Initial Validation of a Convective Weather Avoidance Model (CWAM) in Departure Airspace

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30th Digital Avionics Systems Conference

October, 18th 2011

Contents

- Goals and motivations
- Automatic avoidance detection algorithm description
- Analysis of results
- Conclusions and future work

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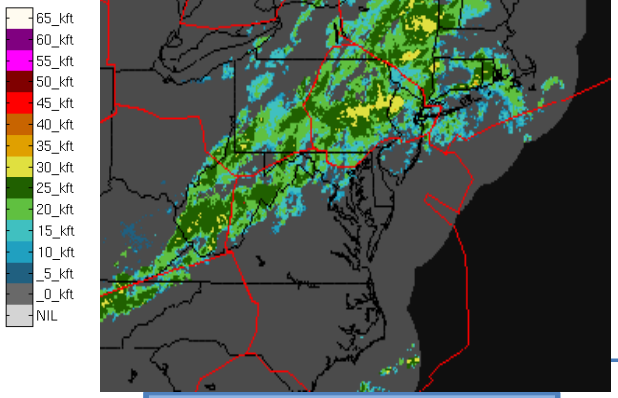
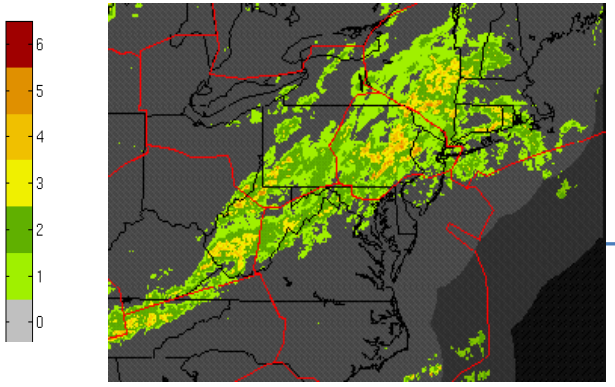
Motivations

- The Route Availability Planning Tool (RAPT) - decision support tool used to help controllers in route management has problems with over-warning and occasional under-warning when weather impacts are in terminal airspace
- RAPT is using Convective Weather Avoidance Model (CWAM) and an airspace use model
- Therefore, CWAM in terminal airspaces needs to be validated

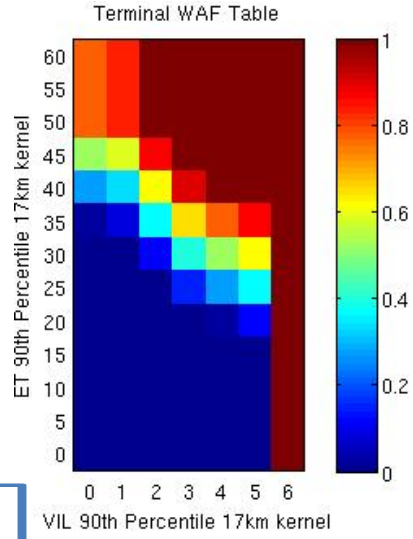
Weather Avoidance Field* description



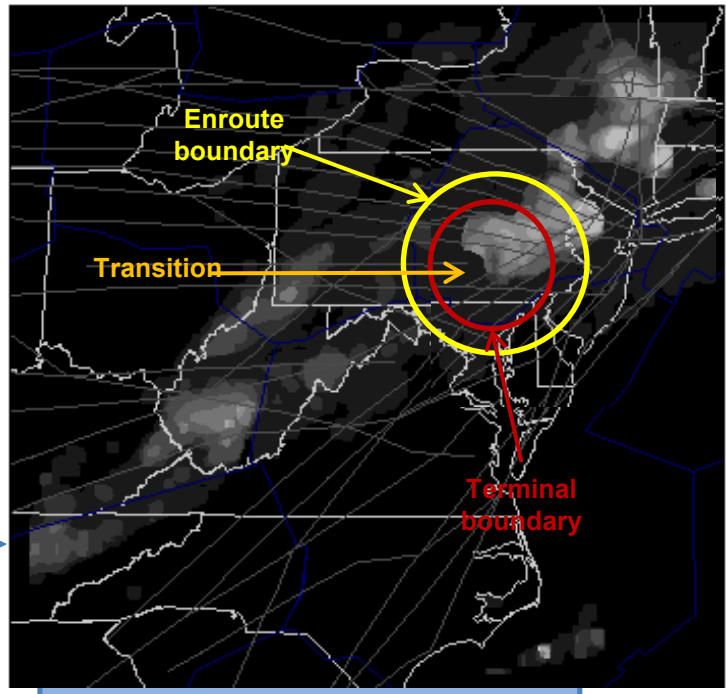
Echo top (storm height)



VIL (precipitation intensity)



Convective Weather Avoidance Model

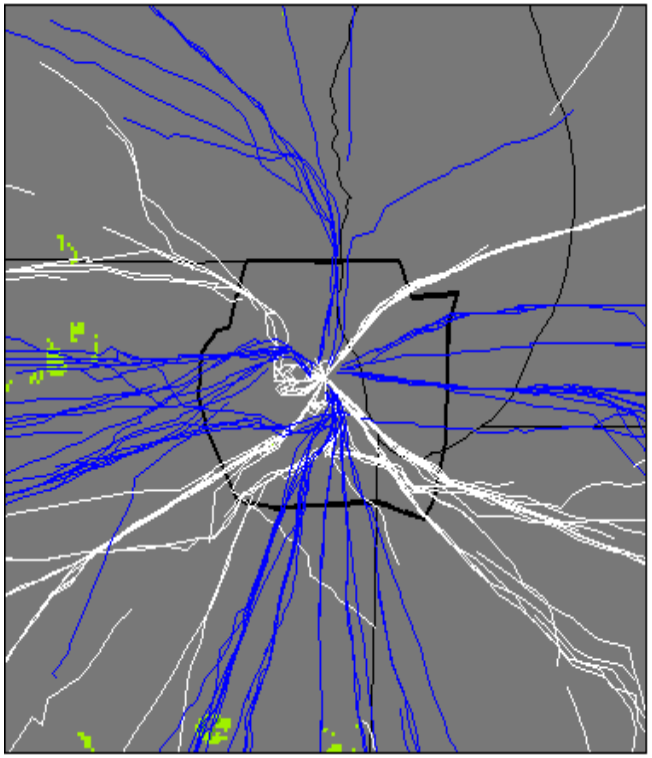


Departure Domain Weather Avoidance Field (WAF) (probability of pilot deviation)

