

Mid-depth circulation in the tropical Pacific Ocean



From observations to theories

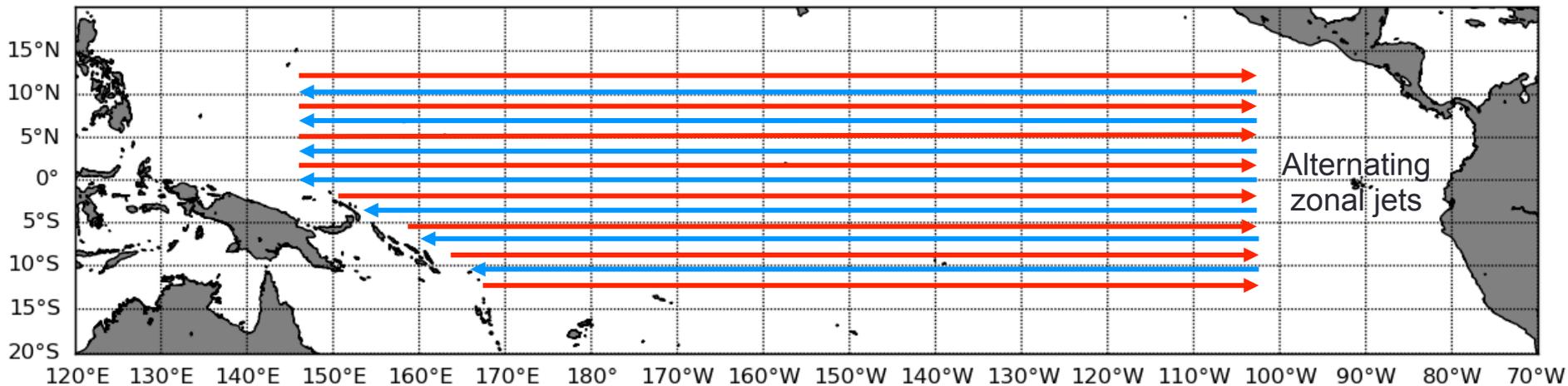
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and Yves Morel¹

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Spatiale - CNRS/IRD/CNES/UPS

2 - MINUTES OVERVIEW

Basin-scale jet-structured circulation

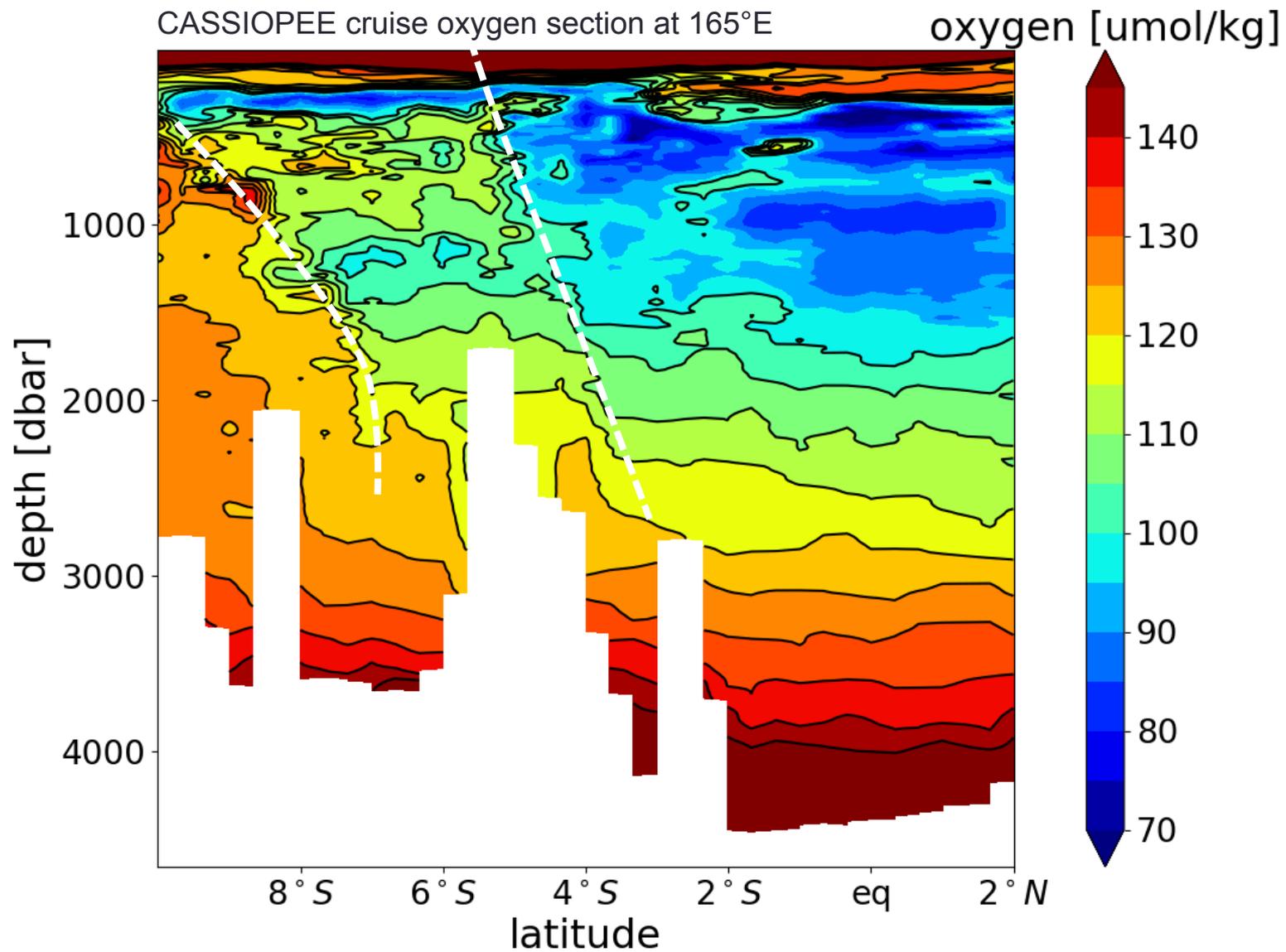
Mid-depth circulation in the tropical Pacific Ocean



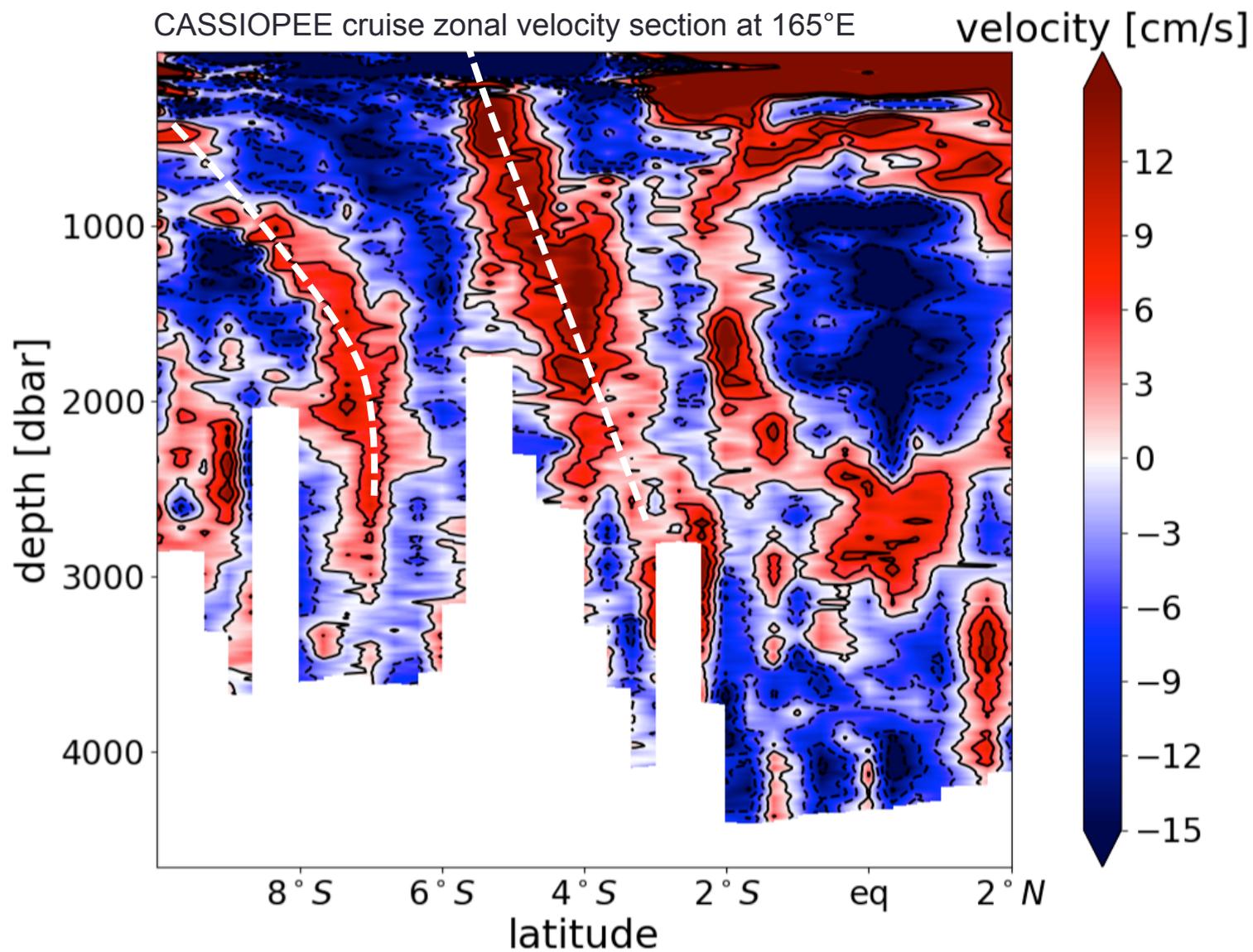
1) Which physical processes drive this circulation ?

