EXTRACTING UNCERTAINTY FROM WEATHER FORECASTS

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NOAA/GSD/Forecast Impact and Quality Assessment Section
UVIG 2017
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Who is FIQAS not?

The Forecast Impact and Quality Assessment Section

Who we are not:

~~FICUS~~

Who is FIQAS not?

The Forecast Impact and Quality Assessment Section

Who we are not:

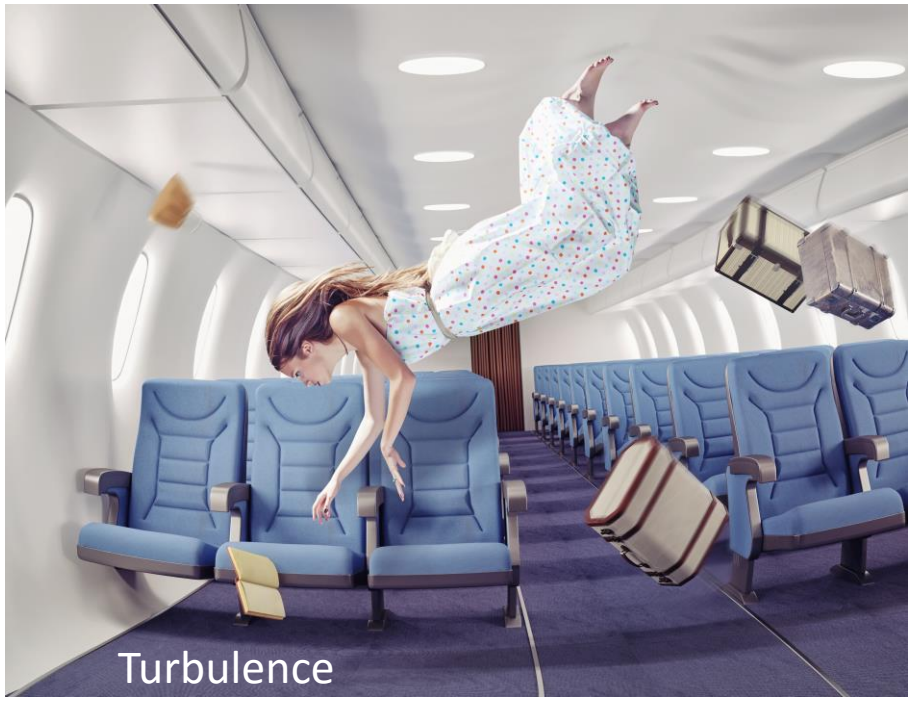
Who is FIQAS?

The Forecast Impact and Quality Assessment Section

We work primarily in the aviation realm doing

- Forecast verification for the FAA and NWS with a heavy focus on the context of how the forecasts are used
- Decision Support
- Common features of our work
  - Use multiple perspectives/approaches in an evaluation to get a comprehensive view
  - Verifying poorly observed/sampled phenomena (e.g., icing, turbulence)
  - Concerned with not just the weather itself, but the impact of the weather

Aviation Weather


Turbulence


Thunderstorms

Aircraft Icing

Uncertainty in Weather Forecasts

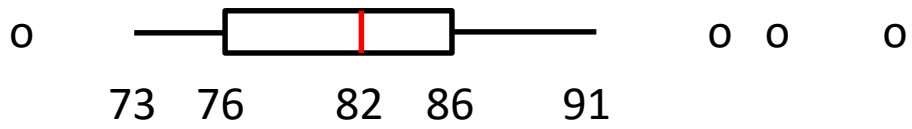
Statistical — climatologies

- Climatology, p(o)

  In the past, forecasts had errors of +/- 5°, Forecast = 80°F → 75° to 85°F

- Conditional climatology, p(o | f)

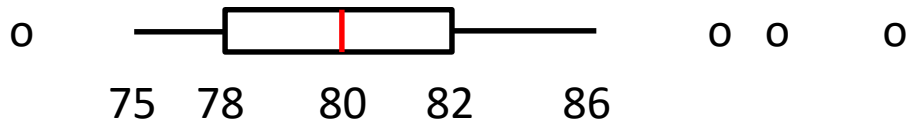
  In the past, when Forecast = 80°F, Obs =



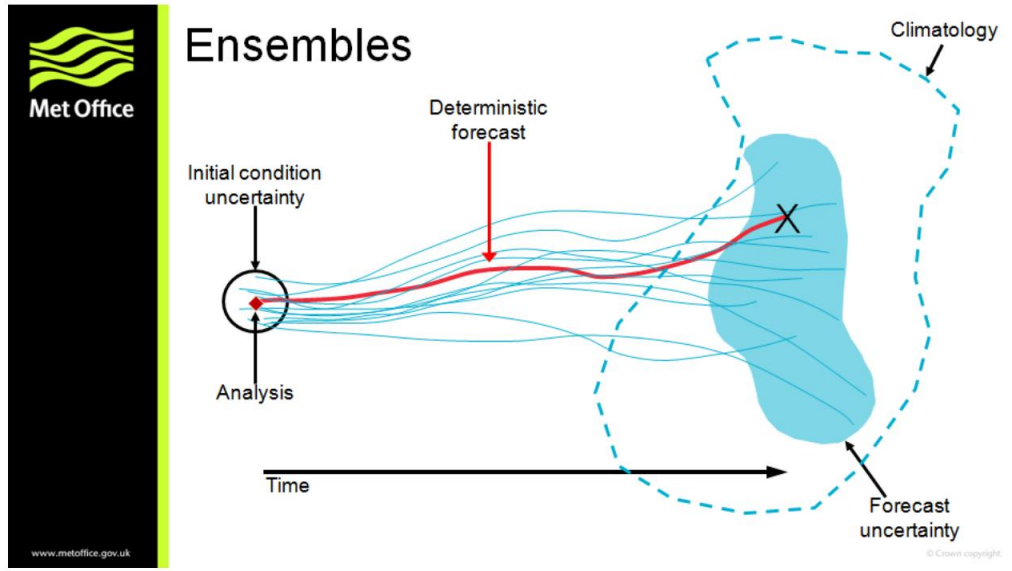
- Model Output Statistics (MOS), multiple linear regression/logistic regression

  In the past, when Forecast T = 80°F, RH = 70%, P = 1014 mb, and W = 12 mph from SW

