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THE ADVANCED SATELLITE AVIATION WEATHER PRODUCTS (ASAP) INITIATIVE: PHASE I EFFORTS AT THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

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1. OVERVIEW

This presentation describes collaboration between the National Aeronautics and Space Administration (NASA) and the Federal Aviation Administration's Aviation Weather Research Program (FAA AWRP) to enhance and extend the use of satellite data sets for applications in aviation weather. The ASAP initiative features collaboration between NASA and the FAA AWRP through involvement of the University of Alabama in Huntsville (UAH), the University of Wisconsin Cooperative Institute for Meteorological Satellite Studies (UW-CIMSS), and the AWRP Product Development Teams (PDTs). The effort represents an opportunity, through NASA sponsorship, to assist the AWRP PDTs in making better use of existing satellite data sets. It will also be used to facilitate an early involvement of the AWRP PDTs in the development process for the next generation of satellite sensors and speed the use and incorporation of these new technologies into the Nation's aviation safety programs.[1]

Specific to this initiative is the direct assistance in testing and evaluation of existing satellite algorithms that have been developed or are proposed by AWRP team members, the introduction of new techniques and data sets to the PDTs from the satellite community, and giving PDT members access to satellite data sets for research and development. As part of ASAP, UAH and UW-CIMSS scientists have the opportunity to transfer proven ideas into operations, and directly interact with AWRP scientists seeking to develop methods that allow for the maximum use of satellite technologies.

ASAP is to occur in two phases. The first ("Phase I" from mid-2003 through late-2005) focuses on enhancing the AWRP PDTs use of current satellite data and processing techniques to address various aviation problems. The second, "Phase II" of ASAP (from late 2005 through 2012), will focus on taking advantage of the dramatic improvements in remote sensing technologies that will be possible with the next generation of high-spectral and spatial resolution satellites, identifying opportunities that these satellites will provide for improving aviation weather products.

The presentation highlights ASAP Phase I activities at UAH in the areas of diagnosing and nowcasting turbulence, convection and clouds using satellite information. Since mid-2003, significant progress has been made.

2. ASAP OVERVIEW

ASAP represents NASA's research role in aviation safety in a manner very similar to the AWRP's relationship to the FAA. The ASAP-AWRP collaboration subsequently interacts with NOAA (the National Environmental Satellite Data Information Service, NESDIS, and the National Center for Environmental Prediction, NCEP) in support of NOAA's Aviation Weather Center. In this way, the ASAP will help the infusion of meteorological satellite data from satellite-data providers to those end users that can benefit most from its processing.

a) PHASE I OF ASAP

Phase I efforts have focused on developing the following infrastructure and communication between UAH, UW-CIMSS and the PDTs members, across the U. S. and at NCAR. The components of this infrastructure are:

- An assembled "core" ASAP team at UAH and UW–CIMSS of long-term scientists who motivate the ASAP agenda.
- Established relationships between UAH and UW-CIMSS scientists and PDT members to facilitate the transfer of satellite technology, as well as to educate the users of these satellite technologies.
- Demonstrate the quality of a given satellite-based method or technique such that the certainties and error sources for a give product are understood.
- Gradually infuse proven scientific methods of processing satellite information toward improving the diagnosis and forecasting of aviation hazards, in

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particular, atmospheric convection, turbulence, and weather over the oceans.

Specifically, during Phase I, work has been done to integrate proven satellite methods for GOES and MODIS instruments' data. Three main audiences for the new UAH research are the Convective Weather, Oceanic Weather, and Turbulence PDTs. The following sections proceed as research, focused to meet the requirements of these PDTs, are being addressed.

1. Atmospheric Convection:

For this PDT, research based on convective initiation (CI) nowcasting research is leveraged to meet the goal of improving 0-2 h forecasts of thunderstorms (Mecikalski and Bedka 2004; *Poster 4.8 this conference*). This UAH CI research accurately addressed the initiation of thunderstorms within the 30 min–1 hour timeframe. Currently, these satellite-based nowcasts of thunderstorms (i.e. the first occurrence of a 25-30 dBZ radar echo) are being evaluated by the Convectiive Weather PDT for one case during 2003 (August 3rd). If successful, this CI research will become an important CI "interest field" within the NCAR AutoNowcaster (Mueller et al. 2003).

Two aspects of GOES data processing required improvement so that CI nowcasts with 60-70% accuracy (when compared again WSR-88D radar data) are possible: a) modifications to the UW-CIMSS satellite-derived atmospheric motion vector (AMV) algorithm (see Velden et al. 1997), and b) development of a procedure that classifies convective clouds in various stages of development.

