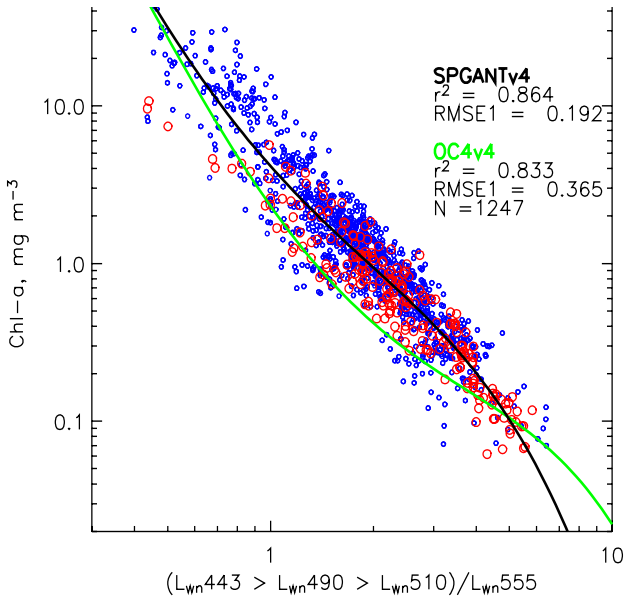
Scoping for Interdisciplinary Coordinated Experiment of the Southern Ocean Carbon Cycle (ICESOCC)

Funded by NASA OBB 2/2014 – 12/2015

Goals Specified in Proposal:

"To define an interdisciplinary and international field campaign to develop improved capability for measuring seasonal variations in NCP and subsurface ventilation at the scale of the entire Southern Ocean and to constrain satellite-derived estimates with atmospheric and oceanic observations and models."

Synthesis and analysis to develop algorithms and models to use as input to forward estimates of NCP = f(chl, E, T), e.g. Laws et al. 2004

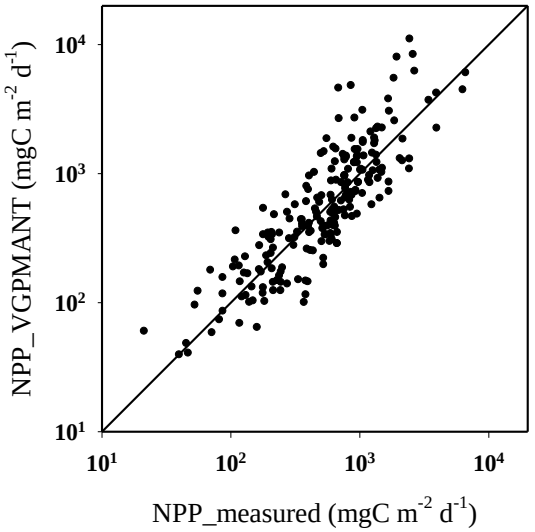


MBR Chlorophyll relationships for S. Ocean compared to standard NASA fit to NOMAD

Green curve = OC4v4 Black curve = SPGANTv4

Red circles = SPG Southern Ocean stations (AMLR, NBP, REV, LMG)

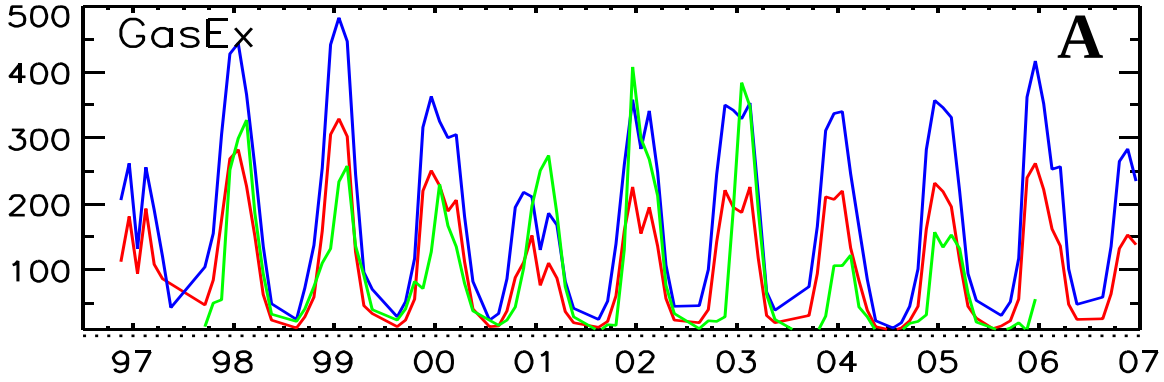
Blue circles = non-SPG Southern Ocean (lon < -55) stations



