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Retracked TOPEX Climate Data Record Summary

OSTST October 2015

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Outline / Overview

- Completed work funded by NOAA Climate Data Records program task: "Generation of Altimeter Climate Data Records Using Retracking and Updated Corrections"
  - Also supported by TOPEX/Jason-1 Project
- Retracking Results
  - Evaluated first version released in January 2015
  - Produced RGDR for cycles 1 - 480 for Skewness = 0.1 and Skew-solve; cycles 21-364 for Skewness = 0. Lists of missing input.
  - Final version generated in September. Data will soon be available on PODAAC
- Sea State Bias Update
  - Doug Vandemark, Hui Feng used standard method to provide
- Issues
  - Unable to correct for leakages
  - Instrument ("WFF") Range Calibration
  - While Alt-B SSB behavior is now fairly similar to Jason-1, Alt-A is not
  - Strange behavior of cycles up to at least 50 (PTR, SSH)

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Overview of Proposed Work – JPL/CNES

- Review history and documentation from Wallops and JPL on TOPEX calibration and retracking approach
  - Alt-A PTR Changes
  - Range Calibration
  - Features of JPL retracking: Gaussian decomposition of PTR; 10 ranges but only 1 of other quantities per frame
- Test retracking on simulated waveforms
  - Need to include leakages at various levels
- Update geophysical standards for final RGDR product
  - Sea State Bias Update. Doug Vandemark, Hui Feng used standard method to provide
- Time frame
  - Initial work done by spring 2016
  - Product update summer 2016
  - Validation TBD (next OSTST?)

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Backup Material

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TOPEX Climate Data Records

- TOPEX RGDR similar to Jason ver_D
  - NetCDF similar to Jason
  - Copy of original GDR
  - Retracking values for range, SWH, attitude
  - New GSFC orbits: std1410
  - New tide model GOT4.10C
  - Improved long period non-equilibrium tides
  - Updated MSS: CNES 2011
  - Reprocessed TMR data (Shannon Brown: improved calibration, coastal resolution)
  - Corrected sigma0 properly for WFF determined changes
  - SSB fitted to Retracked Data by Doug Vandemark
  - ~~New dry tropo correction and associated MOG2D values~~

- Recent issue – Loss of up to 10% of data relative to January 2015

- Future
  - NOAA CDR program to make "operational" – possible to update

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TOPEX Data Conclusions

- Waveform leakages cannot be directly corrected. Could not determine from on-orbit data (low wave height, low range rate)
  - **Lesson:** Checkout the test data. WF "teeth" corrected by weights.
- Point Target Response (PTR) changes can be determined from Cal-1 data to correct Alt-A changes
  - All versions of retracking correct Alt-A SWH for PTR change
  - No obvious changes in Alt-B data
- Range Calibration data are not well understood and contribute to sea level signal
  - **Lesson:** Calibration process should be part of algorithm development, open, widely understood
- Retracked data show different SWH behavior than Jason-1, but Alt-B is more similar than MGDR (Vandemark, Feng analysis)
  - Separate SSB corrections bring data into agreement
- One year is barely long enough average to get SSB. Observed interannual variations in SSB.

