Preliminary results of biogeochemistry simulation with ACCESS-OM2 and plans for OMIP-BGC and IAMIP

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2019-09-03, The COSIMA annual workshop, ANU

Outline

- **OMIP (Ocean Model Intercomparison Project) and OMIP-BGC**
  - **History**
  - **Southern Ocean perspective**
  - **Our plans**
- IAMIP (Ice Algae Model Intercomparison Project)
  - Background
  - Summary of Phase 1
  - Our plans
- Preliminary results of a 500-year test run with ocean biogeochemistry

History of OMIP-BGC

- OCMIP (Ocean Carbon-Cycle Model Intercomparison Project)
  - Phase 1 (1995-1997): 4 model groups participated. Natural and anthropogenic CO2 and C-14.
  - Phase 2 (1998-2001): 13 model groups participated. All model groups used **the same** BGC model.
  - Phase 3 (2002-?): All model groups used **their own** BGC models.

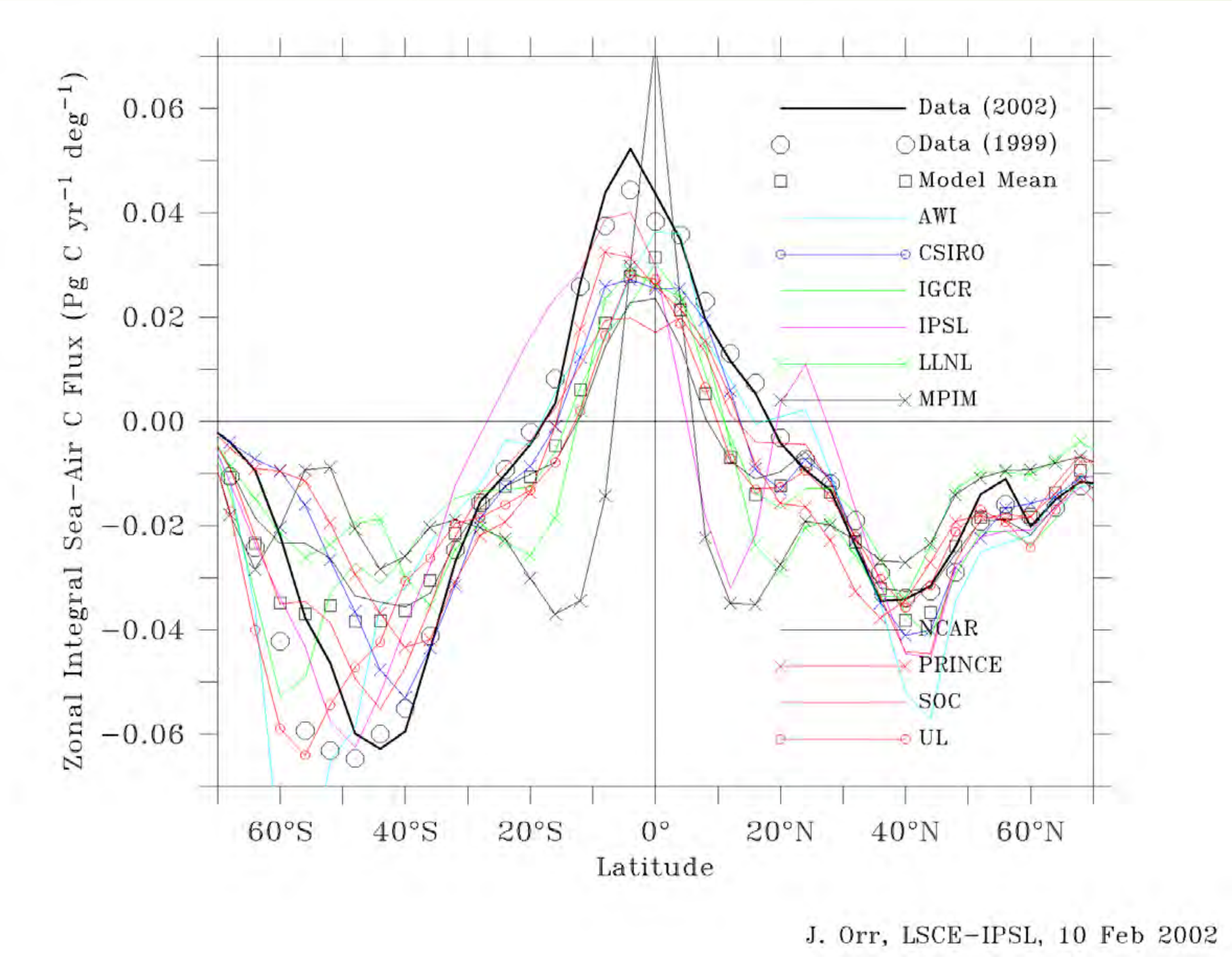
… a decade later …

- OMIP (2016-?): 21+ model groups participating. An endorsed MIP of CMIP6.
  - "OMIP-BGC aims to provide the technical foundation to assess trends, variability, and related uncertainties in ocean carbon and related biogeochemical variables since the onset of the industrial era and into the future" (Orr et al. 2017).

An example outcome of OCMIP Phase 2

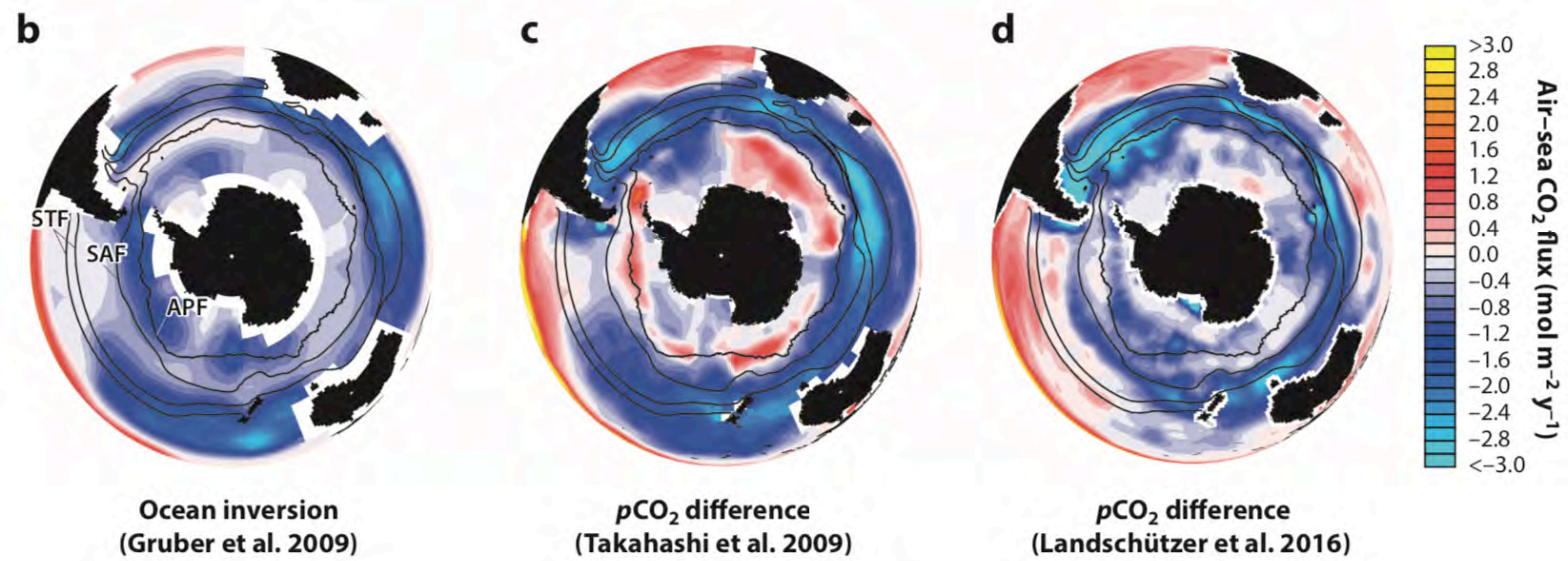
Southern Ocean is a key region of global carbon cycle because:

- Largest sink of atmospheric CO2.
- Largest source of uncertainty around the mean.



http://ocmip5.ipsl.jussieu.fr/OCMIP/talks/Liege_OCMIP_06may2002b.ppt

Observations differ too.



