

Spatiotemporal relational random forest (SRRF) prediction of convectively- induced turbulence:

a severe case study

Jonathan Trueblood
Dordt College

David John Gagne II
University of Oklahoma

Dr. John K. Williams
NCAR

Timothy Sliwinski
Florida State University

Dr. Amy McGovern
University of Oklahoma

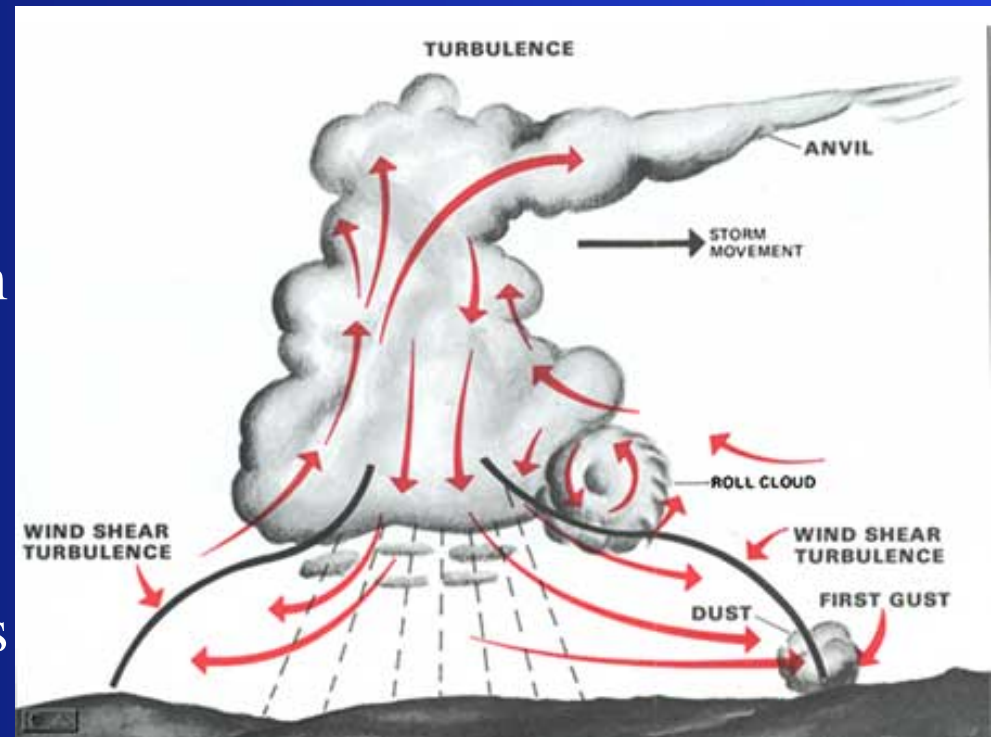
Dr. Jennifer Abernethy
NCAR

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Convectively Induced Turbulence

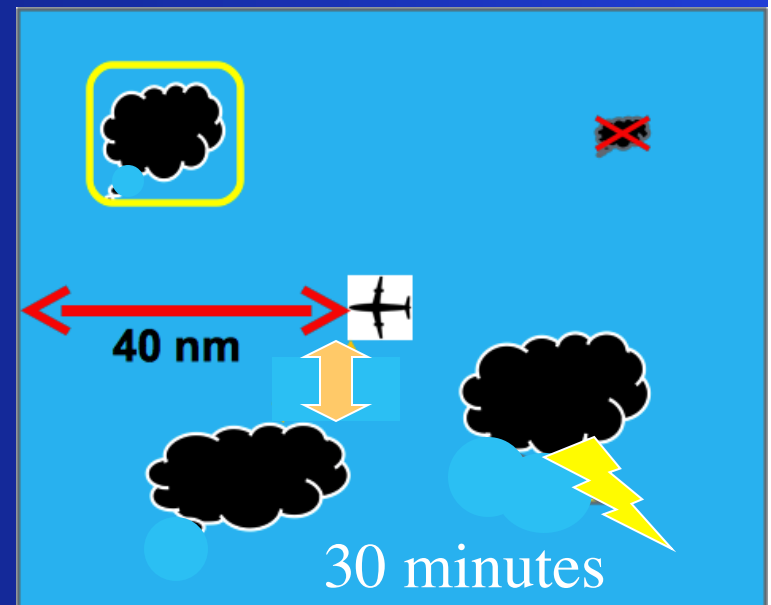
- Occur near and around thunderstorms
 - Effect of large scale convection
- Similar to clear-air turbulence
 - Invisible
 - Not in cloud
 - Associated with the thunderstorm
- Problem for aircraft
 - Delays
 - Structural Damage
 - Injuries to passengers
 - Airline Economics
 - Fatalities



Source: <http://www.webskite.com/weather-seminar/hazards>.