* DeLaura, R., and Evans, J., "An Exploratory Study of Modeling Enroute Pilot Convective Storm Flight Deviation Behavior," *Proceedings of the 12th Conference on Aviation, Range, and Aerospace Meteorology*, Atlanta, 2006

Chicago and New York Airspaces

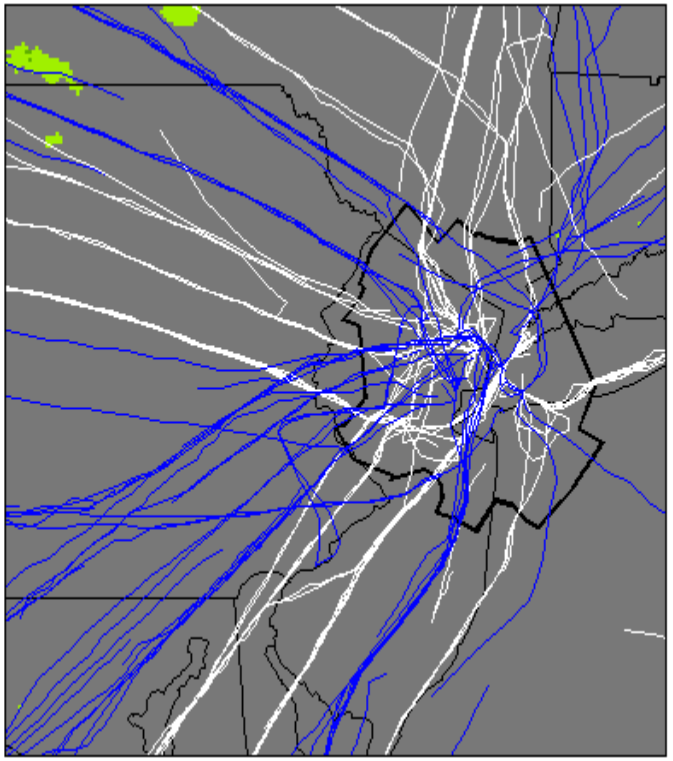
Chicago Airspace



30 minute cumulative traffic

Key:
Departures
Arrivals

New York Airspace



Methodology

- Trajectories from Enhanced Traffic Management System (ETMS), WAF calculated using observed weather from Corridor Integrated Weather System (CIWS)
- Calculated weather avoidance ratio using ***automatic avoidance detection algorithm*** using 5 test days (Chicago) and 8 test days (New York) from 2010
- 489 weather avoidances and 523 weather intersections (Chicago), 1084 weather avoidances and 1337 weather intersections (New York) were identified and analyzed
- WAF calibration using observed avoidance ratio

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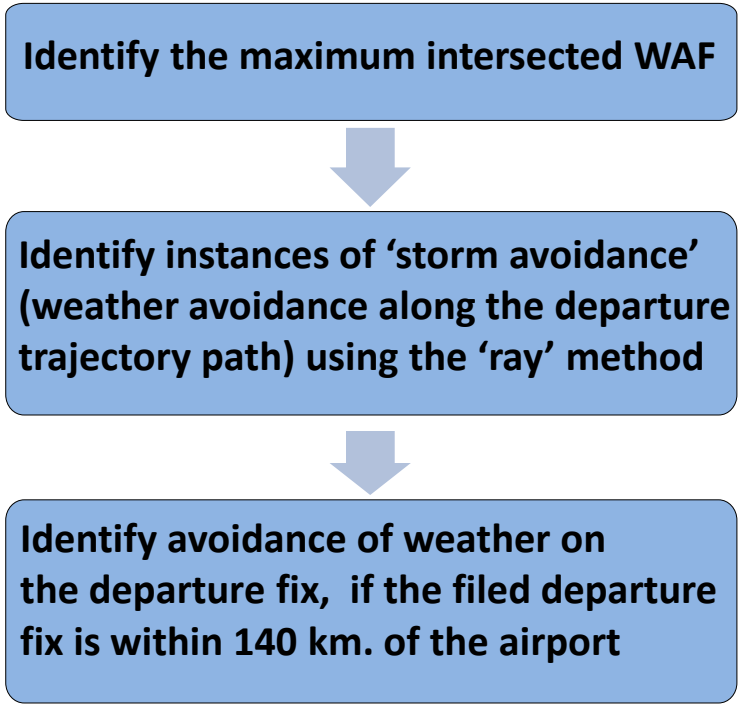
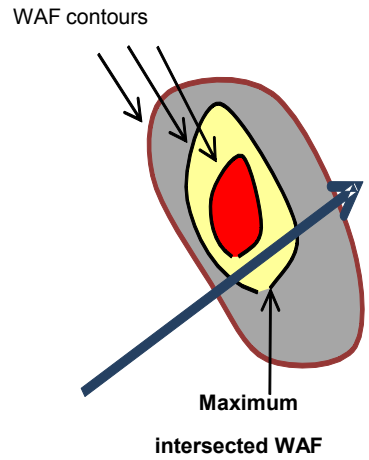
Automatic avoidance detection algorithm description



Algorithm Description (intersection)

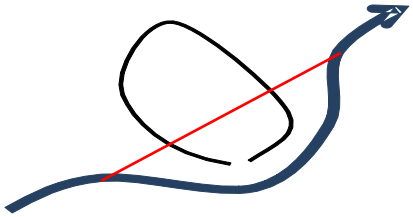
Identify the maximum intersected WAF

WAF intersection

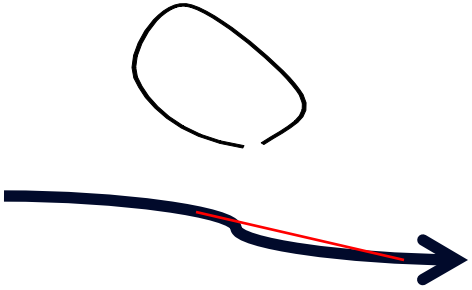


Algorithm Description ('ray' method)

Identify instances of 'storm avoidance' (weather avoidance along the departure trajectory path) using the 'ray' method

