5.2 AN EXPERIMENTAL REAL-TIME INTRA-AMERICAS SEA OCEAN NOWCAST/FORECAST SYSTEM FOR COASTAL PREDICTION

Dong S. Ko*, Ruth H. Preller, and Paul J. Martin
Naval Research Laboratory, Stennis Space Center, Mississippi

1. INTRODUCTION

An experimental real-time ocean nowcast/ forecast system has been developed at the Naval Research Laboratory for the Intra-Americas Sea (Intra-Americas Sea Ocean Nowcast/Forecast System or IASNFS). The IASNFS extends from 55°W to 98°W and from 6°N to 31°N and includes the Caribbean Sea, the Gulf of Mexico, the Straits of Florida, and part of the western North Atlantic Ocean (Fig. 1).

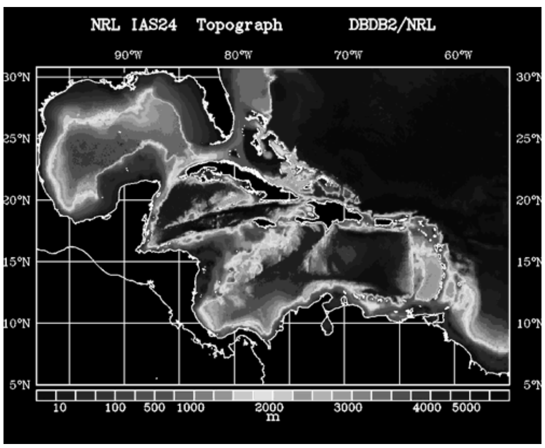

Figure 1. The IASNFS covers the Caribbean Sea, Gulf of Mexico, and Straits of Florida. The model topography comes from NRL DBDB2, a 2-minute digital bathymetry data base.

The system is driven by the U.S. Navy's global atmospheric model, the Navy Operational Global Atmospheric Prediction System (NOGAPS) (Rosmond, 1992). Each day the IASNFS produces a nowcast and a 72-hour forecast of sea level variation, 3-D ocean currents, temperature, and salinity.

For coastal prediction, sea level variation is a major concern. This paper focuses on the IASNFS nowcast/forecast skill for coastal sea level by evaluating the model predicted sea level against NOAA National Ocean Service coastal tide gauge measurements.

Corresponding author address: Dong S. Ko, Naval Research Laboratory. Code 7322, Stennis Space Center, MS 39529; e-mail: ko@nrlssc.navy.mil

2. SYSTEM COMPONENTS

The Intra-Americas Sea Ocean Nowcast/ Forecast System consists a 1/24° (5-6 km), 41-level, data-assimilating ocean model based on the Navy Coastal Ocean Model (NCOM) (Martin, 2000). To generate the daily nowcast, a 72-hour hindcast is performed that is restarted from the previous days nowcast minus 48 hours. The reason for dropping back 48 hours before the previous days nowcast is to allow for data that has been late in arriving.

During the nowcast, the ocean model continuously assimilates the three-dimensional ocean temperature/salinity analyses produced by a statistical data analysis model, the Modular Ocean Data Assimilation System (MODAS) (Carnes *et al.*, 1998). An incremental adjustment scheme with a vertical weighting estimated from the relative errors of the model and the analysis is applied for the data assimilation. Real-time satellite altimeter (GFO, Jason-1, ERS-2) sea surface height anomaly data as well as AVHRR sea surface temperature data are used by MODAS to generate the three-dimensional temperature and salinity analyses.

Three-hourly NOGAPS nowcast/forecast surface wind stress, sea level air pressure, solar radiation, and surface heat fluxes are applied for surface forcing. For the ocean forecasts, 3-hourly surface fluxes from NOGAPS forecasts are used.

The open boundary conditions (sea surface elevation, temperature, salinity and currents) are provided by the NRL 1/8° global NCOM model. The global NCOM model also provides a 3-5 day forecast of these boundary values each day. A one-way coupling with a nudging layer is used to ingest these boundary conditions into the IAS model. The discharge (monthly climatology) from 53 rivers is included as forcing in the IASNFS.

