Towards a meteotsunami warning system along the U.S. coastline (TMEWS)

Estimation of the parameters of the atmospheric disturbances during Boothbay event (2008) based on the analysis of the wind data at meteobuoys

Preliminary report

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5 meteobuoys in the vicinity of the Boothbay, A01, B01, C02, E01 and F01, were used in the analysis. Boothbay is located between buoys C02 and E01. There are 3 more buoys in the area: I01, m01 and N01, however, all of them are to the north-east from the area, I found they are less interesting for us.

Figure 1 shows area of interest and locations of the buoys. The pressure records (Figure 2, bottom panel) are not very impressive. Probably, 10 min temporal resolution is not enough to resolve atmospheric disturbances for such event. Wind direction records, however, (Figure 2, upper panel) is much more interesting. On all records we can clearly see sharp change in the wind direction, the changes are around the time of the event (around 1900Z), and there are clear time lags between these changes at different locations, starting at southwest (point A01) and ending at northeast (point F01).
Let mark the times t_i (i=1,2..5) when direction of the wind is changing sharply (say, crossing the line 140°). Let assume that the front of the wins change (front of squall) is moving with a constant speed, i.e.

$$t = ax + by + c;$$

Where *a* and *b* a components of so called "slowness" vector ***d.*** To estimate slowness, (and thus, estimate phase speed of the squall propagation) we will use least-square method, minimized the error

$$e = \sum_1^5 (t - t_i)^2 = \sum_1^5 (ax_i + by_i + c - t_i)^2 \Rightarrow \min,$$

which, in turn, will let to the system of linear equations. The linear system will essentially simplified in the principal (rotated) coordinates x' y' such as cross-variance is zero. ,

$$\sum_{i=1}^5 x_i' y_i' = 0 \qquad (3)$$

Figure 3 demonstrates such rotated system for the current set of stations, the angle α is about 39.7°. It is clear that stations are located almost along the principal Y axis, thus the results will be much less error along this axis than along the principal axis X.

Because of (3), the linear system is simplified into 2 one-dimensional equations. Along Y axis data nearly linear depends on the distance (see figure 4), the regression coefficient is *b*=0.0445 s/m (phase velocity 22.5 m/s). The coefficient a is poorly defined, here we got *a*=-0.0356 s/m (phase velocity 28 m/s). Combined vector is directed almost to the north, the velocity is about 17 m/s.

Figure 5 illustrates the results for the estimating of the slowness vector as well as error ellipse. The error in Y direction is relatively small, it is 0.0151 s/m (it means that the component of the vector in Y direction is

$$b = 0.0455 \pm 0.0151 \ \ (s/m)$$

In X direction, however, the error is in order bigger than the value itself, i.e.

$a = -0.0356 \pm 0.361 \ \ (s/m)$

So, the value *a* is poorly estimated. It cannot be done by data itself but should use some additional independent information, such as satellite images etc. One of the options is using the direction of the wind itself, which roughly shows the direction of the propagation. At all station the wind directed toward the north. If the disturbances propagate in the same direction, the above estimation of the X component of the slowness vector was nearly true and final result will be propagation speed 17 m/s. If the direction of the disturbance is toward northeast (say, azimuth is 40° true), the propagation speed will be 22.5 m/s

Table. Coordinates of the buoys used in the report.

Name	Latitude	Longitude
A01	42° 31.36'N	70° 33.92'W
B01	43° 10.80'N	70° 25.63'W
C02	43° 34.06'N	70° 03.50'W
E01	43° 42.86'N	69° 21.31'W
F01	44° 03.25'N	68° 59.87'W