Predicting CIT- Method

- Spatiotemporal Relational Random Forests
 - Aircraft centric
 - Temporally and spatially varying
 - Object-oriented
 - Rain, convection, hail, lightning, clouds, aircraft
 - In-situ aircraft data
 - WRF model data
 - Relations
 - Proximity
 - Contains

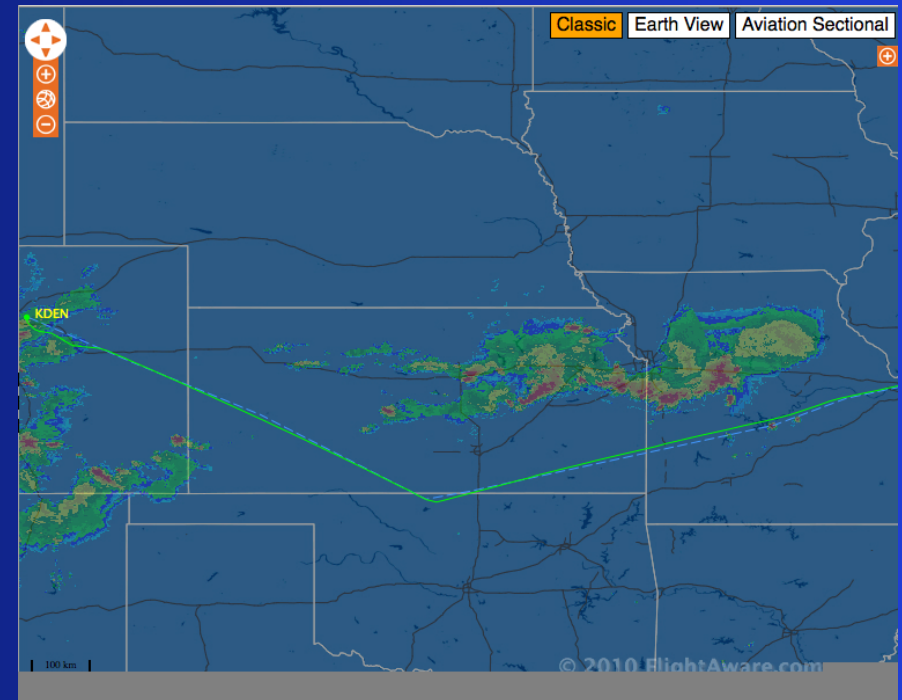


Training the Trees

- Create a probabilistic prediction of turbulence
 - Bootstrap sample set
 - Randomly choose N questions, Split based on chi-squared
 - Send each instance down trained tree
- One run spans 30 minutes before chosen time
 - Old algorithm ran entire day
- Create all aircraft for a CONUS view
 - each Lat/Lon in CONUS
 - 2.8 Gigs
 - Made smaller version, an area of interest
- Run script to collect the label for each aircraft
- Create graphic

July 20th Turbulence

- Flight 967
 - Boeing 777
 - D.C. to West coast.
 - 34,000 ft
 - reported around 0 UTC
 - Multiple injuries
 - Rerouted to Denver



