# Near-surface wind-current coupling, identified in satellite and in situ observations

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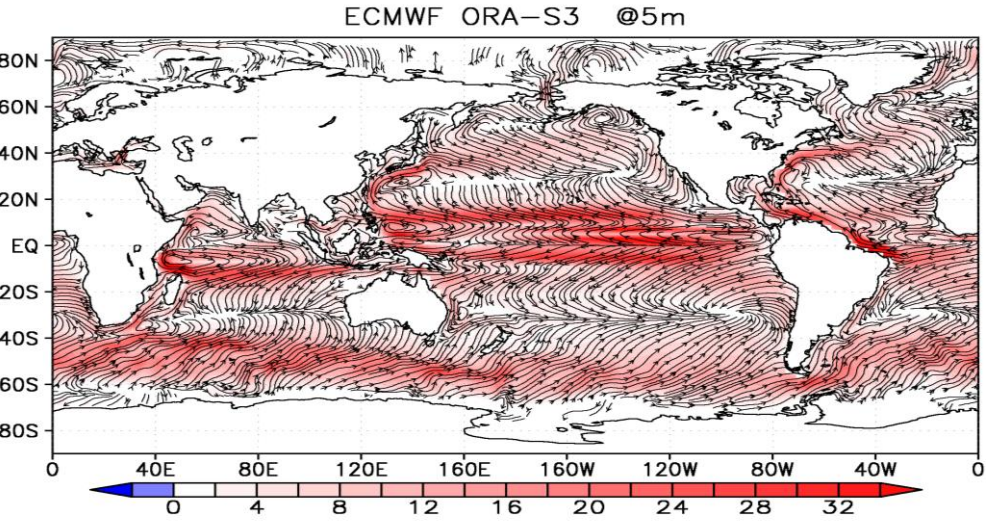
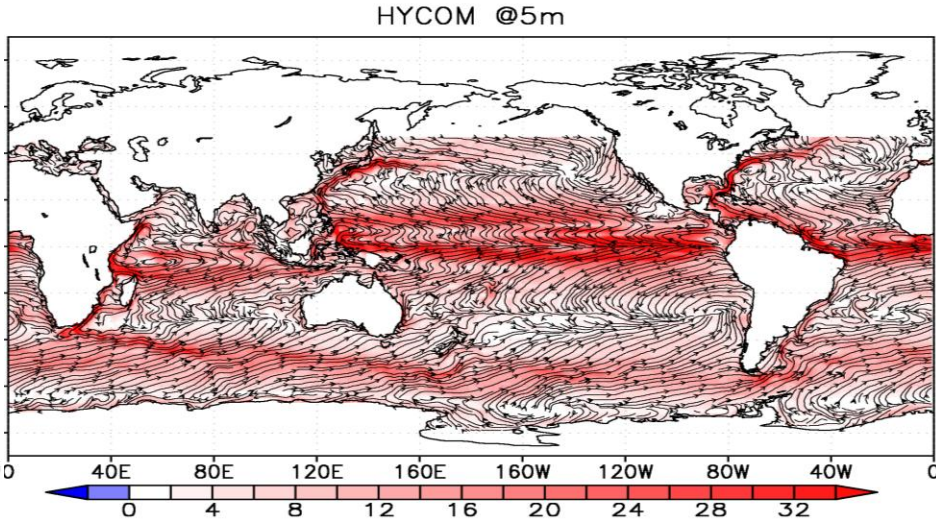
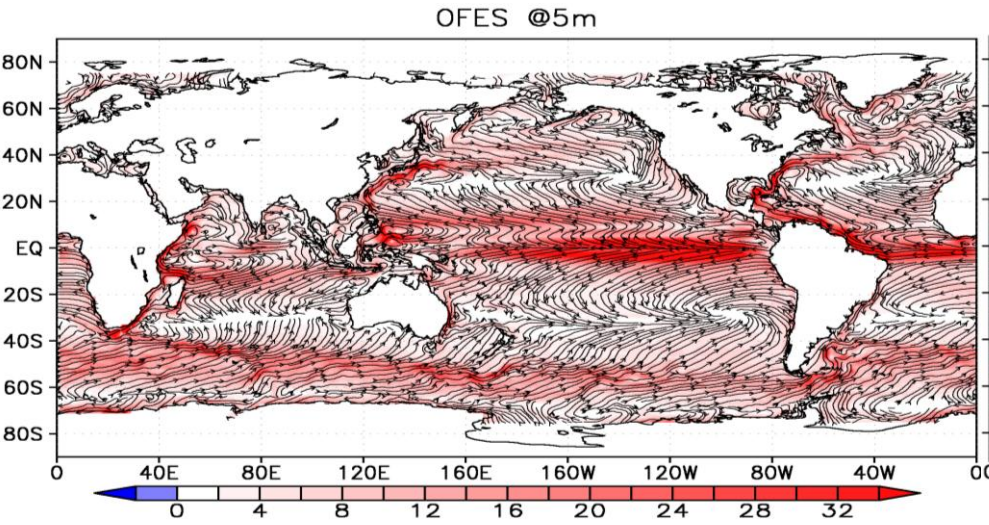
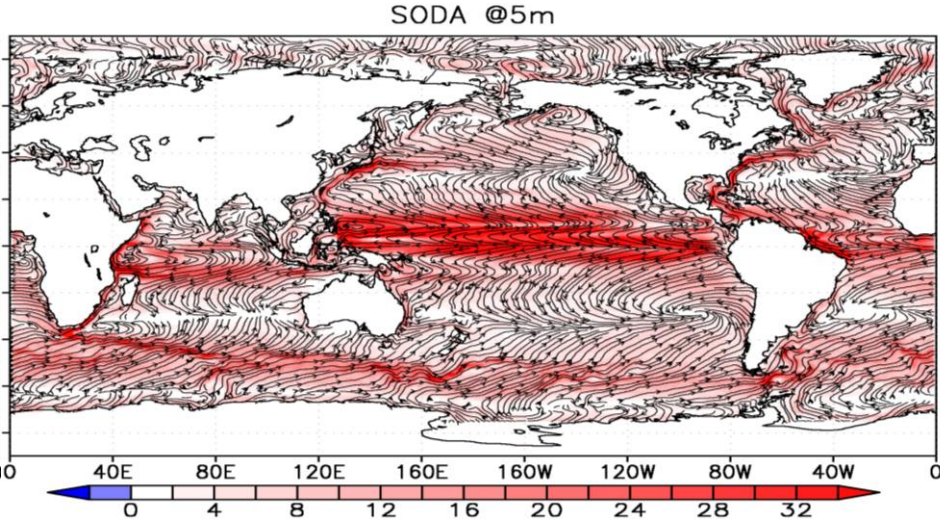
Many thanks to Jan Hafner for help with preparing this presentation.

