

On the temporal and spatial coherence of coastal upwelling**A. Benazzouz¹, J. L. Pelegrí², H. Demarcq³, F. Machín⁴, E. Mason⁵, A. Orbi¹, J. Peña-Izquierdo²**¹*Institut National de Recherche Halieutique, Boulevard Sidi Abderhamanne, BP 20030, Casablanca, Morocco*²*Institut de Ciències del Mar, CSIC, Passeig Marítim de la Barceloneta, 37-49, 08003 Barcelona, Spain*³*Institut de Recherche pour le Développement, BP 5045, 34032 Montpellier cedex 1, France*⁴*InvestigAdHoc, Telde, Gran Canaria, Spain*⁵*Institut Mediterrani d'Estudis Avançats, Carrer Miquel Marquès, 21, 07190 Esporles, Illes Balears, Spain***Abstract**

In a two-dimensional world, with depth and cross-shore distance as the only spatial axes, coastal upwelling responds quite fast to the along-shore sea-surface winds, on time scales of the order of hours to days. This is the reason why coastal upwelling indices, used to predict the intensity of upwelling at some coastal location, are often calculated in terms of the instantaneous along-shore local winds, i.e. the Bakun (1973) index and some of its variations simply assess the intensity of cross-shore Ekman transport. This approach ignores along-shore pressure gradients, internal friction and, most important for our analysis, the advection of upstream momentum.

In this work we first examine under which circumstances, and how much, the upstream momentum can play a role similar to the along-shore wind stress in the sustainment of coastal upwelling. The key condition for the maintenance of upwelling beyond the wind intermittency turns out to be the advective temporal scale (related to the spatial coherence of the wind), which has to be longer than the local temporal scale, i.e. the spatial coherence of the along-shore coastal jet is capable of replacing the temporal intermittency of the cross-shore Ekman transport.

Second, we apply these ideas to the coastal upwelling region off NW Africa. For this purpose we use time series of sea-surface temperature (SST) differences (between the coast and offshore regions) and coastal winds. We calculate the temporal and spatial auto-correlations for the wind and SST differences, and the cross-correlations between both variables. It turns out that off NW Africa the advective time scale is often longer than the local temporal scale, which brings a characteristic temporal memory of the order of 1-2 months.

Finally, we define a cumulative upwelling index as the integration of past cross-shore Ekman transports over a time scale which brings the maximum correlation with the SST differences. This time scale, consistent with the time scale for maximum cross-correlations between SST differences and local Ekman transport, is the temporal memory of the upwelling system.

References

Bakun, A. (1973) Coastal Upwelling Indices, West Coast of North America, 1946–1971, U.S. Department of Commerce, NOAA Technical Report NMFS–SSRF–671.