  Obs =



Uncertainty in Weather Forecasts

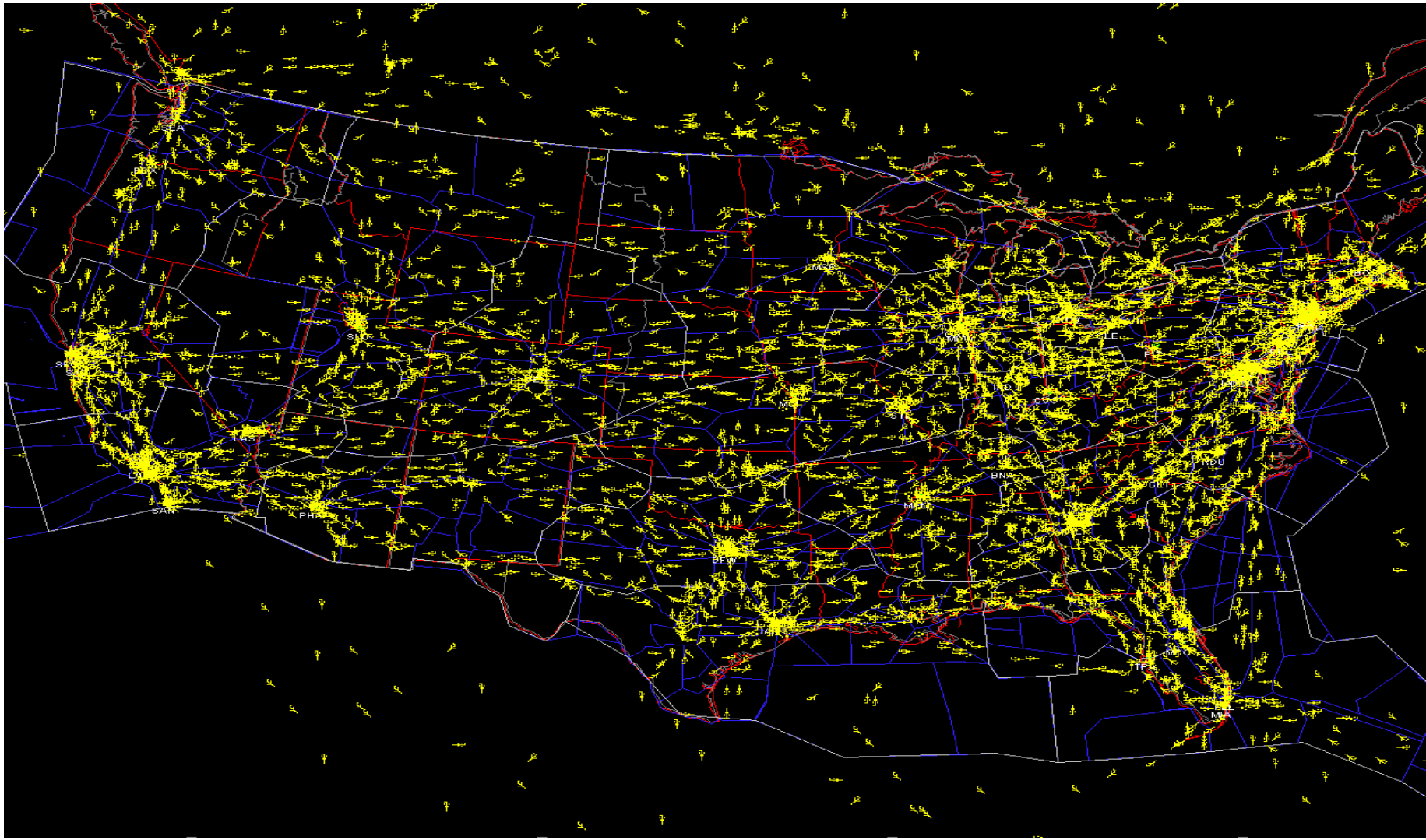


Dynamic — ensembles

- Single Center (e.g., ECMWF)
  - Often underdispersive -- too confident
- Multiple Centers (e.g., NAEFS = GEFS + CMC)
  - Can produce bimodal distributions, which can give misleading information, e.g., the mean of the combined distribution is not as likely as the means of either
- Ensemble of Opportunity (aka Poor Man's Ensemble)
  - Mix of physics, initial conditions, etc., often more dispersive, but typically fewer members—less robust statistics without more involved post-processing

