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Long time-series of export fluxes in the western Ross Sea (Antarctica)

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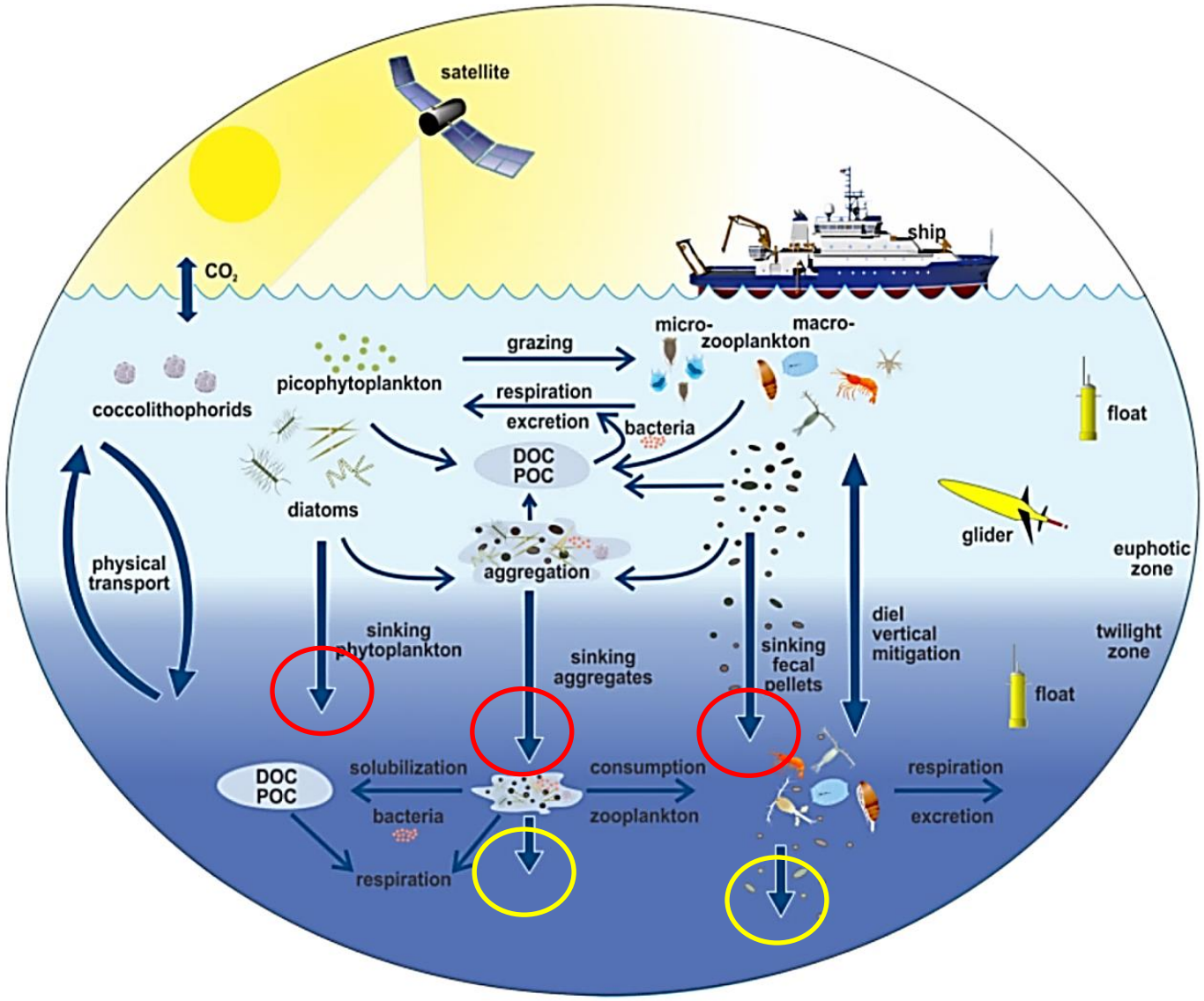
Why measuring particulate organic carbon fluxes?

