Arctic and Antarctic Satellite Composites: Construction and Applications

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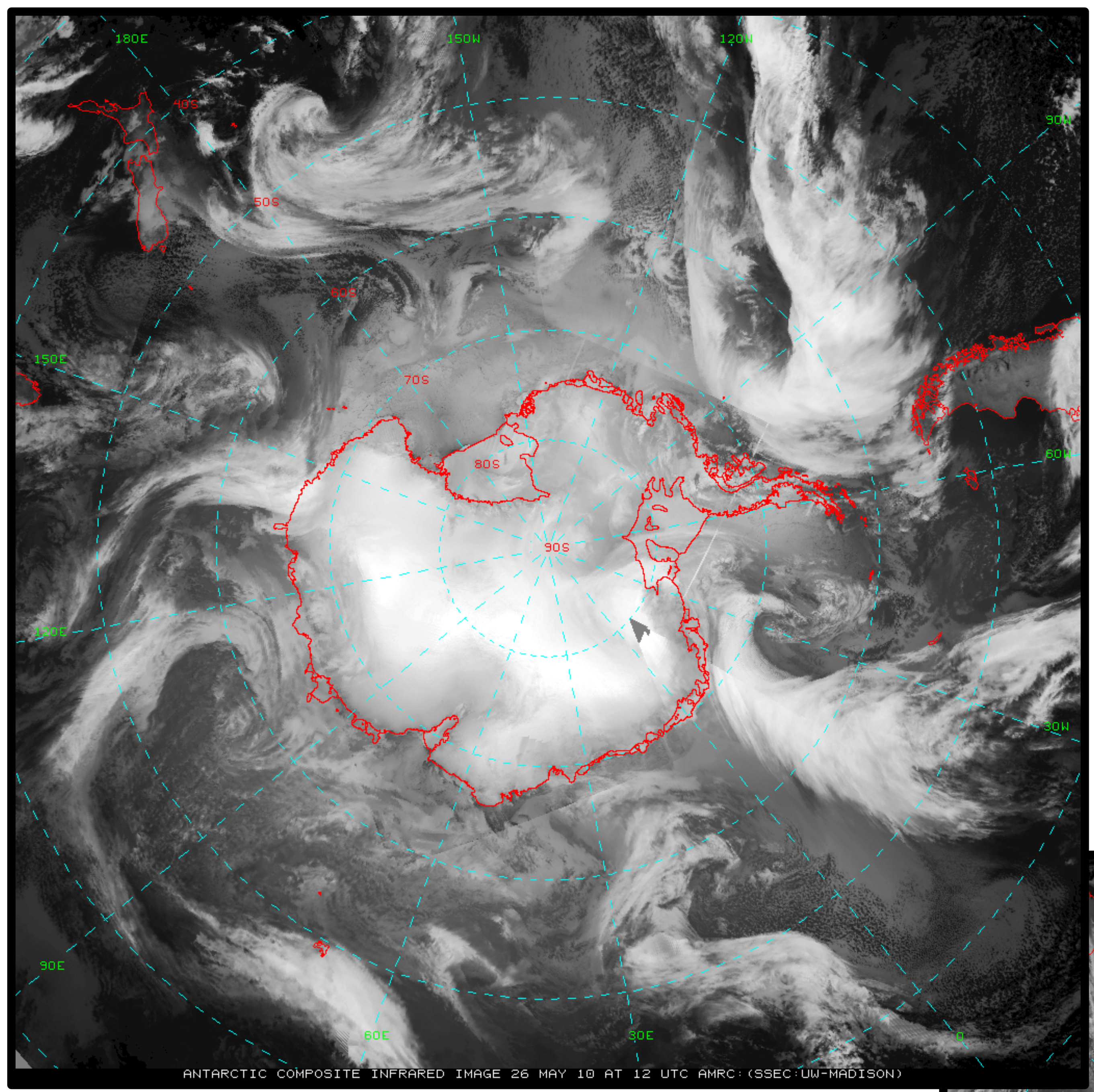
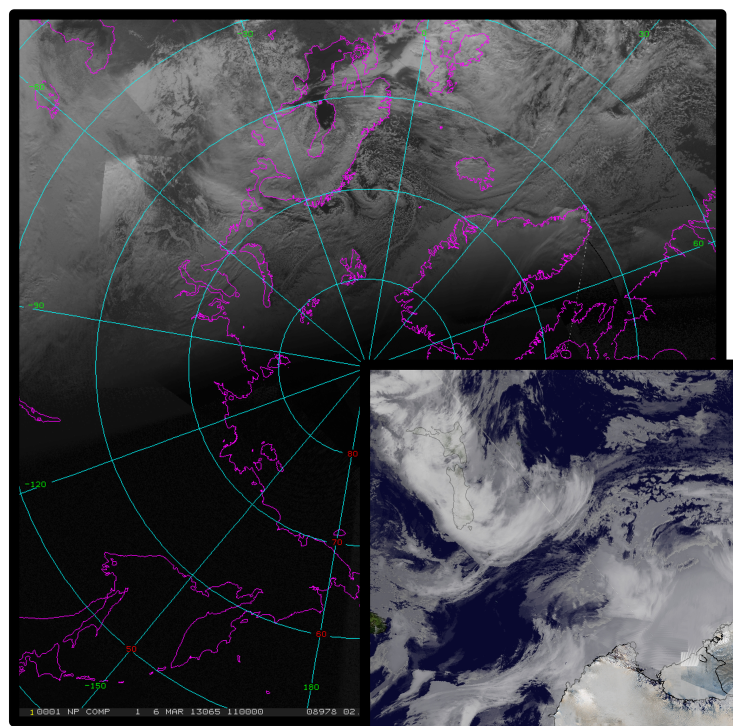
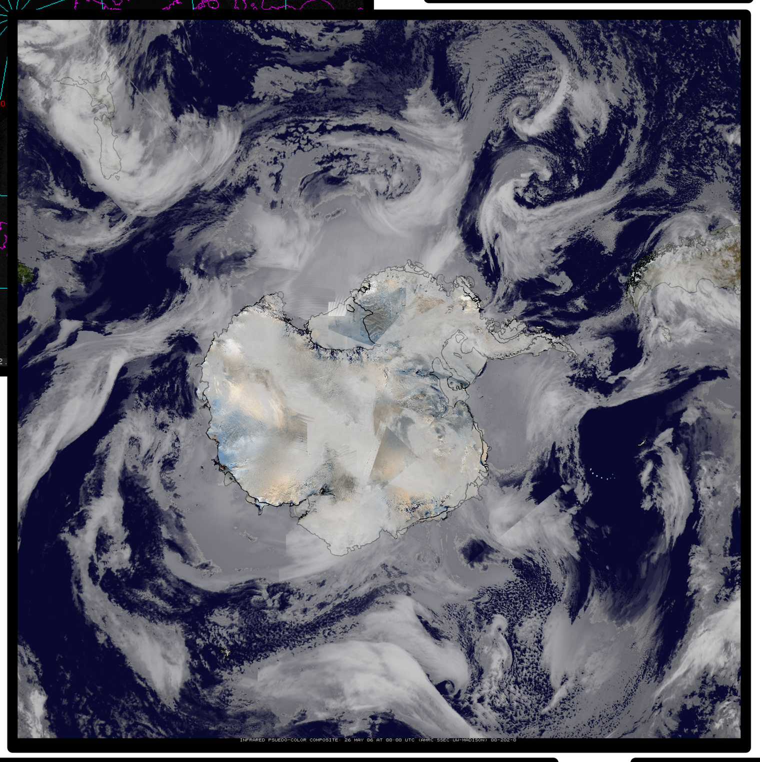
For over 20 years, the Antarctic Meteorological Research Center, Space Science and Engineering Center at the University of Wisconsin-Madison have generated composites of geostationary (GEO) satellites and polar-orbiting or low Earth orbit (LEO) satellites into a mosaic display over the Antarctic and adjacent Southern Ocean. This effort has expanded to the Arctic over the last half dozen years. These composites are created in the infrared window channel (~11.0 microns), longwave infrared (~12.0 microns), shortwave infrared (~3.8 microns), water vapor (~6.7 microns), and visible (~0.67 microns) channels that are most common to meteorological satellite observations. Generally made on an hourly basis, these composites are generated at as much as a 4-kilometer nominal resolution. The construction of the composite images has evolved over the years to consider a variety of factors including limb darkening, pixel resolution, observation time, and other weighting factors. Additionally, the composites have found a diversity of use in forecasting, education and operational arenas. The generation of atmospheric motion vectors (AMVs) from a version of these composites is being successfully produced, and the quality is on par with single satellite AMVs products. The generation of LEO/GEO composite AMVs fills a gap in the generation of global winds from all satellite platforms, and has shown impact when assimilated into the Global Forecast System (GFS).



