Zonal jets in the eastern North Pacific in an ensemble of eddy-resolving OGCM runs

(Furue R et al. 2021. *Ocean Modell.* 159: 101761)

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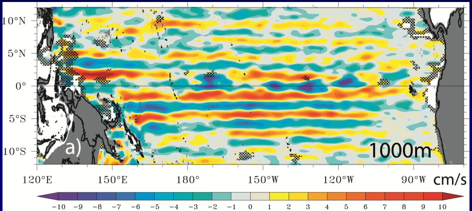
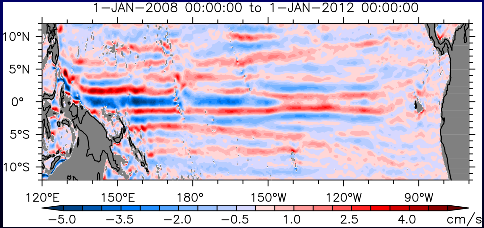
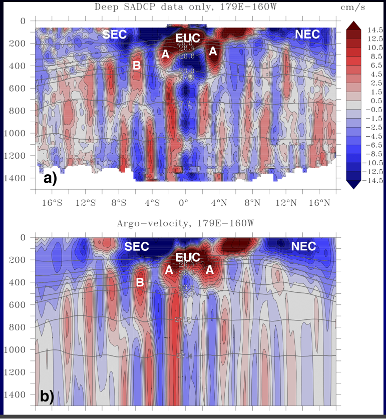
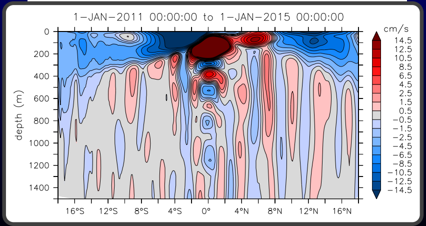
Zonal jets

Cravatte et al's (2012) ADCP & geostrophic velocities.









Deterministic or probabilistic?

Theories & hypotheses:

- Free geostrophic turbulence + β-effect
  $\Rightarrow$ series of jets ("Rhines effect").
- Eddies or some forcing along eastern boundaries
  —Sverdrup-type (re)circulation (Davis et al 2014)
- Instability of annual Rossby waves (Qiu et al 2013).
- Secondary instability (Berloff et al)

Question:

- Are their positions etc. determined by external forcing?

Data & methods

OFES2:

- 1/10°, semi-global (76°S–76°N), 105 levels.
- Surface forcings derived from JRA55-do (Tsujino et al. 2018).
- 1958 to 2016.

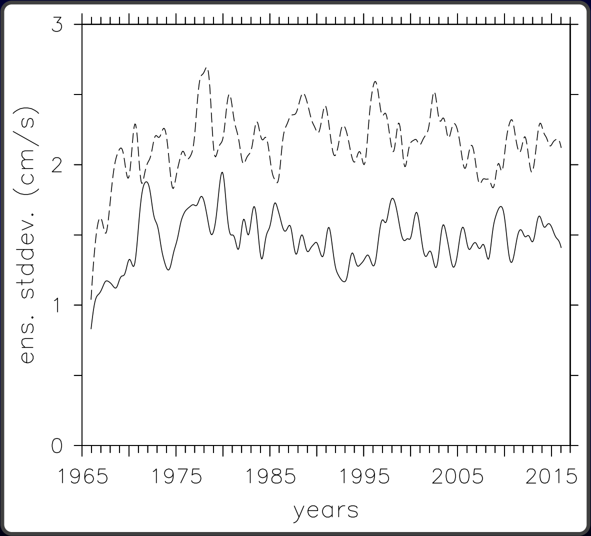
Ensemble:

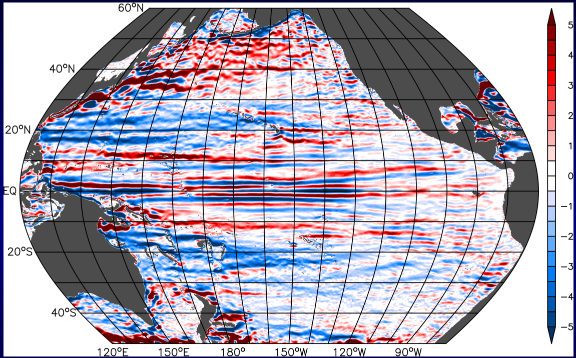
- A 10-member ensemble over 1965–2016, with only slight differences in the initial condition. Use monthly means.

