EGU General Assembly 2020
Session OS4.1

Evaluating the signature of oceanic striations on the distribution of biogeochemical properties in the Eastern Pacific Ocean off Chile

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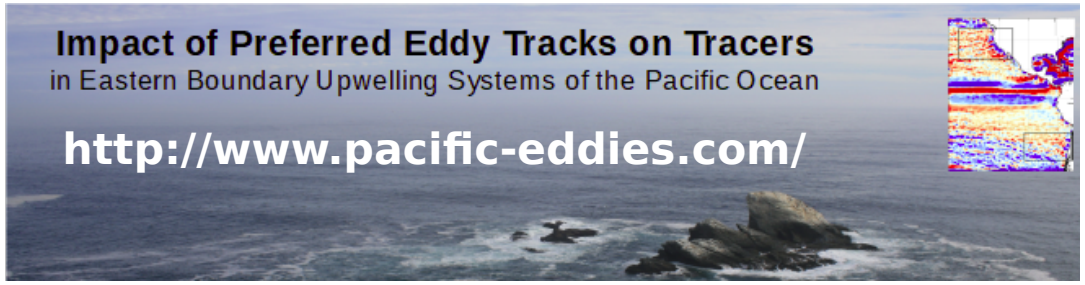
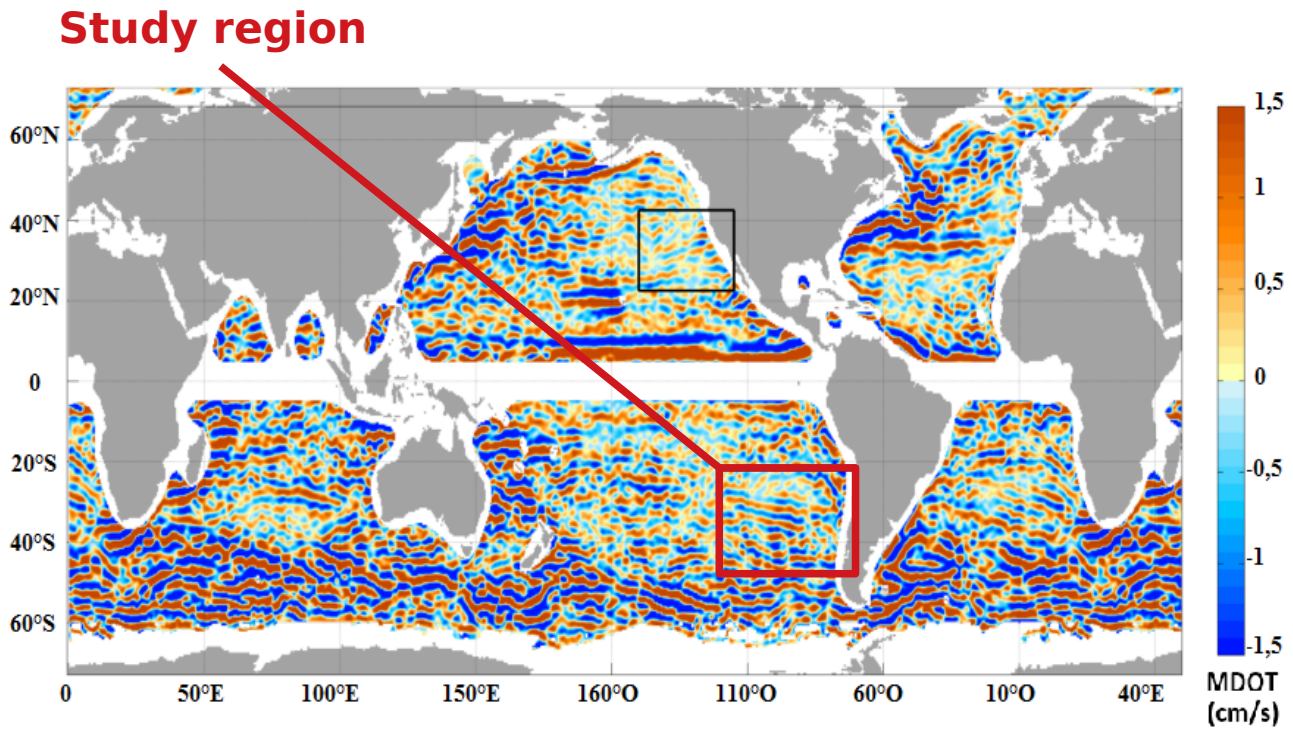


