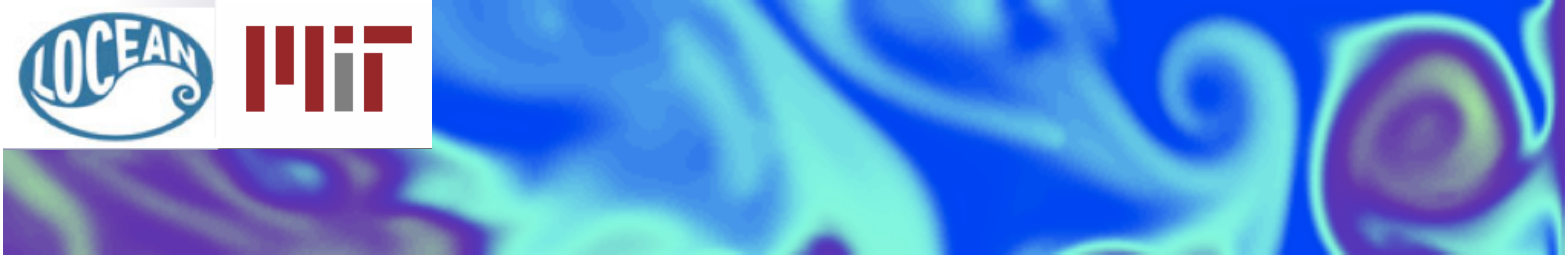
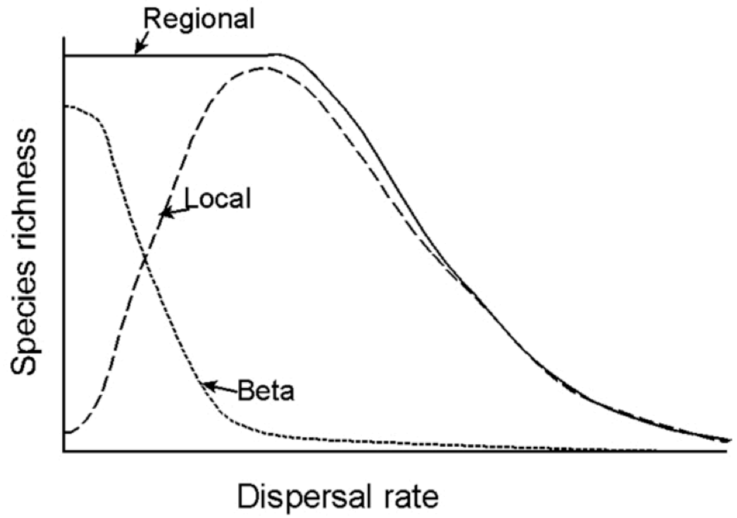


Phytoplankton diverstity affected by oceanic dispersal and mesoscale currents

Marina Lévy
Oliver Jahn, Stephanie Dutkiewicz, Francesco d'Ovidio and Mick Follows

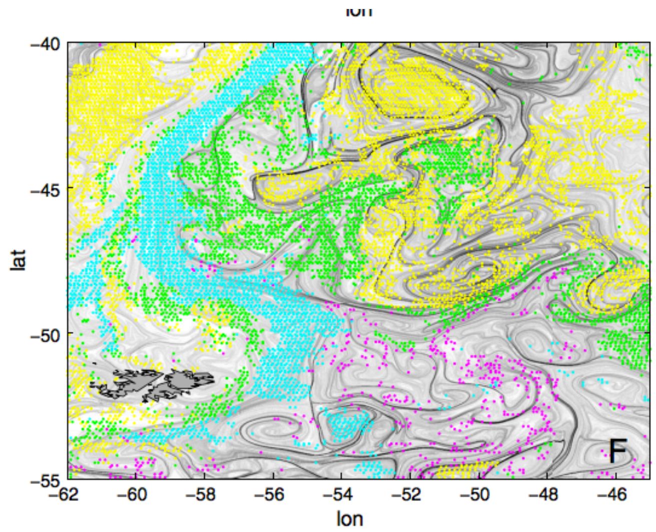
International workshop on Trait-based approaches to Ocean Life, Copenhagen, 26-28 August 2013



Cadotte, 2006

In Terrestrial ecosystems

Evidence for Change of Local & Regional diversity with dispersal



d'Ovidio et al, 2010

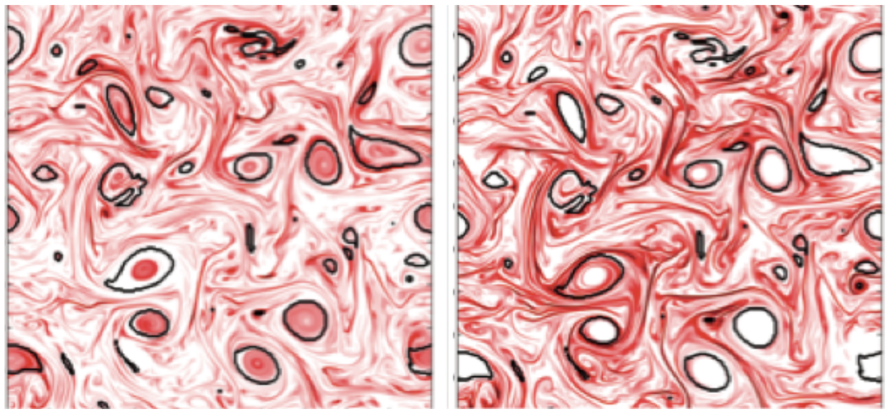
In Aquatic ecosystems

Satellite observations over the ocean show that niches of different phytoplankton groups (colors) are shaped by mesoscale stirring (black lines)

Motivation

Previous ocean models studies have examined co-existence of 2 competing phyto species in very idealized set-up to explain the paradox of plankton