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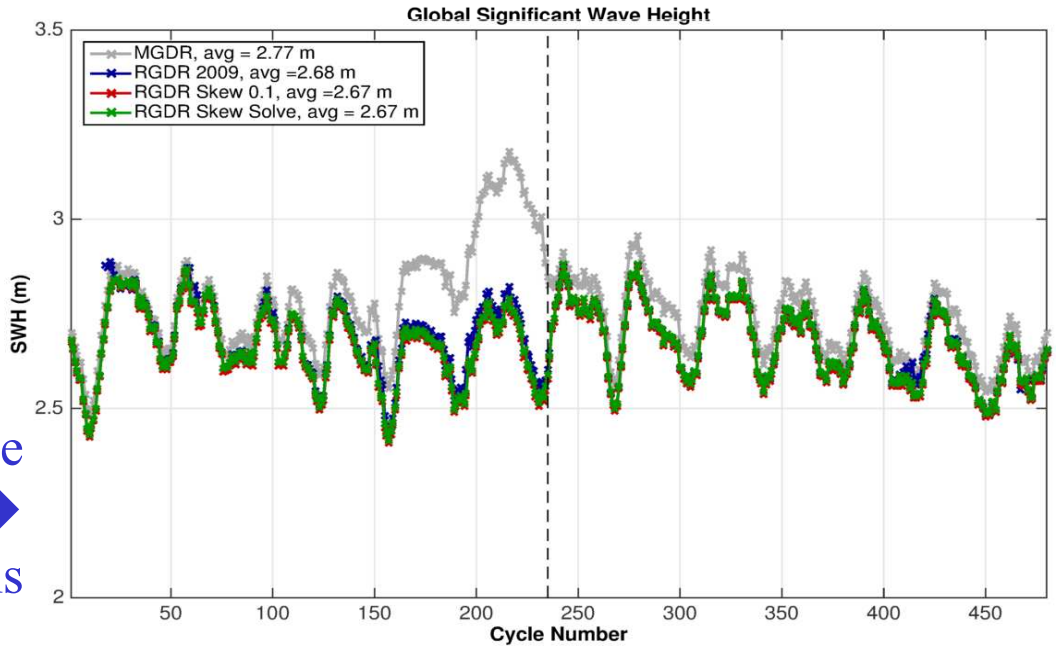
TOPEX Retracking Overview / History

- TOPEX standard processing did not include retracking
- Alt-A had changes in Point Target Response (PTR) beginning about Cycle 140 (mid-1996)
  - Changes became clear in 1997 as apparent increase in SWH
  - Switch to Alt-B in Feb 1999 (Cyc 236). No apparent changes in Alt-B
- Previous versions of retracking in 2007, 2009
  - 2007 used original WFF waveform (WF) weights/gains, hand fit PTRs
  - 2009 used refit WF weights, systematically fit PTRs to Cal-1 data to 10 lobes

- Analysis by Labroue '09 showed that 2007 agreed with MSL trend and improved agreement with Jason-1, while 2009 caused negative MSL trend and SSB was similar to original MGDR and rather different than that for Jason-1

