A Blended Polar Winds Product using Atmospheric Motion Vectors from MODIS Imager and AIRS Moisture Retrieval Data

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Year 1 Progress Report
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Proposed Work

The study and generation of polar winds from the Moderate Resolution Imaging Spectroradiometer (MODIS) imagery was pioneered at the University of Wisconsin by NOAA and the Cooperative Institute for Meteorological Satellite Studies (CIMSS) in the early 2000s. The MODIS polar winds product is composed of both infrared window (IR-W) and water vapor (WV) tracked features, resulting in atmospheric motion vectors (AMVs). The WV AMVs are only attainable at mid- and upper- tropospheric levels due to the MODIS WV atmospheric contribution function, while IR-W images also provide cloud tracers for vectors at lower levels. However, the WV AMVs yield a better spatial distribution than the IR-W since both cloud and clear-sky features can be tracked in the WV images.

As the next generation polar satellite era approaches, it is recognized that there is currently no WV channel planned on the Visible/Infrared Imager/Radiometer Suite (VIIRS), potentially resulting in a data gap with only IR-W derived AMVs possible. This scenario presents itself as an opportunity to investigate using Single Field of View (SFOV) Atmospheric Infrared Sounder (AIRS) moisture retrievals from consecutive overlapping polar passes to extract atmospheric motion from clear-sky regions on constant (and known) pressure surfaces; i.e., estimating winds in retrieval space rather than radiance space.

The goal is to generate a blended product of MODIS imager- and AIRS retrieval-derived AMV datasets. This will be important in preparation for the NPOESS Preparatory Project (NPP) where moisture retrievals derived using the Cross-Track Infrared Sounder (CrIS) could provide the fields to produce clear-sky AMVs.

We propose to:

- Determine to what extent AIRS-derived AMVs can provide coherent and good quality wind information, and characterize the errors. This technique has the potential to provide a 3-dimensional (profiles of wind) dataset, which would improve on the traditional cloud drift AMVs, while also addressing issues with AMV height determination.
- Blend the experimental AIRS moisture retrieval AMVs with the already proven MODIS AMVs in an optimal way to create superior 3-D polar wind fields.
- Perform NWP experiments with the blended product to determine the overall impact on numerical forecasts, and the relative contributions of each data type (MODIS vs. AIRS).

Year 1 plans

From the proposal, the project goals for the first year were to:

a) *Reprocess approximately 4 months of AIRS granules, in two different years, using a SFOV retrieval technique developed at UW-CIMSS to get the best resolution moisture fields for feature tracking.*
b) *Determine if AIRS-derived AMVs can provide coherent and good quality wind information, and characterize the errors.*
c) *Blend the AIRS moisture retrieval AMVs with the MODIS AMVs in an optimal way to create 3-D polar wind fields.*

Year 1 Accomplishments

This is the status as of 30 November 2011. The project began in February 2011, but due to other commitments, no researchers at CIMSS were able to work on this project. We hired Sharon Nebuda in April; she has been working on the project at 50% time. Sharon has developed scripts and processing procedures. Dave Stettner has come on board since mid-November and will create the proposed datasets, compare them to rawinsondes, and blend with the MODIS winds over the next few months. Sharon will primarily run the NWP experiments; this is her expertise as she previously worked at NASA's GMAO.

During the first year we:

- Obtained scripts from NASA's Goddard Earth Sciences Data and Information Services Center (GES DISC) Mirador system to easily retrieve HDF files of AIRS level 1b radiances.
- Installed the International MODIS and AIRS Processing Package (IMAPP) software to process SFOV AIRS radiances to vertical profiles of temperature and humidity. The retrieval algorithm was updated in November 2011, which required changes to our procedures.
- Modified the CIMSS winds software to track features on constant pressure surfaces.
- Developed procedures to access the raw AIRS granules, process, and derive winds from tracking humidity features:
    - Create images of specific humidity on constant pressures surfaces (Fig. 1a)
    - Apply a low pass filter to the images to reduce the noise (Fig. 1b)
    - Track features from a triplet of images (Fig. 2). Figure 3 depicts the spatial distribution of winds for one day, which includes tracking of ozone features in the stratosphere (150 hPa) as gray wind flags.

