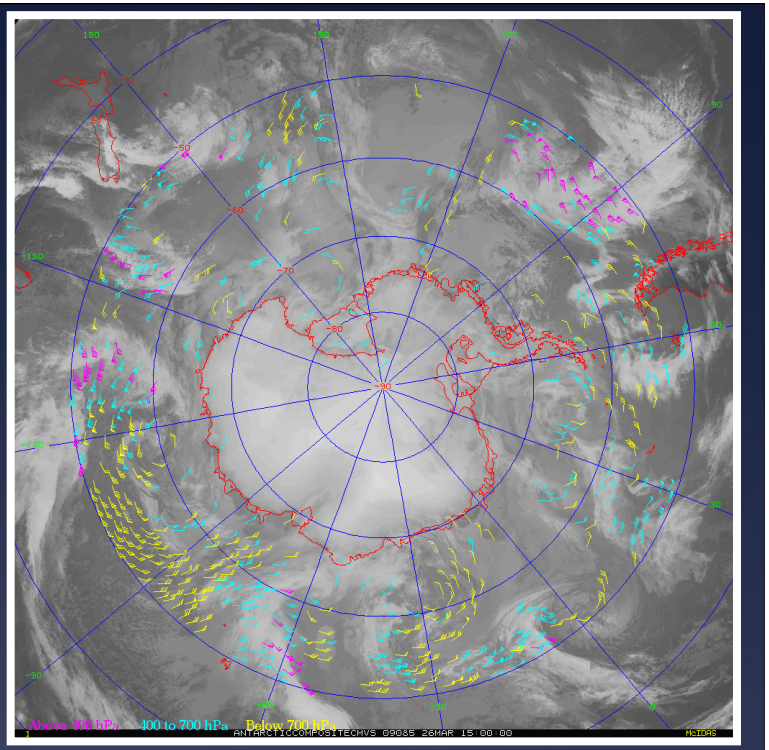
High Latitude Atmospheric Motion Vectors:

Application of Antarctic and Arctic Composite Satellite Imagery



