Ten Year Climatology of CAPE observations from Hyperspectral IR Sounders

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Introduction

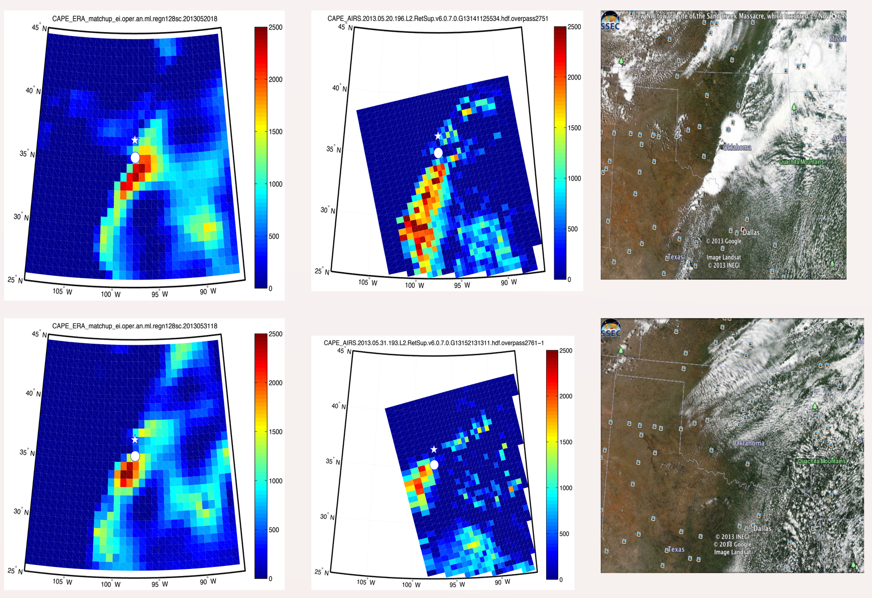
High priority must be given to research for new remote sensing applications especially relating to severe weather. Extreme convective instability from remote sensing technologies should be incorporated into severe thunderstorm risk assessments. For example, a climatology of Convective Available Potential Energy (CAPE) is routinely used to characterize convection as having moderate or severe potential. Relating this climatology to near real time observations from meteorological sensors on weather satellites is going to be a valuable tool in assessing the risk of severe weather. Satellite data products from AQUA AIRS were used to compute a 10 year climatology for the ARM Southern Great Plains site near Lamont, Oklahoma.

Methods

The following definitions were used in the computation of selective convective indices (Blanchard, 1998).

$$CAPE = g\int_{EL}^{LFC} \frac{(T_{v,parcel} - T_{v,env})}{T_{v,env}}\,dz$$

There is much discrepancy in calculating CAPE. Most of the discussion resolves around the standard way to lift a parcel (Doswell, 1994). The 4 most common parcel times are as followed: surface parcels, mixed layer parcels, parcel's with the largest CAPE and the forecasted parcel. This paper utilizes the surface parcel method for calculating CAPE. In addition, this study uses the SHARPpy software routines described in Halbert et al., 2015 in comparison to the UW surface CAPE matlab script. SHARPpy is a program that can be used for both research and operational applications (Hart, 1999).