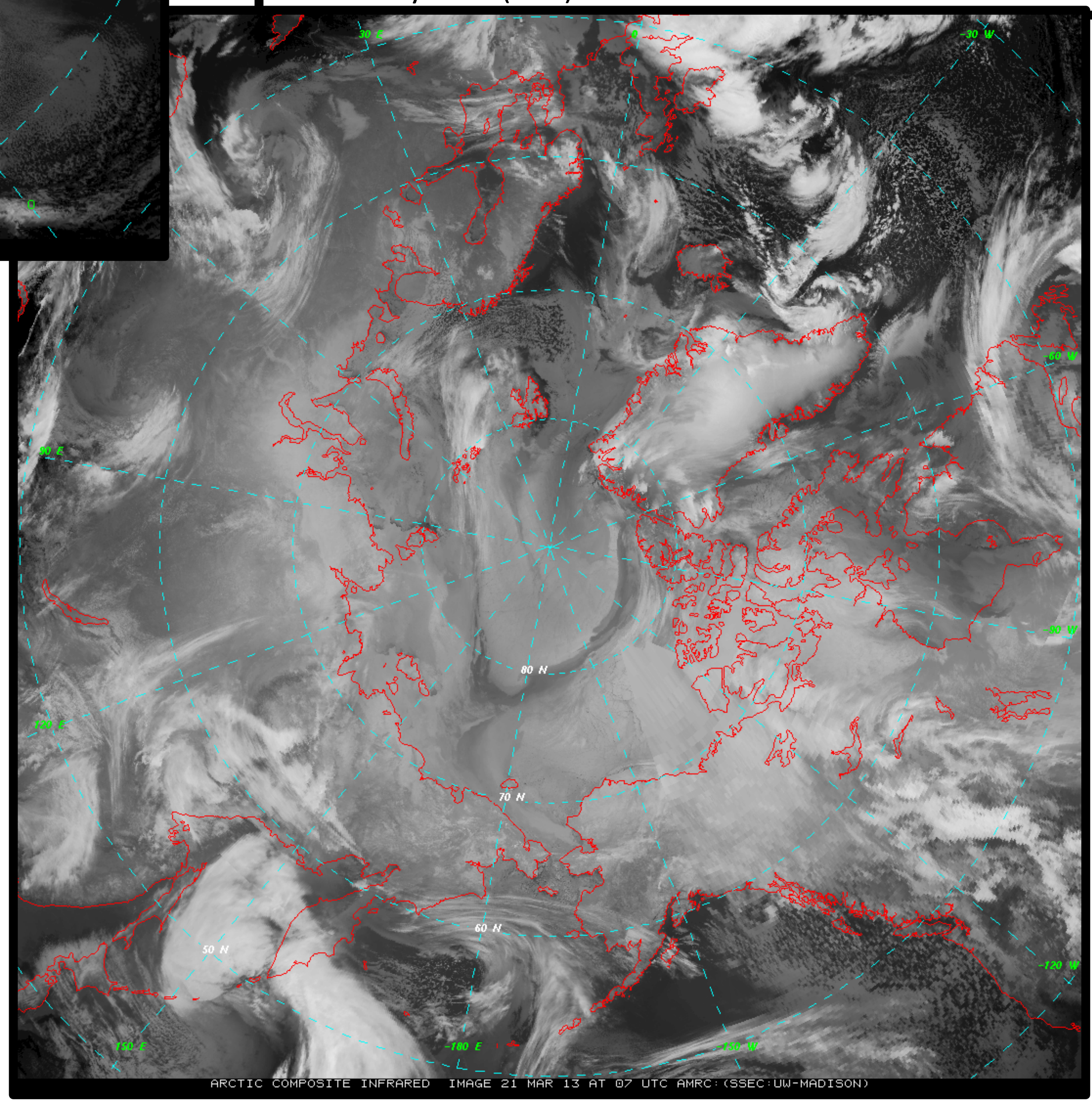
A sample Antarctic infrared composite image.



