Overview of Changes To Near-Real Time 25km QuikSCAT Wind Retrievals

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Outline

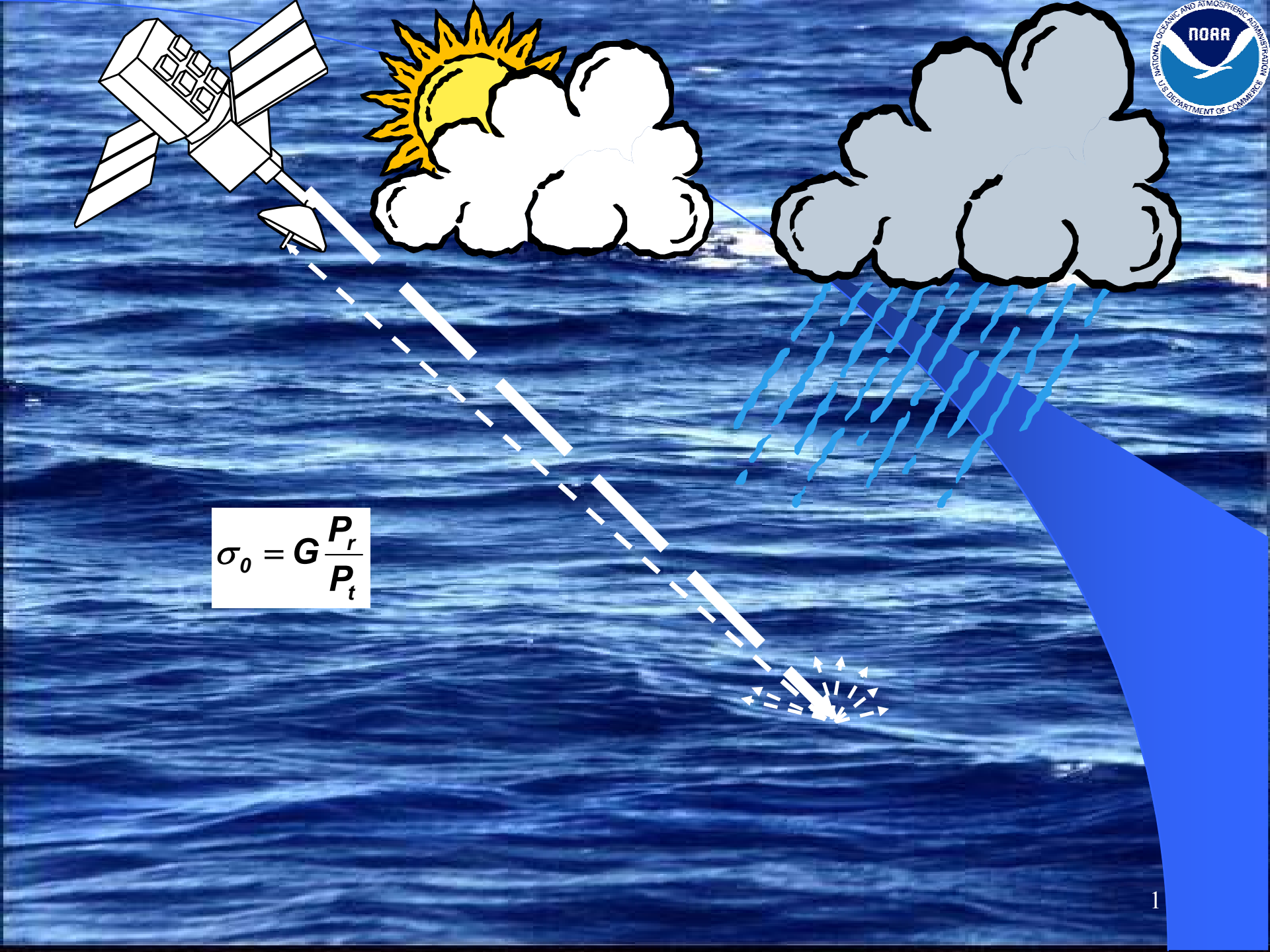
- Reasons for Change
- QuikScat Measurement Technique
- Impact of Changes on QuikSCAT NRT Processing
- Validation of New NRT Wind Product
- Summary

Motivation for New Retrieval Algorithm

- Improvements based on operational and research experience with QuikSCAT data since 1999/2000
  - Retrieved wind speeds too low in high wind areas
  - Overly conservative rain flag
  - Poor retrieval quality on swath edge
  - Lack of retrievals close to coast
- NASA JPL addressed these issues by modifying retrieval algorithm
  - First for science level data
  - Now to be implemented for near-real time data

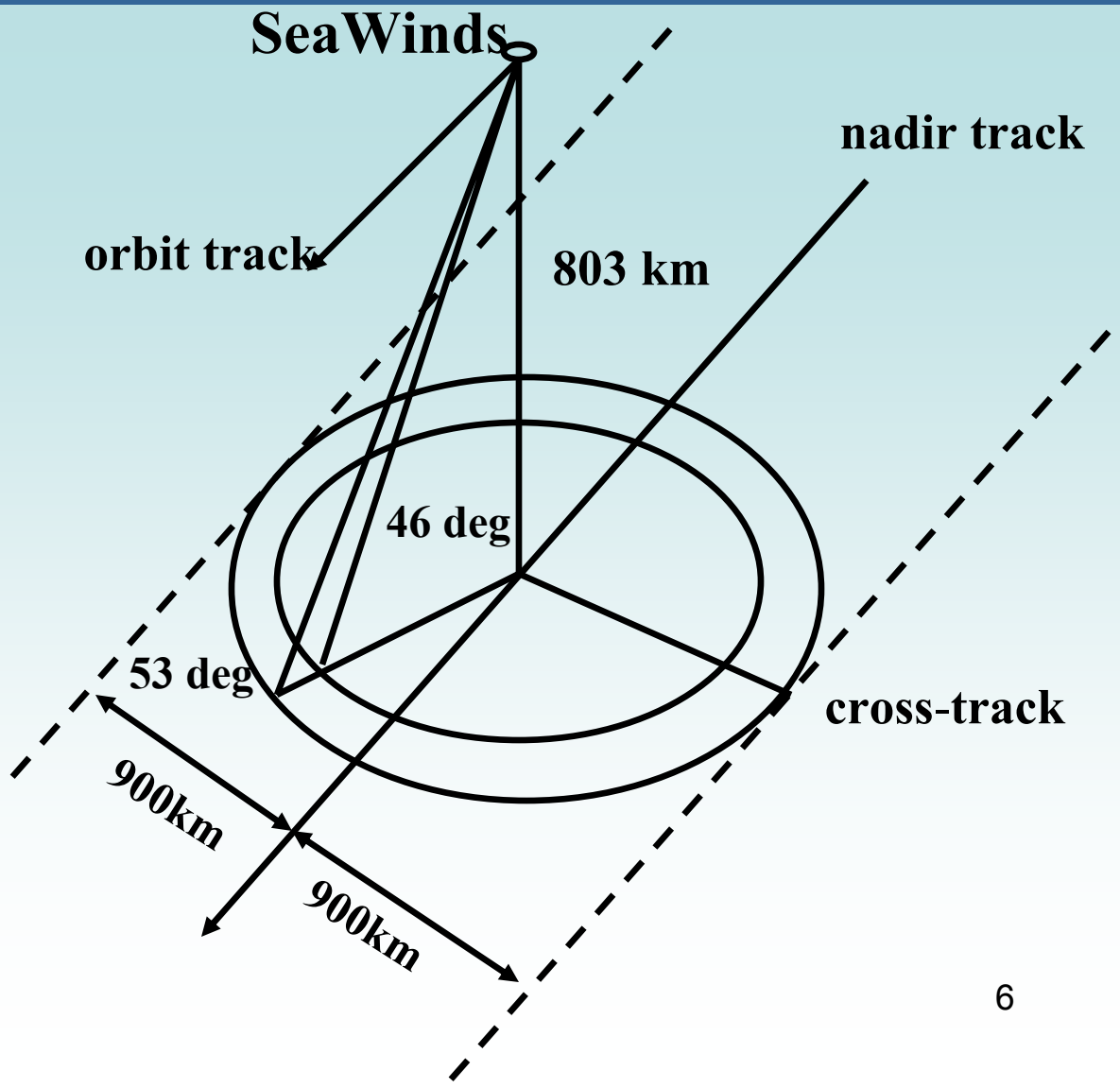
Major Changes

- Refinement of model function (backscatter-wind relationship)
- Retrieval algorithm modification
- Development of new rain impact flag
- Improved edge of swath retrievals
- Reduced land mask for 12.5-km retrieval

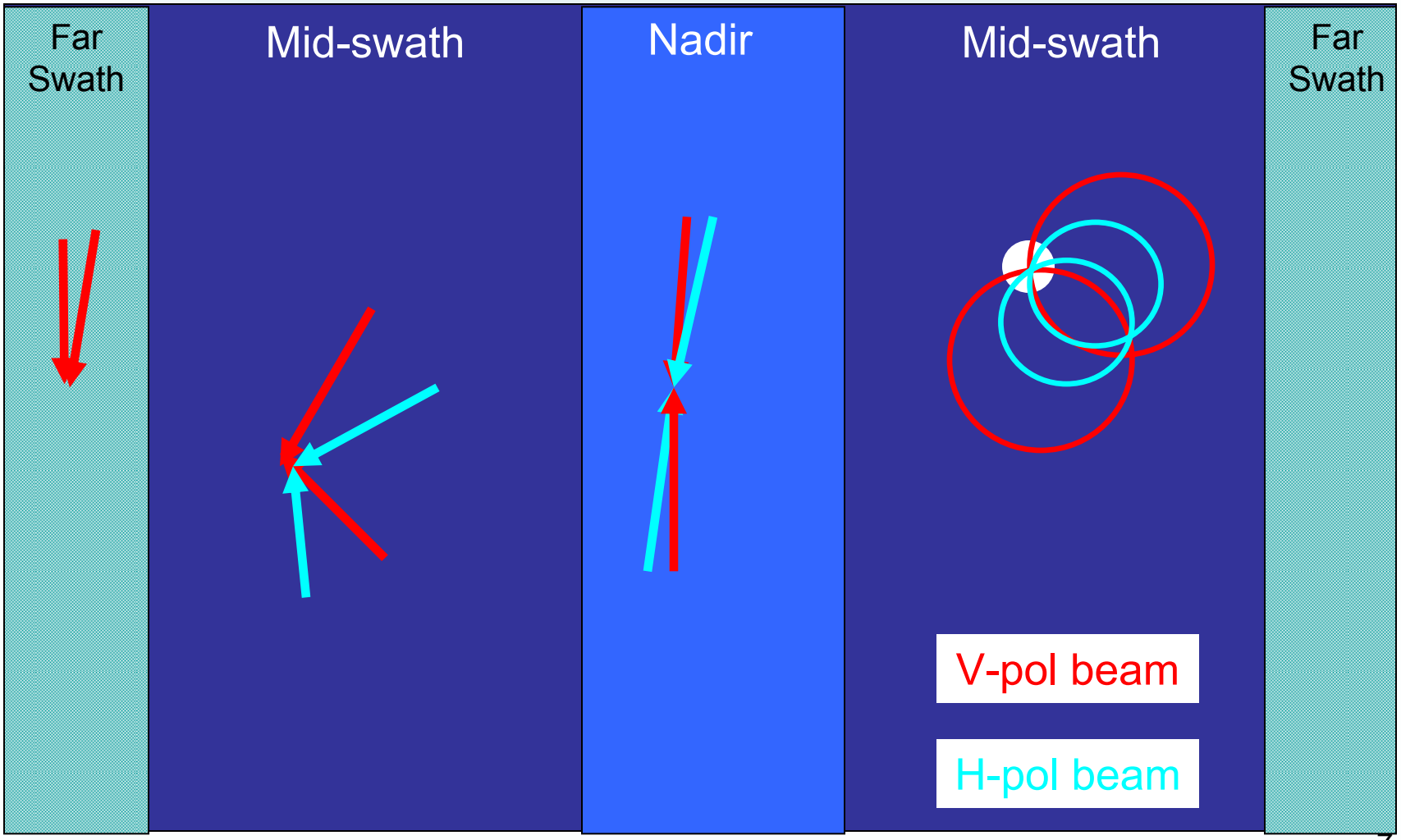

$\sigma_0 = G\frac{P_r}{P_t}$

QuikSCAT Measurement Geometry

- Conically-scanning, dual-pencil beam Ku-band scatterometer
- Acquires global backscatter measurements at 47° (H-pol) and 55° (V-pol) incidence angles
- Measurement swath divided into 76 wind vector cells (WVCs) for 25-km retrievals (152 for 12.5-km)
- Up to four measurements in each WVC are used in retrieval algorithm



Measurement Variability Across Swath

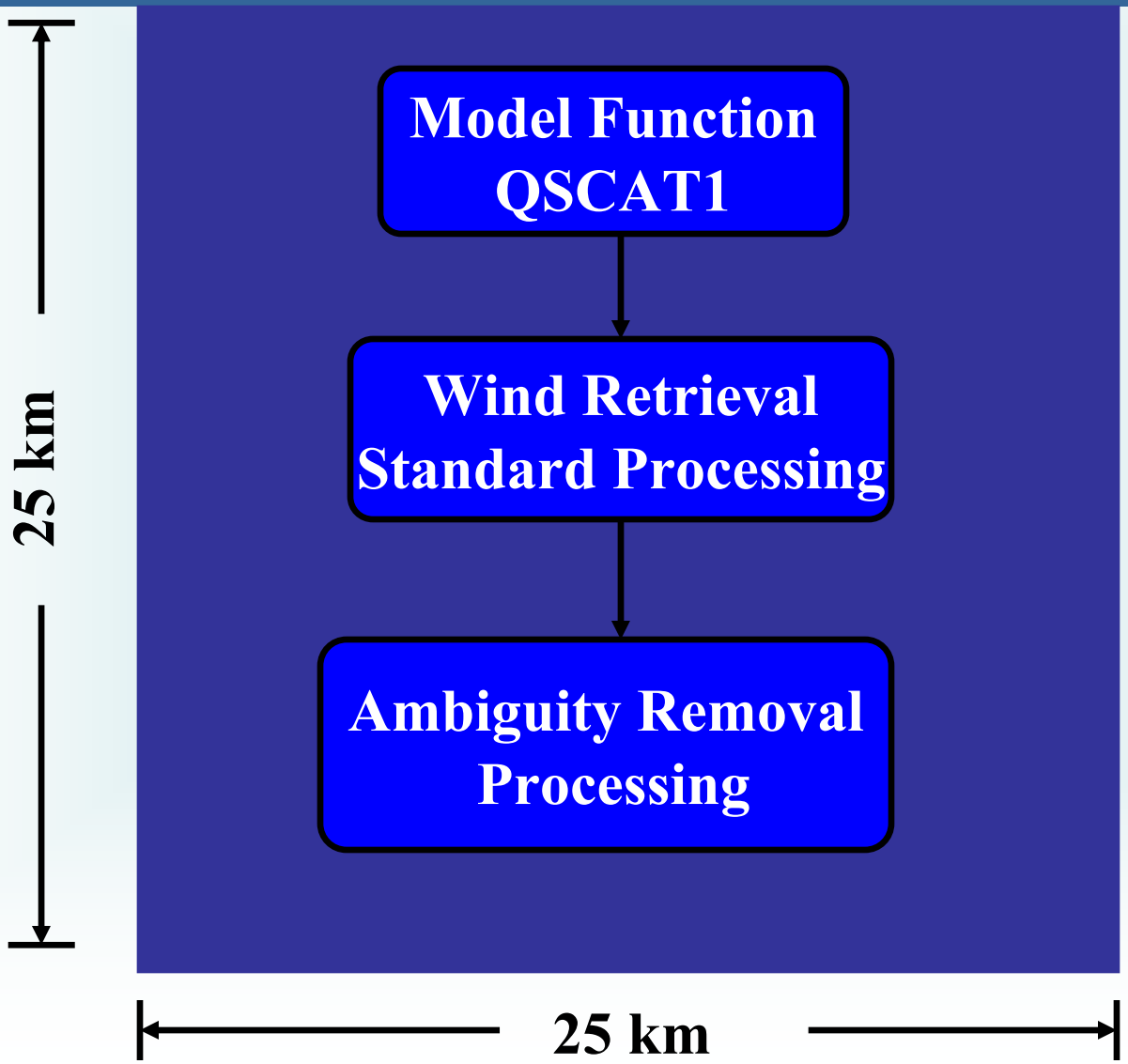


Evaluation of New NRT Retrieval

- Statistical and case evaluations performed on 2003 and current datasets

- New retrievals available for evaluation in real time since June 2006

NRT QuikSCAT Processing Algorithm



Refined Model Function

Geophysical Model Function

A geophysical model function (GMF) relates ocean surface wind field to the backscatter cross section measurements.

