Mesoscale eddies and iron cycling in the North Pacific Subtropical Gyre

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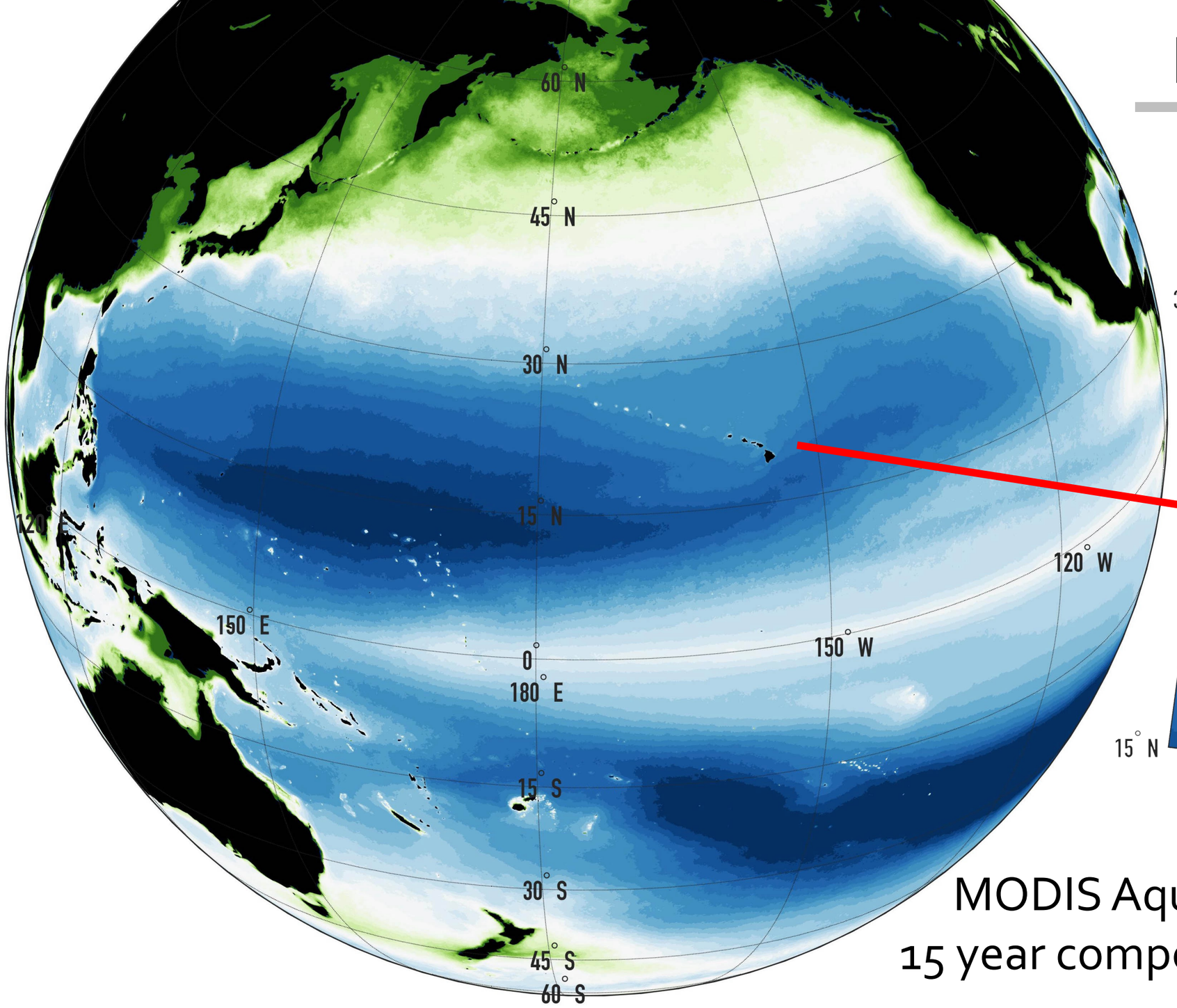
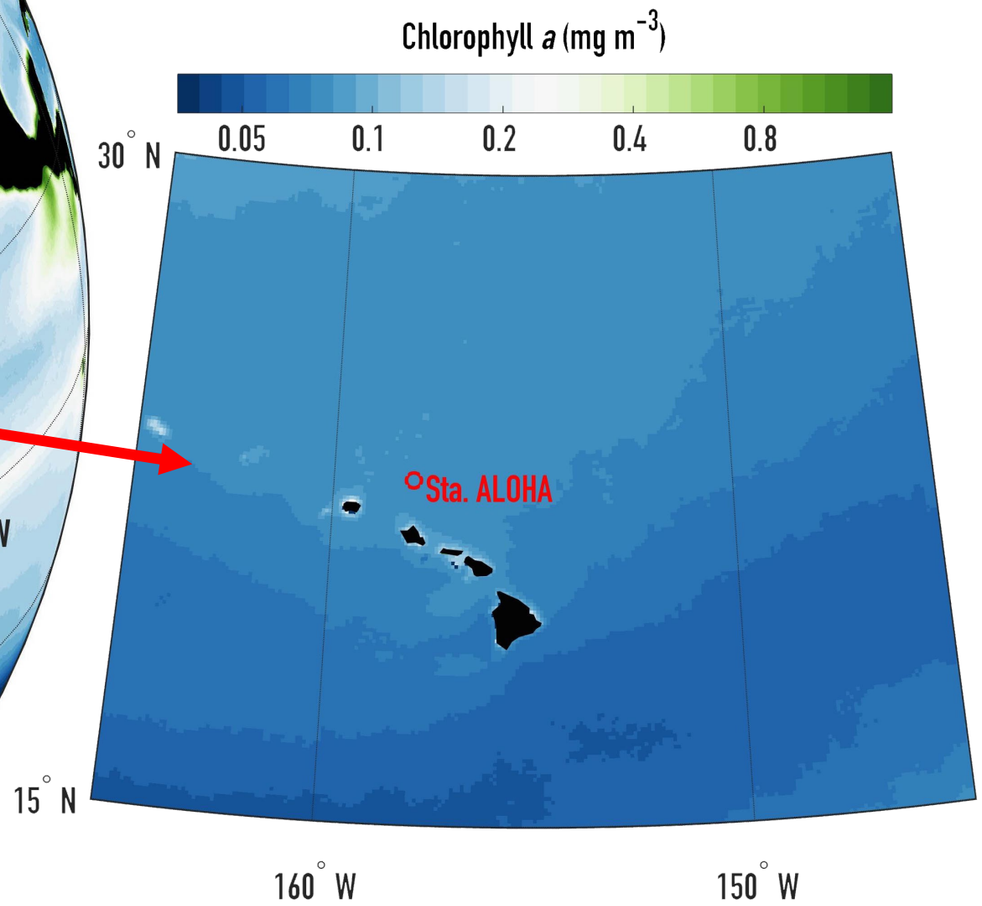
SIMONS FOUNDATION

