

Near-real time CAPE East of the Rockies Combining Hyperspectral IR Satellite Sounding and ASOS Surface Stations:

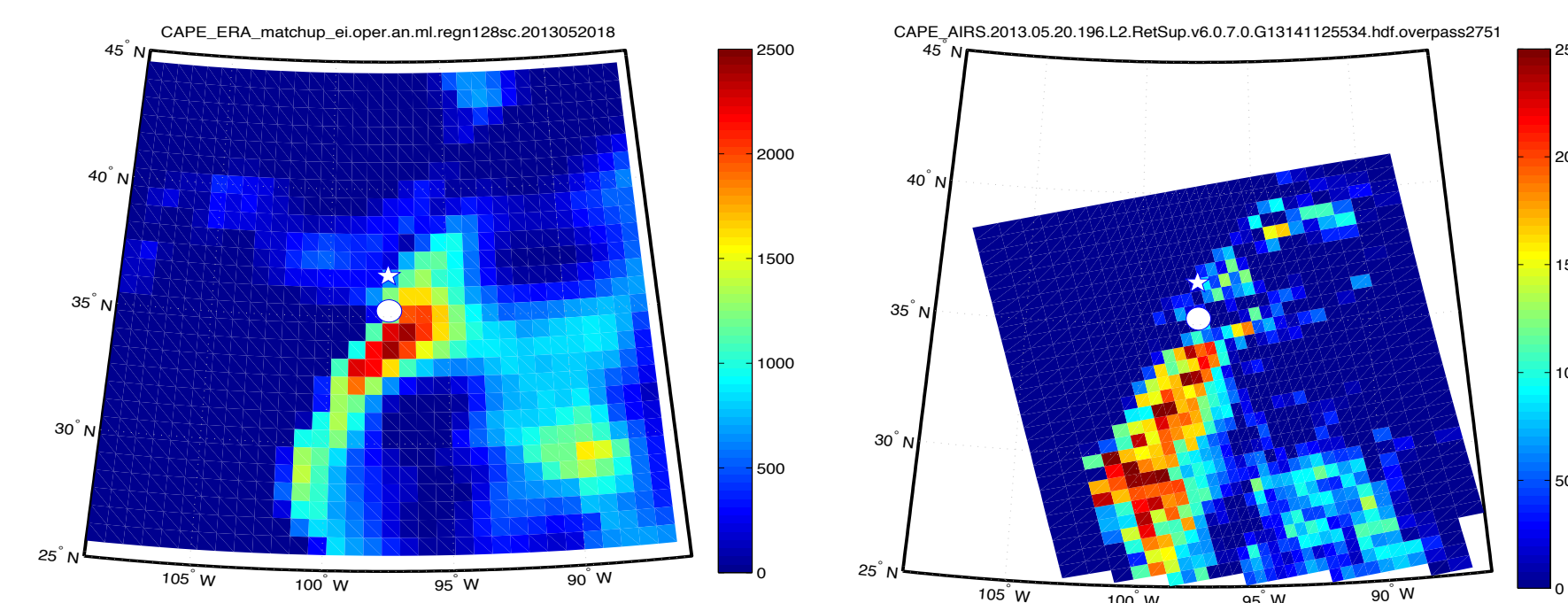
Part II Methodology and Preliminary Results

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Abstract

May 20, 2013 Moore, Oklahoma Tornado Case Study



CAPE calculations from NWP data CAPE from satellite data

Near-real time satellite data can give forecasters the extra edge they need to issue timely and accurate watches and warnings. The Convective Available Potential Energy (CAPE) is a measure of atmospheric instability computed from vertical profiles of temperature and water vapor used the National Weather Service Storm Prediction Center (NWS SPC). CAPE can give forecasters valuable information as to the stability of the atmosphere and therefore the potential for severe weather. The value of using satellite vertical soundings from hyperspectral infrared sensors has been recognized at the NOAA Hazardous Weather Testbed workshops held at the NWS SPC (<http://hwt.nssl.noaa.gov/>) Satellite overpass times from EUMETSAT METOP IASI at 10:30am/pm and NASA AQUA AIRS, Suomi-NPP CrIS, and JPSS J1 at about 1:30am/pm occur conveniently between the operational 0 and 12 UTC NWS radiosondes. In addition to more temporal coverage, satellite data can provide spatial coverage between NWS radiosonde launch sites. The right hand figure above illustrates the spatial coverage from the NASA AIRS satellite which is comparable to the coverage provided from the ECMWF model shown on the left. The May 20, 2013 tornado touchdown occurred in Moore, Oklahoma indicated by the white circle. The white star indicates the Department of Energy Atmospheric Radiation Measurement (ARM) site location where radiosondes are launched each day at 0600 and 1800 UTC. The ARM site is used in the study for assessment of satellite derived CAPE.

Automated Surface Observing System (ASOS) stations currently operate routinely at U.S. airports and provide surface meteorological measurements at 1 minute intervals reported in METAR format. In this study, we restrict our analysis to ASOS surface stations east of the Rocky Mountains where severe storms are common in spring and summer. The methodology section describes a 2-dimensional interpolation technique to create gridded surface values from the non-uniformly spaced ASOS stations. The gridded ASOS surface observation and IR sounder profiles will be merged before computing surface CAPE values. Using the resources of the SSEC we are able to demonstrate a near-real time estimate of the CAPE in the U.S. east of the Rocky Mountains using the direct broadcast reception facility at UW-Madison and access to NASA real-time data streams. A preliminary demonstration of near-real time CAPE using JPSS satellite data is intended to be made available via a restricted web page at SSEC. More information is available upon request.

