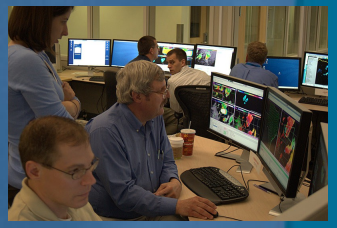
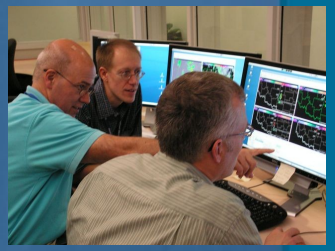
Probabilistic Hazard Information (PHI)

Experiments in Short-term Hazardous Weather Information at NSSL





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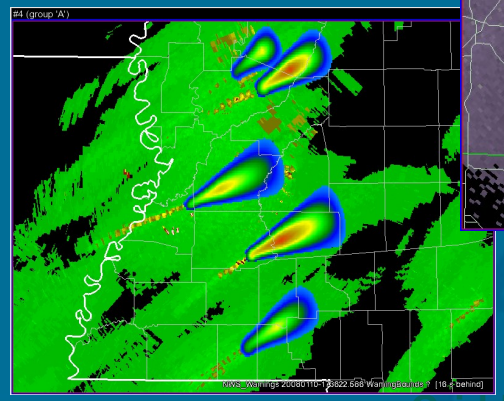
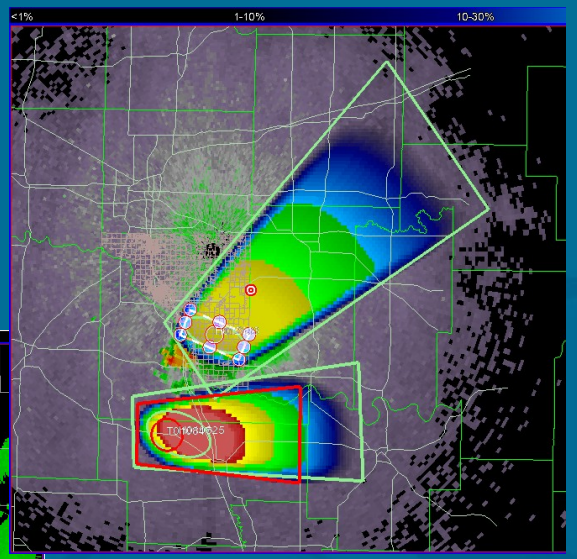




Gridded Probabilistic Hazard Information

Beyond Storm-Based Warnings: Adaptive Warnings

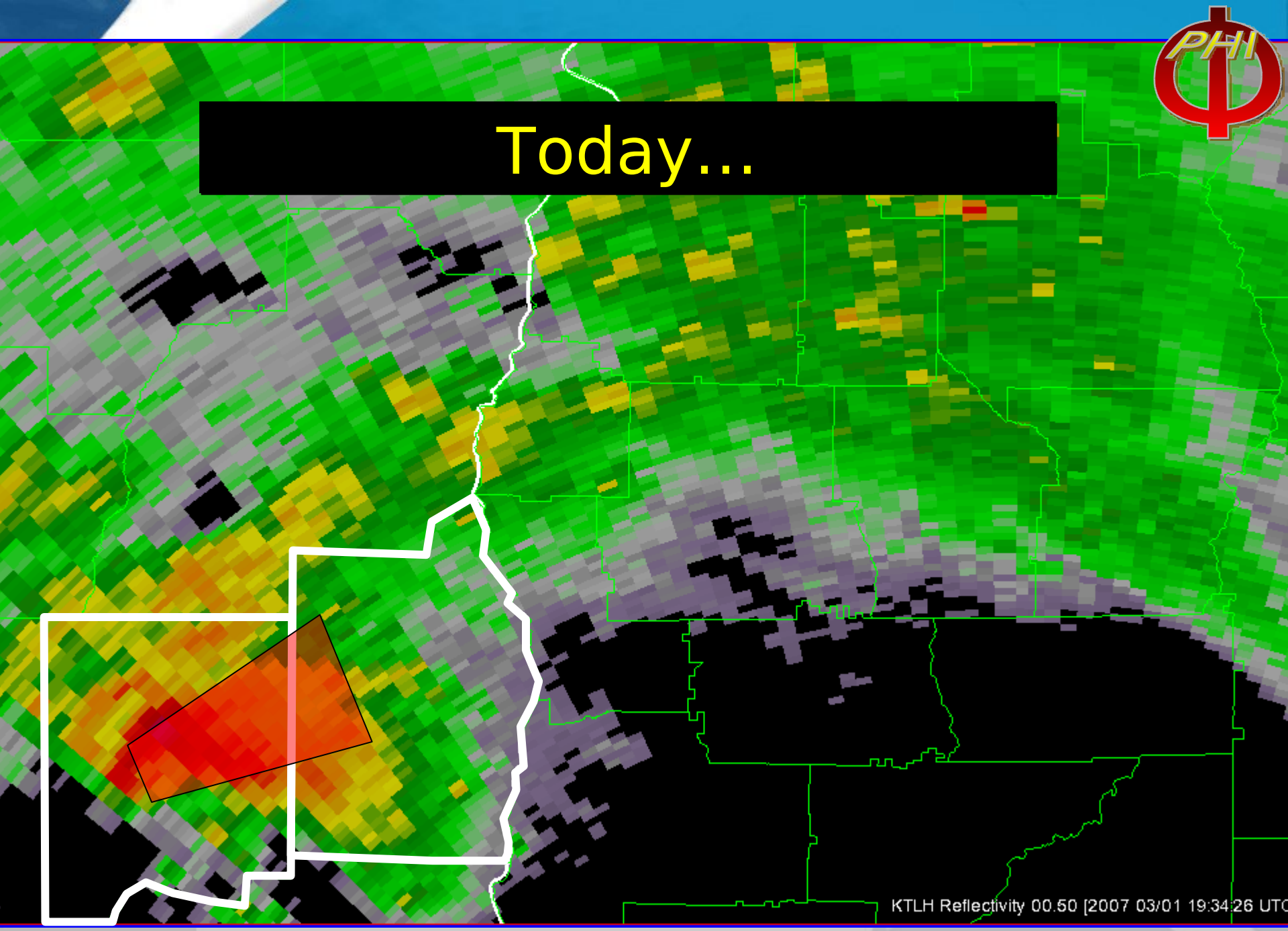
Risk = Hazard * Exposure * Response Time

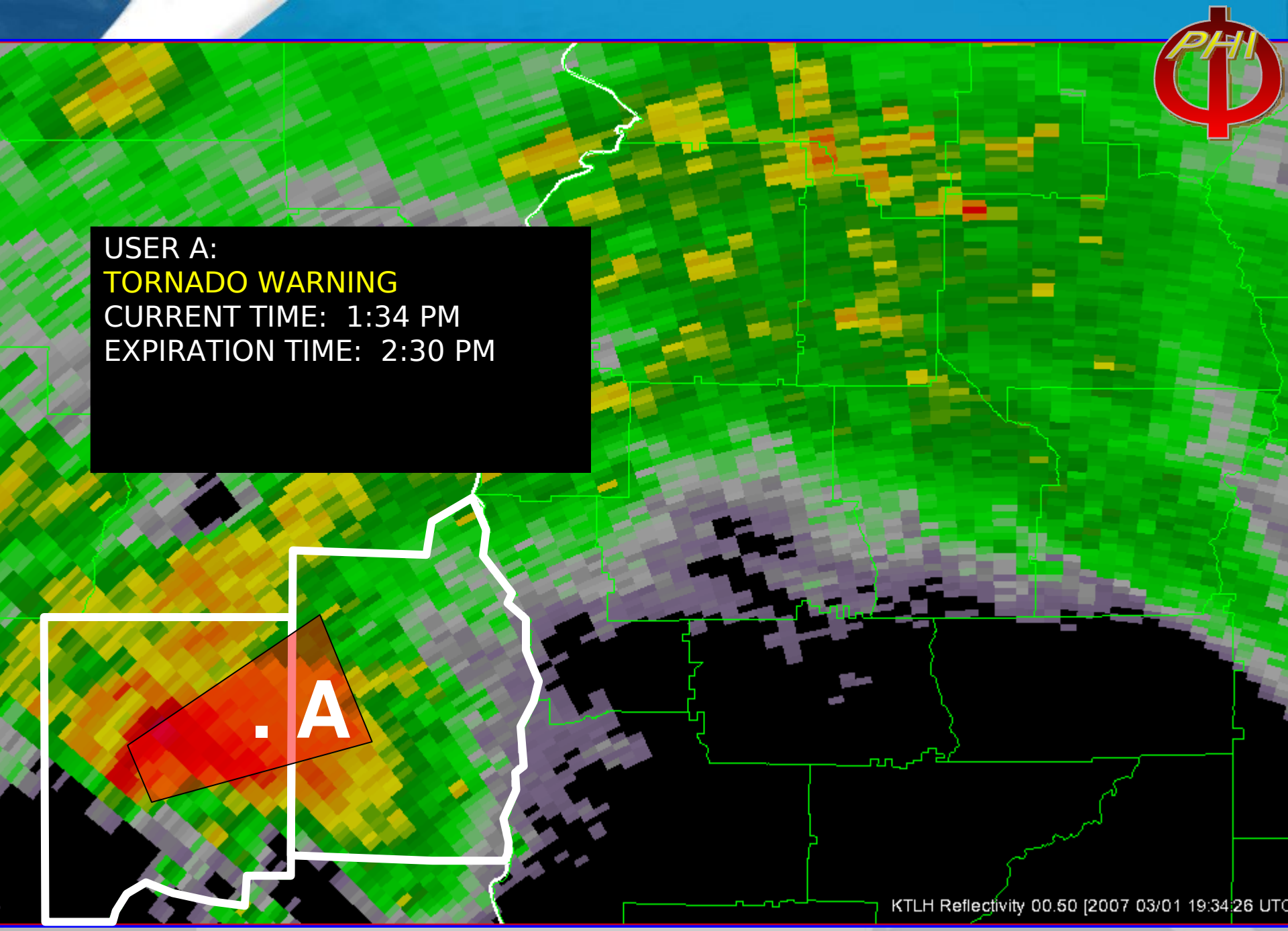
Tornado, wind, hail, other hazards

How to account for this?

- The meteorologist is the expert on interpreting the hazard and its uncer
- The meteorologist cannot anticipate everyone's exposure and response t
- How can weather hazard information be made more adaptable to those that do know their own exposure and response time?

Today...

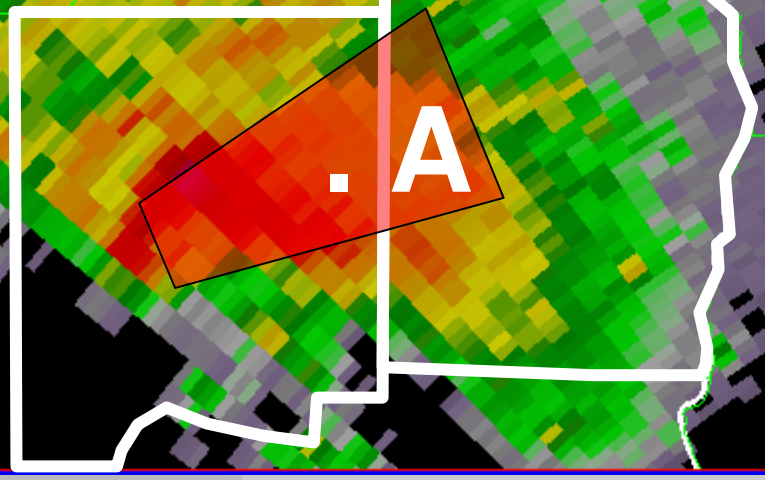



USER A:
TORNADO WARNING
CURRENT TIME: 1:34 PM
EXPIRATION TIME: 2:30 PM
. A
KTLH Reflectivity 00.50 [2007 03/01 19:34:26 UTC

Imagine...

USER A:
TORNADO THREAT
CURRENT TIME: 1:34 PM

TIME OF ARRIVAL: 1:50-1:55 PM
TIME OF DEPARTURE: 2:05-2:10 PM
THREAT LEVEL: 70% (EXTREME)



