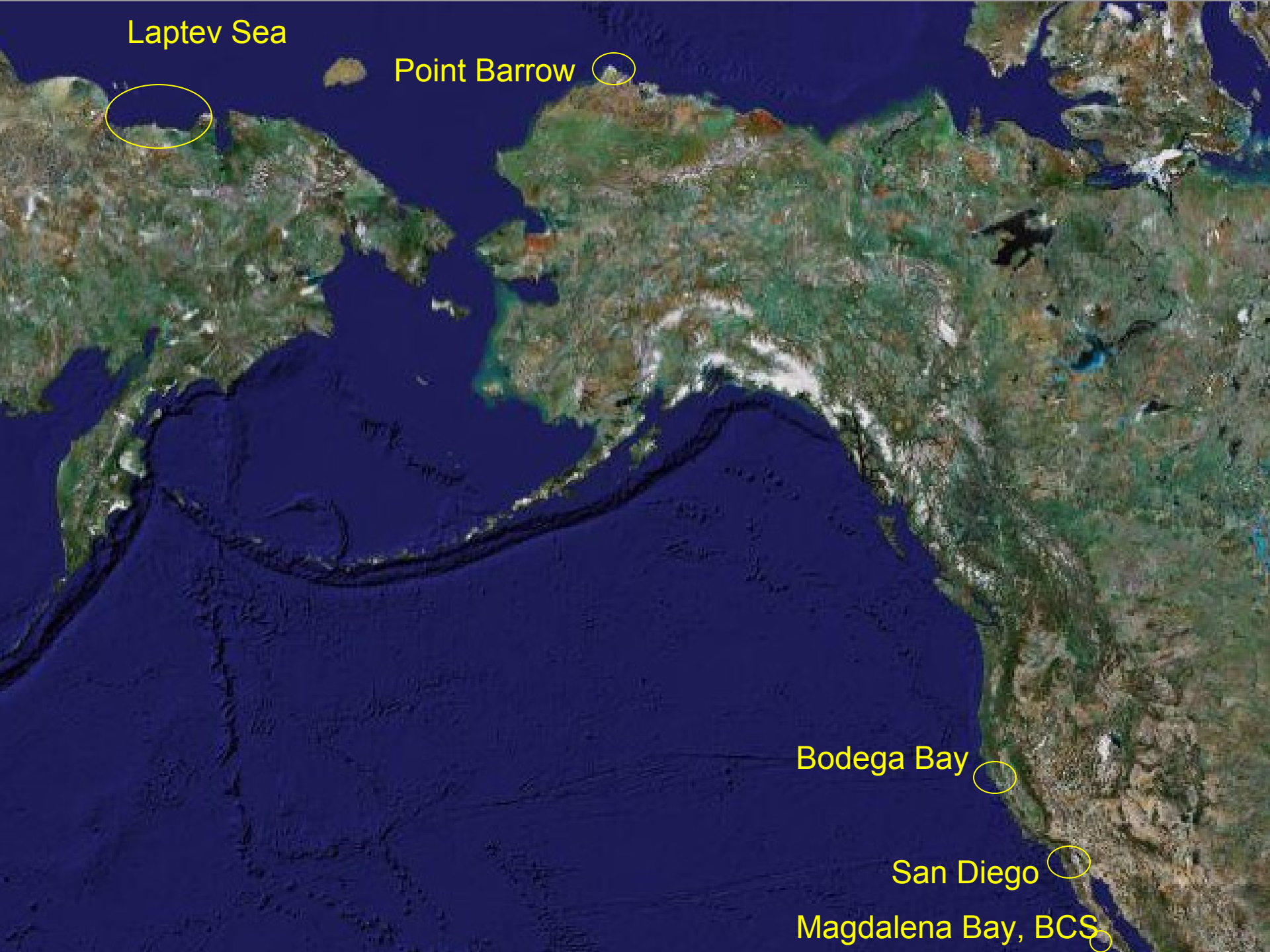
Carbon Dioxide and Methane Eddy Covariance Fluxes for Comparative Ocean and Terrestrial Fluxes

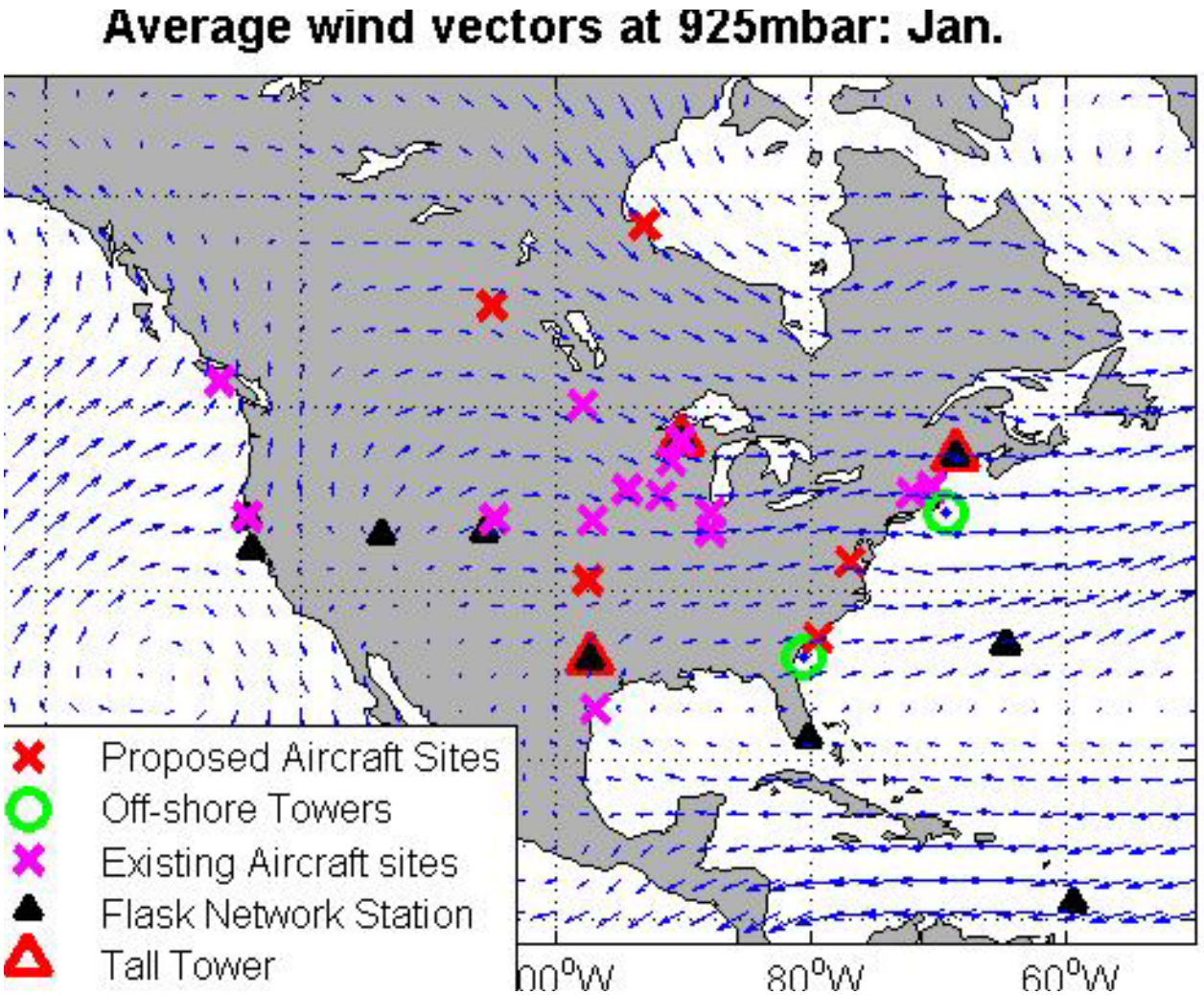
Ocean Carbon and Biogeochemistry (OCB)
Summer Workshop
Woods Hole Oceanographic Institution
July 23-26, 2007

San Diego State University
Minds that move the world

Walter Oechel
San Diego State University


Laptev Sea
Point Barrow
Bodega Bay
San Diego
Magdalena Bay, BCS

Atmospheric Transport



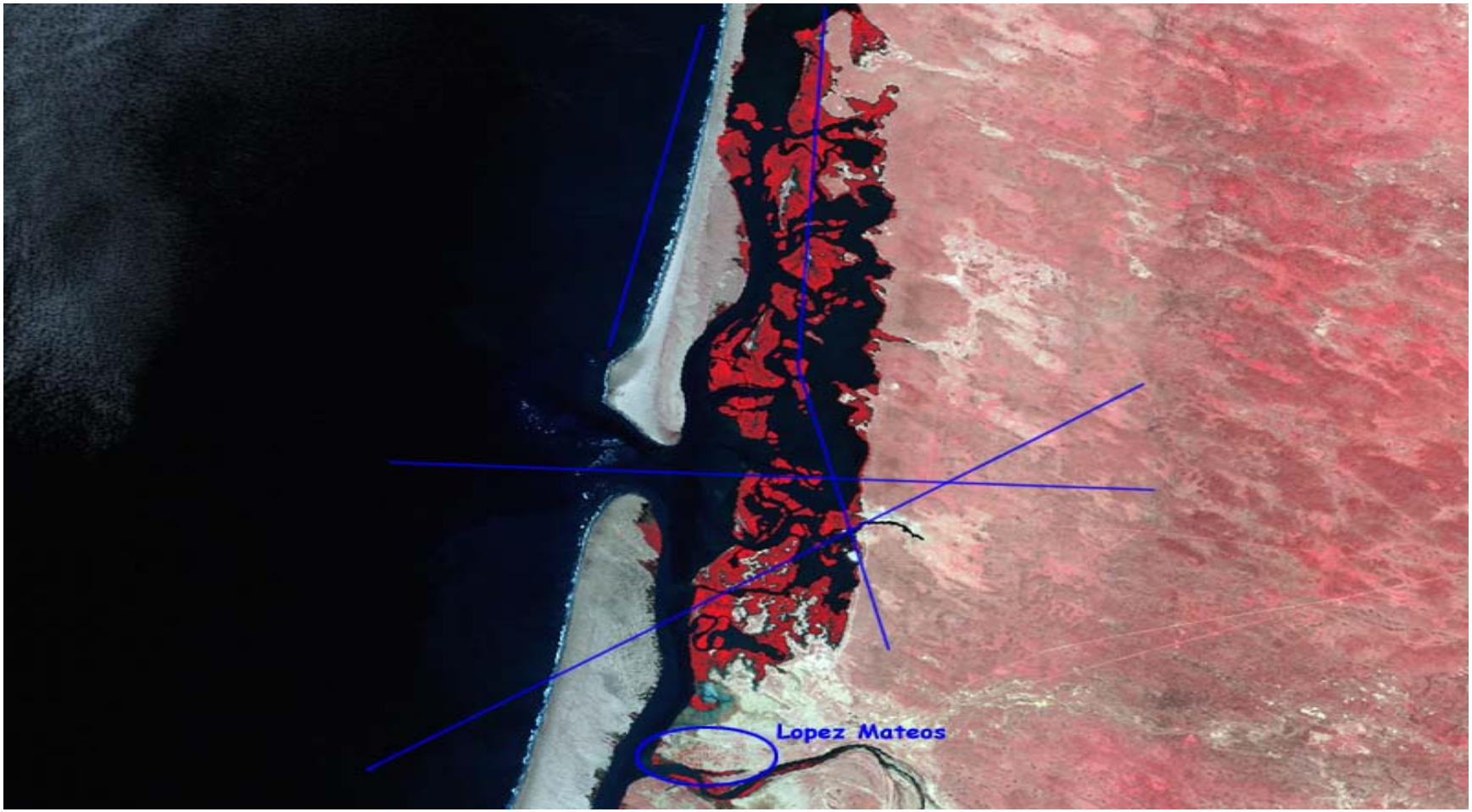

Magdalena Bay, BCS

Magdalena Bay

- Potential upwelling signal
- Collaboration with CIBNOR researchers
- Role of mangroves
- Interaction of agricultural runnoff/water use, desert, mangrove, lagoon, ocean systmes

Sky Arrow Data

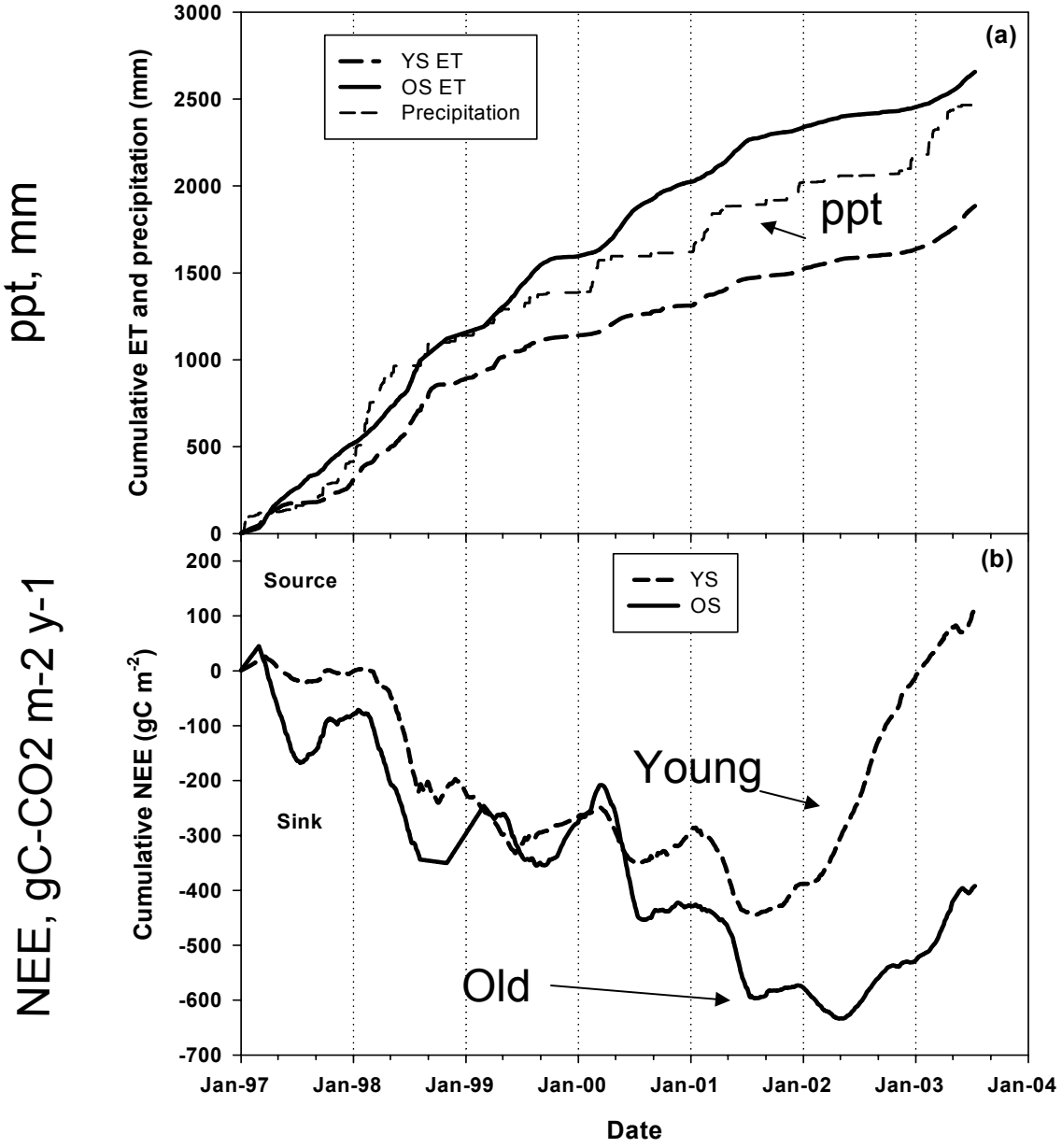
Rommel Zulueta/Joe Verfaillie




San Diego

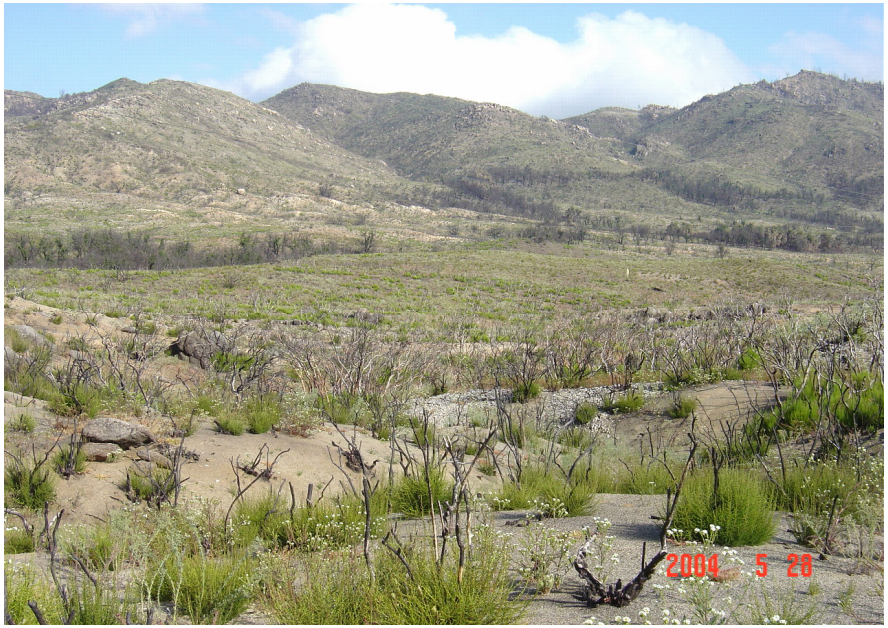
2004 4 11

Cumulative CO2 flux, Evapotranspiration, and ppt



Old stand, young stand and new stand in 2004

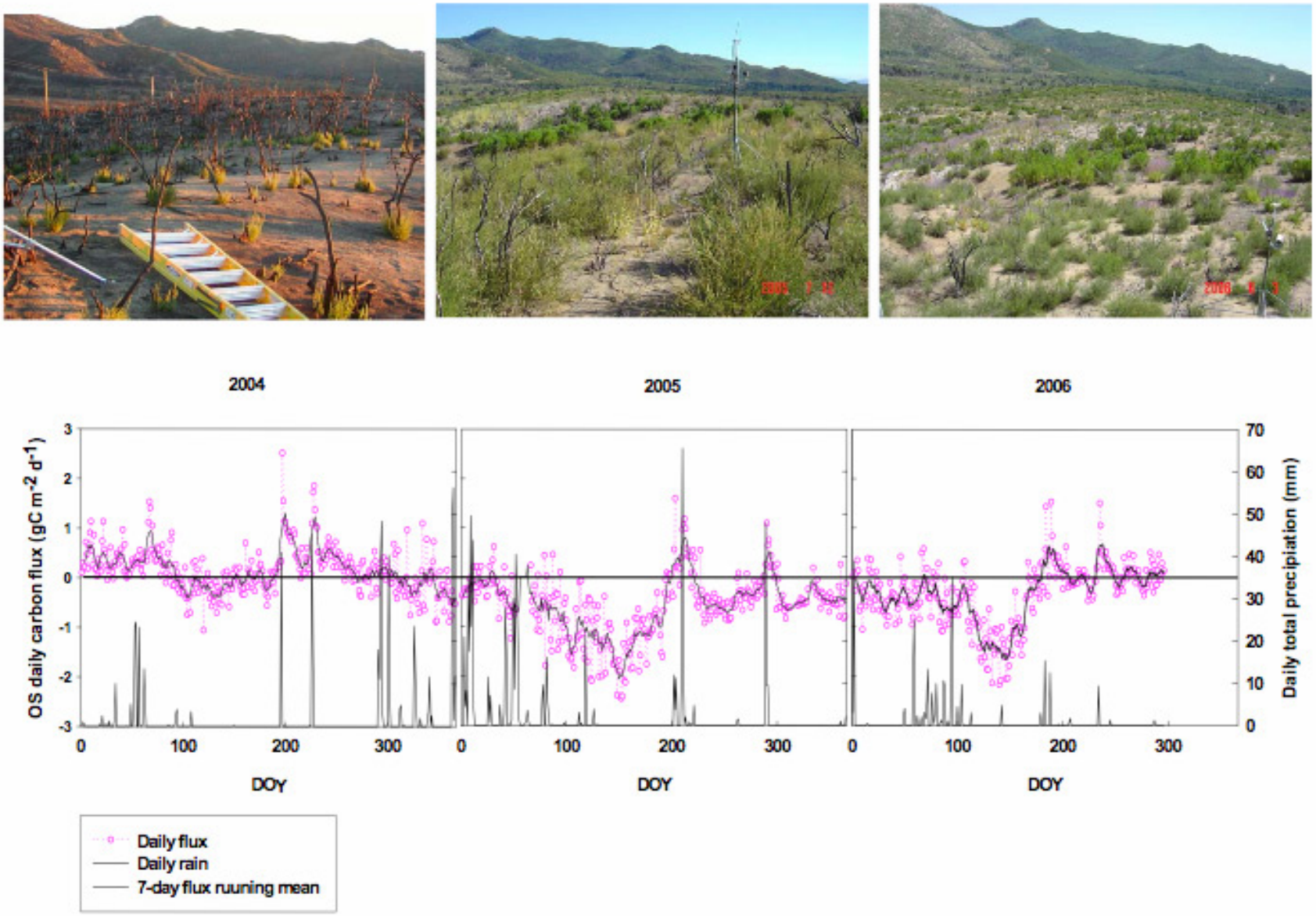
← New stand (>100 years old)