$$\sigma_o^{\text{model}} = f(v, \chi, \theta, p)$$

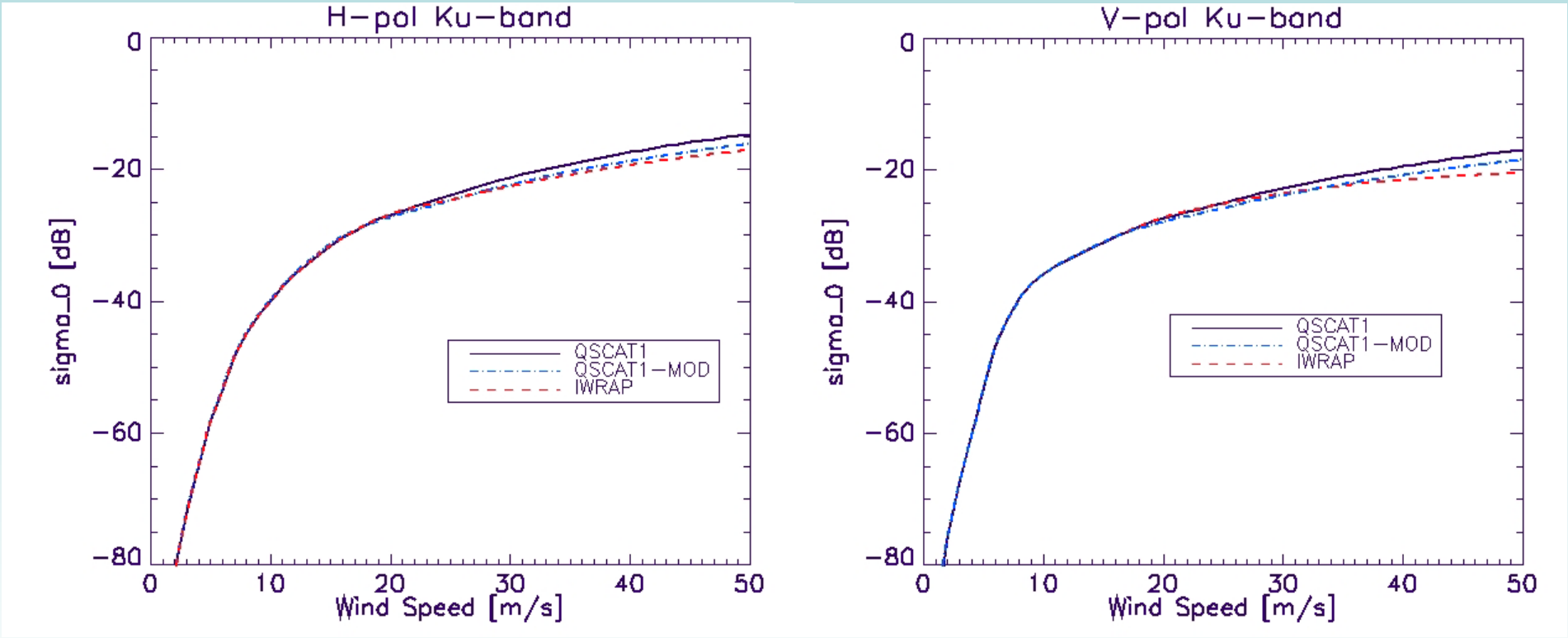
v: wind speed

χ: wind direction

θ: incidence angle

p: polarization

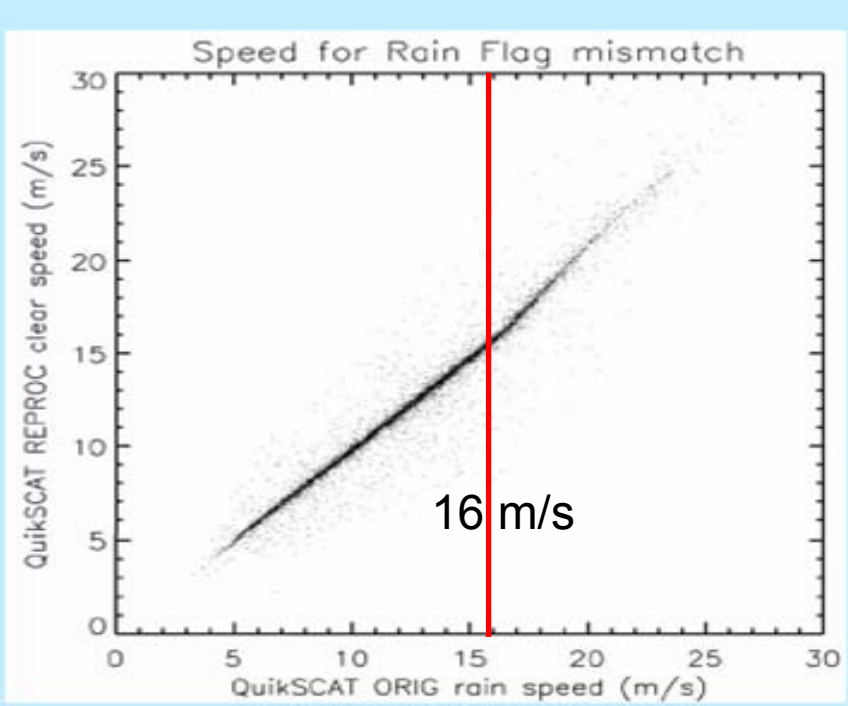
Model Function Readjustment



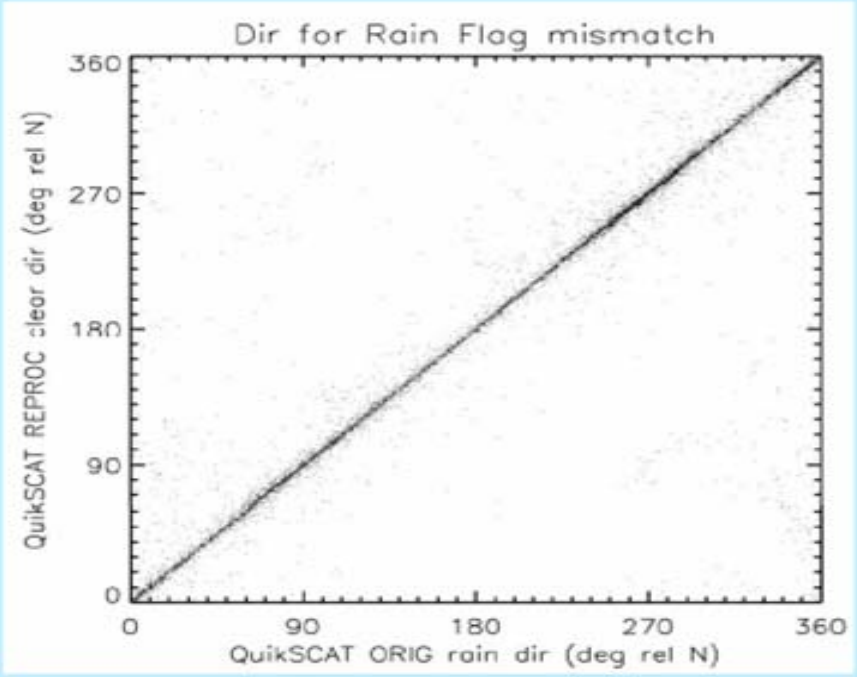
Adjustment of QSCAT model function

QSCAT model function implemented in original NRT processing adjusted by Freilich and Vanhoff for wind speed 16-30m/s using collocated QuikSCAT and RSS SSM/I F13 measurements

Impact on Retrieved Wind Speed and Direction

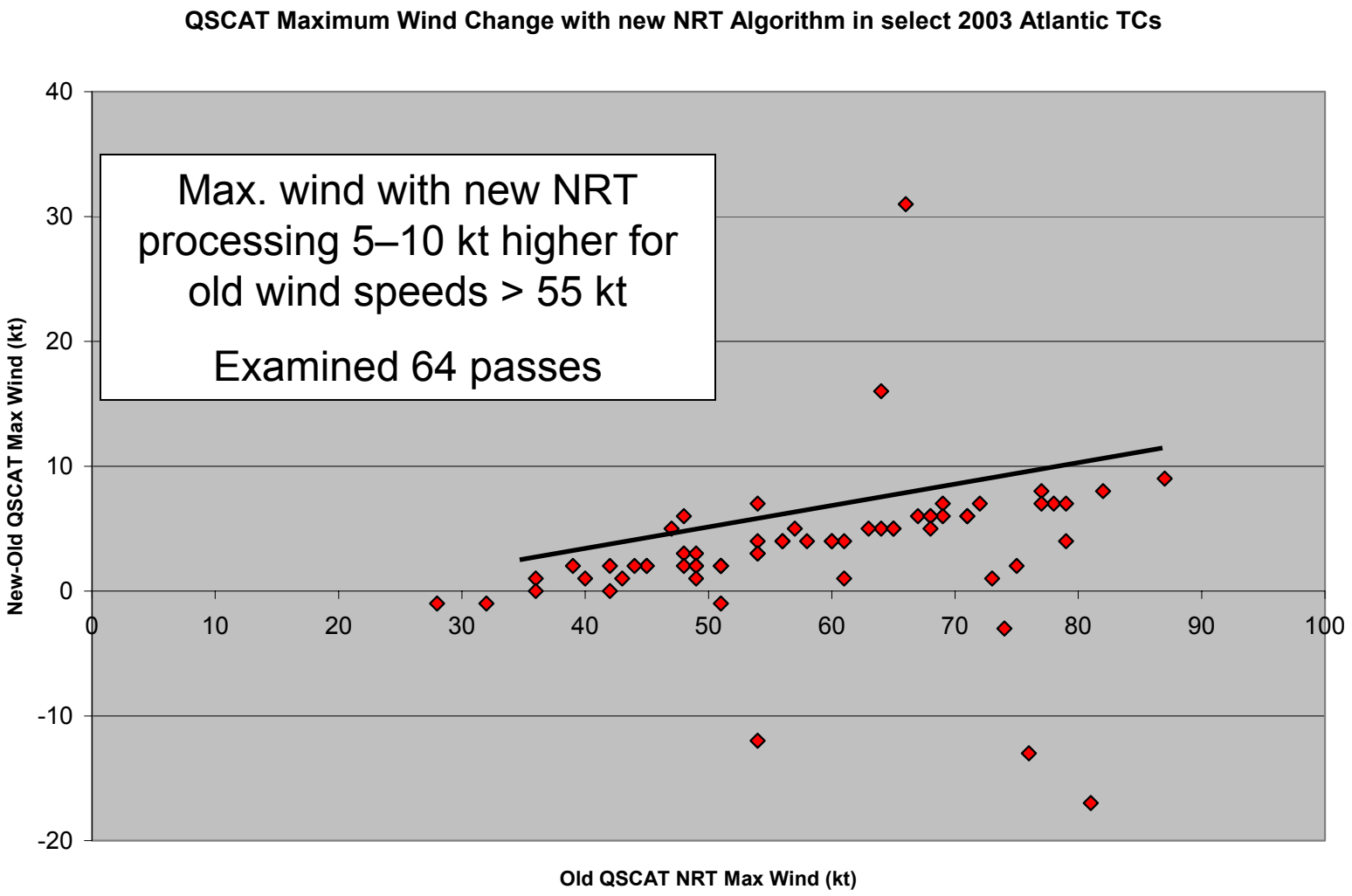


Speed

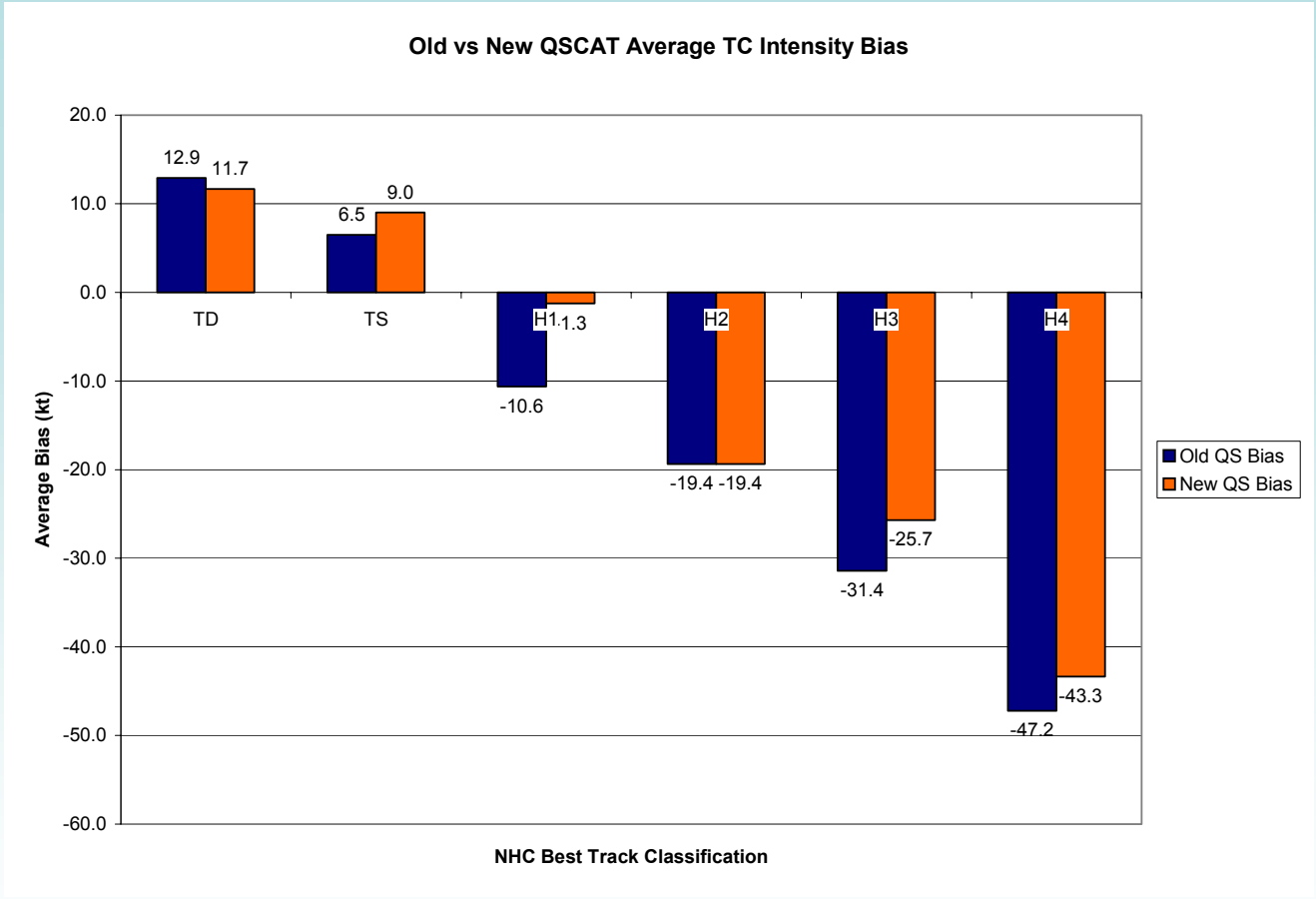


Direction

TC Maximum Wind



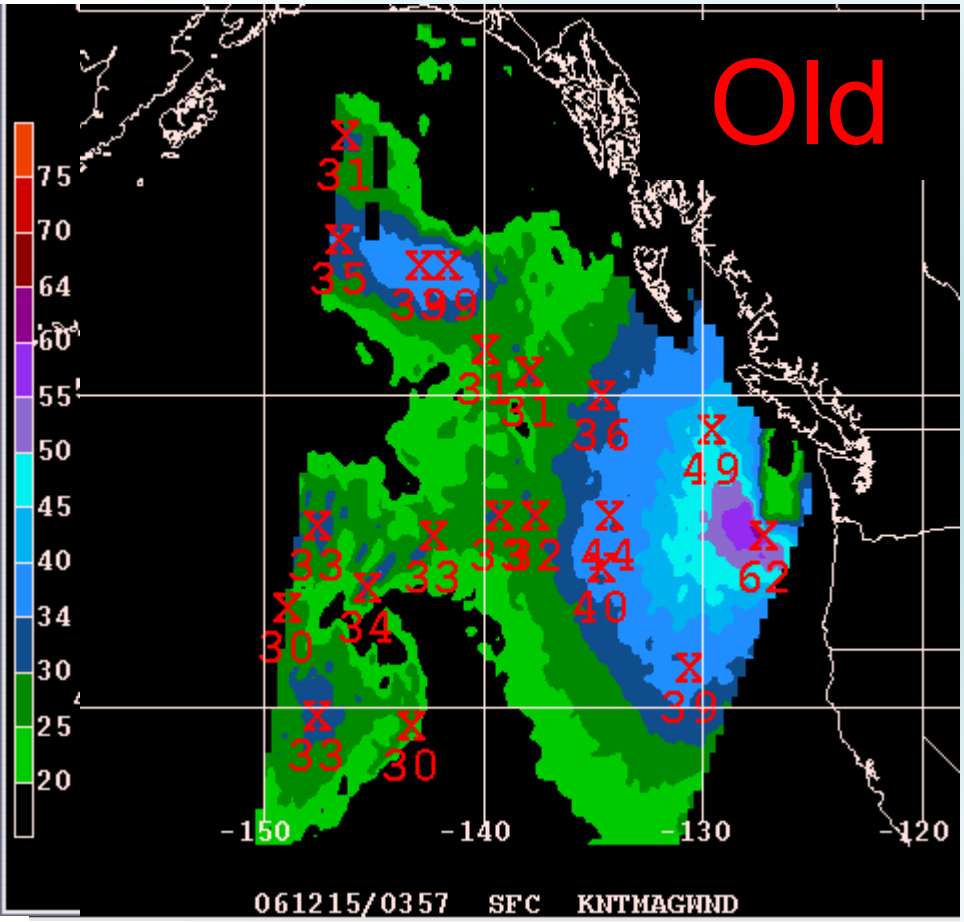
Average bias of 25-km QSCAT maximum wind within 200 nm of best track

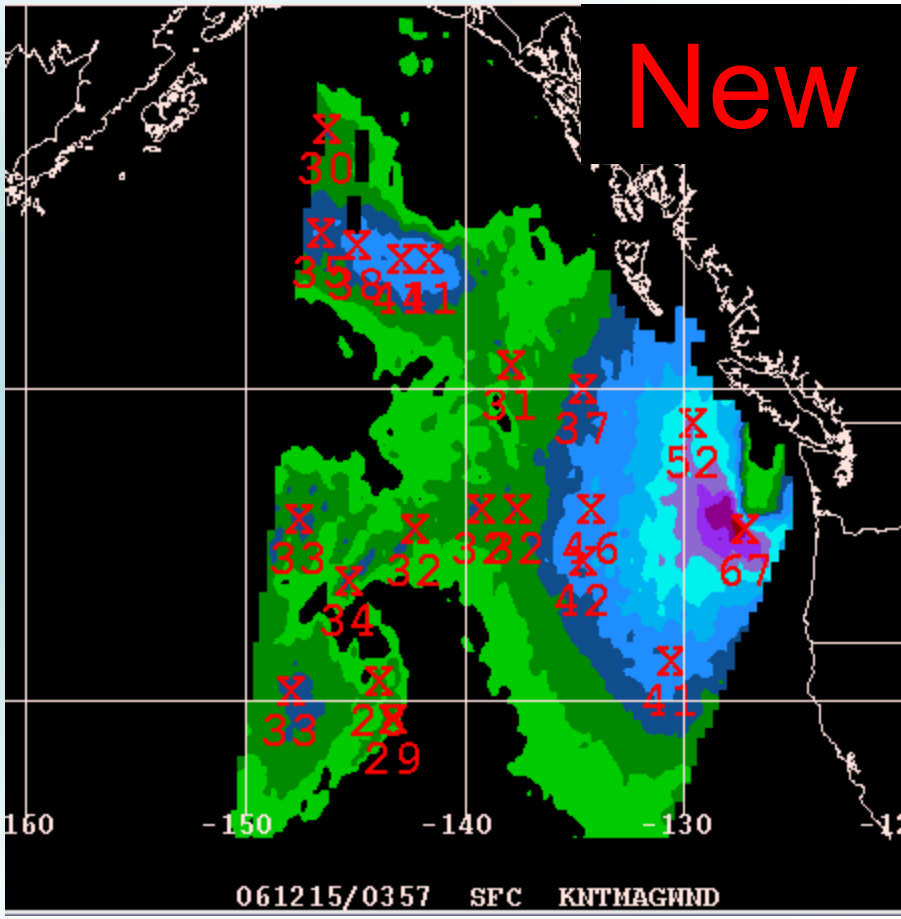


Center for 64 passes over 2003 Atlantic TCs using old and new NRT retrieval algorithm binned by NHC best track classification (tropical depression, tropical storm, Saffir-Simpson hurricane category) at time of pass.