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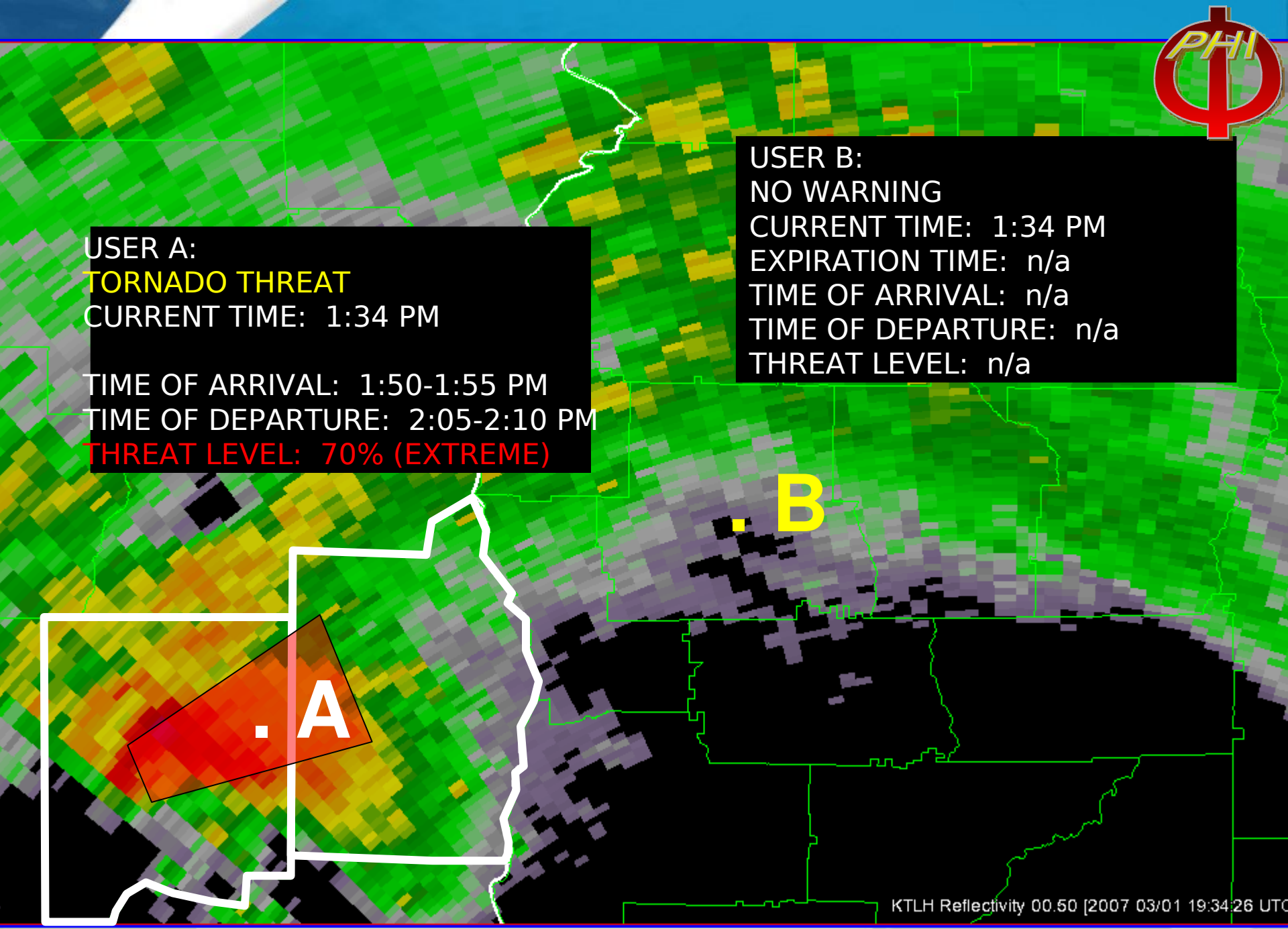
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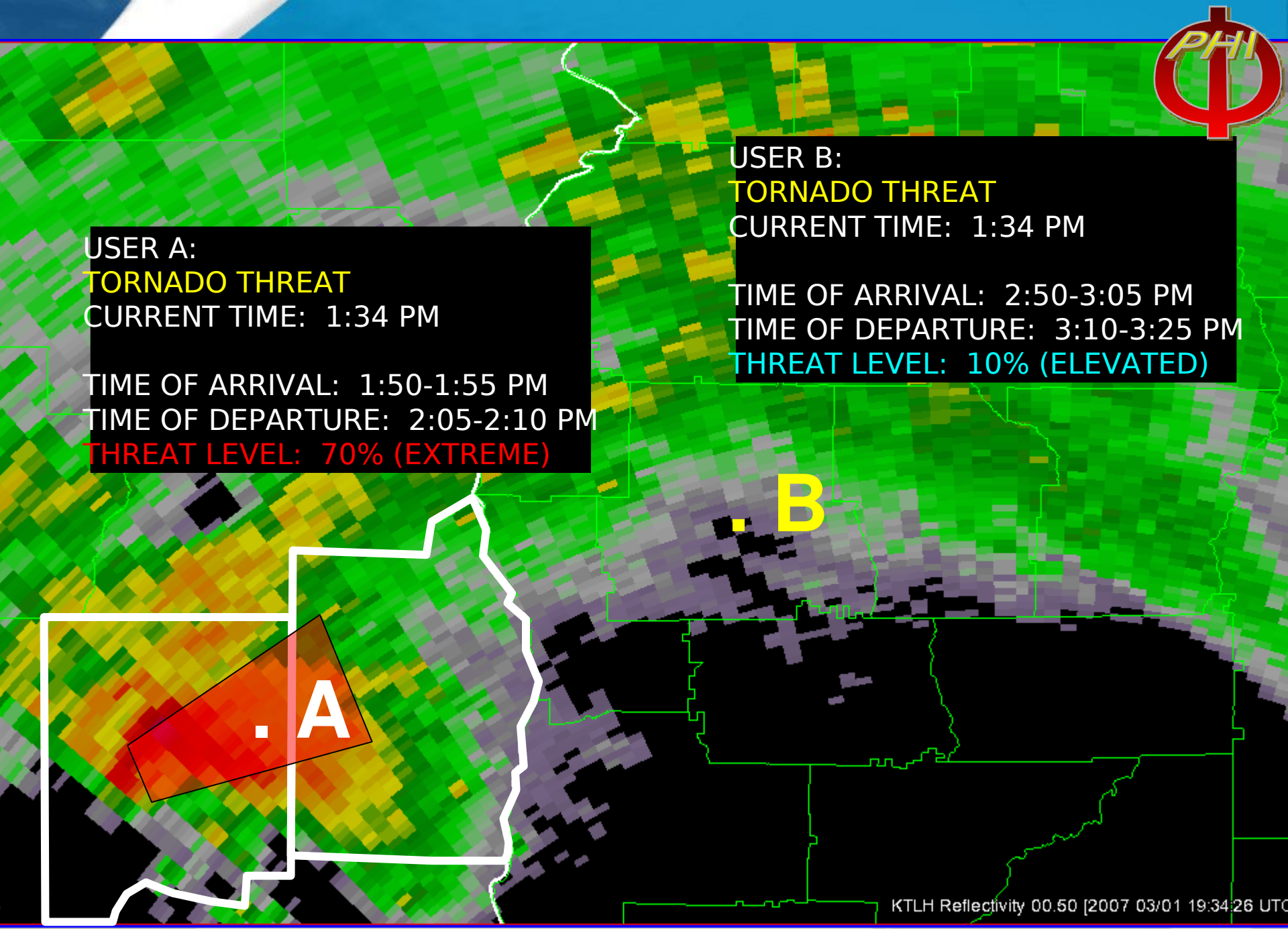
TORNADO THREAT
CURRENT TIME: 1:34 PM
TIME OF ARRIVAL: 1:50-1:55 PM
TIME OF DEPARTURE: 2:05-2:10 PM
THREAT LEVEL: 70% (EXTREME)
USER B:
NO WARNING
CURRENT TIME: 1:34 PM
EXPIRATION TIME: n/a
TIME OF ARRIVAL: n/a
TIME OF DEPARTURE: n/a
THREAT LEVEL: n/a
A
B
KTLH Reflectivity 00.50 [2007 03/01 19:34:26 UTC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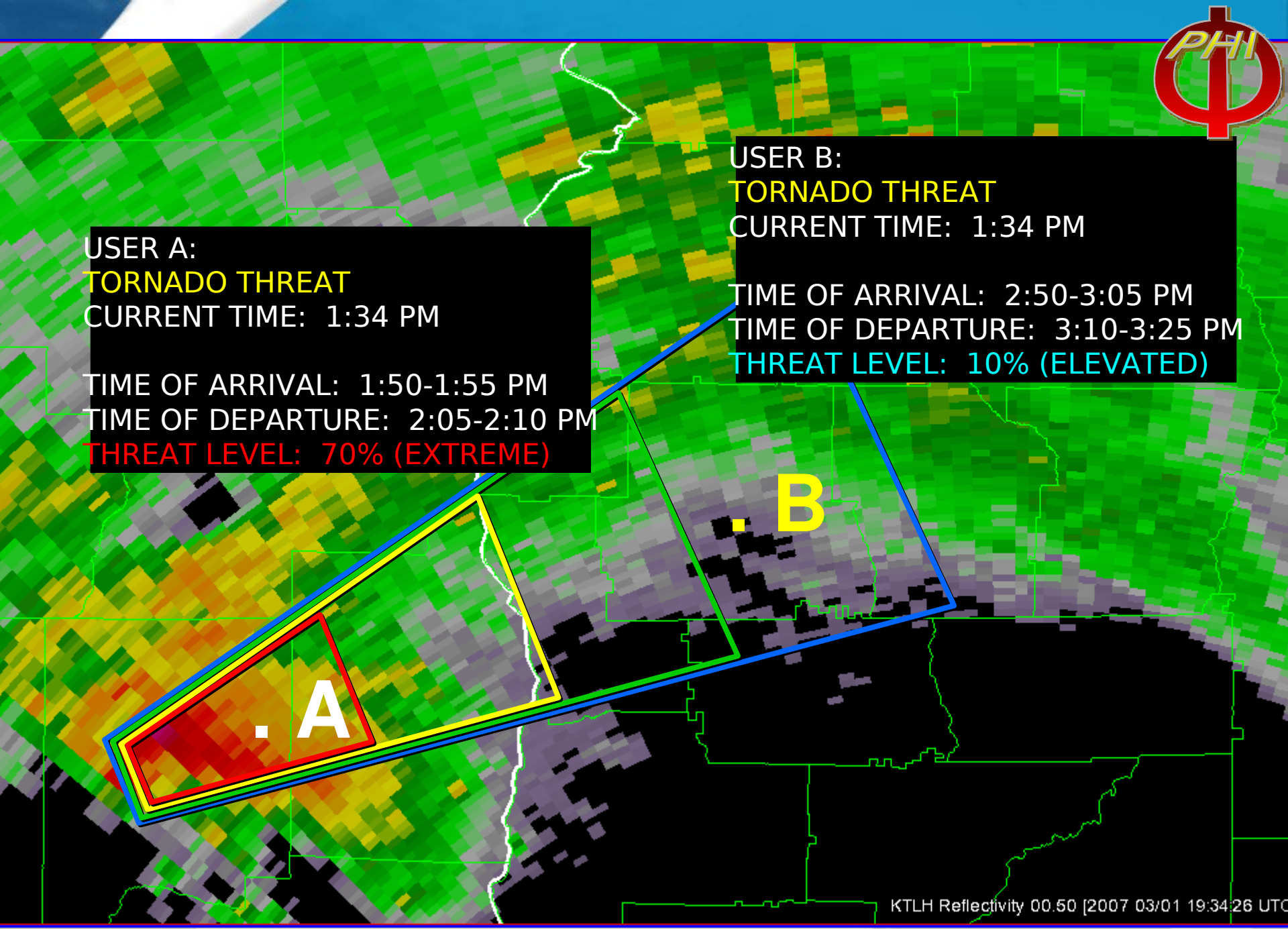
TORNADO THREAT
CURRENT TIME: 1:34 PM
TIME OF ARRIVAL: 1:50-1:55 PM
TIME OF DEPARTURE: 2:05-2:10 PM
THREAT LEVEL: 70% (EXTREME)
USER B:
TORNADO THREAT
CURRENT TIME: 1:34 PM
TIME OF ARRIVAL: 2:50-3:05 PM
TIME OF DEPARTURE: 3:10-3:25 PM
THREAT LEVEL: 10% (ELEVATED)
A
B
KTLH Reflectivity 00.50 [2007 03/01 19:34:26 UTC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TORNADO THREAT
