The Geosat 30th Anniversary Data Set

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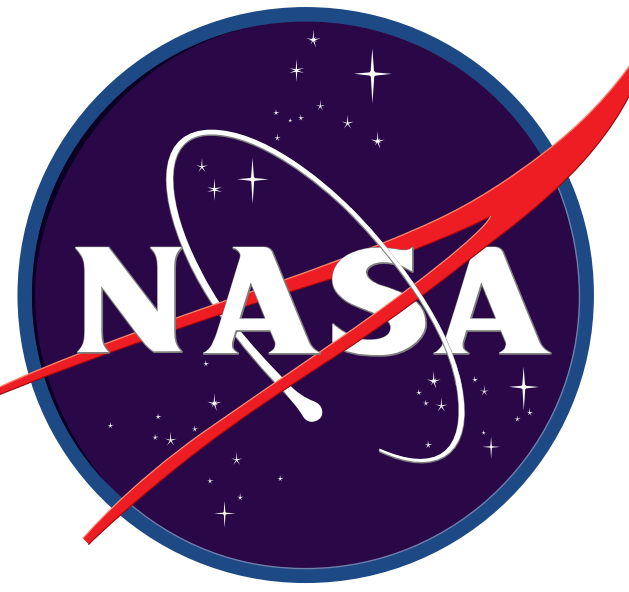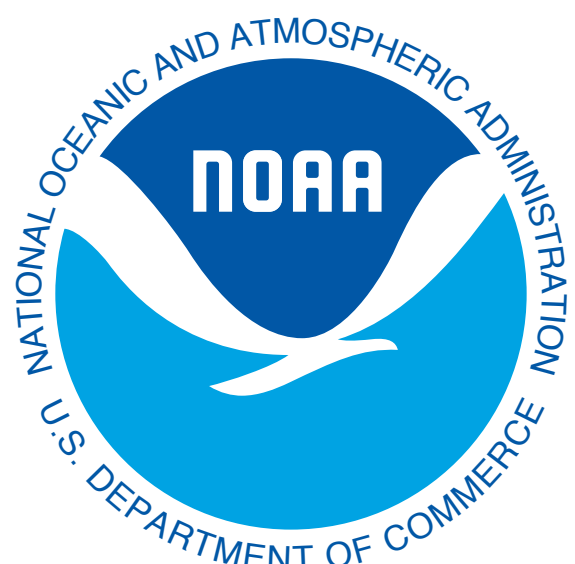
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ABSTRACT: The U.S. Navy's Geosat mission yielded the first multi-year high-precision radar altimetry data set, and provides the only global sea surface height measurements from the late 1980s. NOAA has produced several versions of the Geophysical Data Records (GDRs) for the mission, with the most recent data release in 1997. This was the first set of GDRs that spanned both the Geodetic Mission (GM: March, 1985 to September, 1986) and Exact Repeat Mission (ERM: November, 1986 to December, 1989). In April, 2009 we concluded a major data archaeology effort to recover the original Sensor Data Records (SDRs) for the ERM from 9-track tapes. After the SDRs are combined with their companion Waveform Data Records (WDRs) it is possible to retrack the original radar echoes, yielding an improved level-2 data set. This had previously been done for the GM in 