Air Traffic Analysis, Inc

Weather Impacted Traffic Index (WITI)

Tools for Quantifying Actual and Forecast Weather Impact on Air Traffic

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April 2009

Background / Objectives

Why the FAA Initiated the WITI Program

FAA Needs/Objectives:

- Compare NAS performance over different time intervals with different weather and different traffic demand
- Validate performance improvements of capital investments
- Include ability to "drill down" to regional & local areas/sites for analysis consistent with NAS methodology
- Engage FAA customers in dialogue focused on overall system performance to gain consensus on "good" vs. "bad" days, weeks, seasons

Strategy:

- Develop a suite of measures that reflect macro-level:
  - Weather [en route & terminal, including convective and airport specific]
  - Traffic demand
  - Weather forecast accuracy
  - Operational response – impacts imposed on FAA customers in response to the above elements [service expectations such as delay, predictability, etc]

Measuring Weather / Traffic Impact

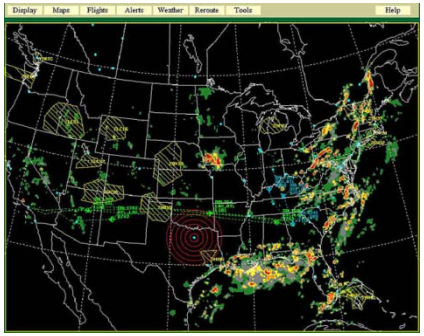
"The Hand the NAS Is Dealt Every Day"

Local Airport Weather

En-route Convective Weather

The Weather Index expresses severity of weather impact on the NAS, weighted by air transportation service demands

Traffic Demand



National Airspace System (NAS)

Capacity, Safety constraints

ATM, Airline Response Strategies

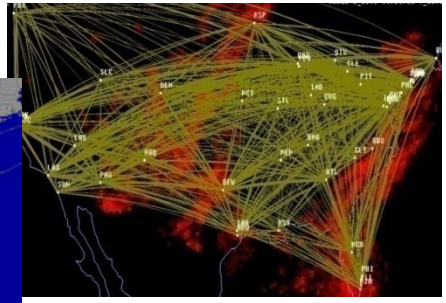
Operational Outcomes

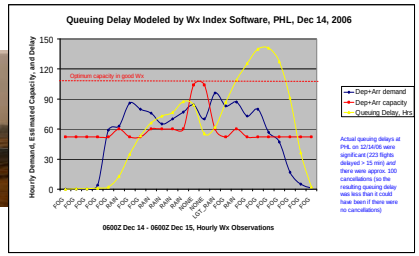
Weather Impacted Traffic Index (WITI)

Weather Weighted by Traffic

WITI is a weighted sum of three components:

- **<u>En-route Component</u>** reflecting impact of convective weather on routes to/from major airports
- **<u>Terminal Component</u>**
  - **<u>Linear part:</u>** capacity degradation due to surface weather impact, proportional to number of ops
  - **<u>Non-linear (Queuing Delay) part</u>** reflecting excess traffic demand vs. capacity



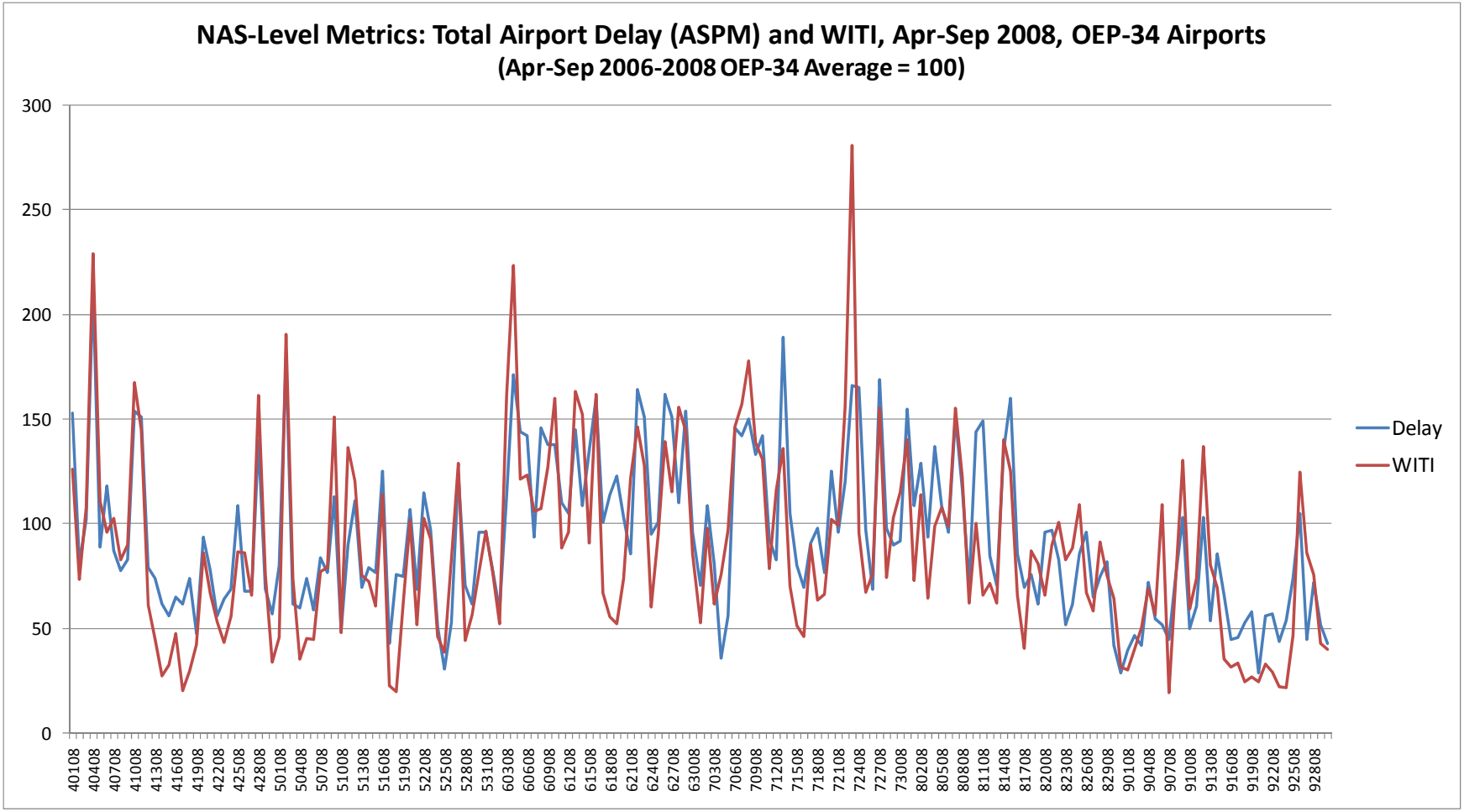


Used by the FAA on a regular basis:

- Measure system performance in an objective manner
- Compare different seasons' Wx/traffic impact with outcomes (e.g. delays)

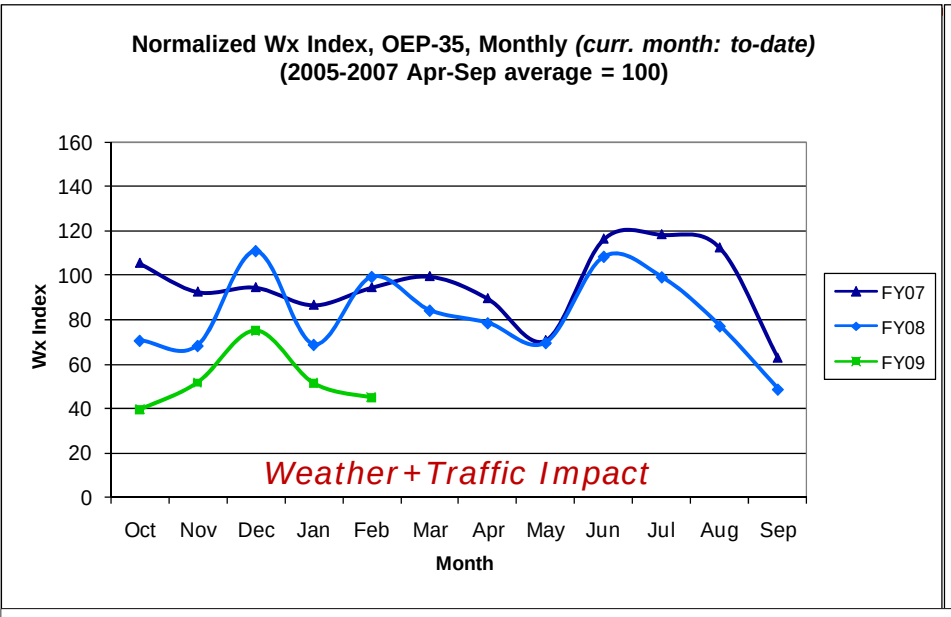
2008 NAS Wx Impact/Response Metrics

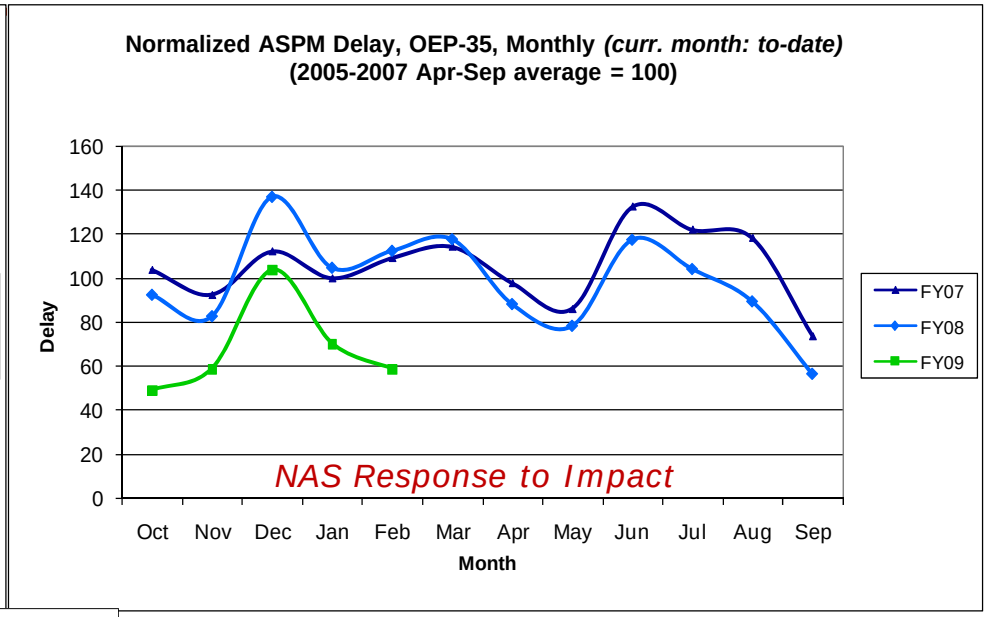
WITI is a good proxy – and "ruler" – for Delay

