BIOGEOCHEMISTRY GROUP
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The coastal carbon cycle challenge

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Acknowledgements:

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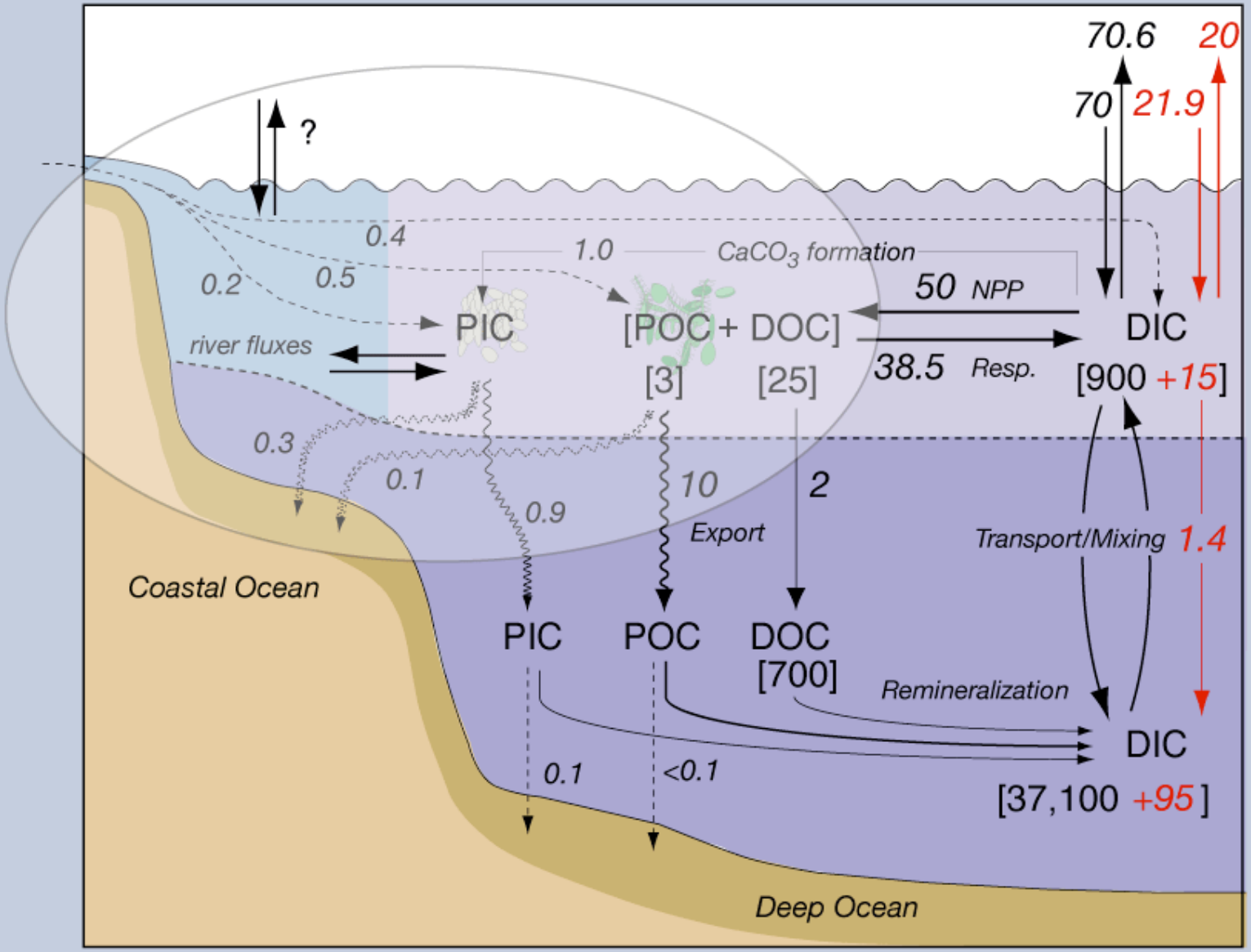
OUTLINE

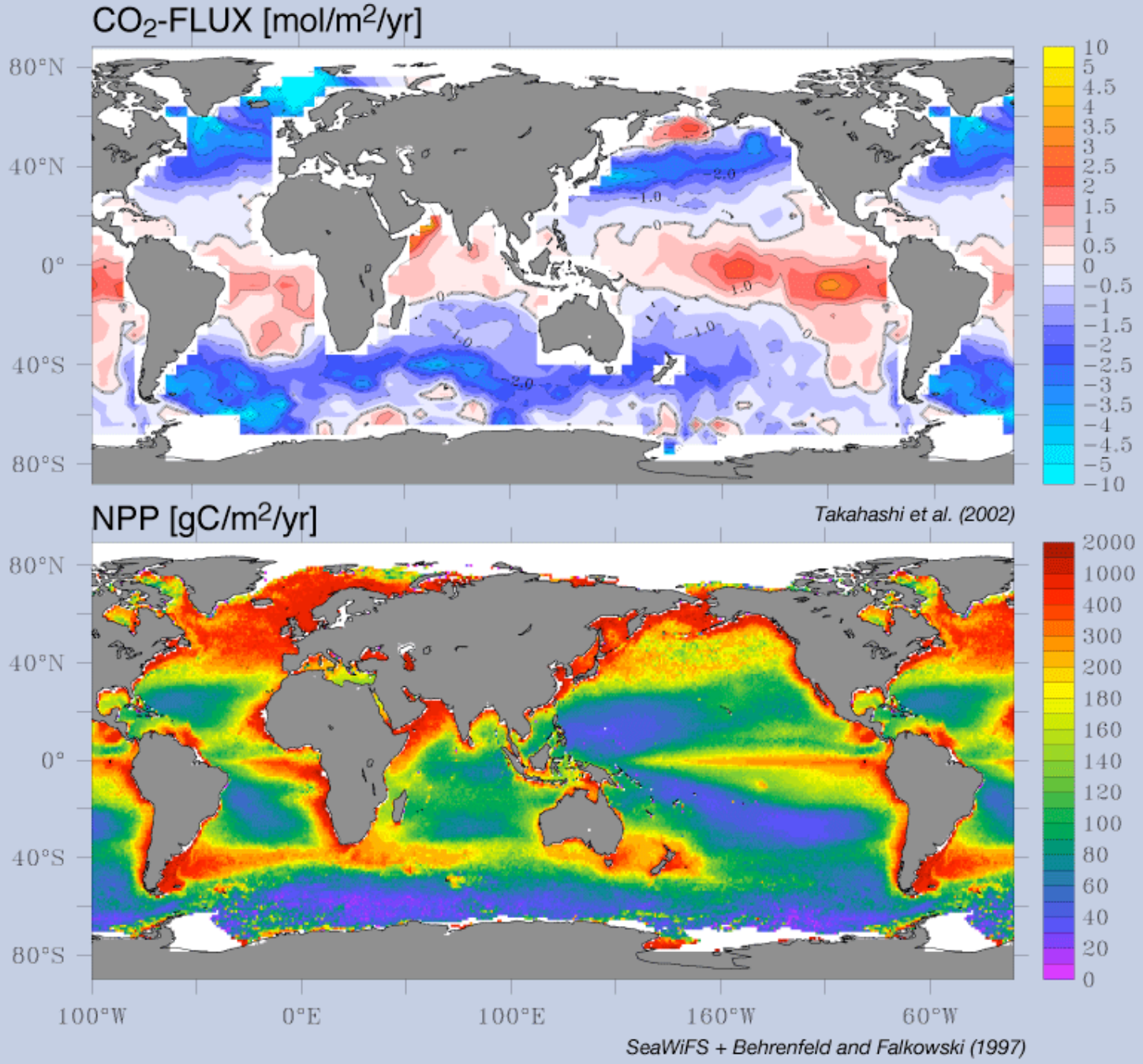
- The role of the contintental margins in the global carbon cycle
- Examples of the coastal carbon challenges:
  - *meso- and submesoscale processes*
  - *diurnal cycle*
  - *surprises*
- How to address these challenges?

OCEAN CARBON BUDGET

AND ITS ANTHROPOGENIC PERTURBATION



Sabine et al. (2004)