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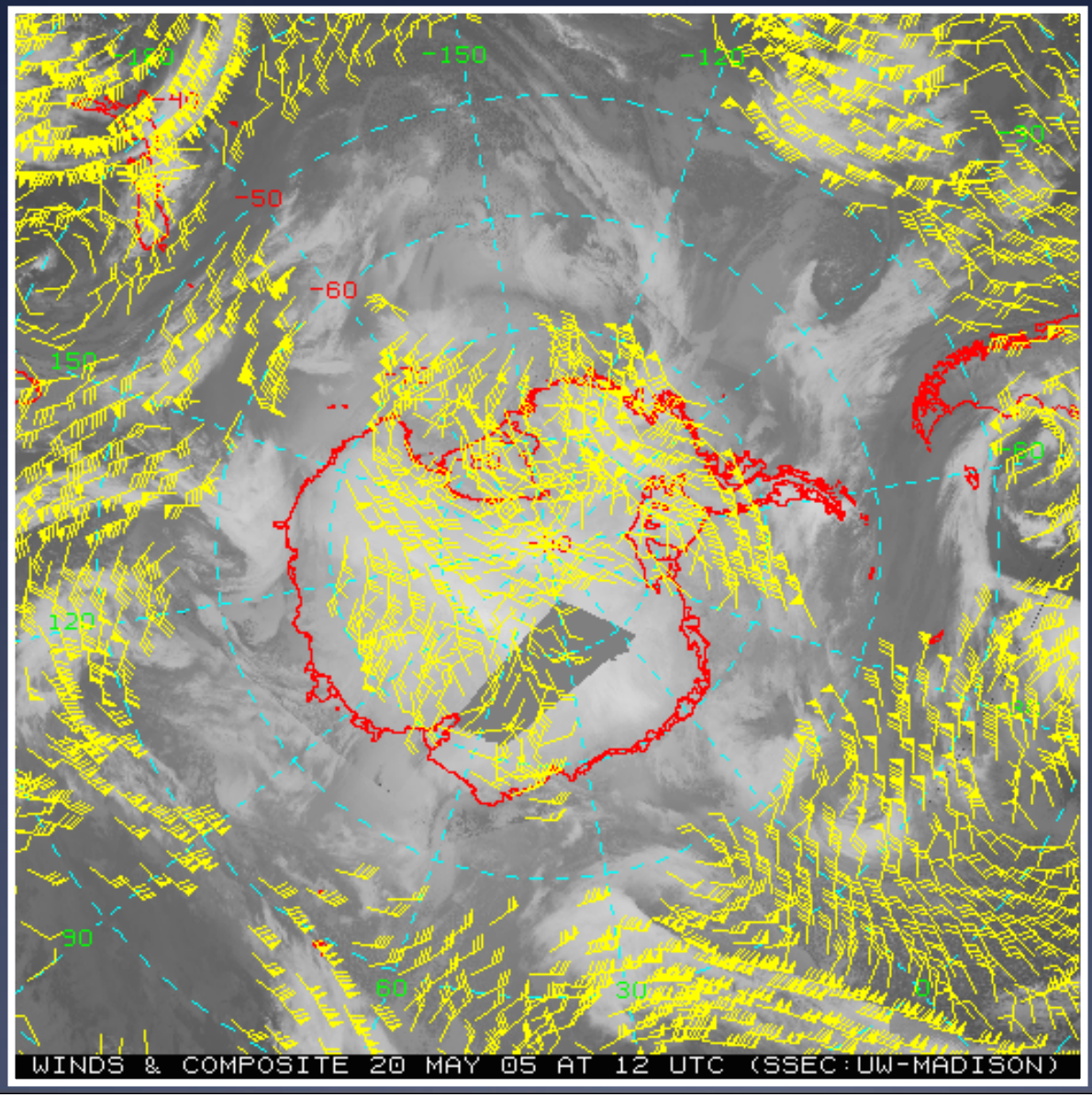
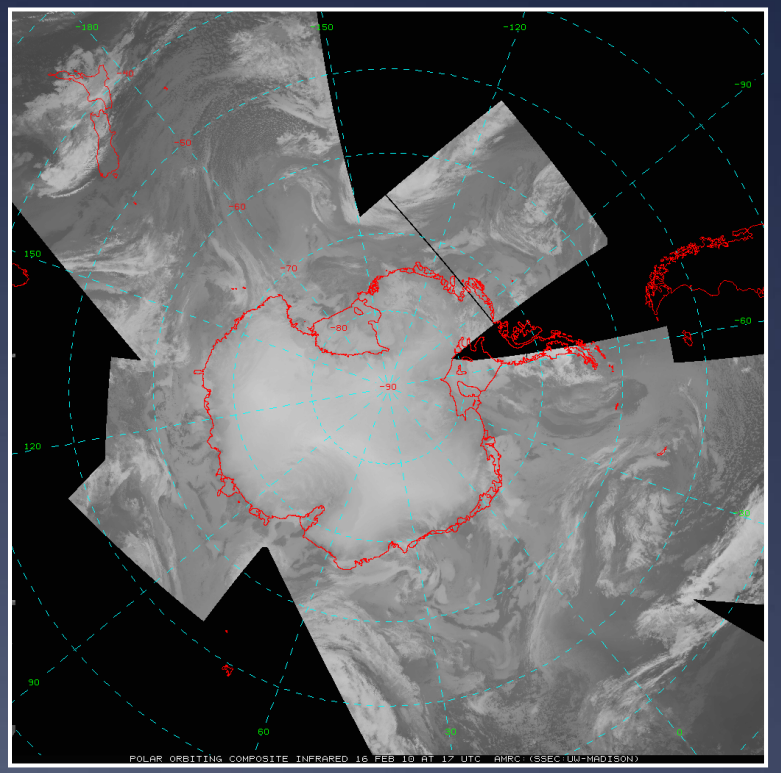
Atmospheric Motion Vectors