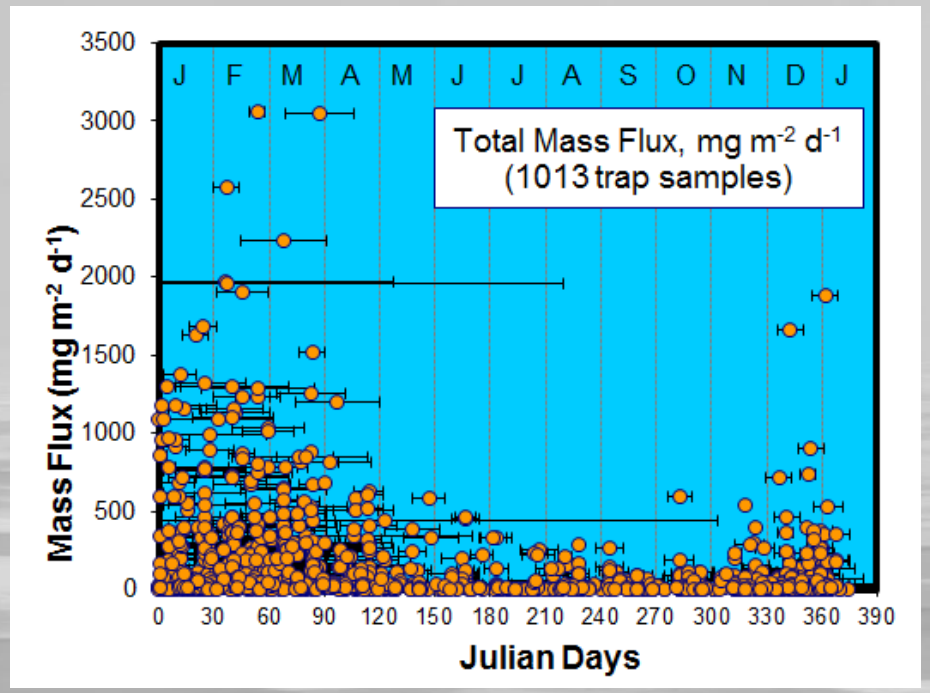


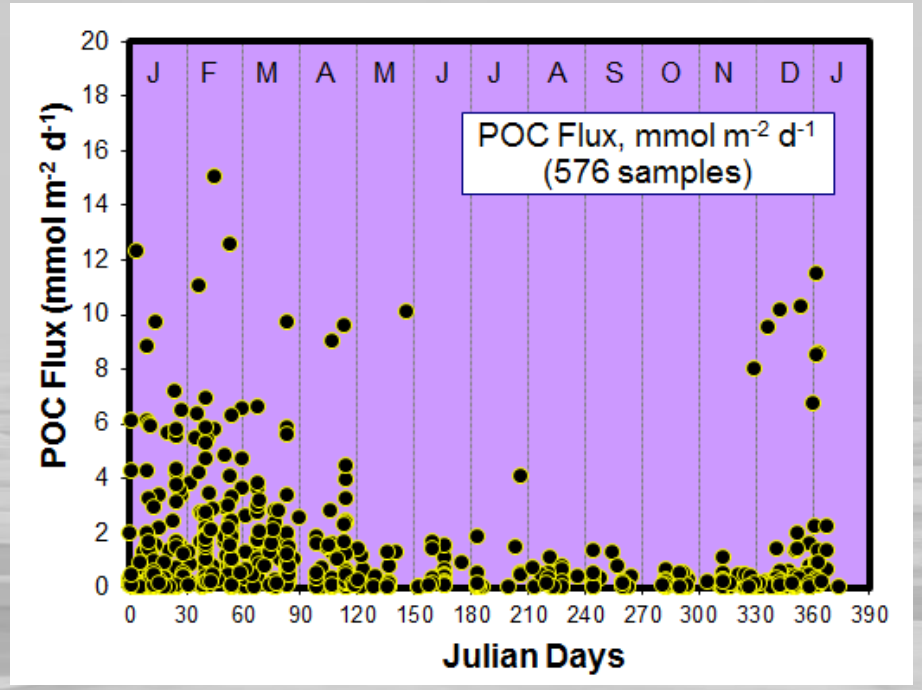
- ✓ The export of particulate organic carbon (POC) from the sea surface is an essential part of the biological pump
- ✓ The biological pump contributes in regulating the global climate
- ✓ Export fluxes are the result of what is produced in surface water and how much is consumed during particle sinking in the water column and then accumulating on the seafloor.
- ✓ Deep ocean and sediment burial retain CO_2 for a relatively long period (decadal to millennial)

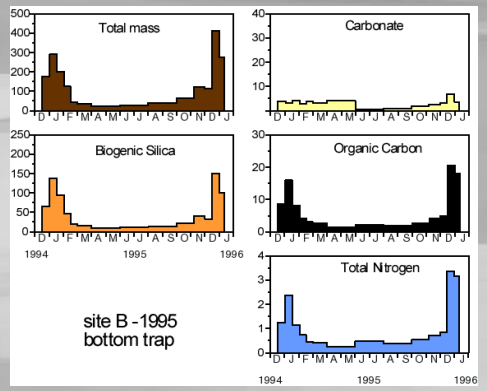
Compilation of all data available (new and published) of vertical particle fluxes obtained by automatic sediment traps tethered to 23 moorings deployed between 1991-2017 in the western Ross Sea (Antarctica)

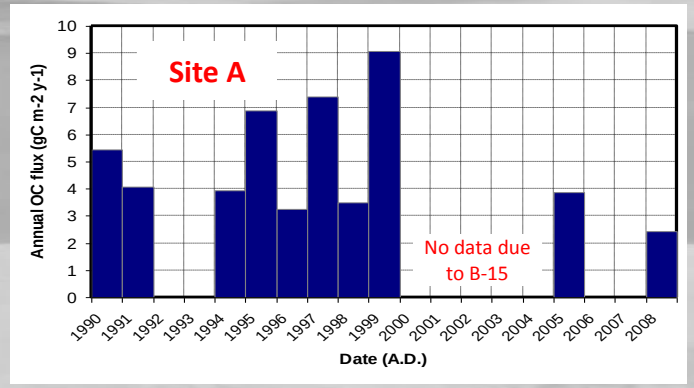
Flux Summary (1/2)

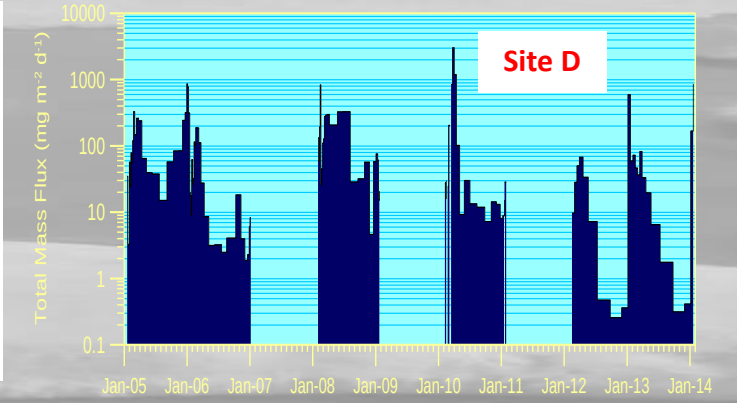
- High **seasonal** variability of POC fluxes with peaks in late summer-fall delayed of ca. 2 months from primary production blooms
- High **interannual** variability
- Organic carbon (OC) fluxes vary by a factor of 3 in SW Ross Sea (site A), and by a 6 factor in the Terra Nova polynya (site D)