2004, and has now been completed for the ERM as well. This poster describes the steps involved in assembling the full GM+ERM retracked altimetry data set. A major enhancement involves the calculation of precise orbits based on the latest gravity models, terrestrial reference frames, and Doppler station coordinates, with improved Vienna Mapping Function atmospheric refractions. The best possible geophysical corrections are provided, along with the retracked sea surface heights, including GOT4.8 tide models, ECMWF tropospheric corrections, NIC09 climatological ionospheric corrections, and a new sea state bias model. Ultimately our hope is to extend the altimetric sea level climate data record back to 1985, with the inclusion of these retracked Geosat measurements. Validation via the global tide gauge network from the late 1980s will allow us to assess the accuracy of the sea level trends observed by Geosat.
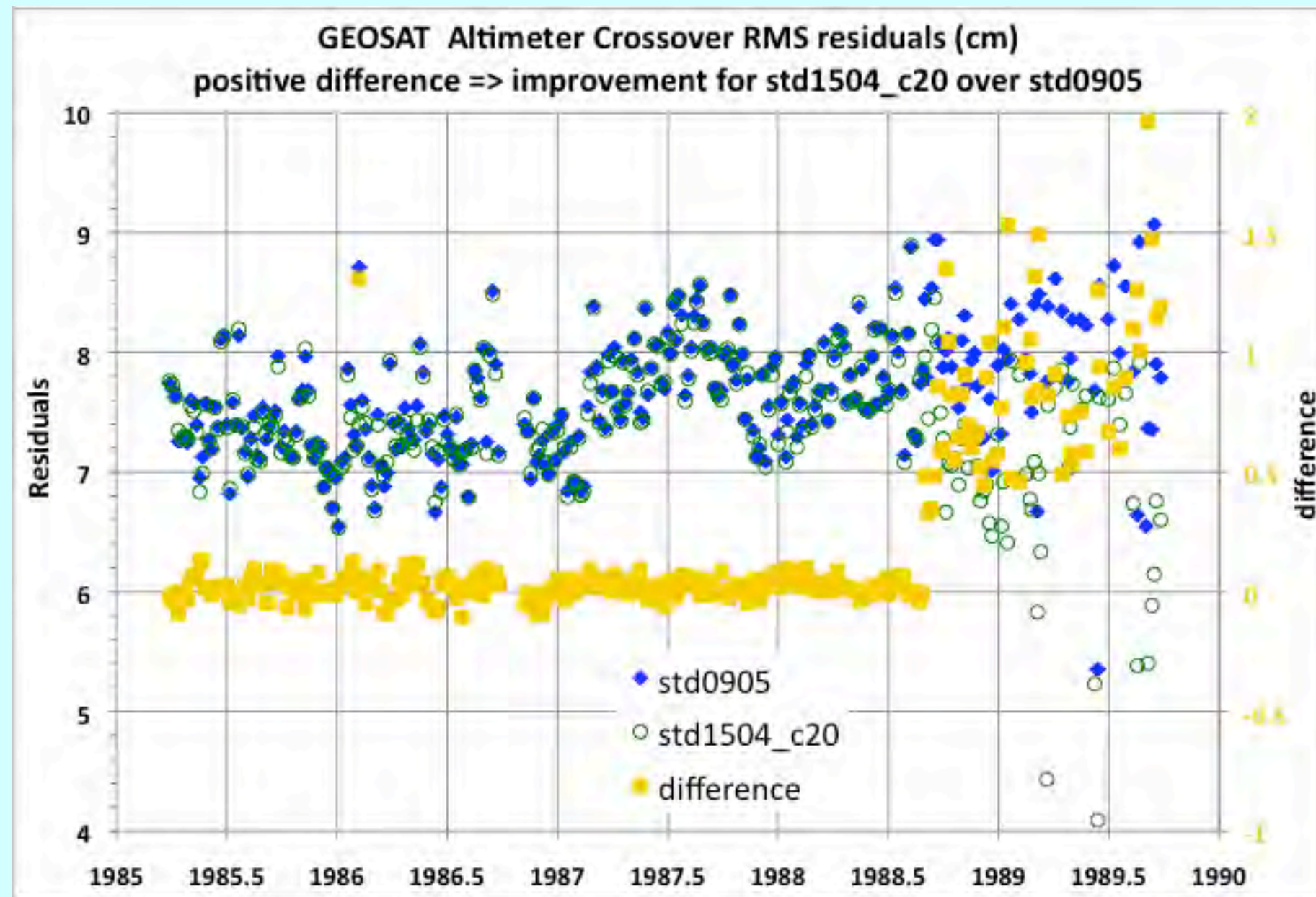
Geosat GM: 1985-03-31 to 1986-09-30
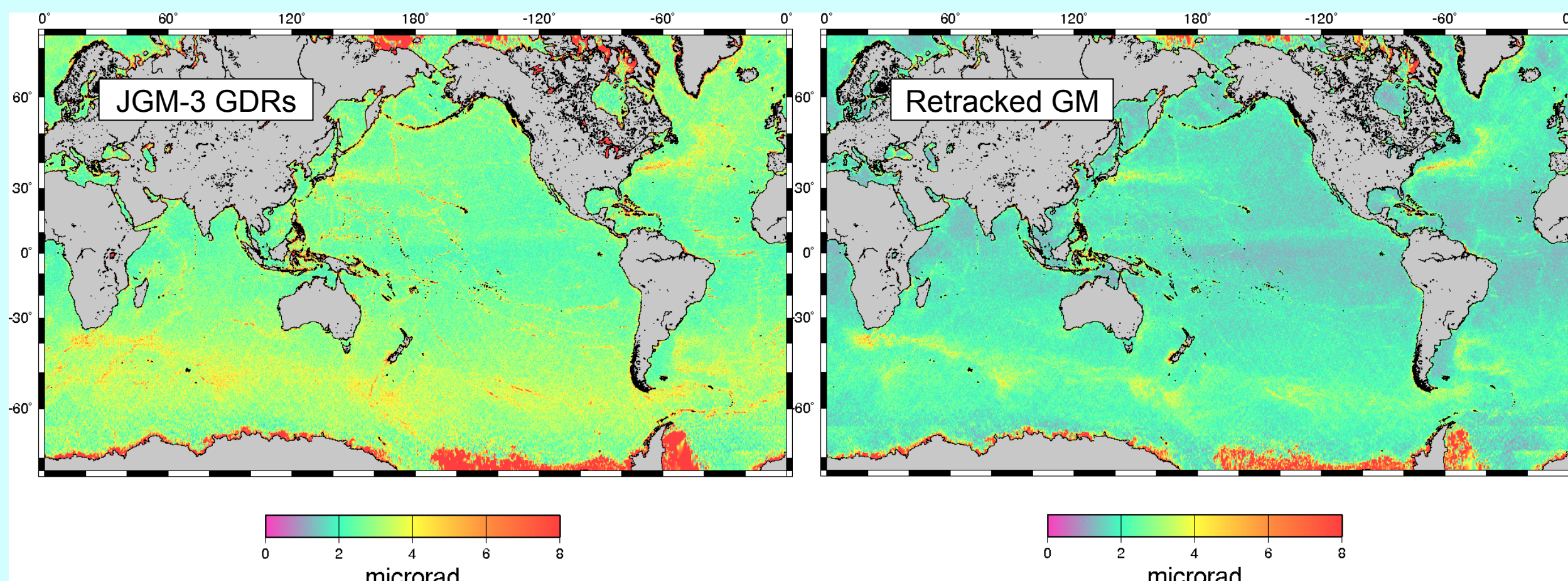
Retracked GM Data - Improved SSH Slope variability

