A 27-year record of satellite-derived polar winds for retrospective analyses

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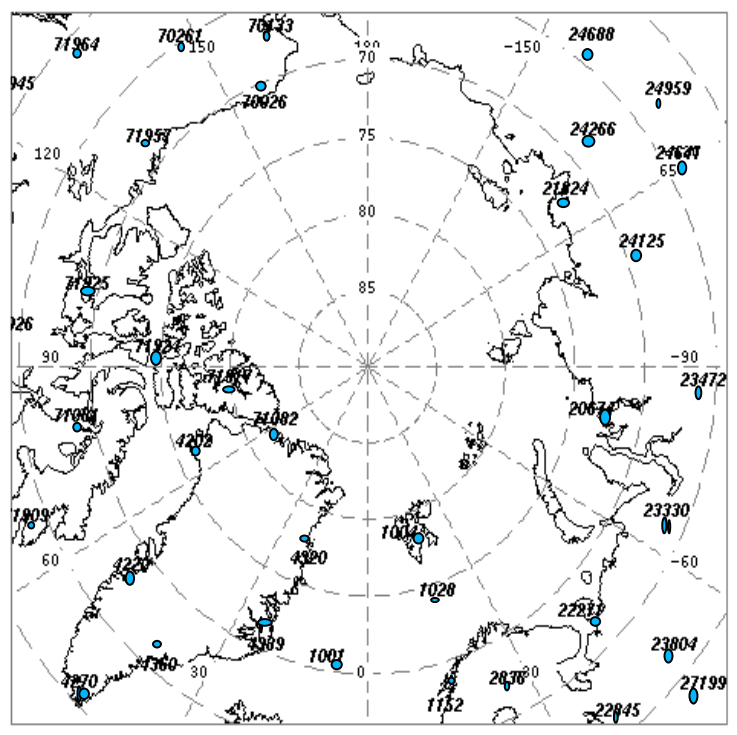
Outline

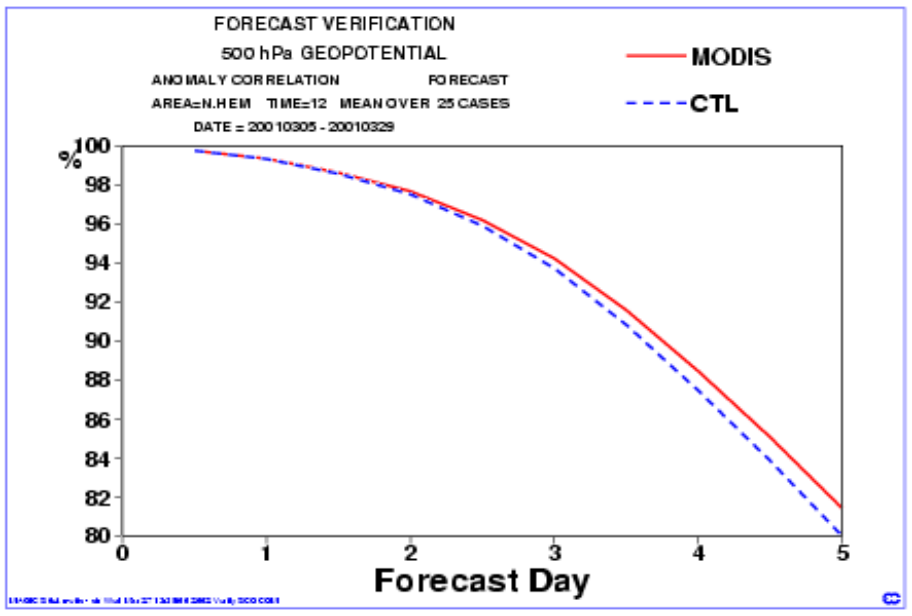
- Motivation
- Data
  - Moderate Resolution Imaging Spectroradiometer (MODIS)
  - Advanced Very High Resolution Radiometer (AVHRR)
- Some issues
- Validation
- Summary and status

Motivation for Polar Wind Data

1. Sparsity of RAOBs



2. MODIS polar winds have a positive impact on forecasts



Motivation for Polar Wind Data

3. Reanalysis Wind Errors

Francis (2002) found NCEP/NCAR and ECMWF Reanalysis winds had large biases when compared to rawinsonde winds that were not assimilated into the reanalysis.