↑ Old stand (1 year old)

← Young stand (1 year old)


2004 - 11

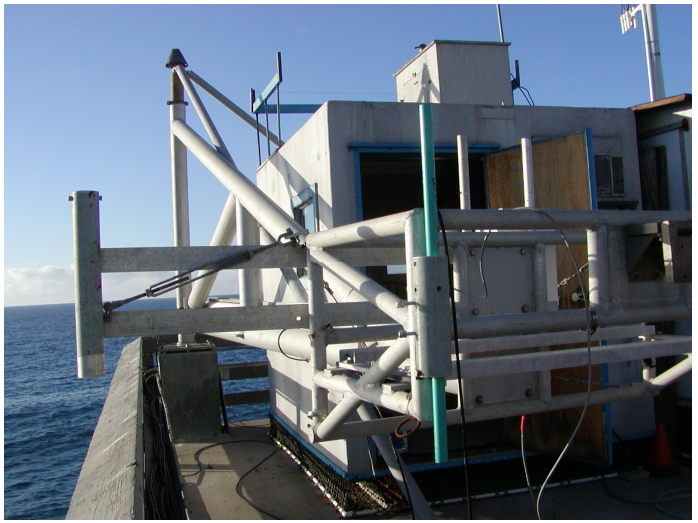

2004
2005
2006
OS daily carbon flux (gC m-2 d-1)
Daily total precipiation (mm)
DOY
DOY
DOY
Daily flux
Daily rain
7-day flux ruuning mean

SCRIPPS pier

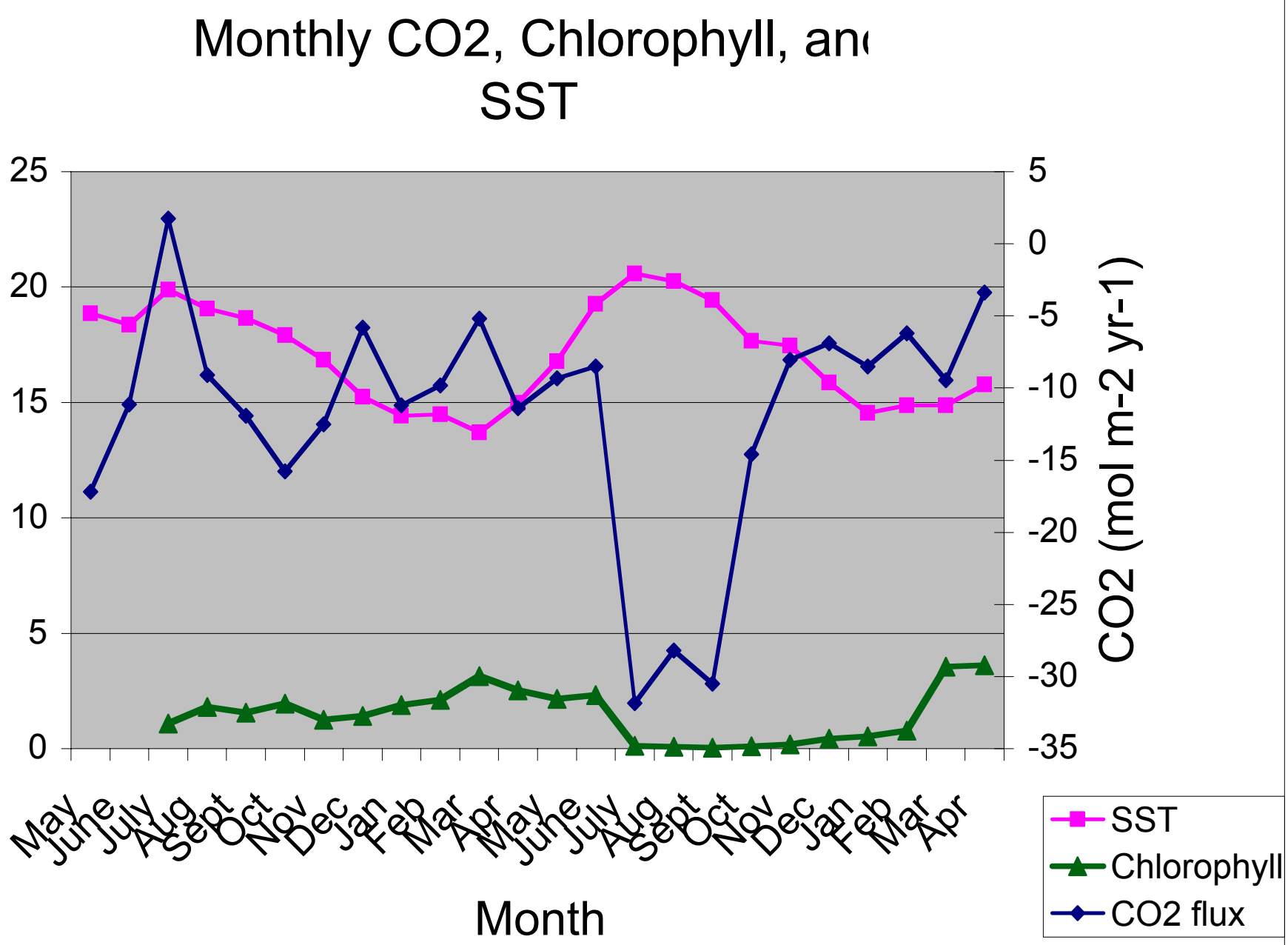
Aerial View

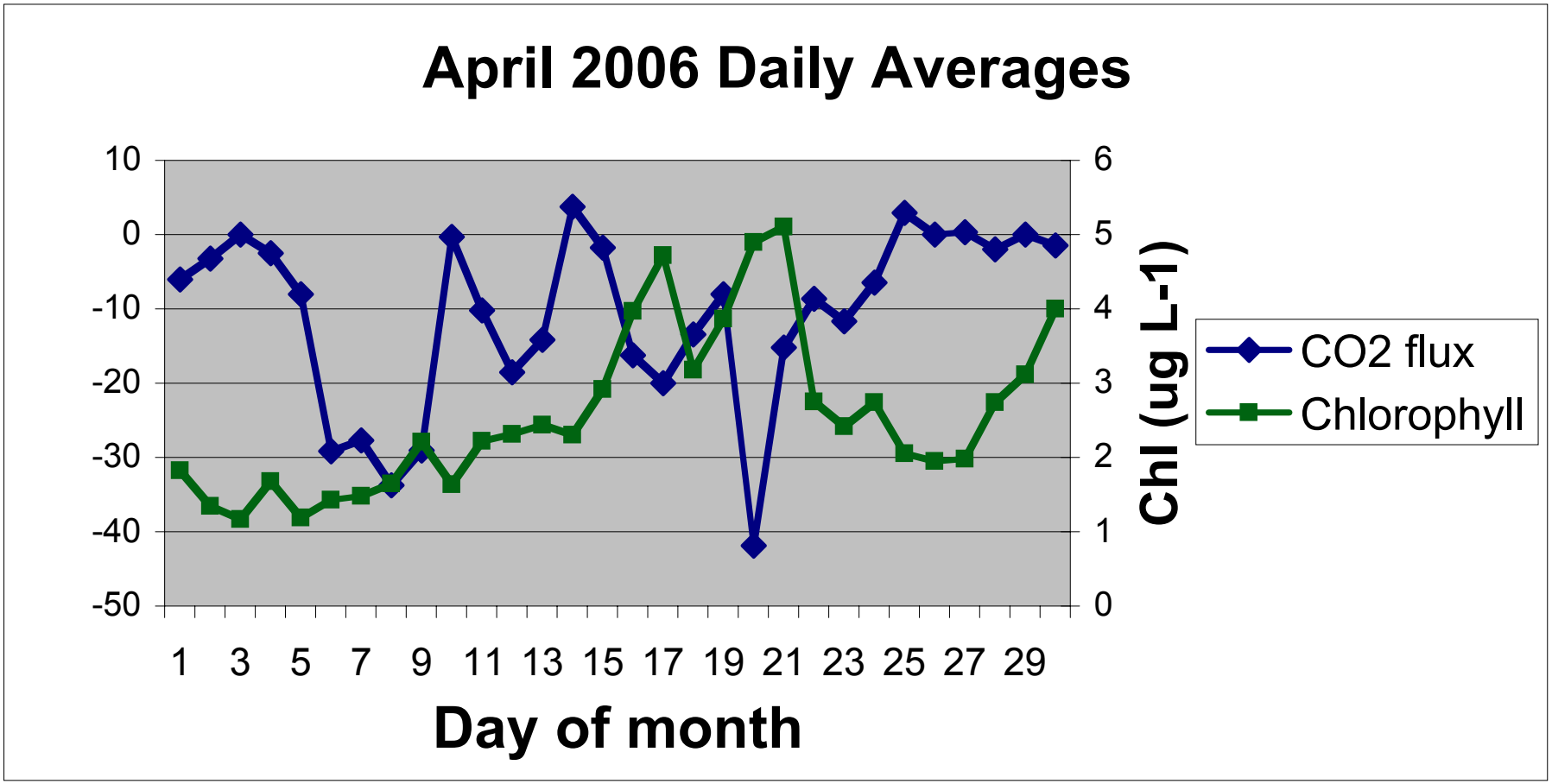
N

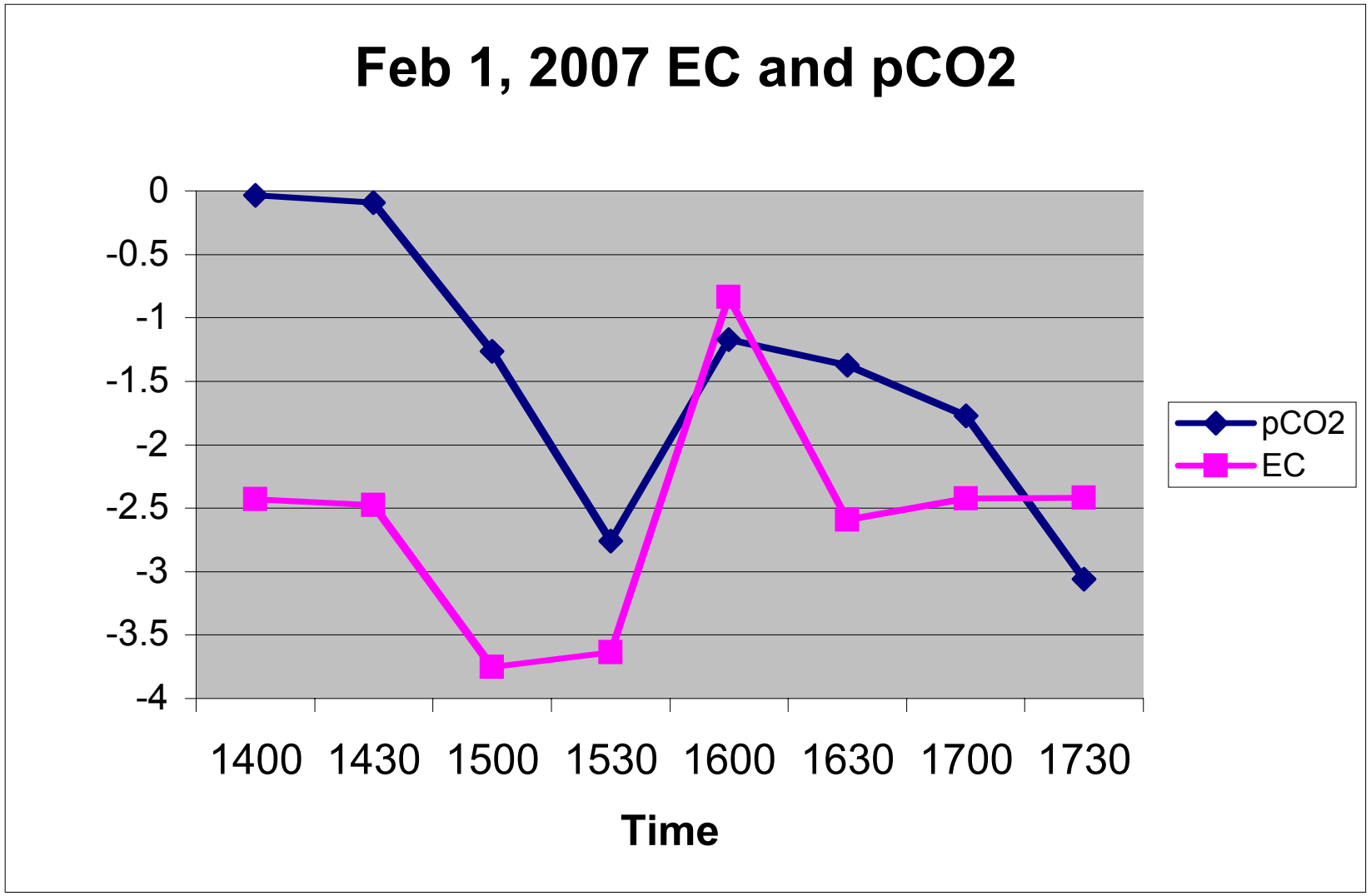
Pier Boom



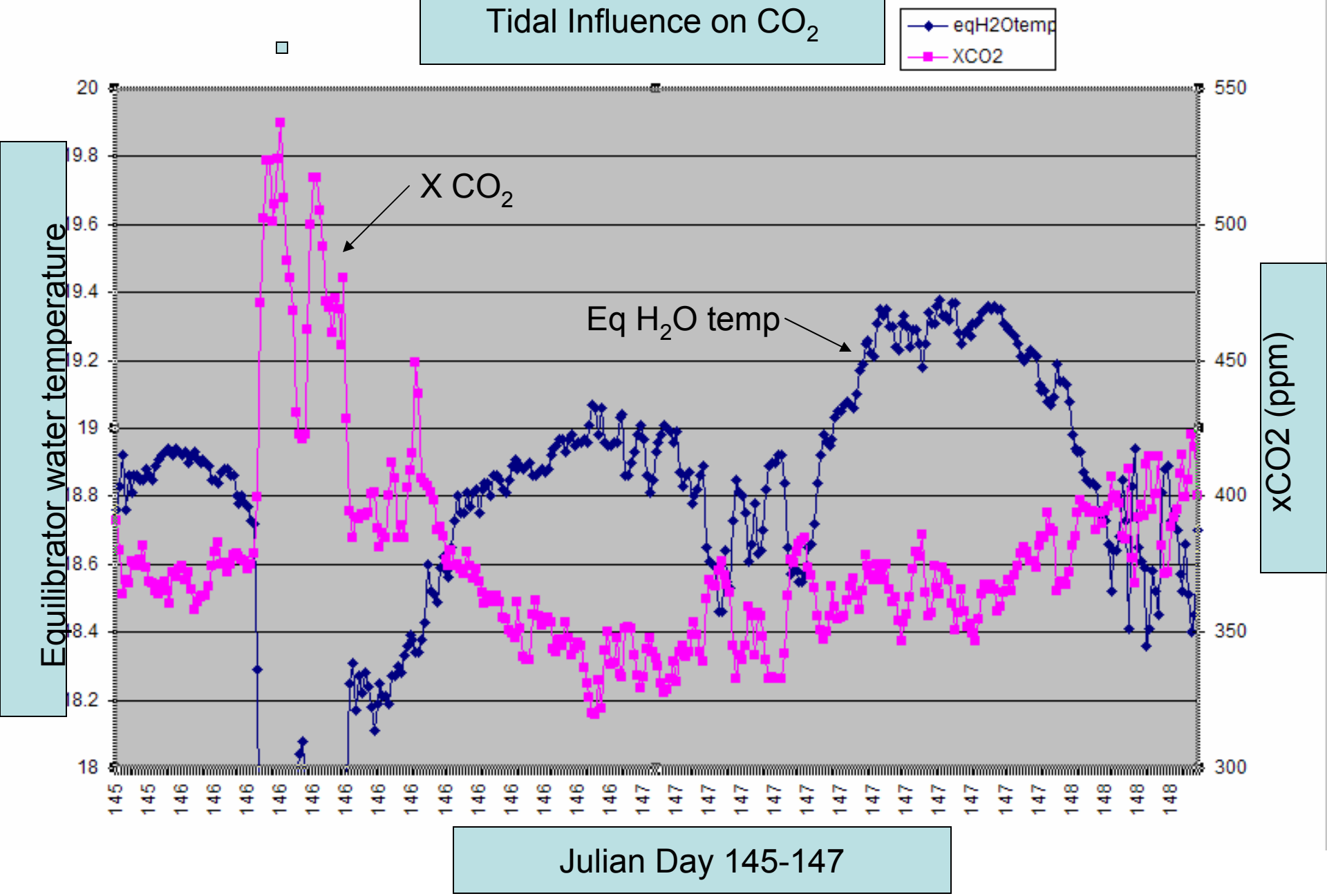
Marine flux in San Diego

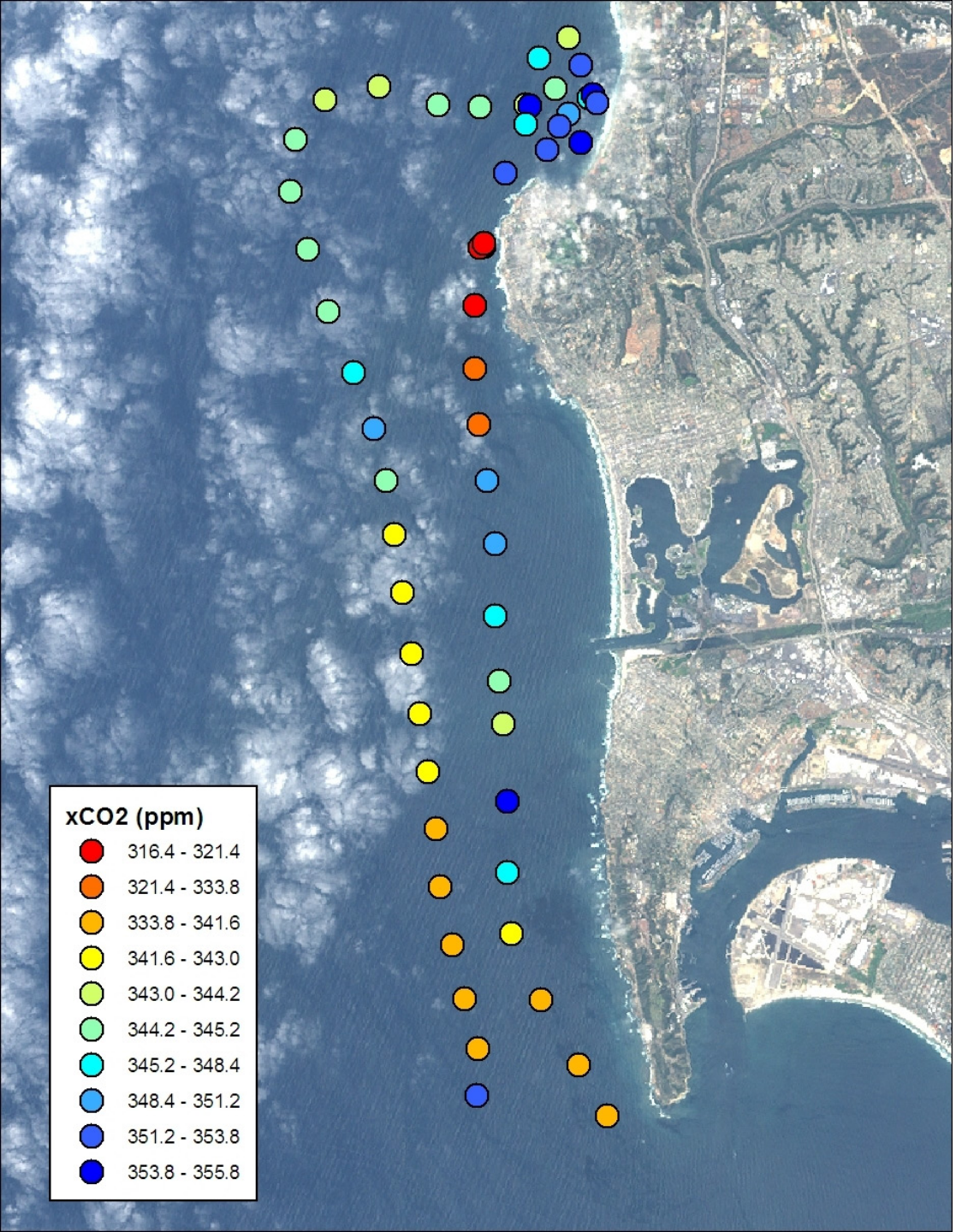

Monthly CO2, Chlorophyll, an
SST
25
20
15
10
5
0
5
0
-5
-10
-15
-20
-25
-30
-35
CO2 (mol m-2 yr-1)
May
June
July
Aug
Sept
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
June
July
Aug
Sept
Oct
Nov
Dec
Jan
Feb
Mar
Apr
Month
SST
Chlorophyll
CO2 flux


April 2006 Daily Averages
10
0
-10
-20
-30
-40
-50
6
5
4
3
2
1
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29
Day of month
Chl (ug L-1)
CO2 flux
Chlorophyll


Feb 1, 2007 EC and pCO2
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
1400
1430
1500
1530
1600
1630
1700
1730
Time
pCO2
EC

Tidal Influence on CO_2





pCO2 measurements near Scripps Pier, Feb 1, 2007

Key Questions Chaparral Coastal Ecosystems

- What happens to terrestrial NEE???