Source: <http://www.flightaware.com>

DENVER, July 21, 2010

United Flight Hits Turbulence, 30 Injured

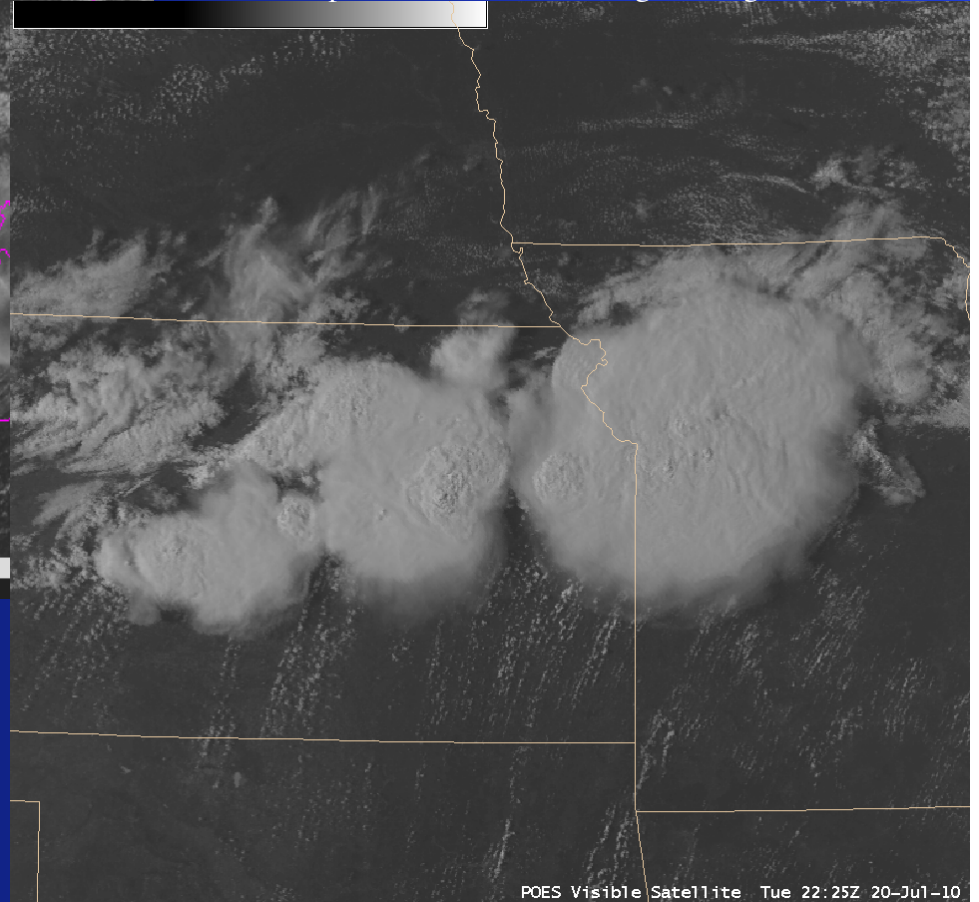
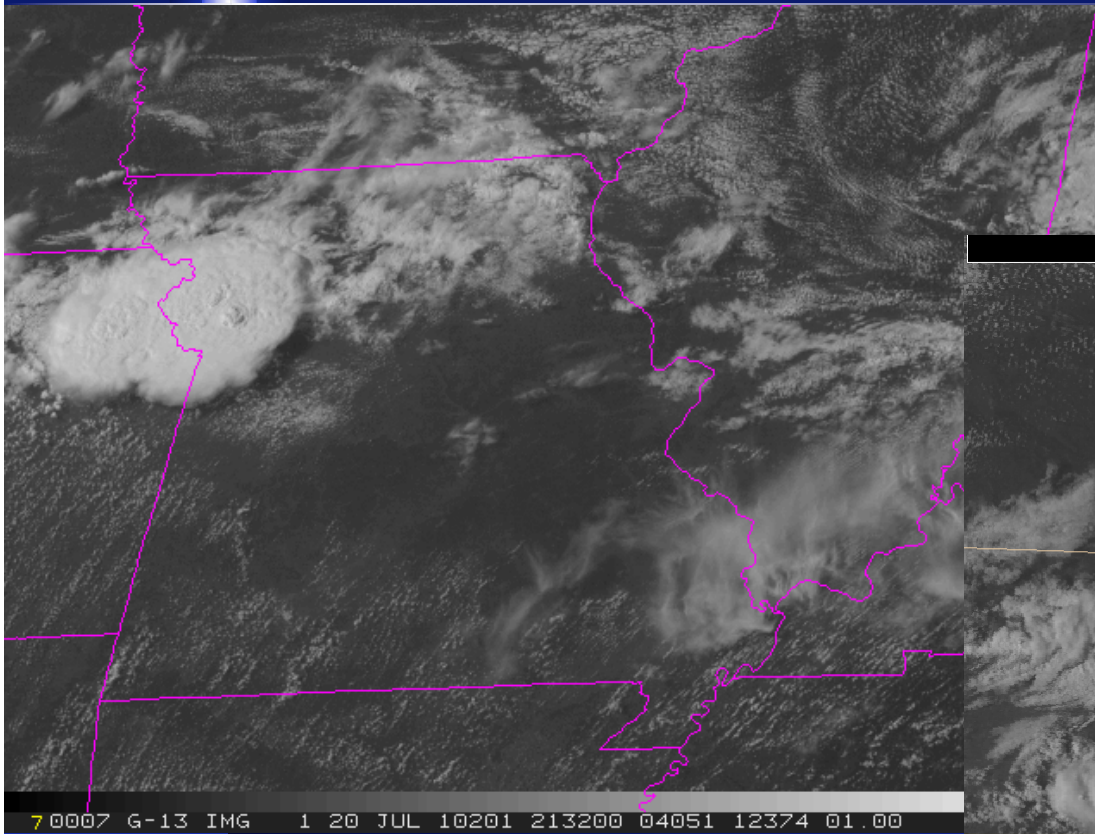
"Significant Turbulence" Causes One Serious Injury and an Emergency Landing in Denver

Source: <http://www.cbsnews.com/stories/2010/07/20/national/main6697254.shtml>

GOES-13 visible imagery from 1945 UTC to 0045 UTC

POES Visible/IR 2225 UTC

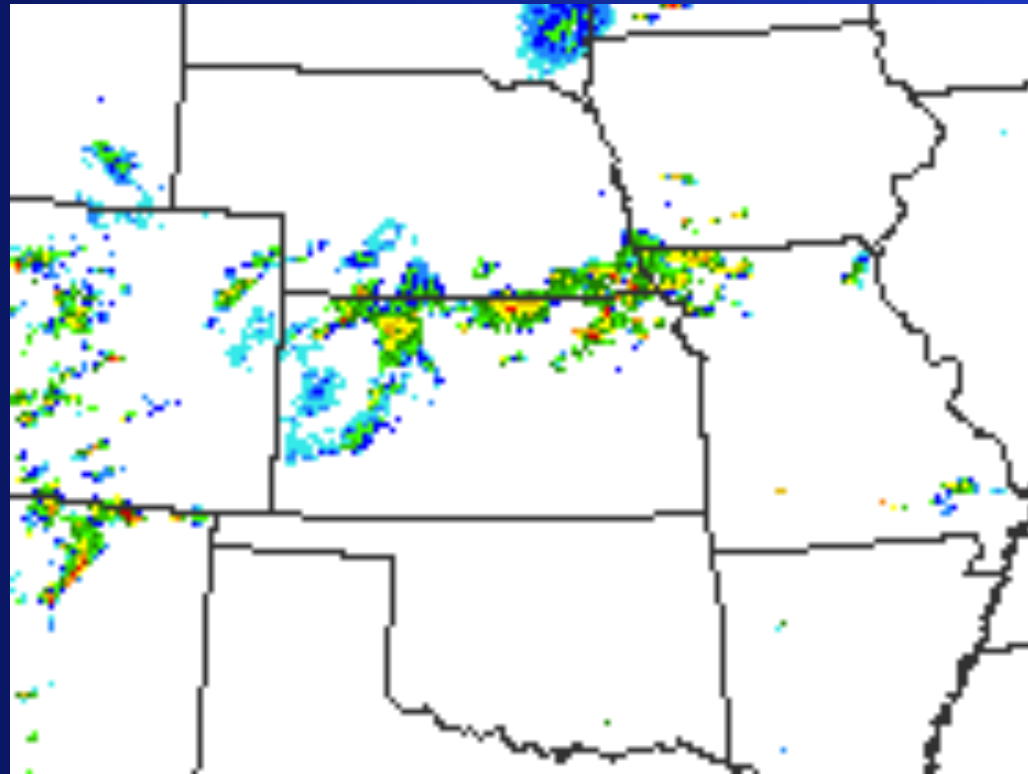
Source: <http://cimss.ssec.wisc.edu/goes/blog/archives/6165>



