Modelling Ocean Carbon Solutions

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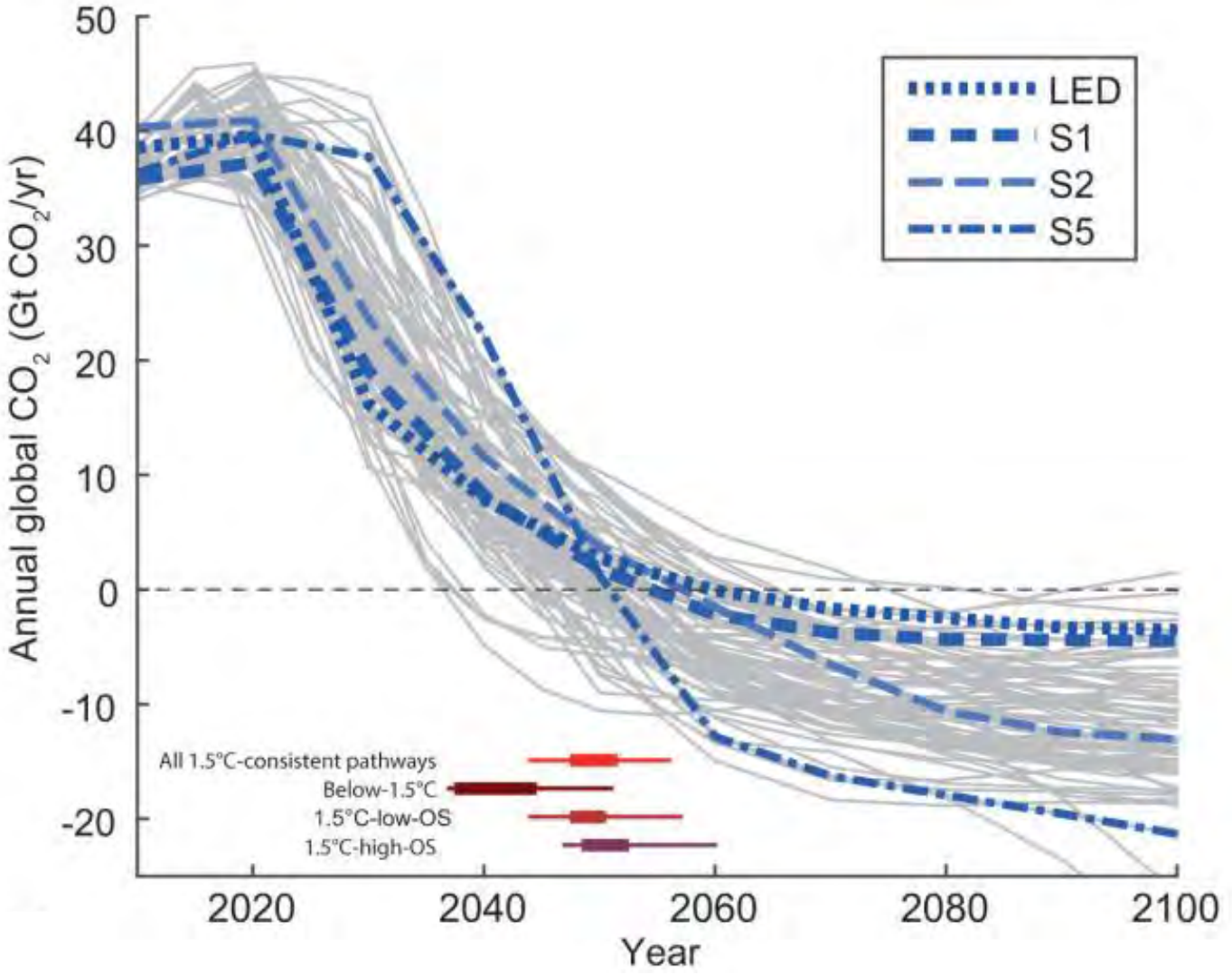
Background

