An operational implementation of GTG-based turbulence forecasting

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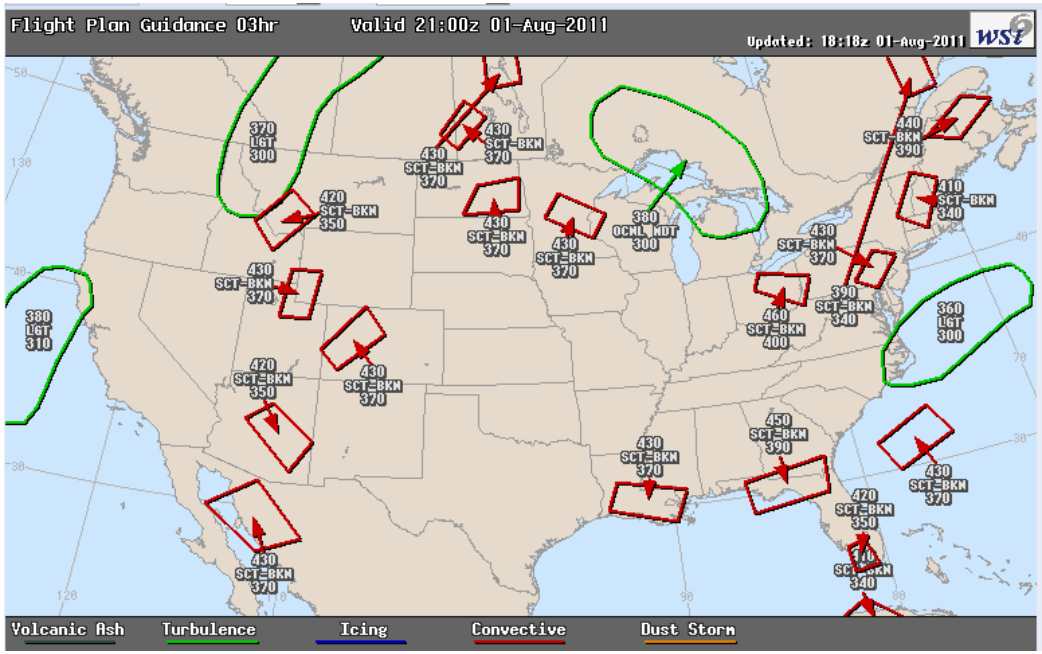
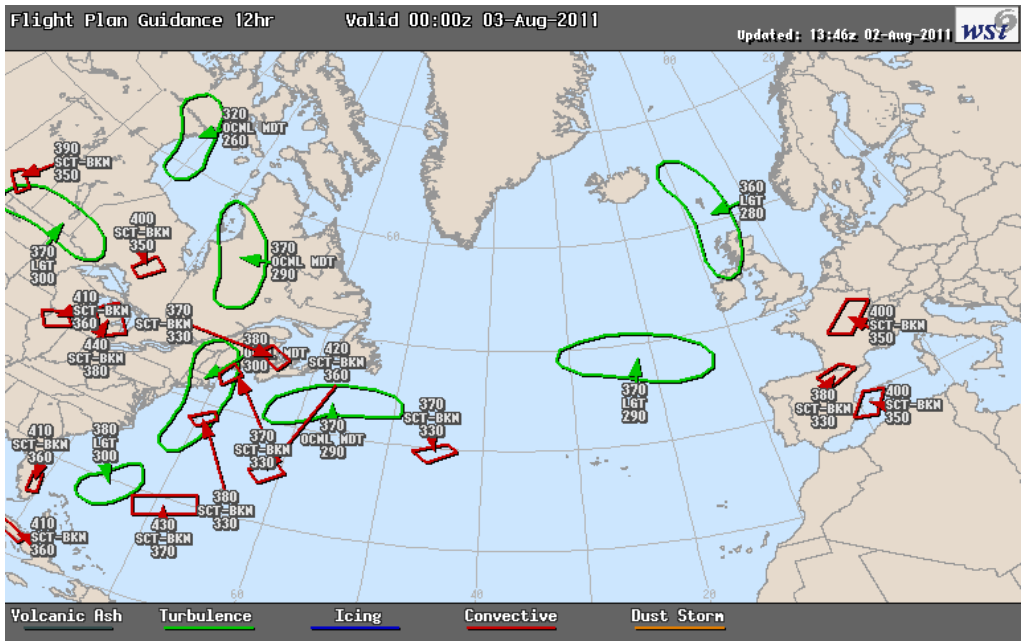
Overview

- Locally run NWP system
- Forecaster guidance and first-guess products
  - TAFs
  - **Flight Planning Guidance (e.g., Turbulence)**
- Process of forecasting en-route hazards





