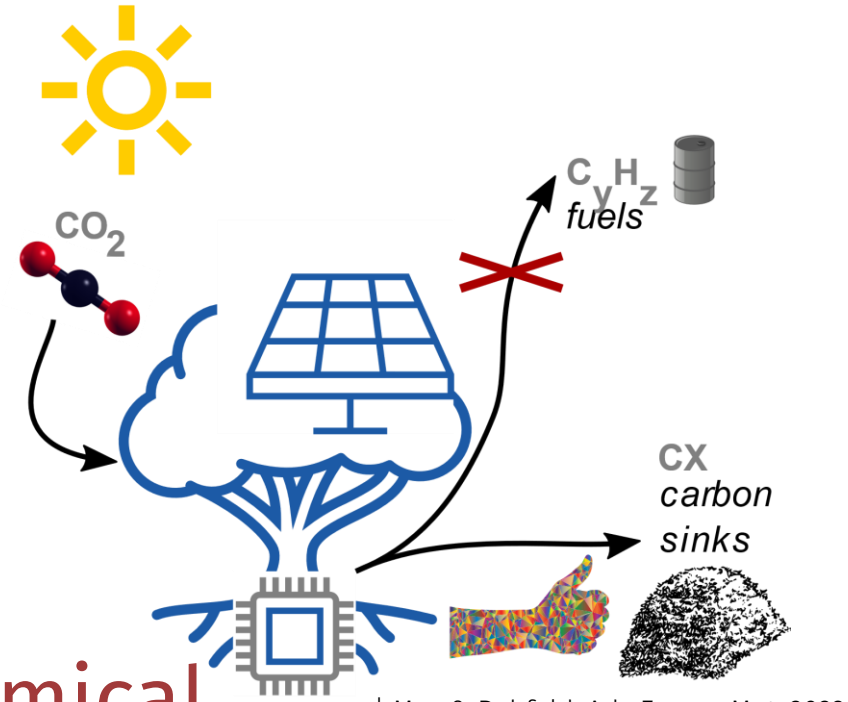

| May & Rehfeld, Adv Energy Mat, 2022

Investigating potential climatic side-effects of photoelectrochemical devices for carbon dioxide removal

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May 24, 2022

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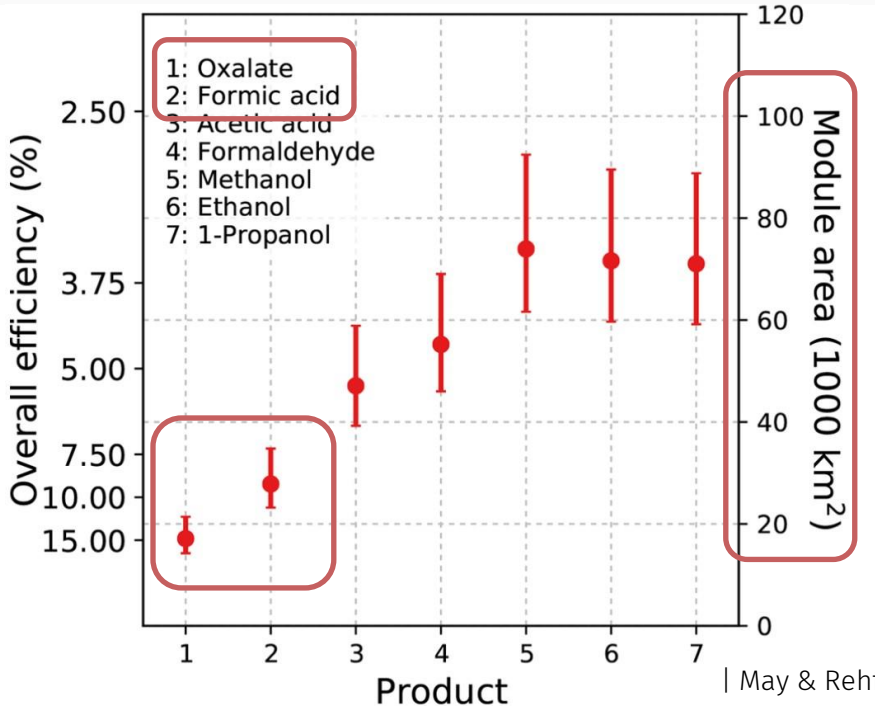
Hypothetical **P**hoto**e**lectro**c**hemical CCS

Irradiation drives catalytic CO_2 reduction

PE Cells: High conversion efficiencies for hydrogen fuel production | Possible optimization for high CO_2 sequestration efficiency