[Gruber et al. 2019]

Proposed contributions from ACCESS-OM2

- **Priority 1:** Experiment “omip2” (upper-ocean studies)
  - 366 years: 6 cycles of JRA55-do v1.4.0 (1958-2018)
  - Initial conditions:
    - Climatologies (WOA13v2* for T, S, oxygen, and nitrate; GLODAPv2 for dic and alk).
    - No specific protocol (detritus and iron)
    - At rest (zero velocity)
    - Sea-ice fields taken from another simulation (?)
    - SSS is restored to a monthly climatology (no specific restoring timescale).
- **Priority 2:** Experiment “omip2-spunup” (deep-ocean studies)
  - Same as omip2 except that the model is initialized from the end state of a 2000-year spin-up run (or something similar).

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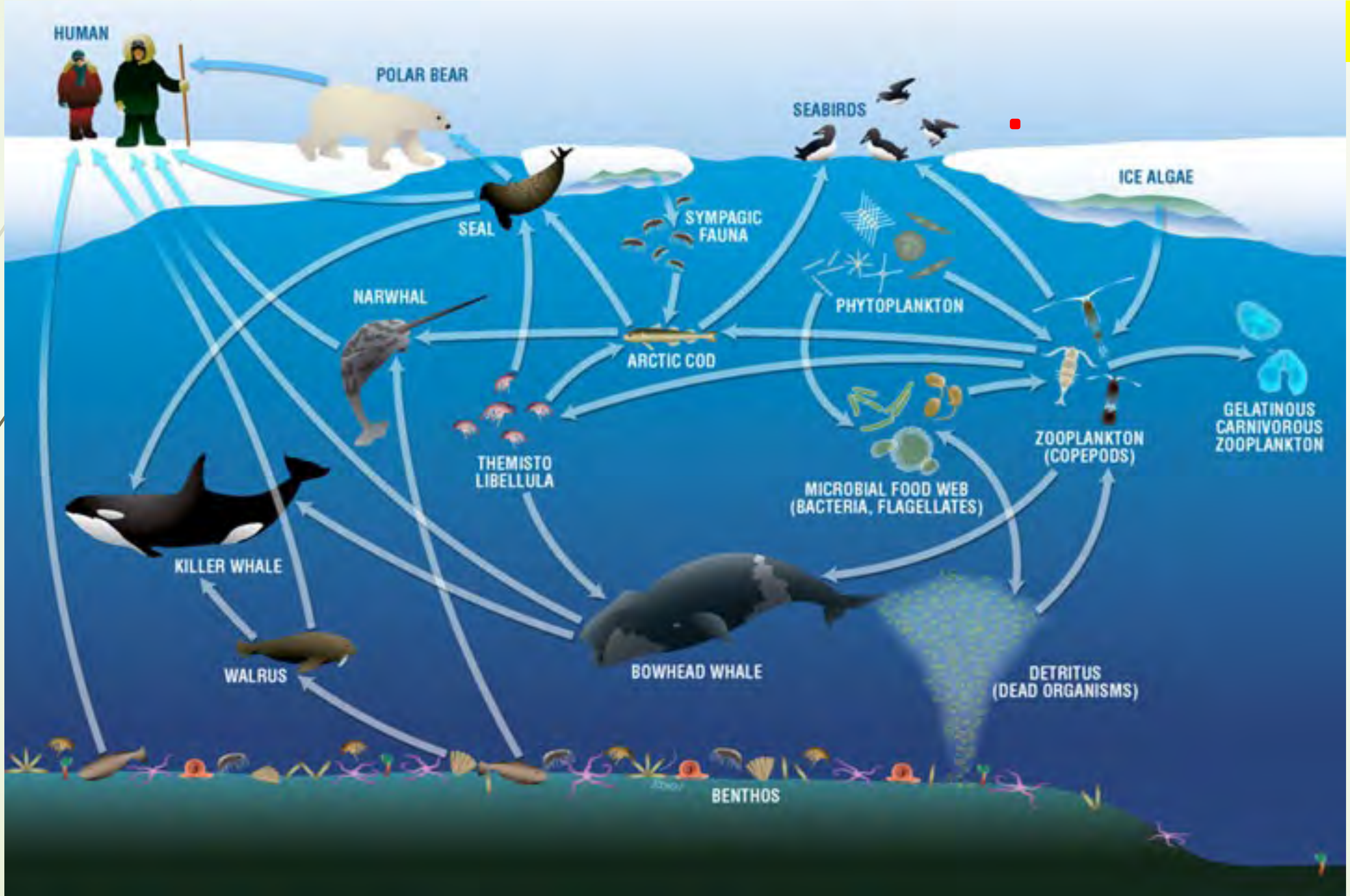
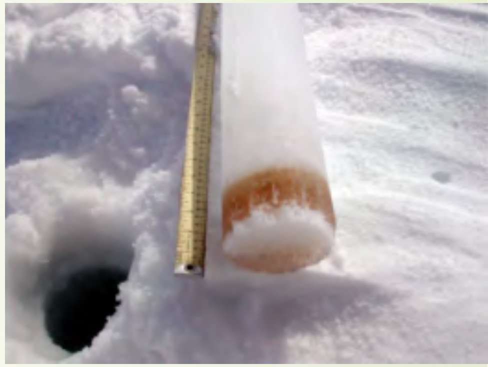
Ice algae: the base of Arctic marine food web

