



seasar 2012

European Space Agency

# ***On* Ocean Surface Wind Retrieval from VH dual-pol Radarsat-2 SAR Imagery**

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# Outline

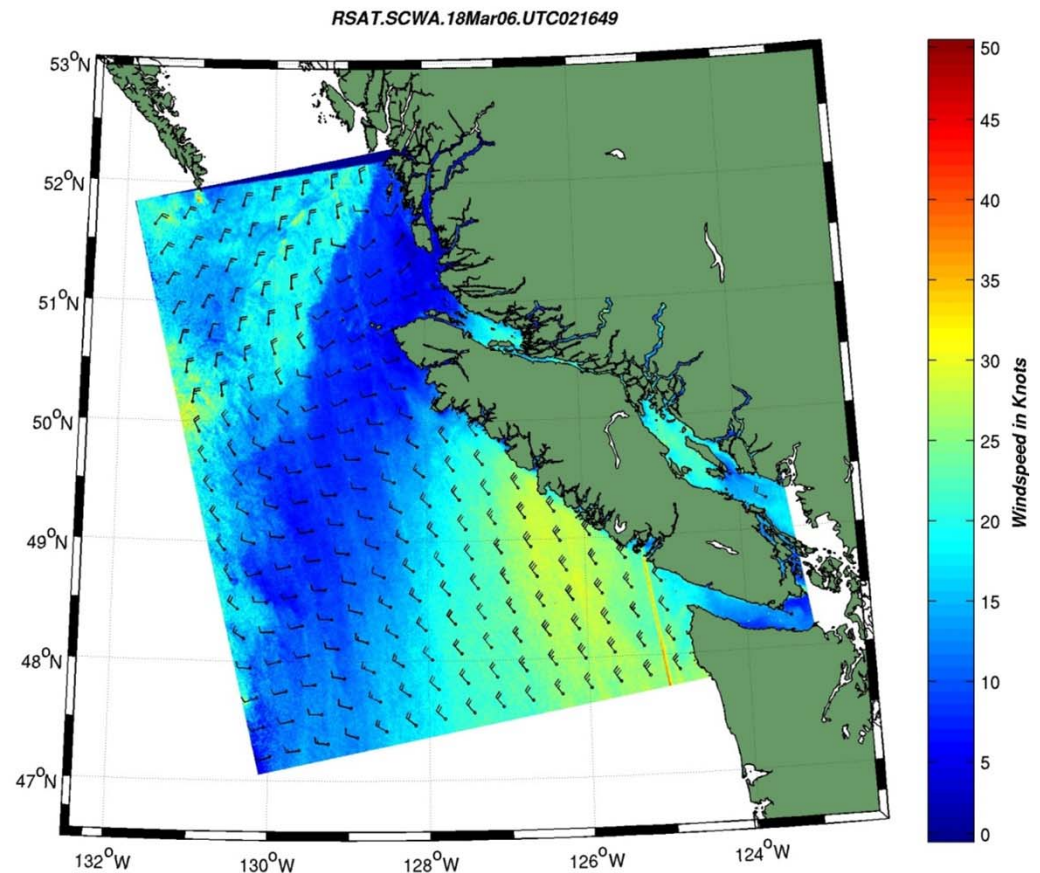
- A brief background introduction
- VH dual-pol Radarsat-2 SAR wind retrieval
  - A de-noise procedure
  - A VH dual-pol GMF
- VH dual-pol SAR high wind retrievals.
- Summary

# Wind speed retrieval from SAR

- SWA
  - SWDA
    - Direction
    - GMF model
- $NRCS = \sigma(sp, dir, inc)$

## C-band

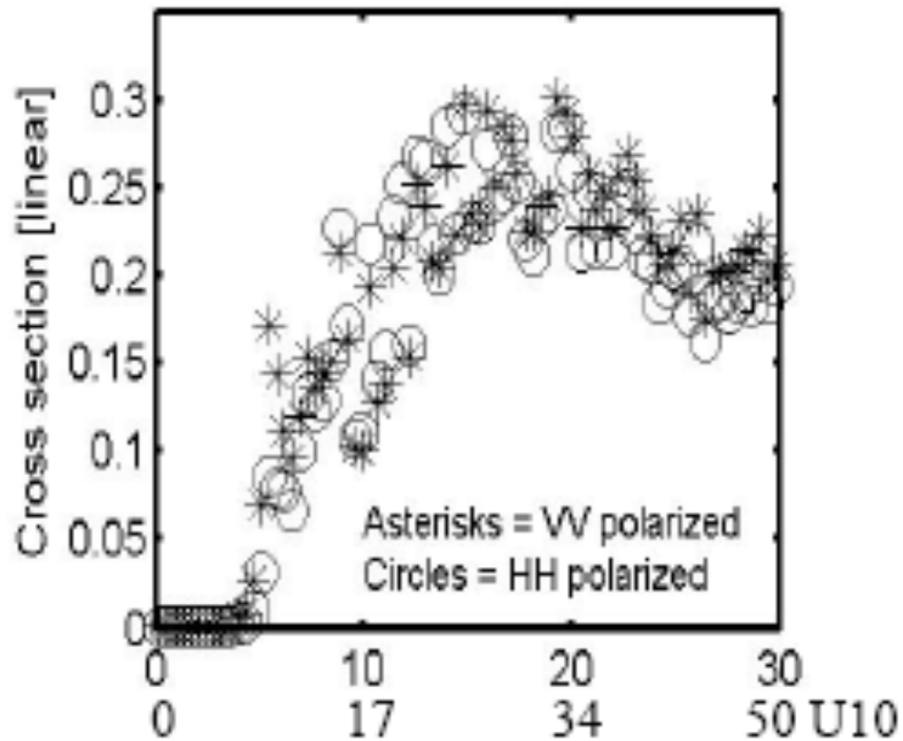
- CMOD5
- CMOD5.N
- HWGMF\_V(H)



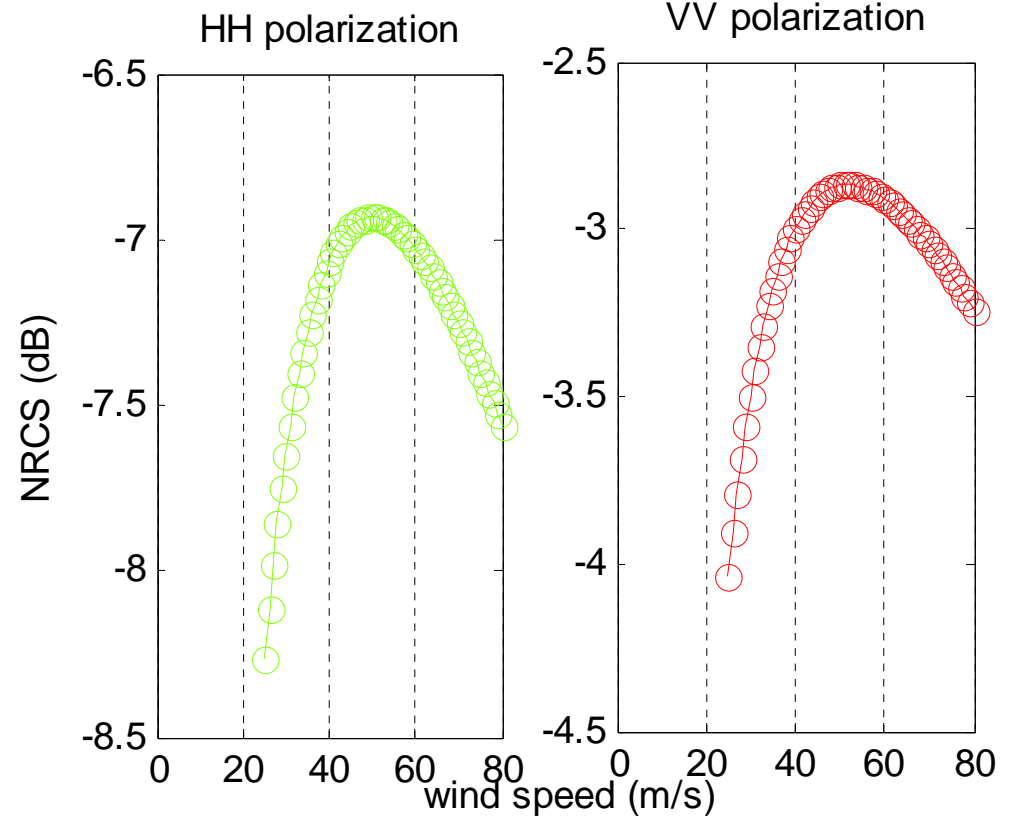
<http://cwind.ca/nsw>

# NRCS under high winds

Donelan et al.



