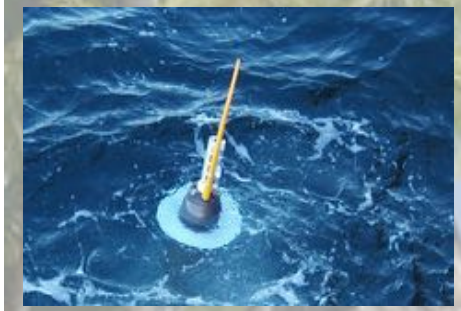
Sub-thermocline and Intermediate Zonal Currents in the Tropical Pacific Ocean: Vertical structure and paths



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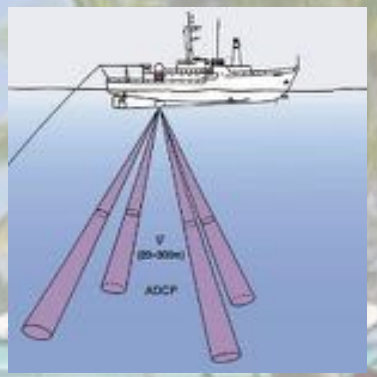
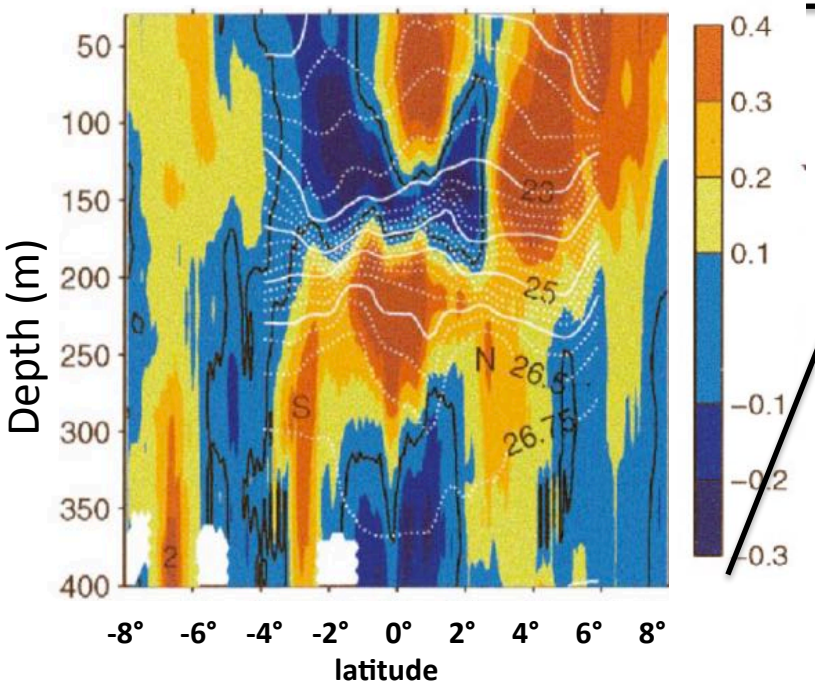


Cravatte et al., *in revision for JPO*

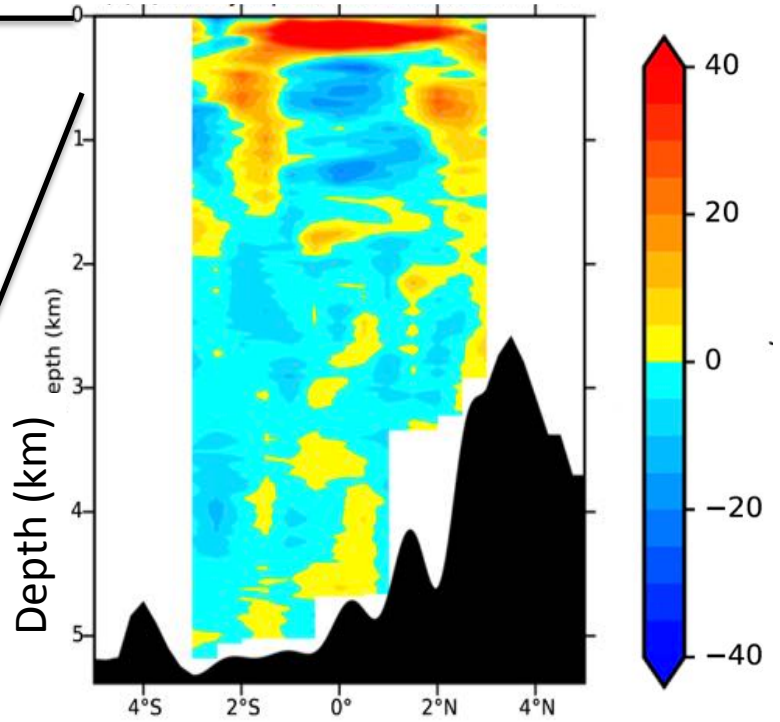
Subthermocline currents in the Equatorial Pacific

U (m/s) at 165°E, nov 1989



Rowe et al. 2000

U (cm/s) at 159°W, may 1982



(Firing 1987; 1998) and others (Gouriou et al. 2006)

• Some years ago… the intermediate circulation (below 400/500m) was only known through few synoptic cruises sections.

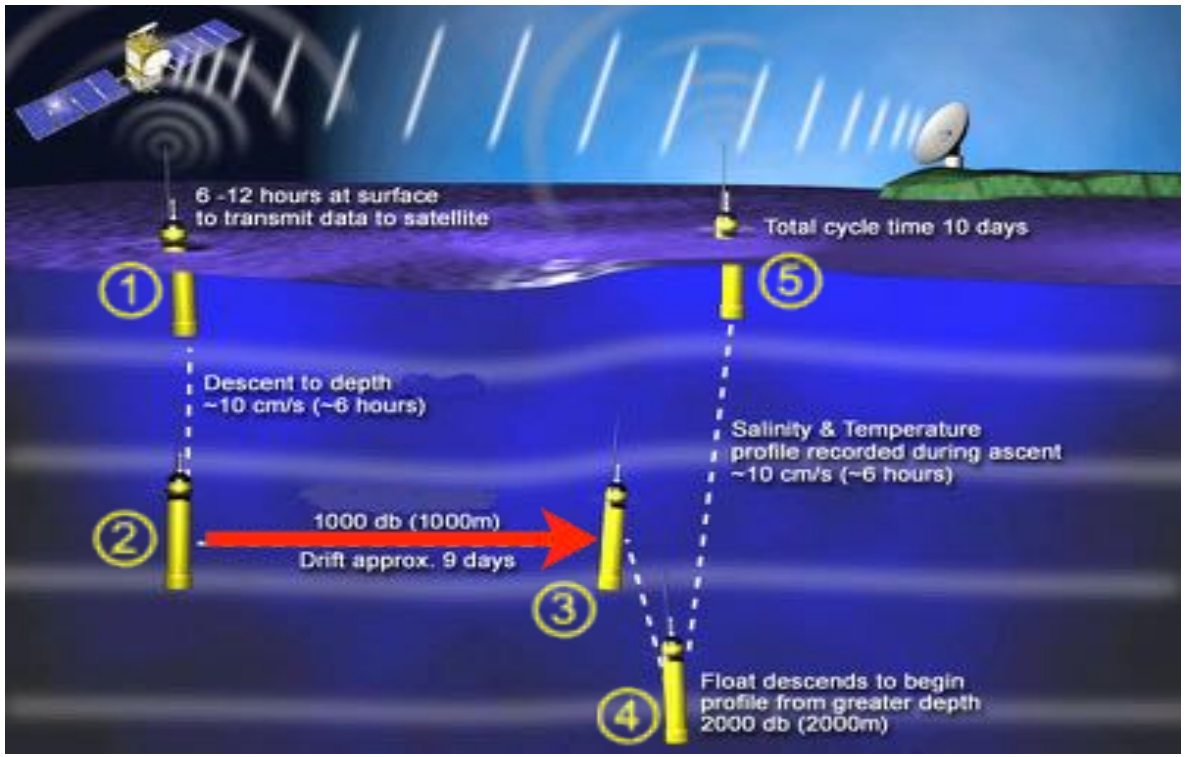
• Questions from Firing, 1998: Meridional extension? Mean and variability?
Zonal coherence? Transport?