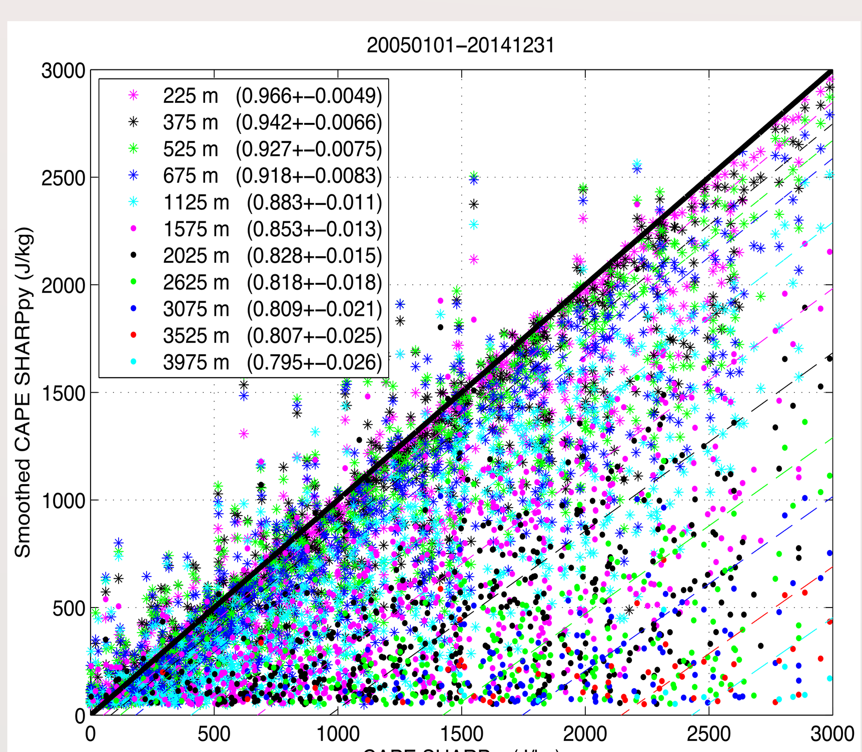


CAPE values (J/kg) computed from ERA-interim (left) and AIRS (midlle) for May 20, 2013(upper) and May 31, 2013 (lower). The star symbol represents the location of the ARM site (36.605 N, 97.485 W) and the circle symbol is the Norman Oklahoma location (35.23 N, 97.45 W), a distance of 153 km. The right panels illustrate the cloud development using MODIS visual satellite imagery.

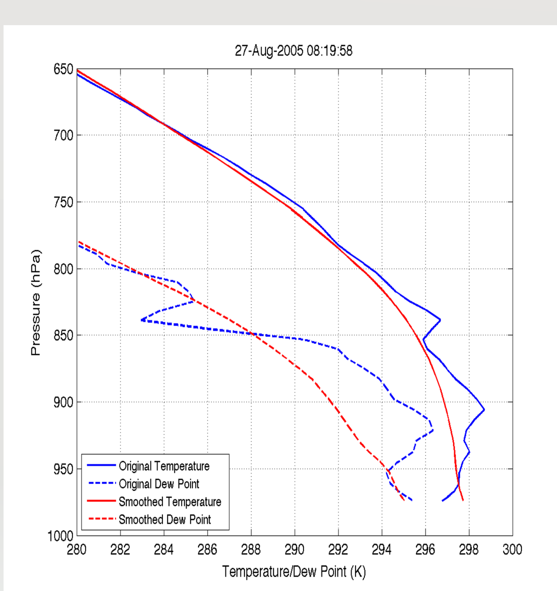
Error Analysis

Vertical Resolution

There were two major sources errors in the AIRS satellite data. The first is the vertical resolution. In order to create a more accurate comparison, ARM sonde data was smoothed at various level. There is a 10 percent error in computing CAPE for a full-width greater than 1000 meters. Between 1000 and 2000 meters the error is between 10 and 30 percent.