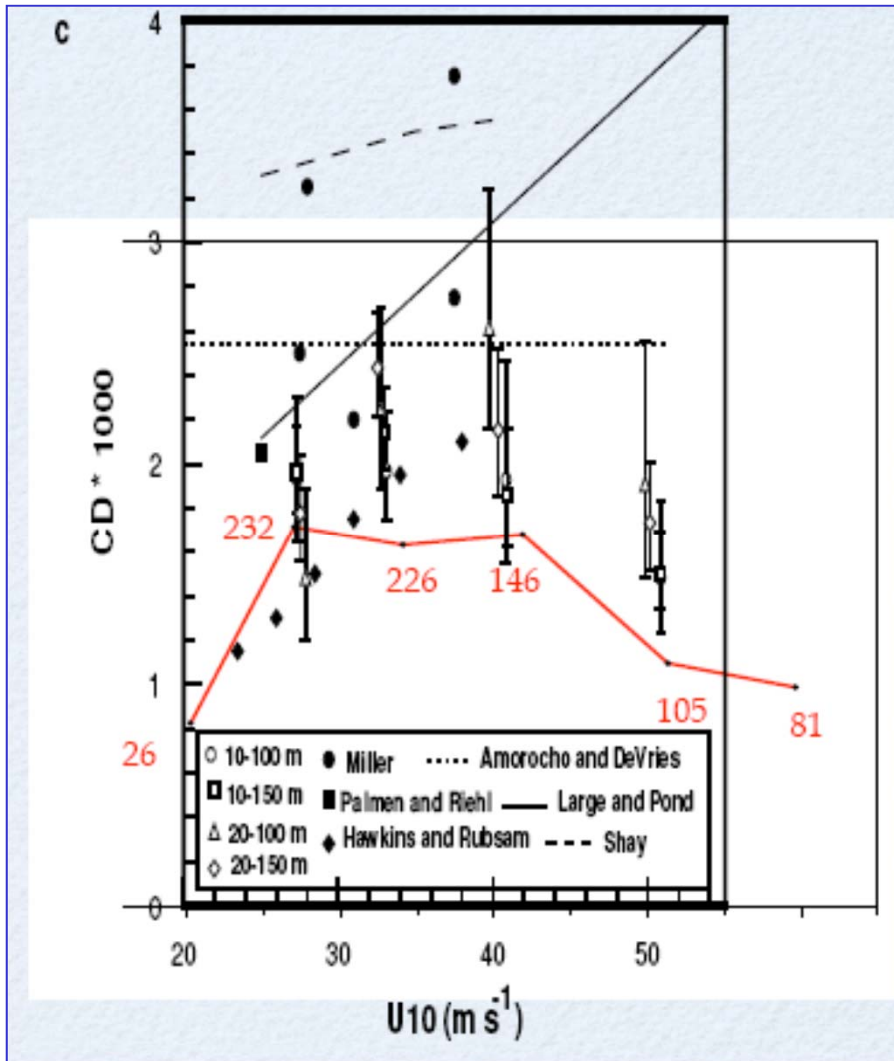
Fernandez et al. (2006)



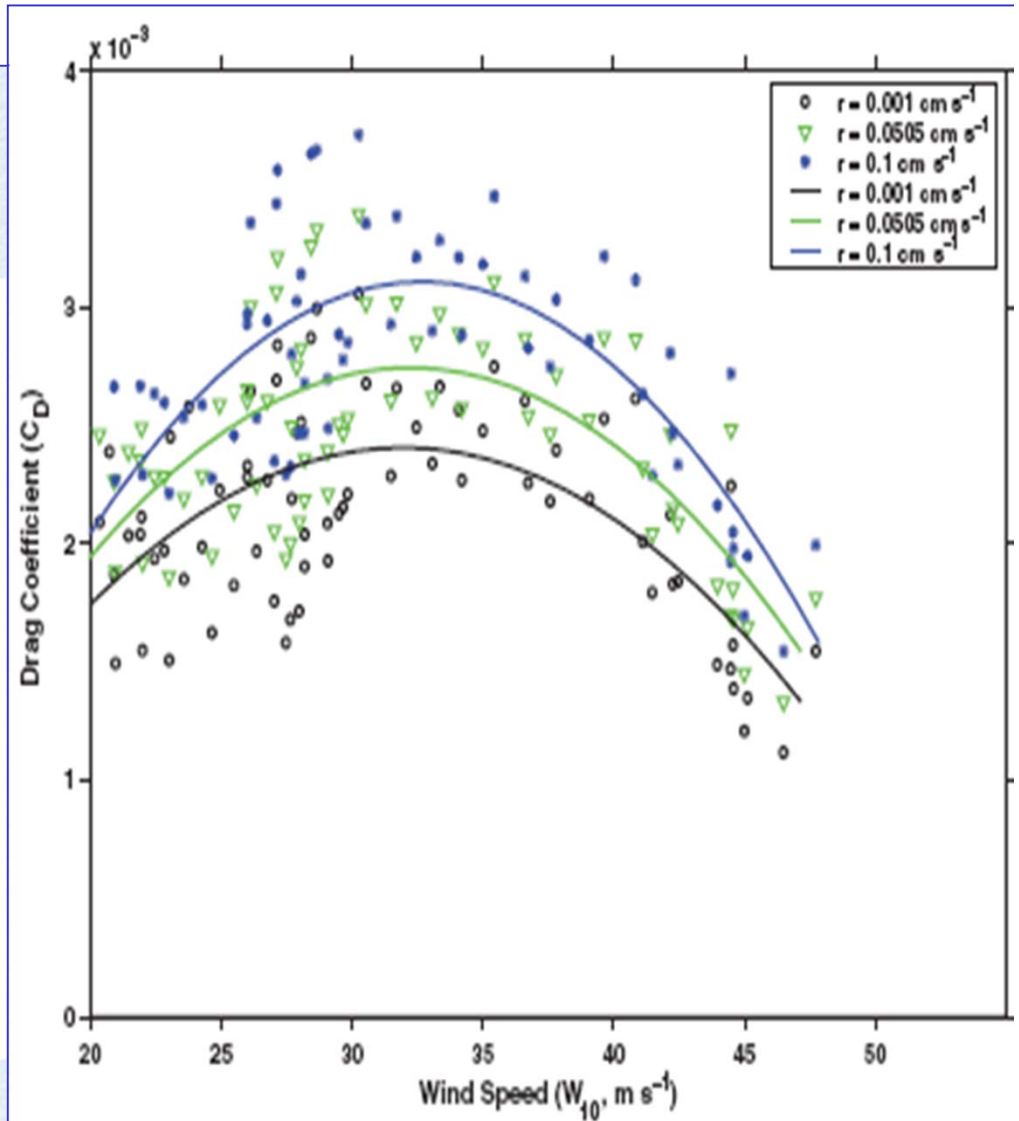
Inc=35°

Inc=31°

**Wind blows to the radar**



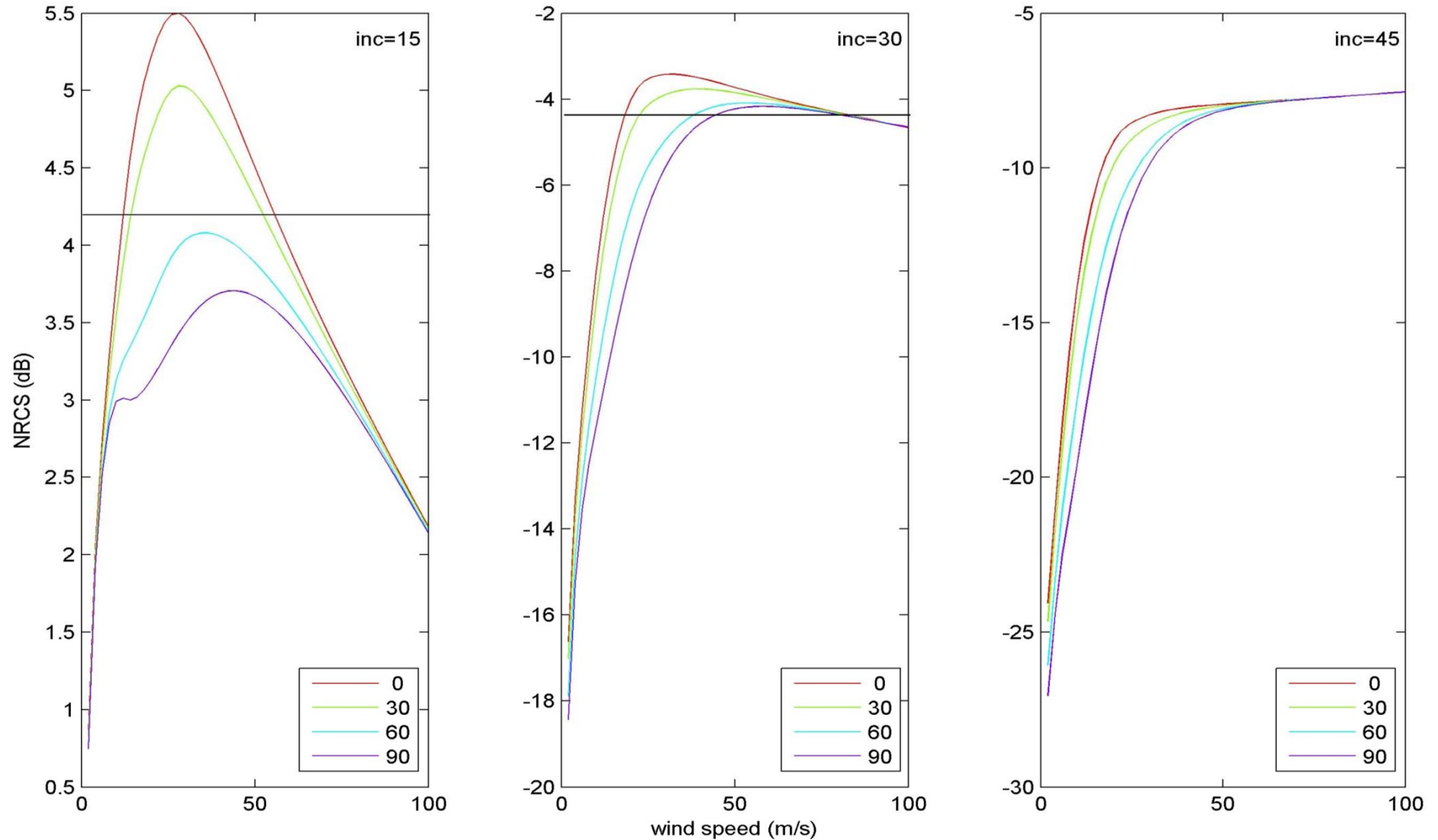
M.Powell (HRD 2006)



