

An Efficient Method for Airspace Analysis and Partitioning Based on Equalized Traffic Mass

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CENTER FOR AIR TRANSPORTATION SYSTEMS RESEARCH

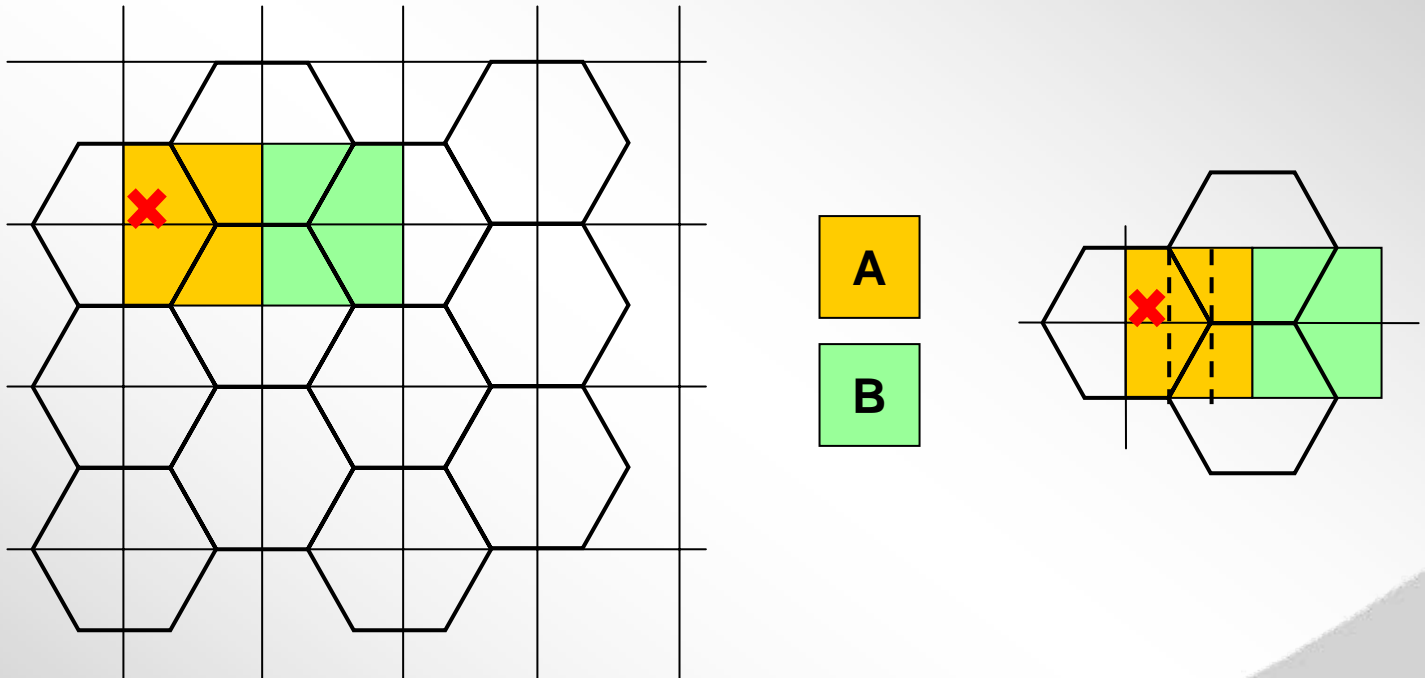


ETMS "TZ" Records Processing

Populating Hexagonal Grid

