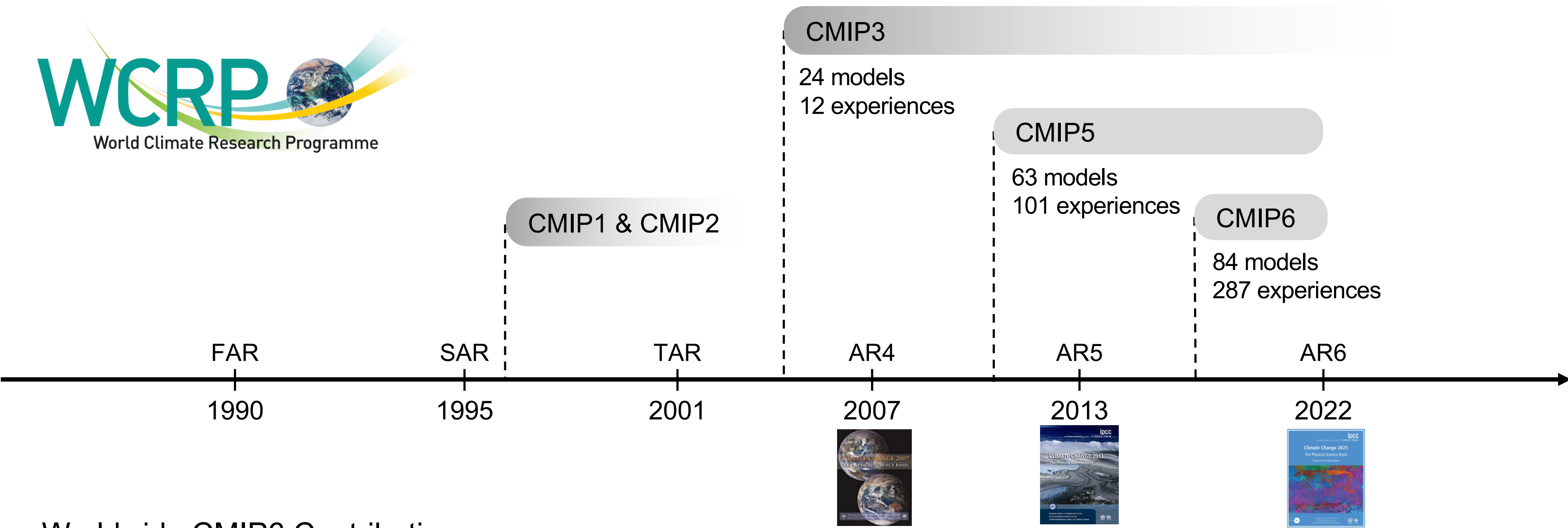
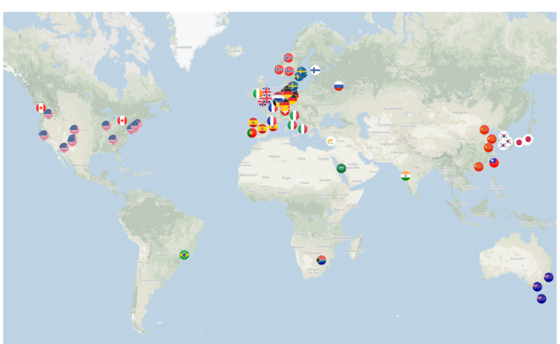
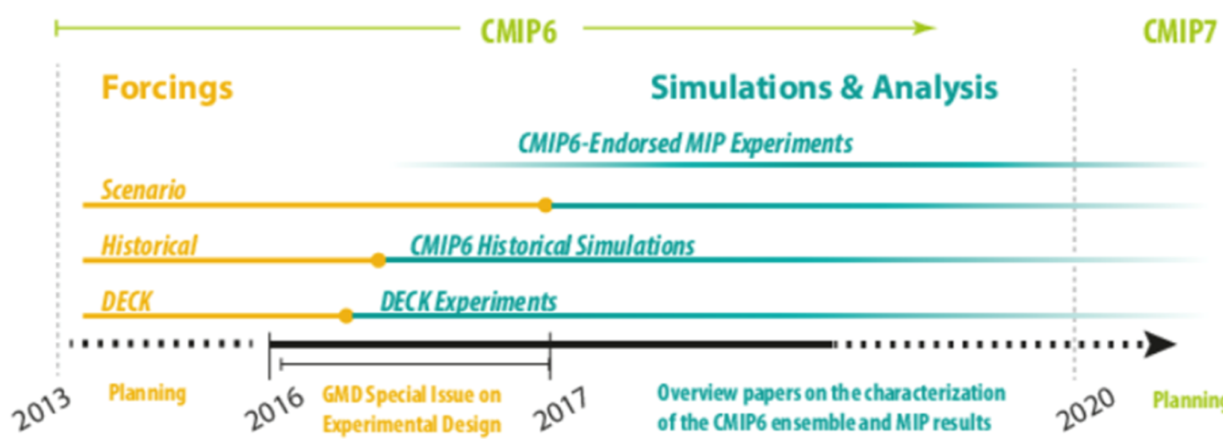
Overall Context



