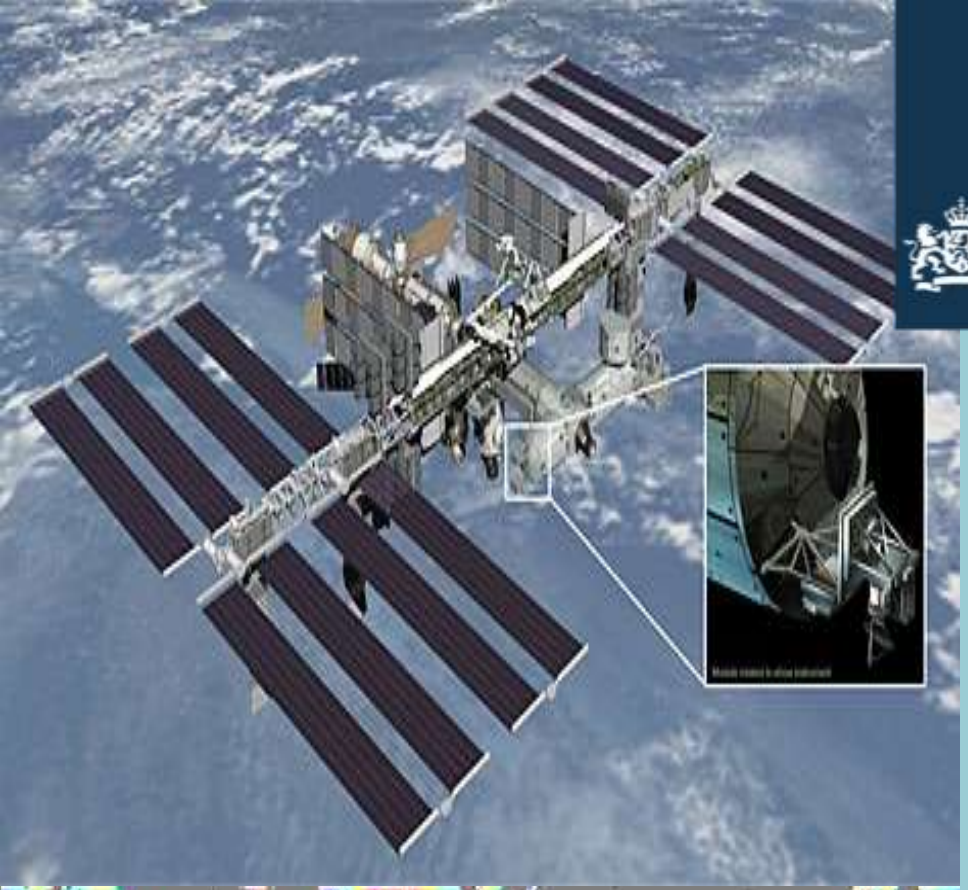
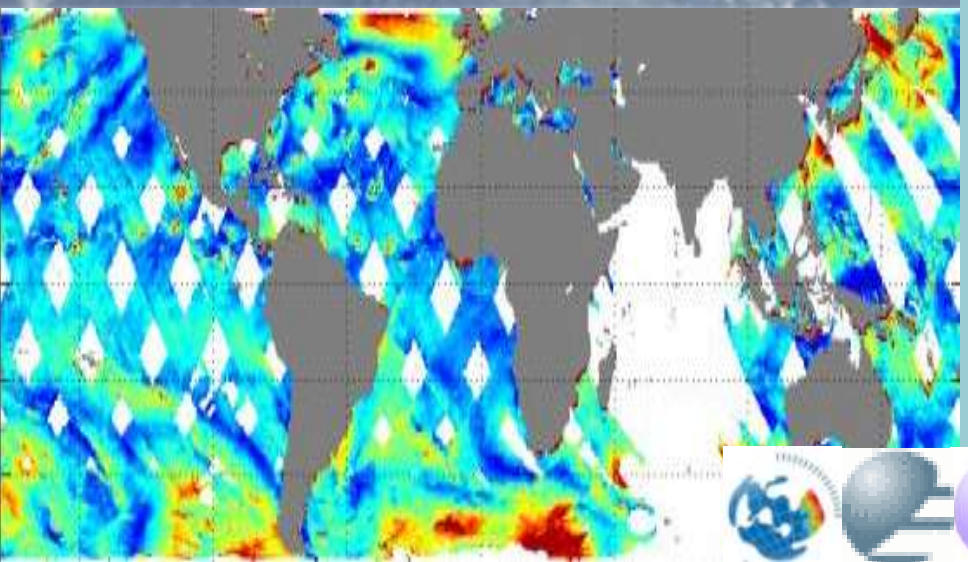




Royal Netherlands
Meteorological Institute
Ministry of Infrastructure and the Environment

RapidScat on the International Space Station ISS

Ad Stoffelen

Manager OSI SAF winds
Manager NWP SAF winds
Manager EU CMEMS satellite winds

Overview

- Scatterometer missions and orbits
- The special ISS orbit
- RapidScat and ASCAT collocation
- Geophyisical Model Function (GMF)
- Rain effects
- Quality Control
- Summary and questions

Committee on Earth Observation Satellites

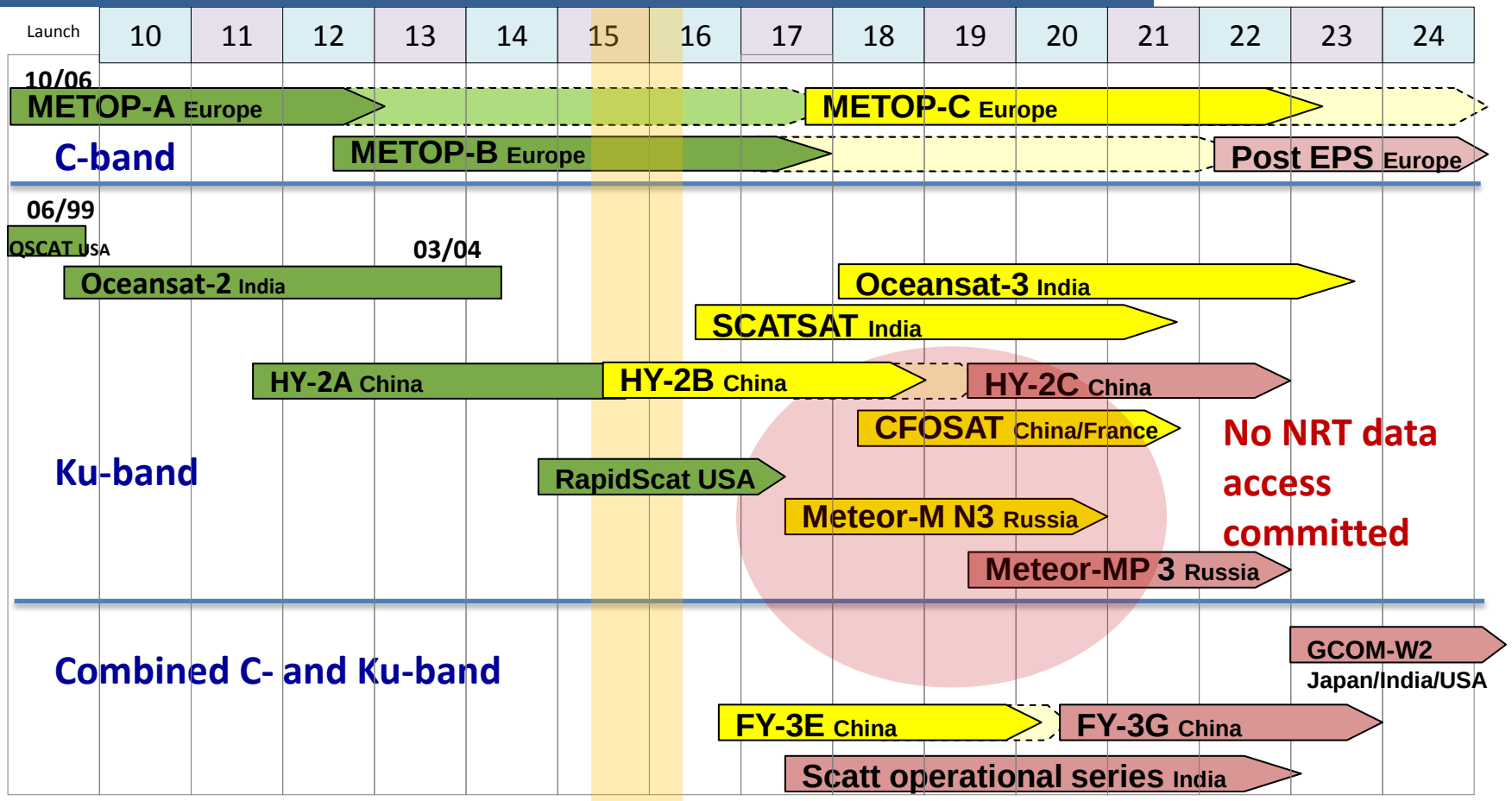
The Ocean Surface Vector Wind Constellation: Status, Health and Future?

CEOS OSVW-Virtual Constellation

Paul Chang (NOAA), Julia Figa Saldana (EUMETSAT) and B.S. Gohil (ISRO)

https://coaps.fsu.edu/scatterometry/meeting/docs/2015/ProgrammaticTalks/PCHANG_IOWVST_OSVW-VC.pdf

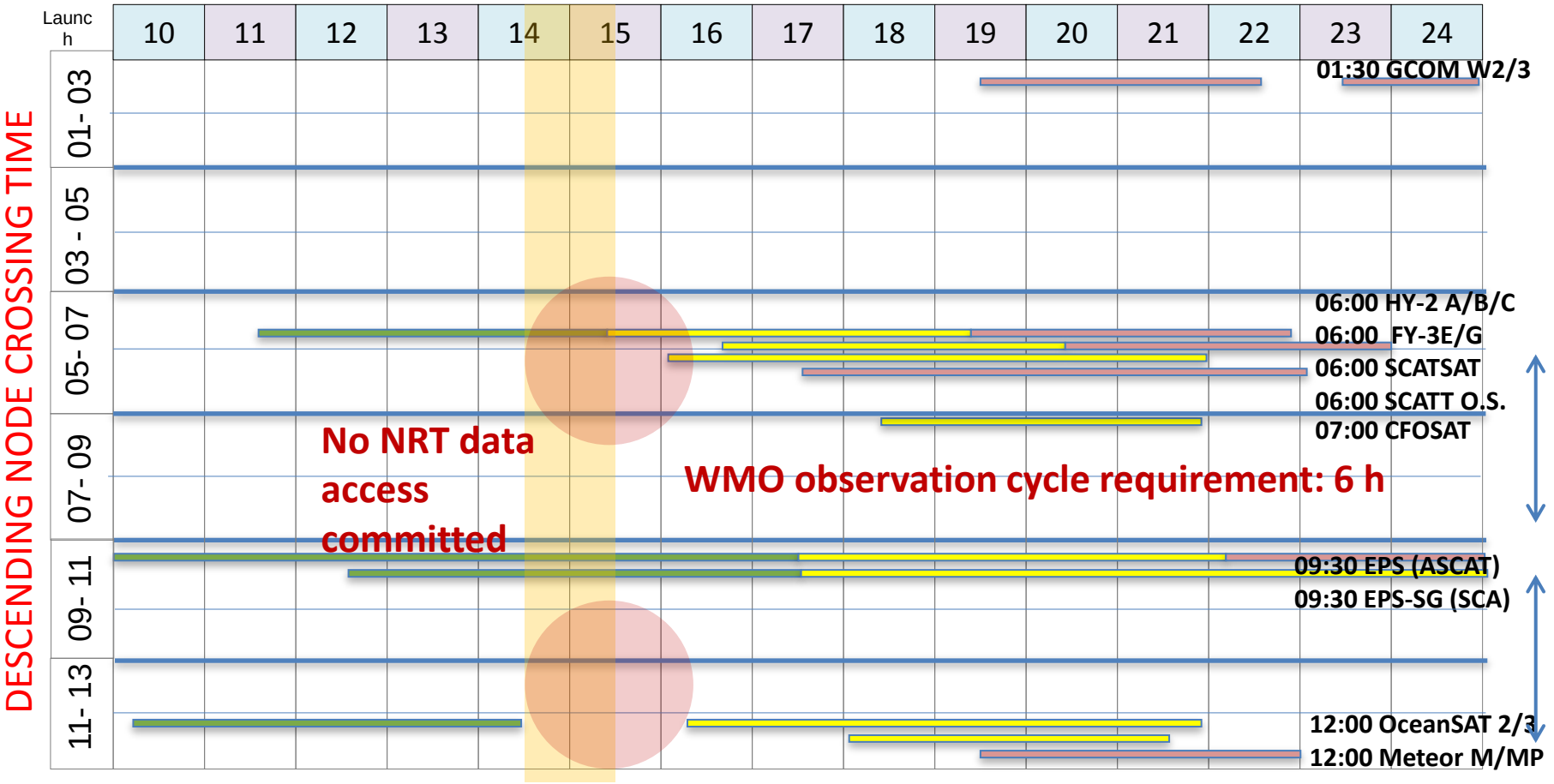
Ocean Vector Surface Winds Constellation
Current status and Outlook – NRT data access



Source: WMO OSCAR database and direct interactions with agencies

CEOS
Committee on Earth Observation Satellites

Ocean Vector Surface Winds Constellation
Local time coverage assessment (ground track) - NRT data access

