OSCAT backscatter stability evaluation using ocean and natural land targets

Sermsak Jaruwatanadilok, Bryan W. Stiles,

Alexander Fore, R. Scott Dunbar,

and Svetla Hristova-Veleva

Jet Propulsion Laboratory,

California Institute of Technology, Pasadena, CA, USA

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Outline

- History
- Part 1: QuikSCAT backscatter information
- Part 2: OSCAT stability evaluation using land targets
- Part 3: OSCAT stability evaluation using ocean data

History

- August 2011: ISRO, JPL and NOAA teams meet in India
- After the meeting, ISRO provides OSCAT data from January 2010 –July 2010
- This set of data is used to produce a calibration number to match with QuikSCAT data. 0.3362 dB for H-pol, 0.2205 dB for V-pol is recommended to be added to OSCAT data
- September 16, 2011: we received 6 revs of data showing that these calibration numbers are properly put into OSCAT data
- We have been receiving NRT data since December 20, 2011
- April 2012: we received a disk from ISRO containing OSCAT data from July 2011 to December 2011
- We monitor the stability of OSCAT backscatter because we believe that the cal loop back is not in used. Therefore, OSCAT backscatter is subjected to change/drift due to change in conditions of instruments

In this investigation on OSCAT stability, we use these data

- January 2010 – July 2010 data received in September 2011. The calibration constants are added to this set. => OSCAT2010
- Reprocess data July 2011 – December 2011 (Received in a disk from ISRO in April 2012) => OSCAT2011
- Current NRT data stream (since late December 2011, 2011 till now) => OSCAT2012
- There is still missing OSCAT data from August 2010 to June 2011 !

Part 1: QuikSCAT information

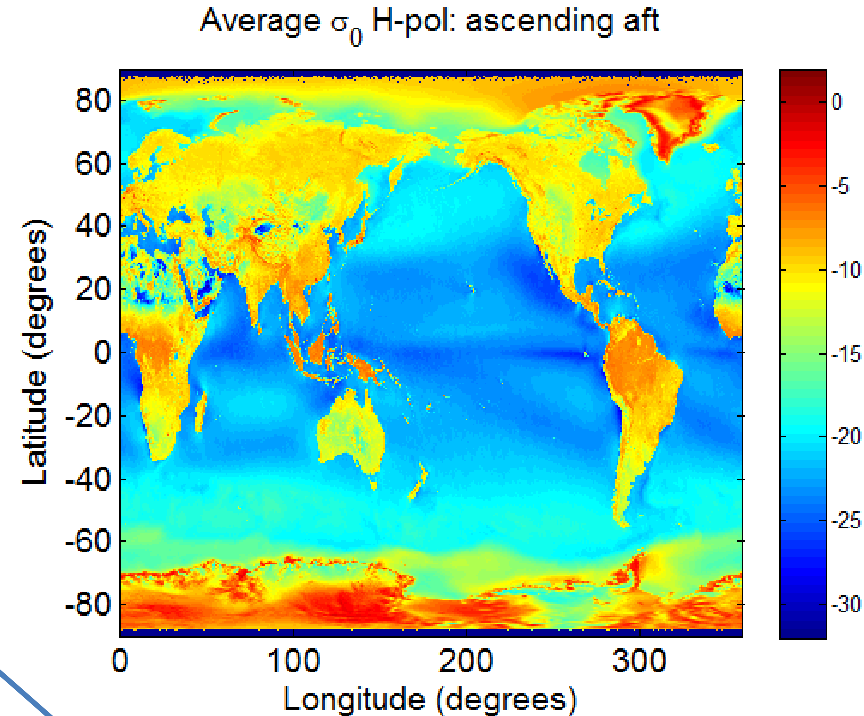
- Analysis of 10-year QuikSCAT backscatter data
- Find proper land targets to be used as calibration sites
  - Time variability
  - Spatial variability
- Stability of QuikSCAT backscatter and retrieved wind speed

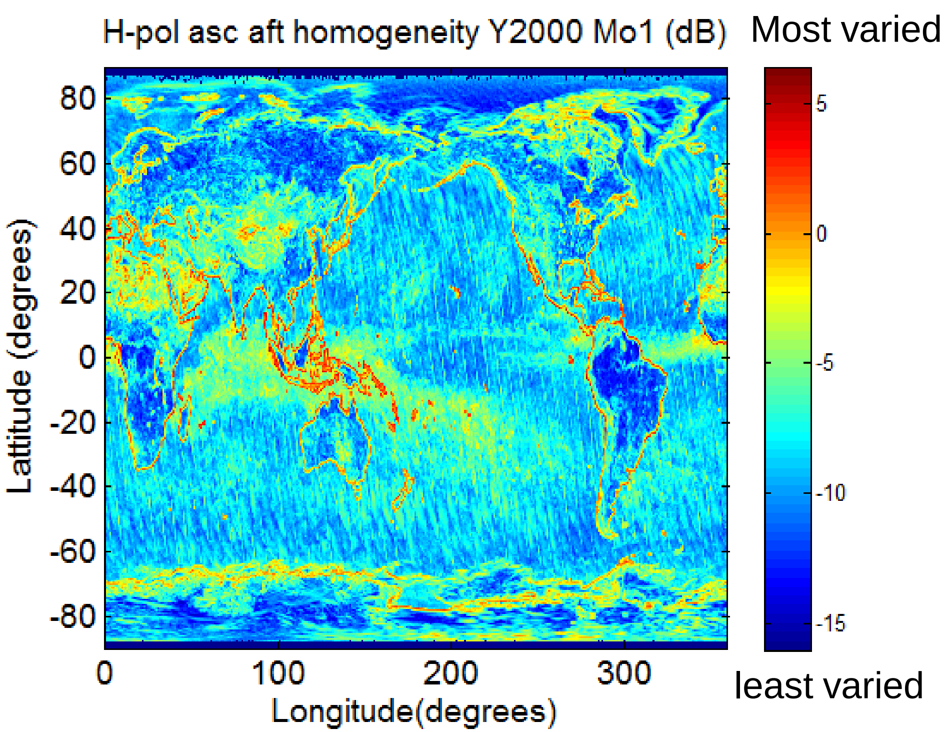
Find ‘constant’ land target

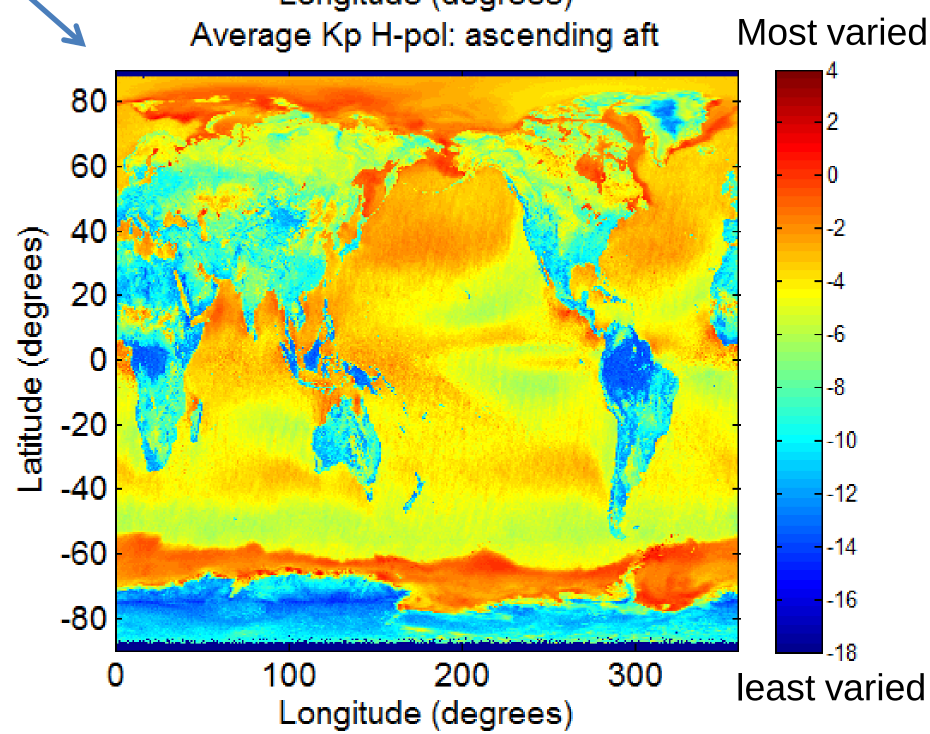
- Bin ‘slice’ sigma0 at 0.1 degrees
- Time variation evaluation
  - Find monthly average sigma0s (Msig0) that fall into that bin. There are 125 months
  - Kp_time = std(Msig0)/mean(Msig0)
- Spatial variation evaluation
  - Use monthly average data at 0.1 degree bins, at a particular bin use statistics of Msig0 of 1 degree around that bin
  - Kp_spat = std(Msig0_0.1d)/mean(Msig0_0.1d)

H-pol ascending aft look example

- Average backscatter (dB)
- Time variability (dB)
- Spatial variability (dB)



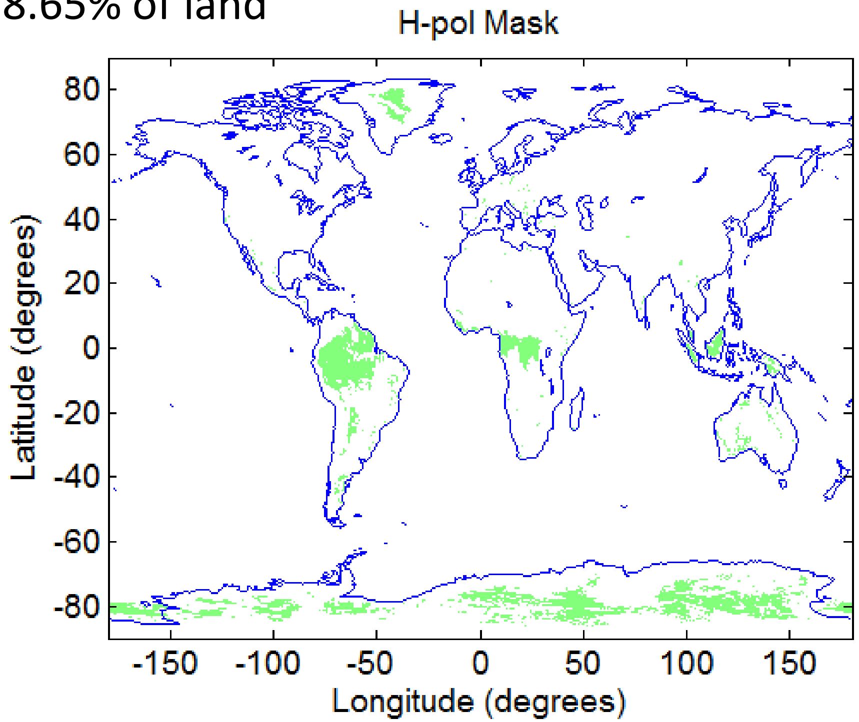




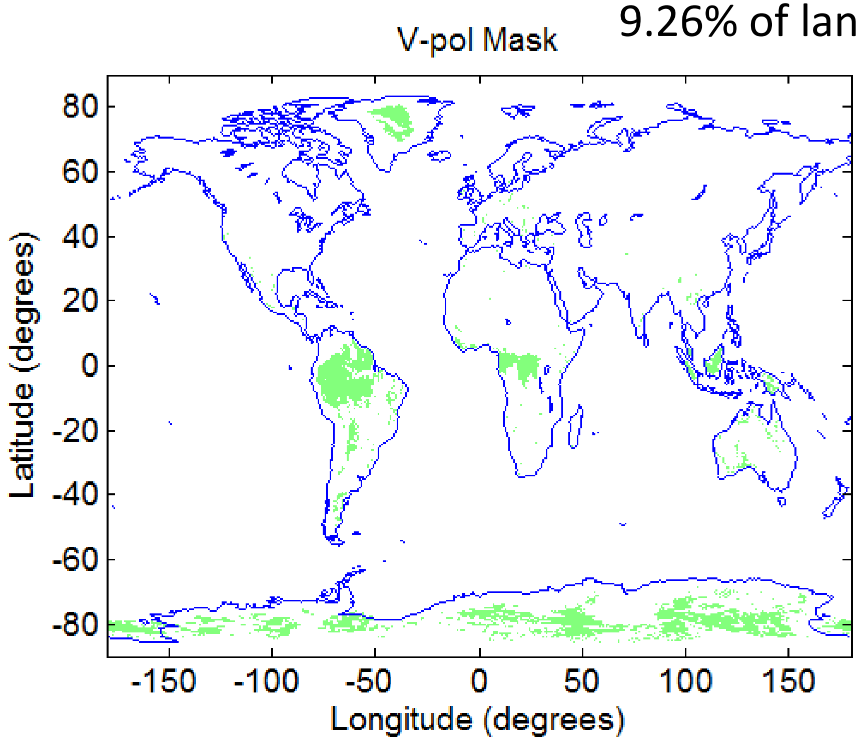
Potential land targets

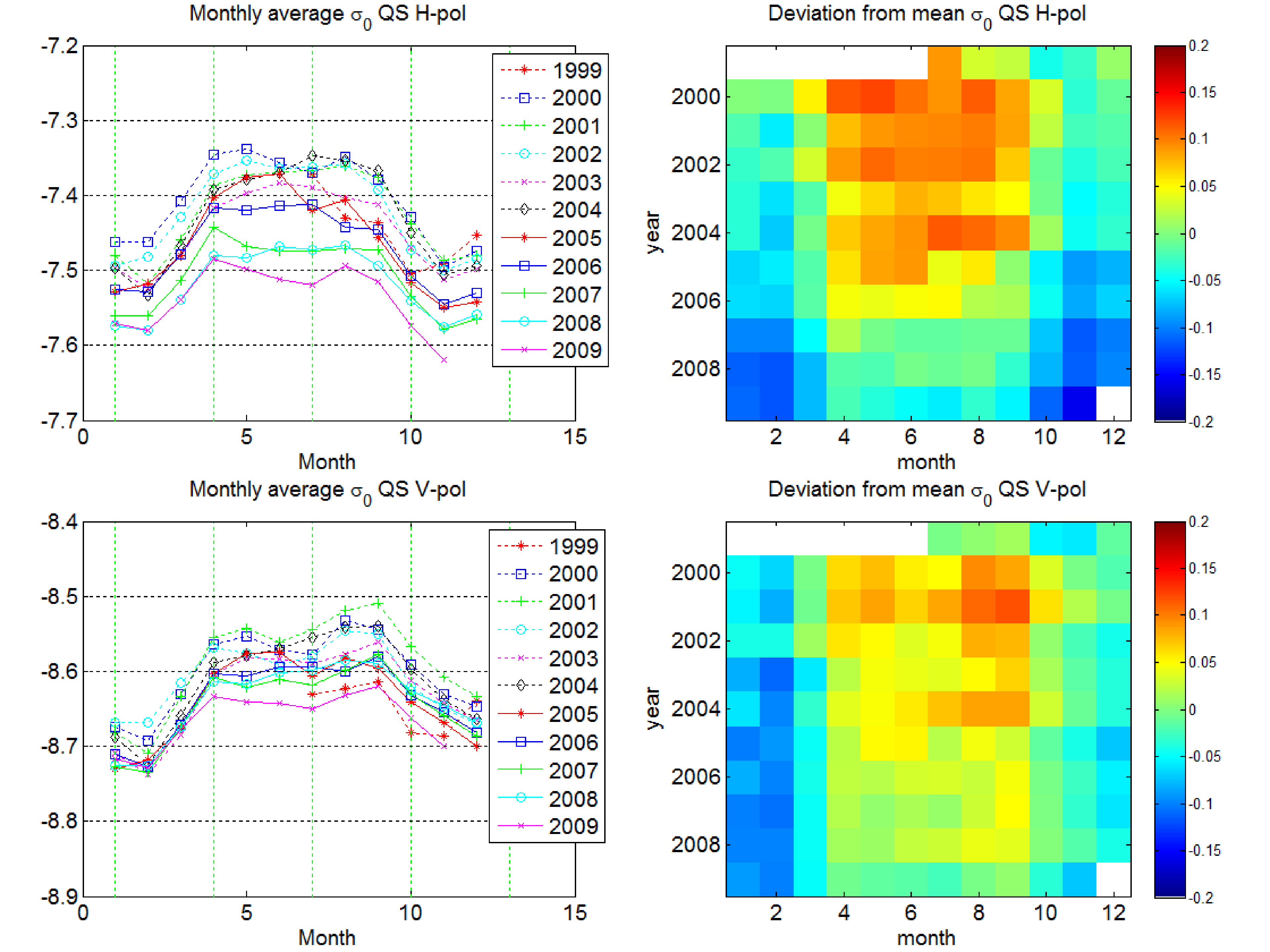
- Global map of places with low time variation and spatially homogeneous
- Kp_spat and Kp_time < 0.1

