



**Federal Aviation
Administration**

Probabilistic C&V Summer Experiment Results and Recommendations Briefing

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Results & Recommendations Briefing

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 - Background
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Introduction



Introduction

- ANG-C61 is funding research focused on improving Ceiling and Visibility (C&V) prediction models' consistency and accuracy.
- Research team
 - National Centers for Environmental Prediction (NCEP), Environmental Modeling Center (EMC)
 - National Weather Service (NWS), Meteorological Development Laboratory (MDL)
 - NWS Aviation Weather Center (AWC)
 - Earth System Research Lab (ESRL)
- ANG-C63 has been tasked to solicit user input for the presentation of an ensemble-based probabilistic C&V product.



Background



Objectives

- Objectives:
 - Determine how users interpret a probabilistic C&V forecast.
 - Determine the best way to present probabilistic C&V information.
 - Determine what information is needed in a probabilistic C&V forecast.
 - Determine the usability of the product.



Phases

- Phase 1: Technical Interchange
 - Conducted technical interchange meetings with AWC developers to perform an iterative design process.
 - Provided feedback regarding color saturation, color-coding, legends, wording, and bin increments.
- Phase 2: Focus Groups
 - Developed storyboards for Focus Groups to:
 - Demonstrated display concepts and product capabilities.
 - Compared display concepts.
 - Obtained user feedback regarding product usability, effectiveness, and suitability based on operational decision-making.
- Phase 3: Summer Experiment
 - Evaluated the modified C&V product in a simulated operational environment.
 - Obtained user feedback for product usability, effectiveness, and suitability during decision-making.



Focus Groups Approach



Focus Groups Users

- 3 focus group sessions were conducted:
 - Focus Group 1 (June 27-29, 2017):
 - Conducted at the AWDE CPAC Lab, William J. Hughes Technical Center in Atlantic City, NJ.
 - Users included:
 - 4 General Aviation (GA) Pilots
 - 1 Helicopter Pilot
 - 1 HEMS Pilot
 - Focus Group 2 (July 6, 2017):
 - Conducted at the National Weather Service (NWS) Forecast Office in Mount Holly, NJ.
 - Users included:
 - 6 NWS Weather Forecast Office (WFO) Meteorologists



Focus Groups Users

- Focus Group 3 (July 10-11, 2017):
 - Conducted at Southwest Airlines Operations Center (AOC) in Dallas, TX.
 - Users included:
 - 4 Airline Flight Dispatchers
 - 1 Airline Meteorologist



Focus Groups Approach

- Focus groups were conducted with multiple users in attendance.
- 5-step process used to allow users to assess C&V Display concepts in the following order:
 - Preference for LAMP vs. HREF C&V display.
 - Single Flight Category vs. Multiple Flight Categories.
 - Bin resolution (Once bin resolution was determined, remaining storyboards used the preferred number of bins, e.g., 5 or 10 bins).
 - Minimum vs. Maximum displays (e.g., “Better than” or “worse than” flight conditions or “Better than IFR” or “IFR or worse”).
 - Color scale preferences using light-to-dark or dark-to-light presentations for probabilities.



Focus Groups Approach

- Product comparisons focused on presentation, suitability, and usability.
- The note-taker recorded all answers and comments.
- Upon completion of the storyboard presentation, users completed a 5-point Likert scale questionnaire.
- The questionnaire also provided space for users to document additional comments for each question.

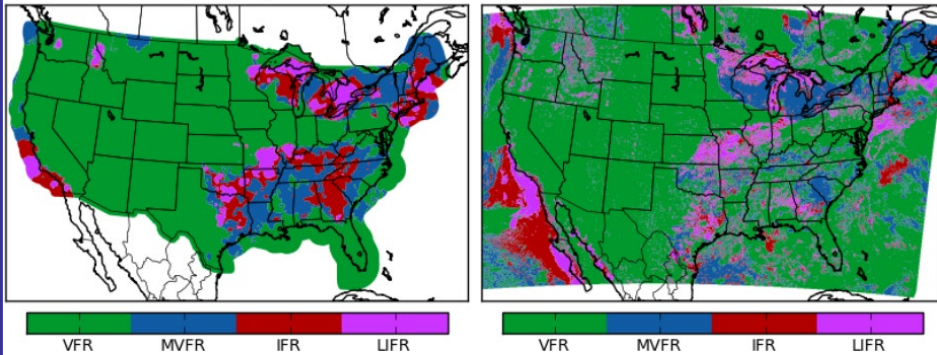


Focus Groups Approach: Storyboard Comparisons

LAMP vs. HREF Mean

LAMP Flight Category Deterministic

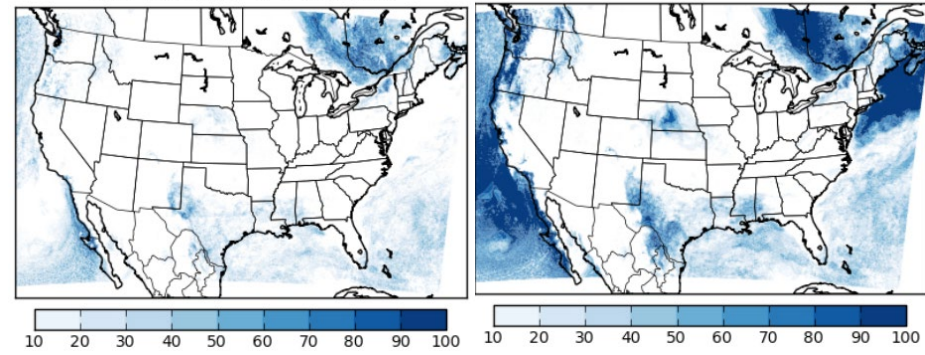
HREF Mean Flight Category



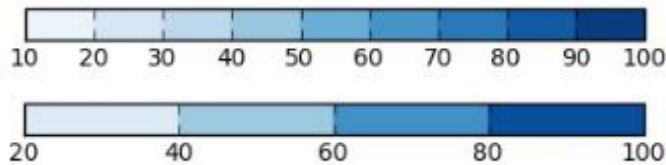
Single vs. Combined

HREF Probability of being MVFR

HREF Probability of being MVFR or worse



Bins

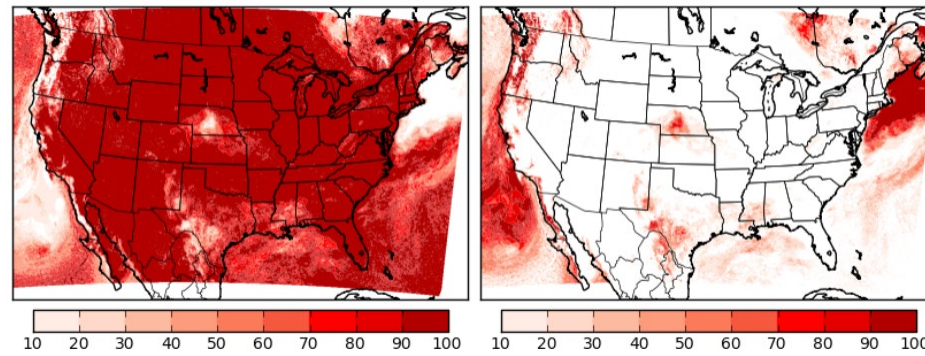


- Resolution of information (increments of 5, 10, or other)
- Zero vs Non-Zero: Probabilities starting at 0 or 10/20

Minimum vs. Maximum View

HREF Probability of being better than IFR

HREF Probability of being IFR or worse

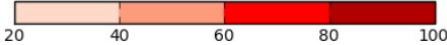
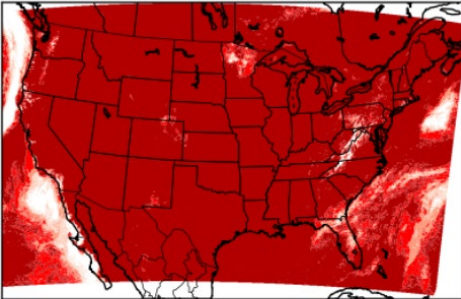


Focus Group Approach: Storyboard Comparisons

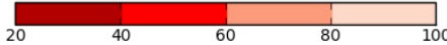
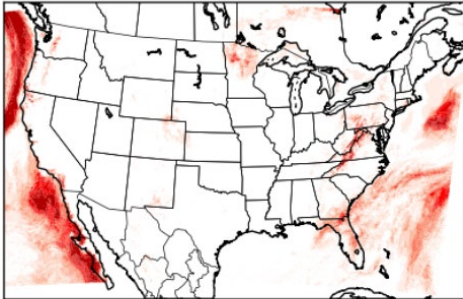
Color Gradients

Higher probabilities are **darker**. Higher probabilities are **lighter**.

