

# *Enabling Information Sharing thru Common Services*

**Expansion of the WXXM with the inclusion  
of probabilistic weather**

Presented By: Mark Oberfield, NWS/OST/MDL  
Date: 1 September 2011



Federal Aviation  
Administration

## **Air Transportation Information Exchange Conference - (featuring AIXM, WXXM and FIXM)**

**August 30, 2011 - September 1, 2011  
NOAA Science Center & Auditorium  
Silver Spring, Maryland**

# Outline



Air Transportation Information  
Exchange Conference - (featuring  
AIXM, WXXM and FIXM)

- Completing the Forecast
- Brief description of the LAMP forecast system
- New product generation
- New NAWX schema
- Current implementation and the future plans



EUROCONTROL



Federal Aviation  
Administration



# Completing the Forecast

In 2006, a National Research Council report stated:

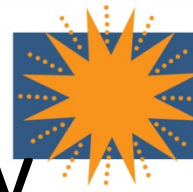
*“Uncertainty is a fundamental characteristic of weather prediction, and no forecast is complete without a description of its uncertainty.”*

and that NOAA Laboratories should lead US efforts to produce probabilistic forecasts.



# Completing the Forecast

- International efforts by scientists to quantify uncertainty in weather forecasts
  - A difficult, multifaceted problem
  - Multiple techniques being explored
- WXXM needs some changes
  - Incorporate uncertainty information



# Quantifying the Uncertainty

- Types of probabilities
  - Discrete (yes/no event) probability
    - “80% chance of thunderstorms at KEWR 4-hrs from now”
  - Exceedance probability
    - “Probability of 2-m temperature below 28° F”
  - Confidence intervals
    - “90% confidence interval of maximum temperature for Day 3”



# What we've done to date....

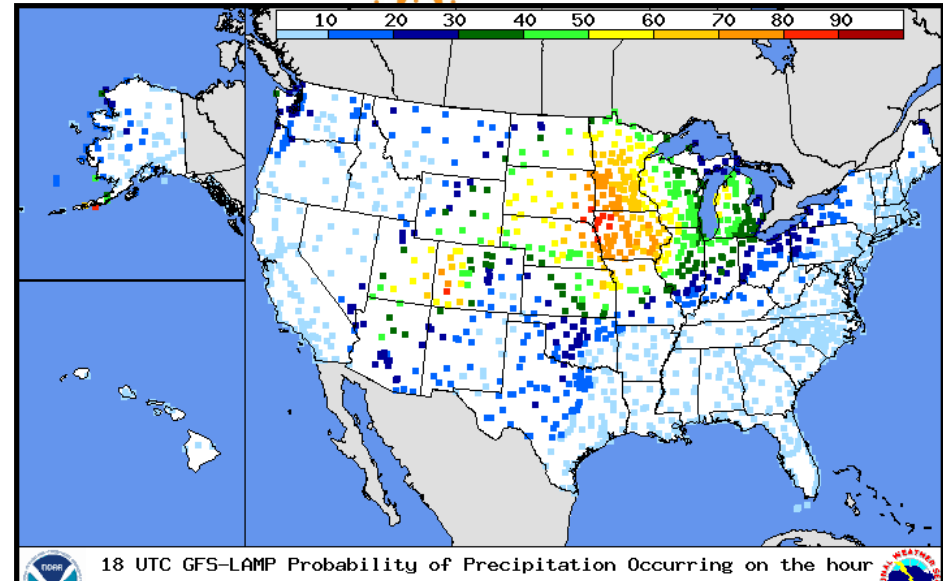
- Created a new experimental product
  - Guidance TAF
  - Has probabilities associated with it
- North American extension to WXXM (NAWX)
  - Already has TAF schema
  - Implemented quickly
  - wxGuidanceTAF.xsd in ver. 1.3.0

# MDL's LAMP Forecast System

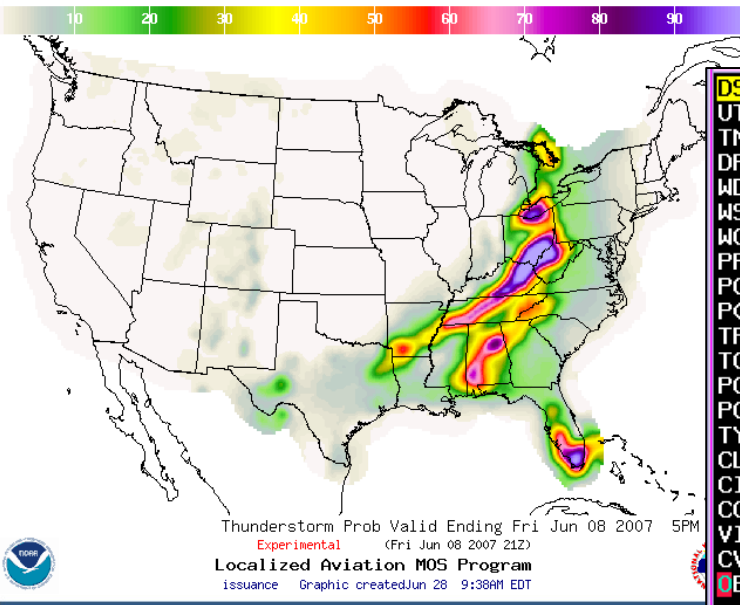


Air Transportation Information Exchange Conference - (featuring AIXM, WXXM and FIXM)

- LAMP provides hourly updates to longer-range guidance
- Forecast out to 25 hours at 1-hr intervals
- Station Guidance (~1600 stations)
  - all elements; CONUS, Alaska, Hawaii, Puerto Rico & parts of Canada
- CONUS Gridded Guidance
  - Tstms; Temp & Dew; CIG & VIS
- Runs 24/7 & operational at NCEP



18 UTC GFS-LAMP Probability of Precipitation Occurring on the hour



DSM	GFS LAMP GUIDANCE 11/30/2007 1800 UTC																								
UTC	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
TMP	27	28	28	27	25	23	23	23	24	24	24	24	24	25	25	26	27	28	27	27	28	30	32	33	34
DPT	2	2	2	2	2	2	3	5	6	7	8	9	10	11	12	14	16	18	18	20	22	24	26	28	32
WDR	33	33	33	35	02	06	09	10	11	12	12	12	12	11	11	11	11	11	11	12	12	12	12	12	12
WSP	10	09	08	07	05	04	05	05	05	06	07	07	08	09	09	11	13	15	15	16	17	16	16	15	17
WGS	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	24	23	23	22	24
PP0	0	0	0	0	0	0	0	1	1	2	3	3	10	17	22	28	33	36	44	51	58	64	69	72	73
PC0	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	Y	Y	Y	Y	Y	Y
P06																		24							
TP2			0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	1	1	1	1	1	1	1
TC2			N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
POZ	1	1	1	1	1	2	3	3	3	3	3	3	4	2	3	13	25	26	28	26	26	24	22	22	19
POS	98	99	99	99	99	98	97	97	97	97	97	97	97	98	97	81	59	47	42	40	38	32	31	30	27
TYP	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	2	2	2	2	2	2	2	2	2	2
CLD	5C	5C	5C	5C	5C	5C	5C	5C	5C	5C	5C	BK	BK	BK	OV	OV	OV	OV	OV	OV	OV	OV	OV	OV	OV
CIG	8	8	8	8	8	8	8	8	8	8	8	8	8	7	7	7	6	6	6	4	3	3	2	2	2
CCG	7	6	6	7	6	7	6	7	7	7	6	6	6	6	6	6	6	6	5	3	3	3	2	2	2
VIS	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	4	3	3	3	3	3	3
CVS	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	4	3	3	3	3	3	3
OBV	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	BR	BR	BR	BR





- LAMP:
  - is a system of objective analyses, simple models, regression equations, and related thresholds which together provide guidance for sensible weather forecasts
  - LAMP guidance is both probabilistic and deterministic
  - bridges the gap between the observations and long-range forecasts
  - provides guidance for aviation elements
  - is useful to WFO forecasters in making the TAFs and to AWC forecasters in making the convective products
  - provides guidance for CONUS, Alaska, Hawaii, Puerto Rico and Canadian sites near US borders.



# LAMP Probabilities



Air Transportation Information  
Exchange Conference - (featuring  
AIXM, WXXM and FIXM)

Probability of:	Event
Convection during 2 hr period in 20km box	Yes/No
Thunderstorms during 2 hr period in 20km box	Yes/No
Precipitation occurring on the hour	Yes/No



EUROCONTROL



Federal Aviation  
Administration

# LAMP Probabilities



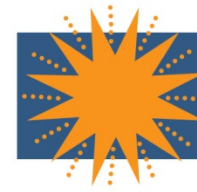
Air Transportation Information  
Exchange Conference - (featuring  
AIXM, WXXM and FIXM)

Probability of:	Event
Total Sky Cover	0/8 (Clear) 1/8 – 2/8 (Few) 3/8 – 4/8 (Sct) 5/8 – 7/8 (Bkn) 8/8 (Ovc)
Precipitation type (Conditional on Precipitation)	Freezing Frozen Liquid
Obstruction to Vision	No obstruction to vision Haze/Smoke Mist/Fog Blowing Phenomena



Federal Aviation  
Administration

# LAMP Probabilities



Air Transportation Information  
Exchange Conference - (featuring  
AIXM, WXXM and FIXM)

Probability of:	Event
Ceiling Height	< 200 feet (VLIFR) 200 – 400 feet (LIFR) 500 – 900 feet (IFR) 1000 – 1900 feet 2000 – 3000 feet 3100 – 6500 feet 6600 – 12,000 feet > 12,000 feet
Ceiling Height (Conditional on Precipitation)	Same as above



Federal Aviation  
Administration

# LAMP Probabilities



Air Transportation Information  
Exchange Conference - (featuring  
AIXM, WXXM and FIXM)