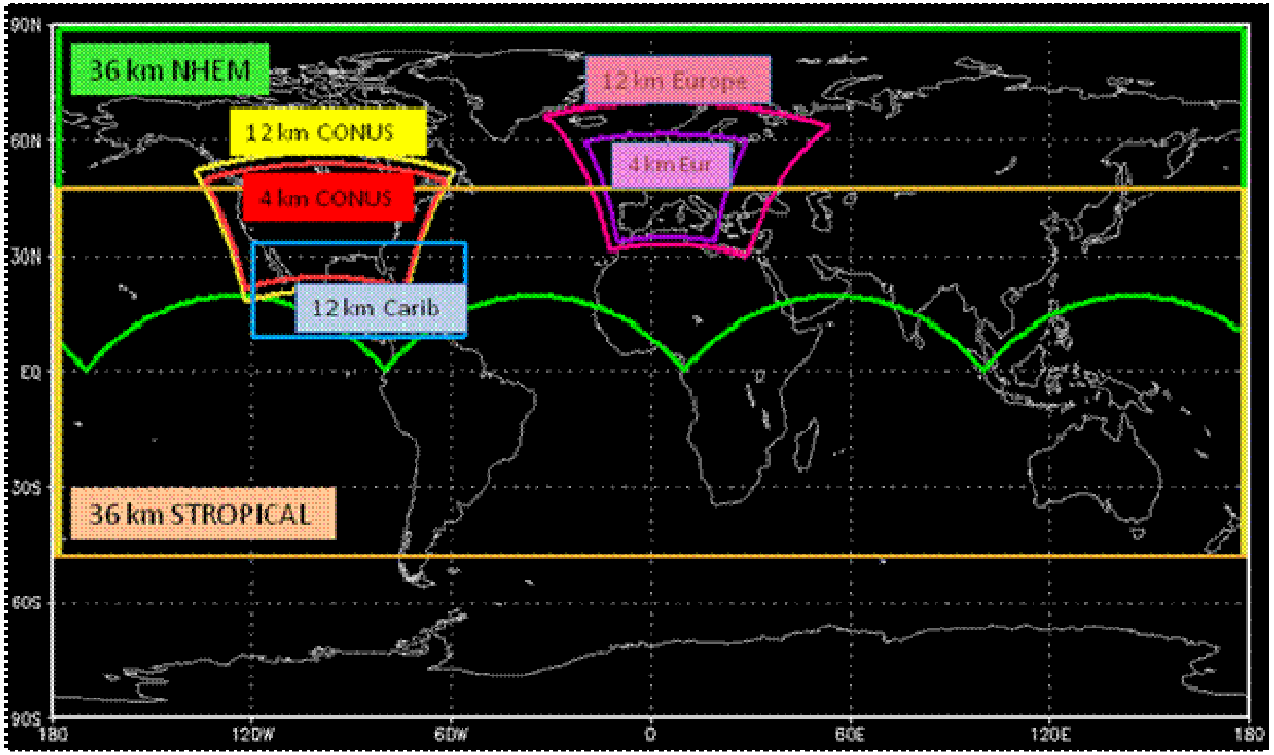
Numerical Weather Prediction System

NWP System

- NWP system
  - Forecasts out to 3 days
  - Nearly global coverage (4-36km)
  - Forecasts updates every 3 - 6 hours
- Operational for over 7 years
  - 24x7 Support
- Hardware
  - 123 servers (660 cores)
  - 34 additional servers (408 cores) coming on-line in Fall

NWP Details

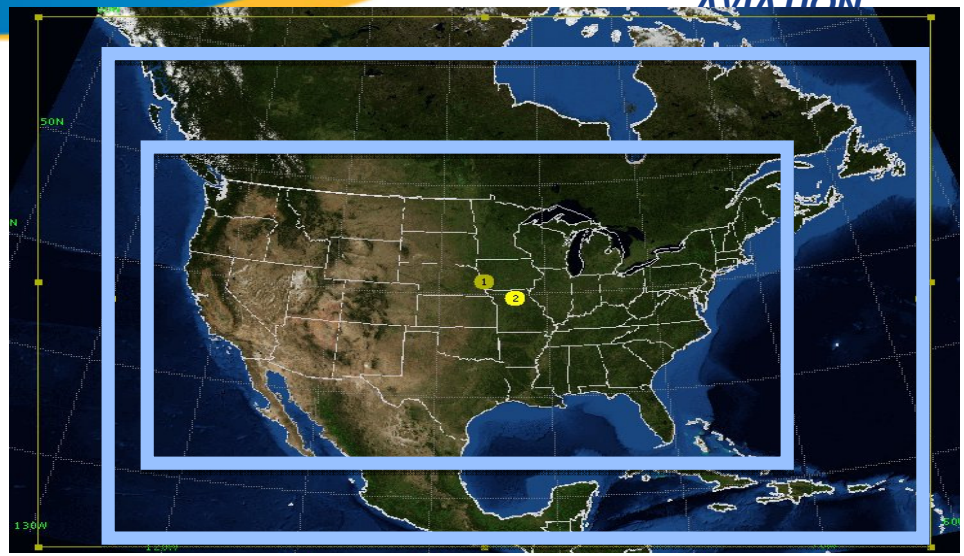
- **Nearly global coverage**: every 6 h at 36 km to 60 h
- **Europe/Carib**: every 6 h; 4km to 42 hr, 12km to 60 h

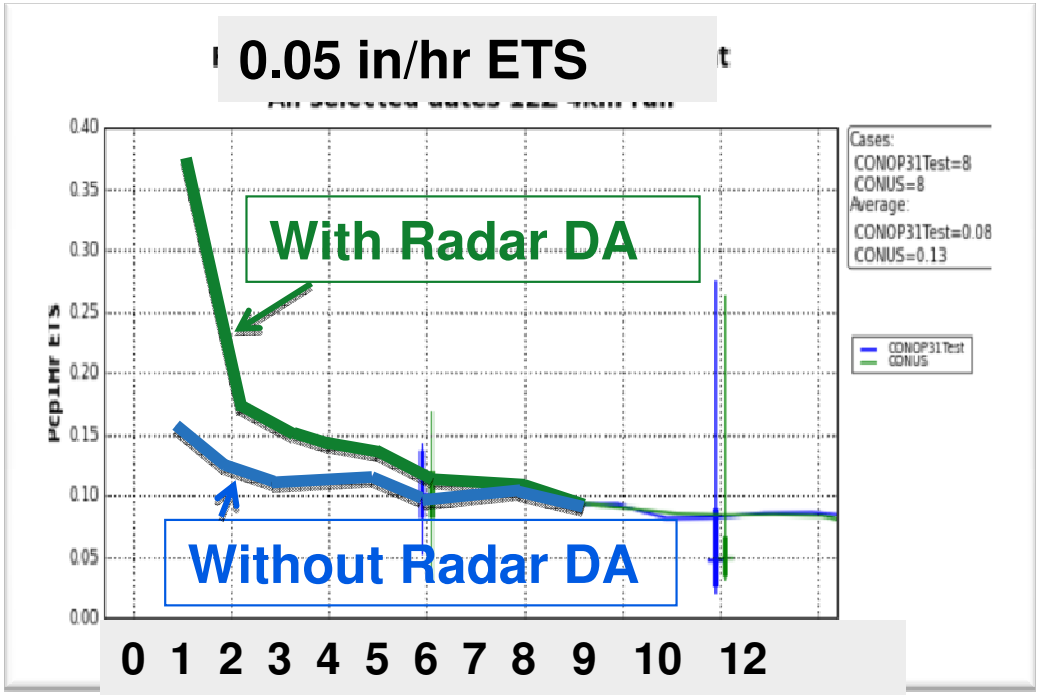


- WRF-ARW with GFS initialization

CONUS NWP Details

- Run every 3 h at 4km to 27 h and 12km to 72 h
- WRF-ARW (NCAR et. al.) is core model in system
- RUC first-guess
- ADAS (University of Oklahoma) is DA system
  - Includes Radar DA

