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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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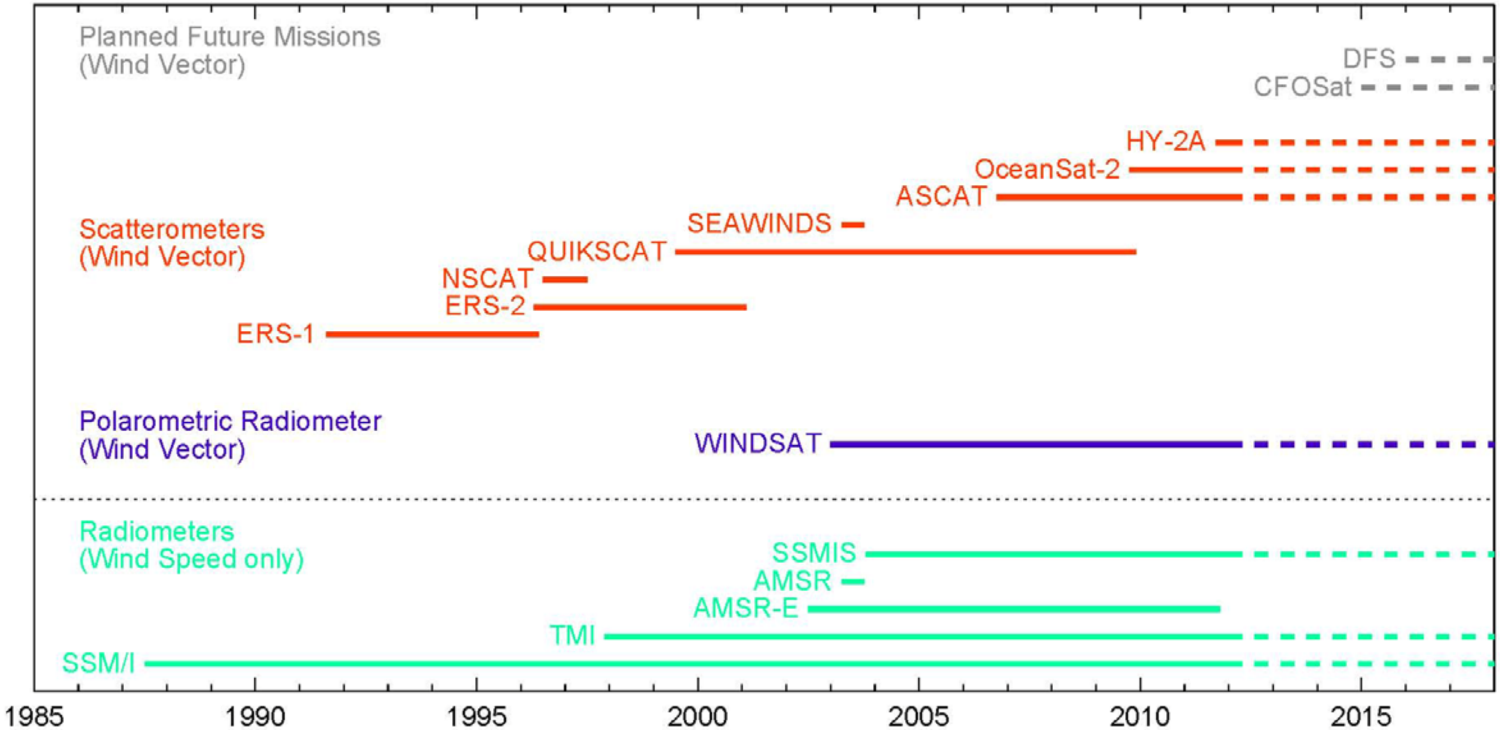
# Ocean Vector Wind missions




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 QSCAT as backbone. QSCAT was reprocessed using the new GMF, Ku-2011, developed to improve high wind speeds retrievals.**
4. **Use QSCAT methodology and calibration target to develop a new ASCAT GMF**

# 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.

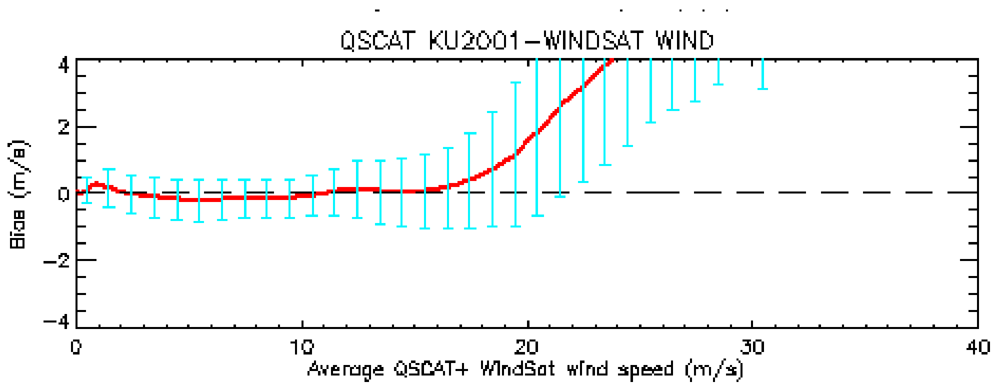
$$\sigma_0 \cong \sum_{i=0}^{N=5} A_i(w)_{pol} \cos(i\varphi_R)$$

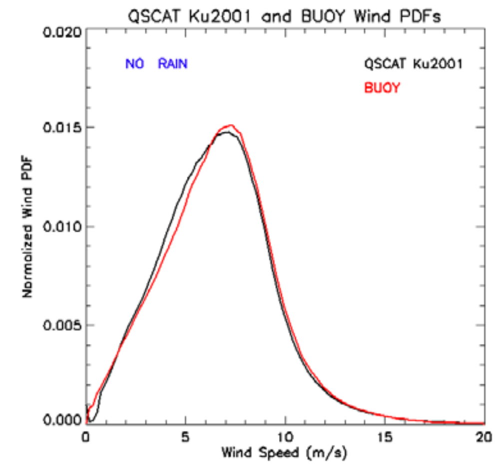
## Methodology

- 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.

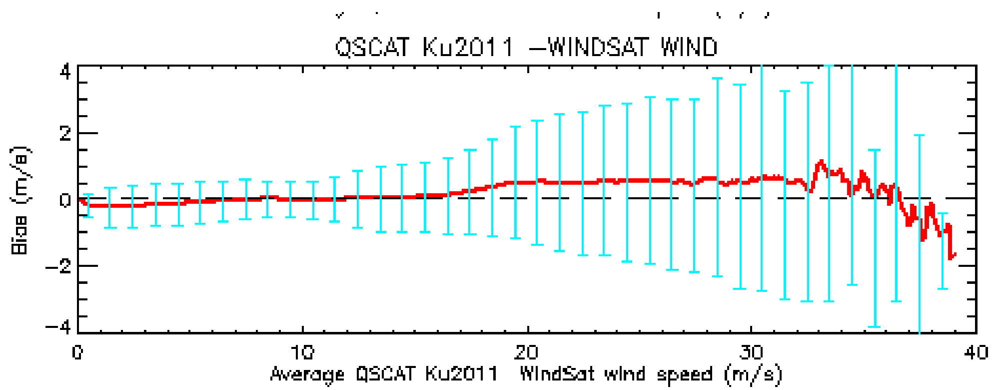
# QSCAT validation, 5 yr stats, rain-free