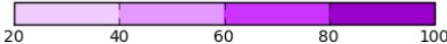
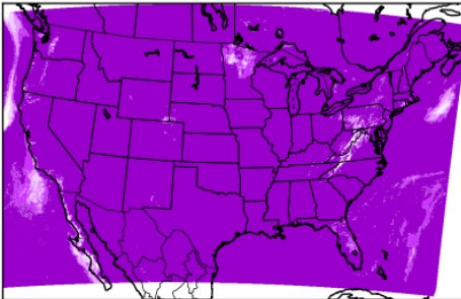
HREF Probability of being better than IFR



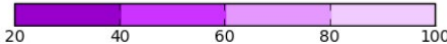
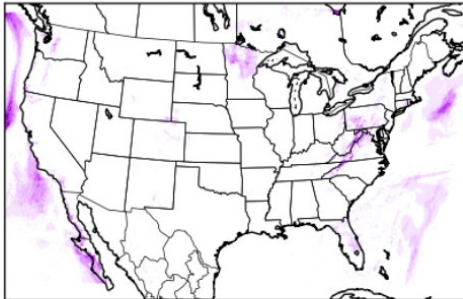
HREF Probability of being better than IFR



HREF Probability of being better than LIFR



HREF Probability of being better than LIFR



Focus Groups Results



Focus Groups Results

Display Concept	Group Preference				
	GA Pilots (N=4)	Helicopter/HE MS Pilots (N=2)	WFO Meteorologists (N=6)	Airline Flight Dispatchers (N=4)	Airline Meteorologists (N=1)
HREF vs. LAMP	HREF	HREF	HREF	HREF	LAMP
Single vs. Combined	Combined	Combined	Combined	Combined	Single
Bins	5 bins	10 bins	10 bins	5 bins	10 bins
Zero vs. Non-Zero	Zero	Zero	Non-Zero	Zero	Zero
Minimum vs. Maximum	Maximum	Maximum	Maximum	Maximum	Maximum
Color Saturation	Higher probabilities darker	Higher probabilities darker	Higher probabilities darker	Higher probabilities darker	Higher probabilities darker

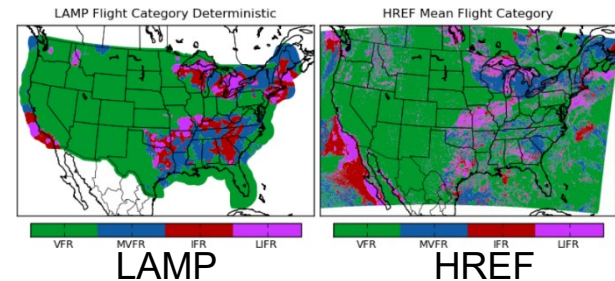


Focus Groups Results: HREF Mean vs. LAMP

- **GA Pilots**

- (N=4) HREF Mean

- Overall, users stated the coverage of the HREF was better because the product has an extended coverage area continuing into the oceanic domains.
 - Users preferred the HREF's 12-hour forecast over the LAMP's 25-hour forecast because HREF was perceived to be more up-to-date and accurate.
 - Users stated the HREF seemed to be more specific because of the coverage areas.

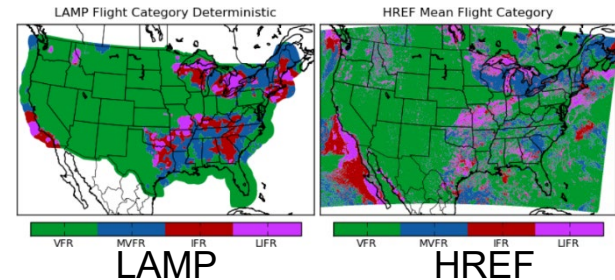


Focus Groups Results: HREF Mean vs. LAMP

- **Helicopter/HEMS Pilots**

- (N=2) HREF Mean

- Users stated the HREF was “more effective as a tool for building a complete picture of flight conditions...It seems to be a useful tool in better understanding the probability and trends expected. I have a generally higher confidence in the product.”
 - Users noted the LAMP proves “24 hours for an average outlook which is too general for flight planning (the day of). The LAMP could be used as a general reference to help build a more complex picture.”
 - Users found value in the HREF showing LIFR off the coasts.

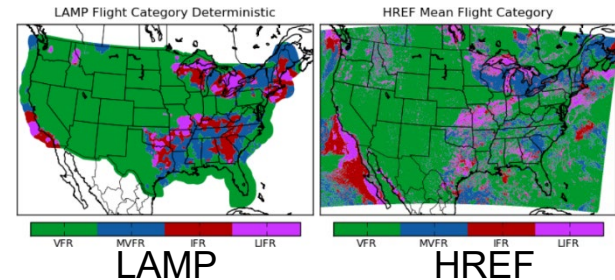


Focus Groups Results: HREF Mean vs. LAMP

- **WFO Meteorologists**

- (N=6) HREF Mean

- Users found the HREF to be more detailed and refined. However, forecasters would still look at both to compare.
 - Users noted the Probabilistic presentation had more radar information, which would indicate the forecast is better.
 - Users found the HREF's higher resolution to be helpful.
 - Overall, users noted the LAMP was limiting.

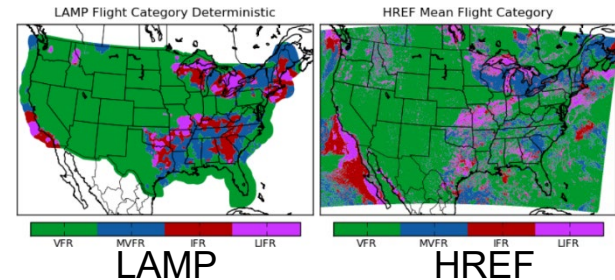


Focus Groups Results: HREF Mean vs. LAMP

- **Airline Flight Dispatchers**

- (N=4) HREF Mean

- Users noted the LAMP looked cleaner because the edging of the colors was clear and distinct.
 - Users noted the HREF display was more difficult to understand because the colors were pixelated, which made boundaries difficult to see.
 - Users noted difficulty to distinguishing between blue and magenta in the HREF.
 - Users stated the HREF used more data, but the LAMP was easier to read.

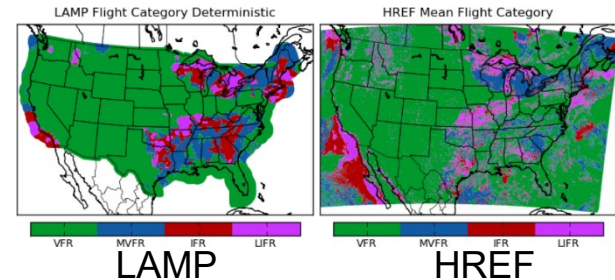


Focus Groups Results: HREF Mean vs. LAMP

- **Airline Meteorologist**

- (N=1) LAMP

- The user noted the HREF ingested more data, possibly making the product more accurate.
 - The user noted the LAMP display looked cleaner and was easier to read.
 - The user stated because the HREF used more data, HREF may over-forecast, so meteorologists would prefer to use LAMP. The meteorologist also stated the LAMP product would be used with the other weather products available.

