SESSION IV

Research Methods and Applications

Chairpersons: Jaime Daniels and Ken Holmlund

Session IV covered the topic of research methods and applications where a wide variety of subjects were covered. These subjects included: image navigation, cloud detection, feature tracking, turbulence, mesoscale winds, height-resolved water vapor winds, MISR winds, satellite-derived upper tropospheric divergence, IGEOLAB, and polar winds.

In the first presentation, Lu Feng reported on the status of his work to improve GOES image navigation by applying the approach used at China's National Satellite Meteorological Center (NSMC) for the FY2B satellite. His results showed good improvements in the GOES-9 navigation as a result of earth center determinations using earth edge measurements. In particular, improvements in spacecraft attitude roll and pitch parameters were contributing factors to the improvement. This approach has possible benefits for improving navigation accuracy for rapid scan imagery where no landmarks exist.

Liu Jian presented his results from his research on an automated, dynamic threshold cloud detection algorithm used on FY-2C imagery. A histogram analysis of pixels in a small area, together with knowledge of surface classification data, resulted in good results in most cases. Problem areas include strong surface temperature inversions at high latitudes, clouds over snow and ice covered surfaces, very thin cirrus, and low stratus at night.

Wang Zhenhui discussed an approach for deriving atmospheric motion vectors (AMVs) from satellite imagery using a 2-D Fourier phase analysis technique. The potential advantage of this approach is the ability to overcome the problem of sub-pixel motion when using super rapid scan imagery. Application of quality control measures that apply consistency checks between derived vector pairs was deemed necessary to remove unrealistic wind vectors.

Jaime Daniels discussed results done at NESDIS involving application of an optical flow algorithm, where brightness constancy is the only constraint, to derive AMVs for GOES-11. The algorithm was tested over a variety of conditions that included image (IR window and water vapor imagery) sequences where the displacements were controlled to actual image sequences. The evaluation included a comparison of the AMVs generated via the optical flow algorithm and the more traditional pattern matching approach (sum of squared differences) to radiosonde wind observations. The results indicated the optical flow approach is a useful, if not superior, alternative to correlation tracking approaches in regions of clear sky water vapor characterized by less structure. It was also found that the optical flow approach tested should not be used in jet regions with low temporal resolution imagery nor should it be used, in its current form, to track convective clouds. It was cited that more research is needed on application of optical flow approaches for deriving AMVs.

Alexander Nerushev described a methodology for deriving dynamic characteristics (vorticity and eddy diffusivity) of the middle troposphere based on atmospheric thermal radiation information (5.35um – 7.15um; 6.85um – 7.85um) measured by the SEVERI instrument. The high spatial and temporal resolution of the SEVERI imagery made it possible to apply this method on a synoptic and regional scale allowing for studies of turbulent flow in the vicinity of jet streams, intense cyclones, and frontal boundaries.

Jim Purdom's presentation focused on the severe storm environment and what the demands and requirements (spatially, spectrally, and temporally) would be for a geostationary satellite system in order to capture mesoscale cloud motions needed to estimate such things as: vertical wind shear, updraft strength, cloud-top rotation, storm environment interaction and the development of dynamic pressures, evolving atmospheric instability field, and the strength of storm produced cold pool. It was stressed that analysis techniques, different than those used in automated systems today, would be necessary to arrive at these estimates. Synergistic use of high spectral information from satellite interferometers with multi-spectral rapid scan observations will also be needed to understand, model, and nowcast convection.

Steve Wanzong presented results from his case studies where image triplets of constant pressure level moisture analyses, calculated from simulated hyperspectral satellite retrievals, were used to derive height-resolved AMVs in cloud-free scenes. A modified version of the existing GOES AMV tracking software was used to calculate the AMVs. AMVs were successfully calculated at several pressure levels which further demonstrated the concept that the generation of vertical wind profiles is a possibility. While the results were encouraging, but more work is needed in the areas of quality control and validation.

