JOINT GLOBAL CHANGE RESEARCH INSTITUTE

Pacific Northwest
NATIONAL LABORATORY

UNIVERSITY OF MARYLAND

Scenarios for future CMIP

November 18, 2022

Brian O'Neill, Claudia Tebaldi, Detlef van Vuuren

Working Group on Coupled Modeling – 25

Topics

SSP-RCP scenario framework use
- CMIP6 model participation
- Use of scenario framework in research and assessment

Emerging scenario research needs
- Scenarios Forum (including CMIP, IPCC sessions)
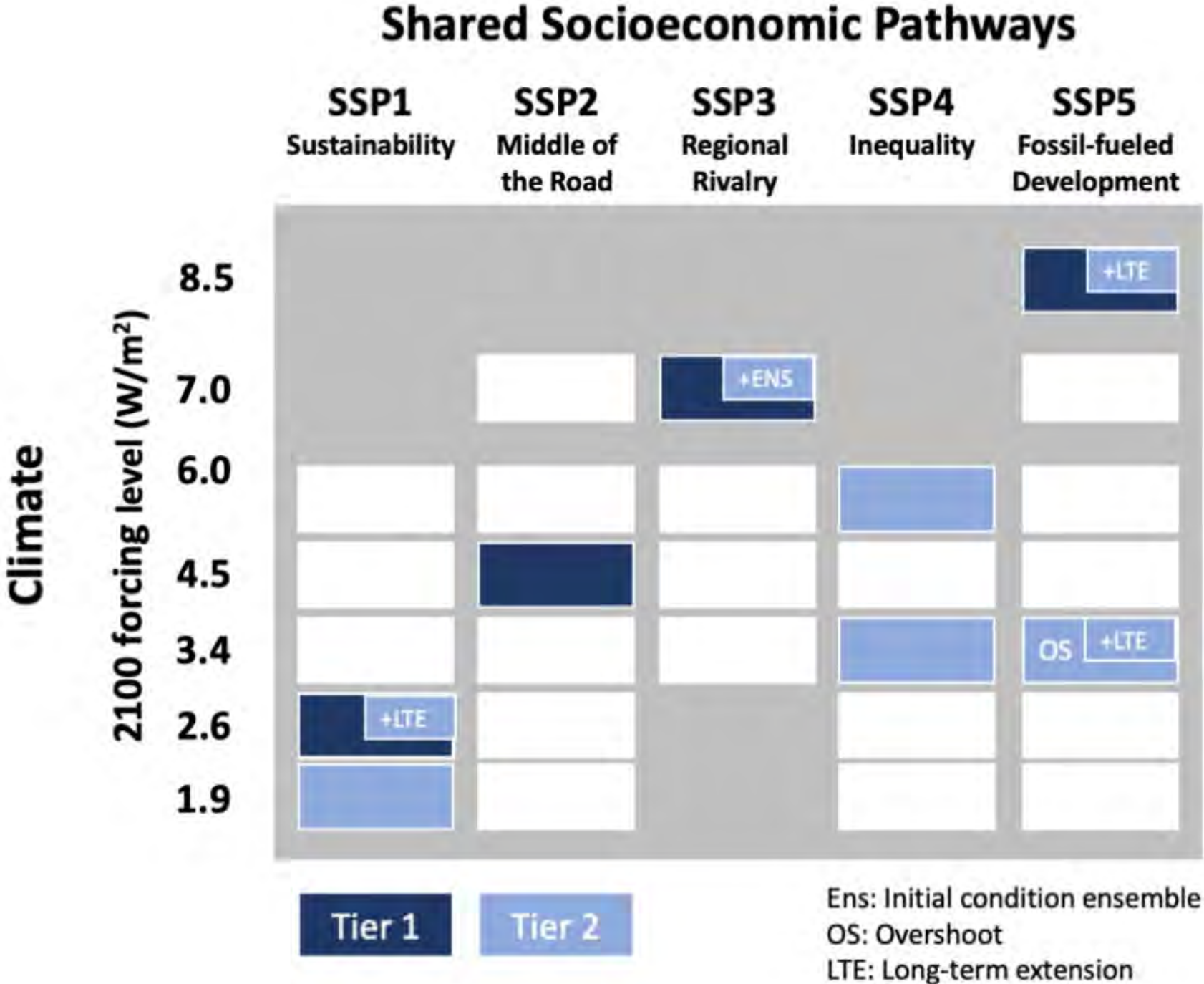- AIMES workshop on human-earth system coupling
- Integrated Assessment Modeling Consortium meetings

Goals for CMIP/ScenarioMIP process

CMIP6 ScenarioMIP ESM runs

Scenario	ESMs
Tier 1	45-50
SSP1-1.9	16
Overshoot	17
Tier 2	10
Lg. Ens.	9

Data courtesy of Neil Swart, Environment Canada.

