An Extension of the Python SHARPpy GUI to Display Combined Satellite Soundings and ASOS Surface Data in Near-Real Time

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Abstract

SHARPpy is a program created by Greg Bloomberg and Kelton Halbert that displays data in a sounding format created by NWS storm prediction center (SPC). Currently SHARPpy supports operational radiosonde upper air soundings of temperature and water vapor as well as selected NWP model fields. The soundings show temperature and moisture vertical profiles as well as give a calculated value of Convective Available Potential Energy (CAPE). The NASA Atmospheric InfraRed Sounder (AIRS) sensor operates on a polar orbiting satellite with sun-synchronous overpass at 1:30a.m. and 1:30p.m.. Retrievals of temperature and moisture from the AIRS data are produced in near-real time. The Automated Surface Observing System (ASOS) is used to measure surface temperature and dewpoint at airports across the U.S.. The SHARPpy GUI (Graphical User Interface) plots points on a map using the latitudes and longitudes present in the locations file. Clicking on an ASOS surface station location will bring up the sounding for the closest AIRS sounding profile with the surface temperature and dewpoint from the ASOS observation data. The extension includes a satellite decoder module which allows for remote access to the sounding locations as well as the profile data. This would allow for users to have access to data in near-real time from satellite overpasses. The use of near-real time satellite and surface observations may help assist meteorologists in the nowcasting of severe weather. This will allow for faster, more accurate predictions that could help with issued watches and warnings.

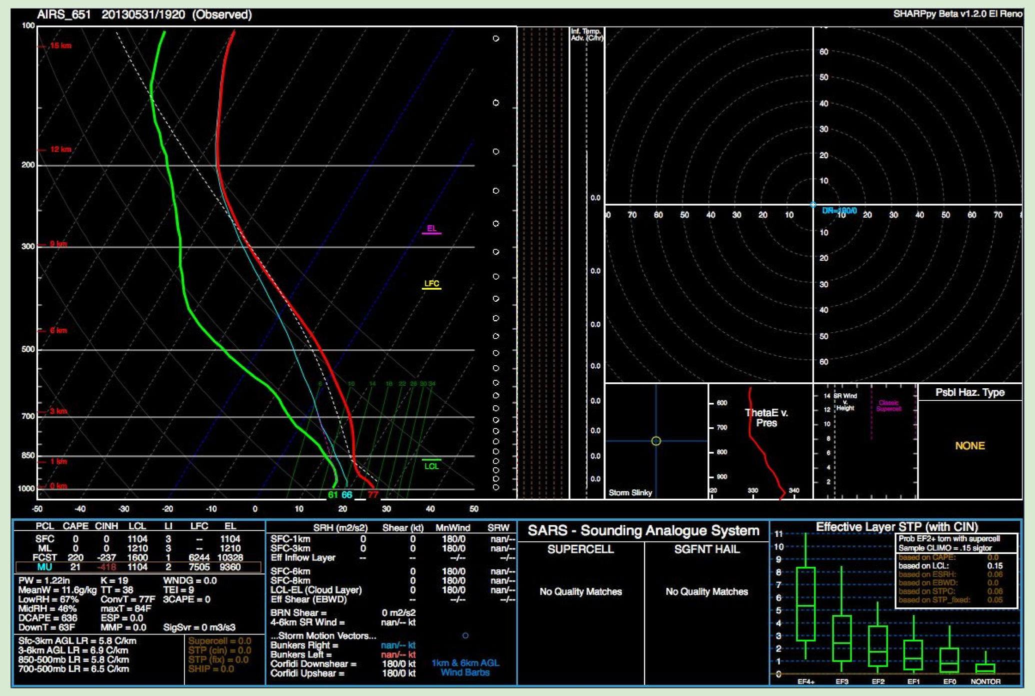
Why Combine Satellite and Surface Data

Satellites are used constantly in weather prediction and observation. However, errors and inaccuracies are commonly overlooked. Satellites orbit the Earth nearly 440 miles from the surface, and though many sensors, like the AIRS sensor on the Aqua satellite, record surface data, the data at the surface is not as accurate as the data gathered higher up in the atmosphere. This can cause errors in calculations, such as the surface Convective Available Potential Energy (CAPE) used in this project.

