QSCAT2012 Geophysical Model Function

Alexandra H. Chau, Bryan Stiles,
R. Scott Dunbar, Ernesto Rodriguez

Jet Propulsion Laboratory, California Institute of Technology

IOVWST Meeting
12-14 June 2012, Utrecht, Netherlands

Outline

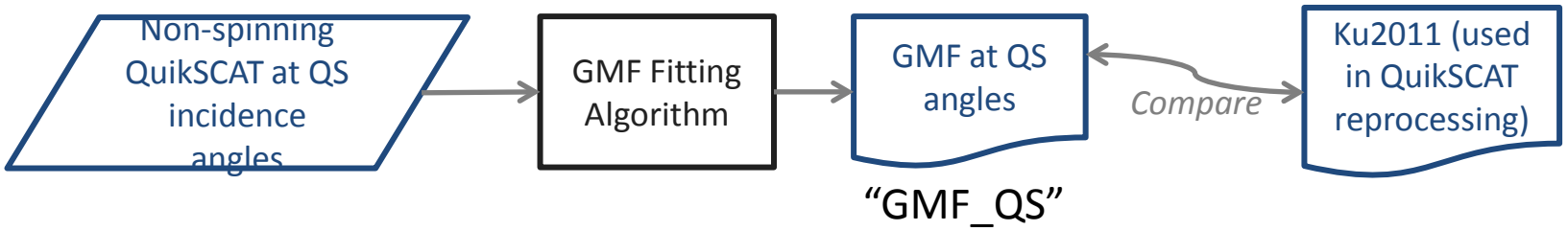
- Non-spinning QuikSCAT
- GMF fitting procedure
- Consistency with Ku2011
  - Ku2011 was used for QuikSCAT v3 retrievals
- Comparison with NSCAT2
- JPL OSCAT retrievals

L Ricciardulli and F Wentz. "Reprocessed QuikSCAT (V04) Wind Vectors with Ku-2011 Geophysical Model Function." Remote Sensing System Technical Report 043011.

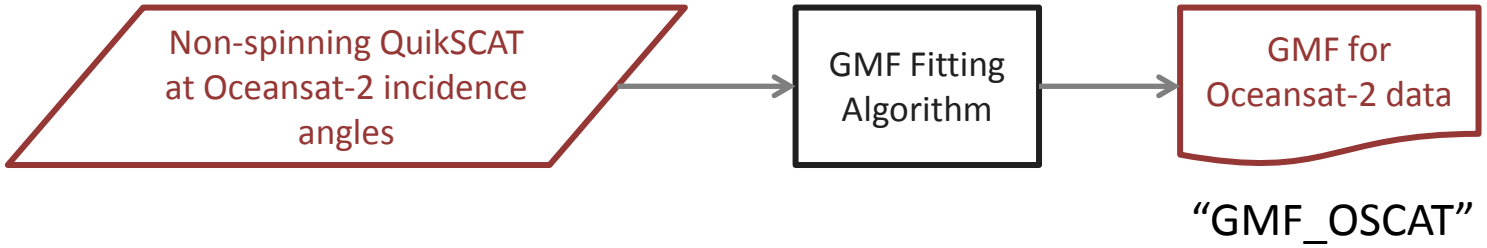
Geophysical Model Function

GMF development utilizes data from multiple sources, ensuring that GMF will yield consistent winds between Oceansat-2 and the QuikSCAT climate data record.

A: Develop GMF fitting procedure and validate it against Ku2011



B: Use validated GMF fitting procedure to develop GMF for OceanSAT-2 data



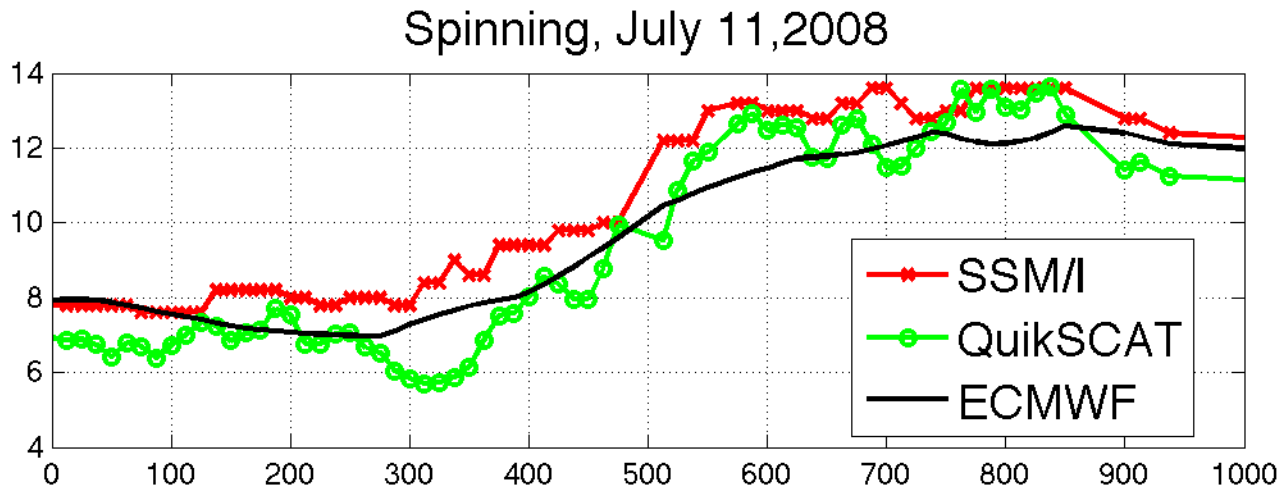
Current status of QuikSCAT

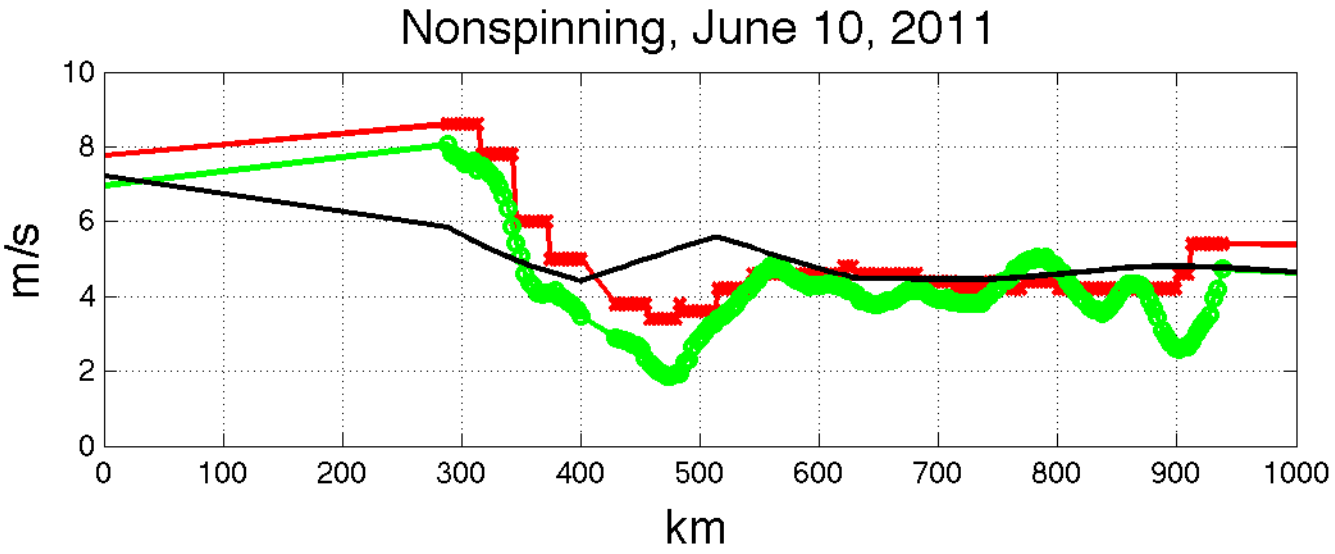
- QuikSCAT stopped spinning on November 23, 2009
- Since then, we have obtained single azimuth data from a variety of incidence angles and polarizations
- Data being used to
  - Develop geophysical model functions at alternate incidence angles, e.g. for Oceansat-2
  - Retrieve accurate wind speed profiles on a narrow (30 km) swath
    - Stiles B, et al. “Retrieving Ocean Surface Wind Speeds from the Non-spinning QuikSCAT Scatterometer”. IGARSS 2011.
  - Calibrate cryosphere products for Oceansat-2

Non-spinning QuikSCAT

- Non-spinning QuikSCAT sigma0s
  - Average 50 consecutive footprint (egg) measurements to produce a ~30km by 30 km backscatter measurement
    - Slice processing is not done because it would require extensive recalibration and accurate attitude knowledge
    - Footprints move ~3.8 km on ground during averaging

Spinning vs. non-spinning wind profiles

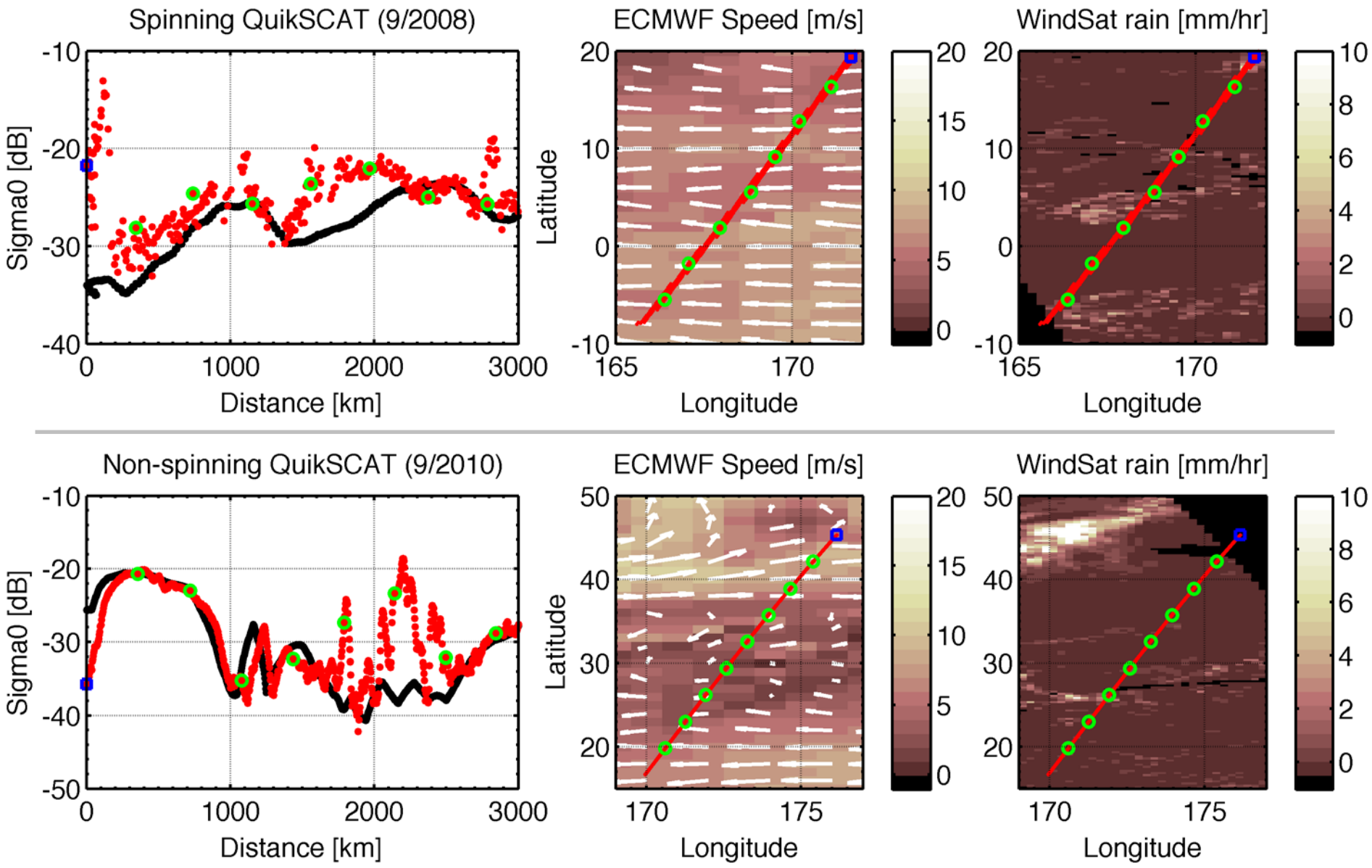




Here we compare a 1000-km long non-spinning wind speed profile (bottom) with a similar profile (top) obtained when QuikSCAT was spinning.

Both profiles are compared with co-located ECWMF and SSM/I wind speeds. Rainy data is omitted.