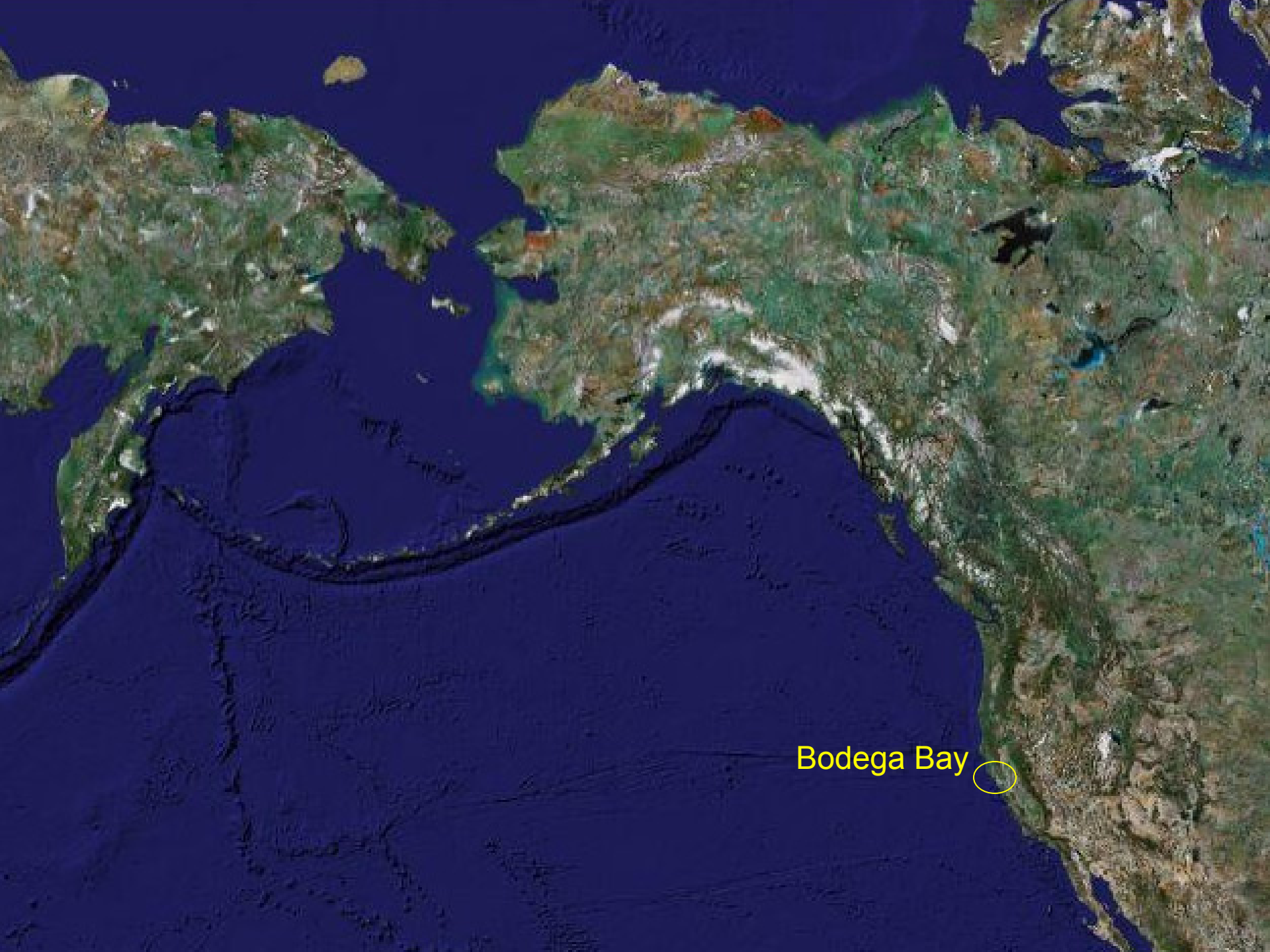
- How much of terrestrial NEE is exported to coastal ocean?

- What is the fate of terrestrial C in coastal ocean system?

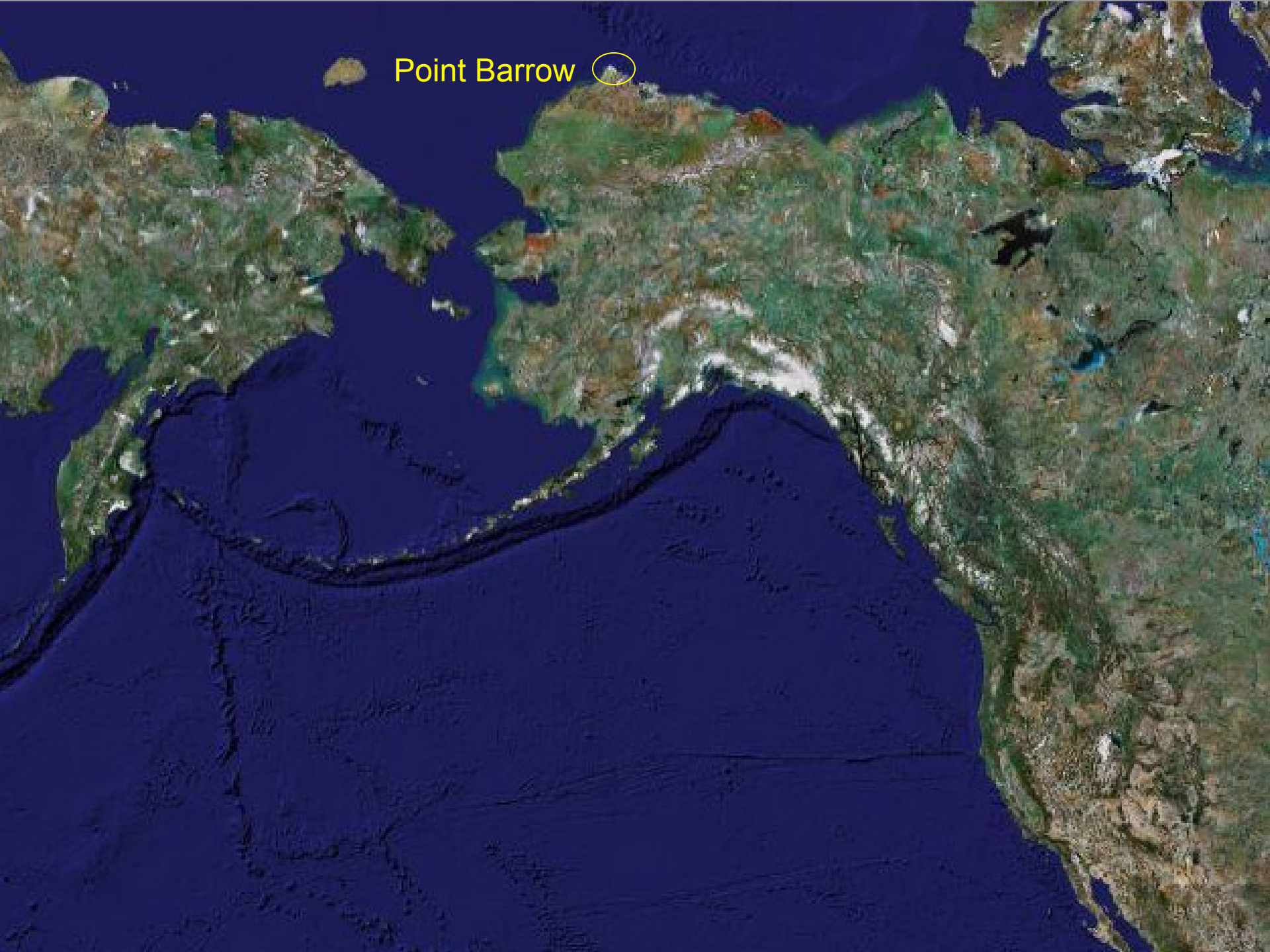
- How much and what is the fate of nutrients, ash and charcoal transported from to the coastal ocean after wildfires? What impact does it have on ocean productivity?

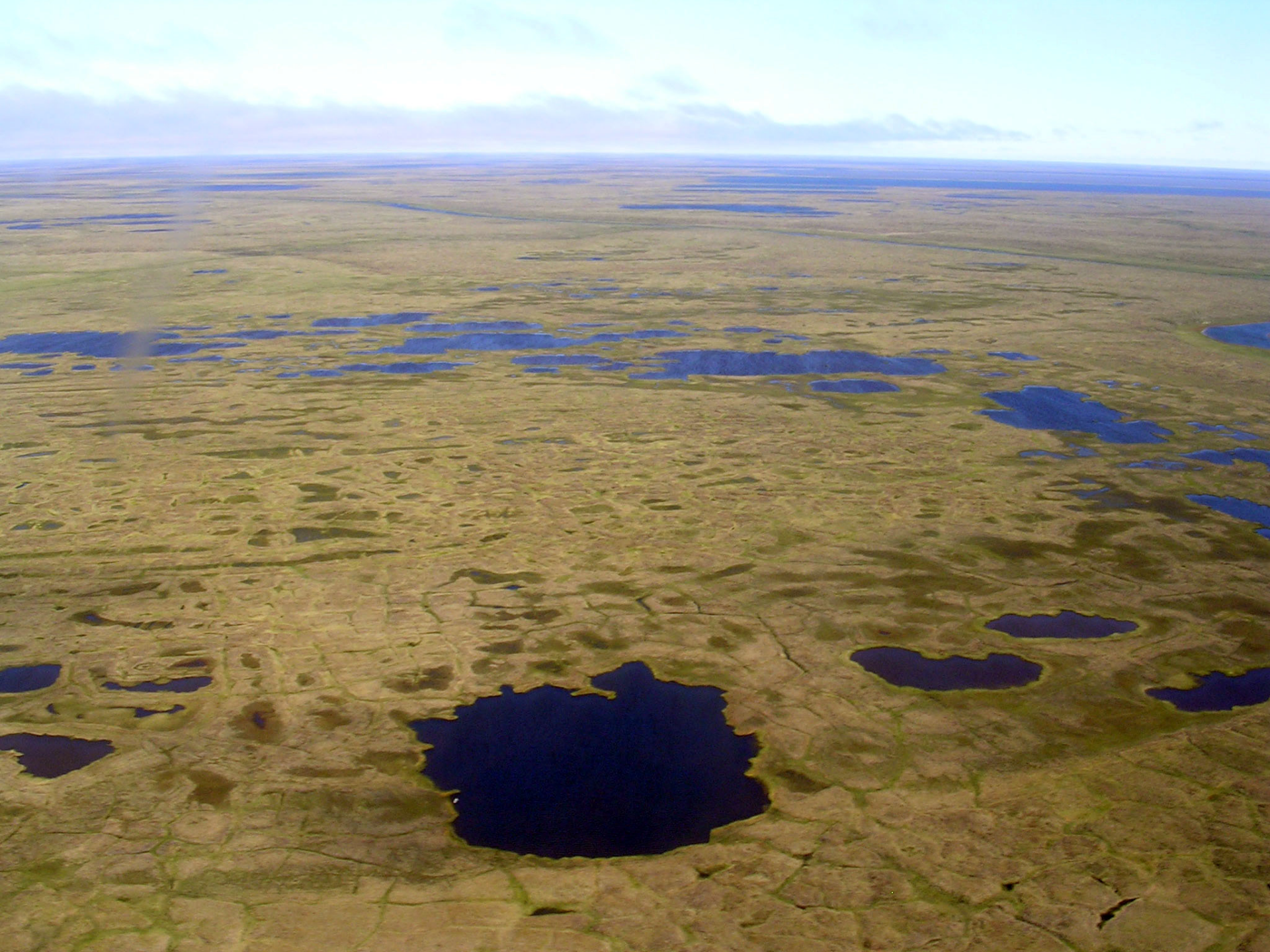
- What is the relative magnitude of CO_2 sequestration of the coastal ocean compared to the land?

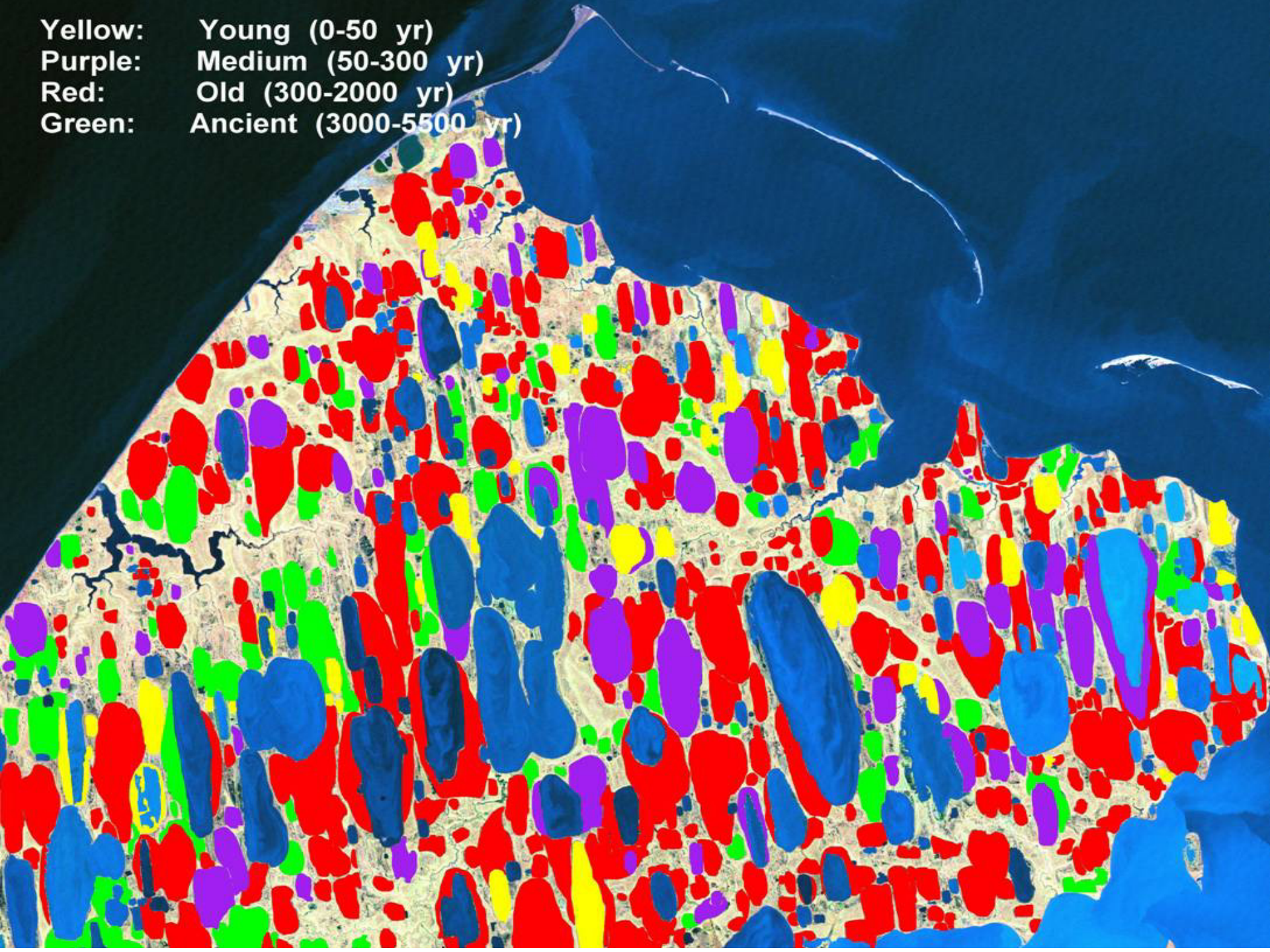
- What are the main patterns of and controls on diurnal and seasonal coastal ocean fluxes?

