16th Weather Squadron

Aim High … Fly, Fight, Win

The SLAT (index) as an indicator of vertically propagating mountain waves using WRF 15km data, and its potential as a turbulence forecast product

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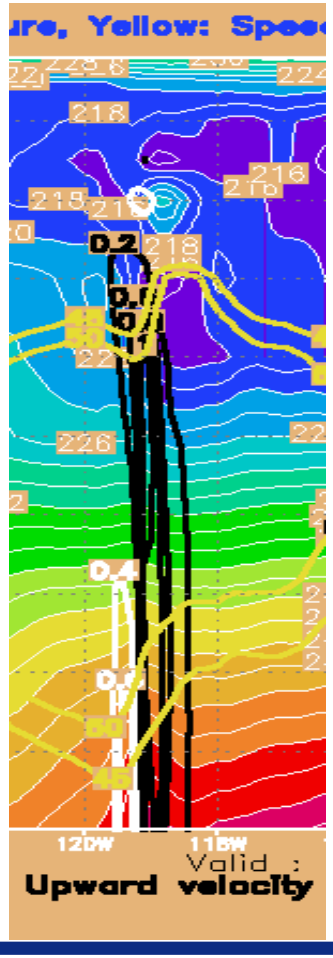
16 WS/WXP

Questions to be answered

- What is SLAT?
- What does the stratosphere have to do with Vertically Propagating Mountain Waves (VPMW)?
- Can we make an operational VPMW forecast from WRF 15km model output?

Questions to be answered



Outline

- The SLAT index
- SLAT in AFWA WRF 15km
- Analysis of model data
- SLAT, VPMW and turbulence

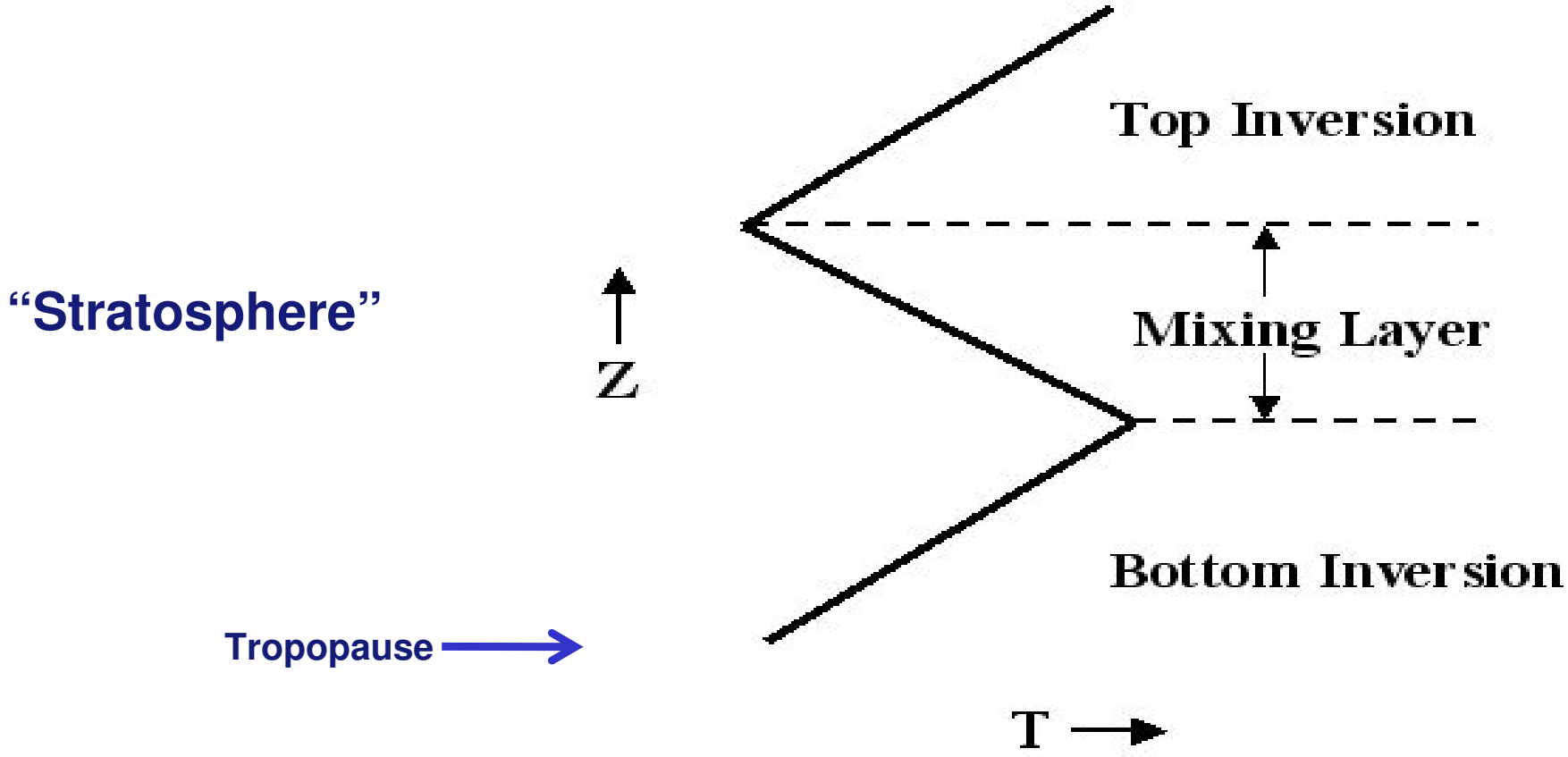
SLAT: introduction

- Reference: *Sinclair, P.C., P.M. Kuhn, 1991. Infrared Detection of High Altitude Clear Air Turbulence, NOARL Technical Note 205, pp. 49.*

- 100% of CAT occurred within SLAT; 95% of SLAT had CAT (HICAT program)

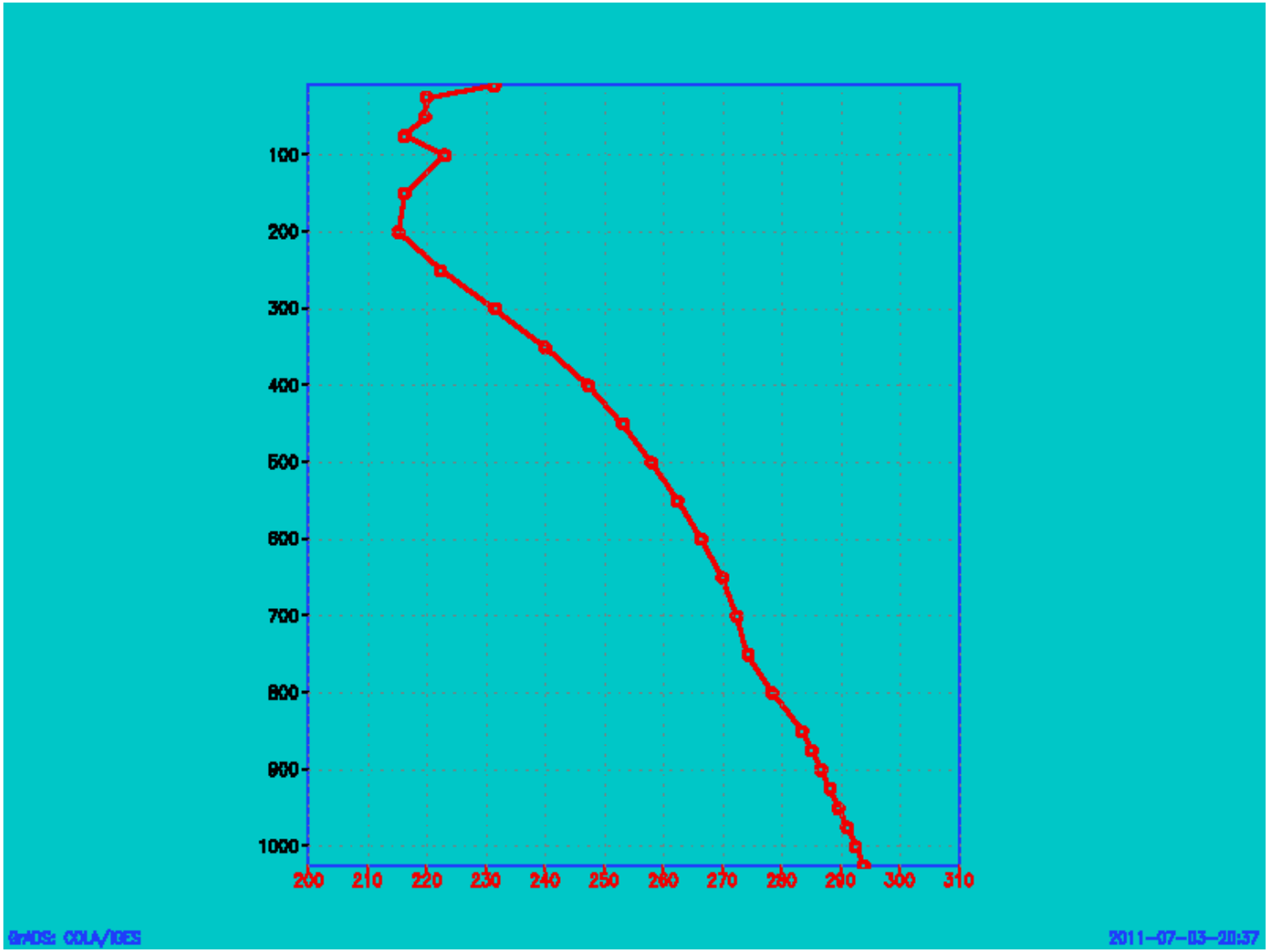
- Stratospheric Layer Advanced Turbulence (index)
  - "SLAT"

SLAT: Introduction



$$SLAT = \frac{[gamma_{ml} - (gamma_t + gamma_b)]\,[20{,}000ft - DZ]}{10C - DT}$$

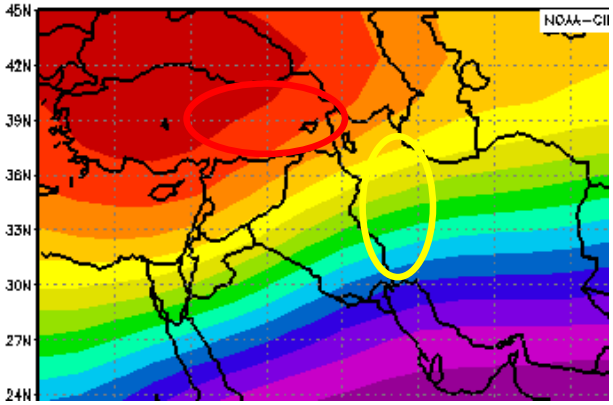
SLAT: Introduction: Model vertical profile



SLAT: Positive evidence as turbulence forecast

- "SLAT is spot on"

- Slat locations consistent with 100-400mb Jet, Trough



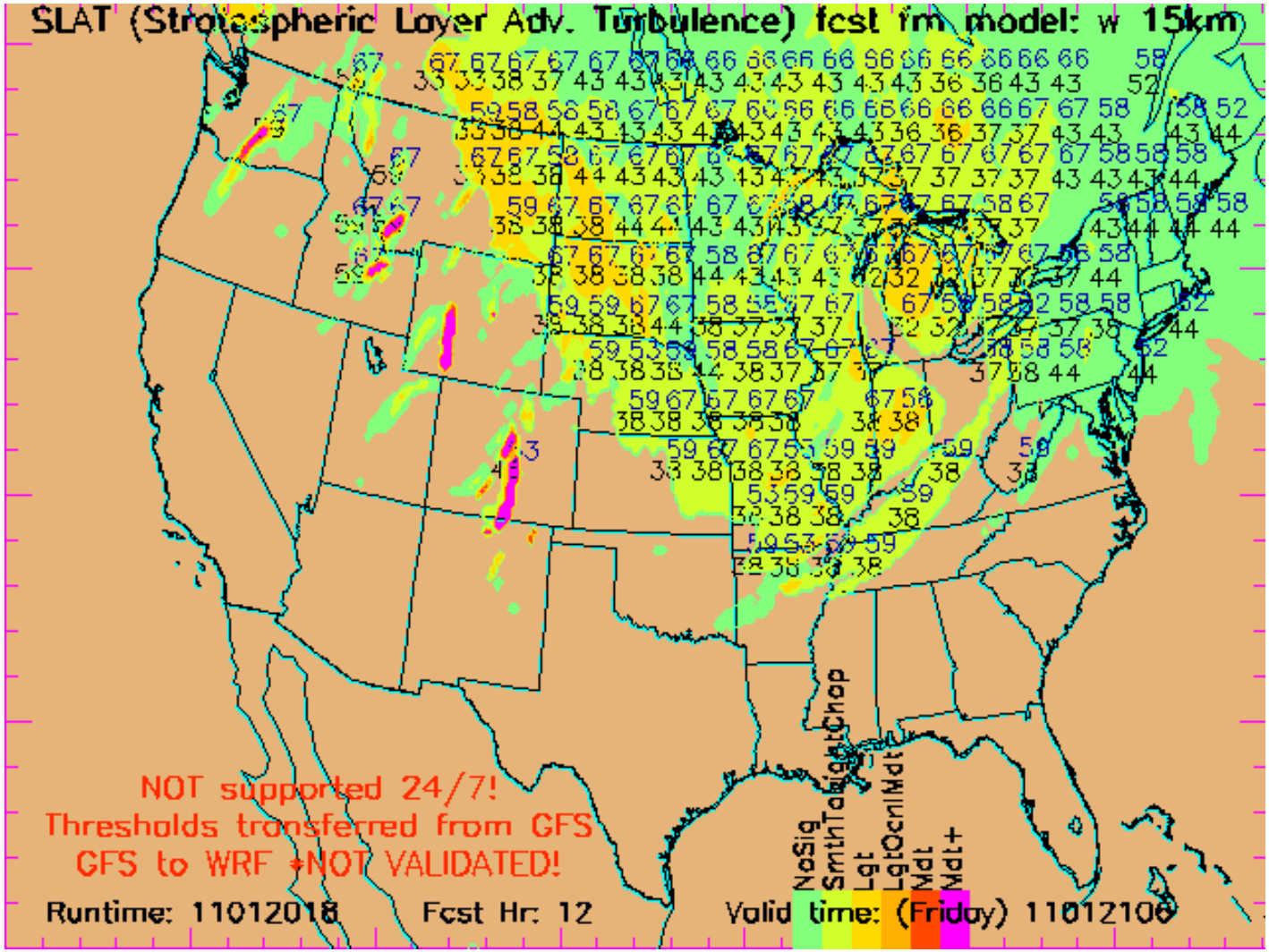
SLAT: Positive evidence as turbulence forecast

- **TREX challenge: "You win"**
  - **Pinpointed turbulent location in a TREX flight**