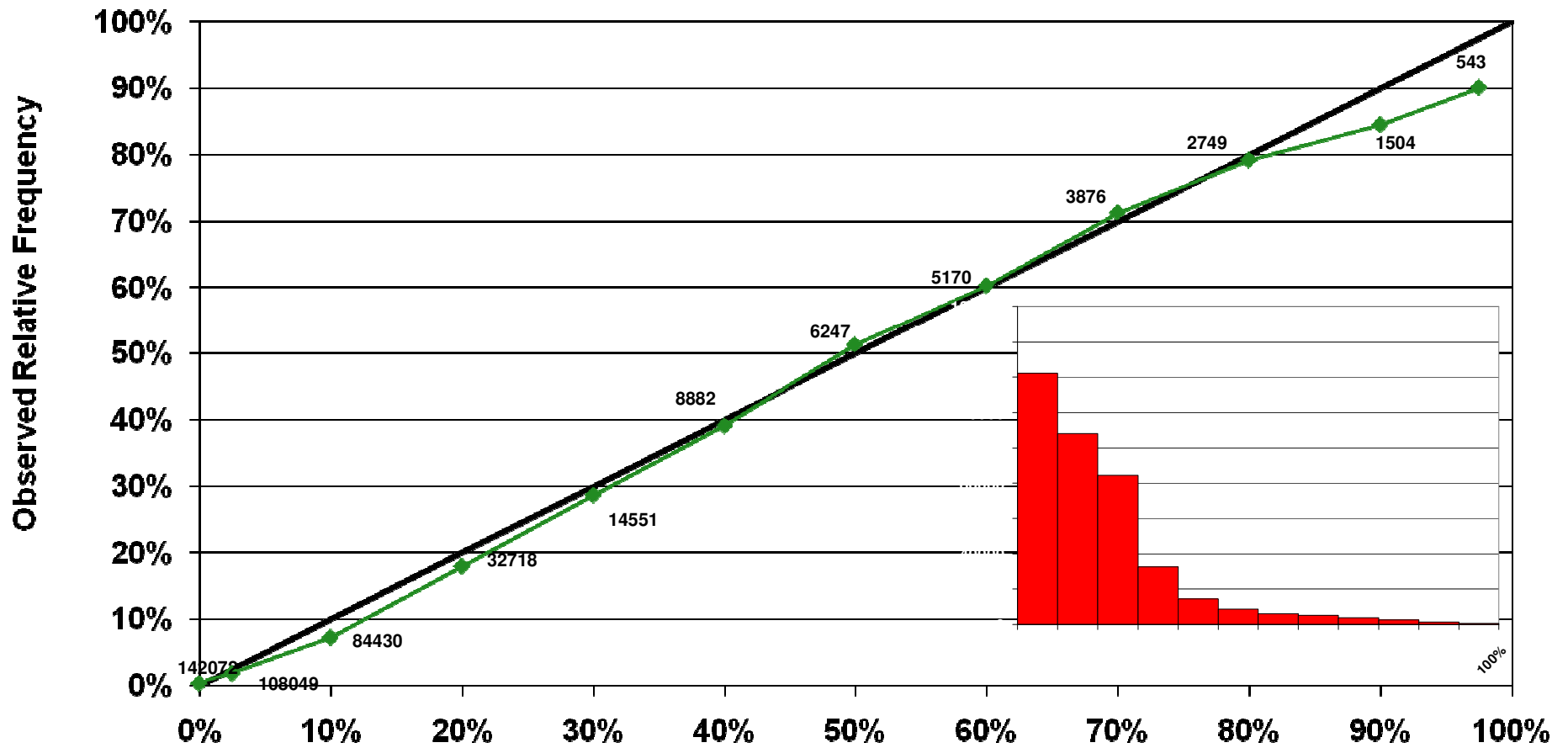
Probability of:	Event
Visibility	< ½ mile (VLIFR) < 1 mile (LIFR) < 2 miles < 3 miles (IFR) ≤ 5 miles ≤ 6 miles > 6 miles
Conditional Visibility (Conditional on Precipitation)	Same as above



