

CHC 2014 – Positioning: Challenges in the Horizontal & Vertical



QA & QC in NOAA ERS Hydrography

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NOAA NOS Office of Coast Survey



QA & QC in NOAA Ellipsoidally Referenced Survey Hydrography

- Introduction
 - The Ellipsoidally Referenced Survey (ERS)
 - Positioning Options
 - Quality Concerns
- Survey Platform Position QA & QC
 - ERS Standards & Software Processing
 - Solution Evaluation & Hydro Context
 - QC Tools & NOAA ERS Data Examples
- Remediation Options
- Summary
 - Wanted: (Re)Processing Mechanization



Ellipsoidally Referenced Survey – ERS Introduction

- ERS raisons d'être
 - Improve Precision in Hydrography, Maintain Accuracy (+)
 - Sub-decimeter *3-D geodetic positioning* of survey platform
 - Measure* vertical position across the entire frequency band
 - Improve Efficiency
 - Decouple chart datum recovery from soundings/delivery
 - Reduce shore-side interactions
- Precise Positioning Options
 - Real Time & Post-Processed; Relative & Point; Inertial Aiding
 - Tightly-Coupled Inertial-Aided Post-Processed KGPS (IAPPK)
- Quality Concerns
 - 100% availability needed to match up with sounding data



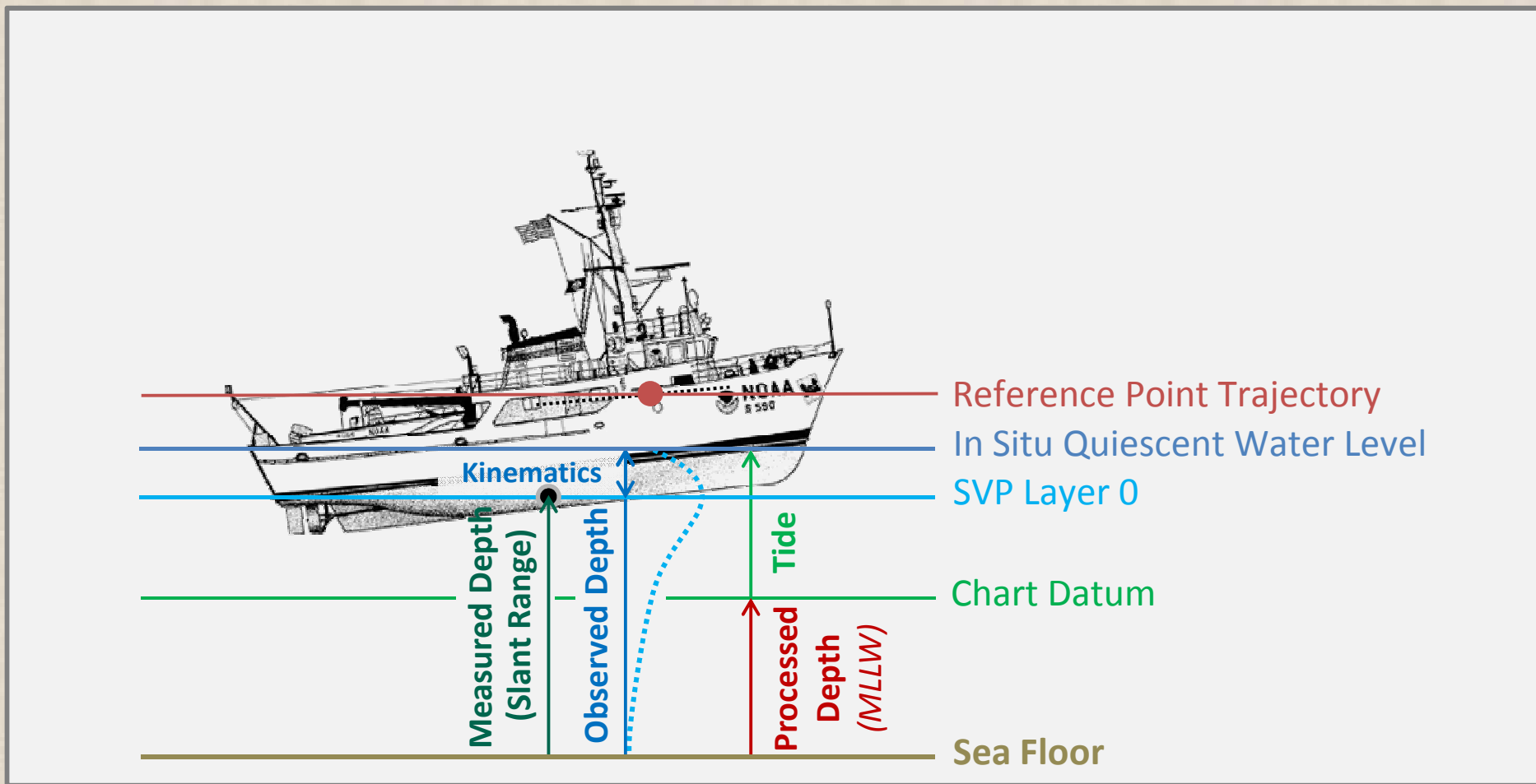
Survey Platform Position QA & QC

- **ERS Standards & Software Processing**
 - Reference Frames & Base Station Coordinates
 - Input, Processing, Export – transformation & velocities
 - Standardized Training & Nominal Processing/QC Steps
 - Threshold & Spike Detection Guidelines ... False Alarms
 - Vertical Datum Verification
- **Solution Evaluation & Hydro Context**
 - Quality Assessment Involves Many Logs & Even More Plots
 - Statistics of what is possibly right or wrong
 - Little feedback into how to fix ... using the available software
 - Contextual Review via the In Situ Water Level “GPS Tide”



ERS Hydro Context

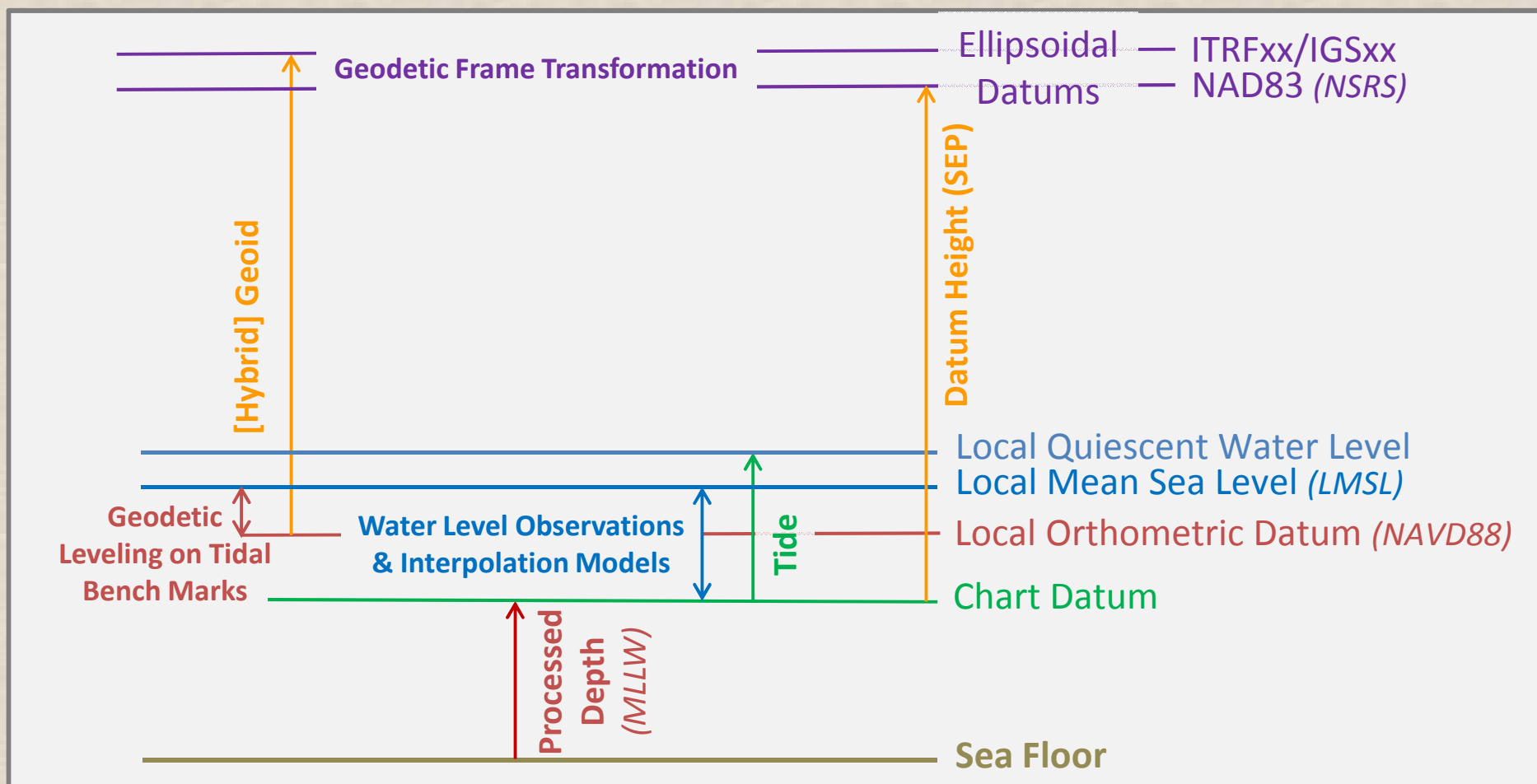
- Survey Platform Vertical Positioning
 - Water Level and Chart Datum Reckoning





ERS Datum Context

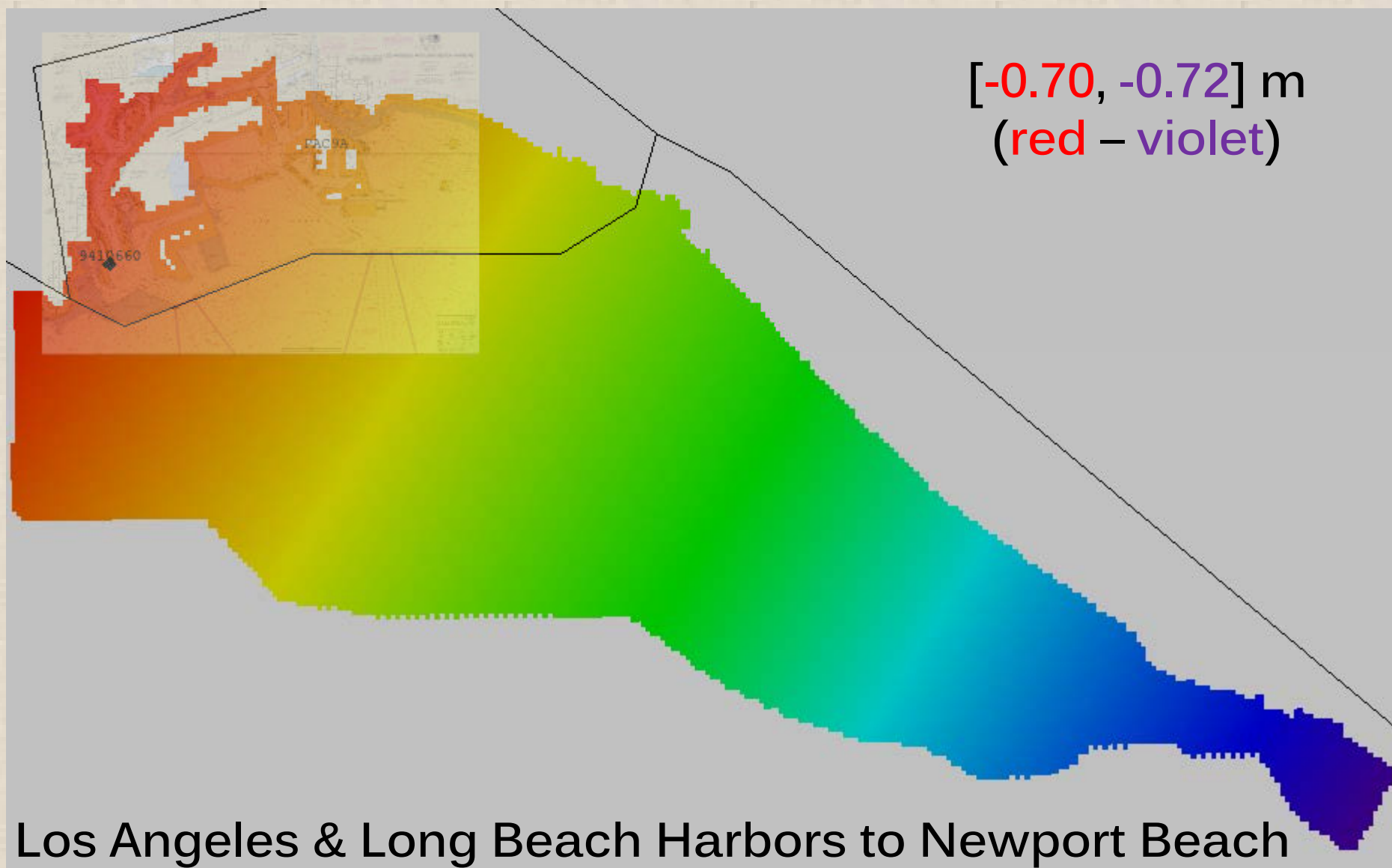
- Reference Frame & Vertical Datum “Sandwich” in ERS
 - NOAA VDatum Philosophy
 - Datum Mapping: Ellipsoidal, Orthometric, and Tidal





