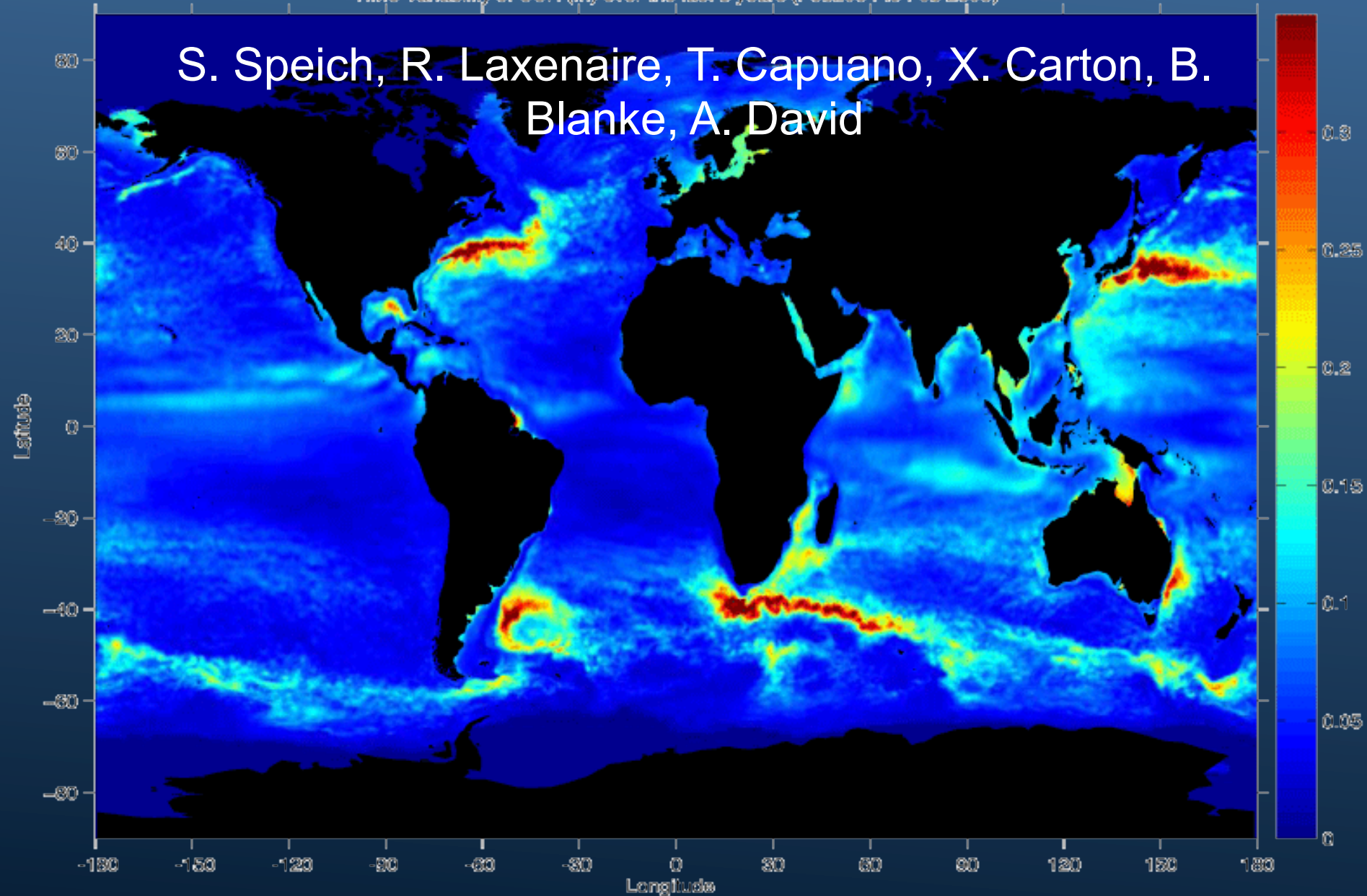


The nonlinear ocean

RMS variability of SSH (m) over the last 5 years (Feb 2004 to Feb 2009)

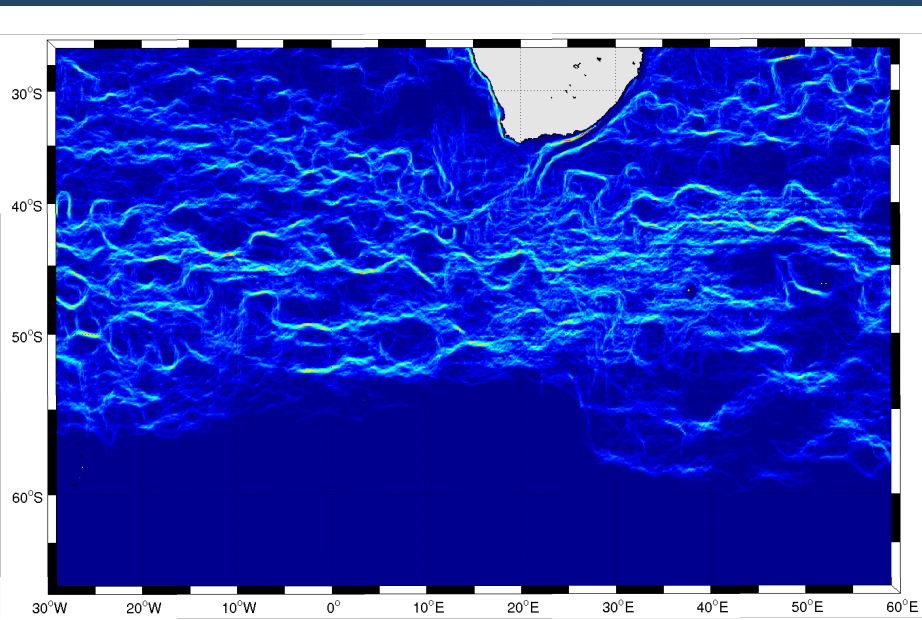
S. Speich, R. Laxenaire, T. Capuano, X. Carton, B. Blanke, A. David



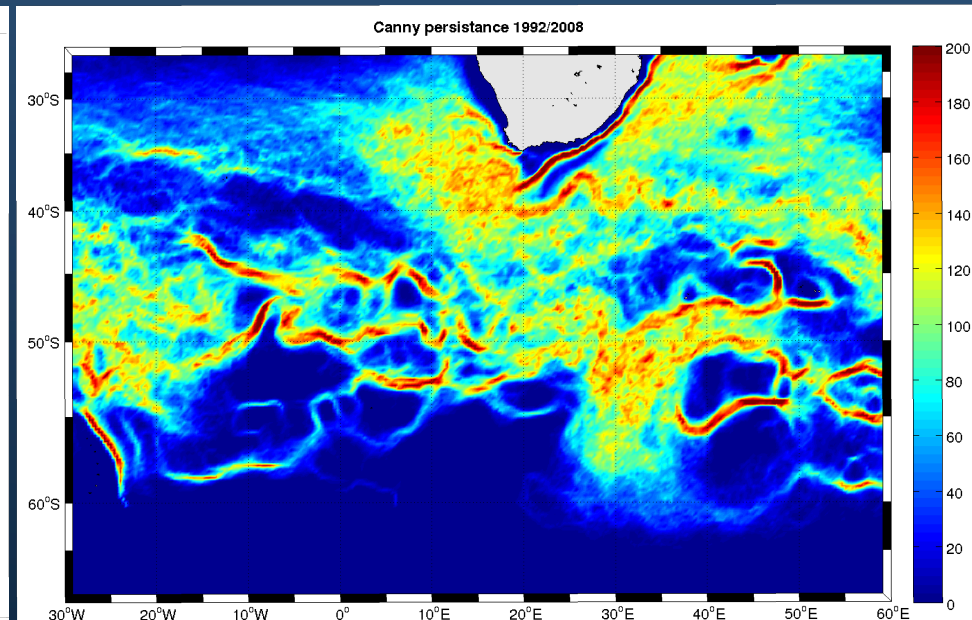
Nonlinear ocean dynamics

Definitions of Southern Ocean Fronts from MADT images

Fronts from MADT gradients detected
with an image processing method
(multiscale Canny method)