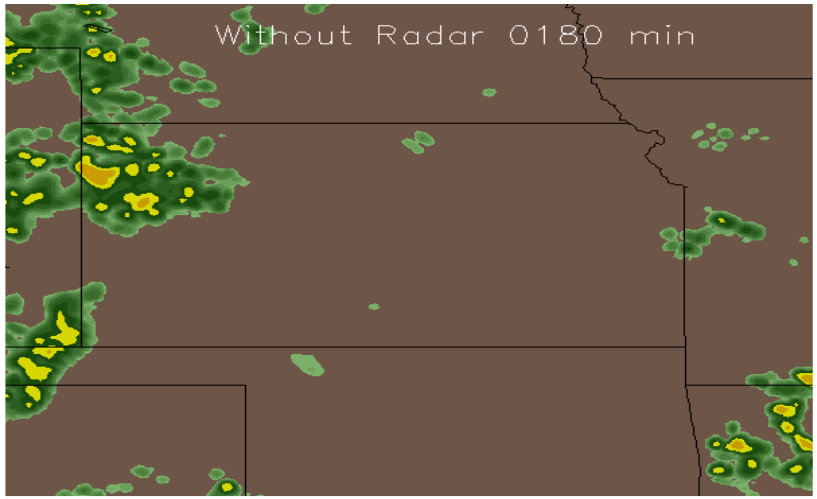




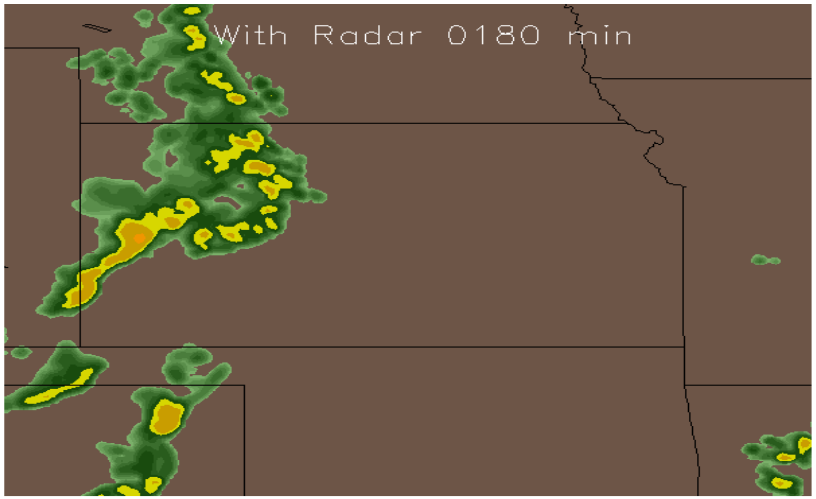
Radar Data Assimilation: Example

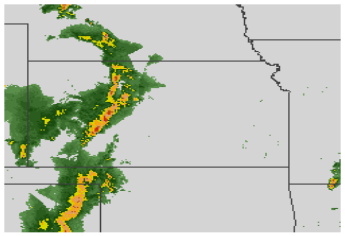
- US domain: August 2010
- Other domains can be implemented as we acquire real-time radar data