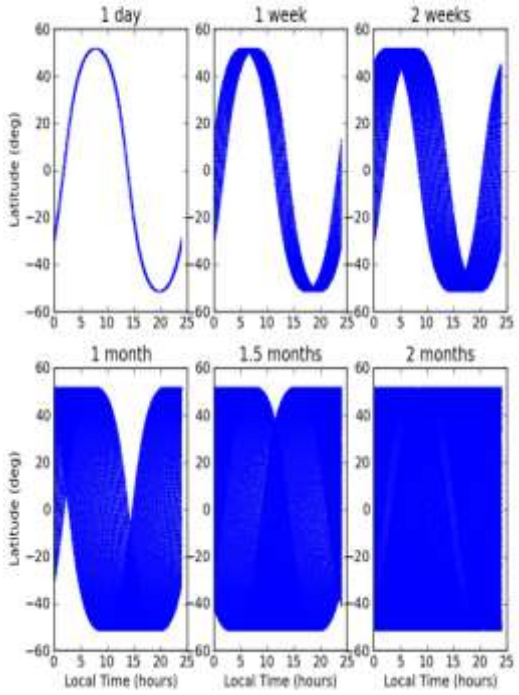


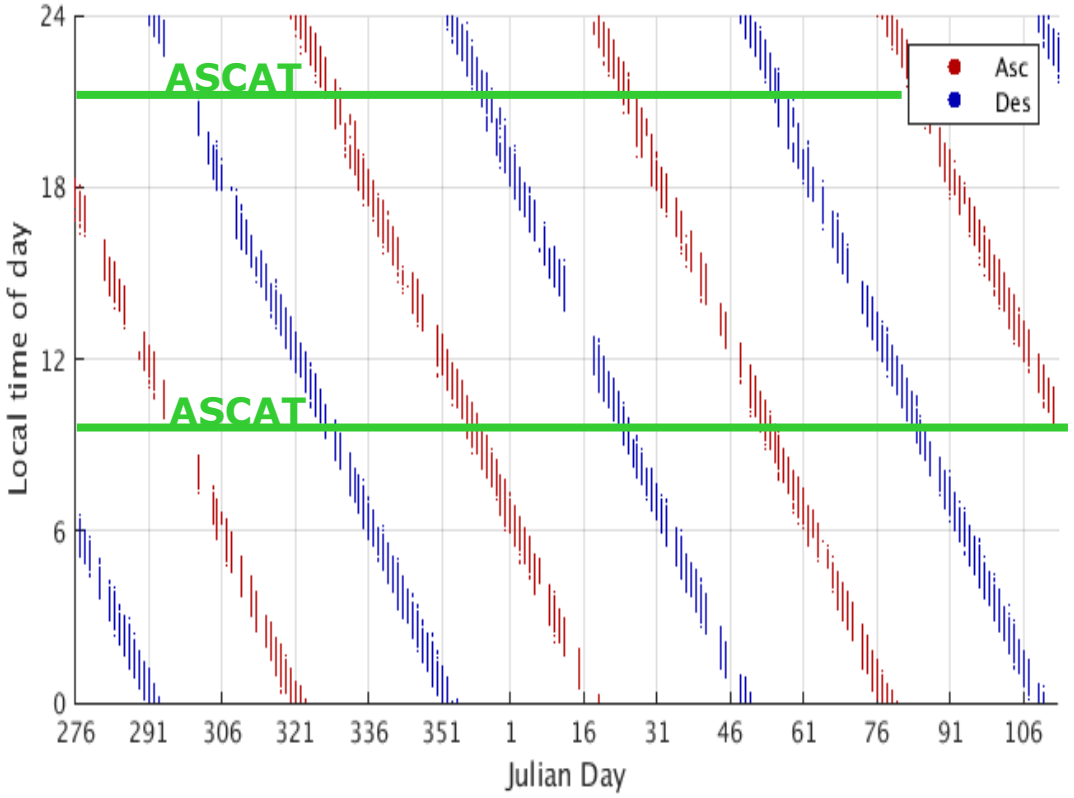
Source: WMO OSCAR database and direct interactions with agencies

Committee on Earth Observation Satellites

RapidSCAT - Diurnal Capability

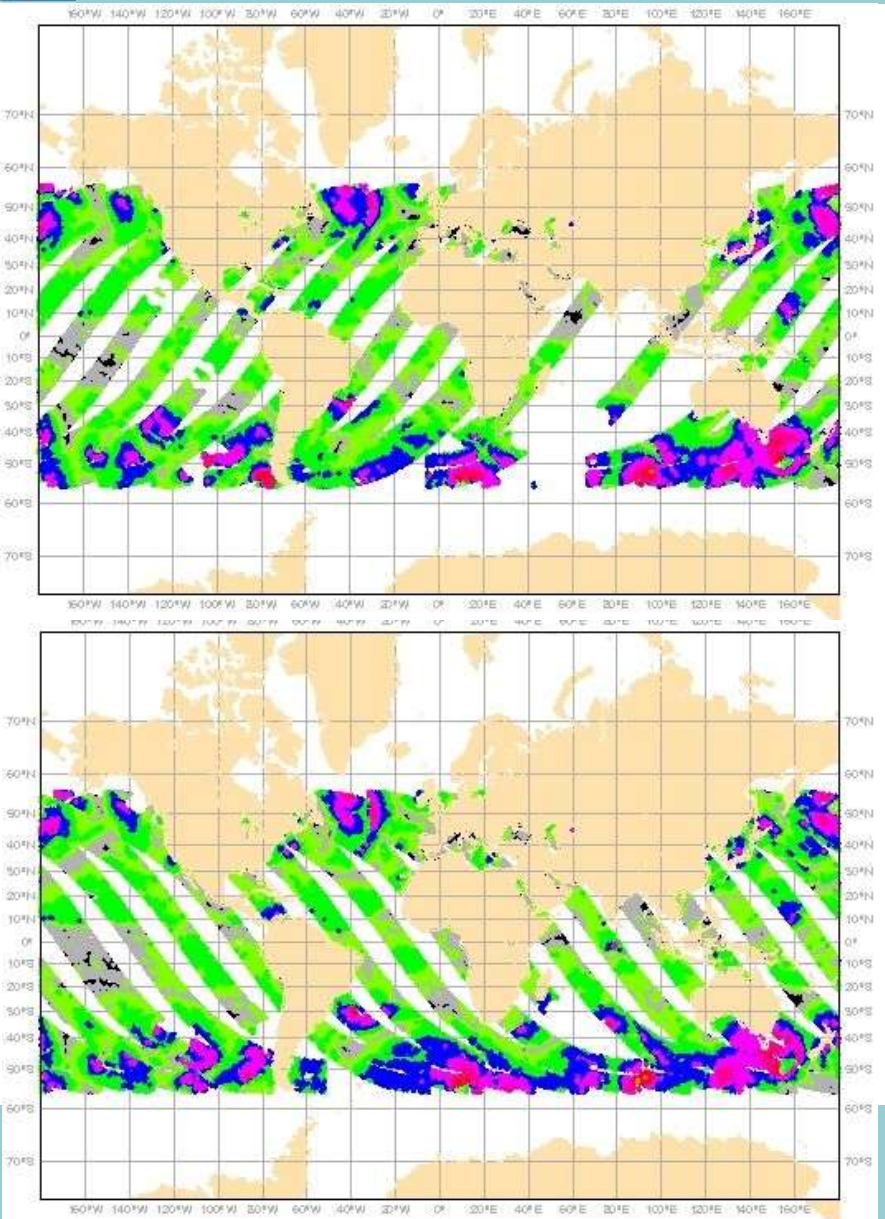
- First scatterometer **not** on a sun-synchronous plaform
- Views a point at all local times of day every two months
- Facilitates cross-calibration of previous scatterometers at different local time-of-days





https://winds.jpl.nasa.gov/missions/RapidScat/

Daily orbits: RapidScat



- Inclined ISS orbit limits coverage to 55S to 55N
- Between latitudes of 40 to 55 degrees swath overlaps and enhanced coverage
- Local time of overpass regresses, which allows
  - intercalibration of scatterometers
  - diurnal cycle analysis

RapidScat on ISS

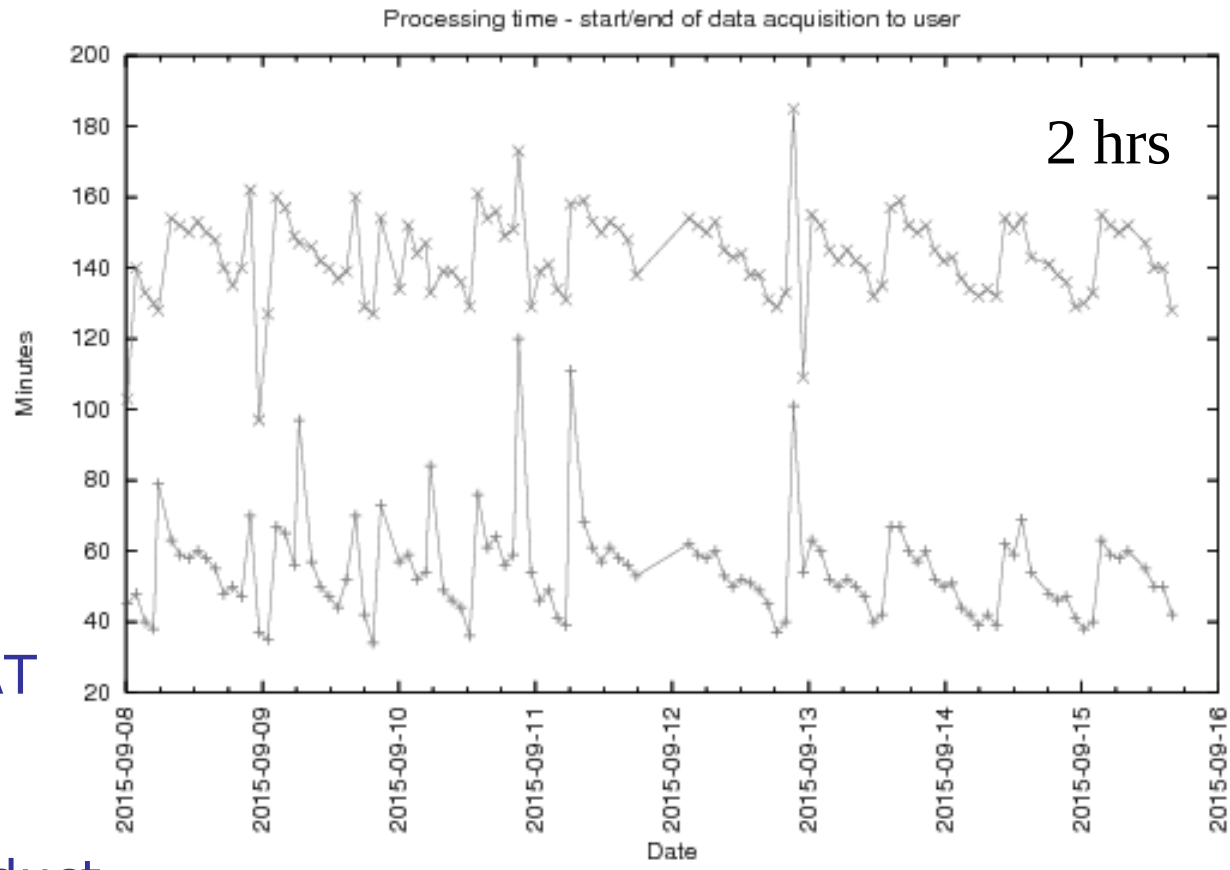
http://www.telegraaf.nl/tv/opmerkelijk/23929606/__Astronaut_filmt_ISS_met_GoPro__.html

ISS Expedition 42_US EVA2 GoPro

NRT RapidScat at KNMI

www.knmi.nl/scatterometer

- RapidScat 25-km 2hrs
  Operational status
- RapidScat 25-km 3hrs
  Operational status
- RapidScat 50-km 2hrs
  Operational status
- RapidScat 50-km 3hrs
  Operational status



- Continuation of OSCAT
  - 50km for NWP
  - 25km for others
- NRT and delayed product
- Products over Europe
  typically within 100 minutes

scat@knmi.nl

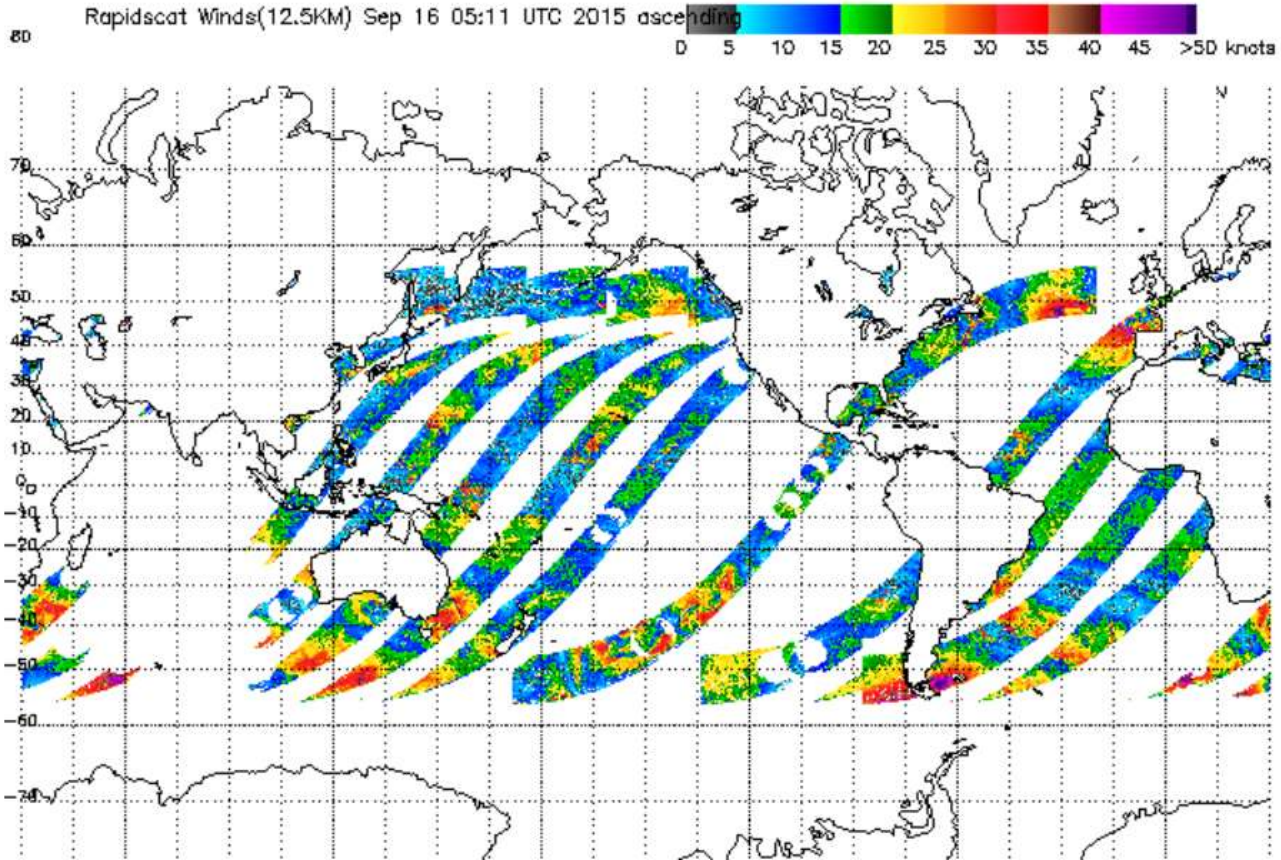
- OSWT Home
- Product Description
- Data Products
  - QuikSCAT/SeaWinds
  - OSCAT
  - RapidSCAT >>
  - ASCAT (METOP-A)
  - ASCAT (METOP-B)
  - WindSAT
  - ERS-2
  - SSM/I
- Research
- Contact Us