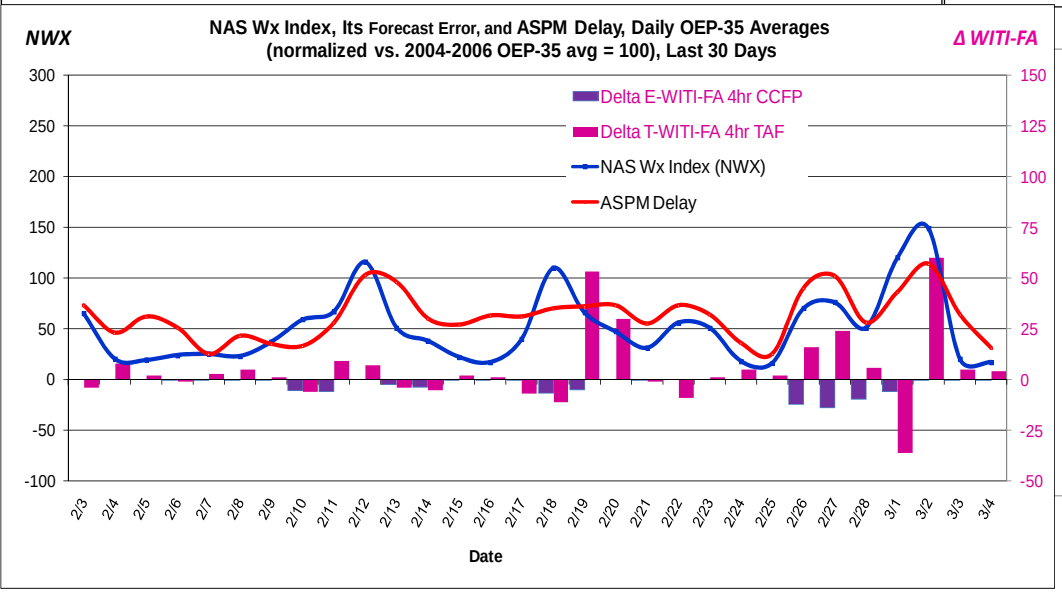


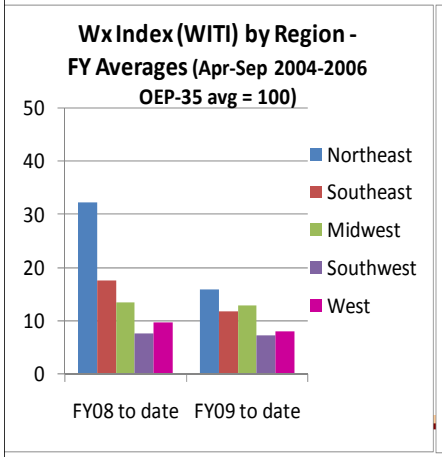
NAS Performance: WITI vs. Delays

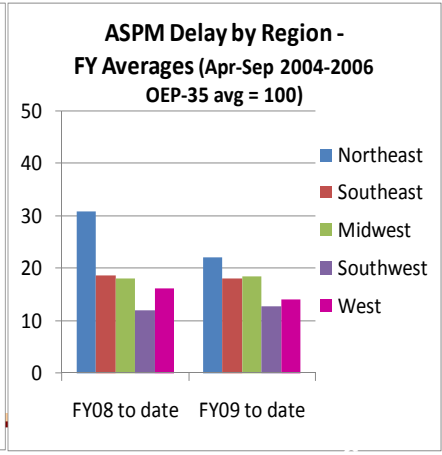
Sample from a Weekly Report for FAA – Mar 2009











NWS Involvement: WITI-FA

Quantifying Impact of Forecast Wx on Air Traffic

NWS Objectives

- Develop a better understanding of how weather forecast impacts air traffic
- Have a better platform for dialogue with the FAA
  - When the forecast contributes to avoidable delay
  - When the forecast accuracy may have been brought up as a contributing factor - but in fact wasn't
  - "Critical points" (airports, Wx factors, geography)
- In collaboration with the FAA, evaluate / compare different convective forecast products from *operational impact* perspective
  - How this is different from traditional verification methods

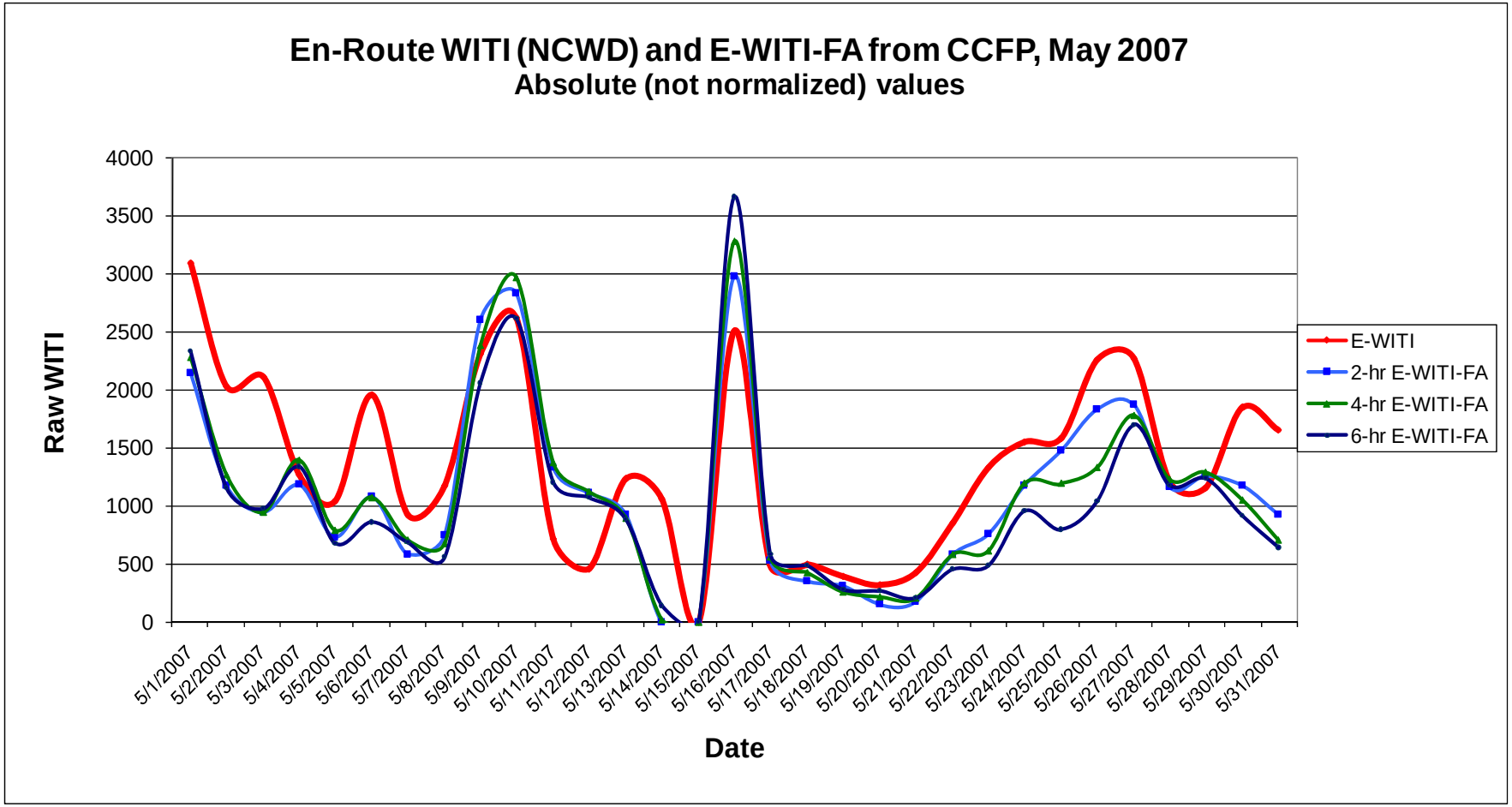
WITI-FA ("Forecast Accuracy")

Like WITI but Uses Forecast not Actual Wx

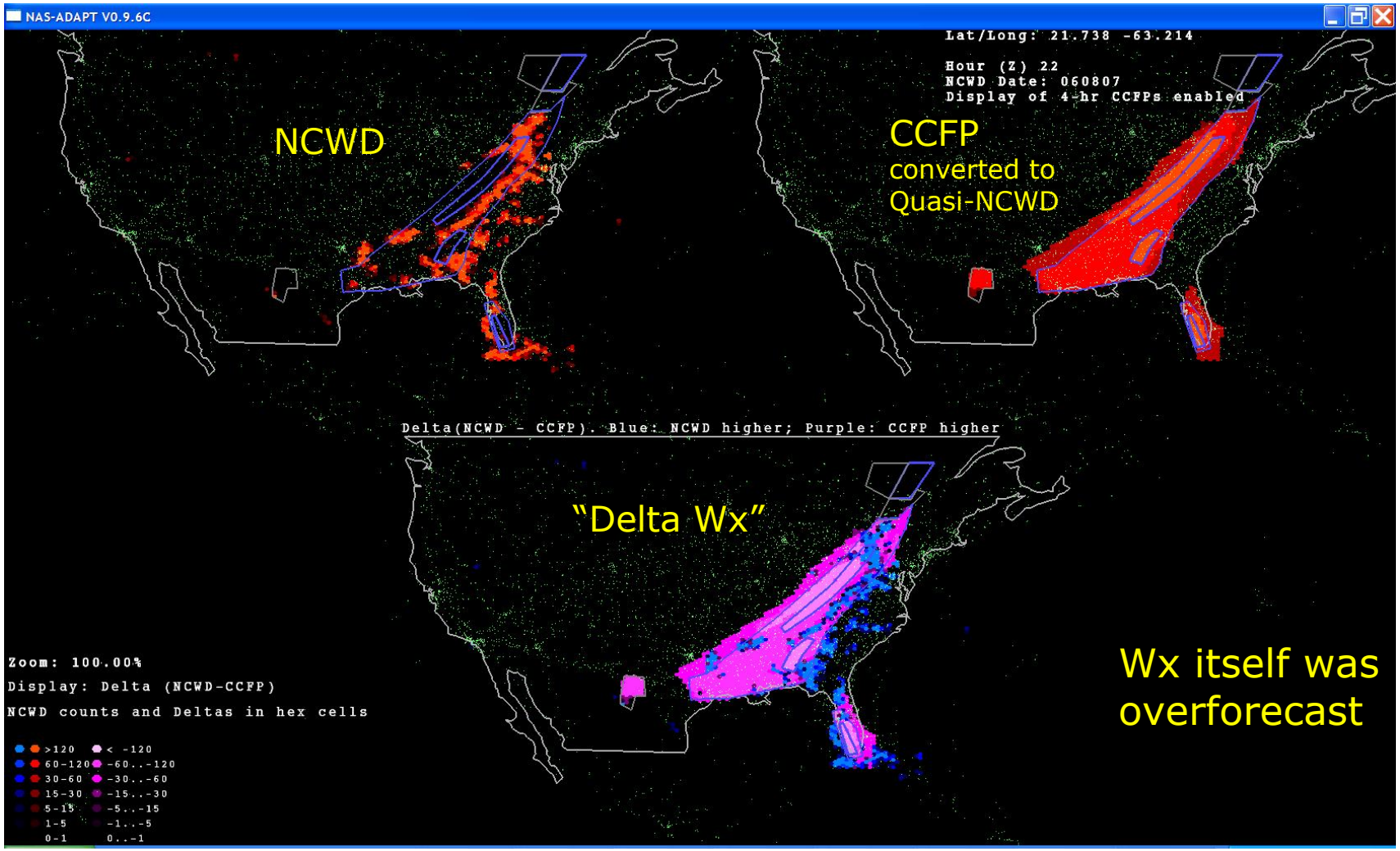
- En-route weather
  - E-WITI uses actual convective Wx data, e.g. NCWD
  - E-WITI-FA uses convective forecast data, e.g. CCFP
  - Both use the same scheduled traffic on major flows
  - Convective forecast data is converted to "quasi-NCWD" format (probability or intensity of Wx converted to % max NCWD score for hexagonal grid cells)
- Terminal weather
  - T-WITI uses actual surface Wx data (METARs)
  - T-WITI-FA uses forecast data (TAFs)
  - Both use the same scheduled traffic at major airports
  - TAF converted to quasi-METAR form, "rolling look-ahead" stream