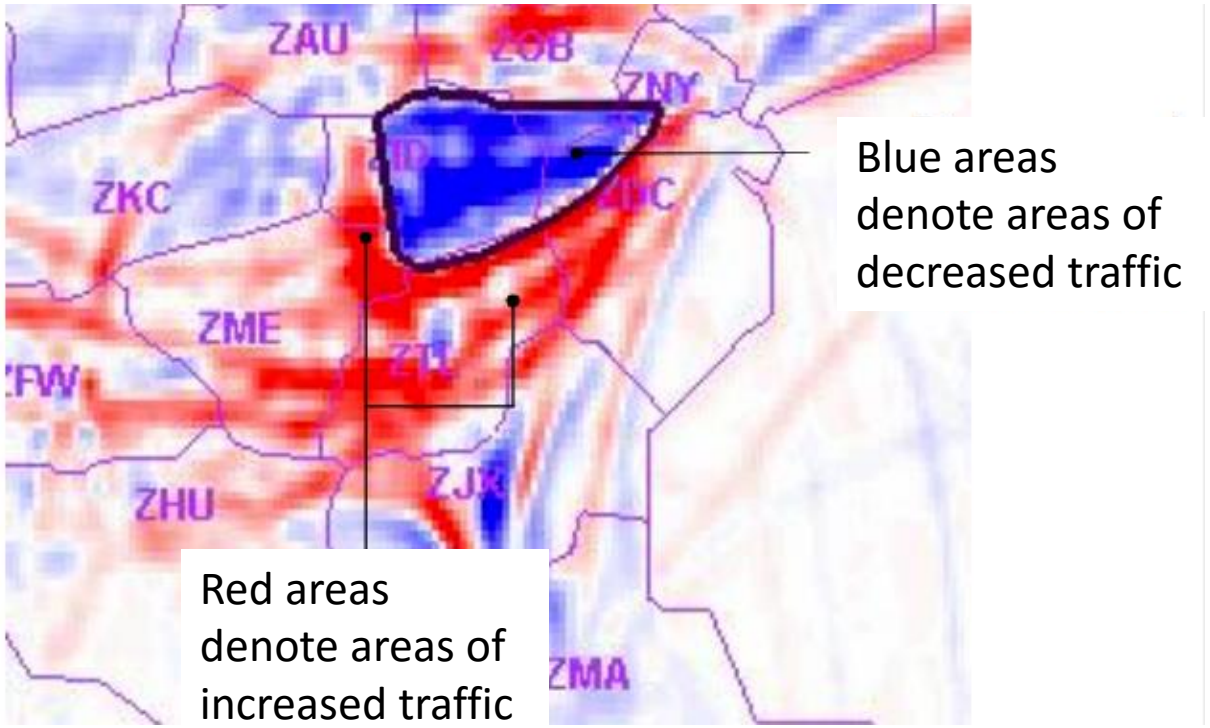
Aviation decision making

- Complex routing decisions to minimize disruptions to air traffic



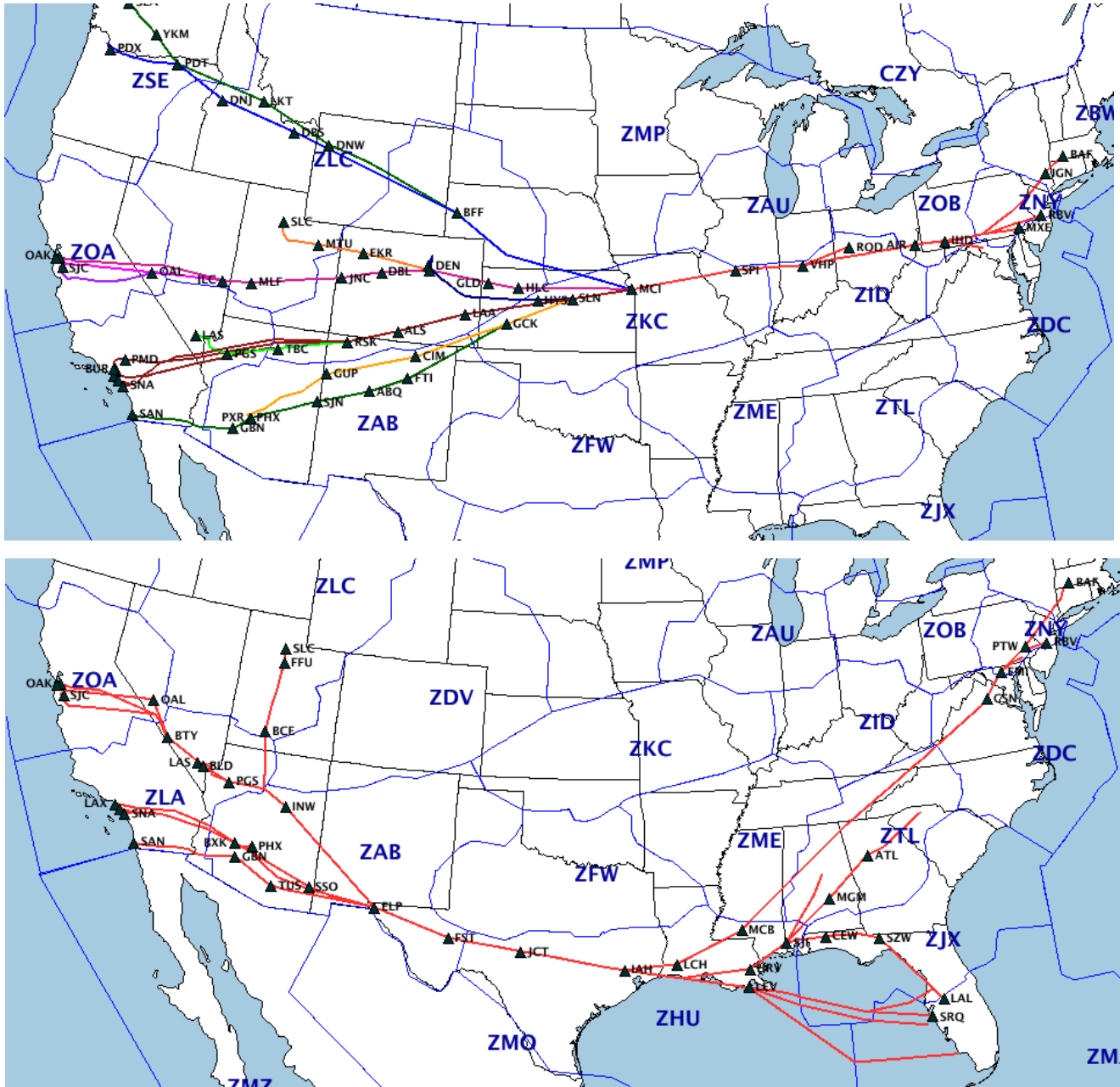
Aviation decision making

- Very sensitive to route blockage by thunderstorms
- But location and timing of thunderstorms is highly uncertain



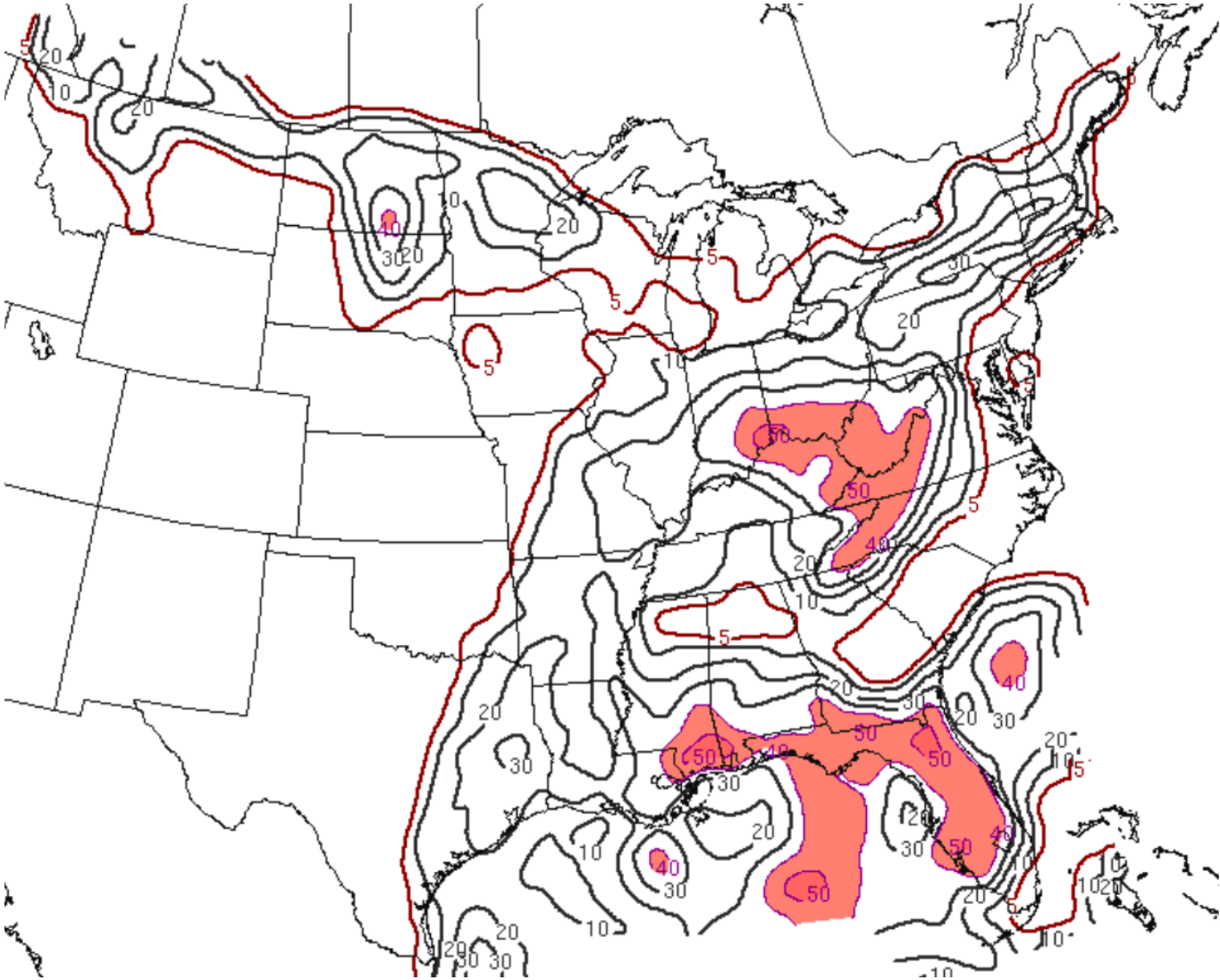
Aviation decision making

- The FAA uses basic sets of routes, or playbooks, to move traffic across the country
- The playbook is chosen to minimize exposure to the day's weather