This paper is Part II of a two part study to investigate the utility of satellite derived CAPE in the continental U.S. east of the Rocky Mountains. Part I of this work can be found at poster 871 Near-real time CAPE East of the Rockies combining Hyperspectral IR Satellite Sounding and ASOS Surface Stations: Part I Validation at the ARM SGP Site. Part II describes the method used to obtain the surface observations and a verification of the merging of the surface and satellite data using 10 years of observations at the ARM southern great plains site.

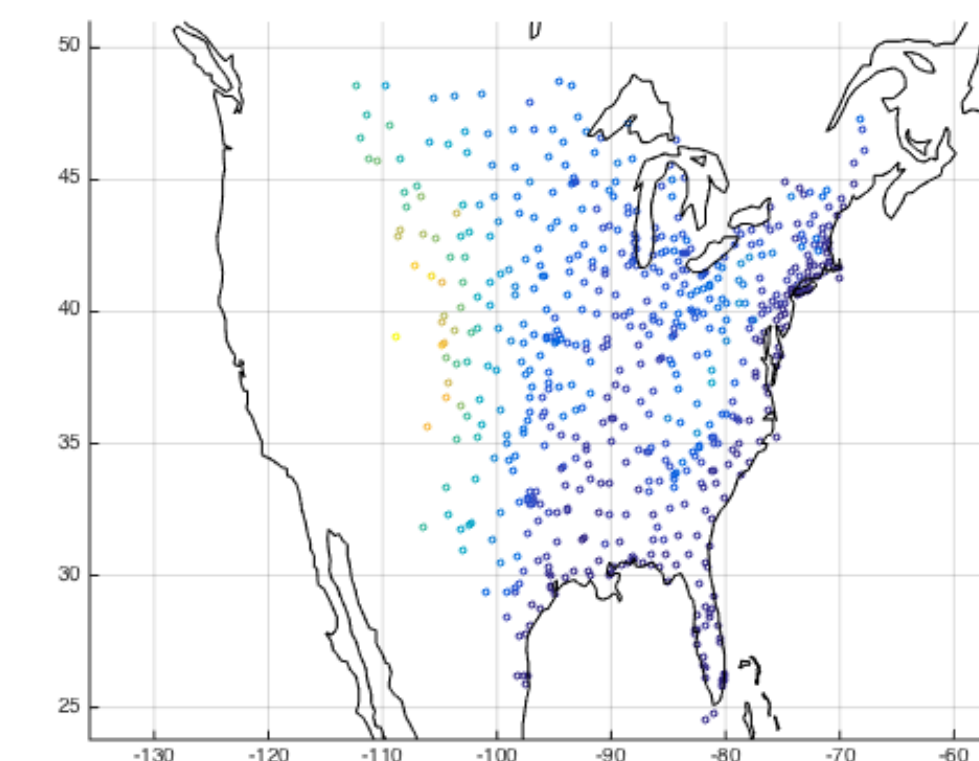
Acknowledgements and Contact

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Methodology

ASOS Station Map



ASOS (Automated Surface Observing System) station locations east of the Rocky Mountains. These are mostly located at airports in the U.S.

NCDC METAR Format Example

```
13969KPNC PNC20130604194011006/04/13 19:40:31 5-MIN KPNC 050140Z AUTO
12011G18KT 10SM OVC049 24/19 A2987 1050 73 2400 110/11G18 RMK AO2 $
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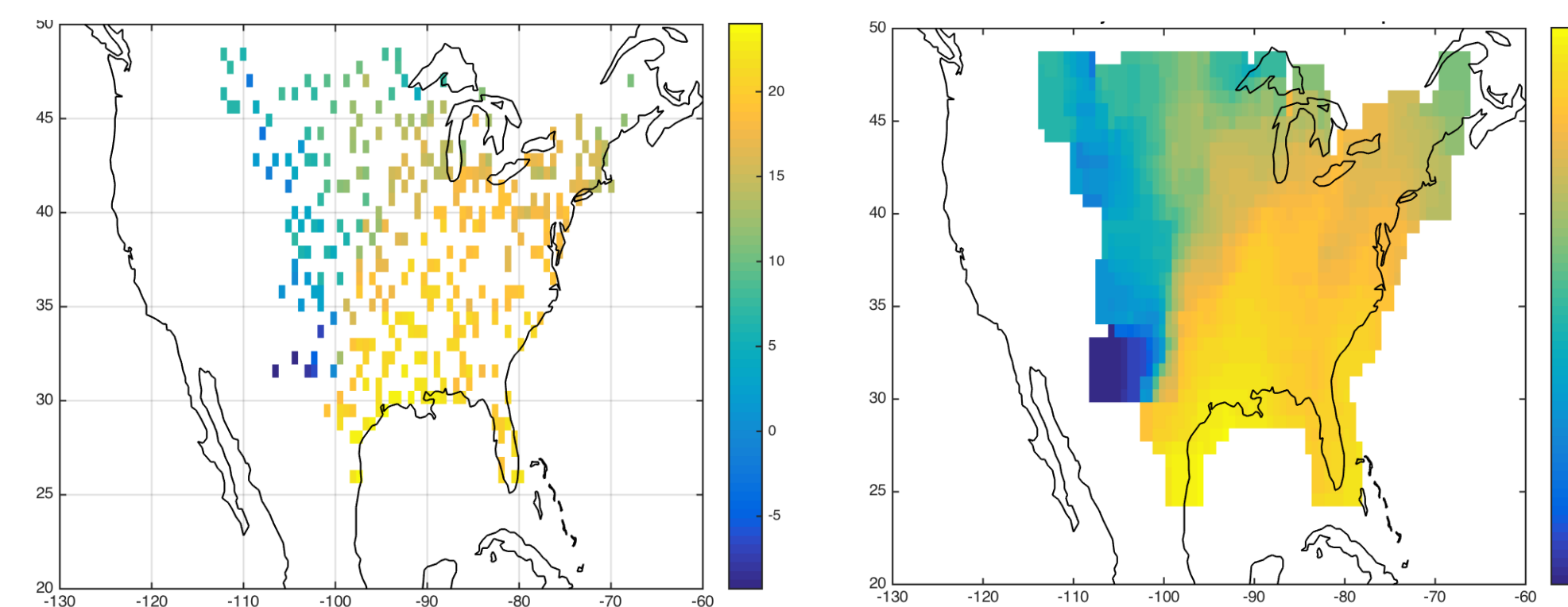
5-minute ASOS data fetched from NCDC (National Climatic Data Center) in METAR format

After decoding METAR, the data was temporally smoothed with a 1 hour boxcar smoother.