- **SLAT has same seasonal tendency as turbulence**

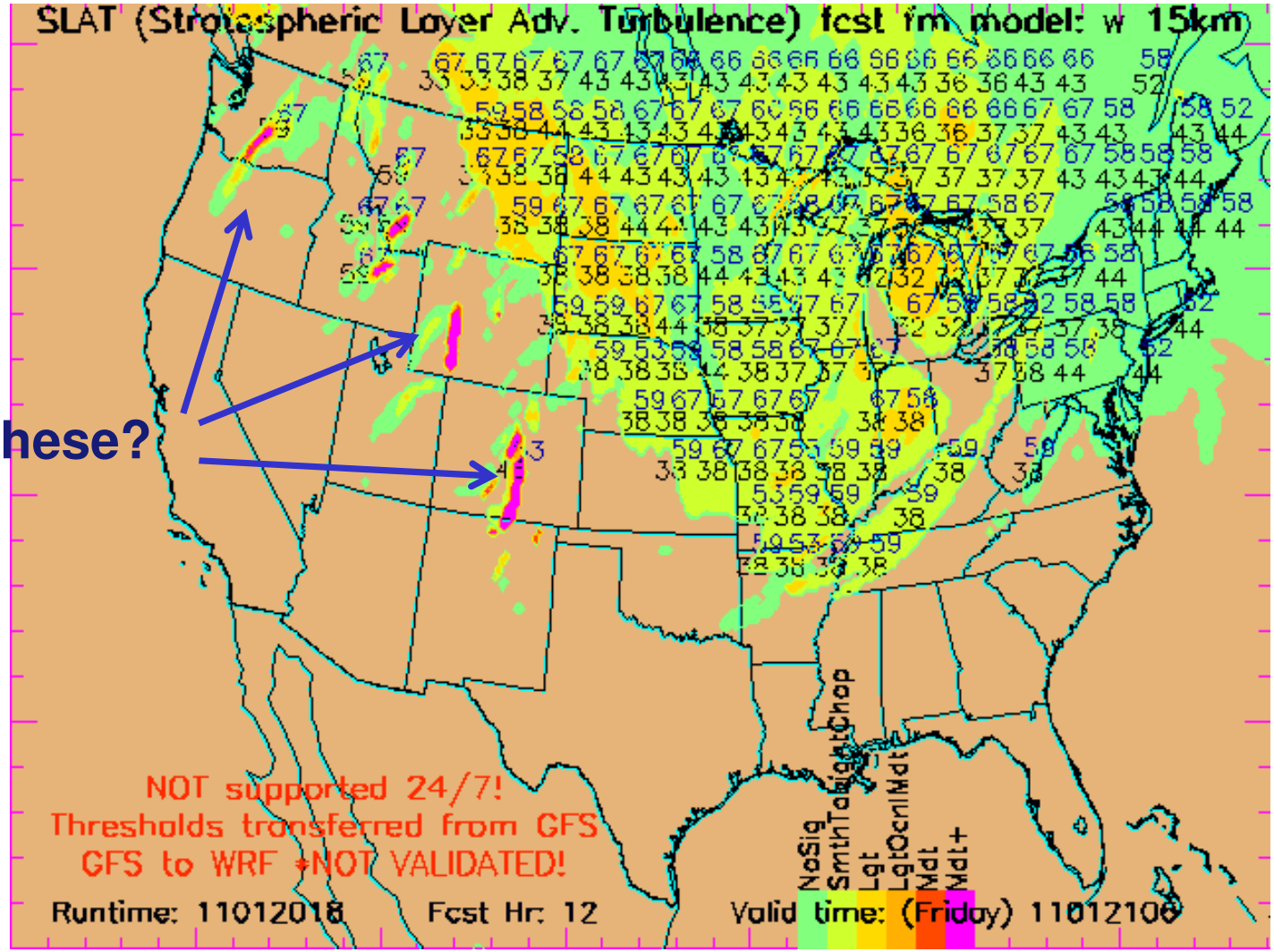
SLAT: WRF 15km

"Synoptic" SLAT?



SLAT: WRF 15km

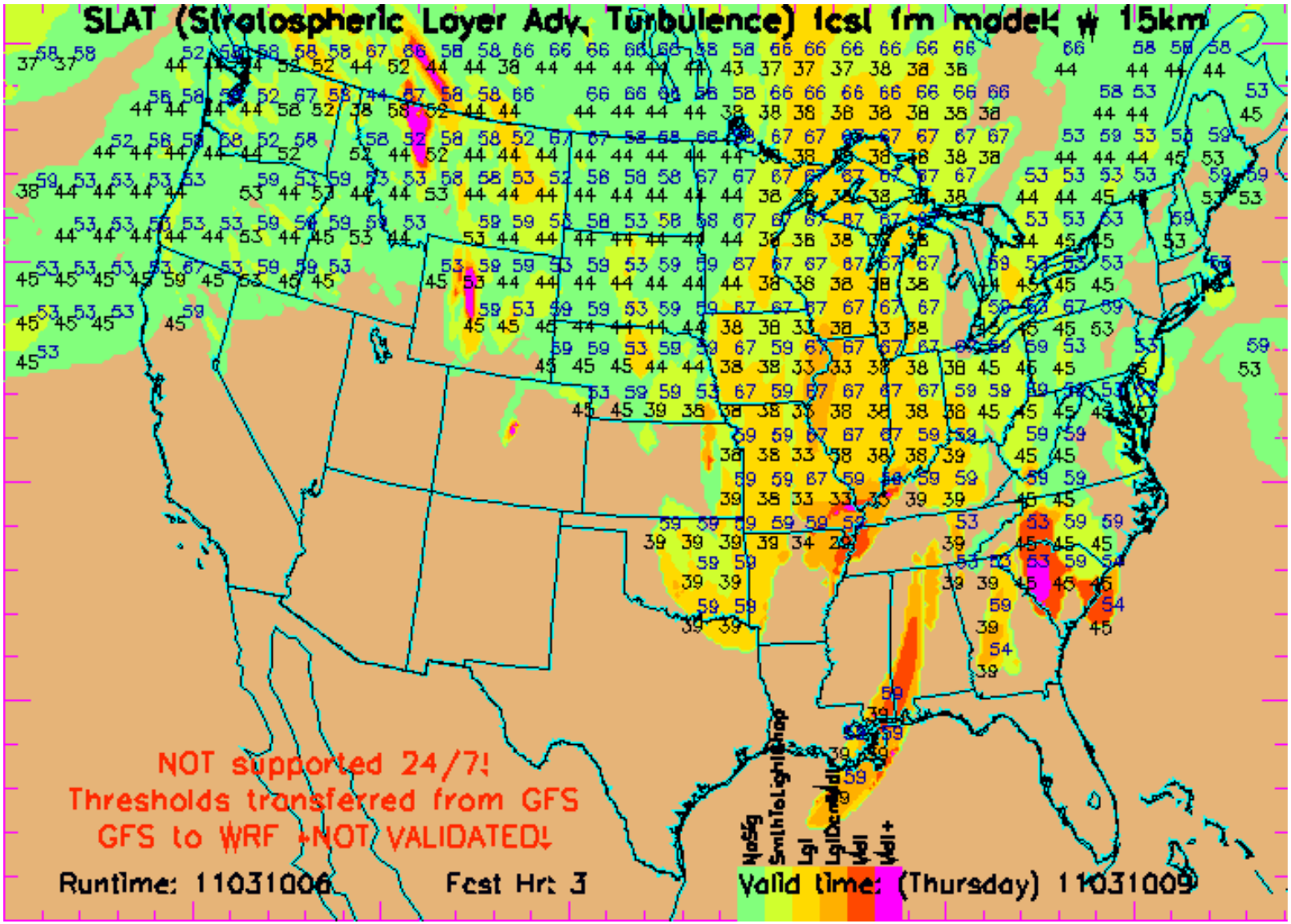
What are **these?**



SLAT: WRF 15km

- How often does this happen?
  - ~6 days per week, November through May
- Map loop to follow…

SLAT: Fhr=3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NOT supported 24/7!
Thresholds transferred from GFS
GFS to WRF -NOT VALIDATED!
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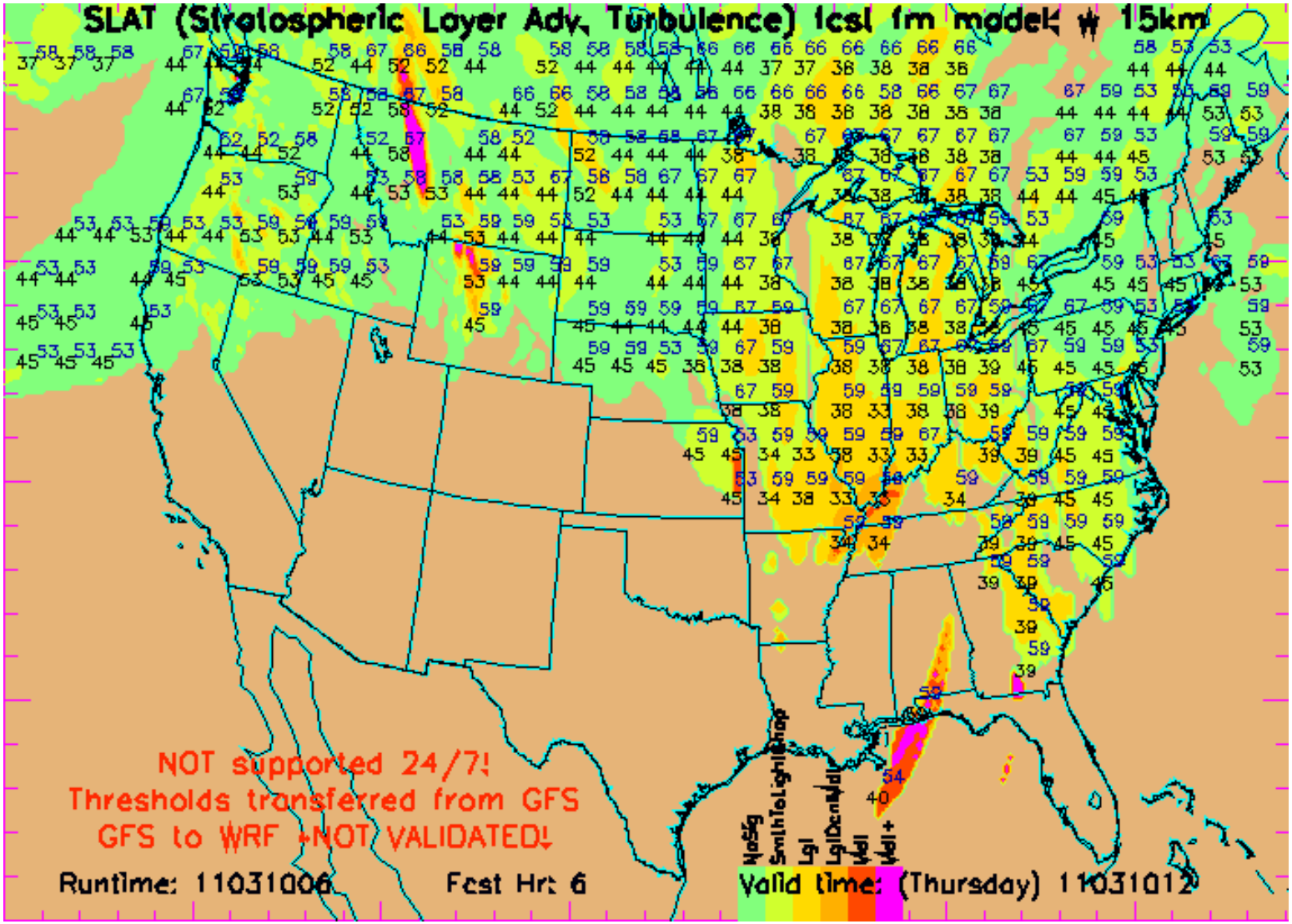
Fcst Hr: 3
Valid time: (Thursday) 11031009