K-strategist r-strategist

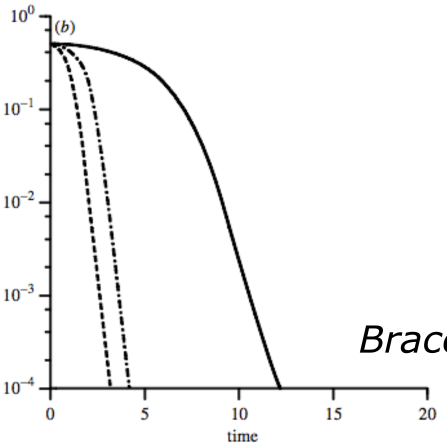


Perruche et al., 2012

1) Eddies are niches for K-strategists

2) Stirring allows co-existence

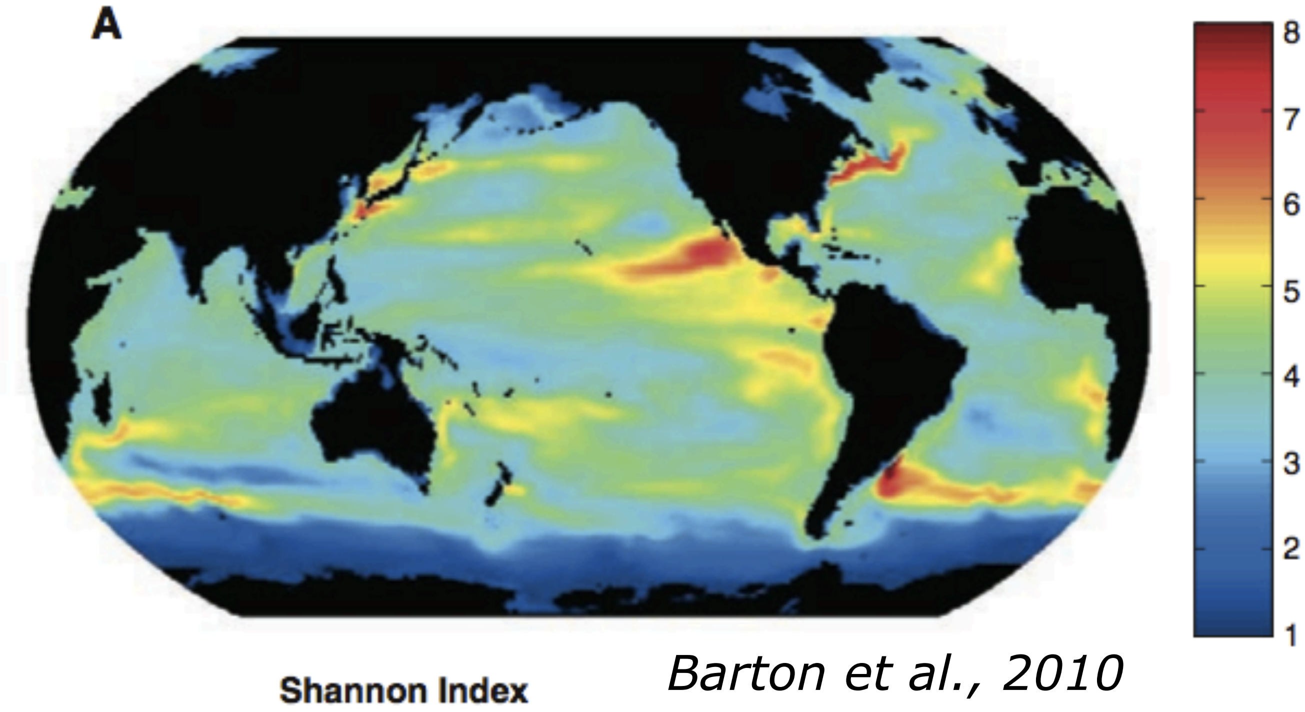
-> Mixing is potentially a mean to increase local diversity



Bracco et al, 2000

3) Eddies provide temporary shelters for less-fit species

-> Eddy niches are potentially a mean to increase global diversity



Barton et al., 2010

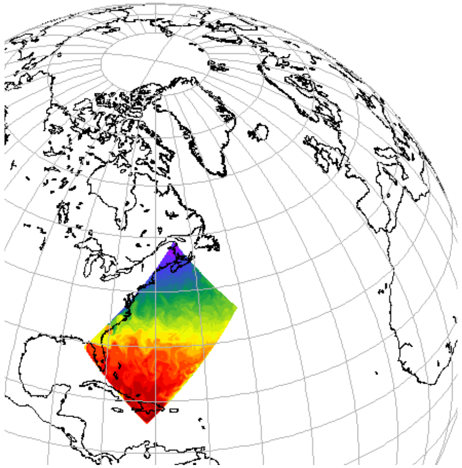
Global model with 100 Phyto show biodiversity “hot spots” in regions of strong currents

How are phytoplankton local and global diversity affected by dispersion ?

Dispersion

Vertical mixing (1-1000m on the vertical)
+
Mean currents (1000 km)
+
Mesoscale/submesoscale currents (1-100 km)

Method: GYRE + DARWIN



\+ **100 phytos** Darwin model

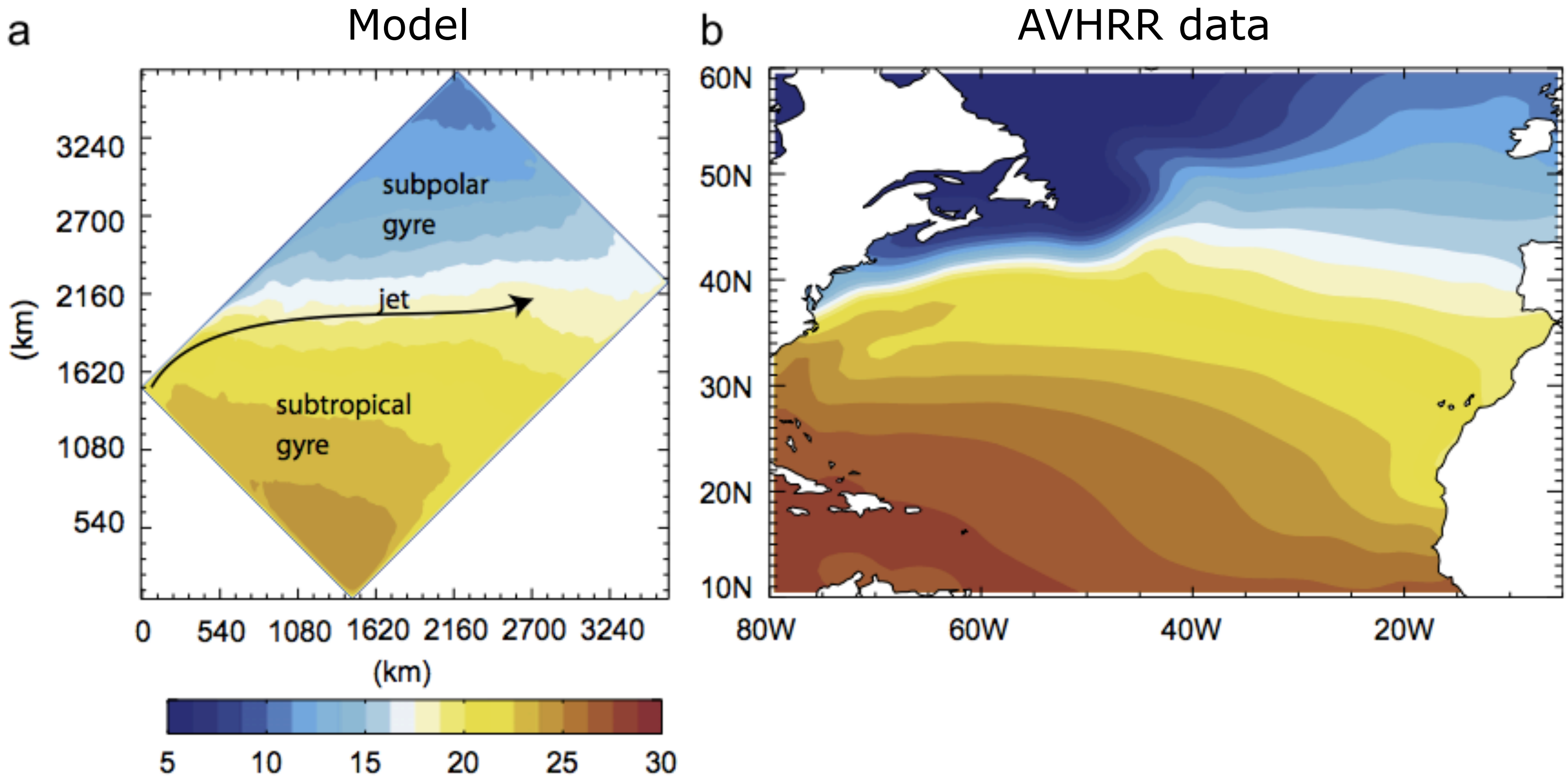
NEMO Ocean circulation model
Run at 1/54° resolution

