

# Vertical Referencing for 2D Modeling of Water Levels

OCS Storm Surge Modeling Perspective

# Problem Definition

- We're using a 2D model for estimating water levels during extreme events
- Law requires the public results to be disseminated in certain vertical reference
- We'd like to know:
  - What vertical reference to use for bathymetry of the model?
  - How to convert acquired water levels to different vertical references ?
- Does the same approach/assumptions work for 3D models?
  - The short answer is yes, but still there might be Topography of LMSL (TSS, signed distance between sea surface and the Geoid) errors to be accounted for
  - Still there might be practical differences, but let's focus on 2D modeling in this document

# Bathymetry

- Different source of bathymetry use different vertical reference levels
- All of the hydrodynamic models initialize at “sea at rest” for cold start
  - This sea at rest is Model Zero (MZ)
  - This means starting from a geopotential surface of sea, i.e. 0 in a **Geoid** model

# Water Levels

- Should we assume the datum for water levels we get from the model is the same as the bathymetry vertical datum?
  - How to take into account the general model bias when comparing obs vs model (even in 3D)
    - The model has bias due to simplification of the physics. The vertical referencing is a post-processing step to remove the bias and to disseminate the results (and it take into account the model bias).
  - In 2D barotropic models some of the geostrophic balancing forces as well as vertically-varying density are missing
    - There will always be a vertical offset between model and observed water level due to the limitation of 2D barotropic modeling, which can not reproduce the TSS well (LMSL to Geoid).

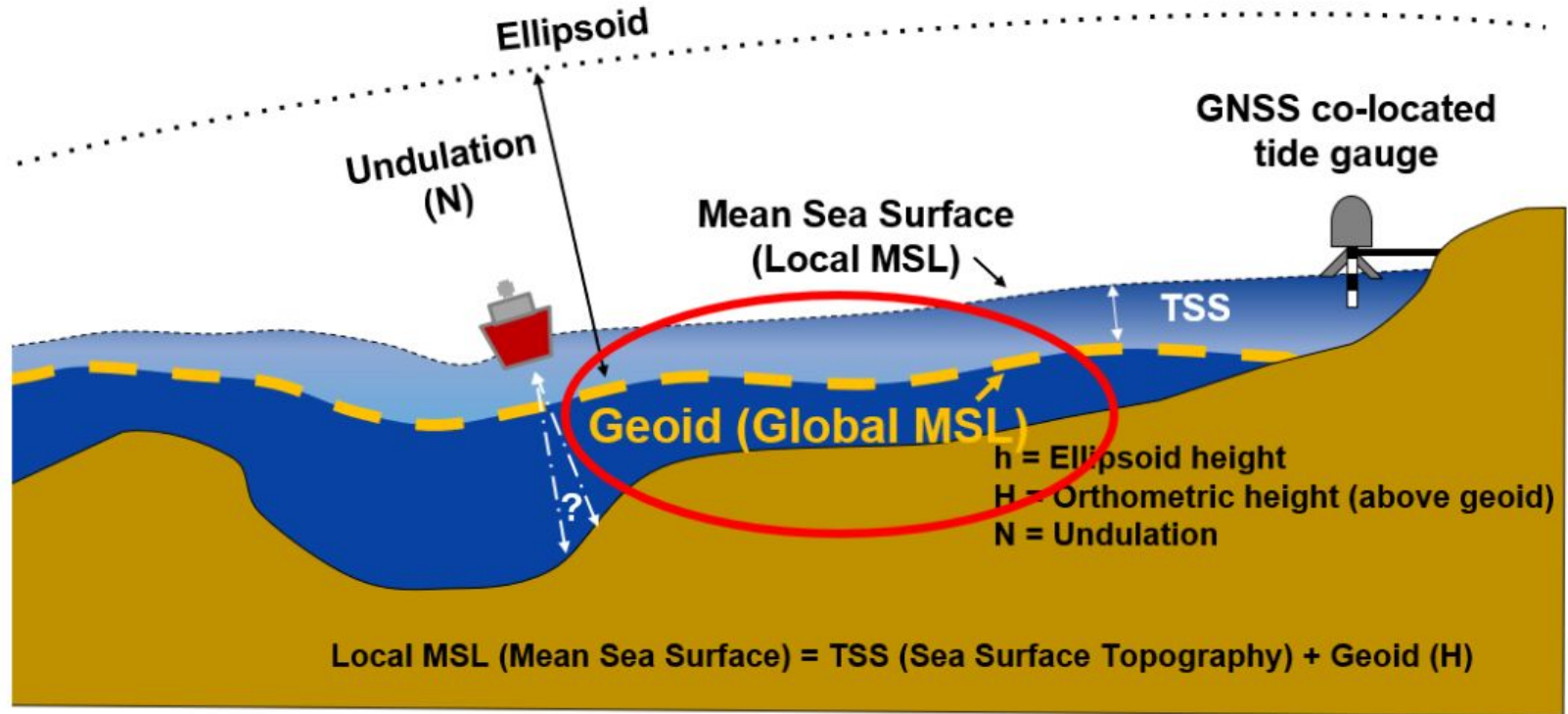
# Solution Overview

- Use Geoid for the bathymetry for the model input
  - i.e. Model Zero (MZ) == Geoid
- De-mean the results based on the average of a long run simulation.
  - The long run simulation yields the Model Local Mean Sea Level (M-LMSL)
  - Note again that this M-LMSL is already referenced to Model Zero (MZ)
  - The long run (e.g. multi-year or multi-month, etc.) simulation should include all the forcing
    - In specific since **NHC collaboration** currently only takes vortex and tidal into account we can do a long run with **tides only**
- Assume deviation from M-LMSL is equivalent to deviation from Observed Local Mean Sea Level (Obs-LMSL)
- Look at deviations from the M-LMSL (assumed == Obs-LMSL; all is relative)
  - Calculate “model output - M-LMSL” (i.e. model output minus the mean from the long running simulation); this is model results w.r.t. the M-LMSL
- Convert from M-LMSL-referenced results to target datum, e.g. NAVD88
- For comparison one may de-mean obs as well
  - If the obs is not a timeseries then we can just use it as it is
  - This is what VDatum modeling team uses for tidal datums comparison, but might not be needed for operational use.

# Terms

- See <https://vdatum.noaa.gov/docs/datums.html#navd88>
- Obs-LMSL: The arithmetic mean of hourly heights observed over the National Tidal Datum Epoch. Shorter series are specified in the name, e.g., monthly mean sea level and yearly mean sea level.
- M-LMSL: The hourly arithmetic mean using gridded output
  - Possible to use 6 minute data
- Geoid: The geoid is a specified equipotential surface, defined in the Earth's gravity field, which best fits, in a least squares sense, global mean sea level (MSL).
- TSS (Topography of sea surface): Signed distance between LMSL and the Geoid
  - TSS used in VDatum: Geoid-LMSL.
  - Positive means GEOID above LMSL; negative means GEOID is below LMSL
- NAVD88: A vertical reference. The North American Vertical Datum 1988 was affirmed as the official civilian vertical datum for surveying and mapping activities in the United States in June 24, 1993

# Height Relationships



# Lingering Questions!

- Should we do all comparisons in relative M-LMSL vs Obs-LMSL or can we take M-LMSL and transform it to NAVD88 (using transformation from LMSL) and then compare
  - We can take M-LMSL data and transform it to NAVD88 to compare to NAVD88 obs (e.g. from COOPS API)
- Can any obs given as MSL be taken as given in Obs-LMSL without de-meaning for comparison sake? Especially if it's a single time data point?
  - Yes, single data observation in MSL is Obs-LMSL