
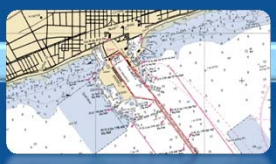
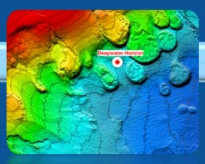


Separation Models for Ellipsoidally Referenced Hydrographic Surveys

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FIG Working Week – Rome, Italy 9 May 2012

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Outline

- Introduction and Background
- Separation Model Development
- VDatum – U.S.
- VORF – U.K. Hydrographic Office
- BLAST – Bringing Land And Sea Together – North Sea
- AUSHYDROID – Australia
- Canadian Continuous Vertical Datum Project
- Other – Caribbean/US Naval Oceanographic Office
- Ellipsoidally Referenced Zoned tides (ERZT) – U.S.
- Conclusions/Recommendations

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Introduction

- FIG Working Group 4.1 – Best Practices Study
- Previous Papers Under WG 4.1 at FIG Congress 2010 and U.S. HYDRO 2011:
  - "Hydrographic Surveying Using the Ellipsoid as the Vertical Reference Surface" – Sydney 2010
  - "Ellipsoidally Referenced Surveys (ERS); Issues and Solutions" – Tampa, Florida 2011
- Goal – FIG Technical Report and Inclusion in IHO Manual on Hydrography

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Background

- Challenges of Ellipsoid to Chart Datum Transformation
- Ellipsoid to Geoid – relatively straight forward
- Geoid to Mean Sea Level (Topography of the Sea Surface – TSS)
- Mean Sea Level to Chart Datum – Water Level Gauges and Hydrodynamic Modeling

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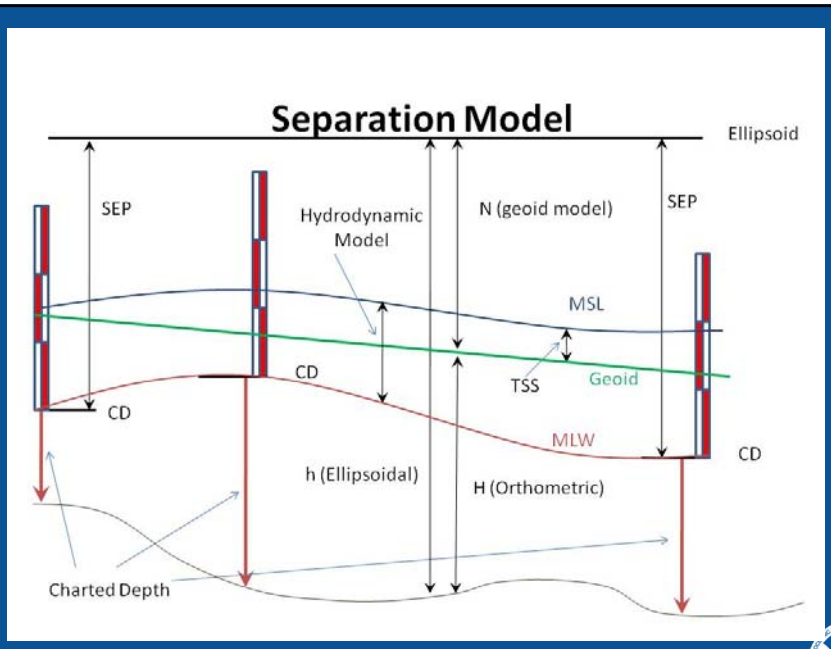

Separation Model Development

- Simple shift – local area only (minimum spatial variation in chart datum, geoid and TSS)
- Interpolate between known SEP locations (assume minimum spatial variation of geoid)
- Interpolate between known SEP locations using geoid model
- Use of MSS, TSS and hydrodynamic models

VDatum – NOAA/NOS (U.S.)

