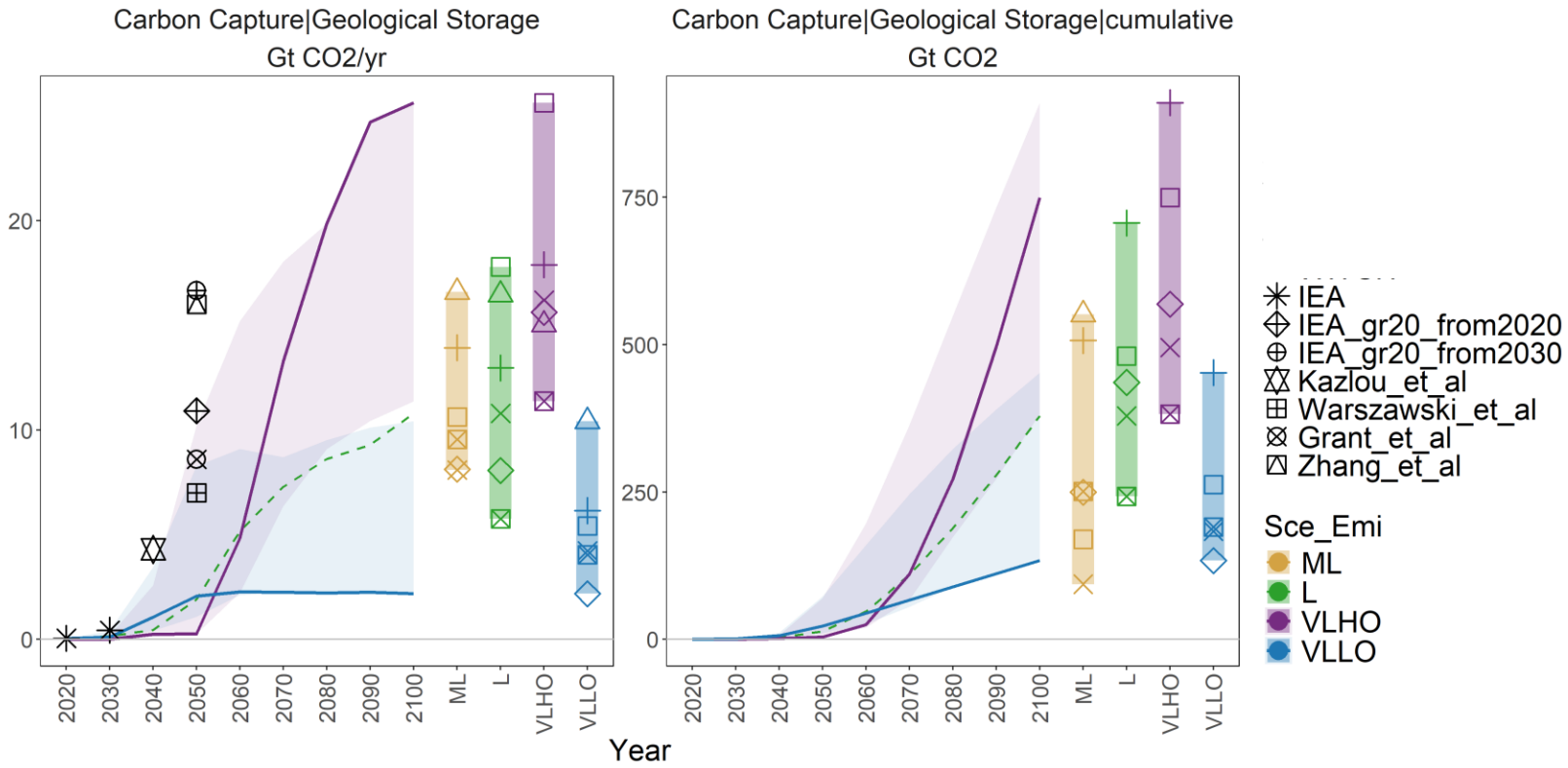
- In VLHO, gross CO2 emission in 2100 is 9.8 Gt/yr, almost the same level as L and VLLO, but gross removal is 33.5 Gt, significantly higher than VLLO due to delayed action.
- VLLO has low carbon removals in the second half of the century due to rapid reductions in GHG emissions.