Worldwide CMIP6 Contributions



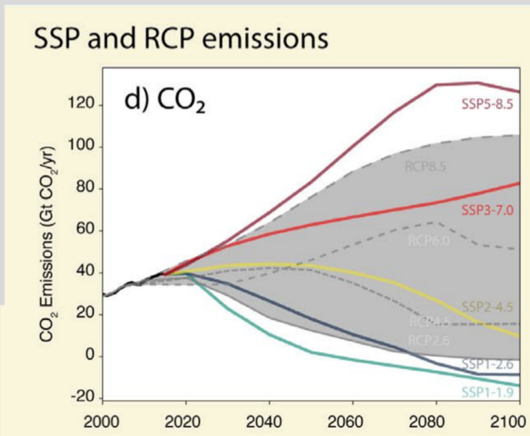


Eyring et al., (2016)

Climate Modelling
classical approach

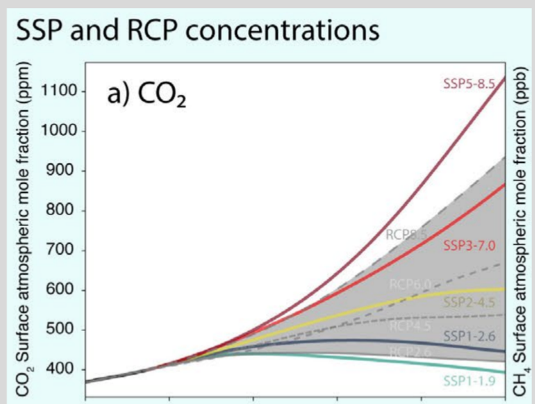
Emissions

External forcings



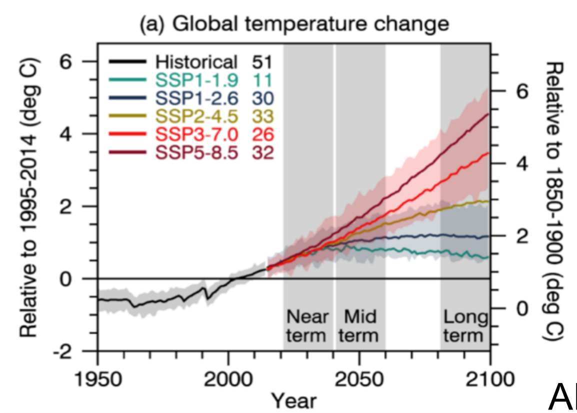
Integrated Assessment Models
Riahi et al. (2017)

Concentrations



version 7.0 of MAGICC,
Meinshausen et al. (2019)
Meinshausen et al. (2011)

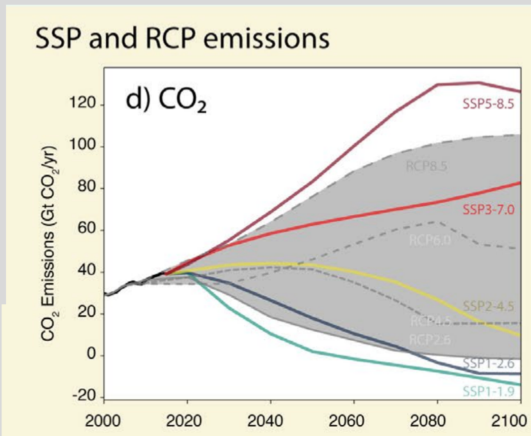
Climate



AR6

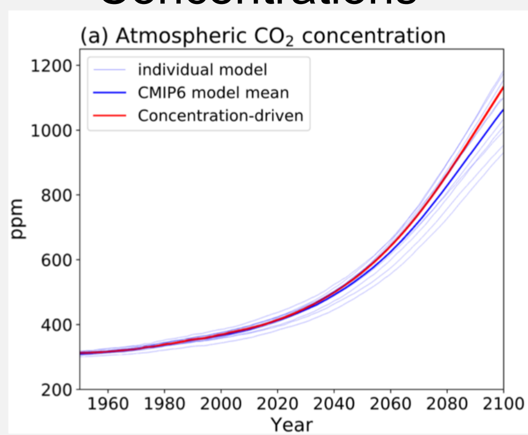
Climate Modelling
biogeochemical approach

Emissions



Integrated Assessment Models
Riahi et al. (2017)

