



The General Aviation Pilot Preflight Weather Planning: Weather Products Usability & Limitations

Embry-Riddle Aeronautical University

Jayde King, M.S

Yolanda Ortiz, M.S

Nicholas DeFilippis, M.S

Thomas Guinn, Ph.D.

Beth Blickensderfer, Ph.D.

Robert Thomas, Ph.D.

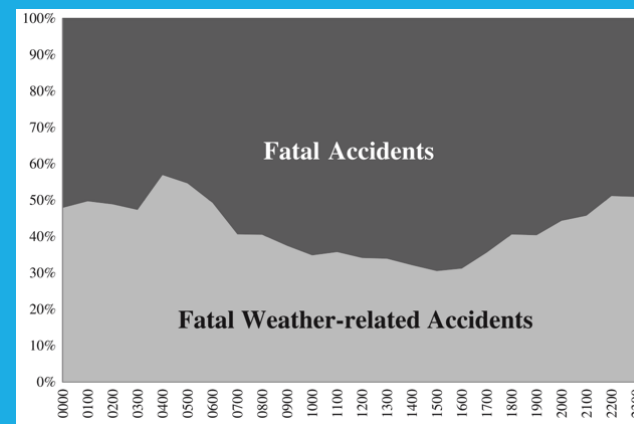
Friends & Partners of Aviation Weather, Orlando, FL, October 2018



PART 01 Background

Over the last 30 years, a large percentage of weather-related aviation accidents have occurred under General Aviation (GA) operations (FAA, 2010; Fultz & Ashley, 2016; AOPA, 2008).

- Novice Private Pilots VFR into IMC
- High Risk For Incurring Fatality



(Fultz & Ashley, 2016).



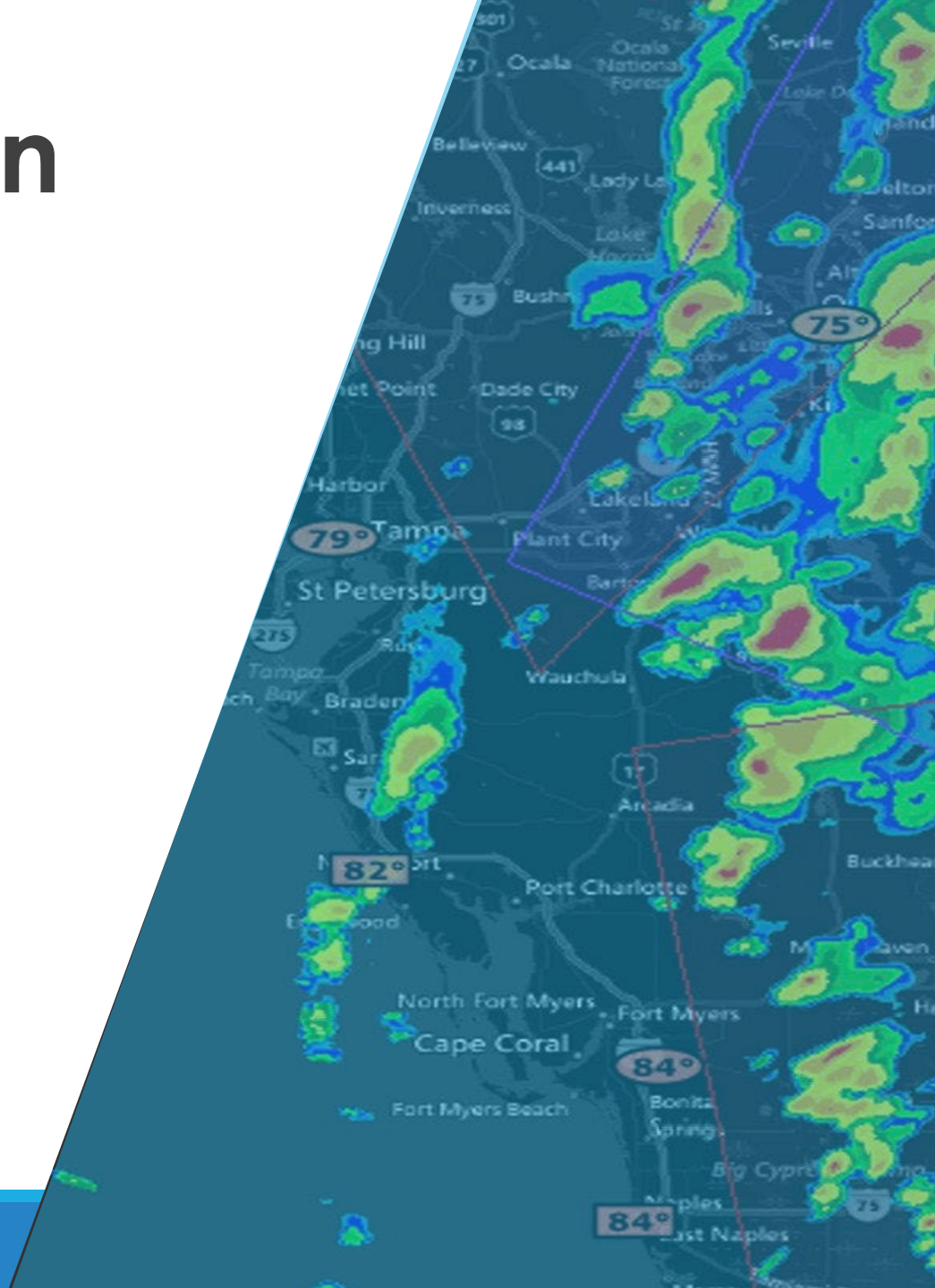
PART 02

Aviation Weather Challenges

1. **Difficult to Interpret Aviation Weather Products**
2. **Pilot's Decision Making Biases and Errors**
3. **GA Pilots' Lack of Aviation Weather Experience**

Difficult to Interpret Aviation Weather Products

- Weather products are crucial for preflight planning
- Poor usability weather products
- Inexperienced GA Pilots' Lack of Aviation Weather Experience



Pilots struggle with Aviation Weather Preflight Tasks

Low experienced pilots may be incurring weather-related accidents due to their inability to:

- Access
- Interpret
- Apply

weather information (Blickensderfer et al., 2018).



New Weather Product Displays

- Aviation Weather Center (AWC) & Federal Aviation Administration (FAA) produce graphical and interactive weather products
- Improved products may be more confusing than helpful

(Latorella & Chamberlain, 2002; Yuchnovicz et al., 2001; Beringer and Ball, 2004).



Purpose

- Compare the usability of AWC and Foreflight weather information and displays.
- Highlight how weather product displays on AWC and Foreflight can hinder or assist with preflight planning processes.
 - Perceive
 - Process
 - Perform

Aviation Weather Knowledge Assessment

Blickensderfer et al. (2018) developed an aviation weather exam to evaluate GA pilots' ability to interpret :

- Observation
- Analysis
- Forecast

Results indicated that, pilots' product interpretation scores were quite low.



Assessment of Interpretability of Weather Products: Phase 1

General Aviation Pilots scored the lowest on the following weather products:

Forecast

- G-AIRMET
- NCWF
- TAF

Observation

- METAR
- Satellite

Product Type	n	Total M (SD)
Satellite	204	54.04 (27.78)
METAR	204	46.14 (20.23)
TAF	204	50.00 (25.84)
G-AIRMET	204	48.82 (20.72)
NCWF	204	45.59 (28.79)

Table 2. Effect of Pilot Rating and Forecast Type on Interpretation Score. (Blick et al., 2018)

Assessment of Interpretability of Weather Products: Phase 2

General Aviation Pilots scored the lowest on the following weather products:

- METARS
- TAF
- Radar
- Satellite

Product Type	n	Total M (SD)
Satellite	176	58.1 (29.4)
Radar	198	60.7 (17.7)
TAF	149	56.9 (24.8)
METAR	149	54.5 (19.0)

(Blick et al., 2018)

Usability Principles

Usability and human centered design can assist with :

- Interpretability
- Product and System Transparency



Poor usability may actually encourage hazardous behavior rather than prevent it.