Modeled vs Measured NPP ; VGPM-ANT

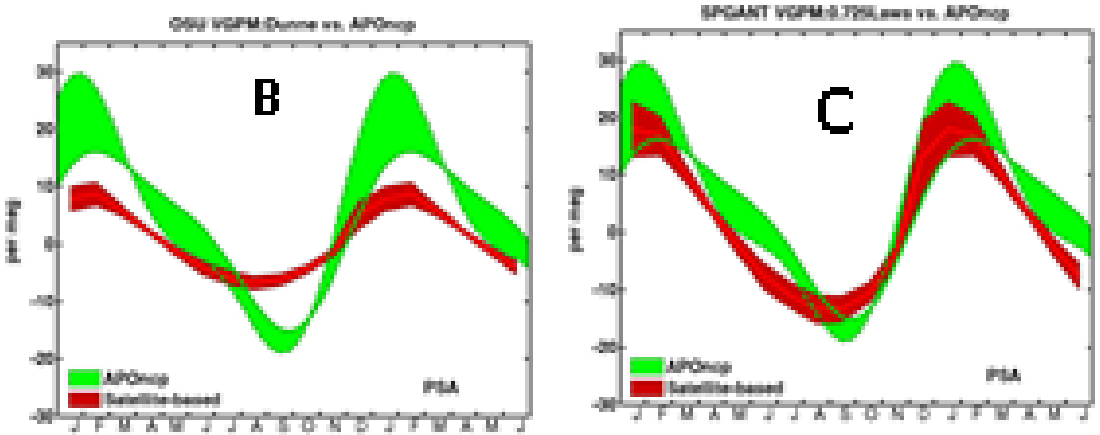
- Synthesis of *in situ* data collected by SPG since 1997 and Saba et al data set
- Reasonable relationship (e.g. typical of NPP comparisons)
- Better fit than standard VGPM or other models tested
- Compounded uncertainty of chla and NPP used as input for NCP satellite models remains a challenge

Export Production (NCP)



A. Satellite time-series *of NCP* at GasEx location using different methods

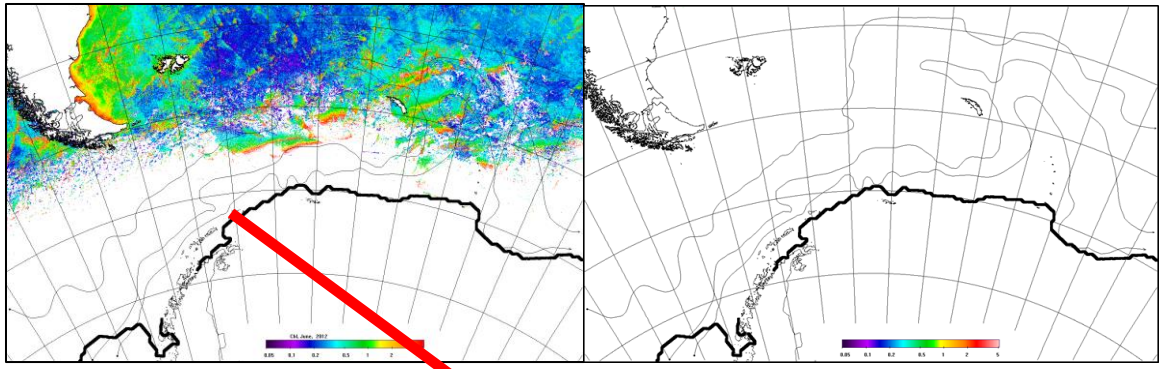
Forward models remain fraught with uncertainty. Can we constrain them??