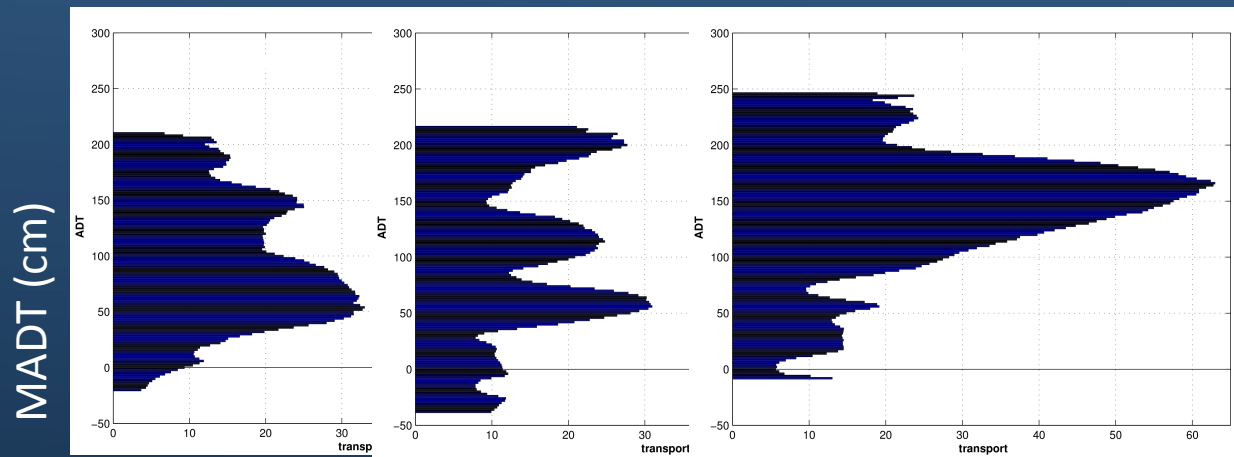
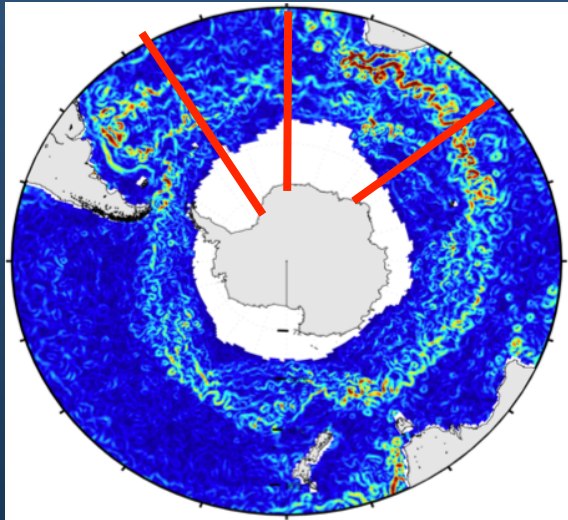


Persistence of fronts from MADT
gradients detected with an image
processing method (Canny)



Nonlinear ocean dynamics

Definitions of Southern Ocean Fronts from MADT images



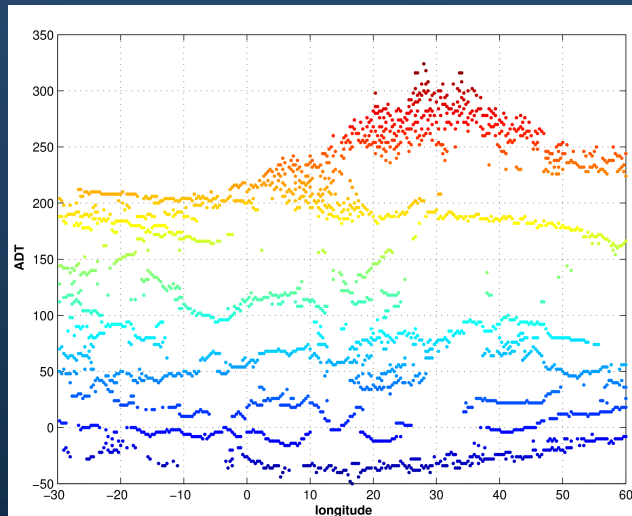
MADT Binned transport at different longitudes

Similar to Sokolov & Rintoul (2009) but computed for every longitude
with varying MADT values

Nonlinear ocean dynamics

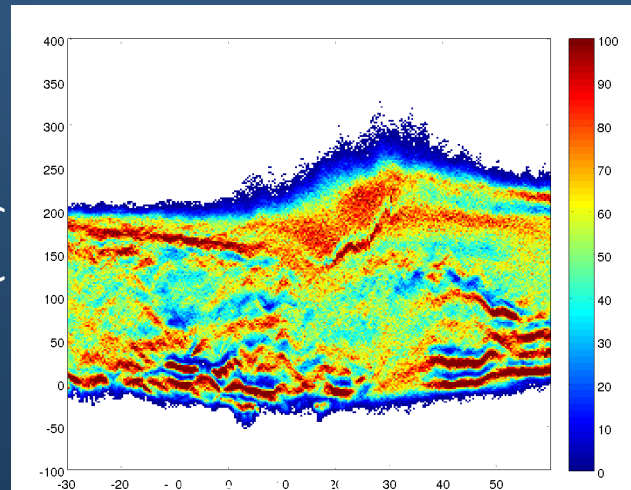
Definitions of Southern Ocean Fronts from MADT images

Mean fronts derived from the kinematic method



LONGITUDE

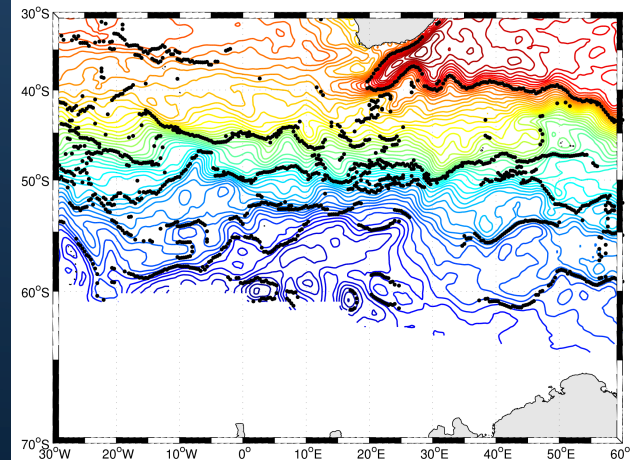
MADT (cm)