Figure 1 provides a sample of the increased satellite-derived AMV density and coverage that can be attained by adjusting the targeting scheme and down-weighting the impact of the NWP first guess wind field within the UW-CIMSS satellite-derived AMV algorithm. As these adjustments are made, AMVs that contain significant mesoscale flow information are the result, with up to a 10-fold increase in the number of AMVs obtained (when compared to the unmodified AMV method). Details of the adjustments needed to create so-called "mesoscale" AMVs are described in Bedka and Mecikalski (2004).

Figure 2 demonstrates the cloud top-cooling rates calculated as mesoscale AMVs are used to track developing cumulus for the May 4, 2003 case. Currently, the techniques described in Mecikalski and Bedka (2004) are implemented in a real-time processing mode over the southern U. S. This will allow for the combined usage of model data (moisture/momentum convergence, temperature for wind height assignment to cumulus cloud pixels) in the CI nowcasting scheme.

A new convective cloud identification system, the "convective cloud mask" (CCM), has been developed at UAH, and is now working within the CI algorithm. This new CCM relies on an unsupervised, cluster algorithm to delineate convective clouds (small cumulus, towering cumulus, cumulus with anvils, anvil cirrus, etc.), based on the methodology of Nair et al. (1998). It will serve the needs of the CI algorithms, as well as potentially be used to help isolate cloud-induced turbulence (CIT; Turbulence PDT) and convection over oceans (Oceanic Weather PDT). This system utilizes a statistical, pattern-recognition based technique with GOES-12 1 km visible data and 4-8 km IR data. A paper describing the CCM will soon be available (Nair et al. 2004). Figure 3 provides a demonstration of this new convective cloud mask. The classifications numbered 3-6 and 11 are important for cumulus cloud identification.

Other work is now being done toward co-locating (i.e. correcting for parallax errors) WSR-88D and GOES-11 infrared data during IHOP_2002 as a means of improving the validation and error-estimates provided by the Mecikalski and Bedka (2004) CI nowcast algorithm. This will allow for more elaborate validation methods to be performed, including multiple regression approaches. Results from this validation effort are needed by the PDTs to assess confidence in using infrared-based CI interest fields in their nowcasting algorithms (e.g., the AutoNowcaster).

2. Turbulence:

Development of a GOES/MODIS satellite cloud and water vapor pattern recognition software for mountain-wave induced turbulence detection (Figure 4). A combined effort using all satellite precursors will lead to a turbulence detection confidence mask. These ideas will be developed in collaboration with the Turbulence PDT. Other new methods for quantifying mountain-wave turbulence (i.e. trapped versus breaking mountain waves) in MODIS and GOES imagery, beyond simply identifying these features in imagery, are under development. Research will be toward making this product an interest field that may help isolate CIT or clear-air turbulence (CAT).

This CCM can be developed for use with any geostationary satellite instrument data, which is especially important for the Oceanic Weather PDT and Turbulence PDT.

3. Oceanic Weather:

Transition of CI research to Oceanic Weather PDT is occurring in two ways: a) demonstrating the CCM for oceanic domains using the GOES-9, -10 and –12 satellites, b) demonstrating the use of the mesoscale AMVs for diagnosing turbulence (clear-air and cloud-induced) across large regions, and c) transitioning of land-based CI assessment to over-ocean convective monitoring. Processing enhancements are required to allow the CI algorithm to operate efficiently and in real-time when 10-40 million 1-km resolution pixels need to be processed per image, however.

For the CCM and mesoscale AMVs, we are considering use of other instruments (e.g., MeteoSat, and its Next Generation, MSG). In particular, emphasis will be placed on more accurately locating hazards surrounding the intertropical convergence zone (ITCZ) and other regions of oceanic thunderstorm activity. ASAP will immediately begin incorporating satellite-derived winds into PDT algorithms where they prove useful for diagnosing oceanic weather hazards (e.g., CAT), as well as for identifying jet stream locations for flight route planning purposes. ASAP will be able to employ satellite-derived information of cloud top heights, cloud depths and cloud layer information into systems that diagnose clouds over oceanic regions.