Jarosz et al. 2007

Wind stress drag coefficient under high wind speed testifies the ocean surface respond to the high wind

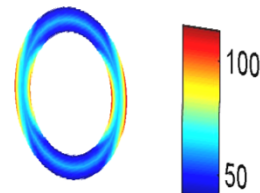
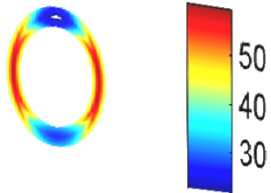
# NRCS simulations by CMOD5



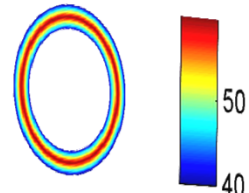
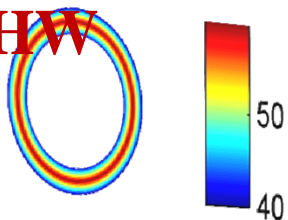
NRCS vs. wind speed in CMOD5 at 3 incident angles + 4 radar-relative wind directions (as labeled)

# Speed ambiguities under high wind

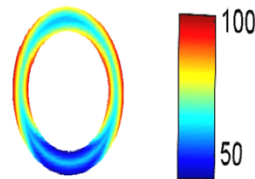
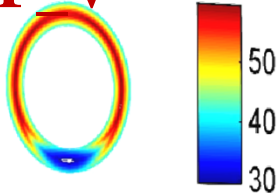
**CMOD5**



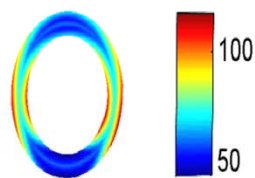
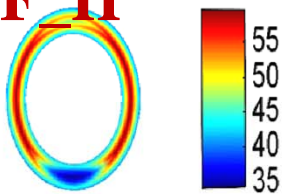
**COMDHW**



**HWGMF V**



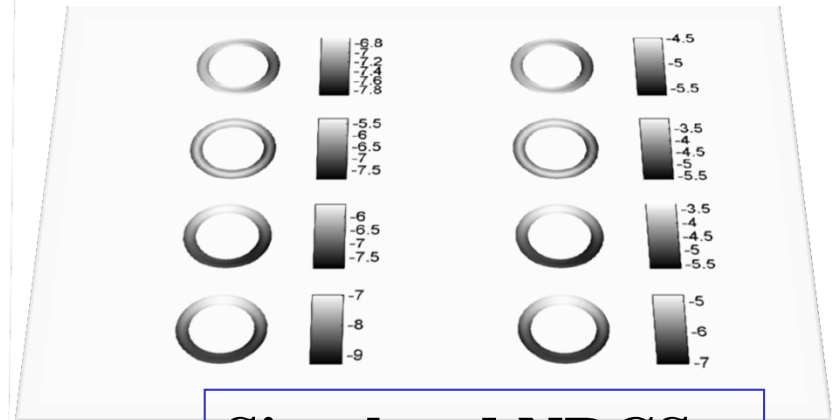
**HWGMF H**



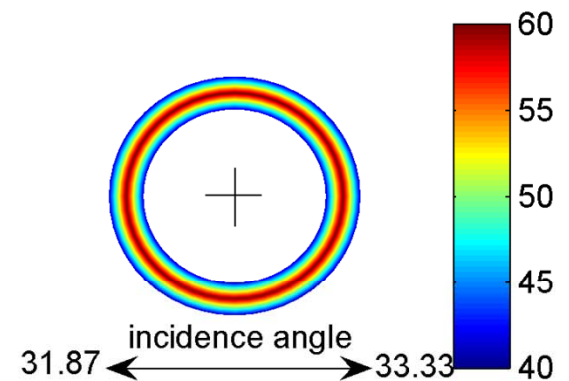
smaller solution

bigger solution

Retrieved wind



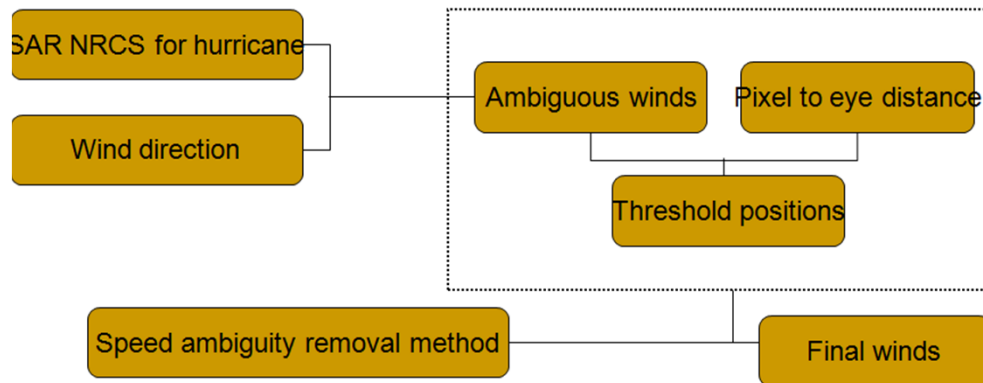
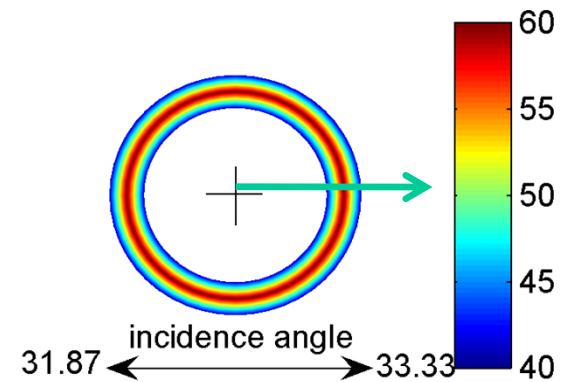
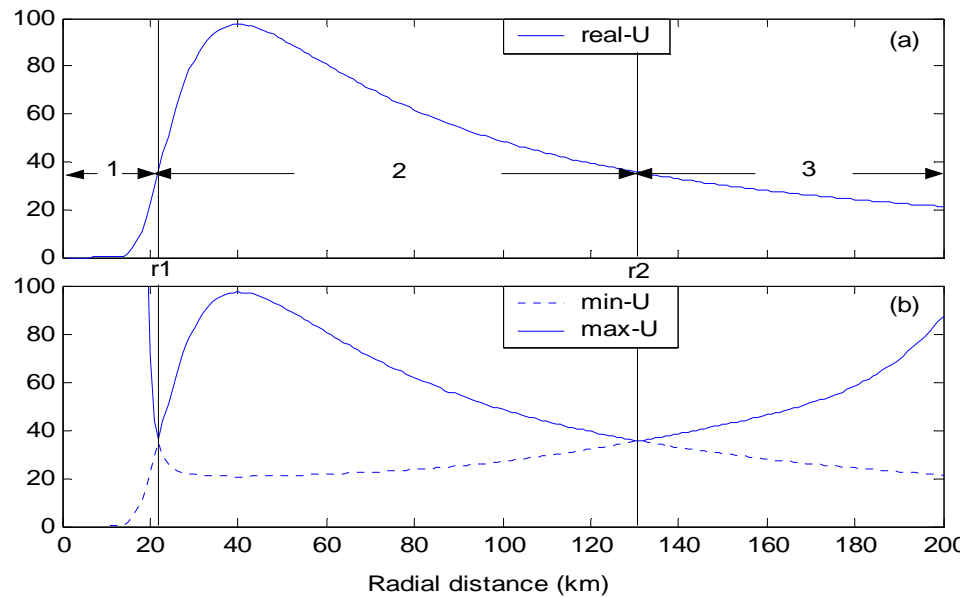
Simulated NRCS



