The Preliminary Assessment of a Clear-Air Turbulence Product

By: Ankita Nagirimadugu

Background

- **Ways CAT is Produced:**
  - Eddies
  - Kelvin-Helmholtz Instability
  - Internal Gravity Wave
- **Effects of CAT**
- **Indicators of CAT:**
  - Jet Stream
  - Transverse Cirrus Bands

Pilot Report (PIREPS)

- Used to enhance flight safety
- Pilots report the occurrence of turbulence to the FAA and the FAA lets all other aircrafts know about this
- They are highly subjective
  - Size, structure and shape or aircraft
  - Experience of pilot

PIREP Codes

Code	
0	None
1	Light
2	Light-Moderate
3	Moderate
4	Moderate-Severe
5	Severe
6	Extreme

DVSI algorithm

- DVSI, also known as the Turbulence Index (TI), is the product of resultant deformation (A) and vertical wind shear (B).

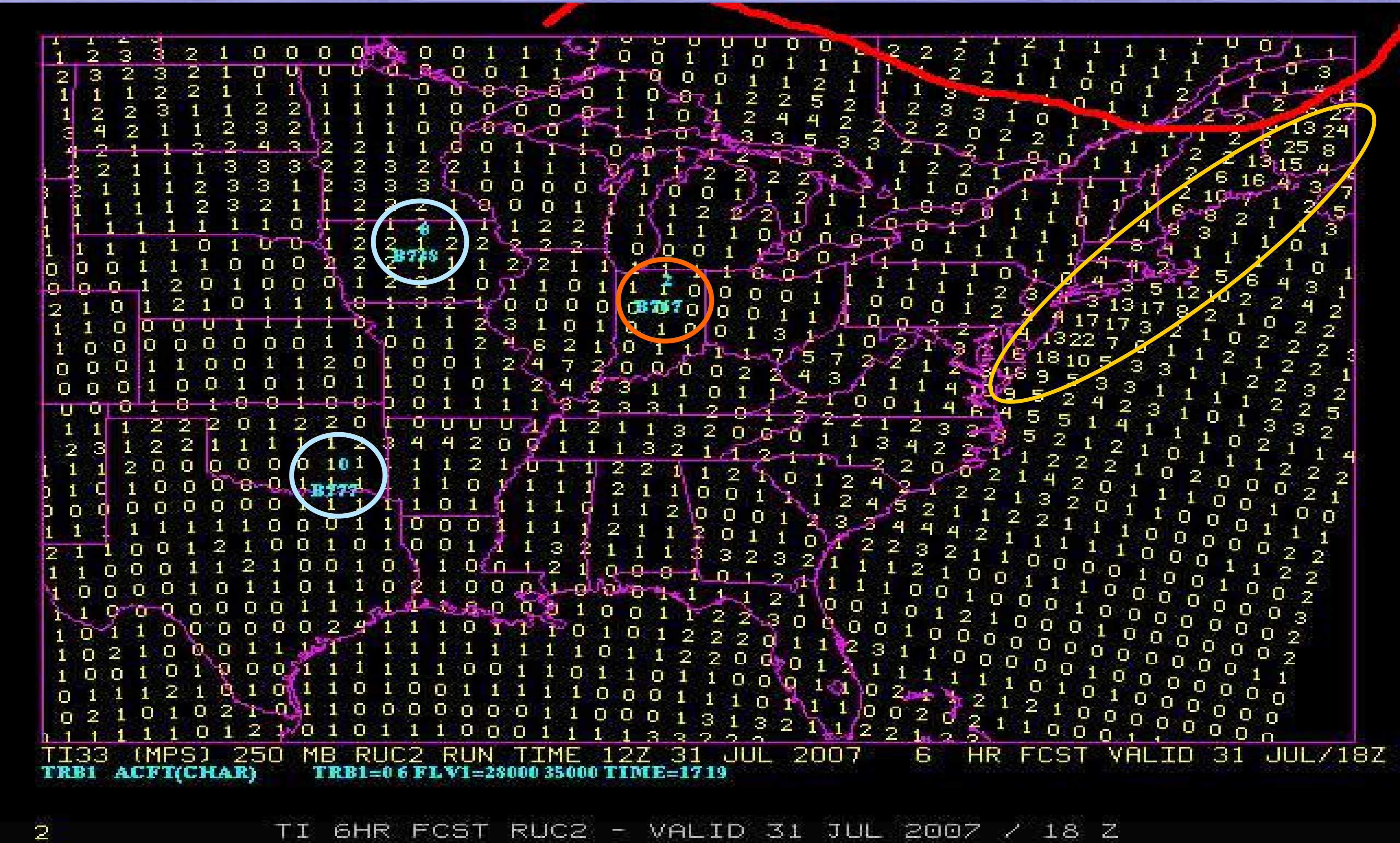
$$\underbrace{[(\delta u/\delta x - \delta v/\delta y)^2 + (\delta v/\delta x + \delta u/\delta y)^2]^{1/2}}_{A} \underbrace{(\delta V/\delta z)}_{B}$$

Methods

Goal: To try to correlate the PIREPS to the turbulence index (unit less)

1. Collect images of forecasted CAT
2. Highlight notable regions
3. Collect data
4. Refine the data
5. Graph and correlate

