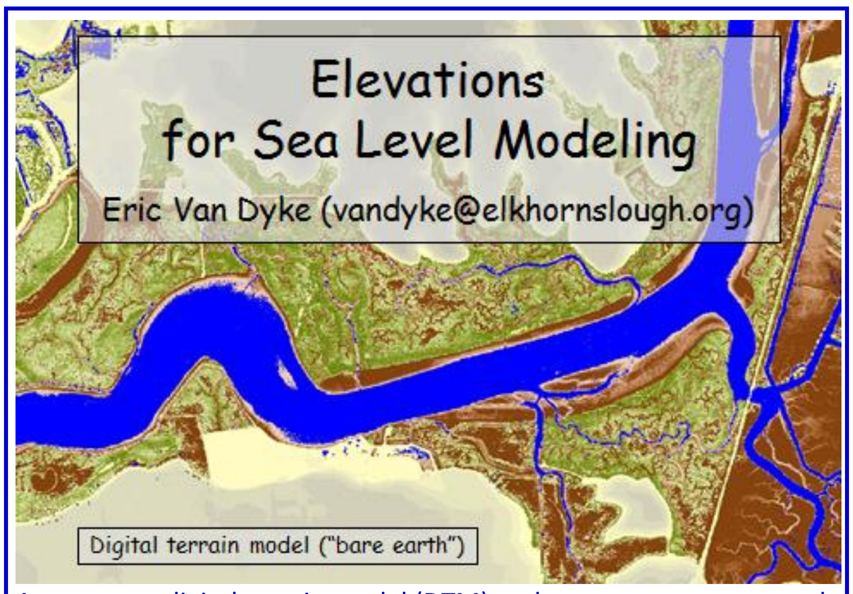
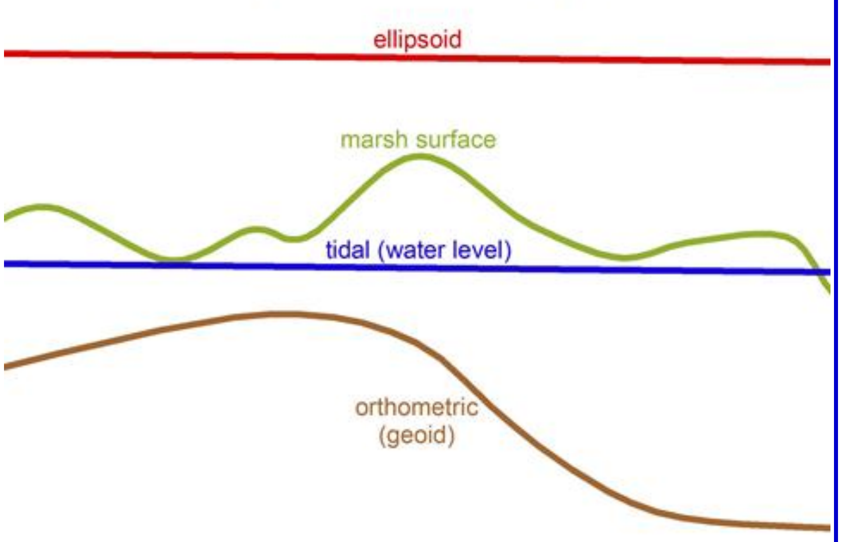
Elevations for Sea Level Modeling

Eric Van Dyke (vandyke@elkhornslough.org)



An accurate digital terrain model (DTM) and an accurate, connected water surface are essential for modeling sea level rise and marsh sustainability.

Vertical datums: orthometric, tidal, ellipsoid



Reconciling three types of elevation measurements (vertical datums) is necessary to produce a DTM and water surface suitable for sea level and marsh sustainability modeling.

Convert LiDAR DTM to connected water surface

NOAA CO-OPS website (tidal datums and benchmarks)
http://tidesandcurrents.noaa.gov

NOAA Digital Coast website (coastal inundation modeling)
http://www.csc.noaa.gov/digitalcoast

Coastal Inundation Mapping Guidebook (2009)
http://www.csc.noaa.gov/digitalcoast/inundation/_pdf/guidebook.pdf

Detailed inundation methods document (for ArcGIS + Spatial Analyst)
http://www.csc.noaa.gov/slr/viewer/assets/pdfs/Inundation_Methods.pdf

NOAA VDatum website (vertical datum transformations)
http://vdatum.noaa.gov

Interpolated datum transformation across the entire wetland, using NOAA's VDatum program, is preferable. Detailed instructions for applying VDatum to a DTM and for enforcing hydraulic connectivity within the resulting water surface can be downloaded from the NOAA Digital Coast website.