Spinning vs. non-spinning sigma0 profiles



QuikSCAT operating modes since 2009

Revs	Dates	Mode
Up to 54315	Up to 23 Nov 2009	Wind Obs. Nominal; antenna freeze during orbit 54315
54316-55960	23 Nov 2009 – 18 Mar 2010	How do we make this thing work???
55961-56321	18 Mar 2010 – 12 Apr 2010	QSCAT outer beam, nominal point; 374 good data revs
56333-56337	13 Apr 2010	ISRO outer beam point; 1553 lockup shortly afterward
56378-57675	16 Apr 2010 – 16 Jul 2010	ISRO outer beam point; bad config after 1553 anomaly recovery, no good data
57676-58317	16 Jul 2010 – 30 Aug 2010	ISRO outer beam point, good configuration (643 good data revs)
58347-60967	1 Sep 2010 – 4 Mar 2011	ISRO inner beam point, 2614 good data revs
60969-62351	4 Mar 2011 – 9 June 2011	ISRO outer beam point, good configuration
62354-62820	9 Jun 2011 – 12 July 2011	QSCAT nadir point, outer beam
62822-63819	12 Jul 2011 – 20 Sep 2011	QSCAT nadir point, inner beam
63822-65658	20 Sep 2011 – 27 Jan 2012	QSCAT high-incidence angle on inner beam (θ ~ 62.5° for H-pol)
65660-66443	27 Jan 2012 – 22 Mar 2012	QSCAT high-incidence angle on outer beam (θ ~ 62.5° for V-pol)
66446-present	22 Mar 2012 – present	ISRO outer beam point (check OSCAT calibration drift)

QSCAT2012 data summary	
OSCAT outer beam	2020 revs
OSCAT inner beam	2614 revs
QuikSCAT outer beam	812 revs
QuikSCAT inner beam	974 revs

Step 1: Gather data for GMF

- Non-spinning QuikSCAT sigma0s
- ECMWF collocation
  - Interpolate analysis field in space and time
- NCEP collocation
  - Interpolate analysis field in space and time
- SSM/I collocation
  - Time difference within 60 minutes
- WindSat collocation
  - Time difference within 60 minutes

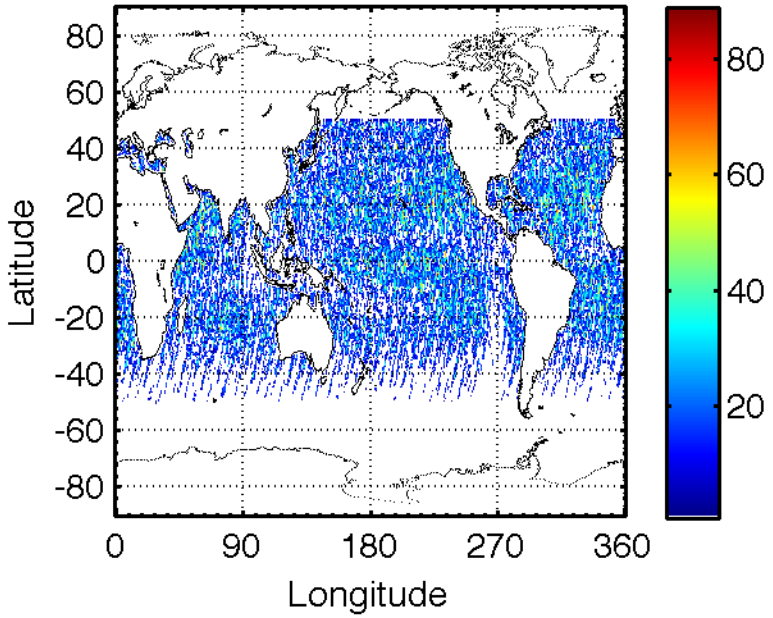
Step 2: Filter for data consistency

- Wind speeds are consistent
  - NCEP, ECMWF, SSM/I, WindSat all have valid winds
  - abs(ECMWF – SSM/I) < 2 m/s
  - abs(ECMWF – NCEP) < 2 m/s
  - abs(ECMWF – WindSat all weather) < 2 m/s
- Wind directions are consistent
  - ECMWF and NCEP directions are within 20°
- Rain is not present
  - SSM/I rain rate and WindSat rain rate are both 0
- Data is timely
  - Time difference within 60 minutes (i.e., +/- 60 min)
    - Between SSM/I and QuikSCAT
    - Between WindSat and QuikSCAT

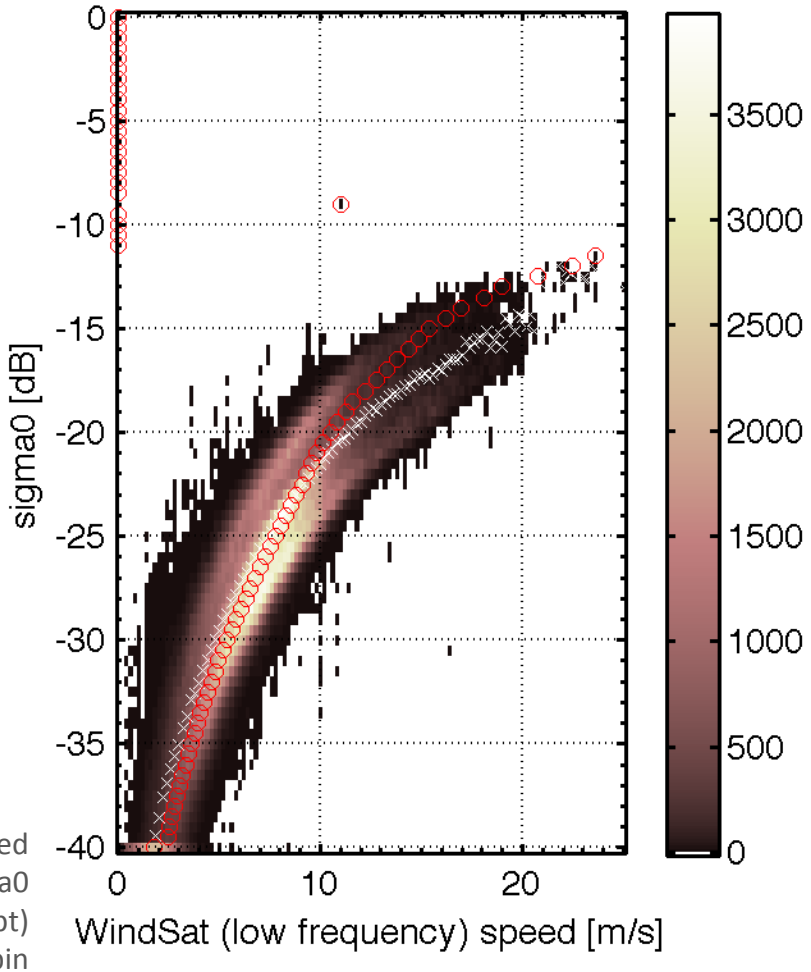
GMF_OSCAT: Inner beam data

Data location histogram

Bin size = 0.5°



Sigma0 histogram



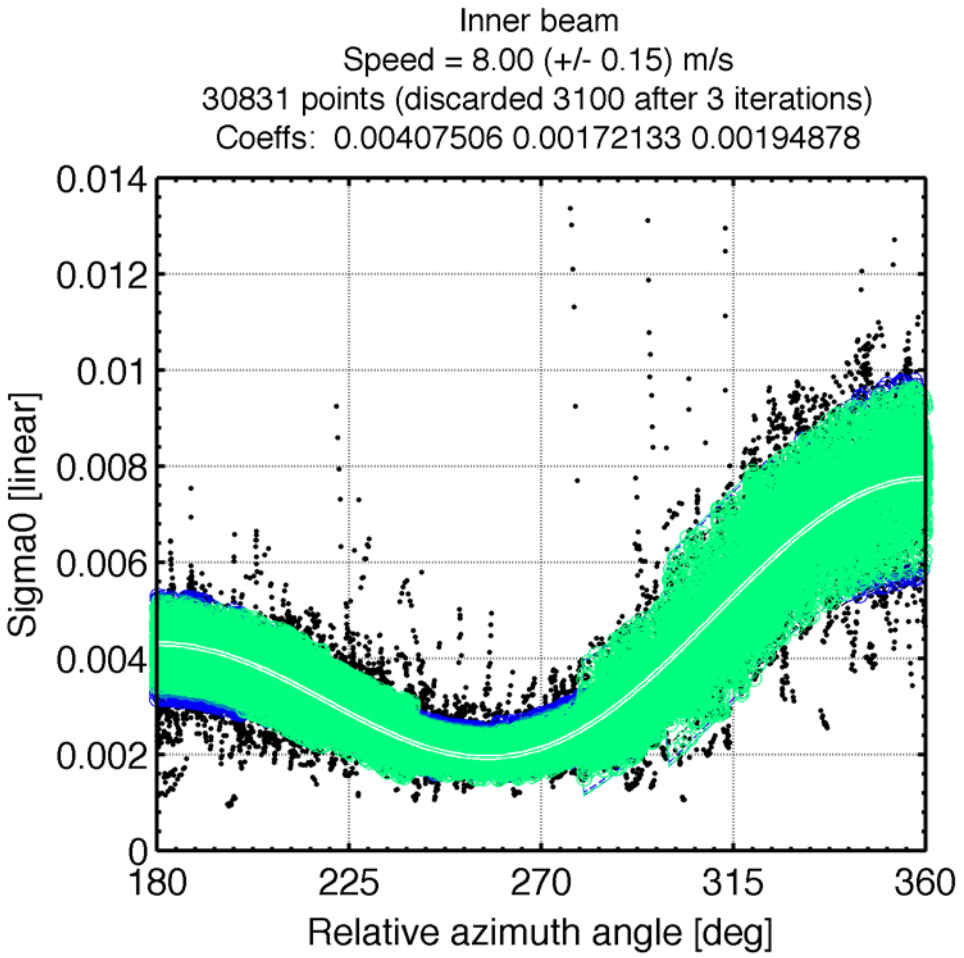
White X = Mean sigma0 as a function of wind speed
Red circle = mean wind speed as a function of sigma0
(Means were taken in linear units with negative sigma0s kept)
Negative sigma0s are in the lowest bin

Step 3: Fit iteratively, removing outliers

Truth: WindSat low frequency speed (consistent with Ku2011) and ECMWF direction

1. Fit the coefficients A0, A1, A2 (least squares fit)
2. Remove outliers
   - For each 20° azimuth bin, trim top and bottom 10% of data, estimate mean and standard deviation, and remove points that are 3*sigma away from previous iteration's model fit
3. Refit the coefficients
4. Repeat steps 2 and 3 until all three coefficients change by less than 1%

