LAMP Developments: Use of Satellite Data for Improving LAMP Between Stations*

NATIONAL WEATHER SERVICE

Clouds, Cloud Ceiling, and Visibility (C&V) Technical Exchange Meeting
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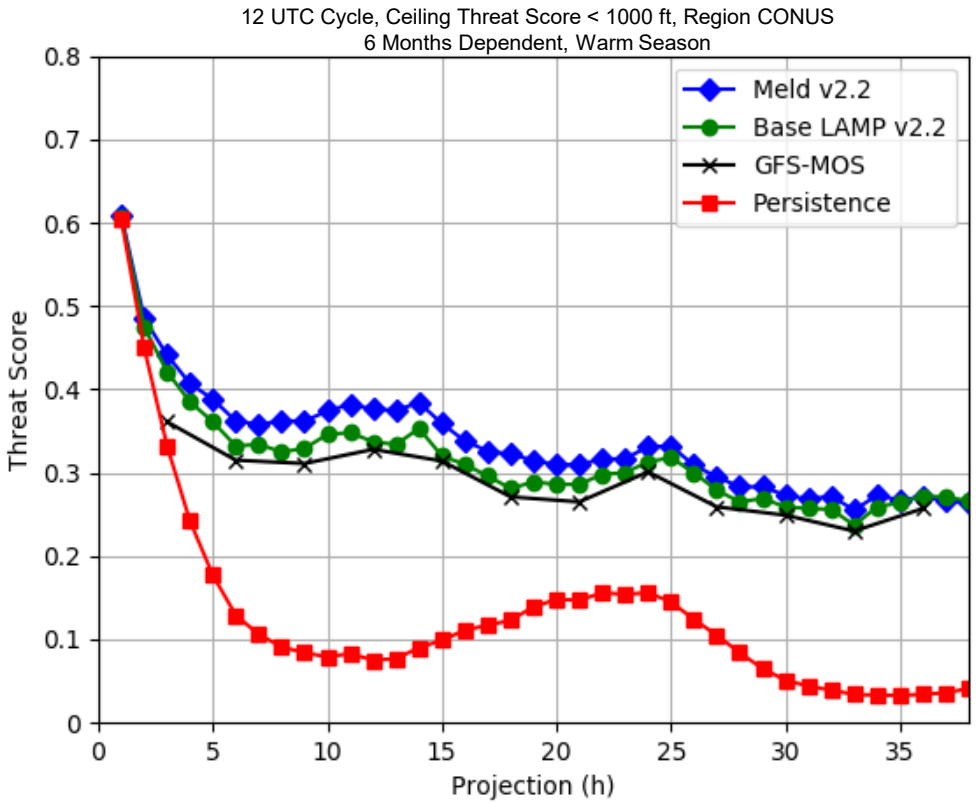
* This research is in response to requirements and funding by the Federal Aviation Administration (FAA). The views expressed are those of the authors and do not necessarily represent the official policy or position of the FAA.

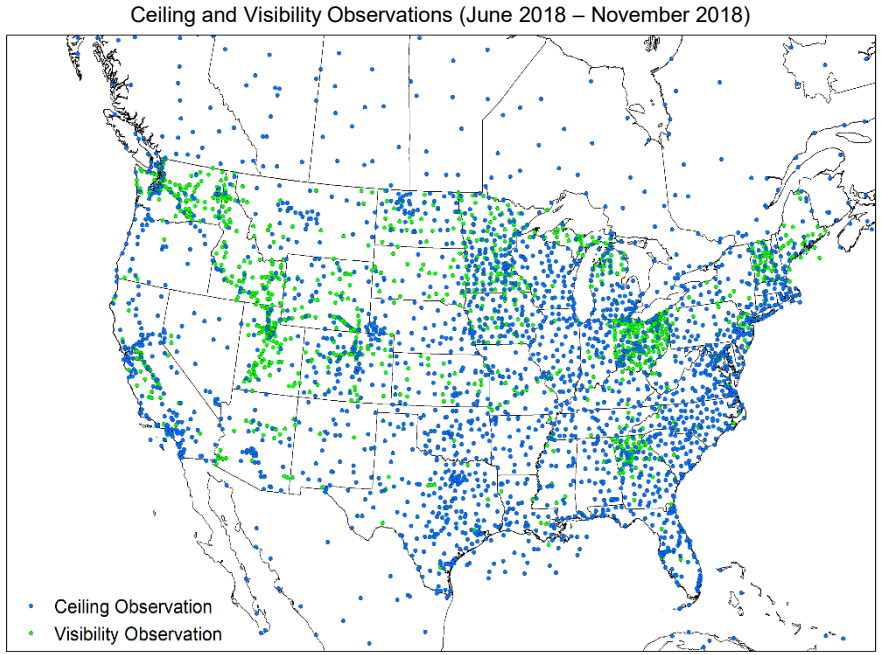
LAMP Background

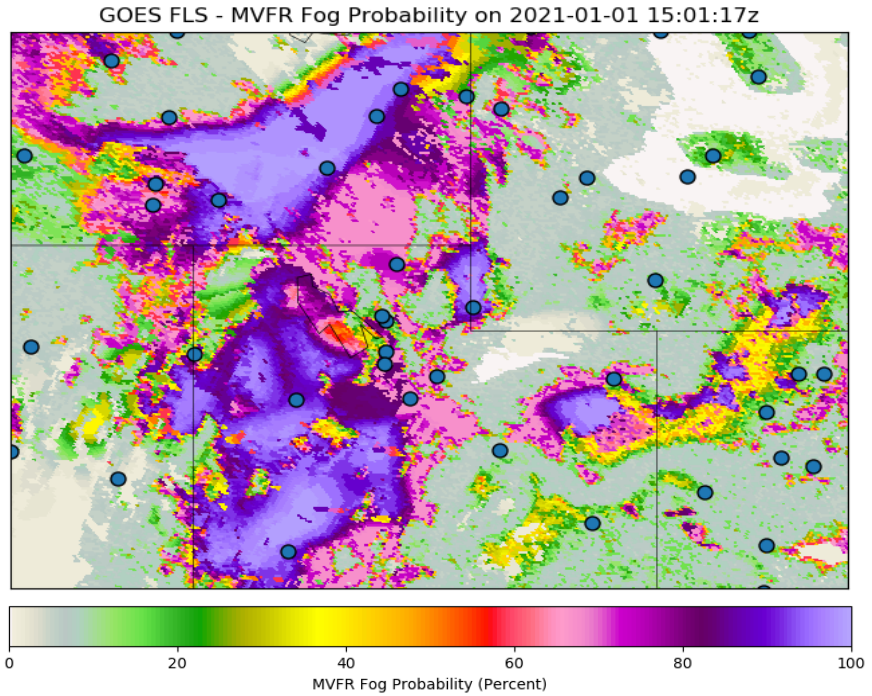
- The Localized Aviation MOS Program (LAMP) produces objective guidance based on the statistical interpretation of observations, MOS output, and model output through multiple linear regression techniques
  - Valid at stations and on a grid
- For ceiling height and visibility
  - LAMP guidance covers the short-range period of 1-38 hours
  - Runs in operations every hour out to 38 hours and every 15 minutes out to 3 hours



Motivation

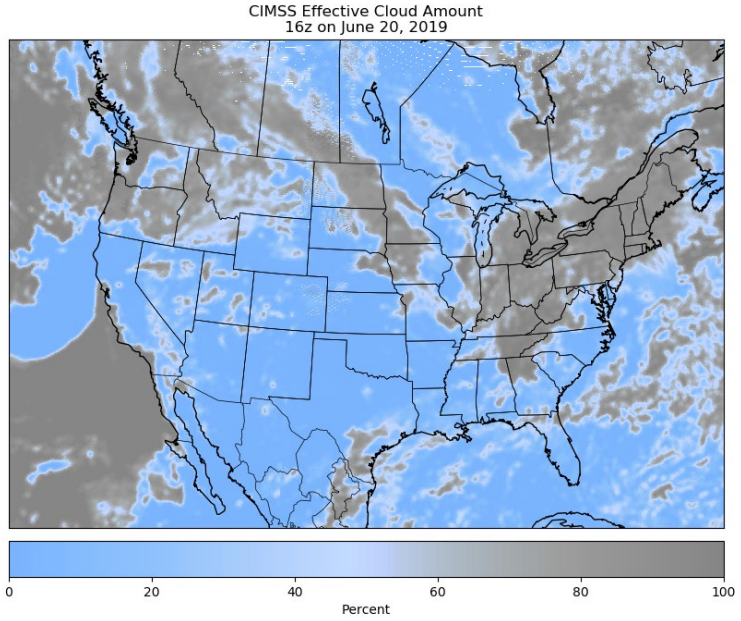
- This work is supported by the FAA's Aviation Weather Research Program (AWRP) for Ceiling and Visibility
- LAMP stations and observations are sparse in some portions of the country, such as the Intermountain West
  - Satellite data could fill in these observation gaps and improve gridded LAMP between stations