Correction of SWH change from Retracking ➔ Similar in all versions



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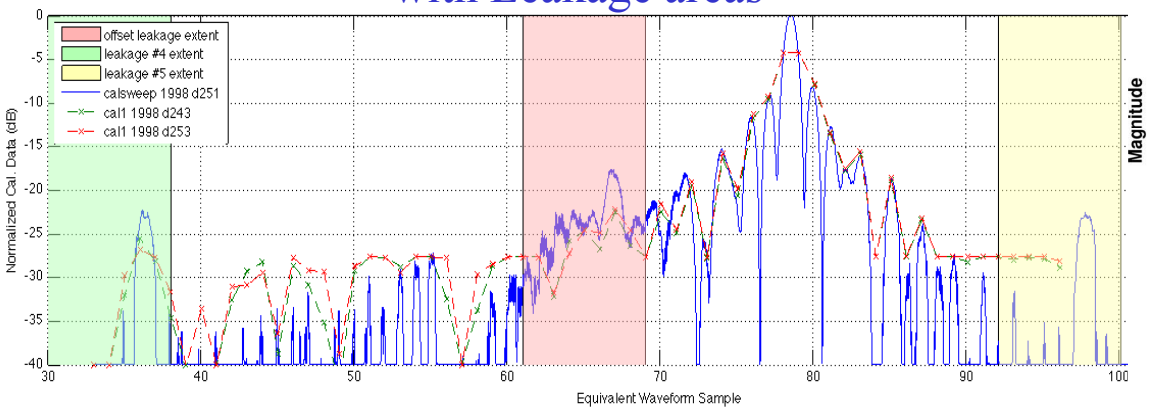
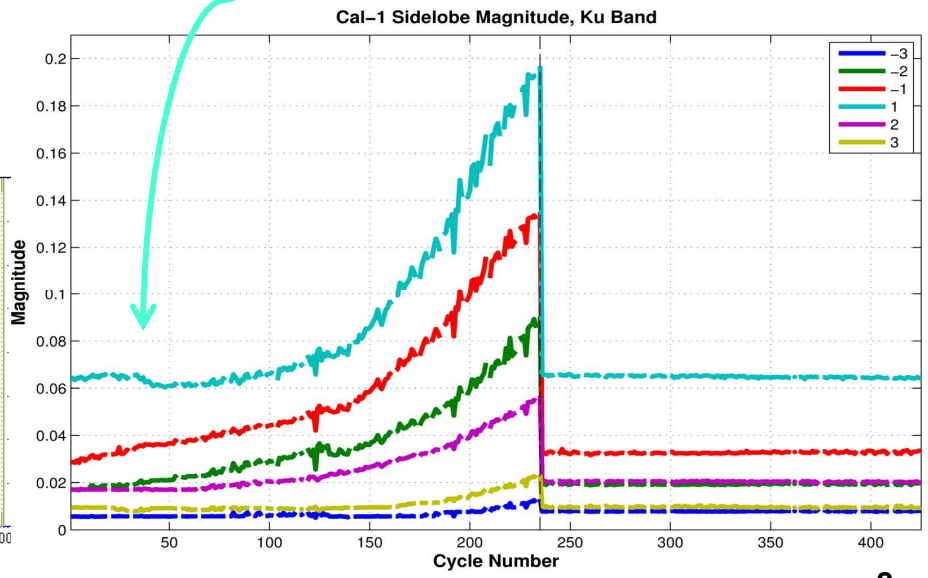
Cal-1 Data for PTR

- Reviewed Cal data based leakage transfer through signal path. (Note: Cal-1 data are just Nyquist sampled.)
  - Left: Data in colored areas are contaminated, not used in PTR – can only use lobes +/-6 from Cal-1 data
  - Right: Changes in sidelobes near cycle 50 (sidelobe +1 drop) seem to produce SSH change in early data
- Extended PTR to ~ +/-30 lobes needed for retracking consistent with PTR changes (increase in sidelobes, missing lobes with increasing phase imbalance)
  - Determined that method with fixed minima gave results not consistent with Cal Sweeps, so used non-constrained method

Cal Sweep and Cal-1 Data, 1998
with Leakage areas





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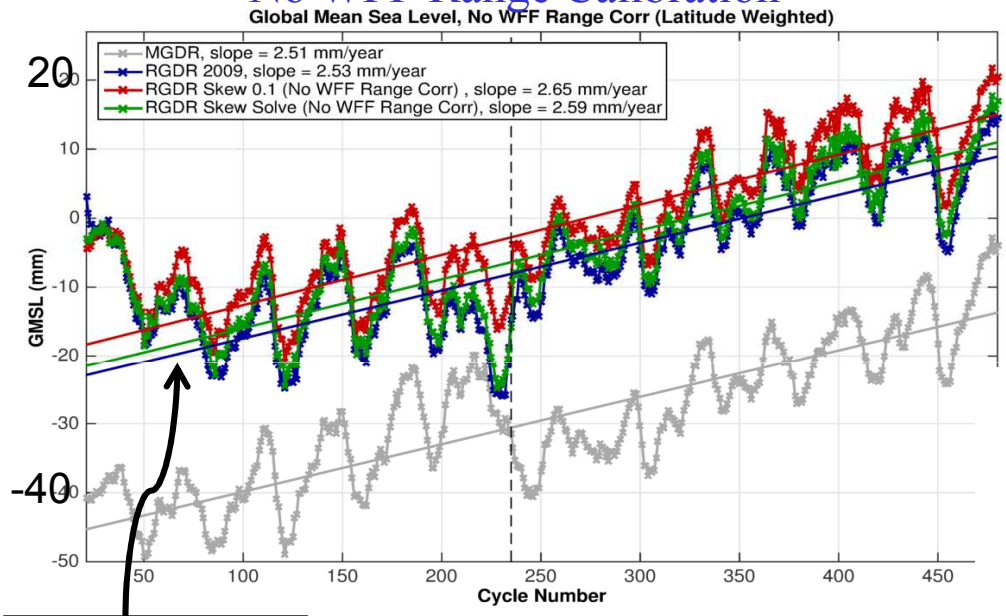
RGDR Analysis: Latitude-Weighted GMSL Trend