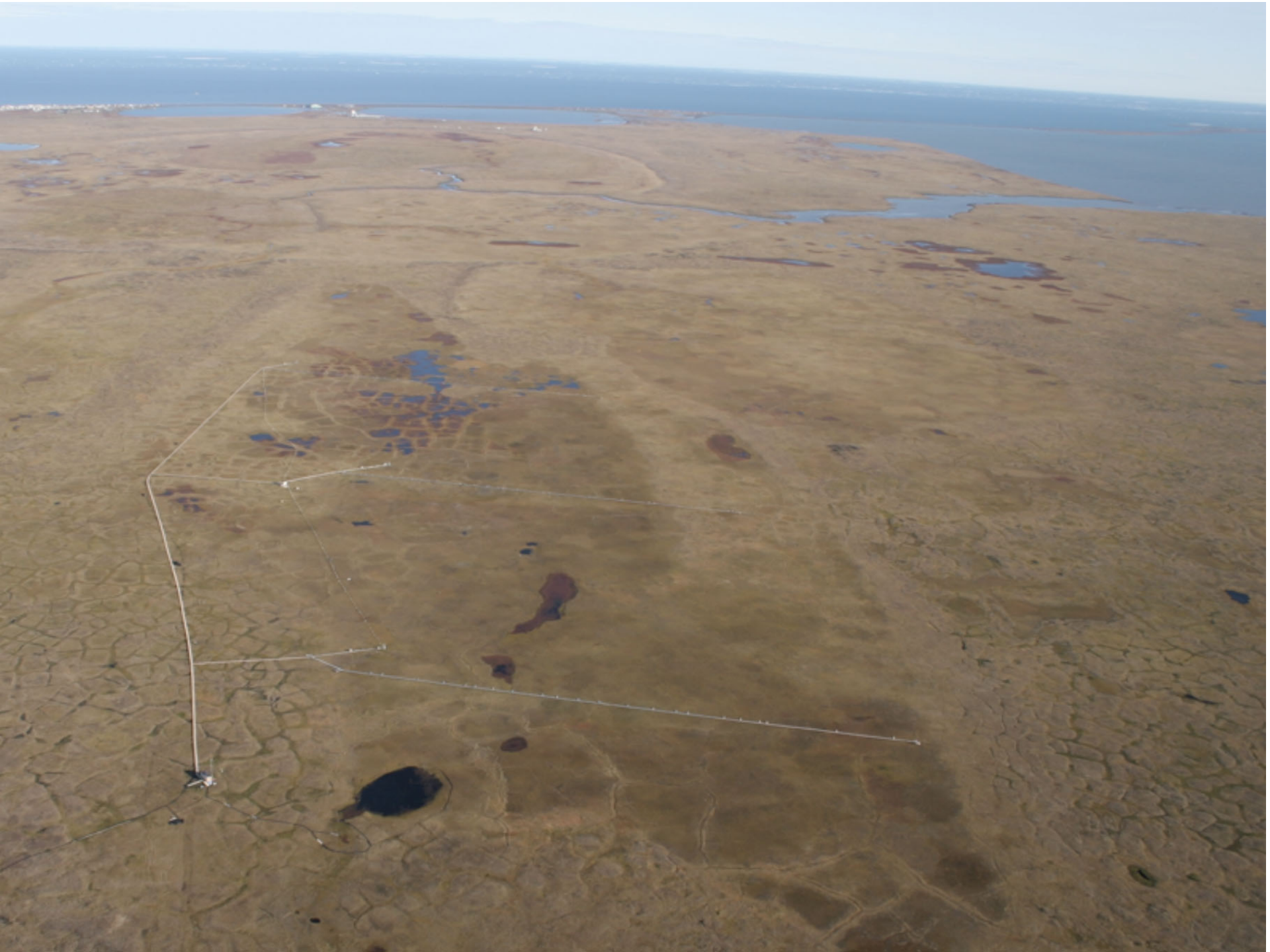

Bodega Bay

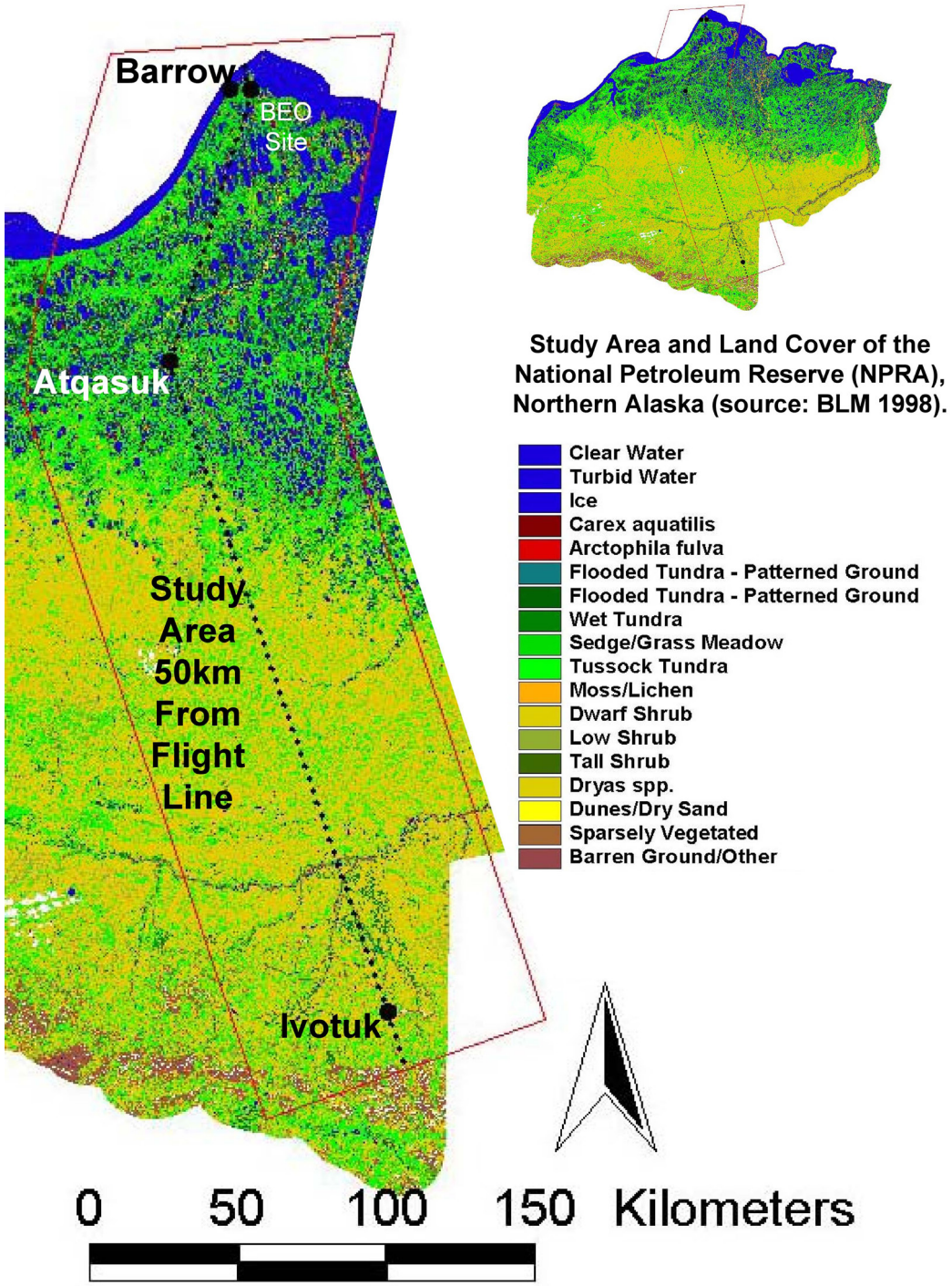

Bodega bay marine flux tow


Point Barrow




Yellow: Young (0-50 yr)
Purple: Medium (50-300 yr)
Red: Old (300-2000 yr)
Green: Ancient (3000-5500 yr)

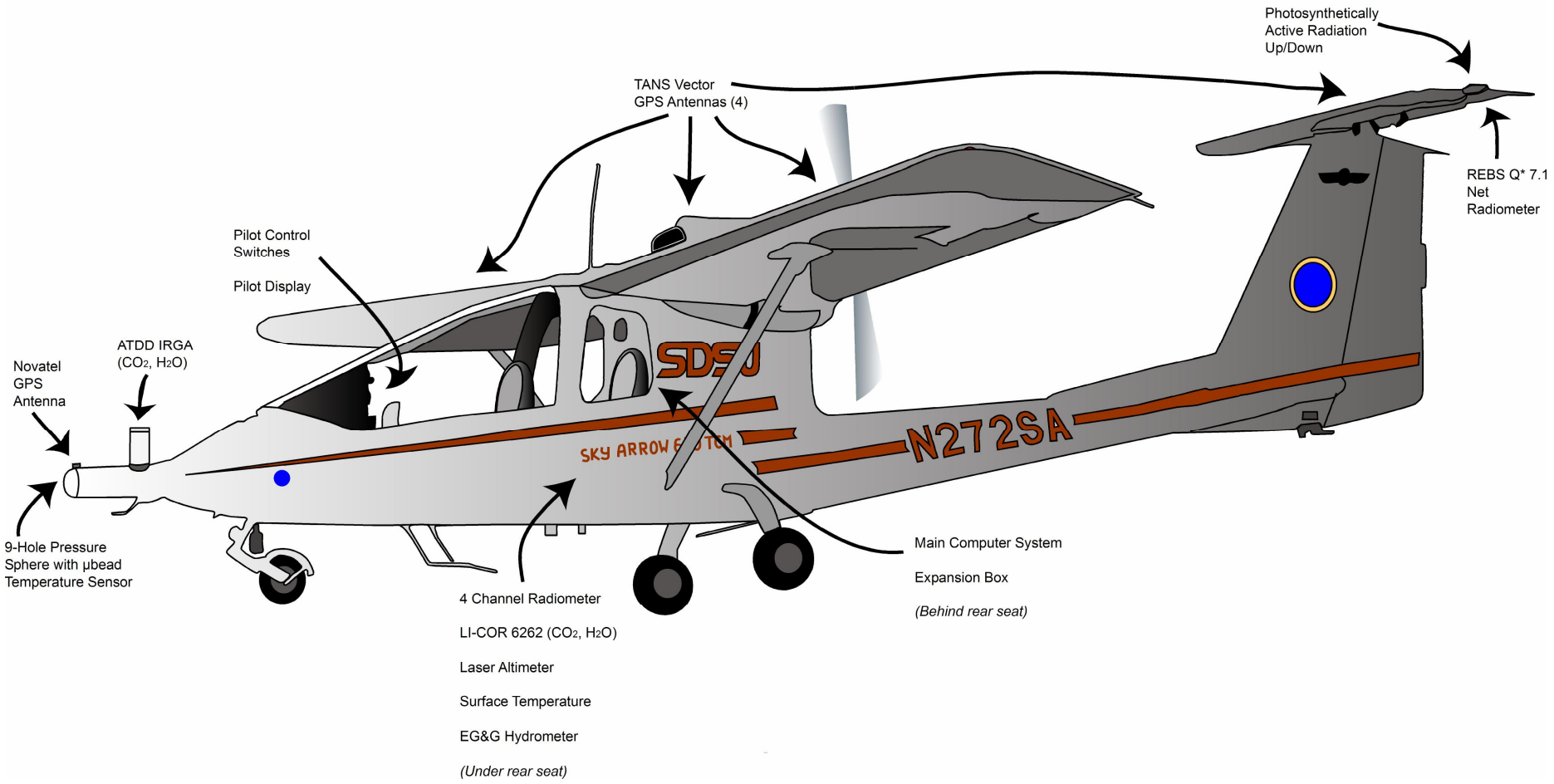




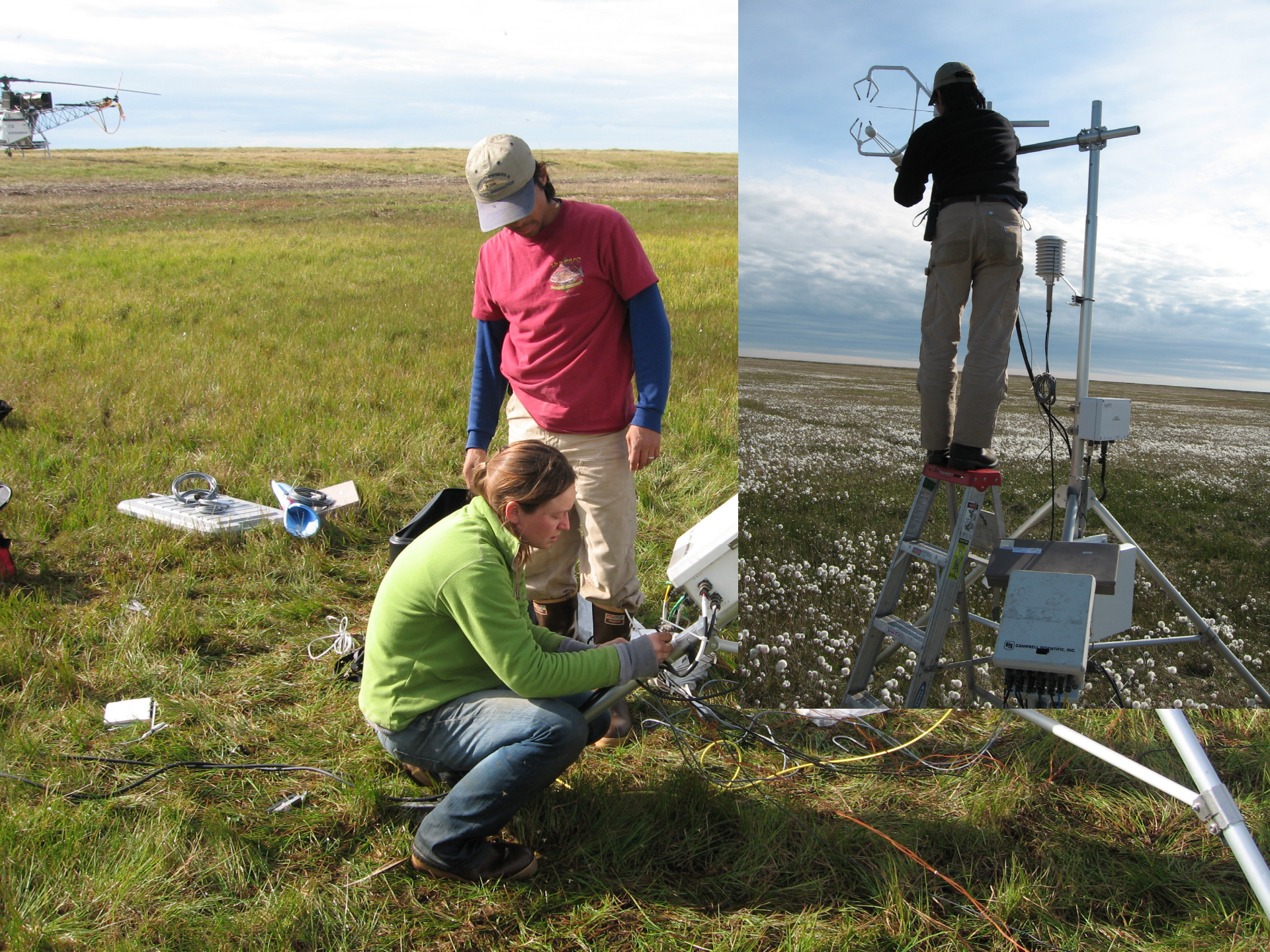
Study Area and Land Cover of the National Petroleum Reserve (NPRA), Northern Alaska (source: BLM 1998).

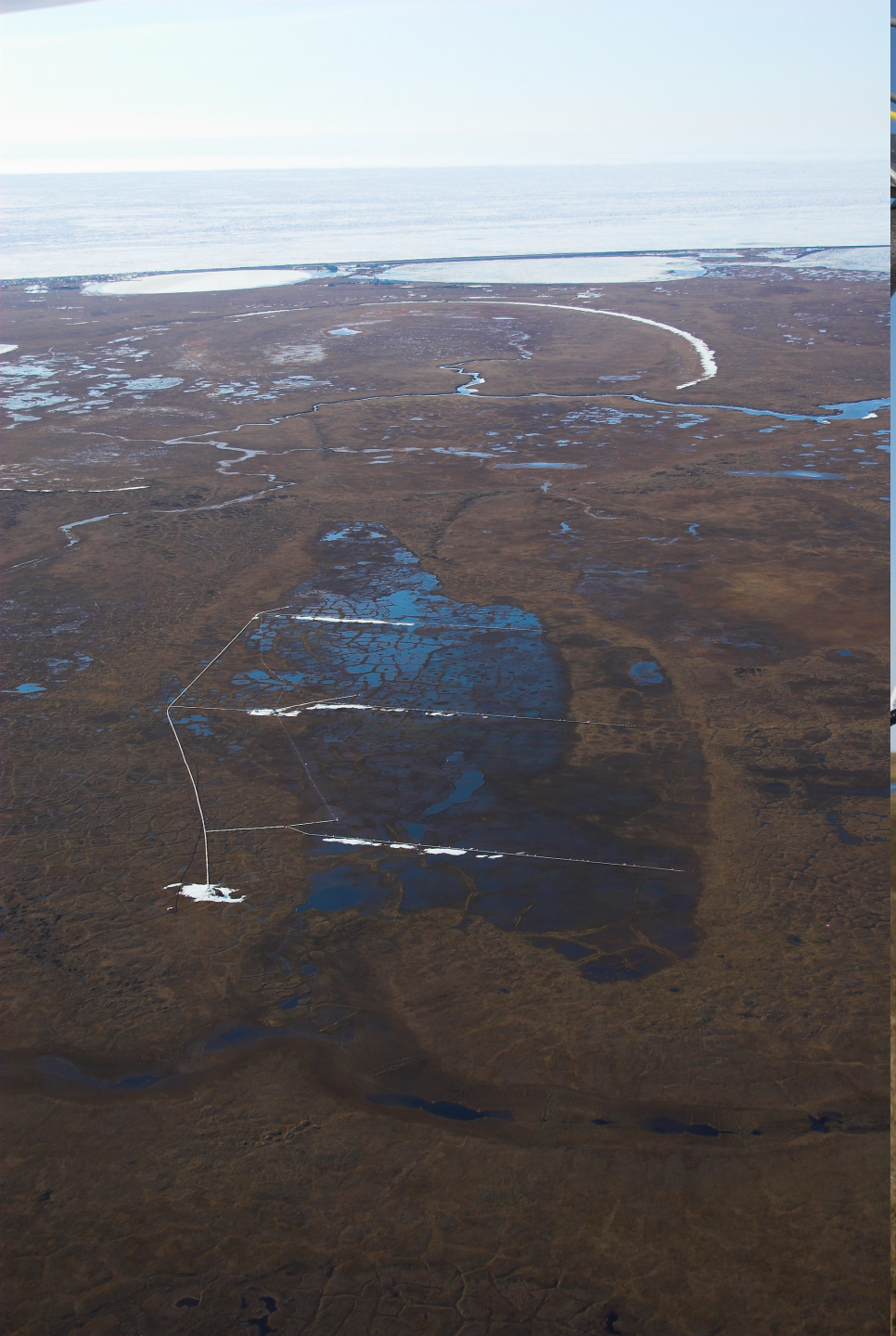
Sky Arrow 650 ERA

(Environmental Research Aircraft)




N48087


CAMPBELL SCIENTIFIC, INC.




