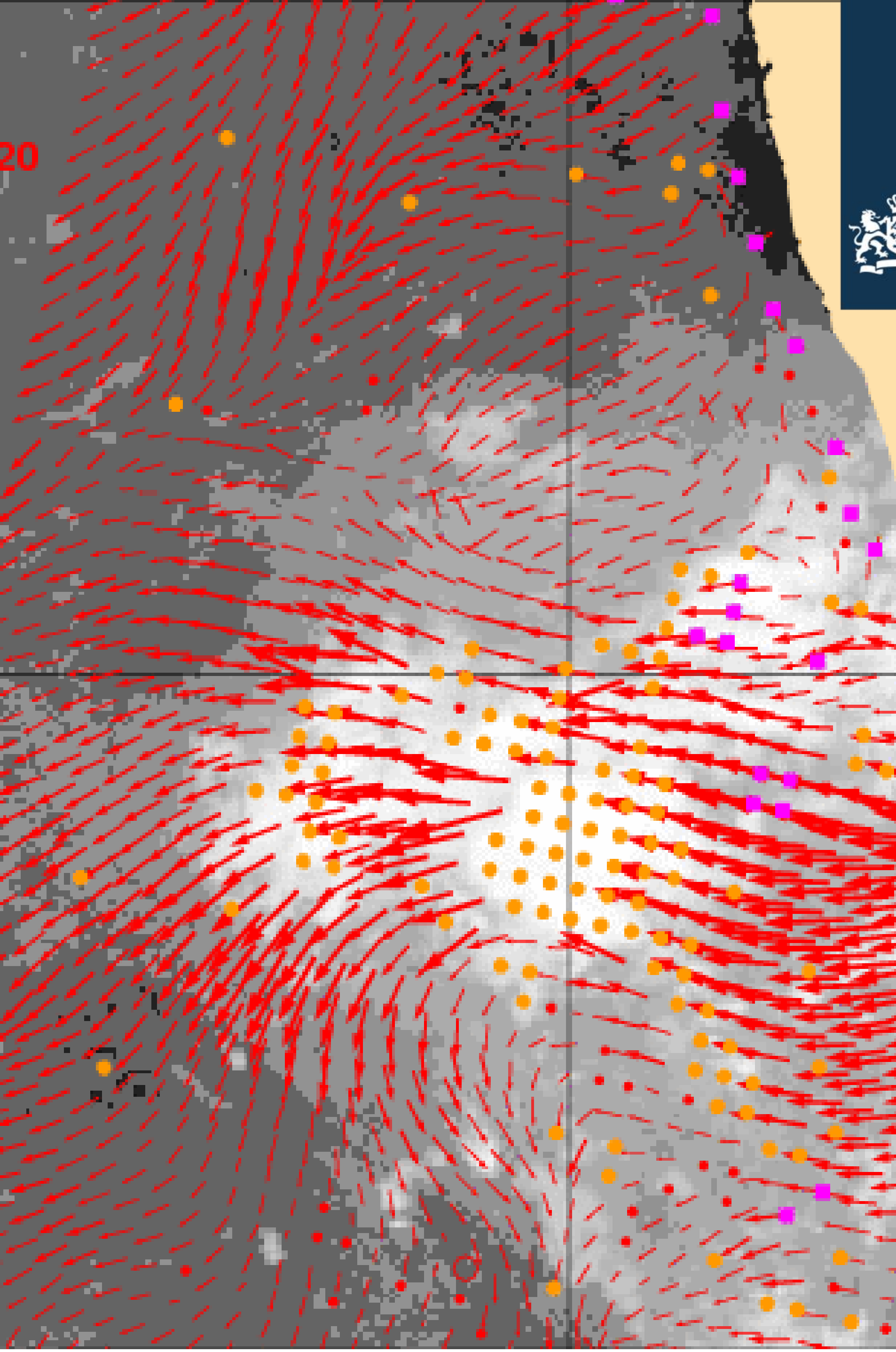


Royal Netherlands
Meteorological Institute
Ministry of Infrastructure and the Environment

Wind product developments for the ASCAT, OSCAT and HY2A scatterometer constellation

Ad Stoffelen

KNMI Scatterometer Team,
ECMWF, Met.Office, Meteo France,
CSIC, IFREMER, EUMETSAT, ISRO,
NSOAS, NOAA, NASA

NWP SAF
Numerical Weather Prediction

OSI SAF
Ocean and Sea Ice

Constellation

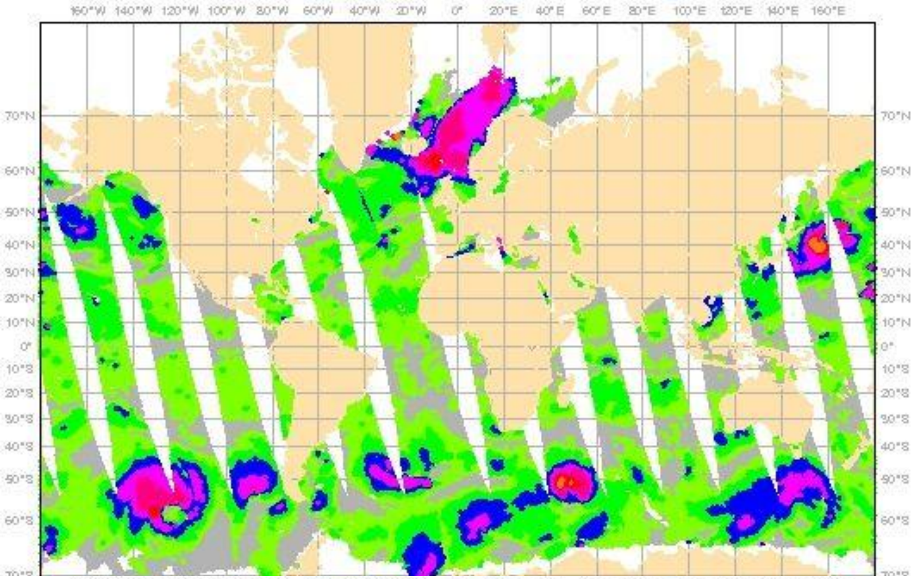
The Committee on Earth Observation Satellites (CEOS) OSVW Virtual Constellation (VC) answers the call for frequent, standardized, NRT satellite winds. The following constellation capability is noted in terms of general temporal coverage:

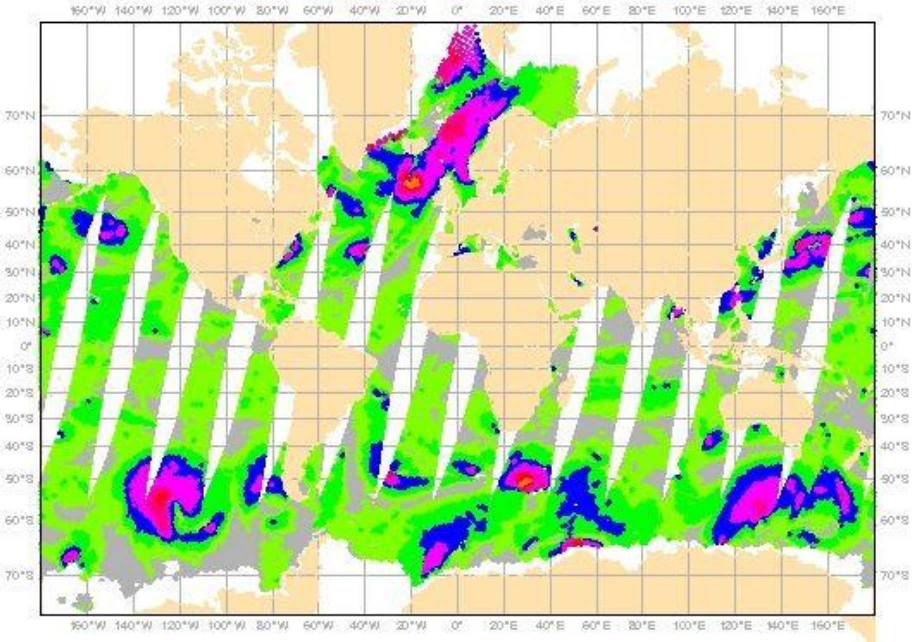
- 0:00 LST & 12:00 LST: OSCAT;
- 6:00 LST & 18:00 LST: from the Chinese HY-2A scatterometer HSCAT or for wind speeds > 8 m/s from WindSat by the USA Naval Research Laboratory (NRL);
- 9:30 LST & 21:30 LST: Advanced Scatterometers ASCAT-A and ASCAT-B carried by the Metop-A and MetOp-B meteorological satellites, operated by the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT);

➢ In each of the three LTAN configurations follow-on instruments are planned (CEOS OSVW VC, 2013). Therefore, applications may be developed that exploit such configuration with a midnight, early morning and mid-morning satellite.

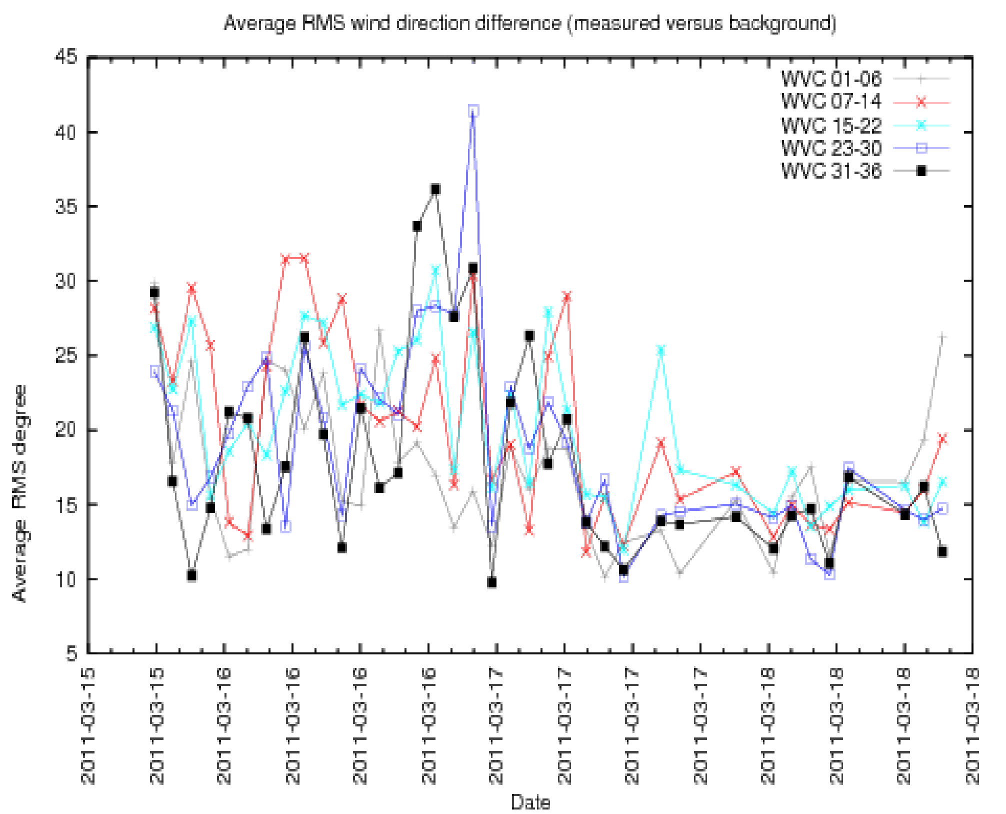
➢ Note that some of the applications that provide maritime warnings for safety of property and mankind, timeliness of satellite data is of prime importance, but not always provided yet.