NSF

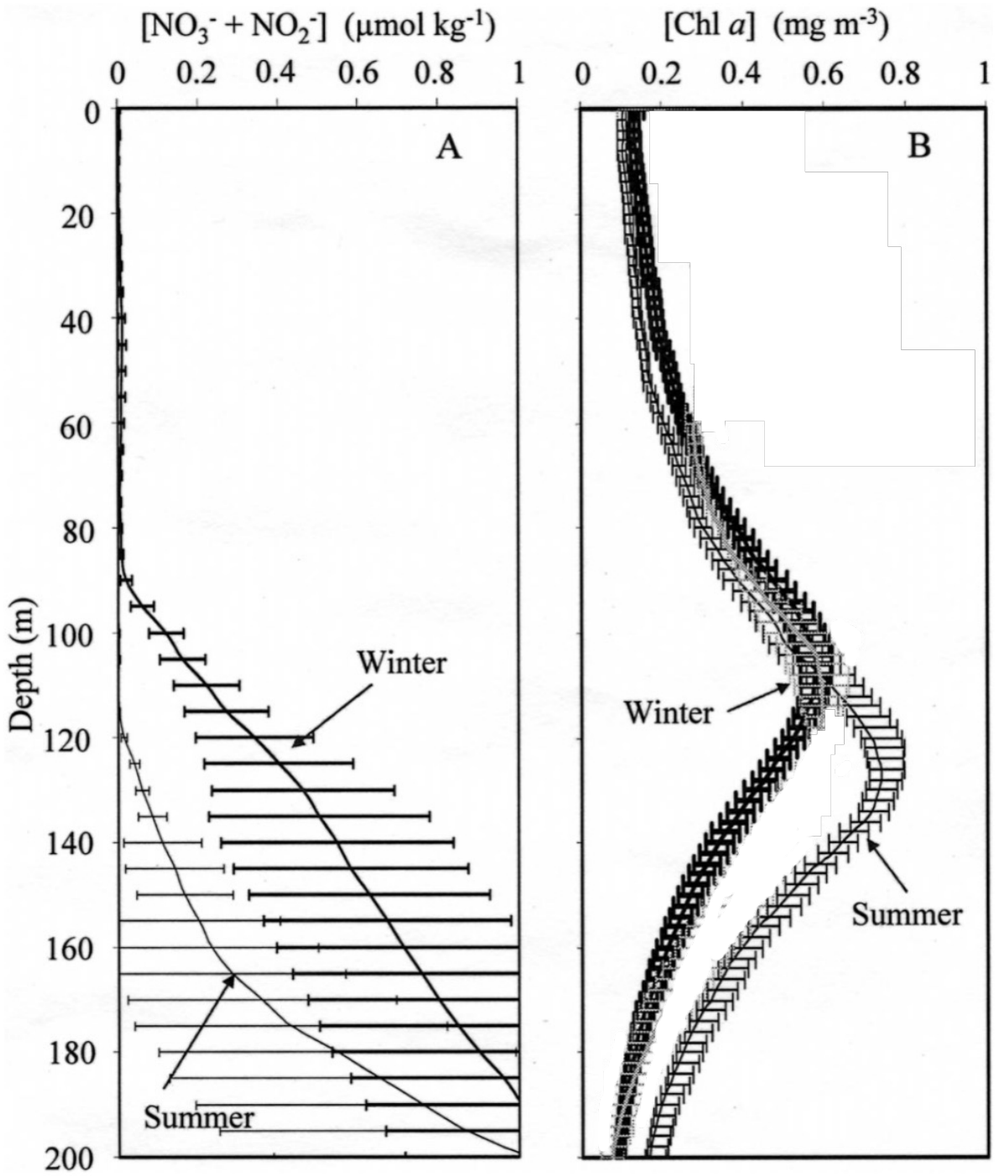
Region of interest





MODIS Aqua
15 year composite

Chlorophyll *a*, nutrients, and light



Adapted from *Letelier et al. (L&O, 2004)*

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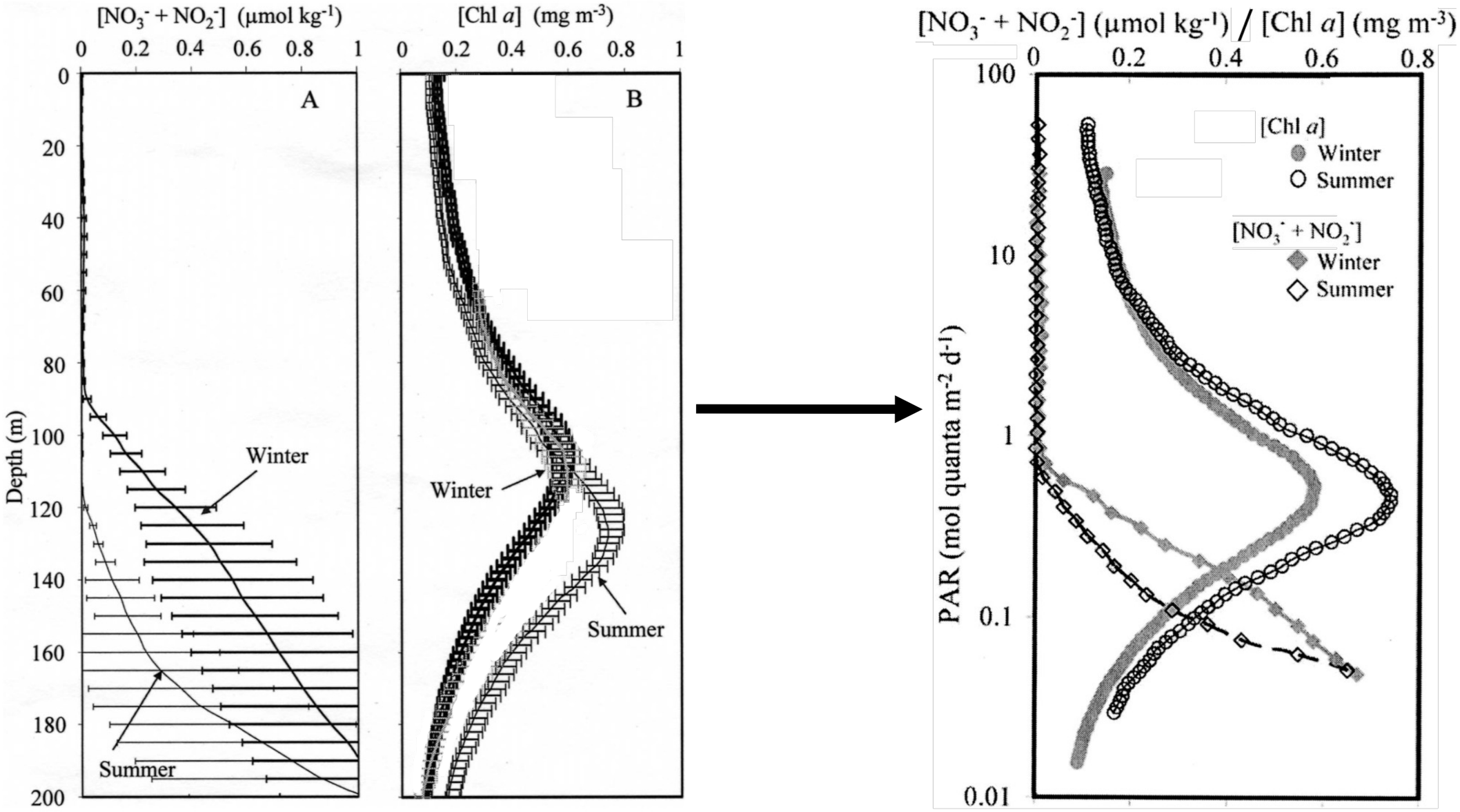

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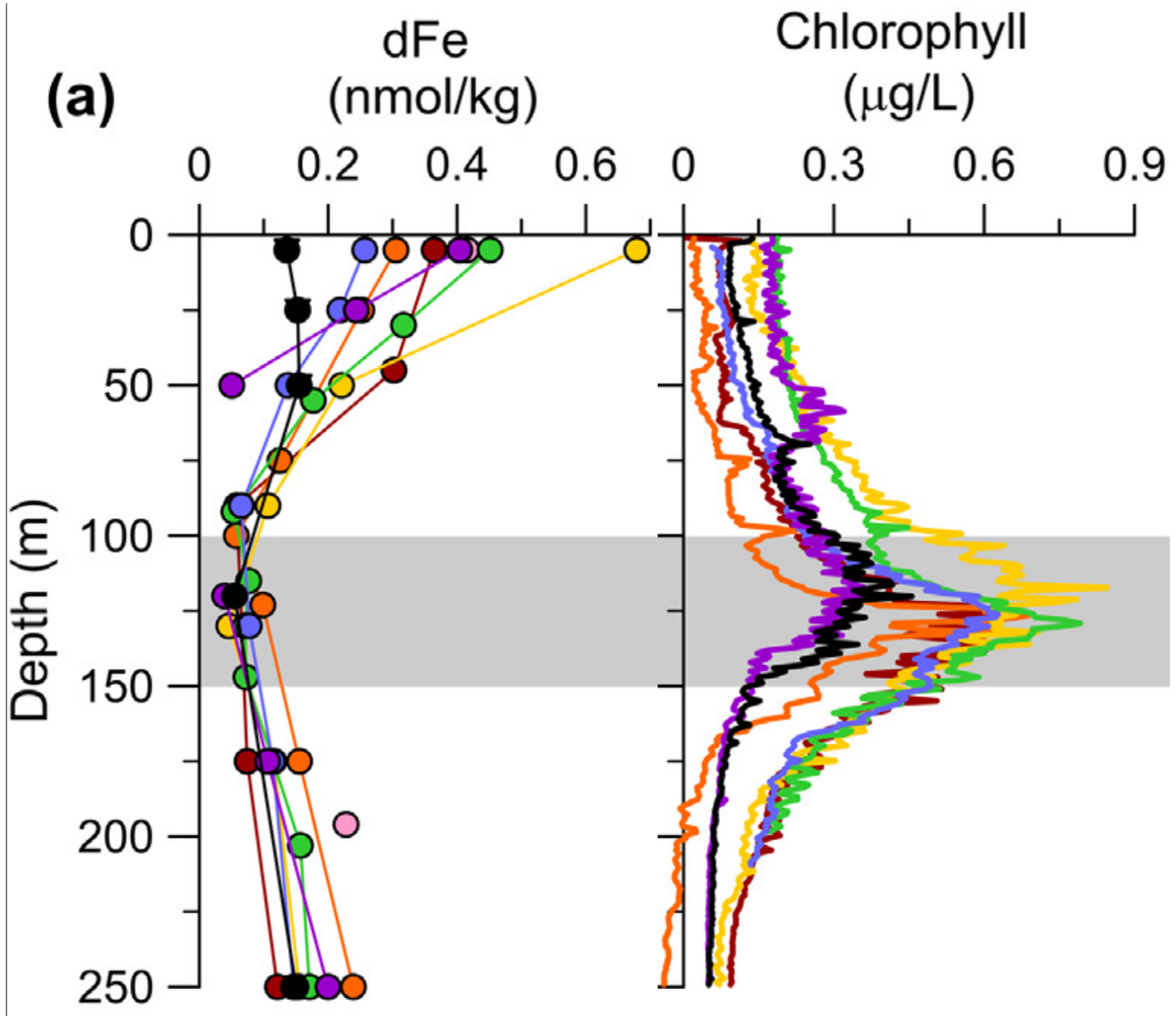
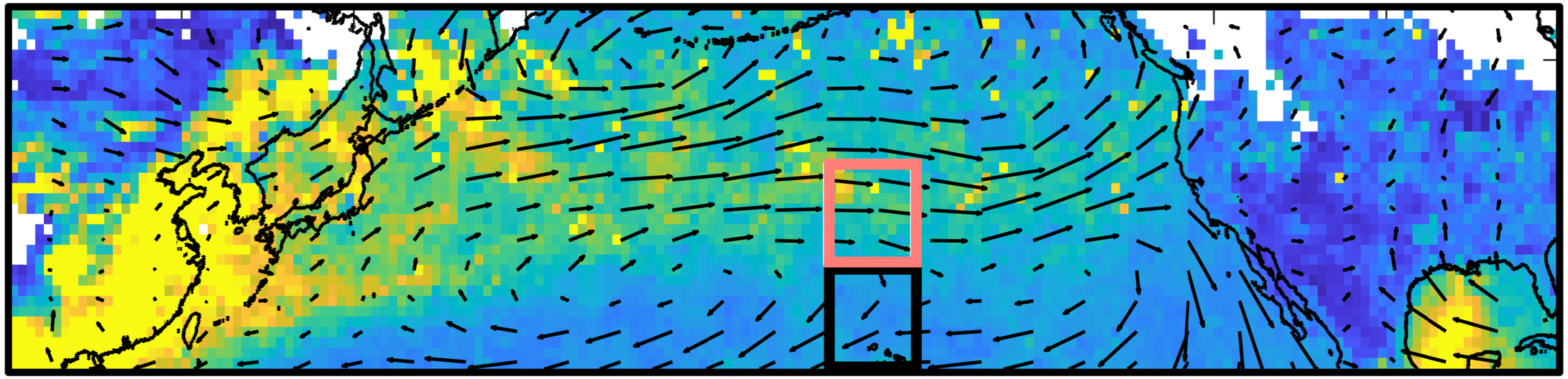
The vertical distribution of iron



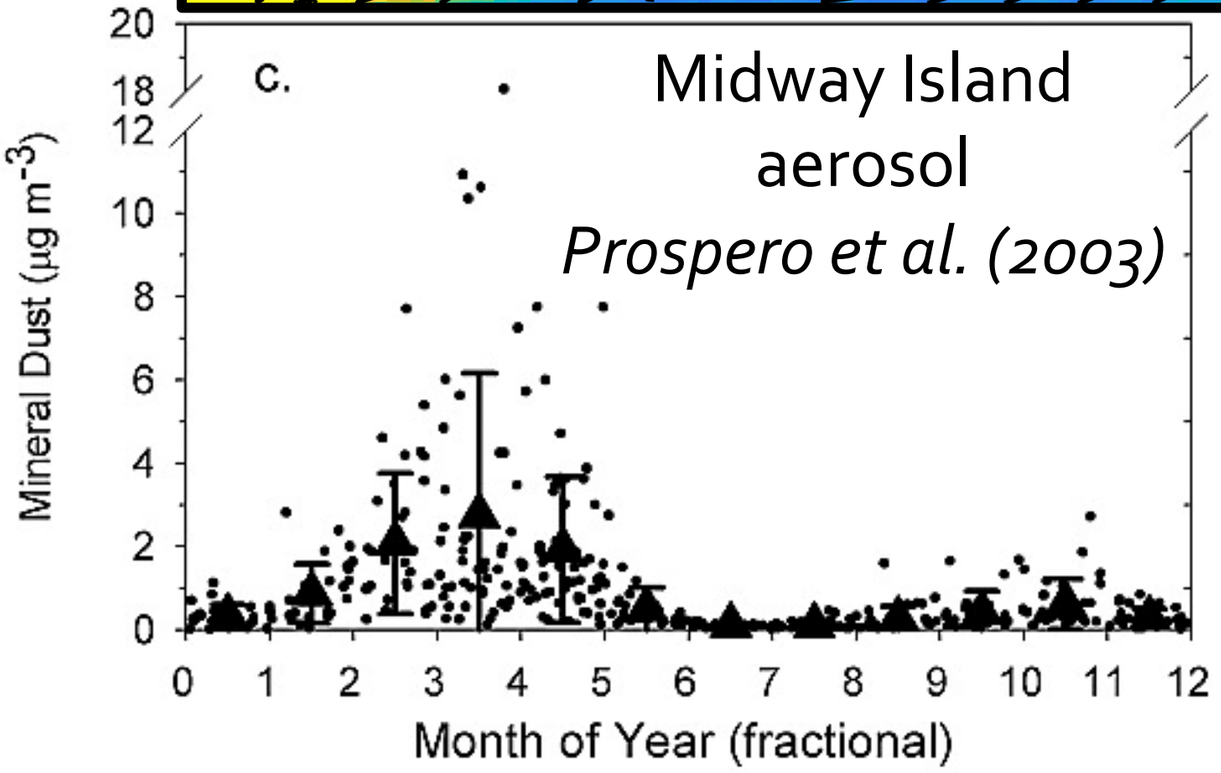
Persistent minimum of dissolved iron near the chlorophyll maximum