2.91 % of globe
8.65% of land



3.12 % of globe
9.26% of land

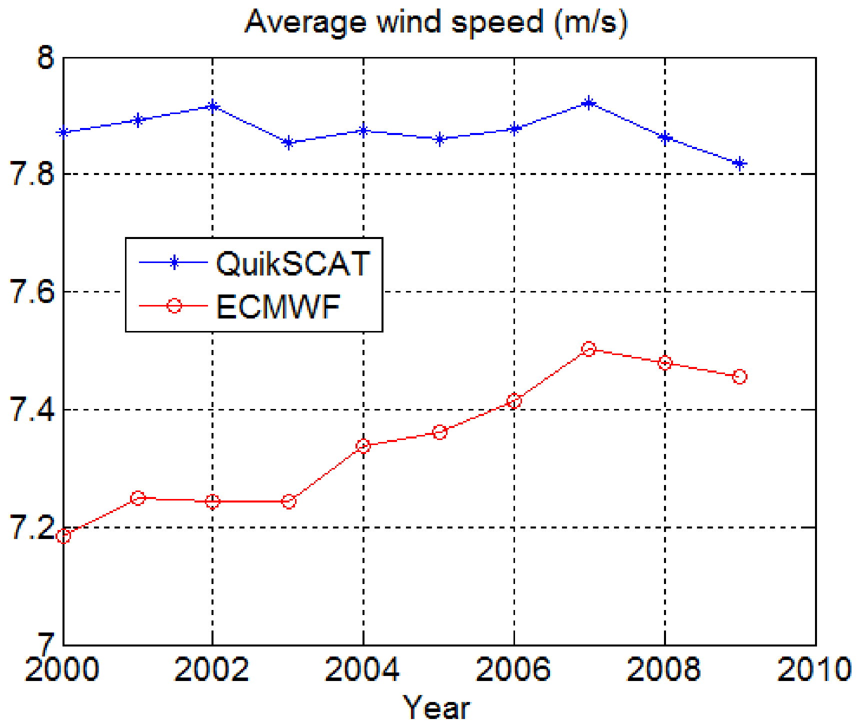




Monthly average σ0 QS H-pol
-7.2
-7.3
-7.4
-7.5
-7.6
-7.7
0
5
10
15
Month
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
Deviation from mean σ0 QS H-pol
year
2000
2002
2004
2006
2008
2
4
6
8
10
12
month
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
Monthly average σ0 QS V-pol
-8.4
-8.5
-8.6
-8.7
-8.8
-8.9
0
5
10
15
Month
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
Deviation from mean σ0 QS V-pol
year
2000
2002
2004
2006
2008
2
4
6
8
10
12
month
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2

QuikSCAT and ECMWF retrieved wind speed versus time

- Yearly average of wind speed
- -60 < lat <60
- QuikSCAT shows no trend in wind
- ECMWF shows increasing wind speed



Part 2: OSCAT stability evaluation using land targets

2-1: OSCAT backscatter for the same time of year
- Characteristic of difference versus signal level
- Variation of difference as a function of time

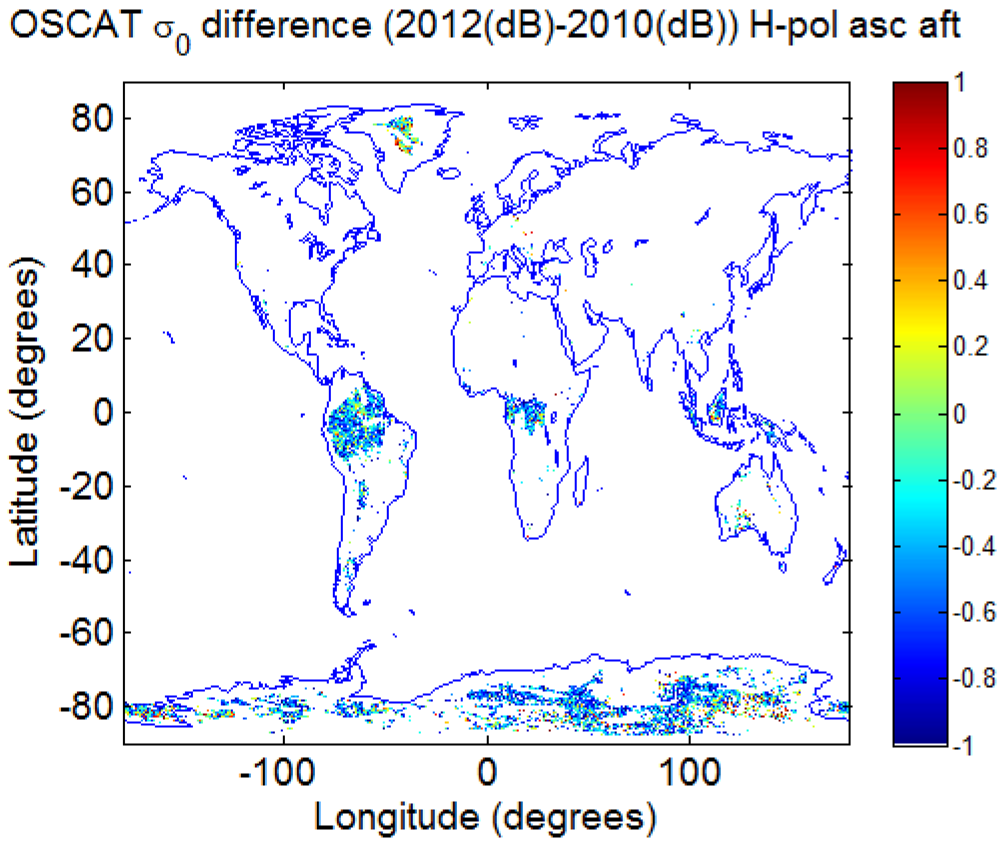
2-2: Comparison with repointed QuikSCAT backscatter

2-3: Seasonal adjust using QuickSCAT data
- Variation of difference as a function of time

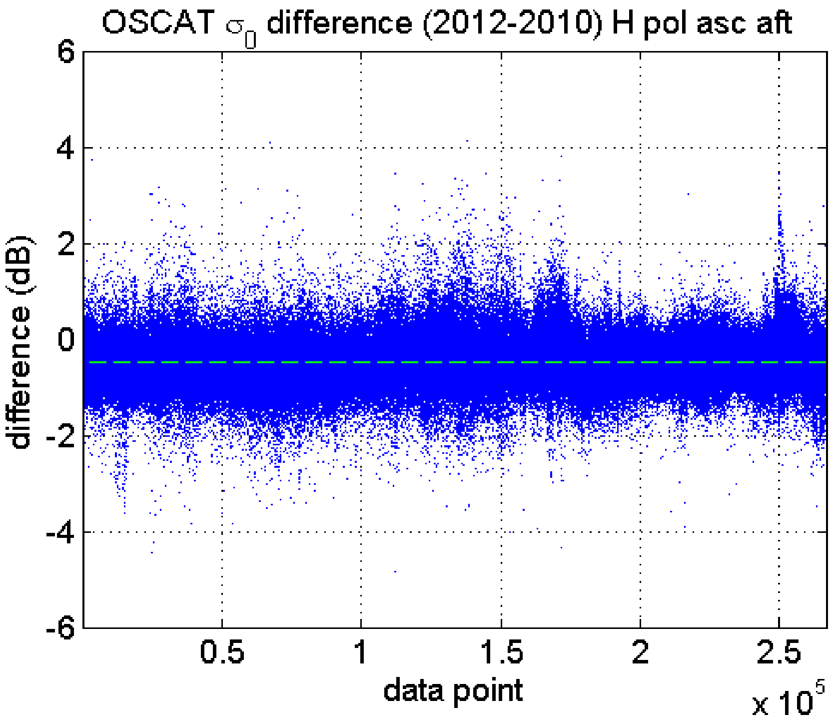
2-1: OSCAT stability for the same time of year

- Use land, spatial and time mask
  - Kp_spat and Kp_time < 0.1
- At these location, calculate average sigma0 in dB scale
- Histogram of backscatter difference
- Backscatter difference vs backscatter level

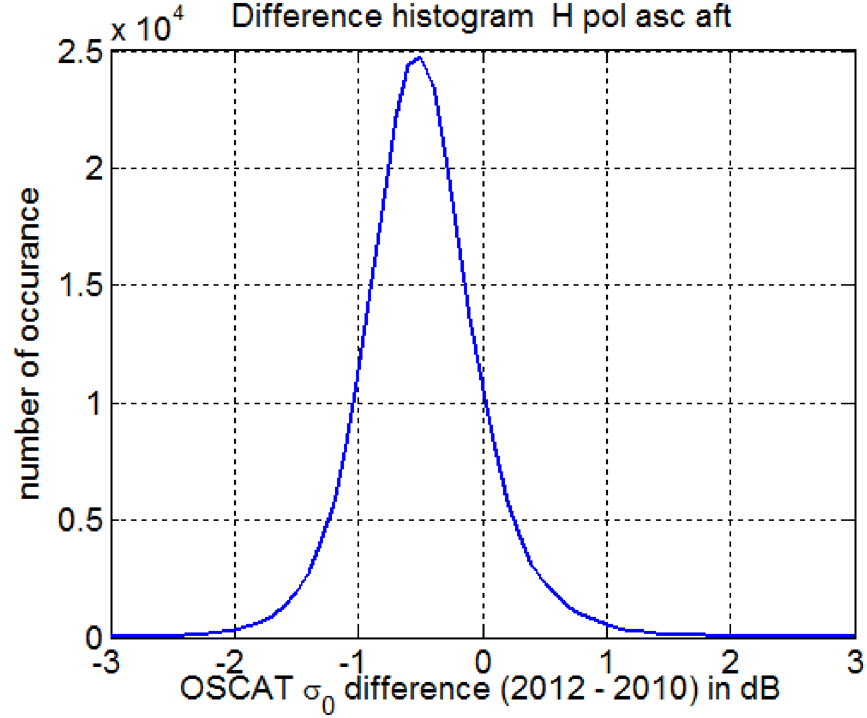
OSCAT backscatter difference Jan 2012 (dB) – Jan 2010 (dB)

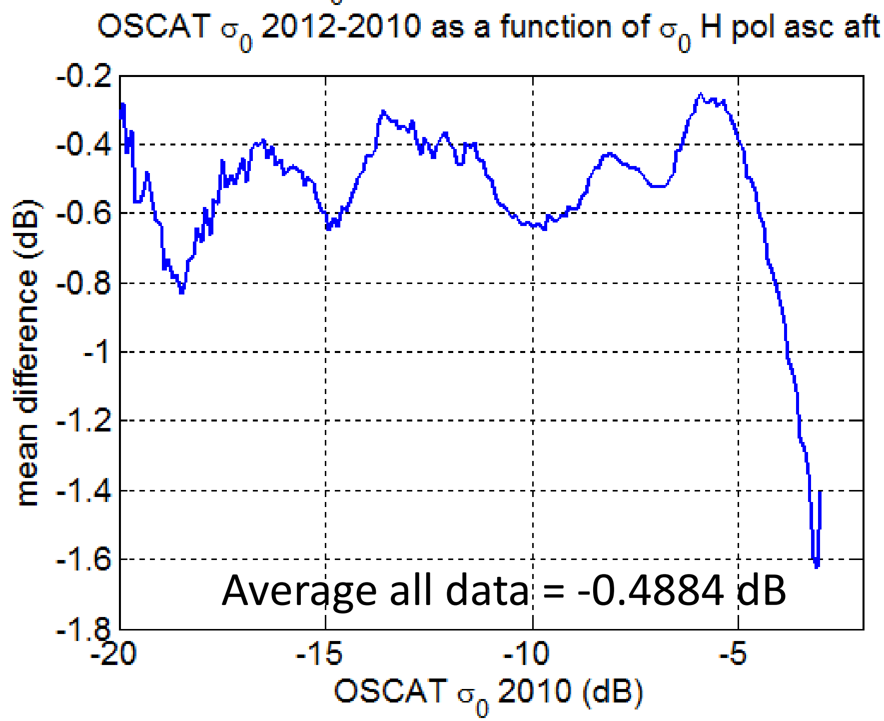


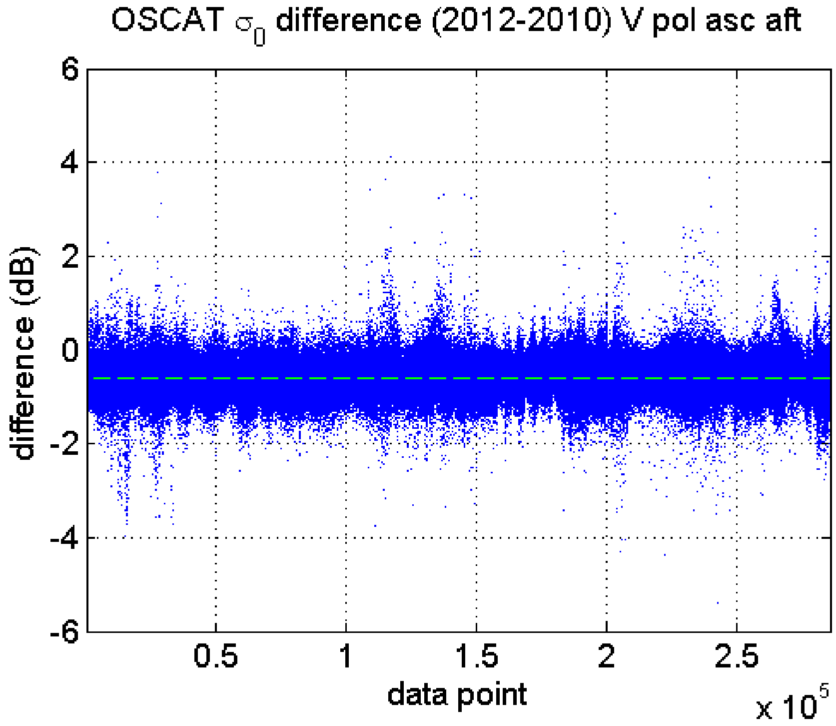
- Lots of negatives

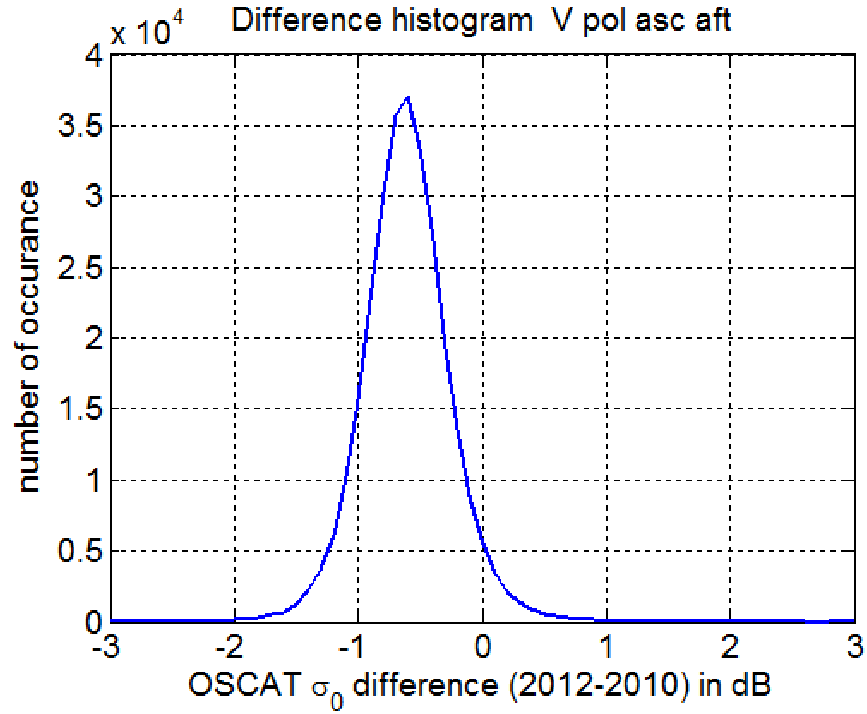


- OSCAT H-pol January backscatter difference (2012-2010)

