

Sensitivity of the National Airspace System Performance to Weather Forecast Accuracy

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Detect the Difference

Presentation Outline

- Data used
- Weather impact on airspace
 - Flight plan loading versus radar track loading
 - Radar track loading versus convection
- Convection forecast accuracy
 - CCFP, Persistence
- Benefit of using clear weather forecasts
 - NAS delay reduction with clear weather forecasts
- Conclusions

Data Used

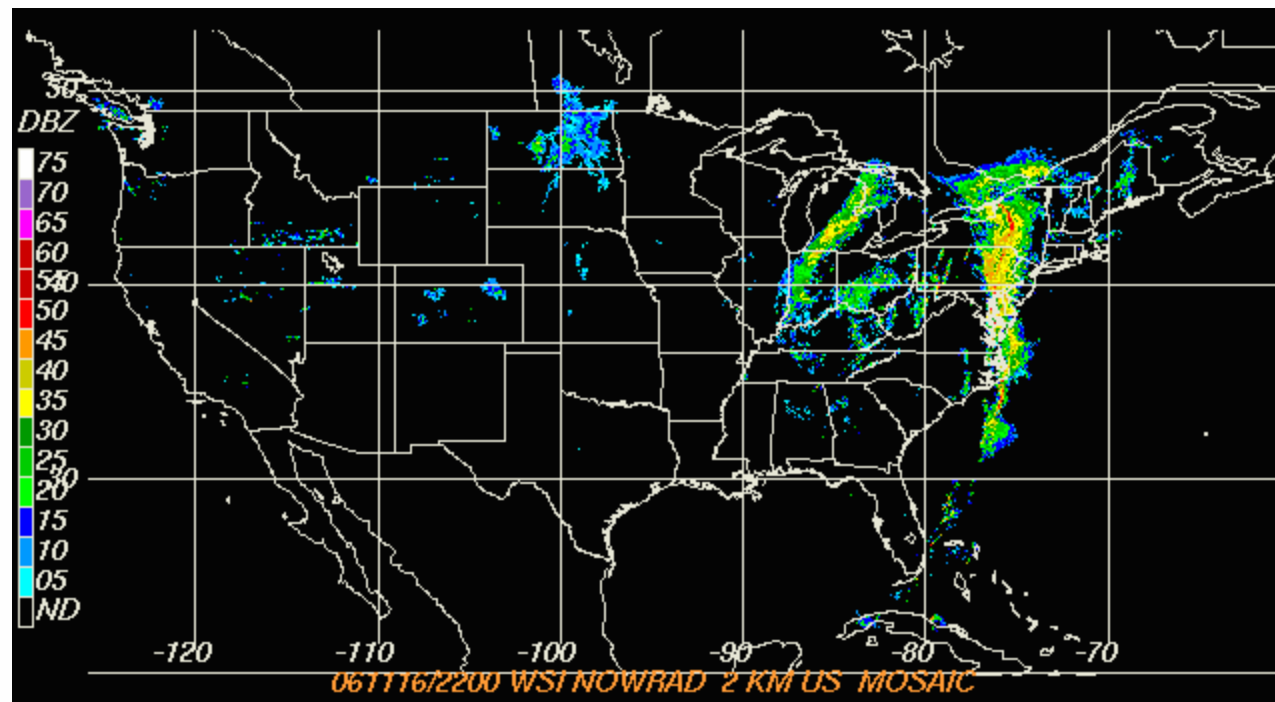
Weather Days

- Five heavy weather days, two control days

Date	Control day?	Convection level
11-09-06	Yes	Light
11-16-06	No	Heavy
1-07-07	No	Heavy
6-23-07	No	Heavy
8-11-07	Yes	Light
8-18-07	No	Heavy
8-30-07	No	Heavy