SLAT: Fhr=6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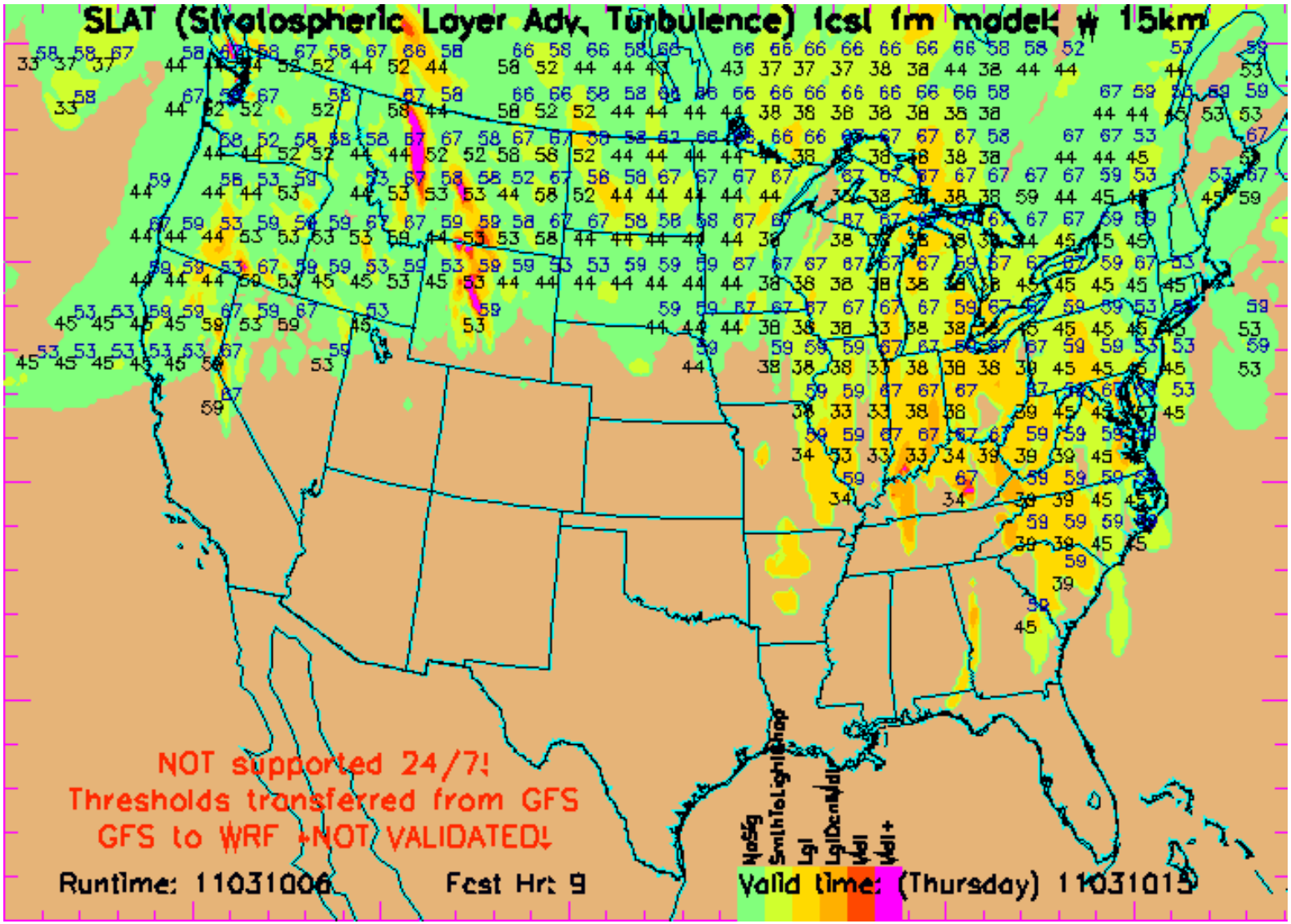
SLAT: Fhr=9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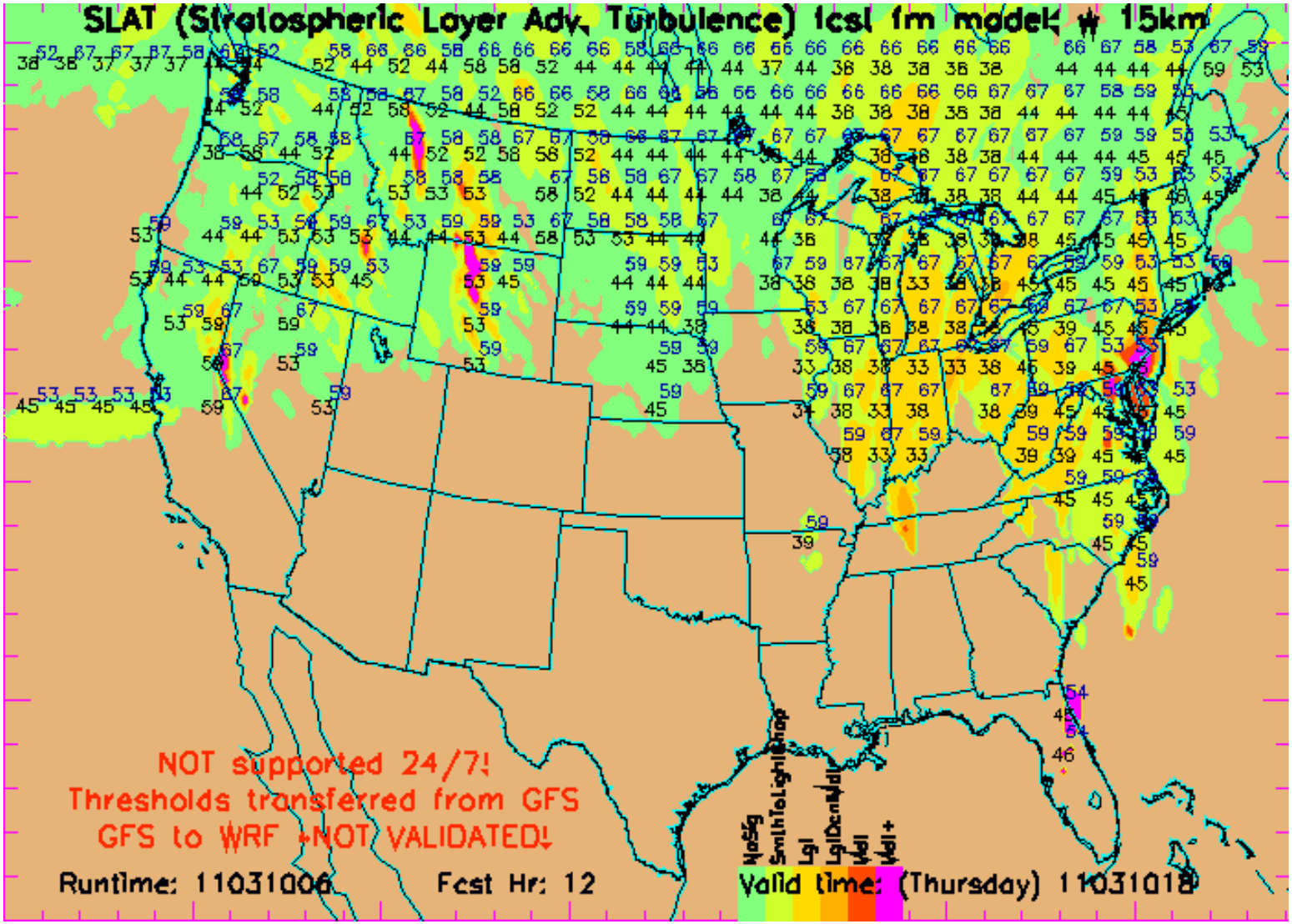
SLAT: Fhr=12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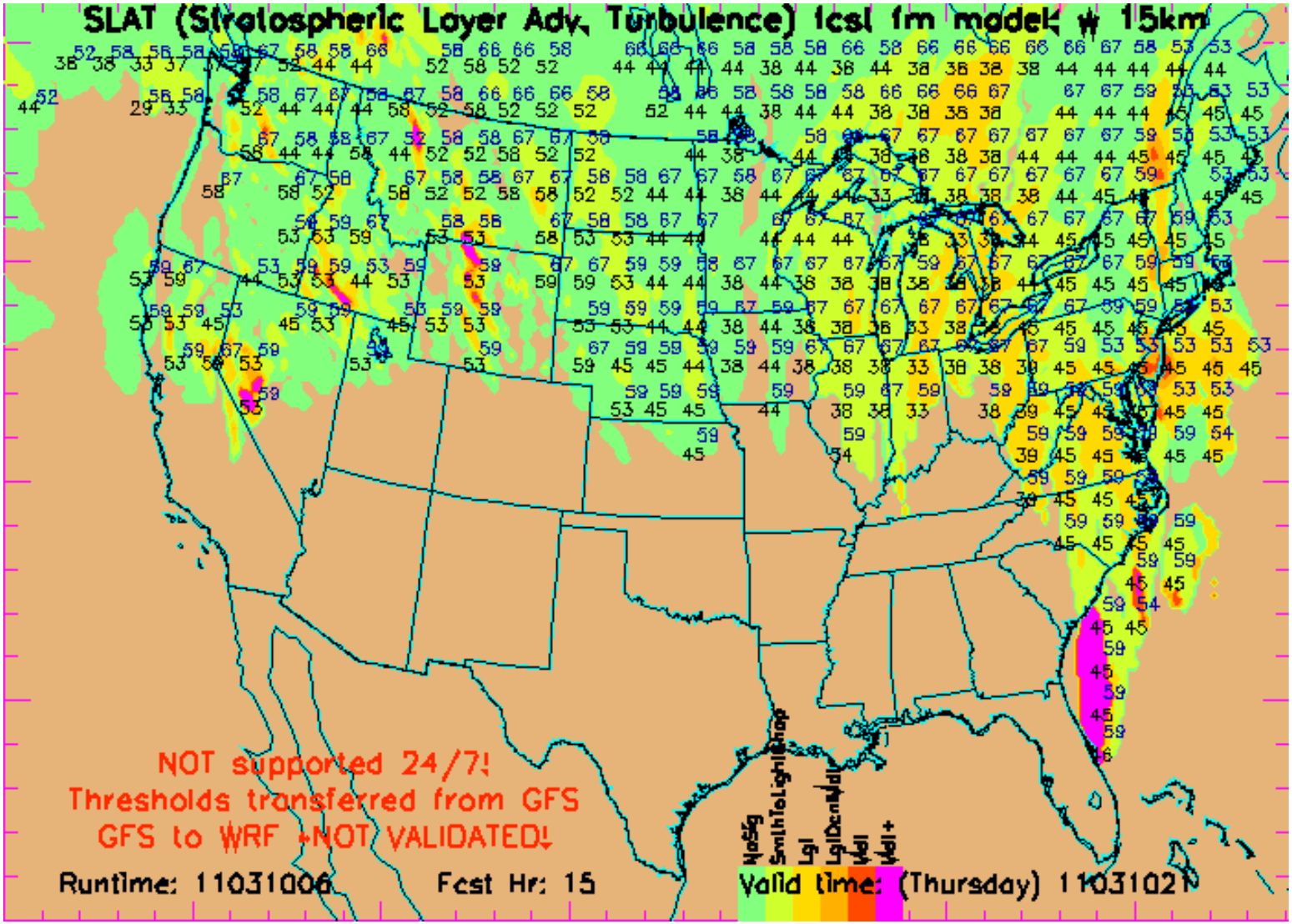
SLAT: Fhr=15