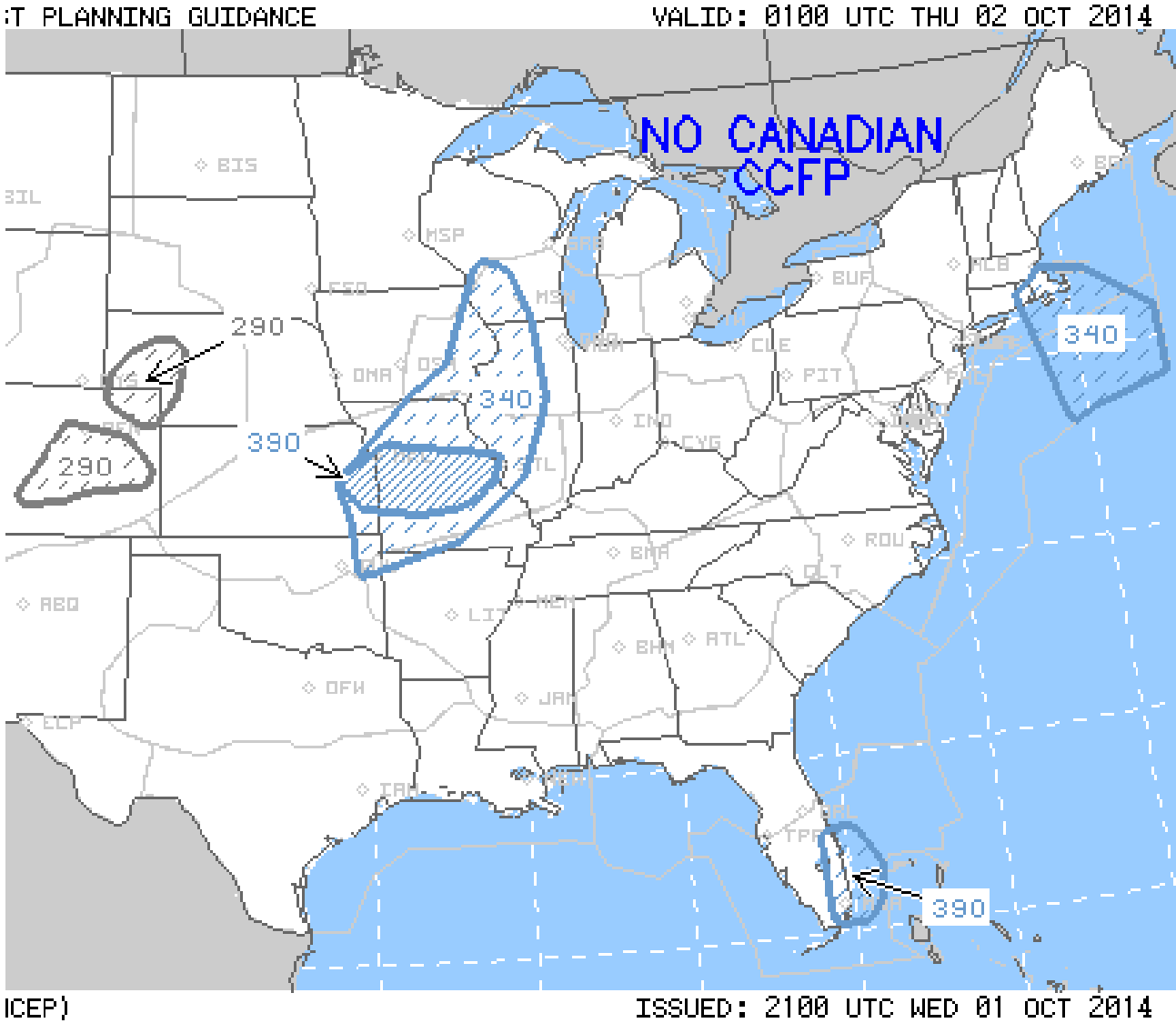
Aviation decision making—uncertainty

- Probability of thunderstorm
- No information about type of storms (e.g., line, cluster, isolated storms), coverage, height of storms, storm motion, etc.



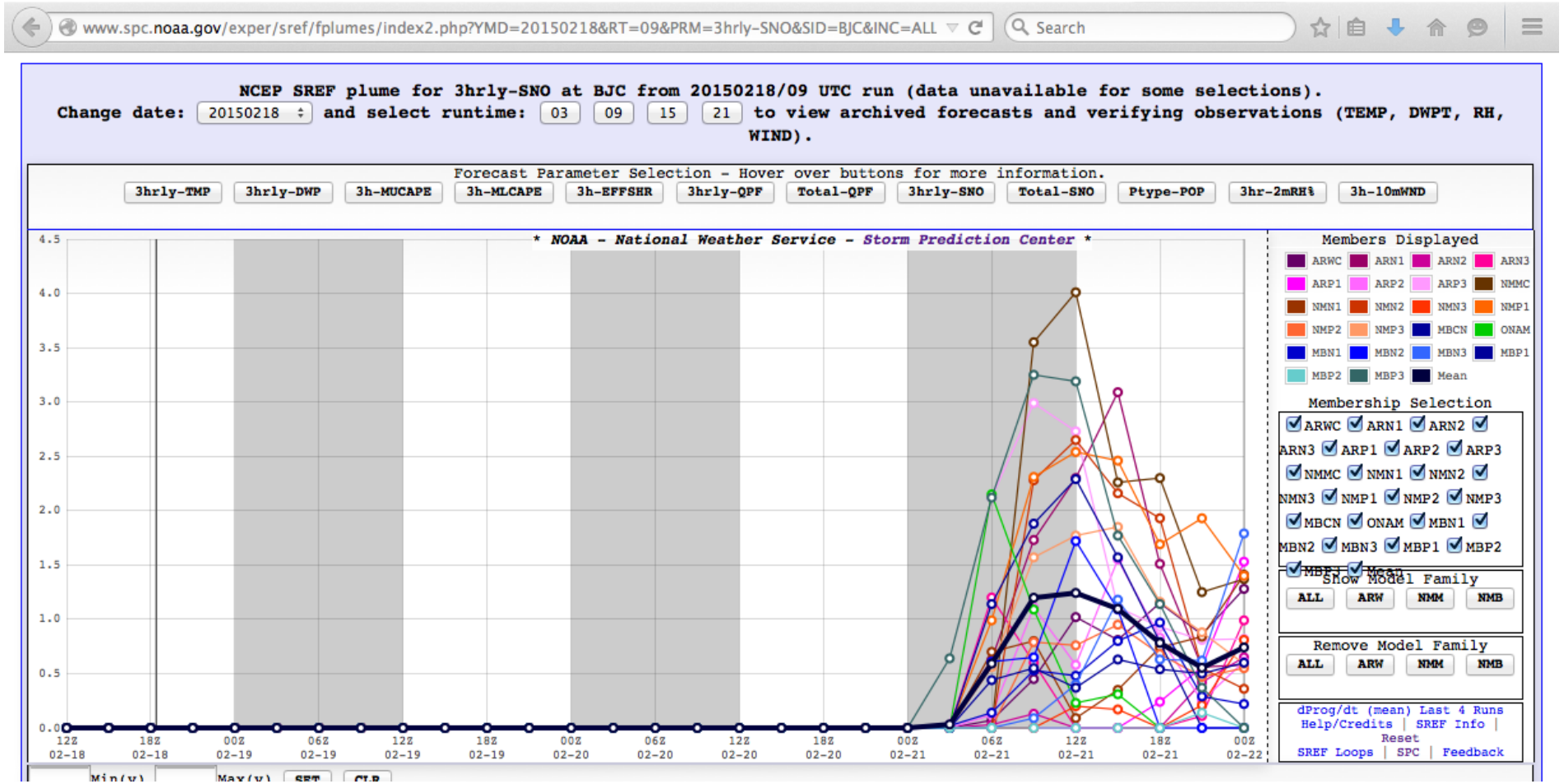
Aviation decision making—uncertainty

- Human-generated polygon of thunderstorms that could impact aviation
- Some information about type of storms (e.g., line, cluster, isolated storms), coverage, height of storms
- Still very hard to plan responses based on this information



