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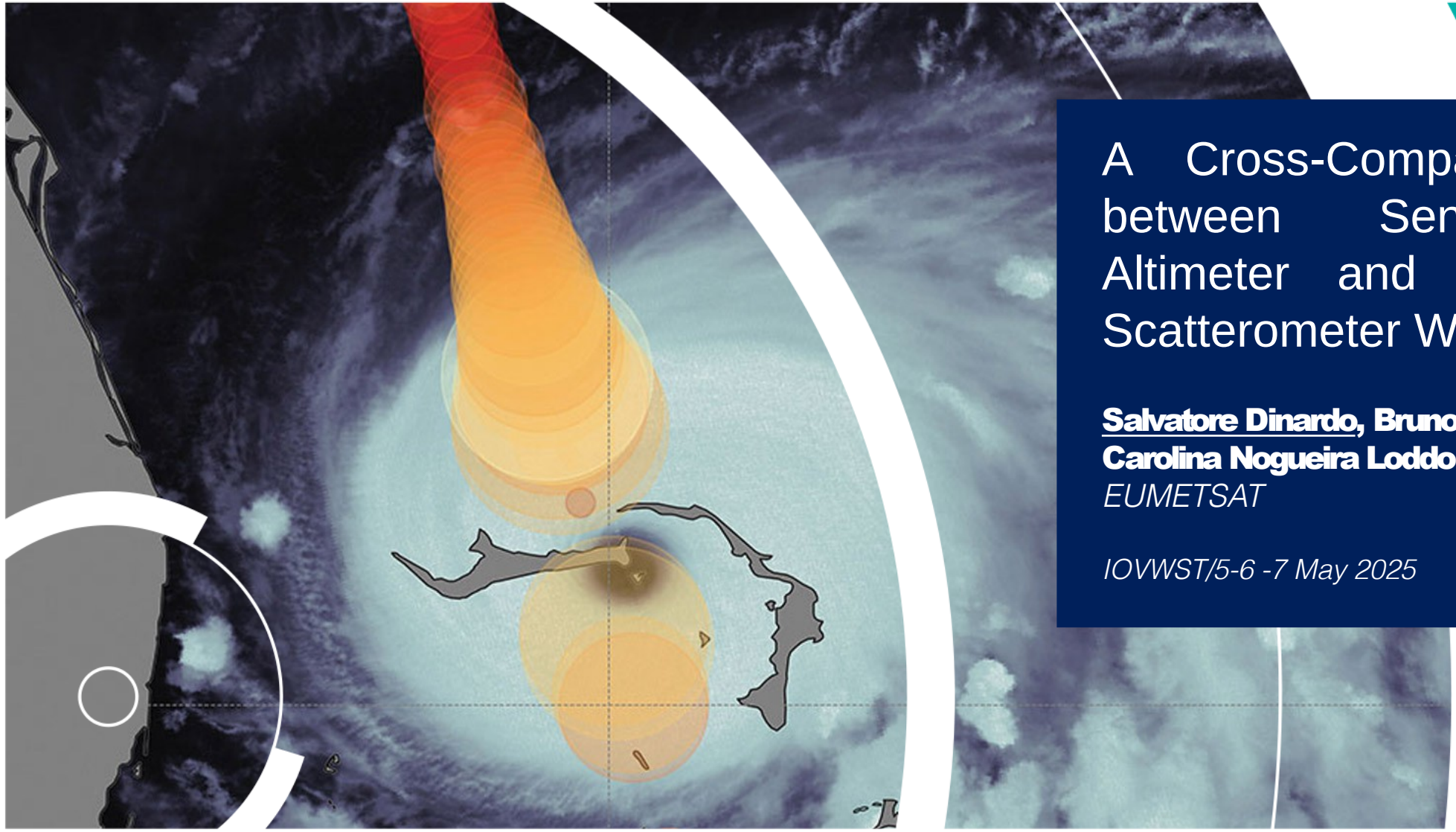

A Cross-Comparison Validation between Sentinel-3A SRAL Altimeter and Metop ASCAT-B Scatterometer Wind Speed

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EUMETSAT

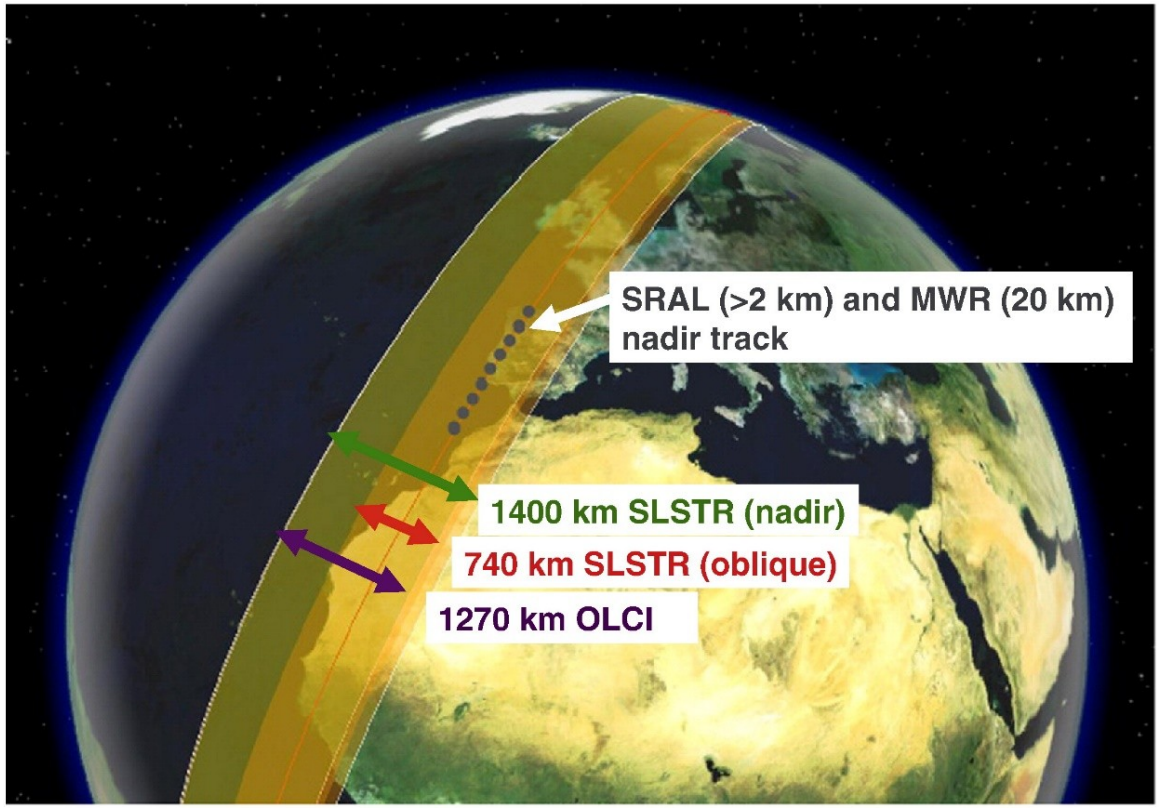
IOVWST/5-6 -7 May 2025

Agenda

- ❑ **Presentation Scope and dataset**
- ❑ **One cycle Cal/Val**
- ❑ **Time- Series**
- ❑ **Conclusions**

COPERNICUS Sentinel-3 SRAL/MWR: Surface Topography Mission

- Sun Synchronous Orbit (814 Km)
- Descending-Node Local Solar Time: 10:00 am (morning orbit) => S3A is crossing the equator 30 min after Metop
- 27 Days Repeat Cycle (Metop Repeat Cycle is 29 days)
- 98.65° Inclination
- Ku-Band (13.575 GHz) , Metop is C-Band
- Nadir-Looking Geometry
- Product Type: SAR (300 m) & PLRM(>2 km)
- S3-A: February 201 6 → still flying
- S3-B : May 2018 → still flying

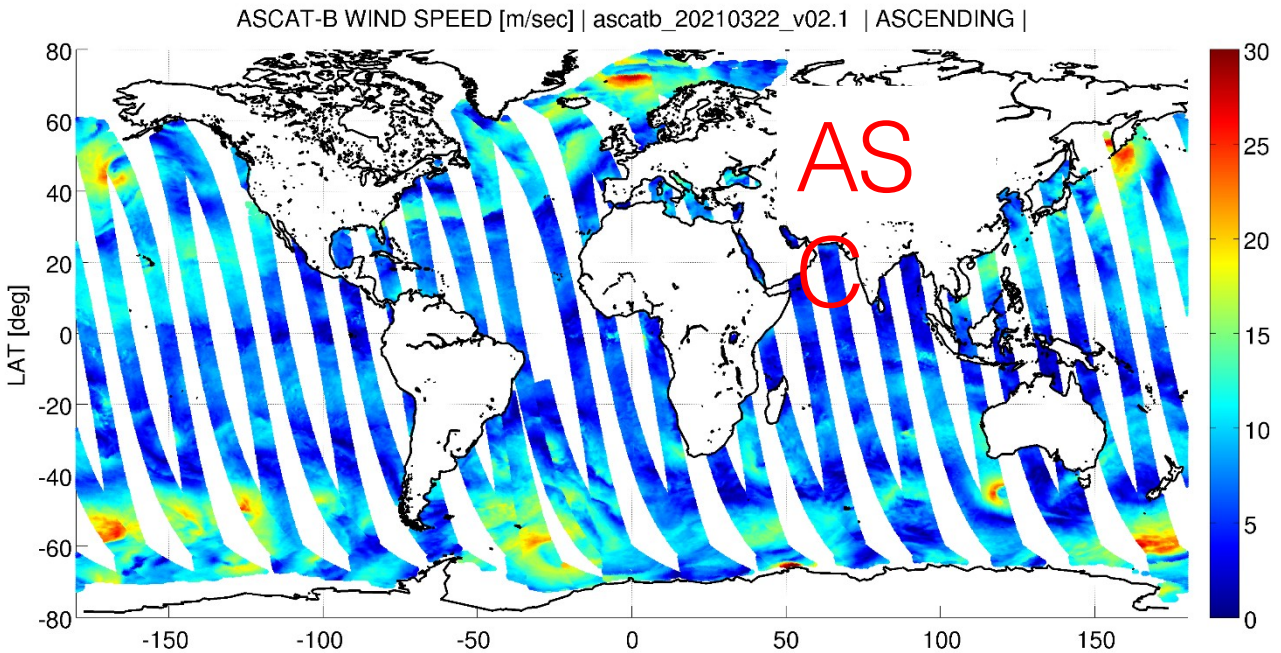


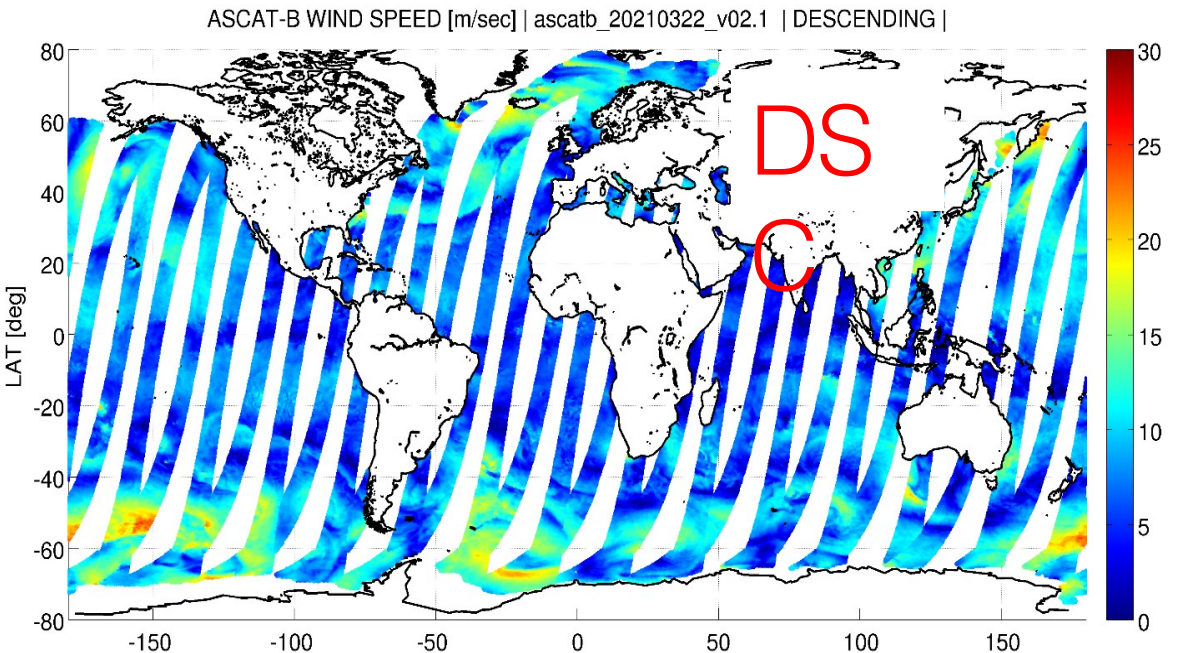
Sentinel-3A SRAL Study DataSet

- Sentinel-3A Marine Baseline Collection **BC005** (REP+OPE), time period 2016-May → 2024-December
- Both wind speeds in the data products considered:
  - ***wind_speed_alt_01_ku*** based on Saleh Abdallah's model (2012), one parameter based (i.e. sigma0 from altimetry)
  - ***wind_speed_alt_2p_01_ku*,** based on Gourrion et al. (2002) & Collard (2005), two-parameters based (sigma0 and SWH from altimetry)
  - Both in SAR mode and both posted at 1 Hz (~ every 7.5 km), given only in magnitude (no direction)