Data from Satellite/Instruments: RapidSCAT

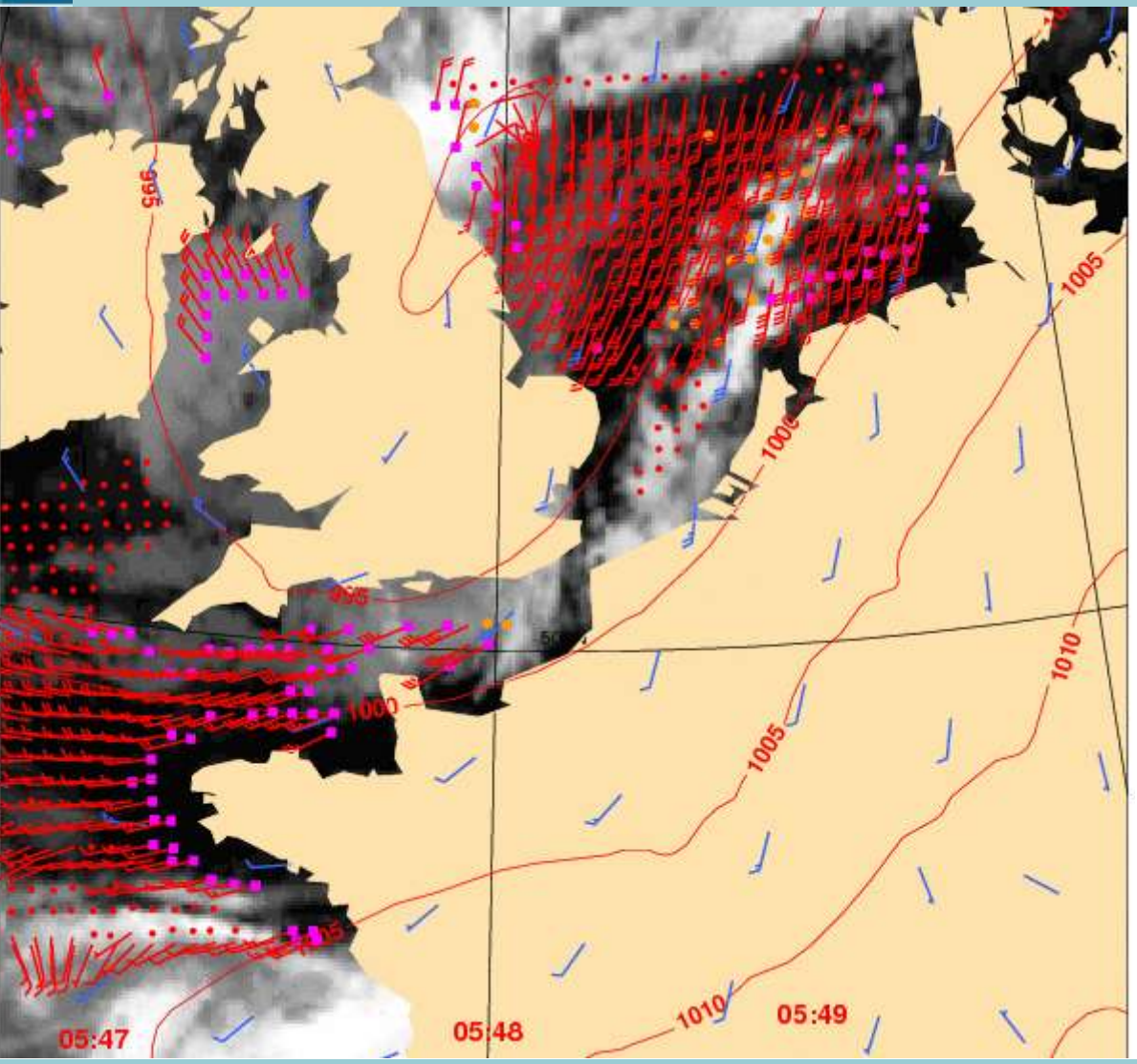
Additional Products: Wind Vectors 10x15 (12.5KM) | Year: 2015 | Month: 9 | Day: 16 | Global(80N80S-180E180W) | Get Images

RapidScat Scheduled Outages

Ascending Pass



RapidScat winds



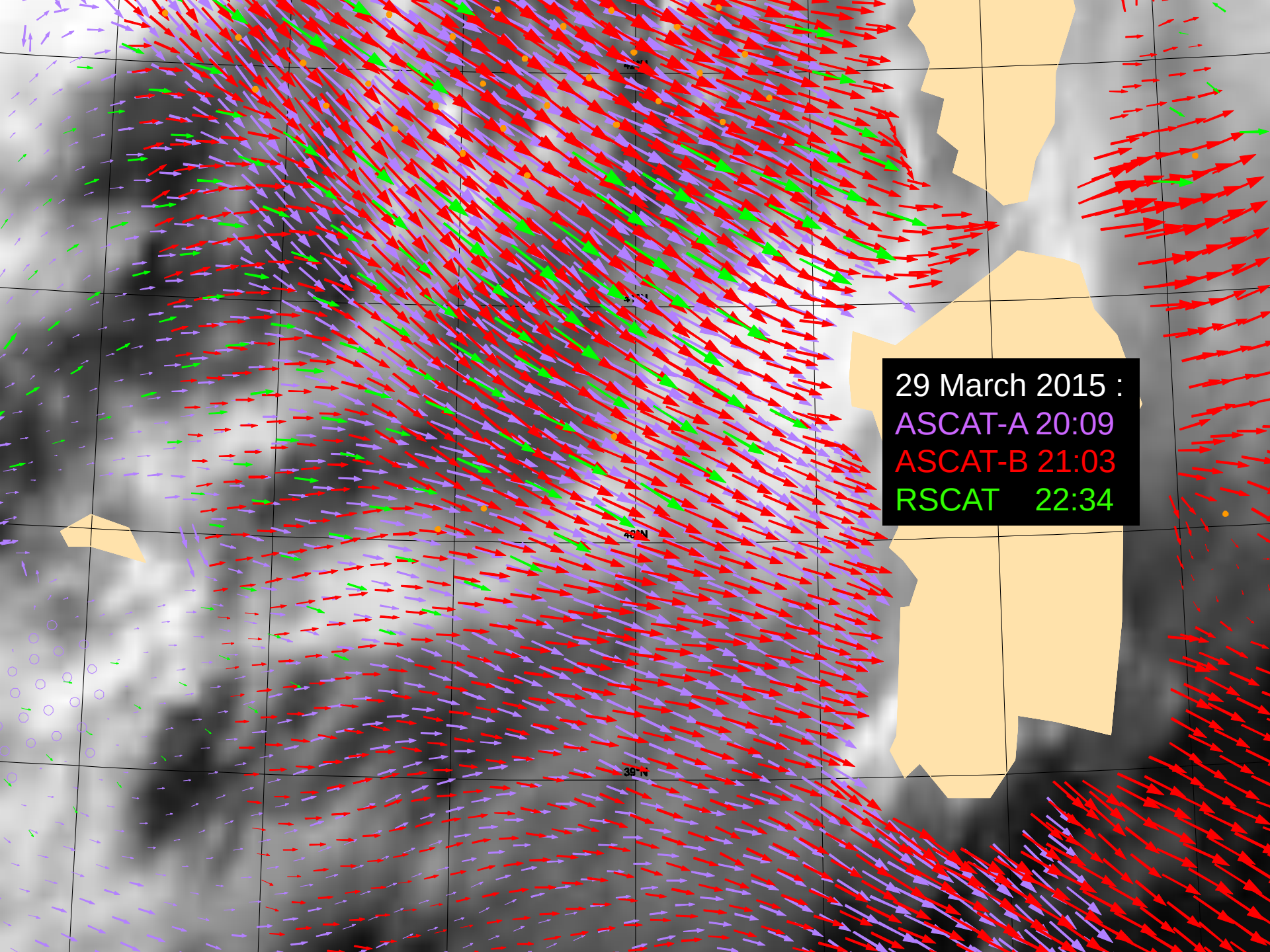
- Orbit files run from S-most point, so European waters are about in the middle and here only half an orbits time (45 min.) is lost in ground transmission
- Systematic gaps in the Indian Ocean
- Events such as vehicle dockings or astronaut/cosmonaut space-walks in service messages
- Recent anomaly

Triple collocation (scat scale)

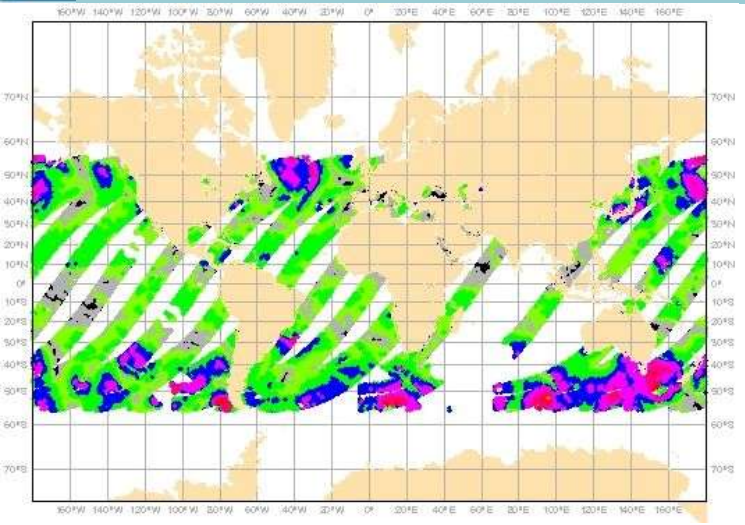
	Scatterometer		Buoys		ECMWF	
SDE [m/s]	εu	εv	εu	εv	εu	εv
25 km RapidScat	0.64	0.67	1.33	1.38	1.17	1.15
50 km RapidScat	0.56	0.53	1.41	1.47	1.06	1.07
50 km OSCAT	0.69	0.54	1.46	1.57	1.03	1.09
25 km SeaWinds	0.79	0.63	1.40	1.44	1.19	1.27

U10N=aw+b	*au*	*av*	*bu* (m/s)	*bv* (m/s)
25 km RapidScat	0.983	0.978	-0.06	-0.03
50 km RapidScat	0.980	0.972	-0.07	-0.04

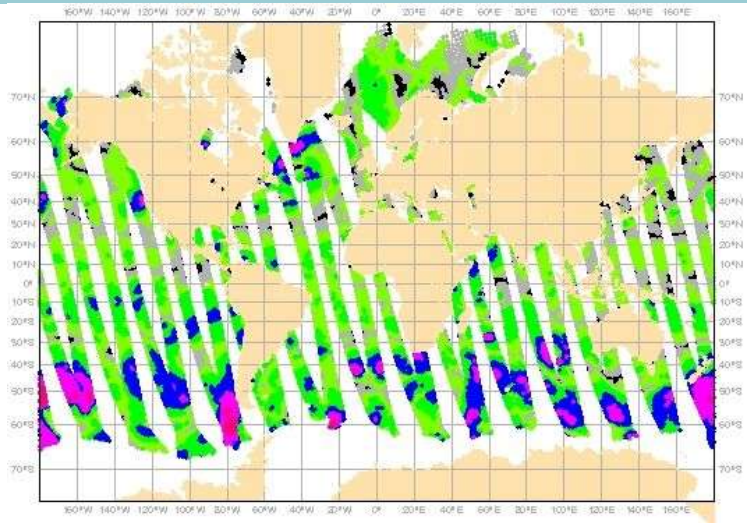
- Good verification of RSCAT
- A bit more QC due to swath pattern
- Different years, but all Nov-Jan

