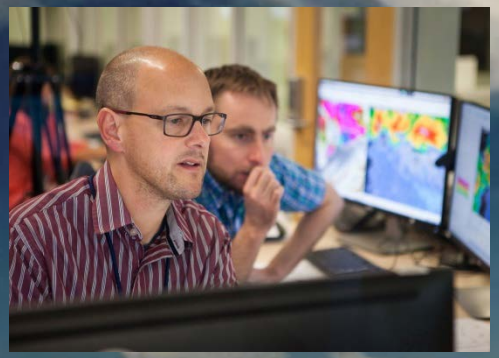
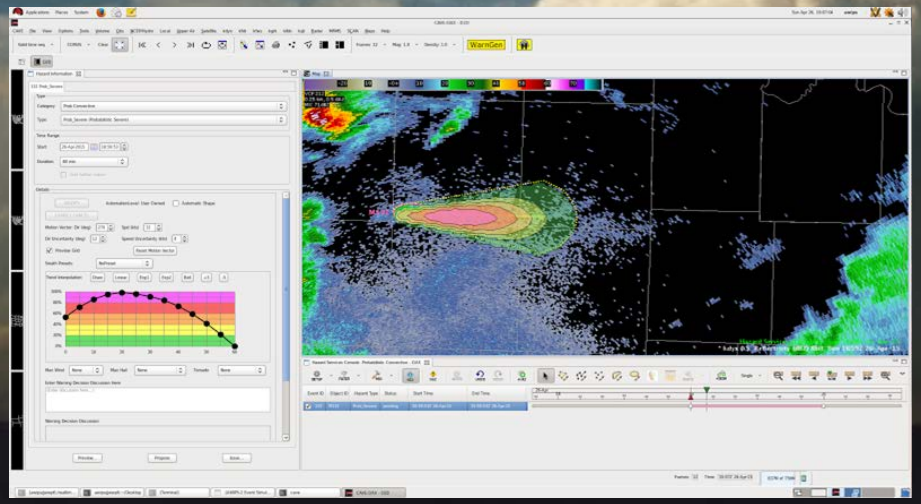




Hazard Services-Probabilistic Hazard Information (HS-PHI)

THREE YEARS OF EXPERIMENTS IN THE HWT

Greg Stumpf
CIMMS / NWS-MDL, Norman, OK
Tracy L. Hansen
ESRL / GSD, Boulder, CO

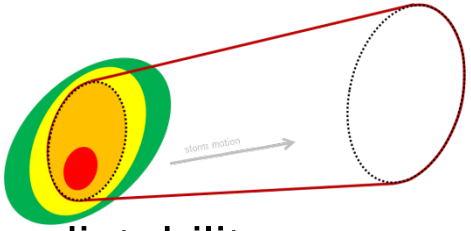
With: Alyssa Bates, Chris Golden, Yujun Guo, Joe James, Darrel Kingfield, Jim LaDue, Chen Ling, Kevin Manross, Tiffany Meyer

BACKGROUND: FACETs and PHI

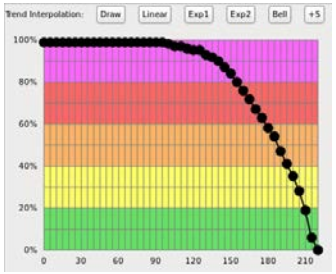
- Forecasting A Continuum of Environmental Threats (FACETs)
  - A next-generation severe weather watch and warning framework that is modern, flexible, and designed to communicate clear and simple hazardous weather information to serve the public.
- Probabilistic Hazard Information (PHI)
  - Rapidly-updating probabilistic hazard grids.
  - PHI can be used to provide custom user-specific products that can be tailored to adapt to a variety of needs – for example, providing longer lead times, at lower confidence, for more vulnerable populations with a lower tolerance for risk.

Warnings versus PHI

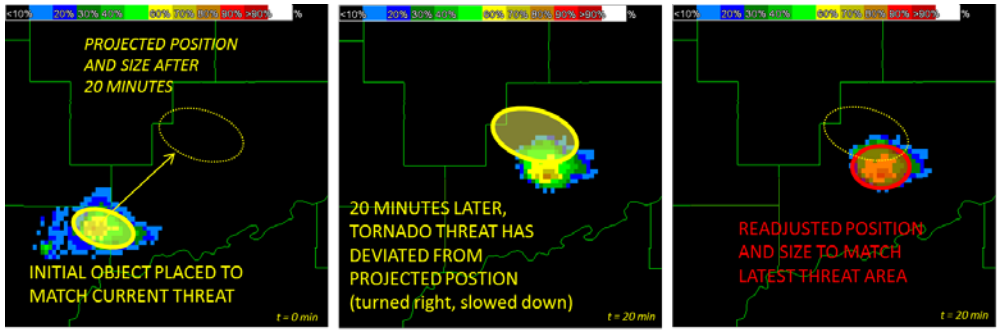
- Track areas, not points or lines.
- Uses motion uncertainty (swath width)



- Addition of probabilistic trend, with limit of predictability (0% or background prob)
  - Durations can exceed typical warning durations for long-tracked events.