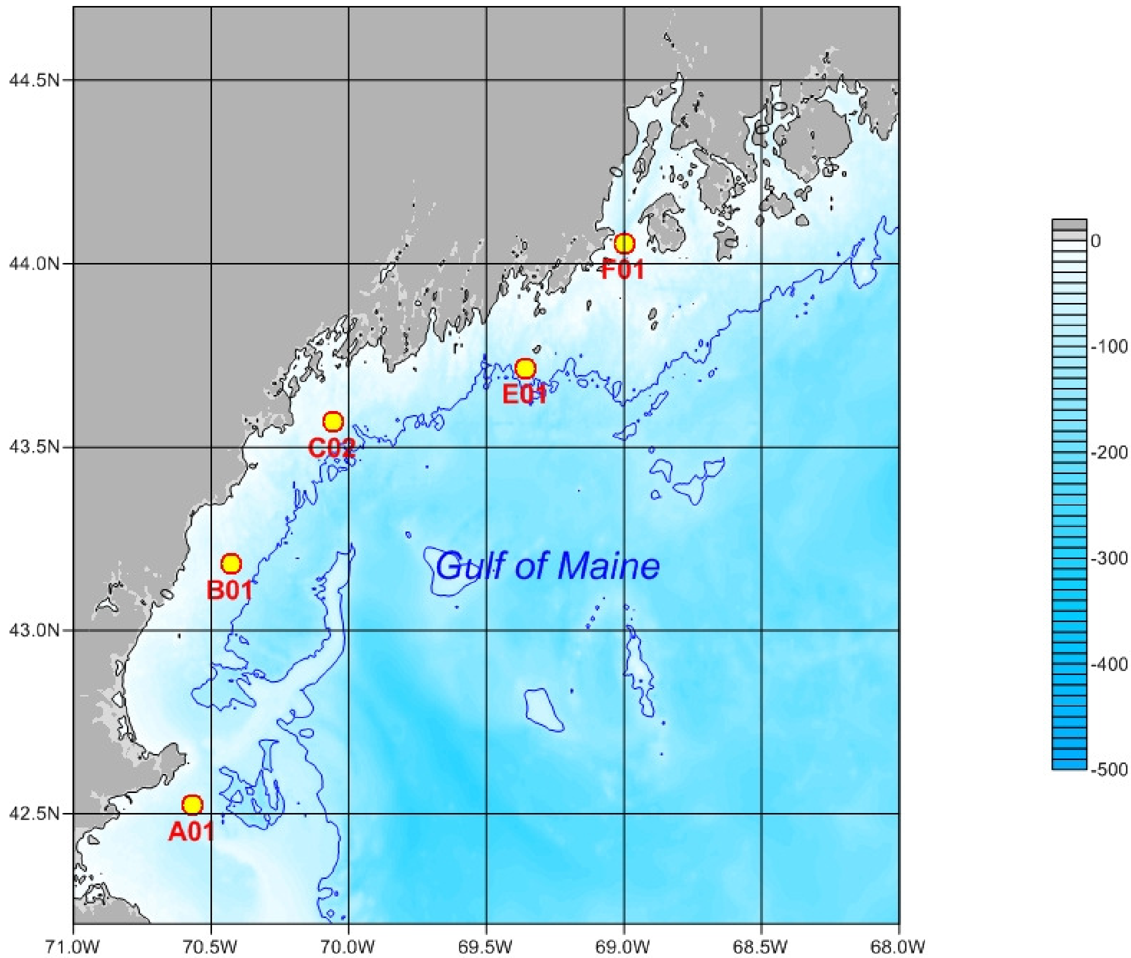

Figure 1. Positions of the meteobuoys A01, B01, C02, E01 and F01

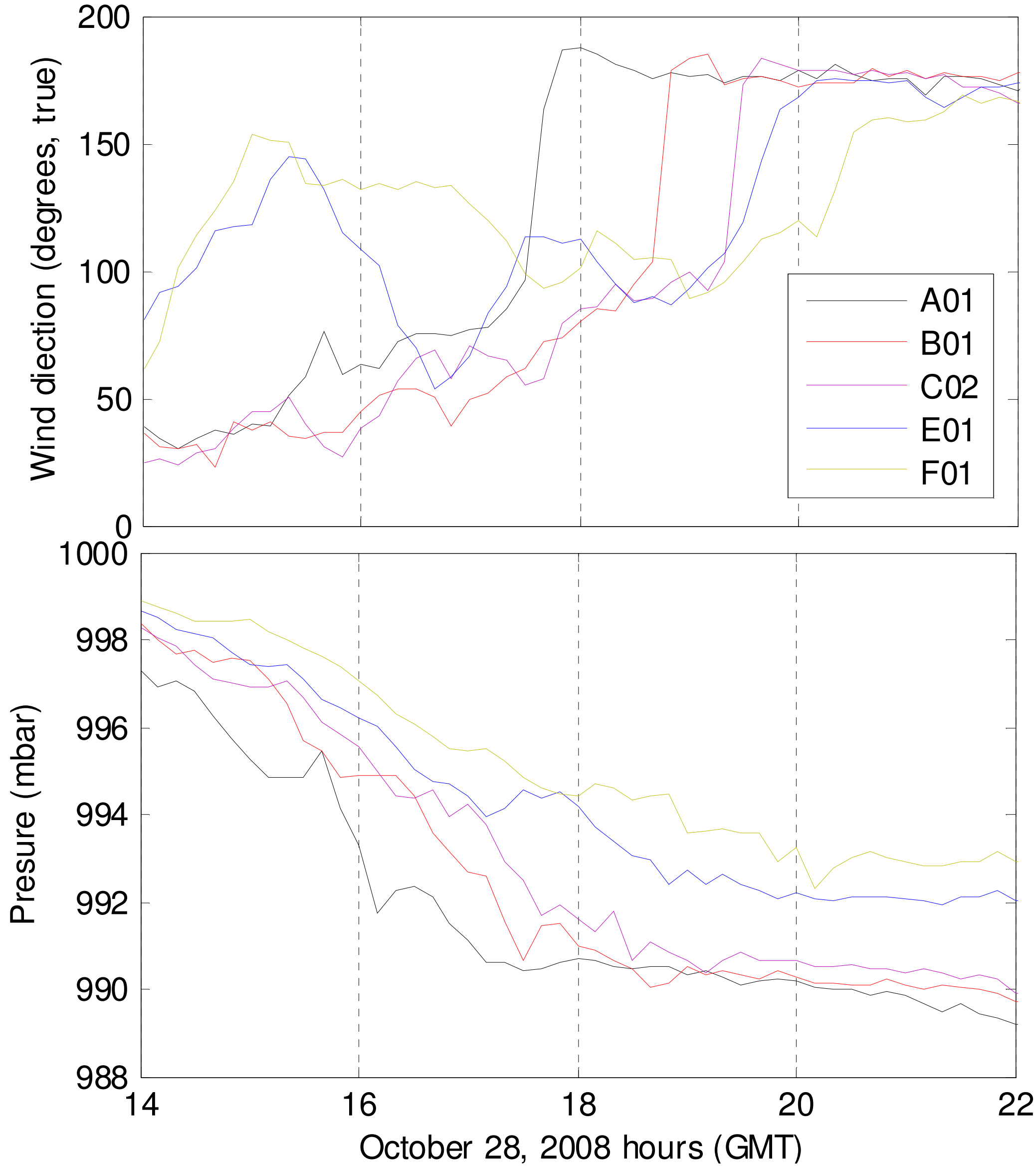

Figure 2. Wind direction records (upper panel) and