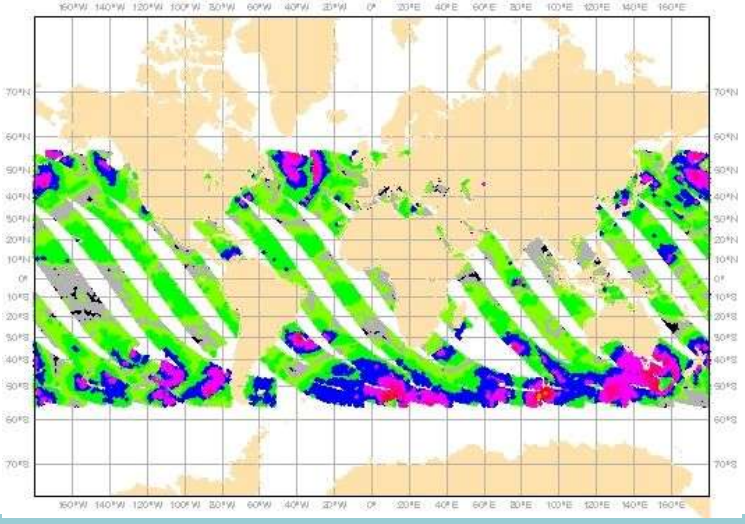

29 March 2015 :
ASCAT-A 20:09
ASCAT-B 21:03
RSCAT 22:34

Daily orbits: RapidScat/ASCAT

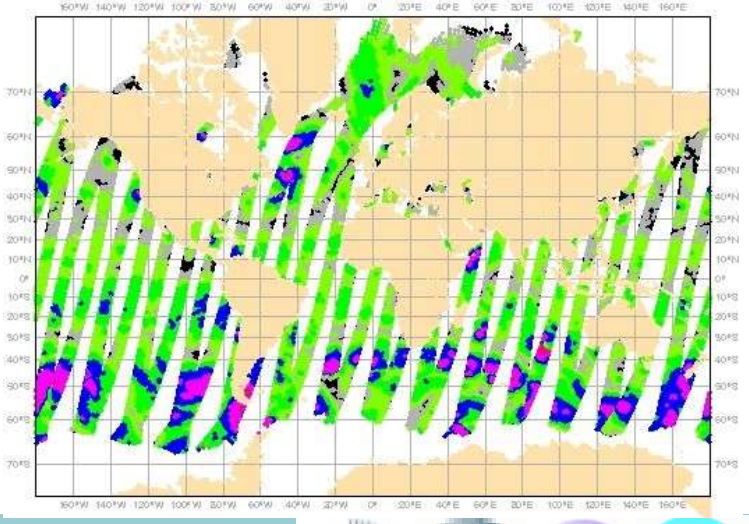


RapidScat
not sun-
synchronous
Ku-band ~2 cm
<=

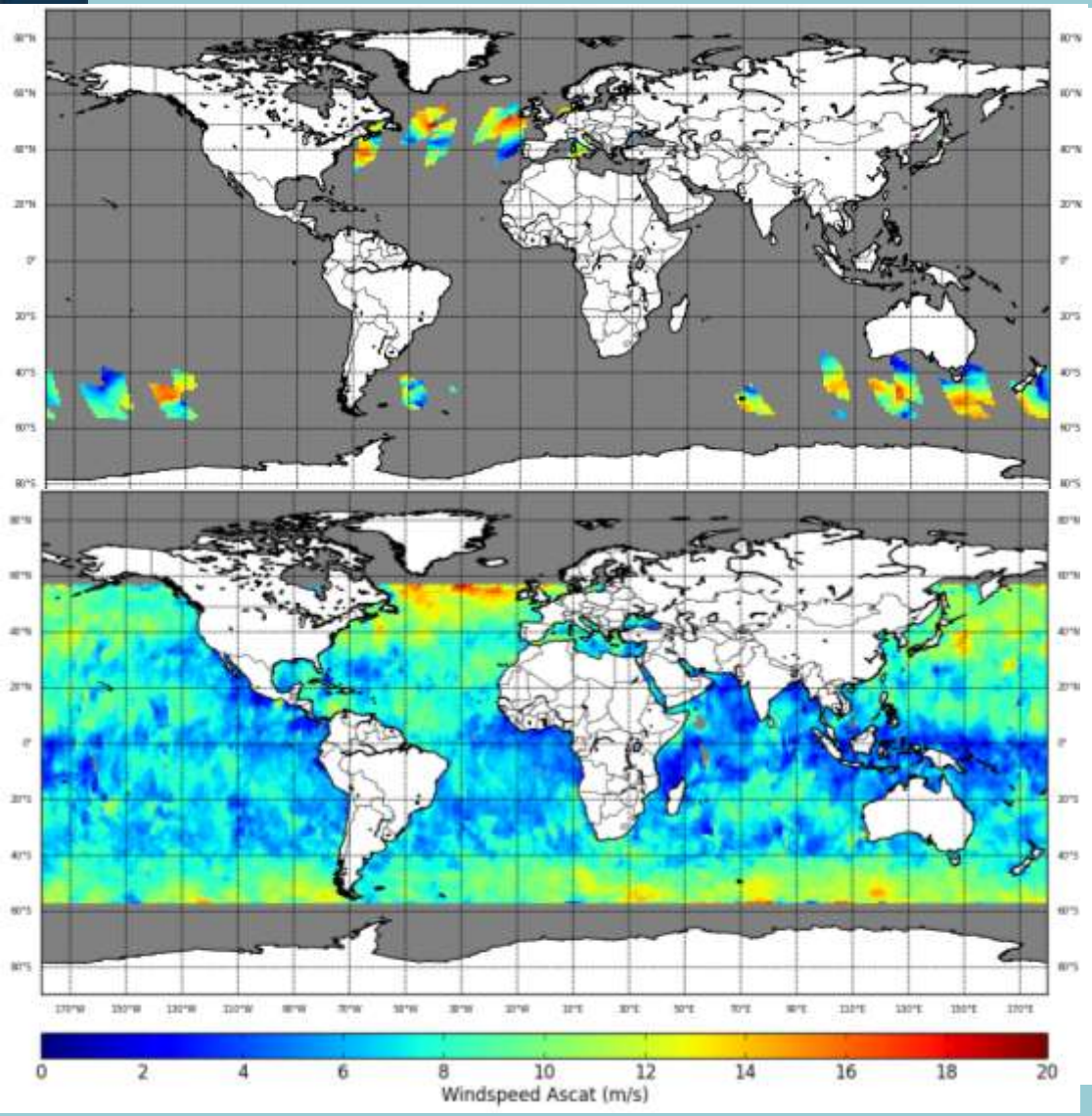




ASCAT
sun-
synchronous
C-band ~5 cm
=>



Collocations RapidScat/ASCAT



< 25 minutes

< 25 km

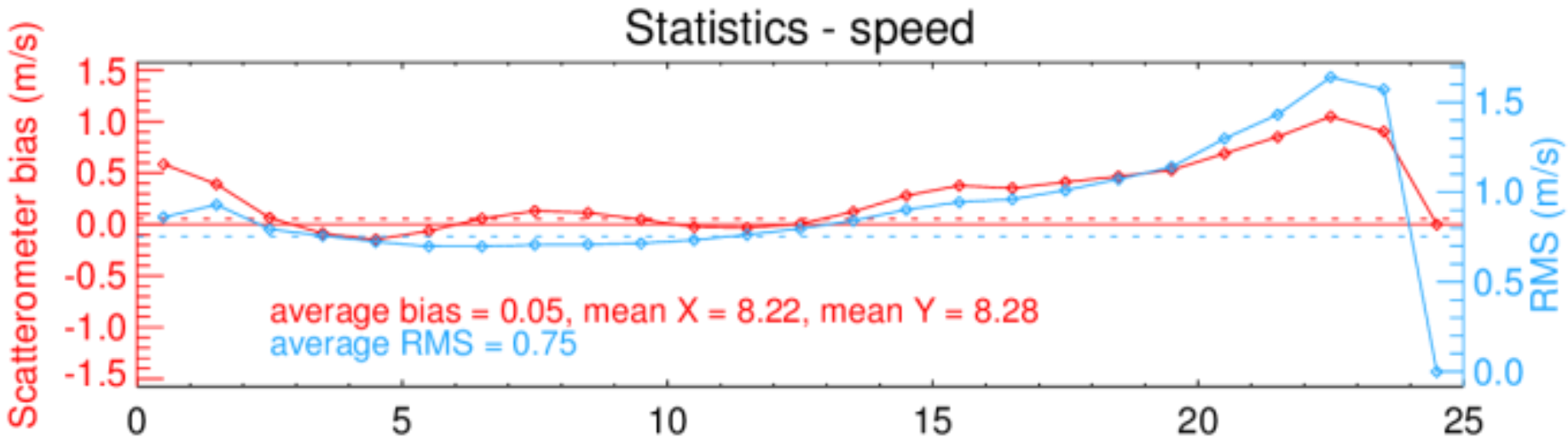
<= One day

<= Nov '14 – Apr '15

RapidScat provides the opportunity to get collocations at the ASCAT overpass time for all ISS latitudes

Rapidscat vs ASCAT

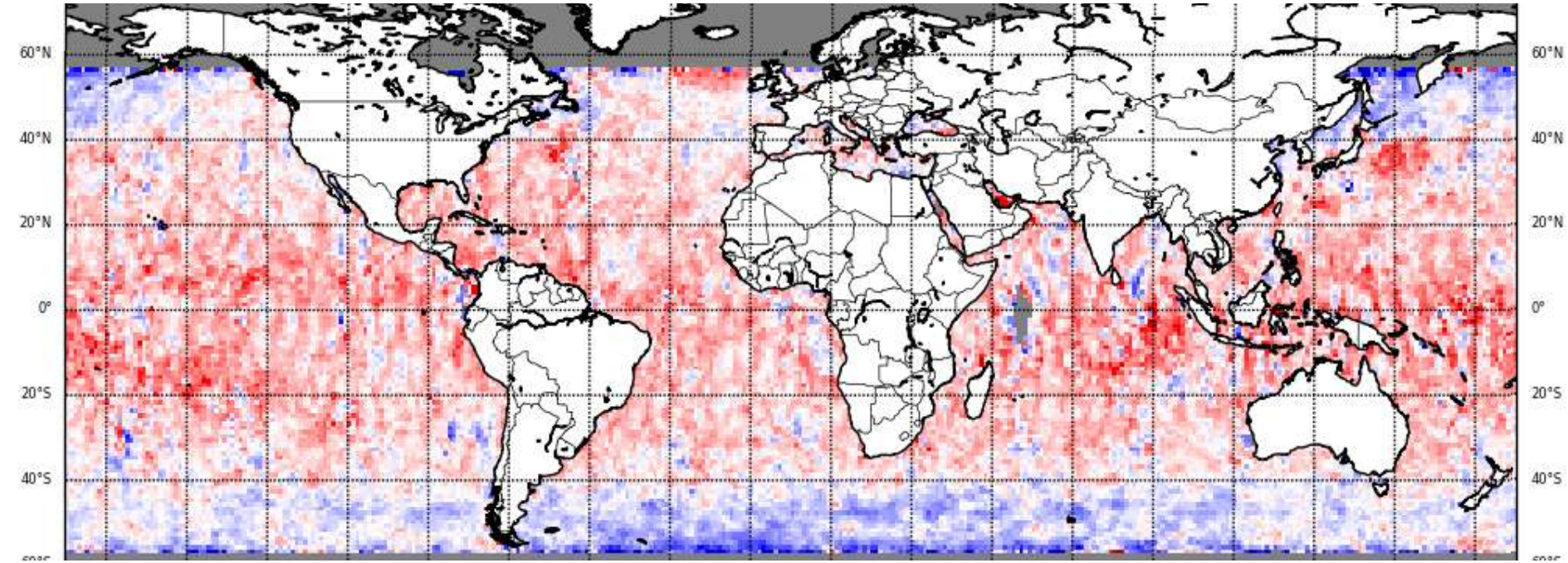
- November thru April, < 25 min, < 25 km & closest
- Good comparison, but different speed scale and QC
- ➢ ASCAT and RapidScat accepted winds are similarly dissimilar to ECMWF
- ➢ High latitude winds are different; not due to speed scale; SST?
- ➢ RapidScat NSCAT4 winds higher at low and high end (vs CMOD6)
- ➢ Low ASCAT winds too often rejected (need CMOD7?)
- ➢ Many rejected RapidScat winds appear close to the diagonal, which calls for further QC improvements (at KNMI)
- ➢ Work in progress!



