NWS's Extra-Tropical Storm Surge (ETSS)-Developing Coastal Inundation Guidance for Extra-Tropical Storm Surge Warnings

H. Liu*, A. Taylor, and C. Belton

NOAA/NWS/OSTI/MDL

36

INTRODUCTION

As part of its mission to save lives and protect property, the National Weather Service (NWS) issues coastal flood watches and warnings for flooding caused by extra-tropical cyclones, events which can produce storm surge and waves on top of the normal tide cycle.

To provide NWS forecasters with guidance for coastal flood watches, the NWS' Meteorological Development Laboratory (MDL) modified the Sea Lake and Overland Surges from Hurricanes (SLOSH) model (Jelesnianski et al. 1992) to predict the impacts of extra-tropical storms. The result was the Extra-Tropical Storm Surge (ETSS) model (Kim et al. 1996), which runs operationally four times daily along the U.S. East, West, Gulf of Mexico and Alaskan Coasts.

Over the last two years, MDL, with Hurricane Sandy Supplemental funding, has been enhancing the ETSS model to meet anticipated requirements for a potential extra-tropical storm surge watch and warning. As of October 2014, ETSS uses 0.5 degree GFS winds and pressure as inputs and creates hourly storm surge guidance out to 96 hours (Taylor et al. 2015). It performs well for both positive and negative surge events (negative surge occurs when strong offshore winds drive water levels below what they normally are at a given time) however; it does not simulate tides, waves, river effects, or overland flooding.

Enhancements

Future NWS coastal flood and storm surge warnings will likely require overland guidance in all US coastal regions. To meet this requirement, MDL made the following enhancements:

1) Nesting the tropical and extra-tropical grids to leverage both the expanse of the large extra-tropical grids and the finer overland details contained within the tropical grids (East Coast and Gulf of Mexico).