# Time mean currents at 5 meters level in different models

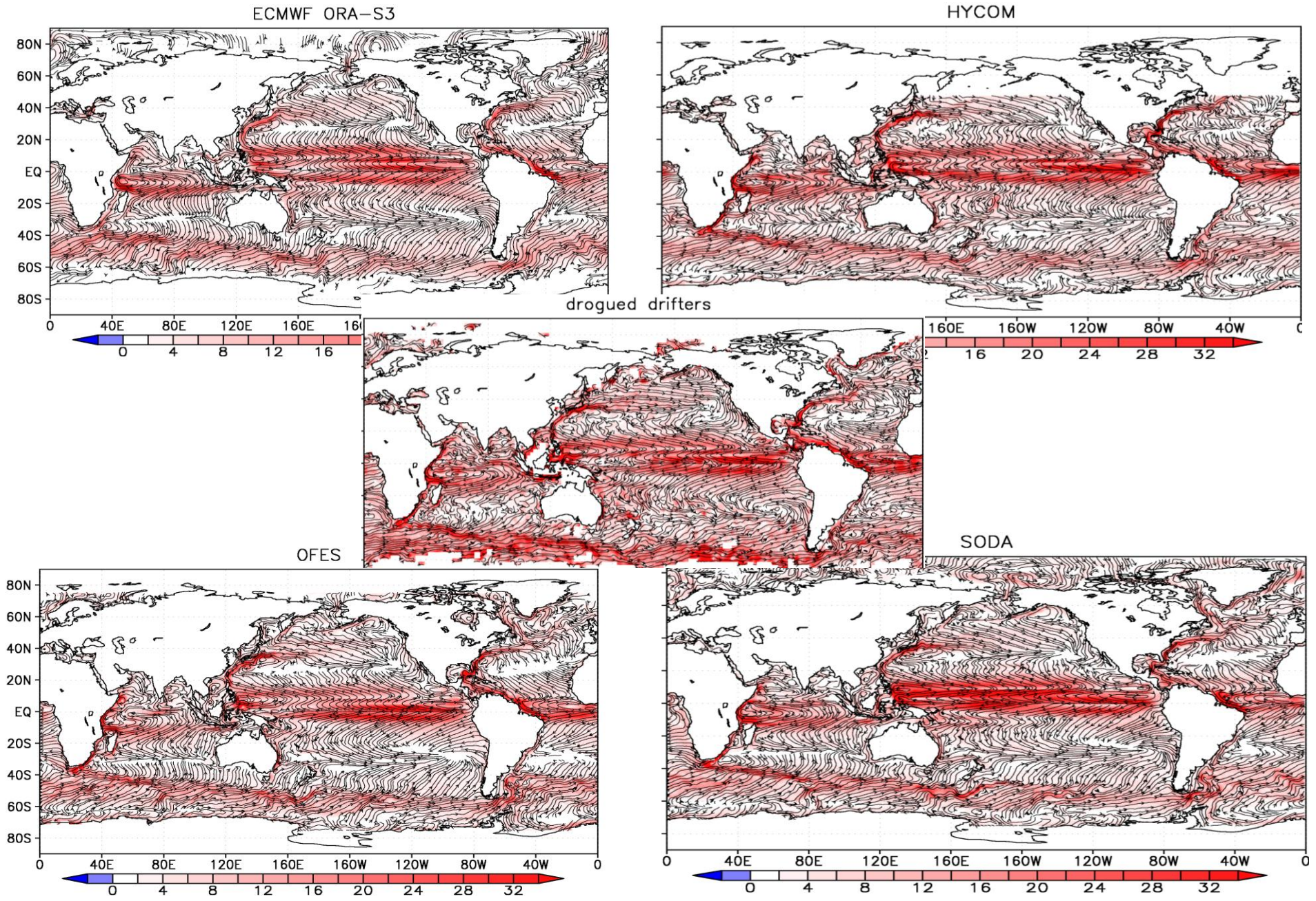


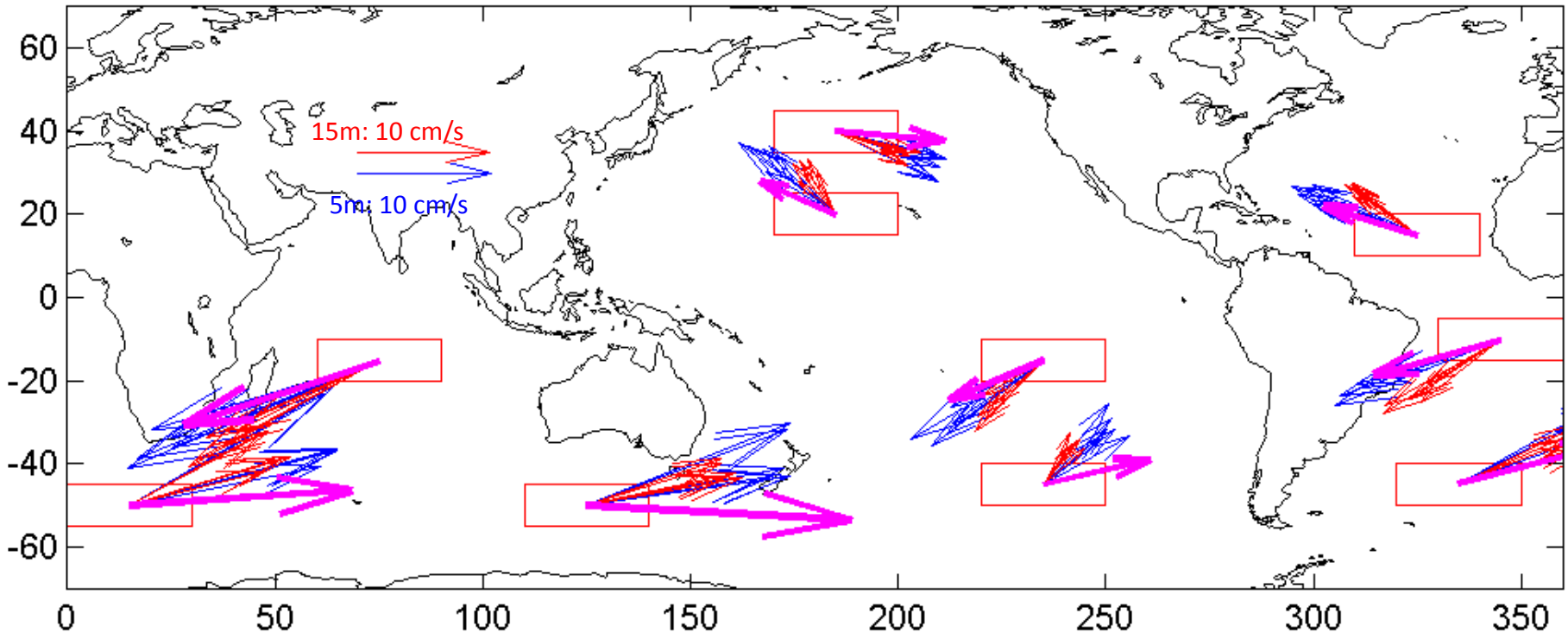



# Time-mean currents at 15 meters level in different models



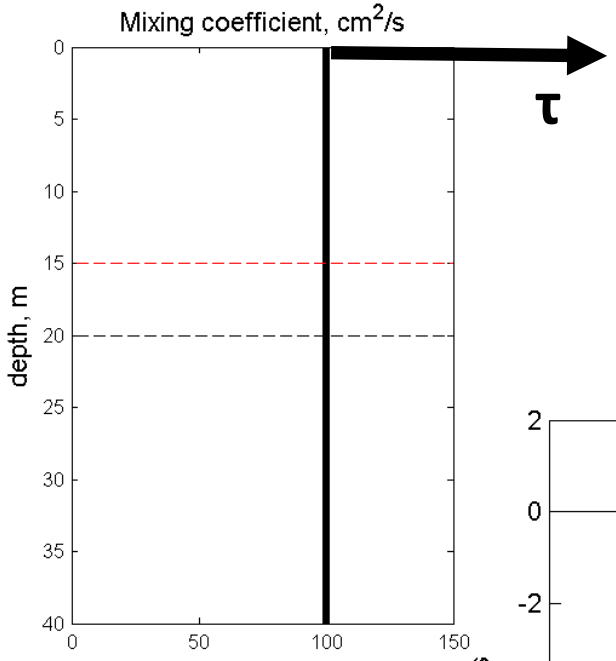
Mean velocities at 5 meters and at 15 meters from ECMWF, HYCOM, OFES, and SODA models, averaged in 30° longitude x 10° latitude boxes. Also 15m drifter velocities.

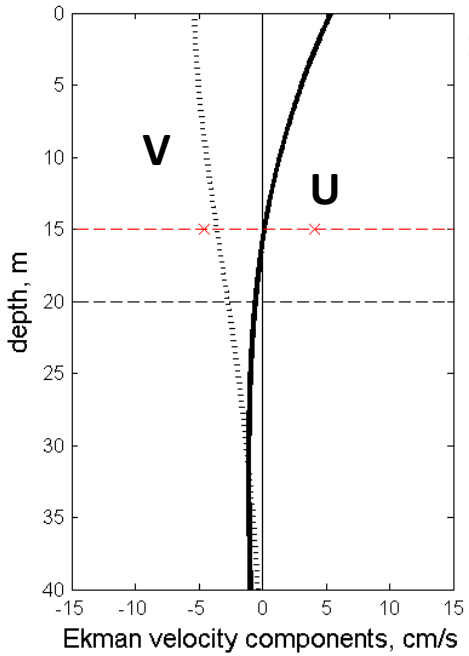



Possible sources of differences:

