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Development of Consistent Geophysical Model Functions for Different Scatterometer Missions: Ku and C-band

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Outline:

- OVW satellite missions
- Intercalibration methodology
- Reprocessed QSCAT (Ku-2011 GMF)
- Development of consistent GMF for ASCAT

Presented at the 2012 NASA International Ocean Vector Wind Science Team meeting
Utrecht, Netherlands, June 2012

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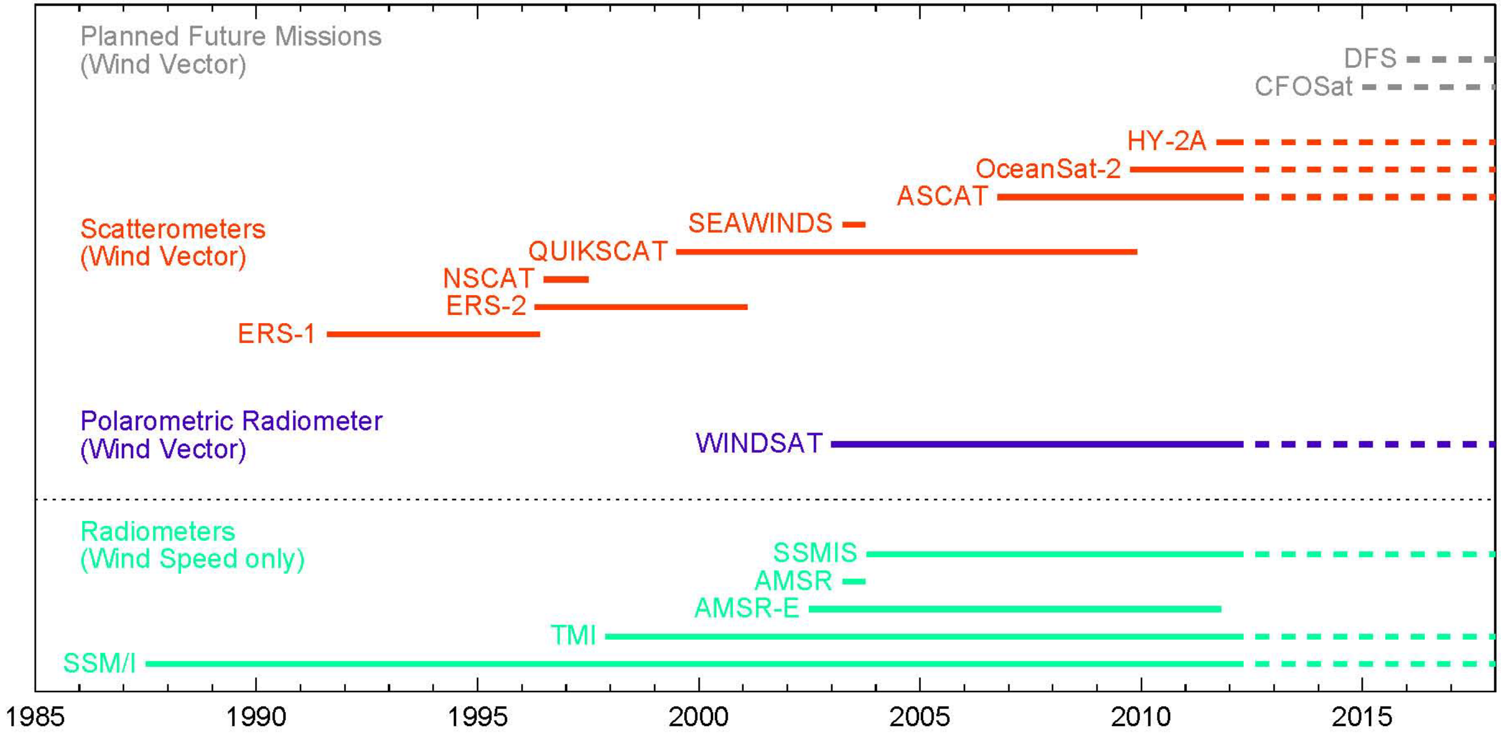
Ocean Vector Wind Missions



1. **Goal: After QuikSCAT, continue the OVW time series using ASCAT**
2. **Long-term goal: produce an intercalibrated climate-quality data record starting with ERS (Wind Vector) in 1991, and with SSMI in 1987 for wind speed.**
3. **Use QuikSCAT as backbone. QuikSCAT was reprocessed using the new GMF, Ku-2011, developed to improve high wind speed retrievals.**
4. **Use QuikSCAT methodology and calibration target to develop a new ASCAT GMF**

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Intercalibration Methodology

- Accurate intercalibration of climate-quality retrievals requires consistency at all wind speed ranges.

- For this purpose it is best to start from the GMF, rather than intercalibrating wind retrievals.

- The GMF is the Geophysical Model Function which relates the observed backscatter ratio to surface wind speed and direction.

- We recently reprocessed all MW radiometer geophysical retrievals at RSS using a Radiative Transfer Model common to all (SSM/I, SSMIS, AMSRE, WindSat). The new radiometer data record is identified as V7.

- For the scatterometers, differences in viewing geometry and frequency do not allow using a common GMF. However we will follow the same methodology and calibration standard to develop consistent GMFs for different scatterometers.

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QuikSCAT New GMF Ku-2011

A new GMF Ku-2011 was developed to improve high wind speed retrievals between 20-30 m/s.

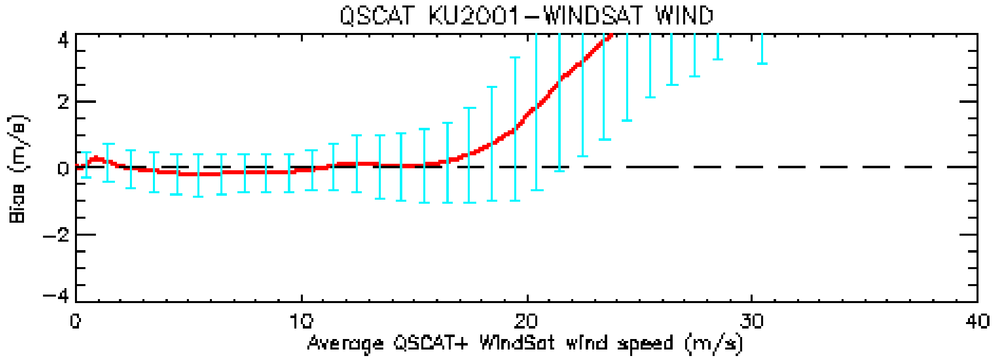
$$\sigma_0 \cong \sum_{i=0}^{N=5} A_i(w)_{pol} \cos(i\varphi_R)$$

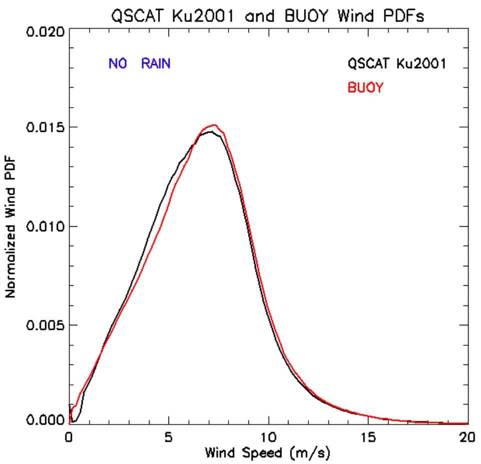
Methodology

- To develop the new GMF we used 7 years of QSCAT sigma0 colocated with WindSat wind speeds (90 min) and CCMP (Atlas et al, 2009) wind direction.
- WindSat also measures rain rate, used to flag QSCAT sigma0 when developing GMF
- We had hundreds of millions of reliable rain-free colocations, with about 0.2% at winds greater than 20 m/s.
- The new QuikSCAT Ku-2011 winds were released in April 2011, available at www.remss.com
- The GMF Ku-2011 was also delivered to JPL, and was used in the newly reprocessed JPL QSCAT winds V3.