Challenge: hexagonal grid doesn't allow direct indexing

Solution: generate hexagonal grid from rectangular grid



Performance

- One day's ETMS; approx. 5-6M TZ hits ingested & displayed in 17 sec

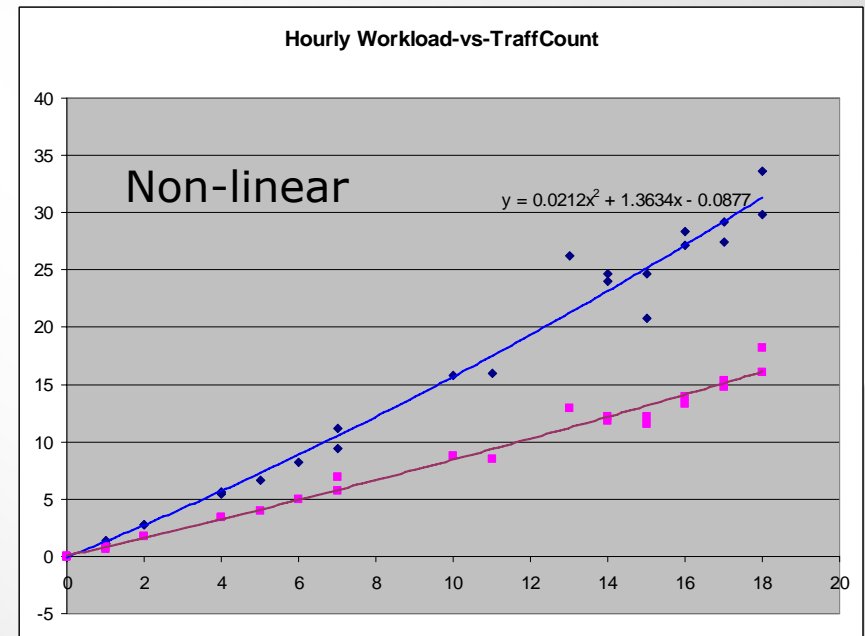
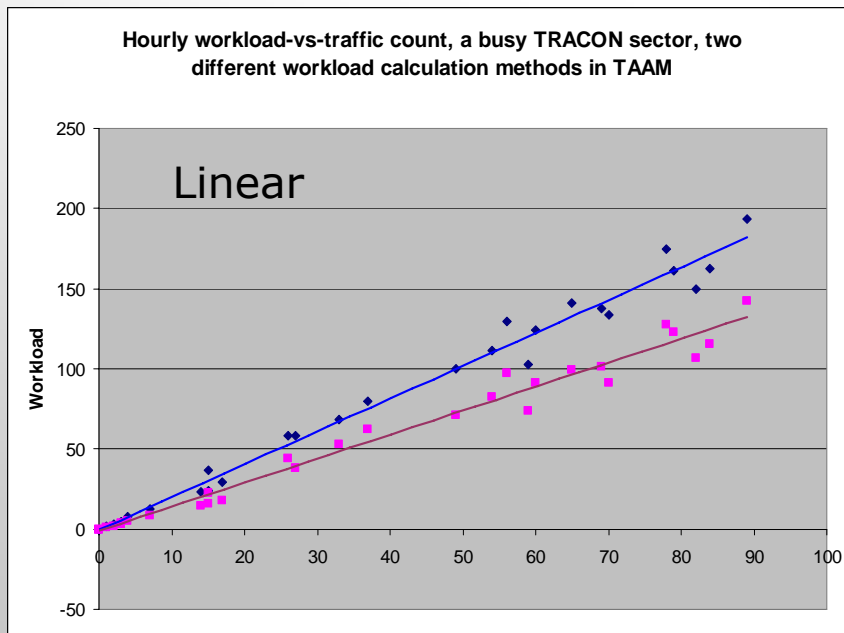
Traffic Mass as a Metric