- Define and edit object attributes - WE DON'T EDIT GRIDS
  - Threat area location at time=0, motion vector, motion uncertainty, duration, forecast probability trend
- Nudging objects
  - Replaces SVS process
  - Threats-In-Motion (TIM)



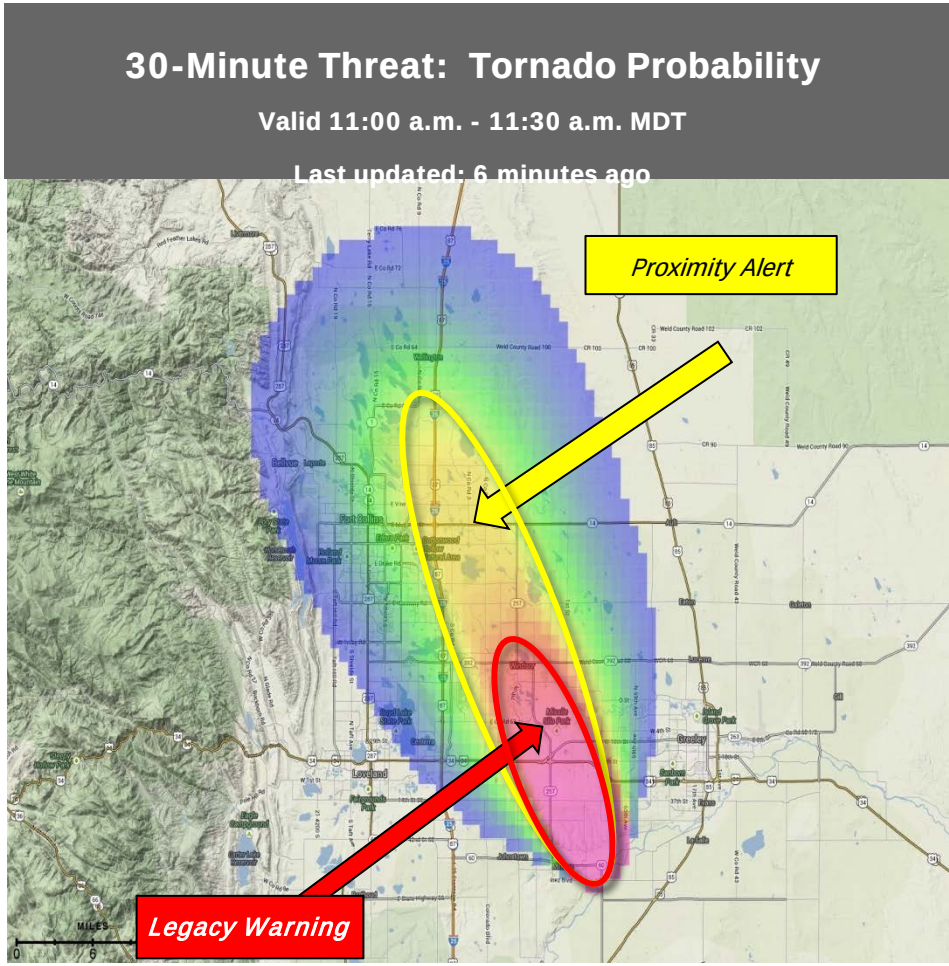
Adaptive warnings from PHI

Evolution from product-centric to information-centric paradigm:

Probabilistic Hazard Information (PHI): forecasters convey threat probability on grids using a new threat management tool.

Legacy products (warnings/watches) result from pre-determined thresholds (probability and/or time of arrival) applied to binary decision-making.

Opens the door for new products and services – such as low-probability longer lead time warnings for high risk users who have greater tolerance to high false alarm ratios.