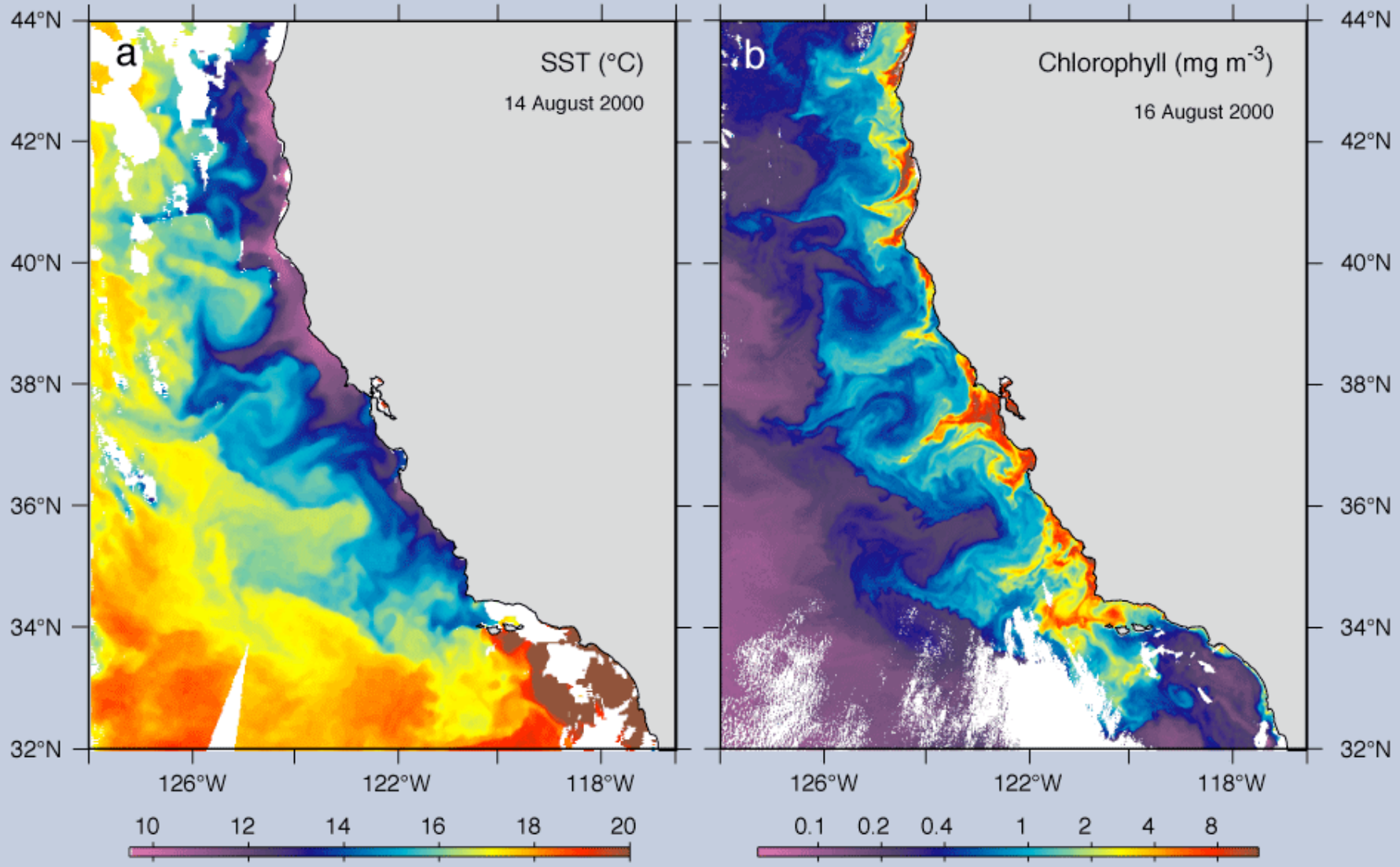

CO2-FLUX [mol/m2/yr]
80°N
40°N
0°
40°S
80°S
10
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
−0.5
−1
−1.5
−2
−2.5
−3
−3.5
−4
−4.5
−5
−10
Takahashi et al. (2002)
NPP [gC/m2/yr]
2000
1000
400
300
200
180
160
140
120
100
80
60
40
20
0
100°W
0°E
100°E
160°W
60°W
SeaWiFS + Behrenfeld and Falkowski (1997)

CHALLENGES

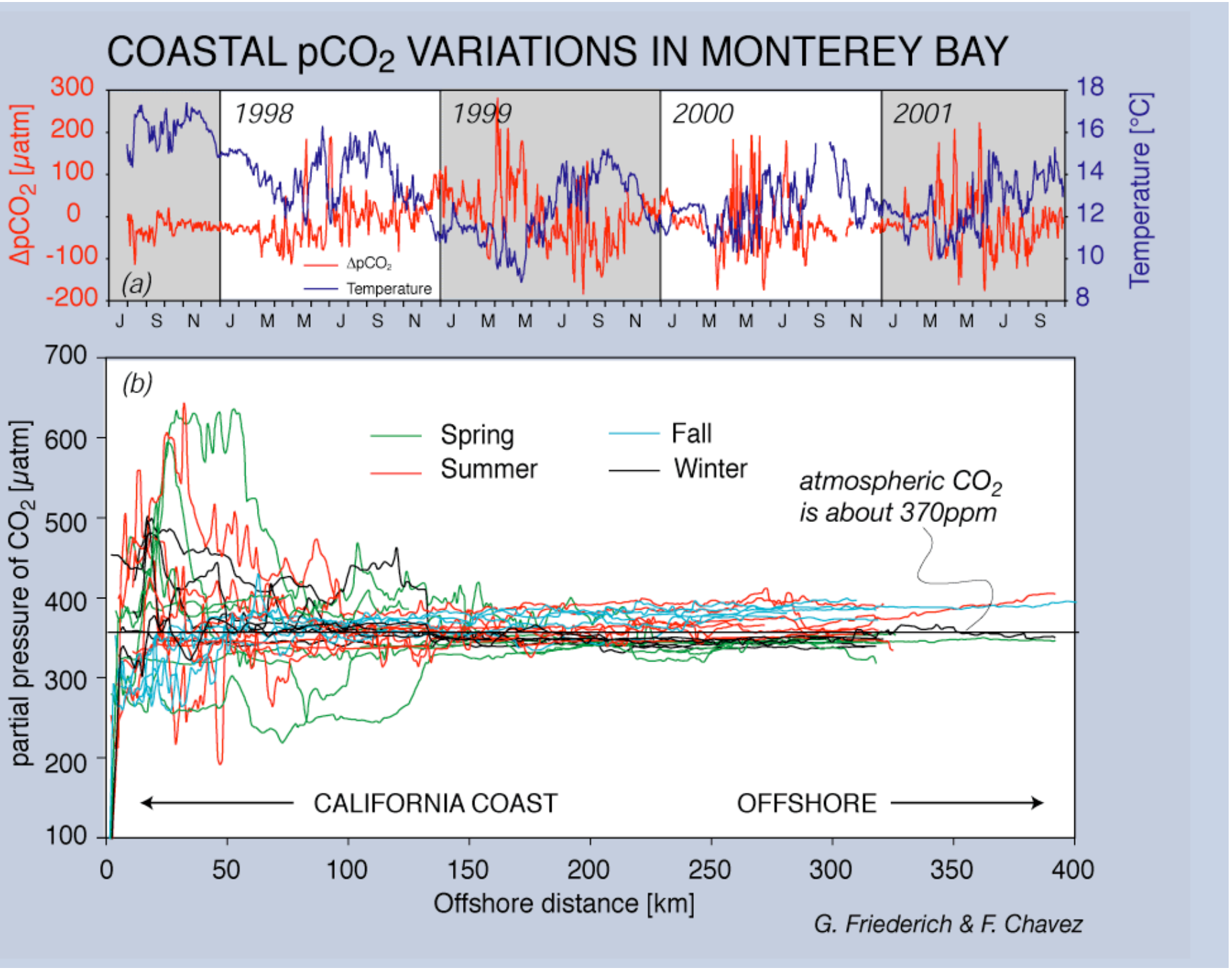
- Examples of the coastal carbon challenges:

1. *meso- and submesoscale processes*
2. *diurnal cycle*
3. *Surprises*

Co-VARIANCE OF SST AND CHLOROPHYLL

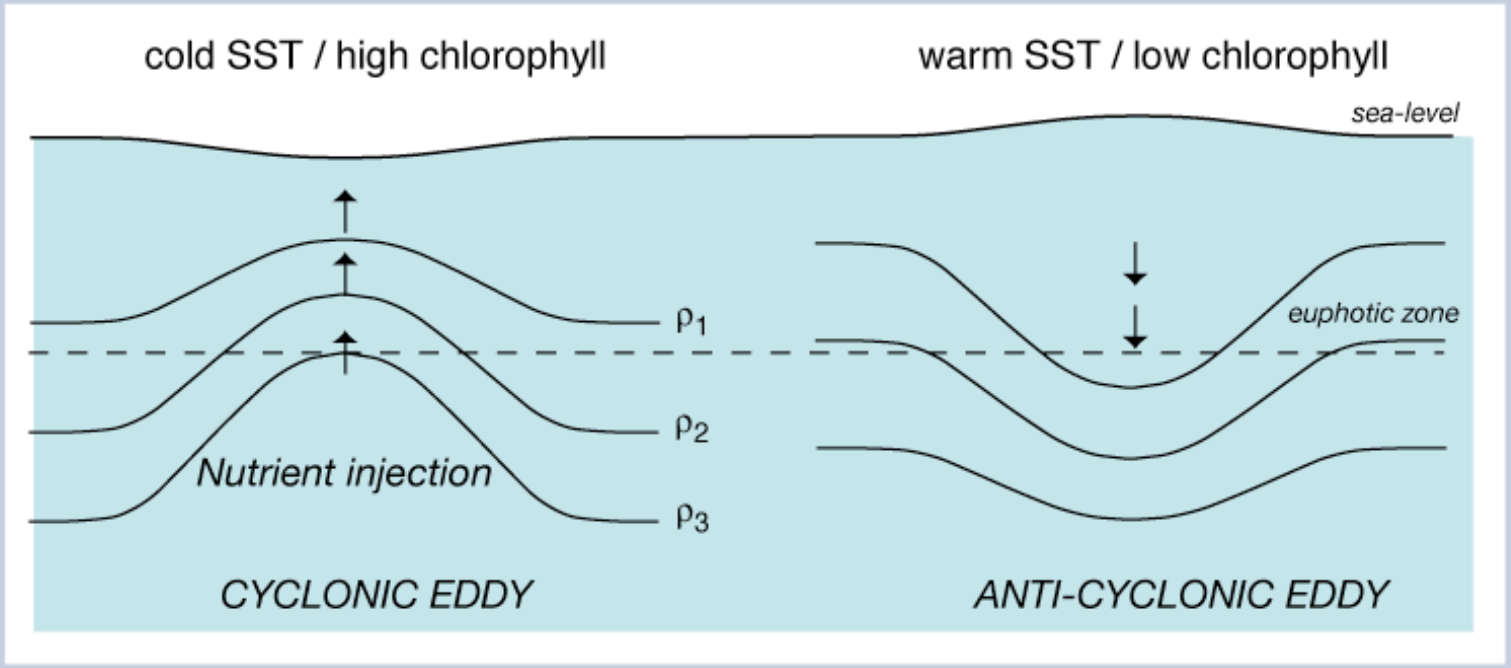


John Ryan, MBARI


COASTAL pCO2 VARIATIONS IN MONTEREY BAY
ΔpCO2 [μatm]
Temperature [°C]
1998
1999
2000
2001
(a)
ΔpCO2
Temperature
J S N J M M J S N J M M J S N J M M J S N J M M J S
(b)
partial pressure of CO2 [μatm]
Spring
Summer
Fall
Winter
atmospheric CO2
is about 370ppm
CALIFORNIA COAST
OFFSHORE
Offshore distance [km]
G. Friederich & F. Chavez