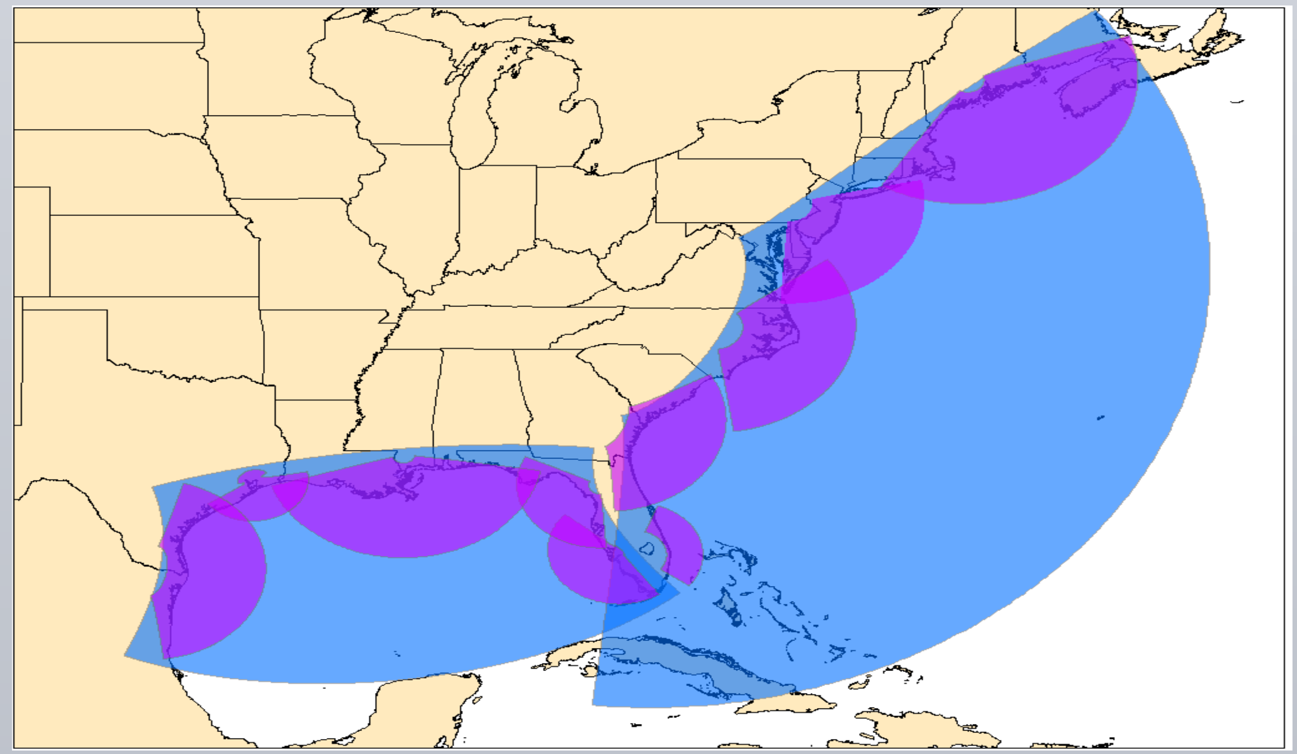


Fig. 1. A sample of the finer overland tropical grids (purple) nested within the coarser extra-tropical grids (blue) in East Coast and Gulf of Mexico.

2) Resolve a performance gap caused by discontinuous water levels between the Bering and Chukchi Seas due to use of separate ETSS basins. NWS is now using a new Bering-Beaufort-Chukchi Sea (eBBC) Alaska basin. The eBBC basin includes updated bathymetry and overland topography

