VERIFICATION OF AUTOMATIC WINDS AND HEIGHTS WITH ASYNCHRONOUS STEREO ANALYSIS

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ABSTRACT

Cloud motion vectors calculated with the CIMSS satellite winds processing algorithm are used to initialize the Asynchronous Stereo analysis of cloud motions and heights. The stereo results have the advantage that they produce a geometric cloud height independent of the optical properties of the clouds. The CIMSS winds algorithm has a long history of development to recognize and track clouds. The stereo analysis can be used as a verification tool for the standard cloud top temperature estimate of cloud height.

Critical to understanding this analysis is the ability to view the cloud vectors with a 3 D interactive display built up from VisAD. The software is portable and is available at: acamar.cira.colostate.edu/autoStereo/selectStereo.html. With a small effort it could be changed to accept other wind data sets for local analysis. This provides a portable tool to test wind vectors and height estimates.

1. Introduction

There is a long history of cloud tracking to estimate wind as evidenced in this workshop. One of the fundamental problems is estimating cloud heights from the infrared temperature since that depends upon the optical depth of the clouds and the temperature structure of the atmosphere. Geometric techniques like stereo simplify this problem by getting a direct estimate of the altitude of the cloud, but they do require additional satellite views beyond a single geosynchronous satellite. We have discussed this before at other wind workshops, but now we have constructed an automatic scheme which merges the automatic wind products from CIMSS or NESDIS with a stereo analysis.

2. Procedure

The basic procedure of wind analysis at CIMSS or NESDIS is first to scan a geosynchronous satellite image for cloud features and then attempt to find those same features in images before and after the reference image. This provides 3 latitude/longitudes and is then used to estimate the motion of the clouds. The infrared temperature is analyzed into a pressure based upon a model estimate of the temperature profile (Olander, 2001).

These real time (up to 24 hours old) data are read into our analysis program and then the GOES East and West satellite images near the time of the wind analysis are read in and remapped to a common projection. Then the triplet of latitude/longitudes is used to search the remapped images to find the best match between nearby times between East and West views of the clouds. This set of 6 latitude/longitudes/times is the basic information used by the asynchronous stereo analysis (Campbell and Holmlund,2000). As an additional check simple stereo analysis with the pairs of images is used assuming that the matching East and West images are simultaneous.

3. Results

Figure 1 shows a display of wind vectors where the colors are based upon the estimated pressure of the cloud from the temperature analysis. Figure 2 shows a comparison of the geometric heights and pressures. This used 4 km IR GOES data. The software actually provides interactive views of this information. Figure 3 is a rotated view of the vectors and pressures, and Figure 4 shows the matching display using geometric height for the 3rd dimension.

Figure 1 CIMSS wind vectors with pressure indicated by color, blue high red low. Day 105 1:00,1:30,2:00 in 2002.

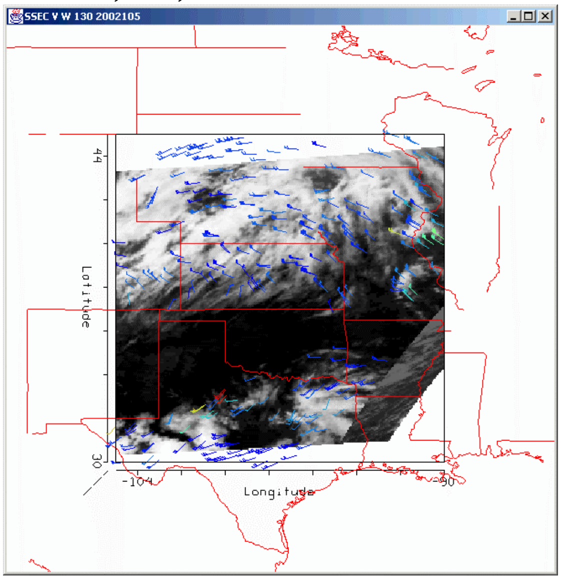
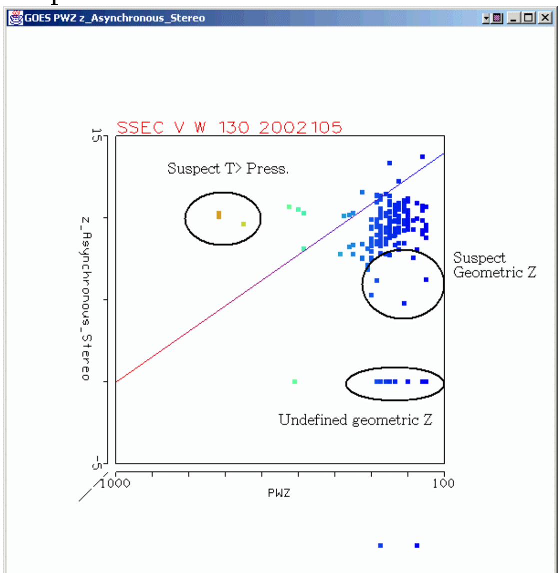


Figure 2 Geometric heights from Asynchronous Stereo Analysis vs Cloud Pressures derived from the cloud temperatures.



There is general agreement between the results. For some individual vectors one can identify suspect Pressure heights. Similarly there a suspect geometric heights when middle clouds are identified, but the temperature is very low. The temperature to pressure scheme will make errors towards higher pressure (lower heights) because the emissivity of the cloud is less than 1 or the coldest cloud pixel is actually partly cloudy mixing in warmer radiances from below. The geometric technique has random errors because a slight miss matches between the cloud edges and because the cloud shape has changed significantly during the analysis. The temperature to pressure analysis does not suffer from the cloud change problem because one is just taking the coldest pixel from the 3 images. (That is a simplification but captures the idea.)