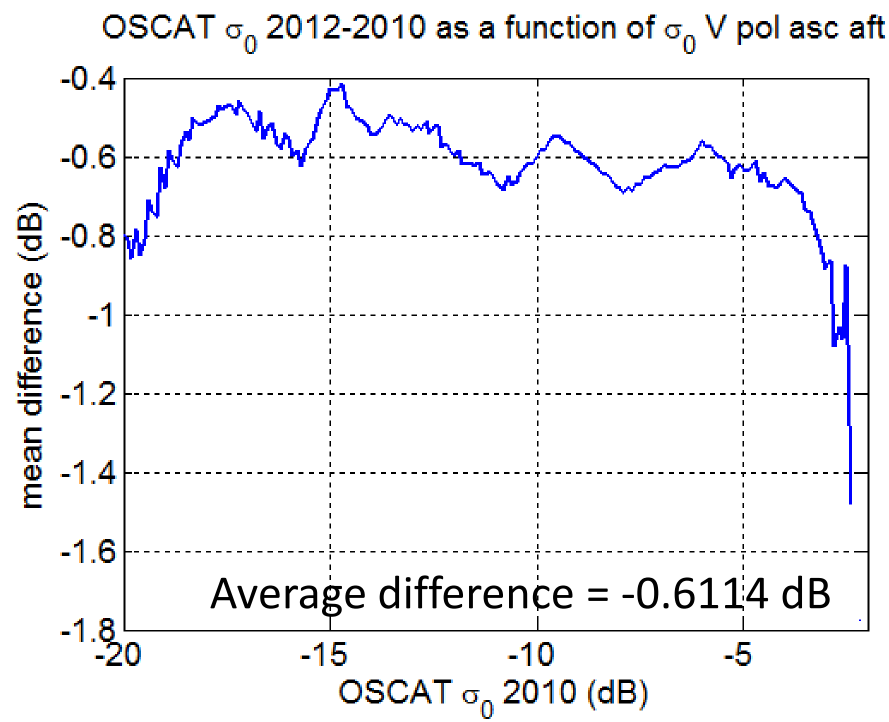








- OSCAT V-pol January backscatter difference (2012-2010)



OSCAT backscatter level difference (2012-2010) as a function of month

H-pol	Asc aft	Asc fore	Des aft	Des for	Average
January	-0.4884	-0.4653	-0.4963	-0.5014	**-0.4879**
February	-0.4670	-0.4572	-0.5095	-0.5200	**-0.4884**
March	-0.4590	-0.4691	-0.4949	-0.5149	**-0.4845**
April	-0.5148	-0.5161	-0.5143	-0.5477	**-0.5232**
May	-0.5183	-0.5265	-0.5323	-0.5720	**-0.5373**

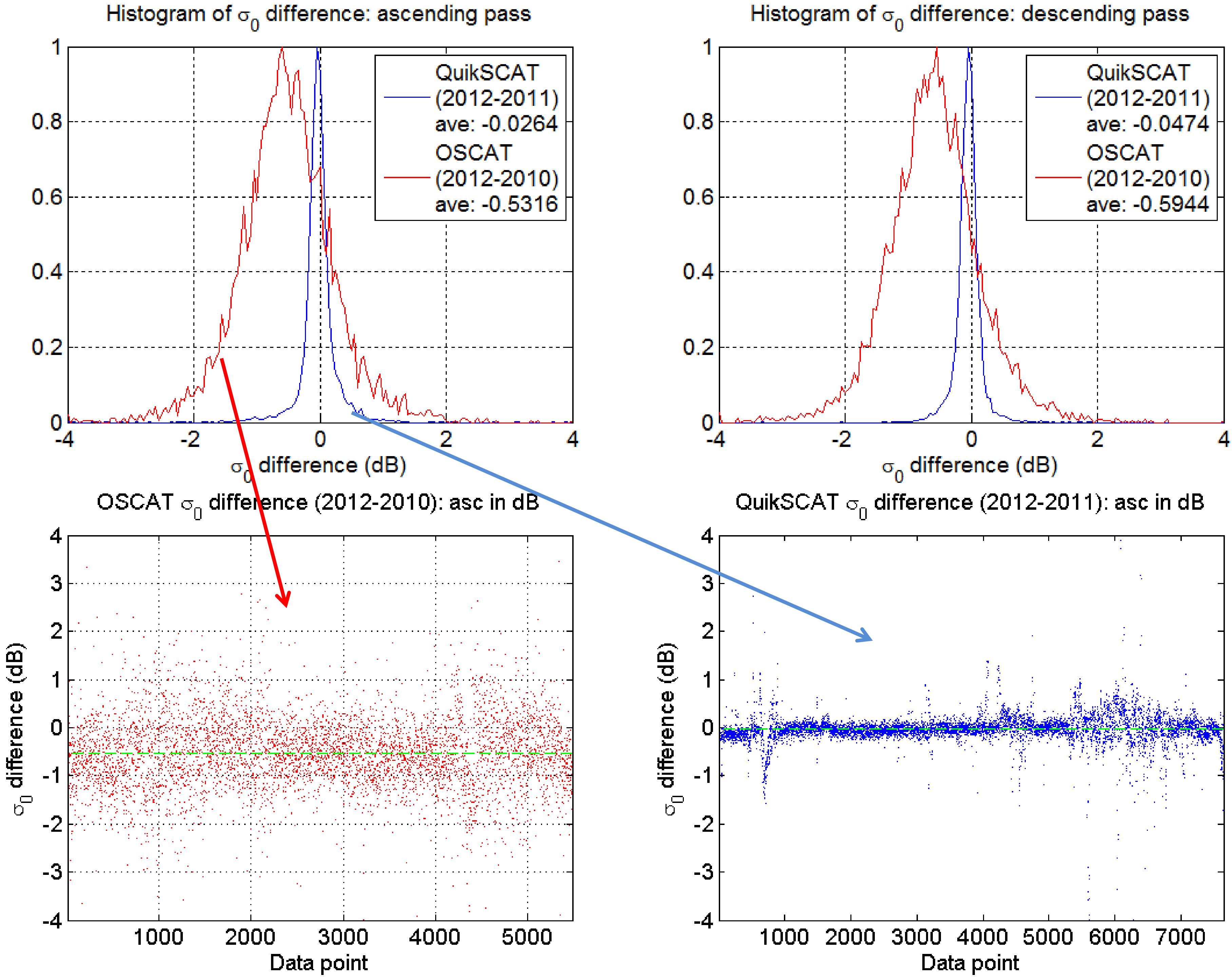
V-pol	Asc aft	Asc fore	Des aft	Des for	Average
January	-0.6114	-0.5804	-0.6052	-0.5994	**-0.5991**
February	-0.5876	-0.5631	-0.6316	-0.6320	**-0.6036**
March	-0.5805	-0.5818	-0.6205	-0.6266	**-0.6024**
April	-0.6482	-0.6520	-0.6420	-0.6517	**-0.6485**
May	-0.6718	-0.6625	-0.6791	-0.6891	**-0.6756**

2-2: OSCAT versus Rep QuikSCAT

- QuikSCAT is commanded to point to OSCAT – V-pol incidence angle on day 82, 2012
- Use data on day 82-107 (March 22 – April 16)
- For same time of year
  - Evaluate difference of OSCAT backscatter for 2012 and 2010
  - Evaluate difference of QuikSCAT backscatter for 2012 and 2011

METHOD

- Pick sigma0 from stable and homogeneous locations
- Use only OSCAT data with the same look geometry as Repointed QuikSCAT
- Evaluate drift by taking the difference in sigma0 in dB scale from one year to another
- Only evaluate at co-location points

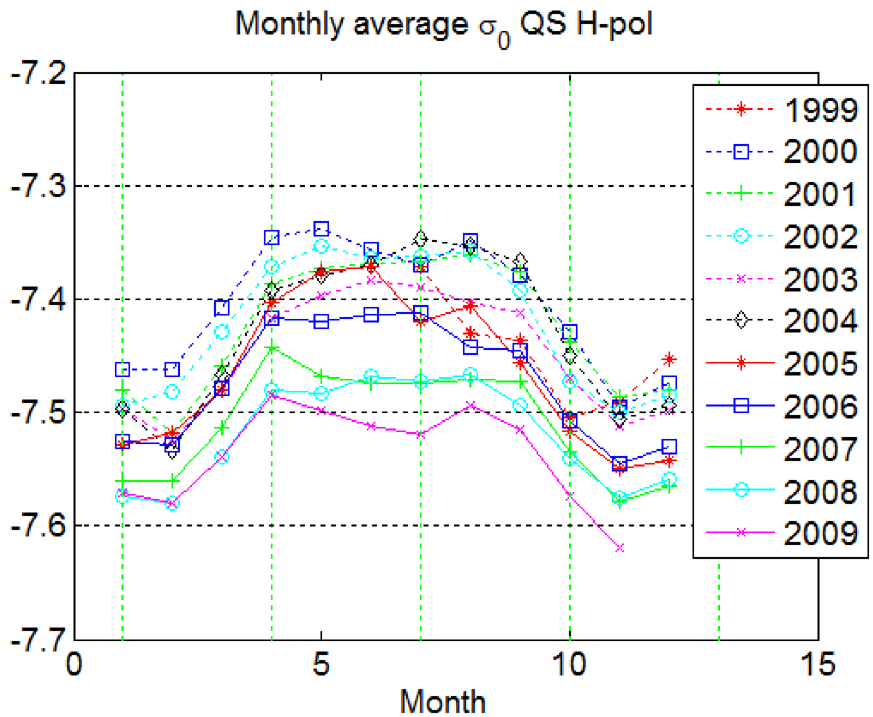


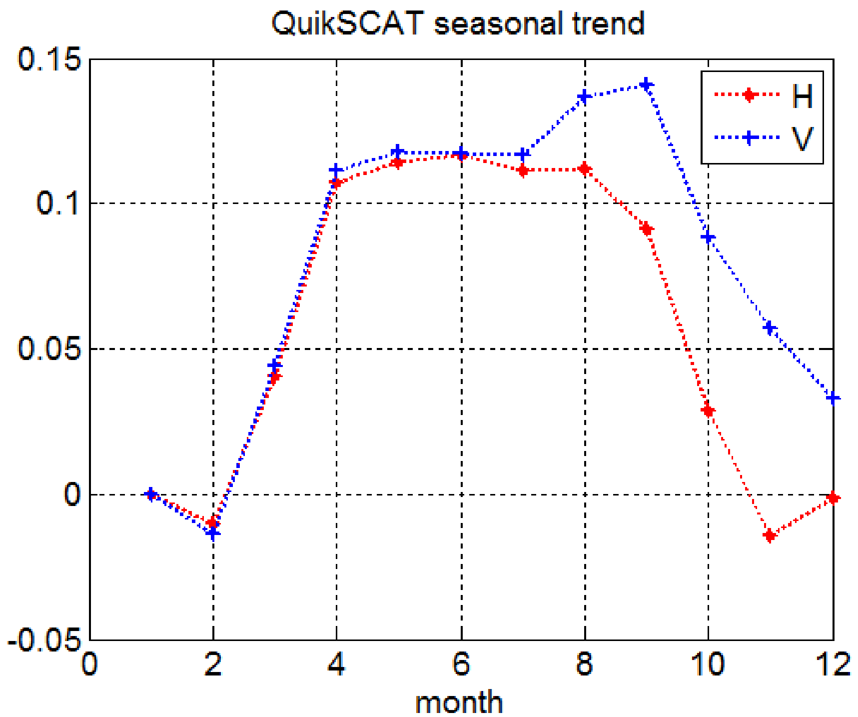
Histogram of σ0 difference: ascending pass
QuikSCAT (2012-2011) ave: -0.0264
OSCAT (2012-2010) ave: -0.5316
σ0 difference (dB)
Histogram of σ0 difference: descending pass
QuikSCAT (2012-2011) ave: -0.0474
OSCAT (2012-2010) ave: -0.5944
σ0 difference (dB)
OSCAT σ0 difference (2012-2010): asc in dB
σ0 difference (dB)
Data point
QuikSCAT σ0 difference (2012-2011): asc in dB
σ0 difference (dB)
Data point

2-3: Drift versus time – seasonal adjusted

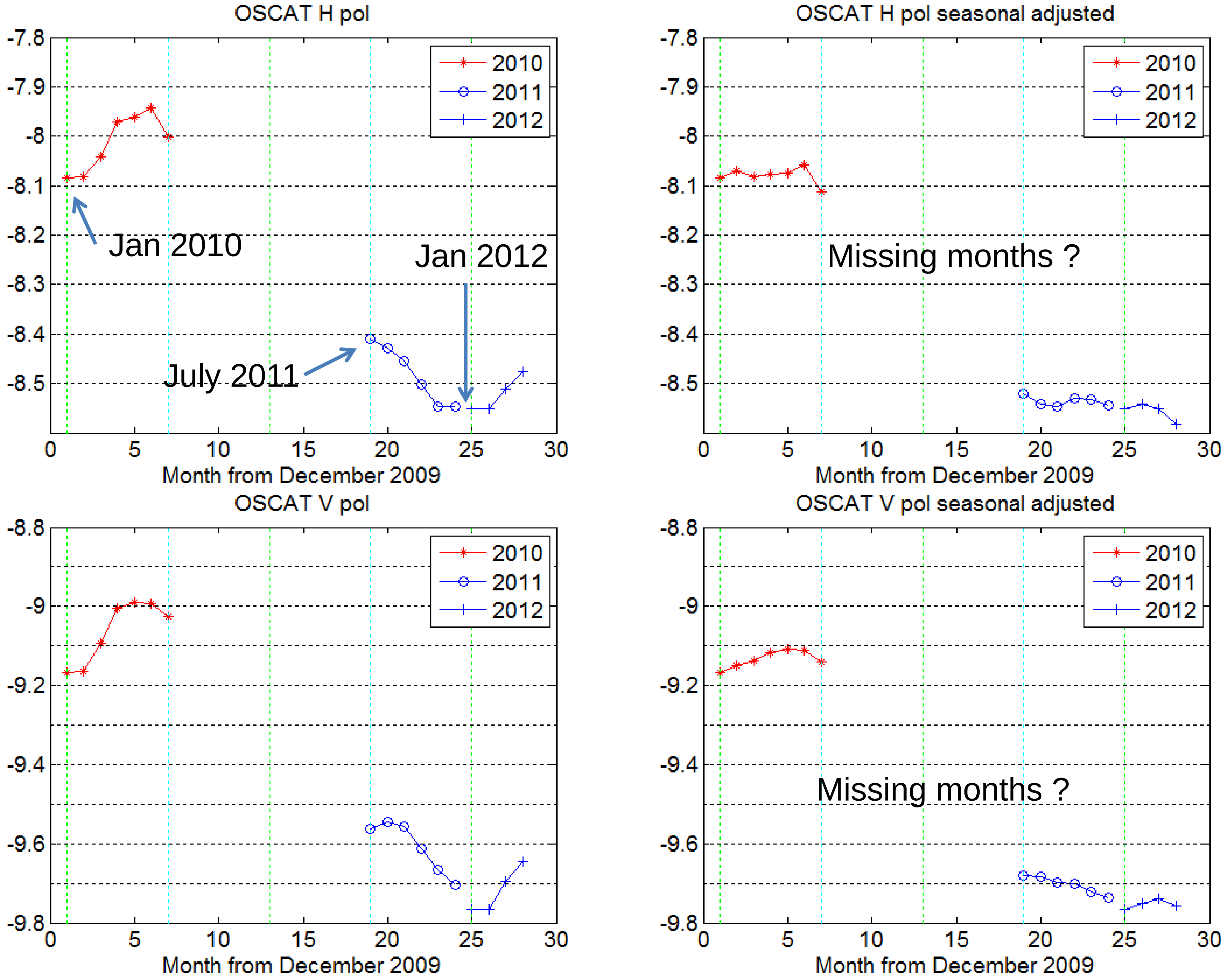
- Use 2000 – 2008 QuikSCAT (spinning) to obtain seasonal trend
  - Average monthly for all 9 years => result is average monthly sigma0 for the whole year
  - Use January as reference, backscatter difference from other months are "seasonally" adjusted
- Apply seasonal adjustment to the OSCAT data
- Behavior of OSCAT backscatter versus time
- Note: Spinning QuikSCAT data has different incidence angle than that of OSCAT so seasonal change of OSCAT backscatter are somewhat different (more). We use spinning QuikSCAT because we have a long-term data record.