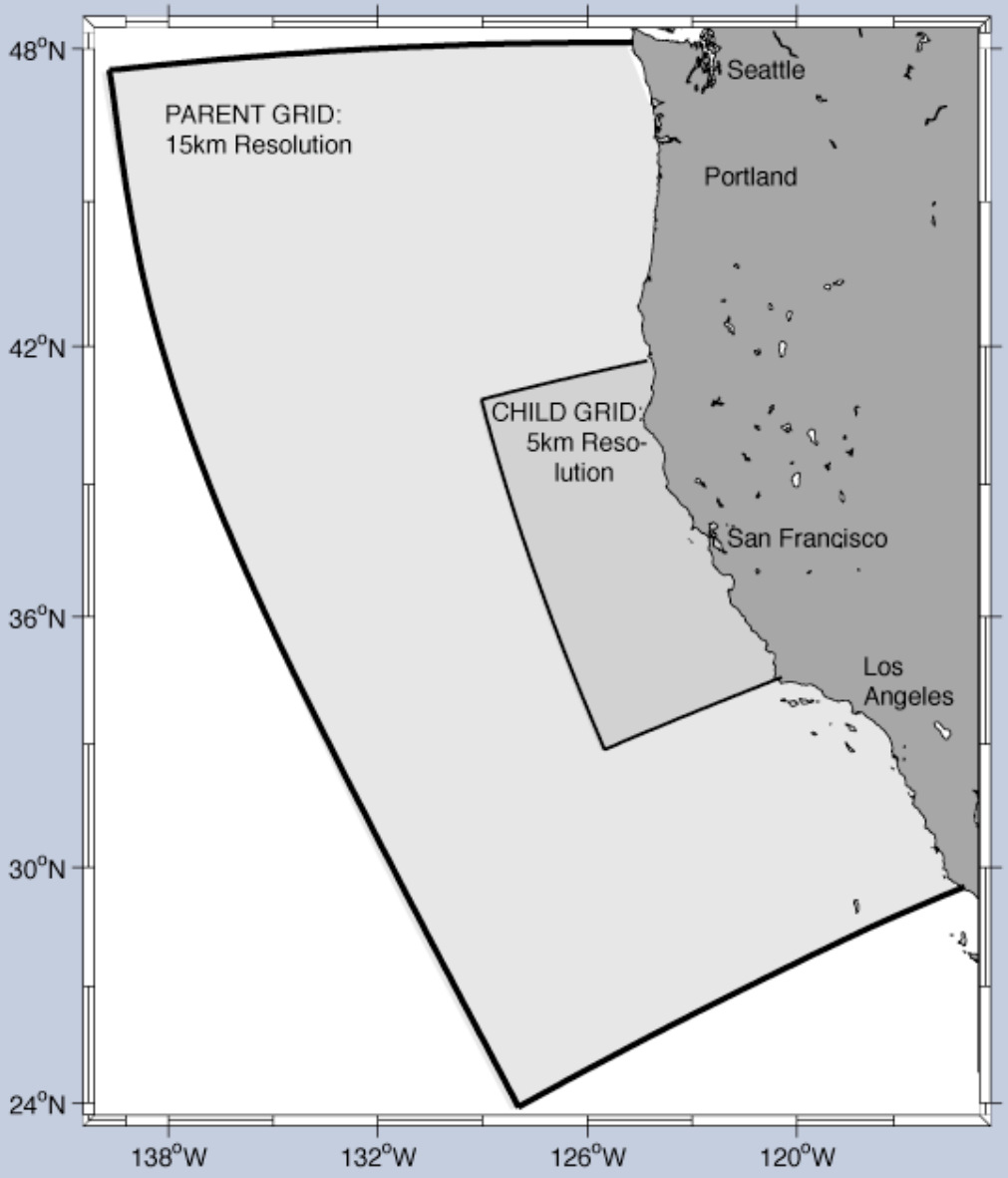
THE PREVAILING "PARADIGM"

Meso- and submesoscale processes increase oceanic productivity as they tend to increase the net flux of nutrients into the euphotic zone
(as a result of a "rectification" effect)



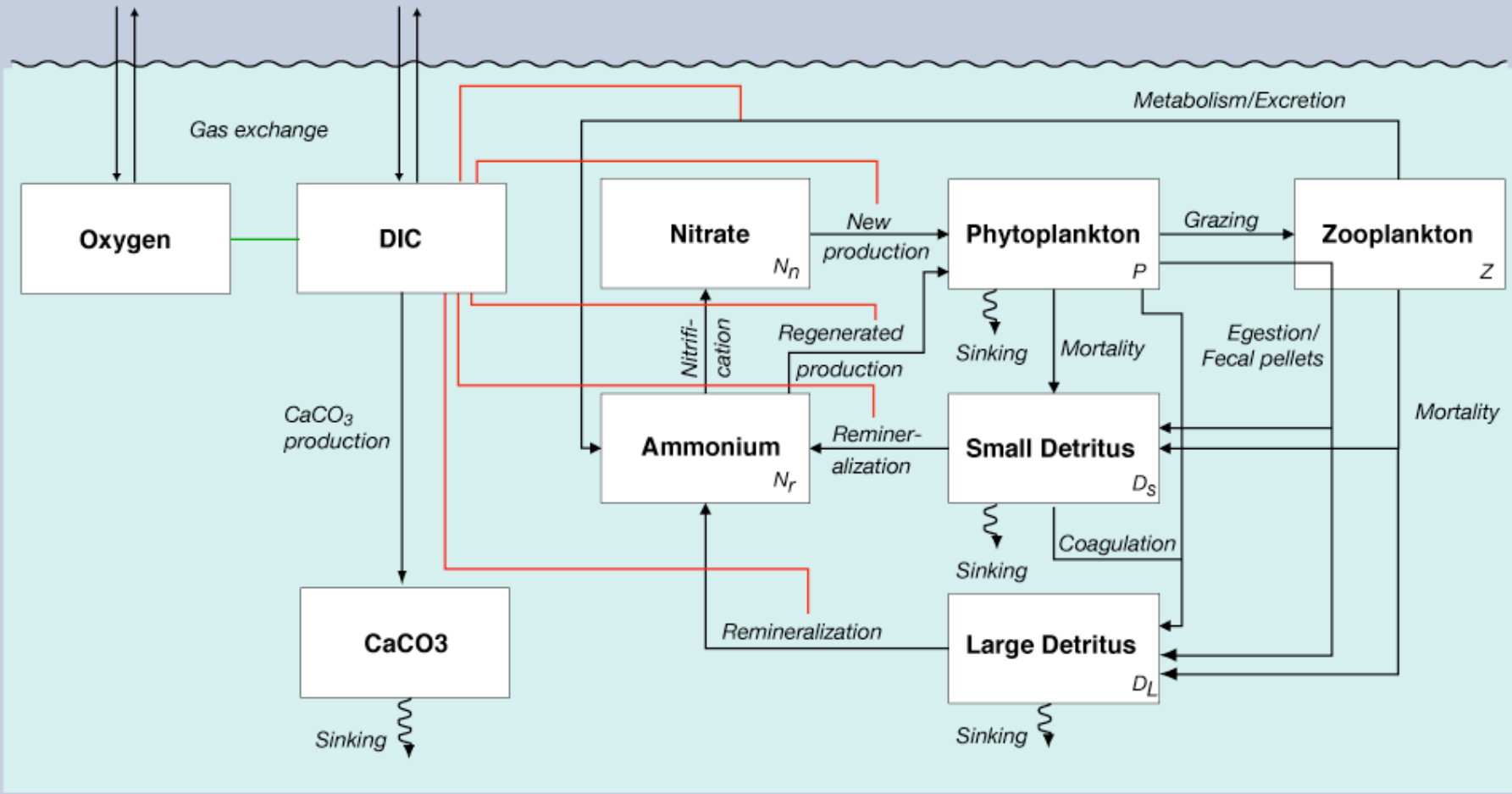
adapted from McGillicuddy et al. (1998)

REGIONAL OCEAN MODELING SYSTEM

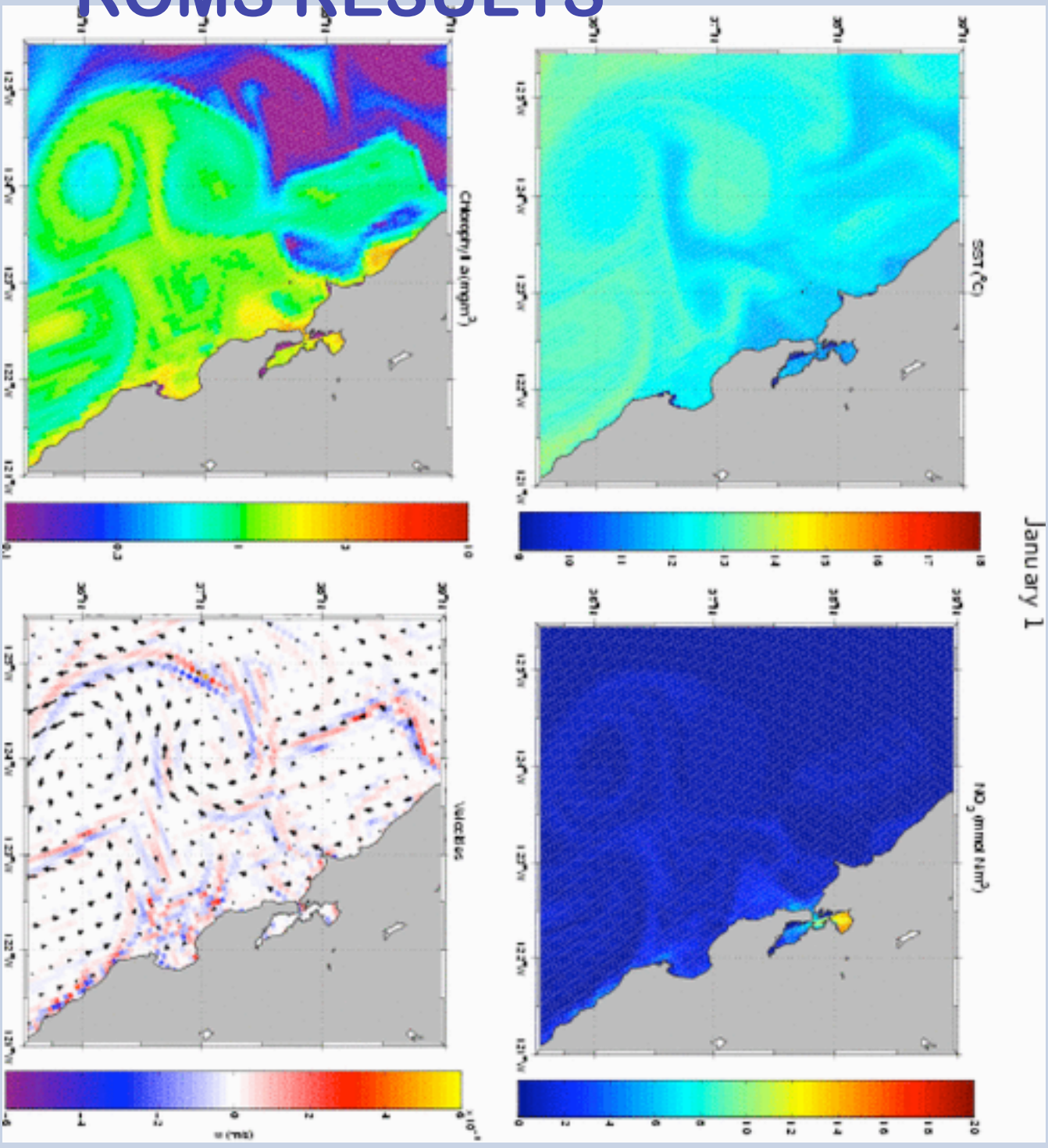


- Sigma-layer model (20 layers)
- Evolutionary descendent of SCRUM
- Improved numerics, boundary conditions, parallelization, and embedding capabilities
- Our simulations here use climatological forcing (WOA01 for T,S; COADS for winds)