Hurricane Force Extratropical Cyclone - Pacific Northwest

December 15, 2006

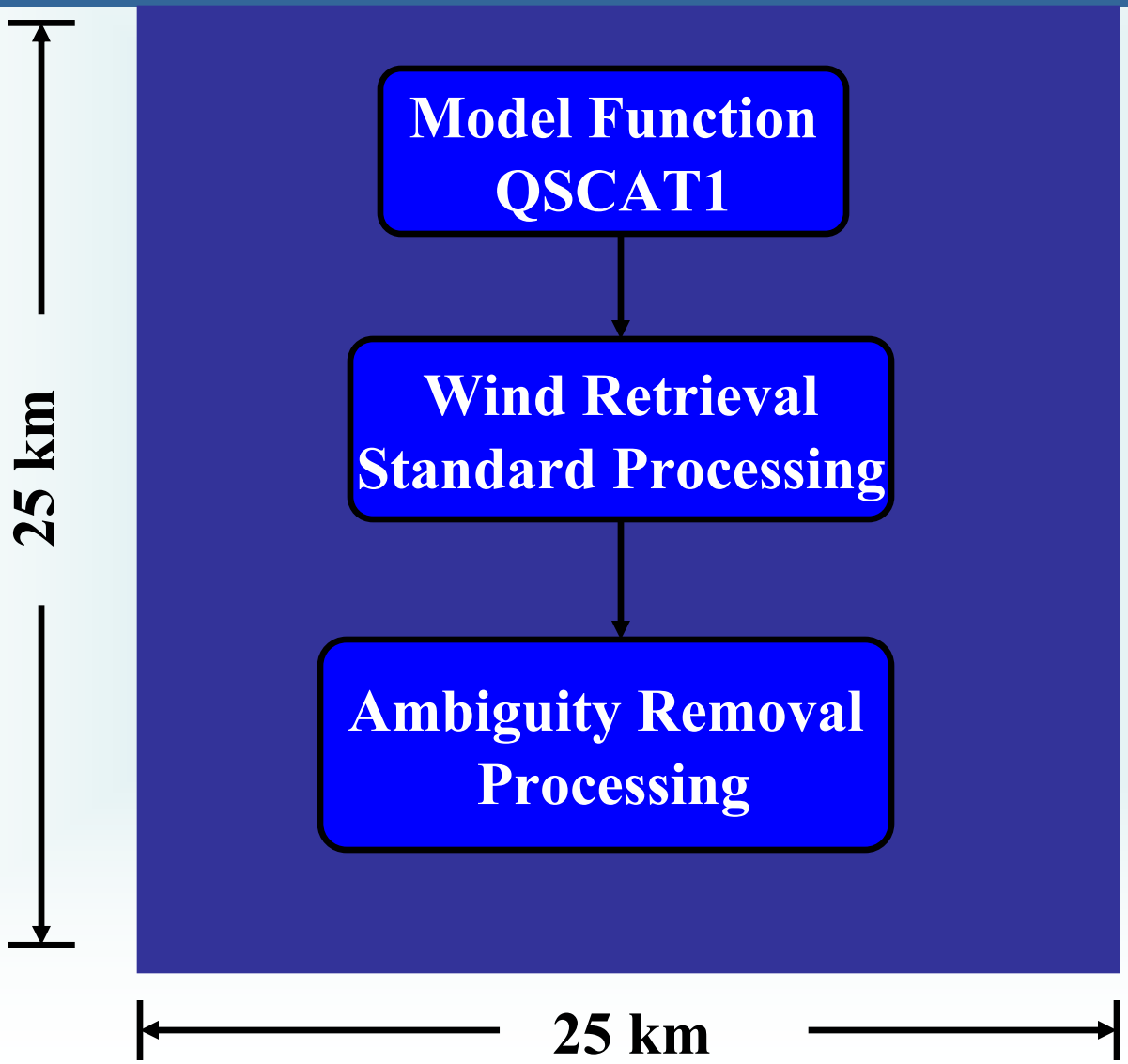




Old Algorithm max wind **62kt**
Storm Force

New Algorithm max wind **67kt**
Hurricane Force

NRT QuikSCAT Processing Algorithm



QuikSCAT Retrieval Algorithm

Wind vectors are retrieved for each WVC using set of collocated backscatter cross section measurements $\sigma_{o,i}^{meas}$

These are compared to the modeled cross section $\sigma_{o,i}^{\mathrm{mod}}$

In an objective function:

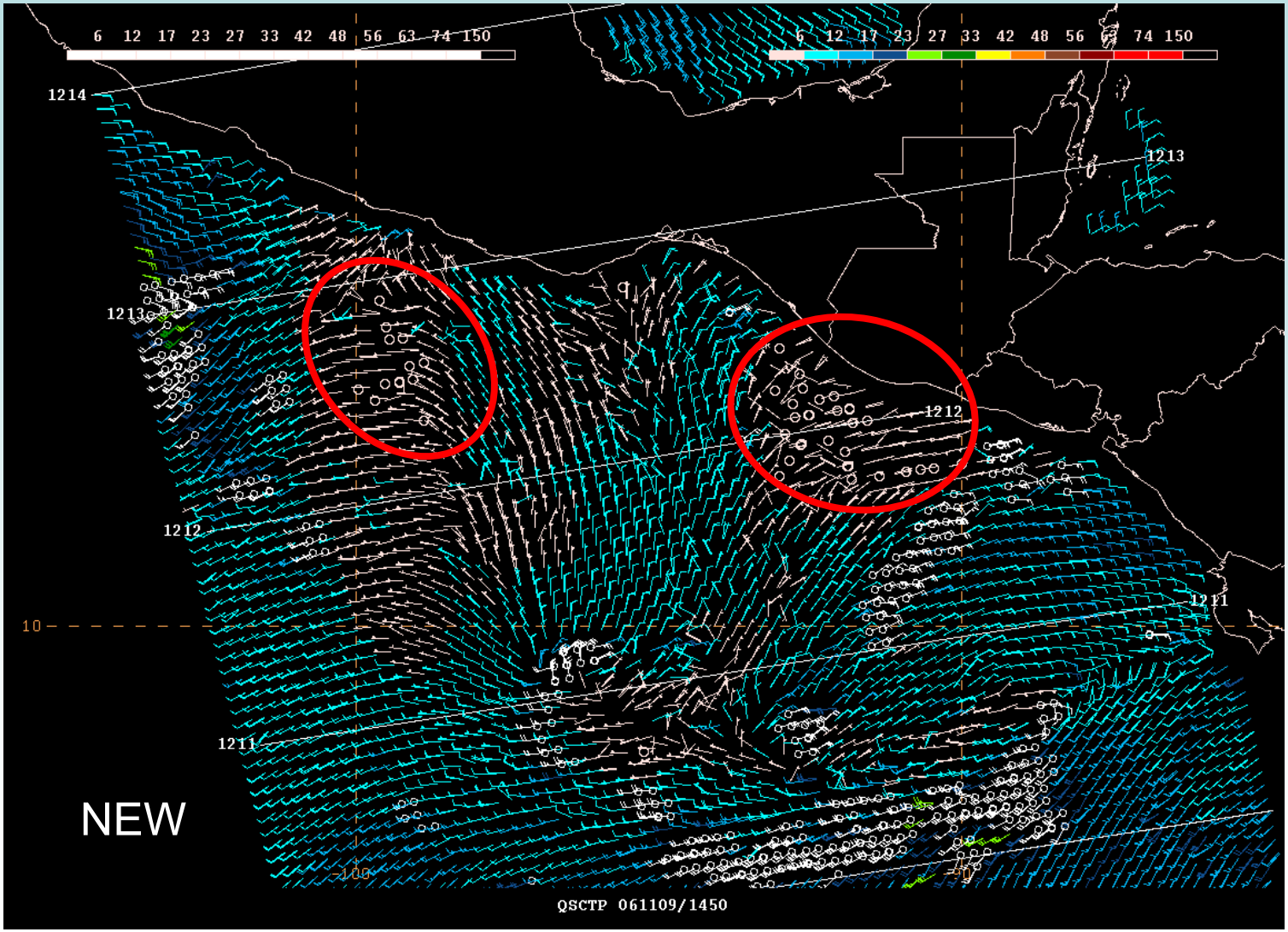
$$J(v,\chi) = -\sum_{i=1}^{N} \left| \frac{\left(\sigma_{o,i}^{meas} - \sigma_{o,i}^{\mathrm{mod}}\right)^2}{Var(\sigma_{o,i}^{meas})} \right|$$

Modified objective function

$$J(v,\chi) = -\sum_{i=1}^{N} \left| \frac{\left(\sigma_{o,i}^{meas} - \sigma_{o,i}^{\mathrm{mod}}\right)^2}{Var(\sigma_{o,i}^{meas})} \right| + \ln(Var(\sigma_{o,i}^{meas}))$$

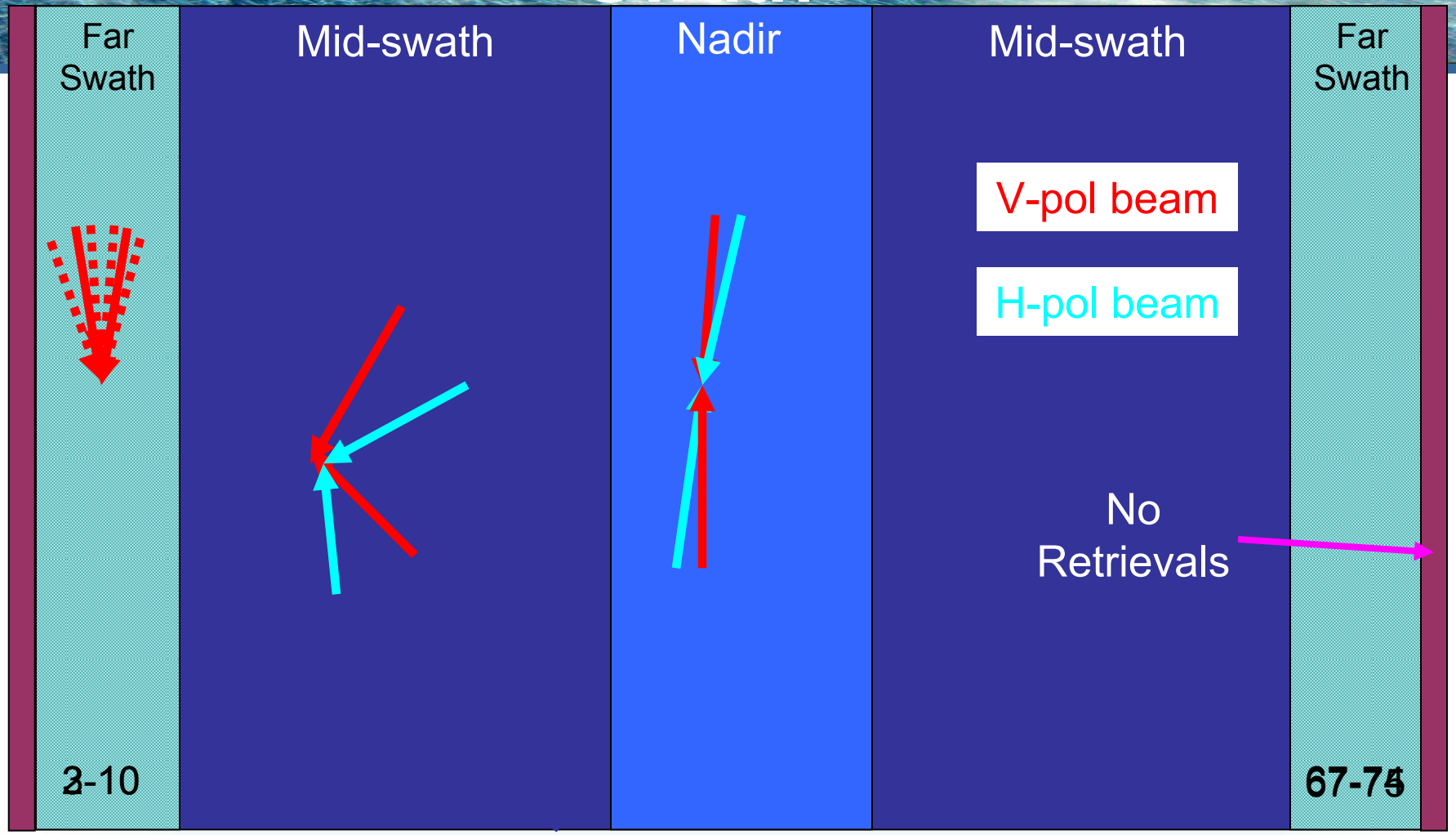
Addition of term related to log of variance of measured backscatter → increased calm wind retrievals

Increased Calm Winds



Swath Edge Retrieval Changes

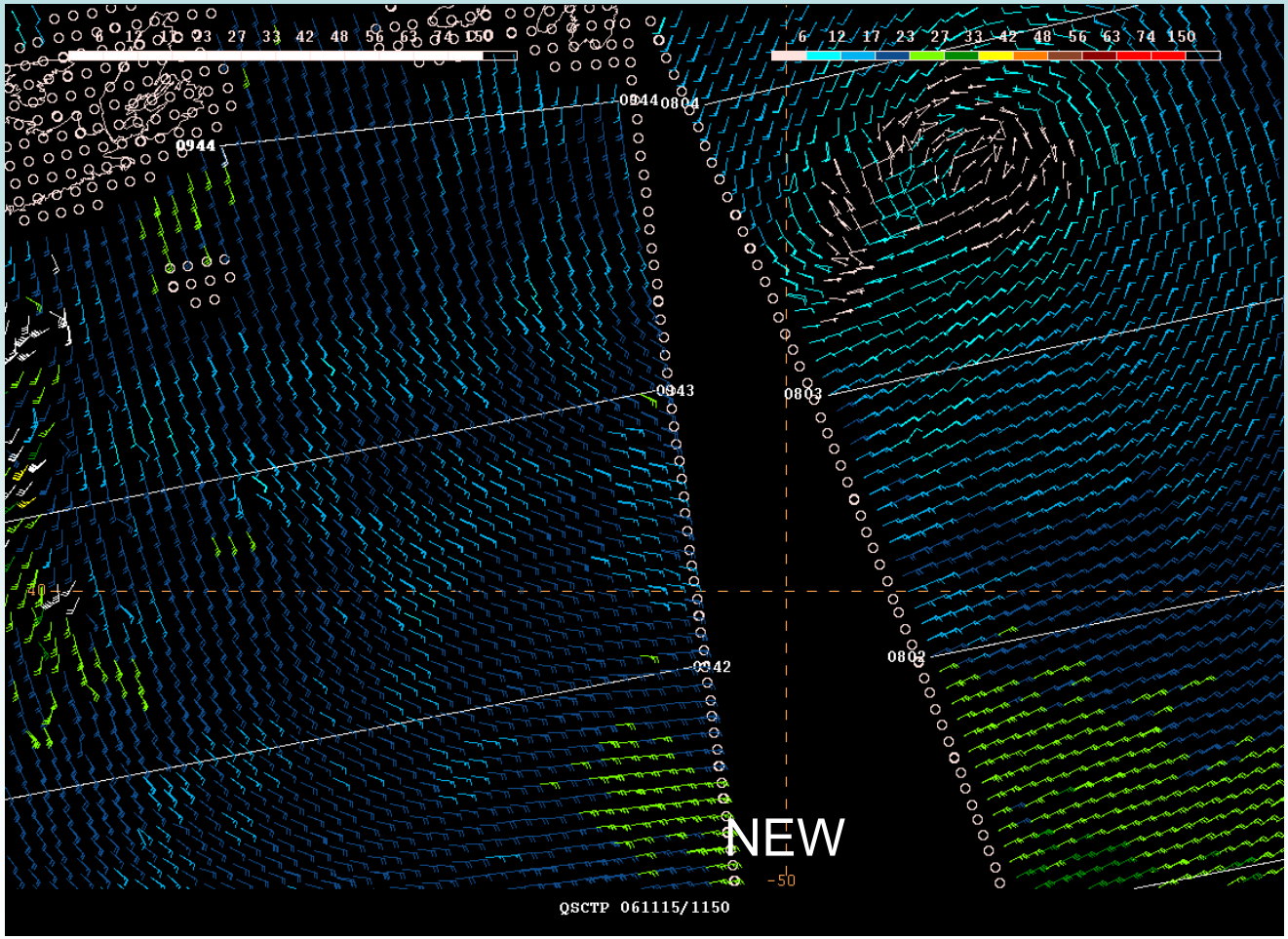
Measurement Variability Across Swath



Far swath V-pol measurements divided into 2 azimuthal ranges – creating 4 looks instead of 2 for retrieval

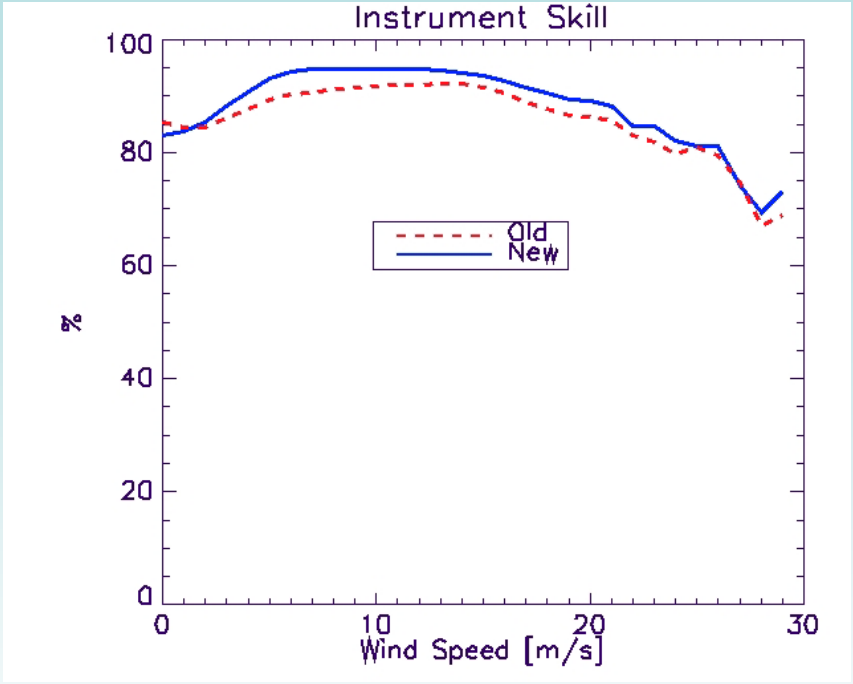
Swath Edge Changes

- White circles represent “null” retrievals
- Wind retrievals along additional row on swath edge with new algorithm