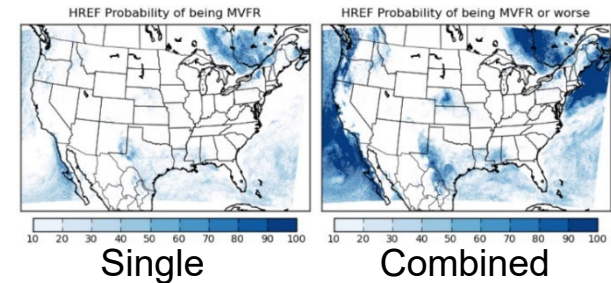


Focus Groups Results: Single vs. Combined

- **GA Pilots**

- (N=4) Combined

- Users indicated the single category display was misleading.
 - Users are focused on avoiding IFR and LIFR conditions.
 - Presenting IFR and LIFR in lighter or white shades made “dangers seem hidden.”
 - Users need to know the probabilities of all flight categories, not just VFR.
 - Due to a concentration on VFR flight, users wanted to see only MVFR, IFR, and LIFR. The “MVFR or worse” display was very effective. In a single display, the product showed the users what areas to avoid.

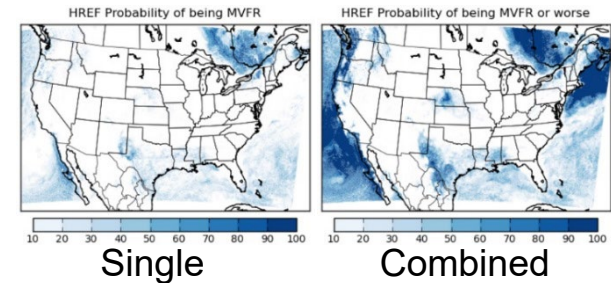


Focus Groups Results: Single vs. Combined

- **Helicopter/HEMS Pilots**

- (N=2) Combined

- Users described the combined concept as a “good planning tool.”
 - “The single display is effective for the worst case scenario, LIFR. Otherwise, this display concept is extremely misleading for any other category.”
 - Pilots need to know probabilities of other flight categories.
 - “Don’t like the image of ‘HREF Probability of being MVFR.’ The color scheme is confusing and not helpful, i.e., what does the white area in this image mean? VFR? IFR? LIFR?”
 - Due to HEMS operations, pilots only require LIFR information.



Focus Groups Results: Single vs. Combined

- **WFO Meteorologists**

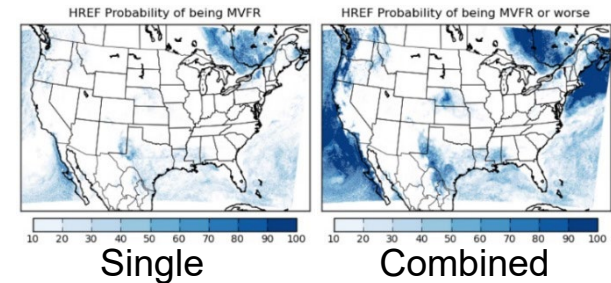
- (N=6) Combined

- Users stated the Combined display provided more confidence because more flight category information is shown.
 - Users stated the Single display only showed probability of one flight category, but meteorologists need to understand if other conditions are possible too.
 - Users expressed concerns the HREF may over-forecast.

- **Airline Flight Dispatchers**

- (N=4) Combined

- Users noted the Single display did not provide enough information for airlines.
 - Dispatchers need to know if conditions are MVFR or worse.

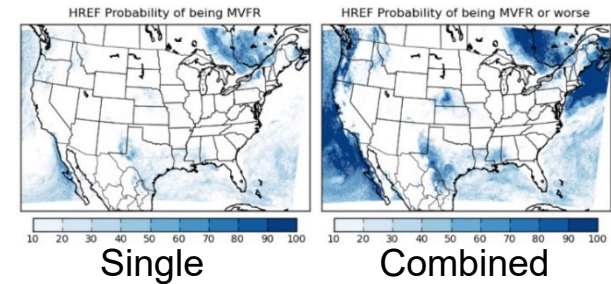


Focus Groups Results: Single vs. Combined

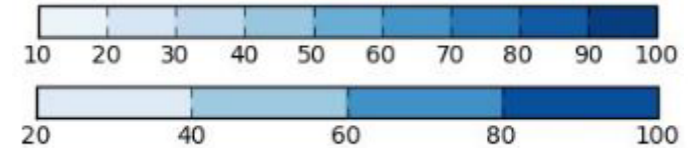
- **Airline Meteorologist**

- (N=1) Single

- The user noted the ability to see each flight category separately was important.
 - Seeing each flight category separately provides a more in-depth forecast that can be assessed to, more specifically, identify areas of concern.



Focus Groups Results: Bins



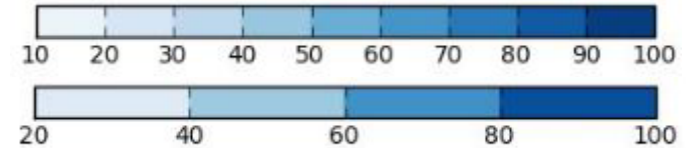
- **GA Pilots**

- (N=2) 5 Bin, (N=2) 10 Bin

- Users found 10 Bins provided more granularity for a regional domain; however, 5 Bins was better for a national domain.
- Users only required 5 Bin resolution as the presentation easily tells pilots where they can or cannot fly.
- Users preferred the 5 Bin presentation for VFR, while the 10 Bin was preferred for IFR. Pilots noted the 10 Bin presentation was more difficult to read.
- All users preferred starting probabilities at zero. Pilots noted this presentation seemed more intuitive.



Focus Groups Results: Bins



- **Helicopter/HEMS Pilots**

- (N=2) 10 Bin

- Users noted the 10 Bin presentation was more specific and provided more information.
 - Users noted the higher resolution concept was easier to read.
 - Users stated if flying GA, 5 Bins would be preferred, but for job decision-making, 10 Bins would be more effective.
 - Both users indicated the scales should start at zero. A scale starting at zero gives more details and confidence.

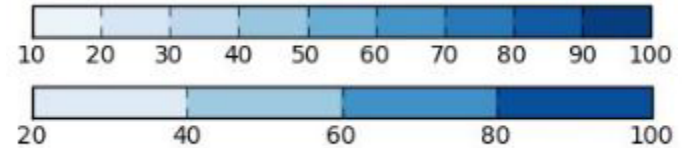
- **Airline Flight Dispatchers**

- (N=4) 5 Bin

- Users preferred the 5 Bin display. This display format is simpler and easier to read.
 - Users noted they would not change decisions based on a 20% difference, so fewer bins still supports decision-making.
 - All users preferred to start the probabilities at zero.



Focus Groups Results: Bins



- **WFO Meteorologists**

- (N=6) 10 Bin

- Users preferred the 10 Bin presentation concept as this presentation provides more detail to support forecasting.
 - Users found the 10 Bin presentation can be too cluttered.
 - Users stated the 5 Bin resolution may diminish and smooth the data too much.
 - Users noted a concern about the 10 Bin display concept giving the perception of more resolution and accuracy, which may lead to a false sense of security.
 - Users noted the probability scales do not need to start at zero.

- **Airline Meteorologist**

- (N=1) 10 Bin

- The user stated the 10 Bins showed higher resolution, which is better for forecasts.
 - The user preferred to start the probability scale at zero.