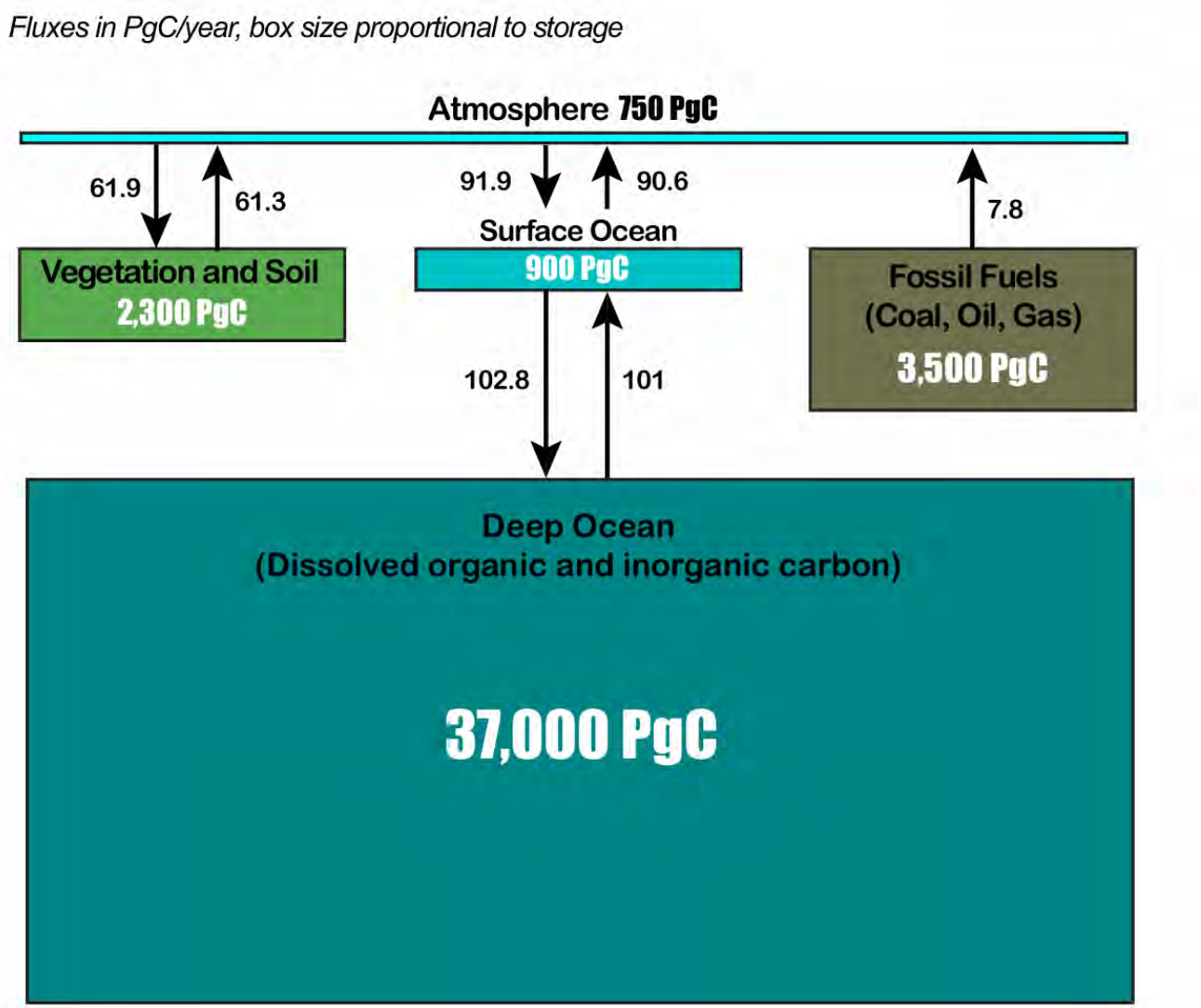
- All projections of 1.5ºC require net negative CO2 emissions
- Requires significant carbon storage methods



IPCC, 2018 p. 113

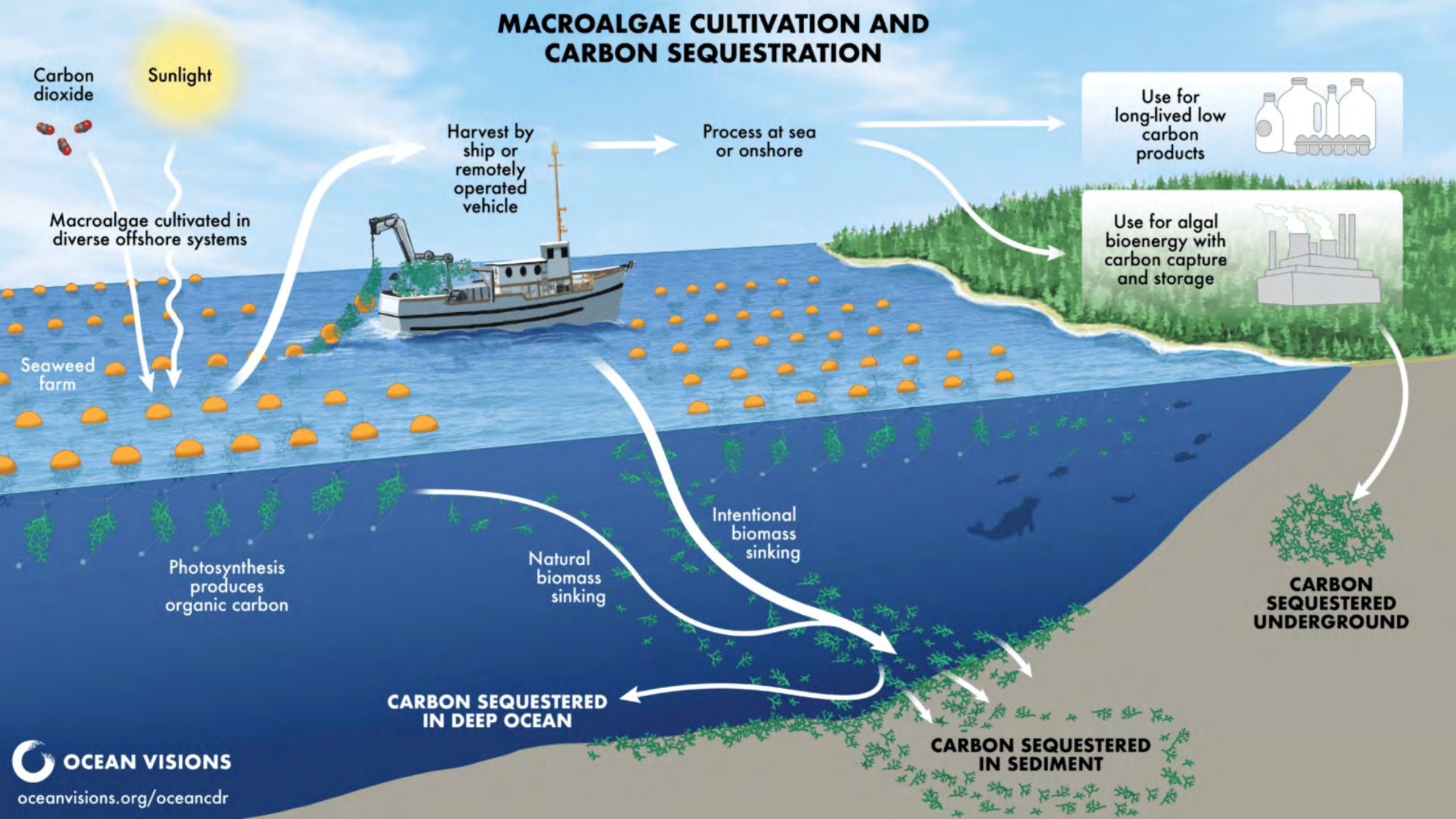
Why the Ocean?