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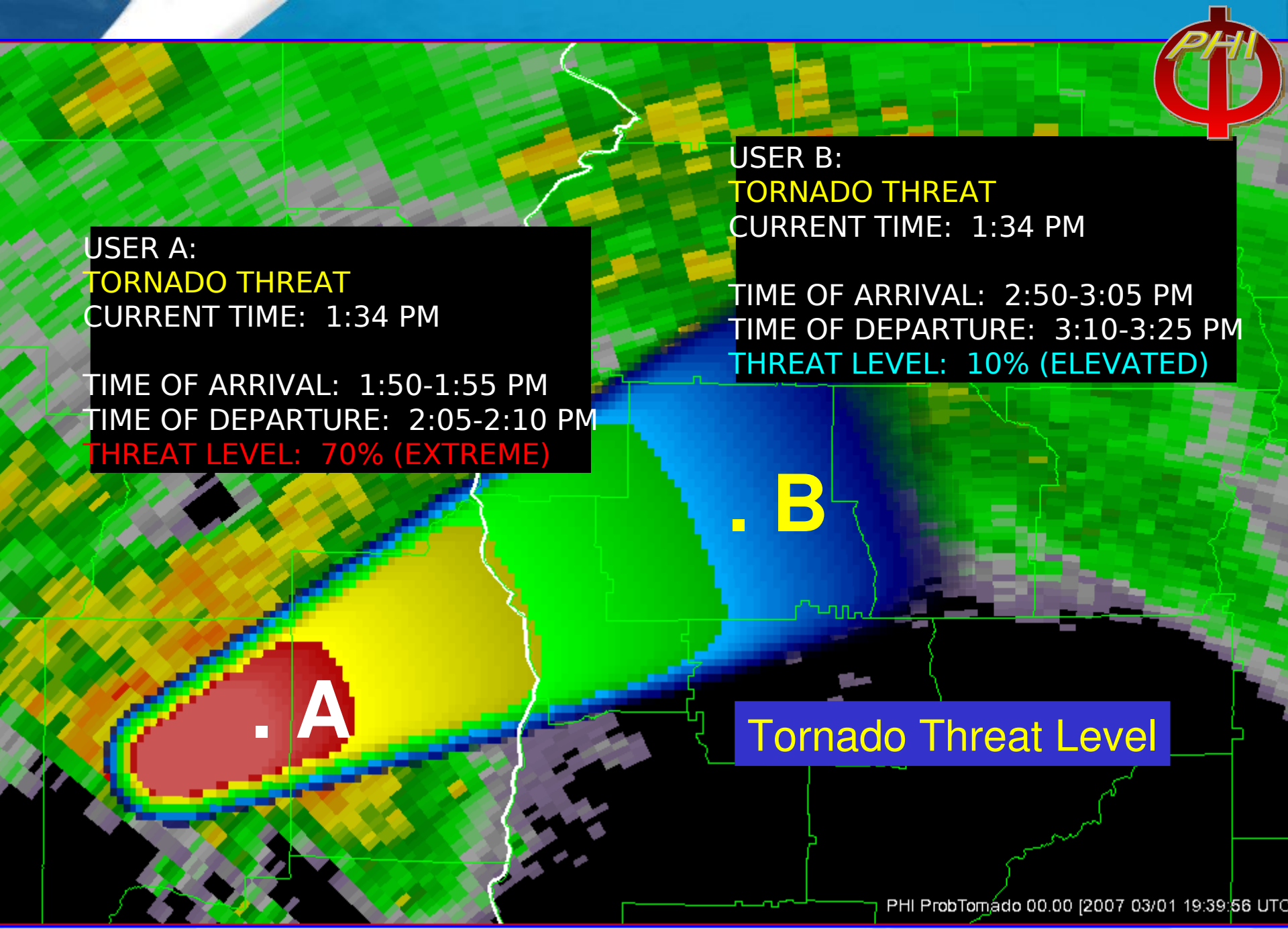
TIME OF ARRIVAL: 1:50-1:55 PM
TIME OF DEPARTURE: 2:05-2:10 PM
THREAT LEVEL: 70% (EXTREME)
USER B:
TORNADO THREAT
CURRENT TIME: 1:34 PM
TIME OF ARRIVAL: 2:50-3:05 PM
TIME OF DEPARTURE: 3:10-3:25 PM
THREAT LEVEL: 10% (ELEVATED)
A
B
KTLH Reflectivity 00.50 [2007 03/01 19:34:26 UTC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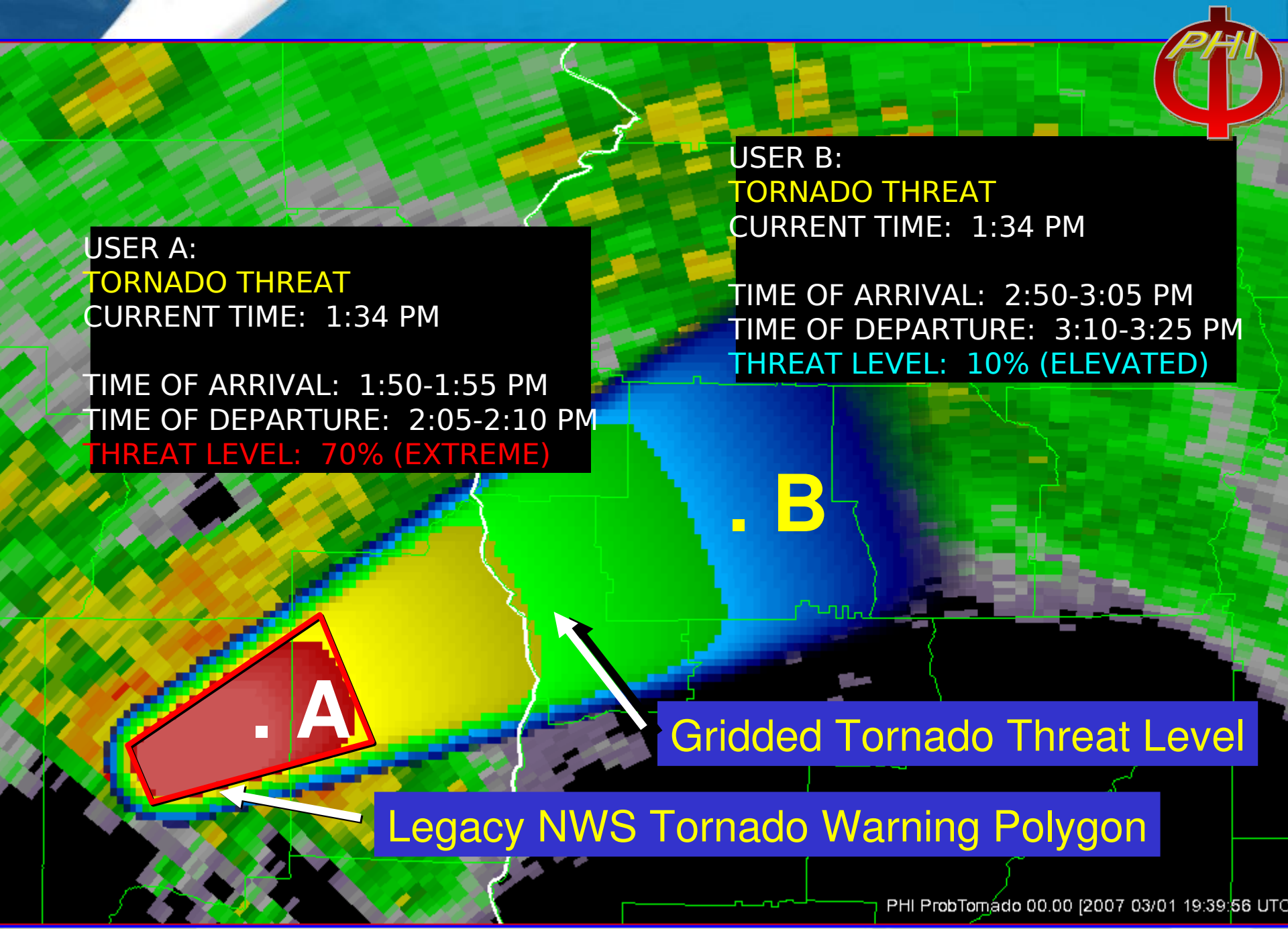
TIME OF ARRIVAL: 1:50-1:55 PM
TIME OF DEPARTURE: 2:05-2:10 PM
THREAT LEVEL: 70% (EXTREME)
USER B:
TORNADO THREAT
CURRENT TIME: 1:34 PM
TIME OF ARRIVAL: 2:50-3:05 PM
TIME OF DEPARTURE: 3:10-3:25 PM
THREAT LEVEL: 10% (ELEVATED)
. A
. B
Tornado Threat Level
PHI ProbTornado 00.00 [2007 03/01 19:39:56 UTC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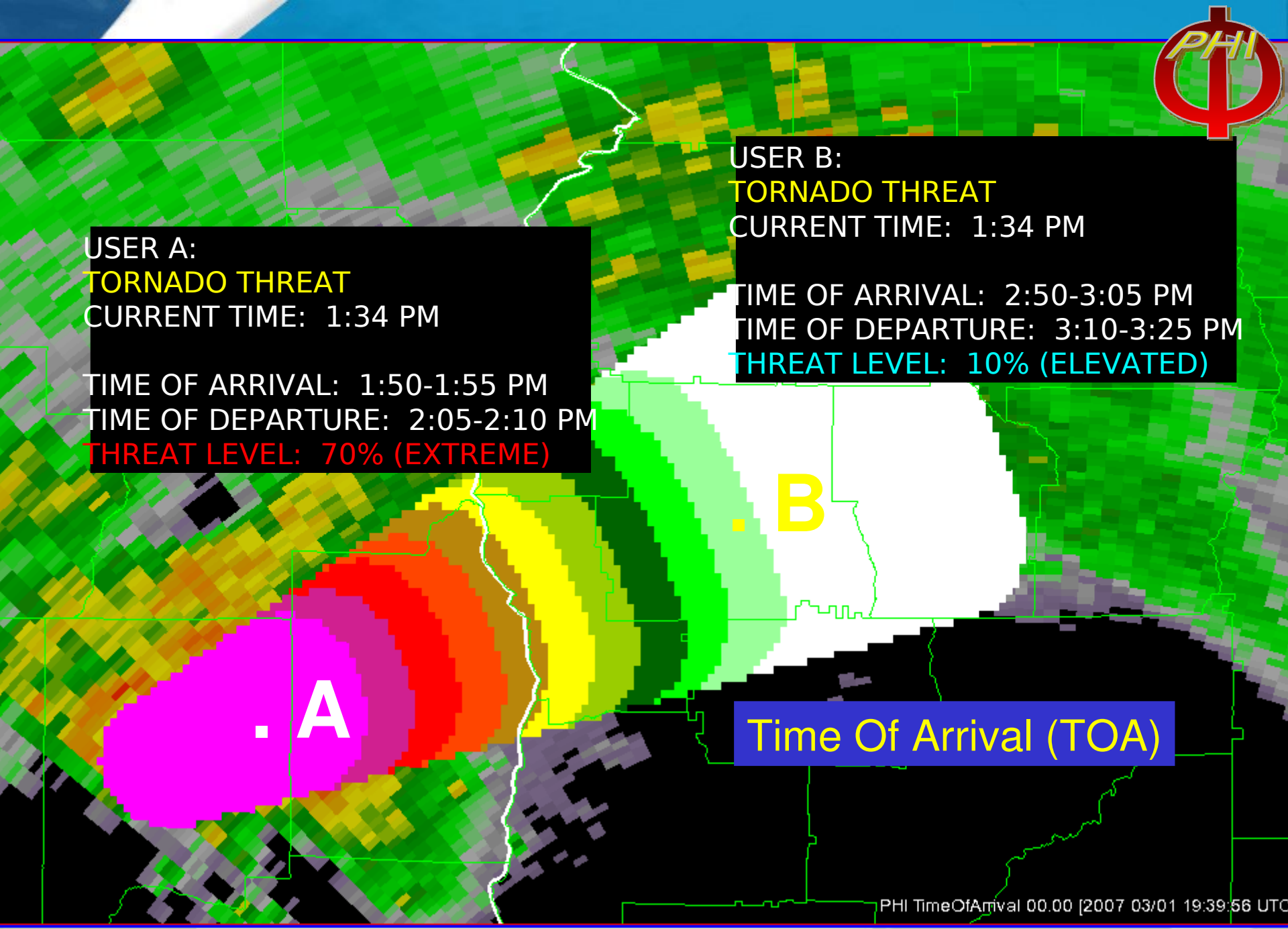
CURRENT TIME: 1:34 PM