Adapted from *Fitzsimmons et al. (GCO, 2015)*

Dust supply and its seasonality



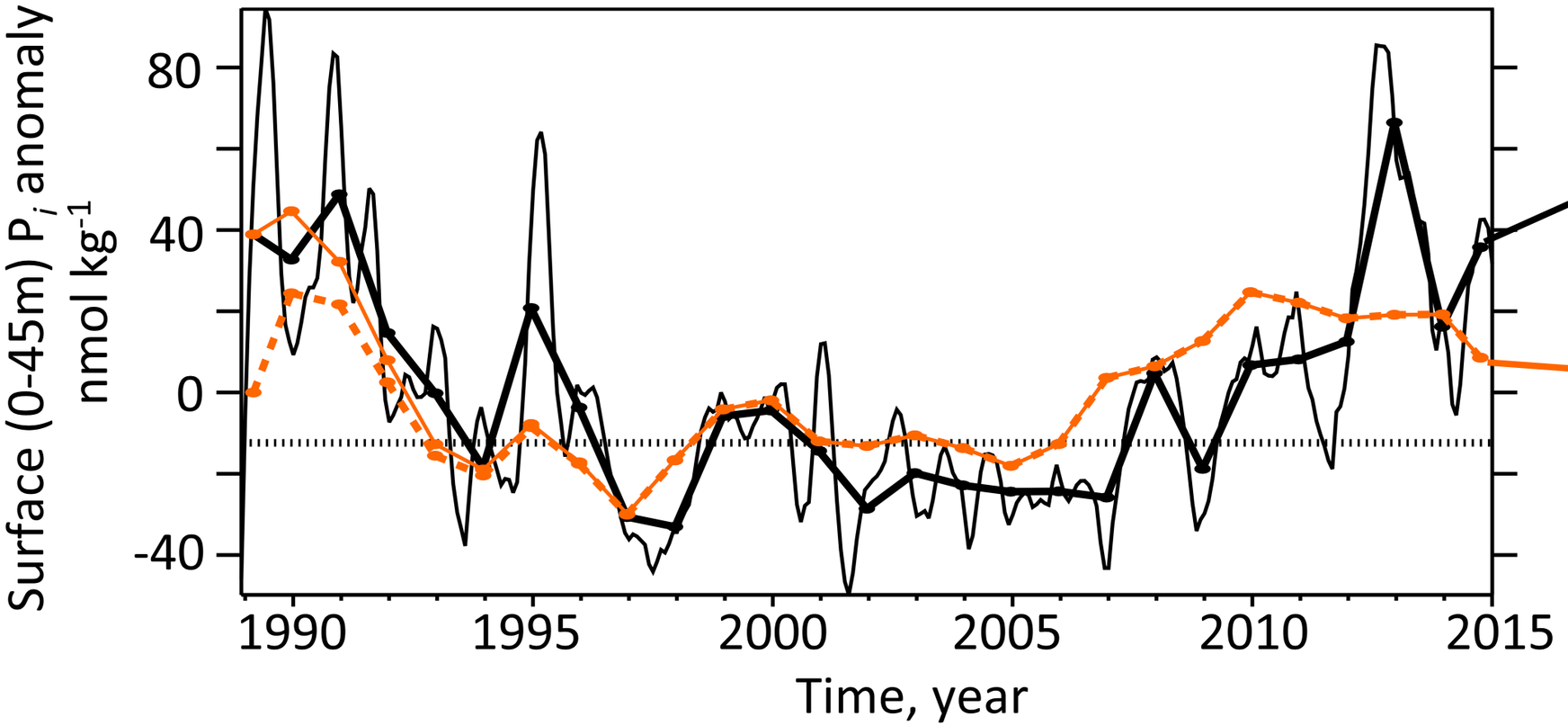
AOD-DT, MODIS Aqua - April 2017



- **Asian dust deposits in the gyre**

- **Deposition peaks in spring**

Dust deposition and phosphorus limitation



Observed monthly anomalies

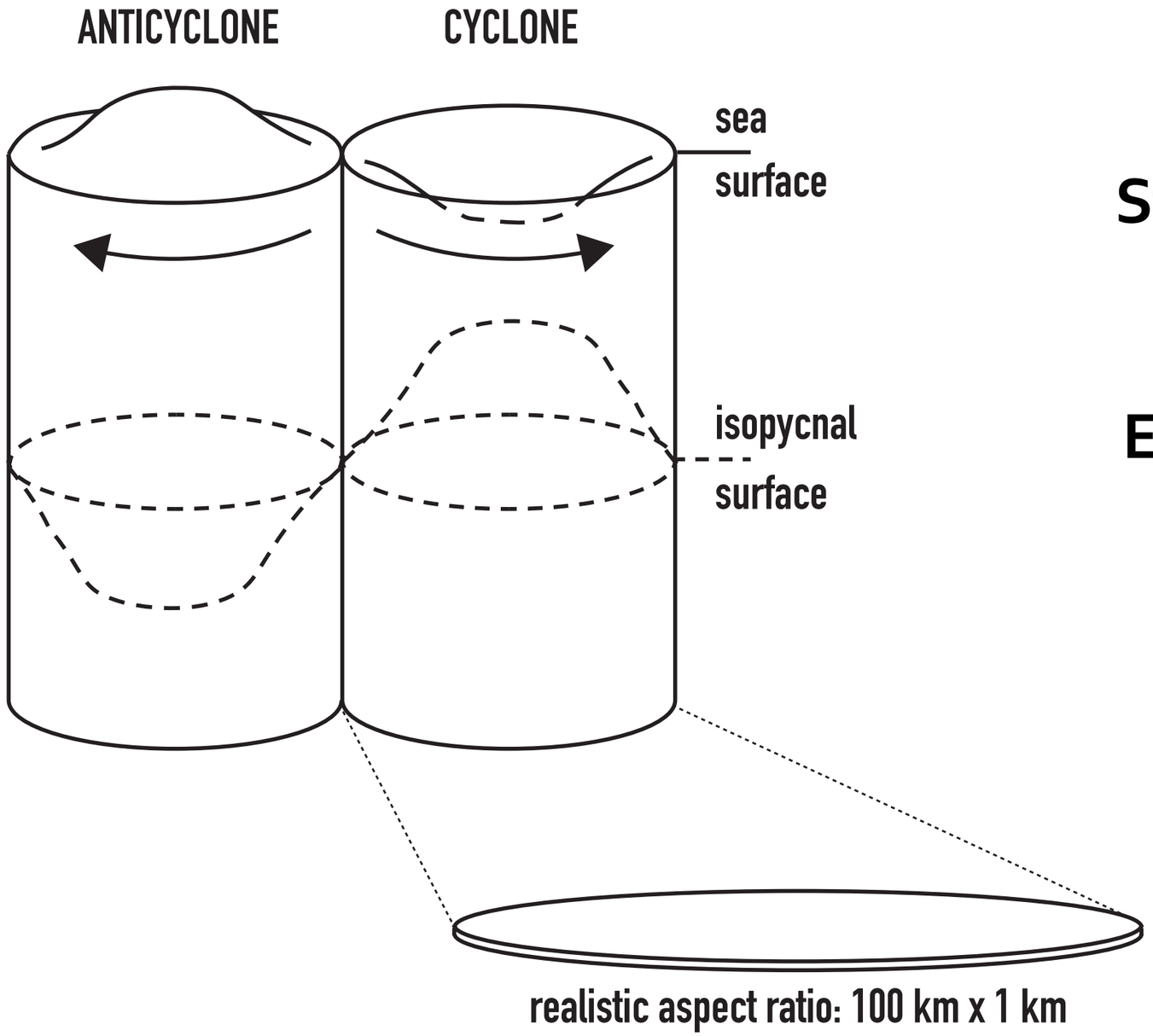
Monthly anomalies based on model of northwest Pacific SLP

- **Iron deposition modulates surface phosphorus at Station ALOHA**

- **Negative PDO correlation with surface phosphorus (4-months lag)**

Letelier et al. (PNAS, 2019)