T+3 h
without Radar Assimilation



T+3 h
with Radar Assimilation





Improved accuracy in 0-6 hour forecast range

Aviation Product Guidance Generation

Forecast Products for Aviation

- Derived Products:
  - Met data presented to forecasters
  - Automated “first-guess” TAFs
    - Forecasters update those TAFs

```
TAF KMIA 240200Z 2402/2502
05005G12KT P6SM BKN040
   FM240400 06004KT P6SM BKN030
      TEMPO 2413/2415 -TSRA
OVC020CB OVC150
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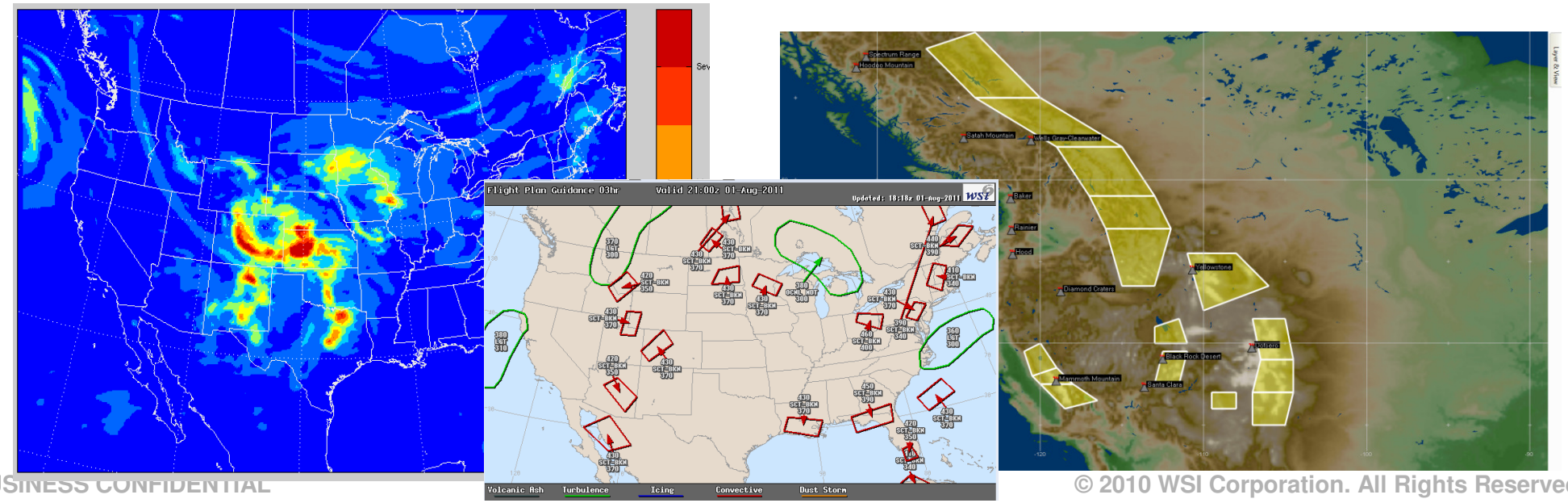
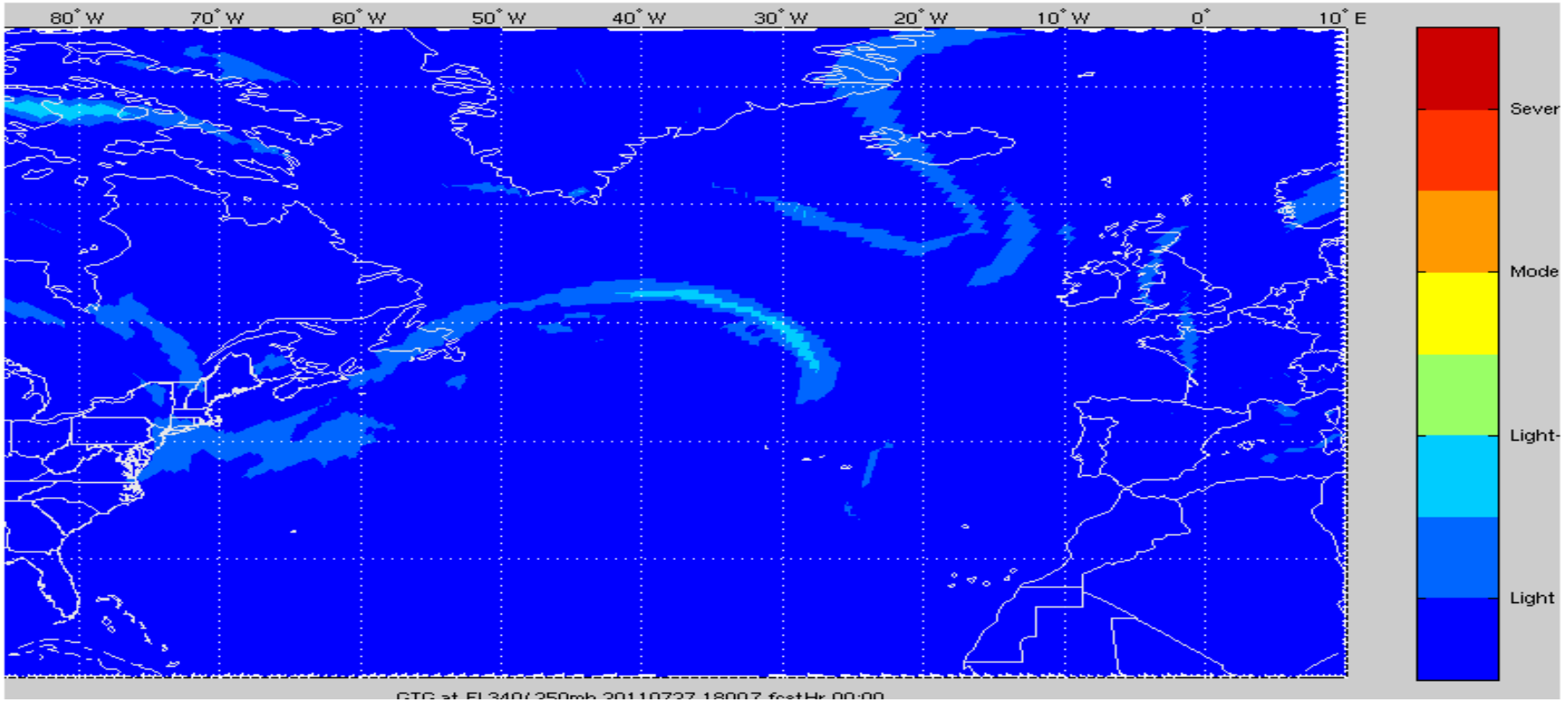
- Flight Planning Guidance