- Software application to transform data referenced to one vertical reference surface to another
- Focus on transforming hydrographic survey acquired on the ellipsoid to chart datum (MLLW)
  - ITRFxx to NAD83 ellipsoid (if necessary)
  - NAD83 ellipsoid to NAVD88 (orthometric datum)
  - NAVD88 to Mean Sea Level (MSL) primary tidal datum
  - MSL to MLLW (chart datum)

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TSS – NAVD88 to MSL

- TSS primarily caused by ocean currents and variations in ocean temperature and salinity
- NOAA method – measure/calculate NAVD88 – MSL difference on BM's at water level gauges
  - Generate regional TSS field by spatial interpolation
  - Along open coasts derive regional TSS field via extrapolation
- Satellite Altimetry – limited to offshore due to inclusion of land in radar footprint

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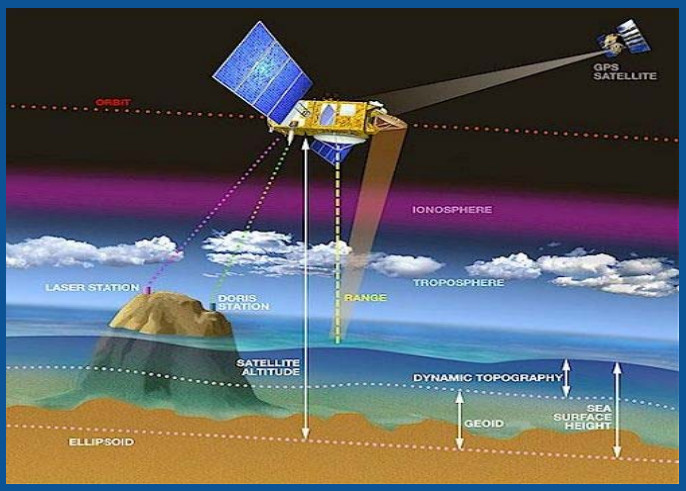
Satellite Altimetry

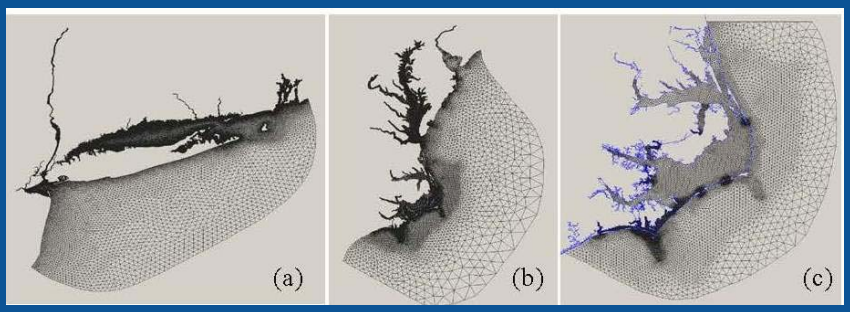


Credit: CNES/D. Ducros

Tidal Modeling - Hydrodynamics

- Mean Sea Level – hourly heights over 19 years
- Mean Lower Low Water – average of all lower low water levels over 19 years
- Spatial variation of tidal datum fields between water level stations
- ADCIRC (Advanced Circulation Model)

Tidal Modeling - Hydrodynamics



Examples of triangular unstructured grids used in (a) Long Island / New York Harbor, (b) Chesapeake Bay, and (c) coastal North Carolina.

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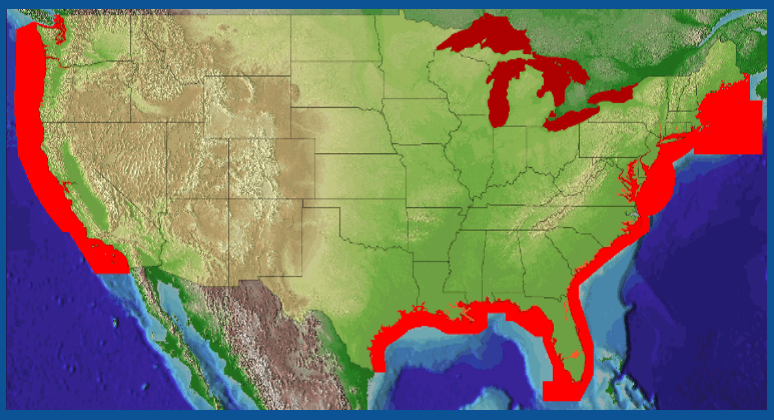
VDatum Coverage