En-route Wx: E-WITI vs. E-WITI-FA

Converting an Area-Based Probabilistic Forecast (CCFP) into Gridded Deterministic Format (quasi-NCWD)

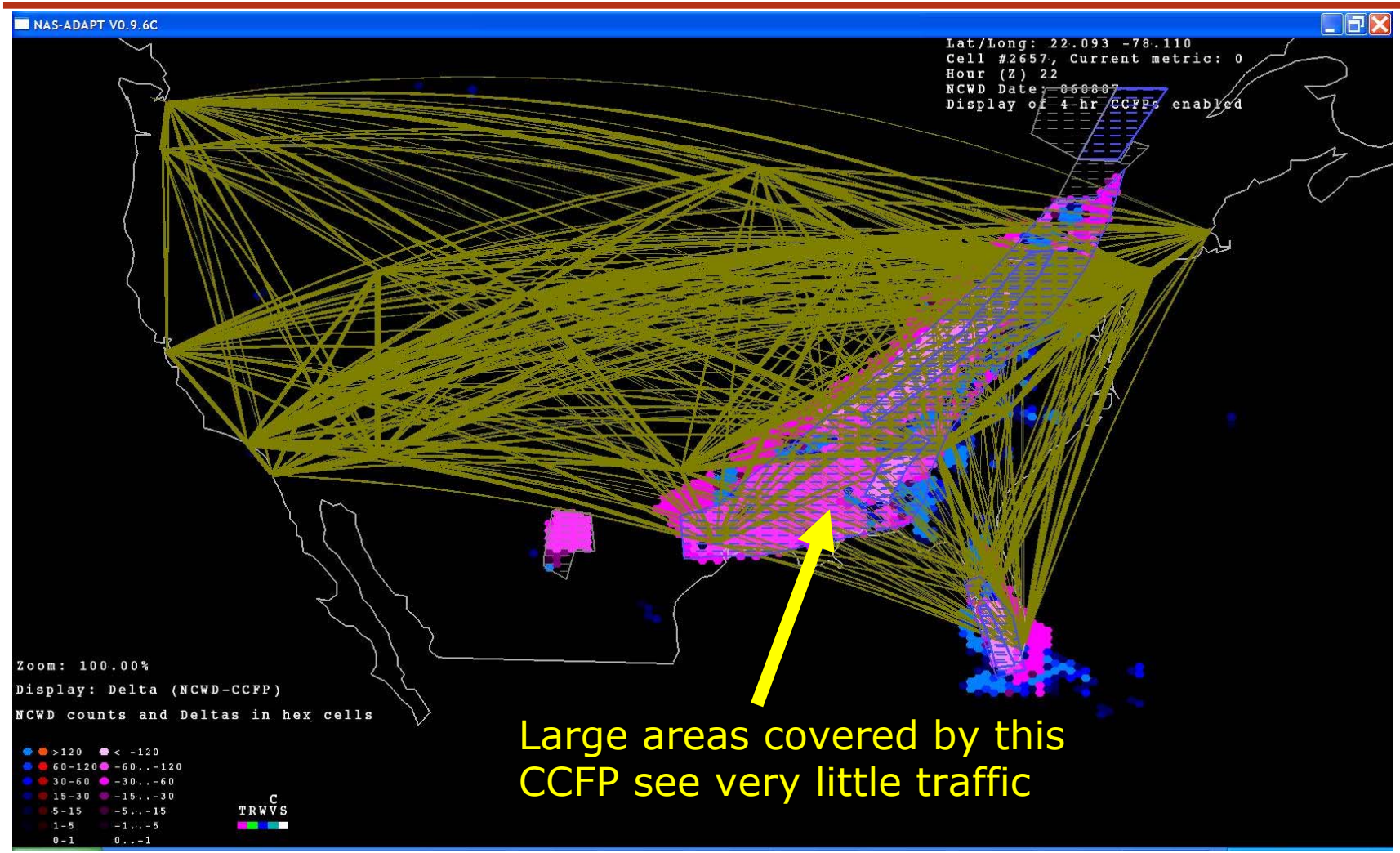


"Delta Weather" vs. "Delta Weather *Impact*" (Delta WITI)



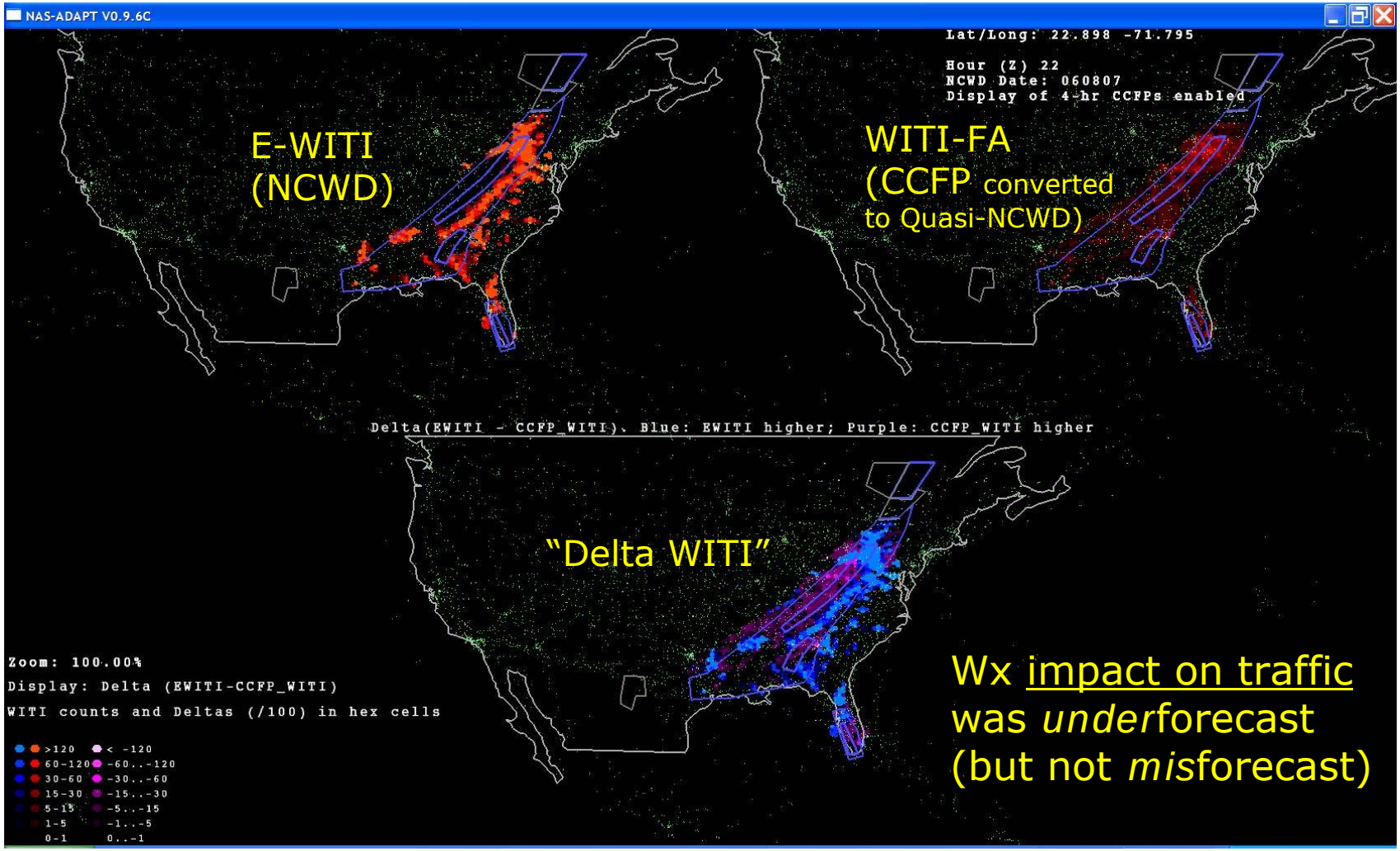
Wx itself was overforecast

"Delta Weather" vs. "Delta Weather *Impact*" (Delta WITI)



Large areas covered by this CCFP see very little traffic

"Delta Weather" vs. "Delta Weather *Impact*" (Delta WITI)



Wx <u>impact on traffic</u> was *under*forecast (but not *mis*forecast)