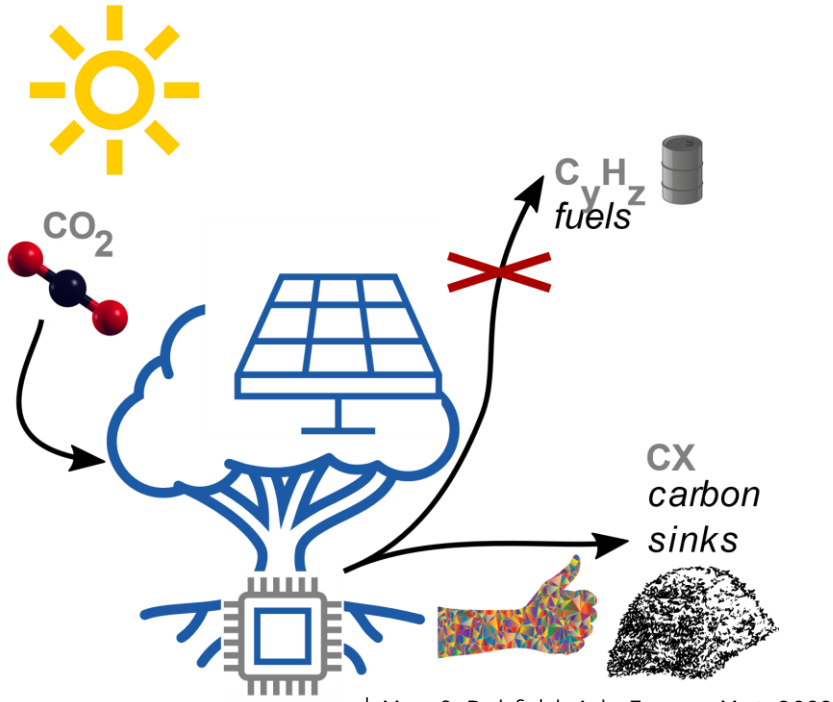
Land-use requirements low compared to other CDR



10 Gt CO_2/yr

Sahara Irradiance

| May & Rehfeld, ESD Ideas, 2019



| May & Rehfeld, Adv Energy Mat, 2022

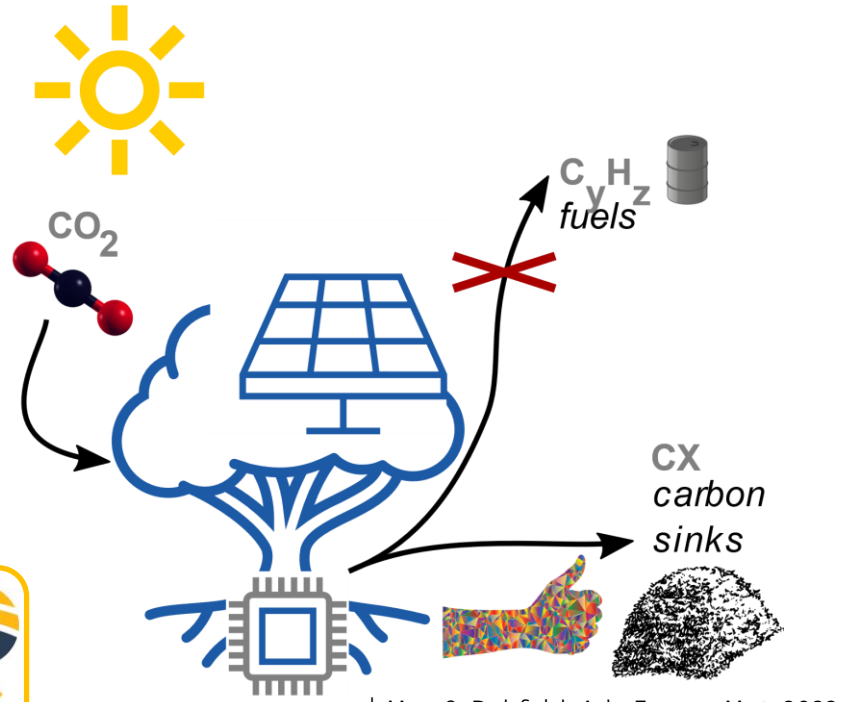
Hypothetical **P**hoto**e**lectro**c**hemical CCS

Irradiation drives catalytic CO_2 reduction

PE Cells: High conversion efficiencies for hydrogen fuel production | Possible optimization for high CO_2 sequestration efficiency

Land-use requirements low compared to other CDR

No prototype exists for CO_2 reduction → NETPEC

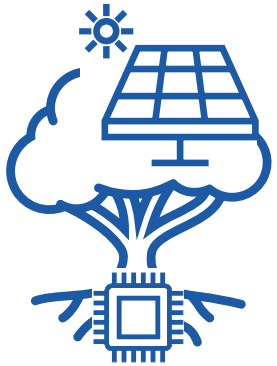


| May & Rehfeld, Adv Energy Mat, 2022

Case Study

Potential side-effects of hypothetical NETPEC Devices on the Earth System?