Geostationary and Polar-orbiting

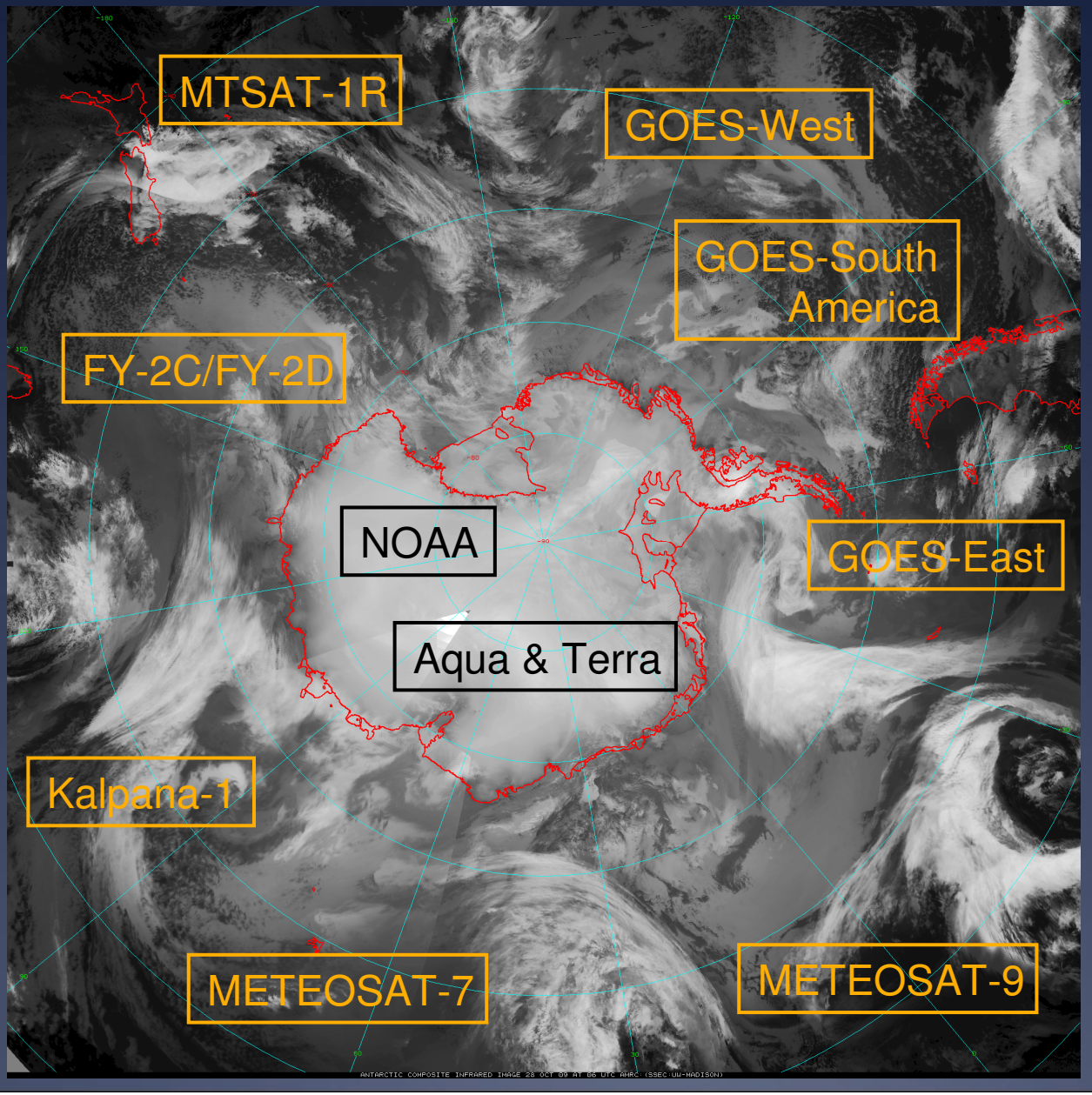


Composite Generation

- Satellite acquisition at SSEC Data Center with additional acquisition at McMurdo Station and Palmer Station (via Internet)
- "Clean up" of bad lines
- Remapping imagery
- Removal of "space" background
- Merge imagery
  - Geostationary first
  - Polar orbiting last
- Post processing and distribution



Satellites Incorporated



Antarctic Composite

Satellite Sources

- Geostationary:
  - GOES-10, -11, -12
  - KALPANA-1
  - Meteosat-7, -9
  - FY-2C, FY-2D
  - MTSAT-1R
- Polar orbiting
  - NOAA-15, -16, -17, -18
  - Aqua and Terra
- Spectral Bands:
  - Infrared Window (~11.0 microns)
  - Water Vapor ((~6.7 microns)
  - *Coming soon:*
    - *Shortwave Infrared (~3.9 microns)*
    - *Longwave Infrared (~12.0 microns)*

Specifications

- 1 hourly data!
  - Used to be 3 hourly data (at synoptic hours 0, 3, 6, 9, 12, 15, 18, 21 UTC)
- Geostationary:
  - Most +/- 15 minutes to the top of the hour
    - Some +/- 50 minutes to the top of the hour
  - Otherwise its left missing…
- Polar-orbiting:
  - Coverage within whole hour
- 5 kilometer nominal resolution
- Polar stereographic (Antarctic)
  - Centered at South Pole -90°
  - Standard/True at -60° South
  - Standard at 140° West
- Weather depiction and forecasting focus

Composite CMV Development

* CCMV are being run parallel on two machines with different settings

Take 3 consecutive hourly composites over the Antarctic and input into wind development algorithm (Windco)

Finding targets by calculating local brightness temperature gradients that exceed threshold; 15 (Default) versus 7

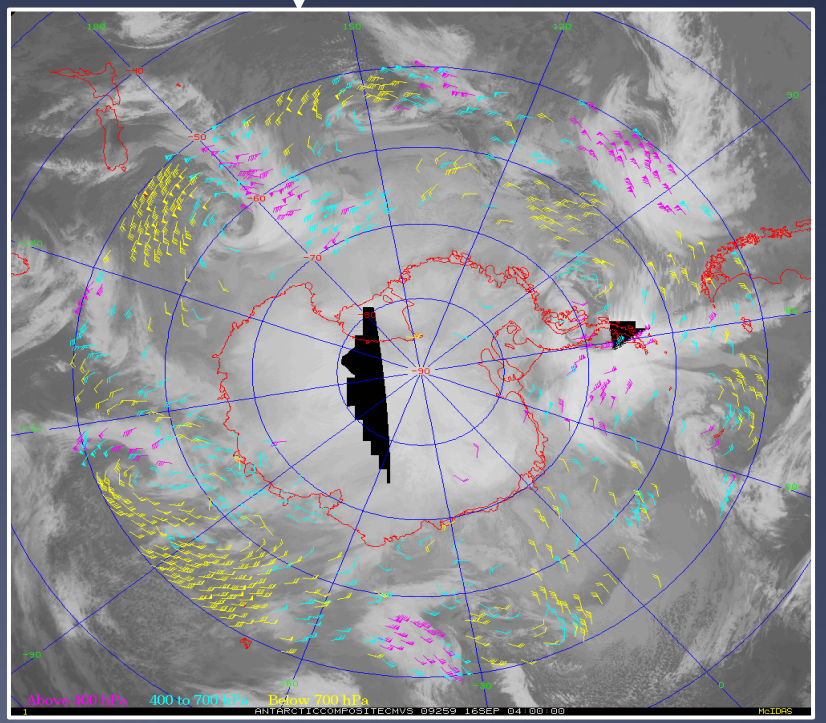
Determine height of target by comparing the average temperature of target pixels to the background field; GFS forecast of 6 to 12 hours

Use background wind field to create search box and find highest correlated gradient point between target and search box