- Latest retracking corrects for GMSL depression near the end of Alt-A in 2009 release
  - Eliminates discontinuity between Alt-A and Alt-B

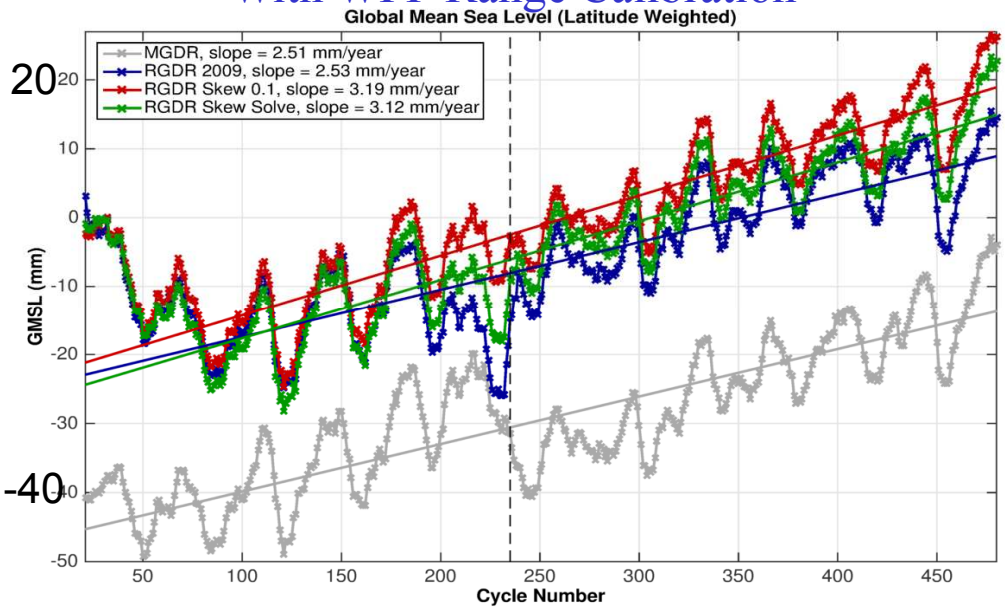
No WFF Range Calibration



From higher early sidelobe +1

- During analysis of the January version of the retracked data, we were reminded that MGDR-B contains the WFF Range Calibration. This calibration from the Cal-1 data produces a significant addition to the GMSL slope for Alt-A.

With WFF Range Calibration



- The WFF Range Calibration was not used in the original GDRs or previous versions of the RGDR

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WFF Range Calibration

- During analysis of the January version of the retracked data, we were reminded that MGDR-B contains the WFF Range Calibration. This calibration from the Cal-1 data produces a significant addition to the GMSL slope for Alt-A from about cycle 80 to 235.