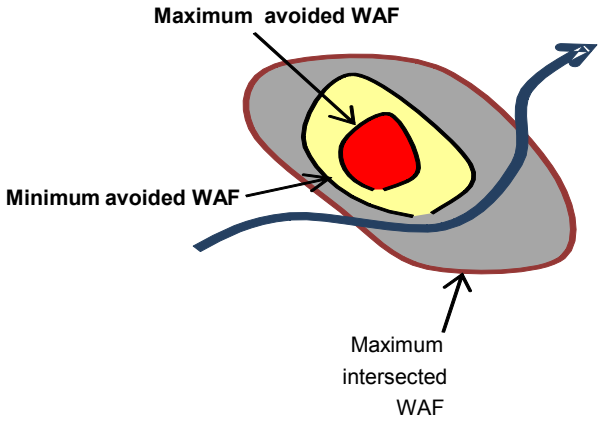


Avoidance detected



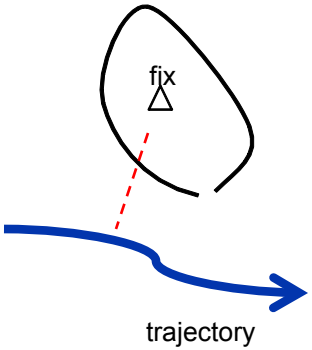
No Avoidance detected

Ray algorithm to identify storm avoidance

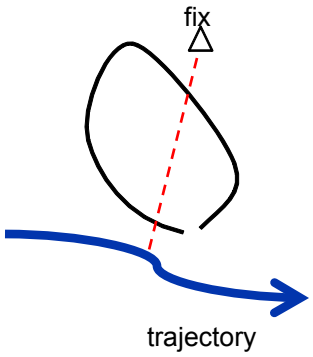


Algorithm Description (departure fix)

Identify avoidance of weather on the departure fix, if the filed departure fix is within 140 km. of the airport

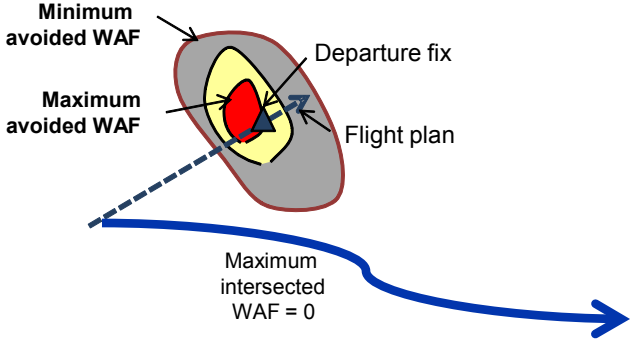


Avoidance detected



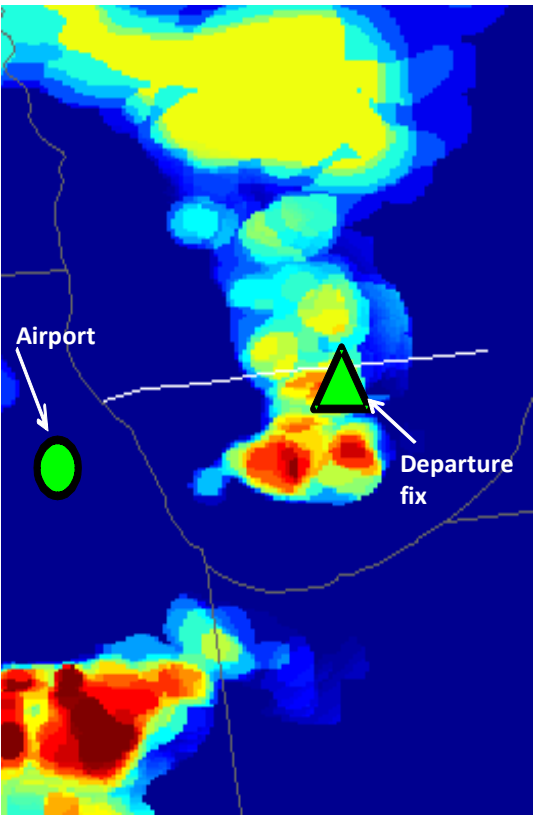
Avoidance detected

Avoidance of impacted departure fix

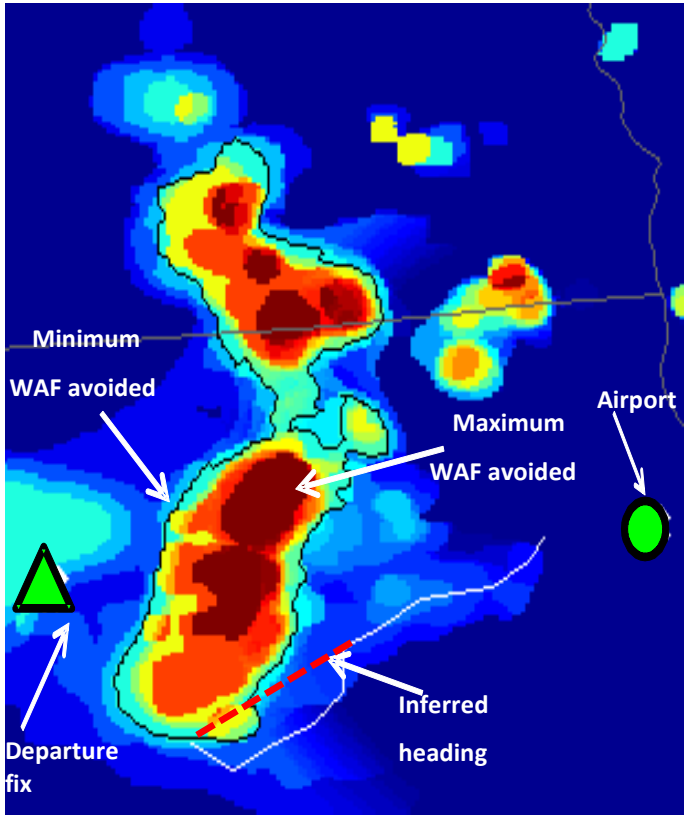


Algorithm Description (illustrations of classifications)