Carbon Cycle

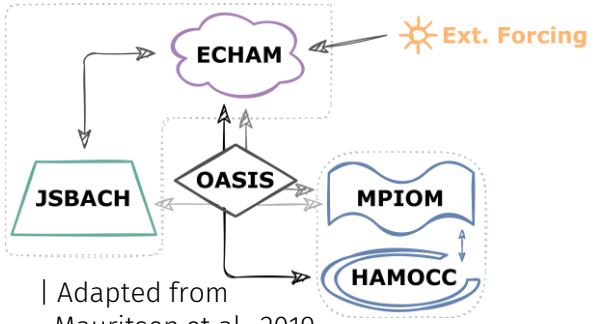


Climate

Technology Diffusion

RQ0

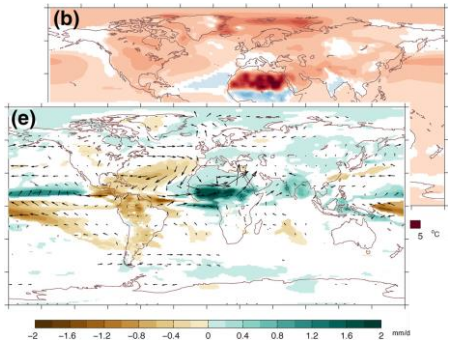
Represent PEC devices in a comprehensive Earth System Model (MPI-ESM)?



| Adapted from Mauritsen et al., 2019

RQ1

Regional climate impacts?