  - GTG (turbulence), Icing, Mountain Wave Turbulence
  - Need for worldwide turbulence motivation for GTG calculations



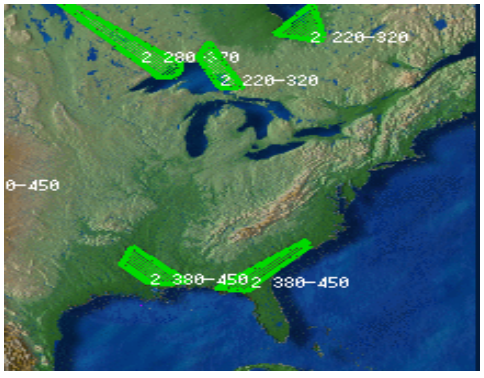
Step 1: Calculate GTG for CAT

- At each forecast time and many flight levels (18-43 k ft):
  1. Calculate 8 most significant GTG parameters and scale to 0-1 range
  2. Produce both weighted and maximum values of GTG
  3. Plot GTG with range 0-1; remap to light-to-severe turb



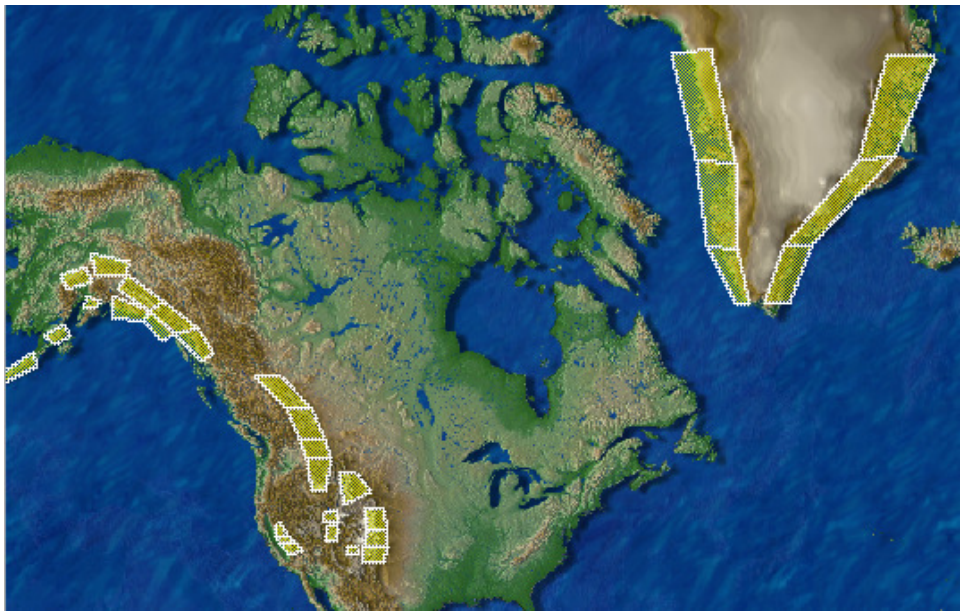
Step 2: Flight Planning Guidance

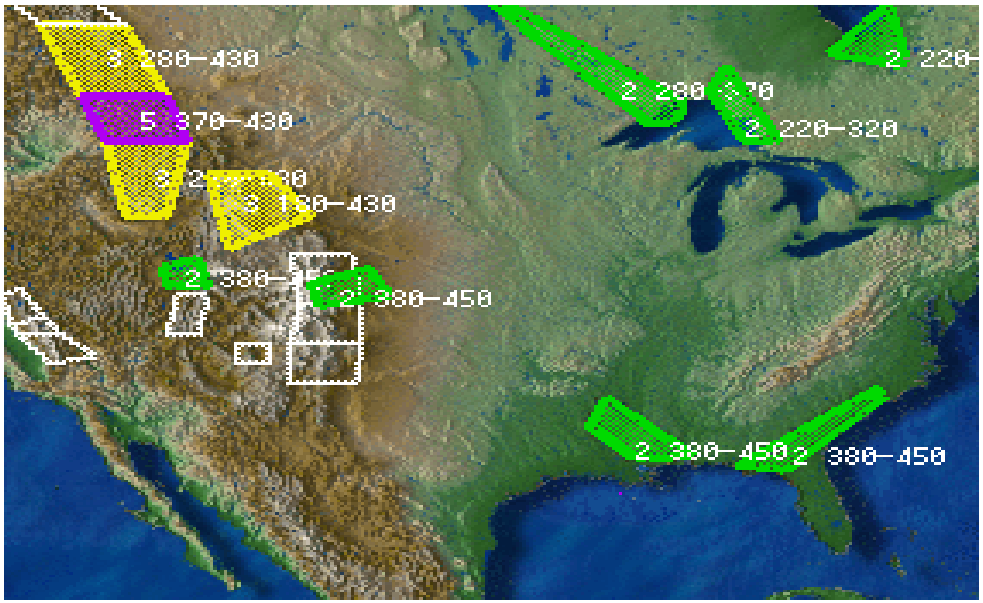
- For each forecast time and flight level (18-43 k ft):