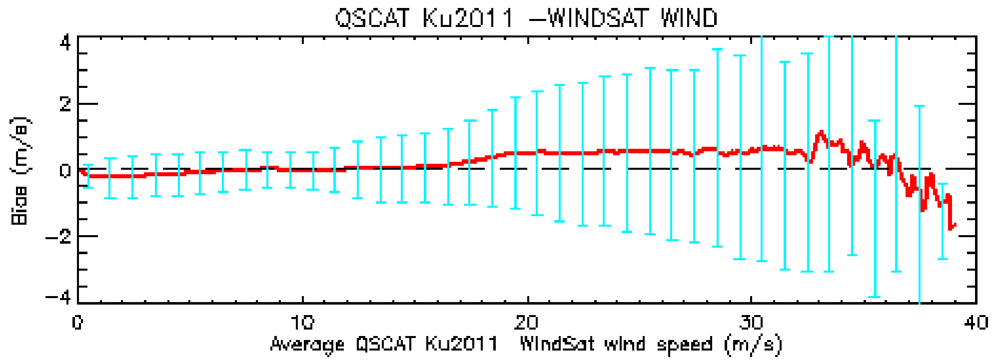
QuikSCAT Validation, 5 yr Stats, Rain-Free

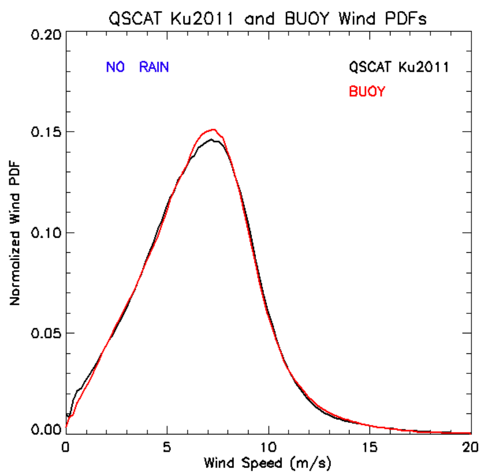
Ku2001





Ku2011





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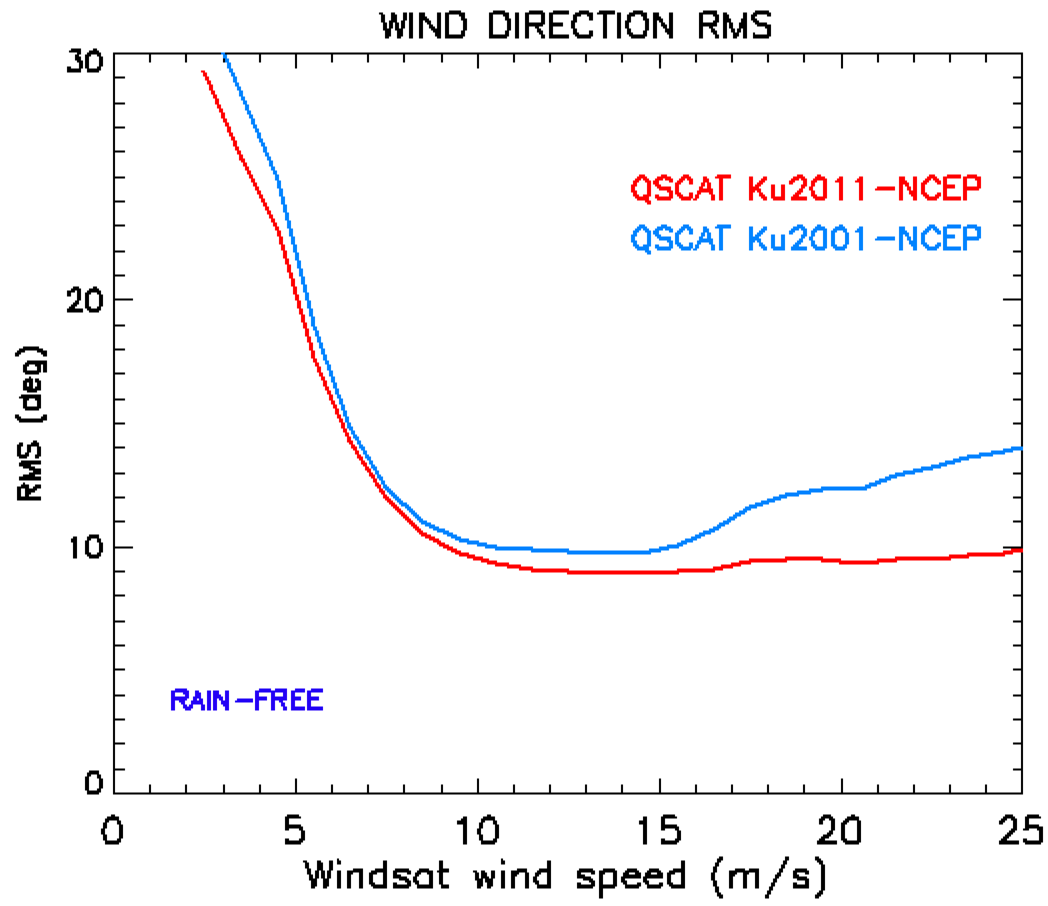
QuikSCAT Wind Direction Validation



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Rain Impact on QuikSCAT Winds

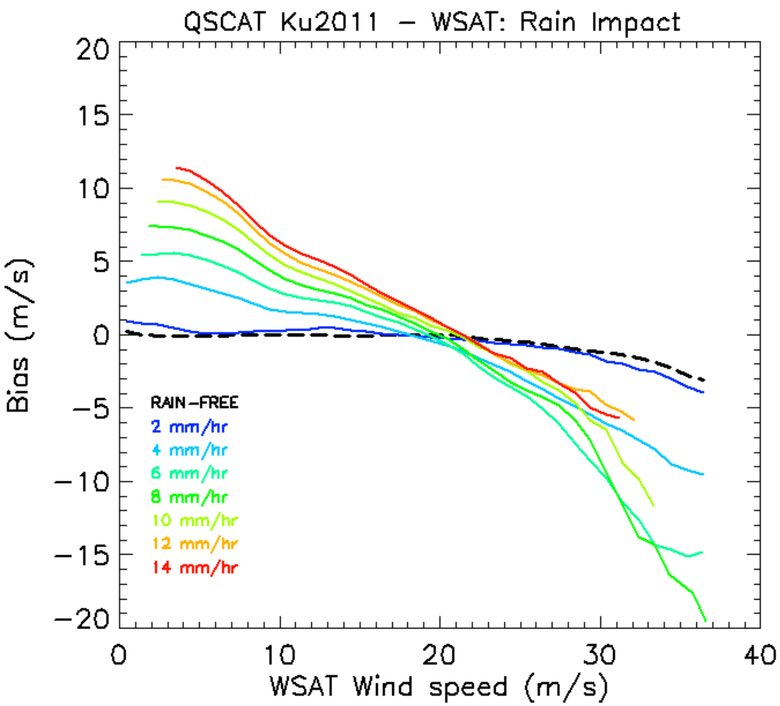
- Ku-2011 was designed to be for rain-free retrievals

- We used 5 yrs of WindSat/ QuikSCAT wind retrievals in rain to determine statistics of rain impact on QuikSCAT

- Bias is proportional to rain intensity

LOW WINDS → POSITIVE BIAS
HIGH WINDS→ NEGATIVE BIAS

- In principle, the GMF can be designed to performed better in rain, in a statistical sense. But rain-free low/high winds would be biased.