Visible Arctic composite image taken two weeks prior to the equinox.



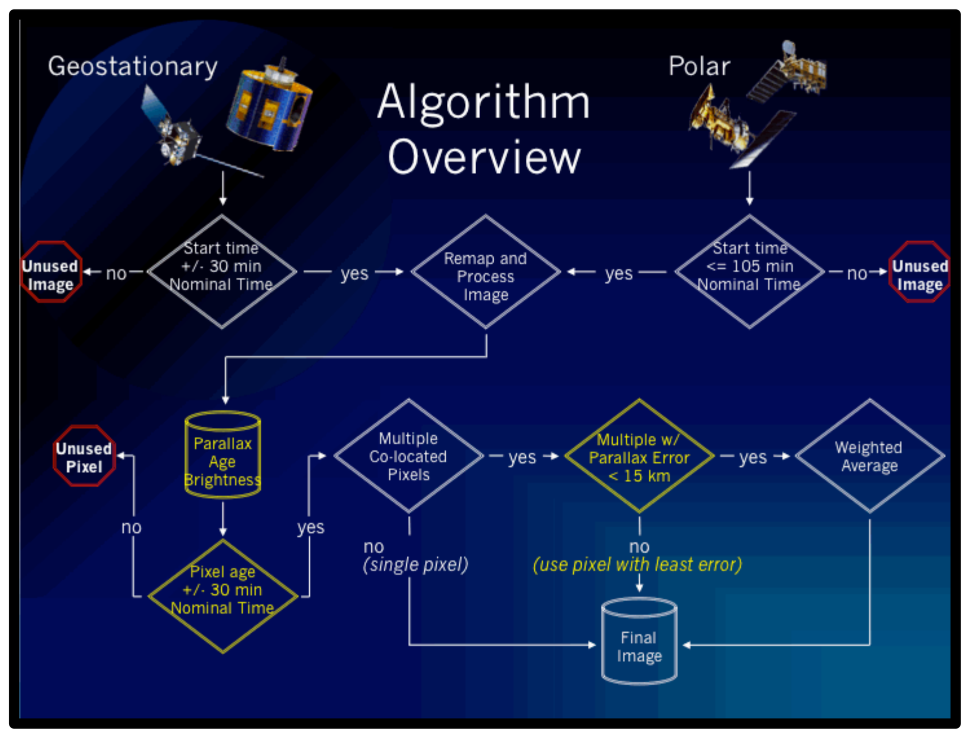
Antarctic infrared composite image over the NASA Blue Marble.