JGM-3 GDRs | Retracked GM — microrad

Geosat Precise Orbit Determination

GEOSAT POD model improvements (Force model)

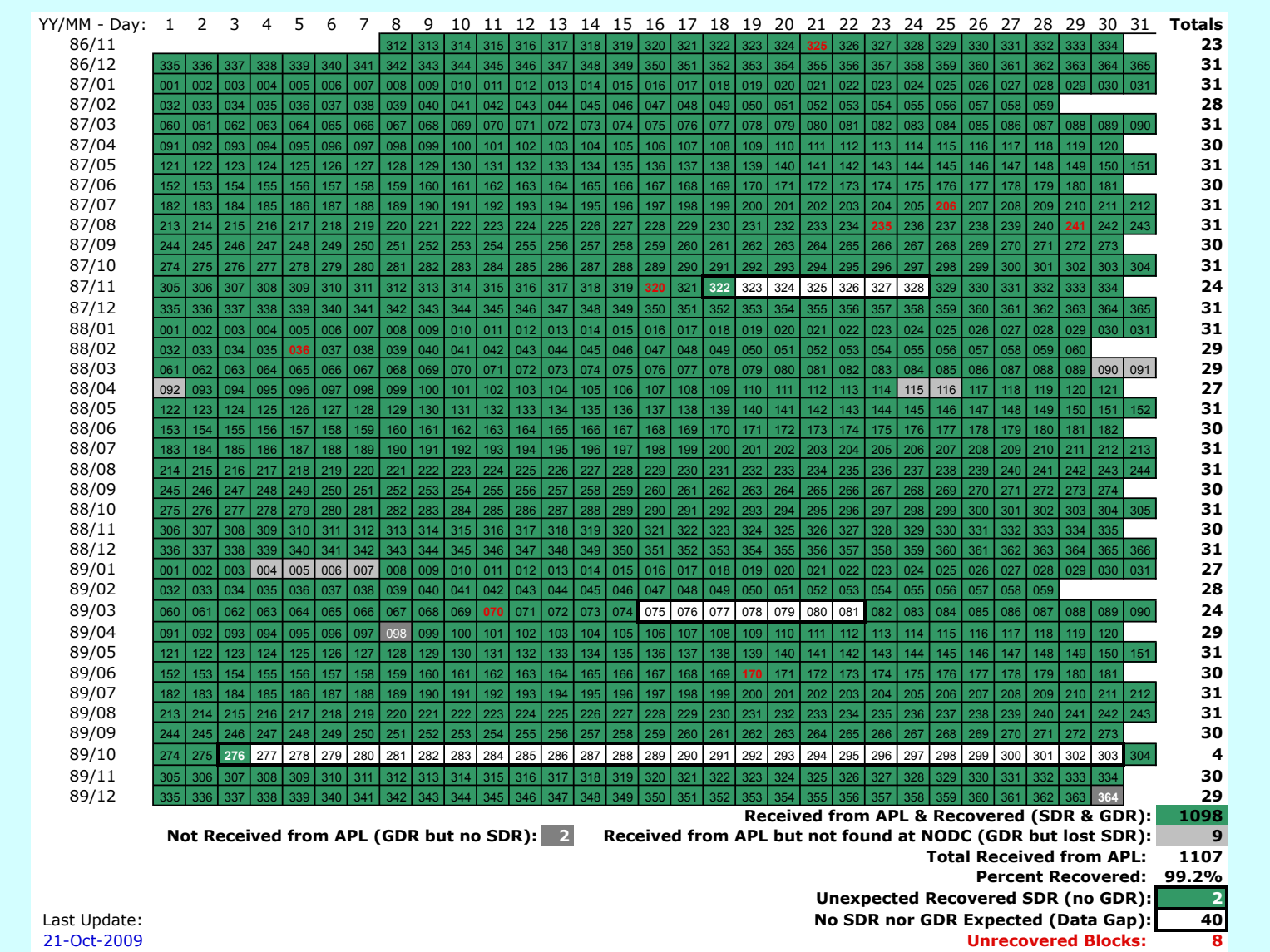| Version	std0905 (2009)	std1504 (2015)
Gravity (static)	EIGEN_GL04S (120x120) (based on GRACE data only 2003-2005)	GOCO2S (120x120, from 6x6) (based on GRACE + GOCE data)
Gravity (time-variable)	C20, C30, C40, C21, S21 rates (IERS2010) + 20x20 annual terms from GRACE	C_{20} from Lageos-1; (L<=5) Parameterized model from 21 SLR+DORIS satellites (1993-2002); IERS2010 for C21/S21 + L=6 to L=20 annual terms from GRACE
Atmospheric gravity	ECMWF, 50x50 @6 hrs	same
Tides Ocean / Earth	GOT4.7(20x20) / IERS2003	GOT4.10 (50x50) /IERS2003
Albedo/IR	Knocke et al., 1988	same
Atmospheric drag	MSIS86	same