$$\sigma^0 = A_0 + \sum_{n=1}^{N} A_n cos(n\chi)$$

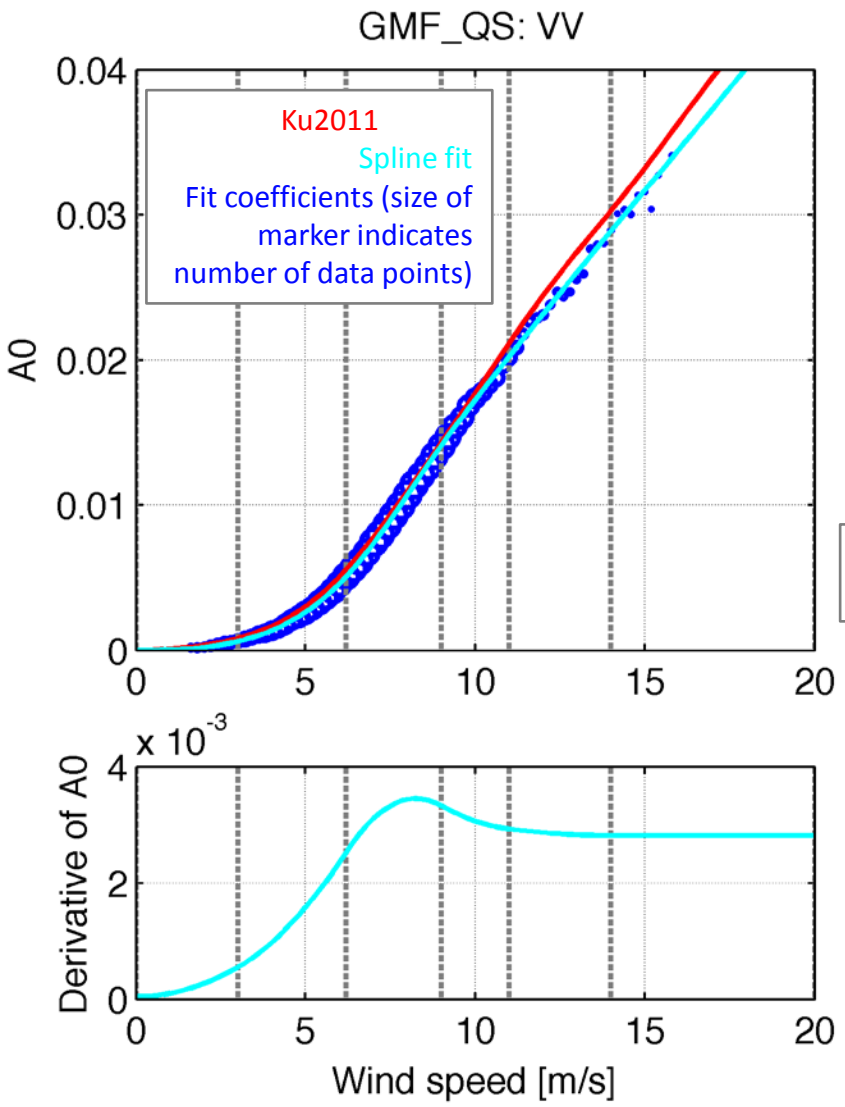


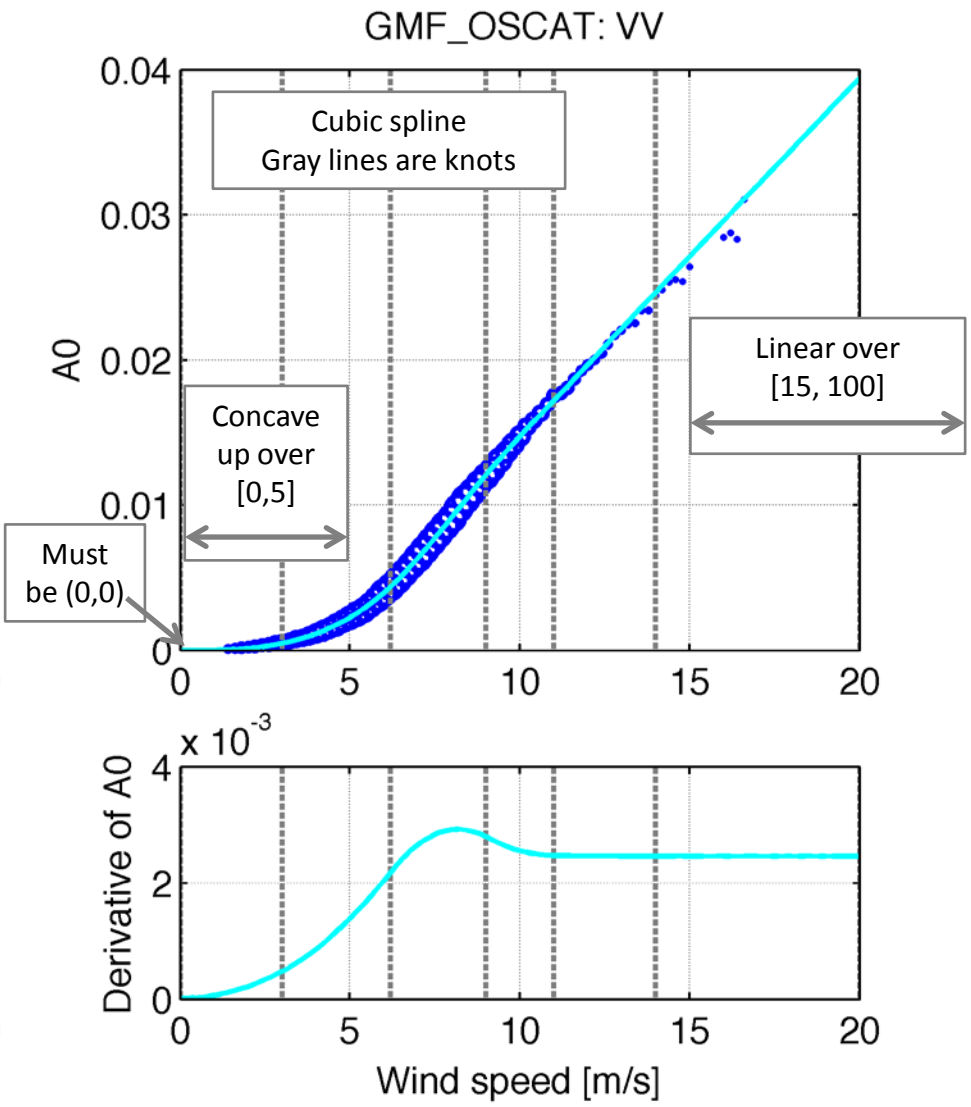
Step 4: Spline fit across speed bins

- Create smoothly varying A0, A1, and A2 coefficients by using spline fit
  - Least squares cubic spline with constraints on the shape of the final function
- To maintain consistency, spline parameters were chosen by comparing GMF_QS to Ku2011 – the same spline parameters were then used for GMF_OSCAT
- Spline fits were performed using “SLMtools”, a freely available toolbox for MATLAB (requires Optimization toolbox).

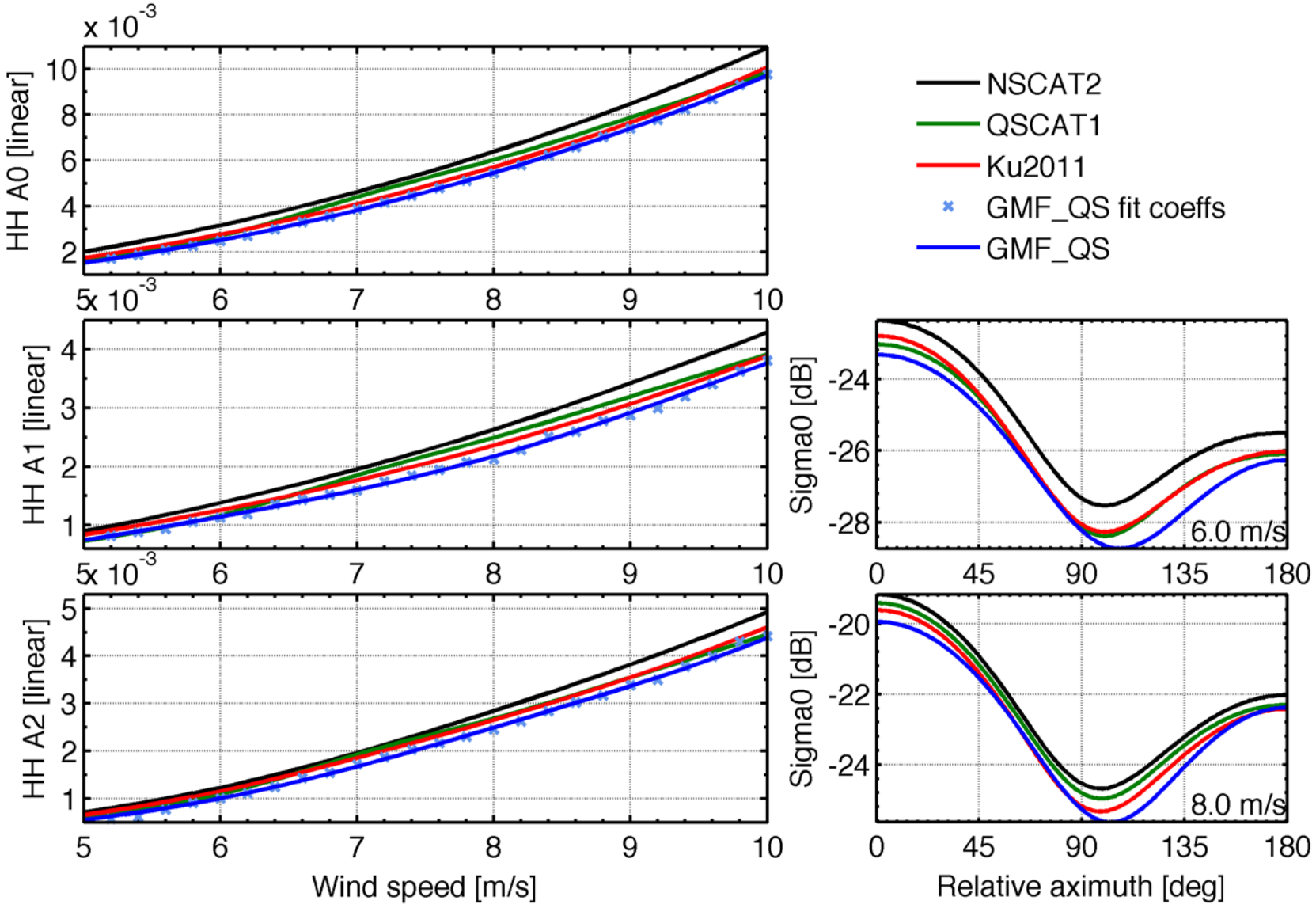
http://www.mathworks.com/matlabcentral/fileexchange/24443

Spline fit example

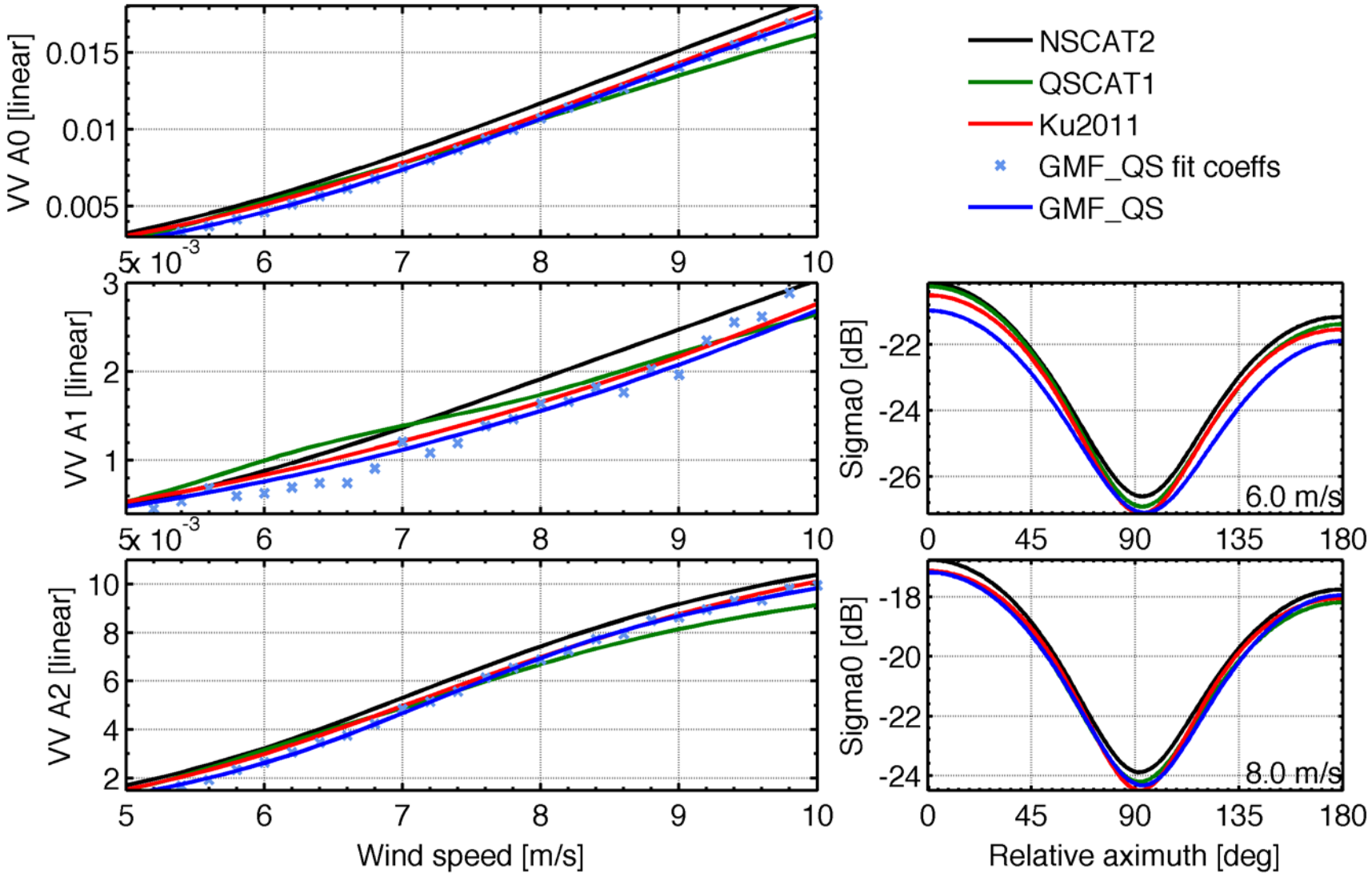




Compare GMF_QS to Ku2011 (HH)

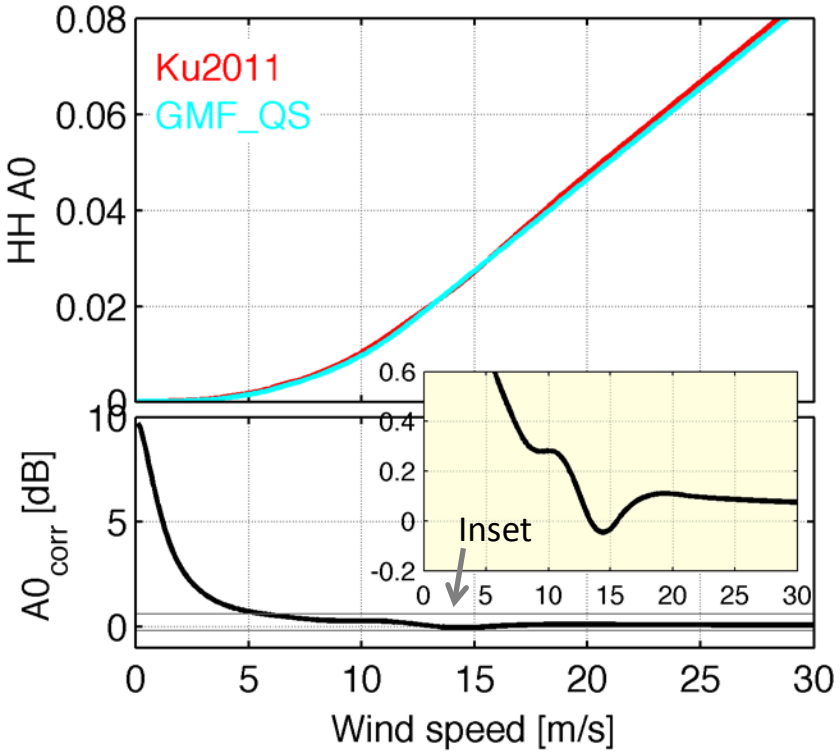


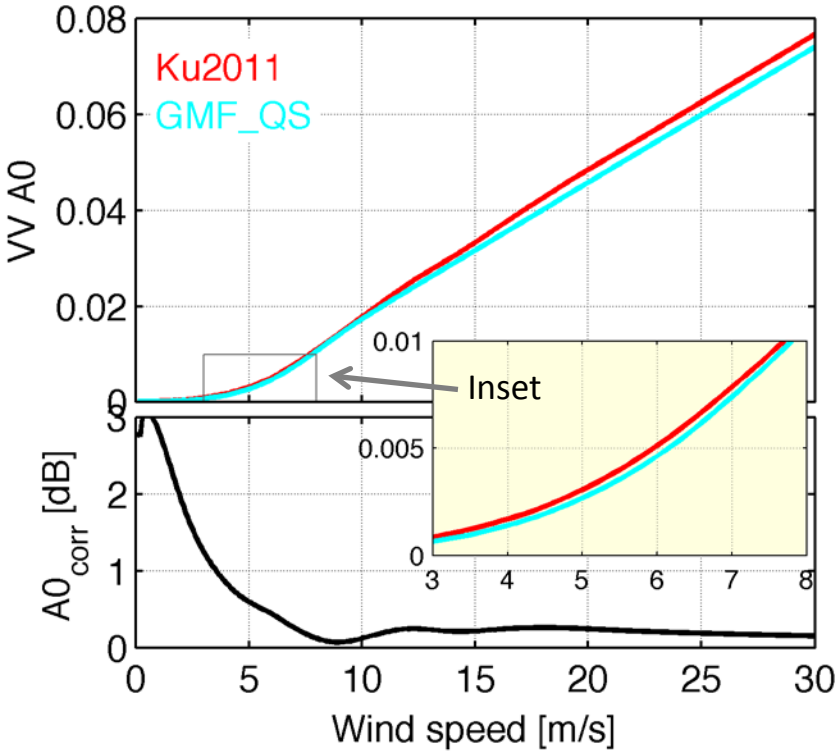
Compare GMF_QS to Ku2011 (VV)