| PV Impacts: Lu et al., GRL, 2021

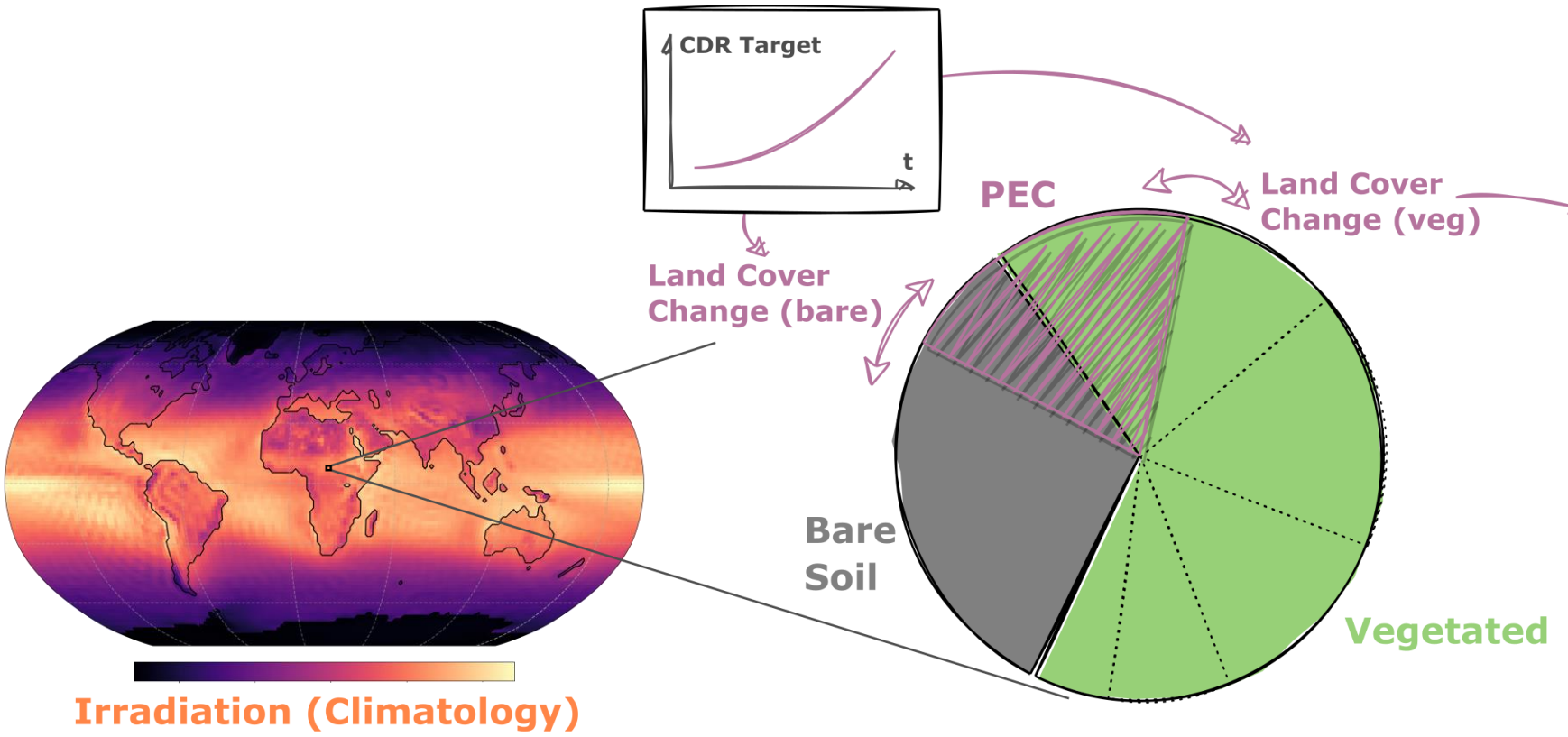
RQ2

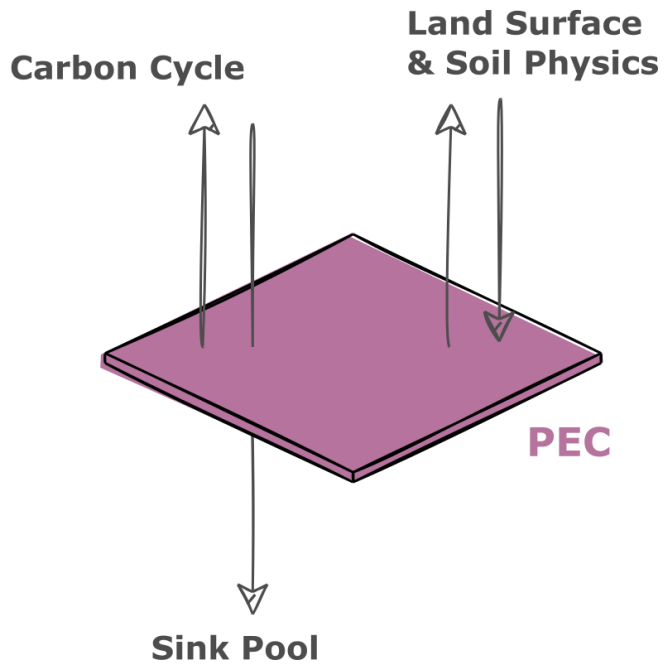
Spatio-temporal carbon cycle impacts?

RQ0

Representing NETPEC devices in MPI-ESM/JSBACH

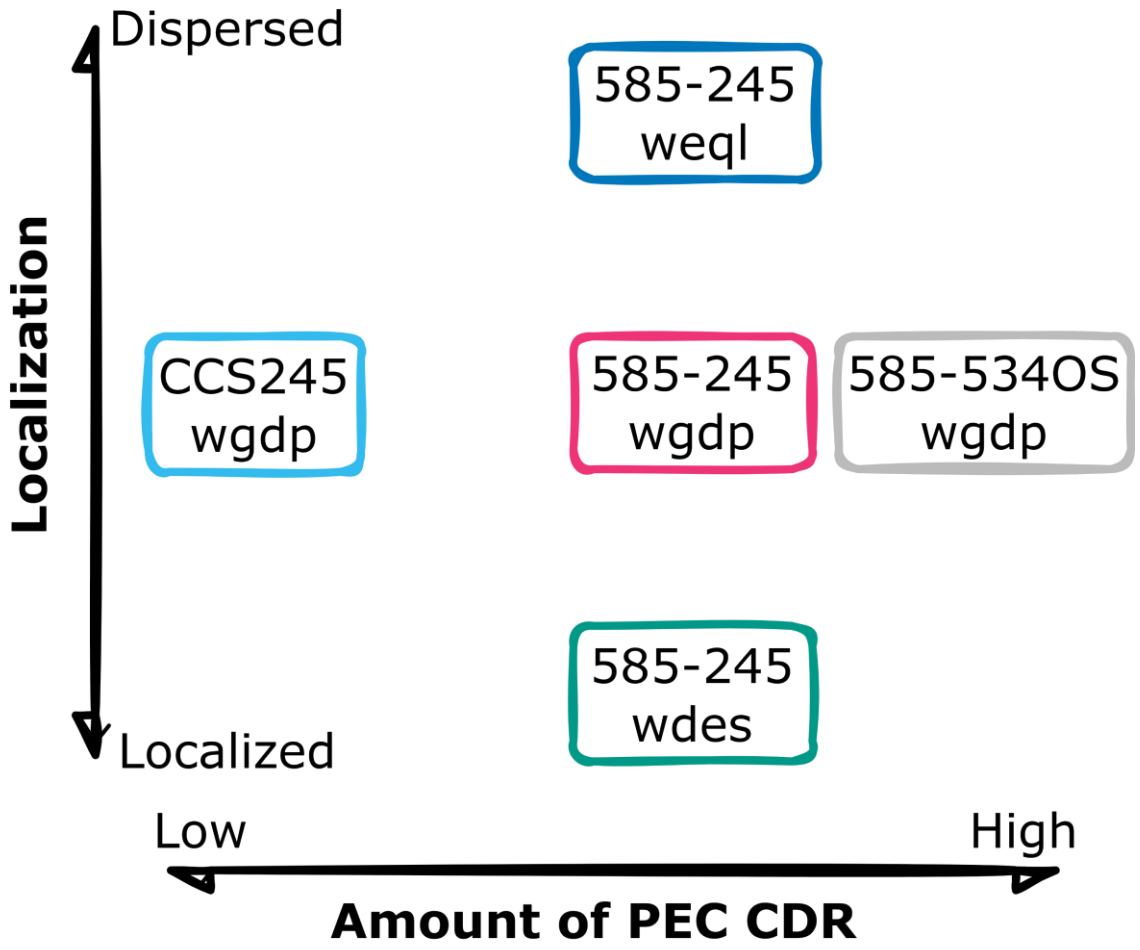
| MPI-ESM: Giorgetta et al., JAMES, 2013 | JSBACH: Reick et al., JAMES, 2013