The accompanying poster presentation overviews our progress to date on ASAP. See Mecikalski et al. (2002) for further details on the ASAP initiative.

b) Phase II of ASAP

During the late-2005-2012 timeframe, ASAP research activities will transition from the processing of the existing satellite capability into the processing of hyperspectral information from the next generation of sensors (e.g., VIIRS, AIR, CrIS). Although demonstration products and analyses using test hyperspectral data (e.g., NAST-I, Scanning High-resolution Infrared Sounder, S-HIS) will be performed during Phase I, a switch to a reliance on these data will occur as the meteorological community trends toward the new operational hyperspectral instruments [e.g., GOES-Advance Baseline Imager (ABI) and the Hyperspectral Environmental Sounder (HES)] by about 2012-2013, as well as other hyperspectral instruments supported by non-US nations.

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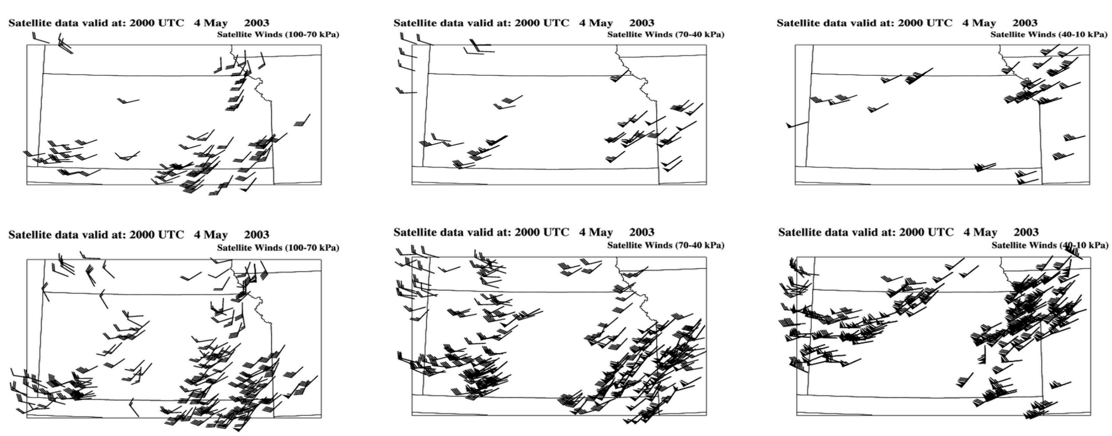
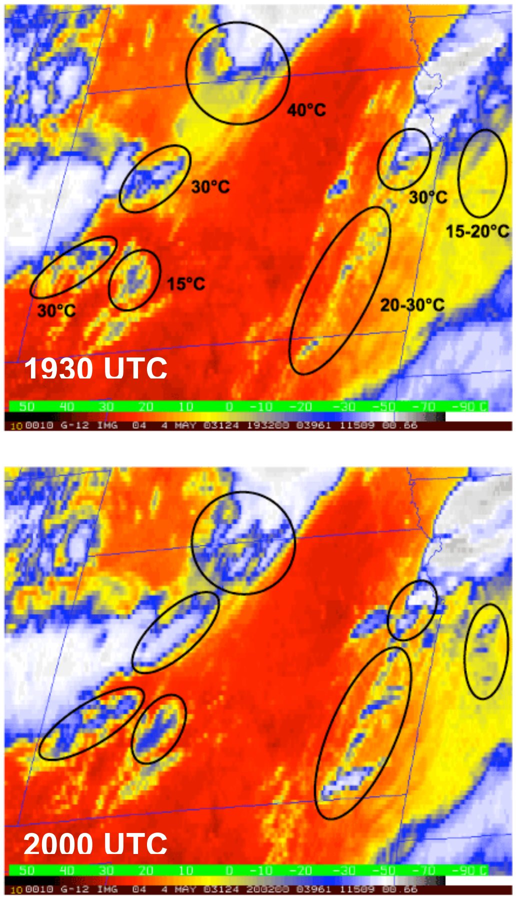


Figure 1: (top panels) AMVs (in knots) within the 100-70, 70-40, and 40-10 kPa layers, respectively, constrained to the NWP background wind field at 2000 UTC on 4 May 2003. (bottom panels) AMVs within the same atmospheric layers, using the Bedka and Mecikalski (2004) technique, where the background wind field is down-weighted, allowing for retrieval of the synoptic- and meso-scale flow. Only 20% of the total wind vectors in the bottom panels are shown for clarity.



