NASA's Land Information System Supports Land Analysis for NOAA's Climate Forecast System Reanalysis (CFSR)

Christa D. Peters-Lidard and the LIS Team, Code 614.3, NASA GSFC

NOAA's National Centers for Environmental Prediction (NCEP) recently completed a new coupled global reanalysis, known as CFSR, for the period 1979–present. This reanalysis has significantly higher temporal and spatial resolution than previous reanalyses.

The NASA Land Information System (LIS) infrastructure is employed to execute the Global Land Data Analysis System (GLDAS) for CFSR. To support CFSR-GLDAS, NCEP took advantage of LIS' flexible grid and parameter support to configure LIS with the identical land model setup as in the fully coupled Climate Forecast System.

Compared to previous reanalyses, this CFSR-GLDAS uses observed global precipitation analyses as direct forcing to the land surface analysis, which leads to a more realistic soil moisture initial conditions for the coupled reanalysis system. CFSR-GLDAS interacts with the reanalysis once per day, instead of every time step.

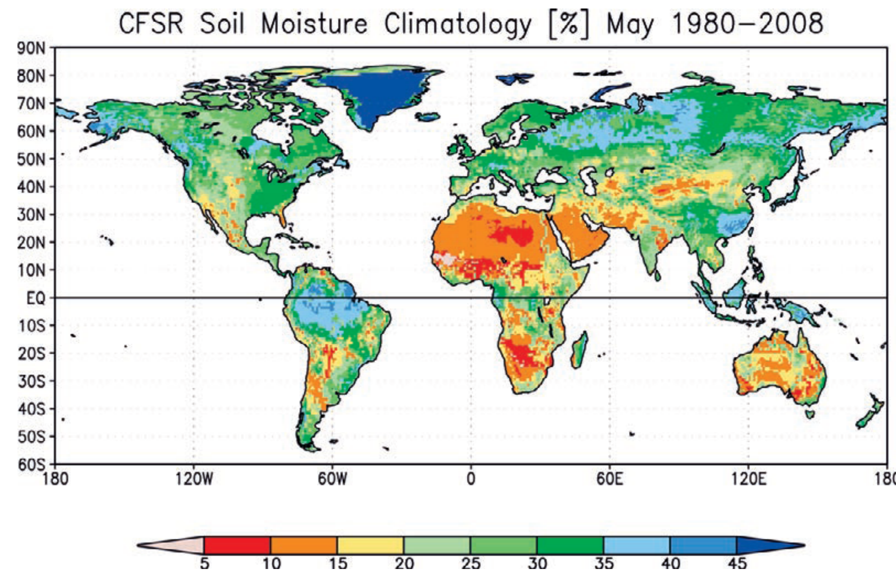

Figure 1: The 2-m volumetric soil moisture climatology of CFSR, from the LIS-based CFSR-GLDAS for May averaged over 1980–2008.

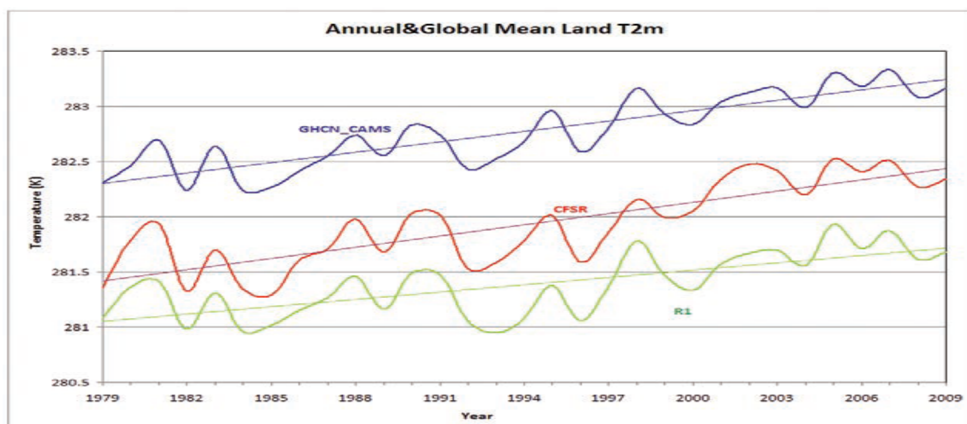

Figure 2: Time series of annual and global mean 2m temperatures over land, with previous reanalysis shown in green, CFSR in red and independent (non-assimilated) observations in blue. The 2m air temperature over land is sensitive to the land surface soil

