N93-20094

Investigation of Cloud/Water Vapor Motion Winds from Geostationary Satellite

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Work has been primarily focussed on three tasks: (A) comparison of wind fields produced at MSFC with the CO2 autowind/autoeditor system newly installed in NESDIS operations, (B) evaluation of techniques for improved tracer selection through use of cloud classification predictors, and (C) development of height assignment algorithm with water vapor channel radiances. The contract goal is to improve the CIMSS wind system by developing new techniques and assimilating better exisitng techniques. The work reported here was done in collaboration with the NESDIS scientists working on the operational winds software, so that NASA funded research can benefit NESDIS operational algorithms.

(A) Comparison of A Wind Set Produced by MSFC with the New Operational CO2 Autowind/Autoeditor (C. Hayden, NOAA/NESDIS, C. Velden, CIMSS)

In the early spring of 1990 a team from the Cooperative Institute for Satellite Studies (CIMSS) joined with the NESDIS Interactive Processing Branch and the Satellite Analysis Branch in introducing and testing at the VAS Data Utilization Center a new software system for automated cloud motion winds with pressure altitude assignment using the CO_2 slicing method. Wind vectors generated during this demonstration were given to the NMC to investigate forecast impact. One of the highlights of this effort occurred on April 24 and 25 when the new pressure assignment method succeeded in correctly locating the altitude of thin cirrus tracers off the coast of California associated with a shortwave which would later affect the weather over the U.S. (Merrill,et al. 1991). The success of this venture breathed new life into applied research for improving the vectors obtainable from satellite imagery, and one consequence was an agreement with Marshall Space Flight Center (MSFC) that they use the April test case with their vector generating software for comparison with the new NESDIS system, the eventual goal being the amalgamation of better aspects of the two methods. MSFC agreed to this task, and subsequently delivered a data set to CIMSS which included vectors from visible, infrared window, and water vapor (6.7 micrometer) imagery for April 25, 00 UT. CIMSS evaluation of these data was conducted under this contract and the results are briefly highlighted here.

CIMSS has developed a system for objective quality control of the winds generated from tracers. This quality control includes both pressure altitude reassignment by objective assimilation with other data and ojective editing (Hayden, 1991; Hayden and Velden, 1991). It is a part of the new wind generating system which became operational at NESDIS on February 12, 1992. The MSFC wind data were evaluated by this quality control system.

The principal conclusion from examination of the MSFC data set is that NESDIS should be paying more attention to visible data to improve vector coverage. A second conclusion is that MSFC seems to have a superior technique for obtaining targets in the water vapor imagery. Certainly their density is much higher. Finally, the NESDIS assimilation system was quite successful in blending the MSFC winds into the analysis, despite the deficiencies of the initial height assignment. Although an obvious bias to the NMC forecast is enforced by the reassignment, the end result in comparison to rawinsondes shows an rms improvement over the forecast.

Hayden, C. M. and C. S. Velden, 1991: Quality control and assimilation experiments with satellite-derived wind estimates. *Preprint Volume, 9th Conference on Numerical Weather Prediction*, Denver, CO. Amer. Meteor. Soc., 19-23 October.

Hayden, C. M. 1991: Research leading to operational methods for wind extraction. *Proceedings of the Workshop on Wind Extraction from Operational Meteorological Satellite Data*, Washington, DC, 17-19 September, Eumetsat ISBN 92-9110-007-2.

Merrill, R. T., W P. Menzel, W. Baker, J. Lynch, and E. Legg, 1991. A report on the recent demonstration of NOAA's upgraded capability to derive cloud motion satellite winds. *Bull. Amer. Meteor. Soc.*, **72**, 372-376.