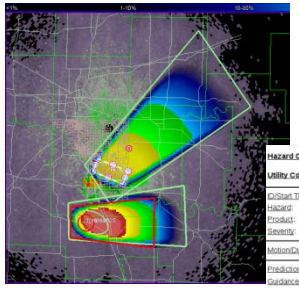


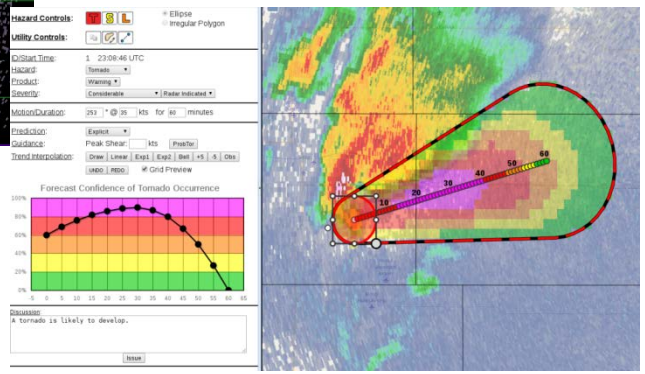
PHI Evaluation History in the Hazardous Weather Testbed (HWT)

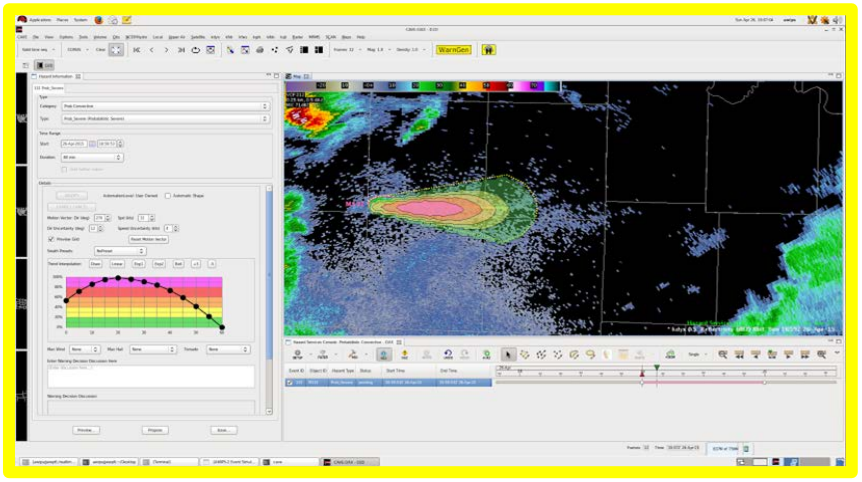
PHI Tool Evolution:

- First NSSL PHI prototype tests using Warning Decision Support System II (WDSSII), tested in 2007, 2008.

- Second modern NSSL PHI Prototype using a web browser-based design, tested in 2014, 2015, 2016, 2017.
  - Look and feel based on AWIPS2 Hazard Services
  - Integrated user component with Emergency Managers and TV broadcasters using the Enhanced Data Display (EDD) to display custom products derived from PHI.







- **USWRP Grant:** Developed initial capability in AWIPS2 experimental Hazard Services – PHI (HS-PHI) using PHI Prototype as a guide, tested in 2016-2018.

Hazard Services: Unifying Legacy Applications

WarnGen

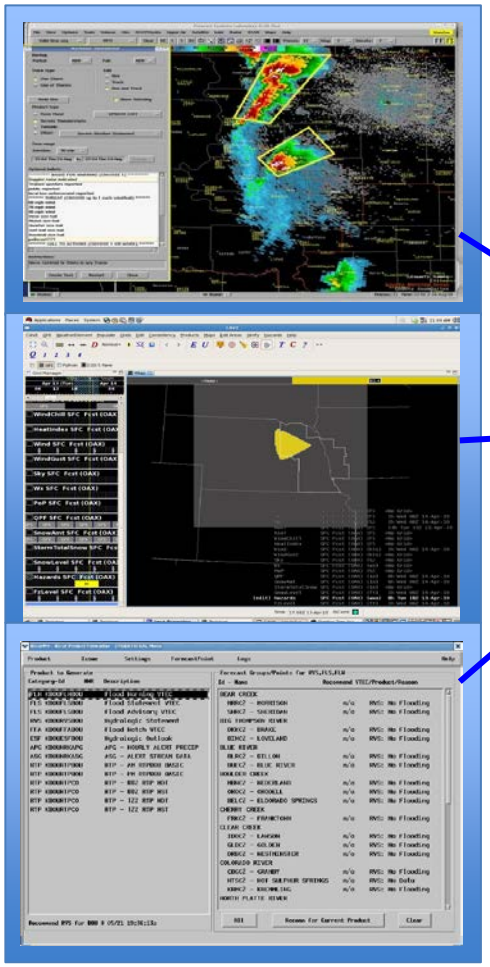
(<1 hour)