TIME OF ARRIVAL: 1:50-1:55 PM
TIME OF DEPARTURE: 2:05-2:10 PM
THREAT LEVEL: 70% (EXTREME)
USER B:
TORNADO THREAT
CURRENT TIME: 1:34 PM
TIME OF ARRIVAL: 2:50-3:05 PM
TIME OF DEPARTURE: 3:10-3:25 PM
THREAT LEVEL: 10% (ELEVATED)
. B
. A
Gridded Tornado Threat Level
Legacy NWS Tornado Warning Polygon
PHI ProbTornado 00.00 [2007 03/01 19:39:56 UTC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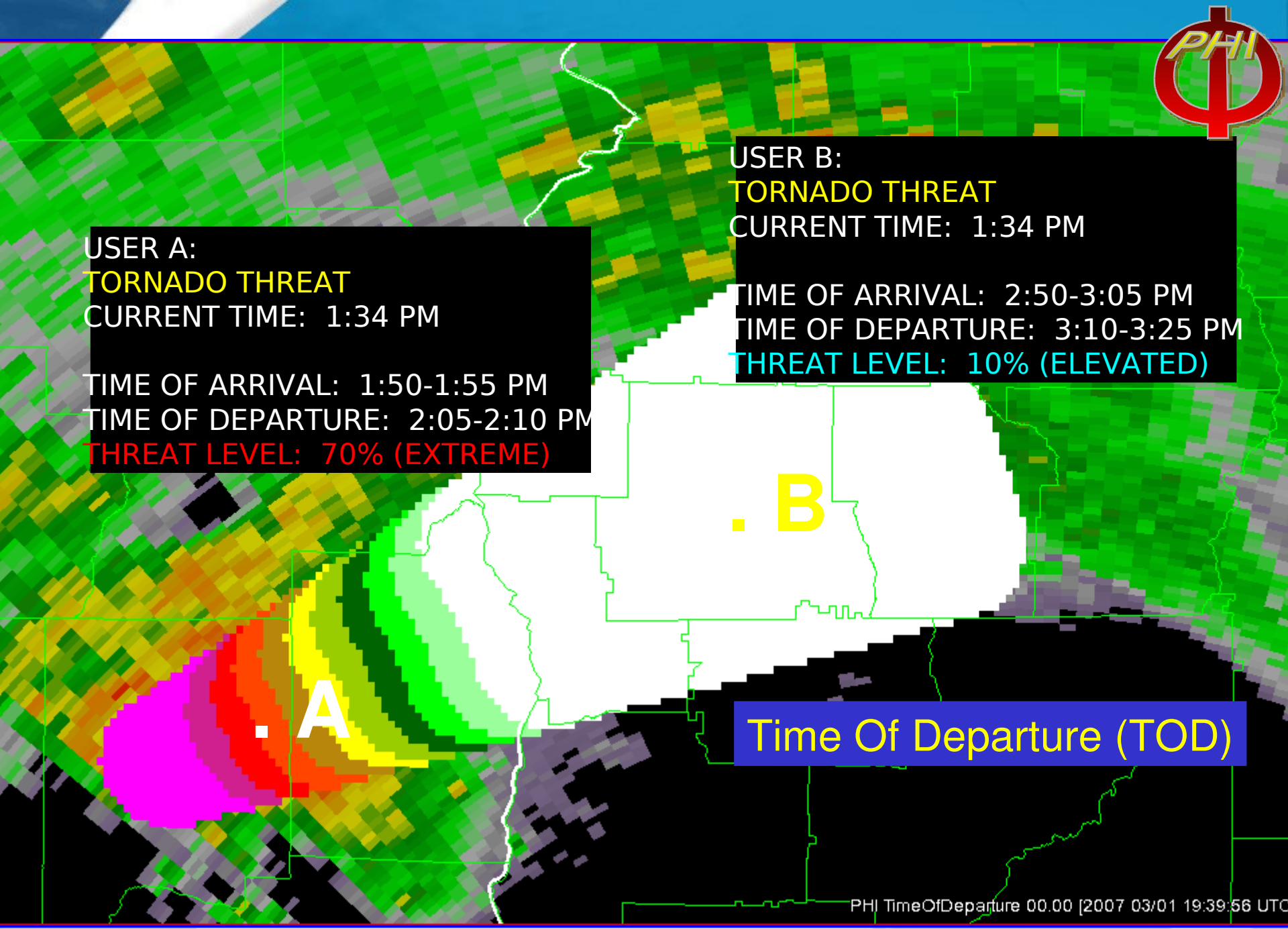
CURRENT TIME: 1:34 PM
TIME OF ARRIVAL: 1:50-1:55 PM
TIME OF DEPARTURE: 2:05-2:10 PM
THREAT LEVEL: 70% (EXTREME)
USER B:
TORNADO THREAT
CURRENT TIME: 1:34 PM
TIME OF ARRIVAL: 2:50-3:05 PM
TIME OF DEPARTURE: 3:10-3:25 PM
THREAT LEVEL: 10% (ELEVATED)
A
B
Time Of Arrival (TOA)
PHI TimeOfArrival 00.00 [2007 03/01 19:39:56 UTC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TORNADO THREAT
CURRENT TIME: 1:34 PM
TIME OF ARRIVAL: 1:50-1:55 PM
TIME OF DEPARTURE: 2:05-2:10 PM