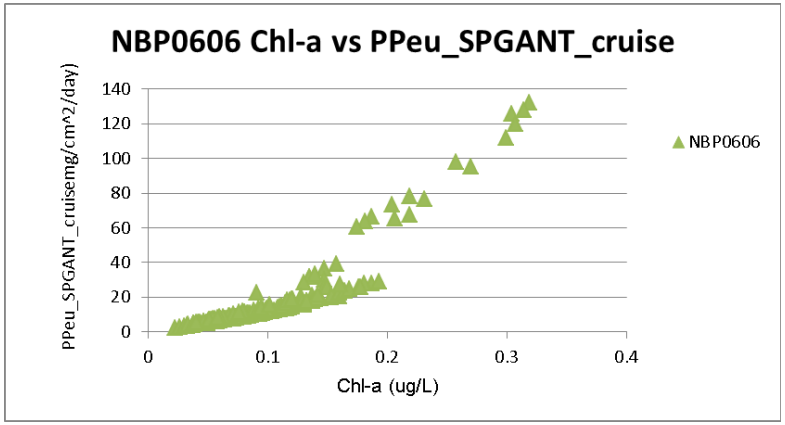
Nevison, Keeling, Kahru, Manizza and Mitchell, GBC, 2012

Annual cycle climatology of APO-based NCP estimate (green) compared to satellite estimates (red). **B.** Satellite based on standard NASA OC4 into VGPM into standard Laws et al, (2004). **C**. using regional chl, VGPM (Mitchell and Kahru, 2009) and modified Laws to fit Schlitzer (2001).

Ocean Chl and Mean Ice Edge for June, 2012 MODISA+MODIST+VIIRS), With and Without flags **particularly HISOLZEN** (set if > 75 deg)



Chl-a and NPP relatively high in July – August at 60°S in Drake Passage!



Can open water north of the ice edge provide reasonable satellite retrieval?

Need for autonomous systems in winter

From Sigman et al. 2010

"….In the Antarctic, both light (Mitchell et al. 1991) and the trace nutrient iron (Martin et al. 1990) are thought to control the productivity of phytoplankton and the export of their organic matter…..***if iron is the central limiter of annual Antarctic productivity***, then the degree of consumption of the major nutrients (nitrate and phosphate) should depend on the **supply ratio of iron relative to the major nutrients**…."

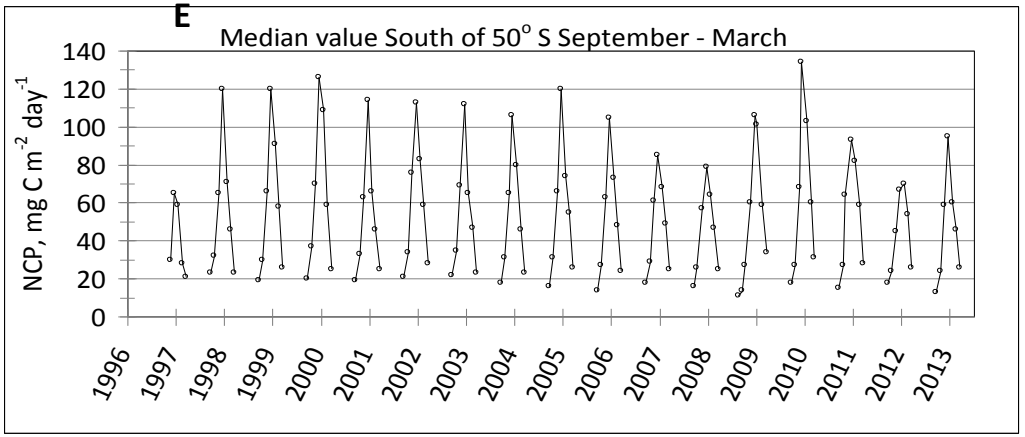
Is there *REALLY* a 2x difference in the interannual supply of iron???