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References:

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Data Sources: LIS version 5 software, downloaded by agreement from lis.gsfc.nasa.gov by our partners at NOAA NCEP, including Michael Ek, Jesse Meng, and Heilin Wei on the NCEP Land Team. Numerous other data sources used in the reanalysis, including NASA's Aqua/AIRS, AMSR-E and AMSU-A, are described at http://cfs.ncep.noaa.gov/cfsr.

Technical Description of Figures:
Figure 1: This figure is taken from the CFSR BAMS article (Figure 17), and shows the 2-m volumetric soil moisture climatology of CFSR, from the LIS-based CFSR-GLDAS for May averaged over 1980–2008.

Figure 2: This figure is taken from the CFSR BAMS article (Figure 19), and shows time series of annual and global mean 2m temperatures over land, with the previous reanalysis shown in green, CFSR in red and independent (non-assimilated) observations in blue. The 2m air temperature over land is sensitive to the land surface soil moisture.

Scientific significance: Improvements to land surface states, including soil moisture, temperature , snow pack and vegetation, lead to direct improvements in land surface fluxes and atmospheric states such as 2m air temperature. The flexibility and configurability of the LIS software infrastructure simplifies the process for improving land analyses for our partners at NOAA/NCEP.

Relevance for future science and relationship to Decadal Survey: The adoption of the LIS infrastructure by our partners at NCEP sets them up to be early adopters of Decadal-Survey era data, including precipitation from GPM, and soil moisture from SMAP, among others.

Snowmageddon snowfall and snow water equivalent (SWE) retrieval using AMSR-E and GOES 11-12 observations

James Foster, Code 614.3; Gail Skofronick-Jackson, Code 613.1 - NASA GSFC

This is one of the first studies to link satellite detection of falling snow to subsequent snow pack parameter estimations.

Falling snow detection and SWE derivations were quite reasonable for the rather complex physiographic conditions found in the Baltimore/Washington D.C. area.

Significant increases in snow depth and SWE were observed following the extreme snowfall events of February 2010.