  1. Values of Smoothed GTG exceeding 0.22 are encompassed by a polygon
  2. Assign turbulence level (2-5) to each polygon:
  3. Merge polygons in space and into single layer:
     1. Polygons within 175 km and 1 turb level are combined
     2. Polygons within 10k feet are combined
     3. Combined Polygons are assigned a height range
     4. Combined Polygons assigned a turbulence level equivalent to the maximum in the non-combined input polygons



Step 3: Mountain Wave Turbulence

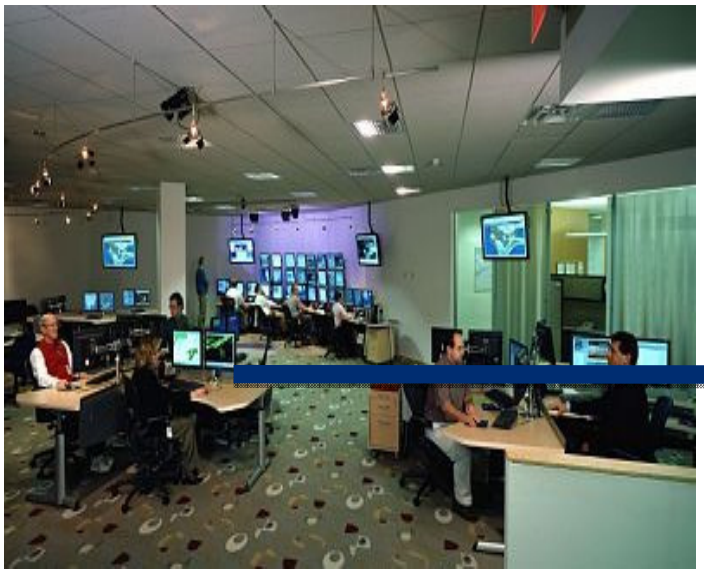
- For each forecast time and flight level (18-43 k ft):
  1. Calc GTG in pre-defined “wave” regions