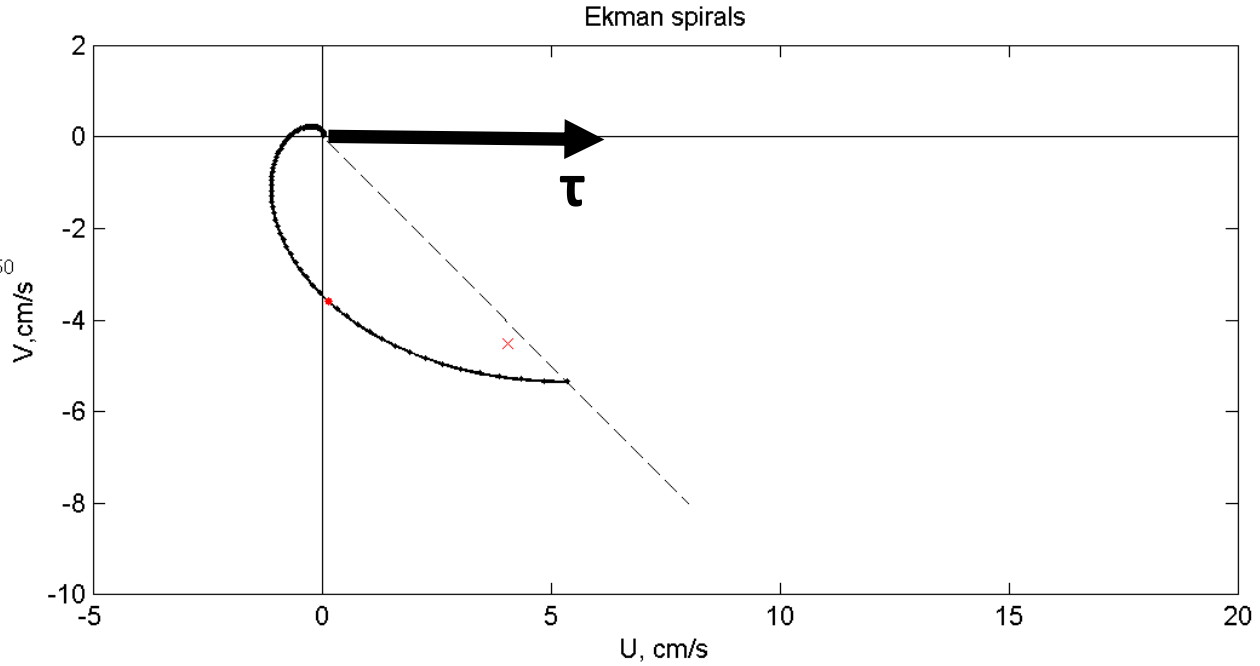
- Different time span (less important for long runs)
- Forced by different wind products
- Mixed layer dynamic representation

# Sensitivity of Ekman currents to model

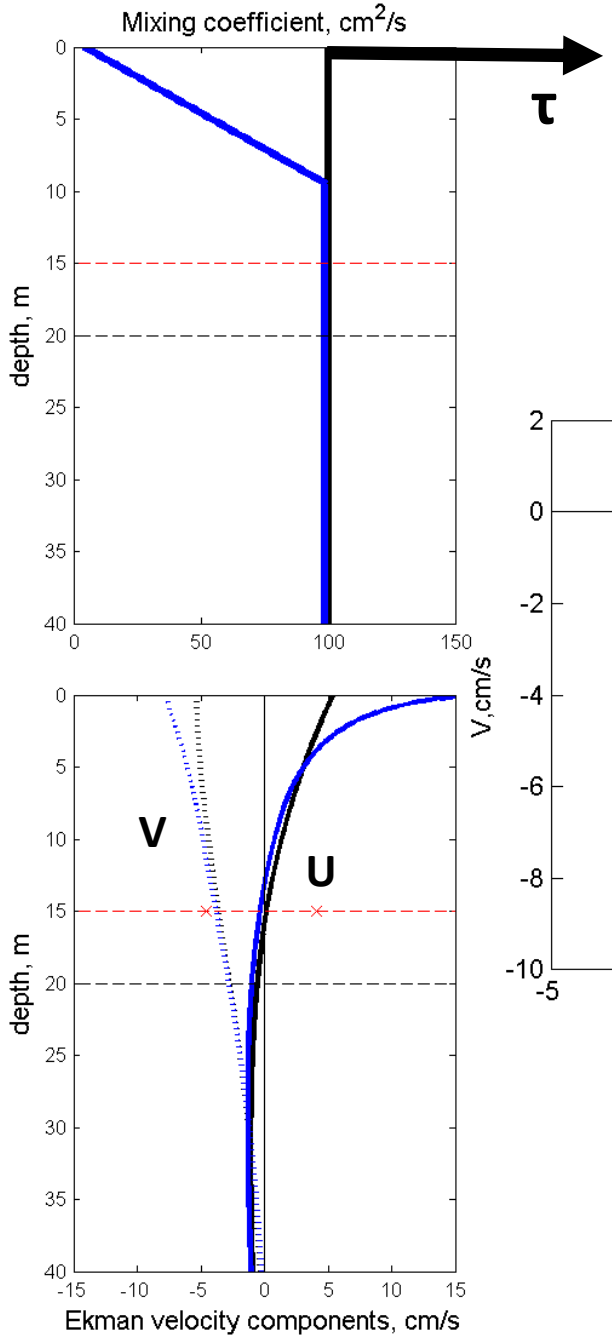



Case 1: constant mixing coefficient
Location: ~ 20N, dateline
Mean QuikSCAT wind ~ 6m/s
τ ~ 0.53 dyn/cm^2
H_ekman ~ 20 m

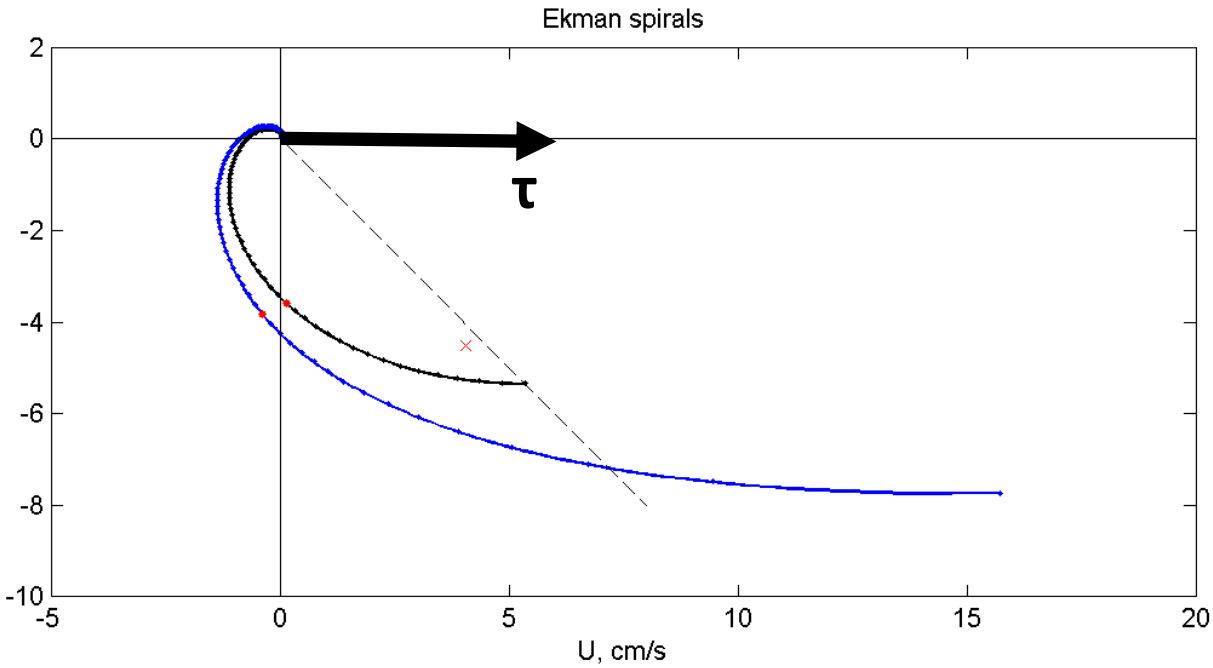


# Sensitivity of Ekman currents to model

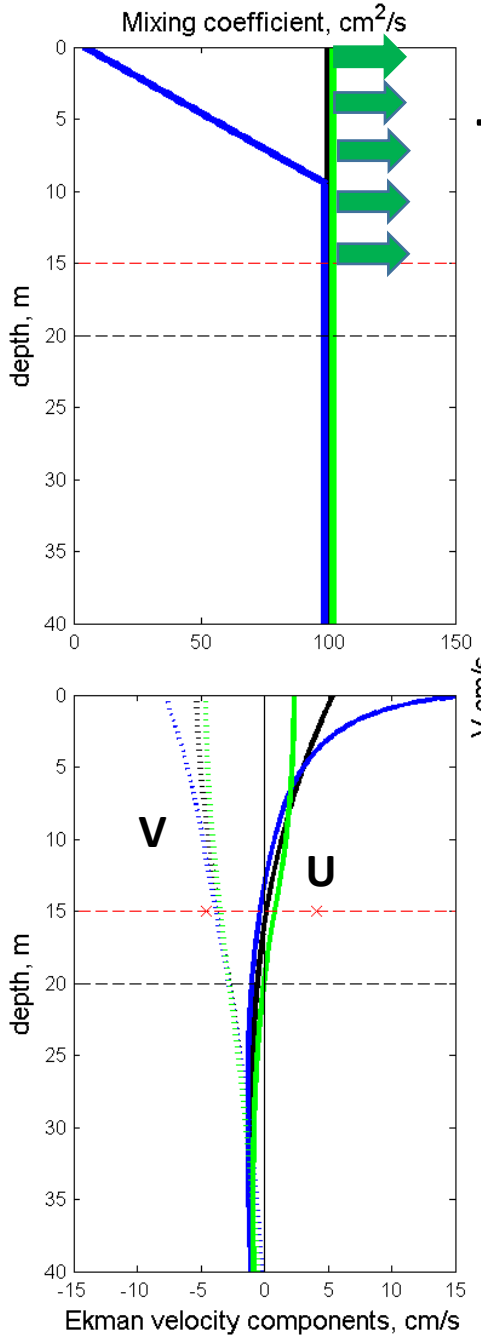



## Case 2: Logarithmic boundary layer

Same as Case 1 but mixing coefficient drops linearly from 100 cm^2/s at 10 meters to 5 cm^s at the sea surface