METOP ASCAT-B Wind Products

- METOP ASCAT-B Wind Products from RSS (Remote Sensing Systems), link :
  - CLIMATE-QUALITY (v2.1) ByteMap, wind-vector daily products (split in Asc/Dsc), gridded [0.25 x 0.25 deg] + Rain Flag + Misfit (SoS), pole-2-pole, 2-week latency, (doi), 0.2 m/s wind speed granularity
  - Built as from EUMETSAT L1B 12.5 km data products (recalibrated sigma0) and using RSS internal wind model (C-2015 GMF) computed exploiting $|120\ \text{min}|_{max}$ crossovers between ASCAT and TMI/GMI radiometers (non-SSO on low-inclination orbit → drifting orbits)





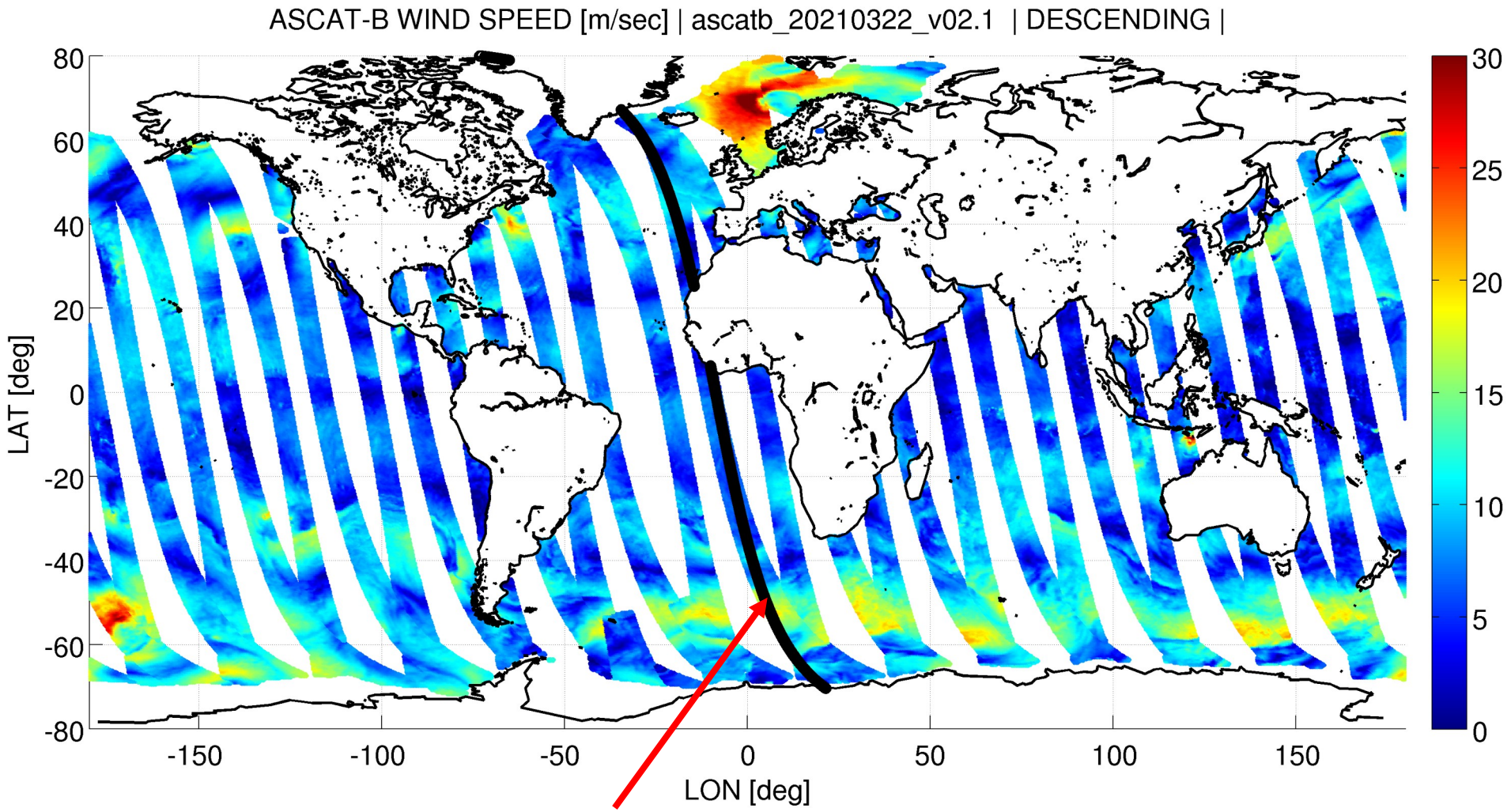
ECMWF NWP ERA-5 Re-analysis model

- Fetched from Copernicus Climate Data Store (link) and documented here . Time period 2016-01 -> 2024-12
- Field: *ocean surface stress-equivalent 10 m neutral wind speed* (air-surface stress driven and coupled ⇄ with wave model)
- One remark: for this field, **ERA-5 pads to 2 m/sec values below 2 m/s.**
- Grid [0.5 x 0.5] deg, 1-H temporal sampling, effective resolution ~70-100 km
- In ERA-5, assimilation of ASCAT A/B "reprocessed" dataset, Sentinel-3 altimetry data are not assimilated

Data Editing and Post-Processing

- S3A SRAL wind speed: No Coastal zone (dist2coast>10 km), no ice (SIC=0), No Rain, Low-misfit (MQE<5) (to avoid alga blooms)
- ASCAT-B: no rainy data, Low-misfit (SoS<1.9)
- Valid measurement (i.e. No Fill Value) for S3A, ASCAT-B, ERA5 at same time (in order to have the same number of points)
- Application of a Low-Pass Filtering (running mean) with filter length of 70 km in order to have a consistent spectral scale between all datasets

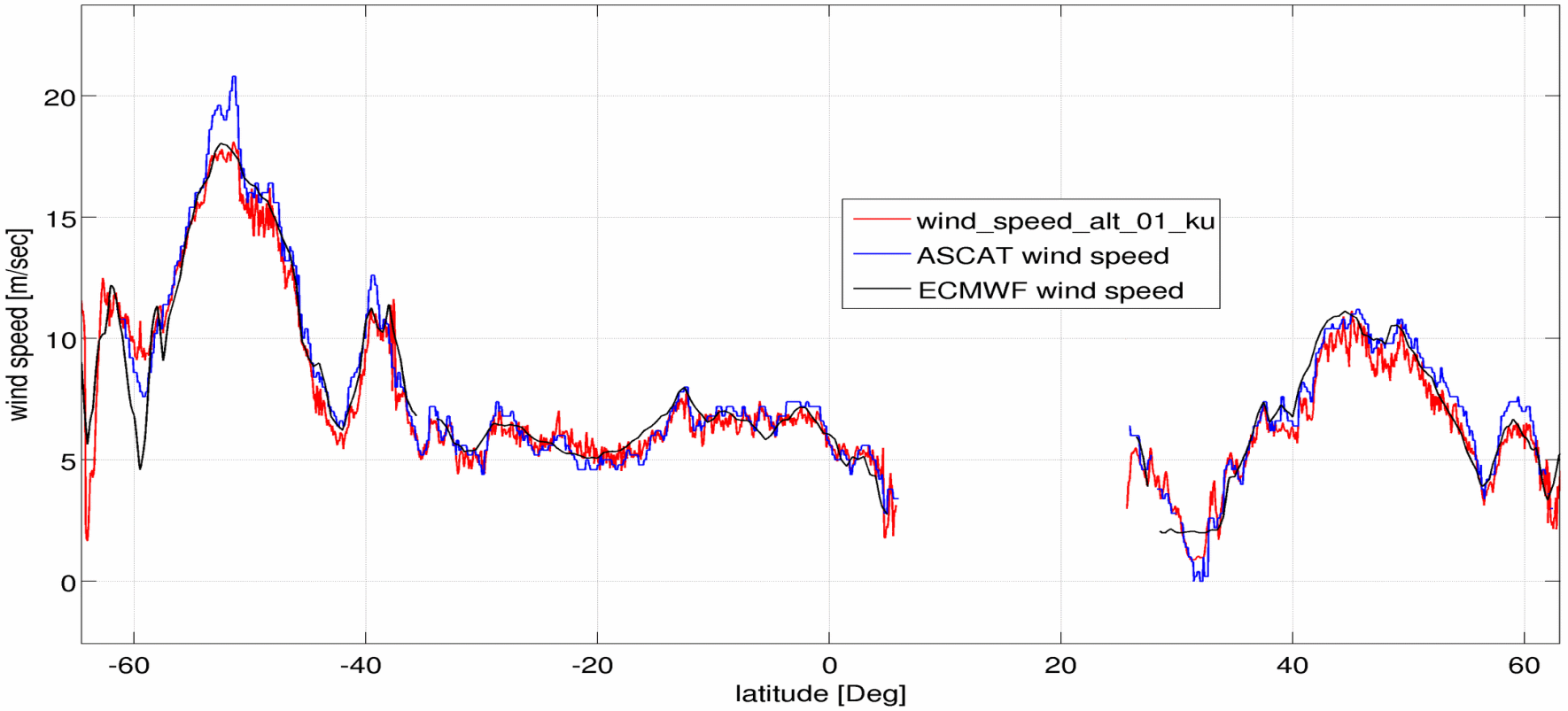
Cross-Over between S3A and METOP-B



Cross-over criteria:

- For each altimeter 1 Hz record, **closest** point between 1 Hz record and ASCAT grid pixel
- Max Time Interval: **90 min**
- Same Orbit Direction
- As visual example, S3A track is in black in the map showing ASCAT wind speed in one day (descending case)

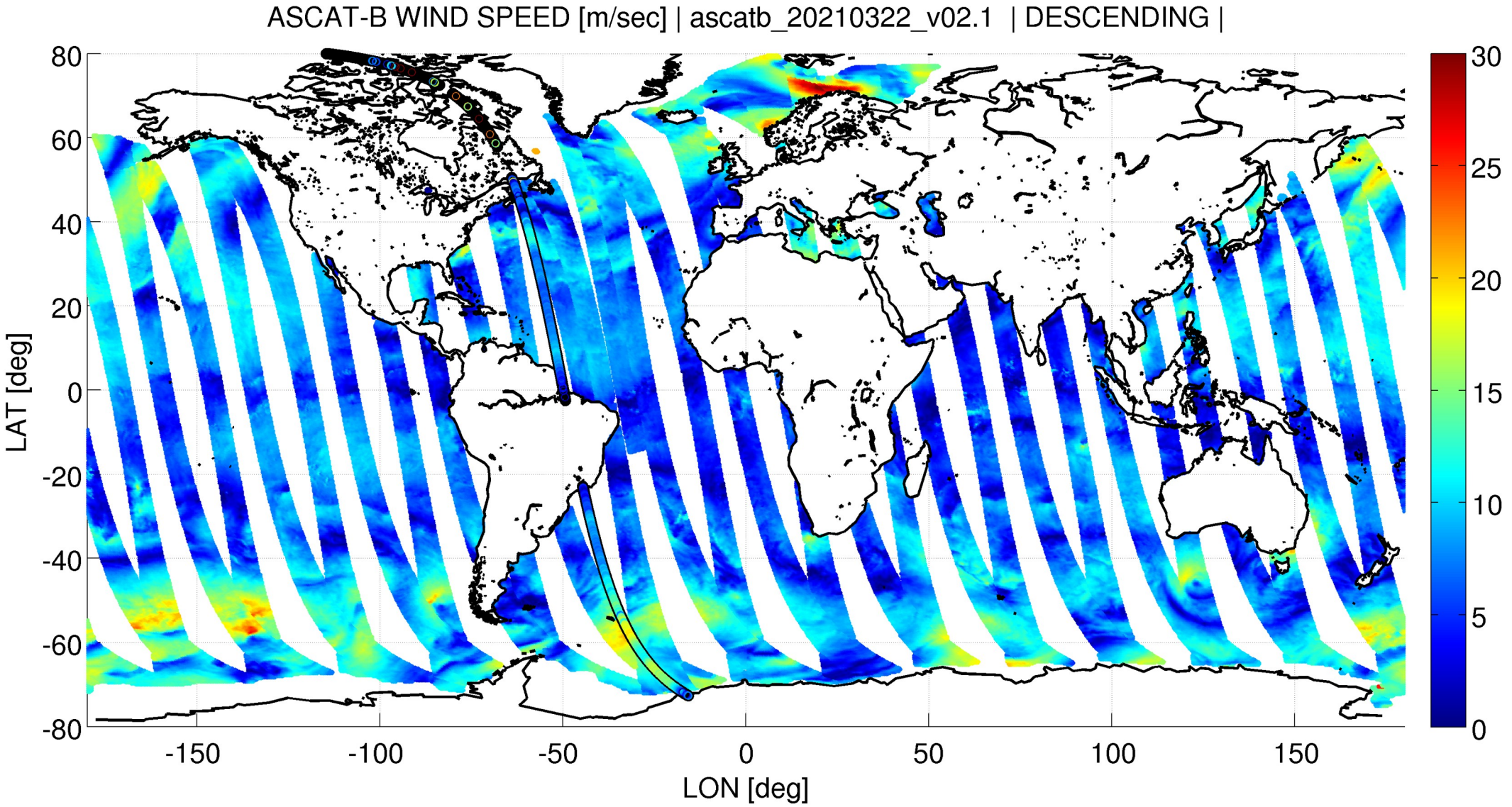
Long Transect between S3A and METOP-B



ERA-5, ALT, ASCAT wind do not have the same spatial scale (w**hile collocating various sources of data, it is important to ensure comparable scales**):