  2. If 500 mb flow is cross-range, assume mountain waves
  3. “Light” up regions with turbulence level
  4. Remove overlapping CAT regions

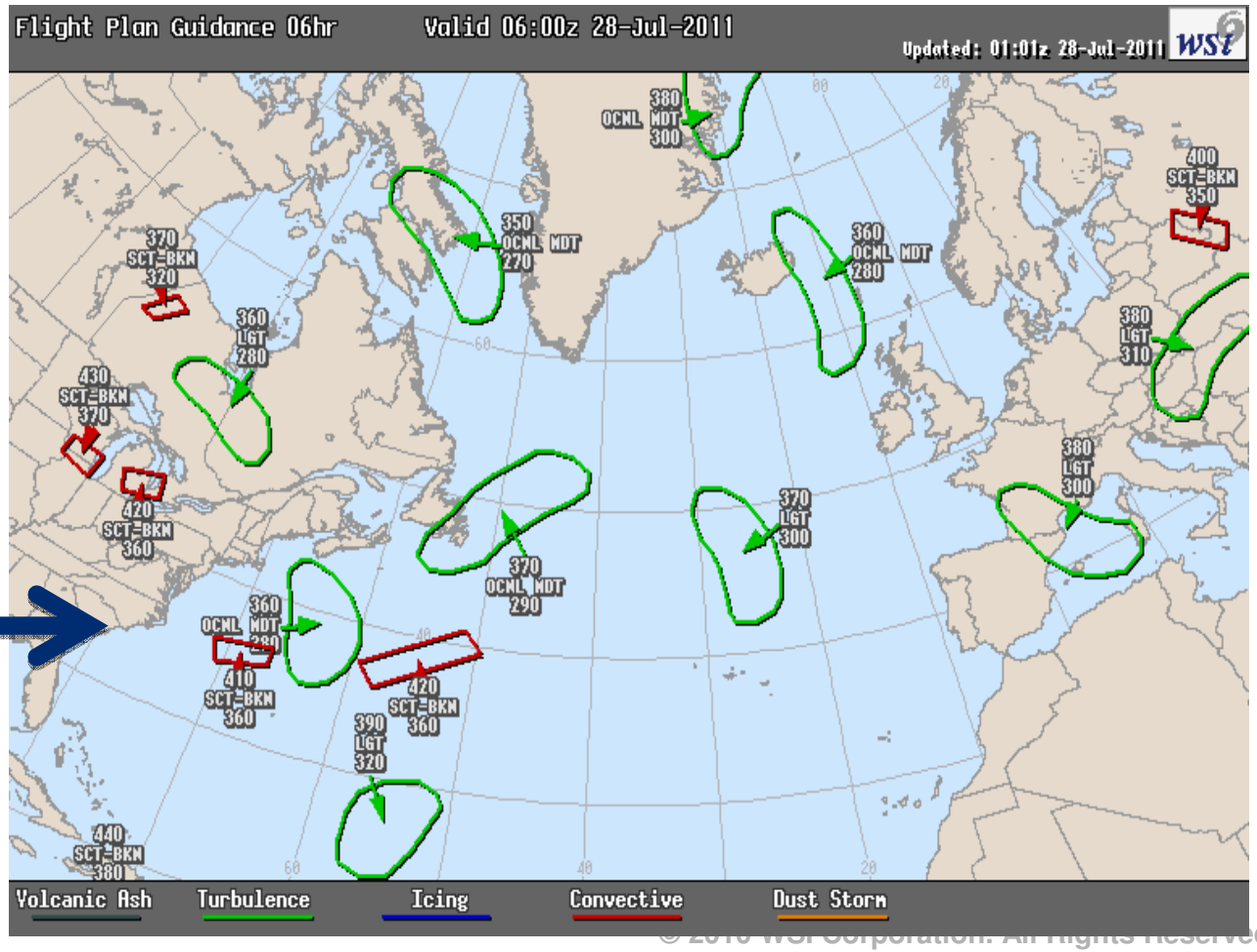




Step 4: Forecaster Creates Products

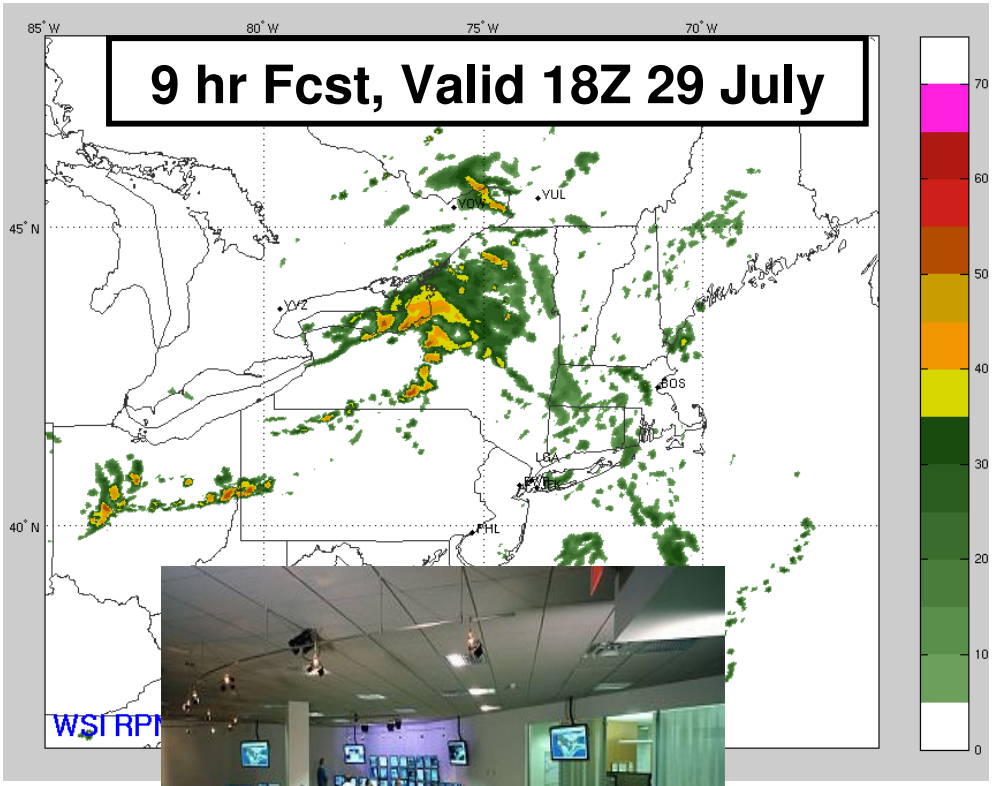
1. Examines GTG plots over time and (3-D) space
2. Updates automated forecast polygons based upon previous observations, other model sources, etc.

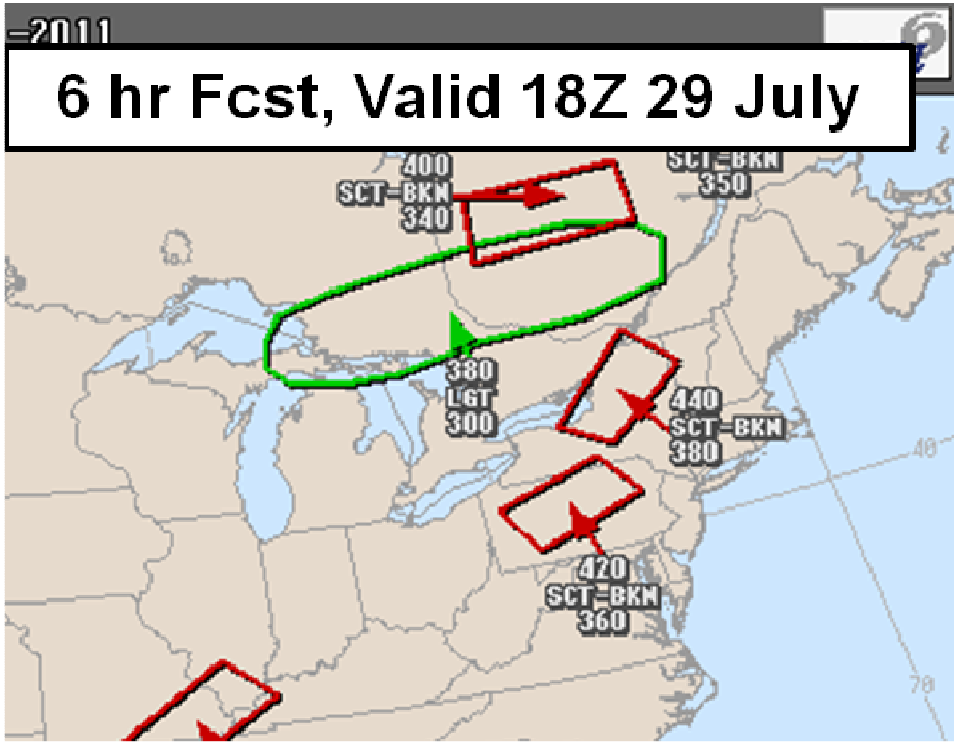




Step 5: Forecaster Adds CIT

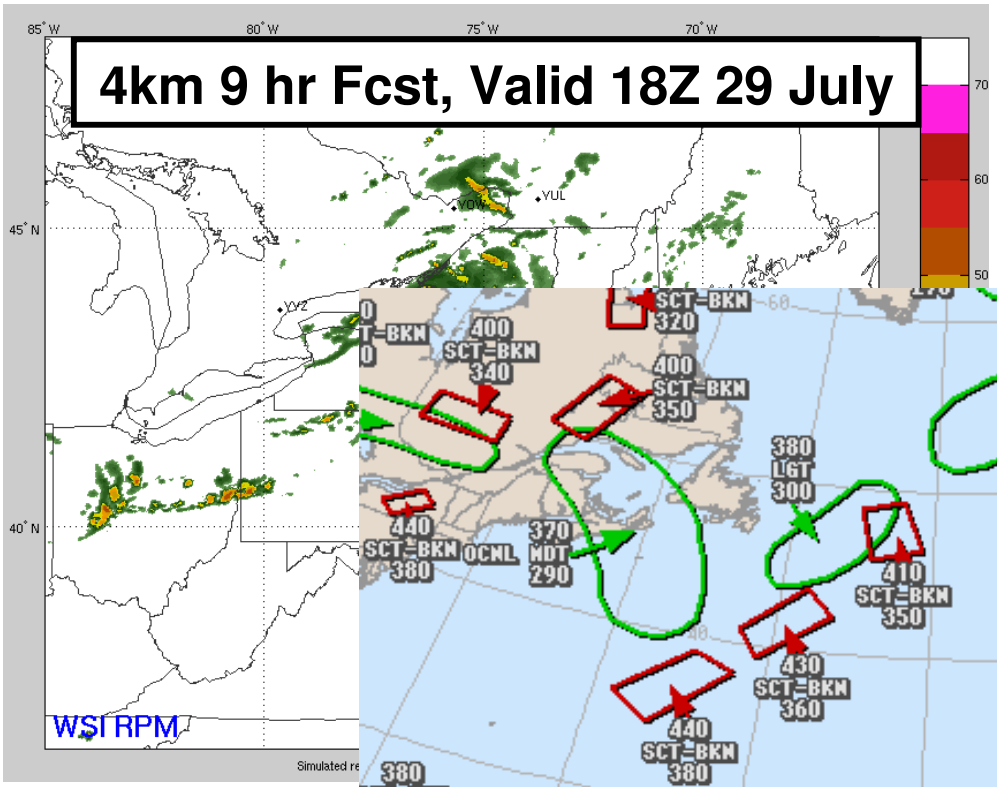
1. Examines NWP Guidance (4km WRF-ARW)
2. Add (i.e., Draw) Regions of Expected Convection