SSP-RCP scenario use in the literature

Wide use in integrated analysis

More than half of studies on impacts

Climate and impact studies use more high-end scenarios on balance

Mitigation analyses use more low-end scenarios on balance

SSP Publications Over the Years

Number of Publications

- Multiple SSPs Used
- One SSP Used

Year

Carole Green, 2022

IPCC AR6 experience

WG1: Strong use in many chapters, Tier 1 + SSP1-1.9

> Possibly over-emphasis on SSP5-8.5 and RCP8.5, but constrained by literature especially at regional level

WG2: No systematic use for synthesis, but significant contribution to assessed literature

WG3: Systematic use as "illustrative pathways", mainly SSP2

SYR: ?

AR7: Workshop coming up in April 2023 for AR6 stock-taking and look forward to AR7
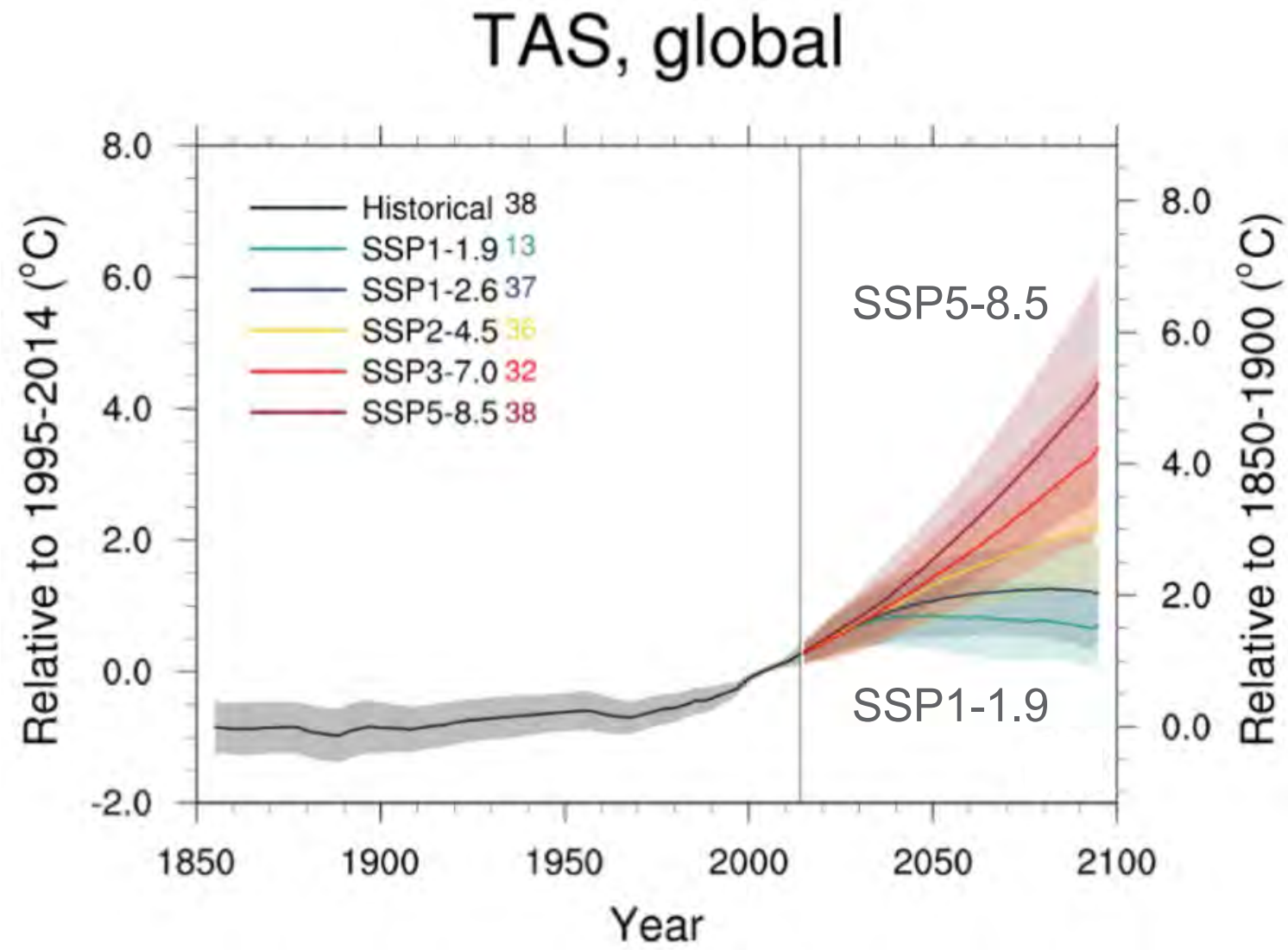
Emerging research needs

Updated CMIP6 scenarios?