Traffic Mass = Total of all TZ hits in a hexagonal bin

Distinct from Traffic Density

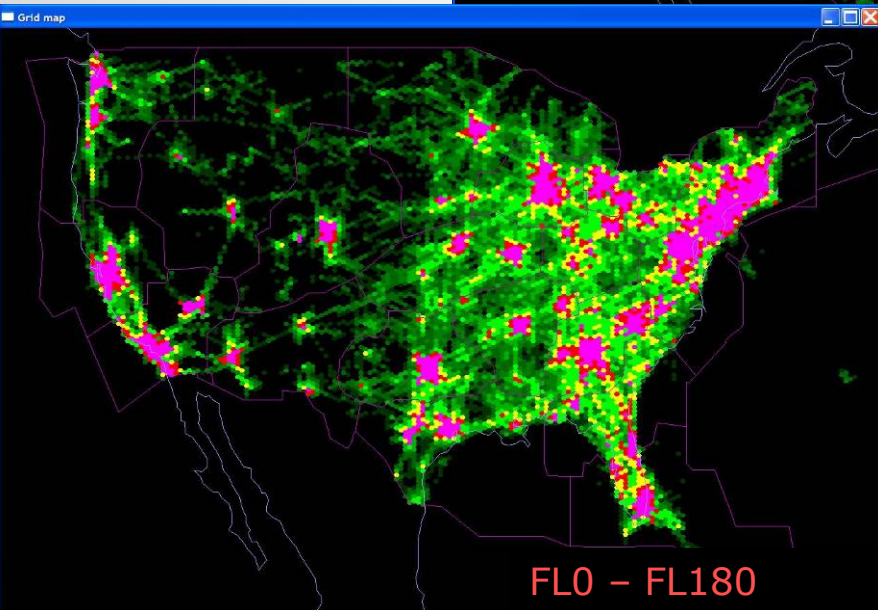
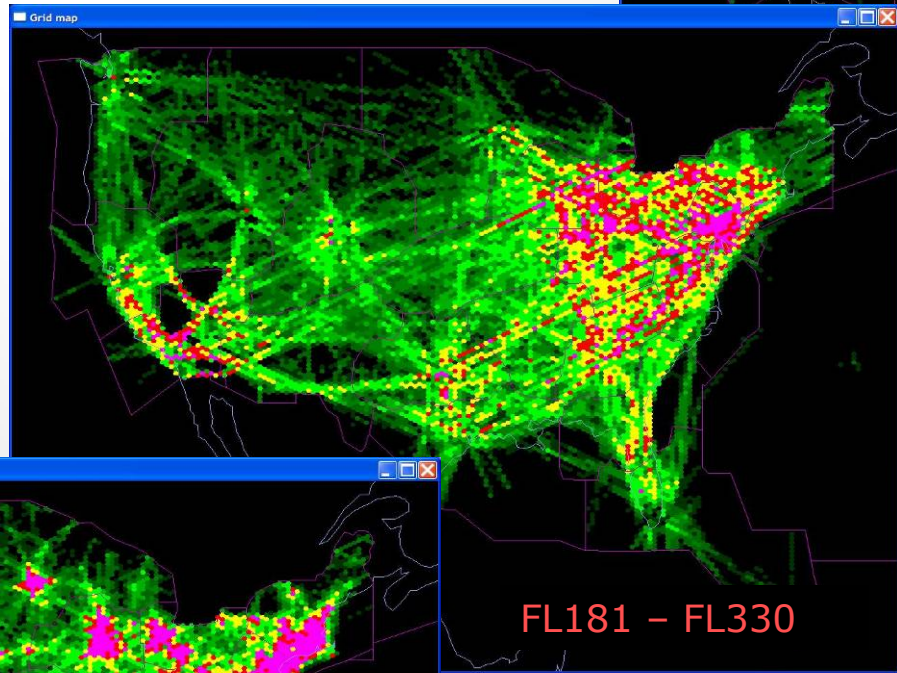
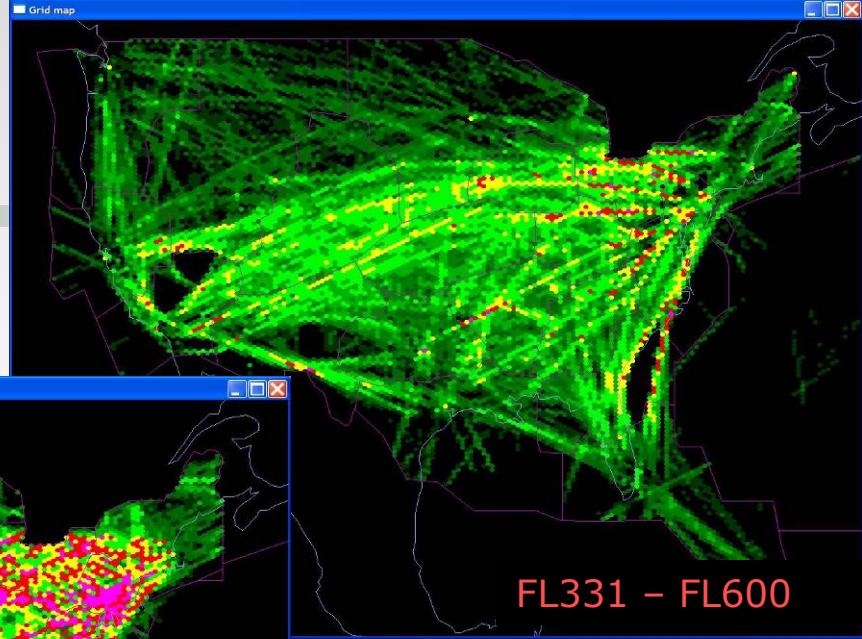
Traffic Mass and Workload

- Linear or slightly non-linear relationship (up to a point)
- Example: TAAM calculations