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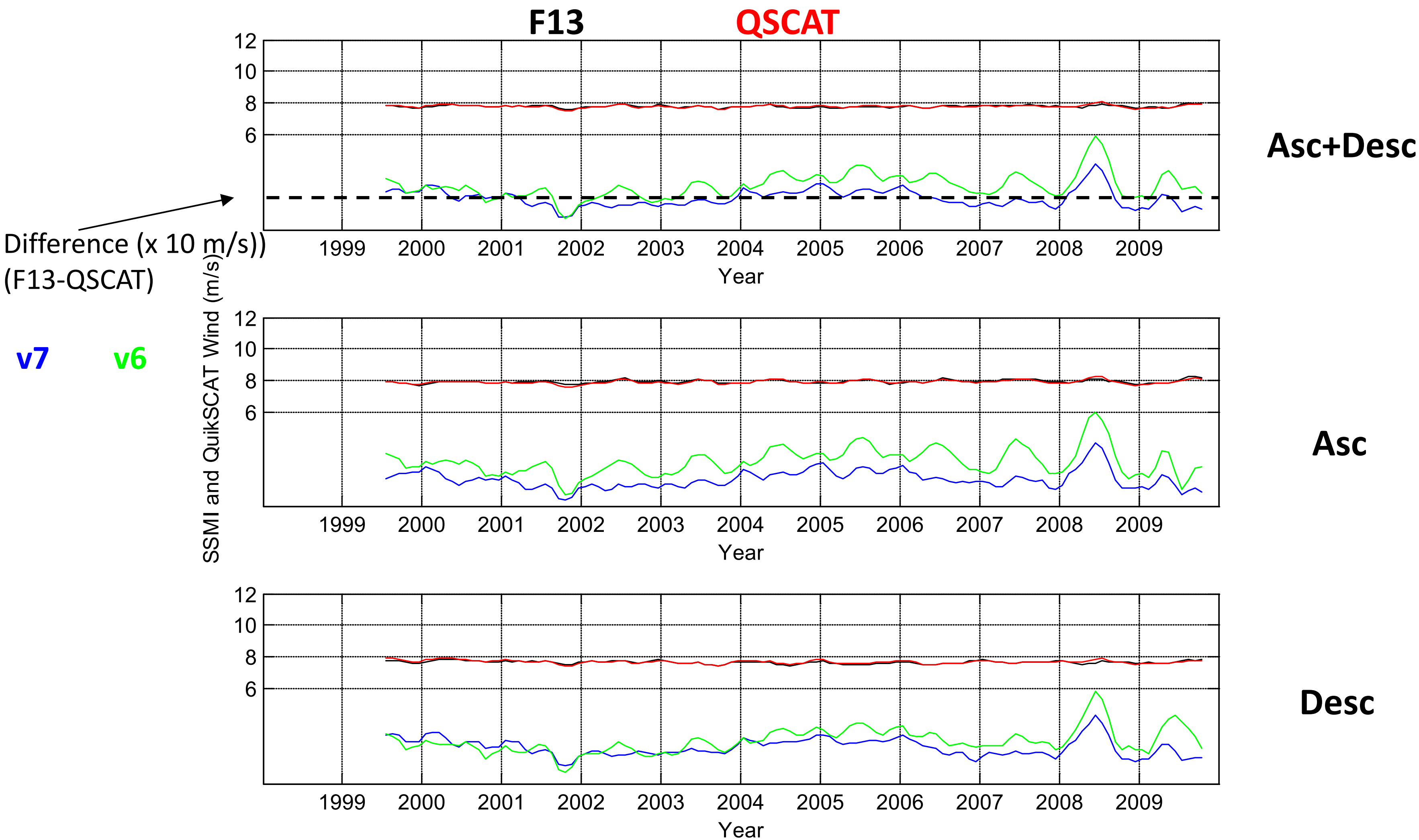
SSMI F13 versus QuikSCAT Timeseries



F13 and QuikSCAT both cross the equator at 6 LT → Colocations close to the equator

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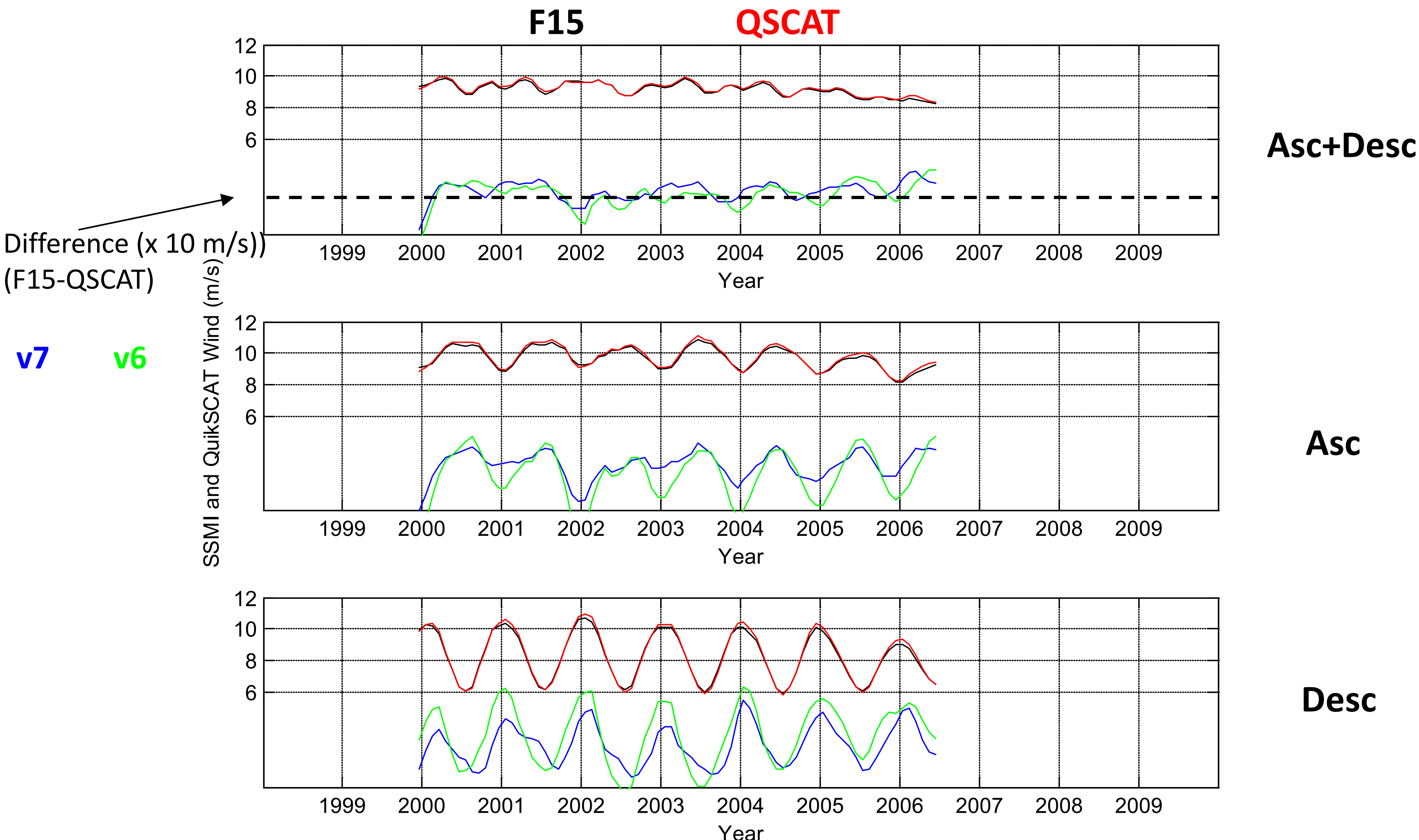
SSMI F15 versus QuikSCAT Timeseries



F15 crossing time drifted from 9pm to 4pm → Colocations off the equator, changing in time (slope) and being affected by seasonal changes to average wind (annual cycle)

New ASCAT GMF

L1B file reorganization

- L1B data from EUMETSAT: May 2007-June 2011
- HDF5 swath files of sigma0 triplets (one for each antenna beam) for 12.5 Km Wind Vector Cells
- Reorganized orbits with RSS definition: orbit begins/ends at S Pole

Sigma0 colocation files

- Colocation files are needed to develop the GMF
- Created colocation files, by colocating each ASCAT sigma0 with CCMP, SSMI, WindSat wind speed and direction, rain rate and time difference (< 3 hrs). Colocations are sequentially listed. Additional variables in colocation files are WV Cell number, incidence angle, time, lon, lat.
- 4 years of data (20000 orbits): One colocation file for each 100 orbits is about 600 Mb.