Terminal WITI Based on Forecast Wx
T-WITI-FA

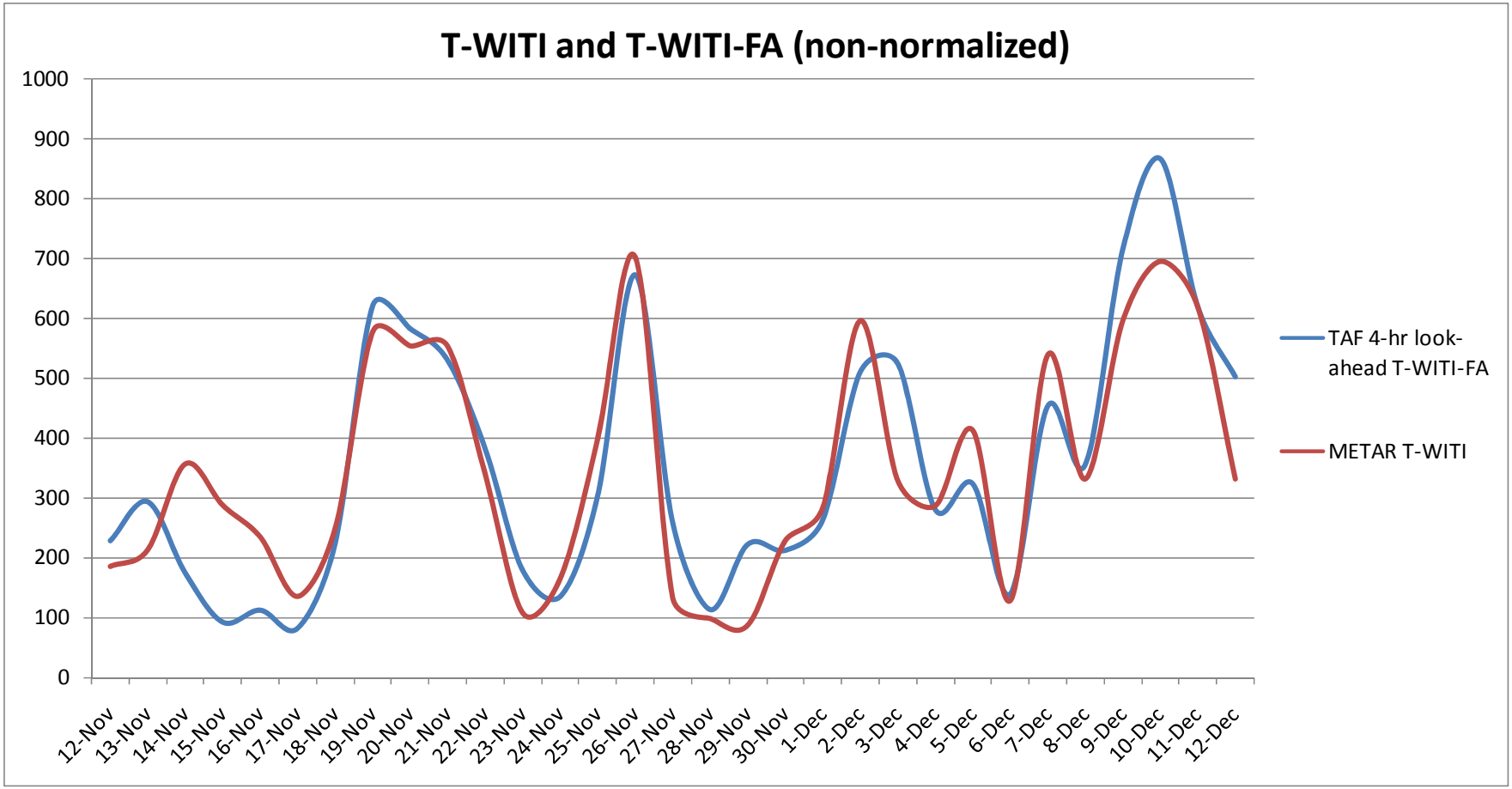
- Apply the methodology developed for en-route convective weather (E-WITI-FA) to terminal weather
- First, compute T-WITI using METARs
- Then, compute T-WITI-FA using TAFs for same airports

```
FTUS43 KLOT 302300
KORD 010423Z 010424 05012KT P6SM BKN250
    FM0900 12007KT P6SM BKN250
    FM1400 24012KT P6SM VCTS BKN035CB
    FM1800 30012G18KT P6SM BKN040
    FM2200 01012KT P6SM FEW050=
```

metar	KORD	2006	4	9	1456	null	999	10	10	7	-3	null	-2	8	49	-1	4	30.29	null
metar	KORD	2006	4	9	1556	null	999	10	10	9	-3	null	0	9	43	250	5	30.29	BR
metar	KORD	2006	4	9	1656	null	250	10	10	11	-3	null	1	10	38	120	5	30.27	RABR
metar	KORD	2006	4	9	1756	null	250	10	10	11	-3	null	1	10	38	0	0	30.24	null
metar_sat	KORD	2006	4	9	1756	null	250	10	10	11	-3	null	1	10	38	0	0	30.24	null

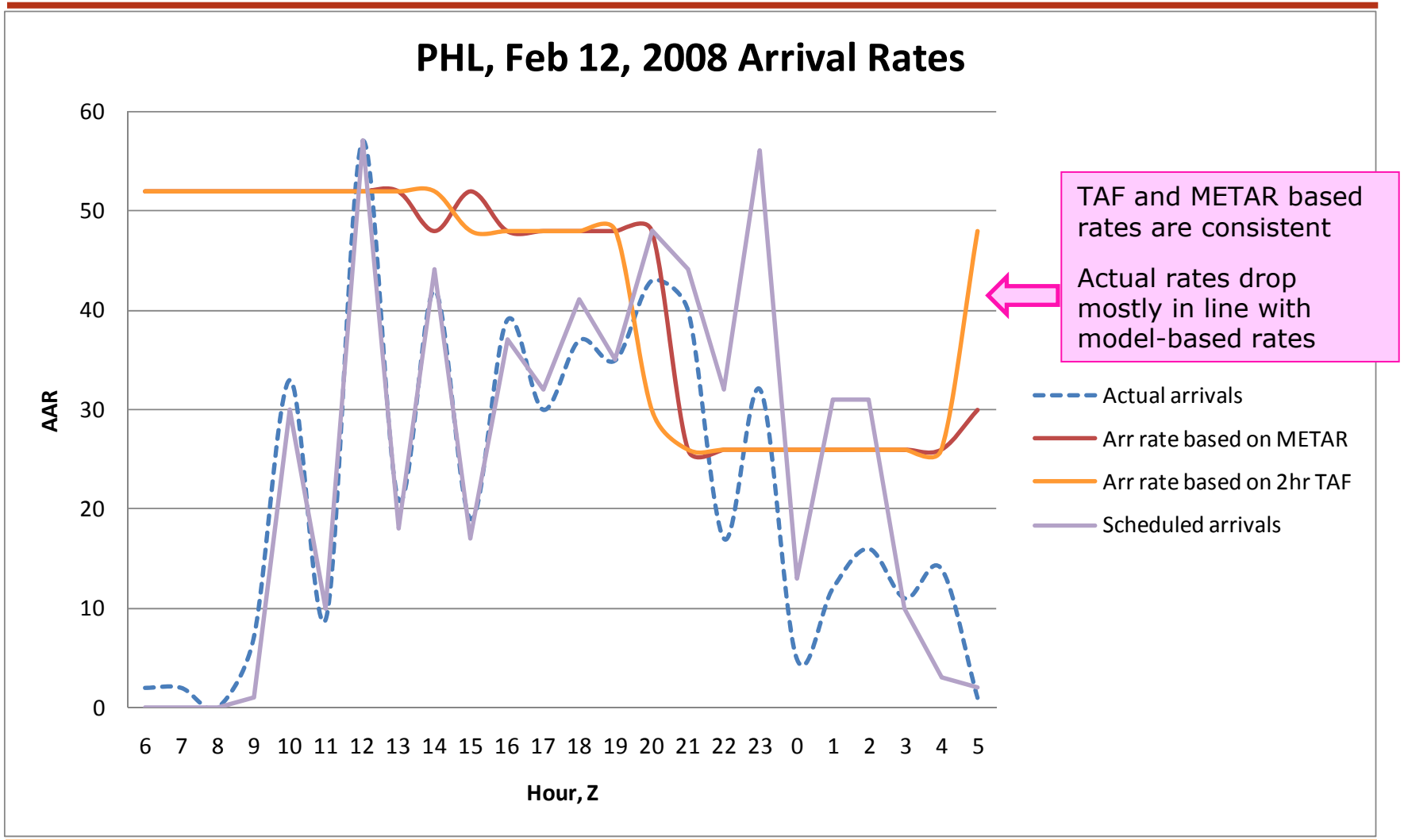
30-Day T-WITI vs. T-WITI-FA (Nov-Dec 2007)

Terminal Wx impact weighted by Traffic Volume



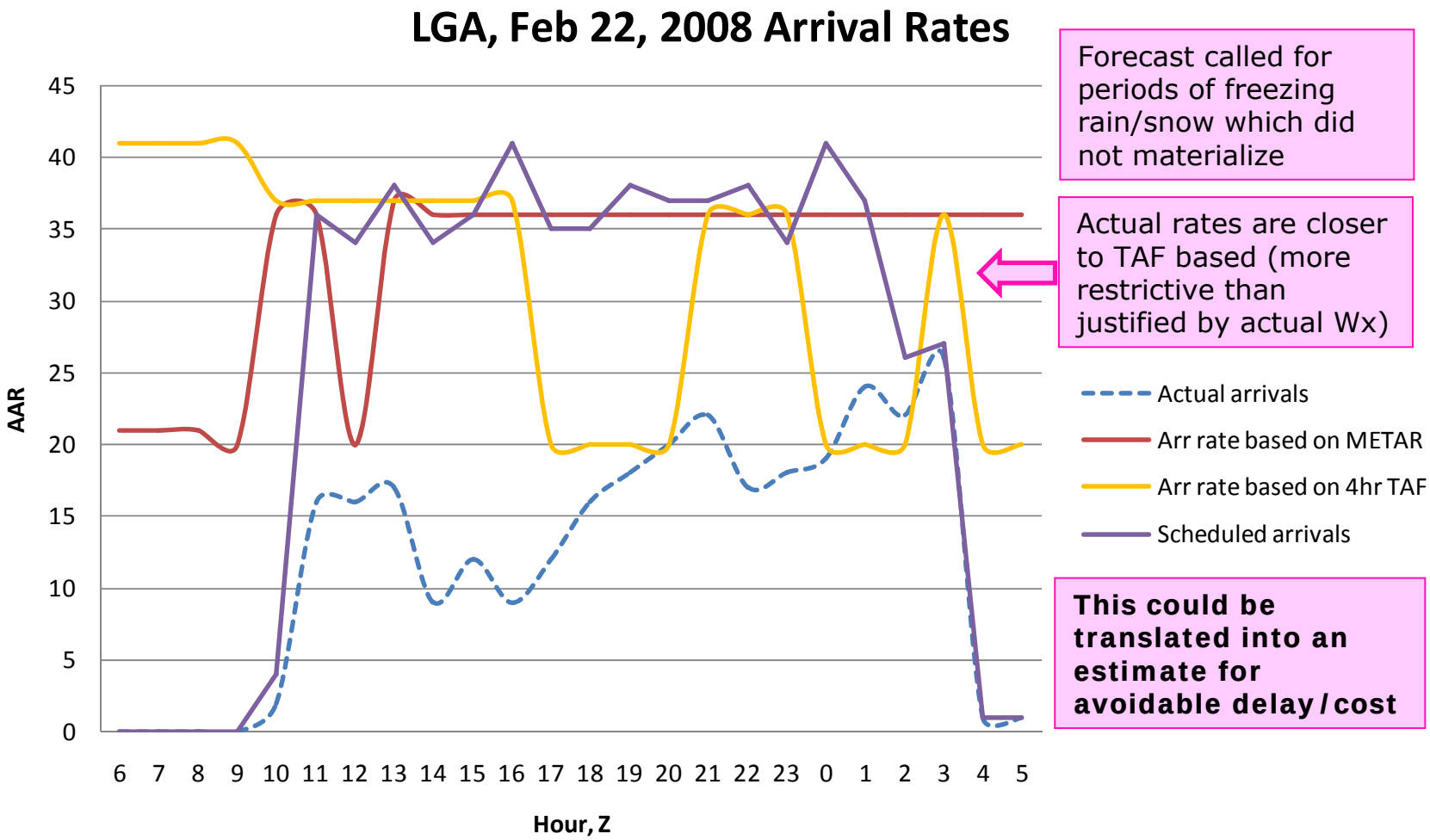
Terminal Forecast Error: Potential Impact (1)

Example of an accurate terminal forecast, Feb 12, 2008



Terminal Forecast Error: Potential Impact (2)