LATITUDE

Persistence of MADT “fronts” detected with the kinematic method

Mean fronts derived from the kinematic method in physical space

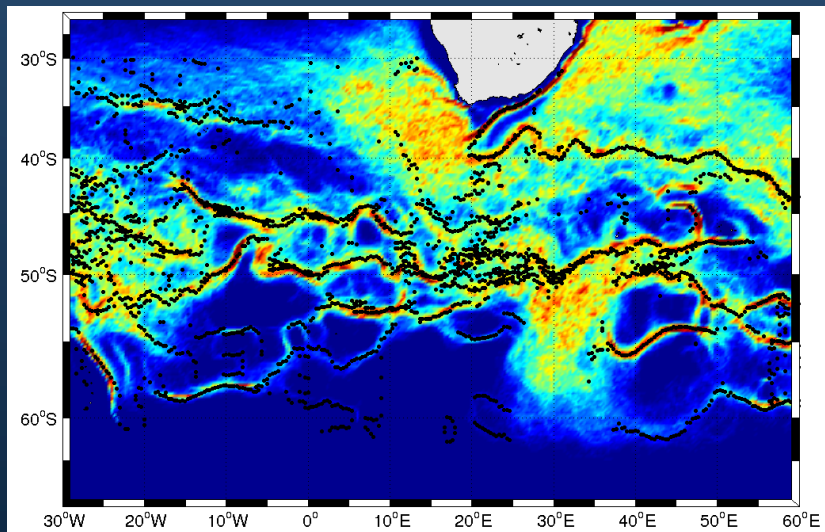


Nonlinear ocean dynamics

Definitions of Southern Ocean Fronts from MADT images

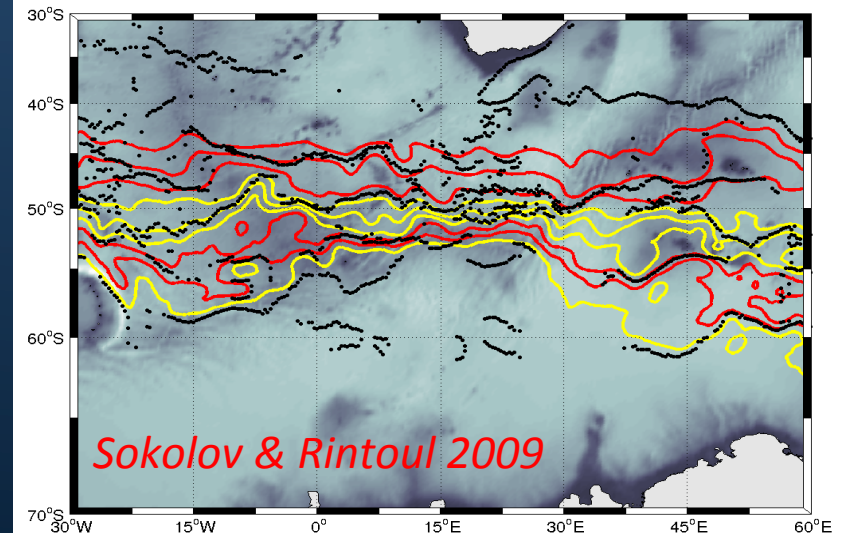
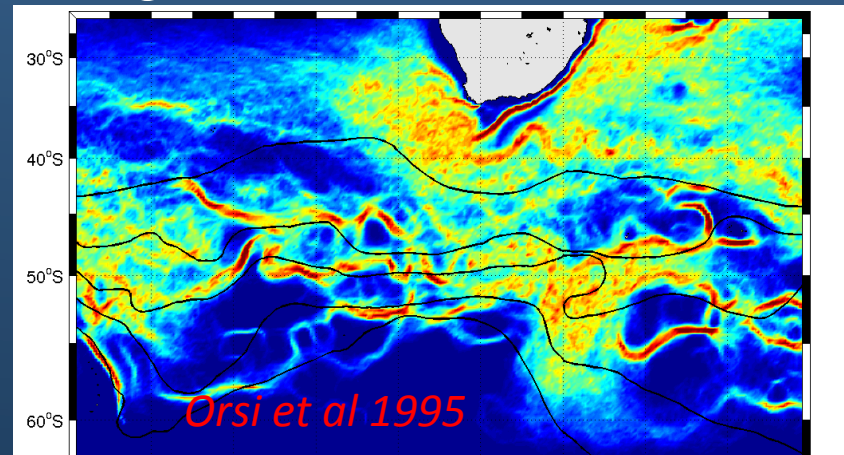
Persistence of fronts from MADT
gradients (Canny)

+ Mean fronts derived from the
kinematic method

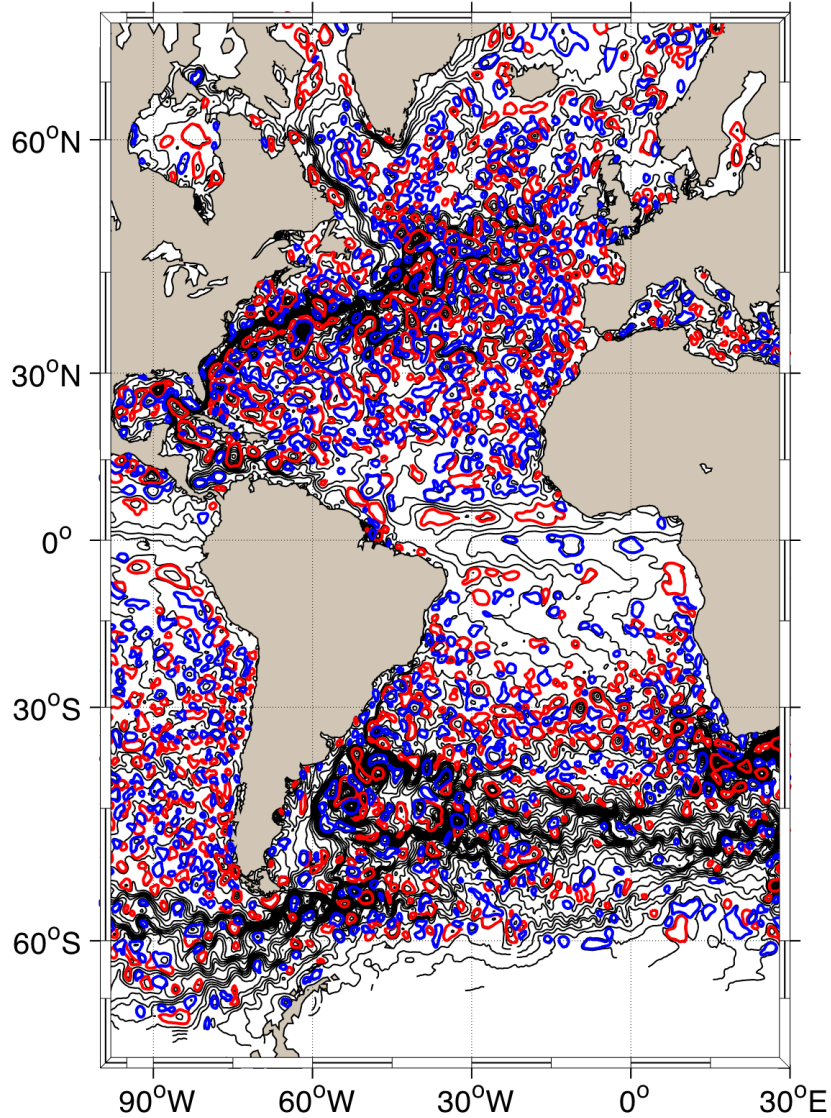


Fronts are NOT continuous

Speich et al. In prep.

