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CASE STUDIES USING HOURLY REAL-TIME GOES SOUNDER OZONE ESTIMATES

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1. INTRODUCTION

For over three years data from the Geostationary Operational Environmental Satellite (GOES) Sounder has been used to estimate total column ozone (TCO) hourly at 30 km by 30 km resolution in real-time. Colocated, instantaneous ozone estimates from the Total Ozone Mapping Spectrometer (TOMS) and the GOES Sounder compare to within 4-7% (Li 2001). Gradients in the GOES Sounder total column ozone field depict ozone features in the atmosphere (Schmidt 2000). TOMS observations, water vapor imagery, and potential vorticity fields are used to confirm these observations. Many atmospheric features, including tropopause folds, breaking synoptic waves, cut-off lows, upper-air troughs, and jet streams, can be identified in real-time from GOES Sounder TCO imagery. Hourly GOES Sounder TCO estimates provide the first real-time glimpse of ozone dynamics over a large region at high spatial and temporal resolutions.

2. TOTAL COLUMN OZONE ESTIMATION METHOD AND ACCURACY

GOES Sounder TCO estimates are made by linear regression against cloud-free and partly cloudy brightness temperatures from the GOES Sounder, latitude, month, and surface pressure. The regression coefficients are derived from the NOAA88b atmospheric temperature, moisture, and ozone profile set provided by the National Oceanic and Atmospheric Administration (NOAA). Regression is the preferred method since physical retrievals fail to improve upon the accuracy of the regression results, and in many cases perform worse than the regression based ozone estimate (Li 2001).

Variations of GOES Sounder ozone estimates relative to TOMS and surface-based observations are small. The relatively small size of the NOAA88b profile training set (2631 profiles) introduces biases into the estimates. Dry atmospheres and hot surface temperatures correlate to the most notable variances between TOMS ozone measurements and GOES ozone estimates. The GOES Sounder has reduced sensitivity to ozone changes outside of the lower stratosphere and upper troposphere, though with little effect on TCO due to the low ozone densities at those levels. Uncertainties regarding surface type, elevation, and thin cloud cover also introduce variances into the GOES TCO field (Li 2001).

3. CASE STUDY: TOTAL COLUMN OZONE AND ATMOSPHERIC VARIABLES

GOES Sounder TCO estimates provide hourly, real-time tracking of ozone features in the upper troposphere and lower stratosphere. Ozone reflects the dynamics of those atmospheric levels through its relationship to potential vorticity and thereby allows for a preliminary diagnosis of atmospheric features that result in or are the result of the deformation of the tropopause (Shapiro 1981; Steinbrecht 1998). Such features include tropopause folds, breaking synoptic waves, cut-off lows, upper-air troughs, and jet streams.

Fig. 1 includes an example of how GOES Sounder TCO relates to potential vorticity and the altered water vapor (AWV) product (Moody 1999). Potential vorticity was calculated from the ETA model 12 UTC analysis and the AWV product was generated from the GOES-8 water vapor channel (6.8 μm) image and ETA model 12 UTC analysis for September 29, 1999. Fig. 1b, the AWV product, shows a dry (dark) region over Minnesota, Wisconsin, and Iowa that corresponds very well with the enhanced ozone region in Fig. 1a. Fig. 1c illustrates the potential vorticity at 200 hPa, and a clearly defined lobe is visible, collocating well with the ozone feature in Fig. 1a. Fig. 1d depicts the cross section of the potential vorticity field. The shape of the contours are reminiscent of the potential vorticity structure along a jet stream axis (Shapiro 1981). The gradients and features observed in the ozone field commonly reflect similar potential vorticity, and therefore lower stratospheric and upper tropospheric, structures (Schmidt 2000). The hourly ozone product resolves these structures with temporal and spatial resolutions that is lacking from most models and traditional sources of ozone data.

