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DESI Evaluation Report 01: NWS Meteorologist Interviews

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Acronyms

AWIPS	Advanced Weather Interactive Processing System
CAPE	Convective Available Potential Energy
CWA	County Warning Area
DESI	Dynamic Ensemble-based Scenarios for IDSS
DSS	Decision Support Services
GFE	Graphical Forecast Editor
GIS	Geographic Information System
GSL	Global Systems Laboratory
HREF	High-Resolution Ensemble Forecast
IDSS	Impact-based Decision Support Services
IRB	Institutional Review Board
LREF	Long-Range Ensemble Forecasts
MIC	Meteorologist-in-Charge
NC	National Center
NDFD	National Digital Forecast Database
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
OMB	Office of Management and Budget
QPF	Quantitative Precipitation Forecast
SOO	Science & Operations Officer
STID	Science and Technology Integration Division
WCM	Warning Coordination Meteorologist
WFO	Weather Forecast Office

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Executive Summary

The Dynamic Ensemble-based Scenarios for IDSS (DESI) tool, developed by the National Oceanic and Atmospheric Administration's (NOAA) Global Systems Laboratory (GSL), allows National Weather Service (NWS) forecasters to rapidly examine large ensemble-based datasets and create probabilistic Impact-based Decision Support Services (IDSS). This report details the findings of the first formal, user-centered evaluation of DESI, conducted through semi-structured interviews with 45 meteorologists from all six NWS regions and National Centers (NCs), as well as one non-NWS meteorologist, between May and July 2024.

Key Findings

- **High Utility and Adoption:** A large majority of participants (67%) reported using DESI at least once per day, with use increasing during active weather. Participants primarily learned to use the tool through internal training or "playing around," with a desire for shorter, video-format training.
- **Workflow Efficiency and Confidence:** Over half of participants (60%) reported that DESI has positively changed their workflows, primarily by increasing efficiency and simplifying data access, often reducing the number of external tools required. A stark majority (90%) indicated that DESI has increased their confidence in both forecast creation and communication, largely due to its ability to meaningfully quantify uncertainty and provide a full range of possible scenarios.
- **Enhanced Communication:** Nearly three-quarters of respondents (74%) stated that DESI has influenced their communication, particularly by revolutionizing their ability to create and share visually appealing, probabilistic graphics for partners and the public.
- **Most Valuable Features:** The **Probability of Exceedance** product was overwhelmingly cited as the "go-to" and most useful product within DESI (93% useful or very useful) for forecast creation, situational awareness, and external communication, especially for informing IDSS. The **Statistics** product was also highly valued (81% useful or very useful) for assessing best- and worst-case scenarios. The **Spread** product and **Timing** product were the least used and understood out of the four products.
- **Commonly Used Variables in DESI:** Precipitation amounts (Quantitative Precipitation Forecast and Snow), Temperature, Wind, and Severe Weather parameters (CAPE and shear) were the most frequently analyzed variables.

Recommendations

Forecasters view DESI as a "game-changer," but shared key recommendations for its continued development.

- A central vision shared by participants is the desire for DESI to evolve into an all-in-one, unified forecasting platform—some even suggested it become "AWIPS 3."
- The most critical functional gap identified is the disconnect between the probabilistic DESI data and the deterministic National Digital Forecast Database (NDFD)/Graphical

Forecast Editor (GFE), urging for an ability to embed DESI outputs directly into the official forecast grid.
- Other recommendations include: continued graphics refinement, incorporating preset templates and customizable color schemes (including consideration for color-blind users), and improving data latency and geographic overlays.

The evaluation results confirm the value of DESI as a crucial decision support tool and provide actionable insights to guide GSL's development efforts in alignment with NWS forecaster needs.

Next Steps

All changes to DESI to date (see Appendix D) and recommendations from this evaluation will inform future development and user interface (UI) and user experience (UX) decisions for NWS Viz. GSL will continue to maintain a non-operational version of DESI for visualization and model development. Findings from this evaluation can and will inform current and future tools and products within GSL.

As it relates to NWS Viz development, a central, participant-derived recommendation from this evaluation includes the need to maintain the speed, intuitiveness, and efficiency for ensemble interrogation. Additional recommendations include enabling the user to zoom in and out of a map or sounding and the capability for user-specific profiles for capturing geographical and meteorological priorities.

Evaluation Overview & Significance

The Dynamic Ensemble-based Scenarios for IDSS (DESI) allows for the rapid examination of large ensemble-based datasets and creation of probabilistic Impact-based Decision Support Services (IDSS) for core National Weather Service (NWS) partners (see Figure 1). DESI facilitates NWS forecaster use of ensembles in a quick and efficient way, advancing from rather rudimentary ensemble interrogation mechanisms and outputs (e.g., spaghetti charts and ensemble means) and providing enhanced capabilities that aid in forecast creation and communication. It enables users to define characteristics and statistics to interrogate meteorological variables and thresholds that are pertinent to their forecast development, service areas, and core partners. The National Oceanic and Atmospheric Administration's (NOAA) Global Systems Laboratory (GSL) has supported the development and operationalization of DESI since 2021.

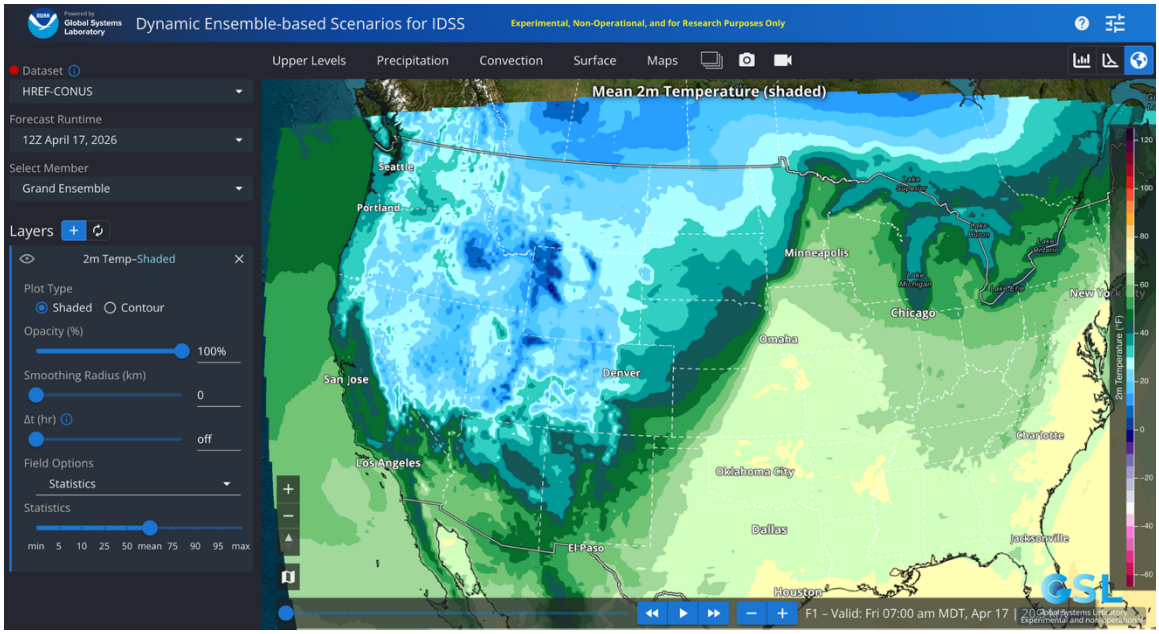

Figure 1. *GSL DESI Landing Page*

While the tool has been developed by researchers with operational forecasting experience and promoted and tested within designated Weather Forecast Offices (WFOs),[1] the web-based platform had not undergone a formal evaluation using rigorous social science and evaluation research methods to inform its refinement from an end user's perspective. The use of probabilistic forecast information has also been heavily promoted by the NWS, with DESI having the potential to be one of the primary tools used for querying probabilistic forecast information for IDSS. Accordingly, GSL's Decision Support Research and Evaluation Branch prioritized the evaluation of DESI to assess: (1) DESI familiarity and use among NWS forecasters; (2) DESI's impact on forecaster workflow, communication, and confidence; (3) the utility of DESI products

[1] DESI 1.0 was released in June of 2021 with a limited number of test offices. In July 2022, DESI expanded to 10 test offices per NWS region. DESI 3.0 (released December 2023) resulted in DESI becoming available in *all* NWS WFOs.

and features; (4) overarching feedback on DESI graphics and graphics generator, and (5) forecaster recommendations and future vision for DESI. Direct outcomes of this work have informed and continue to inform DESI releases, as well as the establishment of a baseline understanding of NWS meteorologists' operational workflows during and outside times of extreme weather (*manuscript in development*).

Methods

Recruitment

To address the four evaluation objectives, one member of the evaluation team (CV) recruited NWS meteorologists[2] from WFOs within all six NWS regions as well as those located at National Centers (NCs). The evaluation recruitment plan followed a stepwise and purposive sampling approach for intentional and ethical engagement given the staffing constraints that many NWS offices had and continue to experience, as well as to ensure we followed the proper outreach protocol for NWS meteorologist engagement.

To begin, we reached out to the Science and Technology Integration Division (STID) Chiefs across all NWS regions to notify them about the project and request approval for forecaster participation within their region (see Appendix A). Interview recruitment processes were informed by STID Chief preferences: either the STID Chief or the evaluation lead (CV) contacted WFO Warning Coordination Meteorologists (WCMs) and/or Science and Operations Officers (SOOs) to inquire about their interest in participating as well as their willingness to recruit additional forecasters within their WFOs or NCs. Then, either the evaluation lead or WCMs/SOOs connected with NWS meteorologists about their availability and willingness to participate in the DESI evaluation. The evaluation team prioritized outreach and recruitment at WFOs and NCs designated as DESI test offices given the likelihood that participants in test offices would be able to speak more to their direct experiences using DESI. However, the recruitment approach also intentionally included non-test offices for comparison. After receiving suggestions for participants through STID Chiefs, WCMs, and SOOs across 19 WFOs and four NCs, the evaluation lead ultimately reached out to 48 potential participants, with 44 agreeing to participate. One participant is a meteorologist situated within another federal agency.

Prior to official recruitment and data collection, this evaluation received Institutional Review Board (IRB) approval through the National Institutes of Science and Technology's (NIST) Research Protections Office (#NOAA-2024-0352) and fell under the Office of Management and Budget (OMB) Generic Clearance (OMB Control #0690-0030).

Data Collection and Analysis

The evaluation team conducted virtual interviews with 45 meteorologists from May to July of 2024. We created and followed a semi-structured interview guide (Appendix B), which includes sets of questions about interviewee roles and experience, their operational workflows, whether and how they analyze weather variables within DESI, DESI's impact on forecast and communication and confidence, questions specific to DESI products and features, and feedback

[2] Throughout the report 'meteorologist' and 'forecaster' are used interchangeably.

and recommendations for improving DESI.[3] While each interview varied in length, they lasted approximately one hour each. Depending on the interviewee's position and experience using DESI, some questions were slightly adapted or skipped accordingly. Prior to the start of each interview, we re-emphasized the purpose of the evaluation and reviewed the consent form with participants (Appendix C). We received verbal consent from all participants confirming their willingness to participate and be recorded before the start of each interview.