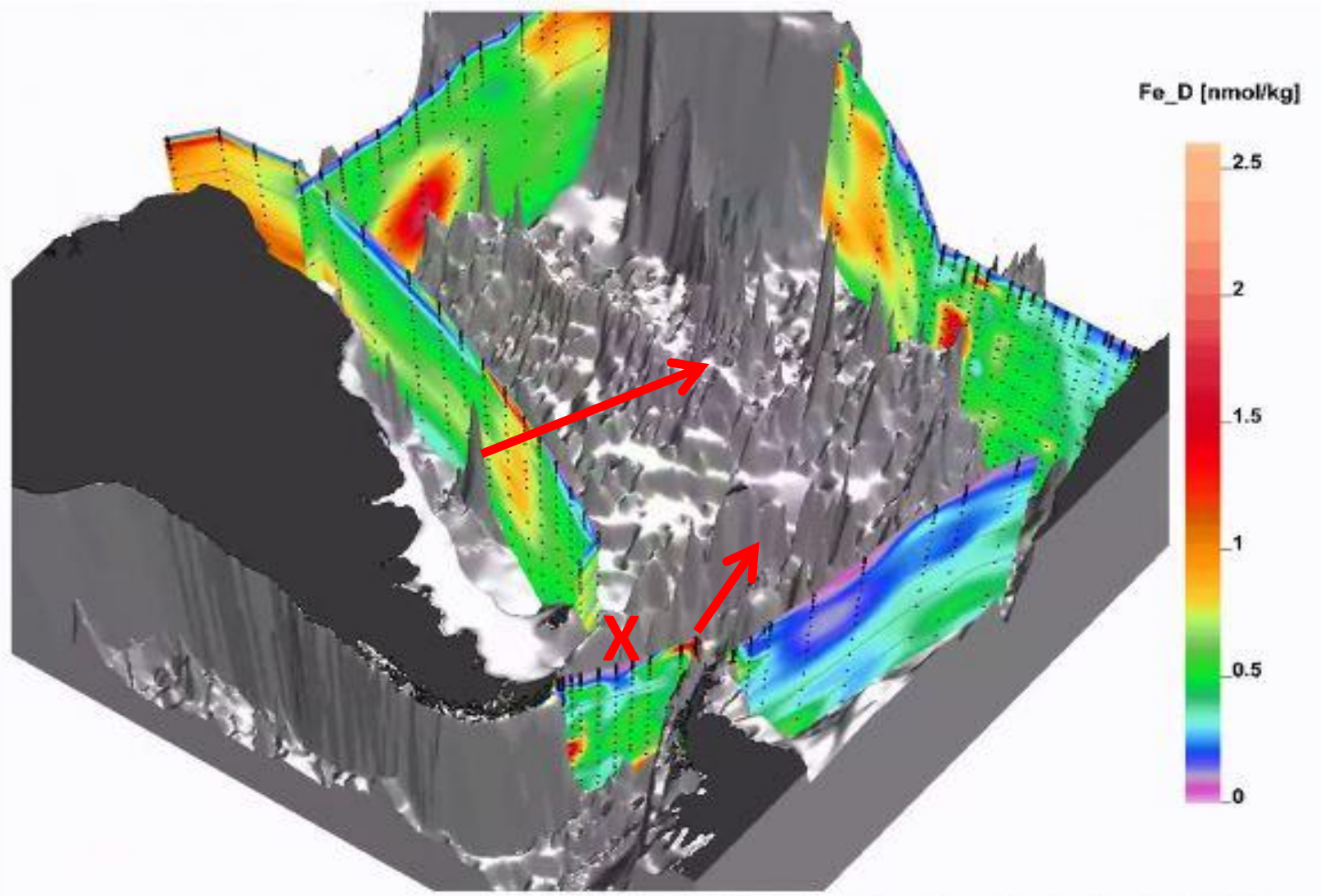
How can we constrain satellite estimates??

SOCCOM bioArgo NO_3, O_2

Atmospheric O_2

What are values in winter?