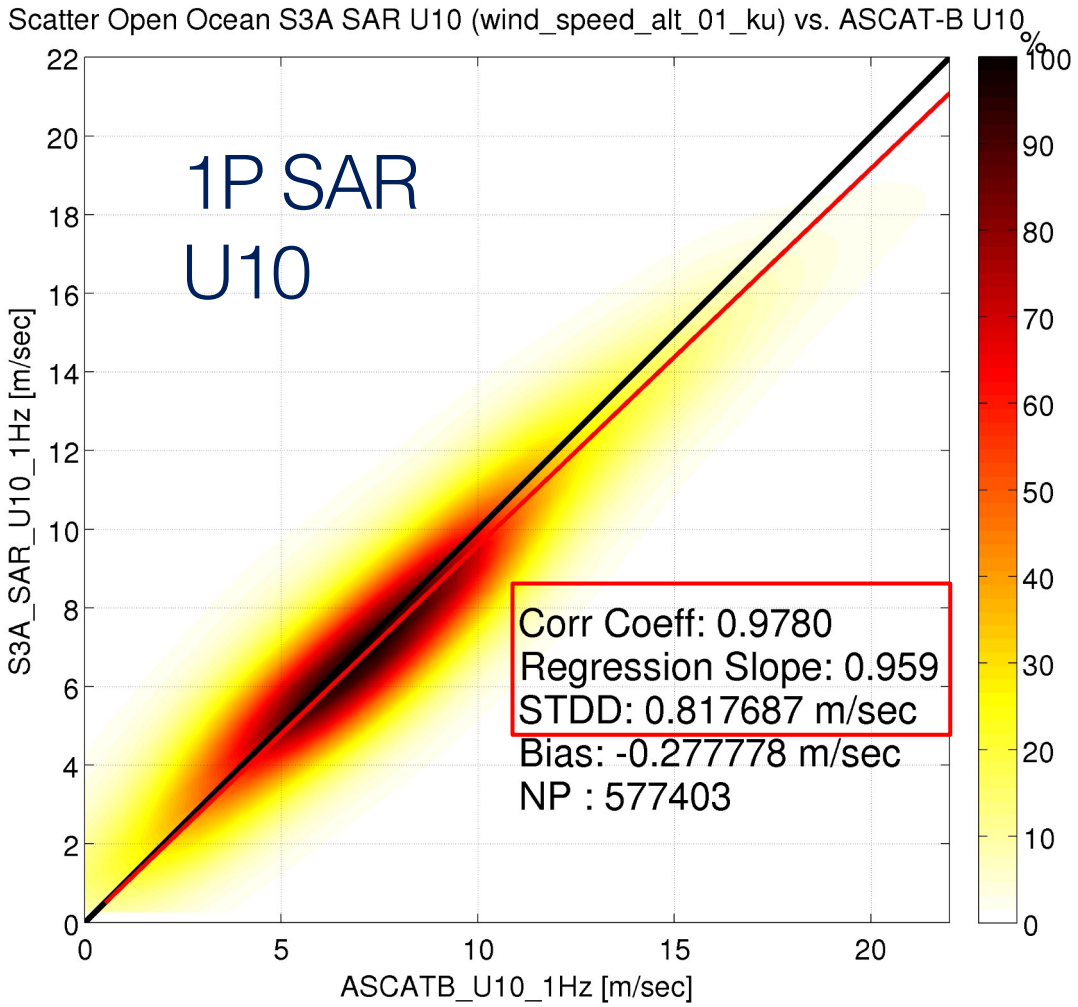
- Altimetry wind speed is prior the running mean with a 70 km length
- Notice the pad at 2 m/sec for low ERA5 wind speed
- Notice the granularity of 0.2 m/sec for the RSS ASCAT winds

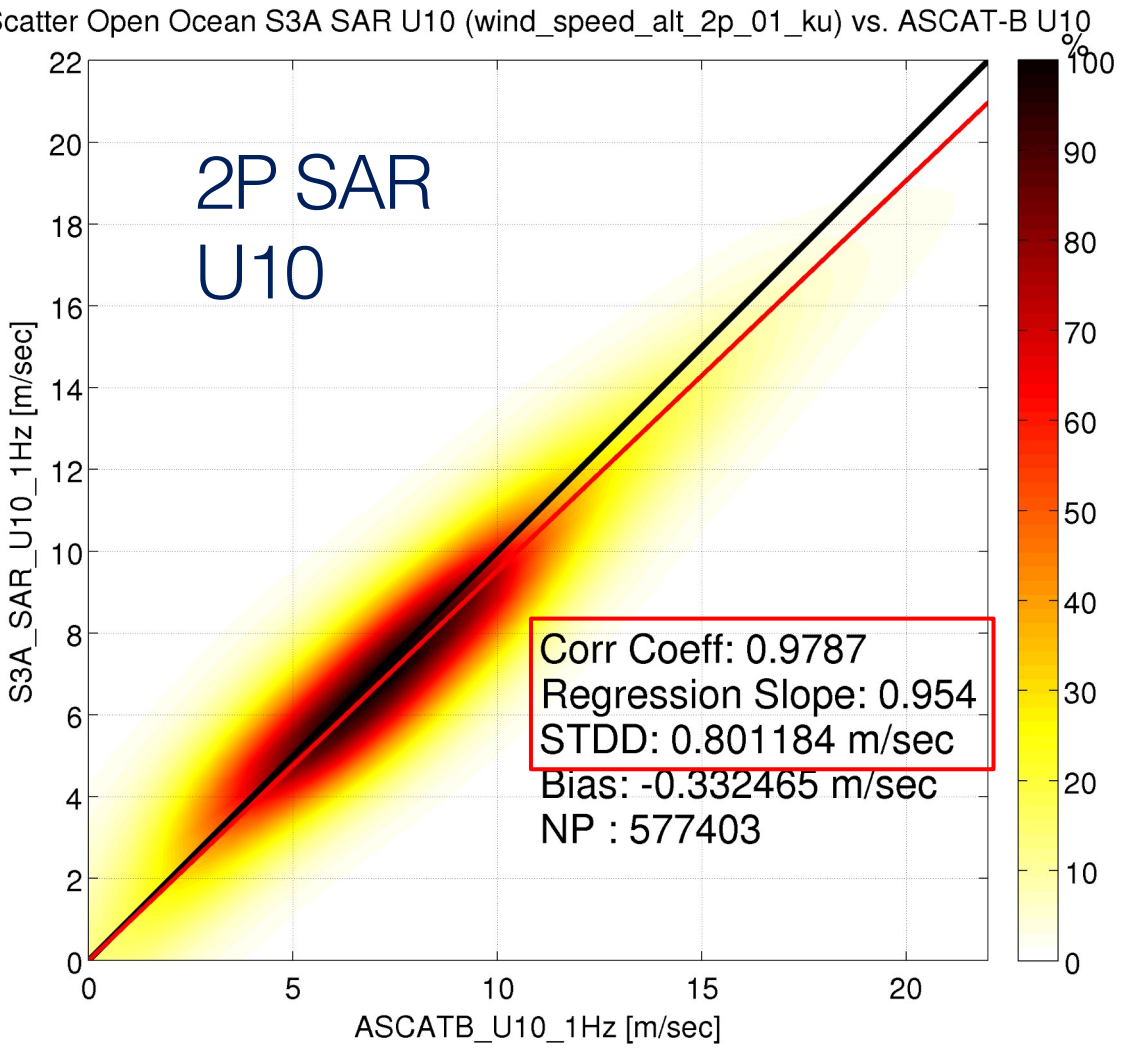
Visual Check of the Agreement between ASCAT and SRAL



S3A SRAL wind speed framed in black on ASCAT-B background

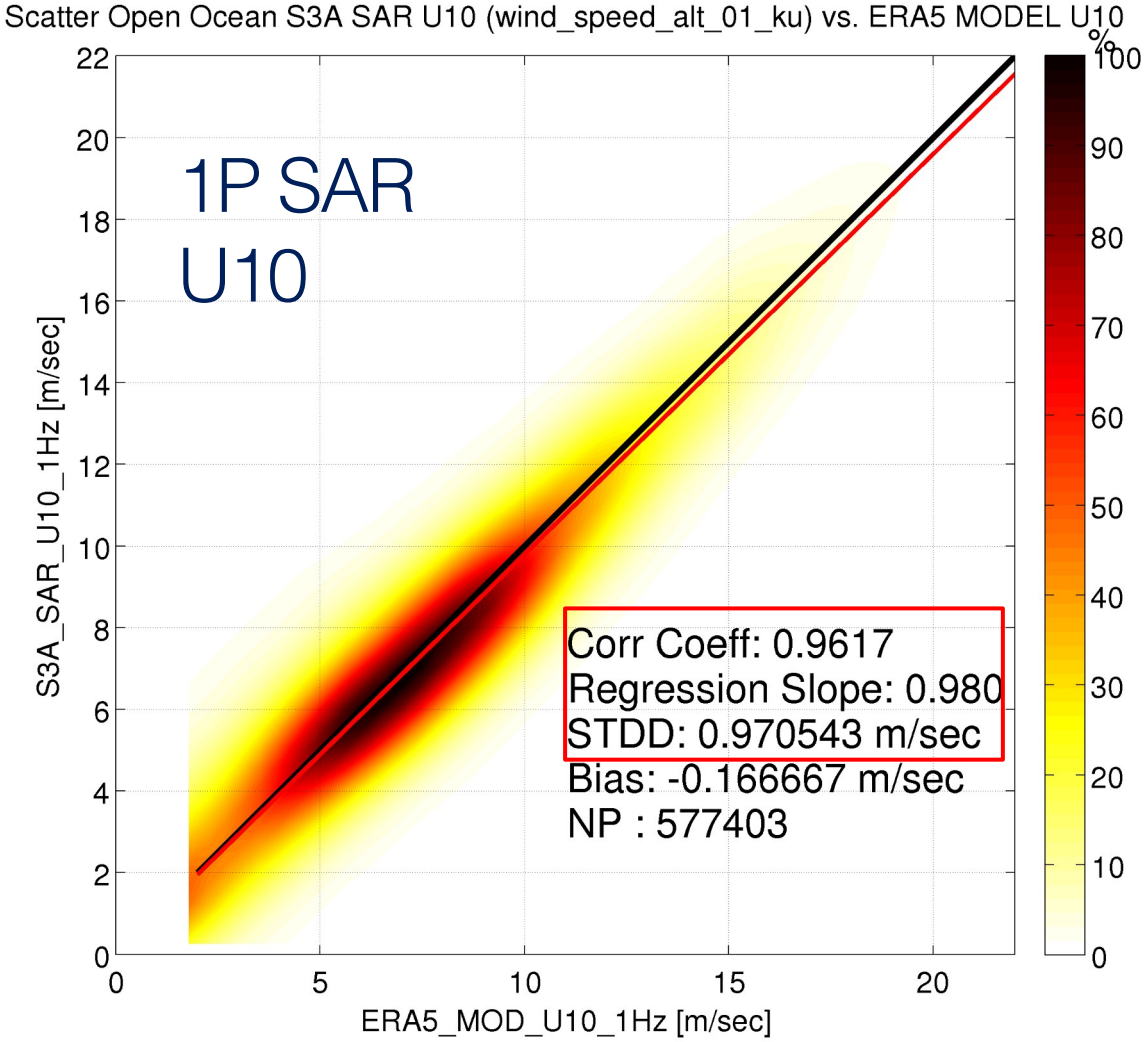
SCATTERPLOT: SAR U10 vs ASCAT-B I S3A CYCLE #70