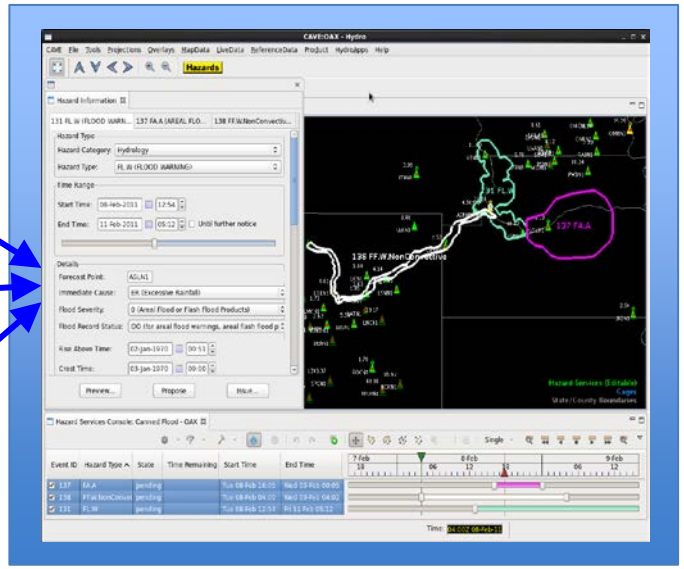
Graphical Hazard Generator

(Hours, Days)