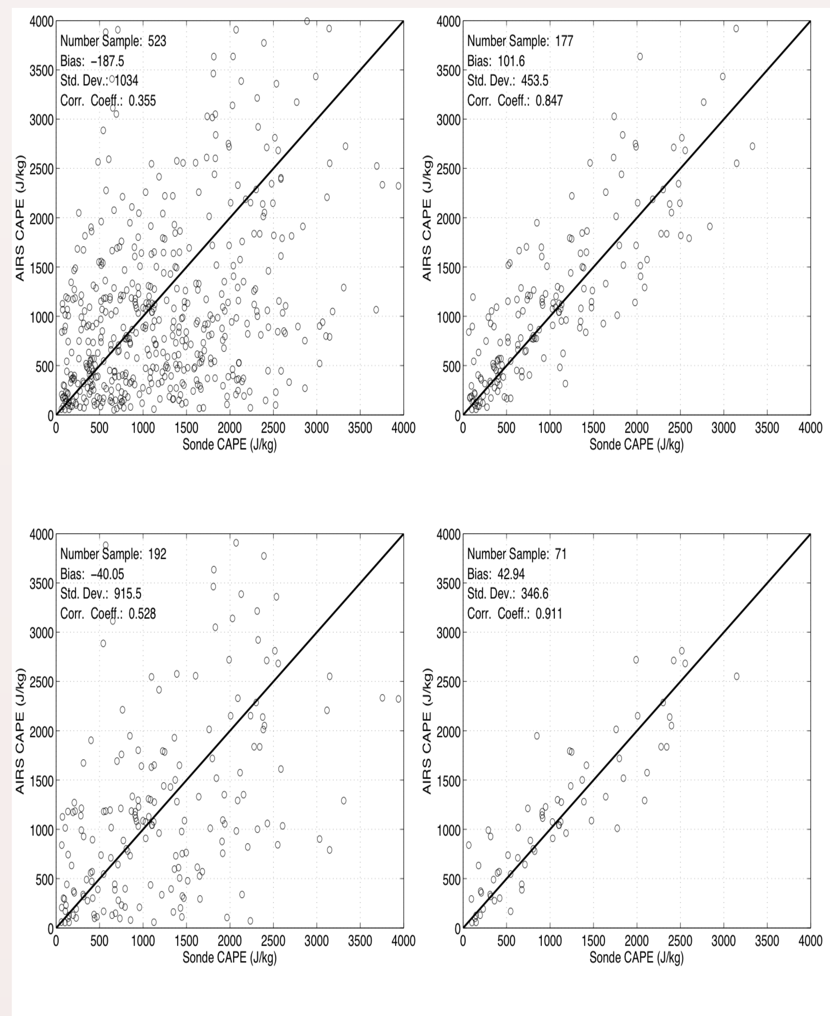
CAPE computed from vertically smoothed sonde temperature and moisture profiles compared to CAPE computed from full resolution vertical sounding at 75 meter resolution. The legend indicates the boxcar smoother full width in meters and the linear regression slope fit.



An example of a smoothed soundings and an original sounding on August 27, 2005 at the ARM SGP site containing a nocturnal temperature inversion.

Surface Dependence

The correlation of AIRS CAPE with coincident ARM Sondes depends on surface dew point temperature error.



The table shows that the mean error in the surface parcel temperature and dewpoint temperature of both AIRS and ERA increases as the Sonde CAPE increases. The figures above show improved correlation for the subset of cases that have dewpoint error < 1 degree C.