Striations : quasi-zonal mesoscale jet-like features

Extension : zonal ~ 1000 km / meridional 200-500km / vertically-coherent over several hundred of meters
Geostrophic balance : anomalies of sea surface height (~1 cm) & zonal velocity (~1cm s^{-1})



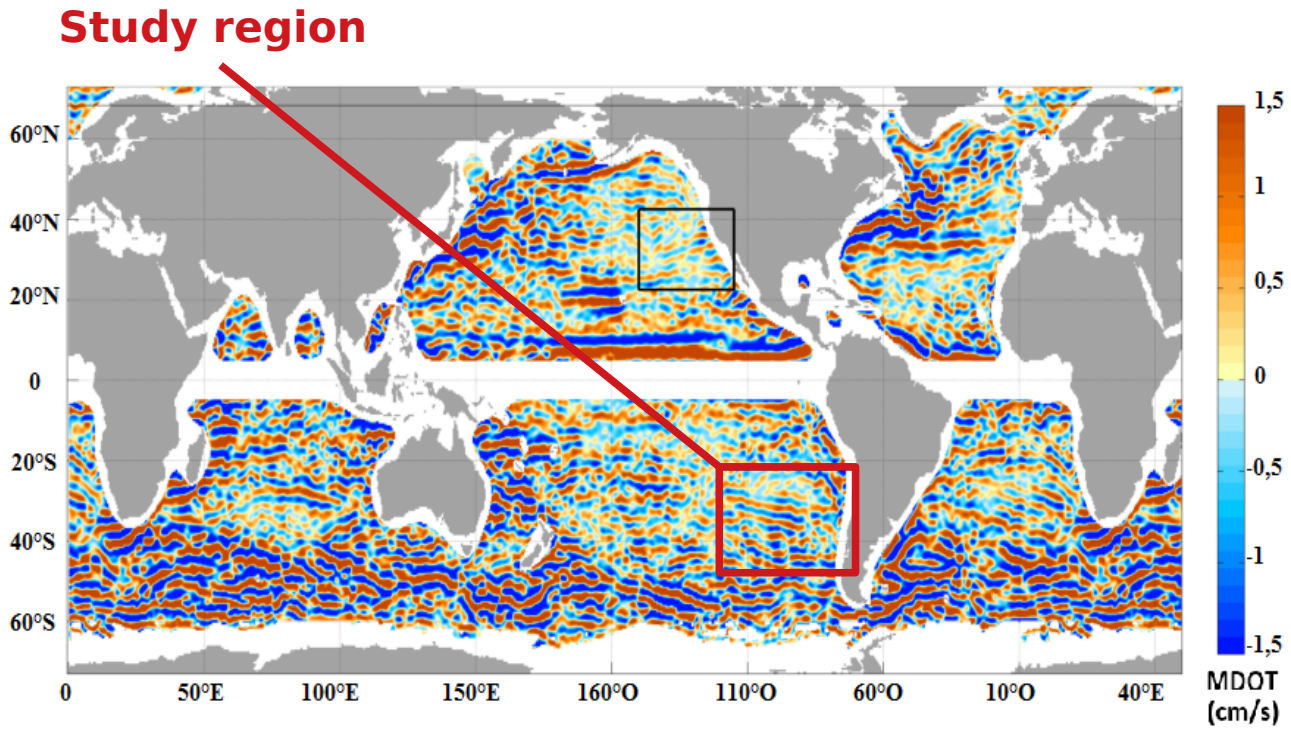
Horizontally high-pass filtered 10-year mean zonal surface geostrophic velocity from mean dynamic topography (cm/s). From Maximenko et al. [2008].

Evidenced in…

• **SSH**	Maximenko *et al.*, 2008; Buckingham & Cornillon, 2013
• **MDOT**	Buckingham & Cornillon, 2013; Buckingham *et al.*, 2014
• **Lagrangian buoys**	Centurioni *et al.*, 2008
• **ARGO floats**	Maximenko *et al.*, 2005; Maximenko & Niiler, 2005; Ivanov *et al.*, 2009
• **XBT**	Van Sebille *et al.*, 2011
• **Numerical models**	Galperin *et al.*, 2004; Kamenkovich *et al.*, 2009; Melnichenko *et al.*, 2010; Belmadani *et al.*, 2017

→ Artifact of time-averaging westward-propagating mesoscale eddies (ME) following preferred eddy tracks ? *Qiu et al. (2008);* ***Belmadani et al. (2017)***

Striations : impact on the distribution of biogeochemical properties ?