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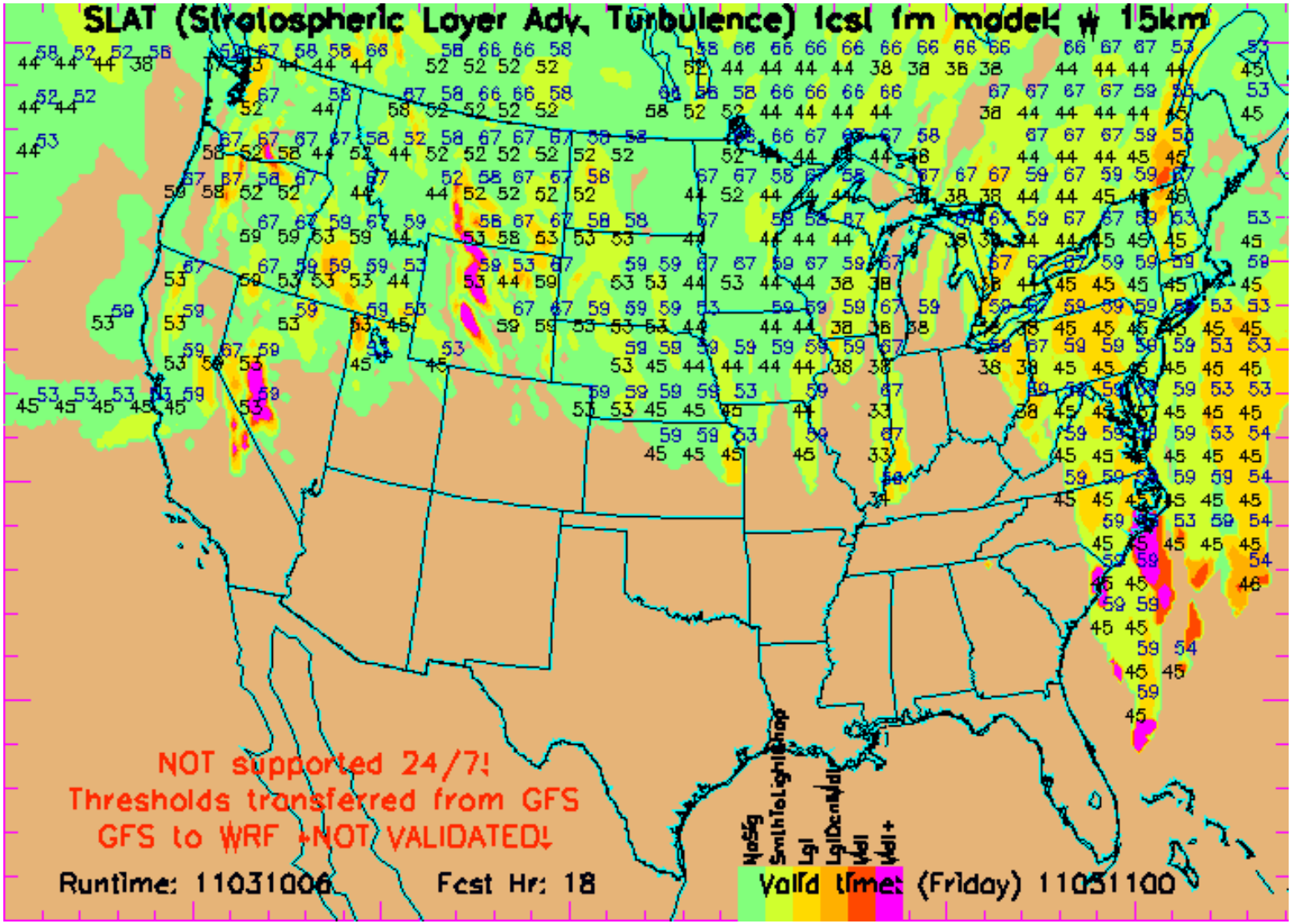
SLAT: Fhr=18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GFS to WRF -NOT VALIDATED!
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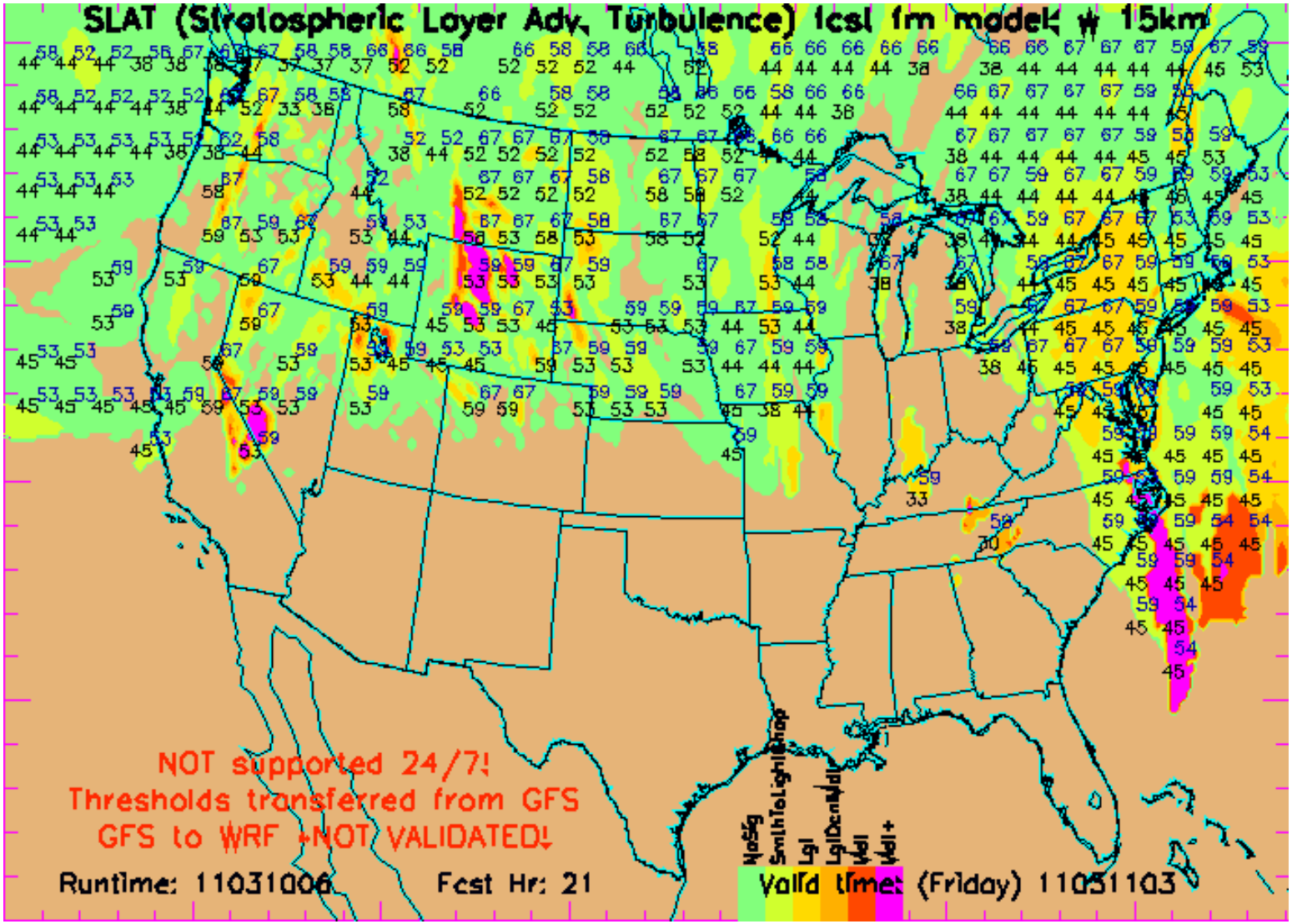
SLAT: Fhr=21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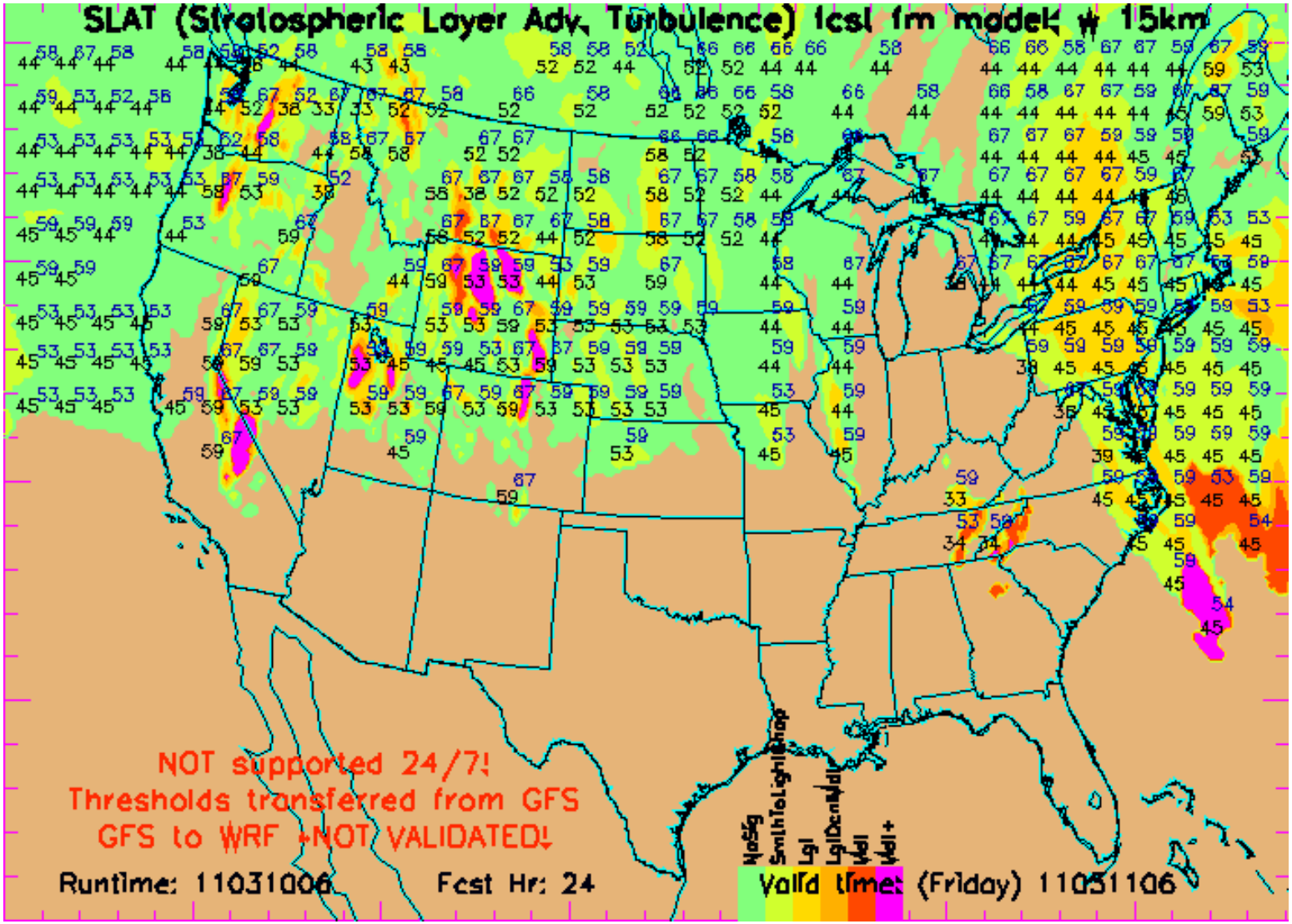
SLAT: Fhr=24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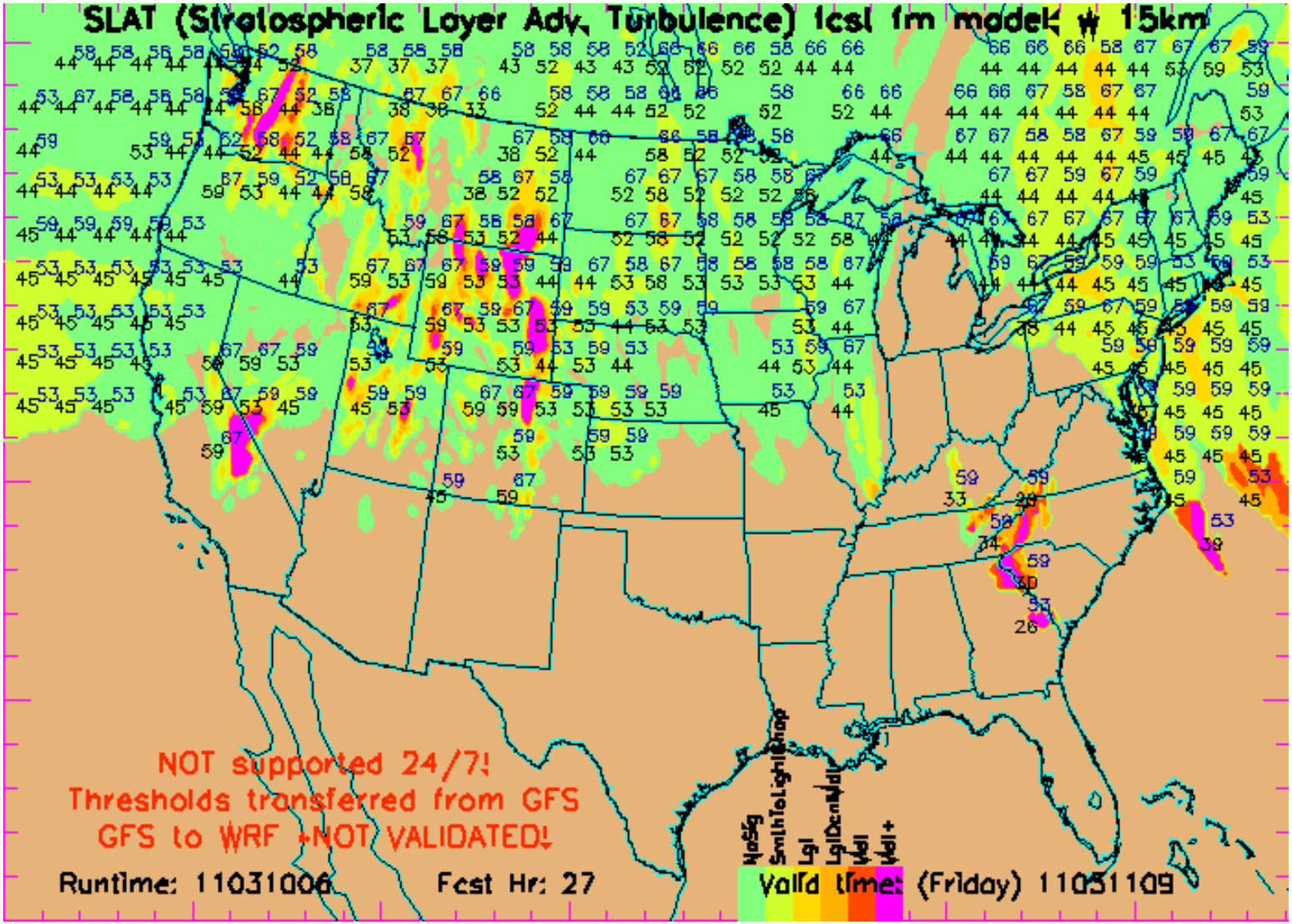
SLAT: Fhr=27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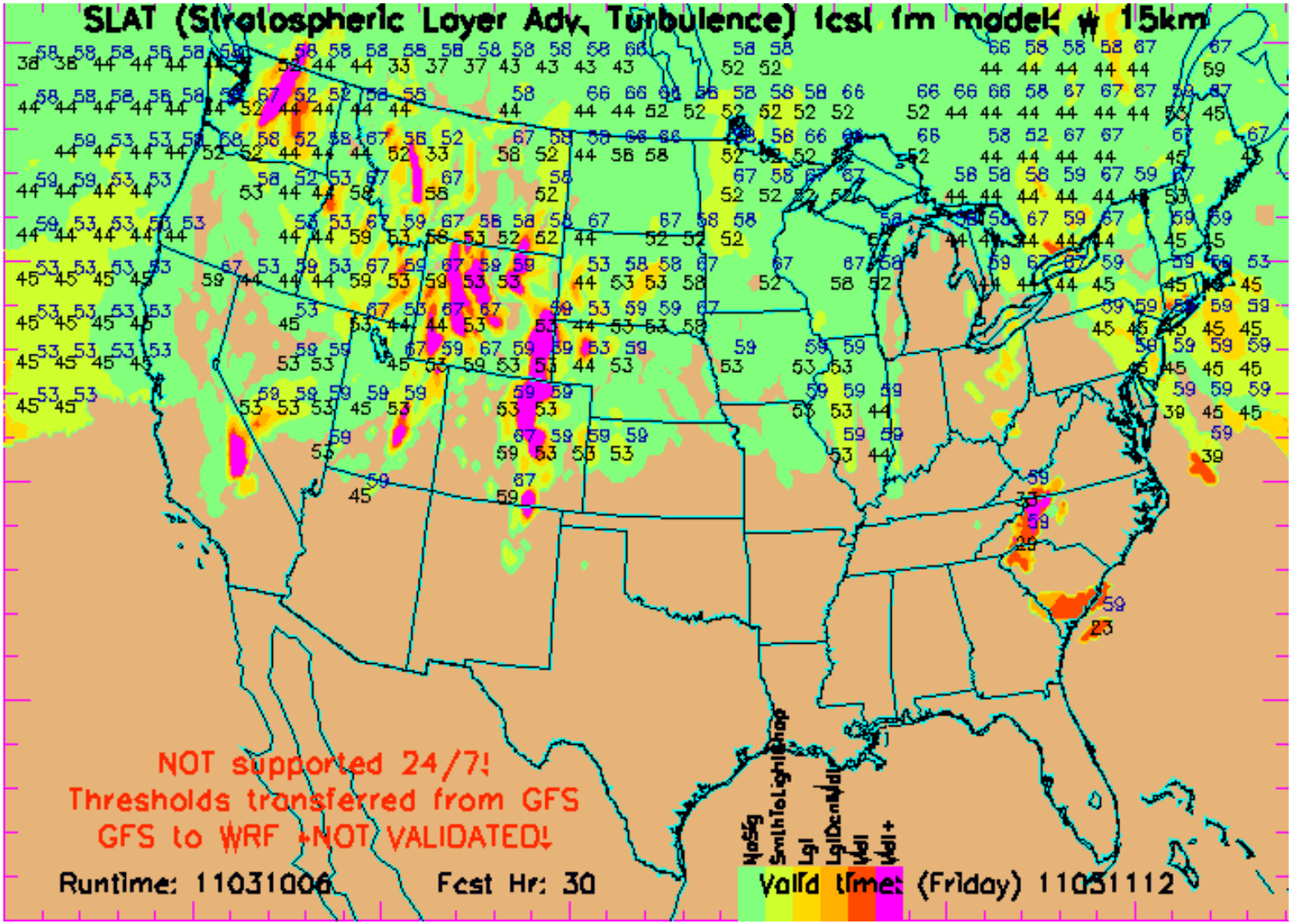
SLAT: Fhr=30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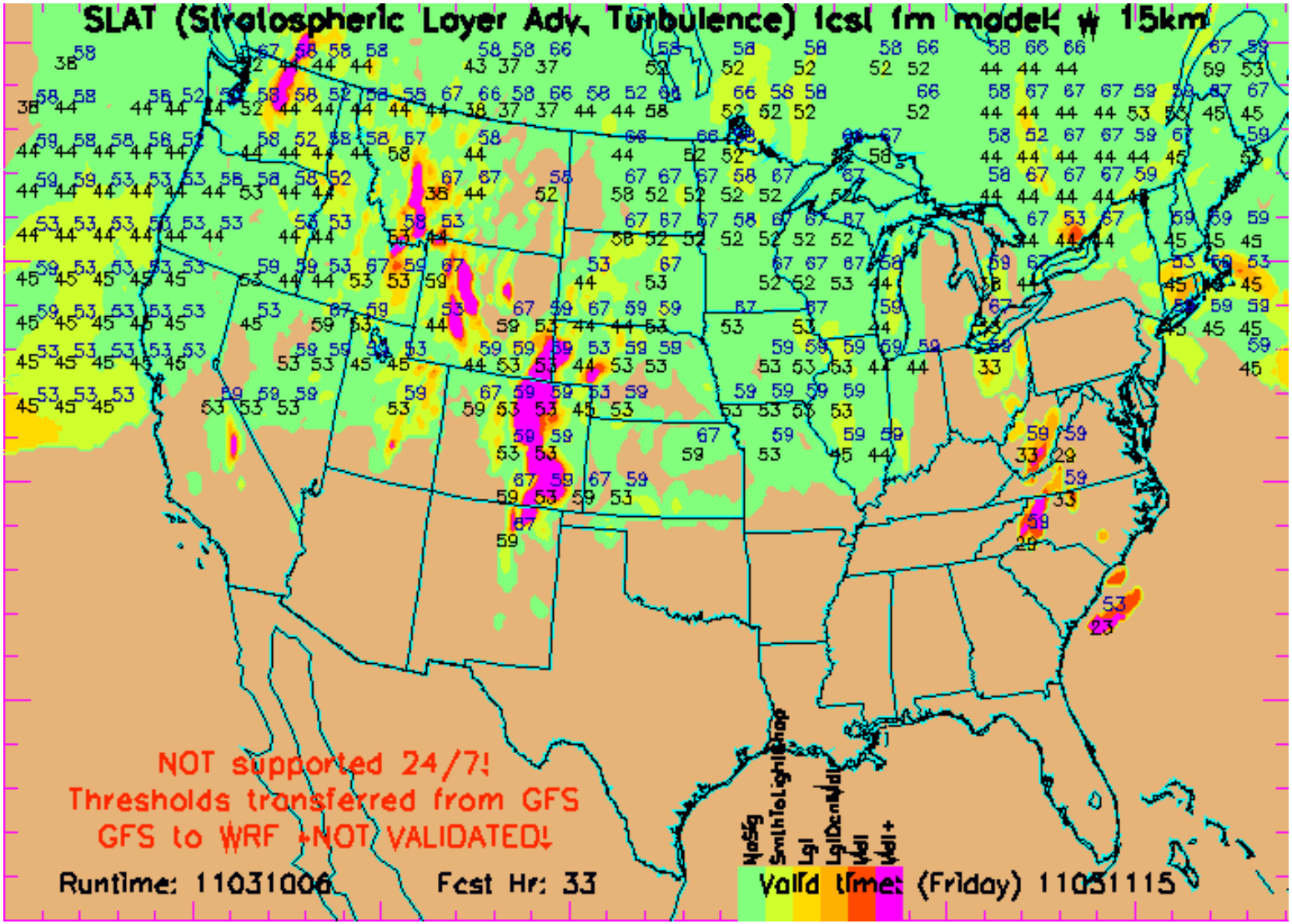
SLAT: Fhr=33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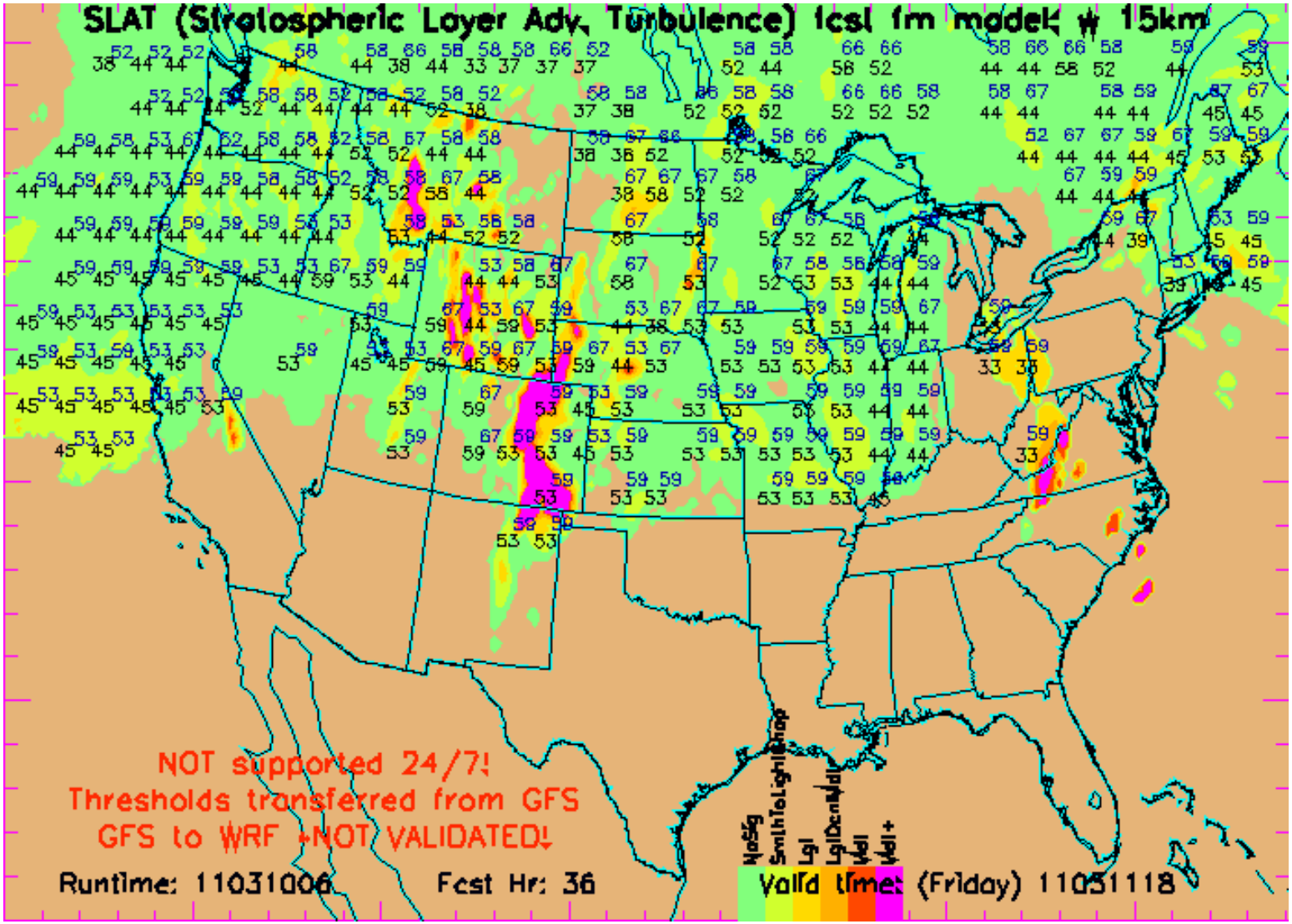
SLAT: Fhr=36