Issues in Creating Sigma0 Table Needed for GMF

GMF: $$\sigma_0(\theta) = f(w, \varphi_R)_\theta \cong \sum_{i=0}^{N} A_i(w,\theta)\cos(i\varphi_R)$$

GMF coefficients from harmonic decomposition

Quality of GMF depends on:

- **Source of ancillary data for *w* and Φ (CCMP, SSMI, WSAT, NCEP, buoys…)**
- **Large number of colocations at all wind regimes, and incidence angle θ**
- **Reliability of ancillary data: Colocation time window**
- **QC of sigma0: Rain impact on sigma0: can we use sigma0 in rainy conditions? C-band (ASCAT) is less affected by rain than Ku-band (QuikSCAT)**

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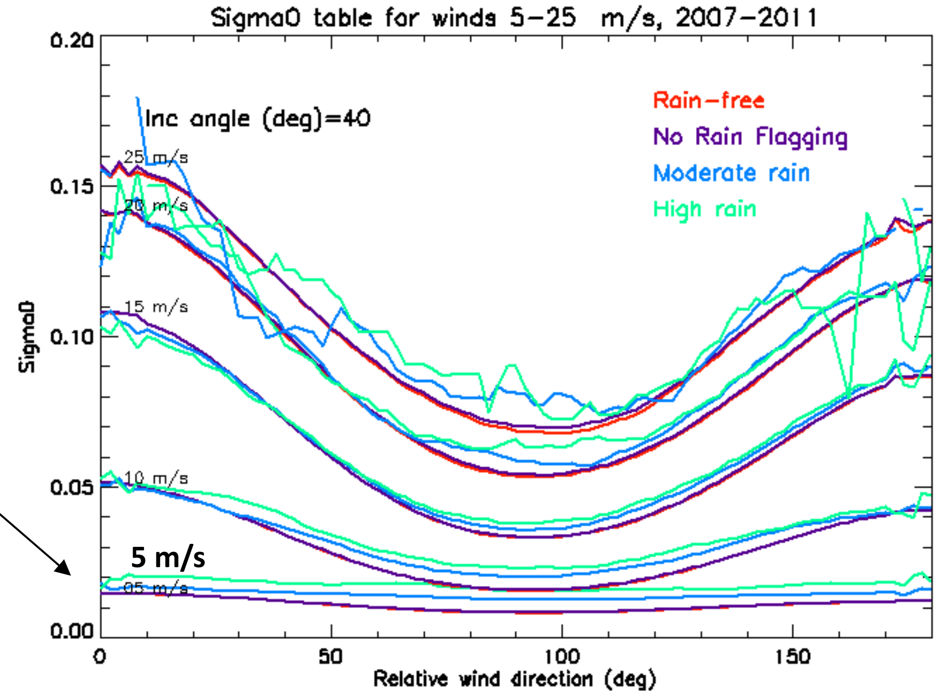
a. Rain Impact

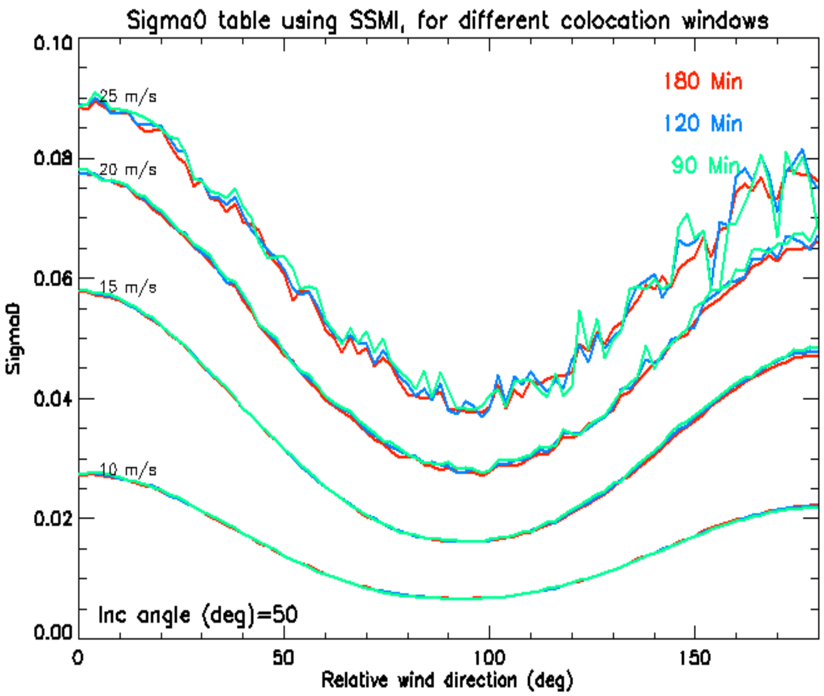
- We looked at the sigma0 table for selected observations in rain compared to rain-free
- Sigma0 at C-band are significantly impacted by rain at low winds.
- Likely, they are impacted also at high winds, but we don't have enough observations to distinguish the signal from noise.

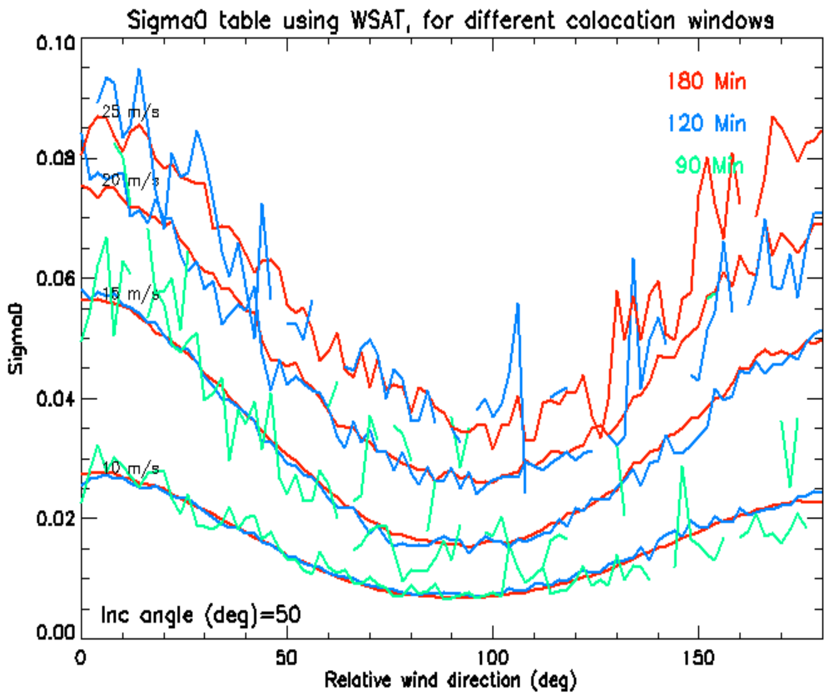


• **Conclusion**: we have to use sigma0 colocations for which an ancillary rain-rate is available in order to discriminate rain-free obs. The requirement significantly reduces the number of colocations (more than 50%).

b. Colocation Time-Window

- We tested 90-120-180 minutes time window with SSMI and WindSat
- Note: ASCAT and WindSat local ascending node times are 2-3 hours apart
- Best colocation match is with SSMIS F16 (8pm)





• **Conclusion:** 120 min is the best compromise between number of colocations and quality (tight colocation).