Seasonal adjust number



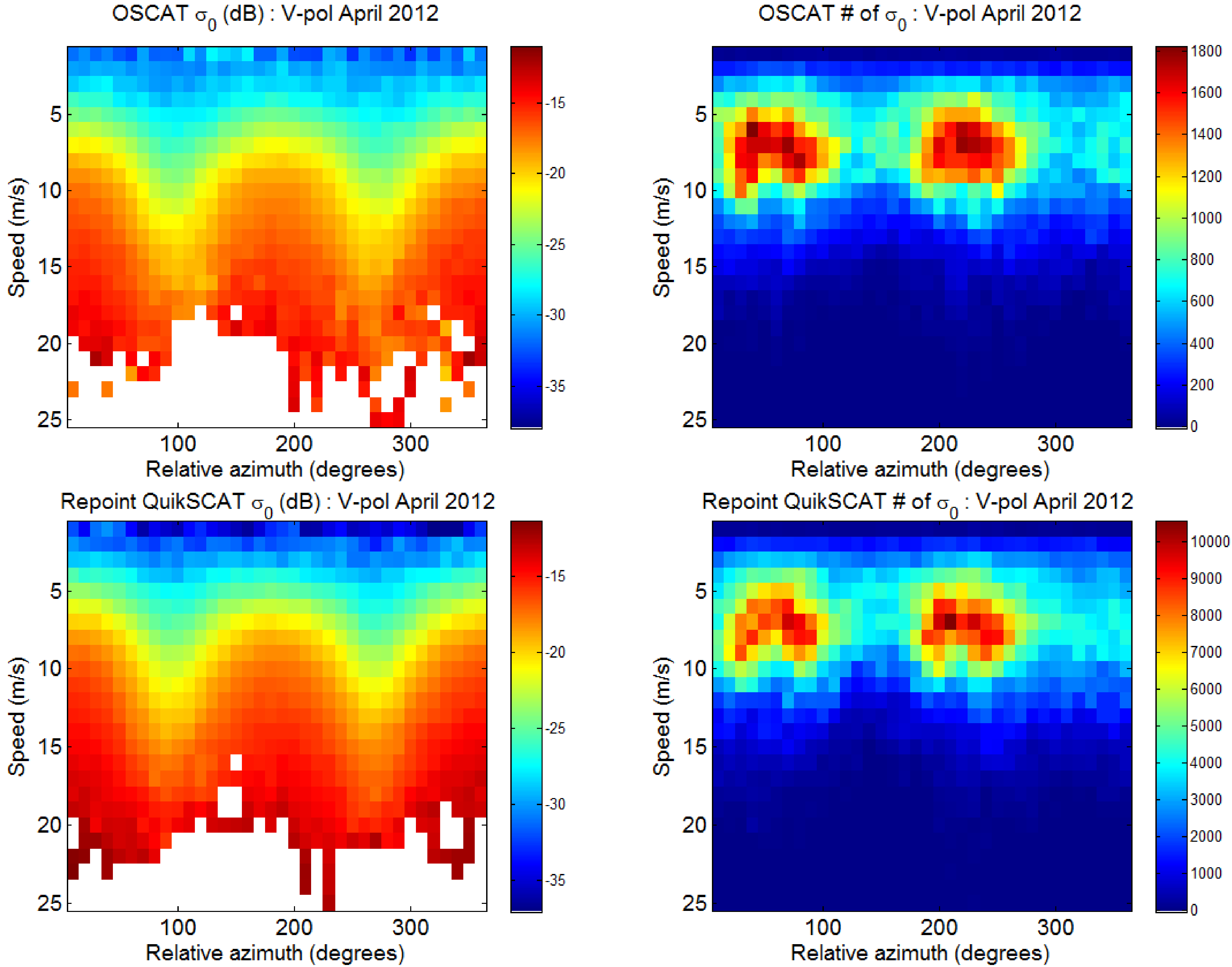


- Magnitude is less than 0.15 dB


OSCAT H pol
OSCAT H pol seasonal adjusted
OSCAT V pol
OSCAT V pol seasonal adjusted
2010
2011
2012
Jan 2010
Jan 2012
July 2011
Missing months ?
Month from December 2009
-7.8
-7.9
-8
-8.1
-8.2
-8.3
-8.4
-8.5
-8.8
-9
-9.2
-9.4
-9.6
-9.8
0
5
10
15
20
25
30

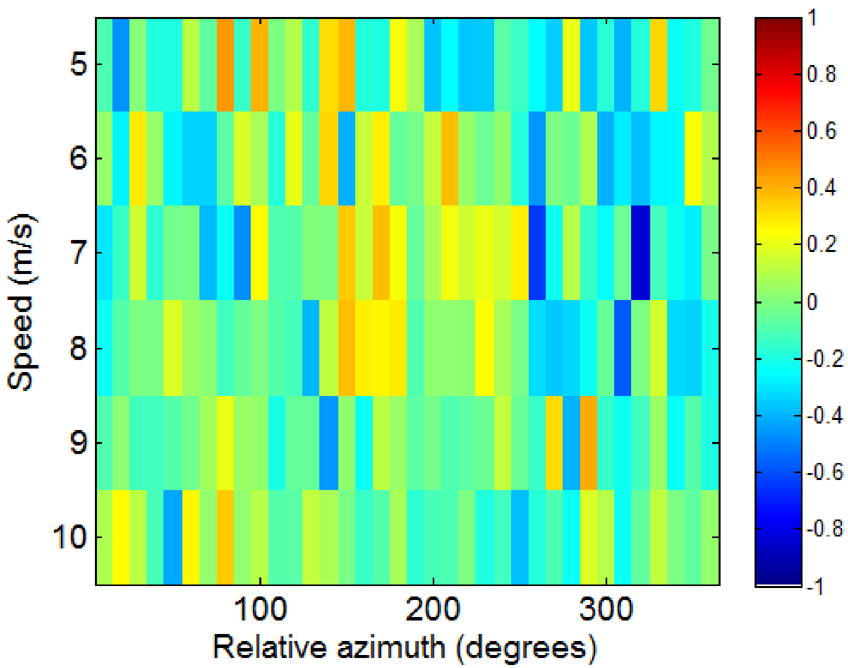
Part 3: OSCAT stability evaluation using ocean data

- For both repointed QuikSCAT and OSCAT data
  - Pick only ocean data, abs(latitude) < 50 degree
- For OSCAT data
  - Pick only scan position 100 for H-pol, 101 for V-pol
  - Use high gain slices (slice #4 for Hpol #6 for Vpol)
- Method
  - Bin data versus footprint matched ECMWF speed and relative azimuth



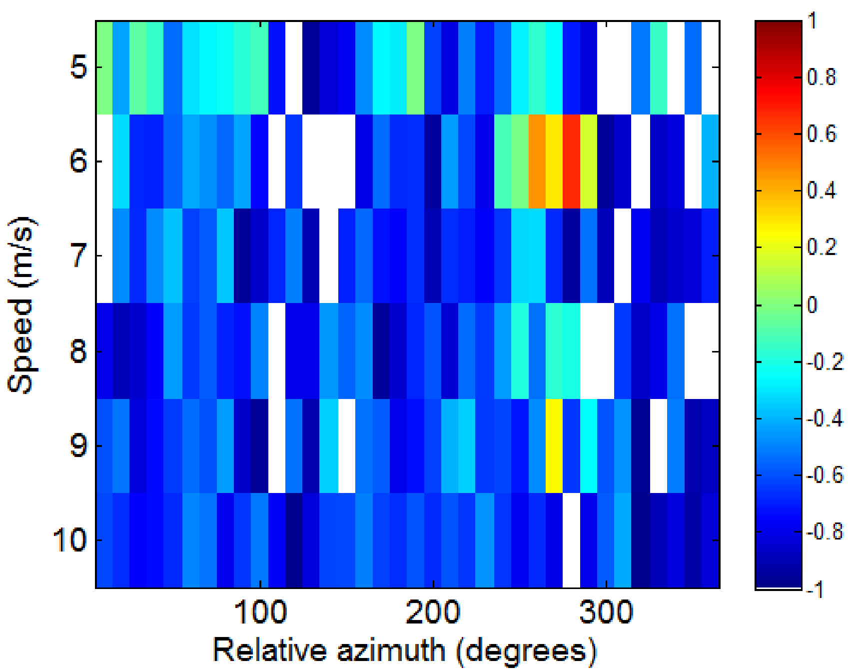
OSCAT σ_0 (dB) : V-pol April 2012
Speed (m/s)
5
10
15
20
25
100
200
300
Relative azimuth (degrees)
-15
-20
-25
-30
-35
OSCAT # of σ_0 : V-pol April 2012
Speed (m/s)
Relative azimuth (degrees)
1800
1600
1400
1200
1000
800
600
400
200
0
Repoint QuikSCAT σ_0 (dB) : V-pol April 2012
Speed (m/s)
Relative azimuth (degrees)
Repoint QuikSCAT # of σ_0 : V-pol April 2012
Speed (m/s)
Relative azimuth (degrees)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0

Repoint QuikSCAT V-pol April 12 σ_0 (dB) - April 11 σ_0 (dB)

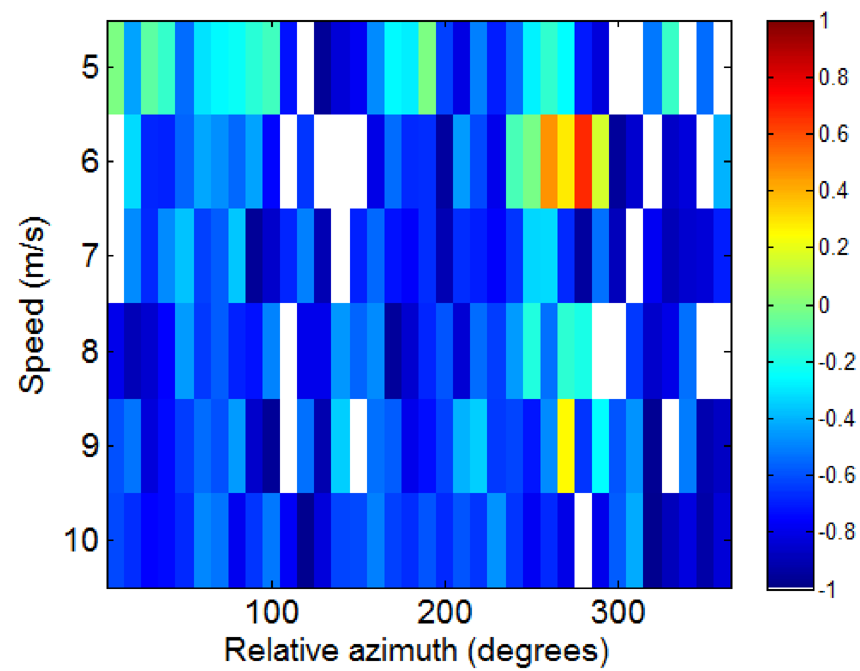


	mean(difference in dB)
QuikSCAT V-pol	-0.0539 dB / 1 year
OSCAT V-pol	-0.6498 dB / 2 years
OSCAT H-pol	-0.622 dB / 2 years

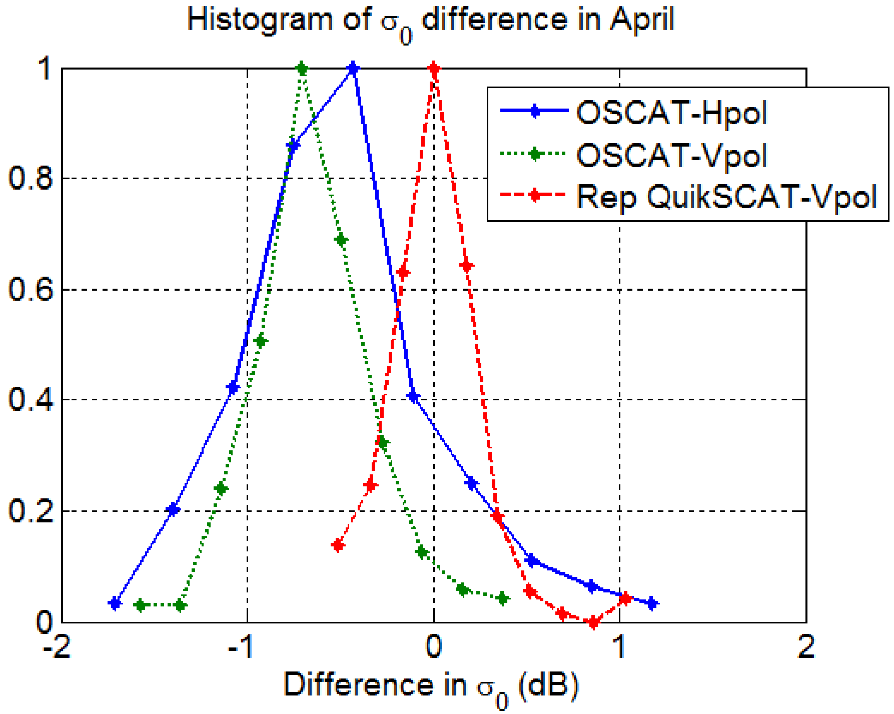
OSCAT V-pol April 12 σ_0 (dB) - April 10 σ_0 (dB)