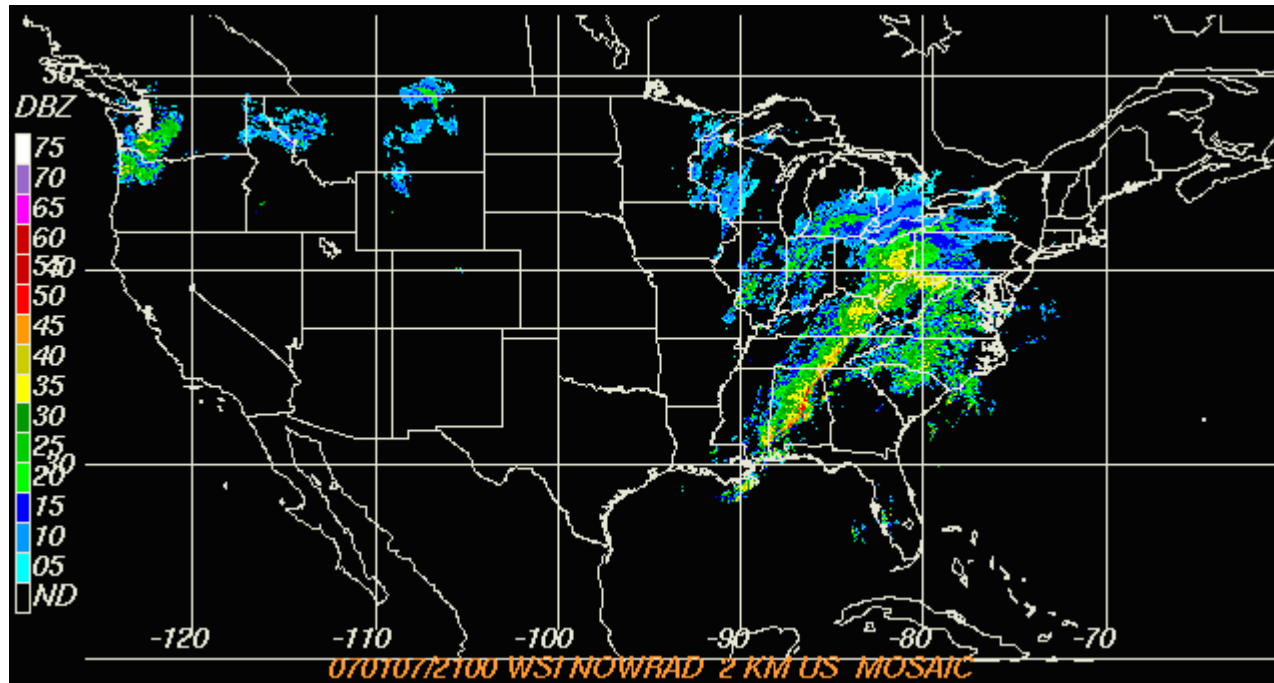
11/16/2006

- Heavy weather in midwest and NE corridor



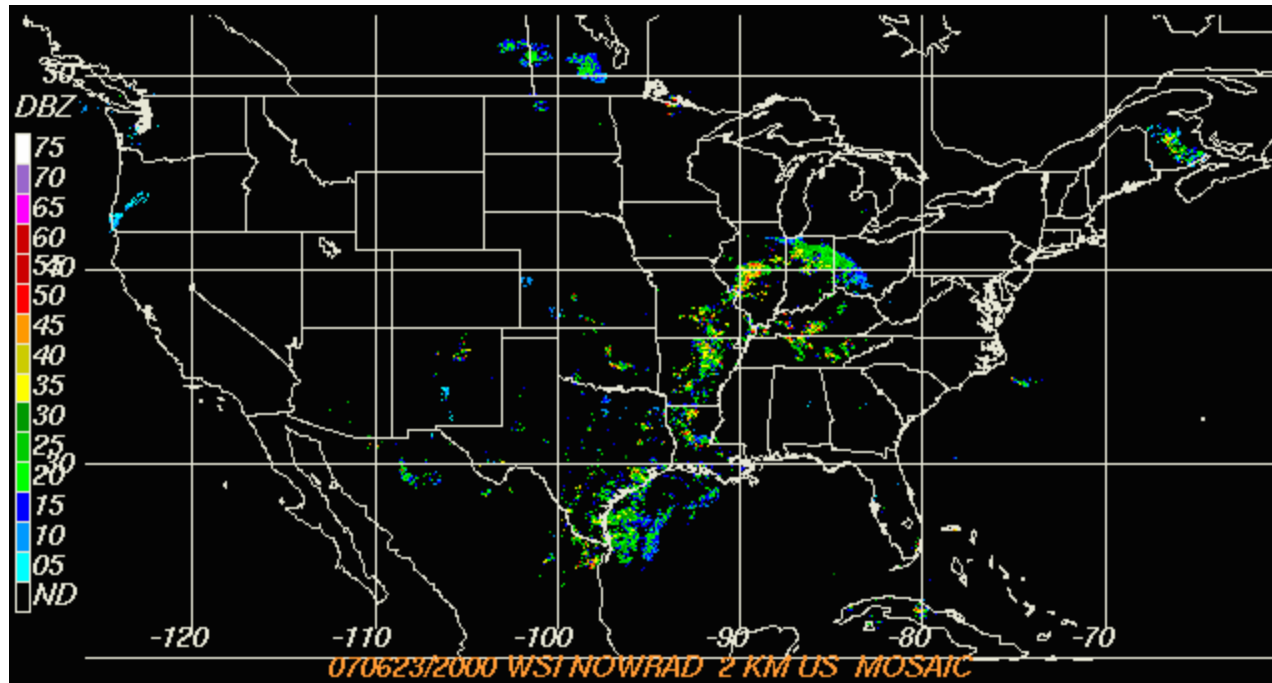
01/07/2007

- Heavy weather in midwest and NE corridor



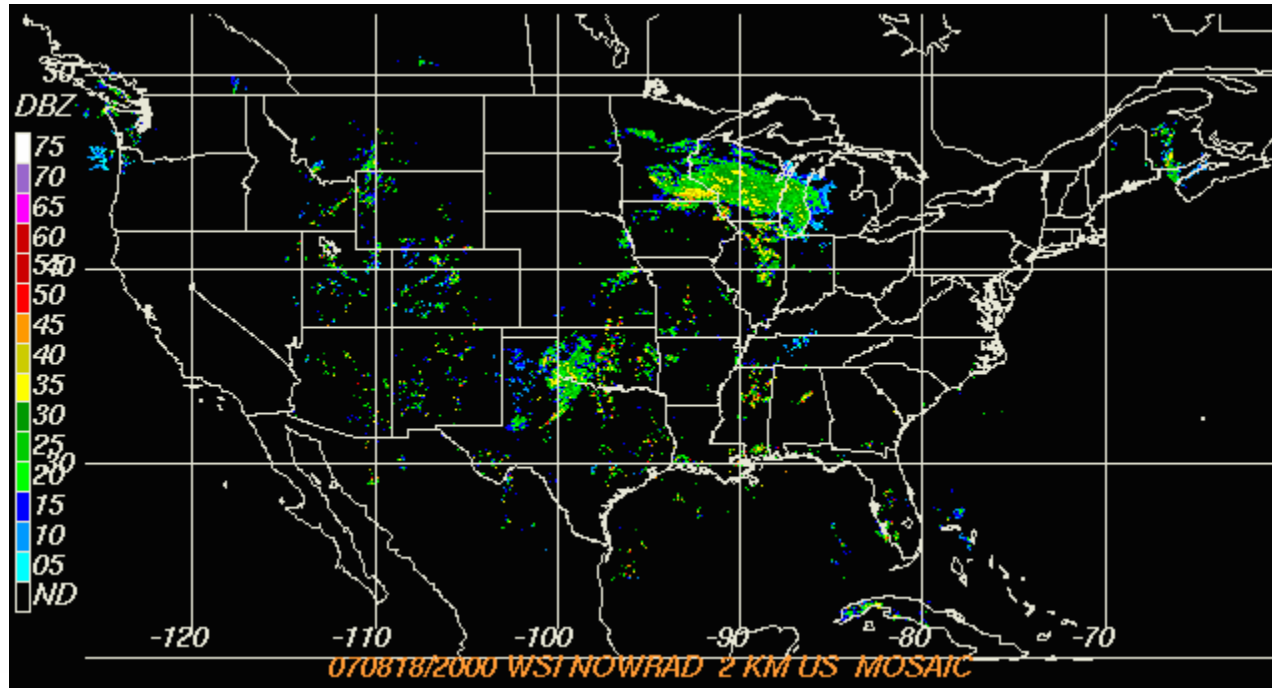
06/23/2007

- Weather in south and midwest



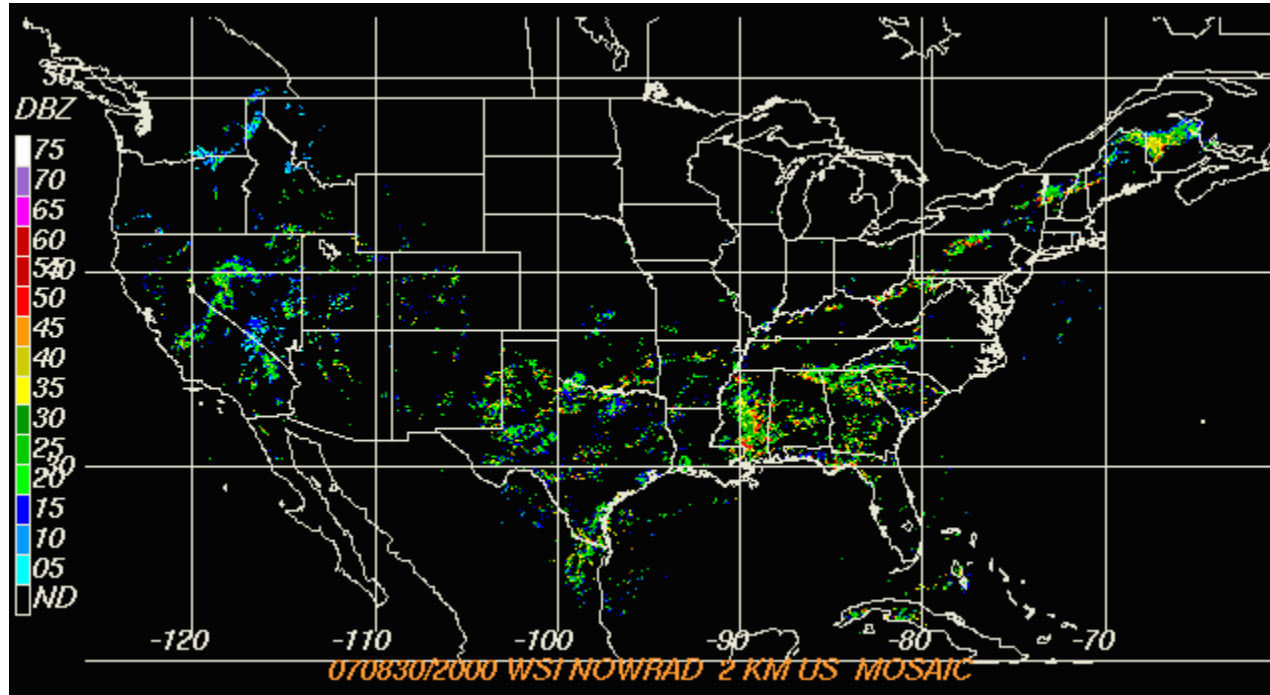
08/18/2007

- Heavy weather in northern midwest



08/30/2007

- Heavy weather in southeast





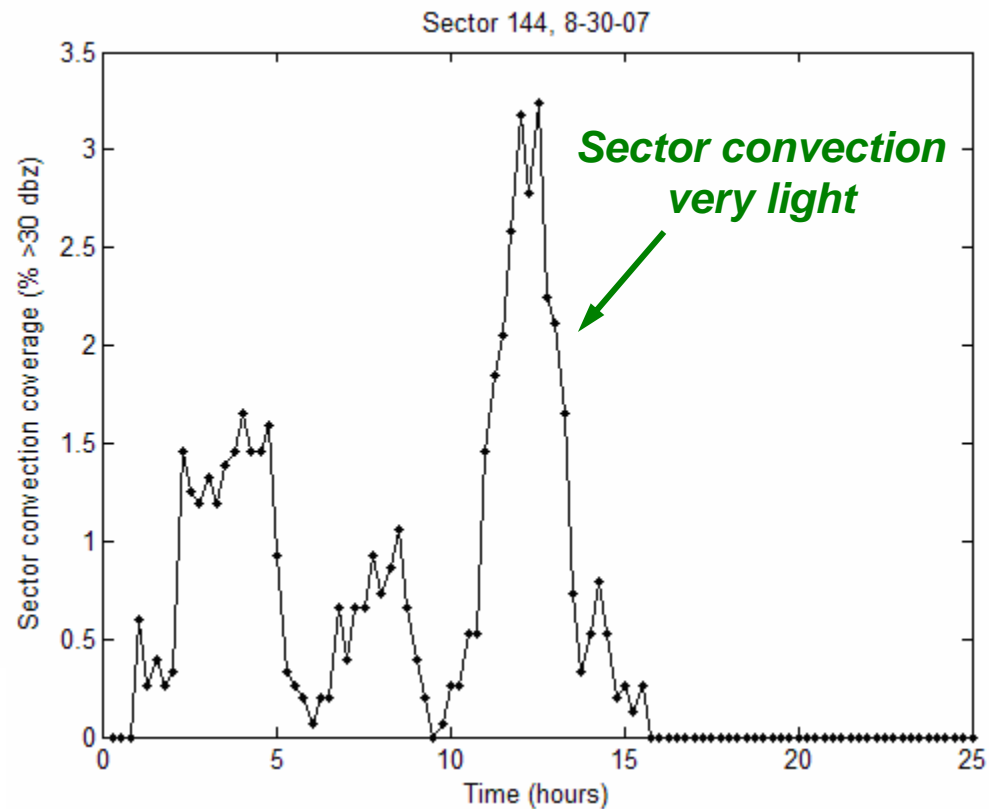
Weather Impact on Airspace

Flight Plan Loading Versus Radar Track Loading

- How well do flight plan data predict observed (radar) airspace loading?
 - Answer: very well in >1 hour sampling time bins
- How much of weather avoidance is evident in flight plans?
 - Indicates strategic rerouting around weather
 - Answer: ~90% or more in heavy weather

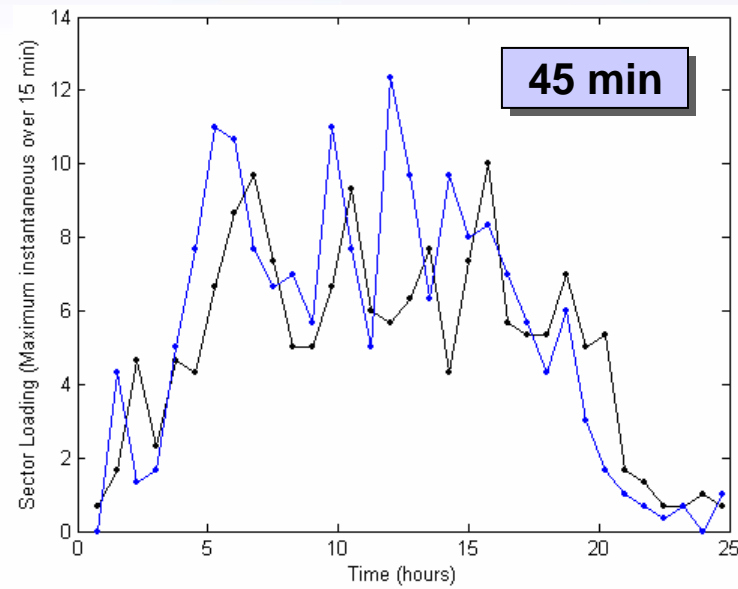
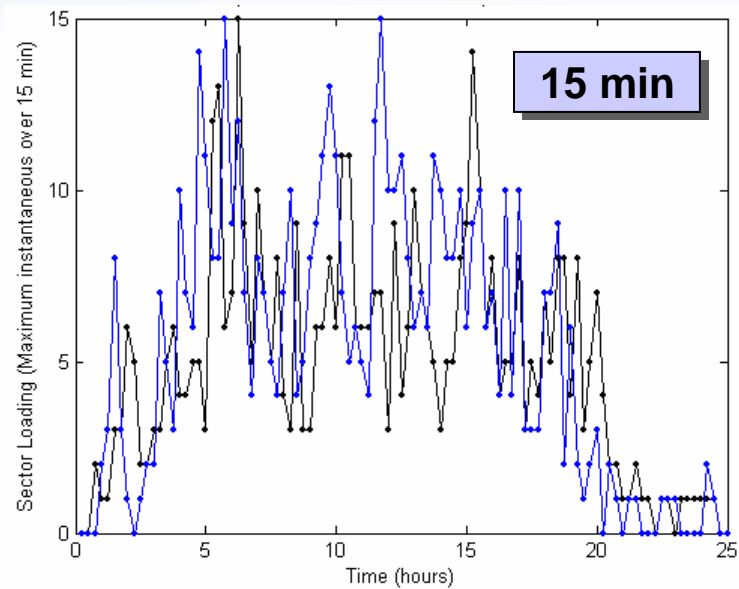
Flight Plan Loading Versus Radar Track Loading

- Flight plans are an unbiased but noisy predictor of sector loading
- Example:
 - 08/30/07
 - Sector 144
 - Very light convection throughout the day

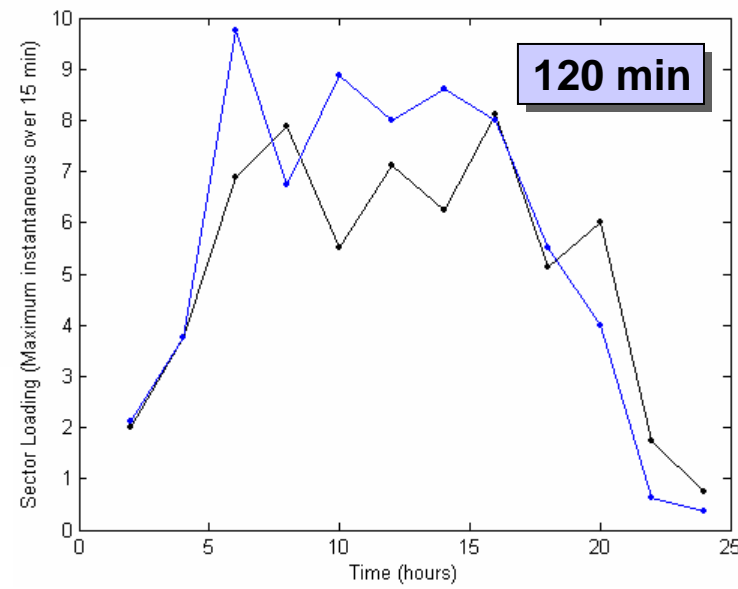
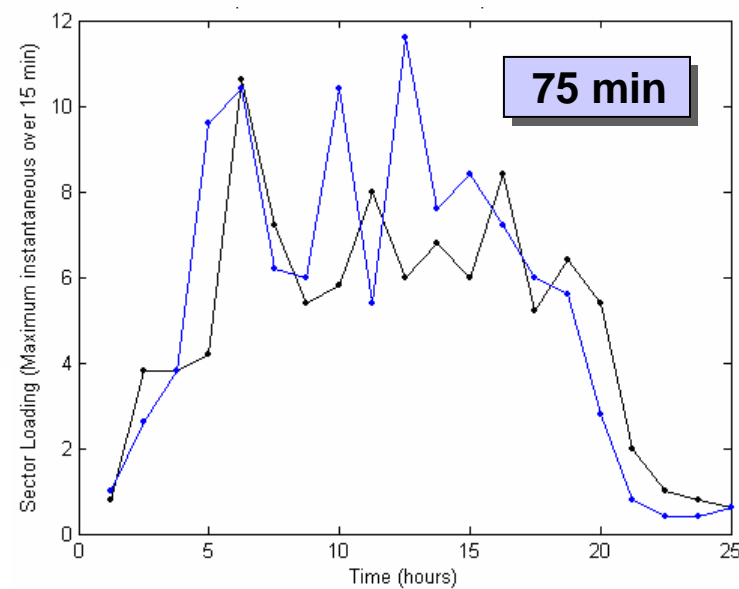


