A Sea Level Fundamental CDR from Reprocessing TOPEX Altimeter Data

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CDR Team Meeting
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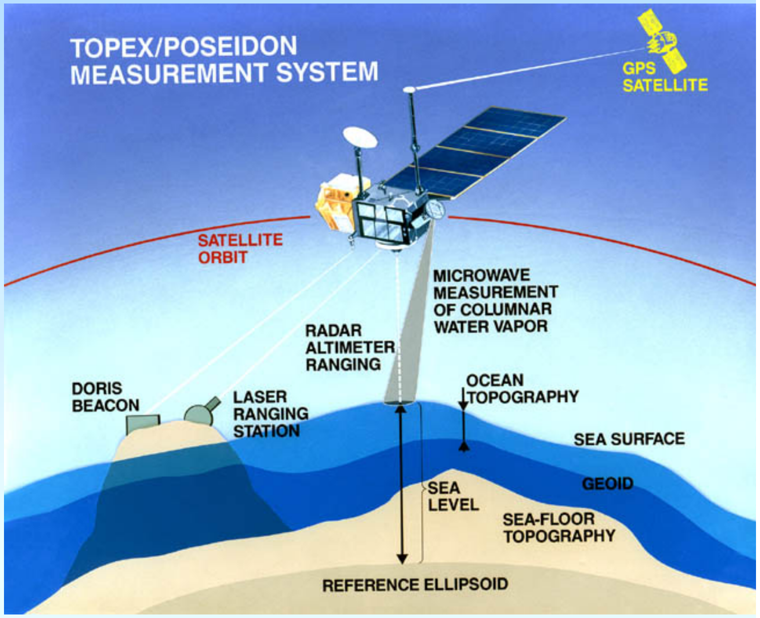
Outline – Sea Level from TOPEX

- Project Description
- Production and QA Approach
- Applications
- Schedule & Issues

Altimeter Sea Level Project Description (1 of 2)

- Fundamental Measurement: Sea Surface Height (SSH) from TOPEX altimeter measurements updated by retracking, improving microwave radiometer data, and using new orbits and ancillary information



- Time Period: January 1993 – October 2005
- Spatial Resolution: Repeating ground track (+/- 1 km, max lat = 66.0 deg). Along-track resolution ~ 6 km (1 sec, with SSH at 10/sec). Along-track points not aligned.
- Time Step: Orbit repeat = 10 days, 127 revs per repeat
- Data Format: netCDF (translated from original fixed length binary records). Consistent with ongoing altimeter missions Jason-1/2.

Altimeter Sea Level Project Description (2 of 2)

- Inputs
  - TOPEX Sensor Data Record (SDR) for waveforms, Calibration data to re-derive PTRs, Geophysical Data Record for translation/ completeness
  - New Precision Orbits
  - New Ancillary Information: Atmospheric Corrections, Tides, Sea State Bias Model(s), Mean Sea Surfaces (MSS)
- Uncertainty Estimate
  - Total SSH error ~ 3 cm for global RMS
  - Individual points provide variation of high rate measurements
  - Main error sources: Altimeter noise (~1.5 cm), Sea State Bias (~1.0 cm), Orbit (1-2 cm), Atmospheric corrections (~1 cm)
- Additional Products: Ancillary fields included in each record
  - Altimeter measurement of Significant Wave Height (SWH), backscatter (sigma0 -> wind speed)
  - Microwave Radiometer measurement of atmospheric water
  - Geophysical Models: Tides, MSS, Inverted Barometer Effect

Project Description Table

CDR(s) (Validated Outputs)	Period of Record	Spatial Resolution; Projection information	Time Step	Data format	Inputs	Uncertainty Estimates (in percent or error)	Collateral Products (unofficial and/or unvalidated)
Sea Surface Height (SSH)	January 1993 – October 2005	Repeating ground track +/- 1 km, 127 revs/ cycle. ~ 6 km along track.	10 day orbit repeat cycle. ~1 sec along track.	NetCDF (translated from GDR binary flat files)	TOPEX SDR (waveforms), GDR, Cal. Reprocessed TMR. New Precision Orbits (POE). New Ancillary data: Atmospheric corrections, Tides, Mean surfaces	SSH Global RMS ~ 3 cm. Altimeter noise ~ 1.5 cm, Sea State Bias ~ 1 cm, Orbit 1-2 cm, Atmospheric corrections ~1 cm.	Altimeter Significant Wave Height (SWH), surface backscatter (sigma0), Radiometer atmospheric water

