The dynamical landscape of phytoplankton diversity

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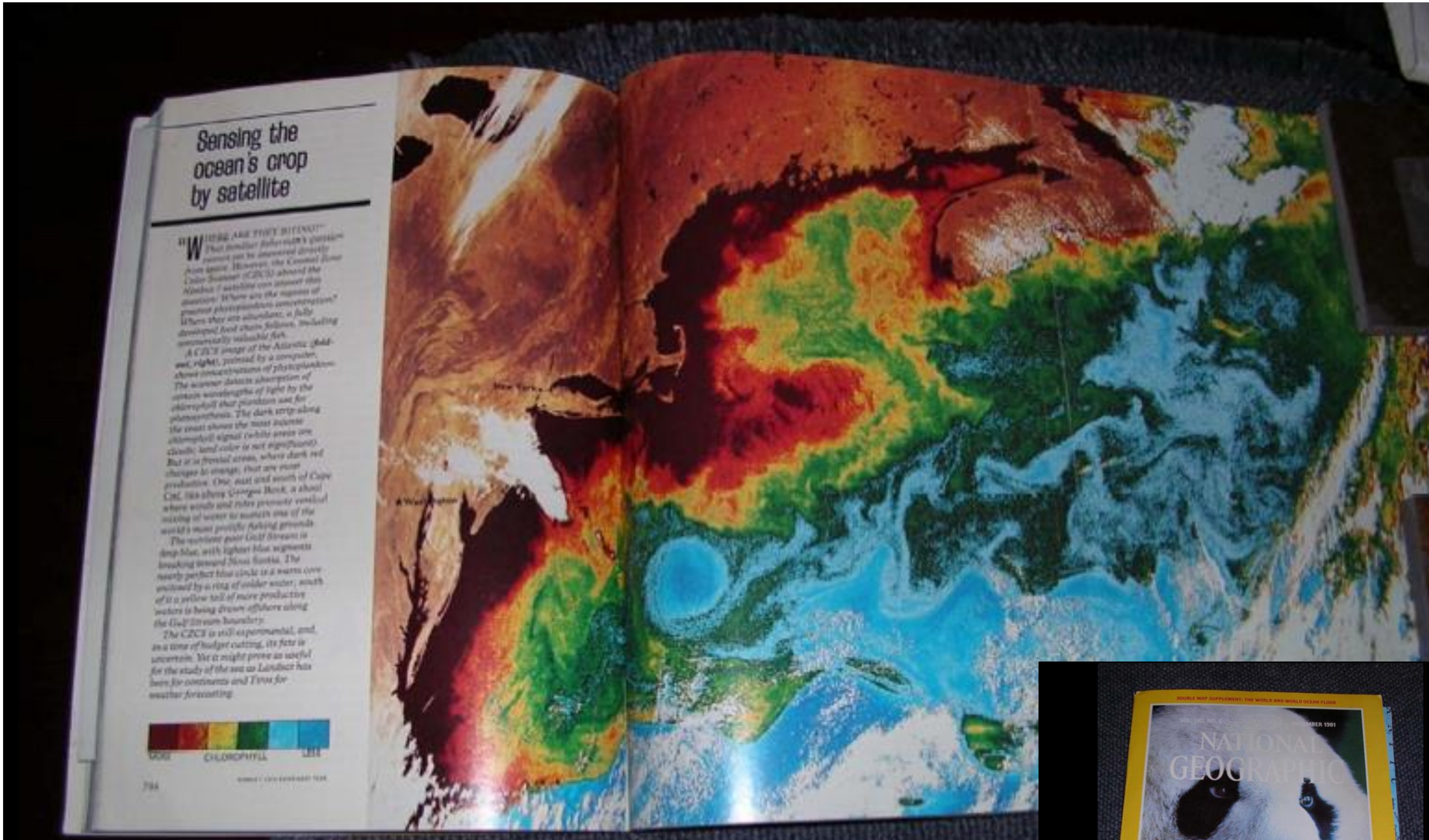
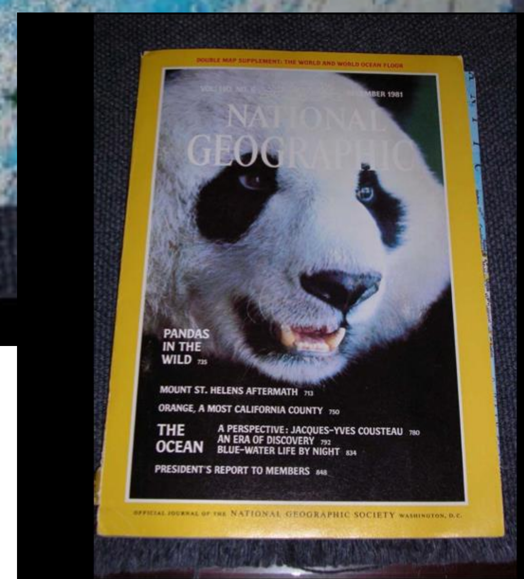
Trait-based approaches to ocean life, 2015, Waterville Valley



