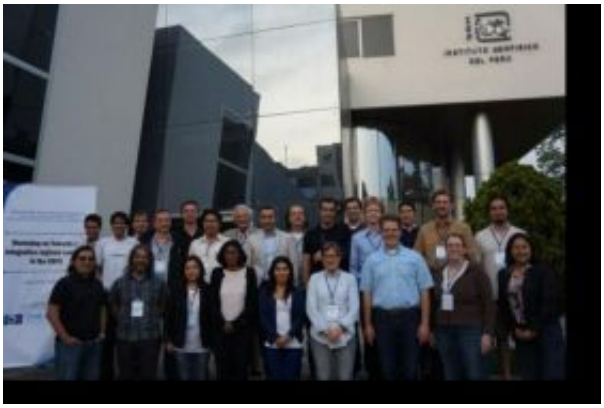
Workshop on « Towards an integrative regional coupling

in the Eastern Boundary Upwelling Systems"



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This meeting is a follow on of the two previous workshops carried out within the Mid-Term Strategy Initiative on "Air-sea gas fluxes at Eastern Boundary upwelling and Oxygen Minimum Zone (OMZ) systems", the first one being held in Lima at IMARPE in November 2010 and the second one being the EUR-OCEANS Deoxygenation Conference organized in Toulouse, France in October 2011. This 3rd workshop was held at IGP since its goal was to establish strong links between the CLIVAR and SOLAS communities to reach an integrated modelling and observational approach for a proper regional assessment of climate change impact on this OMZ region off Perú.

This 3 days-meeting was structured with 2 days of scientific presentations and discussions followed by one day of a series of 8 lectures devoted to capacity building for Peruvian Master and PhD students. The SOLAS IPO, the German SOPRAN program, the French IRD and LEGOS and the Peruvian IGP provided the funding to hold this event (see http://solas-int.org/mts/research-strategy-5.html for full program).

The following general topics were covered during the 2 days workshop : Surface (energy and water) fluxes at the air-sea interface (*in situ* measurements of fluxes and satellite-based flux estimates), and Towards an integrative regional coupling in the EBUS: modelling and observations (*in situ* and remote sensing): atmosphere, physical and biogeochemical dynamics.

For the first topic, measurements of turbulence and mixing in the ocean surface layer in the Labrador Sea obtained with the Air-Sea Interaction Profiler (ASIP) were presented showing evidence of intense turbulence at the surface together with patches of turbulence at the base of the seasonal mixed layer from breaking internal waves. Then it was demonstrated how to close as accurately as possible the heat and freshwater budget during an experiment in the Northeast Atlantic ocean from satellite, *in situ* data, numerical weather prediction model observables and a bulk algorithm. Challenges in modelling of regional ocean-atmosphere interaction in the Perú EBUS were exposed pointing to the bias amplification in regional coupled ROMS-WRF models due to a subestimation of low level

cloudiness resulting in a strong positive SST bias in the coupled model. Strategies to alleviate this bias were discussed. Then projected changes in coastal winds and SST towards the end of the 21st century under a few selected IPCC scenarii showed a reinforcement of the southern flank of the South East Pacific anticyclone leading to stronger winds off central Chile; farther north along the Peruvian coast the projection seemed less clear and probably scale dependent. Then the presentations were more oriented toward GHG topics. The ESA STSE Oceanflux theme Upwelling was presented on how to infer "super resolution" GHG fluxes from vertical column densities (VCDs) of CO_2, inverse atmospheric modeling and nonlinear multi-scale methods. In the Gulf of California, the OMZ is associated to a CMZ and a strong relationship exists between total dissolved inorganic carbon and temperature useful for future applications to analyze the carbon dynamics in this area in the Midriff Islands. A paleo presentation followed to highlight the fact that over the last ~1700 years, during the Current Warm Period the Peruvian Upwelling system experienced the strongest OMZ, the highest export production and the highest anchovy biomass due to an increase in upwelling since ~1900 AD.

During the second day, we focused more on the Perú system by looking at El Nino events in the Perú EBUS and the definition of two independent indices, one for SST off the coast of South America and the other in the eastern-central equatorial Pacific. Characteristics of the intraseasonal variability off Perú have put in evidence 2 regimes: a low period regime (10-25 days), signature of Ekman transport/pumping dynamics and a high-period regime (35-60 days) associated to the combined forcing of oceanic equatorial Kelvin waves and migratory atmospheric disturbances in the mid-latitudes. Then the question was examined of whether the air-sea interaction was inhibited in tropical upwelling systems due to the presence of surfactants and extremely shallow mixed layers. The SFB754 series of planned cruises off Perú end of 2012-early 2013 should bring the answer on the role of these 2 hypothesized inhibition mechanisms. Results of the TORERO campaigns and research flights over the Eastern Pacific Ocean were summarized and the source for unexplained atmospheric glyoxal, a very short lived and water soluble oxygenated hydrocarbon, was shown to be linked to the widespread presence of a surface organic micro layer. The rationale for a reference site of Oceansites 60 km off Perú on the Hormigas de Afuera islands (12°S) was presented and convinced the whole audience. Its location close to the coastal upwelling front is an ideal site for a proper monitoring of oceanographic and atmospheric observables necessary for regional validation of coupled physics-atmospheric models. Discussions on how to proceed efficiently towards its realization were carried out.

The second topic of the workshop was then tacked directly towards biogeochemical implications. Modeling efforts with the ROMS/BIOEBUS modeling platform showed the relative contribution of two major nitrogen loss mechanisms, denitrification and anammox in the OMZ off Perú. Evidence of the presence in the ESSW of a relative phosphate minimum in the OMZ off Perú was presented and potential mechanisms to explain its occurrence were proposed. A modelling study then explored the changes in oceanic N_2O cycling and net flux from the OMZ regions in response to perturbations (changes in extent of oxygen minimum zones, increased nutrient supply). The future evolution of multiple stressors in EBUS was then apprehended with model simulations. They showed that ocean acidification in EBUS is primarily driven by atmospheric CO_2 rise while warming and stratification and local wind changes have a much smaller impact. In contrast, deoxygenation is quite sensitive to physical perturbations with large differences in response between the EBUS reflecting the difference in underlying processes governing the regional oxygen balance. The Paracas dust storms events were presented both on observational and modelling grounds. The one before last talk provided an overview of all european EO missions and the Support to Science Element OCEANFLUX program launched on SOLAS thematics. Professor Woodman, Head of the IGP, gave the final words of these very exciting two days of the workshop.
The program of the 8 lectures can be found at http://solas-int.org/files/solas-int/content/downloads/About/Mid-Term%20Strategy/EBU%20systems/EBU-Syst_Workshop2012_Handbook_2012.pdf.