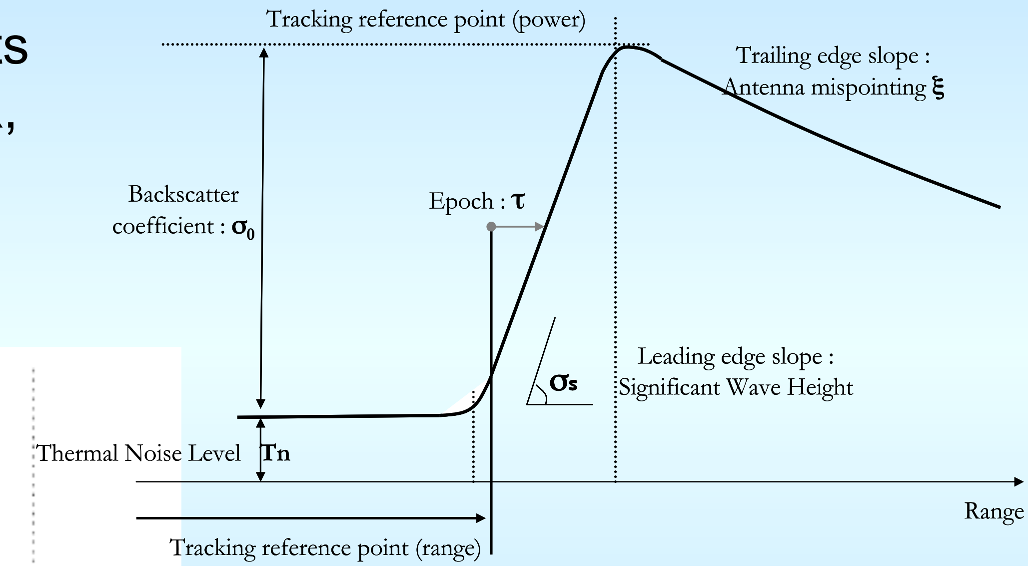
Production Approach (1 of 3)

- Retrack TOPEX data with revised instrument corrections for
  - Leakages in waveform (WF) that move with range rate
  - Point Target Response (PTR) changes in Alt-A
- Use improved processing of radiometer (TMR) data for calibration and coastal
- Data Improvements
  - Precision Orbits (POE): provided by GSFC as part of ongoing altimeter activities
  - Geophysical Corrections/Ancillary Data
    - Atmospheric Pressure products (Dry Tropo, Inverse Barometer): provided by CNES
    - Tides, Mean Sea Surface: provided by OSTST members
  - With above improvements, solve for new Sea State Bias (SSB)

Production Approach – Retracking (2 of 3)

- Instrument corrections needed for TOPEX data
  - Leakages in waveform (WF) that move with range rate

- Return signal Waveform results from convolution of Radar PTR, surface height distribution, flat surface response function.