We are in the process of tuning the low pass filter settings and controls in the winds generation software to produce what we consider a good initial dataset. Additional modifications may be needed as we compare them to rawinsondes and the much higher spatial resolution MODIS AMVs.

The main emphasis of the effort is to track humidity features in the troposphere and blend the AMVs with winds derived from MODIS images. However, as part of the AIRS retrieval process, ozone concentration in the stratosphere is also determined. As time permits, we will also track ozone features (Fig. 4) and assimilate those AMVs in the GEOS-5. This could prove interesting as very few stratospheric measurements are assimilated in global models, although the models extend well into the upper atmosphere.

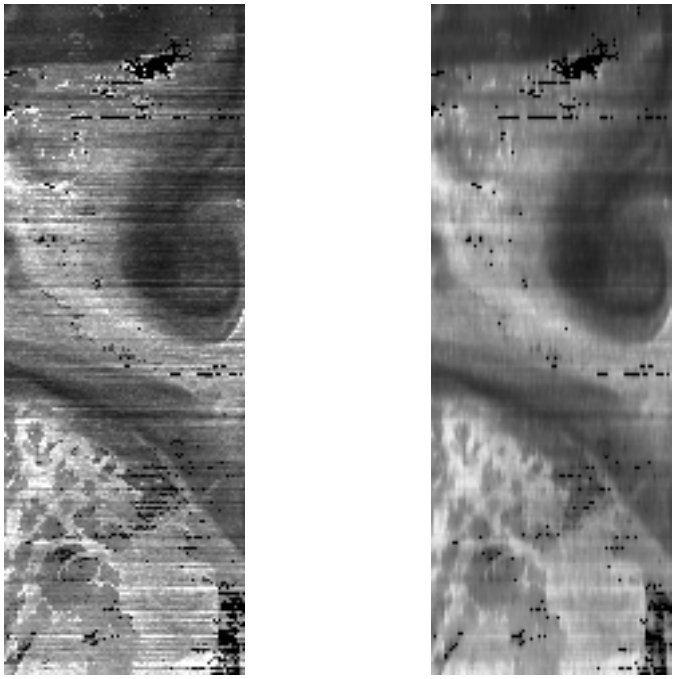

Figure 1. Aqua AIRS 300 hPa humidity retrieval from 5 January 2011 over the north polar region. (a) Original data (left); (b) with a low pass filter applied (right). The black regions represent areas of cloud contamination.