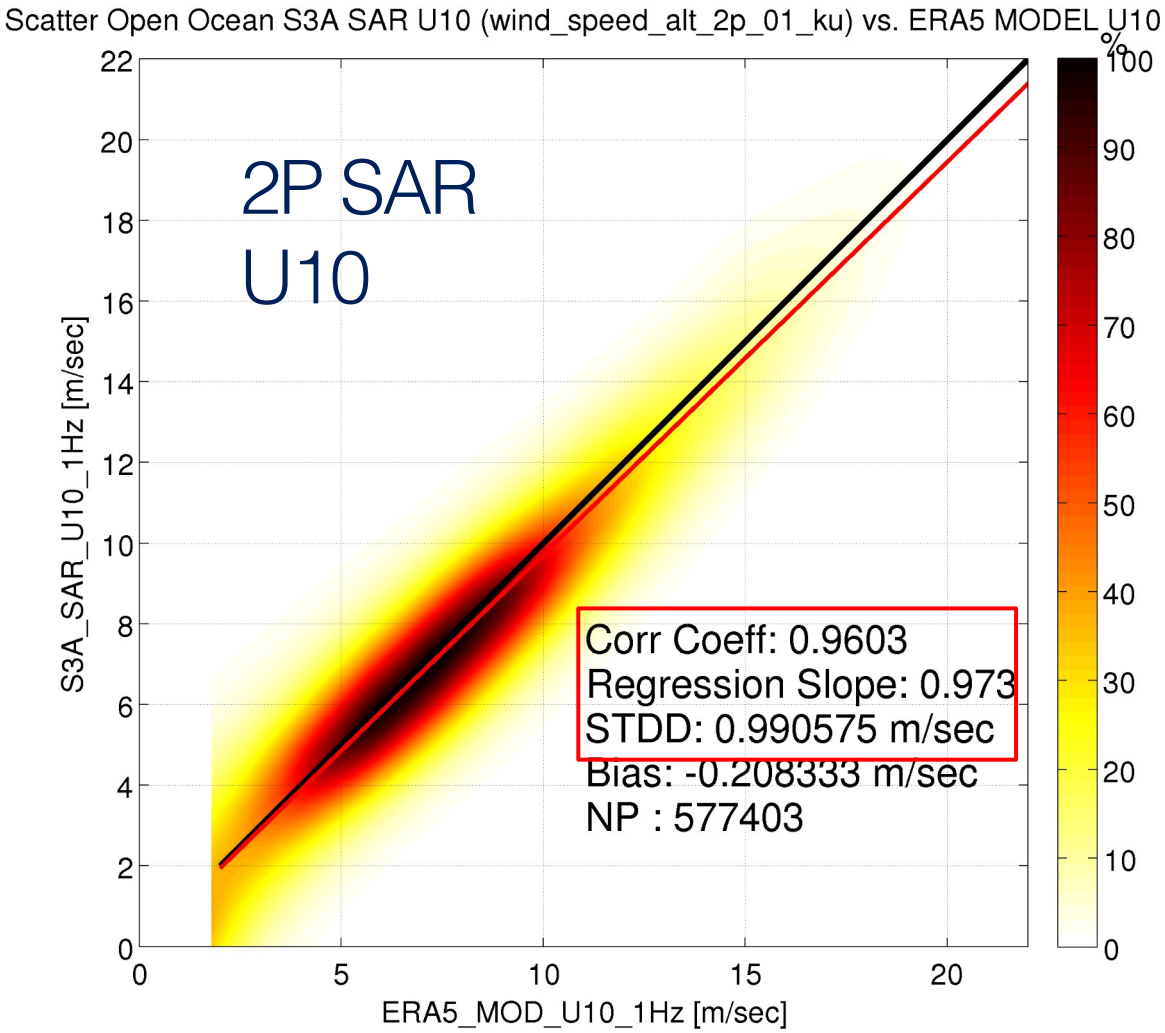




- Left Scatterplot S3A SAR U10 (1P) versus ASCATB at crossovers (S3A cycle #70)
- Right Scatterplot S3A SAR U10 (2P) versus ASCATB at crossovers (S3A cycle #70)

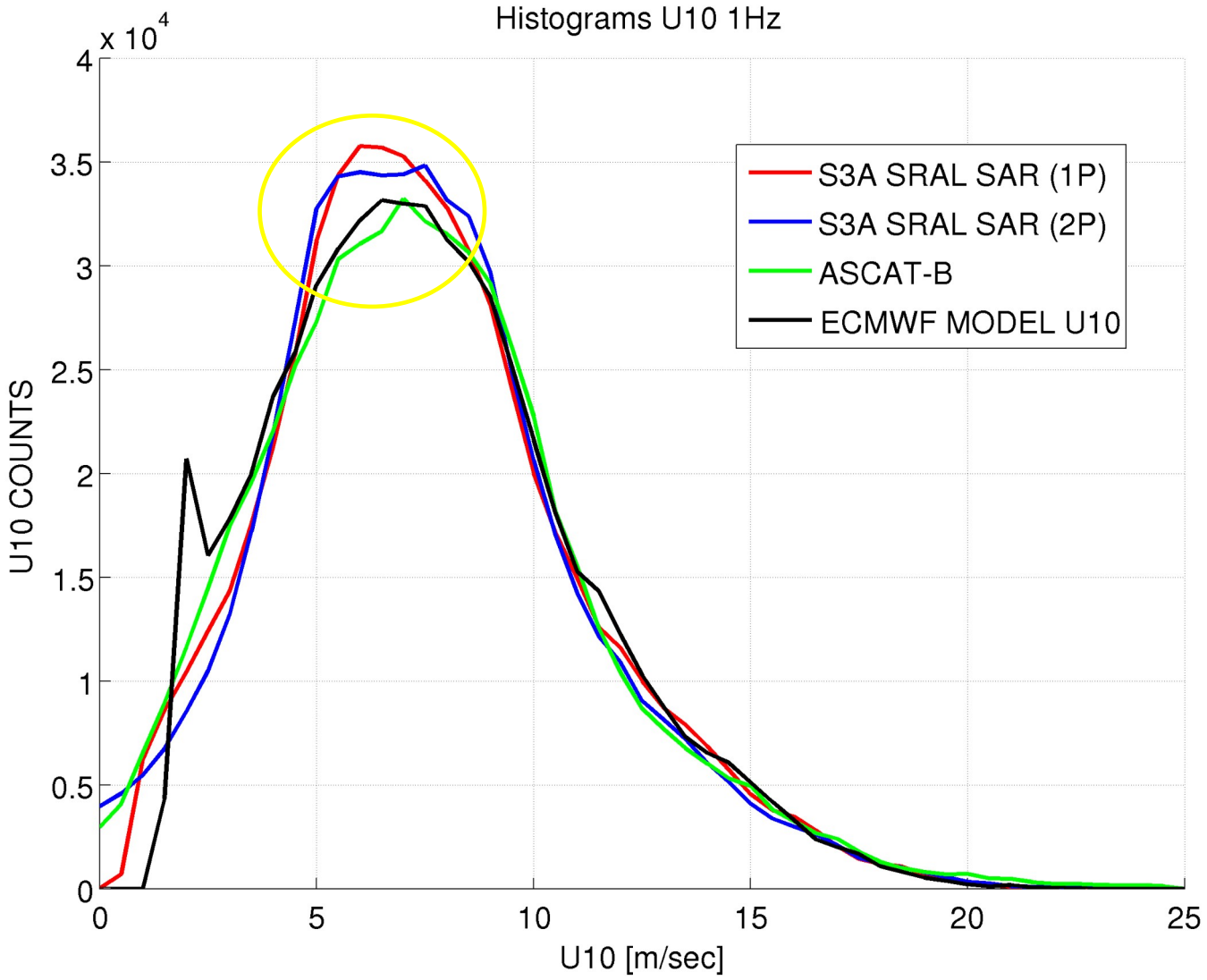
SCATTERPLOT: SAR U10 vs ERA5 I S3A CYCLE #70





- Left Scatterplot S3A SAR U10 (1P) versus ERA5 at crossovers (S3A cycle #70)
- Right Scatterplot S3A SAR U10 (2P) versus ERA5 at crossovers (S3A cycle #70)

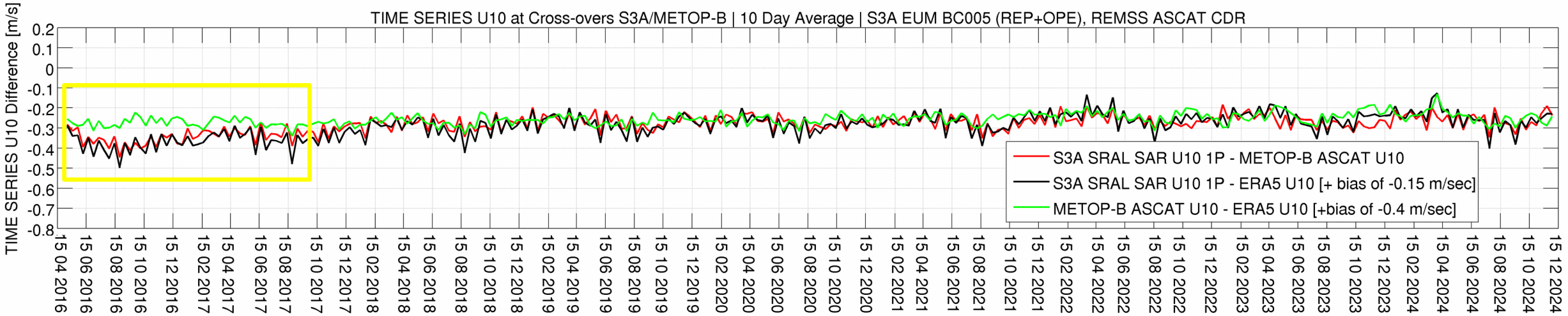
HISTOGRAM I S3A CYCLE #70



- Peak for the pad at 2m/sec for ERA5 histogram
- At low-wind speed, both SRAL (1P) and ASCAT seems to be consistent
- Discrepancy in the distribution between S3A SRAL and ASCAT for wind speed around 5-8 m/sec
- To be understood the root-cause of this …

Time Series of the Wind Speed Mean Difference

- 10-Days mean at cross over between METOP-B ASCAT and S3A SRAL (BC005)



- Red: S3A - ASCAT-B wind speed
- Black: S3A - ERA5 wind speed (+ applied bias of -0.15 m/sec)
- Green: ASCAT-B -ERA5 wind speed (+ applied bias -0.4 m/sec)

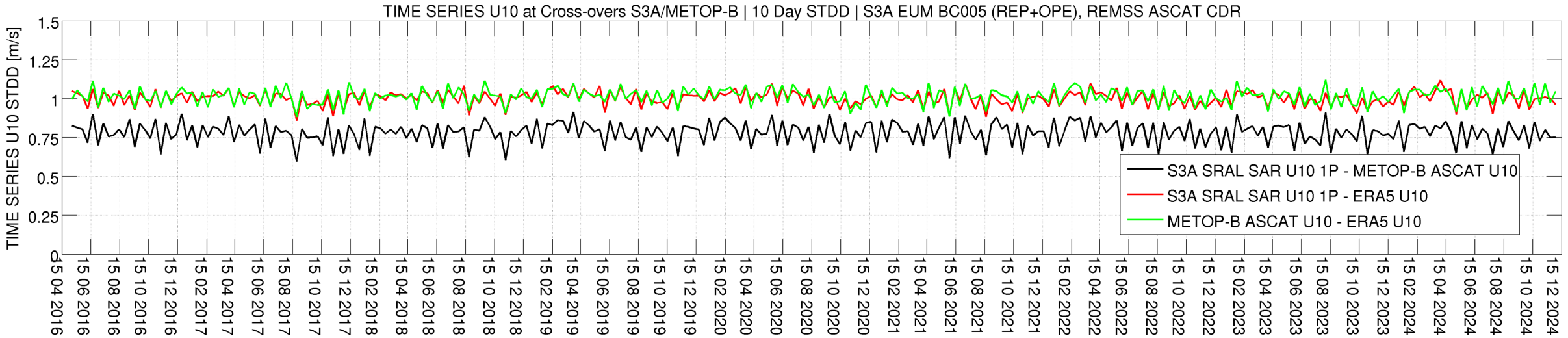
⟶ ASCAT-B wind speed stable wrt ERA5

⟶ SRAL wind speed stable wrt ERA5 and ASCAT **except** in the first and half year of the mission

Sigma0 Instability (around 0.05 dB) in the first and half year is linked to an instrumental behaviour and is expected to be corrected in BC006 improving S3 SRAL calibration

Time Series of the Wind Speed STD Difference (STDD)

- 10-Days std at cross over between METOP-B ASCAT and S3A SRAL (BC005)