Source: <http://rammb.cira.colostate.edu/training/visit/blog/index.php/2010/07/29/united-airlines-flight-967-severe-turbulence-july-20-2010/>

Convection forms in northeast Kansas by 2030 UTC.

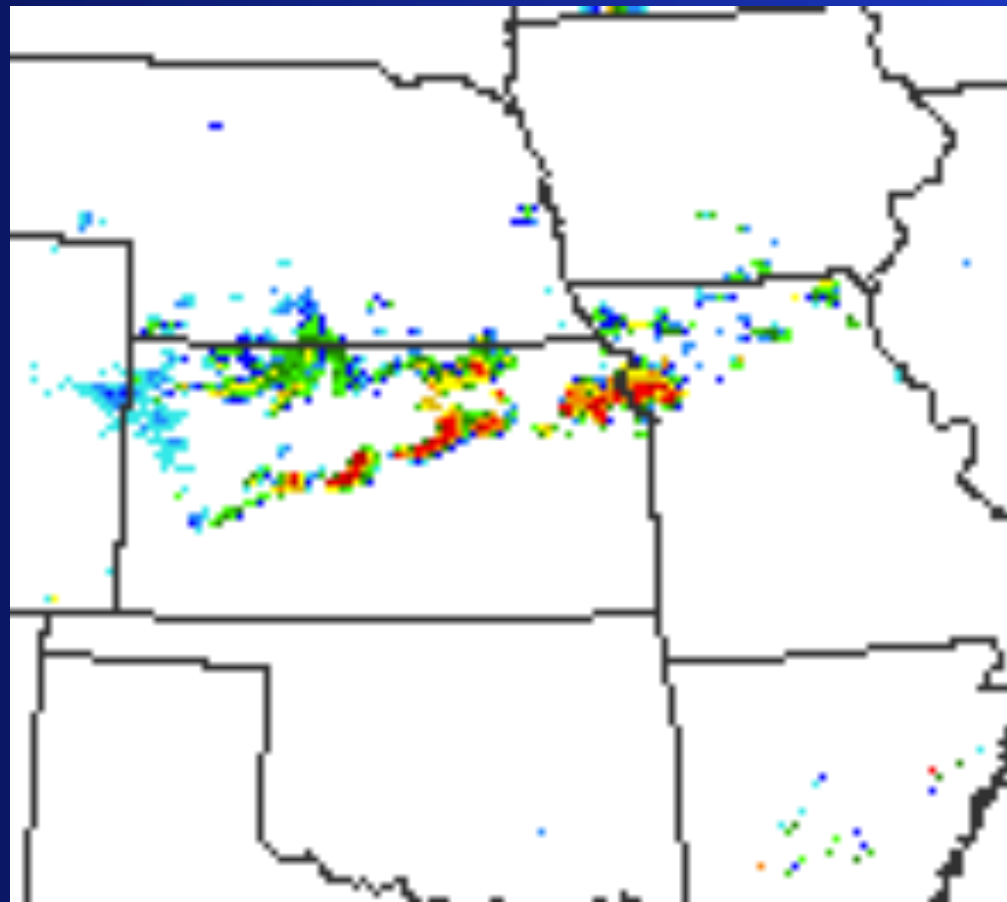