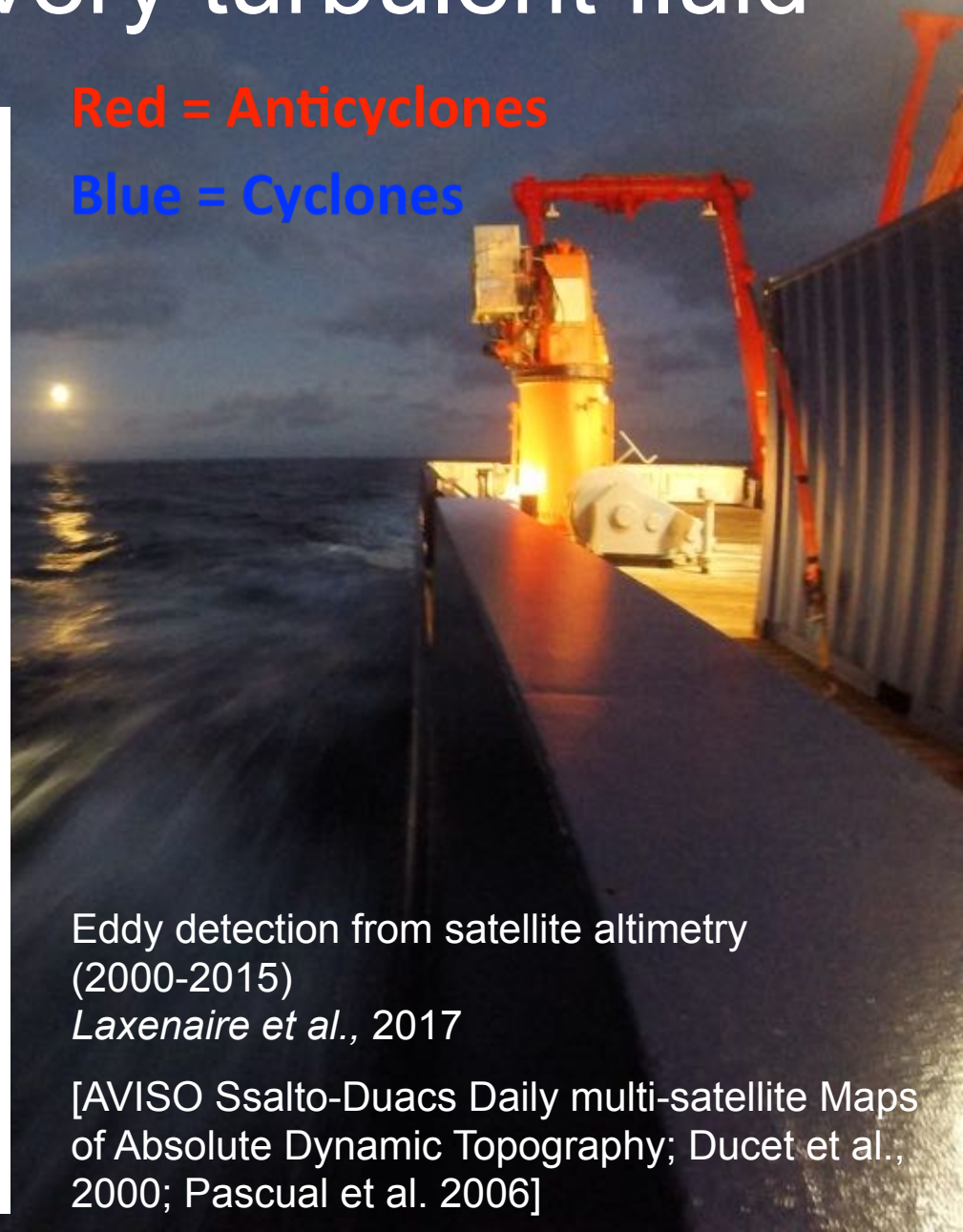


The ocean is a very turbulent fluid



Red = Anticyclones

Blue = Cyclones



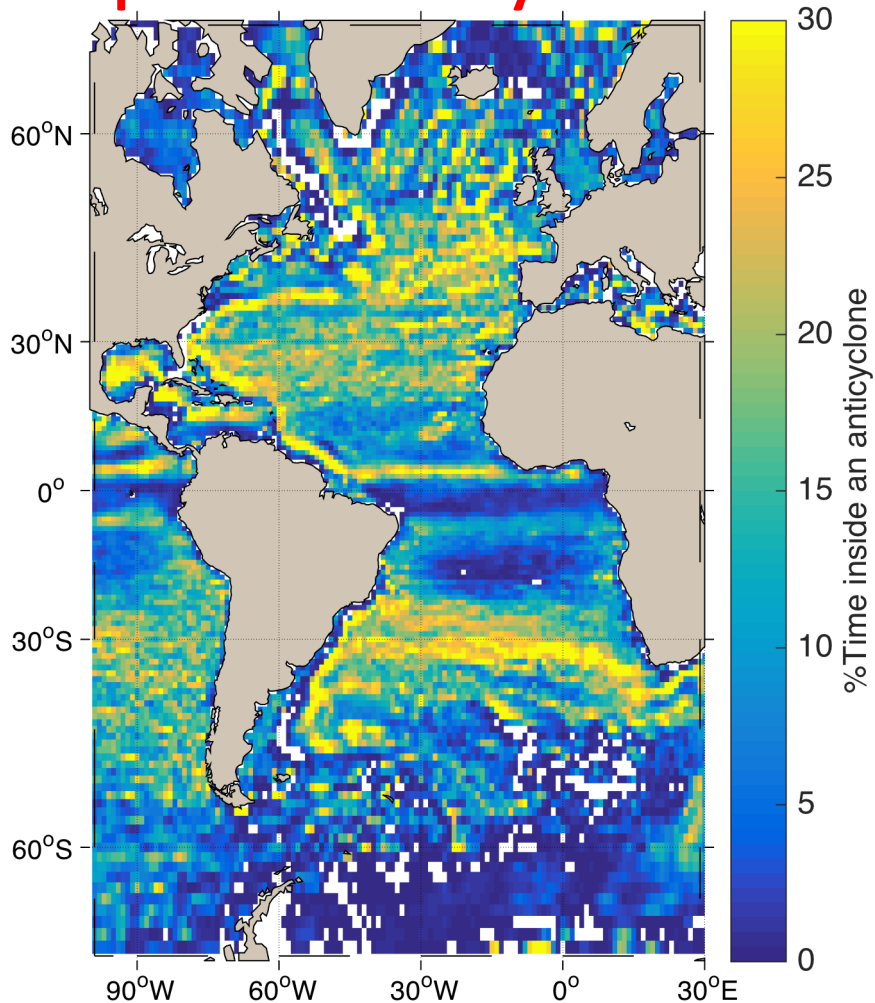
Eddy detection from satellite altimetry
(2000-2015)