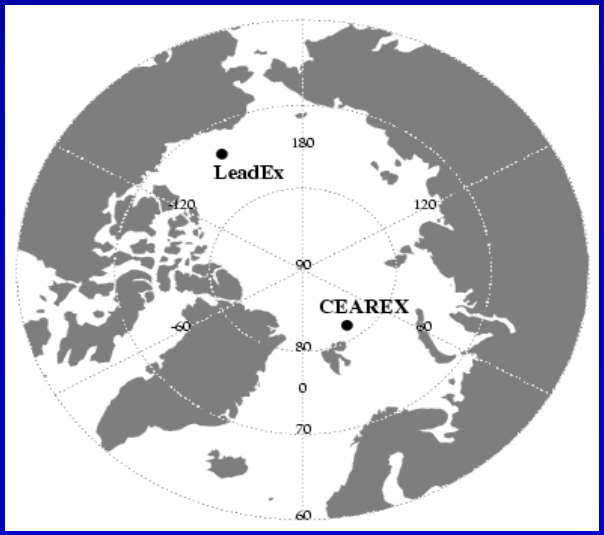
Implications from Francis and Hunter, 2005:

1) Meridional temperature gradients near the experiment sites are too strong.

2) Semi-permanent, synoptic scale features in the upper-level circulation may be misplaced.

3) Using the reanalysis winds to advect energy or moisture, would produce values that are likely too small in the poleward sense.

Both reanalyses exhibit large biases in zonal and meridional wind components, being too westerly and too northerly. Winds are too strong by 25-65%.



Motivation for Polar Wind Data

4. The Community

Recommendations from the 9th International Winds Working (IWW) Workshop (Annapolis, Maryland 14-18 April 2008) to the Coordination Group for Meteorological Satellites (CGMS) includes the reprocessing the AVHRR winds (preliminary proceedings).

The World Climate Research Programme, Global Climate Observing System (WCRP/GCOS) Atmospheric Observation Panel for Climate (AOPC) stated in their list of recommendations (subject to final confirmation) from their 21-25 April 2008 meeting (Geneva, Switzerland): "*AOPC noted in particular that GCOS had previously (in GCOS-107) recognized AVHRR data as a unique fundamental climate record, and thus especially welcomed the plans to derive cloud, aerosol and polar-wind products from reprocessing the complete AVHRR record.*"

The ECMWF will be proposing "*a new reanalysis project covering typically 75 years (from 1938 until 2013). We will of course expect a strong collaboration with your group on the generation of historical polar winds from AVHRR which will be a crucial dataset for us, especially in the 1970-2000 time range.*"

Motivation for Polar Wind Data

5. The Past and the Future

MODIS polar winds: This era is limited to approximately 2000 to 2013(?); Terra and Aqua satellites are already beyond their designed lifetimes.

AVHRR polar winds: Complement the current MODIS winds dataset, though the AVHRR is less robust in terms of spectral channels and spatial resolution.

Future polar satellite sensors: Visible/Infrared Imager/Radiometer Suite (VIIRS) on the NPP satellite, are similar to the MODIS, but lack a water vapor channel.

Therefore, a long-term record of satellite-derived polar winds will only be available using AVHRR-like instruments, which have been around since the 1970s and will continue into the next decade.

Historical AVHRR Dataset

AVHRR on board the NOAA polar orbiting satellites.

Approximately 14 orbits per day with about 100 minute orbital period.

There are two operational NOAA satellites at a given time: AM and PM orbits.