Iliana Genkova then presented results from her work that involved deducing height resolved AMVs from GOES sounder derived moisture analyses. The GOES sounder derived moisture analyses were generated at selected pressure levels using pixel level GOES sounder moisture retrievals. The height-resolved AMV wind fields were reasonable and it was noted more AMVs were generated at pressure levels exhibiting larger variations in moisture. Comparison statistics between the height-resolved AMVs and collocated operational NESDIS AMVs and rawinsonde observations showed reasonably large vector RMS differences, however, further improvements are expected as the methodology is improved along with further refinements and improvements in the areas of quality control and validation.

Roger Davies presented a report on the progress and status of height-resolved cloud motion vector retrieval by the MISR instrument aboard the Terra satellite. He highlighted the major breakthroughs that were made in the MISR processing stream that have led to significant improvements in quality of the MISR winds. A new navigation algorithm that uses sea ice has resulted in sub-pixel accuracy for co-registration of the three cameras. This is turn has improved the quality control of the MISR AMVs. A comparison of MISR AMVs and 6-hour global forecast winds from the NASA/GMAO showed very good agreement. It was then reported that Level 3 MISR global wind products prepared for climate studies are available for use by the climate community; many examples of these gridded MISR wind products were shown.

Johannes Schmetz reported results from a case study where the upper tropospheric divergence field was computed directly from Meteosat-8 AMVs generated from successive 15-minute 6.2µm imagery. The computed divergence values were in broad agreement with those generated via the cloud expansion methodology and were shown to successfully capture the expected diurnal cycle for upper level divergence of convective cloud systems where a maximum occurs over land in the late afternoon/early evening. Comparison of the Meteosat-8 derived upper level divergence field with ECMWF forecasts of the upper level divergence field showed that the global forecasts do not capture the maxima, neither in position nor magnitude. Several uses of satellite-derived upper level divergence fields were suggested which included diagnostic use for the evaluation of convective parameterizations used in global NWP models, assimilation of a gridded satellite-derived divergence field over the tropics, and use in climate reprocessing efforts.

Andre Szantai presented results from a study involving the computation of AMV fields using optical flow techniques on consecutive Meteosat Second Generation (MSG) 10.8um imagery. He showed that dense AMV fields of good quality could be generated when a cloud classification scheme was introduced. Introduction of the cloud classification scheme enabled a better discrimination of motion due to different cloud types at different levels of the atmosphere. The possibility of generating locally dense AMV fields from satellite imagery is exciting because these wind fields could provide new and complementary wind information at smaller scales.

The next presentation by Liu Jian discussed the International Geostationary Laboratory (IGEOLAB) concept. The concept is based on international partnerships and the sharing of the benefits of a geostationary demonstration mission across several space development agencies, operators of operational meteorological satellites, and satellite data users. Two test proposals that were considered high priority and capable of bringing enhancements to the Global Observing System (GOS) were presented. These included the Geostationary Imaging Fourier Transform Spectrometer (GIFTS) and microwave sounding from geostationary orbit.

In the final presentation of the session, Lars Peter Riishojgaard discussed the status of the development of a Molniya Orbit Imager at NASA's Goddard Space Flight Center. The mission concept has broad user community support representing both operational and scientific organizations from several countries. A significant driver for this mission concept is the improvement in medium range forecast skill when near real-time water vapor winds derived over the polar high latitudes are assimilated in operational global NWP models. The current mission architecture and various cost savings scenarios involving alternative launch vehicle options and imager instruments were presented. Results from a Observing System Simulation Experiment utilizing polar winds derived from a Molniya orbit indicated forecast improvements over North America could be realized. Numerous other scientific applications, other than atmospheric winds, were identified for a Molniya orbit imager mission. These include sea ice, vegetation/forest fire monitoring, volcanic eruptions, SO_2 ash clouds, clouds, fog, polar weather, snow cover, regional water quality, and surface radiation budget.

All presentations were followed by a number of questions/comments and lively discussion from the audience. Overall, the session recorded some of the latest advances in AMV research and applications and highlighted the potential of many of the new approaches, particularly in light of the future instrumentation to be flown on future satellite systems.

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