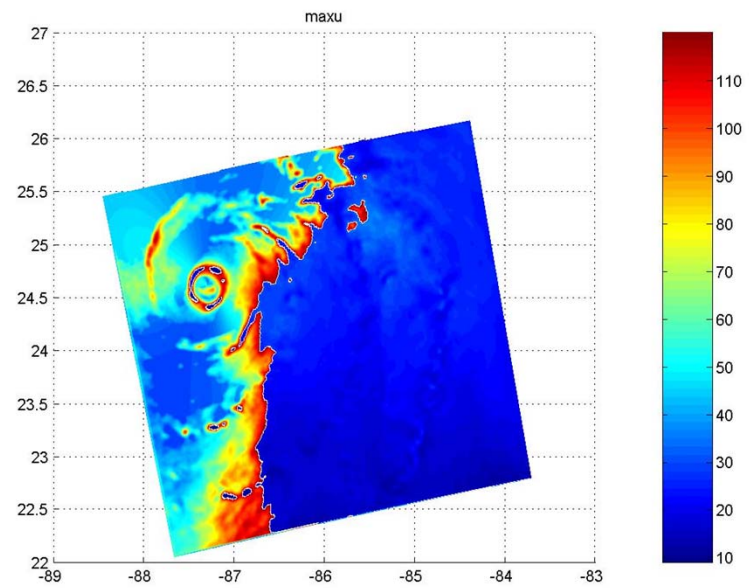
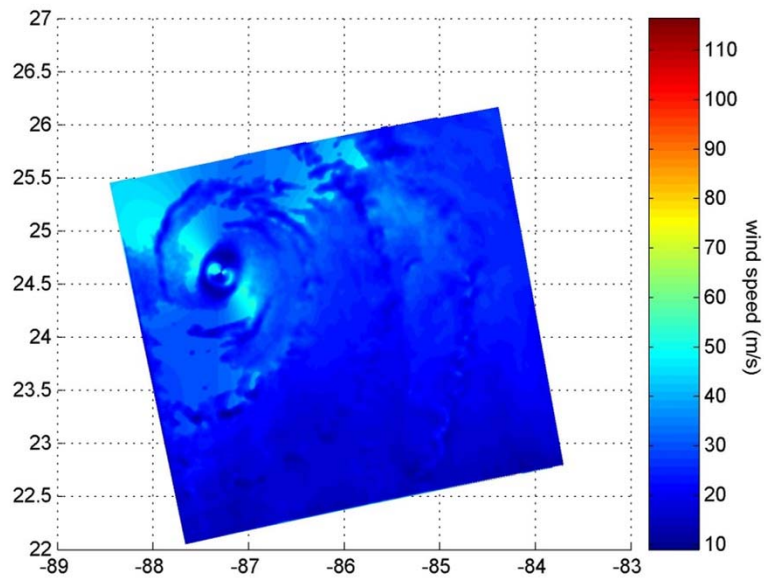
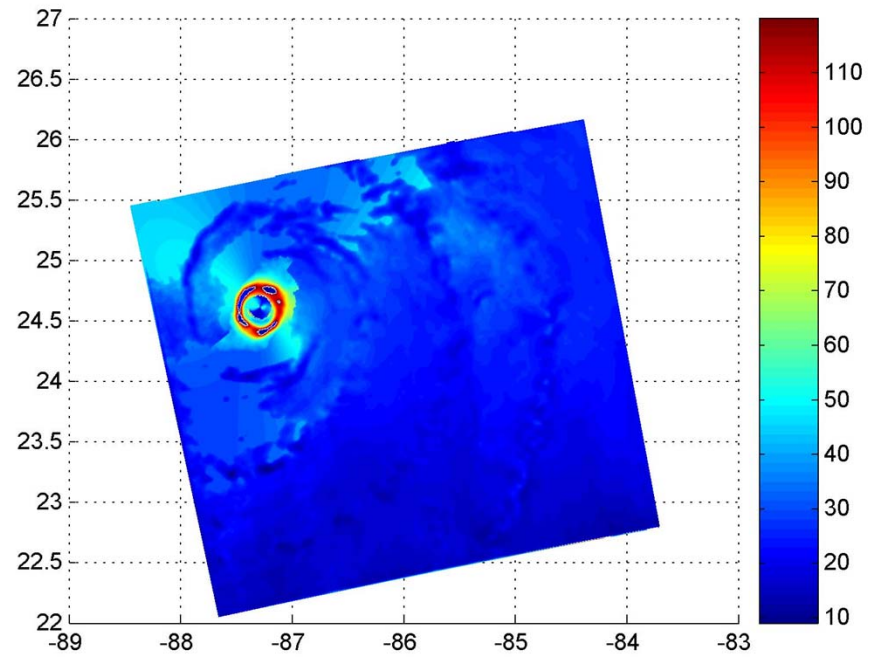
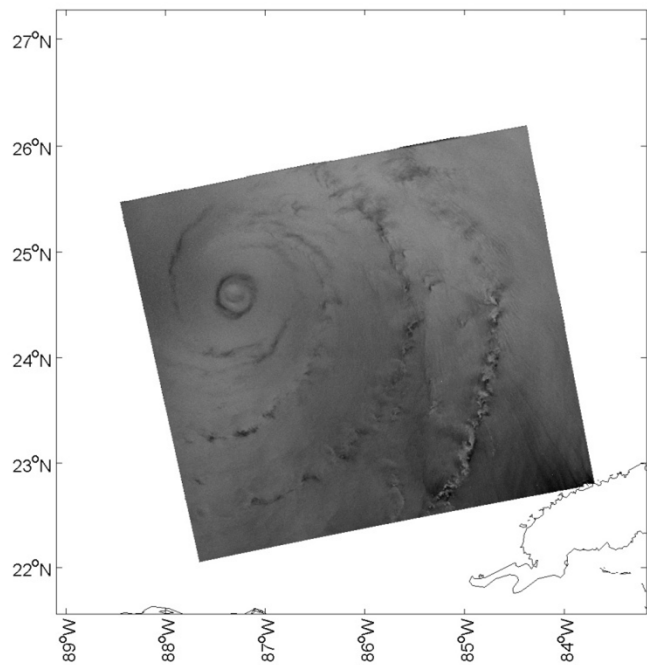
a hurricane wind structure



# A method to remove speed ambiguity under hurricane cases







# Cross pol wind retrieval

Quad  
-pol

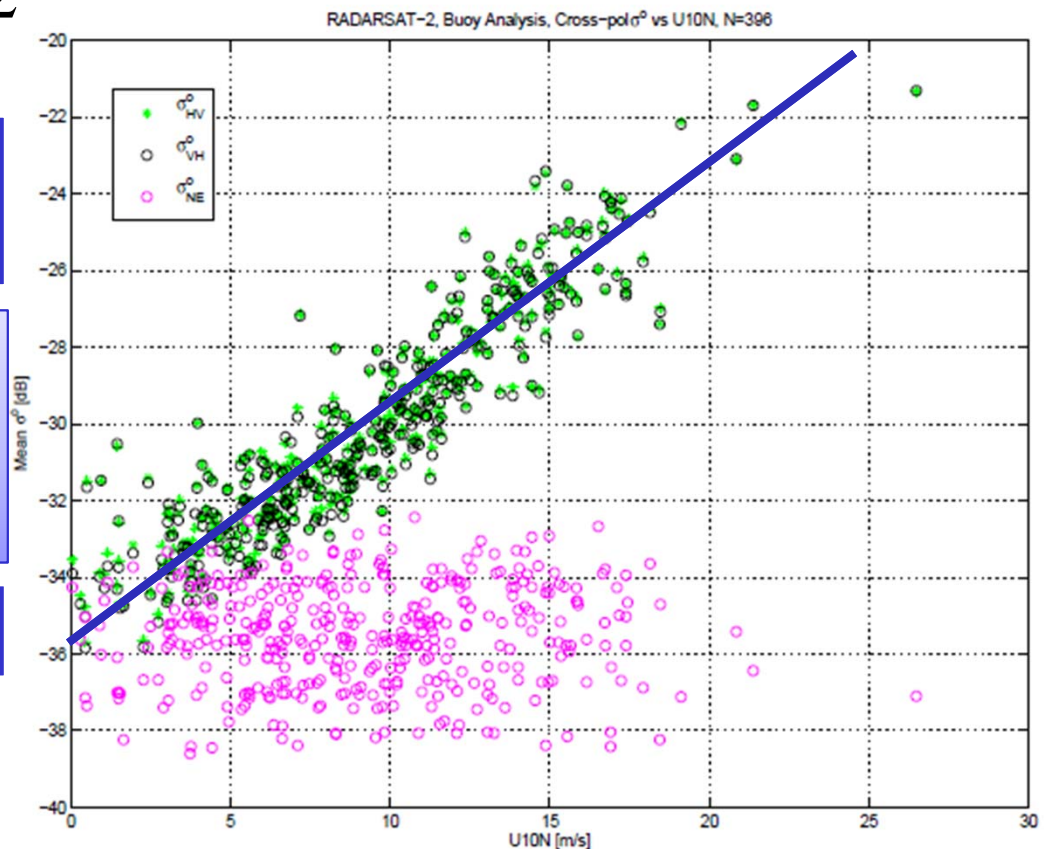
- P. Hwang et al, 2010,2011
- Vachon & Wolfe, 2011
- Zhang et al. 2011,2012