Federal Aviation  
Administration



### Reliability of 0300 UTC 06-h Ceiling < 1000 feet 2006 Aug - 2007 May, 1522 sites



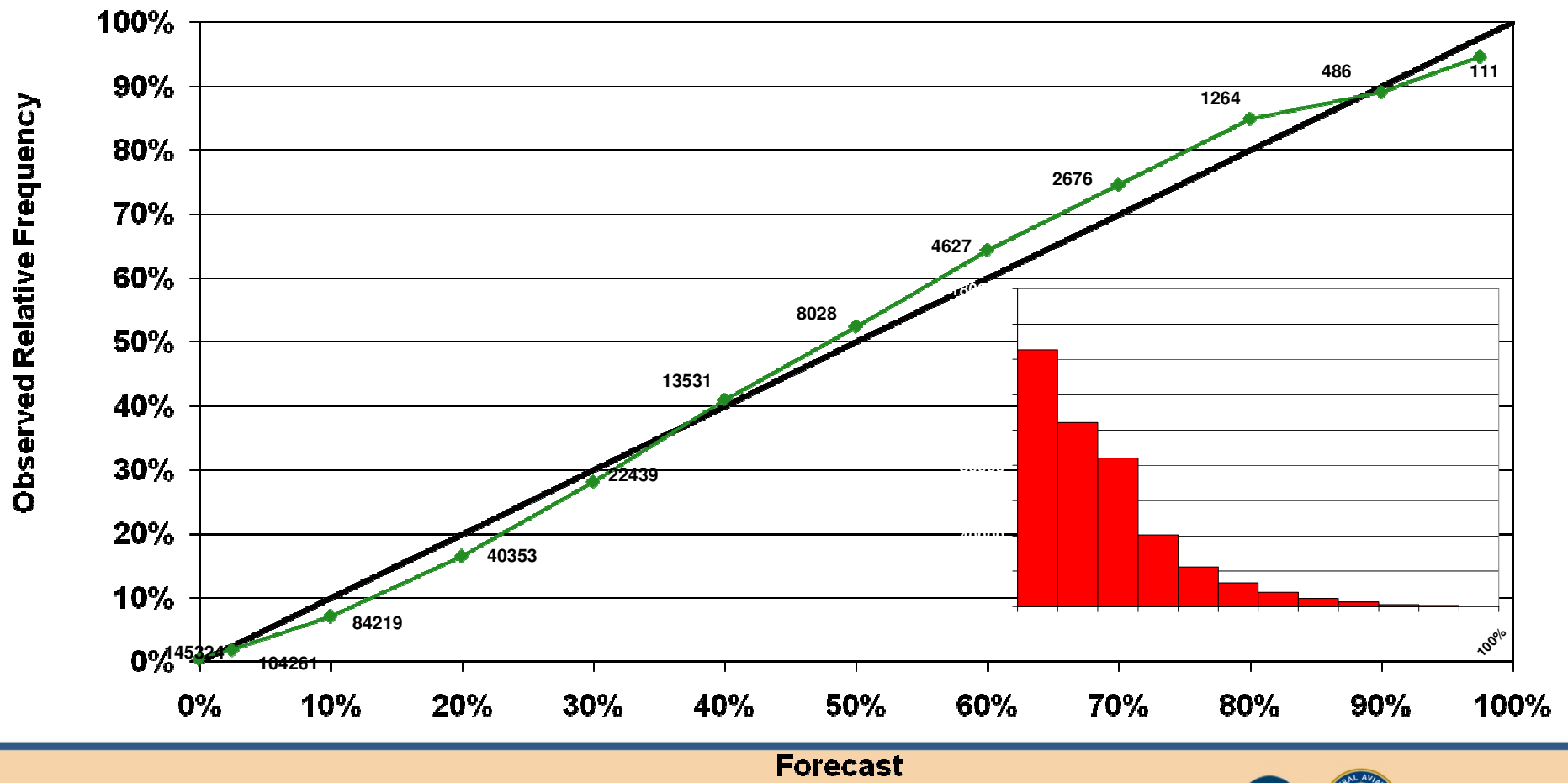
Forecast



Federal Aviation Administration

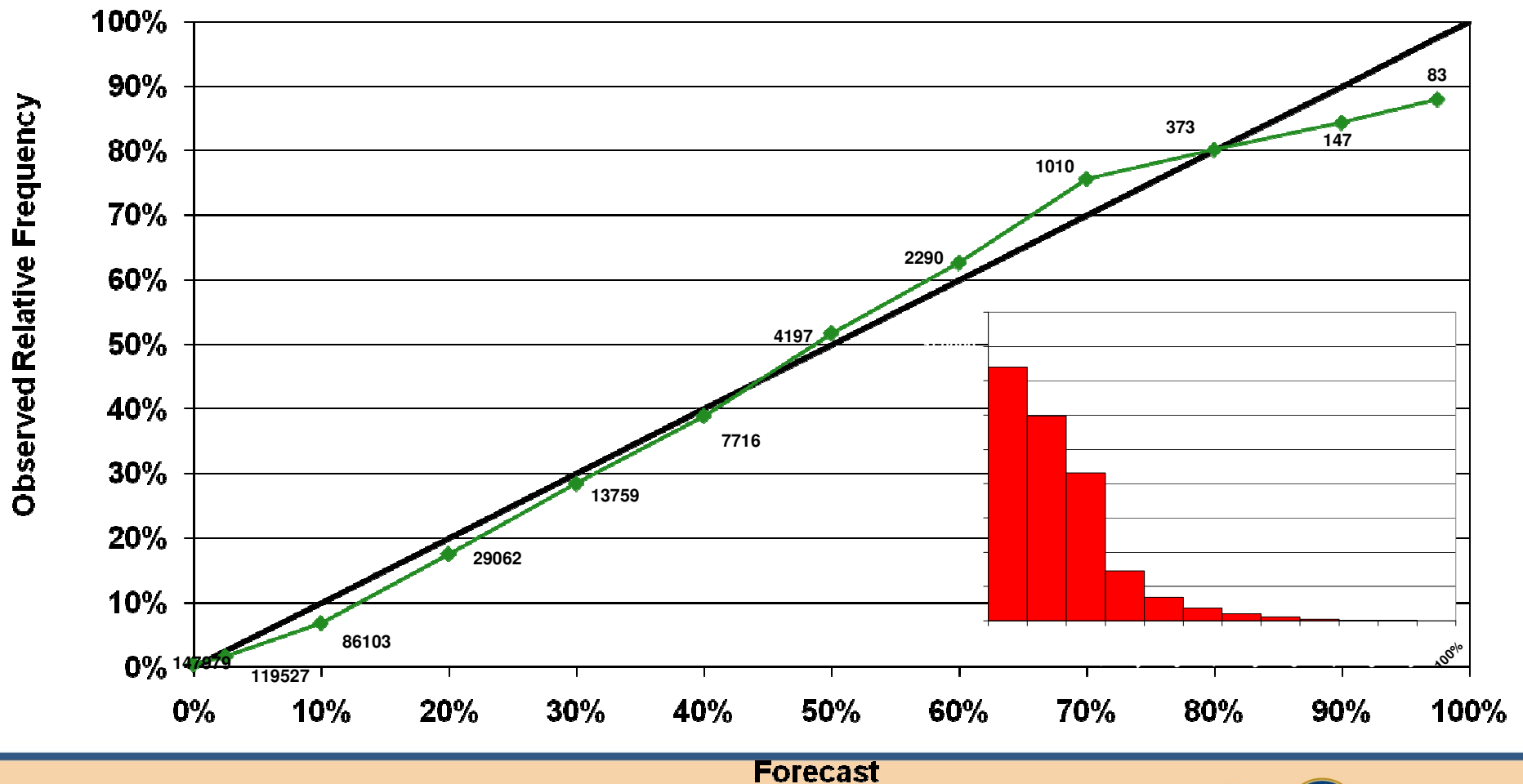


### Reliability of 0300 UTC 12-h Ceiling < 1000 feet 2006 Aug - 2007 May, 1522 sites



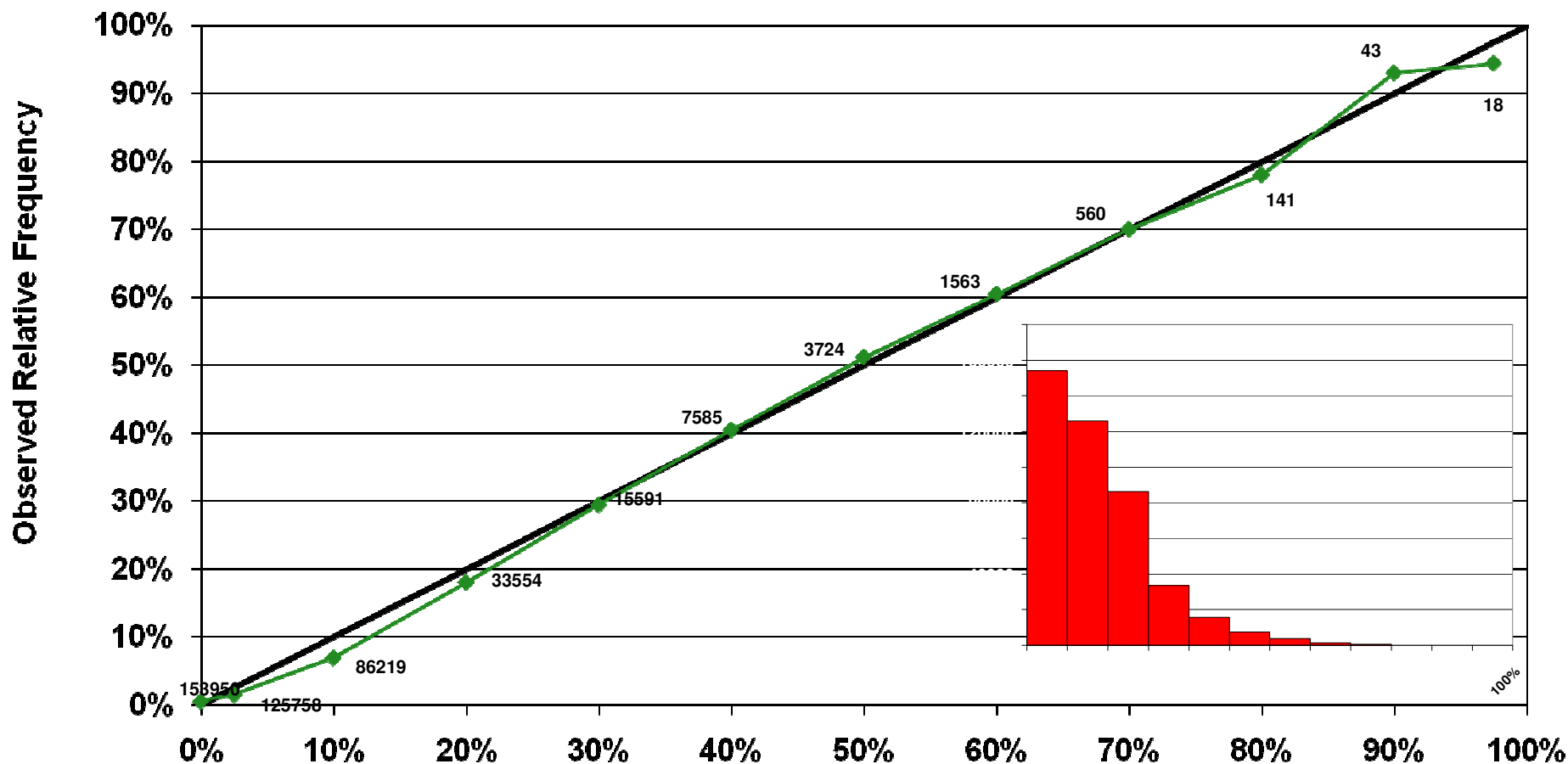


### Reliability of 0300 UTC 06-h Visibility < 3 miles 2006 Aug - 2007 May, 1522 sites





# Reliability of 0300 UTC 12-h Visibility < 3 miles 2006 Aug - 2007 May, 1522 sites



Forecast



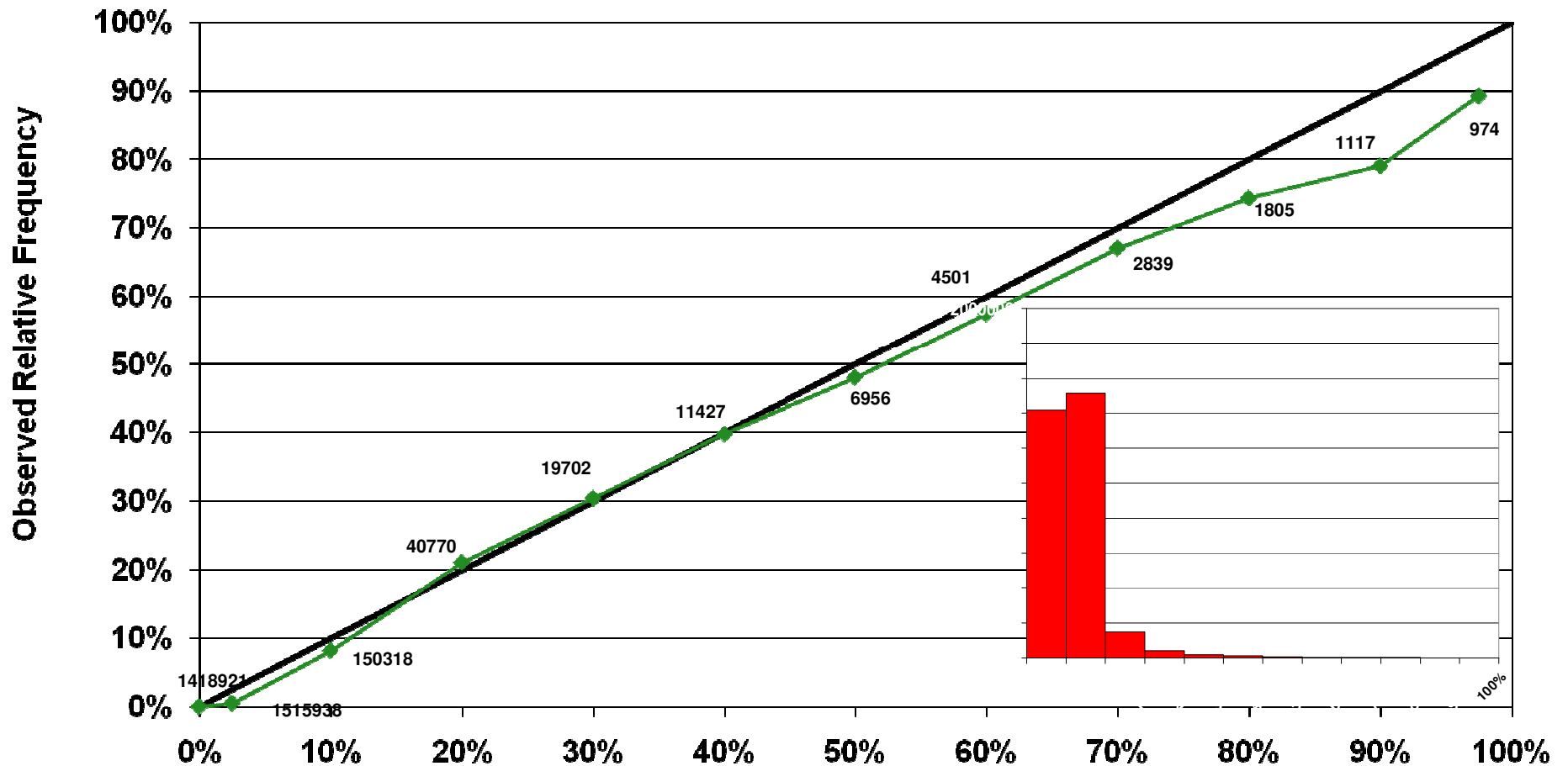
Federal Aviation Administration





### Reliability of 0300 UTC 03-h Thunderstorms 2006 Aug - Sep, 2007 Apr - May, 27373 grid points

Warm Season:



Forecast

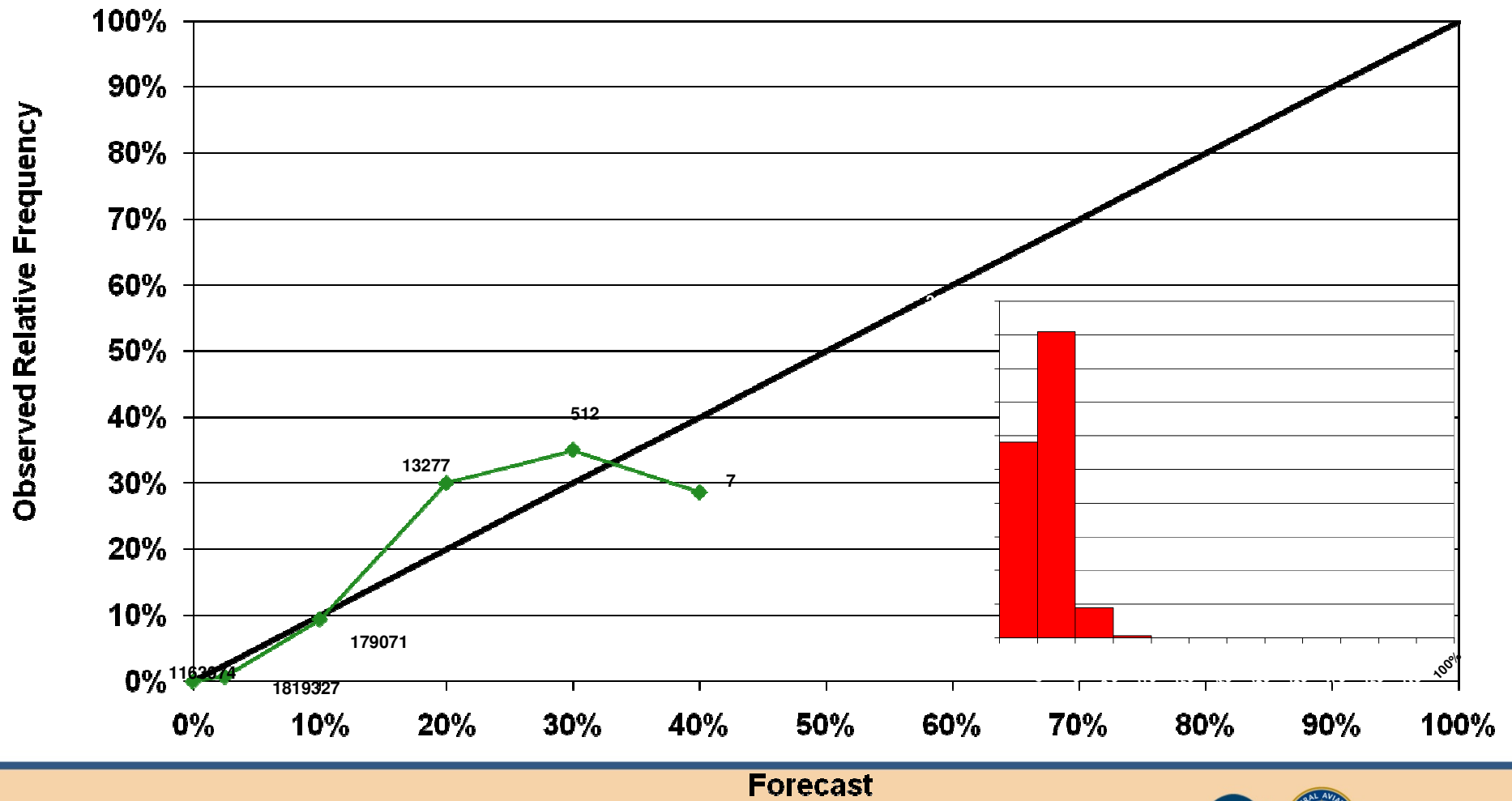


Federal Aviation Administration



### Reliability of 0300 UTC 09-h Thunderstorms 2006 Aug - Sep, 2007 Apr - May, 27373 grid points

Warm Season:



# New LAMP Convective Guidance



Air Transportation Information  
Exchange Conference - (featuring  
AIXM, WXXM and FIXM)

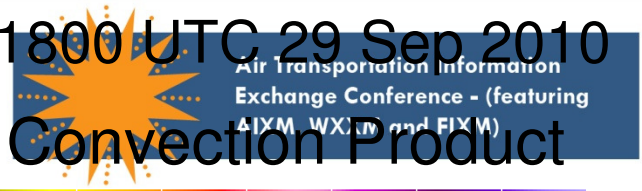
## Thunderstorm (current)

- Features:
  - Defined from Cloud-to-Ground (CTG) Itg
  - GFS MOS 3-h thunderstorm probability predictors
  - 2-h period / 20-km gridboxes
  - 1-h cycle; 3 – 25 h projections
  - Other predictors
- Criticisms:
  - Convection can occur without lightning
  - Thunderstorm probabilities lack sharpness

## Convection (experimental)

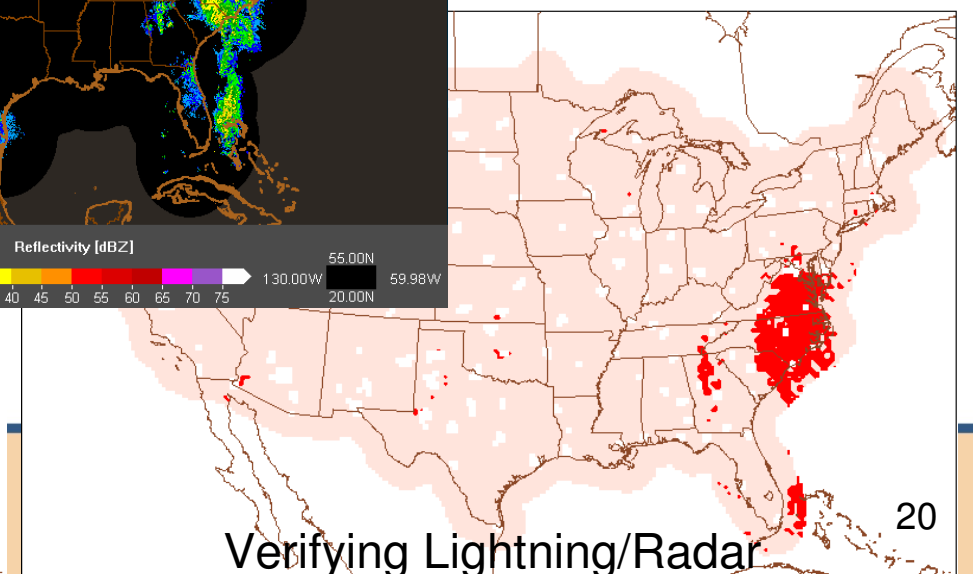
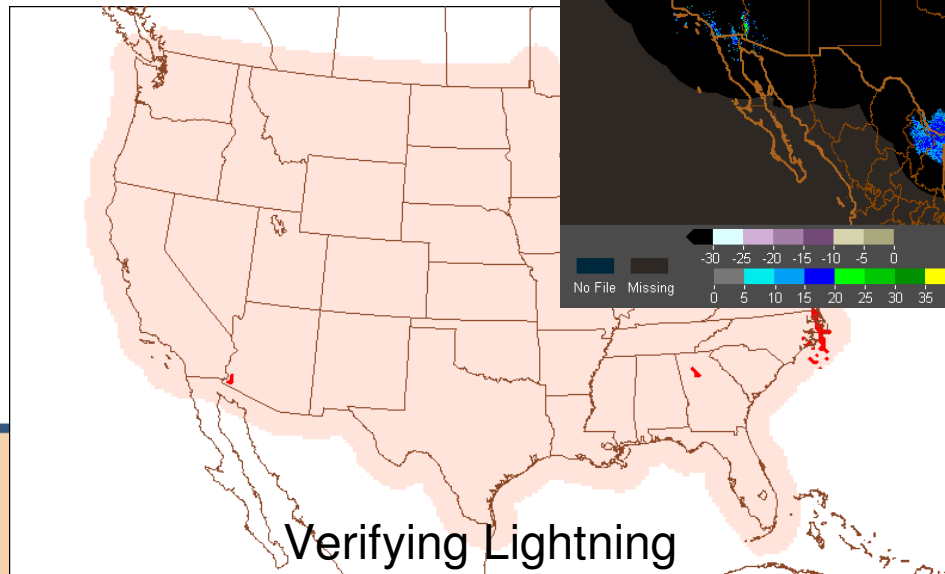
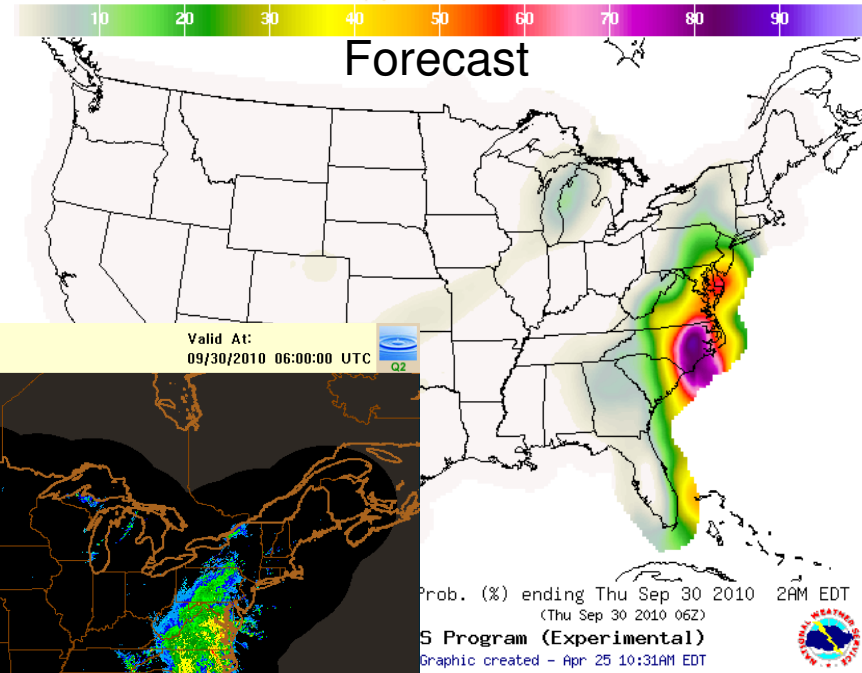
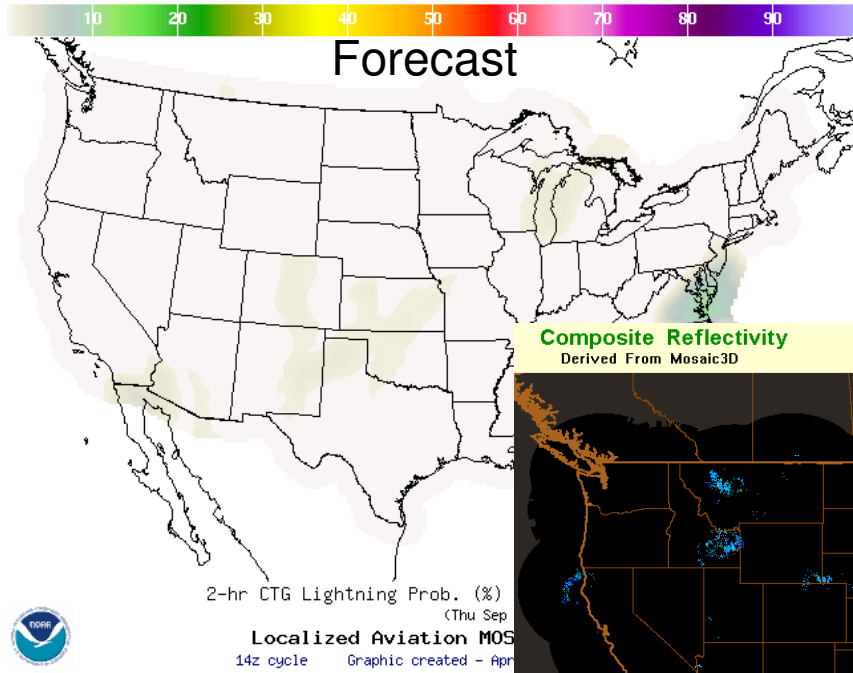
- Features:
  - Defined from CTG Itg /  $\geq 40$  dBZ radar reflectivity
  - GFS & NAM MOS 2-h convective probability predictors
  - 2-h period / 20-km gridboxes
  - 1-h cycle; 3 – 25 h projections
  - Other predictors
- Solution:
  - Convection can be indicated when there is little or no lightning
  - Convection probabilities exhibit good sharpness