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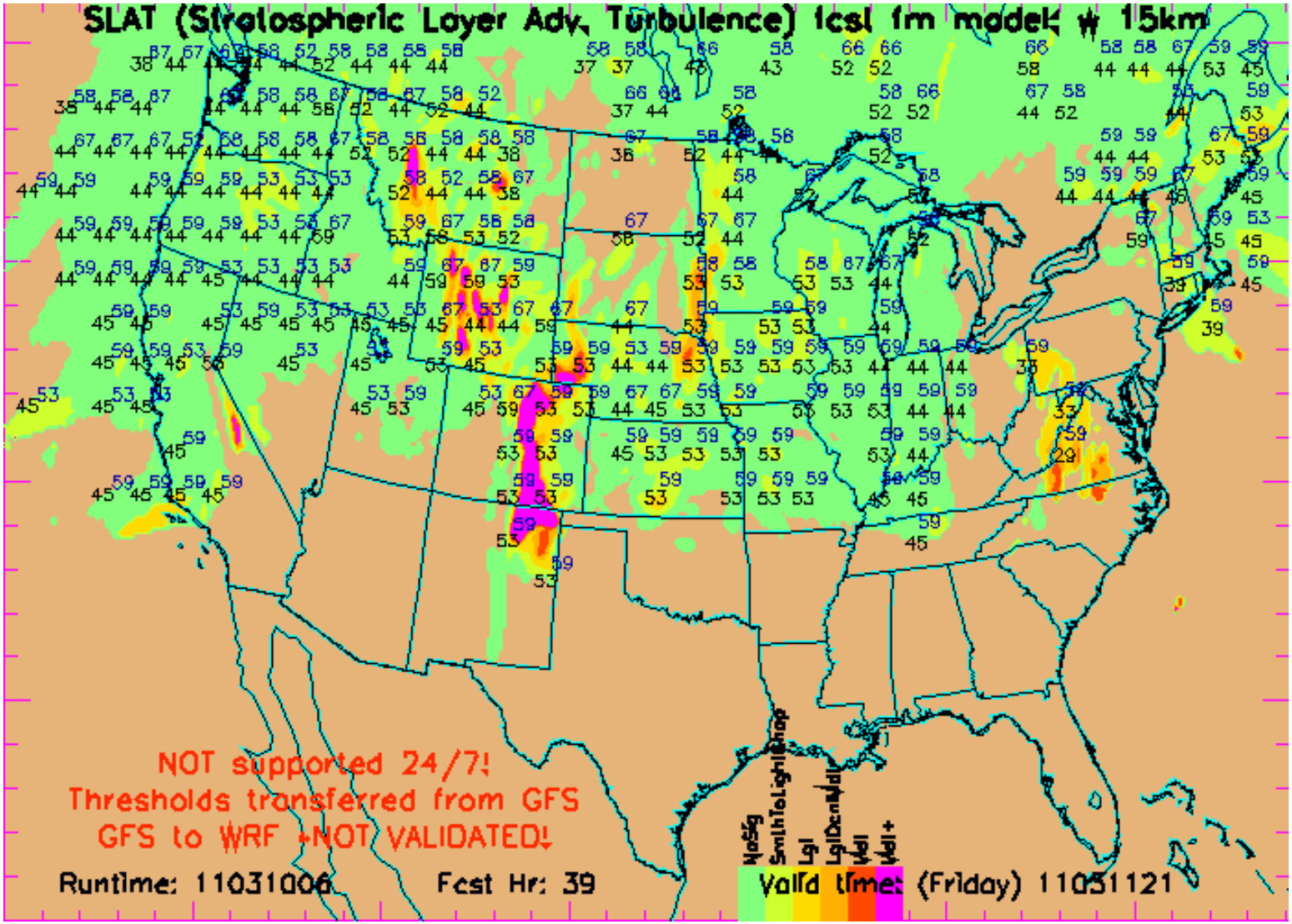
SLAT: Fhr=39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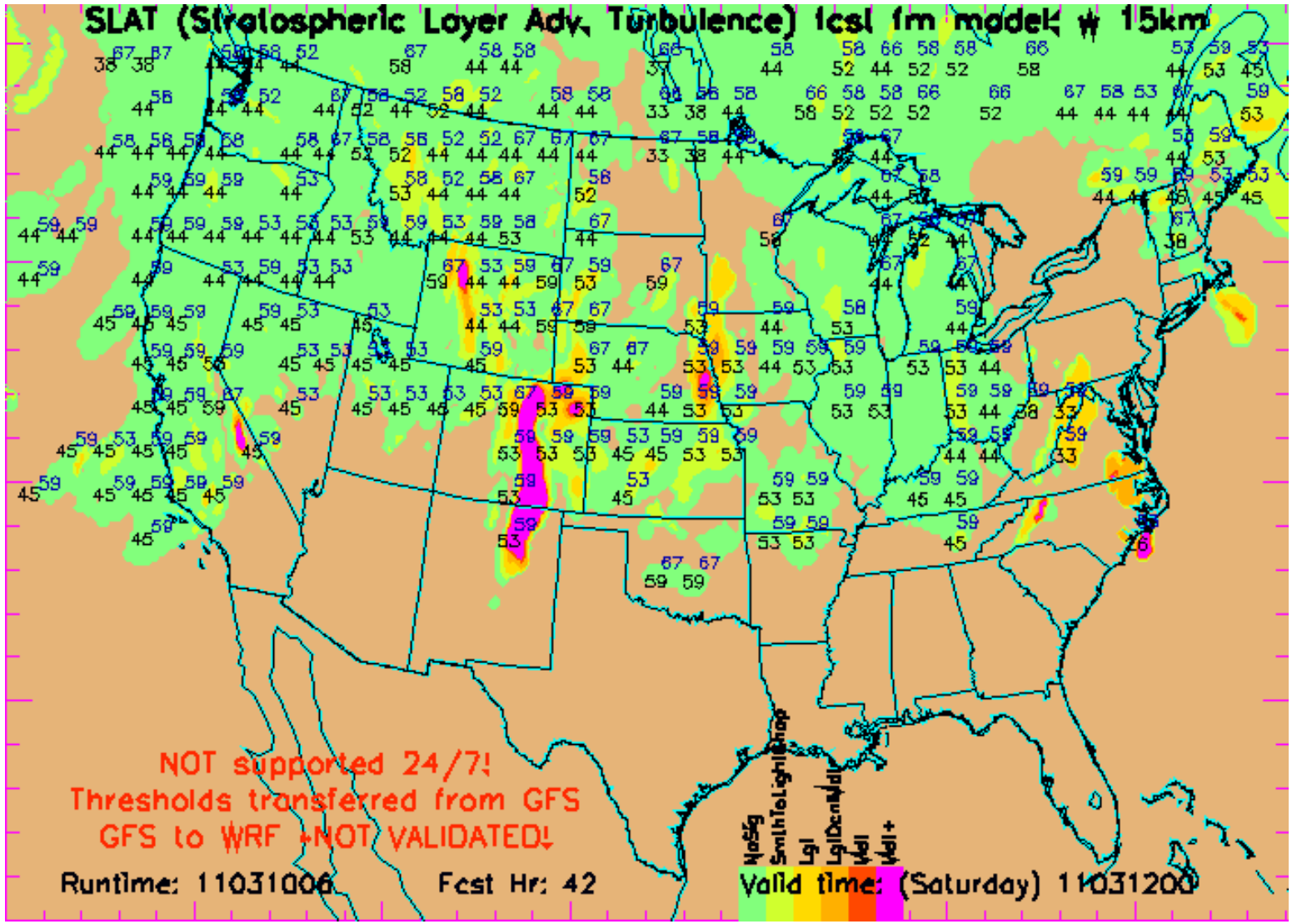
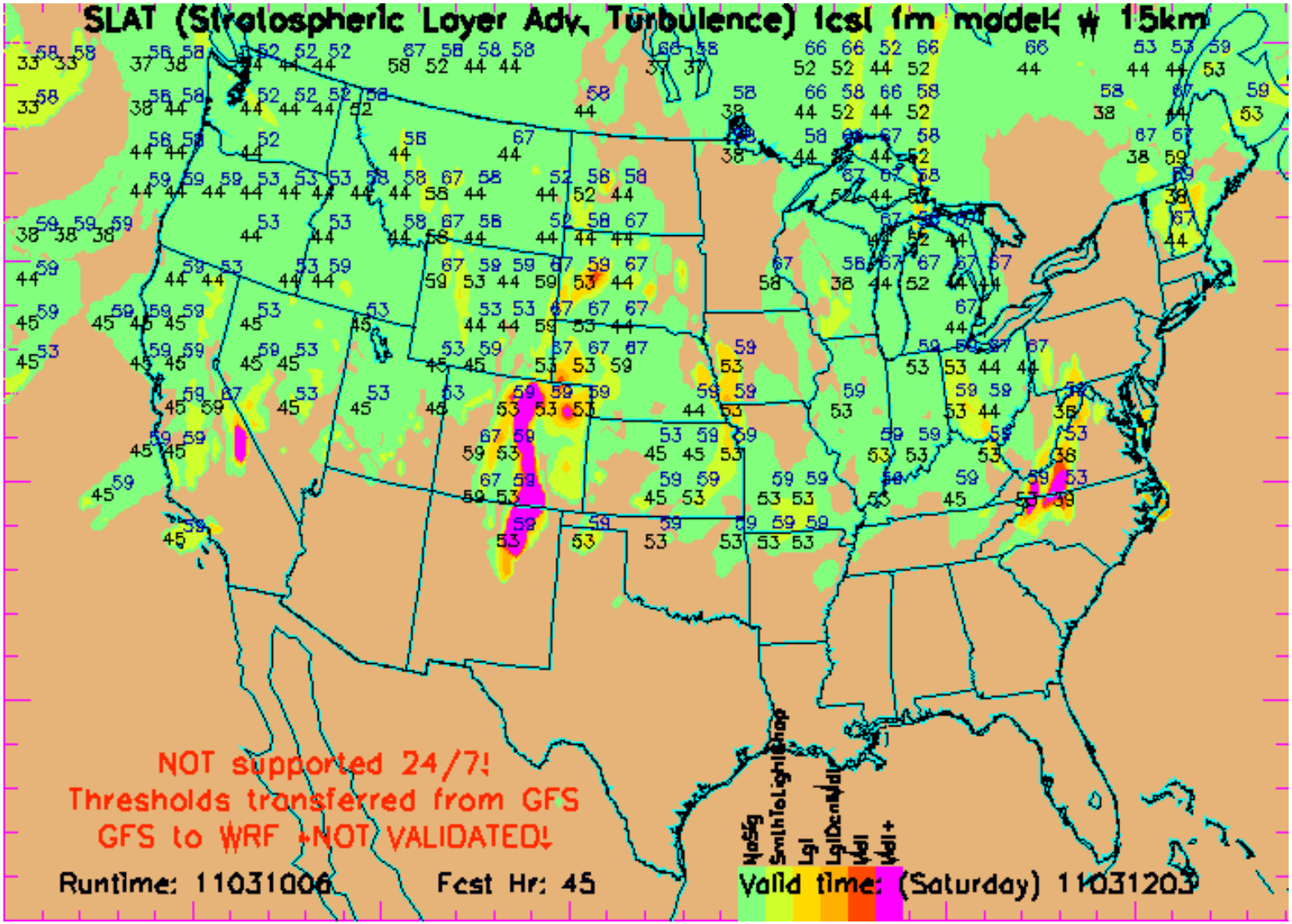
U.S. AIR FORCE