All interviews were recorded and transcribed. As an initial data analysis step, each transcript was reviewed, quality-checked for accuracy and any difficult to decipher areas of the recording, and subsequently summarized into a three-to-five-page document. The summary documents were then shared with each participant as a member-checking procedure to ensure accuracy of interpretation (McKim 2023). Two members of the evaluation team (CV and JV) then took a rapid qualitative analysis approach to the evaluation data by independently reviewing each transcript and summary for initial exploration prior to a more formal analysis of the interview transcripts. One member of the evaluation team (JV) then developed a coding scheme informed by the interview guide. JV and another Decision Support Research and Evaluation (DSRE) Branch researcher co-coded two interview transcripts within MAXQDA 24 qualitative analysis software to assess the reliability and validity of the initial coding scheme (Verbi Software 2024). Using MAXQDA's intercoder reliability analysis feature at a 70% code overlapping rate, we received a Kappa score of .57, which indicates 'moderate agreement' (on the cusp of substantial agreement) (Landis & Koch 1977). We made changes to the coding scheme based on the intercoder reliability results to address discrepancies in code application. One member of the evaluation team (JV) then applied the adjudicated coding scheme to all 45 interview transcripts.

Description of Participants

Evaluation participants represented all six NWS regions as well as three National Centers (NCs), with one participant external to the NWS (see a breakdown of regional affiliations in Table 1). Overall, this sample captured at least three perspectives from each NWS region, with the highest represented regions being Eastern and Central (see Table 1). Their positions within each region or center ranged from SOOs, Meteorologists in Charge (MICs), WCMs, forecasters, and other, non-disclosed positions to protect anonymity. Of the 45 participants, there were eight SOOs (18%), one MIC and one WCM (4%), 29 managerial/lead or staff meteorologists (64%), and six (13%) "other" or non-disclosed staff members. We did not collect any demographic information as part of this study.

[3] Additional questions centered around participants' perceptions of their partners and public understanding of probabilistic information and how outlier events are understood and communicated by participants, which will be detailed in future manuscripts and/or supplemental material.

Region	# of Participants	% of Participants
Alaska	4	8.9%
Central	9	20.0%
Eastern	11	24.4%
Pacific	3	6.7%
Southern	6	13.3%
Western	5	11.1%
National Center (NC)	6	13.3%
External	1	2.2%

Table 1*. Regional Affiliations of Participants*

The specific roles and responsibilities of each interviewee varied according to their WFO or NC position, and for many WFO meteorologists, their responsibilities were dependent upon shift. A general list of responsibilities they shared includes, but is not limited to: forecasting and observations, disseminating information – with a growing emphasis on probabilistic information –, social media outreach, weather briefings, media calls, hydrologic duties, damage surveys, and software maintenance. Participating NC meteorologists shared many of the same responsibilities as WFO participants, but also included specializations in rainfall, winter weather, aviation, and more, depending on the NC.

Findings

The remainder of this report presents findings central to the evaluation's objectives. These include: (1) DESI familiarity and use among forecasters; (2) DESI's impact on forecaster workflow, communication, and confidence; (3) the utility of DESI products and features; (4) overarching feedback on DESI graphics and graphics generator, and (5) forecaster recommendations and future visions for DESI. In the following sections, we illustrate and quantify (to the extent possible) themes and findings that emerged from the data pertaining to these five areas. Importantly, and as indicated earlier in the report, some interview questions were adapted or skipped based upon interviewee role, their experience with DESI, or the time they had available to meet with the evaluation team. As such, we note throughout the report instances where a subset of interviewees was asked particular questions.

DESI Familiarity and Use

The interviewee sample comprised two main user groups based on their length of experience using DESI: those that had used it for more than a year (n=31, 74%) and those that had used it less than a year (n=11, 26%). Three were not asked explicitly about their length of experience with DESI. A large majority (n=30, 67%) of participants reported using DESI *at least* once per day, with one participant stating "*I just can't do my forecast without it*". Two mentioned that they had not used DESI operationally at the time of their interview. Others reported using DESI less frequently, such as every other day or a few times a week (n=8, 18%) or rarely (n=5, 11%). However, across interviews, participants shared the sentiment that use of the tool continues to increase in their respective offices - including among those who were not already avid users. Of

interviewees who reported slower adoption of DESI among forecasters within their office, some explanations centered around the time and effort required to become familiar with DESI to use it in an operational setting. Several participants reported an increase in their use of DESI during active weather days, particularly winter weather (primarily among participants in the Eastern and Central NWS regions), or in conducting a specific part of their job (e.g., aviation or marine forecasts, soundings).

Many participants received DESI-specific training either internally (e.g., from their SOO) or from GSL-produced training videos; however, it was sometimes unclear whether the internal training involved assignment of the GSL videos versus a tailored training provided by their leadership in their respective offices/center. Others mentioned acquiring familiarity and proficiency for using DESI by way of "playing around" with the tool. Over half of interviewees asked indicated that the training they received for DESI was adequate, though some relayed the desire for additional training, with many preferring that it be delivered in a video format. However, a few cautioned that the video should not be too long as it can quickly become cumbersome or overwhelming. For example, one participant mentioned that they were "*glad there hasn't been 45 different modules on little aspects"* of the tool, though they acknowledged that it would be hard to capture the entire tool in one training. Short videos appeared to be powerful aids for DESI training, as it is challenging for many forecasters to participate in long training sessions given their other, often co-occurring responsibilities.

DESI's Impact

A critical objective of this evaluation was to understand the utility and impact of DESI among forecasters. In the following sections, we report findings based on DESI's impact on forecaster workflow, forecaster confidence in understanding and building a forecast, and how they communicate weather information externally to partners and the public.

DESI & Forecaster Workflow

Responses to the question of how, if at all, DESI has changed participants' workflows fell within three response categories: yes, has changed; no, has not changed; and more neutral responses (e.g., yes and no, could change in the future). Out of the 38 participants asked this question, over half (n=23, 60%) shared that DESI has positively changed their workflows. Explanations for how their workflows changed primarily included references to increased workflow efficiency and simplification, such as not having to go to multiple sites for weather information, improvements with how they communicate externally to partners and the public (e.g., social media graphics), and DESI's customizability.

The tool's ease of use and expanded capabilities enables forecasters to quickly find and/or disseminate information, which was described by many as having a positive effect on their workflow. For example, as an NWS meteorologist from the Alaska Region explained:

> *So much more information can be conveyed using the tools that DESI has in terms of the presentation, but also the forecast, making that increase in that confidence of where's [sic] the highest winds going to be? Are we going to hit 60 miles an hour or whatever threshold we're looking for? We're able to see that a lot easier than just pulling up WeatherBell or looking at AWIPS. It's just, it's quicker.*

Many of the same subset of interviewees who indicated DESI's positive effect on their workflow described the tool as critical to their operational duties, and they expressed a greater reliance on DESI for forecasting compared to the Advanced Weather Interactive Processing System (AWIPS) or GraphIDSS. For example, another forecaster from the Alaska Region explained:

> *It's taken place of my workflow when I'm not in my office…I've been deployed a couple of times now and…we don't have too many websites outside of DESI that can give us a lot of weather info. I know at lower 48, there's a lot of different websites, Pivotal Weather, you name it, that you can get weather info like forecasts, looking at different models or so. But there's a lot less of those sites that are offered for Alaska. They just don't have Alaska domains.*

Roughly 40% (n=15) of participants who were asked the question indicated that DESI may have changed their workflow slightly, not at all, or that it could have the potential to affect their workflow in the future. Several participants explained that DESI is "another tool in the toolbox" that supplements the suite of tools and products they already use for their forecasting responsibilities. A meteorologist from the Central Region expressed this sentiment:

> *It's really great at viewing and contextualizing the forecast from a probabilistic perspective, but there are still some variables in just the actual deterministic guidance that other websites do a good job at and I'm used to looking at, so a little bit of familiarity there. So I would say that I use it in combination with those, especially looking at the CAMs or the RAP or other guidance sources like that. I typically use other websites.*

We also asked 40 participants whether their use of DESI has resulted in an overall reduction in the number of tools they use or websites they visit for weather information. Roughly half (n=19) expressed that DESI had reduced the number of tools they use, 15 (38%) participants shared that DESI had not reduced the number of tools they use in their workflows (but that it was supplemental to existing tools and websites), and another six responded that DESI may have *slightly* reduced the number of tools and websites they use or that they could see DESI reducing the number of tools in the future.

Regarding where and how DESI typically "fits" within NWS meteorologists' typical workflows, responses varied by participant - speaking to the different types of roles that participants held, including variances in shift, personal preference, and the types of weather (including extreme weather) they forecast in their respective office or center. For example, while some participants mentioned using it at the beginning of their shift and others the middle, most participants that spoke about "the time" at which they use DESI said it is sprinkled throughout their workday. We learned that DESI is employed *across* the forecast workflow for short-term to long-term forecasting and analysis to decision support.

DESI & Forecaster Confidence

A central question of interest to the evaluation team was whether and how DESI affected forecaster confidence - both in terms of forecast creation and forecast communication. A stark majority (n=36/40, 90%) of participants indicated that DESI has increased their confidence in one or both of these domains, with four others sharing that it may have *slightly* increased their

confidence. Specific reasons shared by participants for how DESI increased their confidence included: reassurance in knowing that they are likely not overlooking key aspects of forecast data; the speed, efficiency, and intuitiveness of the tool; the ability to meaningfully quantify uncertainty; and that it enables them to understand the forecast more deeply, resulting in enhanced decision support to partners. We highlight quotes below that illustrate the ways participants reported how DESI increases their confidence.

> *[DESI gives] you additional context, spread information, distribution information, probability of exceedance information. So in [forecast] creation, [it has] 100% been a game changer and the tools in there have been helpful for that.* - SOO, Central Region

> *I think it has increased my confidence, because it's a much easier way for me to see the extremes, the potential outcomes, and things like that, rather than having to sift through the data elsewhere. I think that it's great, just the flexibility with it is great to pull the exact probabilities that I need … For exceedance especially.. I think that is extremely beneficial to our partners*. - Meteorologist, Southern Region

Regarding the tool's speed, efficiency, and readily available data, a meteorologist from the NWS Eastern Region shared:

> *[DESI] opens up the ability to communicate more with partners and do other things. So, I would say like that speed element of DESI is just being able to quickly look at things so fast and say, okay, well, now I need to look at the moisture fields and then just quickly pulling it up… I think that that is more of an efficiency thing… the dynamic nature of DESI, which I guess leads to some confidence. But I think the access to the data is what really impacts my confidence, changes [my] confidence.*

Additionally, some shared that having the ability to explore model data all in one place and being able to see all possible "solutions" or scenarios makes them feel more informed and situationally aware:

> *Addressing the confidence part of this, like it is really nice to have all 100 members, you know, European, GFS, and Canadian all in that one place… to really assess, you know, it's not a perfect distribution of what could happen, but it's pretty darn good. And I think looking at all of that ensemble data together is something that a lot of folks really haven't had much ability to do up until this.* – SOO, Eastern Region

Another subtheme that rose from the interview data as an outcome of participants using DESI was their enhanced ability to create and communicate decision support services (DSS) materials. A meteorologist from the Central Region explained that, "*as a forecaster, it increases my confidence and gives me a better tool [sic] of saying, 'This is what I want to convey.' This is my best way of presenting that… It gives me more tools in my toolbox than I used to have.."* Because DESI provides a scientifically-based quantification of uncertainty, for some this reduces the "mental load" spent on determining and conveying the uncertainty of a forecast and enables them to provide more specific and nuanced communication and decision support to their core partners. As another meteorologist from the Central Region shared:

> *I would say in communicating the forecast, it has increased [my confidence] because it's a tool that provides this additional context in which we can, instead of saying specifically*

five days out, this is going to happen (which we're not able to really do) versus shrugging our shoulders. We can provide context. We can provide multiple solutions as to what we think is going to happen..[and] our confidence in each of those solutions. We can use this to provide numeric measures of confidence like probability.