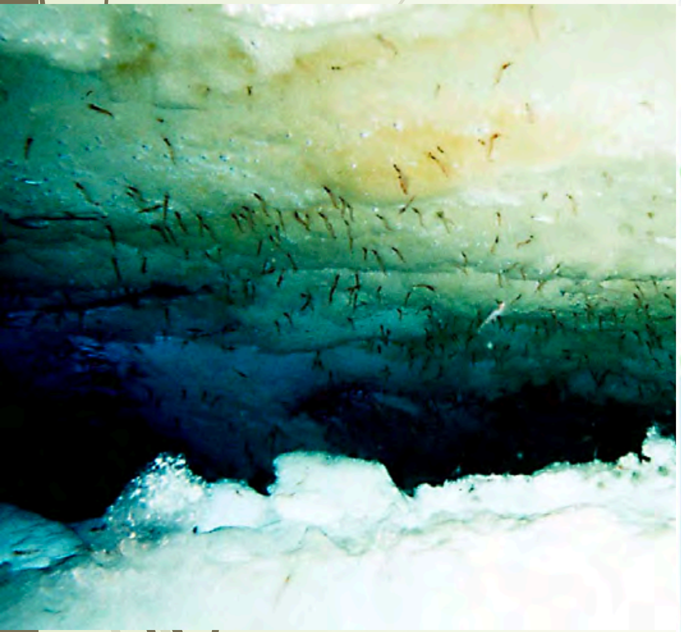


Bottom-up control



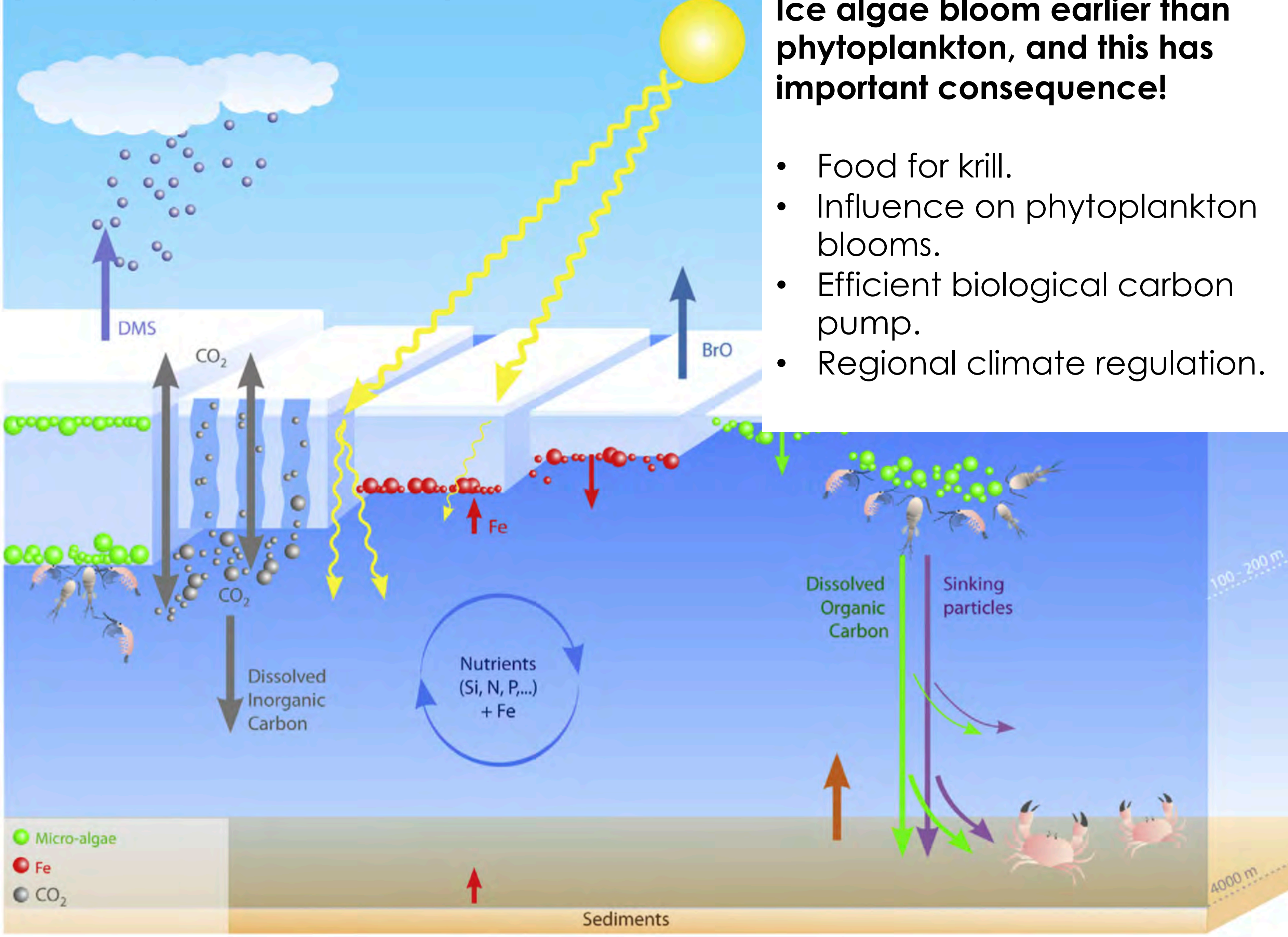
[arctic.noaa.gov]

[Darnis et al., 2012]



https://upload.wikimedia.org/wikipedia/commons/9/94/Krillicekils.jpg

[Vancoppenolle et al. 2013]