Example of a terminal Wx overforecast, Feb 22, 2008



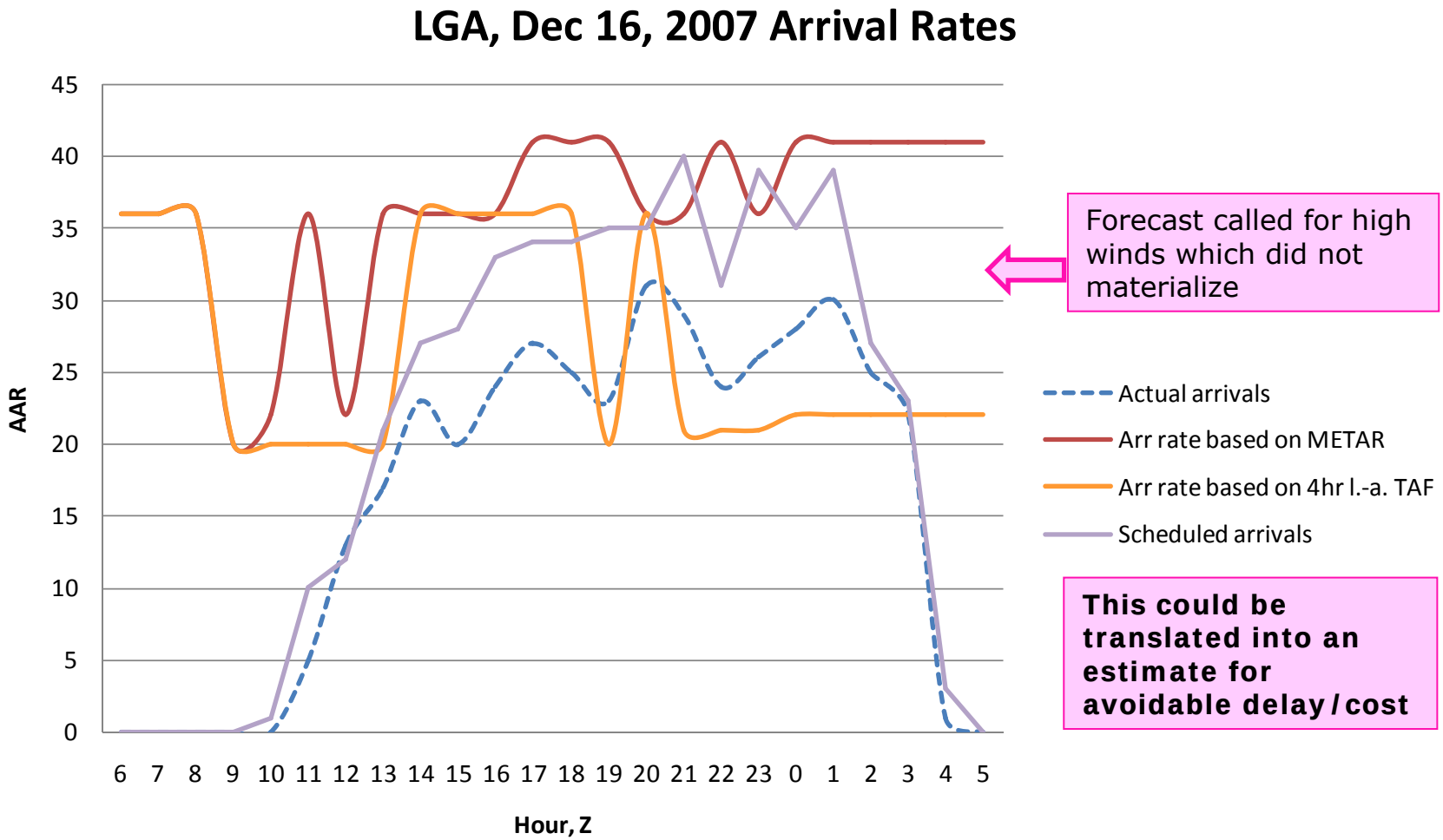
Forecast called for periods of freezing rain/snow which did not materialize

Actual rates are closer to TAF based (more restrictive than justified by actual Wx)

This could be translated into an estimate for avoidable delay/cost

Terminal Forecast Error: Potential Impact (3)

Example of a terminal Wx overforecast, Dec 16, 2007



Forecast called for high winds which did not materialize

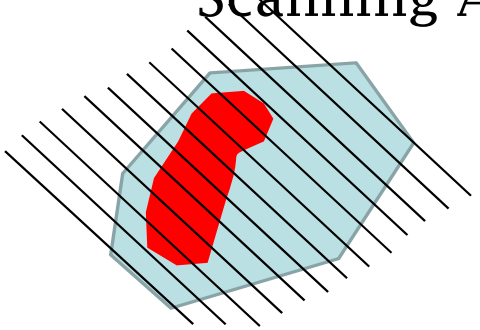
This could be translated into an estimate for avoidable delay/cost

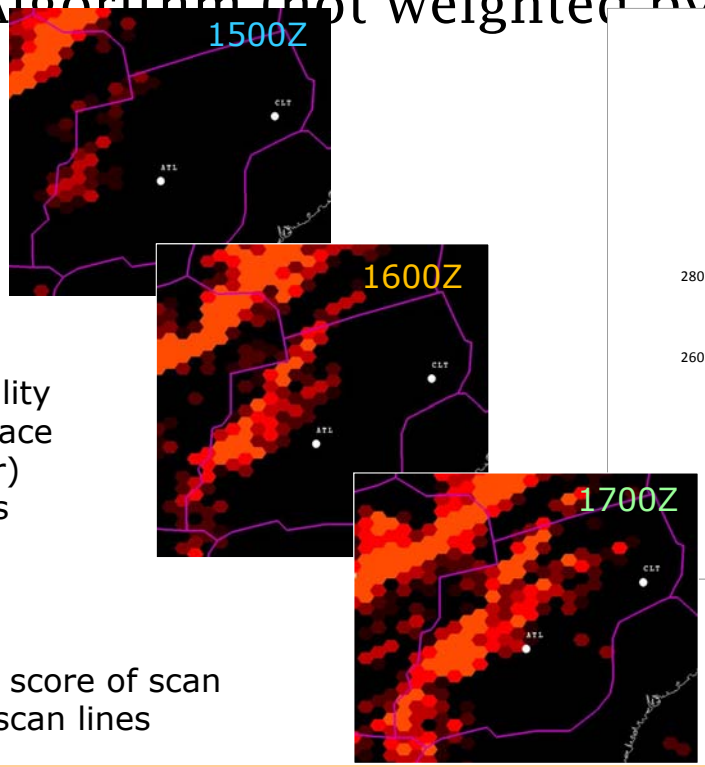
Convective Forecast Product Evaluation

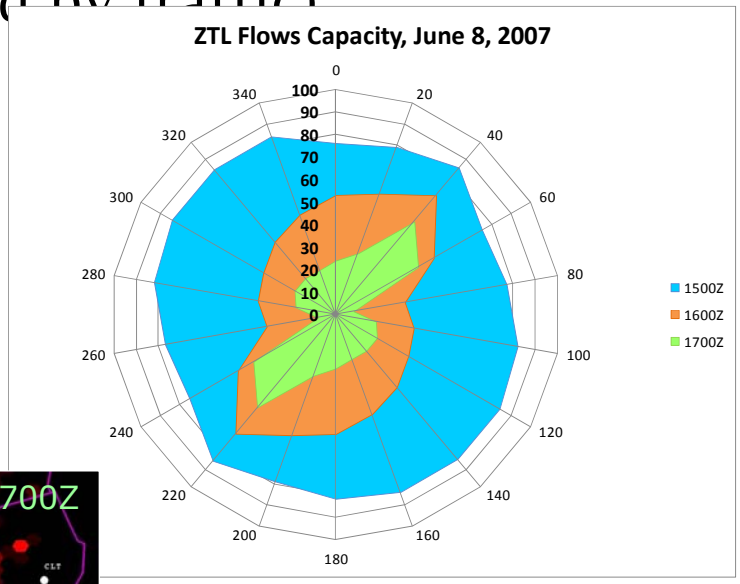
Two Methods for Operational Impact Quantification

1. E-WITI-FA (traffic weighted) – the only WITI component used

2. Estimation of airspace availability in ATC Centers using Scanning Algorithm (not weighted by traffic)







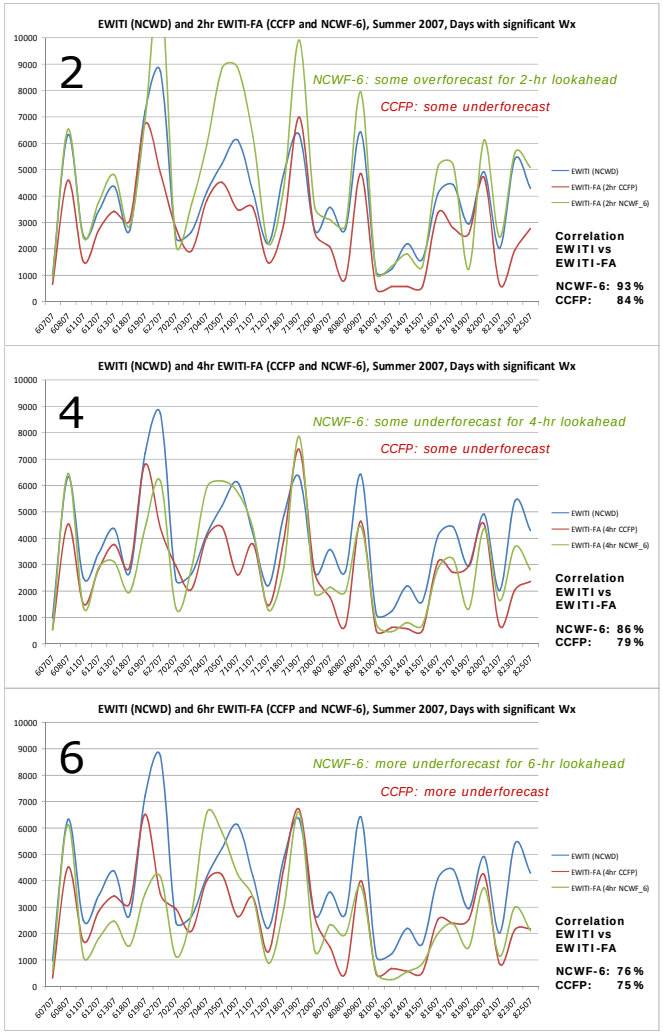
Directional Airspace Availability (DAA) percentage (vs. airspace volume clear of any weather) along direction (heading) *i* is

$$DAA_Perc_i = \sum_{k=1}^{N} P_k / N$$

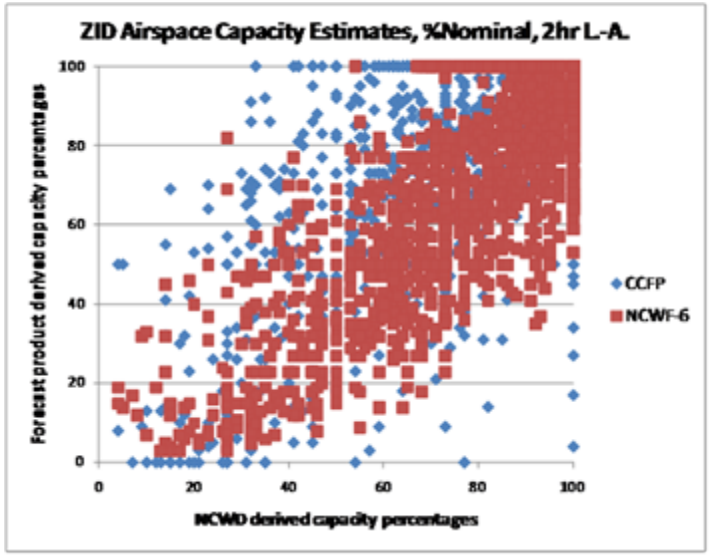
where P_k is the permeability score of scan line *k*; *N*= total number of scan lines