20 years later, revisiting the subthermocline circulation with new tools

Circulation at 1000m from Argo floats

-**The motion of Argo floats shows the absolute 1000m circulation**

(Lebedev et al., 2007; Ascani et al. 2010; Davis et al. 2005; Cravatte et al. 2012, Ollitrault et al. 20013, 2014, Colin de Verdiere et al., 2016, others…)

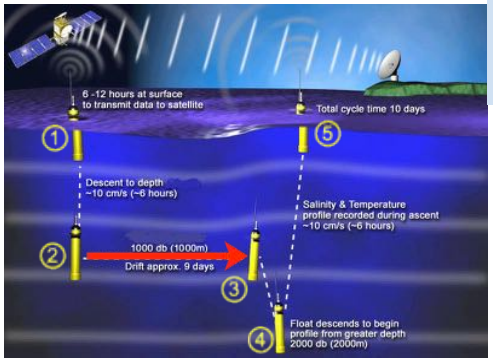


We selected all Argo floats between 15°S-15°N, from 1/2003 to 12/2013

We computed subsurface velocities from float motion

=> Gridded mean seasonal product of velocity at 1000m

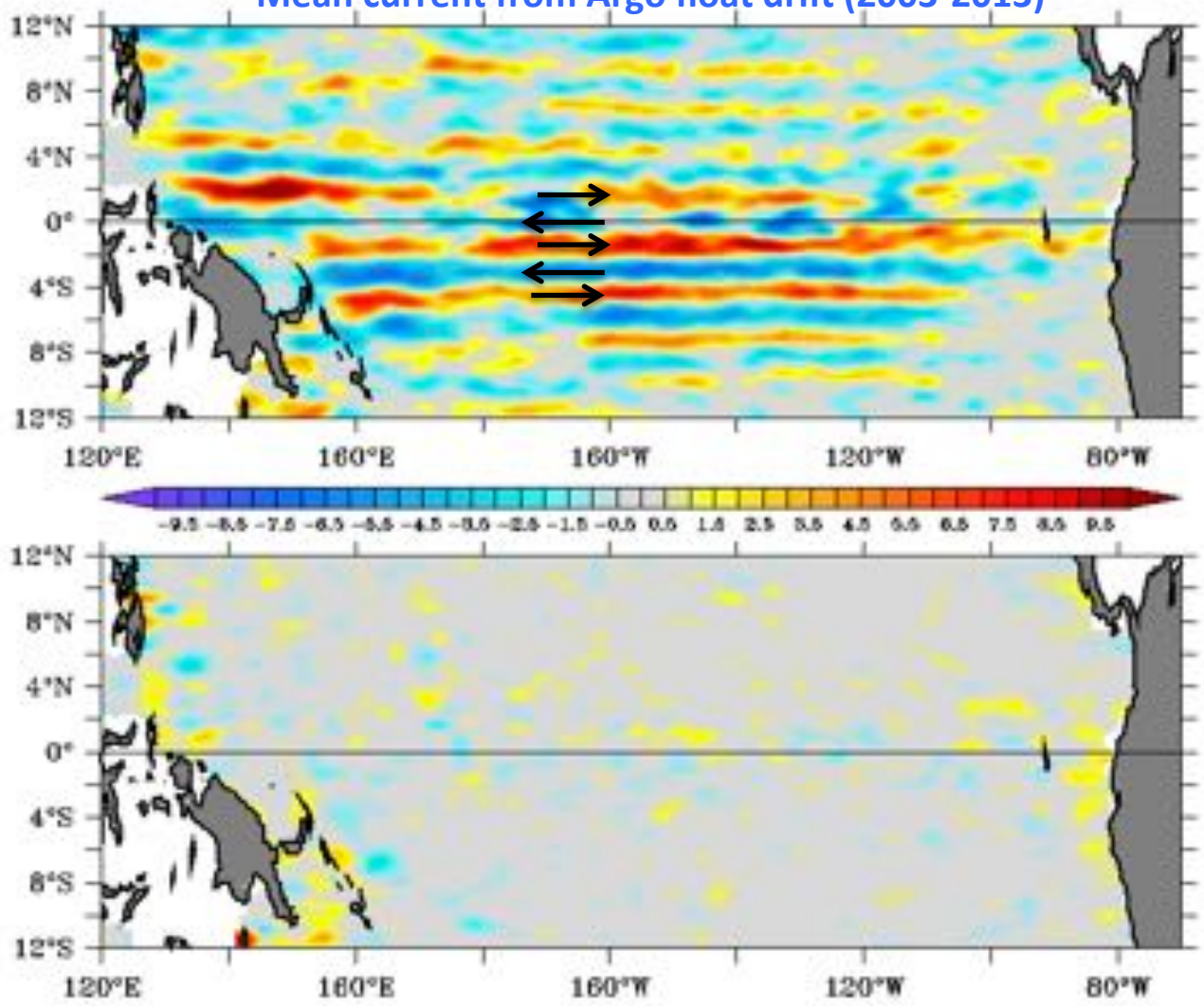
Circulation at 1000m from Argo floats



Mean current from Argo float drift (2003-2013)

U
1000 m
(cm/s)

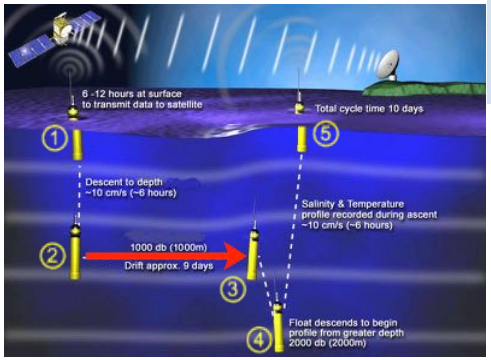
V
1000 m
(cm/s)