ERS & Vertical Datum Transformation Layers

- ITRF08 2005.0 – NAD83(2011) 2010.0



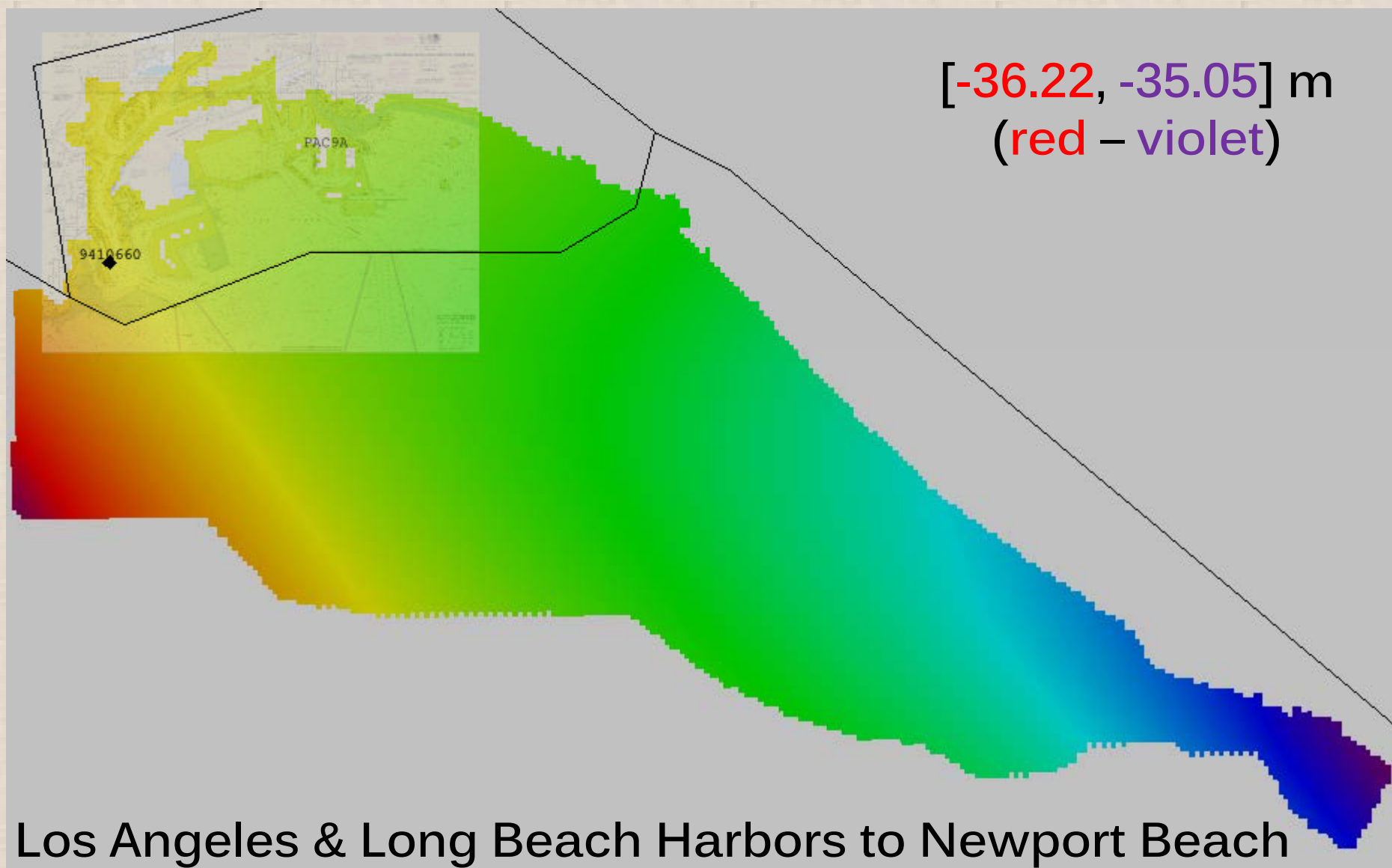
$[-0.70, -0.72]$ m
(red – violet)

Los Angeles & Long Beach Harbors to Newport Beach



ERS & Vertical Datum Transformation Layers

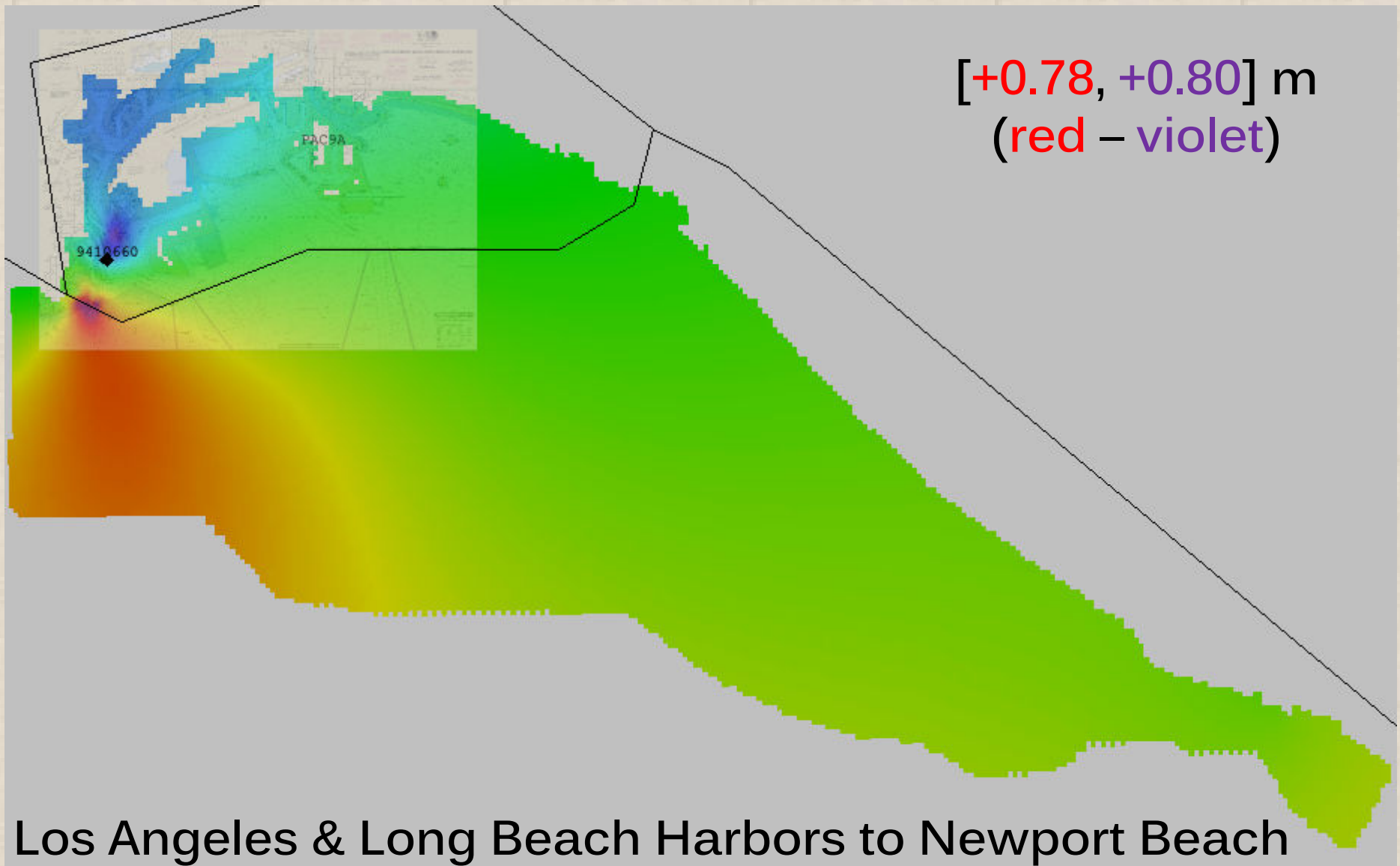
- NAD83(2011) 2010.0 – NAVD88: NOAA GEOID12A





ERS & Vertical Datum Transformation Layers

- NAVD88 – LMSL: Sea Surface Topography (TSS)





ERS & Vertical Datum Transformation Layers

- LMSL – LMLLW: Tidal Chart Datum (NTDE')

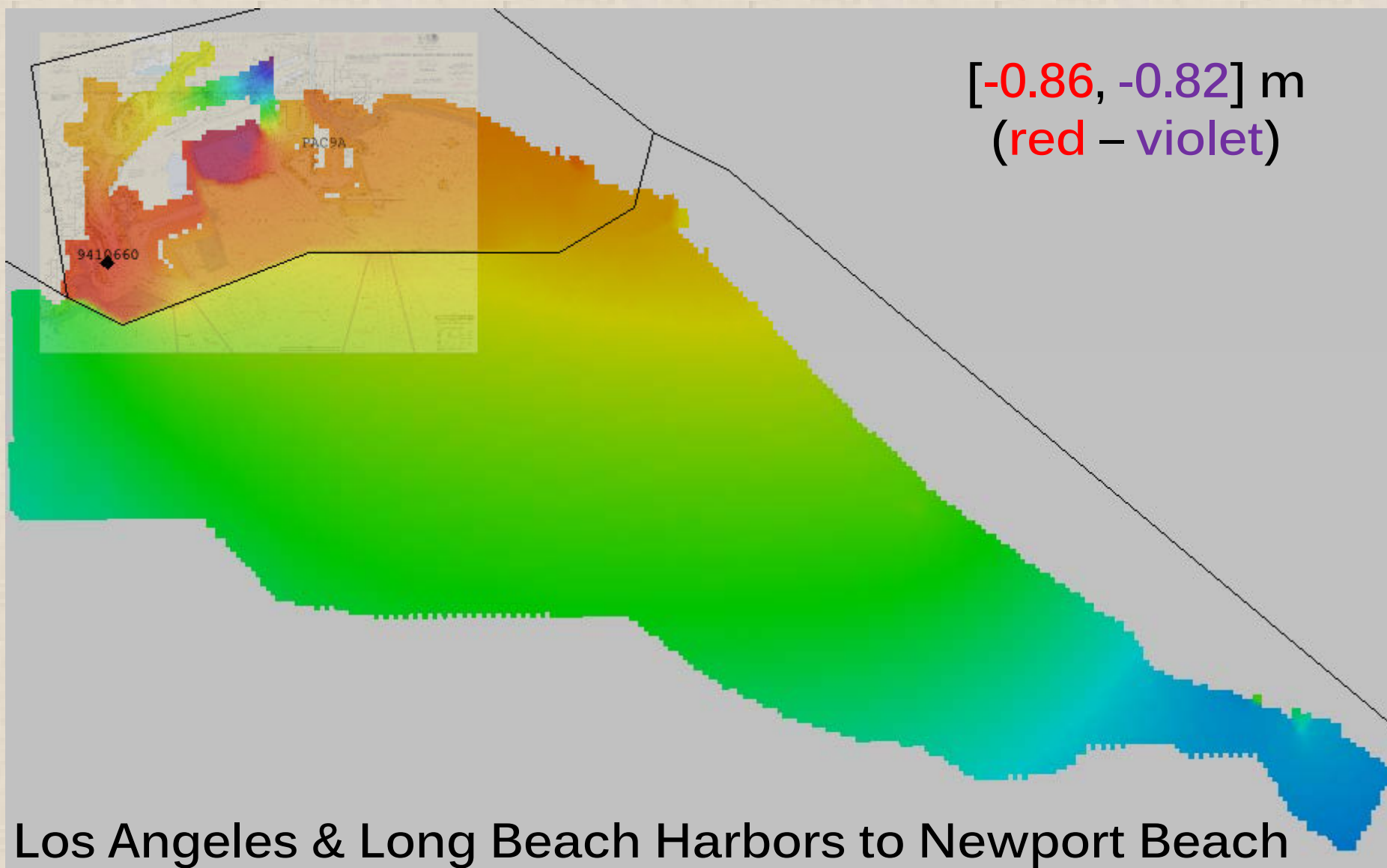
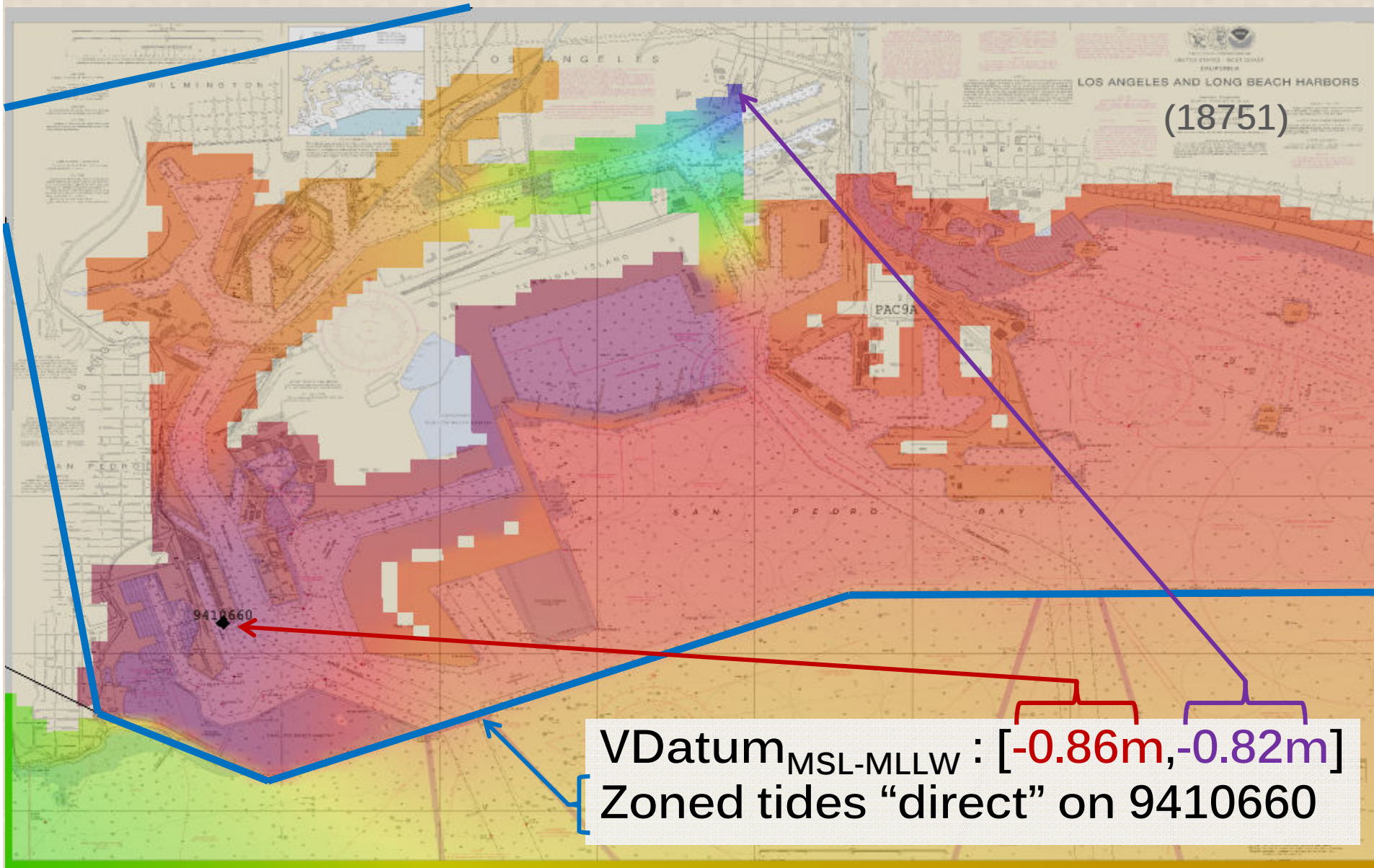