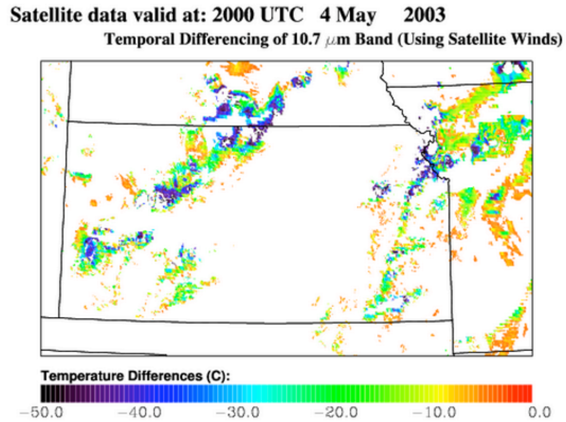


Figure 2: An example of the 30-minute cloud-top cooling rate (upper-right) calculated using the techniques described in Bedka and Mecikalski (2004). Developing convection is outlined with ovals in the left panels and the mean 30-minute cooling rate, identified by a human expert, is displayed in the upper-left.

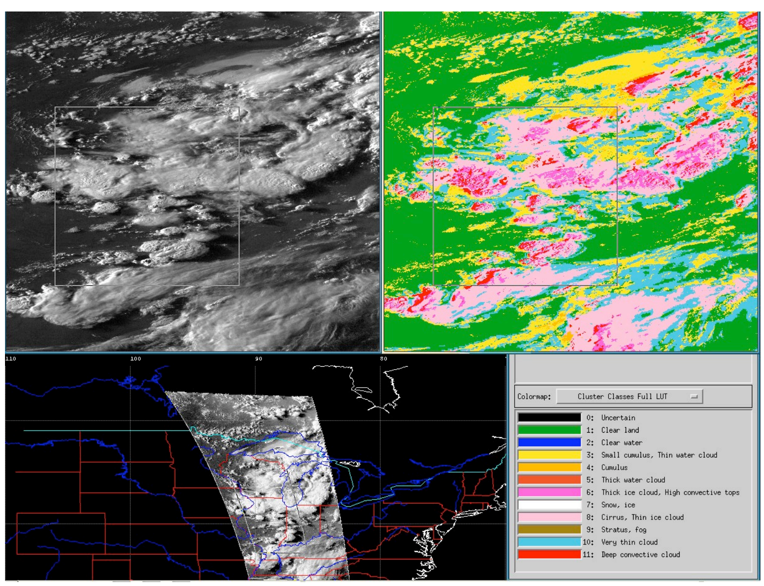


Figure 3: An example of the new UAH CCM product for a convective initiation event over the Upper Midwest on August 3, 2003.

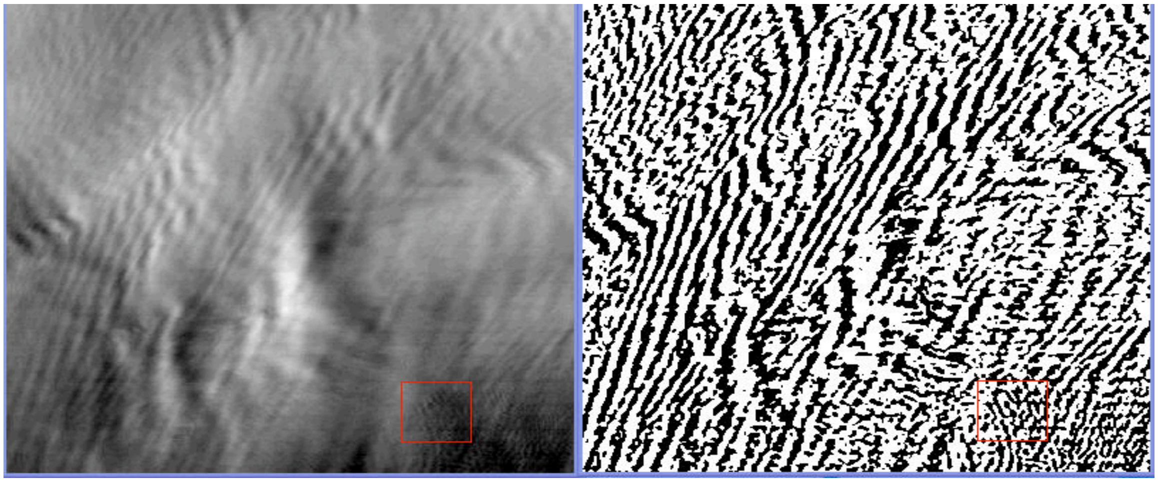


Figure 4: Mountain wave automated identification in MODIS imagery at 05:17 UTC 25 June 2003 over the four-corners region of the U.S., specifically over southern Colorado. Method works by isolating within water vapor (~6.7 μm) imagery the signature of mountain waves. New work is occurring toward quantifying these features as seen in Fig.1 to obtain wave amplitude, altitude, depths, etc.