Update LiDAR DTM geoid model

NOAA NGS website (benchmark datasheets)
http://www.ngs.noaa.gov

NOAA NGS geoid website (geoid models)
http://www.ngs.noaa.gov/GEOID

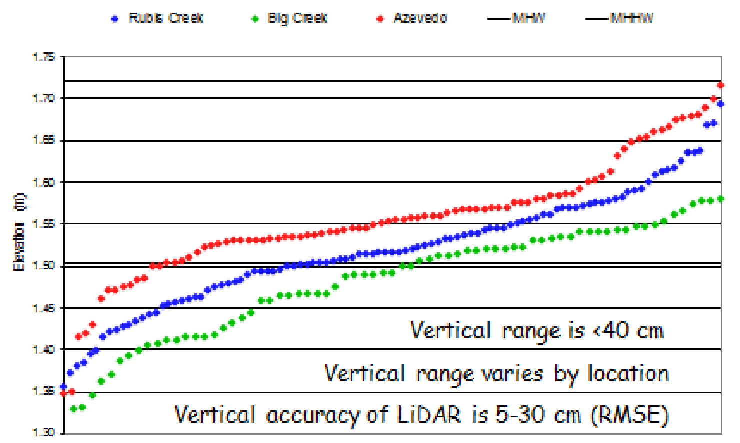
Sea level rise and geospatial data

Technical Considerations for Use of Geospatial Data in Sea Level Change Mapping and Assessment (2010)
http://tidesandcurrents.noaa.gov/publications/tech_rpt_57.pdf

Lidar Data Collected in Marshes: Its Error and Application for Sea Level Rise Modeling (2010)
http://www.csc.noaa.gov/digitalcoast/data/coastallidar/_pdf/Lidar_marshes_slamm_CSC.pdf

GEOID09 and earlier geoid models are available from the NOAA NGS website. Two overview documents, covering the essentials of preparing geospatial data (especially LiDAR) for sea level modeling and mapping, can also be downloaded from NOAA websites.

Sorted marsh elevations (surveyed)



LiDAR elevation data, adjusted to account for tidal variability, barely provides the required vertical accuracy.

tidesandcurrents.noaa.gov

```
Station:  9413651
Name:     Kirby Park, Elkhorn Slough, CA
Status:   Accepted (Mar 25 2009)
                                                    Epoch:  1983-2001
                                                    Datum:       STND

          Datum         Value   Description
          ---------   --------  ----------------------------------------
          MHHW           4.252  Mean Higher-High Water
          MHW            4.034  Mean High Water
          MSL            3.473  Mean Sea Level
          MTL            3.468  Mean Tide Level
          DTL            3.412  Mean Diurnal Tide Level
          MLW            2.902  Mean Low Water
          MLLW           2.572  Mean Lower-Low Water
          NAVD88         2.531  North American Vertical Datum of 1988
          STND           0.000  Station Datum

          GT             1.680  Great Diurnal Range
          MN             1.131  Mean Range of Tide
          DHQ            0.219  Mean Diurnal High Water Inequality
          DLQ            0.330  Mean Diurnal Low  Water Inequality

          HWI            6.86   Greenwich High Water Interval (in Hours)
          LWI           12.35   Greenwich Low  Water Interval (in Hours)

          HAT            4.781  Highest Astronomical Tide
          HAT Date    19861231  Highest Astronomical Tide Date
          HAT Time       10:00  Highest Astronomical Tide Time
          LAT            2.027  Lowest  Astronomical Tide
          LAT Date    19861231  Lowest  Astronomical Tide Date
          LAT Time       17:24  Lowest  Astronomical Tide Time
```

The relationship between tidal and orthometric datums at many (but not all) tidal benchmarks can be determined from NOAA CO-OPS datasheets.

www.ngs.noaa.gov

```
GU3199 ****************************************************
GU3199  TIDAL BM       -  This is a Tidal Bench Mark.
GU3199  DESIGNATION -  941 3651 B TIDAL
GU3199  PID            -  GU3199
GU3199  STATE/COUNTY-  CA/MONTEREY
GU3199  USGS QUAD      -  PRUNEDALE (1993)
GU3199
GU3199                        *CURRENT SURVEY CONTROL
GU3199
GU3199* NAD 83(1986)-  36 50 32.      (N)   121 44 48.     (W)     SCALED
GU3199* NAVD 88        -           2.121  (meters)        6.96   (feet)  READJUSTED
GU3199
GU3199  GEOID HEIGHT-          -33.59  (meters)                       GEOID09
GU3199  DYNAMIC HT     -           2.120  (meters)        6.96   (feet)  COMP
GU3199  MODELED GRAV-     979,874.7   (mgal)                          NAVD 88
GU3199
GU3199  VERT ORDER     -  ?
GU3199
GU3199.The horizontal coordinates were scaled from a topographic map and have
GU3199.an estimated accuracy of +/- 6 seconds.
GU3199
GU3199.The orthometric height was determined by differential leveling
GU3199.and adjusted in March 1993.
GU3199.The height was derived from older observations constrained to new
GU3199.heights in a crustal motion area.  The height is approximate in
GU3199.relation to other heights in its vicinity.
GU3199
GU3199.This Tidal Bench Mark is designated as VM 11895
GU3199.by the CENTER FOR OPERATIONAL OCEANOGRAPHIC PRODUCTS AND SERVICES.
GU3199
GU3199.The geoid height was determined by GEOID09.
```

Because they are positioned with GPS, LiDAR elevations are referenced to the ellipsoid. LiDAR vendors convert to orthometric heights (NAVD88) with an interpolated geoid model. If the latest model (GEOID09) wasn't used, it is important to update heights with GEOID09 for improved accuracy.

Summary

- Use LiDAR elevations
  Vertical accuracy of IfSAR and most NED is >1m (RMSE)
- Update to GEOID09 (if necessary)
- Convert DSM to DTM (challenging in marsh!)
  Compensate for uplift/subsidence?
  Compensate for marsh vegetation bias?
- Enforce tidal connectivity (bridges, culverts)
- Convert DTM to water surface (VDatum)

The sequence of tasks needed to prepare elevation data for use in sea level and marsh sustainability modeling is complex but essential to achieve accurate results.