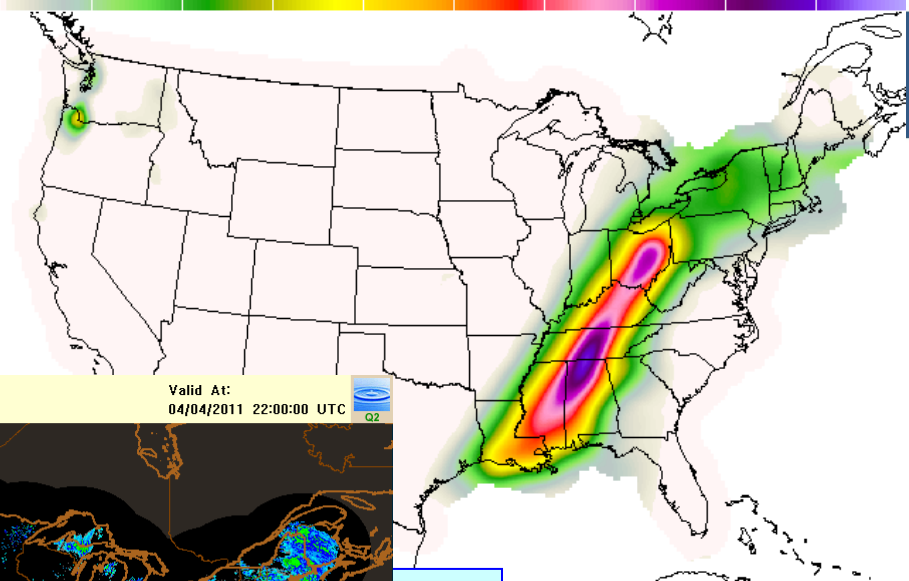
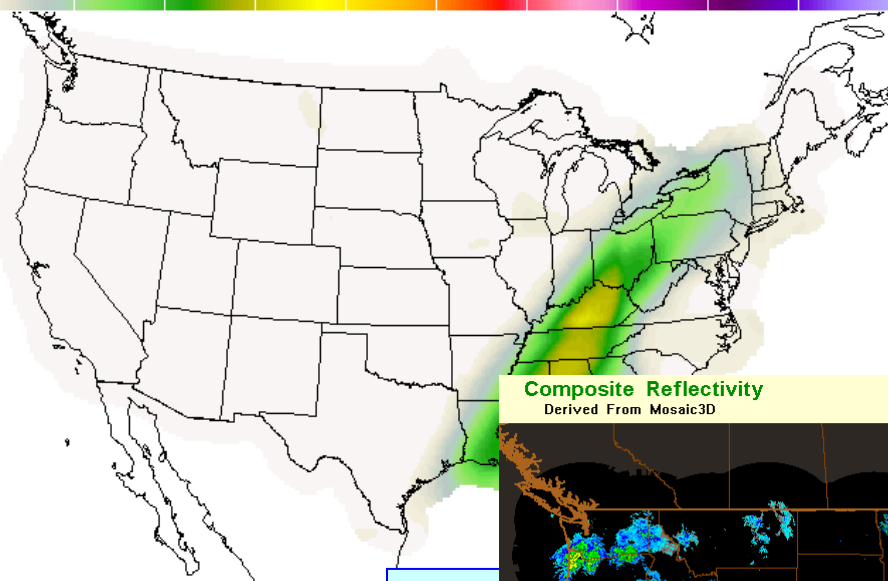
# 12-h LAMP probabilities and verification from 1800 UTC 29 Sep 2010



## LAMP Lightning Product

## LAMP Convection Product





**Composite Reflectivity**  
Derived From Mosaic3D

Valid At:  
04/04/2011 22:00:00 UTC

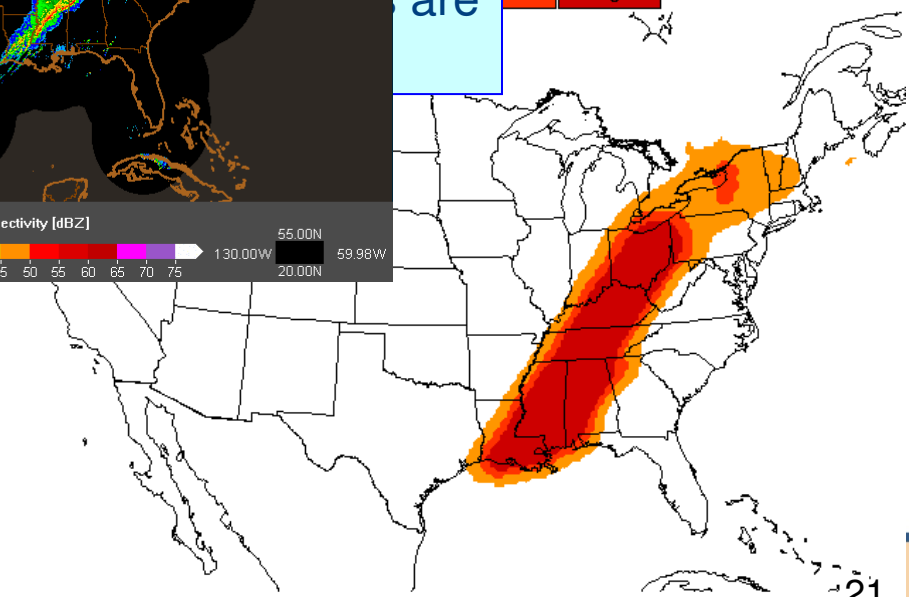
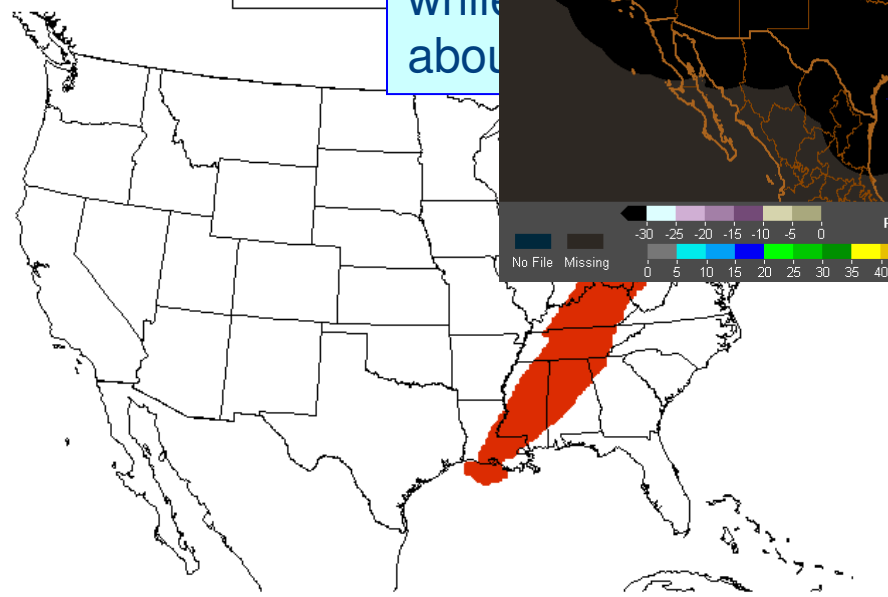
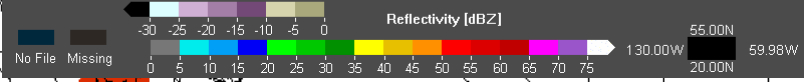
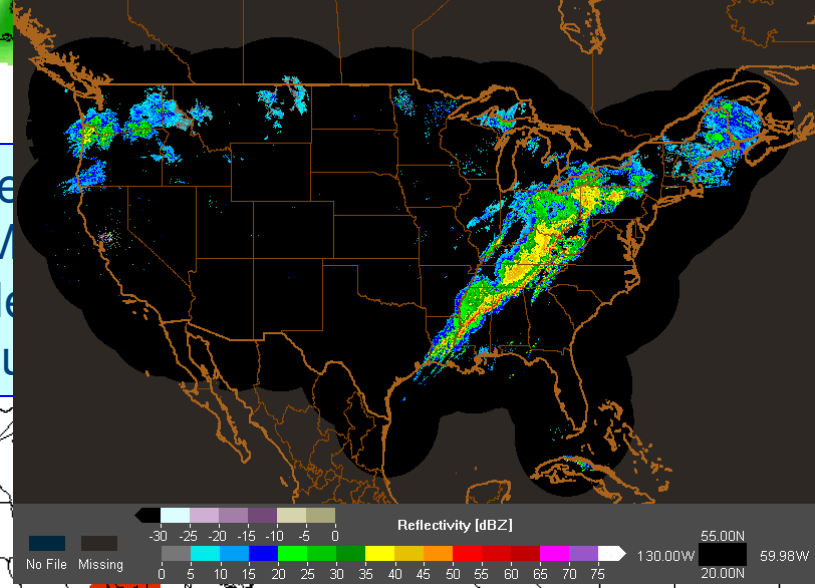


Note  
LAM  
while  
about

the  
0%  
are

Thunderstorm  
Localized A  
issuance Graph

(%) ending Mon Apr 04 2011 8PM EDT  
(Tue Apr 05 2011 00Z)  
rogram (Experimental)  
reated - Apr 03 9:47PM EDT



Thunderstorm Best Cat Valid Ending Mon Apr 04 2011 8PM EDT  
(Tue Apr 05 2011 00Z)

2-hr Convection Potential ending Mon Apr 04 2011 8PM EDT  
(Tue Apr 05 2011 00Z)