STATE-VARIABLES AND PROCESSES OF ECOSYSTEM/BIOGEOCHEMICAL MODEL

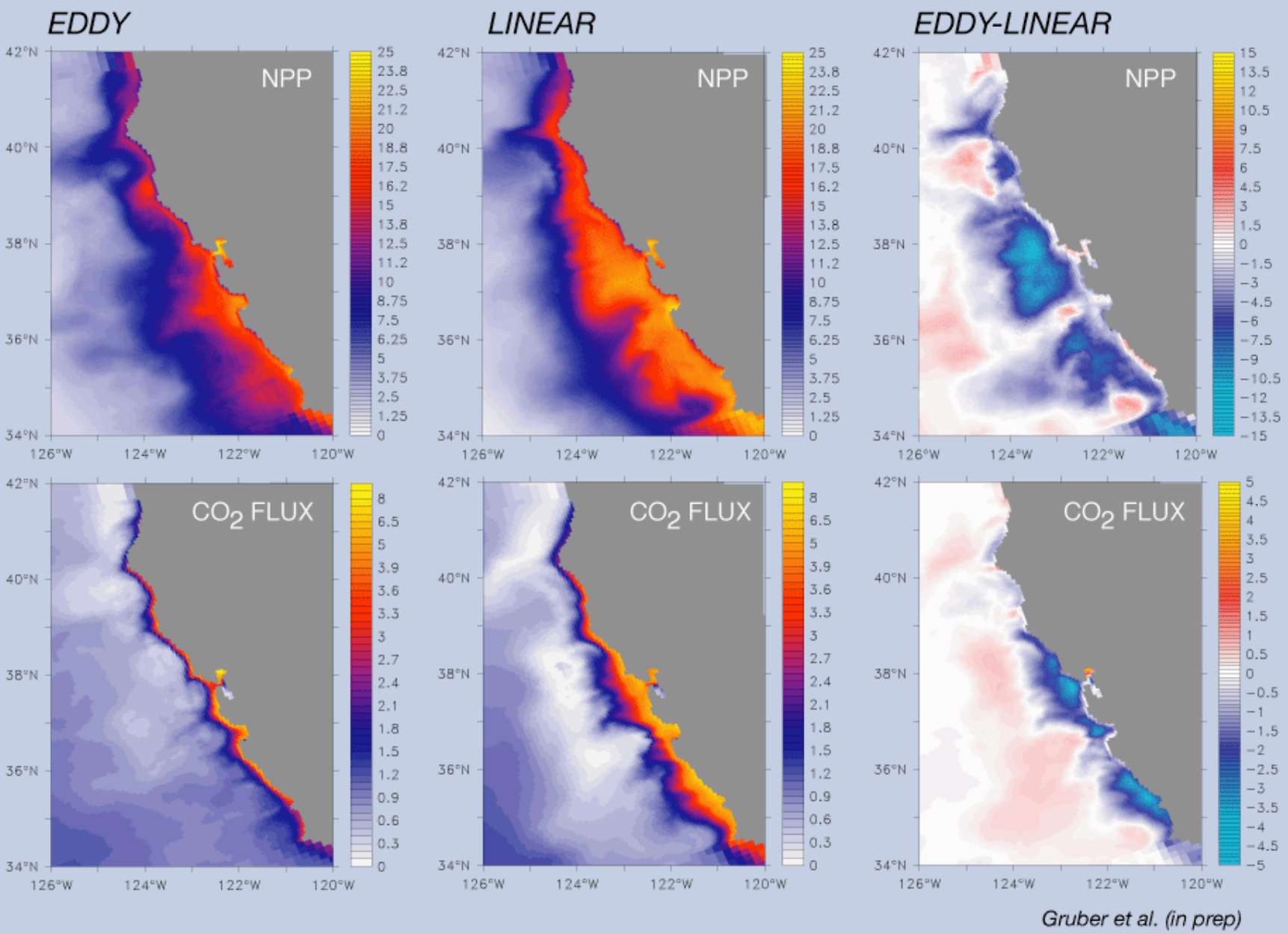


ROMS RESULTS



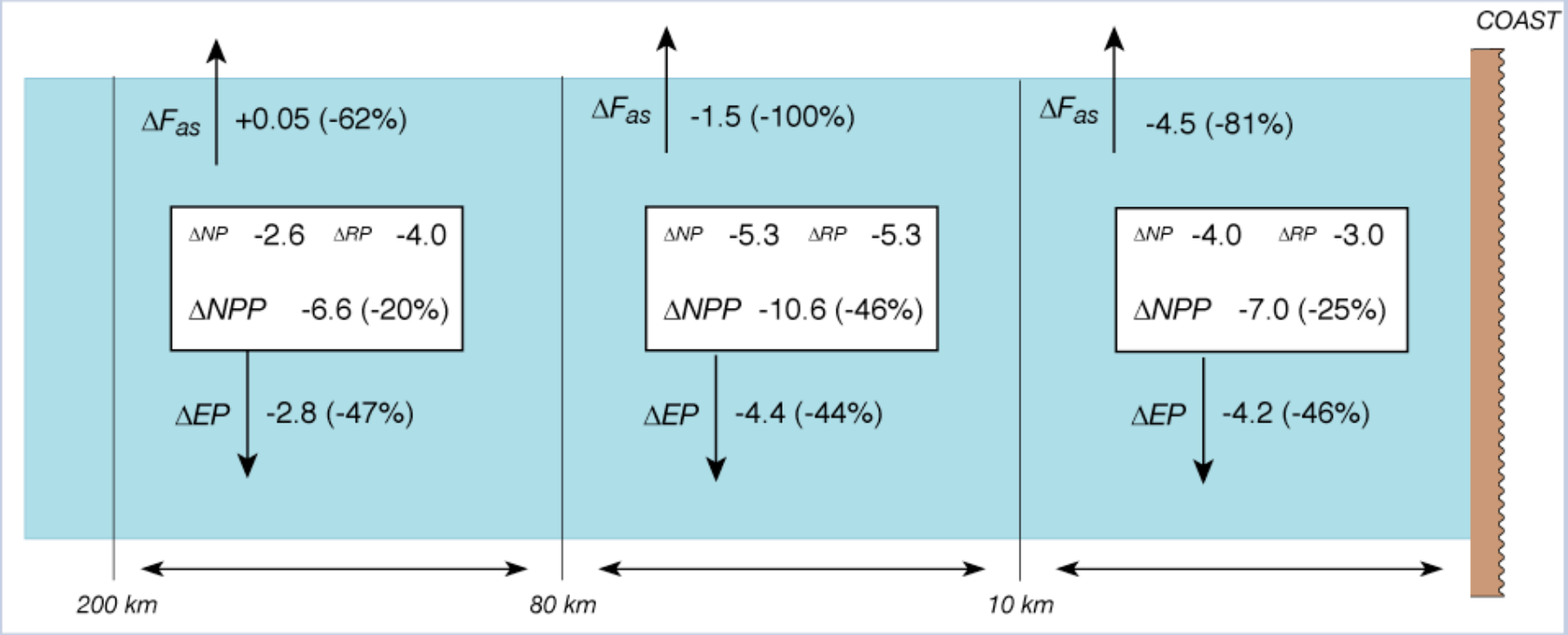
15+5 km nested simulations

IMPACT OF MESO-SCALE PROCESSES



Gruber et al. (in prep)