SLAT: Fhr=42



Aim High … Fly, Fight, Win

SLAT: Fhr=45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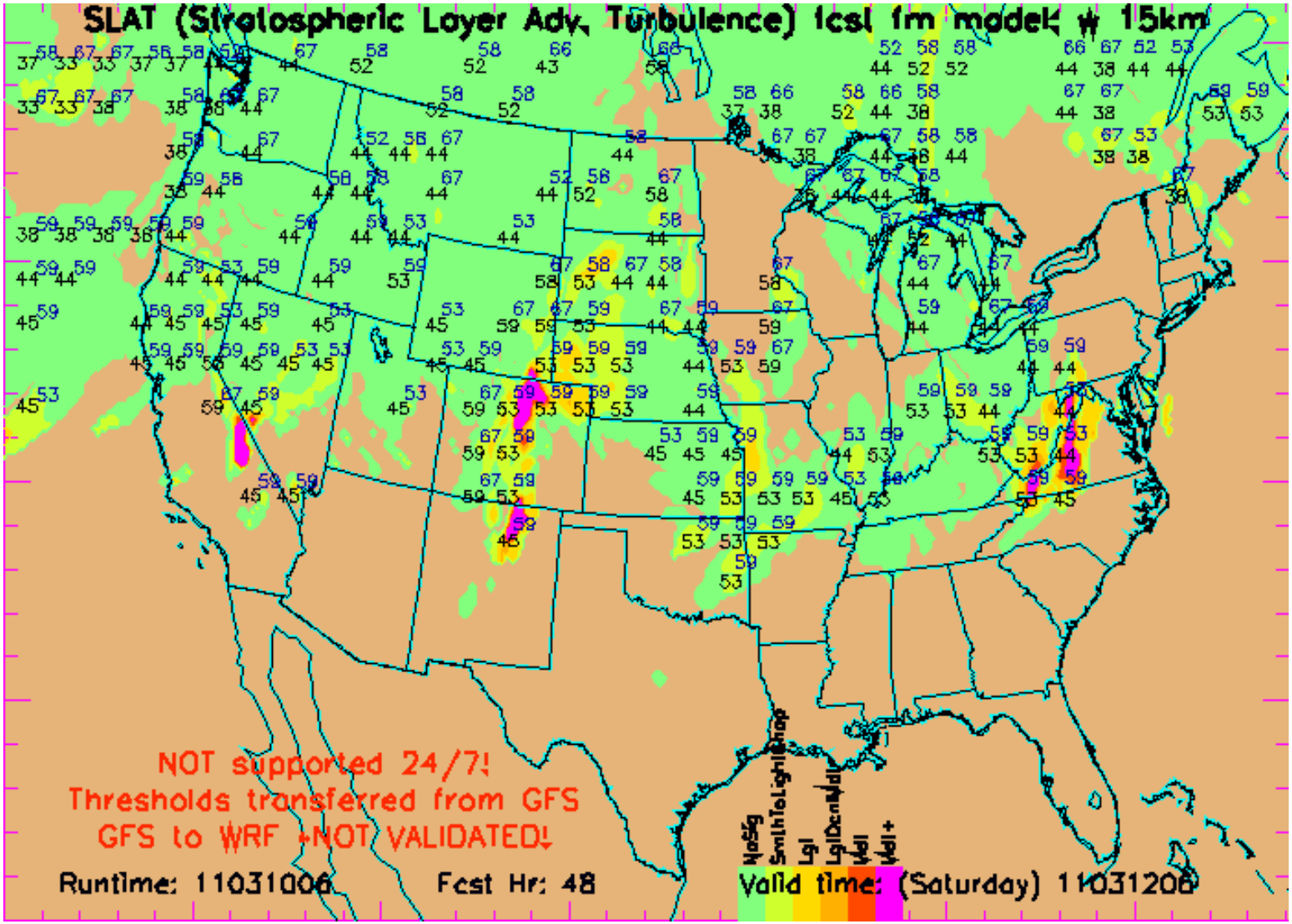
SLAT: Fhr=48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Thresholds transferred from GFS
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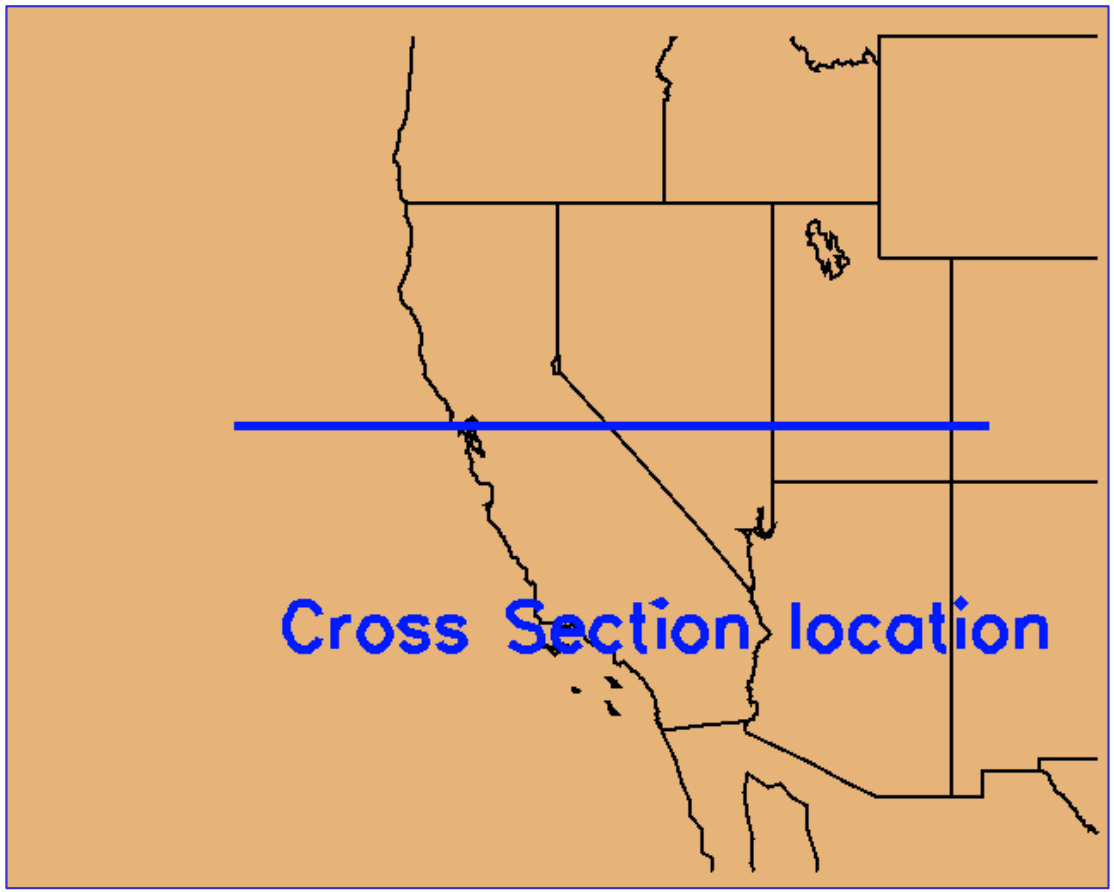
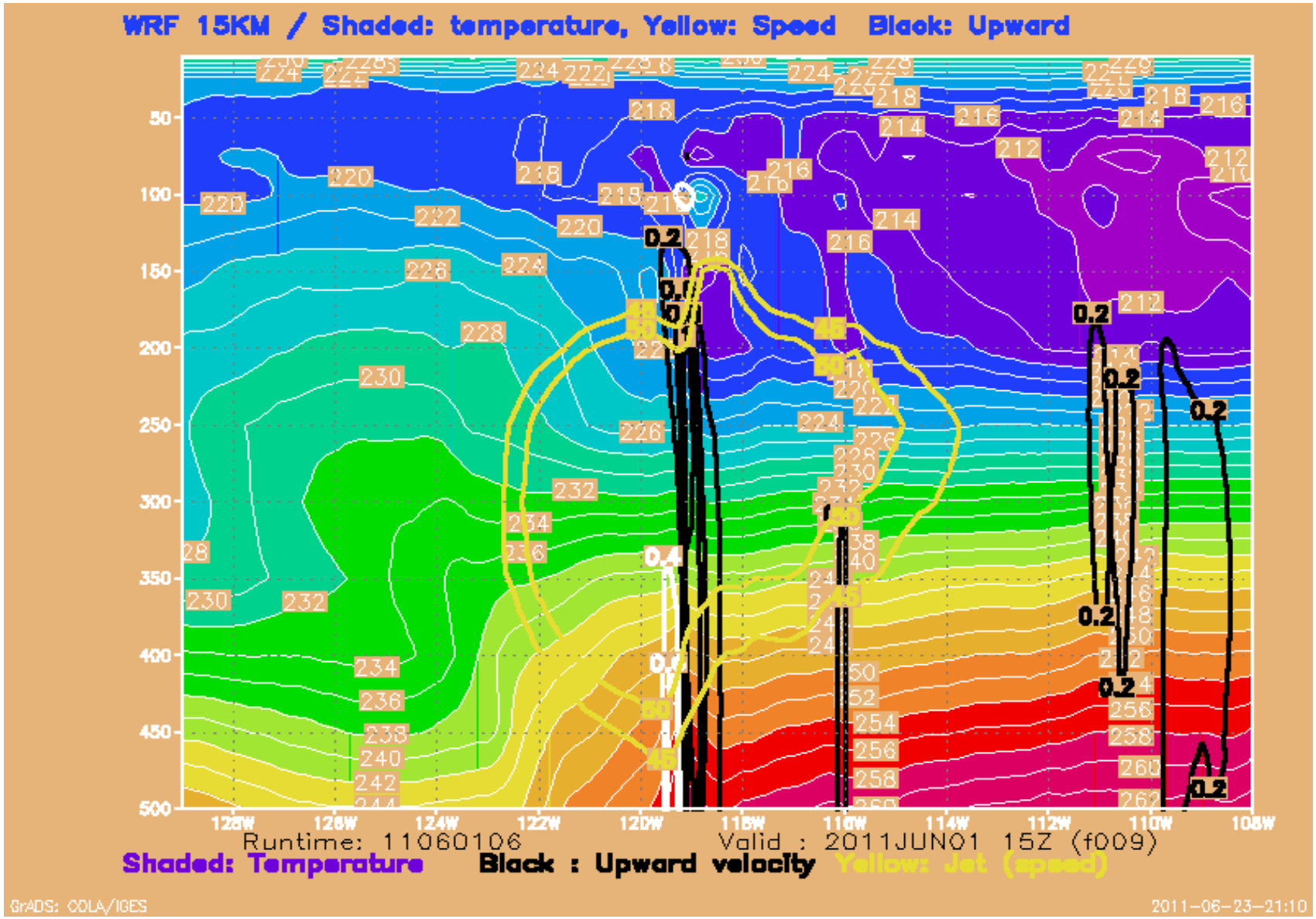
SLAT: Analysis

- Cross Sections…



SLAT, WRF 15km: Analysis



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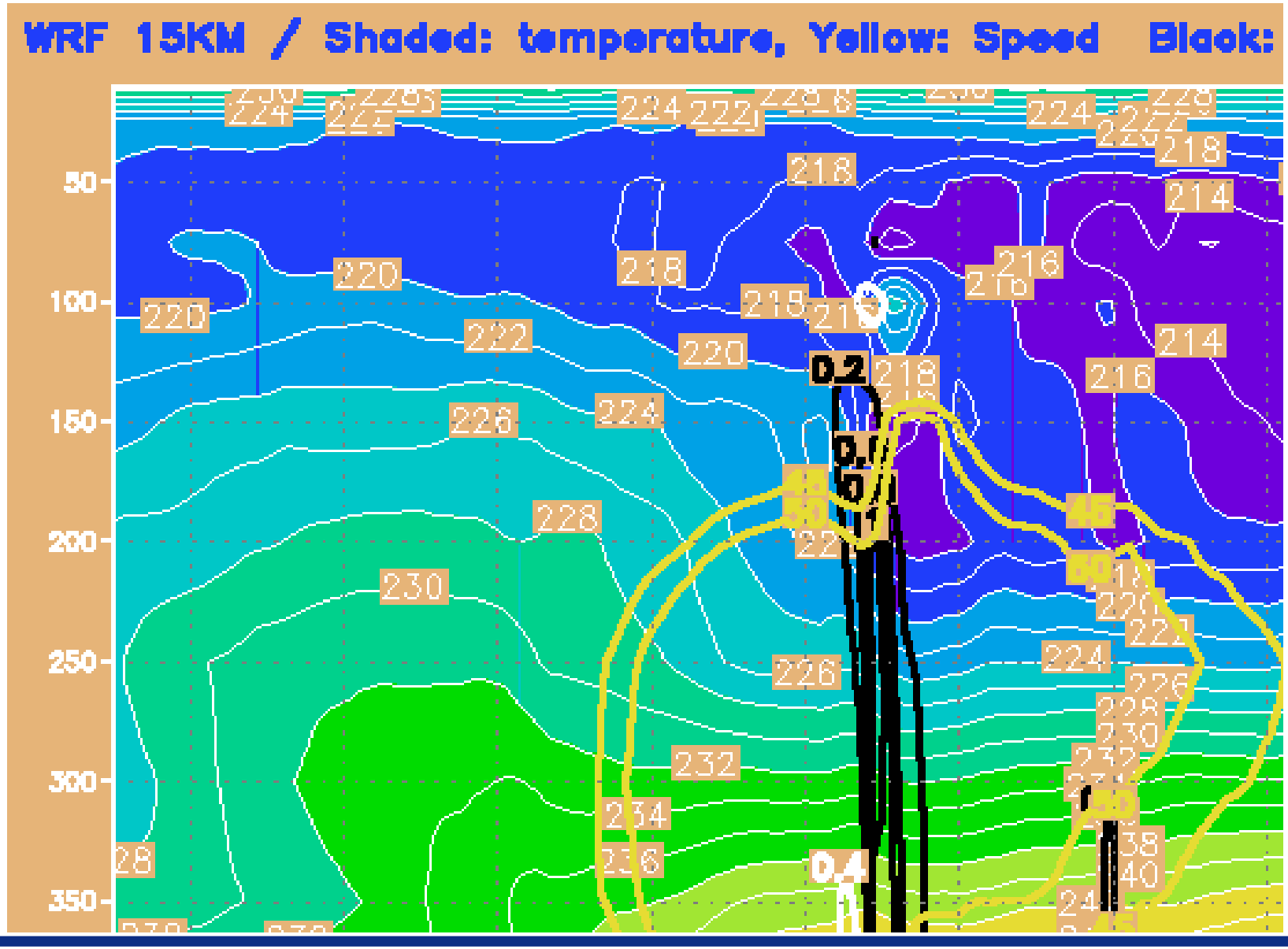
SLAT: Analysis: “S” shape