Averages:

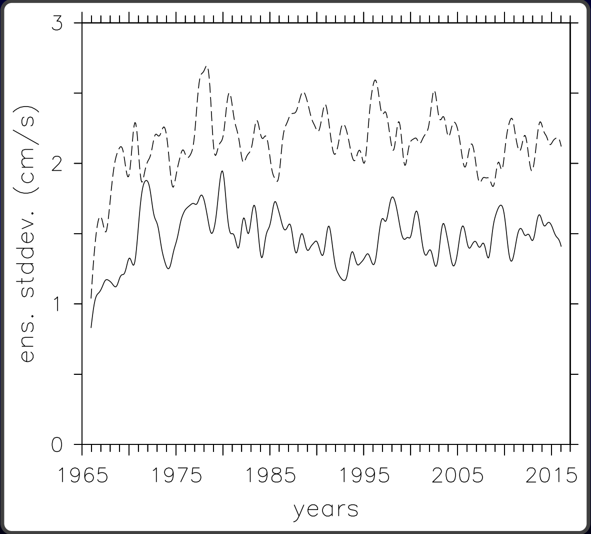
- 2-year moving avr. with Hann window, $\overline{u}$, to average out eddies.
- Ensemble average, $\langle u \rangle$.

Ensemble spread





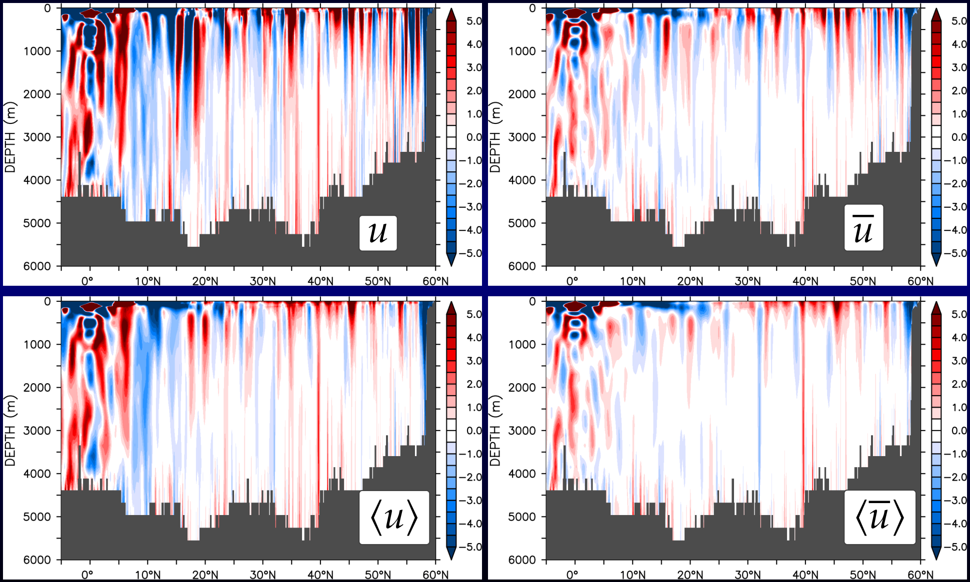
Ensemble spread



- Ensemble spread stabilizes in 5–10 years.

$\Leftarrow$ The ensemble variance of $\overline{u}$ is first averaged over 10°–30°N along 140°W and its square root is calculated (solid), and the same calculation is carried out over 45°–60°N (dashed curve). The curves miss the first and last years because $\overline{u}$ is not defined there.