Ice algae bloom earlier than phytoplankton, and this has important consequence!

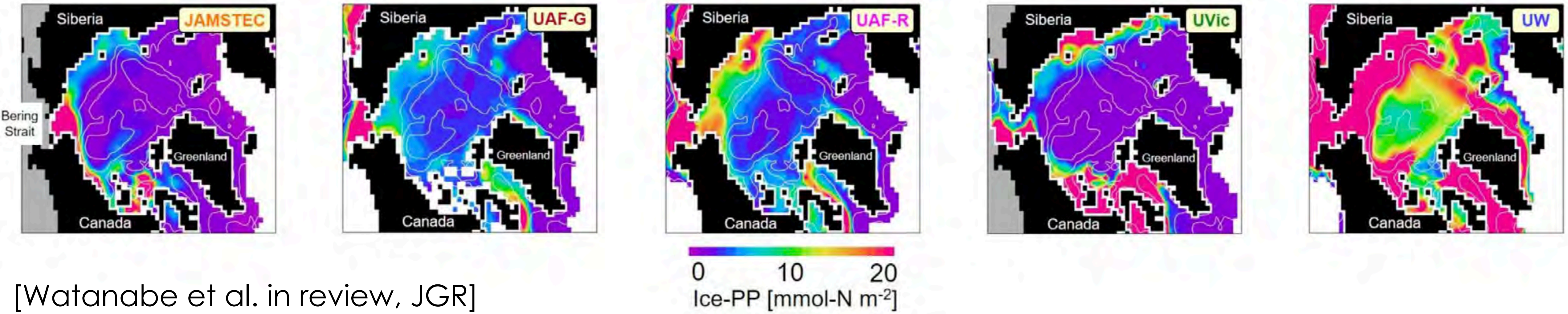
- Food for krill.
- Influence on phytoplankton blooms.
- Efficient biological carbon pump.
- Regional climate regulation.