- Huge capacity for carbon storage
- Can capture all carbon in atmosphere



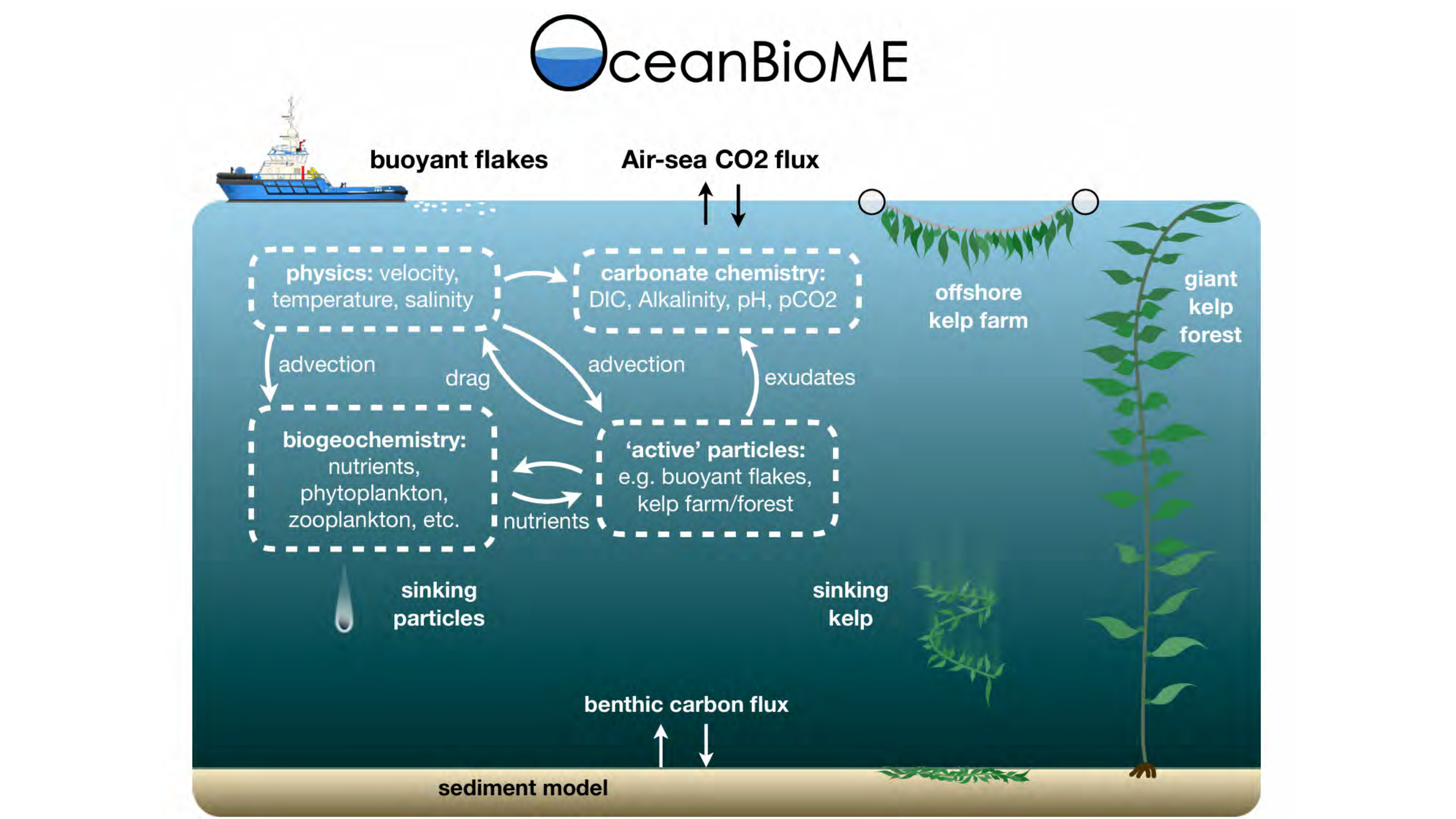
Sarmiento and Gruber, 2002, IPCCAR5 p. 113