FP Versus TZ Loading

For Increasing Sample Periods

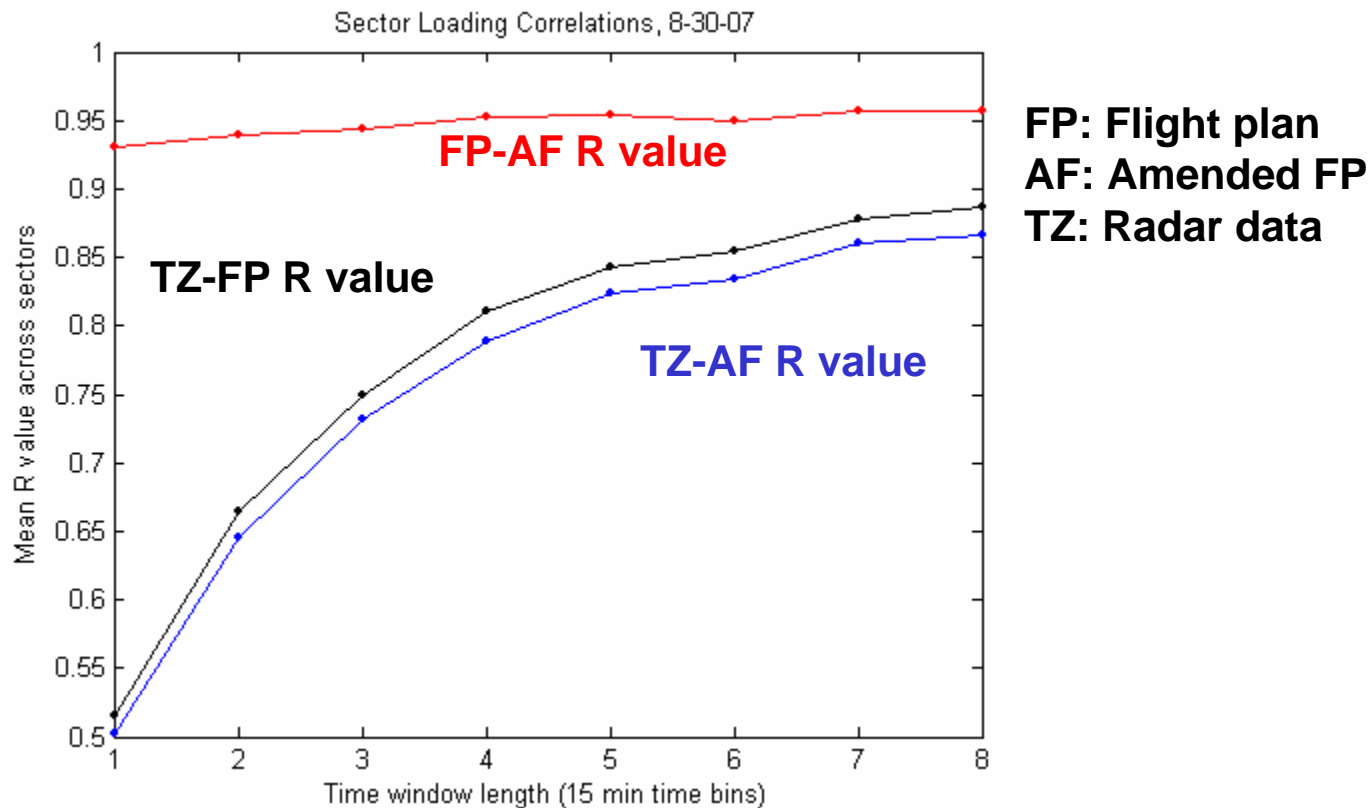


FP ———
TZ ———



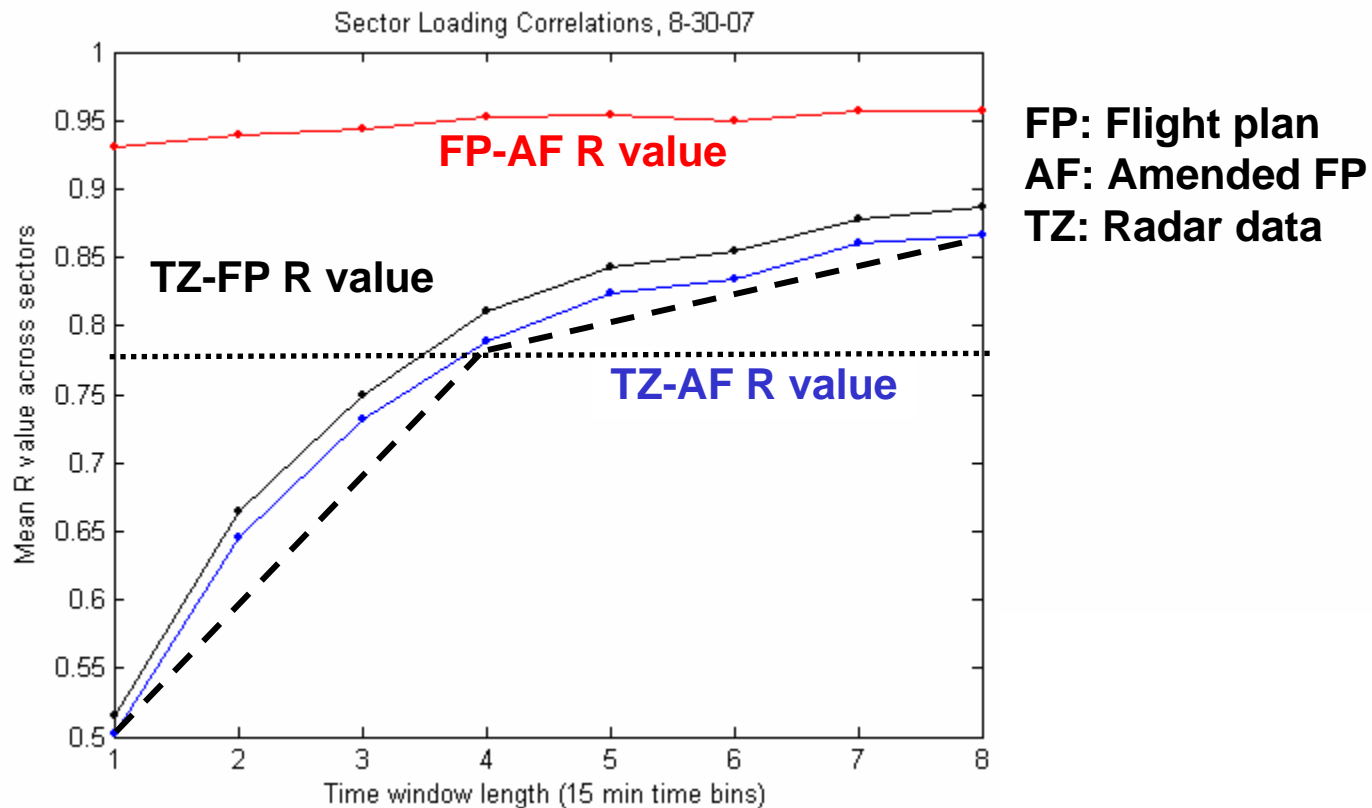
Loading History Correlations

- R value, across all sectors, 08-30-07
 - R value increases with sampling period



Loading History Correlations

- R value, across all sectors, 08-30-07
 - R value increases with sampling period
 - Knee in curve: About 1 hour sampling period



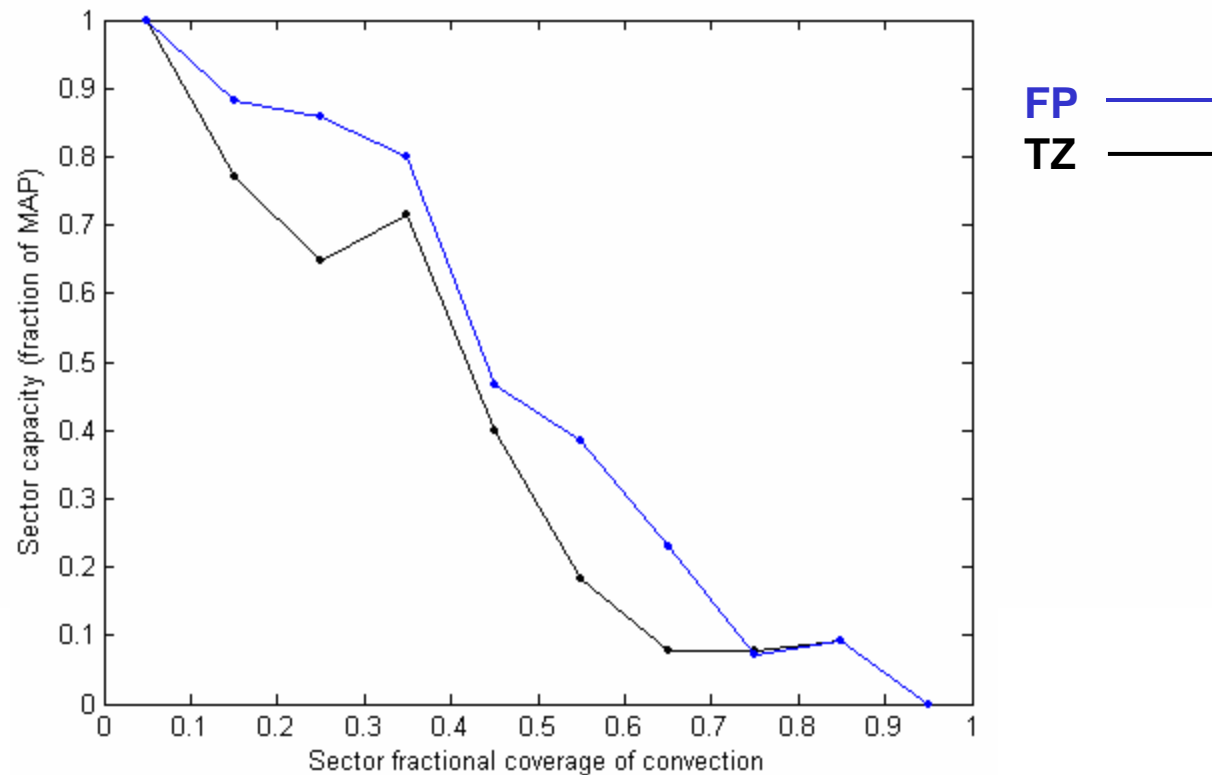
Flight Plan Loading Versus Radar Track Loading

- Strategic versus tactical weather vectoring
 - Airspace unloading evidence in the flight plan reflects strategic rerouting
 - Remaining unloading reflects tactical vectoring