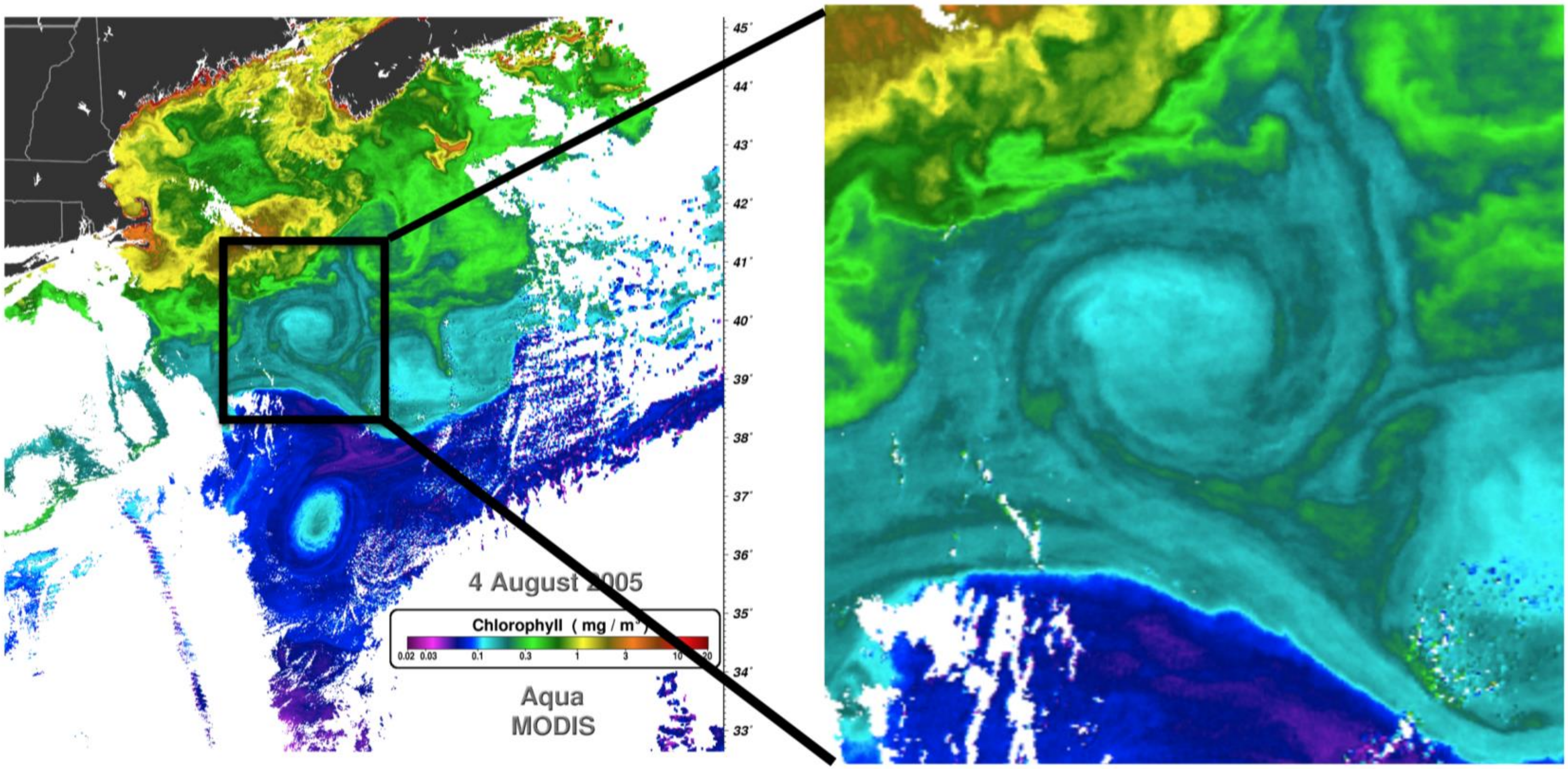


CZCS in National Geographic, 1981

Mesoscale turbulence

Eddies

Fronts



Mesoscale
100 km

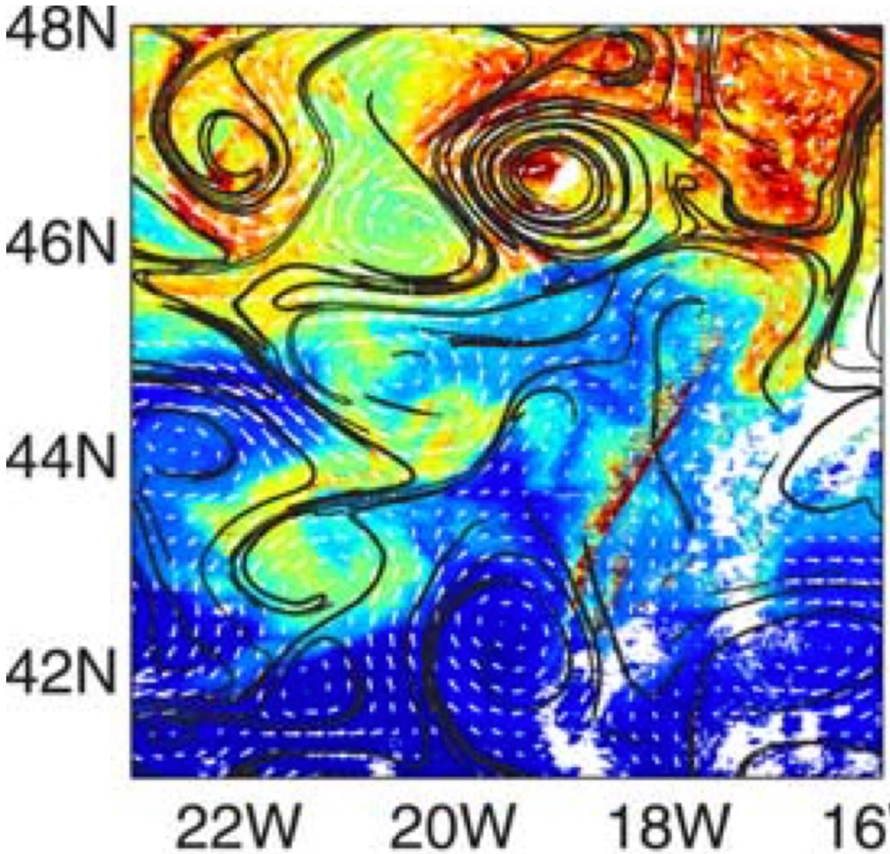
Submesoscale 1-10 km

Months

Days

Synergy with other satellite products: Chl and Altimetry

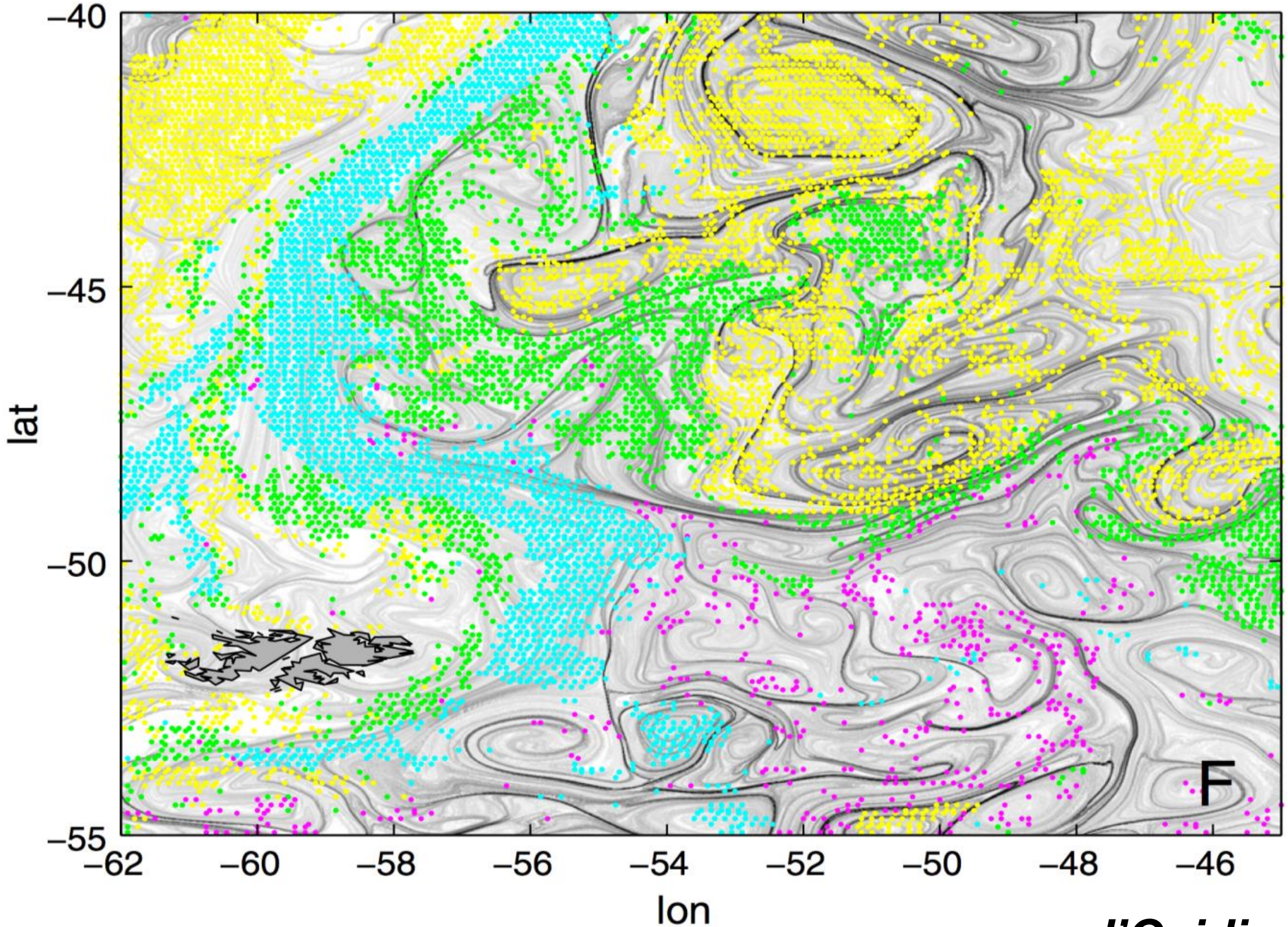
Chl + FSLE



The total Chla landscape is shaped by the currents

Lehahn et al, 2007, JGR

Optical anomalies from PHYSAT (Phyto types) + FSLE



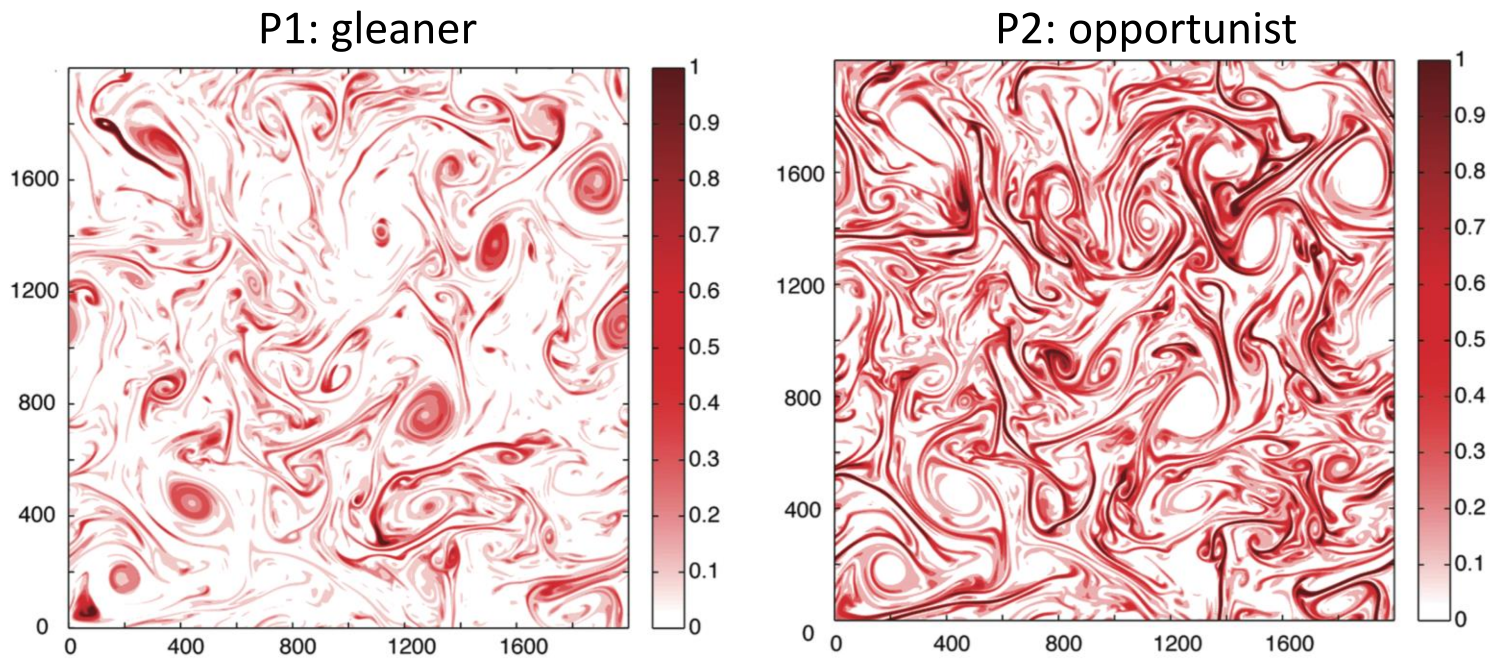
d'Ovidio et al, 2010, PNAS

Meso currents shape the optical anomaly landscape

Questions raised by these observations

- Is phytoplankton diversity shaped by mesoscale turbulence ?
- How are different phytoplankton types (gleaners/opportunists) distributed within eddies and fronts ?
- Consequences on terms of in-situ observations of biodiversity ?

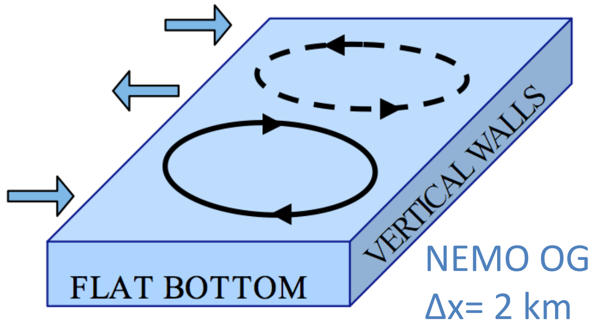
Hypothesis:
- Phytoplankton community described with 2 types
- No environmental gradient
- No seasonality



Conclusions:
Gleaner dominates in eddies, the Opportunist dominates in fronts
The two types co-exist in fronts