OSCAT at KNMI





- Very grateful for NRT OSCAT data
- Quality is very good
- Work on remaining topics



OSCAT Cal/Val AO project

EUMETSAT NWP and OSI SAF – KNMI (PI), Europe
ECMWF - Europe
IFREMER - France
UK Met.Office - UK
Meteo France - France
CSIC - Spain
Instituto de Meteorologia - Portugal
Fisheries and Sea Research Institute - Portugal
Deutscher Wetterdienst - Germany
University of Hamburg - Germany
Norwegian Meteorological Institute - Norway
Istituto di Scienze dell'Atmosfera e del Clima - Italy
UTL-Technical University of Lisbon – Portugal

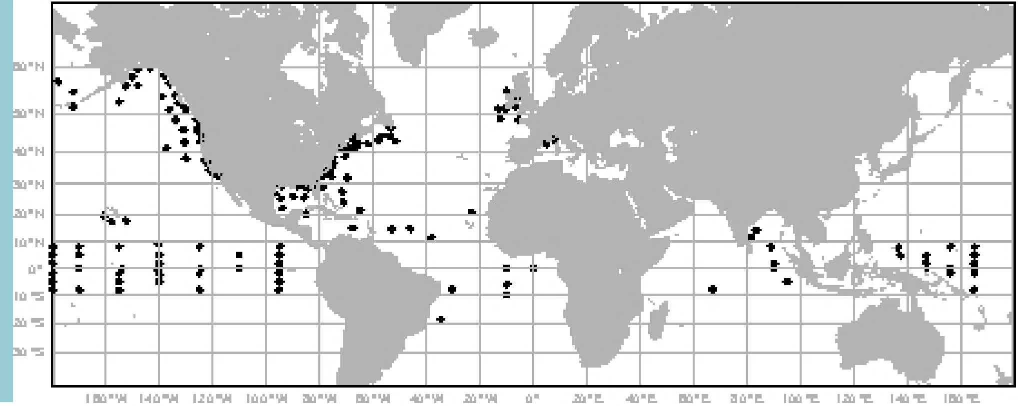
Since November 2012 many more European users due to operational EUMETCAST broadcasts, and new international users on all continents, still growing

OSCAT Wind Data Processor

- OWDP by NWP SAF, now released (Feb. 2013)
- Starting point is the SeaWinds Data Processor (SDP); SeaWinds has similar viewing geometry
- Also, both measure the normalized Ku-band VV and HH microwave backscatter from the ocean surface and thus should obey an identical Geophysical Model Function; we use NSCAT-3

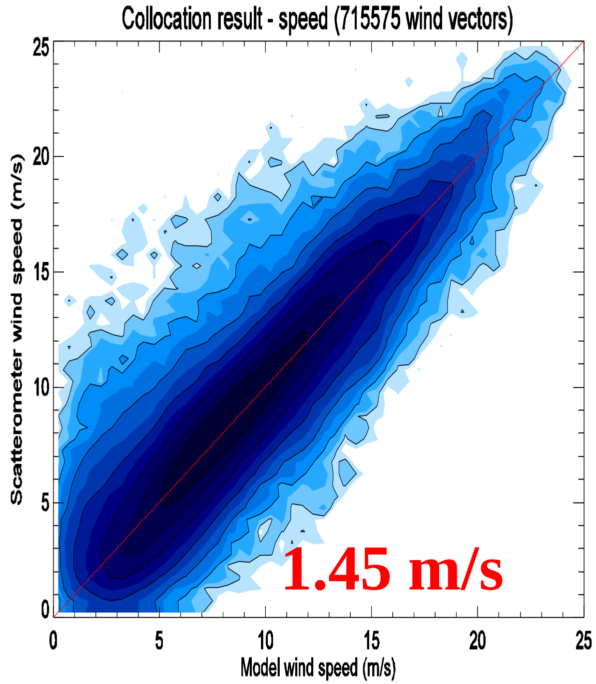
➢ The OSCAT ocean backscatter PDF maps well on the SeaWinds ocean backscatter PDF after NWP ocean calibration (NOC) and orbit-phase dependent correction (ongoing)

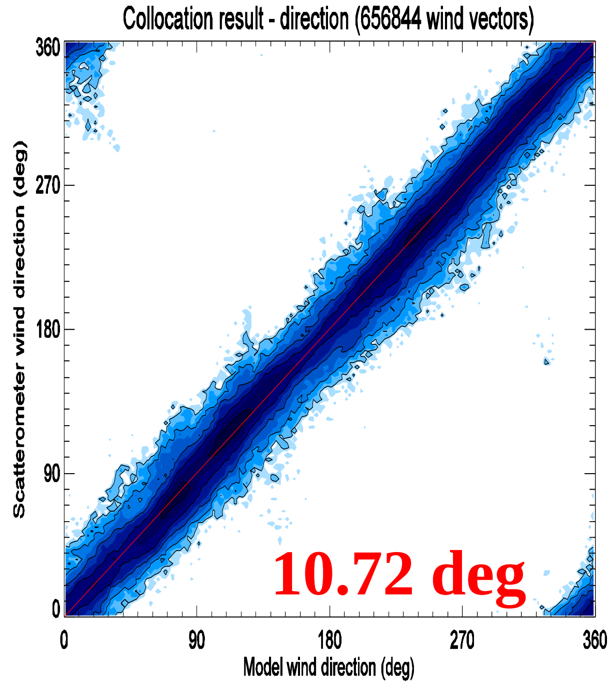
Triple collocation



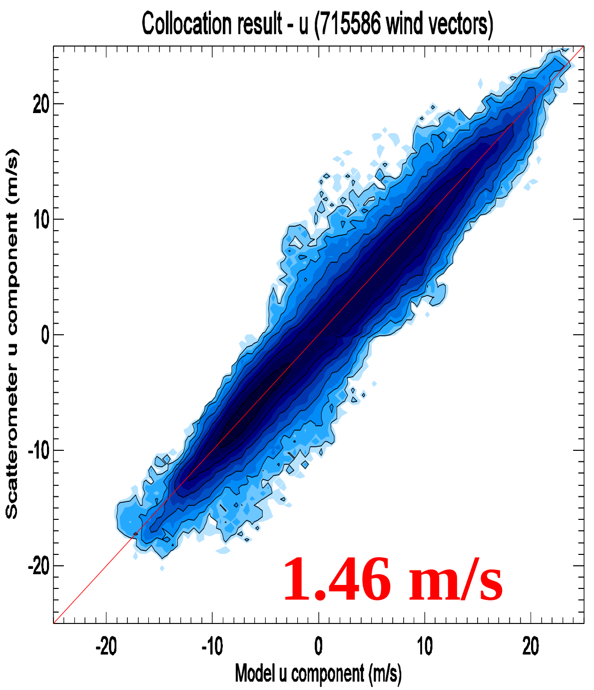
	Scatterometer		Buoys		ECMWF	
	σ_u	σ_v	σ_u	σ_v	σ_u	σ_v
	m/s	*m/s*	*m/s*	*m/s*	*m/s*	*m/s*
OWDP 50-km (all WVC)	0.69	0.54	1.46	1.57	1.03	1.09
WVC 5-32 (inner)	0.67	0.51	1.46	1.57	0.99	1.10
WVC 1-4, 33-36 (outer)	0.74	0.61	1.47	1.59	1.16	1.01
SeaWinds 25-km, 2009	0.79	0.63	1.40	1.44	1.19	1.27

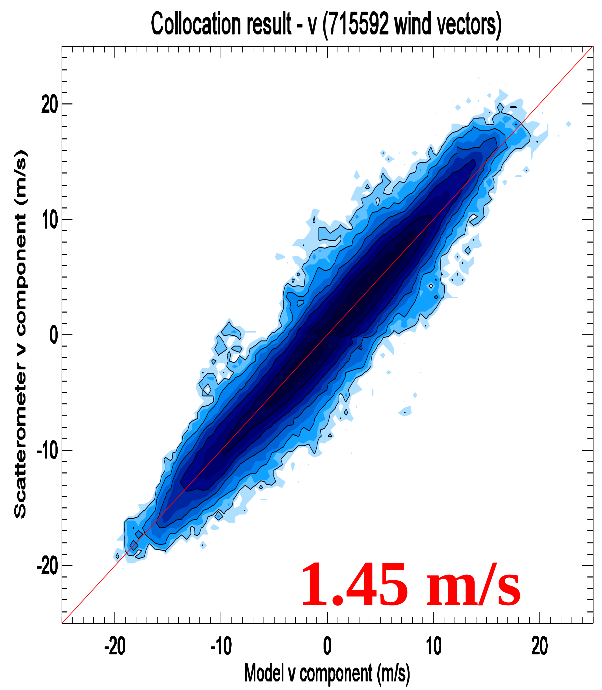
- Similar results for SDP 2009 and OWDP Jan-Mar 2012
- Well within EUMETSAT requirements
- OWDP 50-km closer to ECMWF scales,
  less close to buoy scales





HY-2A KNMI L2B vs ECMWF





- OWDP as used for QSCAT and OSCAT
- -1.7 dB σ^0 corrections
- -0.0001 linear outer beam correction
- All WVCs
- SDs given

- ➢ No speed bias
- ➢ Rain issue reduced
- ➢ Scores similar to QScat and OSCAT

- ➢ Some accumulation at very low winds

Noise at low winds

- $$\sigma^0 = P - N,\ \delta\sigma^0 = \delta P + \delta N$$
- OSCAT regularly provides $\sigma^0 + \delta\sigma^0 < 0$ at low winds
- WVC backscatter distance is minimized for the best *V*
- $$MLE(V) = \sum_i [\sigma^0_i - GMF_i(V)\ ]^2/Kp_i^2$$
- However, a *GMF* cannot simulate negative backscatter since wind speed $V > 0$!
- But negative backscatter values are valid and provide an excellent indication that winds are low

➢ Looking for a scientifically motivated solution
(we tried the others!)