FP Versus TZ Loading

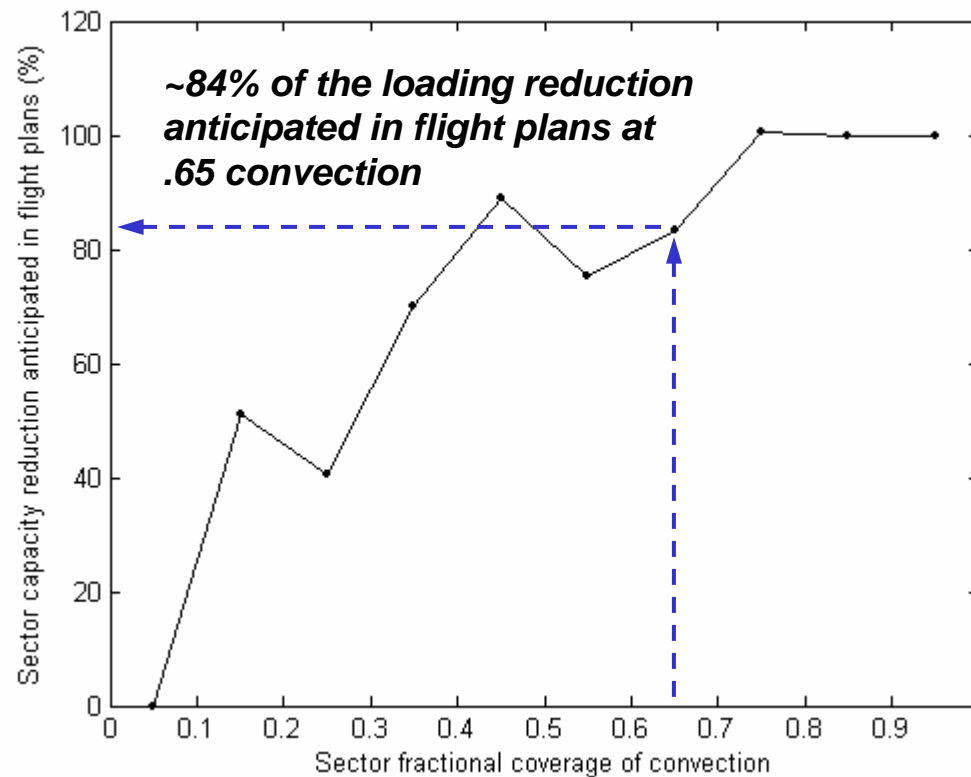
In the Presence of 40 dbz+ Convection

- Maximum loading versus weather



%Redux Anticipated in Flight Plans

- Strategic rerouting more evident in heavier convection

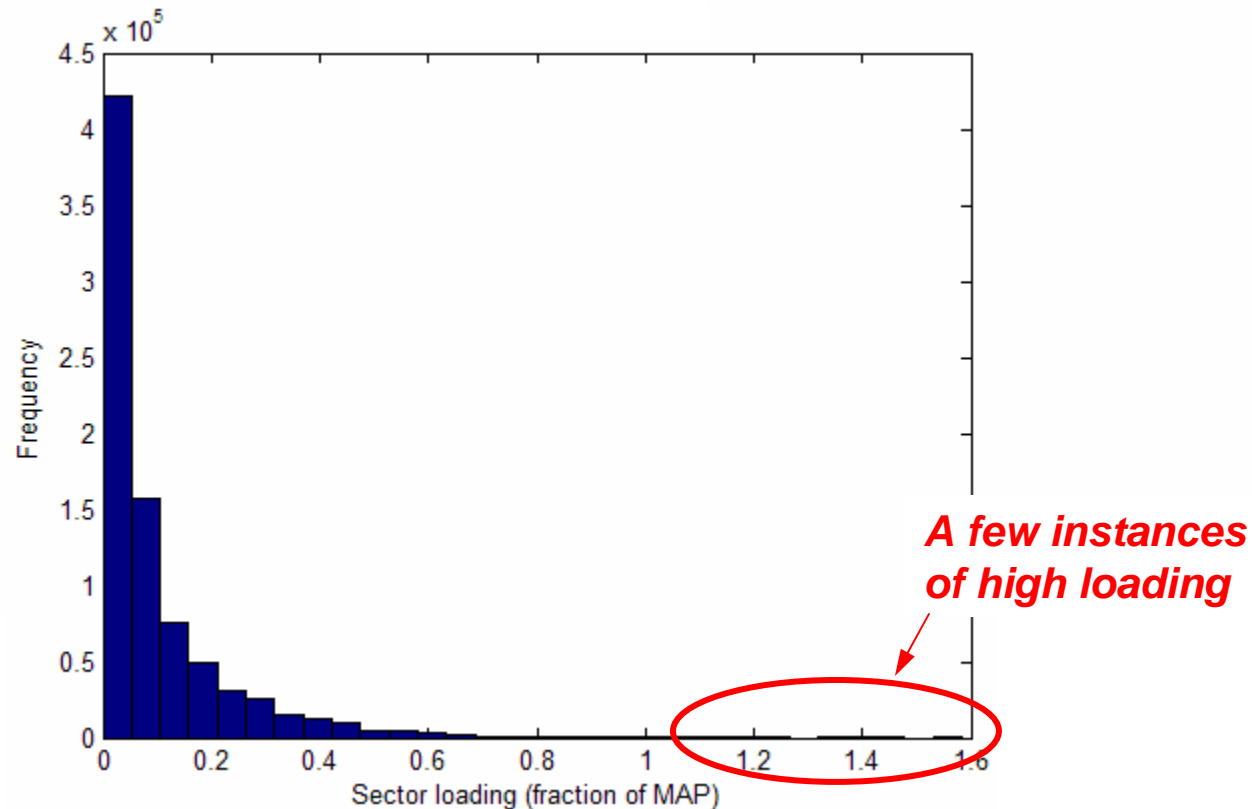


Radar Track Loading Versus Convection

- A first-order, empirical, measure of the impact of convection
- What level of convection is important?

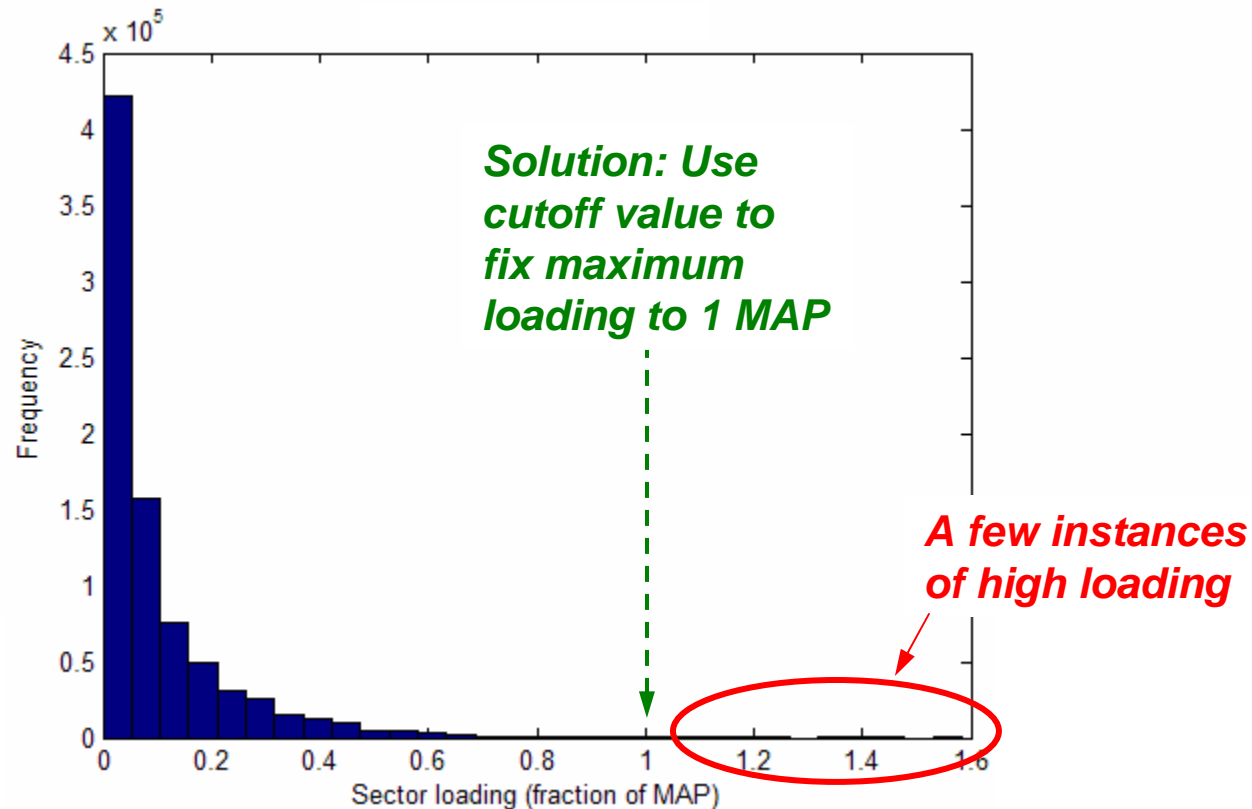
Empirical Impact of Convection on Capacity

- First problem: Is loading observation legitimate?
 - Clear weather loading distribution (fraction of MAP)

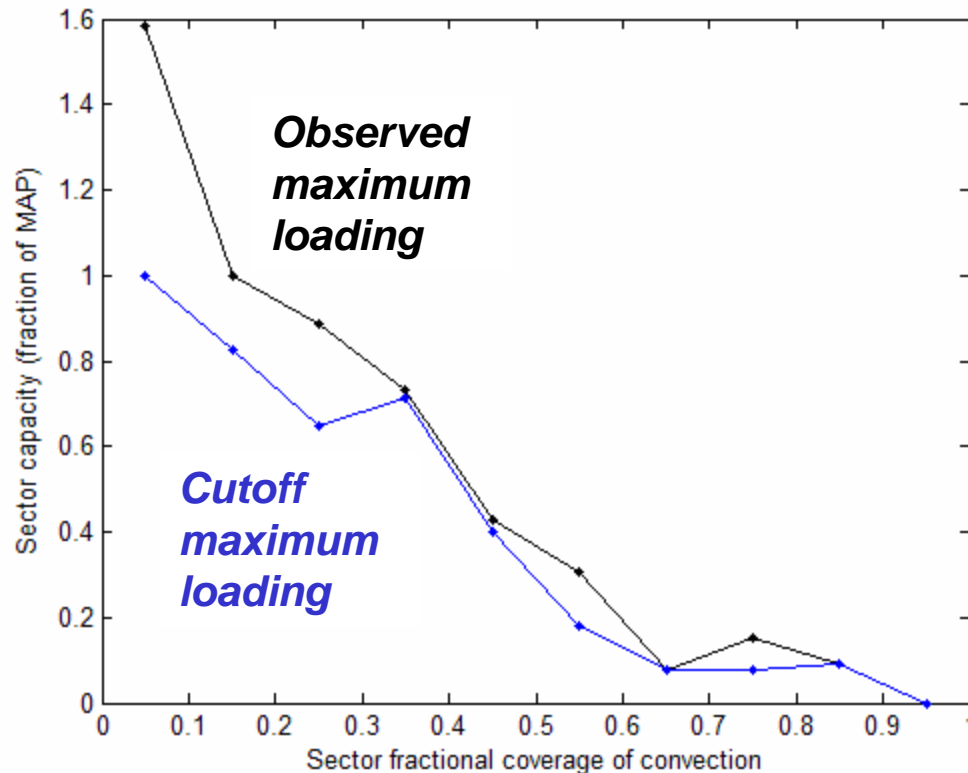


Empirical Impact of Convection on Capacity on Capacity

- First problem: Is loading observation legitimate?
 - Clear weather loading (fraction of MAP)



Estimate Maximum Loading

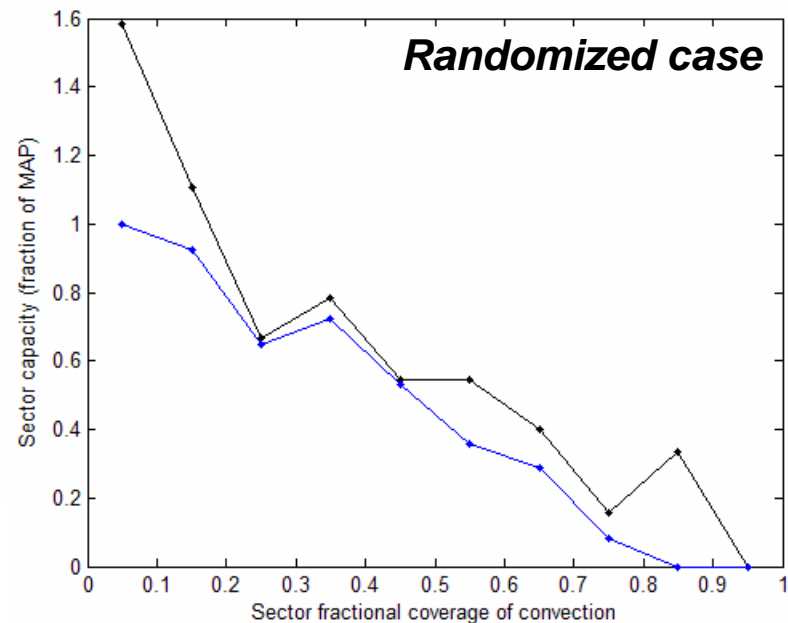
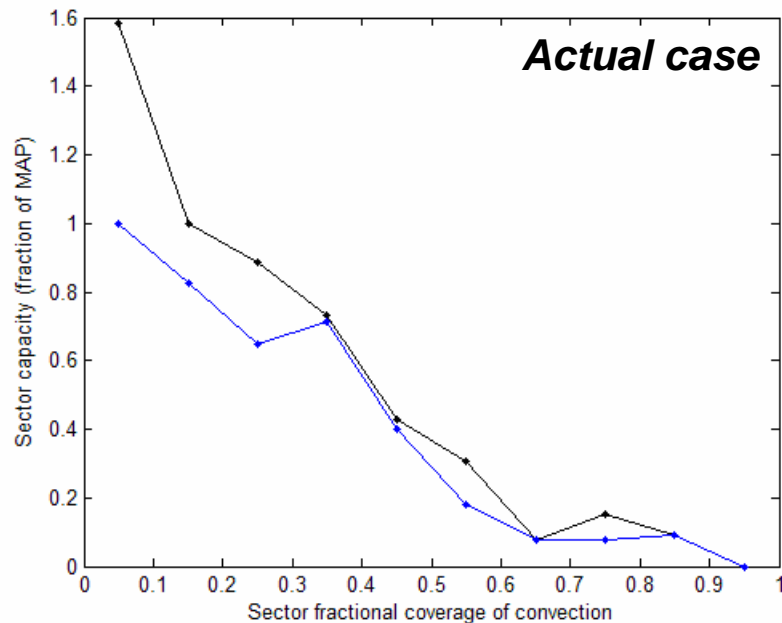


- Use cutoff maximum loading to evaluate impact of convection on sector capacity

Empirical Impact of Convection on Capacity

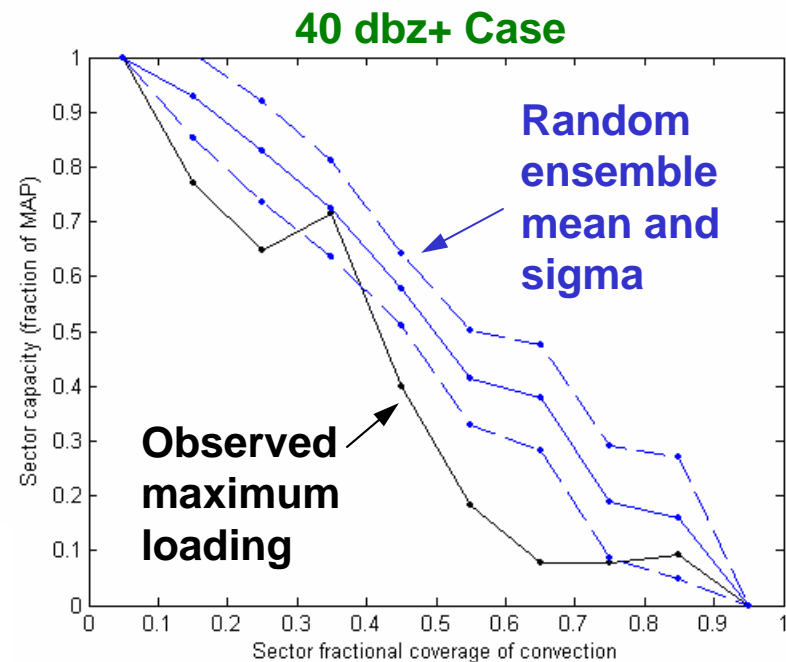
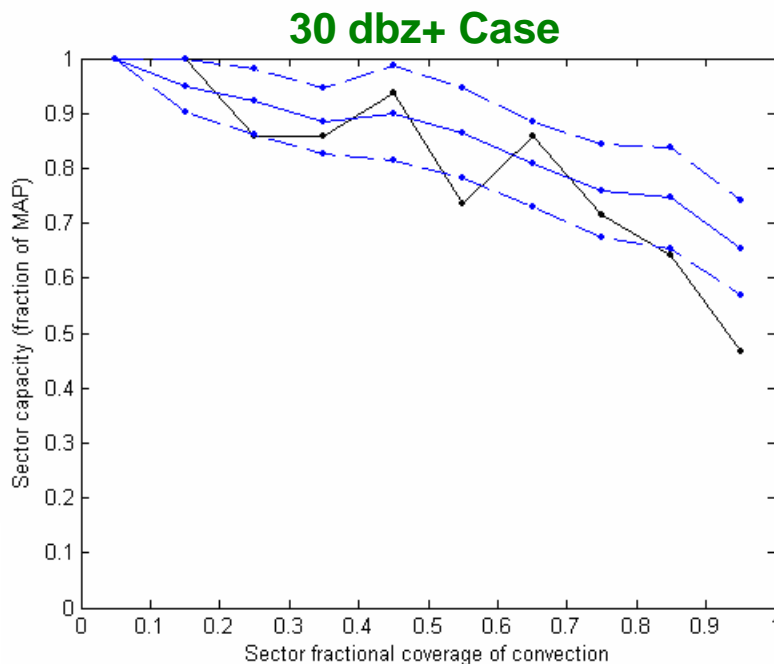
■ Second problem: Sampling bias