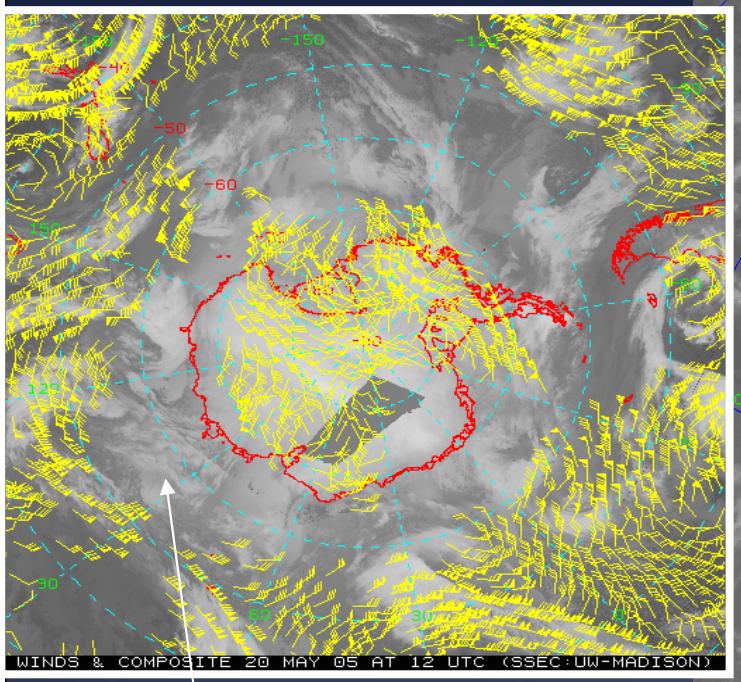
Sub-vectors are generated between images in a triplet and acceleration check is performed to throw out bad vectors.

Post-processing: **With and Without Ckcirrus** etc., Recursive Filtering (RF) to obtain the best possible height assignment and Quality Indicator (QI) values are calculated.

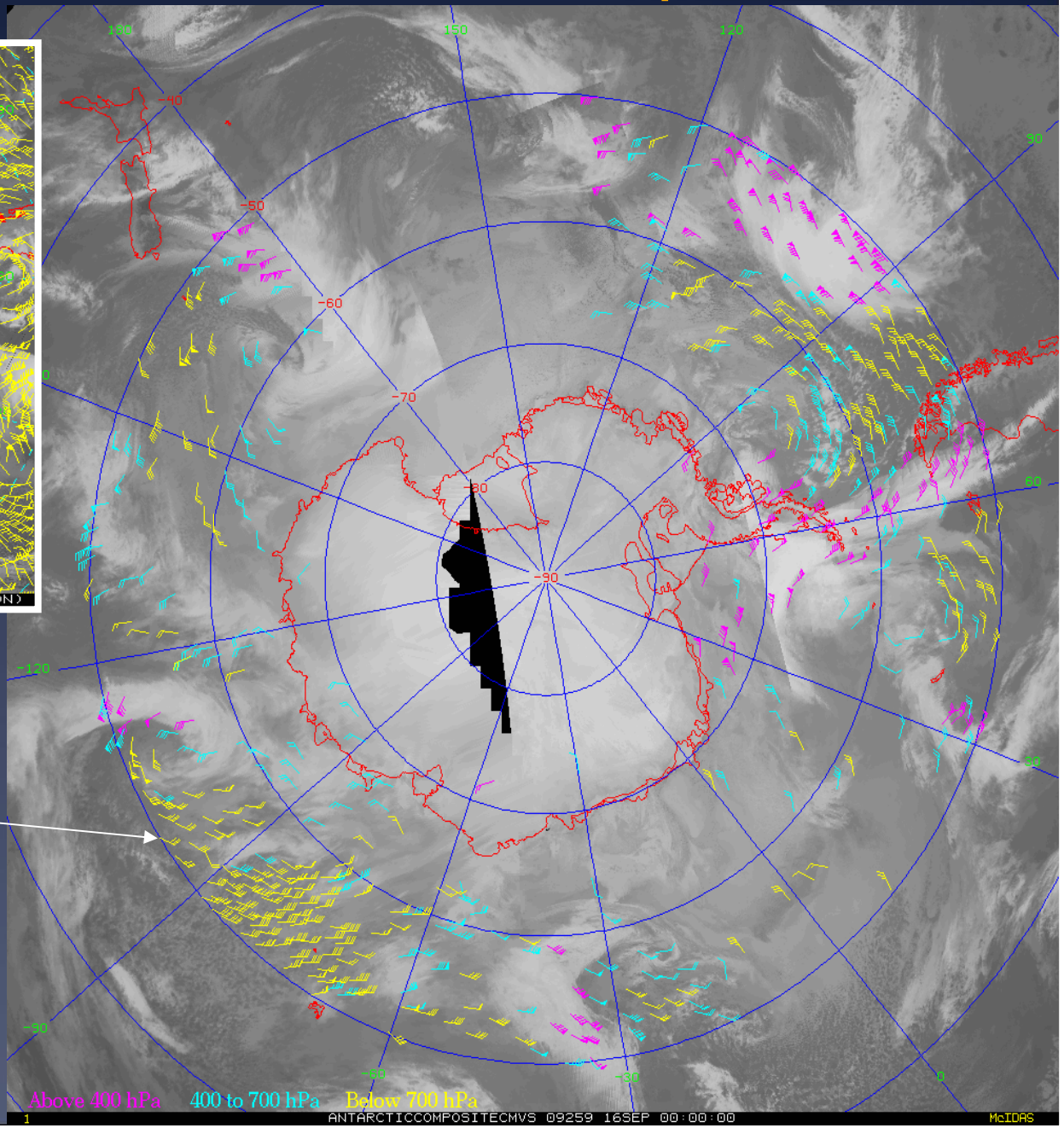
Each vector is given a flag based on RF and QI values(60 vs. 70), and any vectors that surpass threshold are accepted.