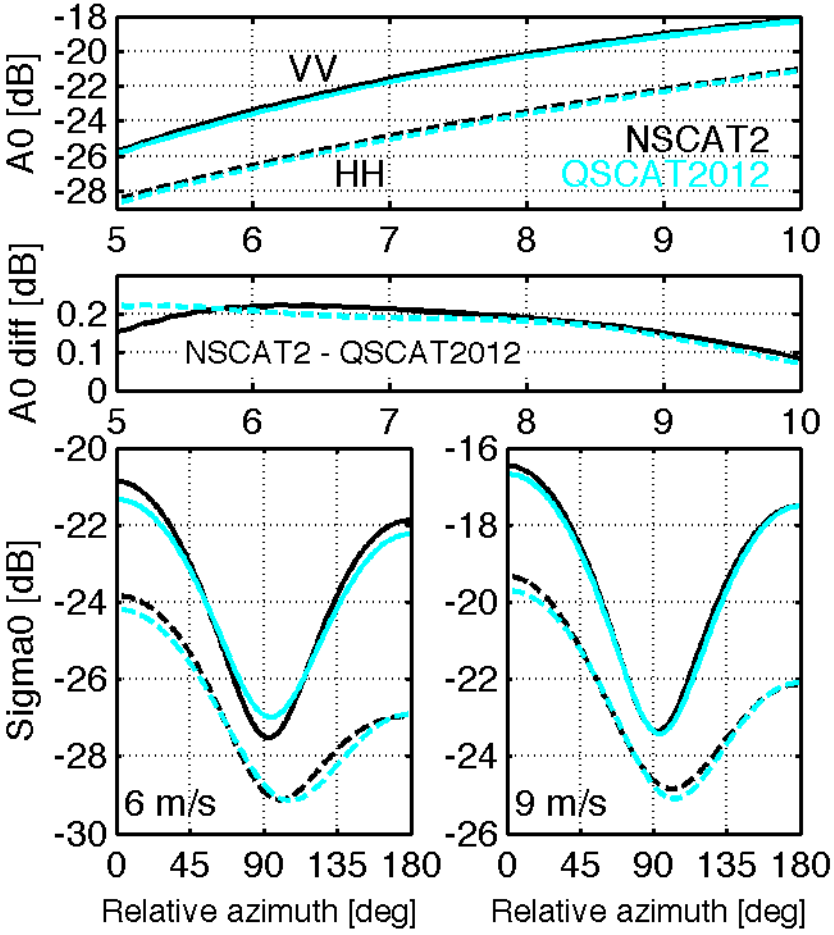
Step 5: Correct A0 bias with Ku2011

- Calculate correction factor: $A0_{\mathrm{corr}} = \dfrac{A0_{\mathrm{Ku2011}}}{A0_{\mathrm{GMF\_QS}}}$
- Apply correction factor to GMF_ISRO
- No corrections for A1 or A2

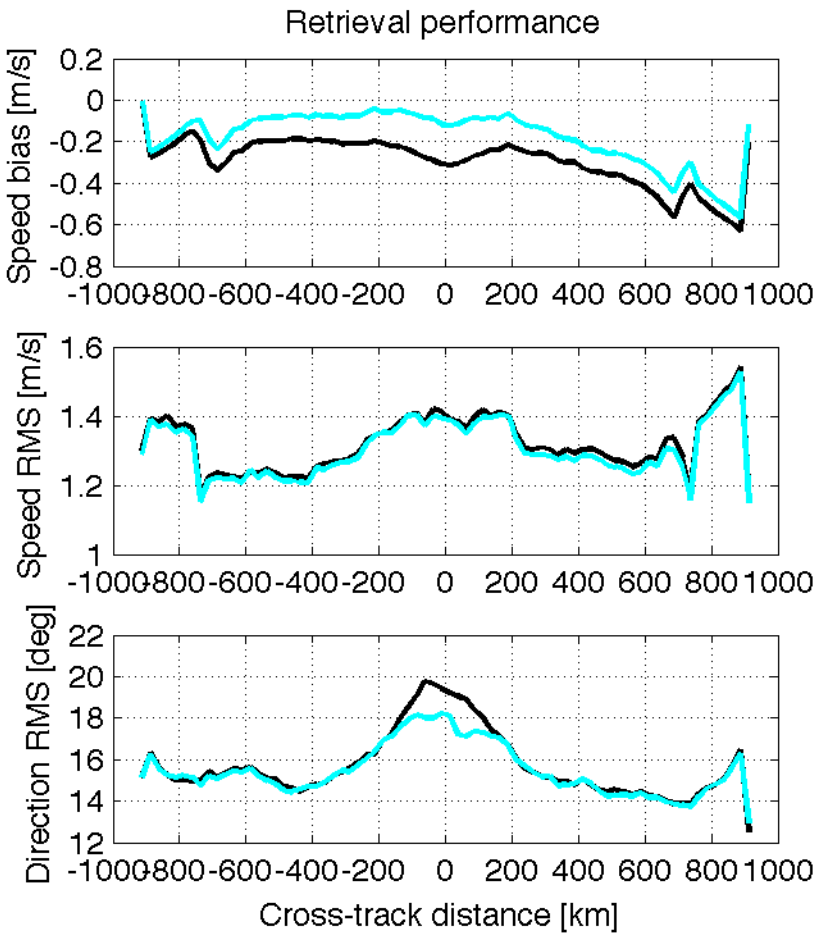




QSCAT2012 with Oceansat-2 data



Wind retrieval using 99 revs from Jan 2012



Summary

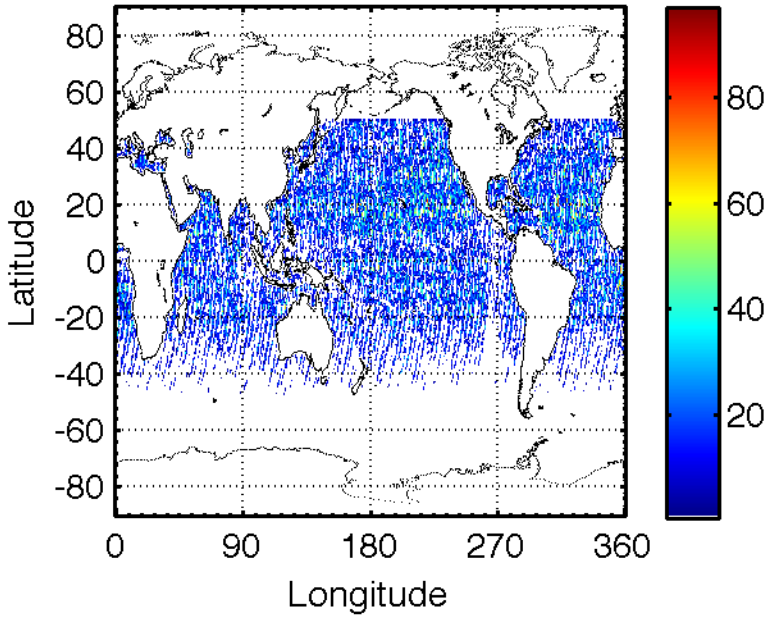
- Nonspinning QuikSCAT data
  - Low noise
  - Potential for investigating model deviations
  - JPL plans to make this data available soon
- New GMF suitable for OSCAT incidence angles
  - Similar to NSCAT2
- GMF is extrapolated outside of 3-12 m/s
- QSCAT2012 combines OSCAT angle GMF with RSS's Ku2011
  - But directional modulation is different!
- Future plans
  - Improve directional modulation consistency with Ku2011
  - Develop GMF at 62° for future applications