- Database is heavily skewed toward low traffic and clear weather
 - Heavy weather cases have fewer samples



Sampling Bias

- Compare to randomized ensemble
 - 30 dbz+ case statistically insignificant
 - 40 dbz+ case deviates from random ensemble
 - Parallels earlier weather avoidance research

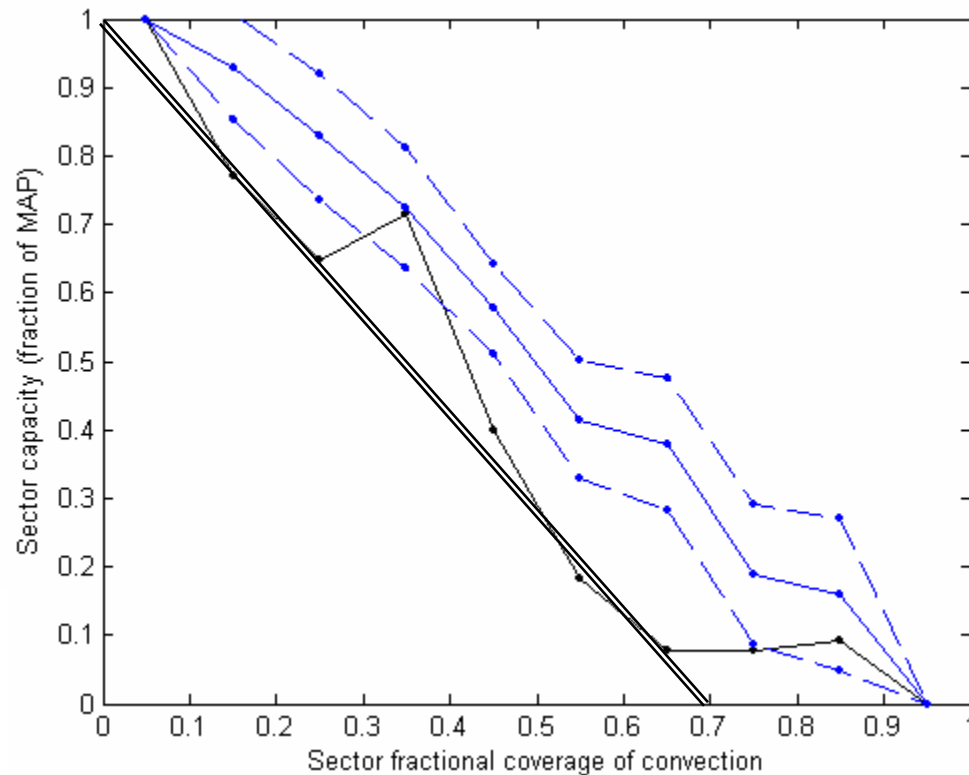


Empirical Impact of Convection on Capacity

- Third problem: What convection threshold to use?
 - Comparison with random ensemble suggests that 40 dbz is a good threshold to use
 - Loading attenuation is non random for convection of 40 dbz and greater

Empirical Impact of Convection on Capacity

- Results suggest linear attenuation model
 - Capacity reaches zero at 70% coverage of 40 dbz or greater convection



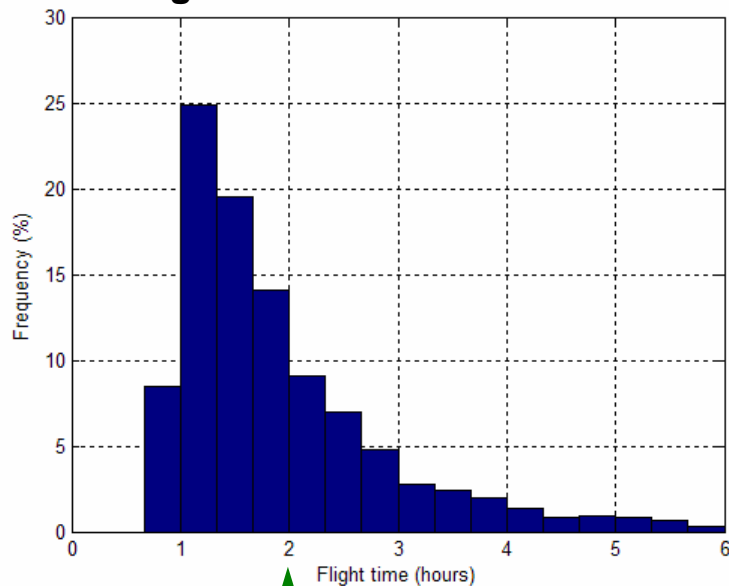


Convection Forecast Accuracy

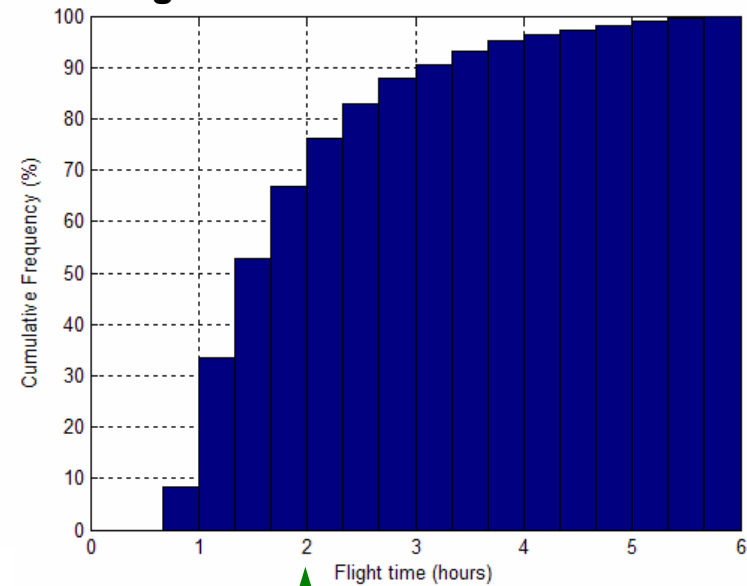
NAS Time Horizon

- Most flights in NAS two hours or less
 - In-flight rerouting more feasible for longer flights
 - So long-range forecasting less important