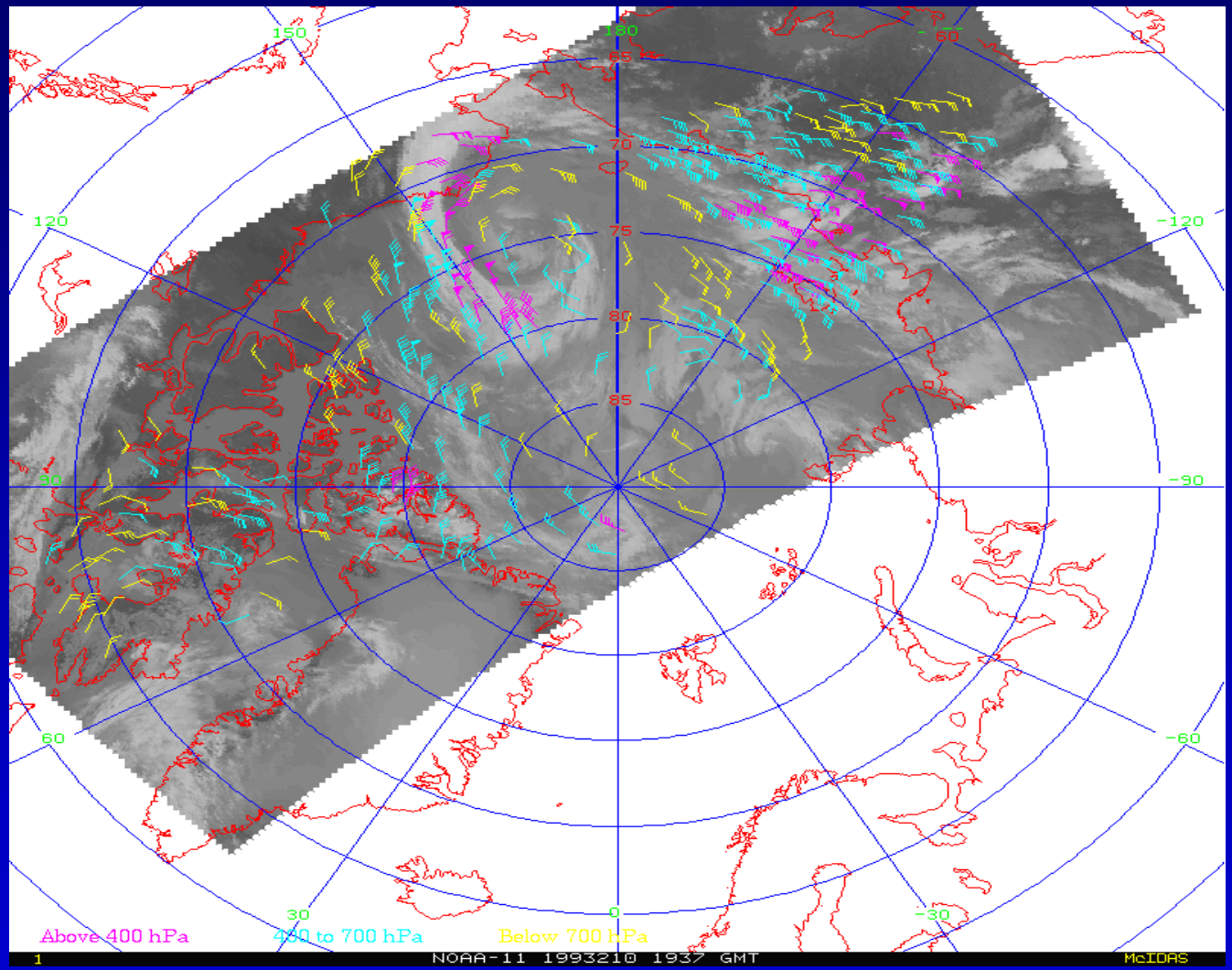
Only the 11 μm IR (channel 4) is used to track cloud features.

Data has been extended into the first half of 2009.

NCEP-NCAR reanalysis grids every 6-hr from 1981 into 2009 are used as first guess and for temperature profile.