Southern Ocean perspective

- Ice algal production can contribute up to **35 %** of the overall primary production in ice-covered waters in the Southern Ocean (Lizotte 2001).
  - Implications for ocean carbon uptake.
- During the ice melt period, iron input from sea ice may represent up to **70 %** of the total daily input to the East Antarctic surface waters (Lannuzel et al. 2007).
  - Iron from sea ice as a fertilizer for the iron-limited Southern Ocean ecosystems.

Ice Algae MIP (Phase 1)

- Watanabe et al. (in review, JGR)
- 5 models participated (1 global, 4 pan-Arctic regional).
- Analysis for the **Arctic** over the satellite era (1980-2009).
- Despite the Arctic sea-ice retreat, the models showed **no trends**.
- The large inter-model spread of ice algal production (Fig. below) **may be** due to the uncertainty in the maximum ice algal growth rate (parameter).



[Watanabe et al. in review, JGR]

Plans for Phase 2 (2019-2021)

- Participating countries (organizations): Australia (COSIMA), Canada (CCCma, UVic), Japan (JAMSTEC), and potentially France (IPSL).
- Aims to assess:
  - Systematic bias. → Follow the OMIP protocols.
  - Longer-term trend. → ScenarioMIP?
  - Model parameter uncertainty. → Perturbation experiments.
  - Antarctic ice algal production. → More participation of global models.
  - Impacts of model spatial resolution → ACCESS-OM2!

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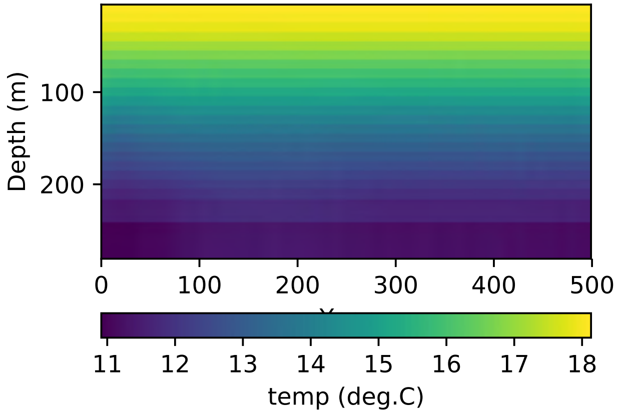
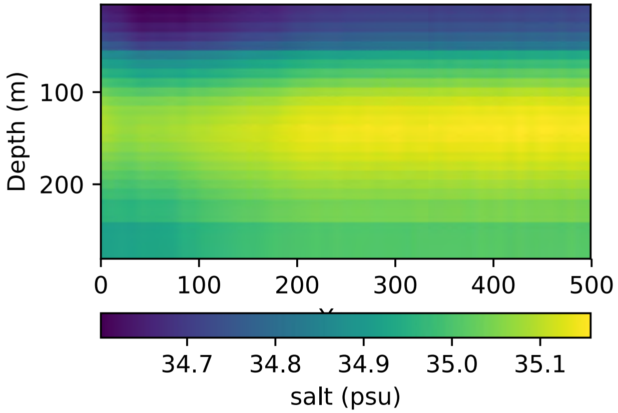
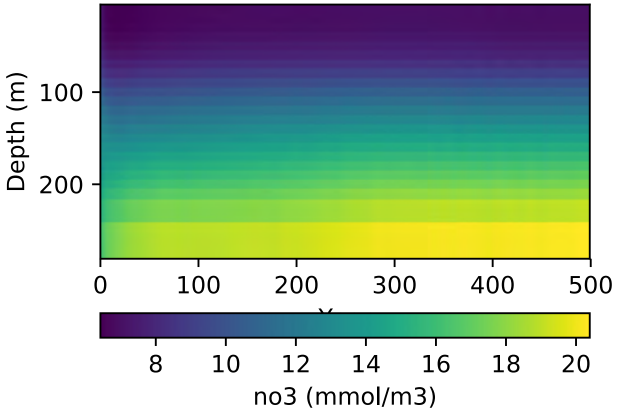
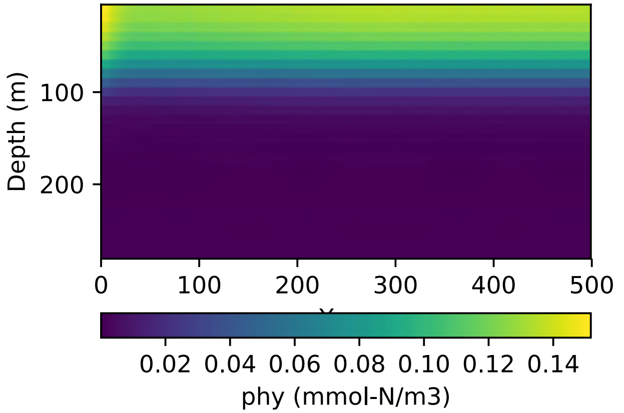
Experimental set-up (ACCESS-OM2-1deg-JRA55-RYF)