atmospheric pressure records (bottom panel) at buoys A01, B01, C02, E01 and F01 on October 28, 2008.

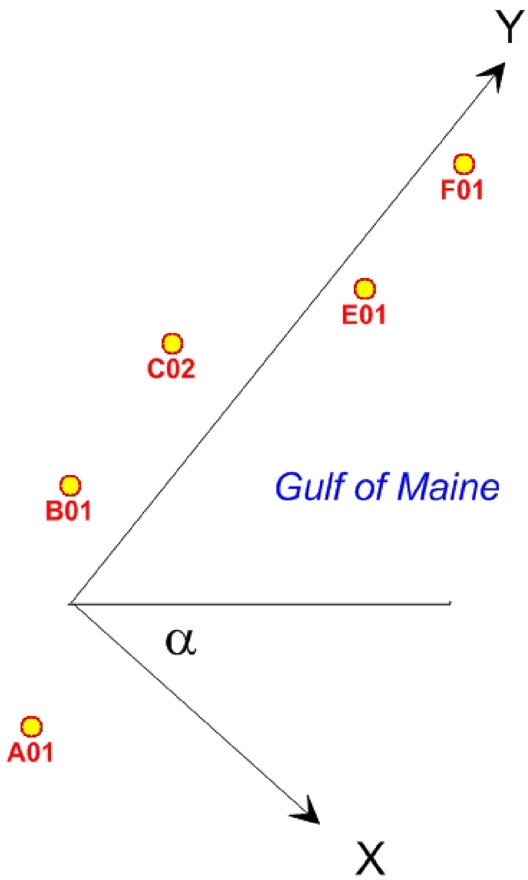

Figure 3. Principal axes of the set of the buoys.