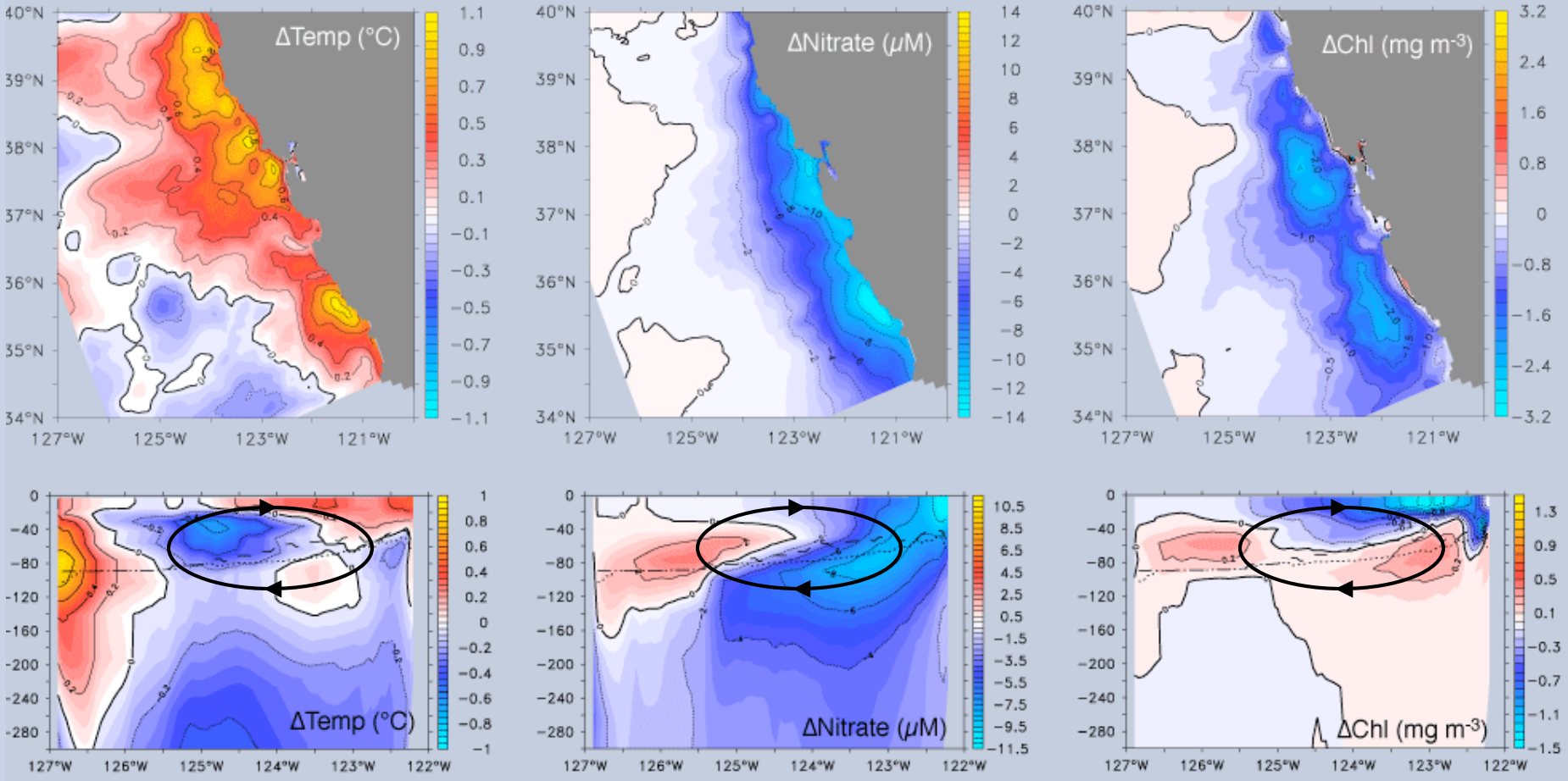
CARBON BUDGETS: DIFFERENCE EDDY-LINEAR



Fluxes: mol C m^{-2} y^{-1}

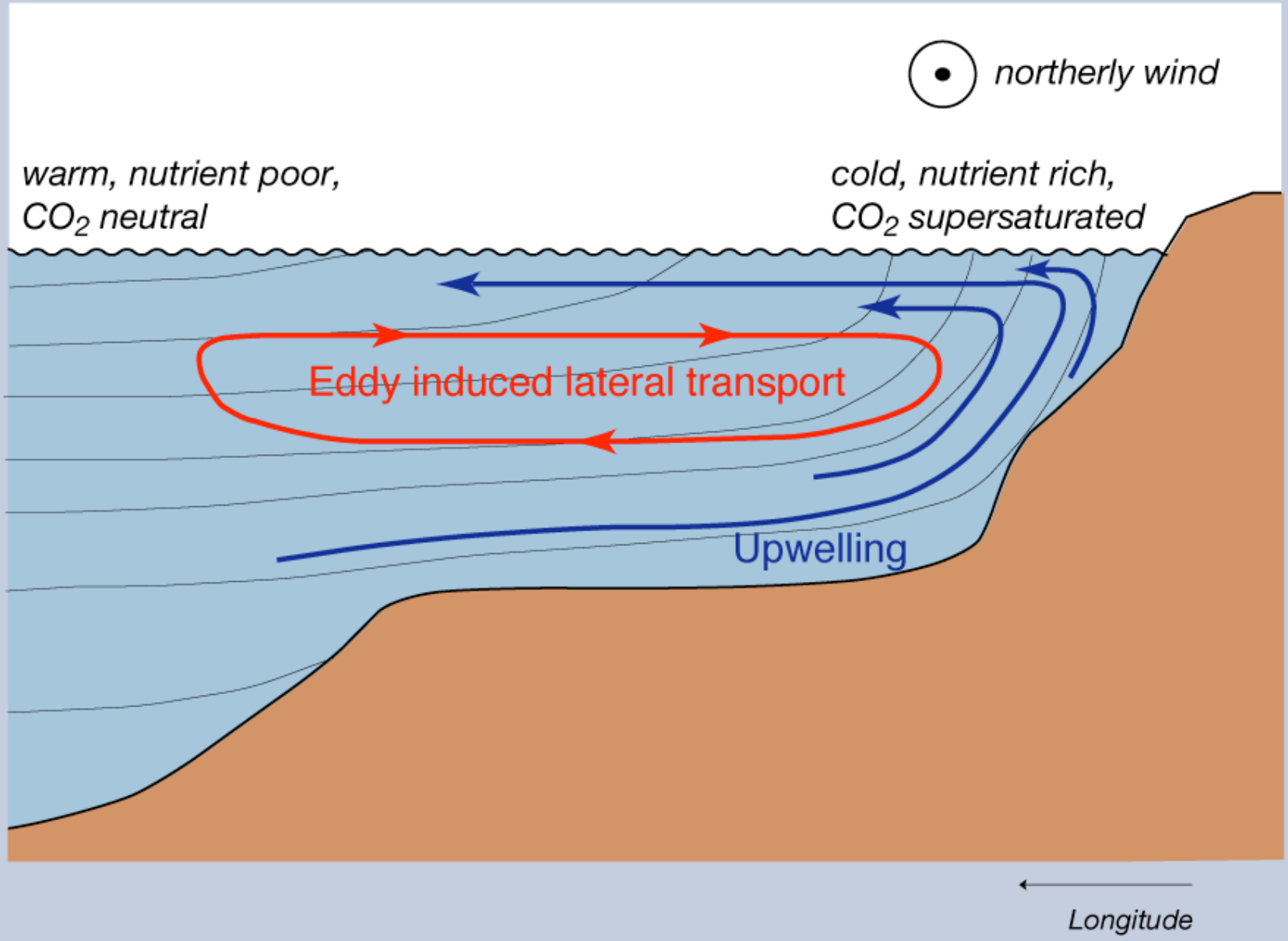
plotted are differences: Eddy-Linear

DIFFERENCES EDDY-LINEAR



Eddy induced anomalous circulation

IMPACT OF MESOSCALE PROCESSES



CHALLENGES

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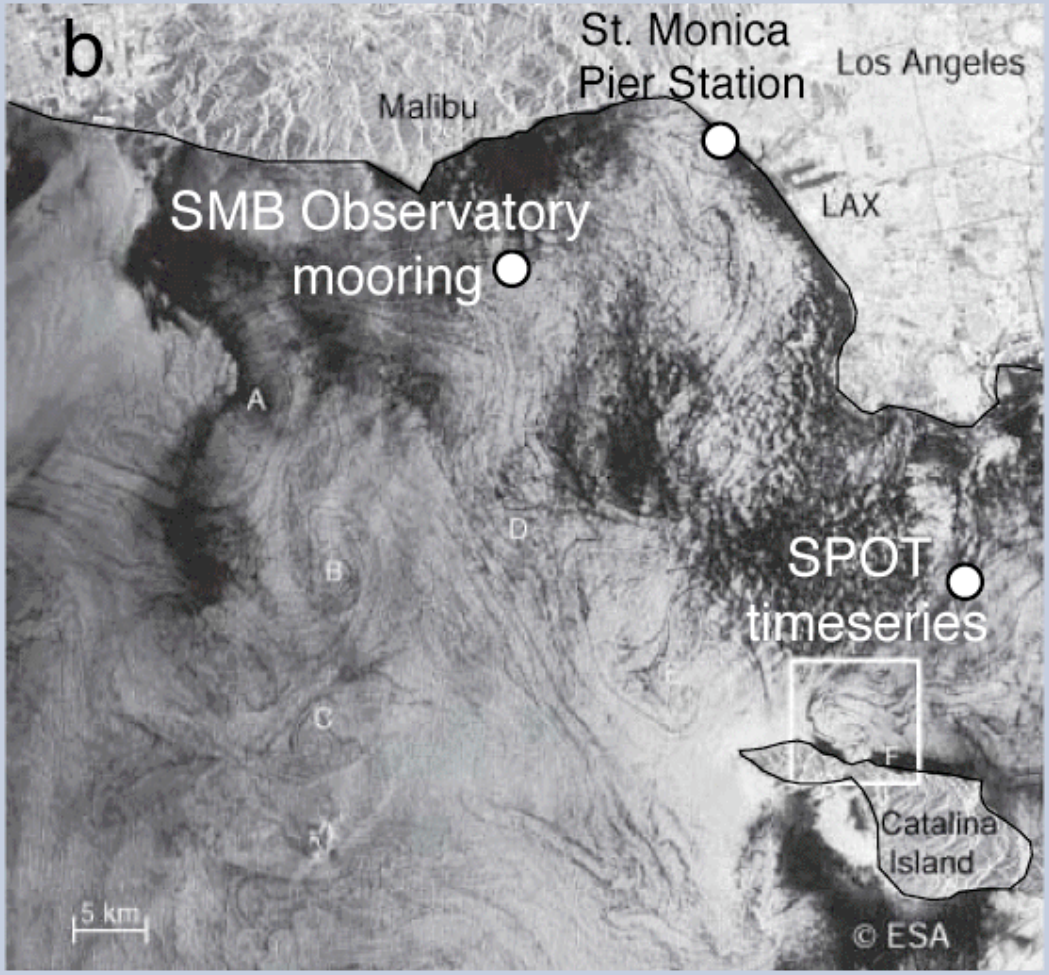
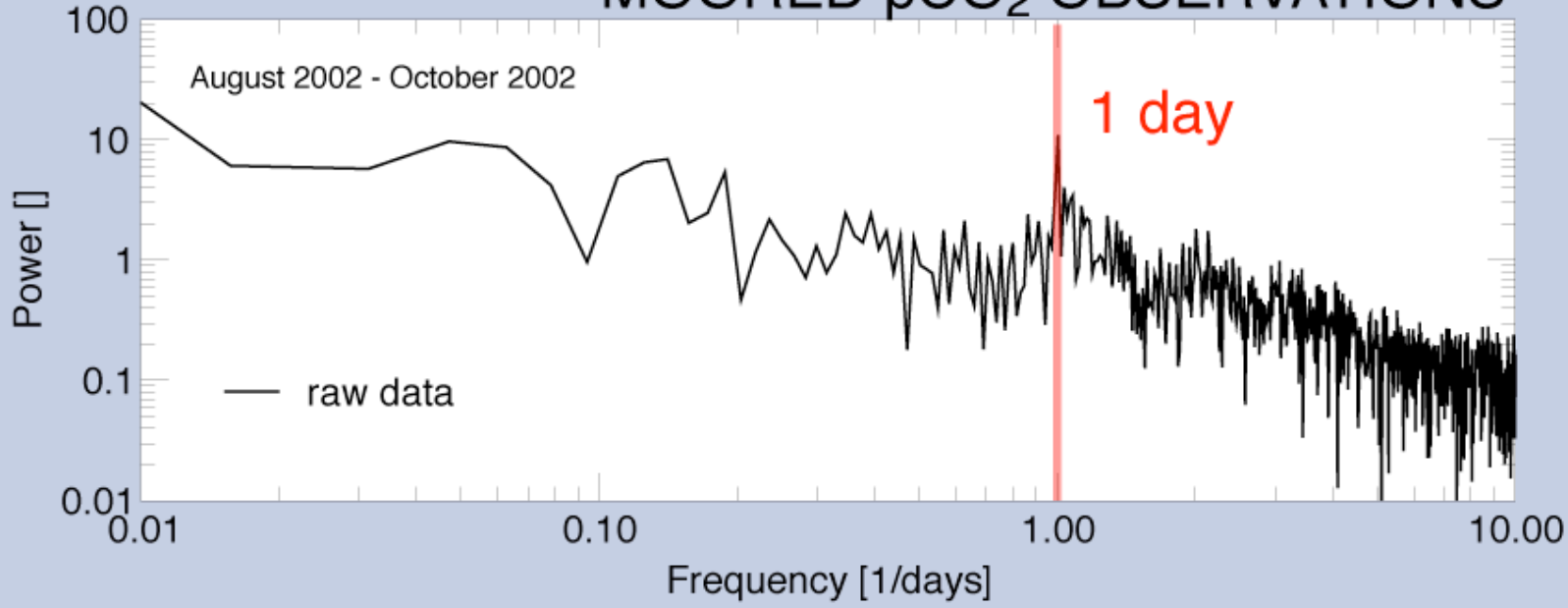
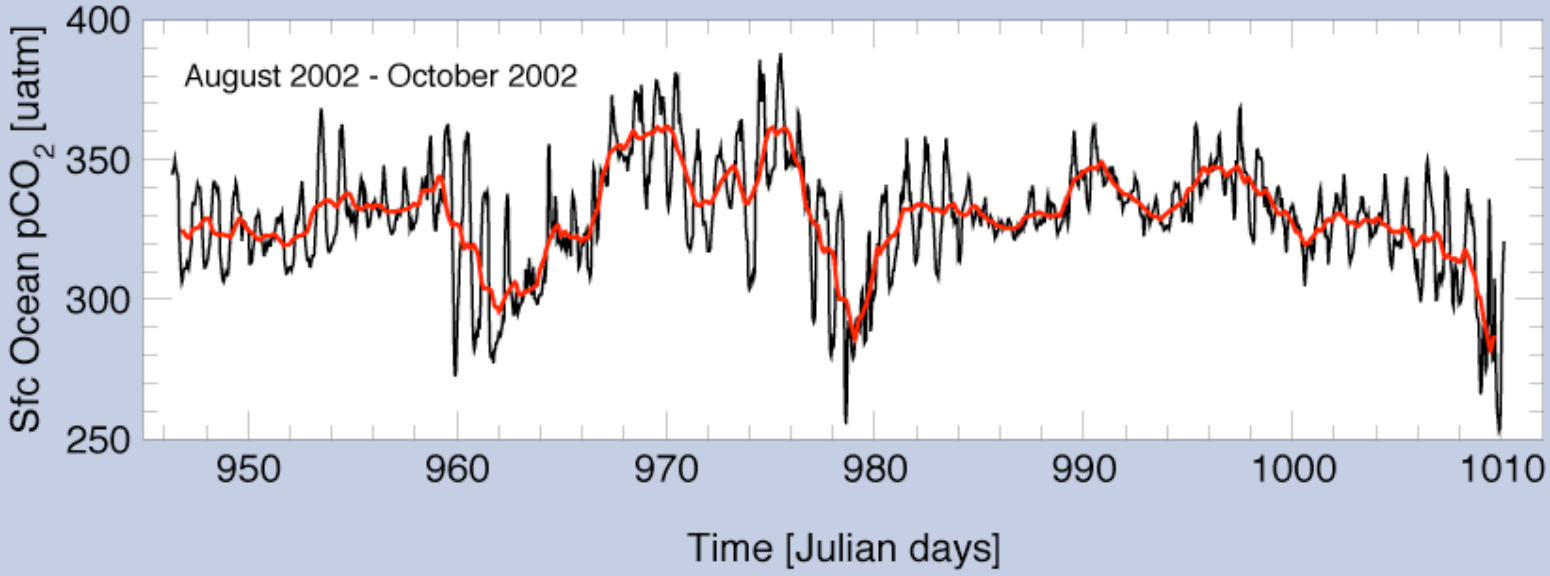
SANTA MONICA BAY OBSERVATORY