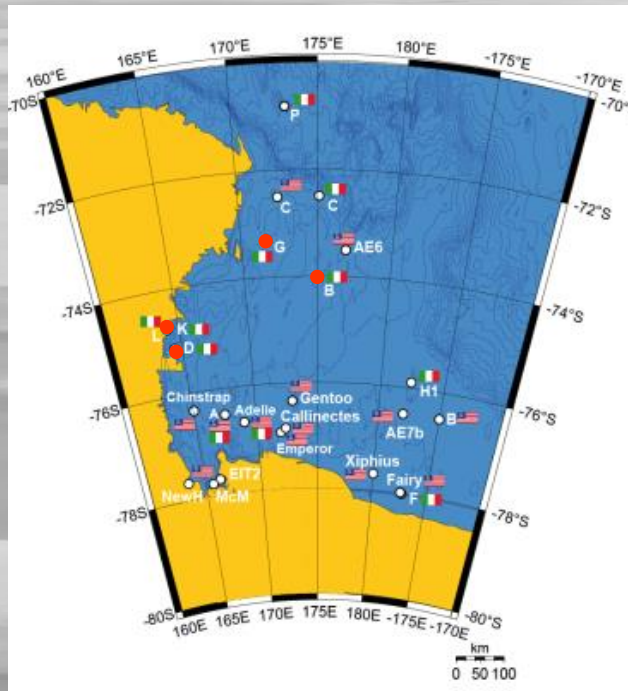






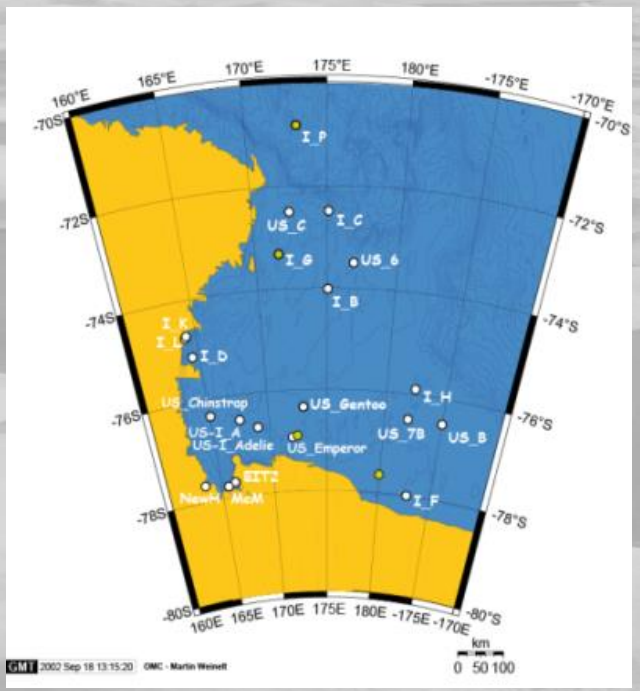


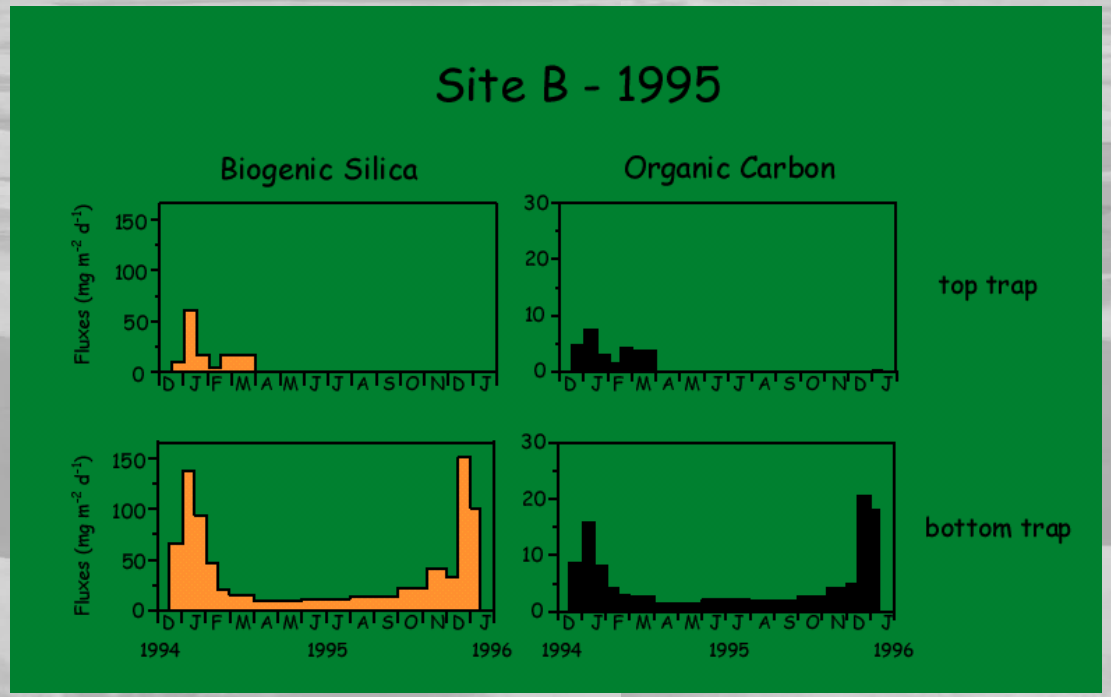




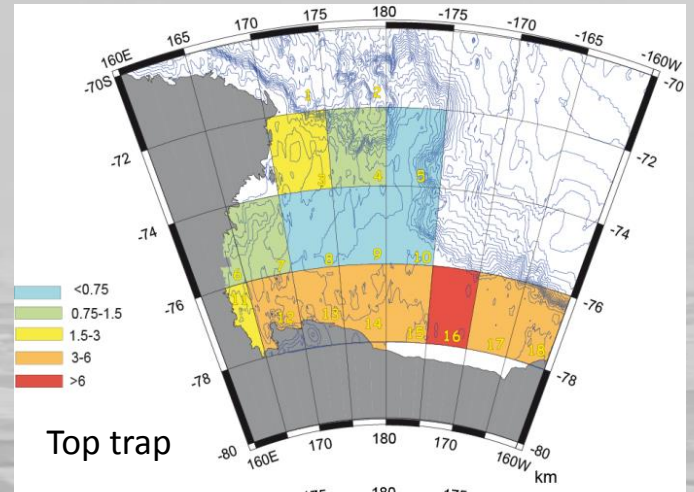
Flux Summary (2/2)

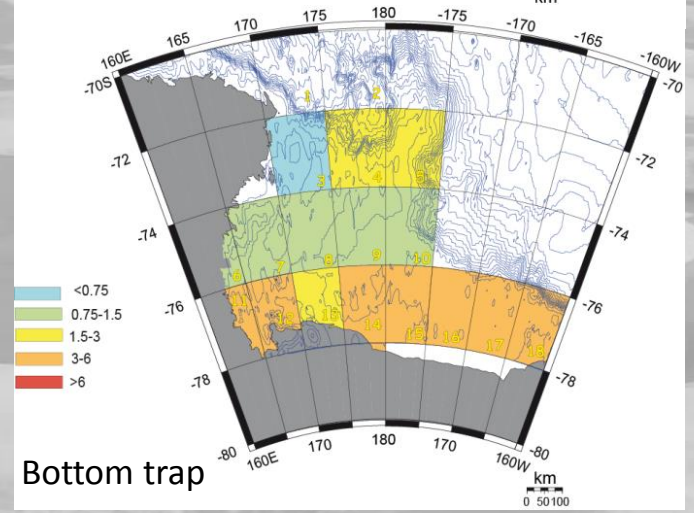
- Total mass fluxes (TMF) higher in bottom traps → **Lateral advection** in near-bottom
- **Spatial gradients** (decreasing from South-North and coast-to-open ocean)