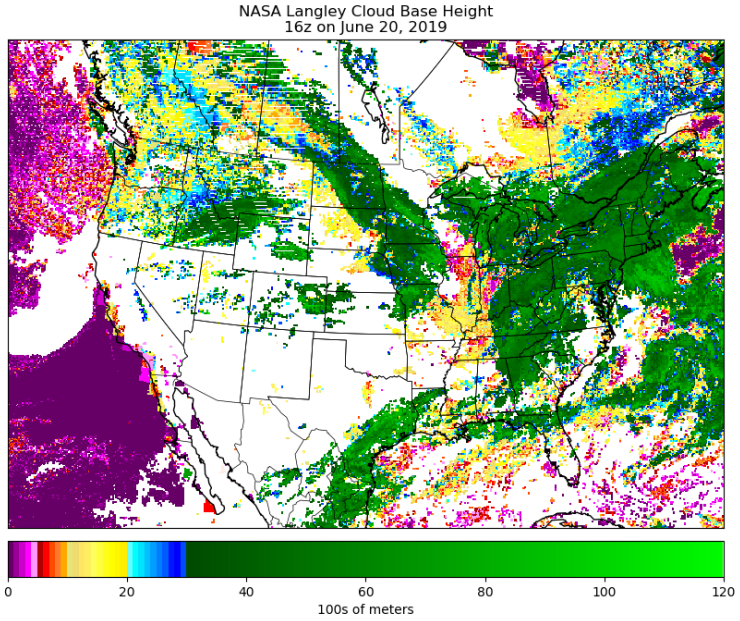


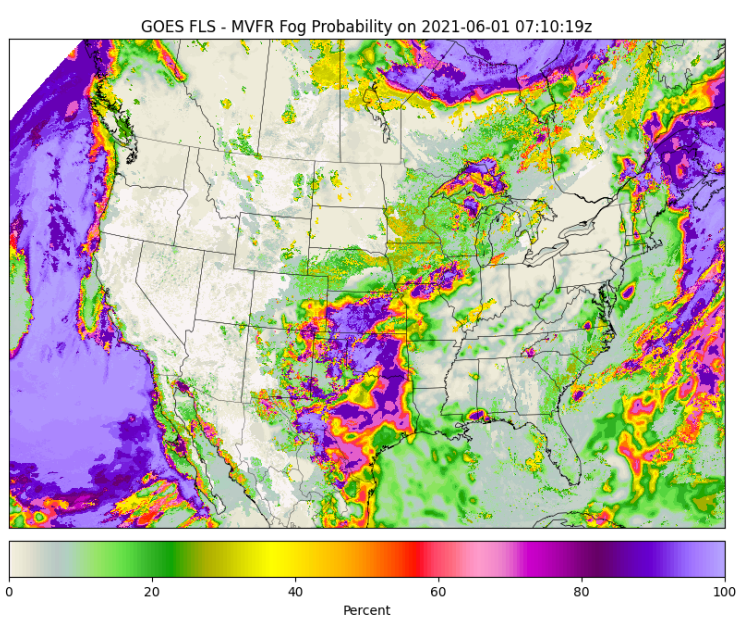


Satellite Product Options

- Limited to satellite products available on NOAA's Weather & Climate Operational Supercomputing System (WCOSS) either operationally or as "data of opportunity" which is maintained by the National Centers for Environmental Prediction (NCEP) Central Operations (NCO)

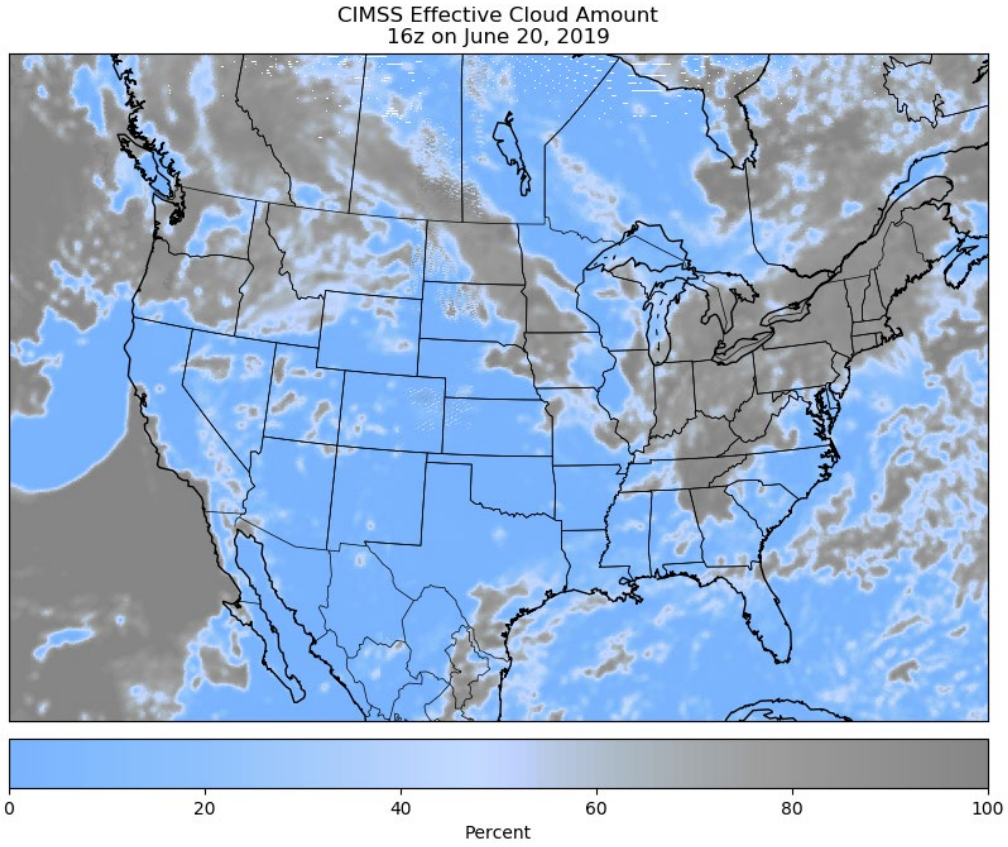






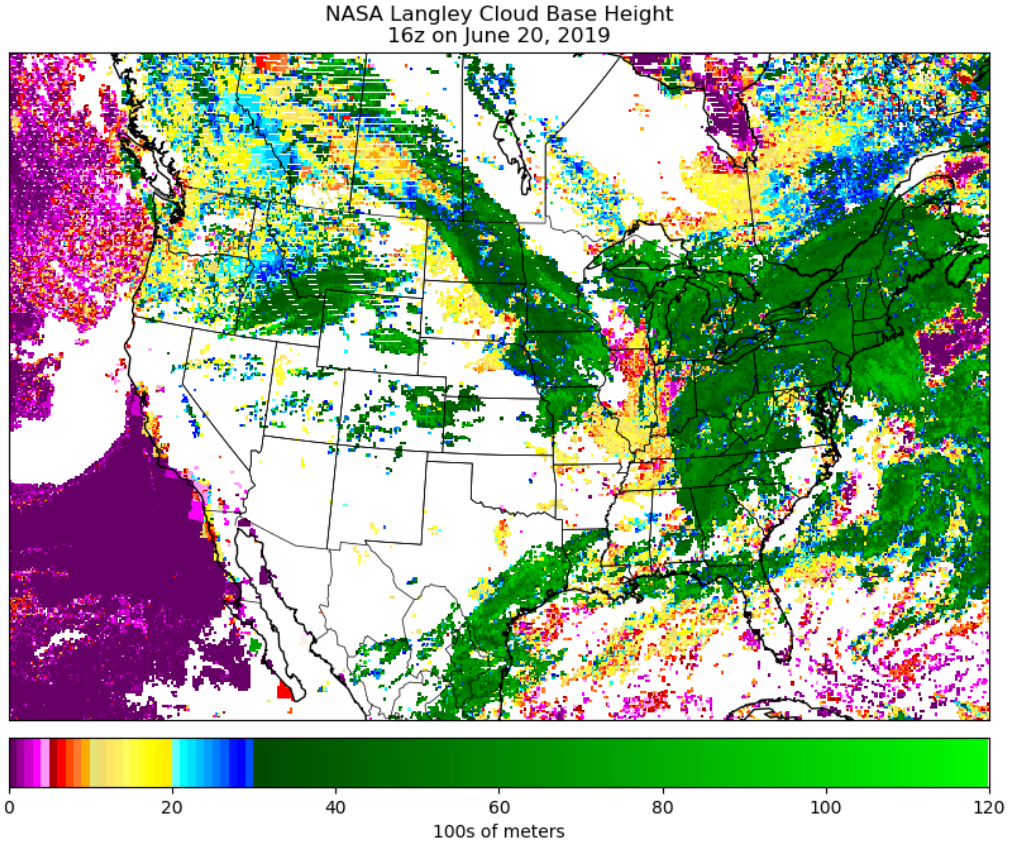
Effective Cloud Amount

- GOES imager effective cloud amount provided by the Cooperative Institute for Meteorological Satellite Studies (CIMSS) at the University of Wisconsin-Madison
- Has issues detecting low clouds, especially at night → producing drastic changes during day/night transition
- Does not provide height information but may be useful as a cloud mask
- RTMA/URMA incorporates in gridded sky cover analysis



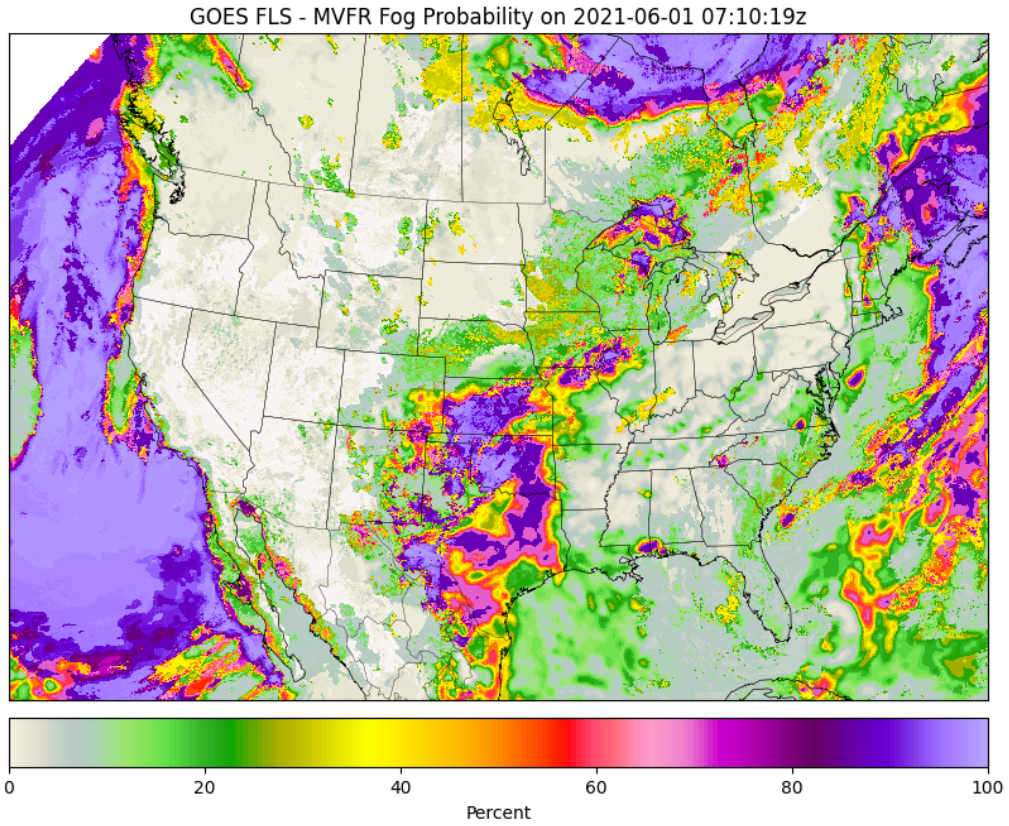
NASA Langley Cloud Products

- Products include: **cloud base height**, **cloud top height**, cloud base pressure, cloud top pressure, equivalent black body temperature, vertically-integrated liquid water content, cloud phase
- Heights are above sea level, extra processing step for above ground level
- At times, produces false clouds during day/night transition
- Cloud tops may be useful as a cloud mask
- Cloud base heights often do not lower enough to what observations detect