$$\sigma_{\text{cross-pol}}^o = 0.585 U_N^{10} - 35.5$$

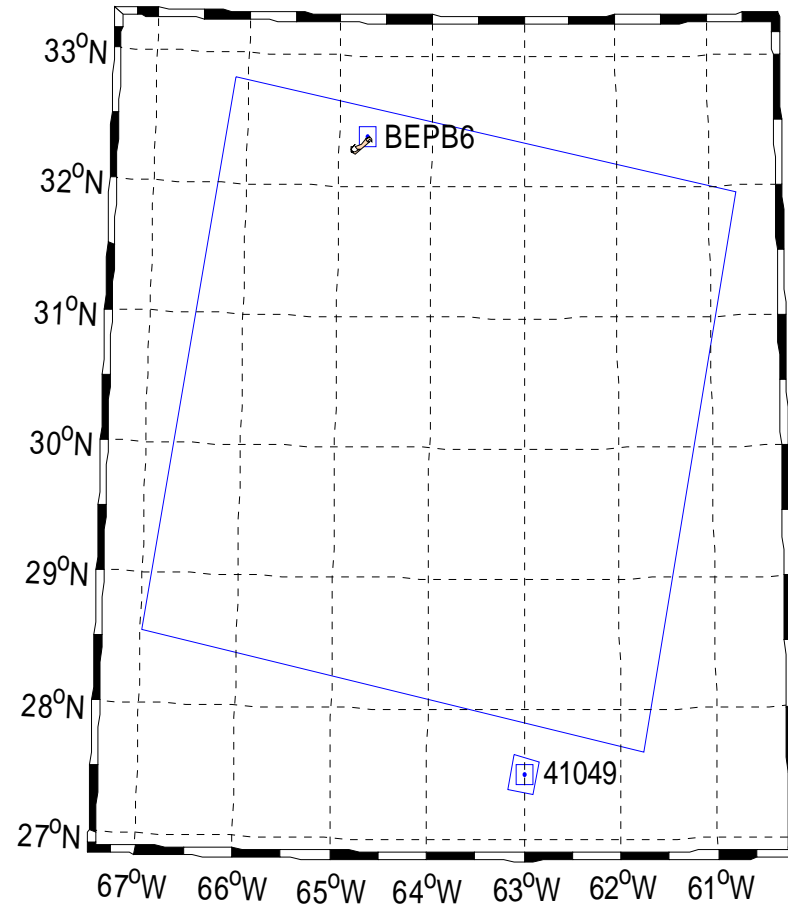
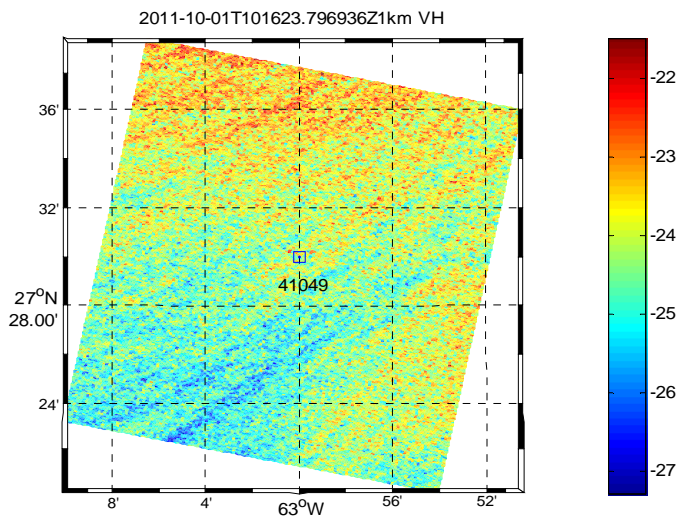
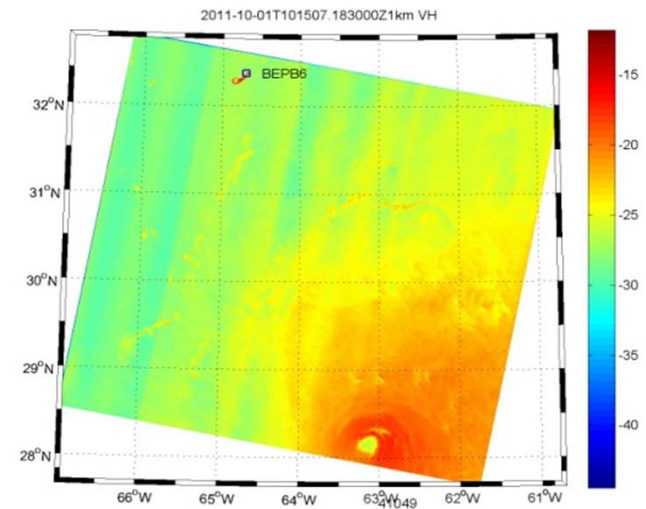
Linear dependence of  
NRCS on wind speed

No dependence on  
incidence angle or wind  
direction

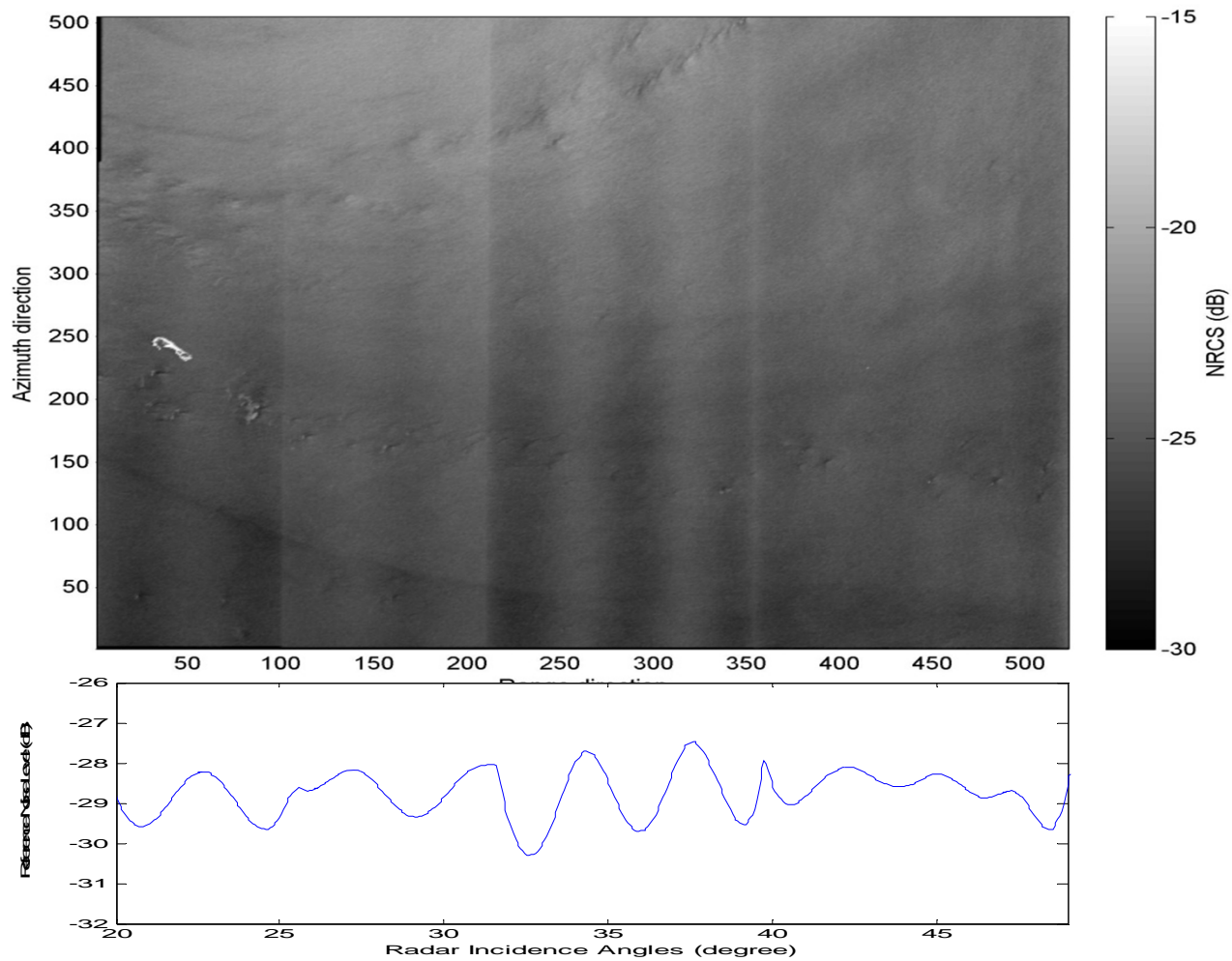
Very low noise level



# VH dual-pol wind retrieval



# A de-noise procedure



# A de-noise procedure

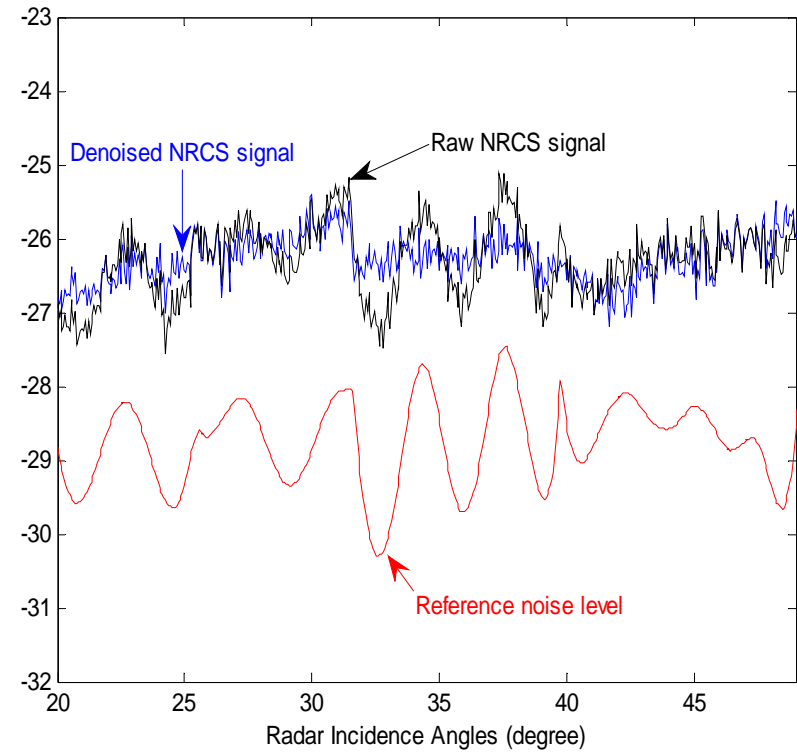
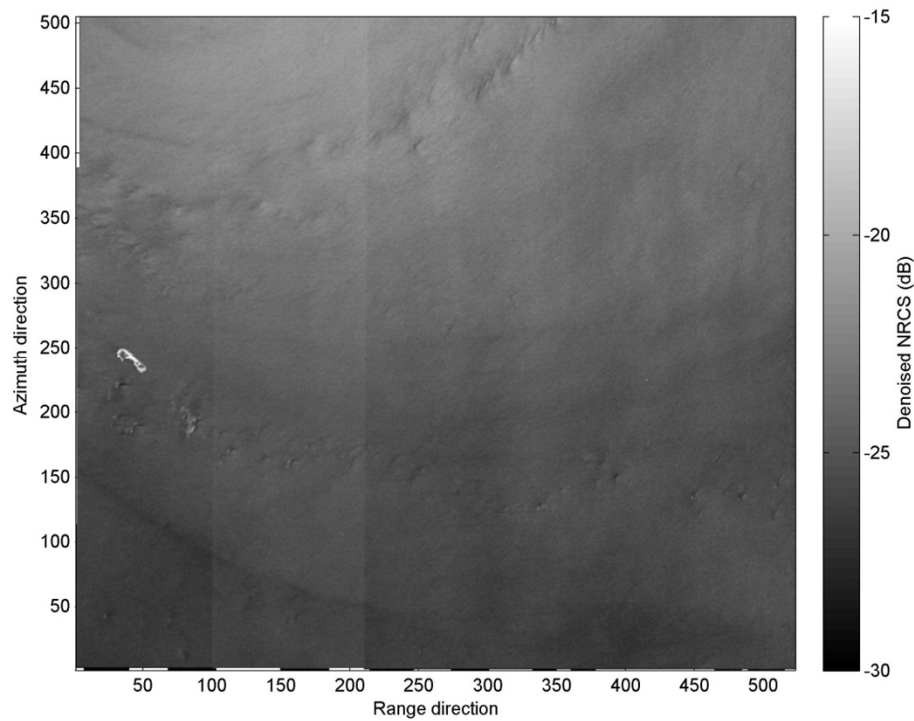
$$Nsig_{linear} = 10^{(Nsig_{dB}/10)}$$