Langone et al., 2000

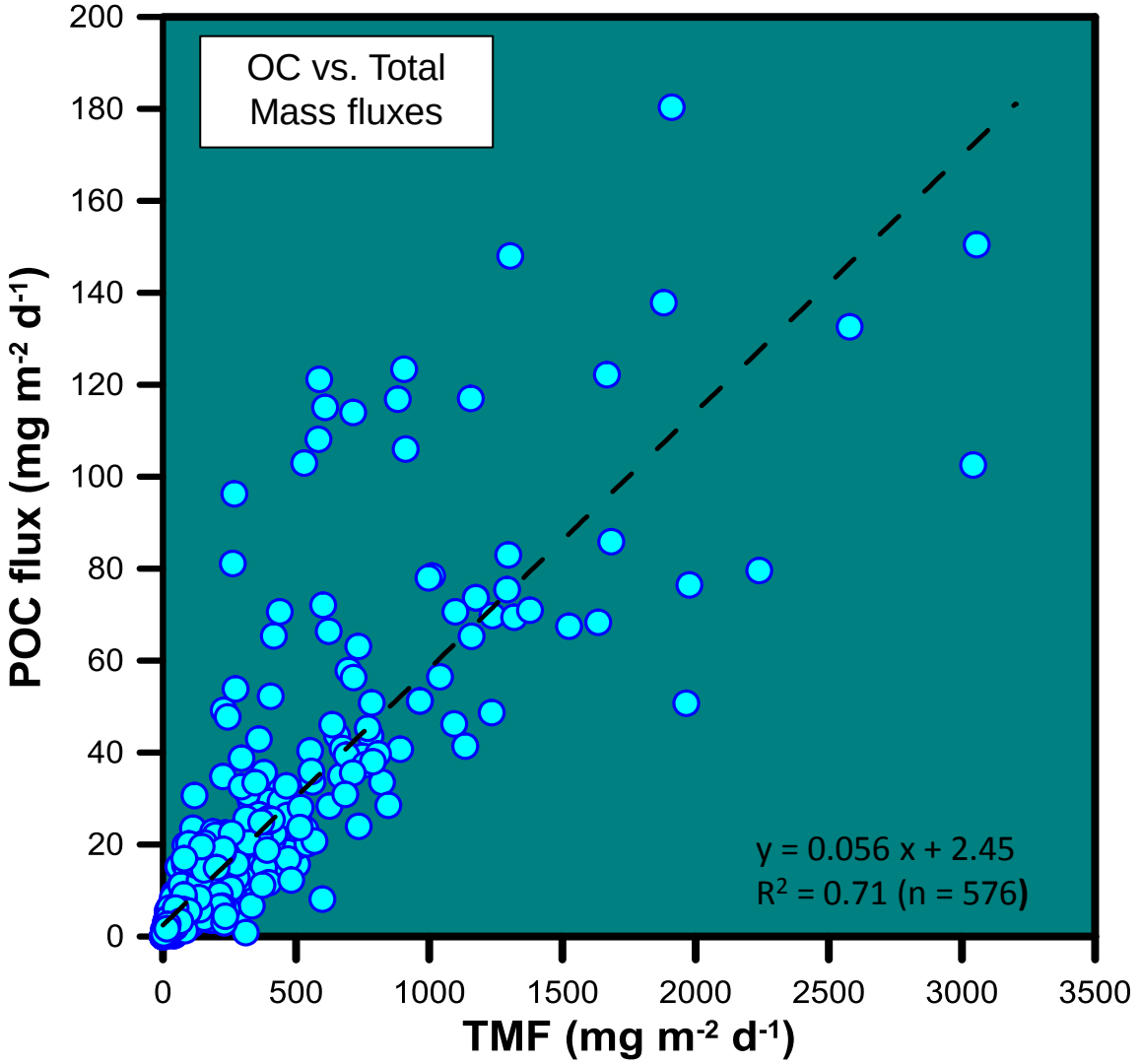


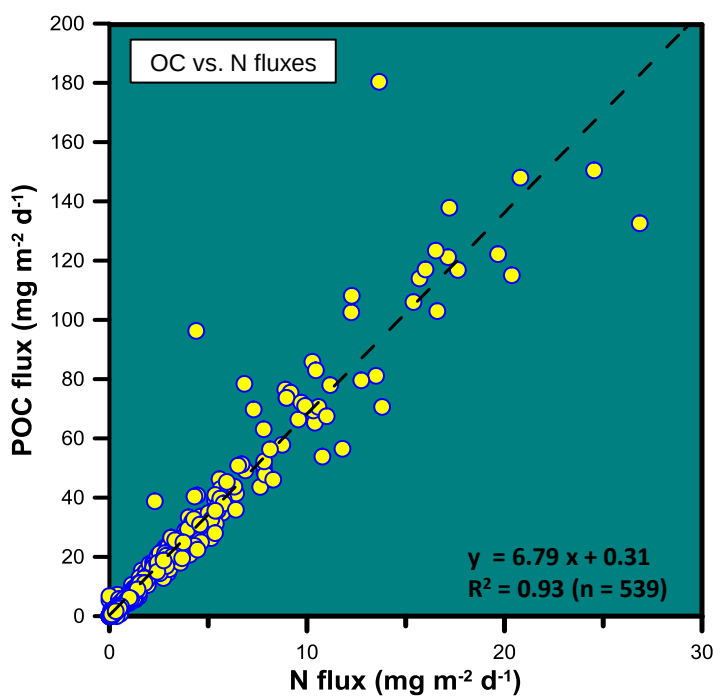


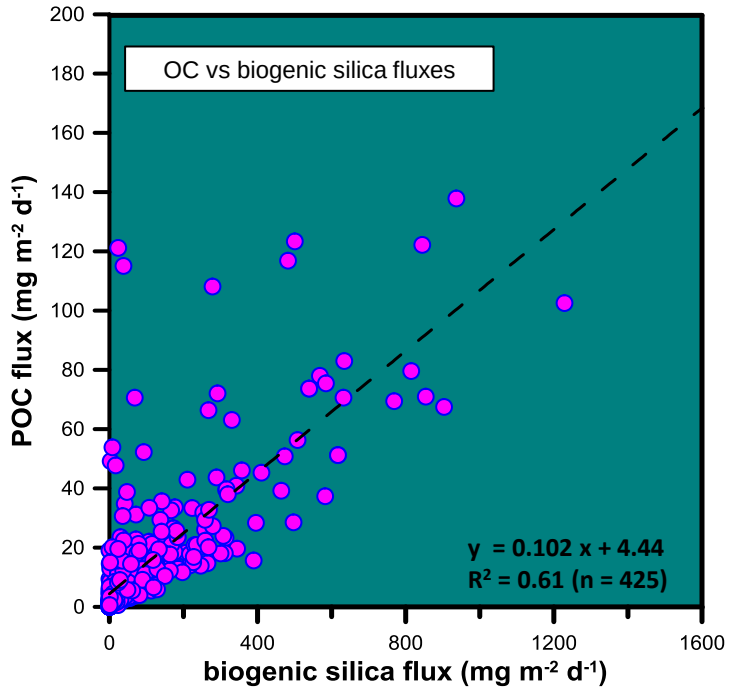
Trap data compilation from Catalano et al., 2010

Elemental composition

- OC vs. N fluxes well correlated
- Good correlation between OC and TMF → **particle fluxes dominated by biogenic debris**
- OC vs. biogenic silica fluxes correlated → **high diatom preservation with respect to other phytoplankton**

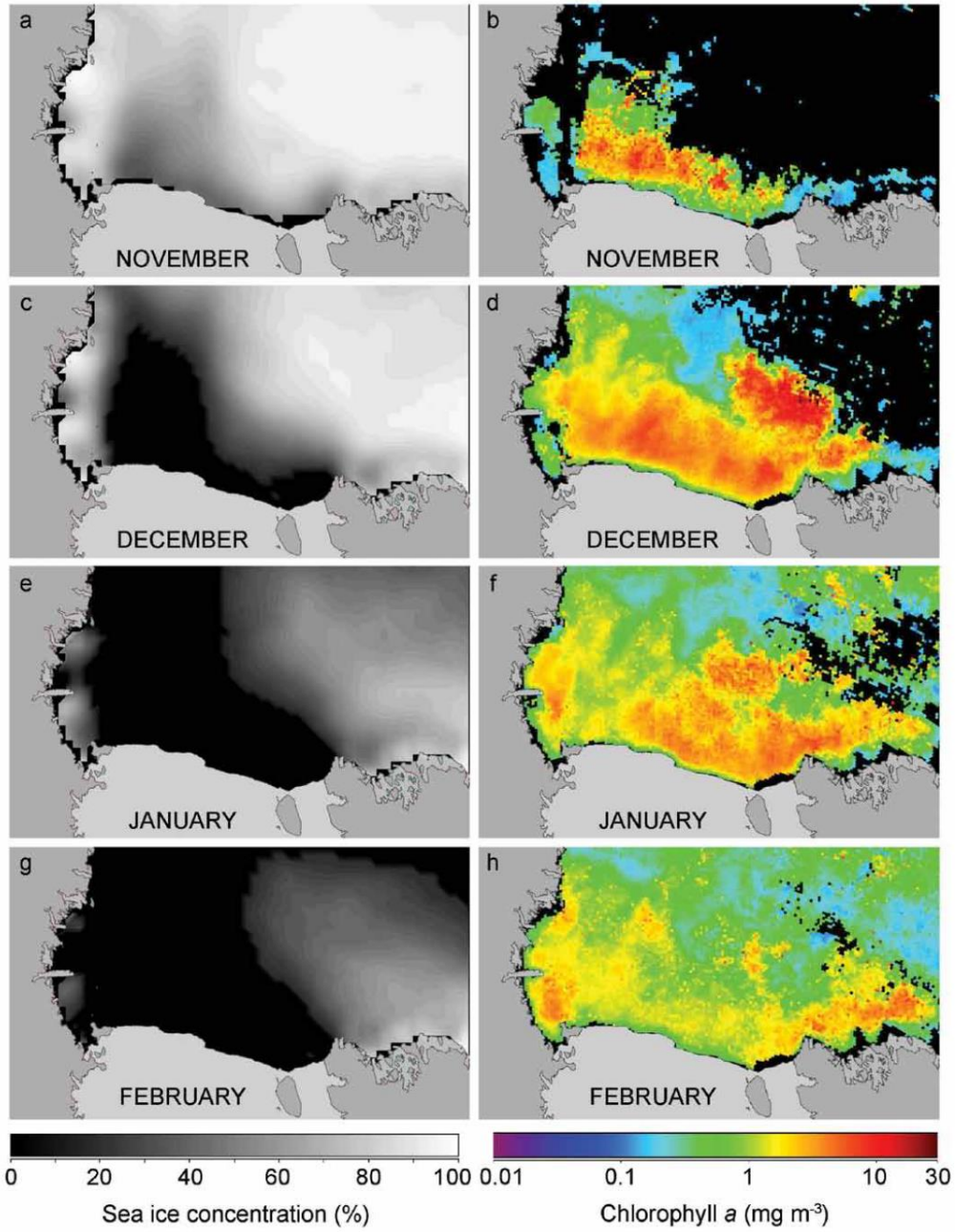






From previous studies in the Ross Sea, **seasonal** variability of particle fluxes and the timing of peaks may depend on:

- Primary production
- Grazing rate
- Autumn convective mixing
- Late-summer algal blooms



(*Data from the SeaWifS and Modis satellites during 1997–2011 (Smith et al., 2012, Oceanography 25: 90-103*

BUT, what about the **interannual** flux variability or **long-term trends** and in case, which are the main factors controlling them?