2) Impact on water masses redistribution ?

2 - MINUTES OVERVIEW

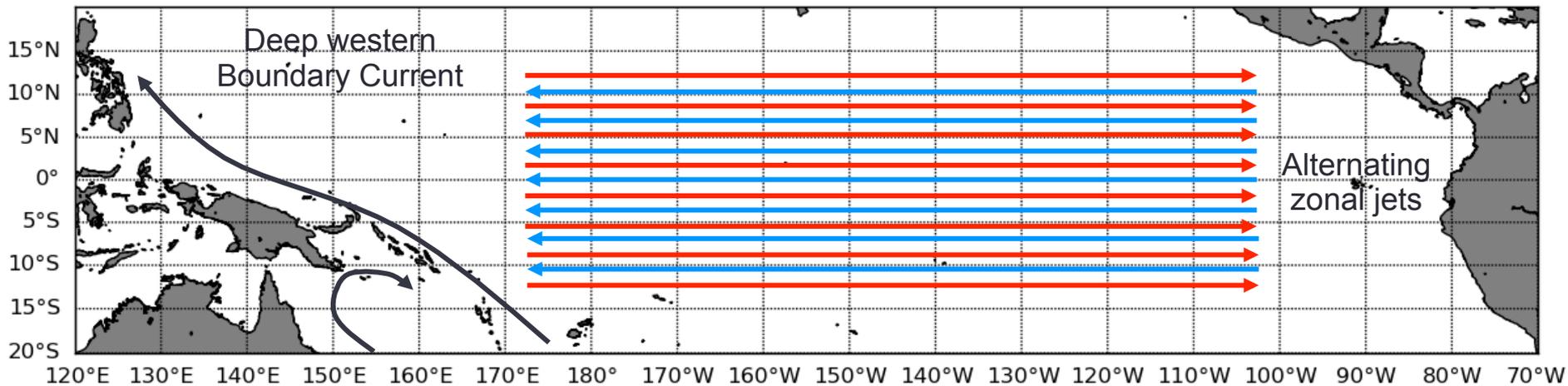


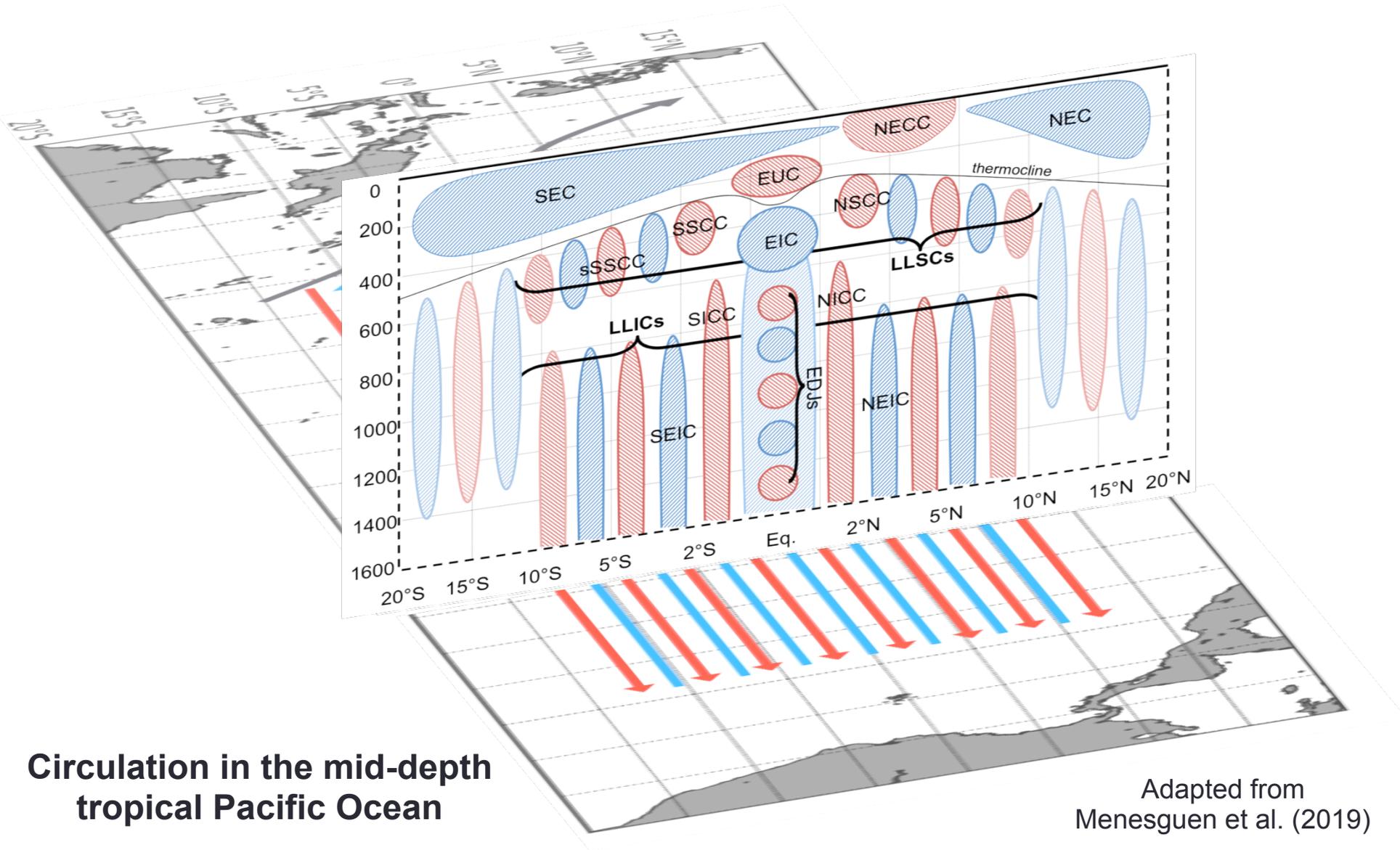
2 - MINUTES OVERVIEW





Circulation in the mid-depth tropical Pacific Ocean



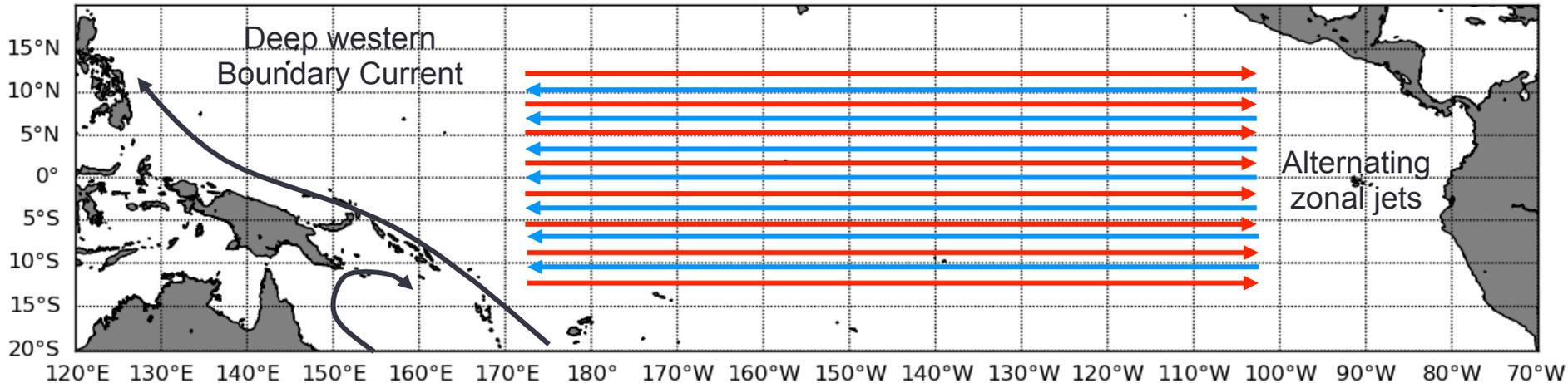


Circulation in the mid-depth tropical Pacific Ocean

Adapted from Menesguen et al. (2019)



Circulation in the deep tropical Pacific Ocean



Characteristics

- Alternating zonal jets structures, meridional scale 3°
- From below the thermocline to at least 2000 m
- About 10 cm/s decreasing poleward
- Hard to observe
- Time-averaged currents
- Not well represented in Ocean Global Circulation Models.

Main issues

- Impact of these jets on water mass properties and ventilation ?
- Physical processes at the origin of this circulation ?



Question : Does this system of zonal jets transport water masses ? Can they redistribute hydrological properties at basin scale ?