Example: NCWF-6, summer 2007

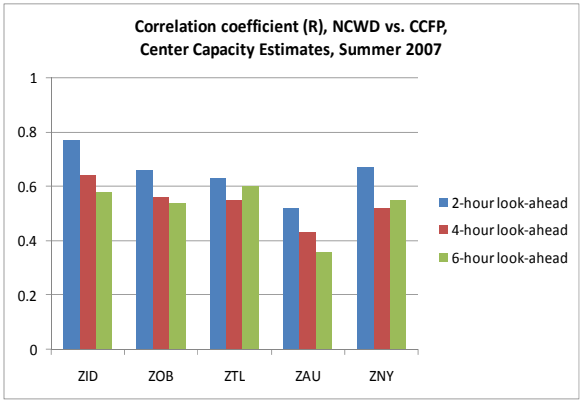
E-WITI

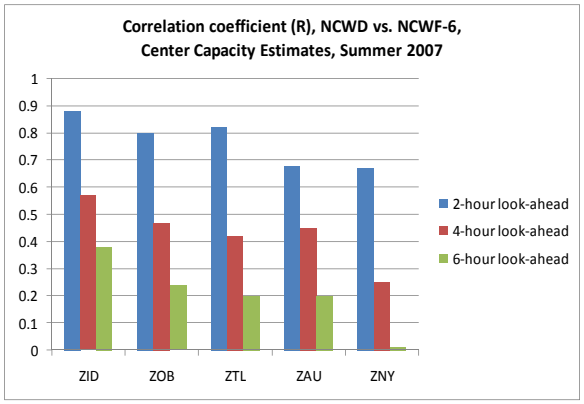


Scanning



CCFP Selected Centers NCWF-6





“Critical Points” Highlighted by WITI

Effect of Weighing Wx by Traffic

- Geography
  - Convective impact on areas of the NAS with high traffic density gets amplified very quickly
  - CCFP can get higher ‘credit’ in WITI than in traditional PoD verification

    (e.g. prediction of major Wx fronts impacting east-west traffic)
- Continuous change in Wx conditions may lead to “quantum leap” changes in airport capacity
  - Ceilings becoming gradually lower -> below IFR minima
  - Wind speed/gusts exceeding a threshold (e.g. high winds)
  - Wind direction changing until it forces RWY config change
  - SIGWX field (e.g. –SN vs. BLSN)

AvMet Website

www.avmet.com

Designed to Track E-WITI-FA and T-WITI-FA

A multi-season database of weather impact data

www.avmet.com

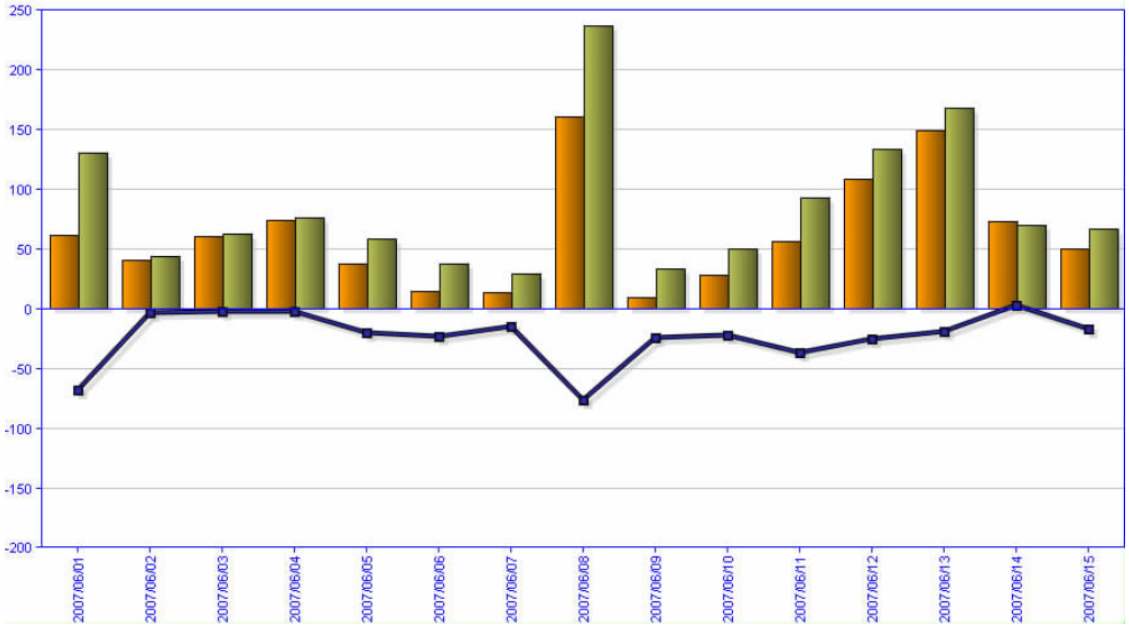
Display of WITI-FA Components and "Deltas" vs. WITI Based on Actual Wx

WITI Score
Release 1.1 Beta

WITI Type	○ Combined WITI	◉ E-WITI	○ T-WITI
Area Selection	◉ NAS	○ Select Region	○ Select Airport
Forecast Look Ahead Time	○ 2 hr	◉ 4 hr	○ 6 hr
Date Selection	○ Last 7 Days	○ Last 30 Days	◉ Select Range (yyyy/mm/dd): From 06/01/2007 To 06/15/2007
	Update WITI Selection		

Displaying: NAS ; E-WITI; 4hr CCFP ; From 06/01/2007 to 06/15/2007

Click on any bar to drill down for more specifics

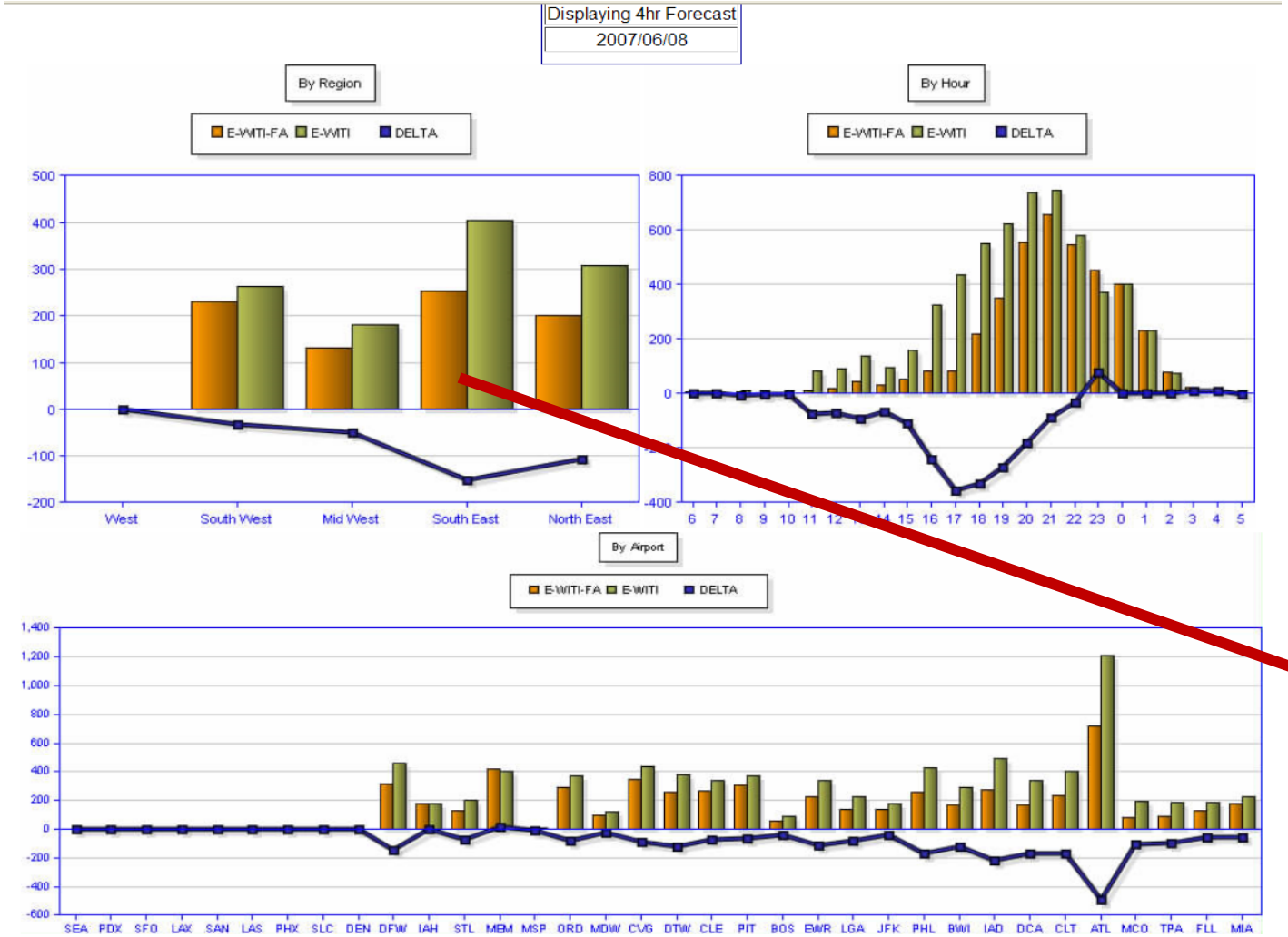


WITI and WITI-FA, as well as their Delta, are shown for a range of days

The user can drill down to individual days / NAS regions / airports / hours of the day