Aviation decision making—uncertainty

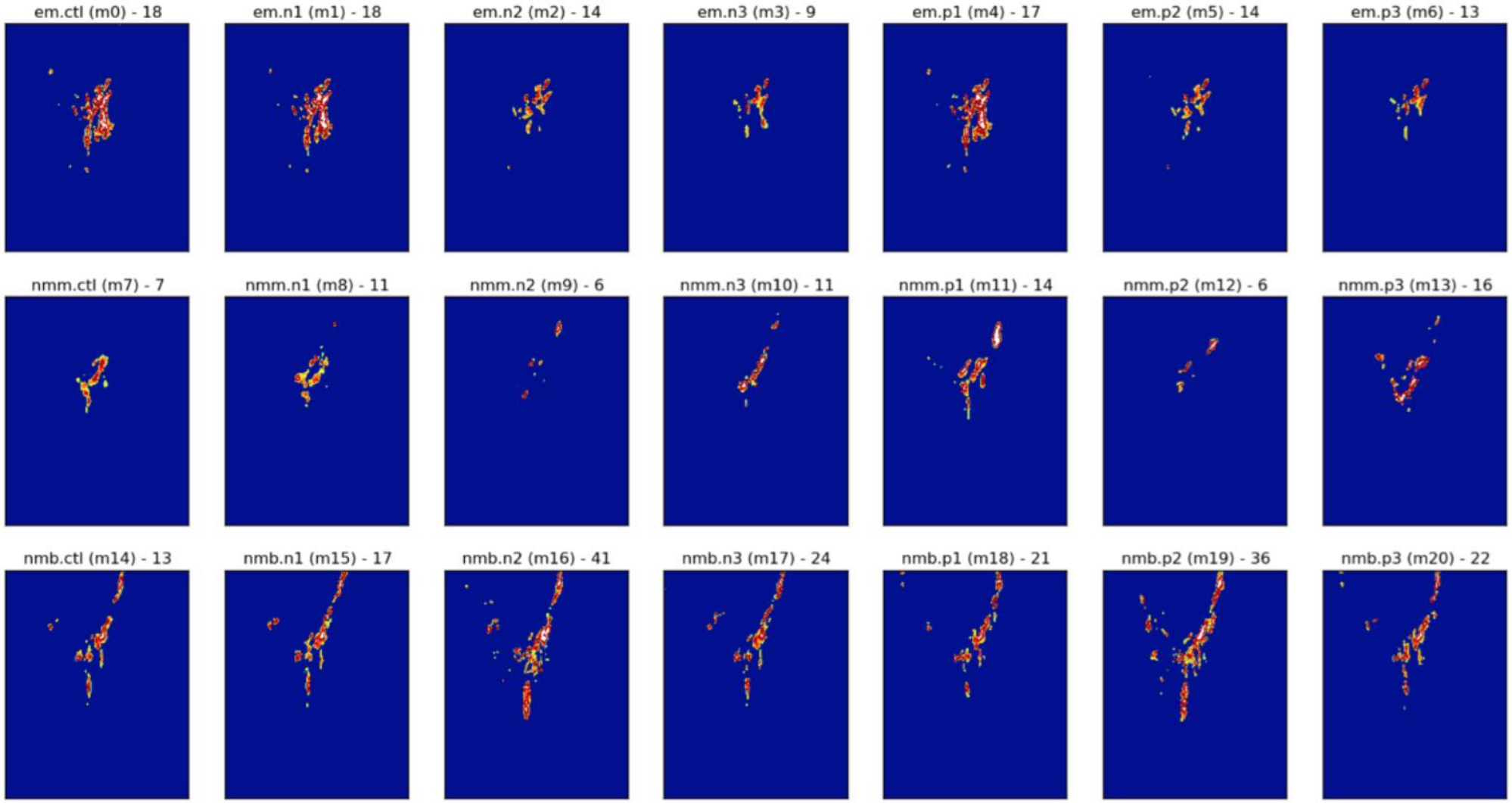
- Show full range of possibilities—can lead to data overload



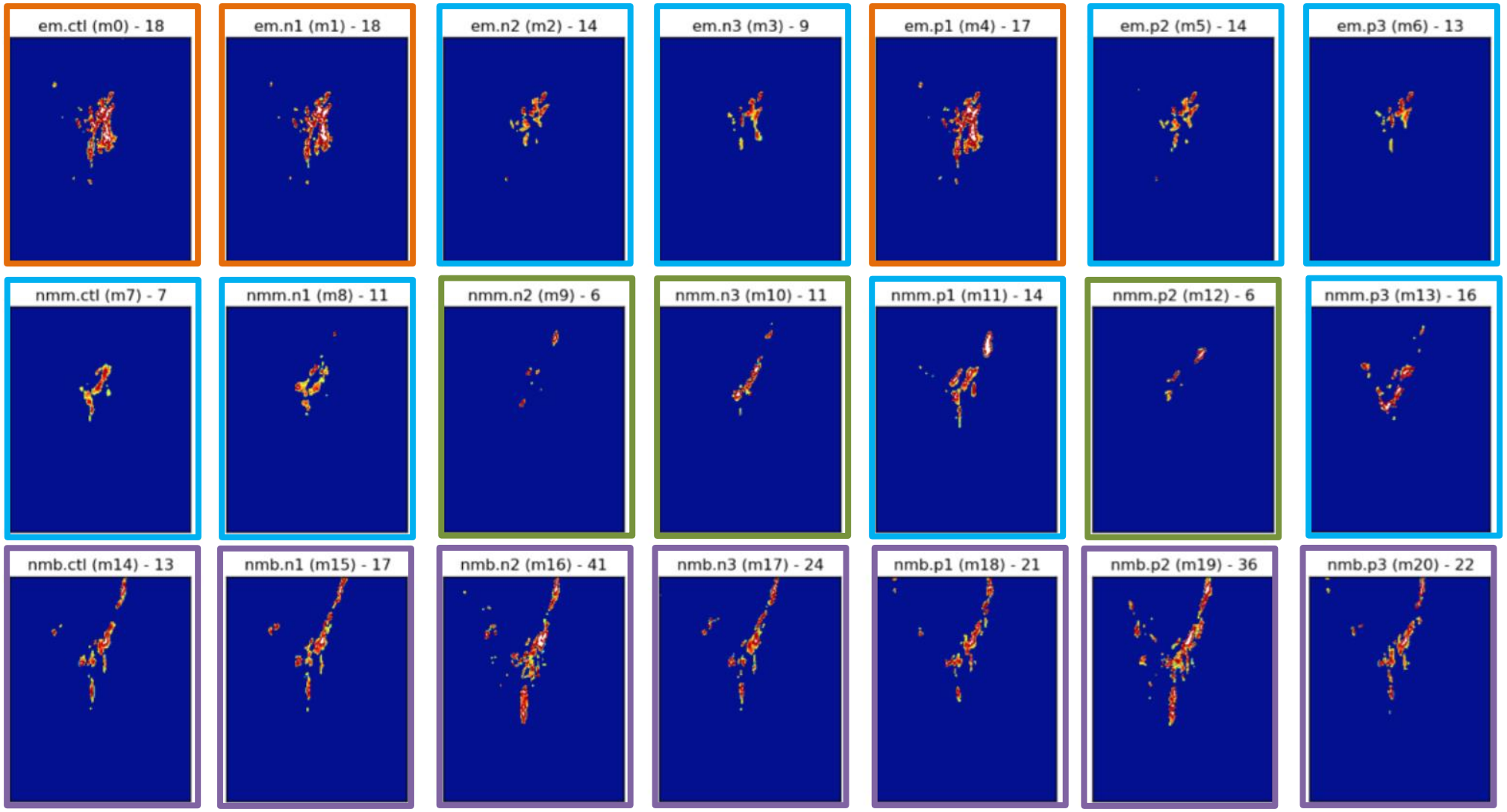
Aviation decision making—weather scenarios

