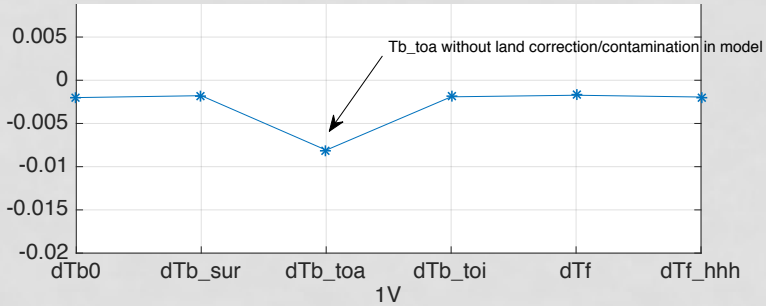
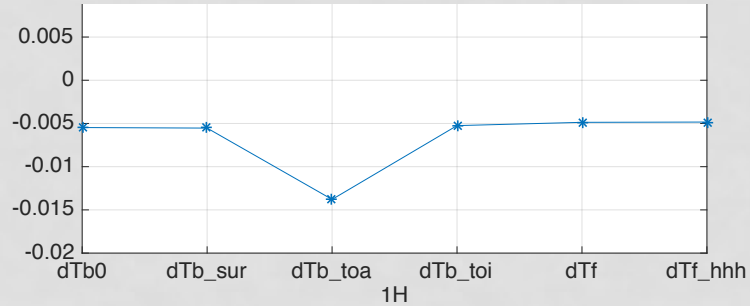
V4.6.0, V4.6.1, V4.6.2 AND V4.6.3

- Our current calibration: retrieval to agree with model at large spatial and temporal bases to remove systematic errors
- **V4.6.0** has all major updates in model, retrieval algorithm and look up tables towards V5.0
  - Complete set of L2 & L3 products
  - **Residual SSS biases (compared to calibration reference, Scripps Argo) ~0.03PSU**
    - Model vs retrieval: Pencil beam v.s. real antenna (especially with even very small land fractions); roughness correction
    - To compensate all errors: V4.6.1
    - To mitigate one by one:
      - Land correction: V4.6.2
      - Roughness correction: V4.6.3 (partial)
- V4.6.1 implemented a constant fix to each of the 6 channels on smooth surface brightness temperature
  - Based on L2_EVSCI_V4.6.0
  - Complete set of L2 & L3 products, including rain masked L3 salinity maps
- V4.6.2 added land correction/contamination in the forward model **(gland> 0.0005)** *[ADPS test]*
  - This makes the forward model and retrieval almost identical between rough surface and antenna Tbs.
  - Our second calibration step, 7-day smoothed dTa applied to Tf forces measurement to model on average. That assumes model replicates the measurement.
  - Based on V4.6.0 with re-calculated drift and Ta corrections
  - L2 only
- V4.6.3 applied modified dTa correction (V4.6.2 dTa + mission long average of (Tf – Ta_exp_hhh) for each channel *[ADPS test]*
  - based on L2_EVQL_V4.6.2 with updated dTa correction table
  - V4.6.2, residual Tb0 error mostly from hh/hhh wind diff. in forward/backword model
    - dTf_hhh = **-0.0030 -0.0047 -0.0085 -0.0119 -0.0052 -0.0085**
    - dTb0 = -0.0031 -0.0051 -0.0091 -0.0128 -0.0057 -0.0092 <- leads to residual dSSS
    - dTf = -0.0009 -0.0021 -0.0012 -0.0012 -0.0006 -0.0013 <- calibration step2
  - L2_EVSCI only
- **Data quality control filter** plays important role in statistics. Analysis in this presentation excludes data affected by
  - Bad pointing; land; ice; rain; moon; galaxy; rfi; sa overflow; consistency; unusual brightness
  - Cold water; heavy winds

RETRIEVAL – MODELED TB'S

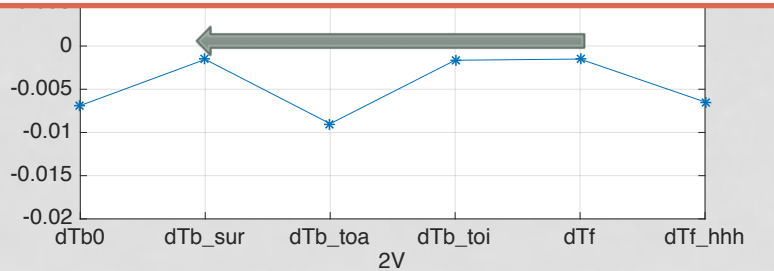
Effect of land correction (red curves) is not negligible in current level of accuracy

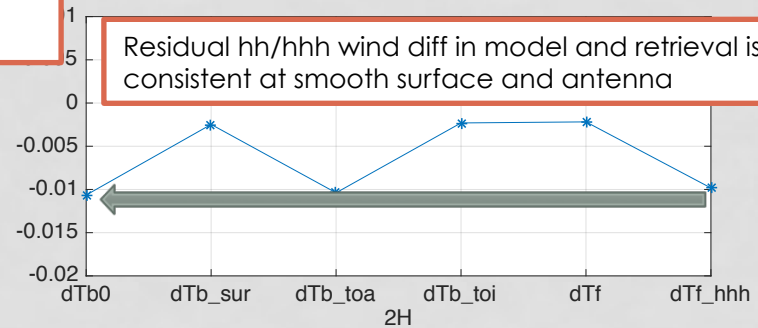


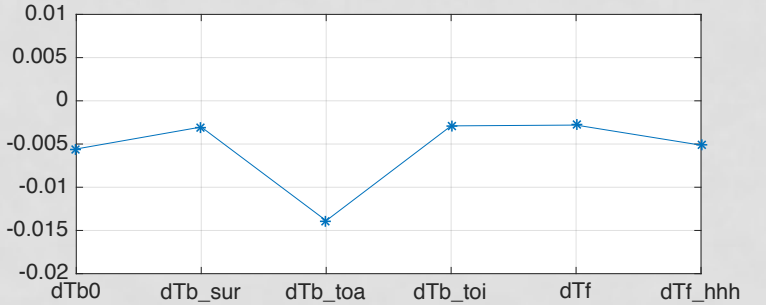


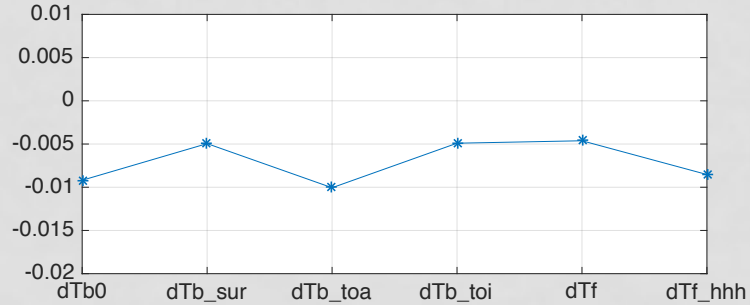
Land correction (lc) in both forward model and retrieval shows successful transfer of Tb differences from top (antenna) to bottom (rough surface)

Residual hh/hhh wind diff in model and retrieval is consistent at smooth surface and antenna

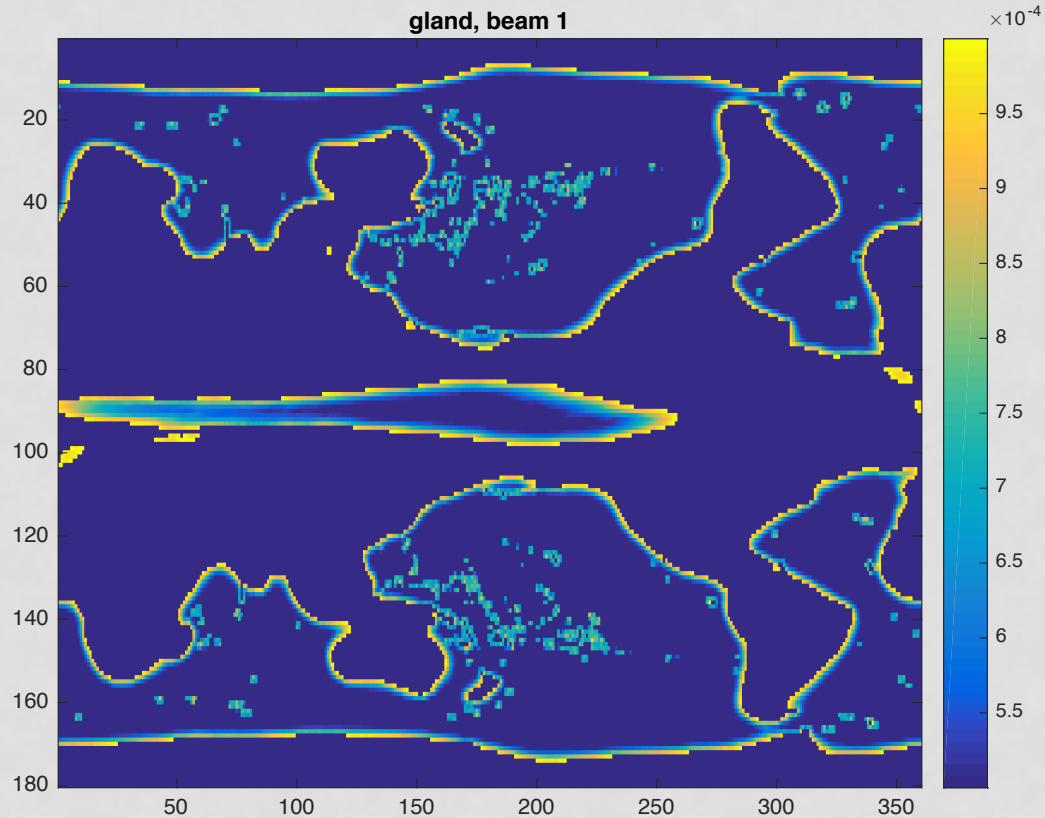








LAND FRACTIONS, [.05%, .1%]