THREAT LEVEL: 70% (EXTREME)
USER B:
TORNADO THREAT
CURRENT TIME: 1:34 PM
TIME OF ARRIVAL: 2:50-3:05 PM
TIME OF DEPARTURE: 3:10-3:25 PM
THREAT LEVEL: 10% (ELEVATED)
. A
. B
Time Of Departure (TOD)
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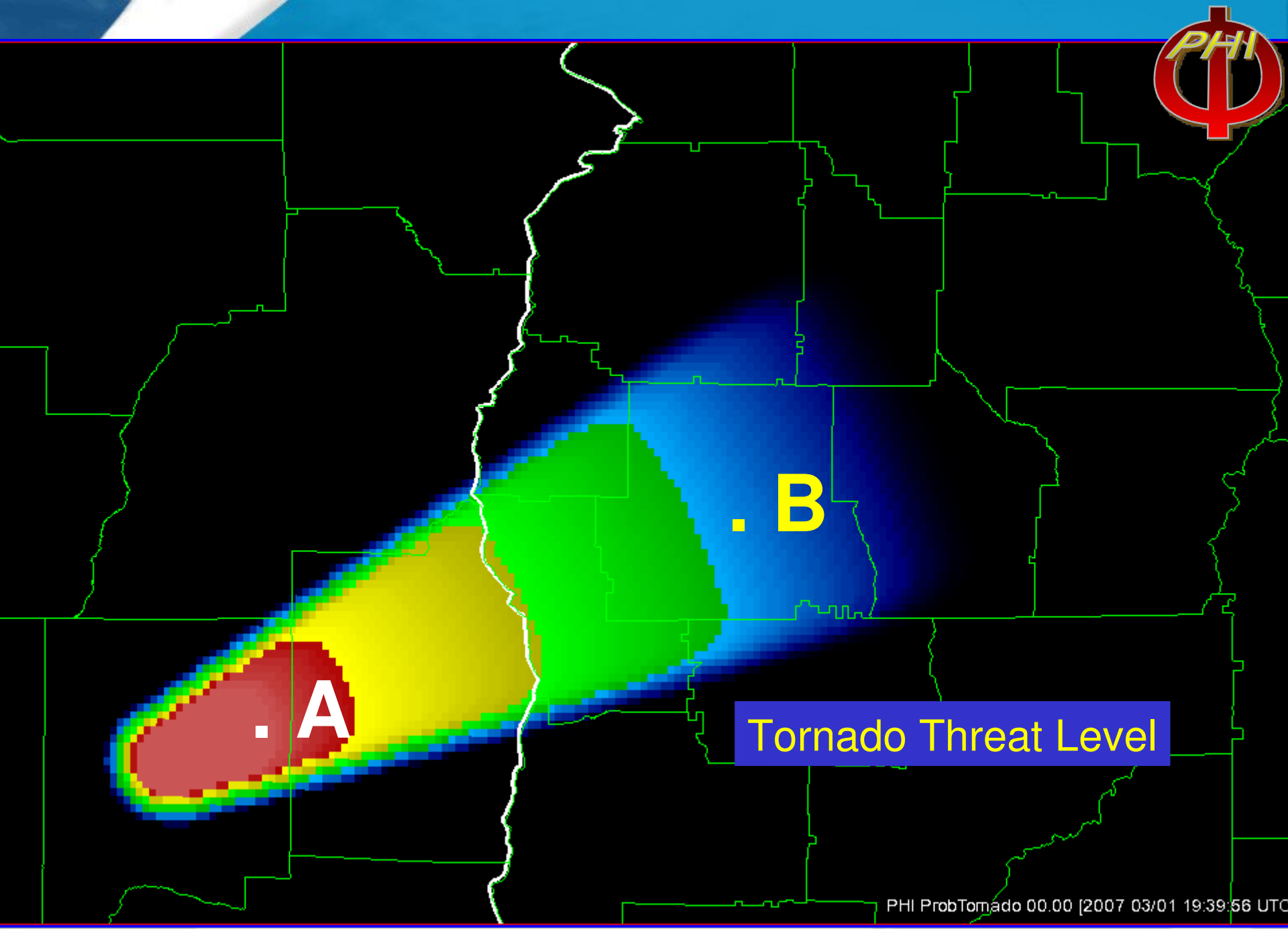
. B
. A
Tornado Threat Level
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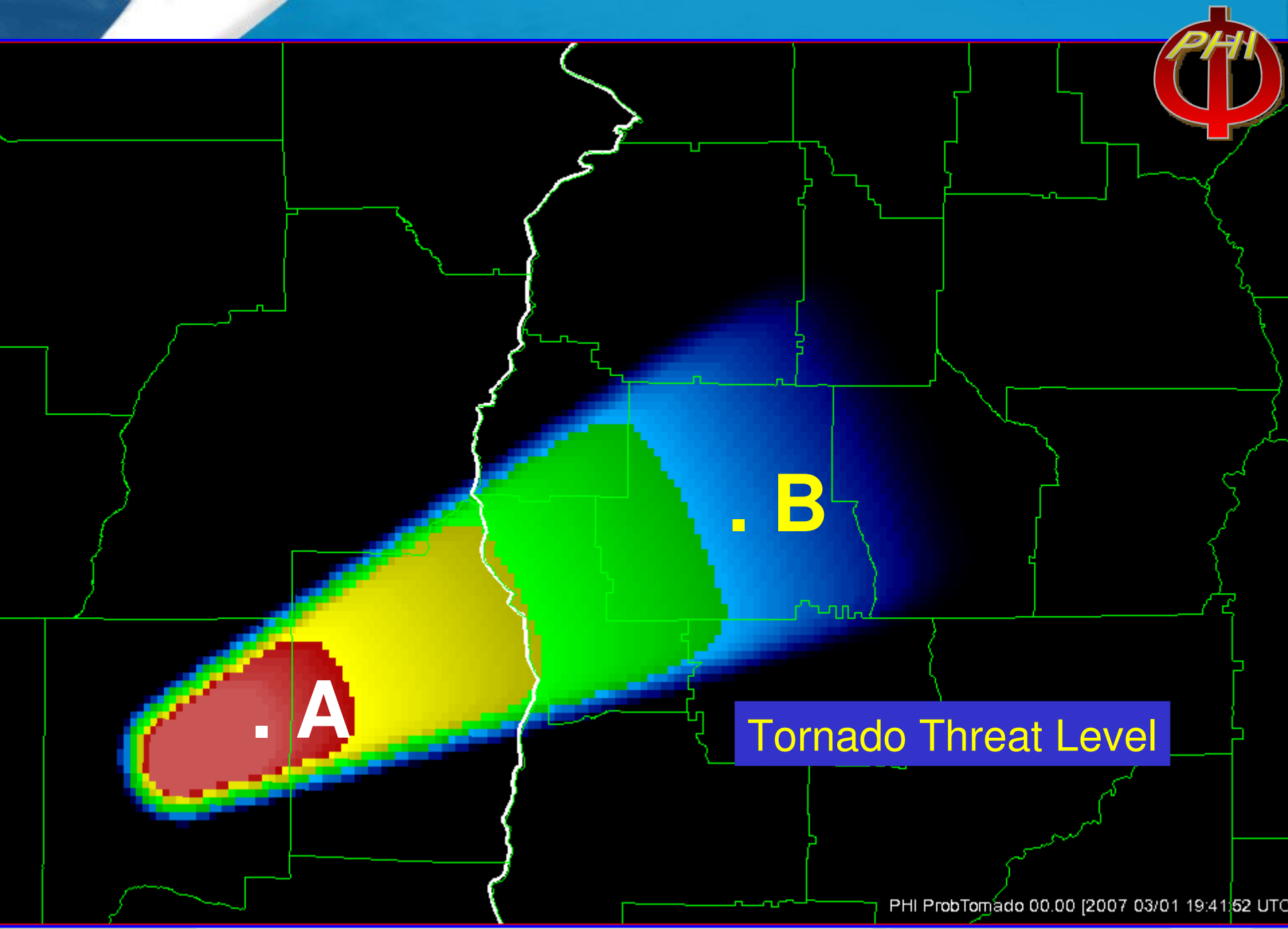
. B
. A
Tornado Threat Level
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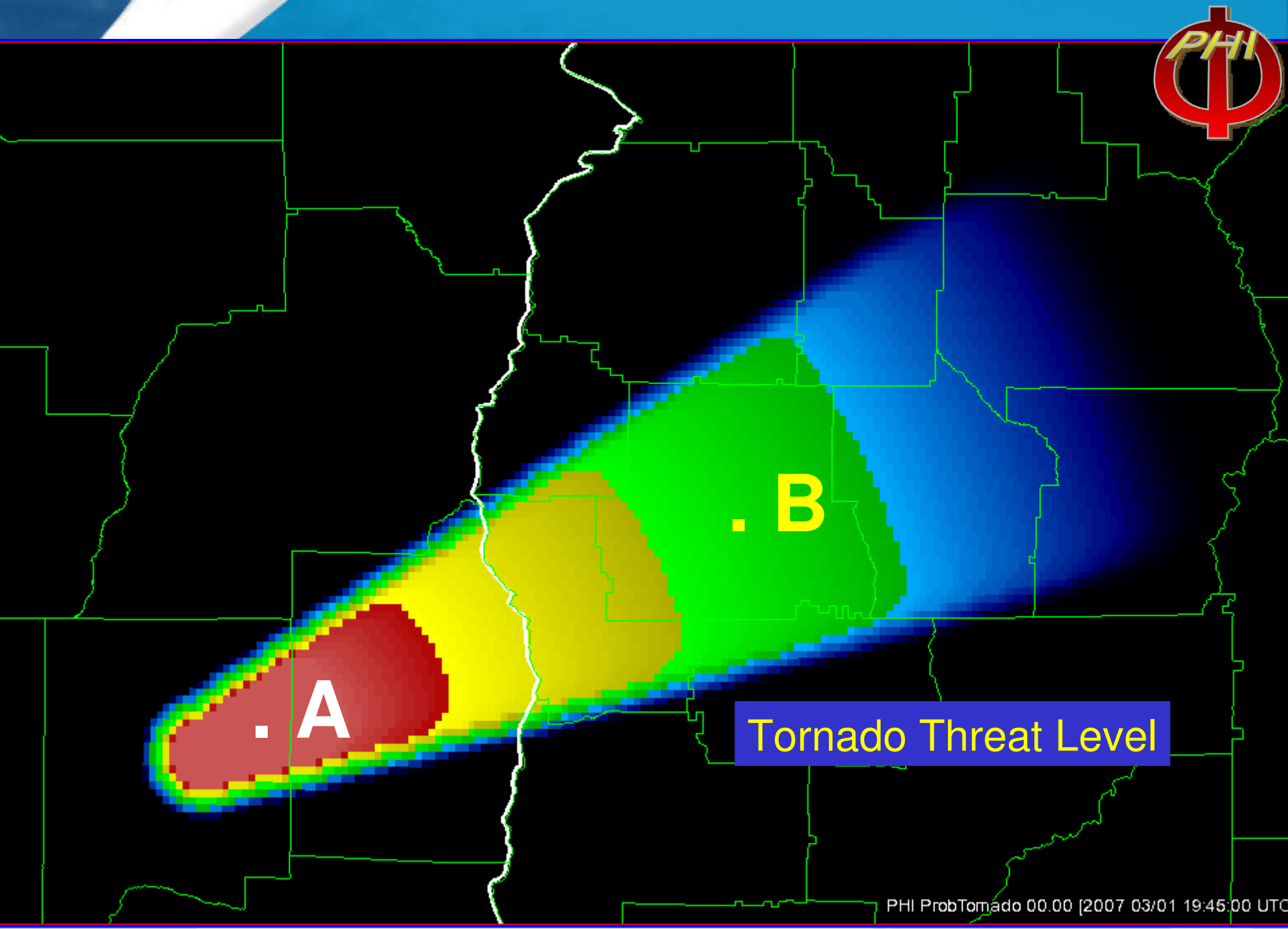
. B
. A
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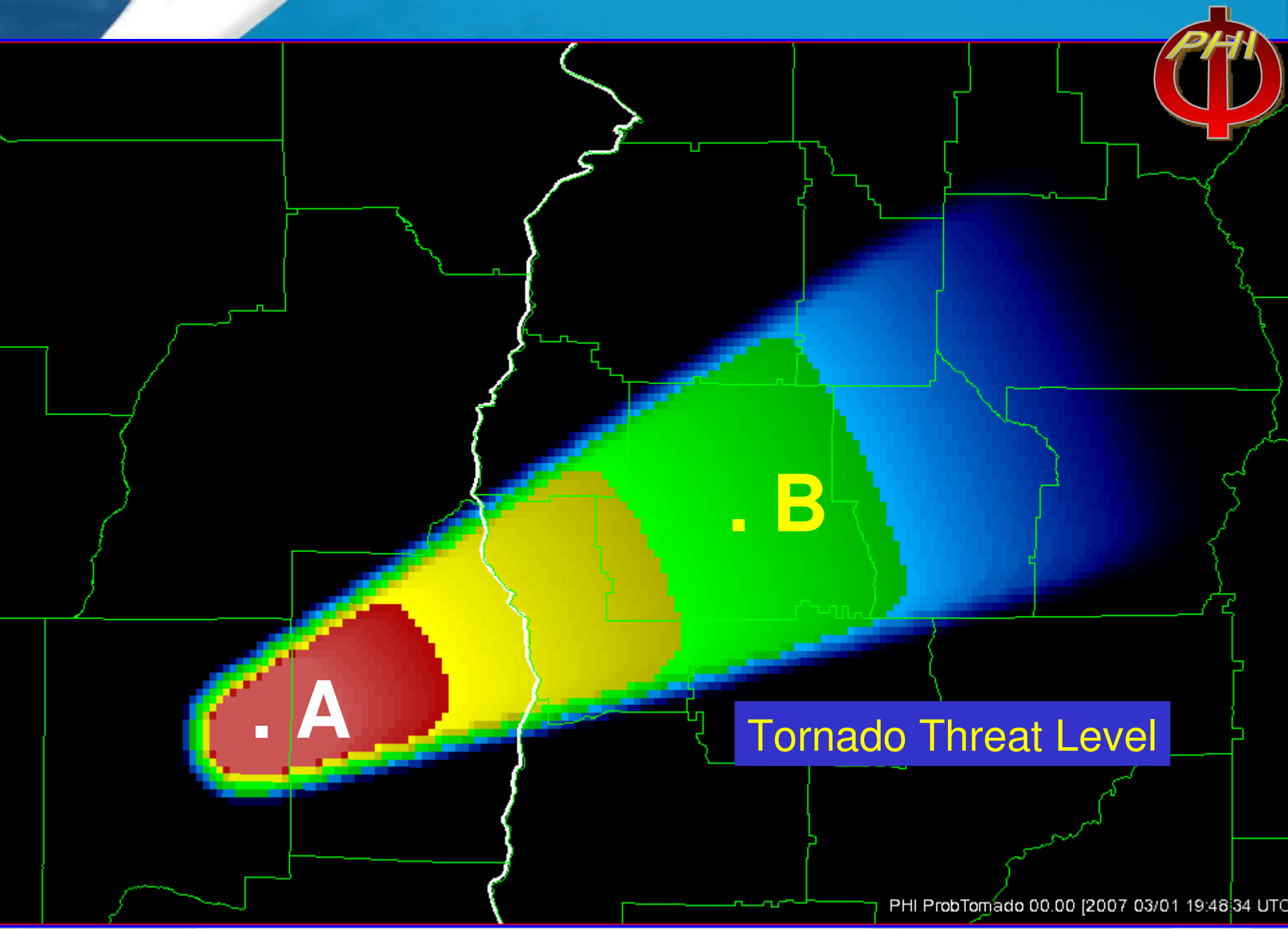
. B
. A
Tornado Threat Level
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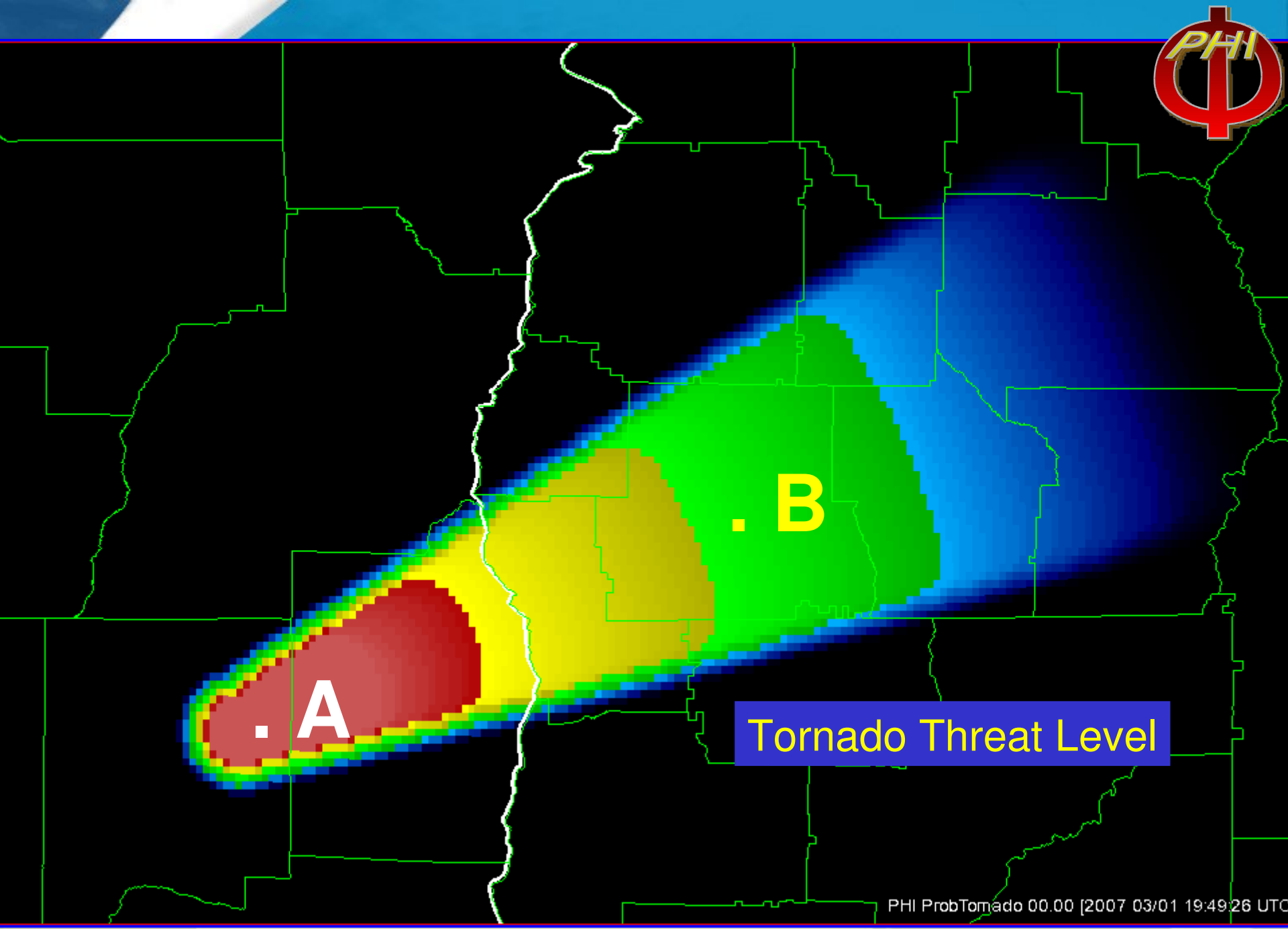
. B
. A
Tornado Threat Level
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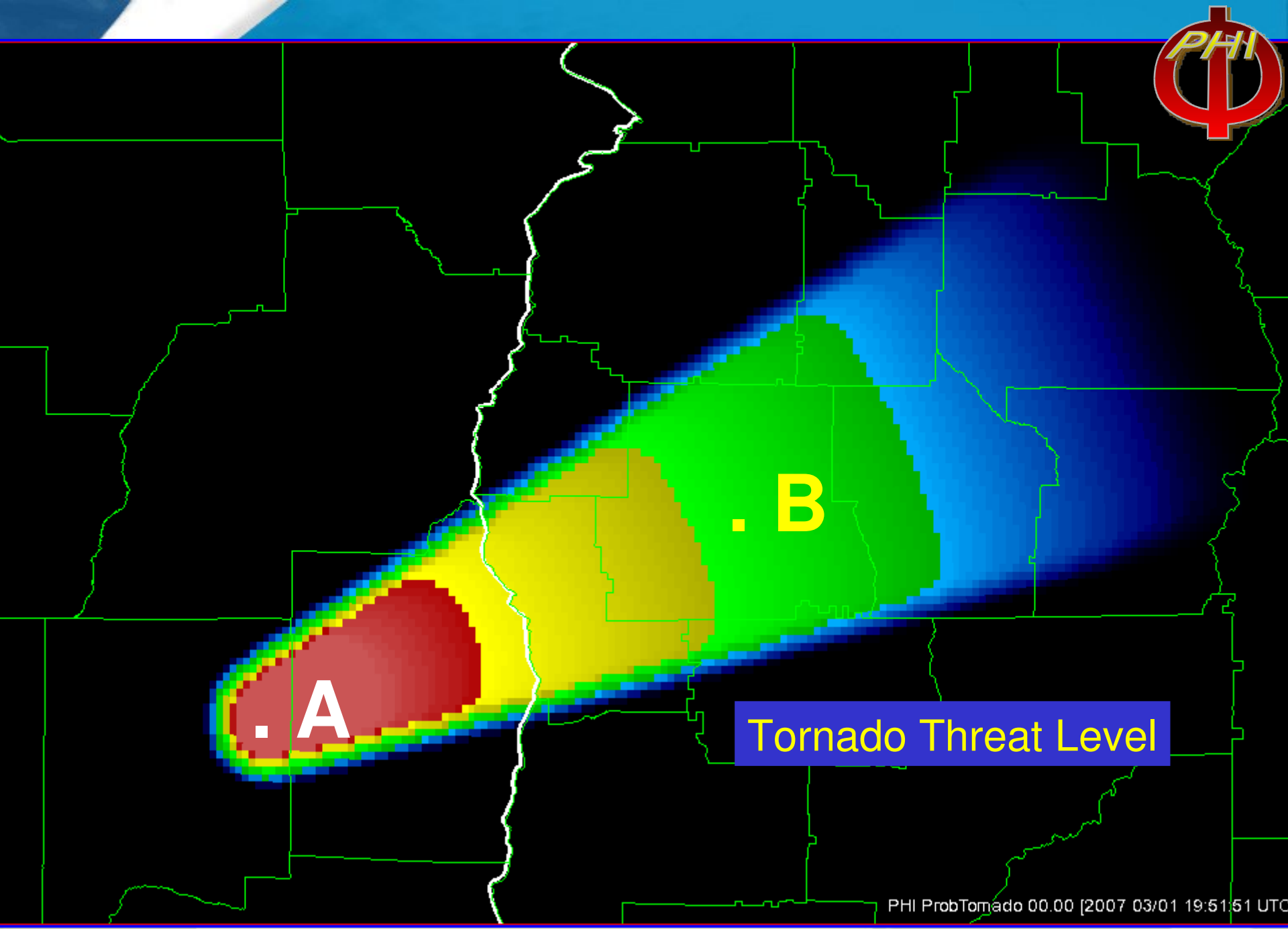
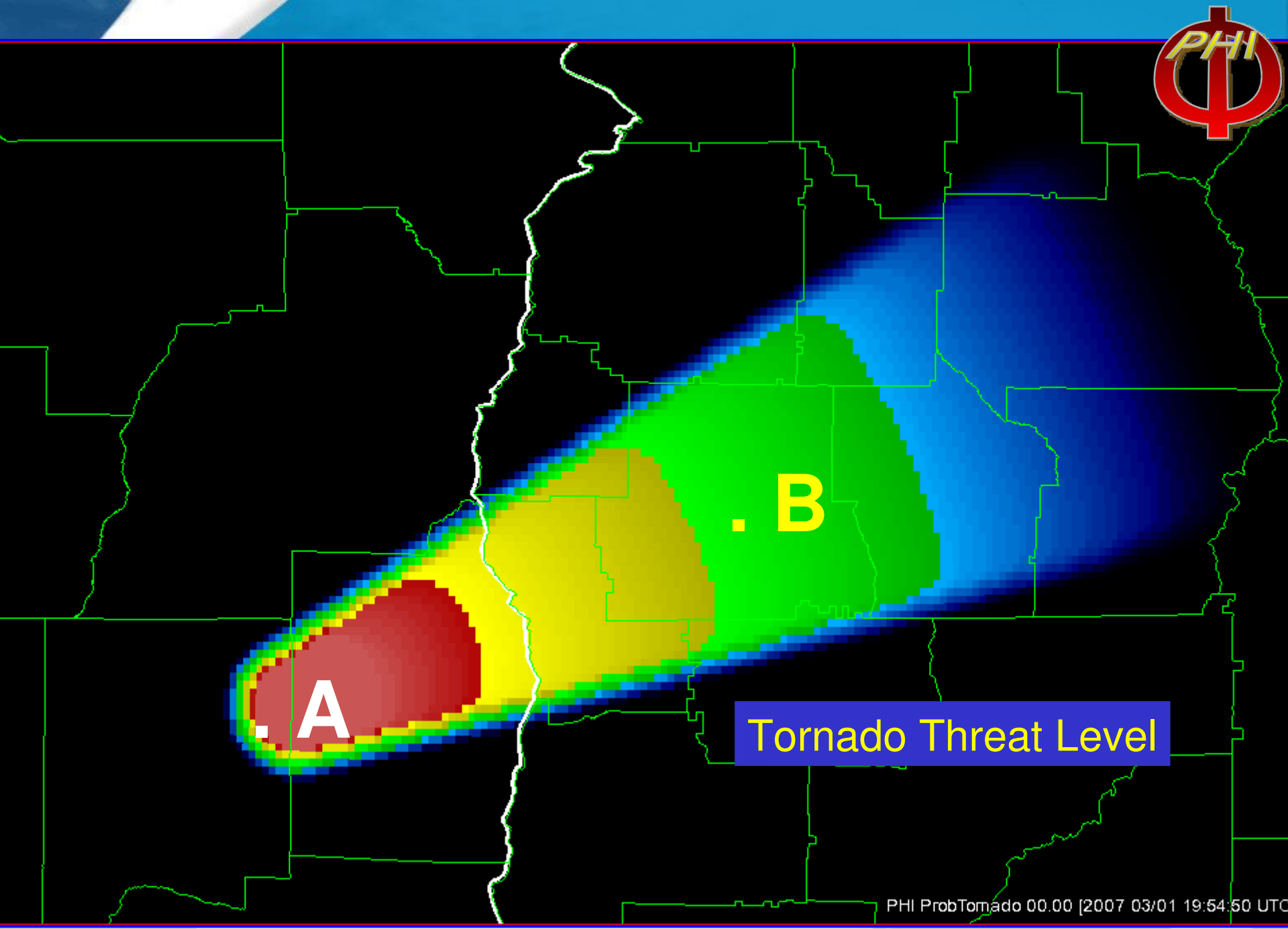