MACROALGAE CULTIVATION AND CARBON SEQUESTRATION



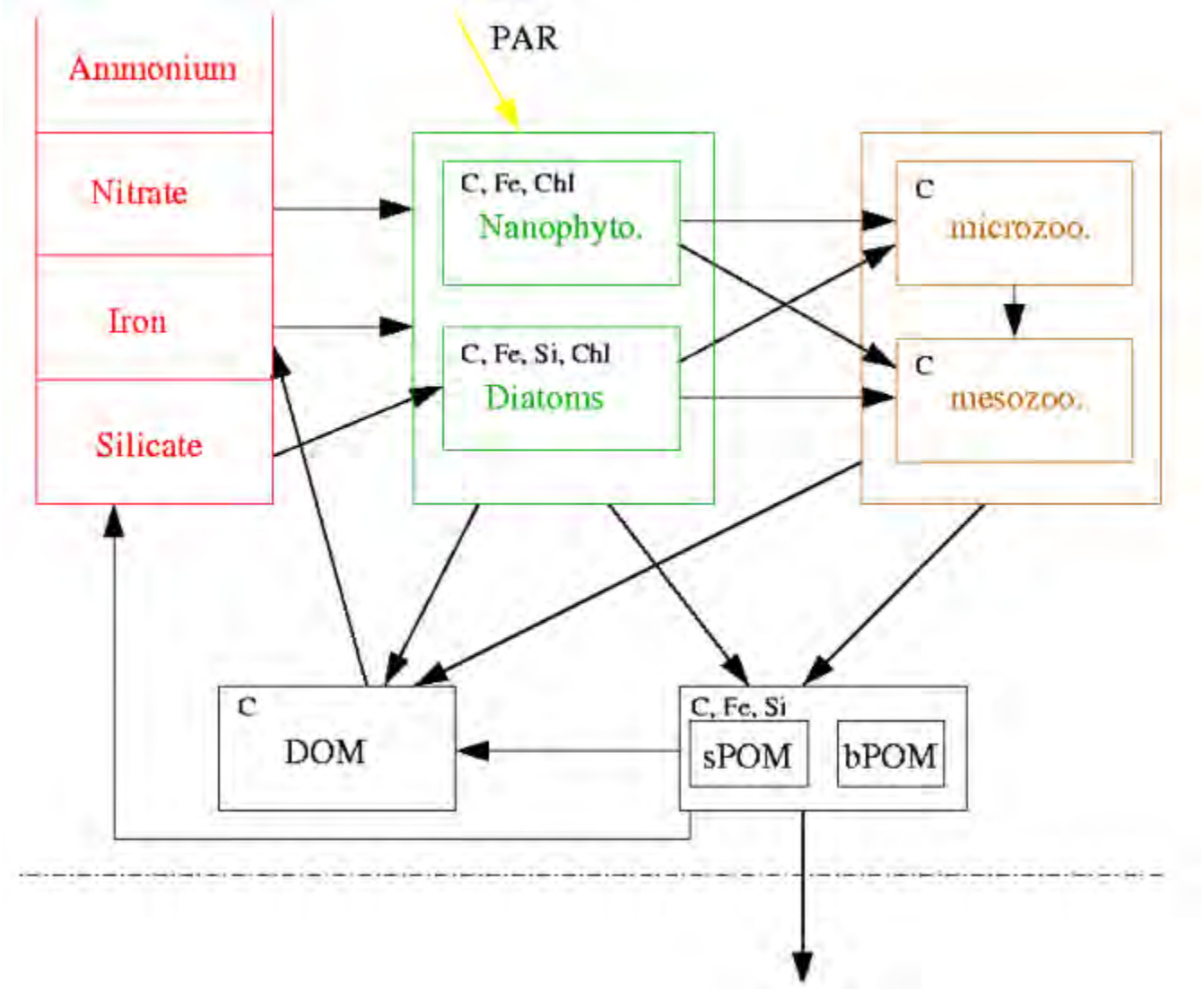
OCEAN VISIONS

oceanvisions.org/oceancdr


OceanBioME
buoyant flakes
Air-sea CO2 flux
physics: velocity, temperature, salinity
carbonate chemistry: DIC, Alkalinity, pH, pCO2
advection
drag
advection
exudates
biogeochemistry: nutrients, phytoplankton, zooplankton, etc.
'active' particles: e.g. buoyant flakes, kelp farm/forest
nutrients
sinking particles
sinking kelp
offshore kelp farm
giant kelp forest
benthic carbon flux
sediment model

What is PISCES?