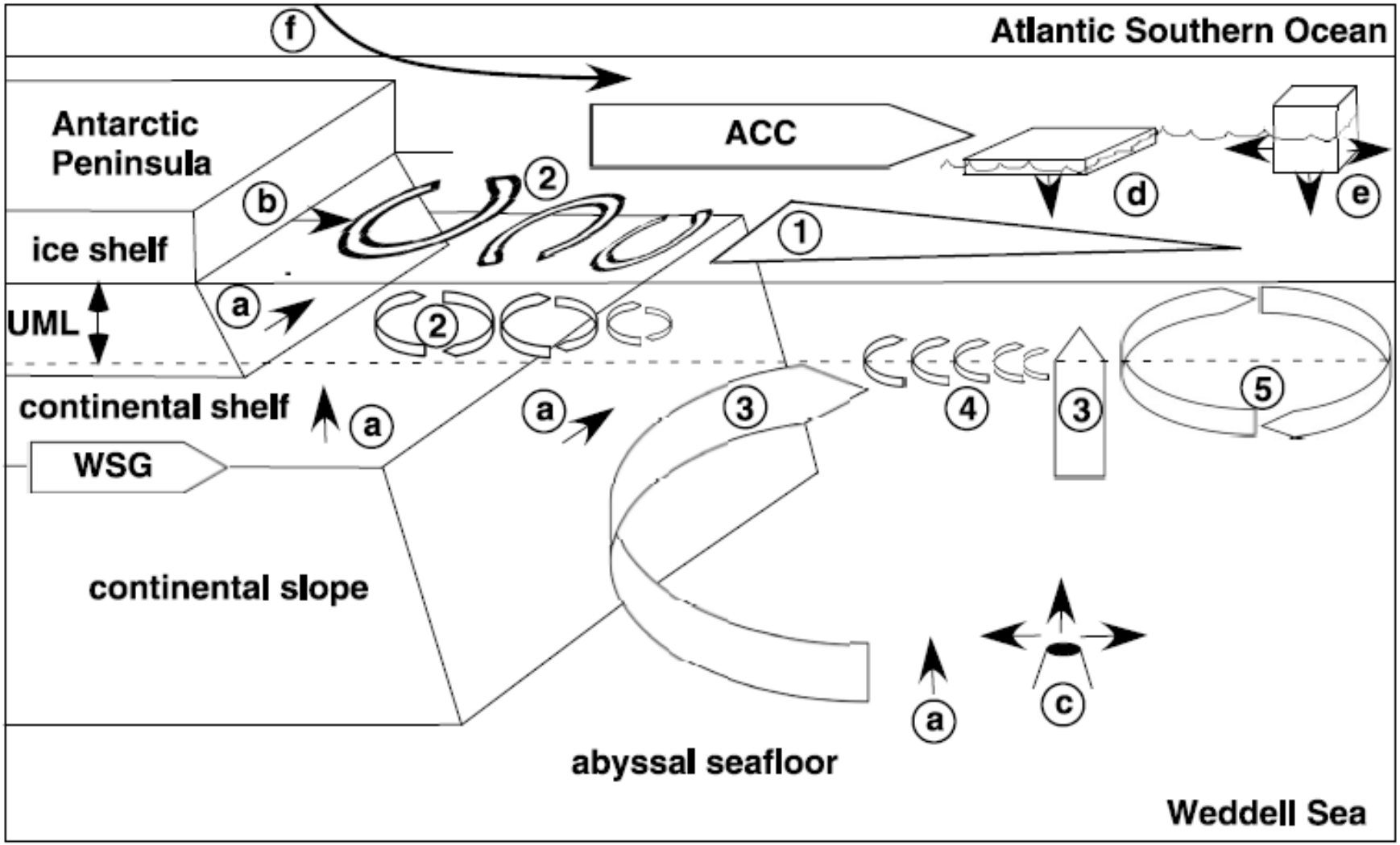
GEOTRACES

Data: Hein de Baar, Fanny Chever, Maarten Klunder, Patrick Laan, Francois Lacan, Abigail Noble, Micha Rijkenberg, Mak Saito, Geraldine Sarthou

Graphics: Reiner Schlitzer

Southern Ocean Fe Budgets – Atlantic Sector

Conceptual – MUST BE QUANTIFIED



De Jong et al. JGR 2012

Major Questions and Uncertainties

Ice sheets are retreating / collapsing

- How will this affect bouyancy and glacial Fe supply?

Westerly winds increasing , ocean is warming

- How will this affect mixing?
- How does temperature affect NPP, respiration?

Sea ice expanding some areas, retreating in others

- How does this affect light and NPP?

Ocean pH is getting lower, ocean more acidic

- How does pH affect Fe solubility, ecosystem structure?

Iron the main regulator?? Views on Fe supply in the Southern Ocean are evolving from dust-centric perspective to recognition of additional sedimentary, hydrothermal, cyrospheric sources

- *Relative impact of different sources on carbon export?*
- *Future trajectory of cryospheric Fe source?*
- *Climate change impacts on sedimentary, dust*
- *Controls on Fe recycling?*
- *In situ Fe chemistry?*

NPP, NCP Satellite
From forward models

Conservation of
Mass Constraint

APOncp
Atmospheric Gases
e.g Nevison et al. 2012

CO_2, O_2, N_2O,

fixation of C, N
by phytoplankton

grazing

respiraton

excretion

Floats - Physical
Biogeochemical
ARGO SOCCOM
e.g. Alkire et al. 2012

Physical mixing DOC
N,P, Si, Fe

egestion

aggregate
formation

break up

Lateral
advection

Base of euphotic zone

Depth of winter mixing

active
vertical migration

passive
sinking of
POC, PIC

consumption,
repackaging

(zooplankton)

respiration

excretion

decomposition

(bacteria)