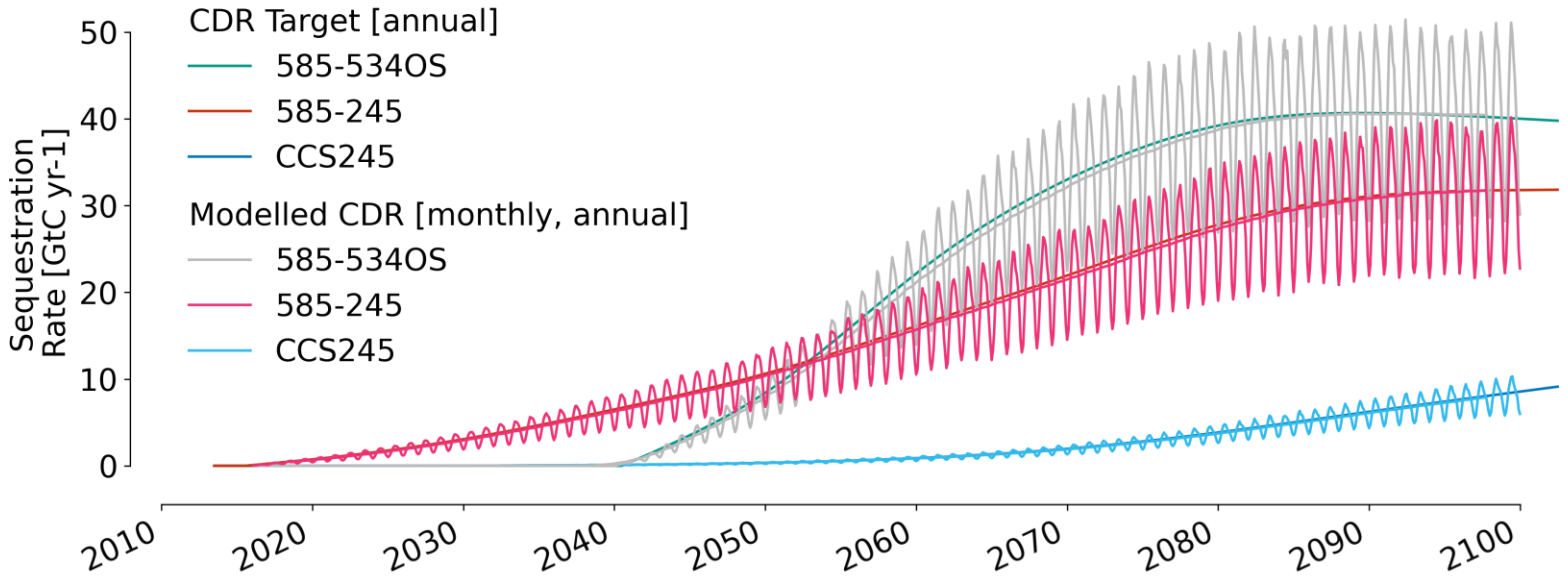


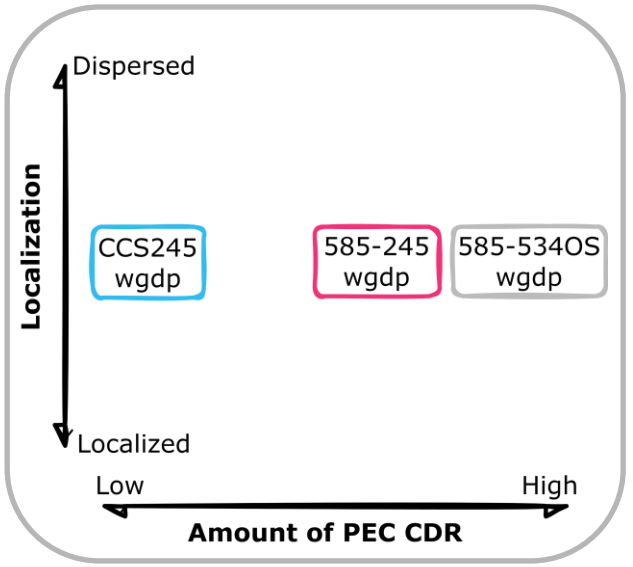
RQ1, 2 Deployment Scenarios from SSPs

| SSP Data: Riahi et al., Glob Environ Change, 2017



RQ0 Interactive PE Cell Deployment – Sequestration Target

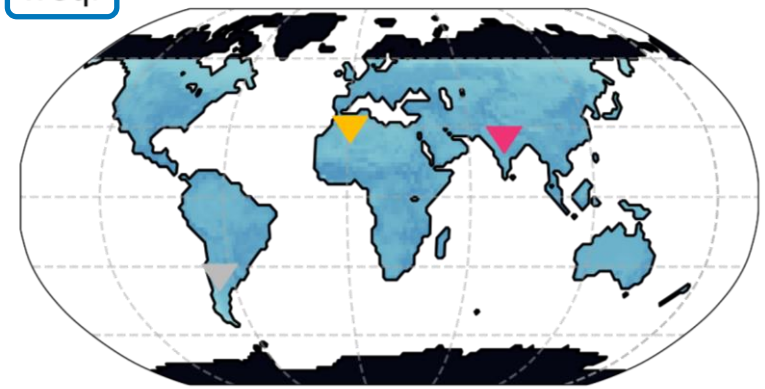




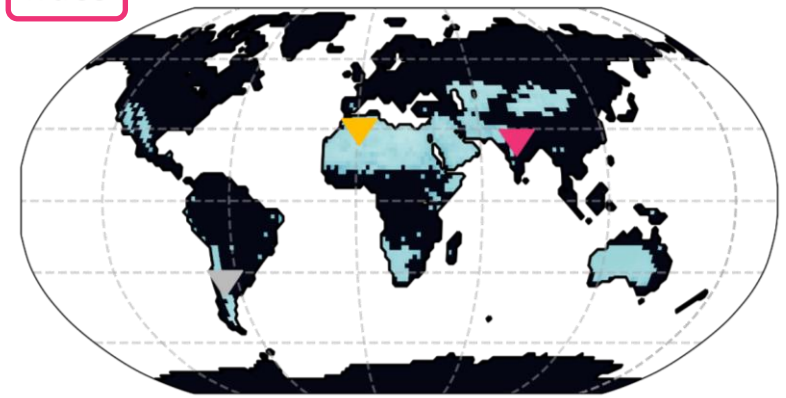
→ Simulated deployment in good agreement with the CDR Target