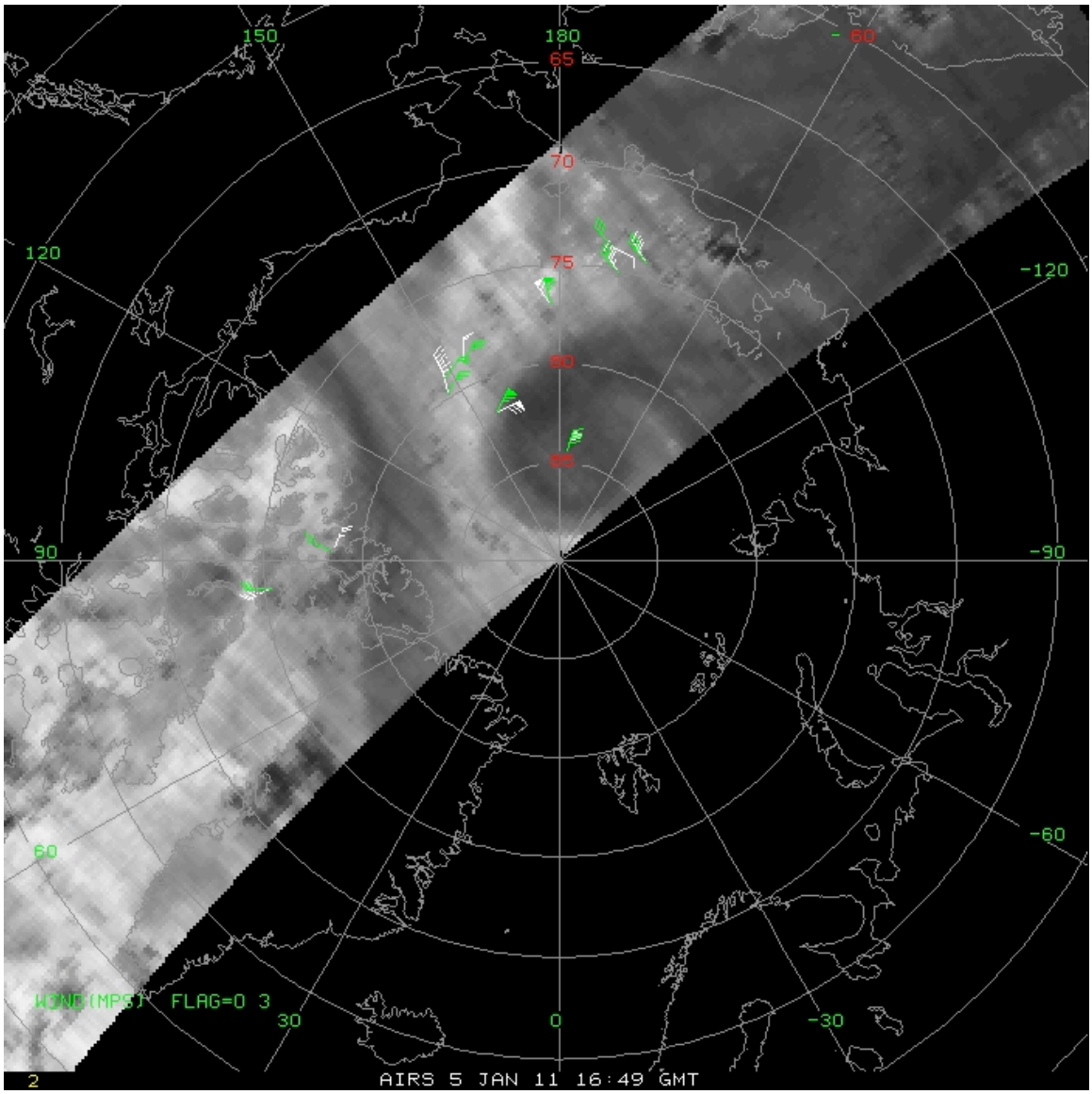

Figure 2. Same data as Figure 1, reprojected to a polar stereographic projection. The wind flags represent tracked features (green) and the background guess wind field (white).