$$sig_{cal} = sig_{linear} - Nsig_{linear} + \text{mean}(Nsig_{linear})$$

$$Sig = 10 \log_{10}^{Sig_{cal}}$$



# A de-noise procedure

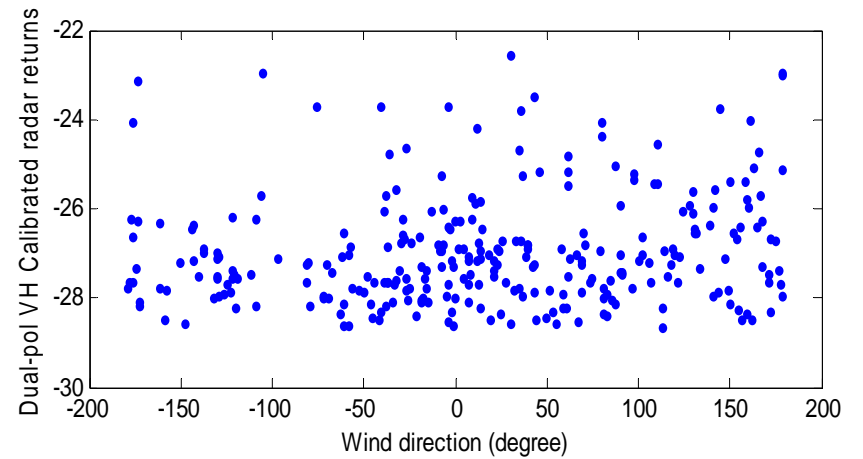
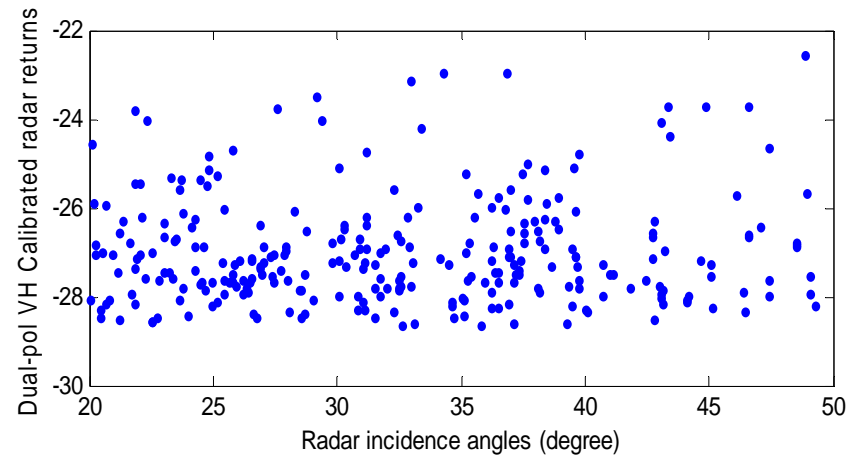
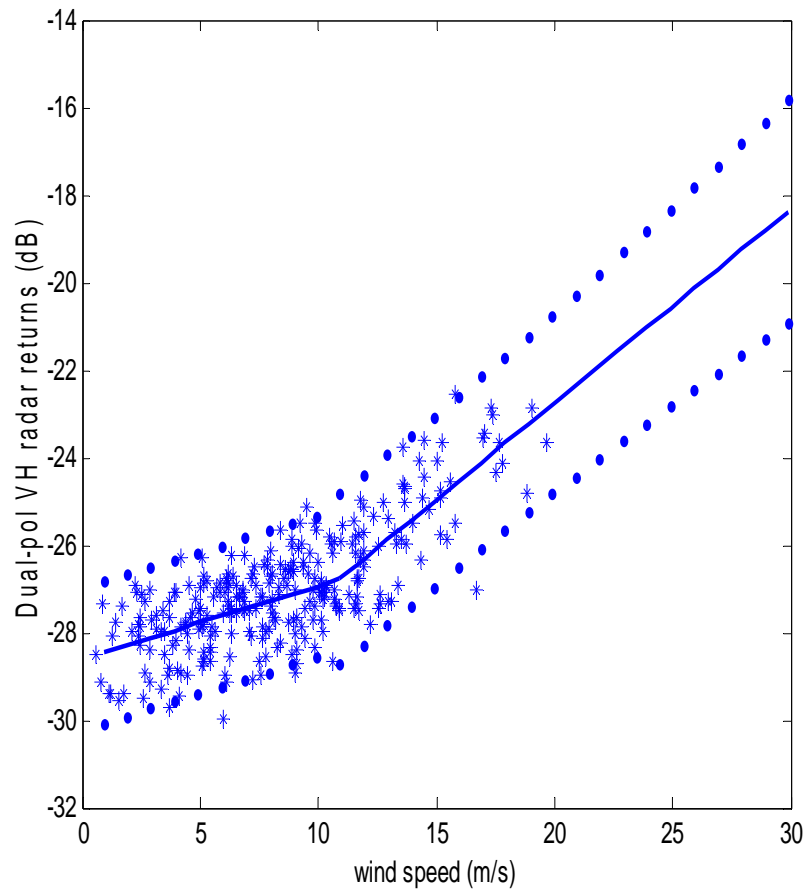


# VH dual-pol GMF

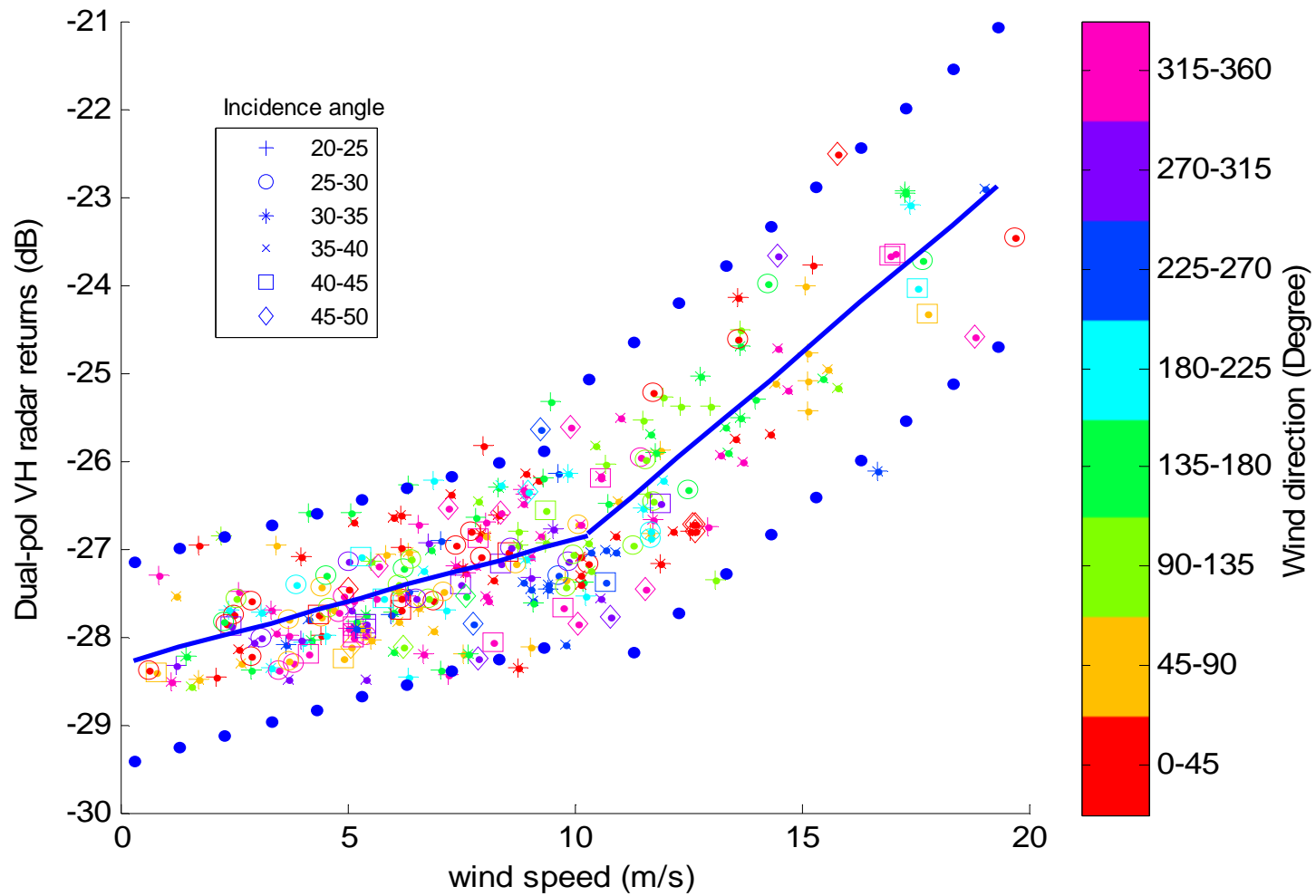
- Dataset
  - 285 Dual-pol ScanSAR images
  - All NDBC buoys
  - 1039 co-located data pairs
- Data process
  - Land mask
  - De-noise
  - Downgrid to 1km\*1km
  - Adjust wind speed to 10m
  - Time difference <30min