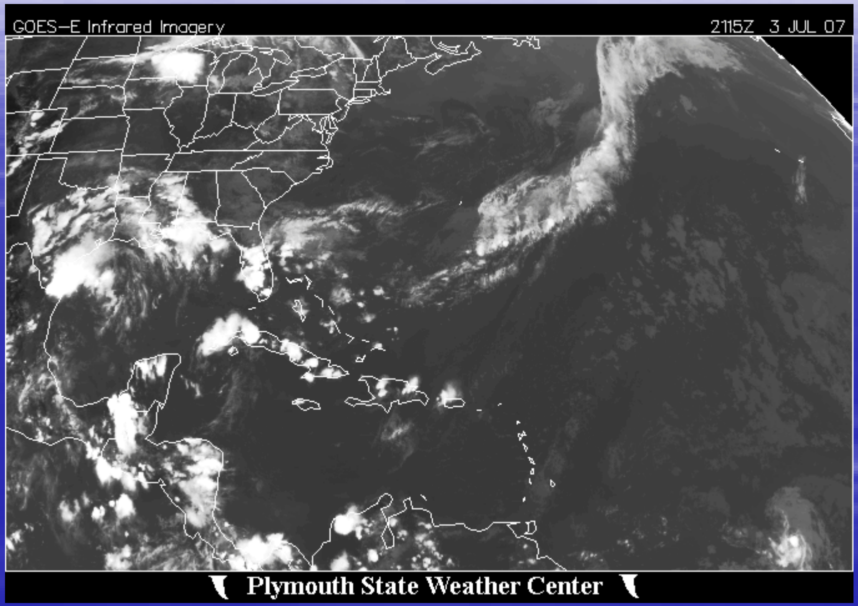
Highlight Notable Regions

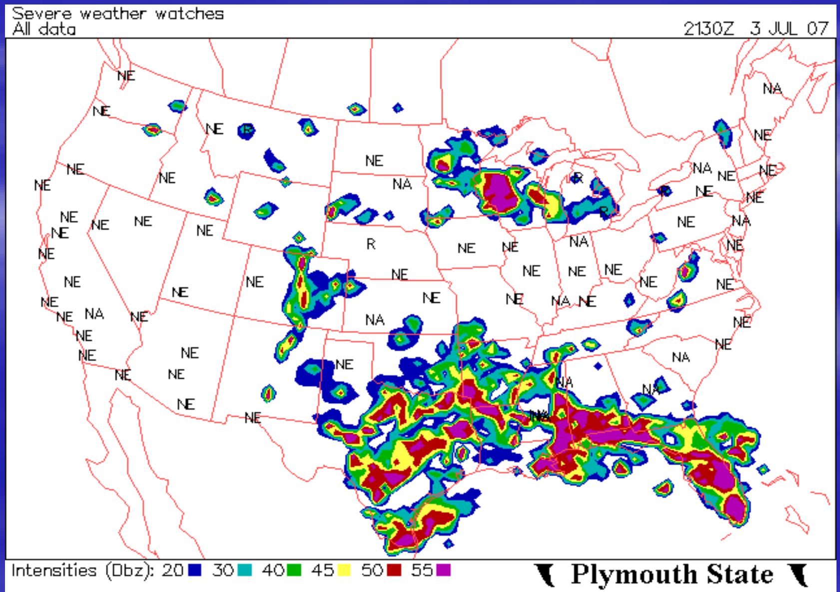


Date	Time(UTC)	Code	Plane Type	Location	DVSI	T-Storm
Jul-31-07	231	2	C525	TN	2	
		2	CRJ7	KY	0	
		0	BE40	WV	2	
	24					
	57					
	810					
	1113					
	1416	2		OK	2.5	
	1719	0	B777	OK	1	
		0	B738	IA	2	
		2	B767	IN	1	
	2022	2	B737	OK	2	
		6	CRJ7	AR	1	
		4		IL	3	
		0	B737	KY	0	

Type of images

- Satellite
- Radar
- Model Forecasted





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		0	B738	IA	2
		2	B767	IN	1
	2022	2	B737	OK	2
		4		IL	3
		0	B737	KY	0