Phytoplankton traits (half-sat, Topt, m) randomly assigned

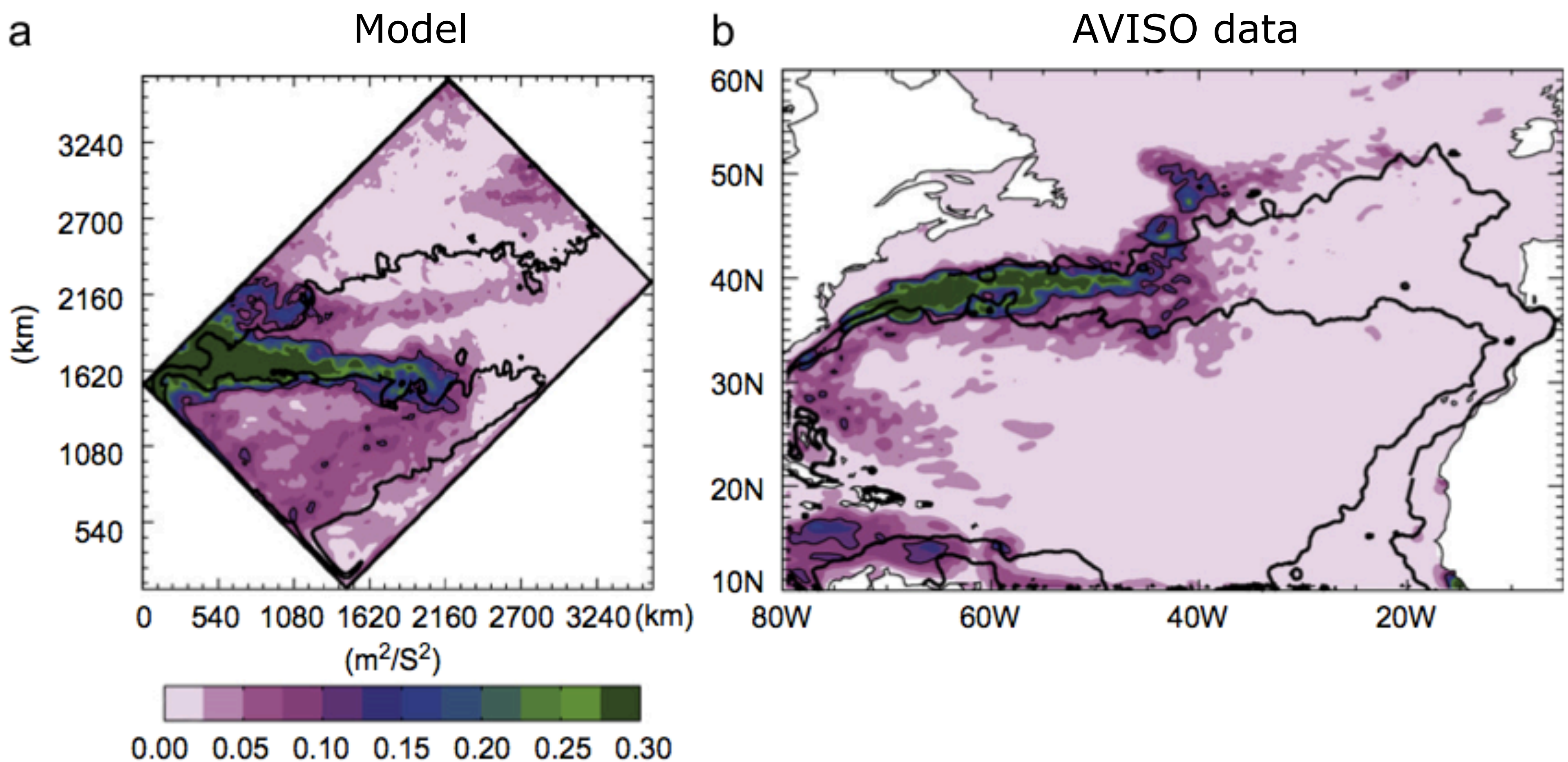
Diversity is not imposed but emerges from the model solution

~20 phytoplankton types out of the initial 100 persist

Simplified eddy-resolving (2 km) model of seasonally varying North Atlantic subtropical & subpolar gyres