DESI & Forecast Communication

When asked about whether DESI has influenced the way participants communicate the forecast, nearly three-quarters of those asked reported that DESI has changed or influenced the way they communicate (n=29/39, 74%). Eight (21%) indicated that DESI has either somewhat changed the way they communicate or did not provide a clear response, while two (5%) responded that DESI has not changed the way they communicate.

For a majority of participants, DESI has revolutionized their ability to create and share probabilistic graphics. A quote from a meteorologist in the Central Region illustrates this sentiment:

The ease of doing graphics and videos is tremendous. That you can put the bullet points in there, you can put a title on it, and it's a very professional, nice looking graphic rather than having to manually clench something in Google presentation or whatever it is, Google Slides, whatever we're using. It's a very nice blend of technical data and being able to nicely present it visually to the general public and emergency managers.

Others shared that DESI has aided their ability to put together decision support services (DSS) briefings, as it allows forecasters to provide multiple scenarios and more specific probabilistic values to their partners. This, in turn, enhances how forecasters communicate and contextualize probabilistic weather information and decision support. As a SOO from the Western Region shared:

I think it makes it easier to respond [to partners]. Sometimes we'll get a partner call and then we're like, wait, I need to go make sure I look at that data…But now with DESI, we can just pull it up - and, you know, [it] pulls up in, like, 30 seconds or whatnot. So we don't have to call them back. I think it's helped [us] be a little more immediate, a little more quicker to respond to partner requests.

Viewing and Analyzing Weather Variables in DESI

This section of the report details evaluation findings specific to the most frequently explored variables within DESI, feedback on viewing options for variables, and graphics feedback within DESI. In the following subsections, we highlight findings from participants' responses to questions regarding the types of variables in DESI they use most frequently, feedback on data-viewing options in DESI, and reported use and utility of DESI-generated graphics.

Variables Used in DESI

In this section of the findings, we focus on participant feedback regarding use of meteorological variables in DESI to understand more deeply how forecasters engage with specific features and products in the DESI suite. To begin, we asked participants, "what weather variables do you primarily use DESI to analyze?" As shown in Figure 2, they provided a range of responses

across 20 variables, with precipitation amounts (Quantitative Precipitation Forecast (QPF) and snow) being the most frequently mentioned (n=34). The next three most frequently mentioned variables included temperature (n=18), wind (n=18), and severe weather parameters, including Convective Available Potential Energy (CAPE) and shear (n=15).

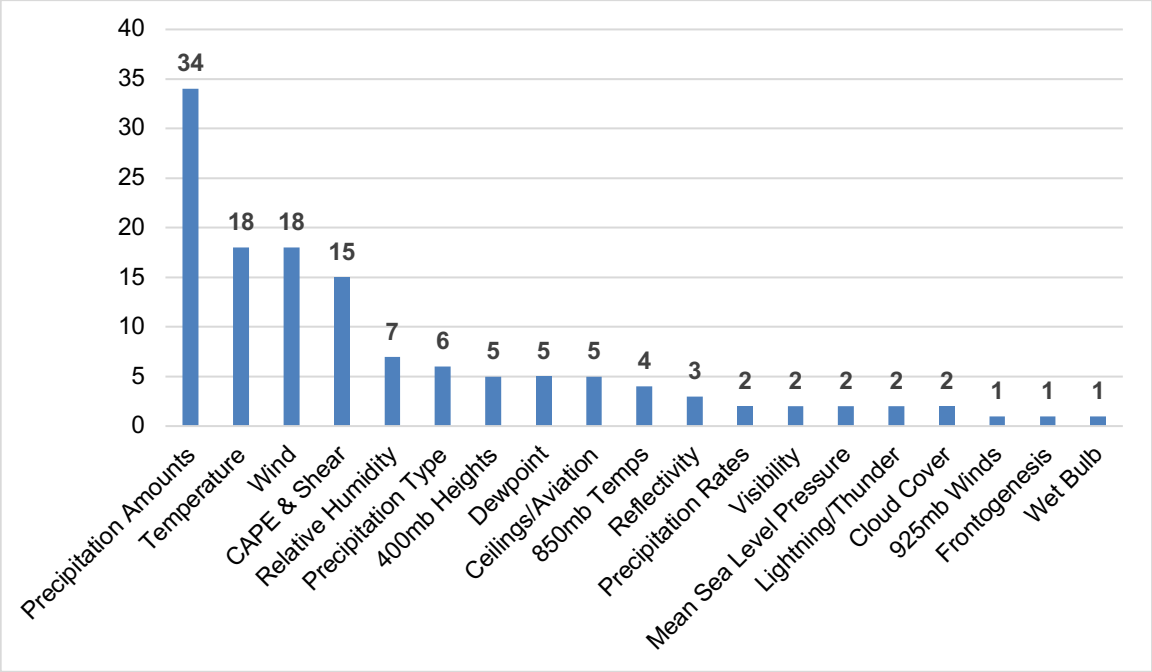

***Figure 2**. DESI Variables Primarily Used by Participants*

Viewing and Analyzing Weather Variables in DESI

Following the question of what variables participants primarily use DESI to analyze, we then asked whether this changes between plan (map) or 1-D viewer. Out of 42 participants asked, a majority (n=27, 64%) indicated that they mainly use the plan/map viewer. Thirteen (31%) reported that "it depends" or that they use both viewers, and two did not provide a meaningfully categorizable response to this question. Some participants were asked a specific follow-up question regarding their viewing preferences for timing information. Of the thirteen asked, five preferred the plan/map viewer for timing information, four preferred the 1-D viewer, and four explained that it depends on the circumstance or what desk they are working (see Figure 3).

The remainder of this section of the report highlights additional feedback and interviewee preferences regarding options for viewing and analyzing weather variables within DESI. Specifically, we report participants' responses pertaining to their use of: (1) the sounding viewer, (2) clusters, (3) chicklet chart, and (4) joint probabilities.[4] Figure 2 illustrates responses to questions regarding whether they use the sounding viewer, clusters, chicklet chart, and paintball feature within DESI. A majority of those asked indicated that they use the sounding viewer

[4] To clarify, chicklets are one aspect of the 1-D/point viewer, clusters are available in both the point and plan view, and paintballs are a small feature within the plan view.

(n=29), chicklet chart (n=22), and clusters (n=27) for analyzing weather variables. We share additional, high-level findings and recommendations specific to these viewing options below.

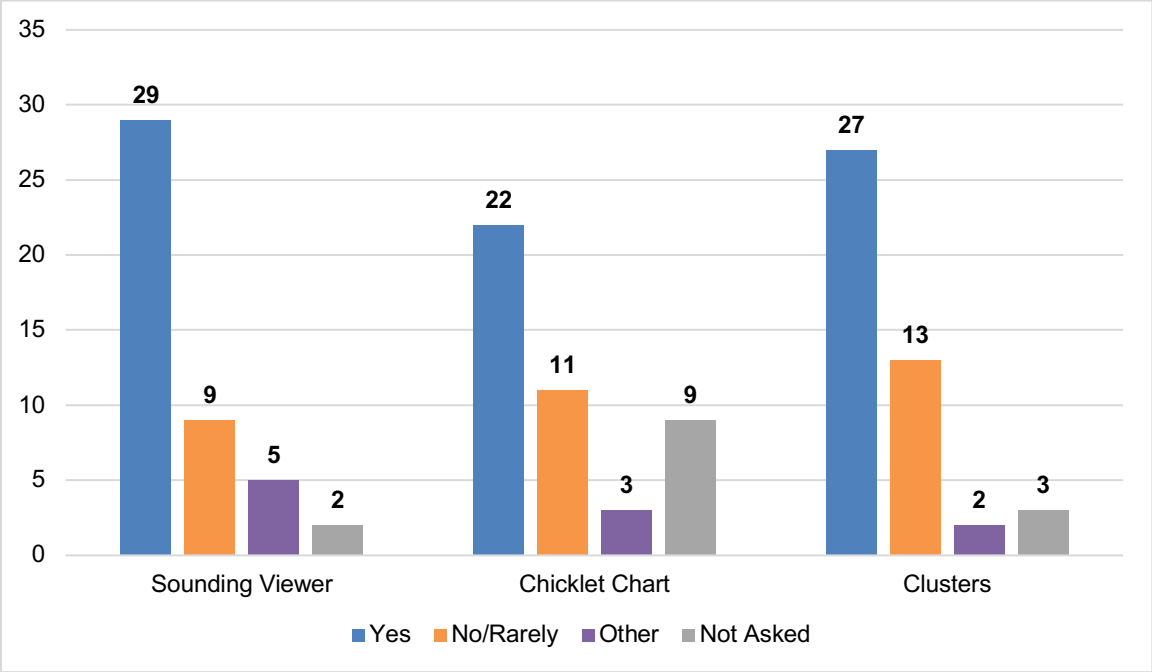

***Figure 3**. Participants' Use of Weather Variable Viewing and Analysis Options in DESI*

Sounding Viewer

The DESI Sounding Viewer (Figure 4) enables users to conduct a vertical analysis of ensemble data, including multi-model and multi-member visualization and interactive probabilistic statistics. While some participants reported using other tools to view model-driven skew-t plots, for many, reported benefits of DESI's sounding viewer is that it enables users to readily identify ensemble outliers and quickly plot a sounding for every point on a map. However, multiple interview participants reported the need to be able to zoom in and out and have greater interactivity with the DESI sounding plots. Specific recommendations include adding height above ground level and exploring ways to clarify or simplify the quantity of lines plotted. For those who did not use the sounding viewer in DESI, and even for many who do, the most frequently mentioned alternatives were BUFKIT Model Soundings followed by College of DuPage Upper Air Soundings.

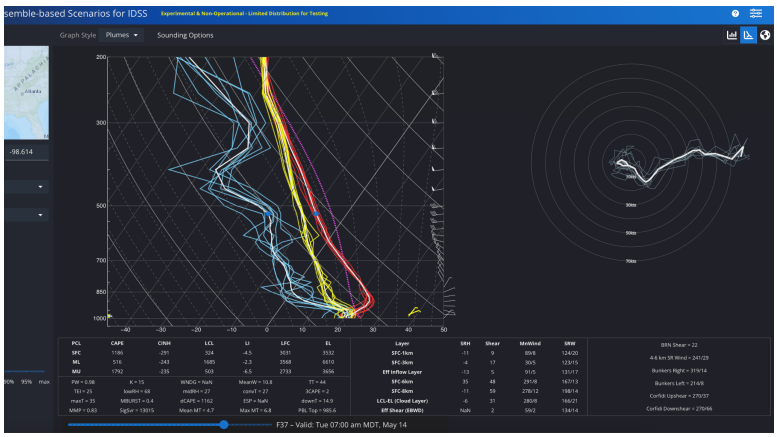

***Figure 4**. DESI Sounding Viewer*

Chicklet Chart

As reported by participants, DESI's chicklet chart (Figure 5) provides a fast and efficient way for forecasters to identify outlier runs in the forecast as well as for determining onset and cessation of anticipated weather conditions. The chart provides a timeline for weather variables occurring across multiple ensemble members. Participants reported using this viewing option most frequently for precipitation and wind, as well as for longer-range forecasts (e.g., LREF). One specific recommendation provided by a participant includes adjusting the "binning" of the histogram to narrow and widen as needed so that users can see how many models are below or above certain impact-based thresholds (e.g., below freezing, for example).