Bayesian retrieval

- $P(x \mid \mathbf{y}) \propto P(\mathbf{y} \mid x)\, P(x)$
- Retrievers usually set $P(x)$ = constant, while searching for the best x
- So, one then poses $MLE = -2 \ln(P(\mathbf{y} \mid x))$ or

  $$MLE = \sum_i [y_i - x]^2 / \sigma_i^2$$

  for multiple y_i with normal noise σ_i
- Now suppose bounded $x \in [0,\infty]$, then $P(x<0) = 0$ and $P(x>0) \neq 0$

➢ $P(x) \neq$ constant

- For low winds $P(V) \propto V$, so

  $$MLE = \sum_i [\sigma^0_i - GMF_i(V)\,]^2 / Kp_i^2 - 2 \ln(V)$$

➢ Successfully being applied for OWDP at KNMI

NWP bias

•OWDP speed bias against the global UK MetOffice NWP model (background) in March 2012:

• uncorrected OWDP

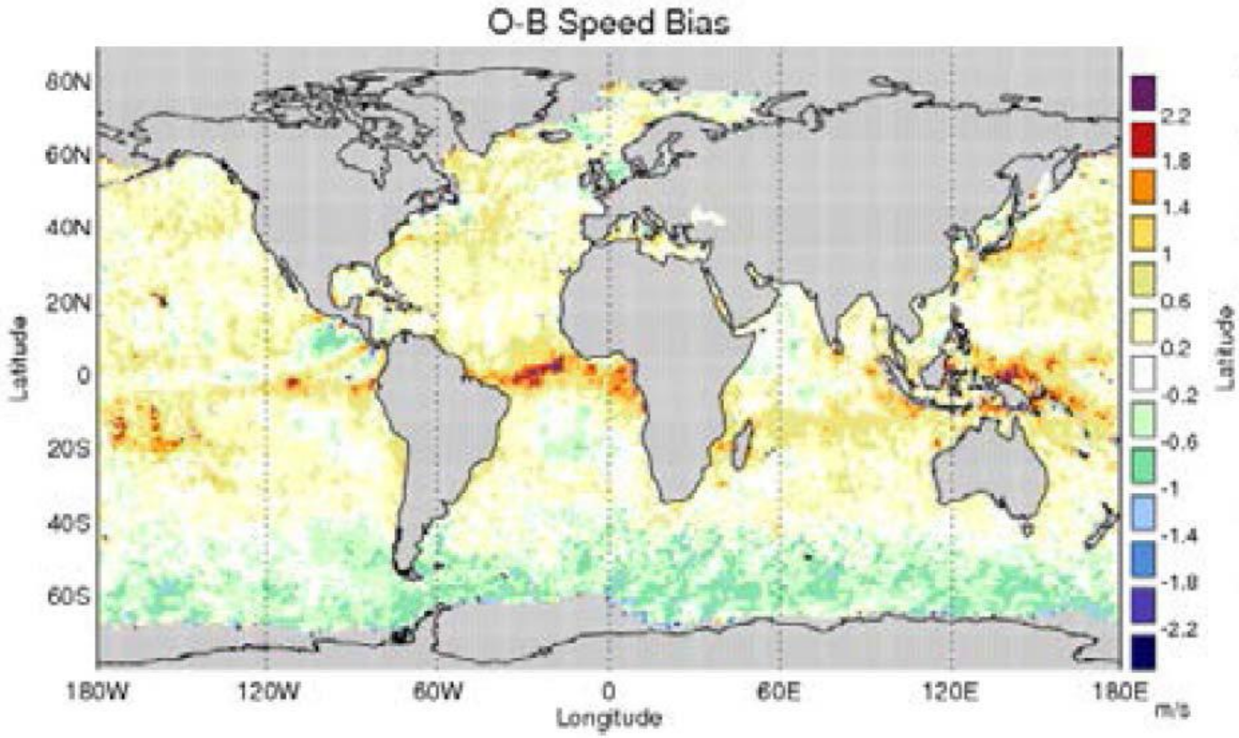
• NSCAT2 GMF

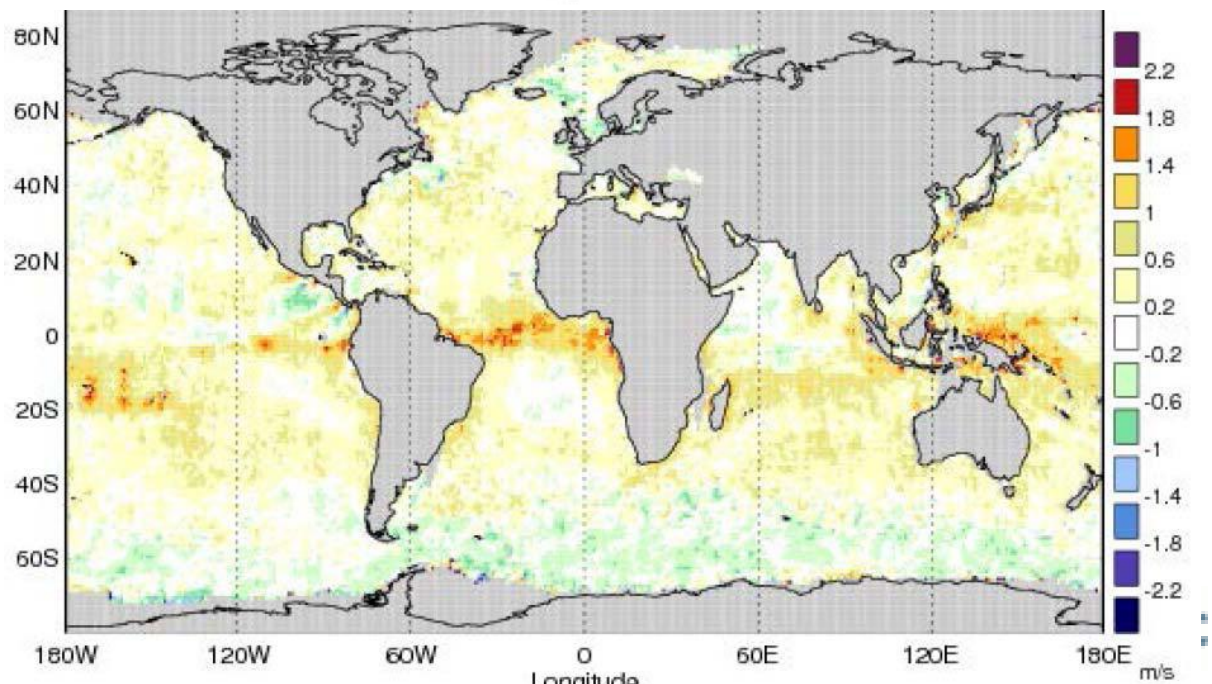
•

•OWDP version with

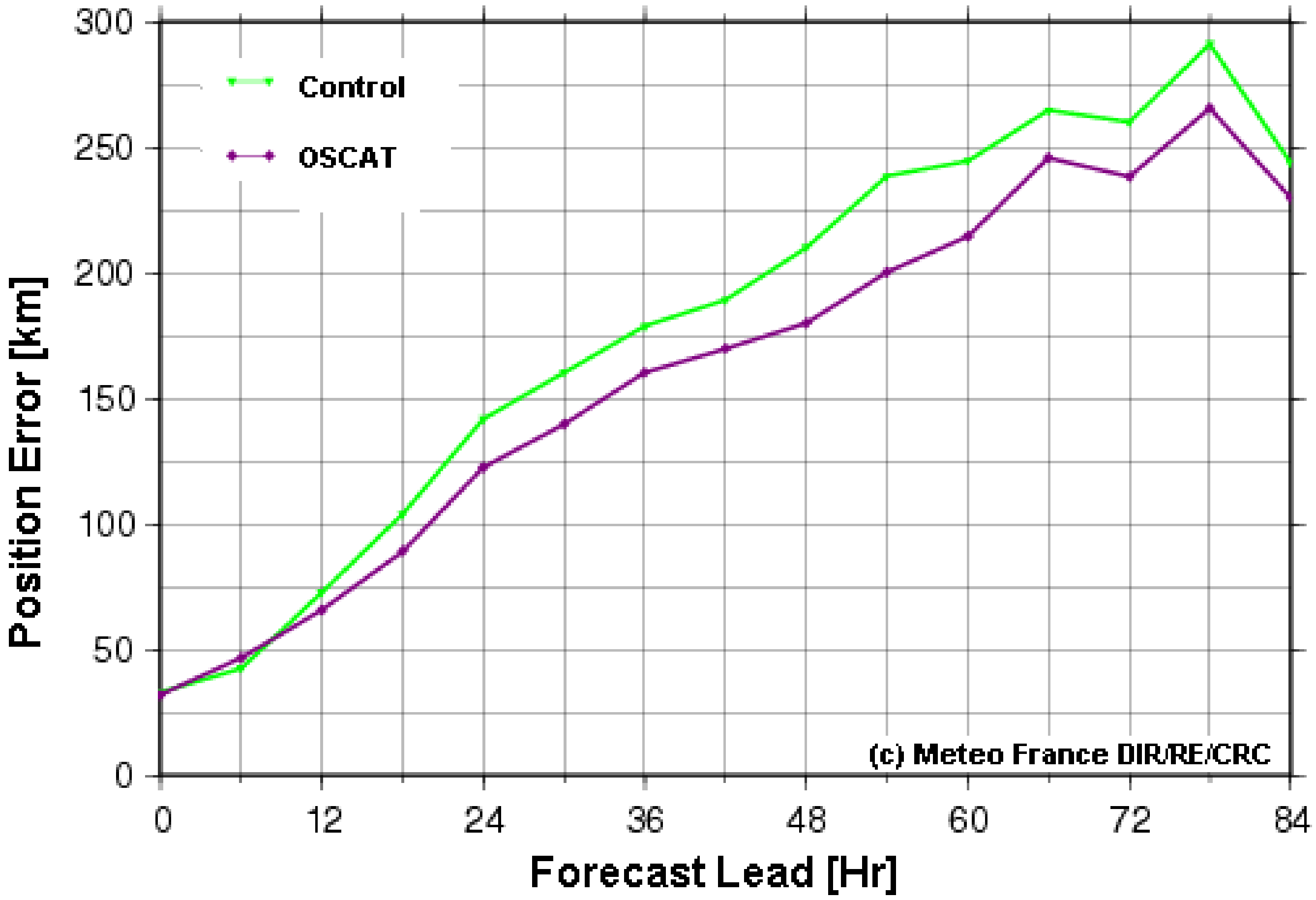
• orbit-height based backscatter bias correction in dB