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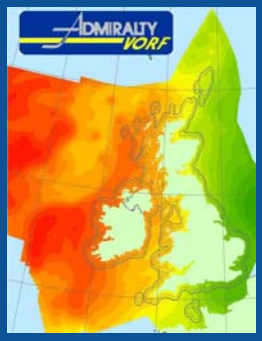
VORF (Vertical Offshore Reference Frame) – UK Hydrographic Office

- Set of surfaces referenced to WGS84 ellipsoid
- OSGM05 gravity model used to establish geoid to WGS84 ellipsoid undulation
- TSS established through water level gauge observations (near shore) and satellite altimetry (offshore)
- MSL and LAT difference from water level gauges and hydrodynamic modeling



Credit: Ziebart & Illiffe, March 2007

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BLAST (Bringing Land And Sea Together) – 7 Northern European Countries

- EGG2008 geoid to WGS84 ellipsoid separation
- DTU10 MSS minus EGG2008 with checks at water level locations (relates geoid to MSL)
- Lowest Astronomic Tide (LAT) Chart Datum to MSL difference from hydrodynamic modeling
- Anticipation that VORF will be aligned with BLAST

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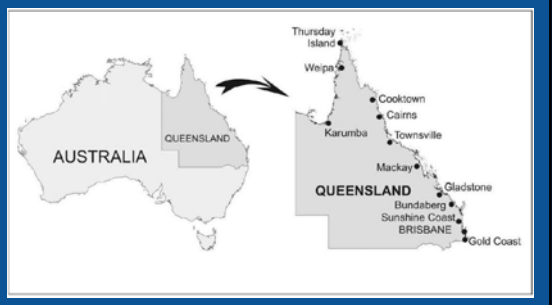
AUSHYDROID – Queensland, Australia

- Height separation between the WGS ellipsoid and chart datum (LAT)
- Determination of the height of AUSHYDROID at the tidal stations
- Interpolation using co-tidal zoning to estimate height of AUSHYDROID everywhere within a chart (does not use hydrodynamic modeling)



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Canadian Continuous Vertical Datum Project

- Preliminary Plans at CHC 2010 – Quebec City
- Strategy
  - QC data holdings and establish links to vertical datums – NAD83(CSRS)2006 and CGVD28
  - Determine mean water level in open ocean from satellite altimetry
  - Use ocean modeling to transform from mean water level to LAT
  - Link offshore to shore based data – VDatum/VORF
- Two papers to be presented at CHC 2012 - May

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Other SEP Modeling Activities

- Caribbean – Study area proposed in 2011 (Trinidad)
  - Quantify separation between land-based datums at discrete points
  - Determine geographic distribution of various tidal datums used at sea
  - Interpolate separation values for entire study area
- U.S. Naval Oceanographic Office
  - Ellipsoid to Chart Datum separation observed at tide gauges – may use offshore tide buoys
  - Interpolation to generate SEP over survey area

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Ellipsoidally Referenced Zoned Tides - ERZT

- VDatum not available in Alaska
- Desire to gain advantages of ERS – obtain more coherent bathymetric data and process sonar data only once
- Develop SEP “zones” from traditional hydrographic survey tidal zoning