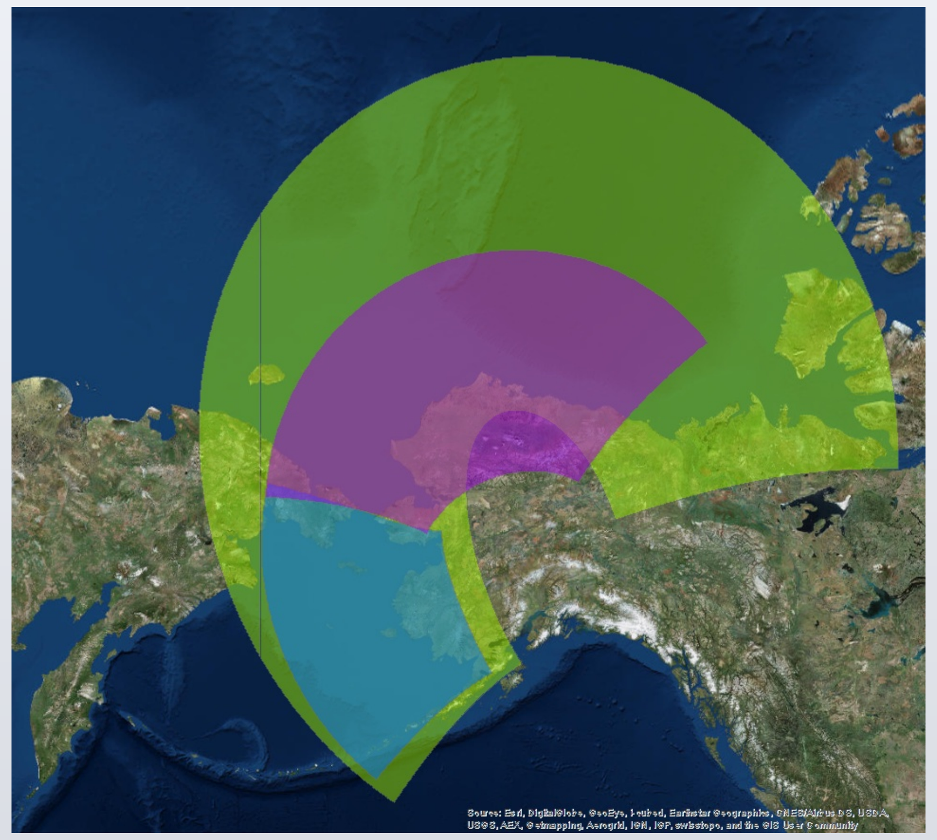


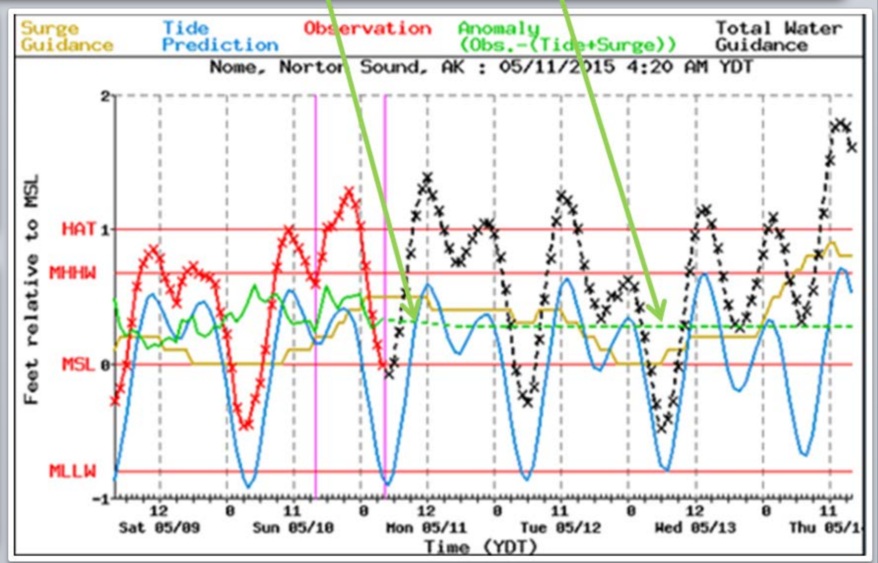
Fig. 2. New eBBC grid (green) and 2 old grids-Arctic grid eOTZ(purple) and Alaska eNOM grid (blue).

3) SHEF-encoded bias-corrected total water level guidance for RFCs to use within the context of AHPS.

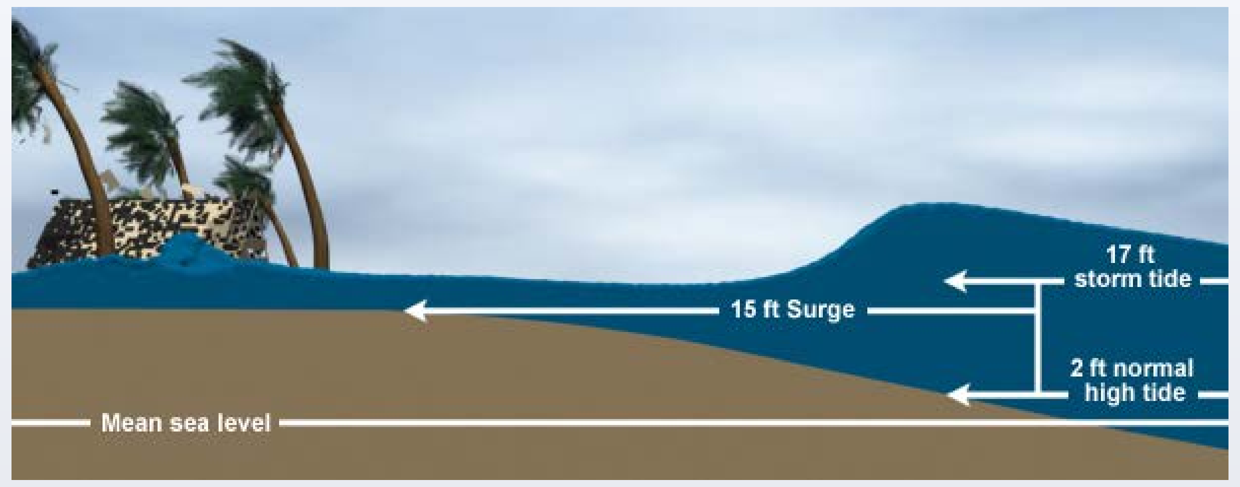
Anomaly(t) = Obs(t) – (Tide(t) + Surge(t))	**Total Water Level(t) = F(t)** + (Tide(t) + Surge(t))
t = hourly 5-day hindcast	t = hourly 96-hour forecast

F(t), for the first 12 hours, is a linear interpolation between Anomaly(t=0) and the 5-day Avg. Anomaly. After that, **F(t)** is the 5-day Avg. Anomaly.