. B
. A
Tornado Threat Level
PHI ProbTornado 00.00 [2007 03/01 19:51:51 UTC


. B
. A
Tornado Threat Level
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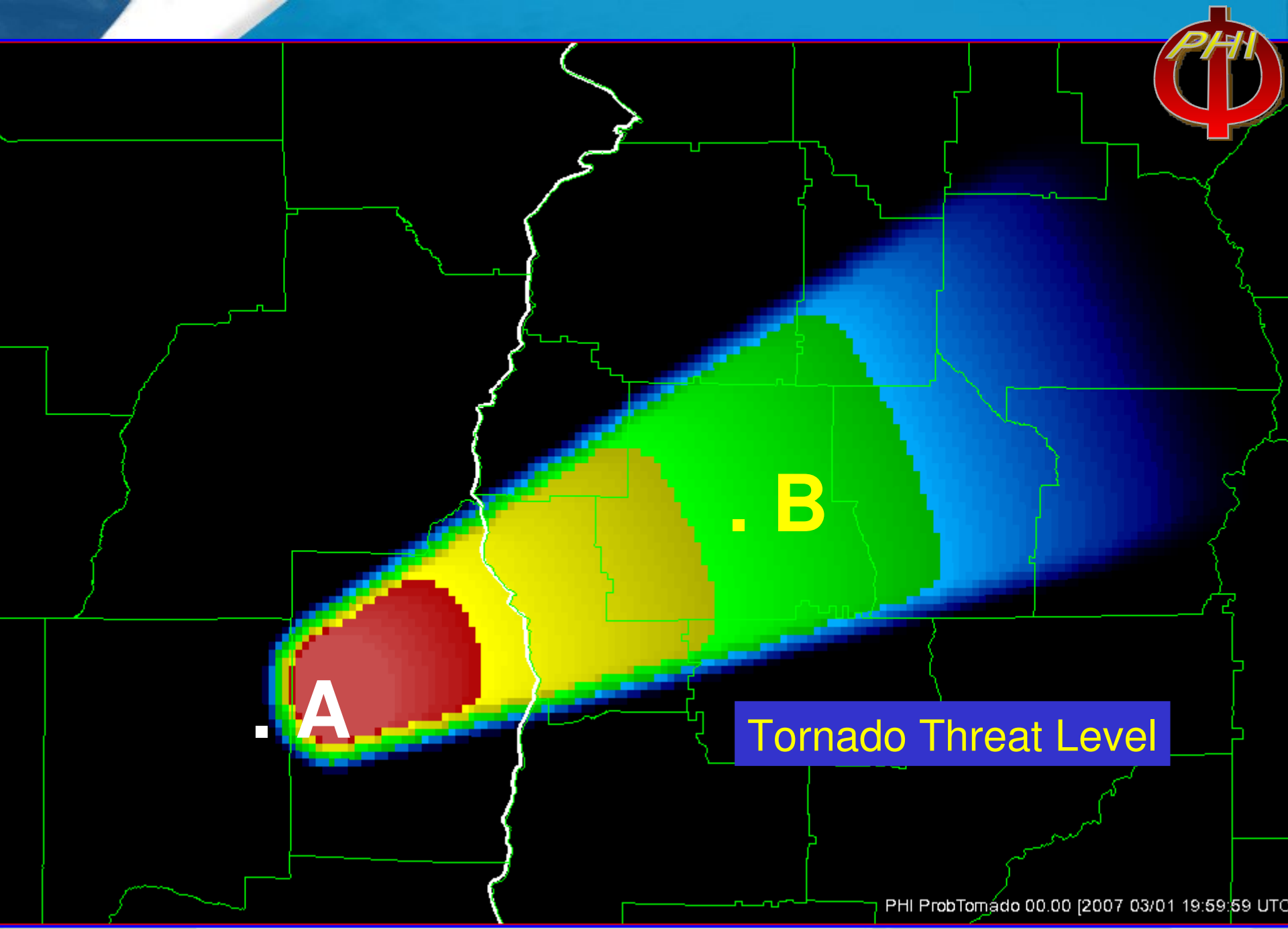
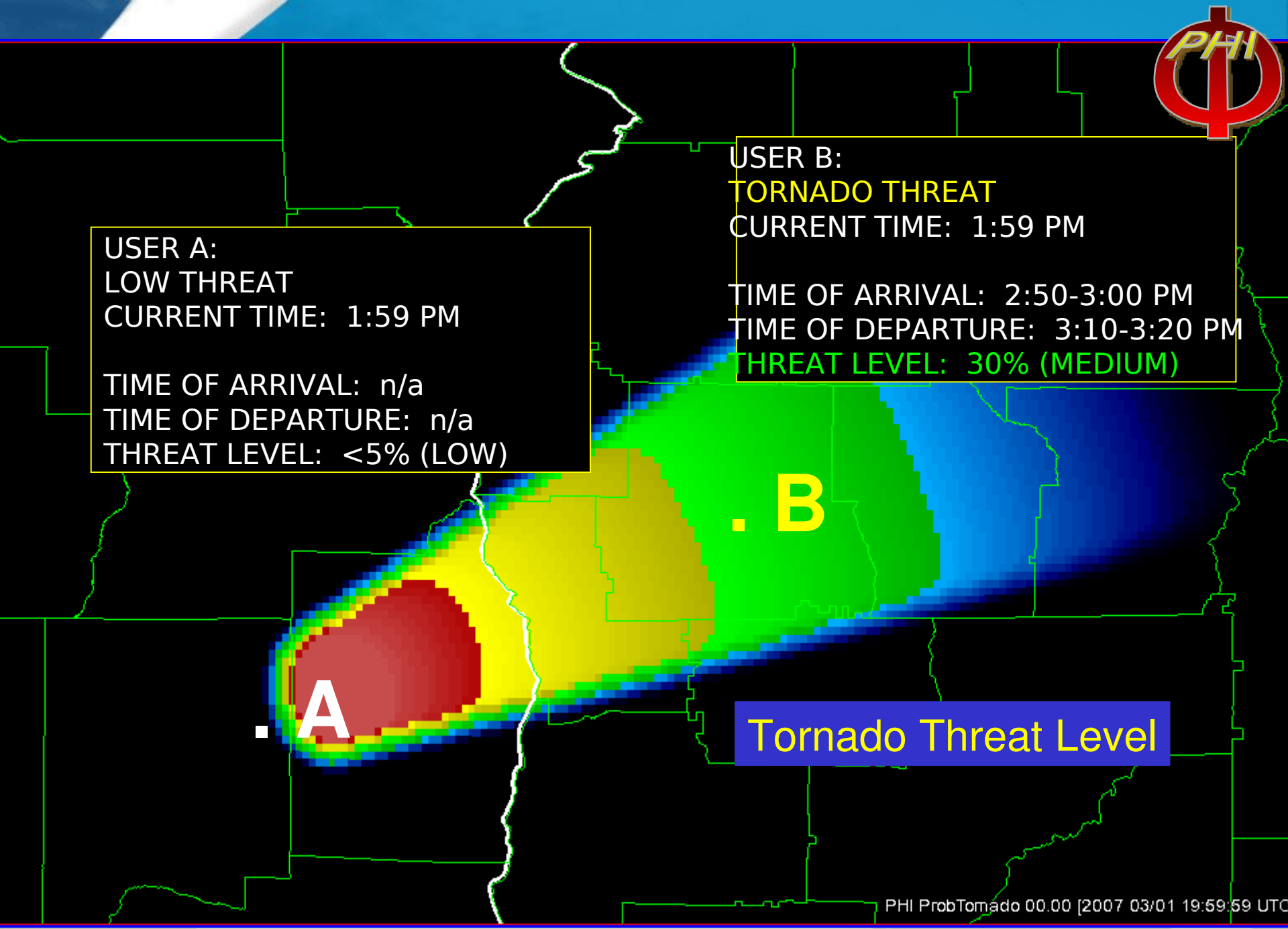

B
A
Tornado Threat Level
PHI ProbTornado 00.00 [2007 03/01 19:59:59 UTC

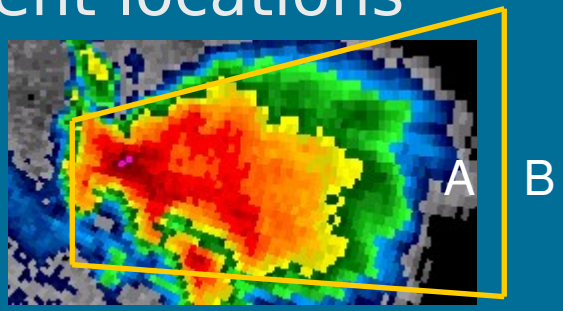

USER A:
LOW THREAT
CURRENT TIME: 1:59 PM
TIME OF ARRIVAL: n/a
TIME OF DEPARTURE: n/a
THREAT LEVEL: <5% (LOW)
USER B:
TORNADO THREAT
CURRENT TIME: 1:59 PM
TIME OF ARRIVAL: 2:50-3:00 PM
TIME OF DEPARTURE: 3:10-3:20 PM
THREAT LEVEL: 30% (MEDIUM)
B
A
Tornado Threat Level
PHI ProbTornado 00.00 [2007 03/01 19:59:59 UTC

Storm-Based Warning Shortcomings

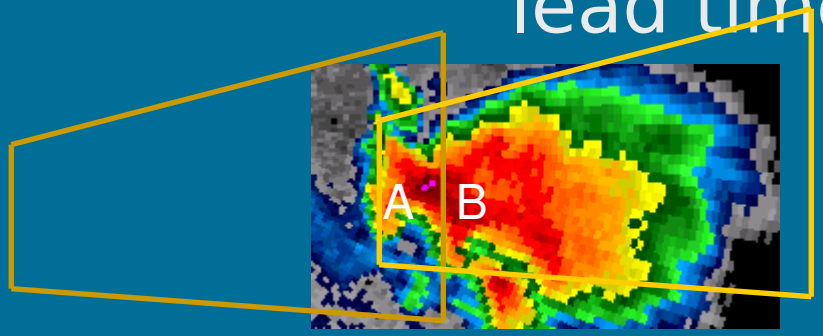
- One-size-fits-all: threat information for the polygon is “monotonic”.
  - Each location inside polygon is under exact same threat for the exact same time period
  - Each location inside polygon is given 100% certainty of event
  - Each location outside polygon is given 0% certainty of event
- Storm-based warnings are <u>area</u> forecasts verified by <u>point</u> events.
- What happens when storm motion changes before warning expires?

Storm-Based Warning Shortcomings

- Very little overlap between adjacent warnings can lead to inequitable lead times for nearly-adjacent locations



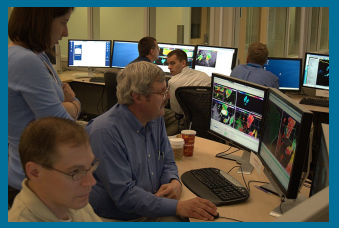
User “A” gets many minutes lead time…

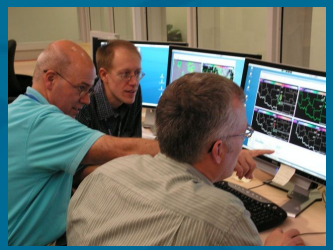


…while User “B” gets only 0-5 minutes

Probabilistic Hazard Information (PHI) Experiment Objectives

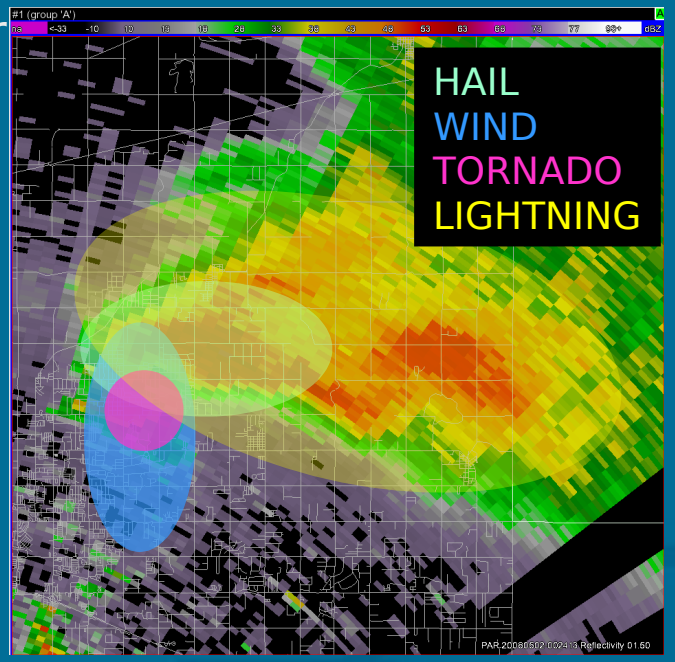
- Within the NOAA Hazardous Weather Testbed (HWT), we teamed up with NWS forecasters in 2008 to evaluate the:
  - Concept of short-fused hazard information on grids.
  - Concept of continuously translating threat areas.
  - Science of adding uncertainty information to warnings.
- This is an emerging concept and certainly not set in stone
- This work must consider many intersecting disciplines:
  - Meteorology
  - Technology
  - Social Science
  - Human Factors / Ergonomics





Hazard Grids

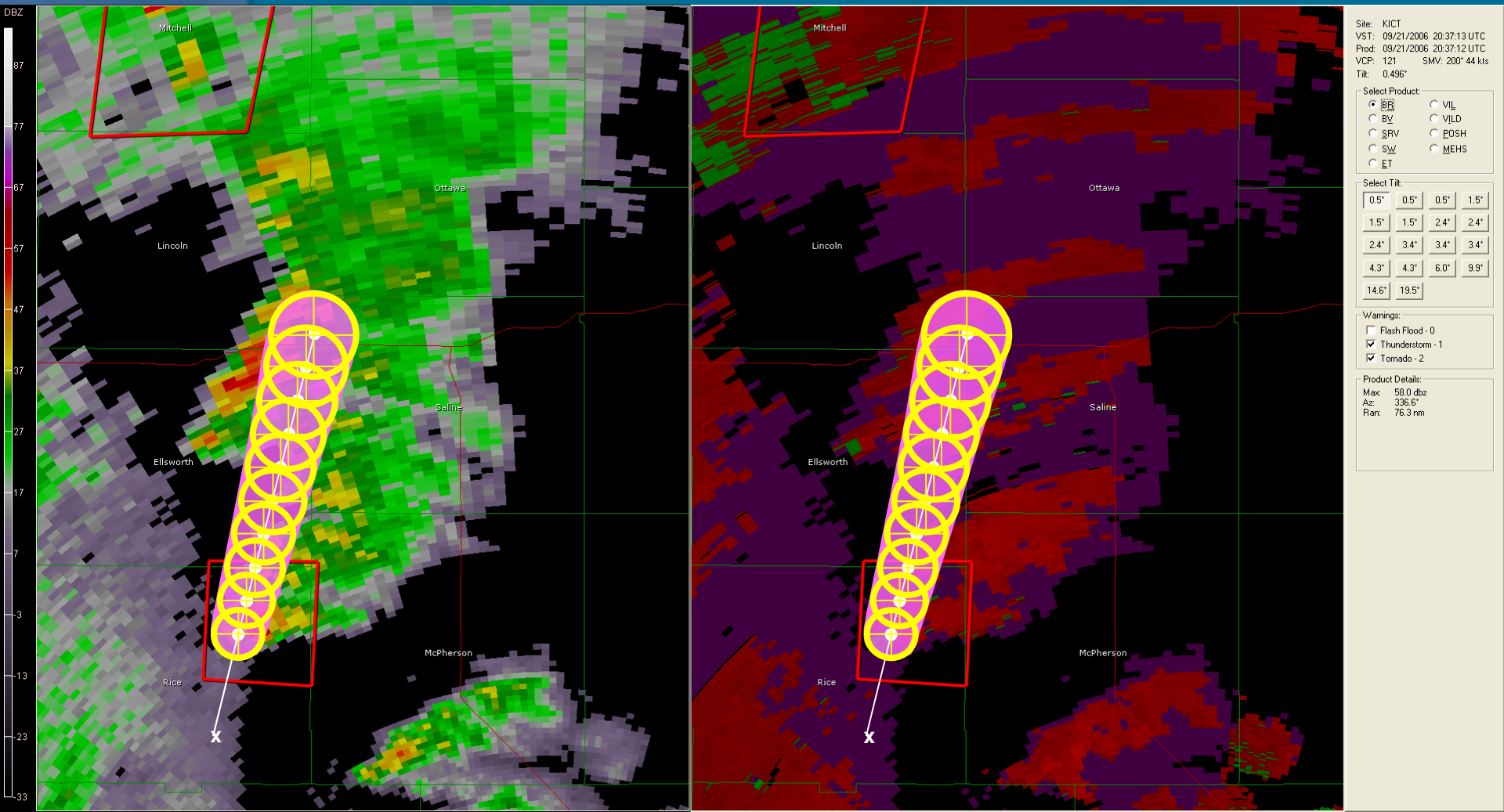
- Each hazard type can be depicted on separ
  - Hail
  - Wind
  - Tornado
  - Lightning
  - Other Hazards
- Threat subtypes could also be depicted (hail size, wind speed)
- Consistency between forecasts and events
- Can be aggregated into simpler formats
- Allows for growth (added detail)



Translating threat areas

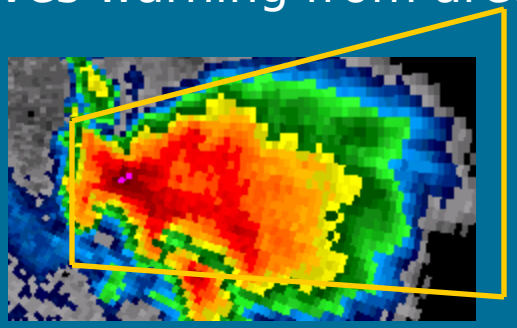
- Instead of the forecaster guessing at the swath…
- …we propose that much more robust warning information can be derived if the forecaster instead determines
  - the initial threat area at time=0, along with
  - the motion vector, and adds
  - motion uncertainty information

Translating threat areas



Automatically translating warnings

- Warning automatically translates downstream based on storm motion until adjusted or cancelled (“SVS”-like updating).
- Provides meaningful information about times of arrival and departure.
- Removes warning from area where threat has passed.