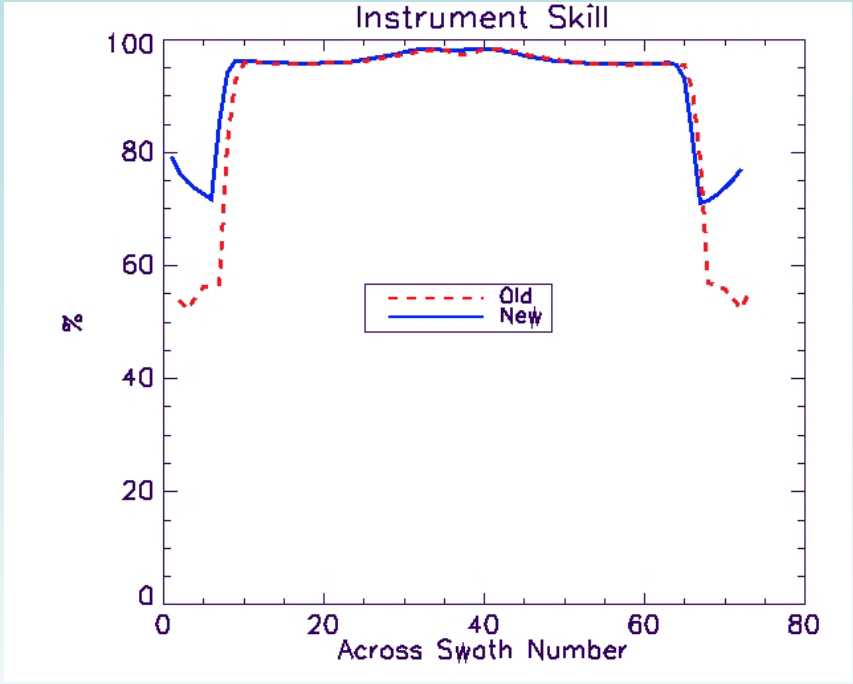


Instrument Skill

Instrument Skill %



Wind Speed m/s

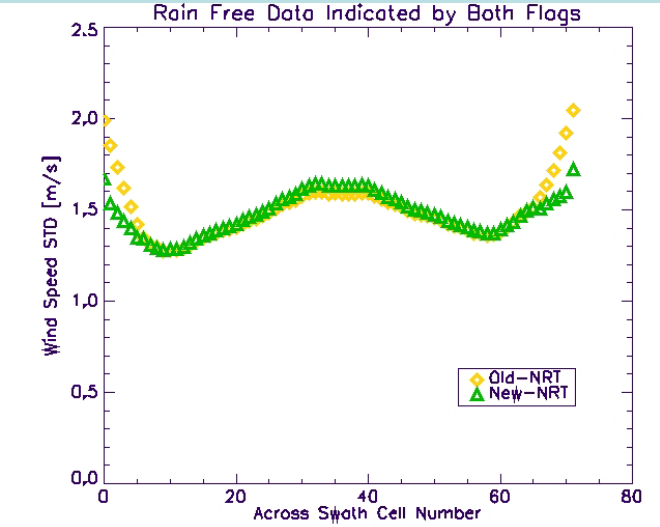


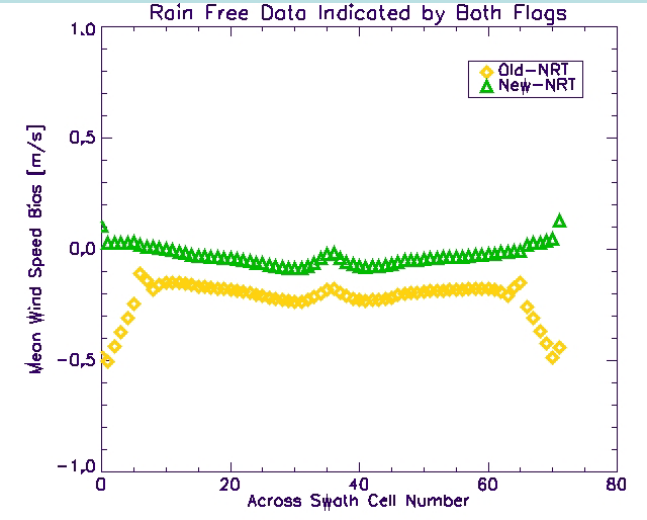
Across Swath Number

Instrument Skill - represents percentage of the first two ranked solutions that were also correct solutions (based on GDAS wind direction)

Across Swath Statistics

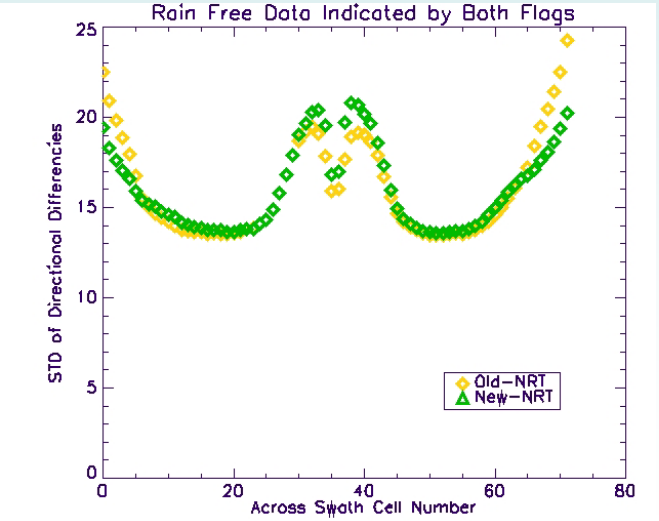
Std. Deviation of Wind Speed

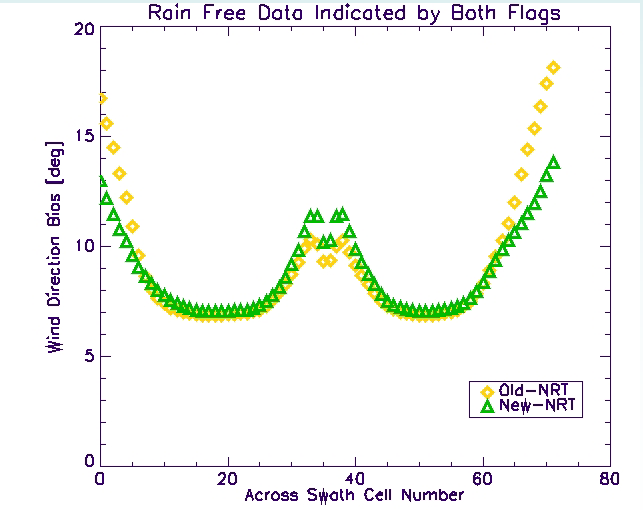




Wind Speed Bias

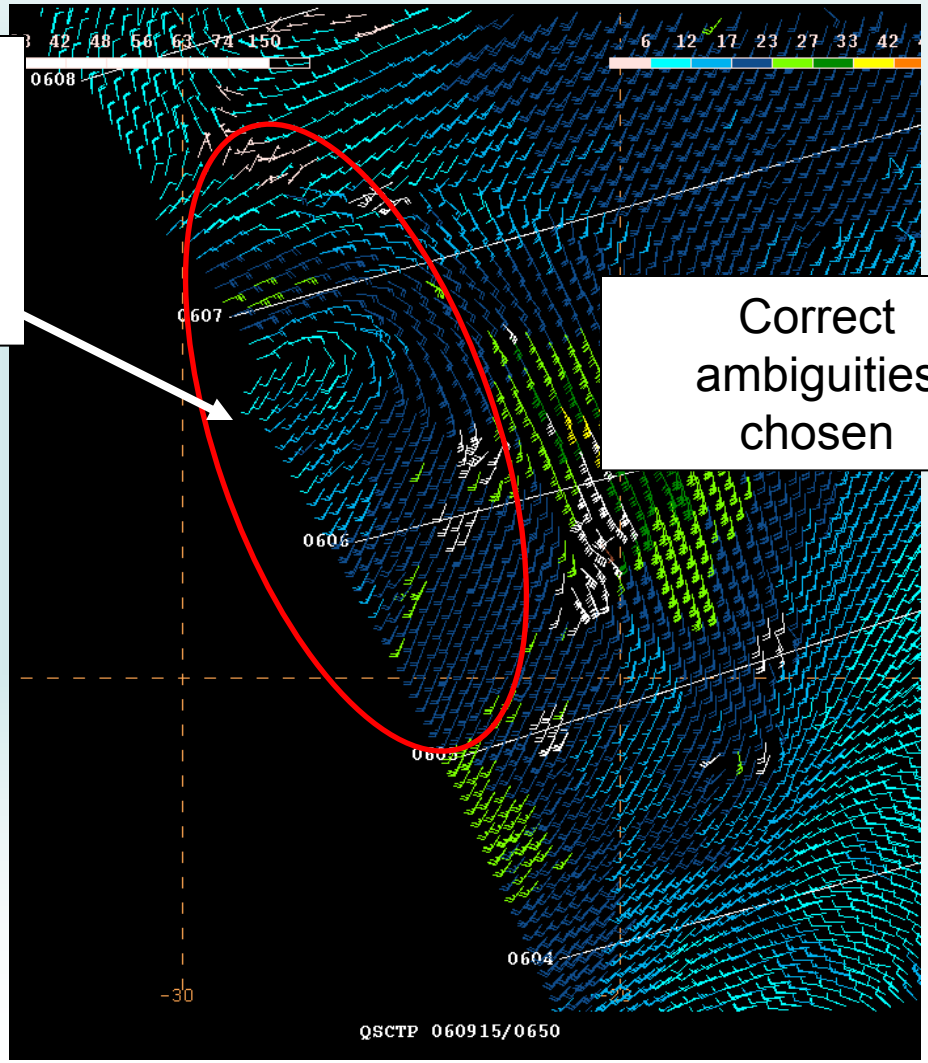
Std. Dev. of Wind Direction





Wind Direction Bias

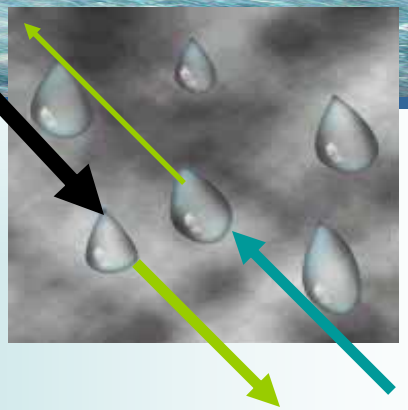
Improved wind direction and circulation better resolved in new retrieval



Correct ambiguities chosen

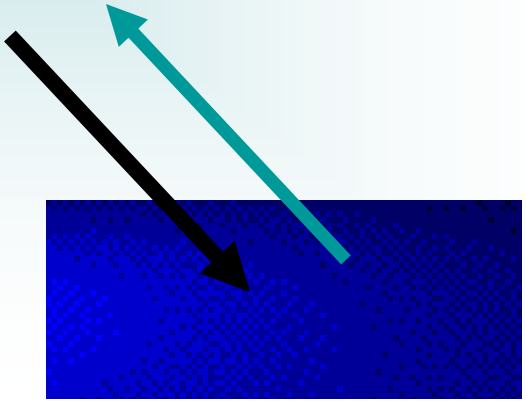
New Rain Impact Flag

Rain Effects



- The radar signal is attenuated by the rain as it travels to and from the Earth's surface → σ_0 ↓

- The radar signal is scattered by the raindrops. Some of this scattered energy returns to the instrument → σ_0 ↑



- The roughness of the sea surface is increased because of the splashing due to raindrops → σ_0 ↑

Rain Detection
Original MUDH Flag

Original MUDH rain flag “rainy” means > 2km mm/hr SSM/I rain rate

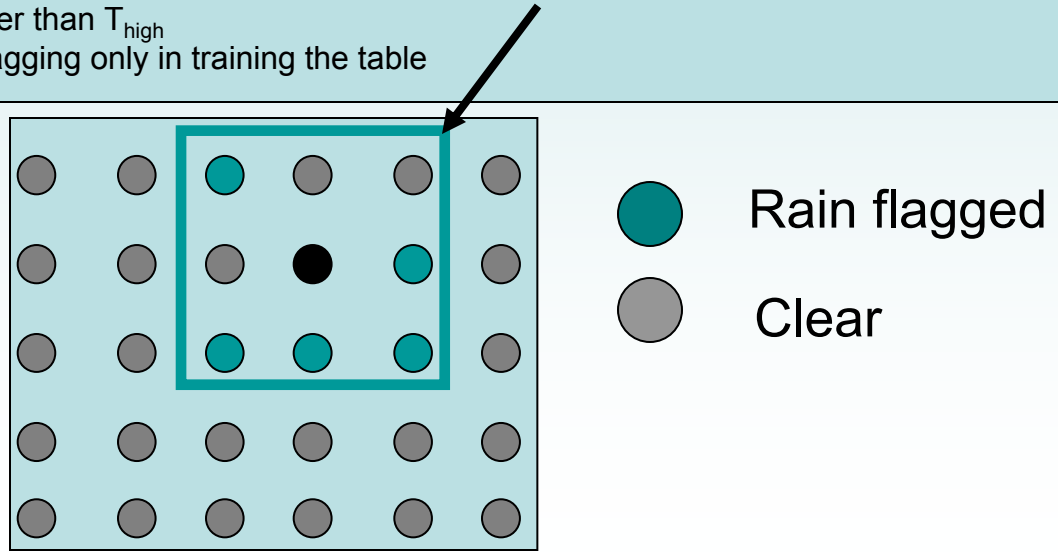
MUDH Flag derived from 5 rain-sensitive parameters

1. Difference in return from V and H pol beams
2. Wind speed of 1st ranked ambiguity
3. Wind direction of 1st ranked ambiguity relative to satellite track
4. Variance of backscatter measurements (tight wind speed gradient)
5. Brightness temperature

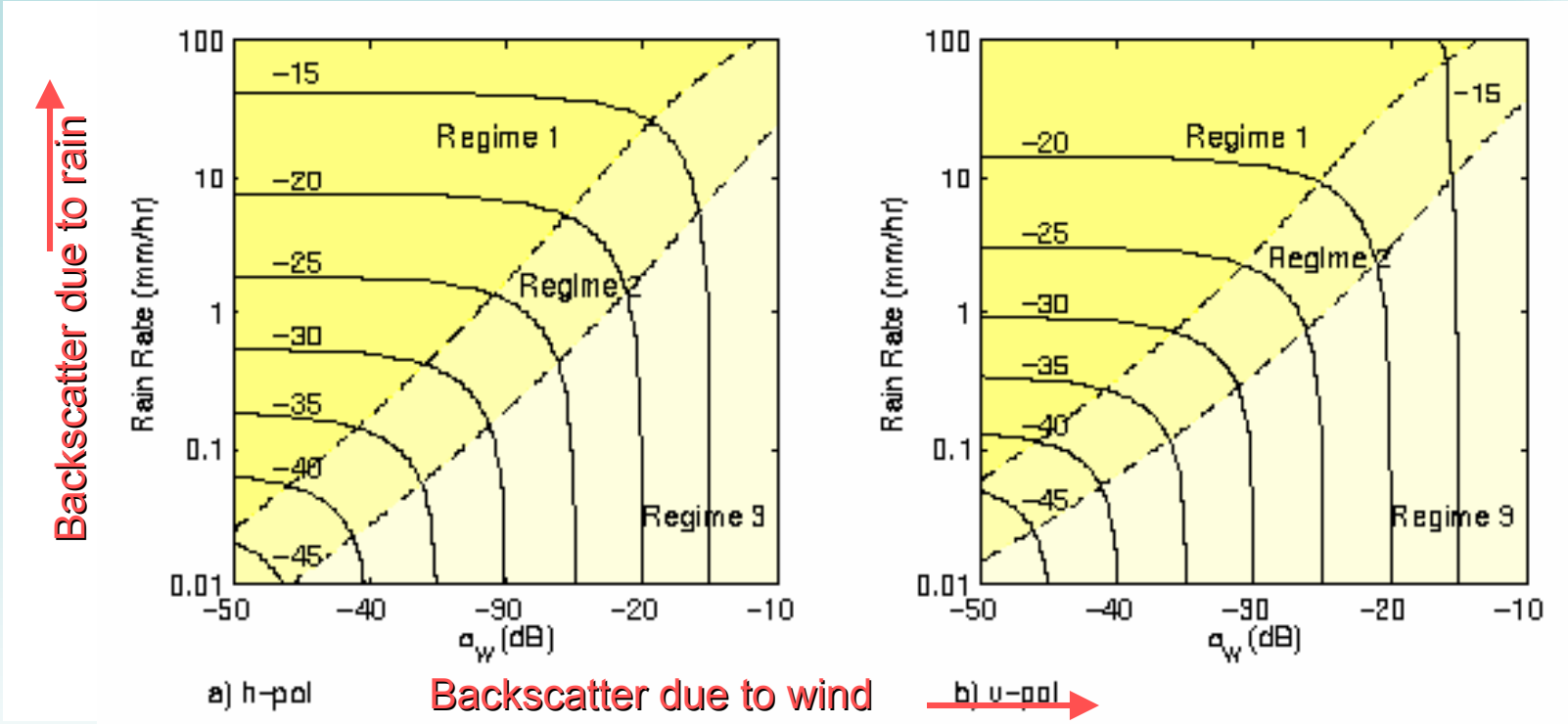
Table used in flagging for each WVC by:

1) read probability from table
2) initially flag if greater than threshold T_{low}
3) remove flag if fewer than K initially flagged neighbors in an NxN window
4) flag if probability greater than T_{high}

SSM/I rain rate is not used in flagging only in training the table



Wind Rain Regimes



- Regime 1: rain dominates wind backscatter – poor quality wind estimates (10% of rain cases*)
- Regime 2: both wind and rain important – can retrieve wind *and* rain rate (34% of rain cases*)
- Regime 3: rain effects insignificant – wind estimates unaffected by rain (56% of rain cases*)
- * Globally, only about 4% of all QuikSCAT data adversely effected by rain

D.W. Draper and D.G. Long, Evaluating the Effect of Rain on SeaWinds Scatterometer Measurements, Journal of Geophysical Research, Vol. 109, No. C02005, doi:10.1029/2002JC001741, 2004.