- Use observations to account for model bias, sea level rise, rainfall, wave action, etc.
- ✓ **Goal**: Provide WFOs, and RFCs with total water level guidance at stations via SHEF messages to AWIPS



4) Incorporating a tide algorithm from SLOSH model to allow inundation guidance in all U.S coastlines based on surge and tide. This requires a gridded tidal database in all domains. For the East and Gulf of Mexico, it uses 37 constituents from ADCIRC's EC-2014 grid. For the West coast and Alaska, it uses 13 constituents from Oregon State University's TPXO Global Tidal model



Results

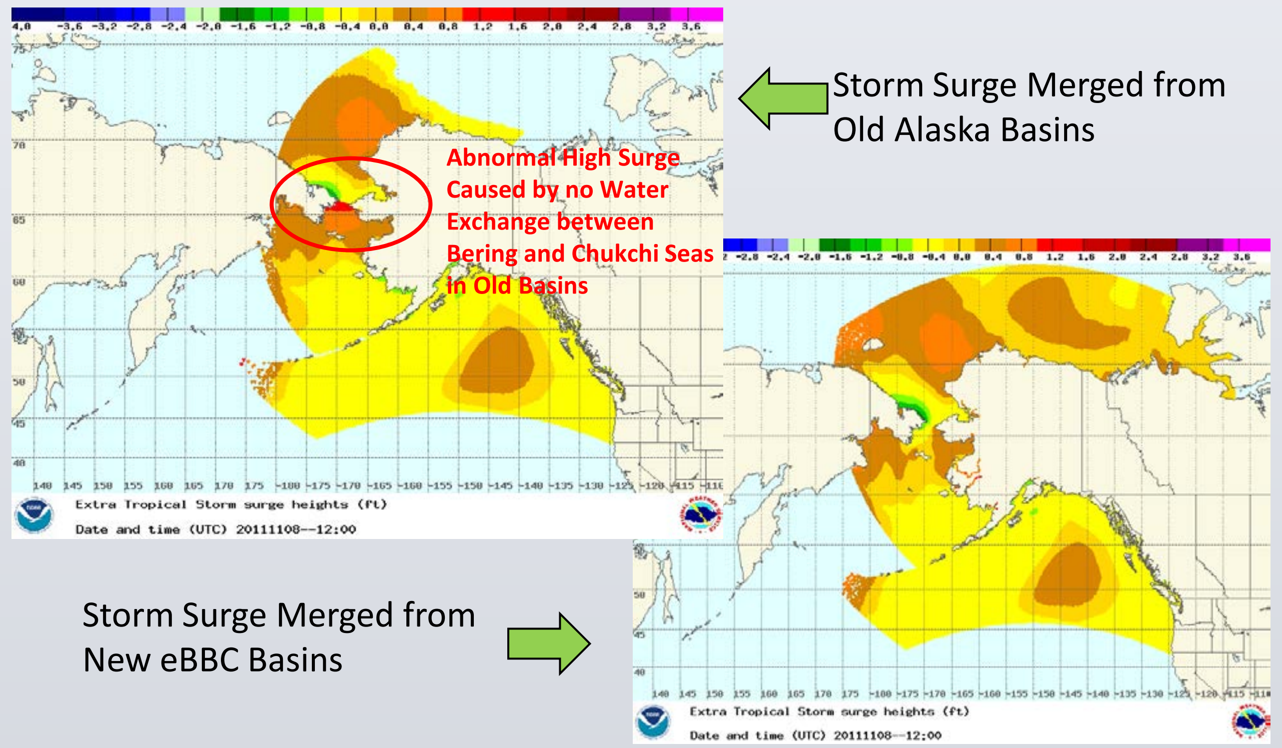


Fig.3. Storm Surge during extra-tropical storm in November of 2011

RMSE	2011 Irene	2012 Sandy	2013 Extra Tropical	2014 Extra Tropical
ETSS	0.67 feet	1.23 feet	0.82 feet	0.78 feet
Enhanced ETSS	0.63 feet	0.99 feet	0.78 feet	0.73 feet

