JP4.5 COMPARISON OF MESOETA WIND FORECASTS WITH TCOON MEASUREMENTS ALONG THE COAST OF TEXAS

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1. INTRODUCTION

Accurate water level forecasts are important for a number of industries including shipping, oil and gas, tourism, and fisheries. While astronomical forcing (tides) is well tabulated, it is often meteorological factors that drive water level changes along the Gulf coast. Their impact on water level is sometimes larger then the tidal range (Cox et al., 2002) yet these factors are presently unaccounted for. The National Oceanic and Atmospheric Administration (NOAA) stated that “presently published predictions do not meet working standards” when assessing the performance of current predictions, a parameter closely related to water levels, for regular weather conditions in Aransas Pass and Corpus Christi Bay (NOAA, 1991, NOAA, 1994). A prototype model based on the use of Artificial Neural Networks (ANN) (Tissot et al., 2002) is presently developed at Texas A&M University-Corpus Christi (TAMUCC) Conrad Blucher Institute (CBI) in collaboration with the Corpus Christi National Weather Service (CCNWS) Office. The model takes into account weather forcing and produces short to medium term up to 48 hours water level forecasts. Inputs to the model include recent measurements of water levels, wind speeds, wind directions, and barometric pressures collected by the Texas Coastal Ocean Observation Network (TCOON), which consists of approximately 60 weather platforms from Brownsville to the Louisiana border (Michaud et al., 2001). Another important input to the model is a set of weather forecasts including forecasted wind speeds and wind directions extracted from the National Center for Environmental Predictions (NCEP) MesoEta model. The model was tested successfully in hind-cast mode while replacing the wind forecasts by previous wind measurements (Cox et al., 2001, Tissot et al., 2002).

In the operational version of the model historical wind measurements will be replaced by actual wind forecasts extracted from the NCEP MesoEta model. Overall a good agreement is expected between MesoEta forecasts and observed measurements for most inland and gulf locations. The presence of sea breezes could lead to larger differences between forecasted and measured winds along the coastline. Other factors such as the height of the wind sensors and their specific locations could have an effect on the wind measurements leading to systematic biases between the wind forecasts and the wind measurements. The goal of this work is to compare NCEP wind forecasts and TCOON wind measurements along and across the Texas coastline and assess the impact of the potential differences for our water level forecasting model.

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2. NCEP MESOETA MODEL WIND FORECASTS

The NOAA NCEP/Environmental Modeling Center (EMC) developed the Eta-12 model (herein the Eta), which is a limited-area, numerical atmospheric model. It integrates the primitive hydrostatic equations in three dimensions. The resolution is 12 km in the horizontal with 60 layers in the vertical. The domain is 106 x 80 of latitude x longitude, centered over the central United States. Each Eta forecast model run is initialized by the Eta Data Assimilation System (EDAS), a continuous process whereby short-term (3-hour) Eta runs are performed within a longer pre-forecast data assimilation period. At the end of each short-term run, the 3-Dimensional Variational Analysis (3DVAR) (Parrish et al., 1996) technique is used to create an analysis. EDAS is fully cycled, thus atmospheric variables (temperature, wind, moisture), soil parameters, turbulent kinetic energy, and cloud water are obtained from the analysis of the previous EDAS.

Each day, NCEP conducts four separate EDAS/Eta modeling system runs. For each run, the output is transmitted to National Weather Service (NWS) Weather Forecast Offices (WFOs) via the AWIPS (Advanced Weather Interactive Processing System) Satellite Broadcast Network (SBN), in the GRIB (GRIdded Binary) file format. This GRIB model data is then written into netCDF-formatted files where the data is also mapped into several numeric grids of varying spatial resolution and domain size. Every six hours surface data is sent to TAMUCC-CBI from the netCDF files containing Eta output mapped to AWIPS Grid 215 (Dey, 1998) with a horizontal grid spacing of 20 km. Eta surface output contained on grid 215 is referred to as the “MesoEta” output. A set of about 40 locations on the Gulf coast, in the Gulf of Mexico and inland were selected. The locations of the selected stations are displayed in Figure 5. 10-meter MesoEta forecasts are used as the inputs to the ANN based water level forecasting model.