Perruche et al, 2011

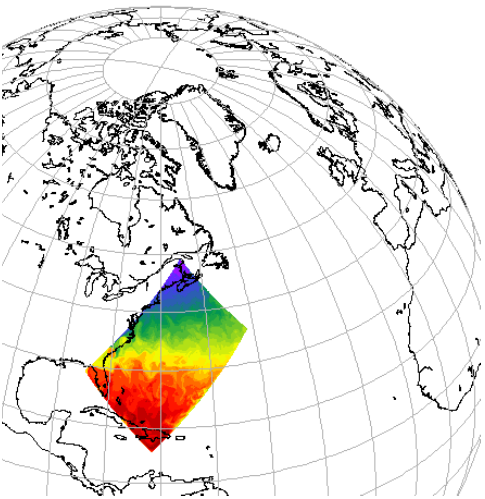
Submesoscale model



NEMO OGCM
Δx= 2 km

+

DARWIN model
100 phytoplankton types



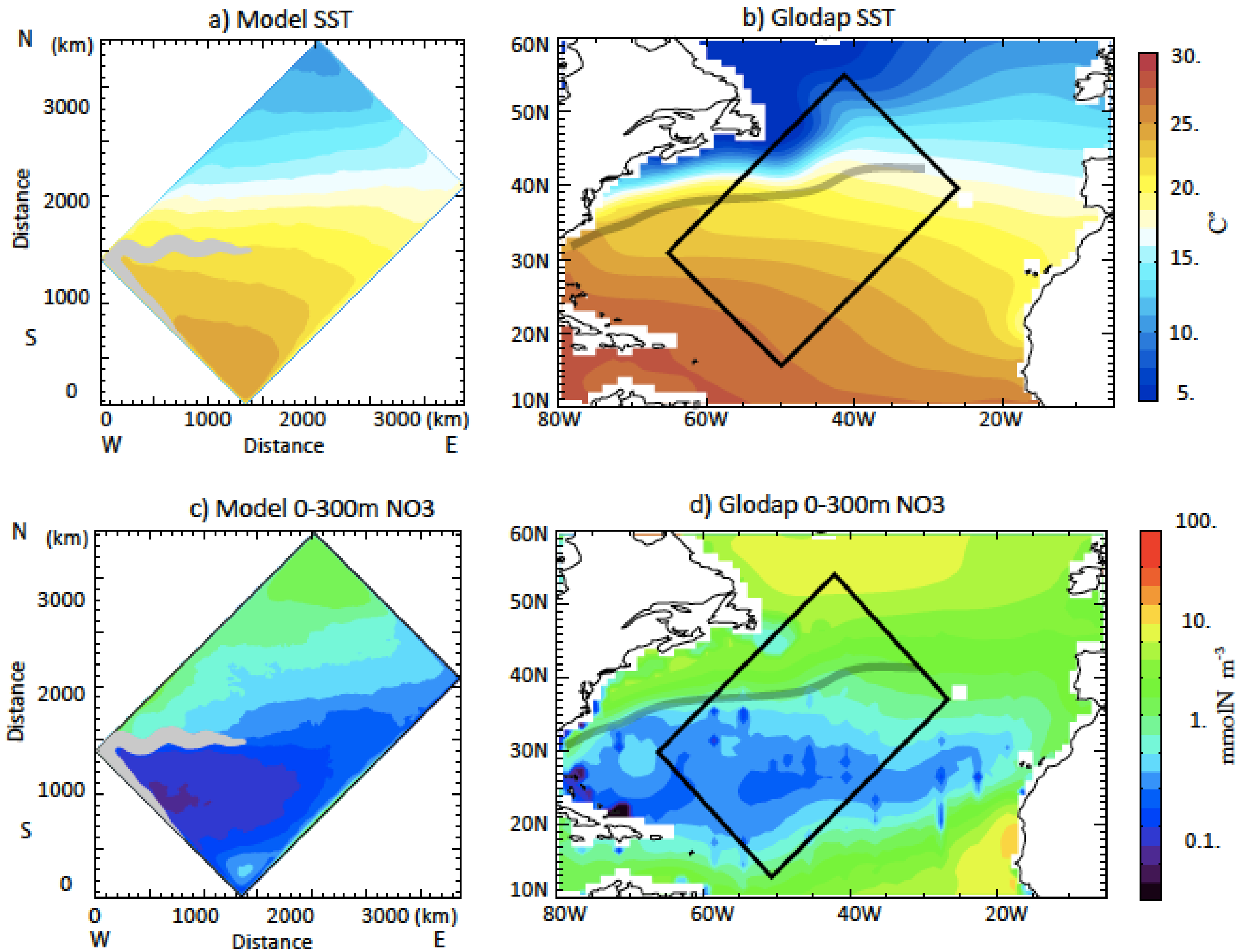
+ Seasonally varying

Environmental gradients

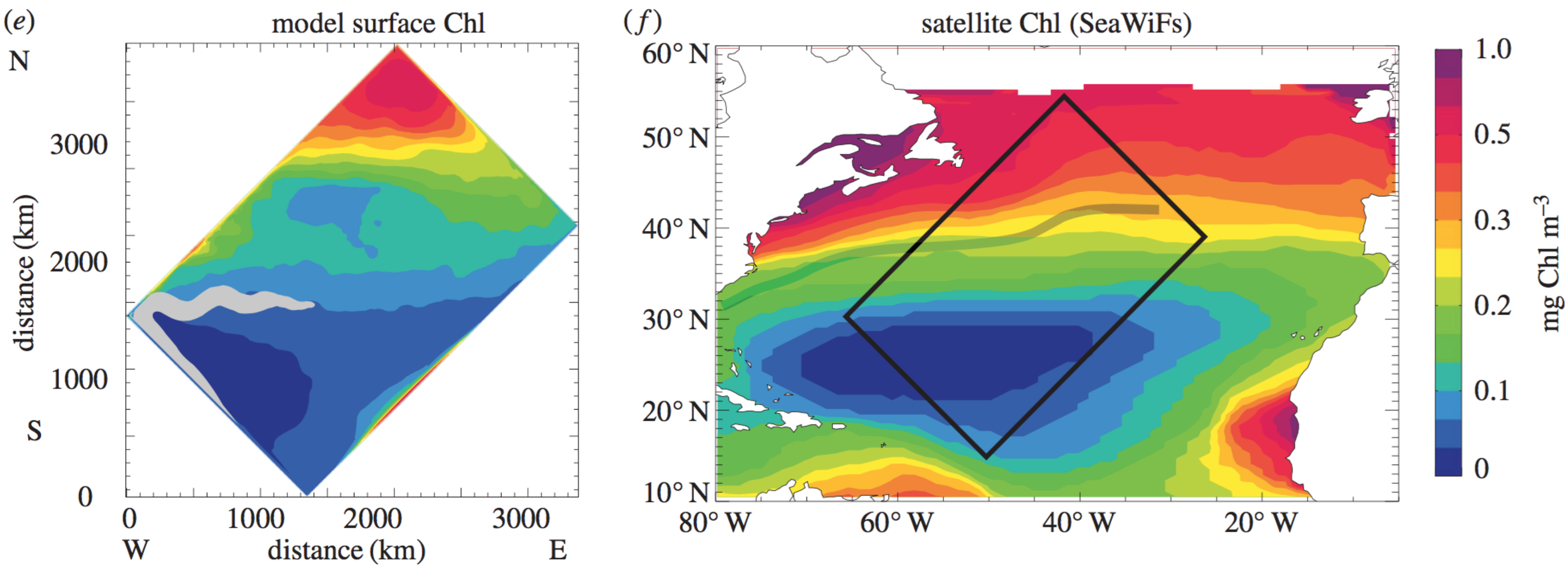
(Temperature, Nutrient)