Composite CMV Development



Filling in the Observation Gap

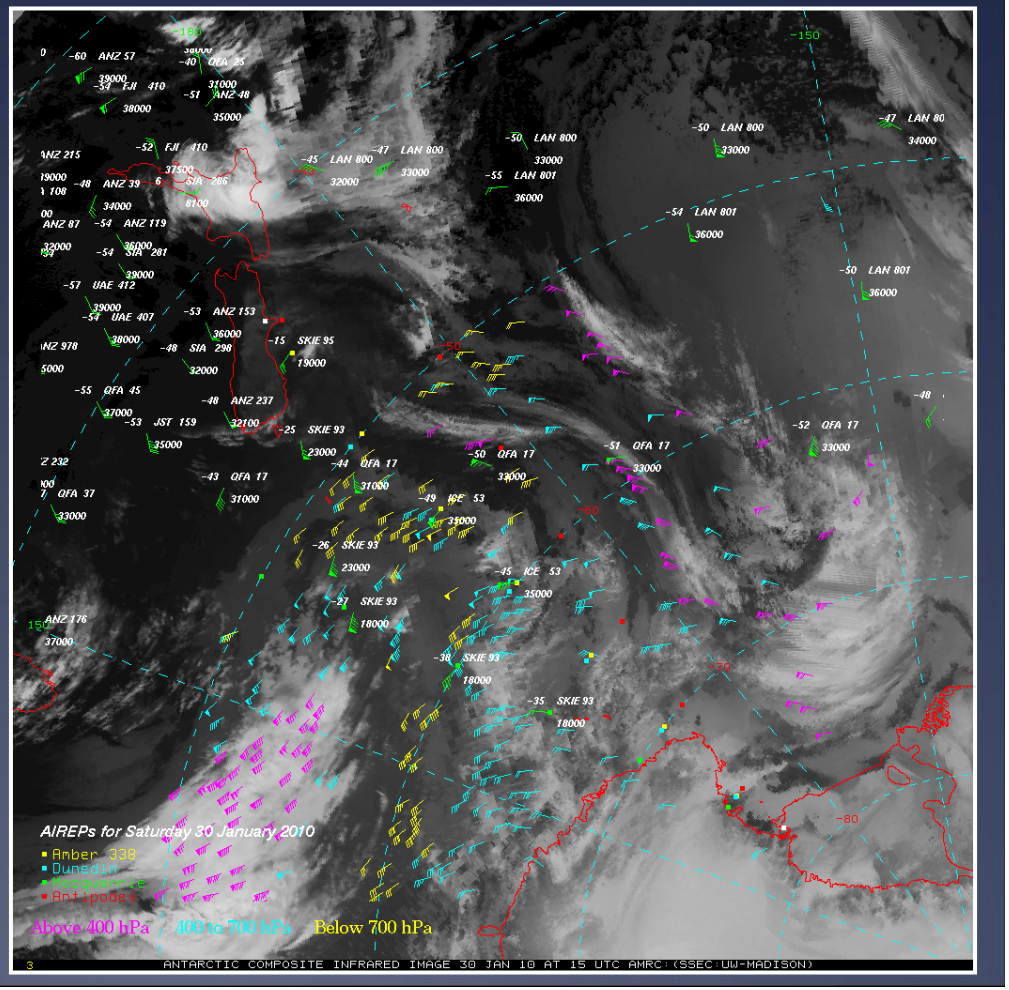


Validation Process

- Run Windco process parallel on two computers: AWS/AMRC. Each computer is running Windco on different settings.
- Retrieve Radiosondes data south of 50° S latitude.
- **Retrieve AIREP reports** …
  ICE = C-17 USAF
  SKIE = SKIER - LC-130 NYANG
  KIW = KIWI - C-130 RNZAF
  SDN = Australia Airbus
  SFR = SAFAIR = South African Air
  LAN = LAN Airlines (Chile)
  QFA = Qantas Airlines (Aussie)
  British Antarctic Survey
- Compare CMVs on both runs

with Observations…

  - Radiosonde: 100 km/50 hPa
  - AIREPs: 100 km/ 500 meters



Validation Statistics

Ckcirrus

Tot Vector RMS = 10.56

	>=850 hpa	850> to 500 hpa	Above 500 hpa
Vector RMS	8.03	6.71	**12.01**
Vetor Diff.	6.70	5.70	8.83
Speed RMS	6.88	4.47	6.58
Speed Bias	-3.51	-0.41	**-0.79**
AVHRR Speed	14.19	17.48	31.08
RAOB Speed	17.69	17.89	31.87
Sample Size	15	95	216

Ckcirrus Removed

Tot Vector RMS = 8.33

	>=850 hpa	850> to 500 hpa	Above 500 hpa
Vector RMS	4.89	6.48	**9.46**
Vetor Diff.	4.37	5.50	7.96
Speed RMS	2.80	4.87	6.49
Speed Bias	-1.66	-0.35	**+0.06**
AVHRR Speed	15.49	18.88	33.98
RAOB Speed	17.15	19.23	33.92
Sample Size	21	135	207

Validation Statistics

* Separate Statistics into Latitude bands

Ckcirrus

	50-60° S		**60-70° S**		<70° S
VEC RMS	**11.79**	VEC RMS	**8.92**	VEC RMS	7.31
VEC Diff	8.26	VEC Diff	7.44	VEC Diff	6.41
SPD RMS	6.40	SPD RMS	5.68	SPD RMS	5.05
SPD BAS	**-0.98**	SPD BAS	-0.80	SPD BAS	+1.55
Cases	184	Cases	127	Cases	13