- Take advantage of full range of solutions, but reduce the amount of data

Aviation decision making—weather scenarios

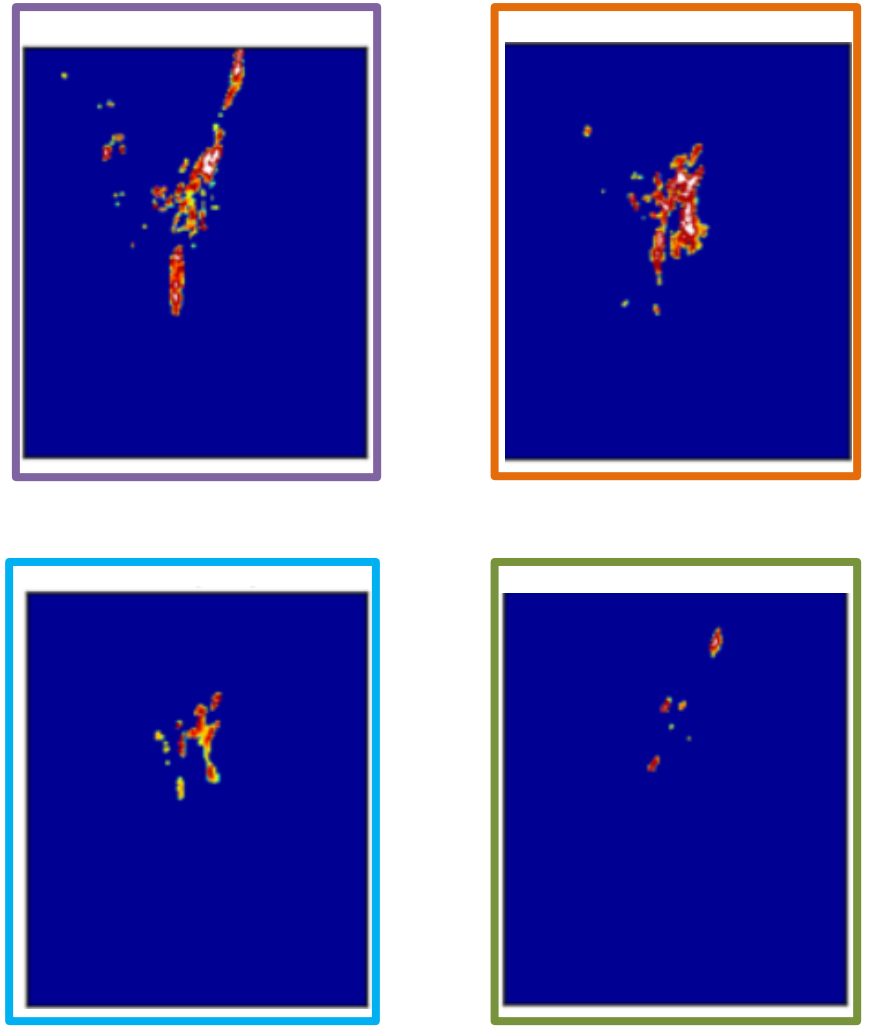


Aviation decision making—weather scenarios



Aviation decision making—weather scenarios

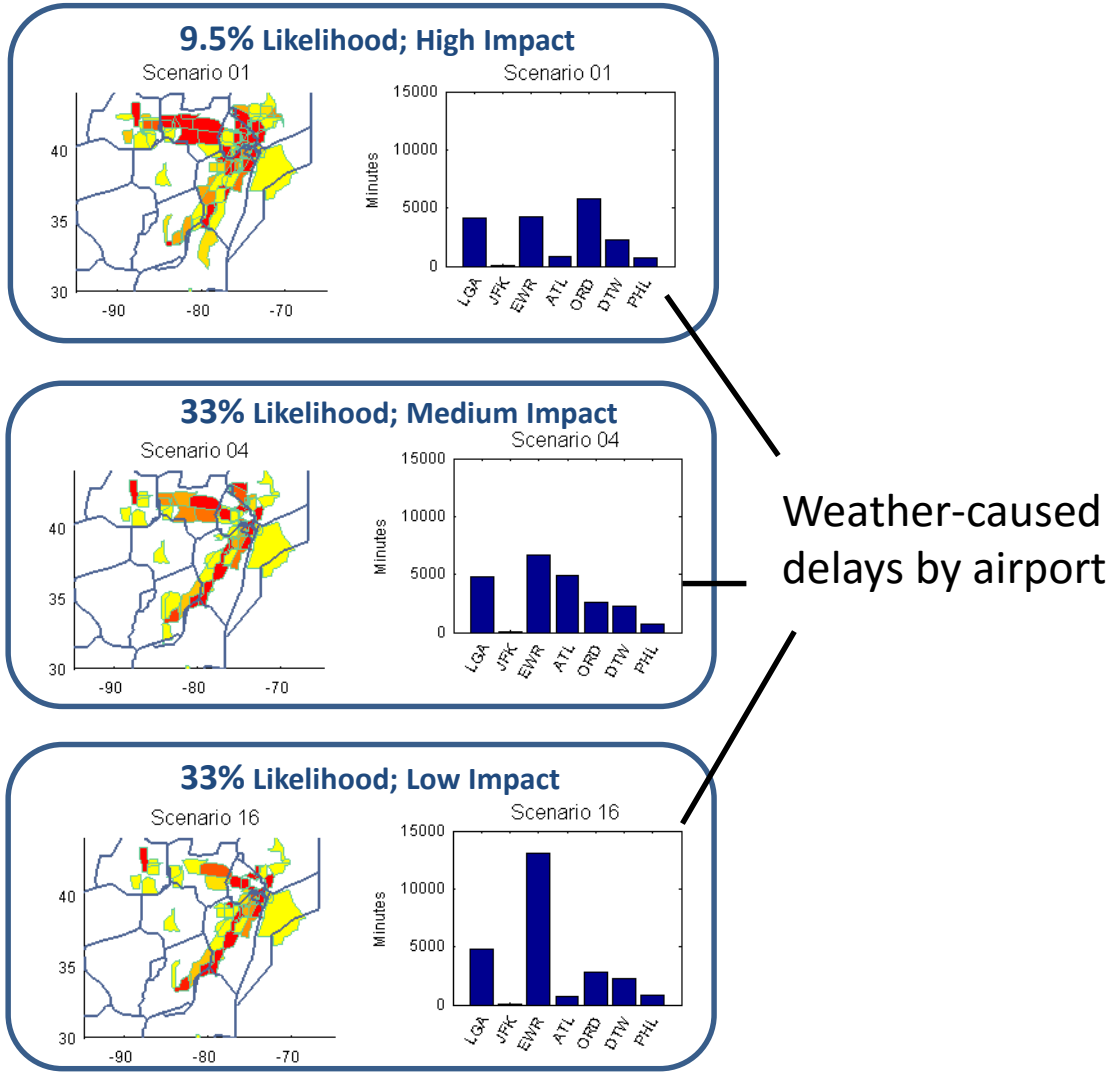
- 21 ensemble members have been reduced to 4 basic scenarios with very different expected responses
- Planners can select playbooks that are safe for any of the most likely scenarios