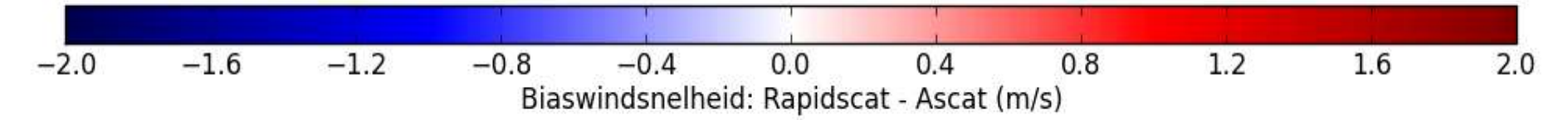
Rscat vs ASCAT speed bias

all swaths

November thru April, < 25 min, < 25 km & closest

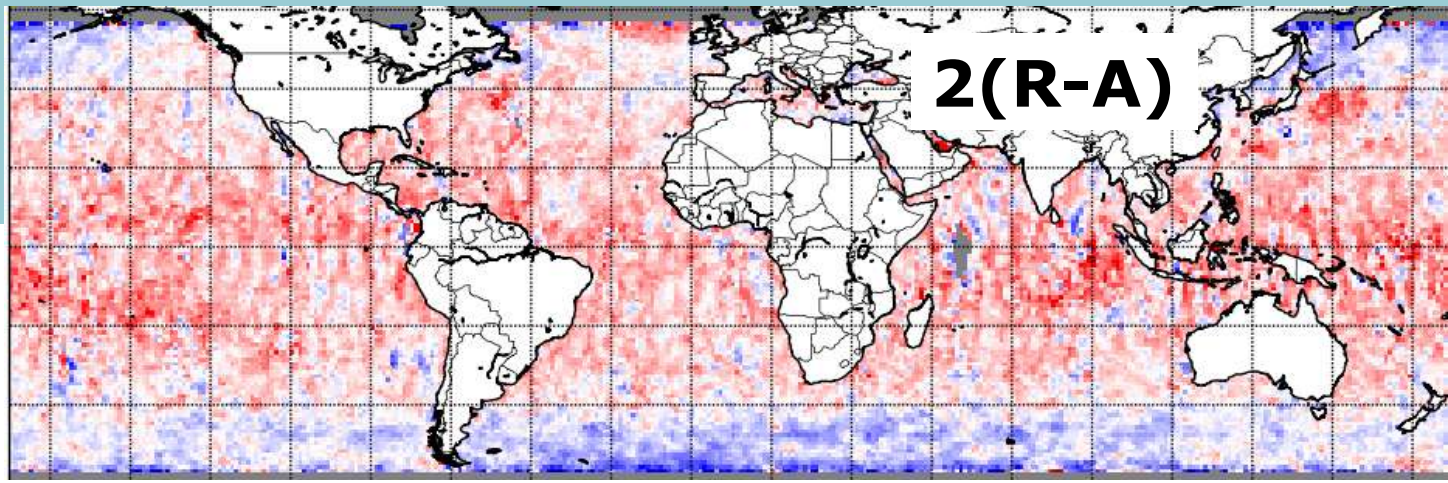


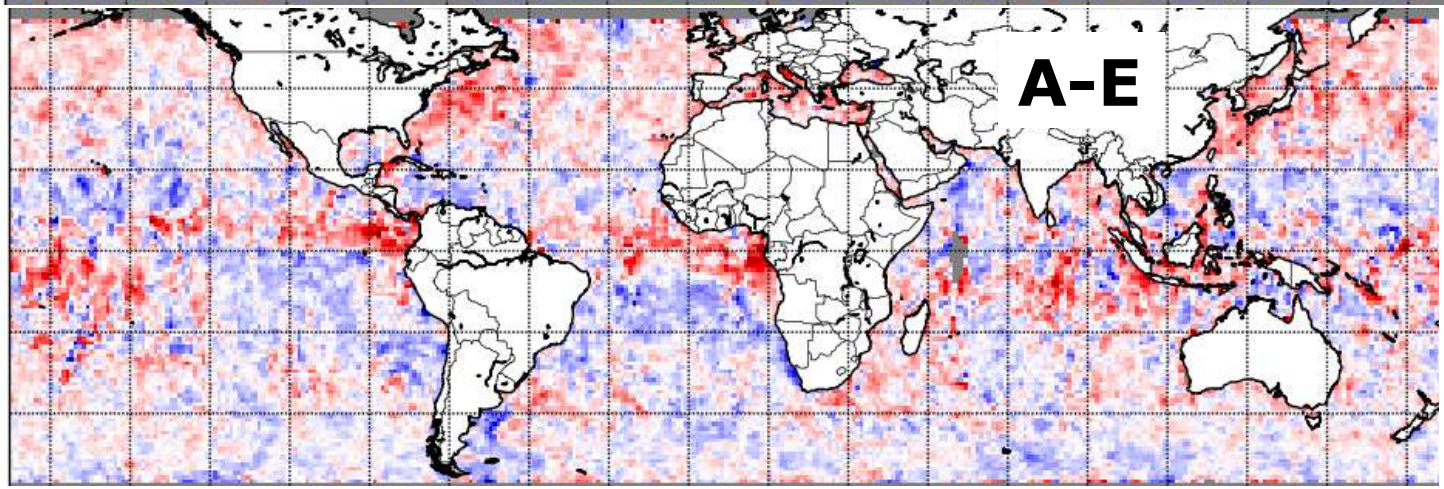
- Large-scale latitude dependence
- Some ASCAT swath patterns (temporal effects?)
- Enhanced differences near convection (rain?)

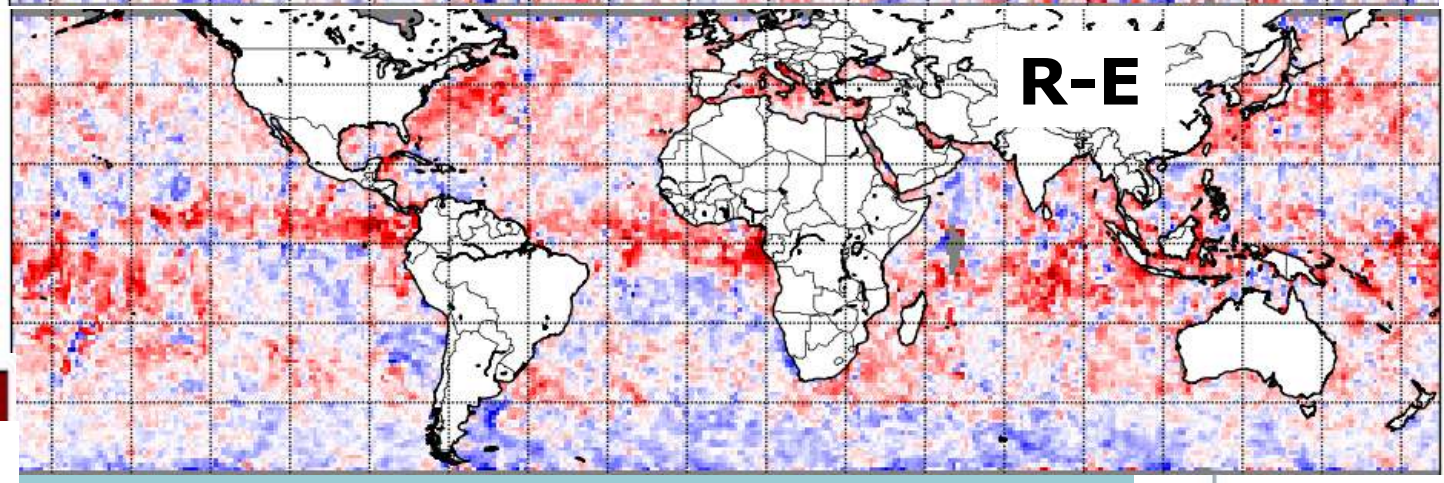


All Δs

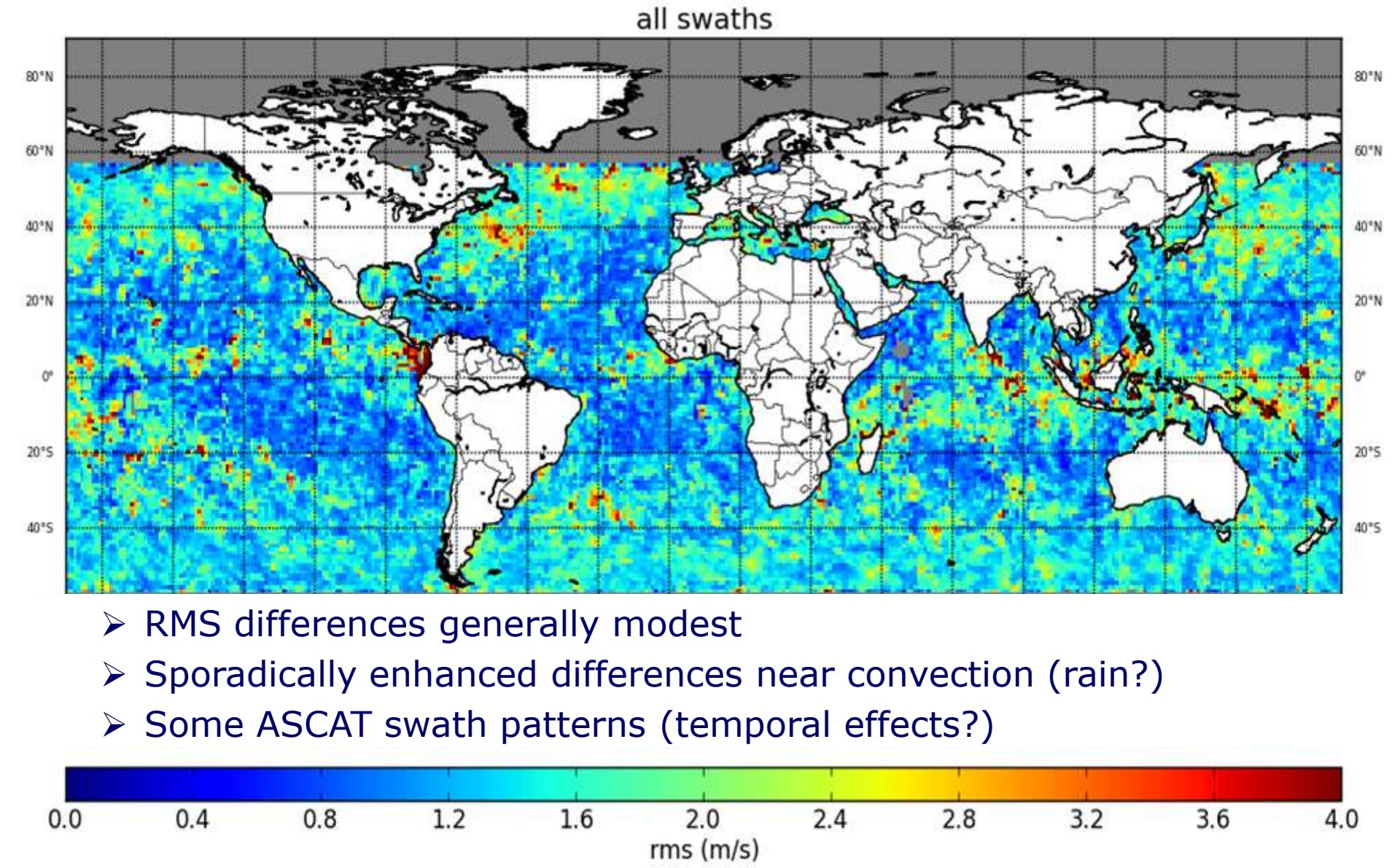
- All WVCs accepted by both
- A/RSCAT rejects 1/10%
- ➢ High latitude low bias RSCAT
- ➢ Convection stands out vs ECMWF
- ➢ RSCAT and ASCAT much agree on small scales! (must be wind, no rain!)
- ➢ RSCAT little more red though in tropics (rain?)
- ➢ Currents?





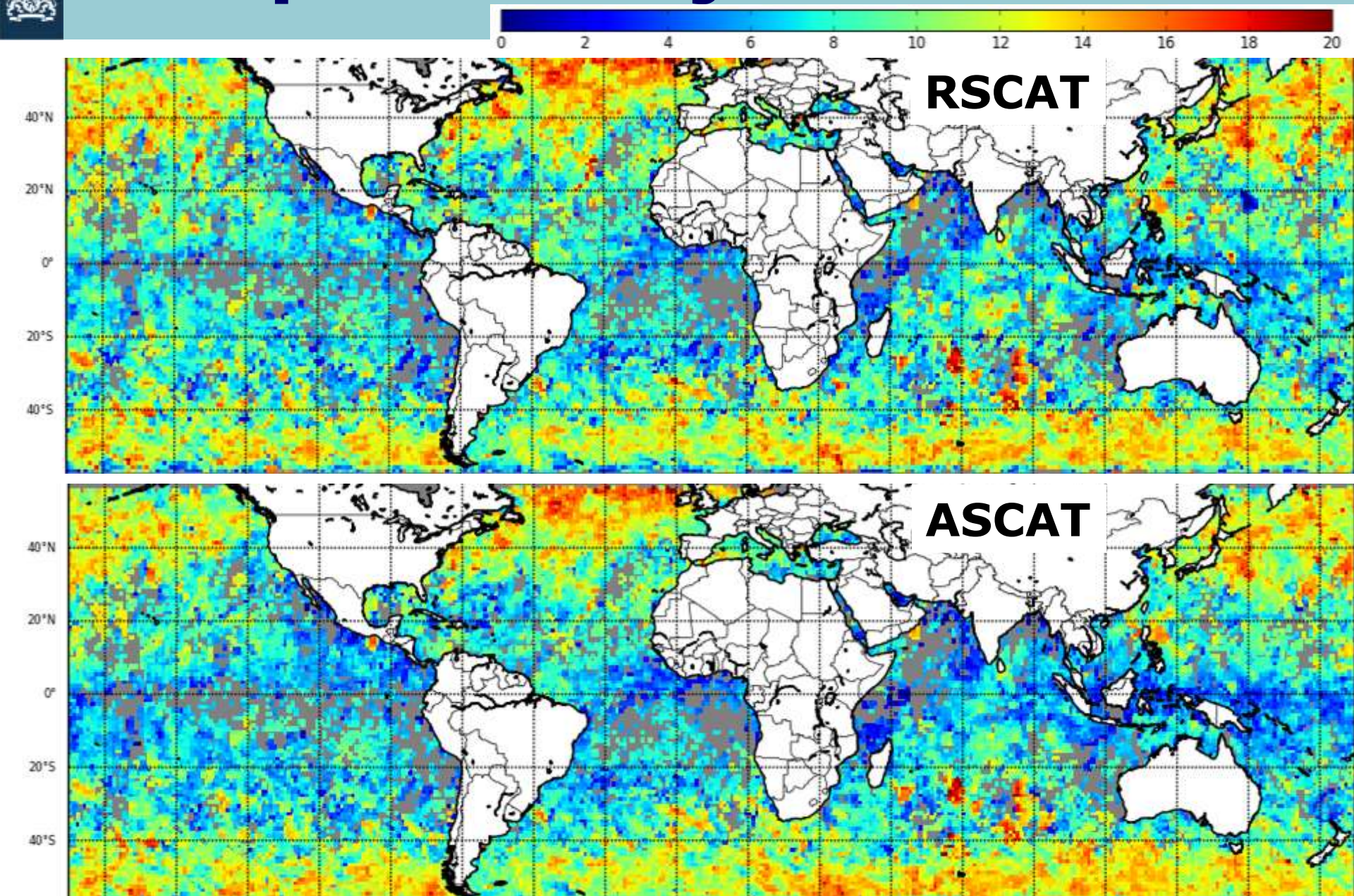


Rapidscat vs ASCAT RMS



- RMS differences generally modest
- Sporadically enhanced differences near convection (rain?)
- Some ASCAT swath patterns (temporal effects?)