Flight time distribution in NAS

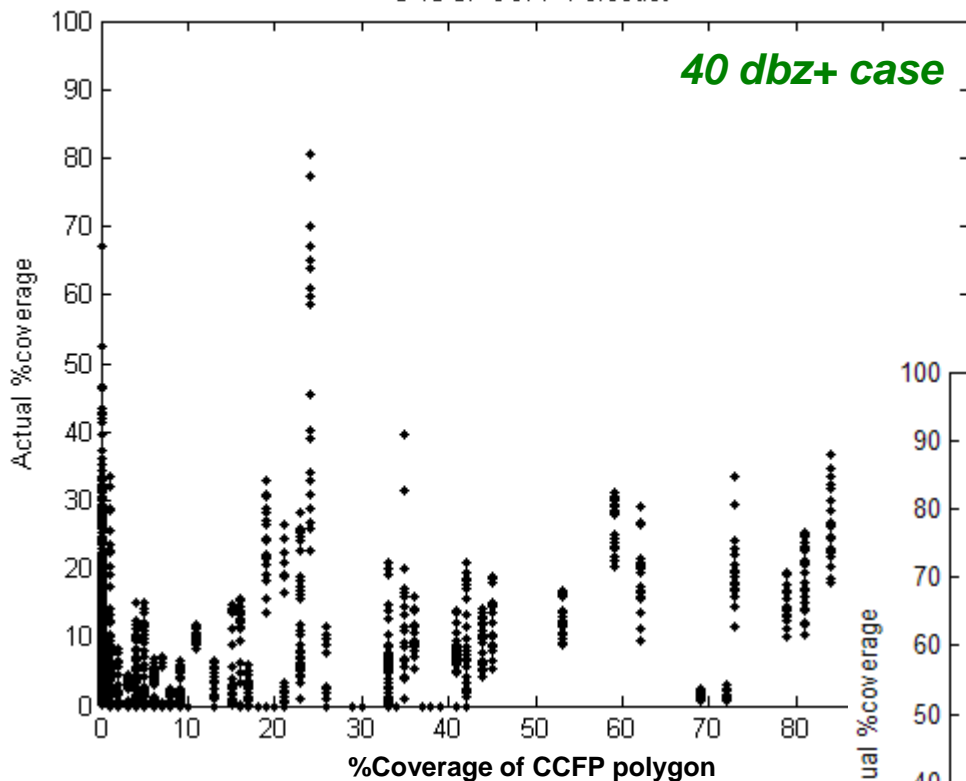


Flight time cumulative distribution

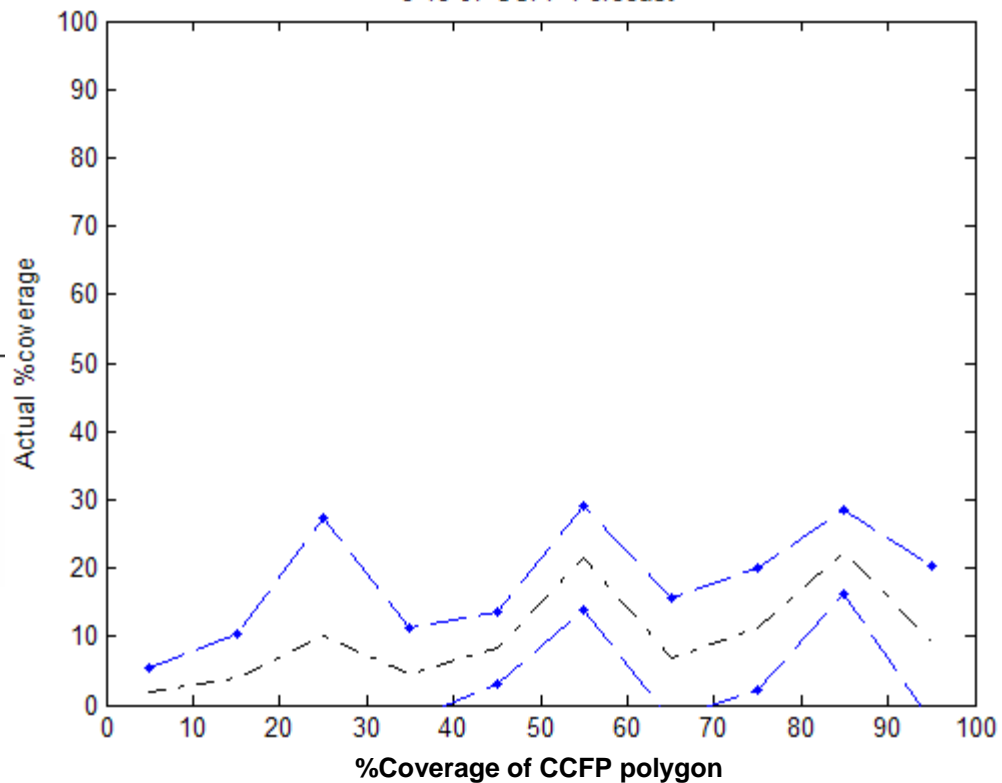


CCFP Convection Forecast

8-18-07 CCFP Forecast



8-18-07 CCFP Forecast

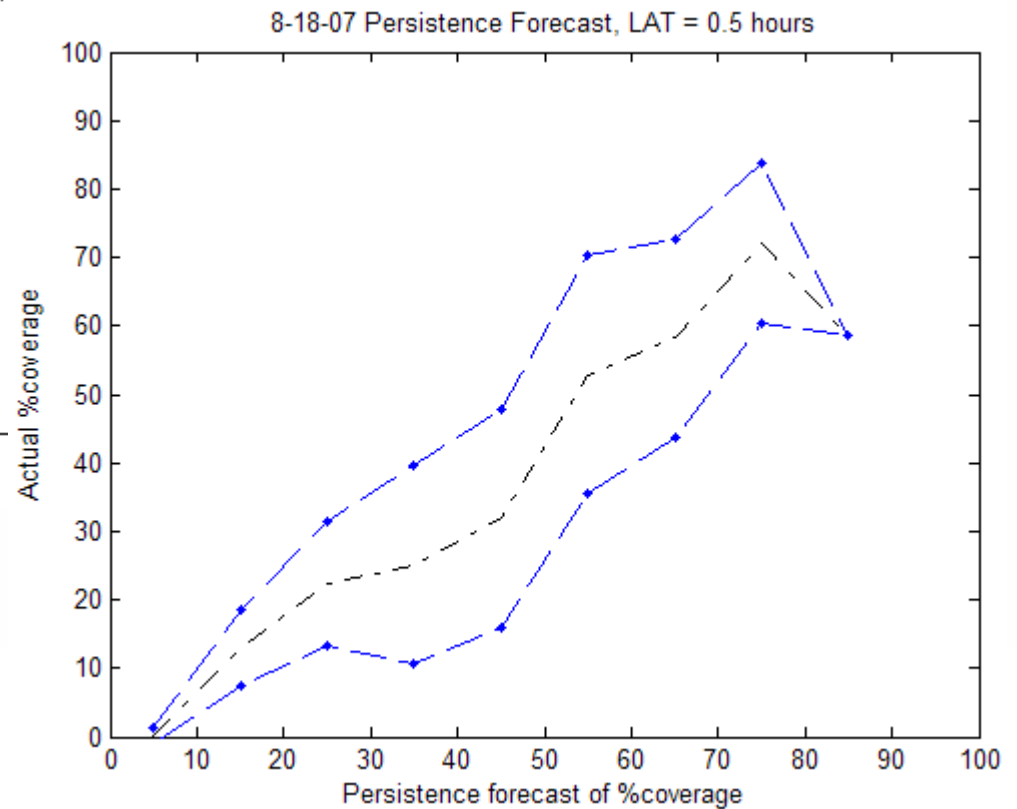
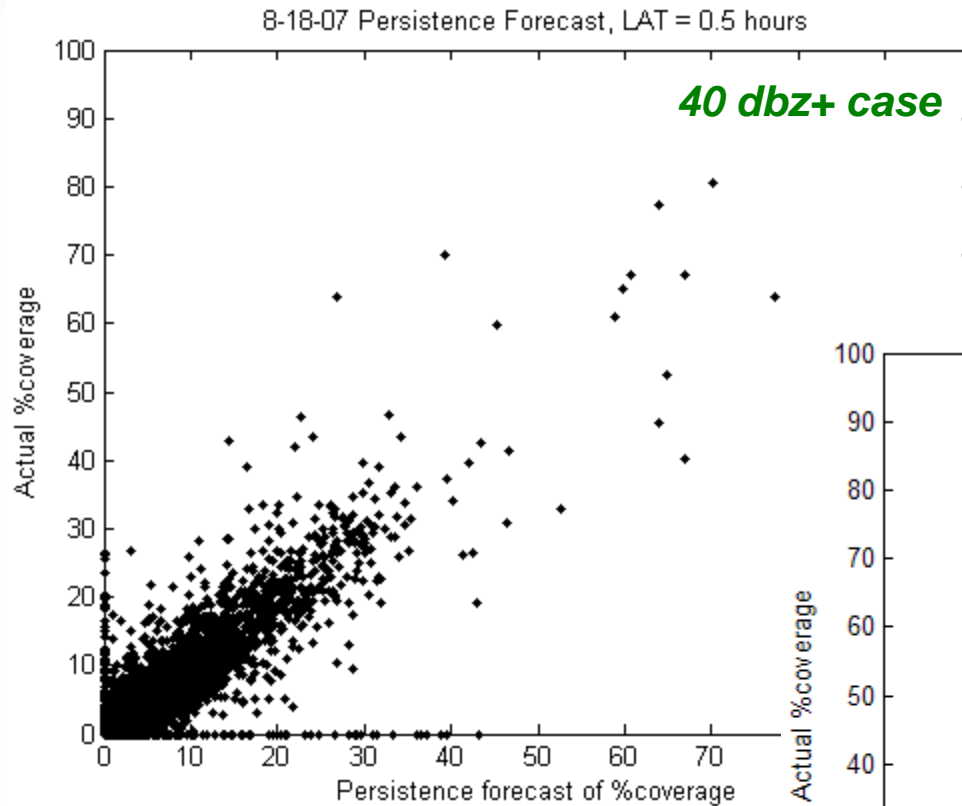


CCFP Convection Forecast

- CCFP weakly correlates with actual percent coverage

Persistence Fx Example

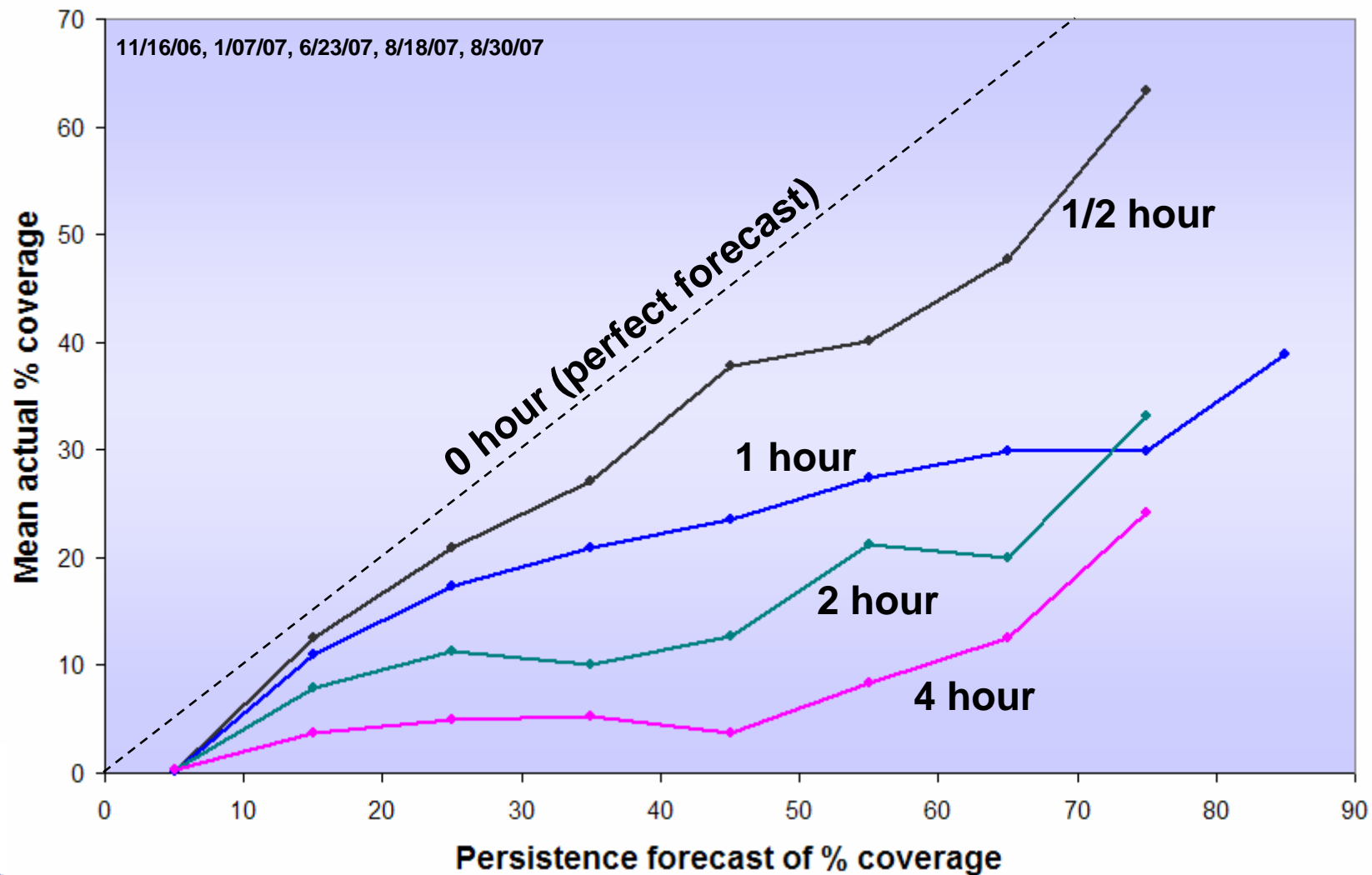
Actual Convection Versus Predicted



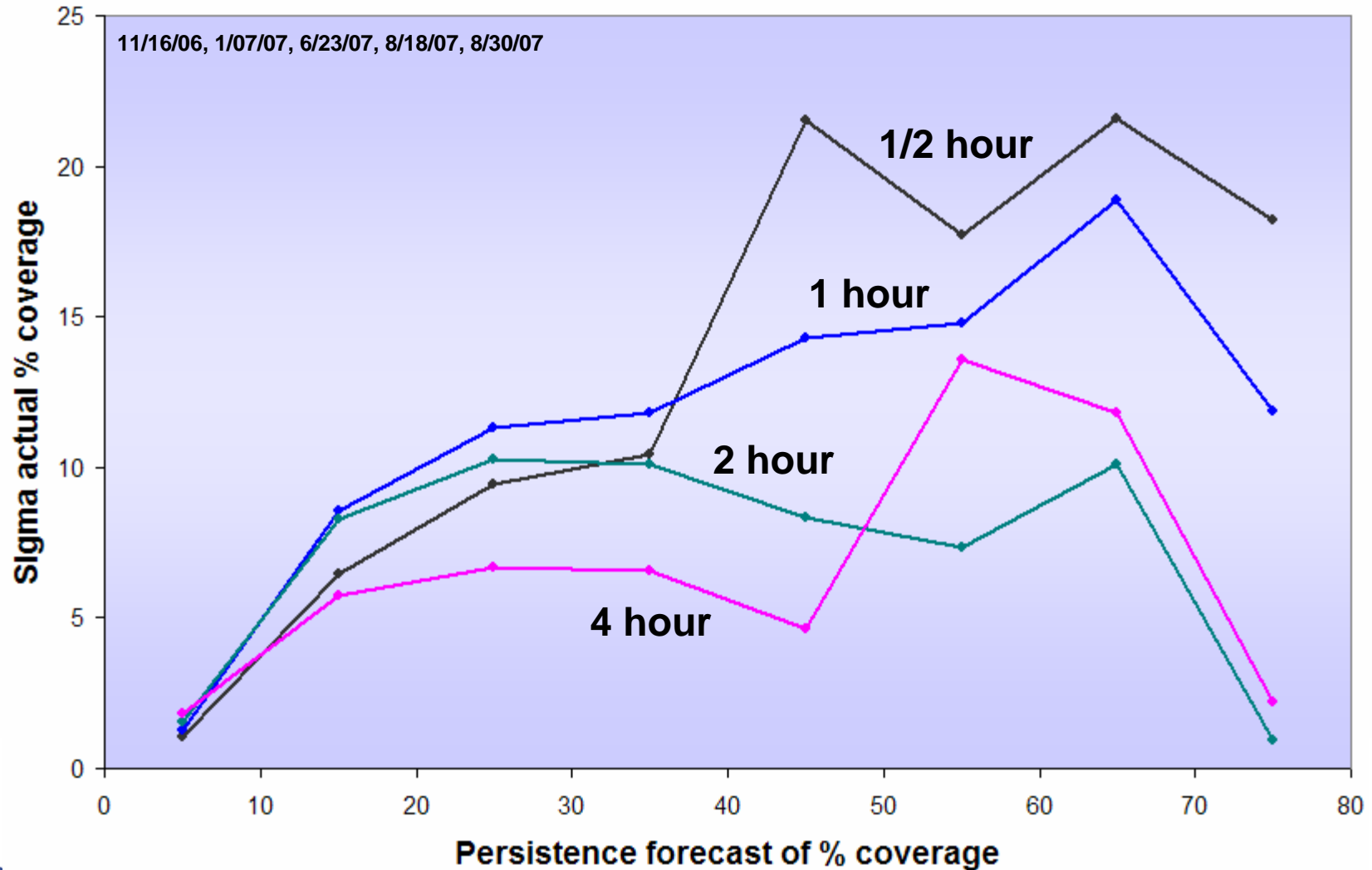
Persistence Forecast

- Average results over five heavy weather days
- Compute mean and standard deviation of actual convection as function of predicted