Horizontally high-pass filtered 10-year mean zonal surface geostrophic velocity from mean dynamic topography (cm/s). From Maximenko et al. [2008].

Documented effect on…

- Advection of the temperature field (Buckingham *et al.*, 2014)
- Structure of surface winds (Taguchi *et al.*, 2012)
- Mixing of tracers (Chen & Flierl, 2015)
- Advection of plastics (Maes *et al.*, 2016)

How we tackle this question ?

→ Analysis of satellite data

→ Numerical modeling

Method : high-pass filtering and quasi-zonal averages

Coupled 3D physical-biogeochemical simulation ROMS-PISCES off Chile (22°-45°S y 70°-105°W)
30 years (1984-2013)

- Sea surface height (SSH)
- Zonal geostrophic velocity (~d/dy(SSH))
- Nutrients, phytoplankton biomass, dissolved oxygen (O_2)

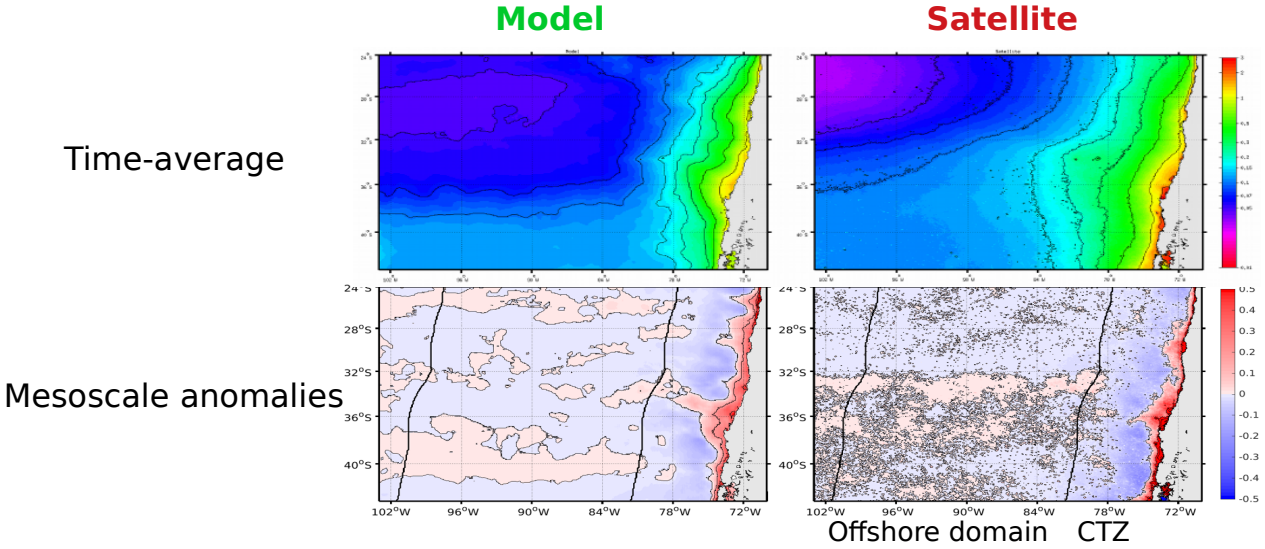
Satellite data

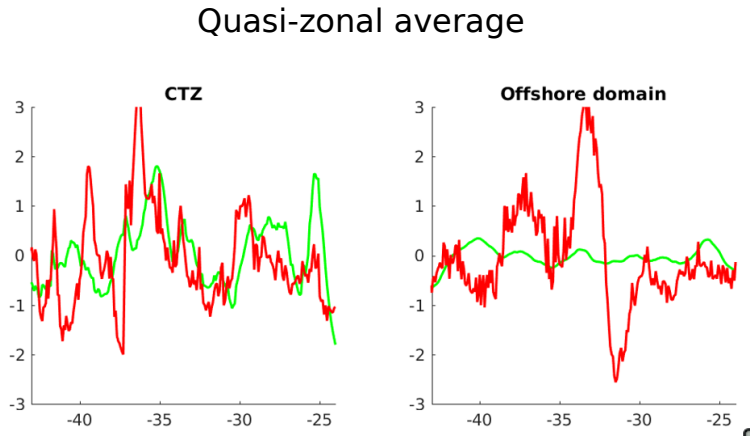
- SSH (AVISO) : 20 years (1993-2013)
- Surface chlorophyll-a (GlobColour) : 15 years (1998-2013)