Ckcirrus Removed

	50-60° S		**60-70° S**		<70° S
VEC RMS	**7.95**	VEC RMS	**9.78**	VEC RMS	5.40
VEC Diff	6.87	VEC Diff	7.44	VEC Diff	4.69
SPD RMS	5.78	SPD RMS	6.13	SPD RMS	4.39
SPD BAS	**+0.10**	SPD BAS	-0.59	SPD BAS	-1.72
Cases	254	Cases	**82**	Cases	27

Validation Statistics

* Take a closer look into 60-70 latitude bands note that the majority of these are AIREP comparisons

Ckcirrus

	500 hpa and Below	Above 500 hpa
Vector RMS	**7.74**	**9.27**
Vetor Diff.	6.21	7.84
Speed RMS	**4.65**	5.98
Speed Bias	**-0.96**	**-0.75**
AVHRR Speed	12.45	29.42
RAOB Speed	13.41	30.18
Sample Size	31	96

Ckcirrus Removed

	500 hpa and Below	Above 500 hpa
Vector RMS	**6.33**	**11.51**
Vetor Diff.	5.08	9.04
Speed RMS	**3.02**	7.53
Speed Bias	**-1.39**	**-0.05**
AVHRR Speed	8.51	25.06
RAOB Speed	9.90	25.11
Sample Size	33	49

Validation Statistics

DVAL=15 (Default)
QI=70

	TOT
Vector RMS	7.63
Vetor Diff.	6.39
Speed RMS	6.52
Speed Bias	+0.85
AVHRR Speed	28.31
RAOB Speed	27.46
VNRMS	**0.28**
Sample Size	72

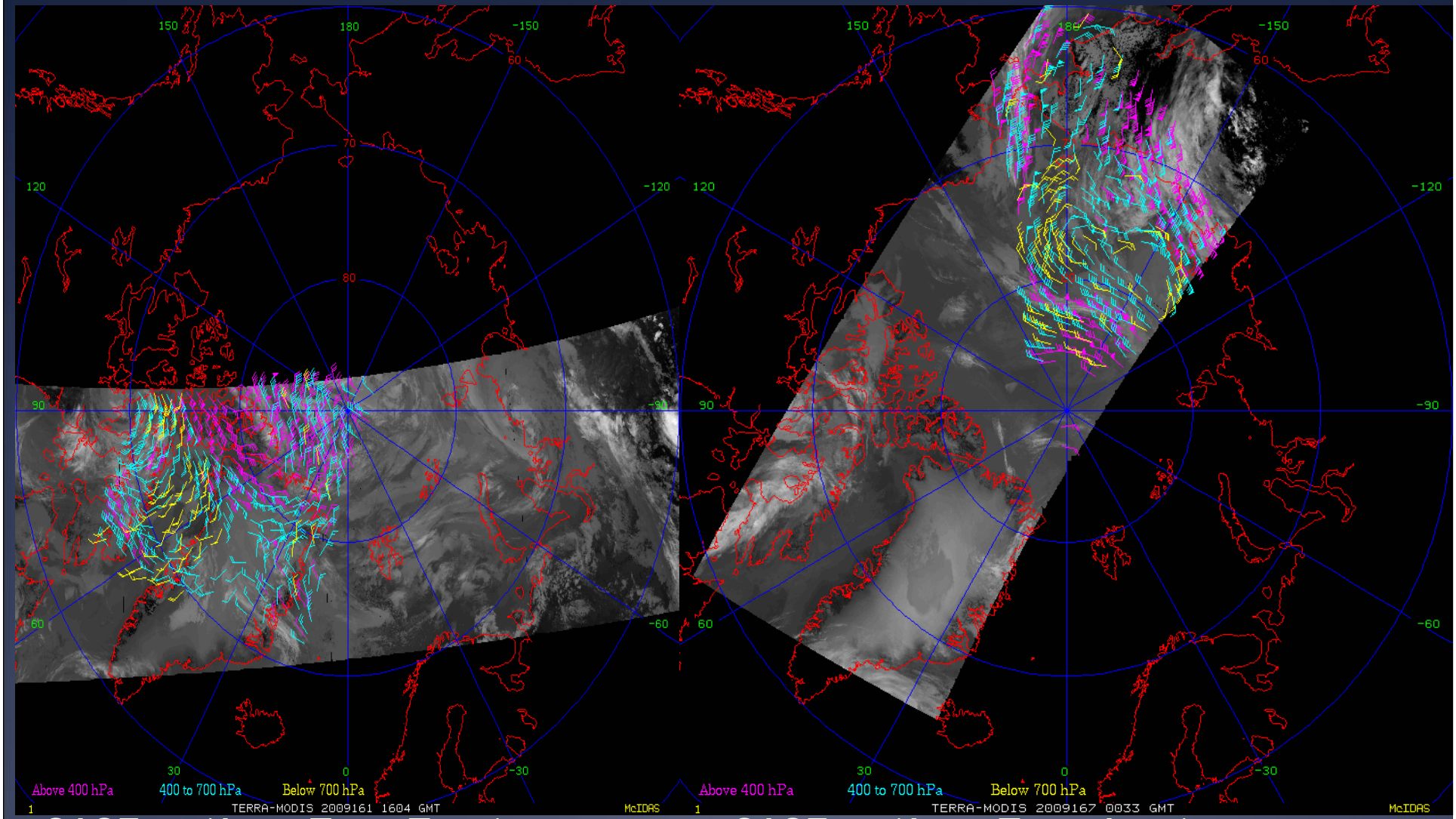
DVAL=7
QI=60 (Default)

	TOT
Vector RMS	7.44
Vetor Diff.	5.78
Speed RMS	5.43
Speed Bias	-0.88
AVHRR Speed	16.79
RAOB Speed	17.68
VNRMS	**0.42**
Sample Size	100

Time Stamping

Why is it important to have accurate time stamps?