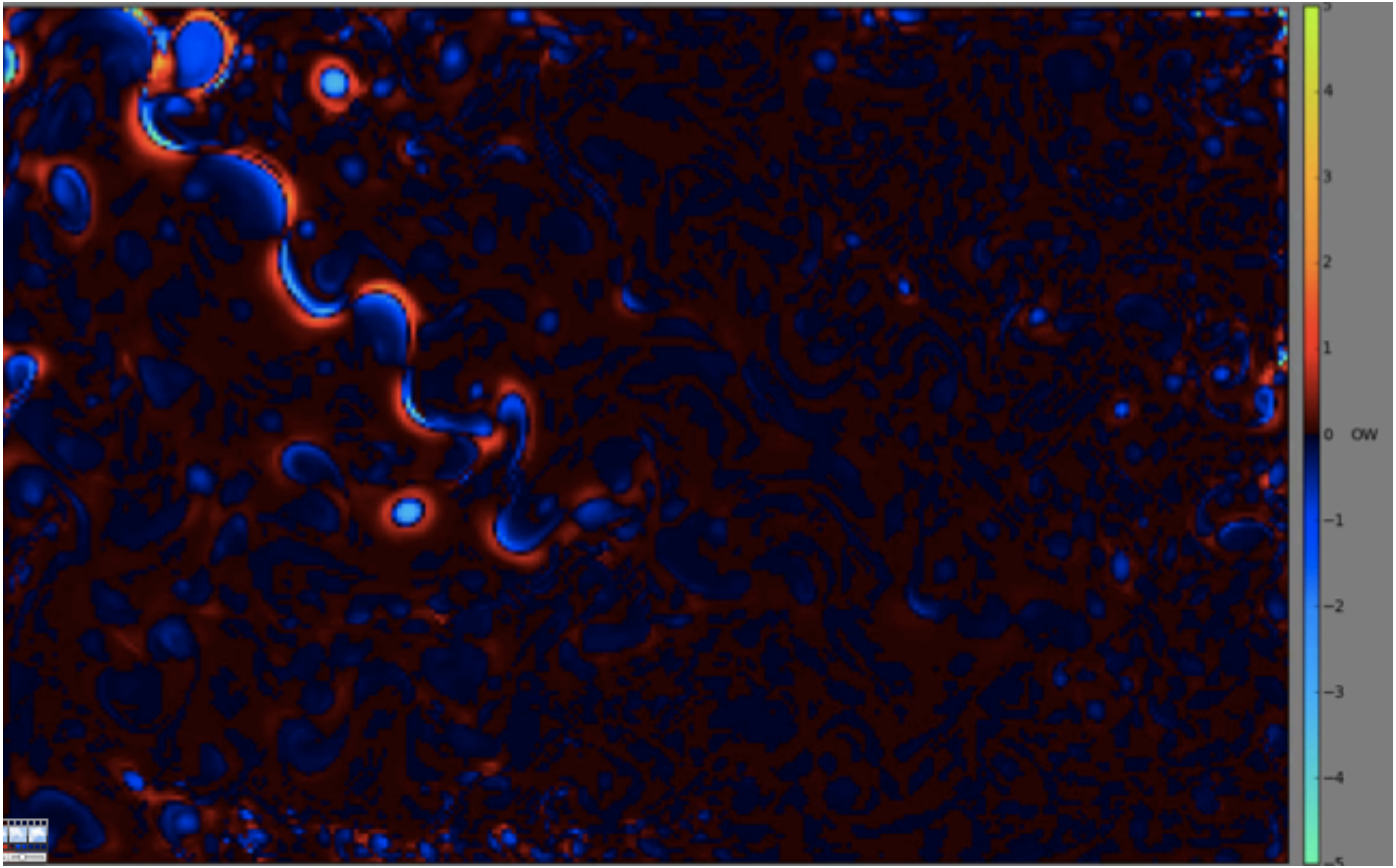


Annual mean SST

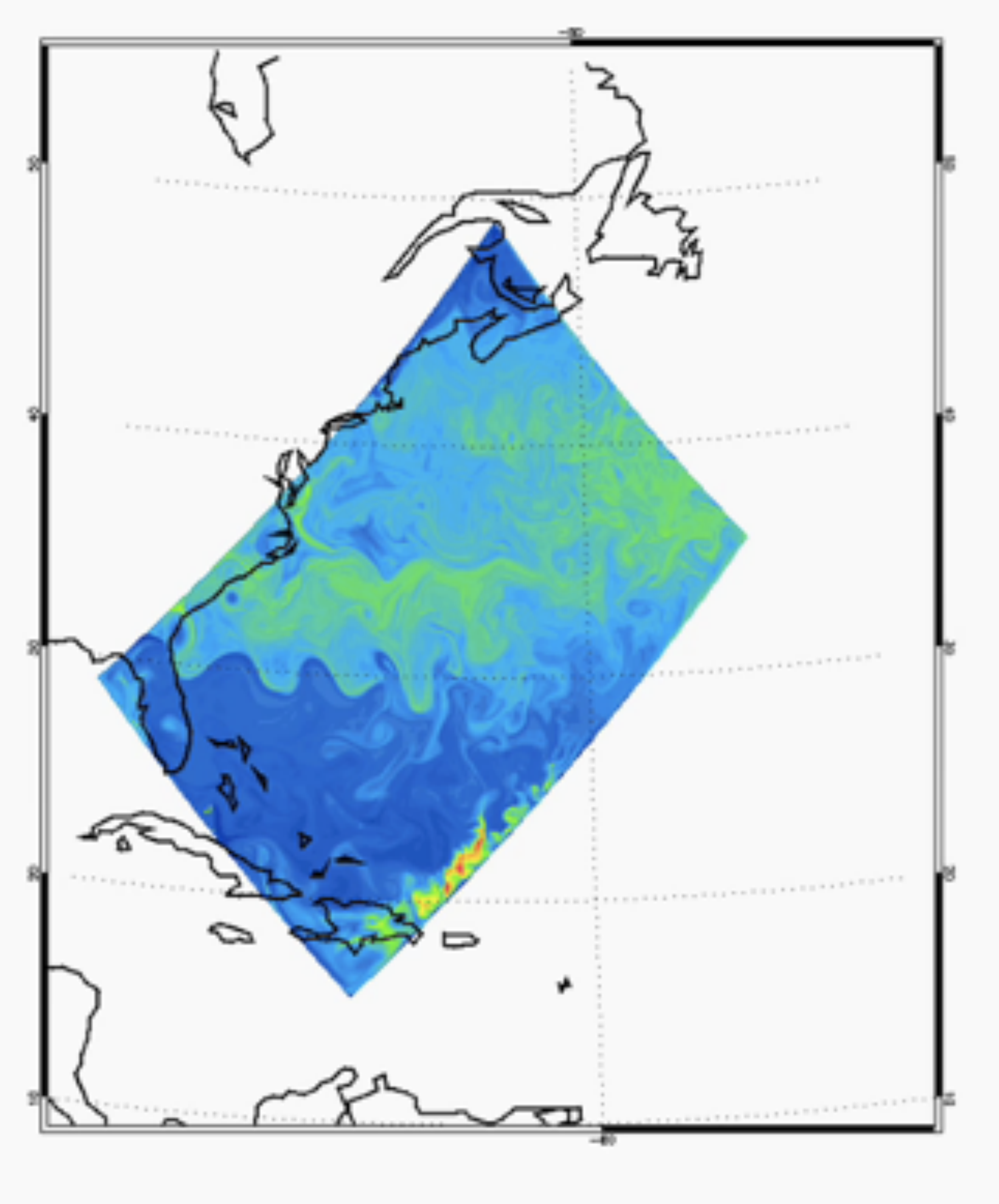


Eddy Kinetic Energy

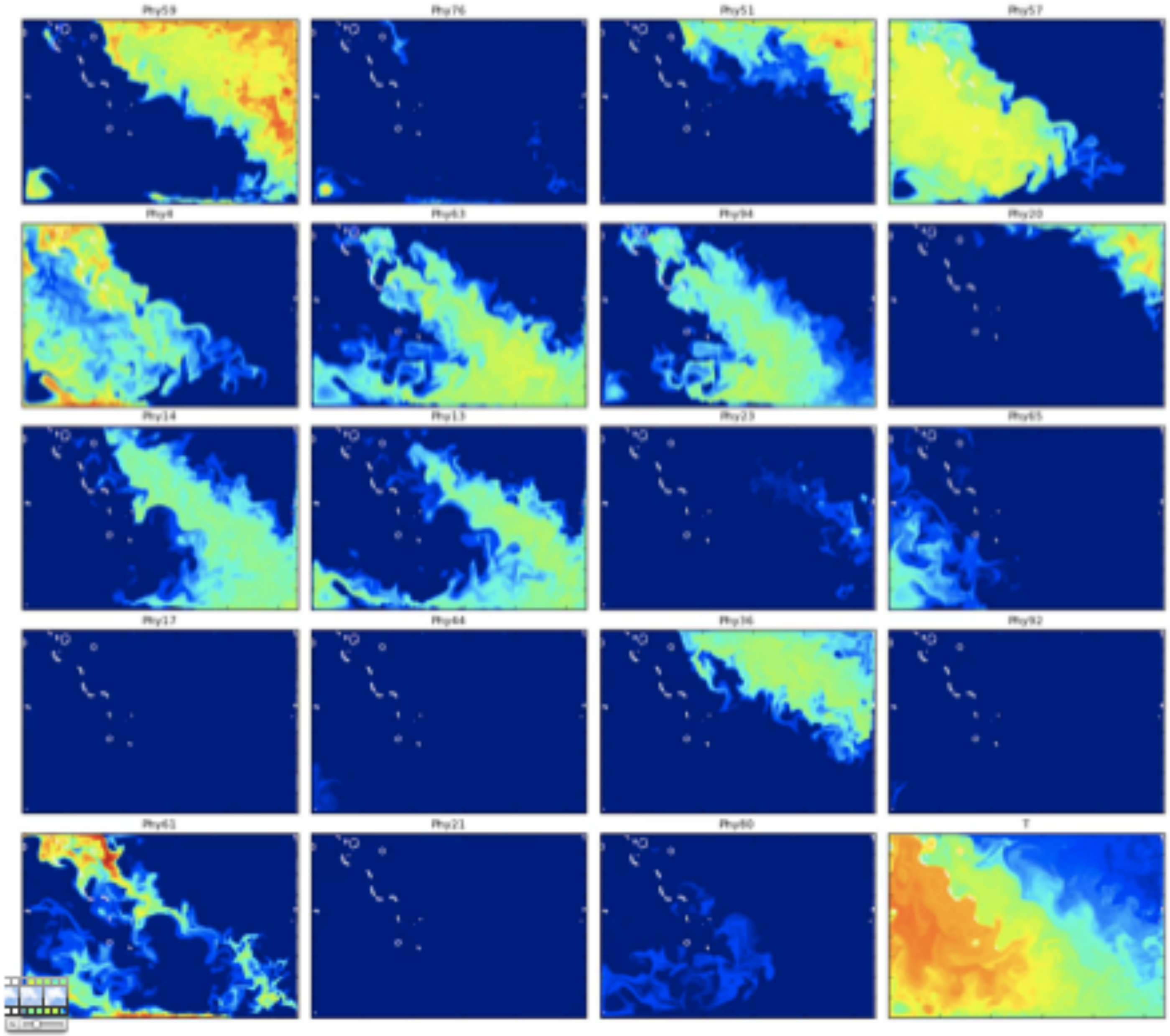
Okubo-Weiss



GYRE experiments



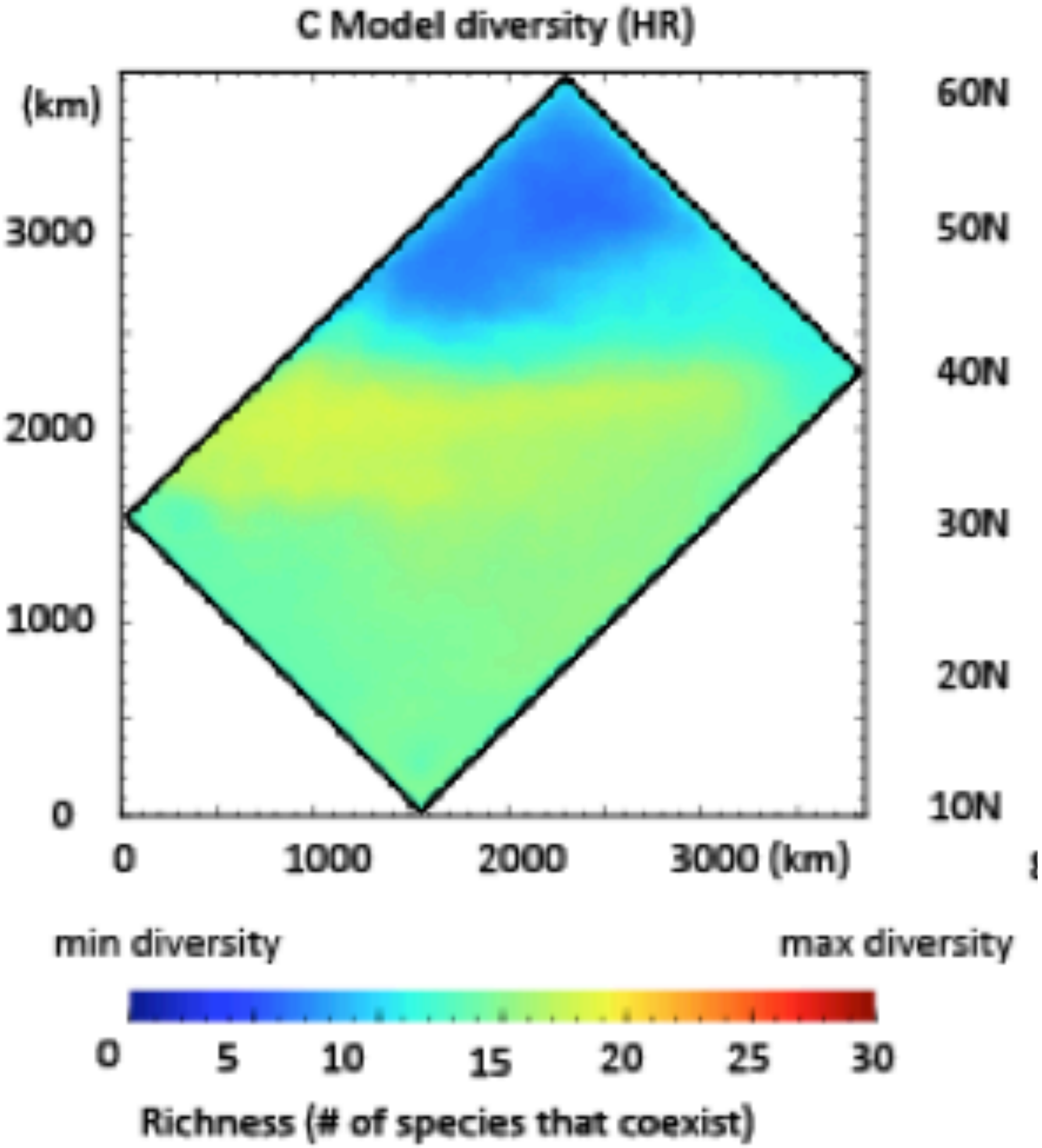
Emergent types



Emergent types