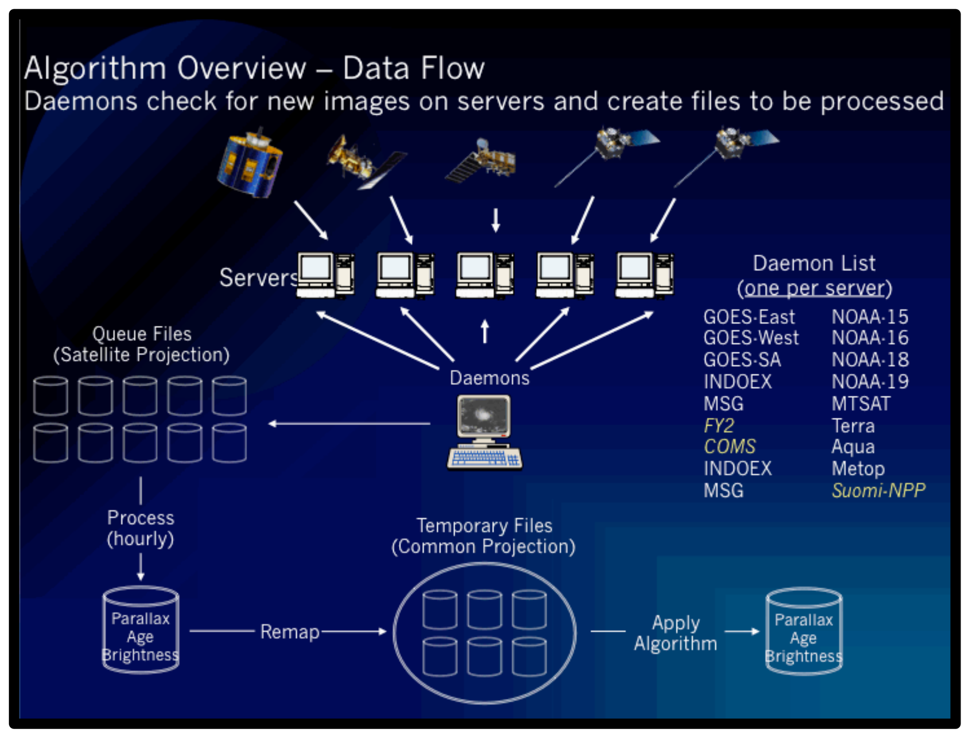


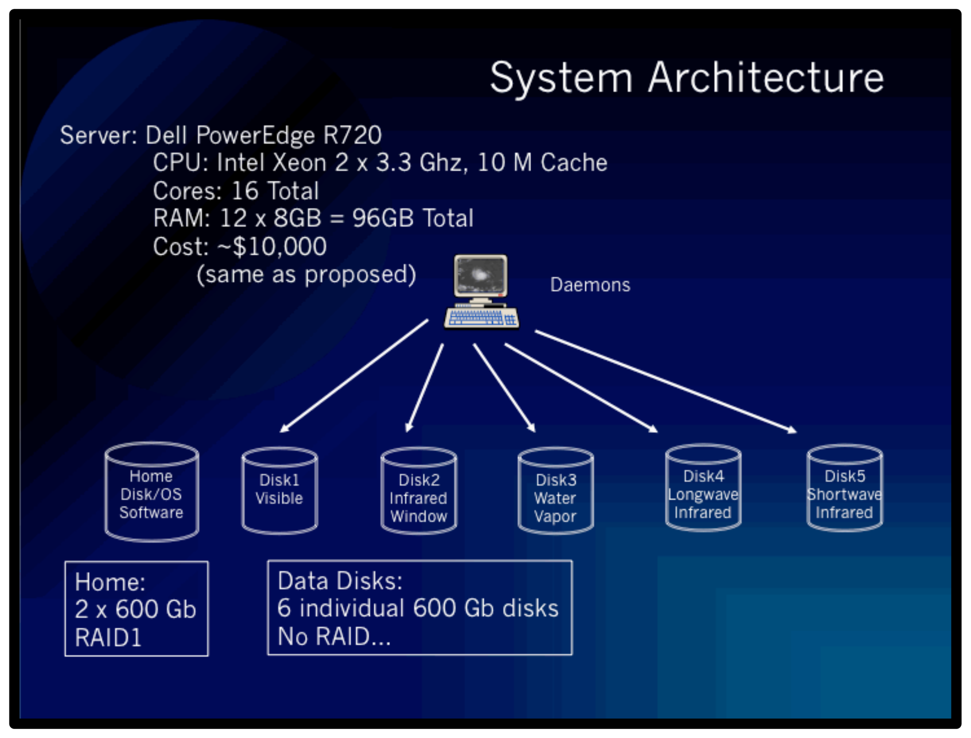
A sample Arctic Infrared composite image.

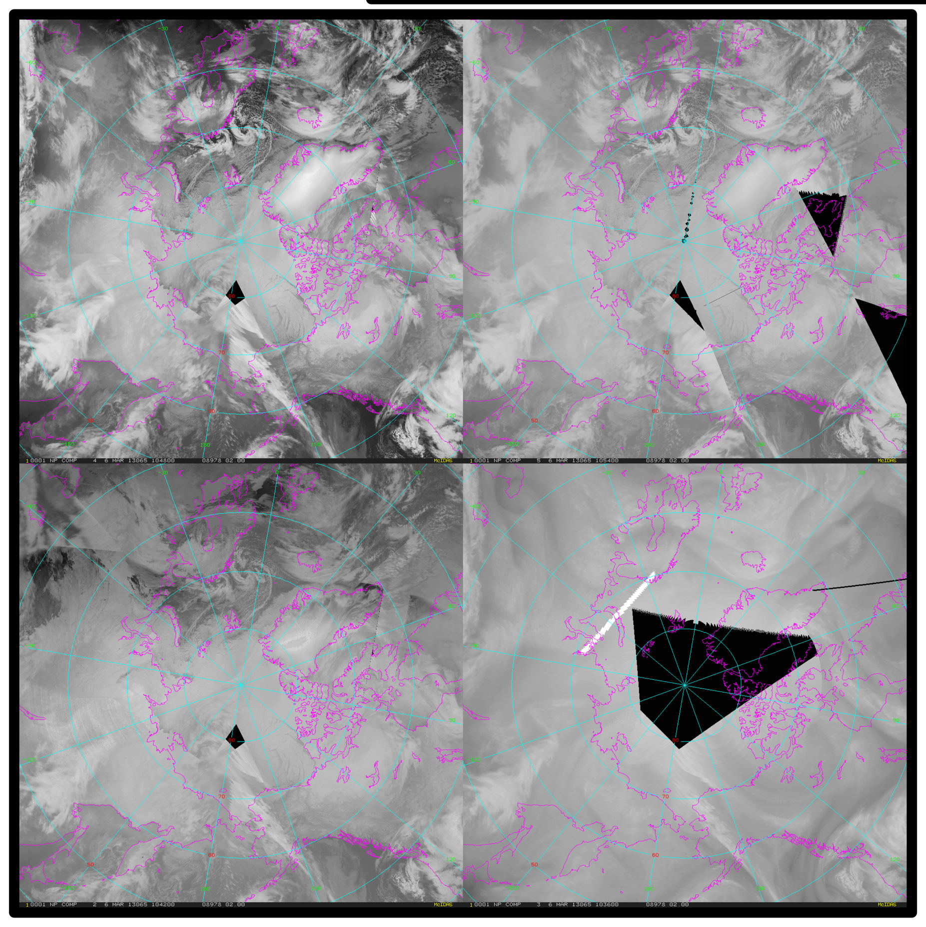
Table 1. Milestones in the development of Antarctic and Arctic composite imagery.