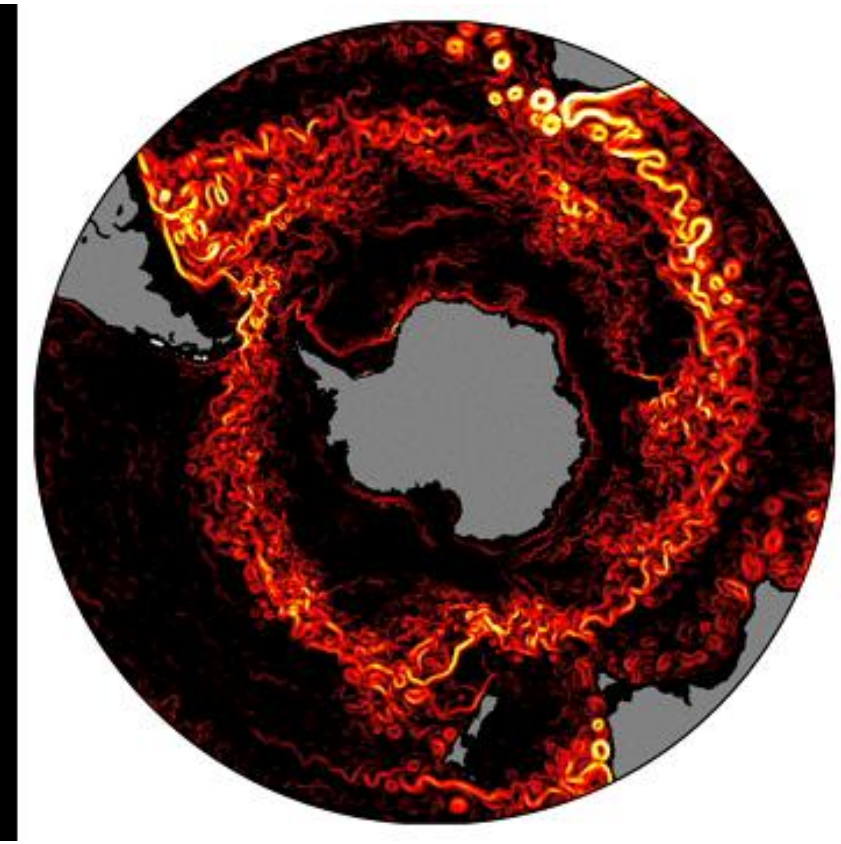
Seabed

ICESOCC co-Investigators

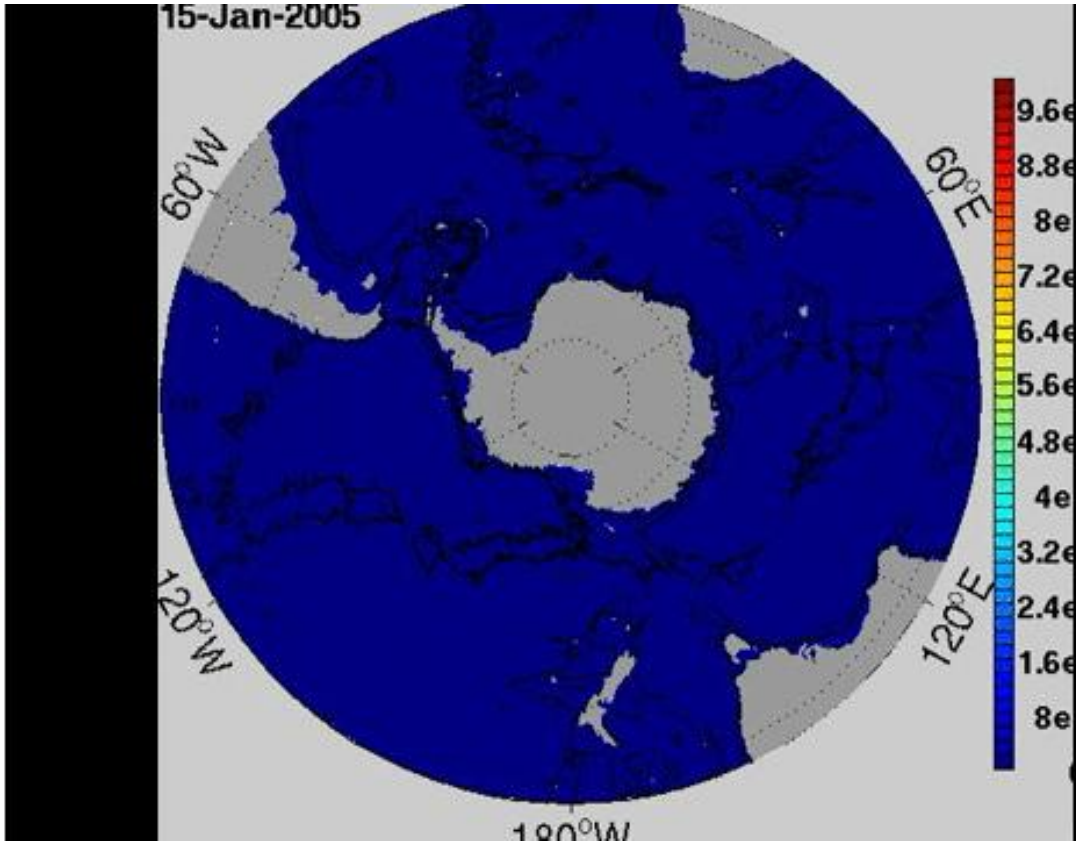
CO-I	INSTITUTION	EXPERTISE
Arrigo, K.	Stanford	Plankton ecology, phytoplankton physiology, satellite remote sensing, lead author IOCCG Polar Algorithms NPP chapter
Barbeau, K.	SIO	Iron Biogeochemistry, GEOTRACES steering committee iron regulation of phytoplankton physiology
Boss, E.	Univ. of Maine	Ocean optics, optical sensors on SOCCOM floats, PACE IOP PI
Ducklow, H.	Columbia U.	Plankton ecology, bacterial processes, lead PI NSF Palmer LTER
Frouin, R.	SIO	Radiative transfer, atmospheric correction, surface radiation, clouds and ice, co-author IOCCG Polar Algorithms atmospheric corrections
Kahru, M	SIO	Bio-optical algorithms, satellite remote sensing
Keeling, R.	SIO	Air sea gas exchange, ocean and atmosphere biogeochemical modeling
Lee, Z.	U. Mass Boston	Radiative transfer, ocean optics inverse models, satellite remote sensing of ocean primary production
Mitchell, G	SIO	Chair ICESCOCC Steering Committee. Plankton ecology, phytoplankton physiology, satellite remote sensing co author IOCCG Polar Algorithms IOP/AOP and NPP chapters
Nevison, C	Univ. of Colo.	Air sea gas exchange, measurement and modeling of atmosphere N_2O