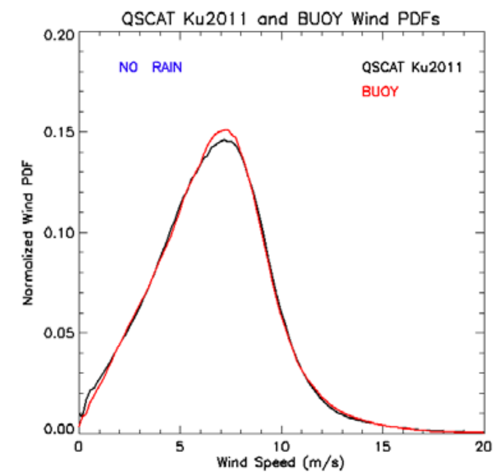
**Ku2001**




**Ku2011**



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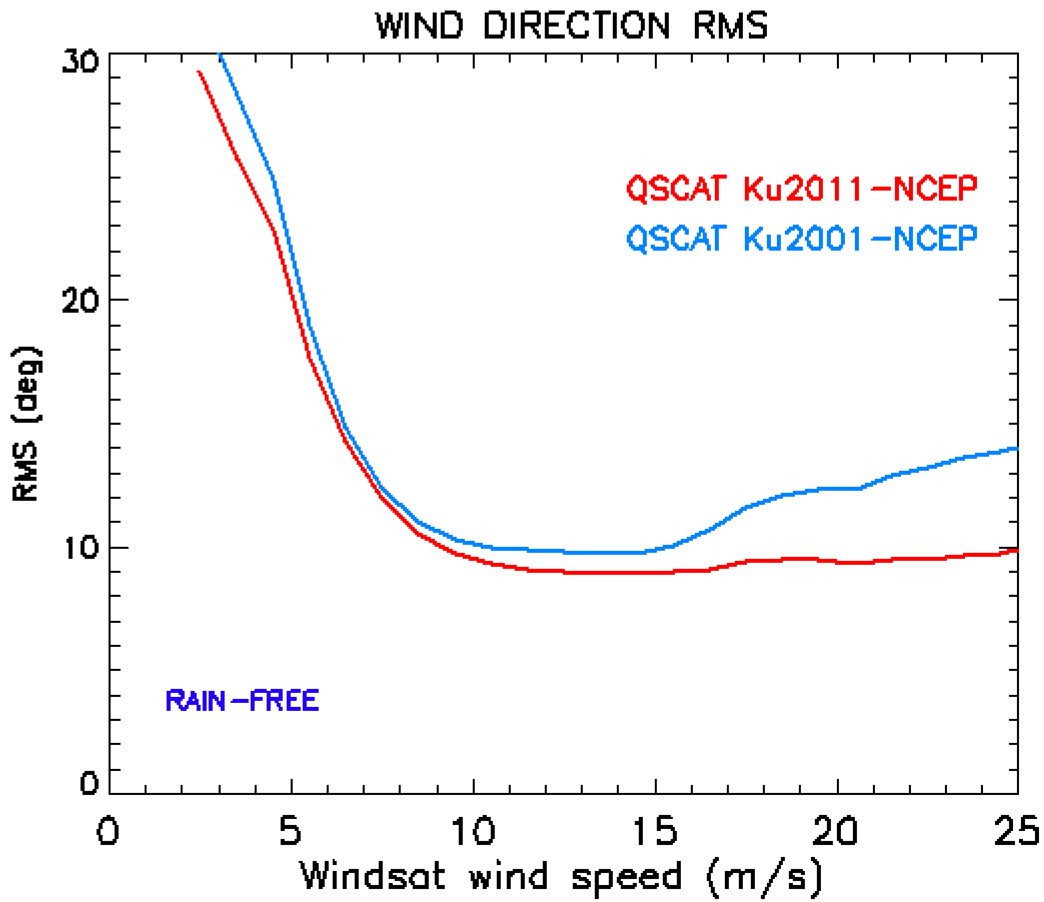
# QSCAT Wind Direction Validation



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# Rain Impact on QSCAT Winds

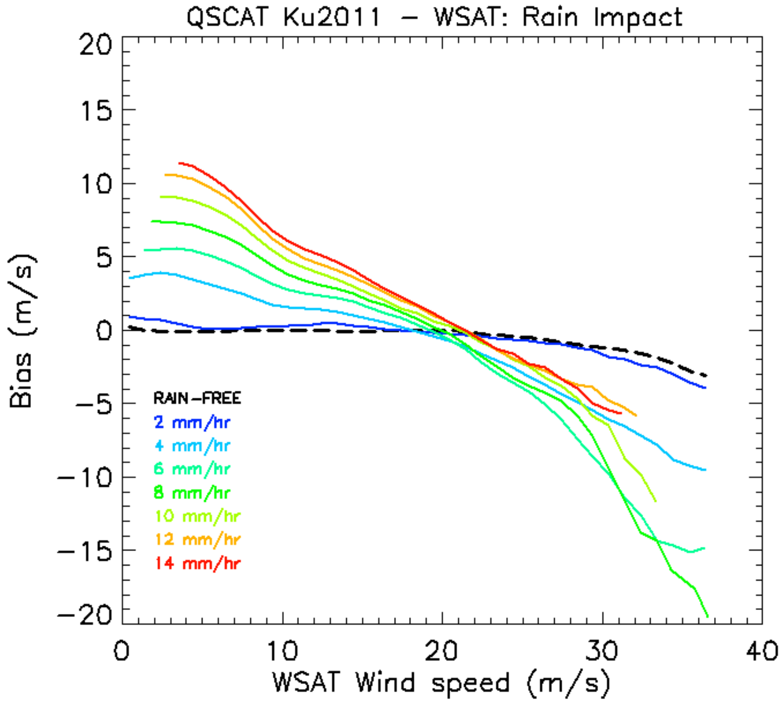
- **Ku-2011 was designed to be for <u>rain-free retrievals</u>**