Importance of MESO-SCALE eddies at Station ALOHA

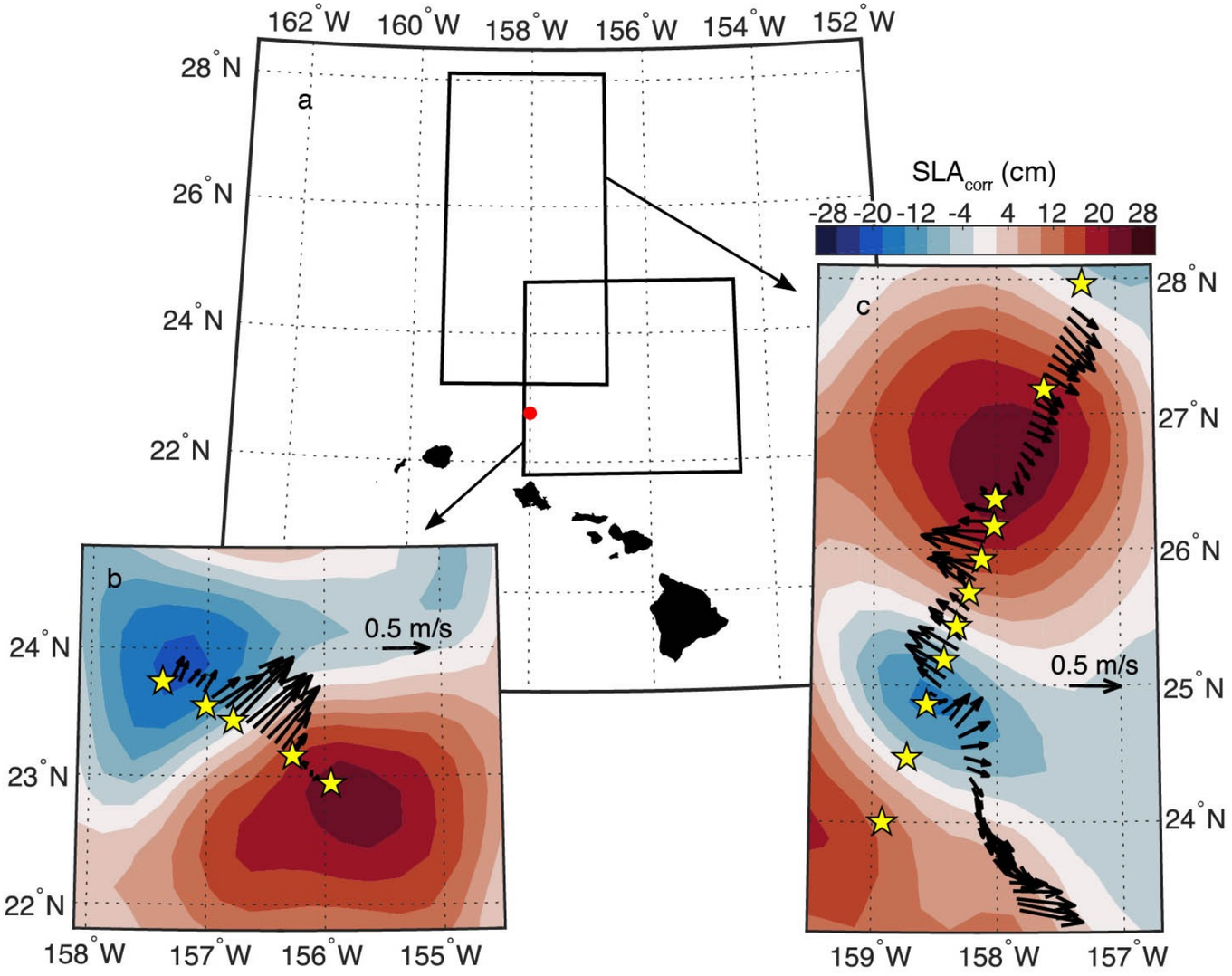


Station ALOHA is in an eddy 31% of the time

Eddies at ALOHA are linked with vertical displacements of the thermocline > 100 m

Barone et al. (JMR, 2019)

Mesoscale variability in mature cyclones (MESO-SCOPE)



Barone, Church et al. (GBC, 2022)

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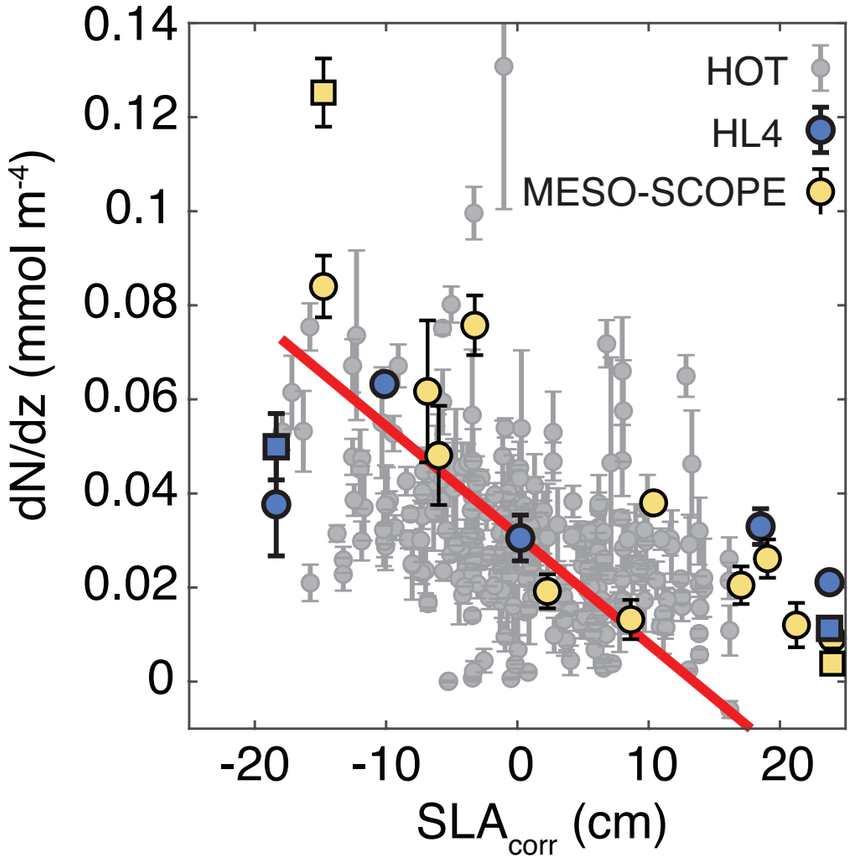
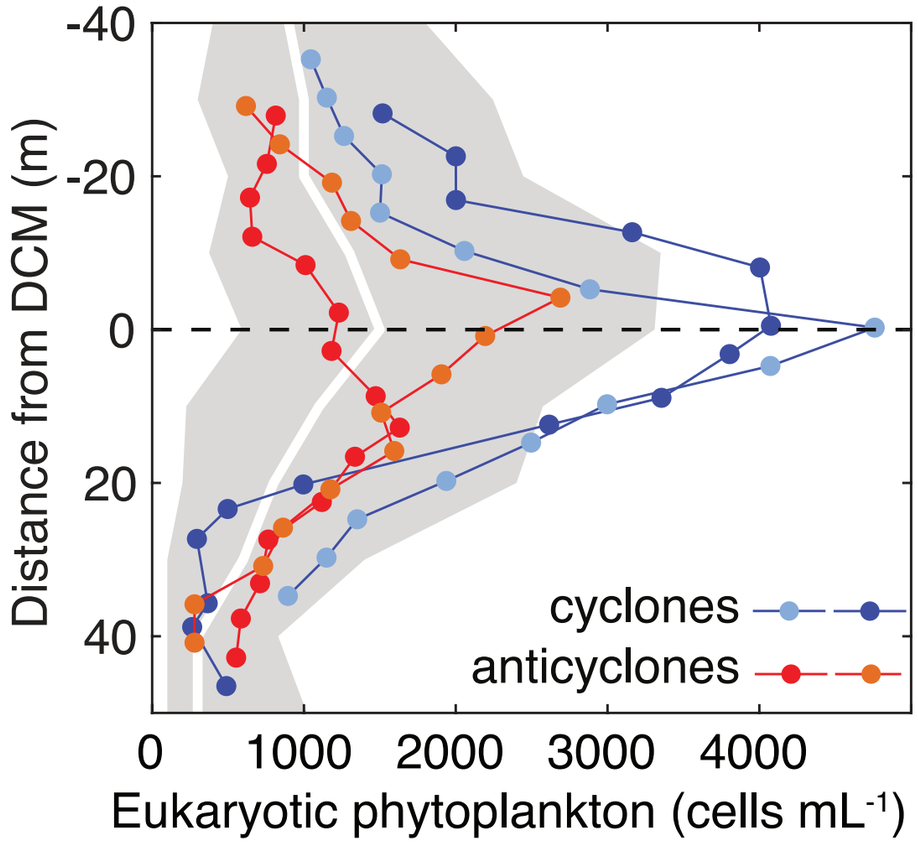
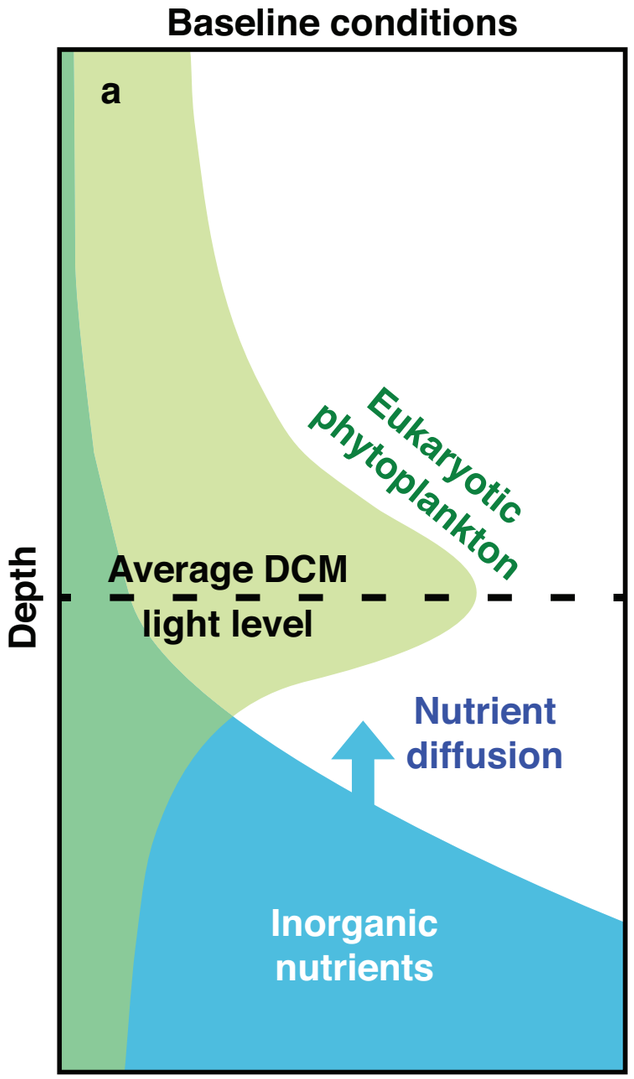




Steeper nutrient gradients and more eukaryotic phytoplankton at the DCM of mature cyclones

Barone, Church et al. (GBC, 2022) & Barone et al. (JMR, 2019)

Impacts of the erosion of the nutricline in cyclones



Barone, Church et al. (GBC, 2022)