Populating NAS Grid

Traffic Mass in Strata



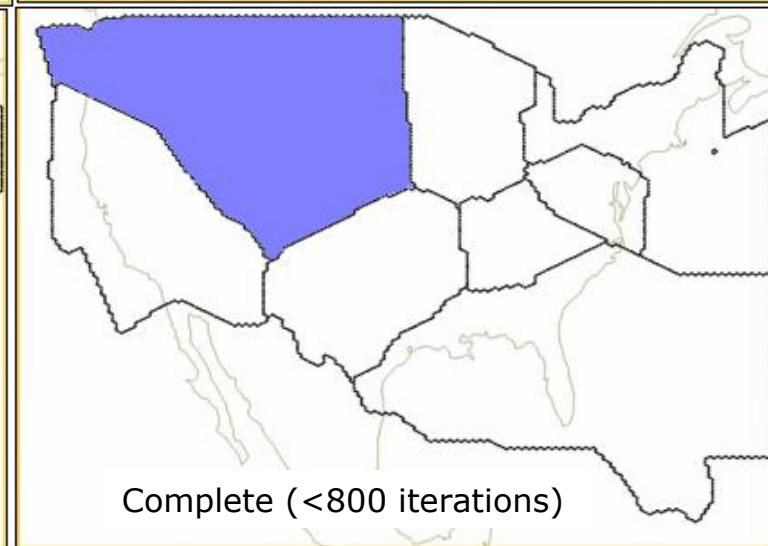
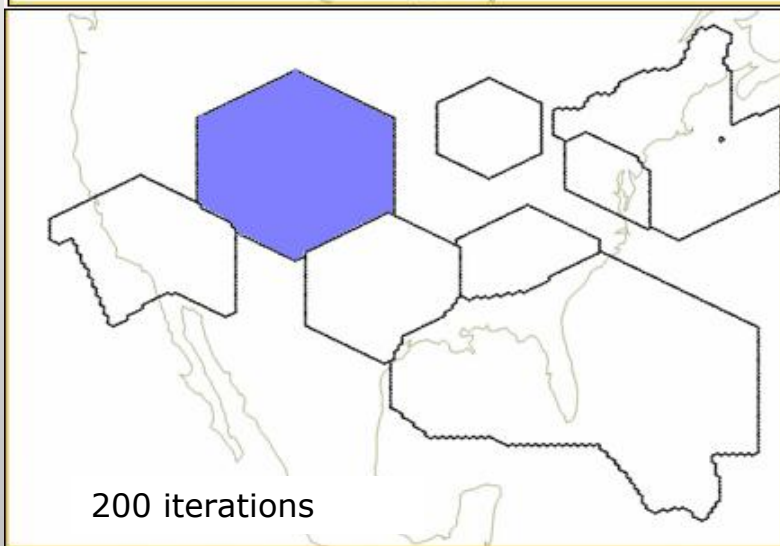
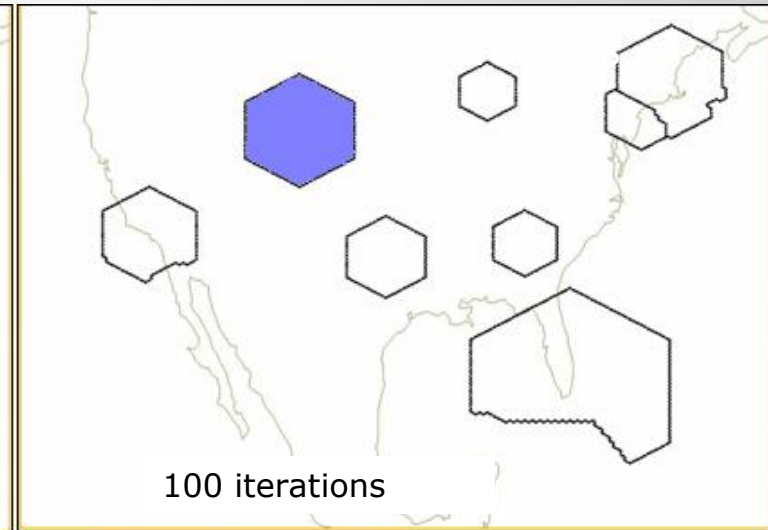
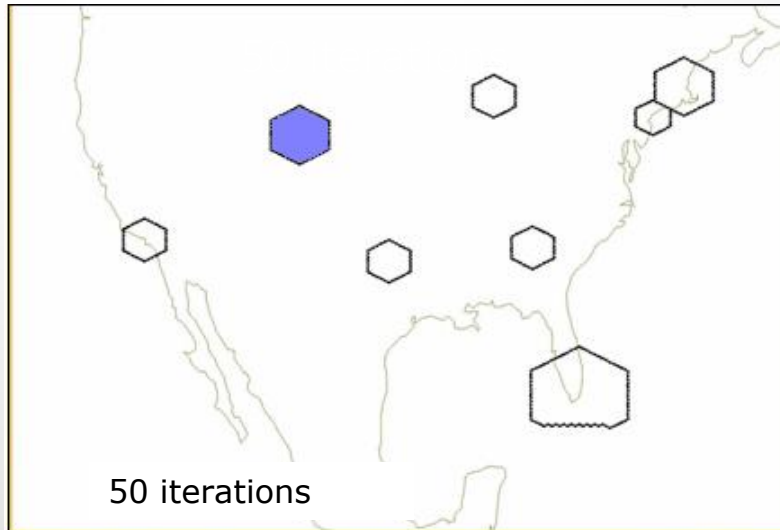
Airspace Partitioning - Objectives



- Alternatives with fewer ATC Centers than today
- Pre-determined number of Centers to try
- Repartition NAS airspace by equalizing Traffic Mass in Centers
- Design criteria to satisfy
- Robustness vis-à-vis changes in traffic patterns
- High performance (*"need for speed"*)
- Aim: a good set of boundaries as a starting point for further work