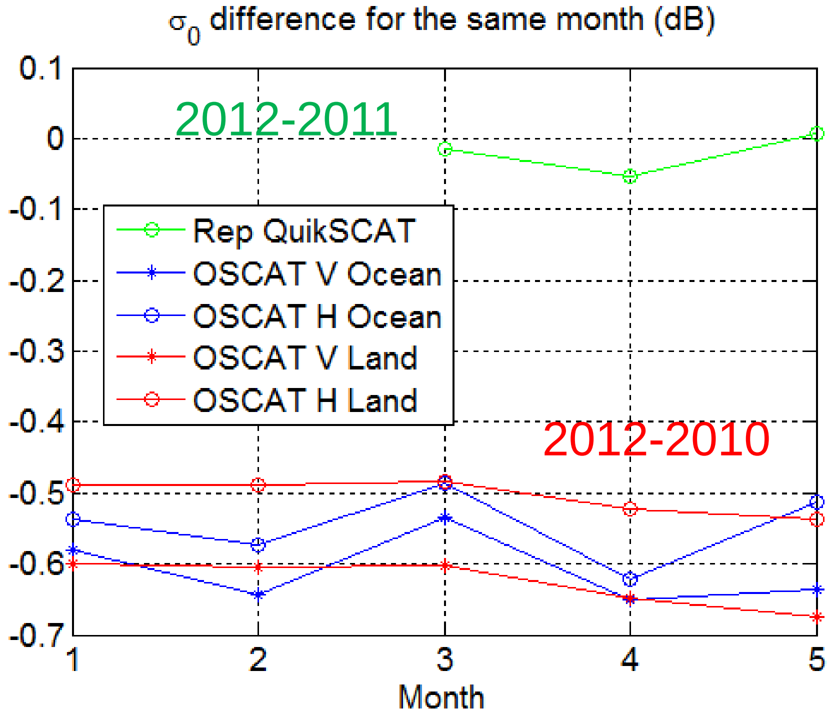


OSCAT H-pol April 12 σ_0 (dB) - April 10 σ_0 (dB)



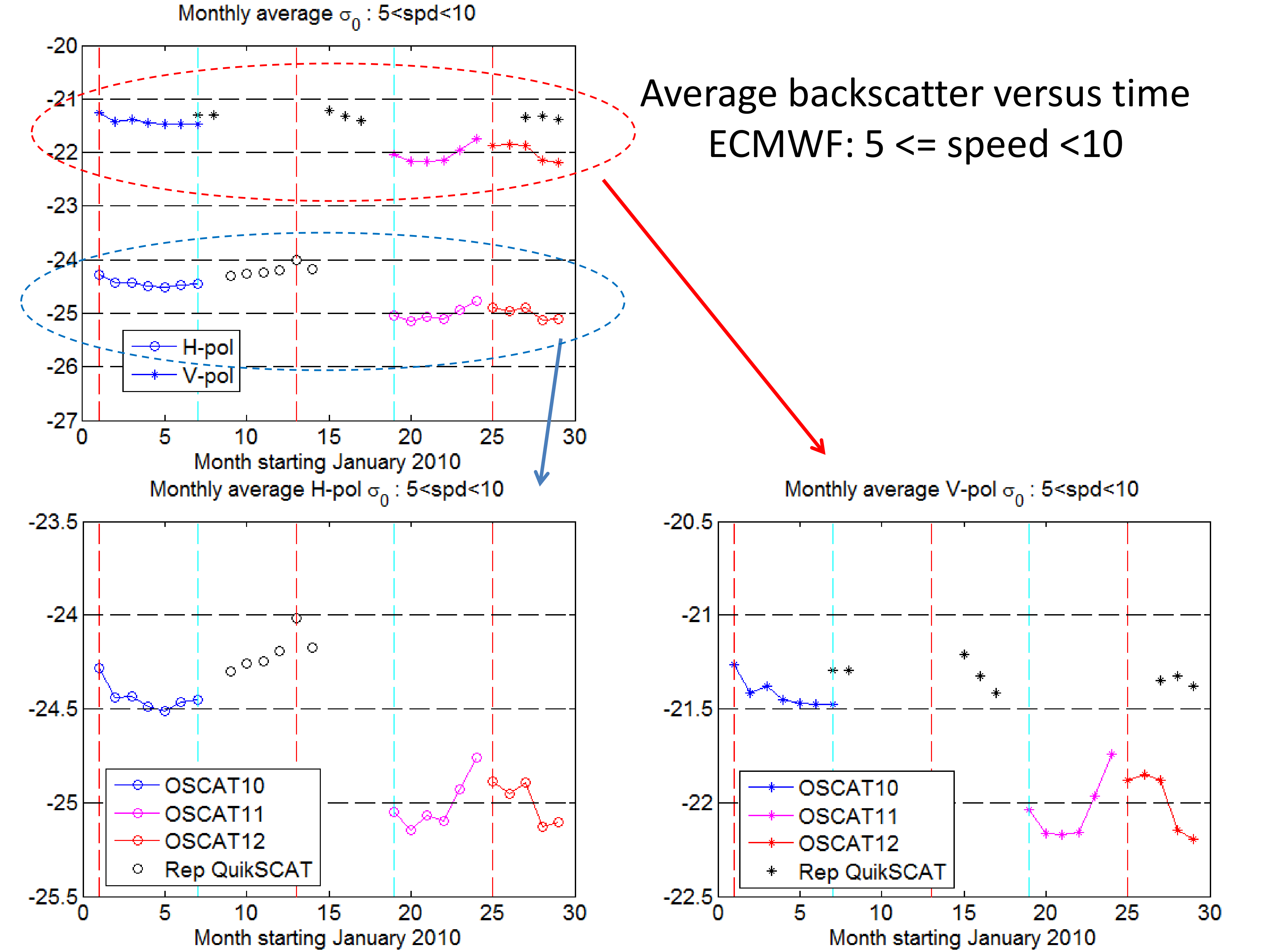
Sigma0 difference (dB) for the same month





	January	February	March	April	May
QS V-pol			-0.0159	-0.0539	0.0058
Ocean OSCAT V-pol	-0.5803	-0.6421	-0.5355	-0.6498	-0.6349
Ocean OSCAT H-pol	-0.5359	-0.5724	-0.4858	-0.6222	-0.5117
Land OSCAT V-pol	-0.5991	-0.6036	-0.6024	-0.6485	-0.6756
Land OSCAT H-pol	-0.4879	-0.4884	-0.4845	-0.5232	-0.5373

Average backscatter versus time
ECMWF: 5 <= speed <10



Conclusions

- Land and ocean are used in evaluating OSCAT backscatter
- It shows that there is definitely a drop in OSCAT backscatter in the order of 0.5 dB in H-pol and 0.6 dB in V-pol in two year time span
- The characteristics of OSCAT backscatter drop is still under investigation. More data is needed, especially, the missing August 2010 – June 2011
- We will continue monitor and characterize this OSCAT backscatter behavior as long as we receive OSCAT data and QuikSCAT is still operating
- Because of its stability, QuikSCAT provides crucial information about any geophysical change which is linked to proper OSCAT backscatter calibration

BACKUP

Absolute calibration check

- The absolute calibration to be applied is adding 0.3362 dB for H-pol and 0.2255 dB for V pol to the previous sigma0 data
- Check by looking at exact same sigma0 location in the exact same rev: "S1L1B2010094_02802_02803.h5"
- Examples: $\sigma_o(10,20,4)$ denote σ_o at scan position 10, orbit position 20, slice number 4

H-pol=> new $\sigma_o(10,20,4)$ = -12.1453 old $\sigma_o(10,20,4)$ = -12.4900 difference = 0.3447

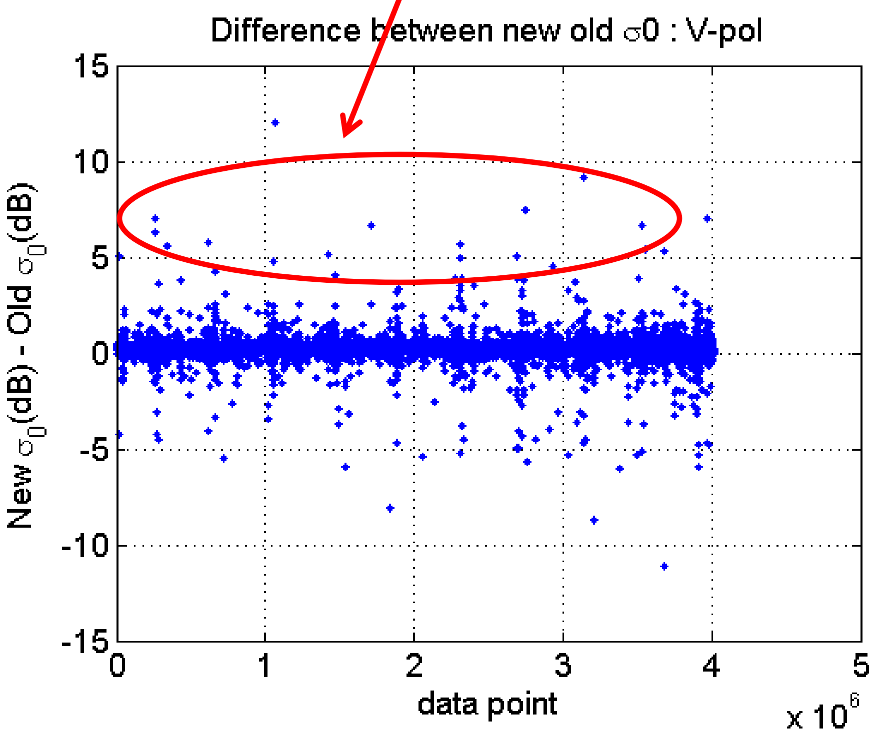
V-pol=> new $\sigma_o(10,20,4)$ = -12.3717 old $\sigma_o(10,20,4)$ = -12.6000 difference = 0.2283

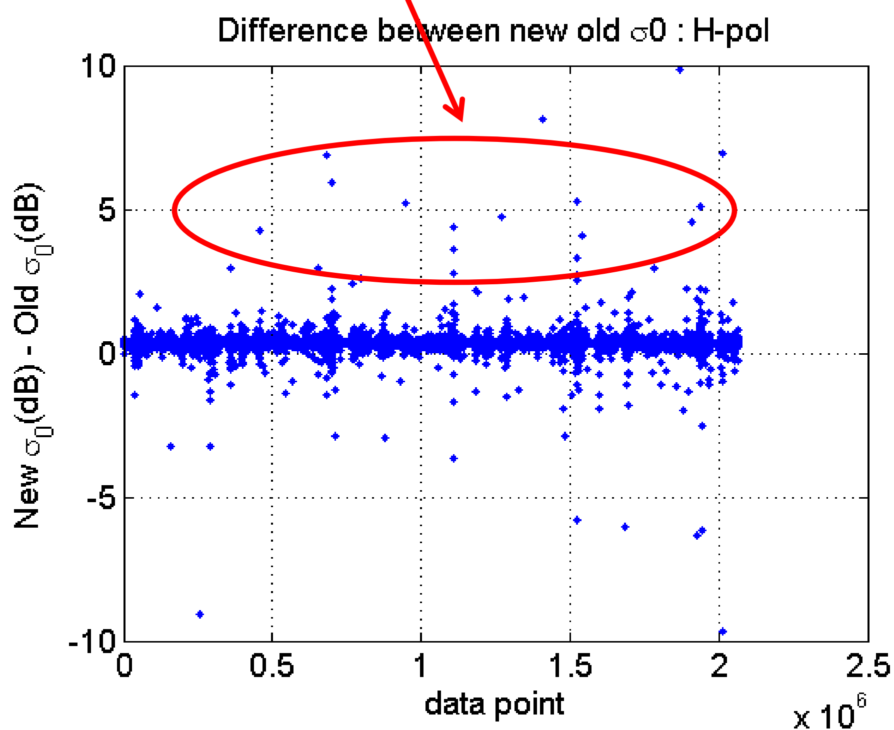
- The difference is NOT exactly, but that is expected because of quantization issue.
- When looking at all data in the file, we found that there are some points where the differences are much larger than this absolute calibration.
- Note: The number of orbit step in new data is different from the old ones in some of the files. For 6 revs we received, only 2 has the same number of orbit step as those of old files.

Difference in new and old files

- Processed file : S1L1B2010094_02802_02803.h5
- Pick good sigma0 data
- Mean of the difference V-pol =0.2205 dB H-pol=0.3312 dB

There are a few points where differences are large





Potential land targets 2

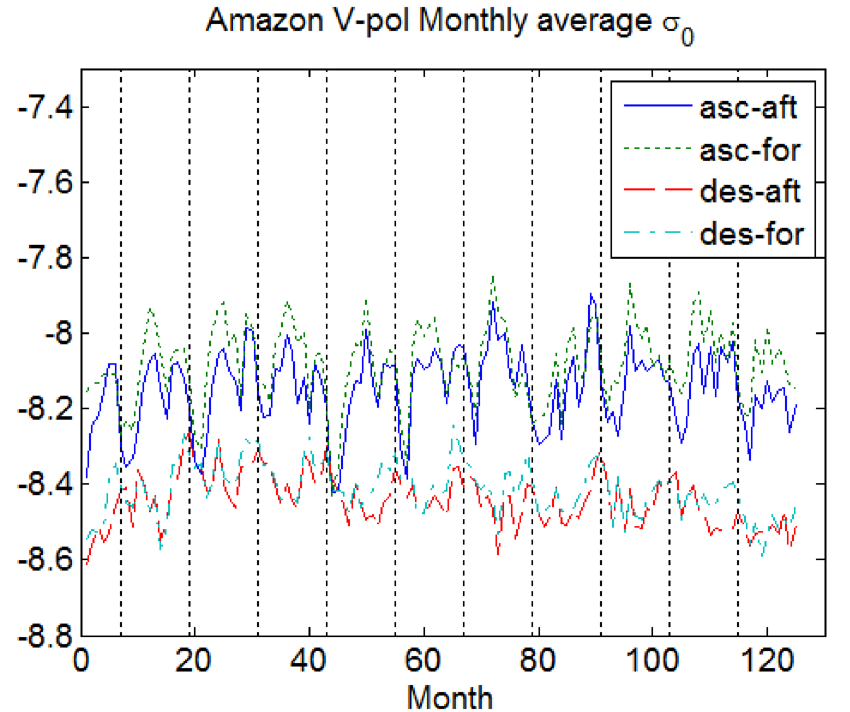
- Specific 1 by 1 degree box with smallest time variation in the regions

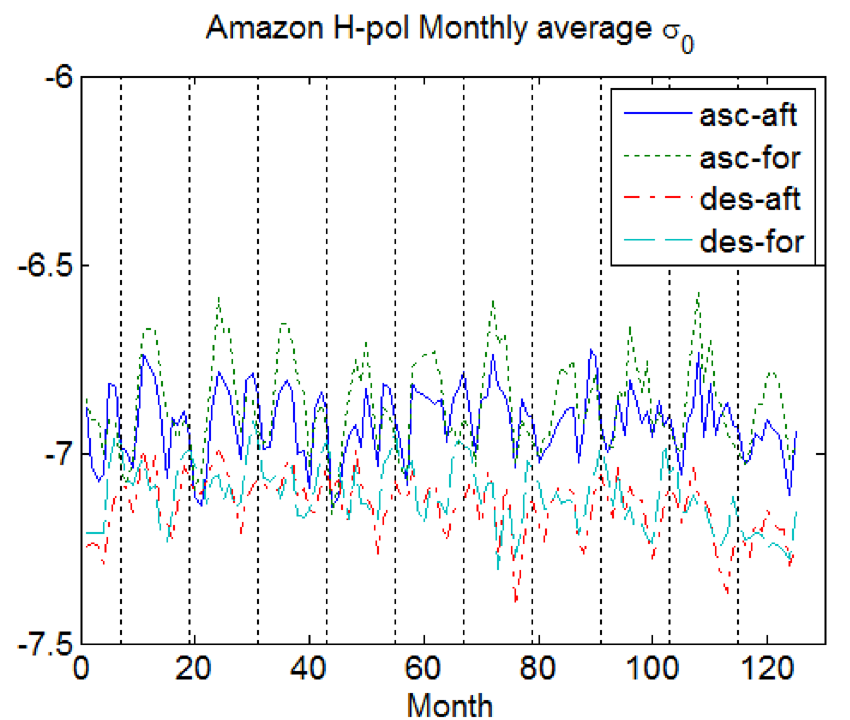
		Amazon	Antarctica	Australia	Congo	Indonesia	Greenland	Sahara
Location of center of box (Lat,Lon)		N 5.3 W 59.2	S 75.1 E 123.1	S 23.5 E 142.7	S 0.2 E 11.2	S 6.0 E 139.5	N 73.5 W 37.5	N 27.2 E 17.8
Average σo (dB)	H-pol asc	-6.891	-6.610	-11.380	-7.373	-7.106	-8.466	-10.346
	H-pol des	-7.123	-6.631	-11.218	-7.553	-7.396	-8.457	-10.344
	V-pol asc	-8.114	-7.441	-13.133	-8.607	-8.564	-8.297	-11.977
	V-pol des	-8.428	-7.459	-12.912	-8.988	-8.847	-8.303	-11.973
Variation (Kp)	H-pol asc	0.0255	0.0275	0.0444	0.0181	0.0299	0.0485	0.0276
	H-pol des	0.0194	0.0282	0.0436	0.0193	0.0192	0.0481	0.0233
	V-pol asc	0.0256	0.0243	0.0443	0.0200	0.0330	0.0414	0.0288
	V-pol des	0.0165	0.0239	0.0447	0.0189	0.0169	0.0405	0.0213