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

- **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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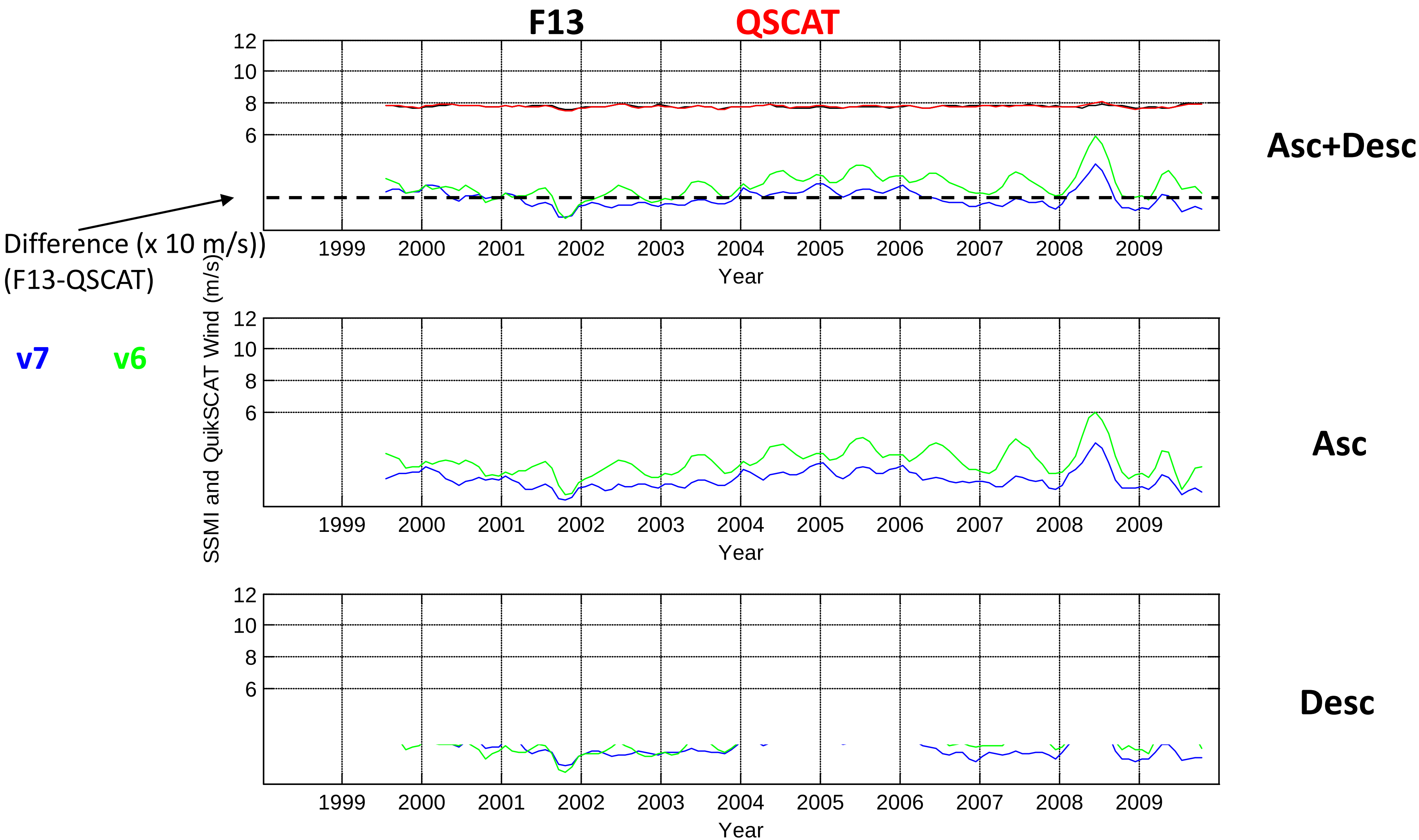
# SSMI F13 versus QSCAT Timeseries




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

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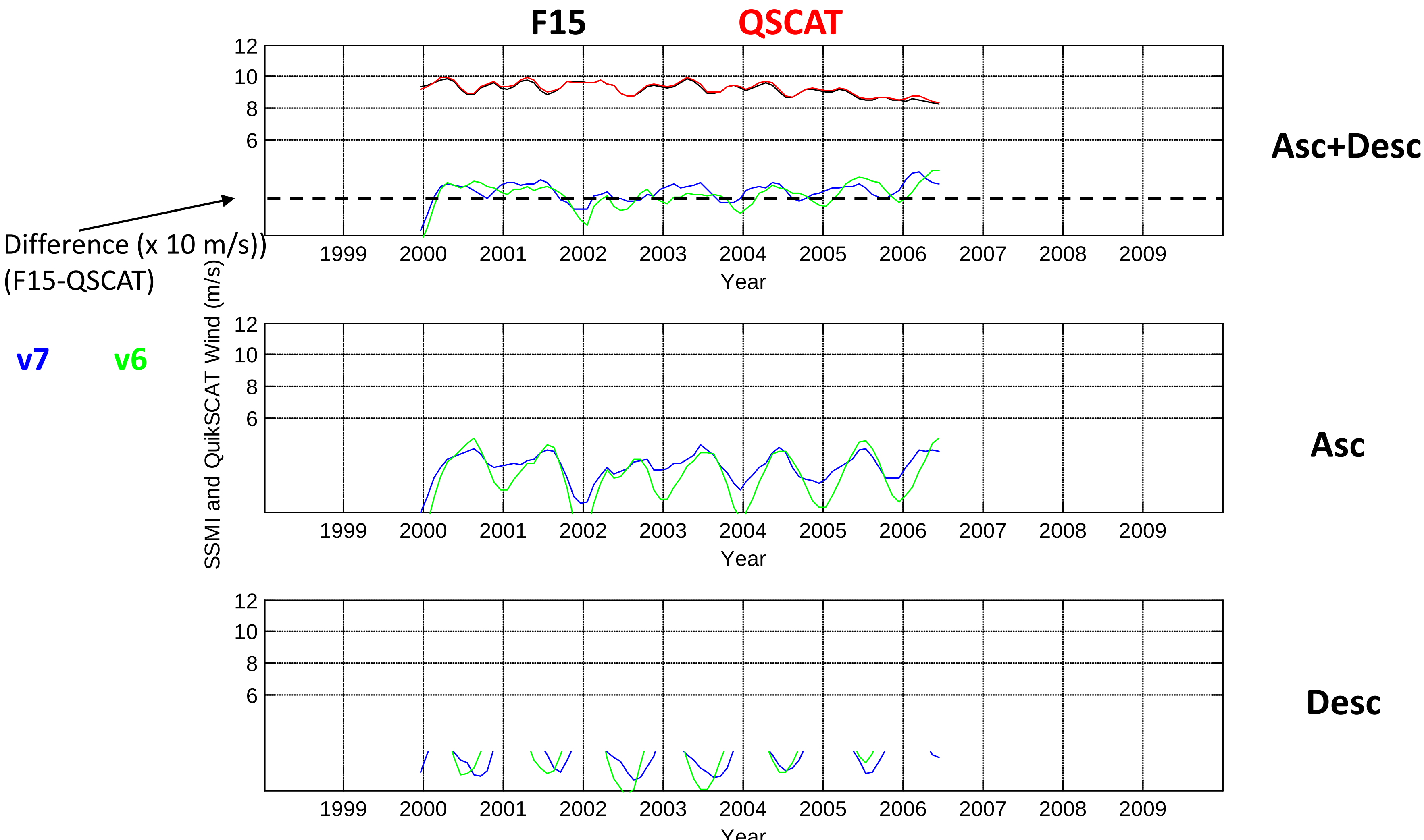
# SSMI F15 versus QSCAT Timeseries




**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 25 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 $\Phi$ (CCMP, SSMI, WSAT, NCEP, buoys…)**
- **Large number of colocations at all wind regimes, and incidence angle $\theta$**
- **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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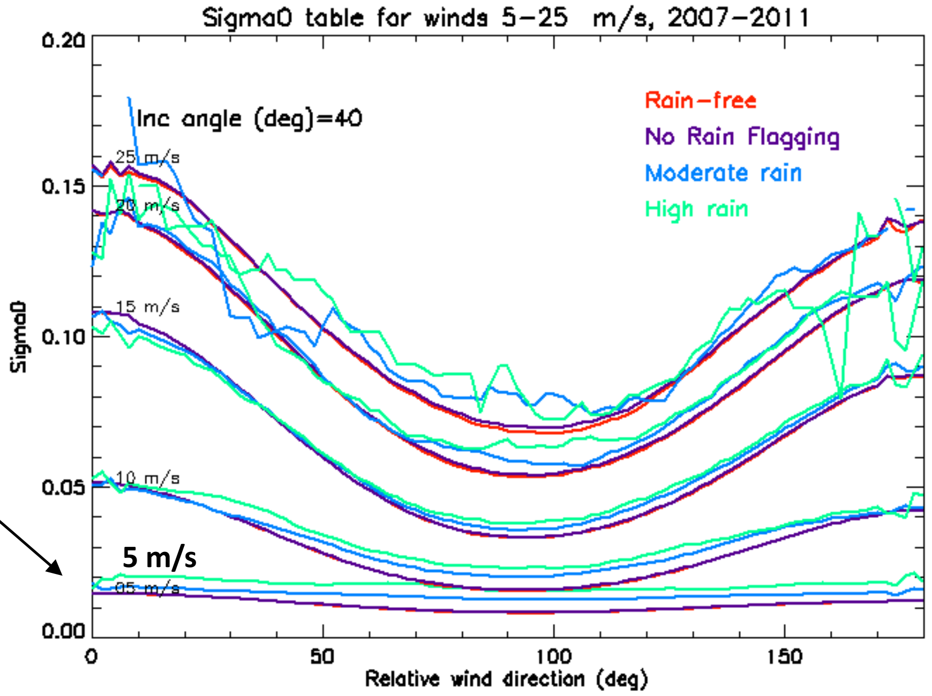
# a. Rain Impact

- 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%).