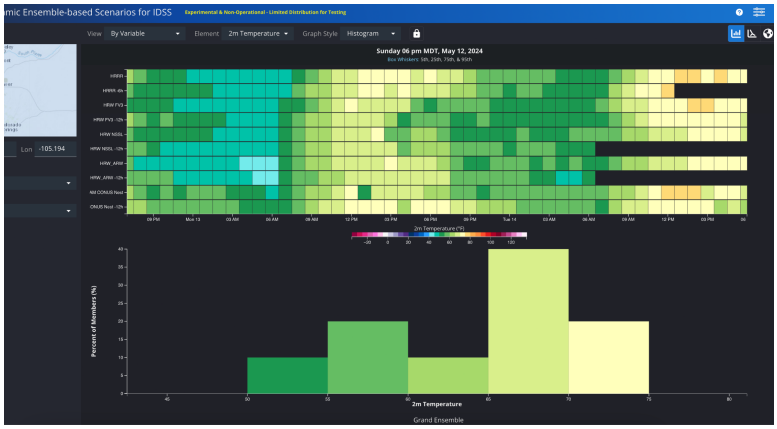

***Figure 5**. DESI Chicklet Chart*

Clusters

The clusters feature within DESI groups multiple individual ensemble members into a set of distinct weather scenarios (Figure 6). When asked if they had used or currently use clusters within DESI, 27 out of 42 (64%) participants shared that they use this feature, though frequency of use varied. For example, some mentioned that their use of the analysis is hazard-dependent or based on the time of year. Thirteen (31%) responded that they do not use (or infrequently use) the cluster feature within DESI, explaining that they either receive this information elsewhere (e.g., Weather Prediction Center) or that they would need to explore this feature

within DESI more to potentially use it. Two participants explained that the cluster analysis feature was not available to their office at the time of the interview. Three were not asked this question.

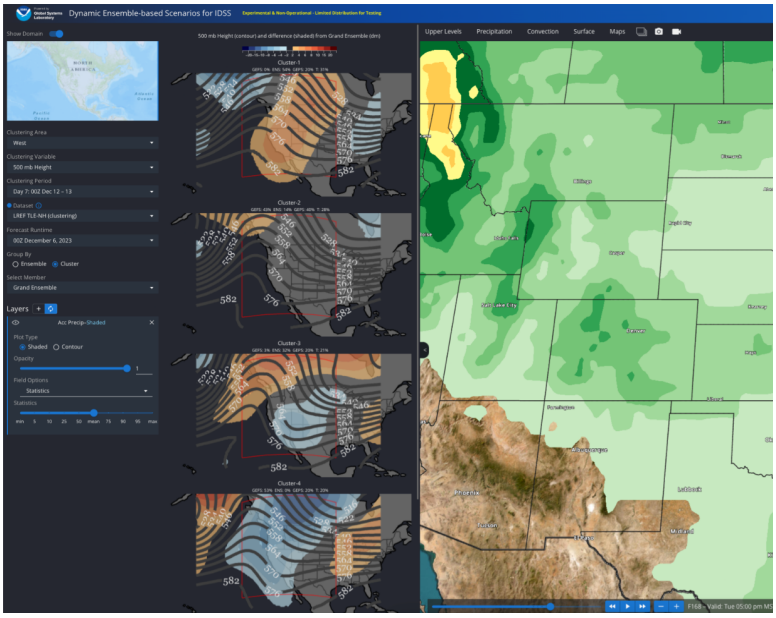

***Figure 6**. DESI Clusters*

Regarding *how* clusters are useful to those who frequently or semi-frequently use this feature within DESI, some shared that it is one of the main reasons that they use DESI in that it is helpful for relaying forecast information internally as well as for establishing situational awareness. Other reasons included that it enables users to "separate out the noise" and identify outliers in conjunction with other tools; that it provides users with a range of possible outcomes; and how it aids decision support by providing additional context that can be relayed to partners. Recommendations for other variables that participants would like to cluster on included sea level pressure, temperature (e.g., 850 millibar), QPF, and surface pressure.

Joint Probabilities

We also asked 35 participants about their familiarity with and use of DESI's joint probabilities feature. Many shared that they had not heard of joint probabilities within DESI or had heard but were unfamiliar with the feature. Roughly half (n=18, 51%) responded that they do use DESI's joint probabilities, while several who responded "no" mentioned that they would like to become more familiar with it and/or could see its potential utility. There were four main weather combinations that participants saw a use case for joint probabilities: (1) CAPE and Shear, (2) Snow and Wind, (3) Temperature and Precipitation, and (4) Relative Humidity and Wind. This indicates the utility of the joint probabilities feature for forecasting severe weather, blowing snow, precipitation type, and fire weather. As one meteorologist from the Eastern Region explained, "*[i]n the past, you're kind of looking at pieces of data here and there and trying to fit them together. One thing I really do like about DESI is that being able to look at those joint probabilities kind of helps…bring that together*."

Product-Specific Feedback

In the next section of the interview guide, we asked participants to describe the usefulness of four DESI products: (1) the statistics product; (2) spread product; (3) probability of exceedance product; (4) timing product; and (5) paintballs product. Specifically, we asked them to indicate if the products were useful for understanding and producing a forecast *and* in terms of communicating forecasts. In each of the following paragraphs, we highlight findings based on participants' responses.

Statistics

Evaluation participants conveyed that DESI's statistics product (Figure 7) is one of the most useful and frequently used products within DESI, with a majority of interviewees (n=34/42, 81%) describing it as *useful* or *very useful* in their forecasting and forecast communication roles. Explanations as to why this product is so useful centered primarily around participants' ability to view and assess reasonable "best" and "worst" case scenarios and that the product provides a range of useful information based upon given percentiles (e.g., 10th, 90th, mean). Some characterized the statistics product's utility in being able to "slice and dice" weather information and providing necessary context for decision support. One SOO from the Eastern Region shared, *"that's [the statistics product] usually the one that I will start with. Just to kind of give me a quick, a quick and dirty look at, you know well I guess it's the mean that comes up by default. And then I can adjust based on that. So yeah, I'd say that's extremely useful."* They went on to explain:

> *Maybe I want to look at the 10th, 25th, 75th or 90th percentile and see kind of like what the worst case scenarios are. And this statistics option easily allows me to just move that slider bar wherever I want and then have it dynamically update. And it's super fast, runs great, and I can pretty quickly ascertain, you know, kind of the bounds of how good or bad that event might unfold.*

Another SOO from the Central Region described the utility of the statistics product from a customizability perspective:

> *I think obviously from the statistics standpoint, you can customize what your point of interest would be. So your threshold that you want to look at. And that's probably really the most important thing. Plus you can set your time, you can pick your period of time that you're looking for, and then you can obviously roll the time forward…I would say definitely this is one of the go-to's I would say for me.*

A small number (n=3, 7%) shared that the product was *somewhat* useful for particular variables (e.g., snowfall) or situational awareness purposes, and four interviewees shared that they have not used the statistics product or do not use it very often. Five participants (12%) had not used or were not very familiar with the product.

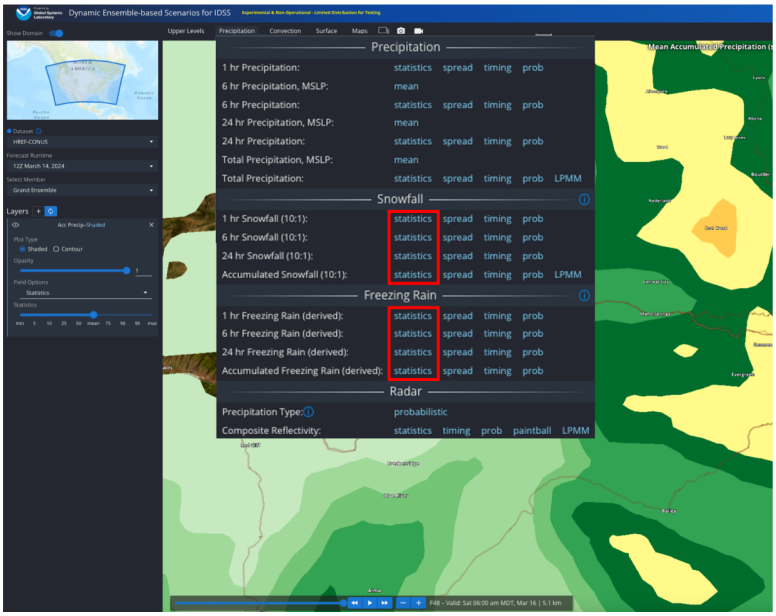

***Figure 7**. DESI Statistics Product*

Spread

Responses regarding the usefulness of the spread product (Figure 8) within DESI showed that a majority of respondents (n=27/41, 66%) either have not used or do not use the spread product often, especially for public communication. Some of the explanations as to why forecasters have not used or infrequently use this product included that they do not have confidence interpreting and incorporating the product into their forecast and communication workflows and that they would need to become more familiar with it to be able to interpret it and apply it confidently. Eleven participants (27%) mentioned that the spread product was either very, moderately, or somewhat useful - particularly for internal decision-making, situational awareness, and identifying where uncertainty is greatest in a given area (less so for public communication). Three participants (7%) mentioned that the product is not useful, with one explaining that "*I just don't understand what it means. I keep reading, and I don't understand*."

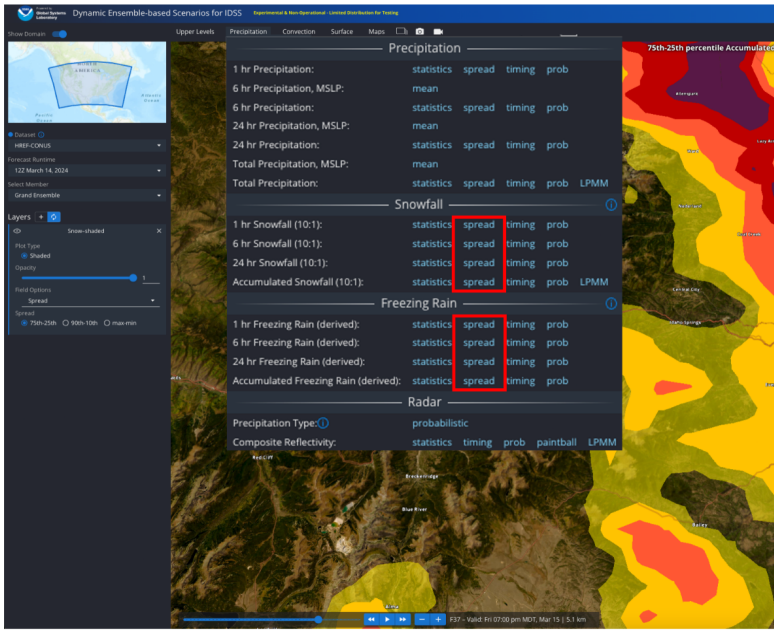

***Figure 8**. DESI Spread Product*

Probability of Exceedance

Participants shared overwhelmingly positive feedback on the probability of exceedance product (Figure 9), with a stark majority (n=39/42, 93%) sharing that the product is useful or very useful for forecast creation, situational awareness, and external communication.