MODIS Mixed (Terra and Aqua) winds with varying time stamps



CASE #1 (Aqua-Terra-Terra)

CASE #2 (Aqua-Terra-Aqua)

Time Stamping
Statistical Comparison

Case #1	65° Cross Tim e= 1615	90° Cross Time= 1609	Operational Time=1604
Count	1645	1331	1421
65-70° #	175	148	172
70-75° #	438	343	376
75-80° #	464	385	392
80-85° #	317	256	285
85-90° #	251	199	196

Ca se #2	65° Cross Time= 0047	90° Cross Time= 0042	Operational Time=0033
Count	918	981	827
65-70° #	251	183	160
70-75° #	331	308	239
75-80° #	194	232	189
80-85° #	131	238	208
85-90° #	11	20	31

Case #1	65° Cross Time= 1615	90° Cross Time= 1609	Operational Time=1604
Orbits 2-1	78	70	67
Orbits 3-2	99	99	99

Case #2	65° Cross Time= 0047	90° Cross Time= 0042	Operational Time=0033
Orbits 2-1	79	64	68
Orbits 3-2	20	35	31

	Case #1 Vector Diff.	Case #2 Vector Diff.
65° vs. Oper	1.89	4.30
90° vs. Oper	1.41	1.41
65° vs. 90°	1.67	4.16

*Comparison made at 25 mb/10 km collocation distance

Time Stamping

Comparison to TERRA only winds

	Case #1 Vector Diff. (#)	Case #2 Vector Diff. (#)
65° mix vs. TERRA	3.55(168)	4.57(123)
90° mix vs. TERRA	3.74(135)	4.20(124)
Oper. mix vs. TERRA	4.11(145)	4.36(107)

*Comparison made at 25 mb/10 km collocation distance

Vector Difference between Uniform TERRA MODIS and Mixed MODIS is close to the magnitude of the time sensitivity differences for larger time increment differences between orbits.

Summary and Conclusions

1) Antarctic Composites are increased temporally from every 3 to 1 hour. This allows them to be used for the development of Motion Vectors
2) CCMV are validated versus RAOBS and **AIREPS**.
3) CCMV have potential to fill in the observation network, the gap between 60-70°S.
4) Validation indicates much improved quality (especially above 500 hPa) when the ckcirrus routine is removed. However, not seen at 60-70º S
5) Additional validation and sensitivity testing is continuing (QI, DVAL,Target size etc.)
6) Time stamping remains an issue to be resolved in the future. Comparison of MODIS MIX AMVs indicate significant sensitivity with changing cross-time stamps
7) MODIS MIX AMVs and CCMVs are NOT yet ready to be used for model assimilation **,** but hopefully soon. **Work in progress**.
8) Future consideration and planning of modifying windco includes the tagging of individual targets with the true (pixel) time.

Future Work

- Generate winds from water vapor composites
- Adding satellites
  - FY-2D
  - NOAA-19
  - MetOp-A
  - Aqua/Terra (water vapor composites)
- Generate AMVs from Arctic composites
- Test compositing techniques for optimal spatial and temporal resolution of all satellites
- Take into account satellite parallax and time of observation into the compositing process
- Modify the wind-derivation software to work with the new composites and metadata information
- Continue validation and trial testing of the compositing and AMV generation process in real-time using NESDIS methods with radiosondes and verification with aircraft (AIREP) observations

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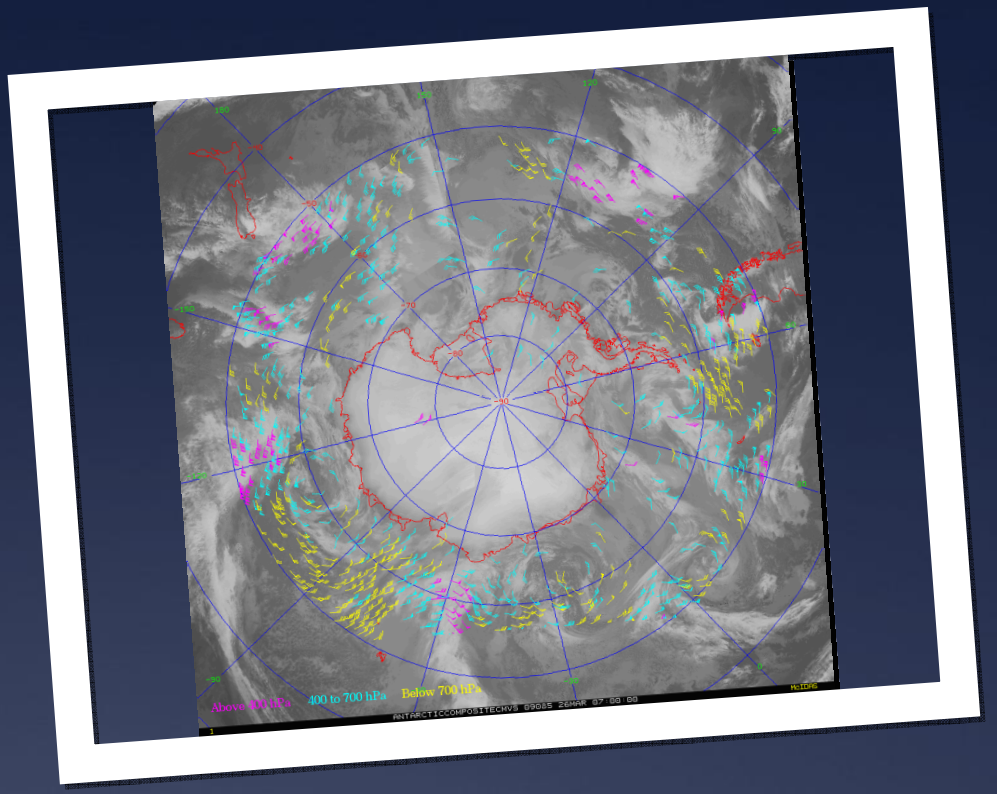
Thank you!