- Tracks C, N, P, Si, Fe
- 24 Components
  - 4 living
    - 2 types of phytoplankton
    - 2 types of zooplankton
- Used to calibrate other biogeochemistry models

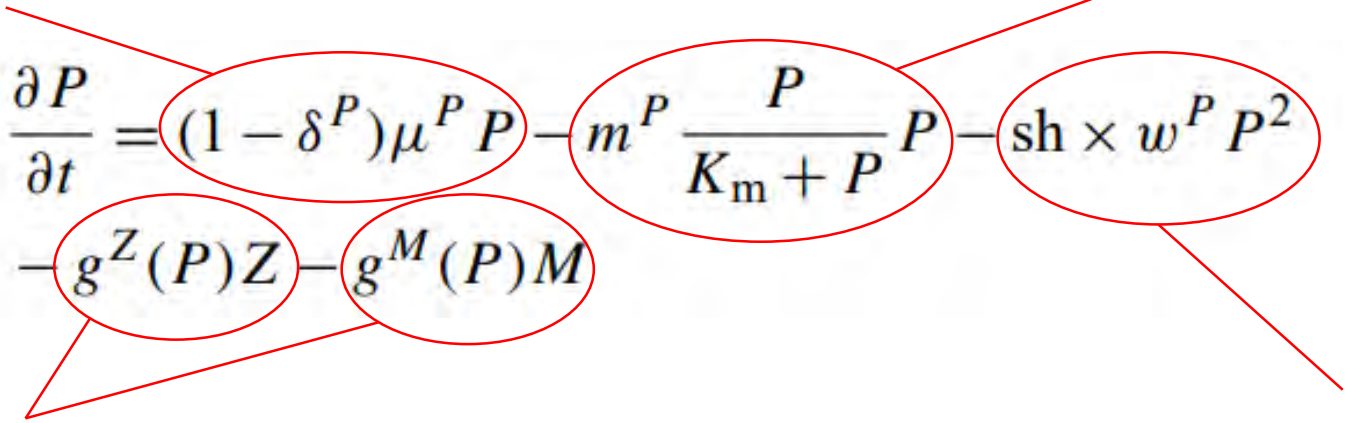


Aumont et al., (2015), PISCES v2

How does it work?