Alt-A Range Calibration

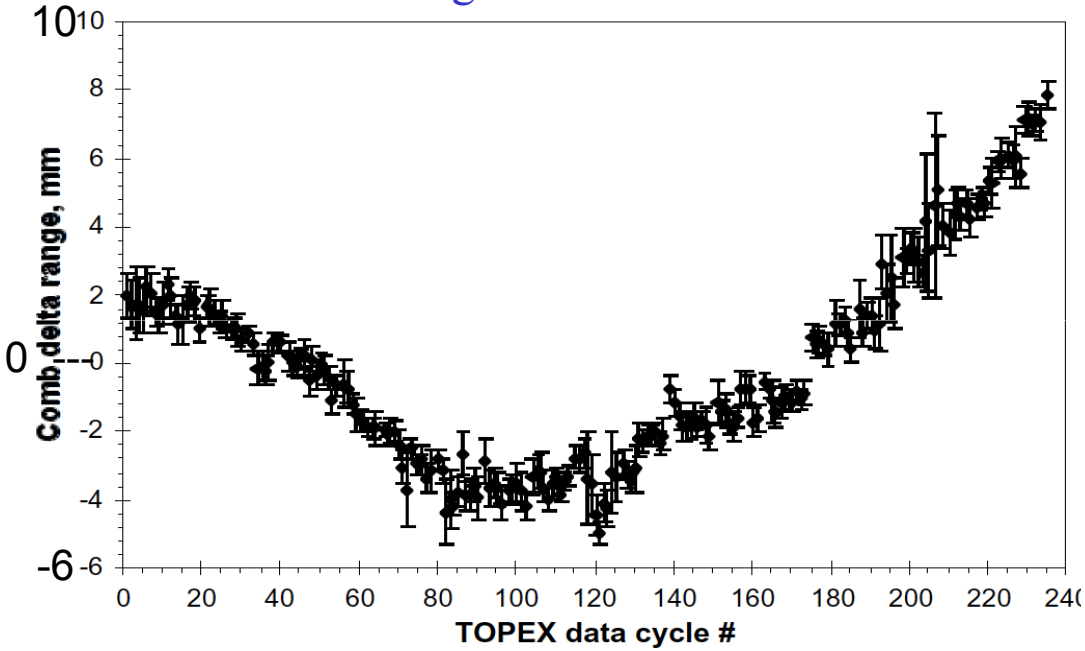

Figure 3-2 Combined (Ku & C) Delta Range vs. Cycle - With UCFM Temperature Correction

Slope from cycle 101 to 235 is 2.95 mm/yr

Calibration is nominally quantized at 7 mm (see below), but through an undescribed process WFF was able to determine mm level values.

Alt-B Range Calibration

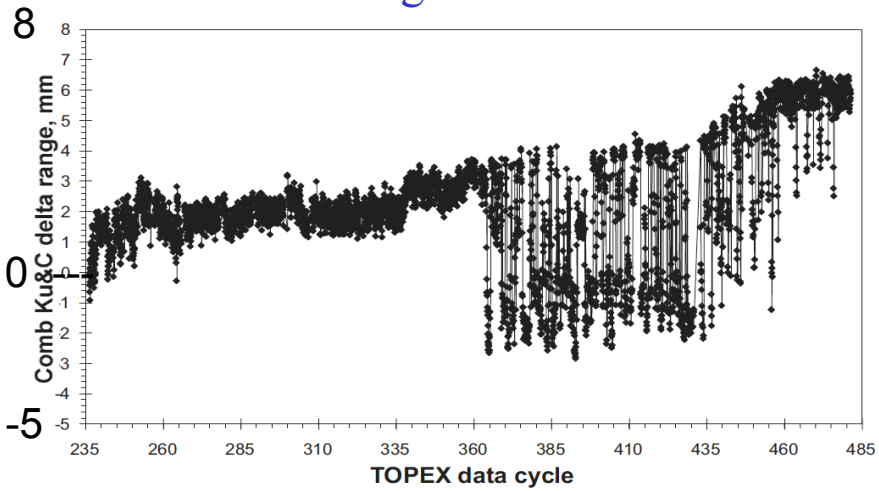

Figure 3-7 Side B CAL1 Step-5 Combined dRange vs. Cycle after Correction for Receiver AGC Temperature