- 2000 UTC



Source: <http://spc.noaa.gov/exper/archive/events/>

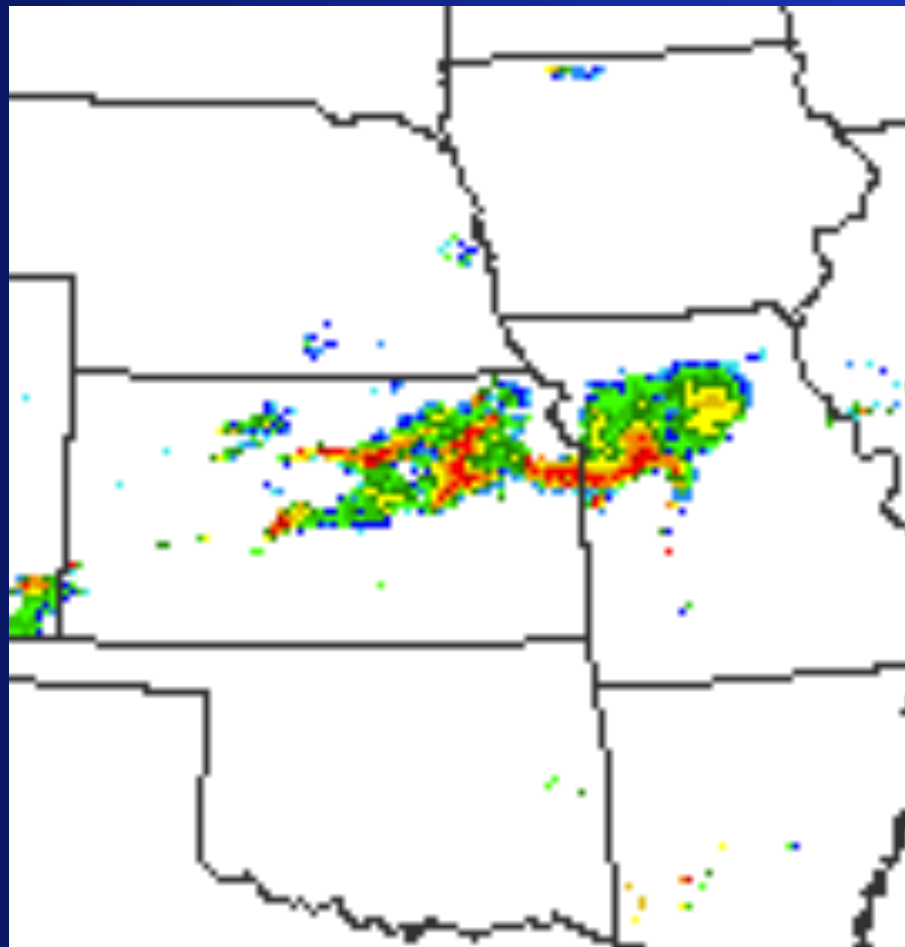
Storms Strengthen by 2130 UTC

- 2130 UTC



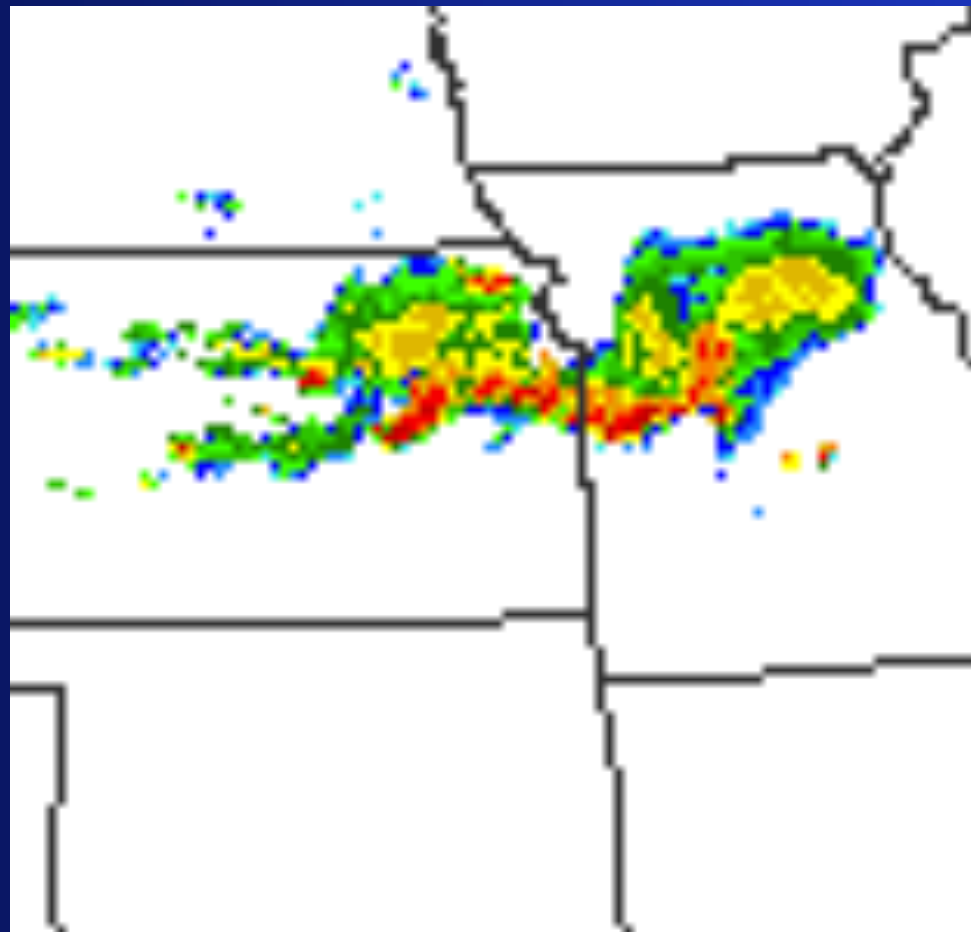
Source: <http://spc.noaa.gov/exper/archive/events/>