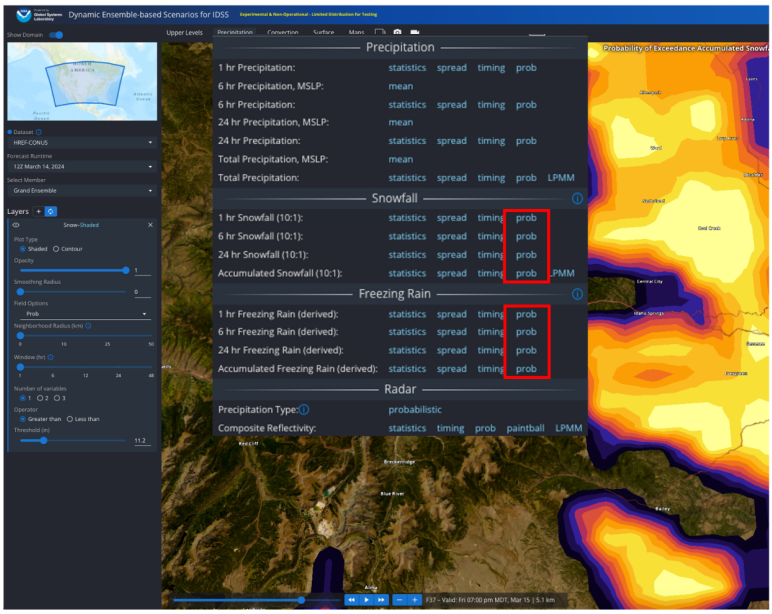

***Figure 9**. DESI Probability of Exceedance Product*

Several mentioned that it is extremely valuable to them in their role, with some referring to it as their “go-to” or most useful tool within DESI, especially for supporting DSS threshold needs and useful more generally in terms of data interrogation and communication capabilities. No interviewees indicated that it was not useful. Three reported that they had not used the

product, though they indicated that it seems like it *could* be useful. The following quotes illustrate the utility and value of the Probability of Exceedance to participants (bolded for emphasis):

Communication with the Public

> *I like this one a lot.* ***It's probably the one I lean on the most.*** *And I think it is the one that we have communicated with partners and the public… So I think as far as messaging and applying like the most information.. getting the most bang out of your buck, I find [that] the* ***probability [of exceedance] is, is usually my go to tool out of DESI****.* – Meteorologist, Eastern Region

> *[Probability of exceedance] is my favorite I think partly because it's most often the one that we get, like our social media interaction with the most.* ***And it's the easiest for me to communicate to certain people****… I can say, oh, yeah, you know, the probability is around this, and I'll be able to like, integrate that into my forecast discussion, and then I'll also be able to integrate it into the forecast grids as well. So yeah, that's probably.. the one that I gravitate towards the most.* – Meteorologist/IMET, Western Region

Customizability

> *..this is one that I am generating stuff out of it all the time, to be honest with you.* ***And I love the fact that I can pick whatever value I want.*** *That's one of the things that I find super helpful, because a lot of the time, the tools that we've had in the past, they would set those values for you. They would give you, okay, 1, 2, 3, 4, whatever, inches, and you were kind of beholding to those.* ***And now I can literally grab whatever probability or whatever amount that I choose and get a probability for it****. So if I've got a user that says, "Hey, four inches of snow is what's important to me," I can go straight there and I can grab it. If it's two inches, I can grab it. If it's some oddball value, two and a half inches, I can grab it.* – Meteorologist, Central Region

We then asked participants if they would like to see an alternate color scheme for the Probability of Exceedance product, with two-thirds (n=25/38, 66%) responding that they would like to see an alternate color scheme or customizable color options. Suggestions for alternate color schemes included particular color scales by hazard indicating intensity or amount (e.g., green for QPF, blue for snow, purple for freezing rain), clearer delineations between values based on shade or color type, and one suggested reducing the number of colors used altogether. Several urged for consistency and standardization across NWS products, regardless of what color scheme(s) are decided upon. At the same time, some participants acknowledged that there is not a “one-size-fits-all” approach to color schemes, arguing that use and interpretation of colors can be subjective - making the endeavor to settle on particular color schemes challenging.

Four participants responded ‘no’ to the follow-up question regarding alternate color schemes, and nine responded that they are either indifferent or would have to see alternatives to make that determination. As we will note here and elsewhere in the report, a couple of participants self-disclosed that they are color-blind, which should be a consideration for any color scheme changes that may occur.

Next, we asked a follow-up question about whether they would like the option of modifying probabilities within the Probability of Exceedance product. Twelve out of 30 (40%) participants responded “yes” and 10 (33%) responded “no”, with seven (23%) indicating that it might be useful to modify probabilities in some cases. One person shared a more philosophical consideration, suggesting that even if forecasters would like to modify probabilities, it may not be the appropriate thing to do:

> *So I think sometimes, forecasters want to adjust, and maybe we can from a best guess perspective. But I think the probabilities are what they are. So I don't know if I answered that right, but it's something I've struggled with myself where, why are the model clusters or suites doing what they're doing? Is there something systematic, or is that really the spread, or is there anything we could remove? But the probabilities are what they are based on the modeling suite that we have. So I would say the answer is I think we want to, but I'm not sure we should.* – SOO, Central Region

Timing

Out of the four products we asked about in detail, responses from a majority of participants indicated that the timing product (Figure 10) was one of the least used both generally (e.g. for forecast creation, situational awareness) and specifically for communication. Out of 43 participants asked, 14 (33%) reported that the timing product was useful to them in their roles, while seven (16%) shared that it is somewhat useful - with caveats such as difficulty capturing timing information over mountainous terrain and that it is more useful for internal communications and situational awareness purposes, but not necessarily external communications. Four (9%) expressed that the timing product was not at all useful to them in their role, citing concerns about its utility for forecasting over mountainous terrain or that they have not figured out how to make it useful to them in their role. Eighteen participants (42%) either had not used the product at the time of the interview or used it rather infrequently.

Of those who did indicate that the timing product was useful or somewhat useful to them, they shared that it was either useful for particular purposes (e.g., aviation) or hazards (e.g., tropical cyclones, precipitation). Although some shared that they use the timing product to inform DSS briefings, they reported that it can be somewhat “clunky” to use and interpret. Importantly, updates to the timing product were made roughly halfway through data collection. Therefore, some earlier feedback may have been addressed following this update.

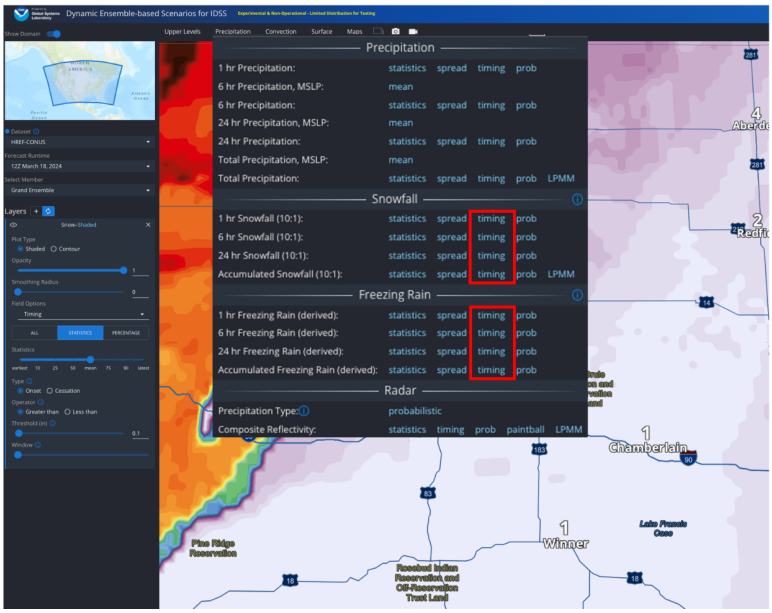

Figure 10. *DESI Timing Graphic*

Paintballs

The paintballs feature was the least used out of the aforementioned viewing and analysis features within DESI. This feature allows users to visualize individual members of the ensemble on a single map (Figure 11). Instead of visualizing spread or means across ensemble members, it illustrates areas where individual members hit a user defined threshold - appearing as “paintball splashes”. Of those asked, 15 participants reported using the paintballs feature, with 21 mentioning that they either did not use or rarely use this feature. Nine were not asked. Of those who indicated that they have not used the paintballs feature within DESI (as well as some who do use it), several reported using the Storm Prediction Center’s High-Resolution Ensemble Forecast (HREF) paintball plots. However, some expressed a desire or intent to use this feature within DESI in the future.

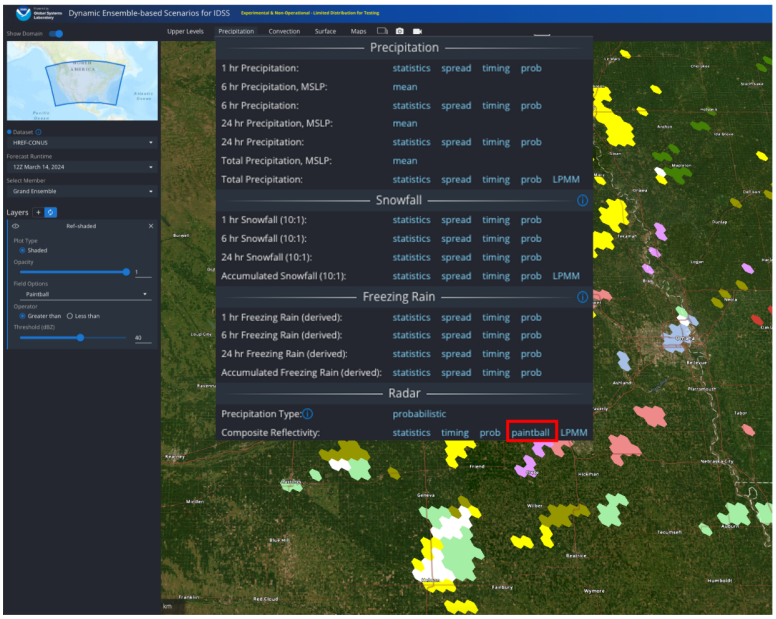

Figure 11. *DESI Paintballs*

DESI Graphics and Graphics Generator

In this section, we document high-level findings throughout interviews pertaining to DESI graphics feedback and the graphics generator.[5] Within the interview guide, we posed questions about the utility of DESI graphics and perceived functionality of the graphics generator, including what participants like (and do not like) about the current graphics, whether they use the graphics generator, and their thoughts on future graphics development.

Beginning with more general comments and themes pertaining to the DESI graphics, a large majority of participants see utility in the chart/table-based 1-D graphics available within DESI, with many reporting that it aided them in "filling voids" within their offices for creating probabilistic graphics. Specific examples of why and how these graphics filled gaps within their offices included their simple and modern design, that they were readily useful for social media dissemination (thus increasing efficiency), and that they provided actionable output. A central theme from the interview data regarding DESI graphics and their utility is that forecasters believed that they are visually appealing and easy to understand, making it easier to effectively communicate to their partners:

> *I think it's helping us for sure improve those connections and relationships with partners just because we can give them more data in a nice, clean, easily visualizable way. But also because we can communicate more effectively because we just have this more cohesive tool set where we can discuss the likelihood and timing and all the things we've discussed through this interview process with them leveraging the tools we're getting from it.* – Meteorologist, Southern Region

[5] Feedback pertaining to DESI graphics were embedded throughout the interviews, thus making it difficult to meaningfully quantify. However, the themes and examples presented here were derived directly from the data based upon their prevalence.