Center Growth Algorithm

Example: Eight Seed Locations



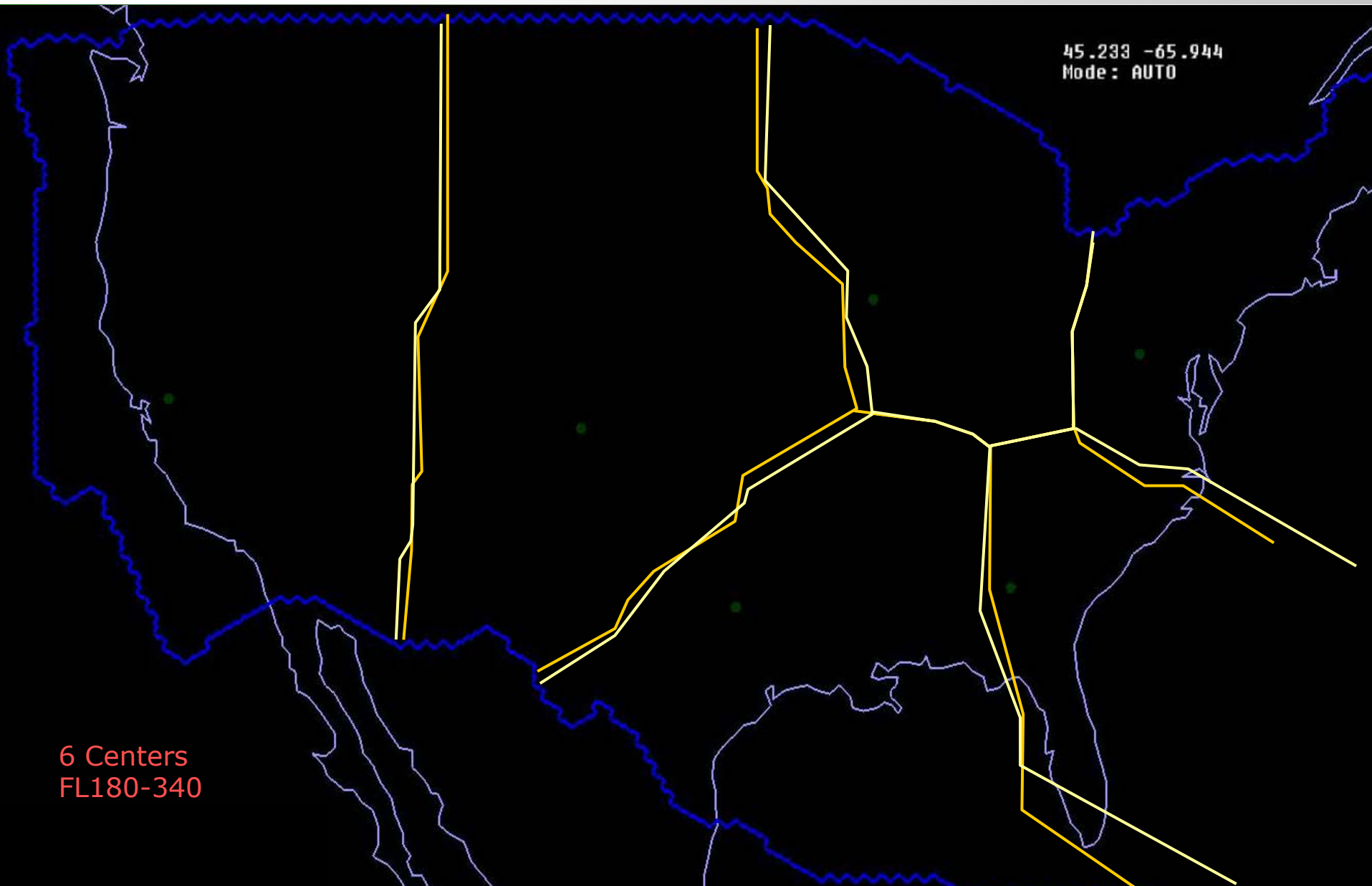
Center Boundary Sensitivity to Weather

2 'good' Wx days (Mar 13 and Apr 17, 2004)



45.233 -65.944
Mode: AUTO

6 Centers
FL180-340

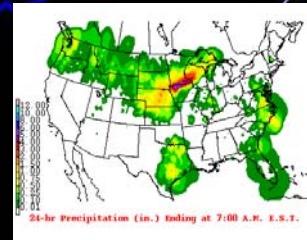


Center Boundary Sensitivity to Weather

A 'good' and a 'bad' day (Mar 13 and Sep 15)