Reynolds, R.	SIO	Phytoplankton physiology, ocean optical properties, bio-optical modeling, lead author IOCCG Polar Algorithms IOP/AOP
Sarmiento, J.	Princeton U.	Ocean-atmosphere biogeochemistry, coupled models of ocean and atmosphere climate feedbacks. Lead PI for SOCCOM
Talley, L.	SIO	Physical oceanography, Southern Ocean convective mixing, co-Chair CLIVAR Southern Ocean Panel lead PI at SIO for SOCCOM

Southwest Atlantic / Patagonia Shelf ocean and iron dynamics: A major sediment source of iron? There remains a critical need to quantify different iron sources

Surface Velocity Fields
Princeton Hi-resolution model
Courtesy J. Sarmiento



Iron from Shelf Sediments
BLING embedded into SOSE
Courtesy A. Verdy, Matt Mazloff



Summary of Overall Plan: Improved models of NCP and Conservation of Mass Constraints on Satellite Forward Models

Intensive Field Campaign with ships

- Build upon EXPORTS framework
- NASA, NSF, NOAA – interagency coordination
- Essential data to improve forward models ***ESPECIALLY IRON***

Extensive Field Campaign

- Bio-optical-ARGO SOCCOM. Improved inverse models
- Routine observations on science logistics transects, GEOTRACES
- Voluntary Observing Ships (VOS)