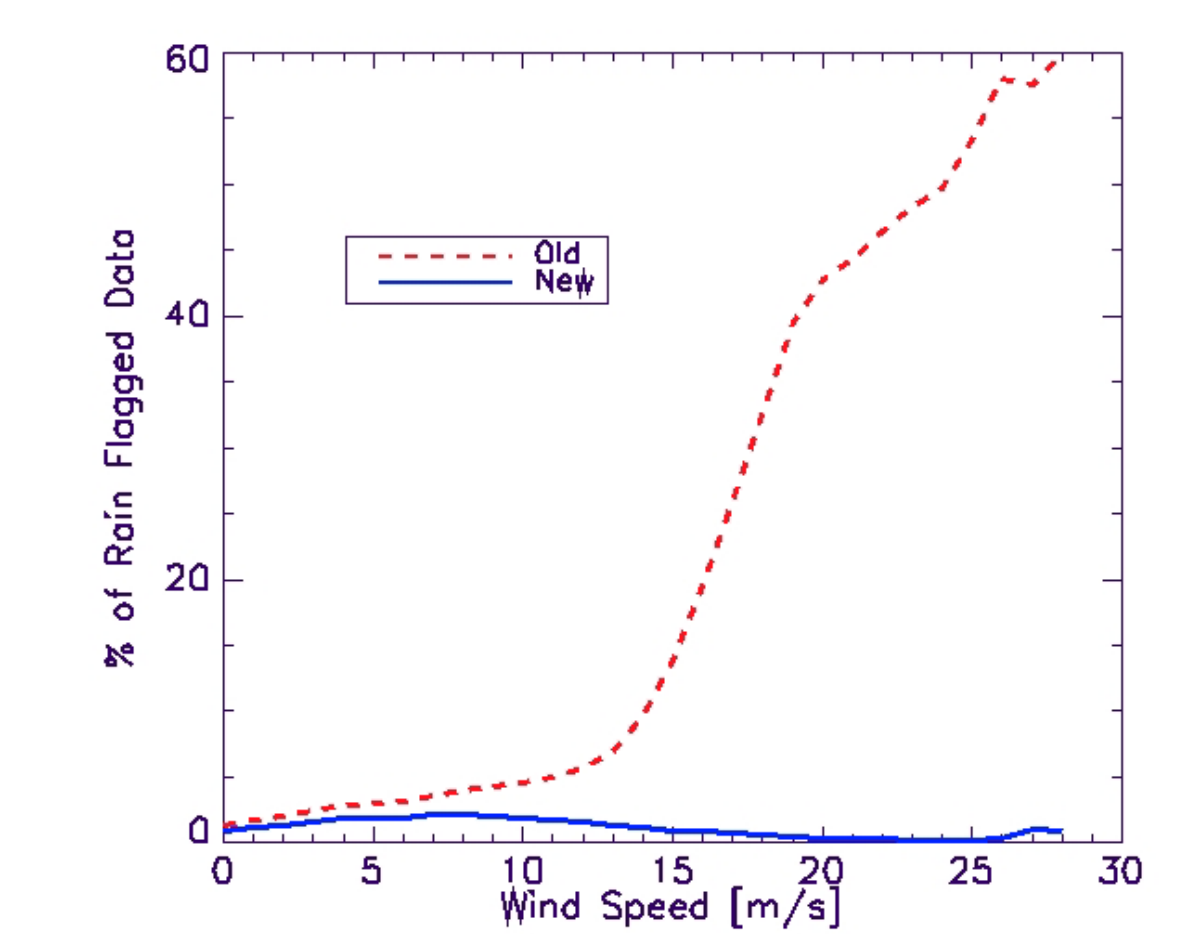
Impact Based MUDH

- “Rainy” defined by how much a cell is contaminated by rain rather than particular rain rate
- Low winds require less rain to be contaminated
- Impact defined to be > 2 m/s speed bias and >15° cross track directional bias due to rain
- Impact measure determined using AMSR rain rate data onboard ADEOS-II
- AMSR rain rate information used to train the table
- Table generated from SeaWinds/AMSR data also used to flag QuikSCAT data.

Rain Flag vs Wind Speed

Old flag removed 4.2% of data

New Impact flags removes 1.8% of data



Wind Speed Error

		All Data Points Across the Swath		Sweet Swath		Nadir		Far Swath	
		Mean	STD	Mean	STD	Mean	STD	Mean	STD
Rain free data indicated by both flags	Old	-0.09	1.18	-0.05	1.05	-0.04	1.09	-0.22	1.51
	New	0.1	1.14	0.096	1.05	0.11	1.04	0.1	1.37
Both Flag Indicate rain	Old	-5.20	3.74	-5.04	3.65	-5.73	3.88	-3.98	3.19
	New	-4.99	3.89	-4.85	3.77	-5.61	4.06	-3.19	3.04
Old Rain Flag On, New Rain Flag Off	Old	-1.60	2.41	-1.52	2.04	-1.6	2.25	1.66	2.36
	New	-1.48	2.44	-1.6	2.42	-1.71	2.72	-1.17	2.19
Old Rain Flag Off, New Rain Flag On	Old	-1.77	2.28	-1.82	2.26	-1.77	2.28	-1.51	2.33
	New	-1.54	2.26	-1.58	2.24	-1.56	2.27	-1.25	2.28

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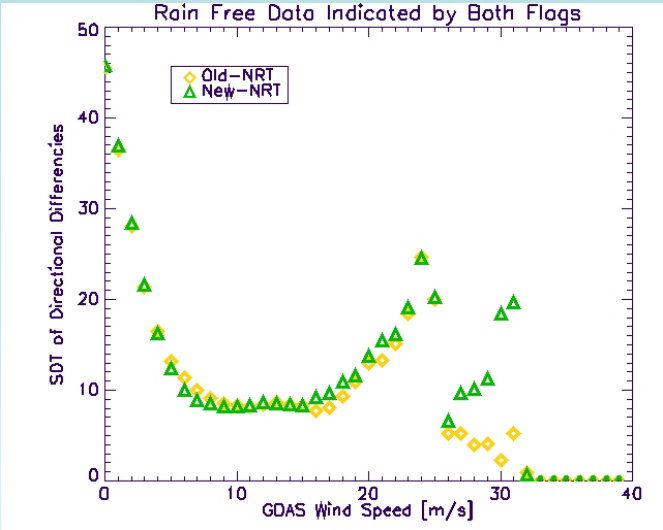
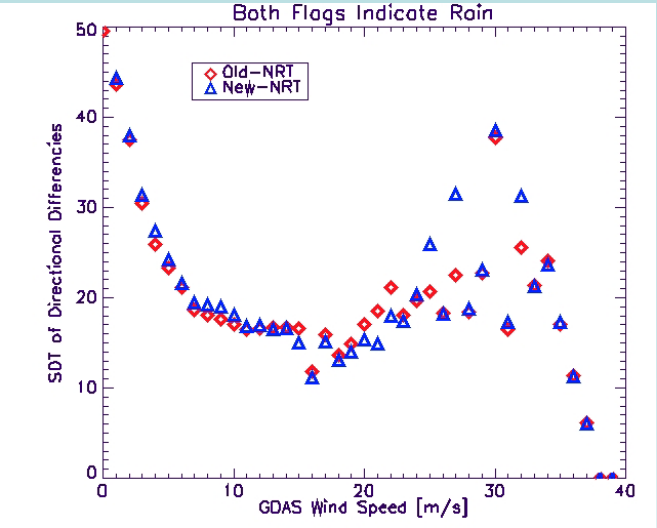
Wind Direction Error