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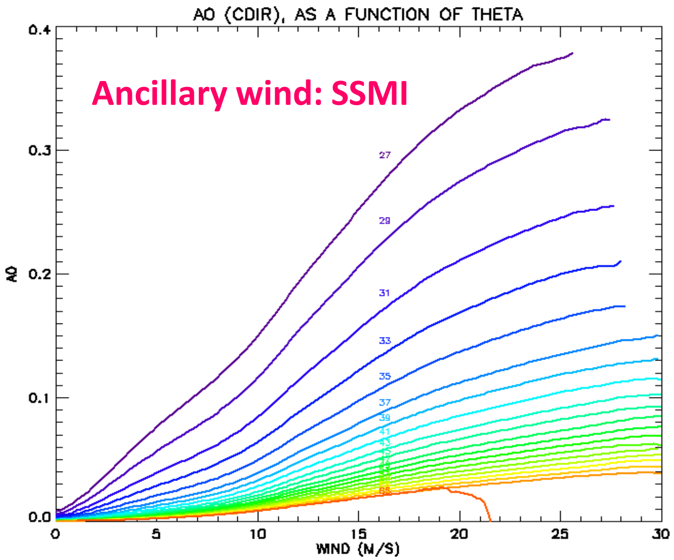
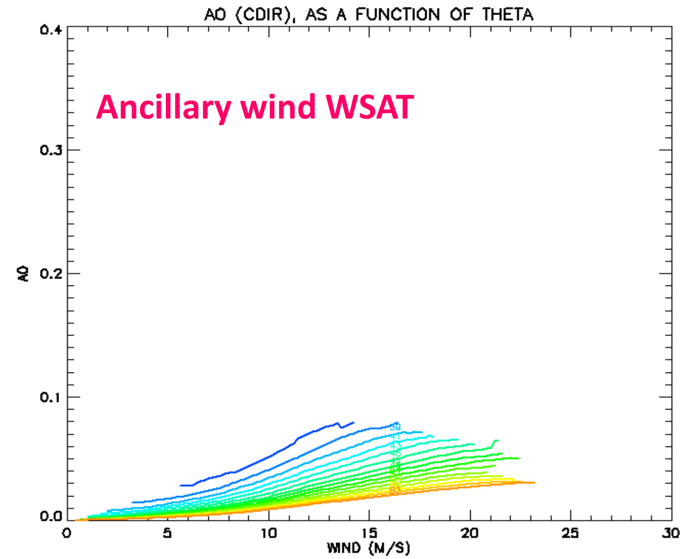
c. Ancillary Wind Speed

- We considered: CCMP, SSMI+SSMIS, WindSat, and a combination of SSMI (2 billion colocations, 120 min) +WindSAT (15 million colocations, 120 min)
- We performed the harmonic decomposition for all cases
- WSAT alone: not enough colocations;
- CCMP: very similar to SSMI results, but less physical behavior at very low winds

A0 coefficient



Wind speed (m/s)



Wind speed (m/s)

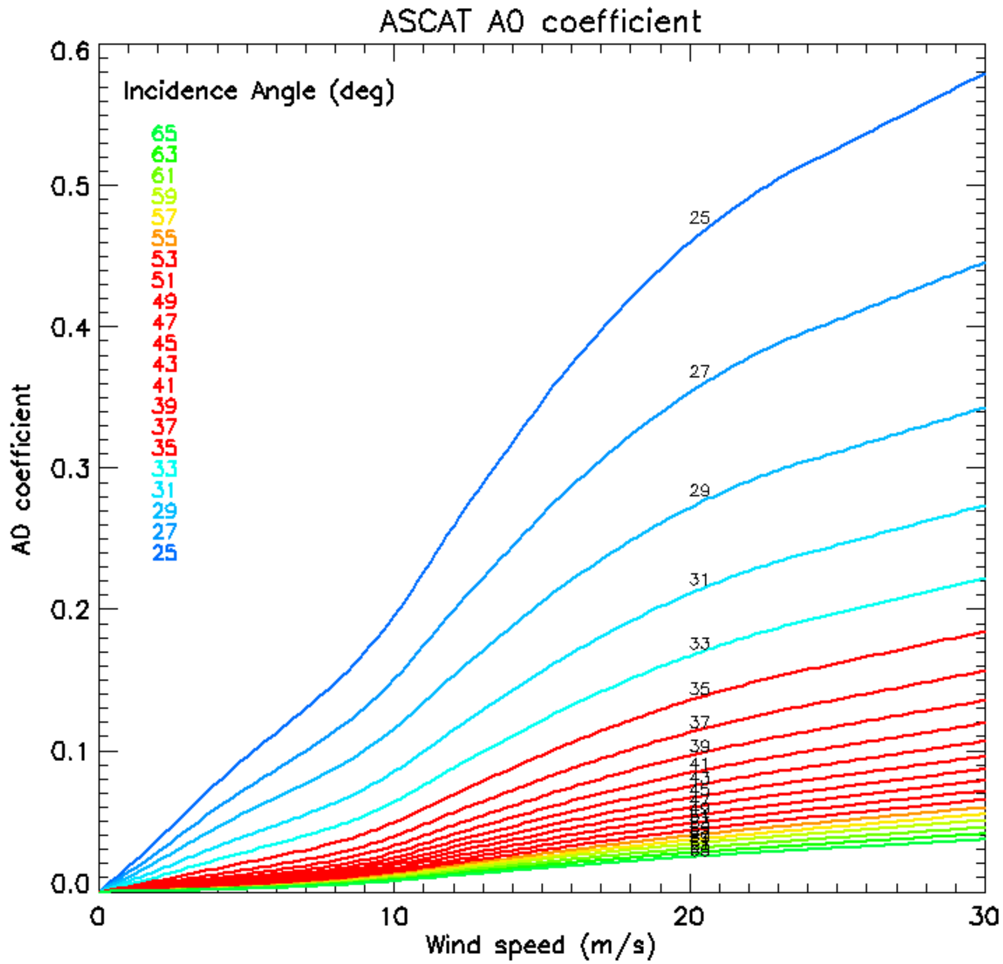
•**Conclusion:** use combined SSMI+WSAT. SSMI and WSAT V7 are intercalibrated, same calibration standard as QSCAT.

Summary of ASCAT GMF Methodology

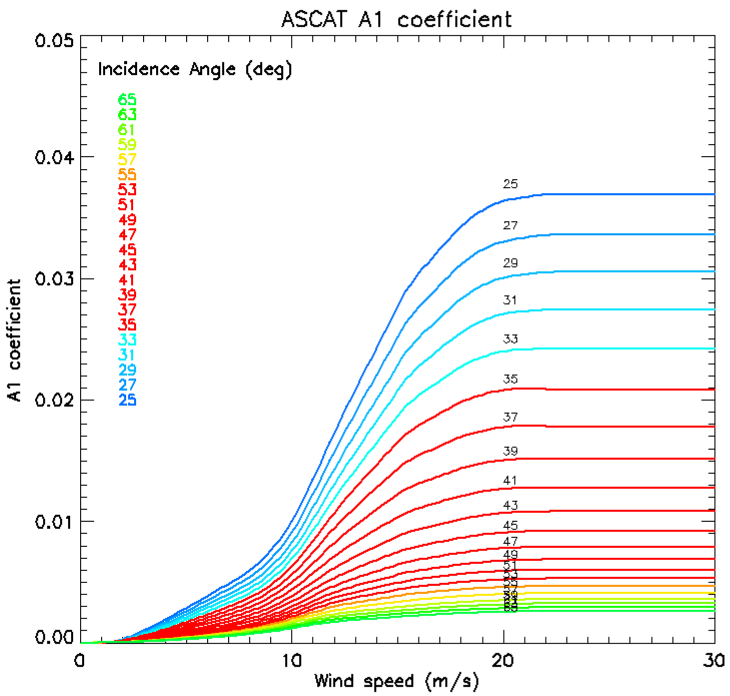
- We performed a harmonic decomposition of the sigma0 table by using
  - SSMI+WSAT wind speed
  - CCMP wind direction
  - For each incidence angle 27<θ<65 deg, with bins of 2 deg