RQ0 Interactive PE Cell Deployment – Spatial Target

weql



wdes



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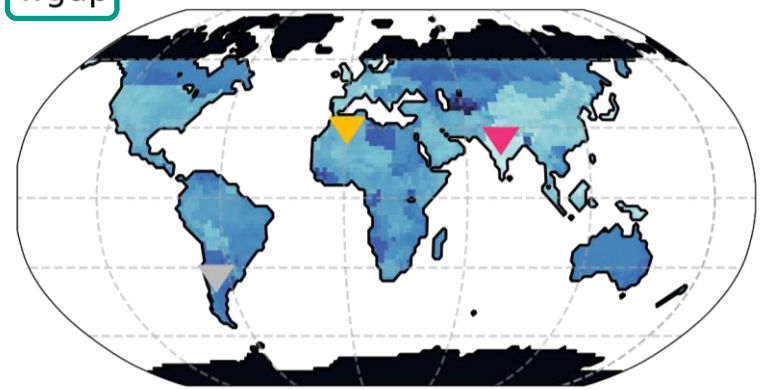
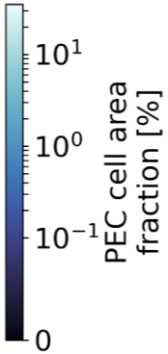
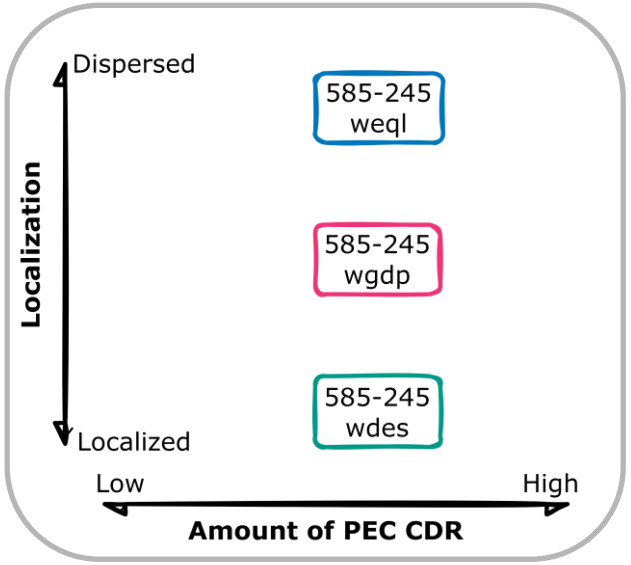
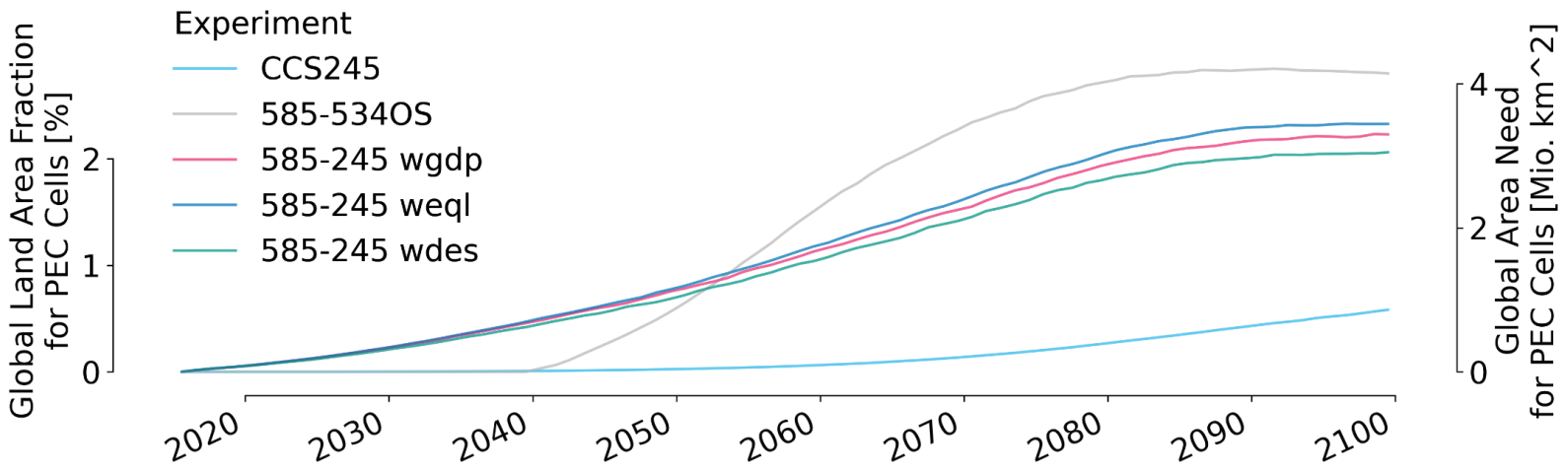
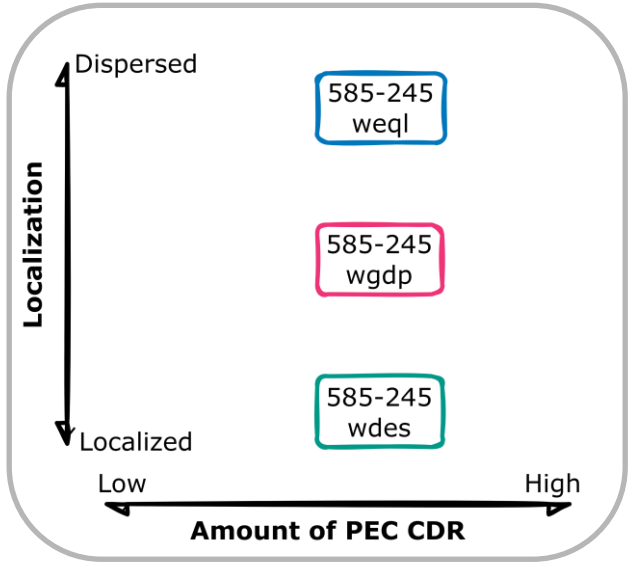