Historical Milestone	Date
First Antarctic Composite	30 October 1992
First test Arctic Composites	23 March 2000
First Antarctic Water Vapor Composite	2 May 2001
Upgrade of Antarctic Infrared Composite to 5 km resolution	1 November 2002
First Experimental Antarctic visible composite	1 January 2004
"Pseudo-color" Antarctic composites start	28 February 2005
First Generation Composites	30 October 1992 to 20 January 1997
Second Generation Composites	22 January 1997 to 2004
Start of formal Arctic Composites	2007
Hourly Antarctic Composites Begin	8 April 2009
Hourly Arctic Composites Begin	2009
Hourly Antarctic and Arctic visible composites formally begin	13 July 2011

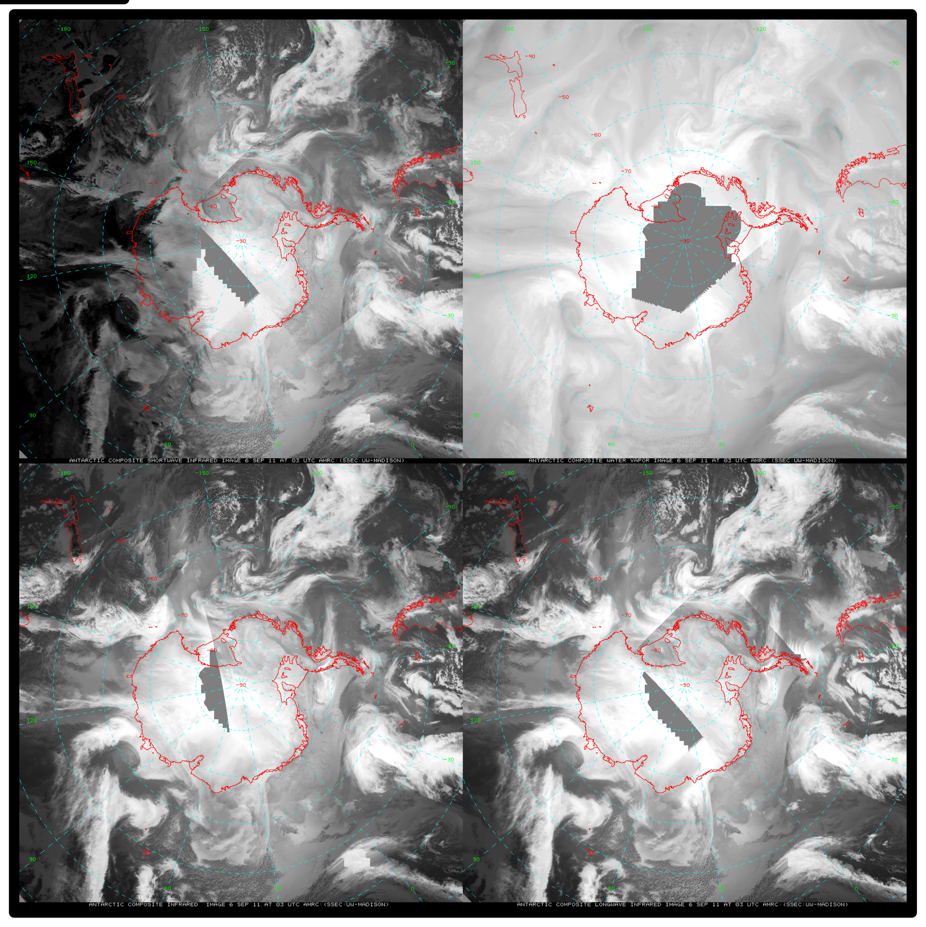




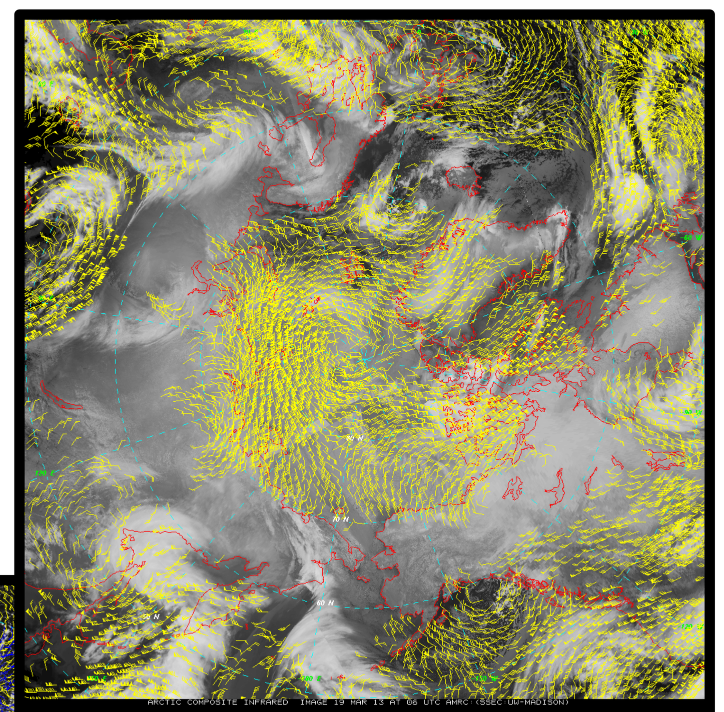


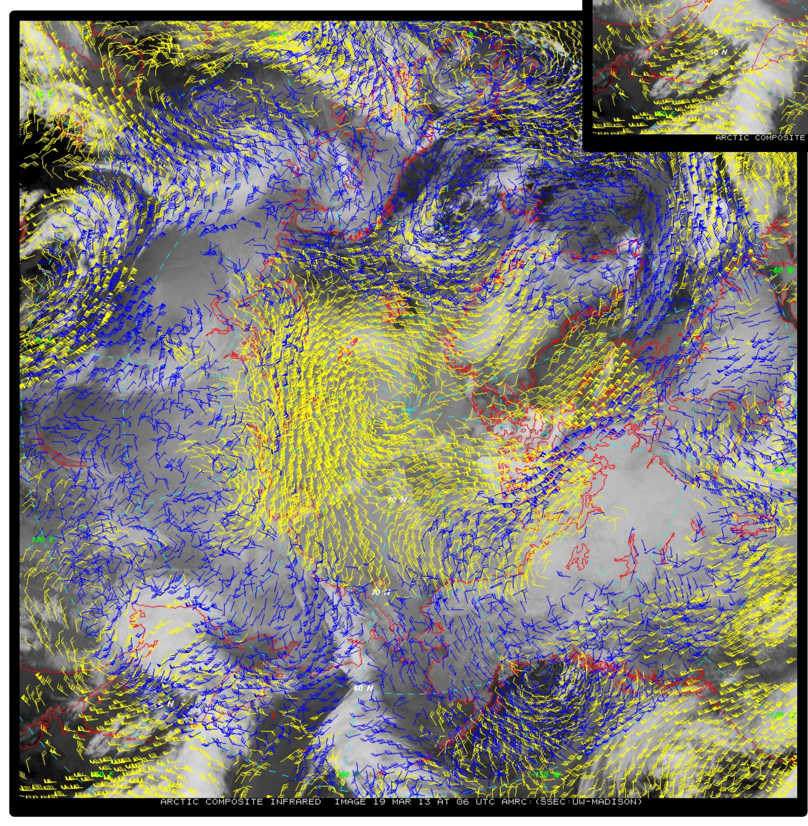


4-Panel Arctic composite



4-Panel Antarctic composite