This work is relevant to snow-related missions such as GPM and CoReH2O

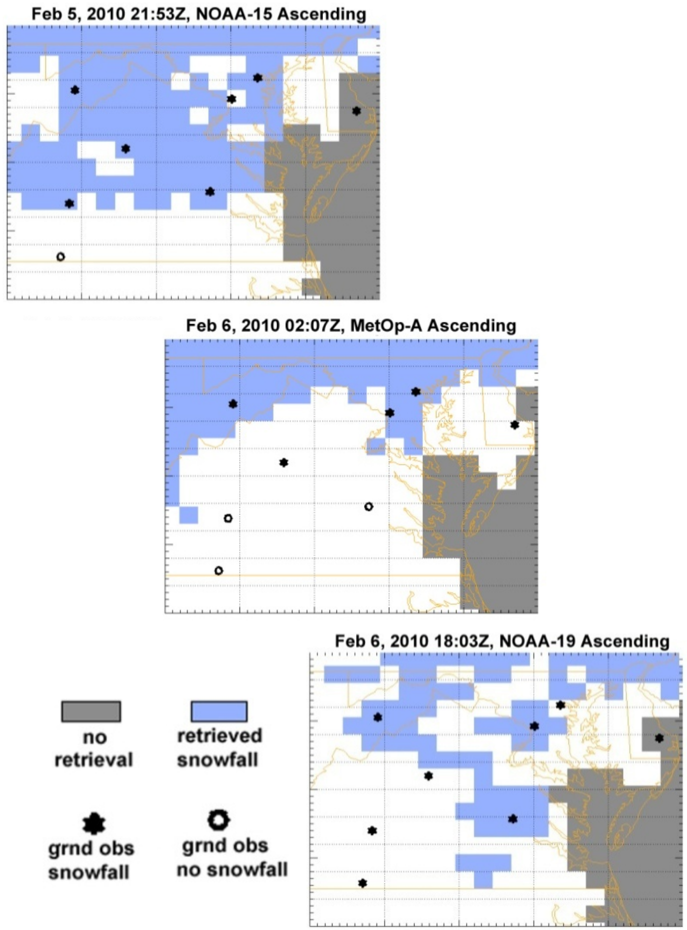

Figure 1: Time sequence of AMSU/MHS detected snowfall for the 5-6 February 2010 snowstorm with ground observations.

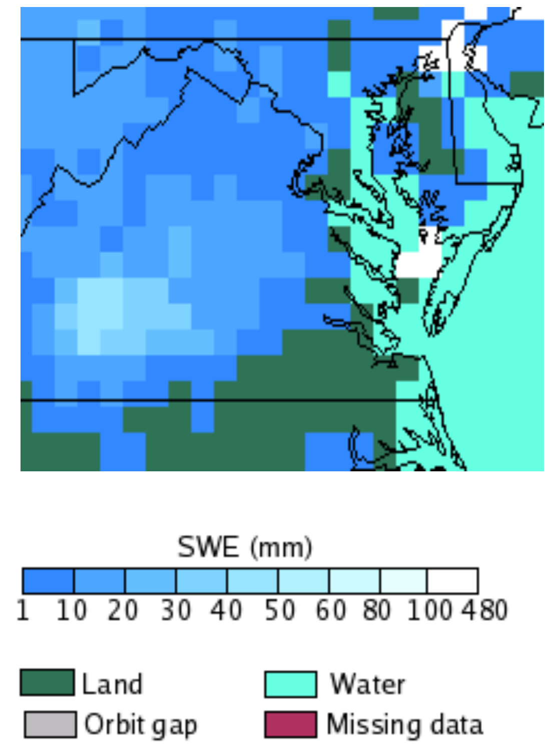

Figure 2: AMSR-E Derived SWE for February 7, 2010

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Data Source/Website:

AMSR-E and AMSU-B passive microwave observations; GOES-11/12 water vapor observations

References/Publication Submission:

"Remote Sensing of the Historic February 2010 Snow Storms in the Baltimore/Washington D.C. Region," James Foster, Gail Skofronick-Jackson, Huan Meng, Jim Wang, George Riggs, Ben Johnson, Dorothy Hall, Son Nghiem, Judah Cohen, Paul Kocin. Submitted to Remote Sensing of Environment (Jan 2011).

Purpose/Use of Images:

To detect falling snow and to retrieve snow depth and snow water equivalent (SWE) in the Baltimore/Washington area following the historic snowstorms of February 2010

Description of Figures:

Figure 1: Left - Time sequence of AMSU/MHS detected snowfall for the 5-6 February 2010 snowstorm with ground observations.

Right - AMSR-E retrieved SWE for February 7, 2010, the day after the historic snow event.

Scientific significance:

Falling snow detection and SWE derivations were quite reasonable for the rather complex physiographic conditions found in the Baltimore/Washington D.C. area. Significant increases in snow depth and SWE were observed following the extreme snowfall events of February 2010. Though the performance of the SWE algorithm is uneven because of the complexity and variability of the snowpack as well as features including vegetation, terrain, and open water, substantial SWE values, indicative of a deep snow cover, were observed following the historical February snowstorms. The snowfall detection algorithm performs well when there is sufficient water vapor in the atmosphere. Research is ongoing to develop new approaches for detecting snowfall in drier atmospheric conditions and to handle the widely varying precipitation signatures.