N272SA
SDSU
SAN DIEGO STATE UNIVERSITY


N272SA

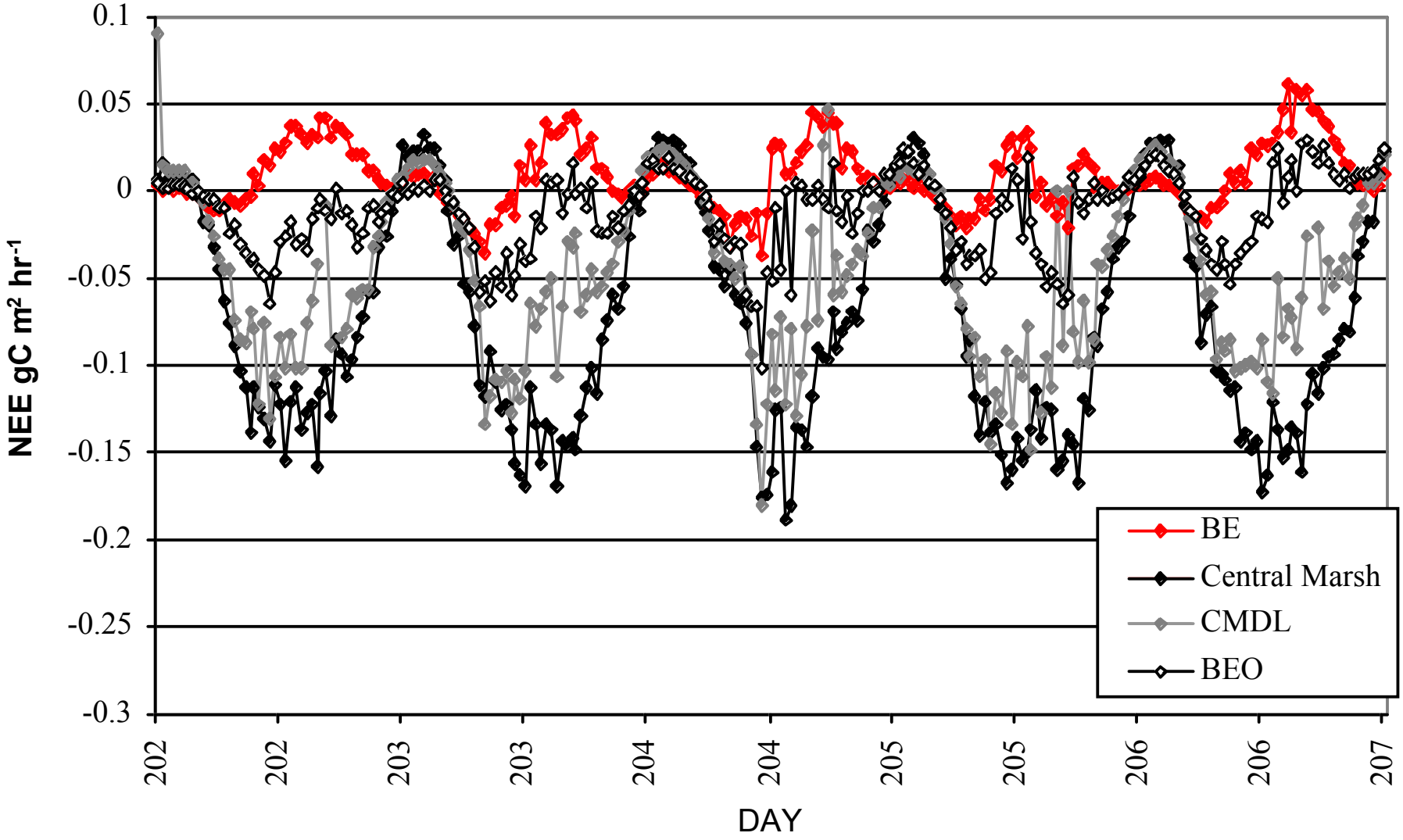
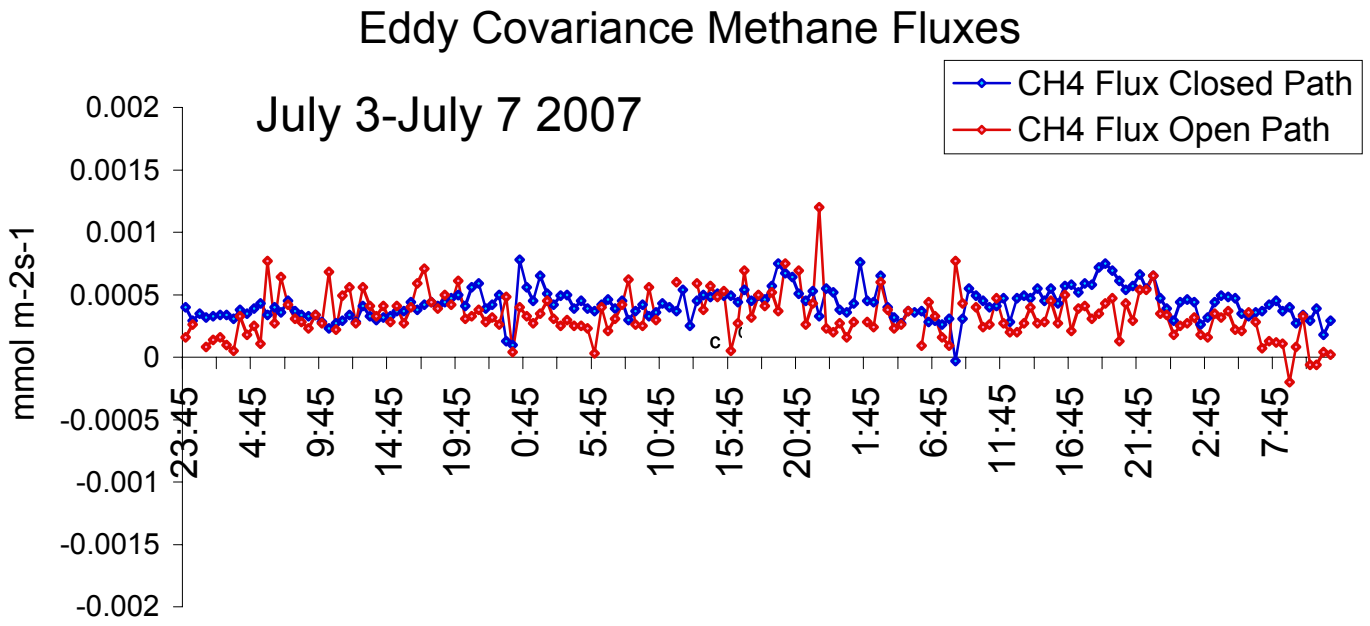
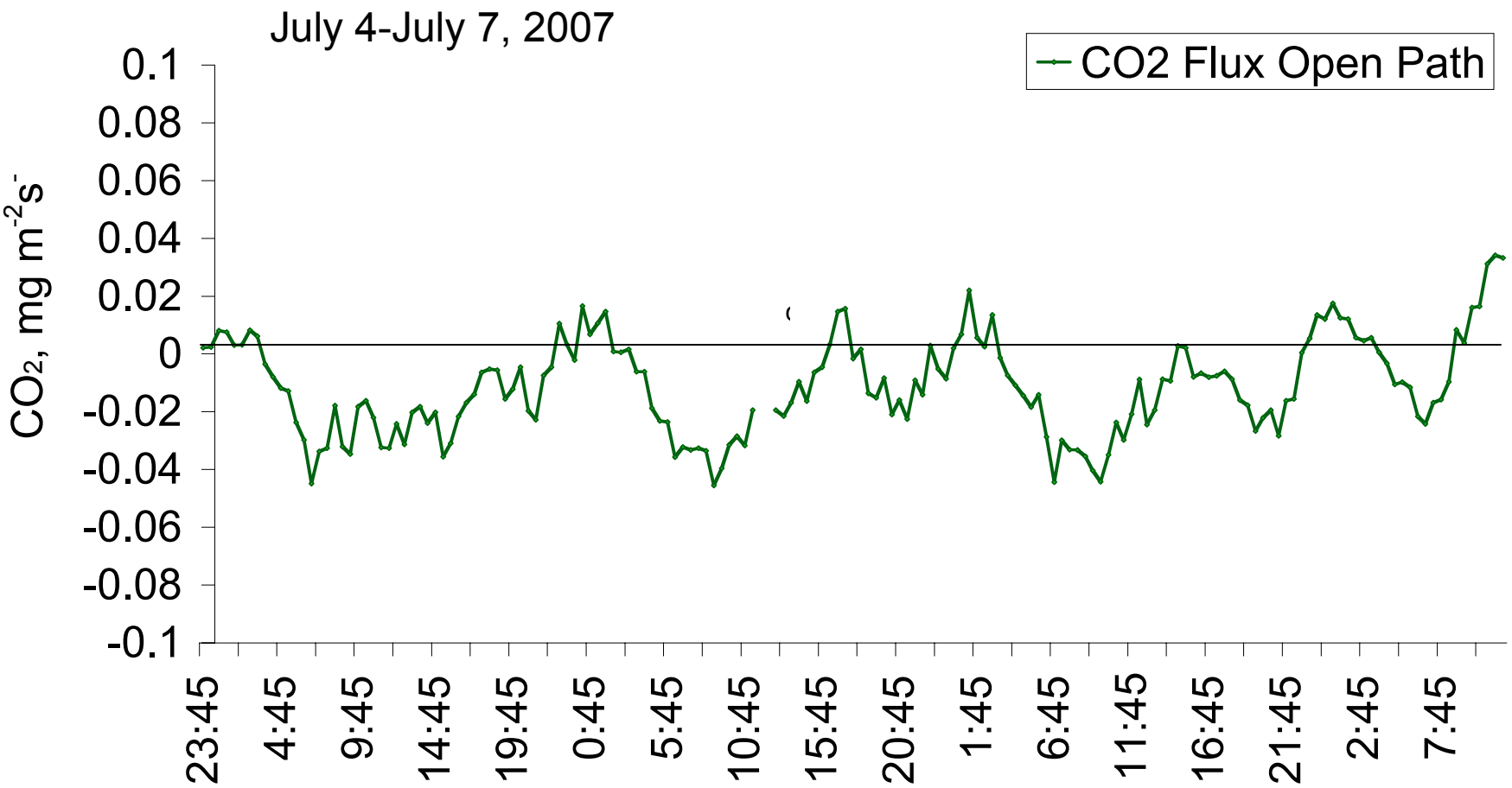


Figure A series of diurnal flux measurements at sites near Barrow, Alaska within 4 km of each other including an old lake basin (BE), a medium age lake basin (Central Marsh) and two wet sedge vegetation types (CMDL and BE) measured in 2005.

North Tower


Eddy Covariance Methane Fluxes
July 3-July 7 2007
CH4 Flux Closed Path
CH4 Flux Open Path
mmol m-2s-1
0.002
0.0015
0.001
0.0005
0
-0.0005
-0.001
-0.0015
-0.002
23:45
4:45
9:45
14:45
19:45
0:45
5:45
10:45
15:45
20:45
1:45
6:45
11:45
16:45
21:45
2:45
7:45

Open Path Eddy Covariance NEE CO_2



Point Barrow

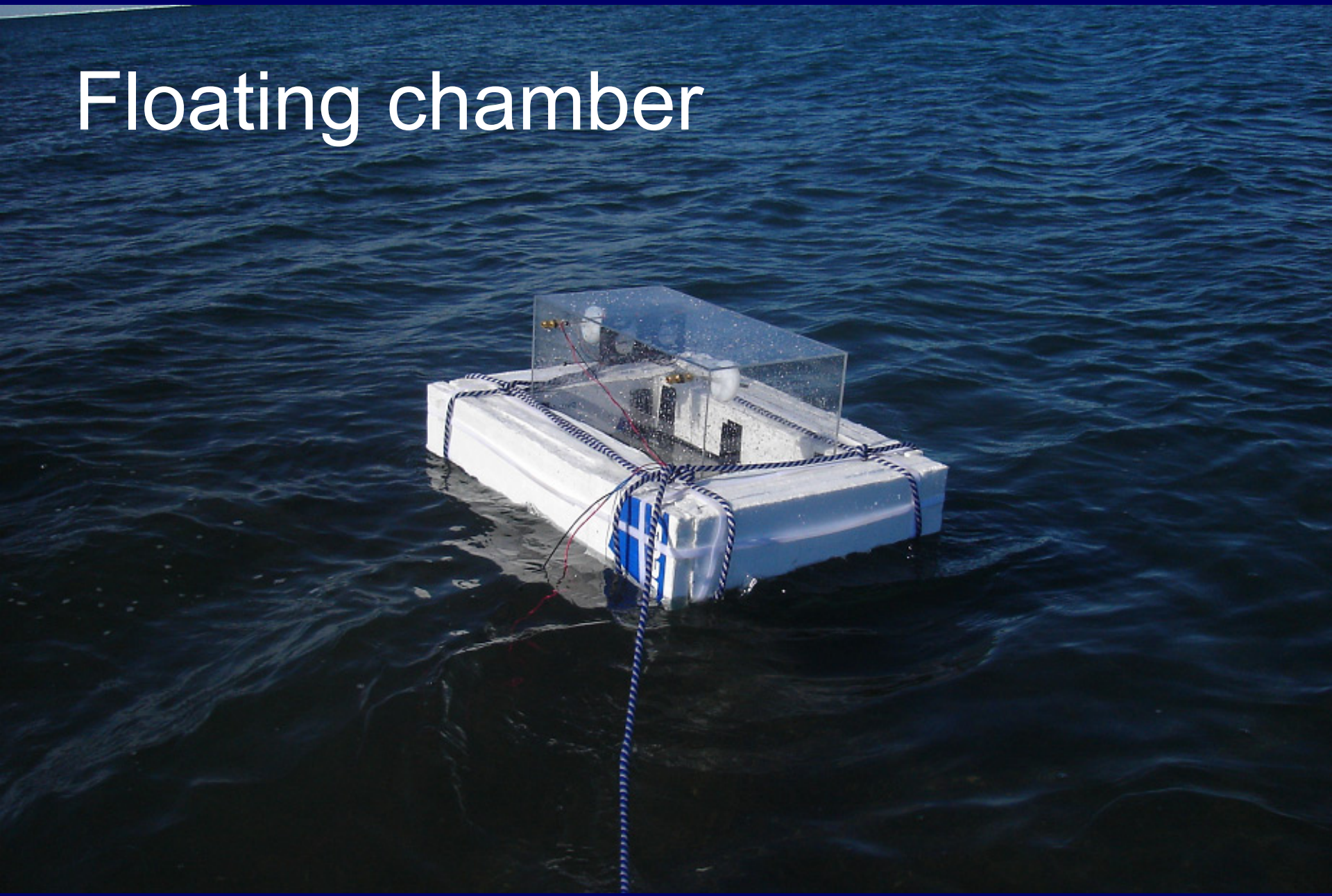
Sea Ice

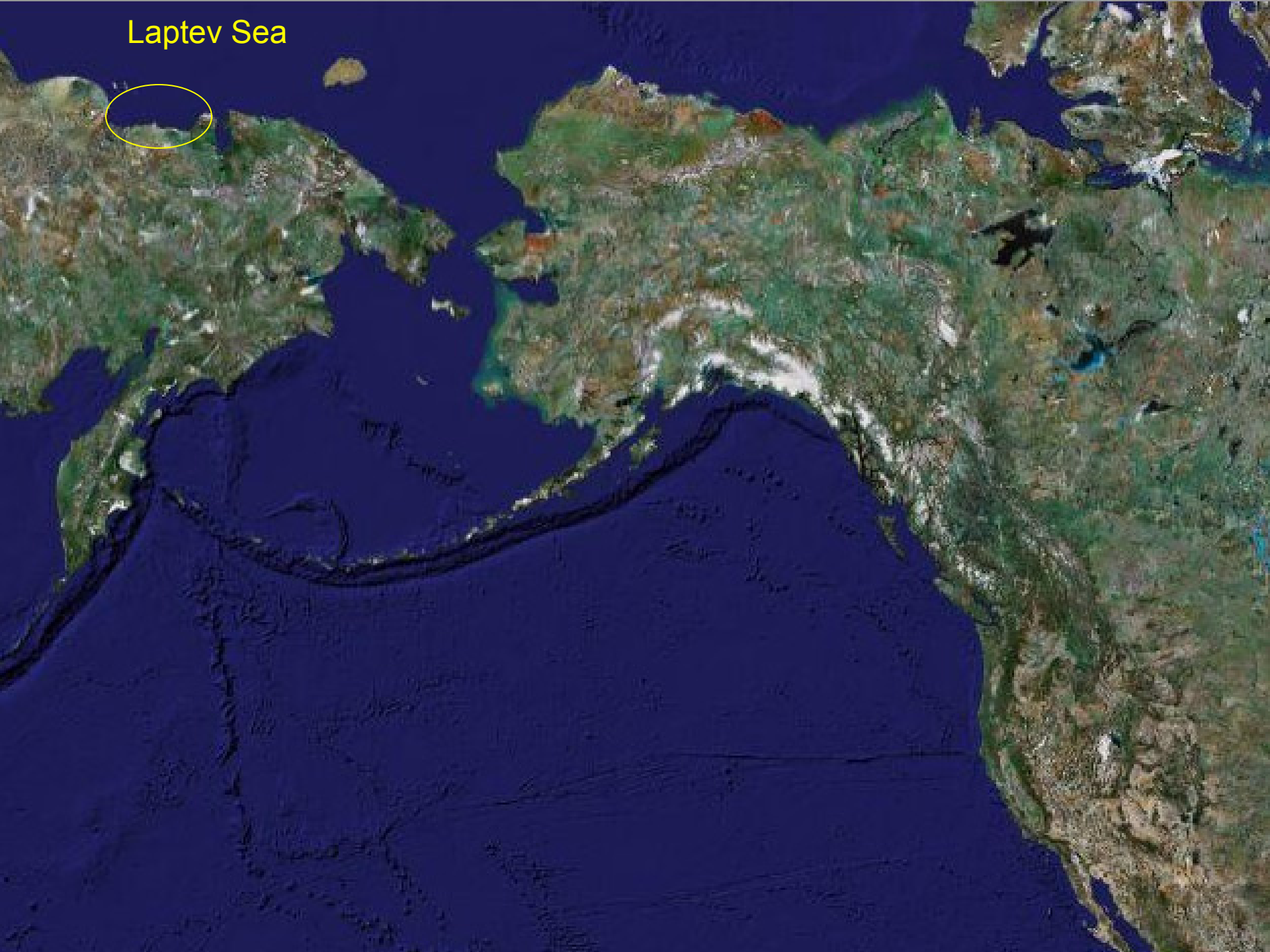
Logistics Issue?

Flux Tower at Point Barrow

pCO_2 system (NARL, Barrow)

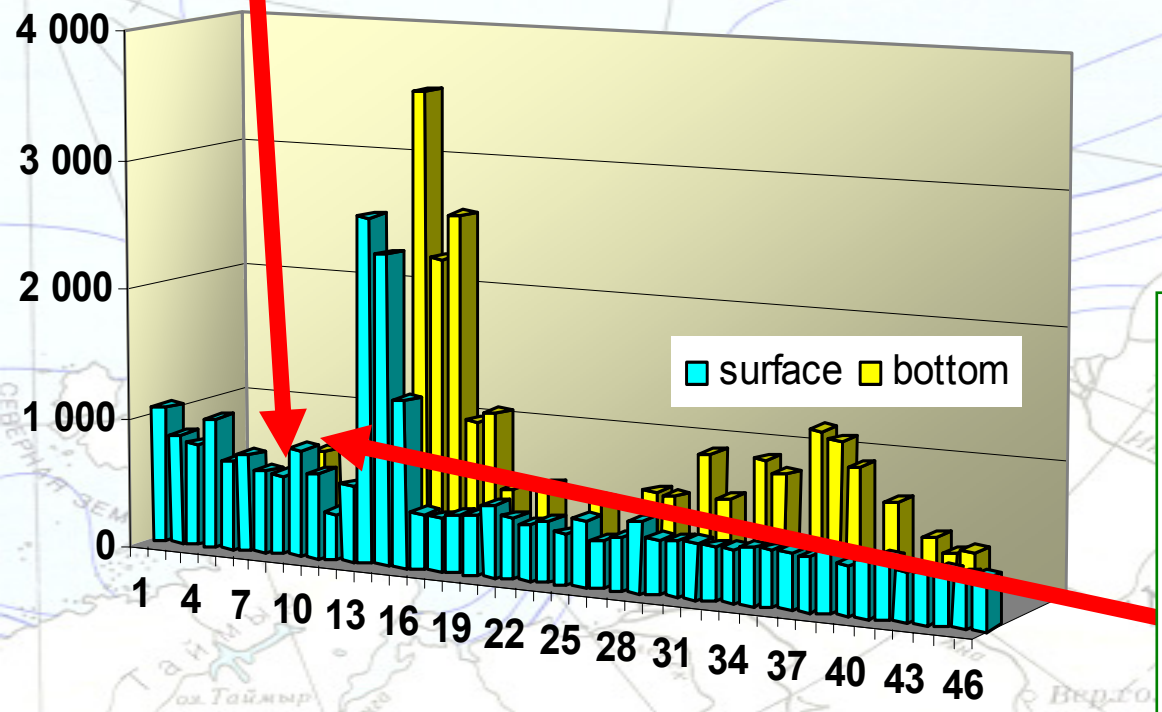
Floating chamber

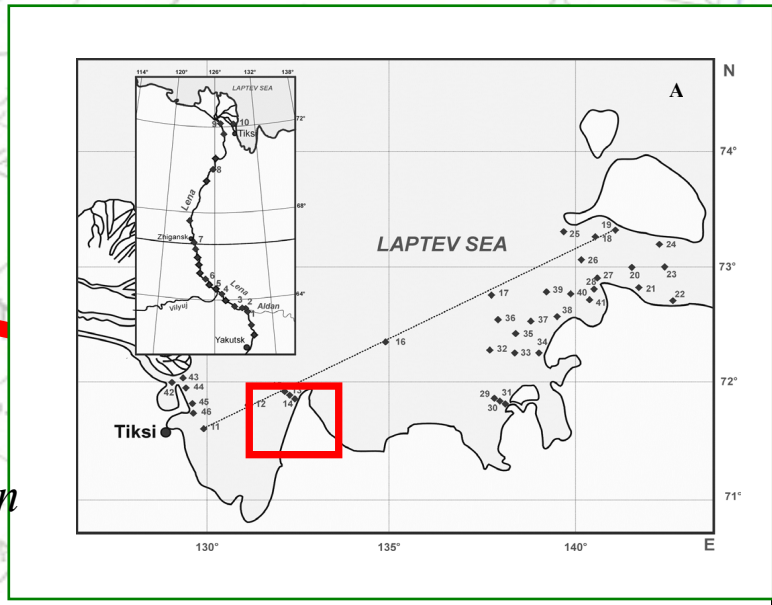



Laptev Sea


Work Of Collaborators:
Igor Semilitov
Nadia Shakova
et al.