Case 1

July 5, 2007, 0Z

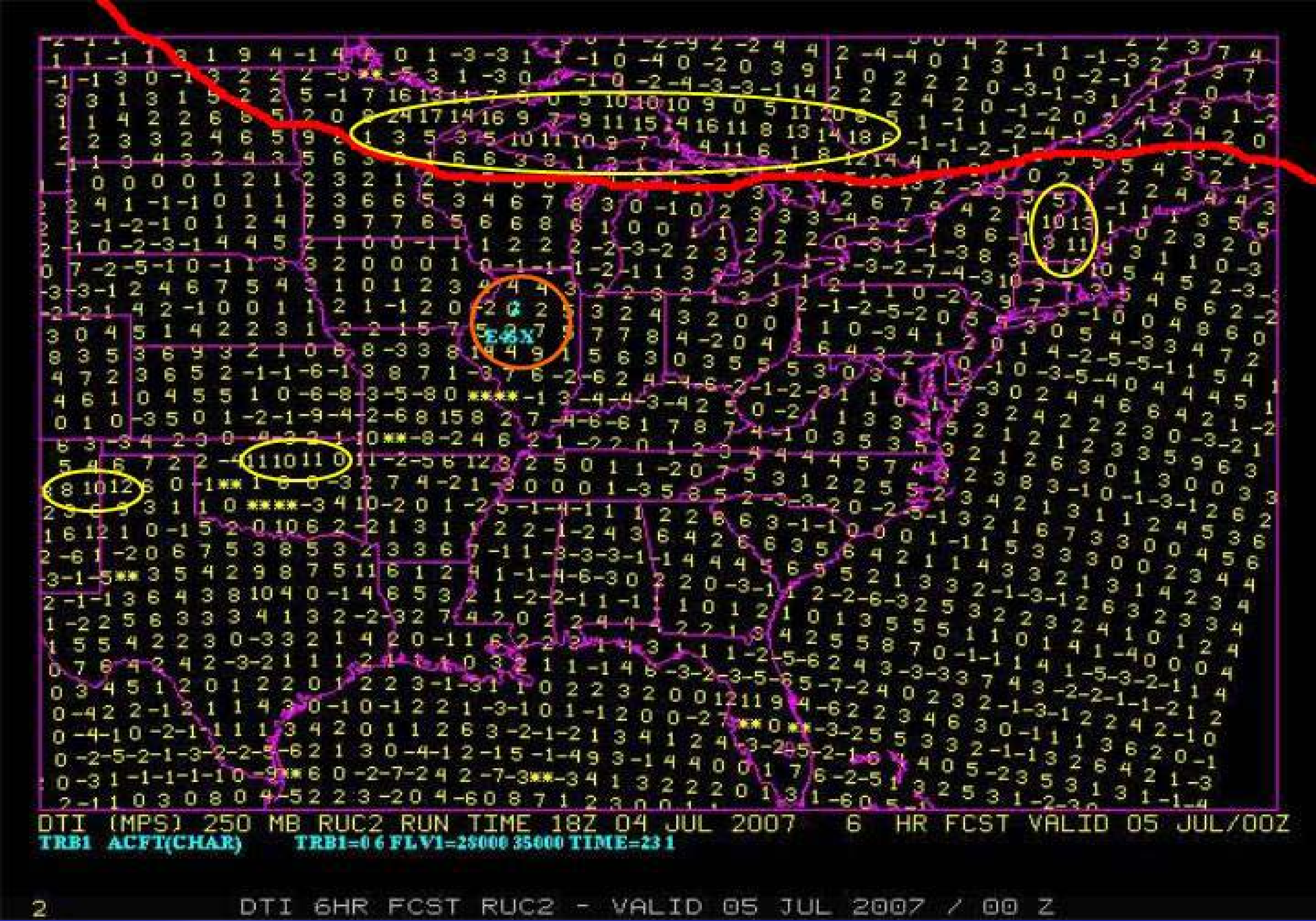

Fig.1: Image of forecasted CAT, point in Illinois removed

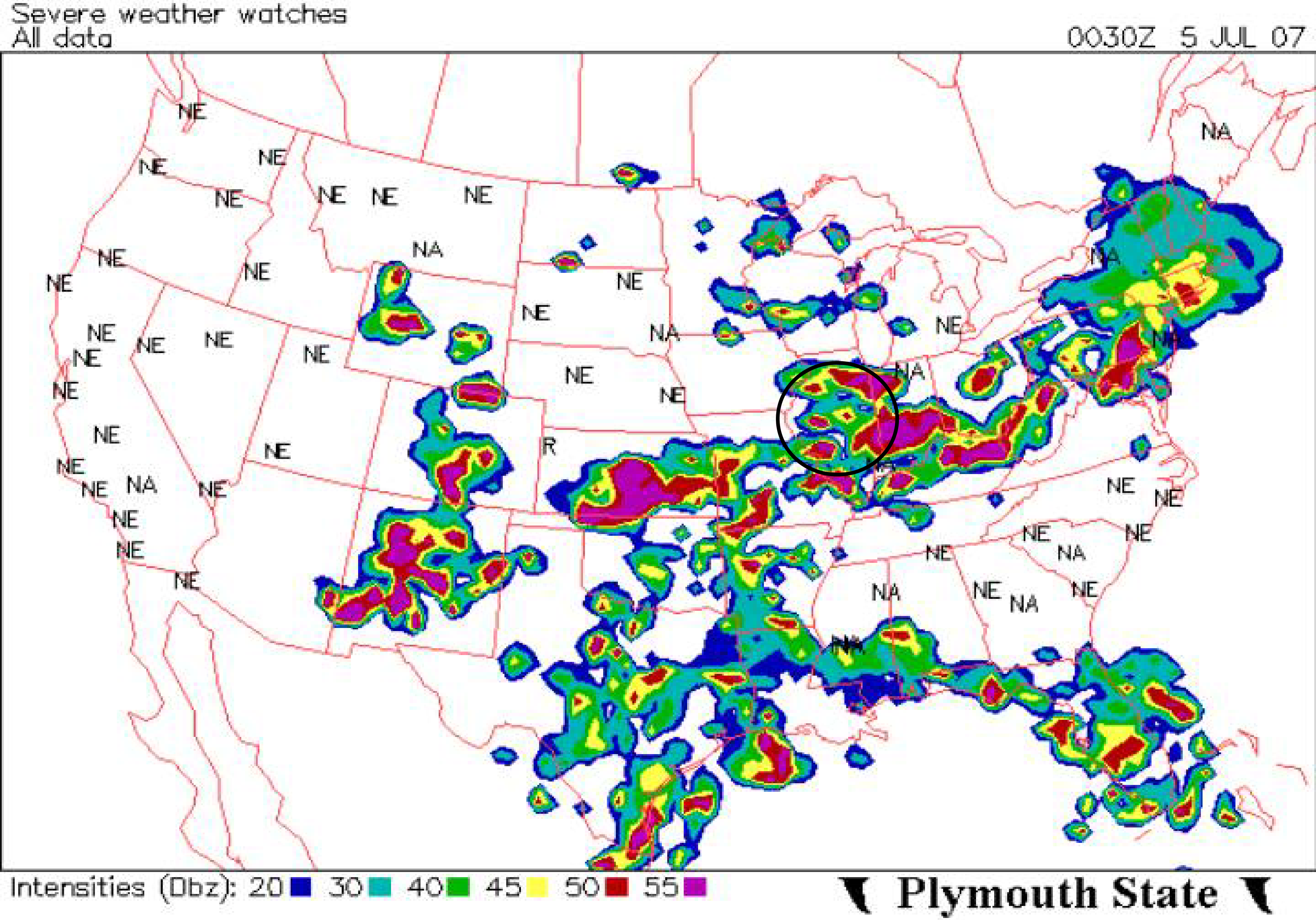

Fig.2 Radar image, doubtful point in Illinois due to storm in the indicated radius

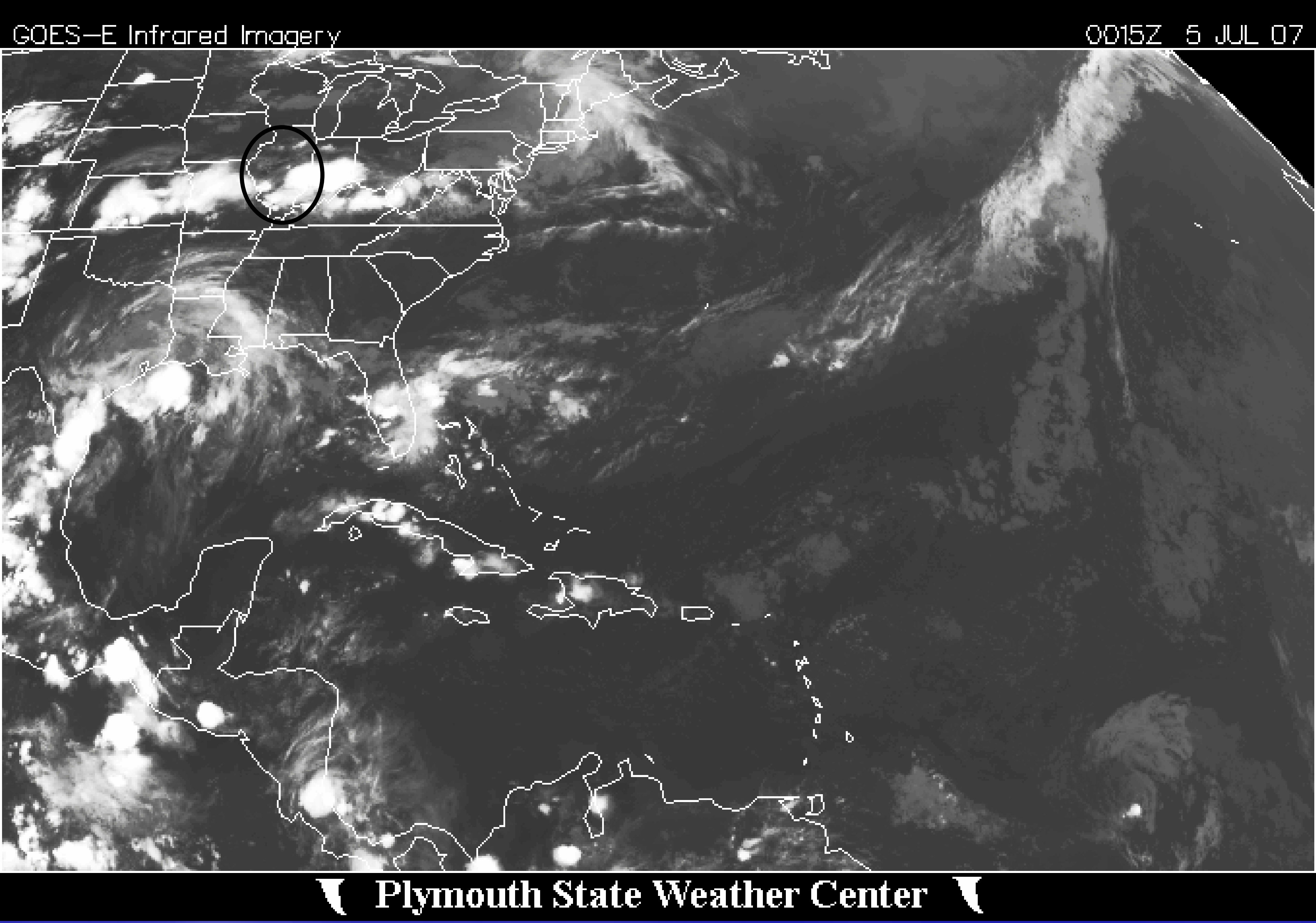

Fig. 3 Satellite Image, doubtful point in Illinois due to storm in the indicated radius