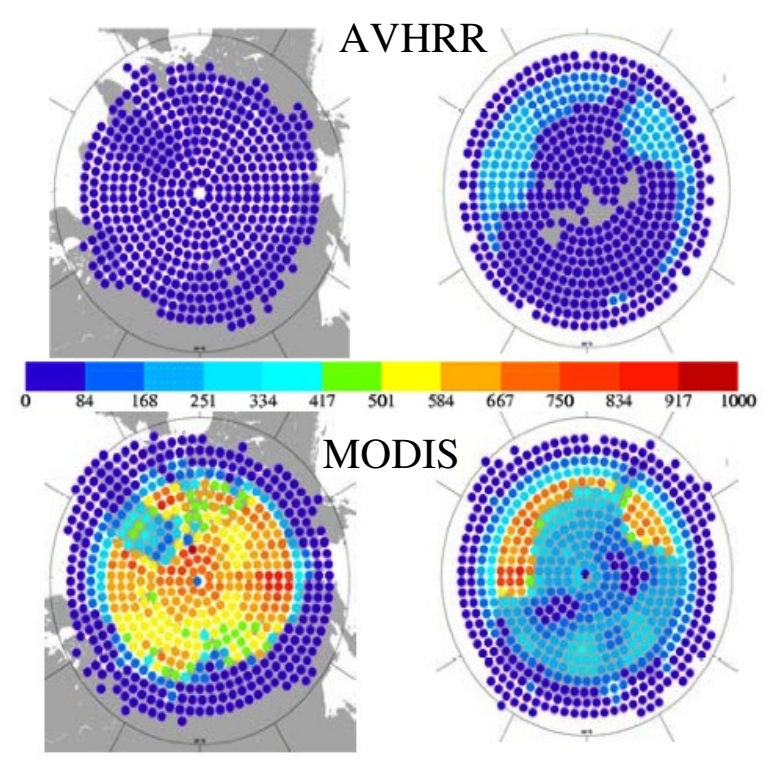
NOAA Satellite	Years
7	1982-85
9	1985-88
10	1986-91
11	1988-94
12	1991-98
14	1995-00
15	1999-02
16	2001-07
17	2002-08

Example of feature tracking from NOAA-11



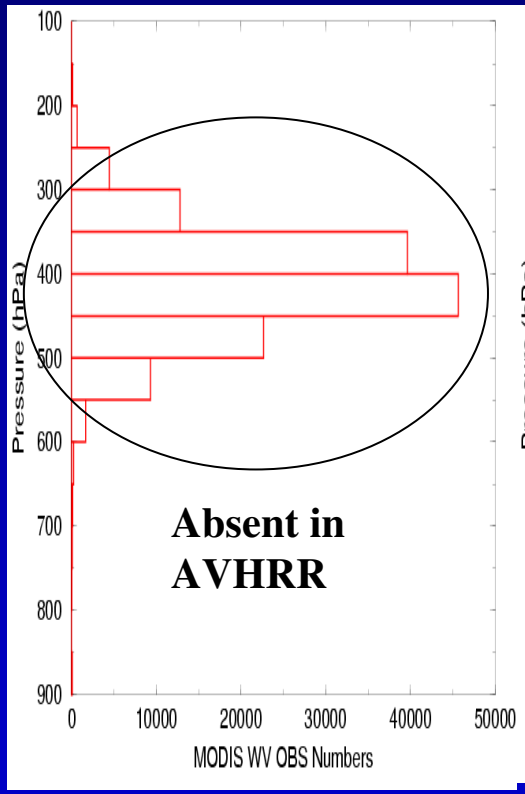
Cyclone over the Arctic Ocean: 29 July through 06 August 1993.