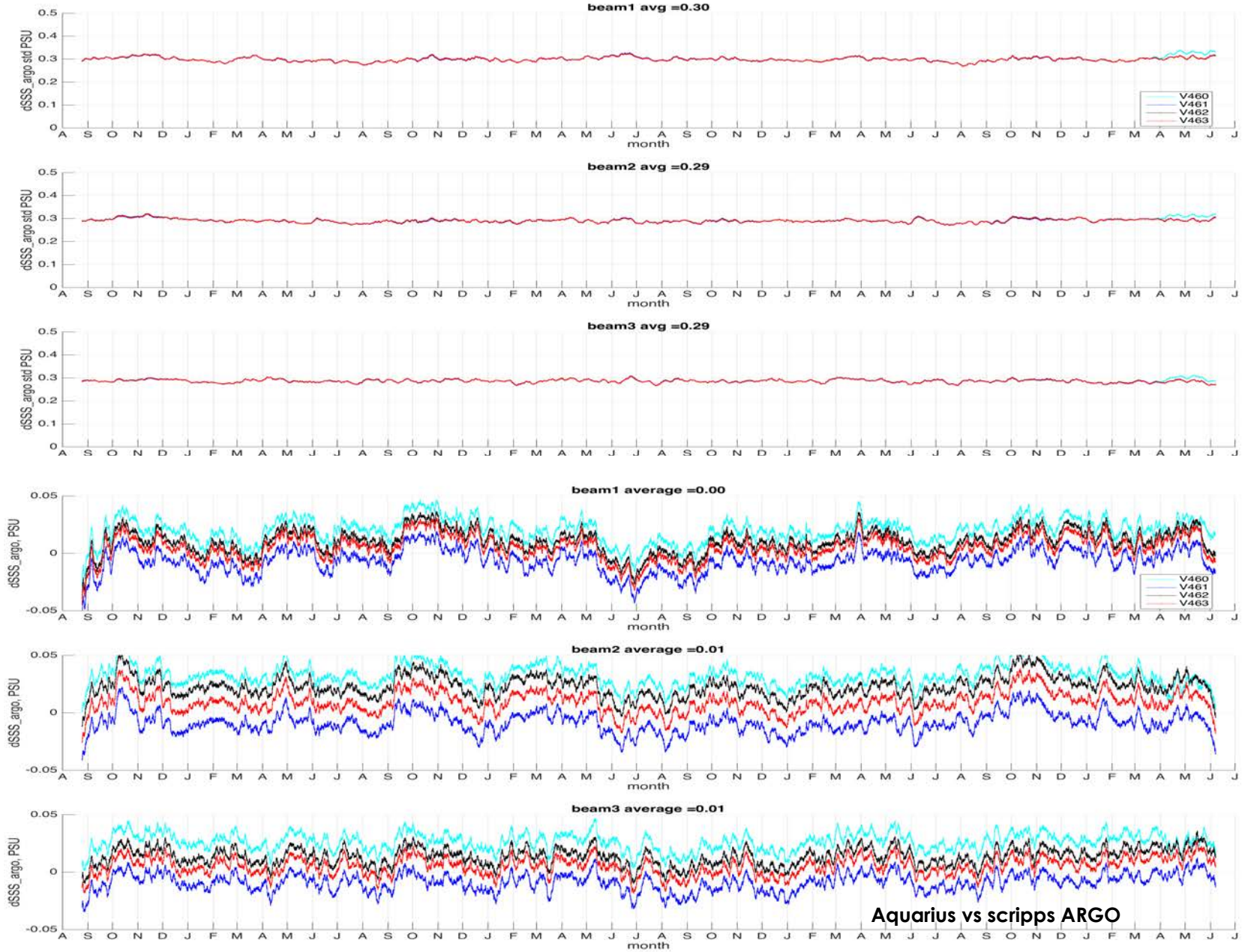


Why including land correction (lc) in model have noticeable effects on overall residual SSS biases?
(lc needed in "open ocean", Gland>0.0005 & gland<0.001)/("open ocean", gland<0.001) for 3 beams, 17%, 18%, 19%, not trivial!

SSS VS SCRIPPS ARGO V4.6.[0-3]