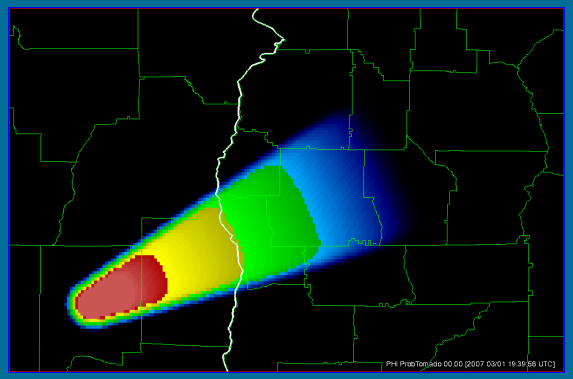


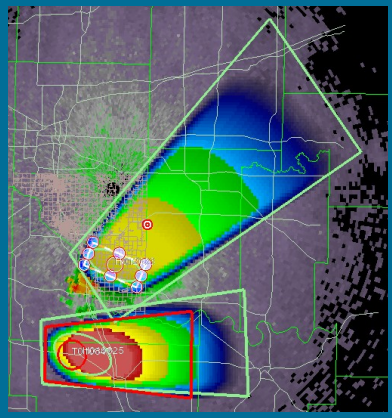
A B

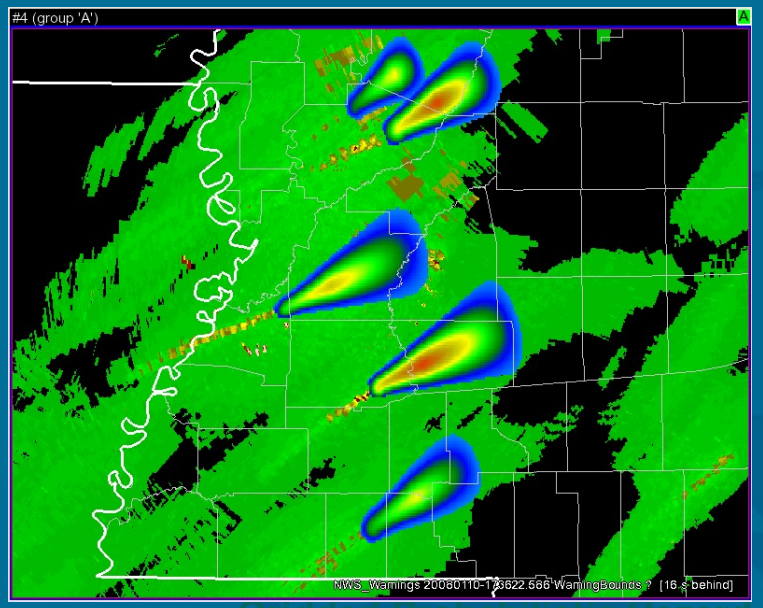
Both “A” and “B” get equitable lead time

Probabilities

- Can include probabilistic trend information on the grids
  - Integration over time results in a probabilistic swath
- Probabilities can be derived from a combination of:
  - Human expertise
  - Storm-type climatology statistics
  - Ensemble numerical guidance (“Warn On Forecast”)

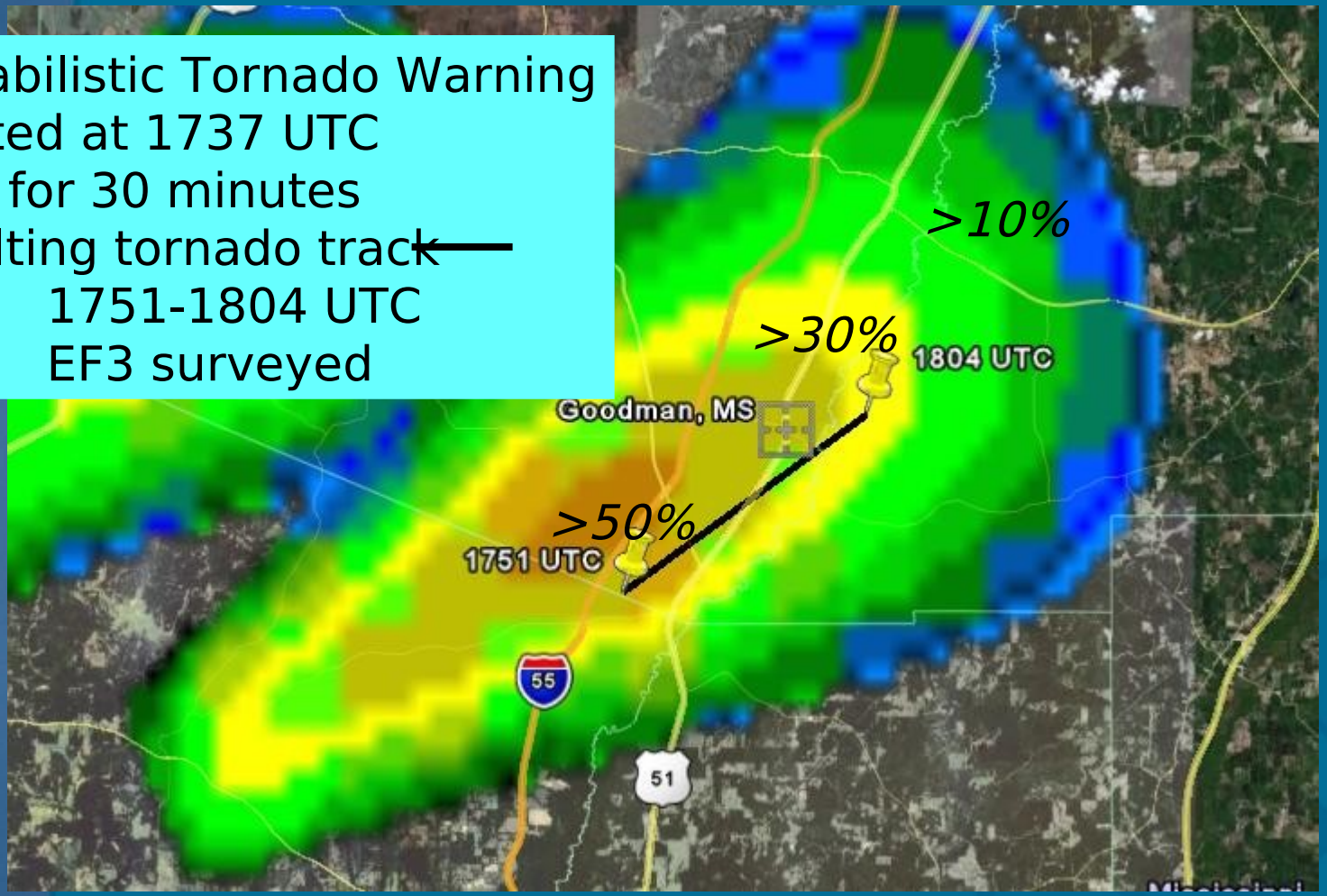






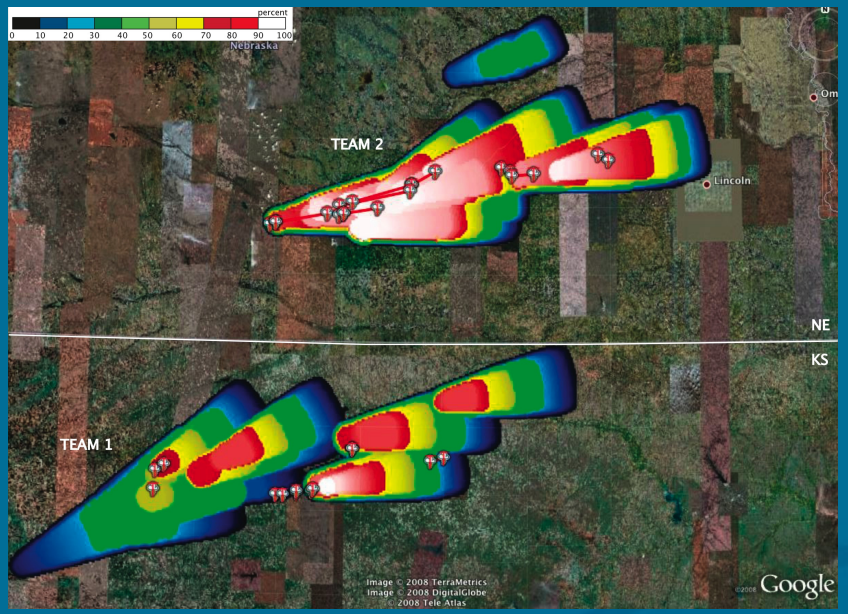
An early trial showed success!

Probabilistic Tornado Warning
Created at 1737 UTC
Valid for 30 minutes
Resulting tornado track ←
1751-1804 UTC
EF3 surveyed



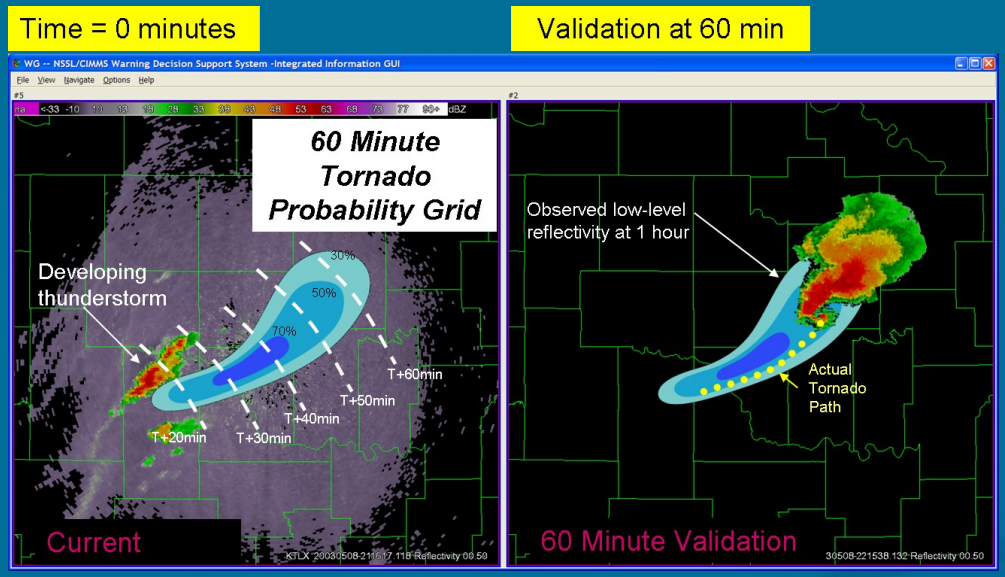
Summarizing the Possible Advantages of PHI

- Improved time specificity (hazard arrival and departure)
- Improved location specificity (smaller aerial coverage, moves with storm)
- Updates continuously in real-time to reflect changes in storm motion and evolution
- Defines type of threat (wind, hail, tornado, lightning)
- Allows for longer lead-times, though with higher uncertainty
- The high detail grids can be aggregated into simpler formats supporting legacy systems.



We envision this as the road map to Warn-on-Forecast

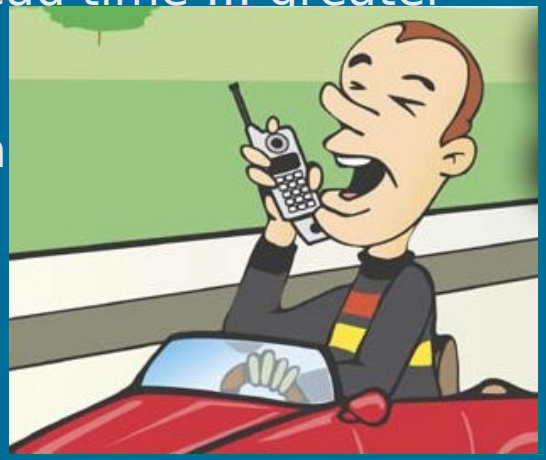
- Today: Warn via extrapolation of past and current hazard information.
- Tomorrow: Warn on predicted development of structures using high-resolution ensemble storm-scale numerical models.
- Warnings (which are just short-term forecasts) become more uncertain with time, therefore the solution will require a probabilistic approach.



How these gridded data can be used?