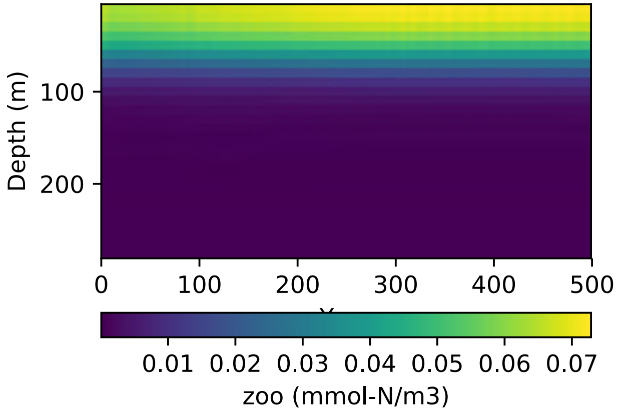
- A 1-degree global configuration (ACCESS-OM2) forced with JRA55-do for 1990-1991 repeatedly (no interannual variability).
- Duration: 500 years (> the duration of "omip2").
- Initial conditions: End of a control run of ACCESS-ESM.
- WOMBAT: ocean biogeochemistry model component
  - NPZD model (Nutrient-Phytoplankton-Zooplankton-Detritus)
  - Iron, oxygen, alkalinity, calcium carbonate, dissolved inorganic carbon (natural & natural + anthropogenic)
- Goals:
  - Test
  - Do the BGC tracers reach quasi-steady states in the upper ocean?