- **Coherent alternating zonal jets ~10 cm/s**

Updated from
Cravatte et al. 2012

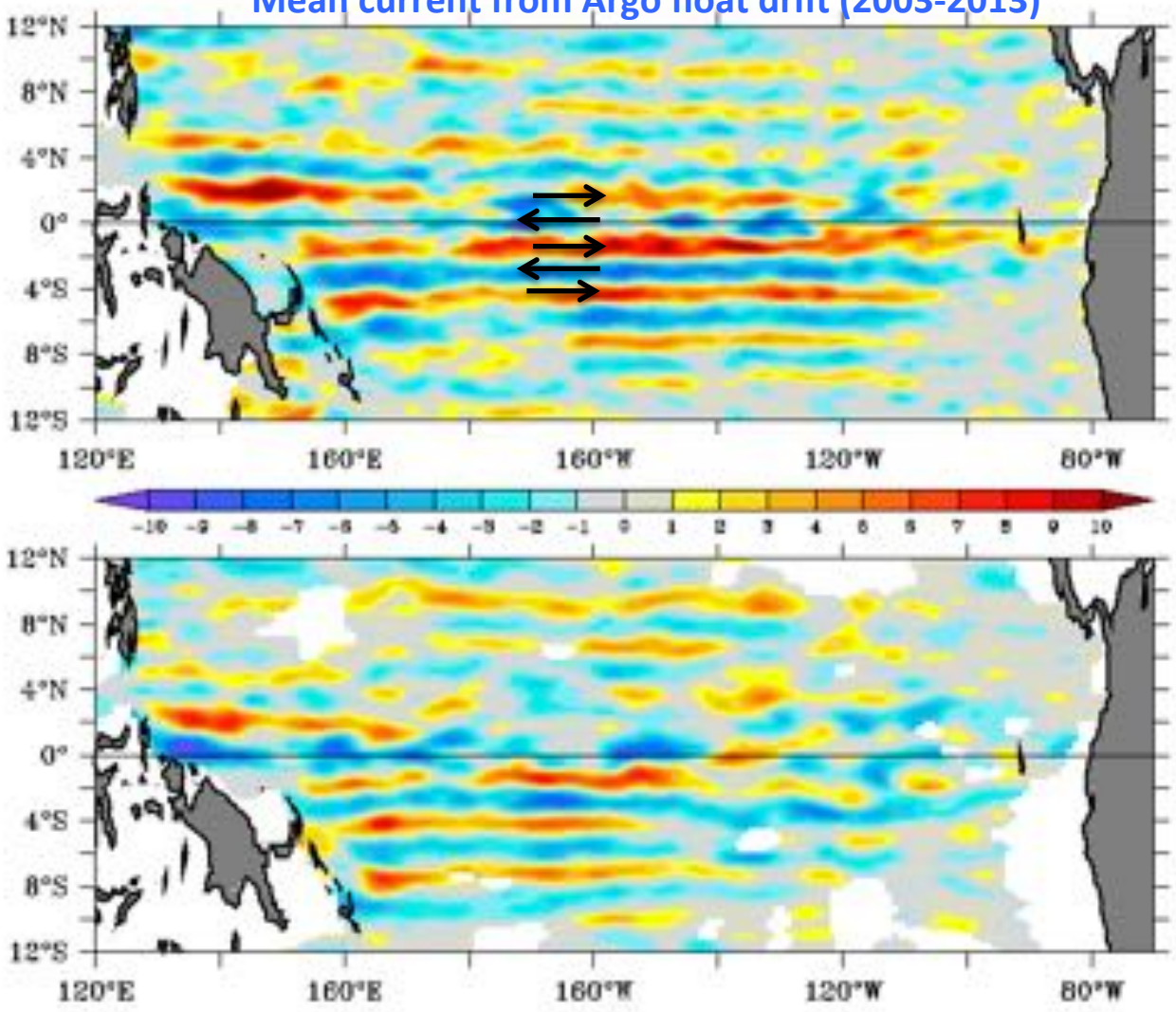
Circulation at 1000m from Argo floats



Mean current from Argo float drift (2003-2013)

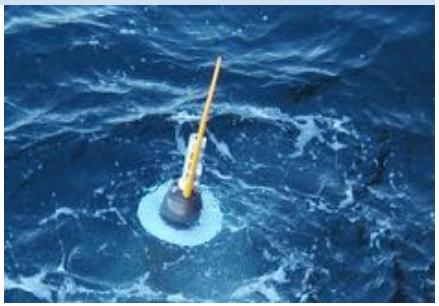
U
1000 m
(cm/s)

U
1500 m
(cm/s)



Vertical consistency between 1000 and 1500m: what is the vertical extent of these jets?

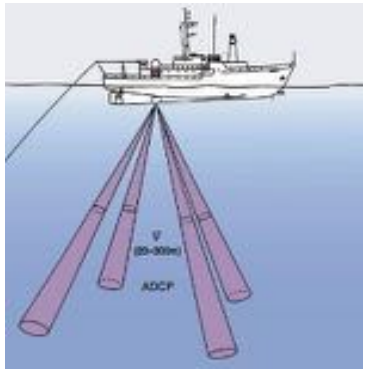
Tools



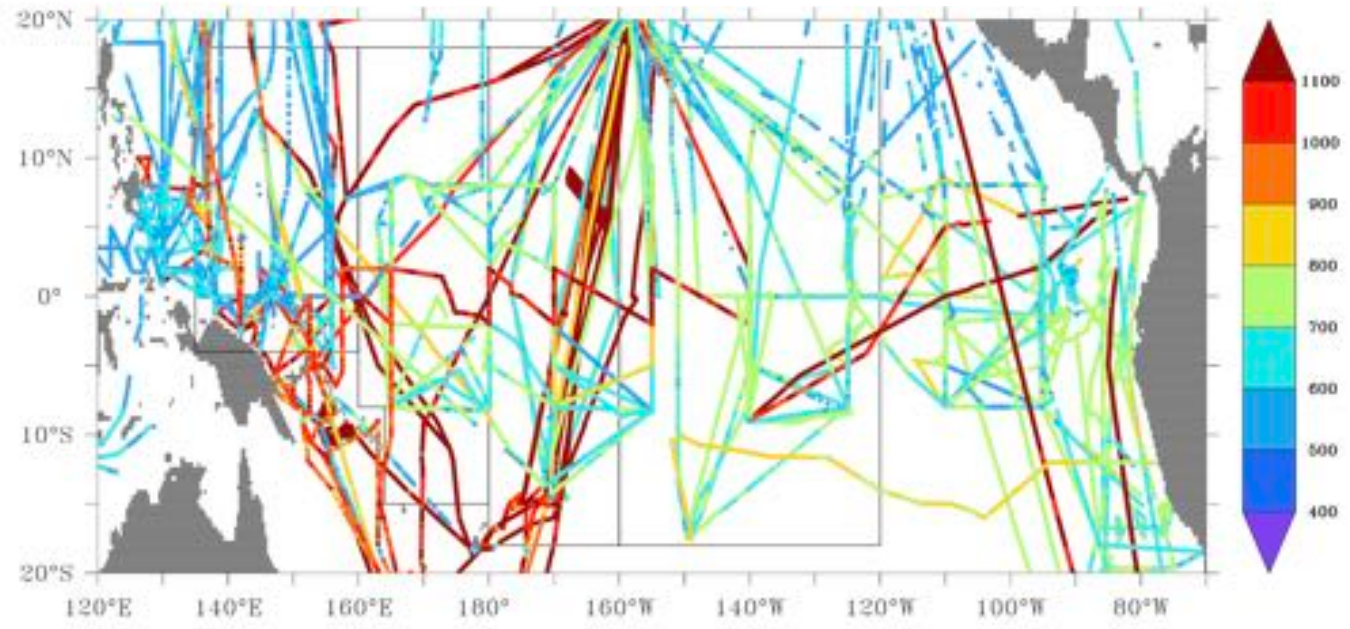
1-**Argo T and S gridded climatology** (1/6°x1/6°)
from Roemmich and Gilson (Scripps)
geostrophic currents relative to 1000m, + current at 1000m (argo drift)