APPENDIX

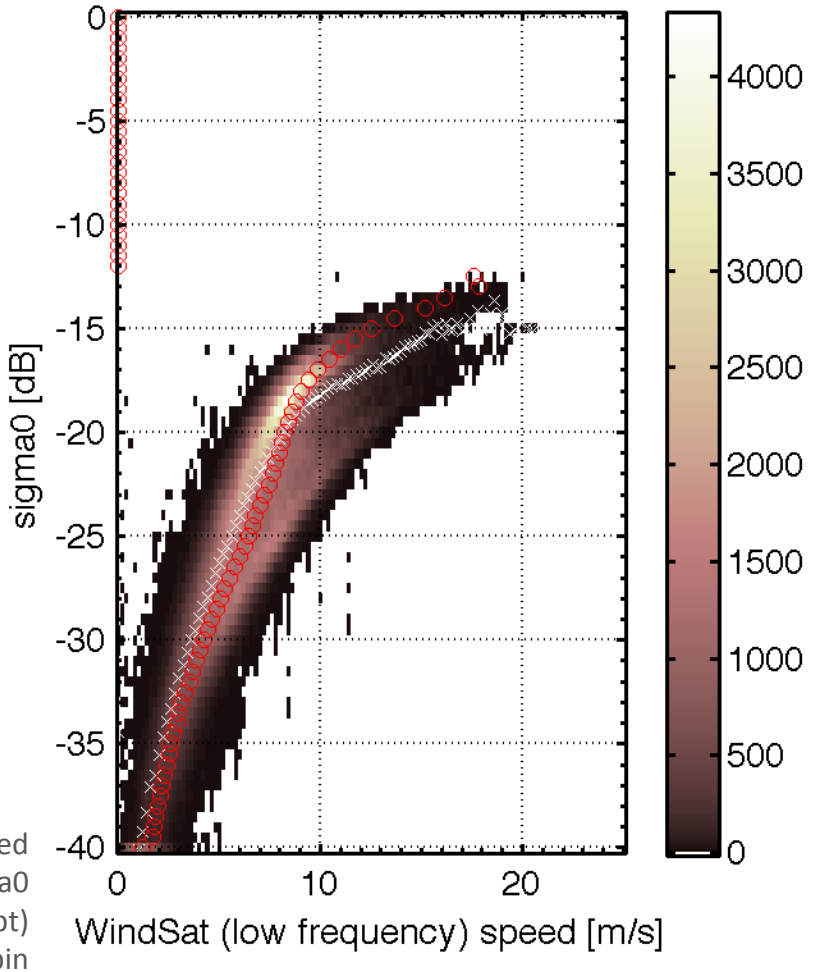
GMF_OSCAT: Outer beam data

Data location histogram

Bin size = 0.5°



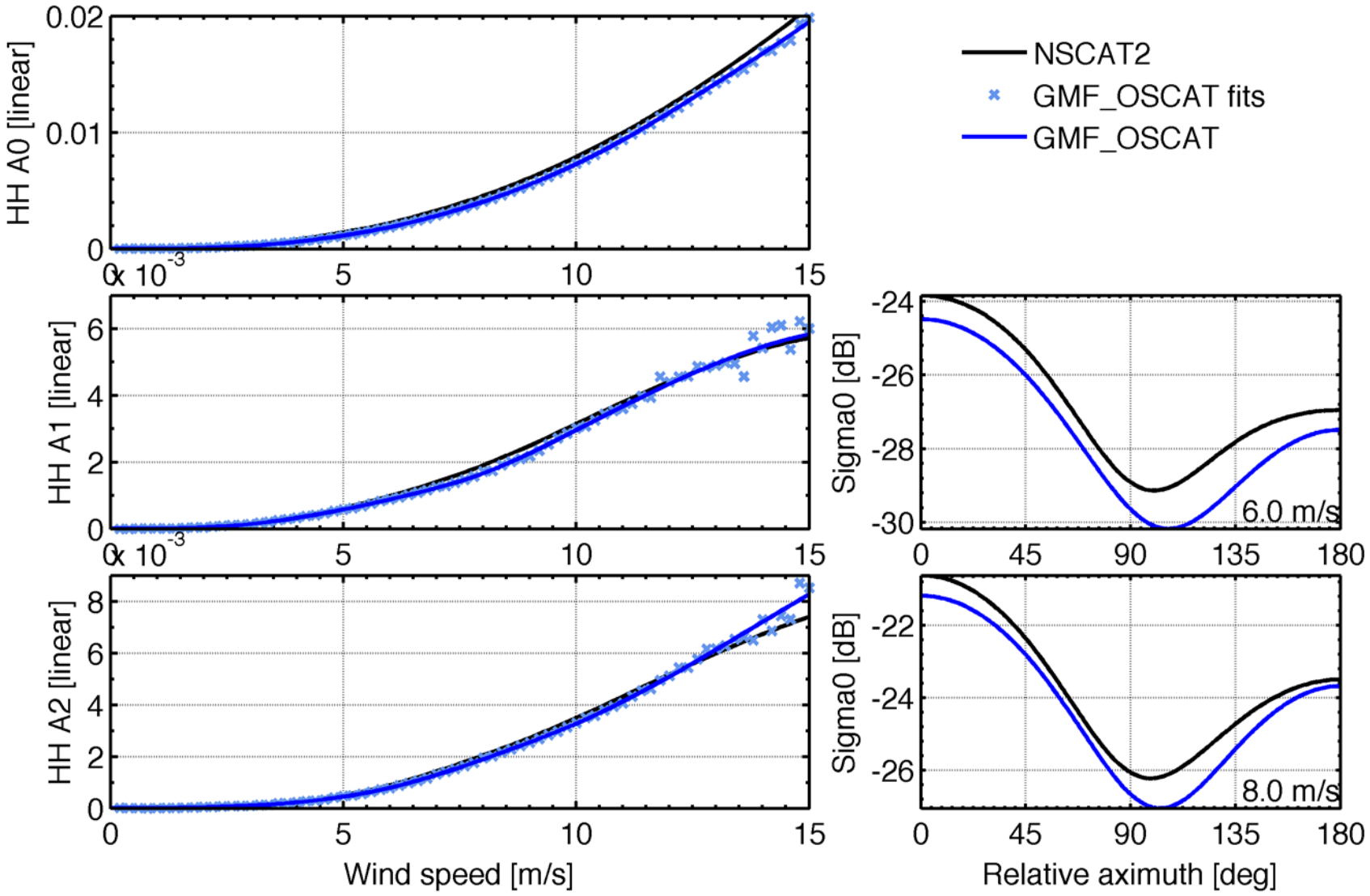
Sigma0 histogram



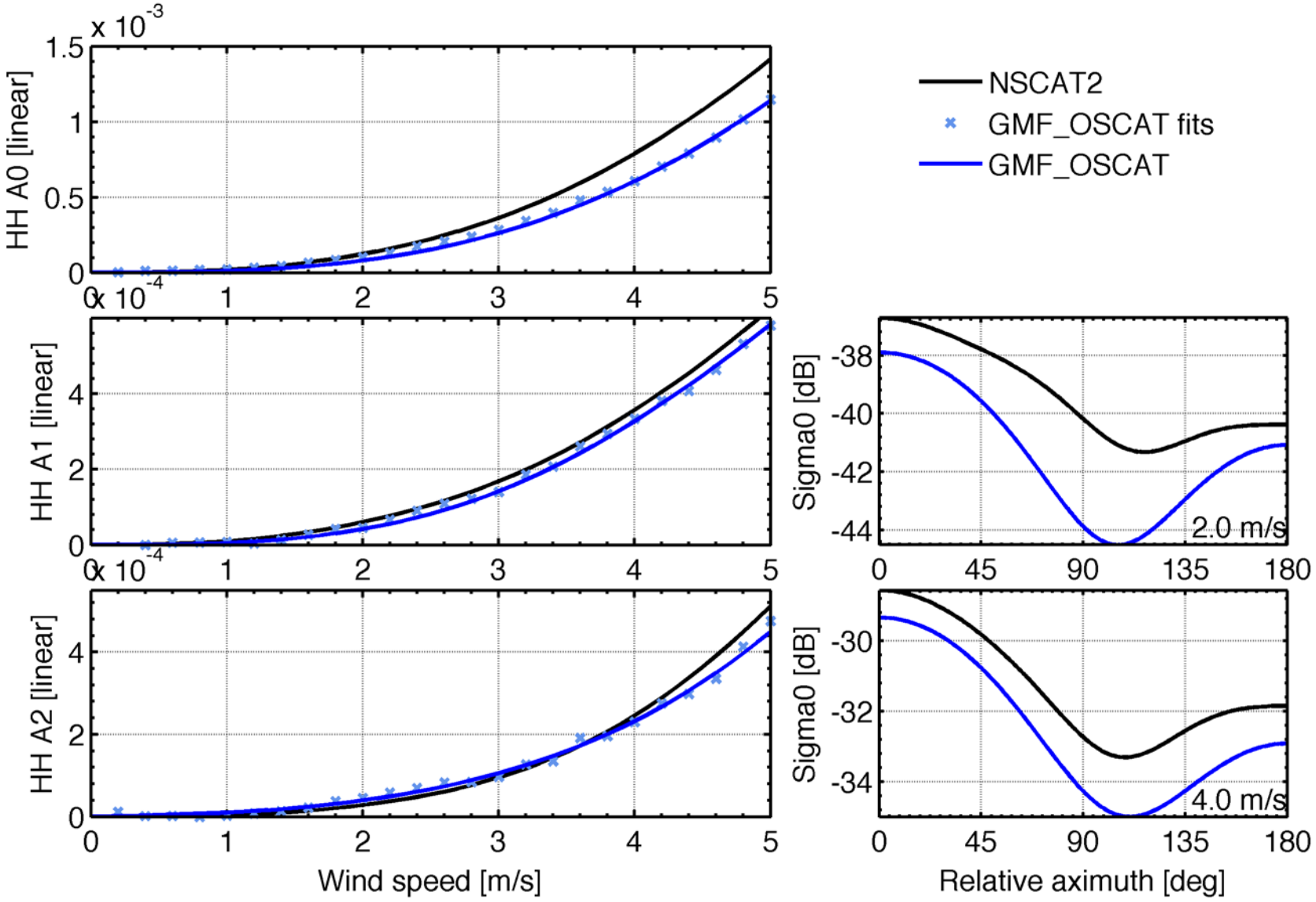
White X = Mean sigma0 as a function of wind speed
Red circle = mean wind speed as a function of sigma0
(Means were taken in linear units with negative sigma0s kept)
Negative sigma0s are in the lowest bin

RAW FIT COEFFICIENTS (GMF_OSCAT)