Case 2

July 5, 2007, 15Z

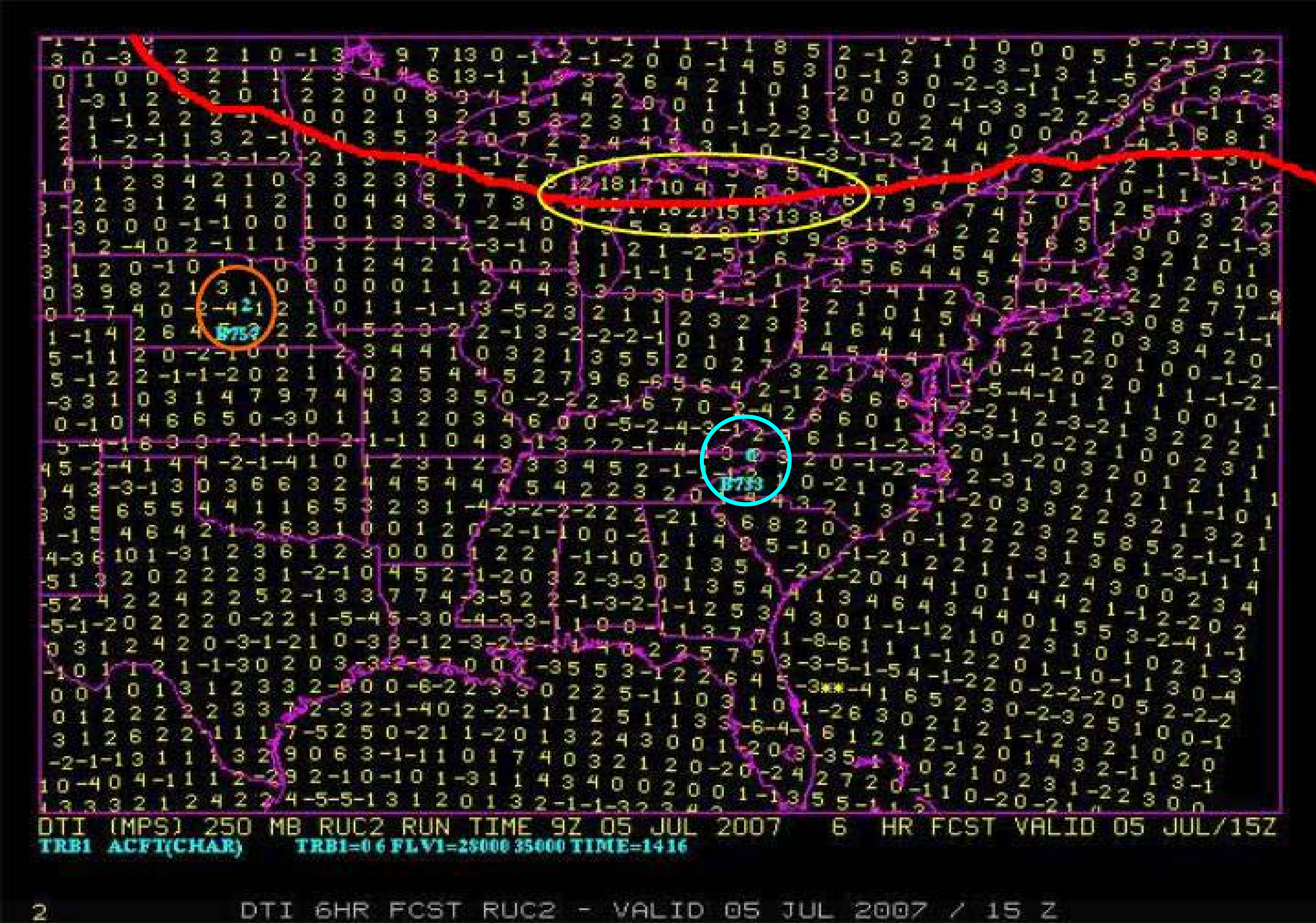

Fig.4: Image of forecasted CAT, point in Nebraska not removed

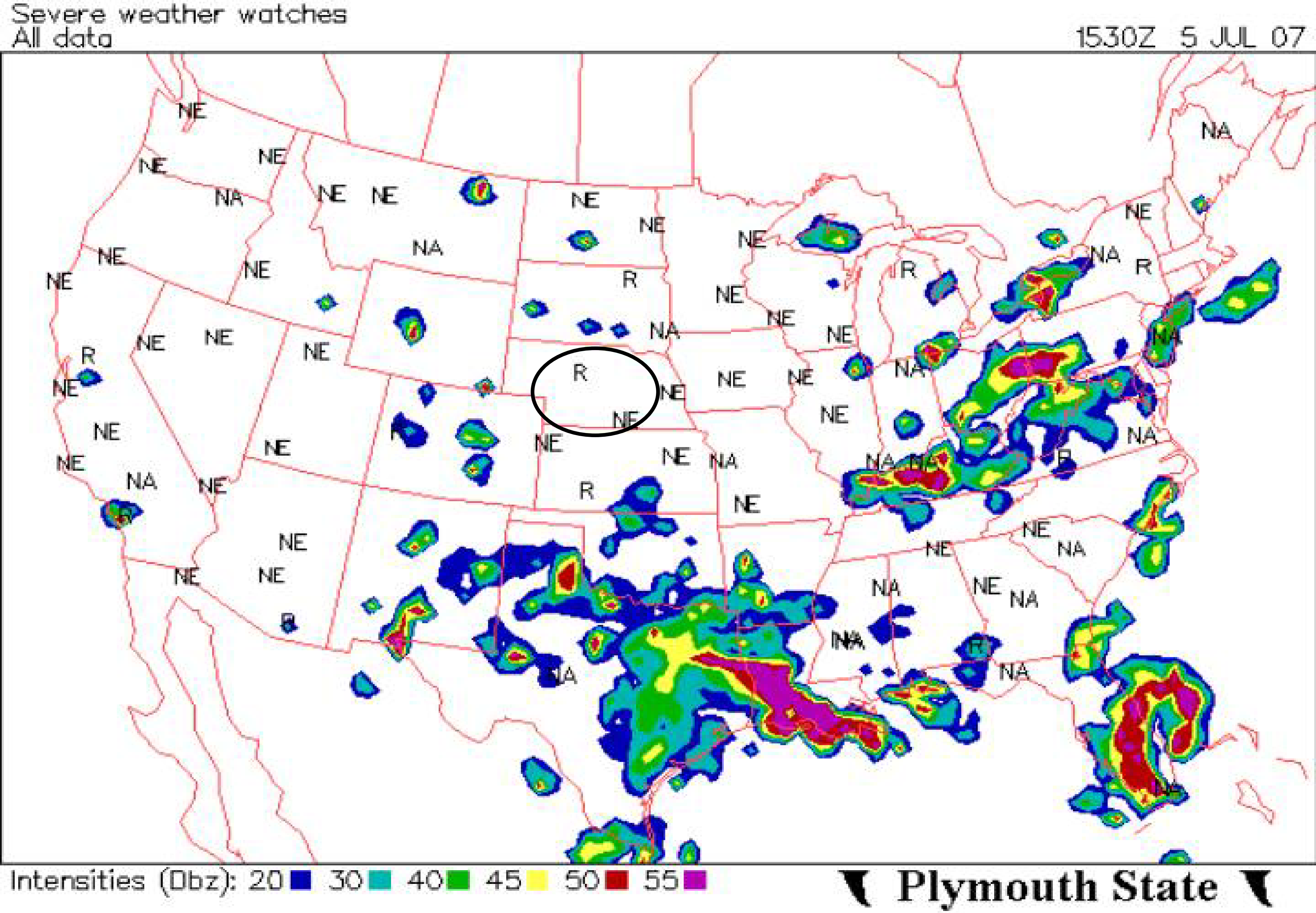

Fig.5: Radar image, doubtful point in Nebraska is not affected by the storms