Concentrations

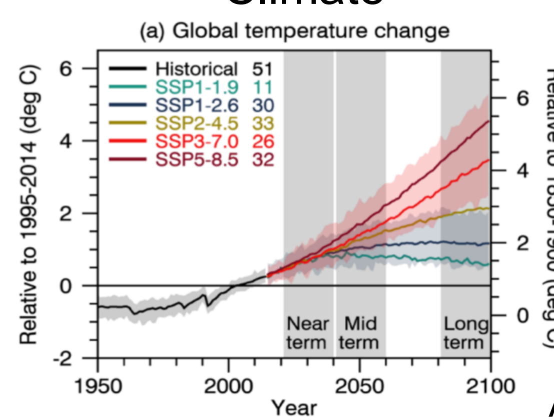


Ocean
PISCES

Land
ORCHIDEE

carbon cycle

Climate



AR6

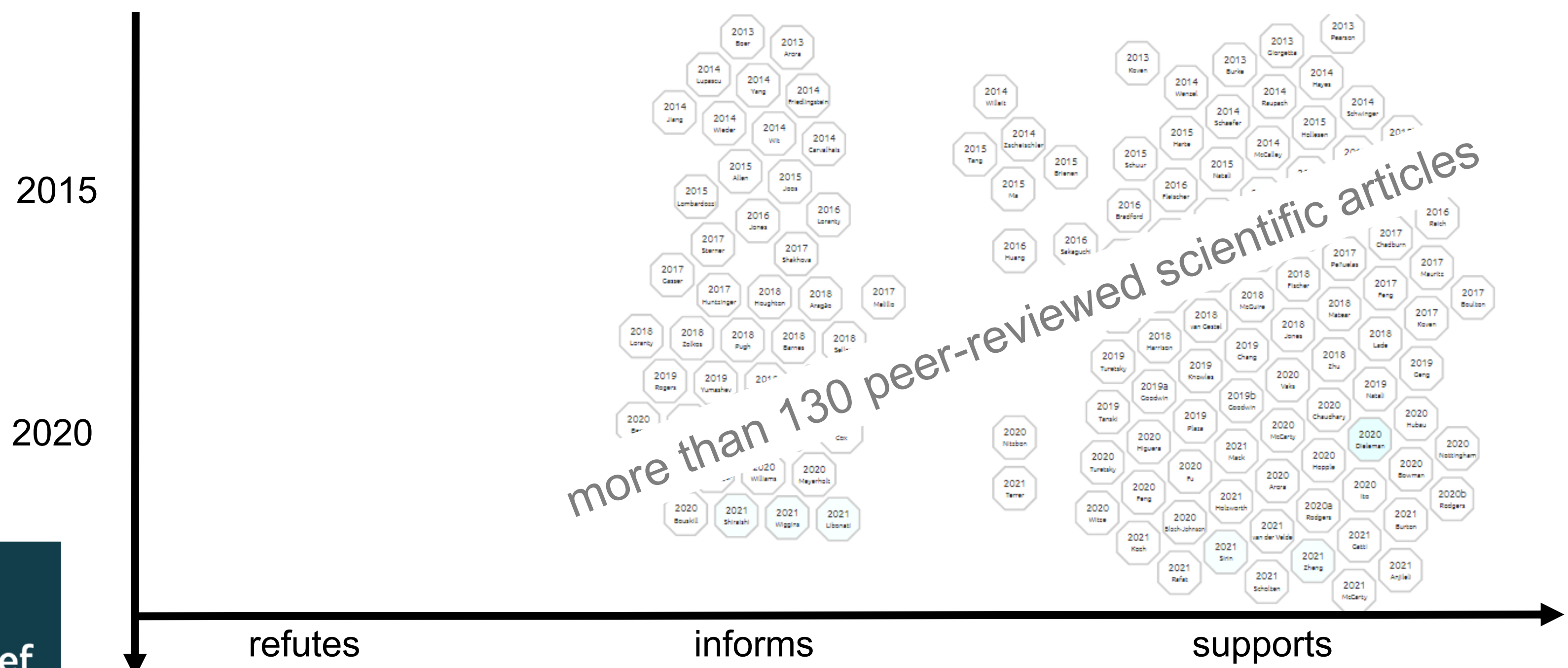
Climate-Carbon Feedback

- Seminal studies indicate a positive feedback (with some uncertainty)
- Since then, positive feedback never refuted and most often confirmed

Cox et al. 2000, **Nature**
Acceleration of global warming due to carbon-cycle feedbacks in a coupled climate model

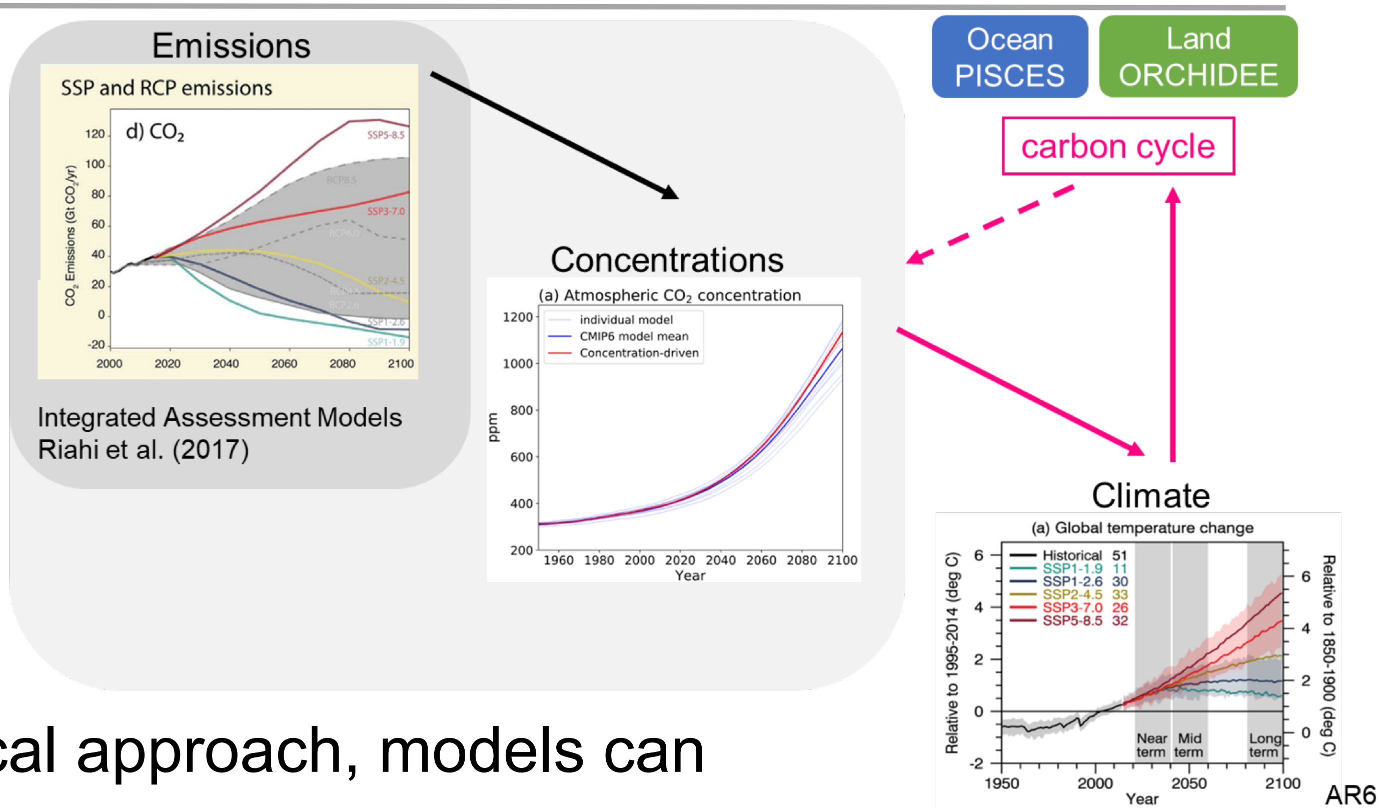
Friedlingstein et al. 2001, **GRL**
Positive feedback between future climate change and the carbon cycle