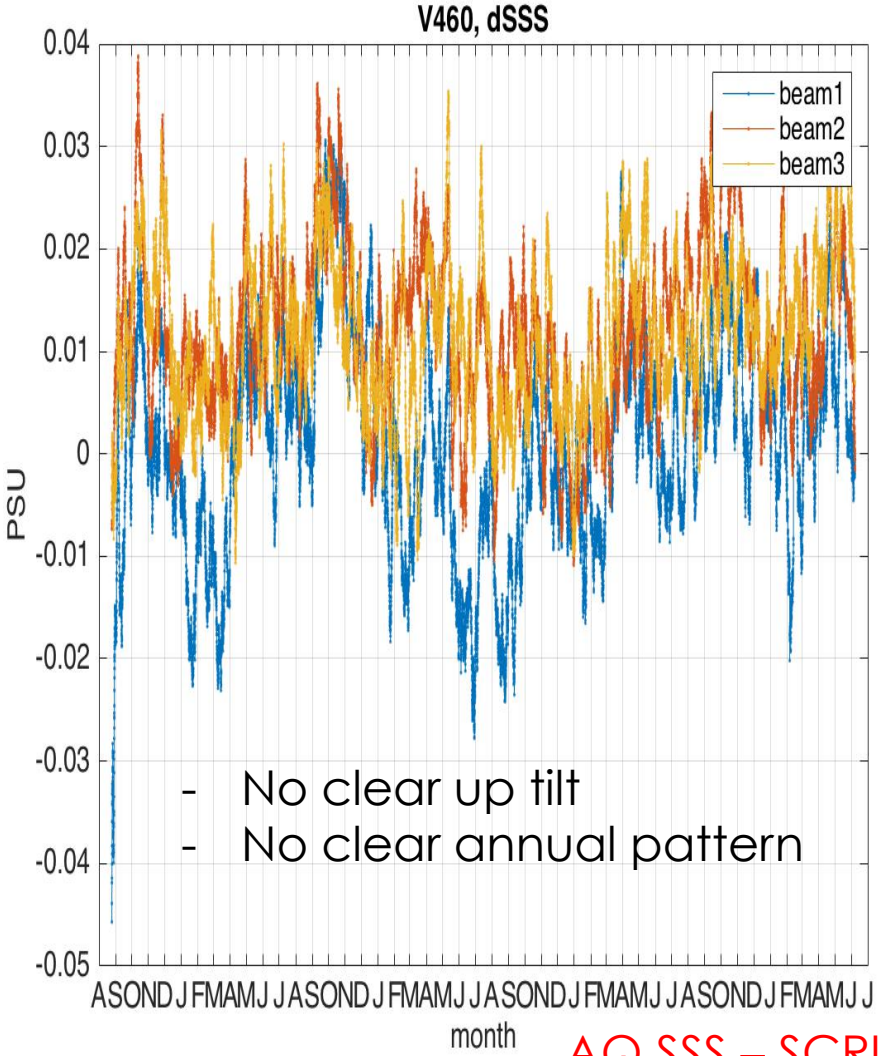
Orbital std

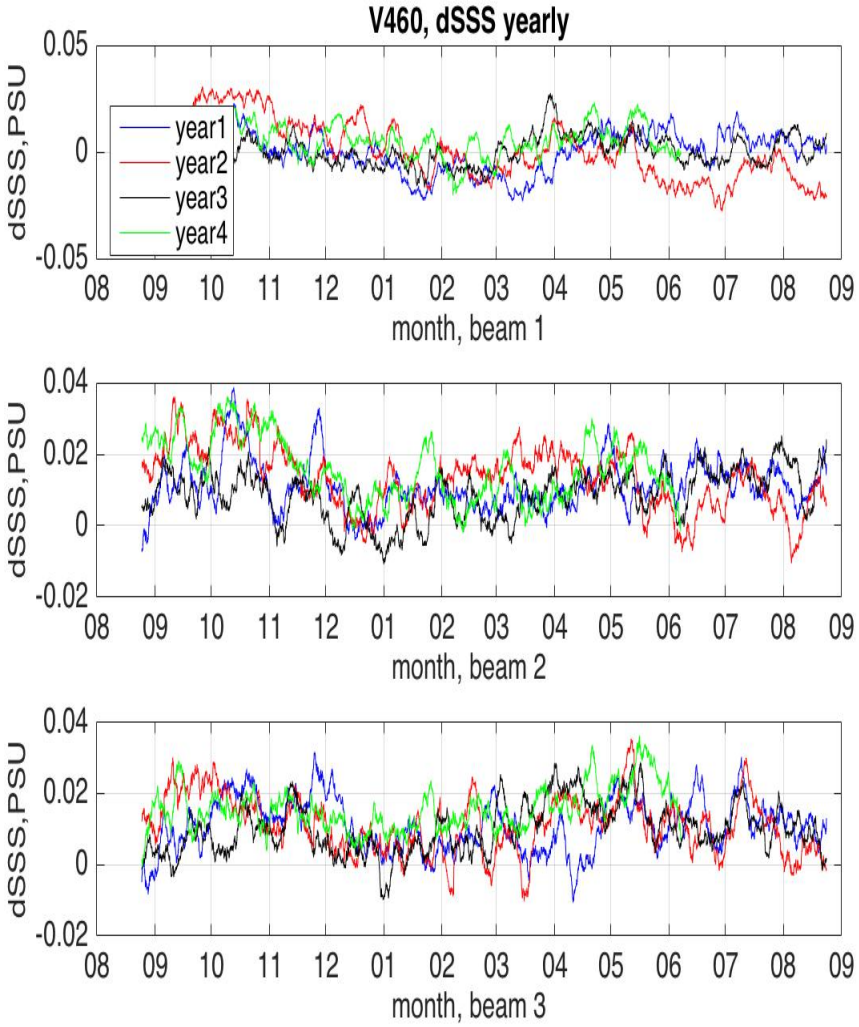
Orbital mean



Aquarius vs scripps ARGO

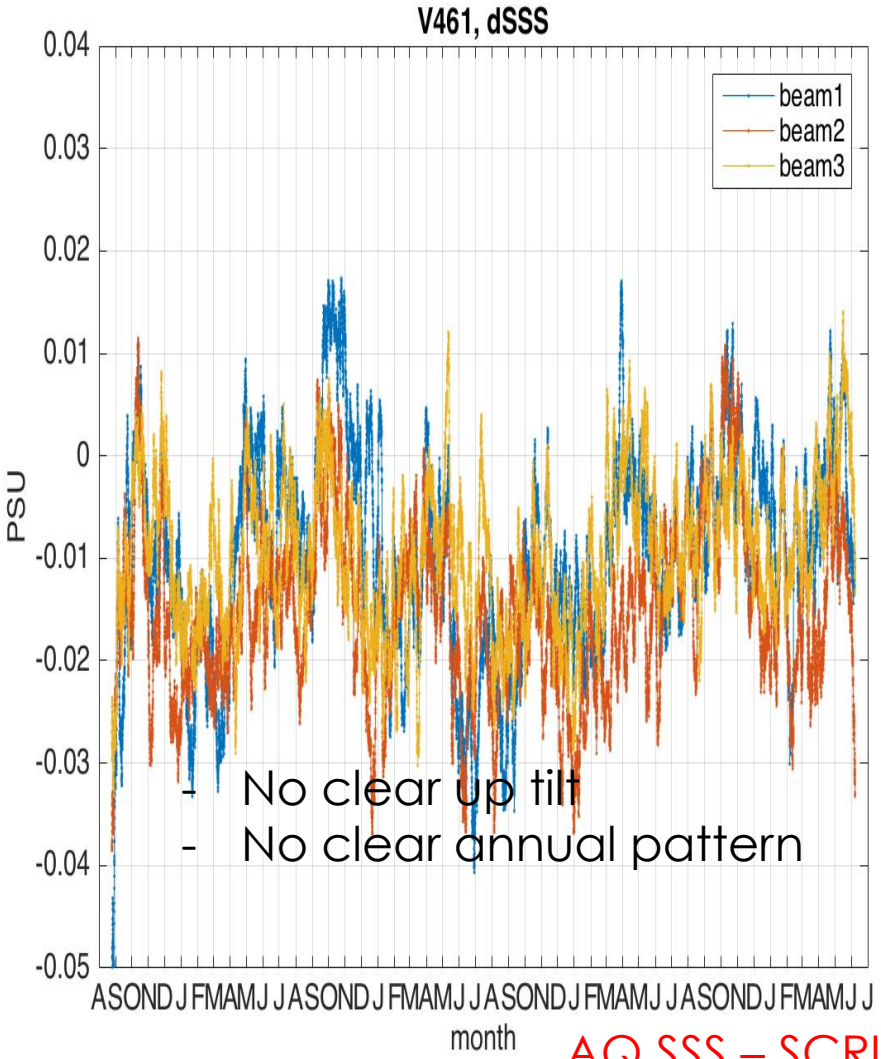
DSSS COMPOSITE V4.6.0

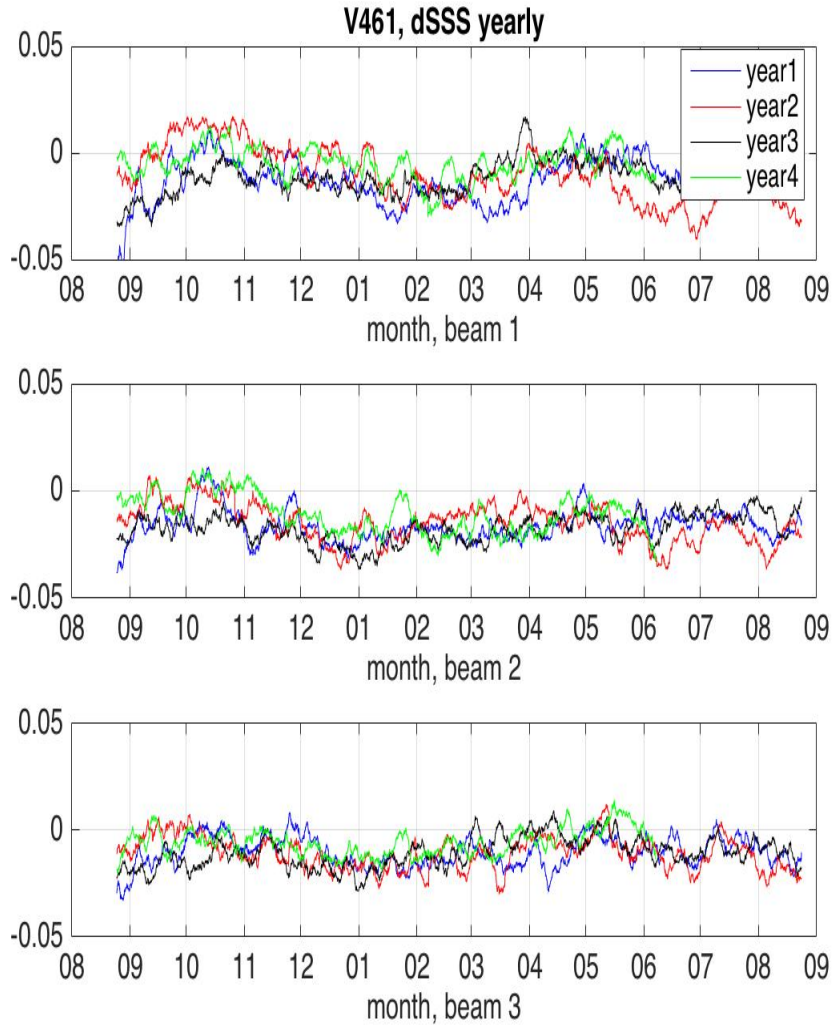




AQ SSS – SCRIPPS ARGO

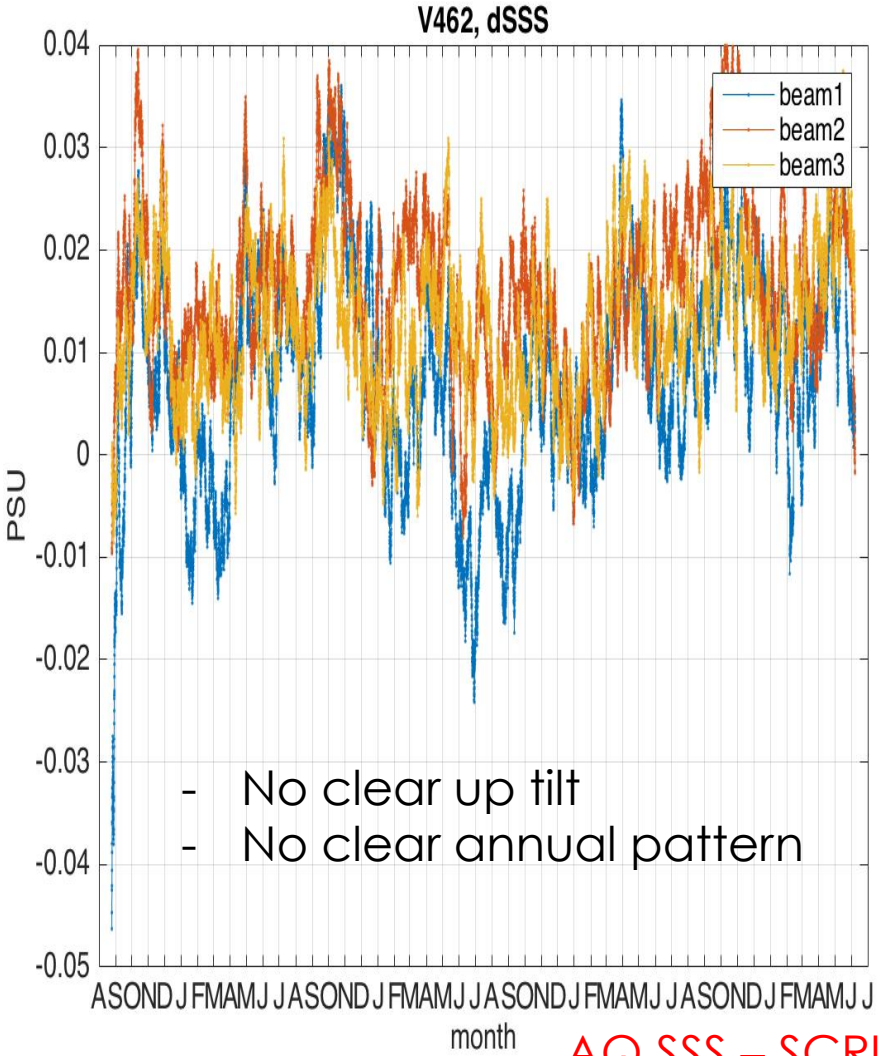