Table-1. The average RMSE over 31 station along the EAST coast

RMSE	NOV 2011	SEP 2012	OCT 2013
ETSS	1.01 feet	0.80 feet	1.28 feet
Enhanced ETSS	0.84 feet	0.63 feet	1.05 feet
Enhanced ETSS with New Wind Drag	0.81 feet	0.56 feet	0.84 feet

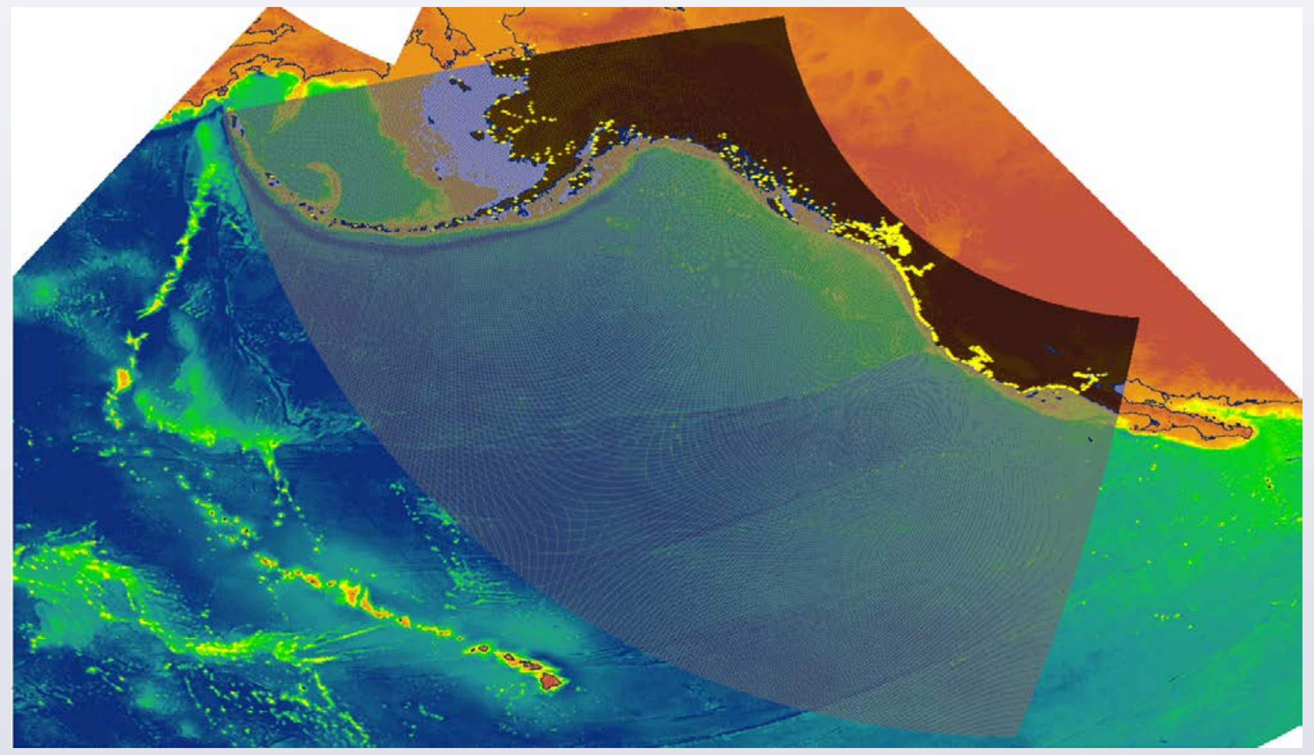
Table-2 The average RMSE over 3 station along the Bering-Beaufort-Chukchi Sea regions