Caveats: Density and vertical distribution

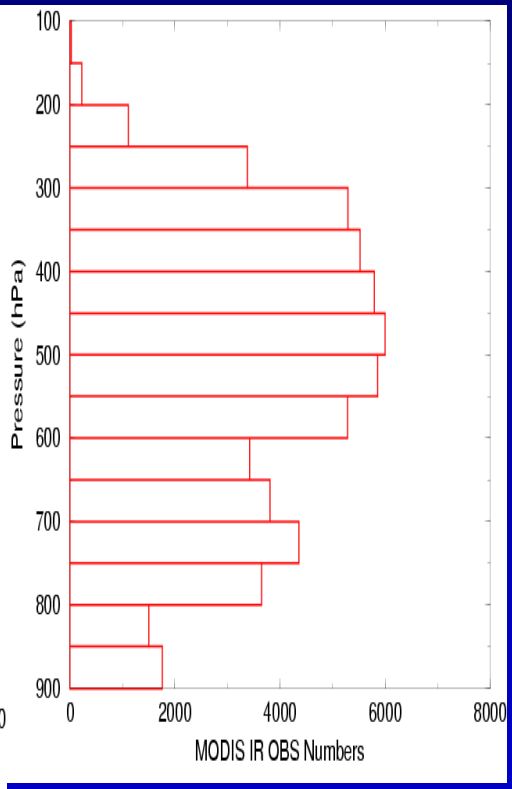


(Delsol et. 2008)

