TITLE: An Application of VISSR Atmospheric Sounder (VAS) Data in Mesoscale Analysis

RESEARCH INVESTIGATOR:

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SIGNIFICANT ACCOMPLISHMENTS:

This research topic is an off-shoot of a study which evaluated the accuracy and representativeness of VAS sounding data with special rawinsonde measurements (discussed elsewhere in this document). General findings of the study concluded that significant discrepancies often occur between VAS sounding and rawinsonde data at the mesoscale. These discrepancies usually represent biases in the satellite soundings which occur because of the poor vertical resolution of VAS especially where significant temperature and moisture fluctuations (inversions) occur. The influence of these biases on the horizontal representation of the atmosphere by VAS usually results in reduced horizontal gradients but often possesses significant mesoscale structure which could be quite useful in diagnostic studies and nowcasting. There are other problems with satellite sounding data other than errors and biases which limit the usefulness of the data, however. Irregular data spacing (due to clouds) often presents a major problem in using VAS data and restricts a detailed mesoscale analysis to a small area. Ordinary attempts to get mesoscale detail with VAS over a large area often result in over-smoothed fields in order to avoid spurious results in data sparse regions. A solution to this problem is to perform a complicated assimilation scheme to combine VAS and rawinsonde data to produce a regional analysis of the atmosphere. This involves considerable effort, does not totally address the satellite-rawinsonde bias problem, may over-smooth the data, and is not very applicable to diagnostic studies. The research highlighted in this write-up presents a very simple and straight forward approach to these problems to produce mesoscale analyses of VAS data over a large area (which may contain cloudy regions) with good temporal and spatial consistency.

Commonly used objective analysis schemes are very effective in producing gridded fields of meteorological parameters where data spacing is uniformly spread over the entire analysis region. The amount of detail contained in these fields can be controlled to produce consisted mesoscale analyses. A scheme similar to Barnes (1973) is employed in this study to produce gridded analyses of basic and derived parameters of satellite data over a 2000 x 1500 km region in the central part of the United States. The general procedure in the Barnes scheme is to apply a correction pass to an initial gridded field where the correction at each grid point is based on the data values and their distance from each grid location. Mathematically this can be expressed as follows:

$$G_{i,j} = I_{i,j} + \frac{\sum_{k=1}^{N} (X_k - XI_k) \cdot W_k'}{\sum_{k=1}^{N} W_k'} \qquad (1)$$

where,

G is the final grid point value,
I is the grid value from the initial pass,
X is an observation,

XI an initial pass grid point value interpolated to an observation,
i x coordinate increment,
j y coordinate increment,
N the total number of observations, and
W´ the weight factor given by

$$\exp\left(\frac{-(D)^2}{\gamma \cdot 4c}\right)$$

with
D being the distance between the grid point and the observation.

This scheme will produce very nice results on uniformly spaced observations with judicious values of γ and 4 c.

In data sparse regions the "goodness" of the interpolated values becomes questionable since both the influence of distant data and the sum of the weight factors can be small (see (1)). This difficulty has been experienced by anyone getting "bullseyes" or "irregularities" in their gridded fields. Reducing the sum of the weights of the observations (denominator of (1)) in data sparse regions, as in this study, increases the influence of the first pass on the final field and produces a somewhat smoother (depending on the information content of the first pass) but consistent analysis in these areas. Mathematically, this modification is accomplished with a slight change to the denominator of (1) above as follows:

$$G_{i,j} + I_{i,j} + \frac{\sum_{k=1}^{N}(X_k - XI_k) \cdot W'_k}{\left(\sum_{k=1}^{N} W'_k\right) + ifl} \qquad (2)$$

The value assigned to "ifl" is somewhat arbitrary and depends on the selected γ , 4c value, and on the data density. A general guideline obtained from experience is to pick "ifl' such that in data rich areas 'ifl' is much less than the sum of the weights and in data sparse regions 'ifl' should be greater than or equal to the sum of the weights. In addition to this modification, the first pass gridded field usually produced by the Barnes scheme was substituted with the first guess field used in the actual retrieval of the satellite temperature and moisture profiles (in this case, an LFM forecast field). The effect of using these changes in the scheme is the generation of a consitent field in data void regions. Near the edge of data sparse regions, the analysis procedure produces a nice blend of the initial pass (first guess) and the satellite soundings which is consistent with the data trends. In regions of dense satellite soundings, the scheme does not significantly alter the sum of the weights normally assigned and produces a conventional product. Use of this first guess is also appropriate since the final retrieved VAS soundings are not totally independent from their first guess (Smith, 1983).

Figure 1a displays a subjective hand analysis of 700 mb satellite derived temperatures at 2035 GMT and the corresponding ground truth rawinsonde observations are in Fig. 1b. Several major items are apparent from looking at these figures. First, dense areas of satellite soundings are available over limited regions. A large data gap exists over east Texas, Arkansas, and Missouri where clouds prohibit accurate retrievals and thinly spaced observations are present over Colorado. Several pockets of cold temperatures exist over northern Kansas, west Texas and along the Big Bend region. A very small pocket of warmer exists over eastern New Mexico. This latter feature is quite small and mainly due to one satellite sounding. The ground truth