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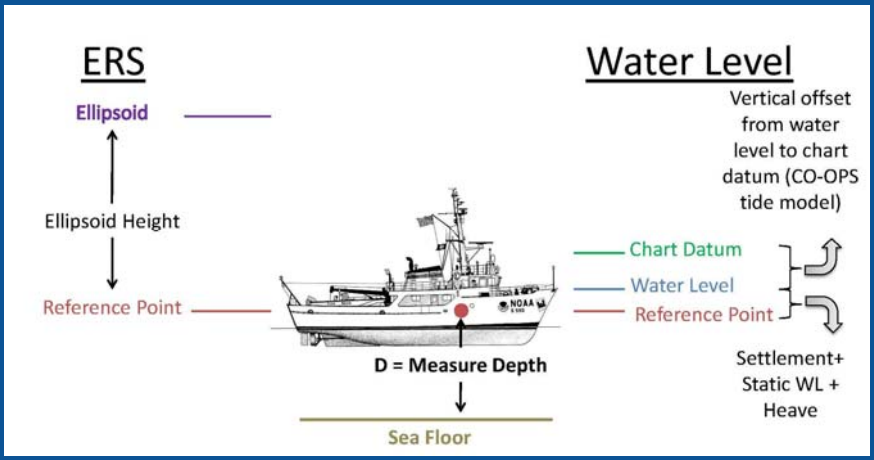
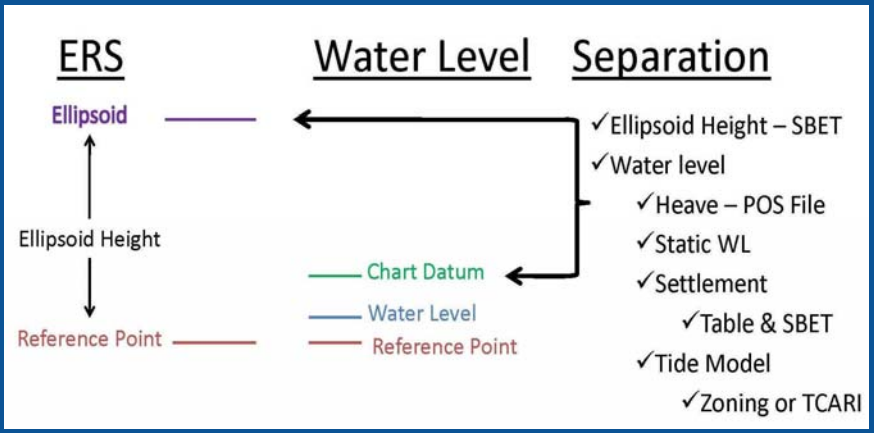
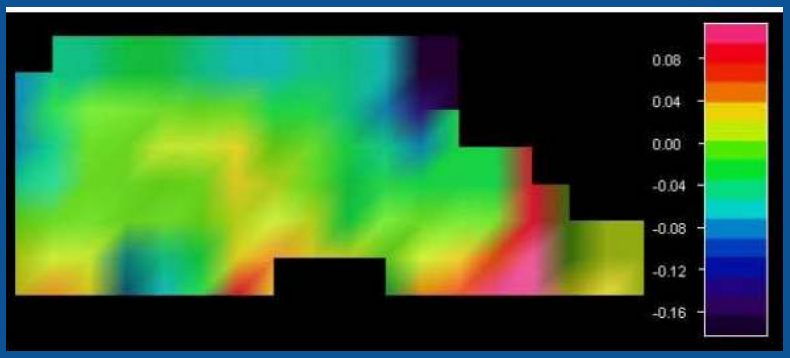
Measurements from Reference Point



Difference Components



ERZT – VDatum Difference (Example)



Difference surface between ERZT and VDatum for NOAA survey H12216 (height in meters) – Puget Sound, Washington

Conclusions/Recommendations

- Include a geoid model for interpolation between water level gauges
- For TSS use water level gauges nearshore and satellite altimetry offshore
- For MSL to CD use hydrodynamic modeling tied to water level gauges
- SEP surfaces should be validated with tide buoy or bottom mounted gauge offshore
- Essential to attach clear metadata to all surfaces and all depth data translated from a SEP

Future Work

- Obtain additional input from the international community to better document SEP modeling activities
- Explore usefulness/efficiency of ERZT developed SEP models and encourage expanded usage
- Substantial research is needed to develop and improve SEP uncertainty modeling
- Publish FIG Technical Report on best practices for Ellipsoidally Referenced Hydrographic Surveys and SEP modeling
- Propose FIG Technical Report for inclusion in IHO Manual on Hydrography

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Questions?

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