

A 27-YEAR RECORD OF SATELLITE-DERIVED POLAR WINDS FOR RETROSPECTIVE ANALYSES

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Abstract

A major gap has historically existed in the global observing system because very few routine measurements of winds are made over the Arctic Ocean and most of the Antarctic continent. This gap has been somewhat mitigated since the early 2000s with the routine retrieval of tropospheric winds in the polar regions by tracking cloud and water vapor features in Moderate Resolution Imaging Spectroradiometer (MODIS) data from the Terra and Aqua satellites. Model impact studies from numerical weather prediction centers worldwide have demonstrated a positive impact on forecasts in the Arctic, Antarctic, and extending into the extratropics with the assimilation of the MODIS winds.

Unfortunately, the era of MODIS polar winds will be limited to no more than several more years as the Terra and Aqua satellites are already beyond their designed lifetimes. Winds derived from NOAA's Advanced Very High Resolution Radiometer (AVHRR) instrument complement the current MODIS winds dataset, though the AVHRR is less robust in terms of spectral channels and spatial resolution. Future polar satellite sensors, for example the 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.

We have begun reprocessing 27 years of AVHRR data to generate a polar winds dataset that can be used in reanalysis efforts. Select time periods are being identified to run limited experiments using time-coincident MODIS and AVHRR winds. The forecast impact of these short-term datasets will be evaluated, in collaboration with the NASA GMAO, using the Goddard Earth Observing System Data Assimilation System Version 5 (GEOS-5). This is in preparation for the entire AVHRR winds dataset to be input into the GMAO's Modern Era Retrospective-analysis for Research and Applications (MERRA) and similar systems in future reanalysis cycles.

INTRODUCTION

The generation of polar satellite-derived Atmospheric Motion Vectors (AMV) began in the early 2000s using data from the MODIS instrument onboard the Terra and Aqua satellites. This has been extended to the AVHRR instrument on the current operational NOAA and Metop polar orbiting satellites. The AVHRR polar winds complement the current MODIS winds dataset, though the AVHRR is less robust in terms of spectral channels and spatial resolution. However, the MODIS polar winds era will be limited to approximately the years 2000 to 2015 as the Terra and Aqua satellites are already beyond their designed lifetimes. In addition, the VIIRS sensor on the NPP satellite is similar to the MODIS, but lacks 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.

DATASET

The historical record of AVHRR data we obtained extends from NOAA-7 in 1982 through NOAA-18 in mid-2009 (Table 1). During most of that time period, two operational satellites are available at a given time from AM and PM orbits. Since the 11 μm IR (channel 4) is used to track cloud features at this time, we have only archived that channel.

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	2002-09
18	2005-09

Table 1: NOAA polar-orbiting satellites and the years of coverage in our archive.

The wind derivation process requires model output grids for a first guess in the tracking process and the temperature profile to assign a cloud height. Grids from the National Centers for Environmental Prediction–National Center for Atmospheric Research (NCEP–NCAR) reanalysis, available every 6 hours, from 1981 into 2009 are used.

Also, the entire 27-year AVHRR dataset and the NCEP/NCAR reanalysis grids were catalogued in a PostgreSQL database. This will permit better access to the data and make it possible to easily move the processing to our cluster computing facility, providing much faster reprocessing of the entire record.

DATA PROCESSING

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

The output wind files are in the following formats:

- Binary Universal Form for the Representation of meteorological data (BUFR)
- ASCII text
- Man computer Interactive Data Access System (McIDAS) Meteorological Data (MD) files
- GIF images of each satellite image overlaid with wind vectors (Figure 1).

This initial pass through the data provides a baseline as we make enhancements and updates to the winds derivation software. The updates will include a correction for parallax and additional error information.

Select time periods were identified to run limited experiments using time-coincident MODIS and AVHRR winds. The forecast impact of these short-term datasets will be evaluated, in collaboration with the NASA GMAO, using the Goddard Earth Observing System Data Assimilation System Version 5 (GEOS-5). This is in preparation for the entire AVHRR winds dataset to be input into the GMAO's Modern Era Retrospective-analysis for Research and Applications (MERRA) and similar systems in future reanalysis cycles. Four months of data were selected for these experiments: January/February and June/July 2009. These were run for NOAA-17 and NOAA-18, with additional processing to account for parallax. This data set has been sent to the GMAO for evaluation.

Also, the MODIS winds are being reprocessed for the same four-month period. This dataset will be superior to our real-time product because:

- a) parallax correction is included
- b) detector variation in the MODIS images is reduced through a destriping algorithm

- c) the vector times are corrected to the satellite pole-crossing time
- d) output to BUFR files is added

This MODIS dataset will also be sent to the GMAO for evaluation.