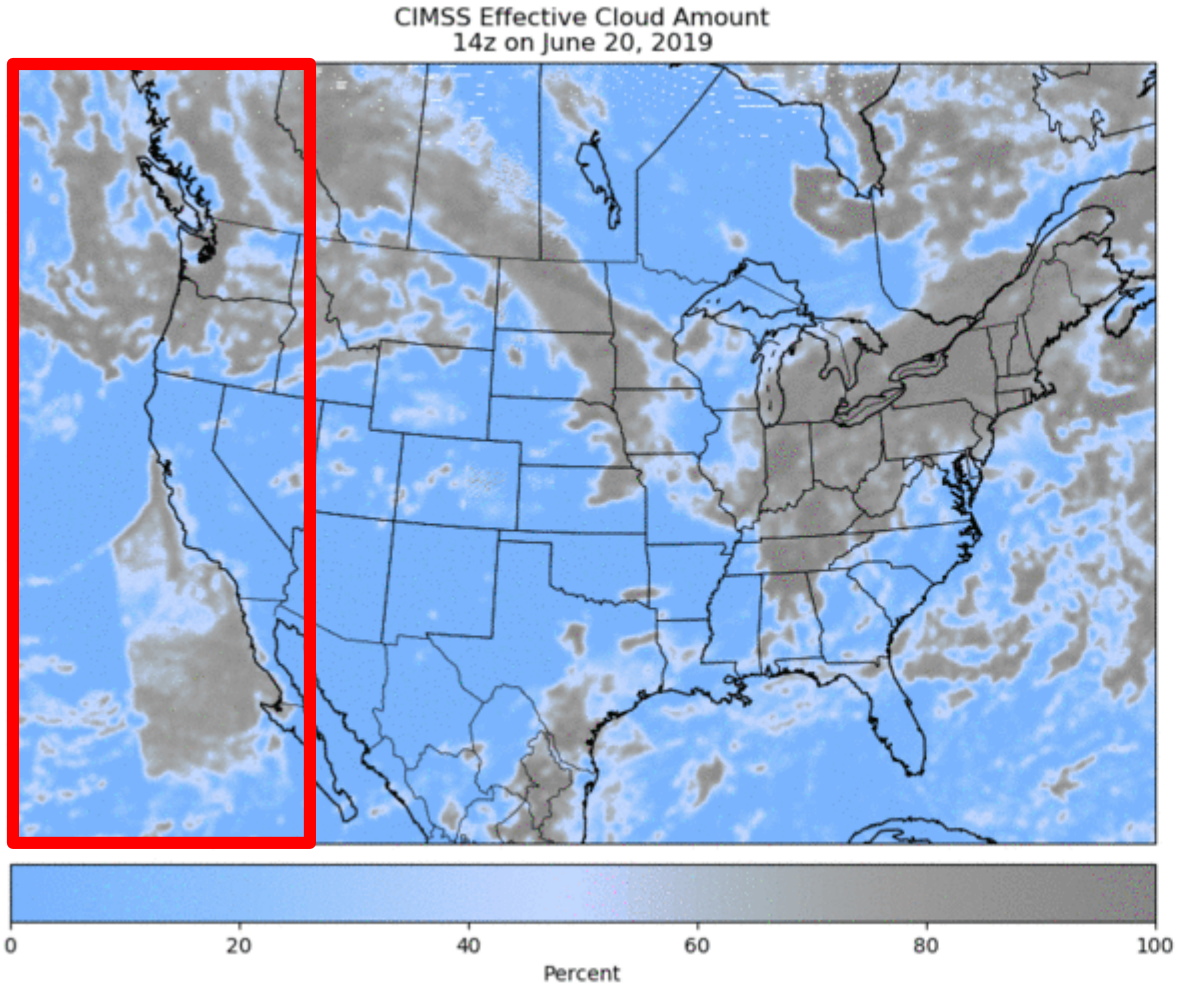


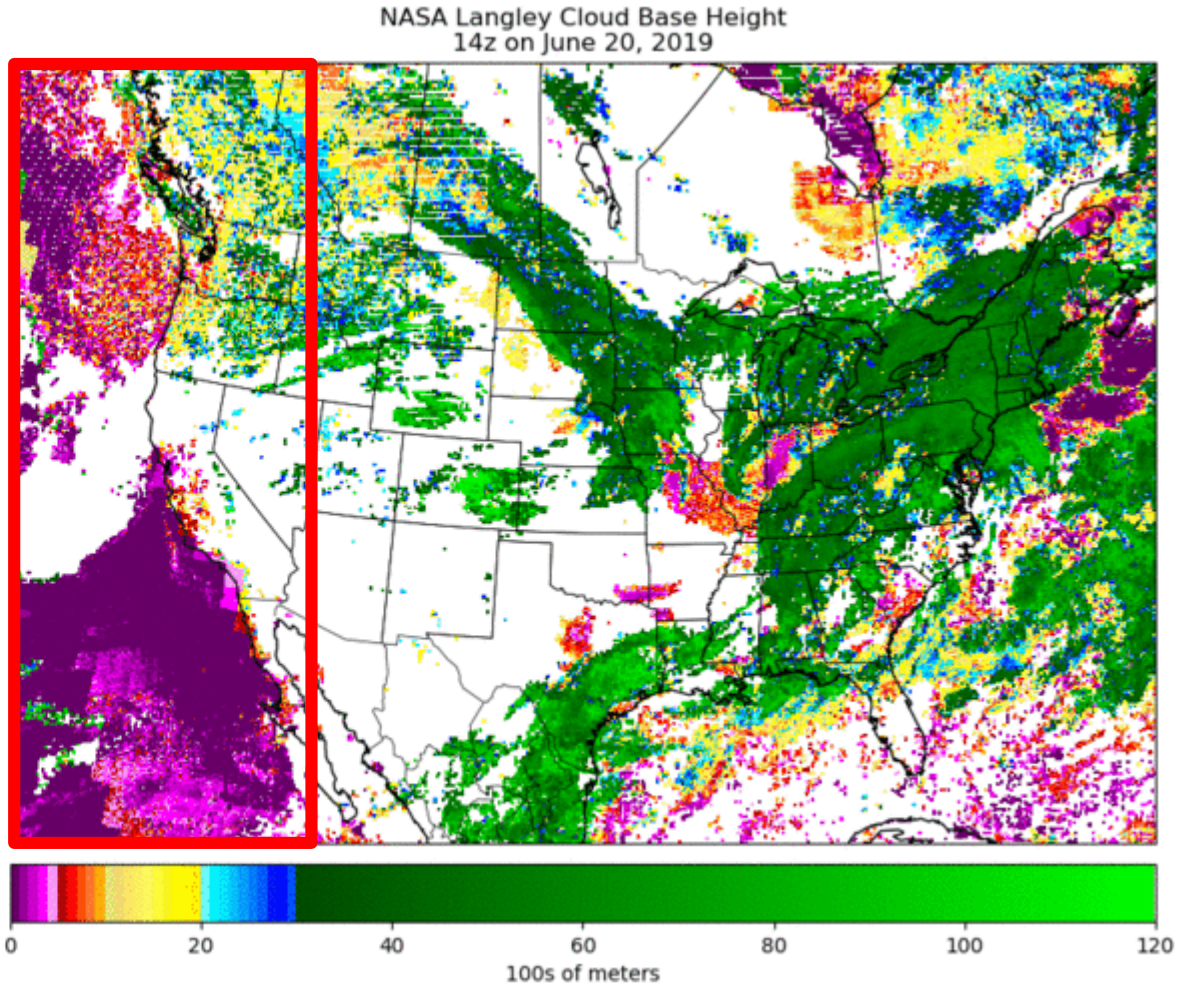
GOES Fog and Low Stratus

- Products include: probability of MVFR and below, probability of IFR and below, probability of LIFR, fog depth
- Archive started late December 2020 which is not yet of sufficient length for development
- Does not provide exact height information
- Does not separate flight category probabilities by ceiling or visibility
- Not available around sunrise and sunset