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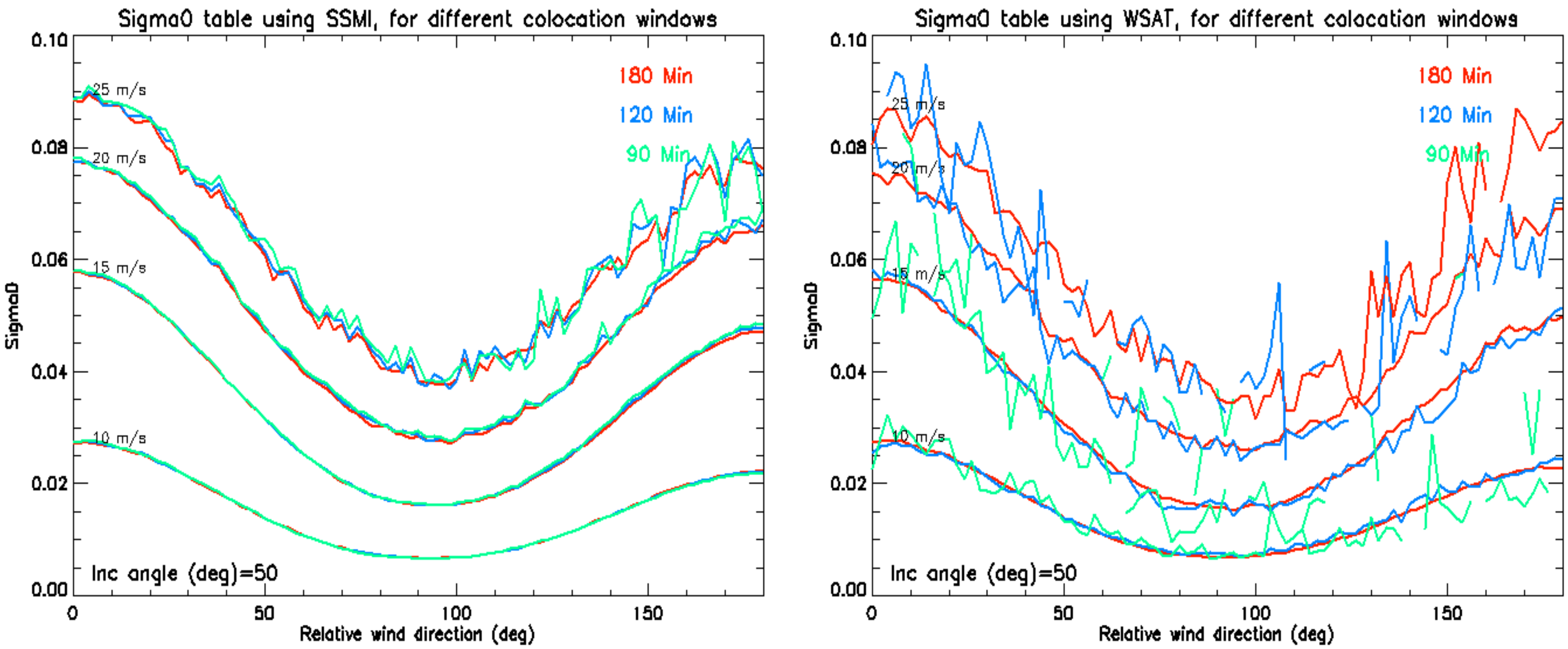
# b. Colocation Time-Window

- We tested 90-120-180 minutes time window with SSMI and WindSat
- Note: ASCAT and WINDSAT LANT 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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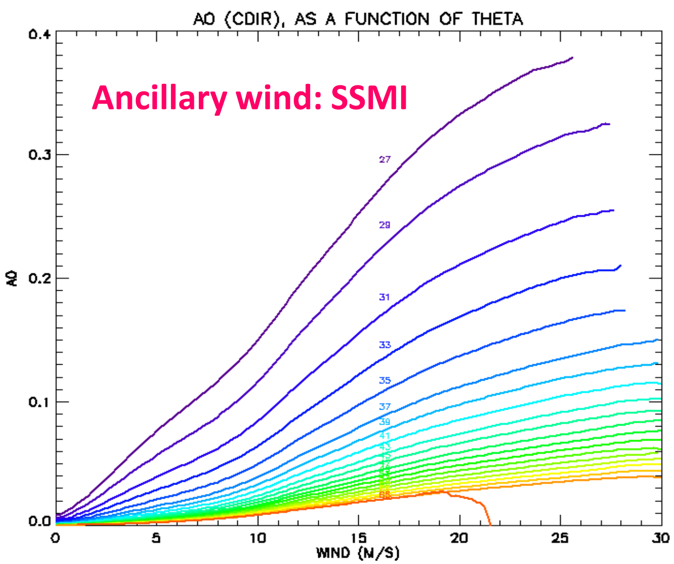
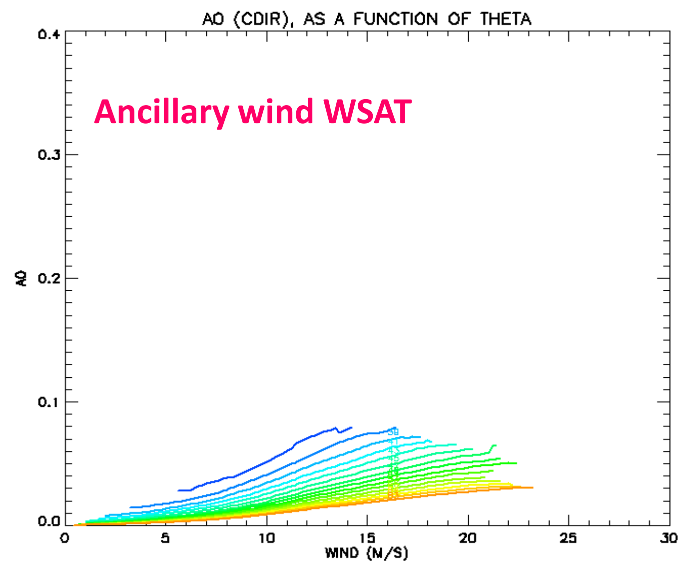
# c. Ancillary Wind Speed

- 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.