Some participants reported *not* using the graphics generated within DESI, or that they only use them in specific situations. For those who do not use DESI-generated graphics, several reported using GraphIDSS or that they use their own, WFO-specific template in which they may take a DESI-generated graphic, crop/edit, and incorporate it into existing templates. Additionally, WFOs may have different graphic needs depending on the hazard or weather variable, partners, and preferences - meaning that they may instead prefer in-house graphics that they can adjust based upon need. Finally, since the National Digital Forecast Database's (NDFD) official forecast and DESI data are different, there was reported reluctance among some interviewees to post a DESI graphic unless they can get one of the percentiles to match closely with the official forecast. This is largely a result of the inability to fully reconcile the deterministic and probabilistic systems both in operation.

Throughout the interviews, we asked participants to share their thoughts on the new, point-based graphics that - at the time of interviews - were either in development or had been recently released. Overwhelmingly, participants reported that they liked and/or saw value in the proposed/new point-based graphics (n=39/41, 95%), even if they had not yet had a chance to interact with them. Some provided additional thoughts and caveats, including that they would like the ability to tweak the graphics and values within them and that their use would depend on the intended purpose and audience.

Graphics Generator

Regarding the graphics generator, multiple participants reported that they have used or regularly use this DESI feature. For some NWS offices, the DESI Graphics Generator is the primary generator available to them, given that GraphIDSS does not work for them. Of those who do not, they mentioned using GraphIDSS or copy and pasting images for DSS briefings and other forms of external forecast communication. Multiple participants expressed that the ability to quickly generate and share graphics out of DESI using this feature has increased their workflow efficiency and ability to communicate with partners quickly. For example, one participant from a National Center expressed, *"[t]he DSS application and this feature you built into it too–wow! I mean, creating TV quality level videos on the fly, I mean that's just to me jaw-dropping. I wish I had this…years ago when I was doing briefings for the WFO."* A forecaster from the Southern Region echoed this sentiment, explaining:

> *That's, I think, where DESI really has utility is in that space. Because not only does it produce really nice graphics, it does it really fast. Especially in a rapidly evolving situation, you may not have the time to sit there and produce a graphic that takes 20 or 30 or 40 minutes to do yourself. But if DESI can do that in 20 or 30 seconds at most, that's a game-changer. So I think that that would be ways for the future that I'd love to see DESI used.*

An NWS meteorologist from the Central Region described how having this capability fills an important communication gap/inefficiency:

> *The most frustrating part is, and that was prior to some of this graphic generation stuff that's in there, is being able to see all this information but have no way to share it. And it would be so frustrating because it's like I want to find a way to get this out to you, to tell*

you and show you what I'm able to see, but I just couldn't do it. So I think this new step that DESI has is a huge step in that direction."

Essentially, as we heard from many participants, having a graphics generation process that does not require them to "*spend a bunch of time in PowerPoint"* is a welcomed advancement for their external communication duties.

Desired Changes to Graphics & Future Graphics Development

Toward the end of each interview, we asked participants if they had any desired changes to the graphics in DESI that they would like to share. Interestingly, there was minimal overlap between participants' responses, with the most frequently mentioned requests being a desire for either customizable or "improved" color scales and enabling the user to be able to control the font size of cities, points of interest, and numbers (though some of these items have now been addressed in subsequent DESI updates). Another request/identified need shared by some participants included the desire for default template setting or pre-canned graphics - often tied to a request for enabling default location settings within DESI. Other specific requests mentioned by participants included: adding highway labels, the ability to turn city/town overlays and other forms of Graphical Information System (GIS) data on and off, inclusion of radar imagery and radar loops, being able to round probabilities to the nearest whole, a mask for their County Warning Area (CWA), and enhanced video making and export capabilities. The evaluation team will work with the DESI Development team to provide more detailed excerpts regarding desired graphics changes, including those specific to video generation.

Forecaster Recommendations and Vision for DESI

Evaluation participants were asked explicitly to share their feedback and recommendations for how DESI could better meet their needs, as well as their vision for the future of DESI. Some of these recommendations are embedded throughout earlier sections of the report, but are re-emphasized here given their prominence in the data. This section of the report heavily utilizes direct quotes from participants to demonstrate alignment with overarching recommendations.

When asked about their future vision for DESI, one shared by several participants is the desire for DESI to become *the* all-in-one tool and unified weather service forecasting platform:

> *When it comes to a web-based model viewer or any sort of weather guidance viewer, I would like this to be a one-stop shop. Making the graphics that are useful for the public and just messaging our partners, things like that, I like that that's tied in here. But for me, just the best thing, if I wouldn't have to pull up another five websites to view other sort of post-process, probabilistic output or ensemble-based output, that would be cool."* – Meteorologist, Central Region

Some participants went a step further to suggest that DESI should be "AWIPS 3":

> *DESI is like what I think I want AWIPS to look like. You know, that sort of interrogation of the data that, you know, AWIPS [is] not built for … in the future, can [DESI] be everything?* – Meteorologist, National Center

> *Honestly, I would love to see it completely replace AWIPS, except for the warning portion of…our job. I think it's already replaced AWIPS in looking at model*

visualization…and then I would like to see it replace our graphic creation. – Meteorologist, Southern Region

I could view it as more of an AWIPS replacement, but I don't know where the investment is going to go. And so to me, it's like this all in one, but not serving anything fully type of thing. - National Center Participant

This NC participant later expanded on this statement to say:

Actually serving as a web-based AWIPS replacement makes a lot of sense to me. Now, whether you can transmit products and things like that, that's a whole other level. But definitely, just a one-stop shop for visualizing data rather than going to the disparate websites that WFOs are currently using.

As reported earlier, many participants would like to see continued development and refinement of DESI's graphic creation and dissemination capabilities.

I would like the tool to be equal in use as a forecasting tool and a communication tool. I think that expansion more so on like the type of messaging capabilities that come from DESI would be great. But in a perfect world, yeah, I'd be able to go to DESI almost all the time to be able to make a graphic. – Meteorologist, Southern Region

Especially in a rapidly evolving situation, you may not have the time to sit there and produce a graphic that takes 20 or 30 or 40 minutes to do yourself. But if DESI can do that in 20 or 30 seconds at most, that's a game-changer. So I think that that would be ways for the future that I'd love to see DESI used. – Meteorologist, Southern Region

One notable pain point participants shared was the frustration with having to fit probabilistic data into a deterministic Graphical Forecast Editor (GFE):

I think ultimately [DESI] needs to be something that is embedded within the actual GFE forecast because otherwise, it's just a tool. It doesn't necessarily become as useful as it could be. – Meteorologist, Eastern Region

In an ideal world, we wouldn't put out a deterministic forecast in AWIPS anymore, and the forecast [would] fall out of the probabilities and out of the probabilistic datasets that DESI…affords us to look at." – SOO, Eastern Region

For many, this disconnect speaks to the need for a unified forecast creation and watch/warning issuance system. More specifically, the ability to either bring DESI into AWIPS or export DESI outputs into the forecast grid, and/or bring the National Digital Forecast Database into DESI to allow for graphical creation of the official forecast.

Notable overarching recommendations shared by interviewees included continued graphics refinement and color scale development. As indicated earlier in the report, several participants mentioned a desire for pre-canned or pre-created graphics that they can readily use and edit as needed. Other specific recommendations mentioned by two or more participants included the desire for presets based upon login, including the ability to have templates unique to their WFO/forecasting entity; improving data latency issues and incorporation of wave data (e.g., wave height), additional sounding parameters such as front point and relative humidity over ice, and fire weather variables.

Conclusion

This evaluation marked the first of its kind in systematically assessing the use and utility of DESI from NWS meteorologist perspectives.[6] Although its development has been informed by researchers with operational forecasting experience and informal feedback provided by end-users, the purpose of this evaluation was to gather systematic, user-centered insights to assess: (1) DESI familiarity and use among NWS forecasters; (2) DESI's impact on forecaster workflow, communication, and confidence; (3) the utility of DESI products and features; (4) overarching feedback on DESI graphics and graphics generator, and (5) forecaster recommendations and future vision(s) for DESI.

Through this evaluation, we are now able to better comprehend the *value* that DESI provides to our partners, as well as ways we can continue to develop DESI with end users in mind. Evaluation findings and recommendations have already informed multiple DESI releases (see Appendix D) and will contribute to the development of NWS Viz, along with current and future products developed within GSL. GSL will continue to maintain a non-operational version of DESI for visualization and model development. As it relates to NWS Viz development, a central, participant-derived recommendation from this evaluation includes the need to maintain the speed, intuitiveness, and efficiency for ensemble interrogation.

Findings will also establish a baseline understanding of meteorologists' operational workflows during and outside times of extreme weather and how meteorologists formulate, package, and communicate probabilistic weather information to their core partners and the public (manuscripts in preparation). In all, findings from this evaluation demonstrate the value of DESI, along with insights that demonstrate support for GSL and NWS's development efforts concerning DESI, NWS Viz, IDSS Engine, and NWS Connect.

[6] Forty-four of the 45 participants worked within the NWS, with one participant external to the NWS but still within the federal government.

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Appendix A. Study Introduction and Recruitment Emails

Email to STID Chiefs:

Hello _____,

My name is Cole Vaughn. I work as a research social scientist for NOAA's Global Systems Laboratory (GSL). I am currently leading an evaluation of one of our tools under development– DESI (Dynamic Ensemble-based Scenarios for IDSS). We are wanting to gather feedback from NWS forecasters on the role DESI is playing in their offices and their daily workflow, as well as understand their future hopes for DESI. I am reaching out to you to request permission to contact the WCMs and SOOs from some of the WFOs in your region. I would like to see if they have any forecasters who would be interested in participating in this work. I also want to be respectful of the burden and workload that WFOs and their individual forecasters are experiencing, and thus wanted to make sure I went through the proper communication channels before beginning to recruit forecasters. My hope is to recruit between 2 and 10 people per forecast region.

Please let me know if this would be a possibility in your region and if so, how you would like to proceed going forward. Again, I want to be mindful of the work already placed on forecasters and want to make sure that we proceed with as little of a burden as possible on forecasters and the WFOs.

Thank you,

Cole Vaughn

Email to WCMs/SOOs:

Hello _____,

My name is Cole Vaughn. I work as a research social scientist for NOAA's Global Systems Laboratory (GSL). I am currently leading an evaluation of one of our tools under development– DESI (Dynamic Ensemble-based Scenarios for IDSS). We are wanting to gather feedback from NWS forecasters on the role DESI is playing in their offices and their daily workflow, as well as understand their future hopes for DESI. I am reaching out to you to see if there are any forecasters in your office (including yourself) who would be interested in participating. I'm looking for two forecasters that would be available for a 45 minute to 1 hour long interview each. I want to be mindful of the workload already being managed by your office and individual forecasters. So if participating in this research is not possible right now, we completely understand and can instead keep you in mind for future projects if you would like. However, if

this is something that your office has the capacity to participate in, please feel free to let me know. If so, would you be able to provide me with contact information for a couple of the forecasters in your office who would be interested in participating?