Focus Groups Results: Minimum vs. Maximum

- **GA Pilots**

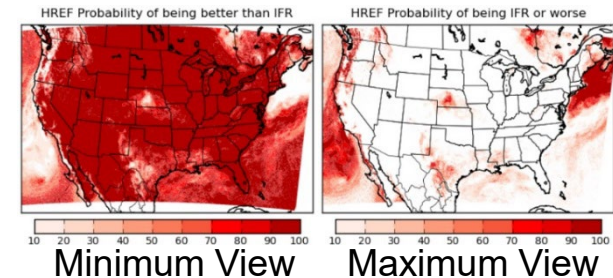
- (N=4) Maximum

- Users stated darker colors should indicate higher probabilities. This display concept is more intuitive and easier to interpret.
 - Users stated darker areas draw attention, so the areas to avoid should be darker.
 - Users found the Minimum View display to be counter-intuitive.

- **Helicopter/HEMS Pilots**

- (N=2) Maximum

- Users stated darker colors should indicate higher probabilities. This display concept was more intuitive and easier to interpret.
 - Users found the Minimum View display to be counter-intuitive.



Focus Groups Results: Minimum vs. Maximum

- **WFO Meteorologists**

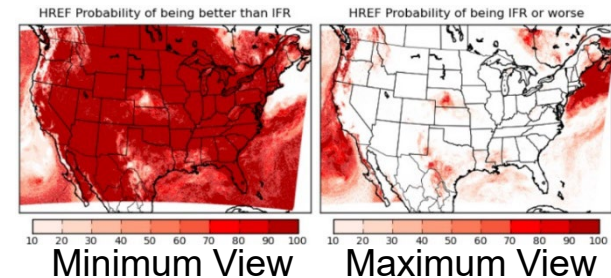
- (N=6) Maximum

- Users noted the Maximum View represented how forecasters currently view products.
 - Users found the Minimum View display to be counter-intuitive.

- **Airline Flight Dispatchers**

- (N=4) Maximum

- Users stated darker colors for higher probabilities highlighted worse conditions better as users were drawn to the darker colors.
 - Users noted the industry norm is to present clear conditions in lighter or white colors. Using lighter colors or white to represent poor conditions is counter-intuitive.
 - All users strongly supported the use of darker colors to represent higher probabilities.

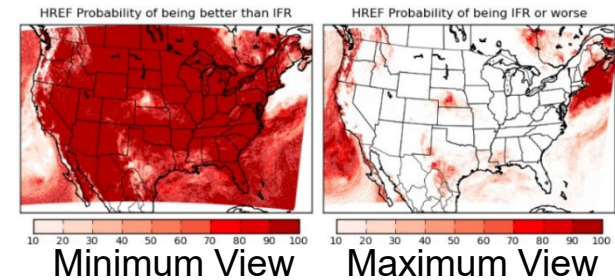


Focus Groups Results: Minimum vs. Maximum

- **Airline Meteorologist**

- (N=1) Maximum

- The user noted darker colors for higher probabilities highlighted worse conditions more effectively as the user was drawn to the darker colors.



Focus Groups Results: Color Gradients

- **GA Pilots**

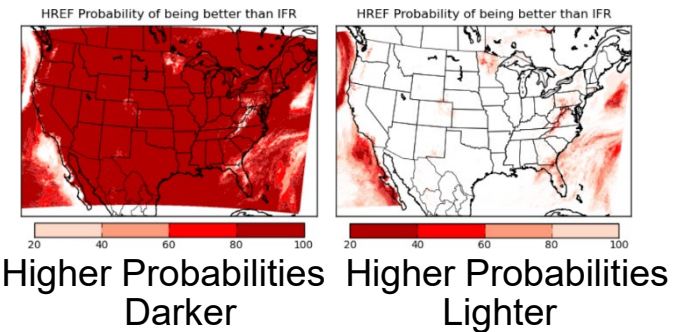
- (N=4) Higher Probabilities Darker

- Users preferred the use of darker colors to represent worse conditions. Better conditions should be lighter.
 - Users stated darker areas intuitively mean worse conditions.
 - Users found colors used for probability in each flight category to be effective and appropriate.

- **Helicopter/HEMS Pilots**

- (N=2) Higher Probabilities Darker

- Users preferred darker areas representing worse conditions, which is consistent with how most weather products use color.
 - Users stated white areas representing worse conditions is counter-intuitive.



Focus Groups Results: Color Gradients

- **WFO Meteorologists**

- (N=6) Higher Probabilities Darker

- Pilots prefer the use of darker colors to represent worse conditions. Better conditions should be lighter.
 - Most current displays use white backgrounds, so lighter colors for clear skies is more intuitive.
 - The increments are easier to see on the white background.

- **Airline Flight Dispatchers**

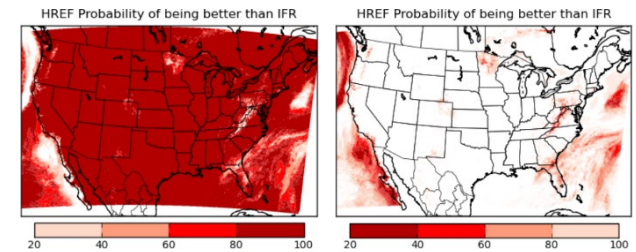
- (N=4) Higher Probabilities Darker

- Users stated darker colors representing higher probabilities was more intuitive.
 - Users stated “tweaking” the current colors (red, blue, magenta, and green) to make them more discernable across probabilities is needed. Dispatchers had difficulty distinguishing between the colors on the display.

- **Airline Meteorologist**

- (N=1) Higher Probabilities Darker

- The user stated darker colors representing higher probabilities was more intuitive.



Higher Probabilities Darker Higher Probabilities Lighter

Additional Capabilities Users Would Like

- **GA Pilots**

- *Zoom capability.
- *Ability to view Ceiling and Visibility separately.
- Cloud tops and bases.
- Weather overlays for precipitation, current weather, pressure systems, and freezing areas.

- **Helicopter/HEMS Pilots**

- *Ability to view Ceiling and Visibility as separate products.
- Overlay of freezing areas.

**Indicates repeated capabilities users stated they would like to see implemented into the product.*



Additional Capabilities Users Would Like

- **WFO Meteorologists**

- *Regional zoom capability to see more detail.
- *Separate Ceiling and Visibility. For WFOs, visibility is generally more important than ceiling.
- Different color scales to accommodate users with color vision deficiency.

- **Airline Flight Dispatchers**

- *Zoom capability to see more detail.
- *Separate Ceiling and Visibility products. Visibility is a more significant issue, especially in areas like California. Airlines do not divert based on Ceiling.
- Ability to view TAFs to compare the product data to TAF data.
- Overlay of core airports.

**Indicates repeated capabilities users stated they would like to see implemented into the product.*



Additional Capabilities Users Would Like

- **Airline Meteorologist**

- *Regional zoom capability to see more detail.
- Contours like those in the SREF.
- Ability to view TAFs to compare the product data to TAF data.
- “From a forecasting perspective, access to raw data would be useful (like the LAMP MOS guidance) indicating probabilities and percentages rather than graphics. The graphics showing probabilities of a flight category occurring is useful, but raw data is preferable.”

**Indicates repeated capabilities users stated they would like to see implemented into the product.*



Focus Groups Recommendations



Focus Groups Recommendations

- **HREF vs. LAMP**

- Use HREF ensemble C&V forecast because:
 - The coverage area is larger and includes the coasts.
 - More data input sources are used (e.g., ensemble).
 - The HREF has a higher horizontal resolution.

- **Single vs. Combined**

- Use Combined display as users prefer seeing a flight category or worse conditions.