→ **absolute geostrophic currents above 2000m: Argo-velocity**

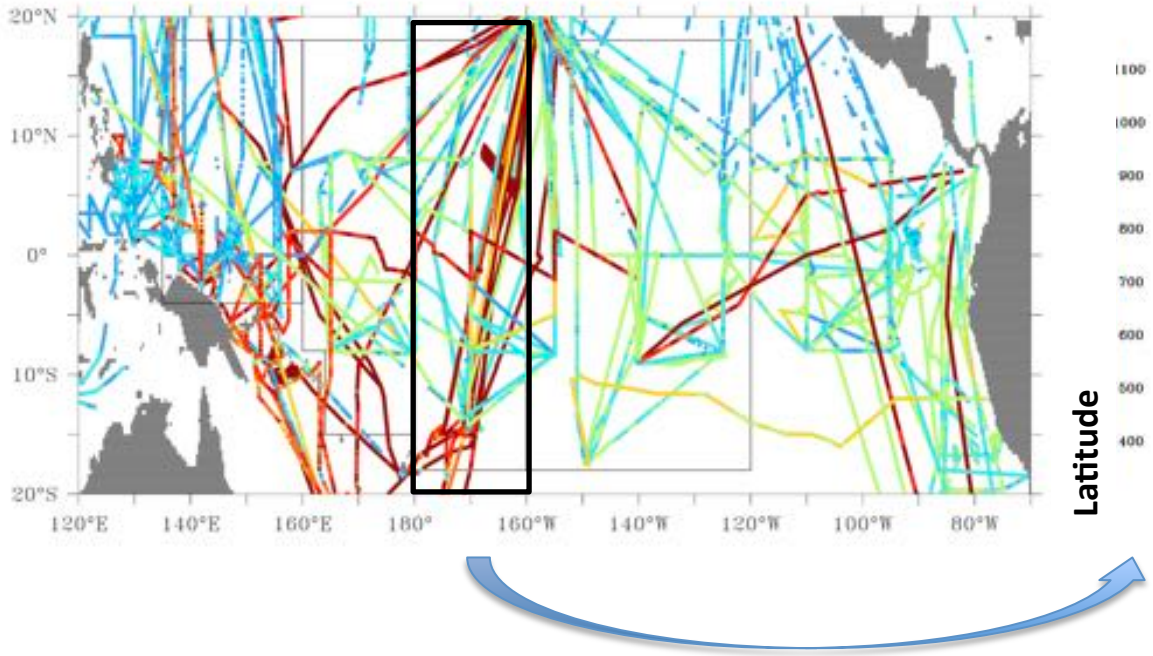
2-**Shipboard ADCP data** (1999-2015):
os75kHz (700/800m) et os38kHz (1300m)



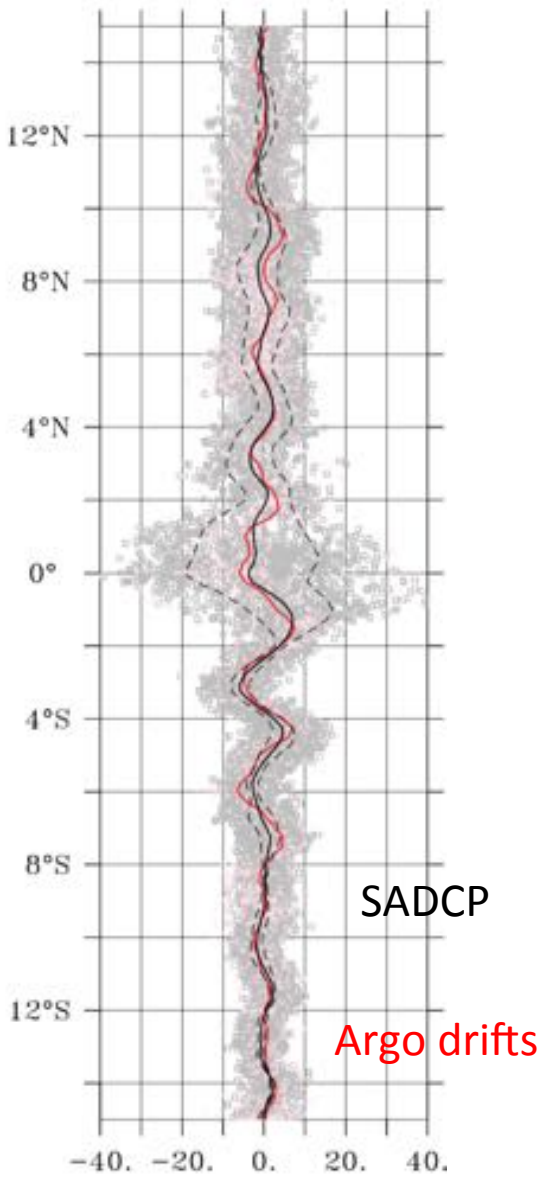
Depth extent of the SADCP data (m): 190 cruises



Tools

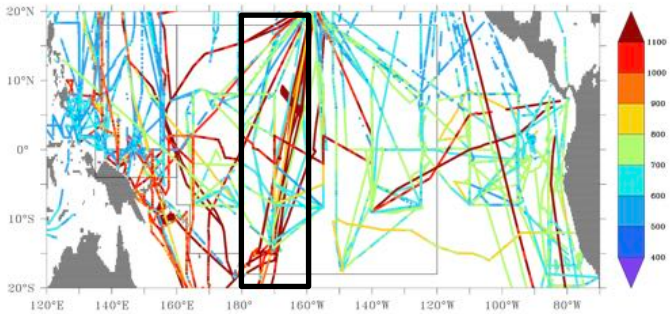


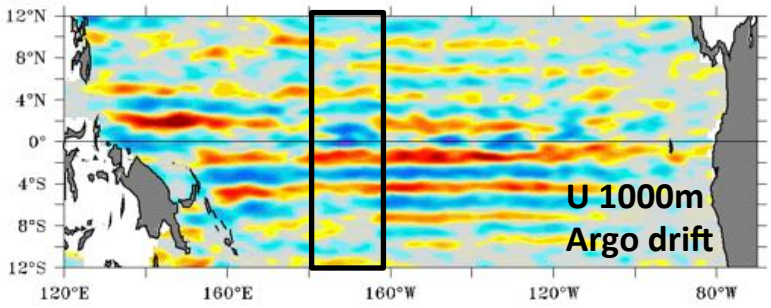
U at 1000 m (cm/s)



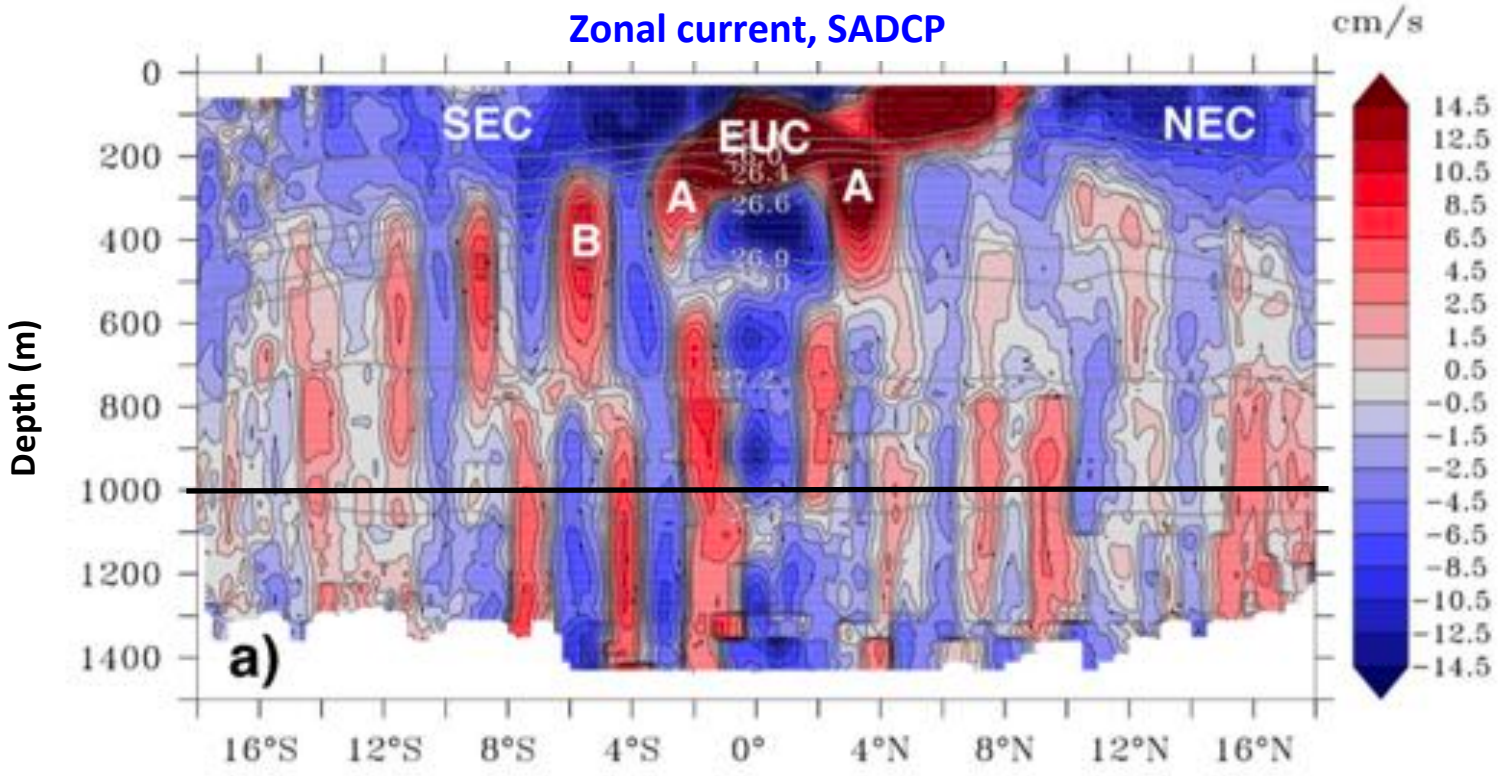
- **Excellent agreement between SADCP and Argo floats drift at 1000m**
- **Zonal currents highly variable: need a temporal average**