- All species that persist are best-fit in a certain environment (their niche) and less-fit elsewhere
- Niches are organized by latitudinal bands, following T°
- Eddies are not permanent niches
- Eddies can be temporary niches which transport species in places where they are not best adapted

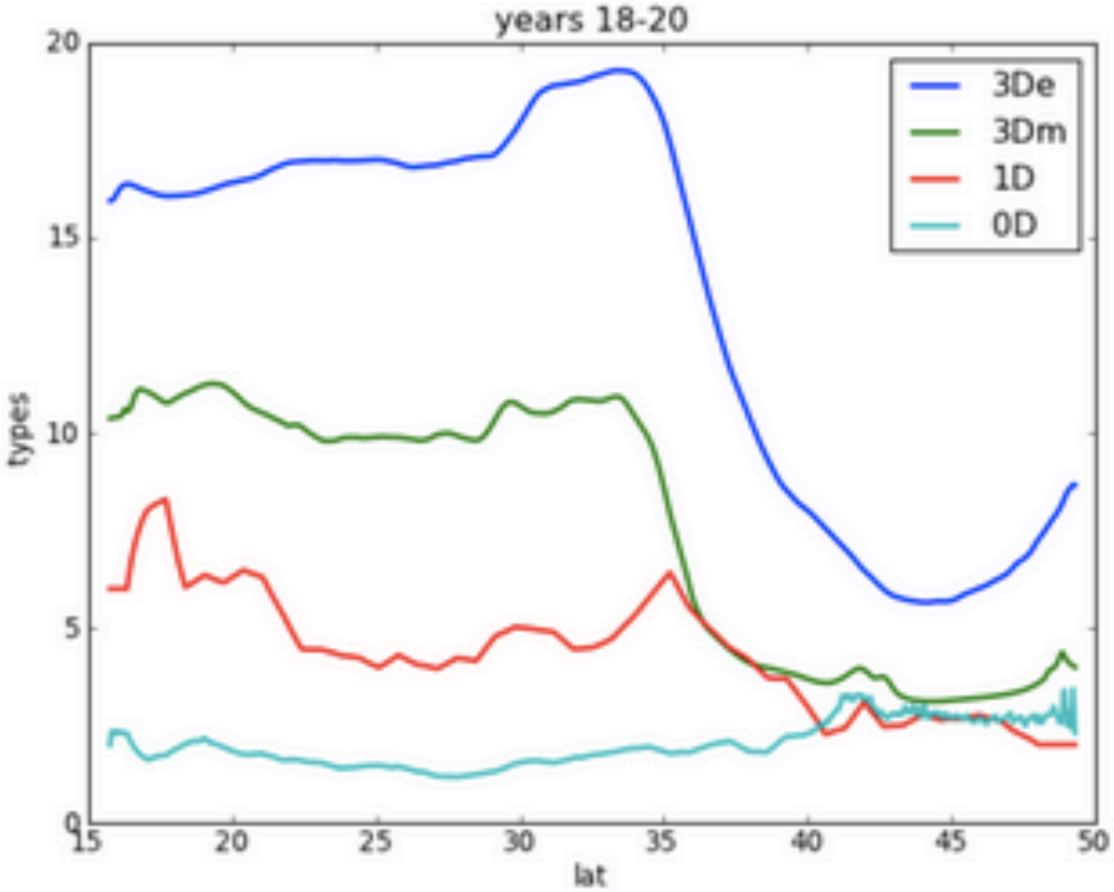