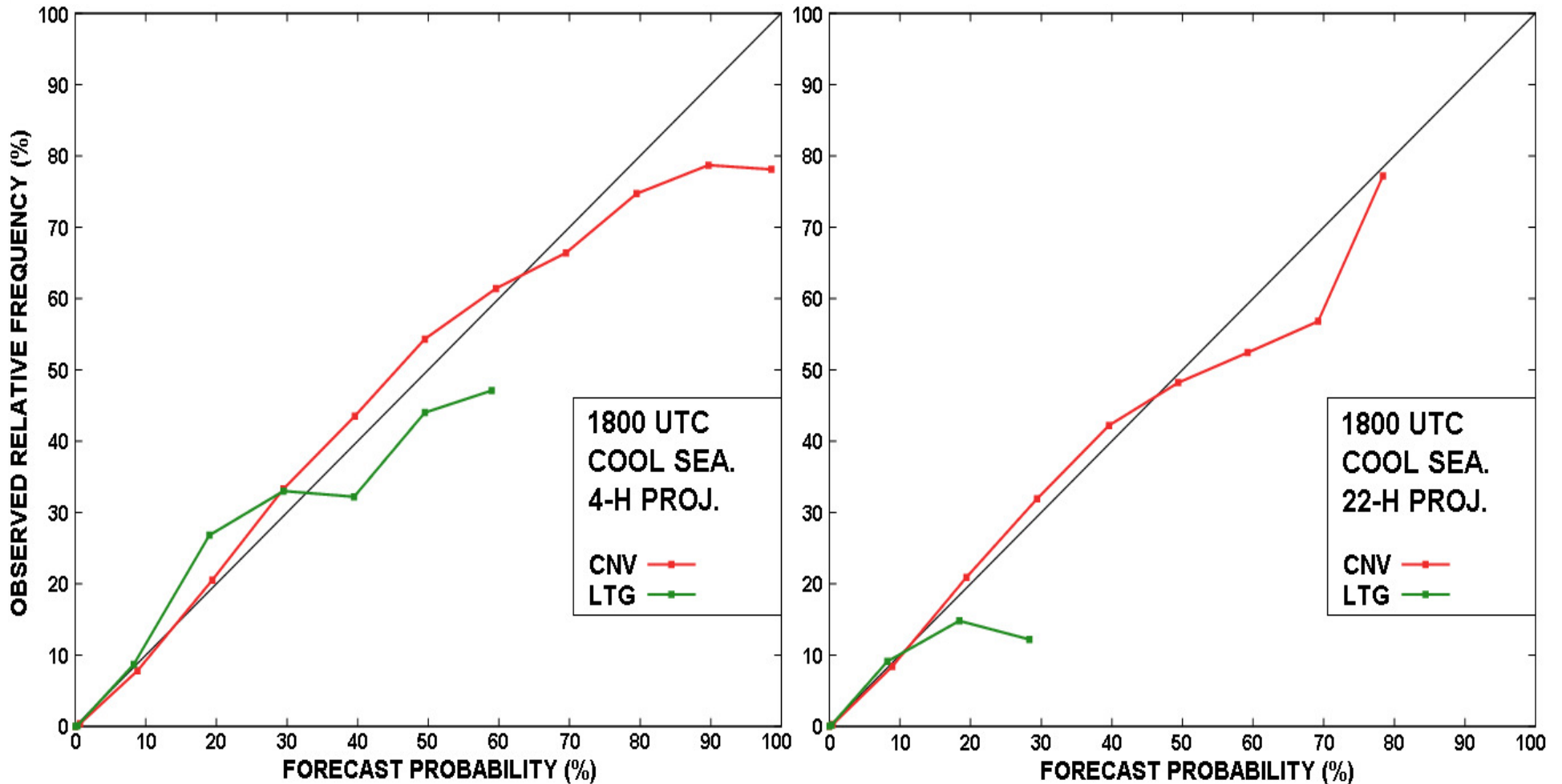
Localized Aviation MOS Program  
issuance Graphic created-Apr 03 9:44PM EDT

Localized Aviation MOS Program (Experimental)  
01z model cycle Graphic created - Apr 03 9:47PM EDT





# New LAMP Convection Forecast Results





# LAMP TAF Generation in 3 steps

		<input type="checkbox"/> All		<input type="checkbox"/> Routine		Format		◆ table		◇ long		◇ short		<input checked="" type="checkbox"/> Flight Categories		<input type="checkbox"/> Probabilities									
KOXR	GFS LAMP	Guidance				08/17/11				1500 UTC															
hour	16	17	18	19	20	21	22	23	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16
TMP	64	66	67	68	69	69	70	69	69	67	65	63	62	62	61	61	61	60	60	60	60	60	60	62	65
DPT	58	58	58	58	58	58	58	58	57	58	58	58	58	59	59	59	58	58	58	57	57	57	57	58	58
WDR	260	250	250	250	250	260	260	260	260	260	270	280	290	290	280	280	270	250	230	240	250	280	300	300	270
WSP	01	02	05	06	07	08	08	08	08	07	06	04	02	02	03	02	02	01	01	02	01	02	02	02	03
WGST	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
VIS	5	5	5	5	6	7	7	7	7	7	7	7	7	7	6	5	5	5	5	5	5	5	4	4	5
CVIS	4	5	5	4	4	4	5	5	5	4	4	5	4	5	5	4	5	4	5	5	5	3	3	3	3
OBVIS	HZ	HZ	HZ	HZ	HZ											BR	BR	BR	BR	BR	BR	BR	BR	BR	BR
CLD	BKN	SCT	SKC	SKC	SKC	SKC	SKC	SKC	SKC	SKC	SKC	SKC	SKC	SKC	SKC	SKC	SKC	SKC	SKC	OVC	OVC	OVC	OVC	OVC	OVC
CIG	3	3	3	8	8	8	8	8	8	8	3	3	3	3	3	3	3	2	2	2	2	2	2	2	2
CCIG	2	2	8	8	8	8	8	8	8	4	3	8	6	3	3	3	4	2	2	2	2	1	2	2	2
PTYPE																									
POS																									
POZ																									
PP0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
PC0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TP2																									
TC2																									

Identify Flight Categories in LAMP Forecast



# LAMP TAF Generation

```

 All  Routine Format   
GFS LAMP Guidance 08/17/11 1500 UTC
TAF AMD
KOXR 171627Z 1716/1812 00000KT 4SM HZ BKN007
FM171700 25002KT 4SM HZ SCT250
FM171800 25005KT 4SM HZ SKC
FM171900 25006KT 4SM HZ SKC
FM172000 25007KT 6SM HZ SKC
FM172100 26008KT P6SM SKC
FM172200 26008KT P6SM SKC
FM172300 26008KT P6SM SKC
FM180000 26008KT P6SM SKC
FM180100 26007KT P6SM SKC
FM180200 27006KT P6SM SKC
FM180300 28004KT P6SM SKC
FM180400 29002KT P6SM SKC
FM180500 29002KT P6SM SKC
FM180600 28003KT P6SM SKC
FM180700 28002KT 6SM BR SKC
FM180800 27002KT 4SM BR SKC
FM180900 00000KT 4SM BR SKC
FM181000 00000KT 4SM BR SKC
FM181100 24002KT 4SM BR 0VC003=

```

Convert each hourly forecast to a equivalent TAF line





# LAMP TAF Generation

```

 All  Routine Format   
GFS LAMP Guidance 08/17/11 1500 UTC
TAF AMD
KOXR 171628Z 1716/1812 00000KT 4SM HZ BKN007
FM171700 25004KT 4SM HZ SKC
FM172000 26005KT 6SM HZ BR SKC
FM180800 00000KT 4SM BR SKC
FM181100 24002KT 4SM BR OVC003=

```

## Summarize aviation elements within each flight category 'block'

- LAMP guidance TAF now converted to XML using WXXM
  - Encoding issues discovered with WXXM TAF schema
    - Dry thunderstorms
    - Low-level wind shear
- Verification of LAMP guidance TAF
  - Jan-Dec 2010 NWS TAFs sites, all cycles.
  - Little degradation compared to 'raw' hourly LAMP values
  - Analysis continues



## Adding probabilities to guidance TAF product

- Allow convenient access to wealth of reliable probabilities generated by LAMP
- Consumers can see TAF text and then investigate further if needed and use the probabilities which the TAF is based on in their own risk assessment.

# Adding probabilistic information to the guidance TAF product



```

<nawx:AerodromeGuidanceWx>
  <nawx:cloudCondition>
    <nawx:DiscreteCloudConditionGuidance>
      <gml:description>Best estimate of total sky cover condition</gml:description>
      <nawx:cloudAmount>BROKEN</nawx:cloudAmount>
      <nawx:probabilityAmount>
        <nawx:ProbabilityCloudAmount cloudAmount="CLEAR" probability="16"/>
      </nawx:probabilityAmount>
      <nawx:probabilityAmount>
        <nawx:ProbabilityCloudAmount cloudAmount="FEW" probability="5"/>
      </nawx:probabilityAmount>
      <nawx:probabilityAmount>
        <nawx:ProbabilityCloudAmount cloudAmount="SCATTERED" probability="6"/>
      </nawx:probabilityAmount>
      <nawx:probabilityAmount>
        <nawx:ProbabilityCloudAmount cloudAmount="BROKEN" probability="6"/>
      </nawx:probabilityAmount>
      <nawx:probabilityAmount>
        <nawx:ProbabilityCloudAmount cloudAmount="OVERCAST" probability="68"/>
      </nawx:probabilityAmount>
    </nawx:DiscreteCloudConditionGuidance>
  </nawx:cloudCondition>

```

VIS	5	5	5	5
cat1	1	1	0	0
cat2	1	1	0	0
cat3	2	2	0	0
cat4	5	5	2	1
cat5	76	62	50	38
cat6	89	78	67	54
CVIS	4	5	5	4
cat1	0	0	0	0
cat2	0	0	0	0
cat3	19	4	0	11
cat4	36	31	21	30
cat5	100	83	70	82
cat6	100	87	85	90
OBVIS	HZ	HZ	HZ	HZ
CLD	BKN	CT	SKC	SKC
BKN	16	36	49	59
FEW	5	8	11	11
SCAT	6	9	8	10
BKN	6	6	6	4
OVVC	68	42	27	16
CIG	3	3	3	8
cat1	2	0	0	0
cat2	39	15	6	2
cat3	33	30	21	15
cat4	1	2	4	2
cat5	0	0	0	0
cat6	0	0	0	0
cat7	0	0	0	0
cat8	26	52	69	80
CCIG	2	2	8	8
cat1	0	0	0	0
cat2	90	57	0	0
cat3	0	23	19	17
cat4	0	0	0	0

# Current Implementation



Air Transportation Information  
Exchange Conference - (featuring  
AIXM, WXXM and FIXM)

- NWS is a 'in-kind' participant in OWS-8
  - Provided four different scenarios which GA pilots and airline decision-makers can use the probabilistic data in the guidance TAF product
  - Provided a public-facing WFS for users to obtain the new product
  - Several OWS-8 participants have prototyped client applications to display the guidance TAFs.
    - Luciad
    - Atmosphere



Federal Aviation  
Administration

# Guidance TAF Visualizer



Air Transportation Information Exchange Conference - (featuring AIXM, WXXM and FIXM)



- Prototype developed by Thibault Dacla  
 ATMOSPHERE [www.atmosphere.aero](http://www.atmosphere.aero)



Federal Aviation Administration



# Future Plans

- Continue to improve guidance TAF text algorithms
  - Guided by verification results
- As more gridded LAMP fields become available in NDGD...
  - Guidance TAFs at any point



# Issues

- WXXM
  - Reliable probabilistic guidance now available and more to come
    - How to best encode them?
  - How will FAA (EuroControl) address the introduction of forecast uncertainty in products?