RQ0 Interactive PE Cell Deployment – Land Use





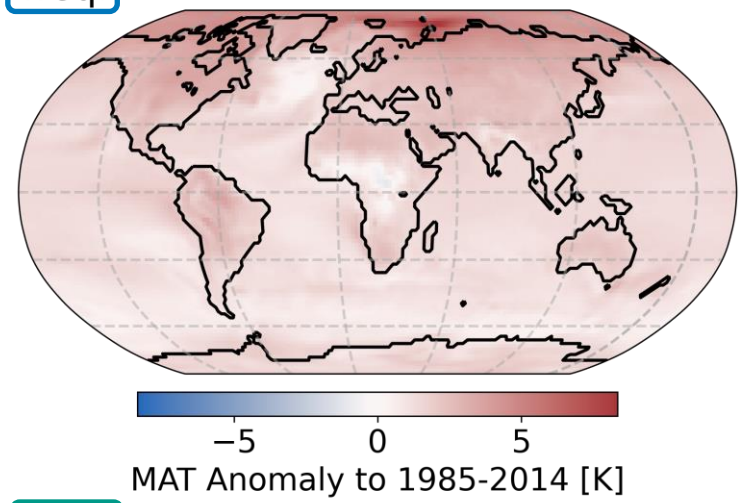
→ Simulated land footprint in good agreement with theoretical expectations