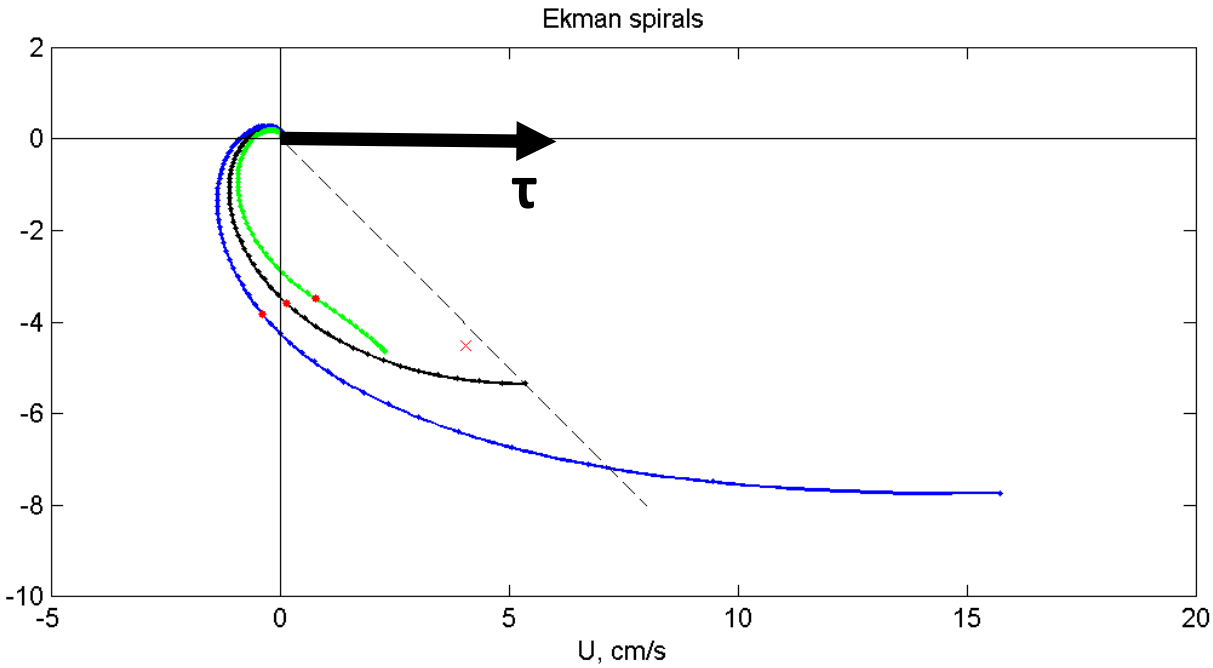


# Sensitivity of Ekman currents to model

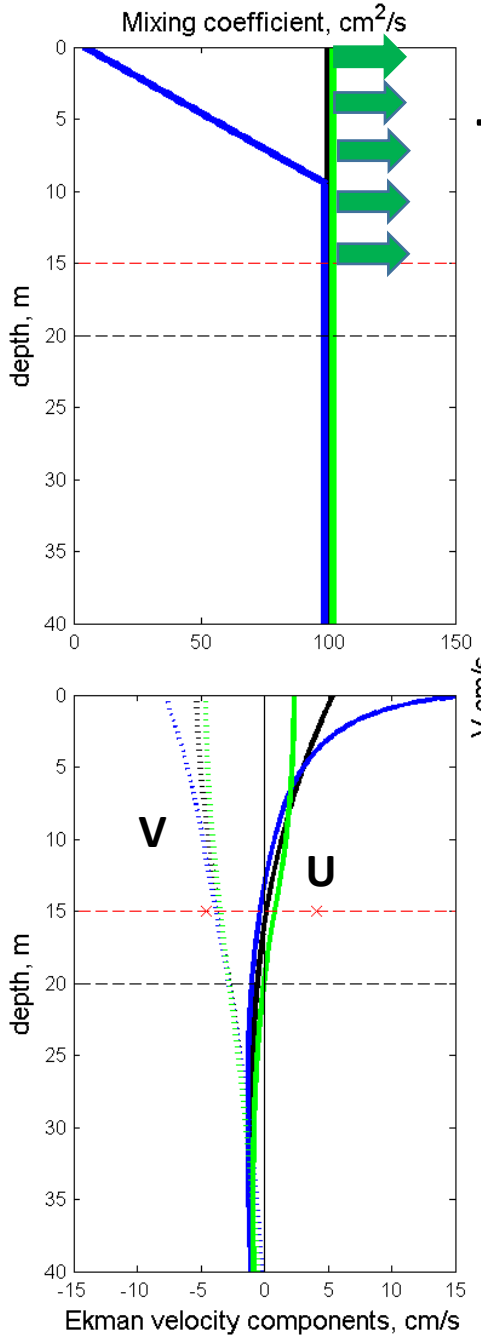



## Case 3: Direct wind momentum injection
## A la Kudryavtsev et al. (2008)

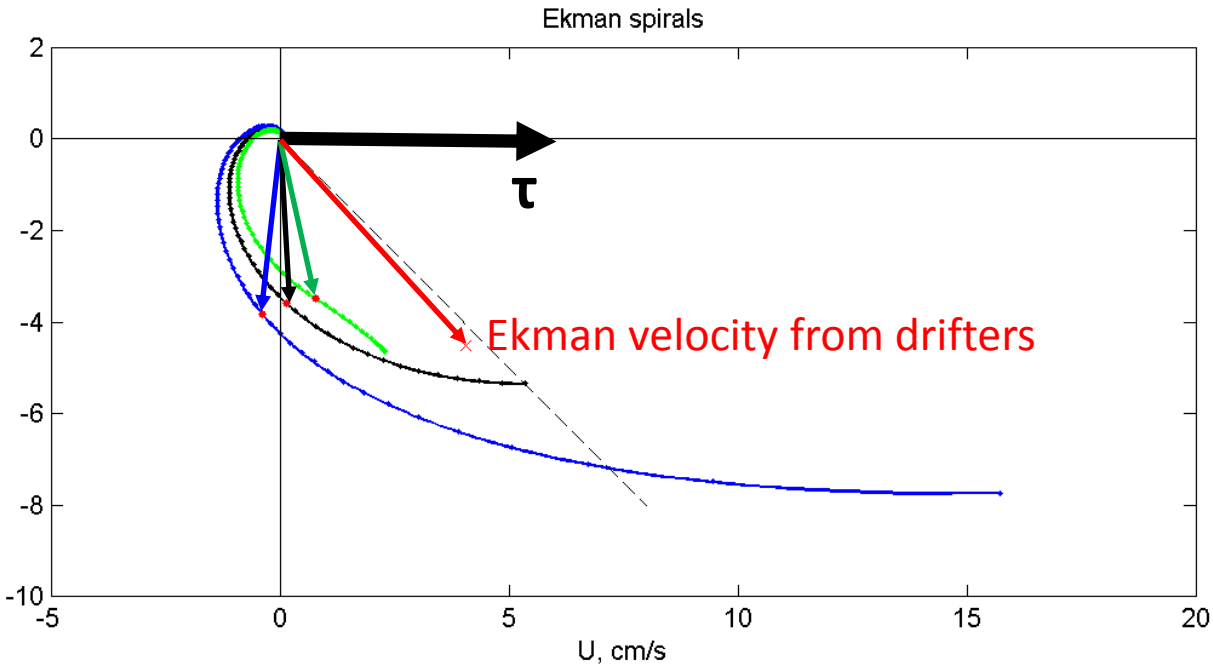
Same as Case 1 but wind stress is uniformly scattered over upper layer (H=15m).