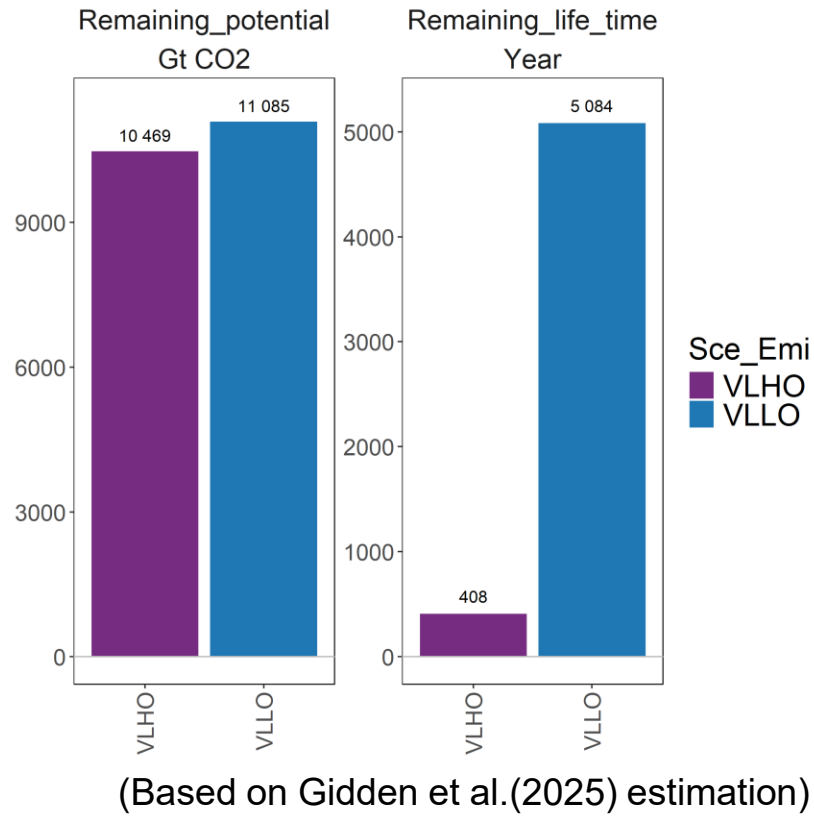
CDR



- In VLLO, CDR demand was suppressed by early emission reductions and demand-side action, and the relatively inexpensive afforestation and BECCS met the demand for CDR.
- In VLHO, DACCS and BECCS became the primary means of carbon removal because of their large potential and few biophysical limitations in scale-up.

Geological Storage

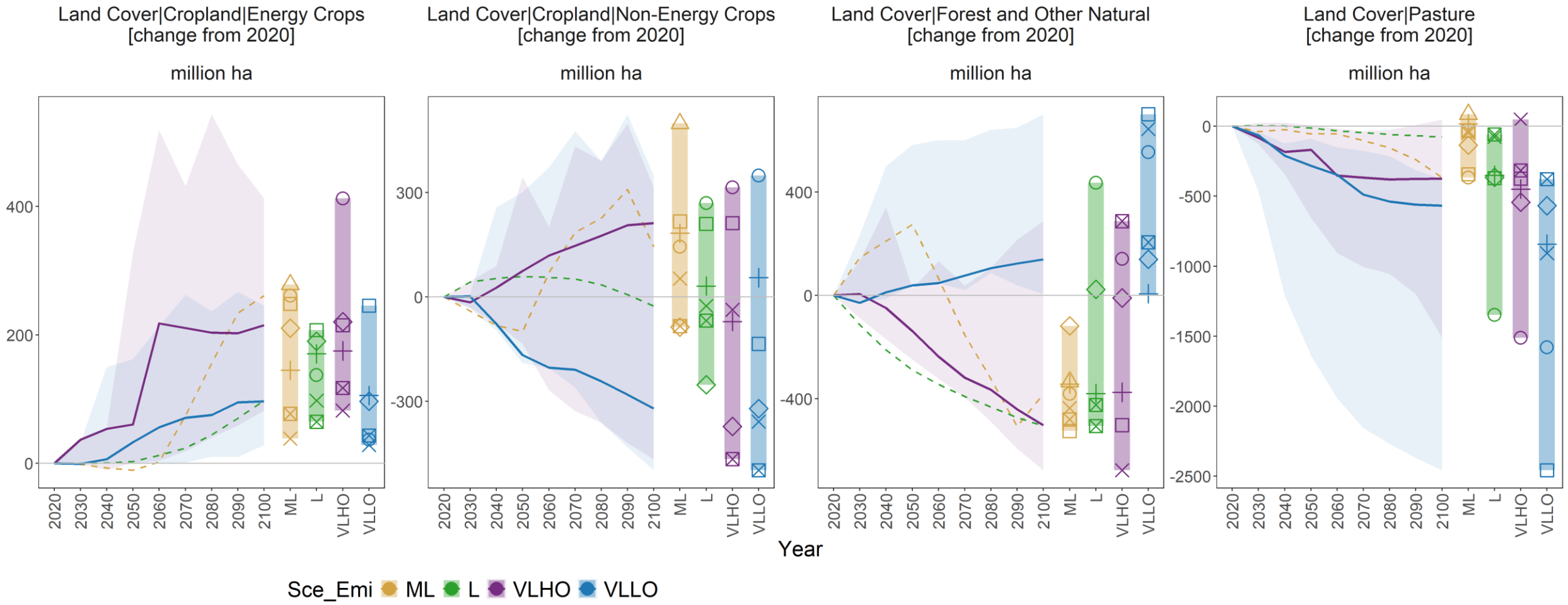




(Based on Gidden et al.(2025) estimation)

- Geological storage is a key constraint of BECCS and DACCS.
- In VLHO, huge amount of storage was used, and the remaining storage was about 400 years for the demand in 2100.

Land use



- In VLHO, crop land increased due to demand for biomass and food, while forest and other natural area decreased instead.
- In VLLO, non-energy crop and pastureland decreased due to reduced livestock demand, and forest and other natural area increased by 139 million ha.

Future tasks

ScenarioMIP workshop report, WCRP, 2023

- To submit final version of scenarios
- To check the variables related to the CDRs and sustainability
- To write a crosscut paper of the CDRs and sustainability

Thank you

Osamu Nishiura
E-mail: nishiura.osamu@nies.go.jp