Laxenaire et al., 2017

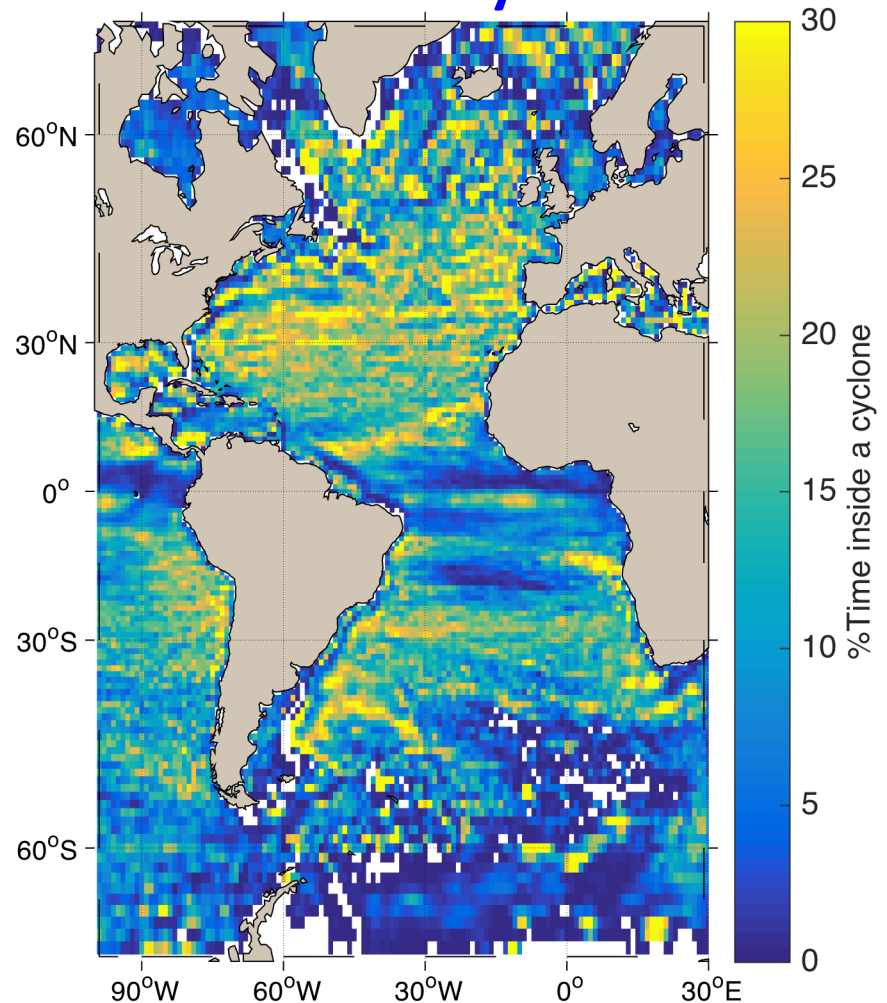
[AVISO Ssalto-Duacs Daily multi-satellite Maps
of Absolute Dynamic Topography; Ducet et al.,
2000; Pascual et al. 2006]

The ocean is filled by eddies

1°x 1° % Time of presence Anticyclones



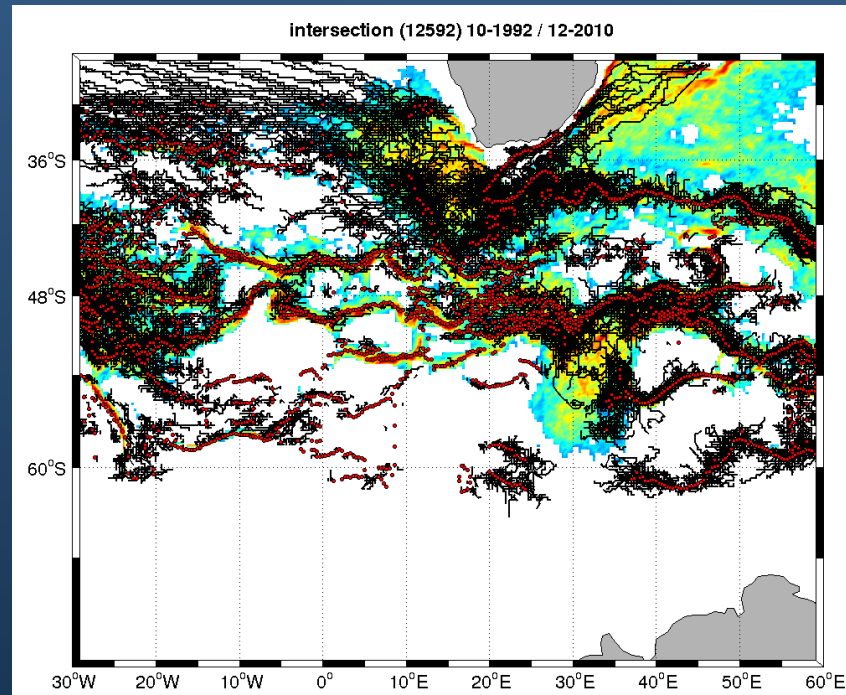
1°x 1° % Time of Presence Cyclones



Nonlinear ocean dynamics

Definitions of Southern Ocean Fronts
from MADT images and eddies transfer

Fronts detection
+
Eddy tracking

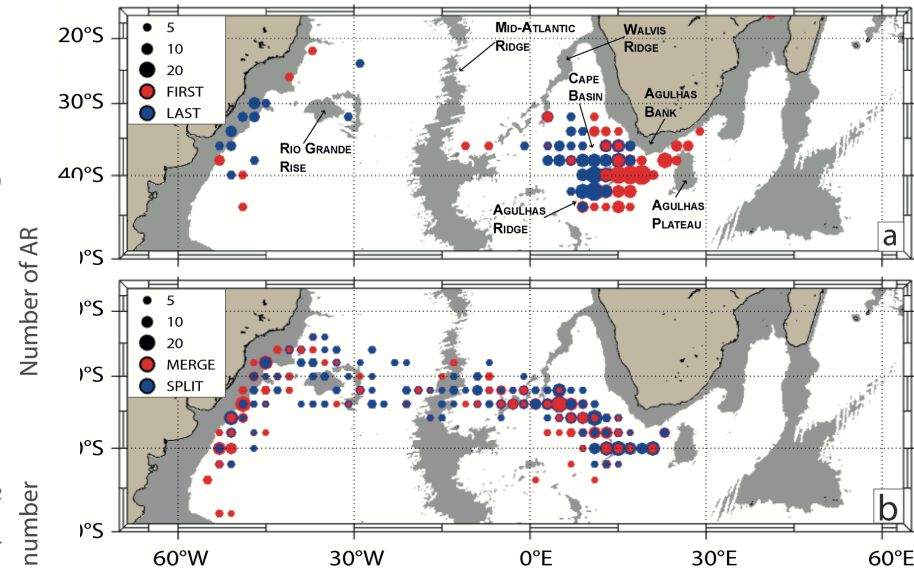
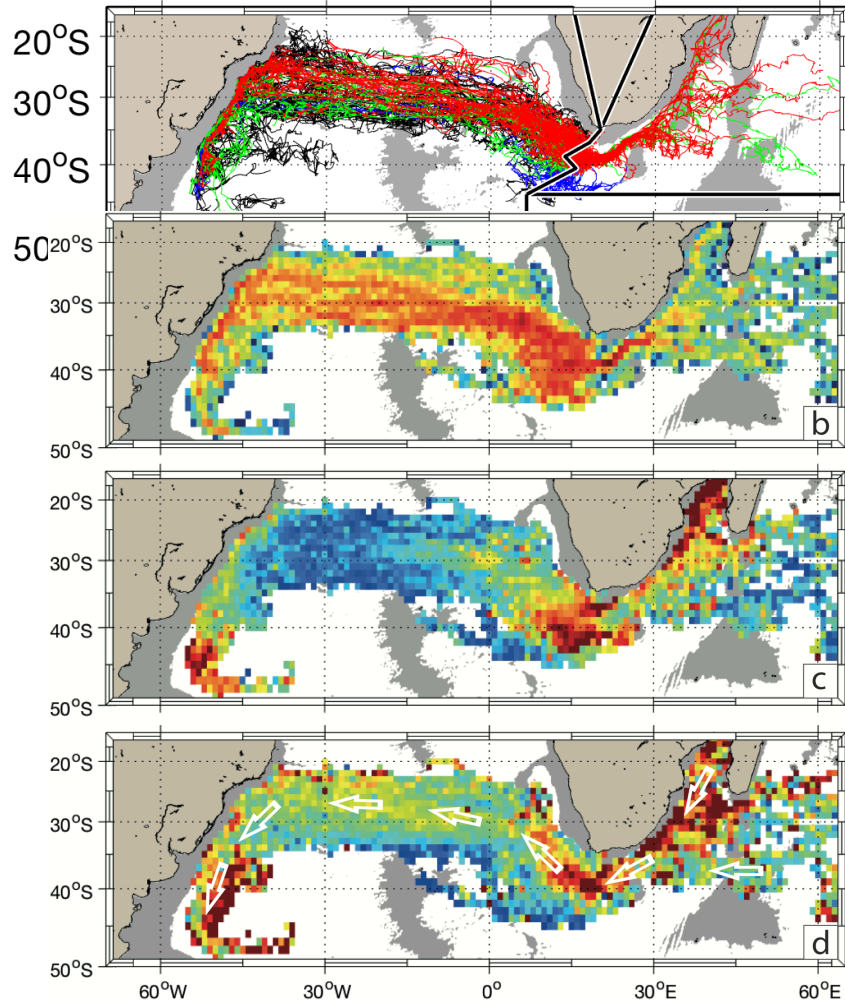