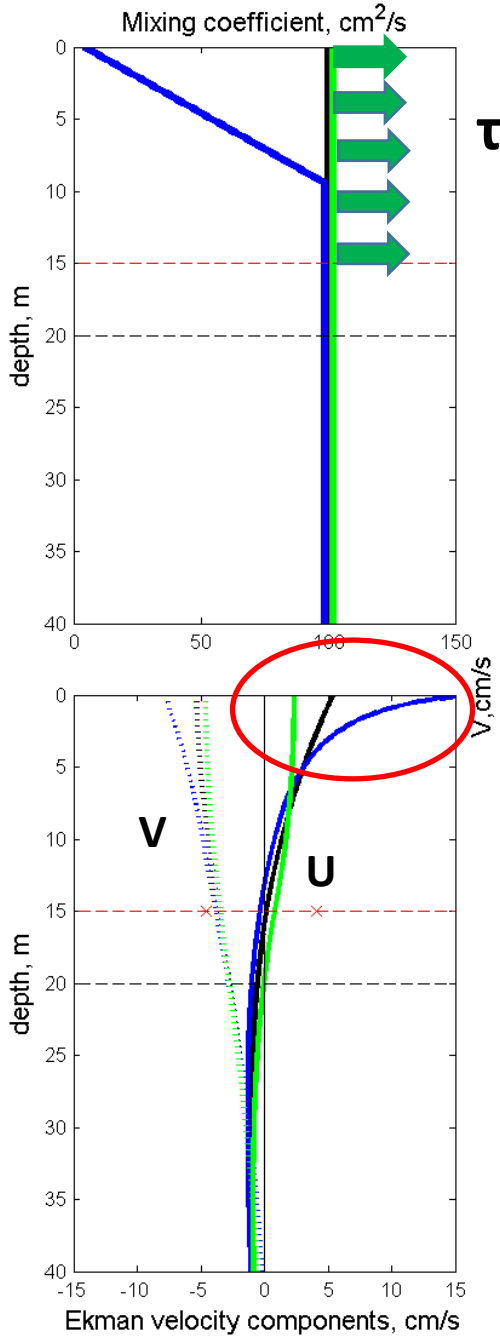
# Sensitivity of Ekman currents to model



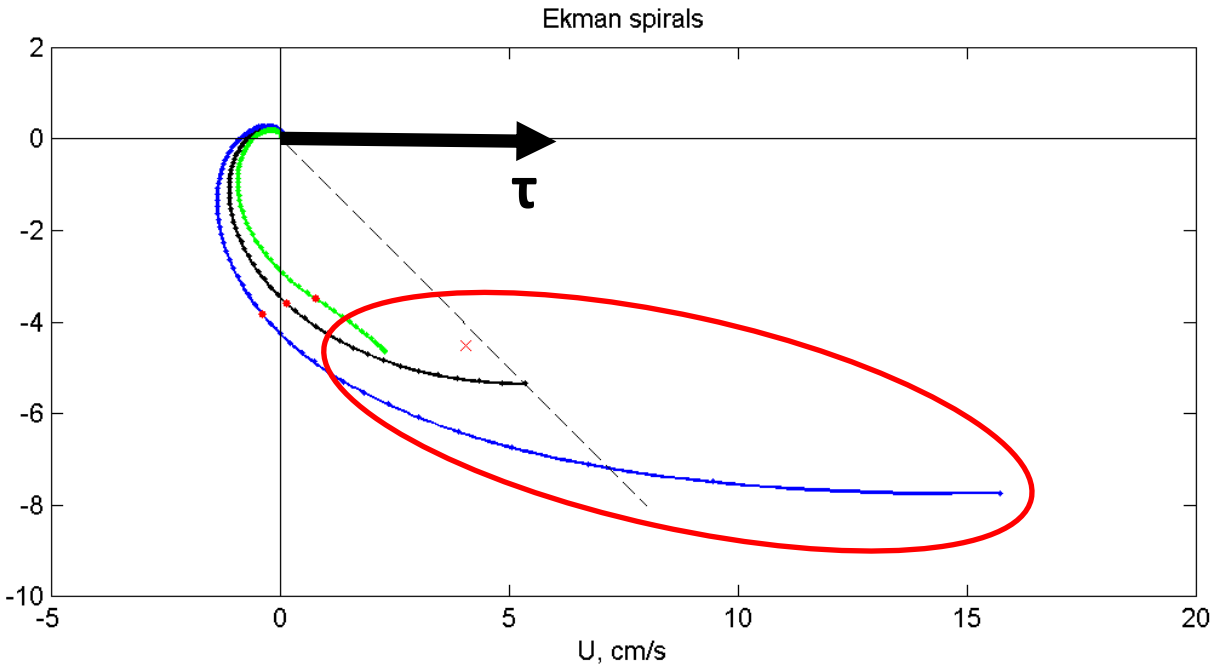

**Conclusion 1.** Simple models have problem with explaining observed trajectories of drifting buoys, drogued at 15m.



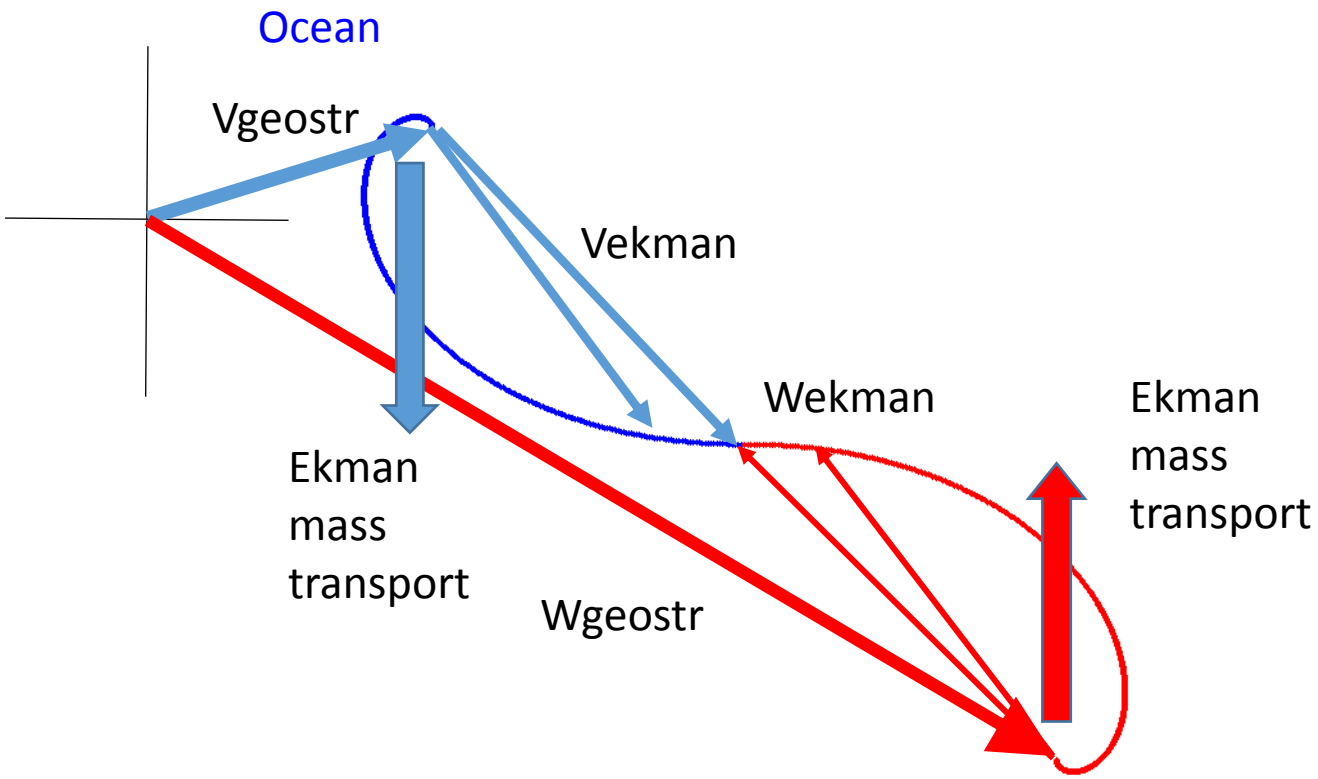
# Sensitivity of Ekman currents to model




**Conclusion 2.** Currents in a few upper meters are most sensitive to parameters of models
Therefore, impact of future satellite missions, able to measure surface currents, on understanding and on applications will be great.