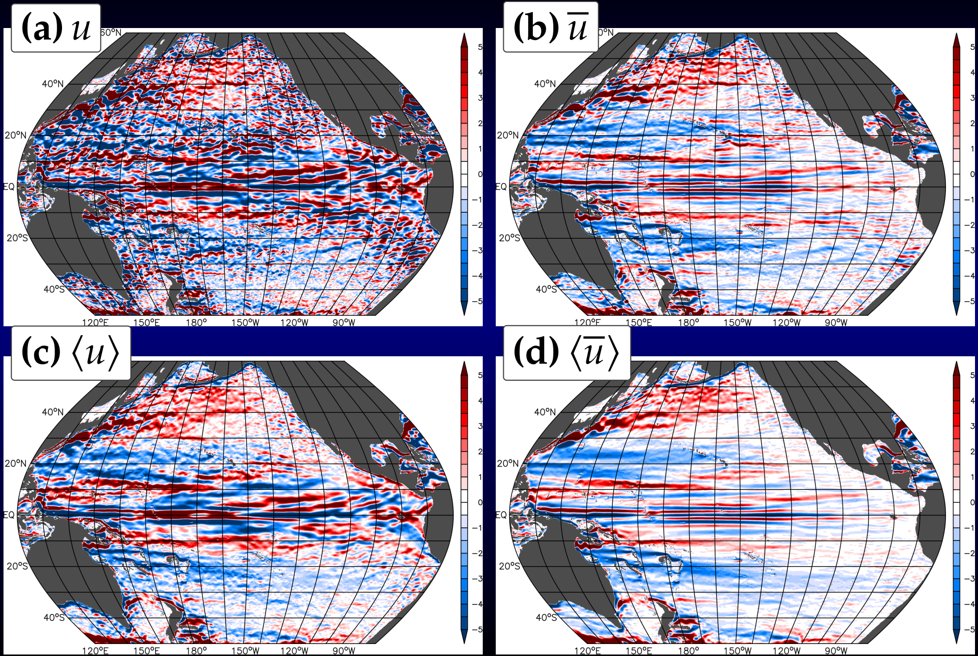
Meridional sections



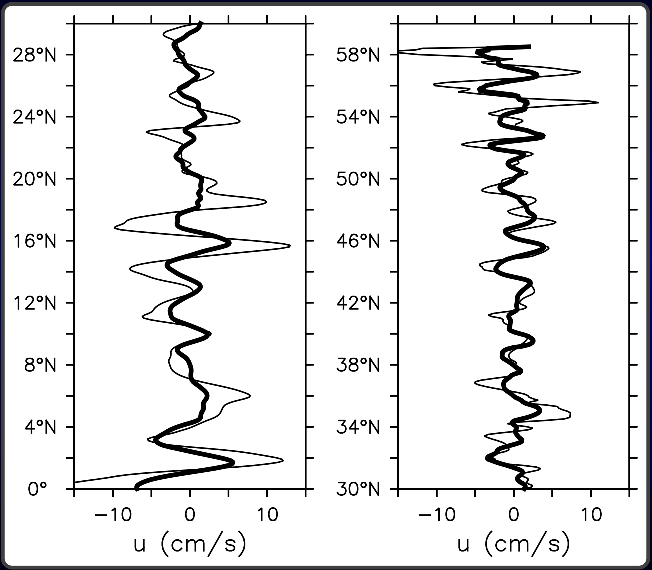
Zonal velocity at 140°W at January 2010 (36th year): (a) monthly mean, u, from M01; (b) 2-year mean, $\overline{u}$, from M01; (c) ensemble average of monthly mean, $\langle u \rangle$, and (d) ensemble average of 2-year mean, $\langle \overline{u} \rangle$. The sinusoidal map projection is used, which renders the length of each latitude circle proportionally to its real length on the sphere.

Maps

$z = -500\,\mathrm{m}$



Detection of jet axes

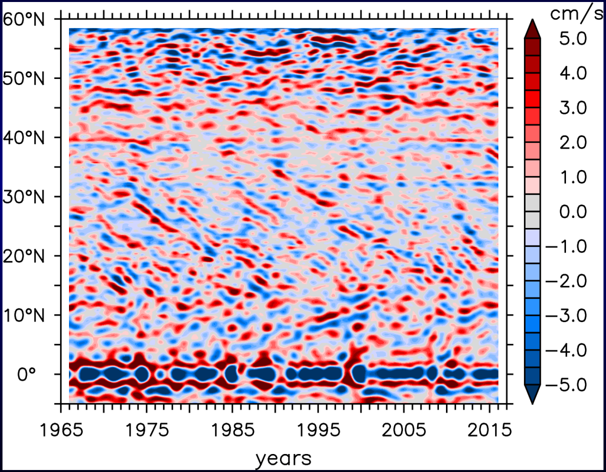


- 2-year Hann filter to remove mesoscale eddies and seasonal cycle.
- Eastward jet axis
  = latitude of local max.
  = y s.t.
  $u(y) > 0$
  and $u(y) > u(y - \Delta y)$
  and $u(y) > u(y + \Delta y)$
  with $\Delta y = 1/10°$.

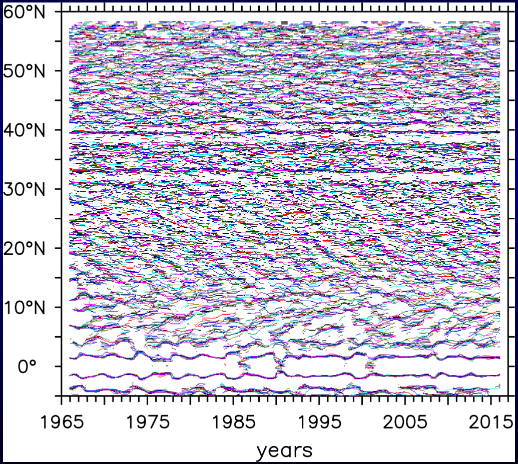
$\Leftarrow u$ & $\overline{u}$ at 140°W, 500 m.