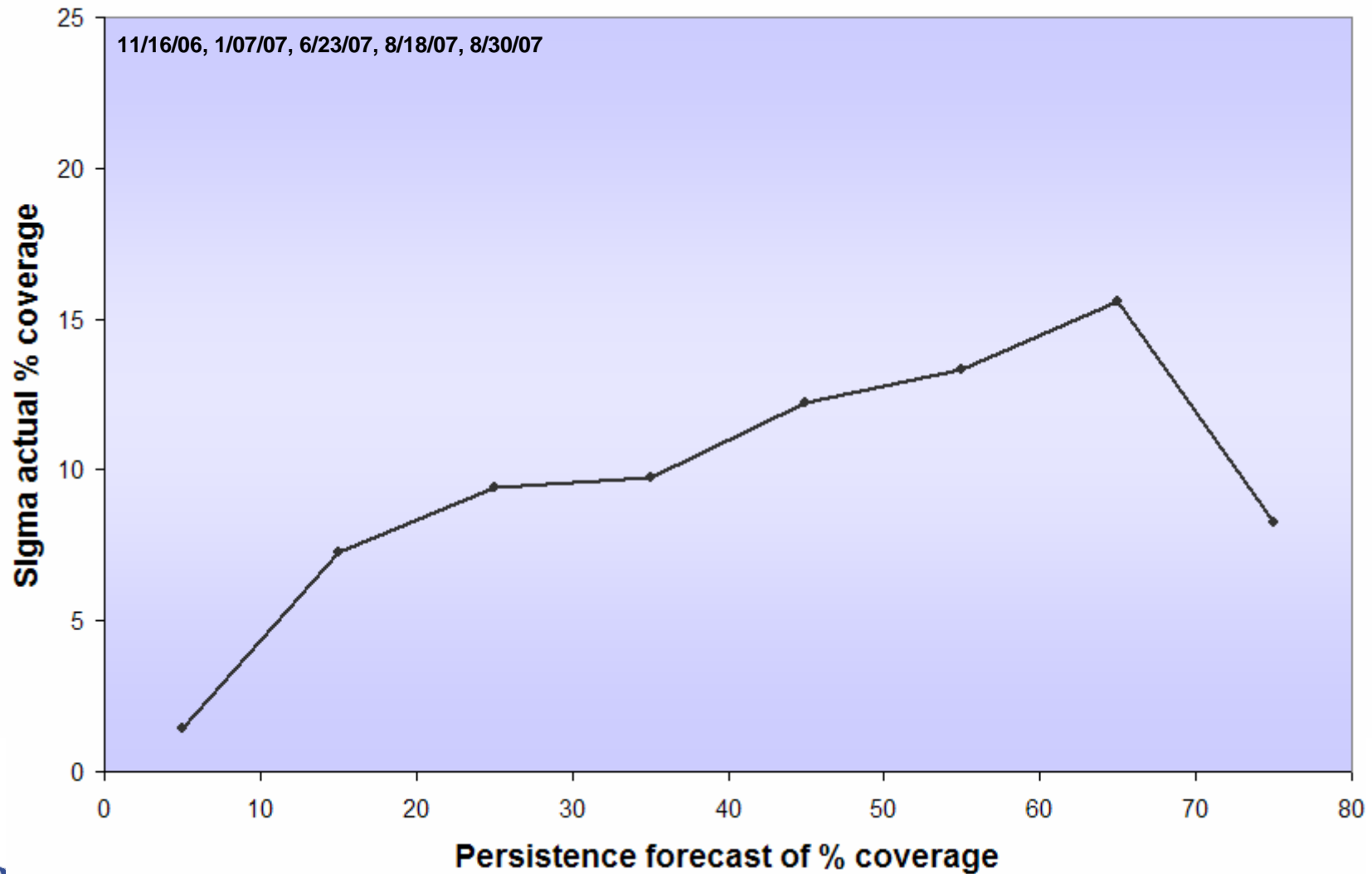
Mean of Persistence Fx's



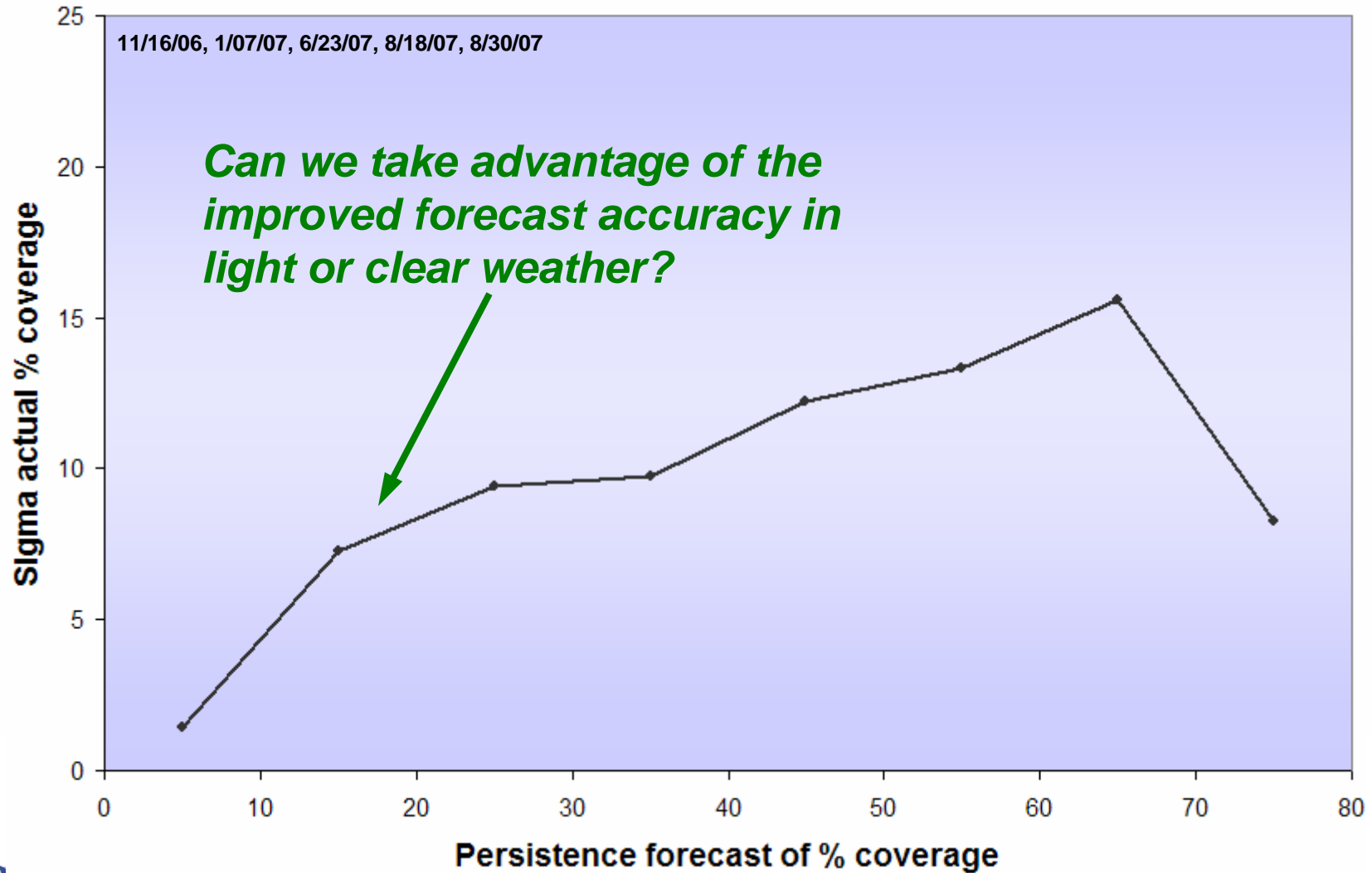
Sigma of Persistence Fx's



Averaged Sigma's Across LATs



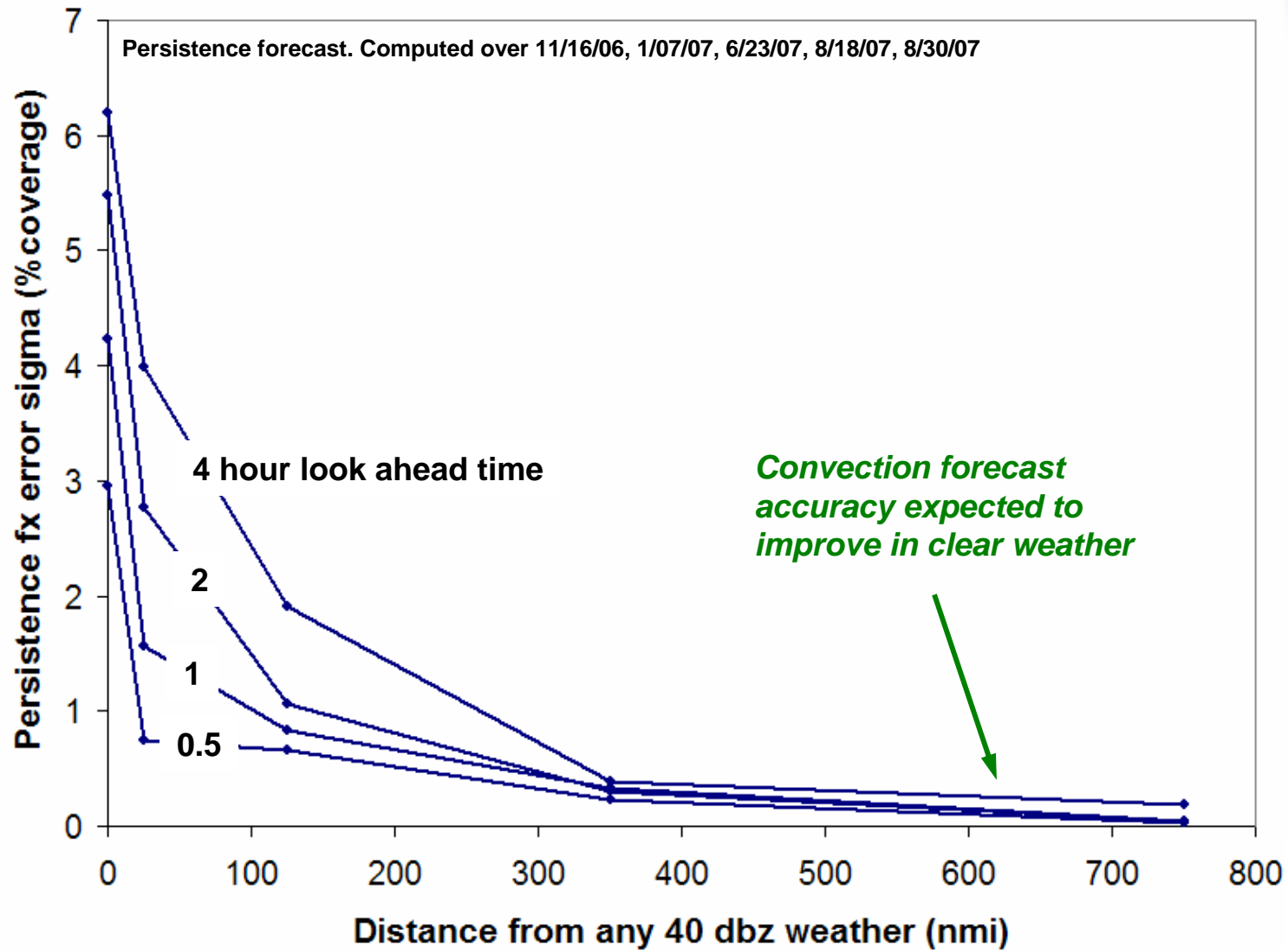
Averaged Sigma's Across LATs



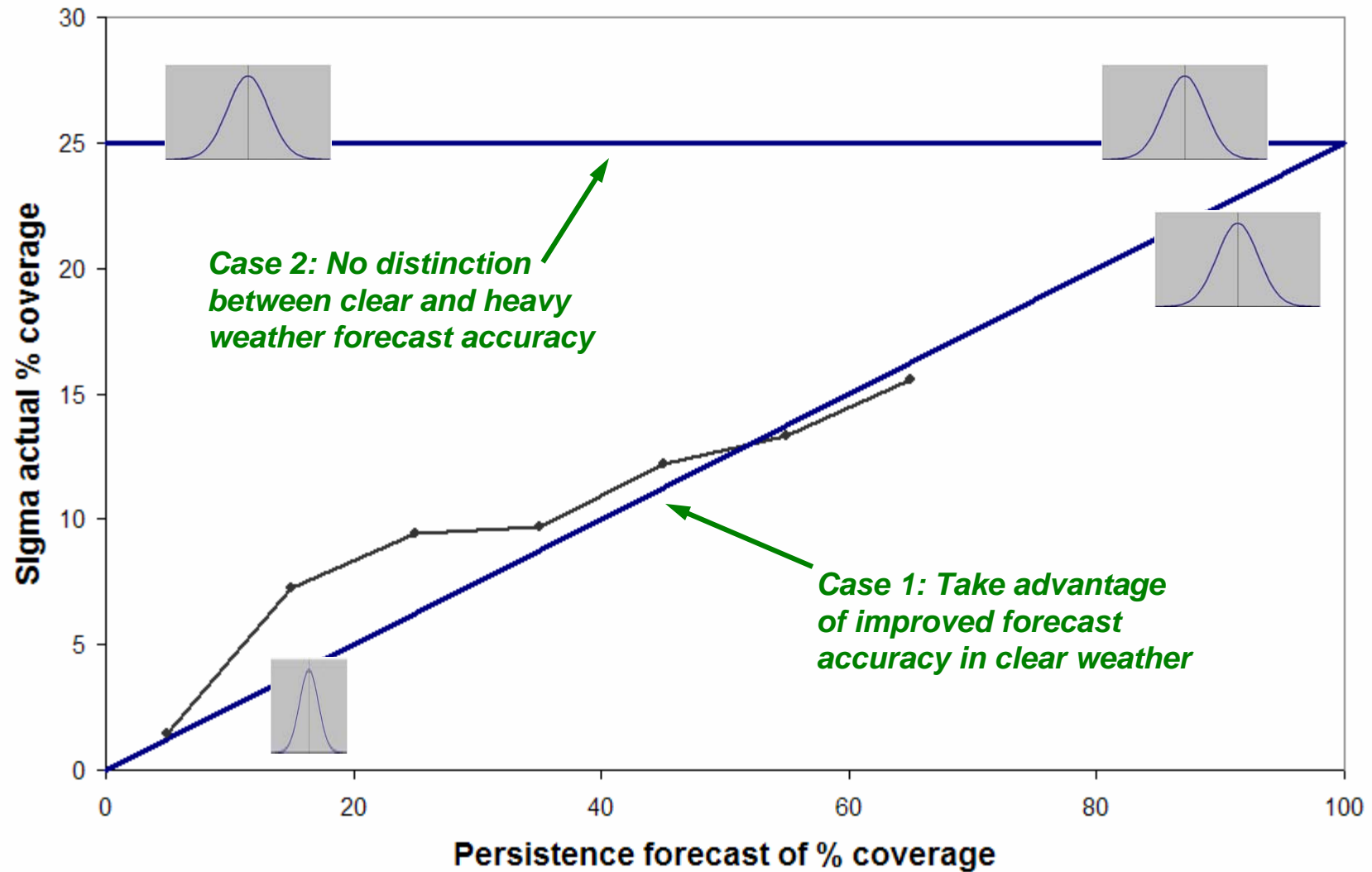


Benefit of Using Clear Weather Forecasts

Clear Weather Forecasting



Future Work: Evaluate Benefit of Accurate, Clear Weather Forecasts



Conclusions

■ Weather impact on airspace

- In heavy weather days, flight plans a good predictor of airspace loading in one hour sampling periods or greater
 - Flight plan amendments not a strong factor
- In regions of heavy weather the vast majority of weather avoidance is inherent in the flight plans
 - This strategic planning increases with convection coverage
- Weather avoidance in 30-40 dbz regions is statistically insignificant