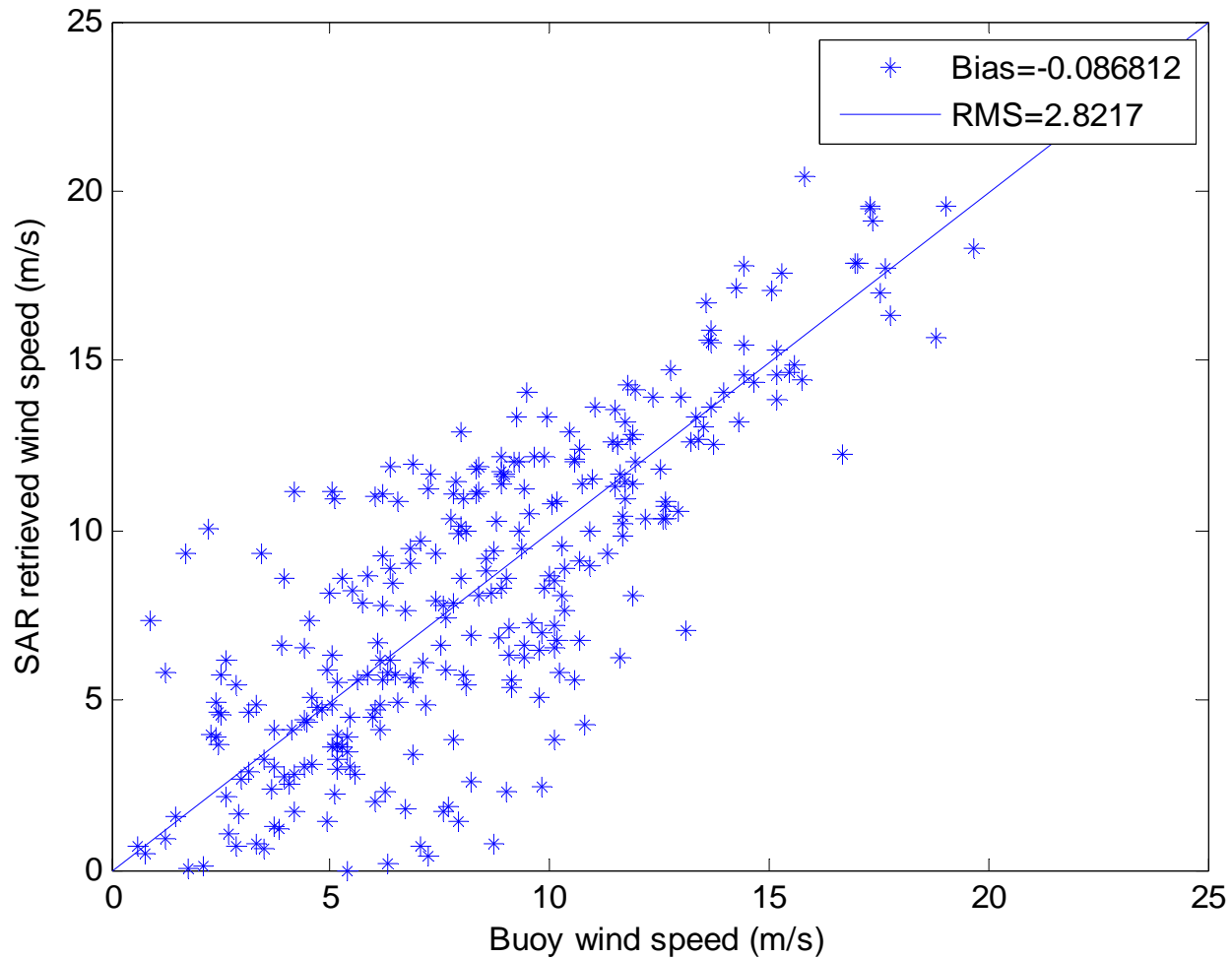
# VH dual-pol

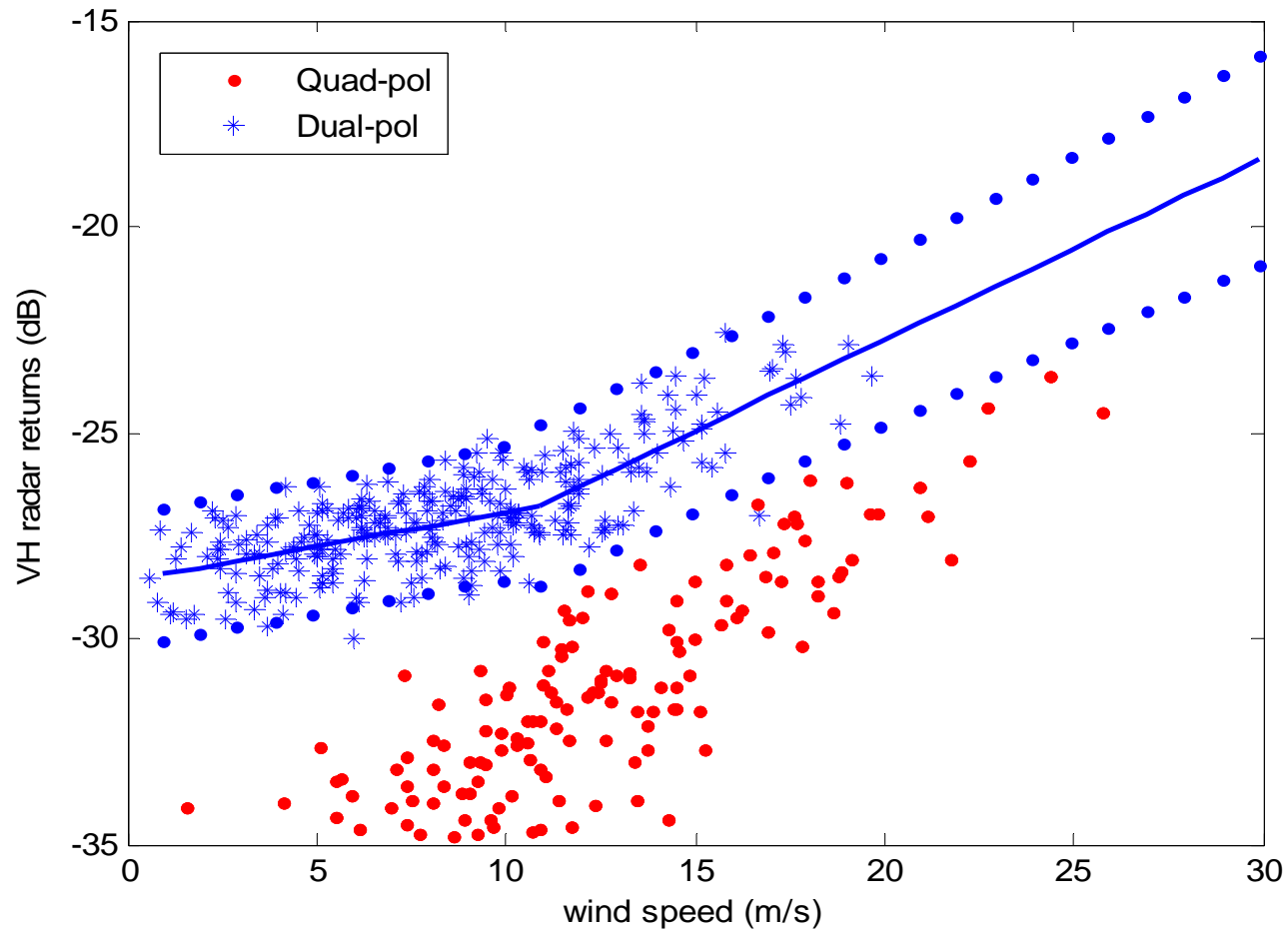


# VH dual-pol



# Validation by Buoys





# Case study: Hurricane Bill

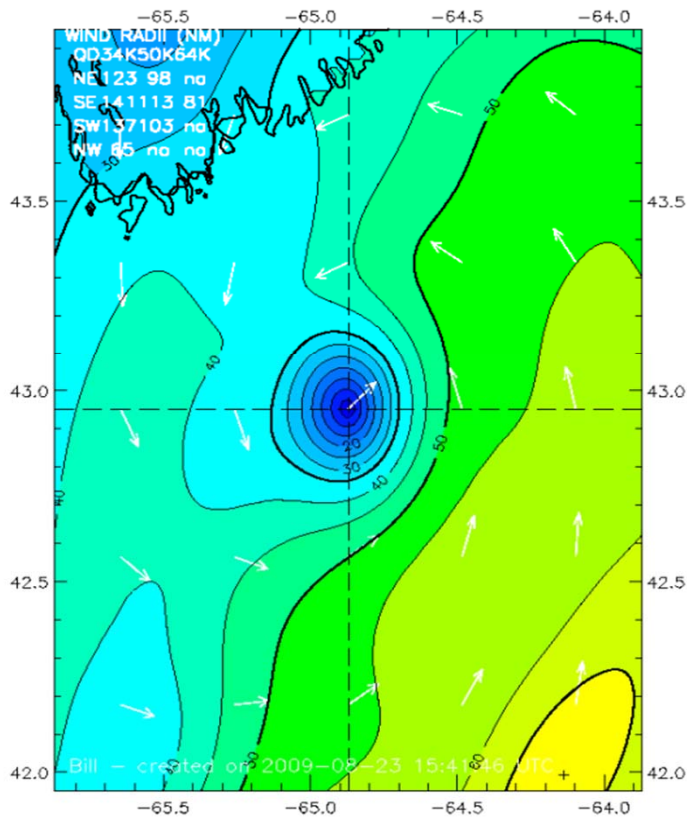
## 2009-08-23 10:40:56

Hurricane Bill 1330 UTC 23 AUG 2009

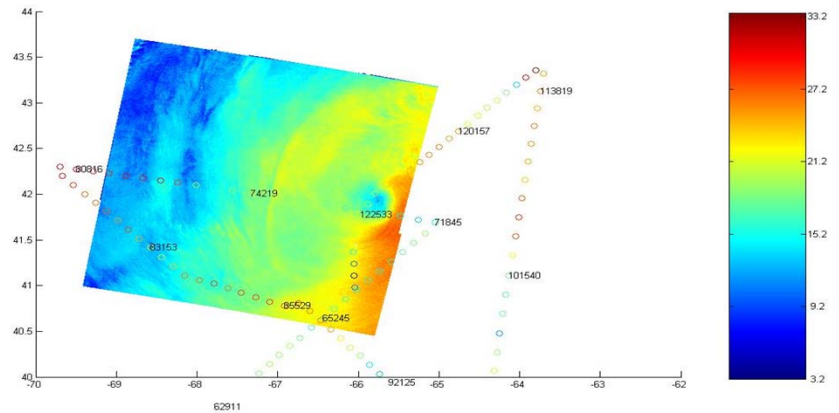
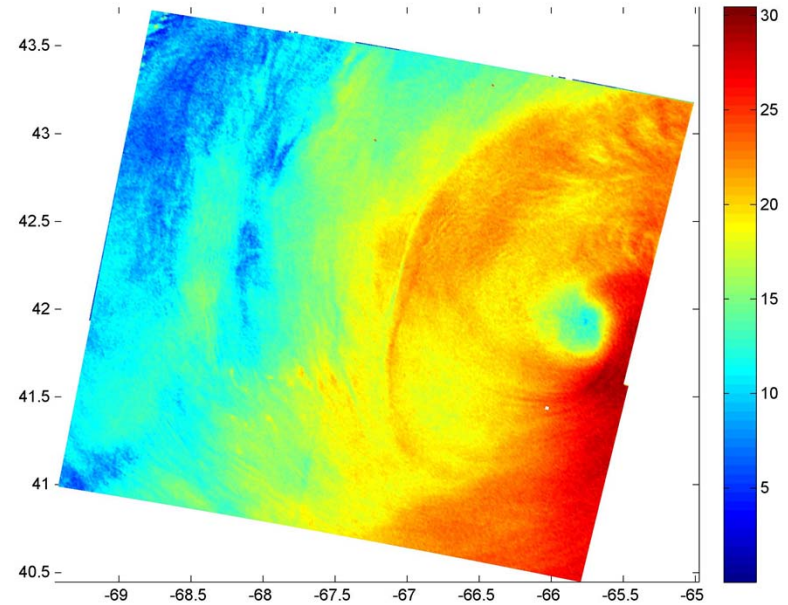
Max 1-min sustained surface winds (kt)

Valid for marine exposure over water, open terrain exposure over land

Analysis based on SFMR\_AFRC from 0505 - 1230 z; METAR from 1030 - 1524 z; CMAN from 1030 - 1515 z;  
 GPSSONDE\_WL150 from 1106 - 1106 z; GPSSONDE\_SFC from 1149 - 1149 z;  
 BACKGROUND\_FIELD from 1330 - 1330 z; MOORED\_BUOY from 1030 - 1515 z;  
 GOES from 1302 - 1302 z; SFMR\_AFRC\_FLAG from 0504 - 1236 z;  
 ASOS from 1030 - 1524 z;  
 1330 z position extrapolated from 1200 z ATCF\_CARQ wind center using 35 deg @ 27 kts; mslp = 965.0 mb

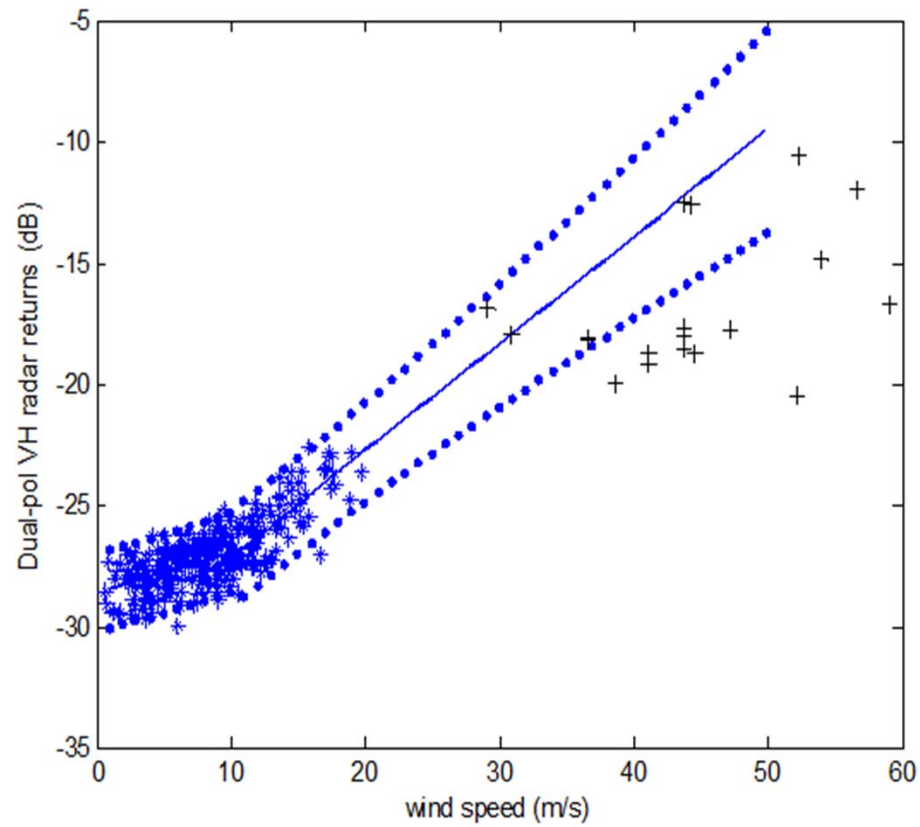


Integrated Kinetic Energy: for Winds > TS force: 36 TJ, for Winds > Hurricane Force: 1 TJ  
 Destructive Potential Rating(0-6) Wind: 2.0, Surge/Waves: 3.3  