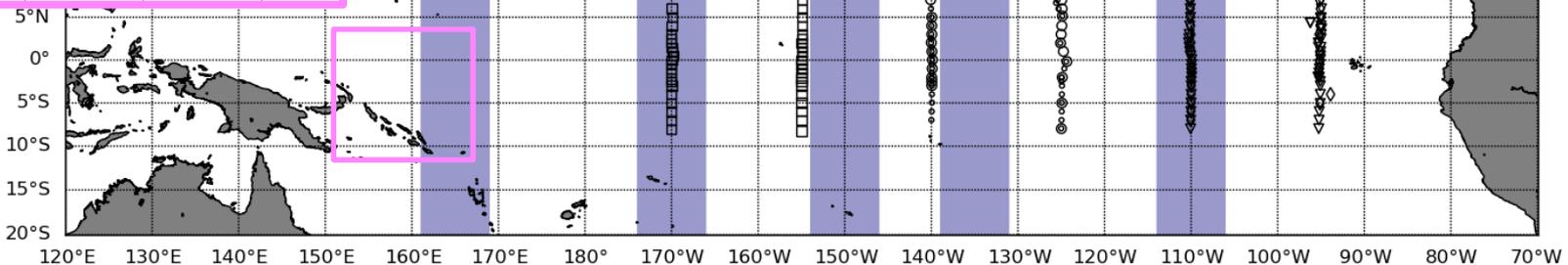
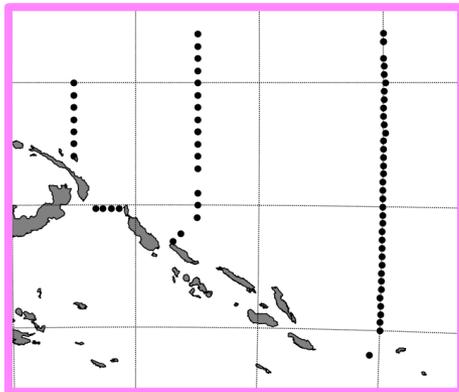
Method :

Comparison of meridional sections of currents and properties on neutral density surfaces.

Variables for diagnostics

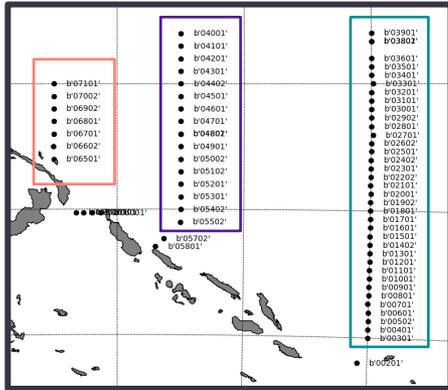
- Oxygen
- Salinity
- Potential vorticity

CASSIOPEE cruise



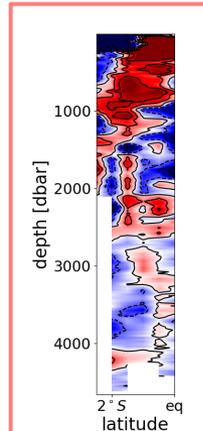


CASSIOPEE cruise : Zonal jets and Oxygen content

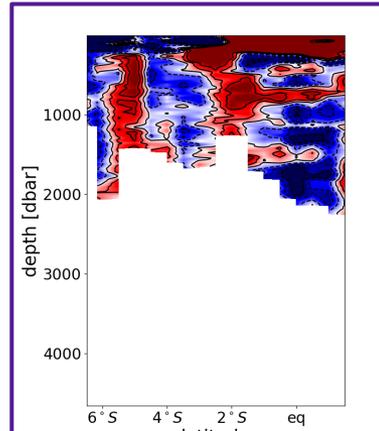


U

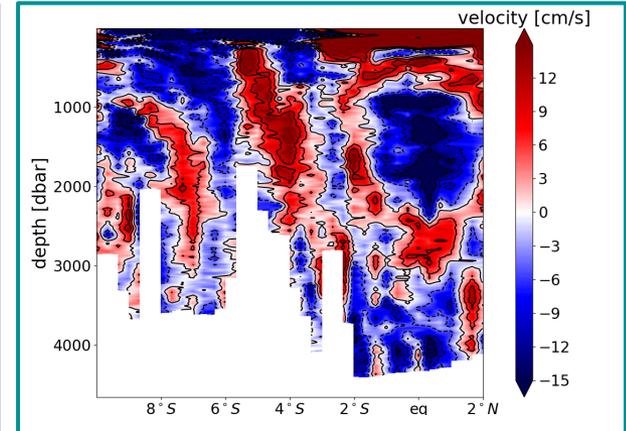
152.5°E



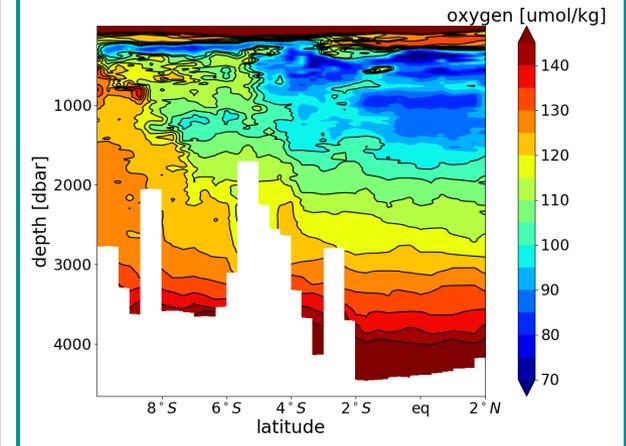
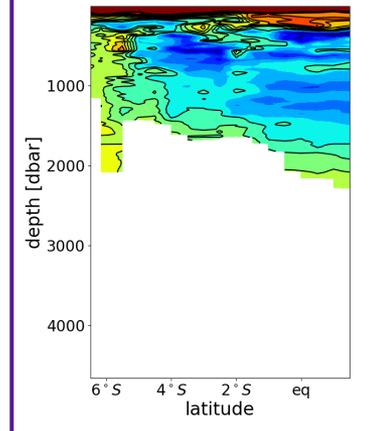
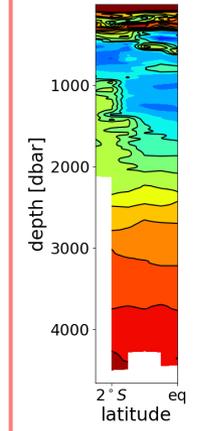
157.5°E



165°E



O₂



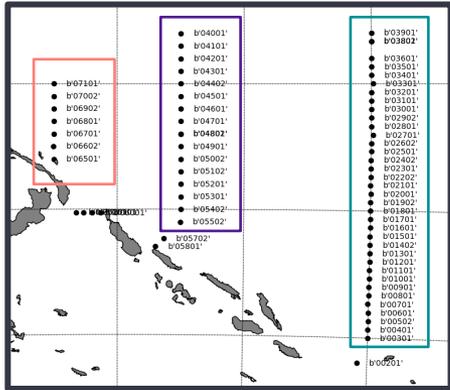
Conclusions

- Presence of higher oxygen concentration in EUC and first LLSCs.
- Presence of oxygen fronts in eastward jets at 1°S, 4°S and 7°S.
- Oxygen homogeneous regions in between.

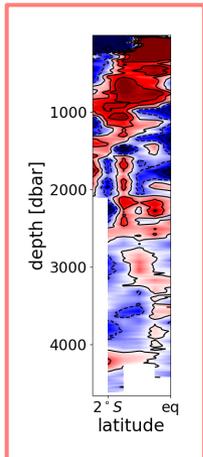




CASSIOPEE cruise : Zonal jets and Potential Vorticity

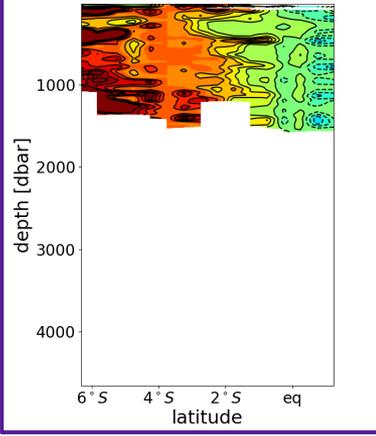
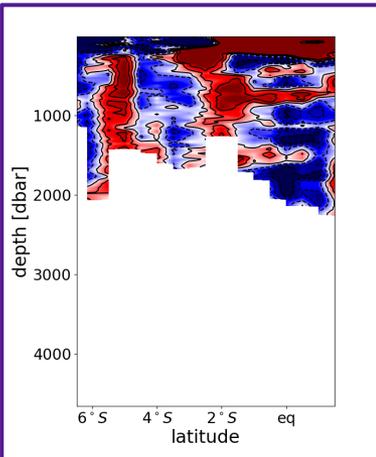