DSSS COMPOSITE V4.6.1

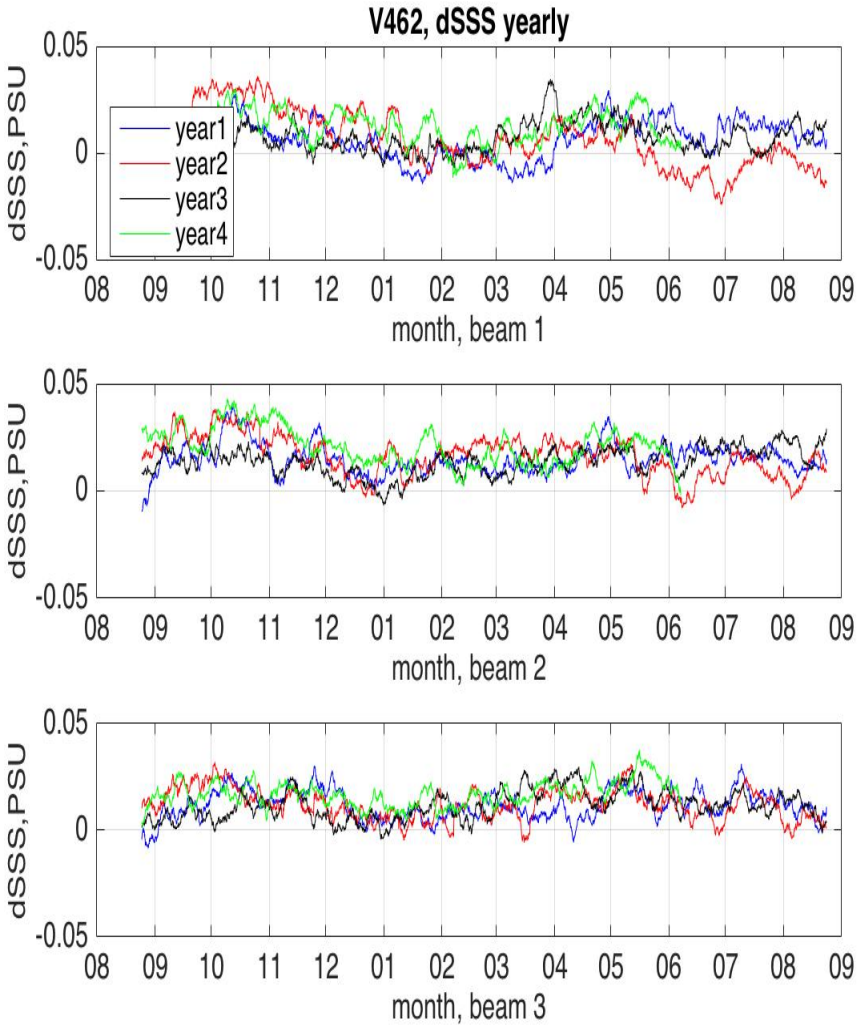




AQ SSS – SCRIPPS ARGO

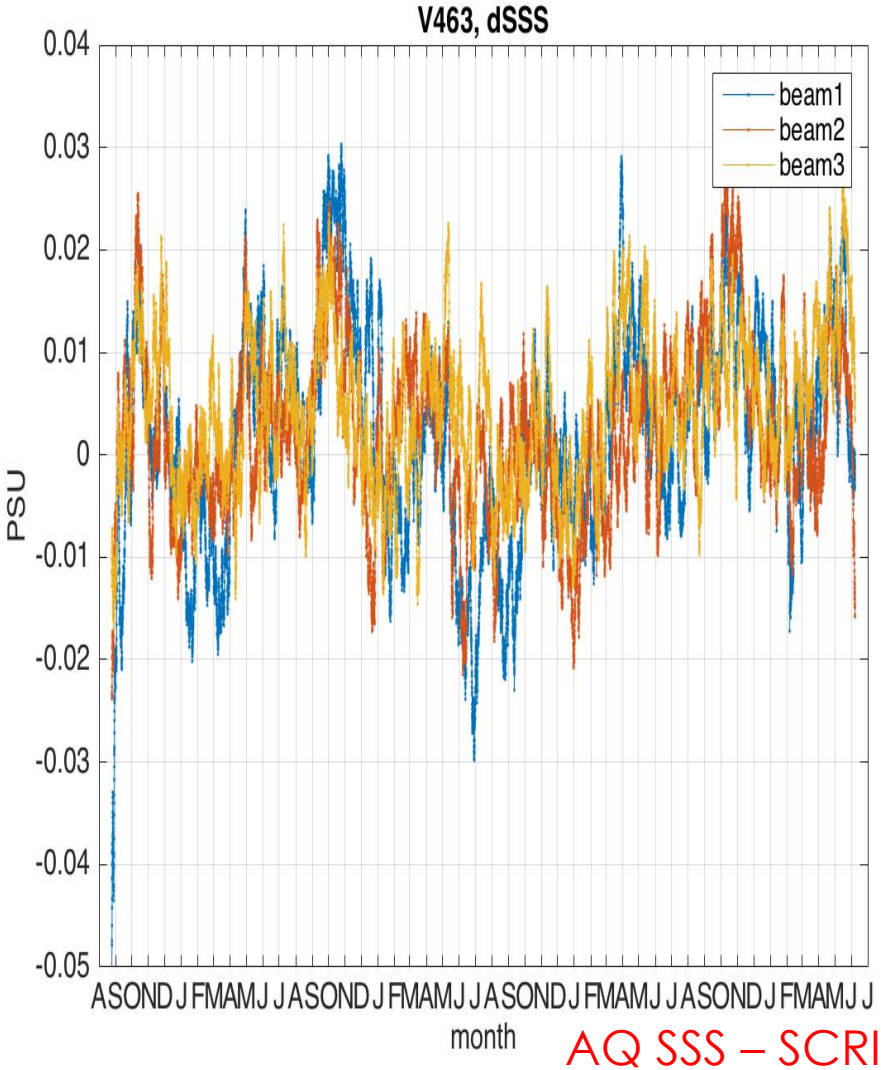
DSSS COMPOSITE V4.6.2

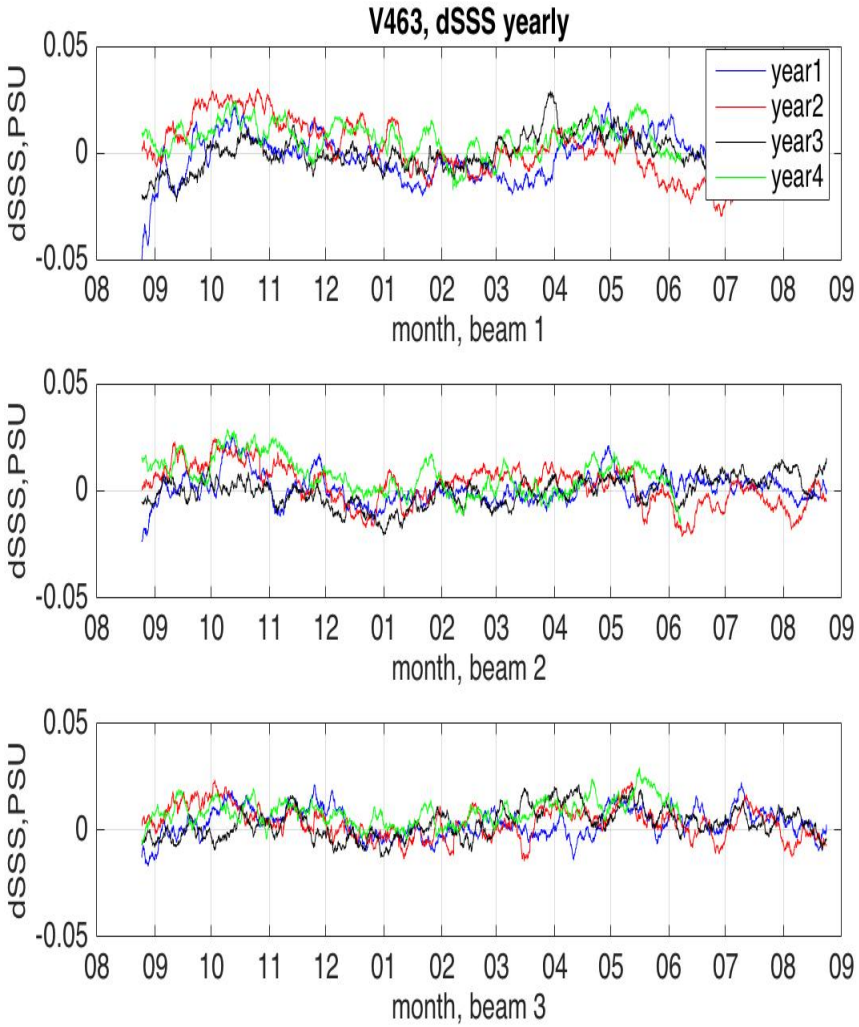




AQ SSS – SCRIPPS ARGO

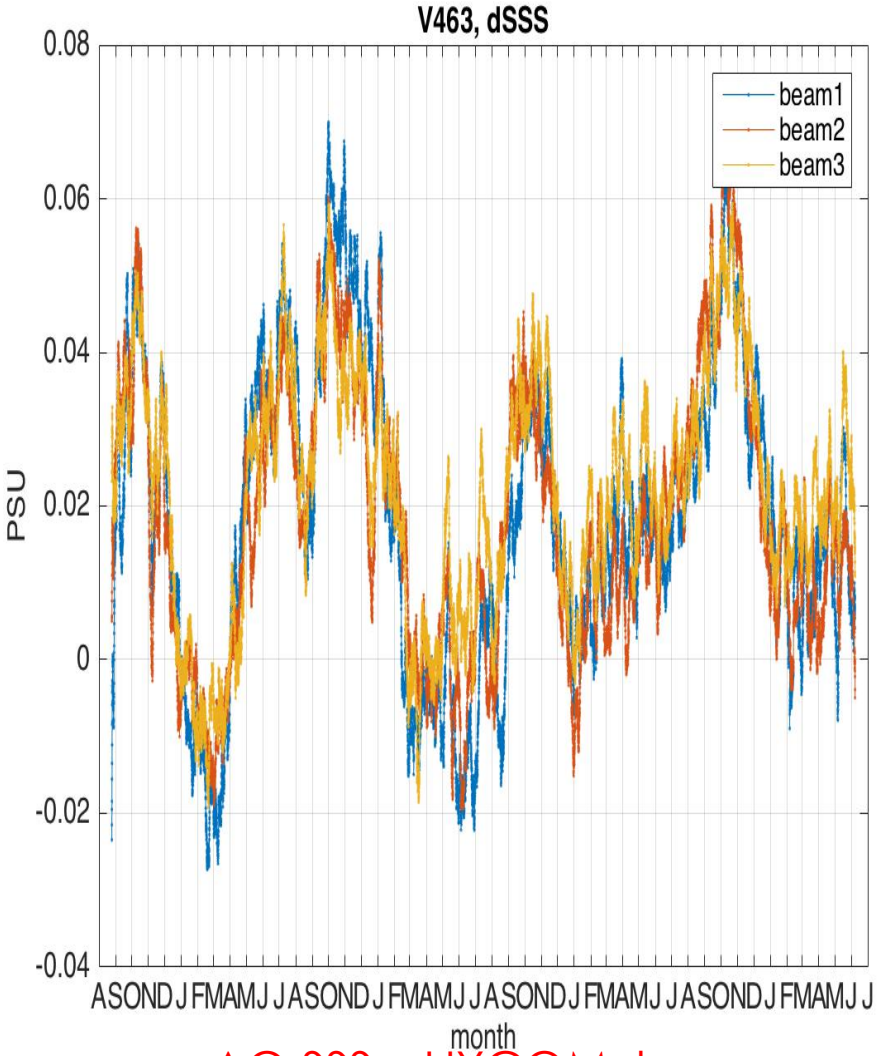
DSSS COMPOSITE V4.6.3