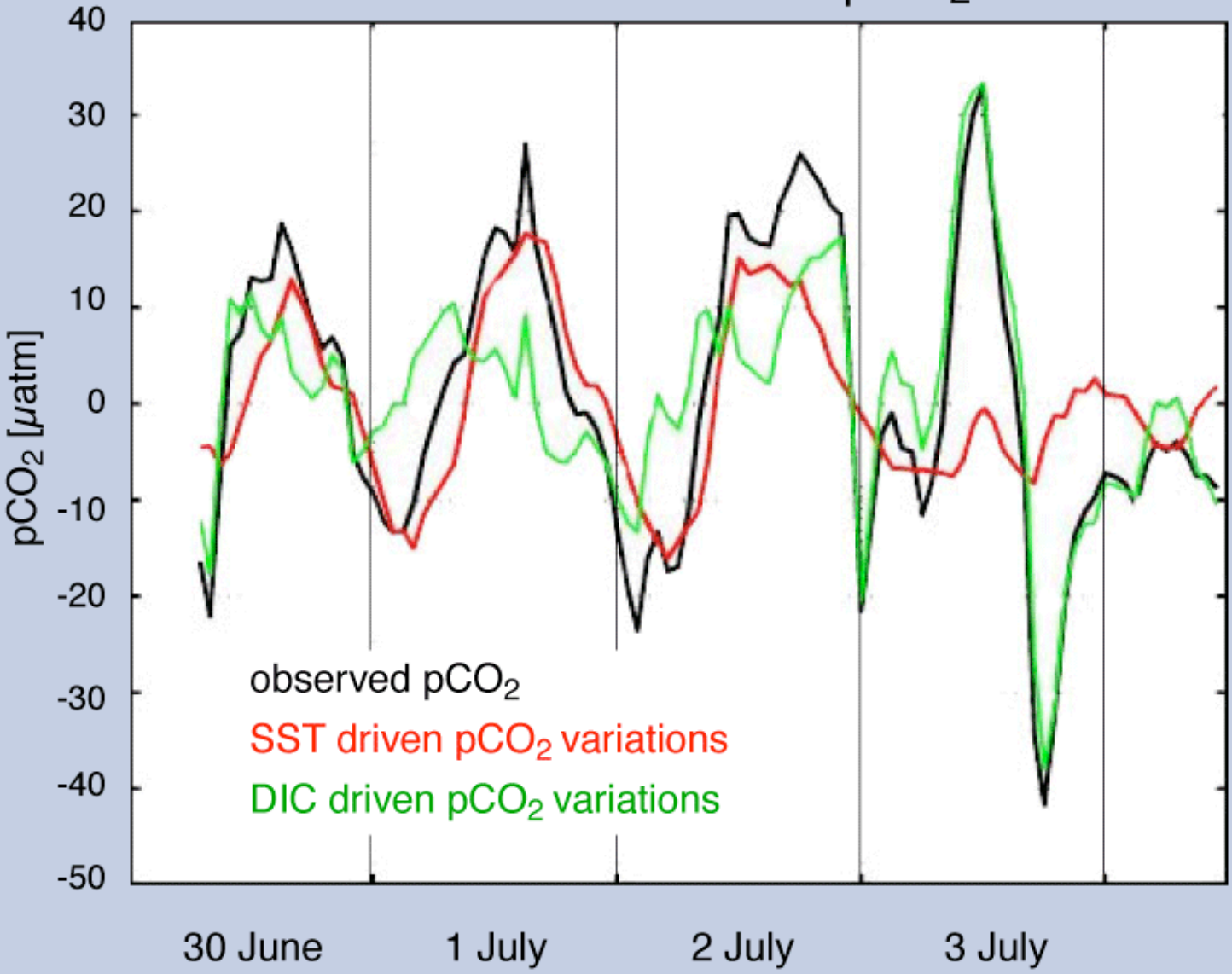
SANTA MONICA BAY OBSERVATORY: MOORED pCO_2 OBSERVATIONS





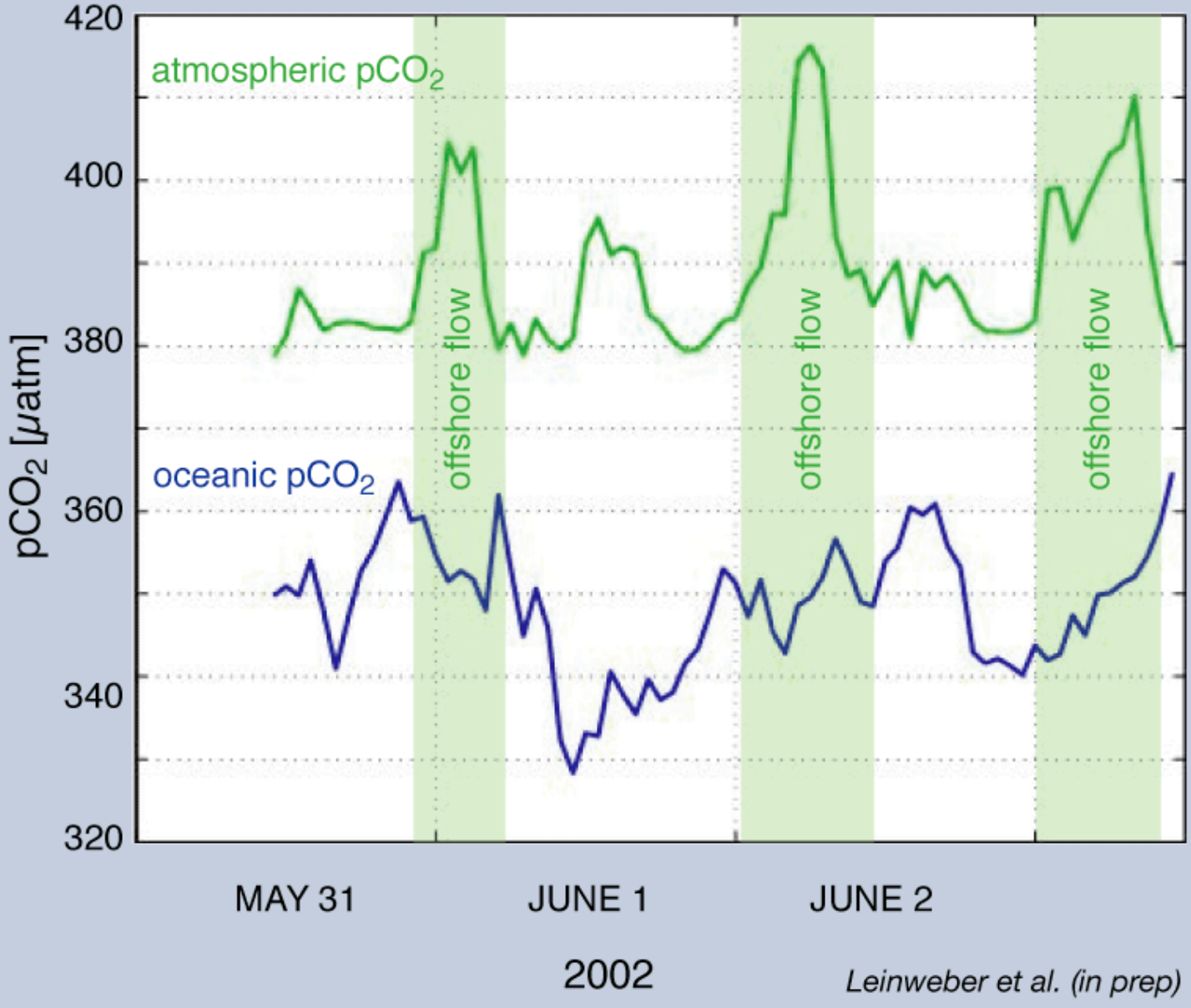
Leinweber et al. (in prep)