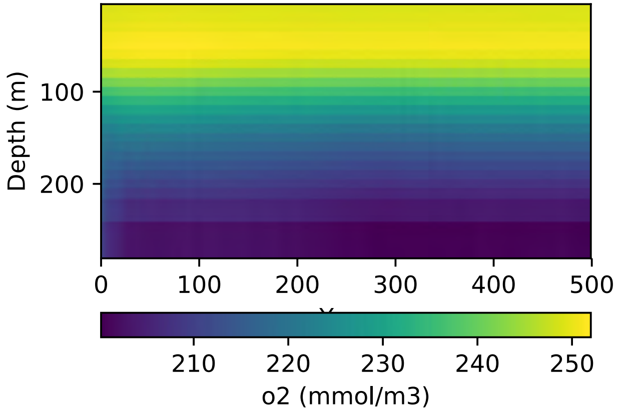


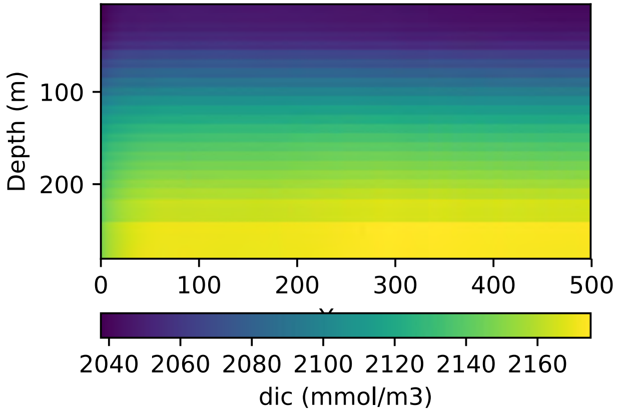




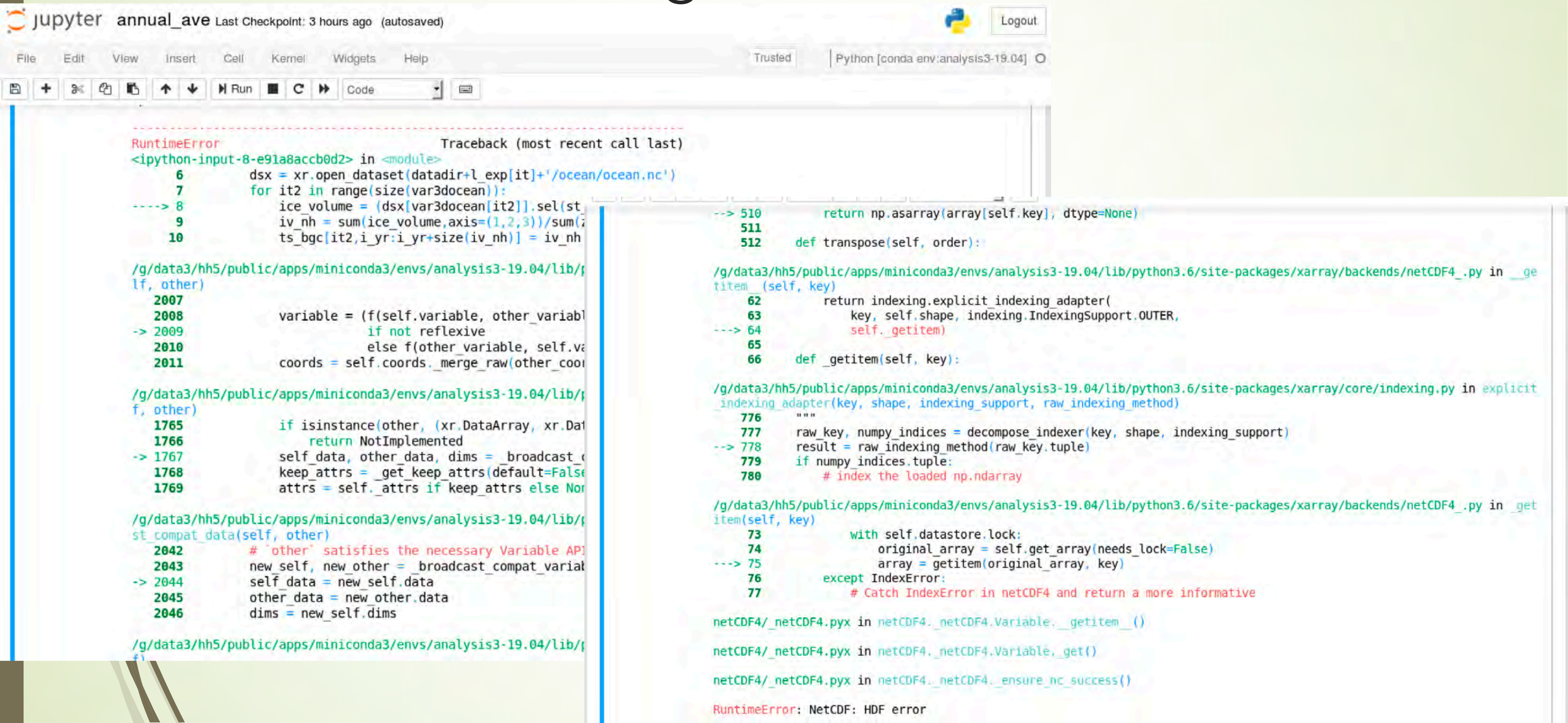
Time series of globally-averaged annual-mean vertical profiles

- Most physical and BGC tracers reach quasi-steady states in the upper 300 m within 500 years.
- The upper 100 m is most relevant for biology.





Have you had random errors like this on VDI using dask.distributed ?



Conclusions and next steps

- ACCESS-OM2 is going to make important contributions to the ocean and sea-ice BGC modelling community with a focus on the Southern Ocean.
- Preparation for OMIP-BGC
  - Spin-up strategies for omip2-spunup (e.g. Chamberlain et al. 2019).
- Preparation for Ice Algae MIP
  - Technical details to be finalized after the 1st meeting in October.
  - Establish ice-ocean coupling of biogeochemistry for ACCESS-OM2.
- **Welcome new ideas, contributions, and collaboration!**