Jet axes

$\overline{u}, m = 01$

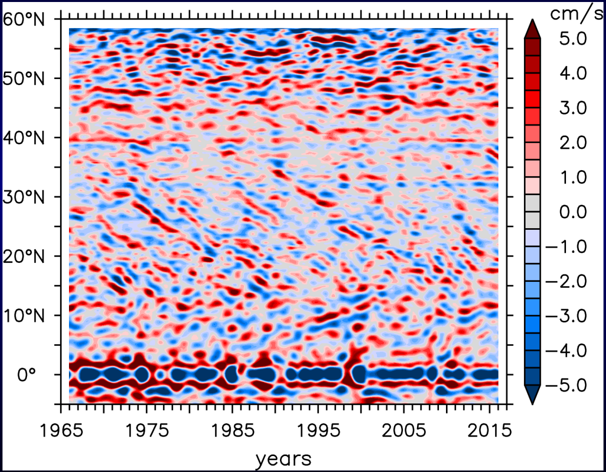


All axes

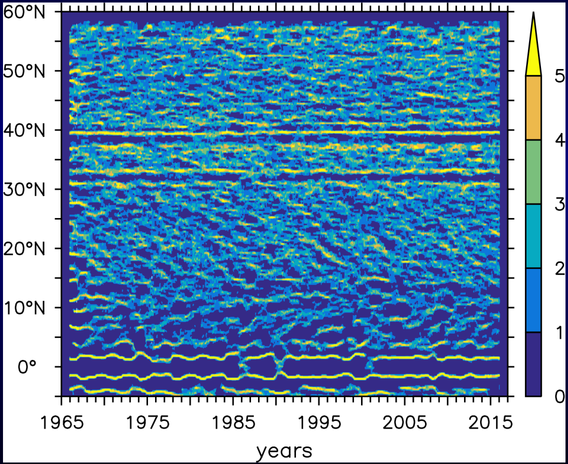


Jet axes

$\overline{u}, m = 01$



PDF



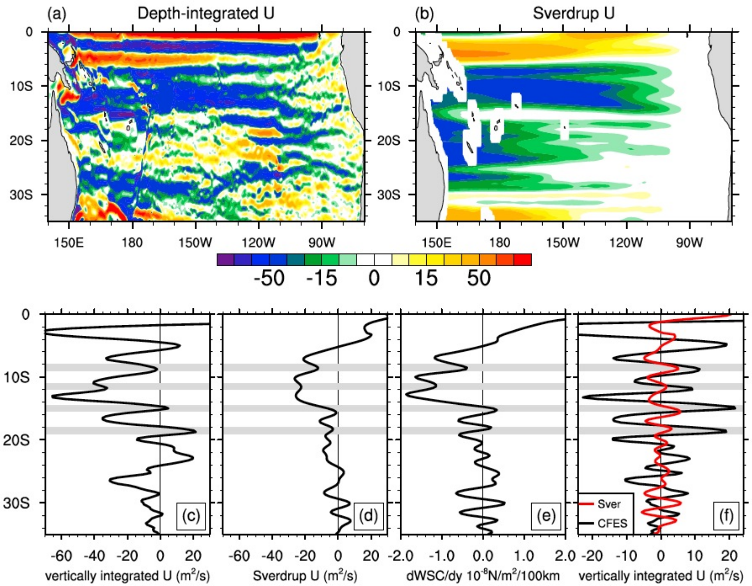
Conclusions

- Tropical jets show some determinism and some tendency to migrate poleward.
- Subtropical jets migrate equatorward; not clear whether determinism exists or not.
- Subpolar jets are random.
- Near the American continent, the meridional wavelengths are shorter, and North American ones seem deterministic.
- There are several steady jets, which are anchored to steep bottom slopes; they, in turn, appear to trap shallower counter jets.

Questions

- What controls the systematic migration of the tropical jets? Basin modes (M. Claus, pers. comm.)?
- What about the subtropical jets (migration, determinism)?
- Are the steady jets anchored or generated at the topographic features?
- What generates the near-America jets with shorter wavelengths? Coastal flows (Davis et al 2014)?
- Are there impacts on the atmos. bndry layer? [What about Kessler & Gourdeau (2006) and Taguchi et al (2012) ?]
- . . . .

Feedback from the atmosphere?



- Kessler and Gourdeau (2006) found South-Pacific deep jets to be consistent with a Sverdrup calculation.
- Taguchi et al (2012):
  Zonal jets
  → SST striation
  → Atmos. bndry layer
  → Anomalous wind curl
  → Jets correlated with Sverdrup calculation.

Ψ ensemble anomomaly

Ψ ensemble average