Eroded organic carbon is oxidized to the end-product: CO_2. The "eroded" pCO_2 value reaches 2,000-3,500 µatm, while "riverine signal" is usually < 1,000 µatm (stations 1-11)



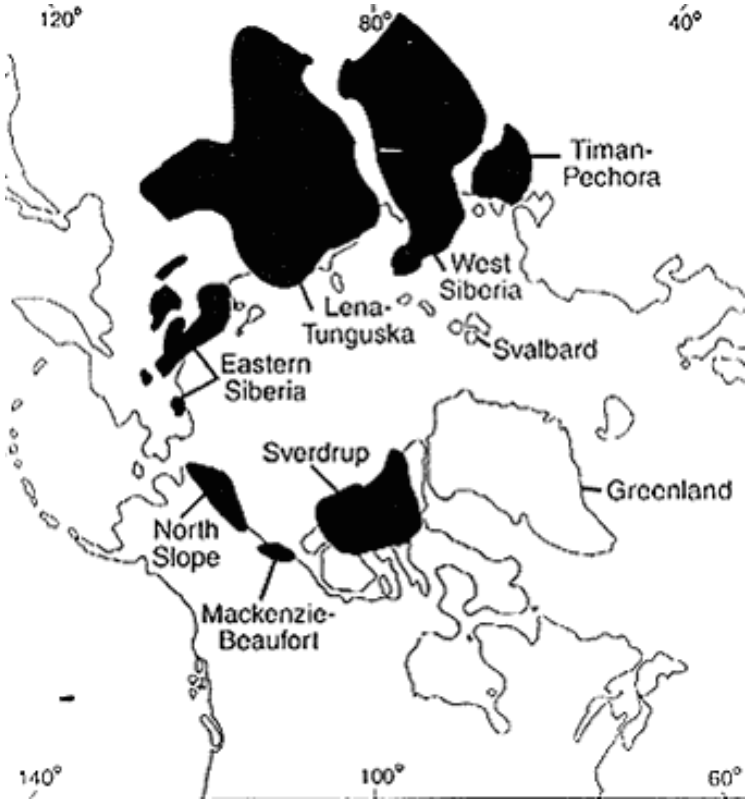


Results were obtained in September 1997, and confirmed in 1998-2004

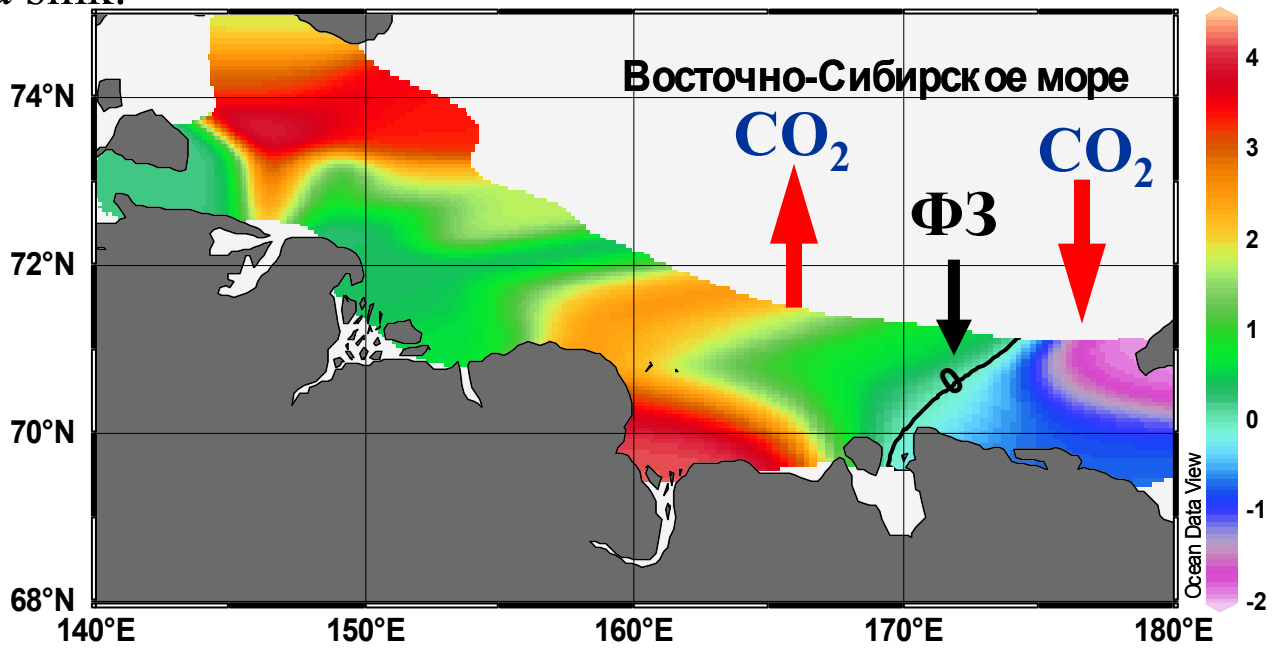
Hydrates are known to occur both within and below permafrost in polar areas.

Several areas in the Arctic show potential for having gas hydrate accumulations. Three provinces are in North America and four are in Russia: (1) northern Alaska, (2) the Mackenzie Delta-Beaufort Sea region, (3) Sverdrup basin of Canada, (4) Western Siberia basin, (5) Lena-Tunguska province (Vilyuy basin), (6) Timan-Pechora basin, and (7) several sedimentary basins in northeastern Siberia and the Kamchatka area. Data from over 1000 wells provide both direct and indirect evidence for the existence of arctic gas hydrates. Most of the information has come from drilling activity in Alaska, Canada, and Siberia.

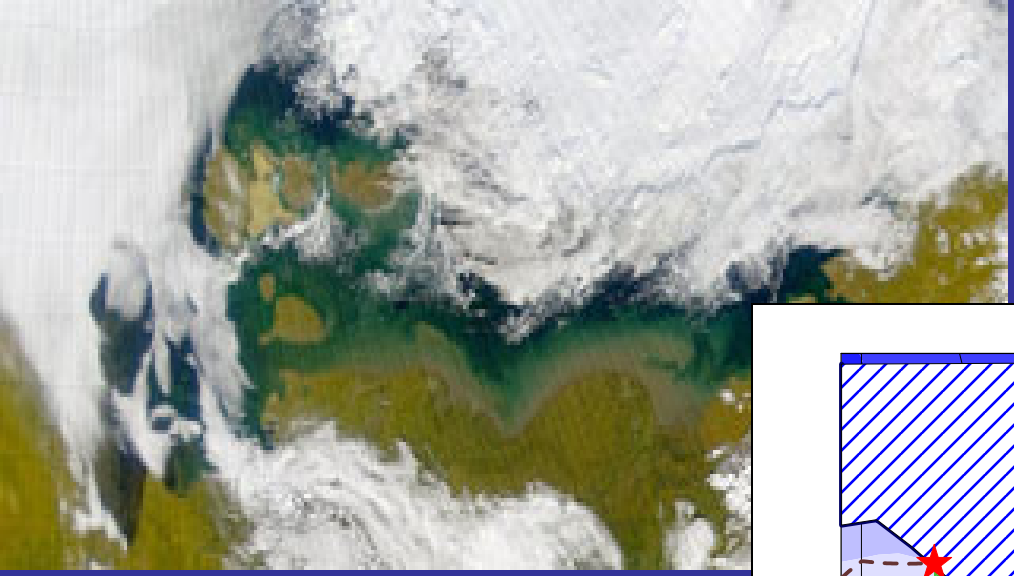
Amount of methane hydrate, presumably stored within the Arctic Ocean is predicted to be ~2260 Gt, from which about 540 Gt underlain the Russian part of the Arctic shelf (Soloviev et al., 1987).



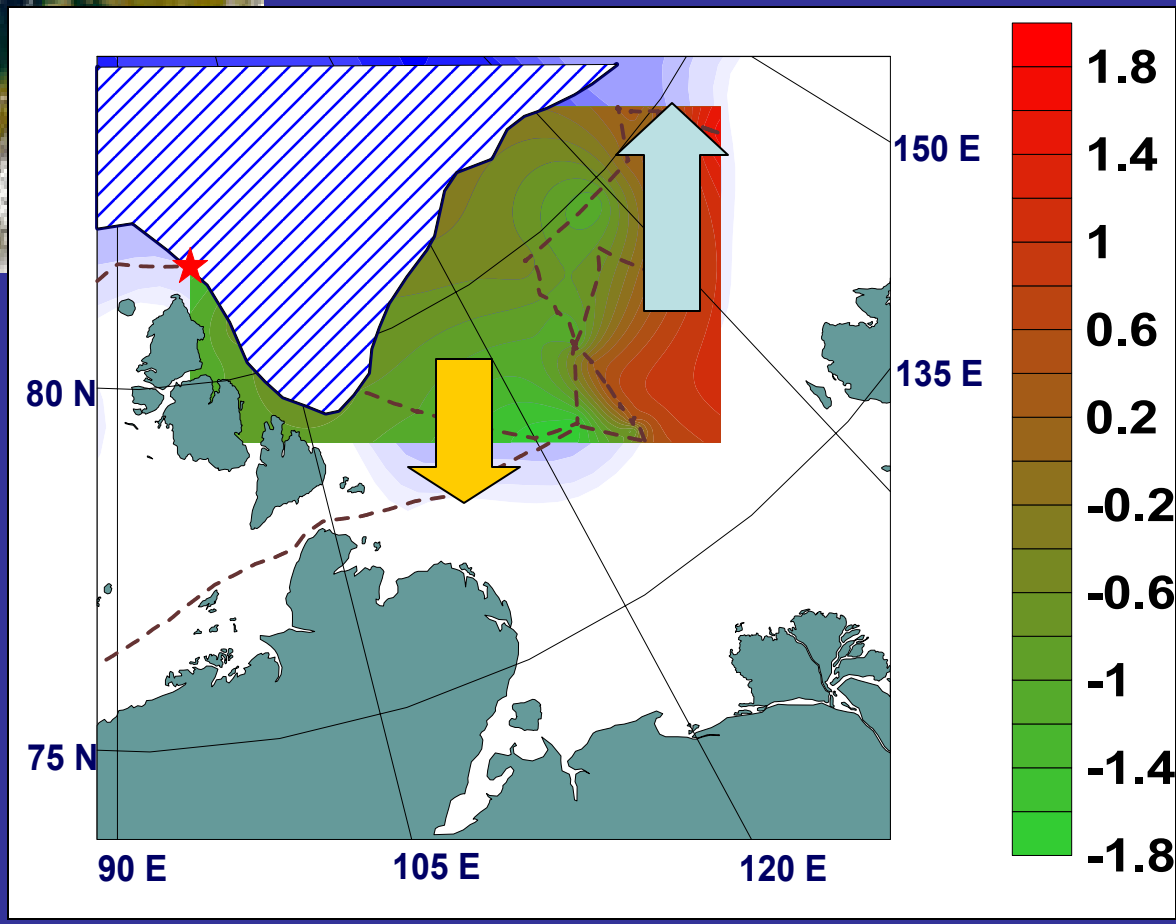
Early, it was supposed that the Arctic Ocean is a sink of atmospheric CO_2. But our study demonstrate a mosaic picture in CO2 fluxes. The low productive shelf waters influenced by coastal erosion and river transport (low transparency) are a source of CO2 , while high-productive (high transparency) Pacific-derived waters are a sink.



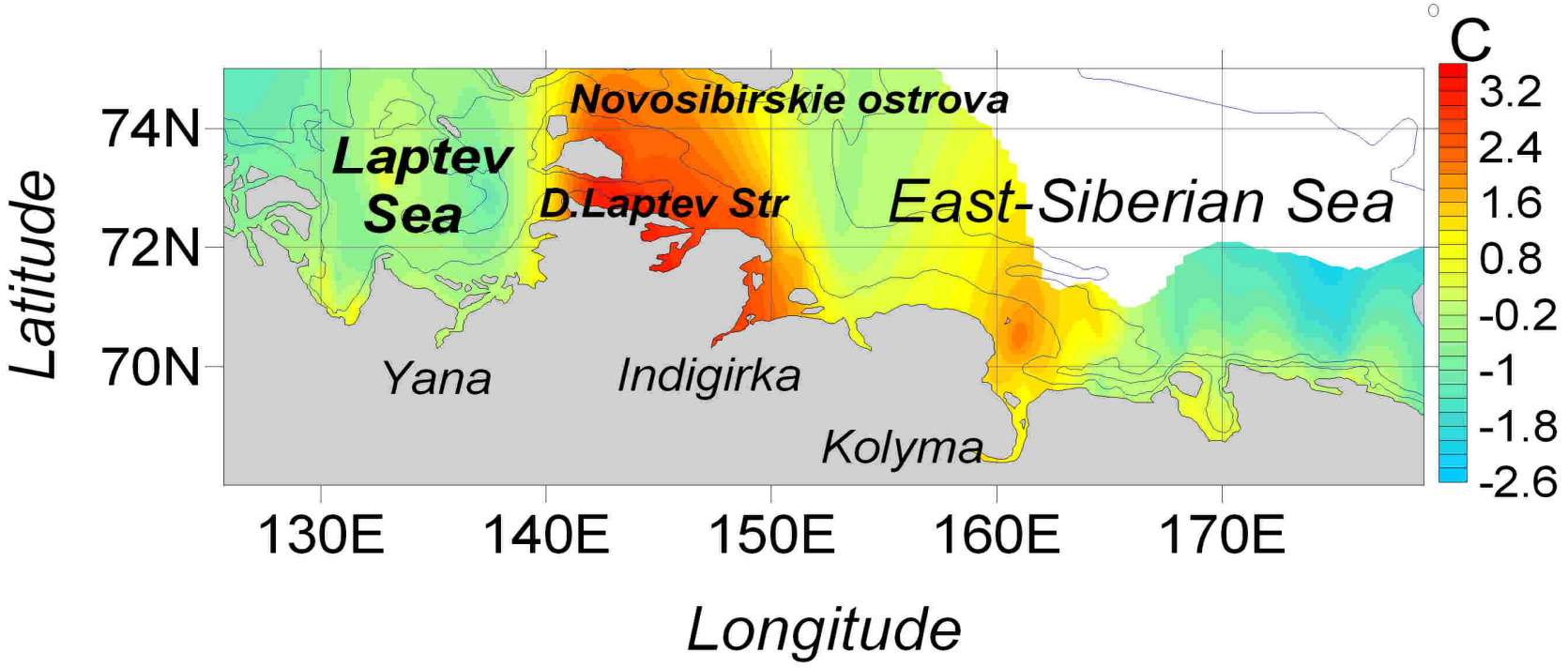
Direction of CO_2 (ммоль/(м^2 day) flux is changed in the Frontal zone between the Pacific-origin waters and local shelf waters (Semiletov et al., 2005; Pipko et al., 2005)



Eddy-correlation data demonstrate mosaic distribution of air-sea CO_2 exchange (September 2005, I/B Kapitan Dranitsyn)

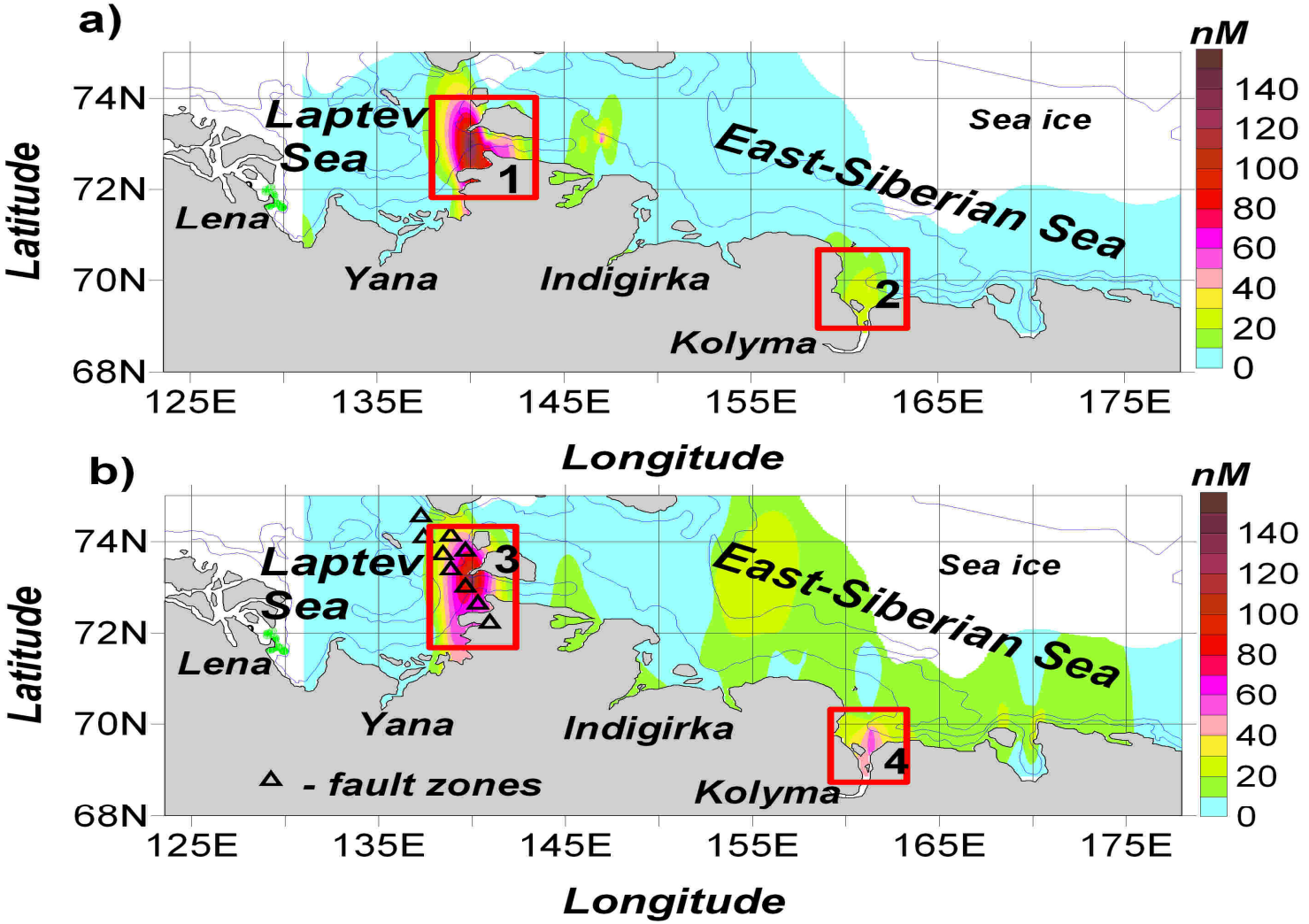


(by Semiletov, I., I.I. Pipko, I.A. Repina, and N. Shakhova, 2007, Carbonate dynamics and carbon dioxide fluxes across the atmosphere-ice-water interfaces in the Arctic Ocean Pacific sector of the Arctic, *Journal of Marine Systems*, 66 (1-4), 204-226).

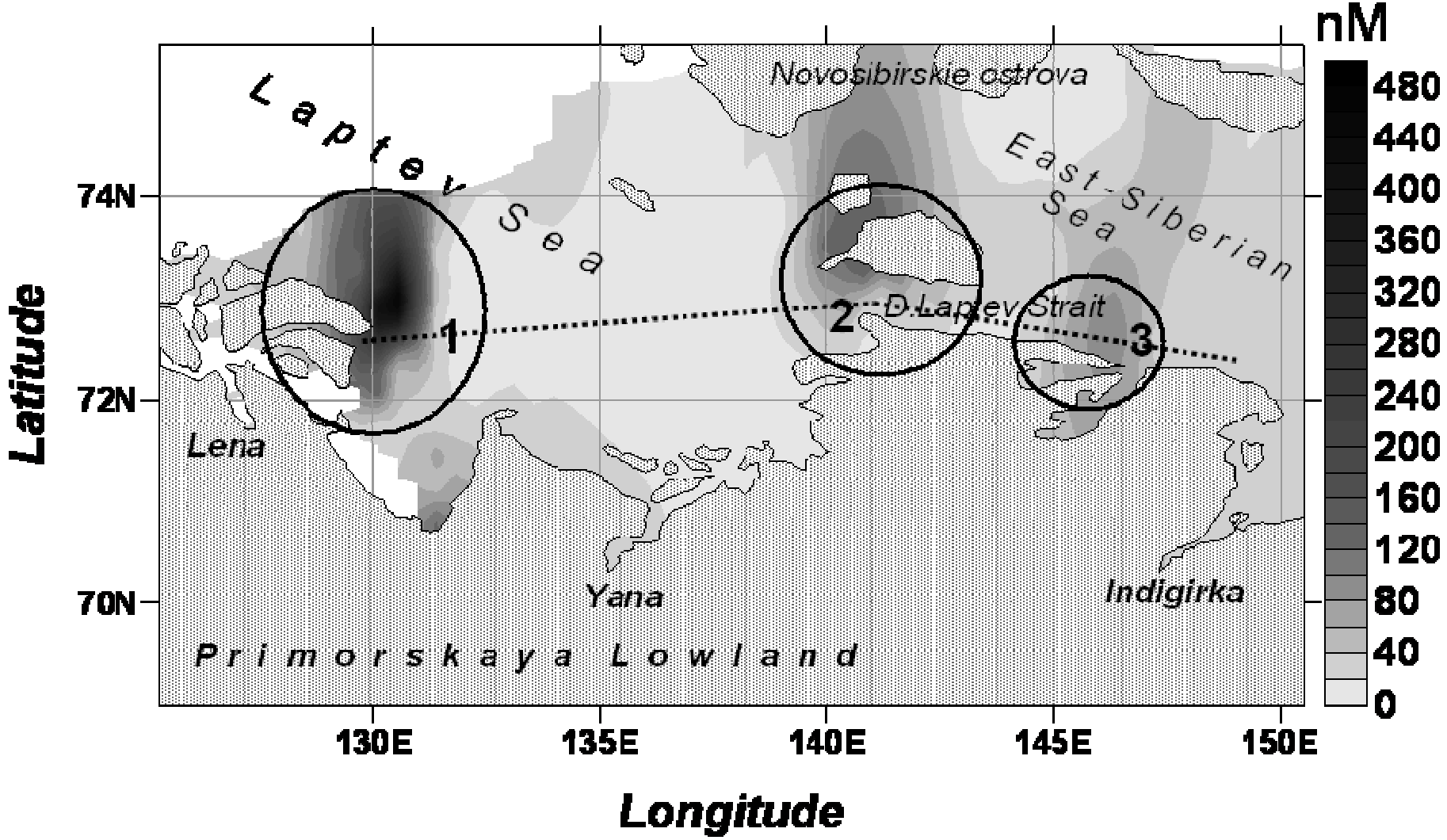


Our data show that mean annual surface sediment temperature (at depth 1m) is positive in some areas (up to +1°C), that indicates on existence of island permafrost (Shakhova and Semiletov, 2007, J.Marine Sys., 66 (1-4), 227-243).