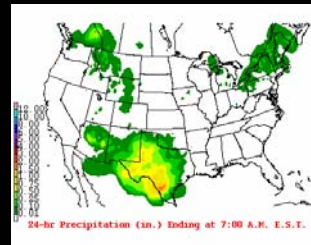


45.233 -65.944
Mode: AUTO



Sep 15

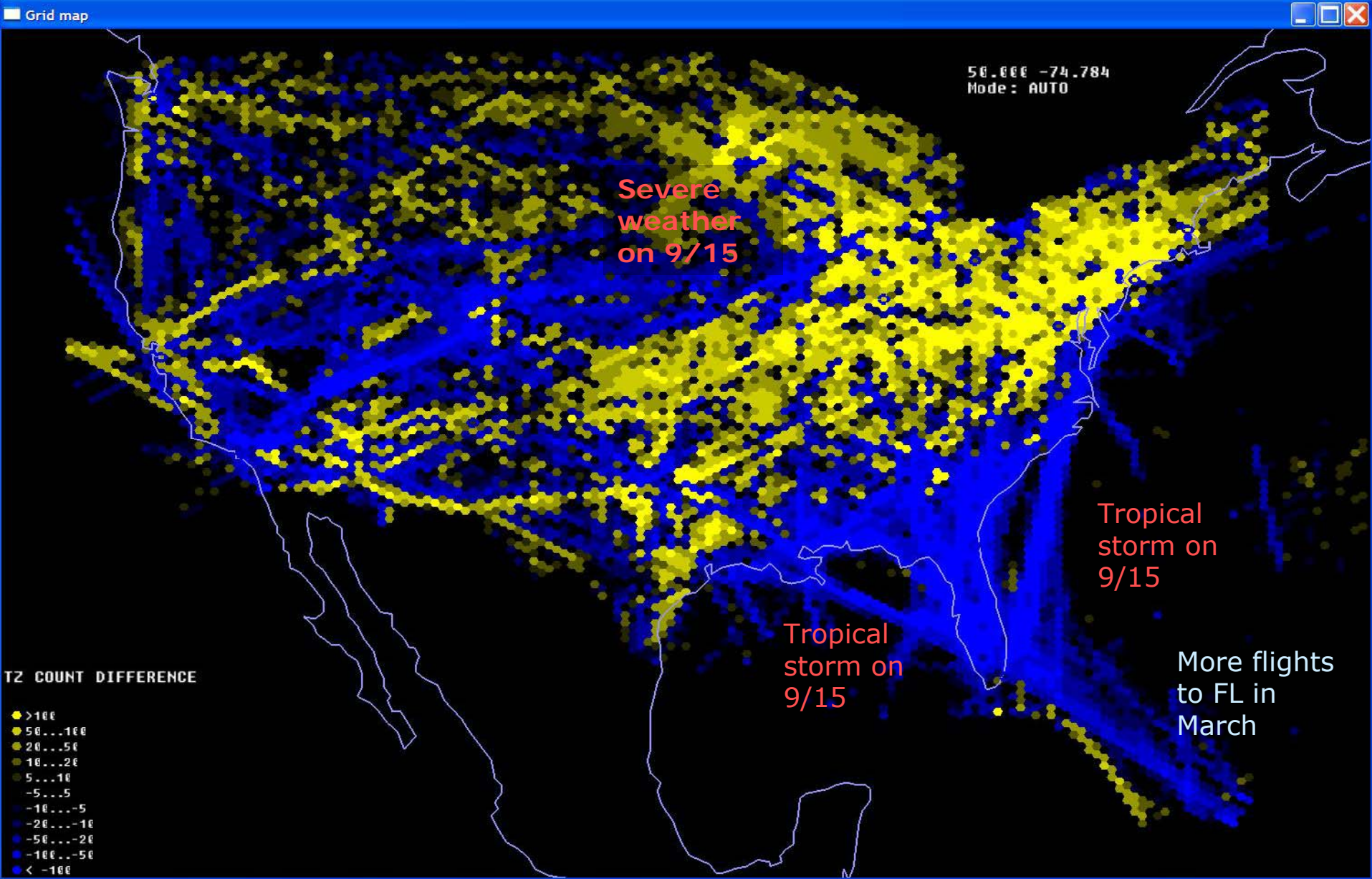
Mar 13



6 Centers
FL180-340

Center Boundary Sensitivity to Weather

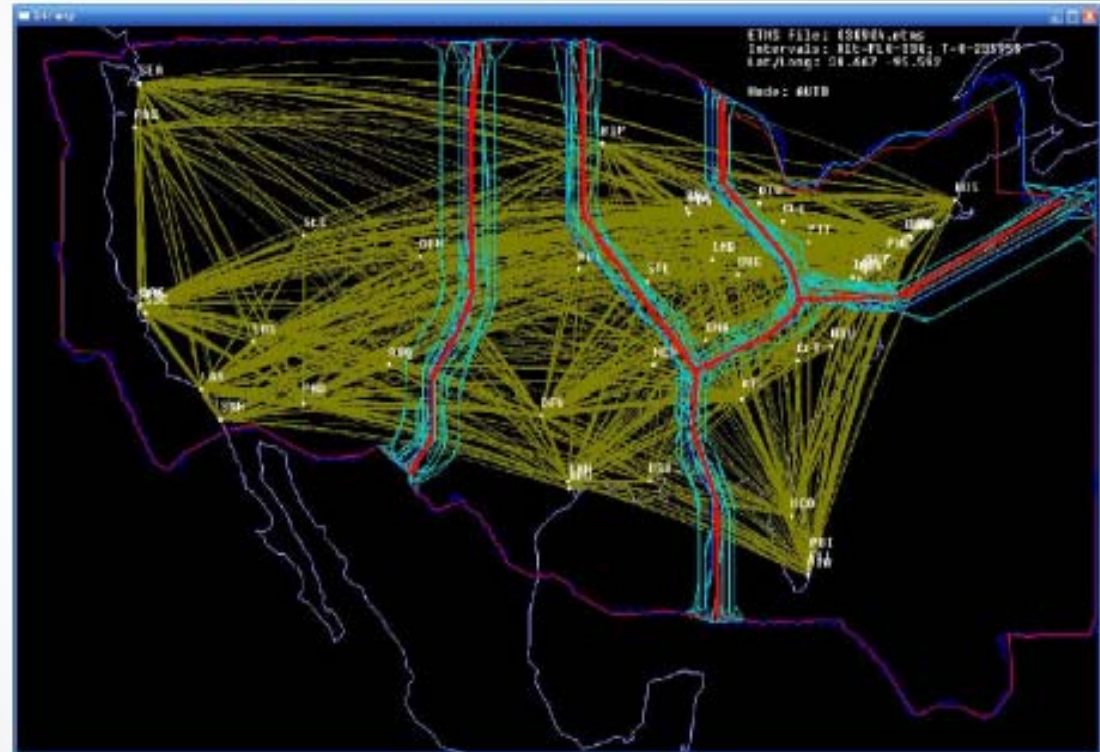
Mar 13 / Sep 15: Delta-Traffic-Mass View