Spatial Coverage Frequency



Vertical frequency of
MODIS WV AMVs

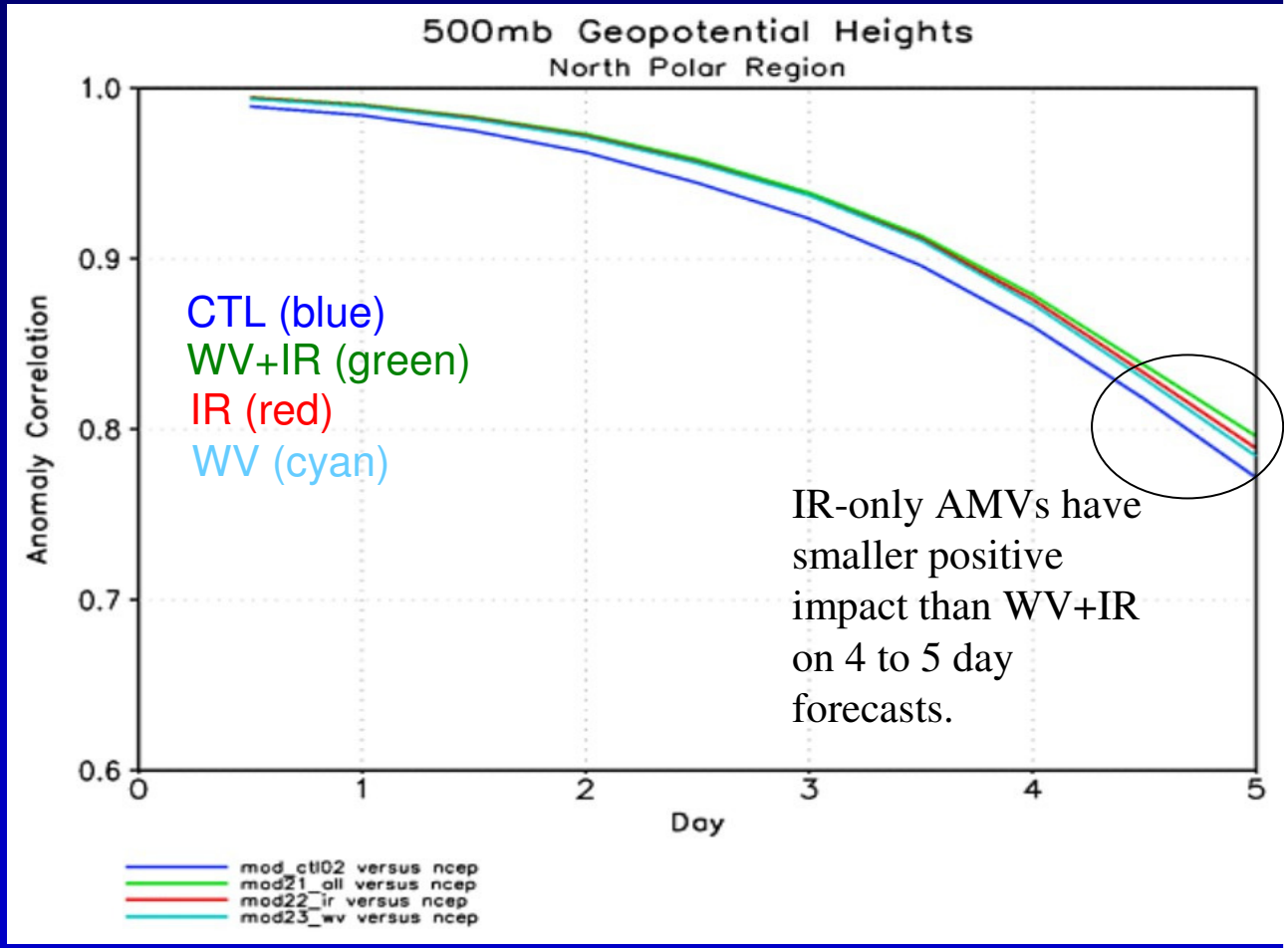


Vertical frequency of
MODIS IR AMVs

(Courtesy of GMAO)

Caveats: Infrared-only

- AVHRR does not have a water vapor channel
  - Fewer mid-level winds than MODIS
  - Potential less impact on forecasts



(Preliminary results courtesy of GMAO)

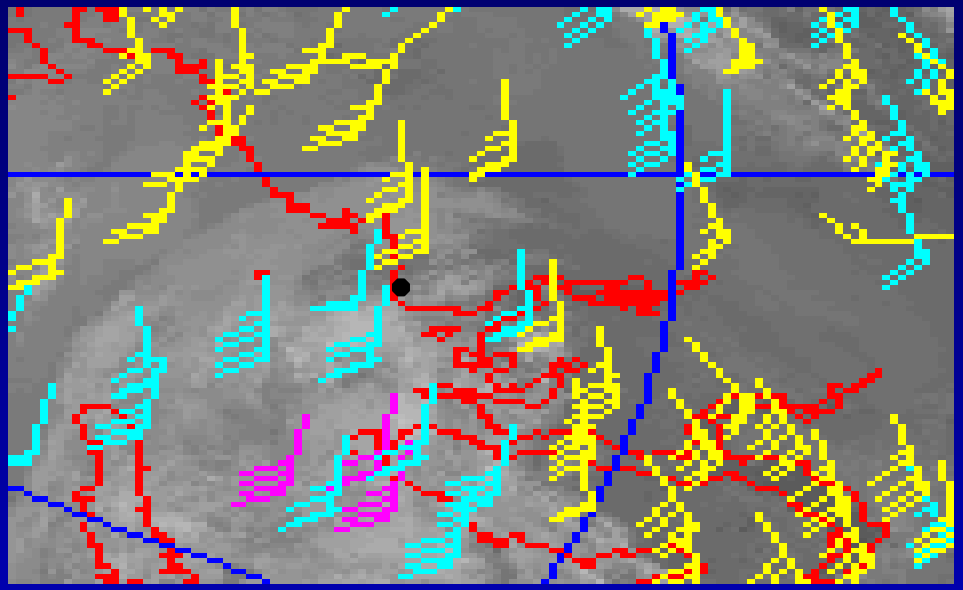
Caveats: Height assignment

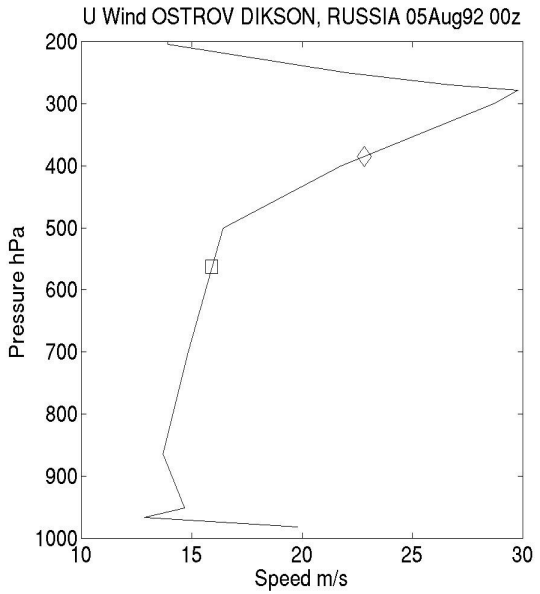
AVHRR AMV:
U_Wind Speed = 23 m/s
Direction = 263°
Target Temp = -18 ℃