Where there are discontinuities in fronts, eddy activity and crossfrontal transfer is the highest

Fronts are not continuous

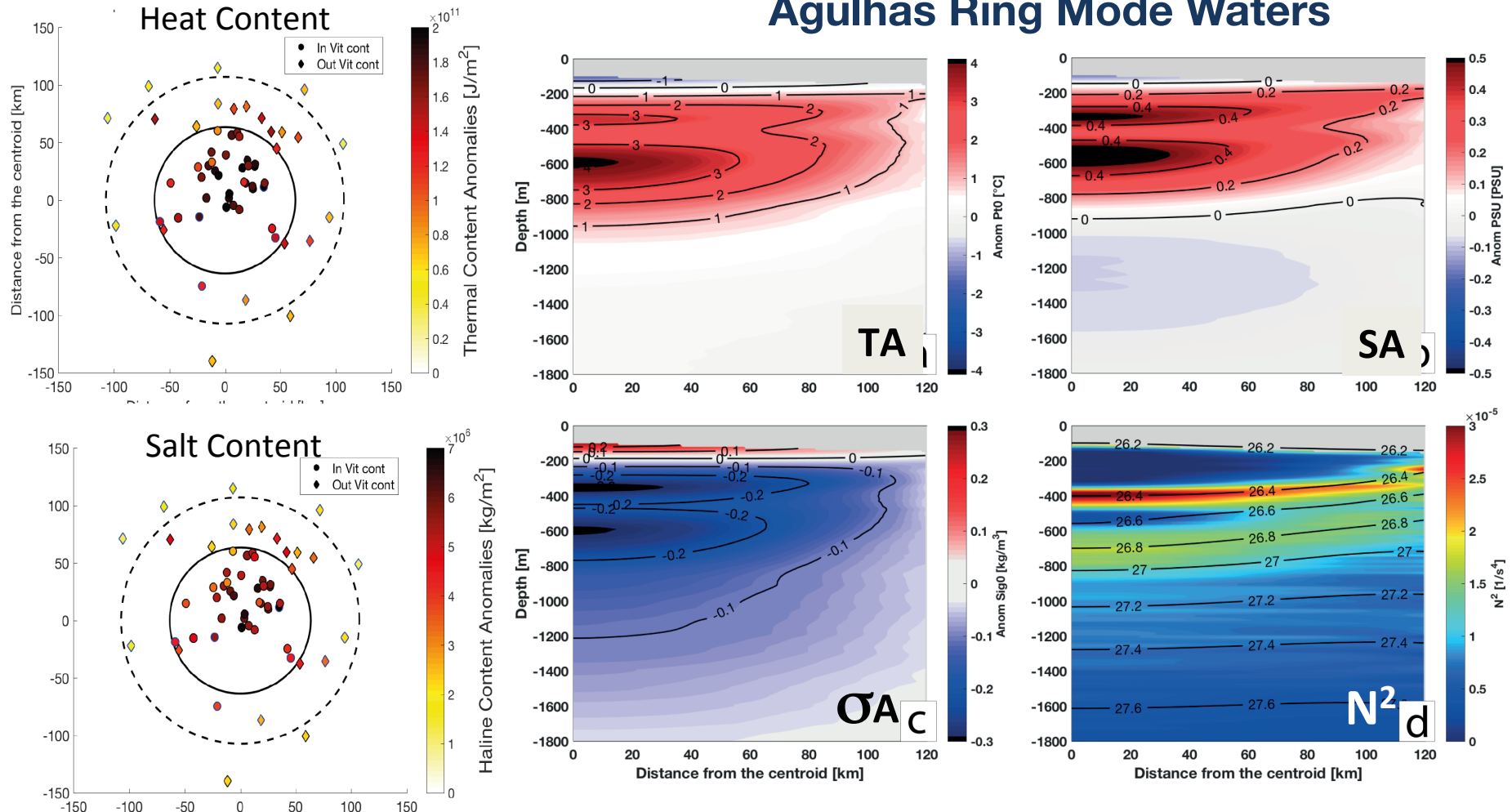
The Agulhas Rings example

Estimating the export of Indian waters by eddies

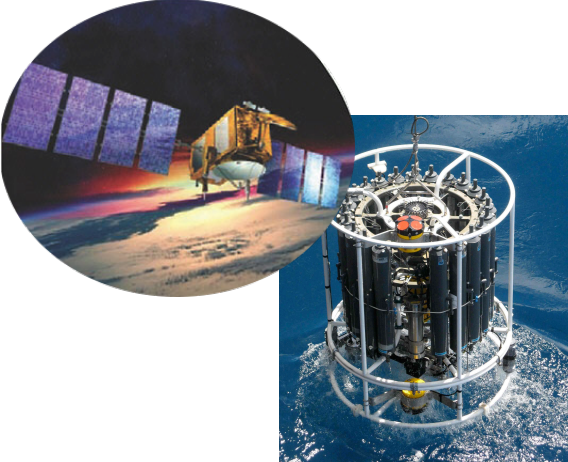


A new eddy identification and tracking method that includes eddy-merging and splitting