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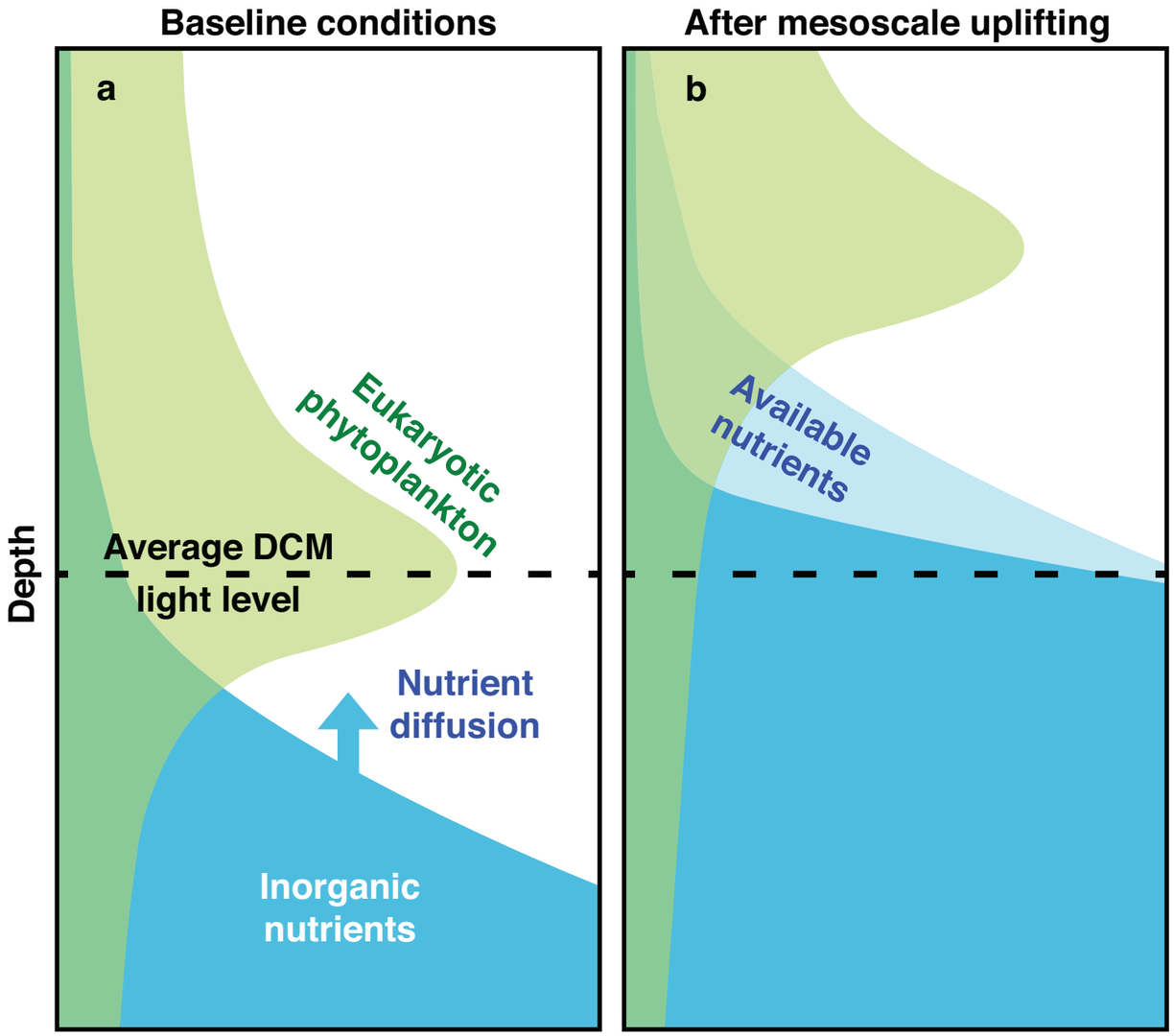

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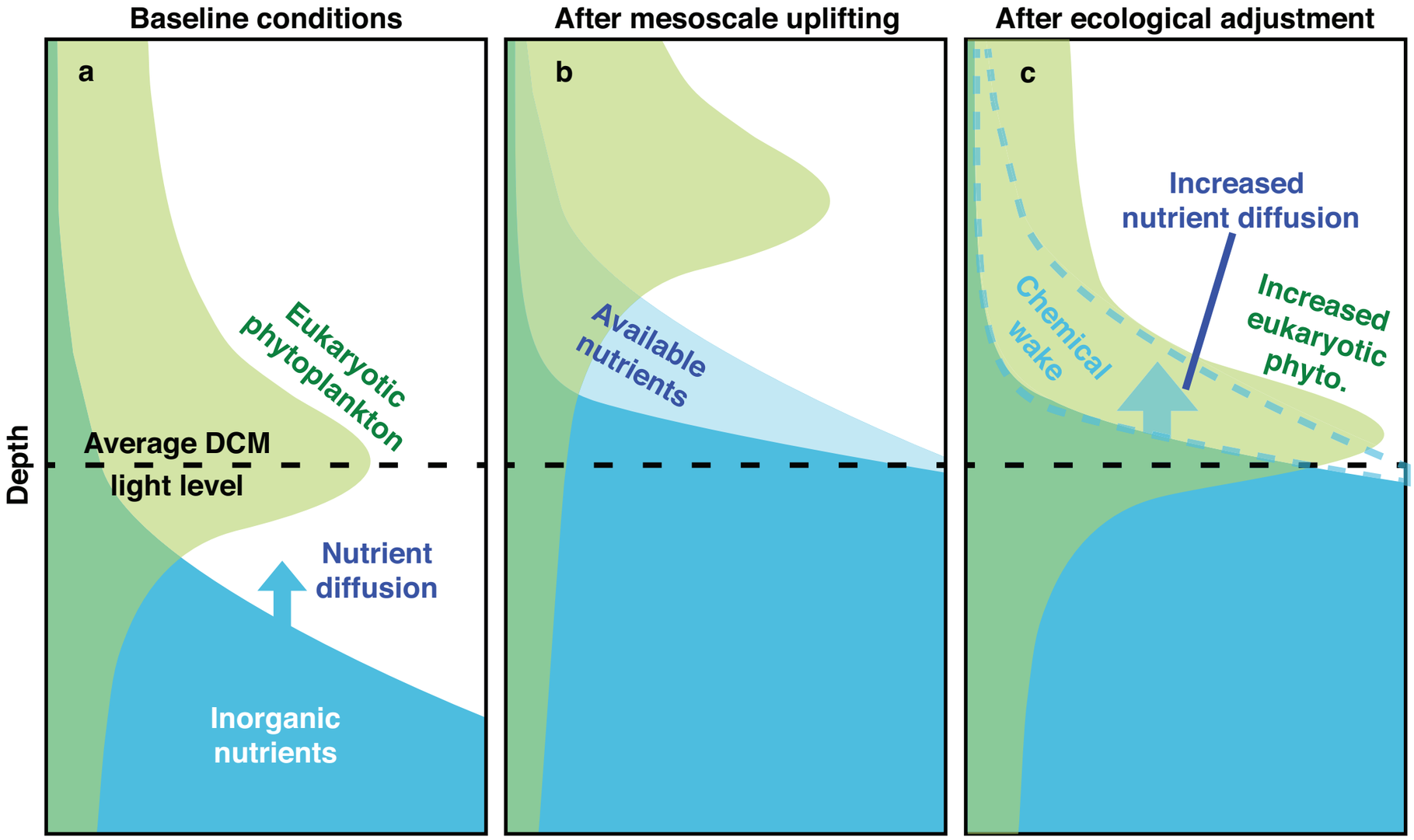
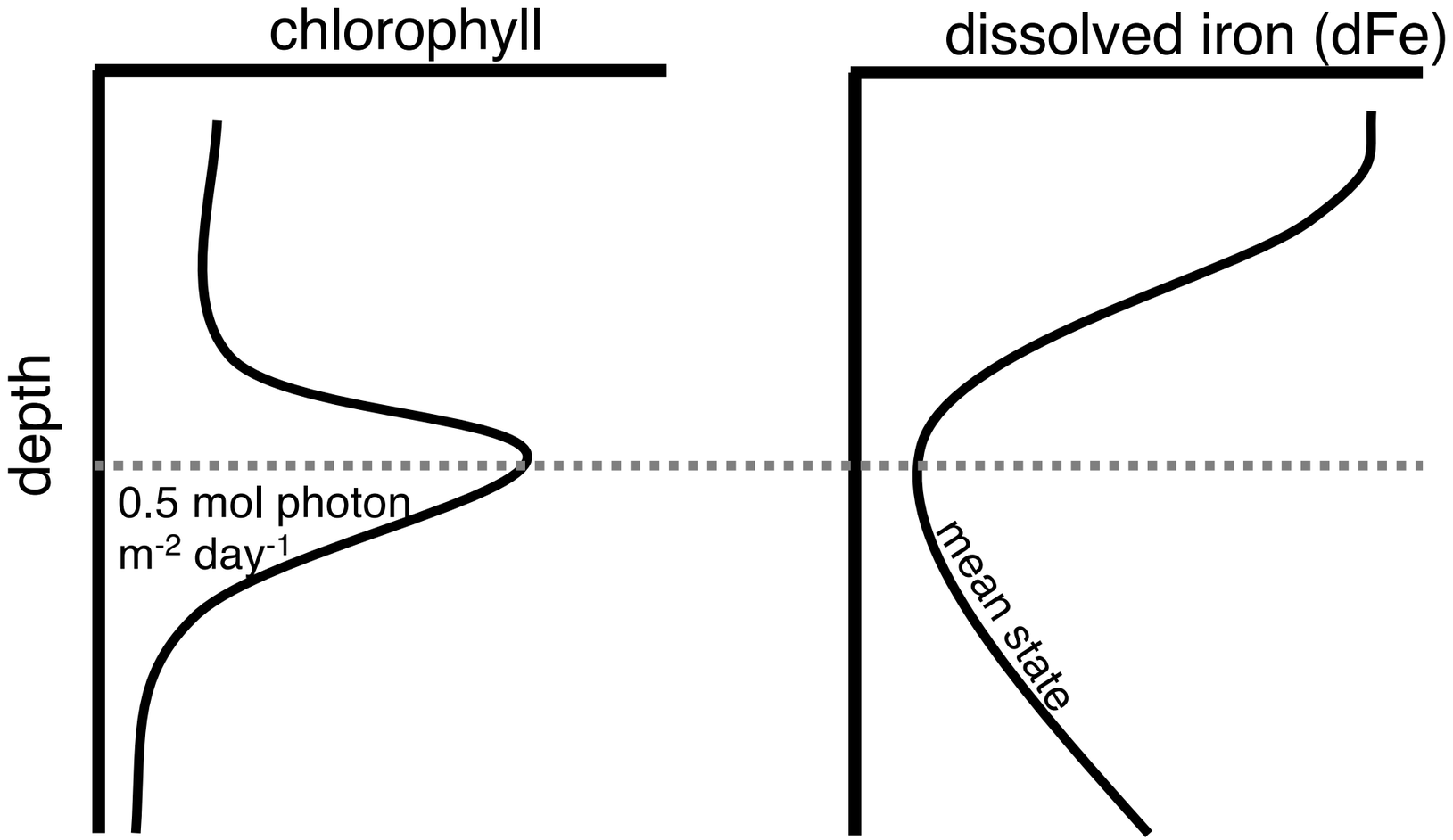


Barone, Church et al. (GBC, 2022)

What do we expect from iron



Hawco et al. (GBC, 2021)