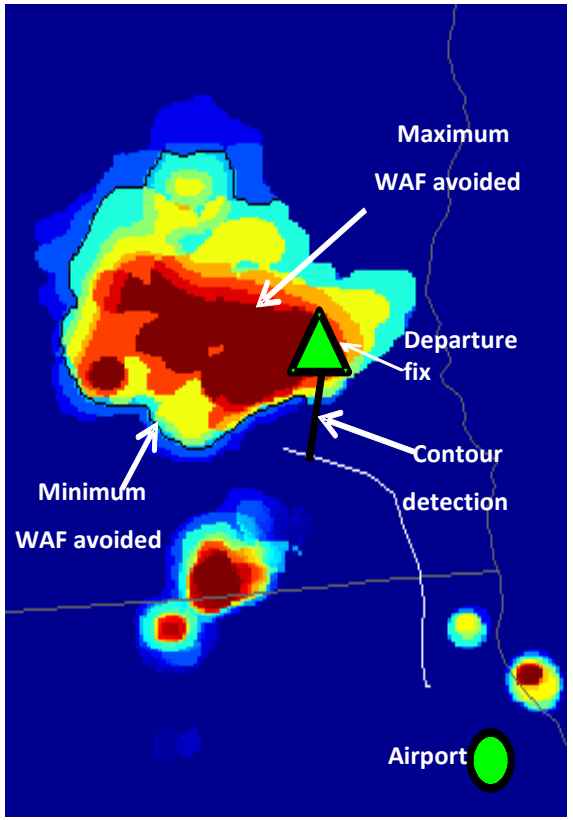
Weather intersection

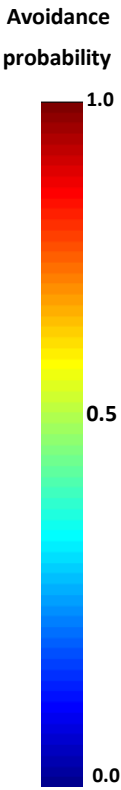


Storm avoidance detection



Fix avoidance detection



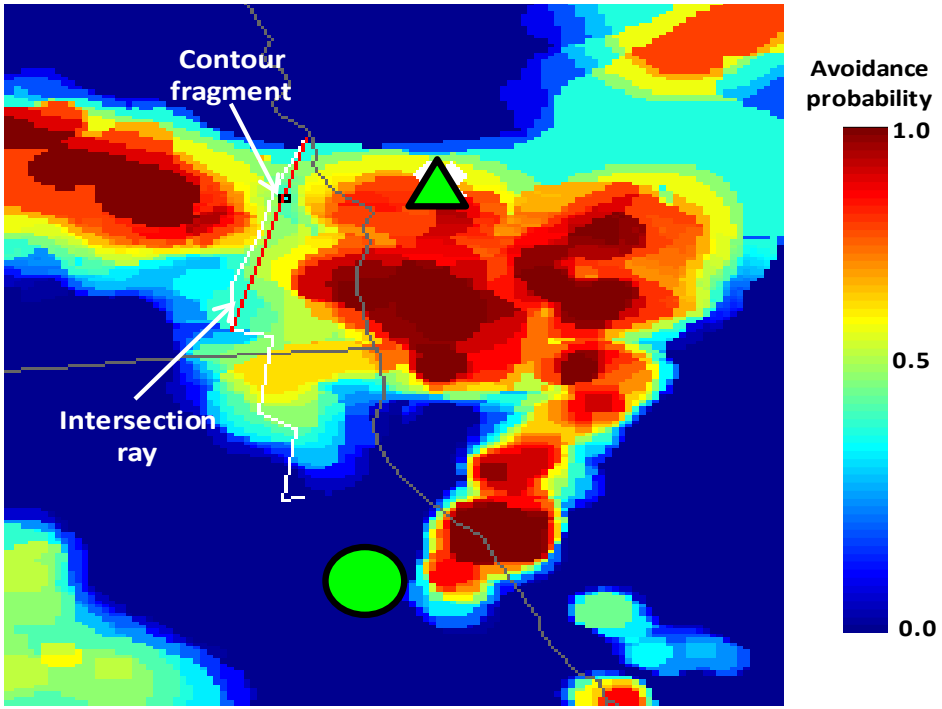


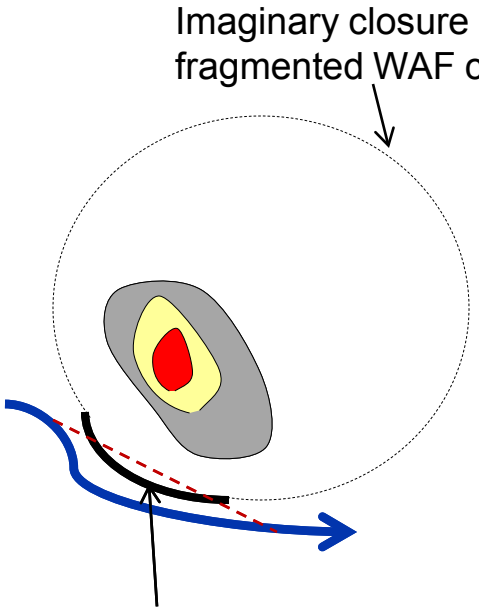
Algorithm Description (validation)

- Visualizations of 547(NY) and 257(Chicago) automated avoidance classifications were reviewed to validate the algorithm.
- The error rate was estimated at ~16%.
- Typical error modes were identified

Algorithm Description (error analysis)

WAF contour fragmentation

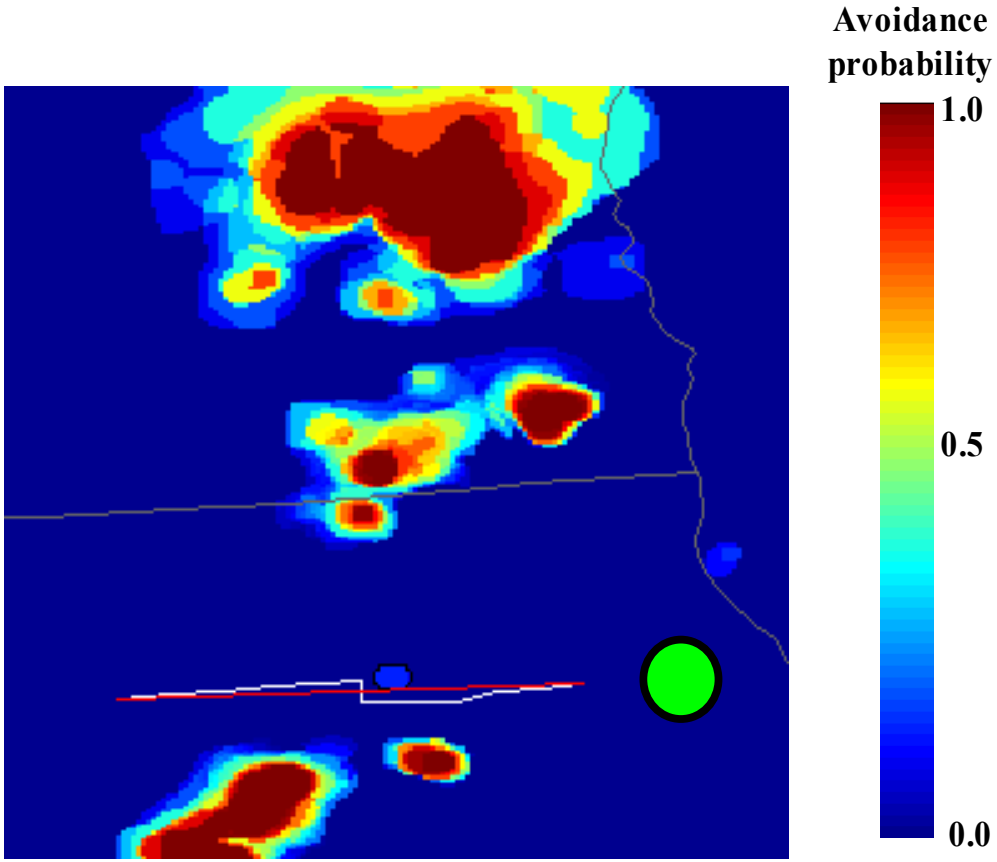




Overestimating the observed avoidance probability for the lower forecast probability associated with the fragment, while underestimating the observed avoidance probability associated with the higher forecast probability associated with the higher region