152.5°E

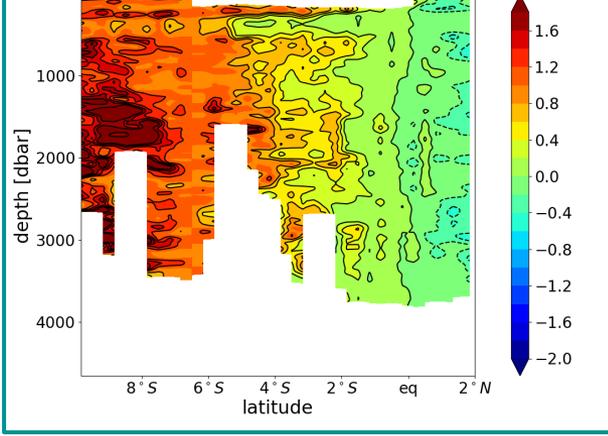
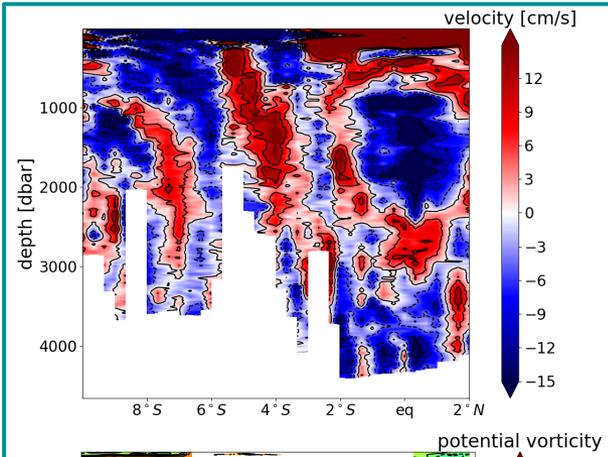


U

157.5°E



165°E



Click here!
i

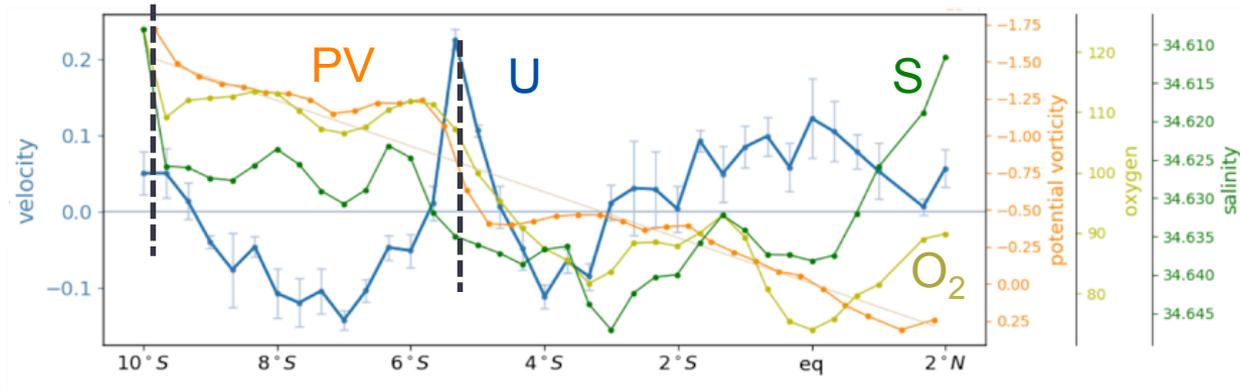
Conclusions

- Presence of potential vorticity fronts in eastward jets at 1°S, 4°S and 7°S.
- Homogeneous regions in between.

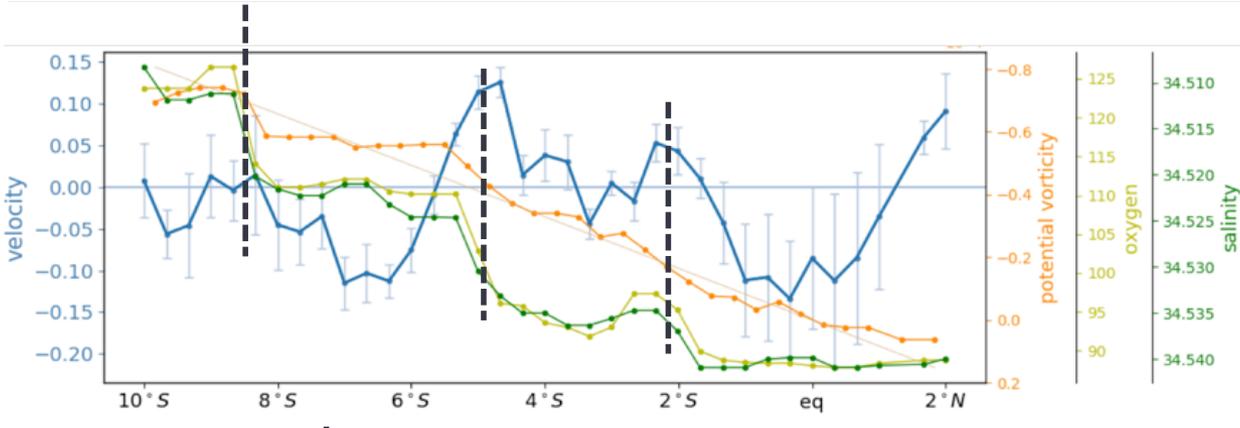
PV



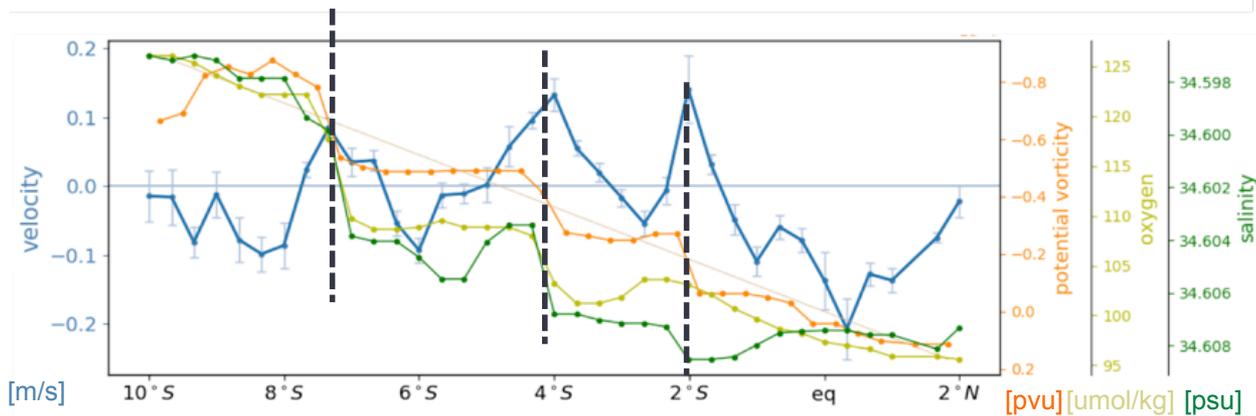
1026.8 – 1027.05 kg/m³
~ 400 – 500 m



1027.15 – 1027.35 kg/m³
~ 800 – 1000 m

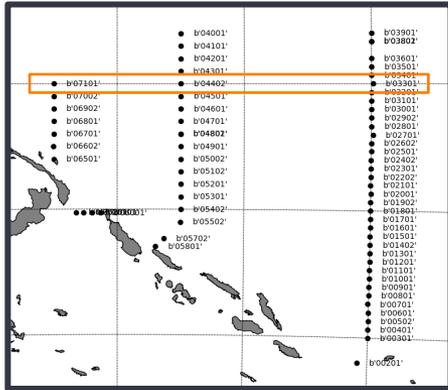


1027.57 – 1027.64 kg/m³
~ 1500 – 1800 m





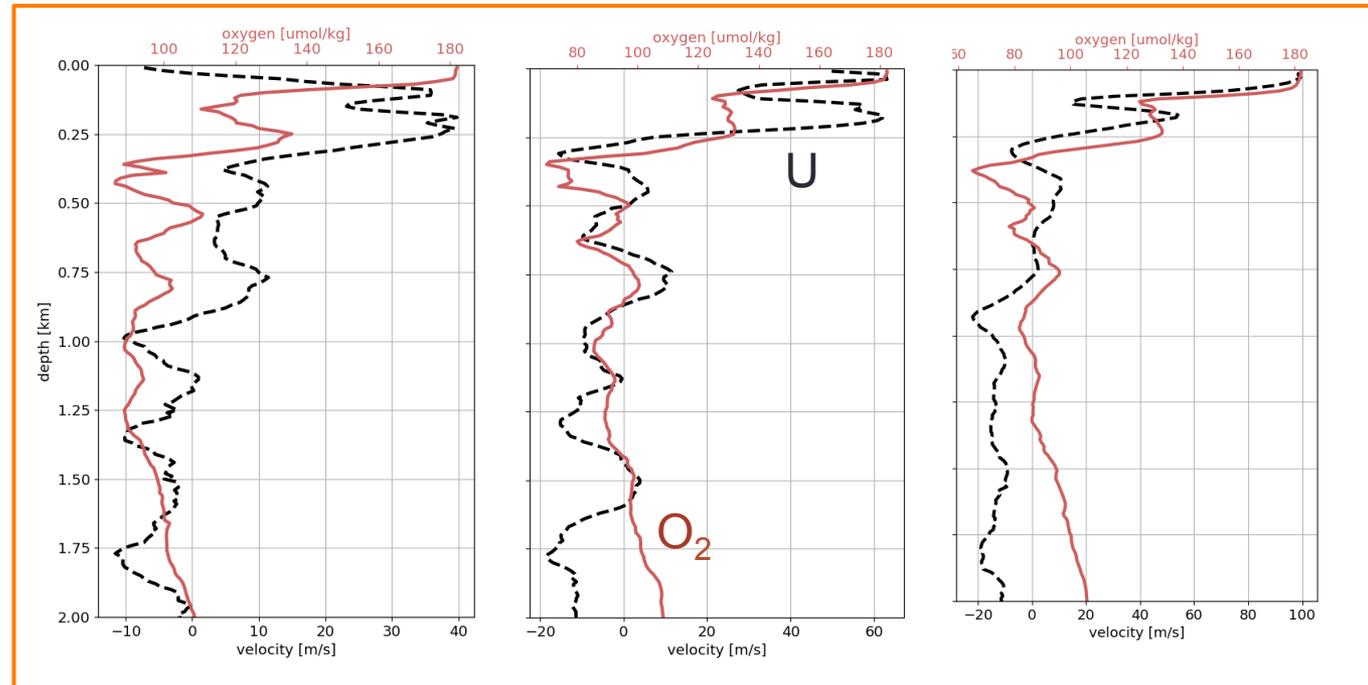
Zonal jets and Oxygen content : Equatorial Deep Jets.