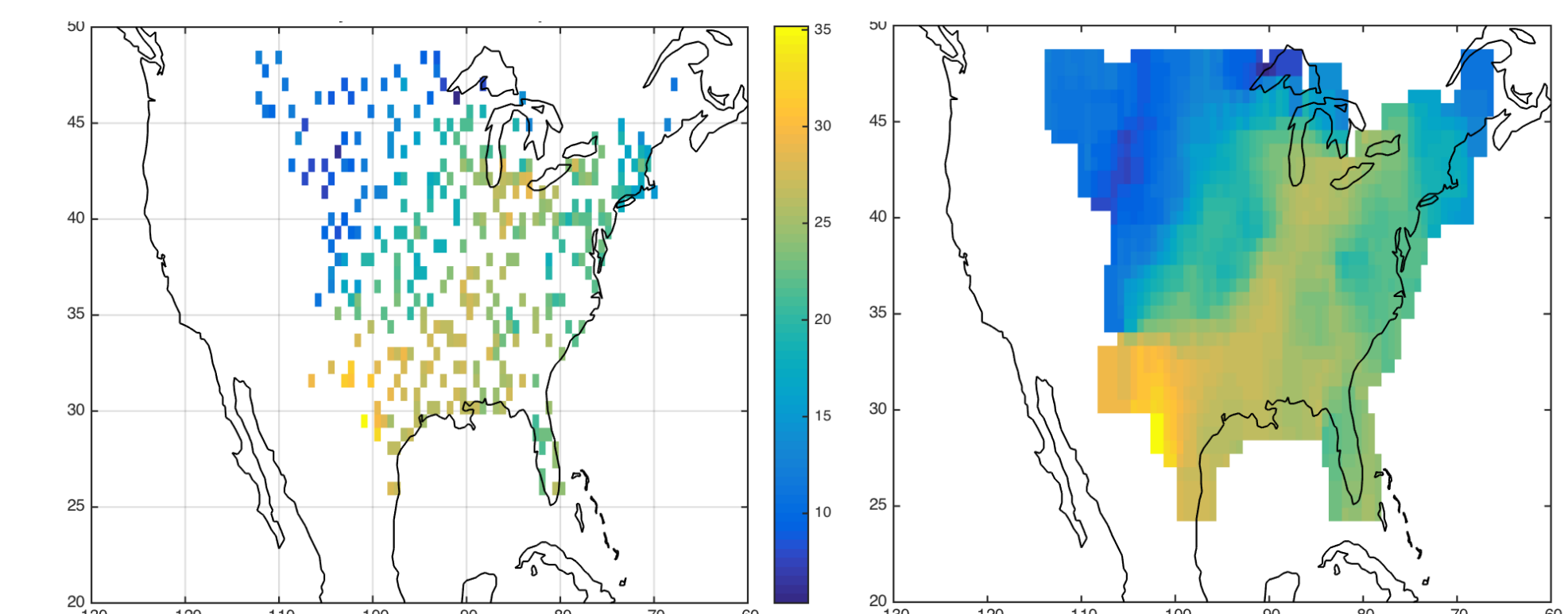
After smoothing, coincident hourly station data was extracted.

Finally, the hourly data was smoothed to a 0.7x0.7 degree grid by a 2-dimensional 5x5 boxcar convolution to interpolate the values in between ASOS stations.

ASOS Data for Case Study Day



The figure on the left is the extracted dewpoint station data for 20 May 2013 at 19:40 UTC to match up with the satellite overpass time. A 2D 5x5 boxcar convolution smoothed this data shown in the figure on the right.