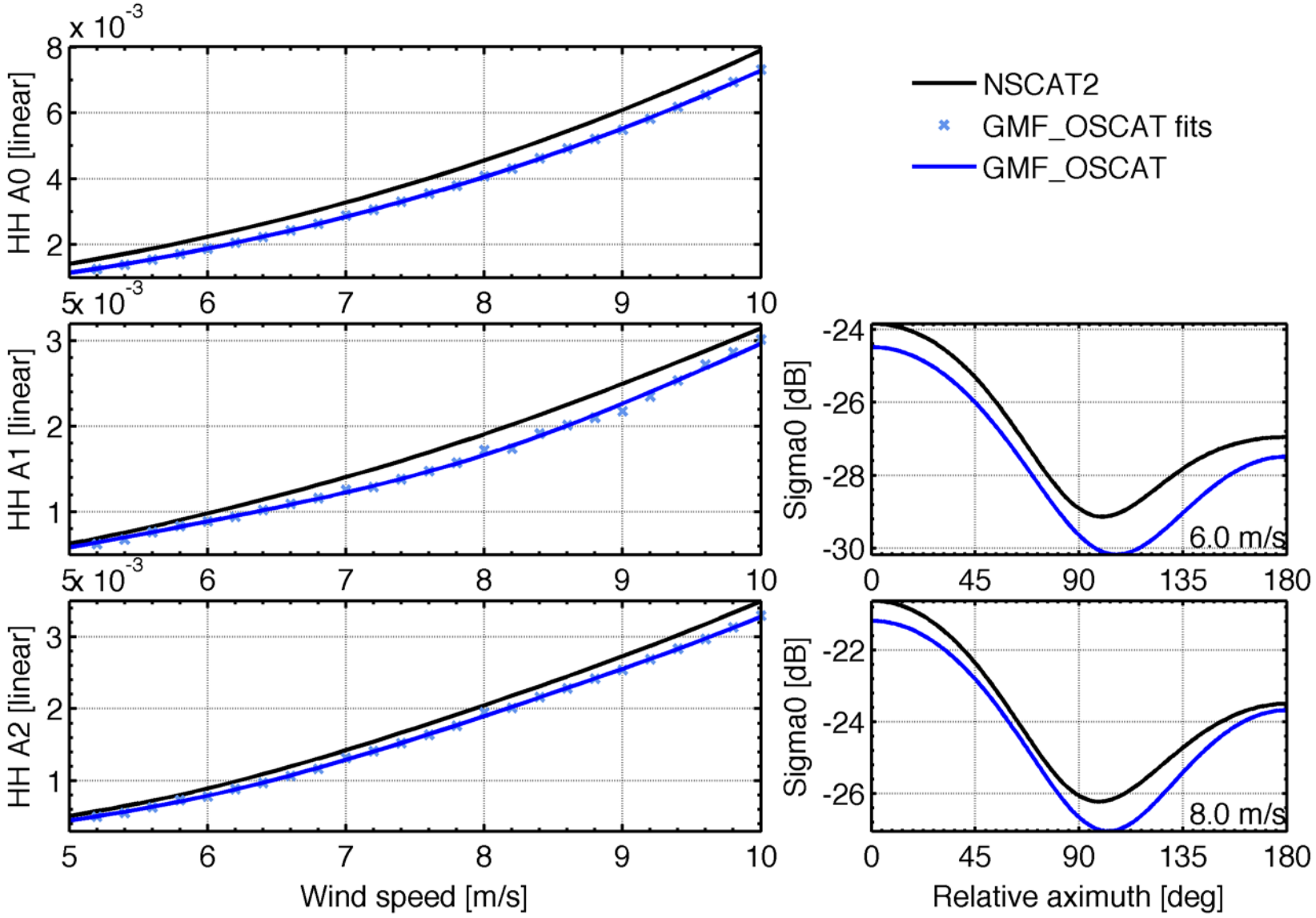
GMF_OSCAT: raw fit coefficients



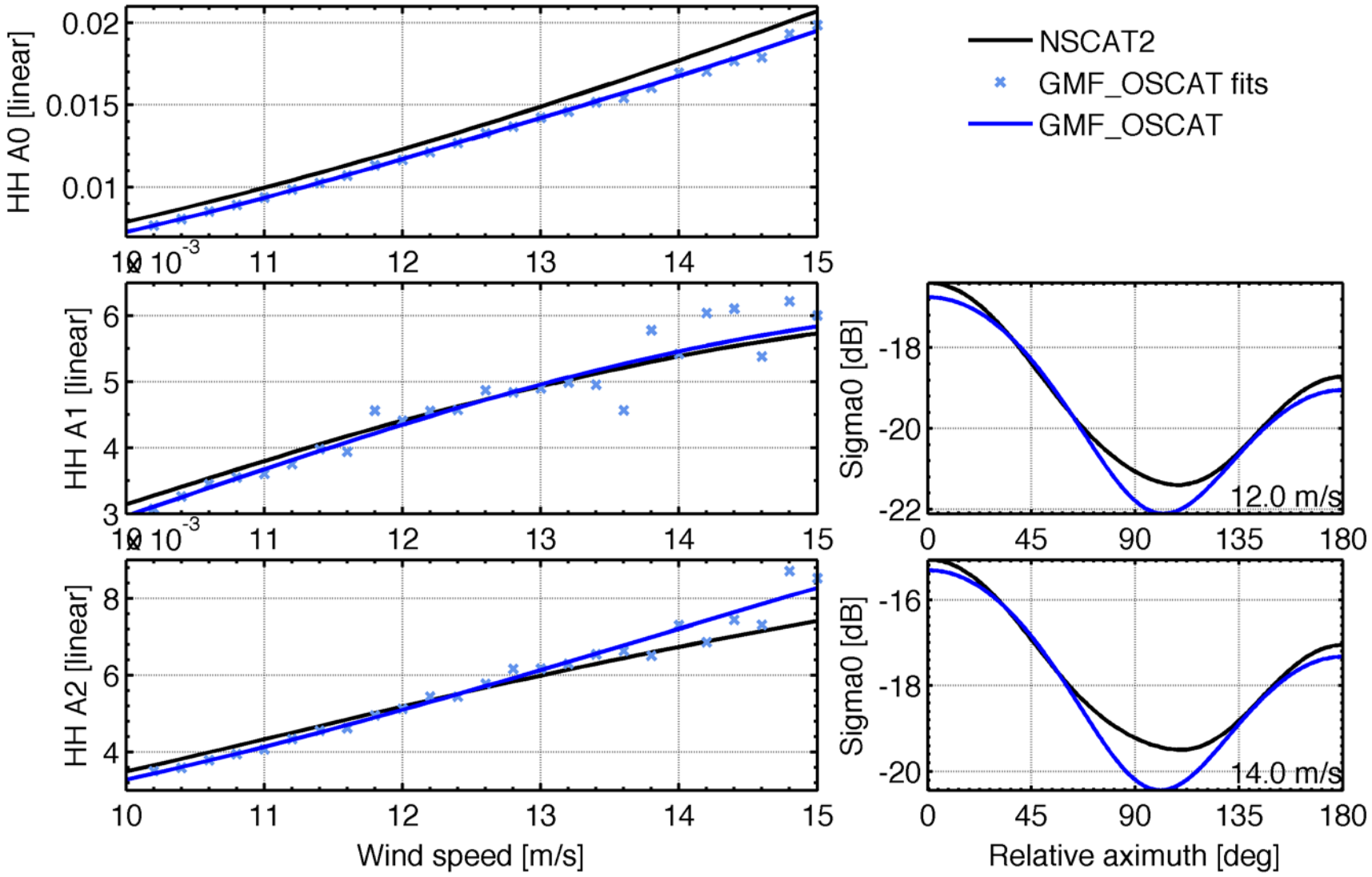
GMF_OSCAT: raw fit coefficients



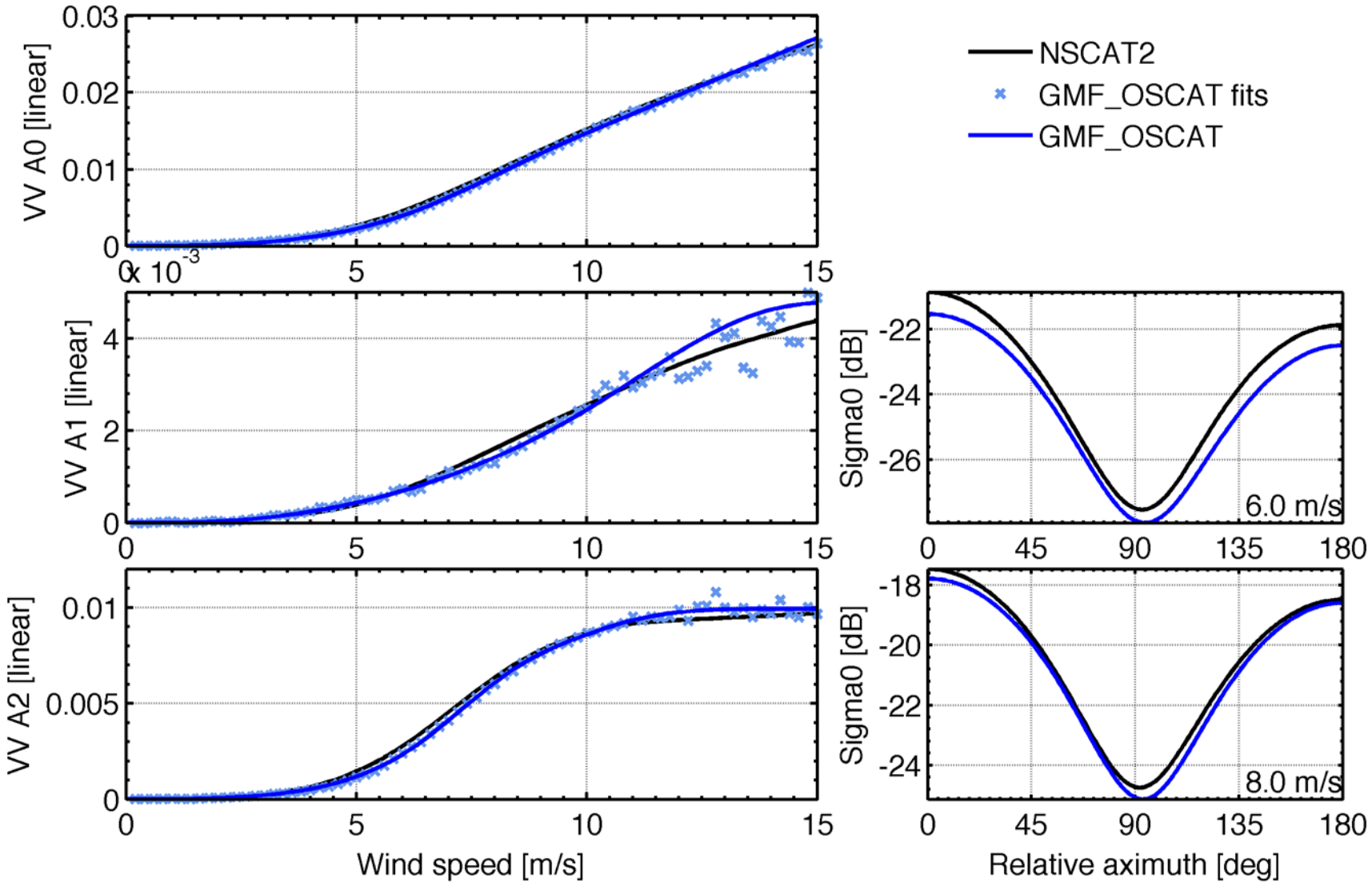
GMF_OSCAT: raw fit coefficients



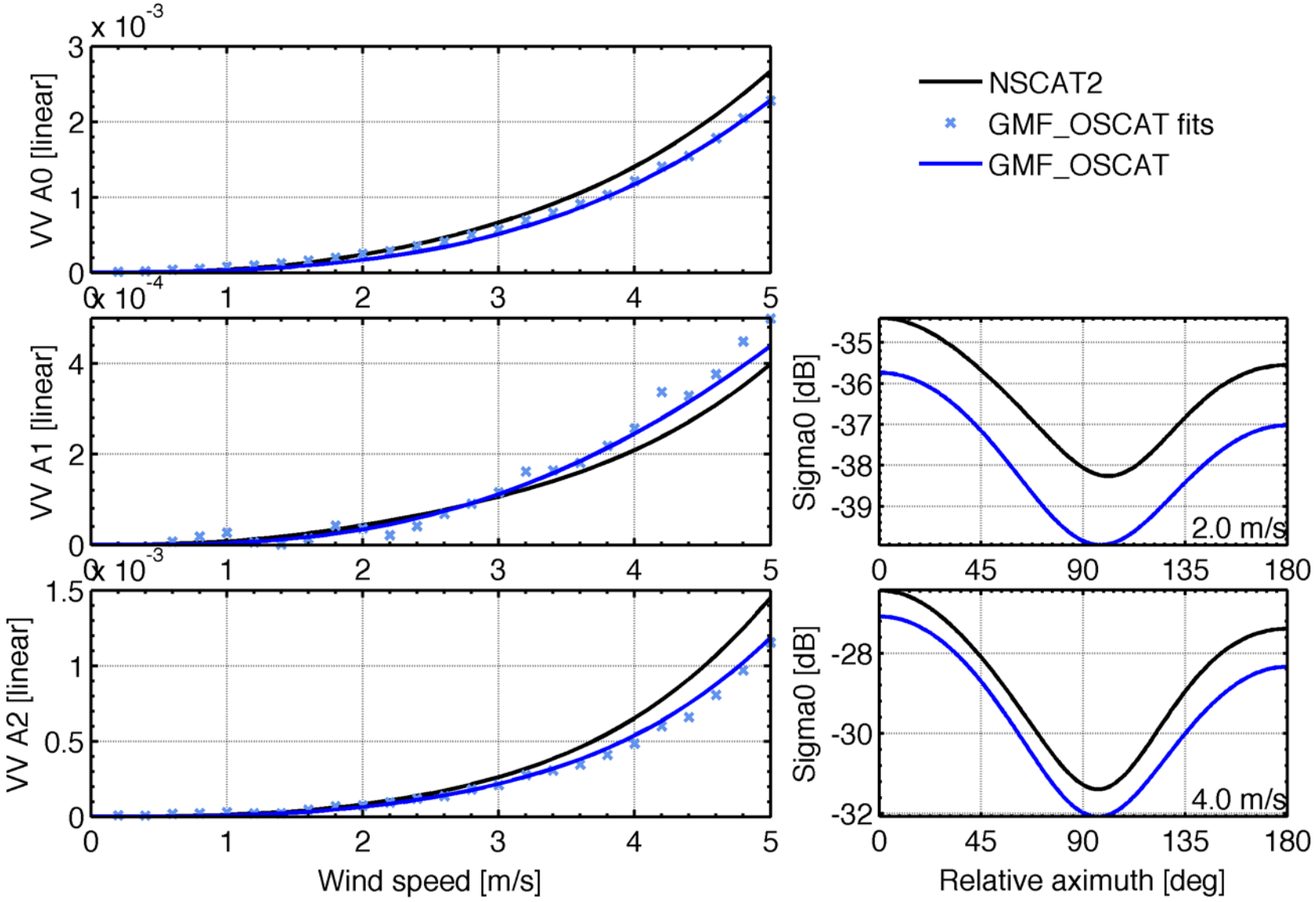
GMF_OSCAT: raw fit coefficients