152.5°E

157.5°E

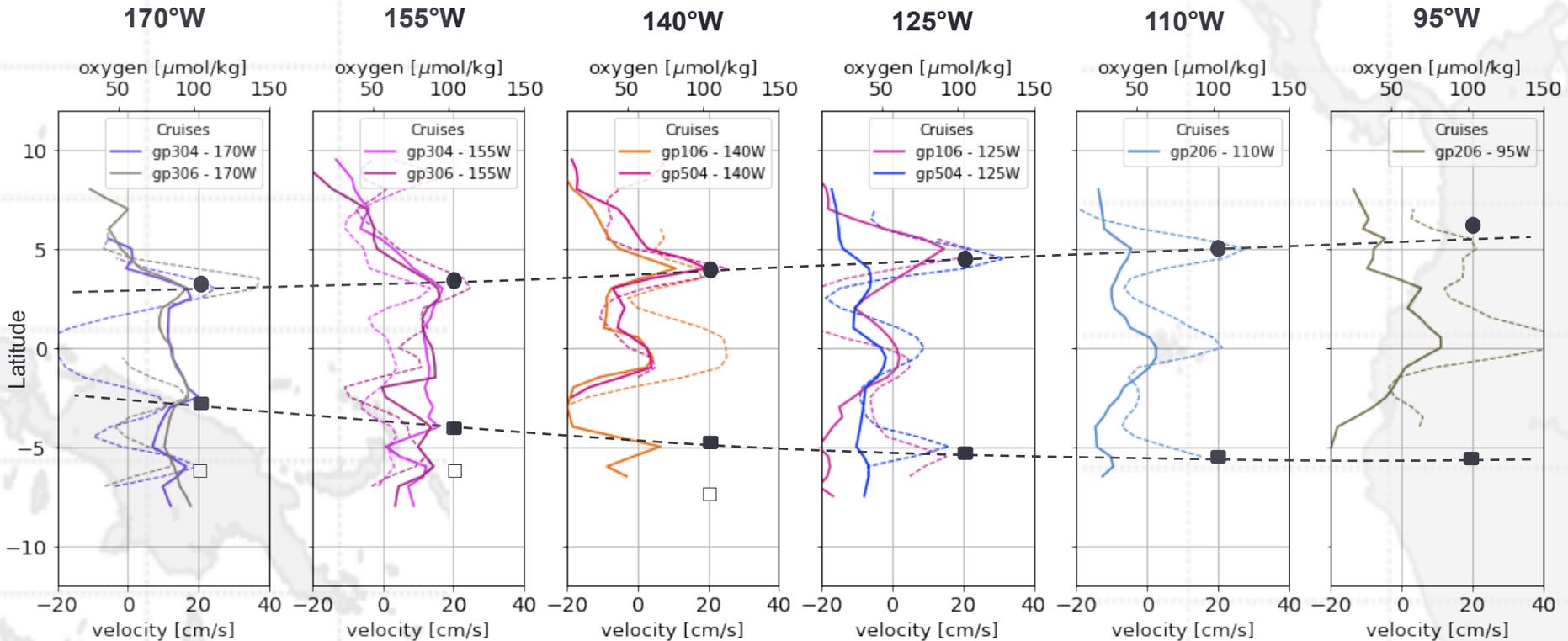
165°E



Conclusions

- Clear signature of higher oxygen concentrations in the EUC (Equatorial Under Current)
- When visible in velocity, the EDJs signal is also visible in oxygen.
- Eastward jets transport oxygen maxima

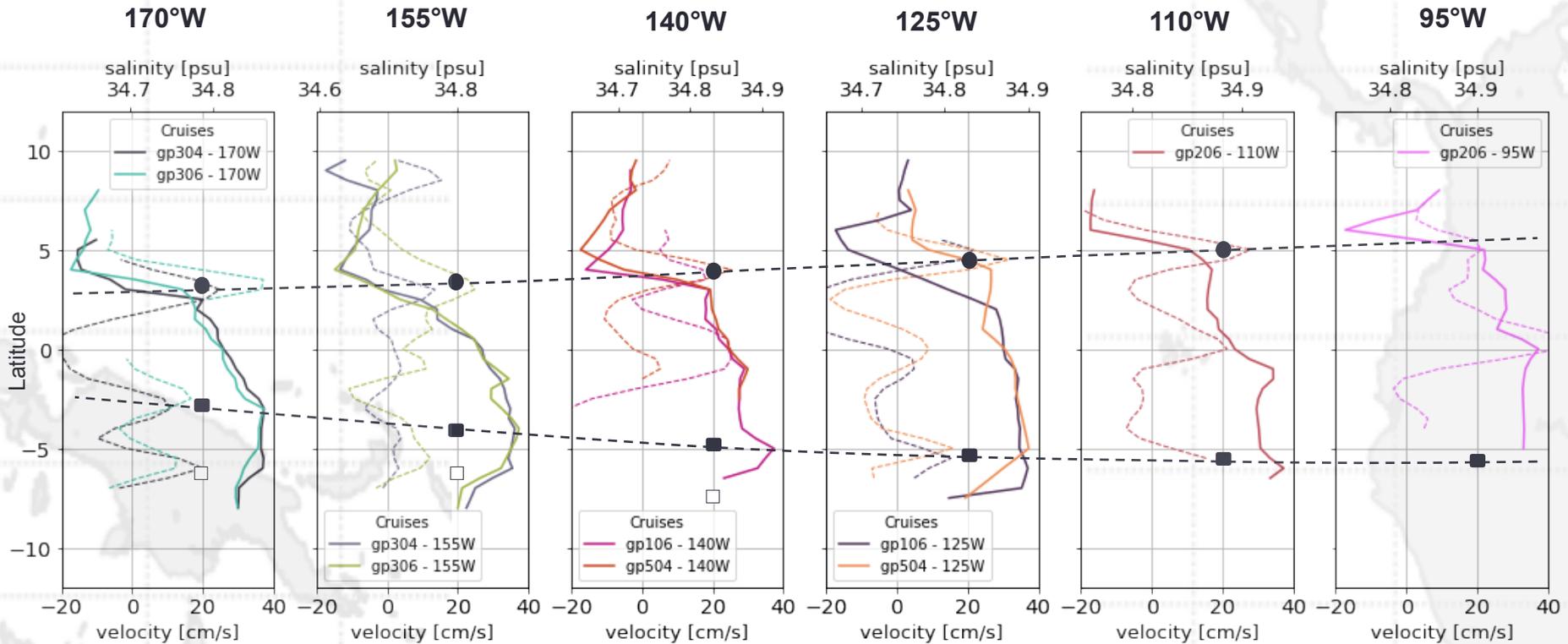
Zonal and Temporal coherence of oxygen anomalies in LLSC system



- NSCC
 - SSCC
 - Secondary SSCC
 - SADCP zonal velocity
 - Oxygen
- (Rowe et al., 2000)