GYRE experiments

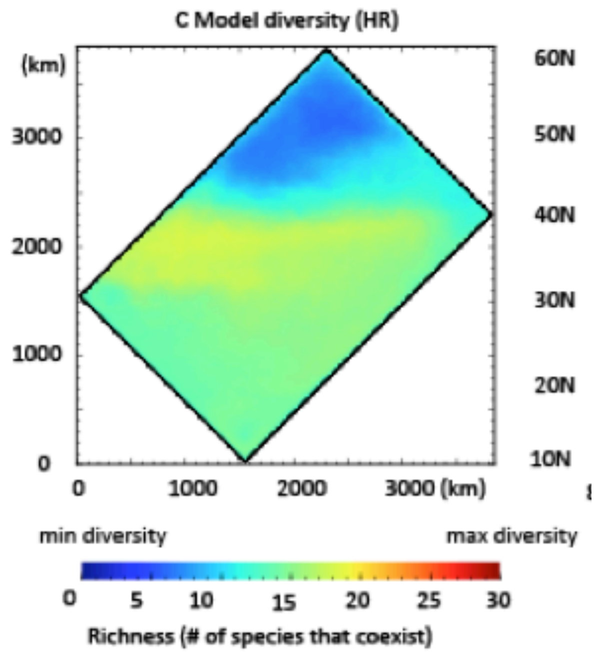


Set of experiments with decreasing dispersal of PHYs

- **3D-e: advection by total current + vertical mixing**
- **3D-m: advection by mean current + vertical mixing**
- **1D : only vertical mixing**
- **OD : no transport at all**