Dufresne et al. 2002, **GRL**
On the magnitude of positive feedback between future climate change and the carbon cycle



UEA ScienceBrief

Concentration vs. Emission Driven



In biogeochemical approach, models can either be forced

- By concentrations (as determined by IAM). Amplification effects (warming) of biogeochemical feedbacks cannot be assessed

concentration driven

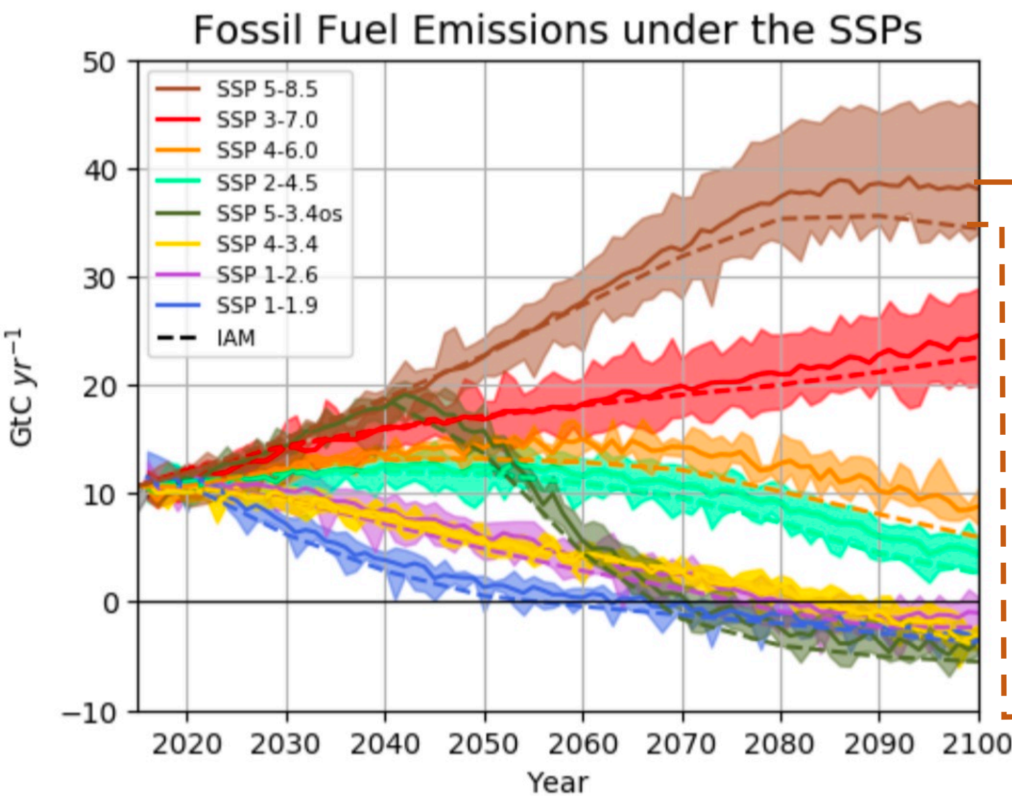
- By emissions. Concentration is dynamically simulated and carbon cycle feedback on concentration is taken into account

emission driven

Compatible Emissions (E_{ff})