Focus Groups Recommendations

- **Bins**

- Use 10 Bin increments starting at zero because of higher resolution.
- Modify colors for Bin increments to increase discernibility between categories.
- Consider gathering additional data because there is a trend indicating meteorologist and Helicopter/HEMS pilots prefer the 10 Bin increment, whereas GA Pilots and dispatchers prefer the 5 Bin increment.



Focus Groups Recommendations

- **Minimum vs. Maximum**

- Use Maximum View:

- All users preferred the darker colors indicating higher probabilities of a flight condition or worse.
- Users' eyes were drawn to the darker areas, decreasing the difficulty of locating areas to avoid.

- **Color Gradients**

- Use darker colors to represent worse conditions:

- The increments were easier to see on a white background.
- Using darker colors for worse conditions is consistent with current products.
- Users' eyes were drawn to the darker areas, decreasing the difficulty of locating areas to avoid.

- Modify color scale for the bin increments to improve discernibility.



Summer Experiment



Summer Experiment Background



Summer Experiment Background

- AWC developers modified the probabilistic C&V based on the Phase 2 Focus Groups results.
- Developers made a “Preferred Display” by changing C&V product’s “HREF Mean/Prob Optimistic” variant to use the use “HREF Mean Flight Category” display and three flight category displays using:
 - Combined displays
 - Maximum View
 - Decile Bins
 - Zero-Bins

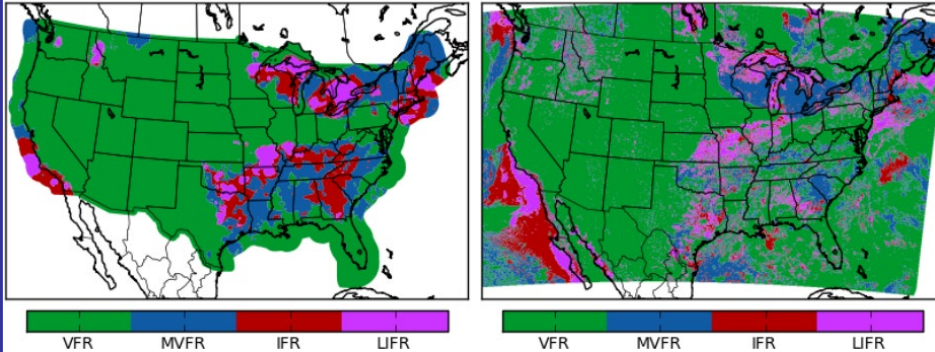


Summer Experiment Background: Preferred Displays from Phase 2

LAMP vs. HREF Mean

LAMP Flight Category Deterministic

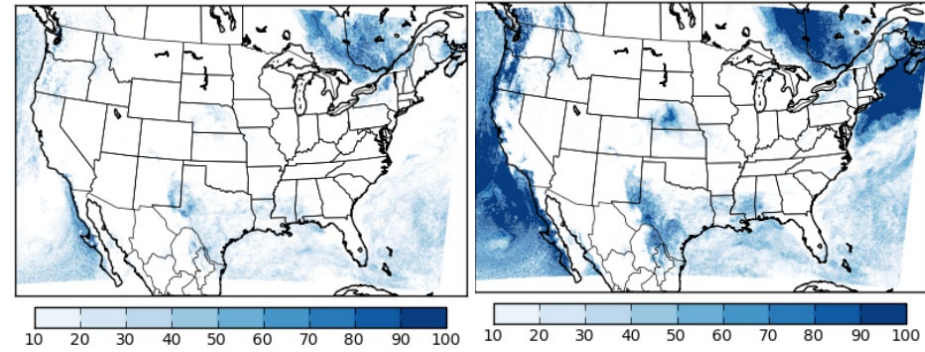
HREF Mean Flight Category



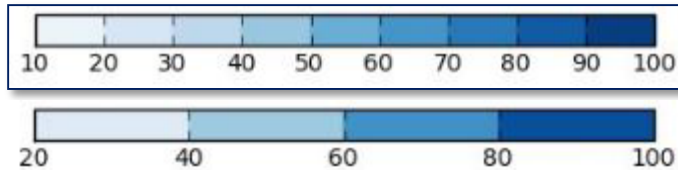
Single vs. Combined

HREF Probability of being MVFR

HREF Probability of being MVFR or worse



Bins

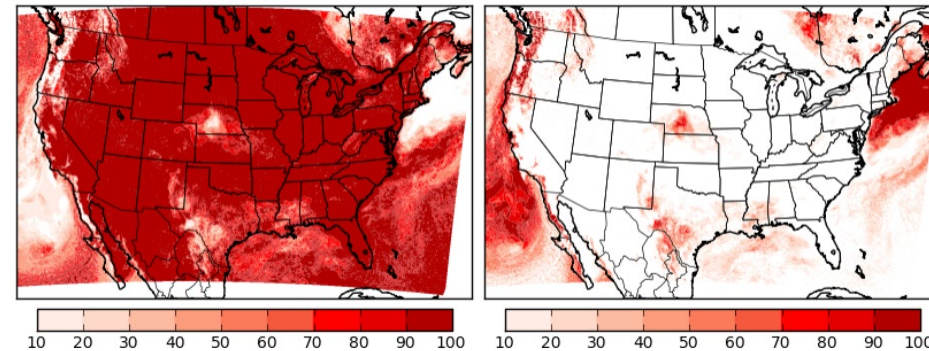


- Darker colors represent higher probabilities.
- Probabilities set at increments of 10.
- Probabilities start at 0.