Thank you for your time and consideration. If you have any questions, please feel free to reach out to me by replying to this email.

Cole Vaughn

Email to Potential Participants:

Hello _____,

My name is Cole Vaughn. I work as a research social scientist for NOAA's Global Systems Laboratory (GSL) where we develop some of the computer models and decision support systems used by the National Weather Service.

I am currently leading an evaluation of the "Dynamic Ensemble-based Scenarios for IDSS" or "DESI" for short. This tool may be familiar to you. We are wanting to gather feedback from NWS meteorologists on the role DESI is playing in their offices and their daily workflow, as well as understand their future hopes for DESI. I am reaching out to you to request your participation in this evaluation. I have reached out to the WCM and SOO at WFO ___ and you were recommended as someone we should speak to.

We are hoping to conduct an interview with participants to gather feedback. The interview will be approximately an hour. If you would like to participate, please let us know by replying to this email.

Thank you for your time and consideration. If you have any questions, please feel free to reach out. I look forward to hearing from you!

Cole Vaughn

Appendix B. Interview Guide

Introductory Questions

1. Could you please briefly describe your position within your office, including your core activities and responsibilities?
    a. Who are the partners or people who rely on you for decision making? You don't have to mention them by name, but can you describe them?
2. Do you use DESI in your day-to-day work?
    a. [*If yes,*] how often do you use DESI?
    b. [*If yes,*] roughly when did you start using DESI?
    c. [*If no,*] why not?
    d. [If no,] are there particular occasions that you have used or would use DESI?
3. Has DESI been promoted within your office?
    a. [*If so*] how? Training?
    b. [*If so*] by whom?

Next, we would like to understand your typical workflow when you are on shift, both during a "typical" shift and one where you are monitoring potential extreme weather conditions. We will then ask how, if at all, DESI fits or could fit within your workflows.

Work-flow Questions

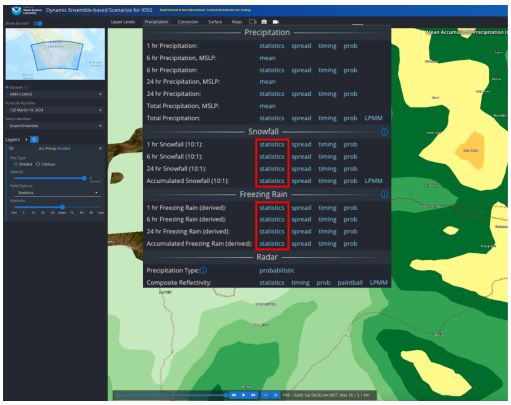
4. Can you describe your typical workflow for me when you are on shift when extreme weather is not in the forecast? (Probably going to be different answers depending on the shift/role)
    a. How does this change when extreme weather is in the forecast?
5. When thinking about your typical workflow, where do you employ DESI (or where could you employ DESI? - needs some wordsmithing)
6. Has DESI changed your workflow? If so, how?
7. [*For those who have not used DESI, but may be familiar with it*], do you see yourself incorporating DESI into your workflow? Why or why not?
8. In what aspects of your job do you rely on DESI the most?
9. Does DESI reduce the number of tools you have to use or websites you have to visit, or do you use it in addition to the other stuff you used before?
10. How do you typically communicate uncertainty? (Prompt: does this vary by hazard/who you are communicating to?)
    a. Do you use probabilistic information to do so?
    b. [*If so*] What type of probabilistic information do you use and when?
11. Do you use DESI more for certain hazards and less for others? Explain.

The next set of questions dig more deeply into how you use DESI. [For those who do not use DESI or are not very familiar, skip to section on communicating risk - we can refine questions so that they can be used regardless.]

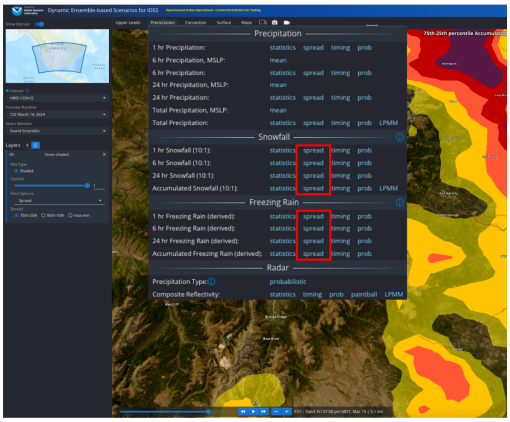
Analyzing Weather Variables in DESI

12. What weather variables do you primarily use DESI to analyze?
    a. Does this change between map view and 1-D view?
13. [*Ask for each product that follows*] How useful is this product in DESI? How useful is this product for communicating the forecast message to your partners and the public?

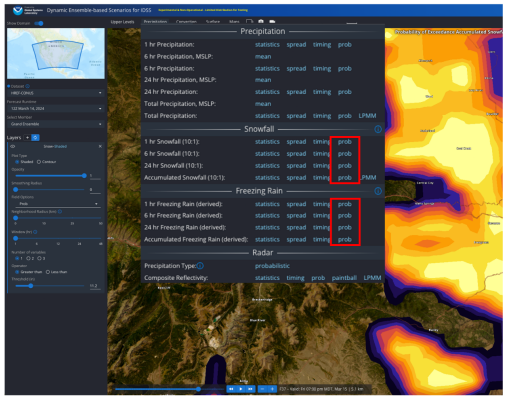
Statistics



Spread

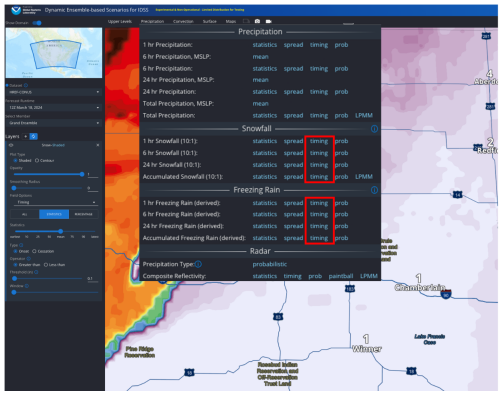


Probability



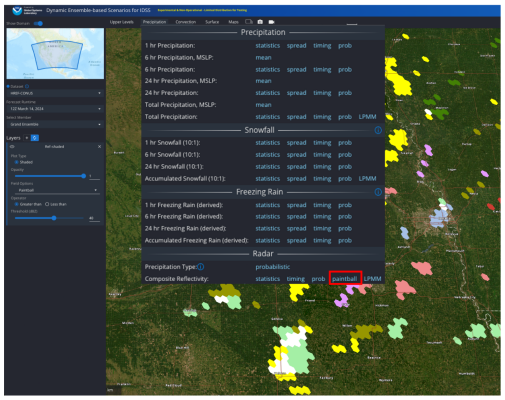
- [Prompt] Would this alternative color scheme make this product more usable?

Timing

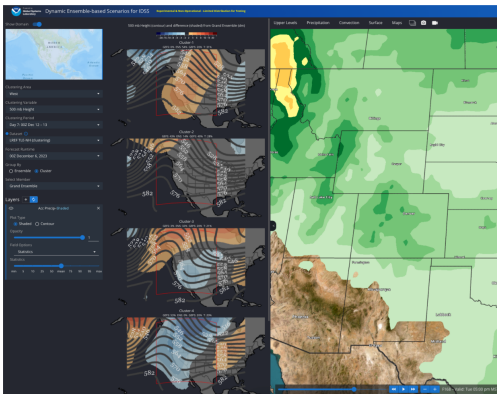


- Do you use the onset or cessation function the most?
- What are some of the difficulties you experience with using this specific product?
- [Prompt] Would this alternative color scheme make this product more usable?
- [Prompt] Do you prefer a 2-d view of timing (onset, cessation) or do you prefer a 1-d view of that information? Why?

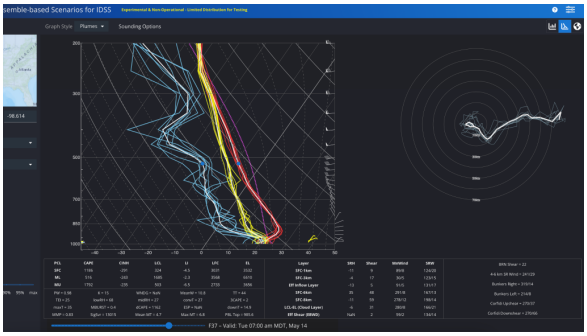
Paintballs



Cluster analysis

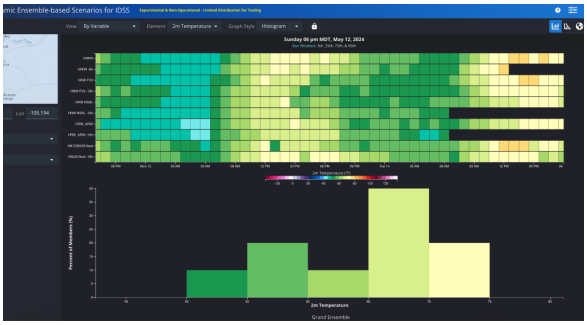


Sounding Viewer



a. When do you use the sounding viewer?
    - Do you prefer this sounding viewer or another that you've used previously? Why?

Chicklet Chart



14. What joint probabilities, if any, do you look at when informing or creating a forecast?
    - [If none] Why don't you use them? (Not applicable, or didn't know they exist)

DESI Impact on Forecast and Communication Confidence

15. How, if at all, has DESI changed your confidence in creating and/or communicating a forecast?
    a. {if so} What makes you feel more confident?

- Why do you think “that” makes you feel more confident?

Communicating the Forecast with DESI

16. How, if at all, has DESI affected the way you communicate with your partners?
17. How well do you think core partners (the public) understand probabilistic forecast information?
    a. What types or formats of probabilistic forecast information do you think partners (and the public) understand well?
    b. Do you think that graphics made in DESI are digestible and understood by the public?
18. Think about the defined percentile ranges you use when communicating a range of possible precipitation totals. We often hear that offices use the 10th to 90th percentile range as the reasonable minimum and maximum of the forecast. (Phil’s Question)

    Can you think of a time when you or your office was pretty confident that the event was going to fall outside of that range—making it an outlier event? [Yes or No]
    [if yes] How did you message that event? Probabilities?
    [if no] Imagine if that situation were to exist. How would you message that event? [Prompt]-what kind of challenges did you face with it?

Evaluative Questions

19. Where is DESI struggling to meet your needs the most right now?
    a. Related to these... what parameters would you like to see added to DESI (e.g., IVT vectors)?
    b. And... what geographic overlays would you like to see added to DESI (e.g., DSS events)
20. What recommendations do you have for improving DESI to meet your needs within the next year?
    a. Where would you like to see the tool in 5 years?
21. How do you *want* to use this tool–This may require adding additional functionality, but how do you want to be able to use this tool?
22. How does DESI compare to other tools for probabilistic ensemble guidance? (e.g., HREF, NBM, Ensembles on proprietary apps)
    a. How does the DESI Graphics Generator, specifically, compare to other ways you create graphics? [*Prompt*] What do you like about the current graphics? Thoughts on future graphics/graphic capabilities? Do you use the videos? Why?
23. Would a mobile version of DESI be beneficial? Why?