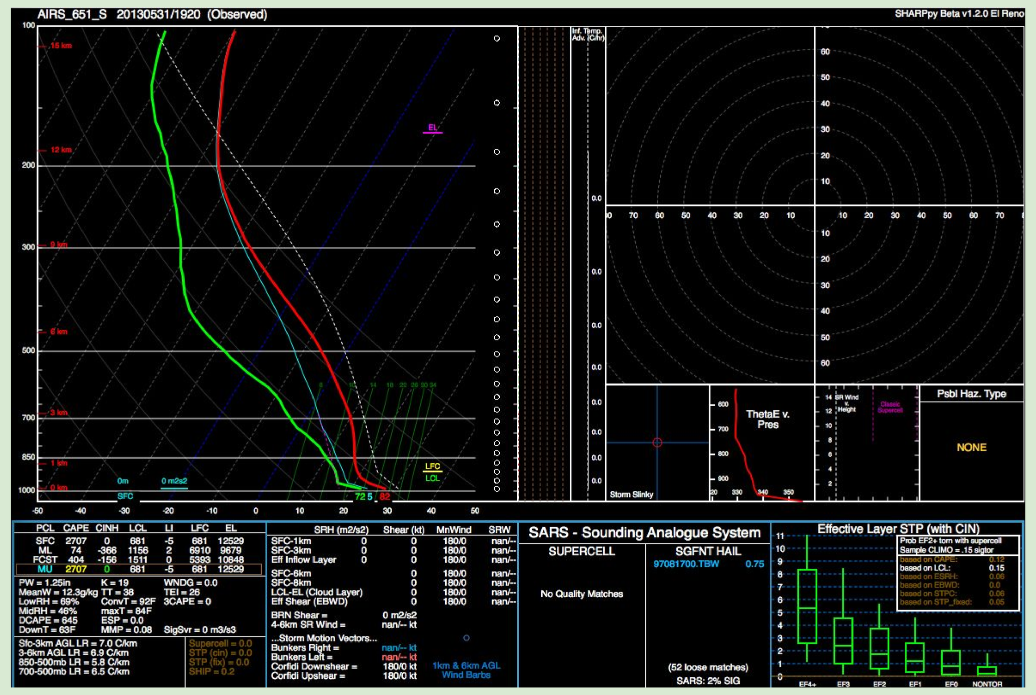
Shown above is the Aqua Satellite

AIRS Compared to AIRS/ASOS

As shown below, the AIRS profile by itself had a surface CAPE value of 0 J/Kg (weak instability) while the AIRS profile with the ASOS surface station data had a surface CAPE value of 2707 J/kg (strong instability). This change in calculated surface CAPE could make the difference in detecting severe weather. Satellite data alone doesn't have the accuracy at the surface level that is needed for a true representation of the instability. Only once the surface parcel begins moving upward in the atmosphere, does the AIRS sensor do a good job of detecting the temperature and dewpoint temperature for each level.



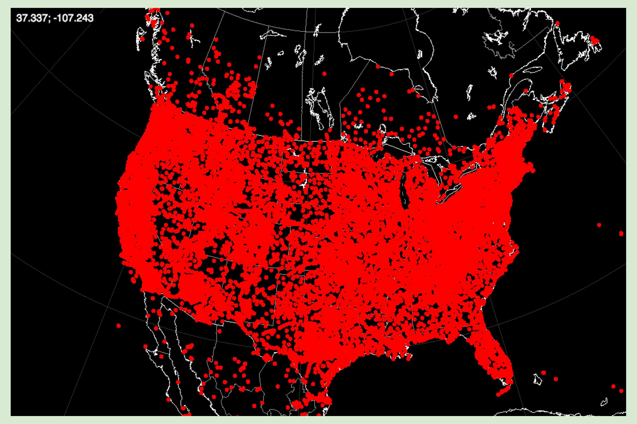
The original AIRS profile 651 is shown to the left. The edited AIRS profile 651, denoted by "_S", is shown to the right. The temperature and dewpoint in the edited profile were taken from ASOS station KBTR, located in the southeastern portion of Louisiana.



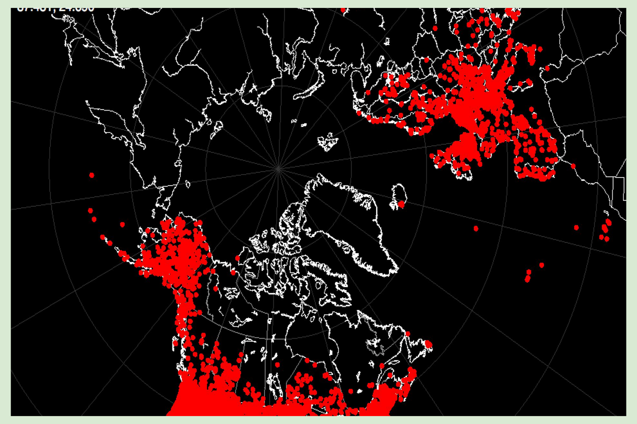
Surface Data Coverage

The ASOS surface data used in the example above is part of a large-scale system that gathers and distributes surface data from around the world called the Meteorological Assimilation Data Ingest System (MADIS). This system encompasses surface data from airports, highways, military observations, NOAA research facilities, and more. The full list can be found here: https://madis.noaa.gov/network_info.shtml With the coverage that MADIS provides, there is potential for satellite and surface data around the world to be combined for more accurate predictions and observations.