Maximum of oxygen in Tsuchiya jets

Zonal and Temporal coherence of salinity anomalies in LLSC system

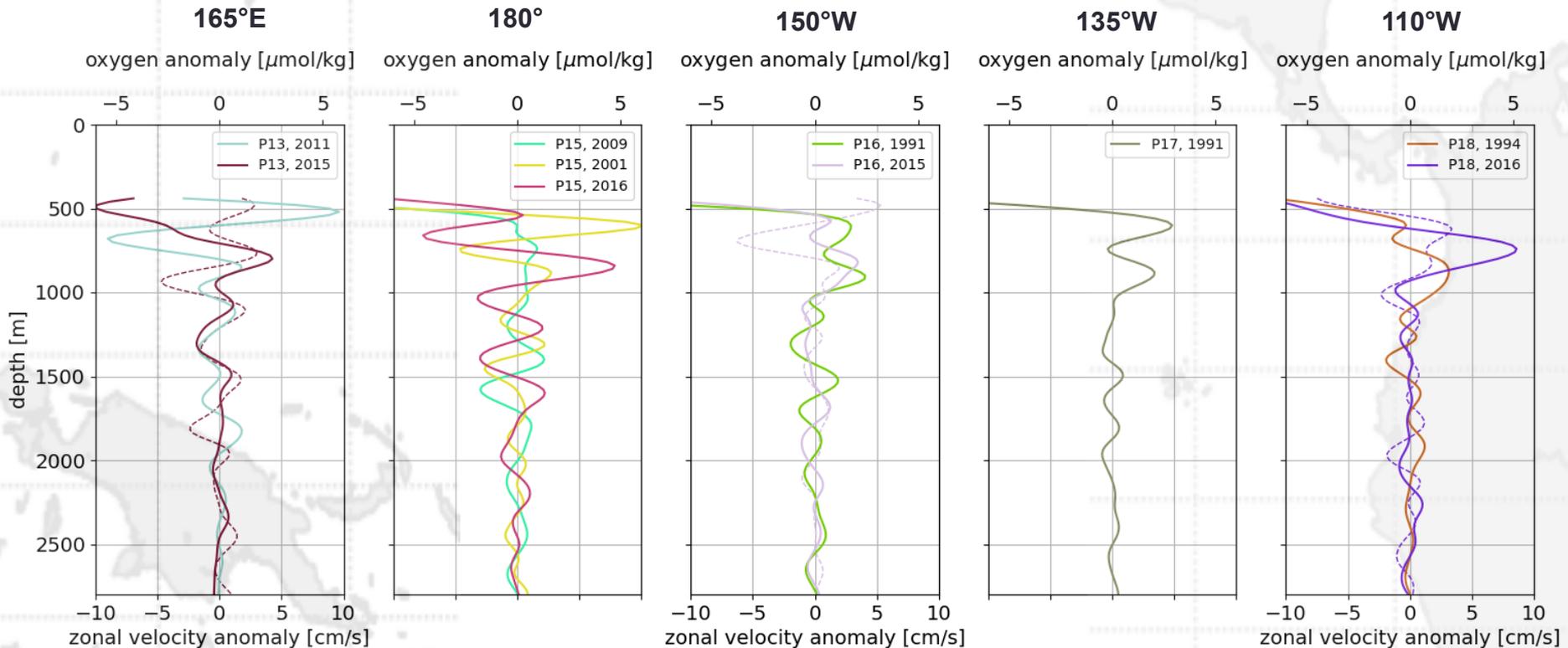


- NSCC
- SSCC
- Sec. SSCC (Rowe et al., 2000)
- S-ADCP zonal velocity
- Salinity

Front of salinity in Northern Tsuchiya jet



Zonal coherence in EDJs system



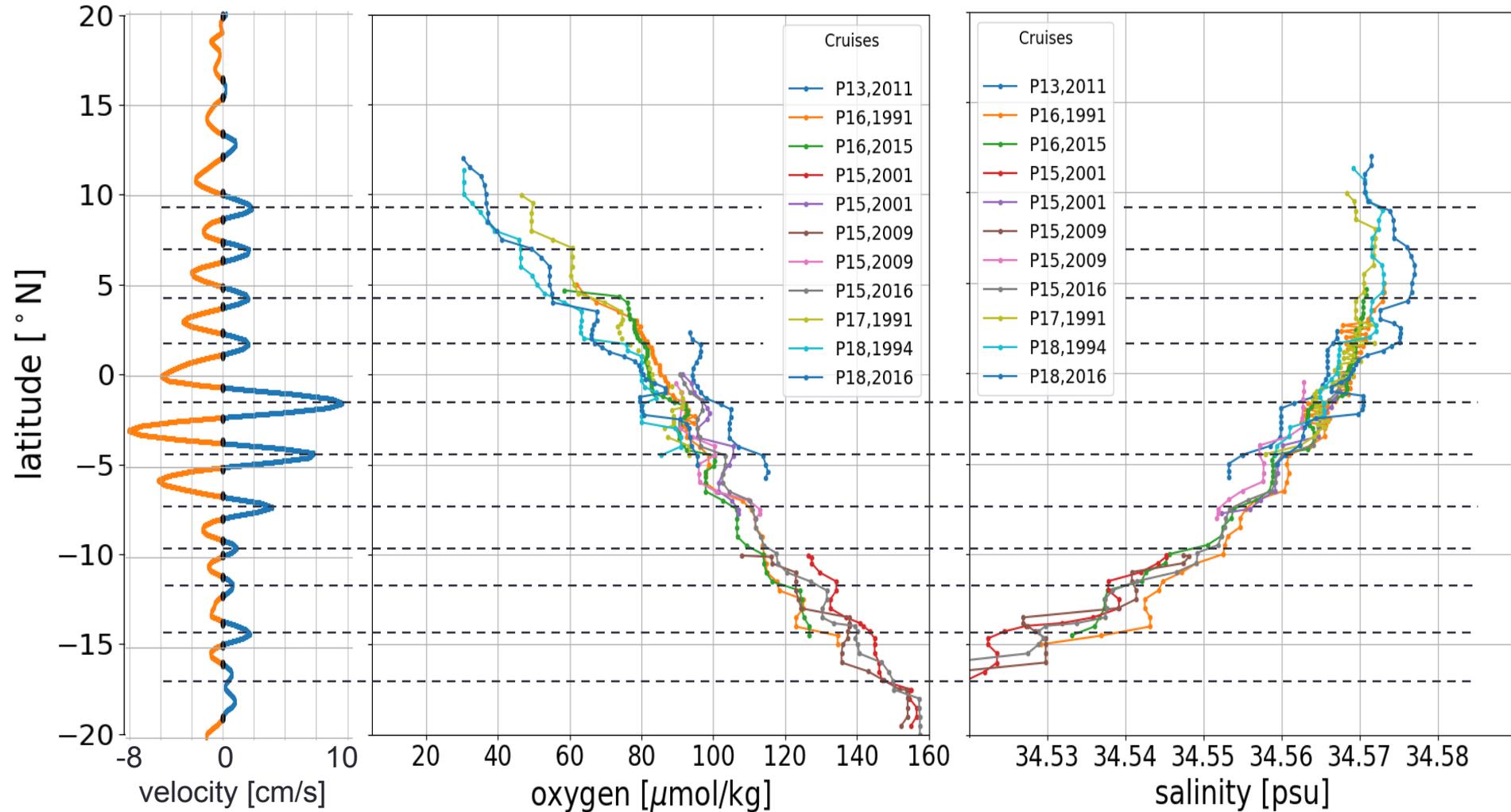
----- L-ADCP zonal
velocity
—— Oxygen

**Transport of oxygen anomalies
by EDJs > 1000m in the
western part**



Zonal coherence in LLICs system

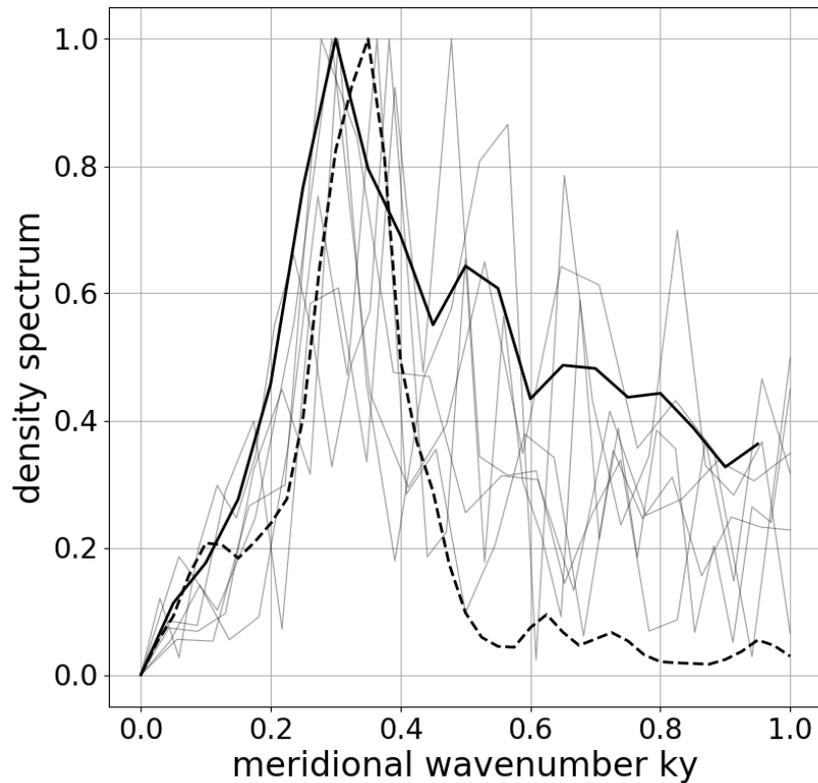
1027.4 – 1027.6 kg/m³



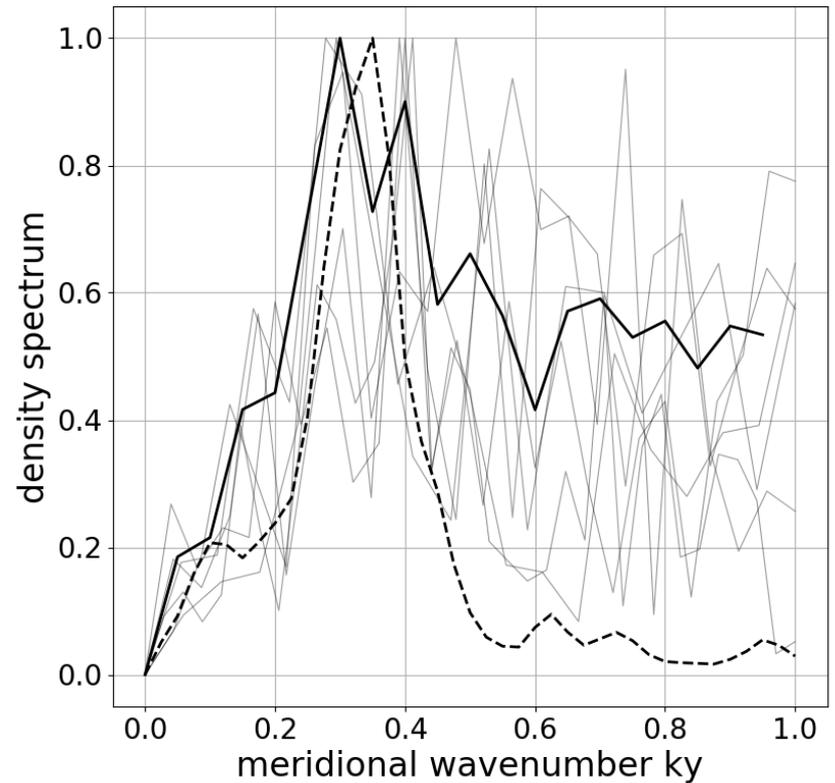


Meridional scale coherence in LLICs system

Oxygen – Velocity spectrum



Salinity – Velocity spectrum



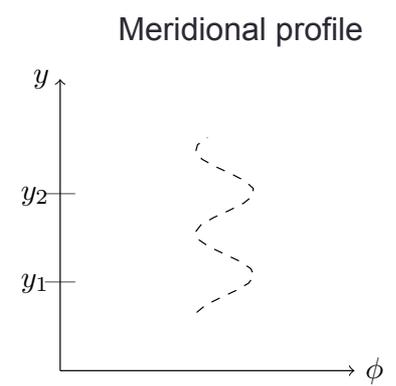
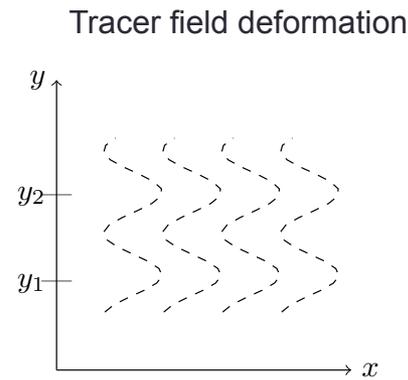