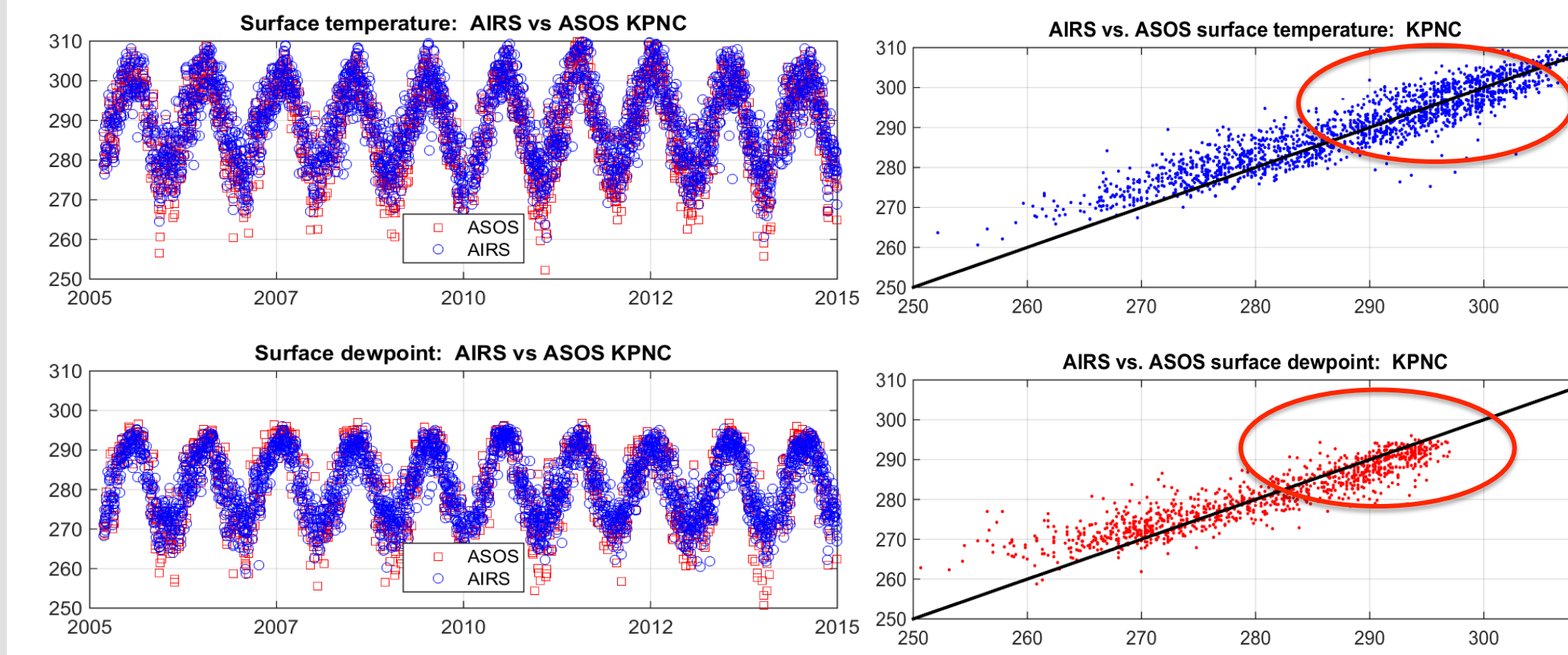


The figure on the left is the extracted temperature station data for 20 May 2013 at 19:40 UTC to match up with the satellite overpass time. A 2D 5x5 boxcar convolution smoothed this data shown in the figure on the right.

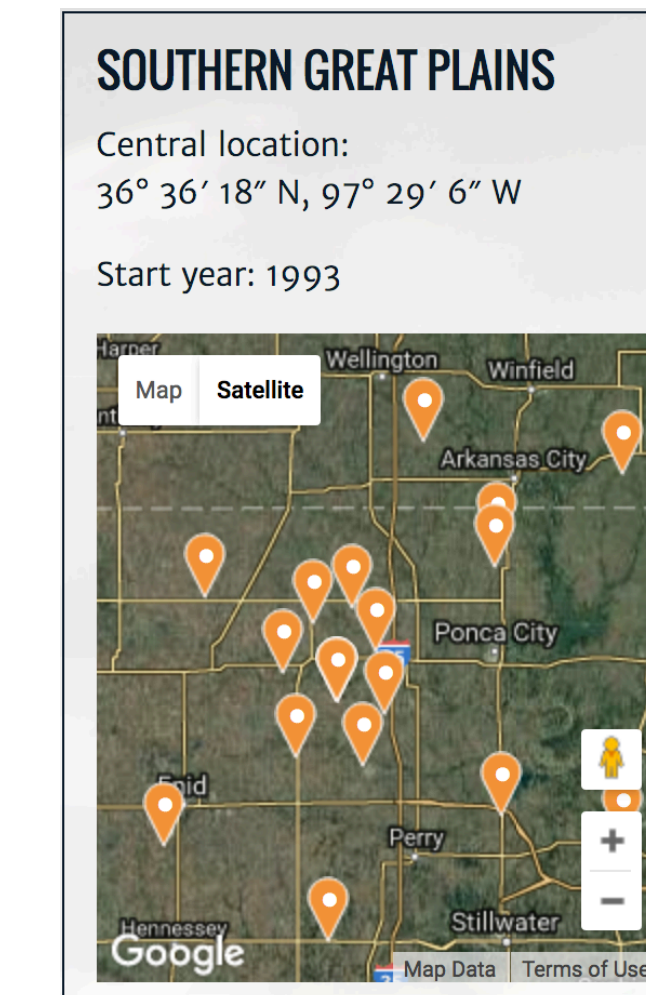
IR Satellite and Surface Data

Surface Parcel Estimate

A comparison was made between the Ponca City ASOS station (KPNC) near the ARM SGP site and the NASA Atmospheric InfraRed Sounder (AIRS) estimate of surface temperature and dewpoint. The circled regions in the figures are summertime cases. We found that AIRS estimate of the 2m air temperature is relatively unbiased. However, AIRS surface dewpoint is biased cold (dry) by several degrees. There is also a large scatter in the error in the surface parcel. Analysis of ERA model data shows similar results.