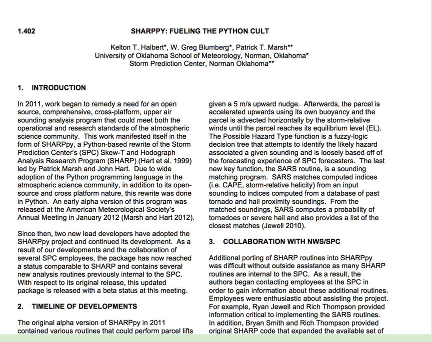
The images below show that while the US and a large portion of Europe have ample surface coverage, many other countries and continents have very few surface stations where combining satellite data would be possible. These areas must rely solely on the satellite data they receive for their storm prediction, data that could be inaccurate. Satellite data can only be improved in areas where there is surface data coverage.



Shown on the left is MADIS coverage in the United States and into Canada. In the center is MADIS coverage in the tropics, mainly focused on Latin America, South America, and parts of Africa On the right is MADIS coverage in Alaska and western Europe.

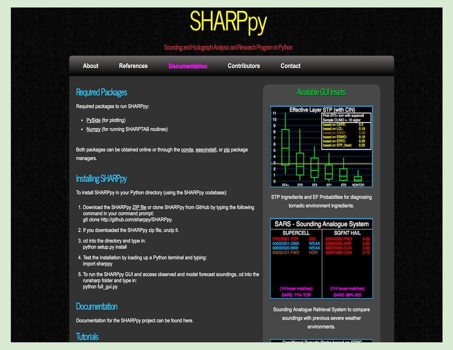


Process of Combining and Distributing the Data



Existing SHARPpy

The current SHARPpy was created by Kelton Halbert and Greg Blumberg. It produces vertical temperature and moisture profiles as well as displays the calculated CAPE values from data in a sounding format that was created by NWS storm prediction center (SPC). The link for the SHARPpy GitHub page is here: https://github.com/sharppy/SHARPpy



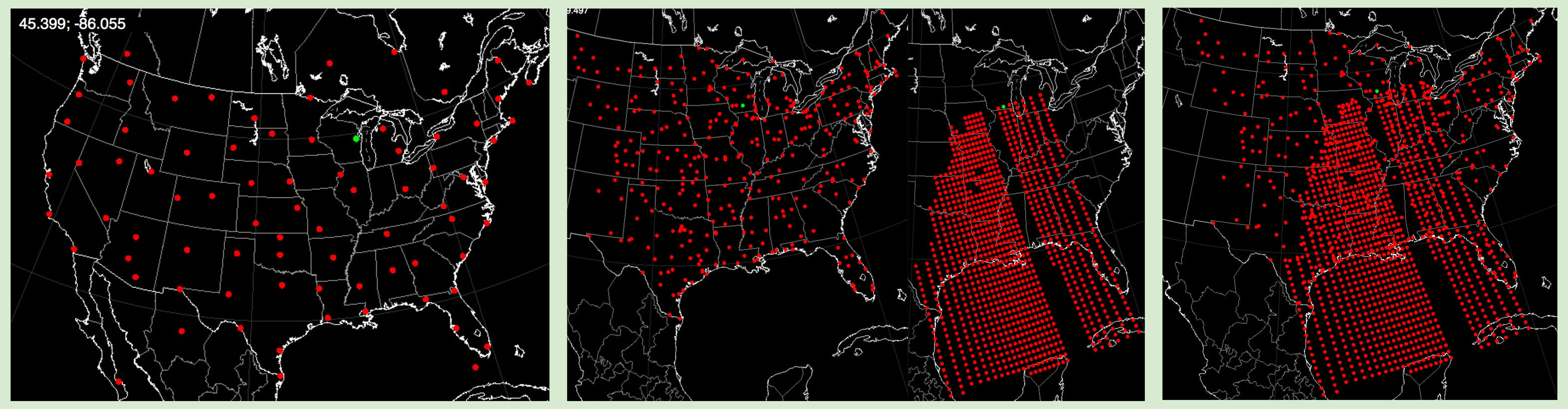
Location and Access to Data

Currently, SHARPpy requires the locations file for each datasource to be present in the .sharppy folder on each user's computer. This limits the usability of SHARPpy based on a user's ability to place the files properly. A change to the .xml file can be made to point the program to a locations file that is at the same FTP site as the data profiles. When a user installs SHARPpy, the locations file along with the data profiles are already present and available for use. This also allows for data to be updated remotely and without the user downloading and replacing the locations file each time new data comes out. A change to the SHARPpy code is being worked on so that new datasources appear with the installation instead of manual placement of the .xml file.