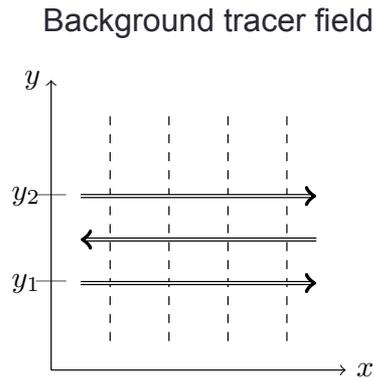
----- Zonal velocity

— Oxygen / Salinity

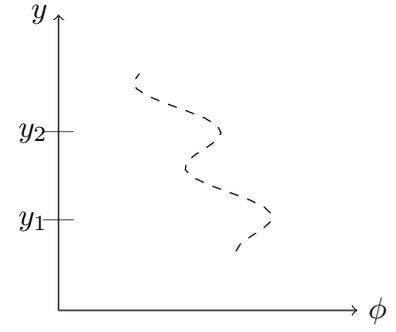
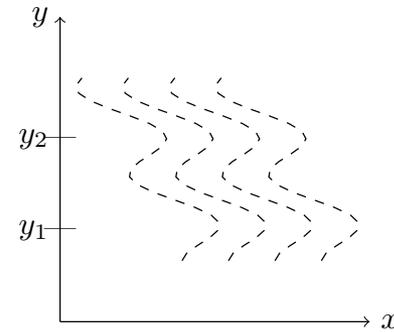
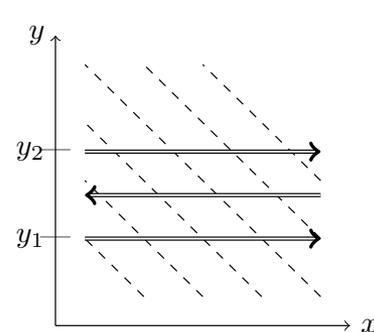


Physical Processes – Background tracer field deformation

(a)
Zonal advection
in zonal gradient



(b)
Zonal advection in
slanting gradient

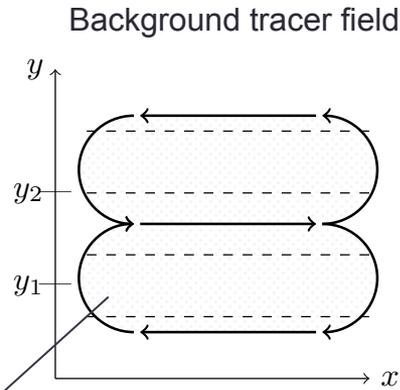


Zonal advection creates tracer fields anomaly

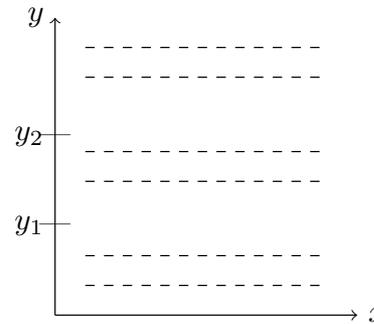


Physical Processes – Background tracer field deformation

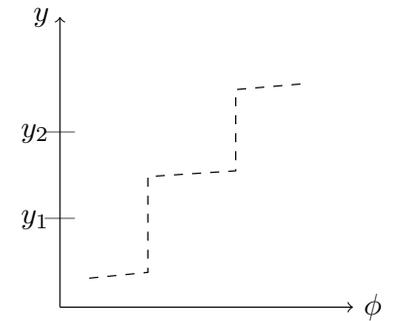
(c)
Recirculation
gyres



Tracer field deformation

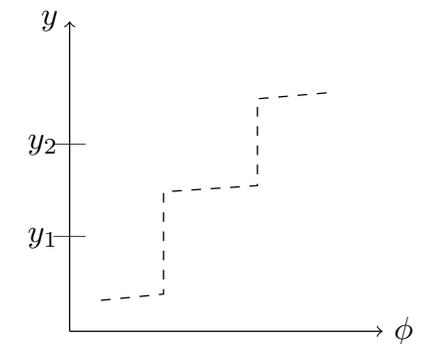
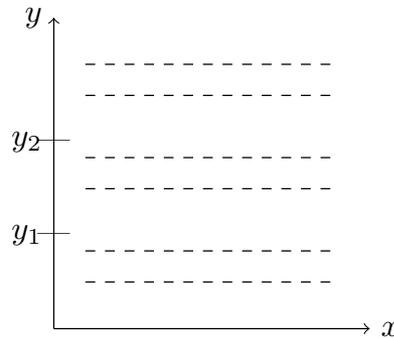
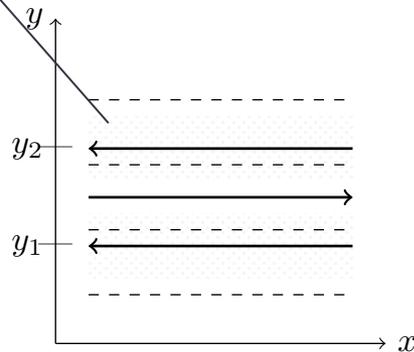