Distribution of dissolved methane in the surface (a) and bottom (b) waters- 2004 (by Shakhova, N. and I. Semiletov, 2007, Methane release and coastal environment in the East Siberian Arctic shelf, *Journal of Marine Systems*, 66 (1-4), 227-243).

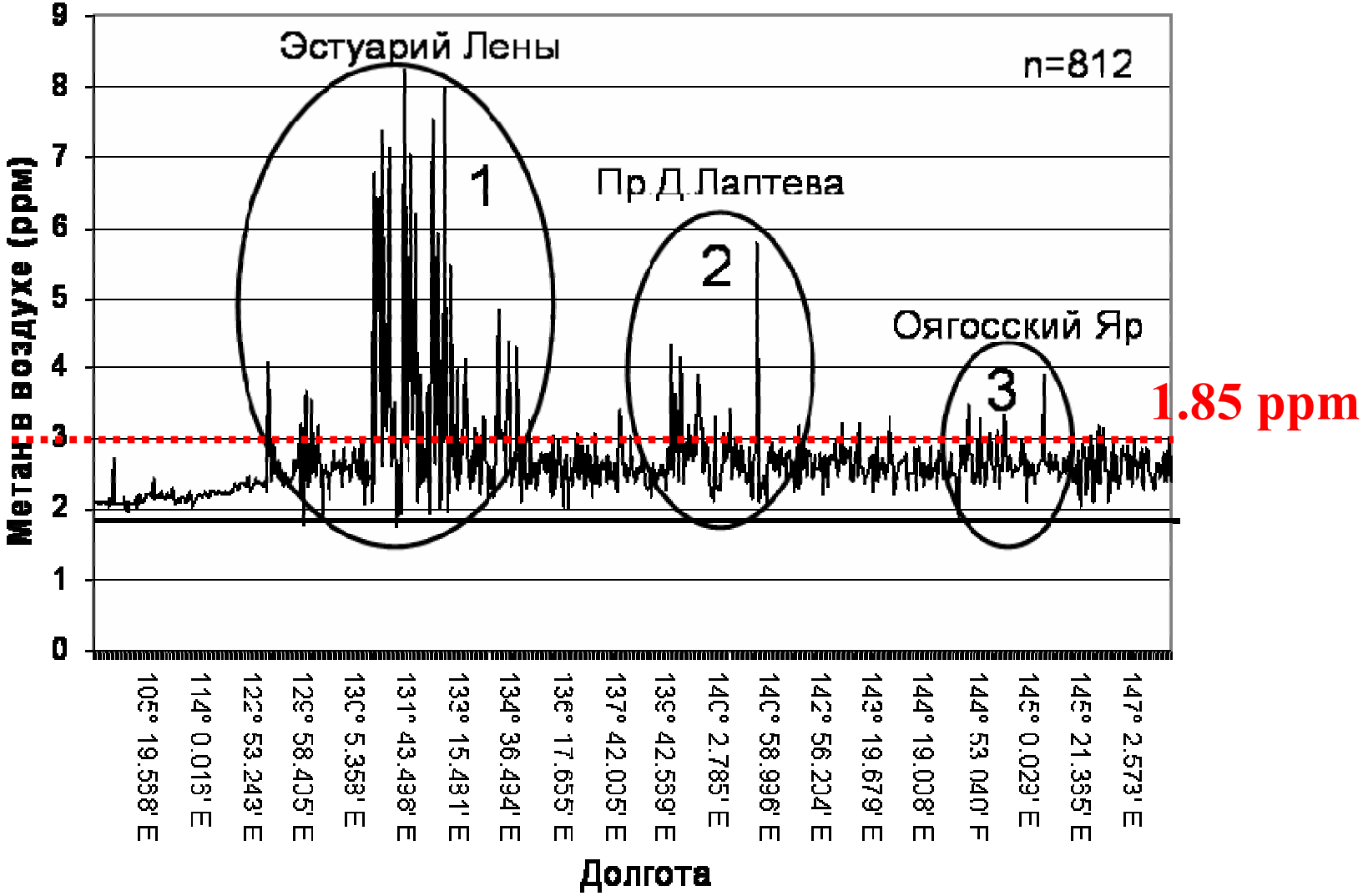


Distribution of dissolved methane in the surface water-2005

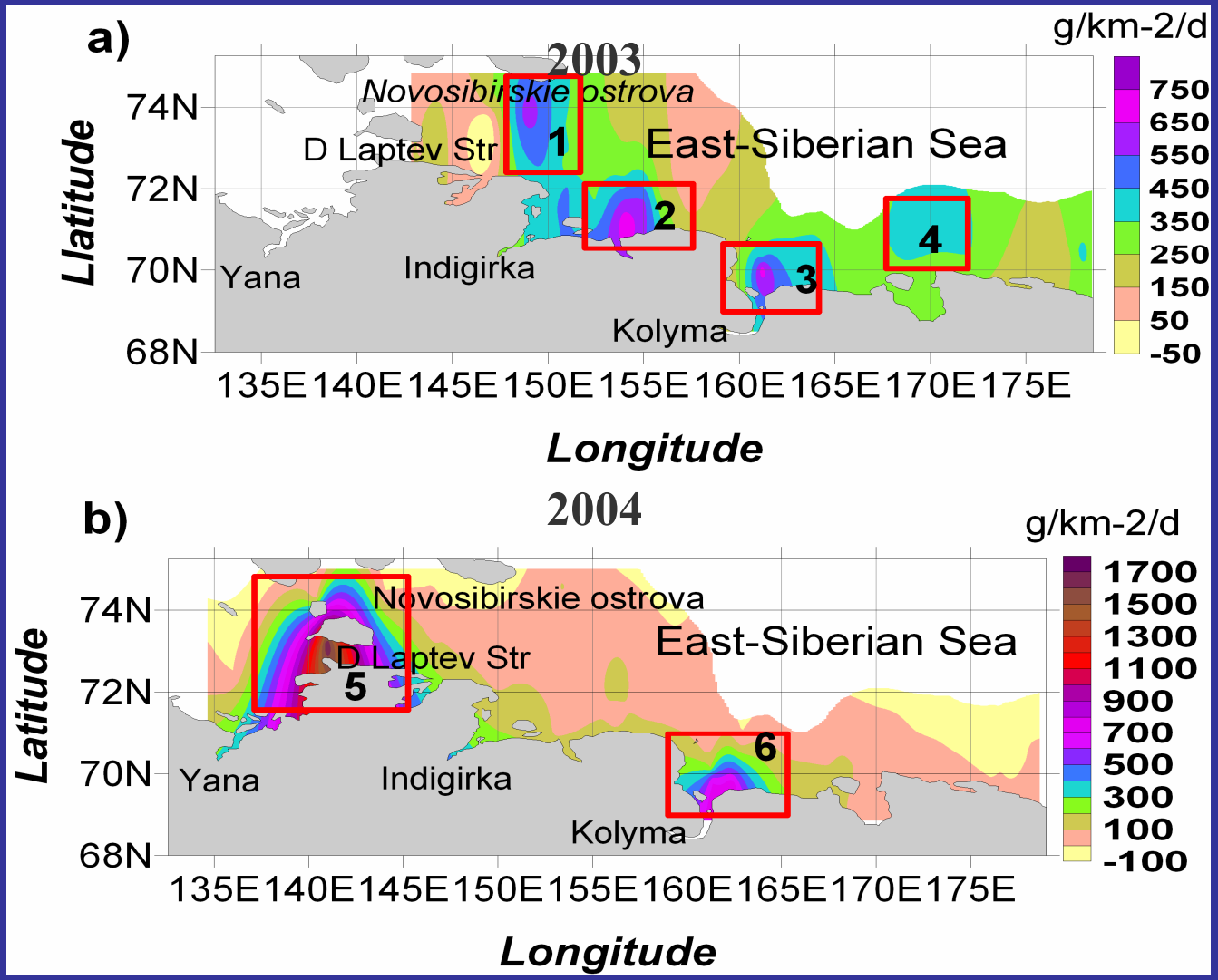


(by Shakhova N., Semiletov I., , A. Salyuk, N. Belcheva, and D. Kosmach, 2007, *Transactions of Russian Academy of Sciences*, 414 (6), (translated in English by Springer).)

Methane anomalies in air are correlated with anomalies of dissolved methane above fault zones (*previous slide*) and river plume (2005)



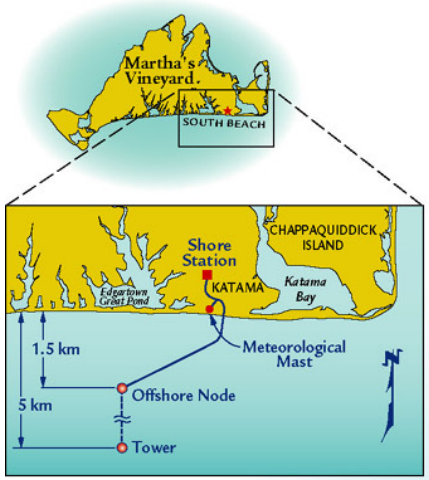
Quantitative evaluation of methane efflux into the atmosphere



The East-Siberian shelf contributes with about 50% of total methane emission from the World Ocean near-shore zone (Shakhova et al., 2005; Macdonald et al., 2006)

Martha's Vineyard Coastal Observatory

(objects not drawn to scale)



· Hydrophone and Fluorescence

· Data and Power Transmission
· Meteorological System
· Currents, Pressure, Waves

Ocean Flux Tower

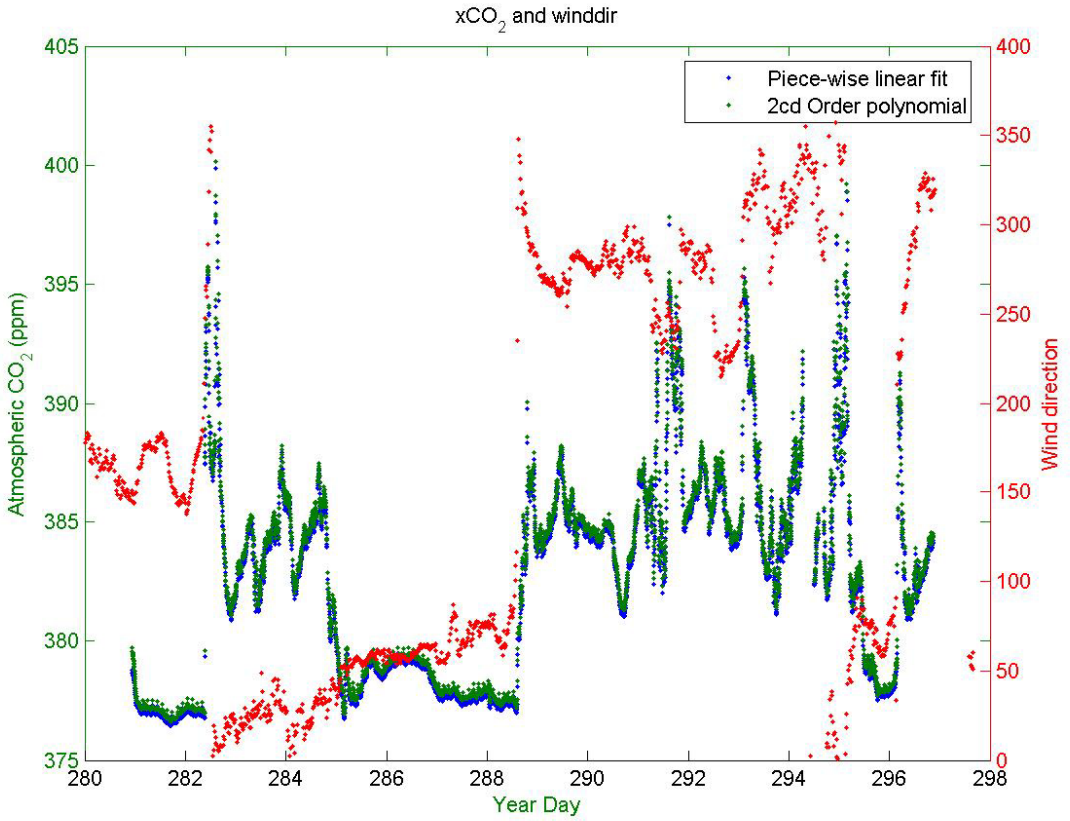
3.5 km offshore

Cabled Data and Power.

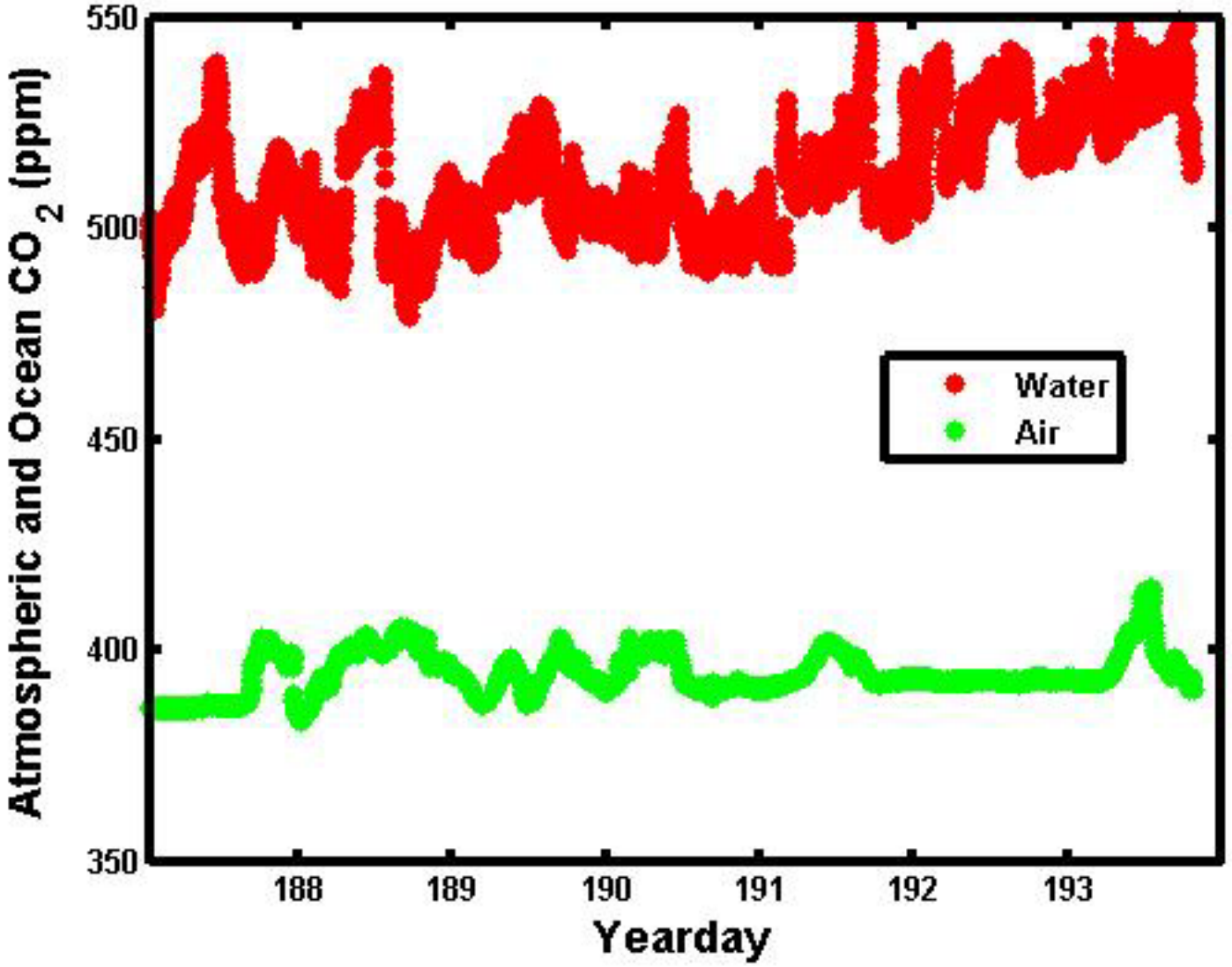
18 meter water depth.

20 meter height.

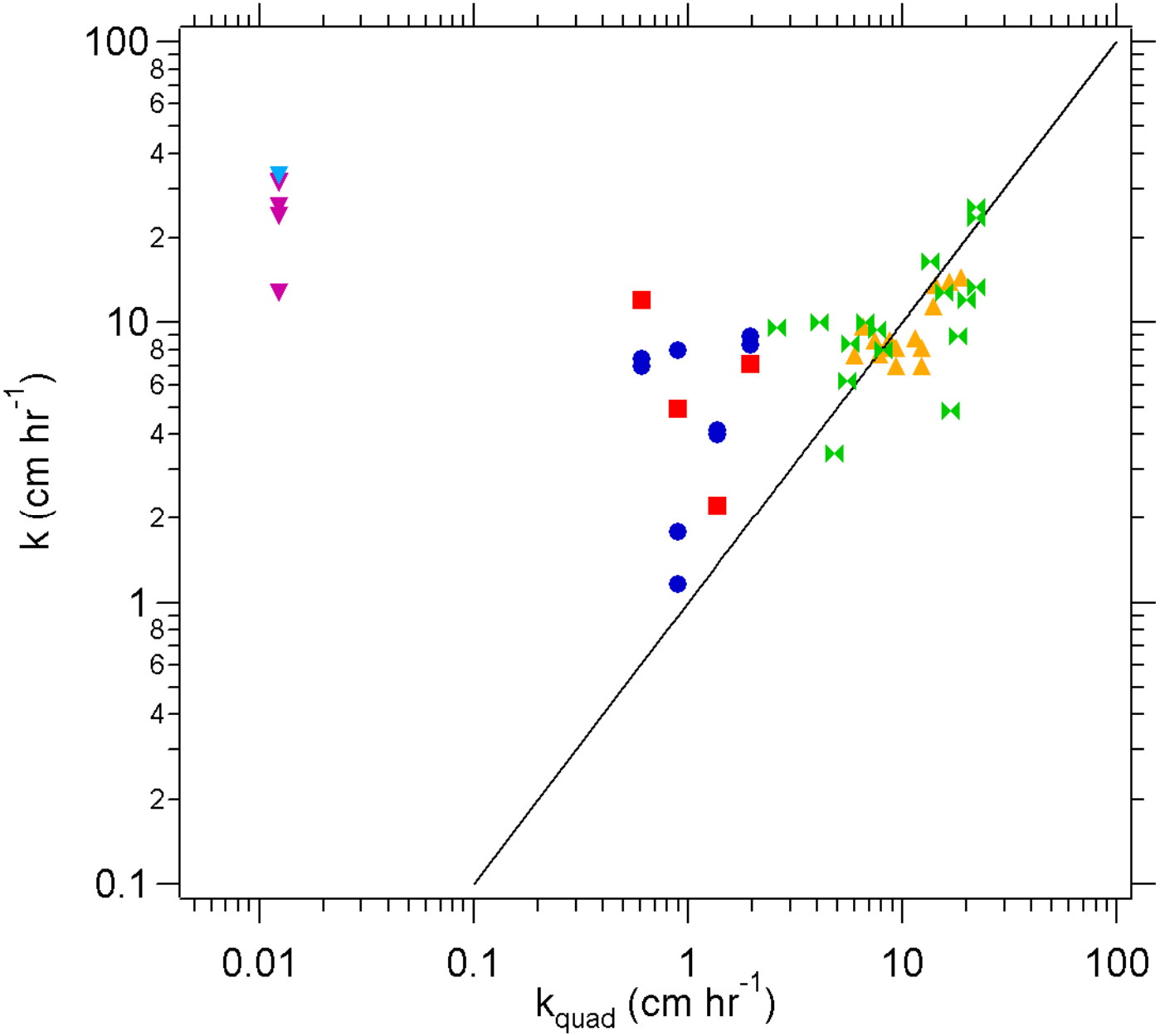
Coupled air-water BL.