3. RESULTS

To compare forecasted and measured winds a set of TCOON stations was selected. The stations are located along the Texas gulf coast from Louisiana to the Mexican border. These stations, from north to south, are Mesquite Point, Galveston Pleasure Pier, Port Aransas, NAS-Corpus Christi, Bob Hall Pier, Baffin Bay, and Port Isabel. These stations are directly on the coast or are a few miles inland. The NWSWX1 station, 17 miles offshore from Port Aransas, was also selected.

For each station the forecasted and measured winds were compared. The comparison is illustrated for Bob Hall Pier in Figure 1.

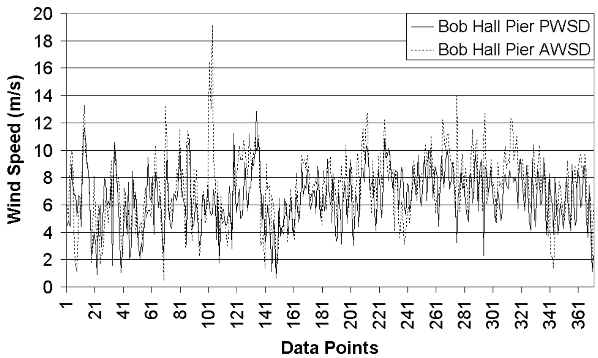

Figure 1. Comparison of predicted (___) and measured wind speeds (…) for 33 hours forecasts at Bob Hall Pier, Texas, located near Corpus Christi, Texas for the period of February 27, 2002 to June 6, 2002.

The difference between the predicted and forecasted winds is presented in Figure 2 for the Bob Hall Pier Station. In Figure 3 the difference between forecasted and measured wind speeds is plotted for the selected TCOON stations along the Gulf coast while in Figure 4, the standard deviation of the wind speed differences is presented.

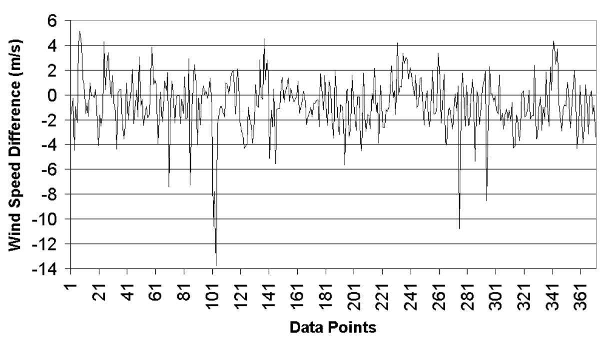

Figure 2. Difference between predicted and measured wind speeds for 33 hours forecasts at Bob Hall Pier, Texas, located near Corpus Christi, Texas for the period of February 27, 2002 to June 6, 2002.

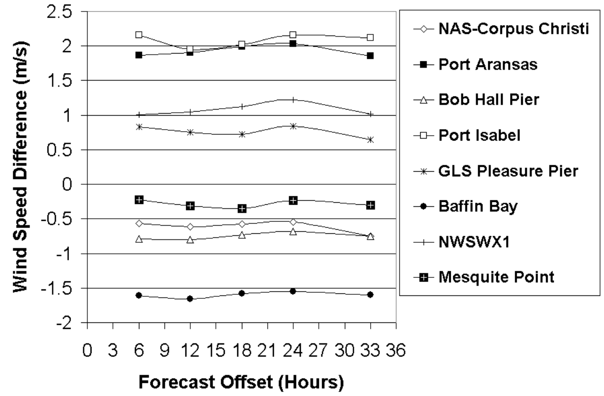

Figure 3. Average differences between predicted and measured wind speeds for the selected TCOON stations over the period of February 27, 2002 to June 6, 2002 with forecast times of 6 hours, 12 hours, 18 hours, 24 hours and 33 hours.