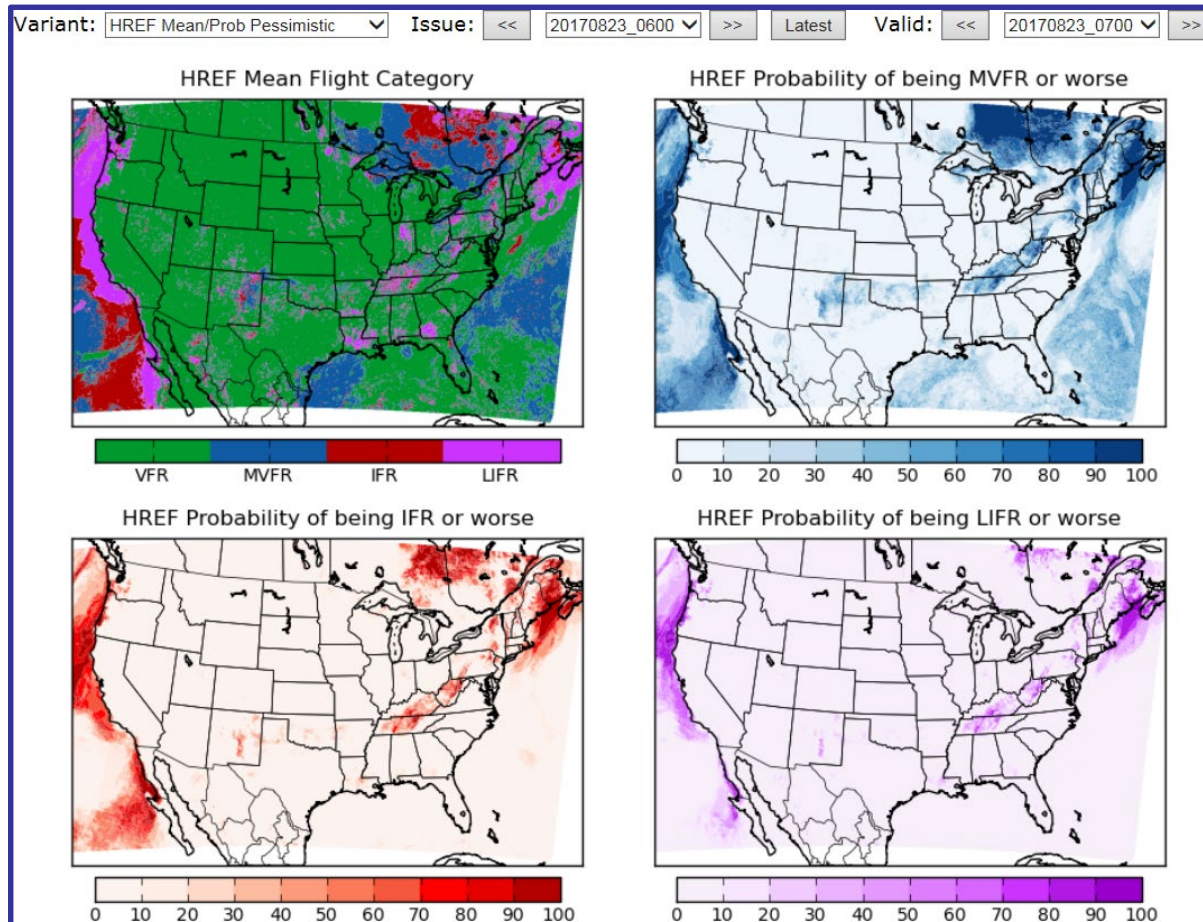
Minimum vs. Maximum View

HREF Probability of being better than IFR

HREF Probability of being IFR or worse



Summer Experiment Background: Summer Experiment Preferred Display



Summer Experiment Approach



Summer Experiment Approach

- Testing at the AWDE CPAC Lab, William J. Hughes Technical Center in Atlantic City, NJ during the Summer Experiment between 8/7/2017 – 8/18/2017.
- 14 users evaluated the Probabilistic C&V. Users included:
 - 1 Air Traffic Controller
 - 1 Airline Operations Center (AOC) Flight Dispatcher
 - 5 General Aviation (GA) Pilots
 - 3 United States Coast Guard Helicopter (USCG) Pilots
 - 1 Helicopter Emergency Medical Support (HEMS) Pilot
 - 2 Meteorologists (1 WFO Meteorologist)
 - 1 Air Traffic Manager



Summer Experiment Approach

- All displays were available to view and interact with during the Summer Experiment.
- Data collection focused on Phase 2 Focus Group preferred displays.
- Users answered questions focusing on the “Preferred Display.”
- Questions focused on:
 - Ease of use
 - Situation awareness
 - Colors
 - Information needs



Summer Experiment Approach

- Users evaluated Probabilistic C&V product.
- AWDE team collected feedback as users interacted with the product.
- AWDE observers asked structured interview questions focusing on presentation, suitability, and usability while users interacted with the product with a focus on the “Preferred Display.”
- 13 users completed the questionnaire.



Summer Experiment Results



Summer Experiment Results

Focus Area	Interview and Observation Results
Ease of Use	<ul style="list-style-type: none"> ● Information provided in the four panels was effective in displaying C&V. The first panel (HREF Mean) provided a good high-level overview while the three others provided the specific information for the most relevant flight categories.
	<ul style="list-style-type: none"> ● All users could easily identify areas of concern based on the flight category color coding.
	<ul style="list-style-type: none"> ● Information provided was not effective in aiding users in decision-making because it does not provide altitude, route, and separate ceiling and visibility information.
	<ul style="list-style-type: none"> ● Distinguishing between the probabilities on the display was difficult. There is not a capability to aid users in distinguishing between the probabilities on the display (zoom, rollovers).
Situation Awareness	<ul style="list-style-type: none"> ● The product was a good situation awareness product. It provided information for the entire CONUS including the coasts. However, in order to aid in decision-making, all users stated the need for a capability to zoom into regional areas. If this capability isn't available, they would only use the product for SA.

- Positive
- Negative/Issue
- Mixed



Summer Experiment Results

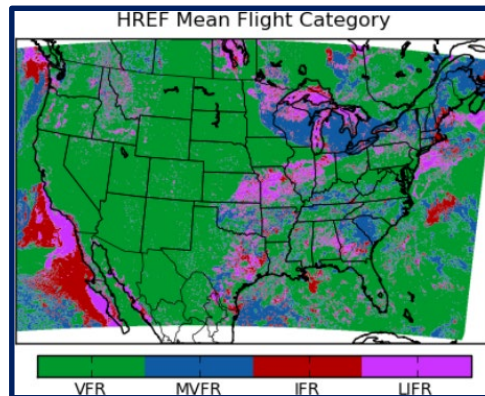
Focus Area	Interview and Observation Results
Color	<ul style="list-style-type: none"> ● The flight category color coding was effective because it is consistent with other weather products.
	<ul style="list-style-type: none"> ● All users found it easy to identify higher probabilities of a flight category when using darker colors.
Information Needs	<ul style="list-style-type: none"> ● For high resolution of information, probabilities in increments of 10 are preferred.
	<ul style="list-style-type: none"> ● All users stated they need the following information: altitudes, routes, ceiling, and visibility.
	<ul style="list-style-type: none"> ● All users stated the update rate of 1 hour is adequate. However, because weather can change quickly, a faster update rate, ideally 15 minutes, is preferred.

- Positive
- Negative/Issue
- Mixed



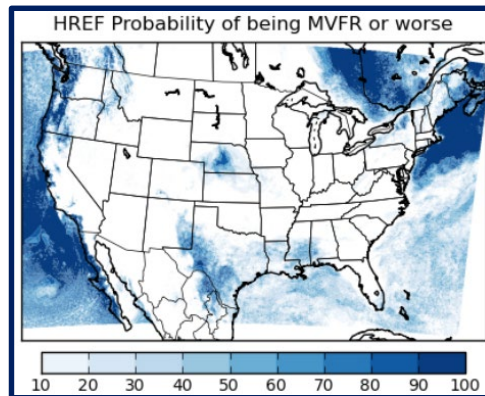
Summer Experiment Results: Ease of Use

- 12 out of 14 users found the “HREF Mean Flight Category” display to be easy to use.
- 2 users (AOC Flight Dispatcher and GA Pilot) stated the green VFR background made the information difficult to see and made the display look too busy. The AOC Flight Dispatcher stated the red and magenta are difficult to distinguish from one another.
- All users noted the display provided good situation awareness for all the flight categories.



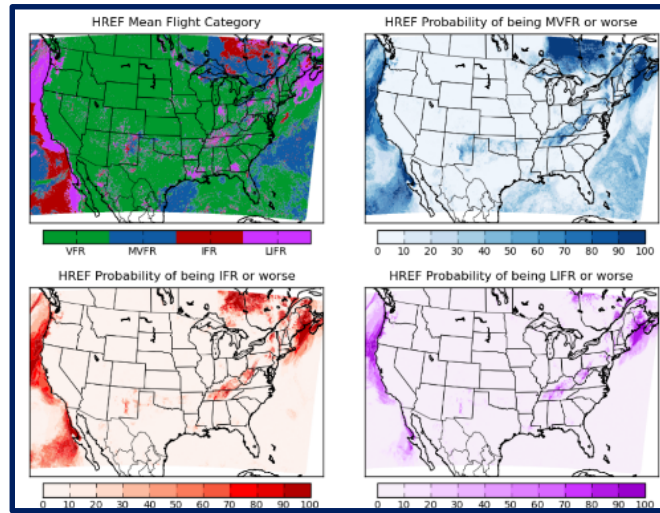
Summer Experiment Results: Ease of Use

- 13 out of 14 users found the “HREF Probability of being [Flight Category] or worse” display to be effective.
 - 13 users found the display to be effective as areas of concern are easy to identify.
 - 1 USCG Helicopter Pilot stated the display was not effective for decision making as the display does not provide route, altitude, ceiling, and visibility information.