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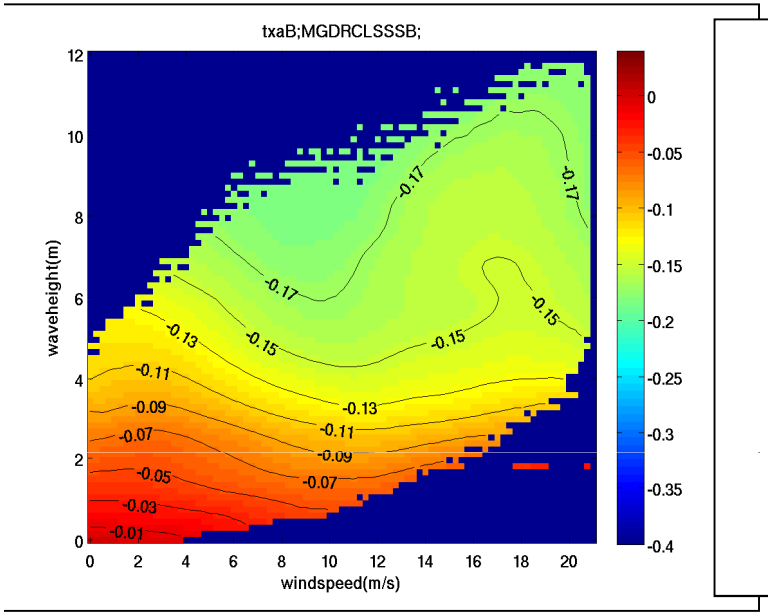
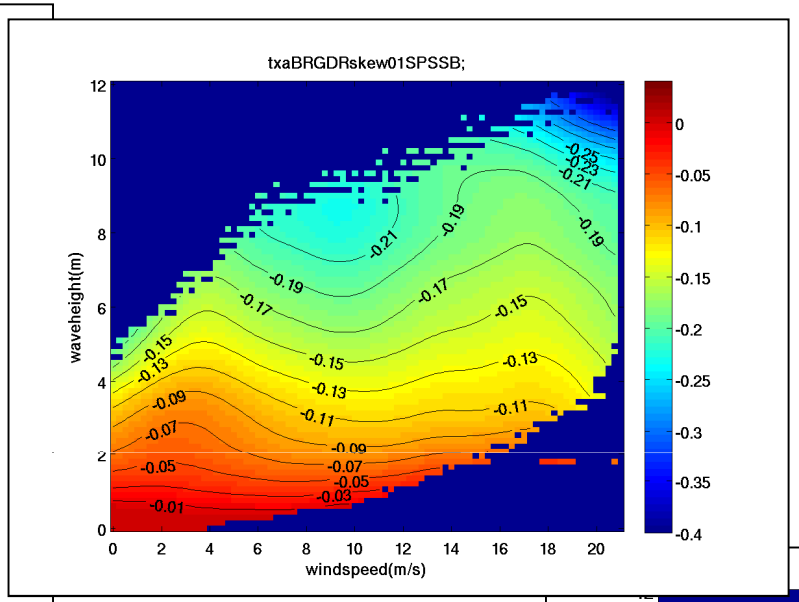
2D SSB models: TPX Side B and J1