SANTA MONICA BAY OBSERVATORY:
pCO_2 DRIVERS



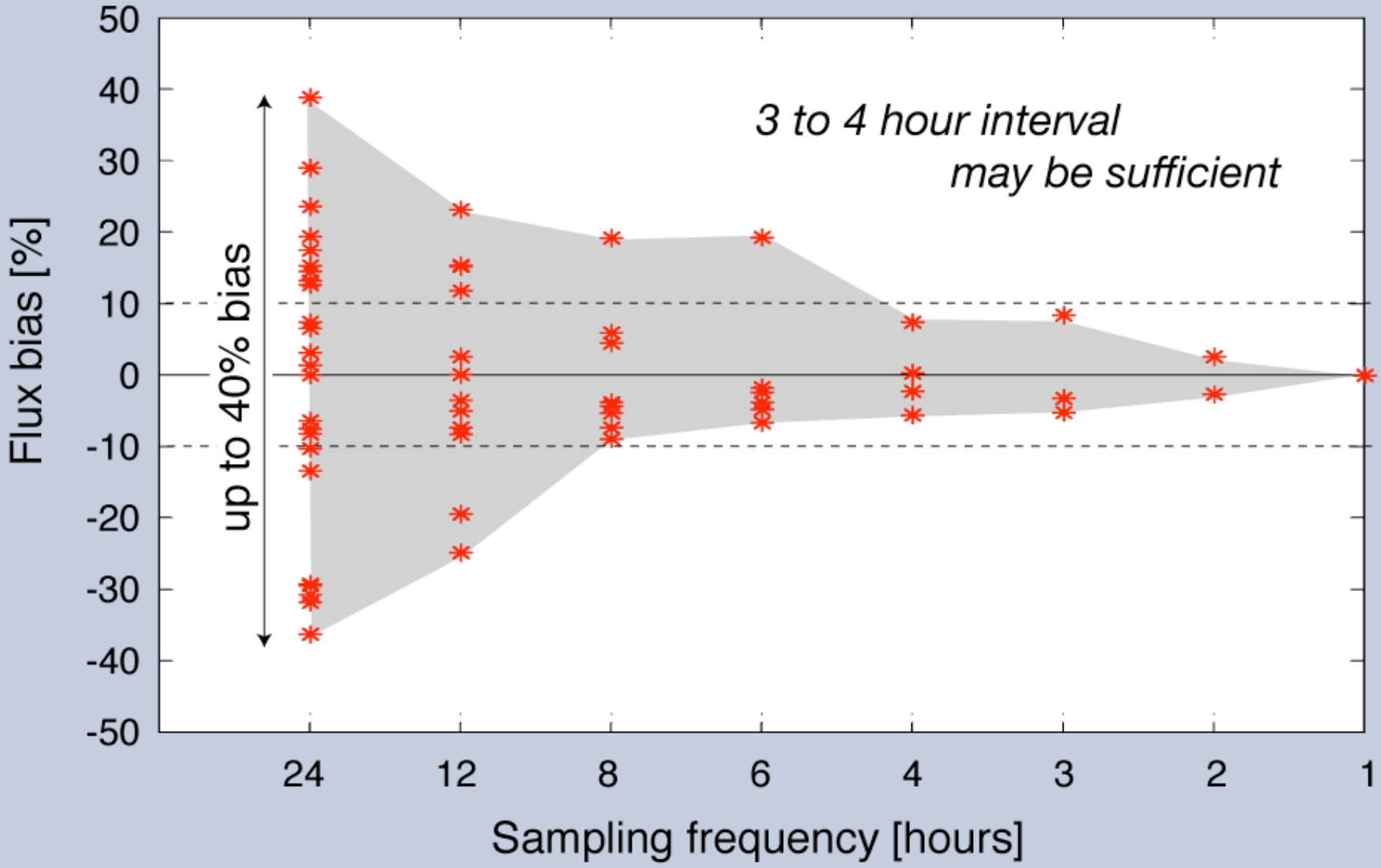
Leinweber et al. (in prep)

SANTA MONICA BAY OBSERVATORY: ATMOSPHERIC AND OCEANIC pCO_2



Leinweber et al. (in prep)

REQUIRED SAMPLING FREQUENCY?



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CHALLENGES

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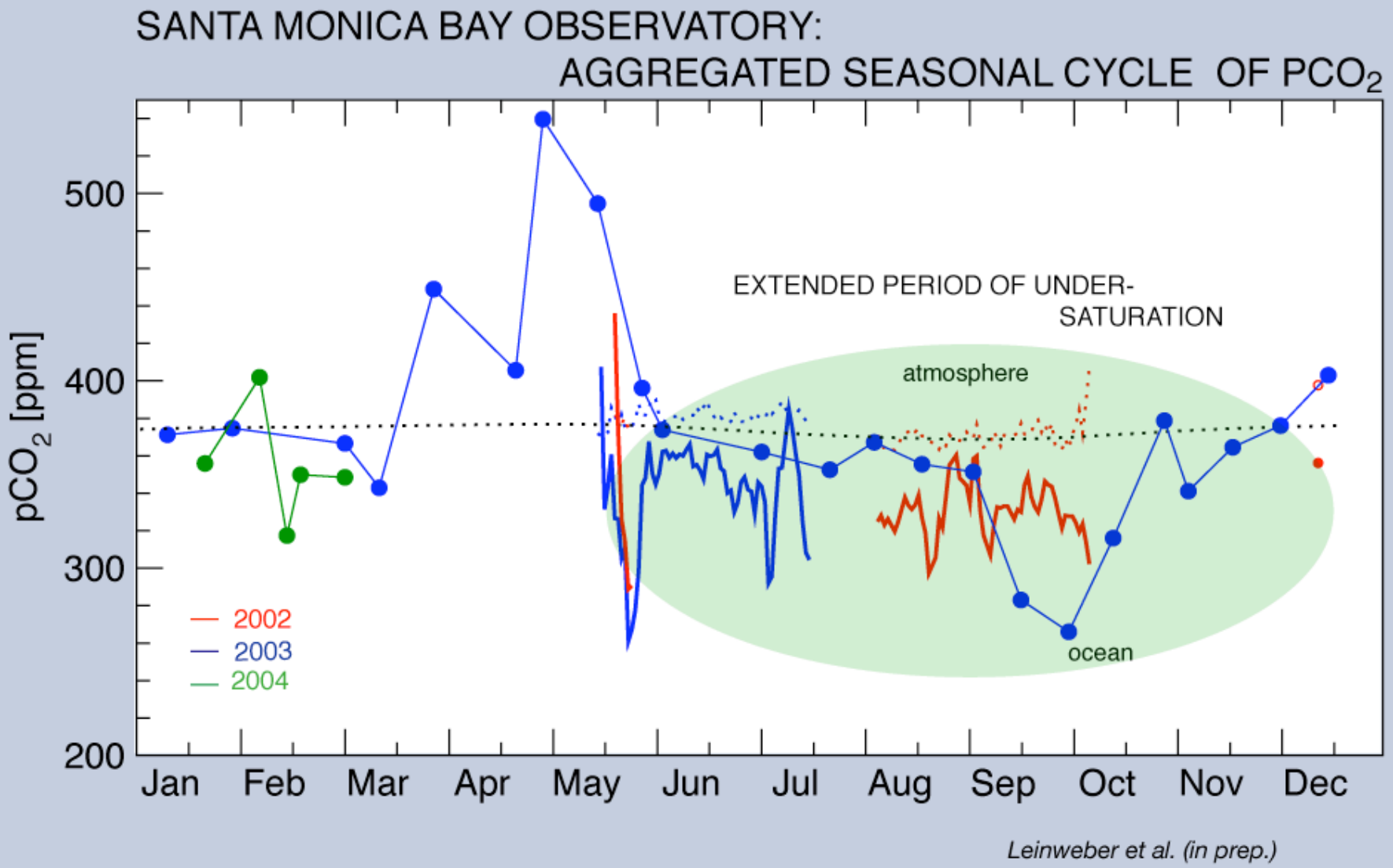
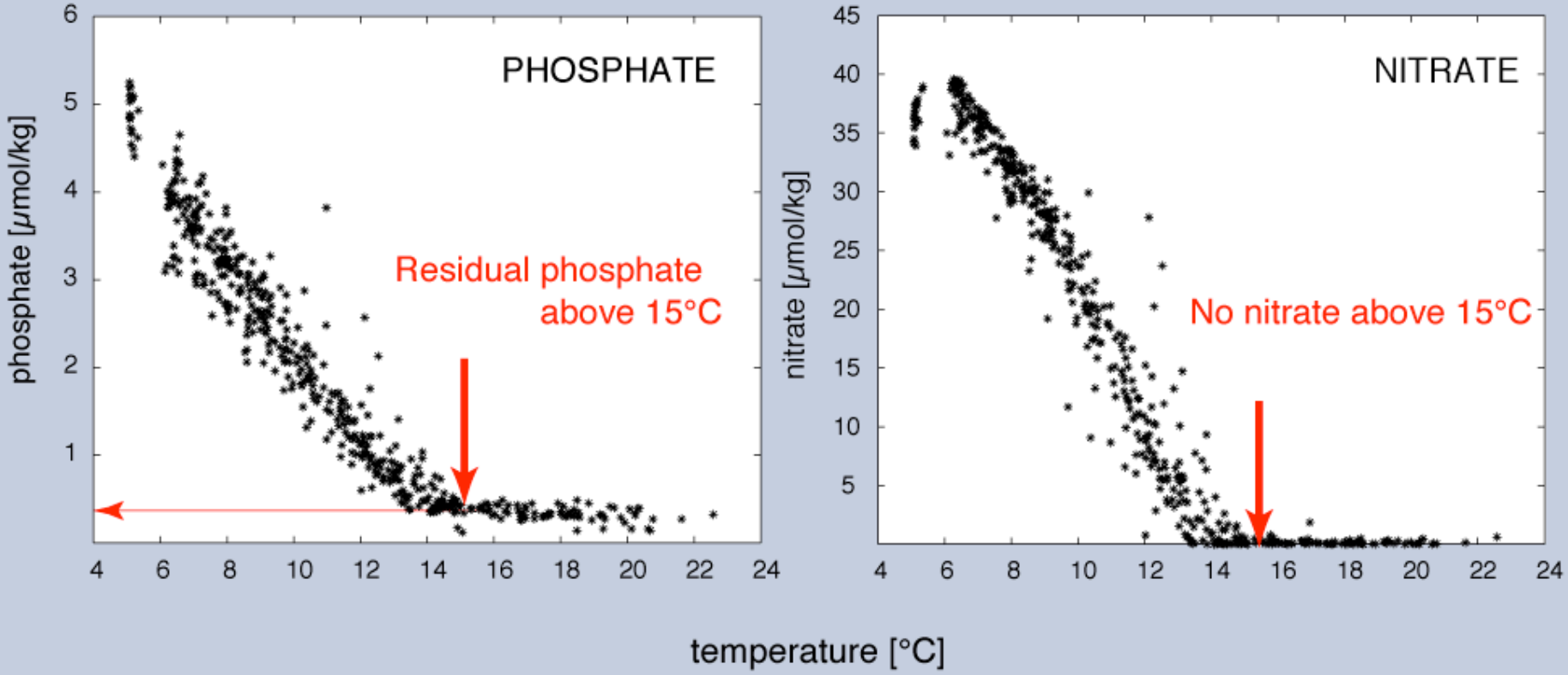