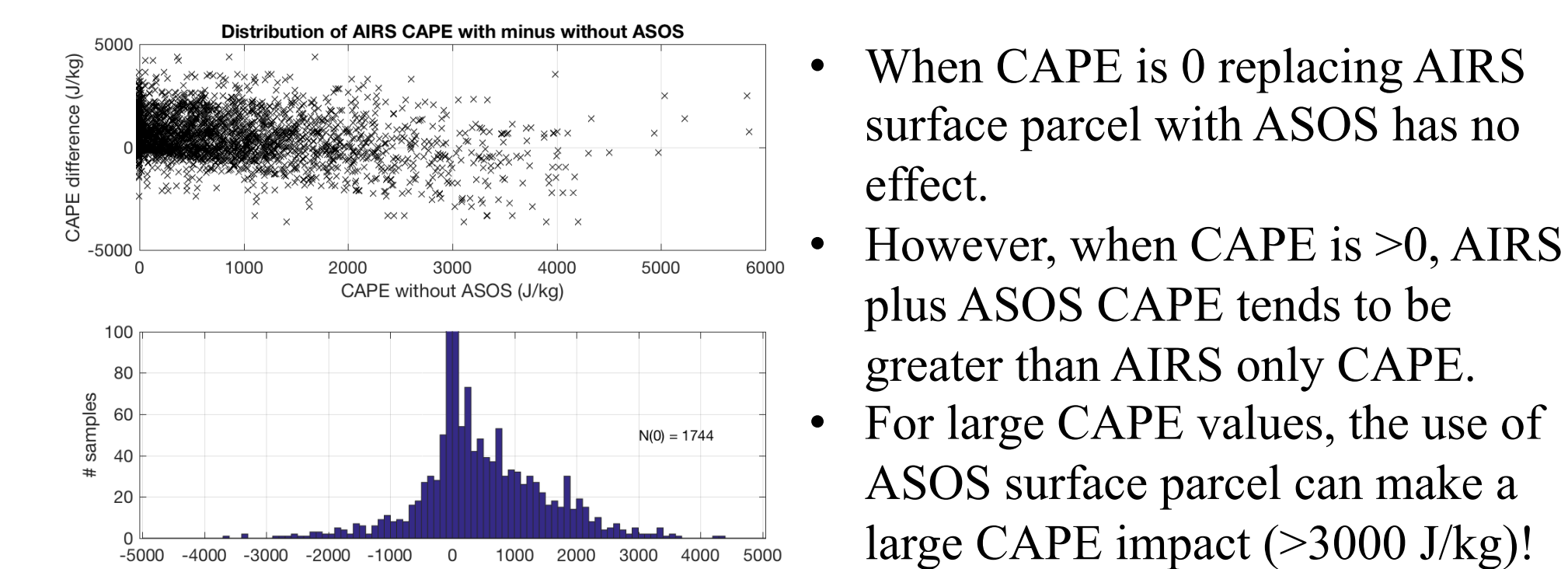
CAPE (J/kg) minimum cutoff	ERA		AIRS	
	Mean/Std. Dev	Mean/Std. Dev	Mean/Std. Dev	Mean/Std. Dev
0	0.93/4.0	-0.80/4.52	1.12/3.48	0.14/4.39
50	-0.34/3.61	-2.2/3.60	-0.29/3.41	-2.11/3.64
350	-0.68/3.94	-2.72/3.75	-0.56/3.61	-2.62/3.75
820	-0.85/4.21	-3.03/3.86	-0.53/3.7	-2.67/3.91
1330	-1.02/4.61	-3.87/4.81	-0.43/2.76	-3.72/4.04
1520	-1.01/4.39	-4.33/4.29	-0.66/2.93	-4.34/2.27
2500	-1.68/4.68	-5.67/5.04	-2.28/5.94	-7.49/5.28
3050	-3.06/6.28	-5.71/7.21	-4.81/6.36	-8.36/6.54



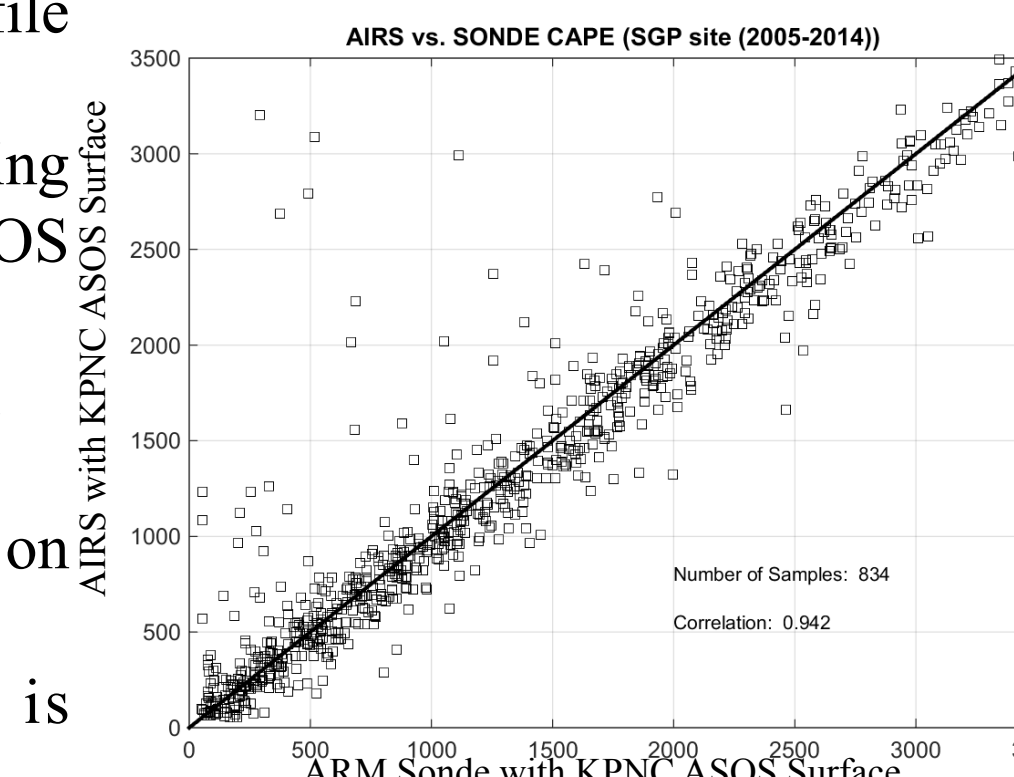
High CAPE values are associated with a very moist boundary layer with high dewpoint temperatures. We found that both ERA and AIRS underestimate the surface dewpoint and temperature in these cases.