Vertical structure of the zonal jets: 180-160°W





Zonal current, SADCP

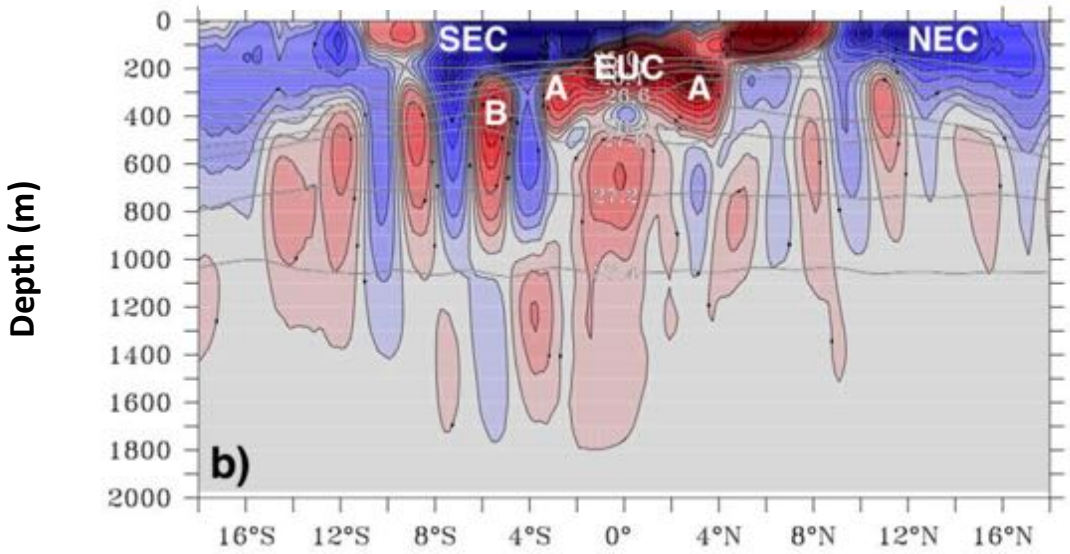


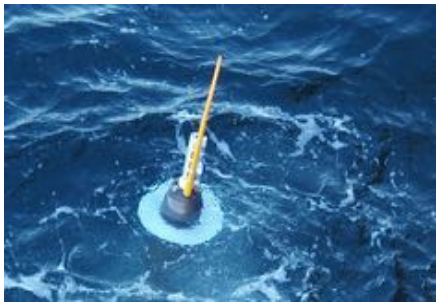
2 distinct meridional structures of zonal jets:

- **multiple subsurface alternating currents between the thermocline and 700-800m: LLSC**
- **intermediate extra equatorial currents below 800m: LLICs**

Vertical structure of the zonal jets: 180-160°W

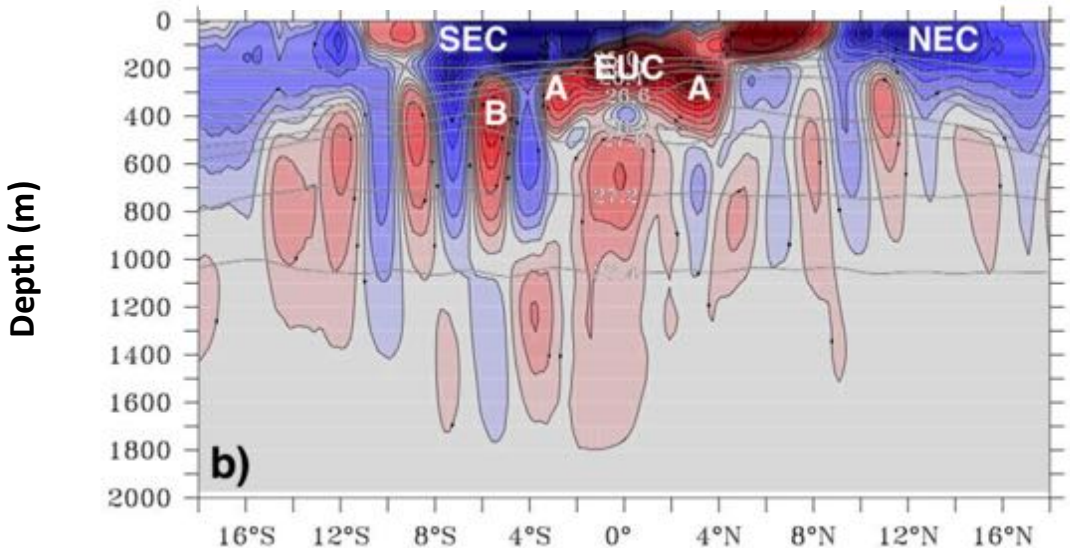
U, Argo , reference no motion 2000m

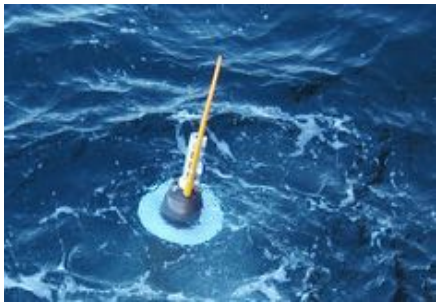




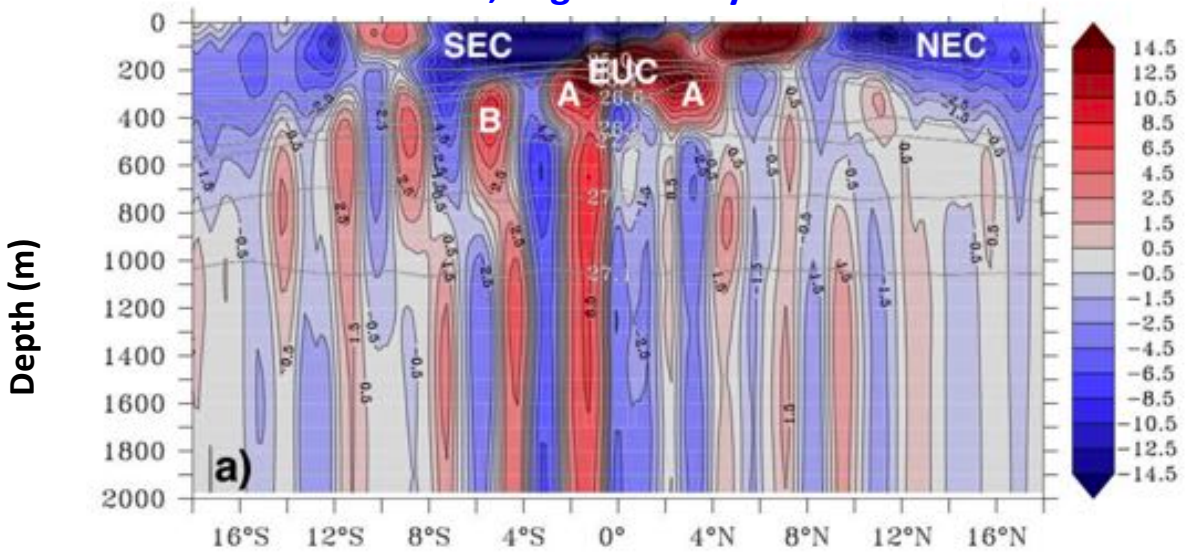
Vertical structure of the zonal jets: 180-160°W