Leinweber et al. (in prep.)

NUTRIENT RELATIONSHIPS



data from SPOT timeseries

DUST DEPOSITION

SUMMARY

- Addressing the Coastal carbon cycle represents a formidable but exciting challenge.

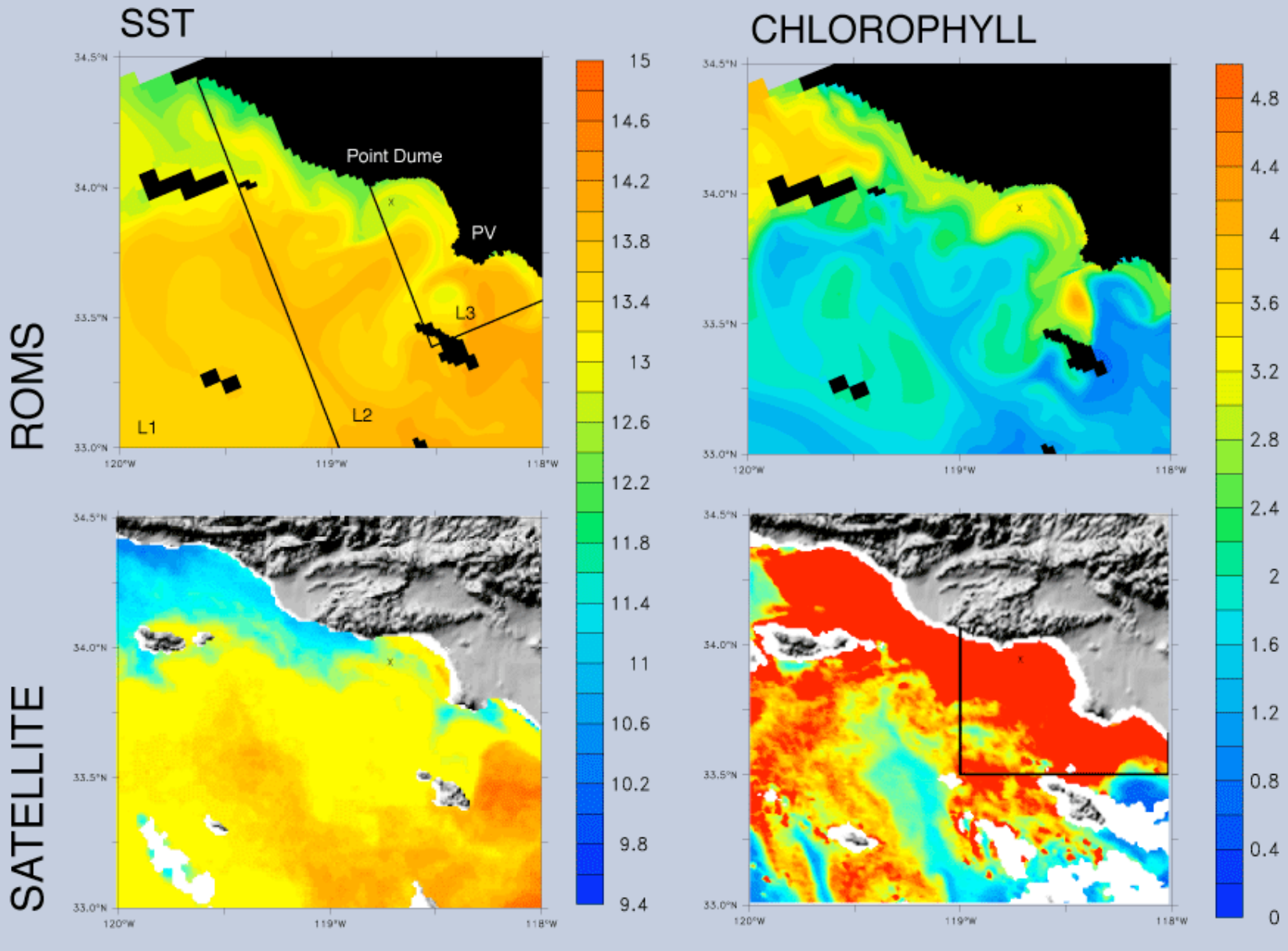
- Challenges that needed to be addressed:
  - Meso- und sub-mesoscale variability with strong impact on the mean state
  - temporal variability on all scales
  - full range of processes including sediment interactions, rivers, atmospheric deposition, etc.
  - etc.

Nevertheless, concepts developed for the open ocean are still applicable!

HOW TO APPROACH THESE CHALLENGES ?

- E.g. Model-data integration

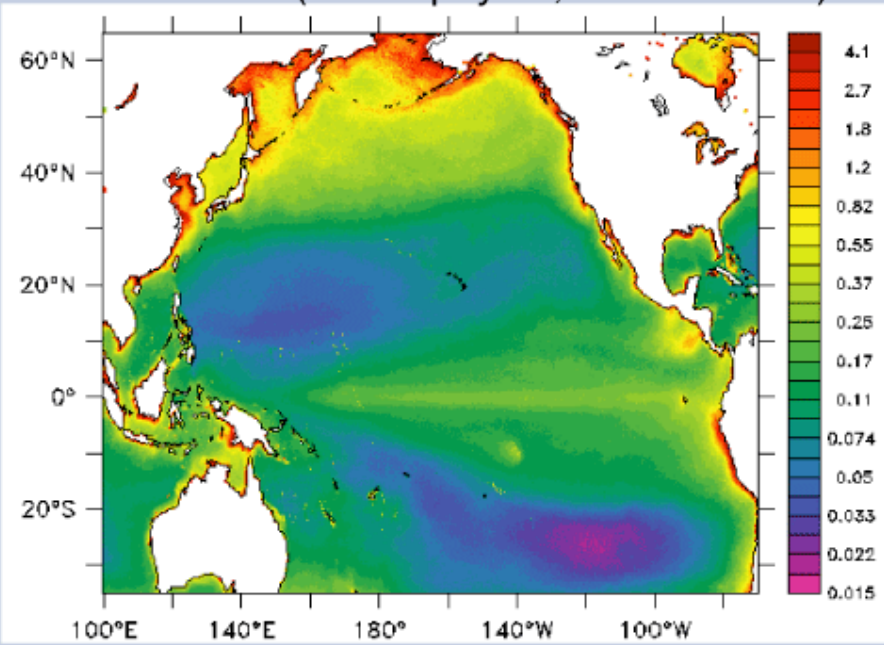
MODELING AN UPWELLING EVENT (MARCH 2002)



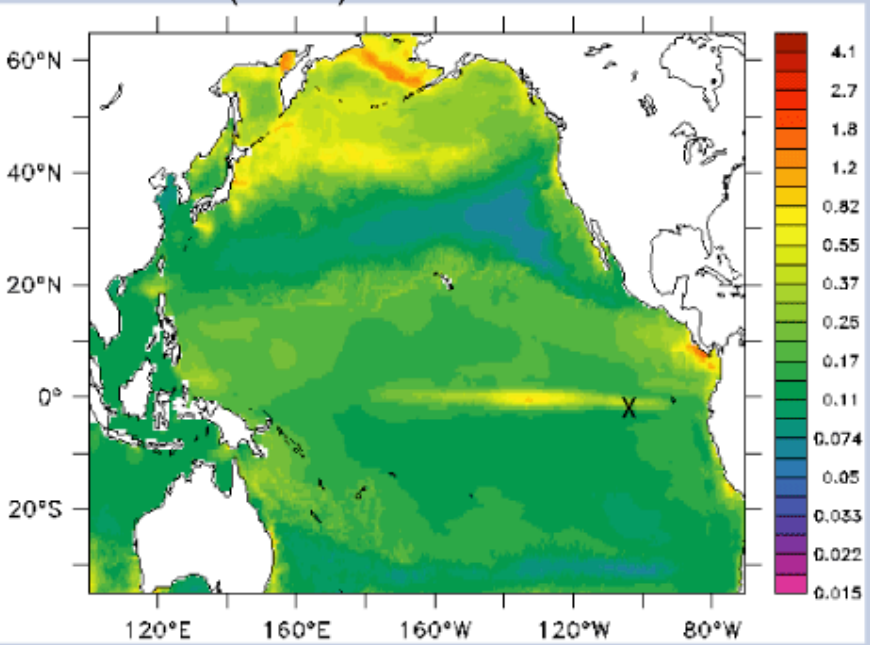
Frenzel et al. (in prep.)

THE NEXT STEPS?

SeaWiFS (Chlorophyll-a, annual mean)



ROMS (0.25°) with FGM



Open questions:

Margin-open ocean exchange

Local versus remote forcing

Cross-biome variance

Coupled biogeochemical cycles

Sediment interactions

Land-river-ocean loop

Anthropogenic forcing

The End.