EUROCONTROL



Federal Aviation  
Administration



# Summary

- Forecast uncertainty is a essential part of the total weather picture
  - Missing in many products for a long time
  - Potentially enormous economic benefits to end-users
- WXXM schemas needs to be able to encode the uncertainty information
- Need regulatory agencies' input



# Questions & Answers / Feedback



Air Transportation Information  
Exchange Conference - (featuring  
AIXM, WXXM and FIXM)



Federal Aviation  
Administration



Air Transportation Information  
Exchange Conference - (featuring  
AIXM, WXXM and FIXM)

# Contact & Sources

Presenter: Mark Oberfield W/OST24  
Product Development Branch  
Meteorological Development Laboratory  
Mark.Oberfield@noaa.gov  
301-713-0056 x192

GFS-LAMP Web Page: [www.nws.noaa.gov/tdl/lamp/](http://www.nws.noaa.gov/tdl/lamp/)

National Research Council, 2006: *Completing the Forecast. Characterizing and Communicating Uncertainty for Better Decisions Using Weather and Climate Forecasts*. National Academies Press. 124 pp.



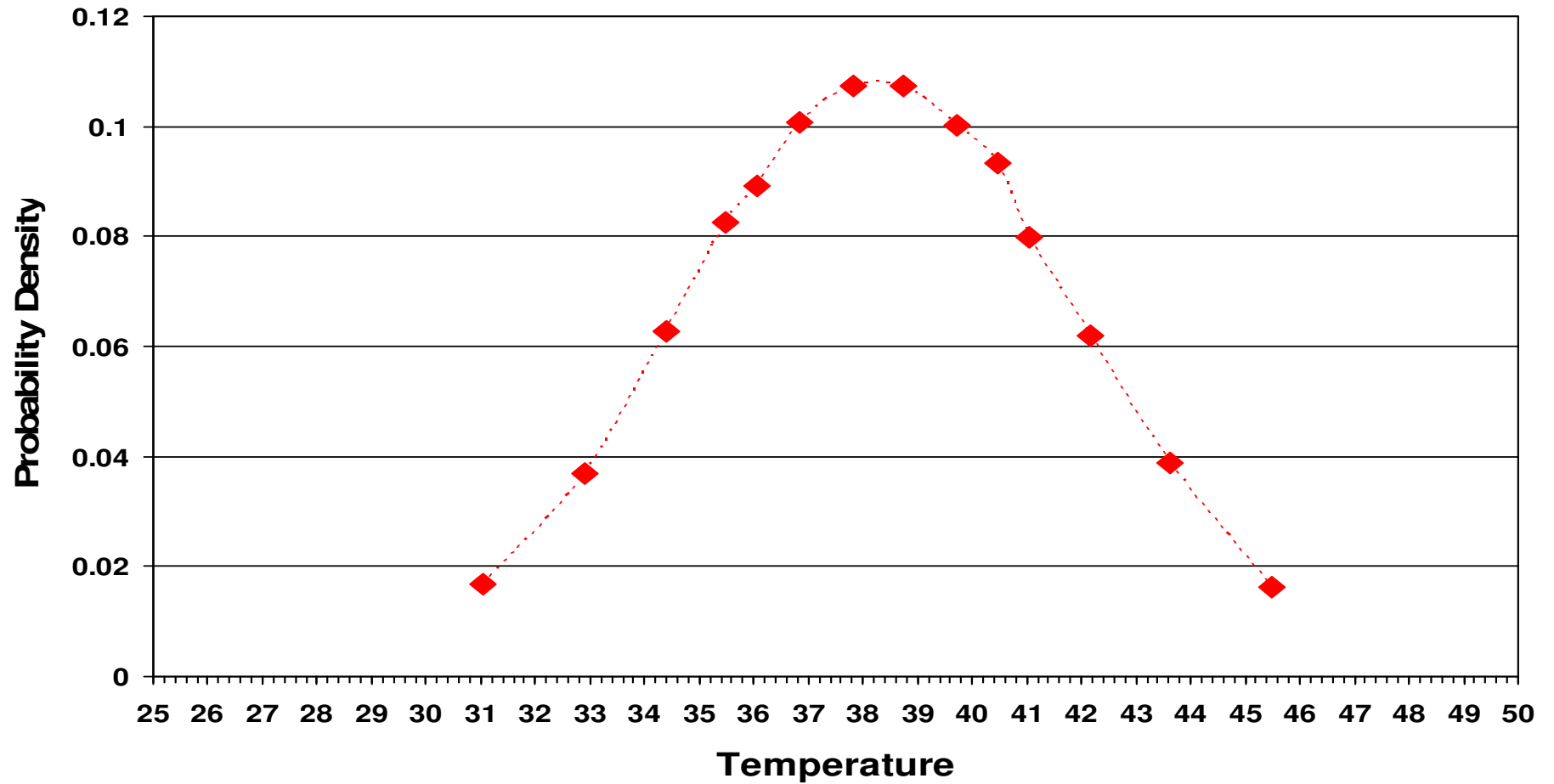