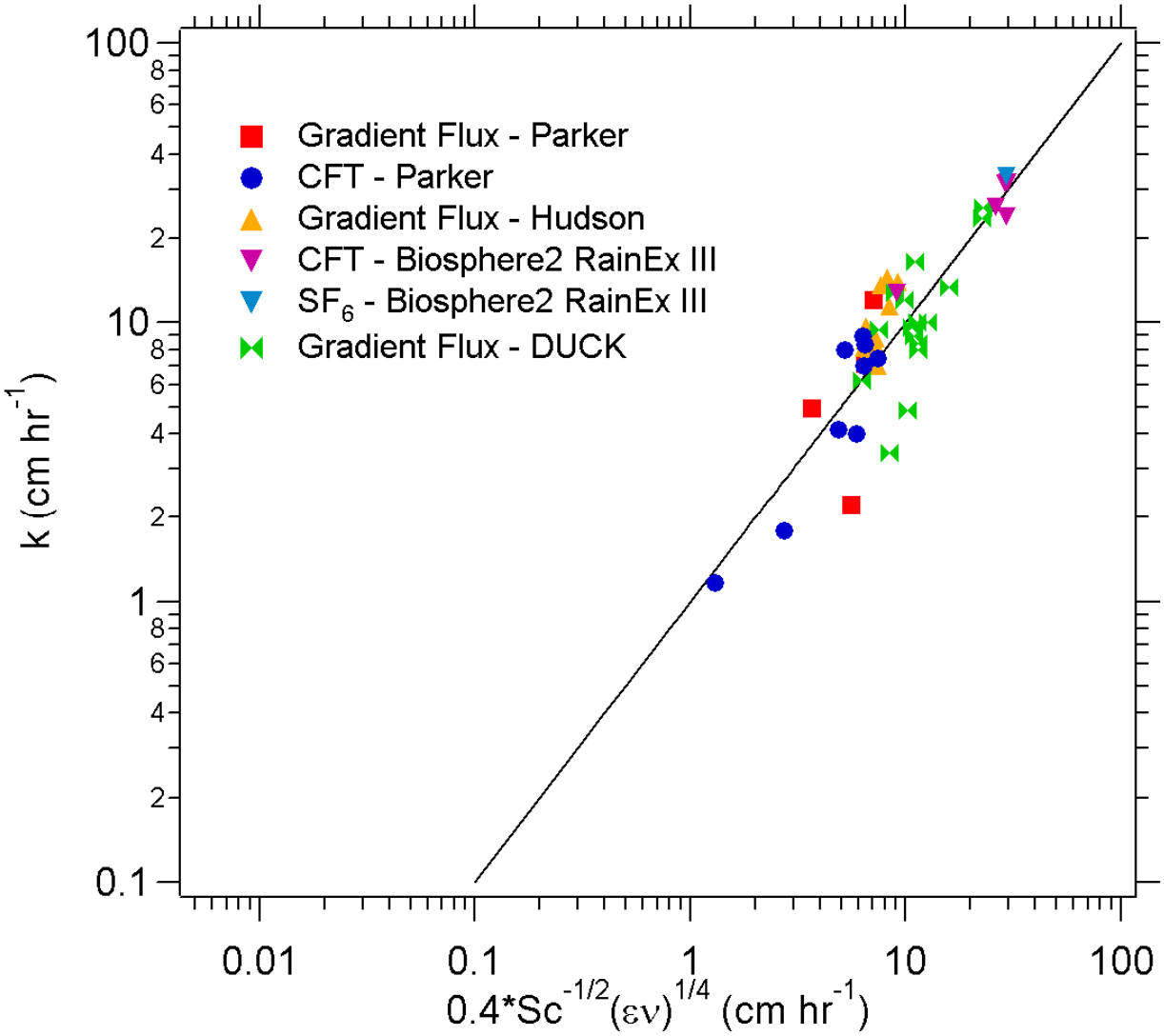


Coastal Tower Atmospheric and Ocean Carbon Dioxide

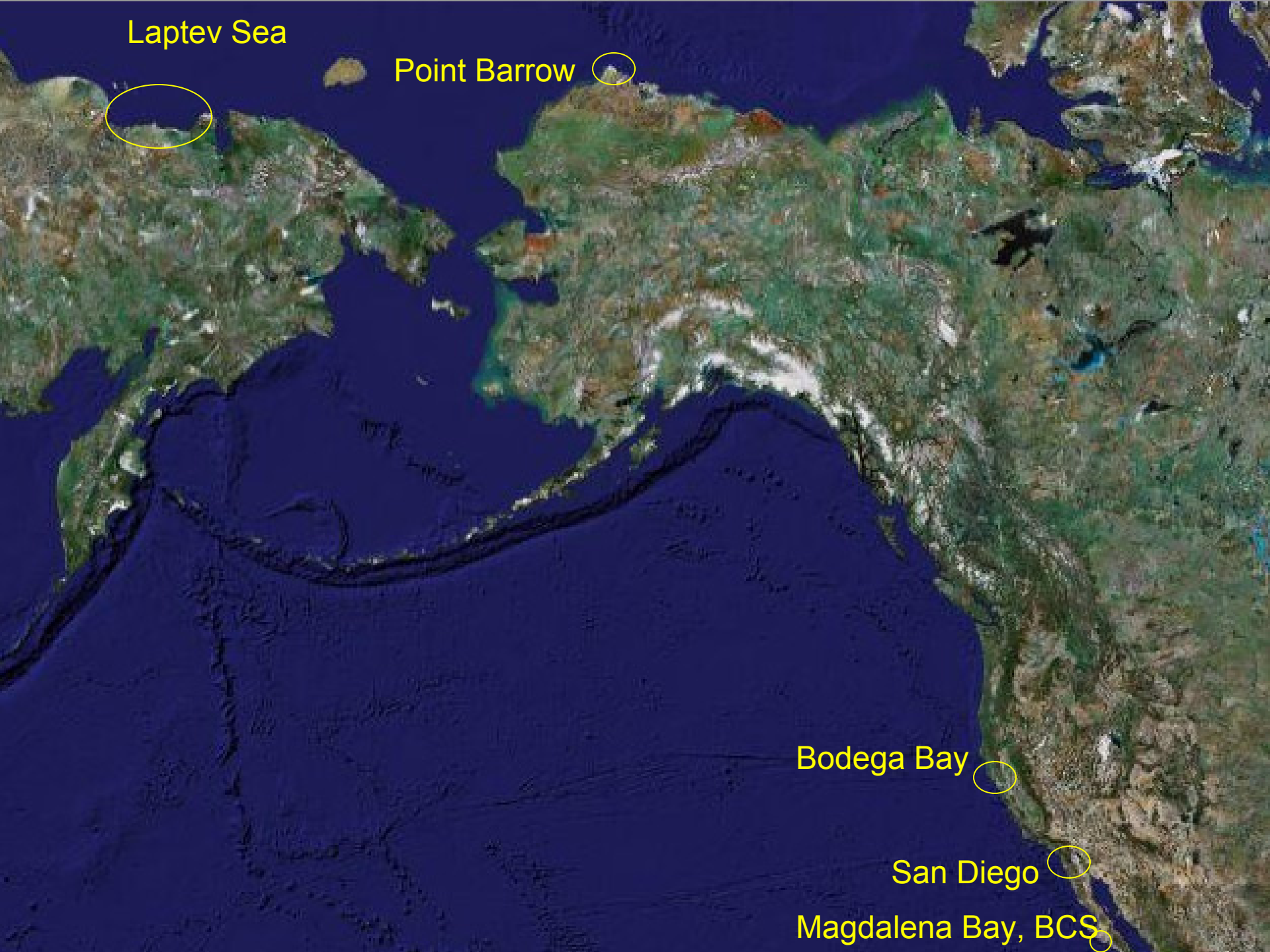


Surface Processes Instrument Platform (SPIP) and R/V Catch the Joy

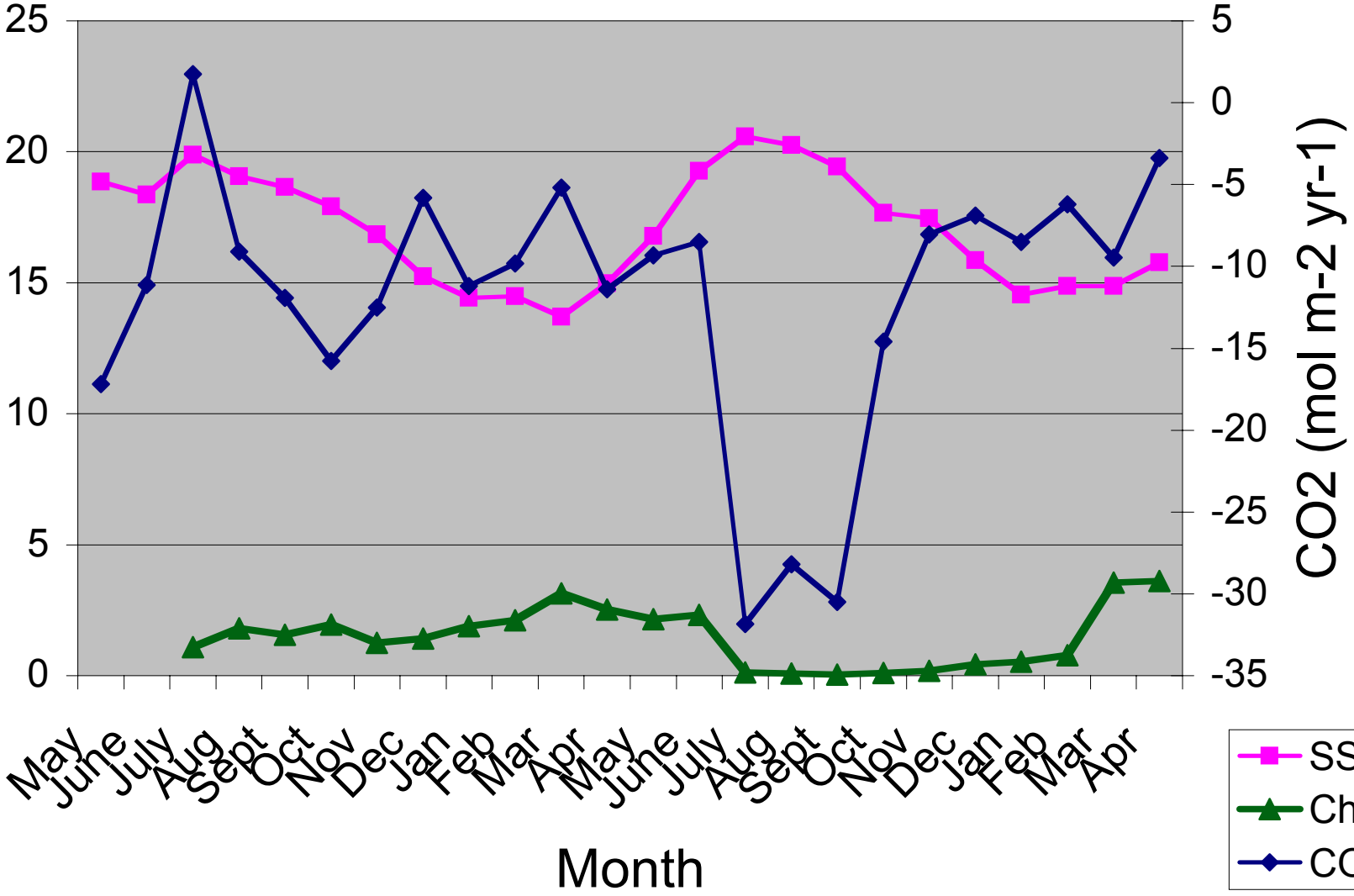

100
8
6
4
2
10
8
6
4
2
1
8
6
4
2
0.1
k (cm hr-1)
0.01
0.1
1
10
100
kquad (cm hr-1)

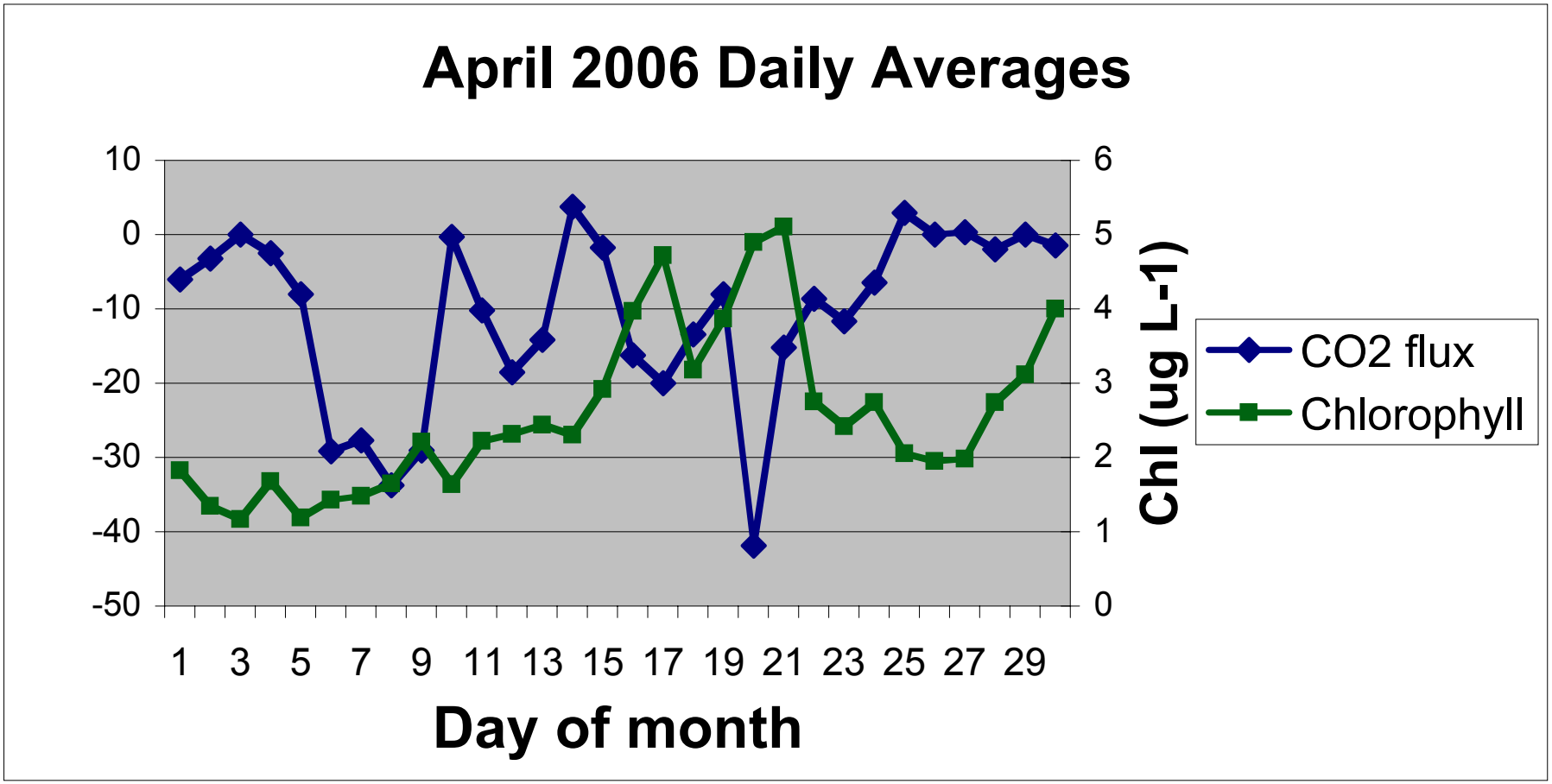

Gradient Flux - Parker
CFT - Parker
Gradient Flux - Hudson
CFT - Biosphere2 RainEx III
SF6 - Biosphere2 RainEx III
Gradient Flux - DUCK
k (cm hr-1)
0.4*Sc-1/2(εν)1/4 (cm hr-1)
100
10
1
0.1
0.01
0.1
1
10
100

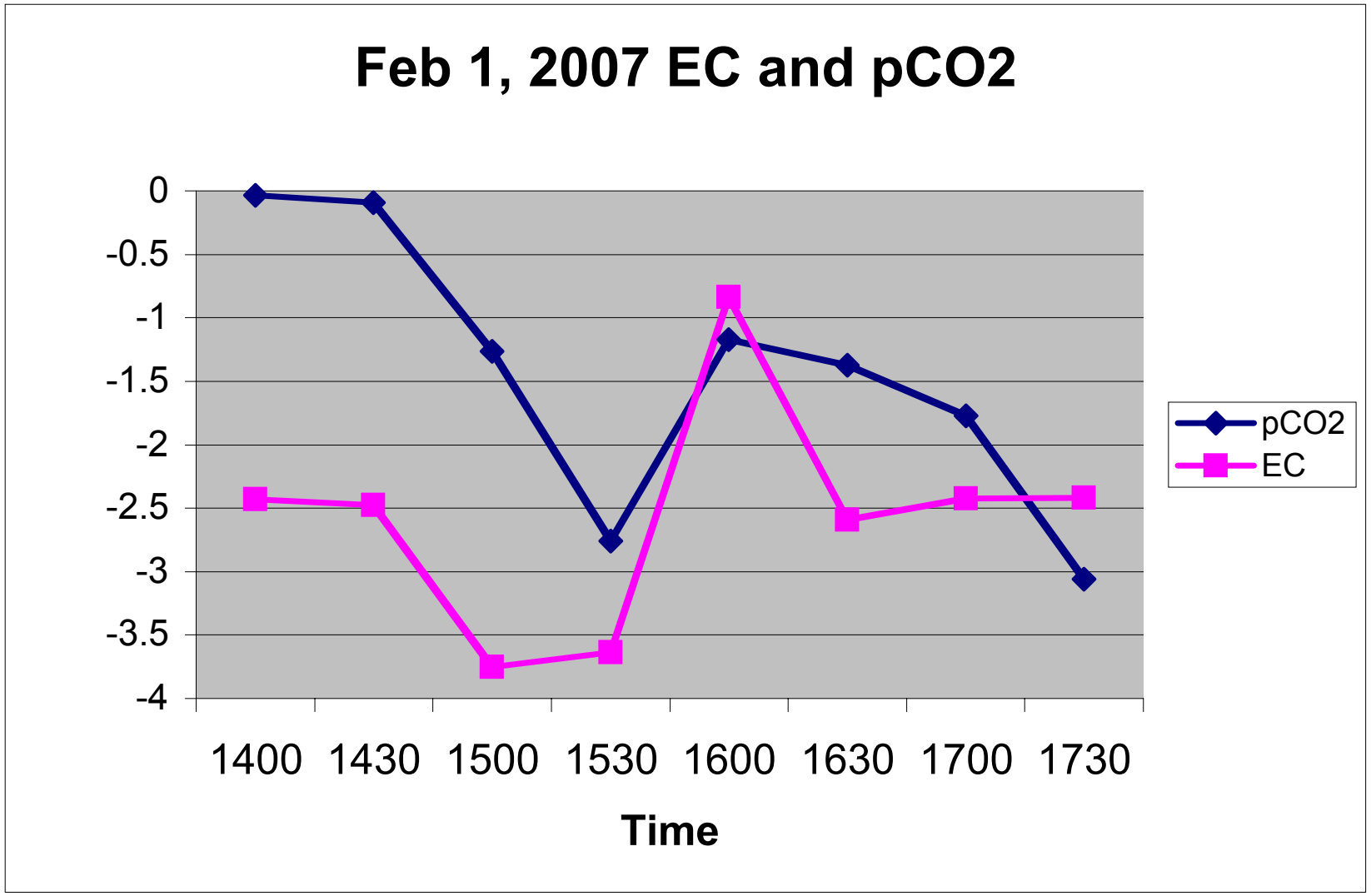

Coastal Processes Rule!


Laptev Sea
Point Barrow
Bodega Bay
San Diego
Magdalena Bay, BCS

Monthly CO2, Chlorophyll, and SST




April 2006 Daily Averages
10
0
-10
-20
-30
-40
-50
6
5
4
3
2
1
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29
Day of month
Chl (ug L-1)
CO2 flux
Chlorophyll


Feb 1, 2007 EC and pCO2
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
1400
1430
1500
1530
1600
1630
1700
1730
Time
pCO2
EC

Tidal Influence on CO_2