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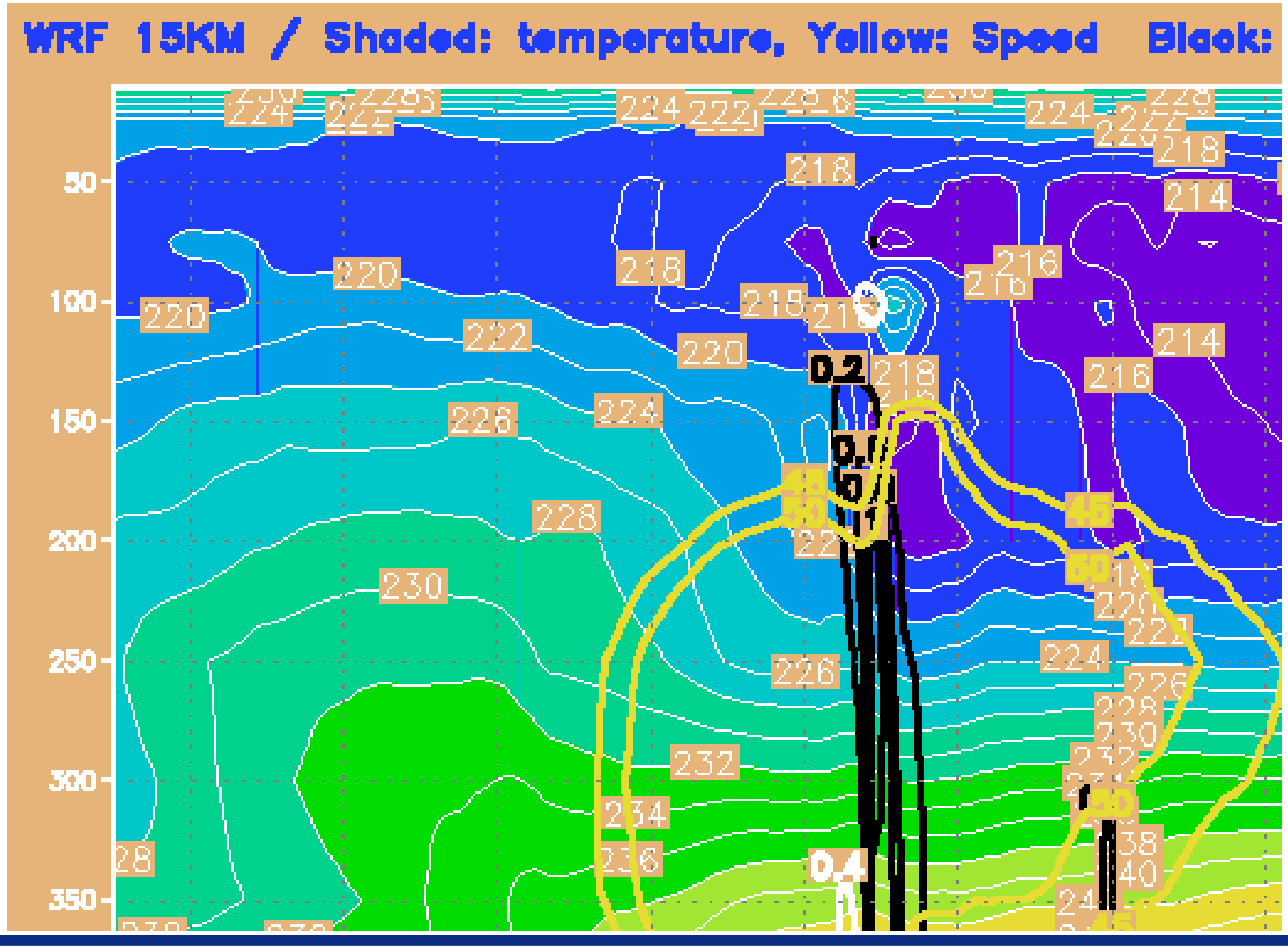
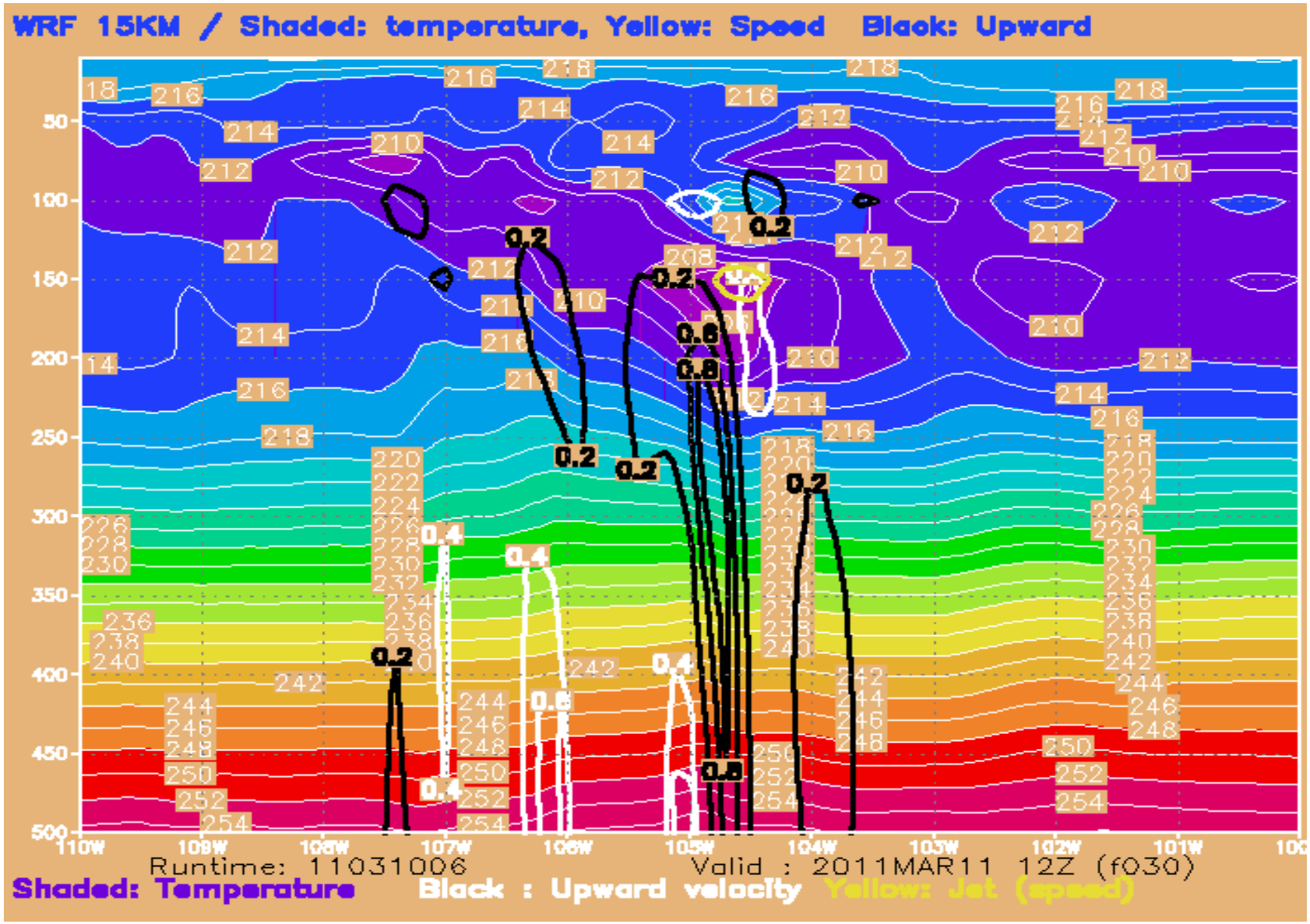
SLAT and "sharp temperature gradients"



Another Day, Another Place (Denver)



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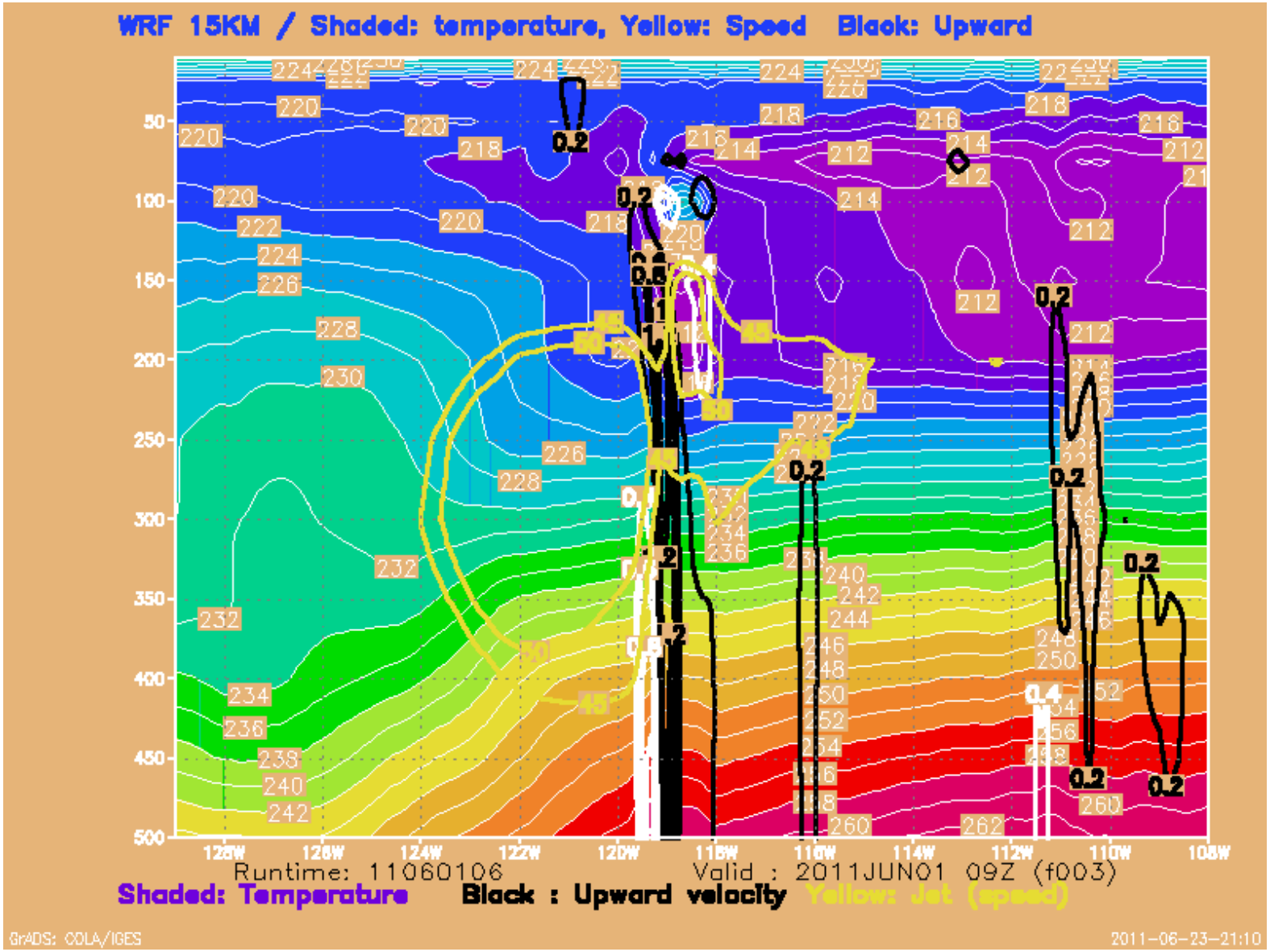
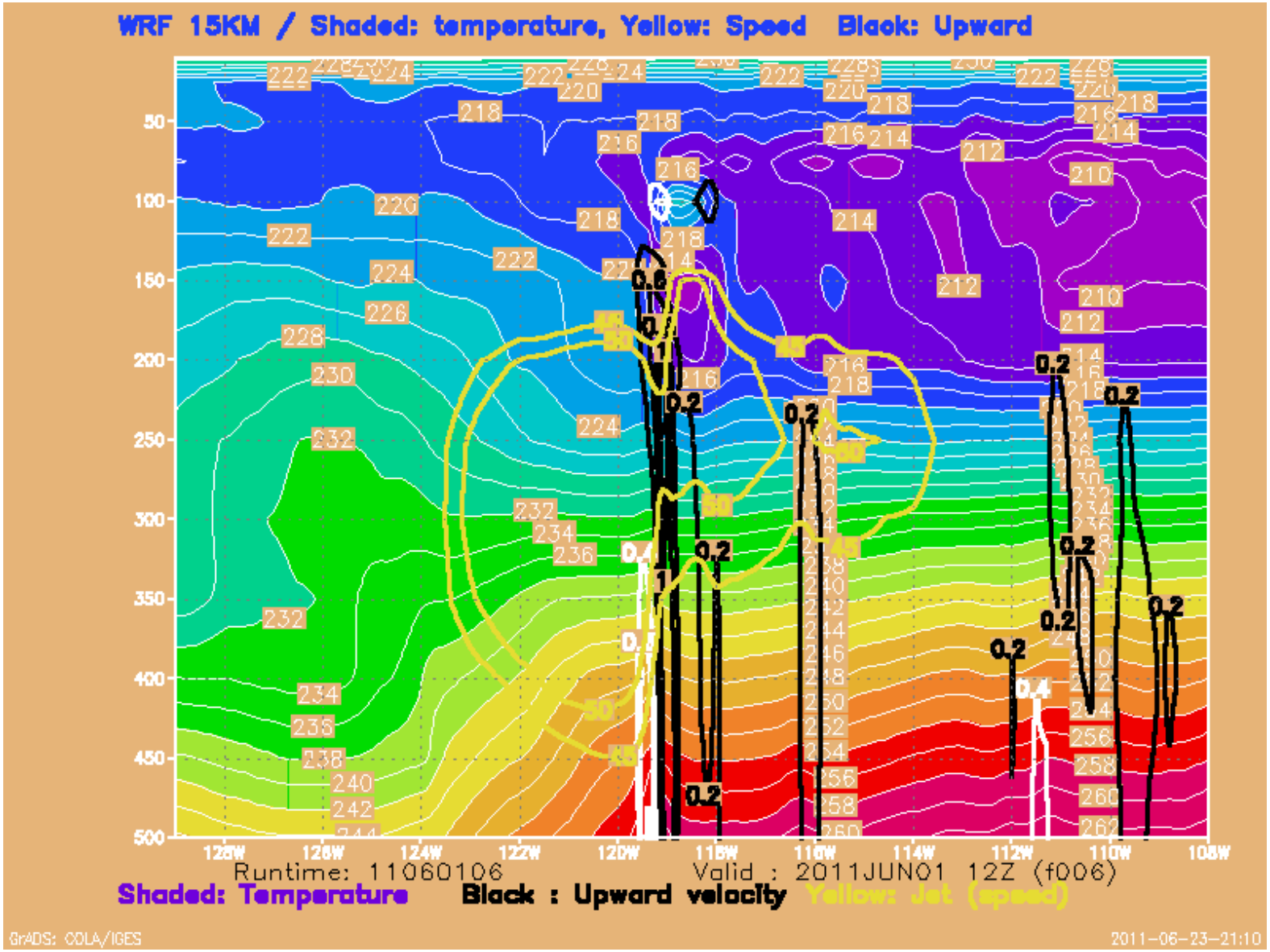
SLAT: WRF 15km