- i.e Radar

(Latorella & Chamberlain, 2002; Yuchnovicz et al., 2001; Beringer and Ball, 2004)



NCWF





AVIATION WEATHER CENTER

NOAA NATIONAL WEATHER SERVICE

Local Foreca

HOME ADVISORIES FORECASTS OBSERVATIONS TOOLS **NEWS** SEARCH

ABOUT USER



National Convective Weather Forecast (NCWF)

[NCWF Home](#)

NOTICE

The National Convective Weather Forecast (NCWF) has been discontinued.

Please use the links below to access replacement products.

[Current Radar](#)

[MRMS Viewer](#)

Page loaded: 10:49 UTC | 03:49 AM Pacific | 04:49 AM Mountain | 05:49 AM Central | 06:49 AM Eastern

Operational Product Viewer

2018 Oct 17 10:46 UTC

◀ 2 min ▶
 ◀ 4 min ▶
 ◀ 10 min ▶
 ◀ 30 min ▶
 ◀ 1 hr ▶
 ◀ 6 hr ▶
 ◀ 1 dy ▶

Current Time

Auto Update ☐

Product Type

- Base Reflectivity
- Composite Reflectivity
- Seamless Hybrid Scan
- Refl At Lowest Altitude
- Layer Reflectivity
- Echo Top
- Layer Thickness
- 3D Mosaic Levels
- Radar Quality Index
- Rotation
- Hail
- Lightning
- Gauge Influence Index
- FLASH
- Q3 Radar Only
- Q3 Gauge Only
- Q3 Gauge Corrected Rad
- Q3 Mountain Mapper
- Vertically Integrated Water
- Bright Band
- Precipitation Flag
- AutoNowCaster