Once the nowcasts and forecasts are produced, they are distributed through the Internet via web pages that are updated daily (see *http://www7320.nrlssc.navy.mil/IASNFS_WWW/*)

3. GENERAL CIRCULATION

The IASNFS produces a realistic ocean circulation for the major current systems in the Intra-Americas Sea. As demonstrated from the nowcast (Fig. 2 and 3), part of the highly saline

North Atlantic Subtropical Gyre occupies the north-east part of the model domain. The North Equatorial Current enters the model domain near the middle of the eastern boundary. The low salinity North Brazil Current, an extension of the South Equatorial Current, enters the model domain through the southern part of the eastern boundary and carries fresh water from the Amazon River.

Both currents enter the Caribbean Sea through passages along the Antilles and form the Caribbean Current. This current meanders toward the west and often forms large eddy. The current intensifies and turns northward once it reaches the east coast of the Yucatan Peninsula and becomes the Yucatan Current. The Yucatan Current enters the Gulf of Mexico through the Yucatan Strait and forms the Loop Current. Occasionally, a Loop Current Eddy separates from the Loop Current and propagates westward and spins up cyclonic eddies.

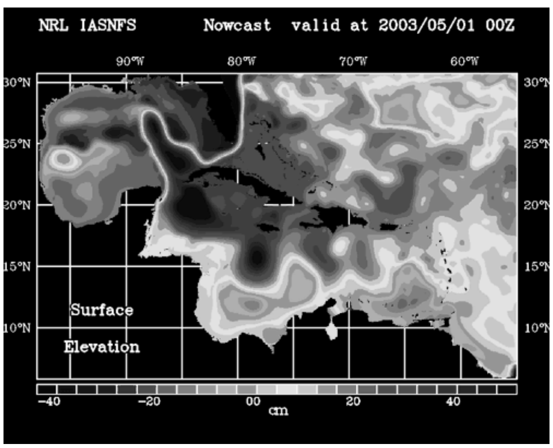

Figure 2. IASNFS nowcast for the sea surface elevation at 2003/05/01 00Z

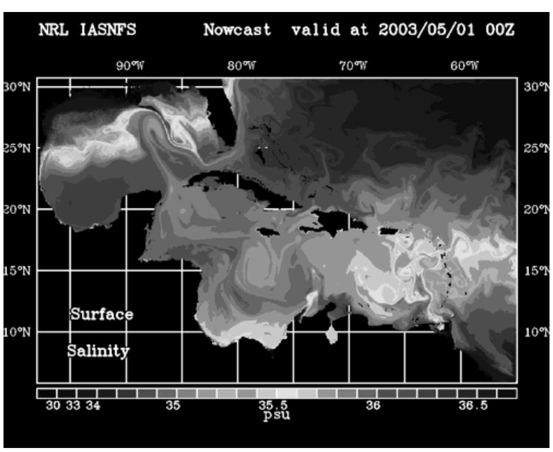

Figure 3. IASNFS nowcast for the sea surface salinity at 2003/05/01 00Z

The low-salinity water in the northern part of the Gulf of Mexico is due to the large Mississippi River discharge. The high-salinity water found in the south-west part of the Gulf of Mexico is the result of a high evaporation rate. The Loop Current exits the Gulf of Mexico through the Straits of Florida as the Florida Current and becomes the Gulf Stream once it reaches the Atlantic Ocean and joins with the Antilles Current.

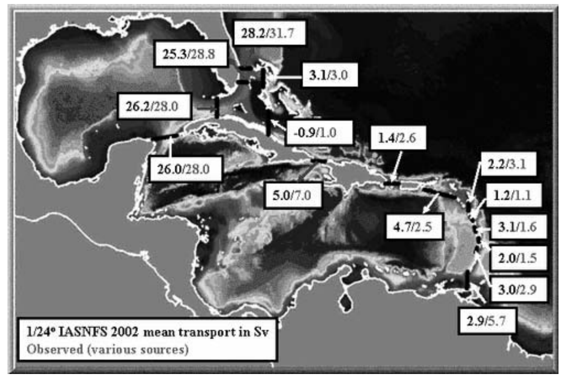

Figure 4. A yearlong (2002) average volume transport produced by IASNFS compared with observations at various locations

This general circulation pattern produced by the IASNFS can be further verified by comparison of the model transports through key straits and passages with estimates from observations. A comparison of the yearlong average transports of the IASNFS current systems to the observations at various locations (Fig. 4) indicates that the IASNFS produces reasonable estimates of the flow in the region.