• NSCAT3 GMF





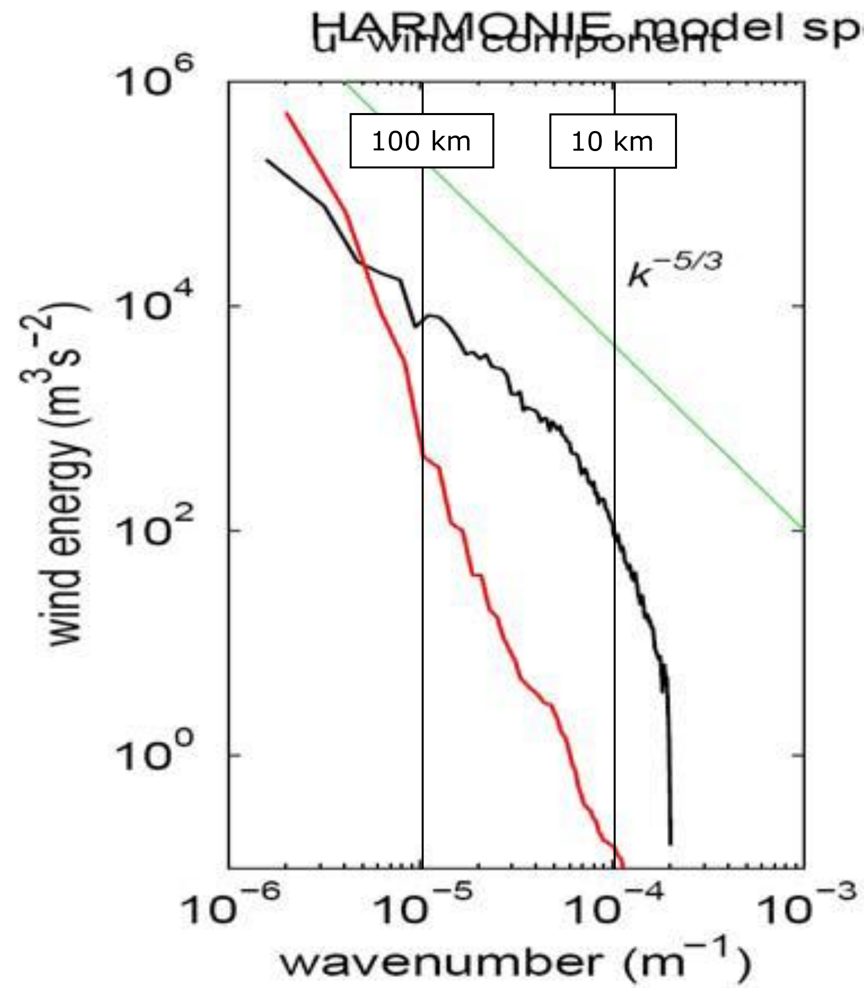
OSCAT impact in TC forecasts



•Mean position errors (of MSLP minimum) of the 2011/2012 Tropical Cyclones in the south-west Indian Ocean as forecast with the regional Aladin Réunion NWP model. An experiment with OSCAT winds (purple) is compared to a control experiment without OSCAT winds (green). ASCAT is used in both. (Dominique Mékiès, , 2013)

Mesoscale data assimilation

- km-grid models do contain 10-100 km scale variability
- These fast scales needs frequent initialization
- 1-hour / 3-hour DAS cycles
- Mesoscale dynamics are constrained by the wind
- Test NWP impact of constellation winds in extreme weather
- Waves, surges



Resume

- OSCAT is a good successor of SeaWinds on QuikSCAT and will help to extend the Ku-band scatterometer data record
- OWDP 50-km product shows good performance after some simple corrections to the backscatter data, some of which are still under investigation
- Int. collaboration with ISRO, NOAA and NASA has been very effective
- Passed EUMETSAT Operational Readiness Review and OWDP release review
- Our users requested a 25-km product on which we proceed
- OSCAT winds are beneficially used all over the globe
- HY2A winds appear potentially useful too
- Constellations impacts already visible

- This is an incentive for the IOVWST to work with NSOAS on cal/val and verification

References

Publications on OWDP, 2DVAR, sea ice, QC/rain, stress, retrieval, buoy verification, … :

www.nwpsaf.org

www.osi-saf.org

www.knmi.nl/scatterometer/publications/

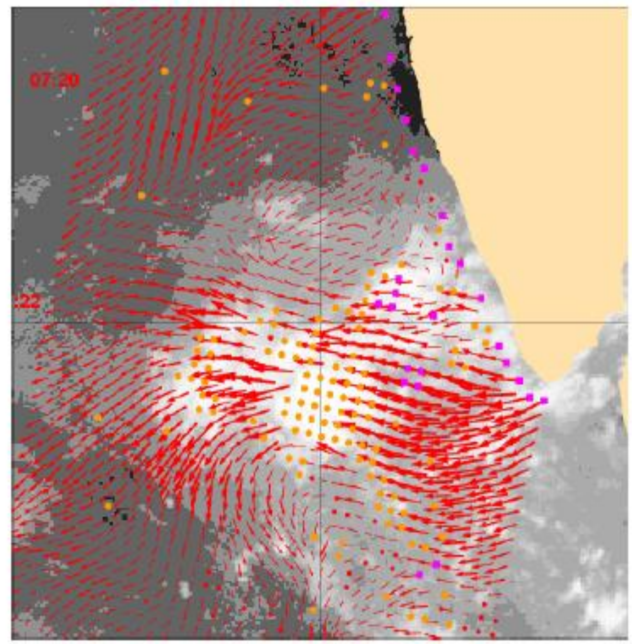
www.knmi.nl/publications/; search "Stoffelen"

scat@knmi.nl

OSI SAF Ocean and Sea Ice | NWP SAF Numerical Weather Prediction | Koninklijk Nederlands Meteorologisch Instituut, Ministerie van Infrastructuur en Milieu

Research and Development in Europe on Global Application of the OceanSat-2 Scatterometer Winds

Final Report of OceanSat-2 Cal/Val AO project



NWPSAF-KN-TR-022

SAF/OSI/CDOP2/KNMI/TEC/RP/196

Overview ECMWF comparisons

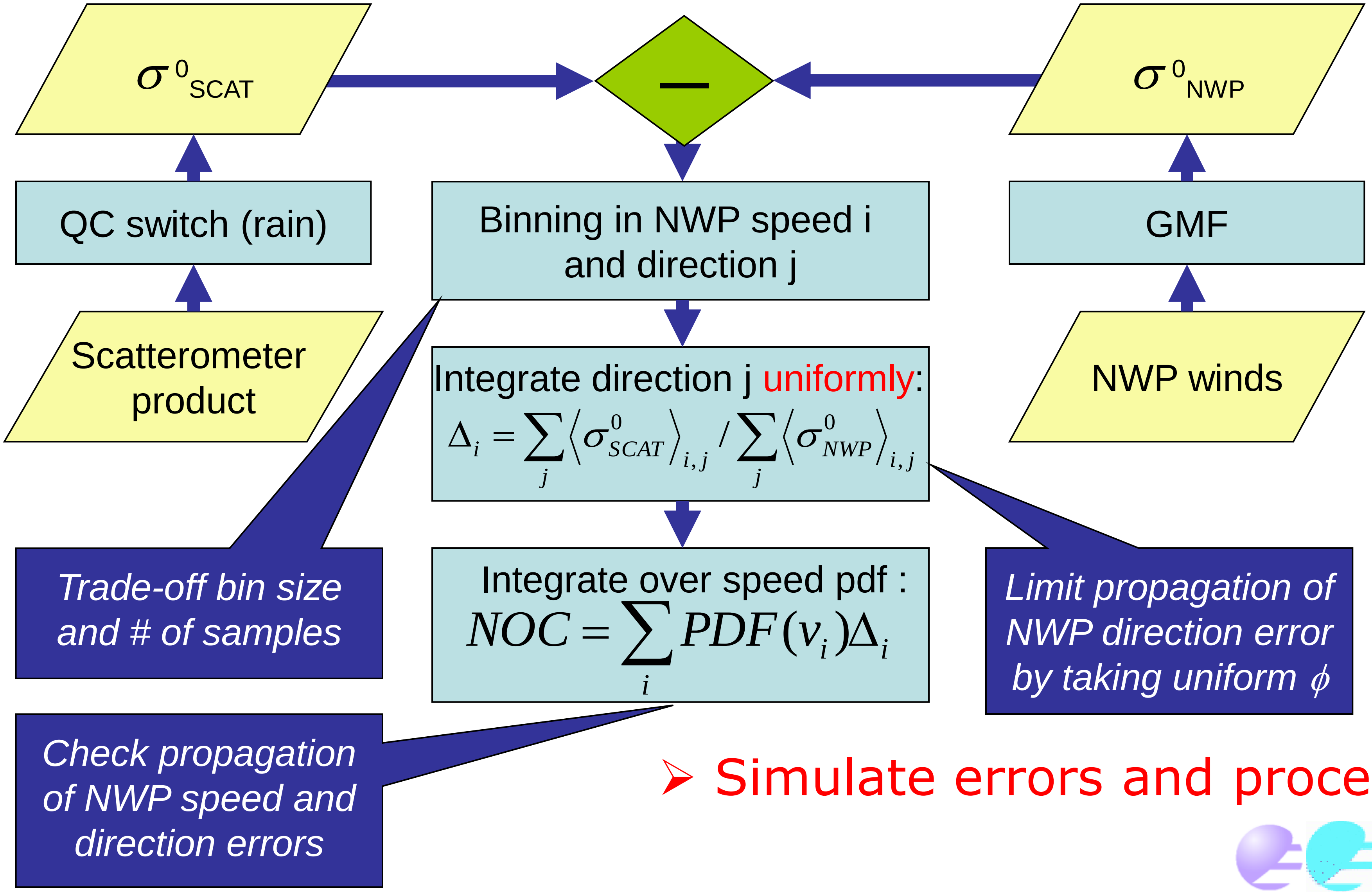
	NSOAS	OWDP all	OWDP no outer	OWDP* no outer	OWDP OSCAT
Number	685672	715592	559557	520554	284703
Bias (m/s)	-0.35	0.17	0.21	1.81	0.19
SD speed (m/s)	1.69	1.45	1.48	1.58	1.38
SD dir. (deg.)	45.11	10.72	10.58	10.80	9.78
SD u (m/s)	4.49	1.46	1.44	1.64	1.37
SD v (m/s)	3.86	1.45	1.44	1.67	1.35