GEOSAT POD model improvements (Data and measurement model)

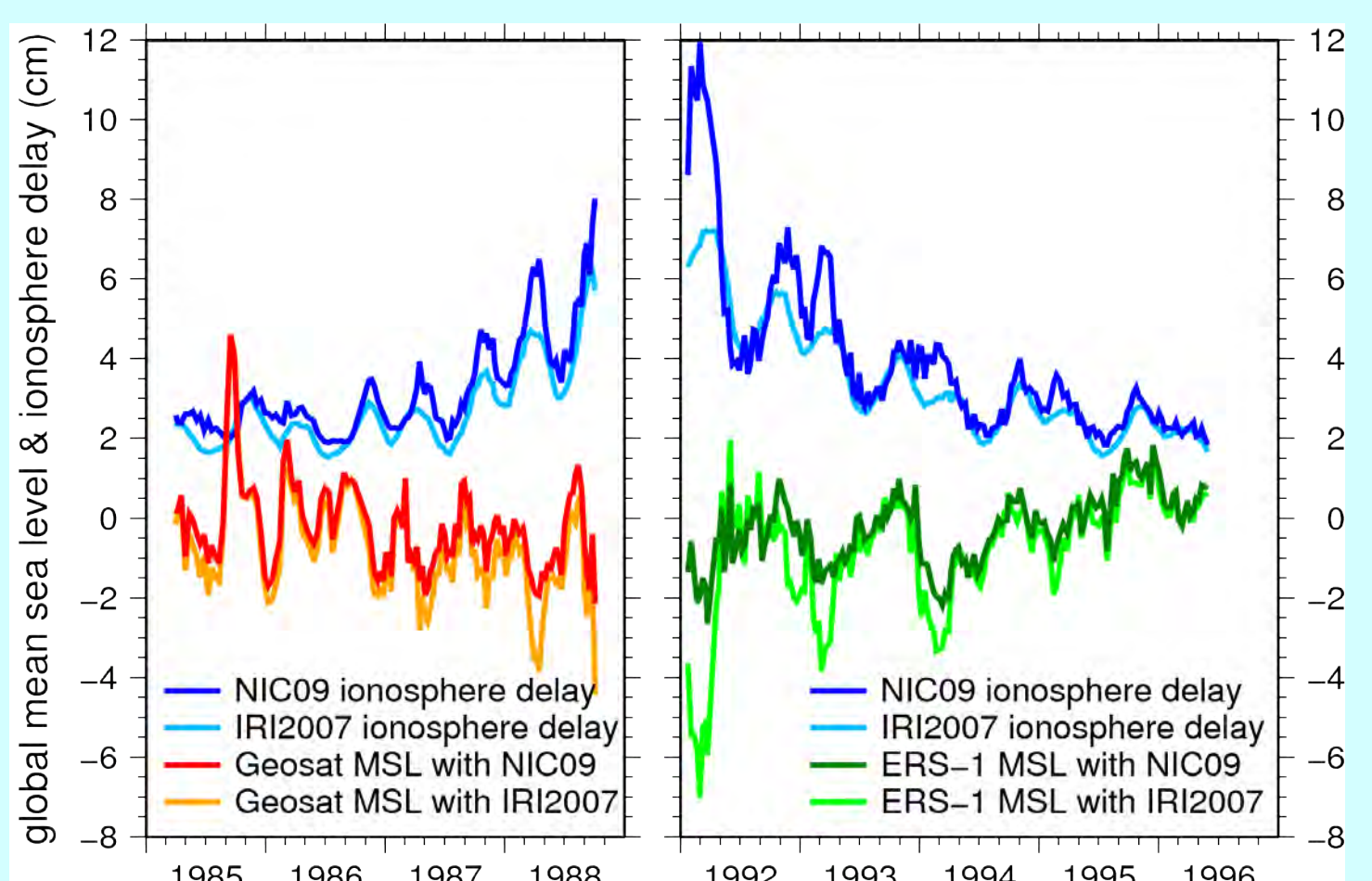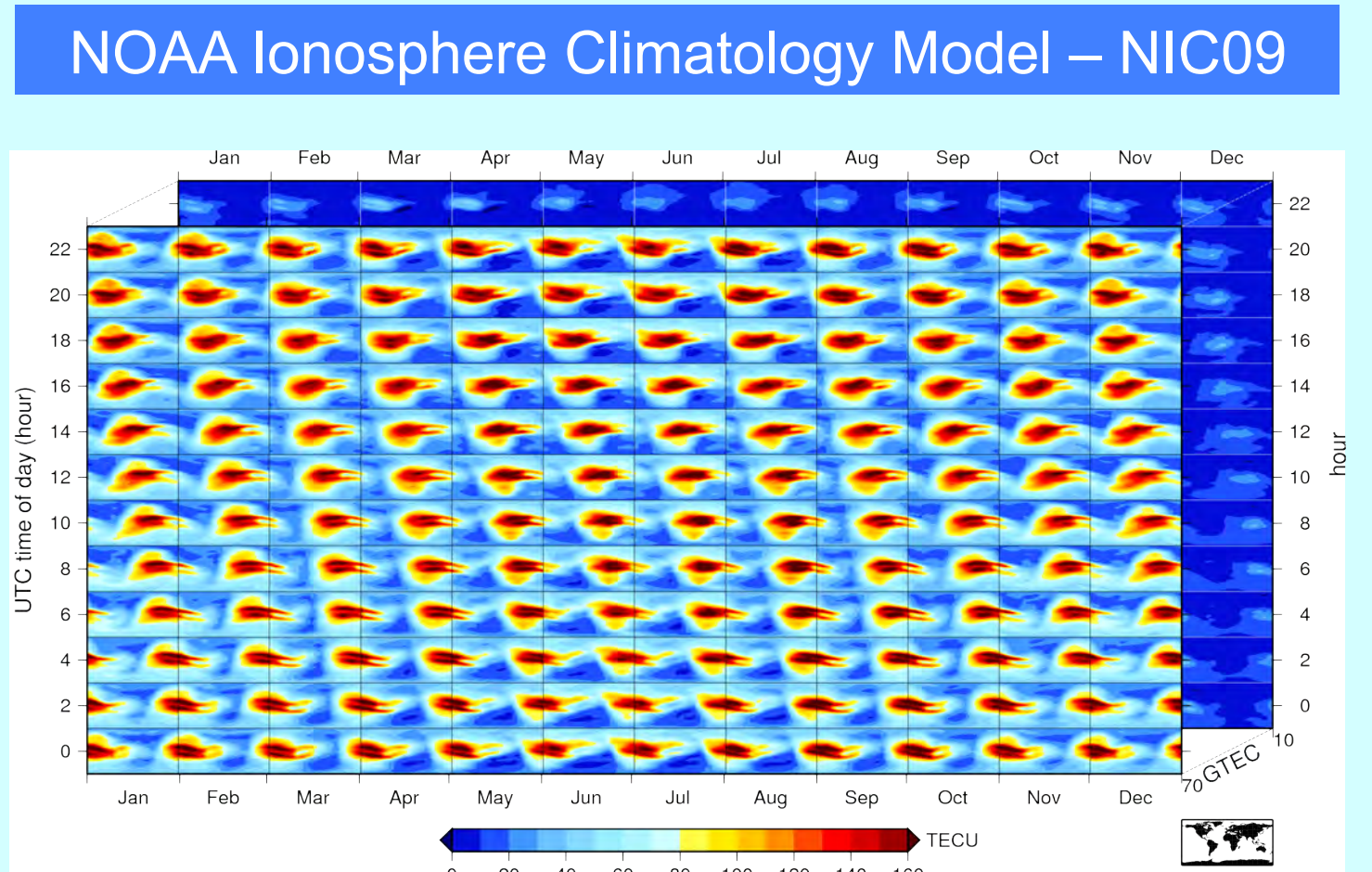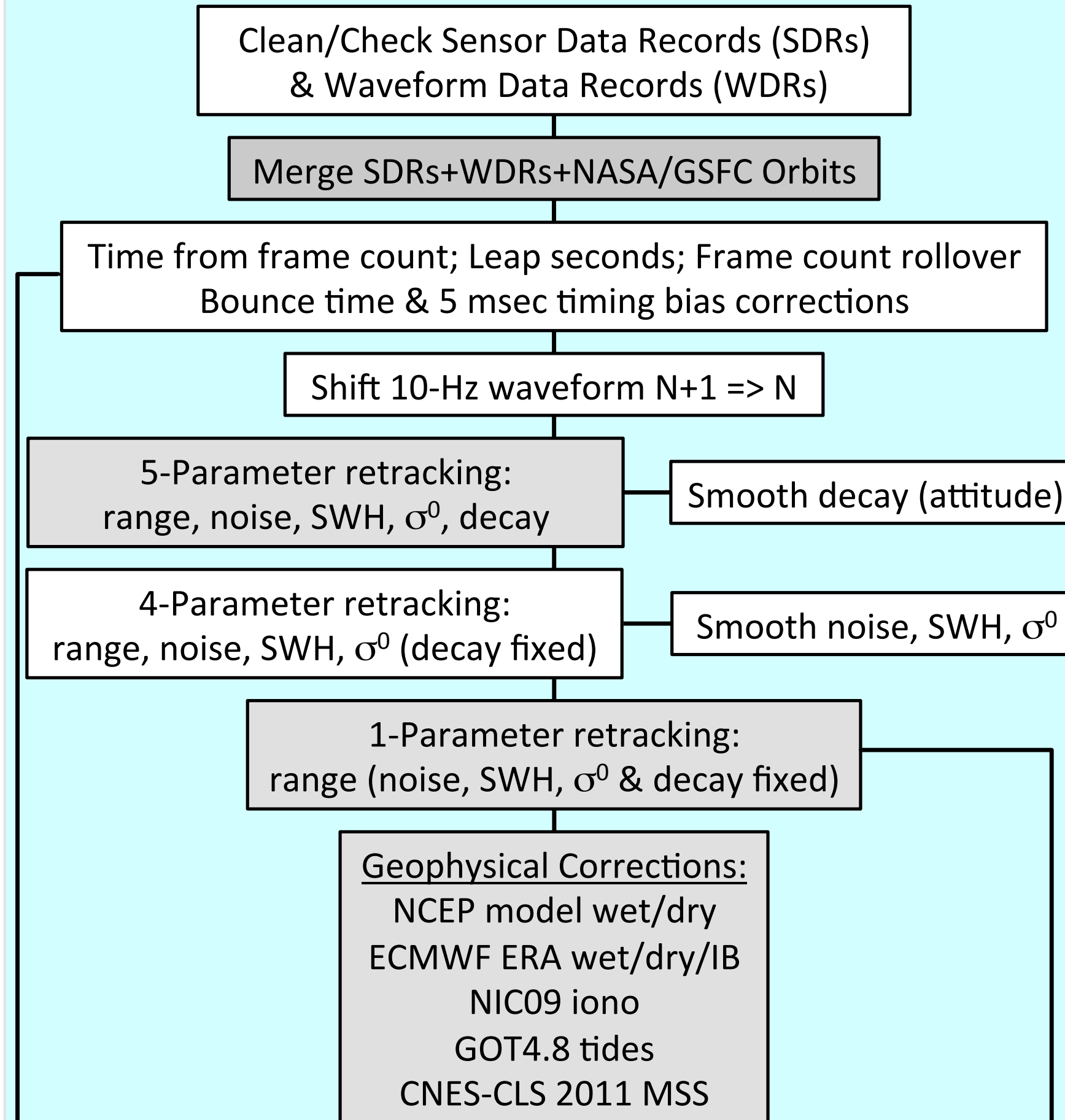| Version	std0905 (2009)	std1504 (2015)
Data	Doppler+Altimeter Crossovers	same
Parameterization	opr/day+ constrained drag / 25 min (high solar activity option)	re-tuned drag constraints
Doppler station coordinates	EIGEN_GL04S (4 years Doppler/crossover)	same
Earth geocenter motion (station correction)	GOT4.7 tidal variations	GOT4.7 tidal variations, X,Y,Z, annual SLR-derived (Ries, 2013)
Doppler data troposphere correction	Hopfield/Niell/GPT	Vienna Mapping Function-1 (VMF1)