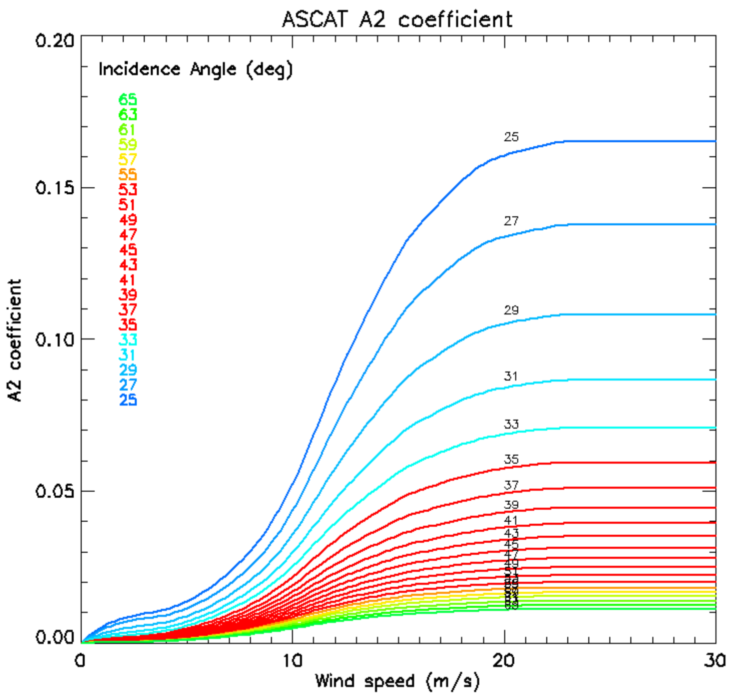
- The final coefficients $A_i(w,\theta)$ required some interpolation and smoothing.

A_0 Coefficient as a Function of Incidence Angle



A_1 and A_2 Coefficients





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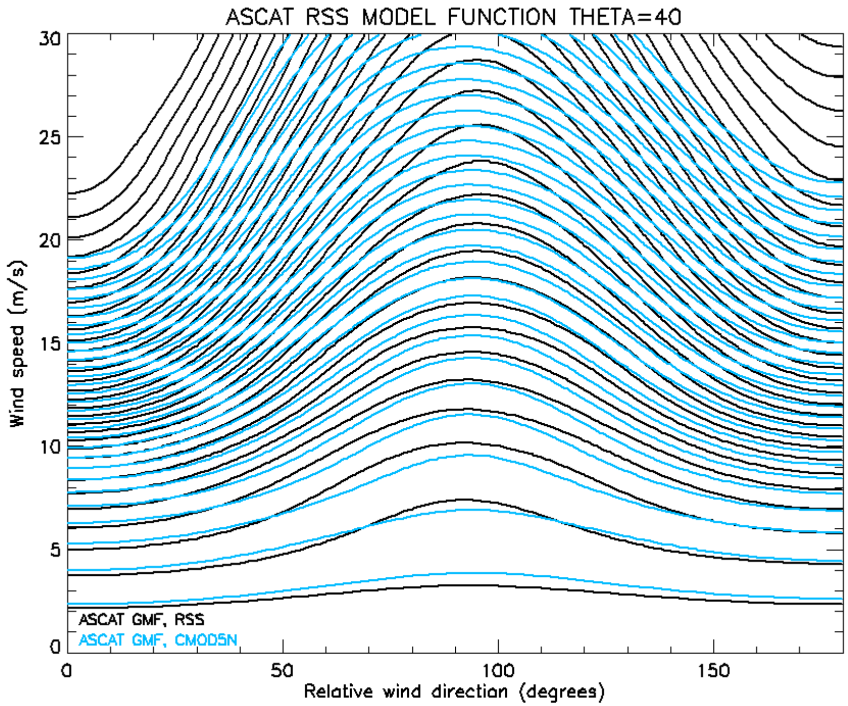
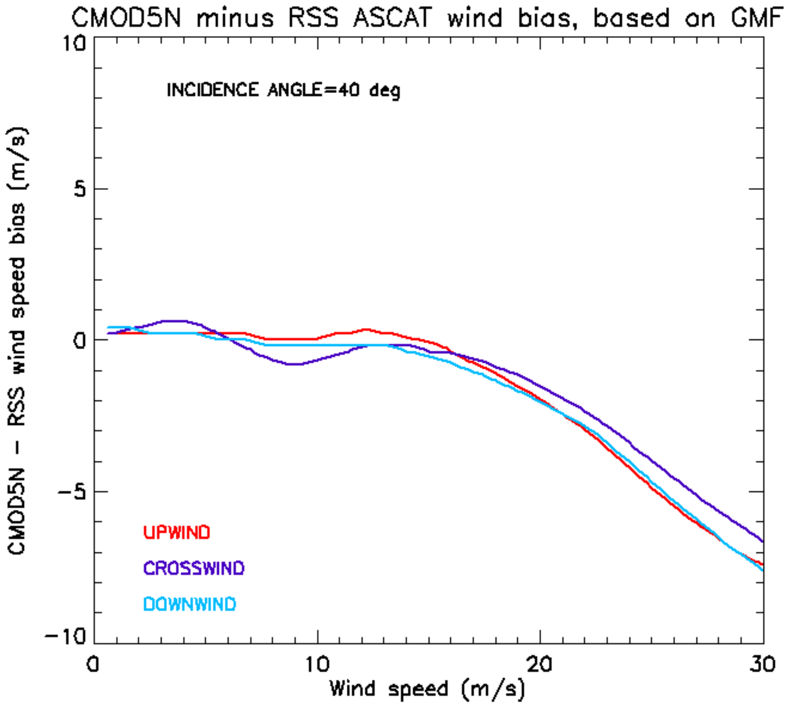
Preliminary Comparison with CMOD5n





Summary and Conclusions

- In 2011 we reprocessed all QuikSCAT wind retrievals using a new GMF (Ku-2011) developed to improve retrievals at high wind speeds
- Ku-2011 rain-free winds were calibrated using WindSat in the range 0-30 m/s
- The GMF Ku-2011 is also used in the new JPL QSCAT V3
- In 2012 we developed a preliminary GMF for ASCAT following a similar calibration standard and methodology as Ku-2011
- We are now writing the code to do the ASCAT wind vector retrievals using this GMF, based on QuikSCAT and NSCAT wind retrieval code.