- KNMI OWDP shows very similar performance for OSCAT and HY-2A after simple HY-2A corrections
- KNMI OWDP shows more data than NSOAS, but obtains good speed verification (little rain contamination left)
- Wind direction of NSOAS needs attention
- Not sure about quality flags

Preliminary analysis

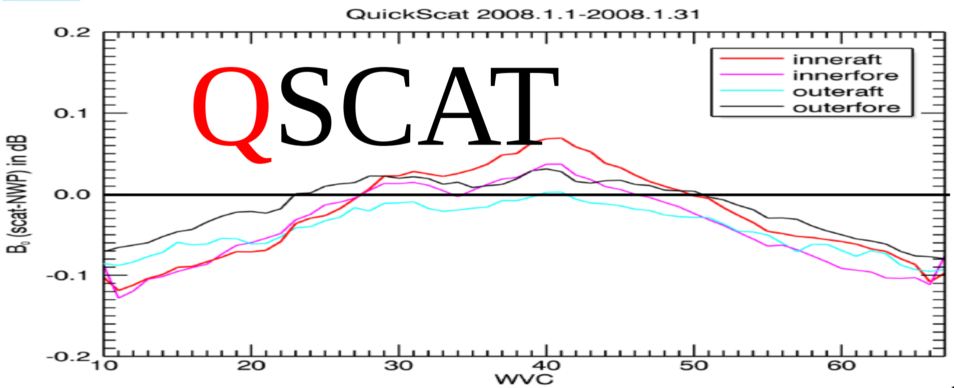
- HY-2A scatterometer measurements look excellent
- HY-2A OWDP winds are similar to those obtained from OSCAT and QuikScat after some simple corrections
- Backscatter distributions of HY-2A, OSCAT and QuikScat appear similar after a linear outer beam correction of -0.0001 and a further correction on both beams of -1.7 dB; it would be interesting to investigate these biases in more detail; L1B data may help us here
- NSOAS winds appear more affected by rain and ambiguity removal errors; we suggest to investigate this further
- More advanced ocean calibration of backscatter is under investigation at KNMI
- L1B data would be much welcomed to further investigate the HY-2A data characteristics as our experience with the cal/val of other scatterometers shows improvement can often be achieved after more detailed analysis