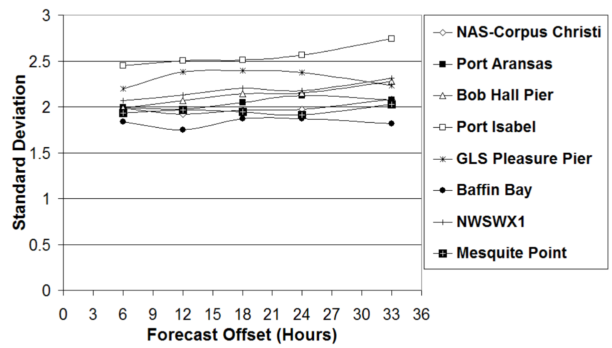

Figure 4. Standard deviation of the average differences between predicted and measured wind speeds for the selected TCOON stations over the period of February 27, 2002 to June 6, 2002 with forecast times of 6 hours, 12 hours, 18 hours, 24 hours and 33 hours.

4. DISCUSSION

Archetypal variations in the difference between forecasted and measured winds are illustrated in figures 1 and 2. For the Bob Hall Pier Station, the difference typically varies between –4 m/s and + 3 m/s. On average the forecasted winds are 0.8 m/s lower than the measured winds for this station. Figure 2 highlights several short events during which the forecasted winds are significantly smaller then the measured winds. These differences are mostly associated with frontal passages occurring regularly during winter and spring. For example the two largest differences take place on March 30th (data point 103) and May 18th (data point 275). In both cases the difference between forecasted and measured winds is due to the development of strong thunderstorms ahead of a frontal passage. As mesoscale convective flows are not explicitly captured by the MesoEta model such events will expectedly result in significant forecasting errors.

The differences between forecasted and measured winds for the other stations are illustrated in Figure 3. As can be observed the forecasted wind speeds systematically under-predict or over-predict the measured wind speeds for the different stations. The size and sign of this bias does not change significantly as the forecast time increases from 6 hours up to 33 hours and varies between –1.7 m/s and 2.2 m/s. The fact that the forecasting error does not change significantly with forecasting time could be due to the nature of the MesoEta model. The largest differences between forecasted and measured winds take place during mesoscale events such as thunderstorms. As these events are not captured specifically by the MesoEta model, the forecasting error does not appear to change significantly from 6 hour forecasts to 33 hour forecasts. Further studies using larger data sets should allow for a better understanding of the variation of the model accuracy with forecasting time.

There does not appear to be a correlation between the geographic location of the stations and the sign and size of the forecasting bias. Because their intensity increases as one moves southward along the coast, sea breezes are not likely a major factor in determining the bias between forecasted and measured wind speeds for a particular station. The height of the wind sensors is typically at NOAA standards, i.e. at or near 10 m +/- 1m. Two of the stations studied here, Baffin Bay and Mesquite Point, have their wind sensors at about 8 m, i.e. lower then the standard 10 m +/- 1m. One station, Galveston Pleasure Pier, has its sensor higher then the standard 10 m +/- 1 m. There does not appear to be a correlation between the height of the sensors and the size and sign of the bias between forecasts and measurements. No correlation can be found either between the bias and how far inland the stations are located. The difference between forecasted and measured winds is therefore likely due to other factors such as the particularities of the site and the model itself. As the biases at each station are well defined they do not represent a problem for the integration of the wind forecasts into the water level forecasting model. The forecasts or the measurements will simply be modified using the respective biases for each station before being used in the ANN model.

The standard deviation of the difference between forecasted and measured wind speeds is displayed in Figure 4. The standard deviation is similar for all stations: between 1.8 m/s and 2.7 m/s. Baffin Bay has the smallest average standard deviation while Port Isabel has the largest overall standard deviation. The standard deviation increases with forecasting time for the majority of the stations although not for all stations. It should be noted that the number of comparisons, at least 300 data points, although large enough to compare trends in the difference between predicted and measured wind speeds is likely not sufficient for a precise determination of the standard deviation for each forecasting time.