- Many opportunities for public-private partnerships
- Adaptive warnings allow users to set their threshold criteria, or allow third-party enabling technology/systems to do this for them
- For super-users: Longer lead time … greater uncertainty

Managers of large venues

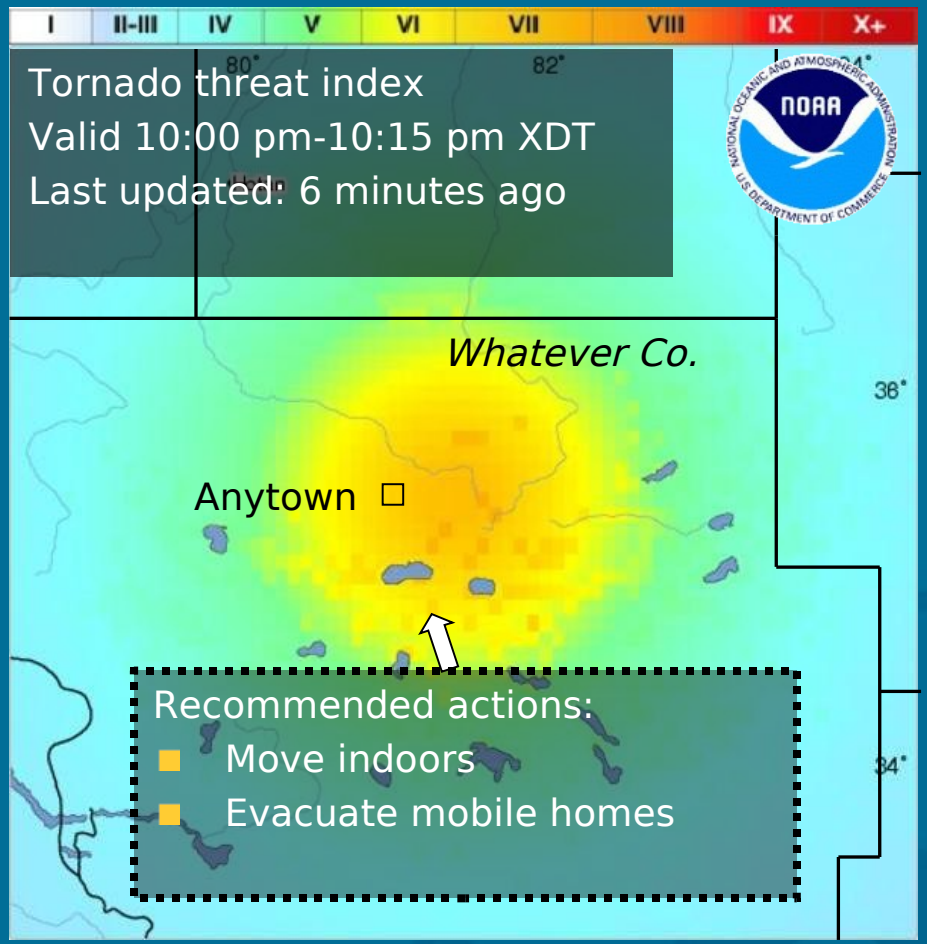


Geo-located cell phones and navigation systems

Facilities with long lead-time needs

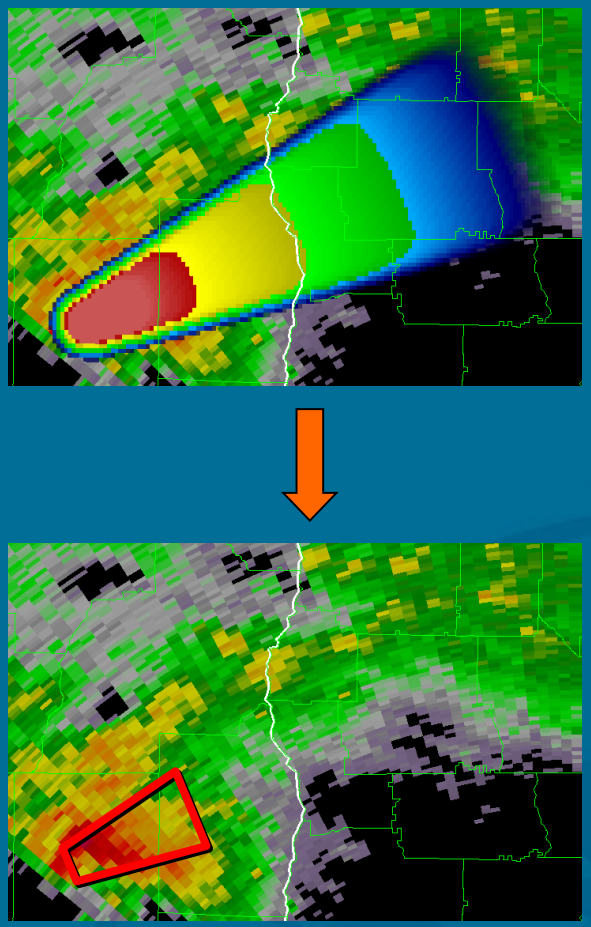
How these gridded data can be used?

- Convert probabilities to a DHS-like “Threat Level Index”.
- Intersect threat GIS layer with demographic GIS layers to create tailored calls-to-action
- Different calls-to-action based on combination of hazard threat level and unique (and sometimes dynamic) exposure/response times of the individual users.



How these gridded data can be used?

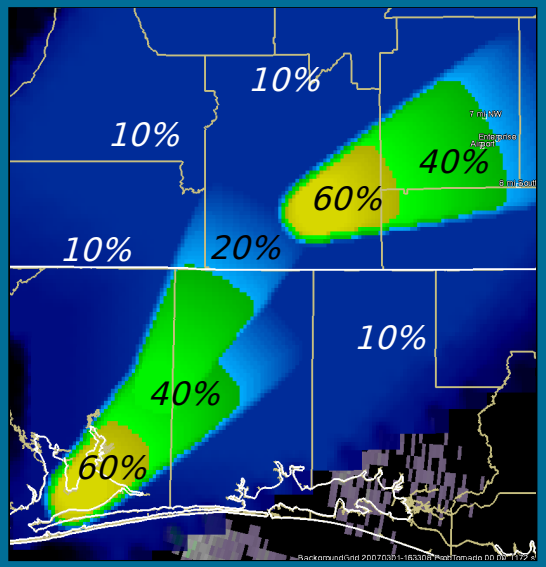
- Any high resolution grid (space and time) can be aggregated into simpler formats
  - Supports legacy county-based warning systems (television crawls, local and NOAA Weather radio).
  - Not every user needs to see the probabilities.



Gridded Probabilistic Hazard Information

How these gridded data can be used?

- Can issue hazard grids at probability values *below* expected thresholds for issuing today's warnings.
  - Provide greater lead time to high risk users.
  - Blend warning probabilities with SPC watch and outlook probabilities for seamless hazard information across all time and space scales.

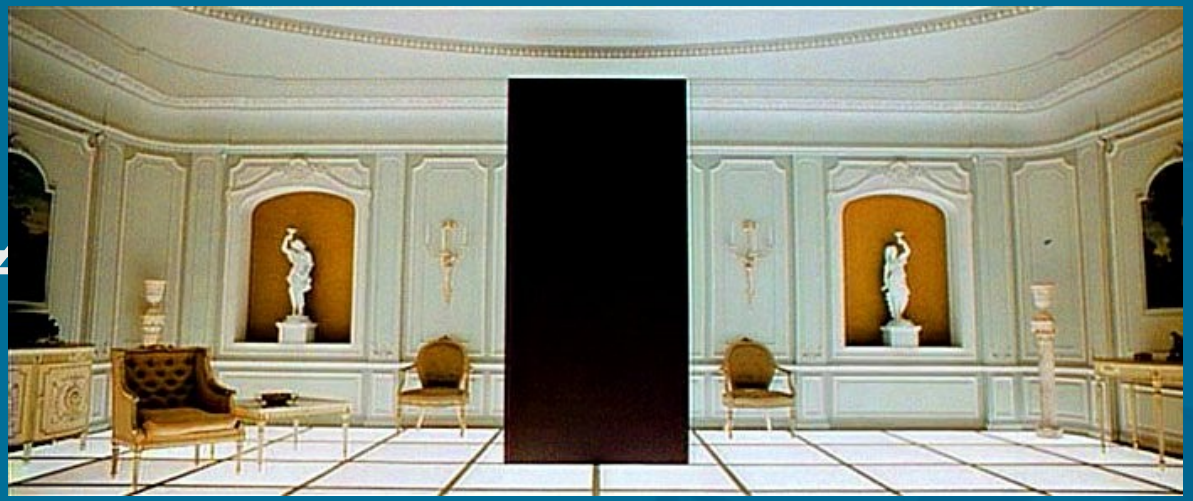


Gridded Probabilistic Hazard Information

Sociological Implications

- FAQ: "Will the public understand probabilistic warnings?"
- Answer:

The Public ≠

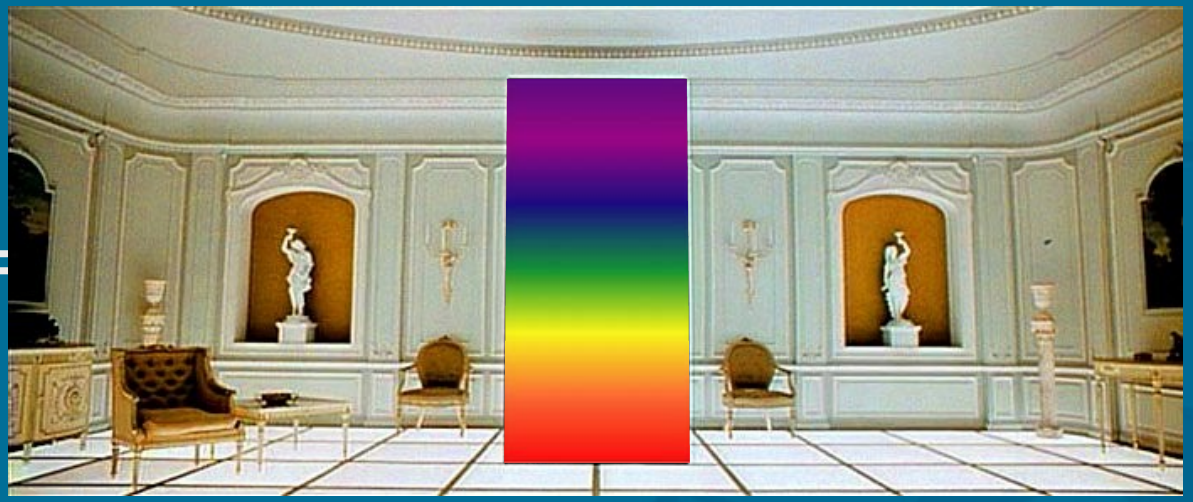


A monolithic mass with equal needs

Sociological Implications

- FAQ: "Will the public understand probabilistic warnings?"
- Answer:

The Public =

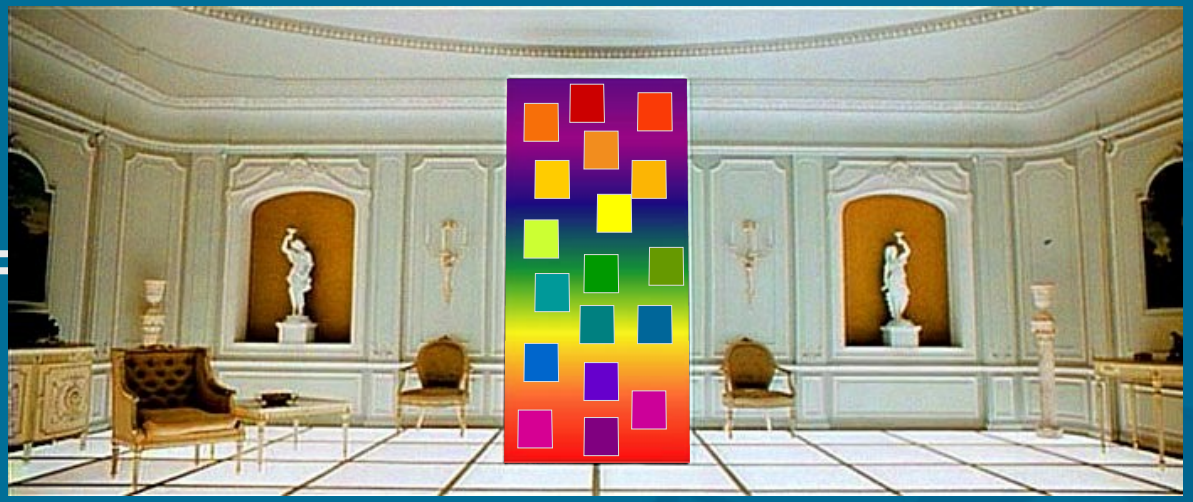


Spectrum of Warning Users with differing ne

Sociological Implications

- FAQ: "Will the public understand probabilistic warnings?"
- Answer:

The Public =



Spectrum of Warning Users with differing ne

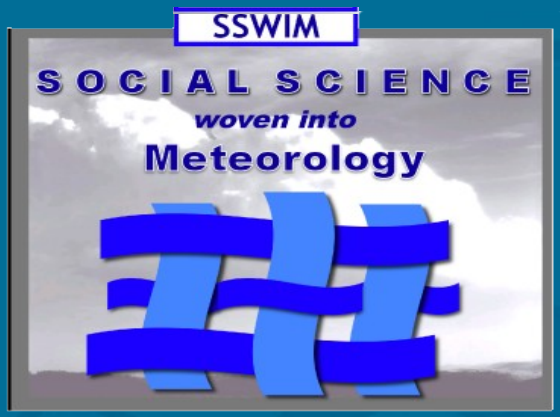
Sociological Implications

Risk = Hazard * Exposure * Response Time

Tornado, wind, hail, other hazards

How to account for this?

- "Beyond Storm-Based Warnings"
  Advanced WAS*IS Workshop – Sept. 2008
  - Meteorologists (researchers and forecasters)
  - Social Scientists
  - Emergency Managers
  - Geographers
  - Educators
  - Economists
  - Anthropologists
  - Media
  - Private Industry



WAS*IS Workshop Themes for discussion

- Inertia:
  - Is it possible to move away from “one size fits all” warnings?
- Vulnerability and cultural groups:
  - Handling the spectrum of users without being overwhelmed by it
  - Understanding how people make decisions to take certain actions
- Verification:
  - Do the current measures of skill really capture how well we are doing?
  - What socially relevant verification measures can we develop and use?

WAS*IS Workshop Themes for discussion

- Communication:
  - How do we develop meaningful scientific ways to convey uncertainty in warnings?
  - What are the best ways to convert gridded probabilistic hazard information to useful products?
- Preparedness:
  - How can we best stress the need for action before the storm arrives?
    - Long-term (months) to short-term (hours)
  - What kind of training and education is required to ensure appropriate understanding for various end-users?
- Experimentation:
  - How might we add a social science component to the PHI experiments in the Hazardous Weather Testbed?

Questions?

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