Ku-band NOC method per WVC

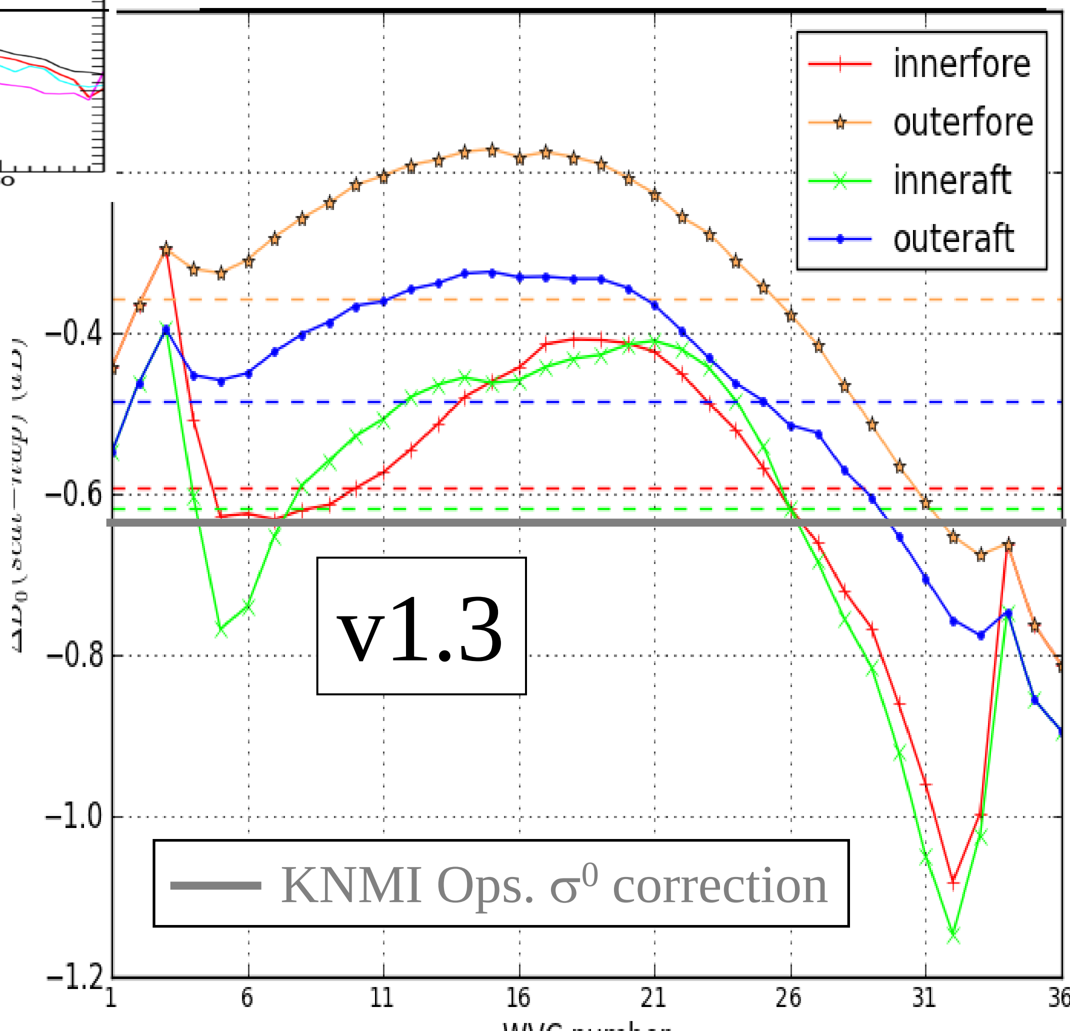


- Simulate errors and process

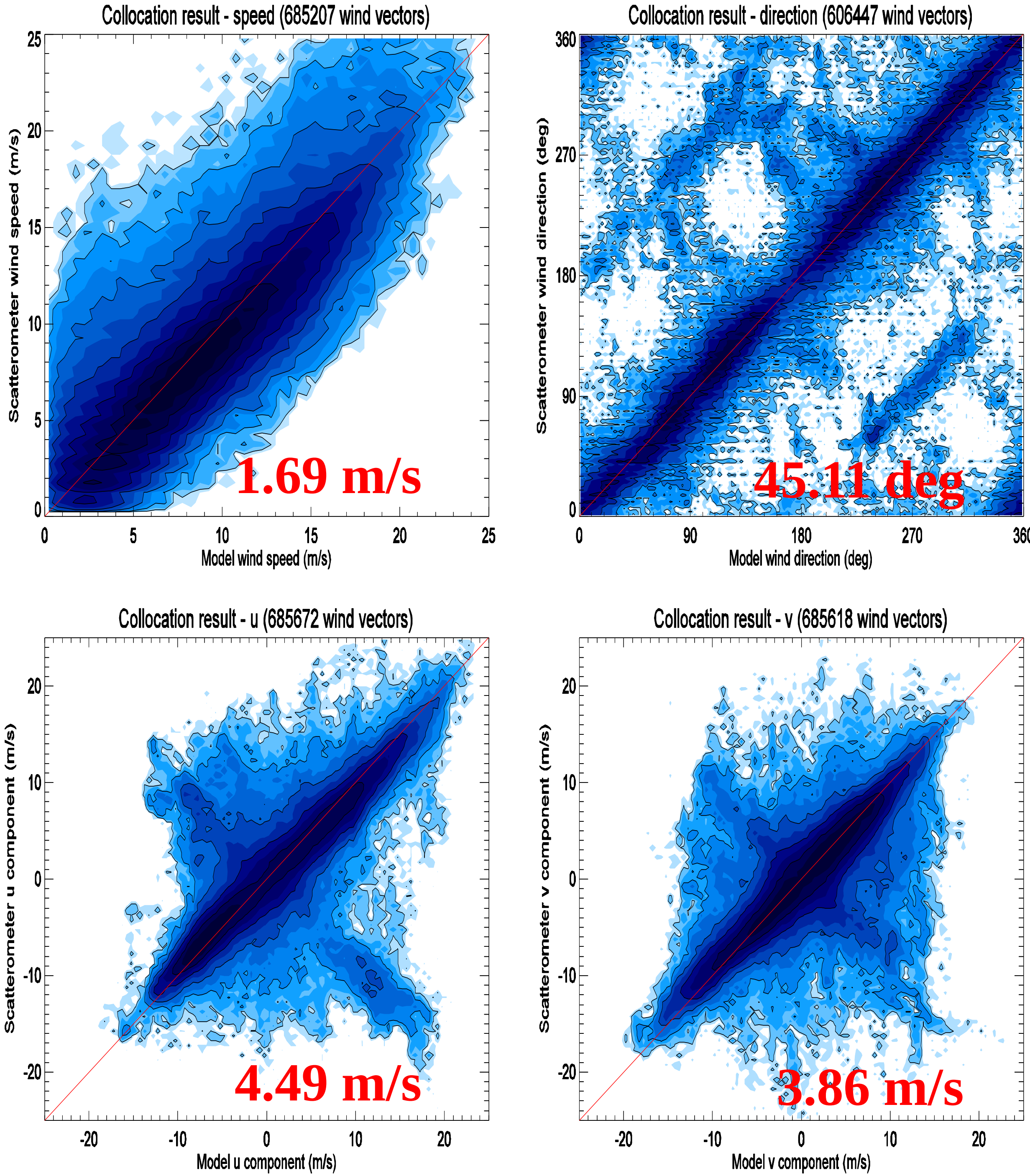
OScat vs QScat



OSCAT



- V1.3 biased w.r.t QSCAT, outer fore/aft, inner/outer
- Large fluctuations

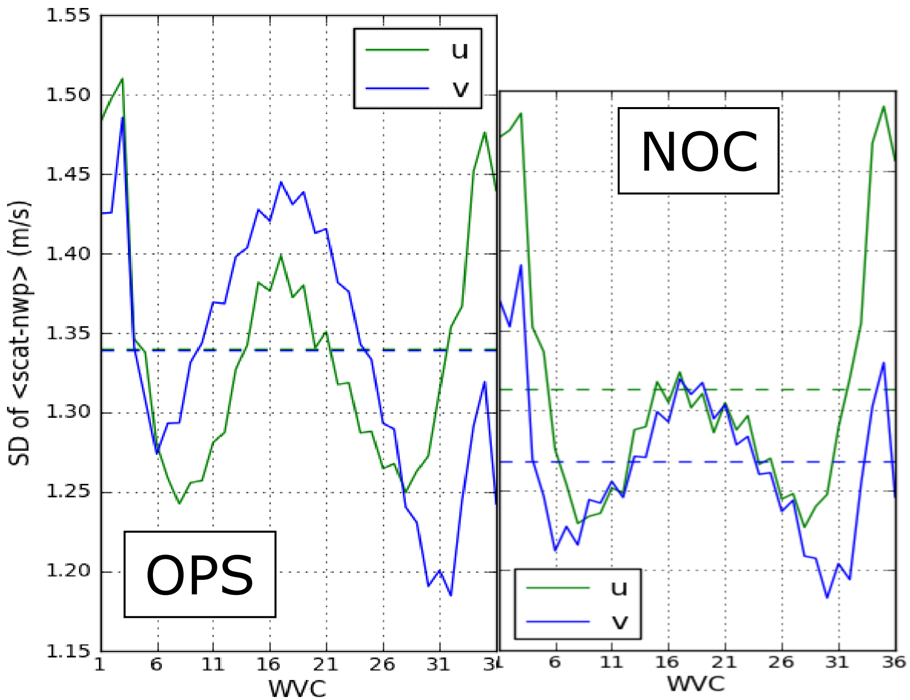


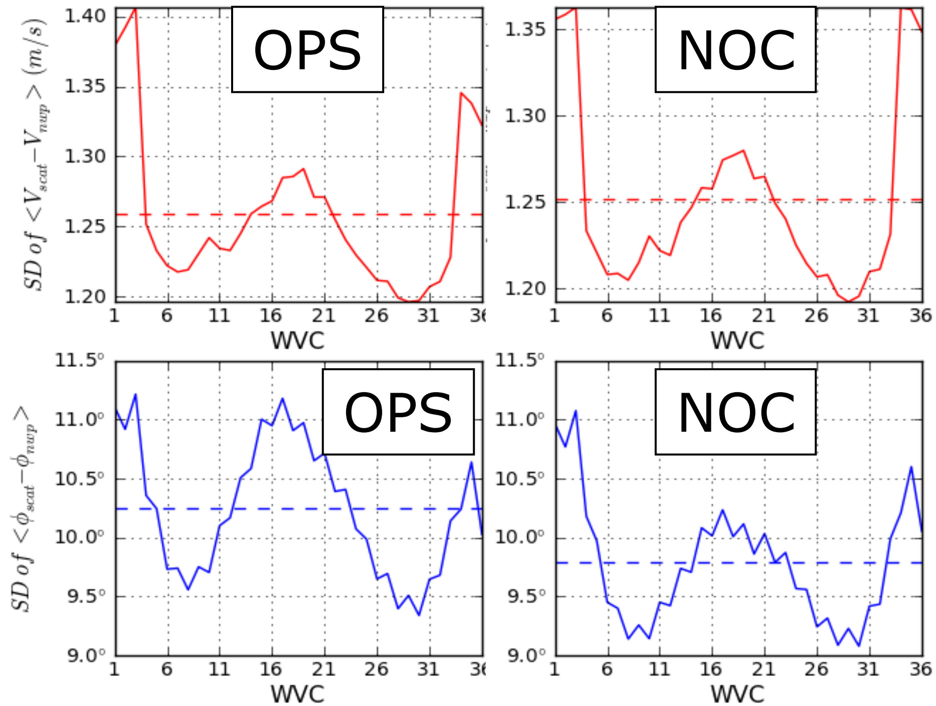
NSOAS L2B vs ECMWF

- SD of difference given in each panel
- All WVCs
- No land, no sea ice

- Rain effect visible
- Ambiguity removal issues
- Many flag bits zero

Wind effect OSCAT NOC

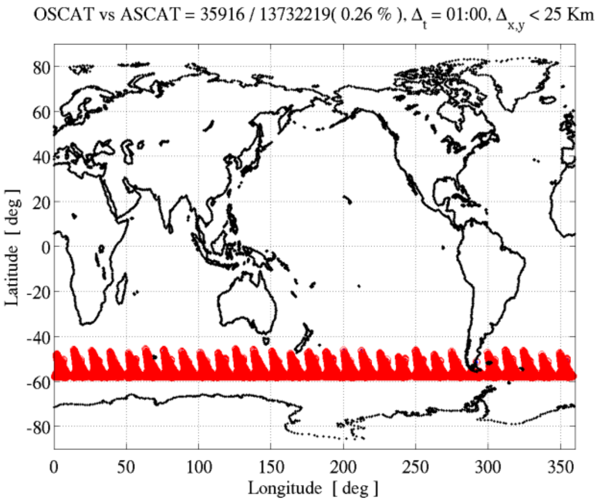


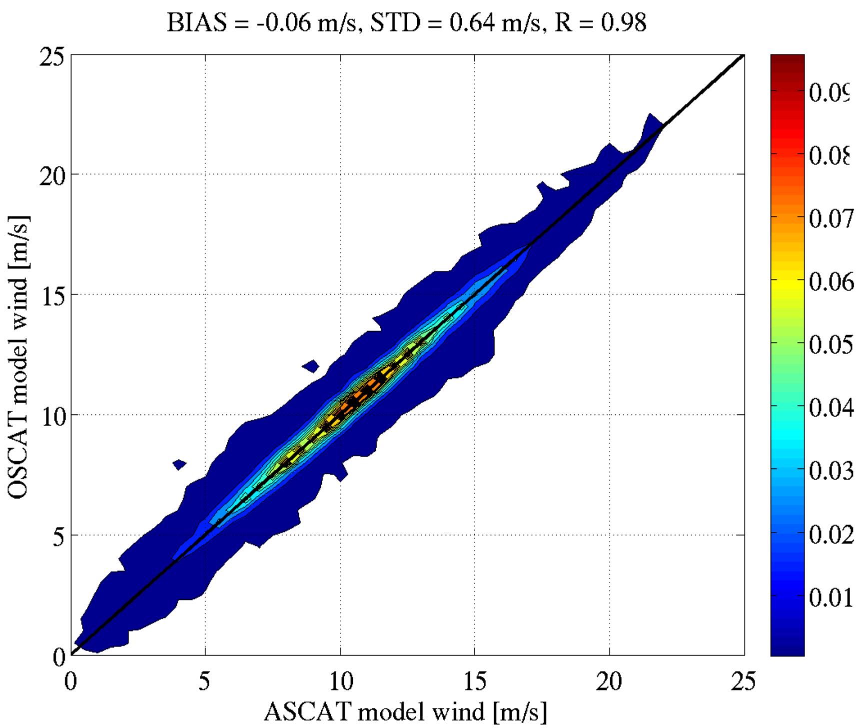


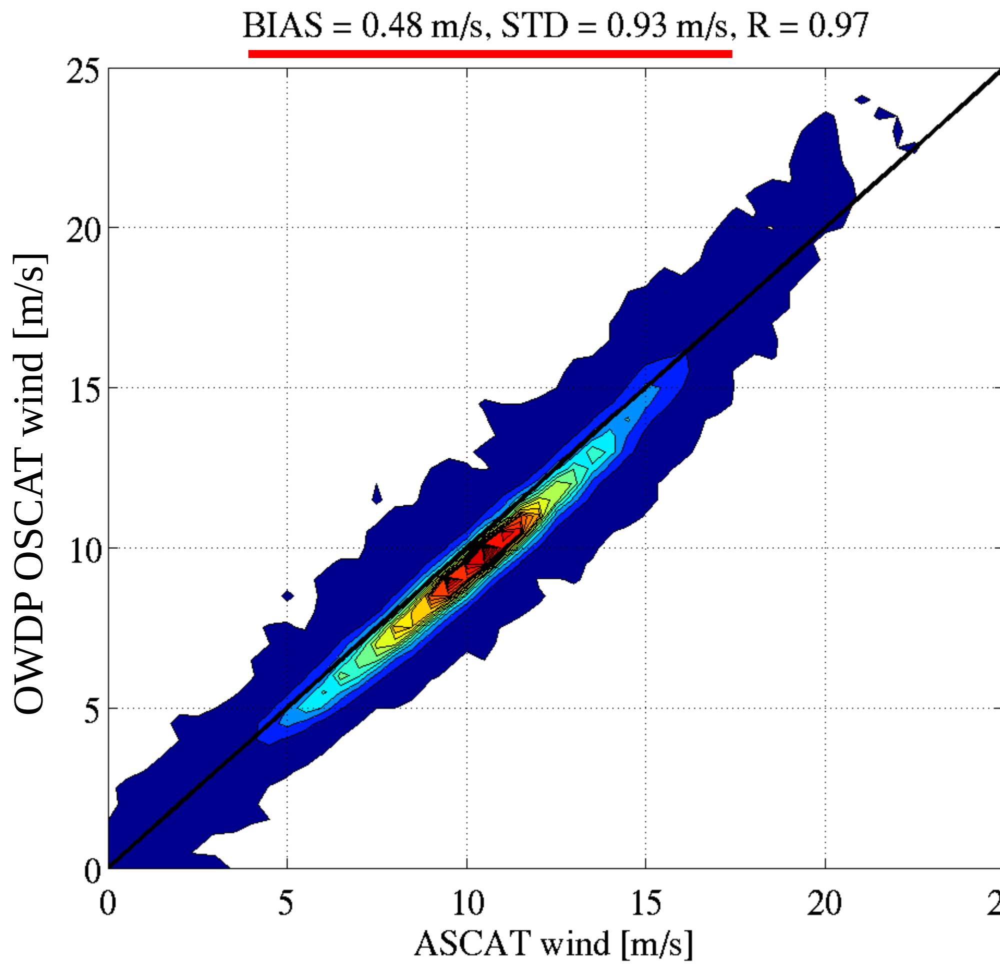
- ➢ Substantially improved wind components
- ➢ Biases remain small

- ➢ Substantially improved wind direction
- ➢ Biases remain small (not shown)