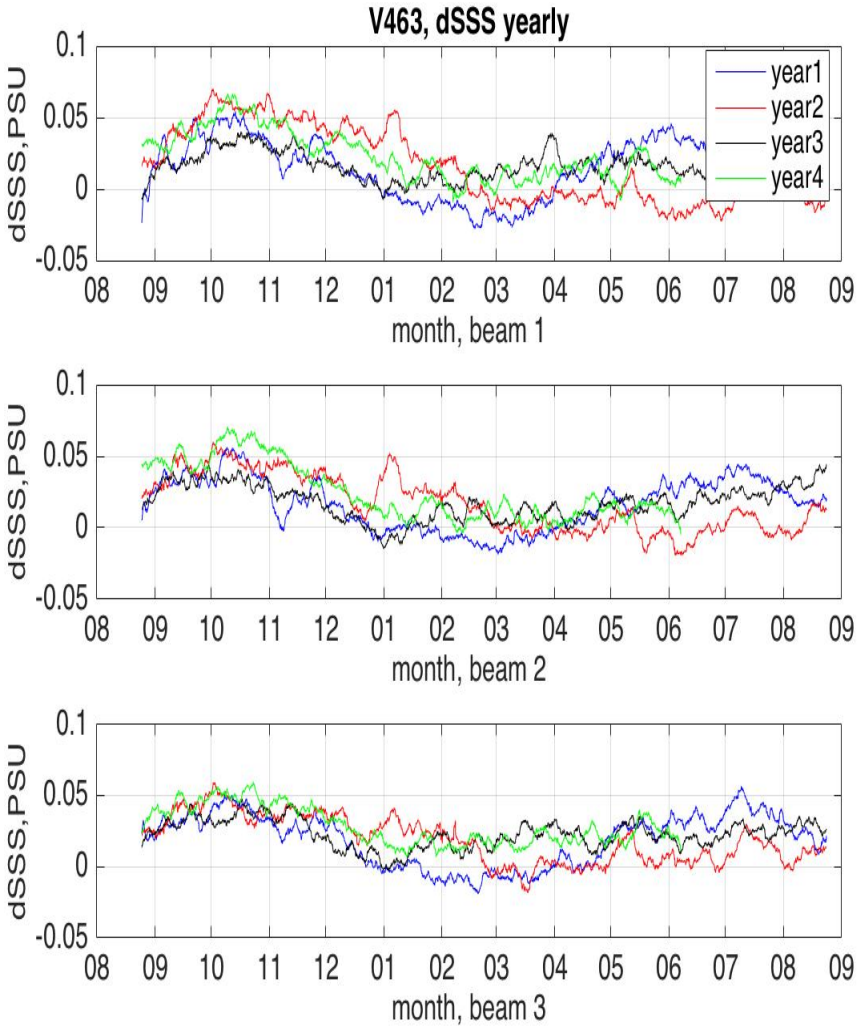




AQ SSS – SCRIPPS ARGO

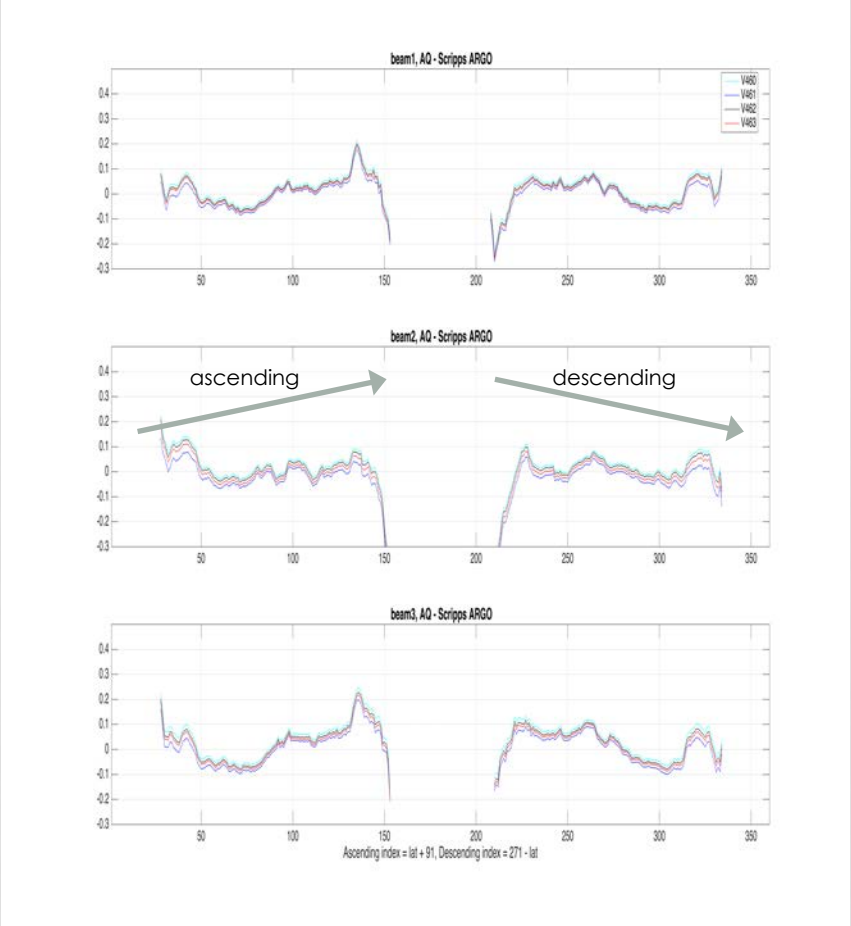
DSSS COMPOSITE V4.6.3

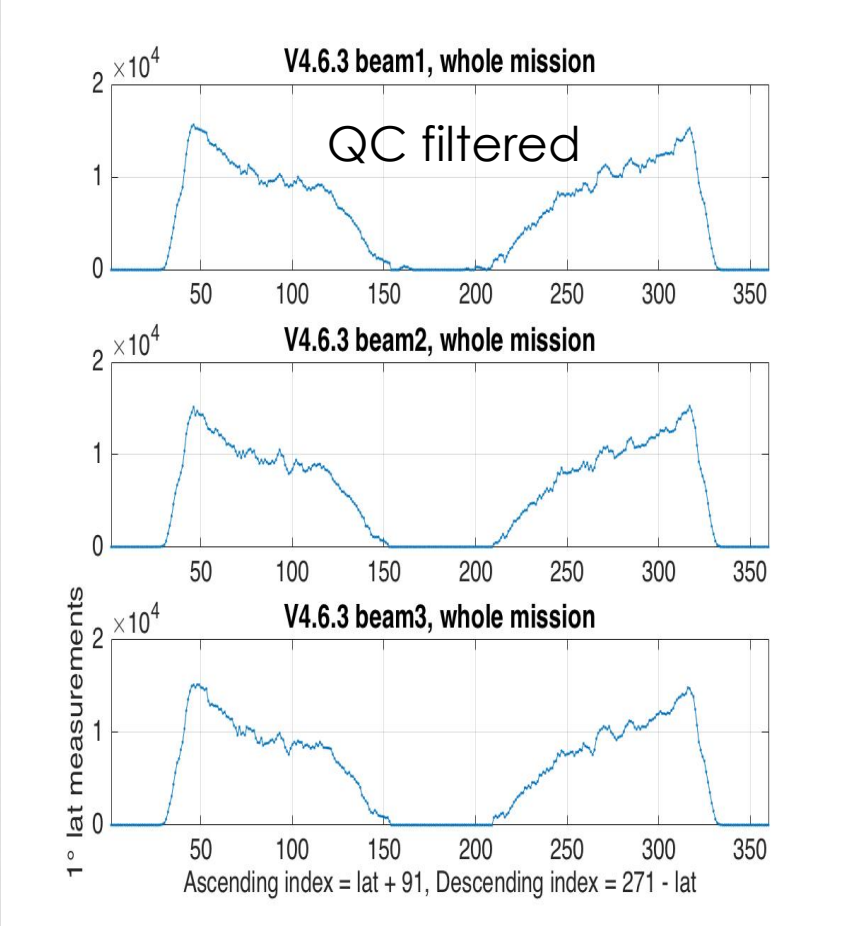




AQ SSS – HYCOM, larger annual fluctuation, +0.02PSU bias

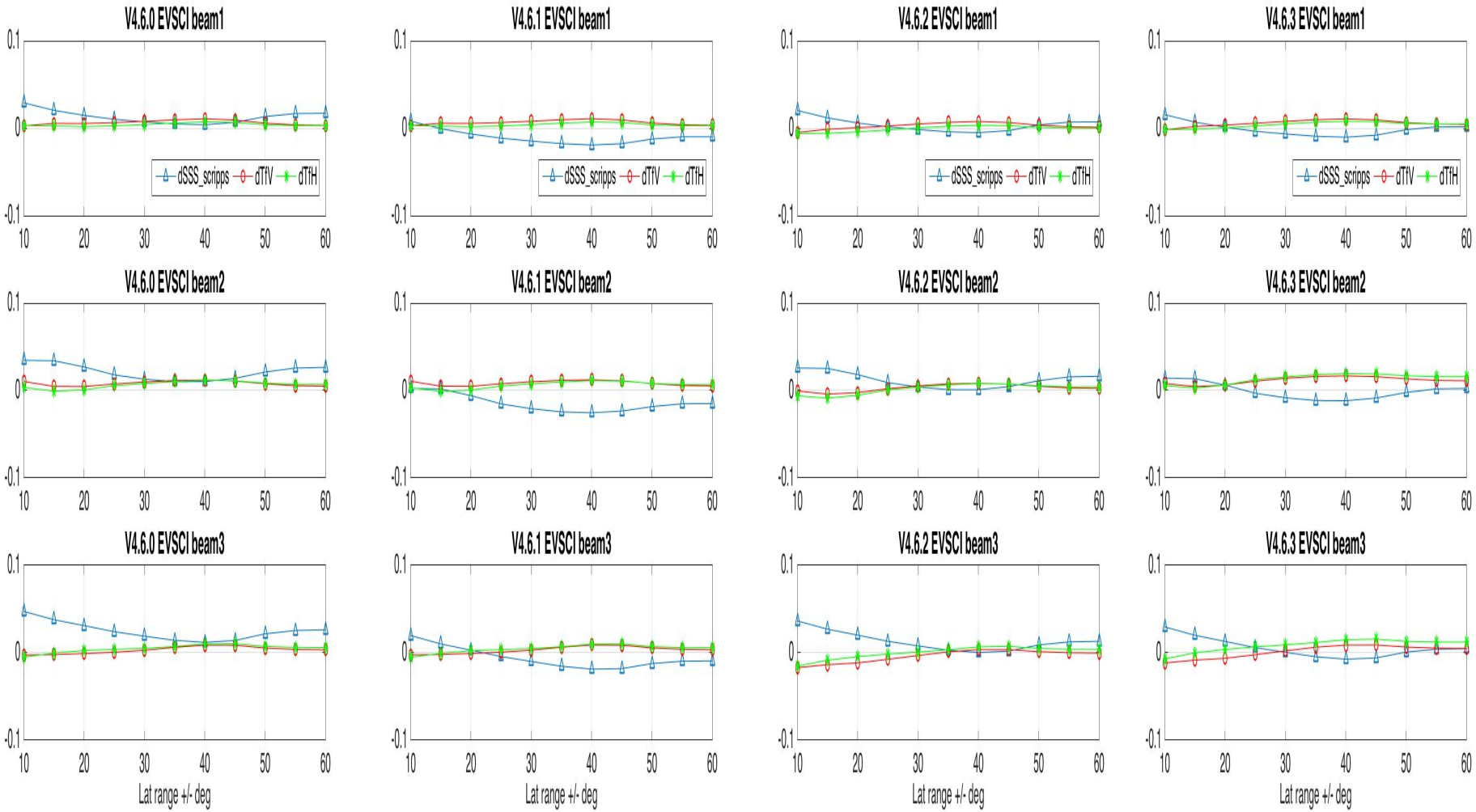
DTF, DSSS(SCRIPPS) LATITUDINAL VARIATIONS V4.6.[0-3]