Atmospheric motion vectors (AMVs) from geostationary and polar orbiting satellites do not cover a belt in the high latitudes. However, AMVs from a version of the composites does as depicted in this display 6 hours coverage of AMVs from 19 March 2013 from 3 to 9 UTC.

Table 3. Validation statistics for the composite LEO/GEO AMVs, partitioned by hemisphere and tropospheric layers (vector height assignments). NRMS is RMSE normalized by the mean AMV wind speed.

	Northern Hemisphere				Southern Hemisphere			
	> 700 hPa	*700 to >400 hPa*	*<=400 hPa*	*Total*	*> 700 hPa*	*700 to >400 hPa*	*<=400 hPa*	*Total*
Vector RMSE (ms^{-1})	4.81	5.98	7.06	6.21	6.18	7.12	9.19	7.82
U-Bias (ms^{-1})	-0.14	-0.39	-0.68	-0.45	+0.89	+0.42	-0.94	0.00
V-Bias (ms^{-1})	-0.05	-0.35	+0.16	-0.12	+0.36	-0.38	-2.55	-1.06
Vector NRMS	0.38	0.37	0.28	0.33	0.50	0.49	0.34	0.42
Mean AMV Speed (ms^{-1})	12.29	15.24	24.36	17.94	13.35	14.06	27.65	18.64
Sample Size	19988	61041	43156	124185	26	169	101	296