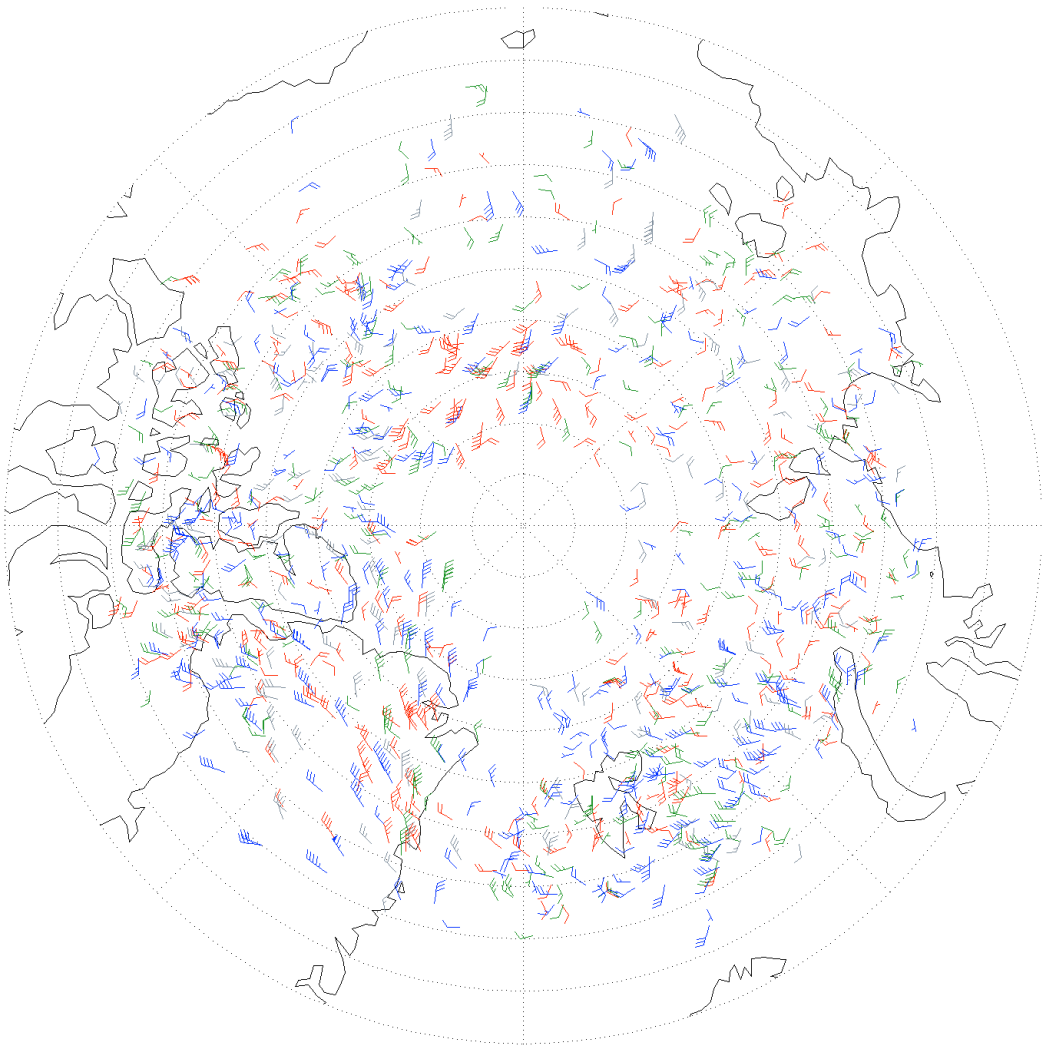

Figure 3. All derived winds from 5 January 2011. They are color coded by level: 700-600 hPa (red), 550-450 hPa (green) 400-300 hPa (blue), 150 hPa ozone (gray).

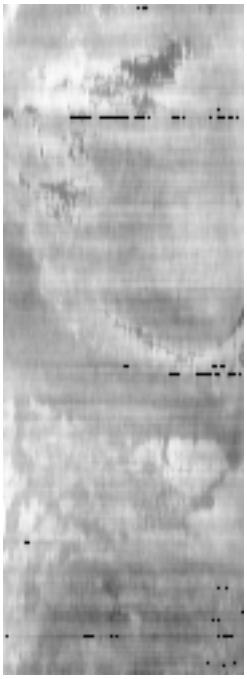

Figure 4. Aqua AIRS 150 hPa ozone concentration retrieval from 5 January 2011 over the north polar region. This is the same scene as in Fig. 1.

Dataset

For testing, we have been working with one month of data from January 2011. We are in the process of expanding the dataset to four months: two in the winter; two in the summer.

Data processing

Unix shell scripts are used to control the processing of the data, which uses the Interactive Data Language (IDL), Man computer Interactive Data Access System (McIDAS), and the CIMSS winds software.

Conferences and workshops

> *Deriving Atmospheric Motion Vectors from AIRS Moisture Retrieval Data.* To be presented at the 12th International Winds Workshop 20-24 Feb 2012, The University of Auckland, New Zealand.

Year 2 Plans

Year 2 plans from the proposal:

Perform NWP experiments with the blended product to determine the overall impact on numerical forecasts, and the relative contributions of each data type (MODIS vs. AIRS). These experiments will be run at the NASA GMAO.

Over the remaining two months of Year 1, we will complete the generation of the four-month dataset of AMVs and generate statistics comparing them to rawinsondes. Then in Year 2:

1. Blend the AIRS retrieval winds with existing MODIS-derived winds datasets.
2. Perform NWP experiments using the GEOS-5 at the NASA GMAO.