RGDR model appears bit closer to J1 in terms of SWH sensitivity

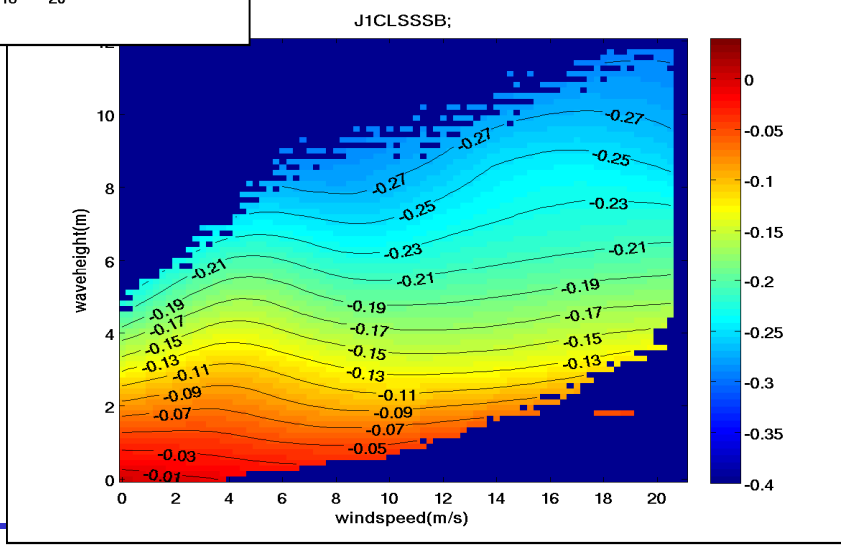
MGDR CLS SSB2d



TxB RGDR (skew01) SPSSB2d



(b) J1 GDR CLS SSB2d



D. Vandemark, H. Feng analysis

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TOPEX Overview / History

- TOPEX standard processing did not include retracking
  - Quantities were estimated onboard with "adaptive gate" (SWH dependent) tracker using sums of power in waveform gates
  - Ground processing corrections for pointing angle and SWH from simulations
- Alt-A had changes in Point Target Response (PTR) beginning about Cycle 140 (mid-1996)
  - Changes became clear in 1997 as apparent increase in SWH
  - Switch to Alt-B in Feb 1999 (Cyc 236). No apparent changes in Alt-B

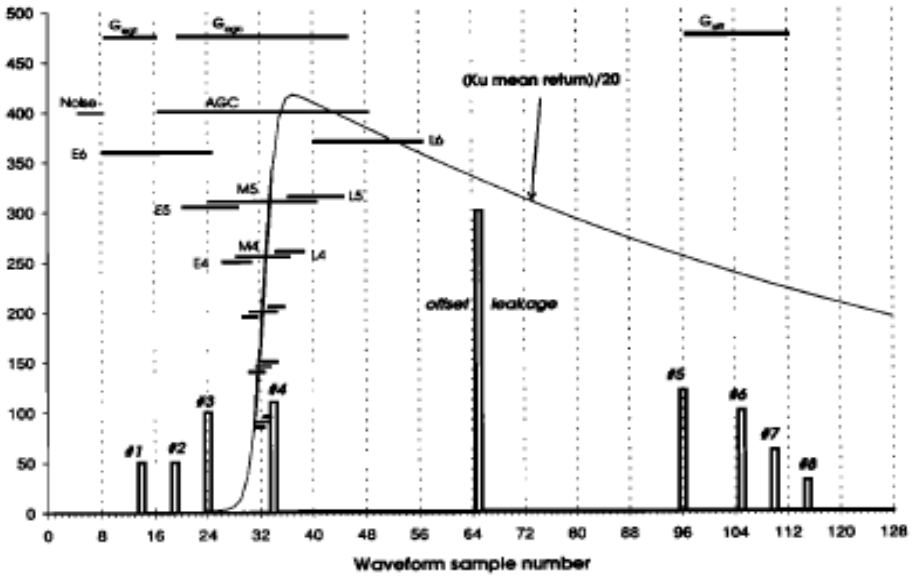

Figure 6. TOPEX Ku altimeter gates, mean return, and center locations of waveform leakage spikes.

- Leakages (x20) in the TOPEX Alt-A waveform from Hayne et al., 1994, JGR, ***99***, 24,941.
  - Need correction in processing via masking or "weights" on WF gates
  - Move with range rate giving North/South Ascending/Descending ("toward" / "away" Eq) differences
  - Onboard gates used to estimate the same parameters obtained from retracking shown as bars

TOPEX Alt-A PTR Changes (2 of 2)

- Investigated changes in the PTR by using data over Lake Ladoga in western Russia. 6 Cycle averages of waveform
  - Below: Line plot – "zero frequency" leakage is prominent
  - Upper Right: Full waveform
  - Lower Right: Difference from first