Growth rate

Linear Mortality

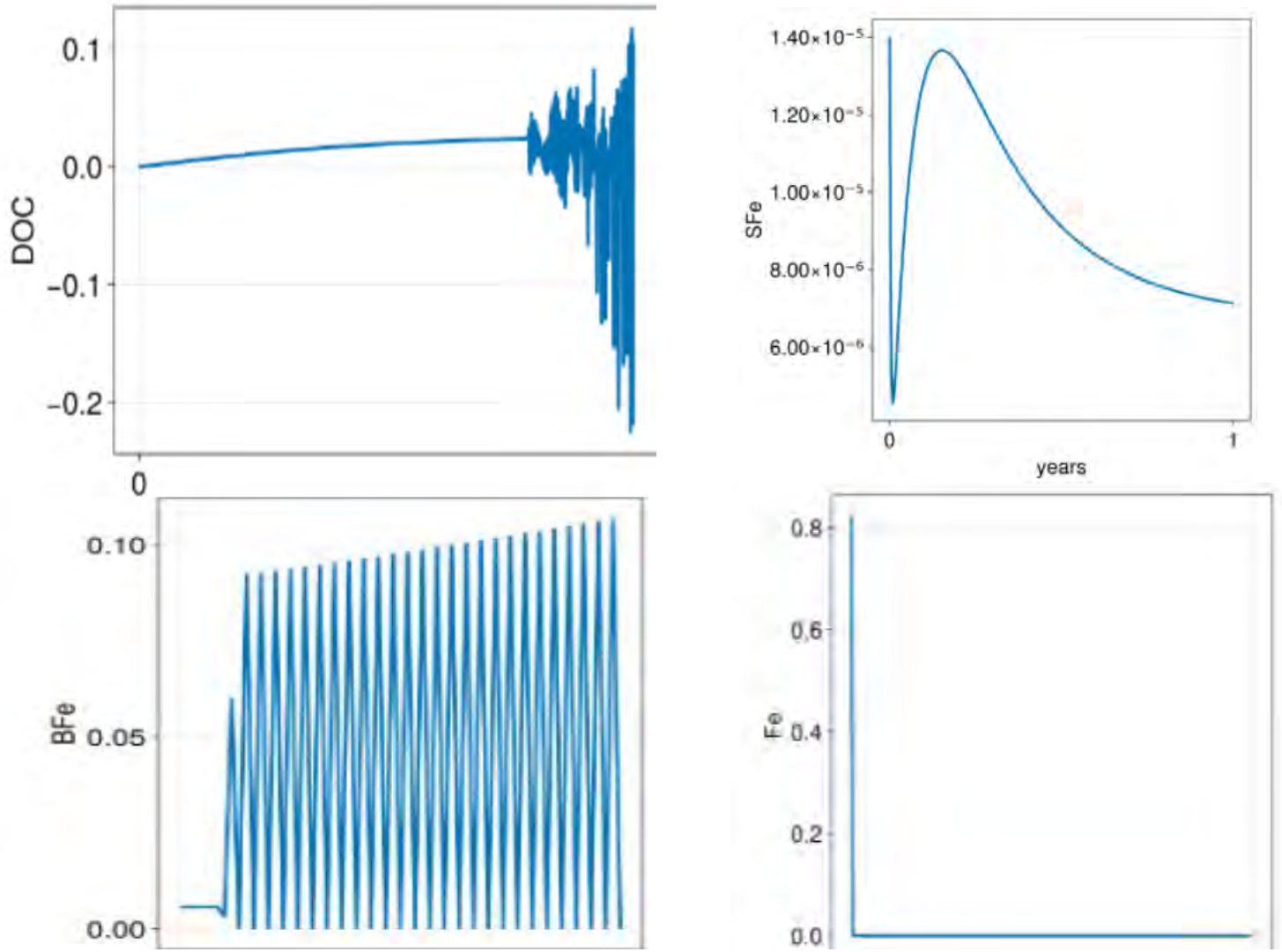


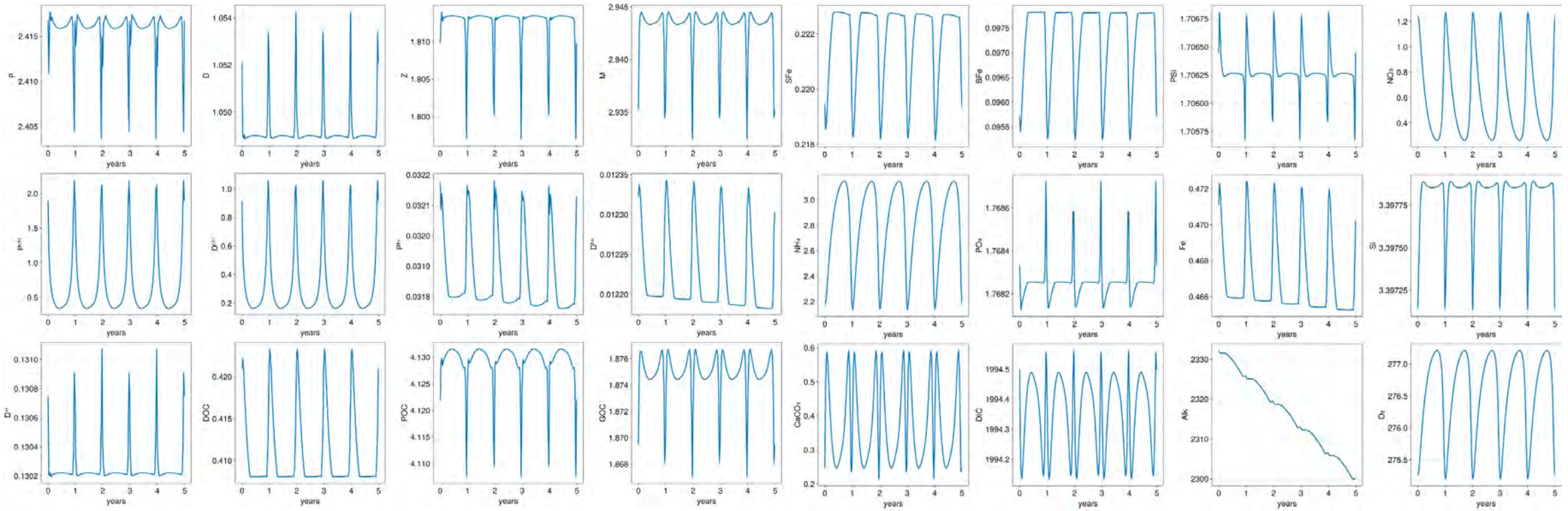
Grazing by zooplankton

Quadratic Mortality