Data treatment

- **Time-average** over periods of some months to years
- Horizontally high-pass filter the large-scale → **mesoscale anomalies**
- **Quasi-zonal average** of the mesoscale anomalies of physical and biogeochemical properties

Surface chlorophyll-a (mg·m^{-3}, 1998–2013) → Evidence of striations in satellite and model data





Method : attribution of biogeochemical anomalies to eddy trapping/stirring

Preferred eddy tracks

=

Meridionally-alternating quasi-zonal bands of **mesoscale anomalies** (+/-)

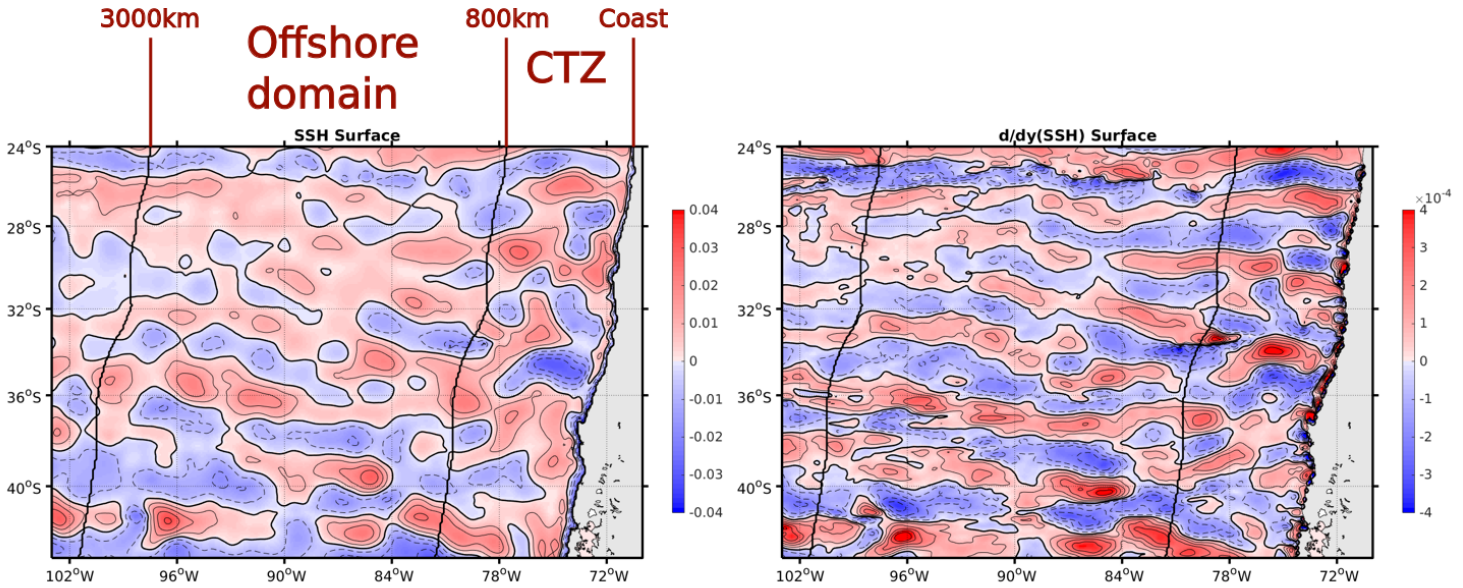
Sea surface height (SSH) → Trajectory of ME → **Eddy Trapping**

Zonal geostrophic velocity (~*d*/*dy*(SSH)) → Tangencial velocity of ME → **Eddy Stirring**

→ Correlations between quasi-zonal averages of physical and biogeochemical striations