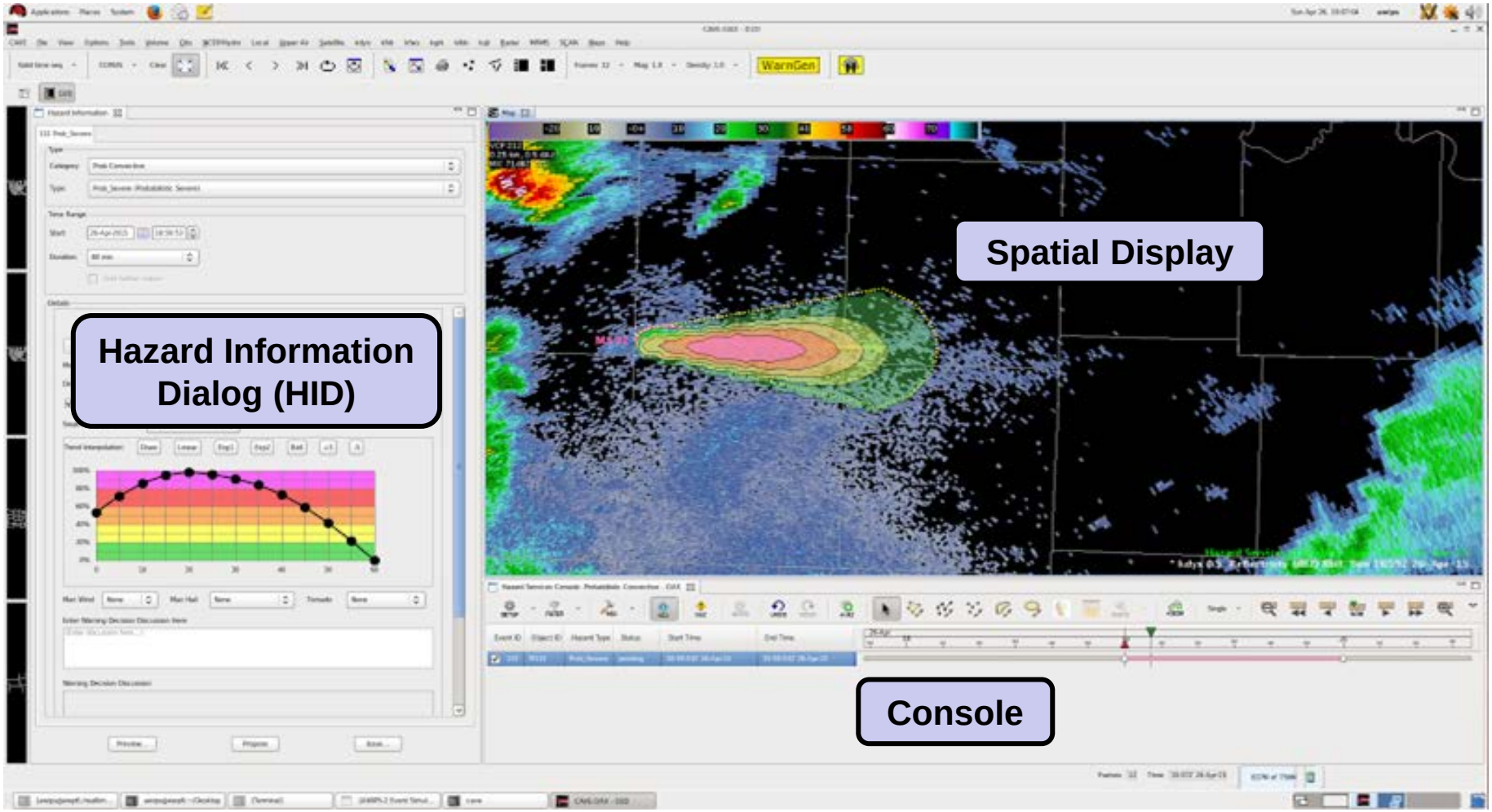
RiverPro

(Days)

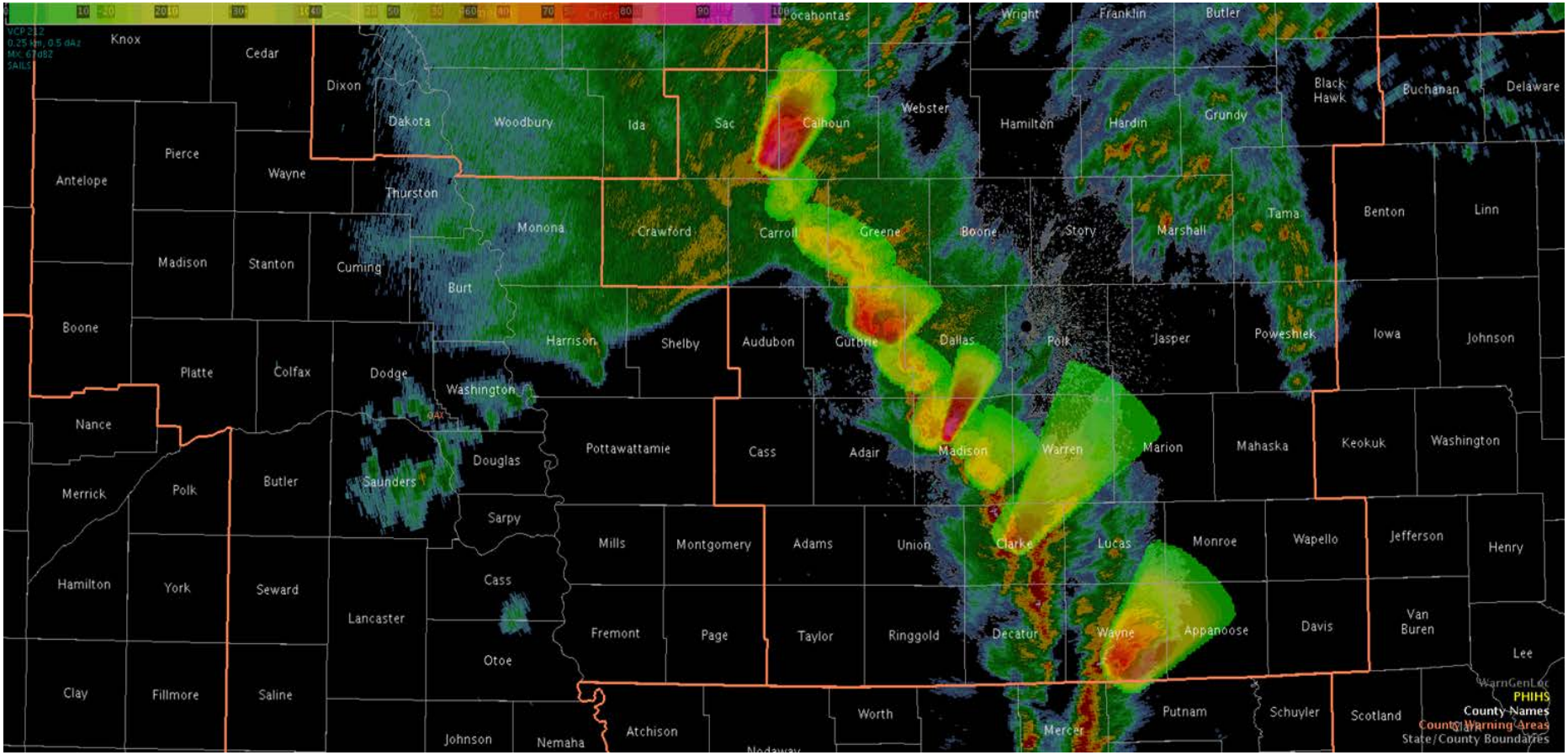




PHI in Hazard Services (HS-PHI)