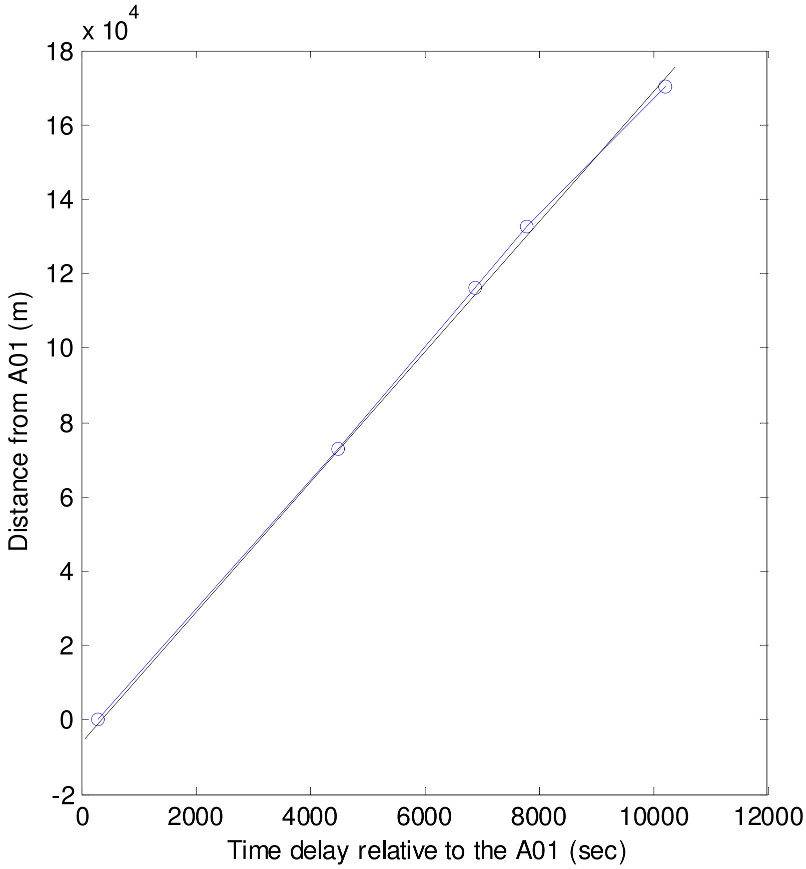

Figure 4. Distance along Y-axis versus time delay for the wind events at October 28, 2008.

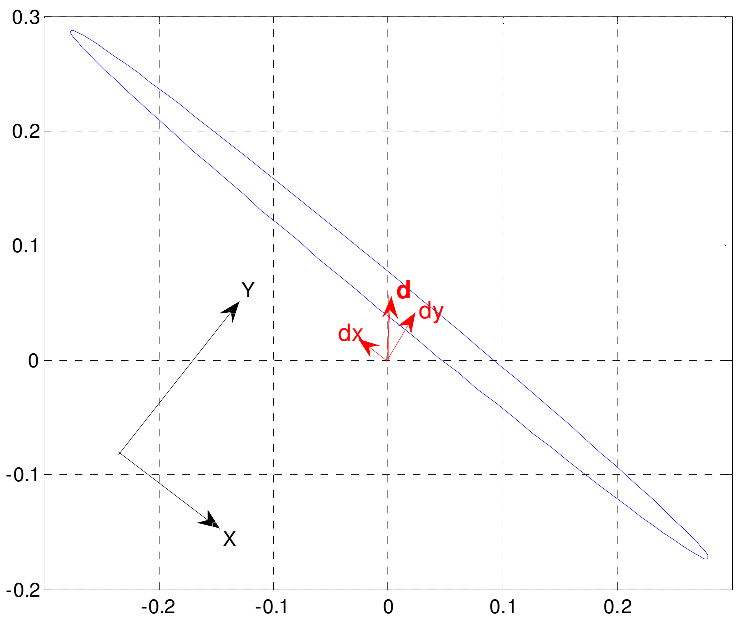

Figure 5. Slowness vector and error ellipse of the vector (95% confidence interval)