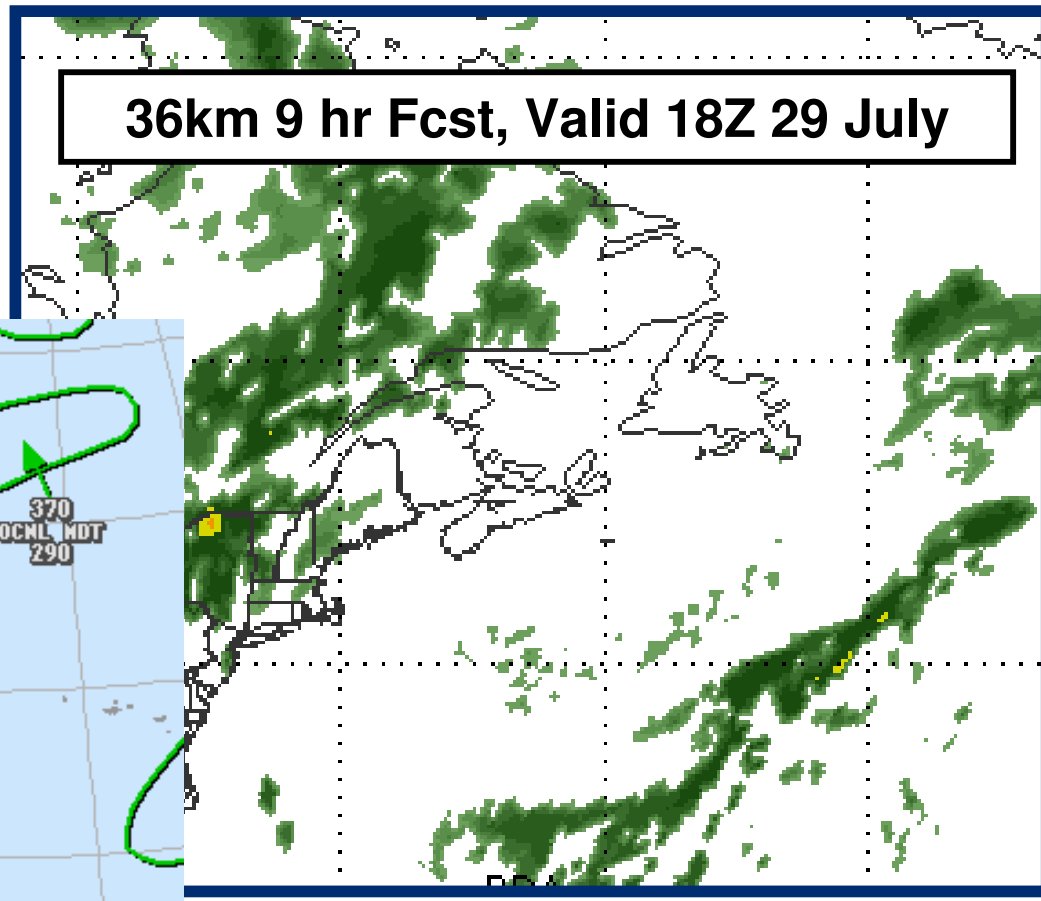




Step 5 (cont.): Convection Outside US

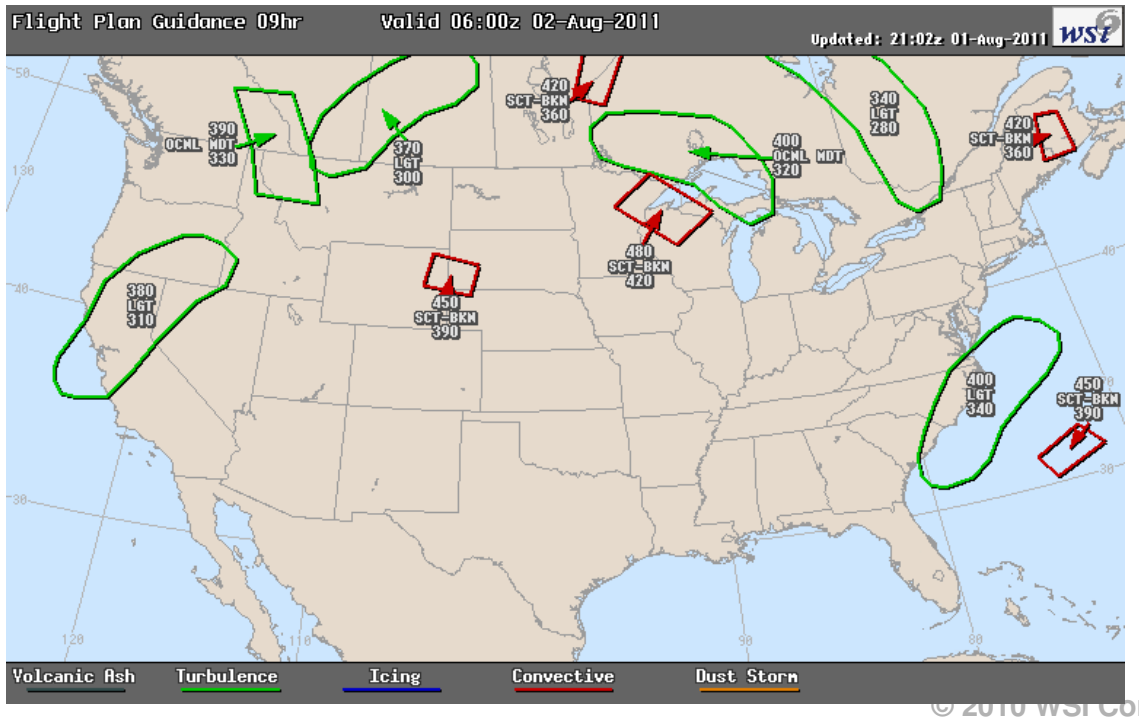
1. For most of world, NWP is not convective-resolving
2. Requires additional forecaster analysis/intuition to outline convective regions





Summary

- NWP system provides basis for forecasting turbulence and convection
- Using first-guess, forecasters produce, flight planning guidance
- 4km convective-resolving simulations provide much value and save valuable time



Atlantic Basin Results

- Benefit in Atlantic Basin
- Need to generate statistics for all domains