CREF

- Max Method
- 1 hr Max
- Un-QC'ed
- Height

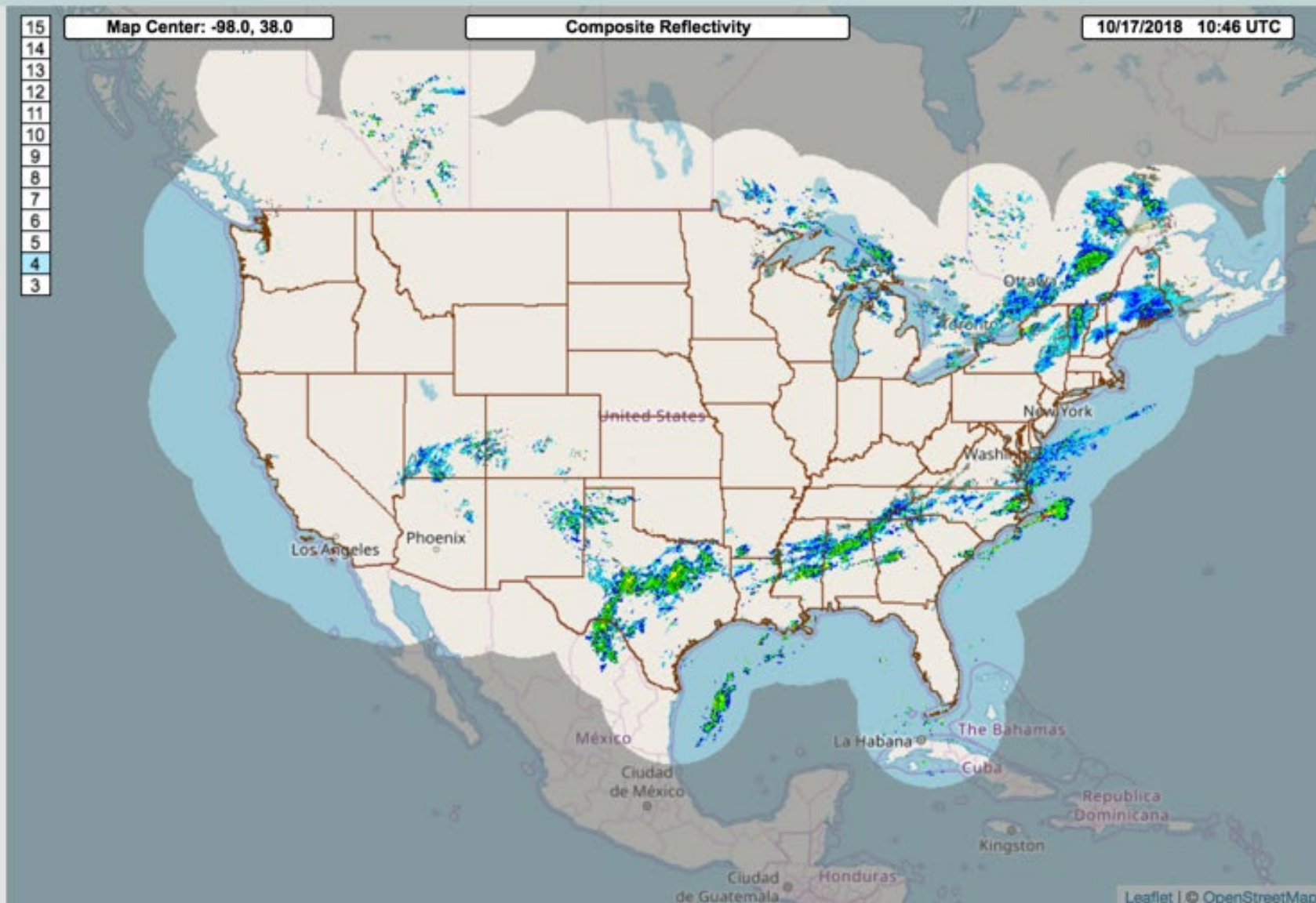
Opacity 0% 100%

Map Center: -98.0, 38.0

Composite Reflectivity

10/17/2018 10:46 UTC

15
14
13
12
11
10
9
8
7
6
5
4
3



dBZ

75
65
55
45
35
25
15
5
-5
-15
-25
-35

Loop Image ☐

Reset Region

mPING Legend

Overlays

Enable Mouse Wheel ☐

mPING Reports None

Base Map Layer

METAR & TAF

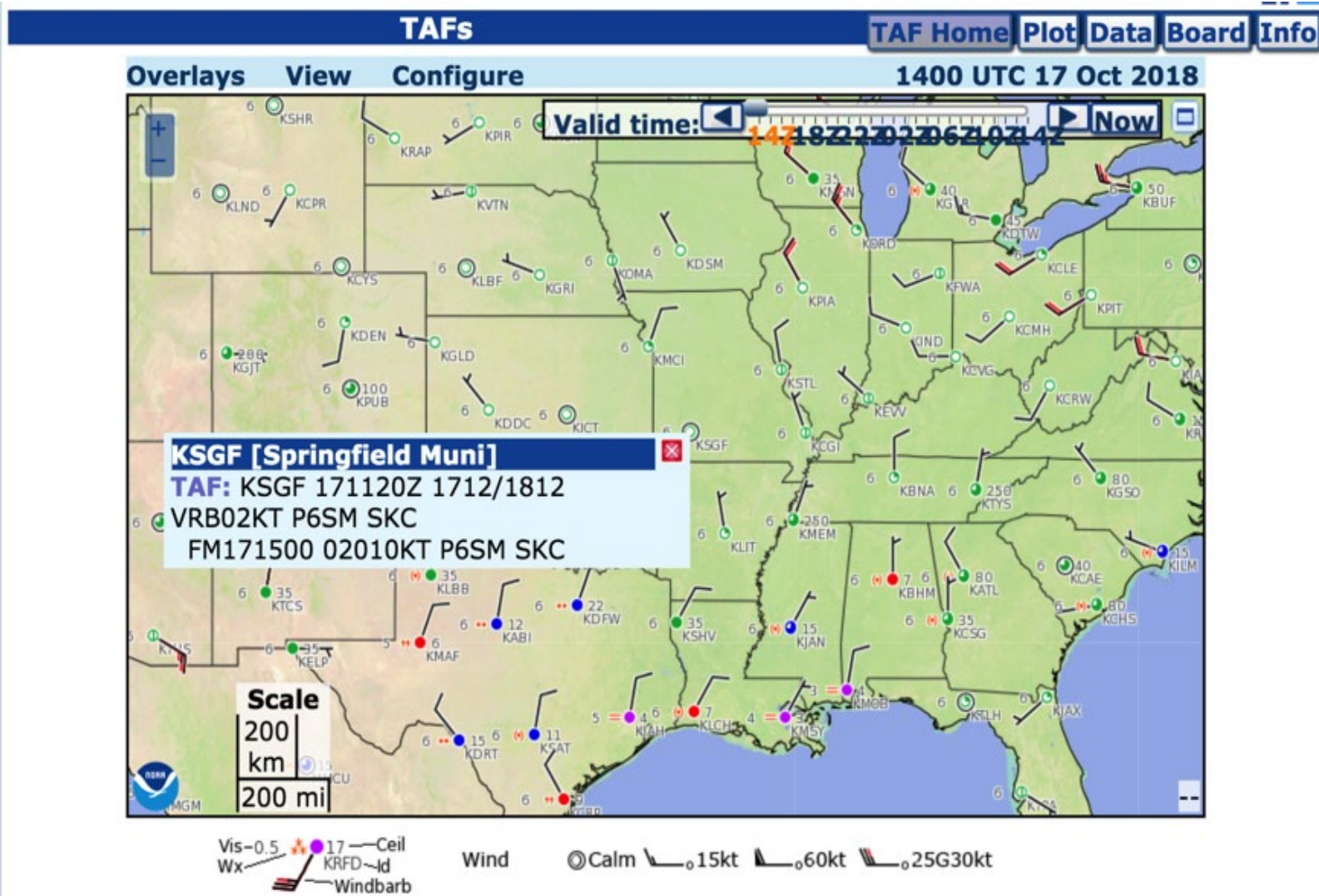
Aviation Weather Center

Pros:

- Issuance times
- Decoded option

Cons:

- Does not provide color coding based on interpretation (vfr/mvfr/ifr)
- Does not recommend METARS to check



METAR & TAF

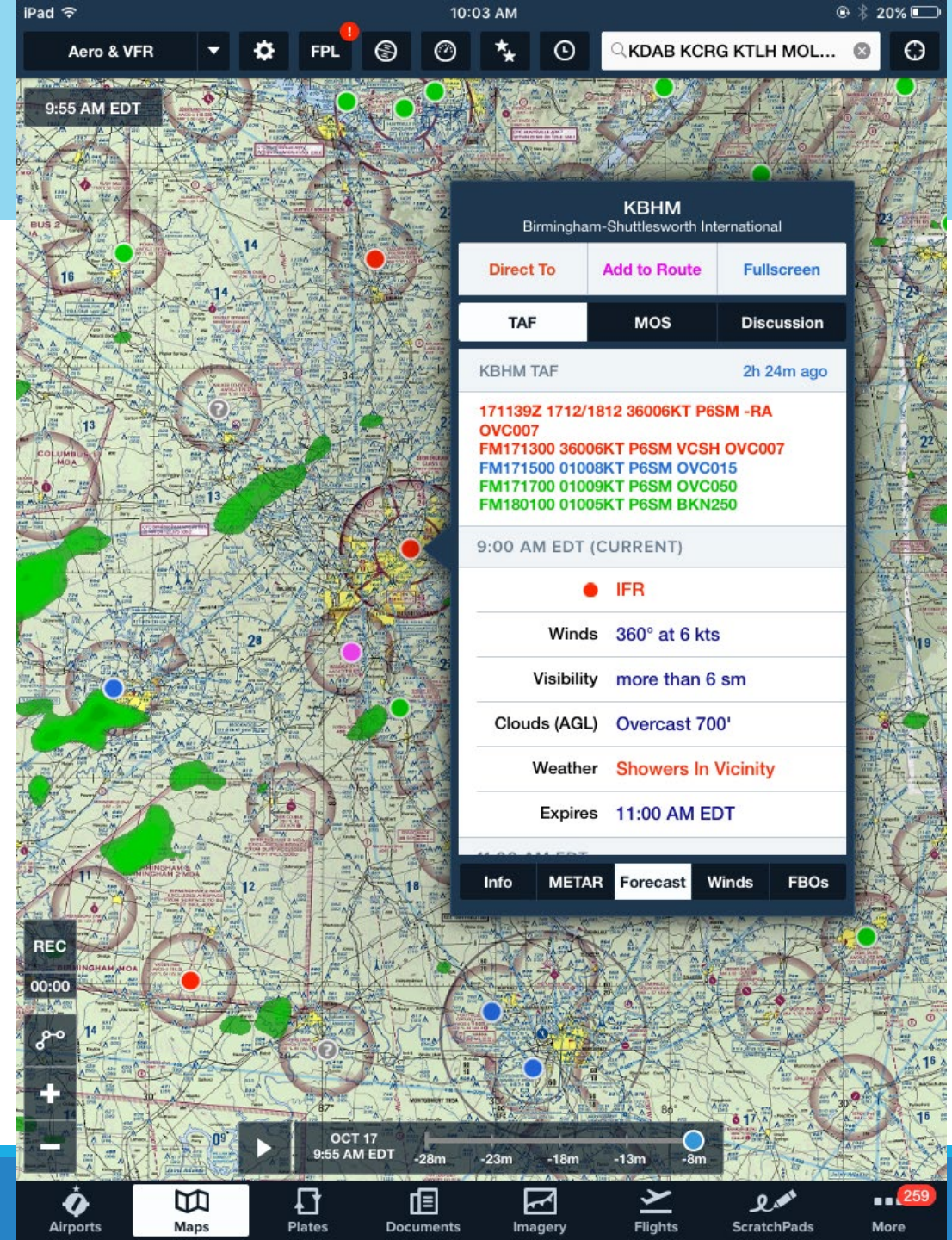
Foreflight

Pros:

- Issuance times
- Multiple times before the requested METAR for trending
- Color Coded (VFR/MVFR/IFR)
- Recommended METARS along the flight route
- Provides graphical depiction of METARS

Cons:

- Does not provide the option for including TAFs with the METARs



G-AIRMET

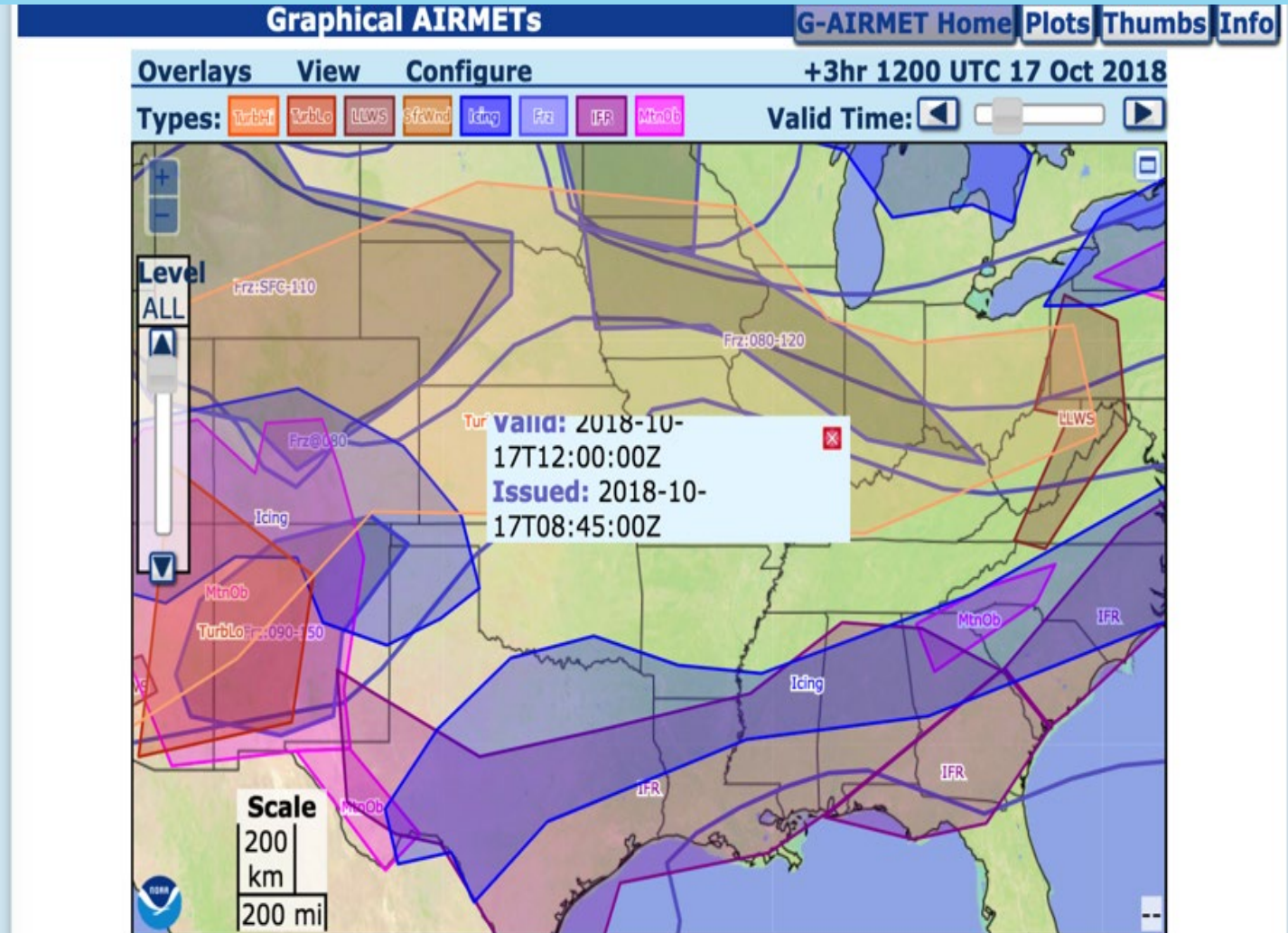
Aviation Weather Center

Pros:

- Features Legend
- Allows users to easily transition between different time stamped G-AIRMET Products
- Allows users to overlay different G-AIRMET types

Cons:

- Confusing issuance times
- Ambiguity on the criteria for the weather phenomena to be reported is
- Does not include reference to the users flight route or location



G-AIRMET

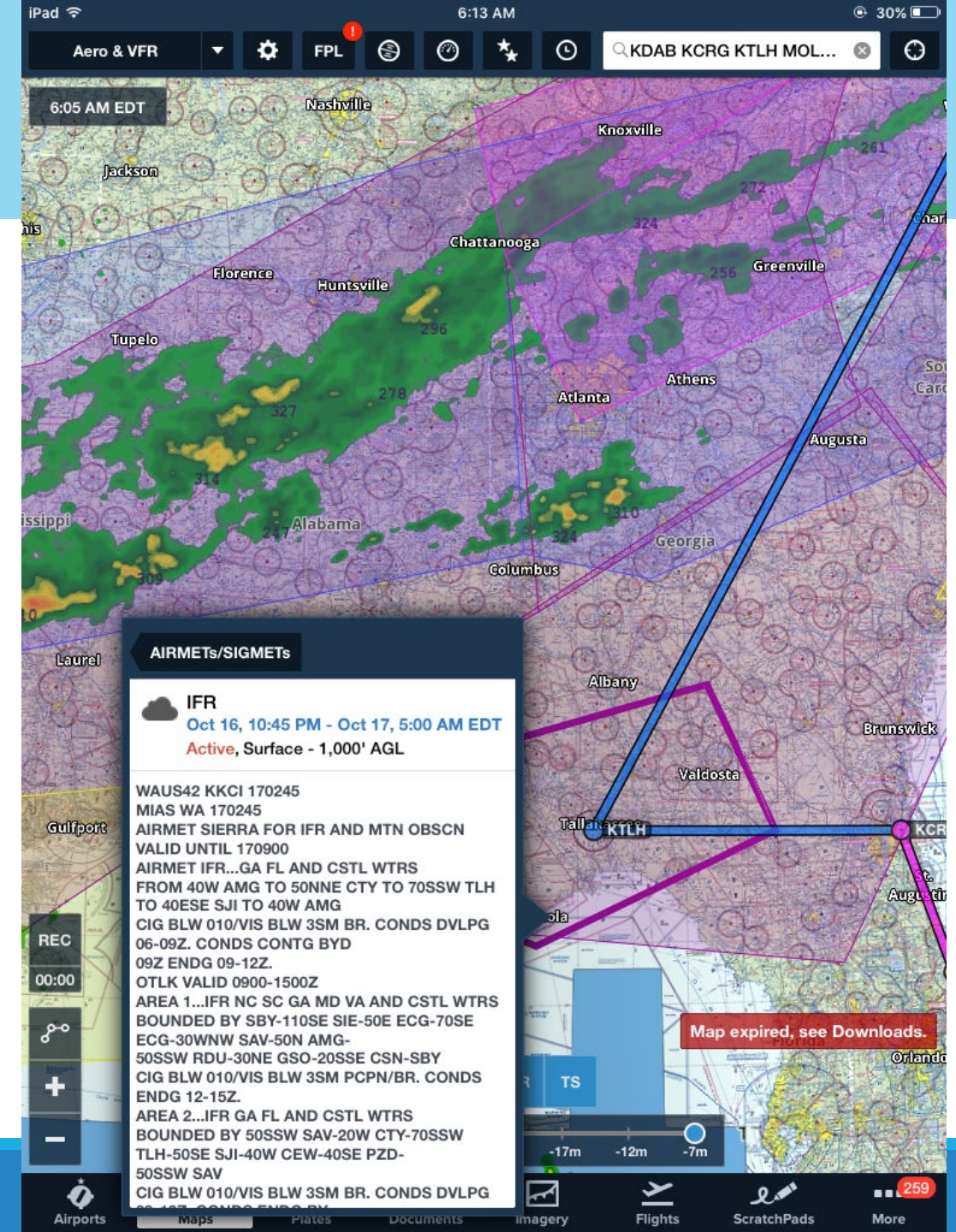
Foreflight

Pros:

- Displays the G-AIRMET in plain text
- Allows users to easily transition between different time stamped G-AIRMET Products
- Allows users to overlay different G-AIRMET TYPES, satellite, radar
- Makes the issuance times easy to understand

Cons:

- Does not feature legend
- Ambiguity on what the criteria for the reported weather phenomena



Satellite

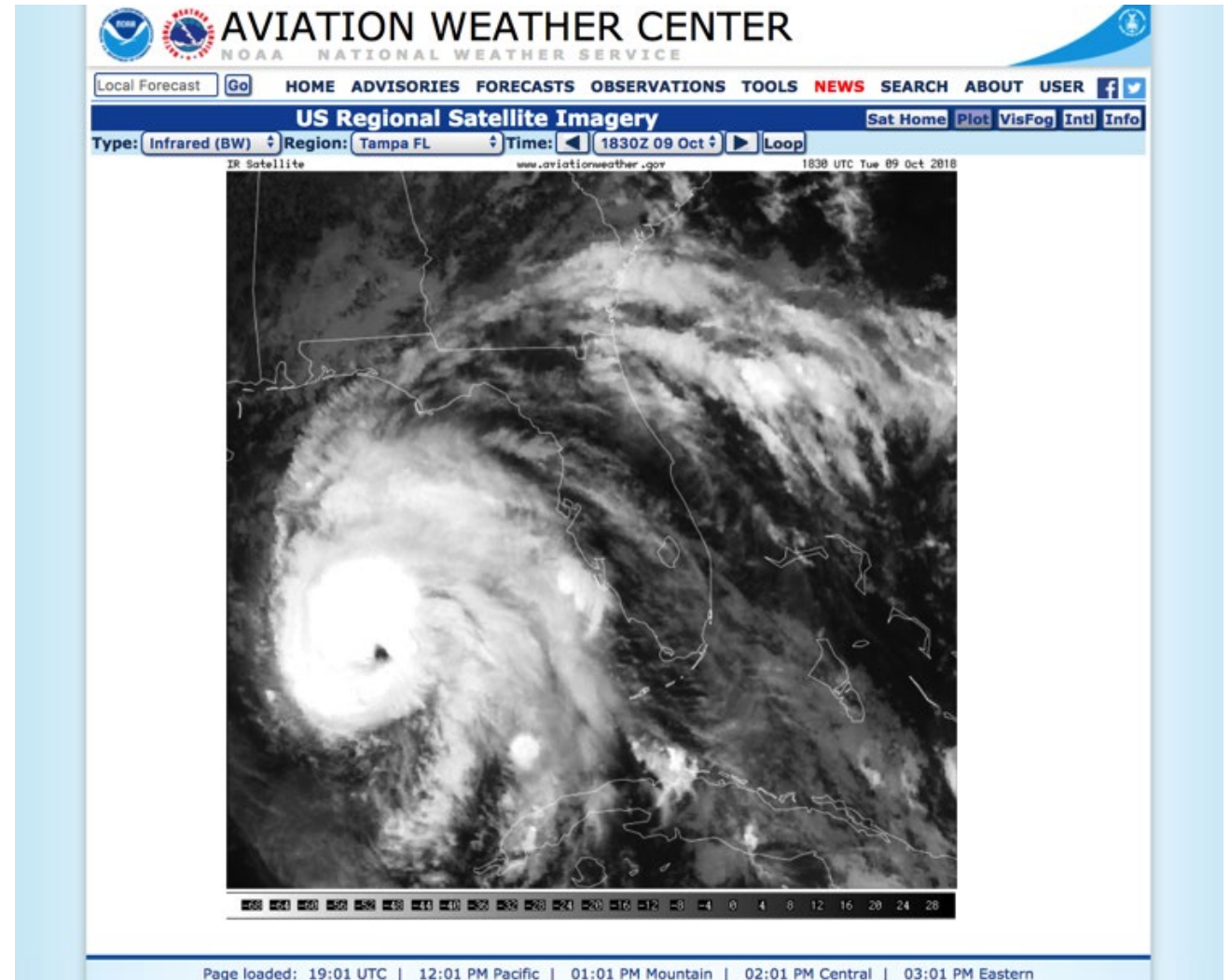
Aviation Weather Center

Pros:

- Allows users to overlay different Satellite types, regions, and times

Cons:

- Features legend that is difficult to link the weather phenomena
- Does not indicate cloud height
- Does not easily display valid times and issuance times



Satellite

Aviation Weather Center

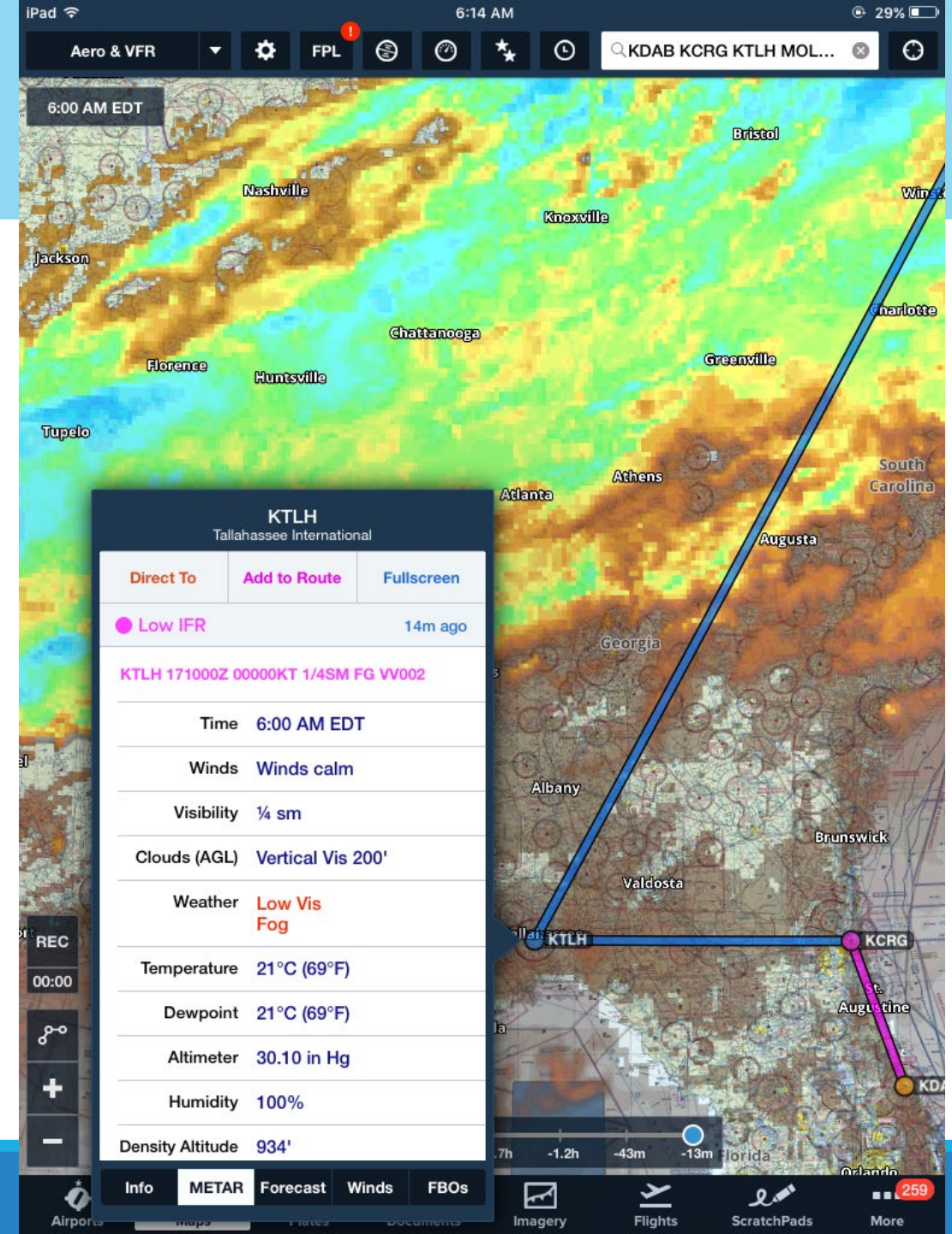
Foreflight

Pros:

- Allows users to overlay satellite data over various map types such as aeronautical sectional charts
- Also allows users to overlay METAR & TAF information on the display
- Allows users to access different Satellite types, regions, and times

Cons:

- Features legend that is difficult to link the weather phenomena
- Does not indicate cloud height
- Does not easily display valid times and issuance times



Radar

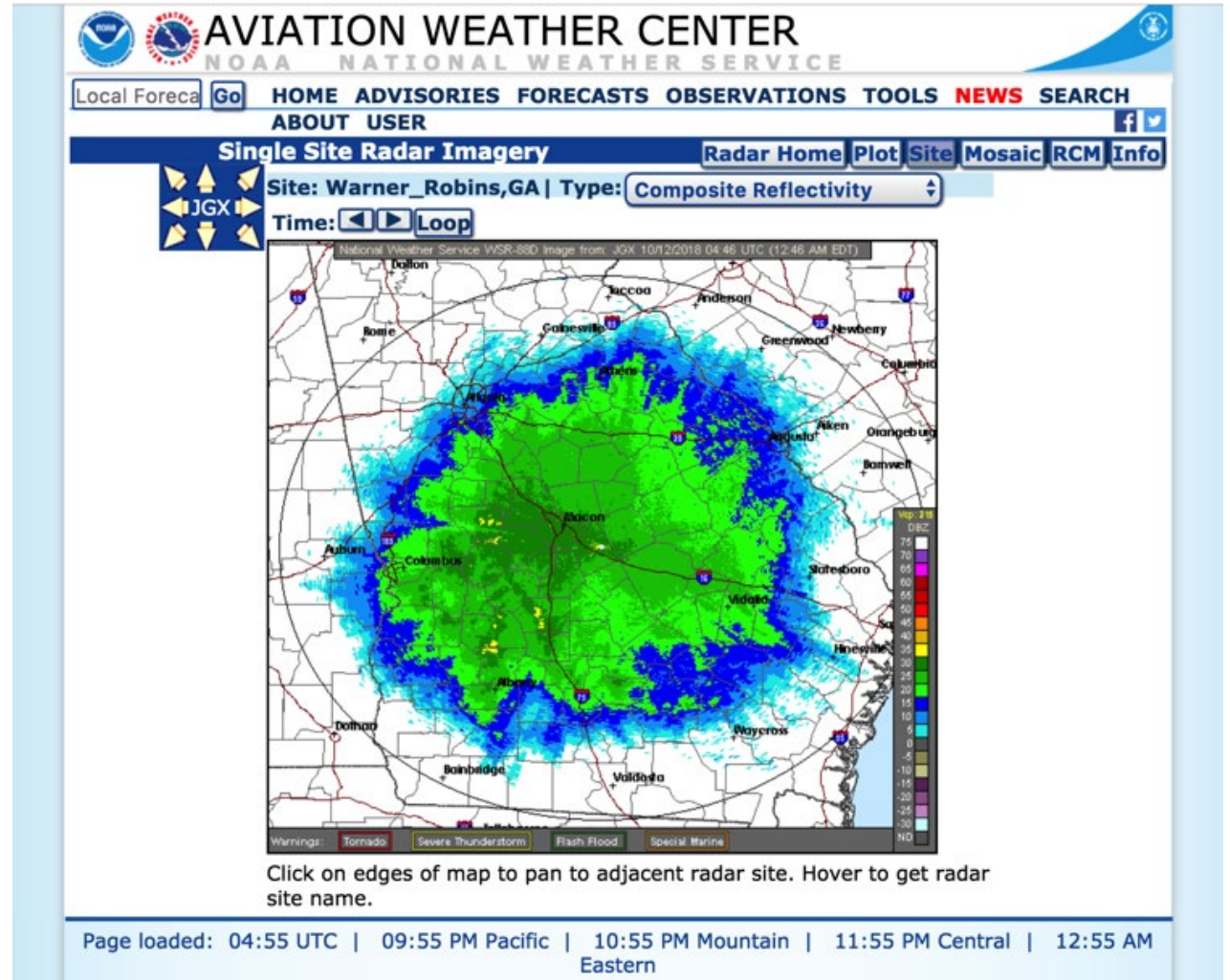
Aviation Weather Center

Pros:

- Features a limited legend without all the symbols from the weather product.
- Allows users to switch between different types of reflectivity and regions

Cons:

- Does not easily display valid times and issuance times
- Does not display a legend that easily relates to the reported weather phenomena



Radar

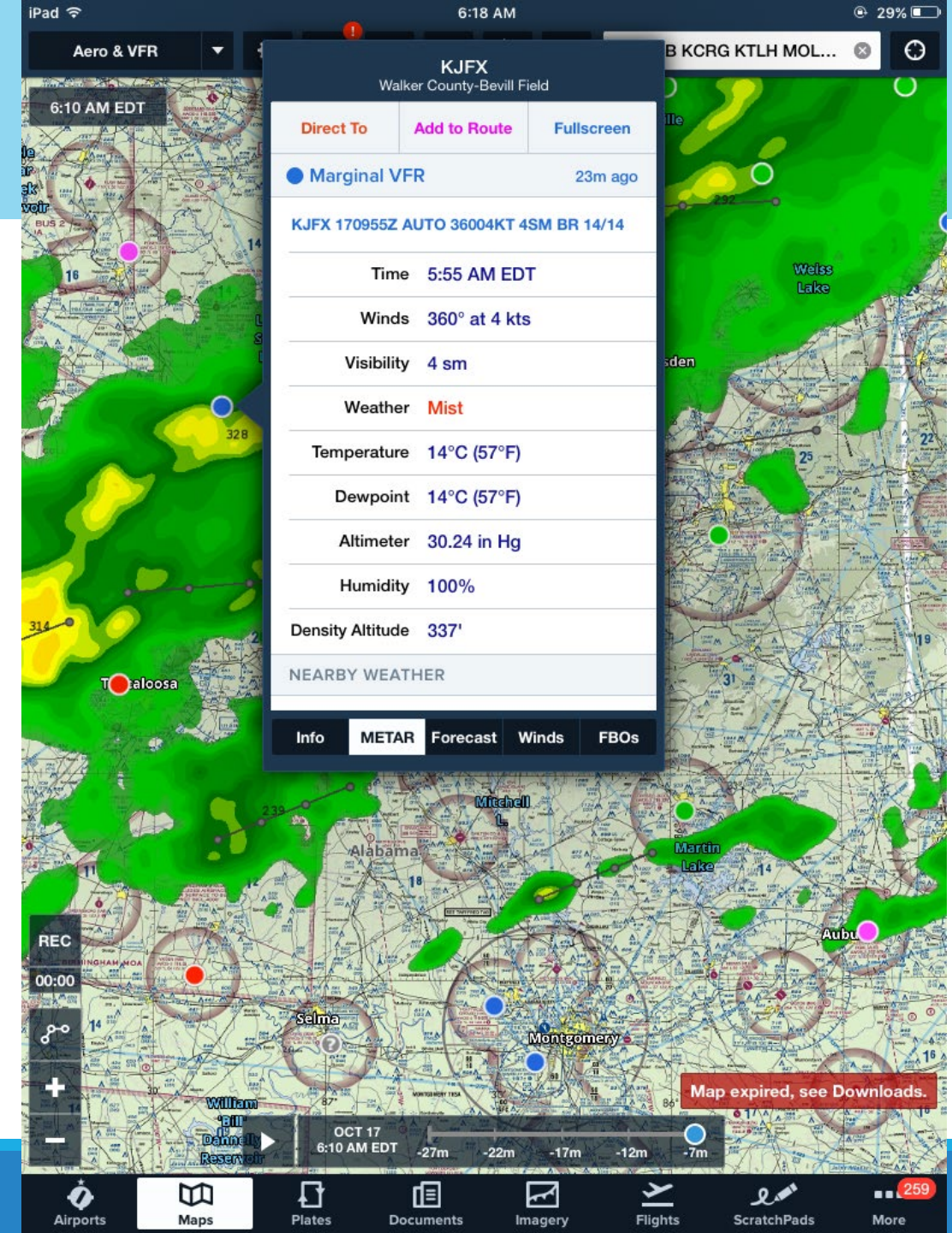
Foreflight

Pros:

- Allows users to switch between different types of reflectivity and regions
- Allows users to overlay radar over the aeronautical sectional chart

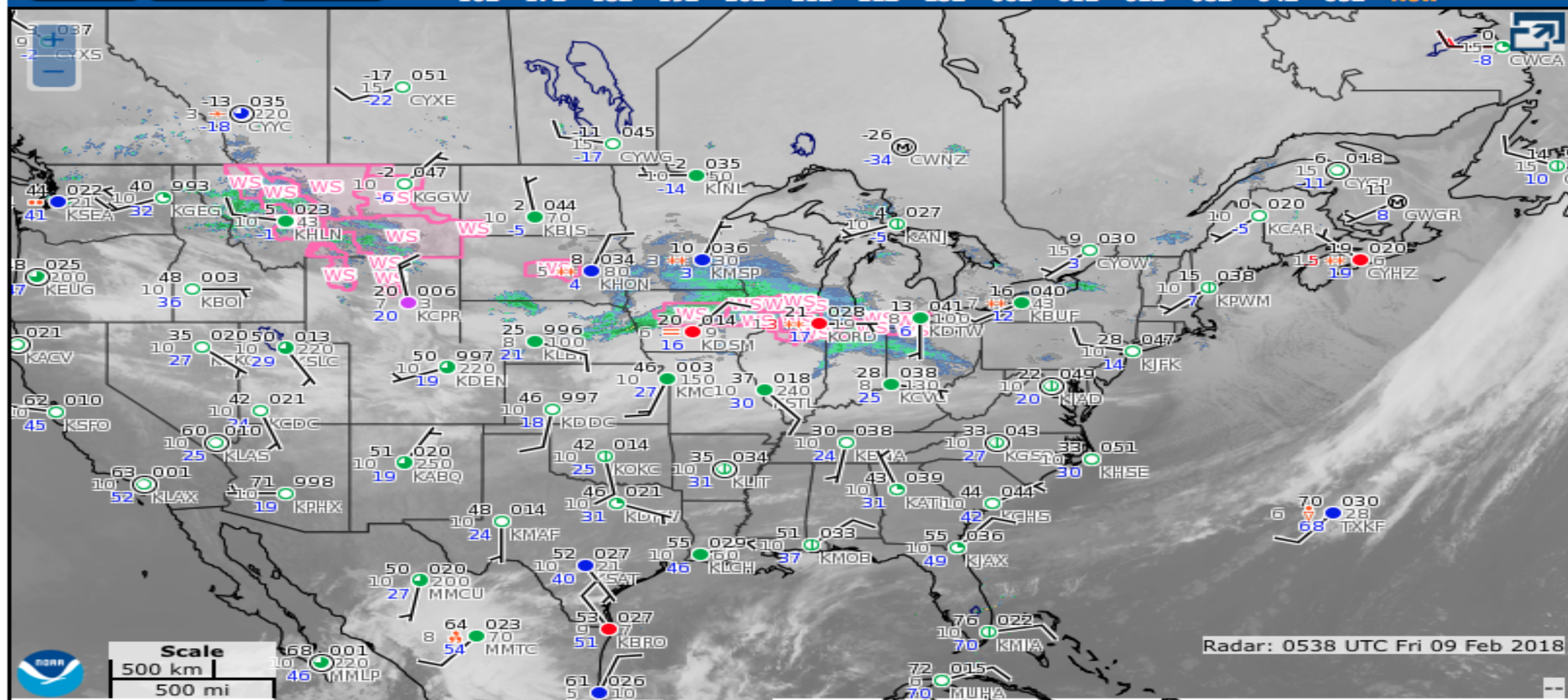
Cons:

- Does not easily display valid times and issuance times
- Does not display a legend that easily relates to the weather phenomena that relates the the legend



Graphical Forecast for Aviation (GFA)

- New, Web-based weather display
 - Covers the continental U.S., ground up to 42,000 feet
 - Observations (current weather data)
 - Forecasts
 - Updated hourly
- **Three major components:**
 - Satellite (low ceiling and visibility)
 - Radar (presence of precipitation)
 - Station Plots (symbols used to represent wind speed, rain and other precipitation)



Results - Mean Percentage Correct

	Radar M(SD)	Station Plots M(SD)	Satellite M(SD)
Private	54.01 (17.11)	36.30 (22.83)	56.83 (26.81)
Private w. Instrument	60.82 (18.63)	35.77 (21.59)	64.81 (28.05)
Commercial w. Instrument	67.22 (15.15)	43.68 (22.89)	59.61 (28.33)
CFI/CFII	67.06 (19.27)	50.00 (22.92)	55.36 (30.36)
Total	60.53 (18.22)	39.44 (22.67)	59.76 (27.89)

- 3 separate 2x4 ANOVAs were conducted to compare the effect of Product and Pilot Certificate/Rating on the Interpretation score
 - Station Plots and Satellite
 - Radar and Satellite
 - Radar and Station Plot
- Scores were quite low!

Results – Station Plots and Satellite

	Radar M(SD)	Station Plots M(SD)	Satellite M(SD)
Private	54.01 (17.11)	36.30 (22.83)	56.83 (26.81)
Private w. Instrument	60.82 (18.63)	35.77 (21.59)	64.81 (28.05)
Commercial w. Instrument	67.22 (15.15)	43.68 (22.89)	59.61 (28.33)
CFI/CFII	67.06 (19.27)	50.00 (22.92)	55.36 (30.36)
Total	60.53 (18.22)	39.44 (22.67)	59.76 (27.89)

- Mixed between and within-subjects ANOVA was conducted to assess impact of Product type and Pilot Certificate/Rating on scores
 - No interaction between Product type and Pilot Certificate/Rating
 - Main Effect for Product, partial eta squared = 0.21
- *Suggests that pilots interpret Satellite products better than Station Plot*

Results – Radar and Satellite

	Radar M(SD)	Station Plots M(SD)	Satellite M(SD)
Private	54.01 (17.11)	36.30 (22.83)	56.83 (26.81)
Private w. Instrument	60.82 (18.63)	35.77 (21.59)	64.81 (28.05)
Commercial w. Instrument	67.22 (15.15)	43.68 (22.89)	59.61 (28.33)
CFI/CFII	67.06 (19.27)	50.00 (22.92)	55.36 (30.36)
Total	60.53 (18.22)	39.44 (22.67)	59.76 (27.89)

- Two-way between groups ANOVA was conducted to assess impact of Product type and Pilot Certificate/Rating on scores.
 - No interaction between Product type and Certification and/or Rating
 - No Main Effects for Product OR Rating
- *Pilots interpreted Satellite and Radar at about the same level regardless of skill level.*