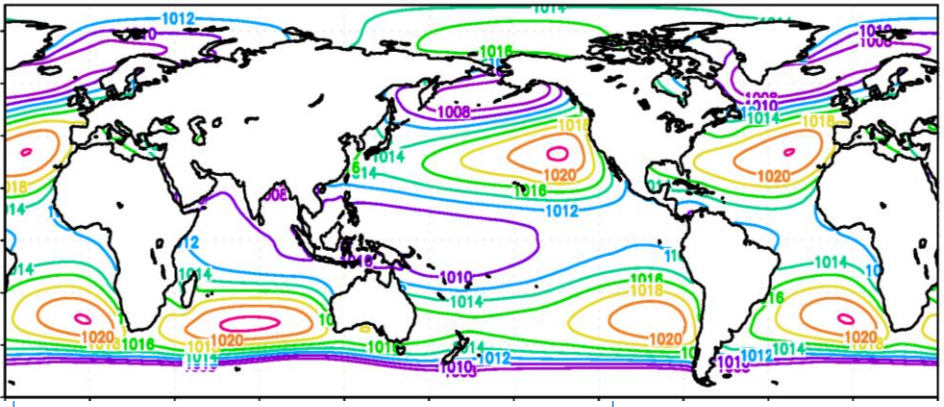
Coupled Ekman spiral (for the Northern Hemisphere)

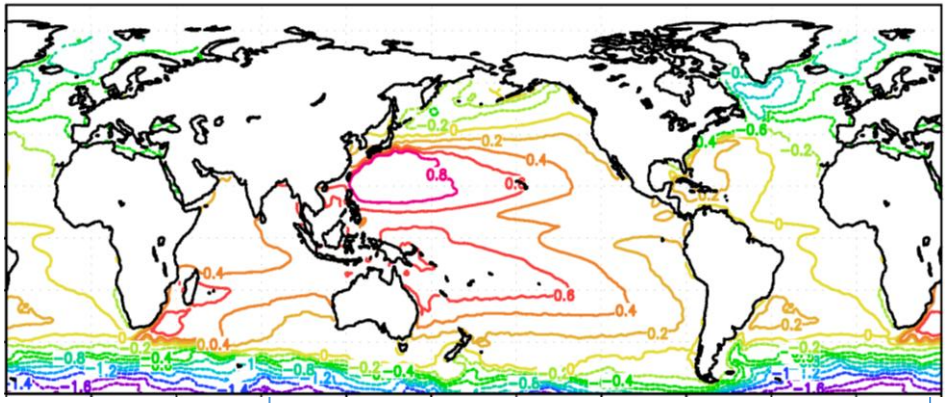


Sea level pressure (ECMWF)

Ekman wind against Ekman currents

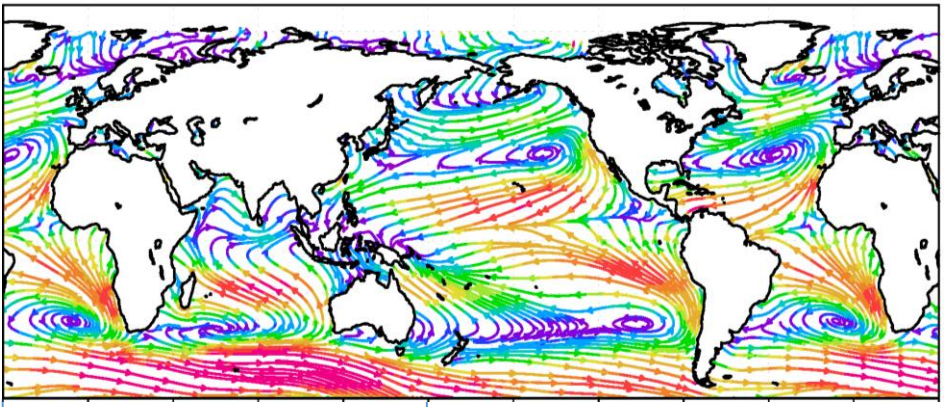
MDOT (GRACE)

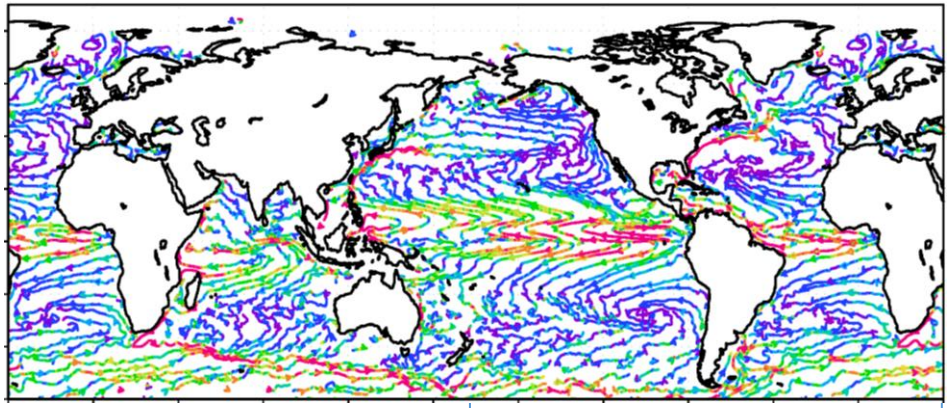




Mean 10m wind (QuikSCAT)

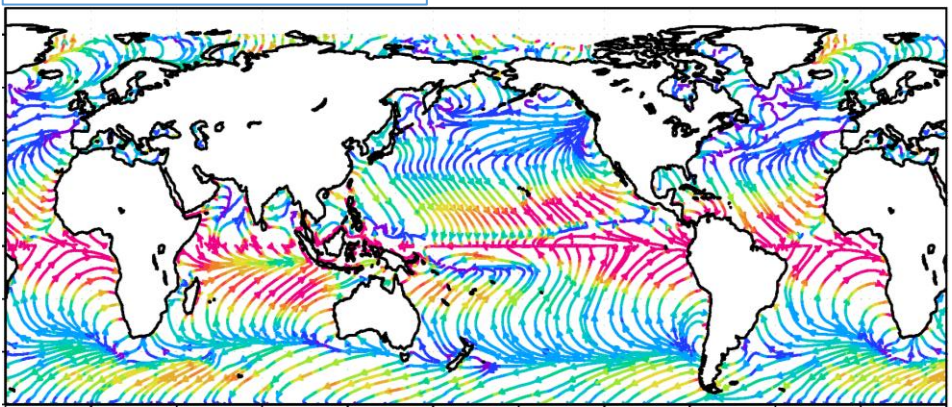
Mean currents at 15m (drifters)

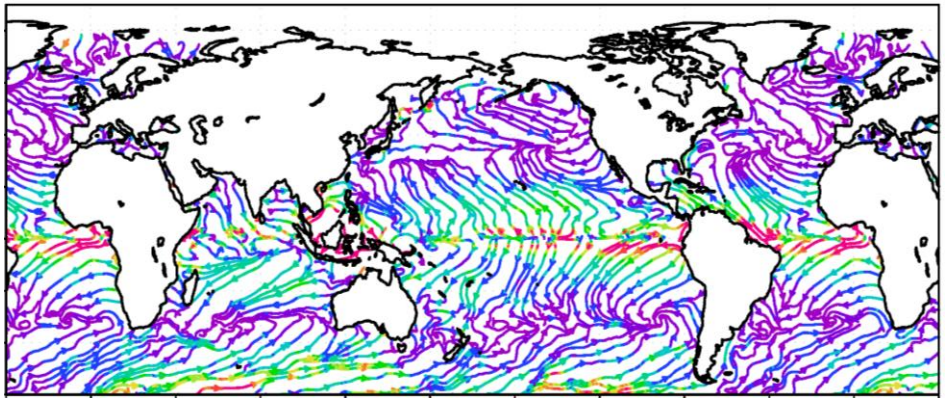




Mean Ekman winds

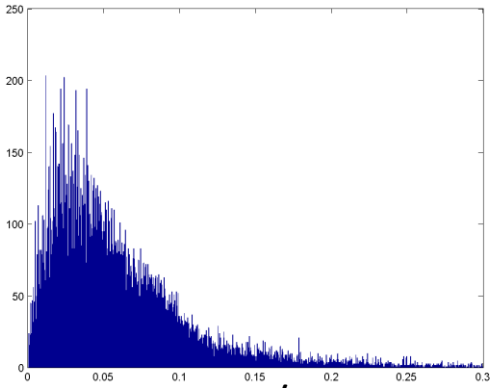
Mean Ekman currents





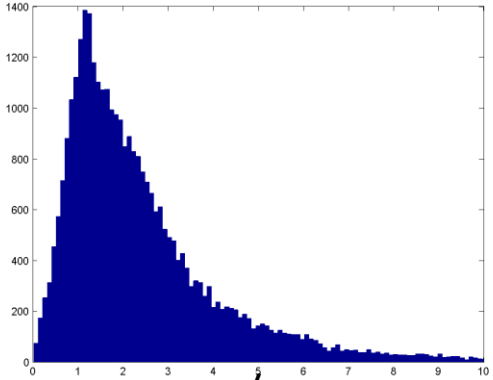
Mean Ekman currents rotated and scaled to mean Ekman winds