RapidScat rejections bad?



Rain

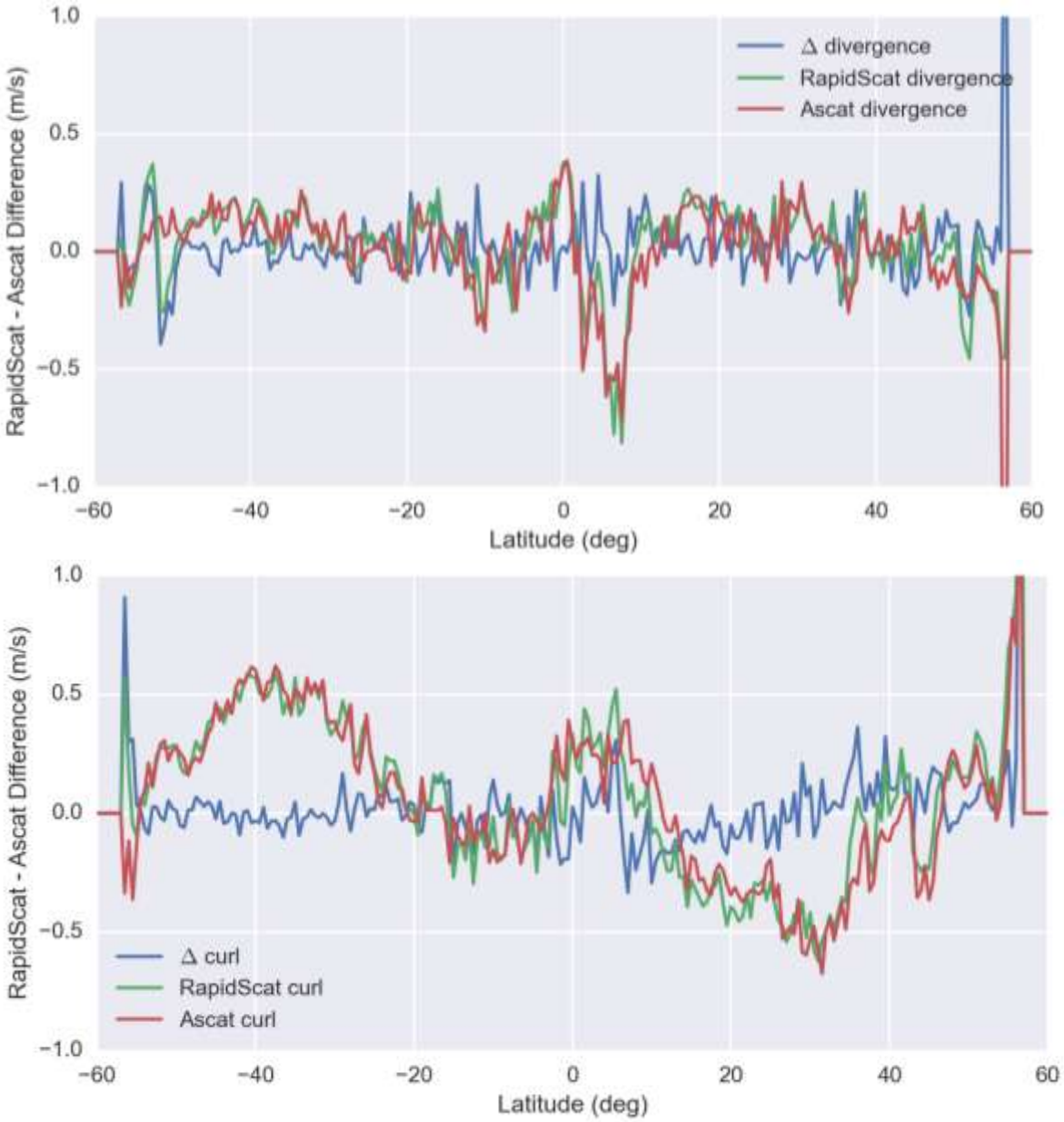
Effects that should show large RMS and bias effects

1. Attenuation/backscatter in clouds
   - Very different for C and Ku band due to power law
2. Surface wave damping due to water turbulence in heavy rain
   - Dissipation depends strongly on wavelength
3. Surface roughening due to droplet impact
   - Rings form at ~2 cm wavelength

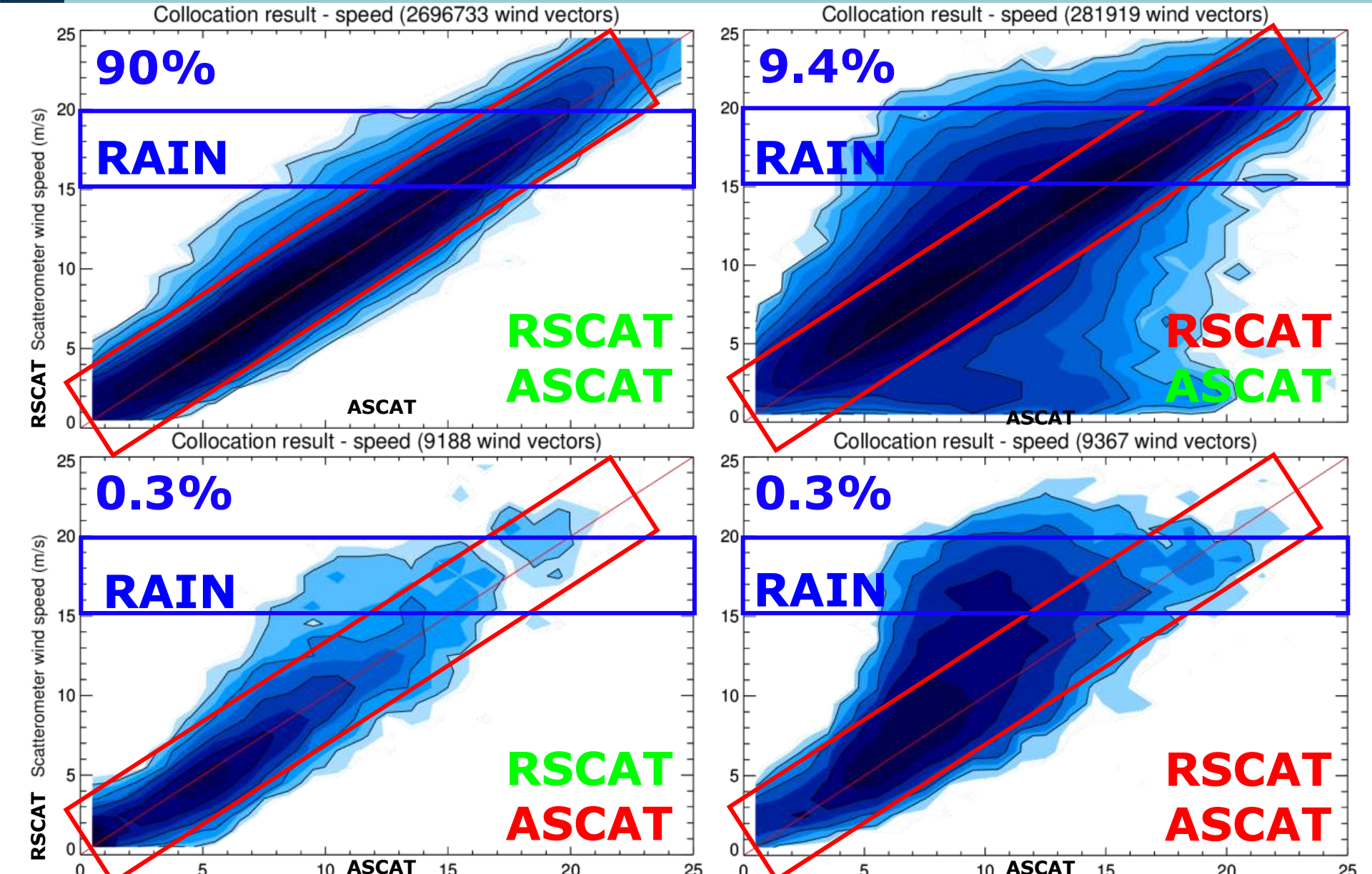
Wind effects are similarly represented in ASCAT and RSCAT winds and appear dominant (through the inverted GMFs)

ISS-RapidScat

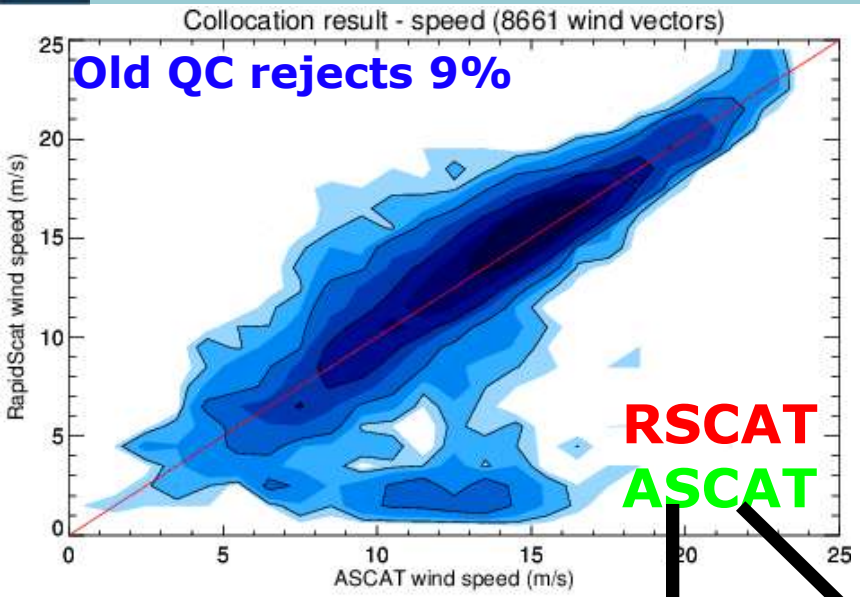
Zonally Averaged Wind Divergence and Curl



Speed and QC

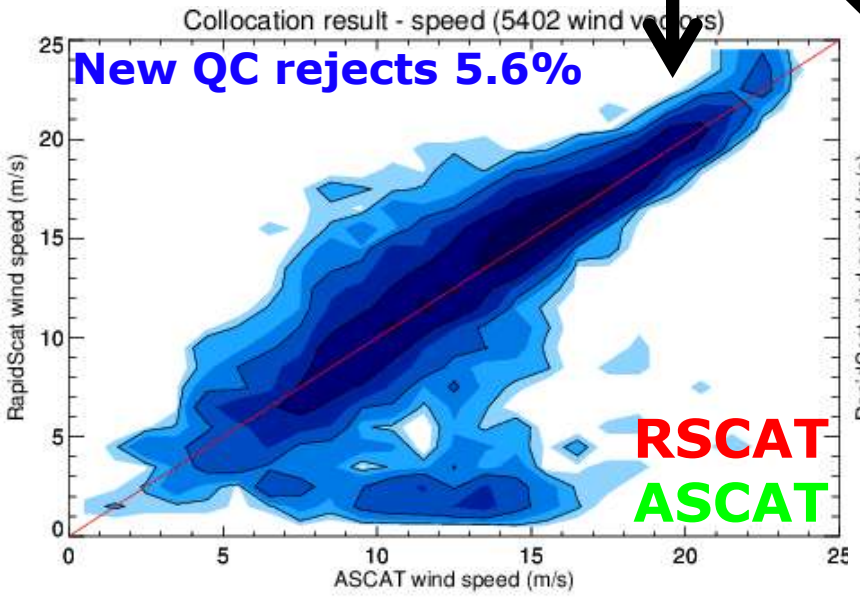

Collocation result - speed (2696733 wind vectors)
90%
RAIN
RSCAT
ASCAT
RSCAT Scatterometer wind speed (m/s)
ASCAT
Collocation result - speed (281919 wind vectors)
9.4%
RAIN
RSCAT
ASCAT
ASCAT
Collocation result - speed (9188 wind vectors)
0.3%
RAIN
RSCAT
ASCAT
RSCAT Scatterometer wind speed (m/s)
ASCAT
Collocation result - speed (9367 wind vectors)
0.3%
RAIN
RSCAT
ASCAT
ASCAT