GEOSAT Altimeter Crossover RMS residuals (cm) positive difference => improvement for std1504_c20 over std0905

POD Strategy		RMS Residuals		1-day orbit overlap differences (cm)		
		Doppler (cm/s)	Xover (cm)	Radial RMS	Cross-trk RMS	Along-trk RMS
GM	std0905	0.3227	7.369	2.14	15.67	14.76
	std1504_C20	0.3233	7.342	2.14	16.60	14.65
ERM	std0905	0.5166	7.820	2.44	20.24	14.58
	std1504_C20	0.5164	7.494	2.44	19.98	14.28

Geosat ERM: 1986-11-08 to 1989-12-30

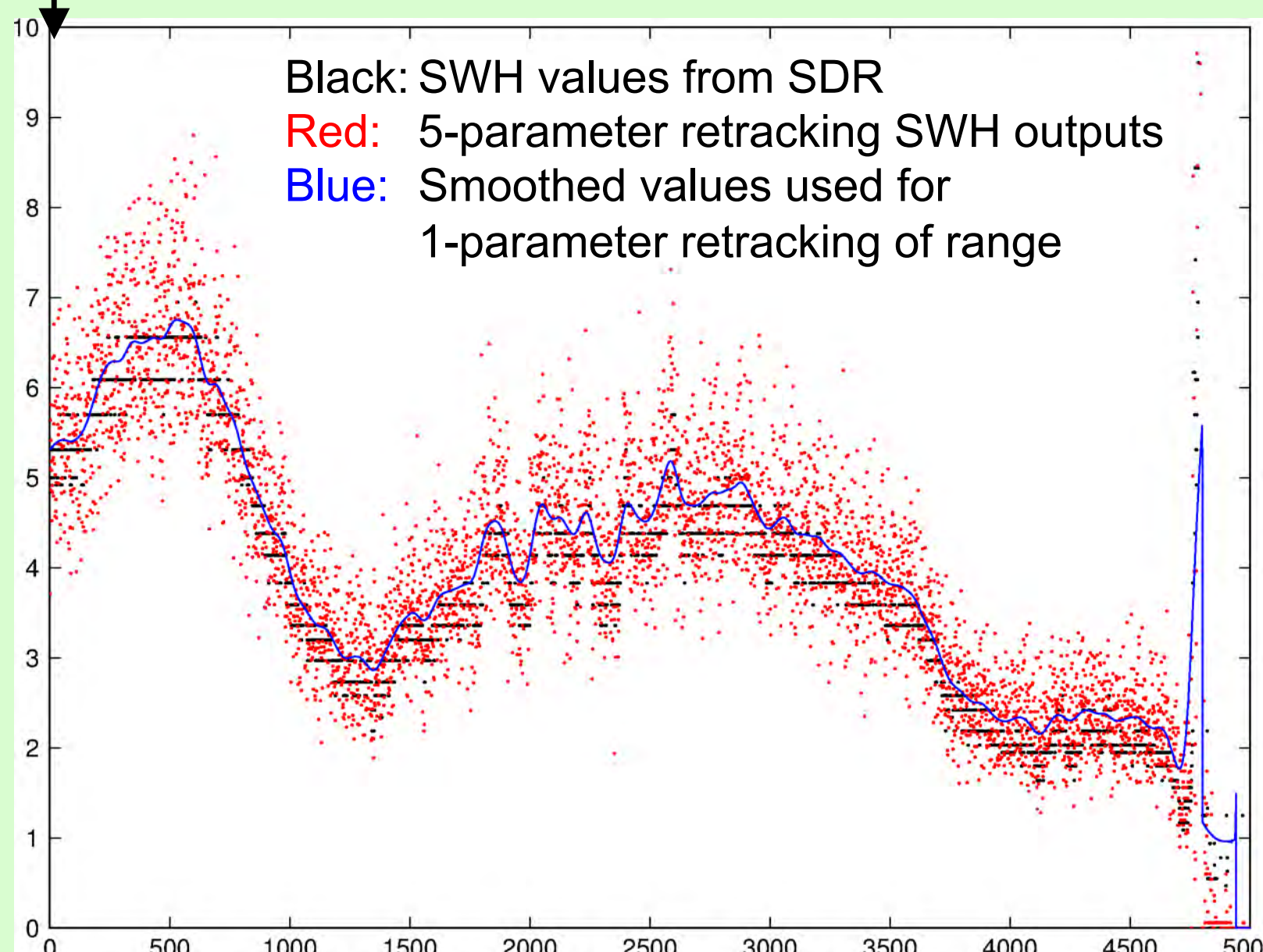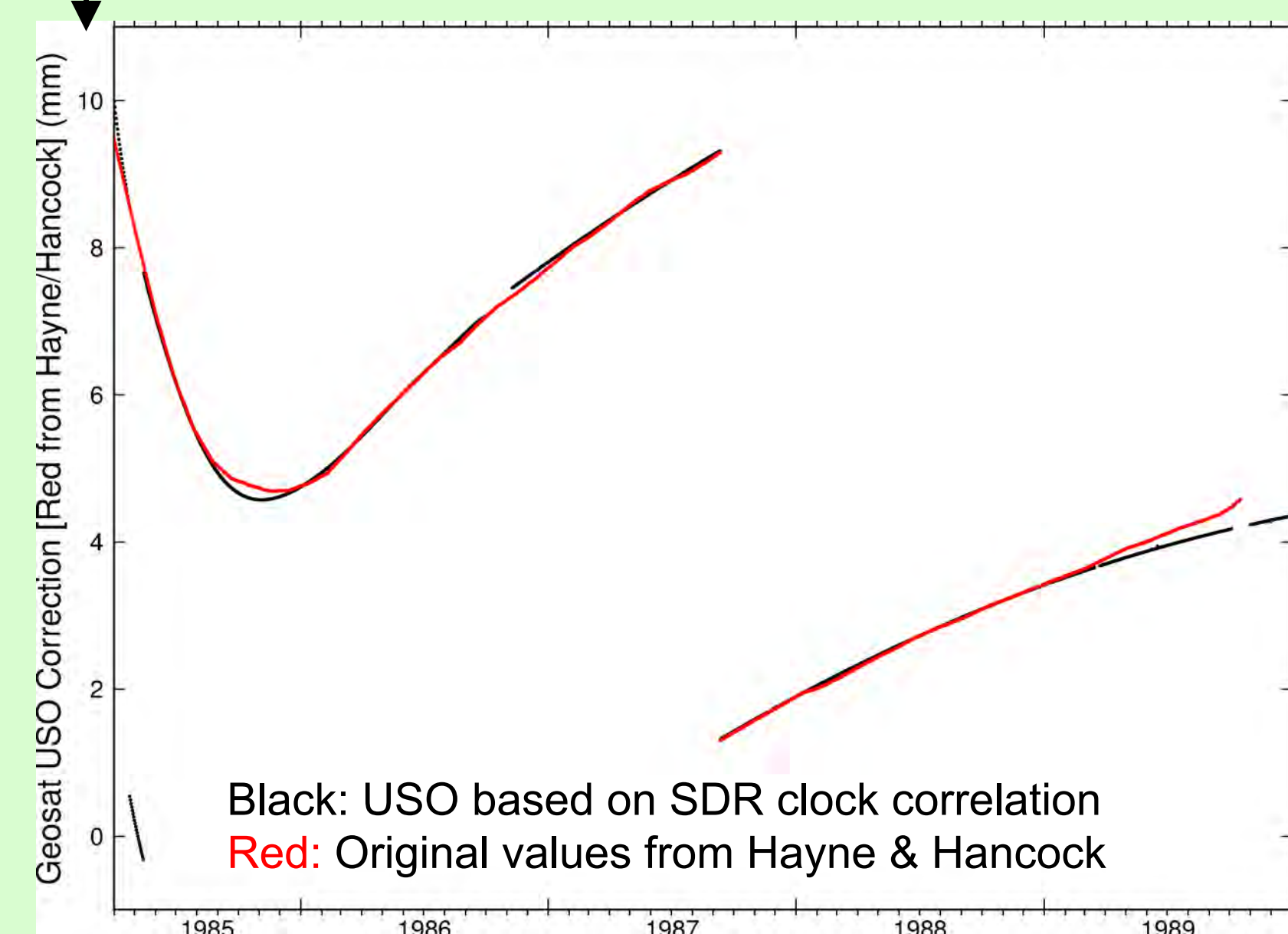9-Track Tape Recovery Project - 1098 daily SDRs Completed April, 2009 - 99.2% Success