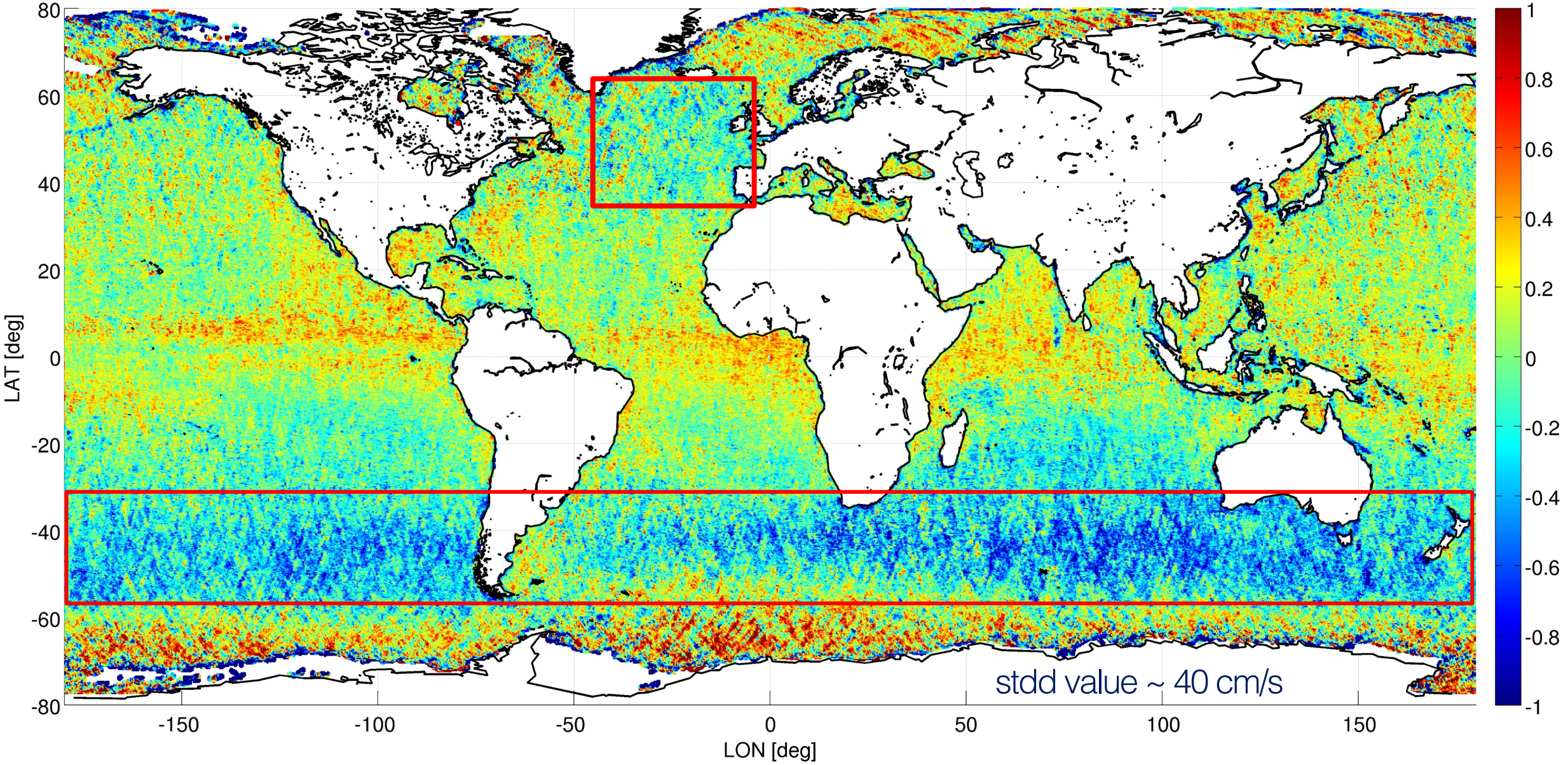


- Red: S3A - ASCAT-B wind speed case
- Black: S3A - ERA5 wind speed case
- Green: ASCAT-B -ERA5 wind speed case

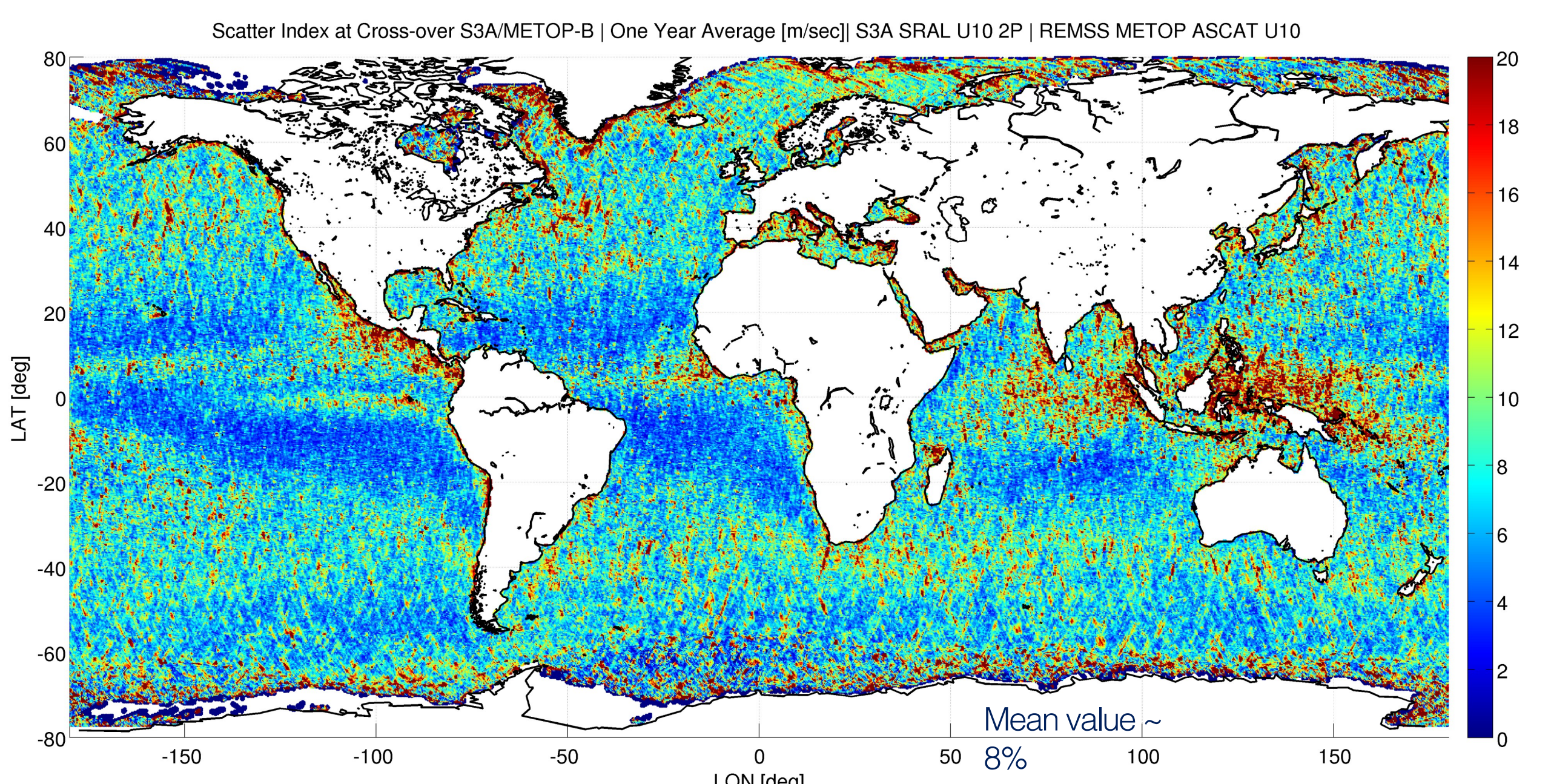
→ ASCAT-B - ERA5 STDD around **1 m/sec**, stable. Same performance for S3A SRAL (1p and 2p)

→ S3A SRAL - ASCAT-B STDD around **0.8 m/sec,** stable

Mean [m/sec] at Cross-over Map (one year average) I 1P vs. 2P



Scatter Index (%) at Cross-over Map (one year average) T1P vs. 2P



Conclusions

- Excellent consistency between altimetry wind speed and scatterometry wind speed at cross-overs (STDD around 0.8 m/sec, bias around -0.3 m/sec)
- S3A SRAL wind speed at one parameter (sigma0) and at two-parameters (sigma0 and wave-height) present comparable performance wrt scatterometry wind-speed
- S3A SRAL wind speed slight instability in the first year and half of the S3A mission, caused by a strong and fast instrumental aging (to be solved in the BC006 under preparation and planned to deployed operationally prior end of the year)
- In the EUM RSP altimetry team, we are studying to understand how to use scatterometry data as independent observation dataset to validate altimetry wind speed on a routine base
- Scatterometry data might be used in future to develop better 2p wind speed model for Ku-Band altimetry (in the framework of the EUMETSAT COPAS service, link)

Thank you!

Questions are welcome.

BACKUP SLIDES

References:

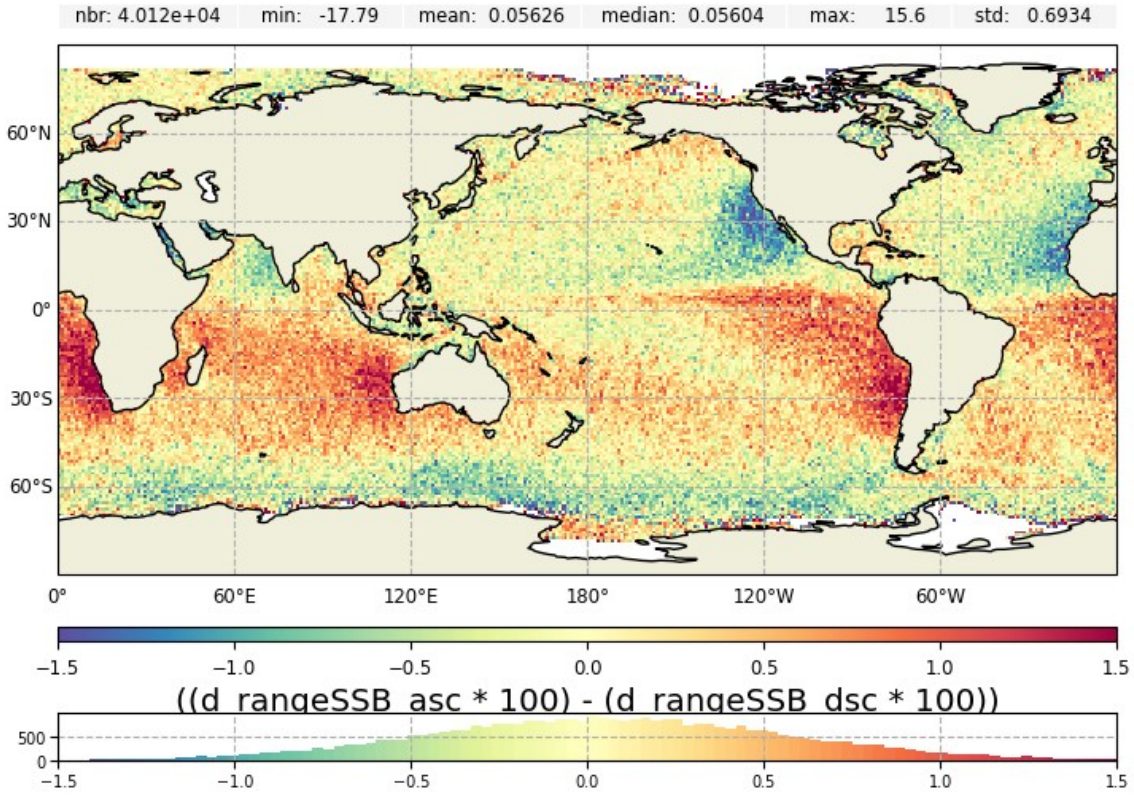
- Abdalla, S. (2012): *Ku-Band Radar Altimeter Surface Wind Speed Algorithm*. Marine Geodesy, 35(sup1), 276–298. https://doi.org/10.1080/01490419.2012.718676
- Gourrion, J. & Vandemark, D.C. & Bailey, S. & Chapron, B. & Gommenginger, G. & Challenor, Peter and Srokosz, Meric. (2002): *A Two-Parameter Wind Speed Algorithm for Ku-Band Altimeters*. Journal of Atmospheric and Oceanic Technology - J ATMOS OCEAN TECHNOL. 19. 2030-2048. 10.1175/1520-0426(2002)019<2030:ATPWSA>2.0.CO;2.