- Variation Kp = std()/mean() in linear scale

Amzlim=[4.8 5.8 300.3 301.3];

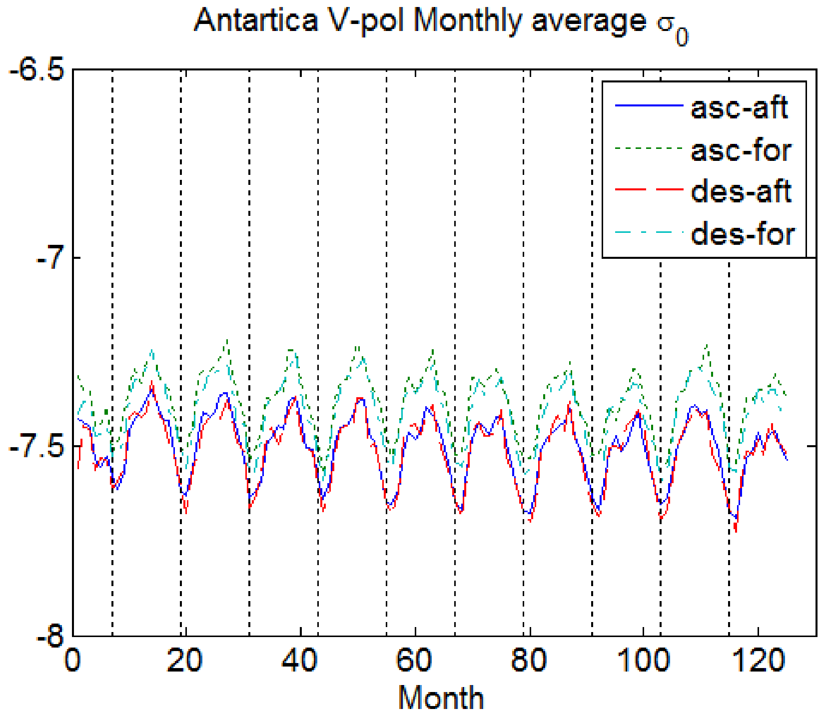
	Kp	Sigma0 (dB)
V pol	0.0422	-8.2677
V pol aft	0.0399	-8.2918
V pol for	0.0438	-8.2438
V pol ascending	0.0256	-8.1135
V pol ascending aft	0.0245	-8.1471
V pol ascending for	0.0243	-8.0802
V pol descending	0.0165	-8.4276
V pol descending aft	0.0163	-8.4414
V pol descending for	0.0161	-8.4138
H pol	0.0351	-7.0055
H pol aft	0.0325	-7.0251
H pol for	0.0370	-6.9860
H pol ascending	0.0255	-6.8913
H pol ascending aft	0.0214	-6.9154
H pol ascending for	0.0280	-6.8674
H pol descending	0.0194	-7.1228
H pol descending aft	0.0184	-7.1376
H pol descending for	0.0197	-7.1079

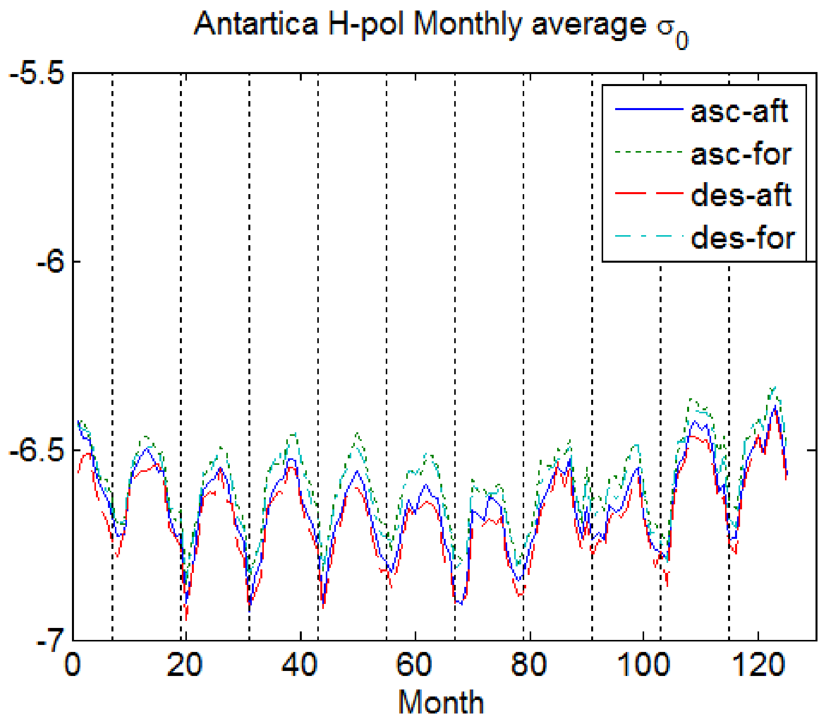




Antlim=[-75.6 -74.6 122.6 123.6];

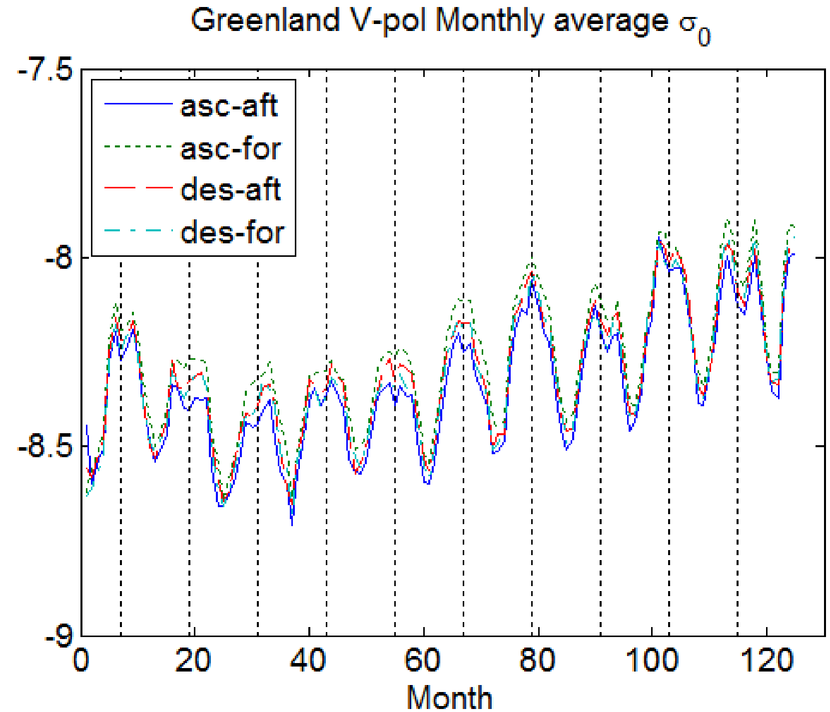
	Kp	Sigma0 (dB)
V pol	0.0242	-7.4500
V pol aft	0.0203	-7.5073
V pol for	0.0204	-7.3934
V pol ascending	0.0243	-7.4412
V pol ascending aft	0.0199	-7.5027
V pol ascending for	0.0198	-7.3805
V pol descending	0.0239	-7.4588
V pol descending aft	0.0208	-7.5119
V pol descending for	0.0205	-7.4063
H pol	0.0280	-6.6205
H pol aft	0.0275	-6.6568
H pol for	0.0260	-6.5844
H pol ascending	0.0275	-6.6103
H pol ascending aft	0.0273	-6.6426
H pol ascending for	0.0259	-6.5784
H pol descending	0.0282	-6.6306
H pol descending aft	0.0274	-6.6711
H pol descending for	0.0261	-6.5905

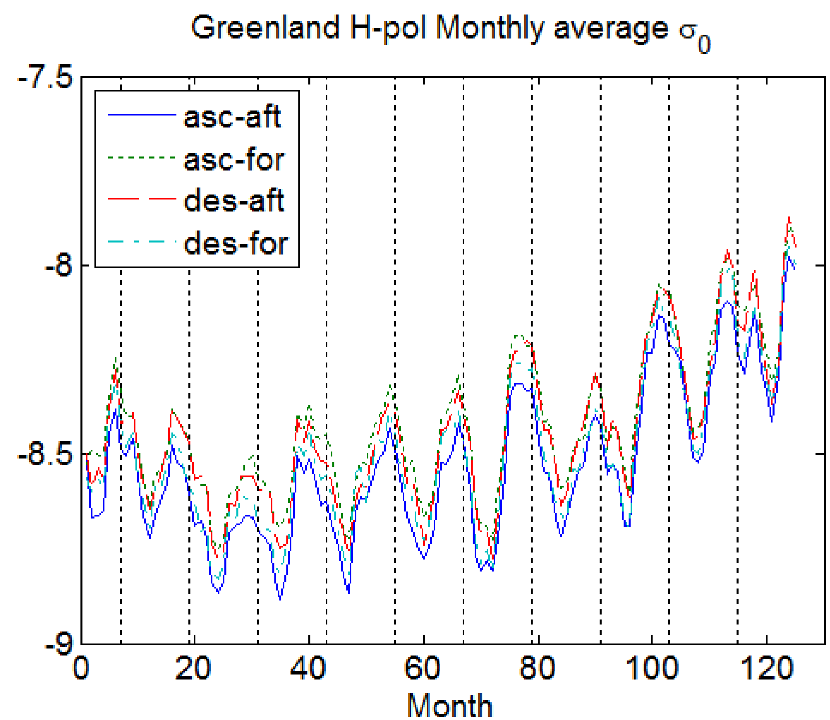




Greenland [73.0 74.0 322.0 323.0]

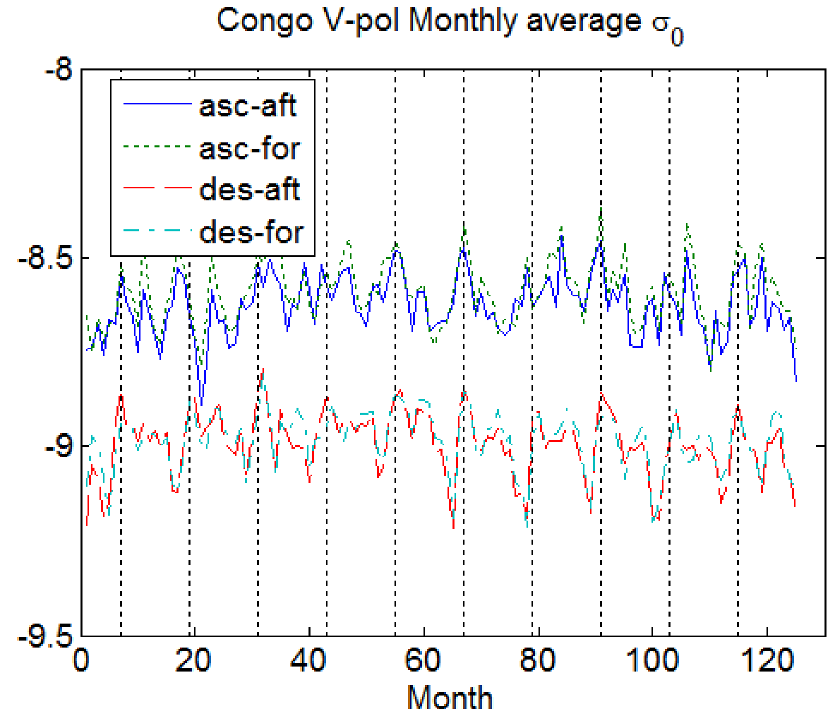
	Kp	Sigma0 (dB)
V pol	0.0409	-8.3001
V pol aft	0.0403	-8.3162
V pol for	0.0413	-8.2841
V pol ascending	0.0414	-8.2973
V pol ascending aft	0.0401	-8.3343
V pol ascending for	0.0411	-8.2606
V pol descending	0.0405	-8.3029
V pol descending aft	0.0402	-8.2981
V pol descending for	0.0409	-8.3076
H pol	0.0482	-8.4614
H pol aft	0.0488	-8.4772
H pol for	0.0475	-8.4456
H pol ascending	0.0485	-8.4656
H pol ascending aft	0.0480	-8.5218
H pol ascending for	0.0457	-8.4101
H pol descending	0.0481	-8.4572
H pol descending aft	0.0475	-8.4331
H pol descending for	0.0481	-8.4814

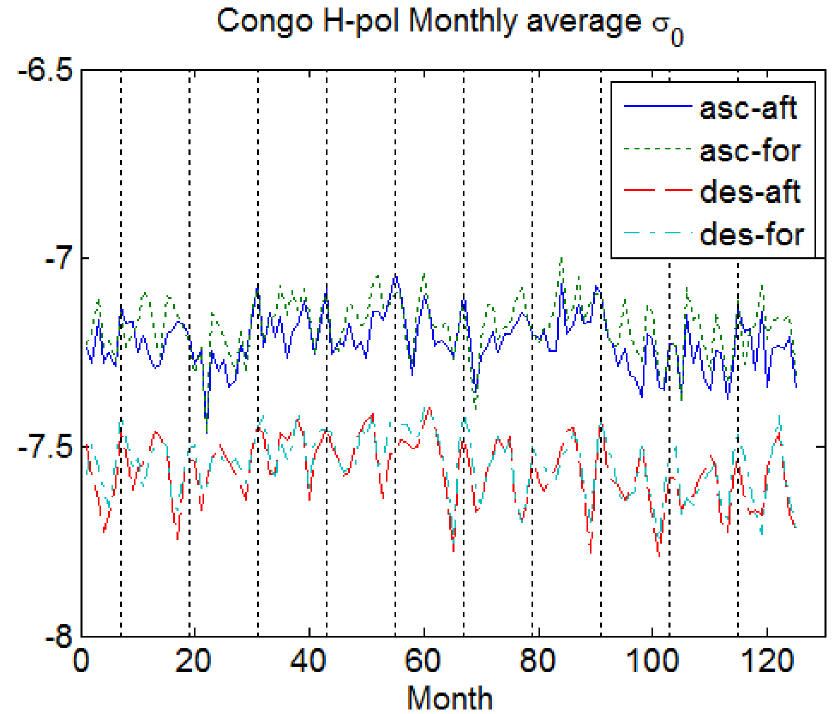




Conlim=[-0.7 0.3 10.7 11.7];