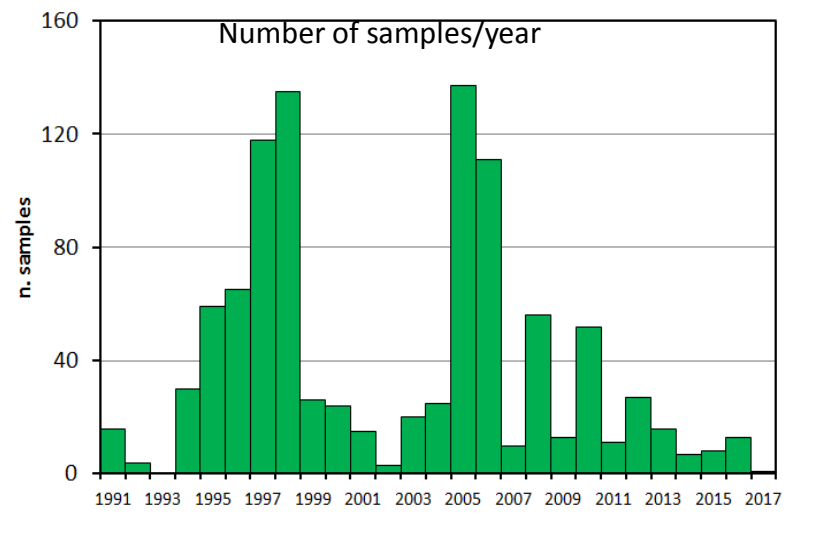
Changes in:

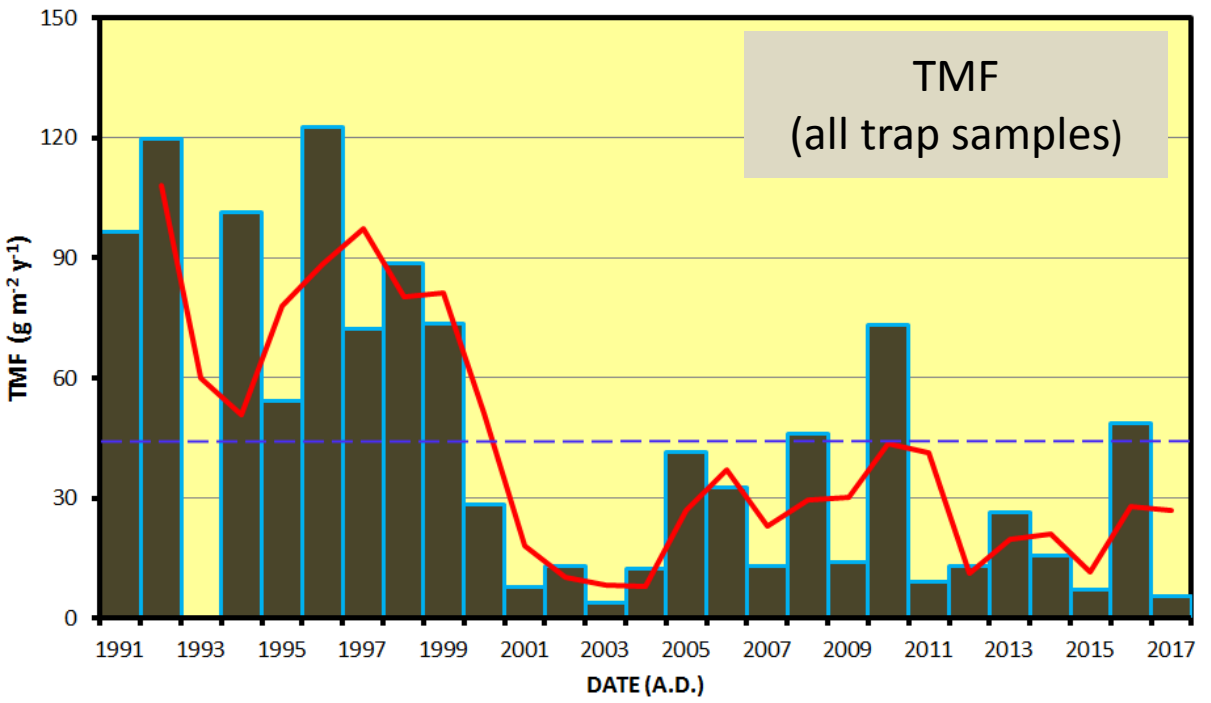
- ✓ Biological production
- ✓ OM consumption
- ✓ other processes (e.g., lateral transfer of biogenic particles in/out the Ross sea)

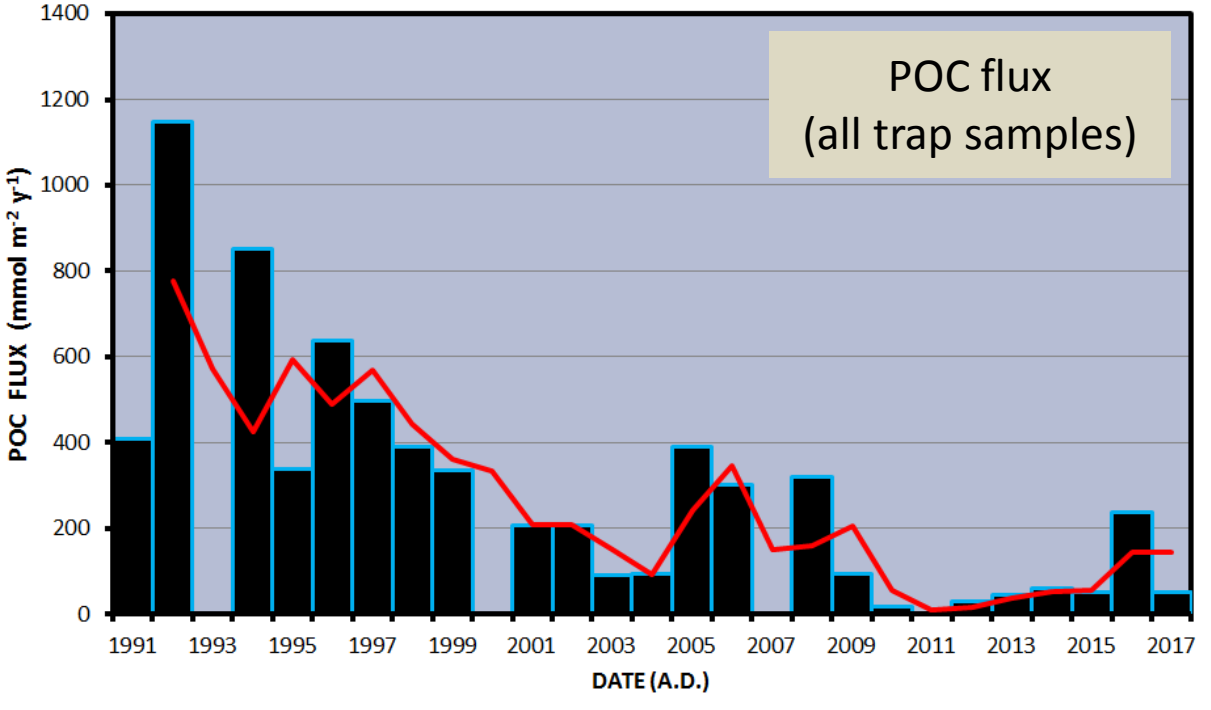
Interannual variability and long-term trend

- ✓ Large interannual variability of TMF (3.8-122.6 g m^{-2} y^{-1}) and POC fluxes (17-1147 mmol m^{-2} y^{-1})
- ✓ Negative shift of TMF and POC fluxes after 2000
- ✓ Reduced export fluxes between 2001-2004 (B15 & C19 icebergs)

Are particle fluxes decreasing in 21st century?