Directionality of the wind effect on SAR Range

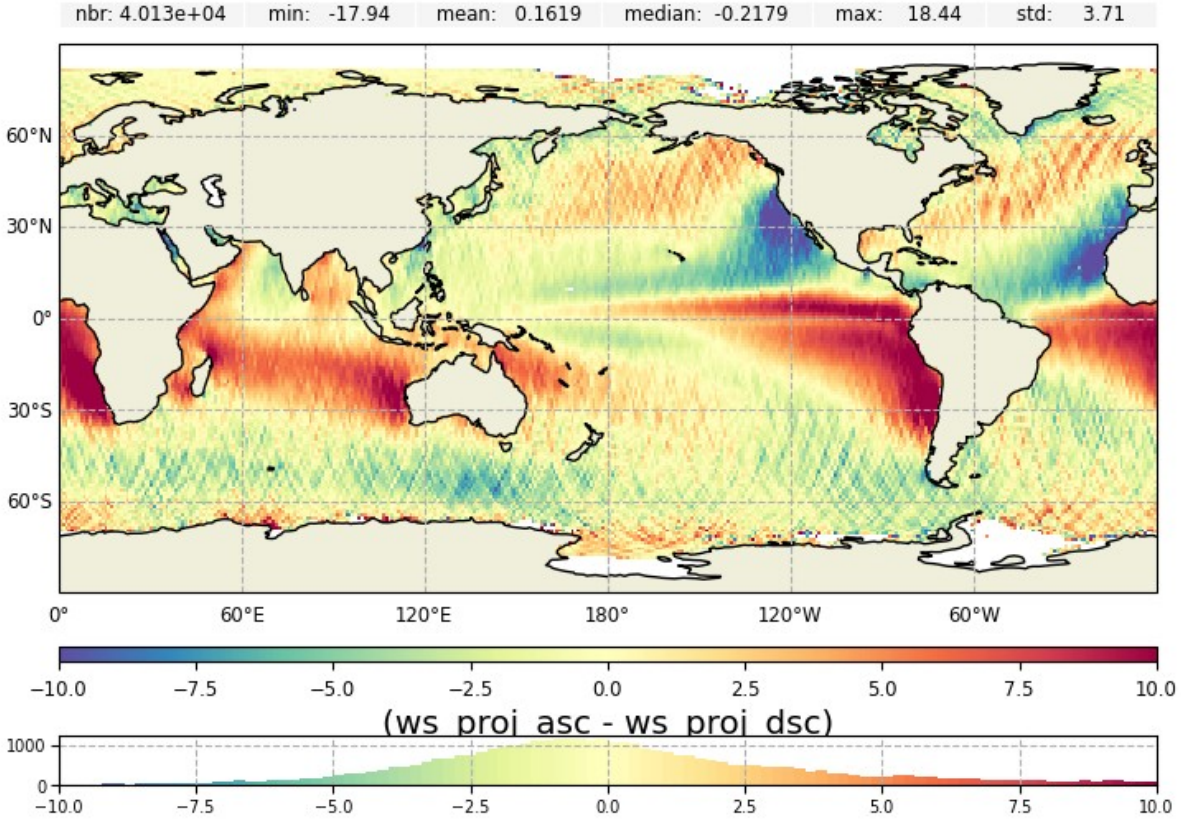
SARM - PLRM asc - dsc Range (BC005)

- Clear correlation between SAR- PLRM asc-dsc range difference with along-track wind projection
- Range bias (up to ±2 cm) present in SAR mode (driven by the SAR focusing process)
- Pictures from COPAS SSB study (link) by CLS (Ngan Tran)

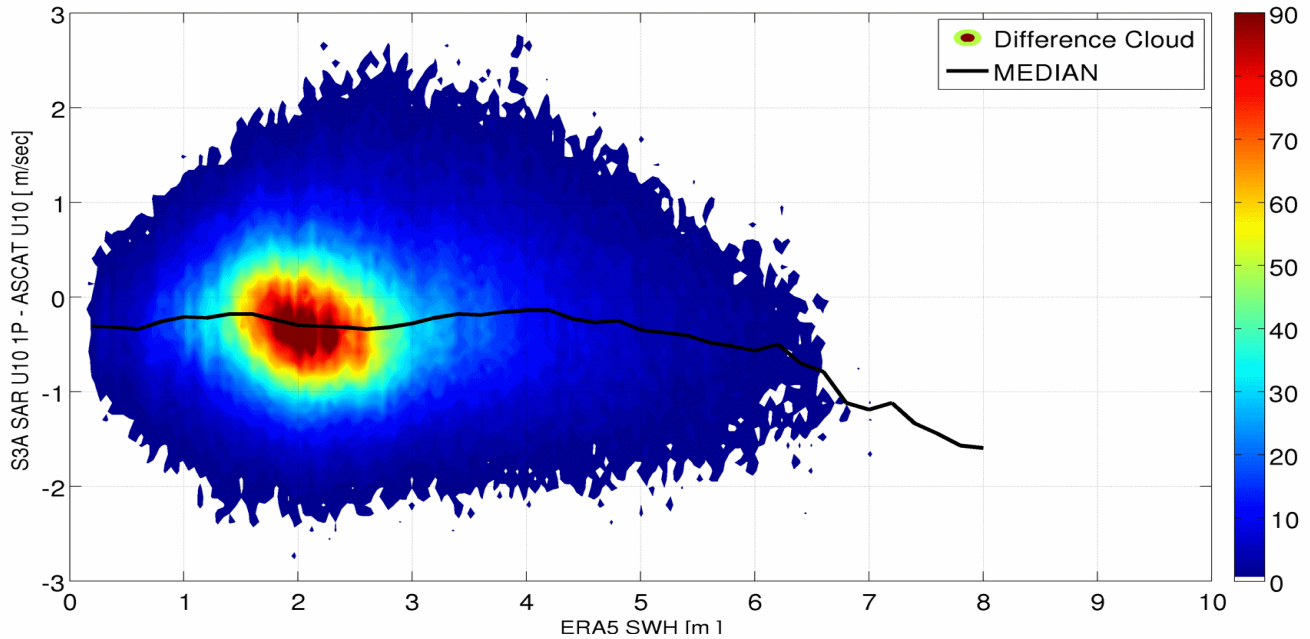
S3A - SARM/PLRM (range+SSB) differences, (ASC-DSC) maps (MEAN in cm)
Cycles 59 to 86



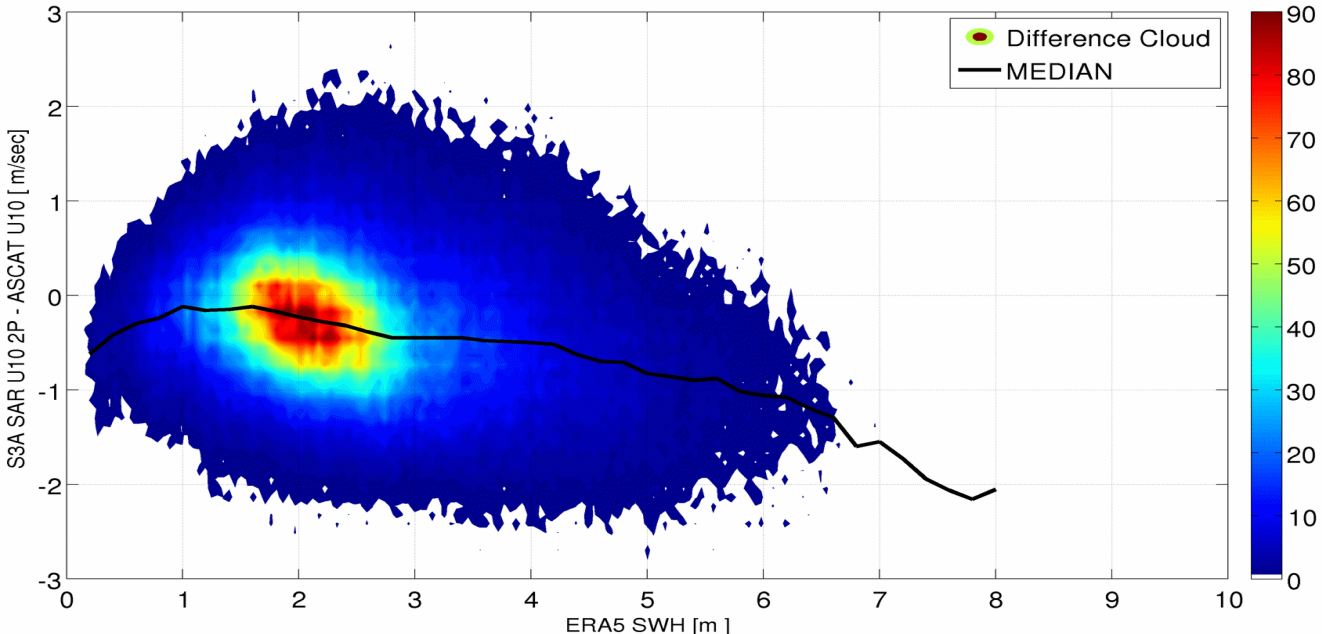
S3A - Along-track Wind projection, (ASC-DSC) maps (MEAN in m/s)
Cycles 59 to 86



Dependency Plot: Diff U10 ALT- ASCAT vs. ERA5 SWH



❑ 1P Case



❑ 2P Case

Wind Speed dependency on "wave age" (wave development stage)

From Saleh Abdallah, 2012 paper (link) :

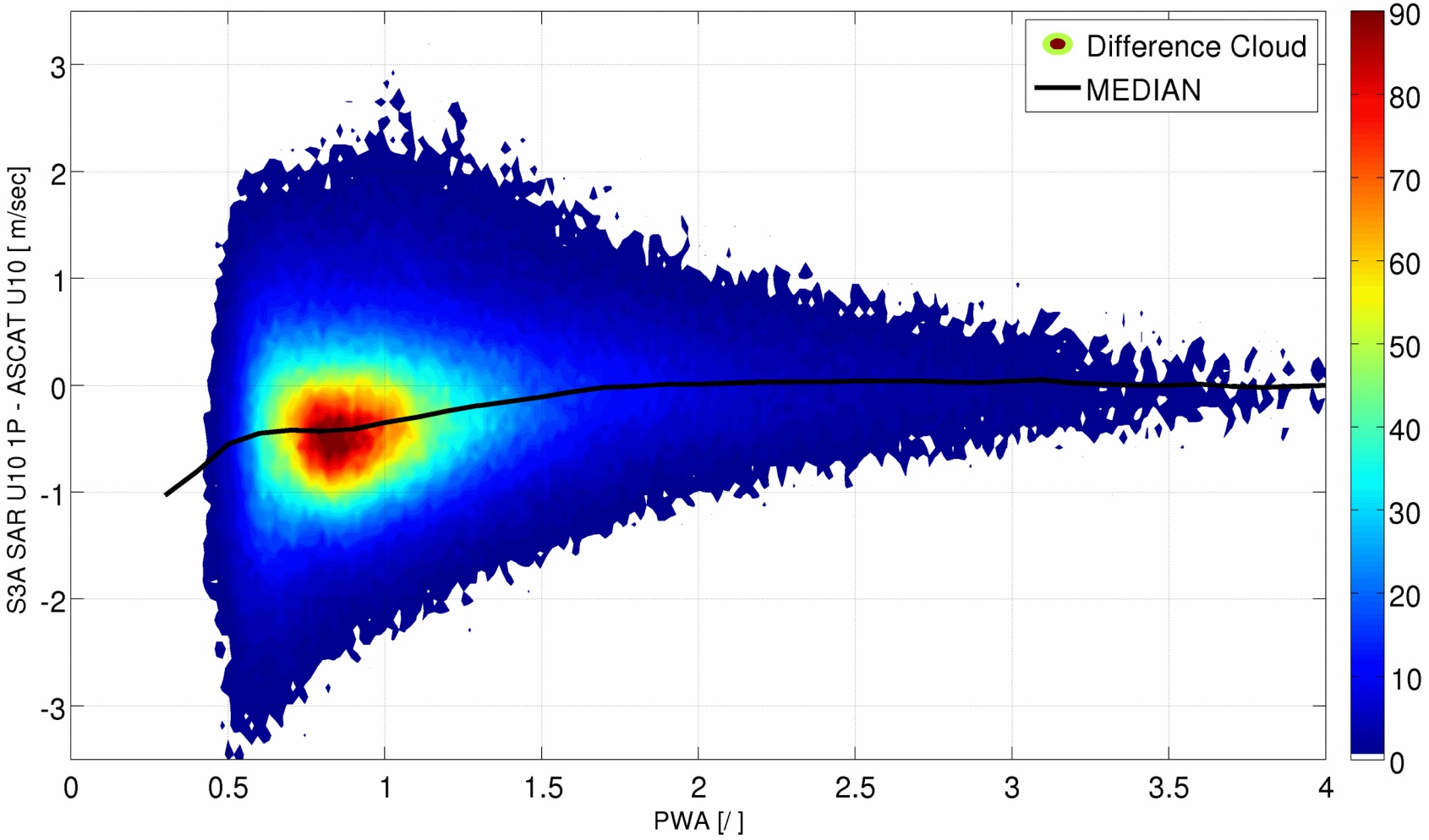
There is consensus that altimeter wind speed retrieval depends on the sea state besides the backscatter. The sea state may be better described using wave steepness or wave age.