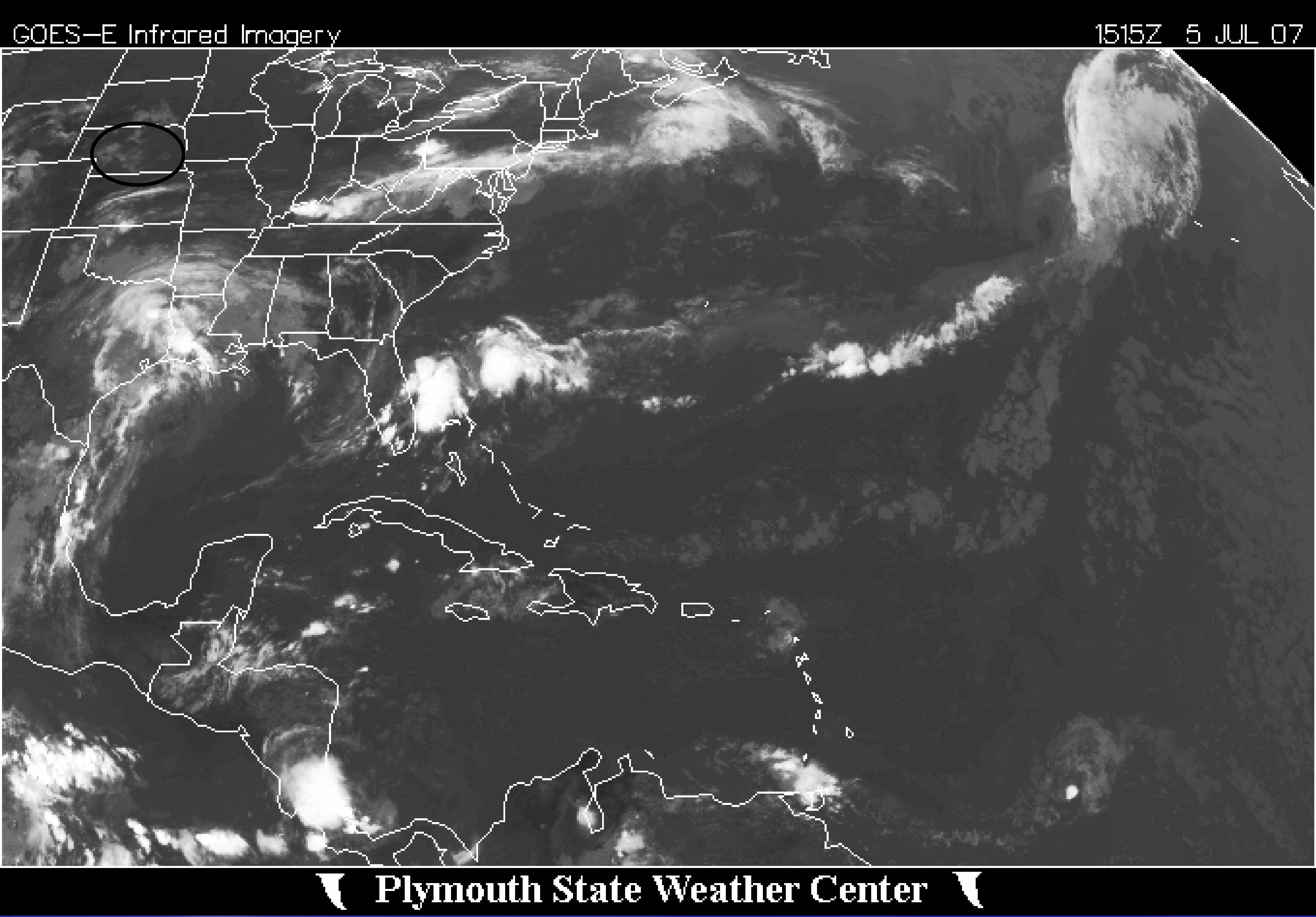

Fig. 6 Satellite Image, doubtful point in Nebraska not removed

Case 3

July 3, 2007 21Z

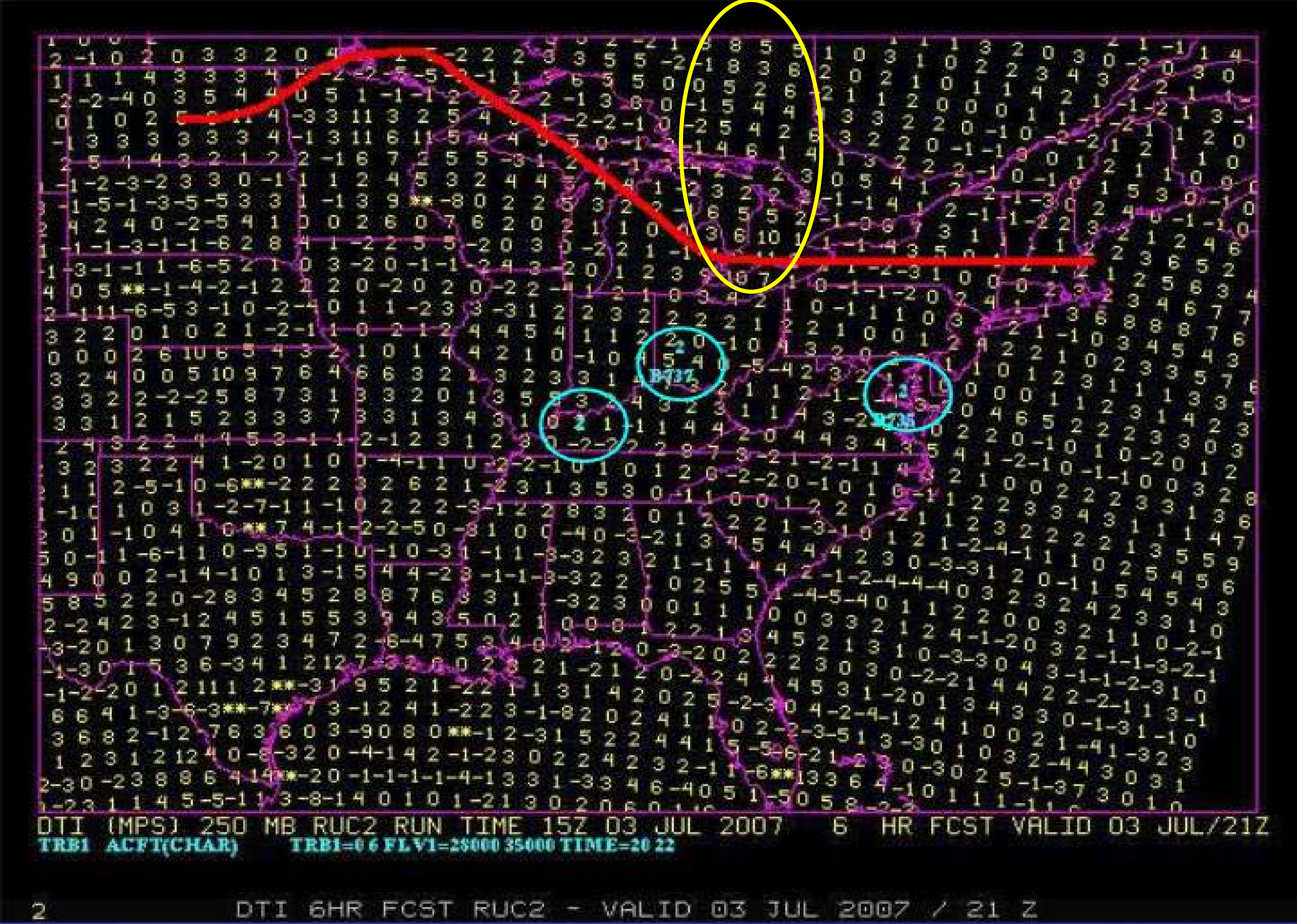

Fig. 7 Image of forecasted CAT, points in Kentucky, Ohio, and Maryland