MIT GCM

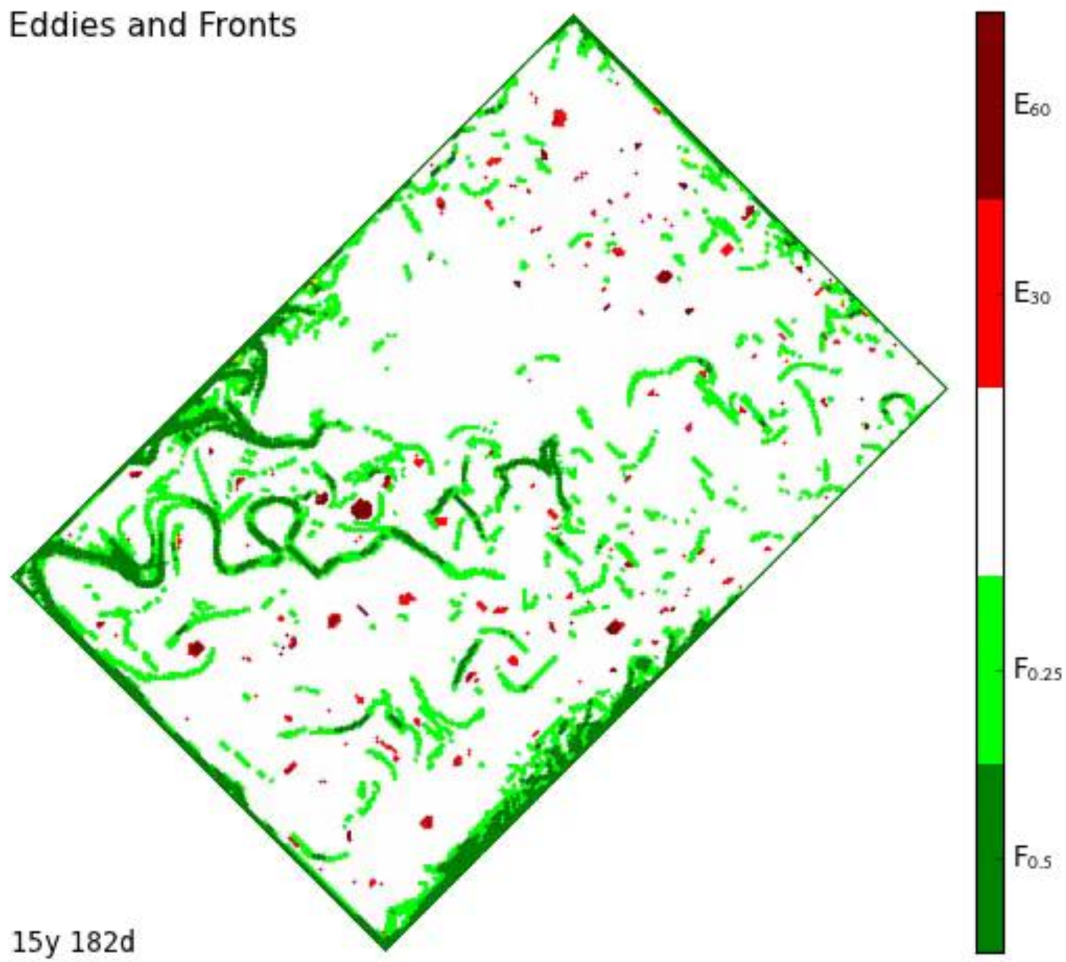
Environmental gradients

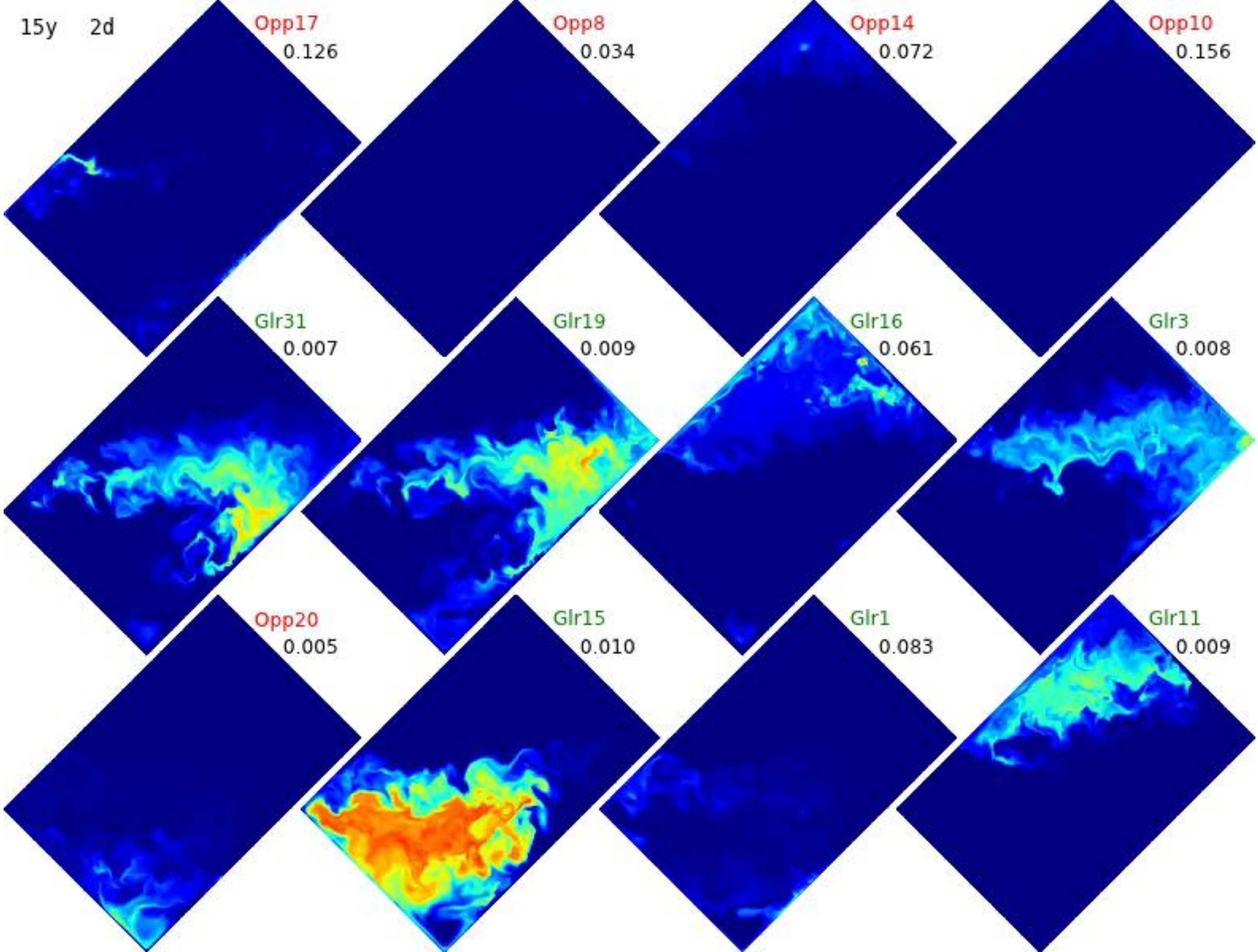


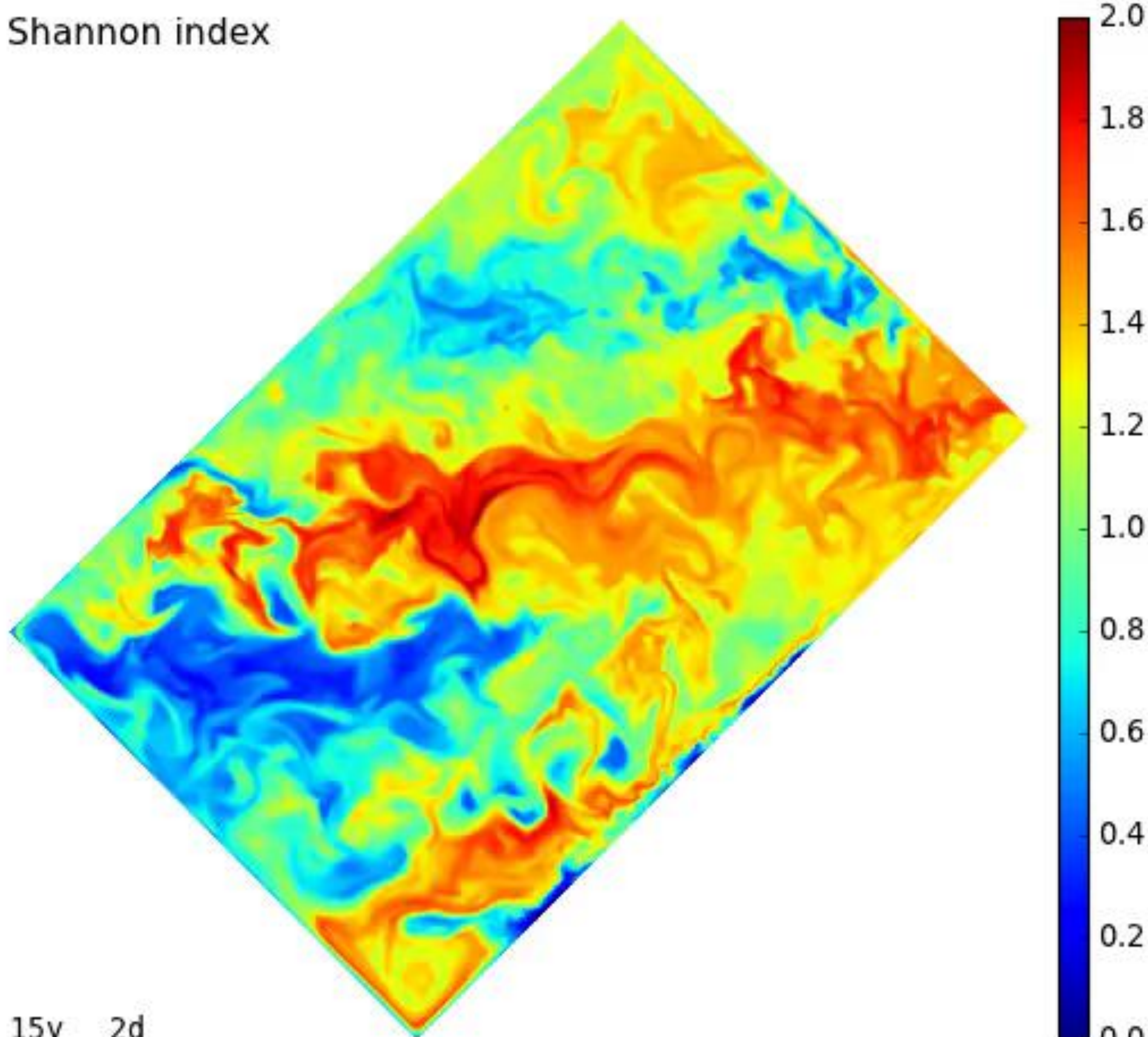
Total Chla distribution annual mean

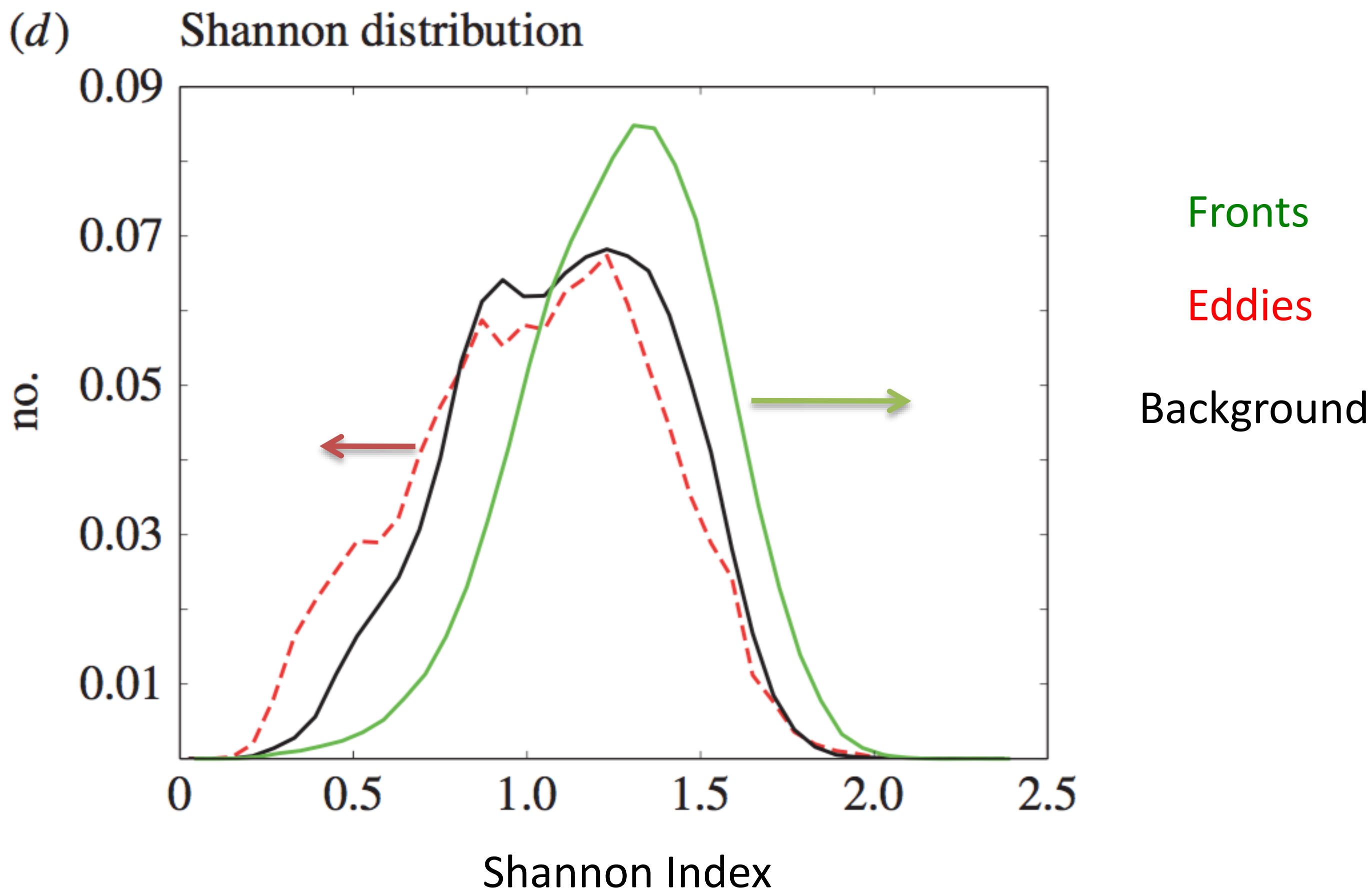