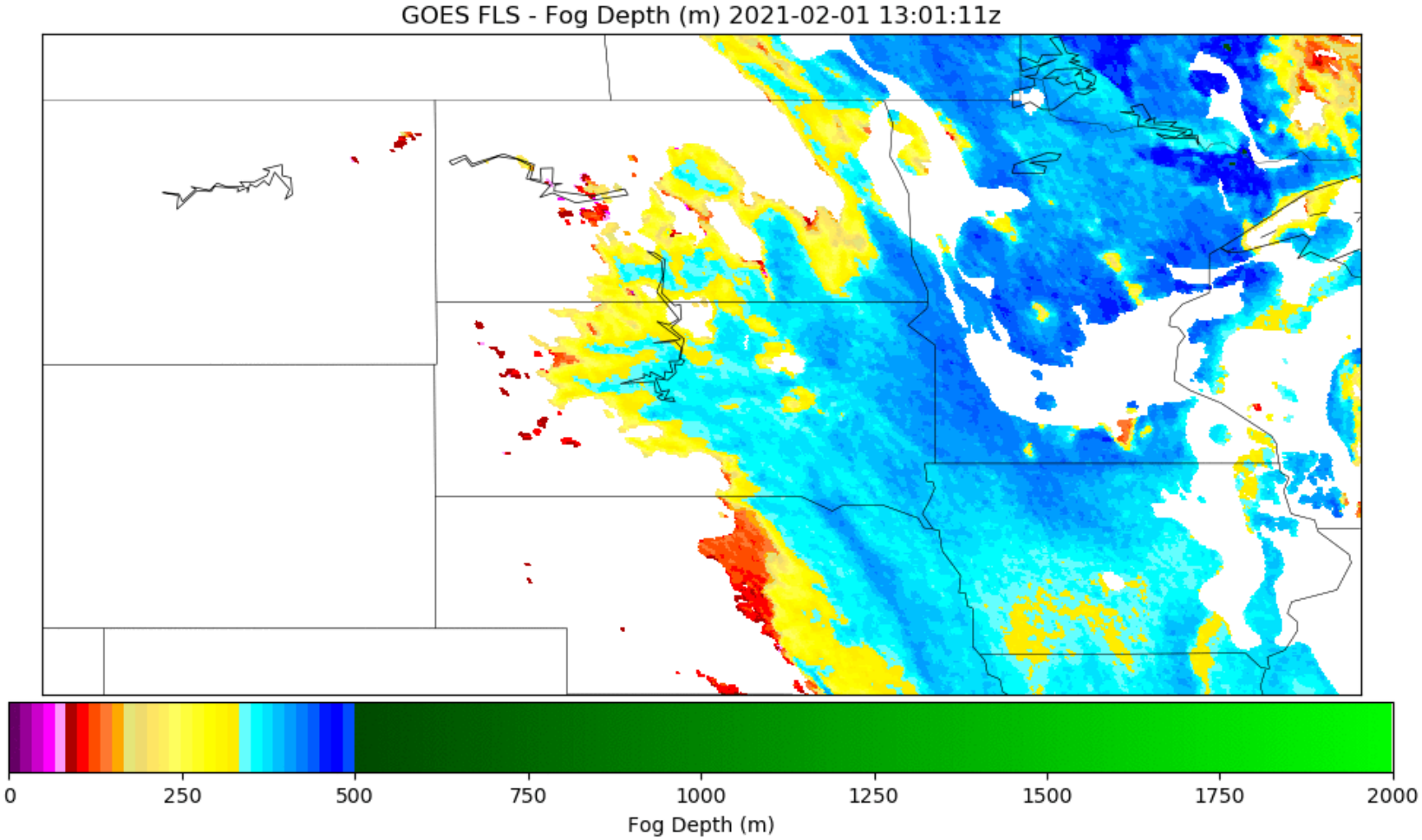
Night/Day Transition



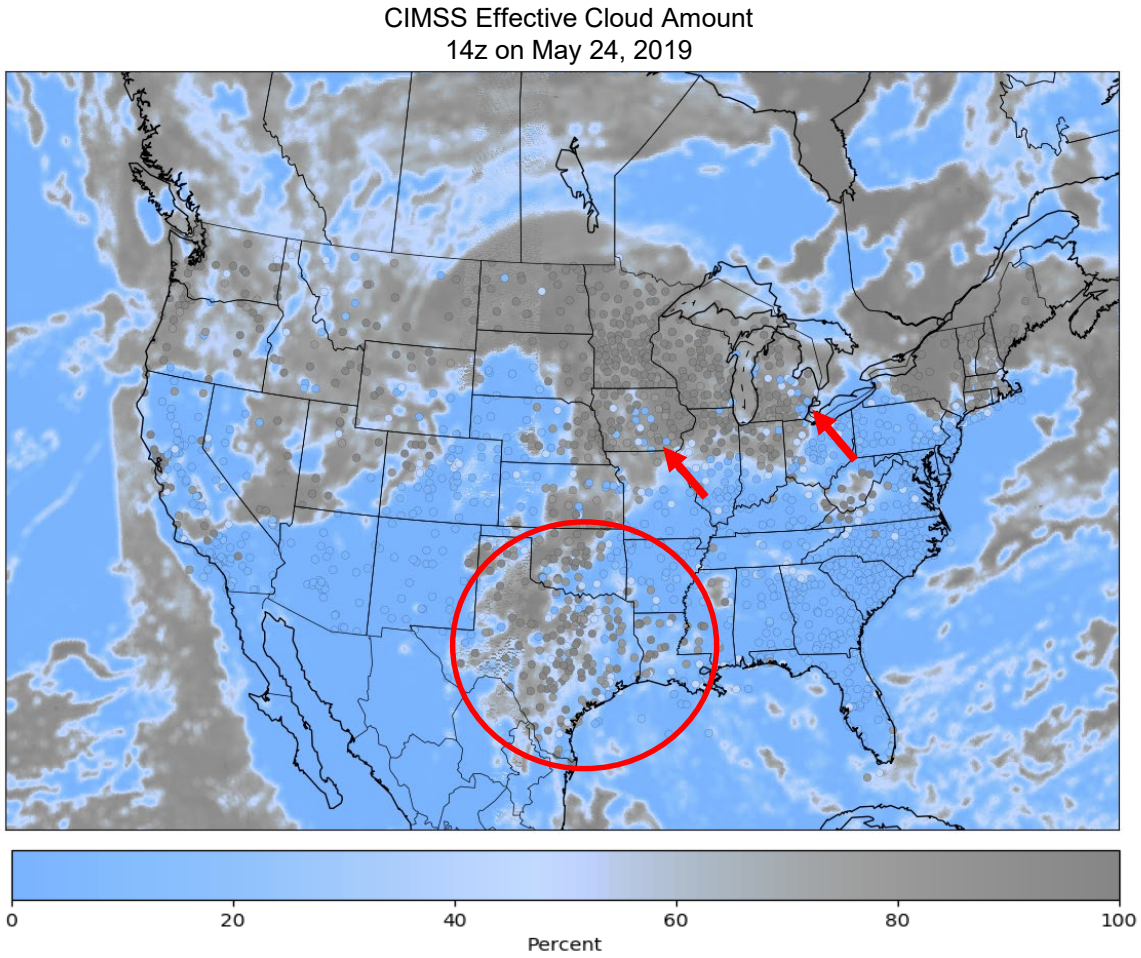


Night/Day Transition

- Example of the sunrise transition in the GOES-FLS fog depth product



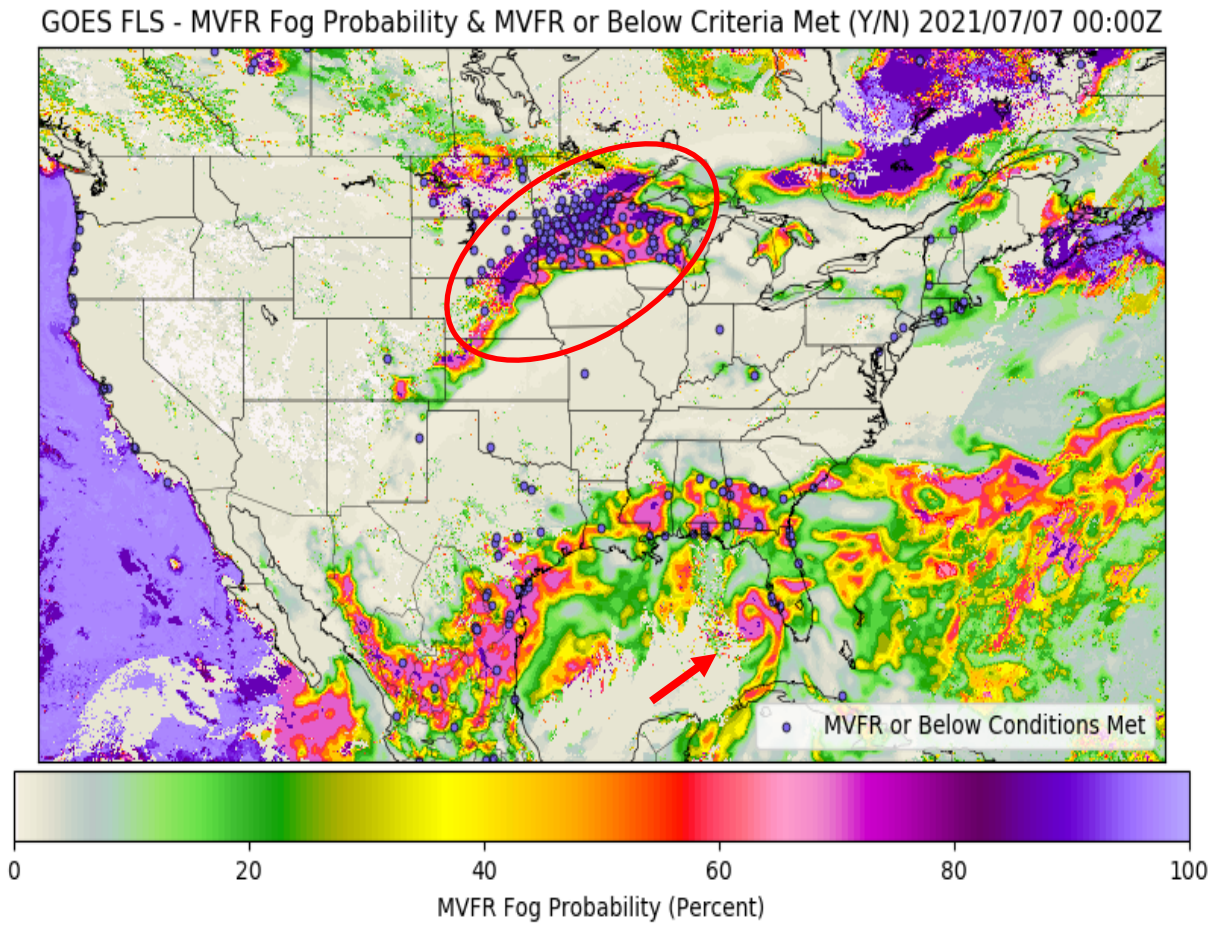
Verification



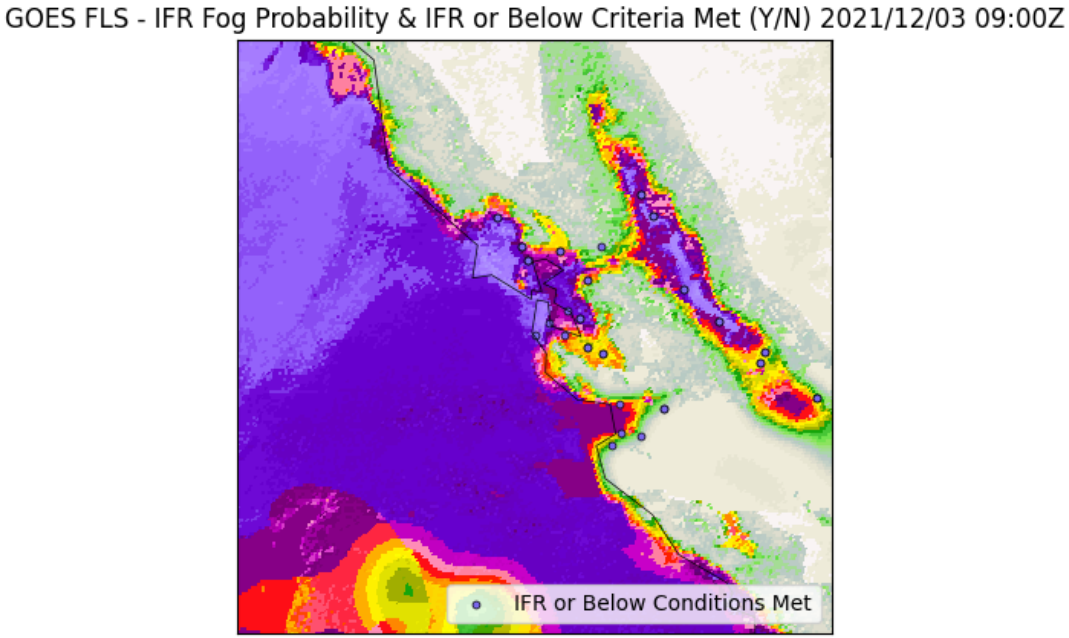
- Points are METAR sky cover observations
- Overall, the effective cloud amount verifies well against observations during the day but may have missed some clouds in Texas and the Southern Plains
- Again, the day/night transition is very apparent in the Pacific Ocean off of the California coast

METARs are not automated to report clouds greater than 12,000 feet, ***but* human observers can add cloud information above 12,000 feet

Verification



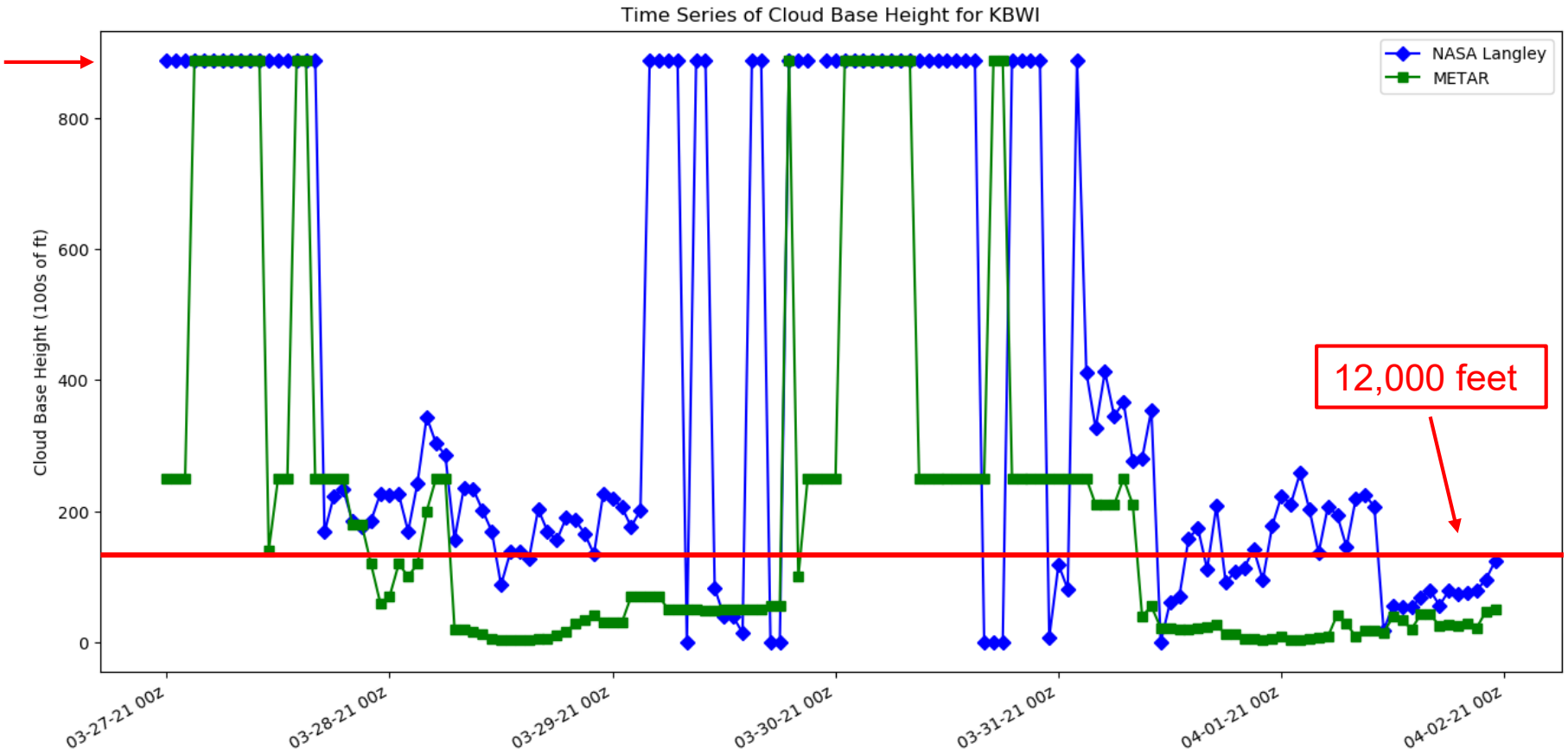
- Points are ceiling height or visibility observations that meet the flight category and below