5. CONCLUSION

Wind speeds forecasted by NCEP MesoEta model were compared with measured wind speeds at a set of TCOON monitoring stations. It was found that the agreement between predicted and measured wind speeds varied depending on the stations and was characterized by a systematic bias. The standard deviation of the wind speed differences was found to be similar for most stations and to increase with time for the majority of the stations. The respective bias measured for the different stations will be taken into account when using the forecasts within the ANN-based model developed to forecast water levels along the Texas coast. The consistency of the bias and the relatively small standard deviation should allow for a straightforward integration of the NCEP MesoEta forecasts into the ANN water level forecasting model.

6. ACKNOWLEGEMENTS

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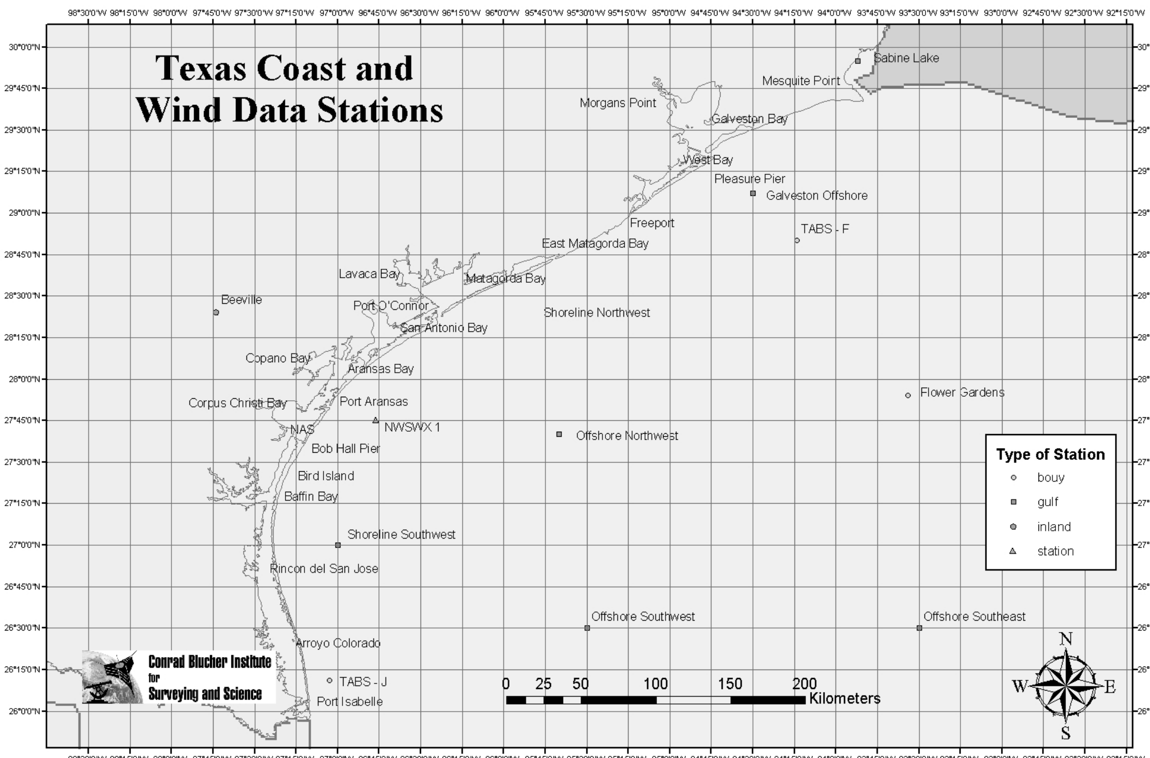

Figure 5. Locations for which MesoEta forecasts are extracted by CCNWS and sent to TAMUCC-CBI to be part of the input to the ANN model forecasting future water levels.