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THE ADVANCED SATELLITE AVIATION-WEATHER PRODUCTS (ASAP) INITIATIVE FOR DIAGNOSING AND NOWCASTING WEATHER HAZARDS FOR IMPROVED AVIATION SAFETY

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1. OVERVIEW

This presentation describes a proposed 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 will feature collaboration between NASA and the FAA AWRP through involvement of the University of Wisconsin Cooperative Institute for Meteorological Satellite Studies (UW-CIMSS), and the AWRP Product Development Teams (PDTs). The collaborative 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 collaboration will be 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 available through UW-CIMSS. As part of ASAP, UW-CIMSS scientists will have the opportunity to transfer proven ideas into operations, and directly interact with AWRP scientists seeking to maximize their use of satelllite technologies.

The proposed collaboration would occur in two phases. The first ("Phase I" from late 2002 through 2005) will focus on enhancing the AWRP PDTs use of current satellite data and processing techniques to address various aviation problems (current includes new platforms to be launched in the next year or two). 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 and identifying the opportunities that these satellites will provide for improving aviation weather products. These new satellite technologies will include the Geosyncronous Imaging Fourier Transform Spectroradiometer (GIFTS) hyperspectral instrument.

The presentation will highlight first ASAP research, as well as highlight several key areas of new research in the areas of diagnosing and nowcasting turbulence, clouds, convection and in-flight icing through the inclusion of value-added satellite information.

2. THE ASAP RESEARCH AGENDA

Figure 1 shows the relevance of the ASAP initiative within the scheme of weather analysis and end user needs for aviation safety. In effect, 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 then will interact 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

As stated above, the ASAP will proceed in two phases as current and new satellite technologies are more aggressively infused into AWRP programs. The first order of business during Phase I will be the following:

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- Assemble "core" ASAP team at UW–CIMSS, which involves identifying the long-term UW–CIMSS scientists who will motivate the ASAP agenda.
- Establish, through a dedicated UW–CIMSS employee, a UW–CIMSS presence at NCAR to facilitate the transfer of meteorological satellite technology, as well as to educate the users of these satellite technologies.
- Begin to infuse proven scientific methods of processing satellite information toward improving the diagnosis and forecasting of aviation hazards, in particular, atmospheric convection, turbulence, in-flight icing, weather over the oceans, and those caused by suspended volcanic ash clouds.

Specifically, during Phase I, work at UW–CIMSS will be done to integrate proven satellite methods for GOES and MODIS instruments. Five main areas of new research will begin, with potential benefits to many AWRP PDTs (e.g., Convective Weather, Oceanic Weather, Turbulence, In-Flight Icing, Terminal and National Ceiling and Visibility, and Winter Weather).

1) Turbulence: Important work in this area will assist the Turbulence PDT in evaluating the fundamental scales of turbulence as determined from numerical simulation. Since clear air turbulence (CAT) is relatively poorly understood, UW–CIMSS will work with this PDT to isolate the signatures in satellite imagery that correspond with aircraft-observed CAT. It is anticipated that some level of automated pattern detection algorithm development for CAT in satellite imagery will be developed. Research will also be performed in the area of including satellite cloud-motion winds in algorithms that detect turbulence, as well as evaluate how profiling remote sensing systems can be used to evaluate low-level (below 5 km) CAT. Work will also begin in monitoring the relationship between satellite-derived ozone and abnormal folds in the tropopause. For high-flying commercial aircraft, this has implications for moderate to severe CAT.

2) In-Flight Icing: Work on the evaluation of supercooled clouds using MODIS imagery (twice-per-day) of cloud microphysical patterns or thermodynamic phase (e.g., liquid cloud drops versus ice crystals) across regions. MODIS data will be particularly helpful during winter months when stratus cloud sheets, covering large geographical regions, are evaluated for their potential to create significant icing hazards for aircraft flying through them. Work will also proceed on using GOES data for similar purposes, namely to assess cloud microphysical patterns; this research follows upon ongoing work at NASA Langley.

3) Atmospheric Convection: Through ASAP, a continued development of a number of parameters for evaluating convective initiation using geostationary satellite data will occur, namely a pattern recognition scheme efforts to recognize the location of small, growing cumulus clouds in satellite imagery. Beyond this, work will continue on the identification of cumulus cloud lines, the relationships between cumulus cloud lines and existing frontal/low-level outflow boundaries, the longevity and growth rates of cumulus clouds, and cloud deepening rates. Through the use of MODIS imagery, we will also develop procedures to assess cloud-top glaciation as an important precursor to convection first producing precipitation. Over oceans, our methods will seek to identify areas of convection-dominated weather and employ the above techniques. In addition, ASAP will begin preparing, in particular, the Convective Weather and Oceanic Weather PDTs nowcasting systems for the use of derived product imagery (DPI) in the assessment of atmospheric stability. These include convective available potential energy (CAPE), lifted index (LI) and convective inhibition (CIN), as currently produced in realtime at UW–CIMSS. All of the research listed above will be transferred into the nowcasting systems run at NCAR by directly employing proven methods at UW–CIMSS into their processing routines.

4) Oceanic Weather: The above methods for evaluating turbulence, in-flight icing and convection will be employed over large oceanic regions by processing geostationary data from GOES, METEOSAT and GMS. 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.