- Weather avoidance in 40+ dbz regions is statistically significant

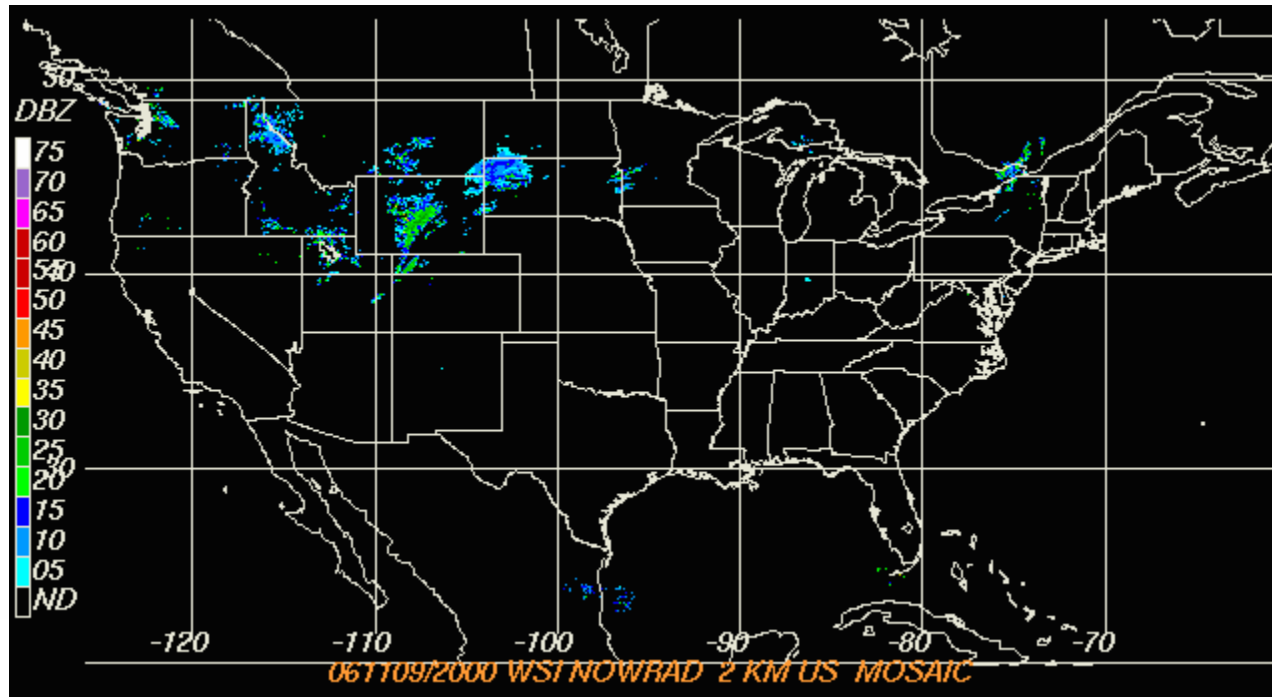
Conclusions (continued)

- **Convection forecast accuracy**
 - CCFP weakly correlates with actual %coverage
 - Persistence shows stronger correlation
 - Degrades with look ahead time
 - In all cases, accuracy improves in lighter weather
- **Benefit of using clear weather forecasts**
 - Need to evaluate benefit of using clear weather forecasts to reduce NAS delay in heavy weather days.

Backup

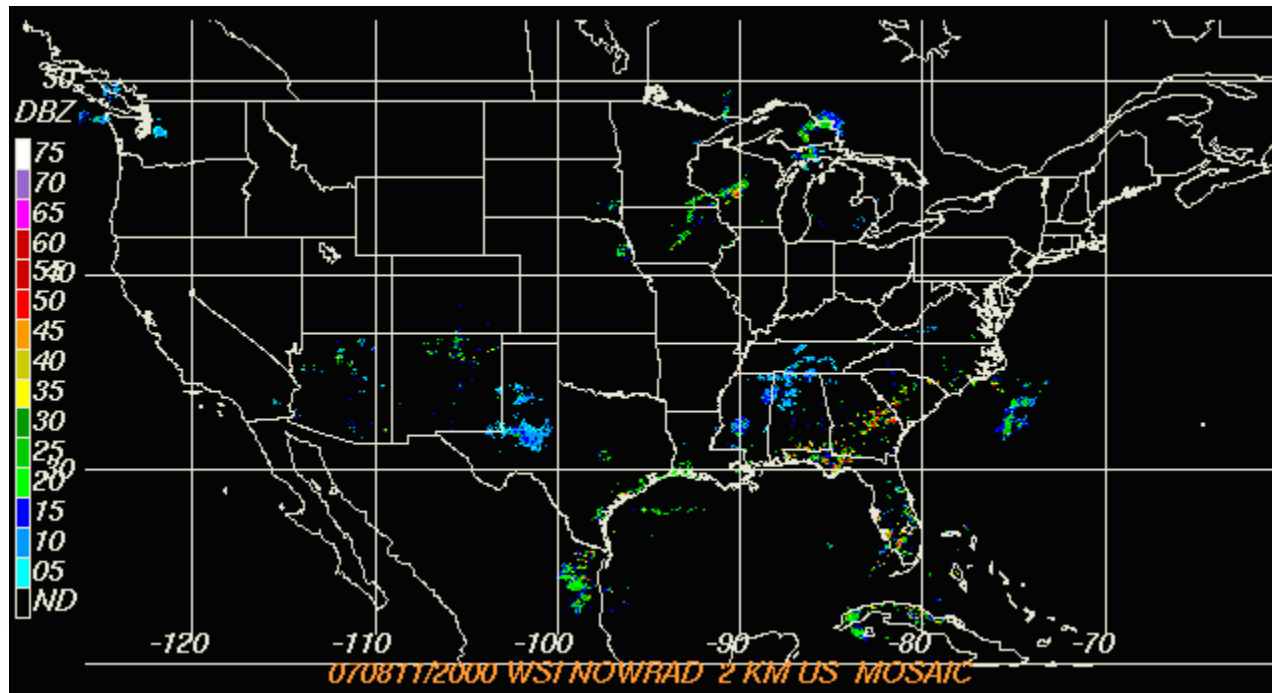
11/09/2006

- Very light weather
 - Control day for 11/16/06



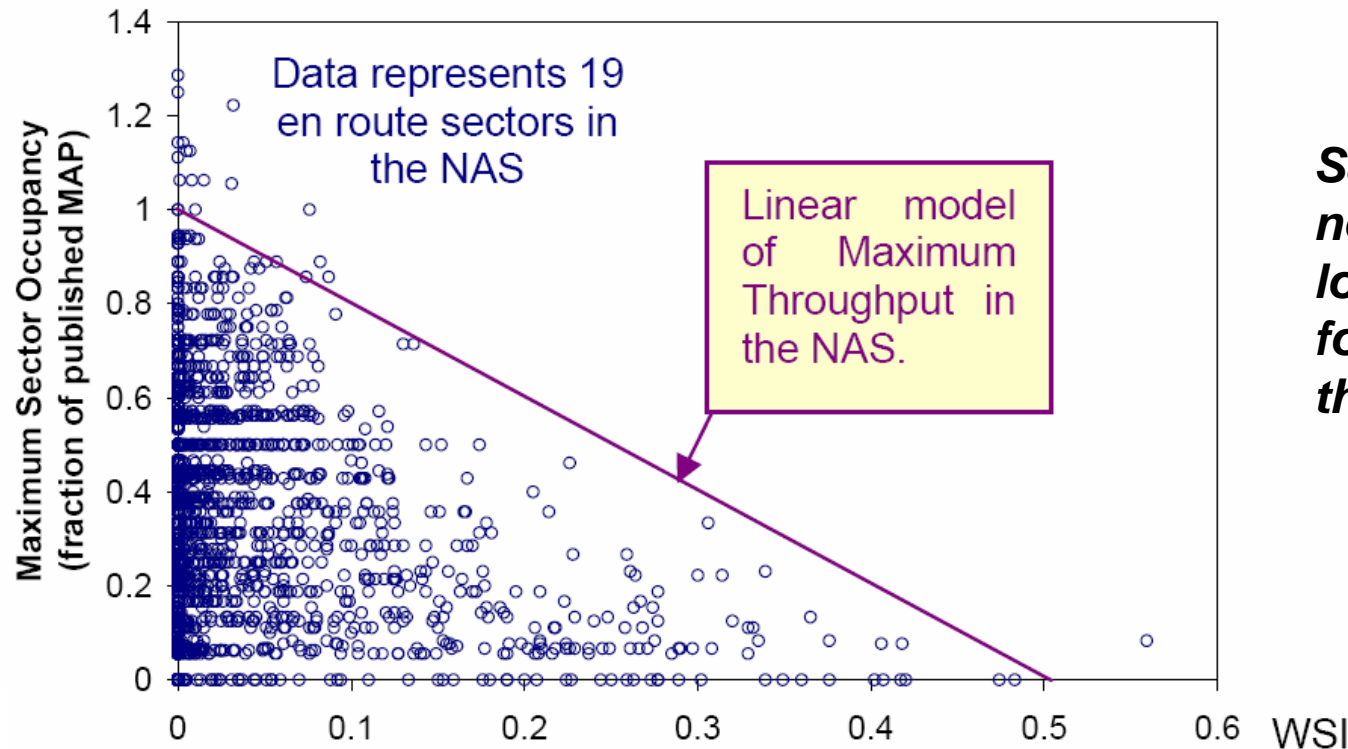
08/11/2007

- Very light weather
 - Control day for 08/18/07



Empirical Impact of Convection on Capacity

- Second problem: Sampling bias
 - Typical example from literature



Sampling bias, not capacity loss, accounts for majority of the trend