Local diversity





Dispersion adds ways to achieve comparable fitness

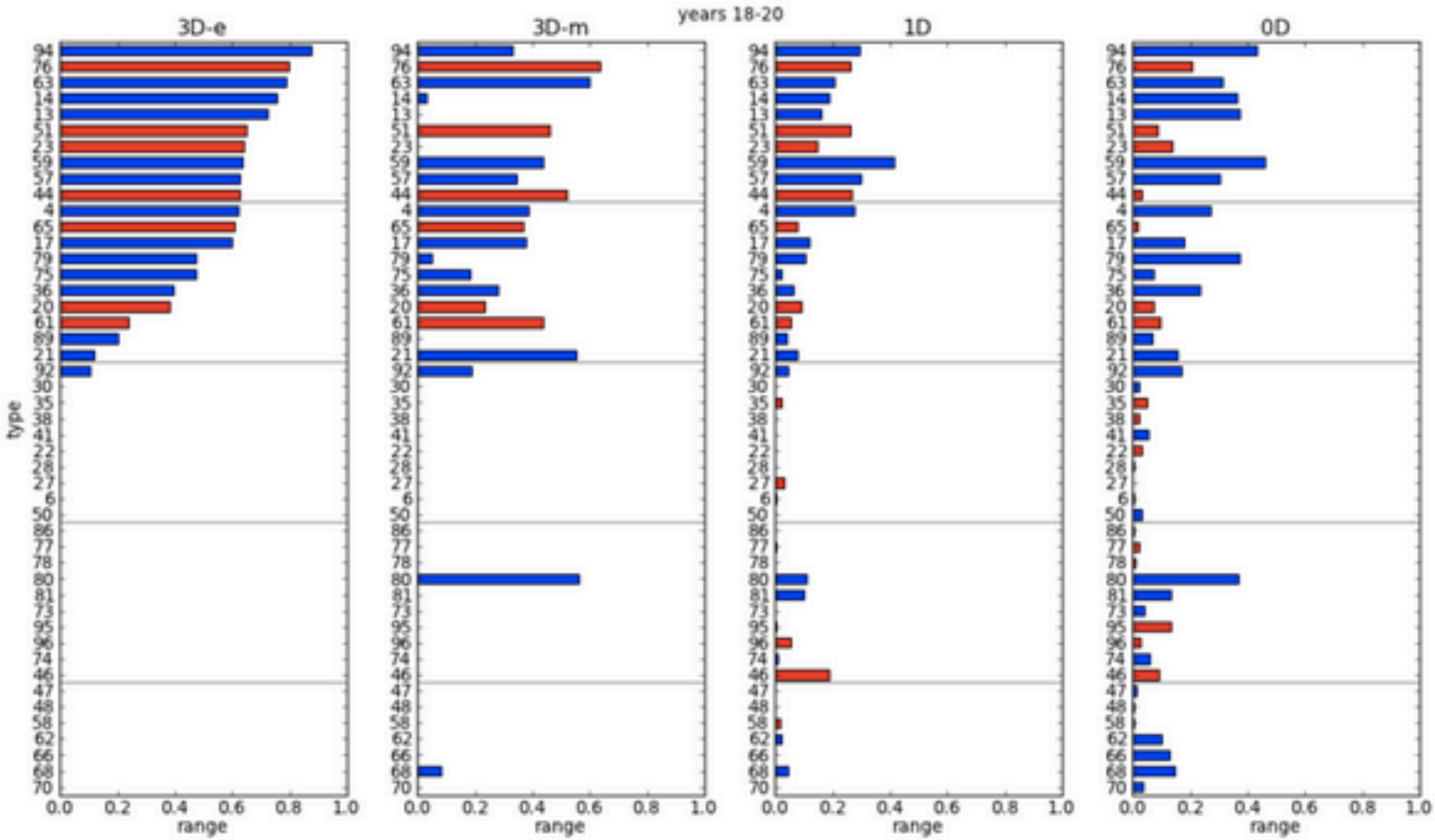
Increase of local diversity :
more ways to achieve the same R*

$$\frac{\partial P_j}{\partial t} = \mu_j \frac{R}{R+k_j} P_j - m_j P_j - \nabla \cdot uP_j - \nabla \cdot \overline{u'P_j'} + \partial_z k_z \partial_z P_j$$