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This effort is funded by National Science Foundation
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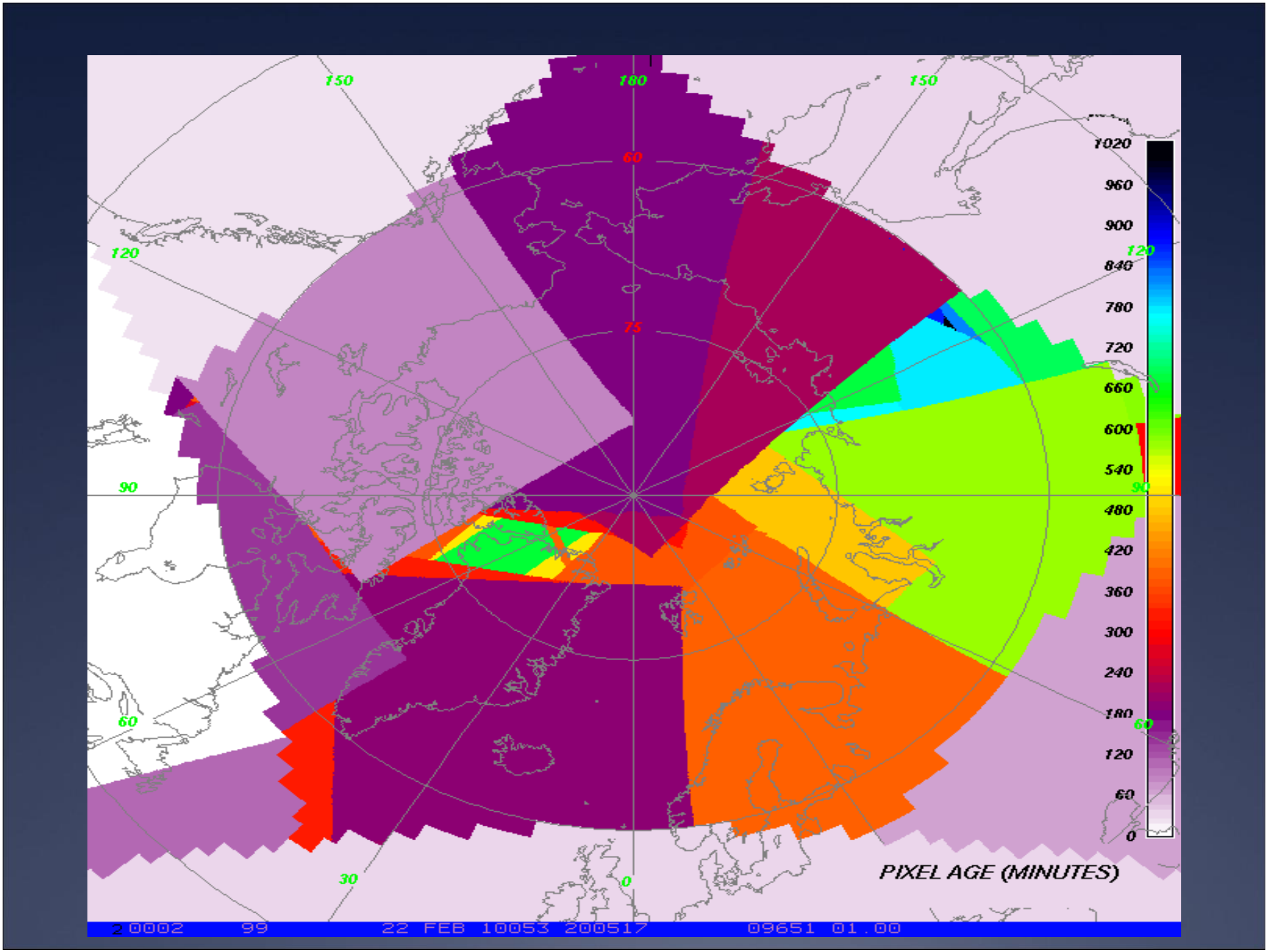
Time Stamping

Comparison to radiosondes

Case #1	Sequential(#) AAT,TTA
VEC RMS	**10.97 (1603)**
VEC Diff	8.74
SPD RMS	**8.60**
SPD BAS	**-3.40**
VNRMS	0.53

Case #2	Non-Sequential(#) TAT,ATA etc.
VEC RMS	**13.40 (1424)**
VEC Diff	10.61
SPD RMS	**11.33**
SPD BAS	**-5.69**
VNRMS	0.56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