Algorithm Description (error analysis)

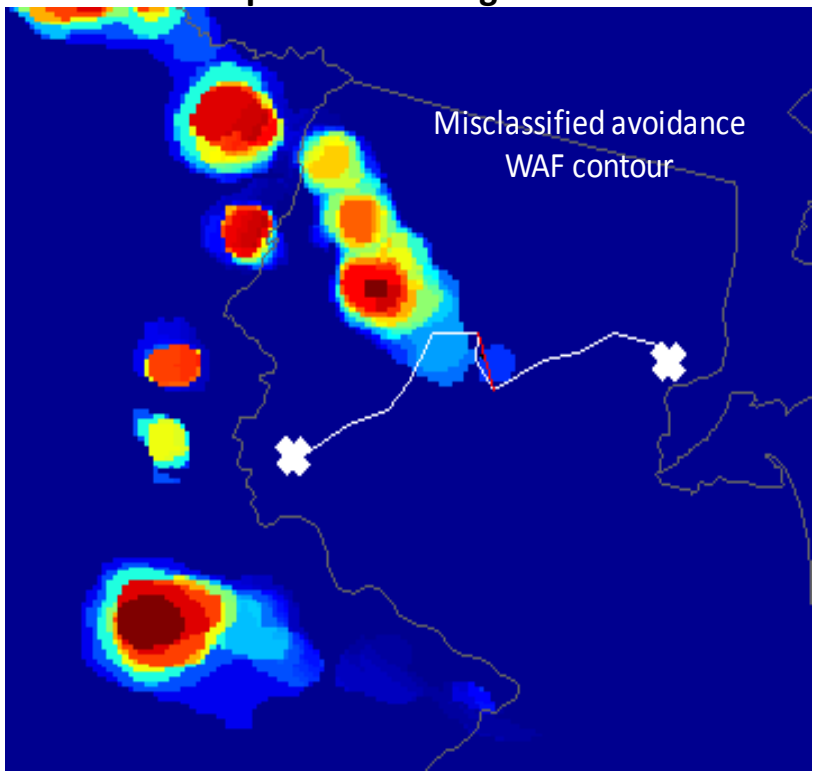
Small misclassified deviations



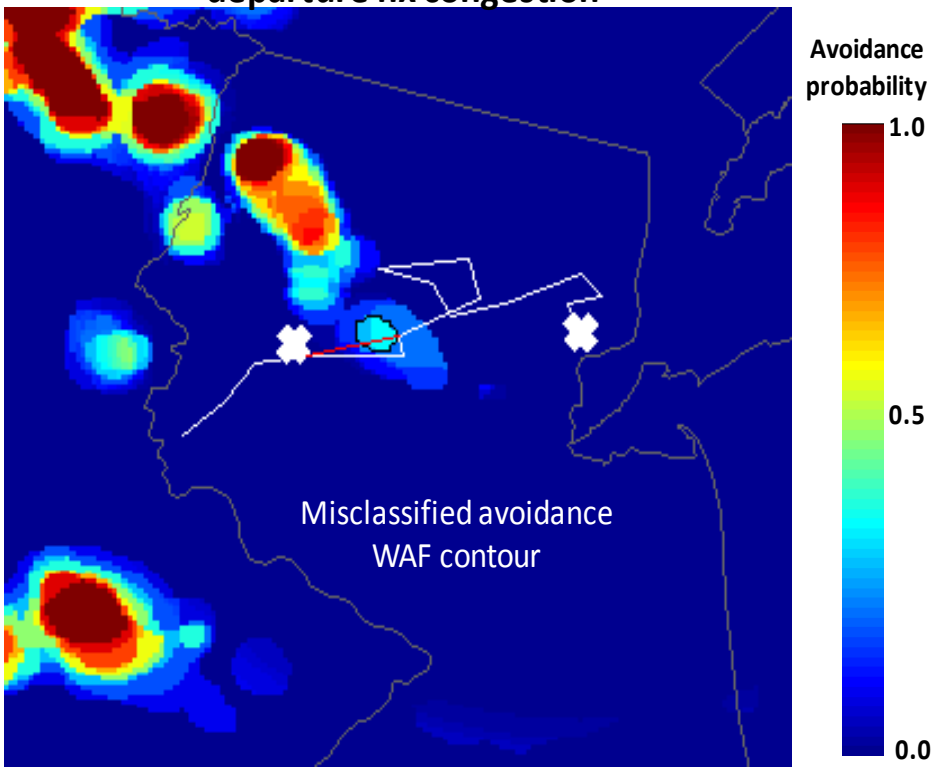
Algorithm Description (error analysis)