Appendix C. Study Overview & Consent Language

Study Summary

This study is a part of a broader and ongoing effort to understand how probabilistic forecast information is being used by both experts and laypeople. This project is being conducted by NOAA's Global Systems Laboratory (GSL) which specializes in developing computer systems and tools to help forecast and visualize the weather forecast. GSL has developed a tool called DESI (Dynamic Ensemble-based Scenarios for IDSS) which provides visualization of ensemble weather model data, displaying a variety of statistics related to the weather forecast. This tool has the potential to impact the forecasting process from generation with the forecaster to reception by the forecast consumer. The tool can impact the forecast, forecaster confidence, decision making, communication, etc. The Social and Behavioral Science Branch at GSL is leading this evaluation to better understand these impacts that DESI may be having. Given your role as an NWS forecaster we have sought your participation in this study to understand your job responsibilities, usage of probabilistic information, usage of DESI, and future hopes for DESI. Findings from this study will be used to make improvements to DESI and afford us a better understanding of your needs as an NWS meteorologist.

Consent of Participants

The purpose of this interview is to contribute to an evaluation aimed at understanding the usage and future of DESI amongst NWS meteorologists.

This interview will help us better understand how the tool is impacting workflow, forecasting, decision-making, and communication. **The interview will take approximately 45-minutes to an hour.** There are not necessarily right or wrong answers to the questions you will be asked, we are predominantly interested in your opinion and your perspectives. If you do not know the answer to a question, please let us know. If you have any questions or need clarification throughout this interview, please feel free to ask. **Please know your participation is completely voluntary, and you can withdraw at any time without any effect to you.**

This interview will be recorded and transcribed. Are you okay with us doing this?

The end result of this evaluation may include a written report or white paper, presentation(s), and/or publication(s). We will not include your name or organization, and your survey and interview data will be de-identified and stored in a secure drive only available to the evaluation team. Your deidentified data may be used to inform future research projects, publications, and presentations, and may be published in a data repository in compliance with upcoming open-data policy from the Office of Science and Technology Integration.

Despite these steps to protect your privacy and confidentiality and given our employment with a federal agency, any information collected through this interview is subject to a Freedom of Information Act (FOIA) request. FOIA provides the public the right to access federal government records in order to keep the public aware of the government's activities and to promote governmental integrity. However, even in the event of a FOIA request,

the research team will do everything within its power to avoid releasing information that could reveal the identities of the participants in this study. If you have any questions please feel free to reach out to Cole Vaughn at cole.vaughn@noaa.gov or Jamie Vickery at jamie.vickery@noaa.gov.

We thank you for your interest and willingness to participate in this study!

Privacy Act Statement

(Record Meetings and Training Sessions)

Authority: The collection of this information is authorized under 5 U.S.C. 301(Departmental regulations), 5 USC 552a (Records maintained on individuals); 15 U.S.C. 1512 (Powers and duties of Department), and 44 U.S.C. 2904 (General responsibilities for records management).

Purpose: Individual's permission is required for use of photographs, video, transcriptions and audio in any format, used for communications, outreach, interviews, and dissemination of mission products intended to promote an awareness and appreciation of the environment and NOAA's science, service and stewardship roles.

Routine Uses: The information is used for the purpose set forth above and may be: forwarded to another NOAA or non-NOAA user social media account; shared among NOAA staff for work-related purposes. Photographs, videos, audio recordings may be shared externally and displayed on NOAA websites and social media platforms, and as part of physical displays/exhibits. Disclosure of this information is permitted under the Privacy Act of 1974 (5 U.S.C. Section 552a) to be shared among Department staff for work-related purposes. Disclosure of this information is also subject to all of the published routine uses as identified in the Privacy Act System of Records Notice DEPT-18, Employees Personnel Files Not Covered by Notices of Other Agencies.

Disclosure: Voluntary; by joining and participating in the meeting consent is being given to the recording.

Appendix D. Evaluation-informed DESI Changes

Findings and recommendations from the DESI evaluation informed - and continue to inform - DESI releases. Specifically, since the beginning of this evaluation, results have influenced changes to the DESI timing graphics, color schemes, and basemap options as well as the inclusion of additional meteorological variables and datasets. A bulleted overview of these changes, along with visuals, are provided below.

Timing Graphic changes

- Changed time of onset/cessation instead of hours from model initialization (ex: “Fri, Mar 6” instead of “T+36 hrs”)
- Simplified colors from a complex rainbow to neutral, tame, and not directly associated with a specific forecast variable (see Figures D1 and D2)
    - *Multiple colorblind-friendly options were tested before settling on the current blue to yellow gradient found in DESI.*
- Added user definable binning of colors when shading the timing graphic (3 hour bins, 6 hrs, 12 hrs, etc)
- Added “smoothing” option (see Figures D1 vs. D2)

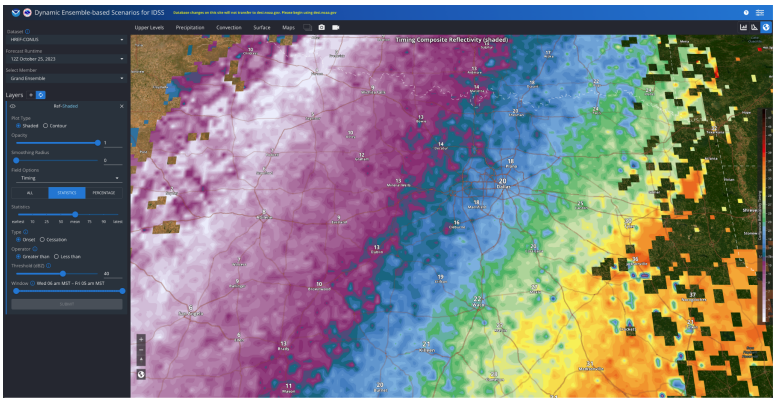


Figure D1. Original DESI Timing Display

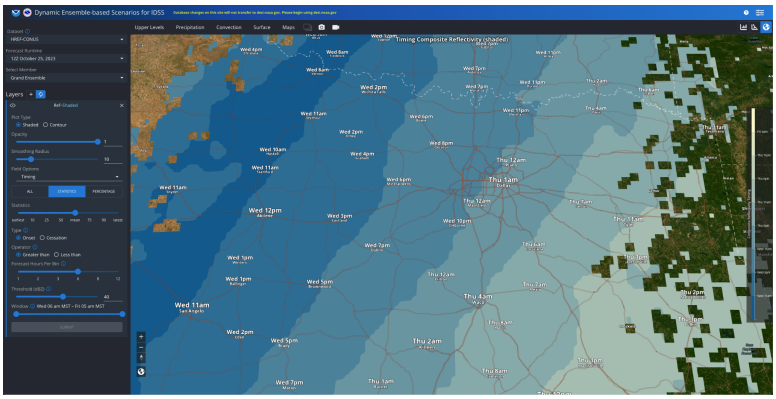


Figure D2. Updated DESI Timing Display

Color Tables

- Updated the color tables for multiple weather variables to match NWS standards to better align with the variable being communicated as well as to meet accessibility needs (see Figures D3 and D4)
    - Updated variables include: temperature, dew point, precipitable water, low/mid/high cloud cover, vertically integrated smoke, etc.

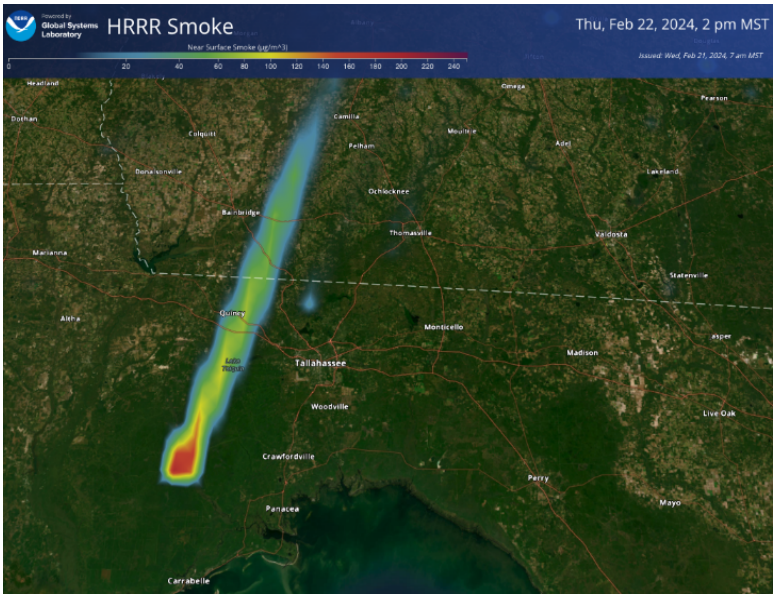


Figure D3. Example of Original Color Tables

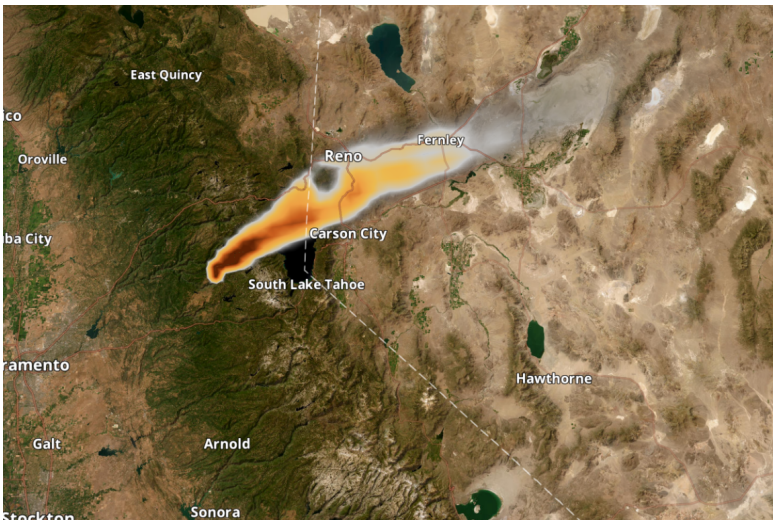


Figure D4. Example of Updated Color Tables

Basemap Options

- Added two new “simplified” basemap options for graphics creation (see Figures D5 and D6)

- Many default ESRI basemaps make it difficult to see road networks when combined with complex weather data layers. Other maps add noisy backgrounds that further complicate comprehension.

Figure D5. Updated Basemap Option Ex. 1 with Road Networks

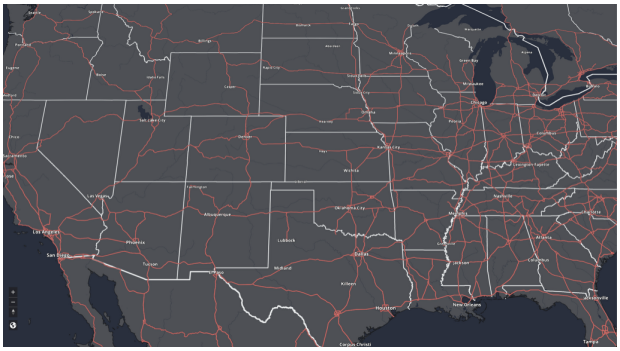


Figure D6. Updated Basemap Option Ex. 2 with Road Networks

Added Datasets and Other Functionalities

- Wave data
- Enhanced Bookmarking
  - Save current displayed area
  - Save displayed variables
- Climatology plots
- SPC outlooks
- P-surge hurricane product
- Enhanced Graphics
- Height above ground level incorporated into Sounding Viewer
- Changed font size of cities to make it more visually appealing and easier to read