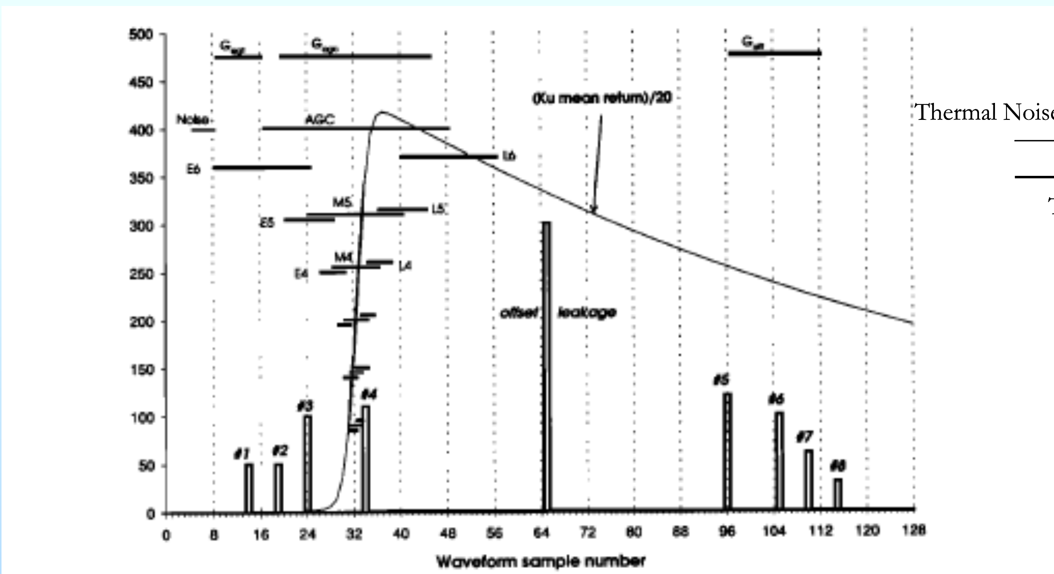


Figure 6. TOPEX Ku altimeter gates, mean return, and center locations of waveform leakage spikes.

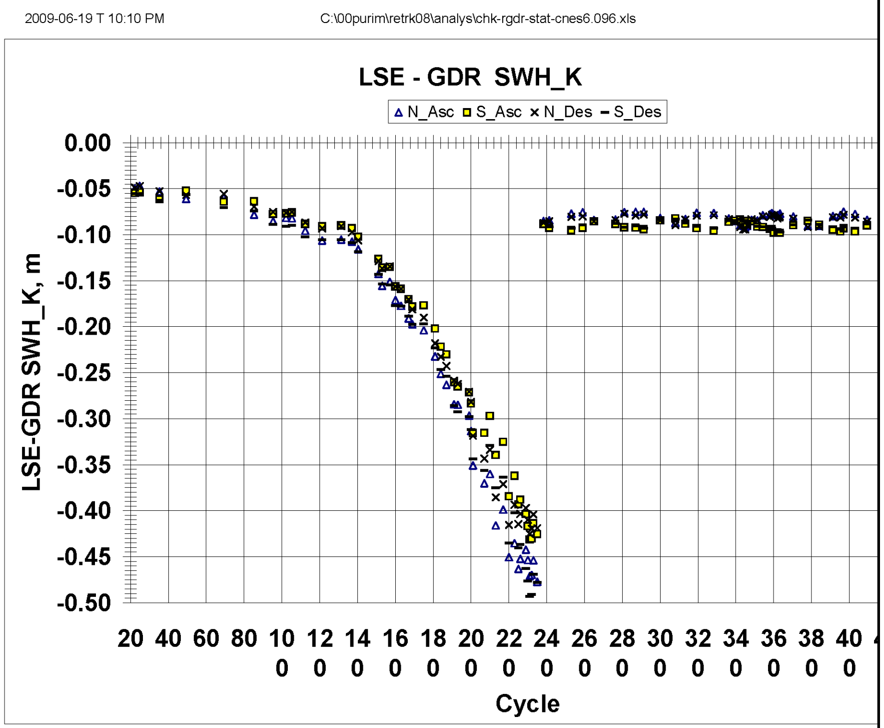
↑ "Retracking" is solving for the parameters in the waveform model: Range/Epoch, Amplitude/Power (sigma0), Slope (SWH), Antenna Pointing