- The MVFR and IFR products verify very well against observations



Verification

- Time series of METAR cloud base height vs. NASA Langley at KBWI
- NASA Langley captures lowering of clouds, but not as low as the METAR

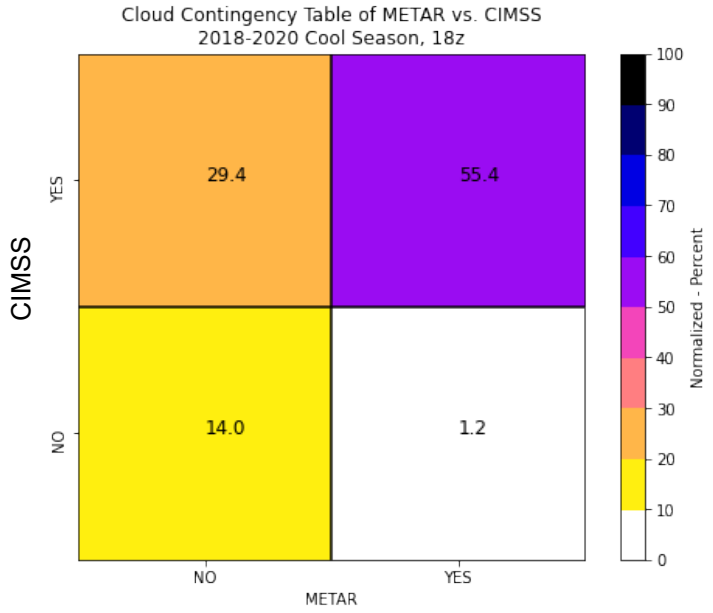
888 value = no clouds

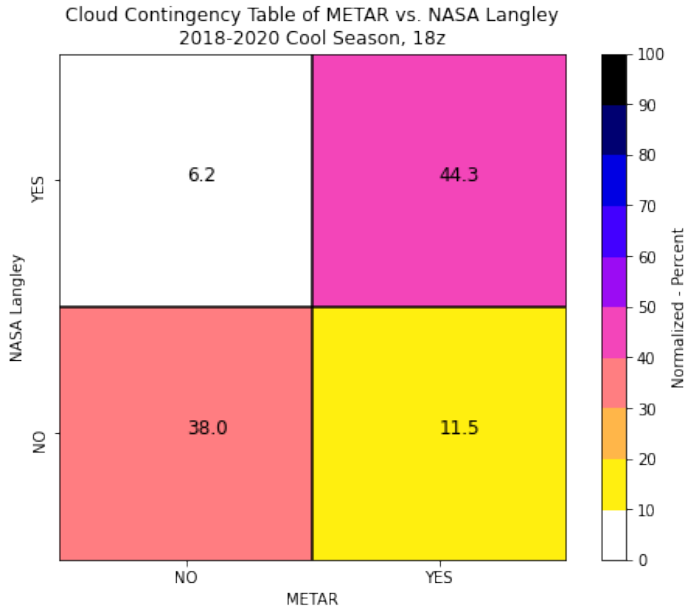


Verification

- Contingency tables show the percent frequencies of cloud presence at METAR locations vs. CIMSS and NASA Langley
- Percent of true null event (no/no) and hit (yes/yes)
  - ECAM: 69.4, NASA Langley: 82.3

**CIMSS false alarm expected due to ASOS limitation to 12,000 feet





**Limited cloud base height observations to <= 12,000 feet

Improving LAMP at Stations
Ceiling <= 3,000 feet

MLR Dev Predictors:

NASA Langley cloud base height

- < 200 ft
- < 500 ft
- < 1000 ft
- < 2000 ft
- <= 3000 ft
- <= 6500 ft
- <= 12000 ft