Pseudo-wave age corresponding to T_{02} (mean wave period) is a proxy for wave age, given by:

$$PWA(T_{02}) = \frac{c(T_{02})}{U_{10}} = \frac{g \cdot T_{02}}{2\pi \cdot U_{10}} = \frac{2\pi \cdot g}{2\pi \cdot U_{10}} \sqrt{\frac{m_0}{m_2}} = \frac{2\pi \cdot g \cdot SWH}{8\pi \cdot U_{10} \cdot \sigma_v} \approx \boldsymbol{f(SWH, U_{10})}$$

- **Low PWA -> young sea (rough, steep, skewed)**
- **High PWA -> mature (or developed) sea (gaussian, more regular)**

Dependency Plot: Diff S3A SAR 1P U10- ASCAT vs. P-Wave-Age



Dependency Plot: Diff S3A SAR 1P U10- ASCAT vs. Wave-Period

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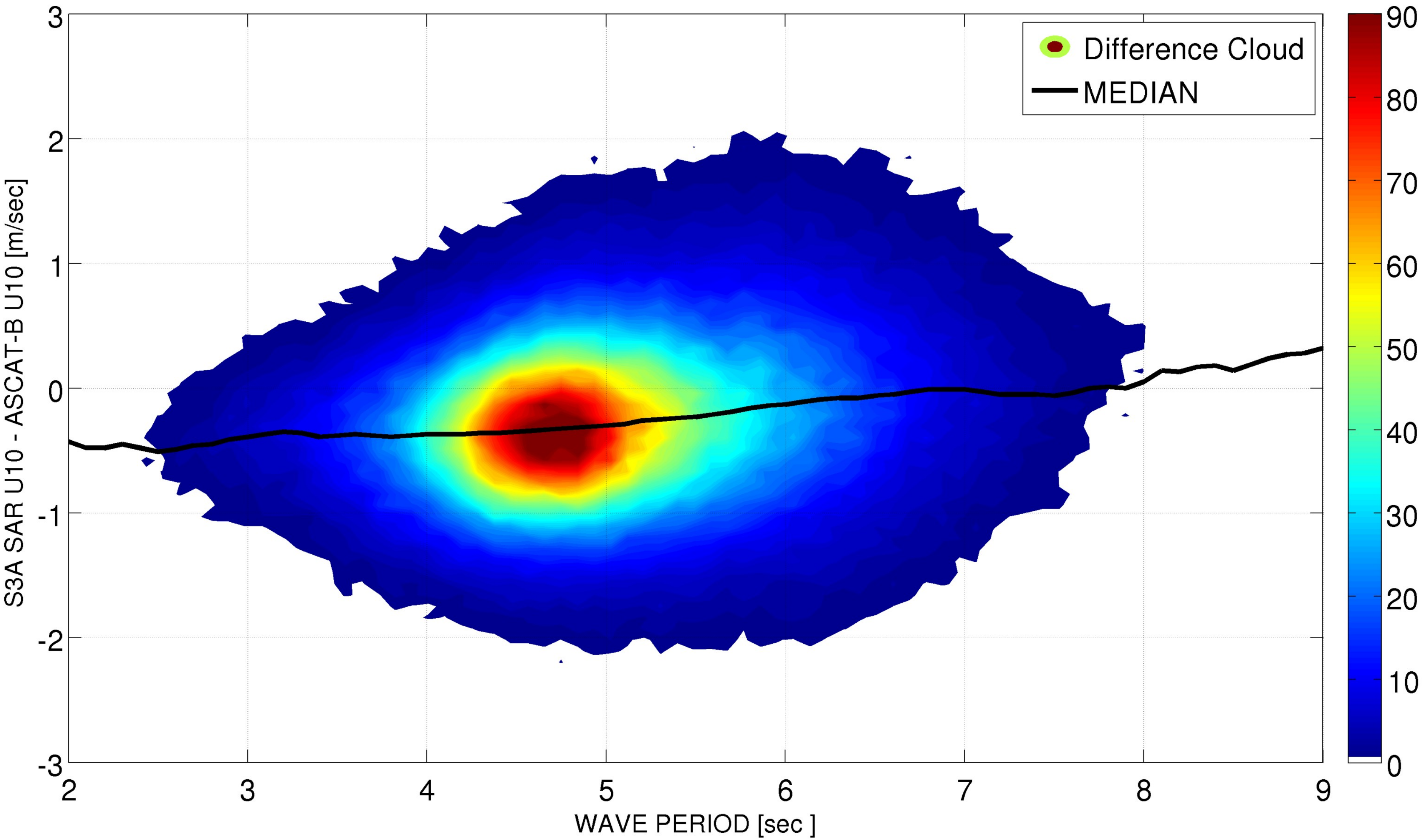
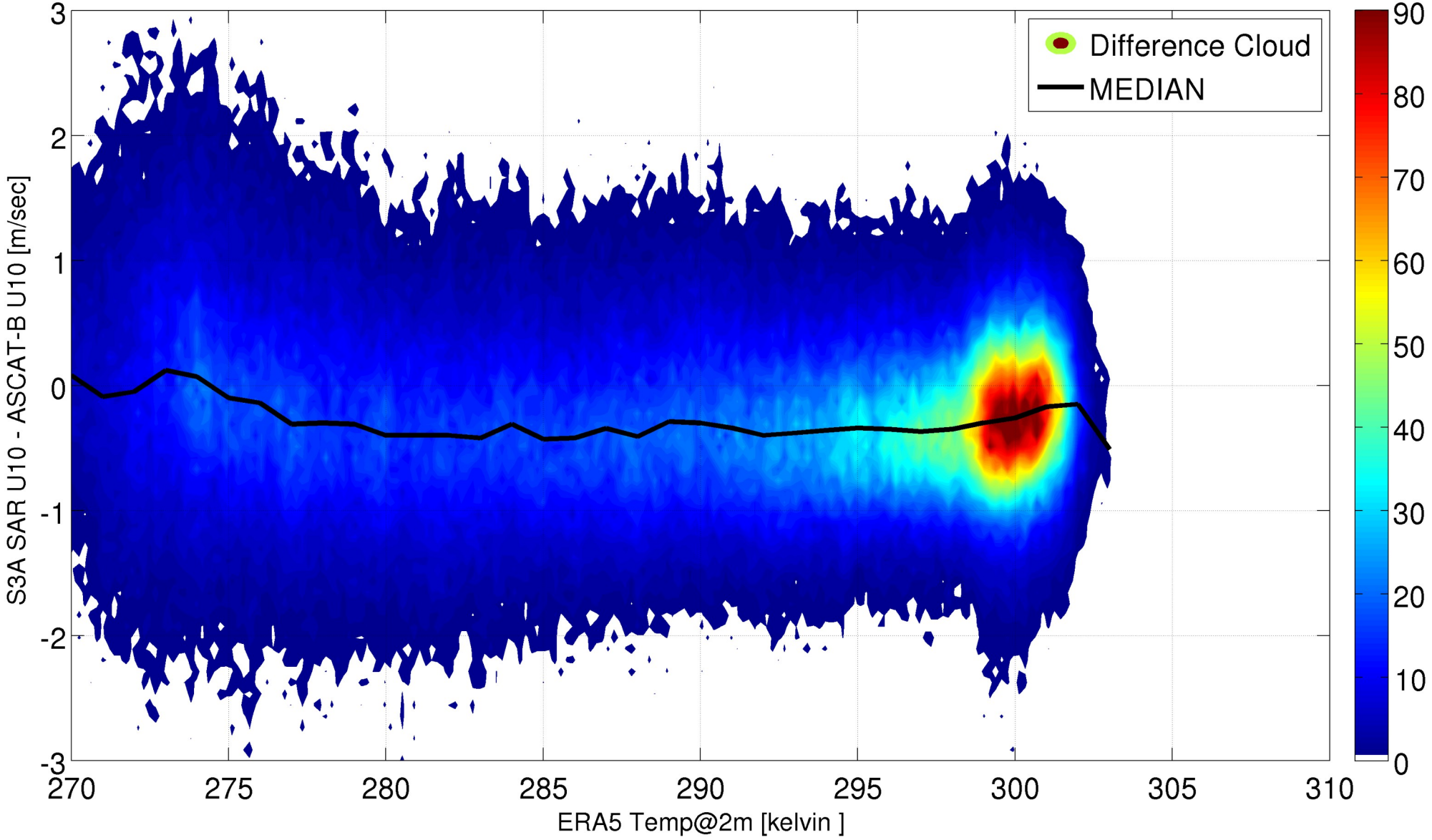
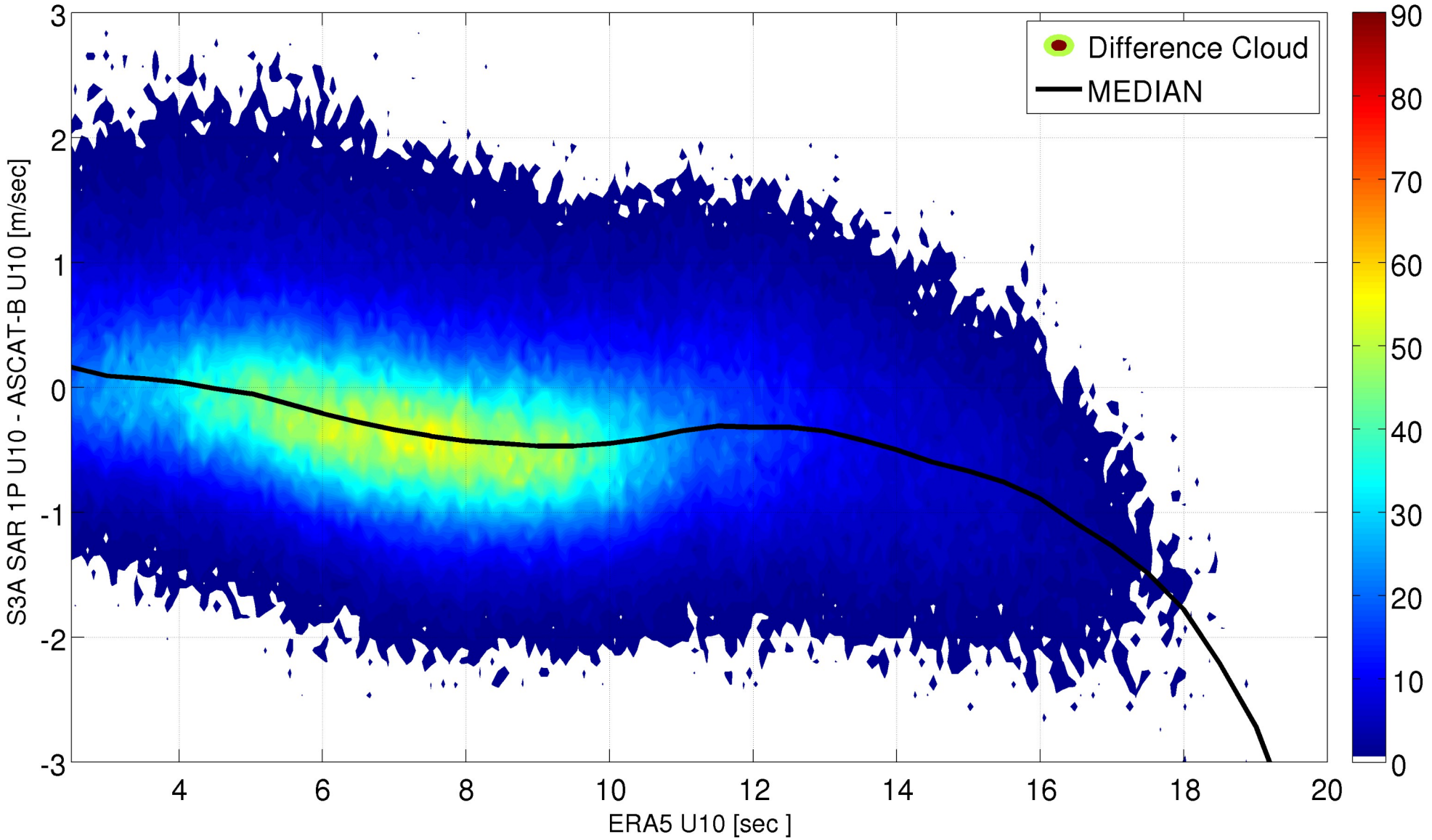