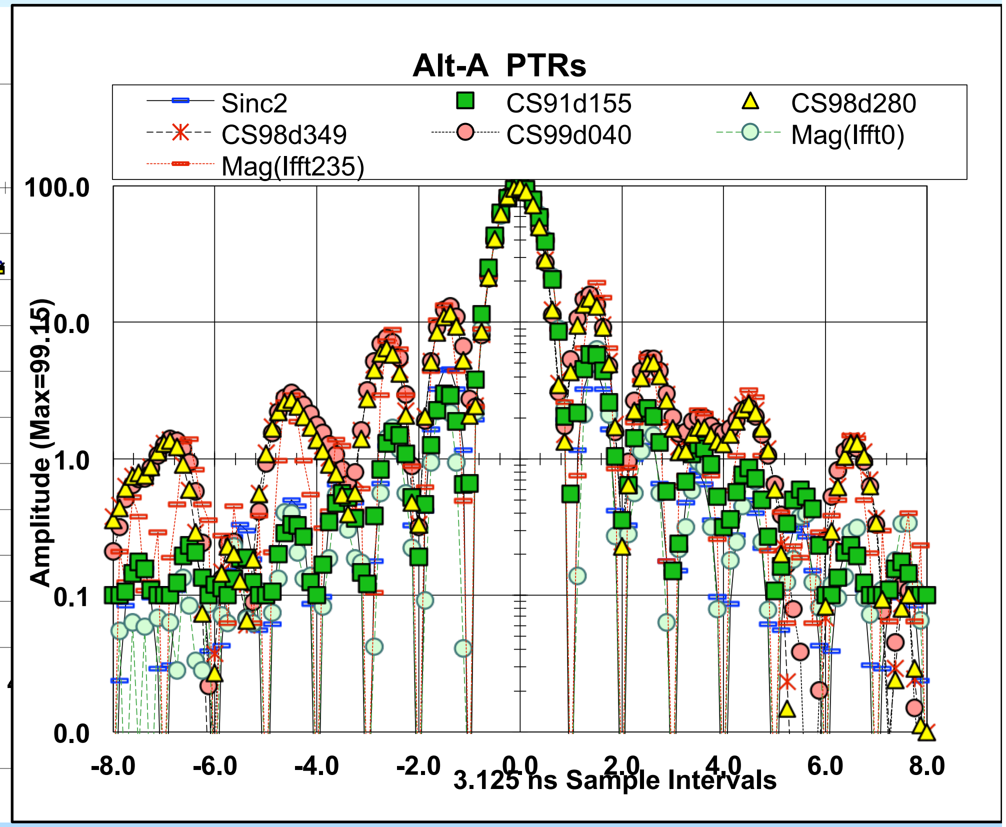
← Leakages (x20) from Hayne et als, 1994, JGR 99, 24,941.

Production Approach – Retracking (3 of 3)

- Instrument corrections needed for TOPEX data
  - Point Target Response (PTR) changes in Alt-A

Changes in PTR (right) – increase and distortion of sidelobes – caused changes in SWH (and range) that are corrected when the when the correct/ actual PTR is used in processing.