    Population/GDP updates occurring now, (presumably) IAMs to follow

    Encourage/request Tier 2 scenario simulations

Re-assess high/low end scenario plausibility, policy relevance

Re-assess high/low end scenario plausibility

TAS, global

Legend:
- Historical 38
- SSP1-1.9 13
- SSP1-2.6 37
- SSP2-4.5 36
- SSP3-7.0 32
- SSP5-8.5 38

SSP5-8.5

SSP1-1.9

Implausible emissions (coal use)? Implausible lack of impacts?

Implausible rate of emissions reduction? Use of negative emissions?

Tebaldi et al., 2021, ESD.

Emerging research needs

Updated CMIP6 scenarios?

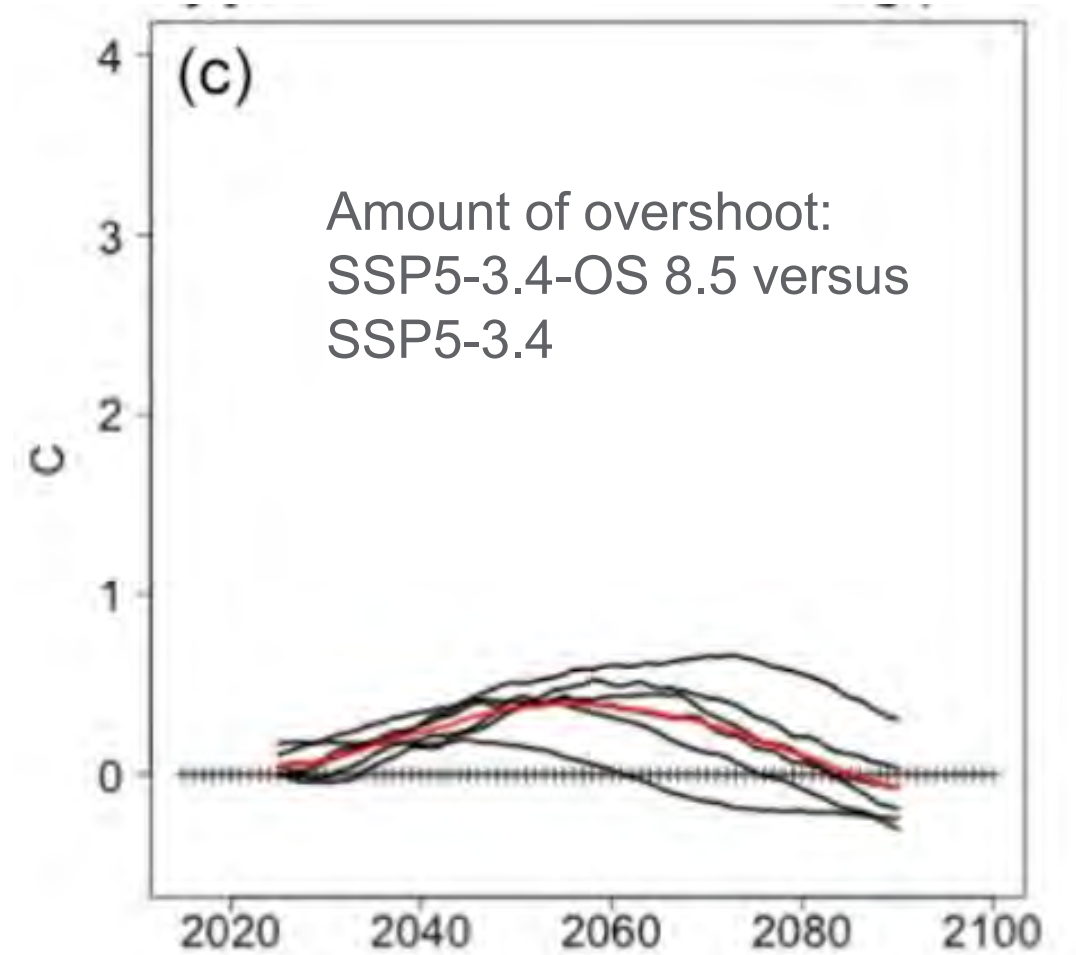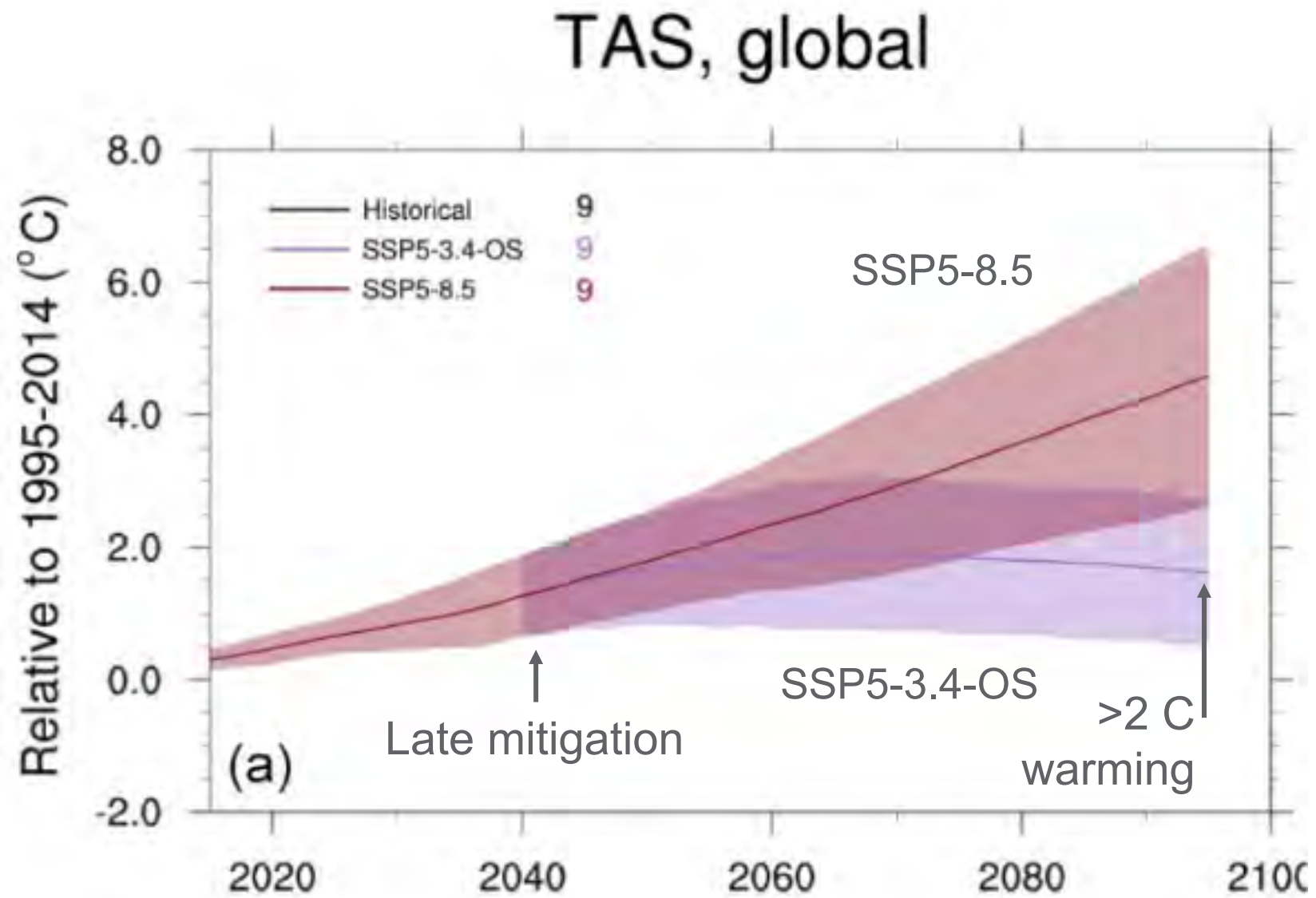   Population/GDP updates occurring now, (presumably) IAMs to follow

    Encourage/request Tier 2 scenario simulations, esp emissions-driven overshoot

Re-assess high/low end scenario plausibility

Temperature overshoot scenarios

    Particularly lower magnitude than SSP5-3.4-OS

Temperature overshoot scenarios

TAS, global

SSP5-8.5

Historical 9
SSP5-3.4-OS 9
SSP5-8.5 9

SSP5-3.4-OS

>2 C warming

Late mitigation

(a)

(c)

Amount of overshoot:
SSP5-3.4-OS 8.5 versus
SSP5-3.4

Tebaldi et al., 2021, ESD.