2330 UTC



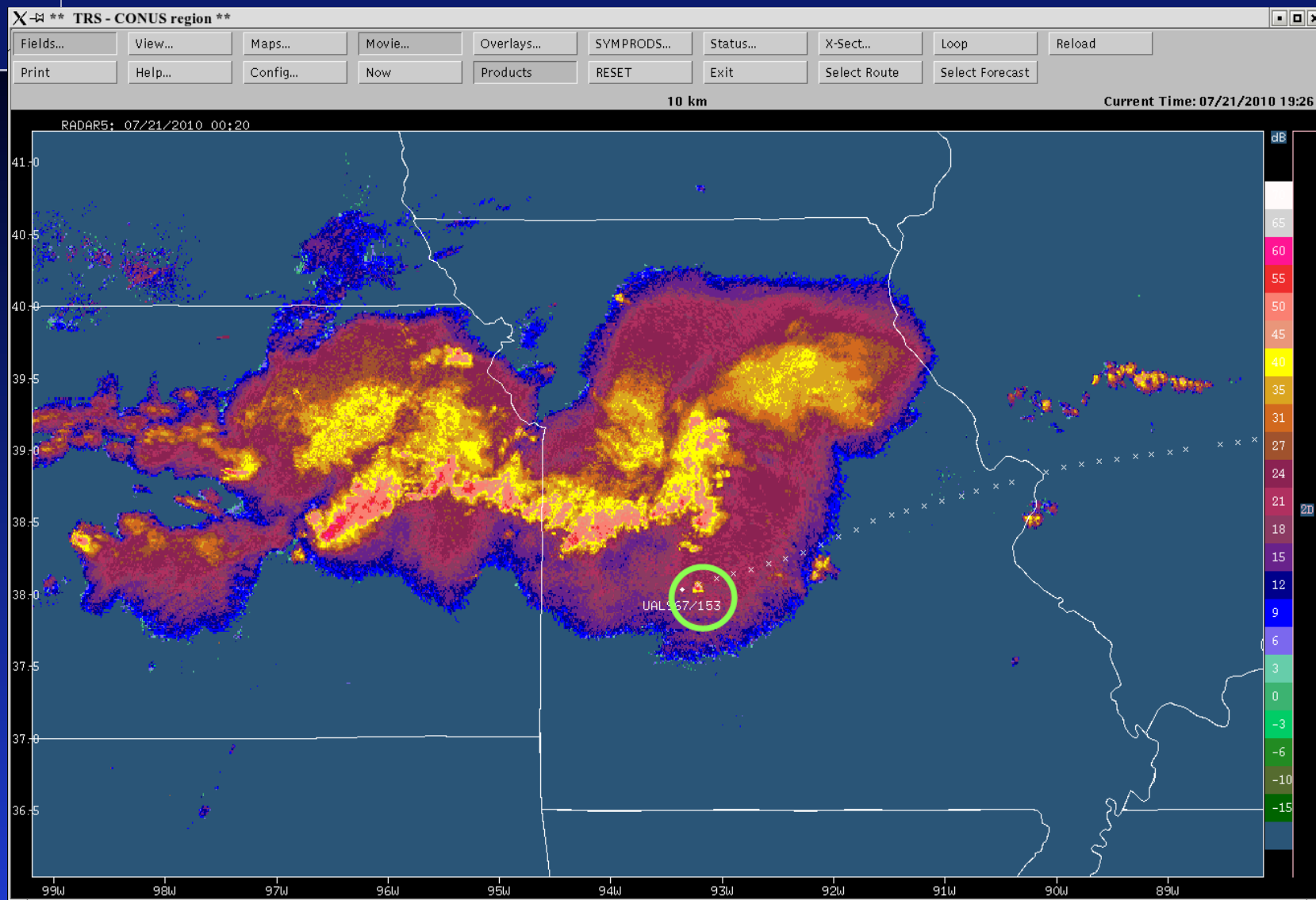
Source: <http://spc.noaa.gov/exper/archive/events/>