Identification of mesoscale eddies and submesoscale fronts



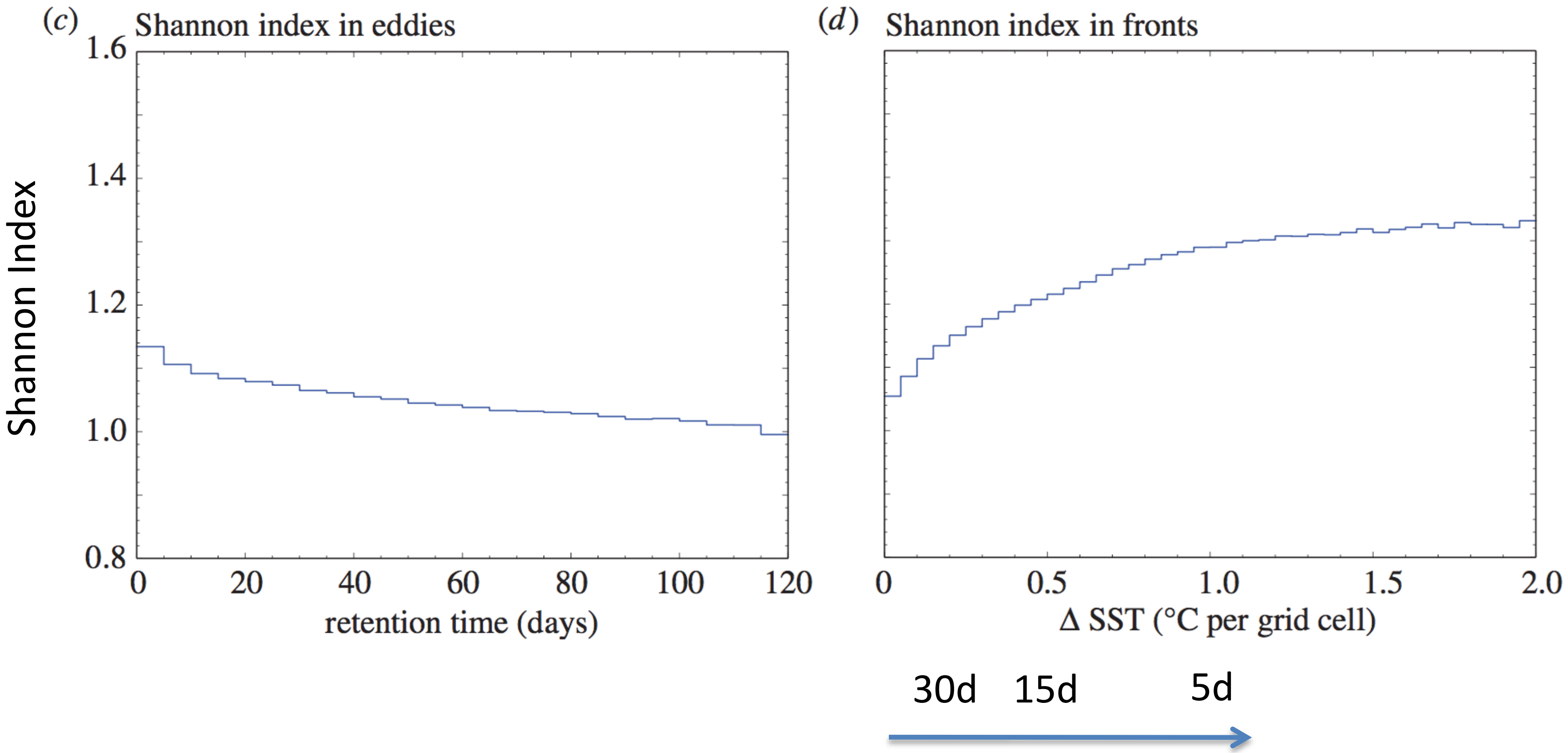

15y 2d
Opp17
0.126
Opp8
0.034
Opp14
0.072
Opp10
0.156
Glr31
0.007
Glr19
0.009
Glr16
0.061
Glr3
0.008
Opp20
0.005
Glr15
0.010
Glr1
0.083
Glr11
0.009