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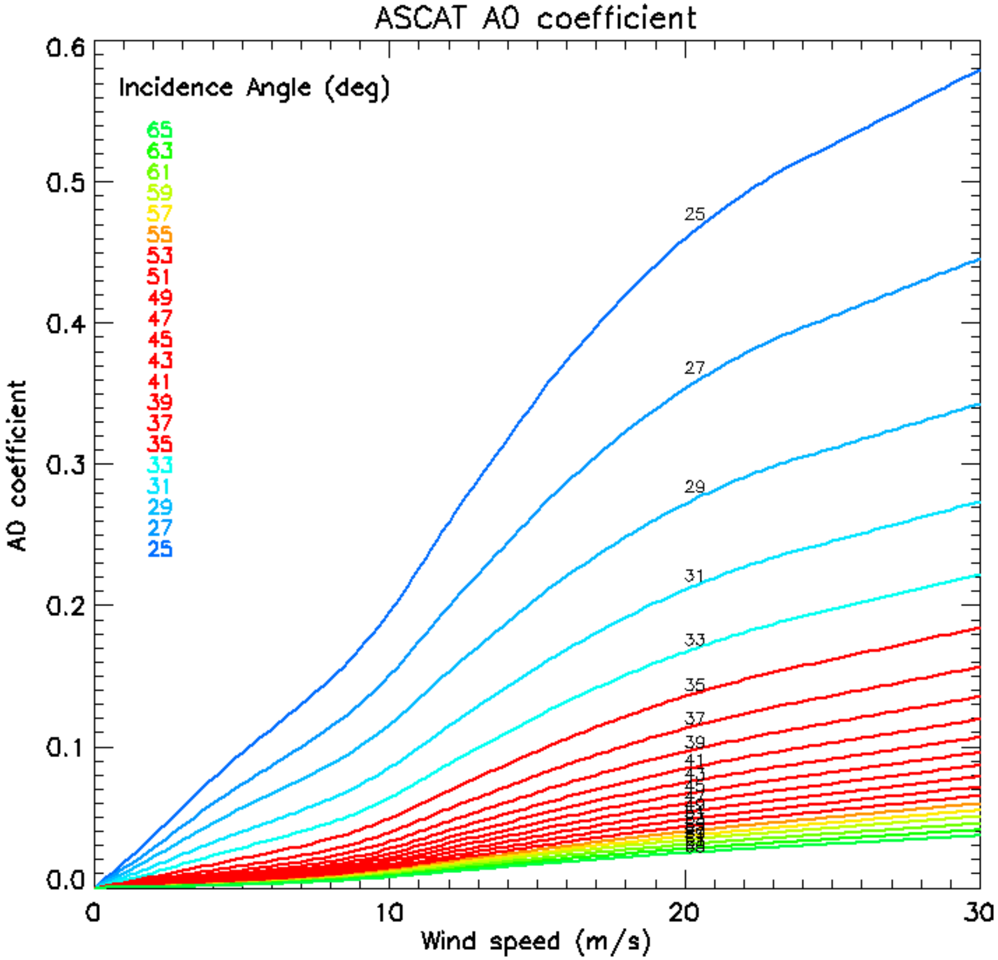
# $A_0$ coefficient as a function of incidence angle



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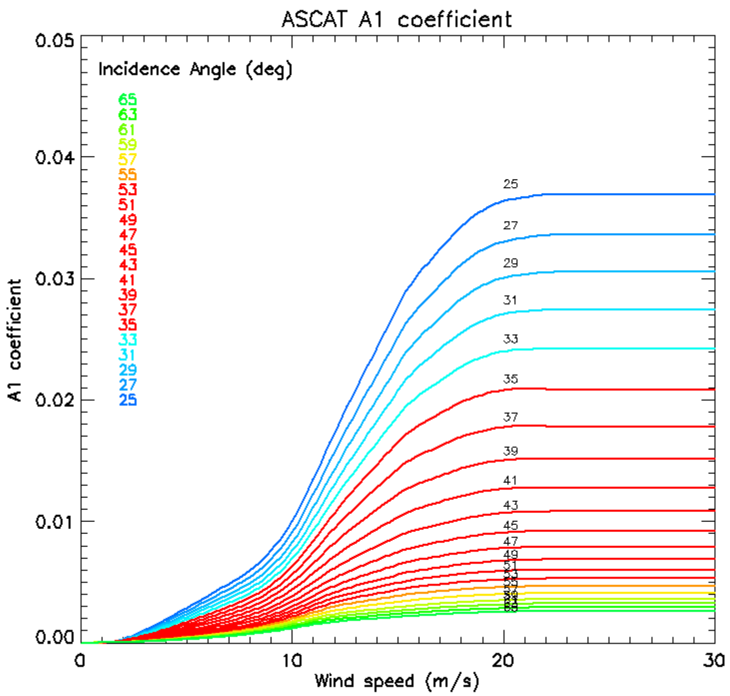
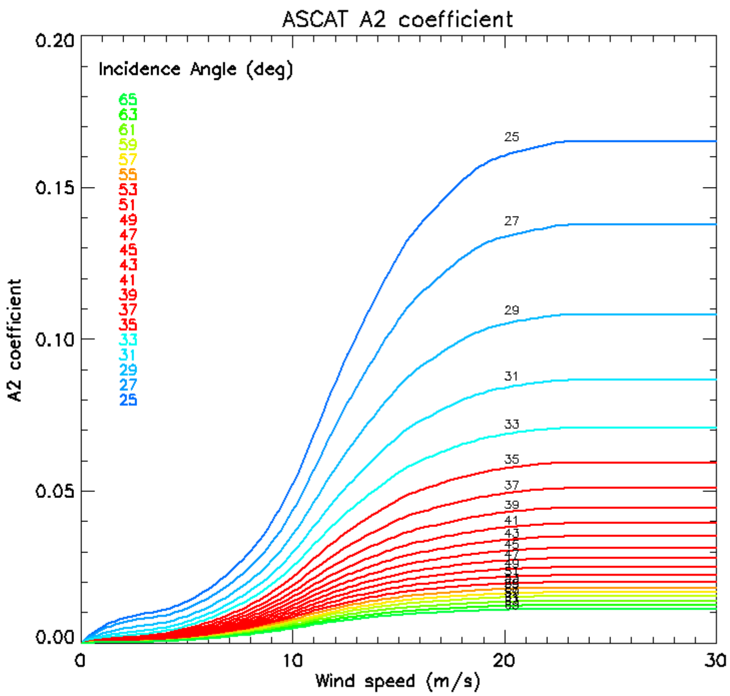
# $A_1$ and $A_2$ coefficients