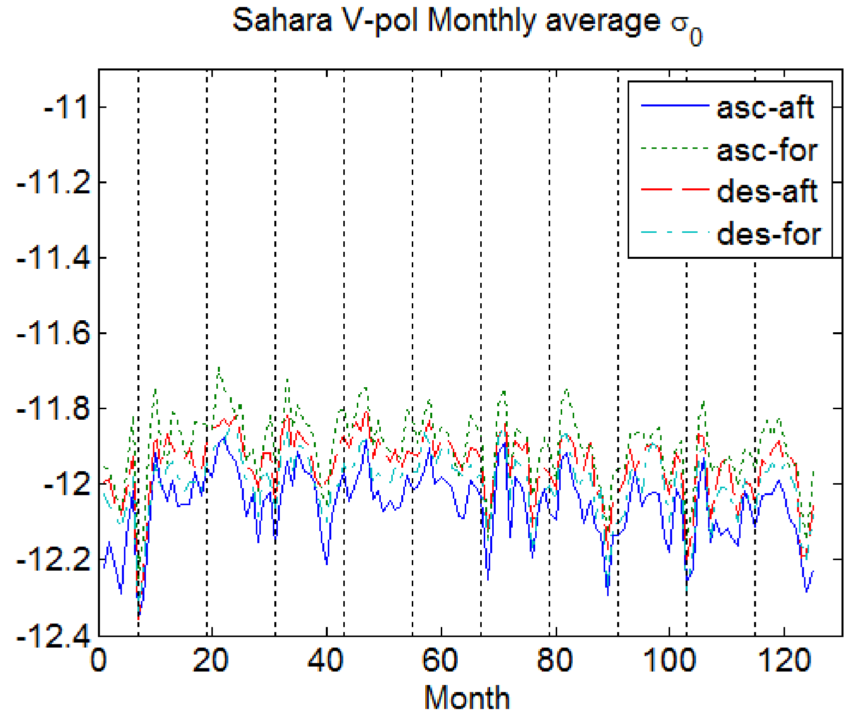
	Kp	Sigma0 (dB)
V pol	0.0480	-8.7933
V pol aft	0.0465	-8.8047
V pol for	0.0493	-8.7819
V pol ascending	0.0200	-8.6073
V pol ascending aft	0.0190	-8.6256
V pol ascending for	0.0202	-8.5892
V pol descending	0.0189	-8.9876
V pol descending aft	0.0200	-8.9916
V pol descending for	0.0178	-8.9835
H pol	0.0447	-7.3726
H pol aft	0.0435	-7.3871
H pol for	0.0458	-7.3582
H pol ascending	0.0181	-7.1997
H pol ascending aft	0.0171	-7.2193
H pol ascending for	0.0180	-7.1802
H pol descending	0.0193	-7.5527
H pol descending aft	0.0198	-7.5616
H pol descending for	0.0187	-7.5439

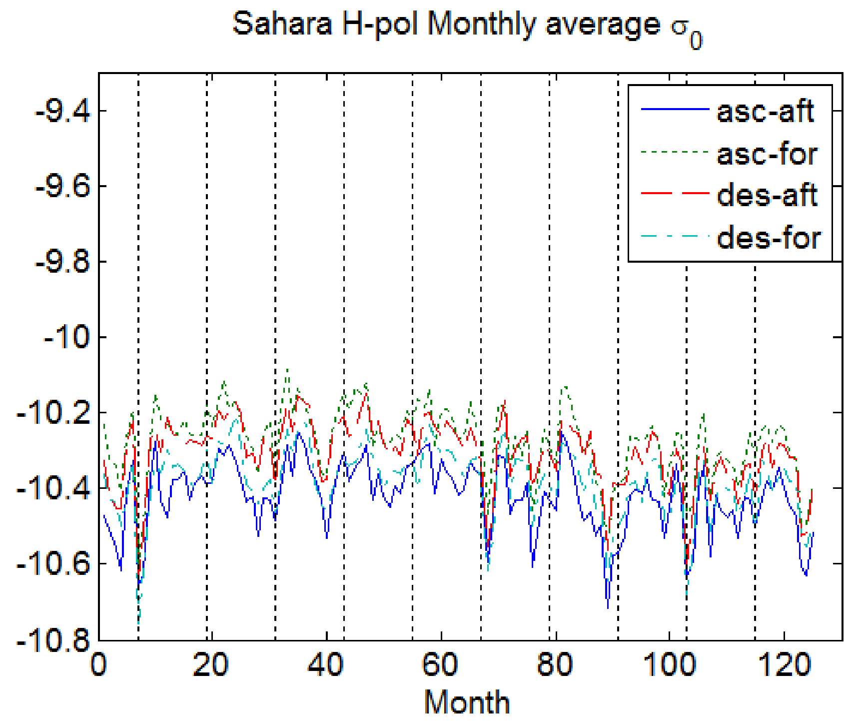




Sahlim=[26.7 27.7 17.3 18.3]

	Kp	Sigma0 (dB)
V pol	0.0253	-11.9750
V pol aft	0.0247	-12.0029
V pol for	0.0243	-11.9472
V pol ascending	0.0288	-11.9766
V pol ascending aft	0.0224	-12.0556
V pol ascending for	0.0225	-11.8990
V pol descending	0.0213	-11.9733
V pol descending aft	0.0208	-11.9508
V pol descending for	0.0206	-11.9960
H pol	0.0254	-10.3450
H pol aft	0.0251	-10.3634
H pol for	0.0251	-10.3266
H pol ascending	0.0276	-10.3460
H pol ascending aft	0.0215	-10.4207
H pol ascending for	0.0219	-10.2724
H pol descending	0.0230	-10.3440
H pol descending aft	0.0212	-10.3068
H pol descending for	0.0216	-10.3814

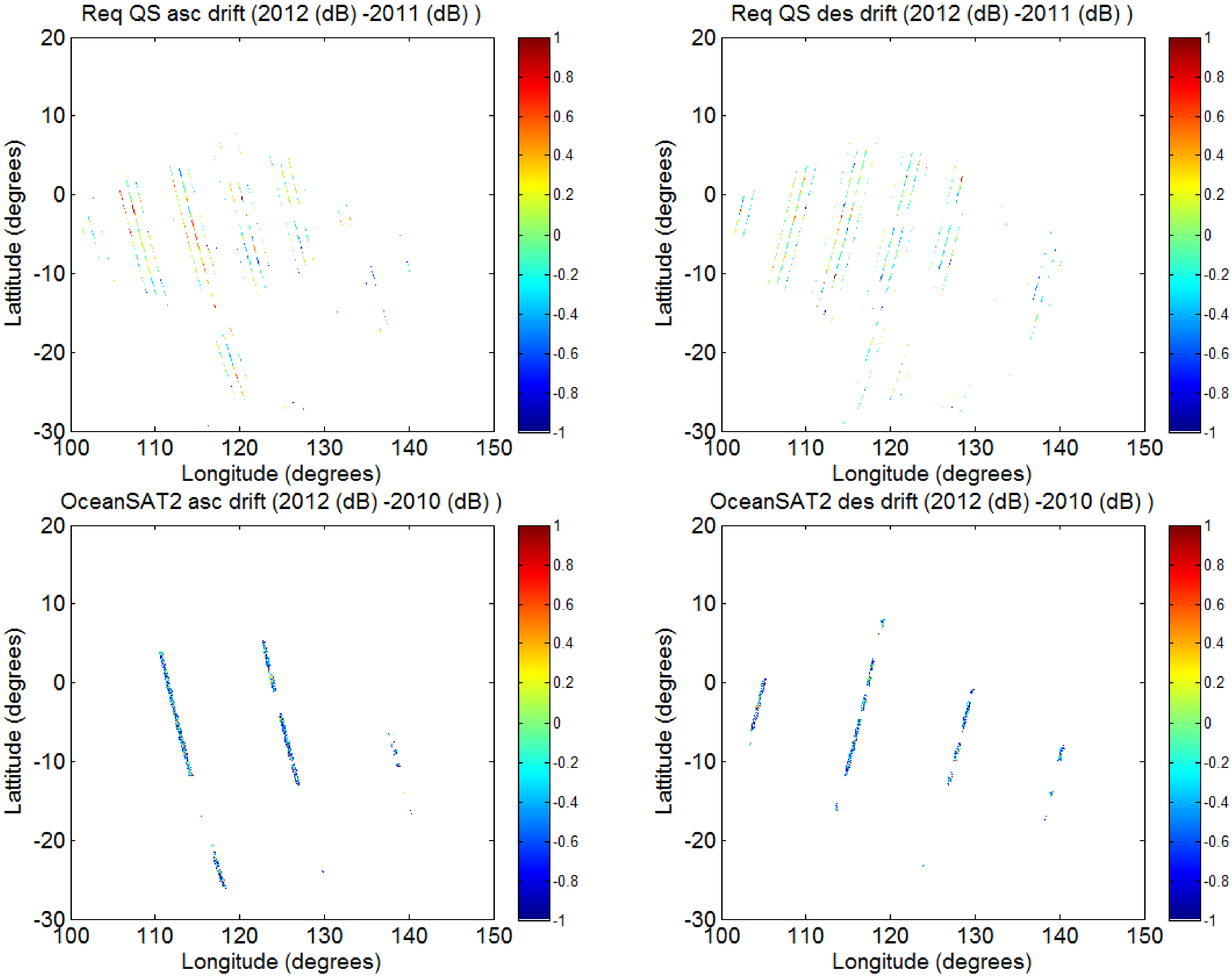


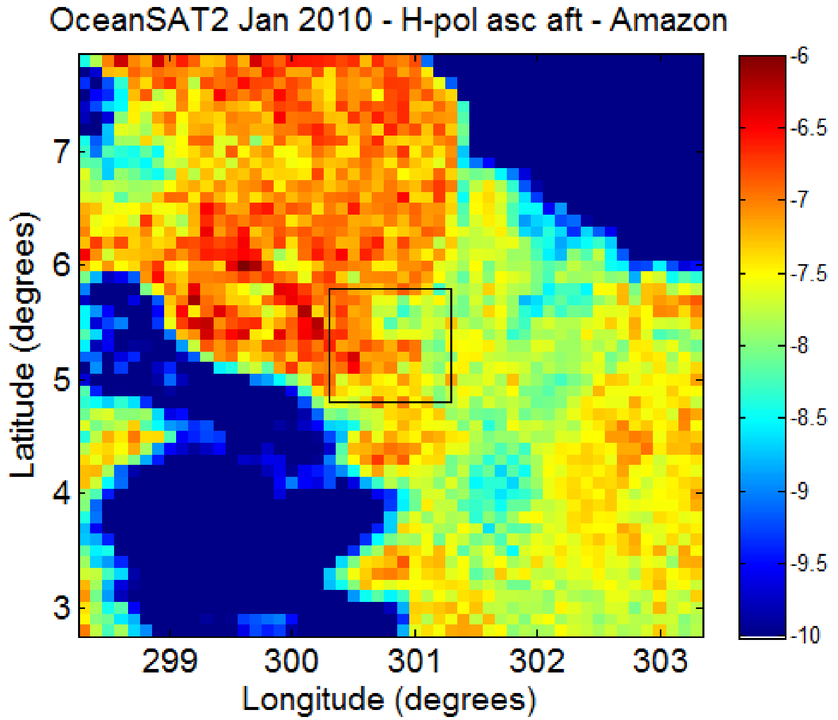


Small region check

- Backscatter image at several regions
- Drift of backscatter at one by one degree box

		Amazon	Antarctica	Congo	Greenland	Sahara
Location of center of the box (Lat,Lon)		N 5.3 W 59.2	S 75.1 E 123.1	S 0.2 E 11.2	N 73.5 W 37.5	N 27.2 E 17.8
Drift (dB)	H-pol	-0.51	-0.632	-0.4090	-0.373	-0.7146
	V-pol	-0.6254	-0.7130	-0.6201	-0.6284	-0.6730

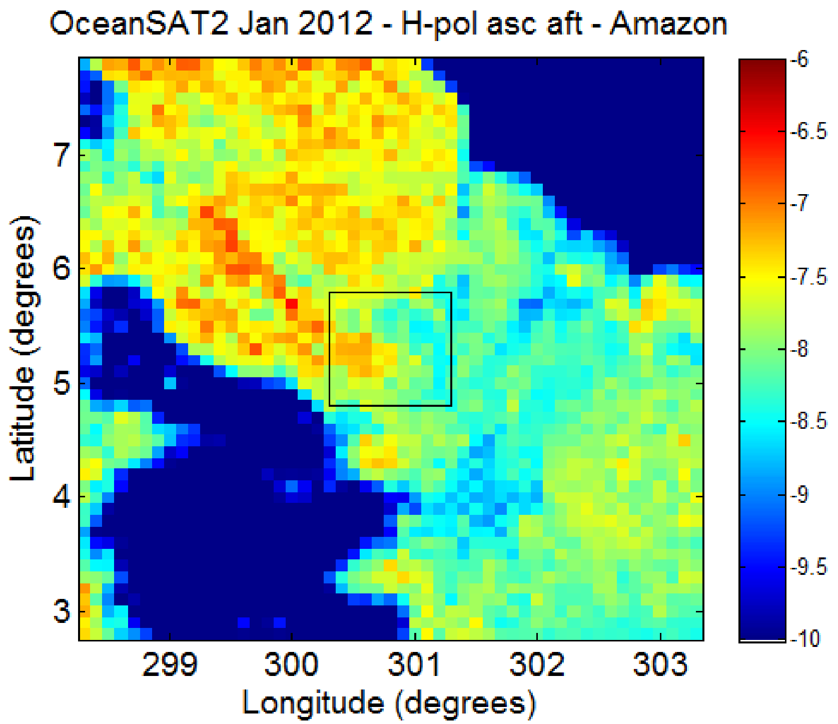

Req QS asc drift (2012 (dB) -2011 (dB))
Req QS des drift (2012 (dB) -2011 (dB))
OceanSAT2 asc drift (2012 (dB) -2010 (dB))
OceanSAT2 des drift (2012 (dB) -2010 (dB))
Lattitude (degrees)
Longitude (degrees)
20
10
0
-10
-20
-30
100
110
120
130
140
150
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1