Chart Datum Modeling: Zoned Tides & VDatum MSL-MLLW

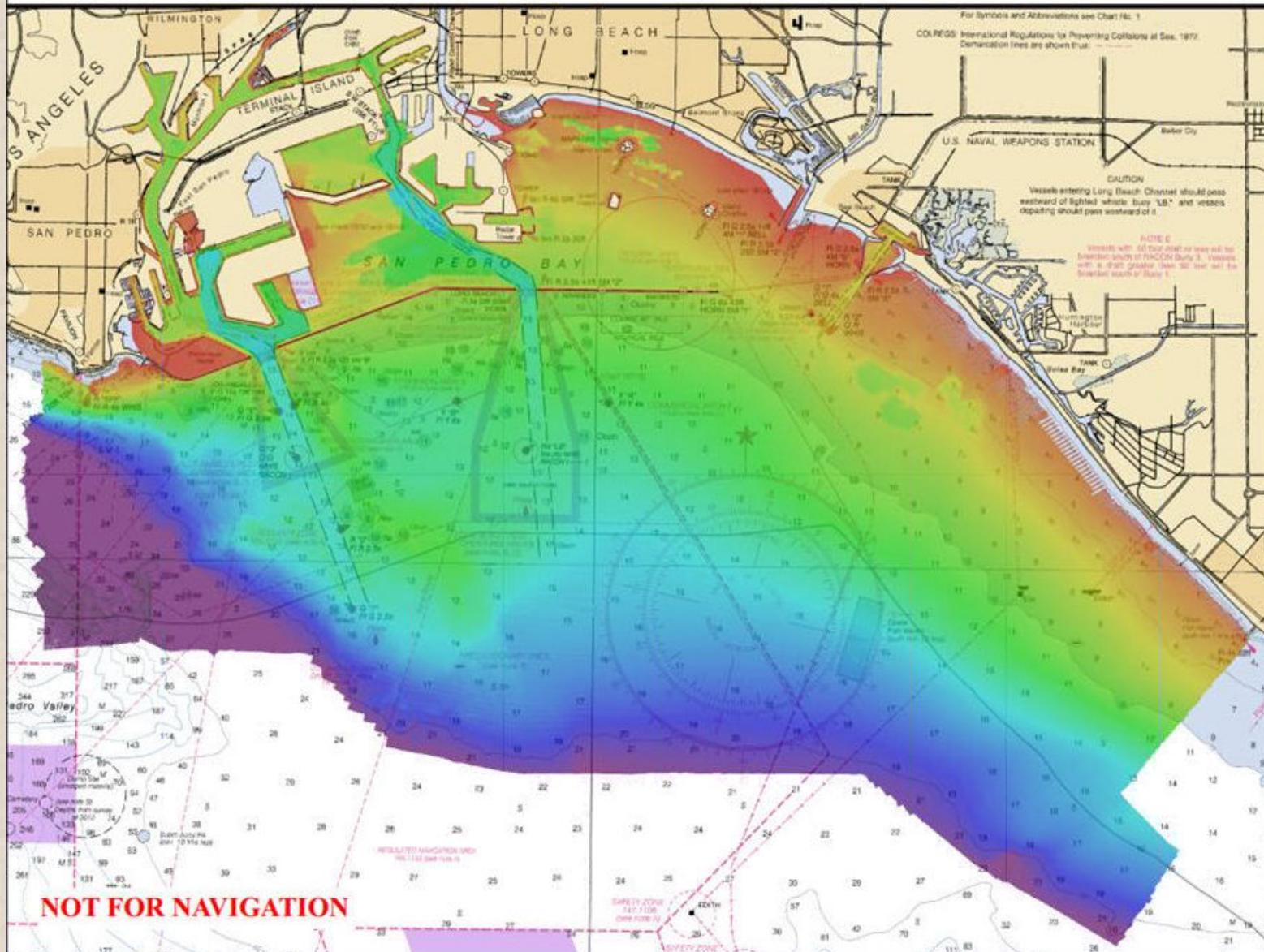
Approaches to LA/Long Beach, CA – OPR-L318-FA-13



Office of Coast Survey
Approaches to LA/Long Beach, CA
OPR-L318-FA-13



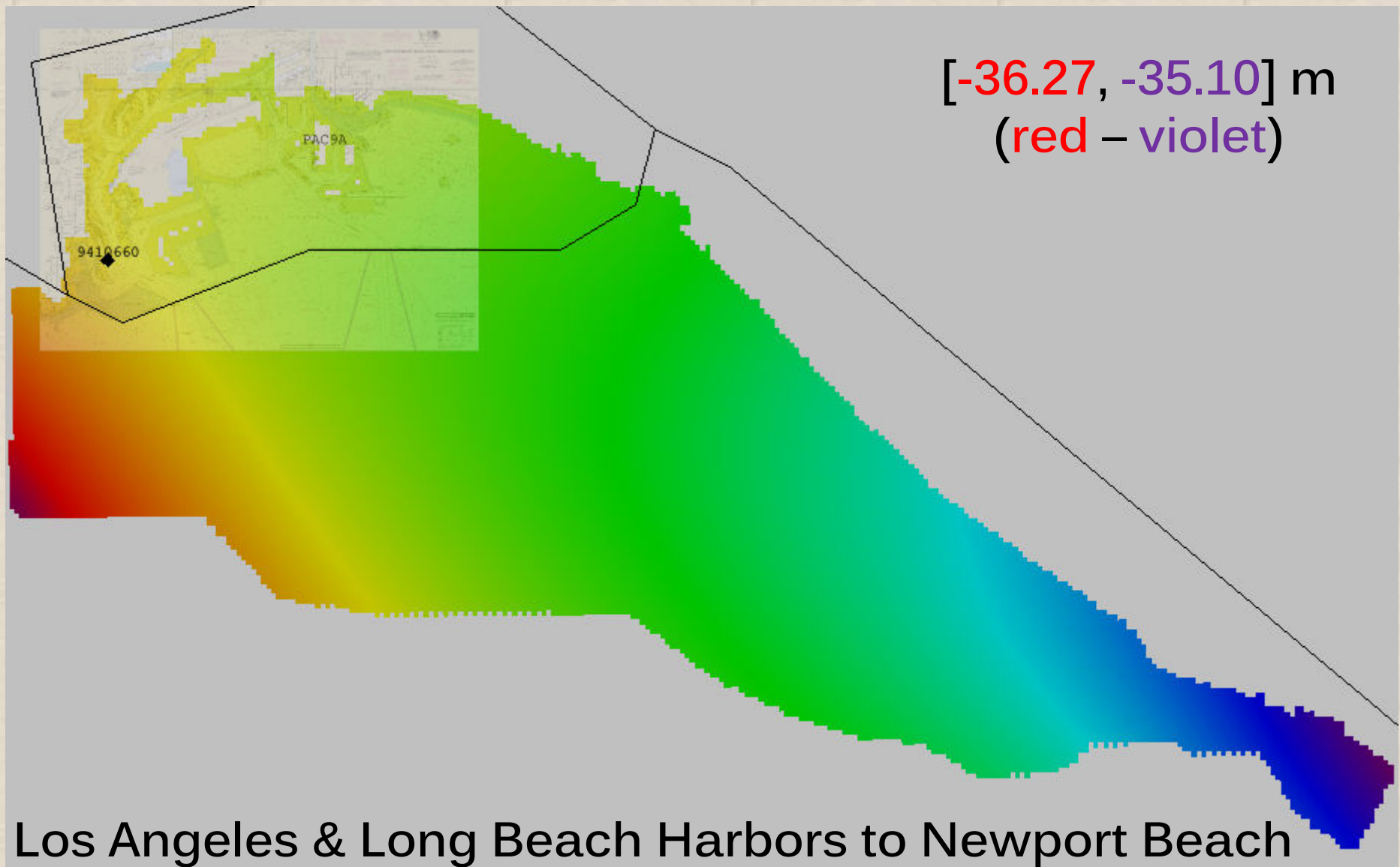
Surveyed By:
NOAA Ship *Fairweather*, S220
CDR James M. Crocker, Commanding Officer
September – November 2013