Compatible emissions (E_{ff}) are the emissions that it would be required to force the model with, in order to simulate a given concentration

$$E_{tot} = E_{ff} + E_{luc} = G_{atm} + S_{ocean} + S_{land}$$



Liddicoat et al. (2021)

where

E_{tot} is the total anthropogenic CO_2 emissions

E_{ff} is the CO_2 emissions from fossil fuel combustion and cement production

E_{luc} is the land use change CO_2 emissions

G_{atm} is the growth rate of atmospheric CO_2 concentration

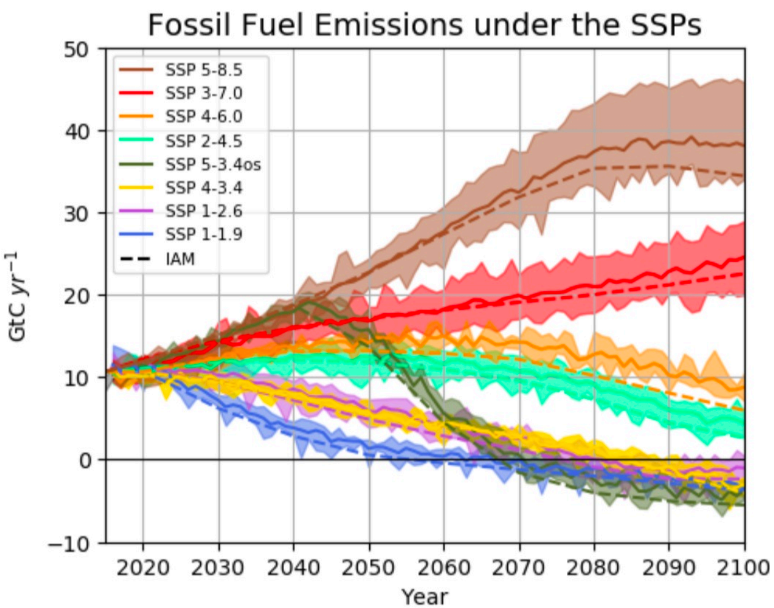
S_{ocean} is the ocean sink

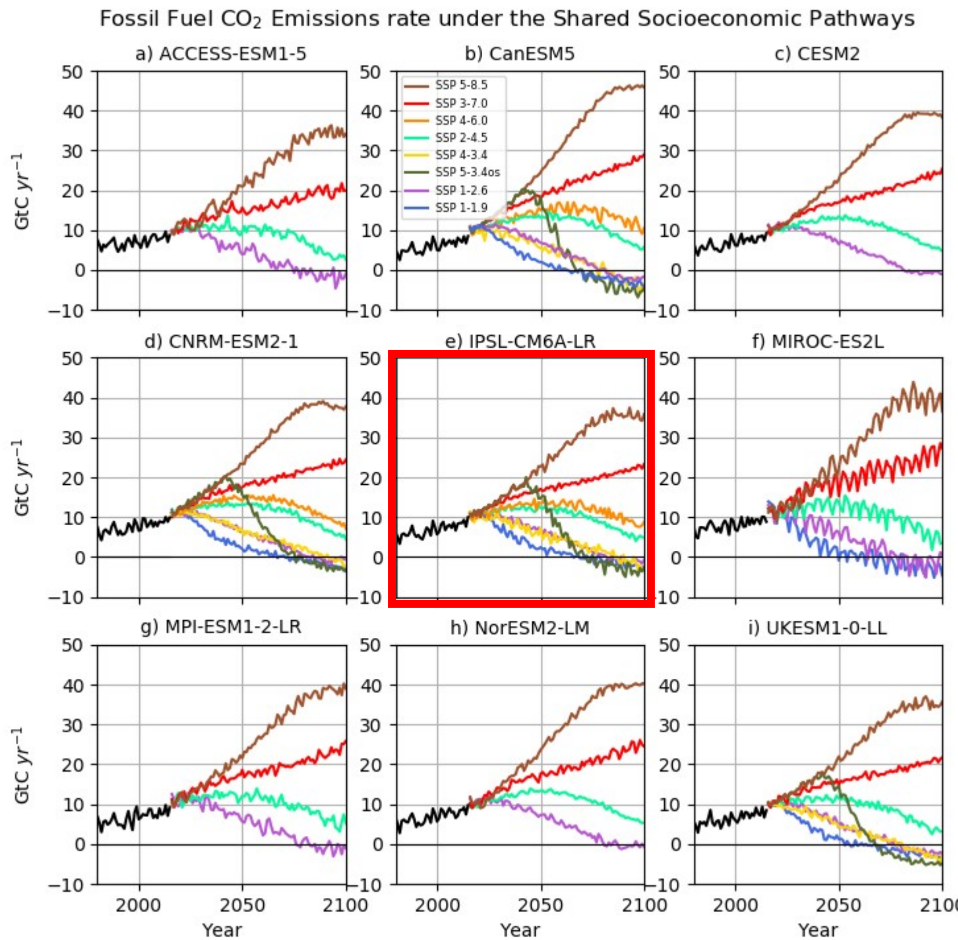
S_{land} is the terrestrial sink

$S_{land} - E_{luc}$ is the terrestrial carbon fluxes

- Models mean simulate greater compatible emissions than IAM emissions
- Model spread is more important for SSP5-8.5 and SSP3-7.0