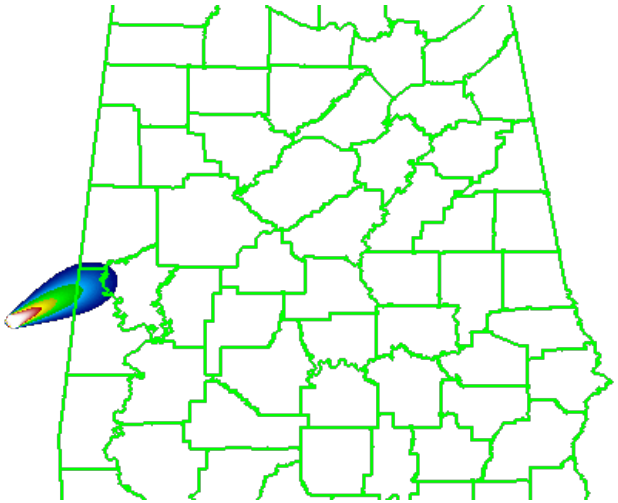
PHI Output Grids in AWIPS2



Cross-Organizational Team

- **MDL** -- Experimental Design coordinator, Product Owner writing Functional Tests and prioritizing tasks. Conduit between PHI Prototype and PHI into Hazard Services / AWIPS / Operations. PHI visionary.
- **GSD** -- Software design and development, integration with AWIPS, Hazard Services concepts, and VLab.
- **Forecasters** -- Trying new paradigm, input from operation perspective, feedback on improving software, concepts, and process, O2R
- **NSSL** -- FACETs concept and collaborations, IT support, Hazardous Weather Testbed facility, overall management of the grant / funding, future funding
- **WDTD** -- Development of the Training including future operational use and best practices
- **University of Akron** -- Human Factors

HS-PHI HWT Experiment Objectives



"Threats-In-Motion (TIM)"

Technology: Evaluate HS-PHI components and performance so that the software can be improved before operational implementation.

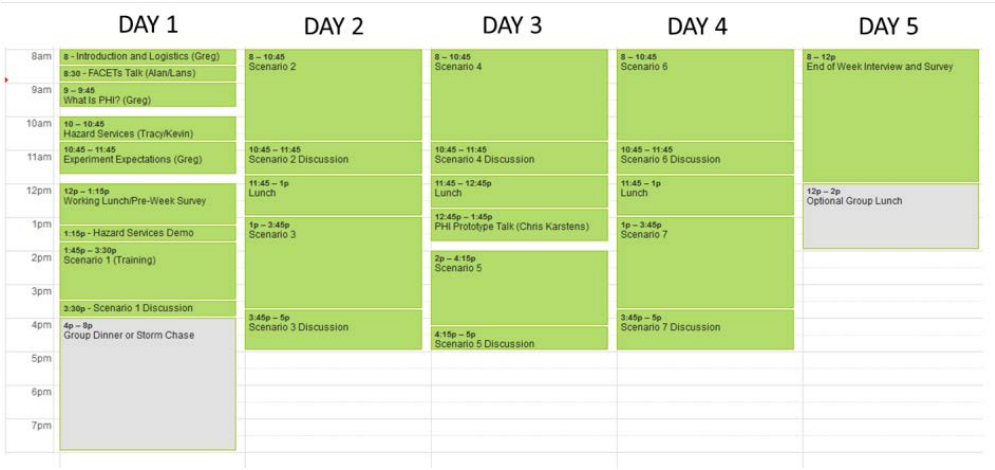
Human Factors: Measure forecaster workload using HS-PHI, including ease of use and graphical design.

Methodology: Assess how forecasters adopt and evolve their current warning methodology into the HS-PHI environment, including evaluating the human-machine mix with automated ProbSevere guidance.

Conceptology: Collect and analyze data on forecasters' thoughts on the paradigm change from deterministic warning products to probabilistic hazard information.