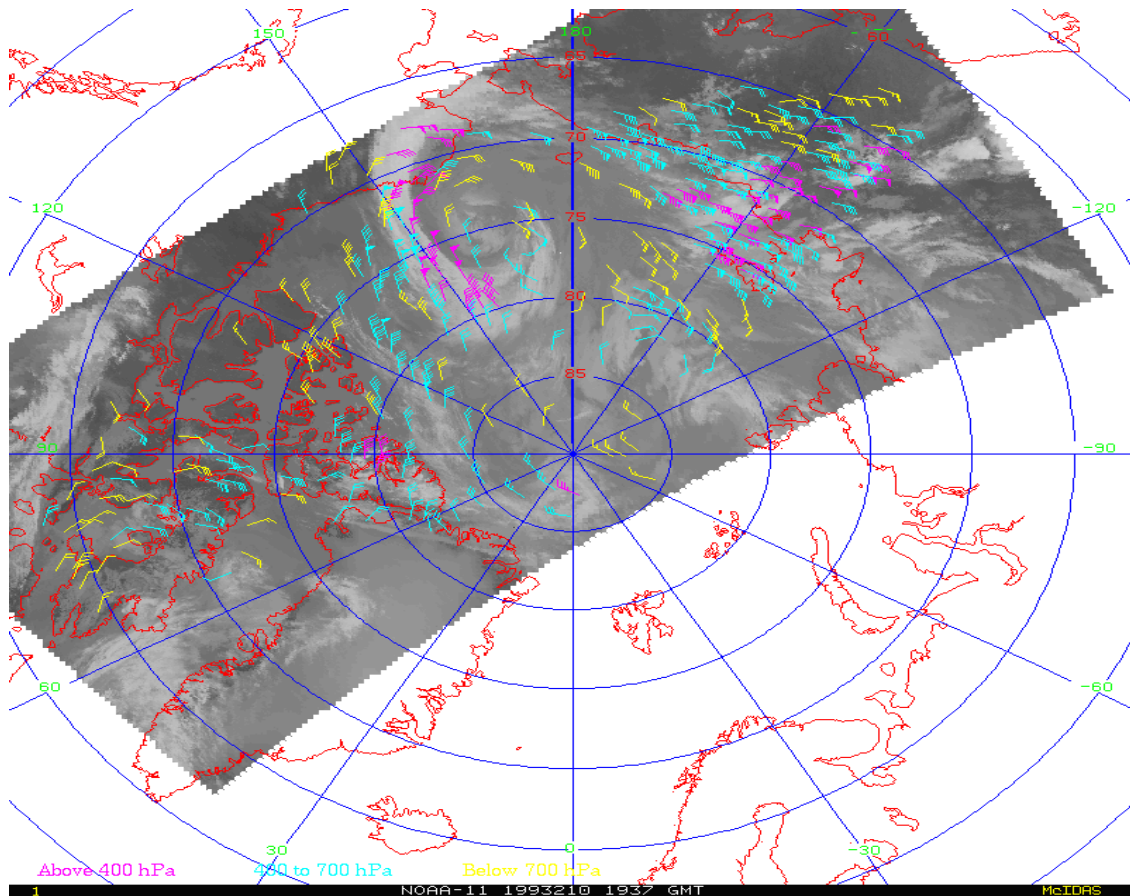


Figure 1: AMVs plotted over NOAA-11 image from 29 July 1993 at 1937 UTC.

VALIDATION

A study by Dworak and Key (2009) compared the AVHRR polar winds to RAOBS and found that the AMVs are of good quality (AMVs at low levels over the Antarctic being the only exception) with the lowest vector RMSE at midlevels. When comparing the AVHRR AMVs to CEAREX and LeadEx RAOBS, the AVHRR AMVs have smaller error statistics than both the ERA-40 and NCEP-NCAR reanalyses. Since these reanalyses did not include these field program RAOBS, it indicates that the AVHRR winds will provide additional information at these high latitudes.

STATUS

A first pass through the 27-year AVHRR dataset using the two operational satellites is complete. The data has been catalogued in a database and scripts have been modified to permit the reprocessing on a computing cluster. Additional processing steps have been added, including parallax for the AVHRR data and destriping for the MODIS data.

Experiments using these AVHRR and MODIS winds datasets will be run at the NASA GMAO using the GEOS-5. Upon successful results of the experiments, the entire historical AVHRR winds dataset will be regenerated sometime in 2010.

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REFERENCES

Dworak and Key, 2009. Twenty Years of Polar Winds from AVHRR: Validation and Comparison with ERA-40. *J. Appl. Meteor. Climatol.*, **48**, 24-40.