The stereo analysis is not successful in some instances because it is not possible to identify the features between the remapped images. In that case, heights are assigned a missing value, but they still appear on the plots for reference. Also the satellite data was sometimes missing do to the predefined sectors being processed. These vectors are also plotted at –10 km heights. This will occur with other data source because the GOES transmitted sectors often do not overlap.

As a further comparison, Figure 5 shows a comparison of simple stereo and the asynchronous analysis. The motions because of the 1 minute mismatch in time between the GOES East and West images do not seem to cause a major problem, and the simple stereo gives as good an answer as the analysis with 6 images.

Figure 3 Rotated view of the CIMSS winds results.

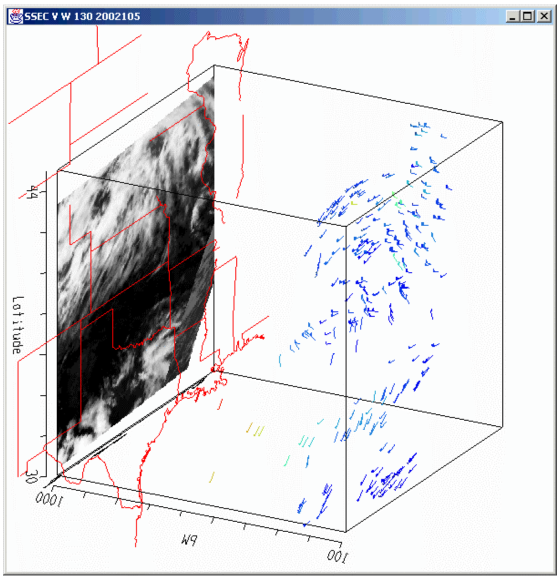


Figure 4 Rotated view of Asynchronous results.

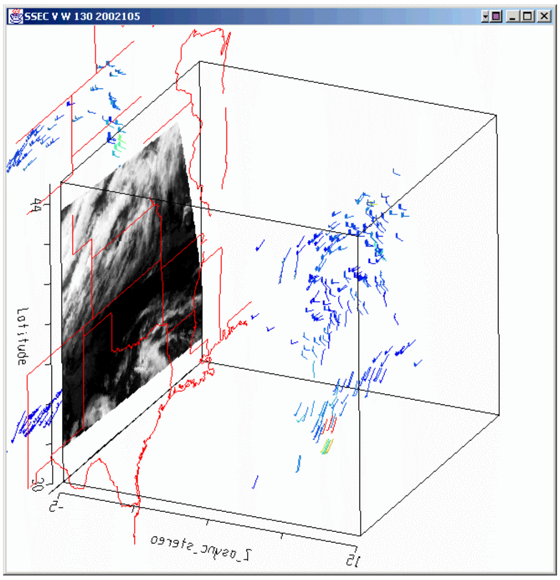
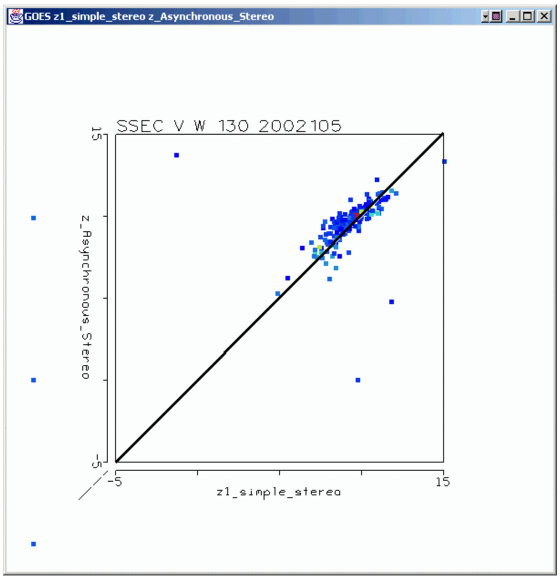


Figure 5 Asynchronous Stereo heights vs Simple stereo heights from just 1 GOES West and 1 GOES East image.



4. Software

VisAD is a portable software package providing two important components for this project (Hibbard et al 2002): The ability to access the real time wind products from CIMSS via an ADDE server. And second, the ability to display the results in an understandable manner.

In the automatic analysis, first a request is made to retrieve a set of wind vector estimates either from the CIMSS server or the NESDIS server. Then satellite images are gathered for matching times. In the GOES cases, 3 images from GOES East and 3 from GOES West, then they are all remapped to a common projection. The wind vector data includes positions of the clouds for each time (3 latitute/longitudes). A patch of pixels from West image 1 is selected centered at that location. Then the East image 1 is searched for the set of pixels with the highest correlation to the west set. The displacement between these is primarily caused by parallax from the two view points. This process is repeated for the 3 image pairs. We could have correlated West 1 with West 2 as well but that search was performed in the initial CIMSS analysis. Finally the locations and times are analyzed by the asynchronous stereo scheme to arrive at a height estimate for the cloud.

VisAD is then used to display the heights and pressures (derived from the temperature at CIMSS) to provide verification of the results. Notice that this last step is not critical to the analysis of the clouds, it just displays the results. The program could be changed to output heights in some standard format. Figure 2 shows a scatter plot between heights and pressures. (In the presentation this will be shown as an interactive display.) A web site has been prepared describing the process, showing some results and providing links to the software: acamar.cira.colostate.edu/autoStereo/selectStereo.html. Improvements to the software and new examples will be stored here for general use.

5. Conclusion

An automatic, portable asynchronous stereo analysis scheme has been developed. It demonstrates that the geometric and temperature cloud height assignment methods are similar. It is possible to identify some clouds which have incorrect heights derived from the temperature, but the stereo scheme has considerable random error.

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