Surface Winds At Near Shore (SWANS) OSTST project (2017-2020)

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Goals:

- Estimate wind stress components of the altimeter-derived wind speed
- Estimate latent (evaporation) and sensible heat flux along the altimeter tracks in coastal areas combining satellite SST and specific air humidity and altimetric wind speed using the bulk formula
- Perform process-oriented studies based on the experimentation with regional oceanic and atmospheric models to better understand the role of air-sea interactions in shaping the low-level atmospheric circulation
SWANS (2017-2020)

Study area:
• Humboldt Eastern Boundary Upwelling System (Chile – Peru)

Fig. 4. (a) Mean surface wind speed and wind vectors. (b) Variance of daily intraseasonal anomalies. Intraseasonal anomalies are defined as departures from the monthly means (Lin et al., 2000). Data are from the gridded daily averages QuikSCAT-ASCAT (2000-2014).
Method:

- **Calibration:**
  \[ U_{10}^c = U_{10} \times \text{slope} + \text{offset} \]

- **Wind stress and drop-off**
  \[ \tau = \rho_a \times C_d \times (U_{10}^c)^2 \]
  \[ U_x = \cos(\theta - \phi) \times U_{10}^c; \quad U_y = \sin(\theta - \phi) \times U_{10}^c \]
  \[ \tau_x = \cos(\theta - \phi) \times \tau; \quad \tau_y = \sin(\theta - \phi) \times \tau \]
  \[ DO_t(lat) = 100 \times \left[ \frac{\int_0^1 U_{10}^c(x, lat)dx - \int_0^1 L_d y(x)dx}{\int_0^1 L_d y(x)dx} \right] \]

- **Transport and upwelling**
  \[ W = \frac{1}{\rho_w f} \nabla \times \tau \quad M = \frac{1}{\rho_w f} \tau \times \kappa \]
Wind speed and drop-off (Astudillo et al., 2017):

Ekman pumping and transport (Astudillo et al., 2017):

**Fig. 5.** Mean vertical velocities in the nearshore upwelling zone from (a) Ekman transport, (b) Ekman Pumping and (c) total upwelling (Ekman transport + Ekman pumping). Comparative detail with the Jason-2 vertical velocities contributions induced by Ekman transport and Ekman pumping.
Sensitivity of the oceanic circulation to coastal wind profiles in a high-resolution model

- **Model**: CROCO at 3km resolution (1/36°)
- **Domain**: central Chile
- **Experiments**: forced simulations (15-years, permanent year 2005) with and without including a coastal wind profiles in the atmospheric forcing
- **Method**: heat budget analysis
- **Objective**: Does the consideration of a wind-drop off in the atmospheric forcing reduces the cool biais?
- **Answer**: Yes but not for the reason we thought
Heat budget analysis in a 50-km coastal fringe:

Results (Astudillo et al., 2019):

• The presence of a wind drop-off reduces Ekman transport with is partially compensated by an increase an Ekman pumping. On the other hand, it yields a reduction in vertical mixing (shallower mixed-layer) which increase the warming tendency associated to heat fluxes (Solar radiation is more efficient in warming SST).

• In addition, the coastal wind profiles impact the baroclinic instability of the coastal currents, which modulates the off-shore eddy flux: Costal winds are thus influential on the regional oceanic circulation.

• Coastal wind profiles are not realistic in atmospheric Reanalyses (even the state-of-the art), which explains why oceanic Reanalyses have a persistent bias in mean EKE along the coast of Peru/Chile.
Modulation of mean EKE at ENSO timescales:

Mean EKE changes are associated to the modulation of the baroclinic instability of the coastal currents due to the oceanic teleconnection (ENSO) and to wind work associated to along-shore wind changes during ENSO.

Perspective:

- Document long-term trends in coastal wind profiles and compare with long-term trend in costal sea level/SST: Can observed discrepancies between sea level trends in the coastal zone and the open-ocean can be explained by trends in the wind stress curl along the coast?

- Enhance the network of meteorological stations in collaboration with partners (Peru/Chile): i.e. maintain stations in location of satellite track for Cal/Val purpose (on-going with CEAZA (Chile))

- Test correction of coastal winds in atmospheric Reanalysis for improving oceanic reanalysis products (collaboration with Mercator-ocean)

- Link with on-going project UPWESWIND: Use of HR Sentinel-1A SAR images to complement Scatterometer/Radiometer products in the coastal zone. HR merged products (0.125°, 1h) on the 2000-2019 period => Indirect «validation» with ocean modeling (SWANS for Humboldt and California EBUS)