The table gives a summary of the error in surface temperature and dewpoint temperature estimates of ERA and AIRS relative to the ARM radiosonde surface values for the time period January 2005 through December 2014. The bias/standard deviation for zero CAPE is quite small (< 1 C). However, for higher CAPE values the ERA and AIRS both exhibit a negative bias (cold bias) and an increase in the standard deviation (higher variability) for the largest CAPE values.

Substitute ASOS Surface Parcel

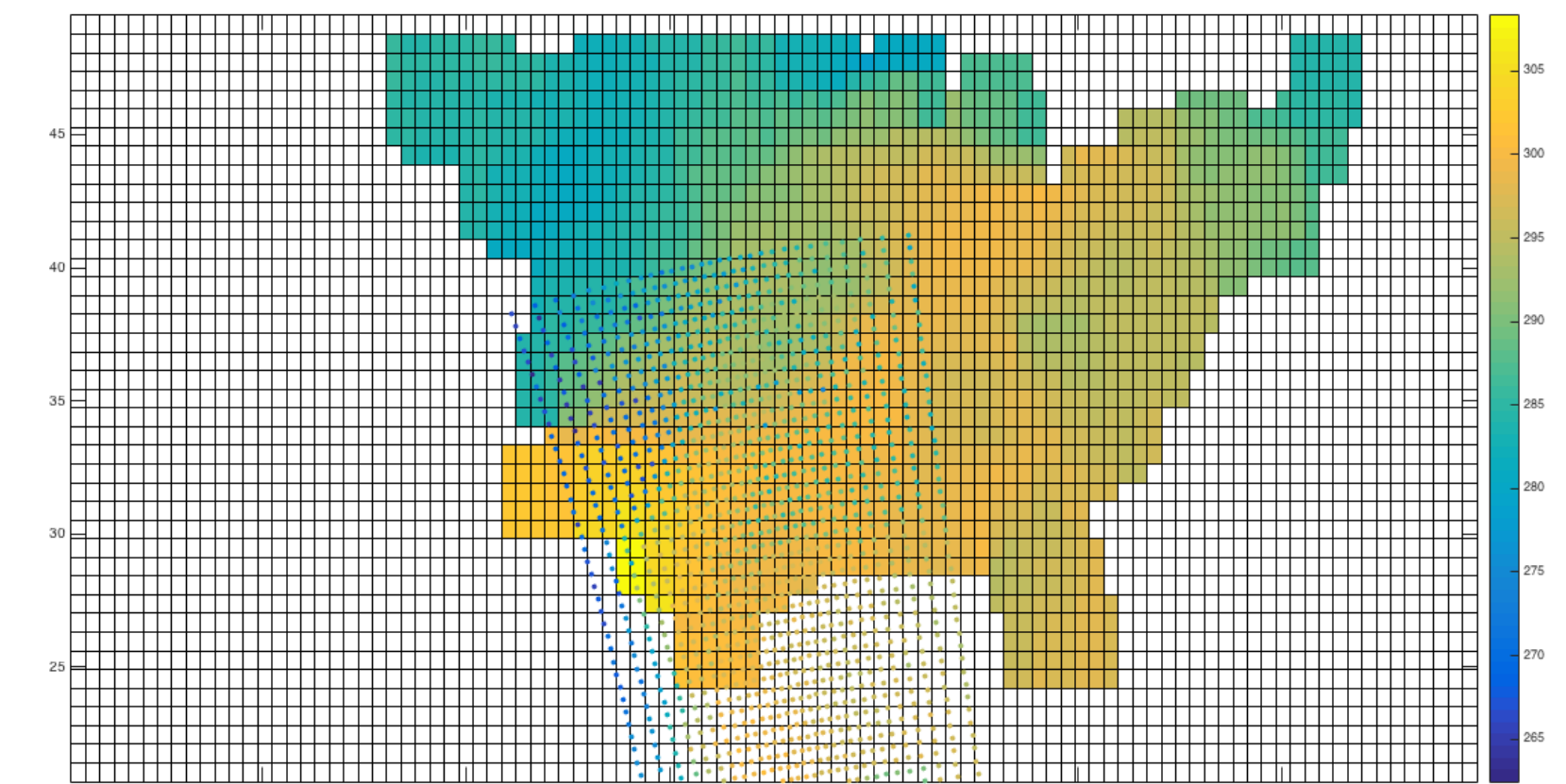


- When CAPE is 0 replacing AIRS surface parcel with ASOS has no effect.