Relevance:

This is one of the first studies to link satellite detection of falling snow to subsequent snow pack parameter estimations and shows the multi-disciplinary nature of the Global Precipitation Mission (GPM) efforts to detect falling snow and snowpack observations from sensors such as AMSR-E. Despite the high variability of the Feb 2010 scene being observed, there is consistency between these falling snow and snowpack retrievals. It is expected that both the falling snow and snowpack (SWE) algorithms would benefit from coordinated retrievals linking falling snow estimates to snowpack estimates.

A Global Map of Uncertainties in Satellite-based Precipitation Measurements

Yudong Tian, Christa D. Peters-Lidard, Code 614.3, NASA GSFC

Determining the uncertainties in precipitation measurements by satellite remote sensing is of fundamental importance to many applications. These uncertainties are a result of an interplay of systematic errors and random errors. To estimate the measurement uncertainties, the measurement spread was calculated from an ensemble of six different TRMM-era high-resolution datasets. A global map of measurement uncertainties was thus produced. The map yields a consistent global view of the error characteristics and their regional and seasonal variations, and reveals many undocumented error features over areas with no validation data available.

High uncertainties also persisted through the seasons over complex terrains, including the Tibetan Plateau, the Rockies and the Andes. Coastlines and water bodies also posed considerable challenges. The global uncertainties also exhibited systematic seasonal, regional as well as rain-rate dependencies, with lowest uncertainties over tropical oceanic regions with strong, convective precipitation, and highest ones over wintery, complex land surfaces with light precipitation.

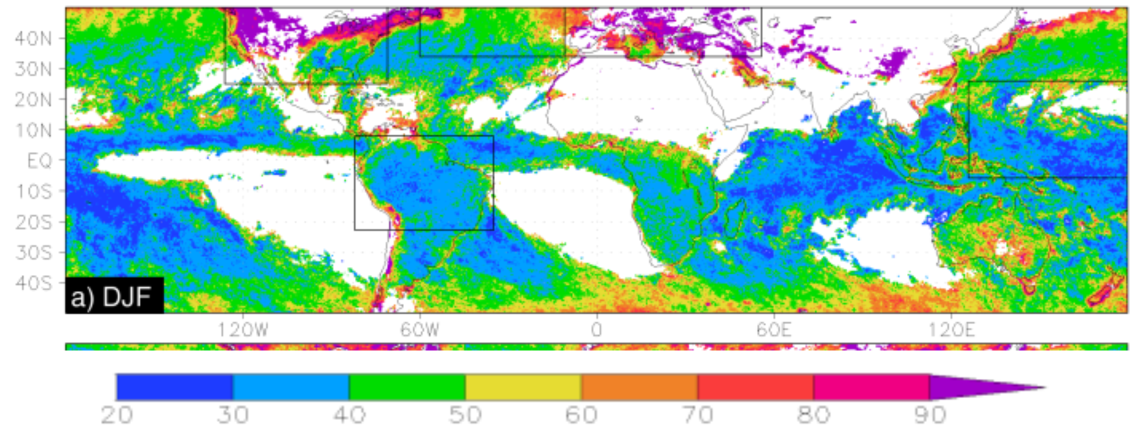

Figure 1: Standard deviation from the ensemble mean, as percentage of the mean daily precipitation, averaged for the winter (DJF) season. Areas with mean daily precipitation less than 0.5 mm are shown as blank as they are deemed unreliable. The boxes delineate the five regions in Figure 2.