Misclassified congestion avoidance maneuvers

a. Trajectory slowed to avoid departure fix congestion



b. Trajectory held to avoid departure fix congestion



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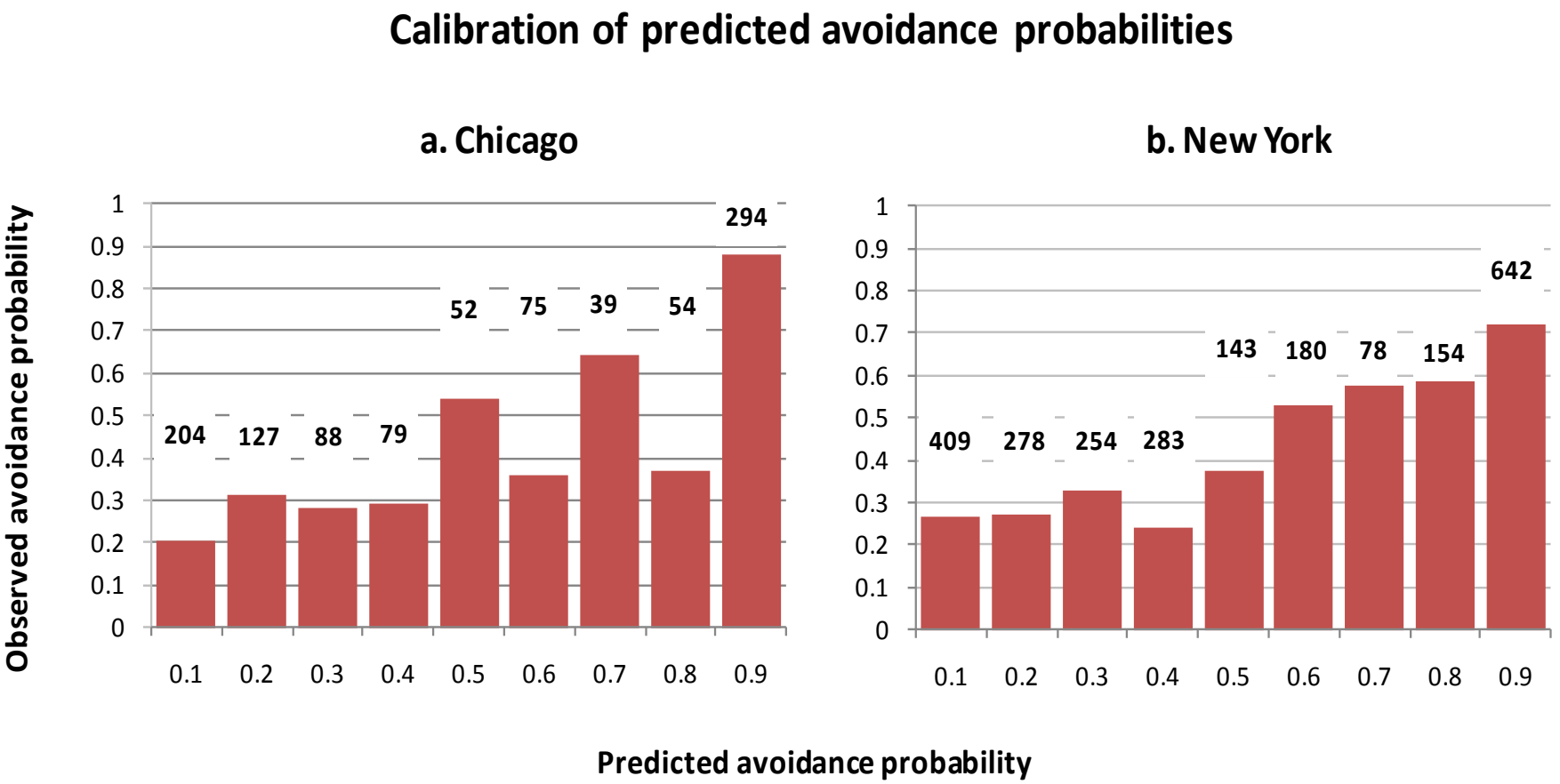
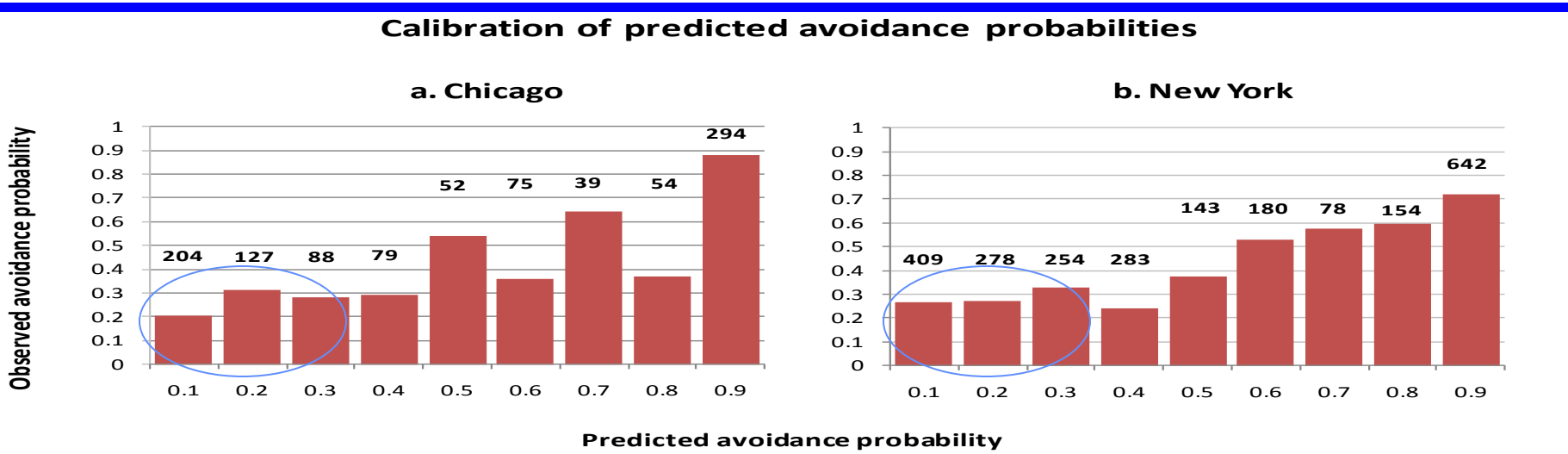
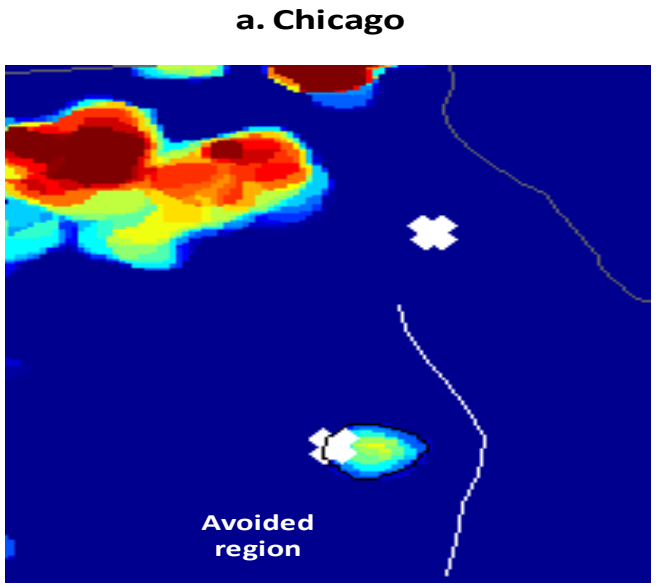
Avoidance probability calibration (results)