4. COASTAL SEA LEVEL PREDICTION

A yearlong sea level variation produced by IASNFS was used to evaluate the system. Four NOS/NOAA tide stations along the Northern Gulf Coast and west Florida coast were chosen for the comparison. The tide gauge data are de-tided with a 40-hour low-pass filter and the model sea level data are filtered with the same filter.

For all 4 stations, there is a high correlation between the IASNFS predictions and the measurements (Fig. 5). The storm surges induced by Hurricanes Isidor and Lili during September/October 2002 are well predicted by the IASNFS.

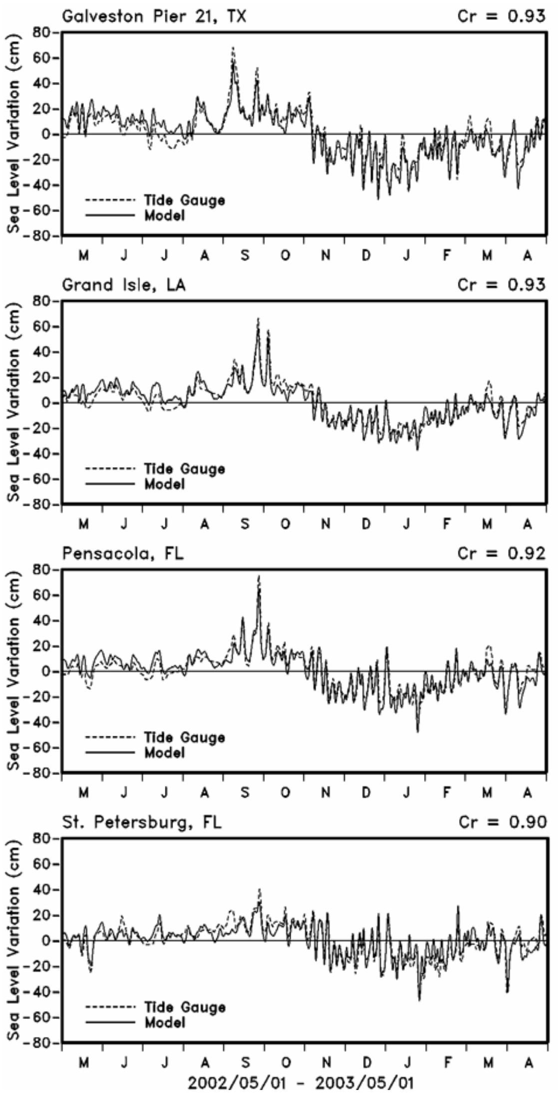

Figure 5. Coastal sea level comparison between IASNFS and NOS/NOAA tide stations. Data are filtered with 40-hr low-pass filter.

The monthly sea level variation shown in Fig. 6 reflects the large-scale wind-induced sea level setup and setdown. It may also reflect the influence from mesoscale eddies or fronts. The IASNFS simulates the seasonal sea level variation very well compared with the tide gauge data.

5. FORECAST SKILL

The IASNFS forecast skill for coastal sea level prediction was evaluated against de-tided tide gauge measurements for a five-month period from December 1, 2002 when the real-time nowcast/forecast was started to May 1, 2003 when the latest measurements are available. The correlation between the forecast and the measurements (Fig. 7) and the root-mean-square (rms) error (Fig. 8) shows that the IASNFS forecast is significantly better than persistence at 72 hours.