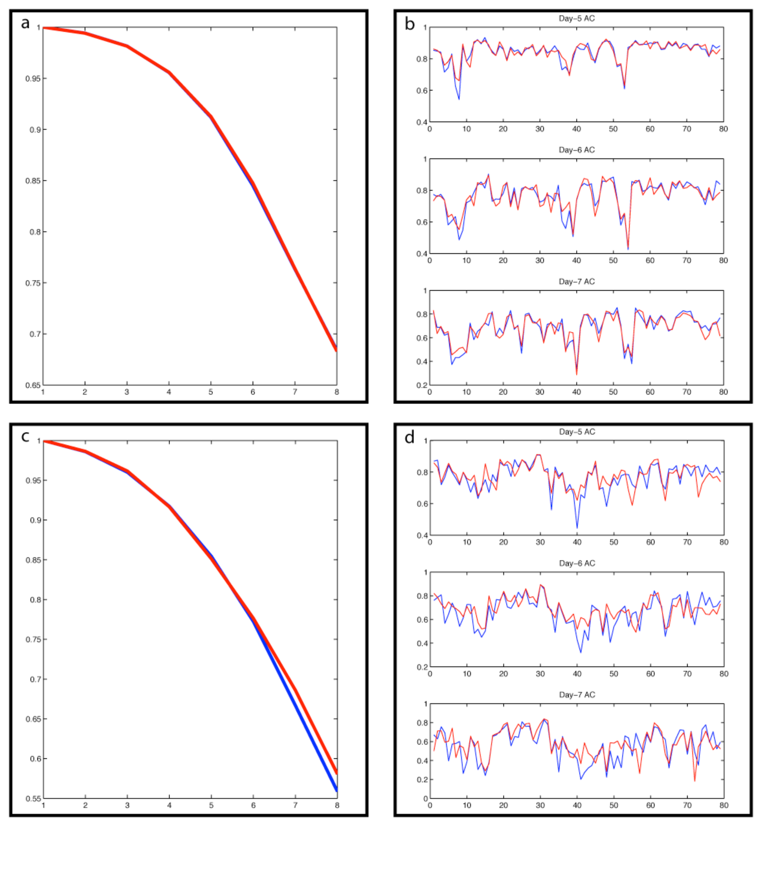
Table 4. Validation statistics for the composite LEO/GEO AMVs partitioned by latitude bands. NRMS is RMSE normalized by the mean AMV wind speed.

	Northern Hemisphere			Southern Hemisphere		
	>= 70°	*60° to <70°*	*50° to <60°*	*>= 70°*	*60° to <70°*	*50° to <60°*
Vector RMSE (ms^{-1})	7.38	6.20	6.21	8.28	8.17	6.64
U-Bias (ms^{-1})	+0.02	-0.38	-0.48	+0.06	+0.12	-0.68
V-Bias (ms^{-1})	+0.01	-0.25	-0.09	2.85	-1.55	-2.28
Vector NRMS	0.43	0.34	0.33	0.58	0.43	0.28
Mean AMV Speed (ms^{-1})	16.96	17.43	18.08	14.02	18.48	23.96
Sample Size	908	26626	96651	40	215	41

Table 2. Satellites used in the making of Arctic and Antarctic composite imagery.

Geostationary		Polar Orbiting	
Satellite Series	*Satellites*	*Satellite Series*	*Satellites*
Geostationary Operational Environmental Satellite (GOES)	GOES-East GOES-West GOES-South America	Polar-orbiting Operational Environmental Satellite (POES)	NOAA-15 NOAA-16 NOAA-18 NOAA-19
Meteosat (at 0° and 57° East)	Meteosat-7 Meteosat-8 Meteosat-9	Earth Observing System (EOS)	Terra Aqua
Multi-Function Transport Satellite (MTSAT)	MTSAT-1R MTSAT-2	EUMETSAT Polar-orbiting System (EPS)	Metop-A Metop-B
Fen Yung-2	FY-2C FY-2D FY-2E		

Mean 500 hPa height anomaly correlations for the northern hemisphere cold season composite AMV experiment. The blue (red) contour represents the control (experiment) height anomaly correlation for (a) the Northern Hemisphere's day 1-8 forecast, (b) the Northern Hemisphere's running means for day-6, day-7, and day-8 forecasts, (c) the Southern Hemisphere's day 1-8 forecast, and (d) the Southern Hemisphere's running means for day-6, day-7, and day-8 forecasts. Composite AMVs do improve the forecast skill in the later time periods



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Poster by Matthew Lazzara