ERS & Vertical Datum Transformation Layers

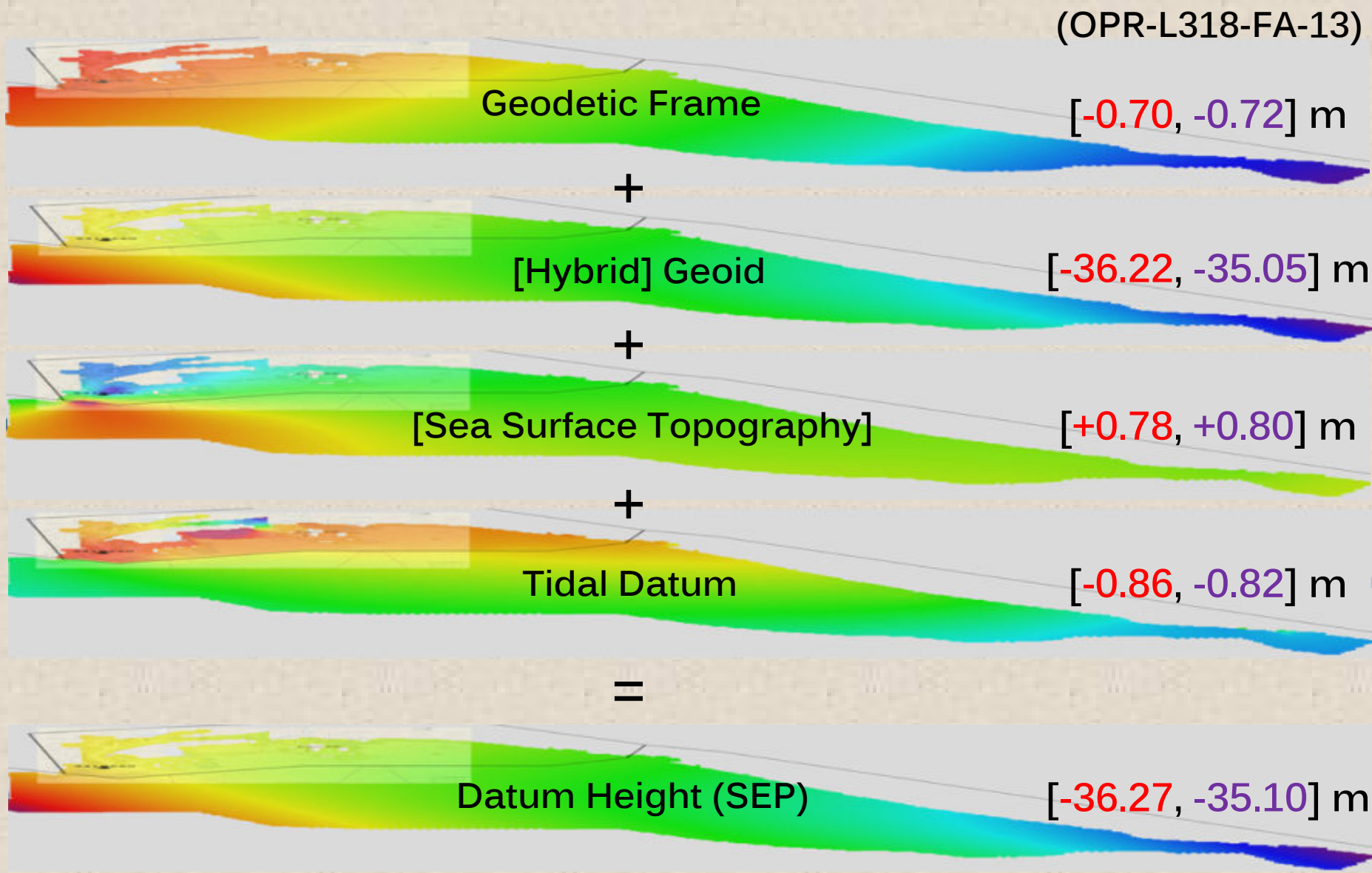
- NAD83(2011) 2010.0 – MLLW Datum Height (SEP)





ERS & Vertical Datum Transformation Layers

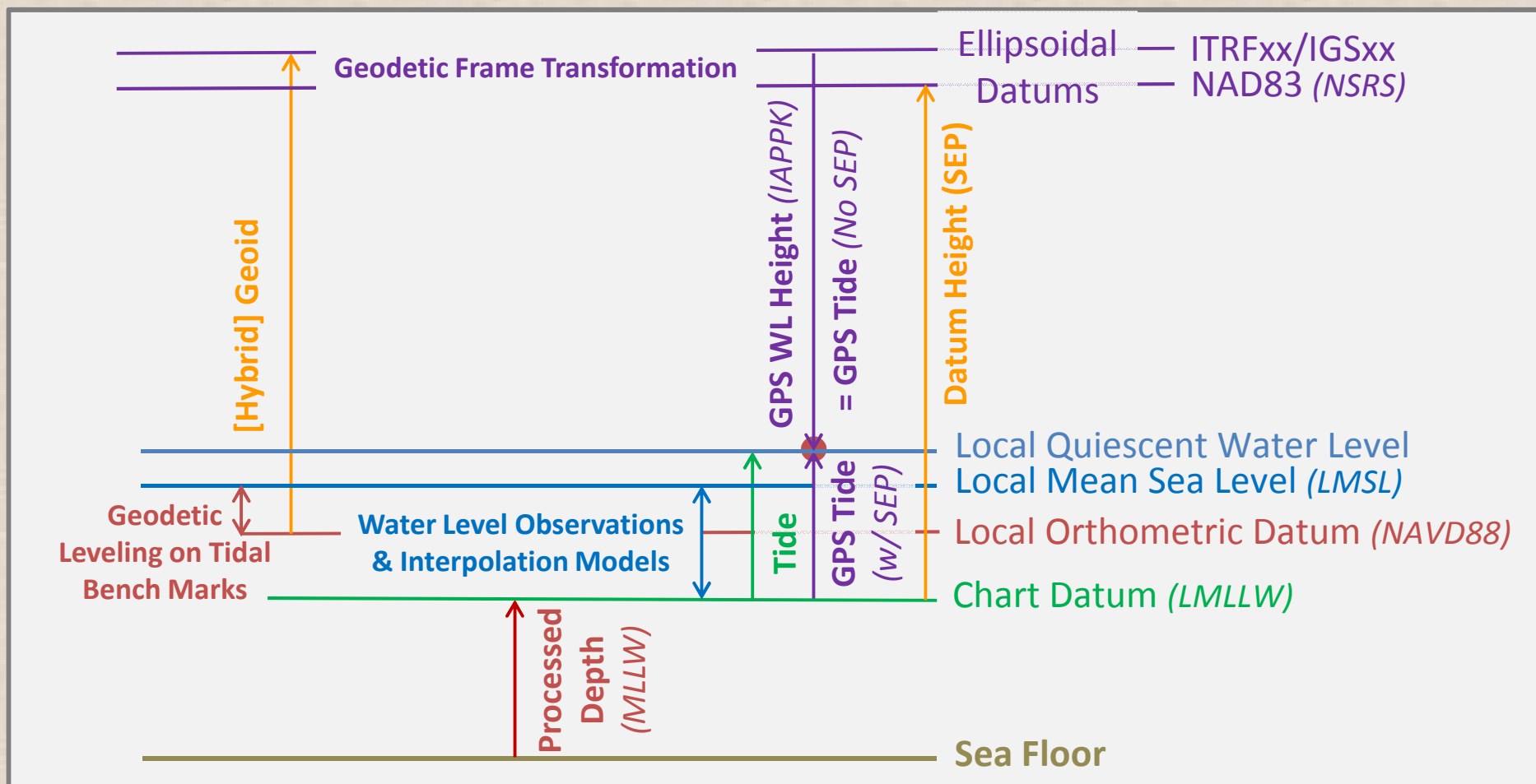
- Smooth Character of the ERS SEP





ERS Datum Key Points

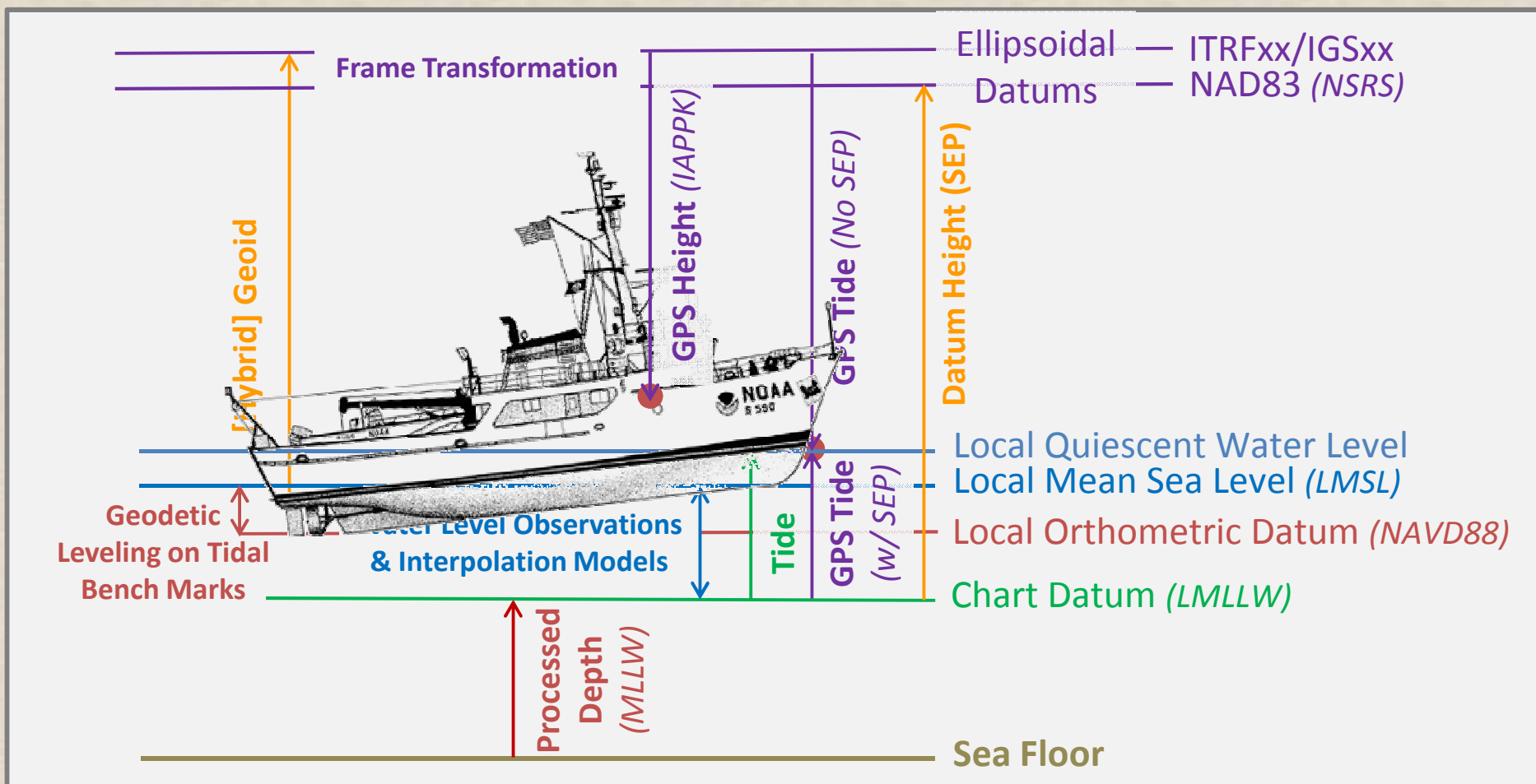
- Reference Frame & Vertical Datum “Sandwich” in ERS
 - NOAA VDatum Philosophy
 - Datum Mapping: Ellipsoidal, Orthometric, and Tidal





ERS Key Points

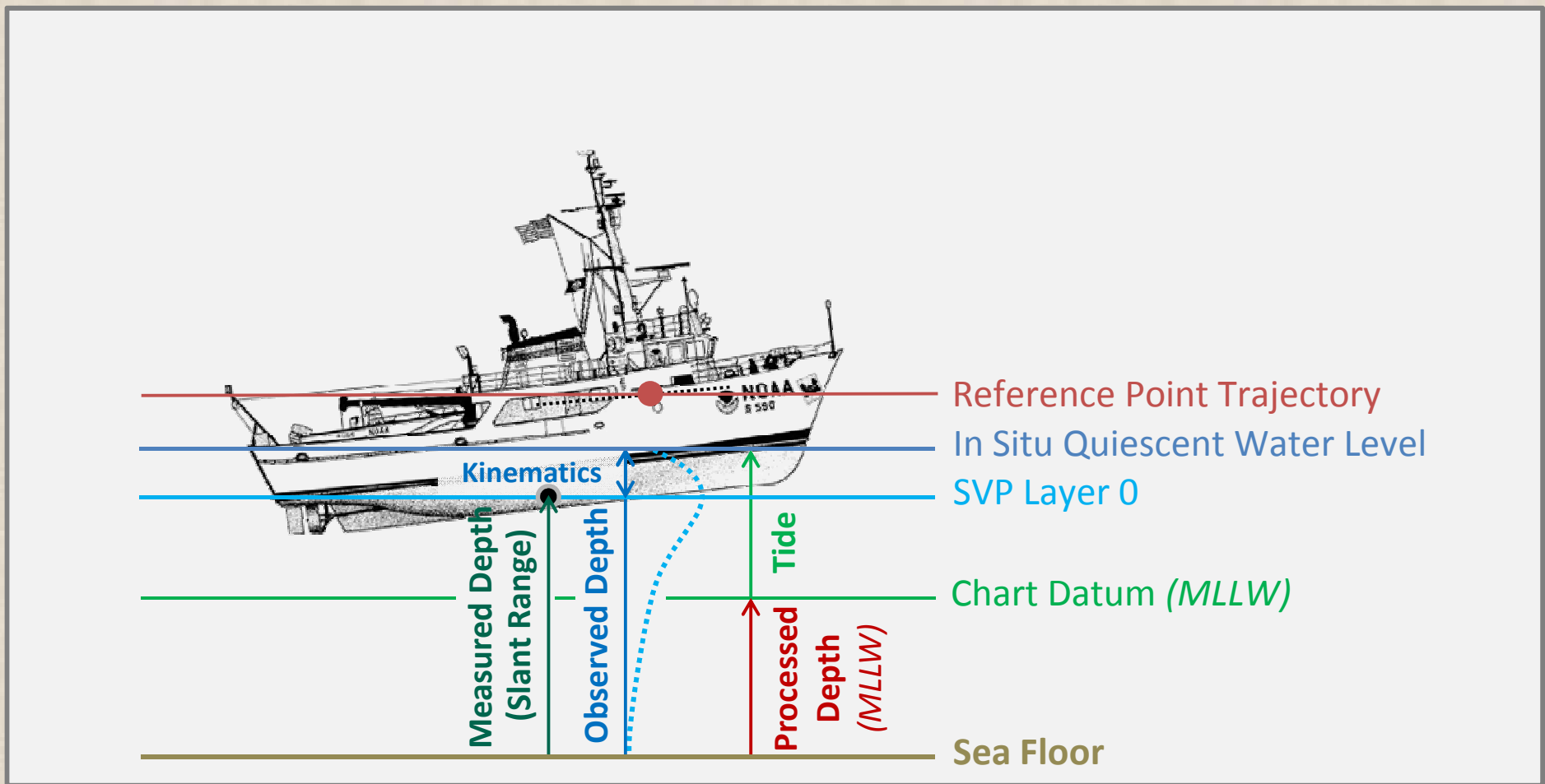
- Reference Frame & Vertical Datum “Sandwich” in ERS
 - Vessel In Situ Water Level and Chart Datum Reckoning
 - GPS-Reckoned Geodetic Heights