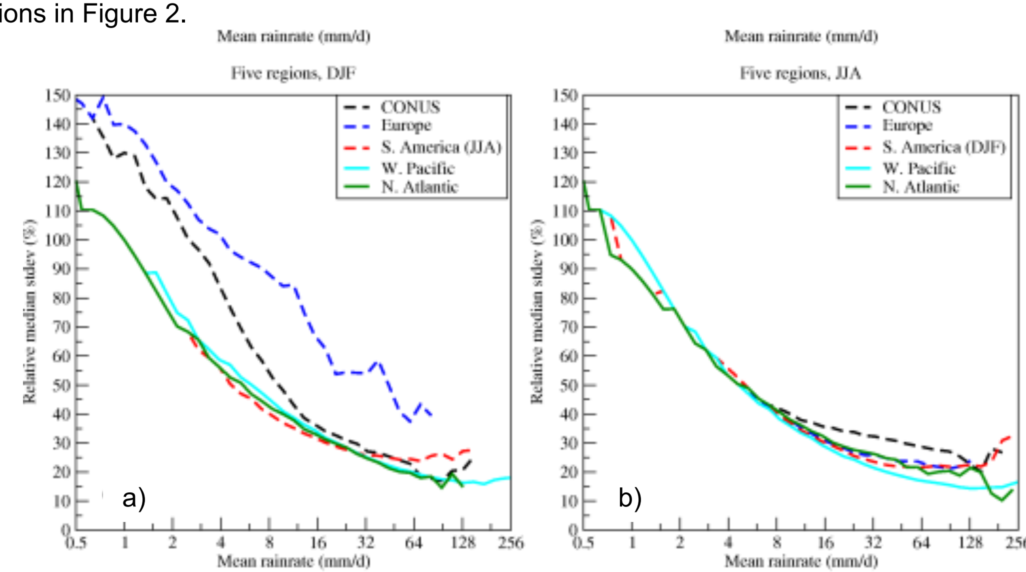

Figure 2: Standard deviation from the ensemble mean, as percentage of the mean daily precipitation at each associated rain rate bin for the five regions for (a) local winter and (b) local summer.

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References:

Tian, Y., and C. Peters-Lidard (2010). A global map of uncertainties in satellite-based precipitation measurements Geophysical Research Letters, 37 (L24407), 1-6. DOI: 10.1029/2010GL046008.

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Tian, Y., C. Peters-Lidard, J. Eylander, R. Joyce, G. Huffman, R. Adler, K.-L. Hsu, F. J. Turk, M. Garcia, and J. Zeng (2009), Component analysis of errors in satellite-based precipitation estimates, J. Geophys. Res., 114, D24101, DOI:10.1029/2009JD011949.

Tian, Y., C. D. Peters-Lidard, B. J. Choudhury and M. Garcia (2007), Multitemporal analysis of TRMM-based satellite precipitation products for land data assimilation applications, J. Hydrometeor., 8, 1165-1183.

Data Sources: Global Satellite Mapping of Precipitation (GSMaP MVK+ Version 4.8.4); TRMM Multi-satellite Precipitation Analysis research product 3B42 Version 6; TRMM Multi-satellite Precipitation Analysis Real-time experimental product 3B42RT; NOAA Climate Prediction Center (CPC) MORPHing technique; Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks; Naval Research Laboratory's blended technique.

Technical Description of Figures:

Figure 1: This figure shows the uncertainties in precipitation measurements for the winter (DJF) season. The uncertainties are quantified as the standard deviation from the ensemble mean, as percentage of the mean daily precipitation, averaged for the season. The uncertainties are relatively small (40-60%) over the oceans, especially in the tropics, and over the lower-latitude South America. There are large uncertainties (100-140%) over high latitude
(>40-degree N/S), especially during the cold season. Areas with mean daily precipitation less than 0.5 mm are shown as blank as they are deemed unreliable. The boxes delineate the five regions in Figure 2.

Figure 2: This figure shows how the uncertainties are affected by regional and seasonal differences. Standard deviation from the ensemble mean, as percentage of the mean daily precipitation at each associated rainrate bin, for the five regions in Figure 1 for (a) local winter and (b) local summer.

Scientific significance: Our results provides a consistent global view of the error characteristics and their regional and seasonal variations, and reveals many undocumented error features over areas with no validation data available. These results can serve not only as estimates of the random errors in these datasets, but also as a measure of the “difficulty” in measuring precipitation by space-borne sensors over various areas of the Earth’s surface. In addition, the uncertainties provide critical guidance in data assimilation of these precipitation measurements for a wide range of applications.