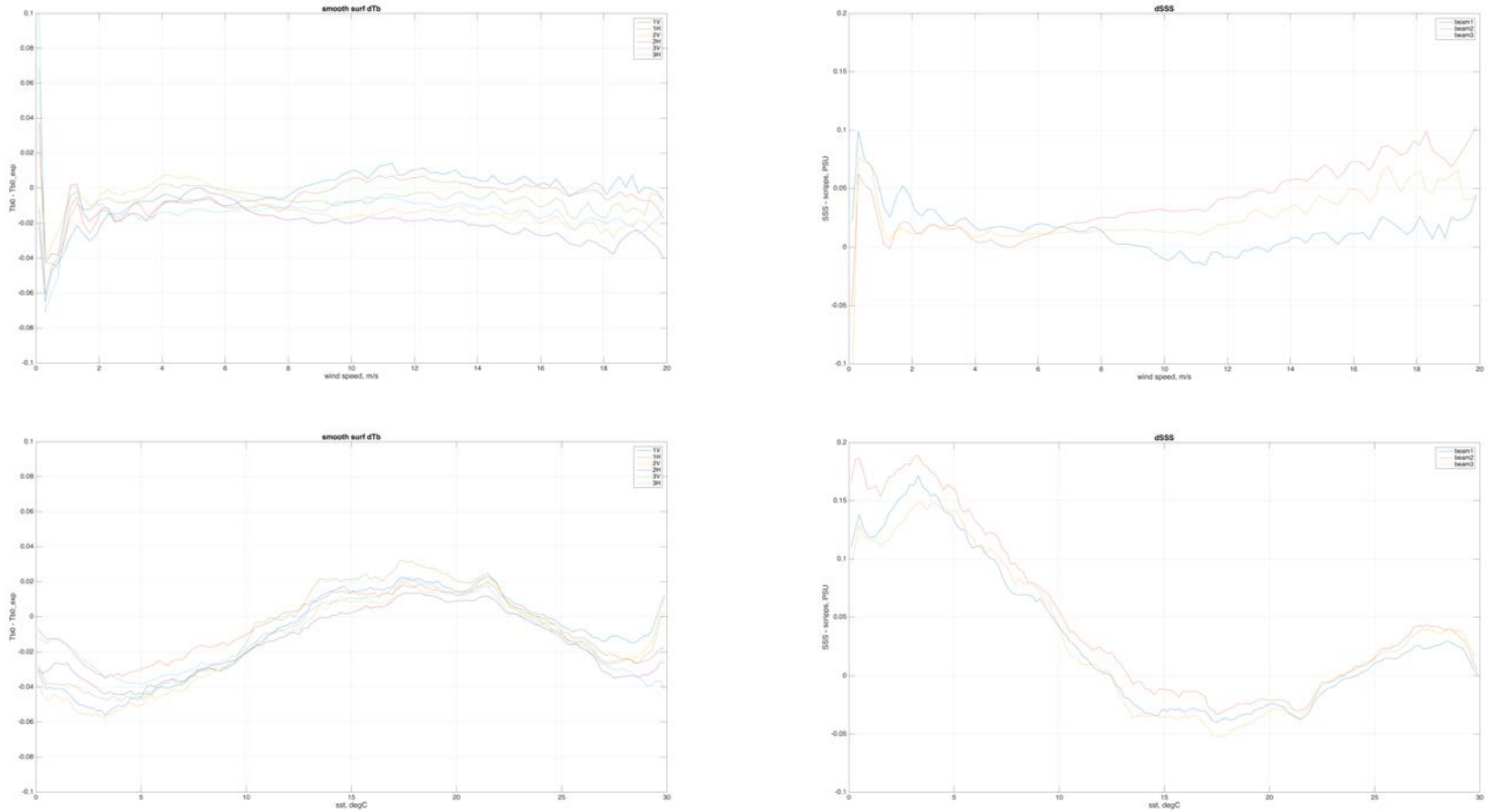


Residual SSS biases in V4.6.0 thought V4.6.3 have basically the same latitudinal variation, with tiny (~0.02 PSU) up/down shifts

DTA AND DSSS(SCRIPPS) V.S. LATITUDE RANGE V4.6.[0-3]

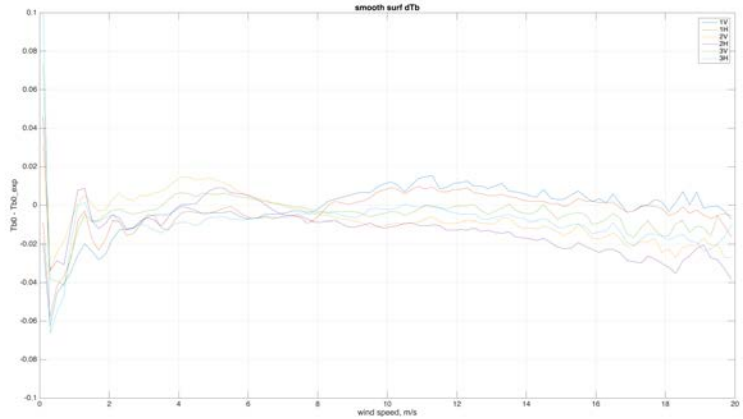


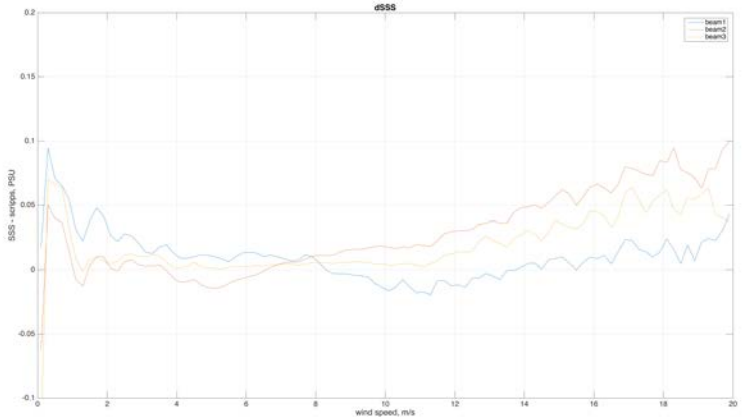
DTB_SMOOTH_SURF & DSSS VS WIND SPEED & SST, V4.6.2



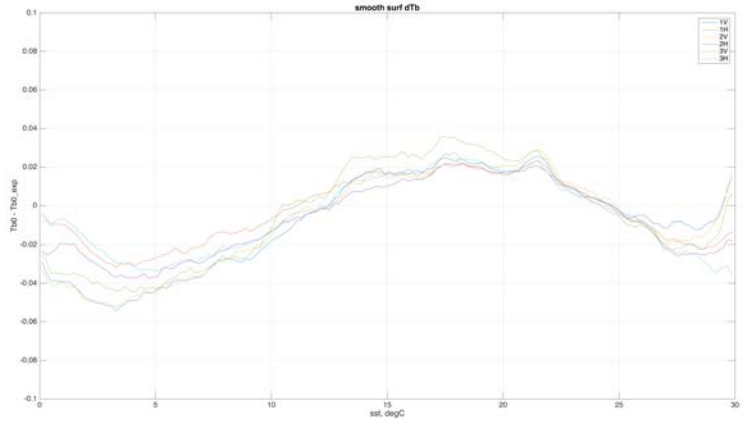
There are still some retrieval error dependencies on SST

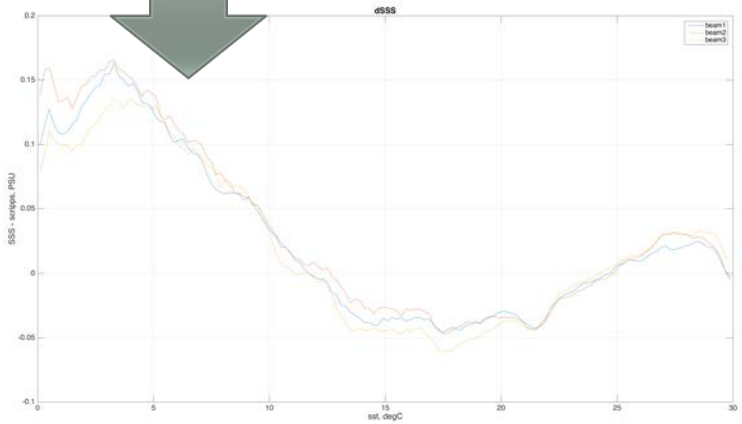
DTB_SMOOTH_SURF & DSSS VS WIND SPEED & SST, V4.6.3

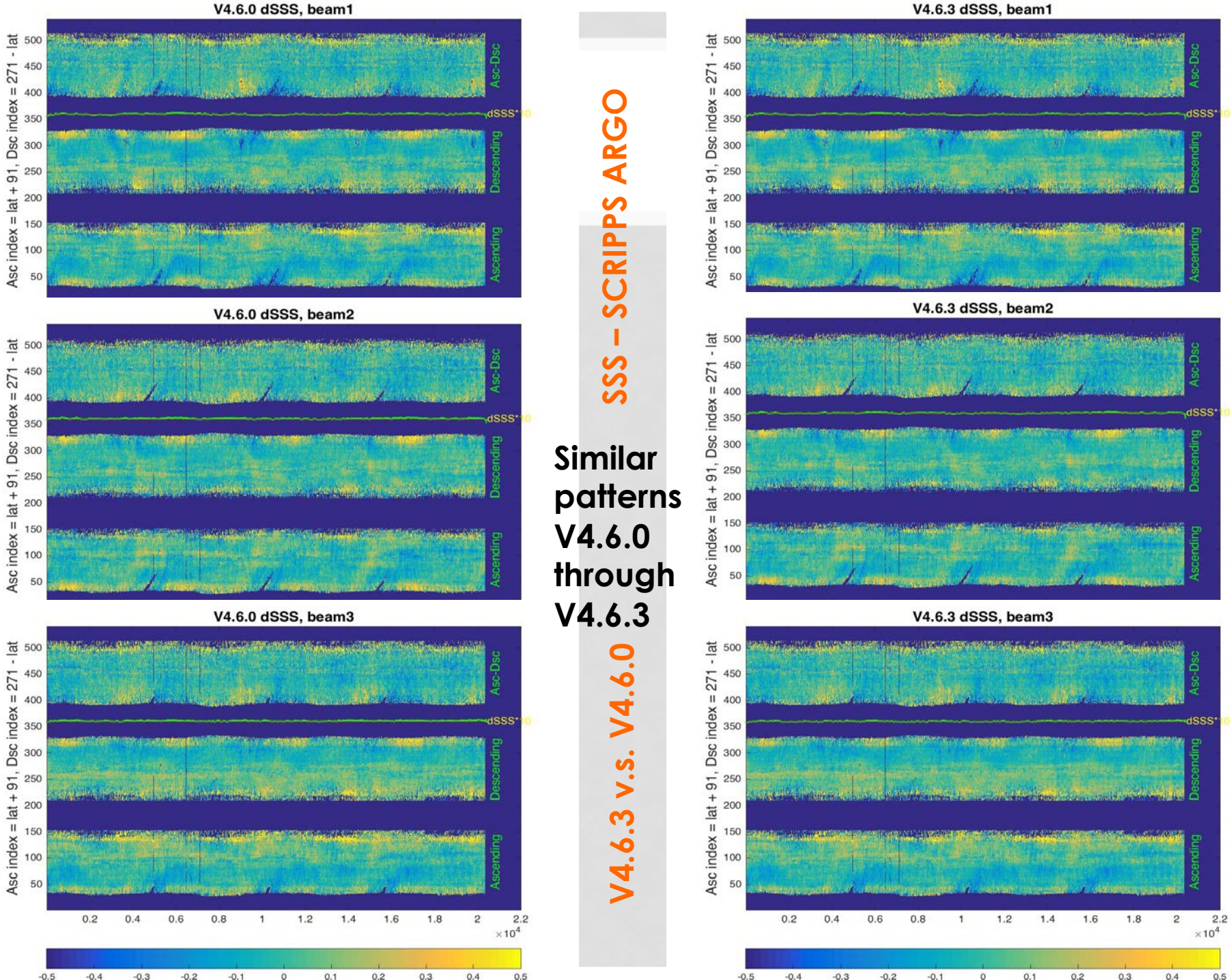




dSSS slightly decreased, average closer to 0






V4.6.0 dSSS, beam1
V4.6.0 dSSS, beam2
V4.6.0 dSSS, beam3
V4.6.3 dSSS, beam1
V4.6.3 dSSS, beam2
V4.6.3 dSSS, beam3
Asc index = lat + 91, Dsc index = 271 - lat
Asc-Dsc
dSSS*
Descending
Ascending
SSS – SCRIPPS ARGO
V4.6.3 v.s. V4.6.0
Similar patterns V4.6.0 through V4.6.3

SUMMARY

- Aquarius radiometer calibration implements corrections derived against a forward model to compensate radiometer gain drifts and some other possible unknown (instrumental) behaviors.
- With all recent major updates, the residual bias (comparing to calibration source as well as to other validation sources) is down to 0.03 PSU, which is much less than the uncertainties.
- Further improvements (Ic in V4.6.2 & hh/hhh dTf inV4.6.3) to adjust known model/retrieval discrepancies can reduce the residual bias to <0.01PSU.
- Future works that help calibration include further analysis and comparison of calibration/validation sources, regional biases in retrieved SSS