Meridional profile



mixing regions

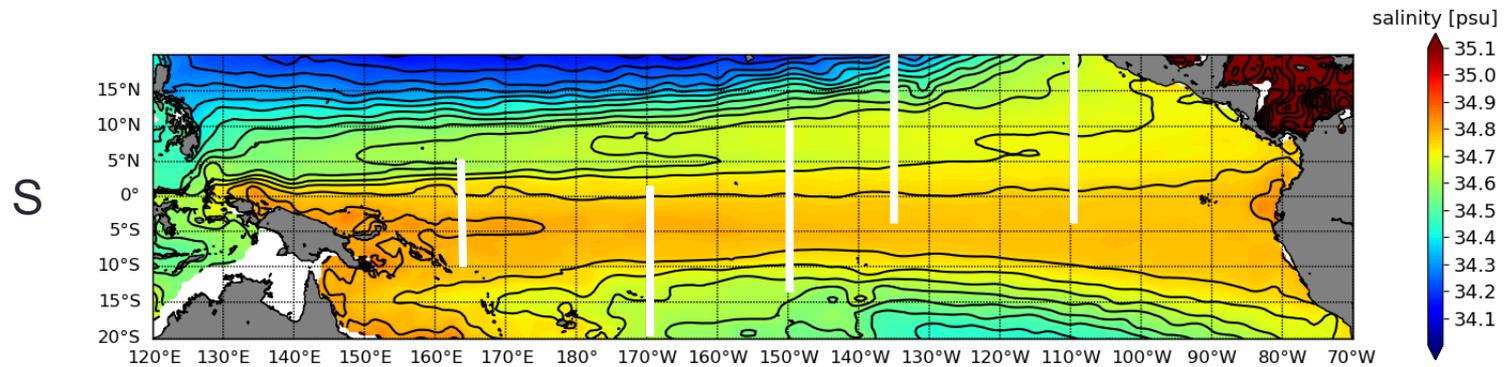
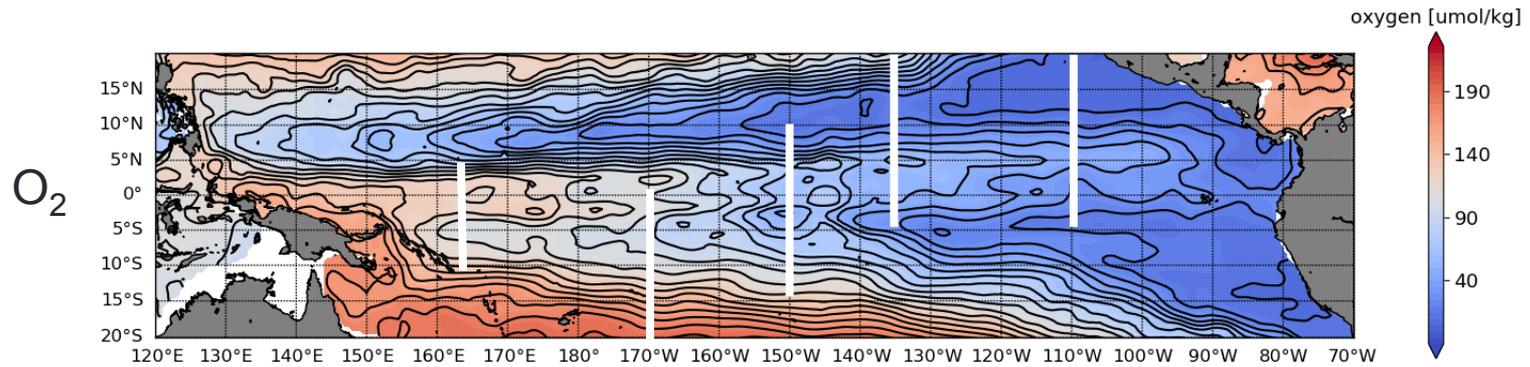
(d)
Inhomogeneous
mixing



Staircase profiles likely driven by inhomogeneous mixing

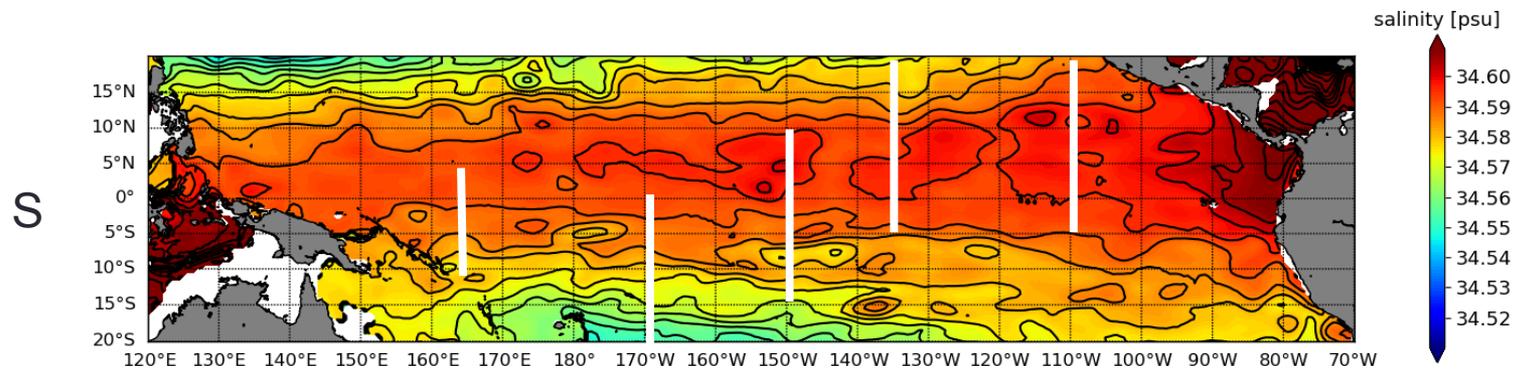
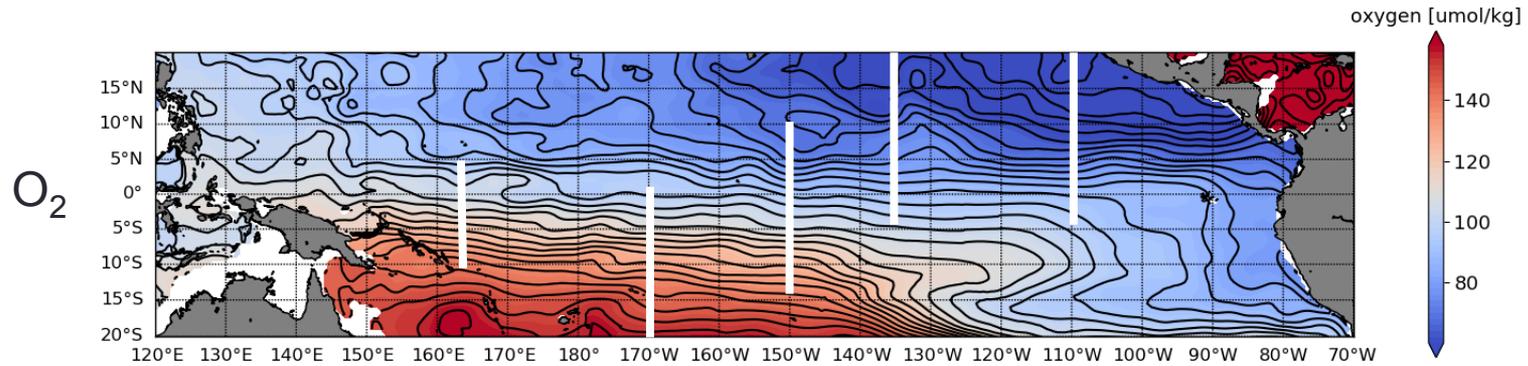


Background gradient – Isopycnal layer : 1026.4-1026.6 kg/m³ (LLSC system)





Background gradient – Isopycnal layer : 1027.4-1027.6 kg/m³ (LLIC system)

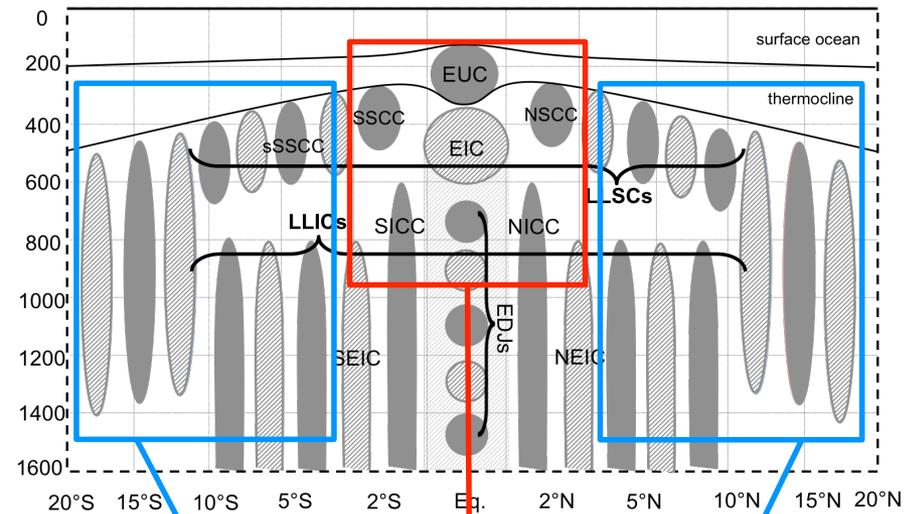




Conclusions

- Tracer field analysis shows two different patterns associated with zonal jets :
 - Maxima / Minima
 - Frontal / Uniform regions
- Water mass displacement and transport of properties restricted to the near-equatorial band and upper 1000 m.
- Important for ventilation of the eastern Pacific Oxygen Minimum Zone (OMZ)
- New features revealed by high-resolution in-situ data : frontal structures in the core of eastward jets and homogeneous regions in the core of westward jets.
- Analytical model of tracer deformation suggest mixing mechanisms
- **A new challenge for theoreticians to explain zonal jets formation ?**

Schematic view of tropical jets properties



Direct ventilation to OMZ

Localized mixing regions



Thank you !

Related papers :

A. Delpech, S. Cravatte, F. Marin, Y. Morel., E.Gronch, E. Kestenare. *Observed tracer fields structuration by mid-depth zonal jets in the tropical Pacific ocean.* (2019) In revision for Journal of Physical Oceanography.

C. Menesguen, A. Delpech, F. Marin, S. Cravatte, R. Schopp, Y. Morel. *Observations and mechanisms for the formation of deep equatorial and tropical circulation* (2019) Earth and Space Science

More information ?

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