EXTRA SLIDES

Global Bias and Standard Deviation
Rain-Free QuikSCAT-Validation Winds

Ku2011-val	BIAS (m/s)	ST DEV (m/s)
BUOY	0.01	0.88
WINDSAT	-0.04	0.65
SSMI V6	-0.04	0.89
NCEP	0.10	0.95
ECMWF	0.44	1.08

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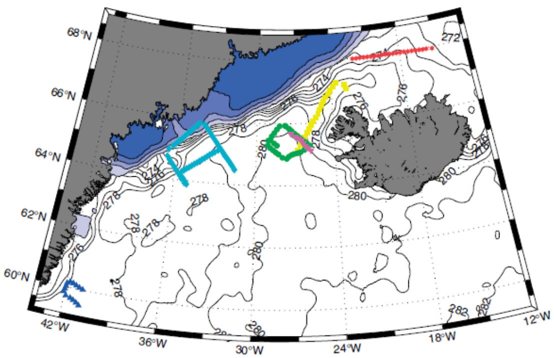
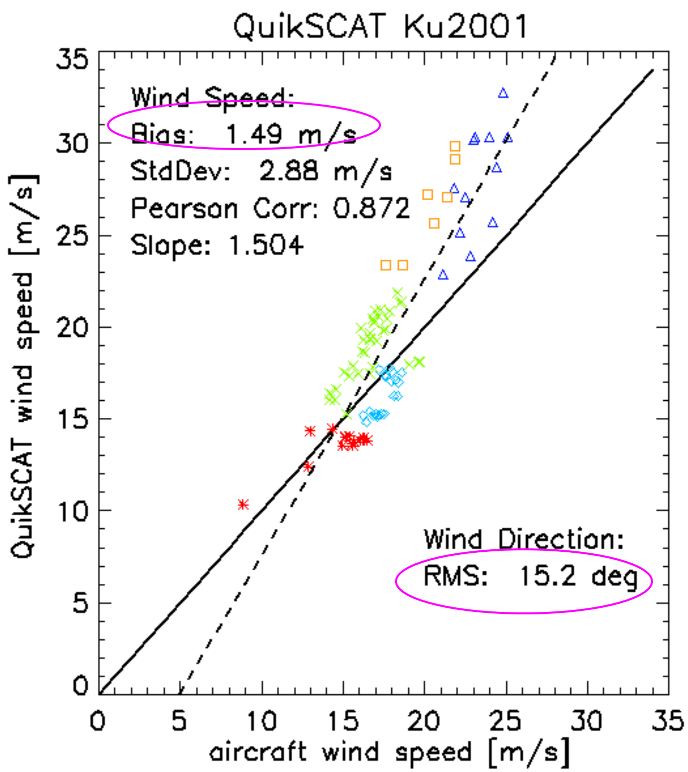
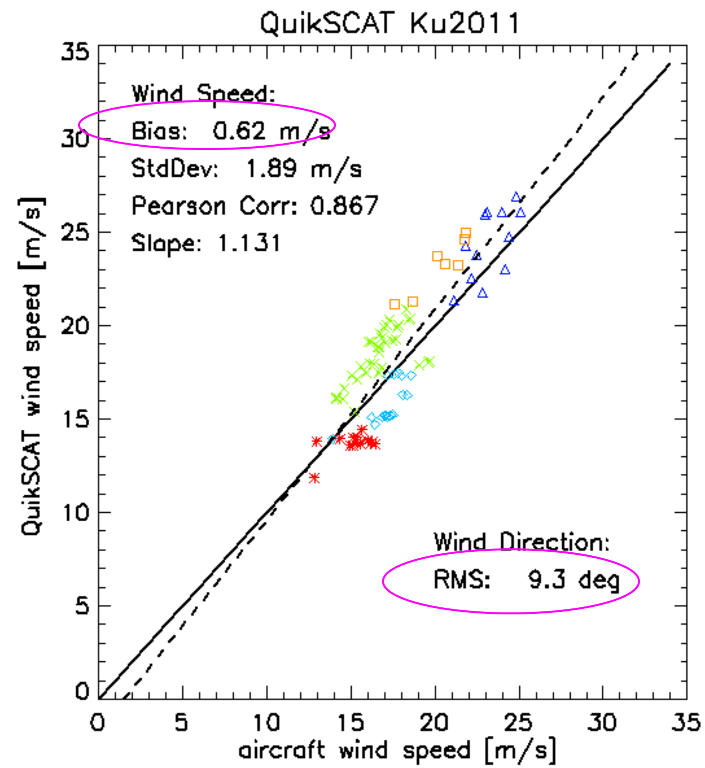
High Winds Validation: AIRCRAFT



Aircraft turbulent probe observations taken during the Greenland Flow Distortion Experiment (GFDex), Feb and Mar 2007 (Renfrew et al, QJRMS 2009).





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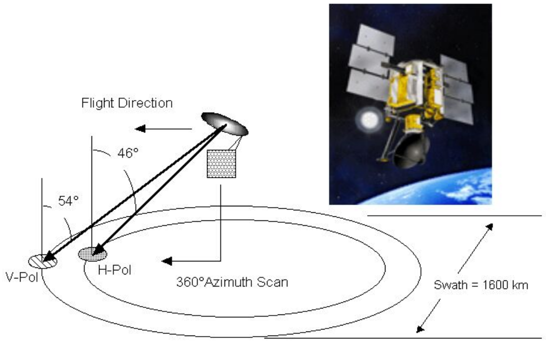
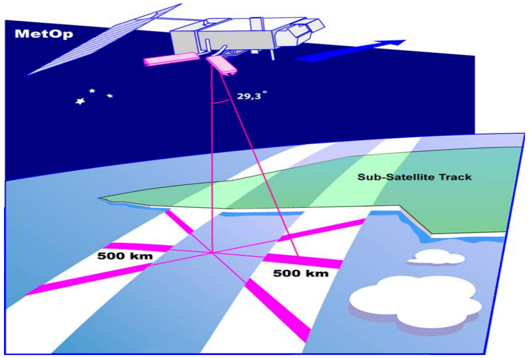
QuikSCAT		ASCAT
		
Conical scanning	Geometry	3 beam antennae
V-Pol and H-Pol	Polarization	V-Pol
13.4 GHz (Ku-band)	Frequency	5.2 GHz (C-band)
6:30am	LTAN	9:30pm
46º (H); 54º (V)	Incidence angle	variable: 25º-65º
1600 Km	Swath	2 swaths of 500 Km
12.5 (25) Km	Sampling (Resolution)	25 (50) Km
1999-2009	Time period	2007-current

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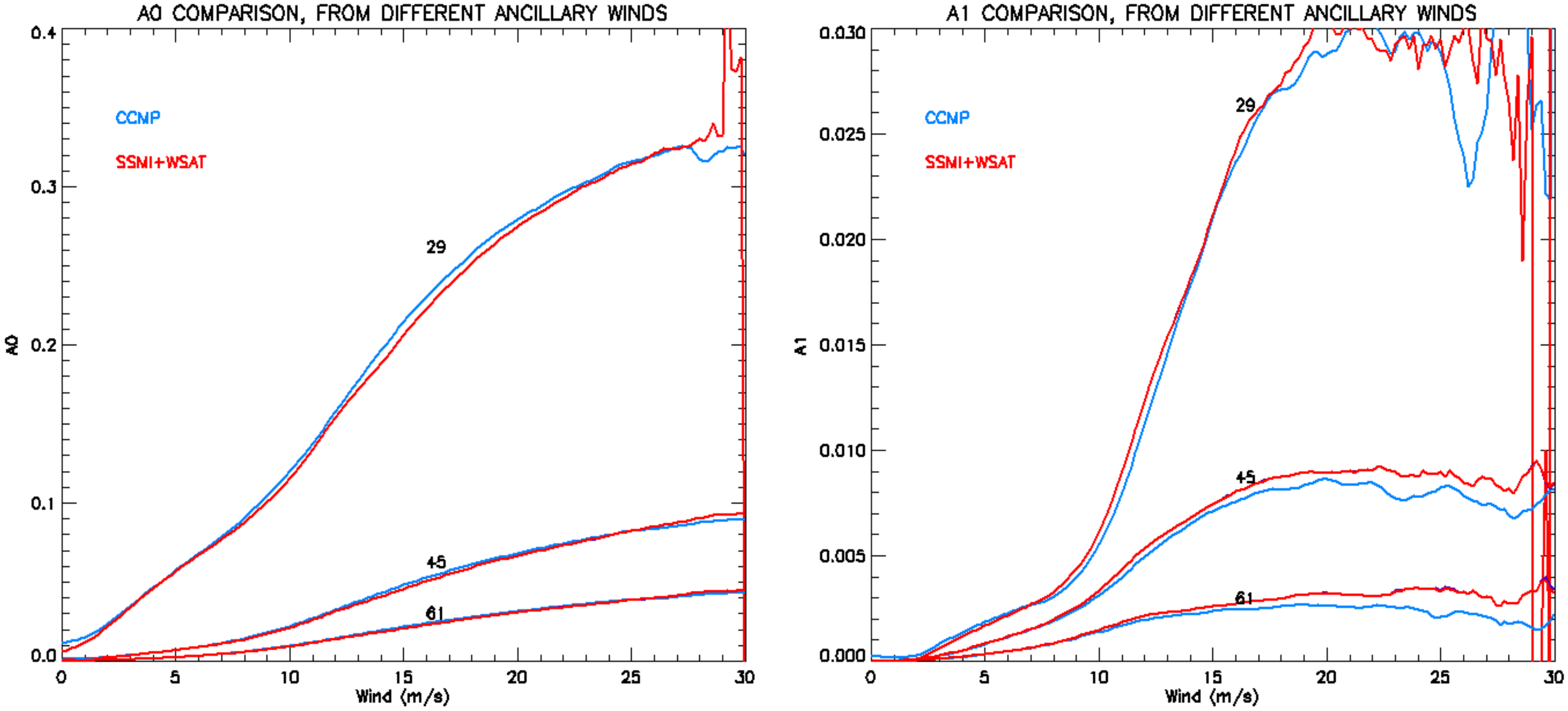
c. Ancillary Wind Speed Choice: CCMP or SSMI+WindSat