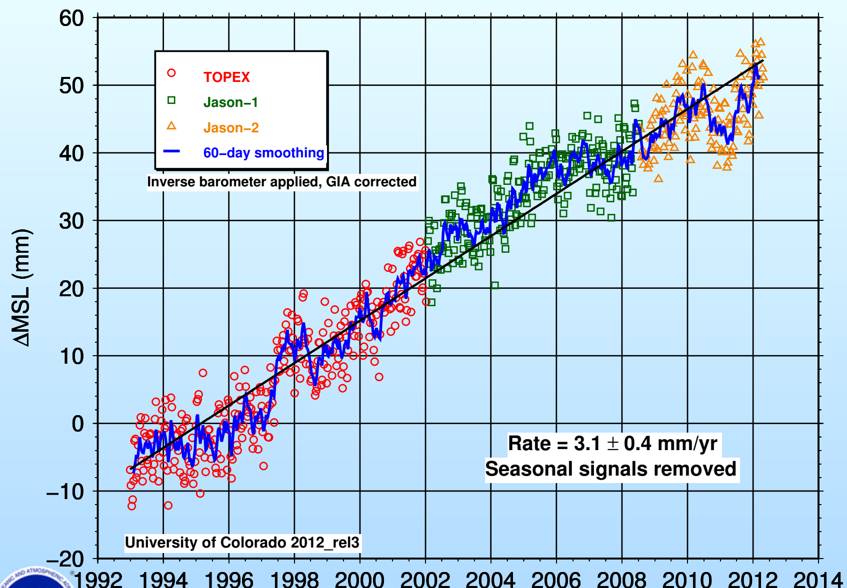


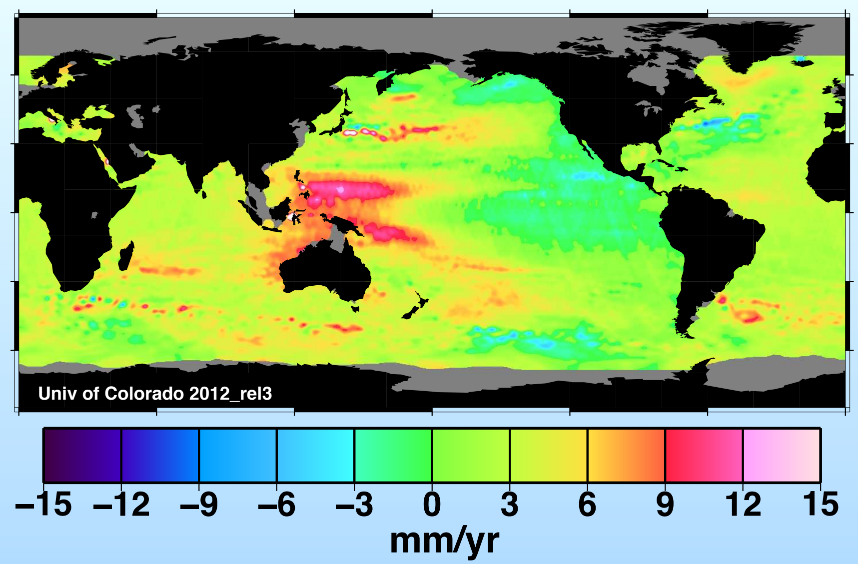
Quality Assurance Approach

- Development
  - Simulations and detailed analysis of waveform residuals used to assess accuracy of processing, fitting
  - Samples through the entire 13 year record will be processed and compared to previous versions, assessed for presence/absence of expected/ unexpected trends
  - Focus on overlap period with Jason-1
- Production data will be evaluated for each 10 day cycle
  - Plots and statistics for each cycle for key quantities – Residual SSH, SWH, Sigma0, Good/Flagged points

Applications

- NOAA Vision for Climate – An informed society anticipating and responding to climate and its impacts
  - Mission: To understand and predict changes in climate, weather, oceans, and coasts
- Main uses of high accuracy altimetry are
  - Climate studies of sea level rise globally and regionally – reflects both ice melt and ocean heating. 1 mm/yr sea level accuracy requires certainty to < 1 cm over 10 yrs. (Diagrams below from http://sealevel.colorado.edu/)
    - ➢ Online viewer of sea level height effects: http://flood.firetree.net/
  - Development of ocean modeling to approach weather forecasting capabilities. Leads to coupled ocean-atmosphere, ocean-biological models