Compatible Emissions (E_{ff})
model breakdown

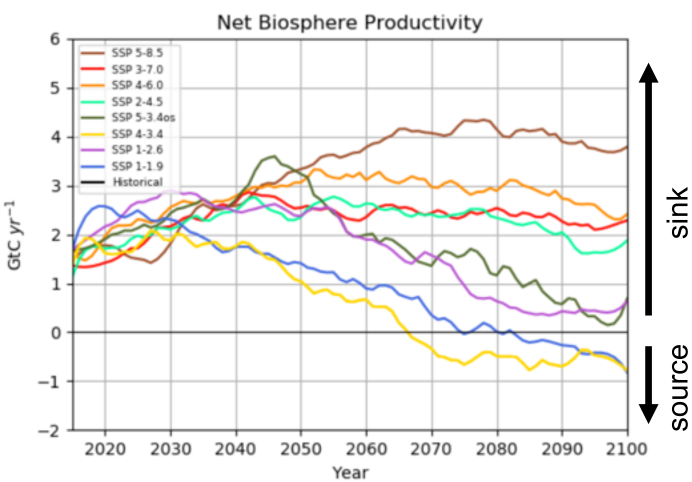


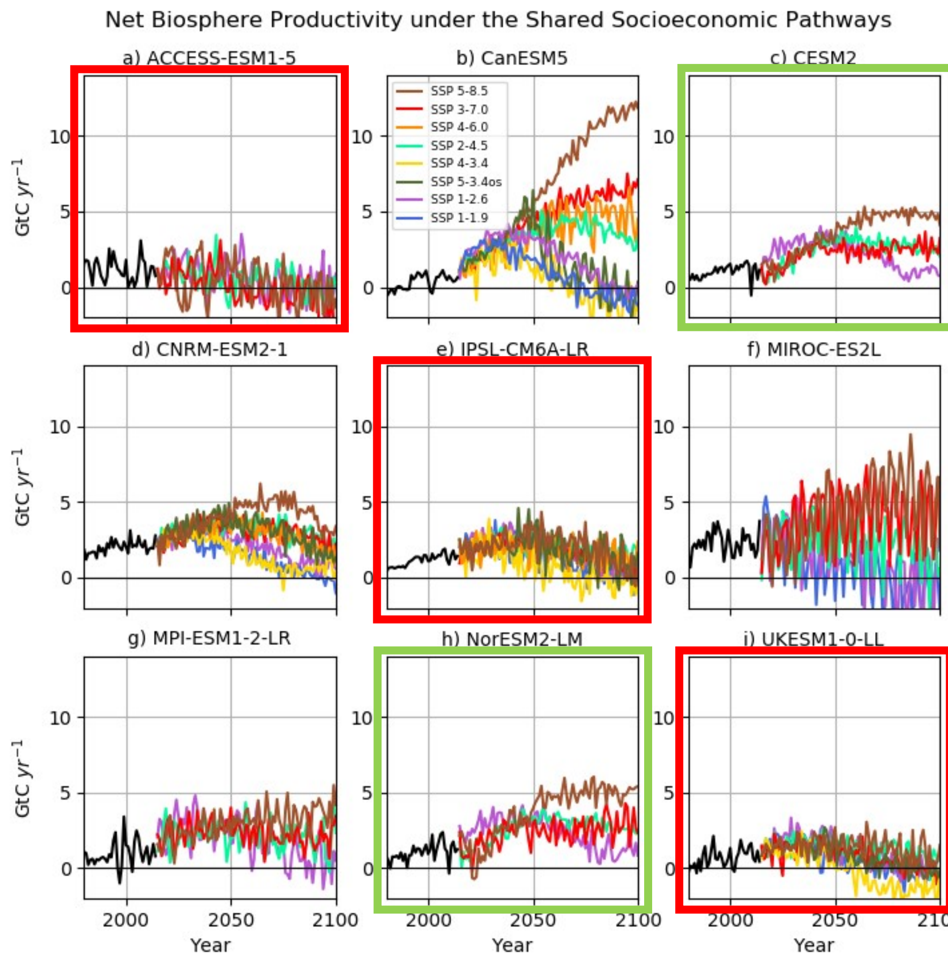


- There is nevertheless a generally strong agreement between the models and IAM
- IPSL model matches well with IAM for most SSPs

Liddicoat et al. (2021)

Terrestrial Carbon Fluxes ($S_{land} - E_{luc}$)