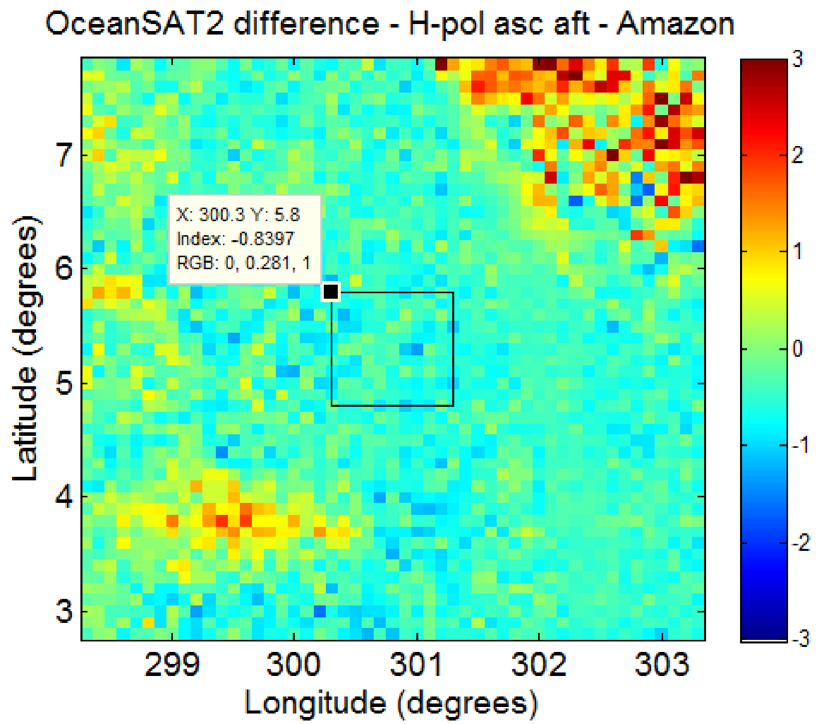


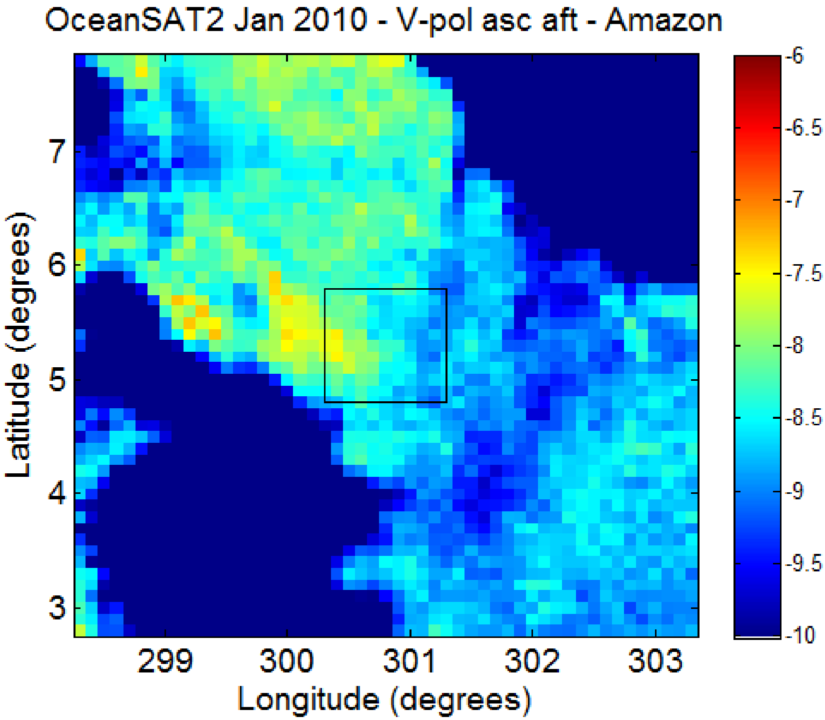
Amazon box – H-pol

Center of the box: N 5.3 W 59.2

Mean drift in box = -0.51 dB



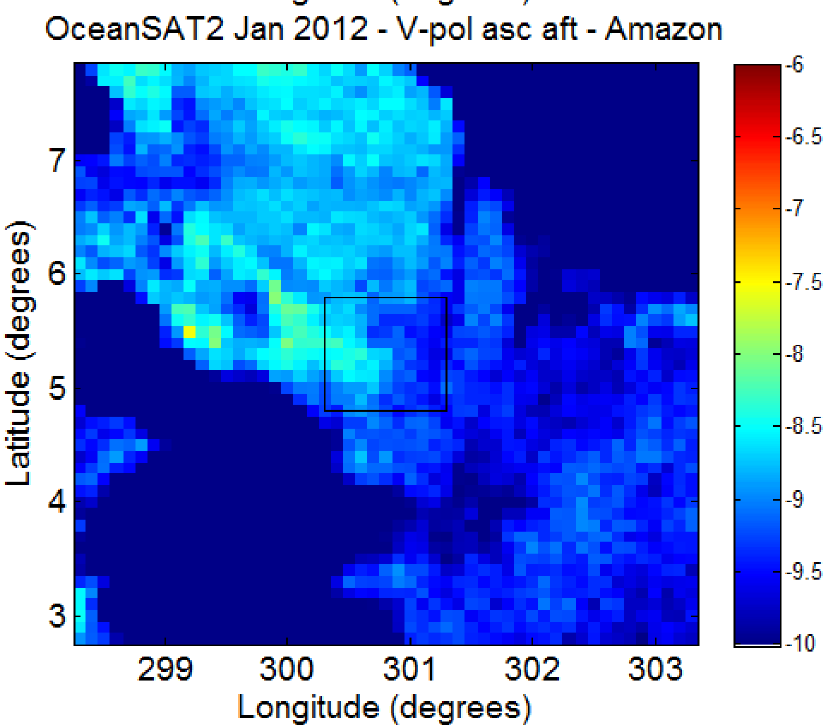


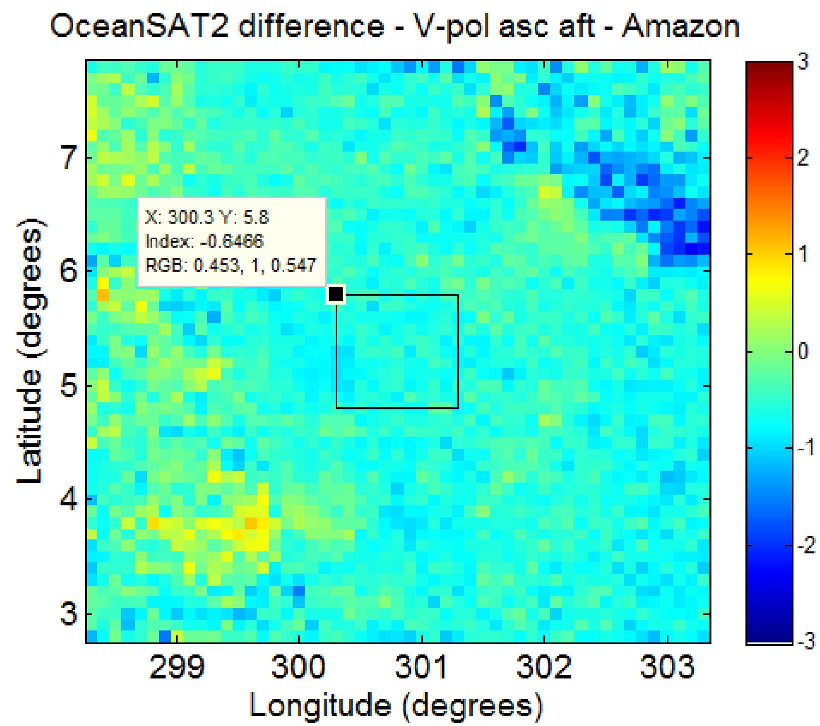


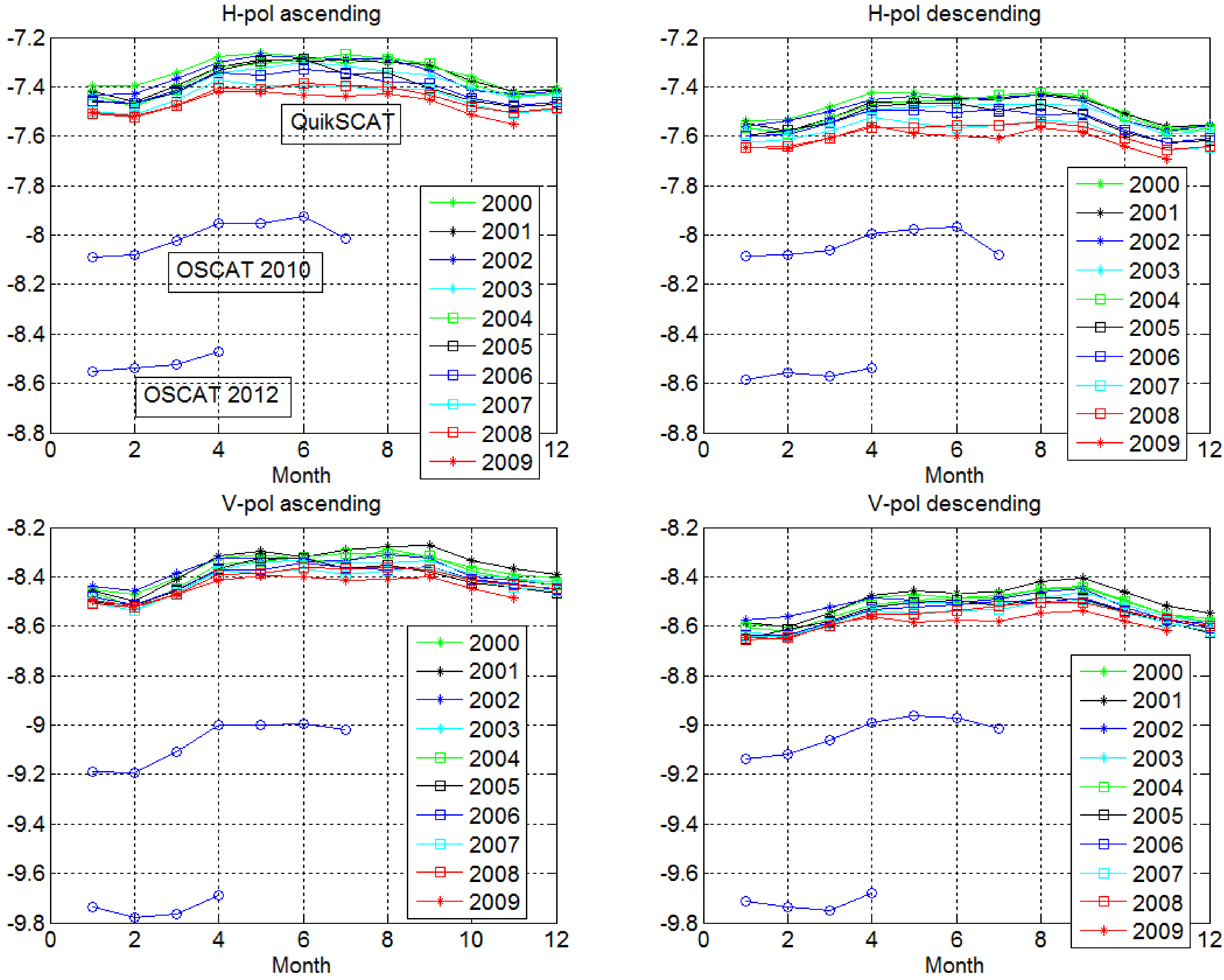
Amazon box – V pol

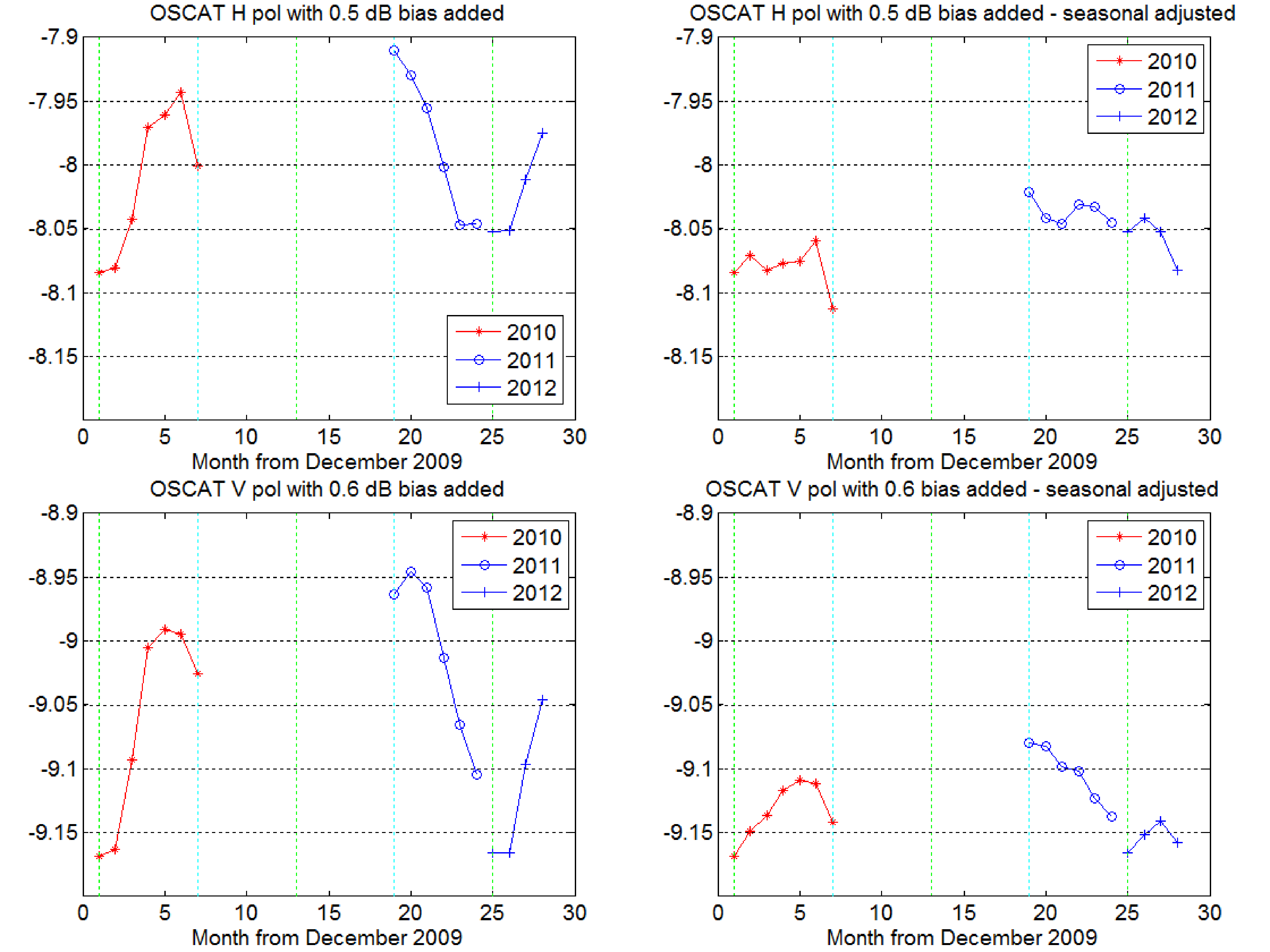
Center of the box: N 5.3 W 59.2

Mean drift in box = -0.6254 dB

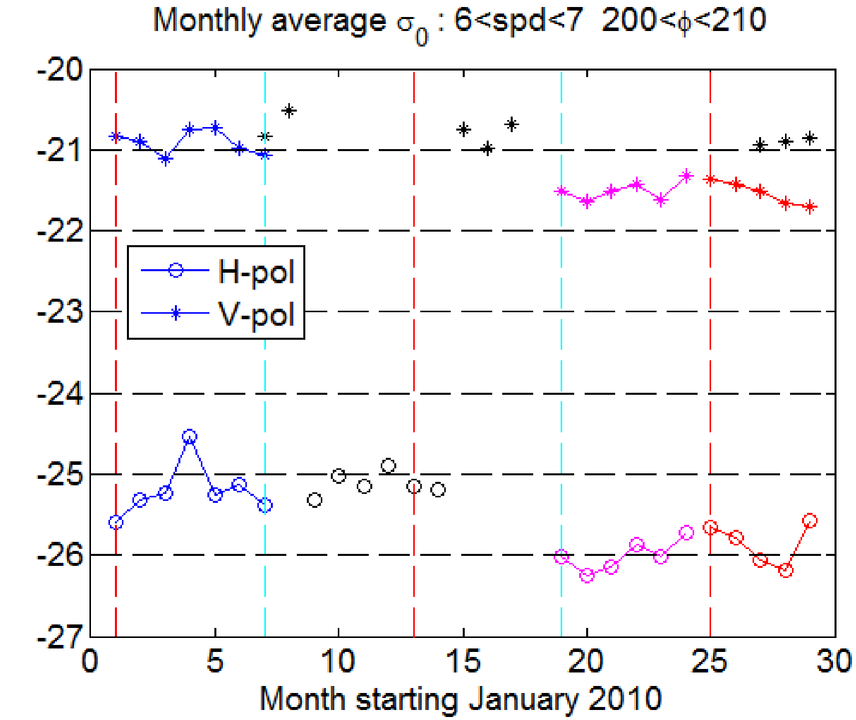





H-pol ascending
H-pol descending
V-pol ascending
V-pol descending
QuikSCAT
OSCAT 2010
OSCAT 2012
Month
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009



OSCAT H pol with 0.5 dB bias added
OSCAT H pol with 0.5 dB bias added - seasonal adjusted
OSCAT V pol with 0.6 dB bias added
OSCAT V pol with 0.6 bias added - seasonal adjusted
-7.9
-7.95
-8
-8.05
-8.1
-8.15
-8.9
-8.95
-9
-9.05
-9.1
-9.15
0
5
10
15
20
25
30
Month from December 2009
2010
2011
2012



Average sigma0 (in linear scale) versus time

6 <= speed <7

200<= relative azimuth <210