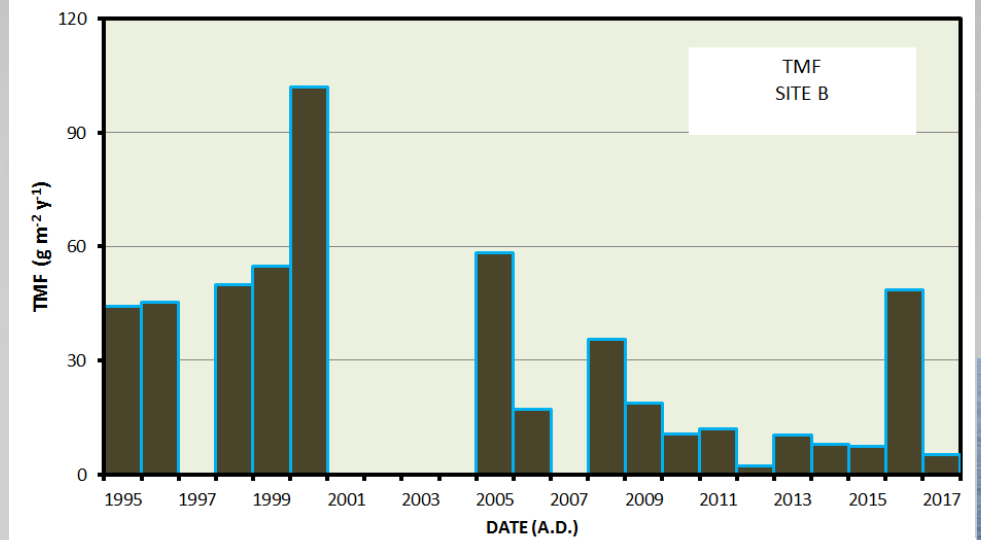


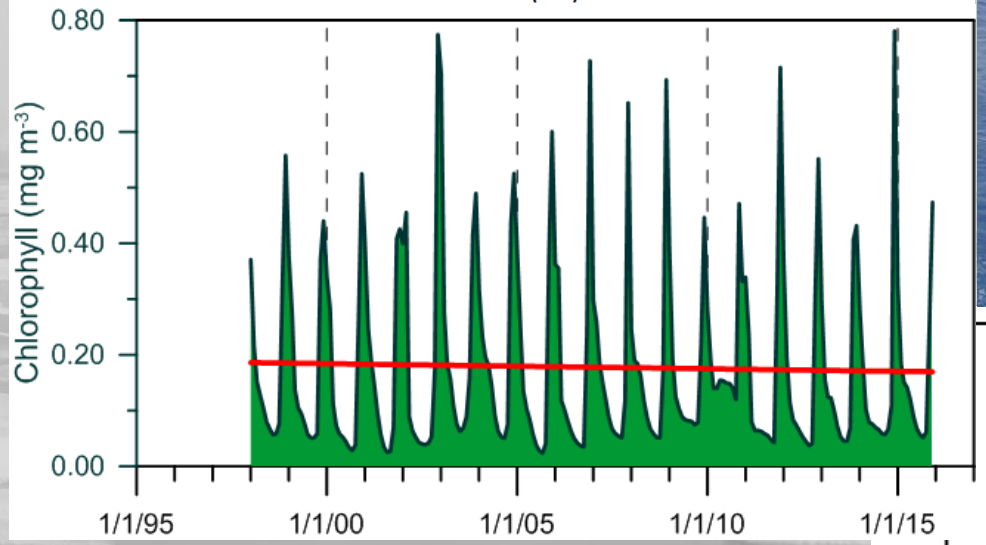


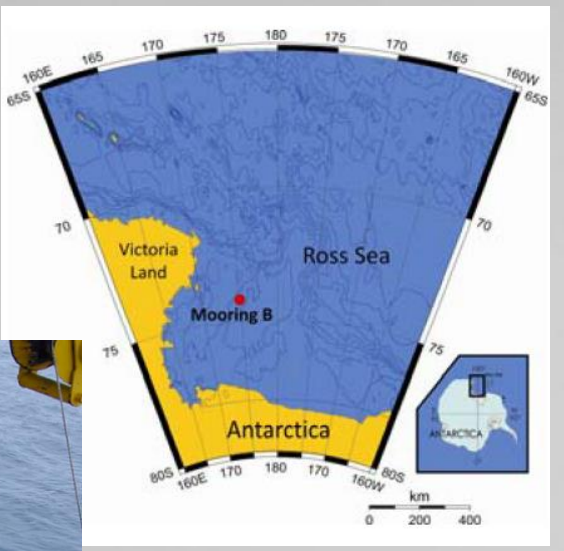


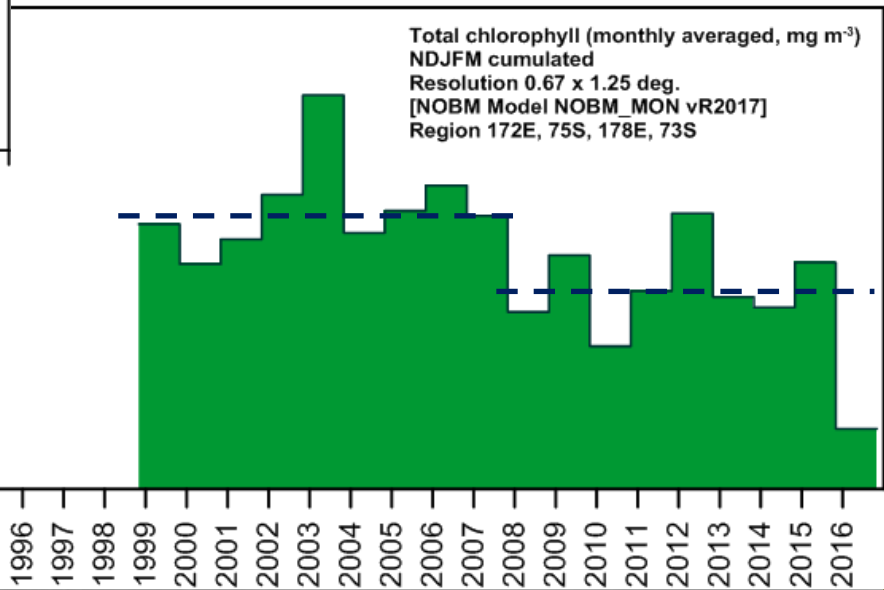
Site B (Joides Basin)