On the left is the AIRS.xml file, pointing to the AIRS_locations.txt file in the hidden directory. On the right is the MADIS.xml file, pointing to the MADIS_locations.txt file at the same FTP site as the MADIS data profiles

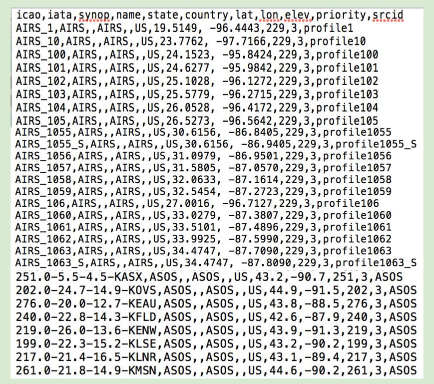
Combining the Data

The temperature and moisture profile shown on the left was created by pairing ASOS stations with the closest AIRS profile based on latitude and longitude. This allows for the most accurate combination of the two data files. Each AIRS file that had the surface data replaced was selected through this process. Shown below is the AIRS granule and the ASOS station map.

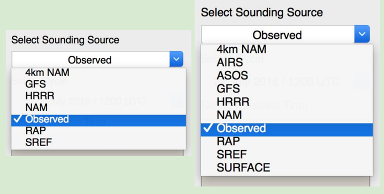


Above are images of plotted data points in SHARPpy. The standard radiosonde launch locations under the SHARPpy Observed data source are shown in the left image. The center image shows the ASOS surface stations and an example AIRS satellite overpass. The right image shows an overlay of the ASOS station locations and the coincident AIRS soundings.

AIRS_Surface_locations.txt (right) gives SHARPpy the information needed to plot the points in the GUI as seen to the left. The corresponding filenames SHARPpy looks for on the remote server are at the end of each row.

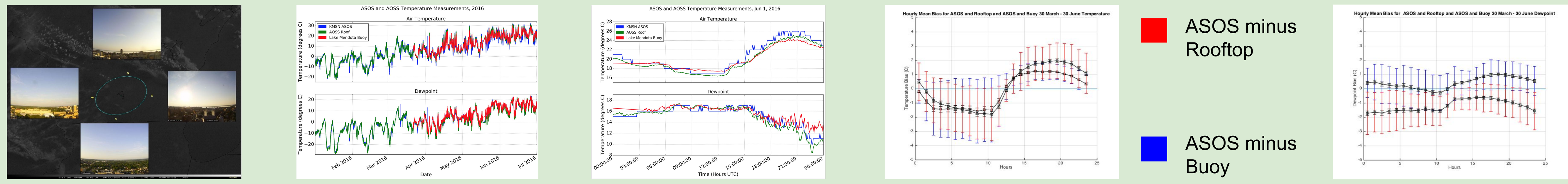


The .xml file adds a new item to the drop down menu in the SHARPpy GUI. On the left is the original drop down menu. On the right is the new one with the added datasources.



Madison Airport ASOS Station (KMSN) Validation Using SSEC Rooftop and Lake Mendota Buoy

The temperature and dewpoint measurements from the ASOS station at the Dane County Airport were compared to the SSEC rooftop measurements and the Lake Mendota Buoy measurements for 2016 to test the accuracy of ASOS data. The hourly Mean Bias and Standard deviation for the differences in the temperature and the dewpoint were calculated for the ASOS station and Rooftop (Blue) and the ASOS station and the Buoy (Red) between March 30, 2016 and June 30, 2016. On average, during the day, the ASOS temperatures get slightly warmer than both the buoy temperatures and rooftop temperatures most likely due to daytime heating, but at night, ASOS temperatures are slightly cooler than the other two locations.



ASOS minus Rooftop

ASOS minus Buoy

Conclusions and Future work

- Applying the ability to have remote locations files and preprogrammed .xml files is still in the working phase, however in the future this will be available for SHARPpy users through distribution on GitHub.
- By creating a new .xml file and locations file, satellite data can be easily displayed in the SHARPpy GUI. This could be automated in the future to provide near-real time data to the user.
- The NASA AIRS satellite data can be improved upon by using ASOS surface station temperature and dewpoint. The ASOS data allows for more accurate calculations of CAPE and temperature and moisture profiles. MADIS coverage across the United States in combination with the coverage over western Europe could be applied to all future AIRS and other satellite data analysis to give more accurate predictions and calculations.
- The adaptations outlined in this project will be helpful in severe storm prediction during the spring storm season.

Acknowledgements

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