Extensive Atmospheric gases

- Expand time and space scales, atmosphere constrain ocean

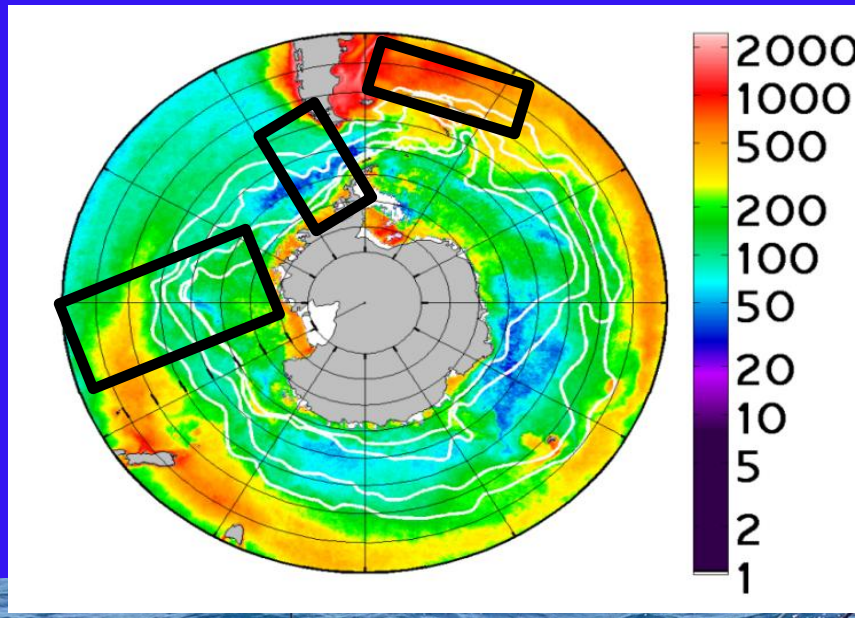
Extensive Models

- Atmosphere and Ocean transport coupled to ecosystem models

Satellites

- Synthesis of existing data
- Collection of new data
- Improved forward models

All require interdisciplinary, international coordination



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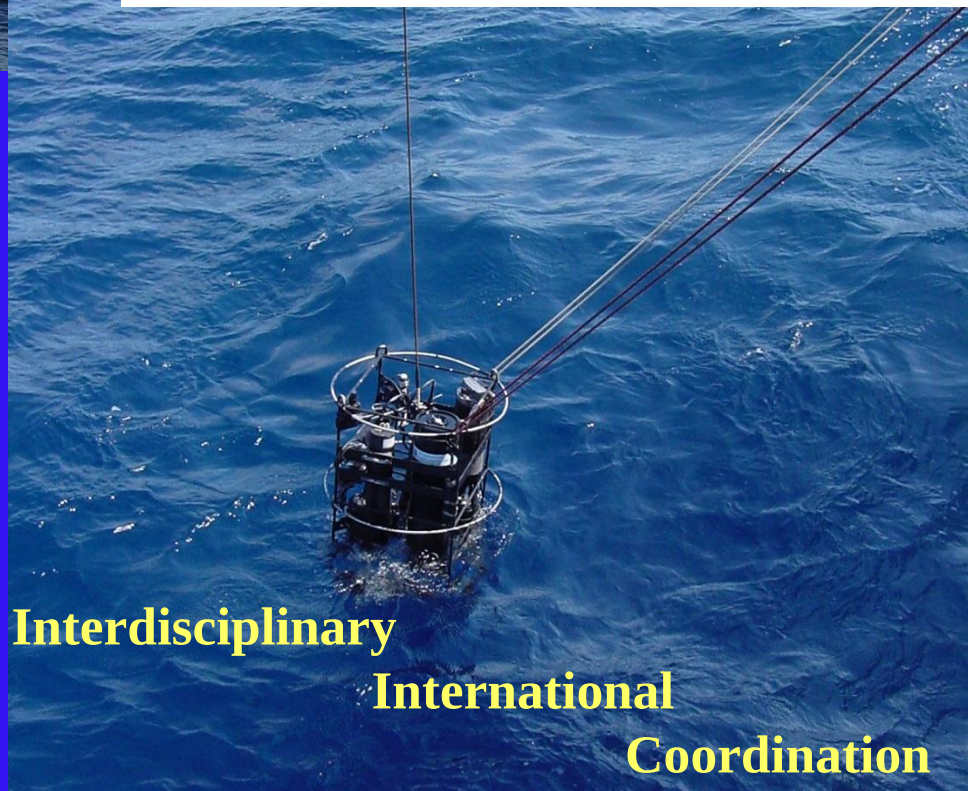
Thank you!



Interdisciplinary

International

Coordination