Histogram of Ekman current speed




m/s

Histogram of Ekman current speed

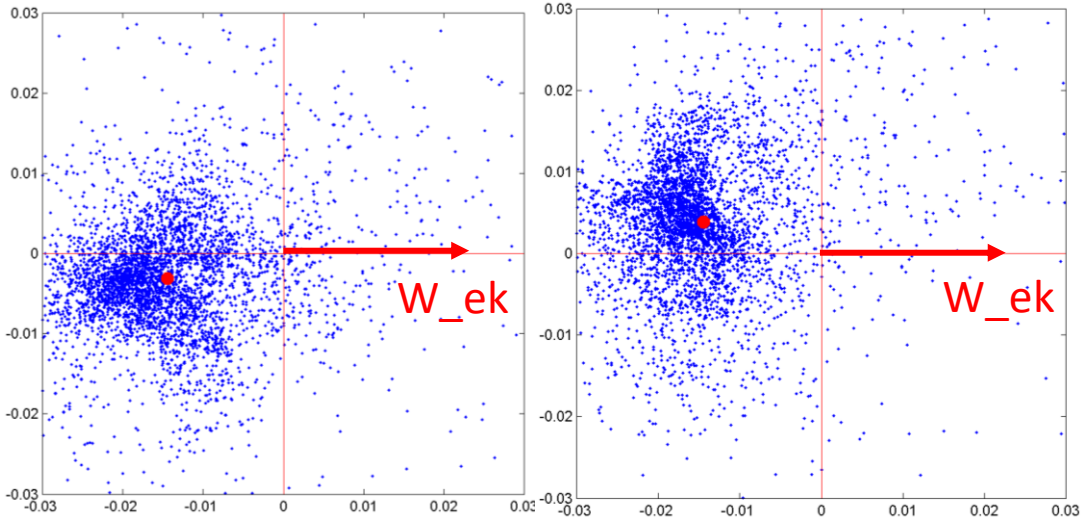



m/s

E = (Uekman + i*Vekman)/(Wx_ekman + i*Wy_ekman)

10-40N

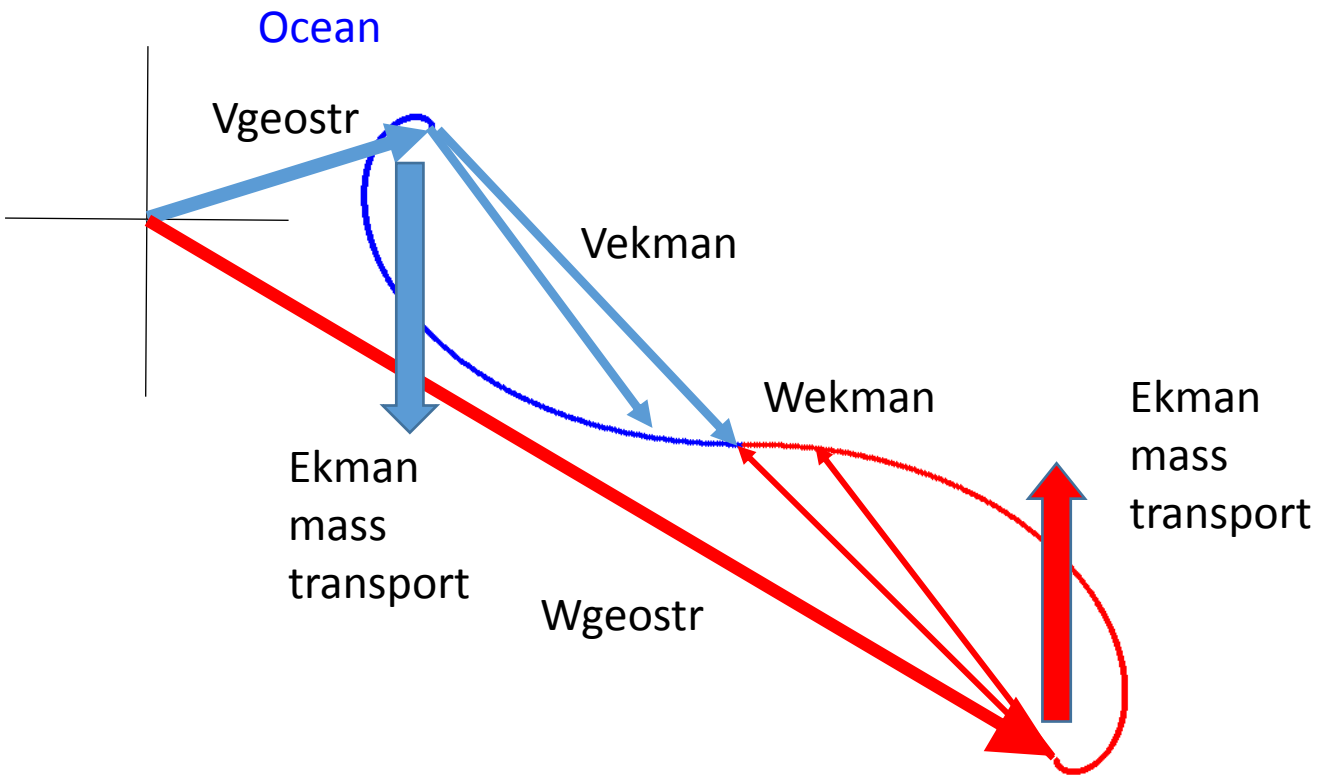
|W_ek|>0.5 m/s




10-40S

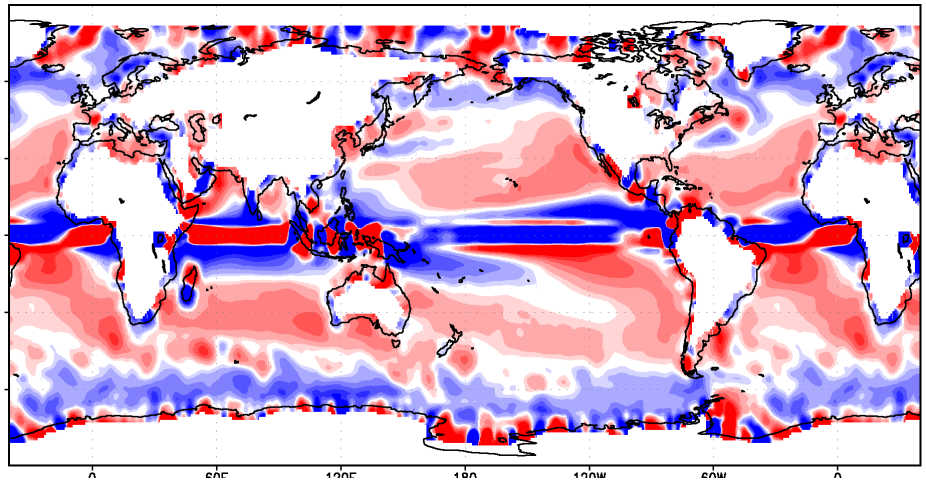
|W_ek|>0.5 m/s

Coupled Ekman spiral (for the Northern Hemisphere)

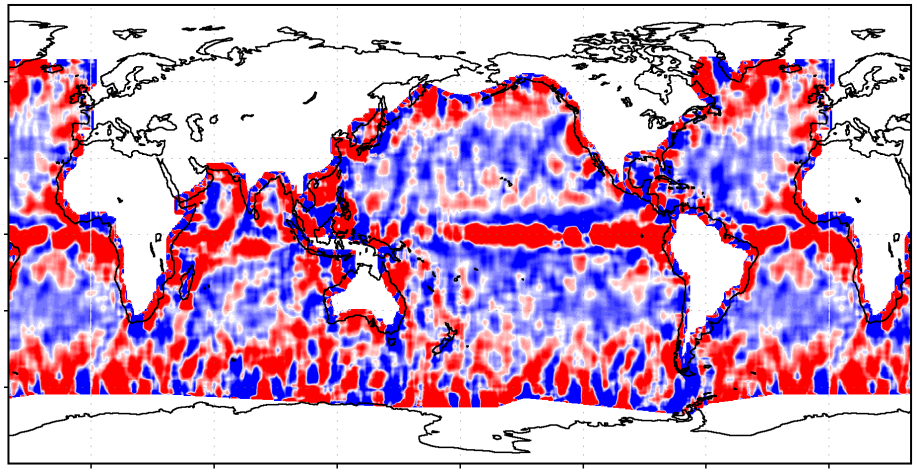


# Map of Ekman convergences: wind vs current

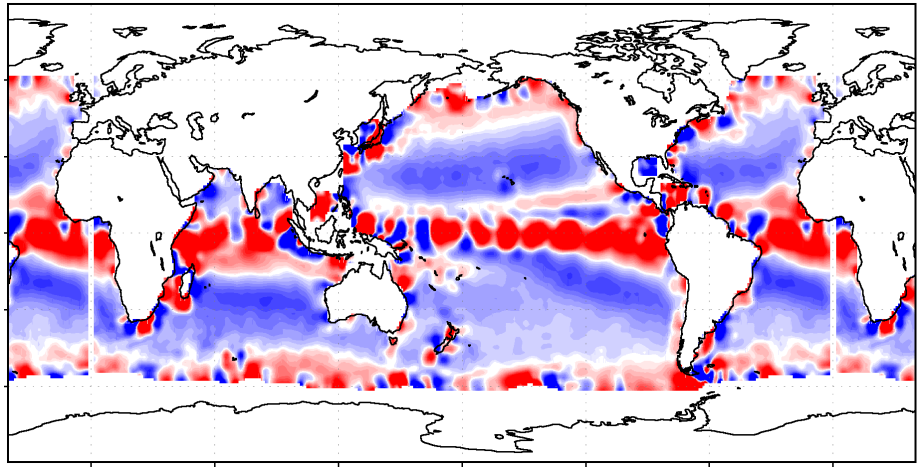
## Divergence of Ekman wind (QuikSCAT)