Aviation decision making—weather impact scenarios

Clustering on the weather gives different weather patterns

More useful would be to cluster on the impact, or on the optimum response, but this requires an accurate translation from weather to impact

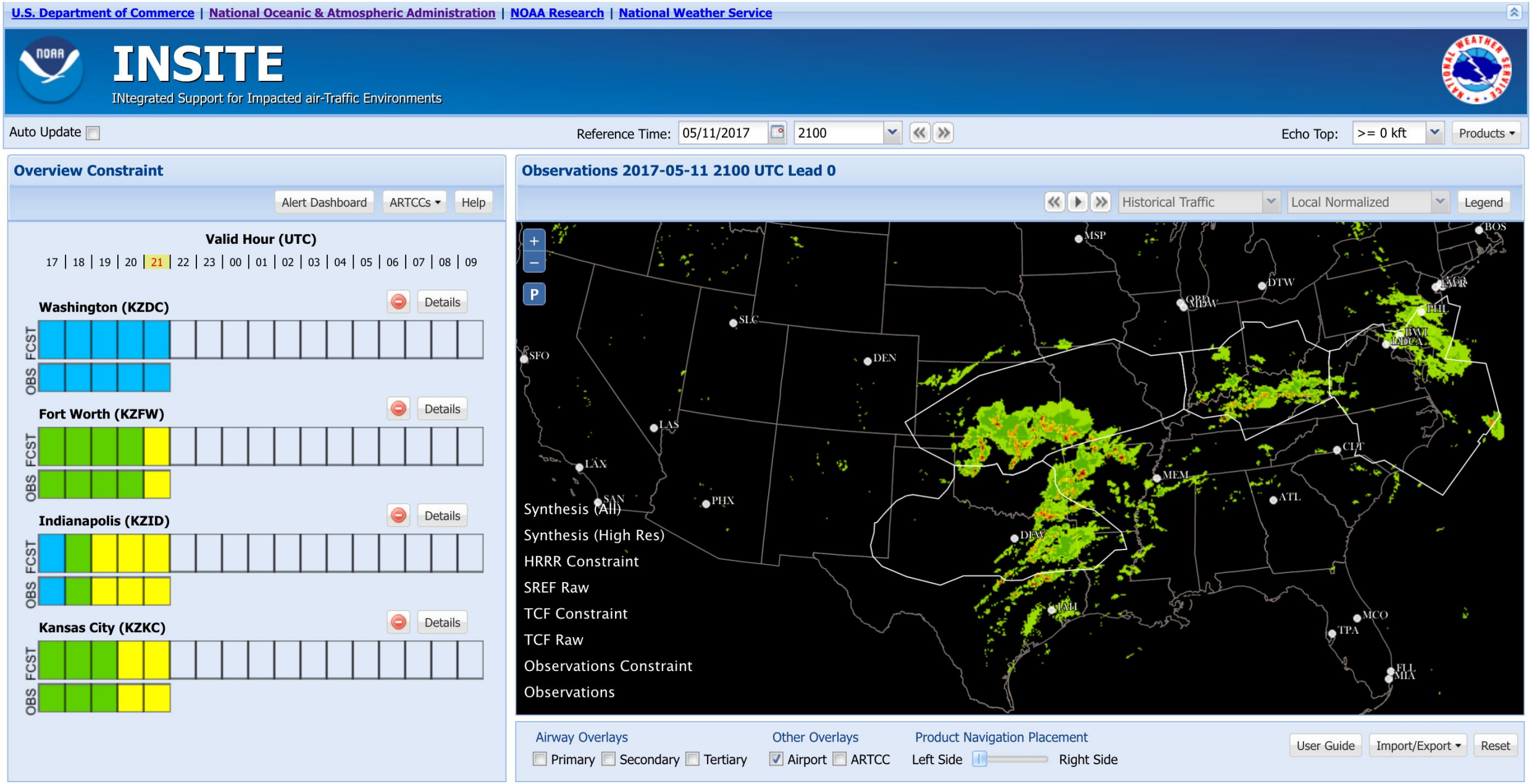


Picture Source: MITRE

Aviation decision making—constraint

Not all weather features are equally important

Focus should be on weather that impacts aviation interests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INSITE
INtegrated Support for Impacted air-Traffic Environments
Auto Update
Reference Time: 05/11/2017 2100
Echo Top: >= 0 kft
Products
Overview Constraint
Alert Dashboard
ARTCCs
Help
Valid Hour (UTC)
17 | 18 | 19 | 20 | 21 | 22 | 23 | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09
Washington (KZDC)
Details
FCST
OBS
Fort Worth (KZFW)
Details
FCST
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Indianapolis (KZID)
Details
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Kansas City (KZKC)
Details
FCST
OBS
Observations 2017-05-11 2100 UTC Lead 0
Historical Traffic
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Legend
Synthesis (All)
Synthesis (High Res)
HRRR Constraint
SREF Raw
TCF Constraint
TCF Raw
Observations Constraint
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DTW
BOS
SLC
DEN
SFO
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Other Overlays
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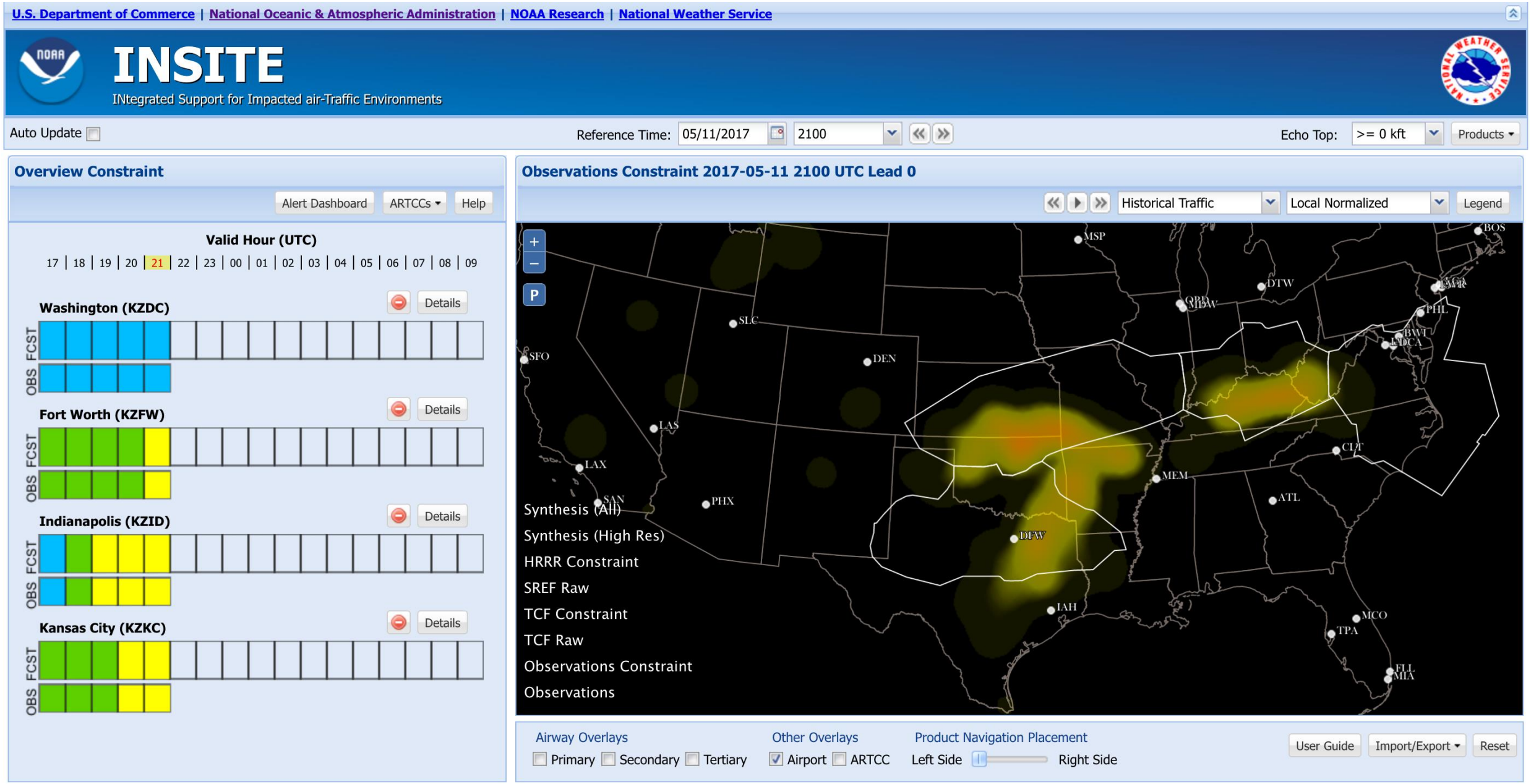
ARTCC
Product Navigation Placement
Left Side
Right Side
User Guide
Import/Export
Reset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LAX
SAN
PHX
CLT
MEM
ATL
DFW
IAH
MCO
TPA
FLL
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Airway Overlays
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INSITE