ERS Key Points

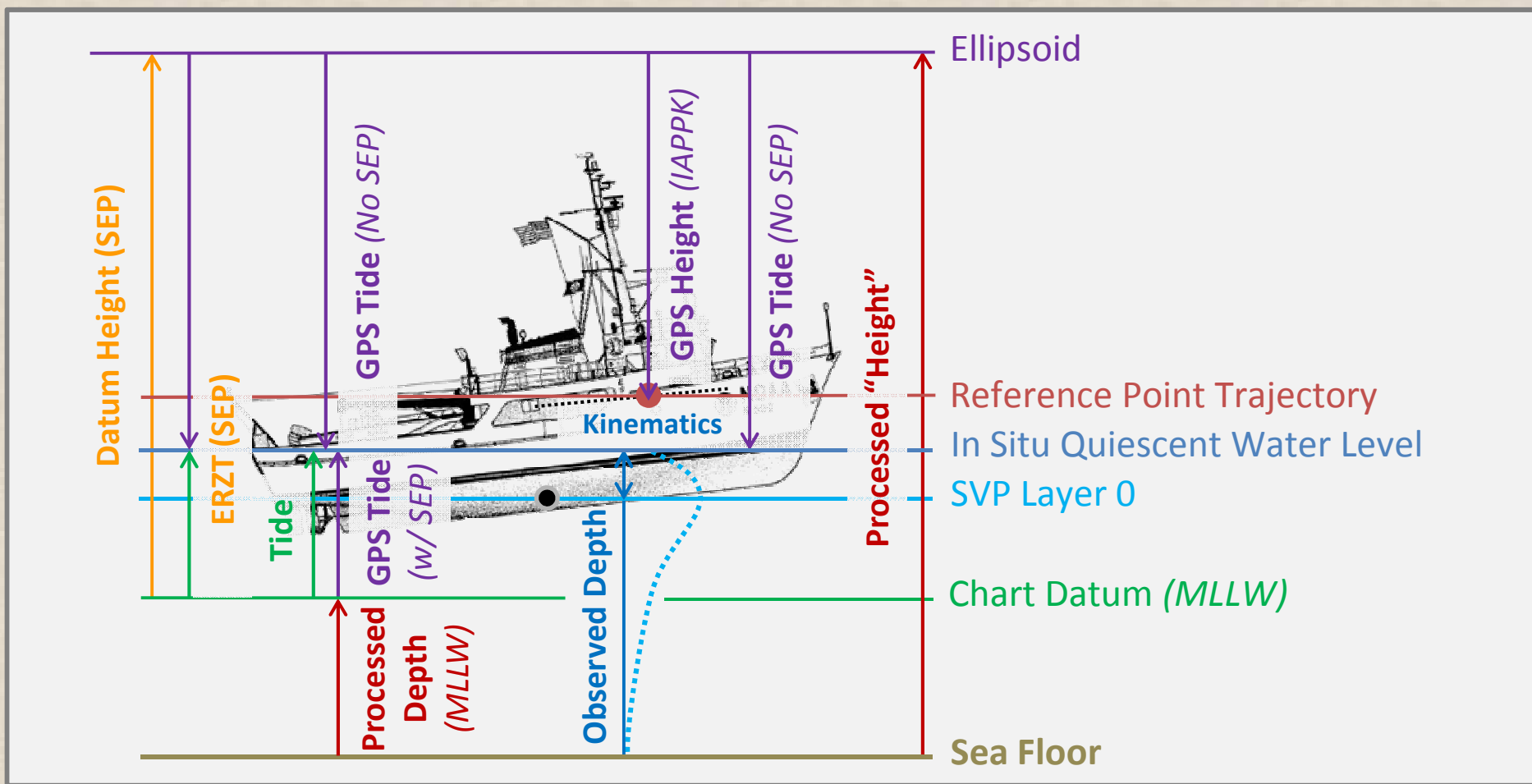
- Survey Platform Vertical Positioning
 - Water Level and Chart Datum Reckoning





ERS Key Points

- Survey Platform Vertical Positioning in ERS Hydro
 - Water Level and Chart Datum Reckoning
 - GPS-Reckoned Geodetic Heights





ERS QC Tools: POSPac MMS [Consolidated] QC

- Input / Settings
 - POSPac Project file
 - SBET
 - <Options>
- Output QC Summary & Plots
 - Status
 - SBET
 - RMS
 - SMERS
 - SMRMS
 - IAKAR
 - SRD

POSPac Automated QC

Settings

POSPac Project: E:\Data\NOAA\POSPac\F\A\POSPAC\H12617\F\A-2005\2013_258_2005\2013_258_2005.povoc

NAVDP Reference SBT: E:\Data\NOAA\POSPac\F\A\POSPAC\H12617\F\A-2005\2013_258_2005\2013_258_2005\2013_258_2005\2013_258_2005.out

Sustained tolerance: 1 minutes (processing mode)

Run Auto QC

Summary | Status | SBET | RMS | SMERS | SMRMS | IAKAR | SRD

Processing 2013_258_2005

Configure:

9/15/2013 18:16
GPS week 1758, Leap seconds 16
DWS05.02-Mar/10/10
VNS4
HW3.1-7
SN2411

Base station log:

| Date | Station | Distance | Data Type | Data Rt* | Current Rt** | Status | Service |
|-----------|---------|----------|-----------|----------|--------------|----------|---------|
| 9/16/2013 | VTIS | 1.65 | GPS | 15 | NA | Imported | SOPAC |
| 9/15/2013 | VTIS | 1.65 | GPS | 15 | NA | Imported | SOPAC |
| 9/16/2013 | TORP | 11.67 | GPS | 30 | NA | Imported | CORS |
| 9/15/2013 | TORP | 11.67 | GPS | 30 | NA | Imported | CORS |
| 9/15/2013 | PVE3 | 12.03 | GPS | 15 | NA | Imported | SOPAC |
| 9/16/2013 | PVE3 | 12.03 | GPS | 15 | NA | Imported | SOPAC |
| 9/16/2013 | LRCH | 12.4 | GPS | 20 | NA | Imported | SOPAC |
| 9/15/2013 | LRCH | 12.4 | GPS | 30 | NA | Imported | SOPAC |
| 9/15/2013 | PVPK | 32.69 | GPS | 15 | NA | Imported | SOPAC |
| 9/16/2013 | PVPK | 32.69 | GPS | 15 | NA | Imported | SOPAC |
| 9/15/2013 | CATS | 33.6 | GPS | 30 | NA | Imported | CORS |
| 9/16/2013 | CATS | 33.6 | GPS | 30 | NA | Imported | CORS |

*Data Rate: base station rate used for POSPac processing
**Current Rate: current CORS base station logging rate available online (verified 2/19/2014)

Coverage:

PRSV(BNAV): 0.98932 (tolerance range 0.95 to 1.0)

Message log:

<OBPP Backward navigator>
Vehicle to reference alignment angles : 0.000 0.000 0.000
Multi-path setting : LOW
Reference to primary GNSS lever arm : -0.306 -0.682 -3.174
GNSS antenna separation : 1.449
GNSS baseline vector : -0.002 1.449 -0.002
GNSS heading calibration threshold : 0.000
GNSS heading correction : 0.000

<OBPP Forward navigator>
Vehicle to reference alignment angles : 0.000 0.000 0.000
Multi-path setting : LOW
Reference to IMU lever arm : -0.008 -0.031 0.130
Reference to IMU alignment angles : 0.000 0.000 0.000
Reference to primary GNSS lever arm : -0.306 -0.682 -3.174
GNSS antenna separation : 1.449
GNSS baseline vector : -0.002 1.449 -0.002
GNSS heading calibration threshold : 0.000
GNSS heading correction : 0.000

<IMU Data Continuity>
1 sync log anomalies found.

Calibration Installation Parameters:

Reference to primary GNSS lever arm
when: Mean: 0.000, StDev: -0.735, -3.169
xStd yStd zStd: 1.26e-04, 2.90e-05, 9.76e-05
Max Figure of Merit: 100.0

Solution Status:

Min # SVs: 5
Max PDOP: 3.55 (> 3.0 for 17.3 minutes)
14 PDOP spikes are found and saved into shapefile
Max Baseline: 3477.5 m

Processing Mode:

Fixed NL Mode(0): 208.4 minutes
Fixed WL Mode(1): 156.4 minutes
Float Mode(2): 19.3 minutes
DGPS Mode(3): 3.8 minutes
RTCM Mode(4): 0.0 minutes
JAPPP Mode(5): 0.0 minutes
C/A Mode(6): 0.0 minutes
GNSS Mode(7): 0.0 minutes
DR Mode(8): 0.0 minutes

Total 23.1 minutes in non-fixed mode (sustained tolerance: 1 minutes)
0 period of minimum 1 minute(s) sustained non-fixed mode, ignoring 21.9 minutes startup

Smoothed Best Estimate of Trajectory (SBET):

2 Altitude spikes are found and saved into shapefile

Smoothed Performance Metrics (RMS):

Max RMS Error (SDev) : Tolerance
North: 0.022 (0.003) - 0.07 m
East: 0.028 (0.004) - 0.07 m
Down: 0.058 (0.009) - 0.07 m
Roll: 0.860 (0.060) - 1.20 arc-min
Pitch: 0.863 (0.060) - 1.20 arc-min
Heading: 3.704 (0.126) - 3.00 arc-min

Smoothed Estimated Errors (SMERS):

SMRMS:

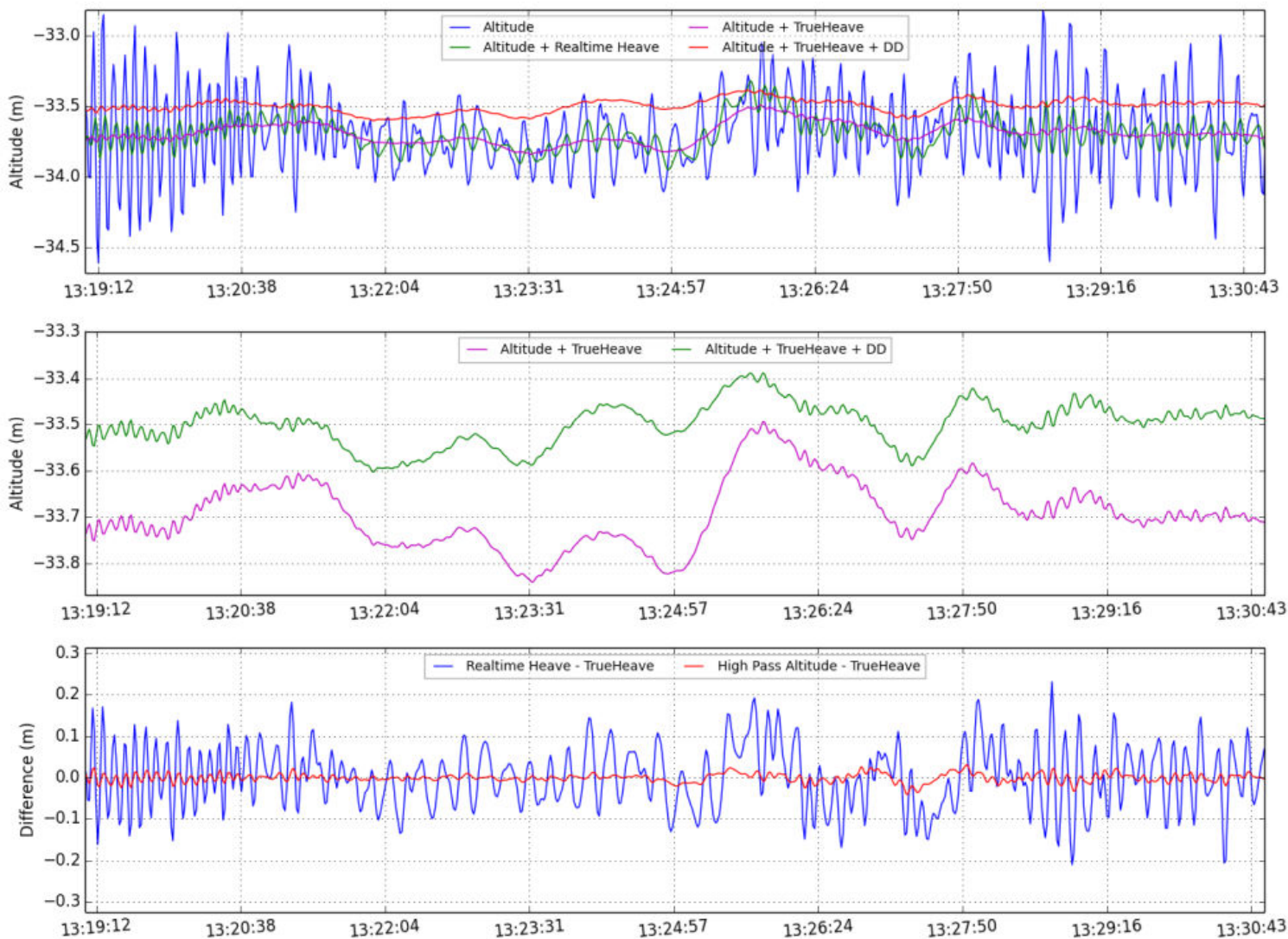
SBET IAKAR Separation:

Smoothed Reference Data (Realtime Difference):

| | Median | (SDev) |
|------------------|--------|-----------|
| North Pos. Diff: | 0.200 | (0.212) m |
| East Pos. Diff: | -1.115 | (0.153) m |
| Down Pos. Diff: | 0.403 | (0.417) m |

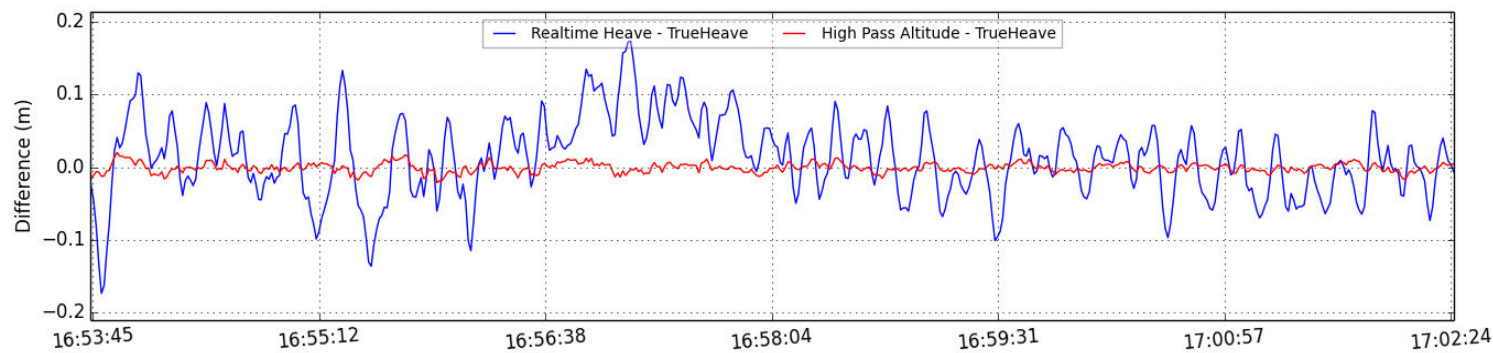
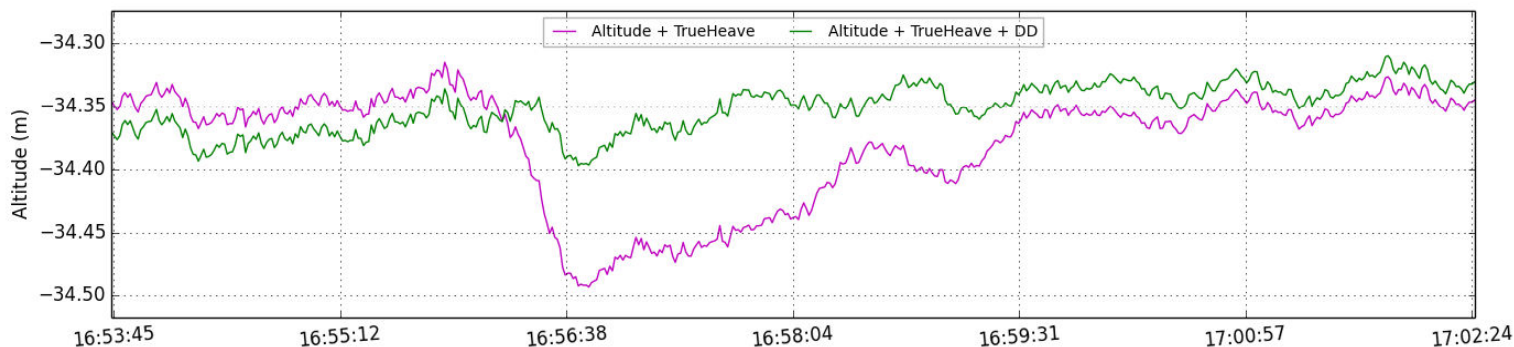
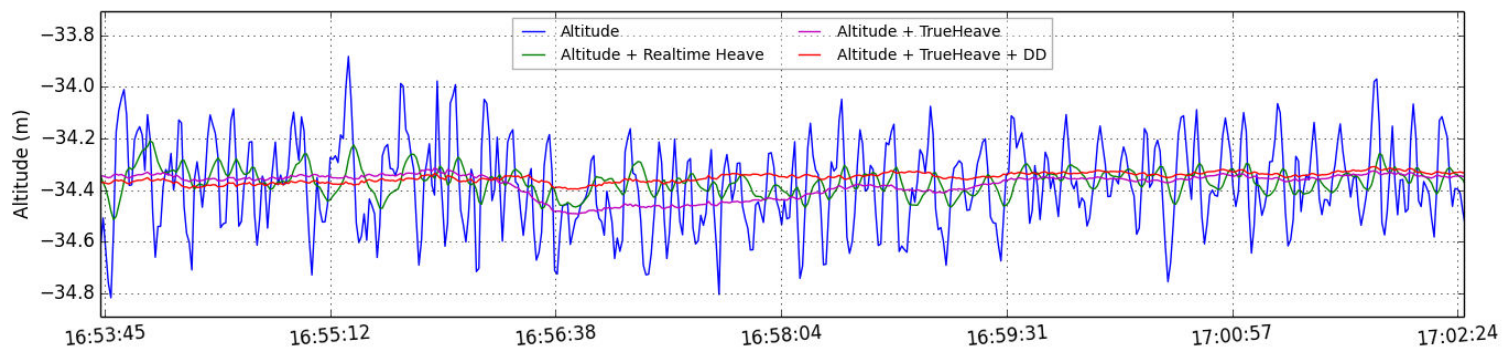


NOAA Ship TJ (S222): Altitude + Heave + Dynamic Draft





NOAA Ship FA (2807): Altitude + Heave + Dynamic Draft





ERS QC Tools: Pydro POSPac Auto QC – Status Tab Plots





Ellipsoidally Referenced Survey – ERS Key Points

CARIS HIPS and SIPS - [H12617_SEselect_Standalone]

File Edit View Tools Process Select Window Help

18751_1
H12617_SW
H12617_SW_MLLW_50cm
H12617_SW_ELL_50cm
H12617_SW_ERS_50cm

Deep
Density
Depth
Hypothesis_Count
Hypothesis_Strength
Mean
Node_Std_Dev
Shoal
Std_Dev
Uncertainty
User_Nominated
Bounding Polygon

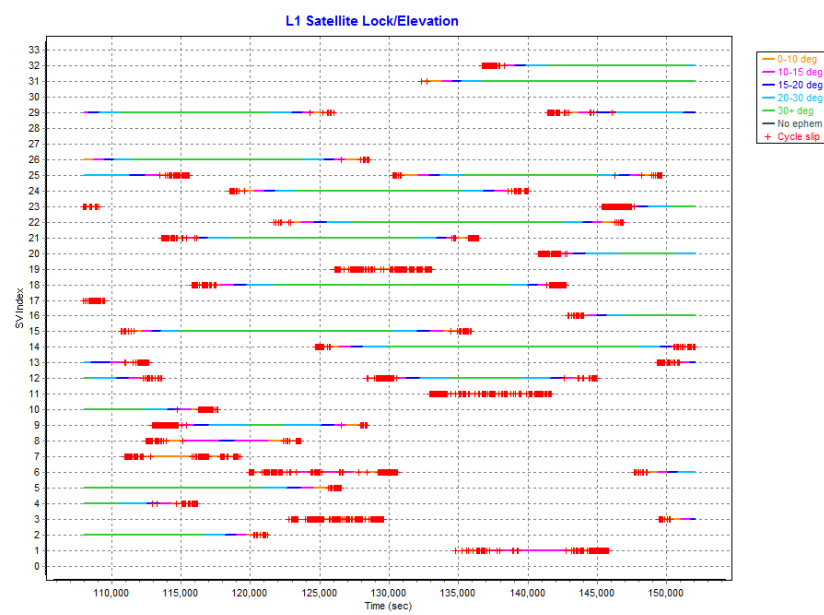
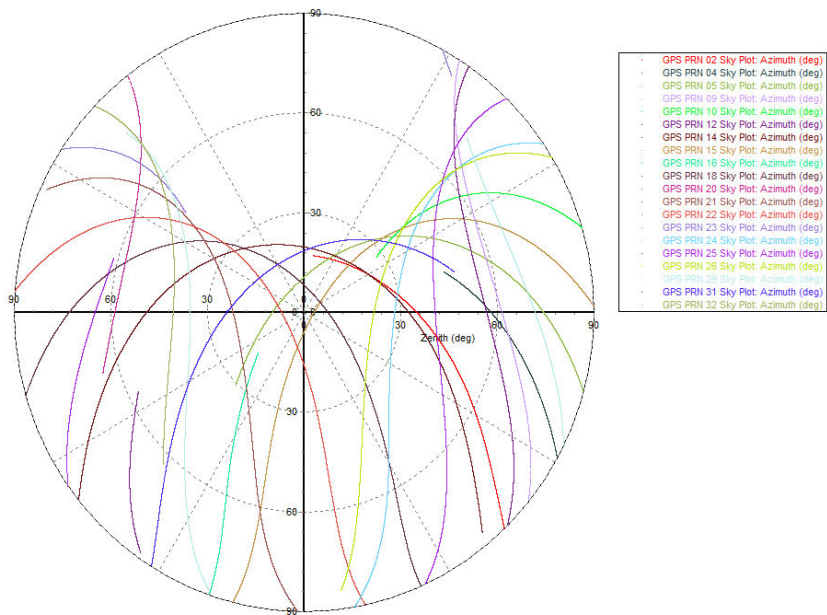
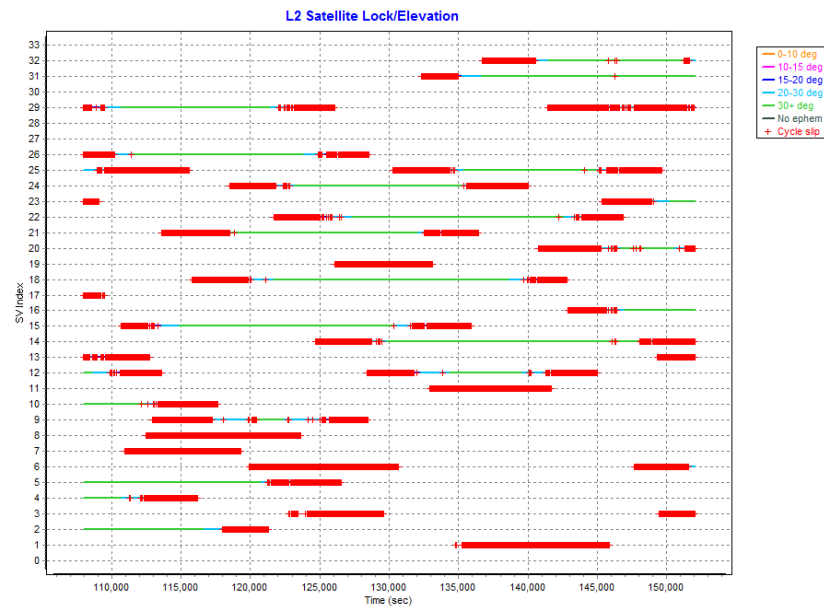
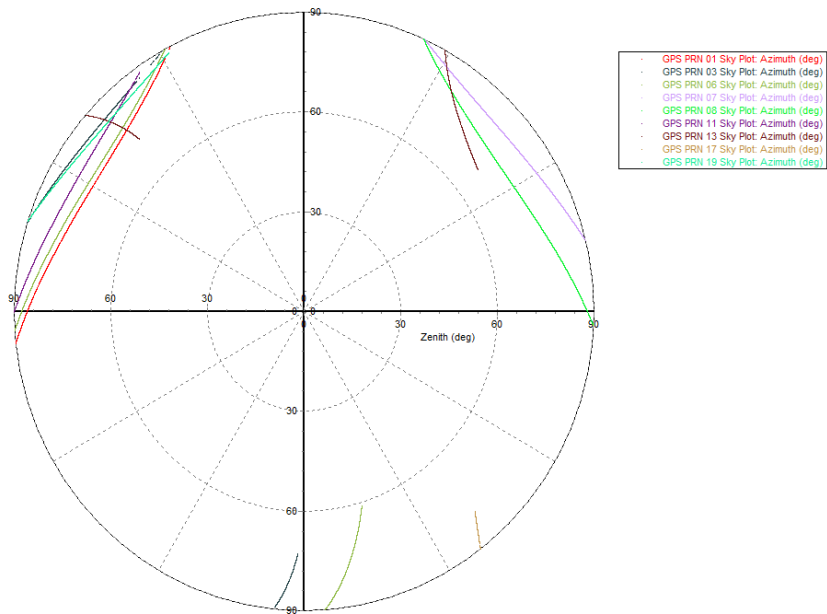
Worksheet