5) Volcanic Ash Hazards: Due to the significant hazard that suspended volcanic ash presents to high-flying aircraft, work will be performed to analyze volcanic ash plumes in an automated sense using MODIS data. This involves developing a system that automatically collects the appropriate "direct broadcast" MODIS imagery to continuously monitor the vertical and spatial extent, and qualities of ash plumes. The existing analysis techniques at UW–CIMSS for processing MODIS imagery will be tested and employed within the existing volcanic ash-detection schemes at NCAR. ASAP and the AWRP PDTs will work along with the Volcanic Ash Advisory Centers (VAAC) to use these MODIS data processing in conjunction with information from these Centers.

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 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., GIFTS, 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 Advanced Baseline Sounder (ABS/HES)] by about 2012, as well as other hyperspectral instruments supported by non-US nations.

All hyperspectral research for the benefit of aviation safety will leverage the ongoing hyperspectral research supported by GIFTS data processing (through NASA) and GIFTS algorithm development for atmospheric parameter retrievals (through the Navy) at UW-CIMSS.

3. References

Mecikalski, J. R., D. B. Johnson, J. J. Murray, et al., 2002: *NASA Advanced Satellite Aviation-weather Products (ASAP) Study Report*, NASA Technical Report, 65 pp. In press.

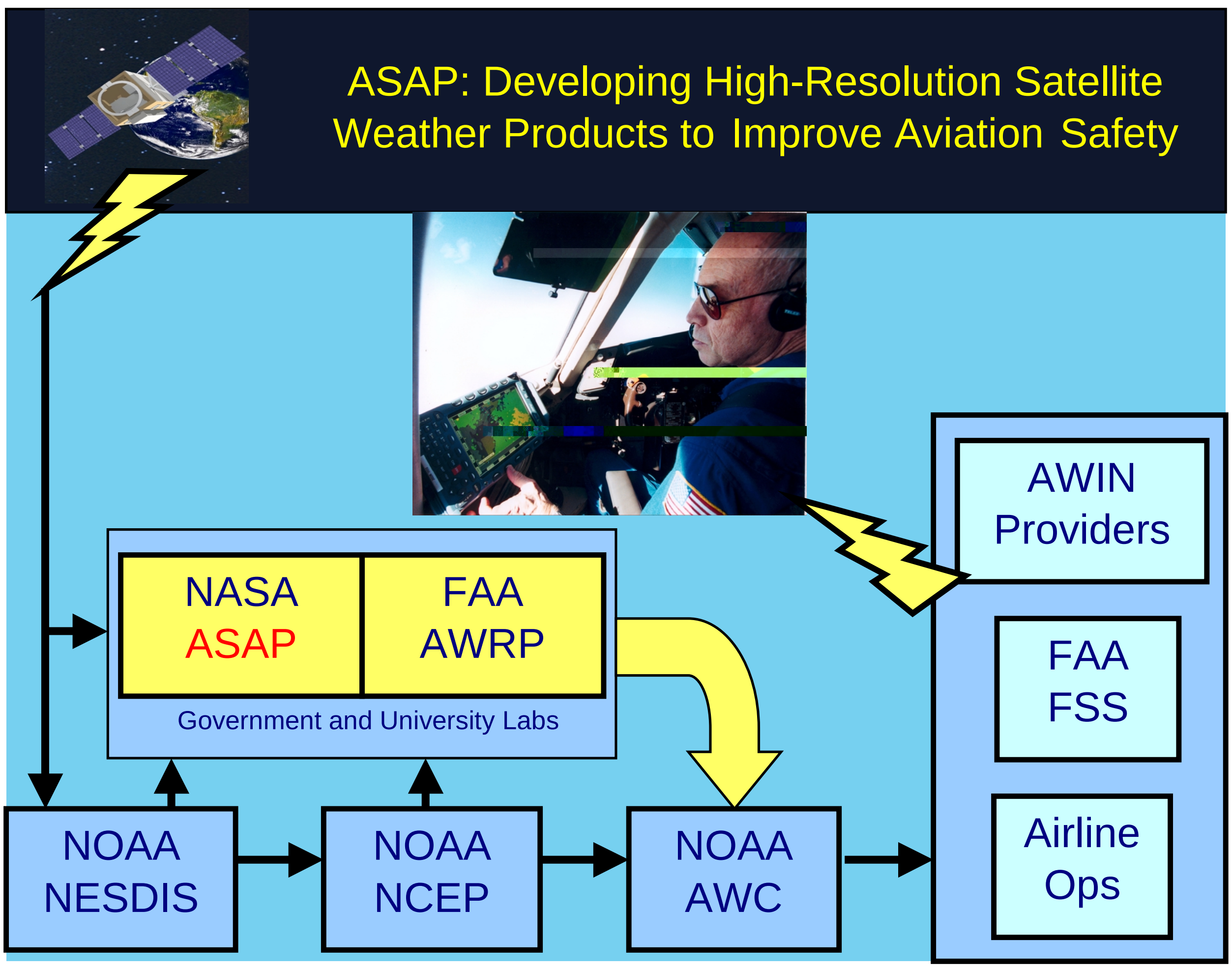

Figure 1: A schematic of the roll the ASAP initiative will play in relation to ongoing weather research efforts and other national operational weather centers. See text for explanation.