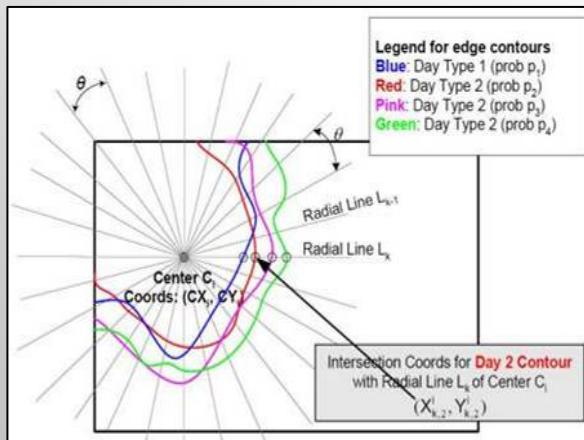
Boundary Averaging Method*

Using 12 Typical Days

- 4 day-types depending on weather impact
- 3 days of each type
- Automatic algorithm for scanning boundaries
- Averaged coordinates for each θ increment: single-day boundary intersections with radials are weighted by each day's % occurrence



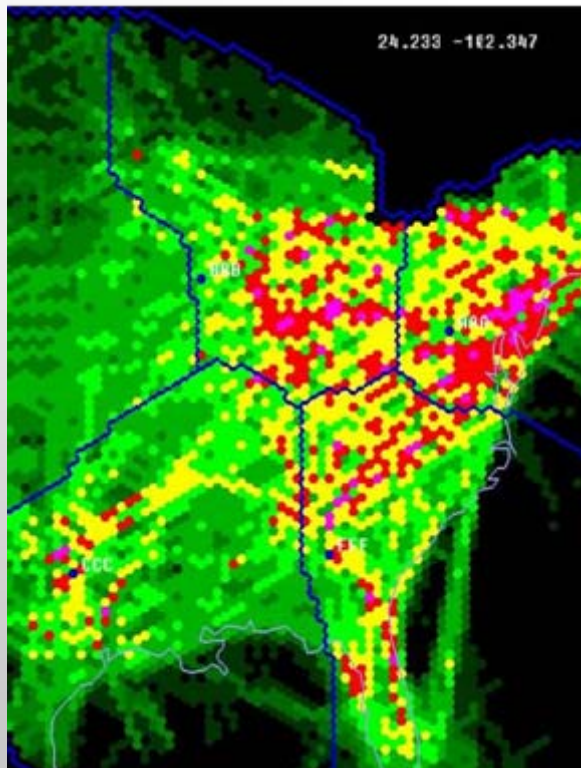
Resulting averaged boundary is more robust than any single day's boundary