0008 UTC



Source: <http://spc.noaa.gov/exper/archive/events/>

Plane Location

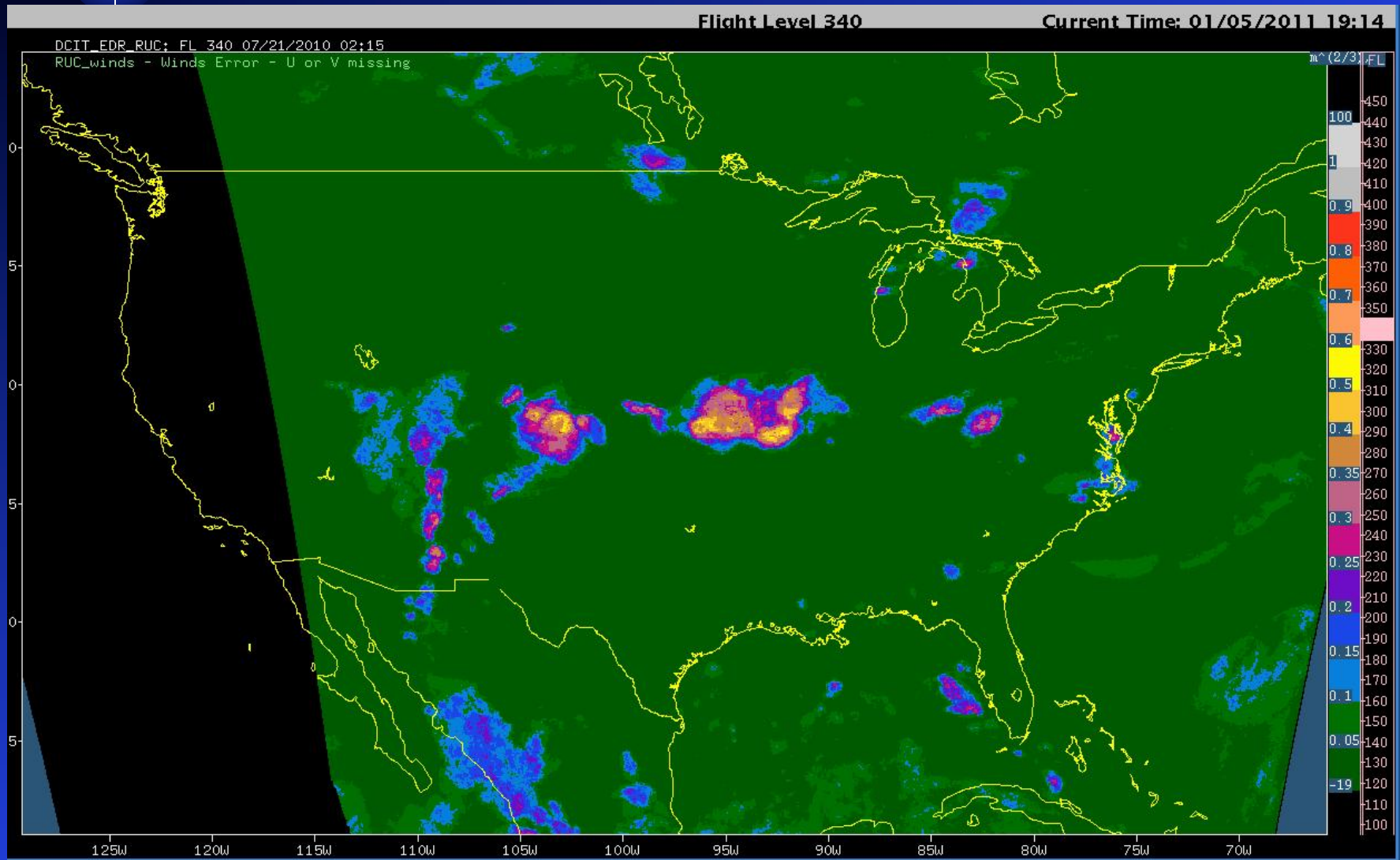


Source: <http://rammb.cira.colostate.edu/training/visit/blog/index.php/2010/07/29/united-airlines-flight-967-severe-turbulence-july-20-2010/>