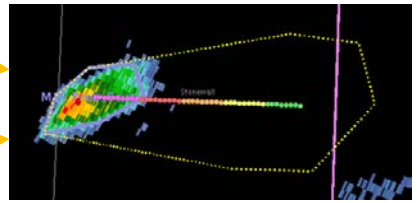
HS-PHI 2016-2018 HWT Experiments

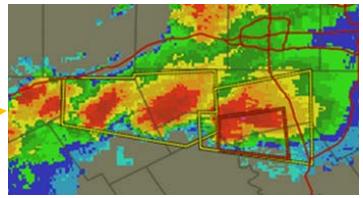
- 2016-2018 Operations Weeks:
  - Three weeks per year (Mar-Apr).
  - 2 forecasters per week.
  - 18 WFO forecasters have participated from 5 of the 6 NWS regions.
- Training materials hosted by Virtual Lab Collaboration Services

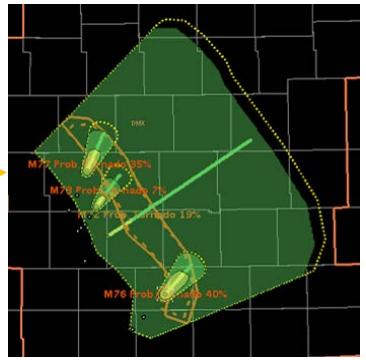


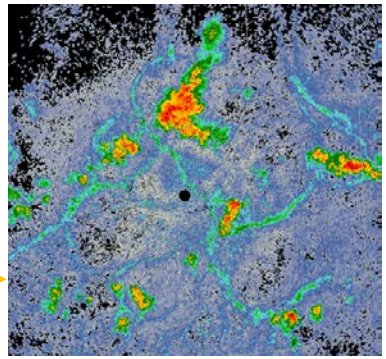
Displaced Real-Time Scenarios

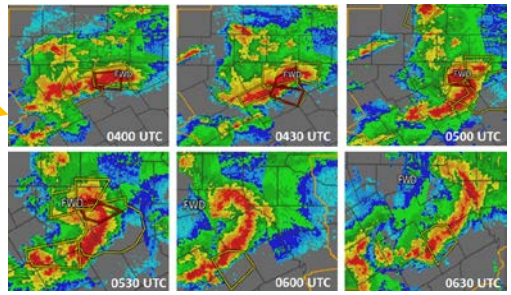
- Isolated marginally severe storm
  - Provide forecasters with basic concepts of PHI
- Developing supercell
  - For continued practice with PHI and object nudging.
- Merging/splitting supercells
  - Dealing with many events in very close proximity
- Quasi-Linear Convective System Tornadoes
  - Multiple-scale PHI
- Low-Shear Summer Southeast Microbursts
  - Random slow motion
- Upscale growth to squall line
  - Merging objects to larger objects
- Mature supercells
  - To study issues with cross-forecast area **collaboration**

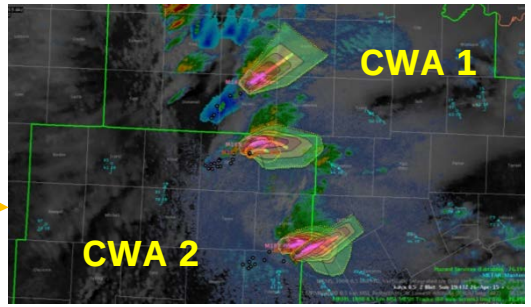










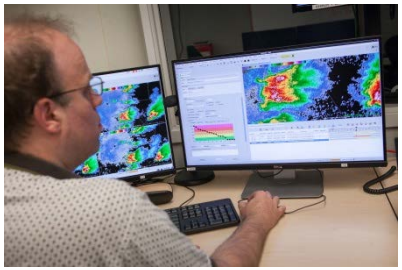


Human Factors Data Collection

- Pre-operations survey
  - Internal probability thresholds, ProbSevere use, WFO warning team composition, forecasters' ideas for warning improvement
- Live video of forecasters, desktops, and group discussions
- Discussions during events with meteorologists, developers, trainers, and human factors scientists
- Post-event survey/discussion (60 minutes each)
  - NASA Task Load Index (TLX) Mental Workload Survey
    - Mental Demand, Physical Demand, Temporal Demand, Performance, Effort, Frustration
  - Confidence Survey
- End-of-Week Discussion (Friday)
  - Post-Study Usability Survey
  - Long Interview touching on the four main objectives
    - Technology, Human Factors, Methodology, Conceptology

Forecaster contributions

- Visiting forecasters provided suggestions to improve the software.



- These suggestions are triaged to determine if they can be:
  - Incorporated into HS-PHI directly
  - Incorporated into both the PHI Prototype and HS-PHI
  - Require proof-of-concept testing in the PHI Prototype first.