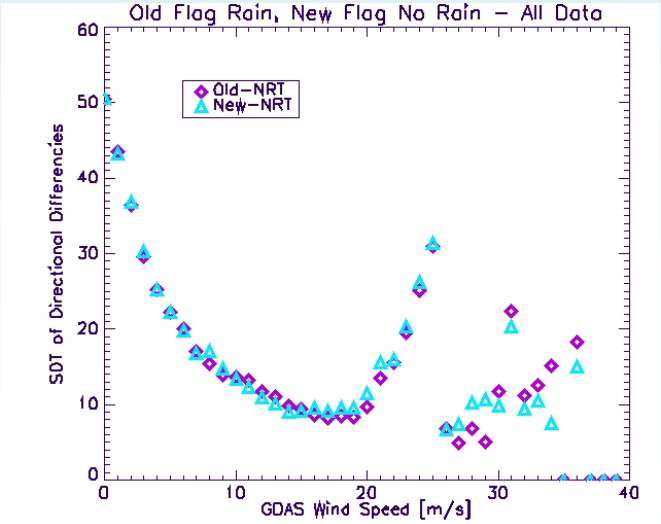
Both flags clear

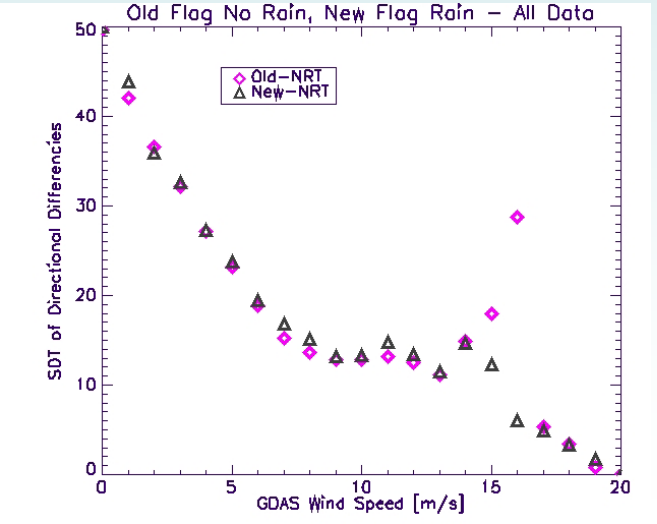




Both flags rain

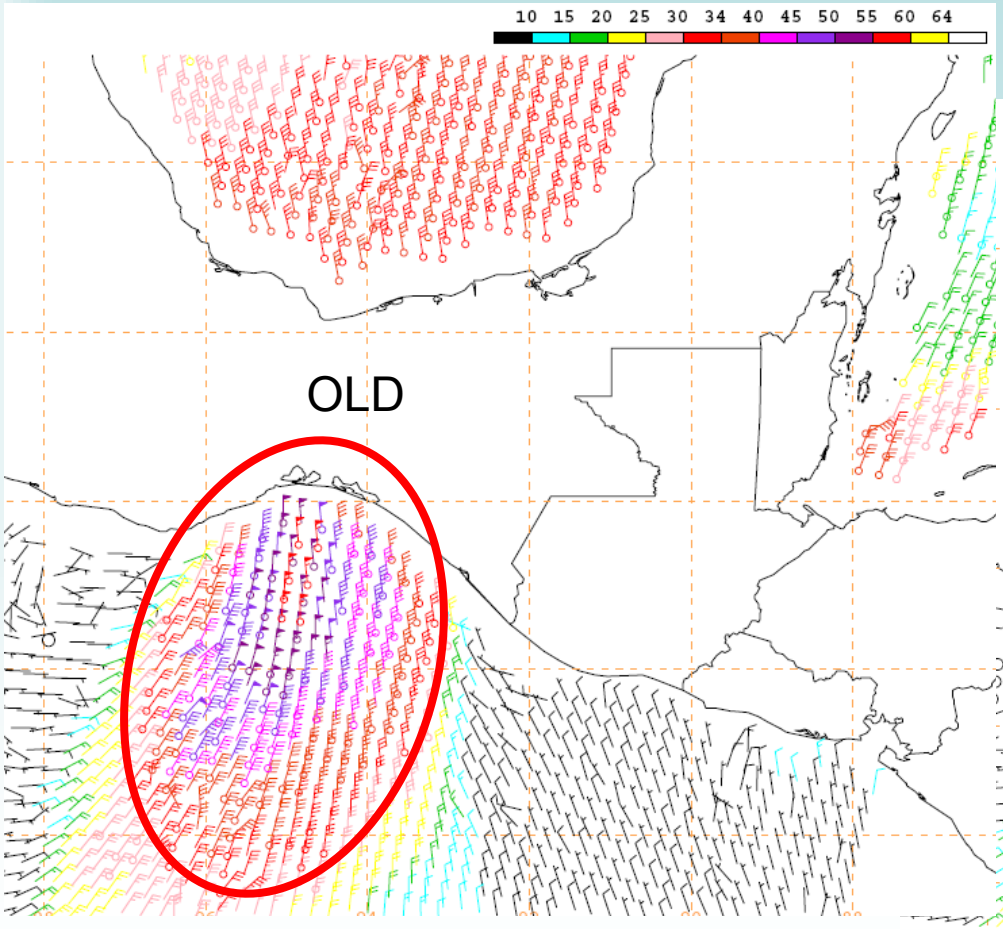
Old flag rain – New flag clear

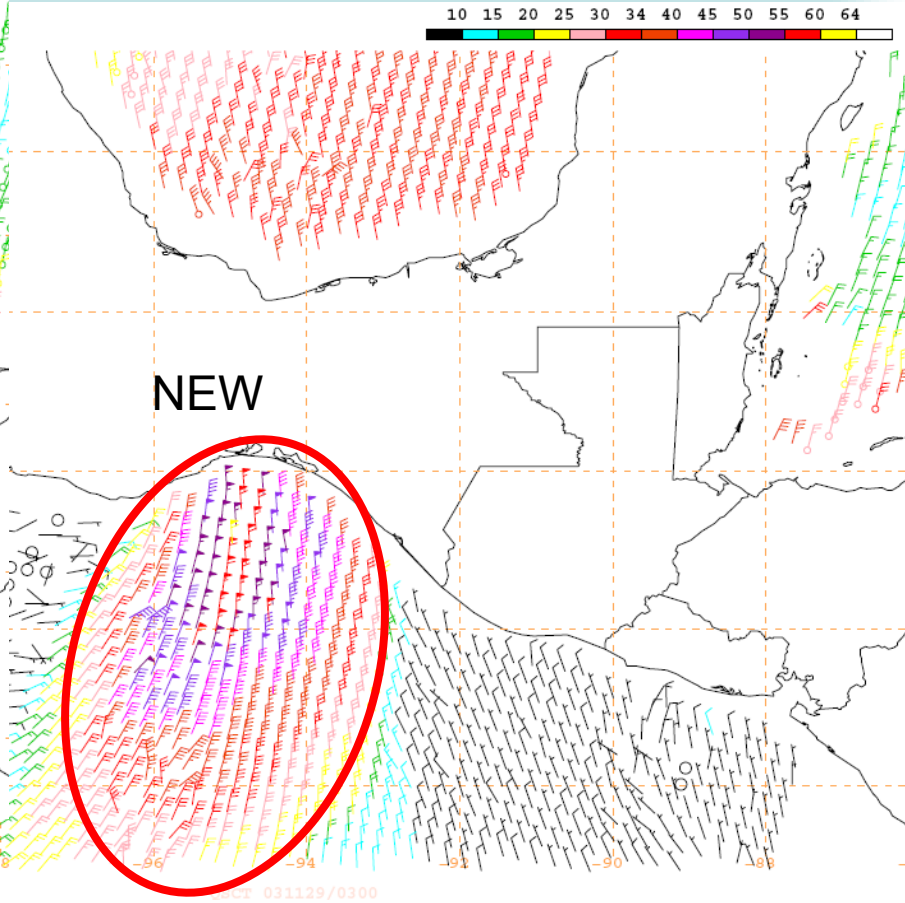


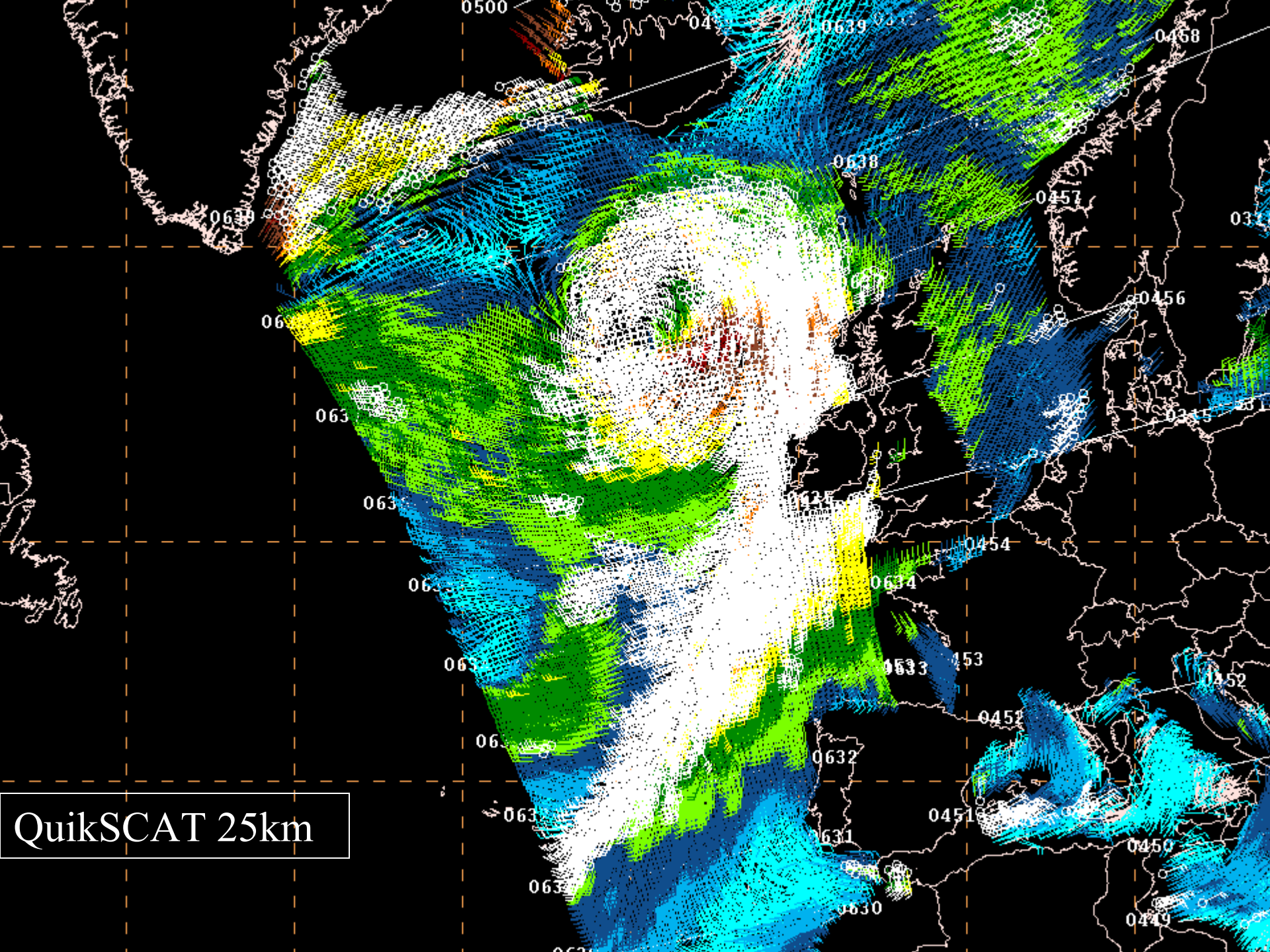


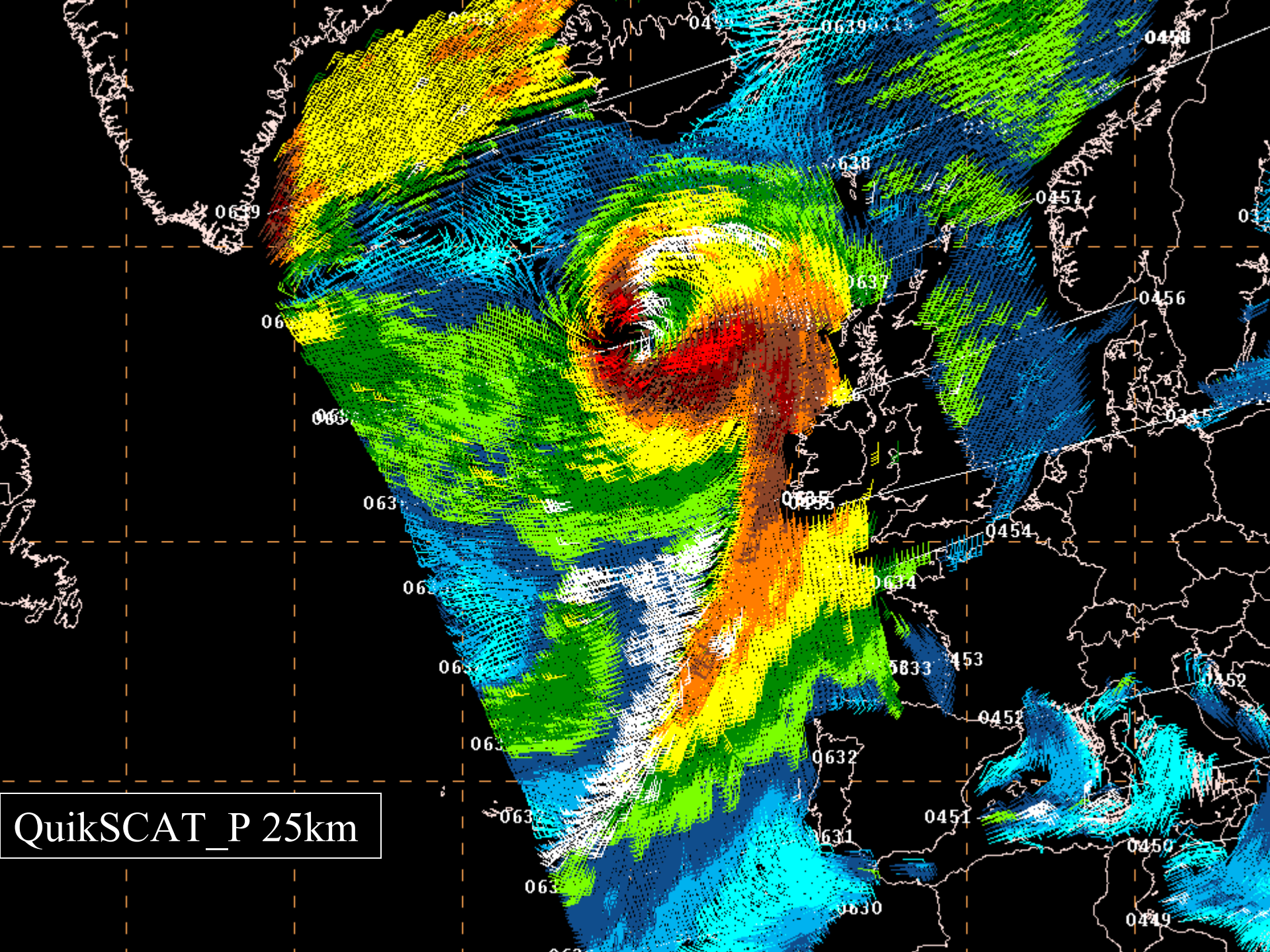
Old flag clear – New flag rain

New Rain Impact Flag Examples
Gulf of Tehuantepec





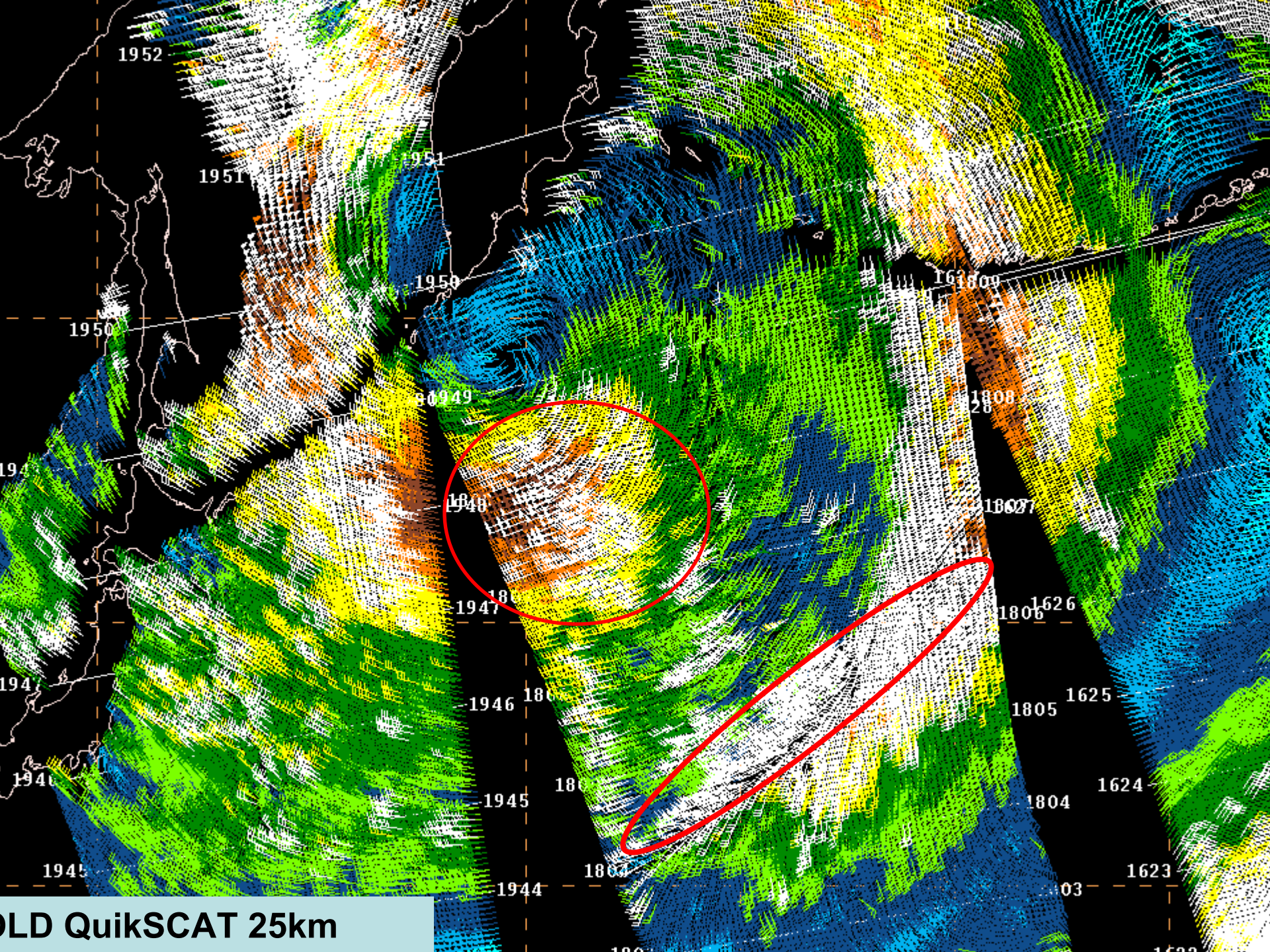

QuikSCAT 25km


QuikSCAT_P 25km

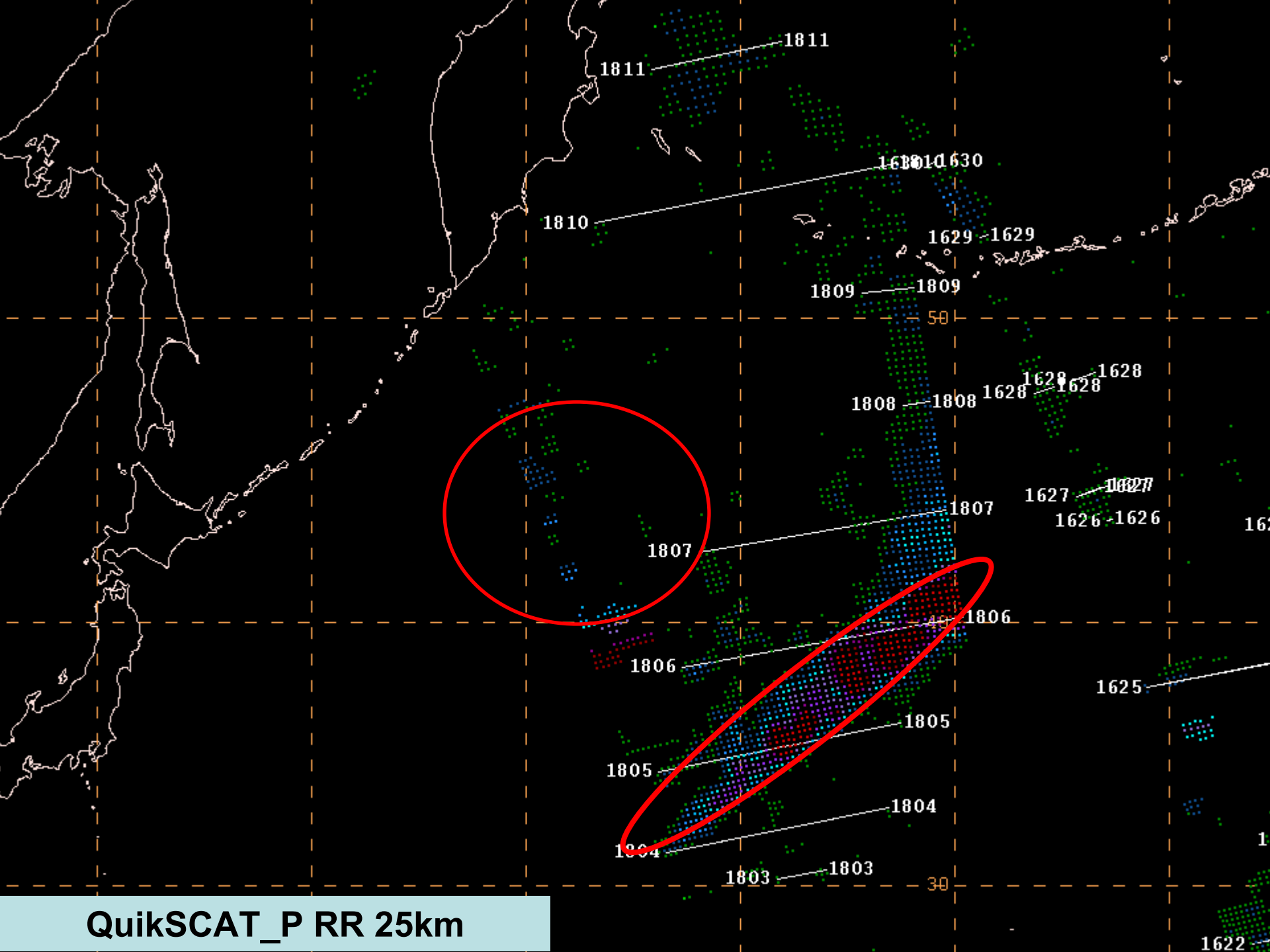
Rain Rate

Courtesy Prof. Linwood Jones

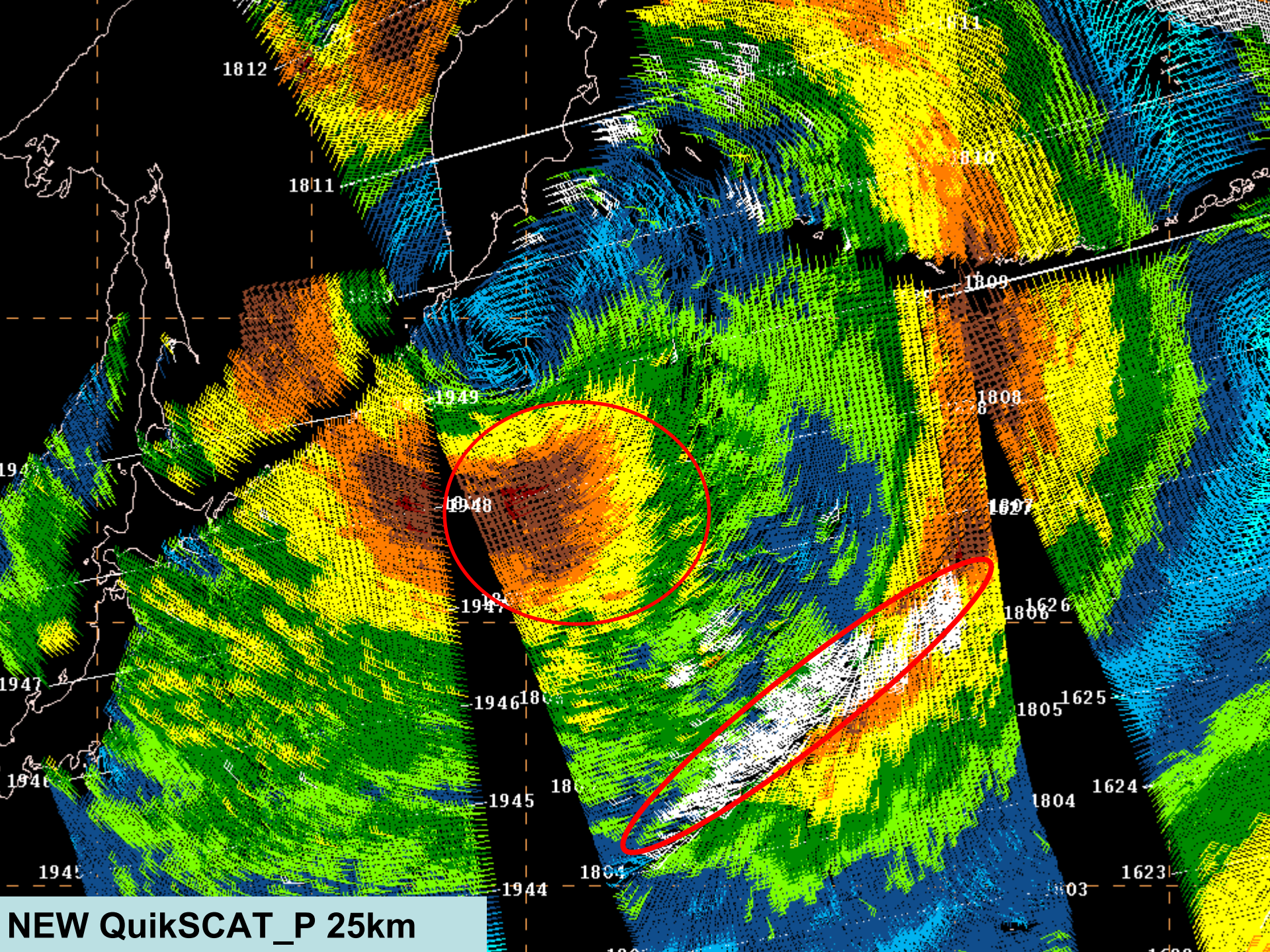
- In addition to measuring radar backscatter, QuikSCAT simultaneously measures the microwave brightness temperature of the atmosphere/surface.
- This passive microwave measurement capability is known as the QuikSCAT Radiometer (QRAD). QRAD rain rate retrieval algorithm was developed at University of Central Florida by Khalil Ahmed and Linwood Jones.
- New QuikSCAT NRT product includes these rain rate estimates. Product will be available in NAWIPS system as well.



OLD QuikSCAT 25km



QuikSCAT_P RR 25km


1812
1811
1809
1808
1949
1948
1947
1946
1945
1944
1626
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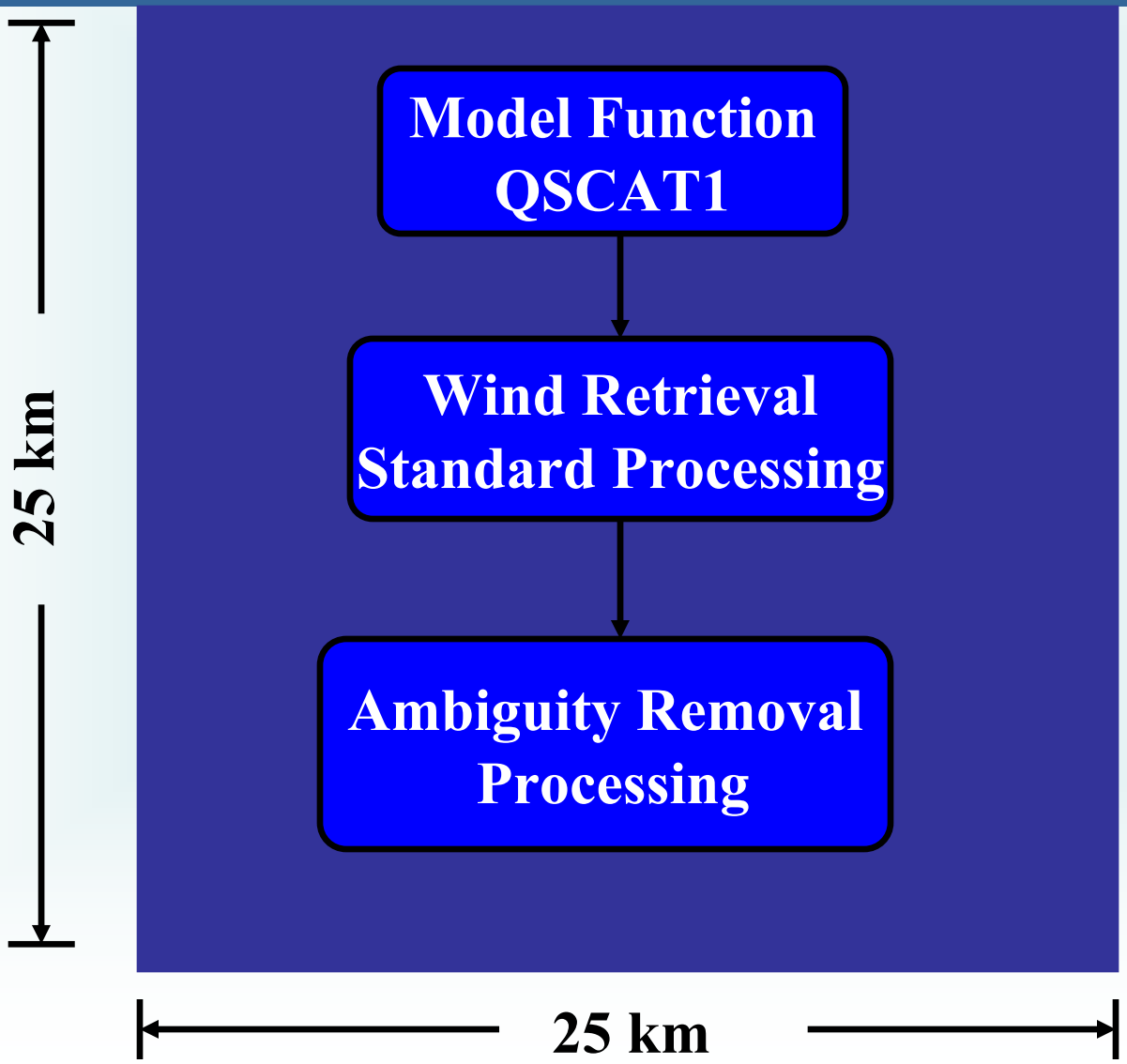
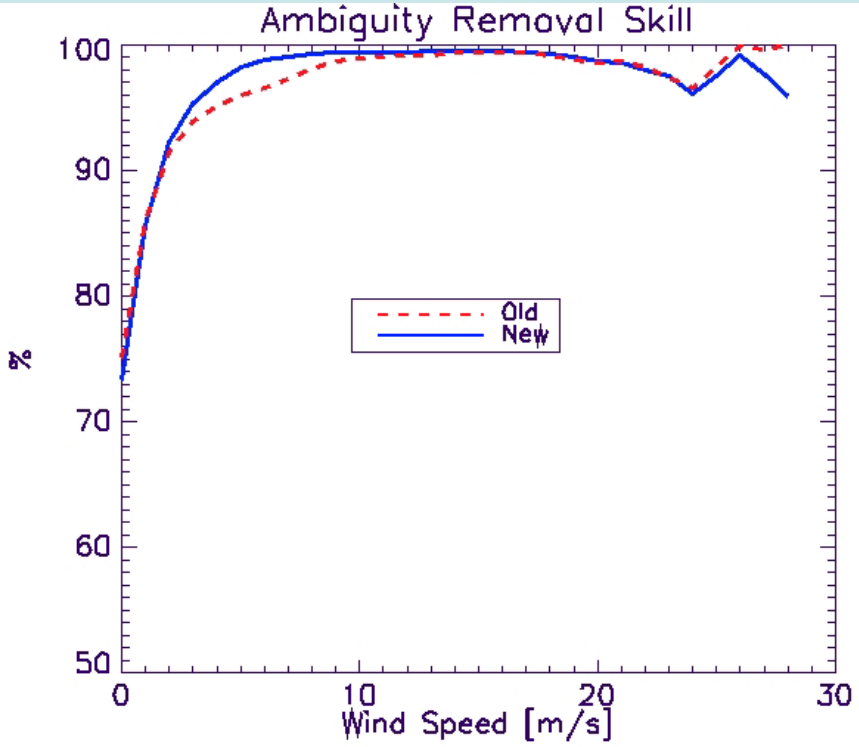
1623
1805
1804
NEW QuikSCAT_P 25km