Interactive **simulation framework for PEC CDR** in MPI-ESM/JSBACH

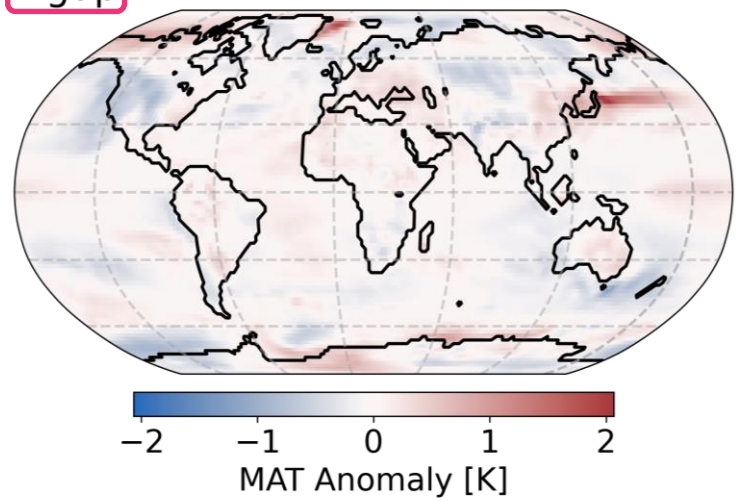
RQ1

Preliminary Result: Temperature & Precipitation Response

weql



wgdp



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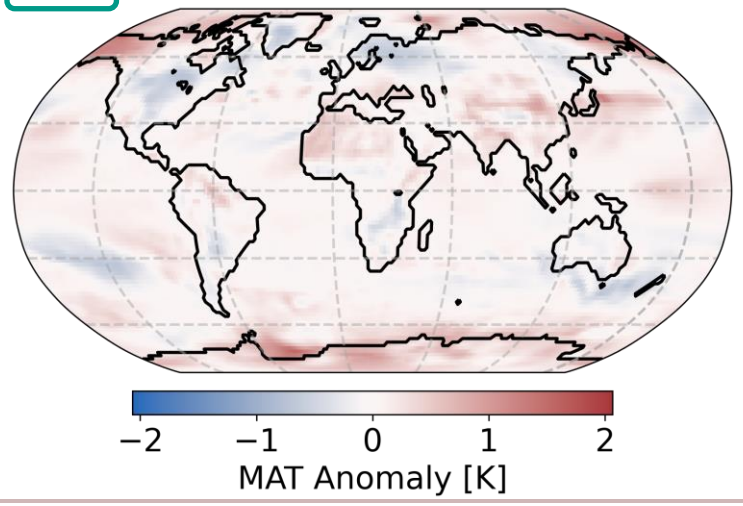
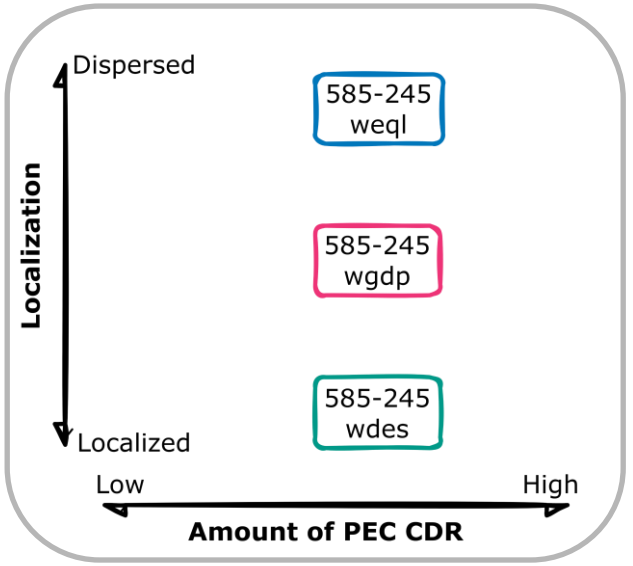
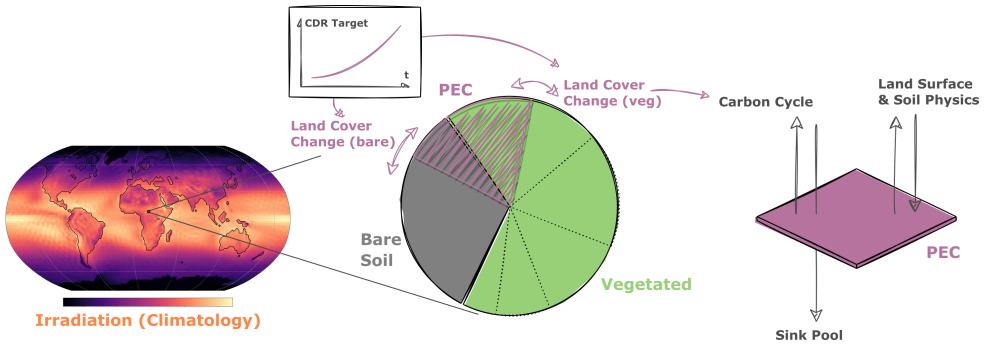


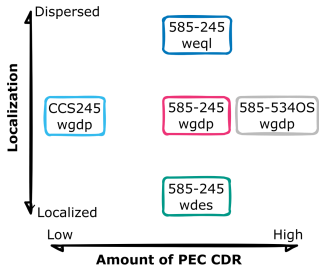


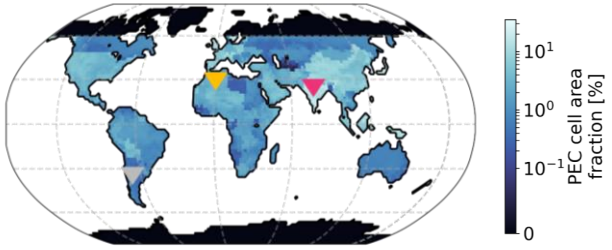
Temp: Differences between scenarios likely within variability of baseline

Precip: Some seasonal anomalies for grid cells with PEC fraction >10%

Extended simulations/ensembles needed for statistical assessment







Summary/Conclusions

Interactive **simulation framework for PEC CDR** in MPI-ESM/JSBACH

Impacts on surface climate likely small, carbon cycle effects to be investigated

PEC devices could be **highly land-use efficient** but **prototypes to be built** →

NETPEC

Future Work & Points for Discussions

- Refine Scenarios
- Simulation Ensembles
- Expand Impact Assessment

Thank you! Questions?

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