- ✓ The more complete time series by site B
- ✓ Again, lower export fluxes after 2000
- ✓ Chlorophyll is lowering (very slowly) at long time scale
- ✓ Productive season in NDJF
- ✓ Possible shift toward lower values in NDJF from winter 2007-08





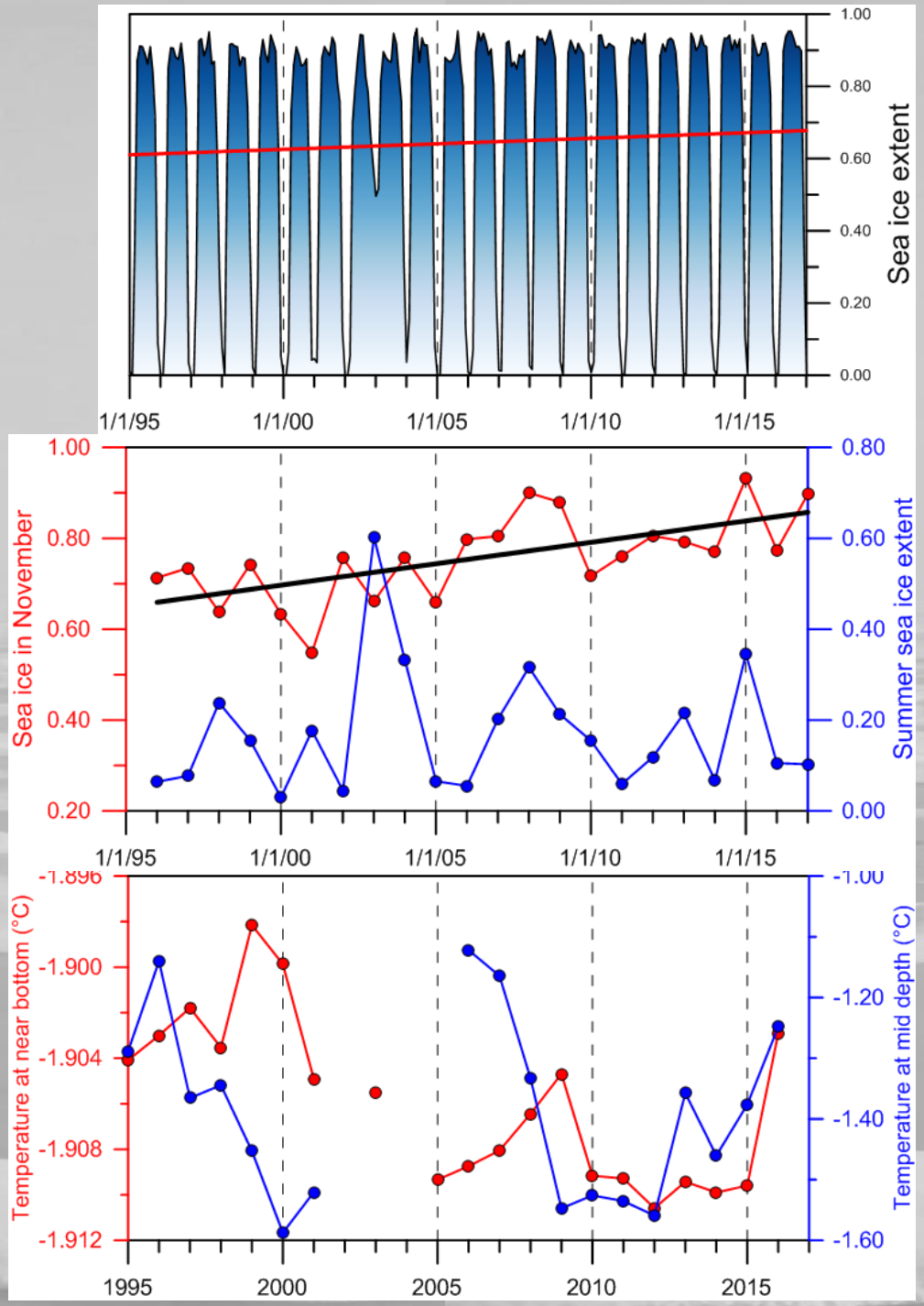




giovanni.gsfc.nasa.gov/giovanni
Region 172E, 75S, 178E, 73S, Joides basin

Site B (Joides Basin)

- ✓ Water temperature is decreasing over time at both depths
- ✓ From 2002-2005, shift toward colder, fresher, and less dense bottom waters (no data in 2002 by B15 and C19 icebergs)
- ✓ At mid-depth, marked interannual variability (10-y frequency)
- ✓ Temperature inversely correlated at the 2 depths before 2010. After that, temperatures oscillate in phase (higher water column homogenization)



- Weak increase of sea ice extent on long time interval
- The duration of sea ice cover is increasing in November (algal blooms delayed?)

Temperature data from MORSEA, Italian Marine Observatory
http://morsea.uniparthenope.it/

Summary

What about the export fluxes in the Ross Sea during the last 25 years?

The efficiency of biological pump is decreasing, too?

- Export fluxes in Ross Sea are decreasing on a long term time scale, with a clear shift after 2000
- In addition, export fluxes show also an interannual variability
- At long time scale, chlorophyll, temperature and salinity show a slight decrease, while sea ice are increasing, specially in November (MIZ retreat delayed and shorter growth season?)
- Lower temperatures could imply less intrusion of CDW during the last 20 years, and hence, less available nutrients and Fe
- CDW intrusion (and nutrient supply) could drive interannual variability of export fluxes

We do not know. As a working hypothesis:

- ✓ Delayed algal blooms and/or shift in algal composition may cause lower particle sinking rate and less fecal pellets with lower preservation of organic material sinking in the water column

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