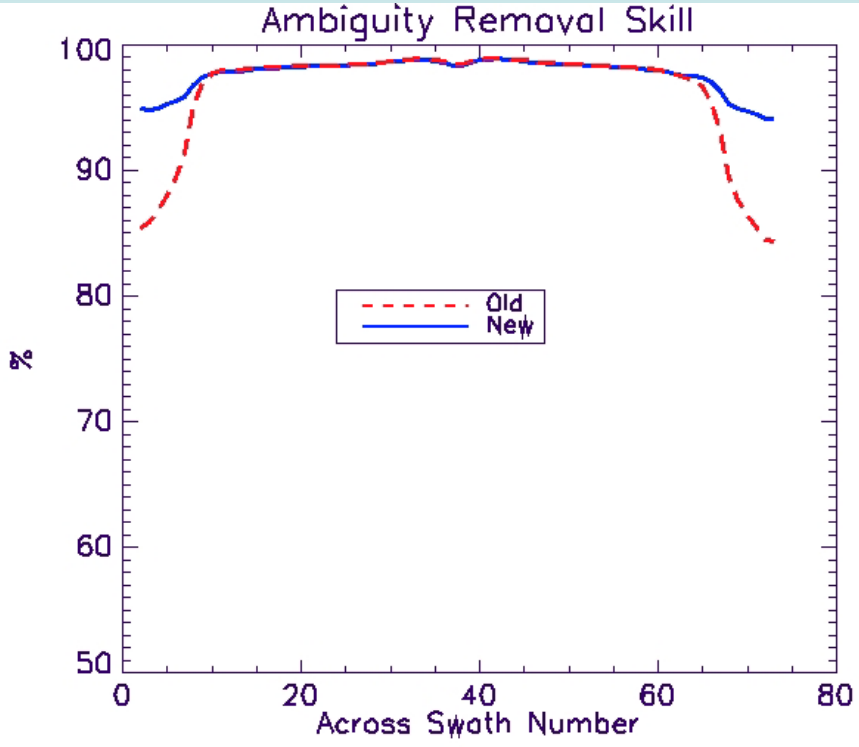
NRT QuikSCAT Processing Algorithm



Changes in Ambiguity Removal Processing

- Old NRT processing version utilized 3 pass medium filter ambiguity removal algorithm.
- New algorithm implements 4 pass scheme taking account coastal and ice WVC as well as rain flagged ones





Summary of New Retrievals

- New NRT processing algorithm produces higher wind speeds
- Performance of algorithm at swath edge substantially improved
  - Additional row of retrievals on swath edge
- Number of ambiguities produced is the same for both algorithms across entire swath
- Overall retrieval error similar to old algorithm
- Sign of wind speed bias reversed

Summary of New Retrievals

- Produces higher percentage of retrievals with calm winds
- New rain flag flags ~1.8% of data instead of 4.2%
  - Accuracy of un-flagged vectors in rain areas similar to vectors in non-rainy areas
- New data files will contain QRAD rain rate estimates

Implementation

- Tentative implementation in May 2007
- Notification via email to the listed near real-time users pulling QuikSCAT data from NESDIS within the next few weeks
- Files are available for parallel testing
- Main issue from the data assimilation perspective will be additional data as a result of the rain impact flag

Additional Slides

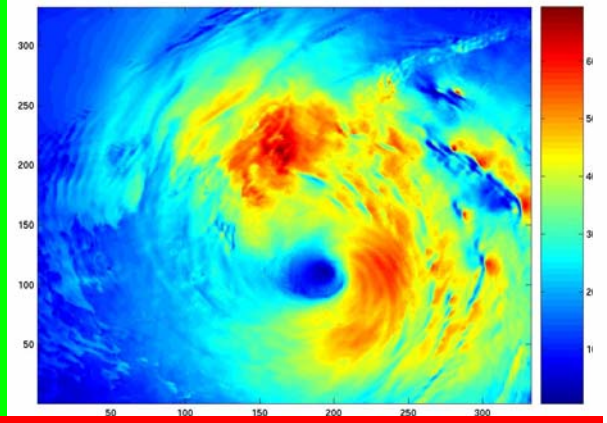
What is the Lowest Acceptable Resolution?

User Requested

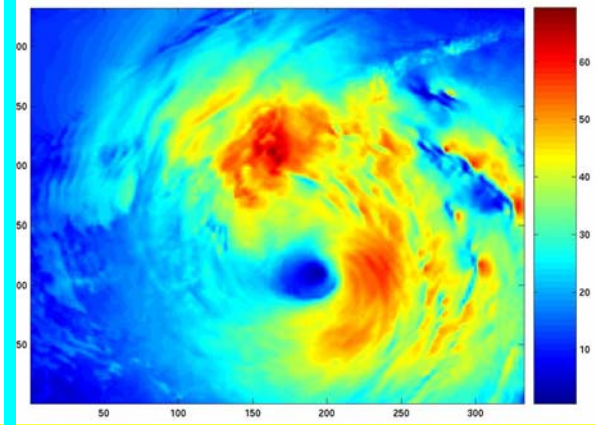
Definitely Achievable

Available Today!

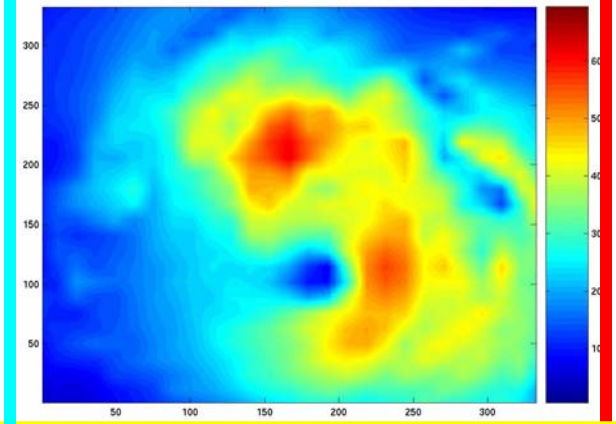
1km resolution
Max wspd 137.8 kts
True Wind Field



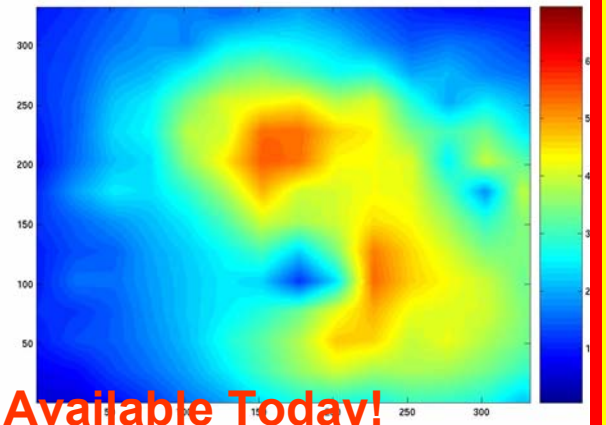
2km resolution
Max wspd 134.3 kts
rms 2.14 kts



13km resolution
Max wspd 120.7 kts
Rms 5.71 kts

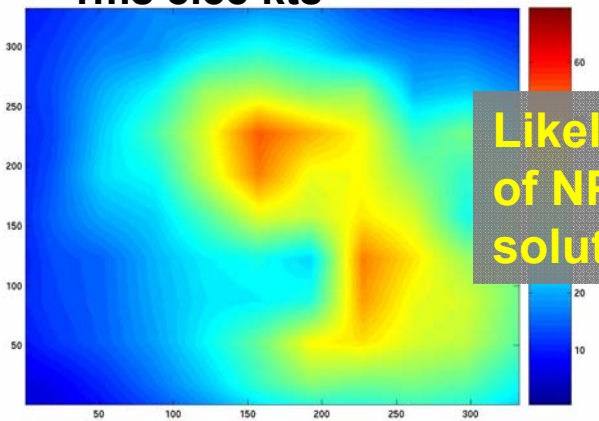


25km resolution
Max wspd 105.9 kts
rms 7.72 kts

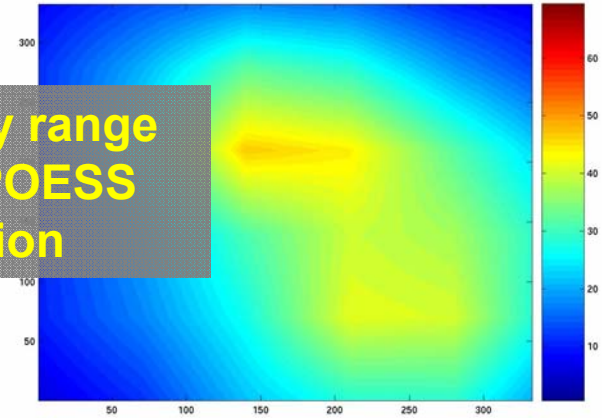


Available Today!

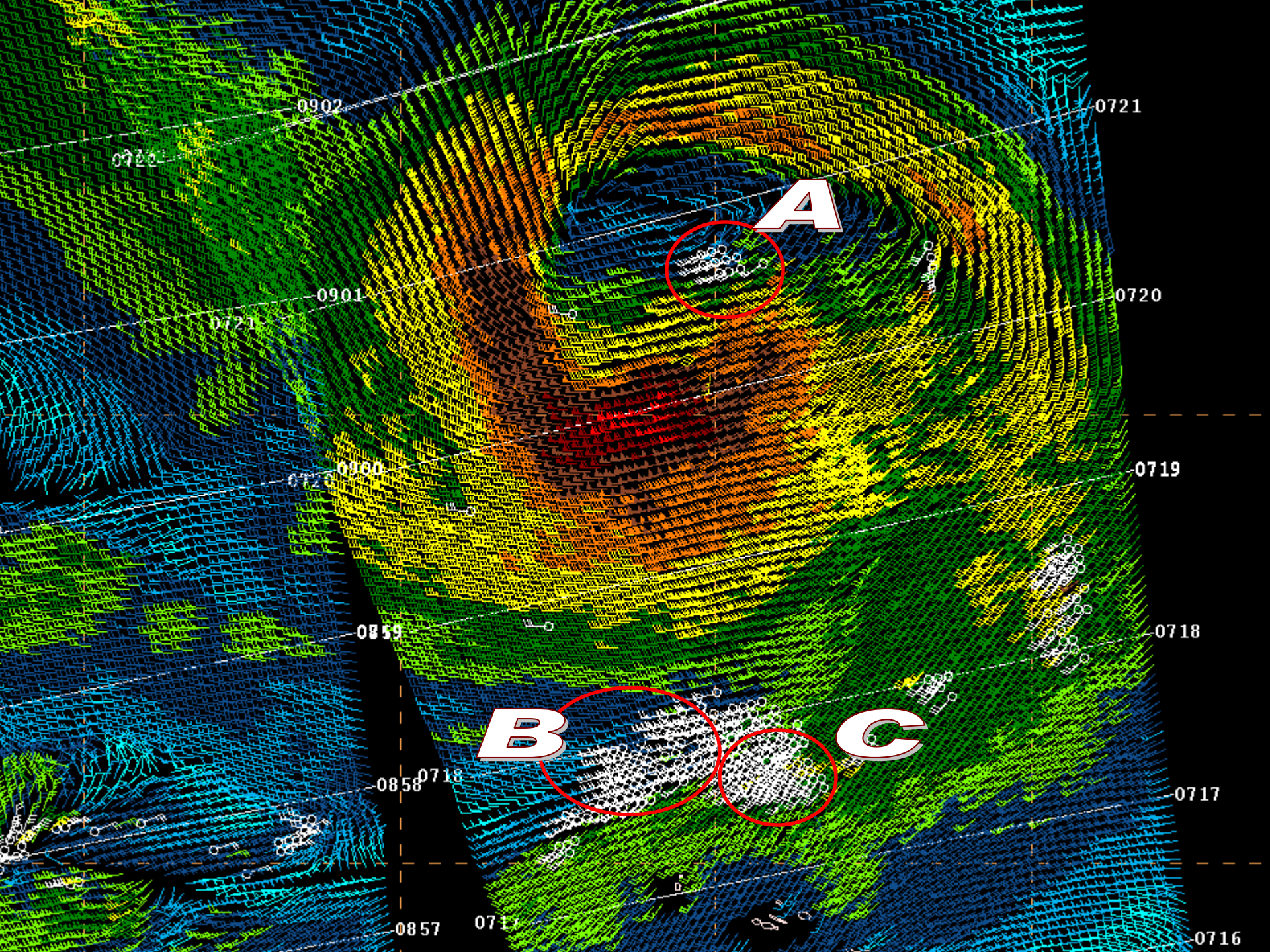
35km resolution
Max wspd 106.1 kts
rms 8.88 kts