Collocation, 1H, 25km, Jan to Mar



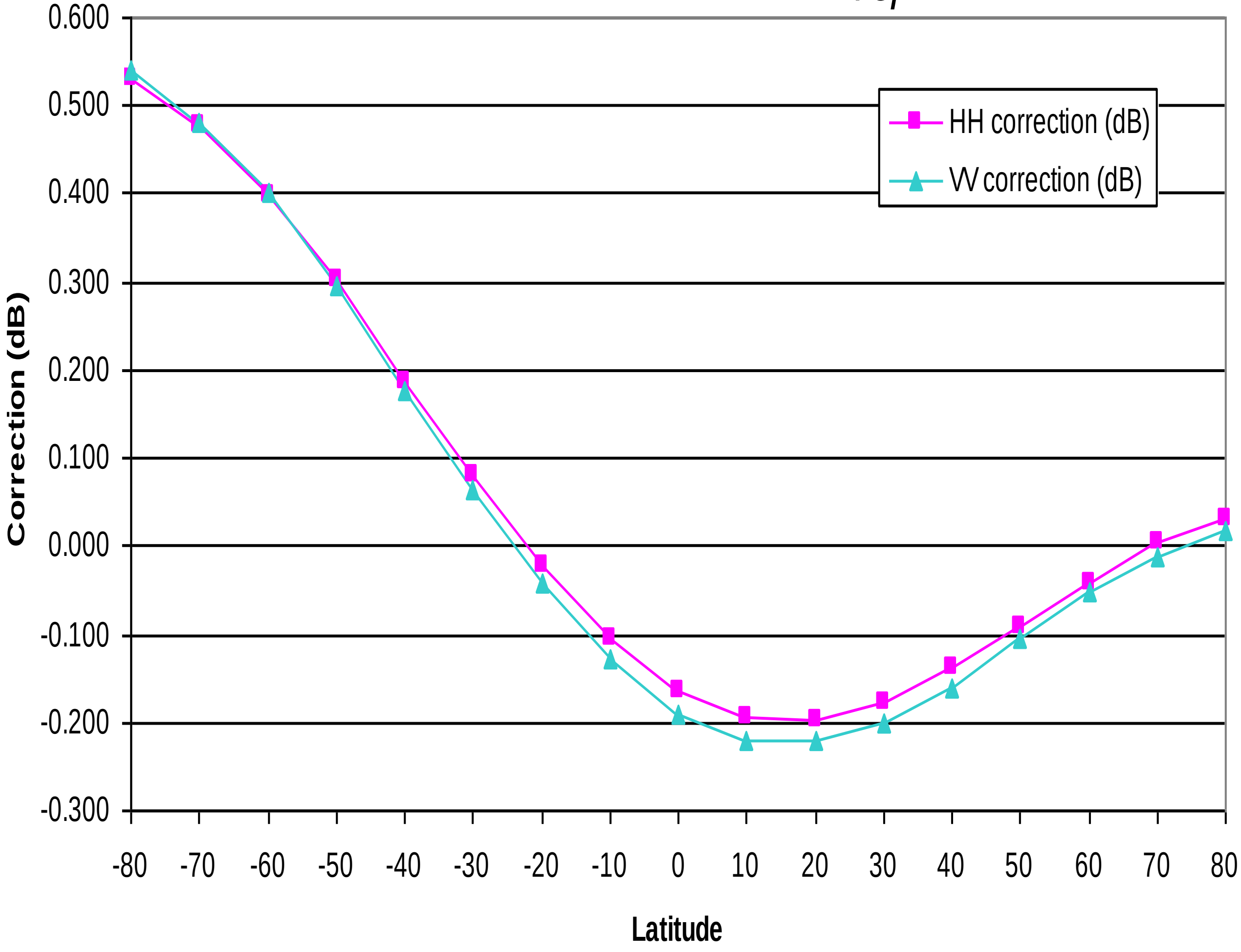




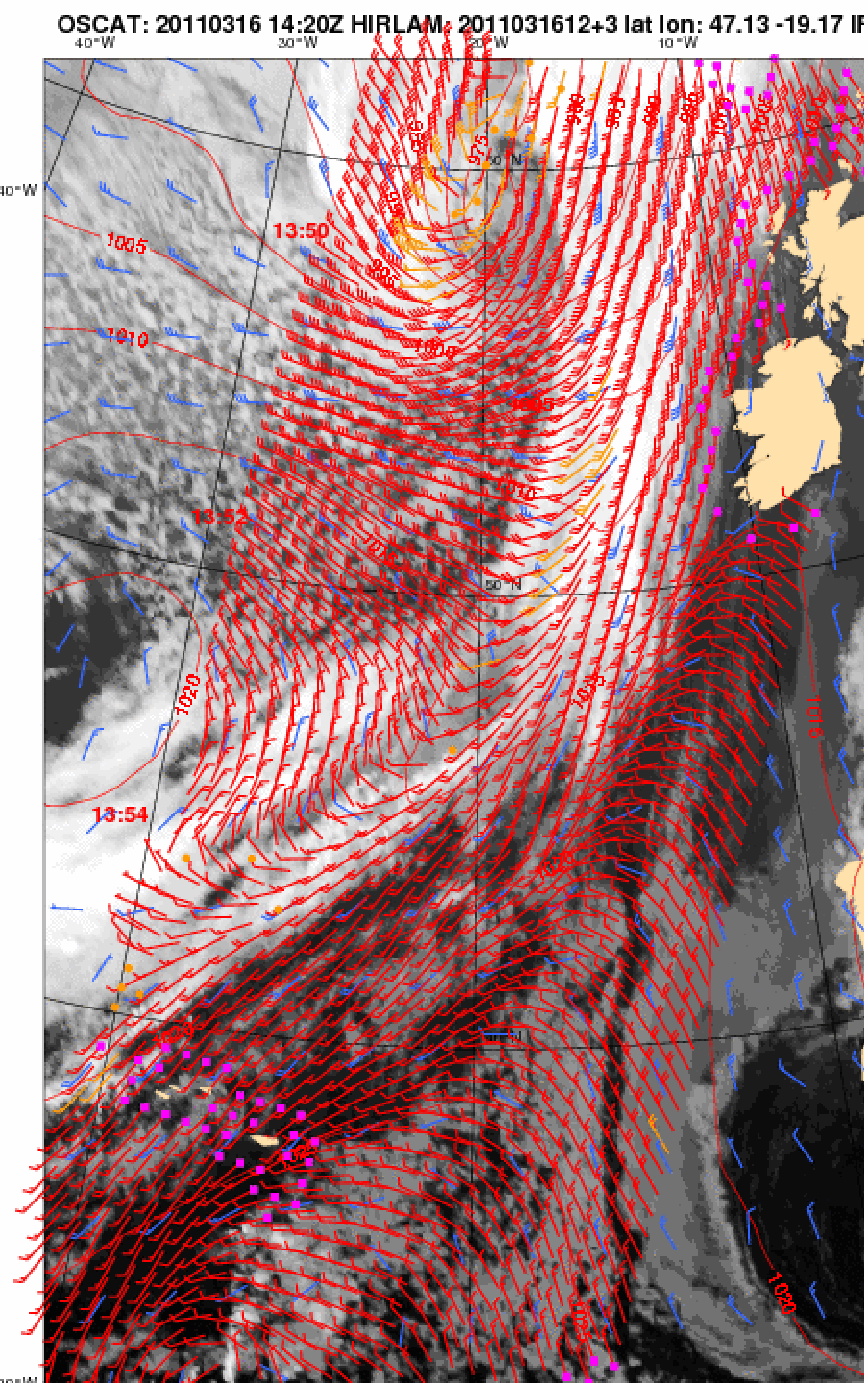
S. Guimbard, M. Portabella, A. Verhoef

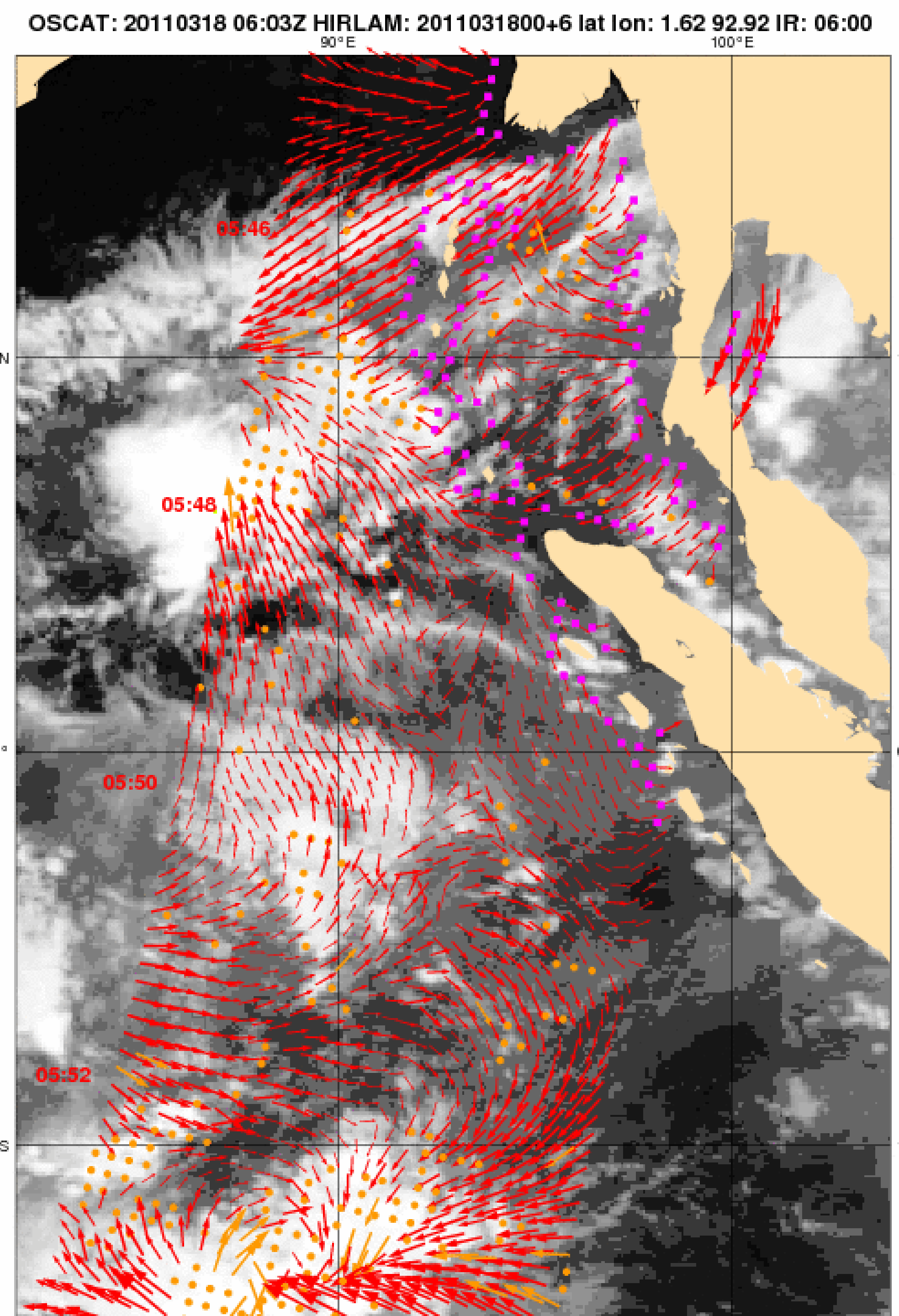
ΔG

$$\Delta G = 10 \cdot \log((R / R_{ref})^4)$$

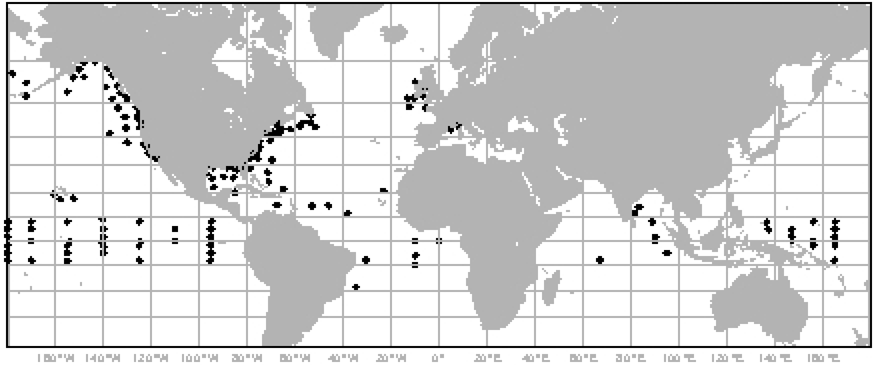


- ~0.7 dB variation along orbit
- Twice ΔX variation
- 0.35 dB is ~0.2 m/s bias reduction in the SH

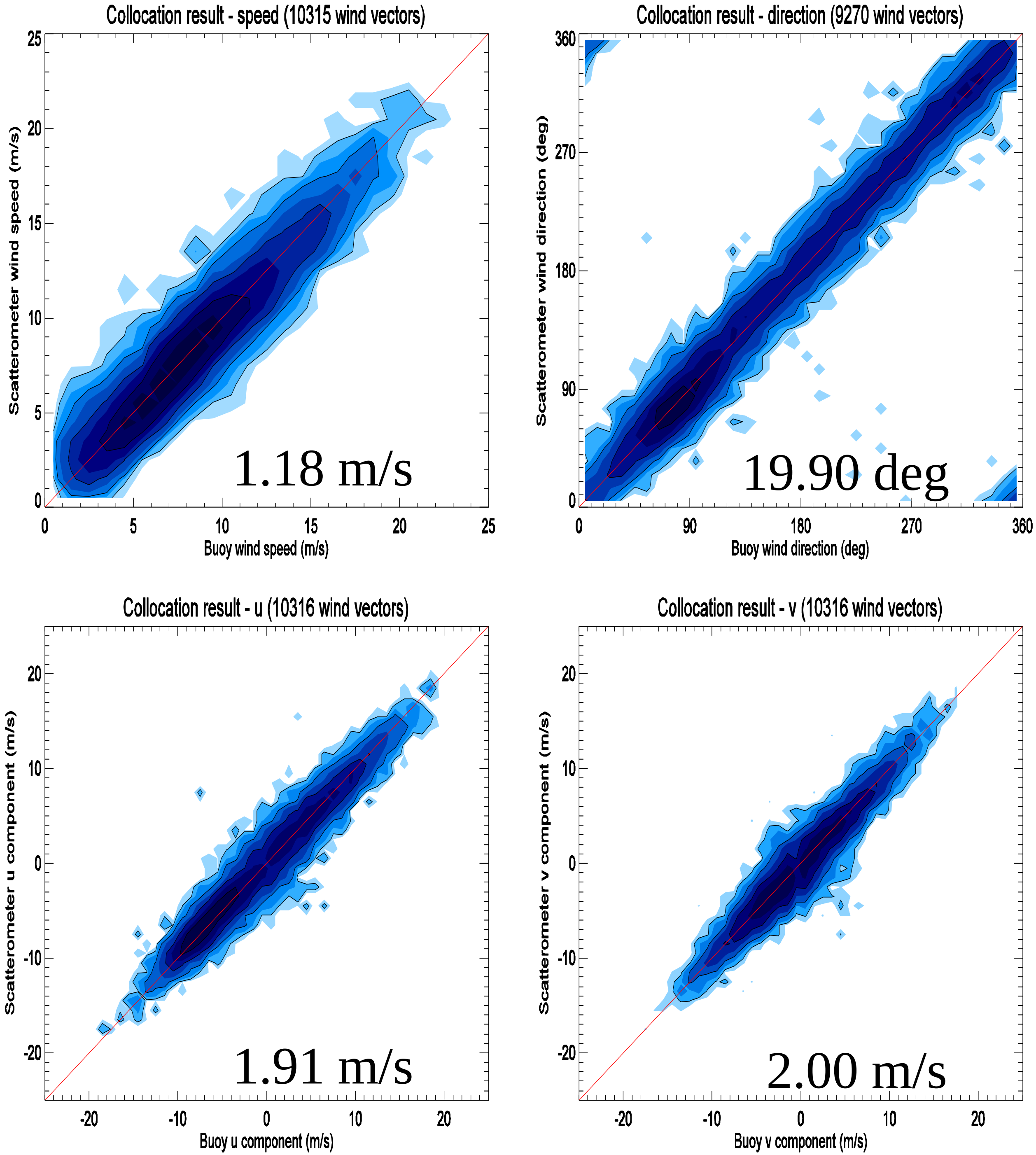

OSCAT: 20110316 14:20Z HIRLAM: 2011031612+3 lat lon: 47.13 -19.17 IR
40°W
30°W
20°W
10°W
13:50
13:52
13:54
1005
1010
1020
1015


OSCAT: 20110318 06:03Z HIRLAM: 2011031800+6 lat lon: 1.62 92.92 IR: 06:00
90°E
100°E
10°N
0°
10°S
05:46
05:48
05:50