Relevance for future science and relationship to Decadal Survey: Precipitation is one of the most difficult atmospheric variables to measure, but also one of the most critical variables for studies in climate change, water resources, hydrology and agriculture. Though rain gauges have been used for centuries, ground-based radar and space-borne sensors for decades, accurate measurement of precipitation and error characterization in the measurement, are still a challenge. This challenge is what motivates the Tropical Rainfall Measurement Mission (TRMM) and the upcoming Global Precipitation Measurement (GPM) Mission.

Is The Africanized Honey Bee Moving Northward?

Wayne Esaias, Code 614.5, NASA GSFC

Working with the USGS Ft. Collins, NASA/GSFC explored four different species distribution models in an Ensemble Technique to make a 1 km habitat suitability map for persistent populations of the Africanized Honey Bee (AHB). Results using MODIS phenology and HoneyBeeNet data indicate that both Temperature and nectar availability limit the AHB. MODIS data made the models more accurate.

A 10/10 non-persistent 'find' of AHB in Albany, GA provides the basis for a "What If" exercise. Albany is well north of the present AHB territory, and the colony arrived there through inadvertent human transport. It had not overwintered.

However, **if** AHB colonies could persist in the area, then the projected suitable habitat extends much farther north, perhaps into North Carolina and southern Virginia. All projections shown here may overestimate the northern extent to some degree due to unavoidable biases in the presence data.

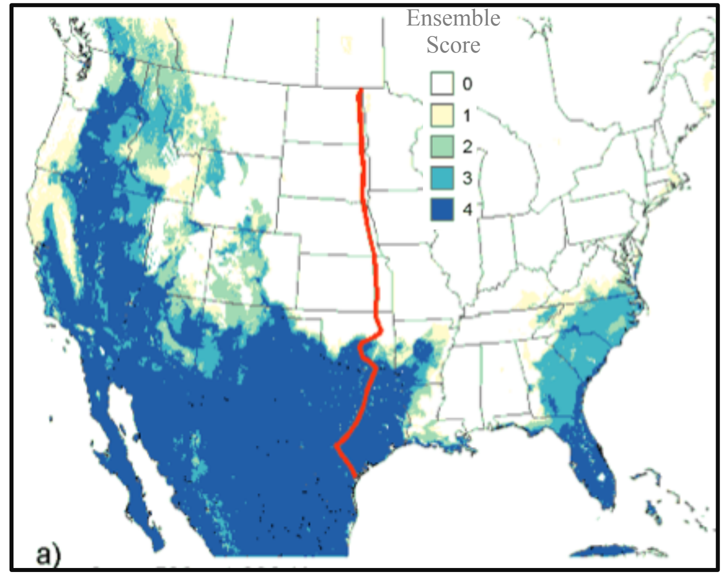

Figure 1: National Map: Correct 93-96%; AUCs >0.92

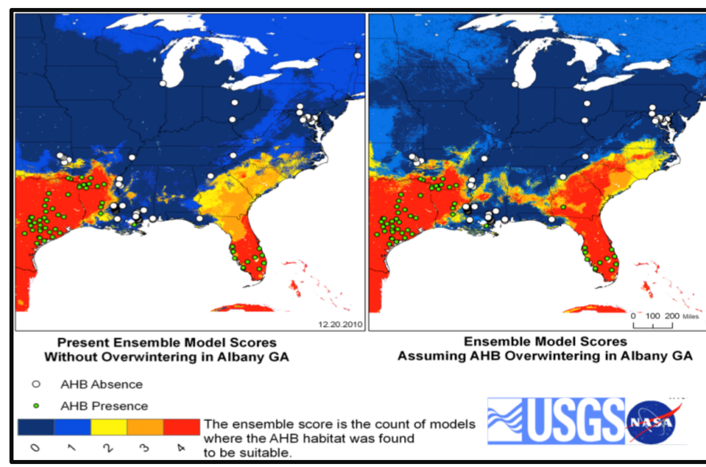

Figure 2: left panel – SE US current map. Correct 87-93%; AUCs >0.91; right panel – hypothetical SE US if Albany, Georgia was suitable for persistent populations