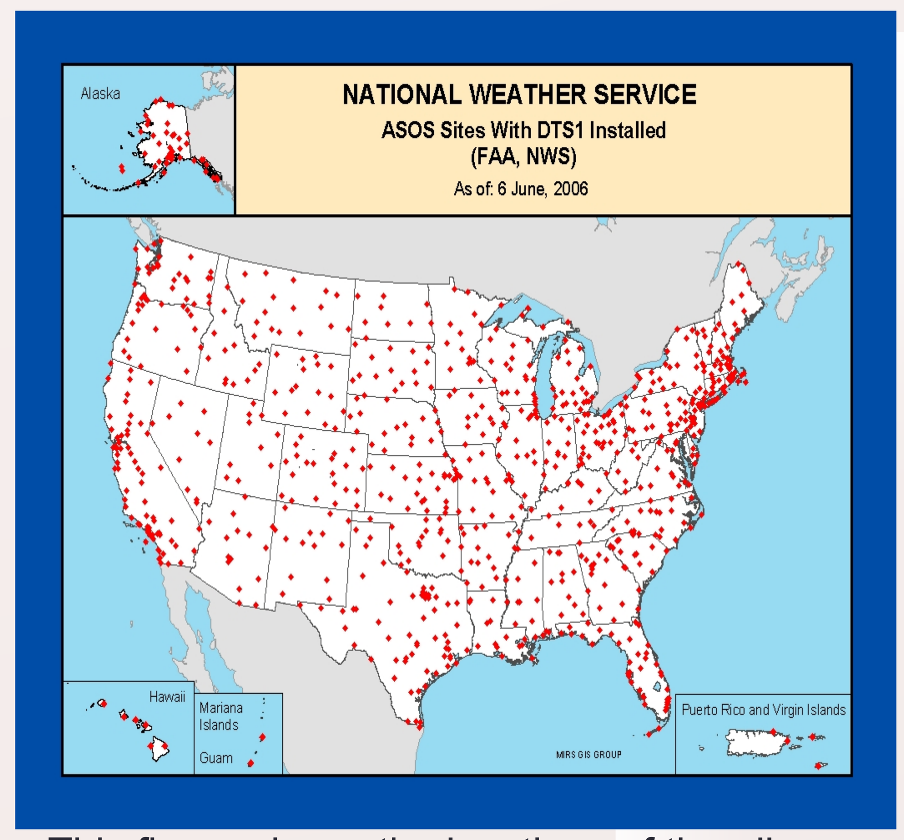
CAPE (J/kg) minimum cutoff for SONDE	ERA		AIRS	
	Surface Temperature	Surface Dew Point	Surface Temperature	Surface Dew Point
0	Mean: 0.93 Std. Dev = 4.0	Mean: -0.80 Std. Dev = 4.52	Mean: 1.12 Std. Dev = 3.48	Mean: 0.14 Std. Dev = 4.39
50	Mean: -0.34 Std. Dev = 3.61	Mean: -2.2 Std. Dev = 3.60	Mean: -0.29 Std. Dev = 3.41	Mean: -2.11 Std. Dev = 3.64
350	Mean: -0.68 Std. Dev = 3.94	Mean: -2.72 Std. Dev = 3.75	Mean: -0.56 Std. Dev = 3.61	Mean: -2.62 Std. Dev = 3.75
820	Mean: -0.85 Std. Dev = 4.21	Mean: -3.0 Std. Dev = 3.86	Mean: -0.53 Std. Dev = 3.7	Mean: -2.67 Std. Dev = 3.91
1330	Mean: -1.02 Std. Dev = 4.61	Mean: -3.87 Std. Dev = 4.81	Mean: -0.43 Std. Dev = 2.76	Mean: -3.72 Std. Dev = 4.04
1520	Mean: -1.01 Std. Dev = 4.39	Mean: -4.33 Std. Dev = 4.29	Mean: -0.66 Std. Dev = 2.93	Mean: -4.3 Std. Dev = 4.27
2500	Mean: -1.68 Std. Dev = 4.68	Mean: -5.67 Std. Dev = 5.04	Mean: -2.28 Std. Dev = 5.94	Mean: -7.49 Std. Dev = 5.28
3050	Mean: -3.06 Std. Dev = 6.28	Mean: -5.77 Std. Dev = 7.21	Mean: -4.81 Std. Dev = 6.36	Mean: -8.36 Std. Dev = 6.54

Climatology of Sonde, AIRS, & ERA

	ARM Sonde SGP site	ERA			AIRS		
CAPE >1000 J/kg	38%	38%	37%	37%	38%	38%	37%
25th	350	260 (-26%)	260 (-26%)	260 (-26%)	260 (-26%)	260 (-26%)	260 (-26%)
50th	820	680 (-17%)	680 (-17%)	680 (-17%)	680 (-17%)	680 (-17%)	680 (-17%)
67th	1330	1100 (-17%)	1100 (-17%)	1050 (-21%)	1050 (-21%)	1100 (-17%)	1050 (-21%)
75th	1520	1330 (-12.5%)	1330 (-12.5%)	1280 (-16%)	1330 (-12.5%)	1380 (-9%)	1330 (-12.5%)
95th	2500	2500 (0%)	2450 (-2%)	2400 (-4%)	2590 (+4%)	2590 (+4%)	2540 (+2%)
99th	3050	3150 (+3%)	3100 (+2%)	3100 (+2%)	3250 (+7%)	3200 (+5%)	3200 (+5%)

Future Improvements

ASOS (Automated Surface Observing Systems) stations will be used to improve satellite CAPE east of the Rocky Mountains by providing an improved estimate of the surface parcel temperature and dewpoint.



This figure shows the locations of the all the ASOS weather stations. By taking the surface temperature and dewpoint from ASOS and the vertical profiles from AIRS, an improved CAPE estimate can be achieved.

References

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Acknowledgements

We gratefully acknowledge the support of the JPSS program through the CIMSS CA grant NA10NES4400013.

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