Shannon index
15y 2d
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0



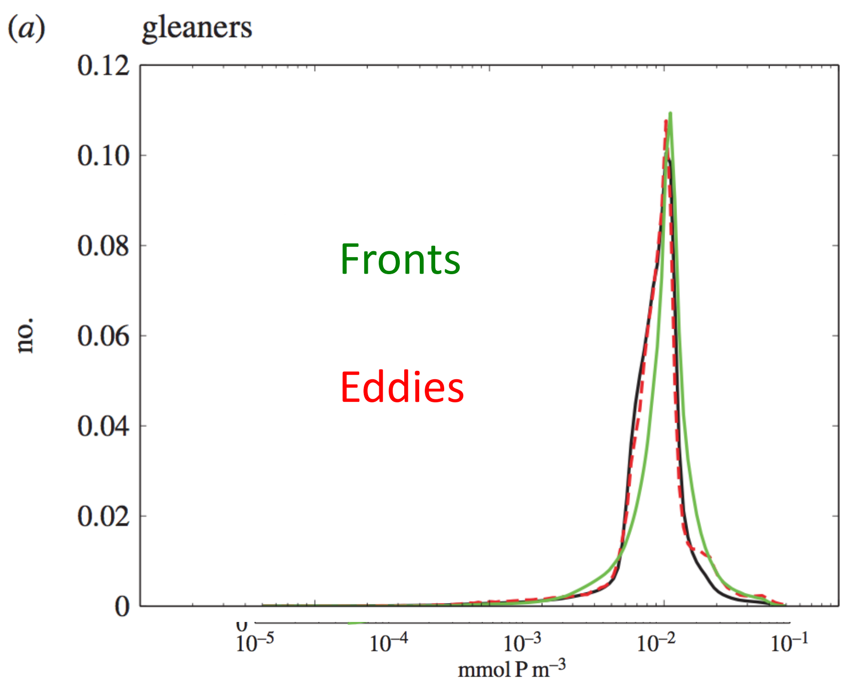
Statistically:
More ability for coexistence at submesoscale fronts
Less ability for co-existence in the core of mesoscale eddies

Time scale

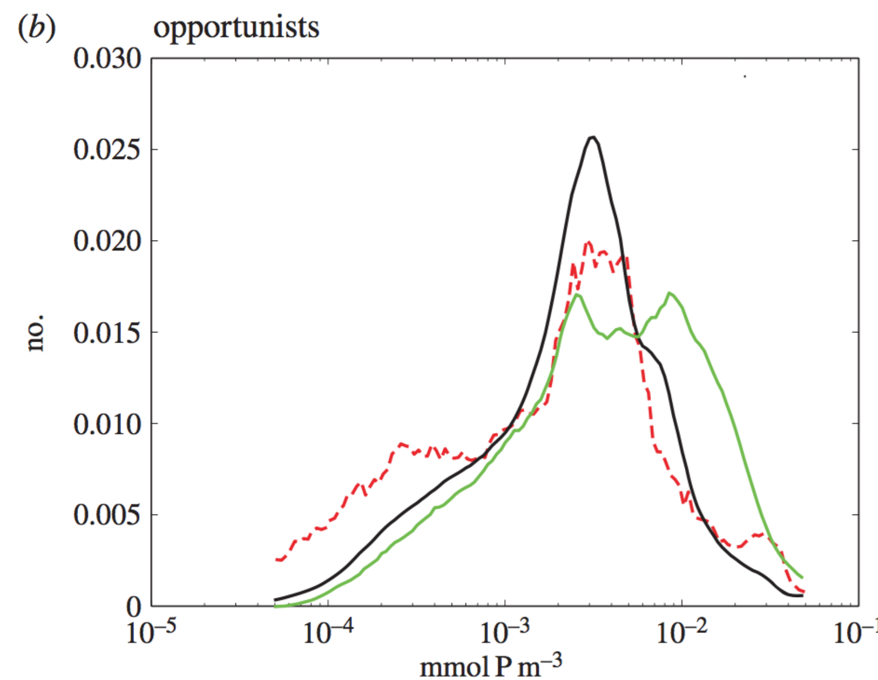


Short time scale: more coexistence
Long time-scale: less coexistence
Related to competitive exclusion

Statistics within eddies and fronts



Gleaners



Opportunists

Conclusions

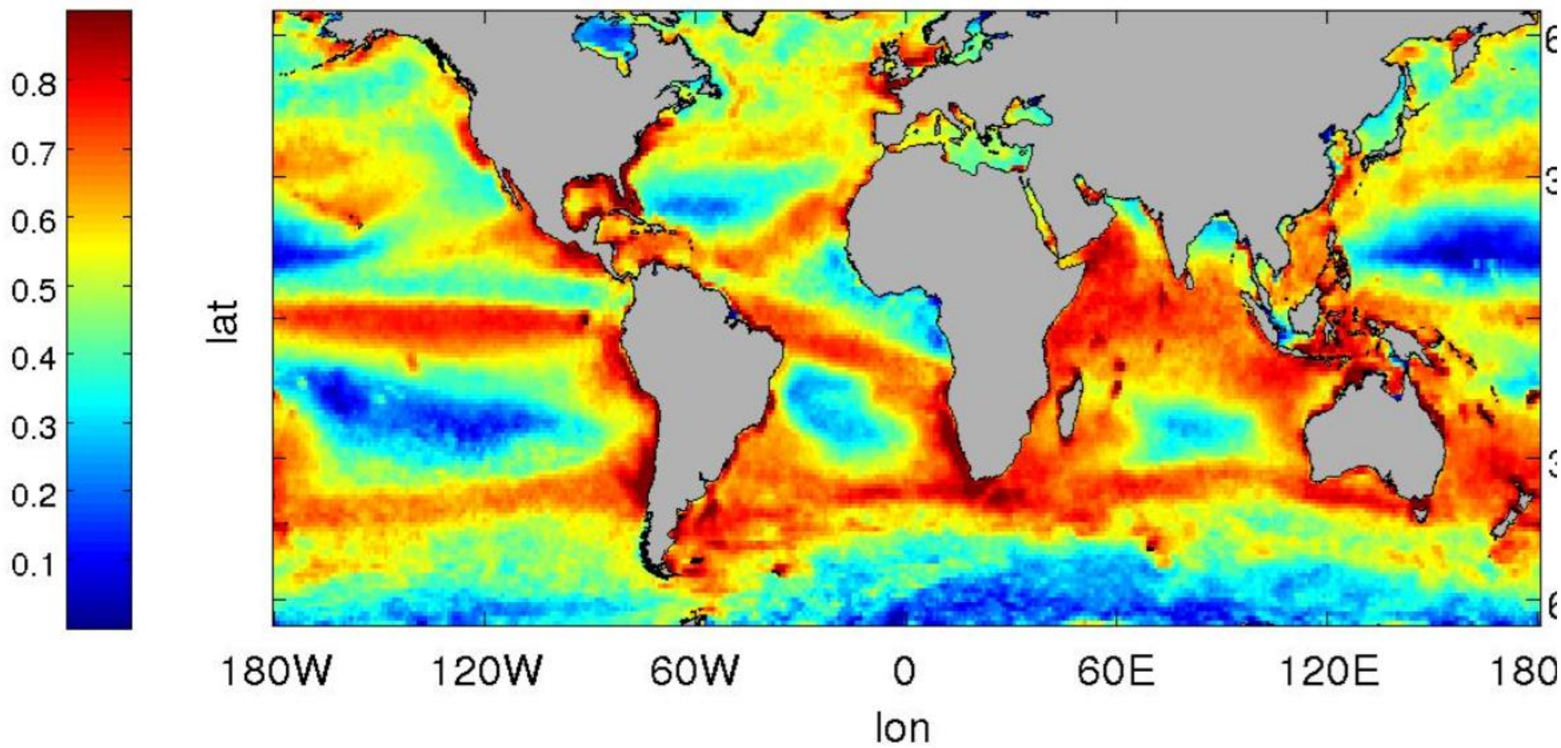
- Things move in the ocean !
- The phytoplankton diversity landscape is very dynamic and shaped by eddies and fronts at time scales of days to months
- Time scales of mesoscale turbulence interact with the time scales of competitive exclusion
- Challenging to evaluate biodiversity from point measurements: Time or space variations ?