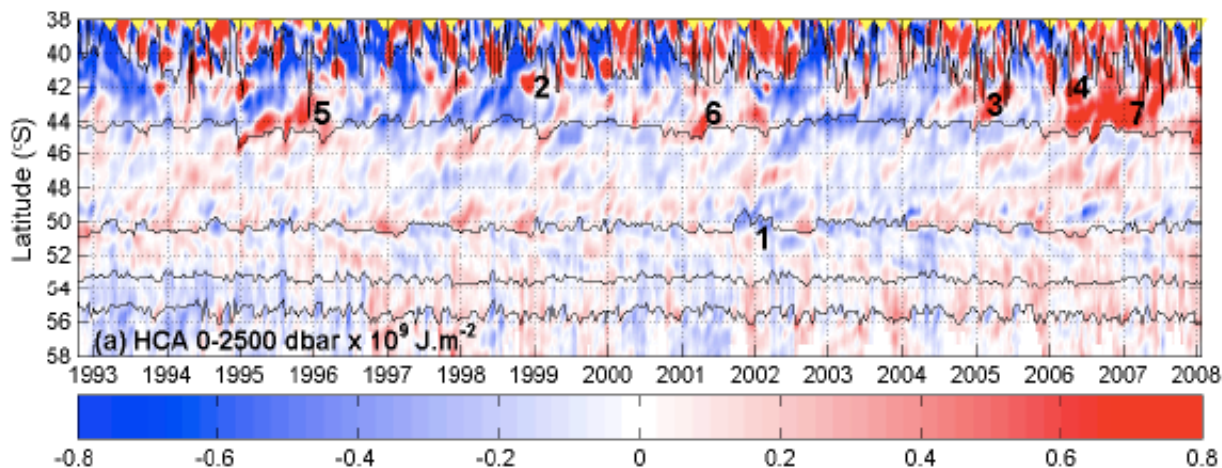
Local formation/transformation of waters



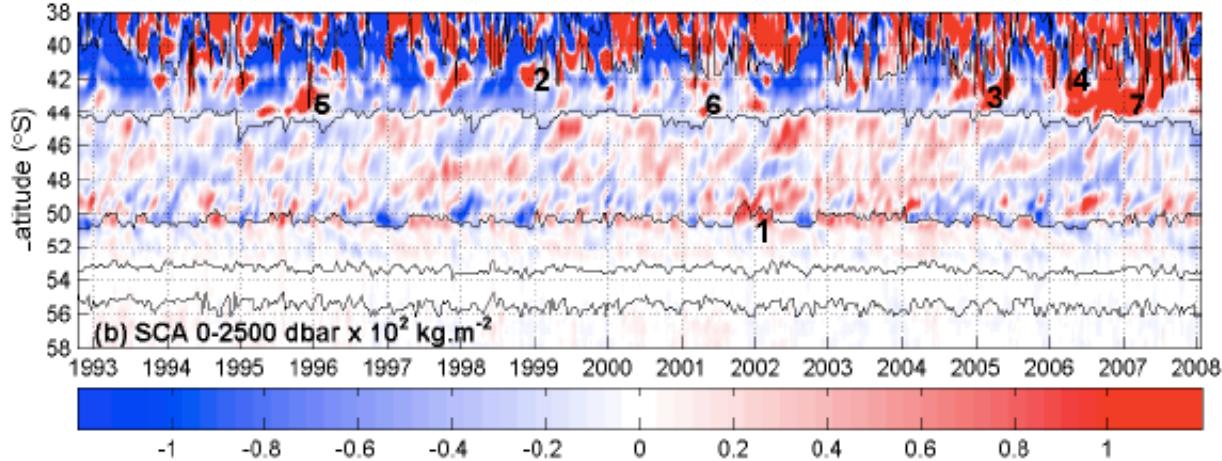
Laxenaire et al., in prep. (2 papers), Capuano et al., subm. (2 papers)



AGEM : Variability in the ACC along GH built using *in situ* data & satellite altimetry



**AGEM
(A PROXY FOR)
HEAT CONTENT
ANOMALY
1992-2008**

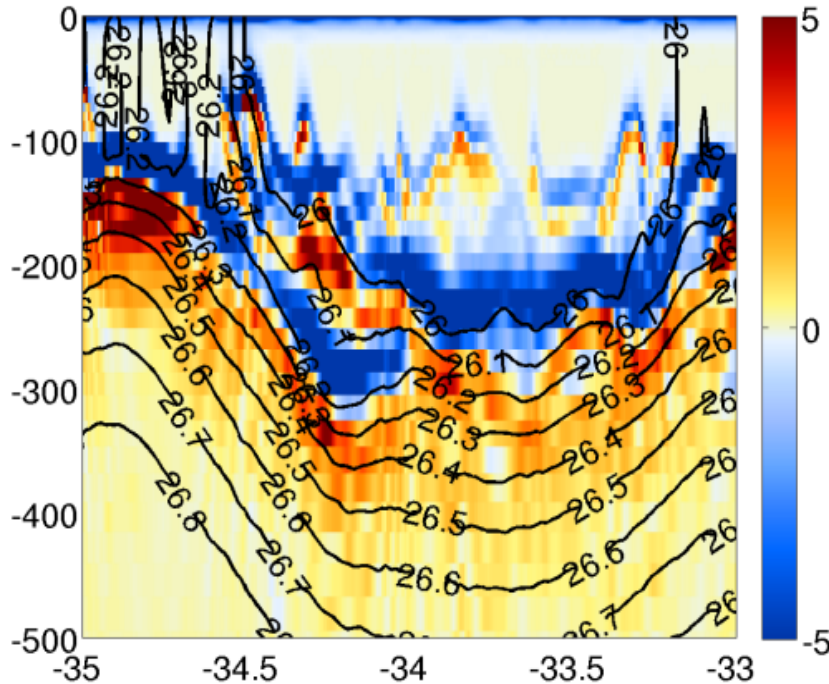


**AGEM
(A PROXY FOR)
SALT CONTENT
ANOMALY
1992-2008**

HR Modelling (1/108° 100 levels) & mesoscale/submesoscale interaction

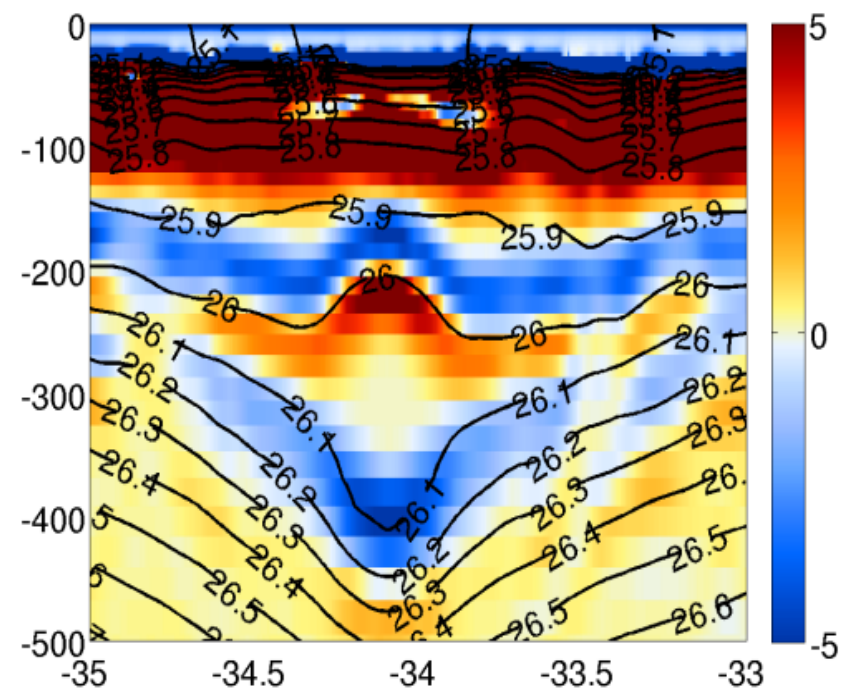
PV, Winter anticyclone

a) dN^2/dz [s^{-1} , 10^{-7}] section at 10°E along winter ACe



PV, Summer anticyclone

b) dN^2/dz [s^{-1} , 10^{-7}] section at 9.2°E along summer ACe

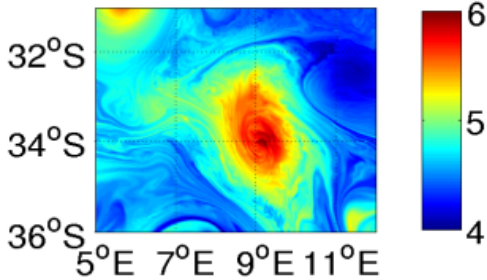


**Realistic MIXING Layer,
Mode water formation by submesoscale subduction**

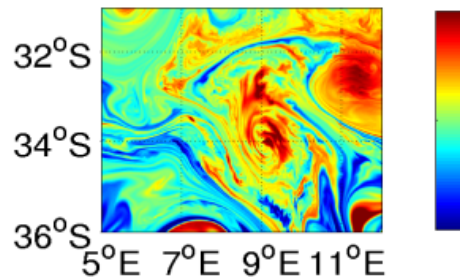
HR Modelling (1/108° 100 levels) & mesoscale/submesoscale interaction