Emerging research needs

Updated CMIP6 scenarios?

    Population/GDP updates occurring now, (presumably) IAMs to follow

    Encourage/request Tier 2 scenario simulations, esp emissions-driven overshoot

Re-assess high/low end scenario plausibility

Temperature overshoot scenarios

    Particularly lower magnitude than SSP5-3.4OS

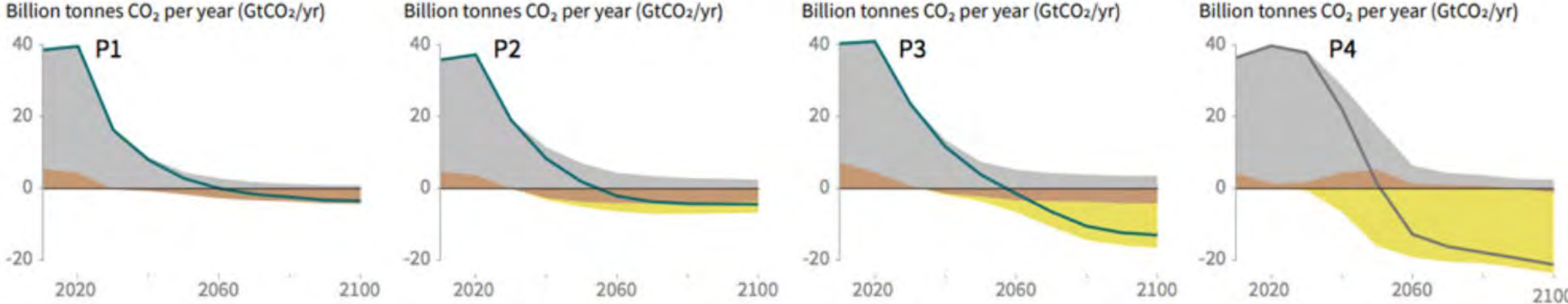Emissions-driven scenarios for deep decarbonization

    Earth system plausibility of large-scale CDR

    Carbon cycle feedbacks, land use effects

Emissions-driven scenarios for deep decarbonization

Breakdown of contributions to global net CO₂ emissions in four illustrative model pathways

Fossil fuel and industry • AFOLU • BECCS ← Land use

1.5 C emissions pathways:
5-20 GtCO2/yr negative emissions by 2100!

IPCC SR1.5, 2018.

Emerging research needs

Updated CMIP6 scenarios?
- Population/GDP updates occurring now, (presumably) IAMs to follow
- Encourage/request Tier 2 scenario simulations, esp emissions-driven overshoot

Re-assess high/low end scenario plausibility

Temperature overshoot scenarios
- Particularly lower magnitude than SSP5-3.4OS

Emissions-driven scenarios for deep decarbonization
- Earth system plausibility of large-scale CDR
- Carbon cycle feedbacks, land use effects

Reference scenarios with impacts
- Implications for ScenarioMIP simulations?

ESM runs for calibration of emulators
- Simple climate models, emulation of global mean temperature
- Spatial climate outcomes for impact assessment
- Substantial progress in emulation since AR6 cycle, several approaches