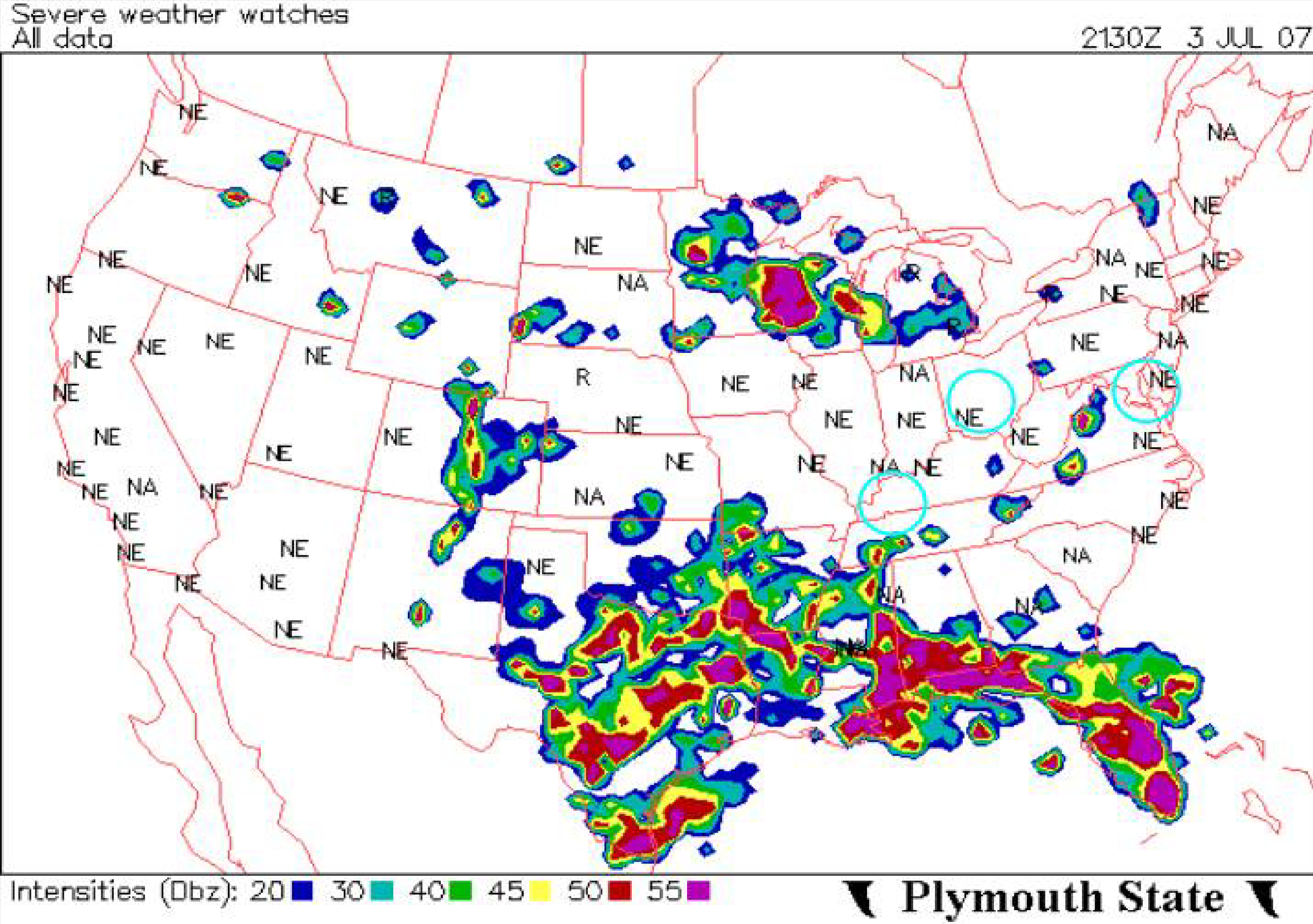

Fig. 8 Radar image of forecasted CAT, points in Kentucky, Ohio, and Maryland

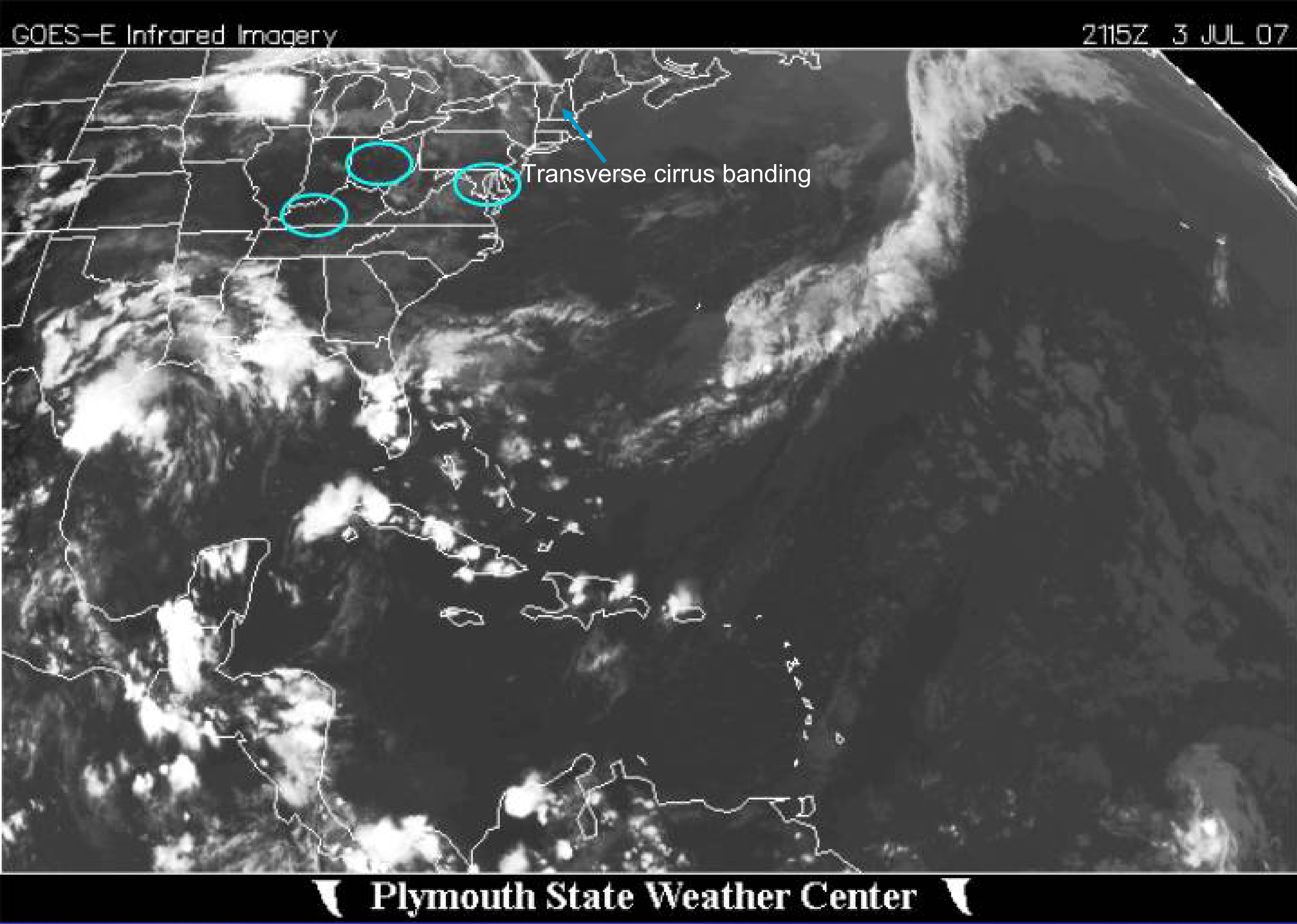

Fig. 9 Satellite image of forecasted CAT, points in Kentucky, Ohio, and Maryland

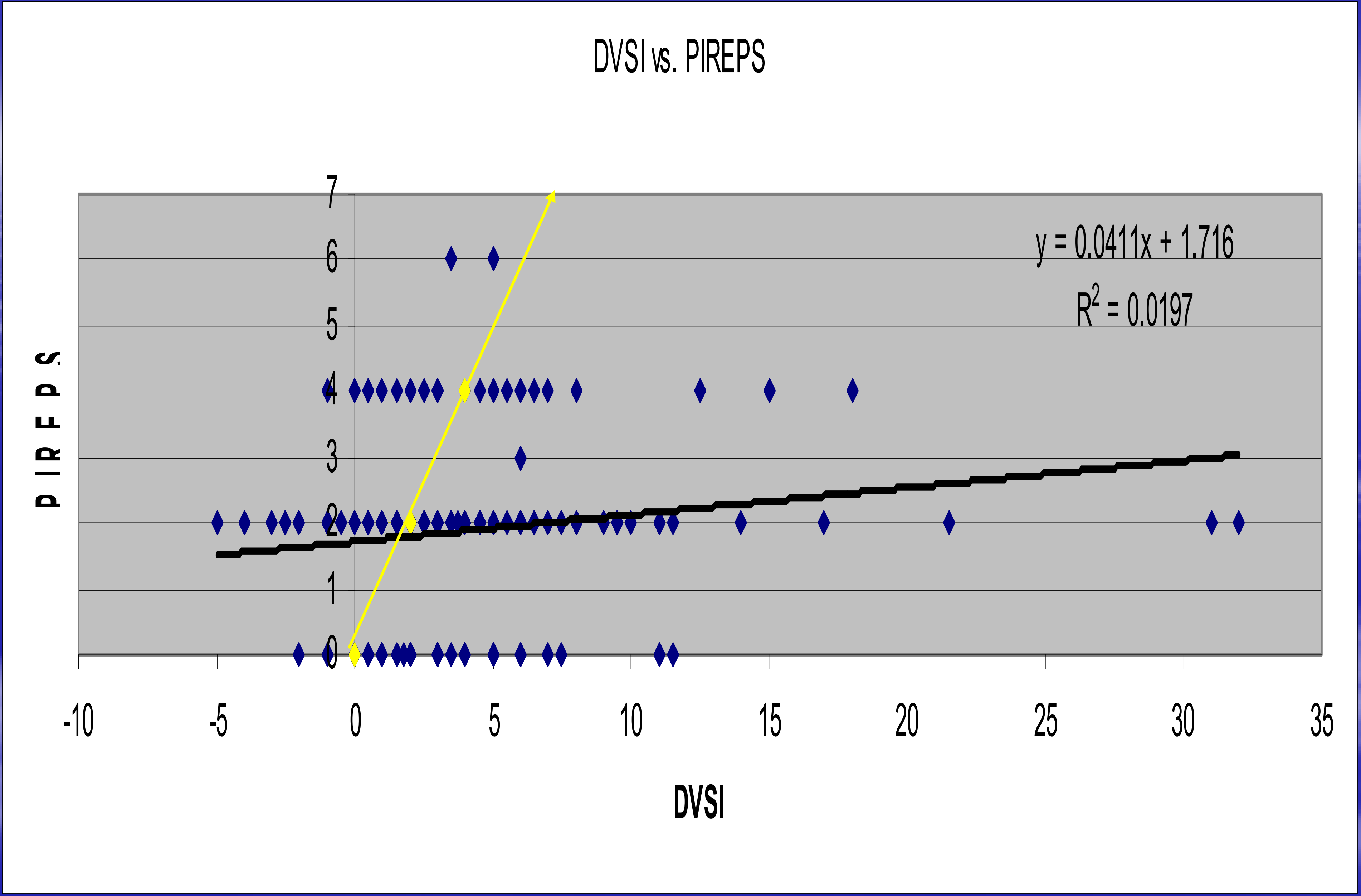

Fig.10 The correlation between the DVSI and PIREPS after the removal of doubtful points

Types Of Aircraft Tested

E145	A320
▪49 passengers ▪Travels at 833km/h, ▪Cruising altitude: 11278m	▪162 passengers ▪Travels at 900km/h ▪Cruising altitude: 11,700m