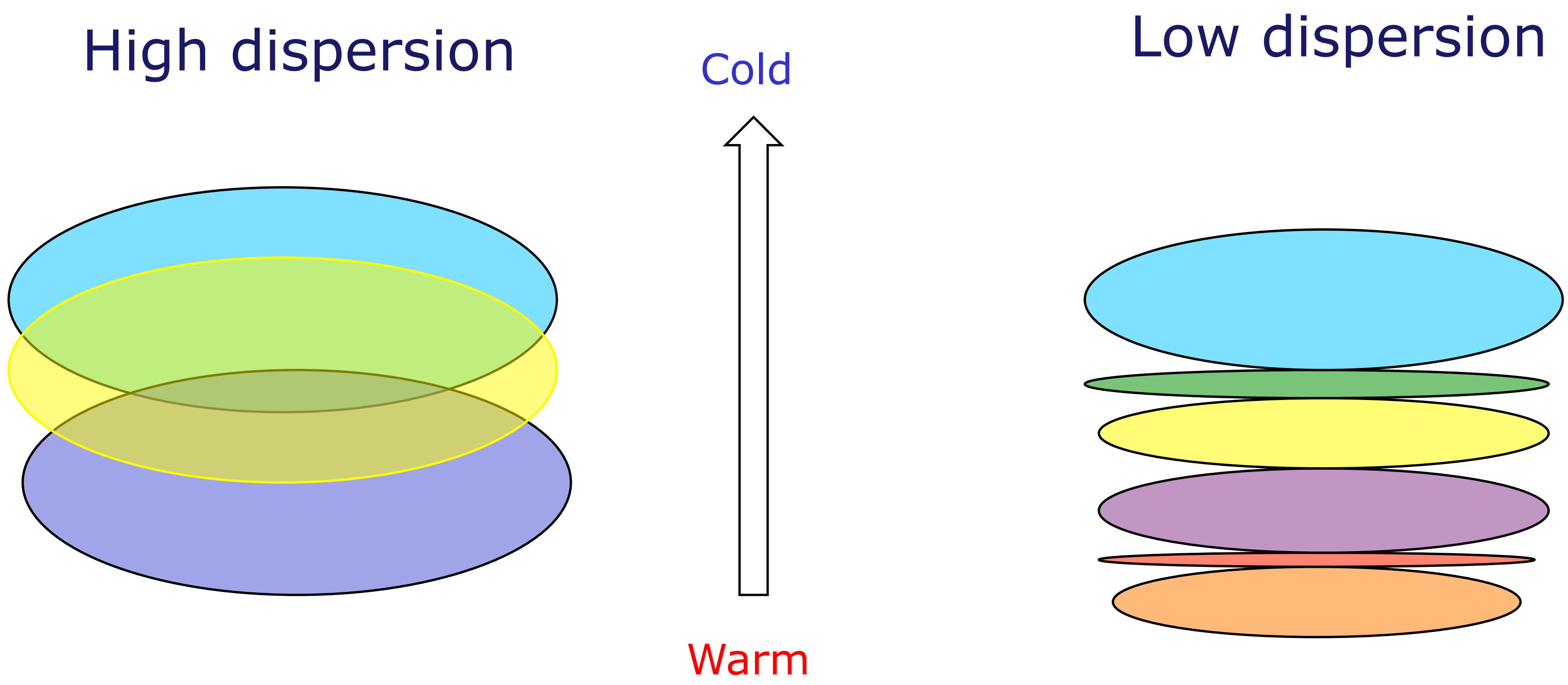
$$R_j^* = \frac{k_j m_j}{\mu_j - m_j}$$

$$R_j^* = \frac{k_j m_j - k_j M_j}{\mu_j - m_j - M_j}$$

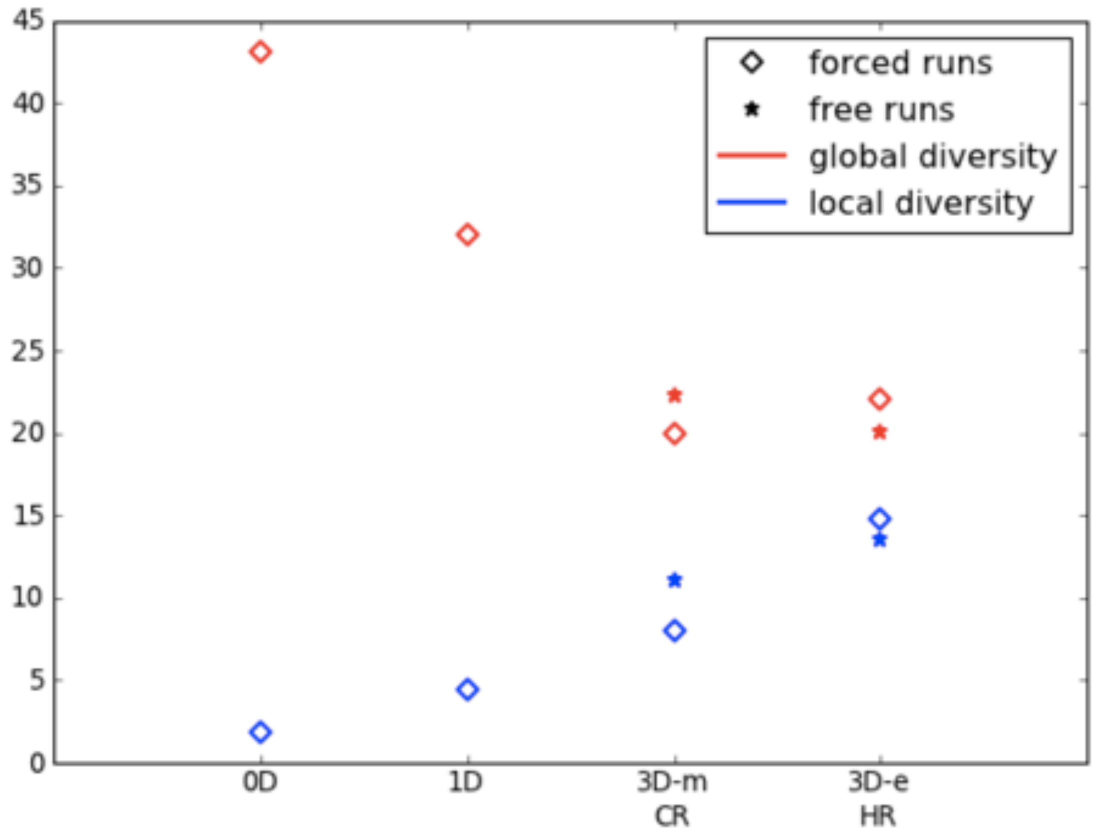
Change in community structure

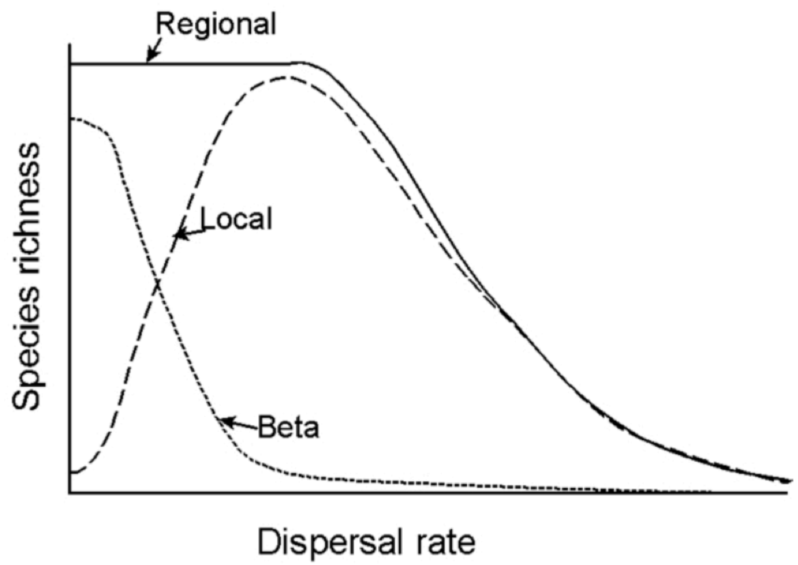


Global / local diversity



Global / local diversity





Conclusions

With increasing dispersion:

- **More local diversity (co-existence)**
- **Decrease of Global diversity**
- **Fewer species over larger niches**

Possible because:

1) Transport adds more ways to achieve comparable fitness (R*)

2) Eddies act as temporary niches (migrants)

Lévy, M., O. Jahn, S. Dutkiewicz and M. Follows, Phytoplankton diversity and community structure affected by oceanic dispersal and mesoscale eddies, in revision for L&O-F&E