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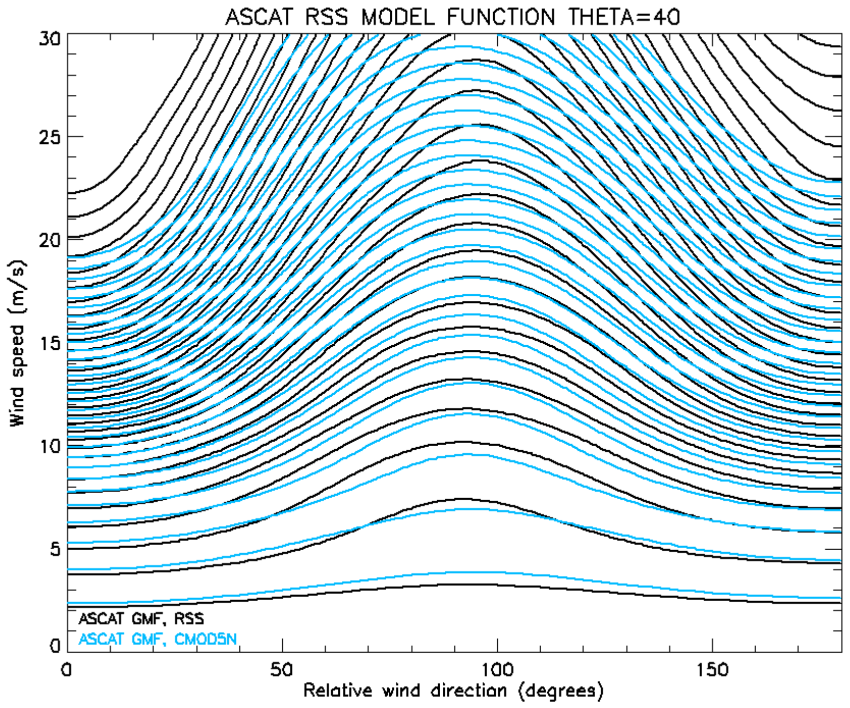
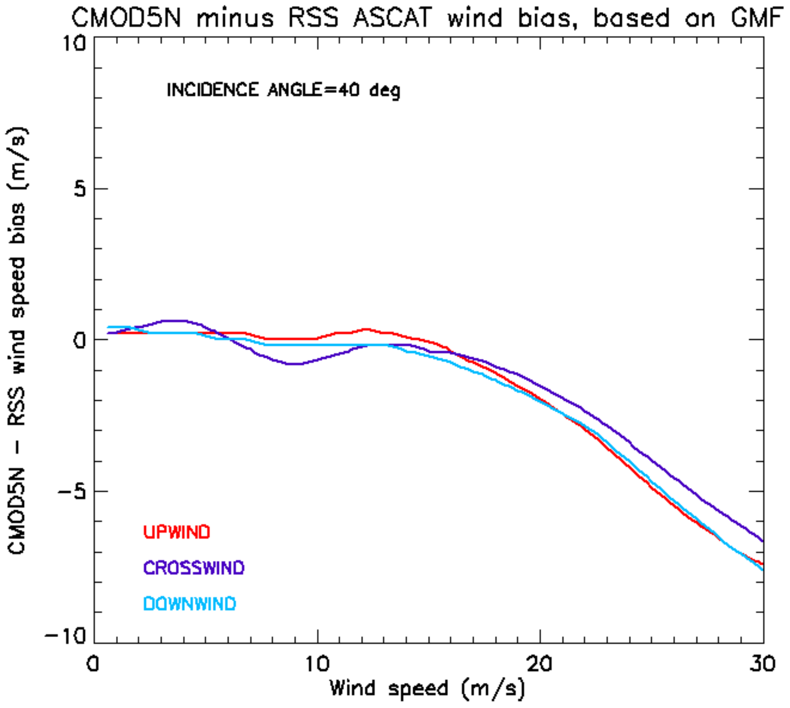
# Preliminary Comparison with CMOD5n



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# 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 QSCAT and NSCAT wind retrieval code.

# EXTRA SLIDES

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# GLOBAL BIAS AND STANDARD DEVIATION: RAIN-FREE QSCAT-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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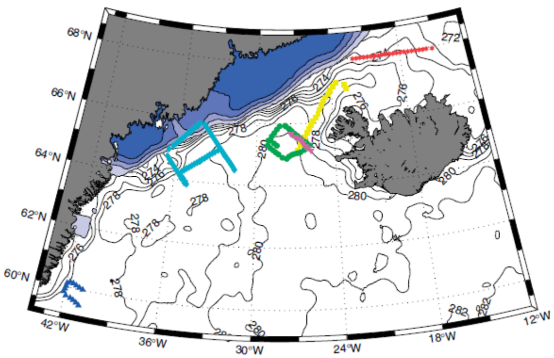
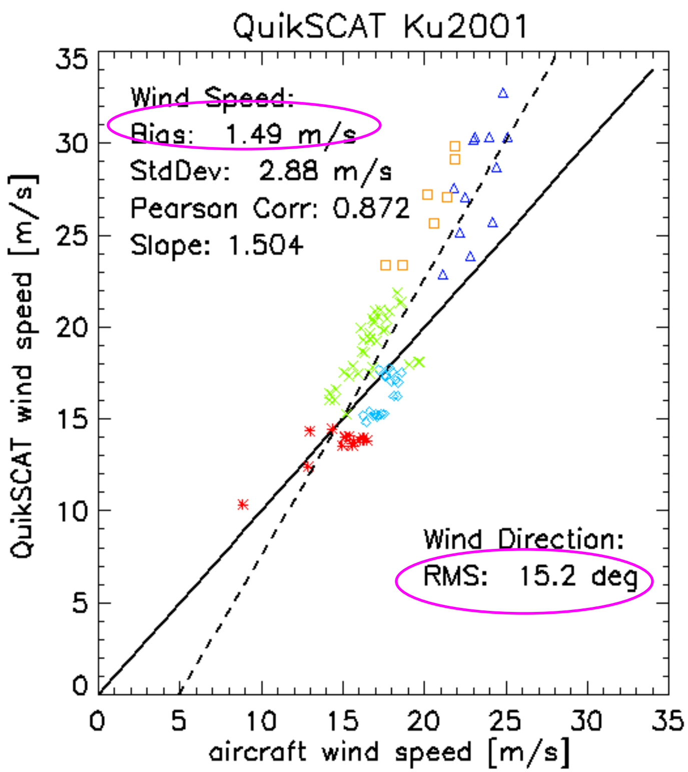
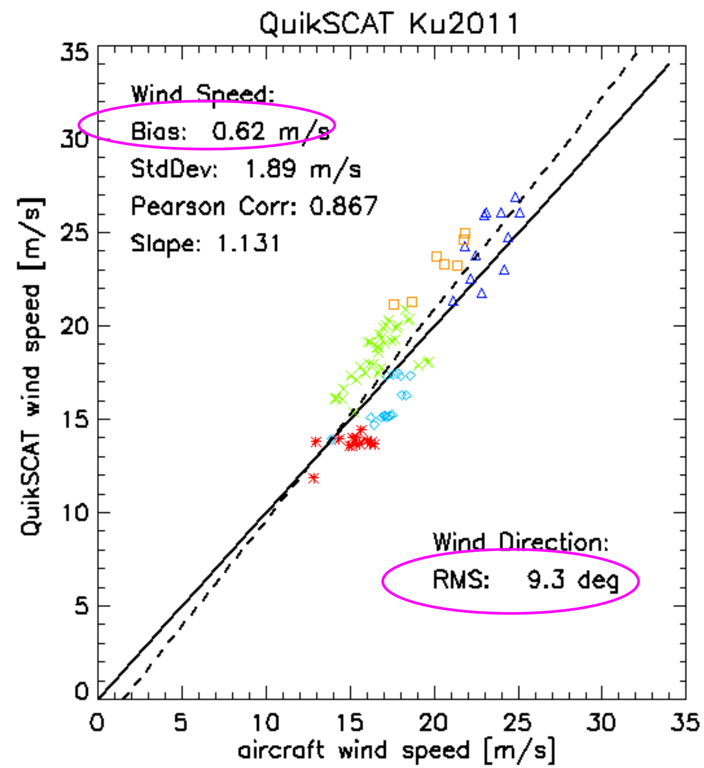
# HIGH WINDS VALIDATION: AIRCRAFT