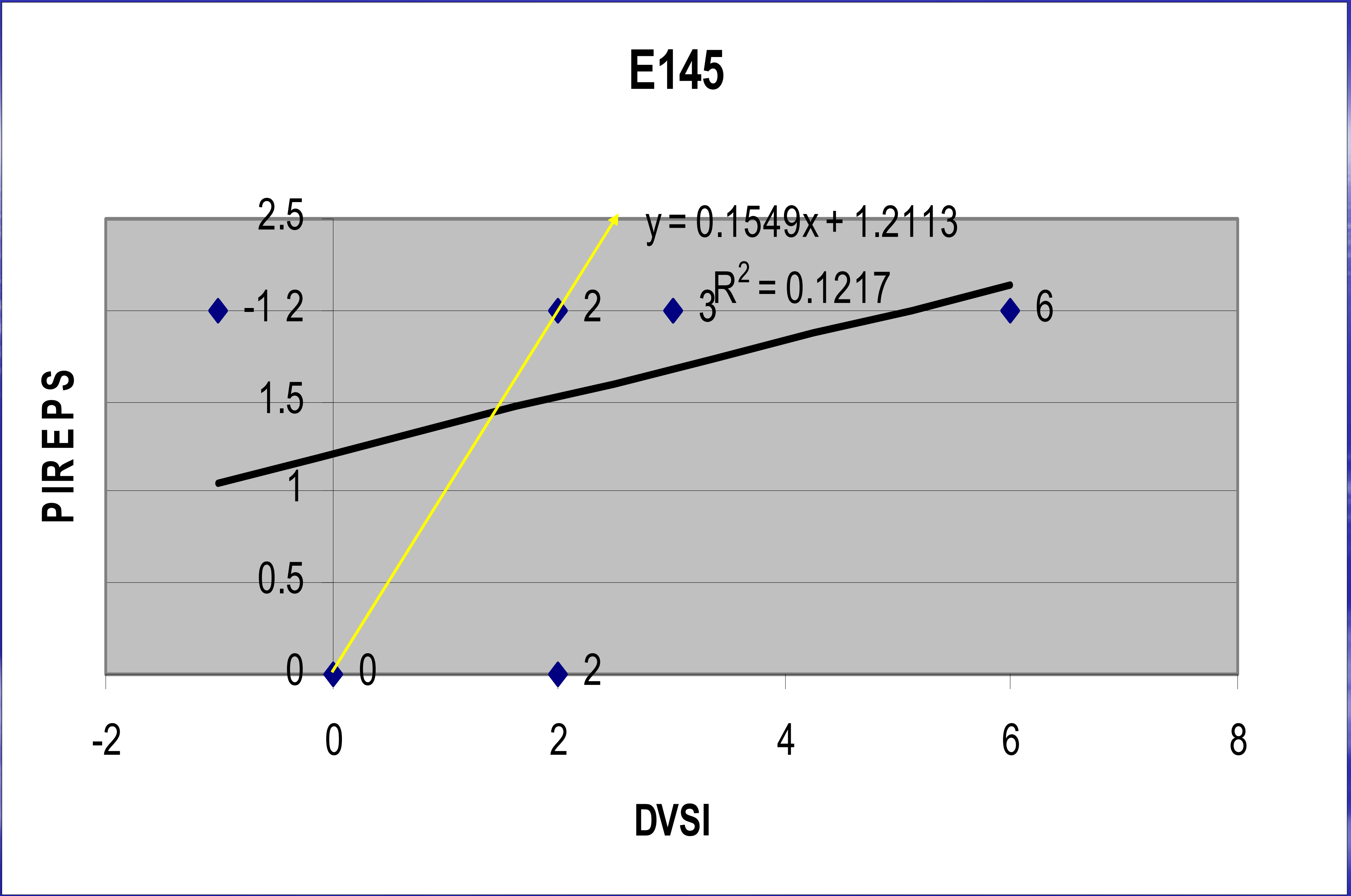

Fig.11 The correlation between the DVSI and PIREPS specific to the aircraft type E145

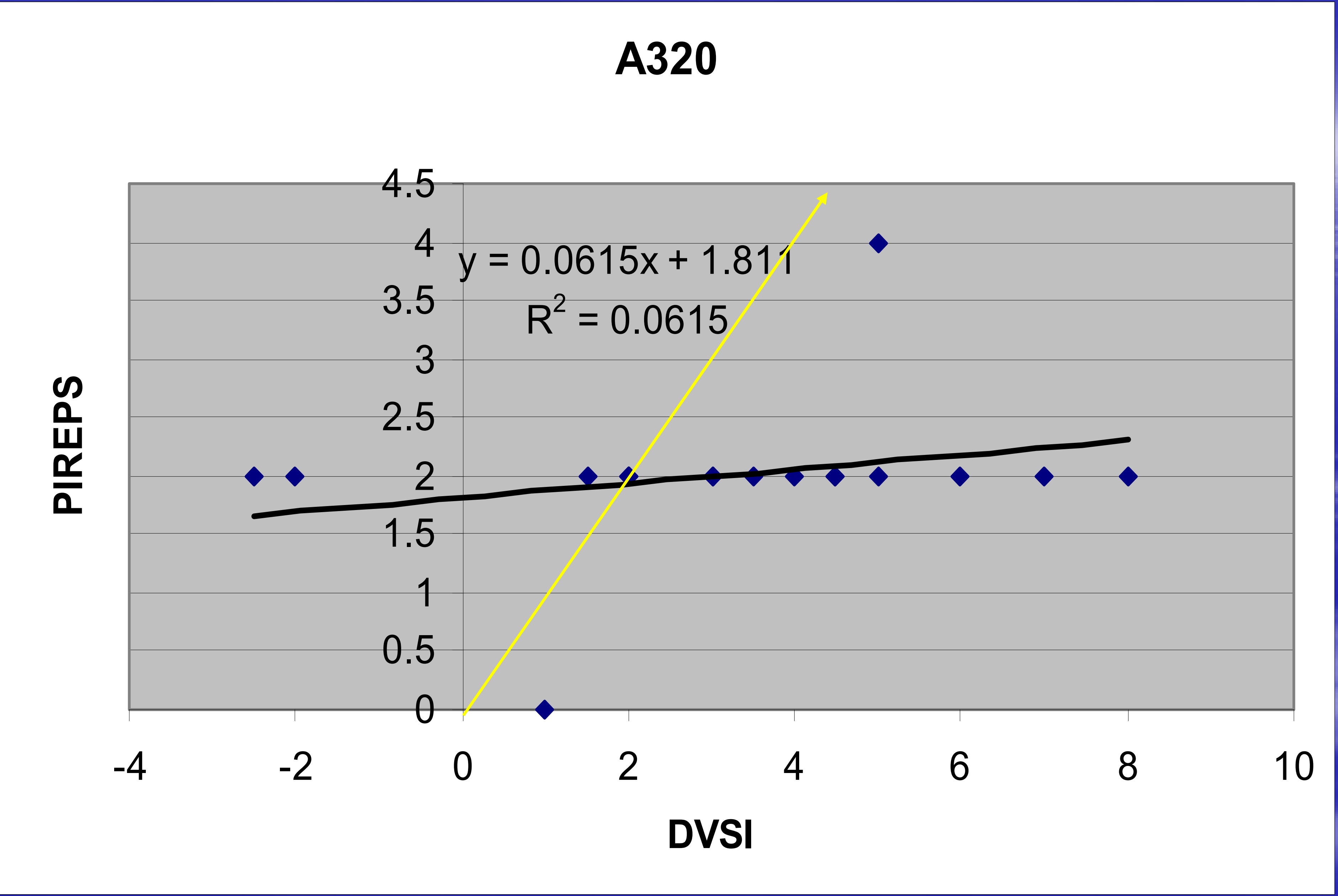

Fig.12 The correlation between the DVSI and PIREPS specific to the aircraft type A320

Conclusions

Goal: To try to correlate the PIREPS to the turbulence index (unit less)

- The turbulence index and the PIREPS did not have a high correlation factor
- Type of aircraft does not have an affect
- Aircrafts using this product are content because understand that the forecasted TI is relative
- Best used in the combination of all three images
- Product tends to overestimate
- Only a primary assessment, further testing is needed

References

- Conway, E. D. (1997). *An introduction to satellite image interpretation* (pp. 1-64, 108-122). Baltimore: The Johns Hopkins University Press.
- Ellrod, G. P., & Knapp, D. I. (1992, March). An objective clear-air turbulence forecasting technique: verification and operational use. *Weather and Forecasting, 7*(1).
- Holton, J. R., Curry, J. A., & Pyle, J. A. (Eds.). (2002). Clear-Air turbulence. In *Encyclopedia of atmospheric sciences*. Amsterdam: Academic Press.
- Knox, J. A., Ellrod, G. P., & WIlliams, P. D. (2006). Improved clear air turbulence diagnostics based on adjustment dynamics. Preprints, *12th Conference on Aviation Range and AerospaceMeteorology*, Atlanta, G Amer. Meteor. Soc.
- Moran, J. M., & Morgan, M. D. (1994). The wind. In *Meteorology the atmosphere and the science of weather* (pp. 188-215). New York: Macmillan College Publishing Company.

Acknowledgements

- **Mr. Pryor**
  - Research Advisor/Mentor
- **Mr. Pearce**
  - Mentorship Coordinator
- **Mrs. Wu**
  - Oceanography Lab Director