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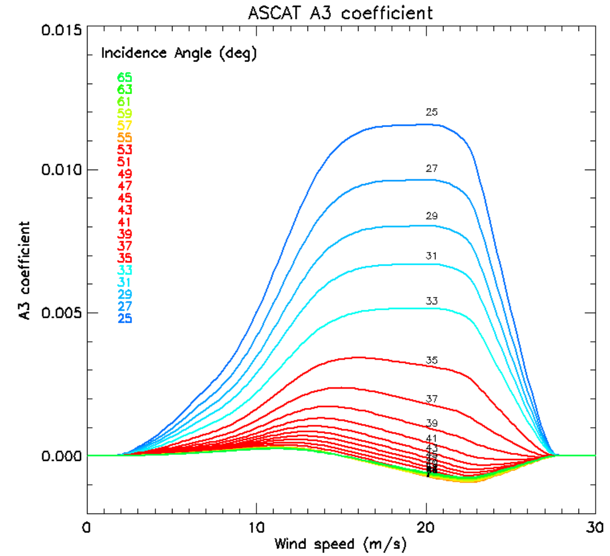
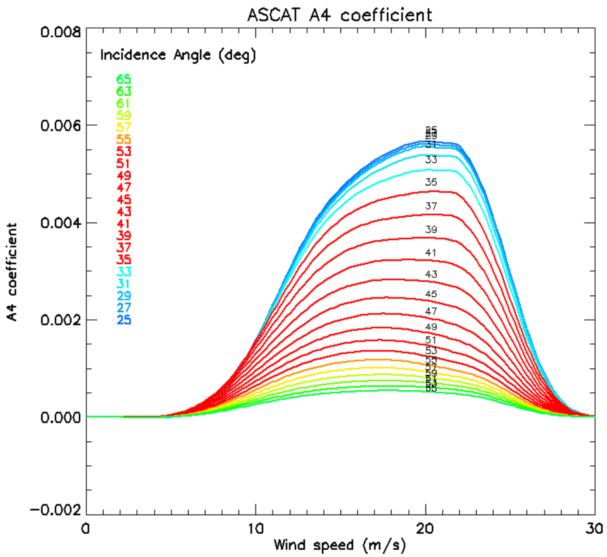
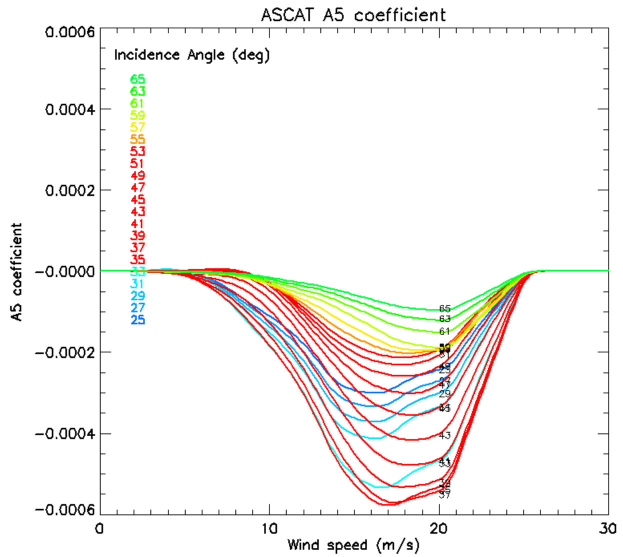
$A_3 - A_5$ Coefficients







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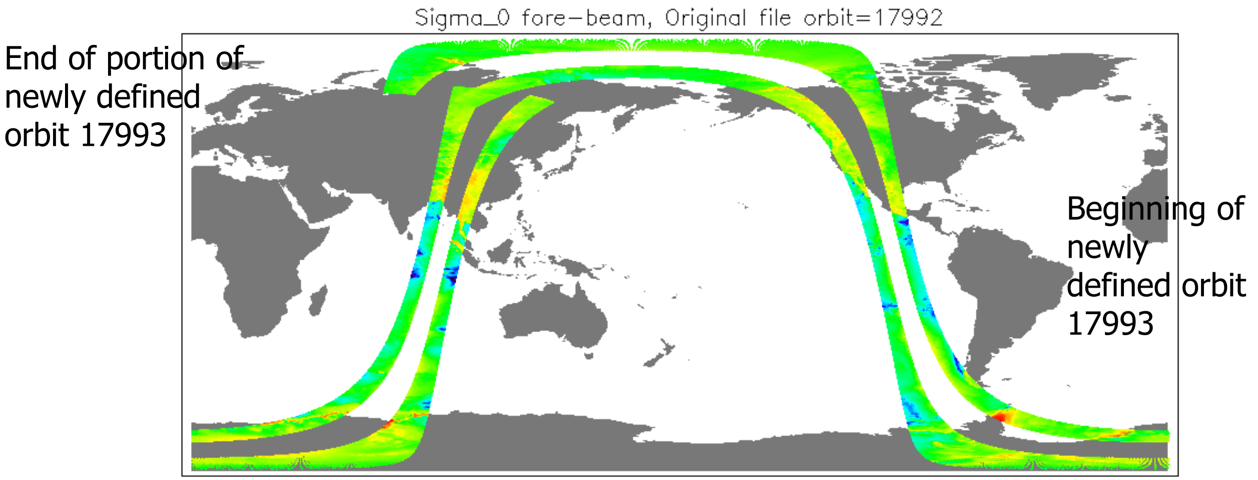
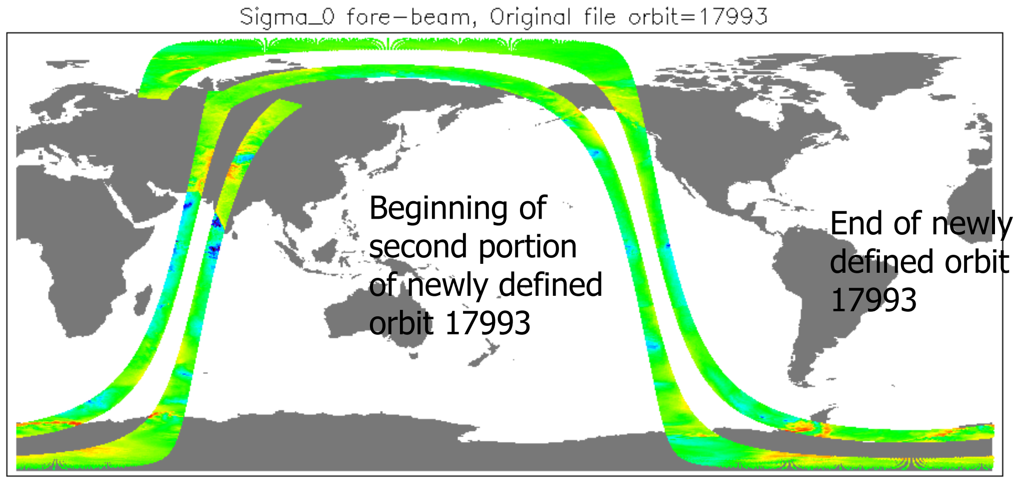
Example of Two Consecutive ASCAT L1B Files from EUMETSAT: Orbits 17992-93





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Example of RSS L1B for Orbit 17993
Obtained by Combining the Two EUMETSAT Files