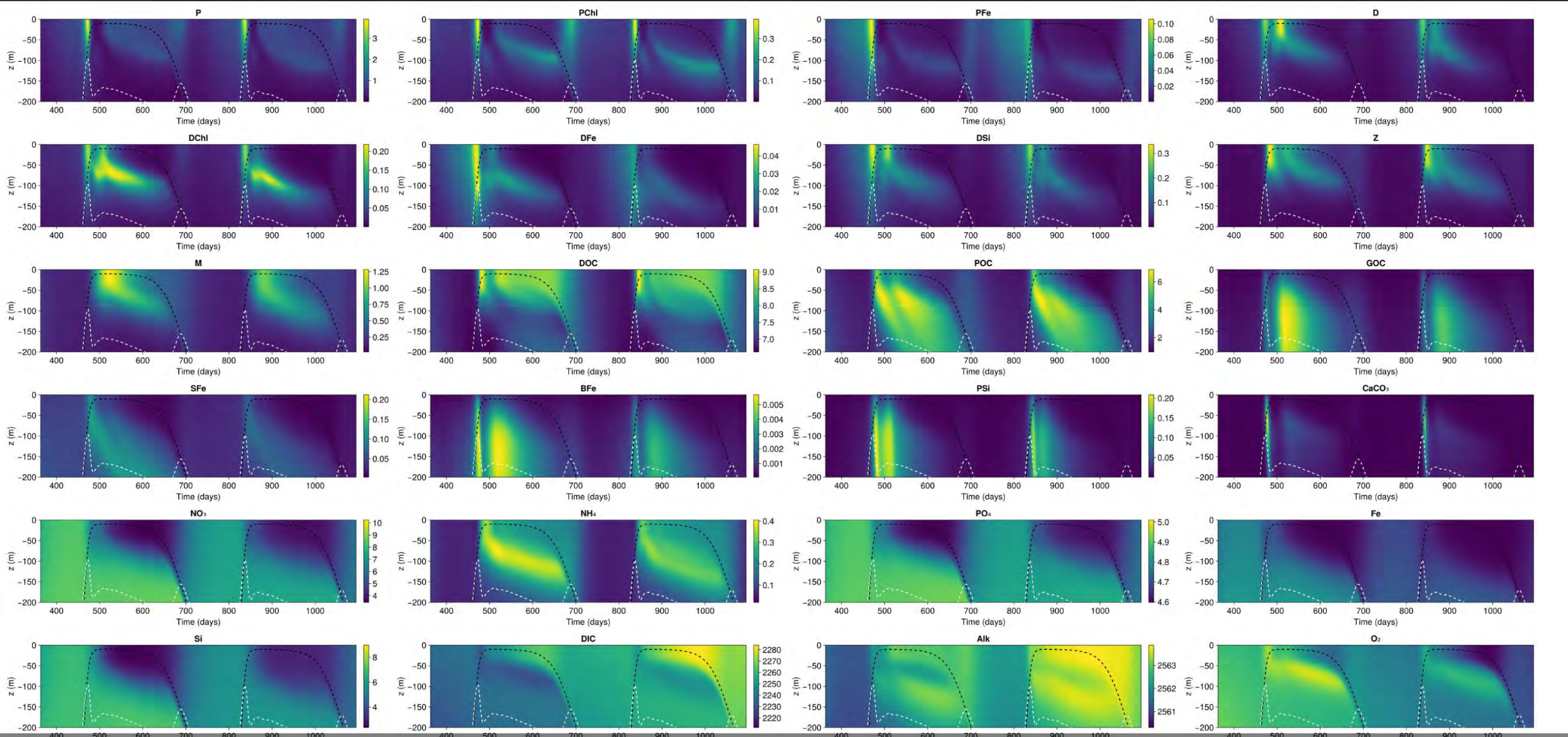
Implementation Challenges

- Instability caused by:
  - Zero Errors
  - Unit errors – some values too small to make sense
  - Paper Discrepancies