U, Argo , reference no motion 2000m





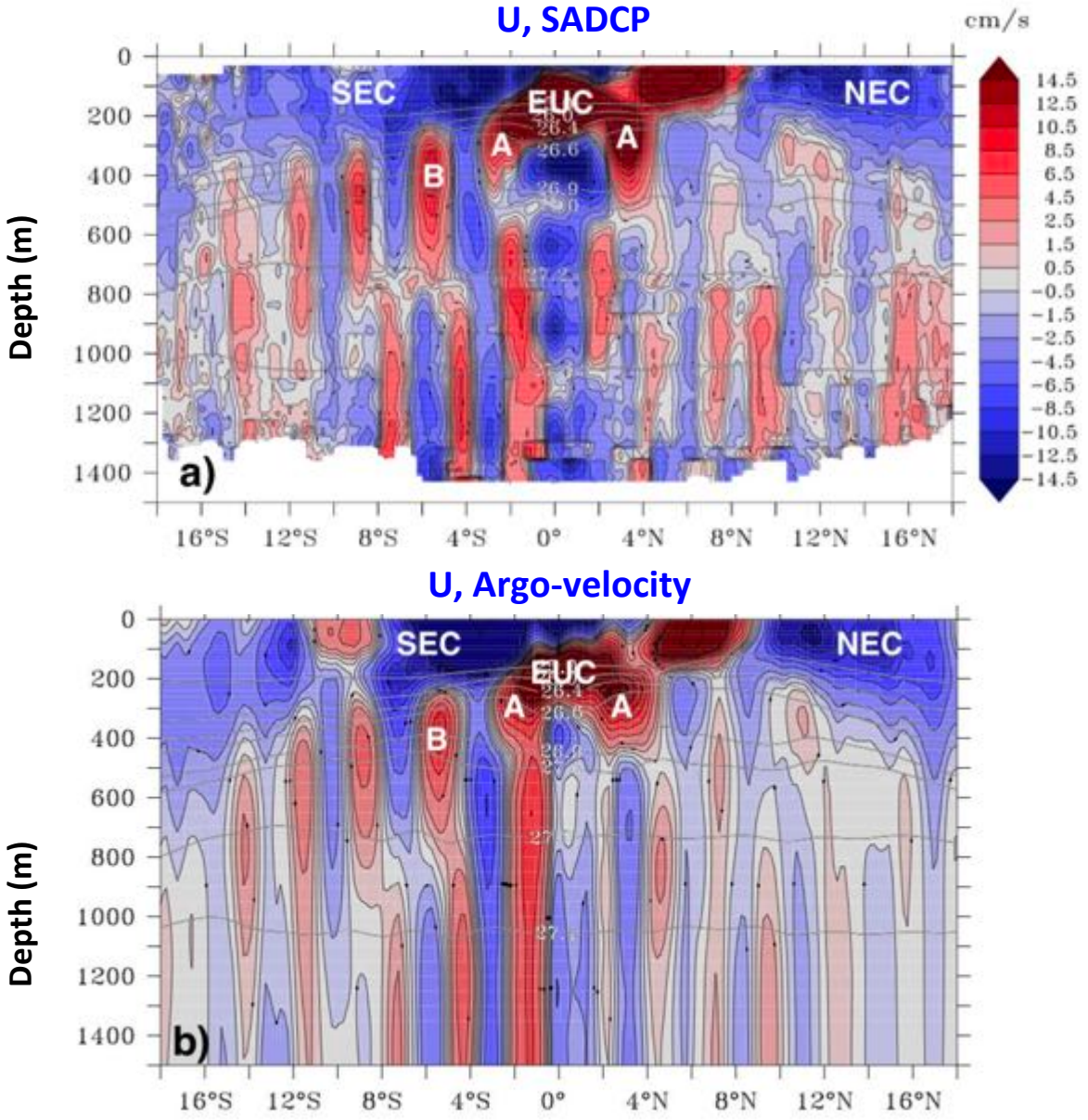
U, Argo-velocity



Argo drift reference at 1000m is crucial to capture the velocity structures.

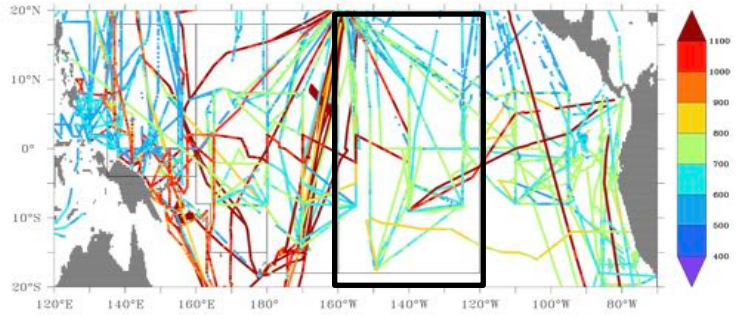
Vertical structure of the zonal jets: 180-160°W

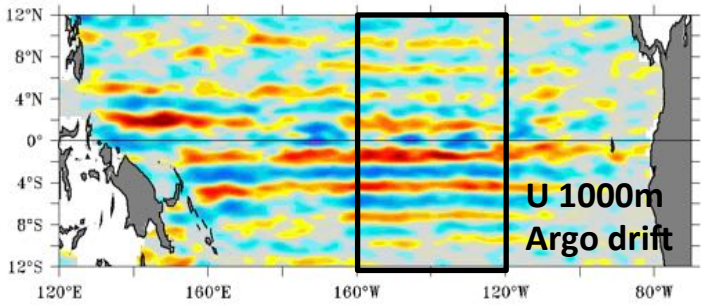
Totally Independent velocity estimations



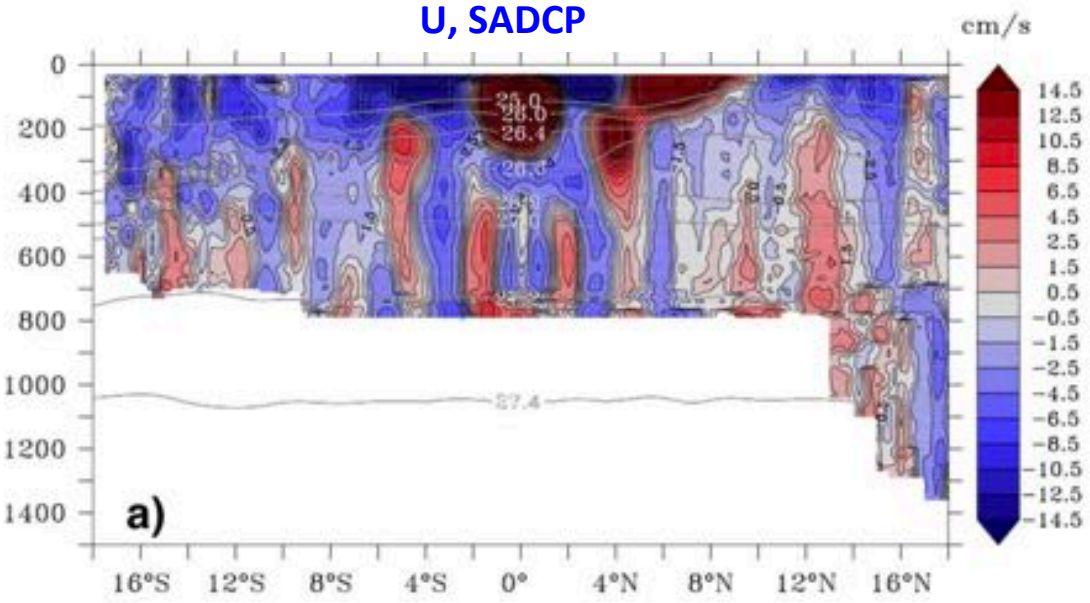
Good confidence in the system of zonal jets seen; get deeper and denser poleward