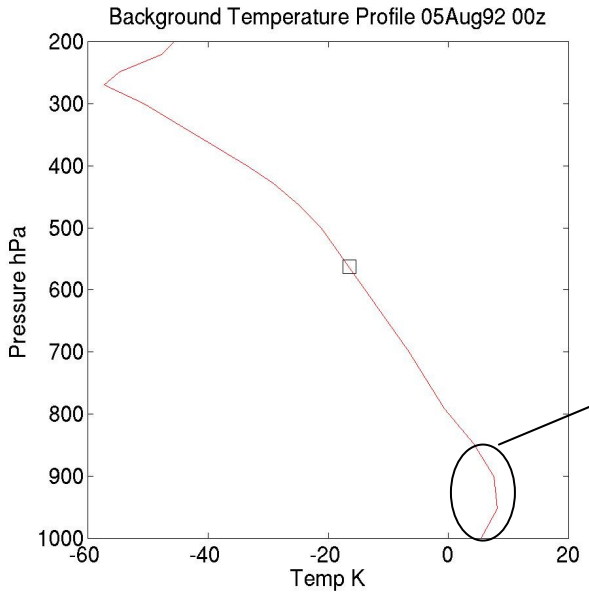
□ 560 mb AMV height

◇ 390 mb bestfit height

Optical Depth = 2.1
Transmission = 0.1







Low-level inversions and isothermal layers can produce height assignment errors for low-level winds.

Validation

Comparison to RAOBS indicate that the AVHRR AMVs are of good quality (AMVs at low levels over the Antarctic being the only exception) with the lowest vector RMSE at midlevels.

Comparison to CEAREX and LeadEx indicate that AVHRR AMVs have smaller error statistics than the reanalysis and should be assimilated into both ERA-40 and NCEP-NCAR reanalyses.

More detailed information:
Dworak and Key, 2009. Twenty Years of Polar Winds from AVHRR: Validation and Comparison with ERA-40. *Journal of Applied Meteorology and Climatology*, 48, 24-40.

Status

A first pass through the 27-year AVHRR dataset is complete; available at ftp://stratus.ssec.wisc.edu/pub/winds/histavhrr/

Data available in: BUFR, text, and McIDAS MD file formats.

The data has been catalogued in a database and scripts have been modified to permit the reprocessing on a computing cluster.

The procedure has been enhanced to account for parallax in the AVHRR satellite data.

Two new sample datasets have been produced: January-February and June-July 2009.

Status

MODIS winds are being regenerated for this same 4 month time period:

- using data from the NASA archive,
- accounting for parallax, and
- correcting for detector striping.

Experiments using these AVHRR and MODIS winds datasets will be run at the NASA GMAO using the Goddard Earth Observing System version 5 (GEOS-5).

Upon successful results of the experiments, the entire historical AVHRR winds dataset will be regenerated sometime in 2010.