**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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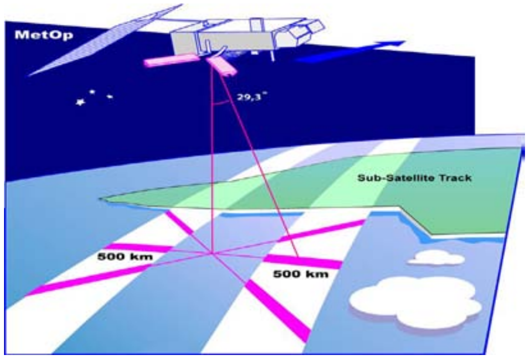
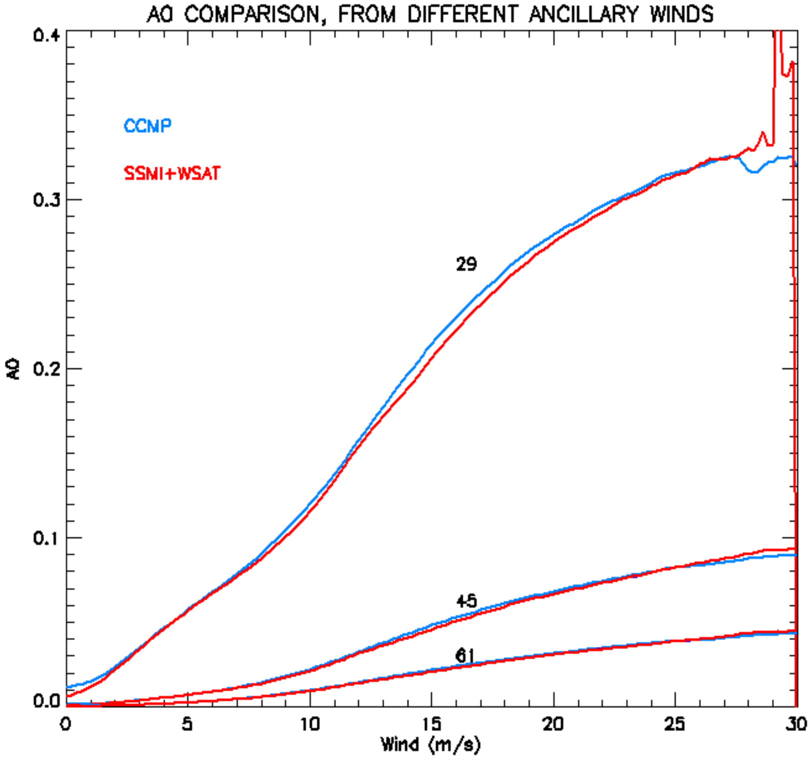
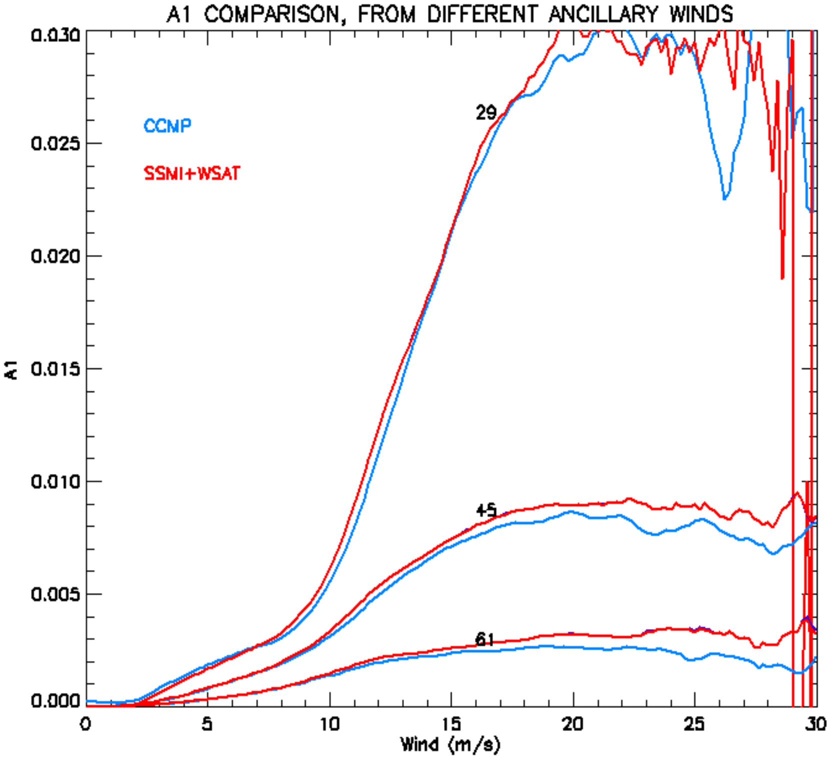



| QuikSCAT | | ASCAT |
|---|---|---|
| Conical scanning | Geometry | 3 beam antennae |
| V-Pol and H-Pol | Polarization | V-Pol |
| 13.4 GHz (Ku-band) | Frequency | 5.2 GHz (C-band) |
| 6:30am | LTAN | 9:30pm |
| 46º (H); 54º (V) | Incidence angle | variable: 25º-65º |
| 1600 Km | Swath | 2 swaths of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