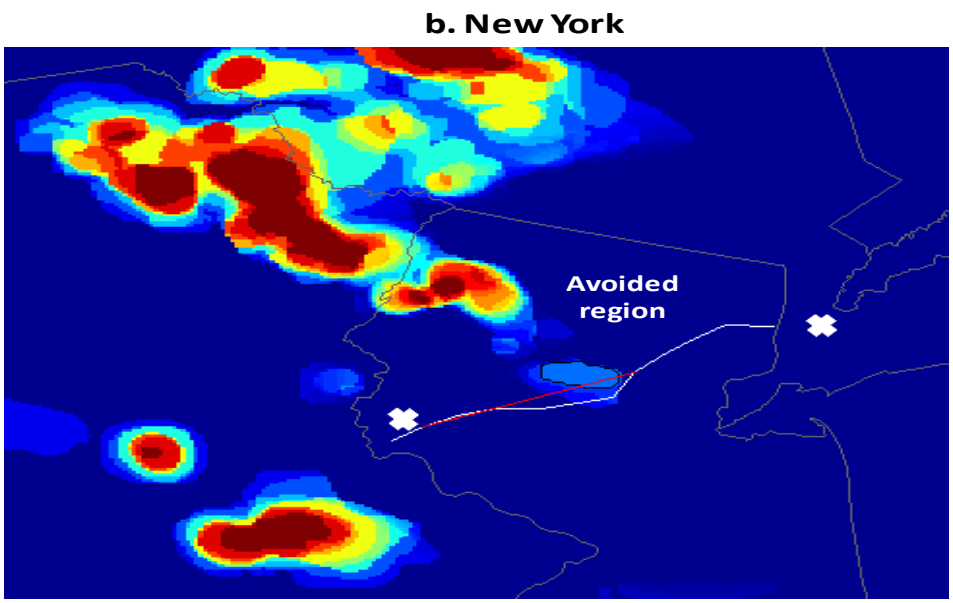


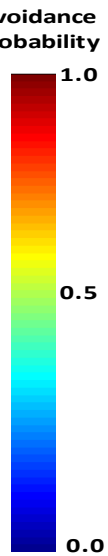
Calibration of departure CWAM from Chicago (a) and New York (b)

Avoidance of small, isolated, weak thunderstorms (results)

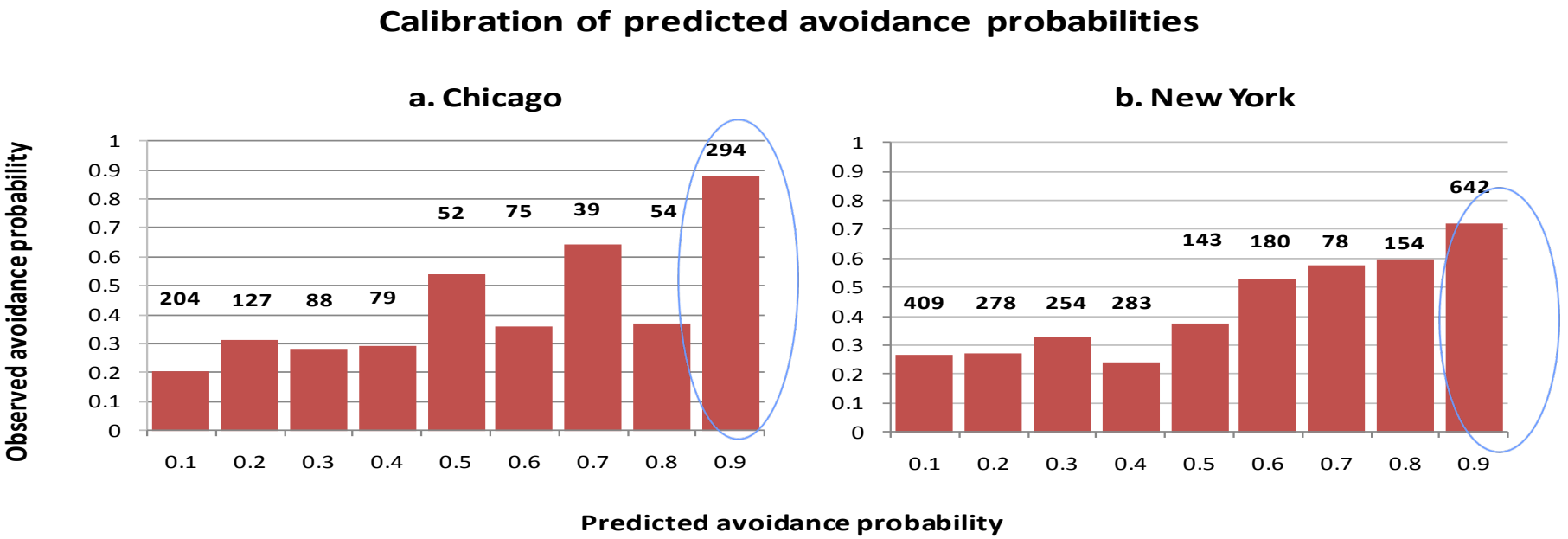








Results (Chicago vs. New York)

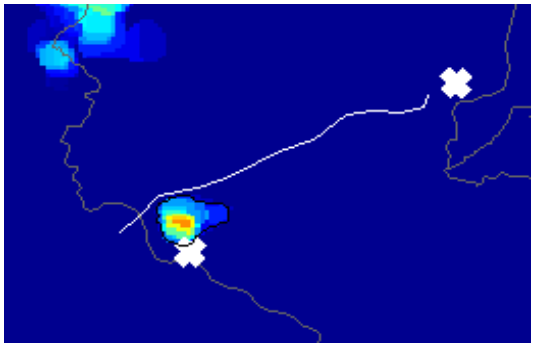


- In New York, only 72% of encounters with maximum WAF probabilities >= 0.9 were avoidances, while that percentage was 88% in Chicago

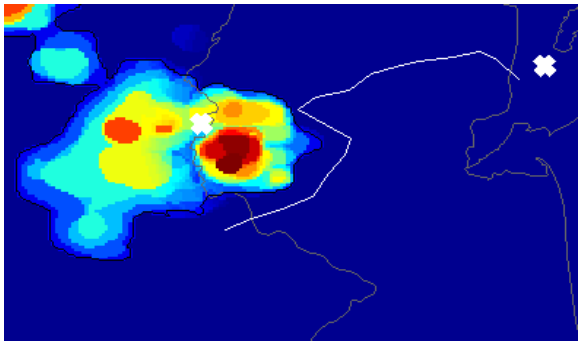
- Possible explanation: lower avoidance rate for New York may be explained by more constrained airspace and stricter avoidance rules in NY airspace