Physical striations

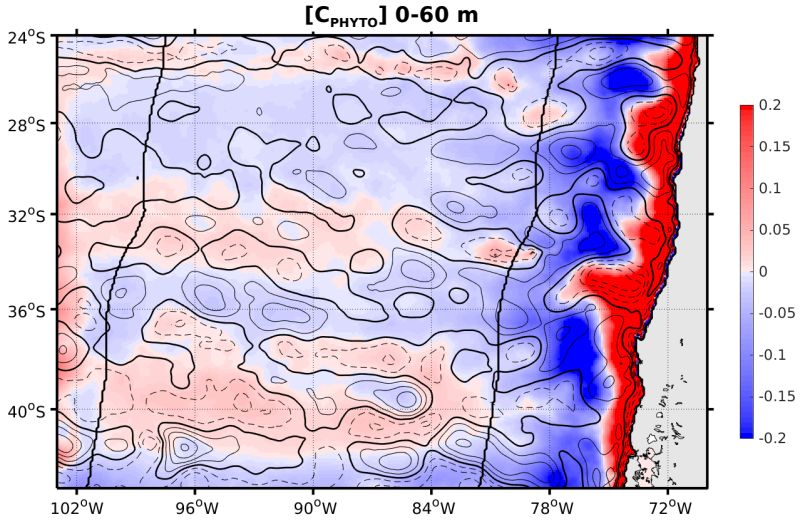
Mesoscale anomalies of SSH and d(SSH)/dy.



Some results...

[C Total phytoplankton]

Biogeochemical striations

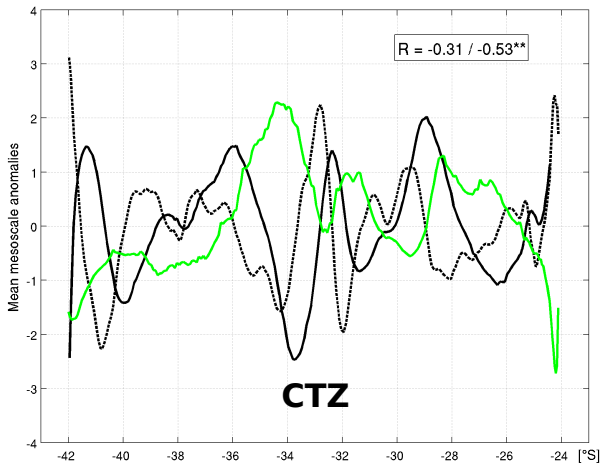


Color : mesoscale anomalies of total phytoplankton carbon depth-averaged over 0-60m depth (mmolC m^{-3}).
Contours : mesoscale anomalies of SSH (m).

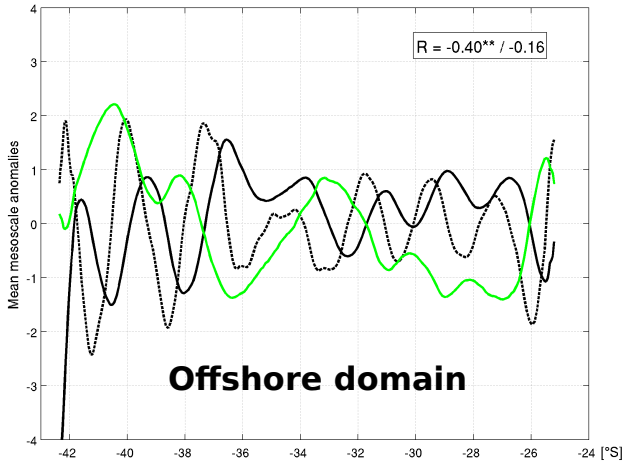
Nota Bene : similar results for the layers 0-60m (mixed layer) and 0-120m (euphotic layer)

Quasi-zonal averages

Physical striations vs [Cphyto] 0-60 m (subdomain : 50-800 km from the coast)



Physical striations vs [Cphyto] 0-60 m (subdomain : 800-3000 km from the coast)



Correlations

(**Significant p<0.01 /** Not significant p>0.01)

[Cphyto]
Trapping (SSH)
Stirring (~d/dy SSH)