CIMSS effective cloud amount

- > 50 %

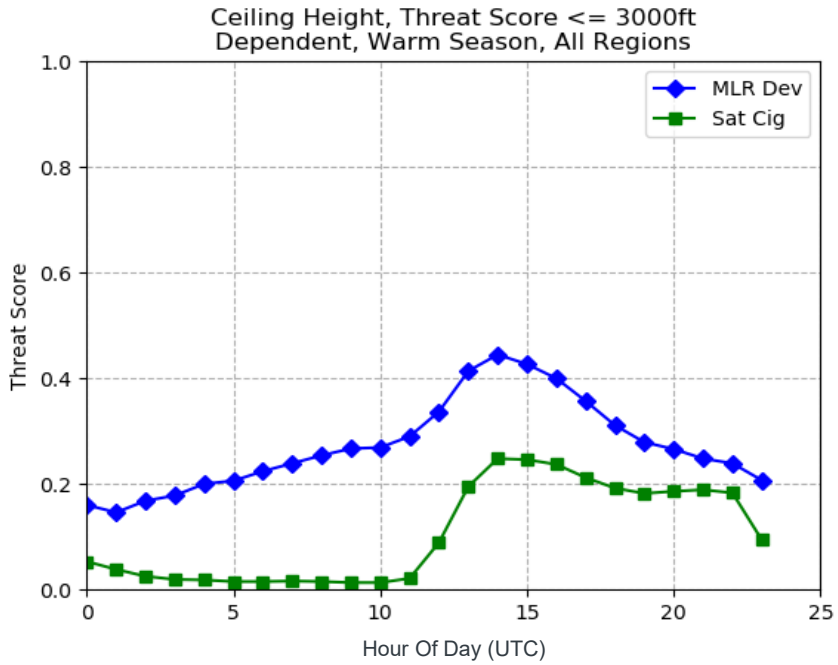
Sat Cig Predictor:

NASA Langley cloud base height when CIMSS > 50%

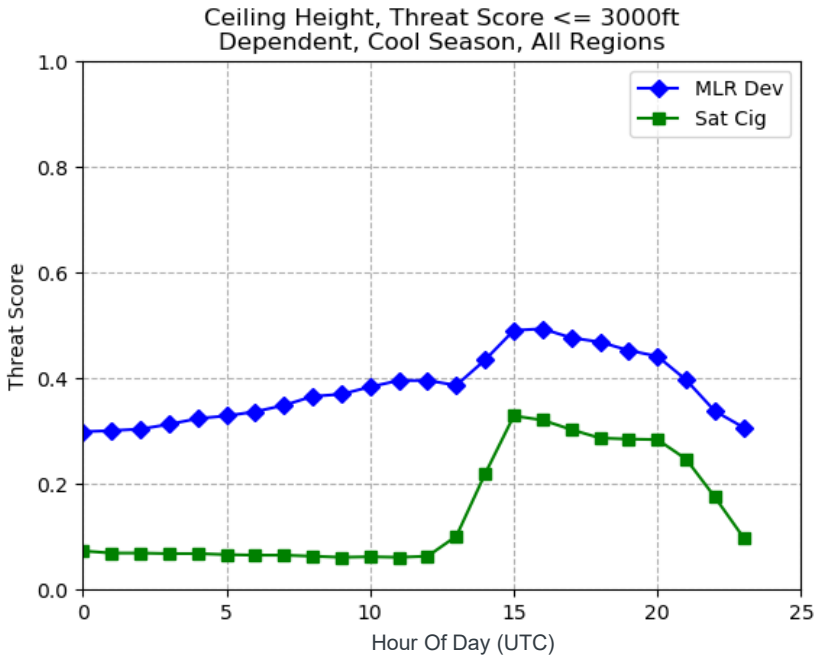
Predictand:

METAR ceiling height observations

Warm



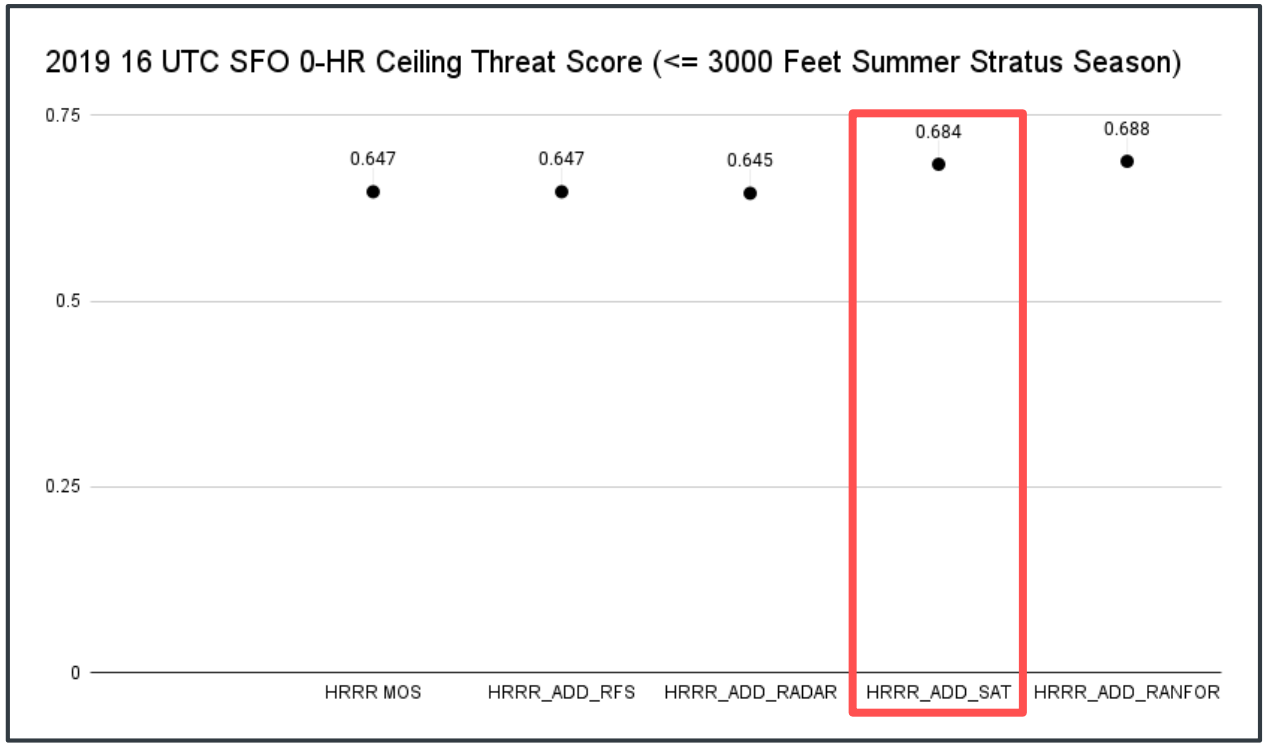
Cool



MLR of satellite products (blue) shows improvement over satellite derived ceiling (green), especially during hours just before sunrise

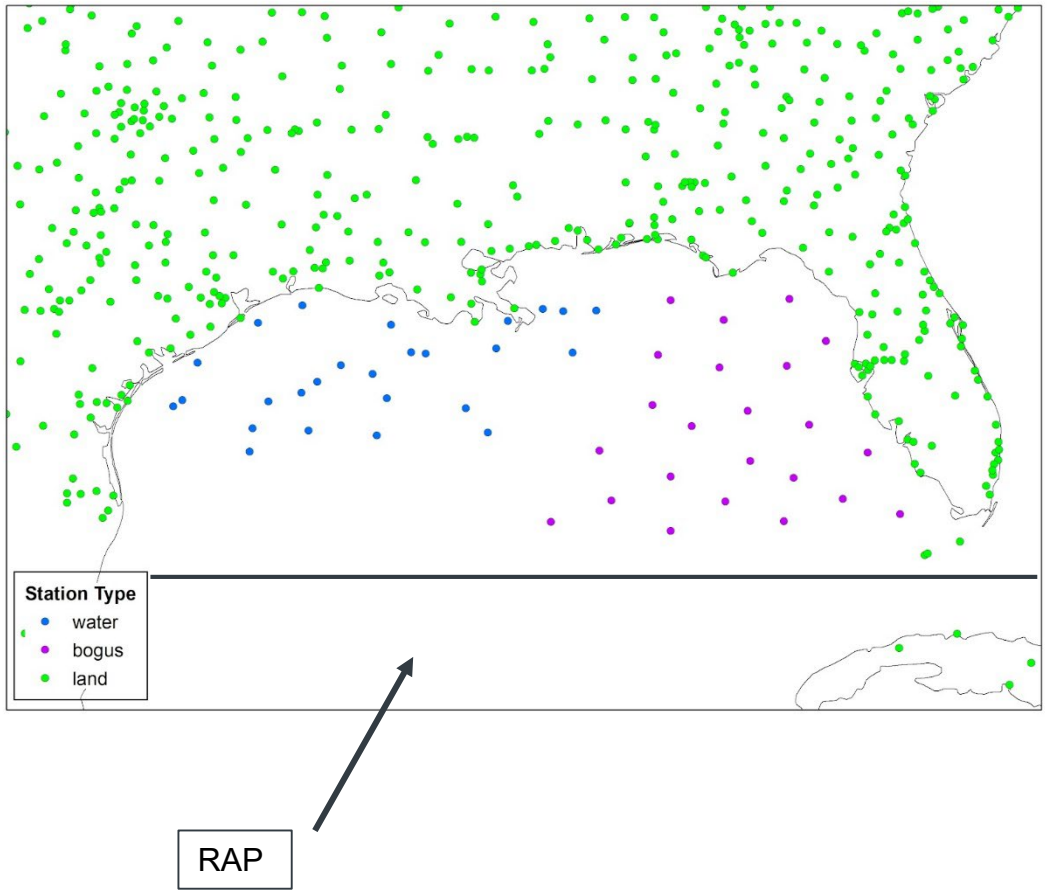
Improving LAMP Between Stations

- Most recent LAMP development: Created equations to predict ceiling height observations at grid points over the San Francisco area
  - The satellite products were picked up by the regression and improved threat scores
  - However, the transition to GOES-17 (GOES-West) and subsequent loop heat pipe problem cut down our sample size too much
  - The satellite data continues to show promise for improving forecast skill and improve LAMP between stations