# c. Ancillary wind speed choice: CCMP or SSMI+WSAT



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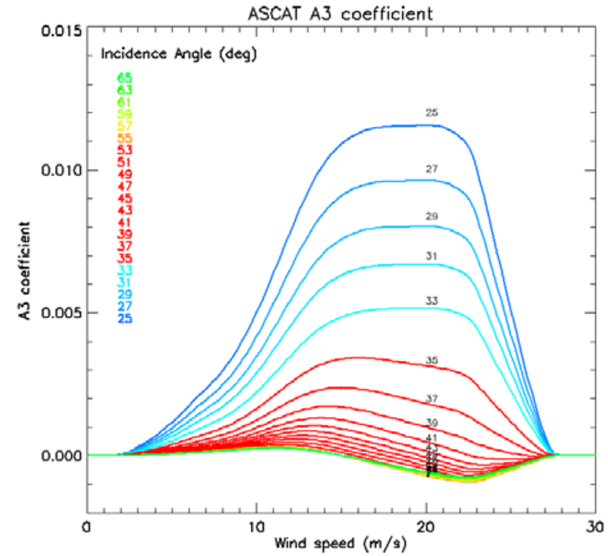
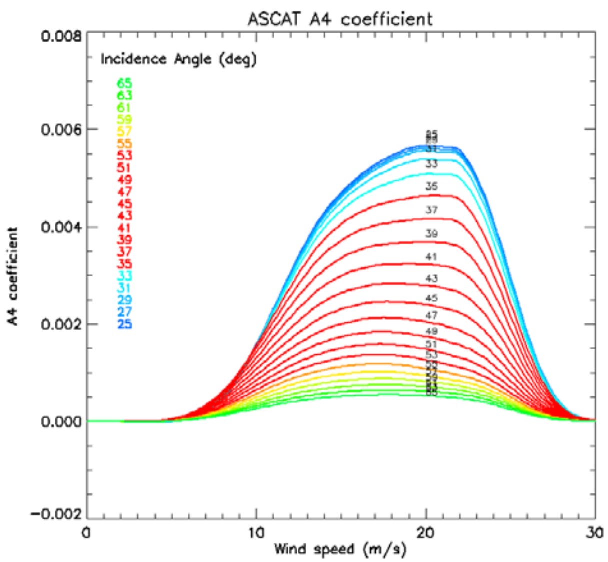
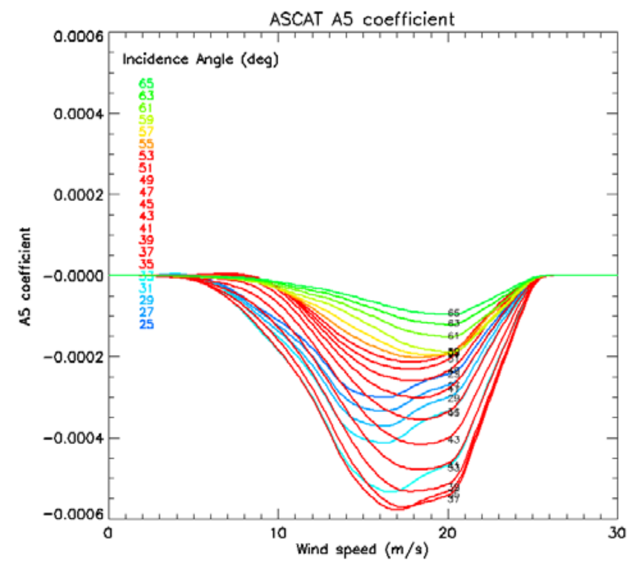
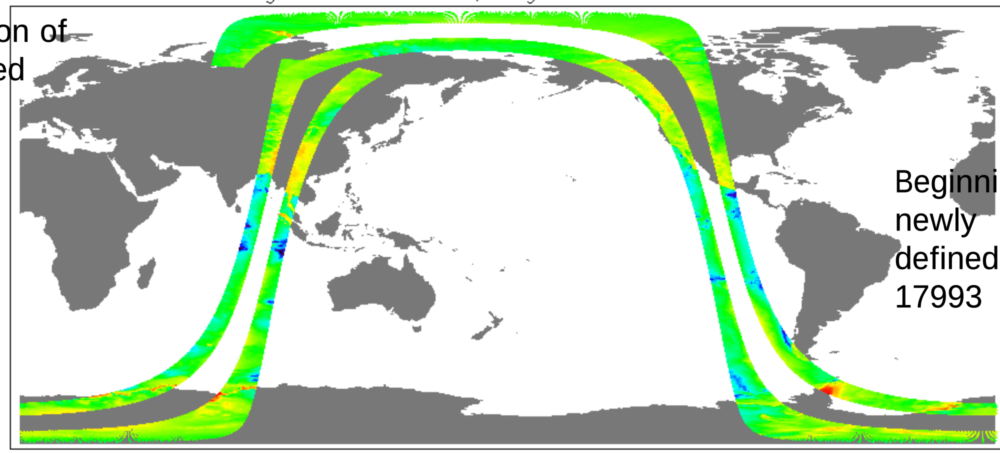
# $A_3$ – $A_5$ coefficients

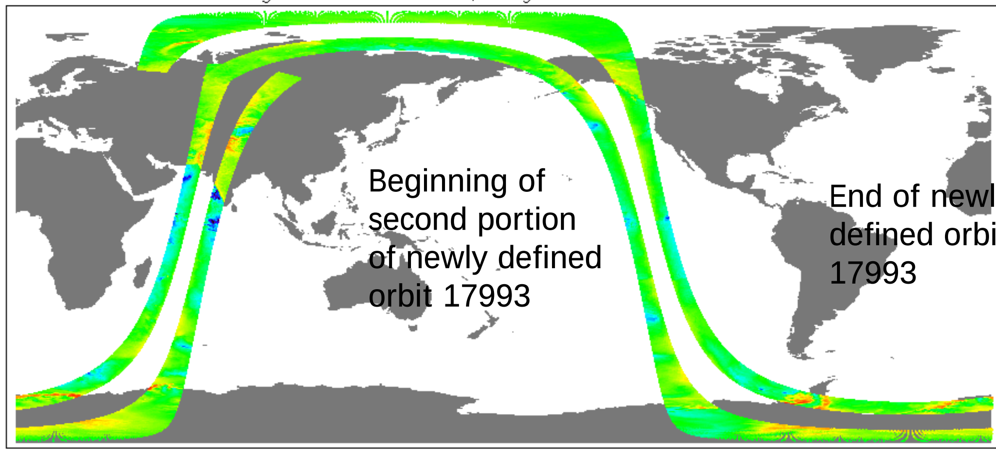


# Example of two consecutive ASCAT L1B files from EUMETSAT: orbits 17992-93



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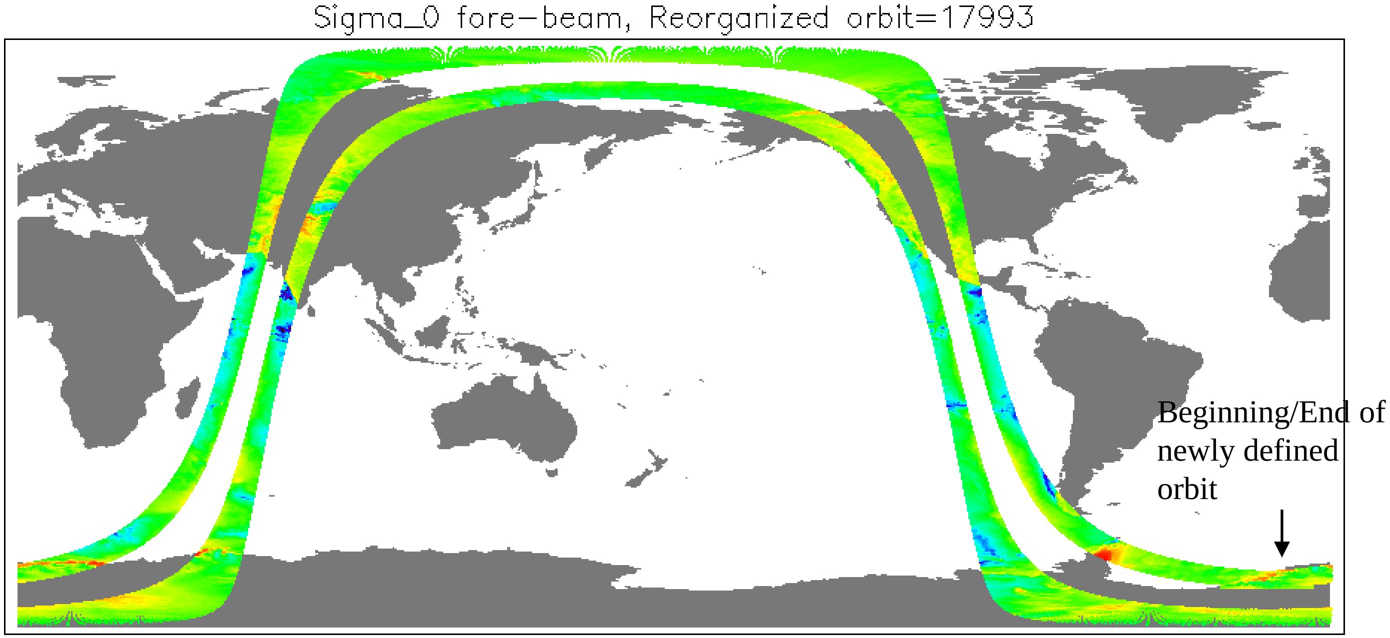
# Example of RSS L1B for orbit 17993

# obtained combining the two EUMETSAT files



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