70km resolution
Max wspd 91.0 kts
rms 12.50 kts



Likely range of NPOESS solution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0720
0719
0718
0718
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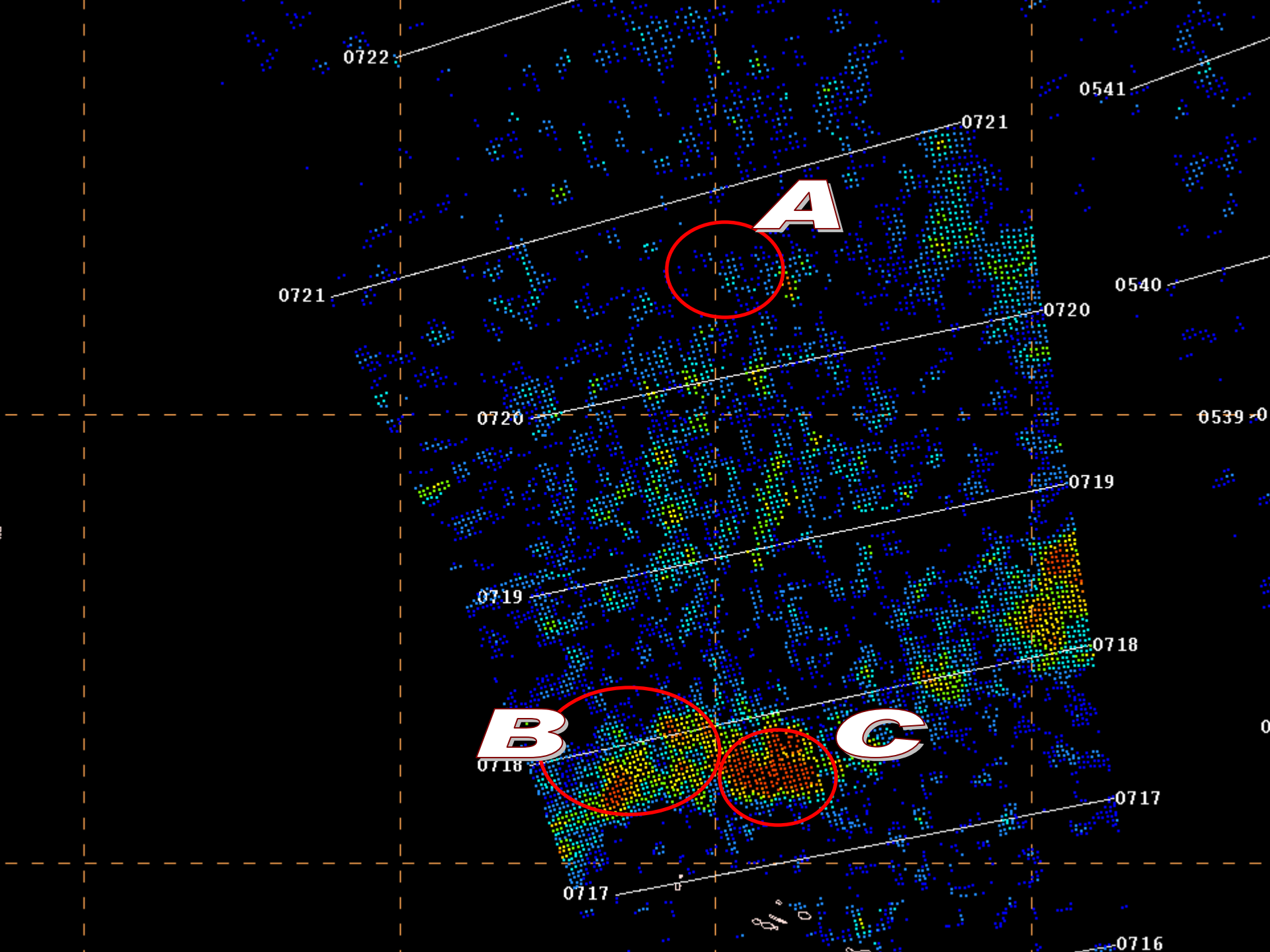
0717
0857
0716
A
B
C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B
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0717
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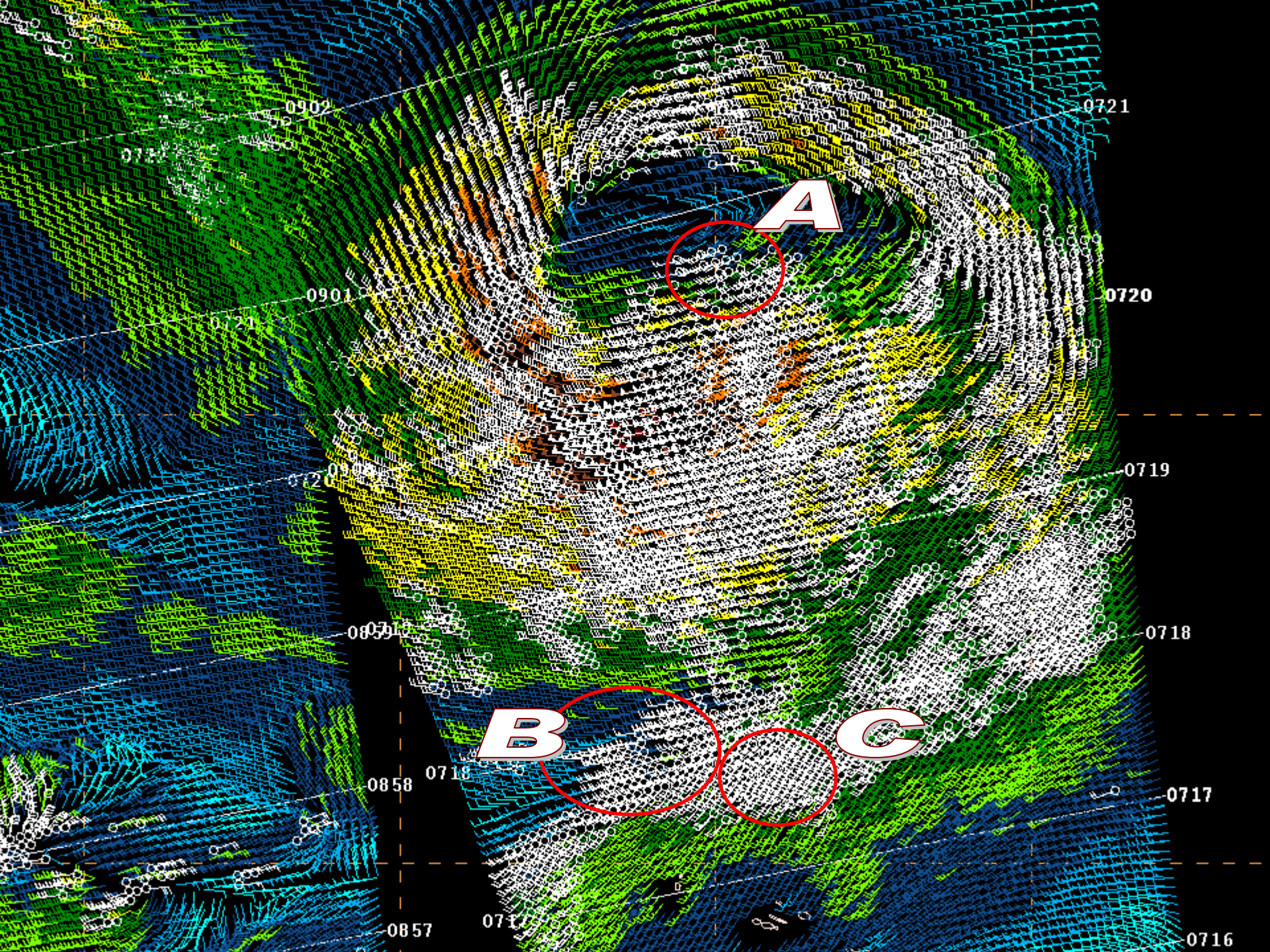
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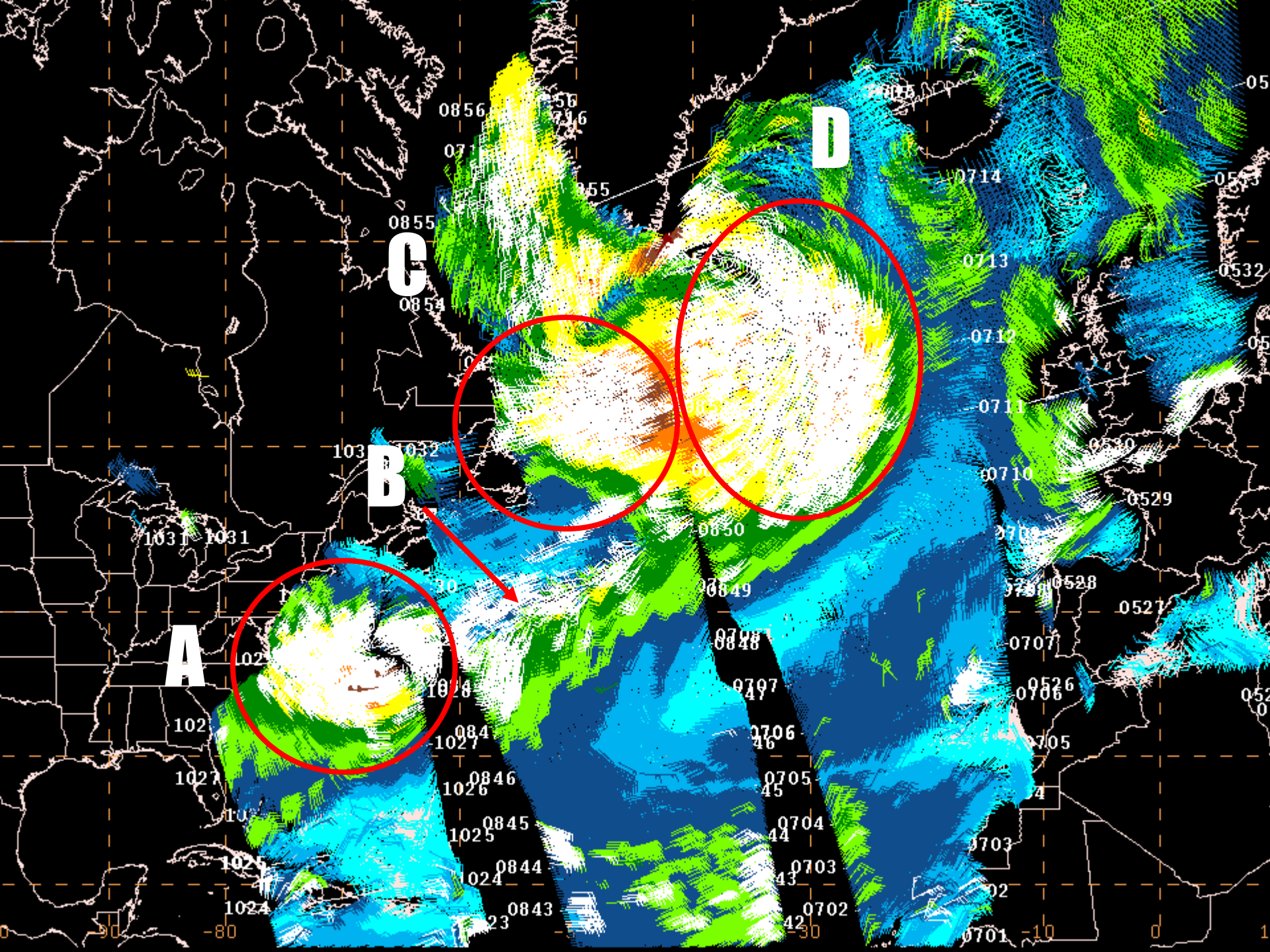
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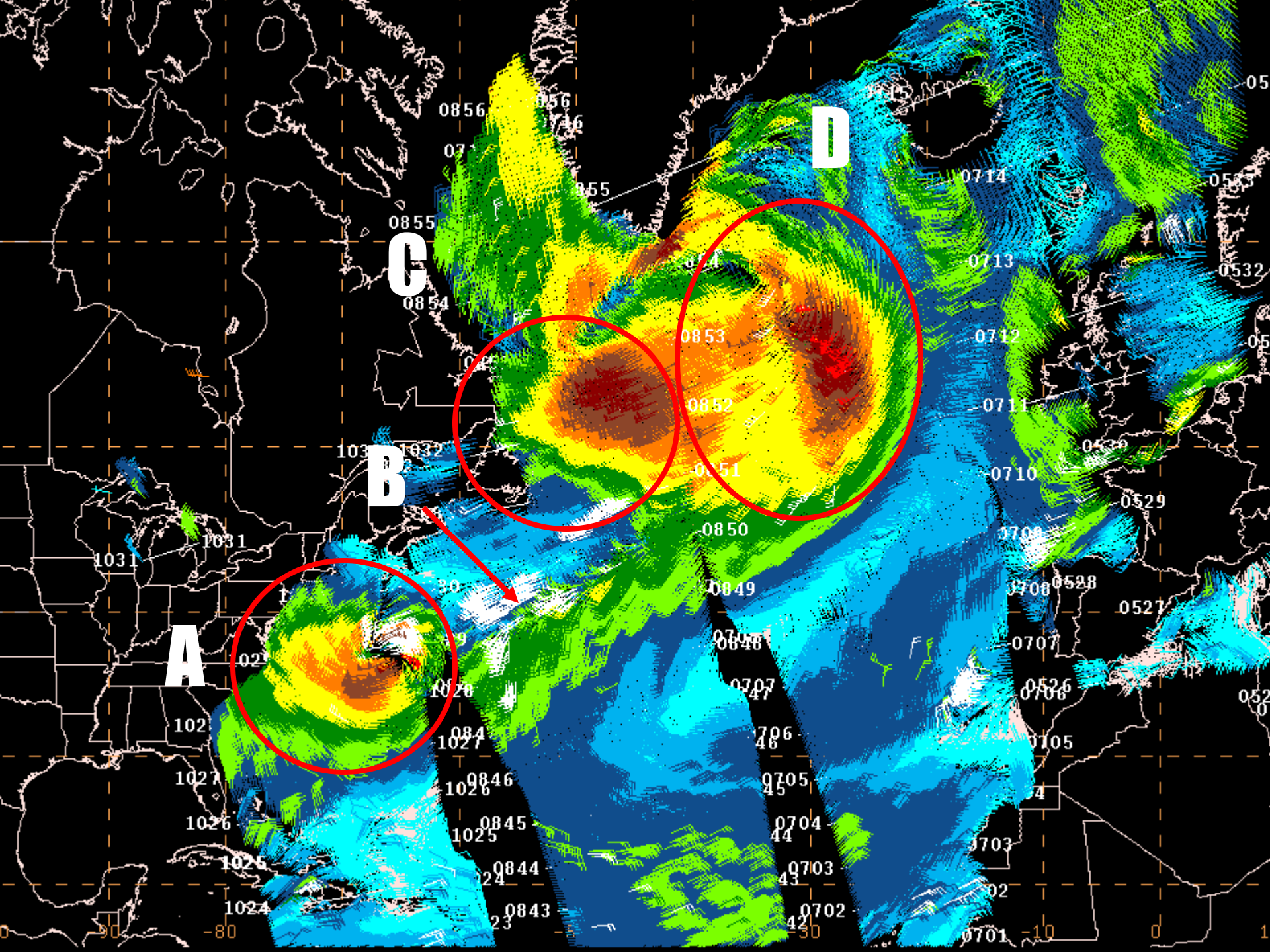
C
D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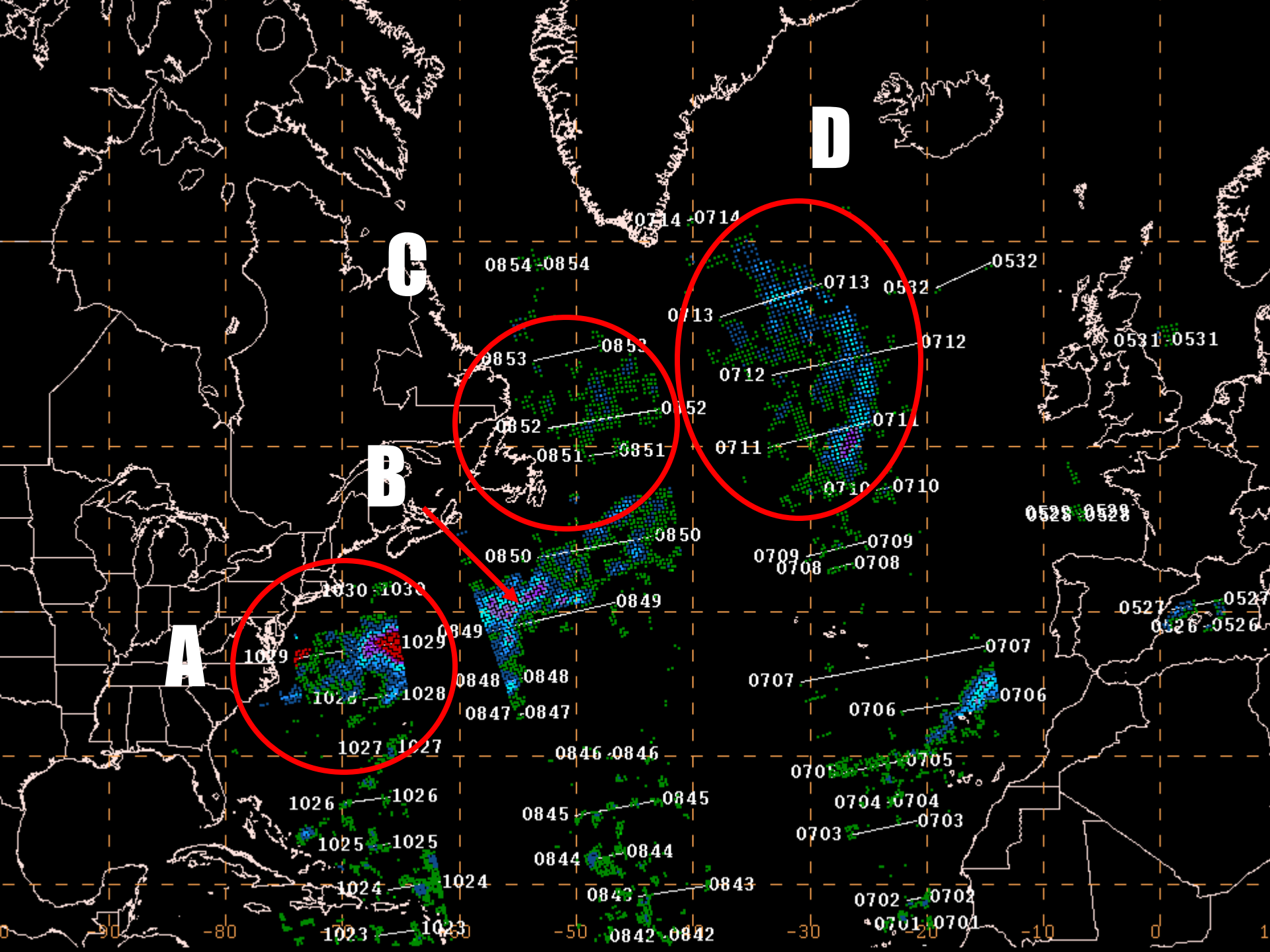
C
D


A
B
C
D
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0702 0702
0701 0701
0532 0532
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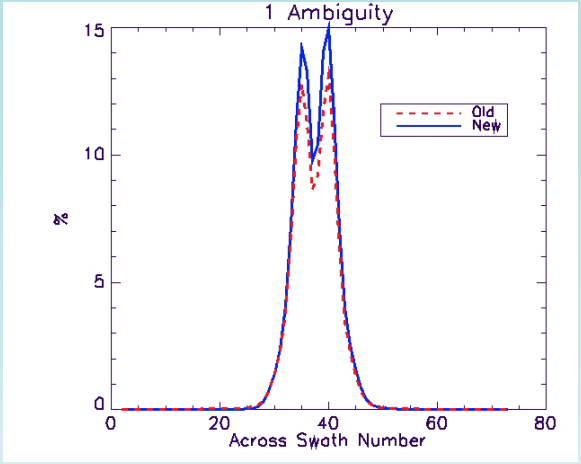
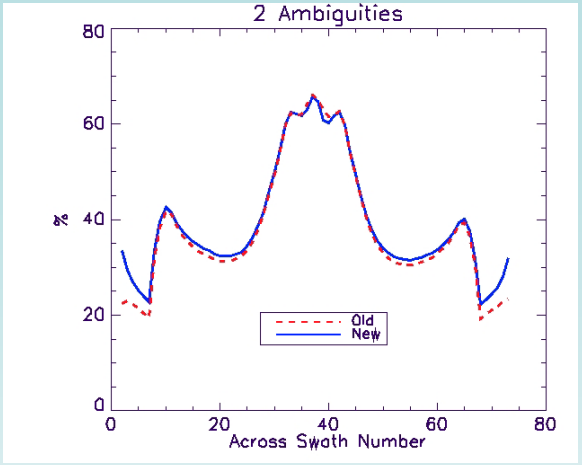
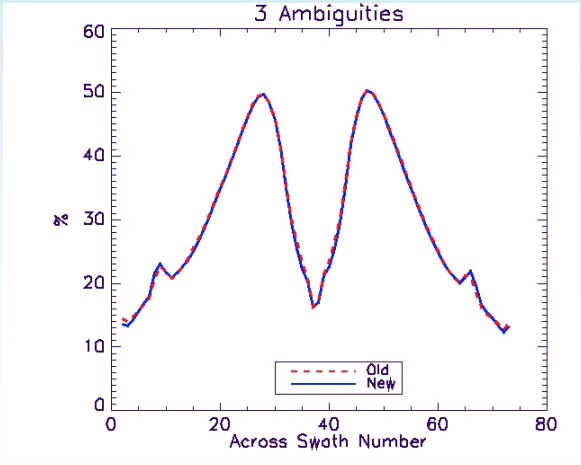
0526 0526
-90 -80 -70 -50 -30 -20 -10 0 1

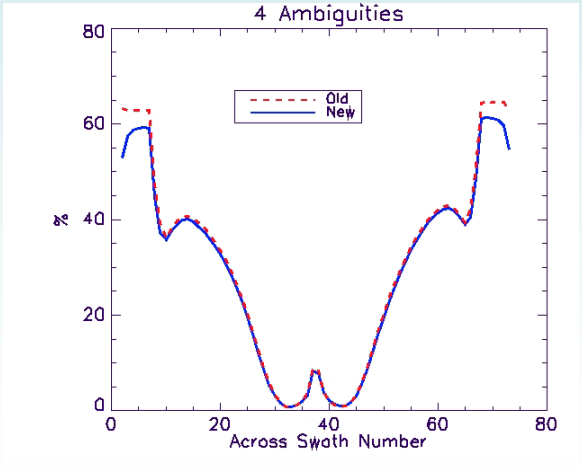
Number of Ambiguities across Measurement Swath

Number of Ambiguities Retrieved









Across Swath Number

Why is Important to Check Ambiguity solutions When In Doubt?