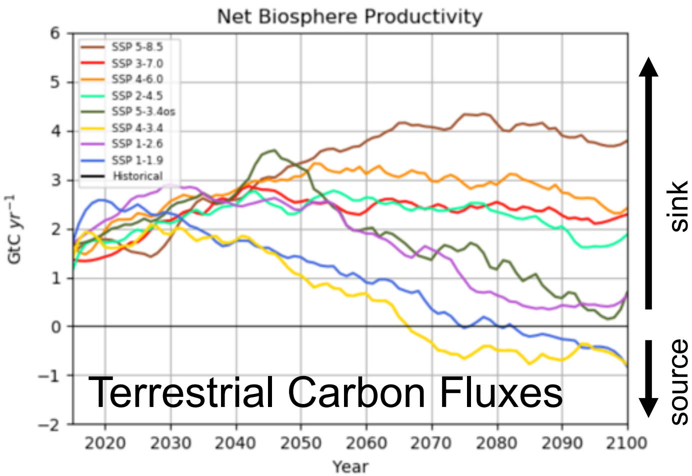


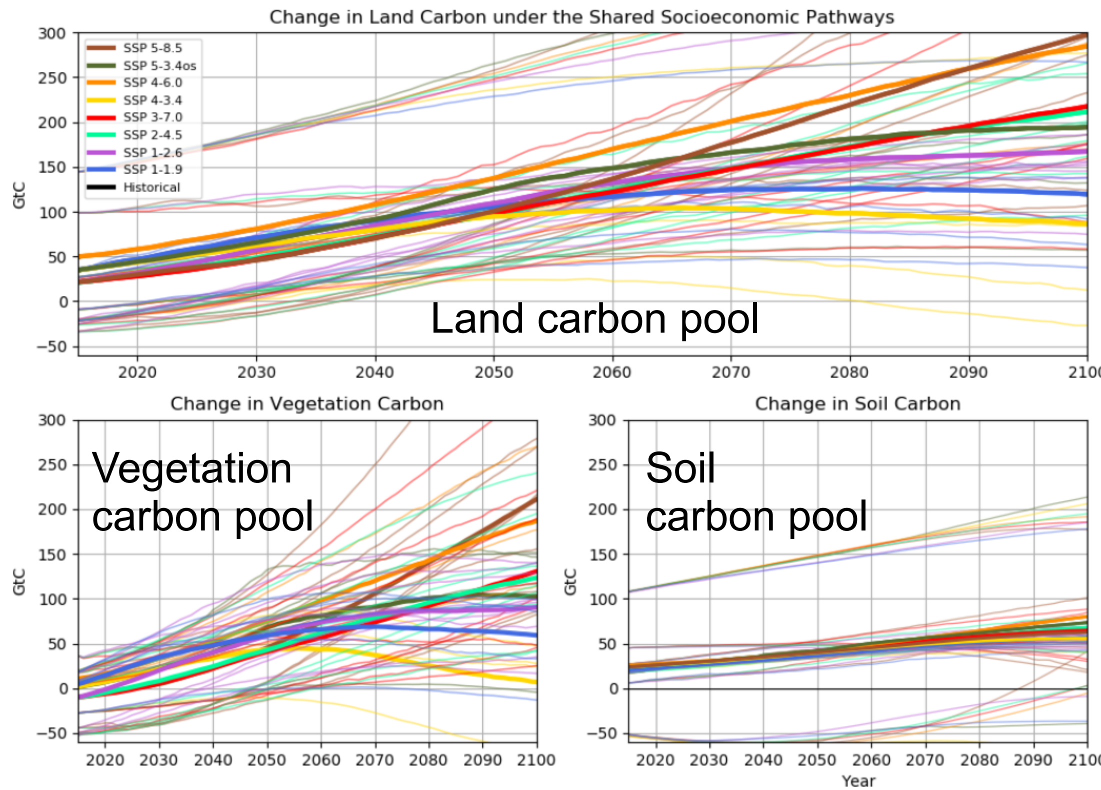
Although the model mean exhibits some inter-scenario spread in the timeseries of NBP, there is very little evidence of this in some models (ACCESS, IPSL, UKESM) and (CESM2 and NorESM2), while NBP in other models is very scenario-dependent (CanESM5, MIROC)

Red = source in 2100; Green = sink in 2100

Liddicoat et al. (2021)