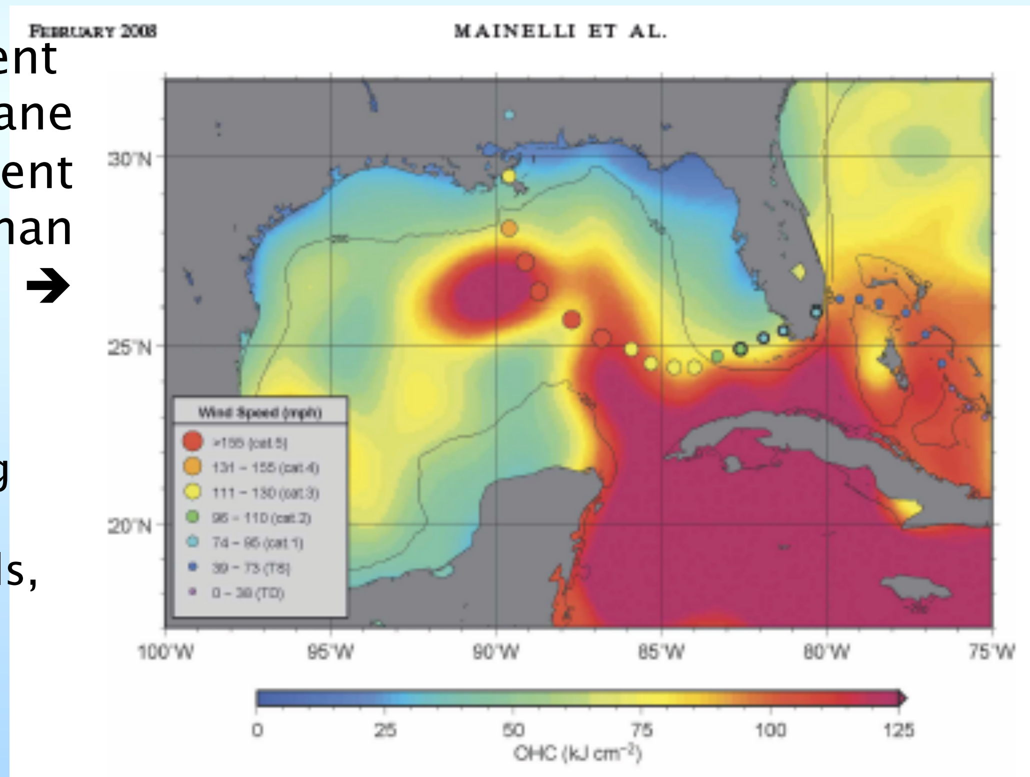
Applications

- Uses for Near Real Time Altimetry
  - See http://sealevel.jpl.nasa.gov/science/ -> Societal Benefits http://www.aviso.oceanobs.com/en/applications/index.html
  - Mesoscale eddy tracking for naval, oil rig, fishing, shipping operations; hurricane intensification over warm eddies; pollution tracking (e.g., oil spills); sport sailing
  - Inland water level tracking (retracked data may improve)

Tropical Storms and Ocean Content
Ocean heat content and Hurricane strength for Katrina. Heat content is much more concentrated than SST ➔

from

"Application of Oceanic Heat Content Estimation to Operational Forecasting of Recent Atlantic Category 5 Hurricanes", MICHELLE MAINELLI et als, 2008, Weather and Forecasting, 23, 3-16, DOI: 10.1175/2