Comparing not just Wx but Wx *impact* on air traffic

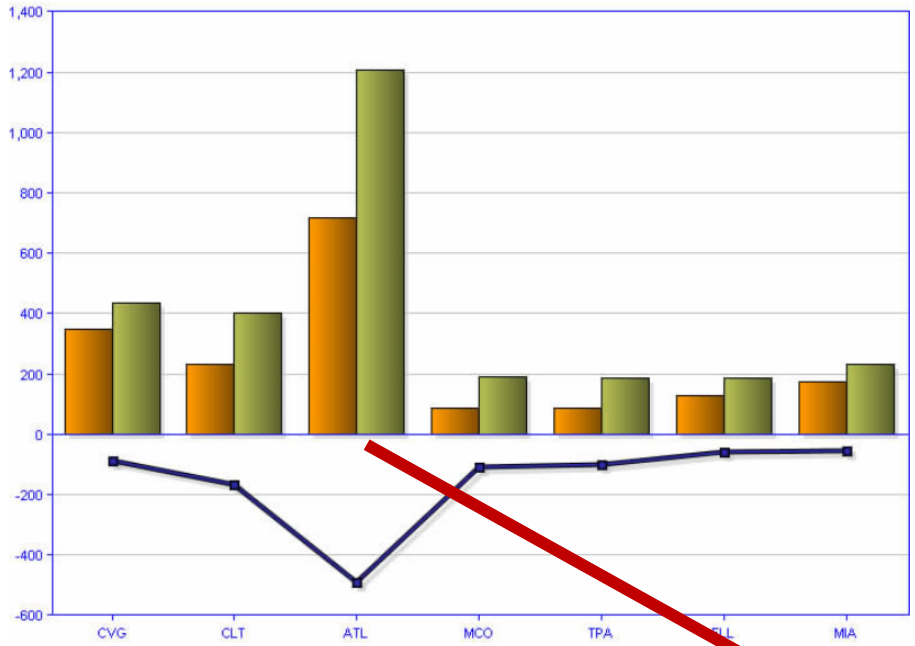
Drill Down Capability

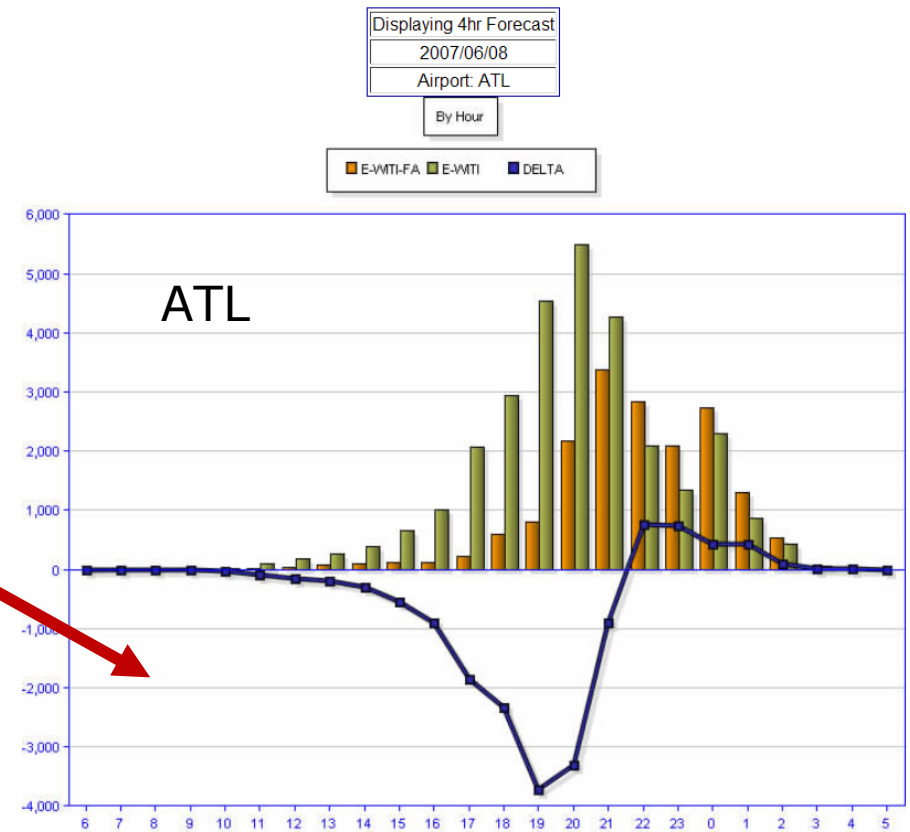


Next slide

Drill Down Capability

Example: South Region, Atlanta

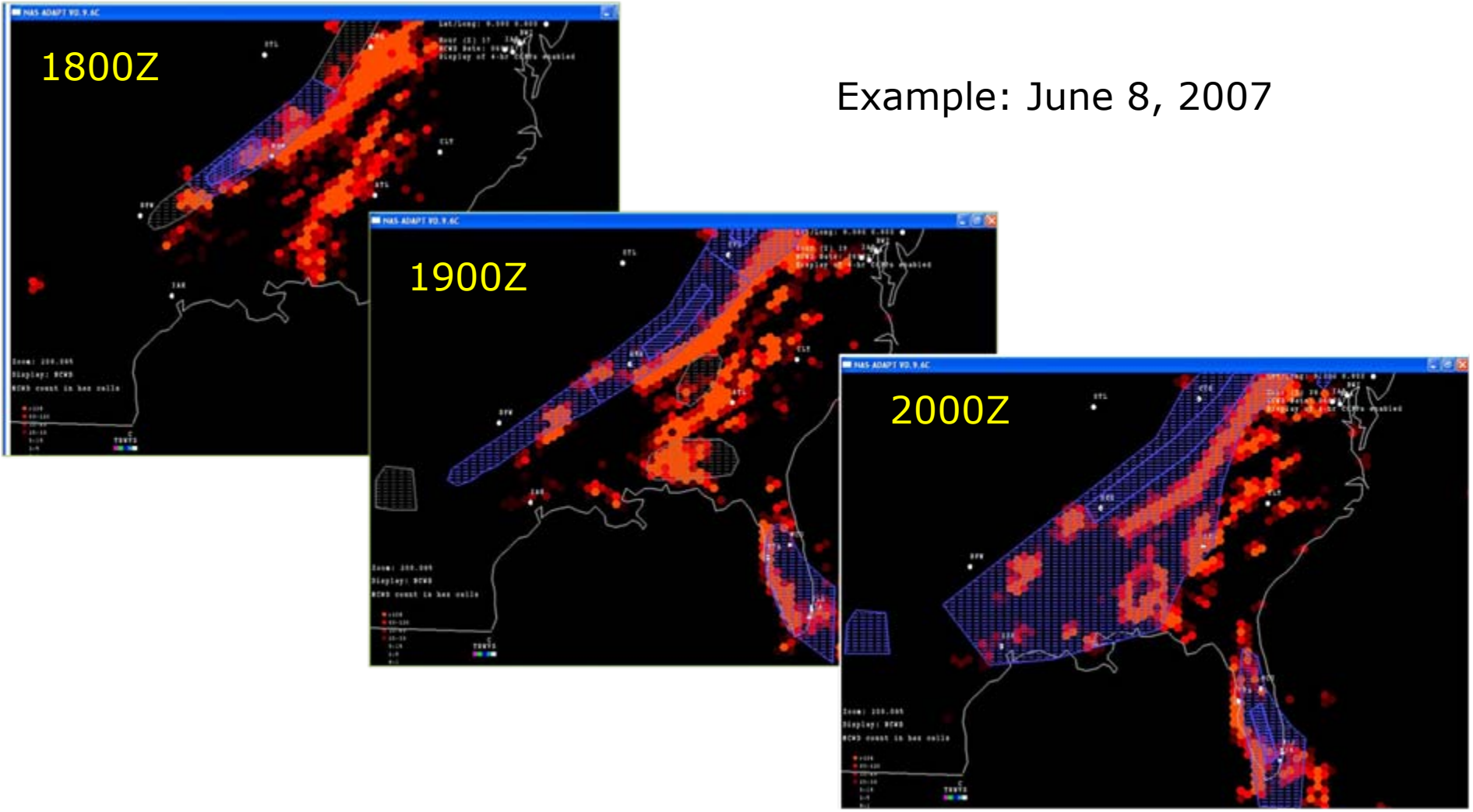




Significant underforecast in early afternoon (Southern region, ATL routes)

Drill Down Capability

Animation of convective weather and CCFP (forecast)

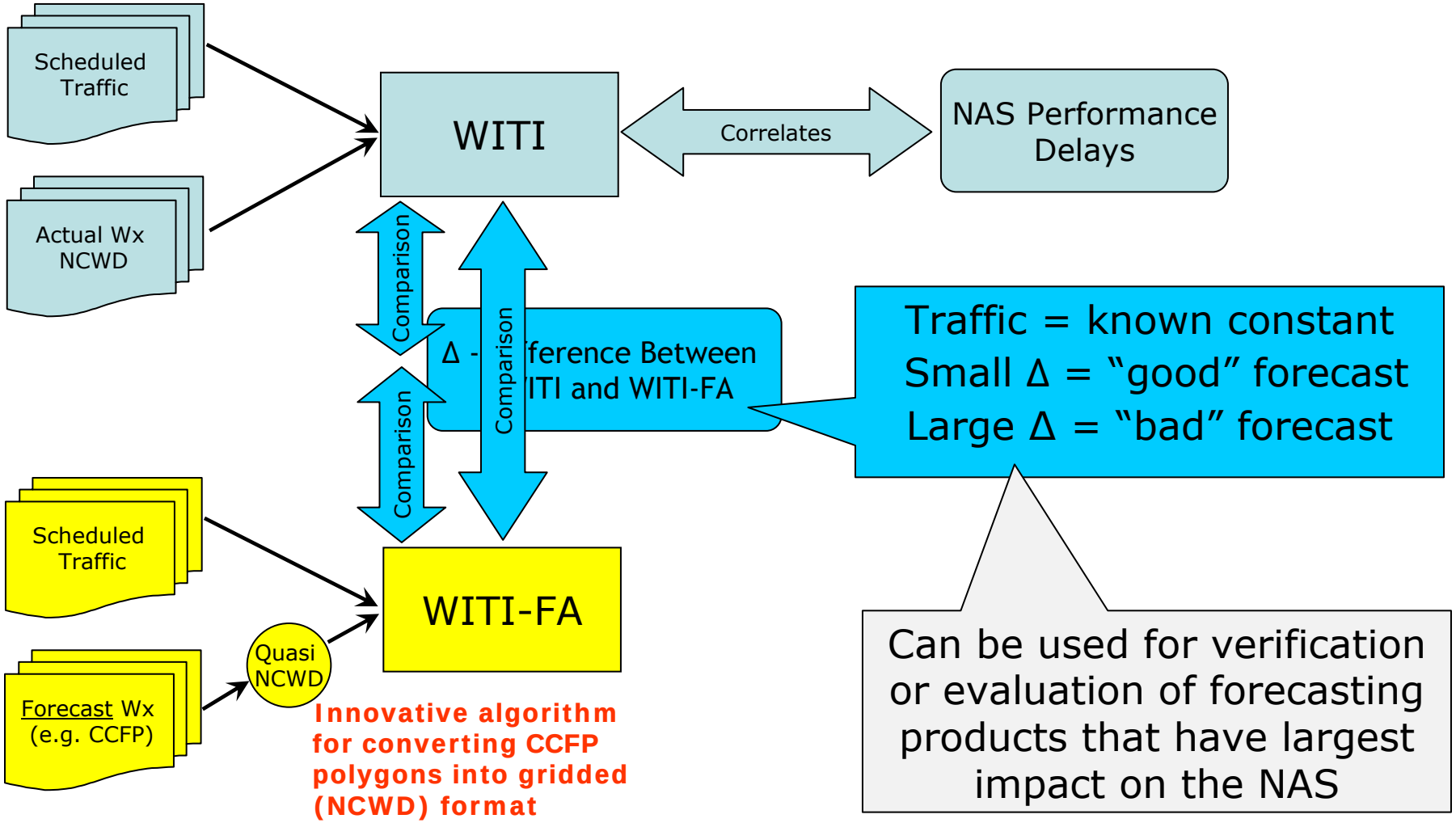


Example: June 8, 2007

Backup Slides

From WITI to WITI-FA ("Forecast Accuracy")