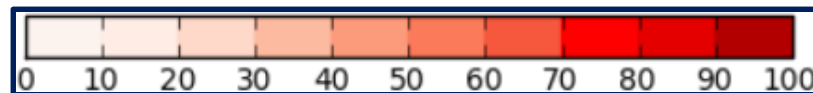
Summer Experiment Results: Ease of Use

- All users found value in the product showing the “HREF Mean Flight Category” and “HREF Probability of being [Flight Category] or worse” on one display.
- All users looked at the “HREF Mean Flight Category” display first and then examined the “HREF Probability of being [Flight Category] or worse” displays to delve further into each flight category’s impacts.



Summer Experiment Results: Ease of Use

- 11 out of 14 users indicated displaying probabilities using increments of 10 was effective and easy to use.
- 3 (GA Pilot, USCG Helicopter Pilot, and WFO) out of 14 users stated the probabilities displayed in increments of 5 were easier to use. The 3 users stated distinguishing the colors of probabilities displayed in increments of 5 was easier than in increments of 10.
- All users preferred the probabilities to start at 0.
 - Provides full scale from 0-100.
 - Provides a reference point.
 - Zero starting point is a preference issue. Users noted probability starting point did not impact decision making.



Summer Experiment Results: Ease of Use

- All users stated the product gives a useful, easy-to-interpret C&V forecast for the Continental United States (CONUS).
- Due to the high visual salience of C&V, users were able to quickly identify areas of concerns.
- All users stated the controls were easy to use and were consistent with other products.

Issue: << 20170823_0600 ▾ >> Latest Valid: << 20170823_0700 ▾ >>



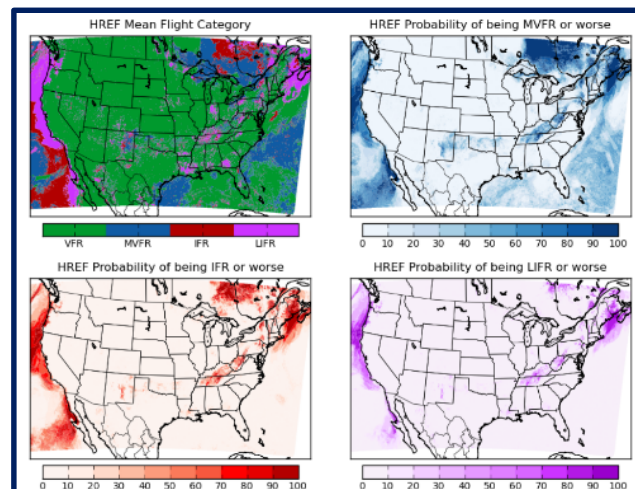
Summer Experiment Results: Situation Awareness (SA)

- All users stated the C&V information provided by the product improved their situation awareness.
 - The product provided a good “first glance” to see C&V information.
 - All users stated the four displays had to be used in conjunction with one another to get a clear understanding of the C&V information.
 - All users stated without additional capabilities (zoom, routes, altitudes, etc.), this tool is only useful for SA. If they were concerned with C&V, they would have to use another tool to delve further and get additional information for decision-making.



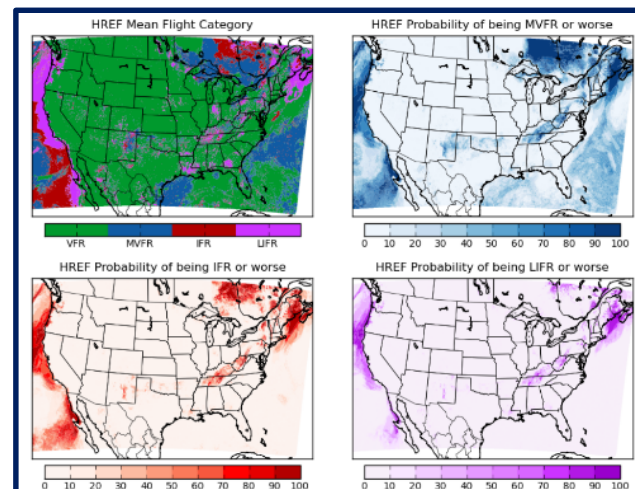
Summer Experiment Results: Color

- 12 out of 14 users found the flight categories' color coding to be effective.
- 2 (AOC Flight Dispatcher and GA Pilot) out of 14 users stated the green VFR background on the HREF Mean Flight Category display made the information difficult to see and made the display look too busy. The AOC Flight Dispatcher stated the red and magenta were difficult to distinguish from one another.



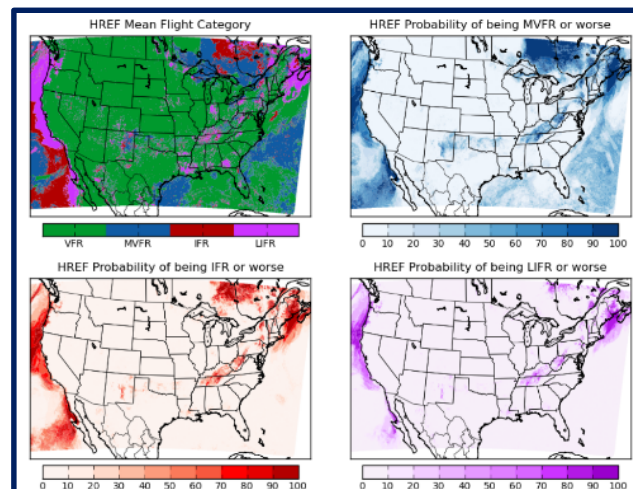
Summer Experiment Results: Color

- 12 out of 14 users stated the green for VFR, blue for MVFR, red for IFR, and magenta for LIFR was consistent with other weather products.
- 2 (GA Pilots) out of 14 users stated other weather products use red to display worst conditions, therefore red for IFR was not effective.



Summer Experiment Results: Color

- All users preferred using darker colors to represent higher probabilities of a flight category occurring.
 - Users stated having high probabilities of an event occurring being represented by darker colors was consistent with other weather products.
 - Users stated having higher probabilities displayed in darker shades made identifying areas of concern easier.



Summer Experiment Results: Information Needs

- All users stated a need to view ceiling and visibility separately.
 - Helicopter/HEMS pilots fly at low altitudes. Knowing if the issue is fog or low clouds is a deciding factor in determining routes.
 - TAFs are developed and issued with ceiling and visibility separate.
 - GA Pilots fly at low altitudes below the ceiling but may be impacted by visibility.
- 13 out of 14 users stated the 1-hour update rate is adequate for decision-making.
 - All users stated they want information to be as current as possible since weather changes quickly.
 - The WFO Meteorologist stated an updated rate of 15 minutes is preferred.



Conclusions



Conclusions

1. Objective: Determine how users interpret a probabilistic C&V forecast.

- All users begin by using the "HREF Mean Flight Category" display to identify general areas of concern. Users then refer to the "HREF Probability of being [Flight Category] or worse" display(s). The display used is determined by aviation role and certifications. For example, a GA Pilot will use the "HREF Probability of being IFR or worse" display to easily see areas to avoid.
- All users would use the Probabilistic C&V product as an SA tool. This is because there aren't additional capabilities, such as zoom or additional information (routes, altitudes) needed for decision-making. Users stated they would use another tool to get the information they need to make their decisions.
- All users are looking for darker colors to identify areas of concern.



Conclusions

2. Objective: Determine the best way to present probabilistic C&V information.

- Display higher probabilities of a flight category occurring using darker colors. This is consistent with other weather tools and allows users to easily identify areas of concern.
- Provide the "HREF Mean Flight Category" and "HREF Probability of being [Flight Category] or worse" on one display. The HREF Mean provides an initial first glance, while the other displays allows users to dive deeper into information for each flight category.
- Use of colors displayed are acceptable as they are consistent with other weather products: green for VFR, blue for MVFR, red for IFR, and magenta for LIFR.