- However, when CAPE is > 0 , AIRS plus ASOS CAPE tends to be greater than AIRS only CAPE.
- For large CAPE values, the use of ASOS surface parcel can make a large CAPE impact (> 3000 J/kg)!
- Compute CAPE using AIRS profile and ASOS surface T/Tdew.
- Compare to CAPE computed using ARM radiosonde profile and ASOS surface T/Tdew.
- High correlation (0.942) is found.
- For CAPE estimates this implies:
 - 1) CAPE is strongly dependent on surface parcel estimate ($\sim 1^\circ\text{C}$)
 - 2) AIRS upper air profile is equivalent to radiosonde profile.



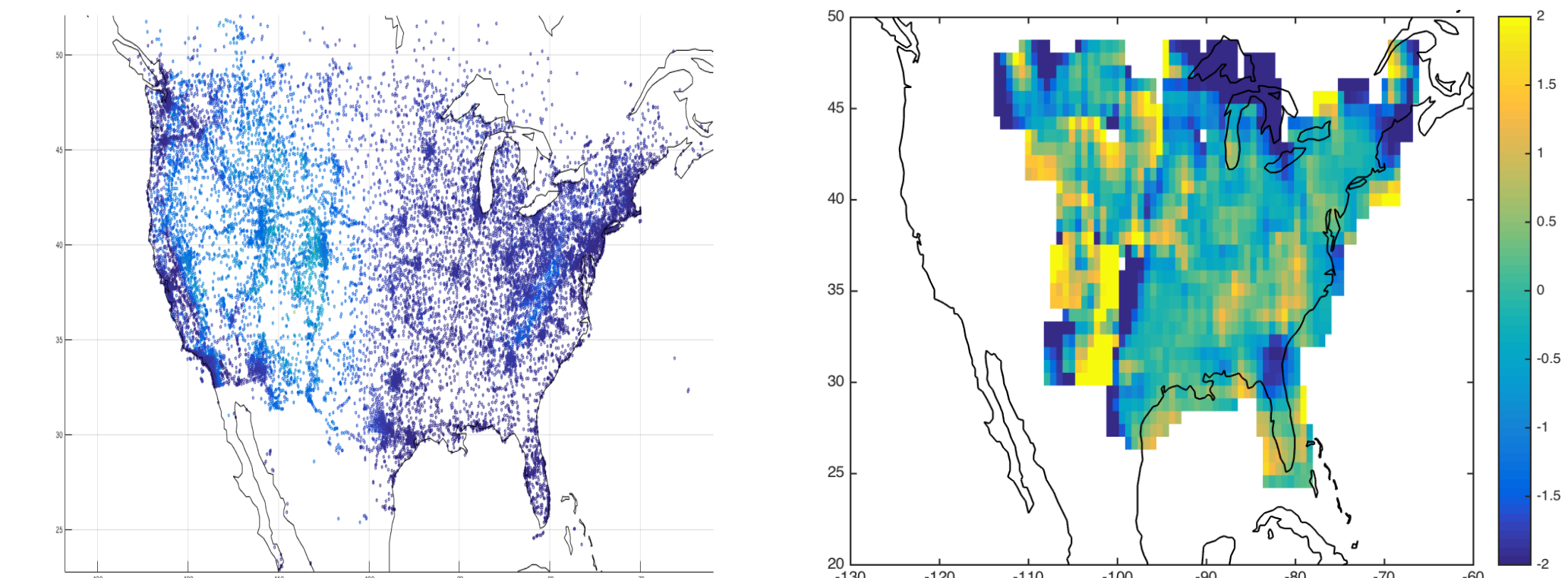
Near-Real Time

Merging ASOS Surface and IR Satellite Profile Data



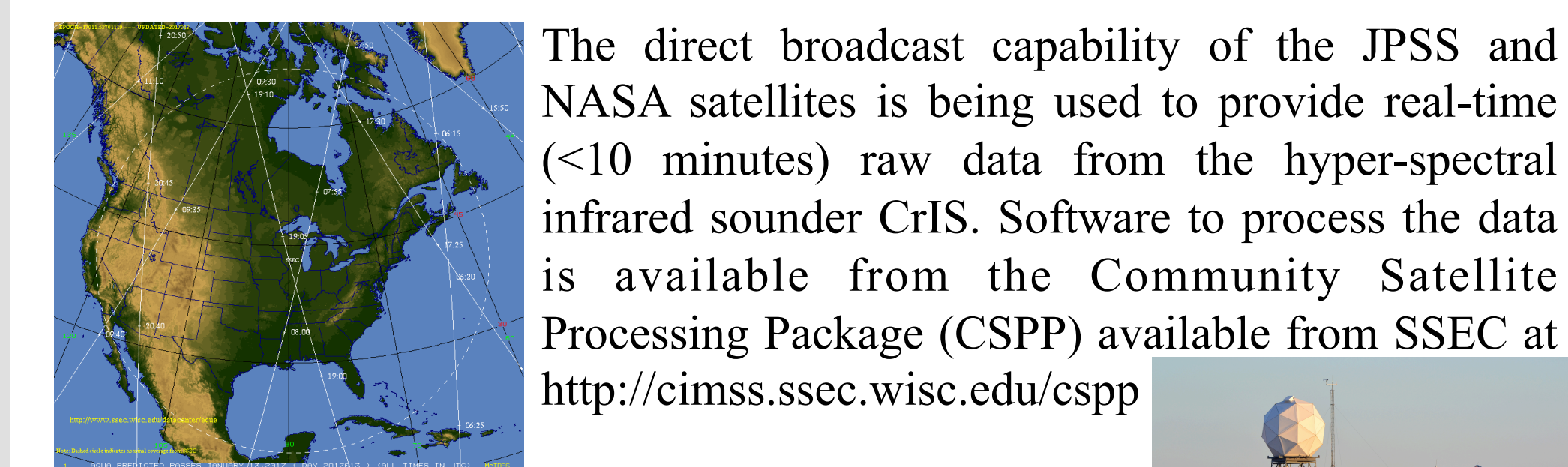
Gridded ASOS Data and AIRS Level 2 footprints of dewpoint (colored dots). ASOS surface will be substituted in place of AIRS surface.