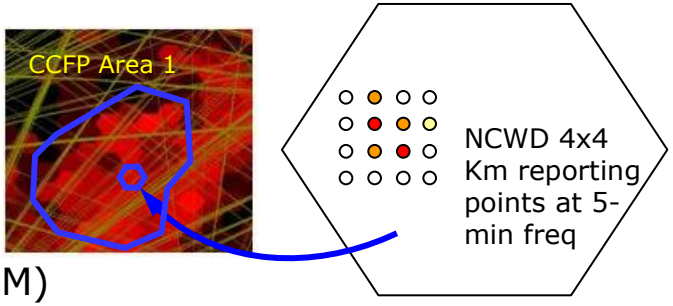
Impact of actual Wx vs. Perceived impact of forecast Wx



Converting CCFP into Quasi-NCWD

Methodology

- For each hexagonal cell inside a CCFP area:
  - Pre-compute how many 4x4 Km NCWD reporting points are in a hexagonal cell
  - Imagine that the CCFP area had 100% confidence and 100% coverage:
    - Each 4x4 Km reporting point inside this hexagon would be reporting convective Wx for the whole hour, every 5 min
    - For this hexagonal cell (diameter about 20 NM) the hourly "quasi-NCWD" score would be:



hourly_quasi_NCWD_score_for_a_hex_cell_in_100%_CCFP_area =
num_5_min_reports_in_1_hr * num_4x4_Km_points_in_hex_cell

  - But our CCFP has a confidence level < 100% and coverage < 100%
  - So:

hourly_quasi_NCWD_score_for_a_hex_cell_in_actual_CCFP_area =
num_5_min_reports_in_1_hr * num_4x4_Km_points_in_hex_cell *
confidence_coef * coverage_coef

TAF/T-WITI-FA Implementation
Summary (1)

- Software reads TAF file, interprets the content
  - Checks forecasts that go over to next day (thru 0600Z)
  - A more fresh forecast for same hour(s) overwrites previous where specific forecast conditions have changed
  - Computes "T-WITI-FA" for each OEP-35 airport and the NAS
- Processes "core" forecast (main line of information for an airport), as well as FROM, TEMPO and PROB lines
  - For TEMPO, applies 100% probability to each affected hour
  - For PROB, applies the specified probability
- "T-WITI-FA" (TAF based) is generated & compared with T-WITI (METAR based). Queuing delay is *not* yet computed

TAF/T-WITI-FA Implementation
Summary (2)

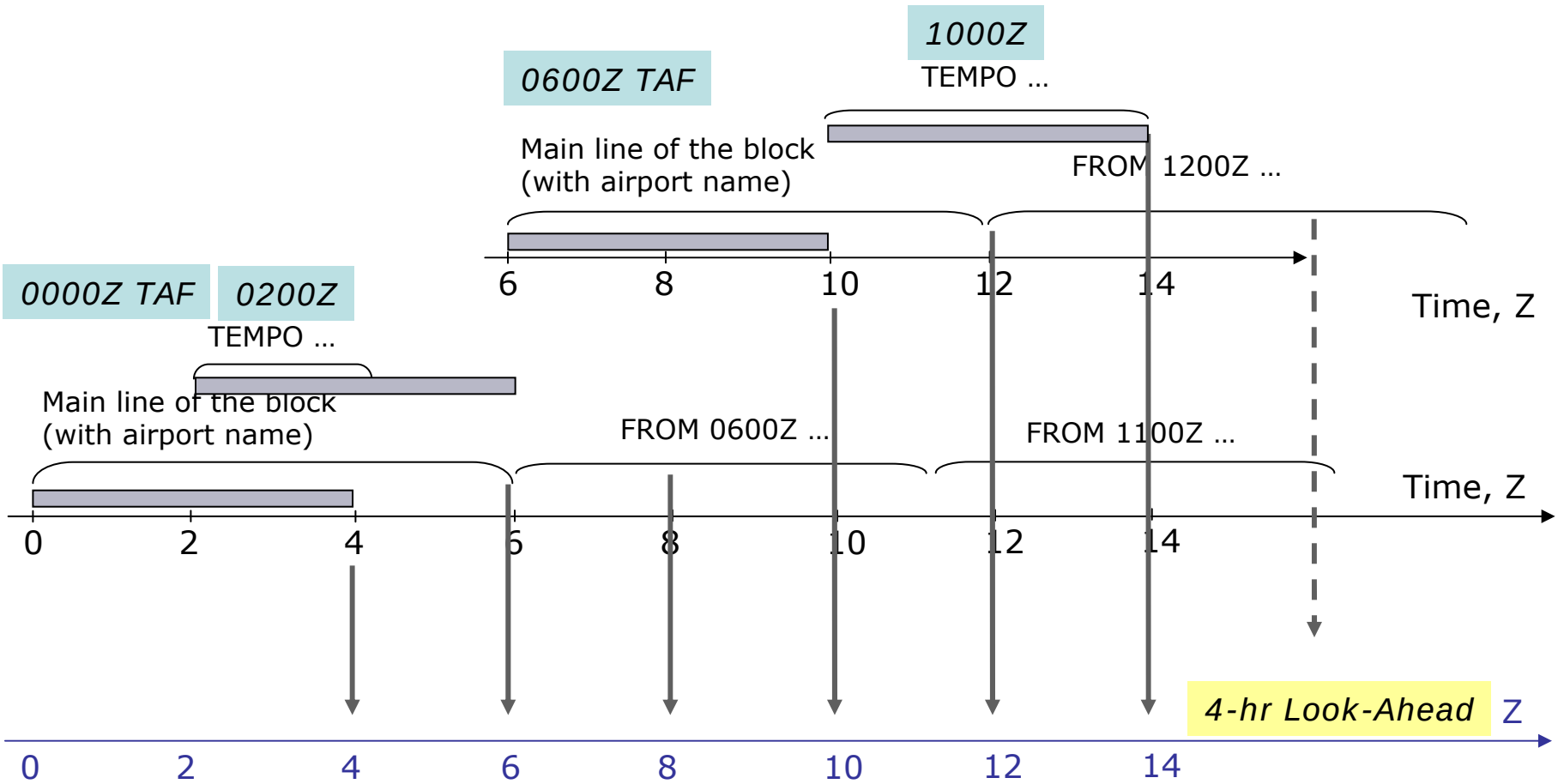
Seven outputs are produced:

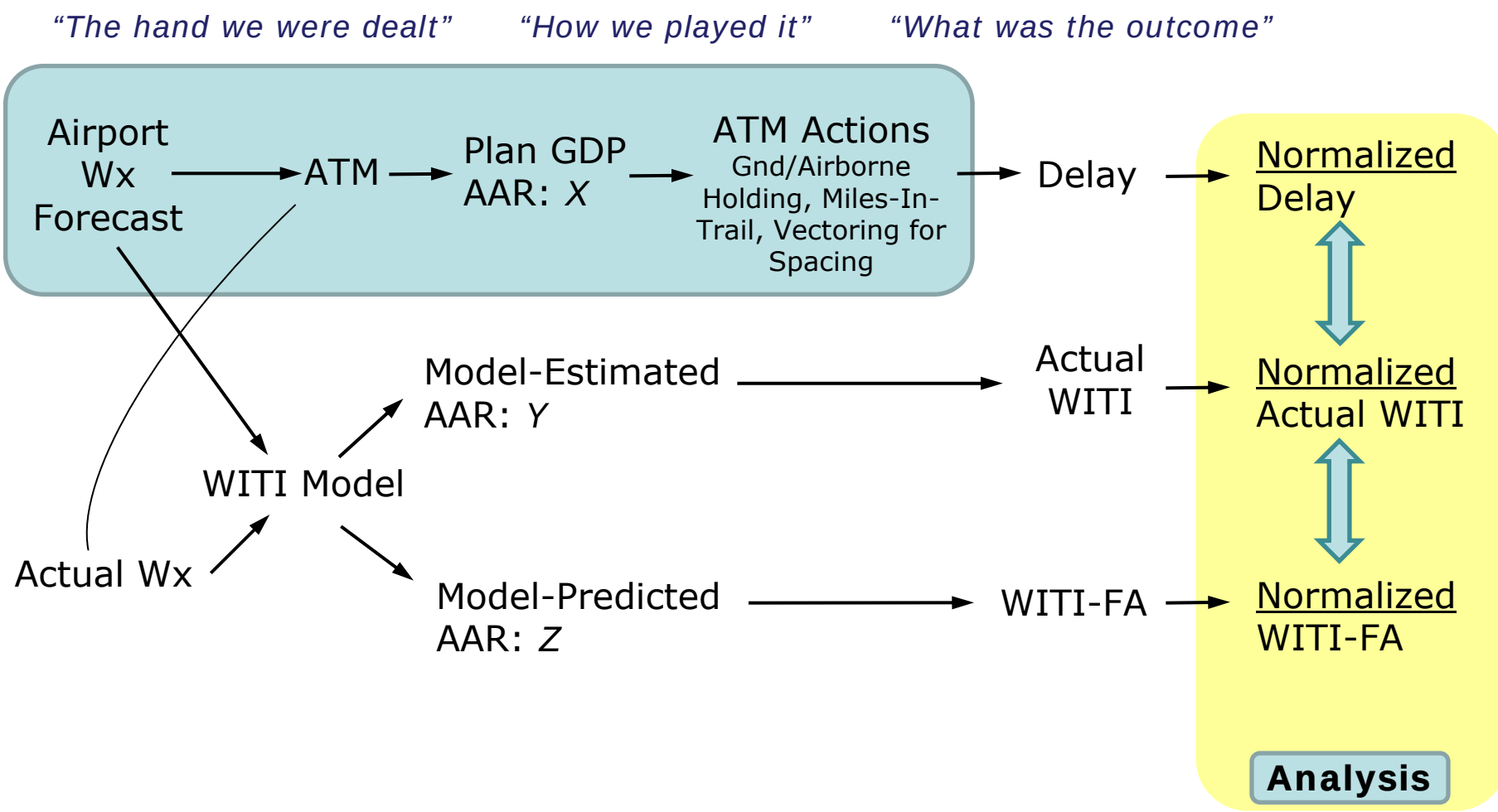
- "Best fit" (combination of all TAF records and amendments for the airport)
  - Can be used as a verification of an "ideal" forecast
- "2-hour look-ahead" (only the conditions forecast for the [time_of_issue + 2 hrs, time_until_which_forecast_extends] interval are used)
- "4-hour look-ahead"
- "6-hour look-ahead"
  - These three outputs correspond to 2-, 4-, 6-hr CCFP
- 0600Z, 1200Z, 1800Z and 0000Z "Pure" TAFs
  - Can be used for QA purposes

Of these seven, we focus on the "4-hr look-ahead" TAF for T-WITI-FA (corresponds to AOC tactical planning horizon)

TAF "Rolling" Look-Ahead

4-hr Look-Ahead



Wx Metrics and NAS Performance

Example: Airport delays