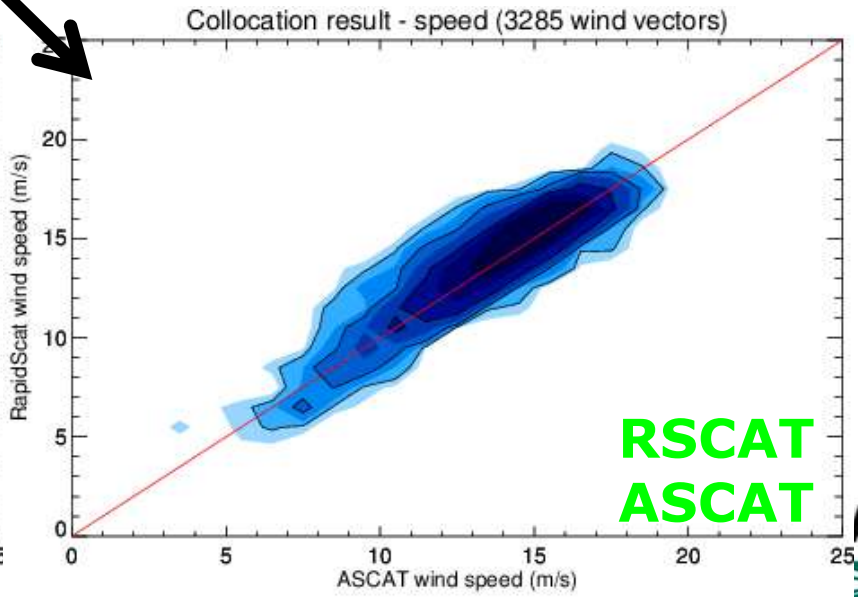
Speed and QC



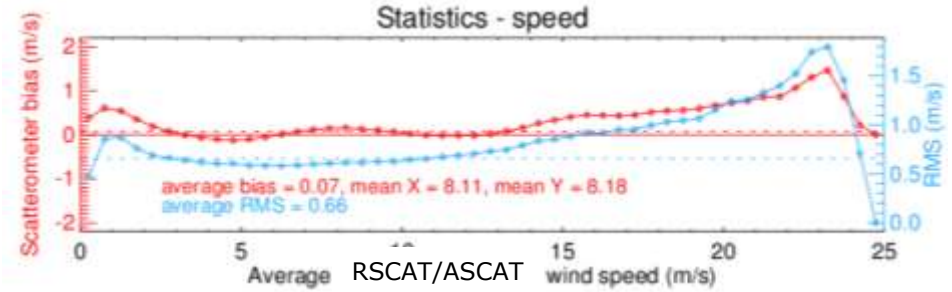
Effect of lower MLE threshold for QC between 6 and 18 m/s

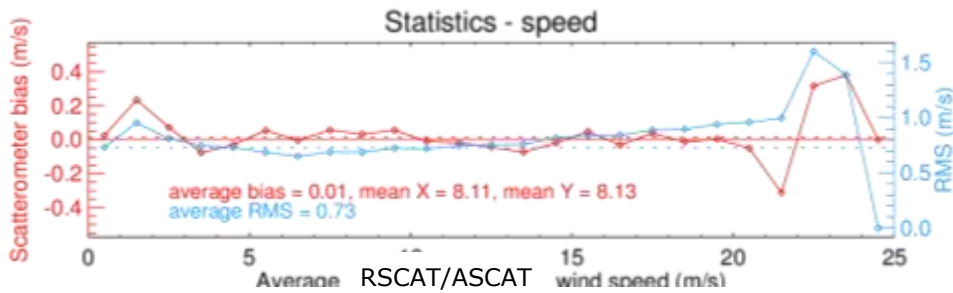
	N	Stdev *u*	Stdev *v*
Old QC accepted	87224	1.07	1.25
New QC accepted	90483	1.10	1.28
New QC extra accepted	3285	1.55	1.93

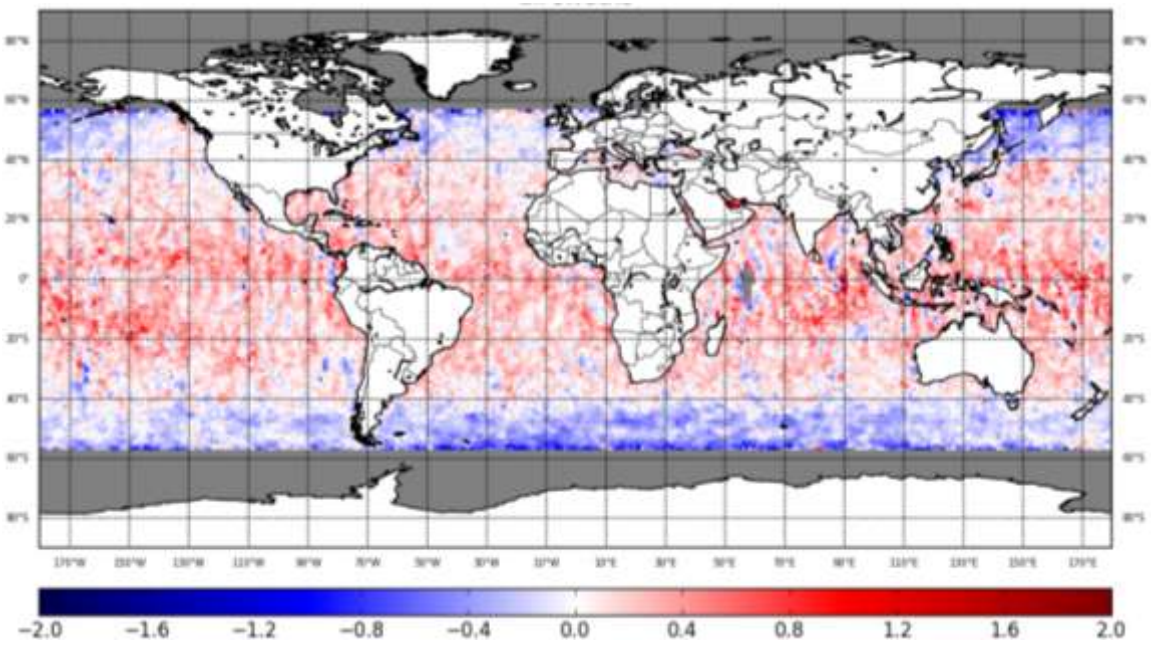




Wind speed dependence

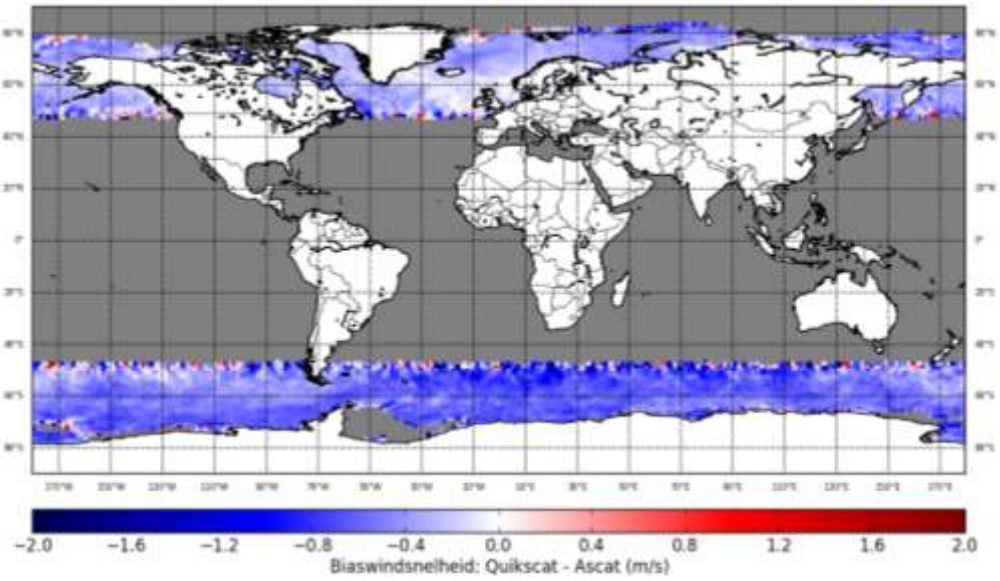


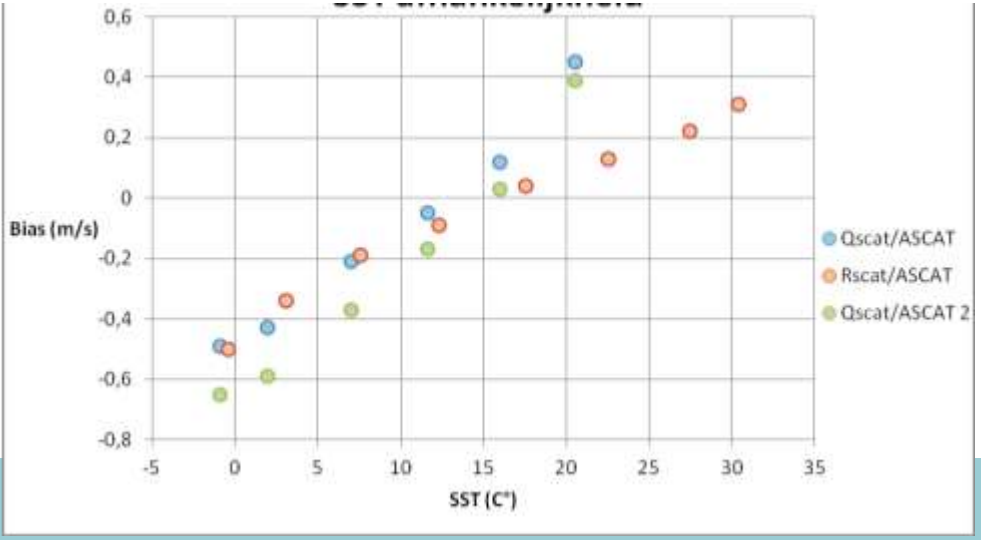




- Wind speed dependent correction applied to get RapidScat and ASCAT on the same level.
- However, the red and blue areas remain!

SST dependence





- Direct QuikSCAT – ASCAT comparisons also show negative bias for Ku-band, but only data available at high latitudes.
- Wind speed bias shows monotonic increase with SST
- Surface tension decreases with increasing temperature
- Formation of wind induced waves appears to be different at 2 cm and 5 cm

ISS-RapidScat

Link to SST

$\lambda_c = 2\pi\sqrt{(\sigma/\rho_w g)}$

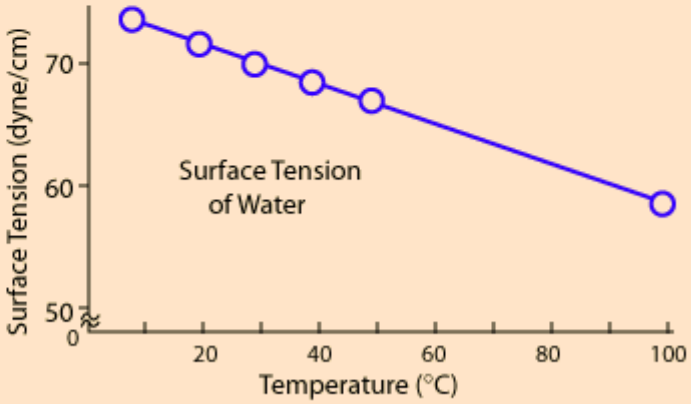
- Capillary and gravity dispersion equal
- ~ 1.7 cm
- 30 degrees corresponds to 6% reduction in σ, i.e., 3% reduction in λ_c (TBC)
- ρ_w= 1024±4 kg m^{-3}, i.e., negligible variation
- g decrease to pole is 0.5%, i.e., negligible variation

hyperphysics.phy-astr.gsu.edu/hbase/surten.html#c3

Surface Tension of Water

The surface tension of water is 72 dynes/cm at 25°C . It would take a force of 72 dynes to break a surface film of water 1 cm long. The surface tension of water decreases significantly with temperature as shown in the graph. The surface tension arises from the polar nature of the water molecule.

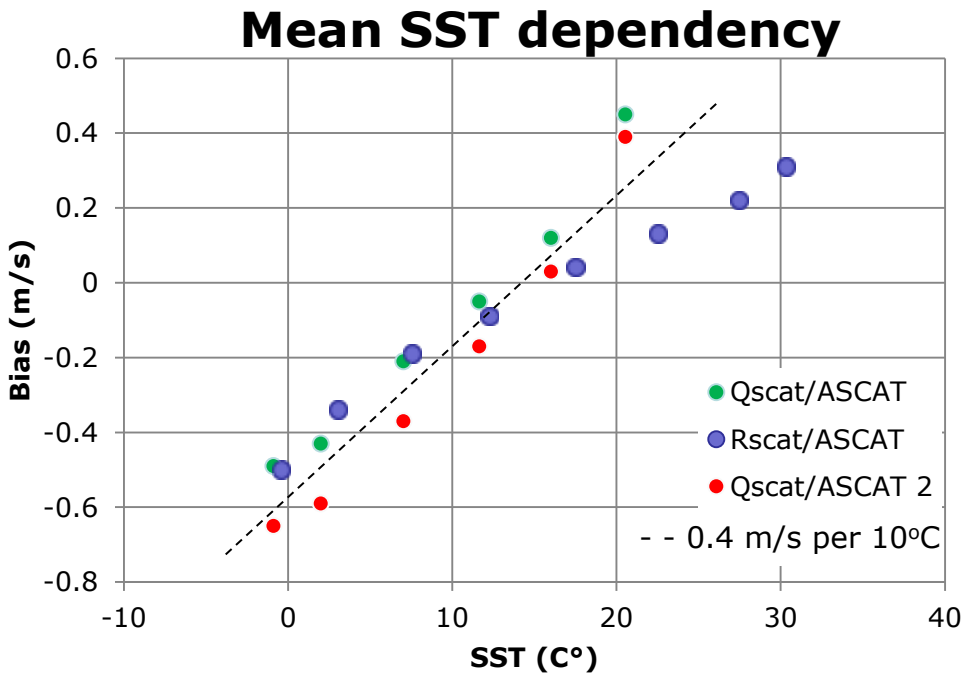
Hot water is a better cleaning agent because the lower surface tension makes it a better "wetting agent" to get into pores and fissures rather than bridging them with surface tension. Soaps and detergents further lower the surface tension.