INtegrated Support for Impacted air-Traffic Environments

Auto Update | Reference Time: 05/11/2017 2100 | Echo Top: >= 0 kft | Products

Overview Constraint

Alert Dashboard | ARTCCs | Help

Valid Hour (UTC)

17 | 18 | 19 | 20 | 21 | 22 | 23 | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09

Washington (KZDC) Details

FCST

OBS

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FCST

OBS

Indianapolis (KZID) Details

FCST

OBS

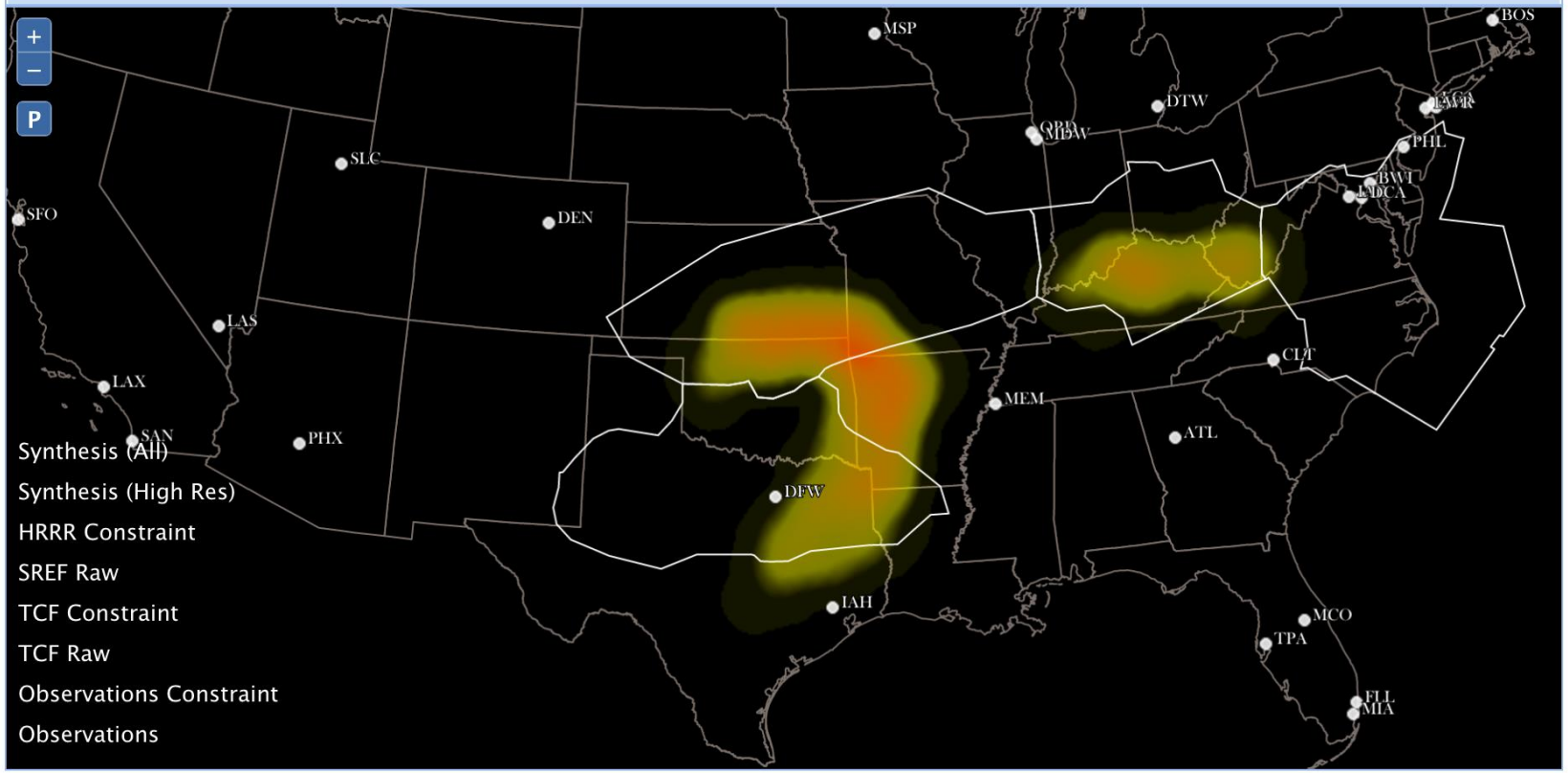
Kansas City (KZKC) Details

FCST

OBS

Synthesis (All) 2017-05-11 2100 UTC Lead 0

Historical Traffic | Local Normalized | Legend



Airway Overlays: Primary | Secondary | Tertiary

Other Overlays: Airport | ARTCC

Product Navigation Placement: Left Side — Right Side

User Guide | Import/Export | Reset

Summary

- Uncertainty in weather forecasts is generally achieved through either statistical (climatology) or dynamic (ensemble) approaches
- Uncertainty can be generic
  - Overall historic performance of model (statistical)
  - Basic probabilities of weather phenomena (dynamic)
- Or specific
  - Performance of model when the atmosphere was similar to today (statistical)
  - Likelihood of particular weather scenarios (dynamic)
- More helpful than simple weather uncertainty, weather can be translated into impact to provide information tailored to users
  - Thunderstorms → Air traffic flow constraint
  - Temperature, humidity → Electricity demand