  Need for interdisciplinary approach

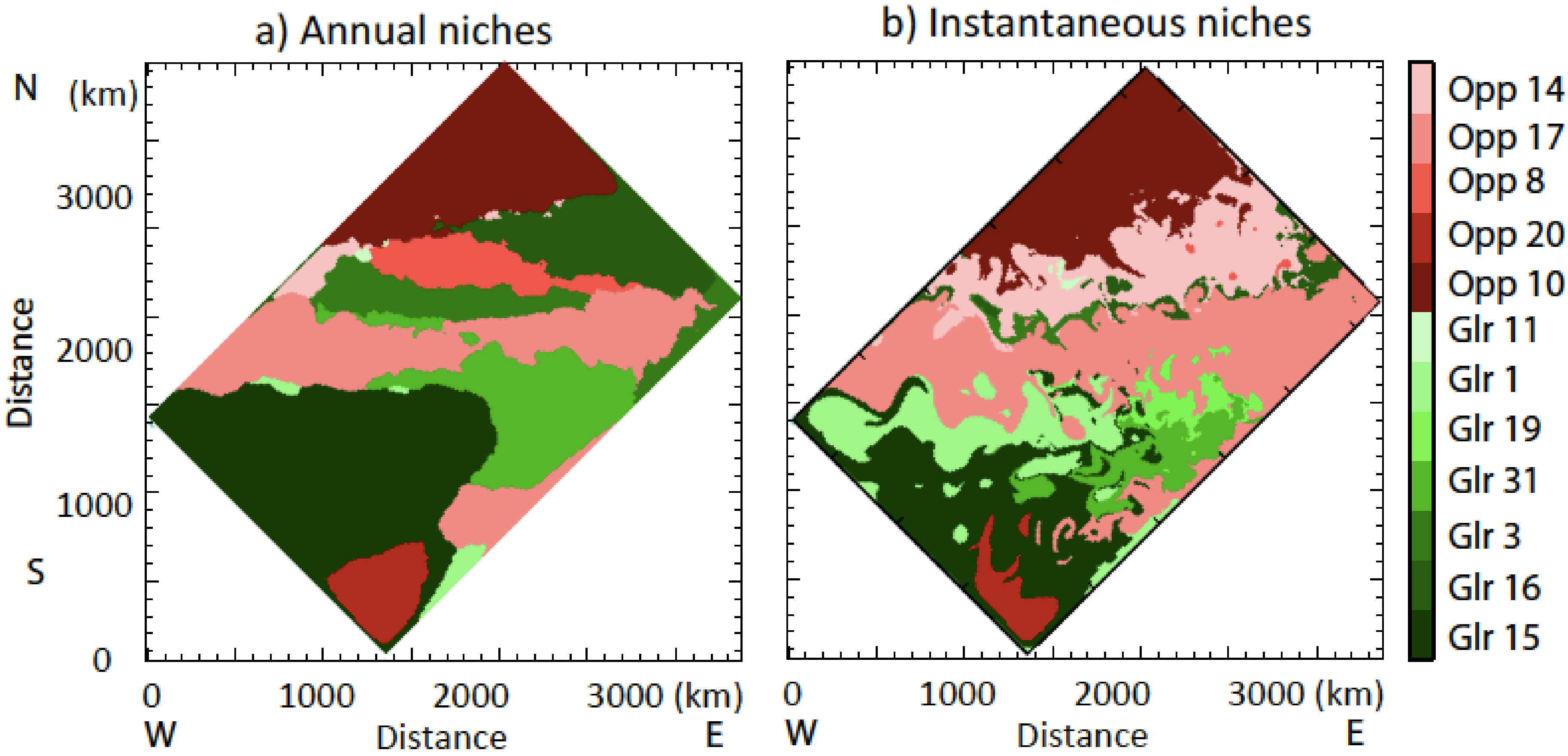
- Potential of satellite ocean color by combining information on local mixing and group distribution

Levy et al., 2015, Royal Society Interface

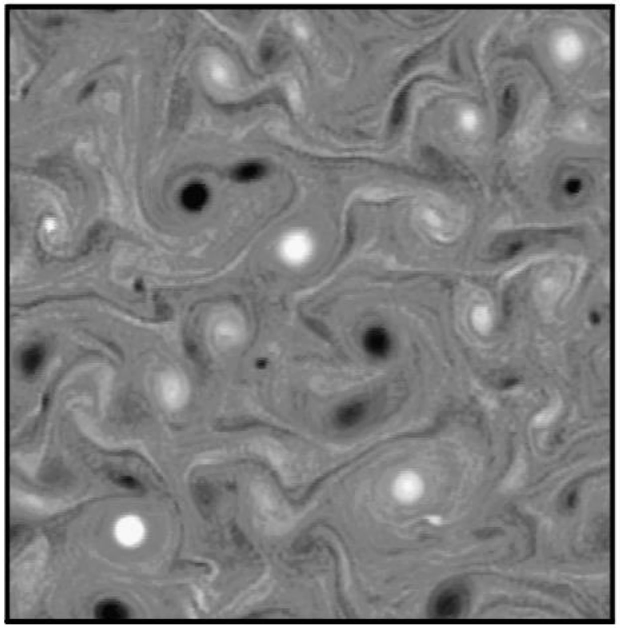
Satellite biodiversity index based on PHYSAT

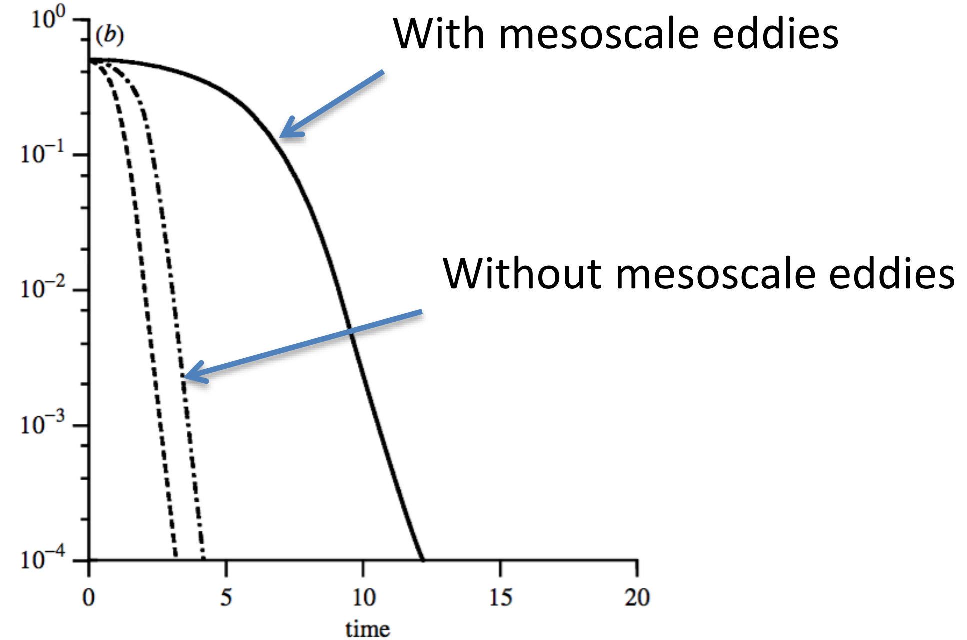


De Monte et al, 2013, IMSE Journal



a) Annual niches
b) Instantaneous niches
N
(km)
3000
2000
1000
S
0
Distance
0
1000
2000
3000 (km)
W
Distance
E
0
1000
2000
3000 (km)
W
Distance
E
Opp 14
Opp 17
Opp 8
Opp 20
Opp 10
Glr 11
Glr 1
Glr 19
Glr 31
Glr 3
Glr 16
Glr 15





- Phytoplankton community described with 2 types
-No environmental gradient
-No seasonality
- One type dominates over the other

The less fitted type is sheltered by eddies

Bracco et al, 2000