05:52

Buoy comparison



- Monthly monitoring of OWDP, ASCAT, etc. is standard KNMI procedure in collaboration with ECMWF (Jean Bidlot)
- Extended to comparison and collocation of OWDP and ISRO L2B winds and QC
- Jan-Mar 2012

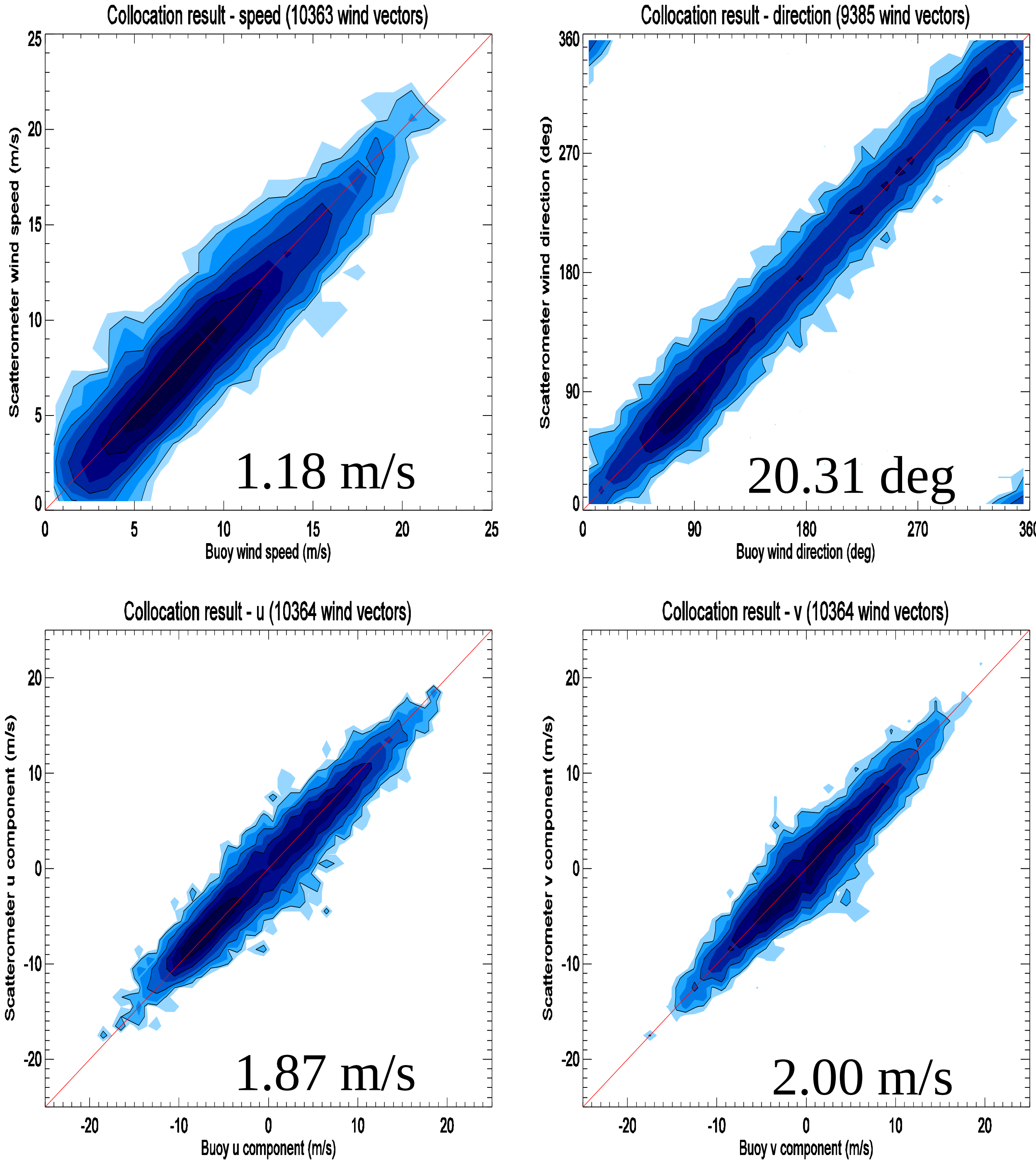


KNMI OWDPv1.3 vs buoys

- Jan-Mar 2012
- NSCAT3 GMF
- SDs given
- All WVCs
- With σ^0 corrections
- Latitude correction

➢ Less QC after latitude correction

➢ Slightly increased SD



KNMI OWDPv1.3 vs buoys

- WVCs @ 25-km
- 4 Jan-Mar 2012
- NSCAT3 GMF
- SDs given
- All WVCs
- With σ^0 corrections
- Latitude correction

➢ Less QC @ 25 km

➢ Scores comparable to 50 km

➢ Still need to test collocated data set