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Project Affiliation (Earth Science Applications Project: ROSES 2007 A.20 Decisions)

References:

1. Wayne Esaias[1], C Jarnevich[2], Pete Ma[3], T. Stohlgren[2], J. Nightingale[3], R. Wolfe[1], J. Nickeson[3], B. Tan[4], J. Morisette[2], J. Harrison[5], J. Hayes[6], J. Pettis[7], USGS, 2011. MODIS data products help map distribution of the Africanized Honey Bee. GSFC Poster Blowout 2011.
1 - NASA GSFC, 2 - USGS Ft Collins, 3 - GSFC/Sigma Space Corp, 4 - GSFC/ , 5 - Arizona State Univ, 6 - Florida Dept. Agric. 7 - USDA/ARS BARC.

2. W. Esaias and C. Jarnevich 2011. Is the Africanized Honey Bee Moving North? Presented at Apiary Inspectors of America Annual Mtg., Galvaston, Jan
5, 2011. Paper undergoing internal USGS review.

Data Sources: This is a joint effort composed of multiple agencies including the USGS, NASA-GSFC, USDA, and 12 state departments of agriculture. The latter supplied locations of AHB, which were assembled into a consistent, quality controlled data base at GSFC. Models were developed and run at USGS, with Bioclim variables and GSFC inputs. Seasonal Honey Bee Hive Weight data are from the GSFC HoneyBeeNet project. MODIS NDVI, and EVI, and Phenology Products are from the GSFC LDAPS system.

Technical Description of Image:

Figure 1   Models are based on presence points of overwintered or persistent AHB populations and compared with over 25 phyisical climate and satellite vegetation variables. The Ensemble Map combines binary maps from each of the four modeling techniques; where each map is labeled 0 for unlikely habitat and 1 for suitable habitat. Individual model projections are based on values where sensitivity was equal to specificity (equal no's of false positives and false negatives). An Ensemble Score of zero indicates that none of the modeling techniques assigned that 1 km^2 area as suitable habitat, while a value of 4 indicates unanimous suitable prediction. Models were boosted regression trees, logistic regression, Multivariate Adaptive Regression Splines (MARS), and Random Forest. Presence points are based on genomic analysis. Absence points are based on HoneyBeeNet Nectar Flow Data or repeated negative genomic samples. Physical climate, MODIS phenology, and Vegetation Continuous Field (VCF) variables were major variables. The red line divides the US into a SW and SE region for this study. AUC is area under the curve, values of 0.5 indicate 50% (chance), while 1 is perfect.

Figure 2 The Southeast US performed poorer than the Southwest Region, which was similar to the US map, but SW was correct in 88-100% of the runs, and AUCs >.91 . The left panel gives the current estimate of areas at risk. The 'What If' study (right panel) illustrates how a single confirmed presence point in Albany GA, if it were to come about, would drive the models to declare much of the SE US as suitable for persistent AHB populations. This encourages future monitoring and reporting.

Scientific significance:

This is the first model of pollinator habitat using MODIS phenology data as a surrogate for forage seasonal availability, and demonstrates the utility of the sensor data to address plant-pollinator interaction studies. Pollination is essential for terrestrial ecosystems and agricultural food production. Earlier predictions of AHB extent relied upon physical climate alone, but were unable to resolve the absence in MS, AL, and N. Florida, or provide estimates of confidence. State Apiary Inspectors use these data to aid sampling programs, and in educating the public, first responders, and beekeepers.

Relevance for The NASA Applied Sciences Program : This project extends the benefits of NASA's Earth Science research to address pollinator distributions, and a public health and agricultural concern. It demonstrates the utility of NASA Earth Science data to address climate impacts on pollination as an ecosystem service, and the potential to use satellite data to study poor forage as a contributor to pollinator declines.