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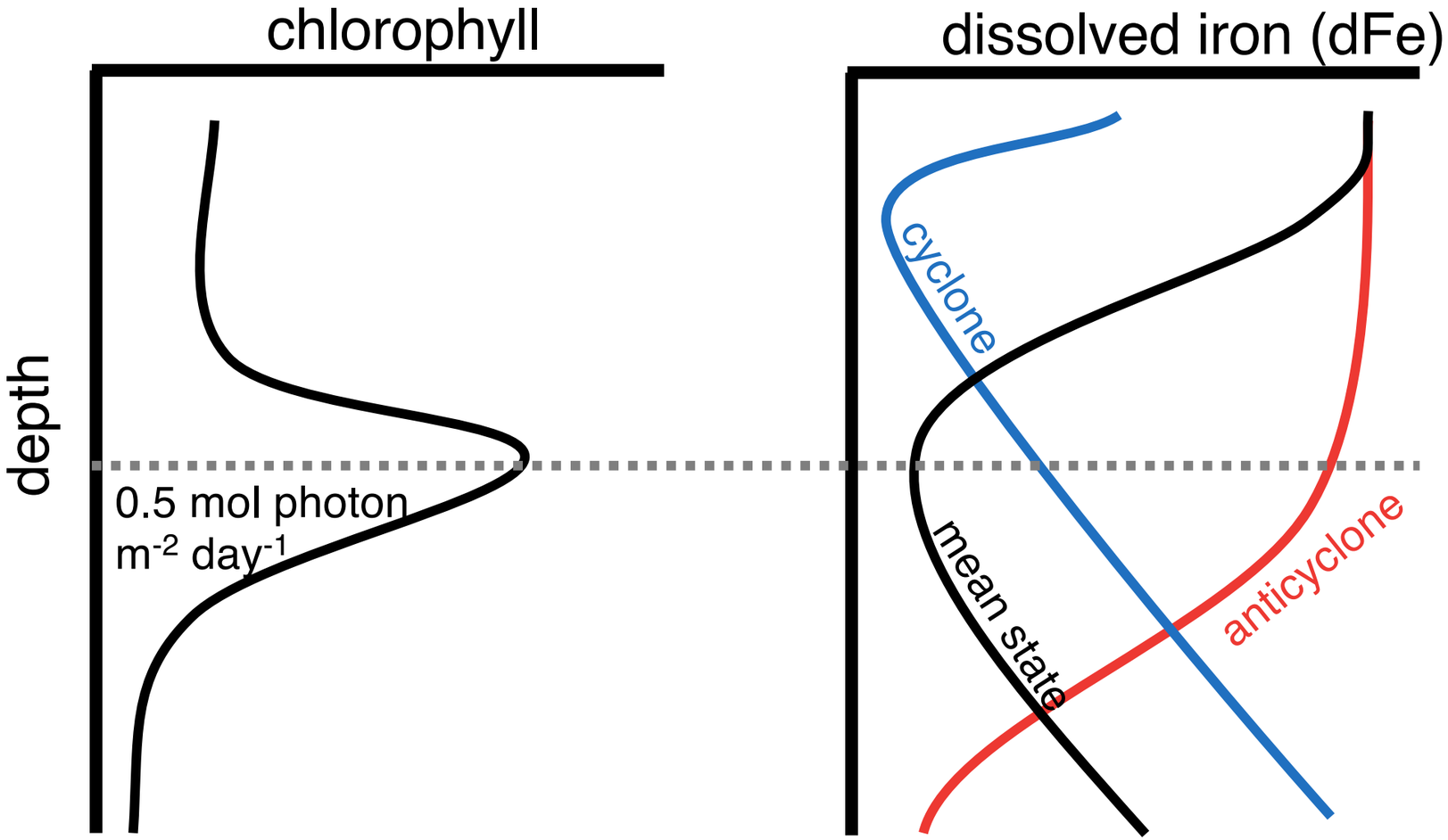
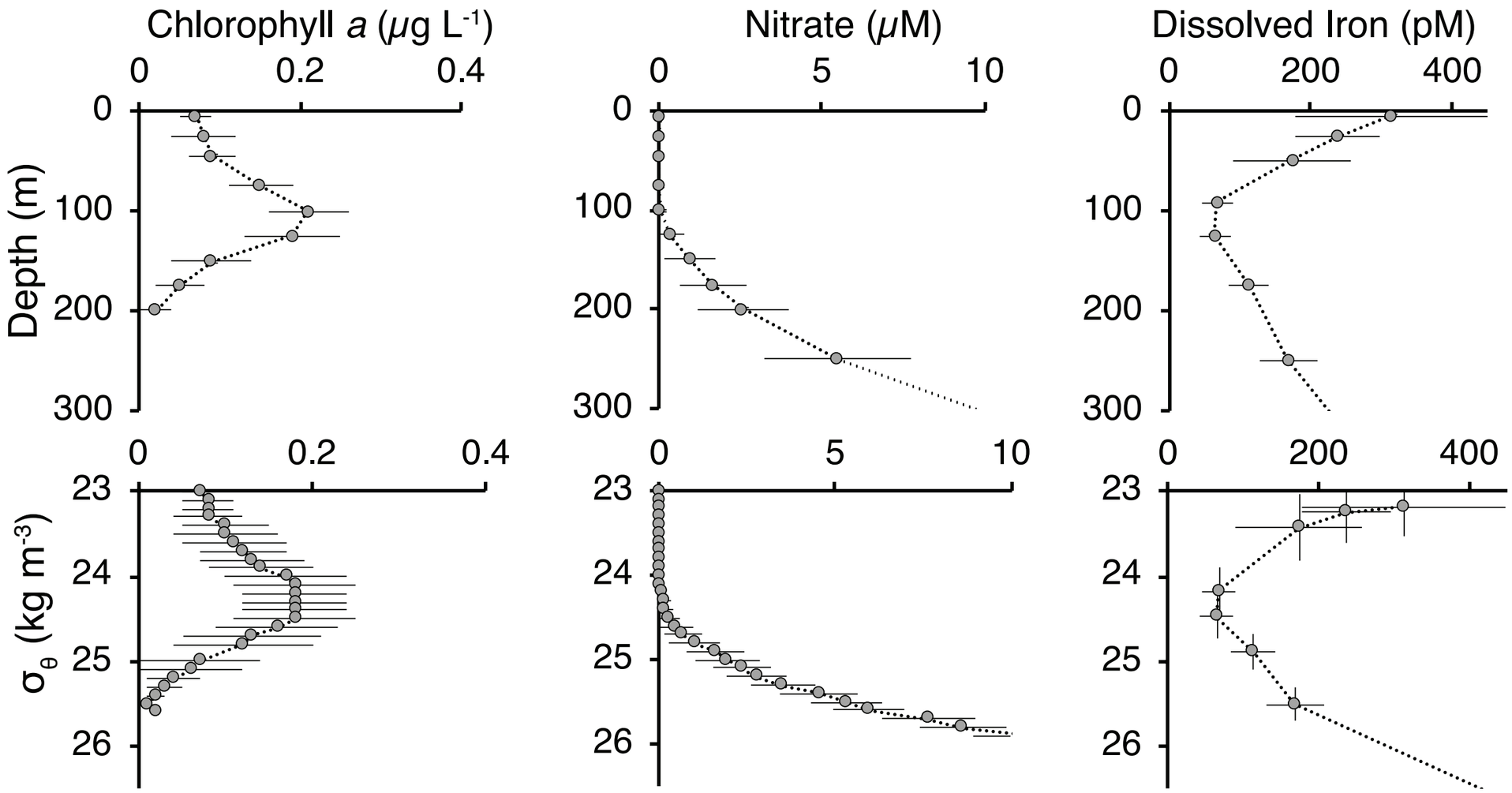


Both eddies should increase iron at the DCM

Hawco et al. (GBC, 2021)

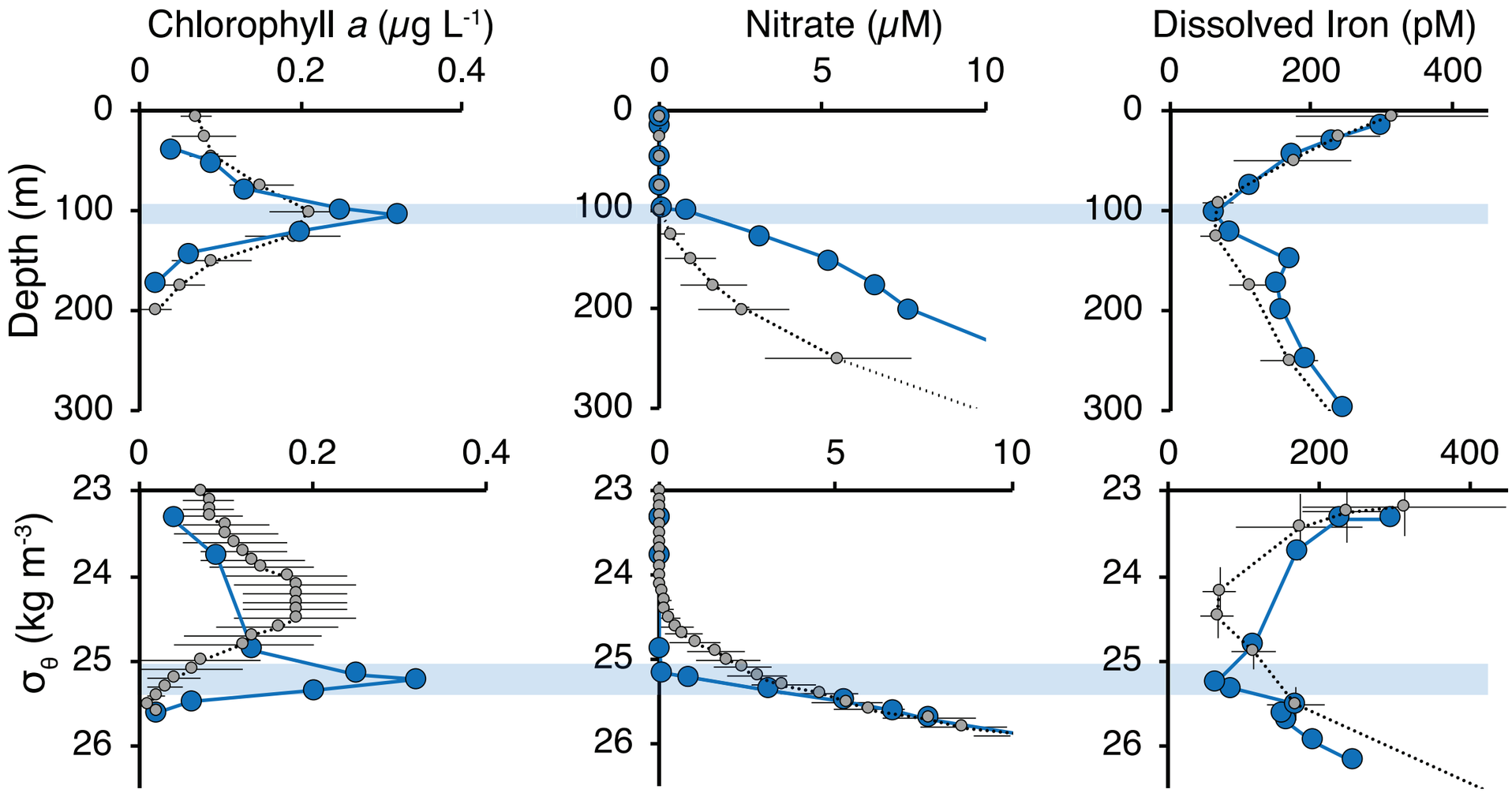
Iron variability across eddies



Expectations from Sta. ALOHA (May-Sep)

Hawco et al. (GBC, 2021)