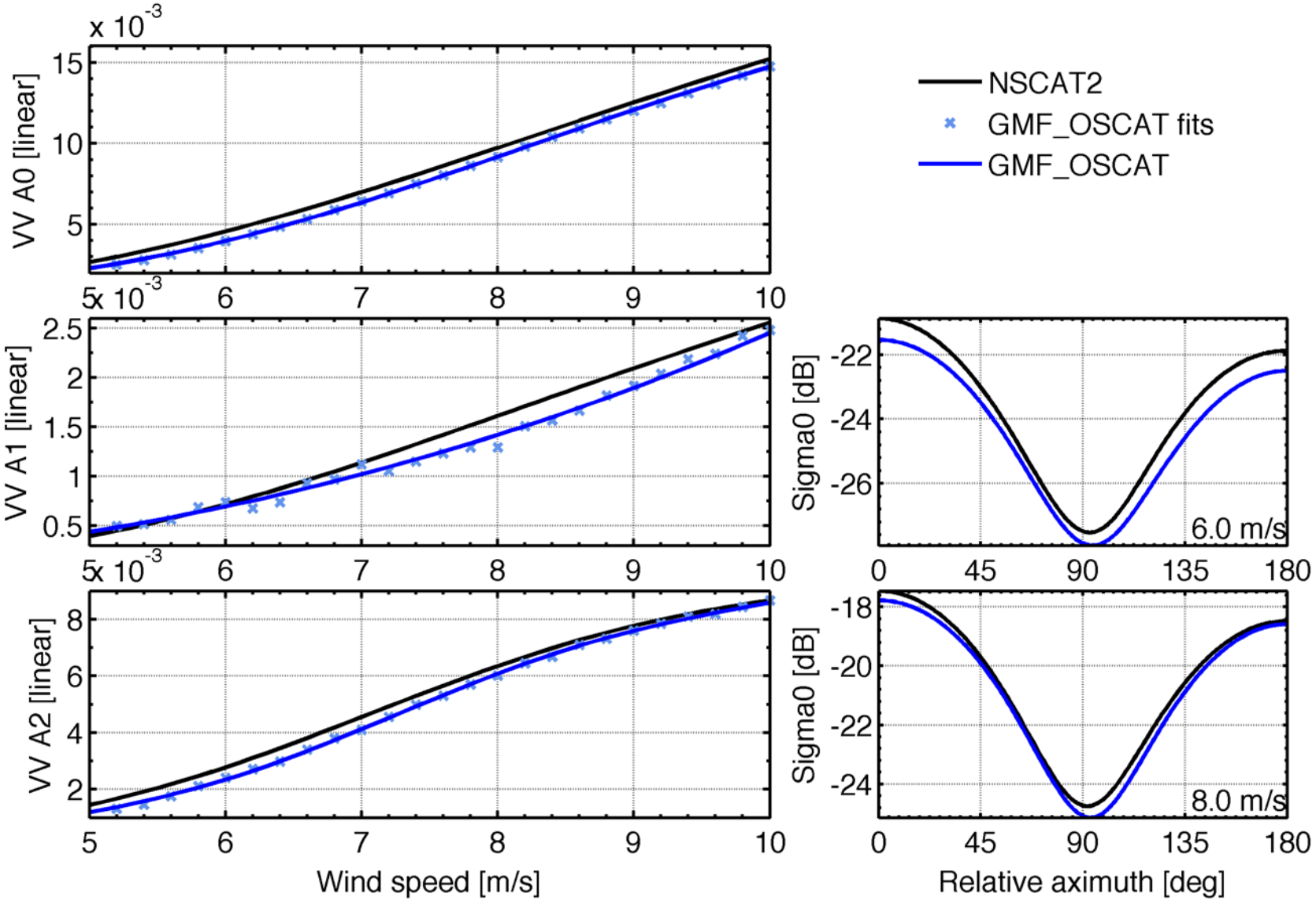
GMF_OSCAT: raw fit coefficients



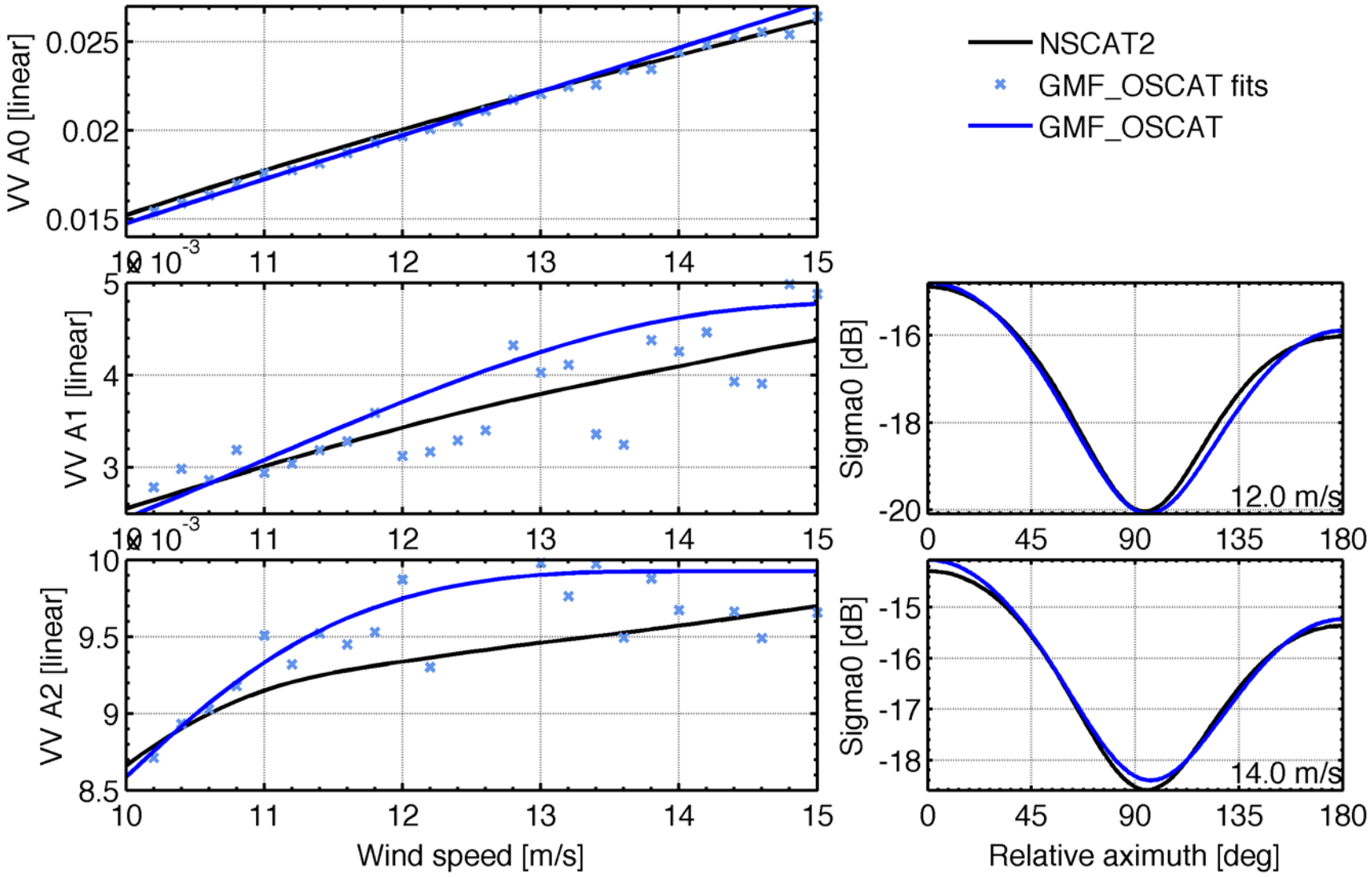
GMF_OSCAT: raw fit coefficients



GMF_OSCAT: raw fit coefficients

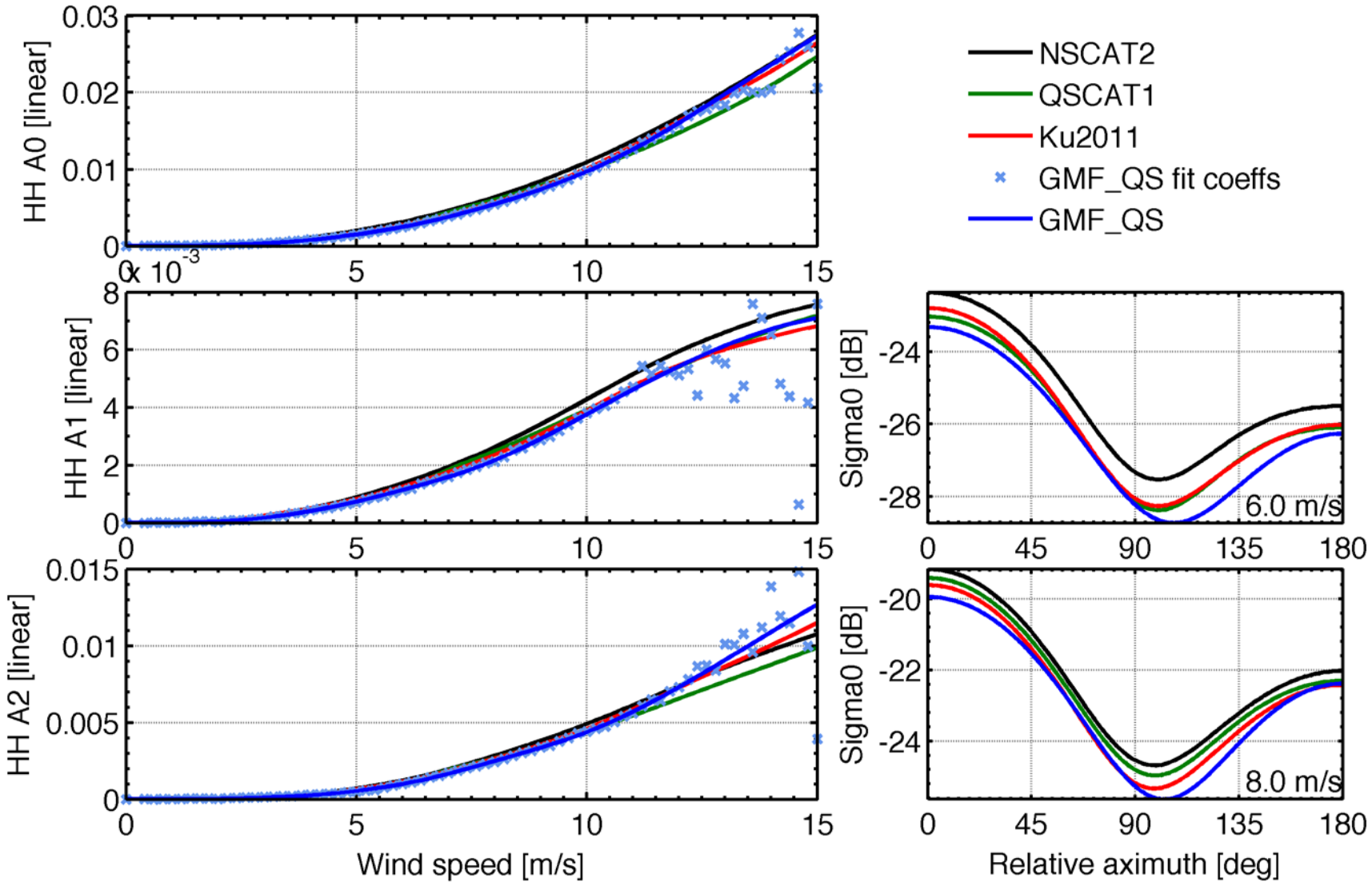


GMF_OSCAT: raw fit coefficients

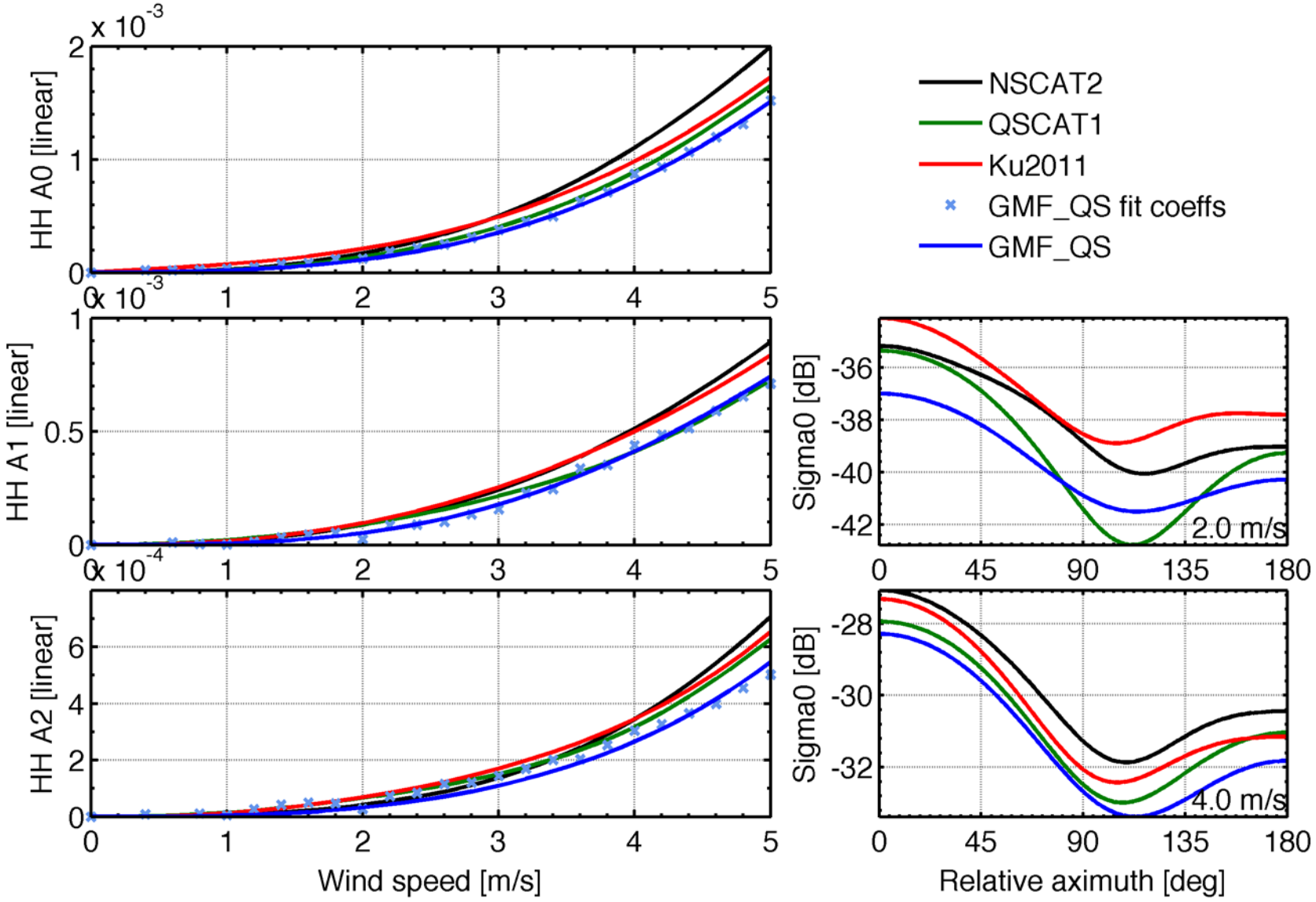


RAW FIT COEFFICIENTS (GMF_QS)