Change in Land Carbon Store

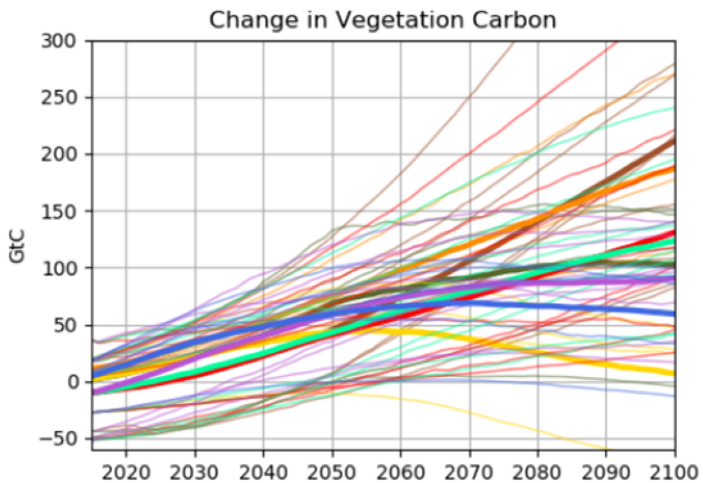


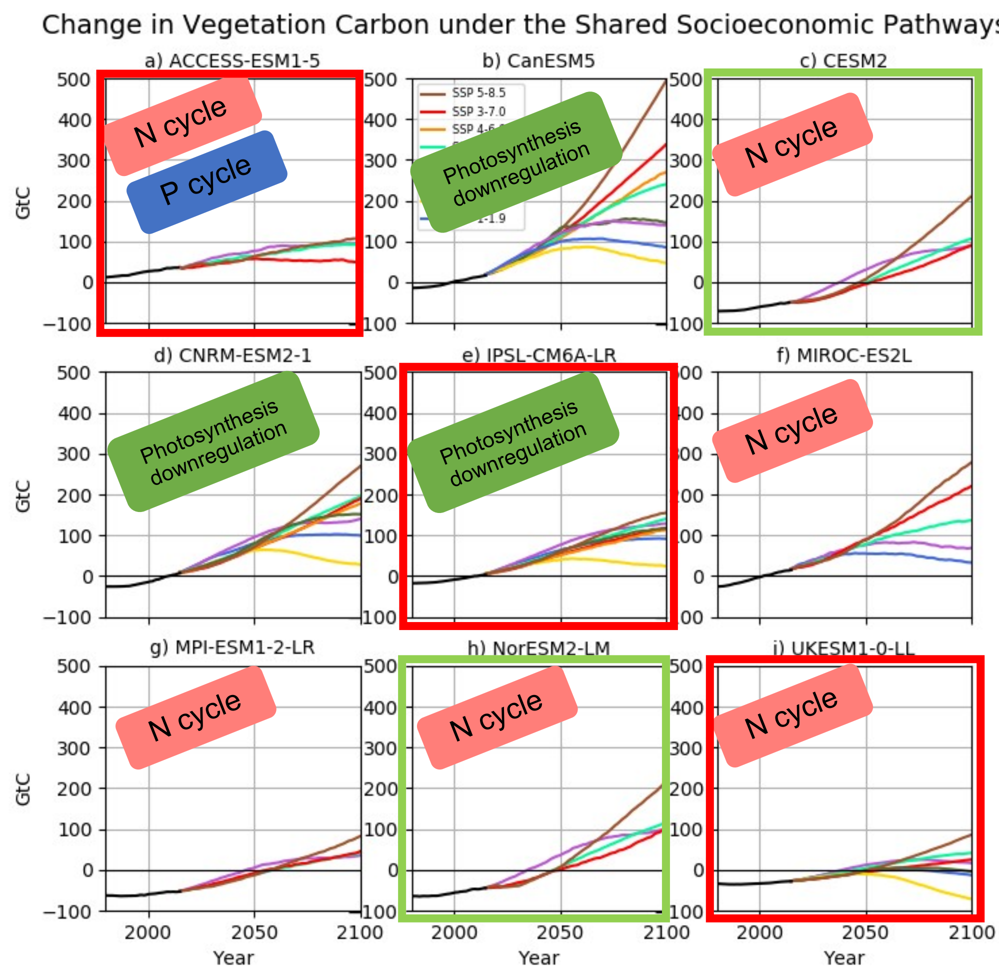


The change in vegetation carbon is primarily responsible for the evolution of land carbon throughout the 21st century

Liddicoat et al. (2021)

Change in Vegetation Carbon Pool



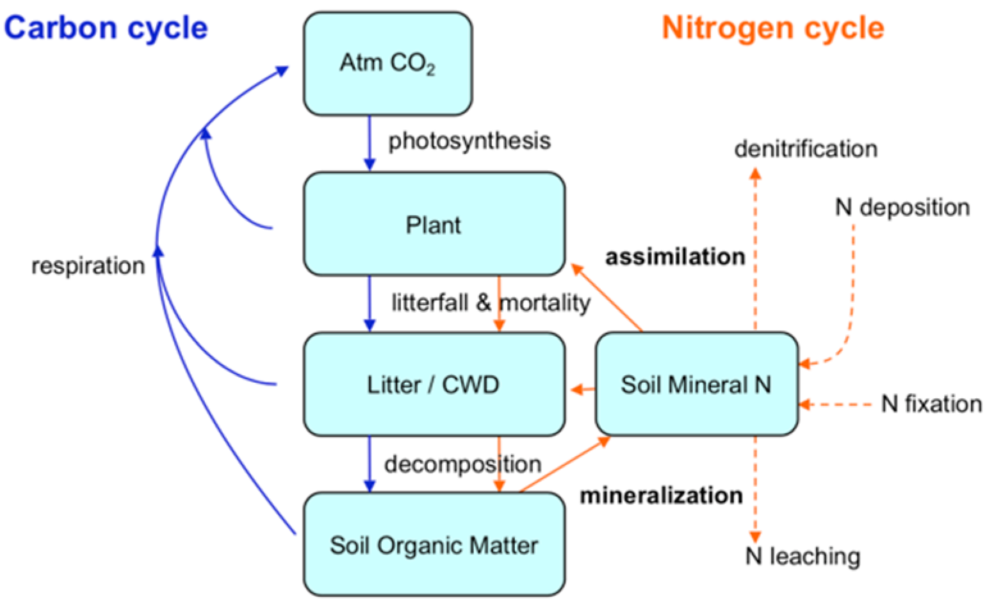


Change of vegetation carbon pool simulated by IPSL is not extremely different from that of models with which it was in agreement on NBP (ACCESS and UKESM)

Yet, different approach to N (and P) cycle(s) modelling

Liddicoat et al. (2021)

Why worry about the N Cycle?



- Affects spatial distribution of productivity
- Affects carbon allocation and turnover of ecosystems
- Causes soil processes to affect vegetation growth and allocation
- Attenuates ability of ecosystems to respond to elevated CO_2 and warming

Courtesy of Sönke Zahele

Take Away

- “ Reduced spread in CMIP6 carbon cycle feedbacks compared to CMIP5 has been postulated to be due to the inclusion of nitrogen cycle processes in about half of CMIP6 ESMs ”
- “ The inclusion of the N cycle results in lower absolute strength of the feedback parameters over land. In addition, the land models that include a representation of the N cycle exhibit a reduced spread in their feedback parameters, despite the additional complexity, compared to when all models are considered. ”
- “ This suggests that if all models were to include the N limitation of photosynthesis, the spread across them will potentially reduce. ”

Arora et al., (2020)

At global and regional scale, does the IPSL CO_2 downregulation allow to simulate the weakening of carbon sinks due to climate change as best as models with explicit N cycle?