(B) Use of Cloud Classification Predictors for Cloud Tracer Selection in Operational Winds Algorithms (C. Moeller, CIMSS)

The utility of cloud feature characteristics as additional information to the operational automated cloud tracking wind algorithm is being investigated. This effort is aimed at improving the quality of operationally produced cloud tracked winds while eliminating computational time spent trying to produce vectors from cloud targets which are not likely to yield good quality vectors. Automated wind vectors can be improved by limiting cloud tracer selection to tracers that are, more often than not, accurately tracked (via correlation technique) through time. A goal of this work is to base cloud tracer selection on cloud feature characteristics as well as the usual pixel brightness and gradient thresholds. The characteristics for describing cloud tracers include cloud albedo, fraction, multilayering, height of base and top, spatial distribution and orientation, connectivity (cloud and background), and type (Garand, 1988). These cloud characteristics are being compared to cloud tracers and vectors produced by the operational cloud tracking procedure in an effort to identify the conditions under which good (and bad) quality wind vectors are produced. Those characteristics demonstrating skill in identifying good (and bad) cloud tracers will be retained; those not demonstrating skill will be removed from the algorithm to reduce computational time.

Garand, L., 1988: Automated Recognition of Oceanic Cloud Patterns. Part I: Methodology and Application to Cloud Climatology. *Jour. of Clim.*, Vol.1, No.1, 20-39.

(C) Compariosn of Several Techniques to Assign Heights to Cloud Tracers (S. Nieman, CIMSS, P. Menzel, NOAA/NESDIS, J. Schmetz, ESOC)

In the current operational use of four geostationary satellites, satellite derived cloud motion vector (CMV) production has been troubled by inaccurate height assignment of cloud tracers, especially in thin semi-transparent clouds. At the recent Workshop on Wind Extraction from Operational Meteorological Satellite Data (Eumetsat, 1991) there was a consensus that the present techniques for height assignment needed further review and that greater commonality in techniques should be encouraged.

Presently heights are assigned by any of three techniques when the appropriate spectral radiance measurements are available. In opaque clouds, infrared window (IRW) brightness temperatures are compared to forecast temperature profiles to infer the level of best agreement which is taken to be the level of the cloud. In semi-transparent clouds or sub-pixel clouds, since the observed radiance contains conributions from below the cloud, this IRW technique assigns the cloud to too low a level. Corrections for the semi-transparency of the cloud are possible with the carbon dioxide (CO_2) slicing technique (Menzel, 1983) where radiances from different layers of the atmosphere are ratioed to infer the correct height. A similar concept is used in the water vapor (H_2O) intercept technique (Szejwach, 1982), where the fact that radiances influenced by upper tropospheric moisture (H_2O) and IRW radiances exhibit a linear relationship as a function of cloud amount is used to extrapolate the correct height. These three techniques are being compared at CIMSS through this contract and other NESDIS supported work.

There is an added impetus to this work. The European community is sharing one of its satellites with the United States, METEOSAT 3; understanding the relative performance of the NESDIS (National Environmental Satellite and Data Information Service) operational CO_2 slicing heights and the ESOC (European Satellite Operations Center) operational H_2O/IRW intercept heights is necessary for the United States to begin production of CMVs with M3. Furthermore, GMS 5 will be supplemented with a water vapor channel so that international commonality of height assignment is closer, if viable H_2O/IRW height performance can be verified.

Evaluations so far suggest that the H_2O/IRW intercept technique is a viable alternative to the CO_2 slicing technique for inferring the heights of semi-transparent cloud elements. On a given day the heights from the two approaches compare to within 60 to 110 mb rms; drier atmospheric conditions tend to reduce the effectiveness of the H_2O/IRW intercept technique. The infrared window channel technique consistently places the semi-transparent cloud elements too low in the atmosphere by 100 mb or more; only in more opaque clouds does it perform adequately. Comparison of the heights produced operationally at NESDIS (with the CO_2 slicing technique) and ESOC with their version of the H2O/IRW intercept technique) reveal that the cloud height algorithms are approaching an international commonality.

EUMETSAT, 1992: Workshop on wind extraction from operational meteorological satellite data, 17-19 September 1991. EUM P 10, ISBN 92-9110-007-2.

Menzel, W. P., W. L. Smith, and T. R. Stewart, 1983: Improved cloud motion wind vector and altitude assignment using VAS. *J. Clim. Appl. Meteor.*, 22, 377-384.

Szejwach, G., 1982: Determination of semitransparent cirrus cloud temperatures from infrared radiances: application to METEOSAT. *J. Appl. Meteor.*, 21, 384.