BACK UPS

- The Aquarius V4.6.0 data has same set of products as in V4.5.1. Changes in algorithm and processing are,
  - Updated radiometer Faraday rotation angle, geometric rotation angle and total polarization angle fields in L2
  - Sea Ice Fraction update (rad_ice_frac, i.e. gice)
  - Scripps Argo fields replaced HYCOM for calibration;
  - Argo matchups included in L2
  - Bug fix in channel 2H ND physical temperature reading
  - Updated galactic symmetrization maps
  - Updated GMF for wind: Dropped dependence on SWH; Updated SST dependence
  - Retrieval uses H-pol and V-pol with equal weight

AQ L2 SSS & RADIOMETER TB QC FILTERS

- rain_flag = double(bitshift(bitand(rFlags,2^2),-2));
- idx_rain = squeeze(rain_flag(1,:,:));

- land_flag = double(bitshift(bitand(rFlags,2^3),-3));
- idx_land = squeeze(sum(land_flag(1:3,:,:)));

- ice_flag = double(bitshift(bitand(rFlags,2^4),-4));
- idx_ice = squeeze(sum(ice_flag(1:3,:,:)));

- wind_flag = double(bitshift(bitand(rFlags,2^5),-5));
- idx_wind = squeeze(sum(wind_flag(1:4,:,:)));

- TfmTe_flag = double(bitshift(bitand(rFlags,2^6),-6));
- idx_TfmTe_V = squeeze(TfmTe_flag(1,:,:) + TfmTe_flag(2,:,:));
- idx_TfmTe_H = squeeze(TfmTe_flag(3,:,:) + TfmTe_flag(4,:,:));

- nav_flag = double(bitshift(bitand(rFlags, 2^12),-12));
- idx_nav = squeeze(sum(nav_flag(1:4,:,:)));

- SA_overflow_flag = double(bitshift(bitand(rFlags,2^13),-13));
- idx_sa_overflow = squeeze(SA_overflow_flag(1,:,:));

- rough_flag = double(bitshift(bitand(rFlags,2^14),-14));
- idx_rough = squeeze(rough_flag(1,:,:));

- pointing_flag = double(bitshift(bitand(rFlags, 2^16),-16));
- idx_pointing = squeeze(sum(pointing_flag(1:2,:,:)));

- consistency_flag = double(bitshift(bitand(rFlags,2^17),-17));
- idx_consis = squeeze(sum(consistency_flag(1:2,:,:)));

- Coldwater_flag = double(bitshift(bitand(rFlags,2^18),-18));
- idx_coldwater = squeeze(sum(Coldwater_flag(1:2,:,:)));

- TFTADIFF_flag = double(bitshift(bitand(rFlags,2^19),-19));
- idx_TFTADIFF_V = squeeze(TFTADIFF_flag(1,:,:) + TFTADIFF_flag(2,:,:));
- idx_TFTADIFF_H = squeeze(TFTADIFF_flag(3,:,:) + TFTADIFF_flag(4,:,:));

- REFL_1STOKES_flag = double(bitshift(bitand(rFlags,2^21),-21));
- idx_refl_1stokes = squeeze(sum(REFL_1STOKES_flag(1:4,:,:),1));

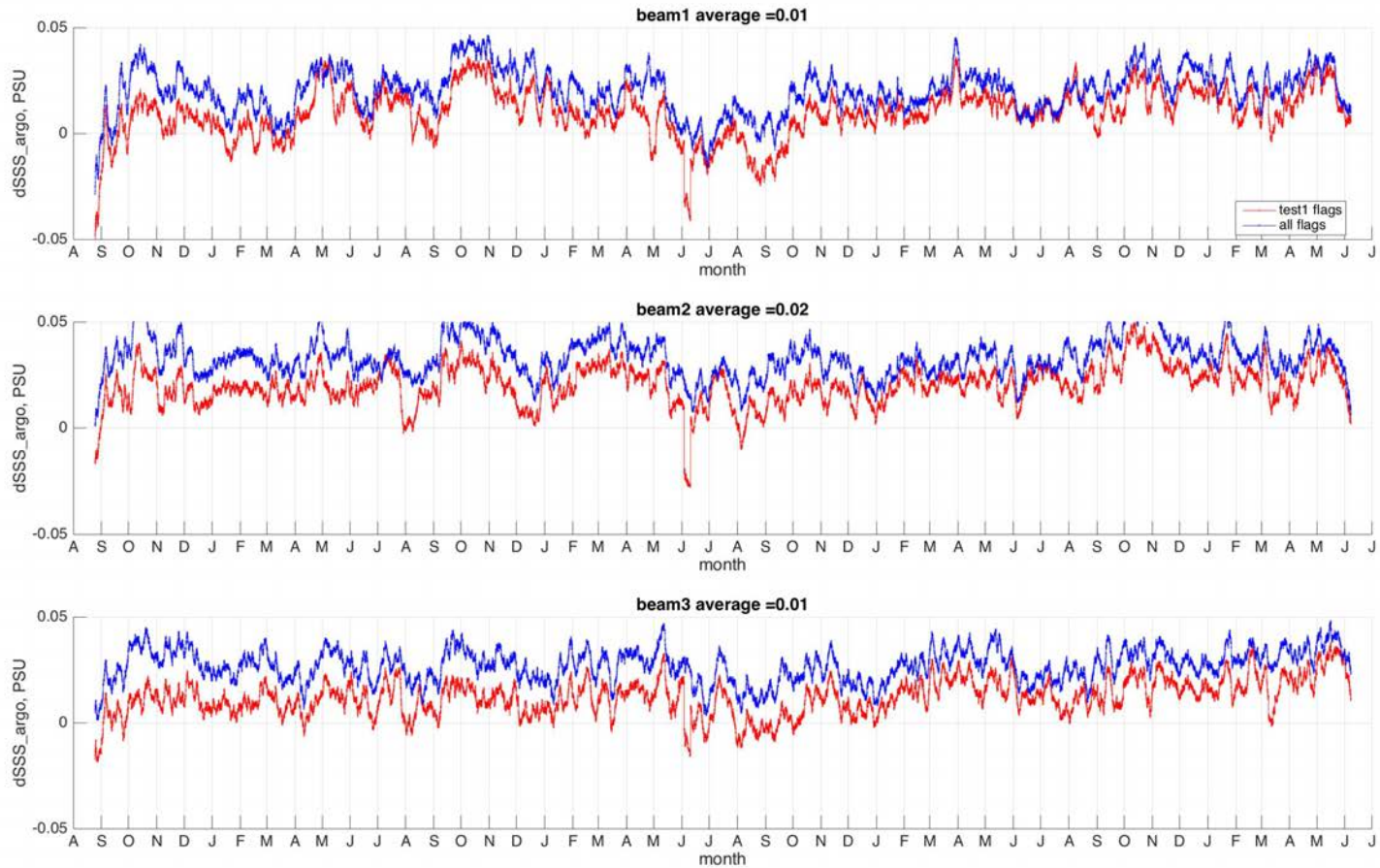
- RFI_region_flag = double(bitshift(bitand(rFlags,2^23),-23));
- idx_rfi_region = squeeze(RFI_region_flag(1,:,:));

- idx_bad = idx_pointing + idx_nav + idx_rain + idx_land …
- + idx_ice + idx_rough + idx_refl_1stokes + idx_rfi_region ...
- + idx_sa_overflow + idx_coldwater + idx_wind + idx_consis;

- idx_bad_V = idx_bad + idx_TFTADIFF_V + idx_TfmTe_V;
- idx_bad_H = idx_bad + idx_TFTADIFF_H + idx_TfmTe_H;

- **The above filters are applied in both calibration process and verification analysis**

EXAMPLE OF DATA QC FILTER EFFECTS



Test1 flags did not exclude RFI regions, moon and galaxy effects, tb consistency, roughness correction failure

SUMMARY OF AQ V4.X VERSIONS

- V4.0 (May, 2015):
- V4.1.0 (Nov, 2015): CAL with instrumental wiggle correction applied before linearity correction; QL adding exponential drift correction to the ND brightness temp.
- V4.1.1 (Feb, 2016): based on V4.1.0, updated the instrumental wiggle correction table
- V4.2.0 (Mar, 2016): based on V4.0, updated SST source with CMC; added uncertainty, rain impact model and spiciness products
- V4.2.1 (Mar, 2016): based on V4.1.1, updated SST source with CMC; added uncertainty, rain impact model and spiciness products
- V4.3.0 (Jul, 2016): based on V4.2.1; with the following 3 empirical correction removed, galactic effect symmetrization; SST correction; Non-linear I-U coupling.
- V4.4.0 (Sep, 2016): based on V4.2.1; updated ancillary inputs and models for expected land surface Tb. Bit 22 (0-based) of the radiometer flags set land RFI, 1-3V 339 K; 344 K; 350 K and 1-3H 327 K; 321 K; 315 K
- V4.5.0(Nov, 2016): based on V4.4.0, EVCAL has instrumental wiggle correction, EVQL adds exponential drift correction, EVSCI adds 7-day moving average Ta error removal; new galaxy and oxygen absorption model with empirical galactic symmetrization off; addition of RIM salinity for 1m, 3m and 5m below surface; radiometer rain flag set using RIM instantaneous rain rate; roughness correction and empirical emissivity adjustment is turned off for surface temperature lower than -9.98degC; updated L2 and L3 metadata for CF compliance.
- V4.5.1(Dec, 2016): based on V4.5.0; turned off empirical emissivity adjustment; fixed SSS histogram by replacing the golden section minimum search with the Brent algorithm; fixed the cold land/ice surface temperature and emissivity; added 4 RIM salinity anomaly products and removed RIM salinity for 1m, 3m and 5m below surface.
- V4.5.2(Feb. 2017) based on V4.5.1 EVSCI with linear adjustments applied directly to Ta/Tf's. Only modified Ta/Tf's are stored, so does the salinity retrieval from these values. EVSCI is the only L2 product, no EVCAL or EVQL's. There is no L3 products either.
- V4.5.3(Apr. 2017) based on V4.5.1. Updates include radiometer Faraday rotation angle, geometric rotation angle and total polarization angle fields in L2; updated Sea Ice Fraction (rad_ice_frac, i.e. gice) input to L2. There is no L3 products for this version.
- V4.5.4(Apr. 2017) based on V4.5.3. Updates include new validation Argo match ups in L2; scripps Argo salinity replacing HYCOM whenever possible in Ta model and calibration corrections; bug fix in channel 2H ND physical temperature reading. There is no L3 products for this version.
- V4.5.5(Apr. 2017) based on 4.5.4. This evaluation run incorporates the updated galaxy symmetrization maps. There is no L3 products for this version.
- V4.6.0(Jun. 2017) based on 4.5.5. This evaluation run completes all major updates towards V5.0. All L2 and L3 products are produced in this version. Updates from previous version include, updated correction to SST dependence of wind signal and wind retrieval with removal of significant wave height correction; 1st guess Aquarius climatology SSS that is used in the HHH wind speed retrieval has been re-derived based on the updated O2 absorption, surface roughness and galaxy; the salinity retrieval uses equal channel weights for V and H.
- V4.6.1(Aug. 2017) based on V4.6.0. A static correction is applied to smooth surface Tb in retrieval algorithm. Rain masked Salinity maps are added to L3 product.
- V4.6.2(Aug. 2017) based on V4.6.0. Land correction/contamination is added to modeled Tb's to symmetrize forward/backward models. This version has L2 products only.
- V4.6.3(Aug. 2017) based on V4.6.2. Mission averaged hh/hhh wind effect differences at Ta seen in V4.6.2 are subtracted from Ta. This version has L2 products only.
- **This includes all test versions generated at ADPS. Use with caution and do not draw scientific conclusions from versions not published on PO.DAAC.**