| Ind... | Geometry Type | Lat | Lon | Time | GPS Second | Spike Type | Spike |
|--------|---------------|--------------------|----------------------|---------------------|------------|---------------------|---------------|
| 0 | Point | 33.698551503940131 | -118.282572125168840 | 09/15/2013 23:26:33 | 84393 | Altitude + TH | -34.91 meters |
| 1 | Point | 33.698222548819167 | -118.282901979506560 | 09/15/2013 23:11:55 | 83515 | Altitude + TH | -35.06 meters |
| 2 | Point | 33.706219364608650 | -118.302661422382100 | 09/15/2013 21:44:33 | 78273 | PDOP | 5.01 |
| 3 | Point | 33.704143893160754 | -118.295461736003730 | 09/15/2013 21:37:39 | 77859 | PDOP | 5.55 |
| 4 | Point | 33.703959154448661 | -118.295575249616420 | 09/15/2013 21:30:44 | 77444 | PDOP | 3.84 |
| 5 | Point | 33.709533225453903 | -118.251481462665850 | 09/16/2013 00:42:47 | 88967 | PDOP | 3.22 |
| 6 | Point | 33.697187731800504 | -118.294651143125440 | 09/15/2013 18:35:20 | 66920 | PDOP | 4.05 |
| 7 | Point | 33.705491020238512 | -118.297445273749200 | 09/15/2013 21:47:40 | 78460 | PDOP | 5.16 |
| 8 | Point | 33.704841634150903 | -118.296683695787370 | 09/15/2013 21:48:58 | 78538 | PDOP | 5.19 |
| 9 | Point | 33.695804428367417 | -118.266669561916290 | 09/15/2013 22:34:53 | 81293 | PDOP | 4.33 |
| 10 | Point | 33.705853803743160 | -118.301025127244660 | 09/15/2013 21:43:42 | 78222 | PDOP | 4.95 |
| 11 | Point | 33.697267675185486 | -118.294423949319180 | 09/15/2013 18:36:33 | 66993 | PDOP | 4.09 |
| 12 | Point | 33.694049528453441 | -118.302327769583940 | 09/15/2013 18:40:52 | 67252 | PDOP | 4.24 |
| 13 | Point | 33.697209106291609 | -118.294594729430470 | 09/15/2013 18:35:38 | 66938 | PDOP | 4.06 |
| 14 | Point | 33.705923999140722 | -118.299182122393560 | 09/15/2013 21:46:36 | 78396 | PDOP | 5.12 |
| 15 | Point | 33.697173390693834 | -118.294683282673450 | 09/15/2013 18:35:09 | 66909 | PDOP | 4.05 |
| 16 | Point | 33.701677877789407 | -118.294355625338570 | 09/15/2013 20:56:01 | 75361 | Proc mode(Fixed WL) | 1.00 mode |
| 17 | Point | 33.698892436614074 | -118.283299491253700 | 09/15/2013 23:27:10 | 84430 | Proc mode(Float) | 2.00 mode |
| 18 | Point | 33.700431572691258 | -118.290175234030130 | 09/15/2013 20:44:06 | 74646 | Proc mode(Float) | 2.00 mode |
| 19 | Point | 33.693848085814508 | -118.284783088100750 | 09/15/2013 18:48:58 | 67738 | Proc mode(Float) | 2.00 mode |
| 20 | Point | 33.693874631394763 | -118.287007376710490 | 09/15/2013 18:47:56 | 67676 | Proc mode(Float) | 2.00 mode |
| 21 | Point | 33.698225533862605 | -118.282901504145340 | 09/15/2013 23:11:54 | 83514 | Proc mode(Float) | 2.00 mode |

0 of 282 selected 1:35740 33-43-53.51N 118-18-20.93W



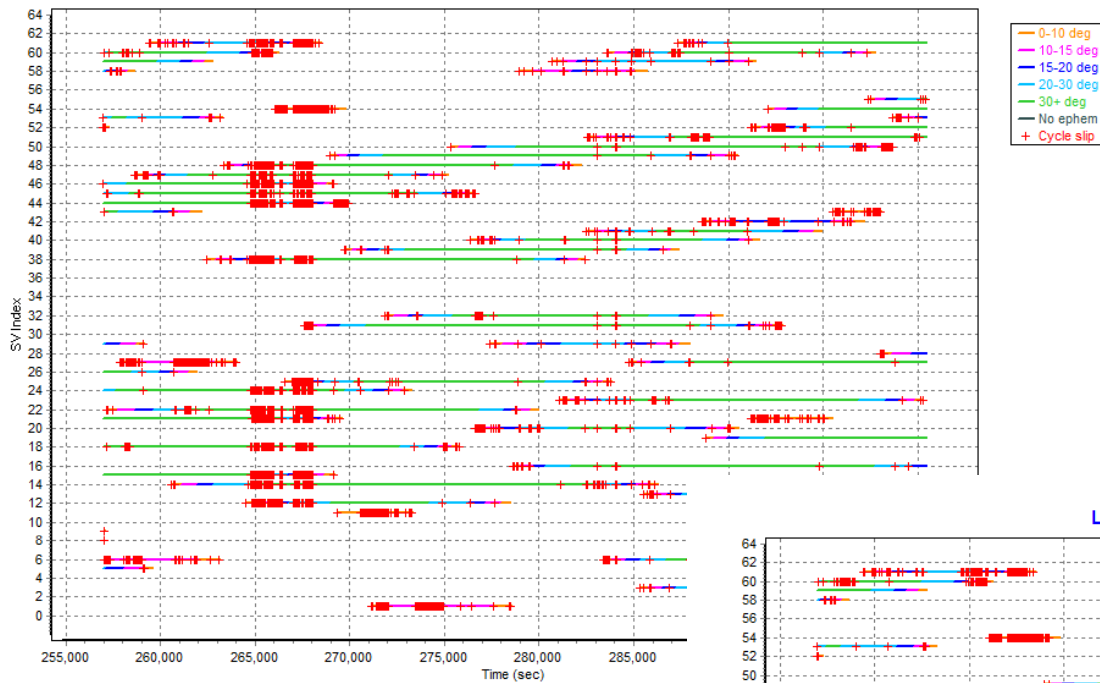
NOAA Ship TJ (S222): Secondary GPS Cycle Slips 2013-140



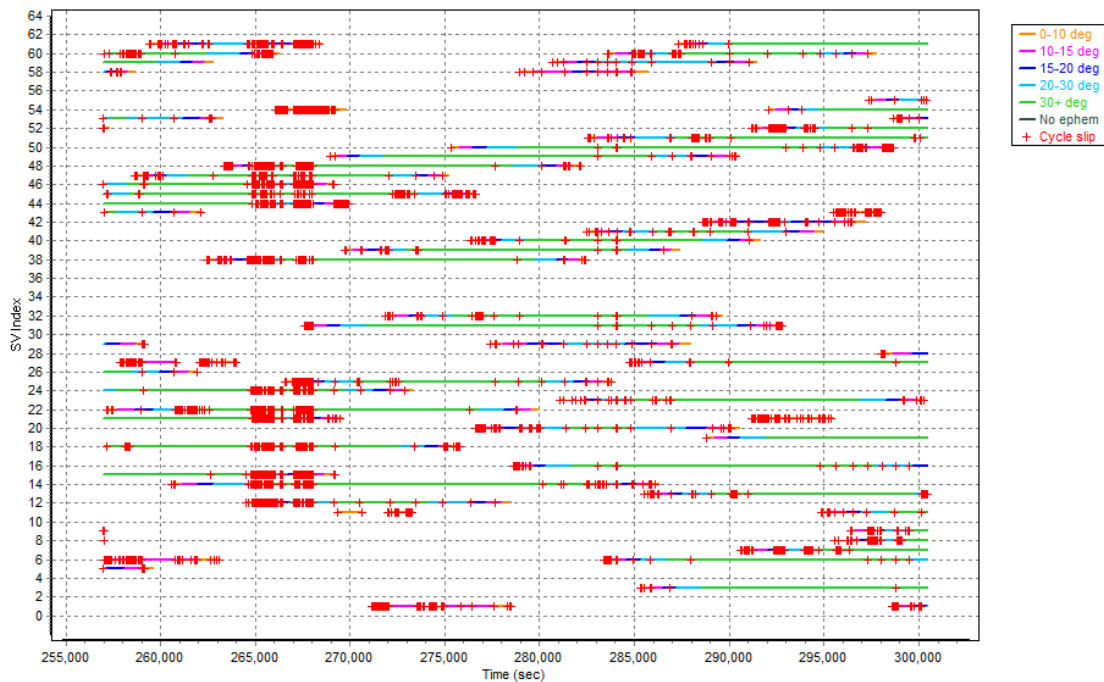


NOAA Ship FH (S250): Primary GPS Cycle Slips 2013-296

L1 Satellite Lock/Elevation



L2 Satellite Lock/Elevation





Survey Platform Position QA & QC

- Remediation Options

- (Re)Processing Sanity Check Per Hydro Context

- Limited Options for IAPPK (Re)Processing

- Alternate base station(s); network arrangement

- Time windows

- Satellites elevation mask & piecewise [total] exclusion

- Self-Fusion: Expanded Options in PPK, then loose (re)coupling

- Data Replacement

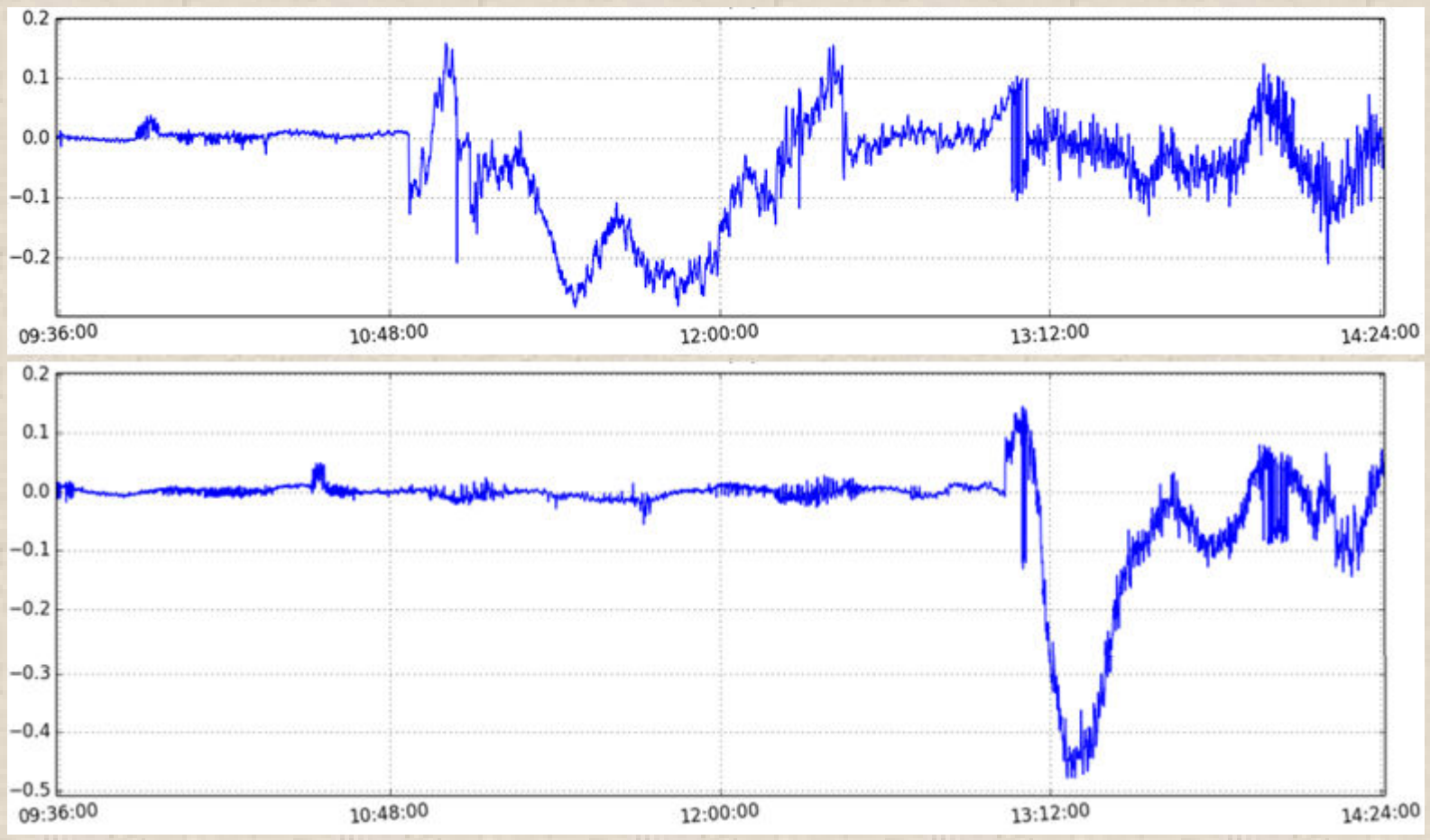
- IAPPP – IGS Final Orbit for 30s clocks; 12-18 day latency