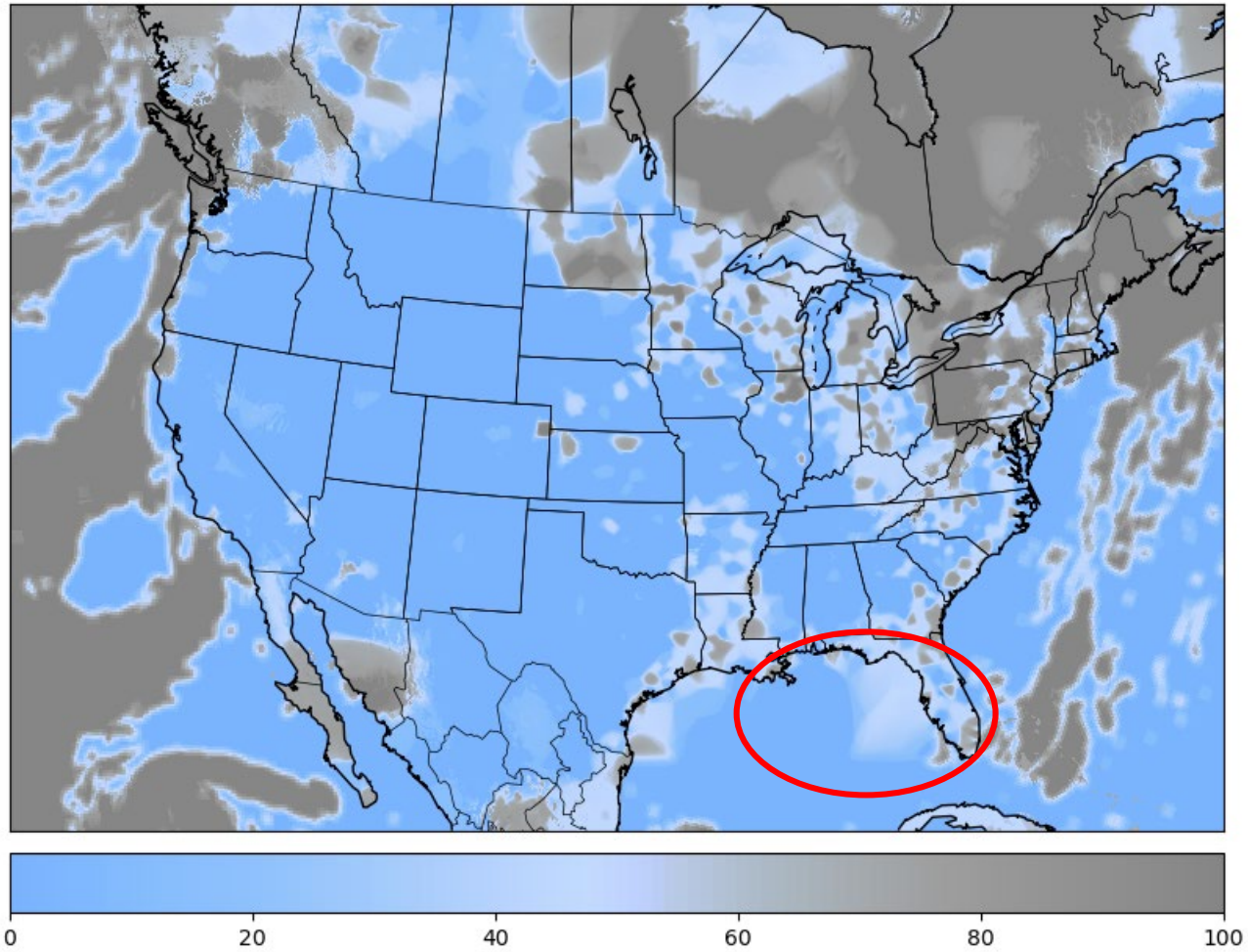
Improving LAMP Between Stations

- Issue: An observation sparse area of the eastern Gulf produced unrealistic features in the 0-hr gridded LAMP sky cover analysis
- Resolution: Create forecast points (we call them bogus points) whose locations can be used to interpolate satellite data to
- Result: More realistic features were produced
- **Note: No points south of black line as this area is covered by the RAP



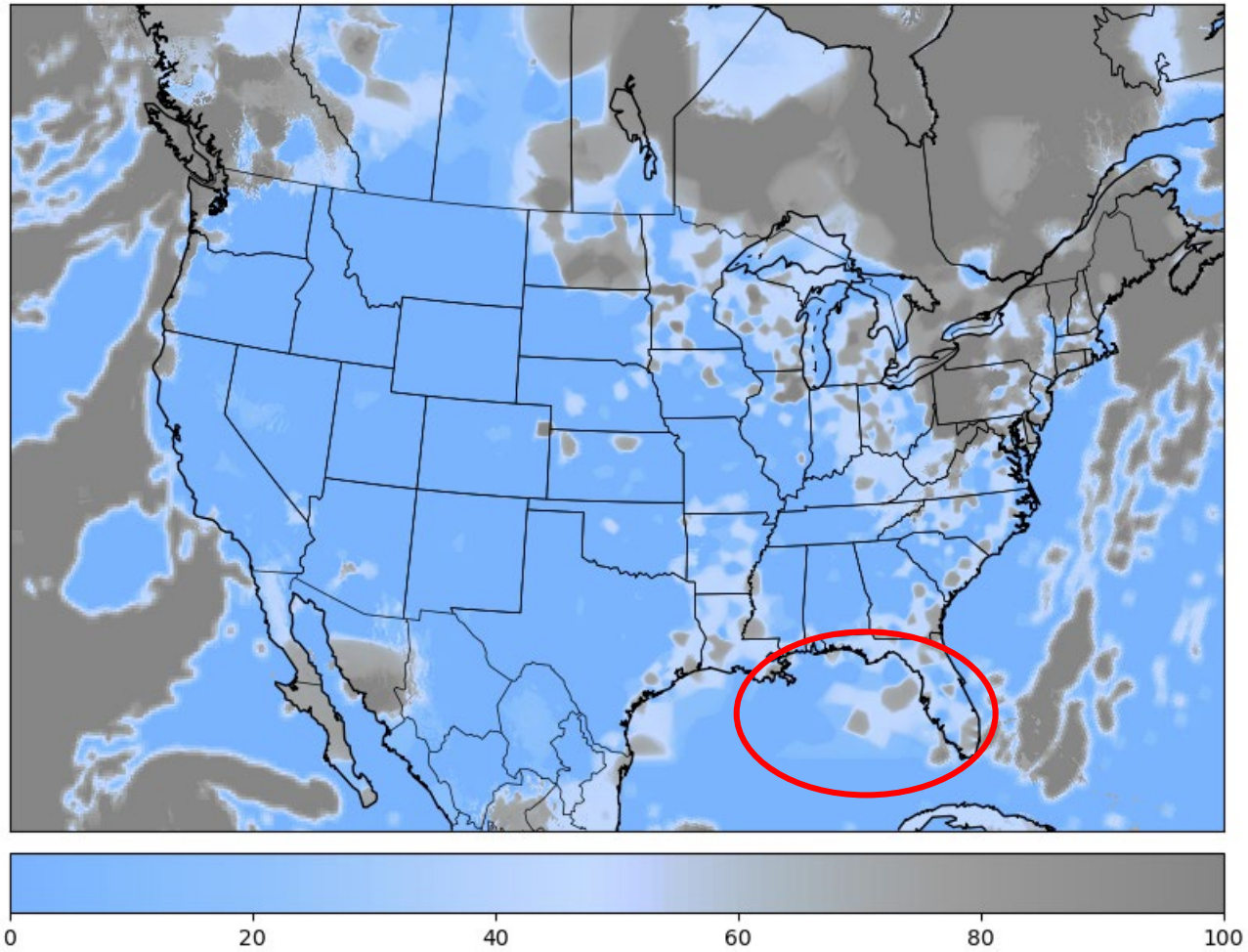
Improving LAMP Between Stations

0-hr GLMP Sky Cover Analysis
July 11, 2020 17z



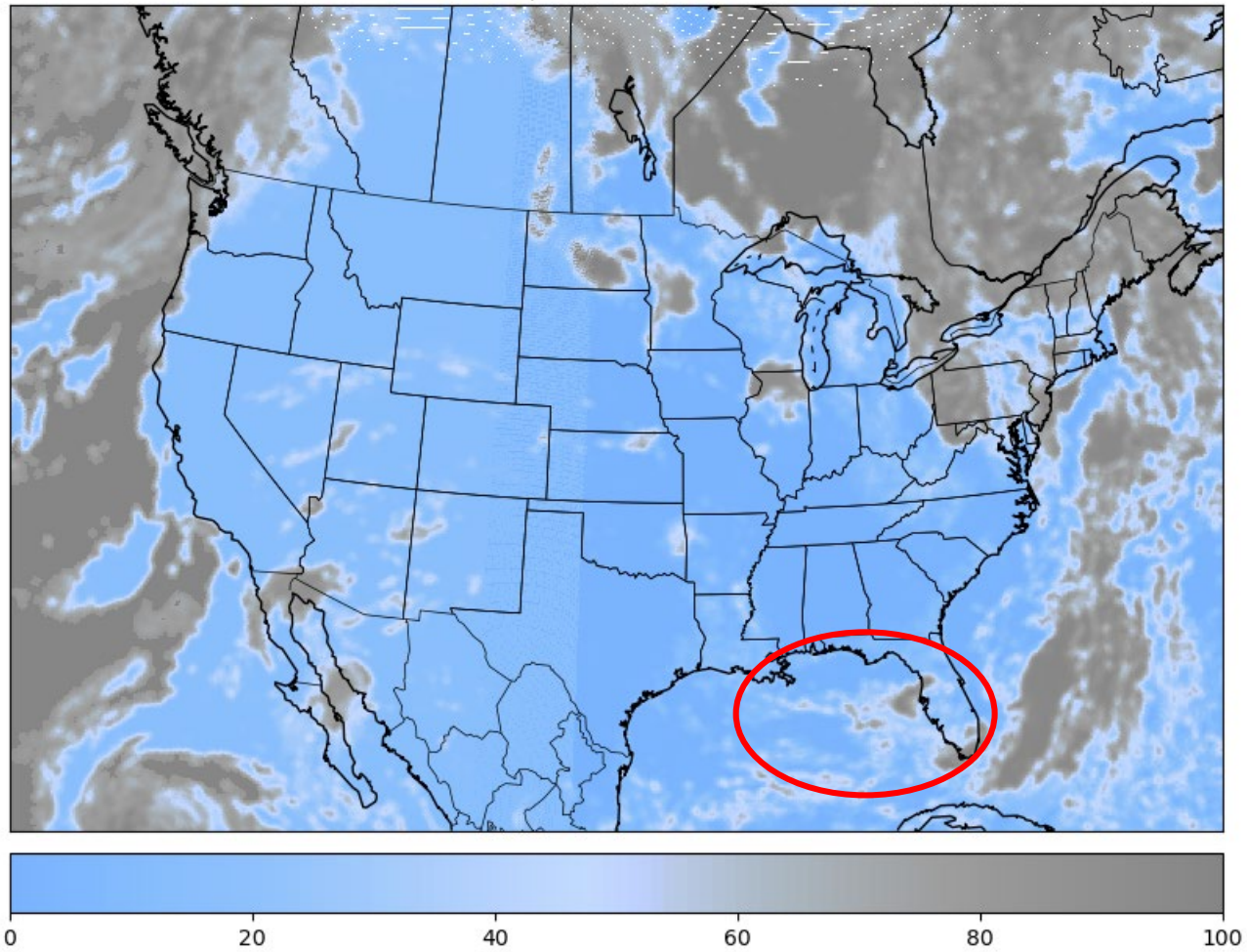
Improving LAMP Between Stations

0-hr GLMP Sky Cover Analysis **w/ Bogus Points**
July 11, 2020 17z



Improving LAMP Between Stations

CIMSS Effective Cloud Amount
July 11, 2020 17z



The inclusion of satellite effective cloud amount was not implemented due to concerns about poor cloud detection at night but this methodology will be considered in future implementations