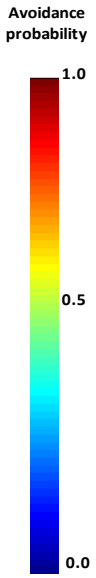
Results (Avoidance strategy)

a. Trajectory following small storm boundary

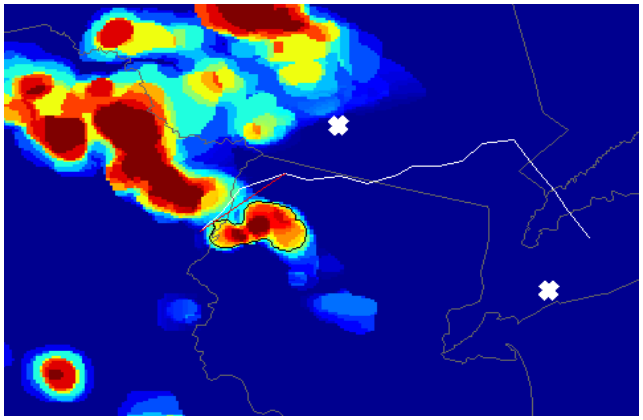


b. Trajectory following large storm boundary





c. Trajectory following 'best feasible option' through weather



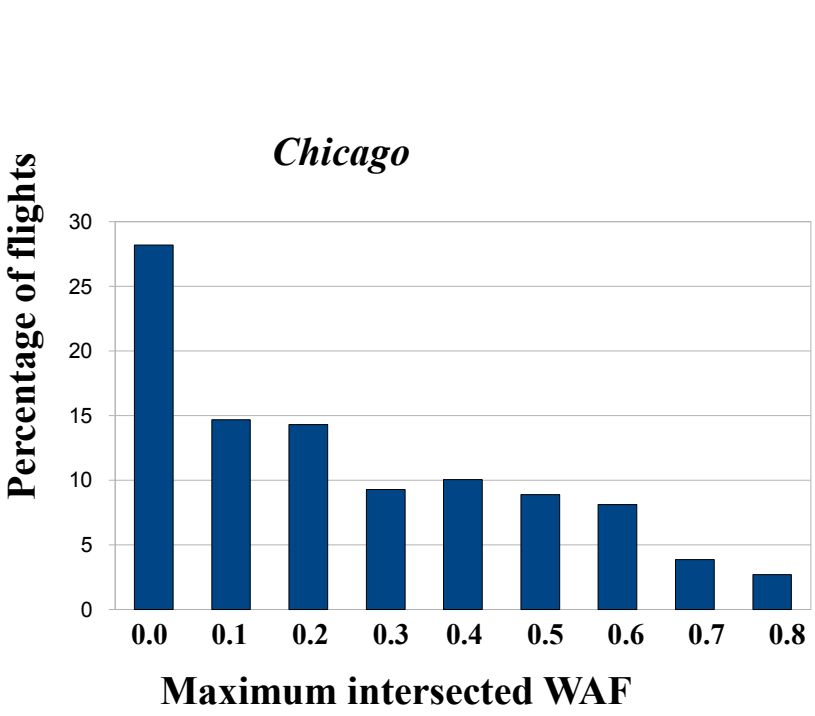
- An avoidance trajectory that avoided the storm core but encountered less severe weather in the vicinity.

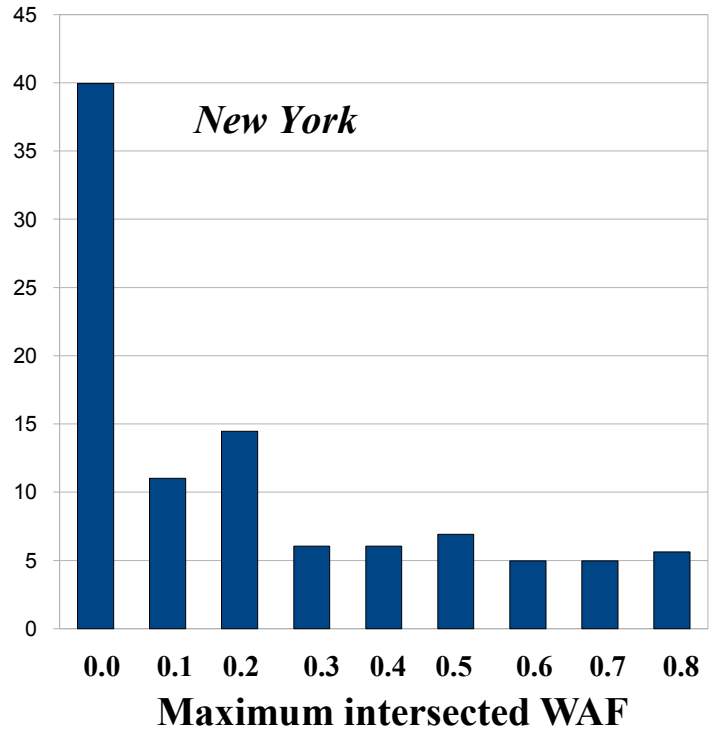
OR

- Avoid all weather and to fly in clear air.

Results (Avoidance strategies)

Maximum intersected WAF for all flights with maximum avoided WAF = 0.9





- ~30%(Chicago)/40%(New York) of flights that avoided WAF of 0.9 avoided *all* weather
- ~ 60%/Chicago)/65%(New York) flights avoided WAF with values >= 0.3.

This suggests that pilots will avoid weather near a storm that they would otherwise fly through if that weather were isolated and not associated with the storm

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Conclusions

- CWAM for departure airspace was evaluated based on data from 5 days of operations in Chicago and 8 days in New York during the 2010 summer.

- An automated weather decision classification algorithm was created
  - The classification error was estimated at ~16

- The departure CWAM produces a reasonably well-calibrated WAF. But over-warning for high WAFs(esp. for New York) and under-warning in low WAFs was detected that matches with RAPT problems

- Avoidance behavior – the WAF intersections for pilots avoiding WAF features with avoidance probability of 0.9 – was also analyzed: where possible, pilots seek to avoid all weather impacts, not simply to reduce them to an 'acceptable' level

Future work

- Investigating of over/under-warning in WAF in context of RAPT
- Evaluation of departure CWAM performance based on forecast weather.
- Development of a single combined departure / arrival CWAM for terminal airspace.
- Enhancements in the automated decision classification algorithm. Application of classification algorithm for verification of various avoidance fields

THANK YOU !