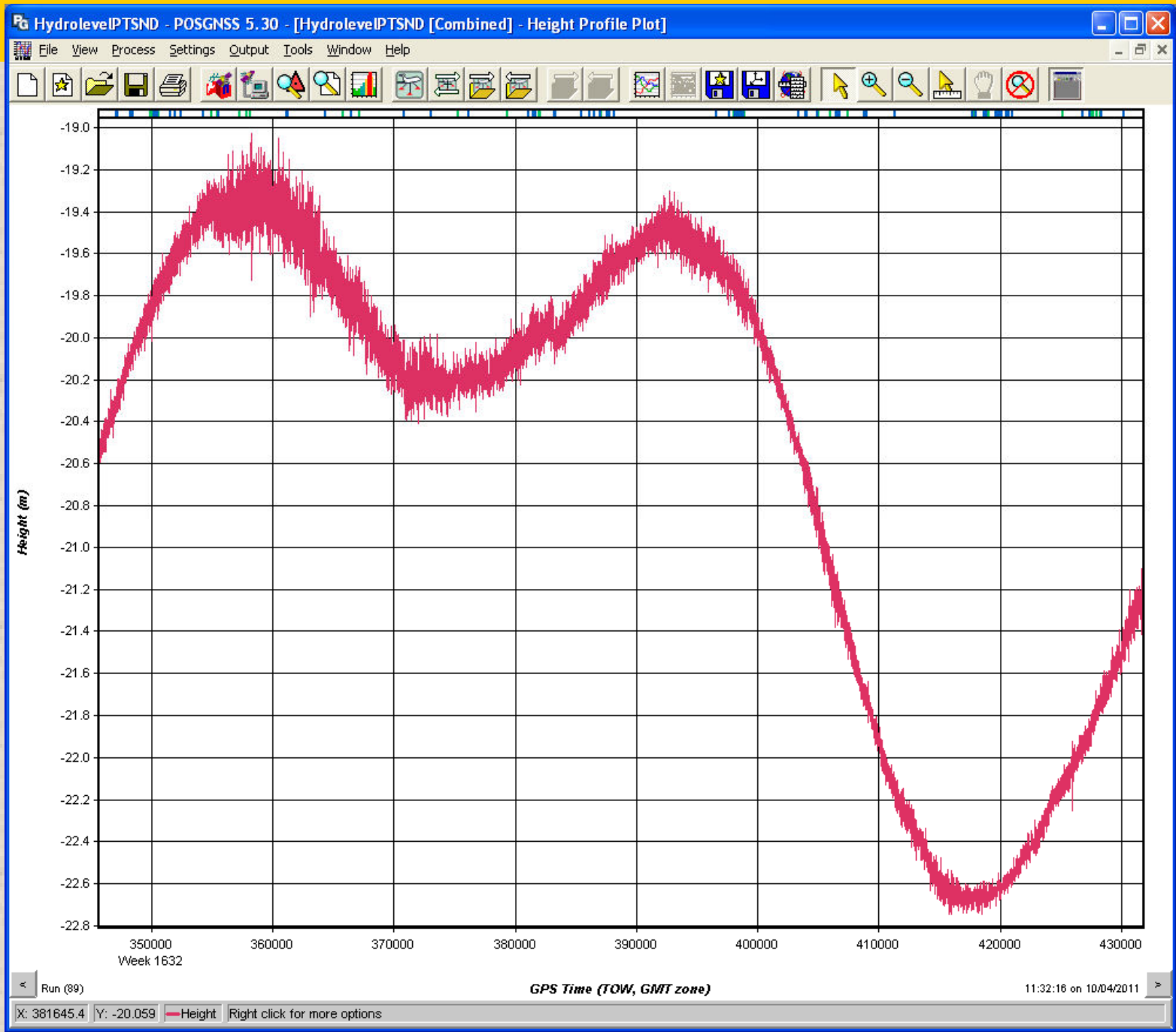
- Non-ERS – Parallel tides requirement; see datum validation (\$)

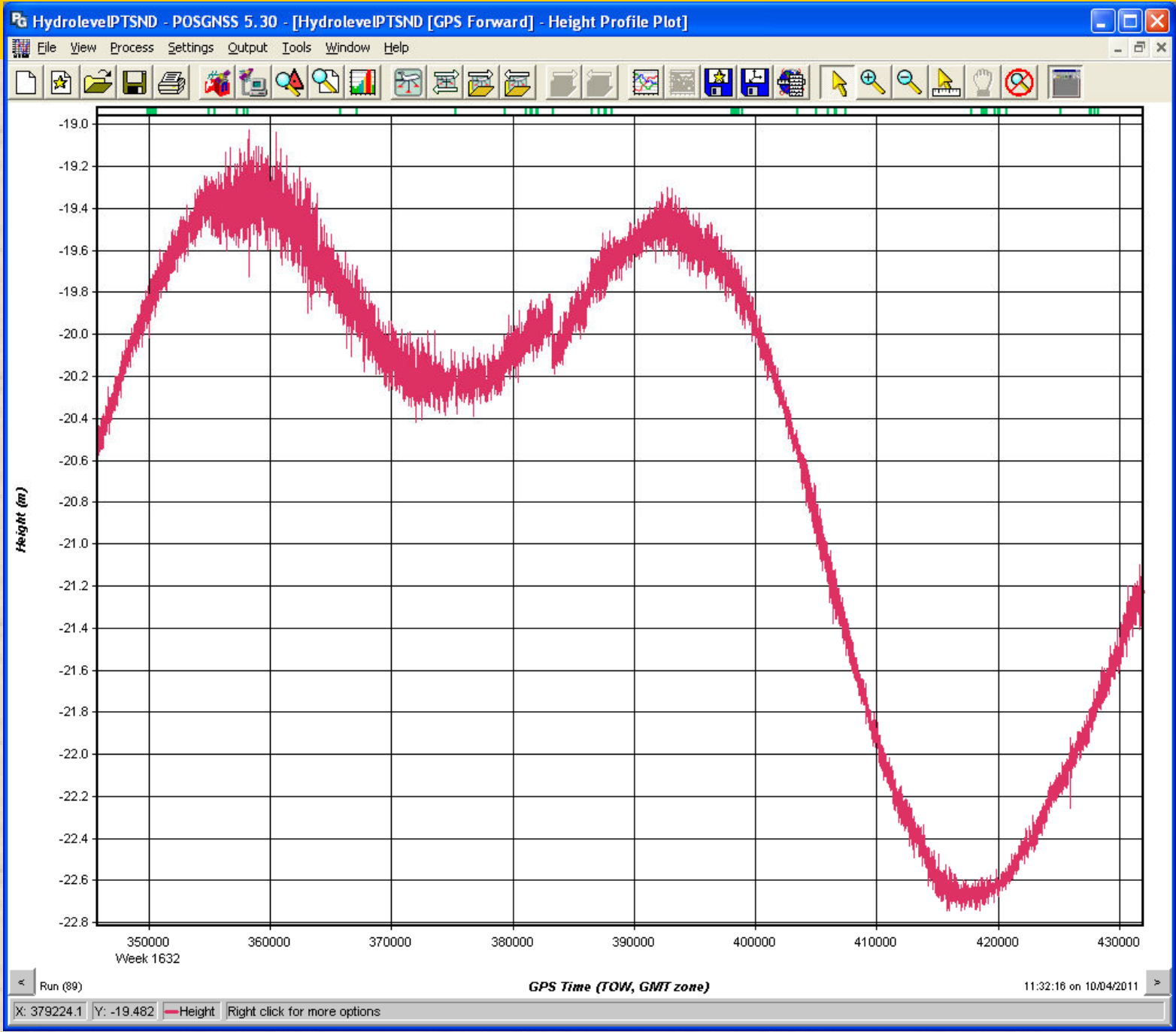
- Re-Acquire

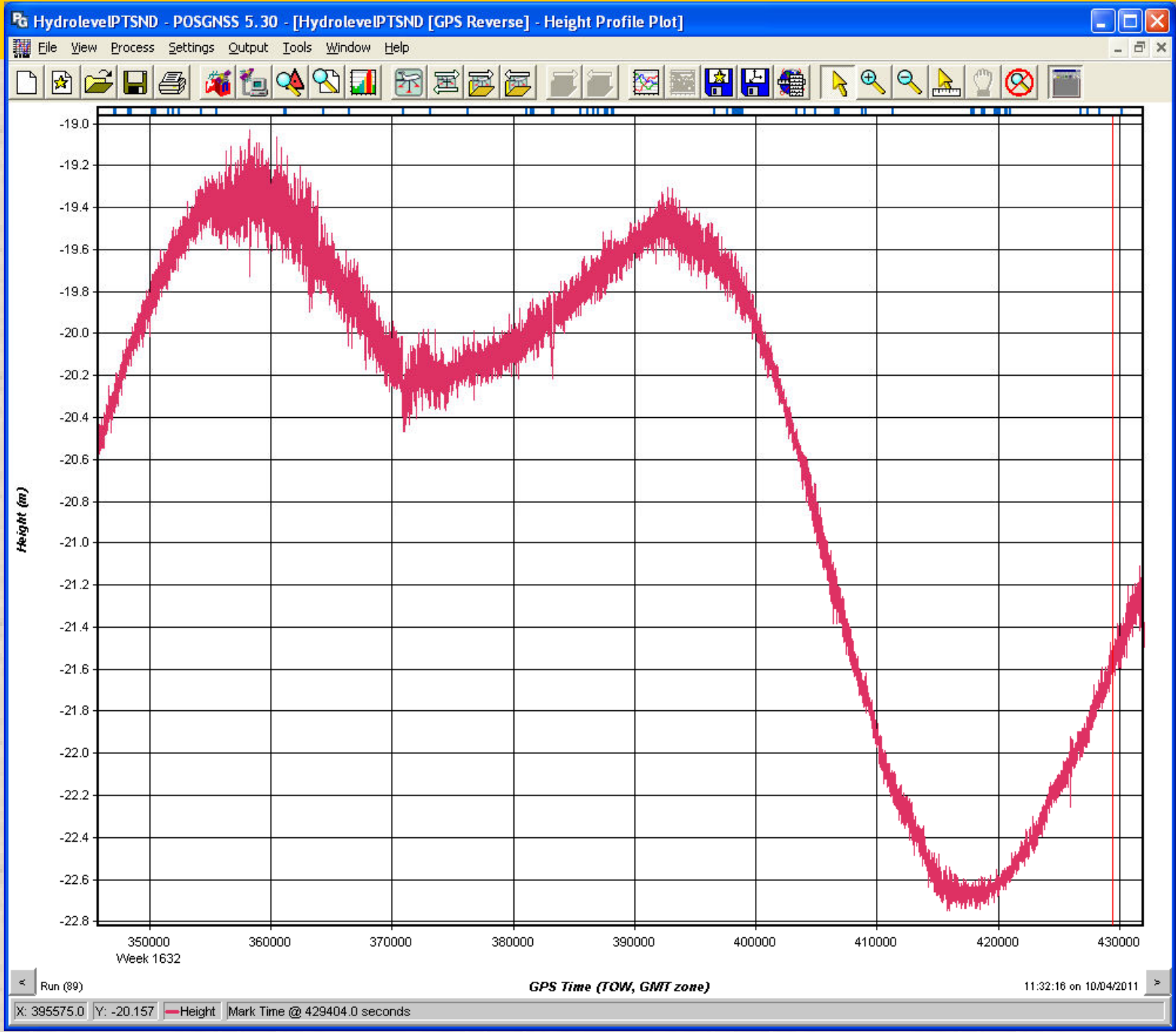


TJ (S222) – Gross SVmask Effects on “bad” data: 15 deg & 7.5 deg











Summary

- **Wanted: (Re)Processing Mechanization**
 - Replace Manual QC that Offers Little Recourse
 - Processing Performance Cause-and-Effect Automatic Feedback
 - Leverage Hydro Context More