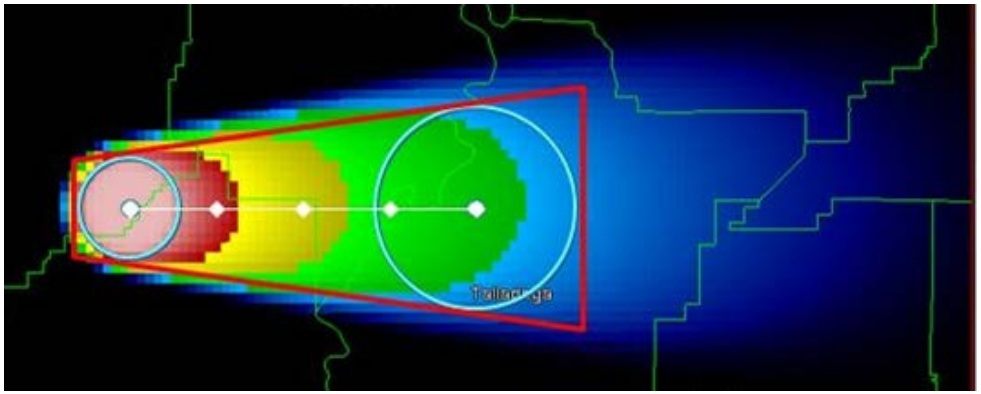
- Forecasters helping to formulate operational best practices – WDTD integration.

Recent Development Progress

- The 2015 version of NSSL PHI Prototype is our current benchmark.
- New systematic software releases and virtual functional testing resulted in better progress and improved stability each subsequent year.
- Recent new functionality added:
  - Convective Recommender
    - Processes ProbSevere detections into Hazard Services – PHI objects.
  - Levels of Automation
    - Forecasters can create manual objects.
    - Forecasters can assume partial or full control of automated objects, and relinquish control back to automation one attribute at a time.
  - New object drawing tools: ellipses, rotation, resizing
  - Buffering of commands for quicker responsiveness
  - Ownership of hazard objects and locking (first step in collaboration tools)
  - Better drawing colors to enhance visibility of objects on radar data

Findings

- How will we effectively extract legacy warnings from a continuously-updating probabilistic grid?
  - Probability thresholds?
  - Time-of-arrival thresholds?
  - Forecaster decision points?

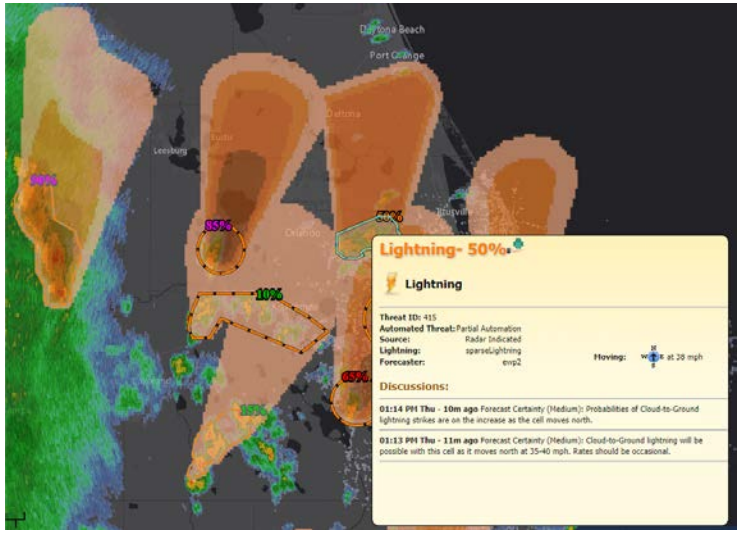


- It will be a challenge to blend probabilities at the storm scale with those from the SPC outlook scale, since they exist from different reference classes.
- Cross-WFO collaboration and object handoff will require significant analysis of inter- and intra-office culture.

Joint Technology Transfer Initiative Funding: Year 1

- We have been granted additional funds via JTTI to begin the incorporation of new functionality:
  - Intermediate “Threats-In-Motion” warnings (without PHI)
  - Warning product generation
  - Lightning PHI

- Another JTTI grant for Cross-WFO Collaboration funded for 2019-2020:
  - Field surveys.
  - Additional collaboration tools.
  - HWT experiment.



JTTI Years 2 and 3: Path to operations

- Addition of new functionality informed by PHI Prototype during 2016-2017 tests)
- Addition of new science as developed in companion JTTI proposals:
  - New probabilistic plume model
  - New storm object ID and tracking model
  - Improved probabilistic guidance
- HWT spring experiments to include users (EMs, etc.)
- Testing at Operations Proving Ground and some WFOs
- Policy and paradigm shift to make FACETs operational