ESM runs for calibration of emulators

GSAT from CanESM5

Legend:
- ssp119
- ssp126
- ssp245
- ssp370
- ssp585
- new scenario

Target GSAT path to emulate
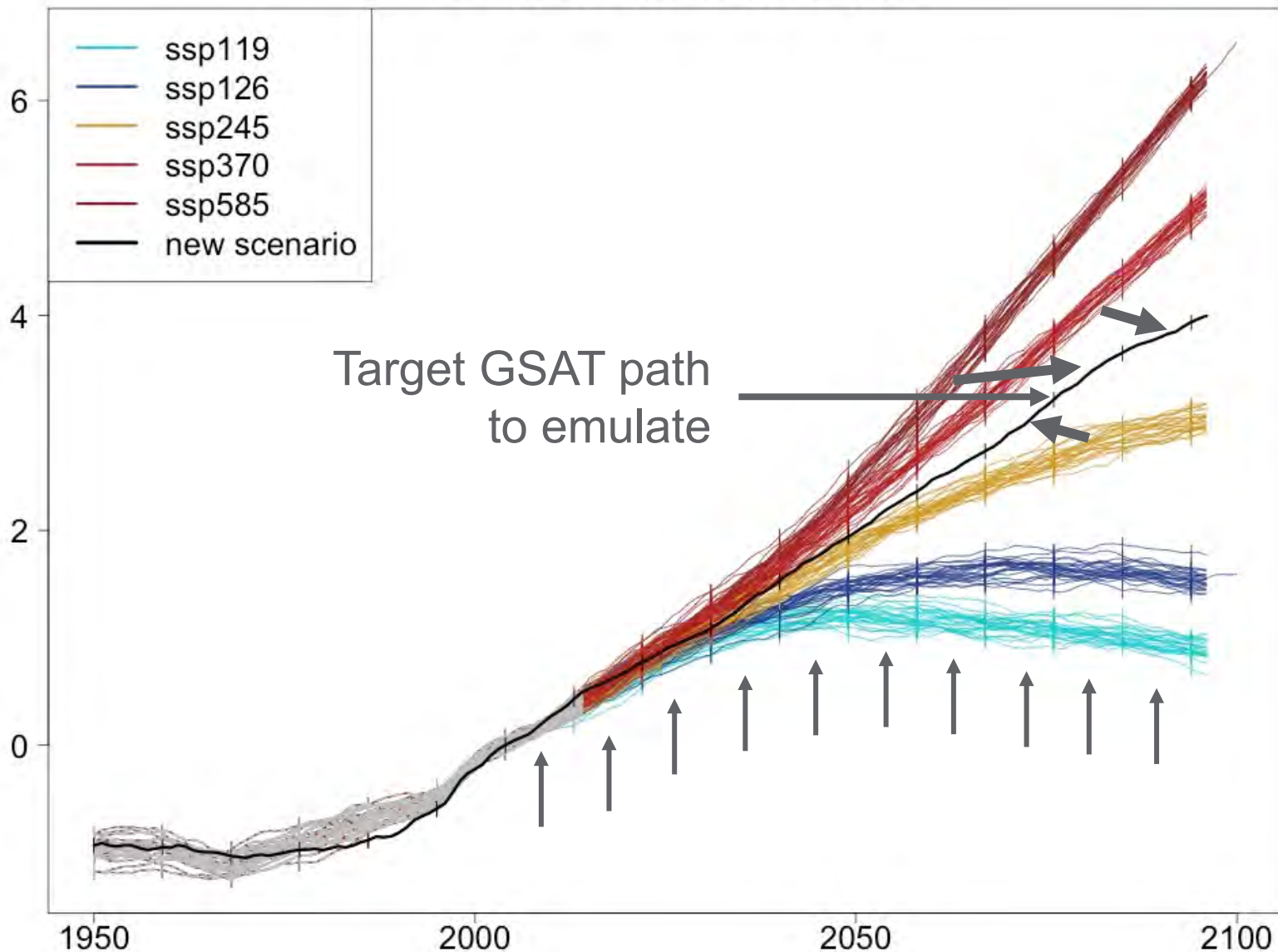
Example of emulation advances:

STITCHES (Tebaldi et al. 2022)

Start with ESM simulations

Define target GSAT path to be emulated (eg from IAM)

Divide all simulations into X-year segments

For each target segment, take ESM segment that has similar GSAT, ΔGSAT

"Stitch" ESM segments together

If ESM has saved it, STITCHES can emulate it! (with caveats…)

Goals for ScenarioMIP process in CMIP7

Reconstitute MIP membership to reflect wider participation by different research communities

- Possibly semi-formal connection to large scale impact modeling

Proceed as MIP without also having a Task Team on same topic

Start process early

- Allow for development of tools to automate IAM->ESM process

Re-evaluate potential role of emulation in ScenarioMIP design

Pursue coordinated approach across MIPs

- Strategic Ensemble Design TT, LUMIP, C4MIP, AerChemMIP, RCMIP, GeoMIP, …
- Repeat the cross-MIP AGCI meeting from early AR6?

Develop short-/longer-term plans, to meet needs for AR7 and beyond

JOINT GLOBAL CHANGE RESEARCH INSTITUTE

Pacific Northwest
NATIONAL LABORATORY

UNIVERSITY OF MARYLAND

Thank you

JOINT GLOBAL CHANGE
RESEARCH INSTITUTE

Pacific Northwest
NATIONAL LABORATORY

UNIVERSITY OF
MARYLAND