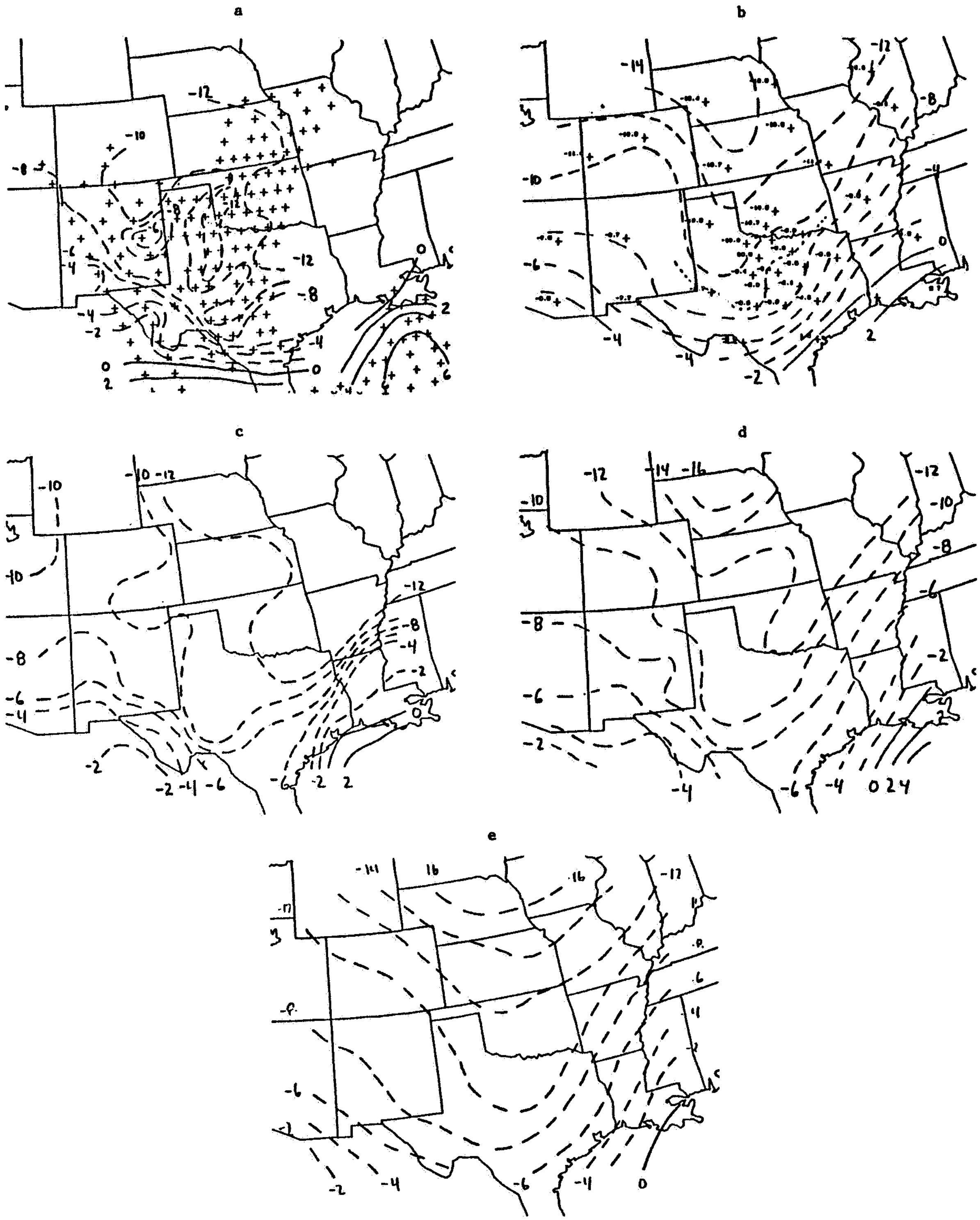

Figure 1. Subjective manual analysis of 700mb temperatures at 2045 GMT 6 March 1982 for VAS (a) and rawinsonde (b) data sets. Conventional two-pass objective analysis of VAS data (c), and the modified scheme gridded temperature field (d) produced substituting a LFM forecast field (e) for the first pass. Temperatures are in degrees C.

rawinsonde data indicate actual environment conditions over the region. The coldest air is centered over Nebraska and Kansas with a thermal trough extending down through west Texas. A ridge of warm air exists in Colorado and New Mexico.

Figure 1c indicates the type of product available over the region with the conventional application of the analysis scheme. In areas where data density is adequate, the satellite soundings are well analyzed, however, in data sparse regions the contours are bunched and/or disorganized. At the eastern edge of the large data void, a somewhat artificial and misleading cold trough is present. This is due to the scheme and also the trend of the data where cloud-contaminated retrievals produce a cold bias. Figure 1d shows the analyzed satellite data when the modified scheme is employed. The LFM first guess data grid which the scheme utilizes is shown in Fig. 1e. This scheme produces a much more realistic analysis in data void regions while maintaining the integrity of the analysis in other areas. The small warm pocket over New Mexico has been modified and the artificial cold trough in the cloudy areas has been removed. The cold trough extending back into west Texas is still present and is one of the dominant features in the satellite and rawinsonde analysis. The application of this scheme at all time periods has produced a consistent satellite data set with considerable mesoscale detail.

CURRENT AND FUTURE WORK:

Current efforts involve refining the technique and testing its performance on several other case studies. Although the scheme is very simple to apply, a judicious choice of the first guess and its influence is essential for a good analysis. Further studies of these restrictions on the data fields are necessary. The application of this scheme to satellite soundings other than those produced by a physical retrieval method should be evaluated to determine the broader use of this procedure.

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1. Application of VISSR Atmospheric Sounder (VAS) Data. NASA Technical Memorandum (in press), Marshall Space Flight Center, Huntsville, 1984.
2. Application of VISSR Atmospheric Sounder (VAS) Data in Weather Analysis. Preprints 10th Conf. on Weather Forecasting and Analysis, AMS, Boston, June 1984 (in press).

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Smith, W.L., 1983: The retrieval of atmospheric profiles from VAS geostationary radiance observations. J. Atmos. Sci., 40, 2025-2035.