 Observed Max Surface Wind: 67 kts, 72 nm SF of center based on 1055 z SFMR AFRC



# Validation of GMF on High wind by Best Track Analysis Data

id	SARname	Hurricane Name
1	2009-08-22T222656	BILL0000
2	2009-08-22T222741	BILL0000
3	2009-08-23T104056	BILL0000
4	2009-08-23T104057	BILL0000
5	2010-08-28T220420	Danielle
6	2010-08-30T095631	Earl0000
7	2010-08-30T095738	Earl0000
8	2010-09-02T225920	EARL0000
9	2008-08-30T112749	Gustav00
10	2010-09-14T091942	IGOR0000
11	2010-09-19T101124	IGOR0000
12	2008-09-10T235457	IKE00000
13	2008-09-10T235603	IKE00000
14	2008-09-10T235604	IKE00000
15	2008-09-10T235611	IKE00000
16	2011-08-24T094548	Nanmadol
17	2011-10-01T101507	Ophellia
18	2011-10-01T212504	Philippe
19	2011-10-05T100003	Philippe
20	2011-10-26T113010	Rina0000



# Summary

- We show good POTENTIAL of VH dual-pol SAR for wind retrieval in high wind conditions.
- VH dual-pol wind GMF is different from VH quad-pol GMF.
- A denoise procedure is necessary to increase signal significance.
- Validation of SAR high wind retrievals remains a challenge.



Thank you.