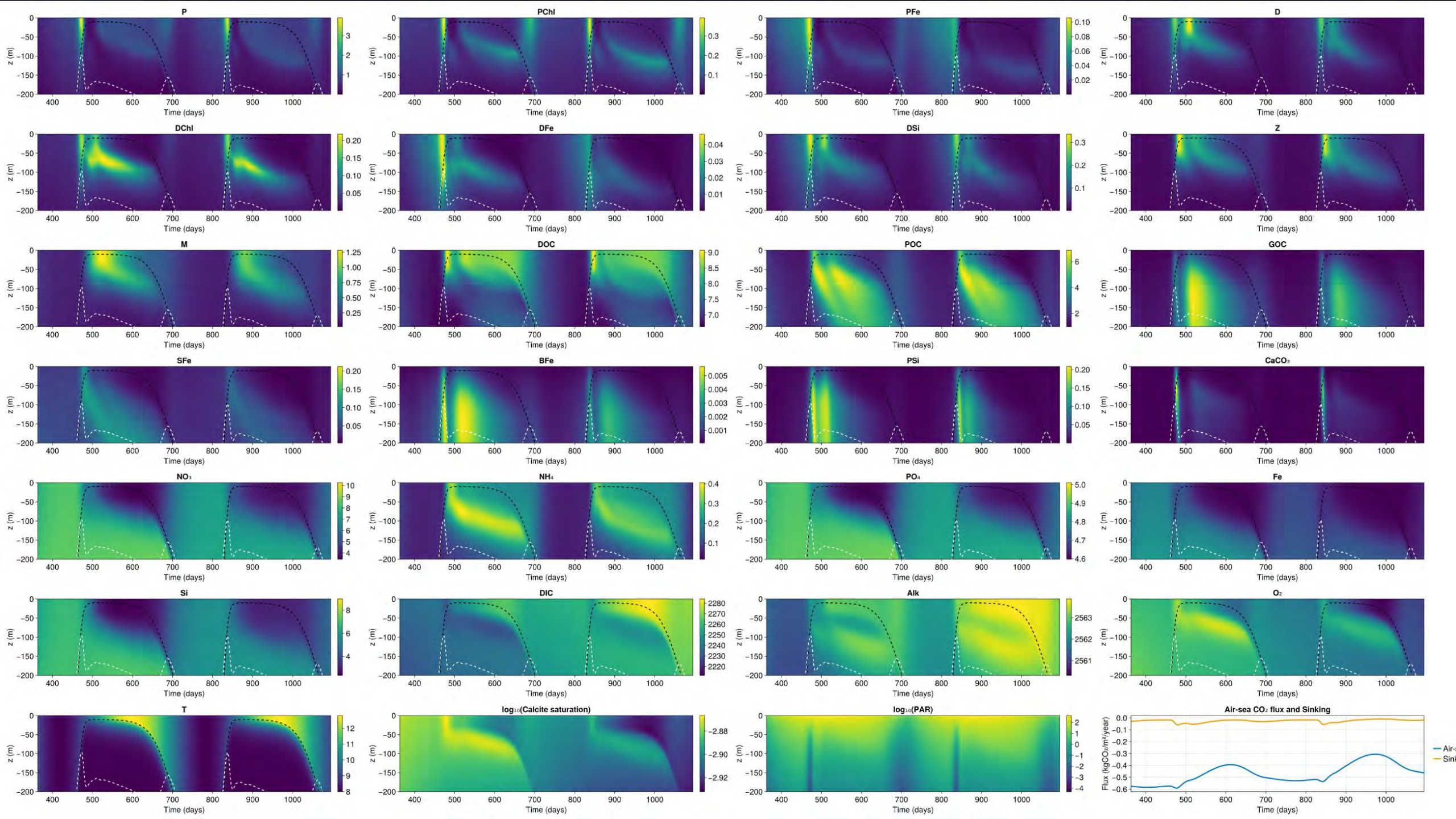


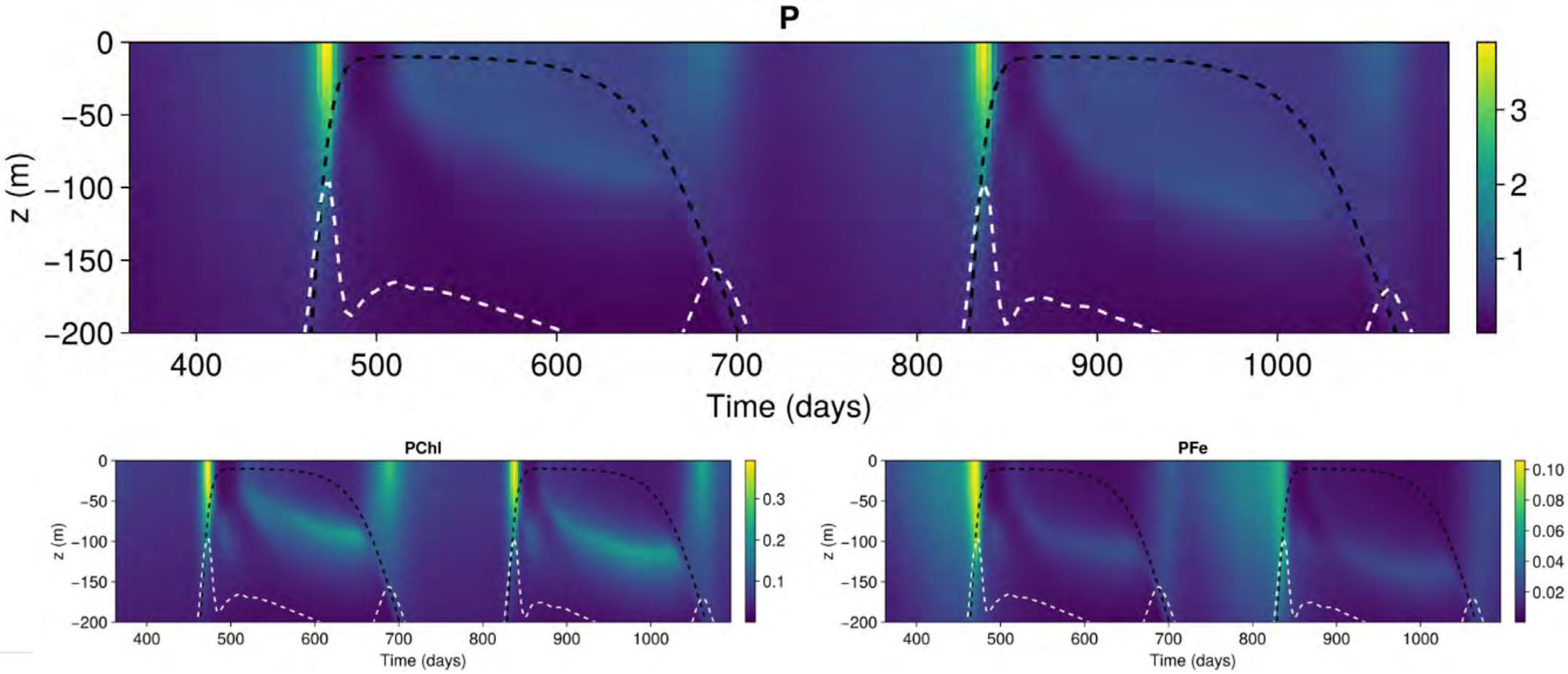


Results – Box Model



Results – Column Model


P
PChl
PFe
D
DChl
DFe
DSi
Z
M
DOC
POC
GOC
SFe
BFe
PSi
CaCO₃
NO₃
NH₄
PO₄
Fe
Si
DIC
Alk
O₂
T
log₁₀(Calcite saturation)
log₁₀(PAR)
Air-sea CO₂ flux and Sinking
z (m)
Time (days)
Flux (kgCO₂/m²/year)
Air-
Sink



Results – Phytoplankton

Next Steps

- Implementation with rest of OceanBioME
- Testing against existing models
- A new, open-source PISCES
- Use to evaluate OCDR strategies

References

- Strong-Wright et al., (2023), OceanBioME.jl: A flexible environment for modelling the coupled interactions between ocean biogeochemistry and physics
- Aumont et al., (2015), PISCES-v2: an ocean biogeochemical model for carbon and ecosystem studies