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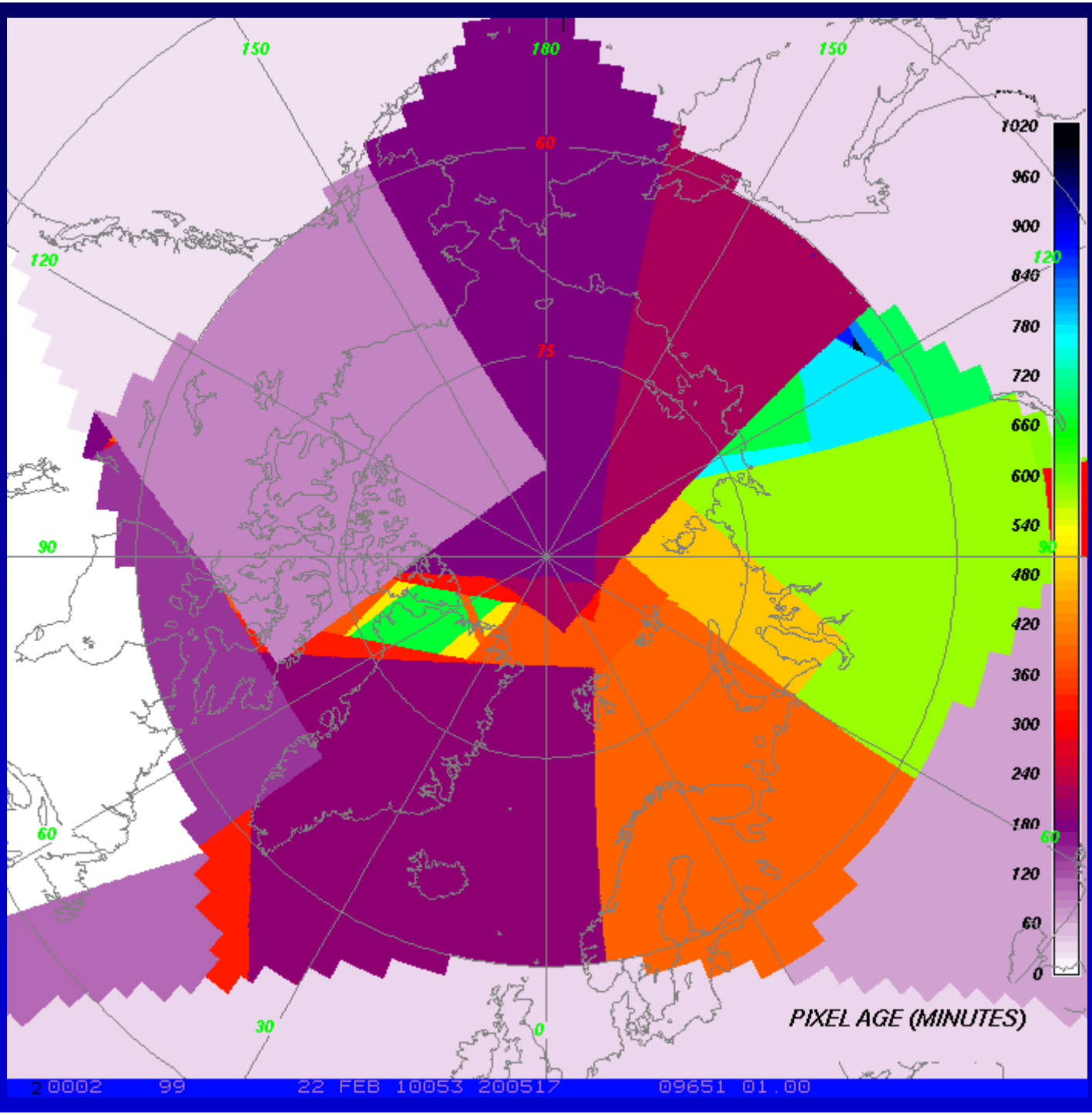
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McIDAS-X 2005: daves@chinook.ssec.wisc.edu
BEFORE
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7 0007 TERRA-L1B 27 3 DEC 09337 181500 03981 01781 04

Overview of Wind Generation Method

Calibration and navigation of AVHRR data

Calculate local brightness temperature gradients and find targets: 13x13 box

Determine height of target by Infrared Window Channel Method

Create search box and find highest correlated point between target and search box

Acceleration check on sub-vectors of triplets

Post-processing: Recursive Filtering (RF) and Quality Indicator (QI) values are calculated

Check RF and QI values, and any vectors that surpass threshold are accepted.