Results – Radar and Station Plots

	Radar M (SD)	Station Plots M (SD)	Satellite M (SD)
Private	54.01 (17.11)	36.30 (22.83)	56.83 (26.81)
Private w. Instrument	60.82 (18.63)	35.77 (21.59)	64.81 (28.05)
Commercial w. Instrument	67.22 (15.15)	43.68 (22.89)	59.61 (28.33)
CFI/CFII	67.06 (19.27)	50.00 (22.92)	55.36 (30.36)
Total	60.53 (18.22)	39.44 (22.67)	59.76 (27.89)

- Two-way between groups ANOVA was conducted to assess impact of Product type and Pilot Certificate/Rating on scores.
 - No interaction between Product type and Certificate/Rating
 - Significant Main Effect for Product on score, Partial Eta Squared = .194
 - Significant Main Effect for Certificate/Rating on score, Partial Eta Squared. = .06
- *Pilots interpreted Radar better than Station Plots*

Discussion

- A major contributing factor in the weather accidents may be Pilots' inability to interpret weather displays.
- New technology is *reusing* existing display formats and symbology that *Pilots may not understand*
- The products are not discriminating: Pilots of ALL ratings and certificates are struggling
- Improving usability could help with product interpretability



Questions?

References

- Alter, S.L. (1980) Decision Support Systems: Current Practice and Continuing Challenges. Reading, MA: Addison- Wesley
- AOPA. (2008). 2008 Nall accident report: Accident trends and factors for 2007. Retrieved from <https://www.aopa.org/-/media/files/aopa/home/training-and-safety/nall-report/08nall.pdf>
- Beringer, D.B., & Ball, J.D.(2004)The Effects of NEXRAD Graphical Data Resolution and Direct Weather Viewing on Pilots' Judgements of Weather Severity and Their Willingness to Continue a Flight. Federal Aviation Administration, Washington, DC. Billings, C., and Woods, D. 1994. Concerns about adaptive automation in aviation systems. *Human performance in automated systems: Current research and trends*, ed. M. Mouloua and R. Parasuraman, 264-269.
- Blickensderfer, B., Lanicci, J., Guinn, T., Thomas, R., King, J., & Ortiz, Y. (2018). Assessing aviation weather knowledge in general aviation pilots: Development of a Written Test. *International Journal of Aviation Psychology*.
- Blickensderfer, E. L., Lanicci, J. M., Vincent, M. J., Thomas, R. L., Smith, M., & Cruik, J. K. (2015). Training general aviation pilots for convective weather situations. *Aerospace medicine and human performance*, 86(10), 881-888.
- Capobianco, G., & Lee, M. D. (2001, October). The role of weather in general aviation accidents: An analysis of causes, contributing factors and issues. *In Proceedings of the Human Factors and Ergonomics Society Annual Meeting* 45(2), (pp. 190-194). Los Angeles, CA: SAGE Publications.
- Chansik (2011). The effects of weather recognition training on general aviation pilot situation assessment and tactical decision making when confronted with adverse weather conditions (Doctoral dissertation, Clemson University). Retrieved from <https://tigerprints.clemson.edu>.
- Cohen, M. S., Parasuraman, R. A. J. A., Serfaty, D. A. N. I. E. L., & Andes, R. (1997). Trust in decision aids: A model and a training strategy. Arlington, VA: Cognitive Technologies, Inc.
- Crocoll, W. M., & Coury, B. G. (1990). Status or recommendation: Selecting the type of information for decision aiding. In *Proceedings of the Human Factors Society 34th Annual Meeting* (pp. 1524– 1528). Santa Monica, CA: Human Factors and Ergonomics Society.
- FAA. (2010). WEATHER-RELATED AVIATION ACCIDENT STUDY 2003–2007. Retrieved from: <http://www.asias.faa.gov/i/2003-2007weatherrelatedaviationaccidentstudy.pdf>
- FAA. (2016). ADVISORY CIRCULAR. Retrieved from: https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/1030235
- Fultz, A. J., & Ashley, W. S. (2016). Fatal weather-related general aviation accidents in the United States. *Physical Geography*. Taylor & Francis. Retrieved from <https://doi.org/10.1080/02723646.2016.1211854>
- Goh, J., & Wiegmann, D. (2001). Visual flight rules flight into instrument meteorological conditions: An empirical investigation of the possible causes. *The International Journal of Aviation Psychology*, 11(4), 359–379. Retrieved from <https://doi.org/10.1207/S15327108IJAP1104>
- Lanicci, J., Halperin, D., Shappell, S., Hackworth, C., Holcomb, K., Bazargan, M., Baron, J., & Iden, R. (2012). General aviation weather encounter case studies (DOT/FAA/AM-12/11). Washington, DC: Office of Aerospace Medicine.
- Latorella, K. A., & Chamberlain, J. P. (2002). *Graphical weather information system evaluation: Usability, perceived utility, and preferences from general aviation pilots* (No. 2002-01-1521). SAE Technical Paper.
- National Transportation Safety Board. (2005). Risk Factors Associated with Weather-Related General Aviation Accidents. Retrieved from <http://www.ntsb.gov>.
- Parasuraman, R., Molloy, R., & Singh, I. L. (1993). Performance consequences of automation-induced 'complacency'. *The International Journal of Aviation Psychology*, 3(1), 1-23.
- Parasuraman, R., & Riley, V. (1997). Humans and automation: Use, misuse, disuse, abuse. *The Journal of Human Factors and Ergonomics Society*, 39(2), 230-253.
- Parasuraman, R., Sheridan, T. B., & Wickens, C. D. (2000). A model for types and levels of human interaction with automation. *IEEE Transactions on systems, man, and cybernetics-Part A: Systems and Humans*, 30(3), 286-297.
- Parson, S., Beringer, D., Knecht, W., Crognale, M. A., Wiegmann, D., & Beard, B. L. (2005). General aviation pilot's guide to preflight weather planning, weather self-briefings, and weather decision making. Retrieved from <https://www.faasafety.gov/files/gslac/courses/content/25/185/GA%20Weather%20Decision-Making%20Dec05.pdf>
- Patel, V. L., & Groen, G. J. (1991). The general and specific nature of medical expertise: A critical look. Toward a general theory of expertise: *Prospects and limits*, 93- 125.
- Shimon Y. Nof (2009). Springer Handbook of Automation (Ed). Heidelberg, Berlin: Springer.
- Wiener, E. L. (1981). Complacency: Is the term useful for air safety? In *Proceedings of the 26th Corporate Aviation Safety Seminar* (p 116-125). Denver: Flight Safety Foundation, Inc.
- Wiggins, M. W., & Griffin, B. (2014). Commentary on the article by Turner: Cultural complexity in pilot selection. *The International Journal of Aviation Psychology*, 24(2), 96-98.
- Wiggins, M., & O'hare, D. (1995). Expertise in aeronautical weather-related decision making: A cross-sectional analysis of general aviation pilots. *Journal of Experimental Psychology: Applied*, 1(4), 305.
- Wiggins, M. W., & O'Hare, D. (2003). Expert and novice pilot perceptions of static in-flight images of weather. *The International Journal of Aviation Psychology*, 13(2), 173-187.
- Wiggins, M. W., Stevens, C., Howard, A., Henley, I., & O'Hare, D. (2002). Expert, intermediate and novice performance during simulated pre-flight decision-making. *Australian Journal of Psychology*, 54(3), 162-167.
- Yuchnovicz, D. E., P. F. Novacek, M. A. Burgess, M. L. Heck, and A. F. Stokes. "Use of Data-Linked Weather Information Display and Effects on Pilot Navigation Decision Making in a Piloted Simulation Study (NASA/CR-2001-211047)." NASA, Hampton, VA (2001).