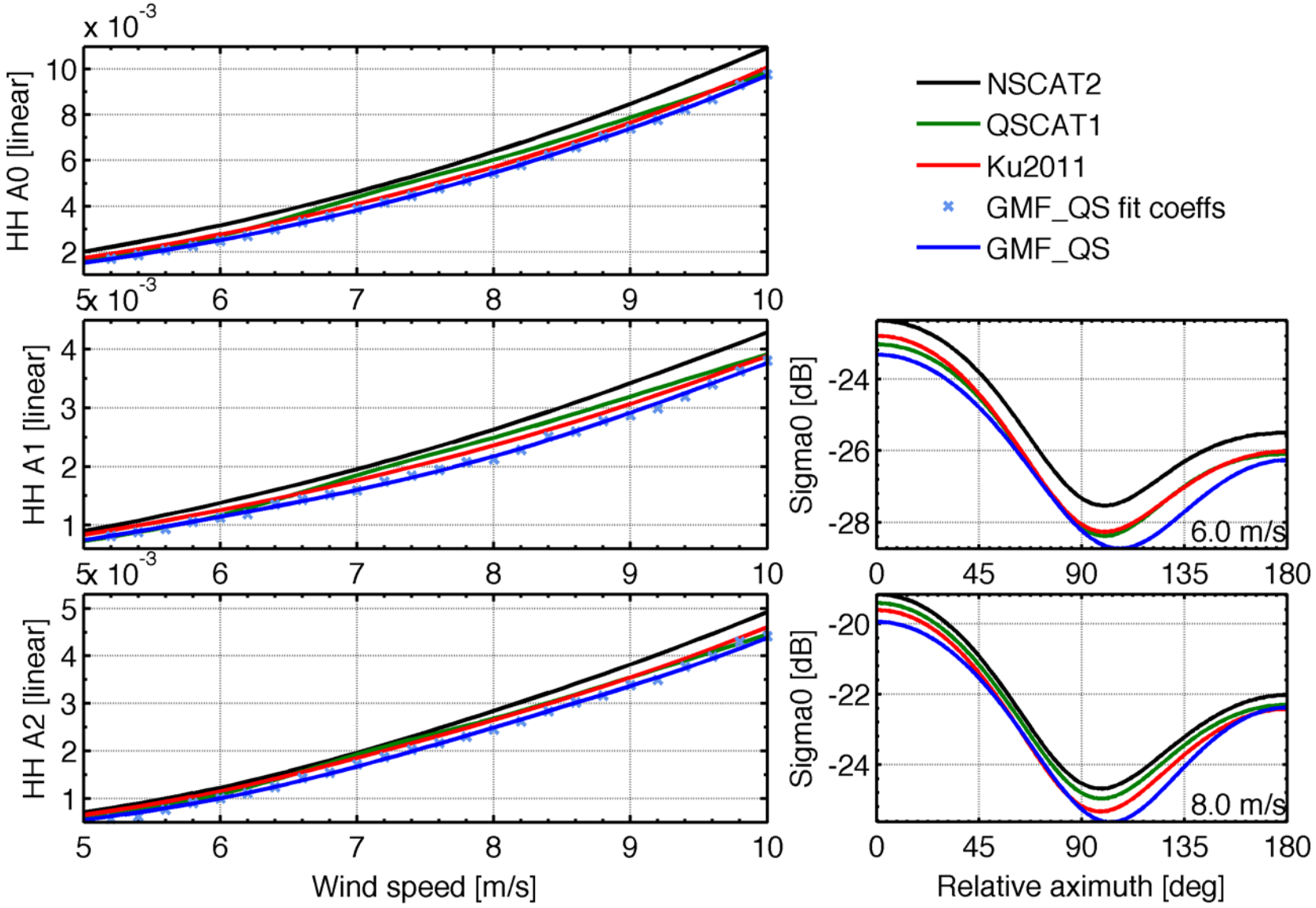
GMF_QS: raw fit coefficients



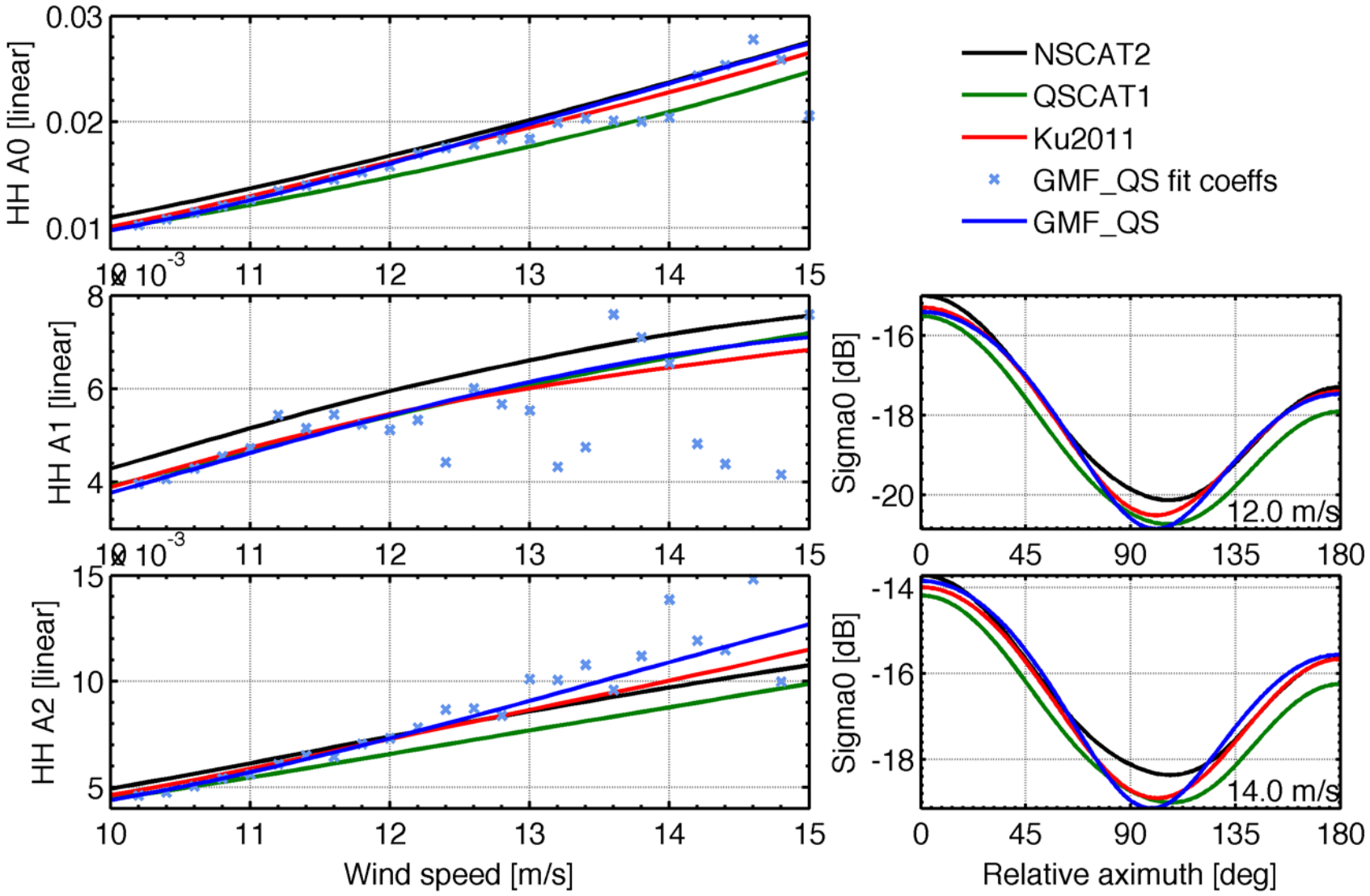
GMF_QS: raw fit coefficients



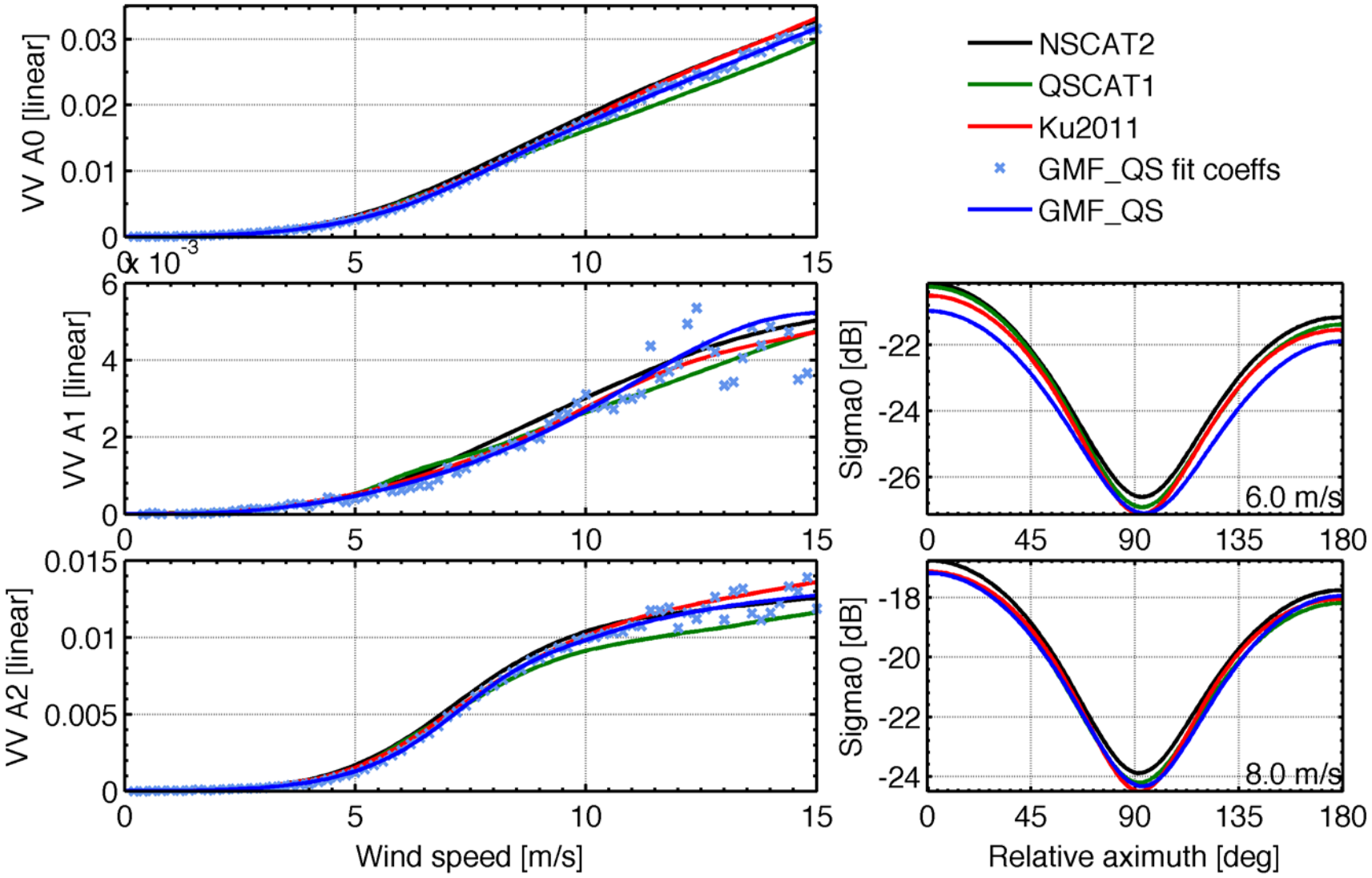
GMF_QS: raw fit coefficients



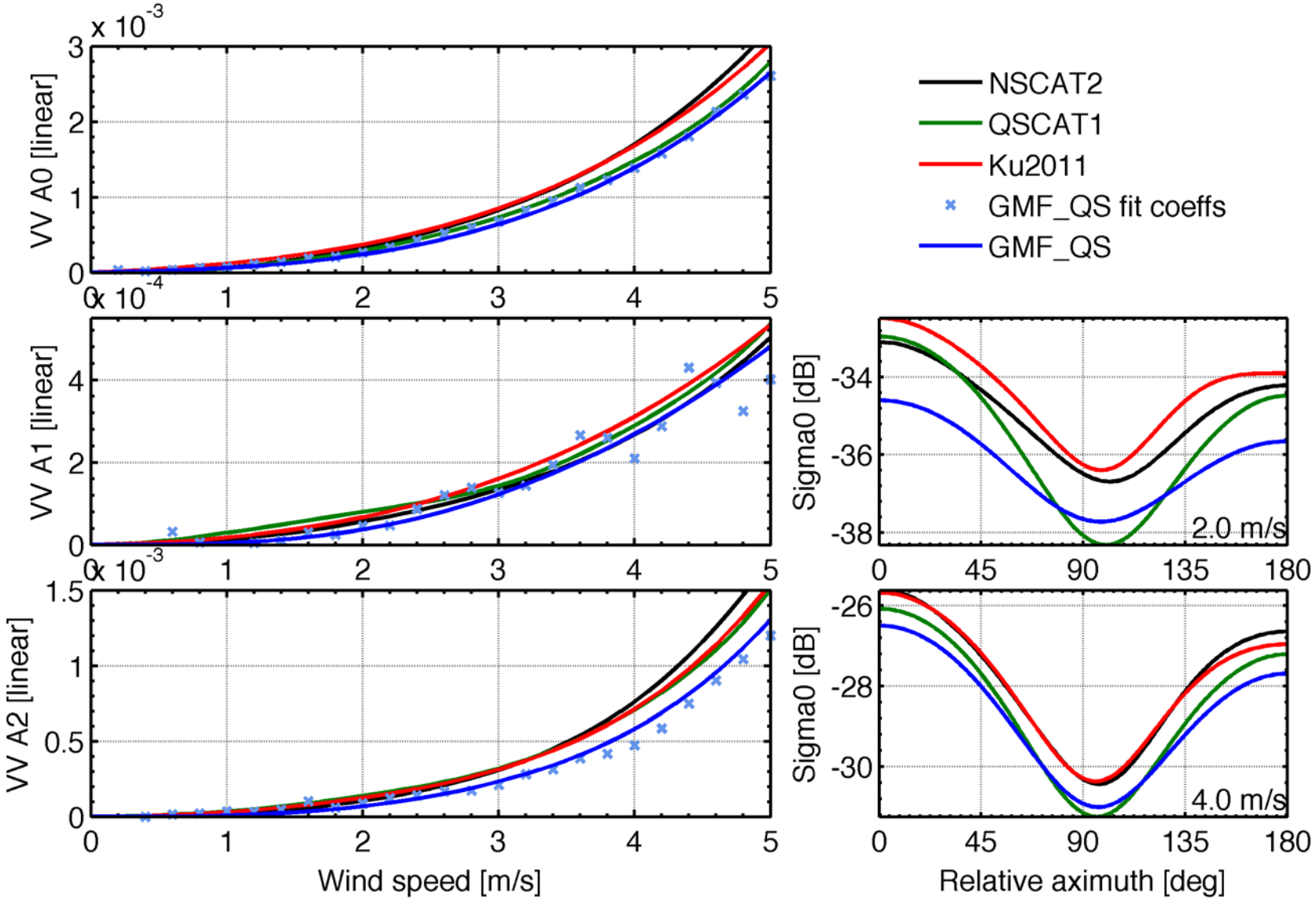
GMF_QS: raw fit coefficients



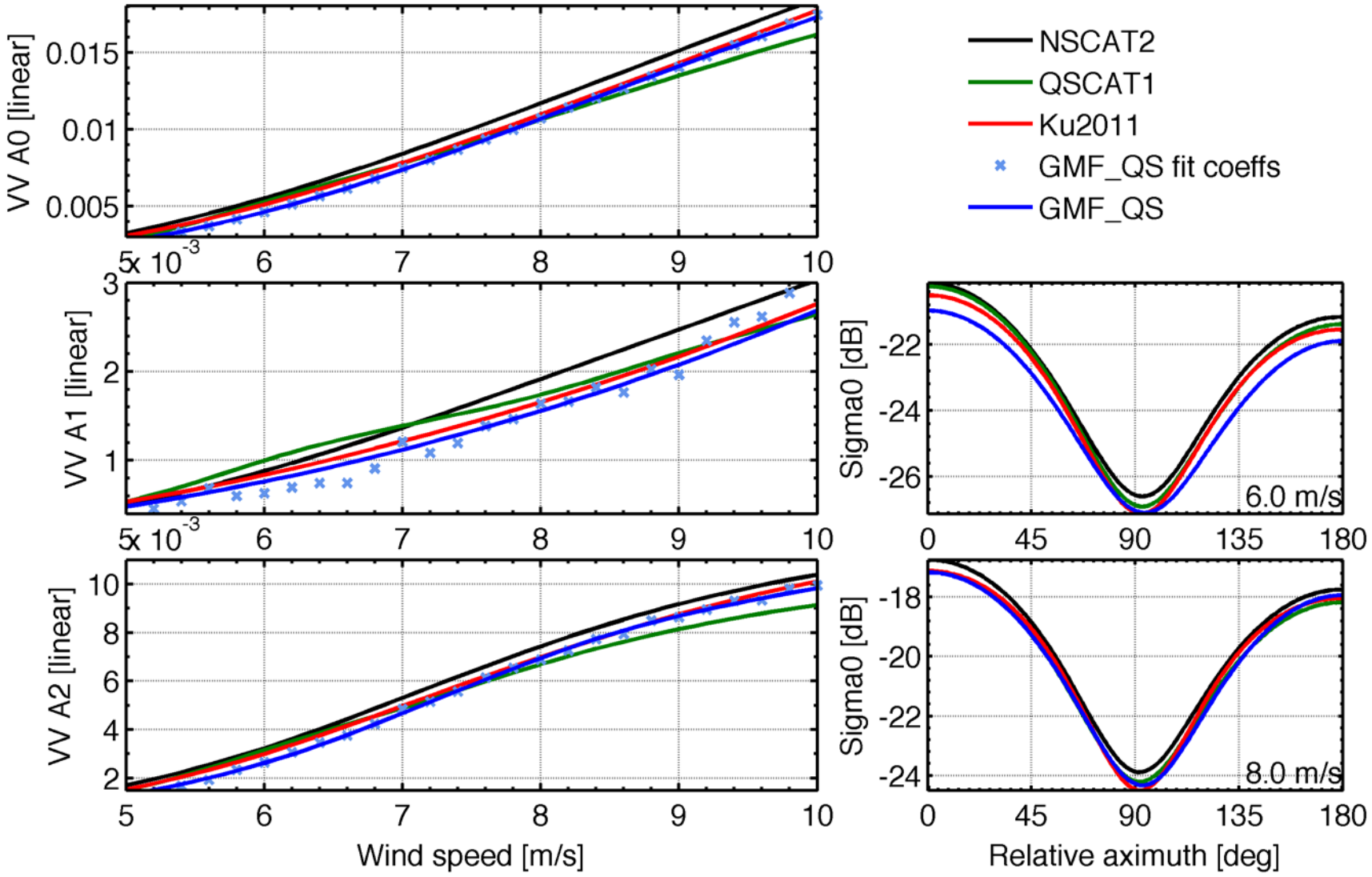
GMF_QS: raw fit coefficients



GMF_QS: raw fit coefficients



GMF_QS: raw fit coefficients



GMF_QS: raw fit coefficients