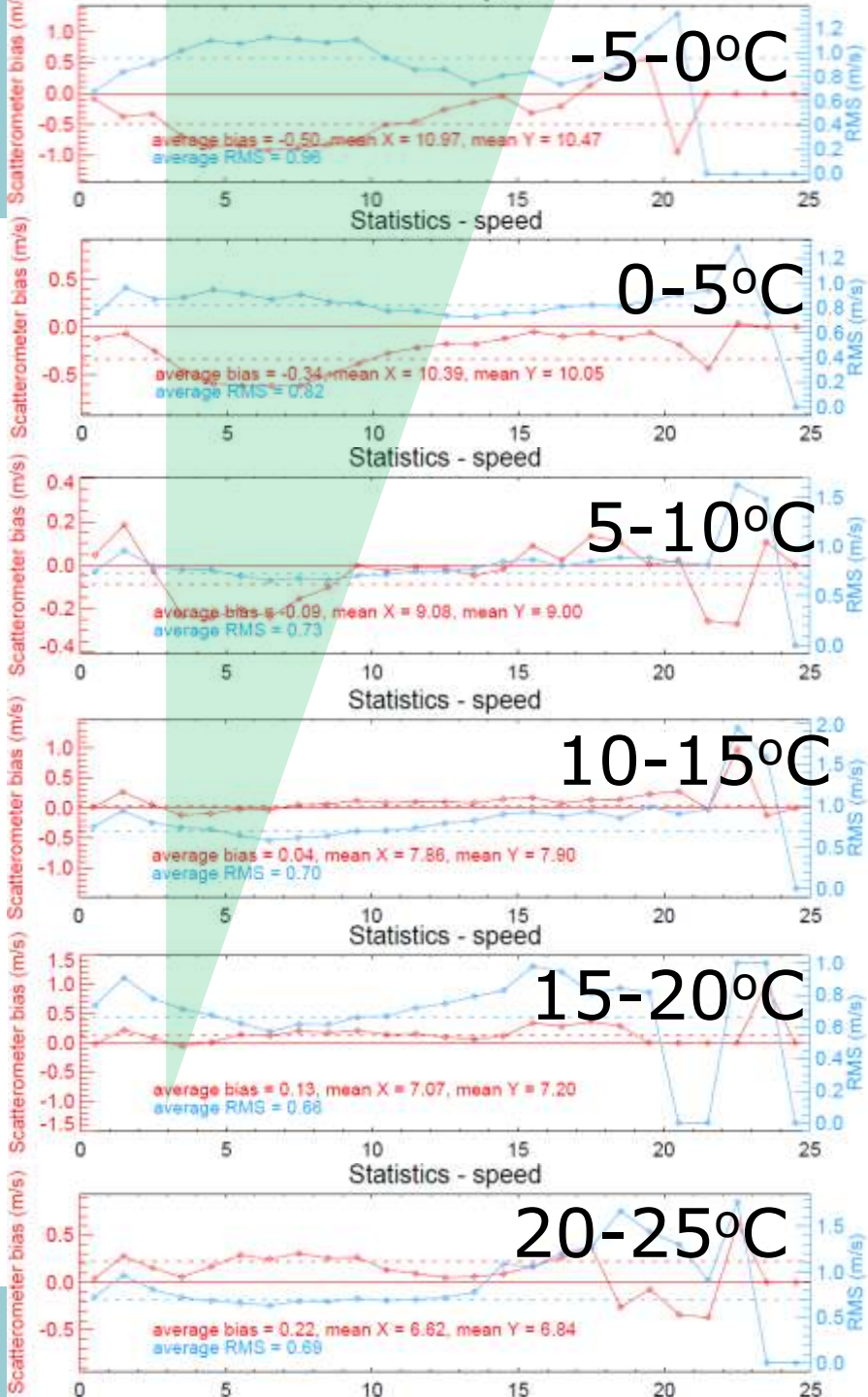
- Ku more affected than C ?

ISS-RapidScat

SST C/Ku effect



- Ku band winds increase w.r.t. C band and NWP winds as a function of SST with about 0.04 m/s per °C
- At low SST, differences appear wind speed dependent and most pronounced at low to moderate winds (dissipation of breaking waves; TBC)

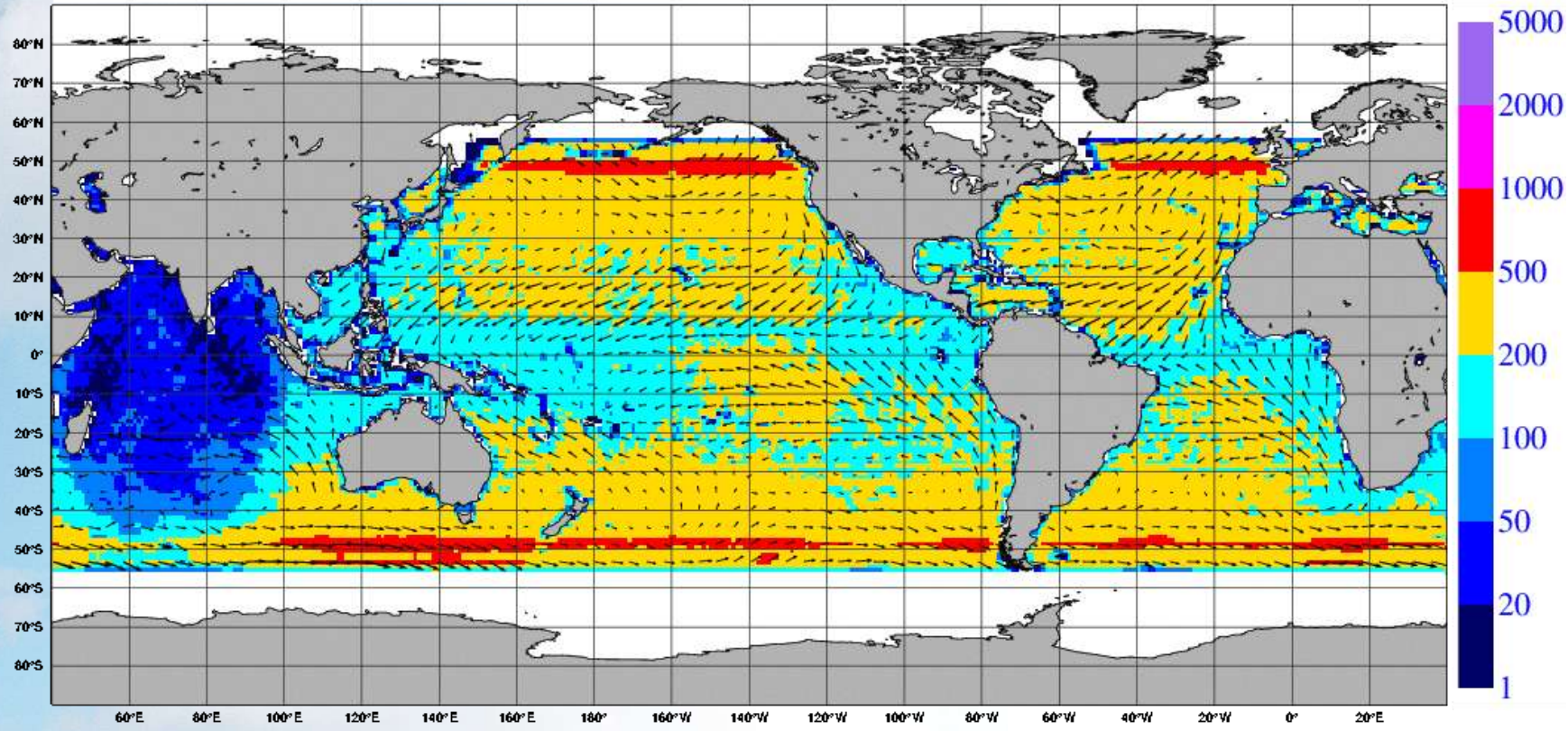


NWP impact

Spatial Coverage

- ✓ Global coverage between 56N / 56S
- ✓ Poor coverage over the Indian Ocean

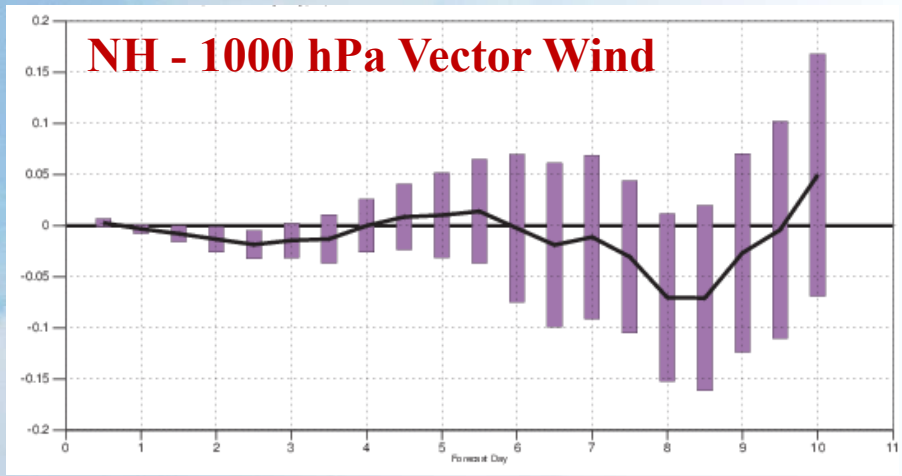
Number of Used Observations from 10 Feb 2015 to 20 Apr 2015



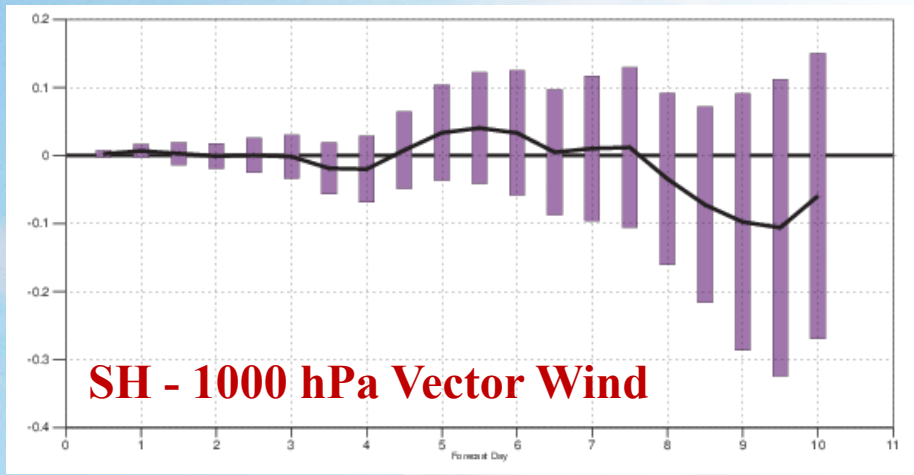
ECMWF

RapidScat Impact on IFS

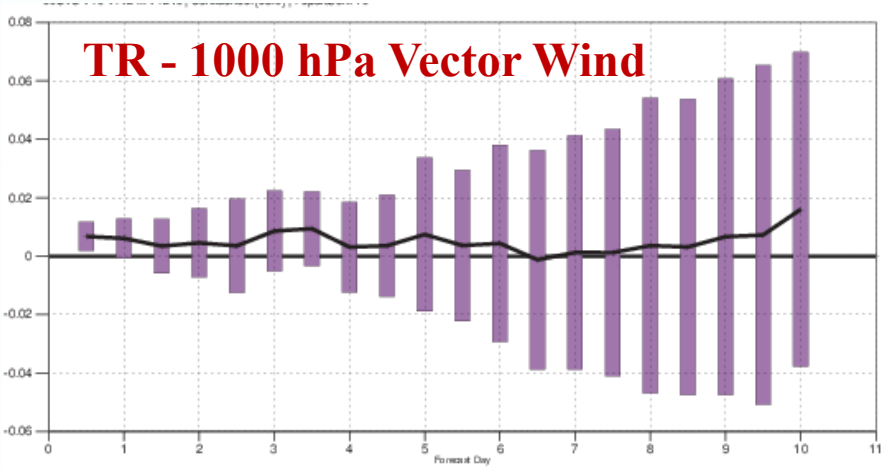
VW RMS Fc Error difference (verified vs Operations)
Exp/WithoutRapidScat – Exp/WithRapidScat



Slightly negative impact in the NH and SH



Slightly positive impact in the Tropics



Similar results at higher model levels and if verified vs own analysis

NWP impact

- Are the multiple observations around 50N and 50S at multiple times in an observation window problematic in fitting a NWP model state?
- Do statistical artefacts develop > 50 latitude due to overfitting by the background error structure functions?
- Less ideal to deal with ISS RapidScat?

Statistics of RSCAT Buoy Comparisons

	Nudged	DIRTH	NC	KNMI
Spatial resolution	25	25	12.5	25
Wind Speed (m/s)				
Number of data	3,184	3,184	1,675	2,334
Bias	-0.07	-0.05	0.23	0.22
Rms difference	1.16	1.11	1.11	0.98
Correlation	0.938	0.943	0.944	0.954
Wind Direction (deg.), wind speed > 3 m/s				
Number of data	2,813	2,813	1,490	2,064
Bias	1.5	0.9	1.6	3.2
Rms difference	25.6	23.7	20.4	19.4
Correlation	0.962	0.967	0.977	0.977

Conclusions

- ✓ RScat wind quality is comparable to QSCAT or OSCAT winds
- ✓ RScat objective of intercalibration with ASCAT successful already
- ✓ RScat winds generally match well with ASCAT winds
- ✓ KNMI appears to reject quite some good quality RSCAT winds
- ✓ Latitude dependent biases are observed, which have already been seen for other Ku-band instruments but are much more obvious now due to close collocations
- ✓ There appears to be a strong correlation with SST and a wind speed dependence of the C/Ku GMF difference
- ✓ Ku band GMF probably needs SST-dependent correction
- ✓ NWP data assimilation of locally (50N and 50S) spatially and temporally dense wind observations appears challenging yet

ISS-RapidScat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