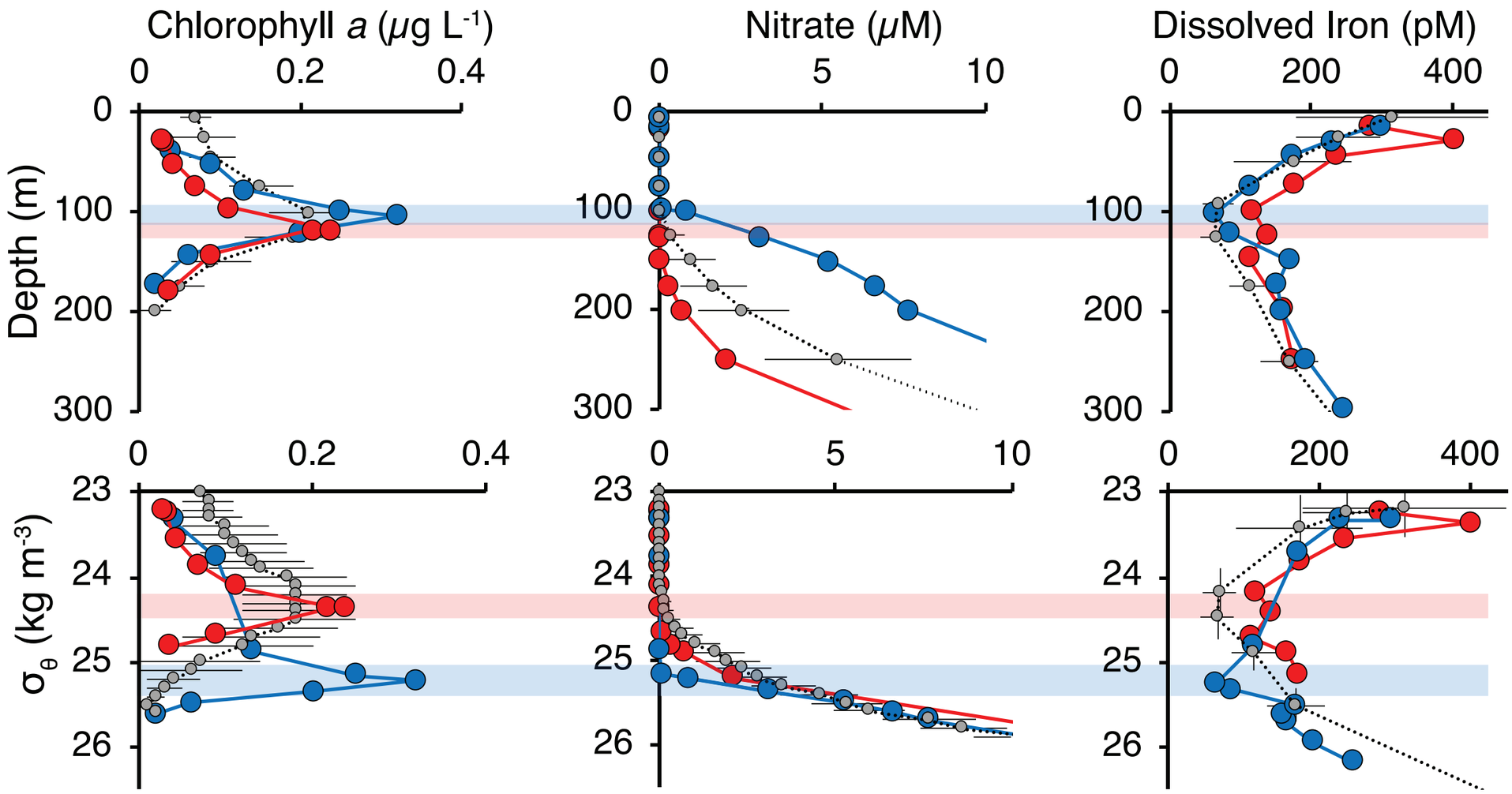
Iron variability across eddies



Uptake of nitrate and iron in the cyclone

Hawco et al. (GBC, 2021)

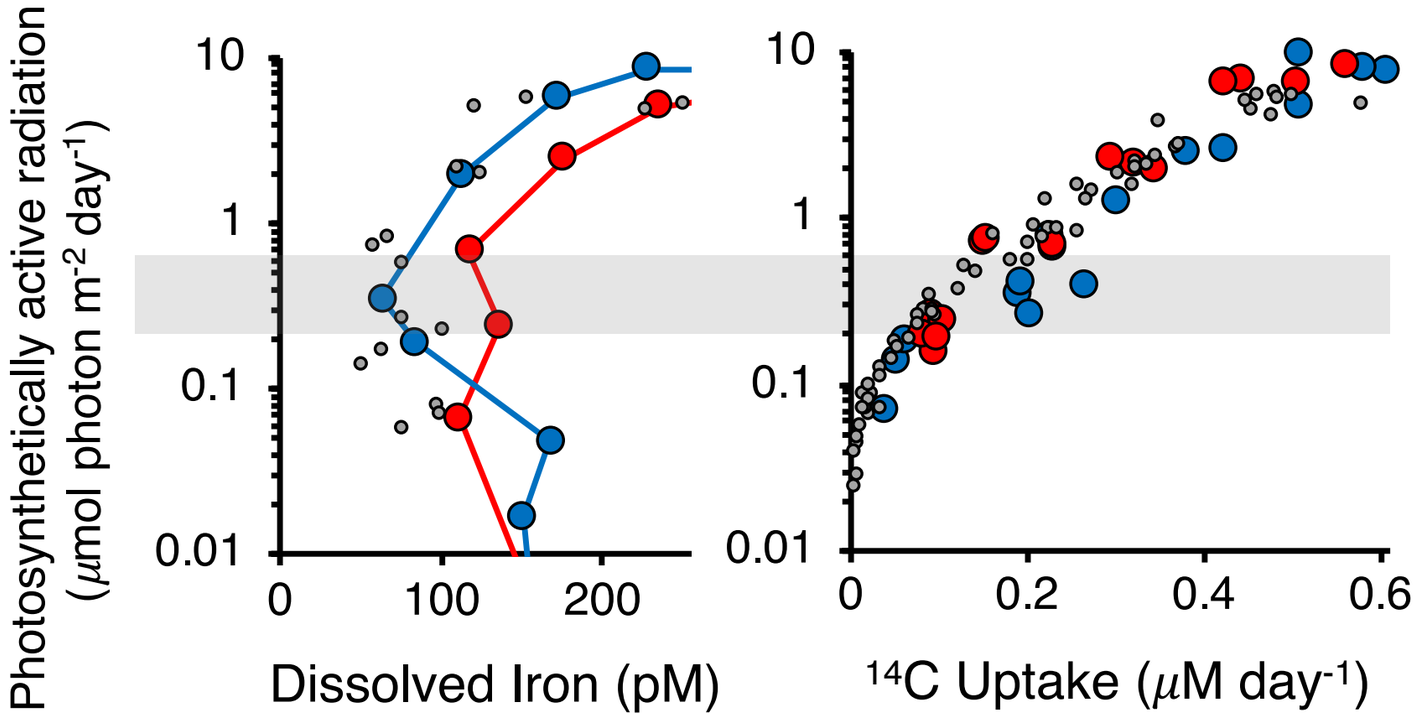
Iron variability across eddies



Iron increases at the DCM of the anticyclone

Hawco et al. (GBC, 2021)

Mesoscale changes with respect to light flux

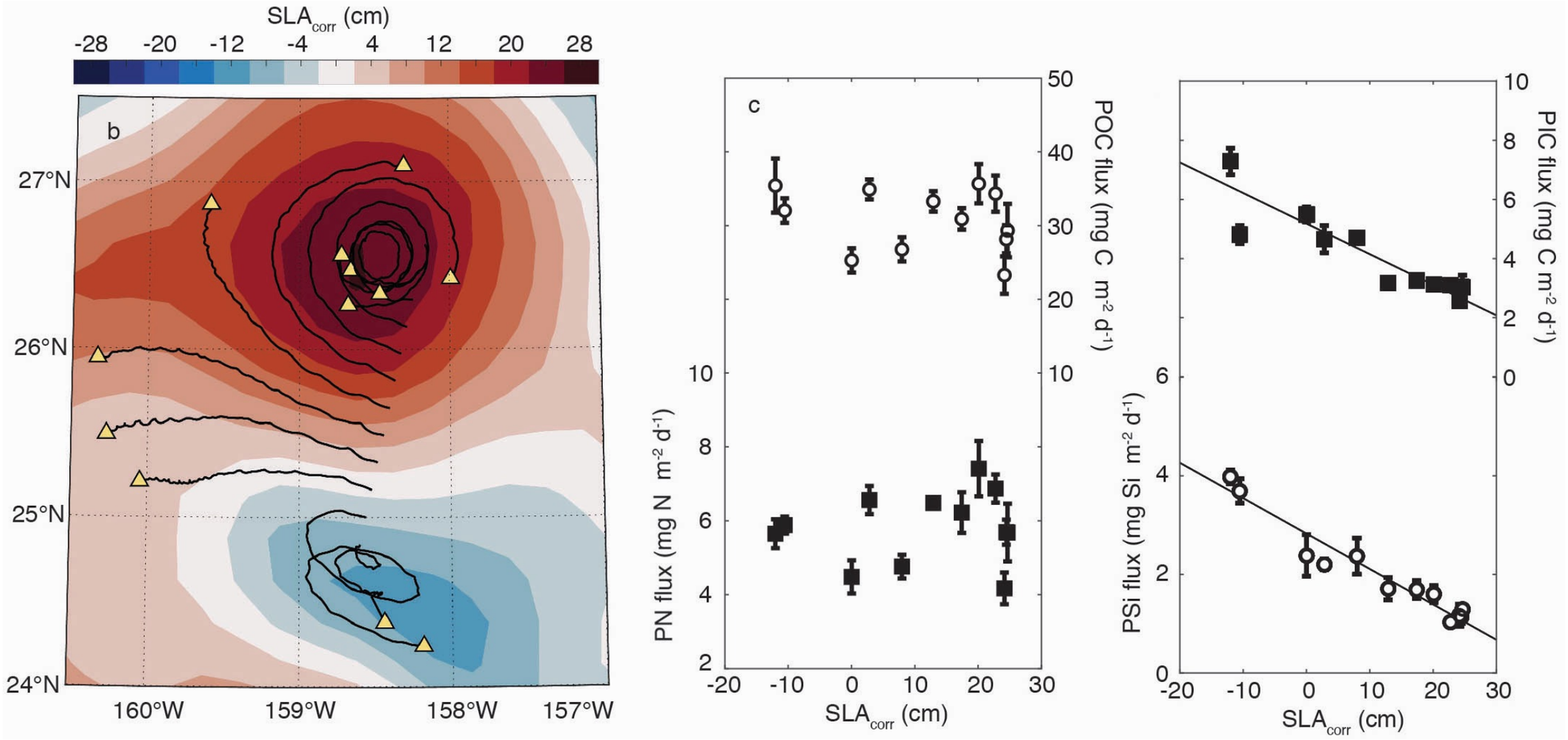


- **Higher photosynthesis in the DCM of the cyclone despite low Fe**

- **Higher Fe in the anticyclone did not lead to increased production**

Hawco et al. (GBC, 2021)