Using MADIS data



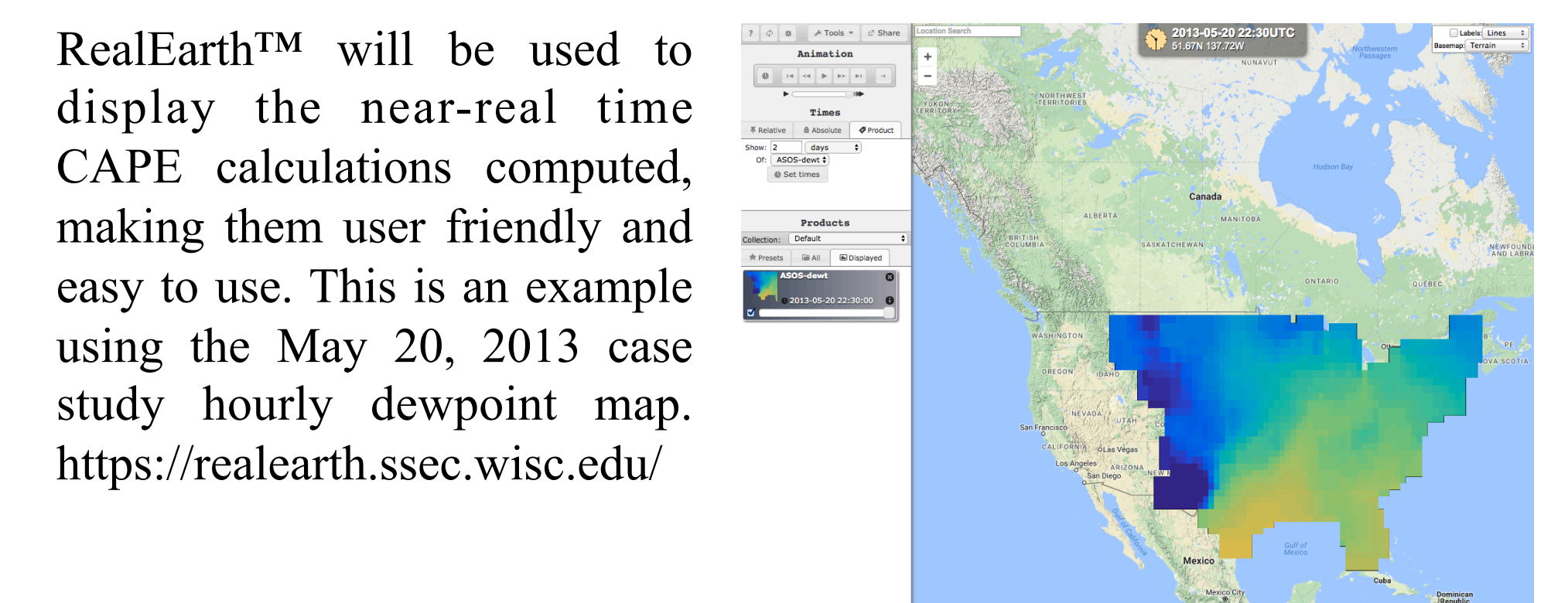
The figure on the right shows the difference between ERA model data and smoothed ERA model data at the ASOS stations showing there is a greater error when stations have a larger separation. Using MADIS data will improve the density of measurements between ASOS stations. MADIS station locations are shown on the left figure.

Direct Broadcast



The direct broadcast capability of the JPSS and NASA satellites is being used to provide real-time (< 10 minutes) raw data from the hyper-spectral infrared sounder CrIS. Software to process the data is available from the Community Satellite Processing Package (CSPP) available from SSEC at <http://cimss.ssec.wisc.edu/cspp>

SSEC RealEarth™



RealEarth™ will be used to display the near-real time CAPE calculations computed, making them user friendly and easy to use. This is an example using the May 20, 2013 case study hourly dewpoint map. <https://realearth.ssec.wisc.edu/>

Conclusions

- Accurate measurements of temperature and dewpoint at the surface are necessary for calculating an accurate CAPE value, which can help in forecasting of severe weather.
- The use of surface station data has been shown to significantly improve the estimates of CAPE from satellite observations.
- Future applications include the near-real time support of NWS watches and warnings using the direct broadcast from JPSS satellites.