Vertical structure of the zonal jets: 160-120°W

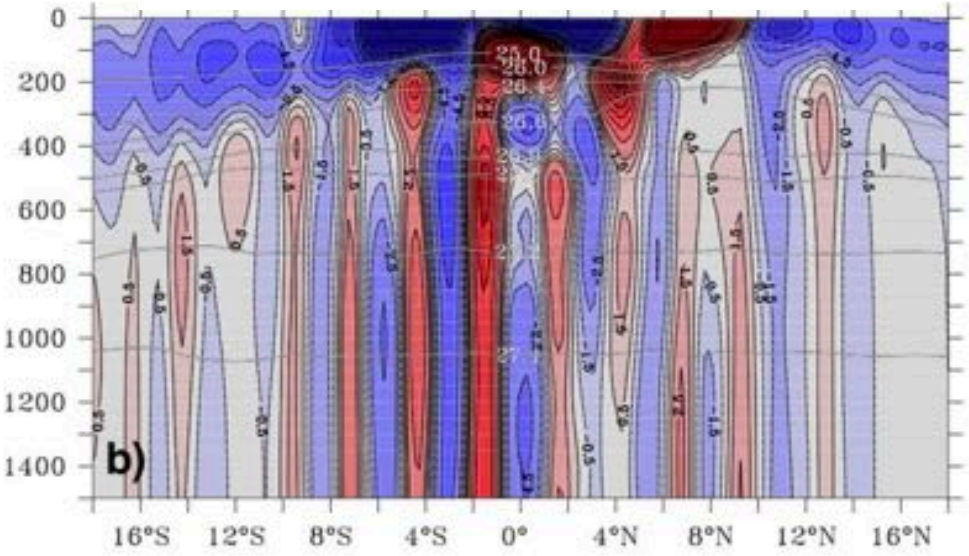




U, SADCP

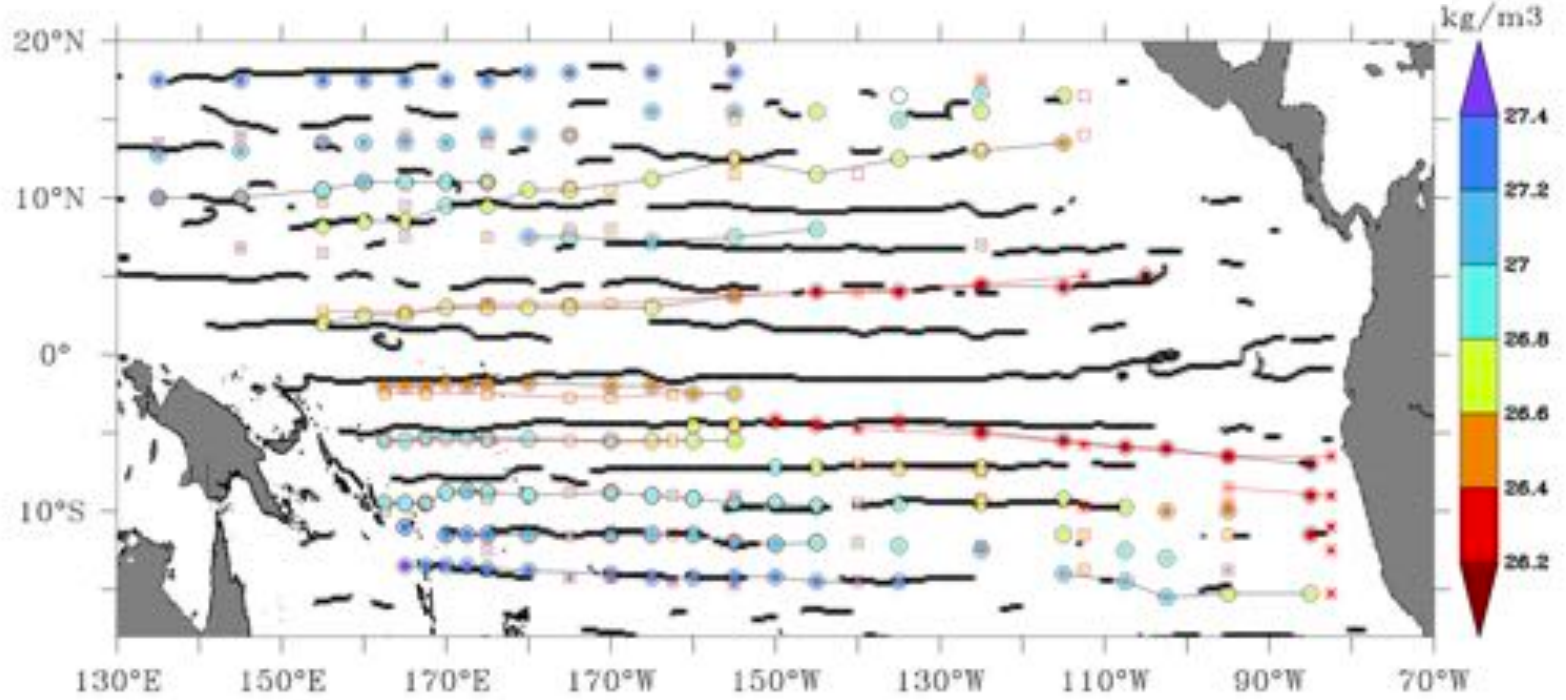


Argo-velocity



Paths of the zonal currents

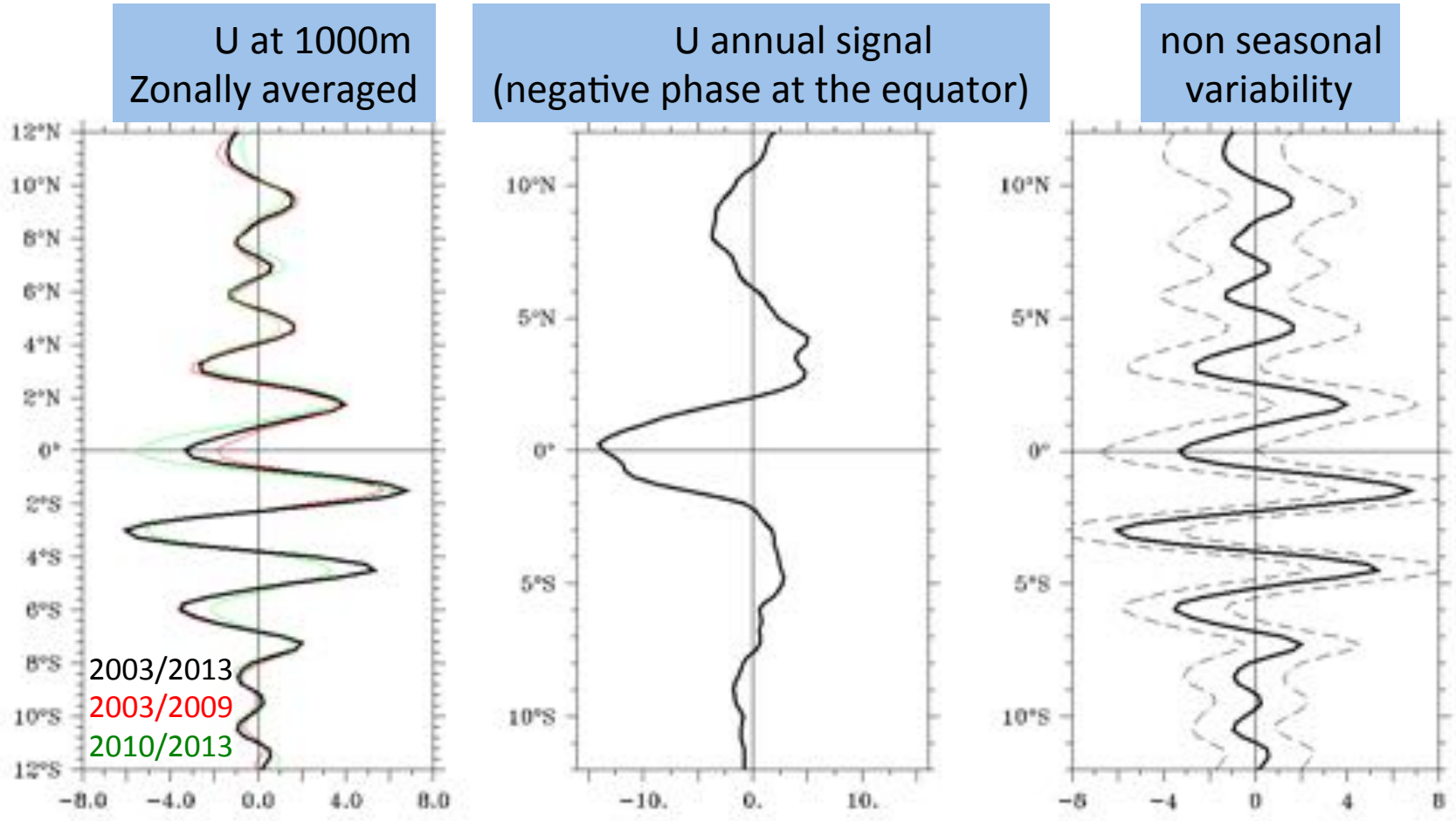
Density of the core of the eastward subthermocline jets (from Argo)



Intermediate LLICs (800-1500m) **Subthermocline LLSCs (250-700m)**

LLSCs diverge poleward from west to east, get denser poleward, lighter eastward.
LLICs: stay constant in latitude

Are these alternating jets persistent?



The 1000m jets are stable in position from year to year (with sufficient sampling)
Annual cycle of u is the well-known vertically-propagating Rossby wave
Some intraseasonal/interannual variability

CONCLUSIONS

• Argo floats trajectories (at 1000m and 1500m) combined with Argo T/S climatologies are useful sources of mid-depth circulation