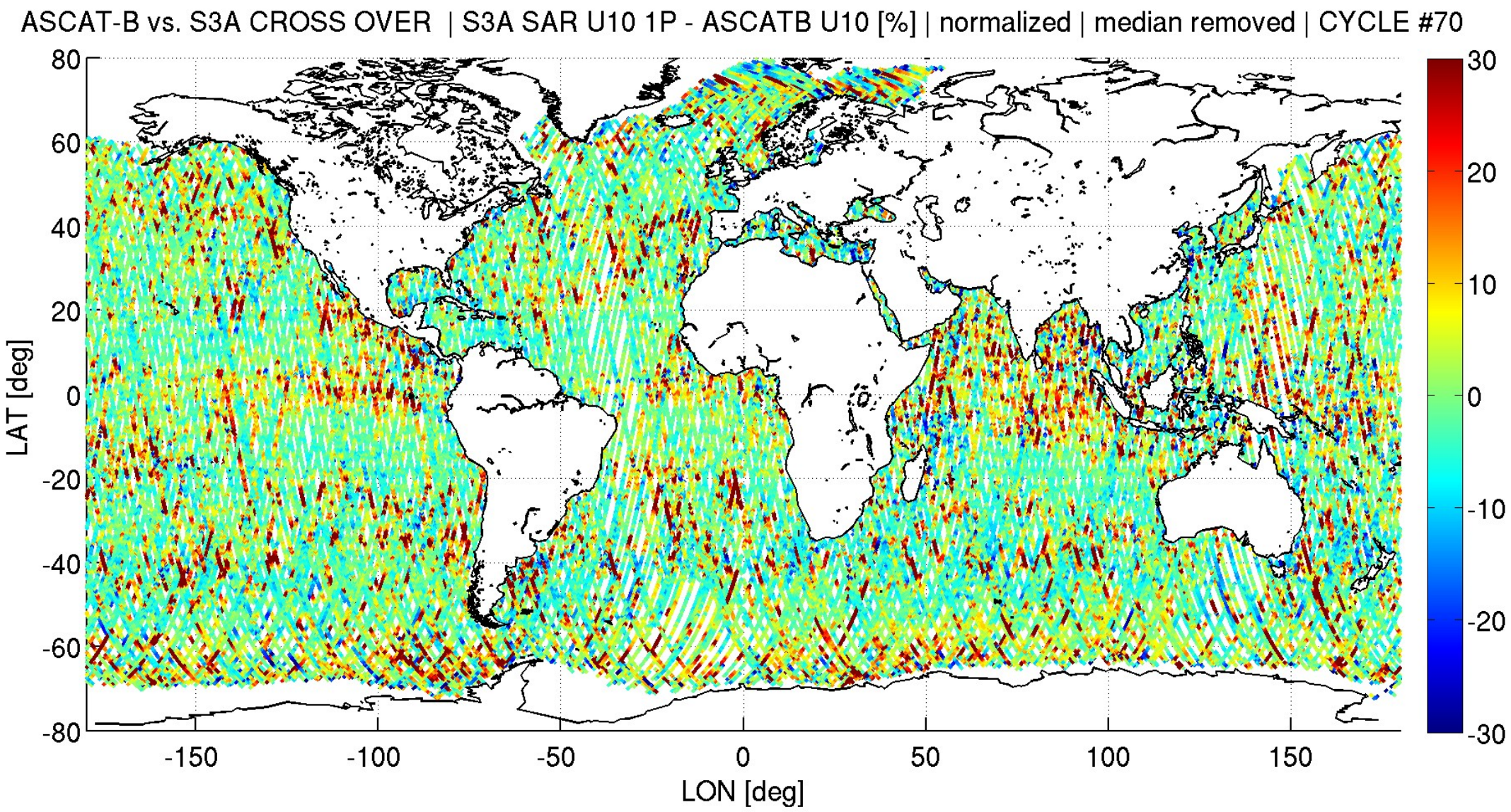
Sea Surface Temperature Effect



S3A SAR 1P U10 minus ASCAT U10 vs ERA5 U10



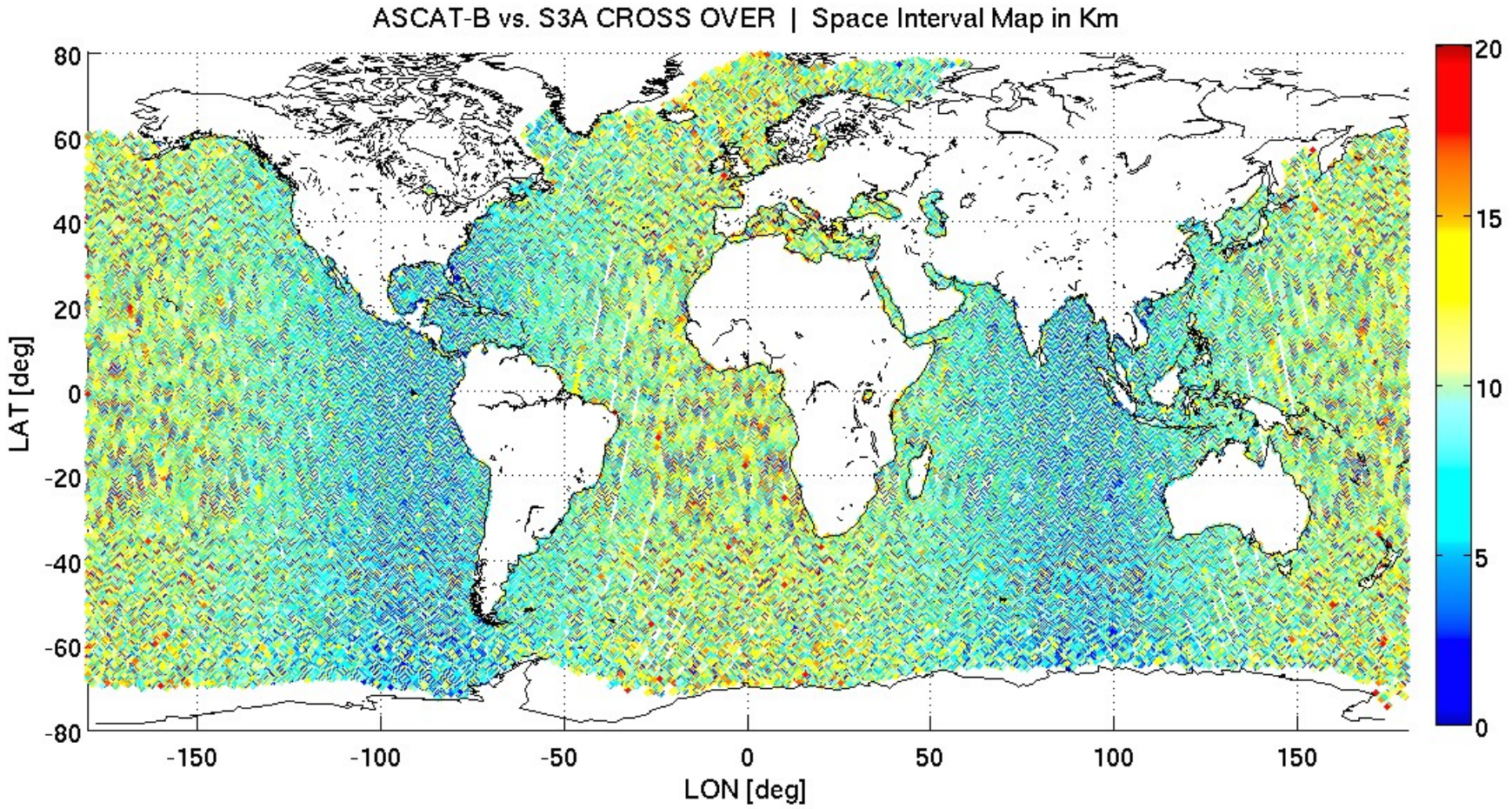
Effect on SWELL on S3A U10 minus ASCAT U10 ?



ASCAT (A/B/C) Wind Products

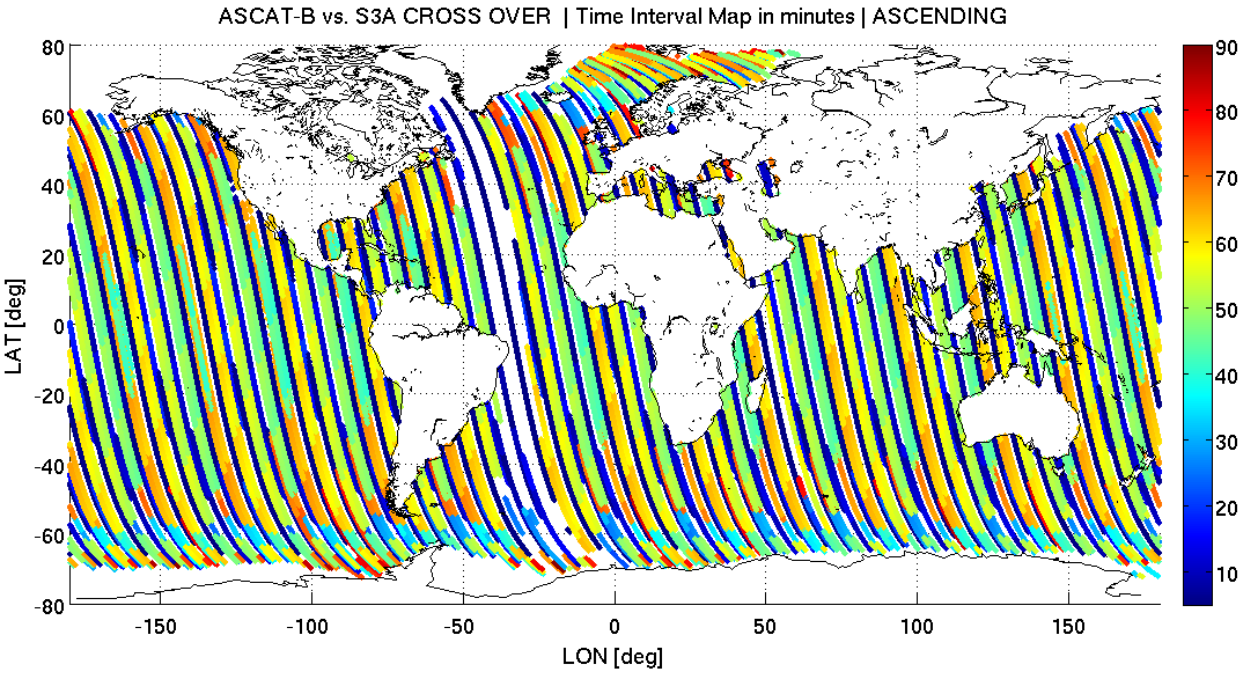
- OSISAF Data Products (link)
  - NRT wind vector "swath-like" products at different fixed grid size (25 km/ 12.5 km/5.7 km), latency 3 H
  - CLIMATE (Reprocessed) ASCAT-A (2007→ 2014) at 25 km/12.5 km,
  - Built as from EUMETSAT L1B data products (recalibrated sigma0) and using OSISAF internal wind model (CMOD7 GMF)
- RSS (Remote Sensing Systems), link :
  - CLIMATE (v2.1) ByteMap, wind-vector daily products (split in Asc/Dsc), gridded [0.25 x 0.25 deg] + Rain Flag + Misfit (SoS), pole-2-pole, 2 week latency, (doi), 0.2 m/s granularity
  - ORBIT "swath-like" products, one-orbit long
  - Built as from EUMETSAT L1B 12.5 km data products (recalibrated sigma0) and using RSS internal wind model (C-2015 GMF) computed exploiting $|120\ \text{min}|_{\text{max}}$ crossovers between ASCAT and TMI/GMI radiometers (non-SSO on low-inclination orbit → drifting orbits)

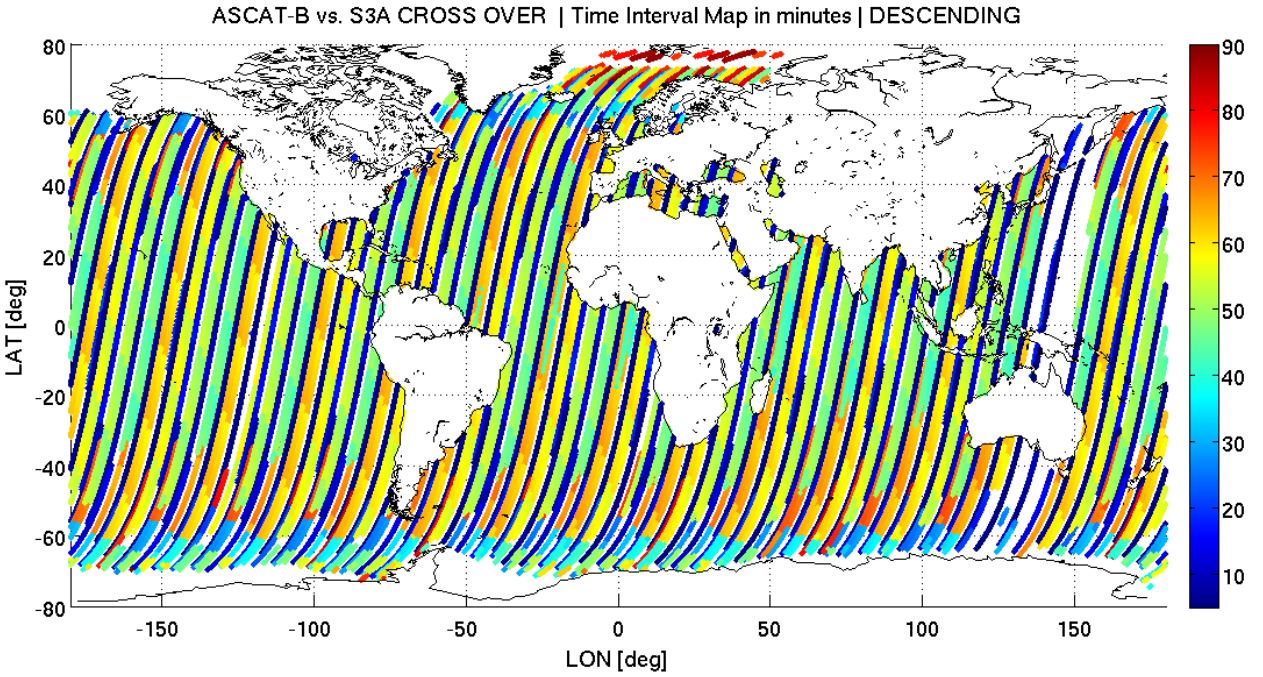
Cross-Over between S3A and METOP-B (S3A cycle #70)



- Space interval at cross-overs between ASCAT-B and S3A
- Max spatial distance 25 km (size of the ASCAT pixel)
- Cross-overs covering all globe

Cross-Over between S3A and METOP-B (S3A cycle #70)





- Map of Time Lag in minutes (split in ASC & DSC direction) at cross-overs
- Cross-overs covering all globe
- For some tracks, METOP-B and S3A flies along same long-transect in a short time interval (~30 min)