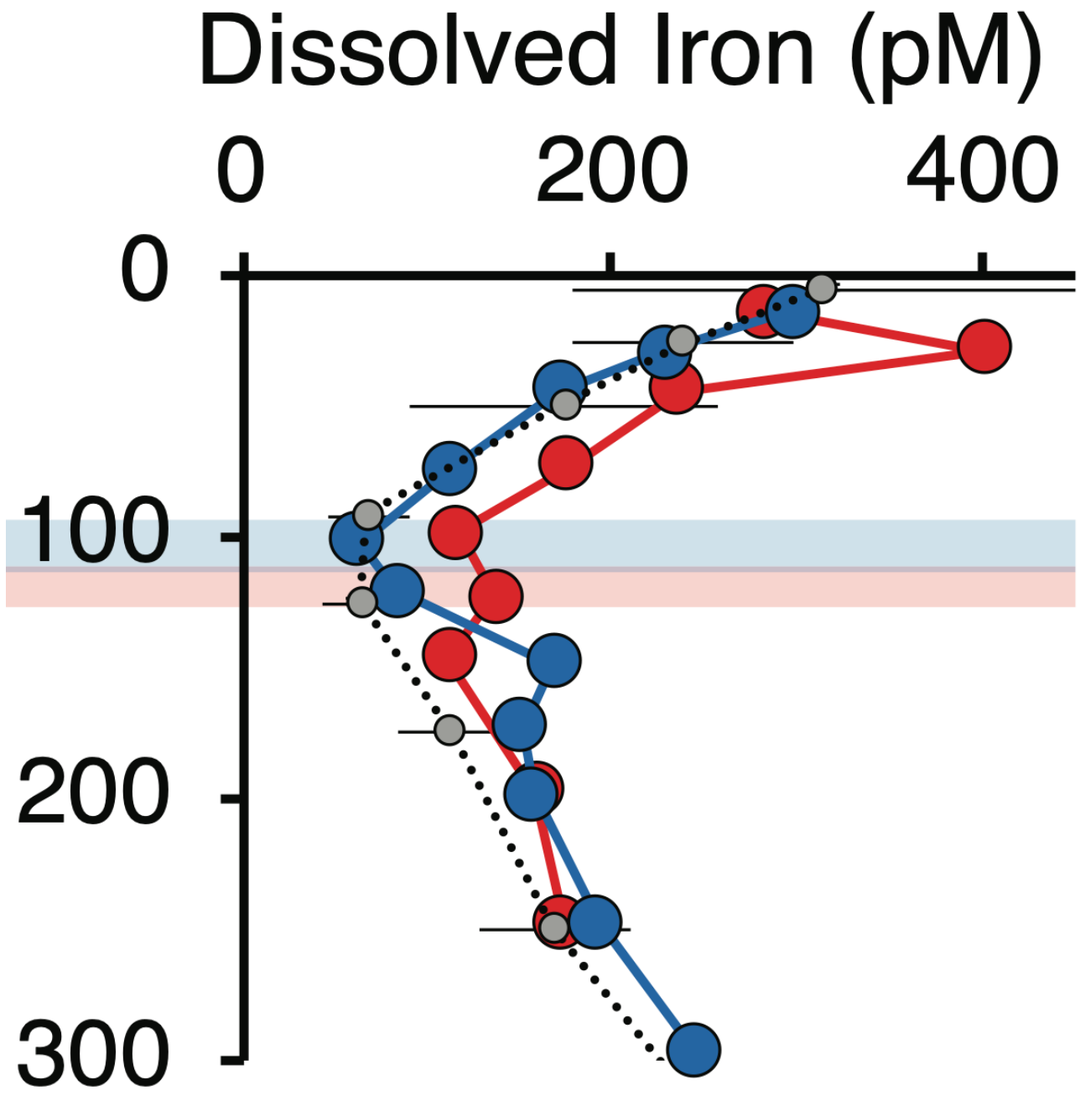
Particle export across eddies



No changes in organic matter export across eddies, but increased flux of biominerals from the cyclone

Barone, Church et al. (GBC, 2022)

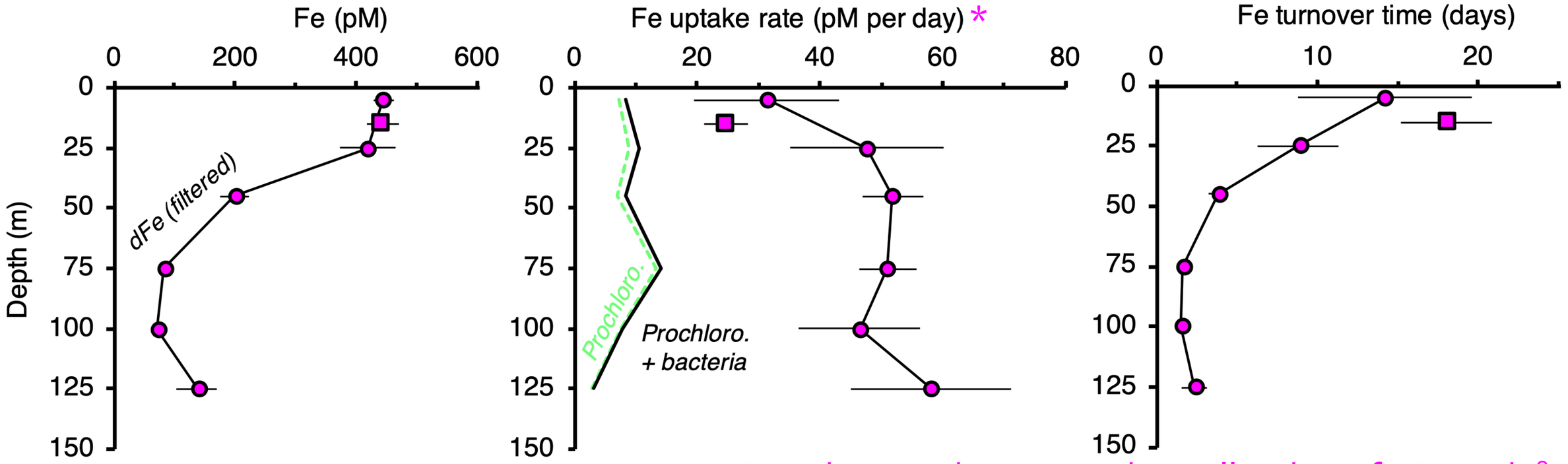
Similarity of the vertical profiles of iron



Despite > 100 m vertical displacement of the thermocline, iron profiles are similar

How fast is the turnover of dissolved iron?

Iron uptake and turnover time



*Based on incubations with small spikes of ^{57}Fe and ^{58}Fe

Turnover times of 10–15 days near the surface and 1–3 days near the DCM

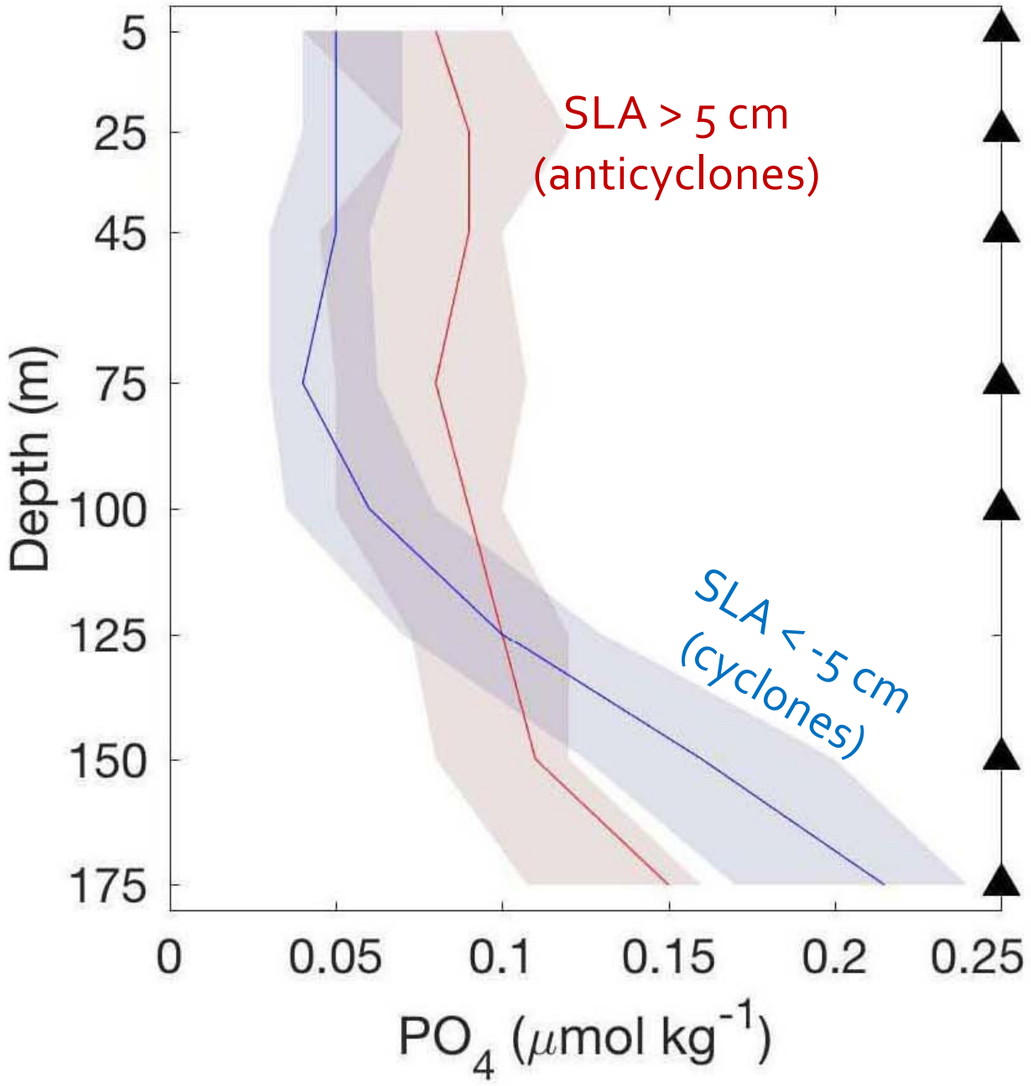
Iron residence time of ~8 months in the euphotic zone based on atmospheric supply from Thorium mass balance

Hawco et al. (L&O, 2022)

Conclusions

- Subsurface ecosystem stimulation in mature cyclones mediated by diapycnal nutrient fluxes
- Mesoscale changes in dissolved iron at the DCM not linked with consistent changes in productivity
- Production at the DCM does not appear iron limited north of Hawai‘i
- Fast iron turnover (days) due to recycling despite apparent iron sufficiency
- Iron residence time likely much longer (months) than recycling scale

Bonus track: A mesoscale curiosity



Barone et al. (JMR, 2019)

Increase in surface phosphorus in anticyclones despite deepening of nutrient-depleted surface layer

Stimulation of photosynthesis by iron addition more likely in an anticyclone, under negative PDO, in late summer