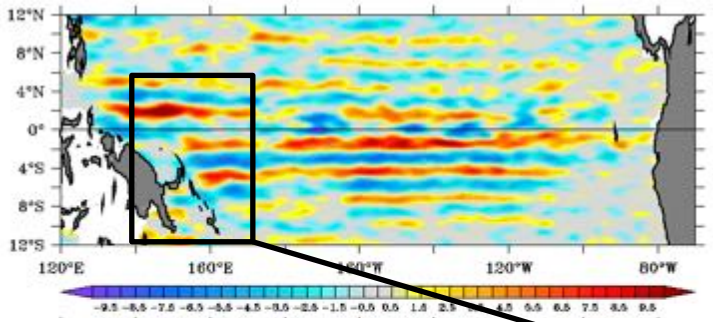
• 2 distincts meridional structure of the zonal currents:
  - LLSC between the thermocline and 700-800m,
    Stronger in the southern hemisphere
  - LLICs below 800m
  - Not the same meridional scale
  - 2 distincts dynamical « objects »

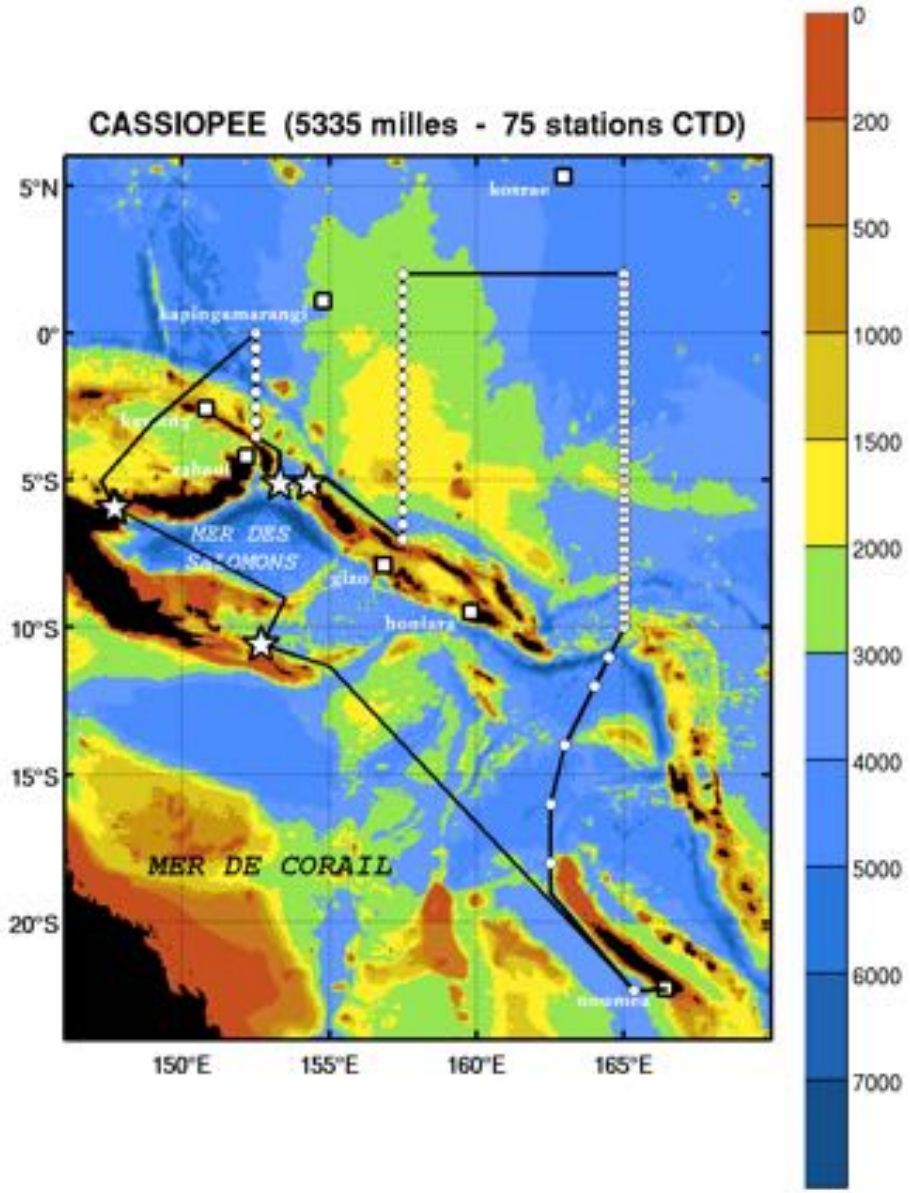
• Equatorial or off-equatorial dynamics phenomenon? No theory yet able to explain all their characteristics (e.g. Ascani, 2010; 2015; Hua et a., 2008; Qiu, 2014, 2015; …)

• Variability at interannual and intraseasonal timescales? In progress

• Not correctly simulated in ocean general circulation models
A problem for redistribution of mass and water properties?

Perspectives - A dedicated cruise: CASSIOPEE (2015)





- **Measurements at high-resolution:**
  - **Surface to bottom currents**
  - **hydrological properties**
  - **bio-geochemical properties**