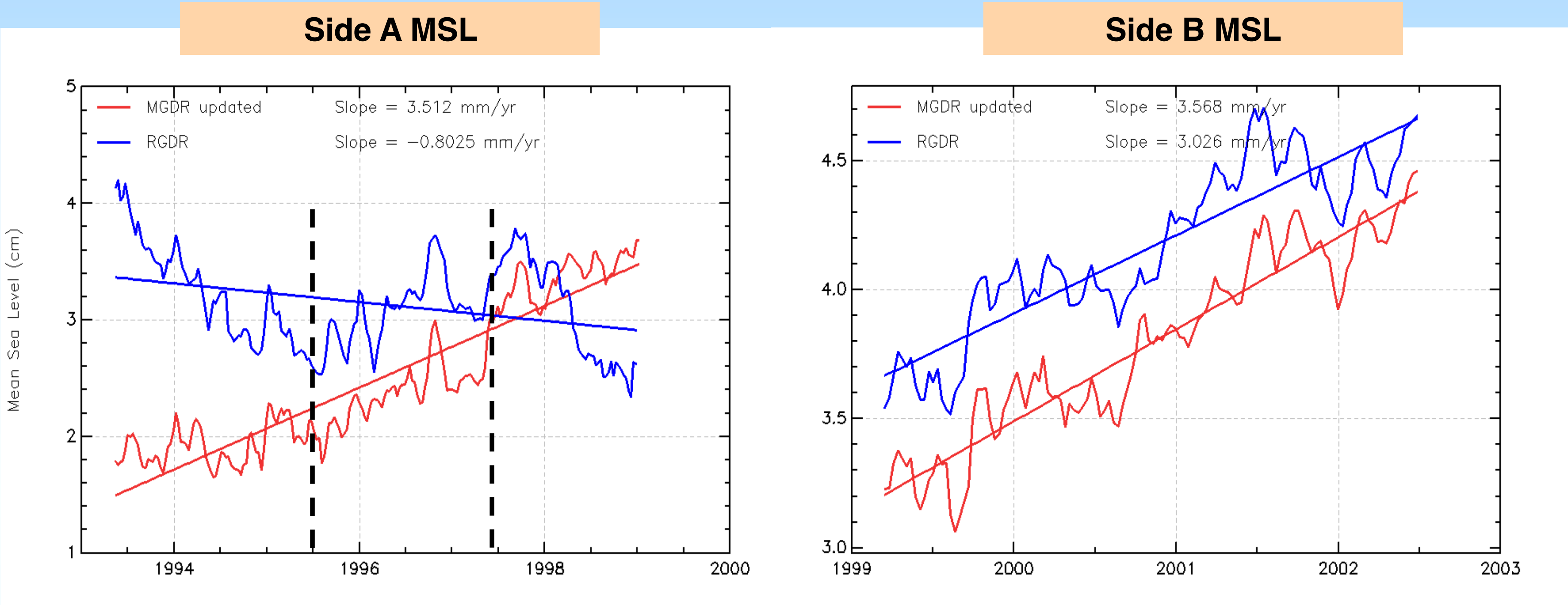


Schedule & Issues

- Status
  - Progress consistent with expenditures. Both are behind original plan.
  - Recovered, investigated original engineering reports, all previous software
  - Making excellent progress on waveform leakage and PTR investigation
    - Had difficulty finding, training appropriate support personnel
  - Estimate about 4 months behind original plan
- Near-term Plans
  - Complete investigation of leakage effects (Sep '12)
  - Complete investigation of PTR fitting (Oct '12)
  - Complete investigation of 59-day variation (Dec '12)
  - Complete development of QA procedures (Jan '13)
  - Process set of test cycles to check corrections, procedures (Mar '13)
  - Assuming test cycles are successful, begin full-scale processing ~ Apr '13
- State any risks or concerns
  - Several inputs come from outside sources:
    - Updated Precision Orbits from GSFC
    - Updated atmospheric correction files from CNES (have contacted and have verbal commitment)
  - Based on current status and reduced FY12-13 funding will probably ask for 1 year no cost extension, but too early to make specific request

BACKUP

Mean Sea Level Analysis by S. Labroue (CNES) '09 OSTST

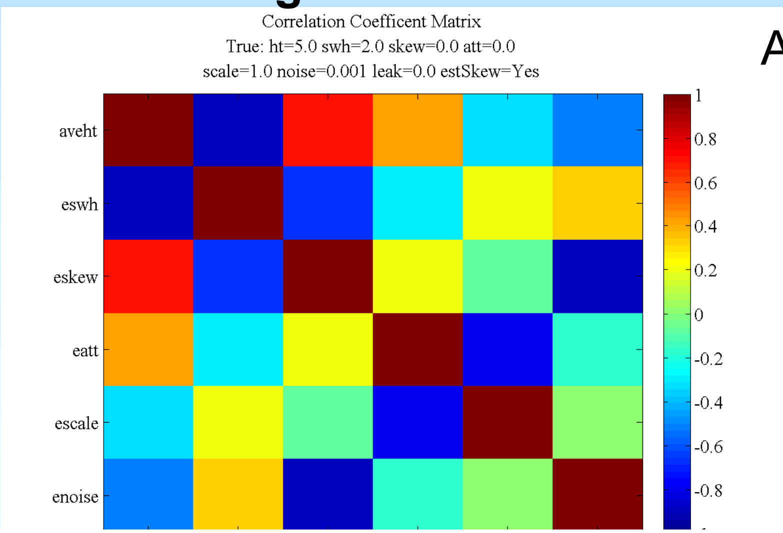


- Side A MSL with RDGR shows strong discrepancy with respect to MGDR MSL. RGDR exhibits a false curve and trend (-0.8 mm/year!!!!). The main differences appear at the beginning and the end of the time series.
- Side B MSL with RGDR data presents a trend lowered by 0.55 mm/year which is significant for MSL studies. We are more confident in MGDR MSL since side B is very stable (validated against in situ data and Jason-1 data)