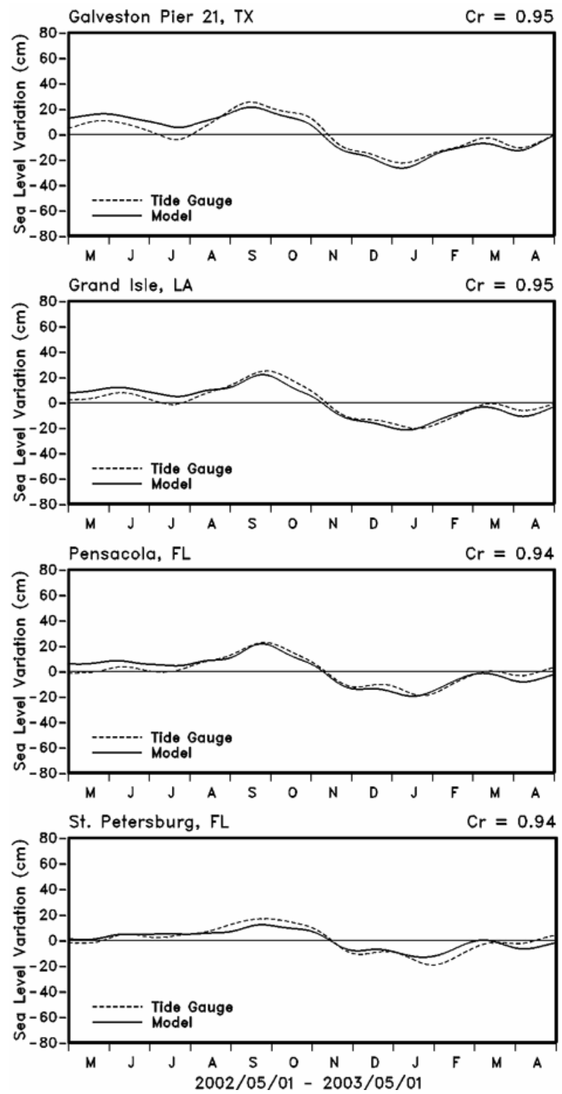

Figure 6. Coastal sea level comparison between IASNFS and NOS/NOAA tide stations. Data are filtered with 30-day low-pass filter.

6. CONCLUSION

A real-time Intra-Americas Sea Ocean Nowcast/Forecast System has been developed and has been in experimental operation at the Naval Research Laboratory since December 1, 2002. The IASNFS produces realistic circulation and sea level variation. In comparisons with tide-gauge measurements at several coastal tidal stations, the nowcast sea level variation shows a strong correlation with the measurements and the forecast sea level shows significant skill over persistence at 72 hours.

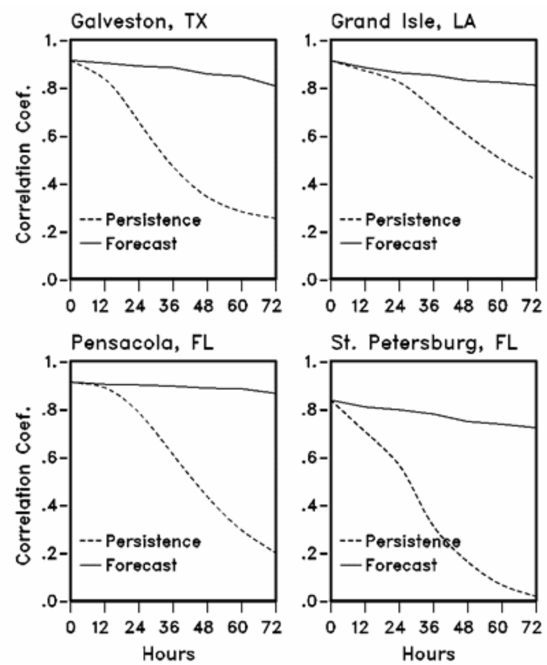

Figure 7. Correlation between forecast sea level and tide gauge measurement

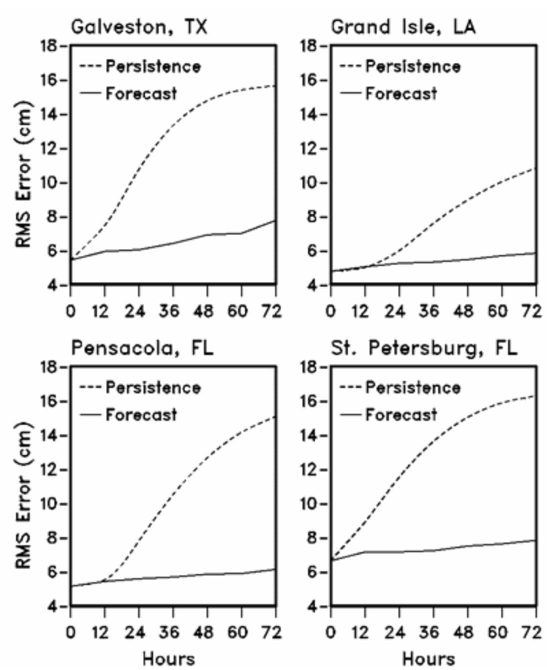

Figure 8. Forecast error compared to persistence error for sea level prediction

7. ACKNOWLEDGEMENTS

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8. REFERENCES

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