## Divergence of Ekman currents (SCUD)

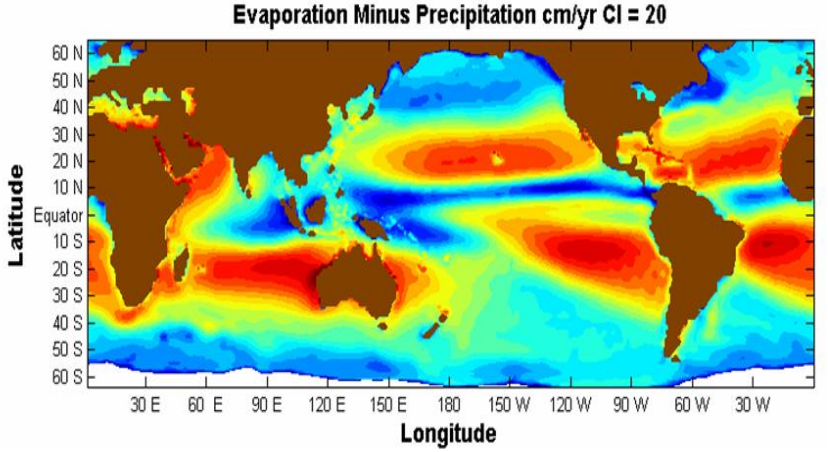


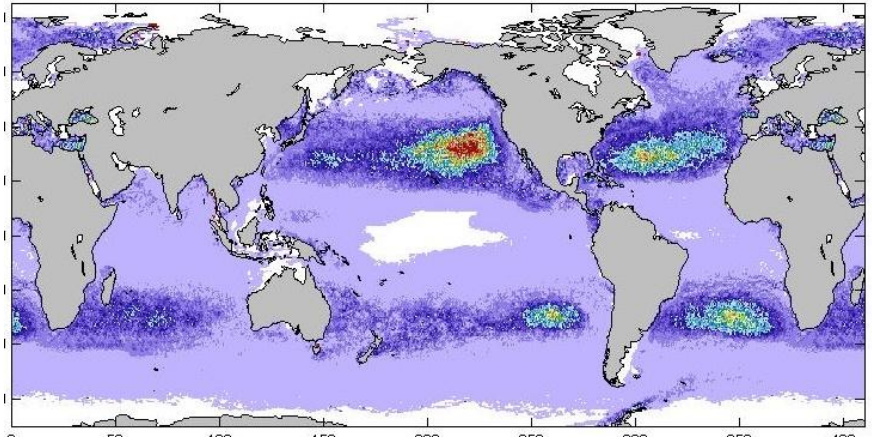
## Divergence of surface currents (OSCAR)



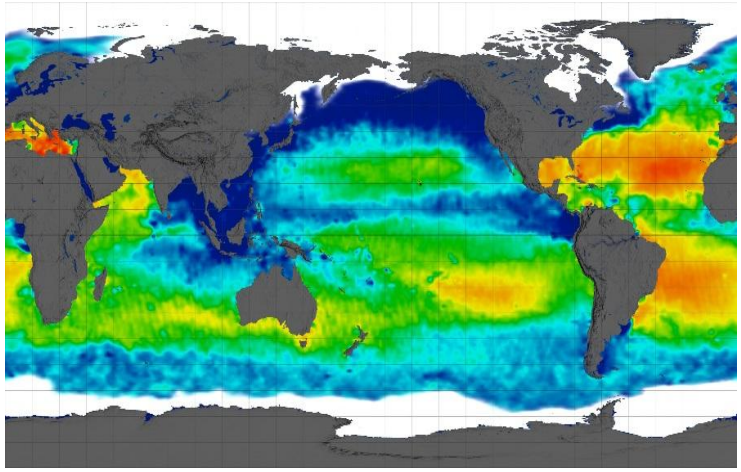
# Signatures of vertical motions, induced by coupled Ekman dynamics

Simulated concentration of marine debris

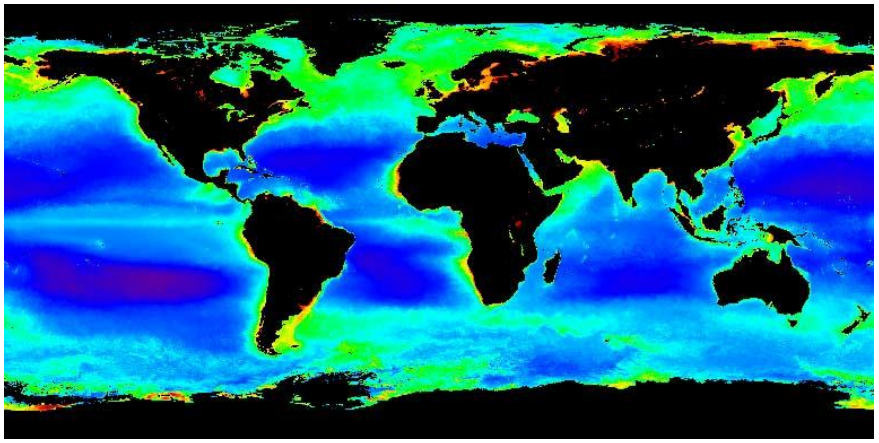


Mean sea surface salinity from Aquarius

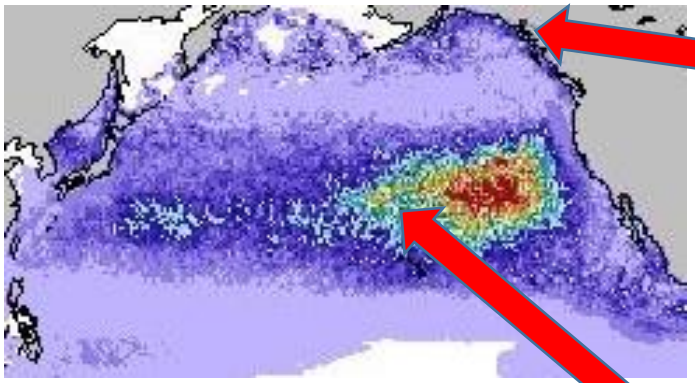


Mean chlorophyll from satellite ocean colors



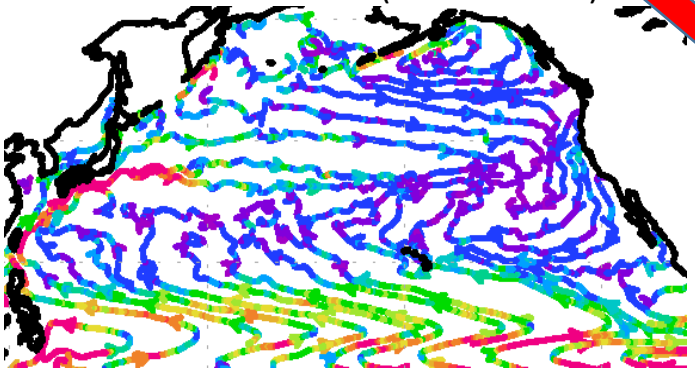
# Marine debris in the North Pacific

Model simulation of low-windage tracer



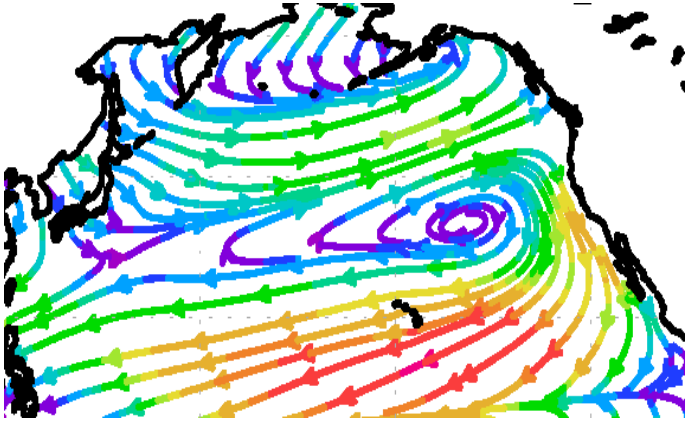
High-windage debris in Alaska

Mean surface currents (15-m drifters)



Low-windage debris in Hawaii

Mean surface winds (QuikSCAT)



**Conclusions:**

- Critical role played by air-sea Ekman coupling in circulations of atmosphere and ocean, fresh water balance, ecosystem dynamics, etc. becomes clearer with the development of multi-component observing system.

- New satellite missions, capable of measuring collocated surface winds, currents, and stress are necessary for future progress in understanding momentum dynamics in the coupled ocean/atmosphere boundary layer, where most of human activity takes place.