DCIT

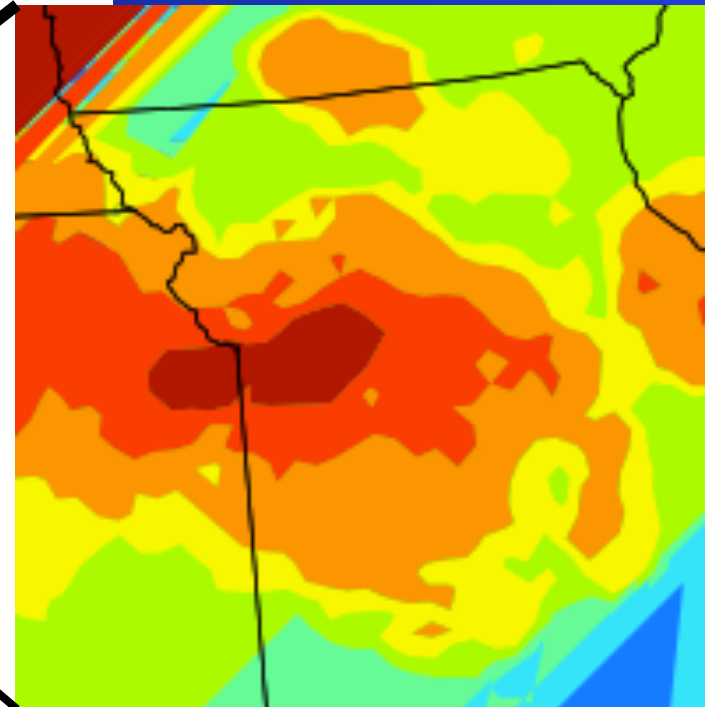
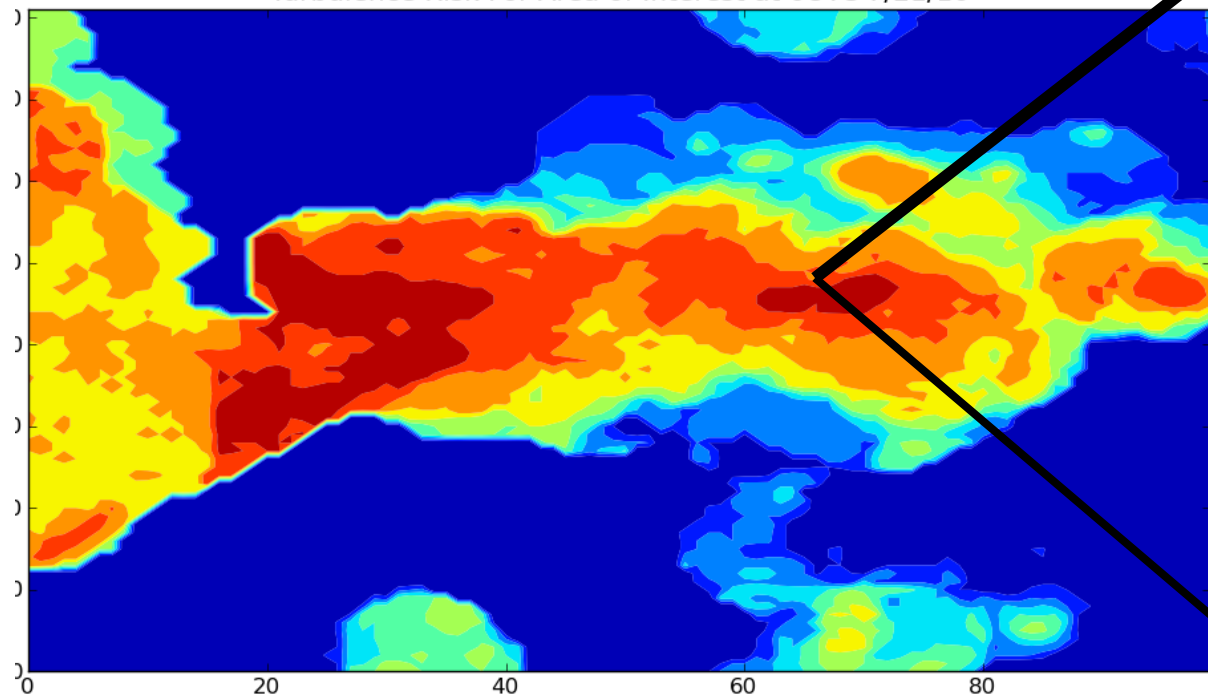
- DCIT system
 - NCAR
 - Regular random forests trained to create a turbulence prediction on most current data
 - Trained random forests create a prediction at each grid point over CONUS where data is available
 - Final product is a snapshot of turbulence locations
 - Updates every 15 minutes
 - Deterministic: gives a turbulence measurement value at each point

DCIT Results



SRRF Results

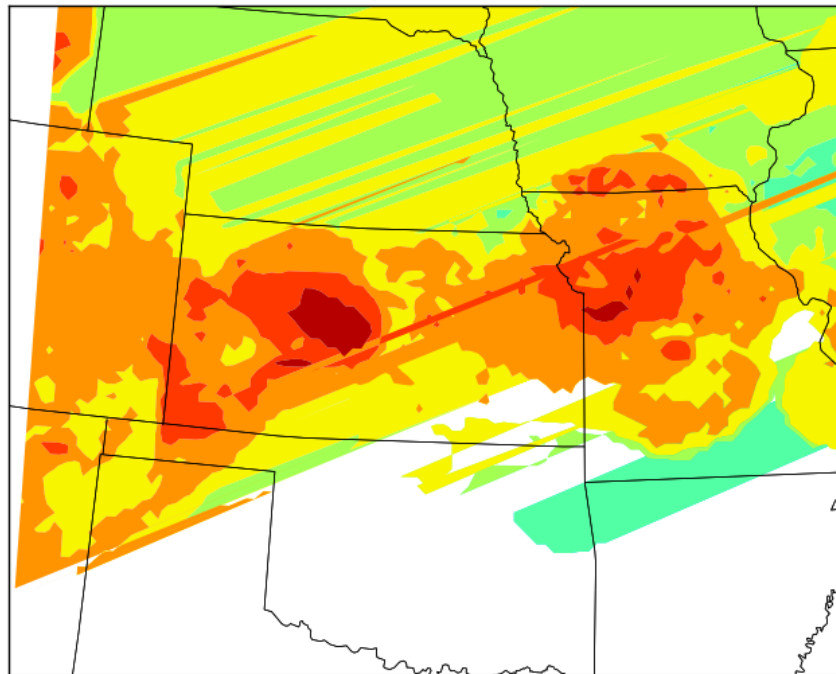
Turbulence Risk For Area of Interest at OUTC 7/21/10



SRRF Results

- 2Z

Turbulence Risk For Area of Interest at 2UTC 7/21/10



Summary and future work

- Flight 967 encountered severe turbulence over central Missouri
- Strong line of thunderstorms caused turbulence
 - Severe turbulence occurred at 001 UTC
- Using SRRF's, we create a probabilistic map of possible turbulence
- Our results match nicely with the DCIT
- Future
 - Full CONUS view
 - Faster time
 - Better prediction