Conclusions

- Nesting the tropical and extra-tropical computational grids to leverage both the expanse of the large extra-tropical grids and the finer overland details contained within tropical grids
- Introducing a tide algorithm and re-introducing the inundation algorithm based on surge plus tide to let simulation more realistic as it considers surge and tide nonlinear interactions and avoids storm surge bounce back from the coastline
- The finer single grid and updated bathymetry and topography allow water to flow between Bering Sea and Chukchi Seas and also allow it to better resolve coastal features

Future Plan

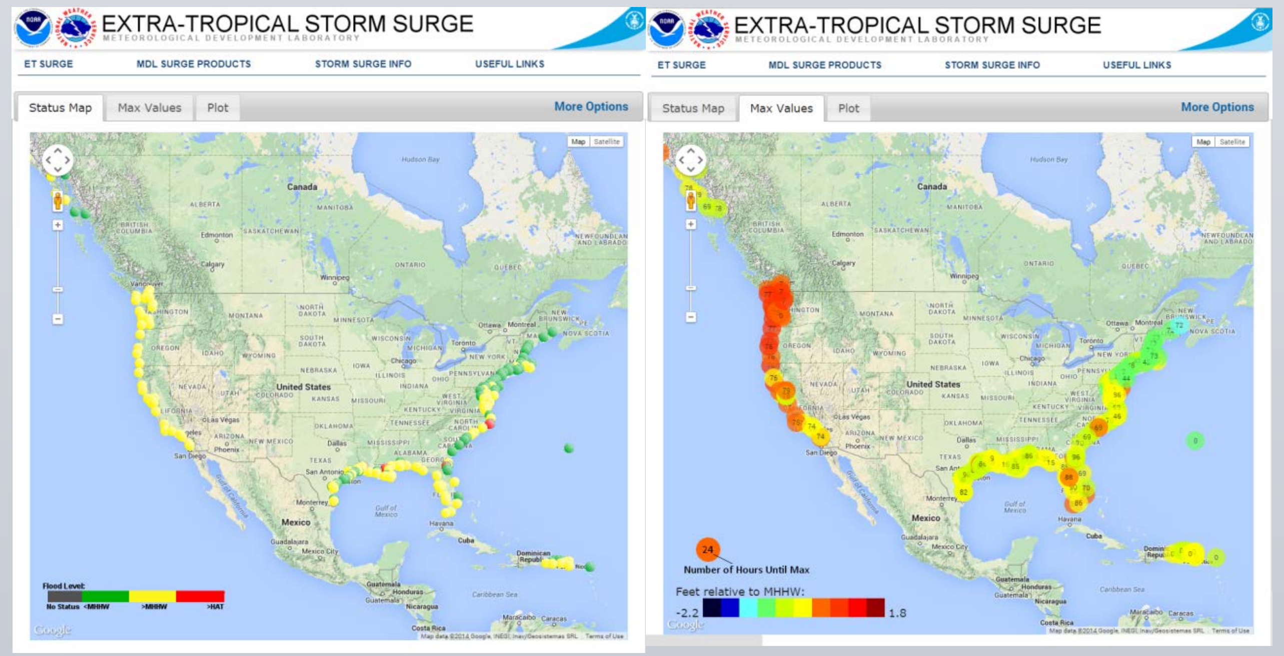
- ETSS2.2 – Merge Gulf of AK and West Coast into one single basin to solve the discontinuous water level at WA state from two basins



- PETSS - Take advantage of GFS (21) ensemble members to create probabilities of storm surge for extratropical systems.

GEFS (21 members) → PETSS → Storm Surge Probabilities Produtcs

- ETSurge 2.0 Website plan



References

Jelesnianski, C. P., J. Chen, and W. A. Shaffer, 1992: SLOSH: Sea, lake, and overland surges from hurricanes. *NOAA Technical Report NWS 48, National Oceanic and Atmospheric Administration, U. S. Department of Commerce*, 71 pp. (Scanning courtesy of NOAA's NOS's Coastal Service's Center).

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*** Huiqing Liu (Huiqing.Liu@noaa.gov)** ***Presented at SOO-DOH National Meeting, College Park, MD, September 15, 2015***