Geosat GM+ERM Processing & Retracking (Gray Boxes in Final Product)

- Clean/Check Sensor Data Records (SDRs) & Waveform Data Records (WDRs)
- Merge SDRs+WDRs+NASA/GSFC Orbits
- Time from frame count; Leap seconds; Frame count rollover Bounce time & 5 msec timing bias corrections
- Shift 10-Hz waveform N+1 => N
- 5-Parameter retracking: range, noise, SWH, σ^0, decay → Smooth decay (attitude)
- 4-Parameter retracking: range, noise, SWH, σ^0 (decay fixed) → Smooth noise, SWH, σ^0
- 1-Parameter retracking: range (noise, SWH, σ^0 & decay fixed)
- Geophysical Corrections: NCEP model wet/dry; ECMWF ERA wet/dry/IB; NIC09 iono; GOT4.8 tides; CNES-CLS 2011 MSS

NOAA Ionosphere Climatology Model – NIC09

- NIC09 ionosphere delay
- IRI2007 ionosphere delay
- Geosat MSL with NIC09
- Geosat MSL with IRI2007
- ERS-1 MSL with NIC09
- ERS-1 MSL with IRI2007

Geosat 30th Anniversary Data Set

- Entire GM+ERM data merged & retracked
- Original SDR parameters (range, SWH...) retained when no waveforms
- 5 & 1-parameter retracked variables + onboard tracker (SDR) values
- New 2015 NASA/GSFC orbits: std1504_c20
- NIC09 Ionosphere & ERA Interim + NCEP troposphere corrections
- Doppler correction based on orbit+MSS (vs. range)
- All variables provided in netCDF format per-pass files

Geosat USO Correction [Red from Hayne/Hancock] (mm)
Black: USO based on SDR clock correlation
Red: Original values from Hayne & Hancock

Black: SWH values from SDR
Red: 5-parameter retracking SWH outputs
Blue: Smoothed values used for 1-parameter retracking of range

Future Updates & Analyses

- Re-estimate coordinates for Doppler stations
- Update low degree Time Varying Gravity model for the GEOSAT era
- Update altimeter data for use in crossovers: new SSB model
- Validate GM+ERM time series via global tide gage network (note gaps in cyclic maps)
- MERRA-2 troposphere corrections

Ascending | Descending

GM | ERM