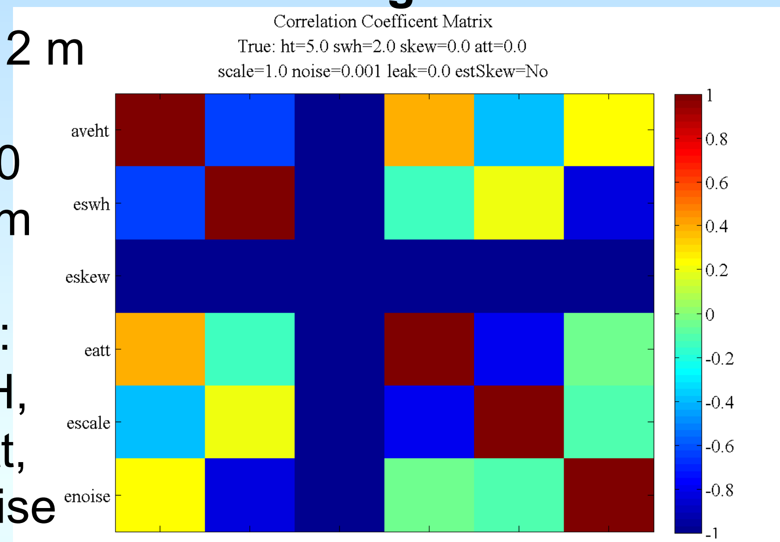
Careful assessment of the PTR correction needs to be performed on the SSH (including PTR corrections on range and SWH (through SSB)). A SSB has been estimated on RGDR products for each altimeter.

Simulation Results

Parameter Correlation Solving for Skewness

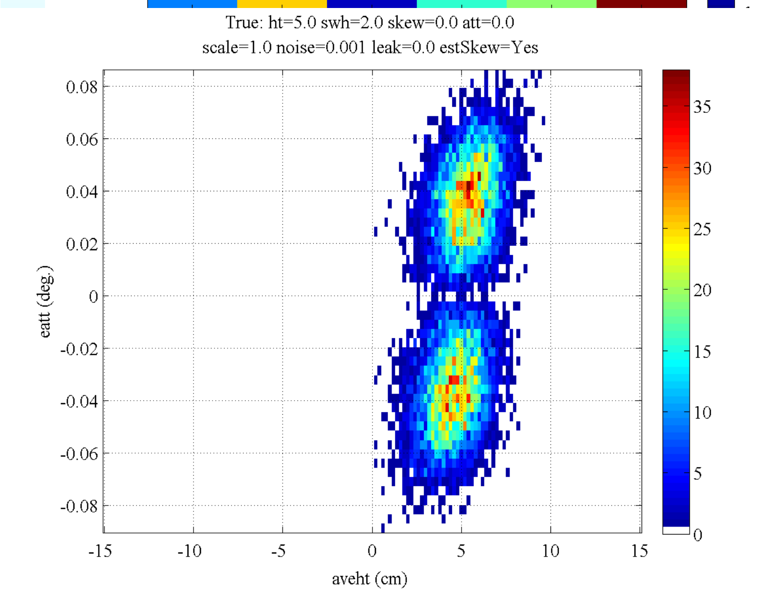


Parameter Correlation Not Solving for Skewness



All: SWH = 2 m
Att = 0
Skew = 0
dH = 5 cm

Params:
dH, SWH,
Skew, Att,
Scale, Noise



← Leakage = 0

Leakage = 2X →

2D Histogram:
Att / dH