Trapping (SSH) r = -0,31
Stirring (*d/dy* SSH) r = -0,53

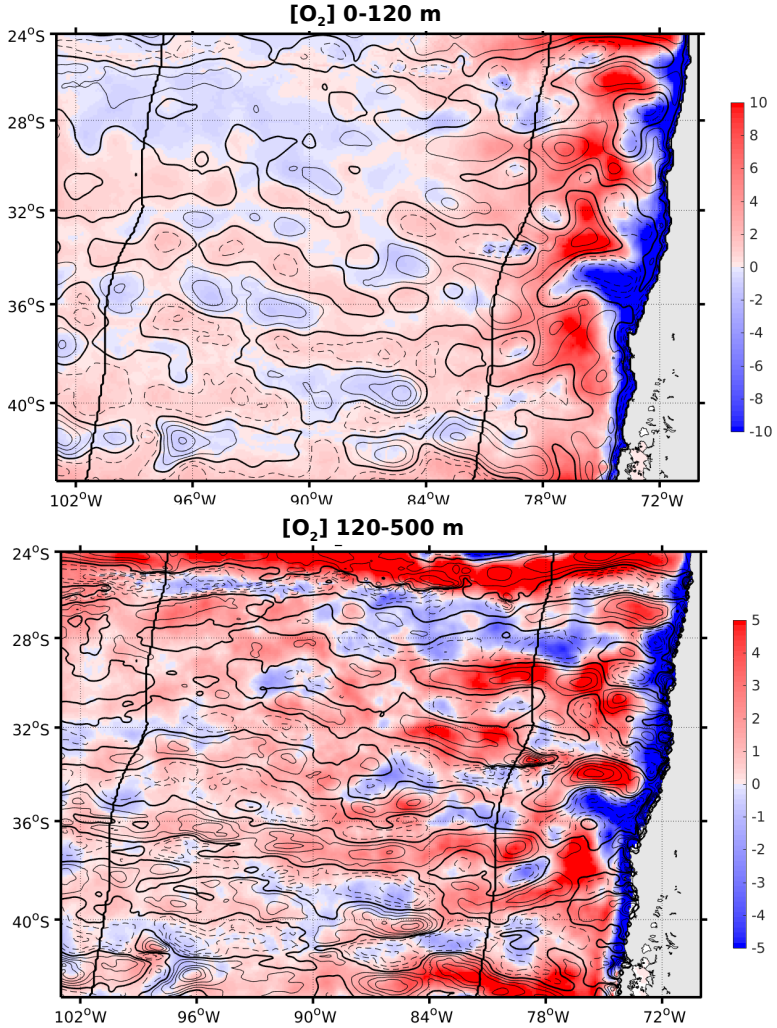
Eddy stirring dominates the striation signal of [Cphyto] in the CTZ
→ fast export of fresh coastal material (filaments)

Trapping (SSH) r = -0.40
Stirring (*d/dy* SSH) r = -0.16

Eddy trapping dominates offshore : CC trap waters with anom. + of [Cphyto] at the coast and transport it westward
→ consist of aged material)

Some results... $[O_2]$

Biogeochemical striations



Color : mesoscale anomalies of depth-averaged O_2 ($mmolO_2$ m^{-3}) over 0-120m depth (top) and 120-500m depth (bottom).
Contours : mesoscale anomalies of SSH (top) and d/dy(SSH).

CTZ
<800 km from the coast

Trapping (SSH) r = +0.21
Stirring (d/dy SSH) r = +0.56

CC (AC) trap waters with anomaly - (+) of $[O_2]$ at the surface but not significant

Advection of anomaly - (+) of $[O_2]$ towards the west (east)

Trapping (SSH) r = -0,25
Stirring (d/dy SSH) r = +0.28

CC (AC) host waters with anomaly - (+) of $[O_2]$ at the surface (coming from the coast) but not significant

Advection of anomaly - (+) of $[O_2]$ towards the west (east)

Offshore domain
>800 km from the coast

Trapping (SSH) r = -0,65
Stirring (d/dy SSH) r = 0.24

Eddy trapping dominates offshore :
AC (CC) host anomaly - (+) of $[O_2]$ in the superficial layer → subsurface-intensified eddies ?

Trapping (SSH) r = -0,06
Stirring (d/dy SSH) r = +0.54

Advection of anomaly - (+) of $[O_2]$ towards the west (east)

Correlations
(**Significant p<0.01 /** Not significant p>0.01)

Ongoing : confirmation by developing a composite analysis based on objective eddy detection and tracking

http://www.researchgate.net/project/Impact-of-Preferred-Eddy-Tracks-on-Tracers-in-Eastern-Boundary-Upwelling-Systems-of-the-Pacific-Ocean

This work is carried out in the framework of the project N62909-16-1-2228 "**Impact of Preferred Eddy Tracks on Tracers in Eastern Boundary Upwelling Systems of the Pacific Ocean**", funded by the Department of the Navy, Office of Naval Research under grant #N62909-16-1-2228. Disclaimer: Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the Office of Naval Research.

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