Summary

- While the satellite products that were researched show promise improving gridded LAMP between stations, the following deficiencies are noted:
  - GOES outages (e.g. transitions, loop heat pipe)
  - Poor cloud detection during overnight hours
  - Overestimation of cloud base heights
- Ongoing work: 15-min gridded LAMP to hopefully include satellite data
- Future work: Artificial intelligence/machine learning techniques will continue to be explored to improve LAMP guidance between stations

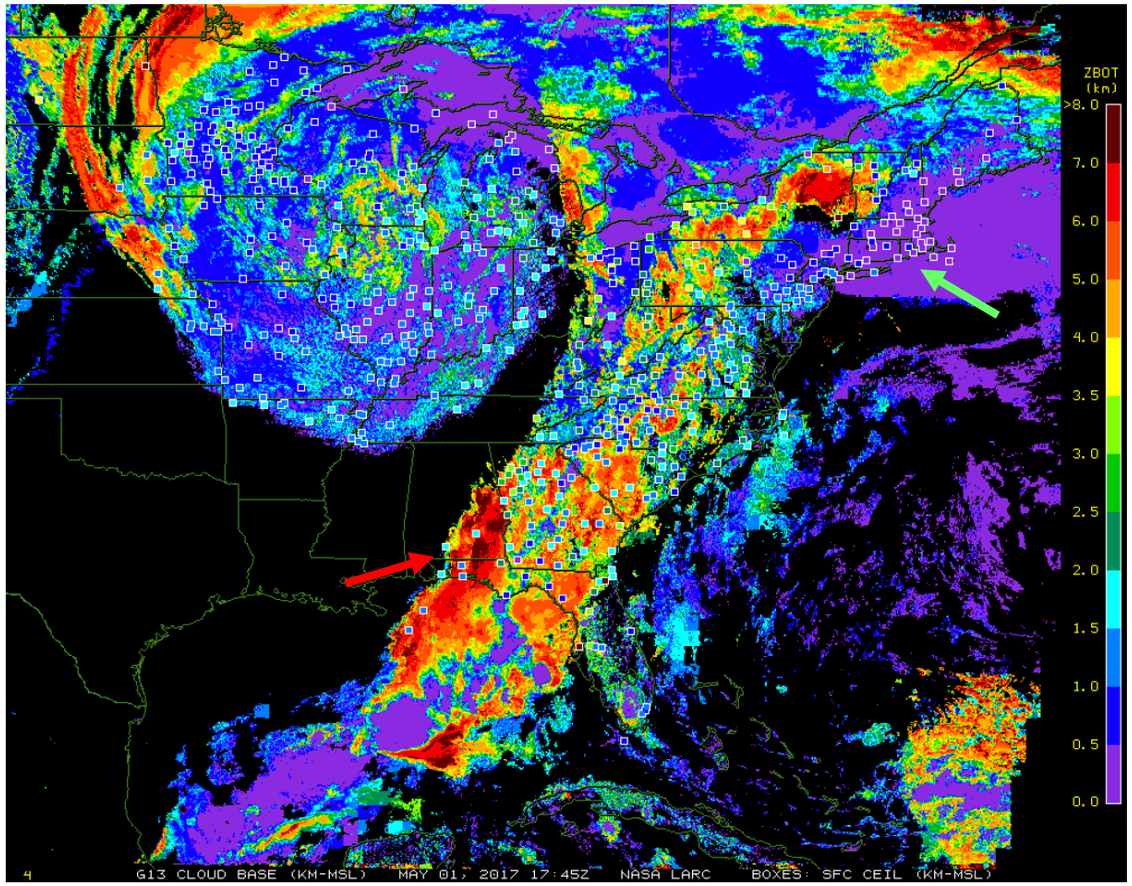
- Contact info: Allison.Layne@noaa.gov

https://www.weather.gov/mdl/lamp_home → https://vlab.noaa.gov/web/mdl/lamp

Extra Slides

Subjective Verification

NASA Langley Cloud Base Height AGL
1745z on May 1, 2017



- Points are METAR ceiling height observations above ground level (AGL) in km
- Observations are only in shades of purple, blue, and green unless human observer adds cloud information above 12,000 feet (~3.6 km)
- Overall, the cloud base height product has good spatial coverage and shows highly defined small scale features

METARs are not automated to report clouds greater than 12,000 feet, ***but* human observers can add cloud information above 12,000 feet

Objective Verification

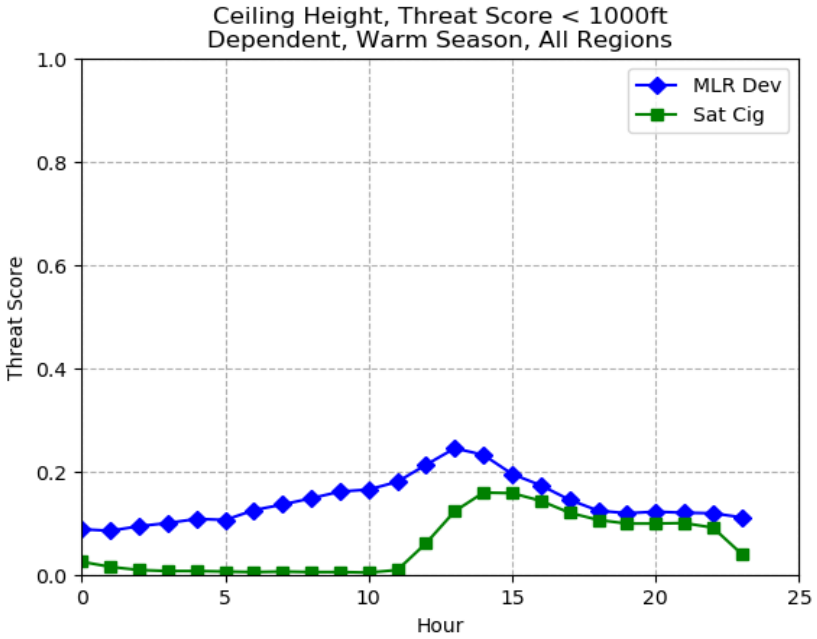
- Contingency tables show frequency distribution between NASA Langley cloud base height (AGL) and METAR cloud base height observations from 2018-2020
  - Perfect table would have the highest frequencies along the bolded, boxed diagonal

09 UTC Cycle, 3 Years of Cool Seasons

		SATELLITE CLOUD BASE HEIGHT (FT)						
		< 200	200-499	500-999	1000-1999	2000-3000	3001-6500	6501-12000
METAR OBS (FT)	< 200	**761**	142	114	156	158	328	377
	200-499	5400	**940**	604	892	949	2775	3803
	500-999	5232	1131	**755**	1098	1326	4355	6191
	1000-1999	6686	1920	1387	**2204**	2067	6976	8243
	2000-3000	3985	1469	1308	1994	**1894**	5914	5984
	3001-6500	3756	1301	1169	2054	2514	**9650**	12026
	6501-12000	1145	413	349	617	878	4253	**9309**

Improving LAMP at Stations < 1,000 feet

Warm



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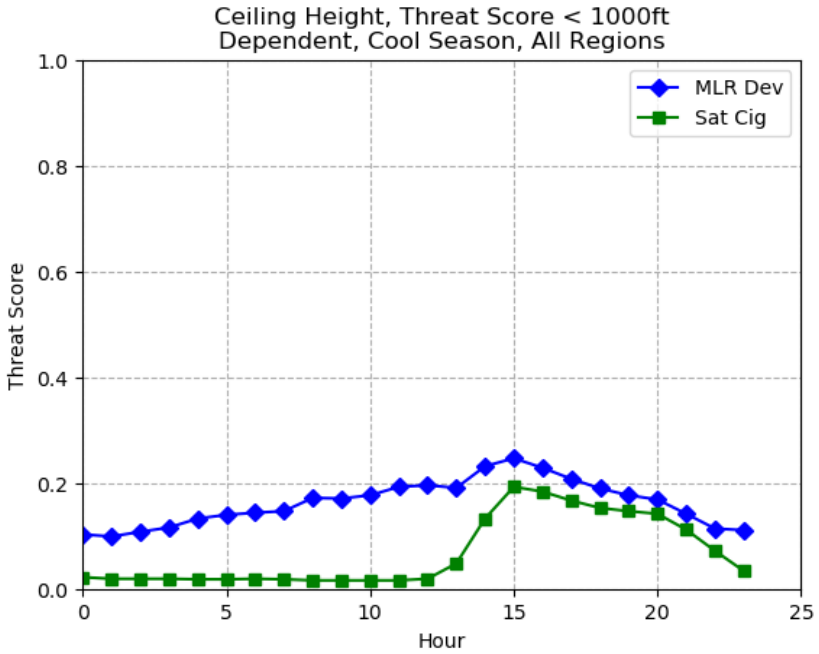

Both MLR of satellite products (blue) and satellite derived ceiling height (green) produce unacceptable scores