NORTH ADRIATIC WINDS AND THE RESIDUAL CURRENTS IN THE INLETS OF THE VENICE LAGOON

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Abstract
The principal components of the wind measured in front of the Venice lagoon are related to the variability of the residual flow in the inlets connecting the lagoon with the Adriatic sea. Lido and Chioggia inlets have an exponential response to the Principal component of the wind (PC1); while the second component (PC2) affects only the Chioggia inlet in a linear way. Thus, during Bora events (detected mainly in PC1 series), the inflow through Lido channel is reinforced as well as the outflowing in Chioggia. On the other hand, Sirocco events (detected in the PC2 series) slow down the outflowing in Chioggia.

Keywords: Adriatic Sea, Currents, Time Series, Wind/Font

Introduction.
Current velocities are monitored in the three inlets, i.e., Lido, Malamocco and Chioggia, connecting the Venice lagoon with the Adriatic Sea. They are relatively narrow and shallow thus making the flow highly polarized along the channel axis, and barotropic. Therefore, analyses carried out on the vertical averages of along-channel components (obtained via Principal Component analysis) can be considered fairly accurate. It is well documented [1] that the astronomic tides account for most of the energy of the current flow, so that more than 90% of the energy can be removed via Harmonic Analysis. Still, an important portion of energy coming from the open sea and atmospheric forcing is evident in the non-tidal component. A quantification of the wind effect on the current velocities is attempted by removing the energy of seiche oscillations and decomposing the wind into its principal components.

Adriatic Seiches and Wind Decomposition
A translation-invariant Wavelet transform was applied to the de-tided vertically-averaged current series in order to decompose the variance on a scale-by-scale basis. It was found that the main portion of energy was in the scales containing the main Adriatic seiche modes of 11 and 22 hours. An additional free oscillation with periodicity of 4.87 hours was also detected. Seiche signals were removed by fitting the corresponding wavelet scales to the de-tided time series. The 88% of non tidal variability in Lido, 92% in Malamocco and 85% in Chioggia were thus removed, leaving the residual time series ready for comparison with the wind vector time series.

Winds were decomposed by Principal Component Analysis. The main axis of variance (PC1) is aligned with the strongest wind in the area, i.e., Bora; while the second component (PC2) is aligned mostly with the Sirocco direction of blowing. Since the principal components are independent up to 2nd order statistics [2], correlations were computed separately between the wind components and the residual currents time series.

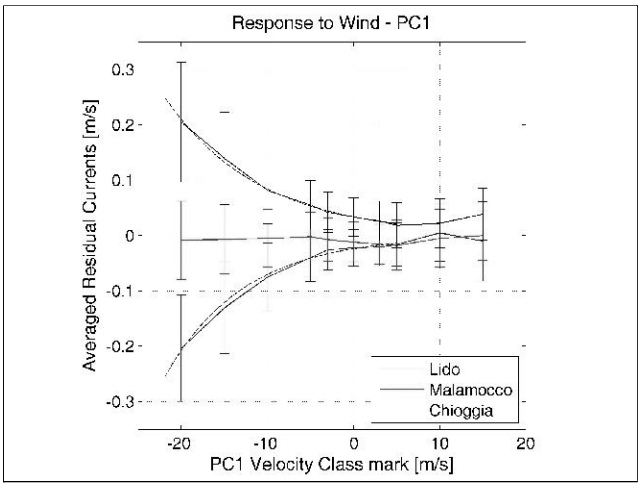

Fig. 1. Exponential response of residual currents in Lido (lower side) and Chioggia (upper side) to PC1 wind velocity classes. Dashed lines show the model fitted to the data. The negative region in PC1 is where actual Bora events are detected. Positive currents mean outflowing from the lagoon.

Results
Overall linear correlation between residual currents is low, on the order of 0,4 in magnitude; but they increase until 0,7 in absolute values during specific events of Bora and Sirocco blowing. The connection is specifically stronger between PC1 and Lido as well as PC1 and Chioggia, but in opposite sense: a Bora event would lead to a stronger inflow of water through the northern Lido channel but reinforcing the out flowing through Chioggia channel in the southern part of the lagoon, with Malamocco showing no significant response at all. Chioggia inlet flow shows also a response to PC2 winds, especially during Sirocco event which slows down the residual out flowing in the inlet. A partition of wind components were done, defining a calm state between -3m/s and 3m/s. Other partition limits being +/-5m/s, +/-10m/s, +/-15m/s and +/-20 m/s. Thus, the effect of PC1 is studied while forcing a calm state on PC2; conversely, PC1 is conditioned to the calm state to study the PC2 effects. It has been found that the flow of Lido and Chioggia inlets has an exponential response to the PC1 wind velocity classes with exponential rates of b = -0,1 following the model Y = A.exp(b.PC1) where A is -0,021 for Lido and 0,033 for Chioggia (Fig. 1). Likewise, the response of Chioggia to PC2 wind velocity classes has a linear fashion Y = a.PC2 + b with a = -0,0036 and b = 0,03844 (Fig. 2). The explained variance is over 96% in each case.

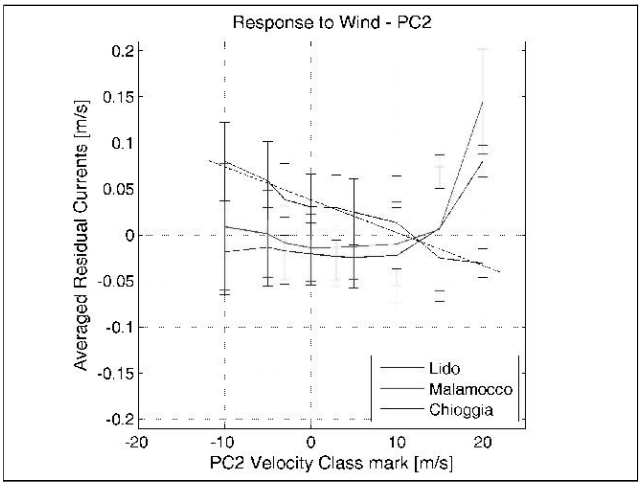

Fig. 2. Linear response of Chioggia residual flow to PC2 wind velocity classes. Dashed line shows the model fitted to data. Lido and Malamocco show no response until PC2 reaches a 15m/s or higher velocity, when the residual flow in Chioggia inlet change its sign. The positive region in PC2 is where actual Sirocco events are detected.

References
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