4. SUMMARY

The fields depicted by the GOES Sounder total column ozone estimates reflect structures in the lower stratosphere and upper troposphere. Model-derived potential vorticity, water vapor imagery, and other data indicate that the features in those ozone fields represent atmospheric structures that involve deforming the tropopause through raising, lowering, or folding. With

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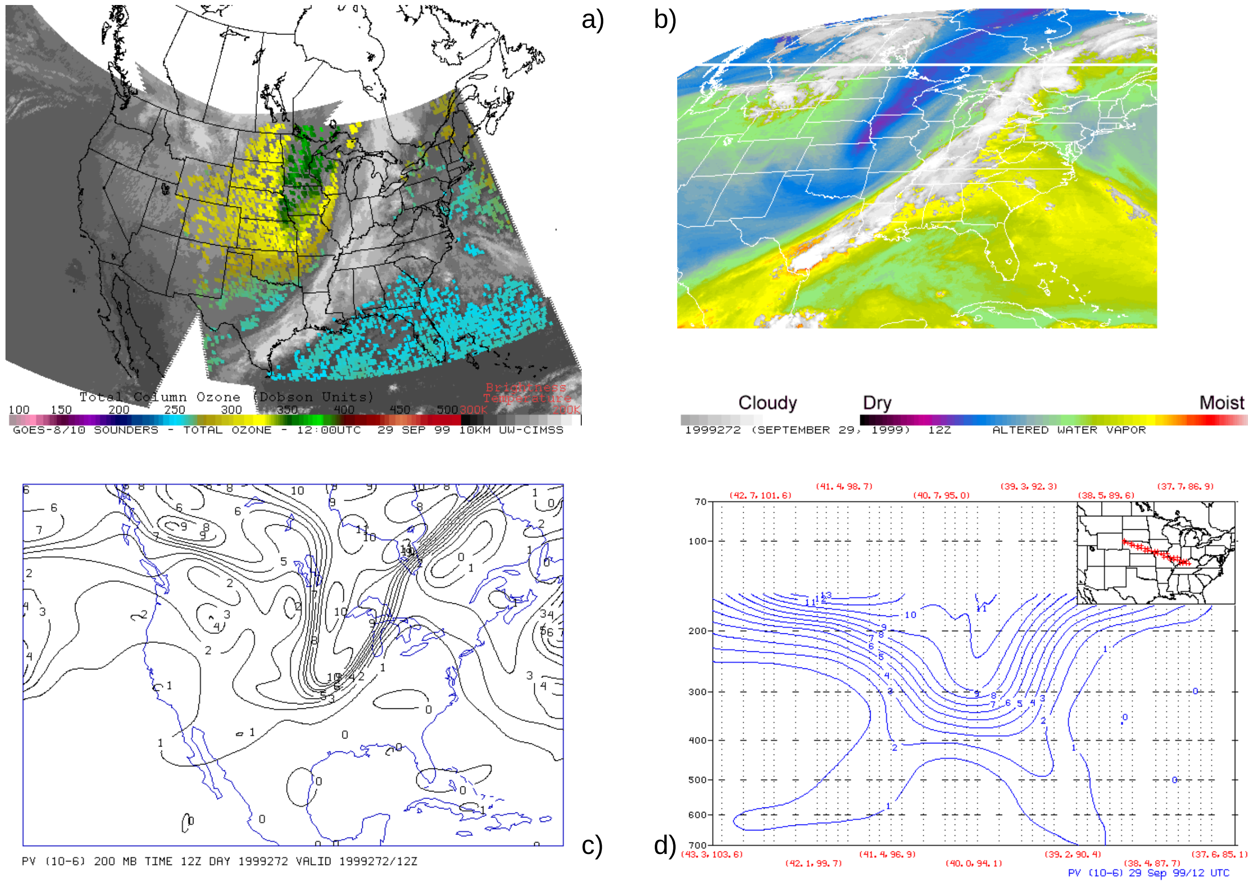

Fig. 1. GOES Sounder total column ozone (TCO), altered water vapor (AWV), and potential vorticity on September 29, 1999 (1999272) at 12 UTC. The AWV and potential vorticity fields confirm that the ozone field represents real atmospheric features. The dark ozone feature in (a) located over Minnesota, Wisconsin, and Iowa correlates well with the features in the AVW (b) and potential vorticity at 200 hPa (c). (d) is a potential vorticity cross-section.

high spatial and temporal resolutions, GOES Sounder TCO estimates allow tracking the life cycles of such features at a level of detail that was previously impossible to achieve. Furthermore, the GOES Sounder TCO fields provide insight into the upper atmosphere in data poor regions as well as opportunities to observe phenomenon, such as clear air turbulence, that exist on too small a scale or for too short a time to be observed with more traditional ozone measurement methods.

Further examples of ozone features observed in the GOES Sounder TCO fields, as well as corroborating information and animations, may be found at: http://cimss.ssec.wisc.edu/goes/amssatconf2001/ozone_p3.36.html

5. REFERENCES

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