Conclusions

2. Objective: Determine the best way to present probabilistic C&V information.

- Provide users the capability to zoom into areas of interest.
 - This will provide the capability to easily differentiate between levels of probabilities.
- Provide additional information such as:
 - Routes,
 - Altitudes,
 - Ceiling, and
 - Visibility.



Conclusions

3. Objective: Determine what information is needed in a probabilistic C&V forecast.

- Provide users the capability to zoom into areas of interest.
 - This will provide the capability to easily differentiate between levels of probabilities on the HREF Probability of being [Flight Category] or worse displays.
 - This will provide the capability for users to easily distinguish between the different flight categories on the HREF Mean Flight Category display.
- Provide additional information such as:
 - Routes,
 - Altitudes,
 - Ceiling, and
 - Visibility.



Conclusions

4. Objective: Determine the usability of the product.

- Overall, the product was easy to use.
- All users found the controls easy to use and consistent with other weather tools.
- All users stated the Probabilistic C&V tool did not provide information beyond basic situation awareness. In order for the tool to be more effective for use, the following capabilities/information need to be added:
 - Zoom,
 - Routes,
 - Altitudes,
 - Ceiling, and
 - Visibility.



Recommendations



Recommendations

- Add zoom capability.
 - Pilots need to see specific areas where C&V impacts may occur along their route.
 - ATC need to see their own airspace to accurately identify areas impacted by C&V.
 - Zooming in will help users differentiate between the probabilities of a flight category.
- Provide an option to view ceiling and visibility separately.
 - Users need to know what the ceiling and visibility impact actually is: a ceiling impact or a visibility impact?
 - Meteorologists issuing Terminal Aerodrome Forecasts (TAFs) need to report each field separately.



Deliverables



Deliverables

- Phase 1: C&V Product Development
 - None.
- Phase 2: Focus Group
 - Focus Group Storyboard Review Straw man Outline/Plan (completed 6/27/17).
 - Focus Group Storyboard Review Questionnaires/Interview Forms/Data Collection Tools (completed 6/27/17).
 - Focus Group Storyboard Review Results and Recommendations Briefing (8/1/17).
- Phase 3: Summer Experiment
 - 2017 Summer Experiment Updated/Revised Questionnaires/Interview Forms/Data Collection Tools (8/4/17).
 - 2017 Summer Experiment Results and Recommendations Briefing (due 9/15/17).



Back-up Slides



Focus Group Questionnaire Results



Focus Groups Results: Mean Values for All Questionnaires

Instructions: Using the 5-point scale, please circle the rating that best describes your view on how the probabilistic C&V product supports flight planning. Question	GA Pilots (N=4)	Helicopter/ HEMS Pilots (N=2)	WFO Meteorologists (N=6)	Airline Flight Dispatchers (N=4)	Airline Meteorologists (N=1)
1. The LAMP deterministic forecast is	4.25	3.5	5	4	5
2. The HREF probabilistic forecast is	4	4.5	5	3.5	5
3. Determining the probability of a flight category using LAMP is	4.5	2.5	5	4	5
4. Determining the probability of several flight categories using HREF is	4.5	4.5	2	3.5	2
5. The C&V information showing probabilities for one flight category is	3.75	4	5	3	5
6. The C&V information showing probabilities for more than one flight category	4.25	4.5	2	3.75	2
7. The bins in increments of 10 is	4.5	4	2	3.5	2
8. The bin in increments of 20 is	4.25	4	4	4.25	4
9. The bins NOT starting at 0 (example not at 0: 10, 20, 30...; example at 0: 0, 10, 20 30...) is	4	2	3	2.5	3



Focus Groups Results: Mean Values for All Questionnaires

Instructions: Using the 5-point scale, please circle the rating that best describes your view on how the probabilistic C&V product supports flight planning. Question	GA Pilots (N=4)	Helicopter/ HEMS Pilots (N=2)	WFO Meteorologists (N=6)	Airline Flight Dispatchers (N=4)	Airline Meteorologists (N=1)
10. The display showing darker colors indicating higher probabilities of being better than a given flight category is	2.5	2	2.67	1.25	1
11. The display showing darker colors indicating the flight category condition or worse is	5	4.5	4.5	5	5
12. Using darker colors for higher probabilities is	3.75	4.5	4.67	3.75	5
13. Using lighter colors for higher probabilities is	2.25	2	2.33	1.75	2
14. The color coding used to represent the different flight categories is	4	4.5	4.5	4.5	5
15. The colors used for the bins using 10 increments (10, 20, 30...) is	4	4	4.17	3.5	2
16. The colors used for the bins using 20 increments (20, 40, 60...) is	3.5	4.5	3.83	3.75	4
17. The probabilistic C&V product for flight planning (based on the display selected throughout the focus group) is	4	4.5	4.5	4.25	4
18. NOT showing Ceiling and Visibility separate for flight planning is	2.75	2	2.8	1.75	2



Summer Experiment Questionnaire Results



Summer Experiment Results: Mean Values for All Questionnaires

<p>Instructions: Using the 5-point scale, please circle the rating that best describes your view on how the probabilistic C&V product supports flight planning.</p> <p>Question</p>	Air Traffic Controller (N=1)	Airline Operations Center Flight Dispatcher (N=1)	General Aviation Pilots (N=4)	Helicopter/ HEMS Pilots (N=4)	Meteorologists (N=2)	Traffic Flow Manager (N=1)
1. Determining the probability of flight categories using the HREF Mean Flight Category display is	4	5	4.5	3.25	3	4
2. Determining the probability of several flight categories using the "HREF Probability of Flight Condition or worse" display is	3	5	4	3.75	4.5	4
3. Having both the "HREF Mean Flight Category" and "HREF Probability of being [Flight Category] or worse" displays available simultaneously is	3	5	4.7	3.75	5	4
4. Combining Ceiling and Visibility into a single probability instead of showing them	2	5	3.5	3	3	4
5. Presenting probabilities in increments of 10 is	4	5	3.25	4	4.5	5
6. The probability scale bins starting at 10 instead of 0 are	4	4	3	3	4	N/A
7. Distinguishing between different levels of probability (e.g., 80% and 90%) is	4	5	3	3	3	3
8. The resolution of information on the display is	4	5	3	4	4	3



Summer Experiment Results: Mean Values for All Questionnaires

<p>Instructions: Using the 5-point scale, please circle the rating that best describes your view on how the probabilistic C&V product supports flight planning.</p> <p>Question</p>	<p>Air Traffic Controller (N=1)</p>	<p>Airline Operations Center Flight Dispatcher (N=1)</p>	<p>General Aviation Pilots (N=4)</p>	<p>Helicopter/ HEMS Pilots (N=4)</p>	<p>Meteorologists (N=2)</p>	<p>Traffic Flow Manager (N=1)</p>
<p>9. The color coding used to represent different flight categories (i.e., green, blue, red, and magenta) is</p>	5	5	3.5	4.5	4	4
<p>10. The colors used for the bins using increments of 10 (i.e., 10, 20, 30...) are</p>	5	5	3.25	3.5	3.5	4
<p>11. Using darker colors for higher probabilities (e.g., 20% is light magenta, but 90% is dark magenta) is</p>	5	5	4	4.25	5	5
<p>12. Locating "trouble spots" on the HREF Mean Flight Category display is</p>	5	5	3.5	4.25	4.5	4
<p>13. Locating "trouble spots" on the "HREF Probability of being [Flight Category] or worse" display is</p>	5	5	3.75	3.75	4.5	4
<p>14. The buttons and drop-down menus for Time Issued are</p>	2	5	3.25	4	4	4
<p>15. The buttons and drop-down menus for Valid Time are</p>	2	5	3.25	4	4	4
<p>16. The text for the buttons and drop-down menus is</p>	3	5	3.25	4.75	4	4