Water properties along the 27.2 isopycnal

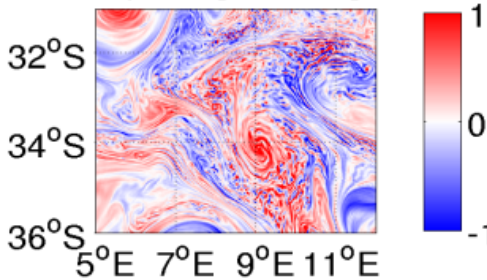
a) HR, T [°C] in summer



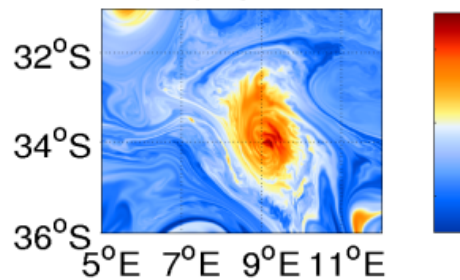
b) S [psu]



c) RV [s⁻¹, 10⁻⁵]

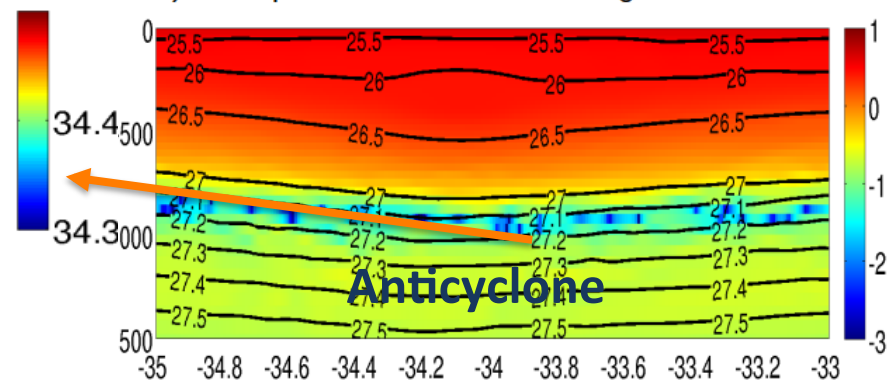


d) Spice

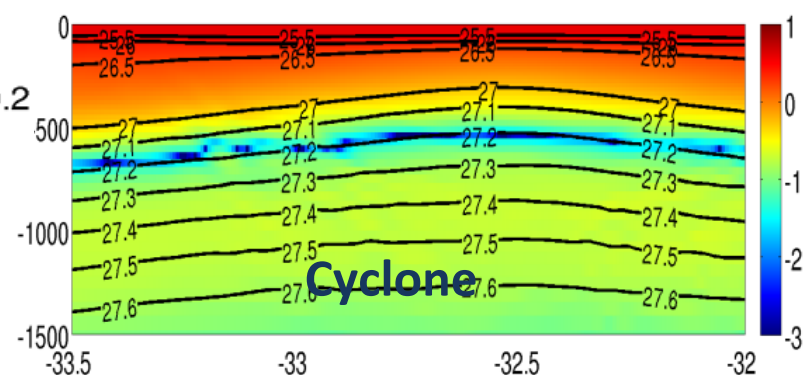


Spiciness (vertical section)

c) HR Spice section at 9.2°E along a summer ACe

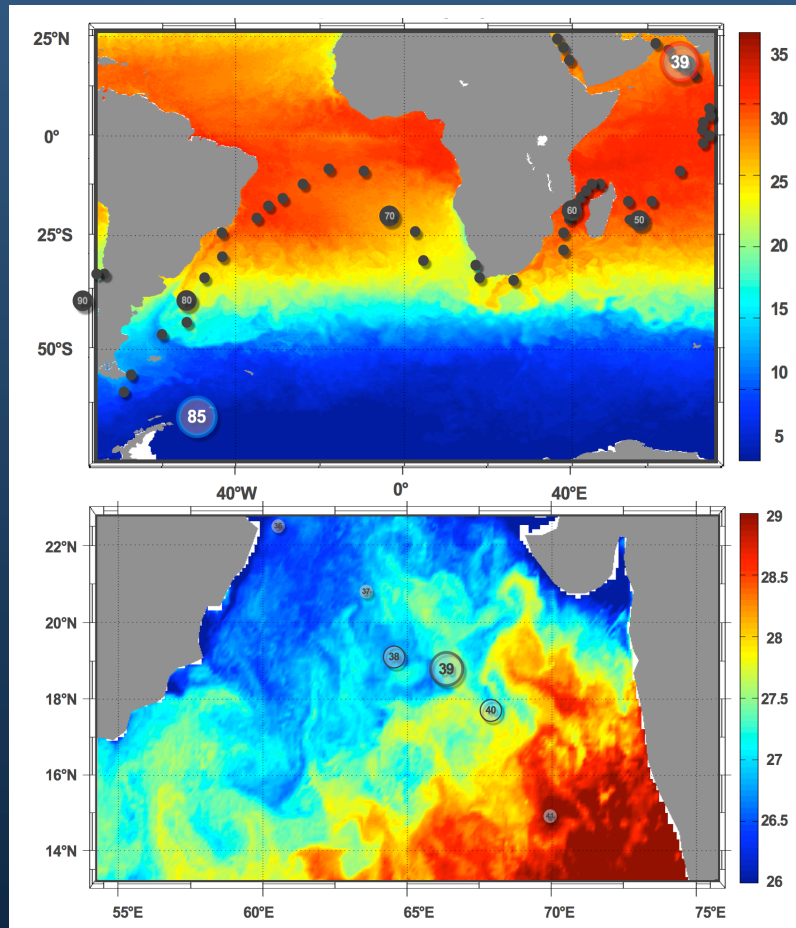


d) HR Spice section at 11.5°E along a summer Ce



Intense submesoscale lateral mixing at depth (here AAIW layer)

Nonlinear ocean dynamics impacts biodiversity



Novel *Kordia sp.*
(Bacteroidetes) highest
abundance after upwelling-
induced phytoplankton
blooms and sinking to the
deep ocean with large
organic matter particles

Nonlinear ocean dynamics & SOCLIM

Dynamical impact of ocean variability (tides, mesoscale, submesoscale)

- Work on satellite altimetry to characterize the SOCLIM period upper ocean dynamics (mesoscale variability)
- Argo + GEMs for 3D thermohaline (and biogeochemical??) reconstruction
- HR regional simulations including tides (external, internal) and biogeochemistry