Table 1. Conditions indicated for the pixel associated with the setting of individual bits in **radiometer_flags**, along with the flag dimension and related data fields

Bit Set = 1	Condition Indicated	Last Flag Dimension	Flag/ Mask	Data Fields
0 (LSB)	RFI moderate contamination 7 <= samples < 15	Polarization (V, P, M, H)	F	rad_samples
1	RFI severe contamination samples < 7	V, P, M, H	F	rad_samples
2	Rain in main beam rain: rate > 0.25 mm/hr missing data	Rain missing data	F/M F	rim_irr
3	Land contamination moderate: 0.001<land frac≤0.01 severe: land frac > 0.01 mask: land frac>0.5	moderate severe mask	F F M	rad_land_frac
4	Sea ice contamination moderate: 0.001 < ice frac ≤ 0.01 severe: ice frac > 0.01 mask: ice frac > 0.5	moderate severe mask	F F M	rad_ice_frac
5	Wind/foam contamination moderate: 15 < wind speed ≤ 20 severe: wind speed > 20 wind speed non-convergence scatterometer flags 29 or 31 (severe RFI) set	moderate severe converge scat RFI	F M M M	anc_wind_speed rad_hh_wind_speed rad_hhh_wind_speed scatterometer_flags
6	Unusual brightness temperature moderate: 1.0<abs(Tf-Ta_exp) ≤3.0 severe: abs(Tf-Ta_exp)>3.0	V moderate V severe H moderate H severe	F	rad_TfV rad_exp_TaV rad_TfH rad_exp_TaH
7	Direct solar flux contamination moderate: 0.02<solar direct≤0.05 severe: solar direct>0.05	V moderate V severe H moderate H severe	F	rad_solar_Ta_dir_V rad_solar_Ta_dir_H
8	Reflected solar flux contamination moderate: 0.02<solar reflect≤0.05 severe: solar reflect >0.05	V moderate V severe H moderate H severe	F	rad_solar_Ta_ref_V rad_solar_Ta_ref_H
9	Sun glint moderate: 0.02<solar glint≤0.05 severe: solar glint>0.05	V moderate V severe H moderate H severe	F	rad_solar_Ta_bak_V rad_solar_Ta_bak_H
10	Moon contamination[2] moderate: 0.02<moon refl≤0.05 severe: moon refl >0.05	V moderate V severe H moderate H severe	F	rad_moon_Ta_ref_V rad_moon_Ta_ref_H
11	Galactic contamination[2] moderate: 0.02<galactic≤0.05 severe: galactic>0.05	V moderate V severe H moderate H severe	F	rad_galact_Ta_ref_V rad_galact_Ta_ref_H
12	Non-nominal navigation abs(roll) > 1.0 abs(pitch) > 1.0 abs(yaw) > 5.0 clat, clon = -999	roll pitch yaw OOB	M M M M	att_ang beam_clat beam_clon
13	SA overflow Overflow bit set in NRT telemetry	overflow	M	radiom_nrt_tlm (L1A)
14	Roughness Correction roughness correction failure no SWH[3]	roughness SWH	F F	anc_swh
15	Solar flare contamination moderate: 5.e-5 < flux ≤ 1.e-4 severe: flux > 1.e-4	moderate severe	F	solar_xray_flux
16	Pointing Anomaly AOCS anomaly from database ACS mode ≠ 5	anomaly acs_mode	M M	acs_mode
17	Rad Tb consistency rad_Tb_consistency > 0.4 emissivity = NaN	Tb_cons emissivity	F M	rad_Tb_consistency
18	Surface Temperature moderate: 0C ≤ SST < 5C severe: SST < 0C	moderate severe	F M	anc_surface_temp
19	RFI Level Moderate: TF – TA > 0.30 or -1.0 ≤ TF – TA < -0.30 Severe: TF-TA < -1.0 or > 0.30	moderate severe	F M	rad_TaX rad_TfX
20	Non-nominal commanded state OpLUT ≠ 0		M	L1A:dpu_status_tlm[1]
21	Moon Reflected Radiation Moon moderate: 0.25<Ta_ref≤0.5 Moon severe: Ta_ref > 0.5 Galaxy Reflected Radiation Ta_ref > 5.6 or (Ta_ref > 3.6 and HH wind < 3.0)	moderate severe severe severe	F M M M	rad_moon_Ta_ref_H rad_moon_Ta_ref_V rad_galact_Ta_ref_H rad_galact_Ta_ref_V rad_hh_wind_speed
22	Land RFI (Thresholds are, 1-3V 339 K; 344 K; 350 K and 1-3H 327 K; 321 K; 315 K)	V H Spare Spare	F	rad_TfV rad_TfH
23	Excessive Asc/Desc difference due to contamination from undetected RFI; geographic zones specified as external file		M	RFI region map[4]
24 - 31 (MSB)	Spares			

Footnotes:

([1]) dpu_status_tlm is a field in the Level-1A product.

([2]) These flags have been superseded by flag 21, but are retained for consistency with earlier versions.

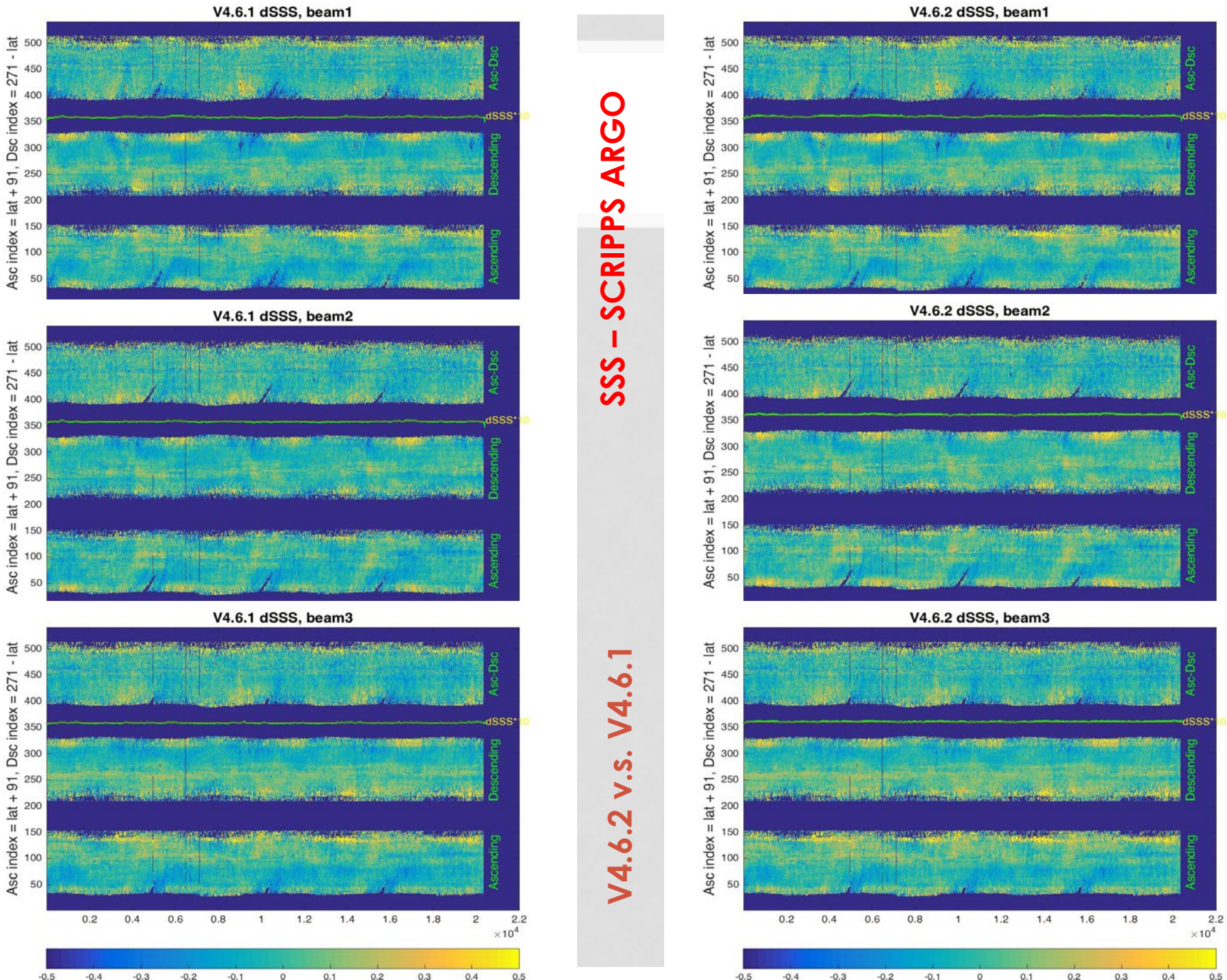
([3]) SWH is not used in V5.0 roughness correction any more

([4]) not a field in L2

Data Masking Notes:

1. Masks for Calibration: The following flags (identified by bit number) are used as masks to isolate a subset of the Aquarius L2 data to be used for calibration: 2, 3, 4, 5, 6, 12, 13, 14, 16, 17, 18, 19, 21, 23. In the case of flags 3, 4, 5, 6 and 18, 19, 21 data are masked whenever the flag level is moderate or severe. For additional information see AQ-014-PS-0006.

2. Masks for L3: The masks used for calibration are also used for transferring data from L2 to L3. However, for L3 data are masked only if the level for flags 3, 4, 5, 18, 19, or 21 is severe, and flag 2 produces a separate L3 product.


V4.6.1 dSSS, beam1
V4.6.2 dSSS, beam1
V4.6.1 dSSS, beam2
V4.6.2 dSSS, beam2
V4.6.1 dSSS, beam3
V4.6.2 dSSS, beam3
Asc index = lat + 91, Dsc index = 271 - lat
Asc-Dsc
Descending
Ascending
dSSS*10
×10^4
SSS – SCRIPPS ARGO
V4.6.2 v.s. V4.6.1

REMAINING TA ERROR COMPARED TO MODEL AFTER DRIFT CORRECTION