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Evaluation of the swell effect on the air-sea gas transfer in the coastal zone

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Air-sea gas transfer processes are one of the most important factors regarding global climate and long-term global climate changes. Despite its importance, there is still a huge uncertainty on how to better parametrize these processes in order to include them on the global climate models. This uncertainty exposes the need to increase our knowledge on gas transfer controlling mechanisms. In the coastal regions, breaking waves become a key factor to take into account when estimating gas fluxes, however, there is still a lack of information and the influence of the ocean surface waves on the air-sea interaction and gas flux behavior must be validated.

In this study, as part of the "Sea Surface Roughness as Air-Sea Interaction Control" project, we evaluate the effect of the ocean surface waves on the gas exchange in the coastal zone. Direct estimates of the flux of CO_2 (FCO_2) and water vapor (FH_2O) through eddy covariance, were carried out from May 2014 to April 2015 in a coastal station located at the Northwest of Todos Santos Bay, Baja California, México. For the same period, ocean surface waves are recorded using an Acoustic Doppler Current Profiler (Workhorse Sentinel, Teledyne RD Instruments) with a sampling rate of 2 Hz and located at 10 m depth about 350 m away from the tower.

We found the study area to be a weak sink of CO_2 under moderate wind and wave conditions with a mean flux of -1.32 μmol/m2s. The correlation between the wind speed and FCO_2 was found to be weak, suggesting that other physical processes besides wind may be important factors for the gas exchange modulation at coastal waters. The results of the quantile regression analysis computed between FCO_2 and (1) wind speed, (2) significant wave height, (3) wave steepness and (4) water temperature, show that the significant wave height is the most correlated parameter with FCO_2; Nevertheless, the behavior of their relation varies along the probability distribution of FCO_2, with the linear regression slope presenting both positive and negative values. The latter implies that in the coastal areas, the presence of swell is the key factor that promotes the intensification of the fluxes into and from the ocean. Further analysis showed that the characteristics of wind speed and water temperature determine the direction in which the FCO_2 occur.