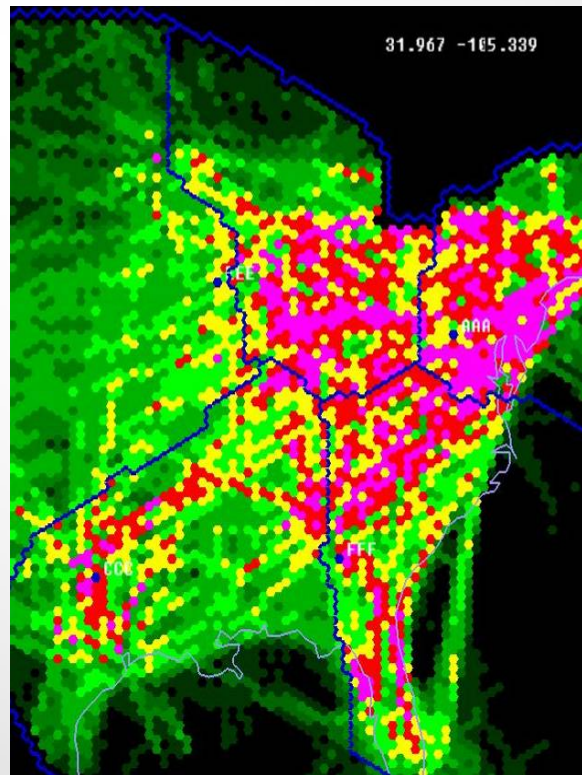
Partitioning

Alternative Metrics

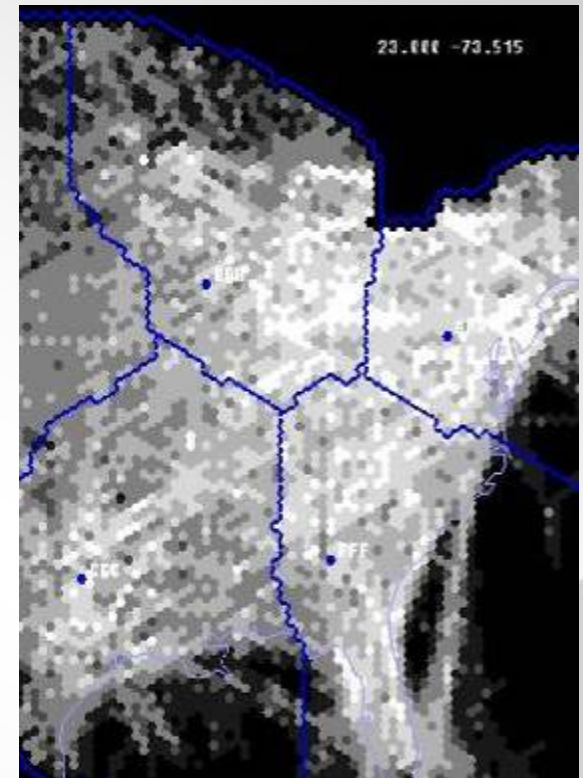
Traffic Mass



Traffic Mass with Non-Linear Tail ($N + 0.00002 N^2$)



Maximum TZ Hit Rate in 30-min Intervals



Conclusions

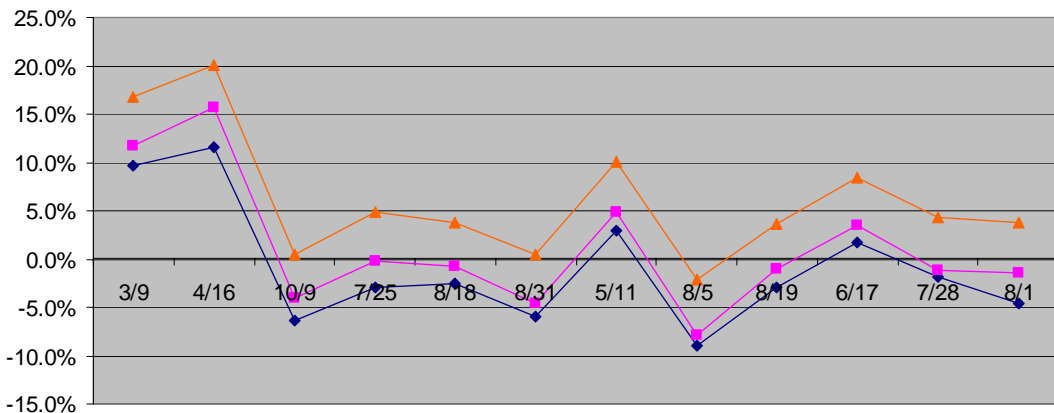
- Traffic Mass introduced as airspace partitioning metric
- Very efficient algorithms designed for:
 - NAS data processing on hexagonal grid
 - Seed Growth algorithm – creates Centers with equal traffic mass
 - Center boundary scanning/averaging for increased robustness
- Additional NAS analysis metrics proposed
 - Delta-traffic-mass
 - Maximum-TZ-hit-Rate
 - Traffic Mass with non-linear tail
- All the above, and more, implemented in a single software tool

BACK-UP SLIDES

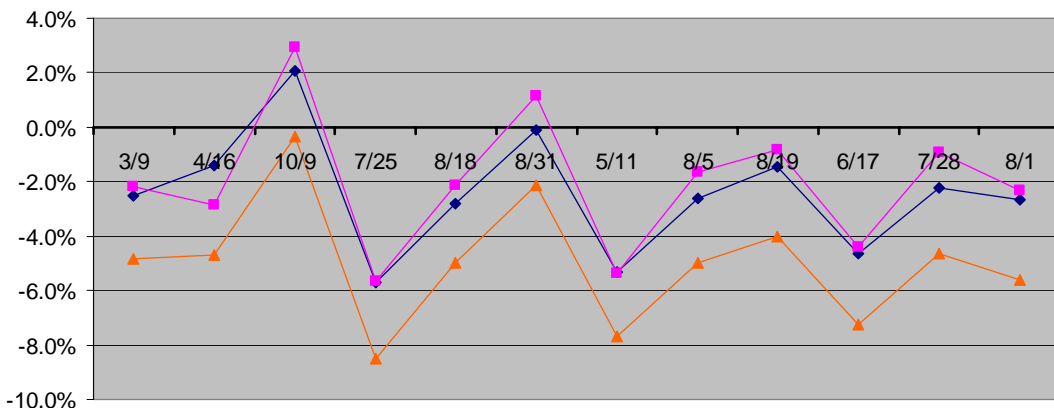
Center Size Variability

5 Low Altitude Centers – Two Examples

Traffic Mass Variability Center CCC



Traffic Mass Variability Center AAA



Typical Days

- ◆ Relative to the average for 10/09/04 optimal seed locations
- ◆ Relative to the average for all optimal seed locations
- ◆ Relative to day 10/09/04 optimal seed locations

If we freeze the boundaries and measure Traffic Mass for the 12 typical days...

Traffic Mass variability within averaged boundaries (blue) is lower than within one day's boundaries (red)

That is, averaged boundaries are more robust