EUROCONTROL



Federal Aviation  
Administration

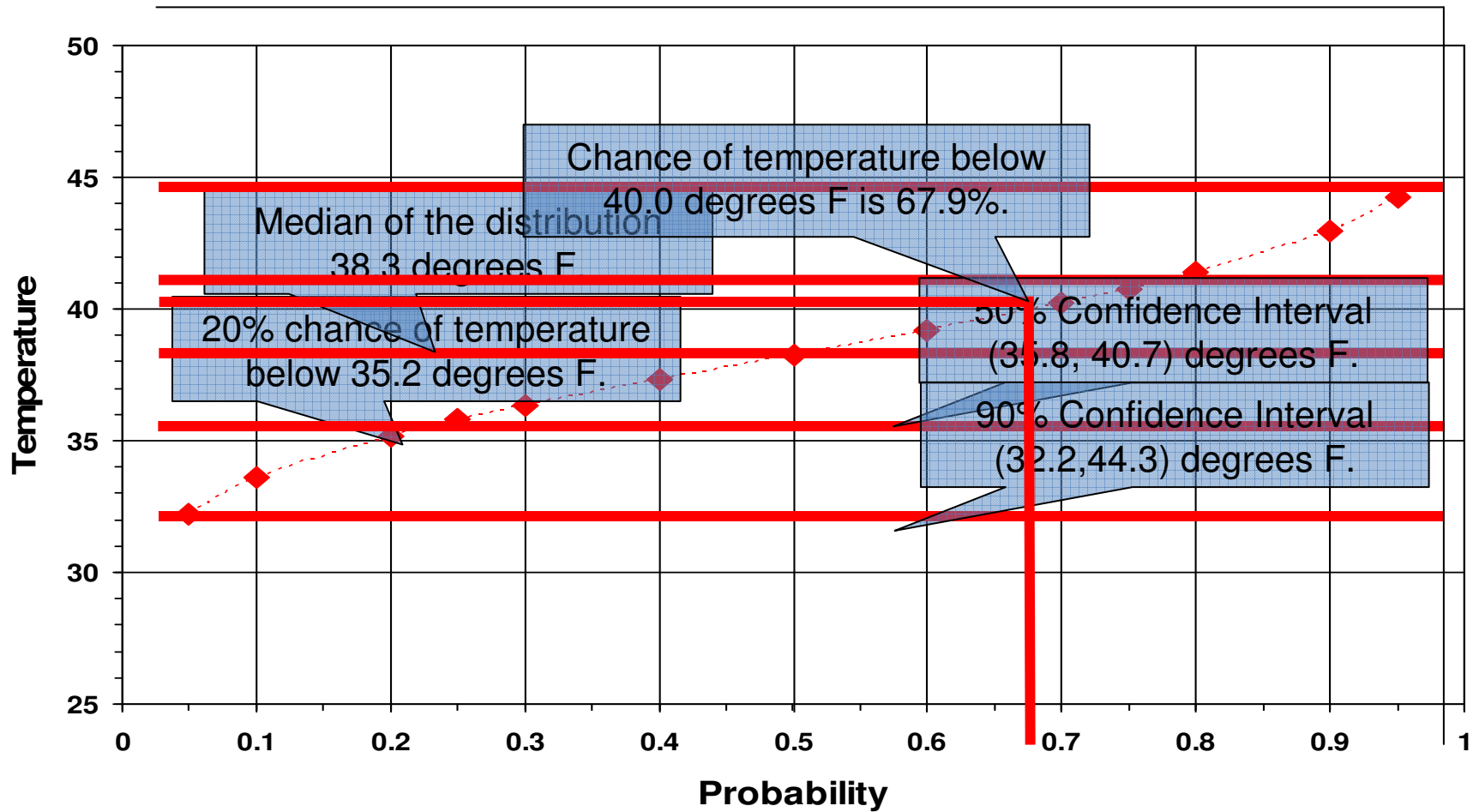


## Sample Probability Density Function (PDF) for T



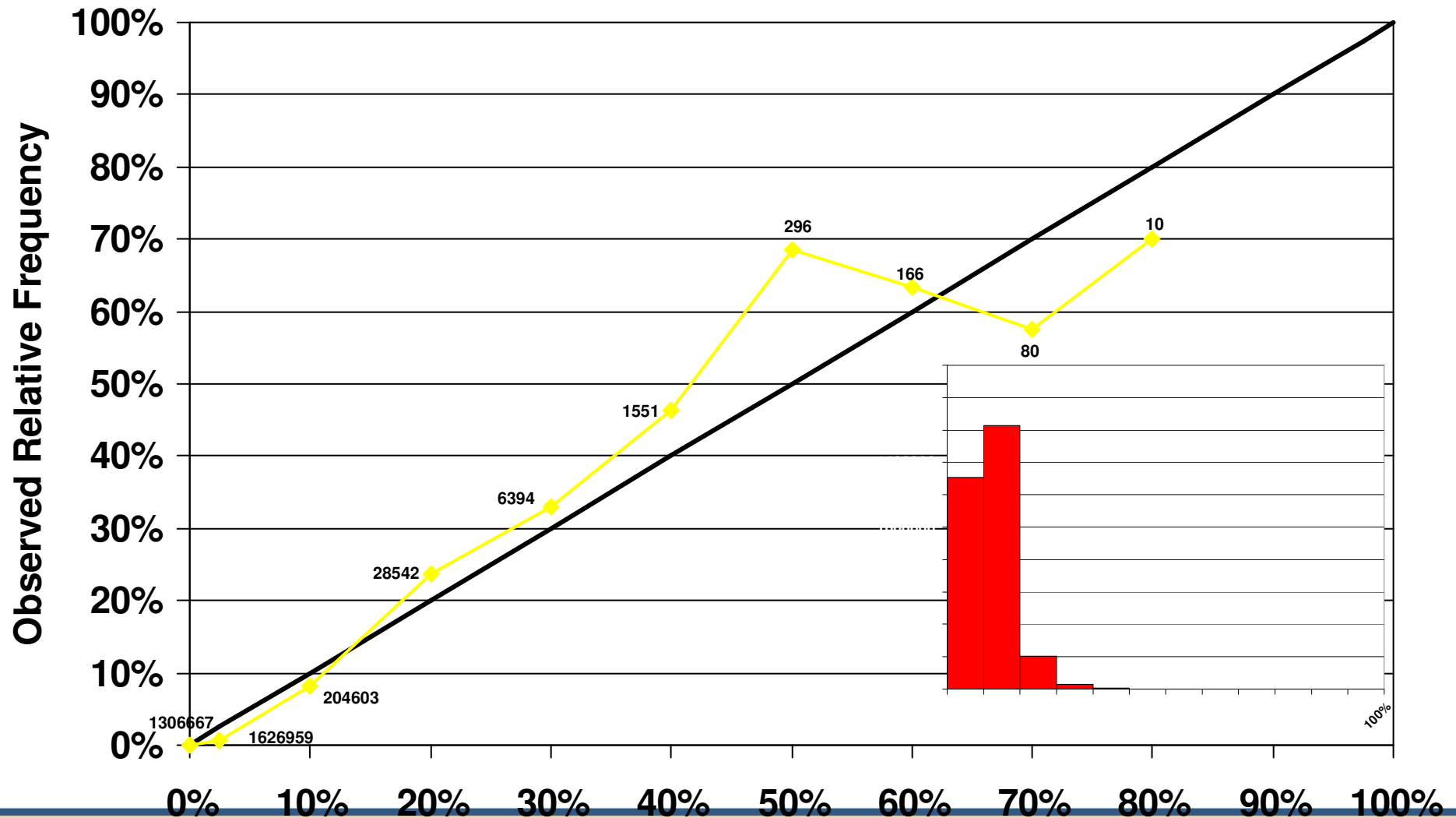


## Sample T Forecast as Quantile Function (CDF)



# Reliability of 0300 UTC 06-h Thunderstorms

Warm Season: 2006 Aug - Sep, 2007 Apr - May, 27373 grid points



Forecast

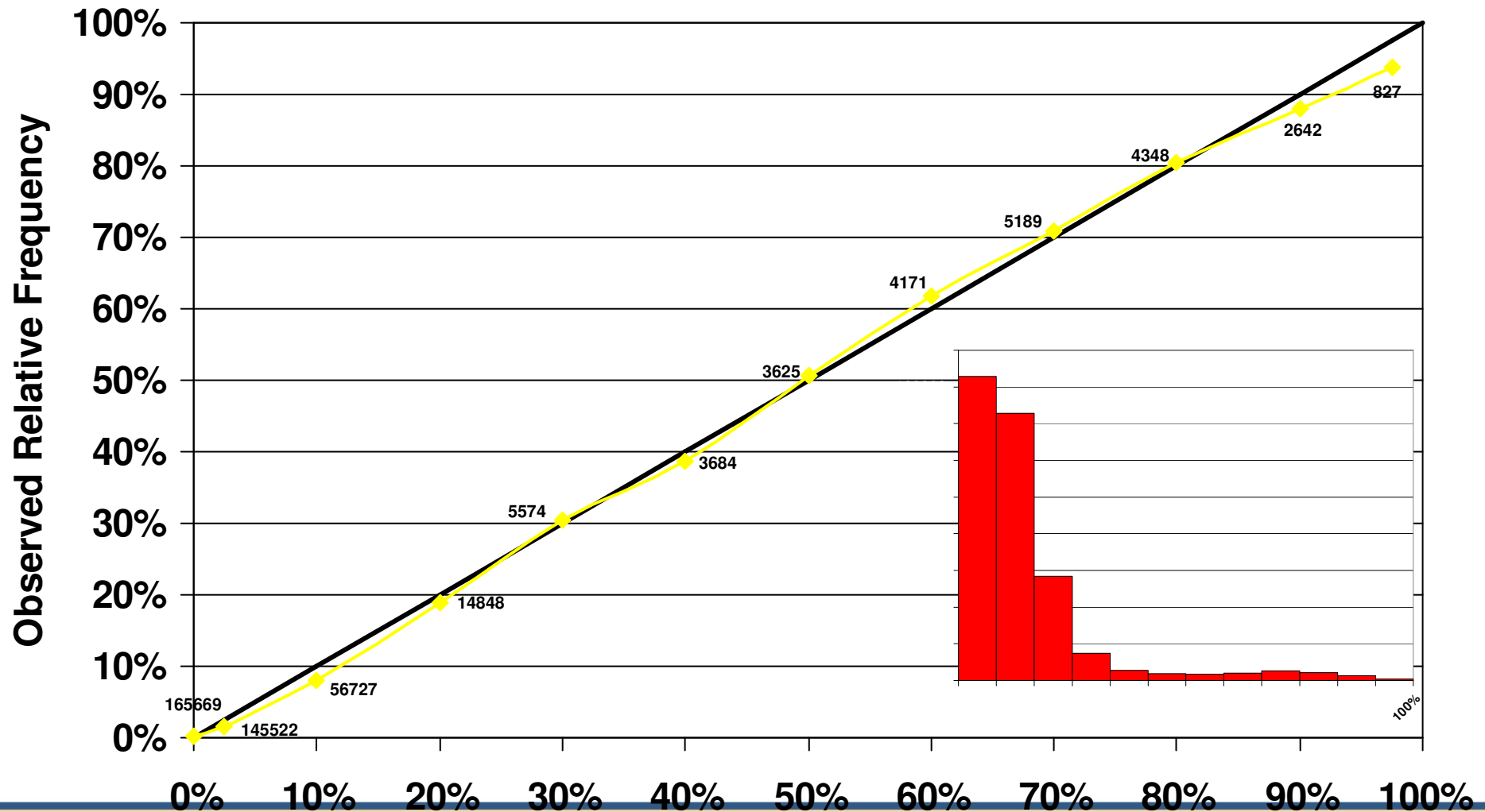


Federal Aviation Administration

# Reliability of 0300 UTC 03-h Ceiling < 1000 feet

2006 Aug - 2007 May, 1522 sites

Air Transportation Information  
Exchange Conference - (featuring  
AIXM, WXXM and FIXM)



Forecast

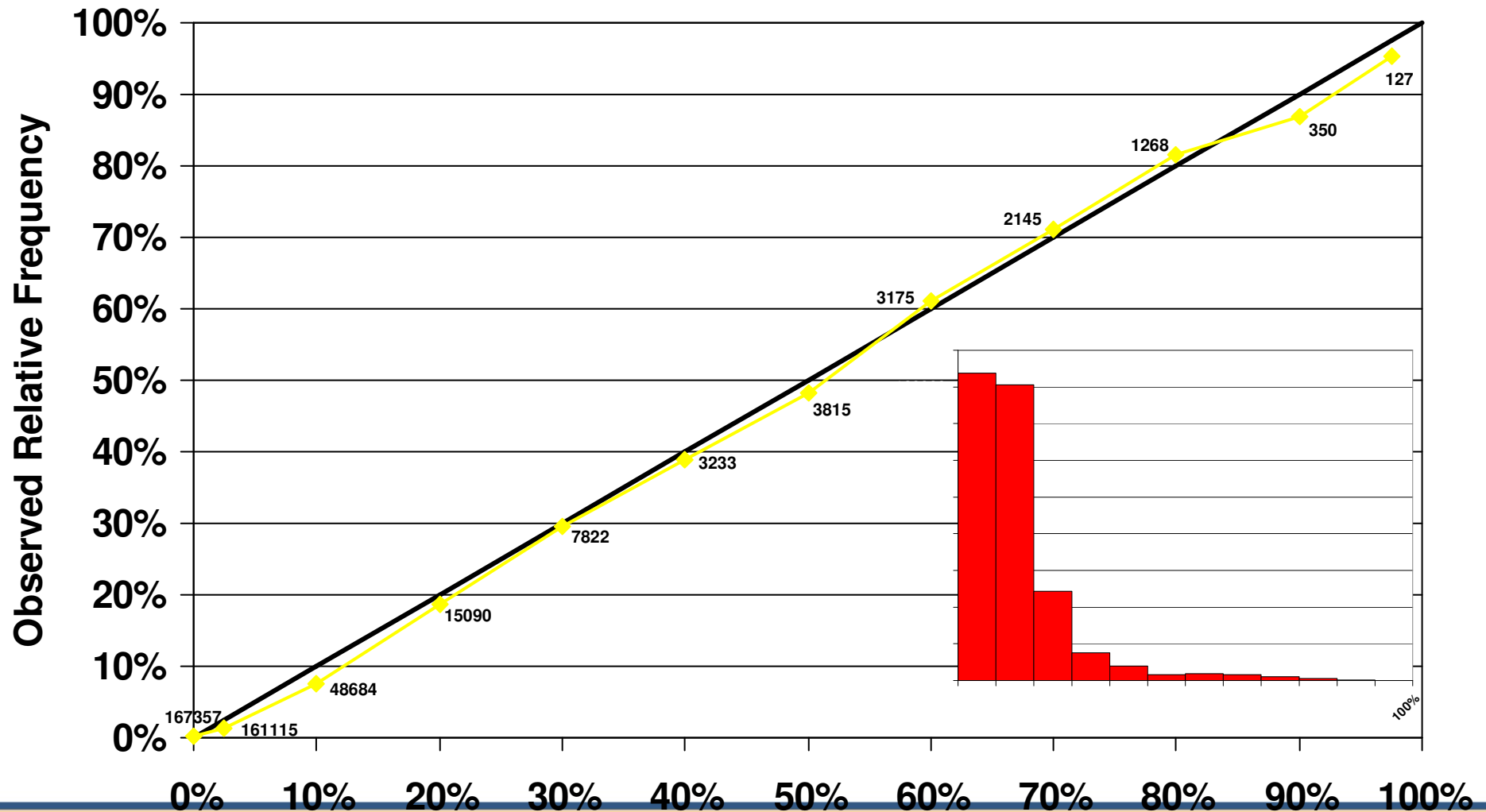


Federal Aviation  
Administration

# Reliability of 0300 UTC 03-h Visibility < 3 miles

2006 Aug - 2007 May, 1522 sites

Air Transportation Information  
 Exchange Conference - (featuring  
 AIXM, WXXM and FIXM)



Forecast



Federal Aviation  
 Administration

# Ceiling Height Verification for 0000 UTC

## Threat of Ceiling Height < 1000 Feet



Air Transportation Information Exchange Conference - (featuring AIXM, WXXM and FIXM)