Vertical Cross Section Loop Follows…

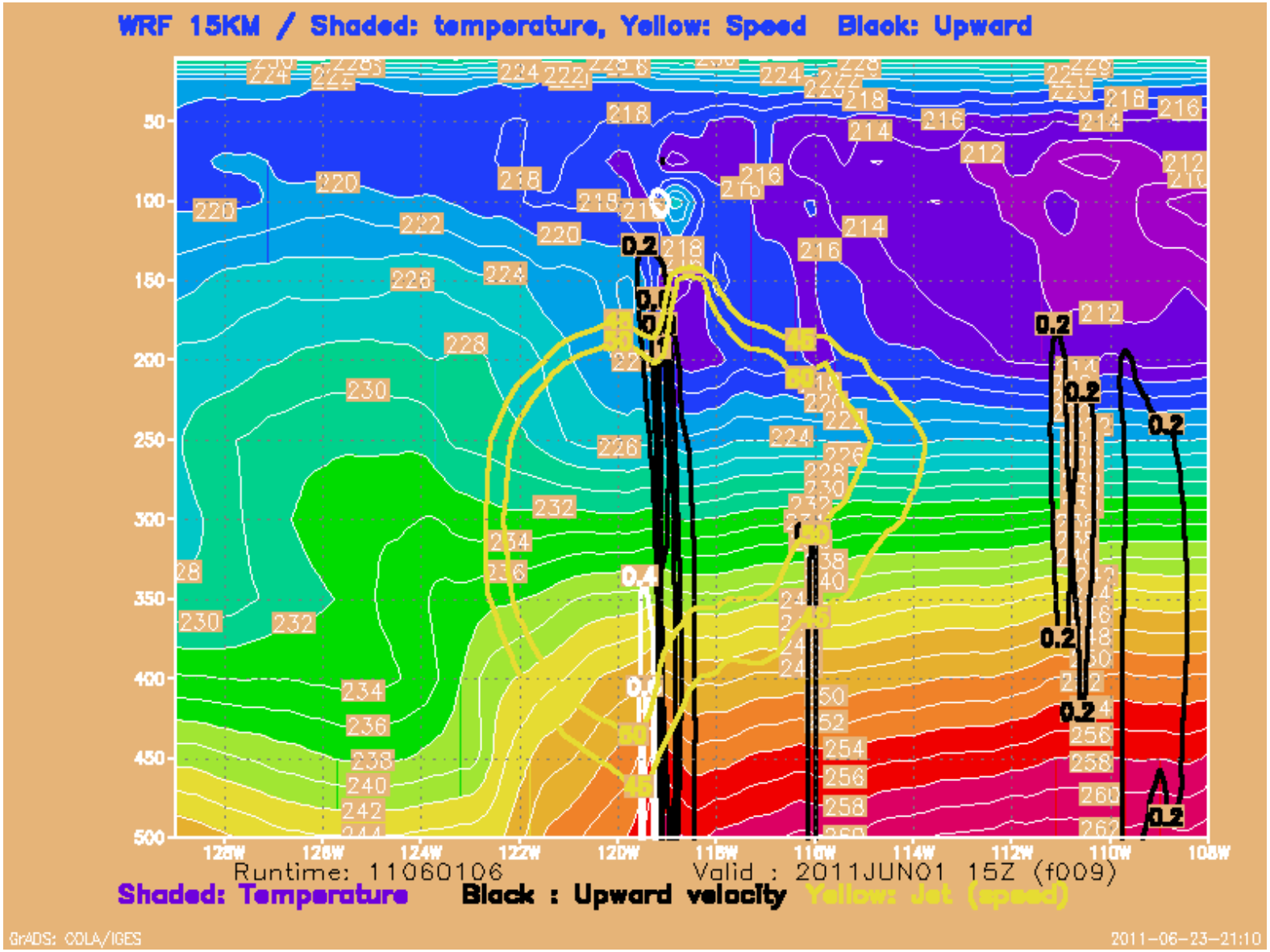
VPMW event: Fhr=3



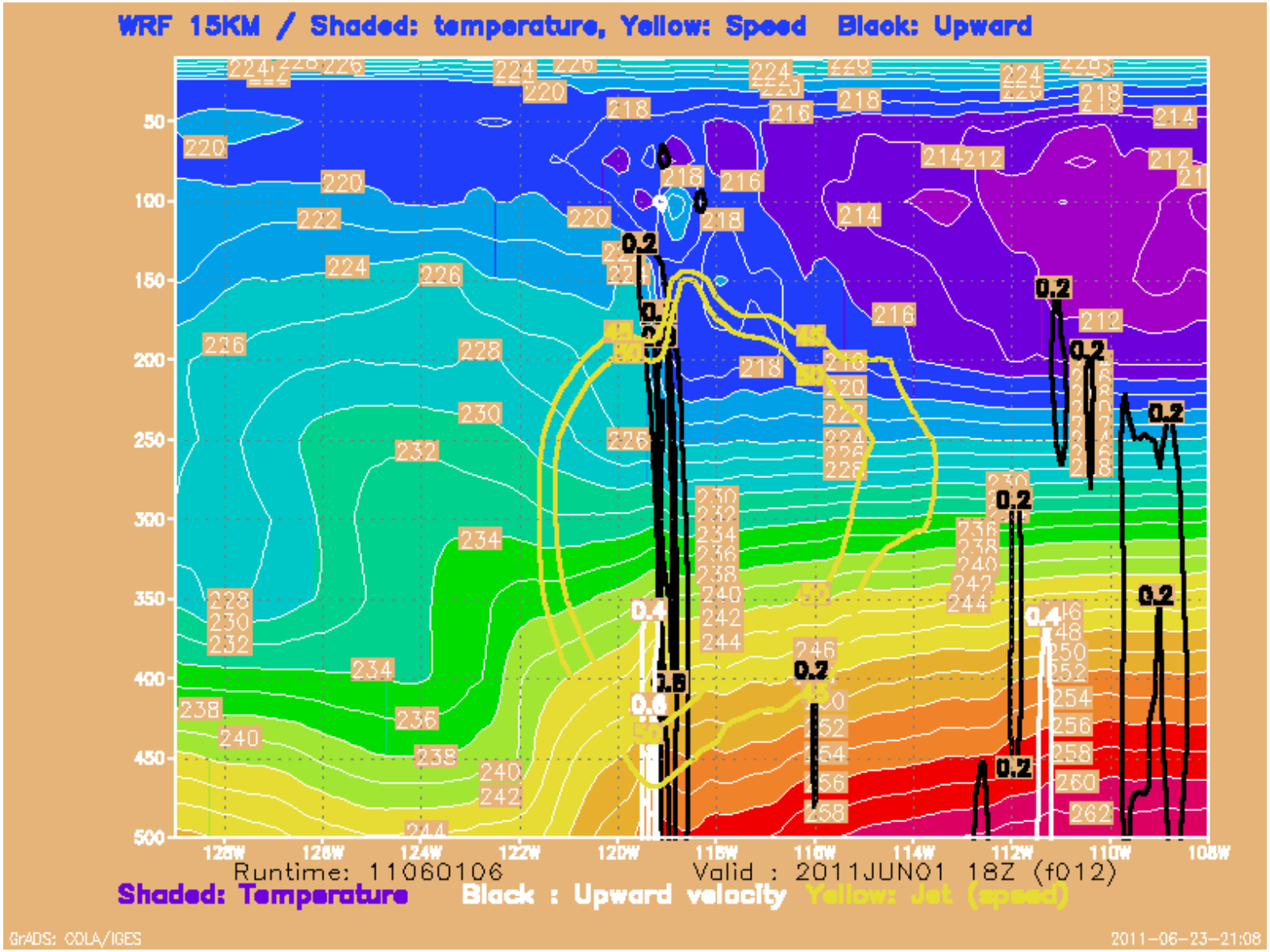
VPMW event: Fhr=6



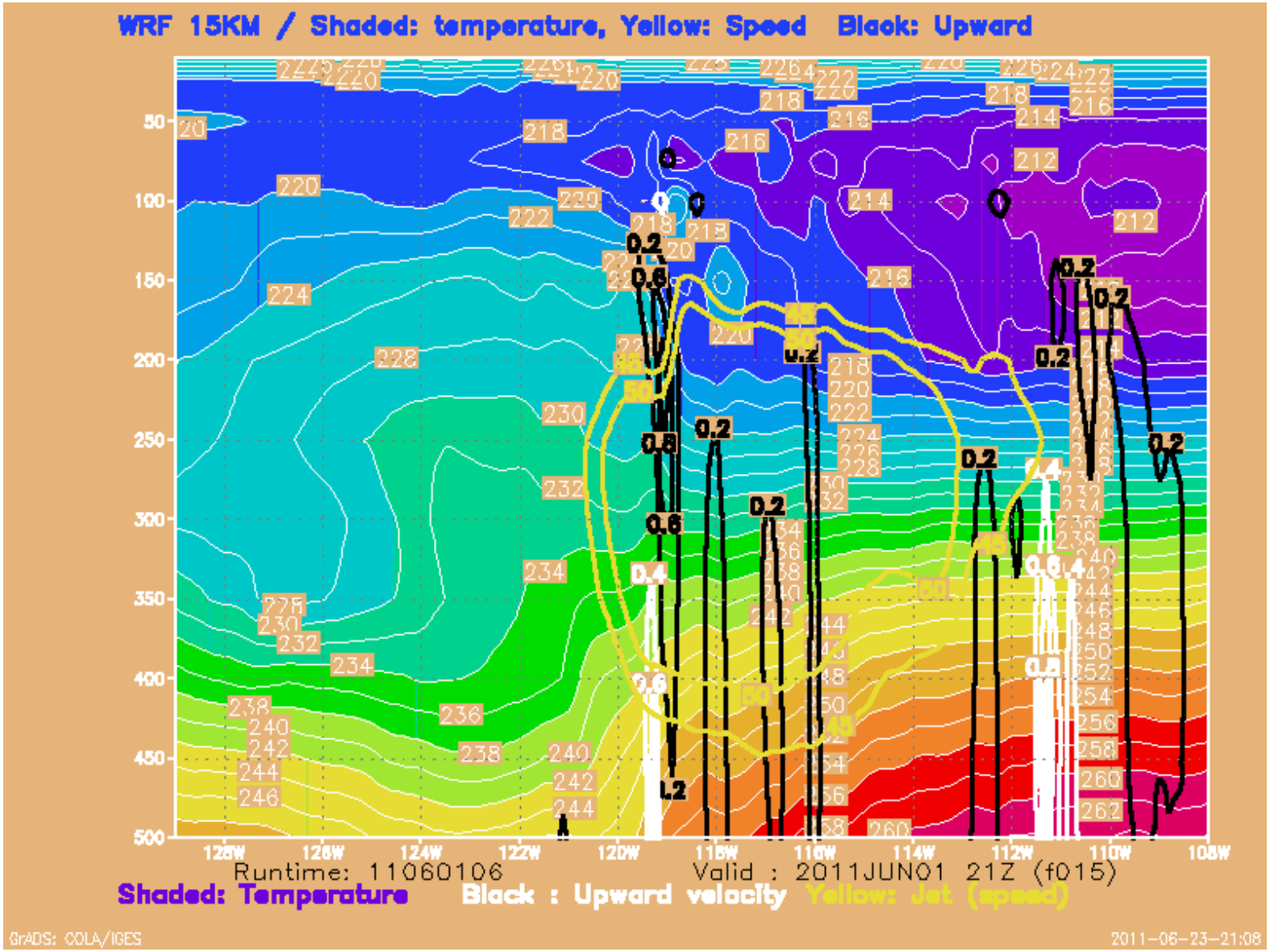
VPMW event: Fhr=9



VPMW event: Fhr=12



VPMW event: Fhr=15



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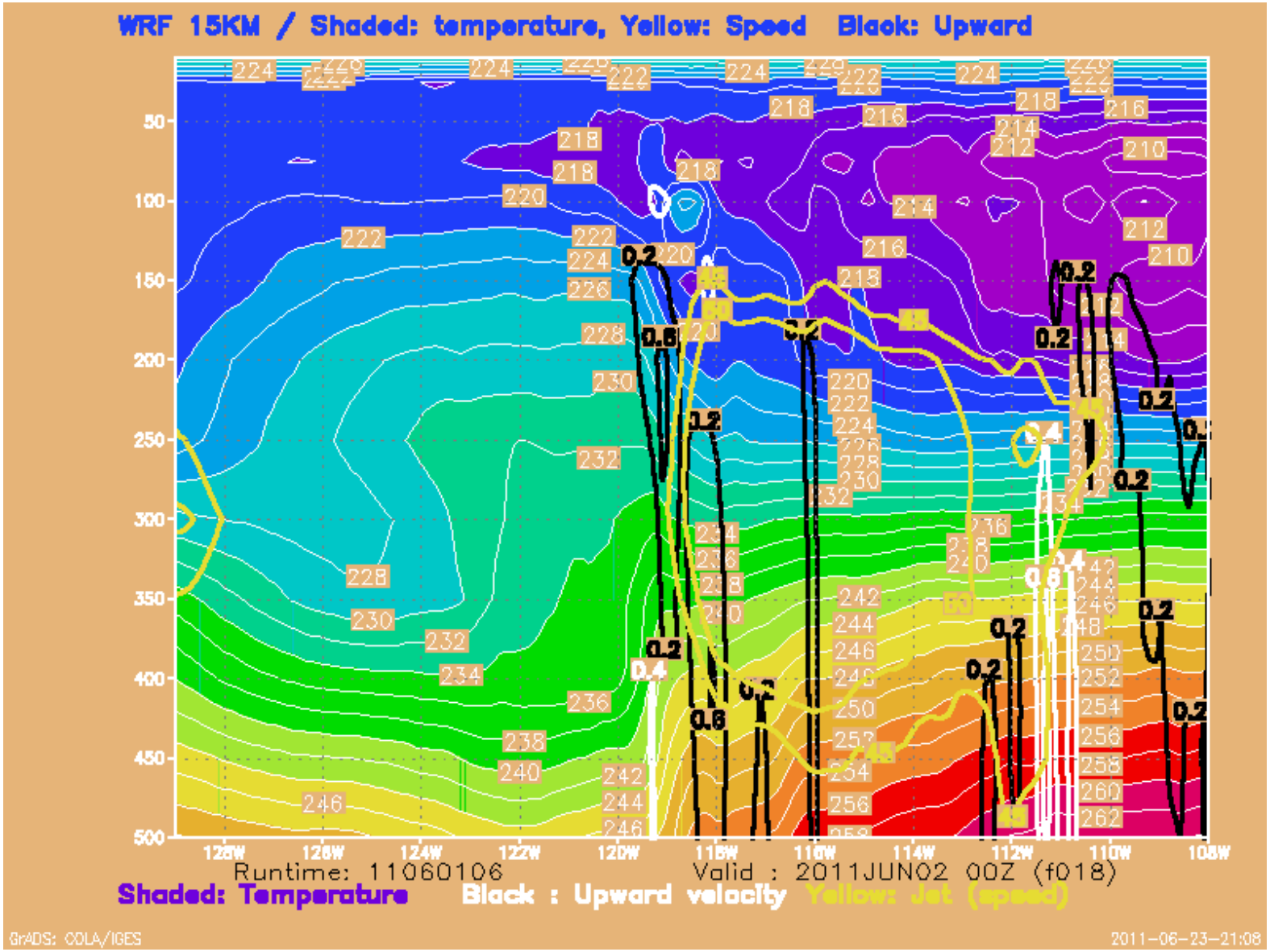
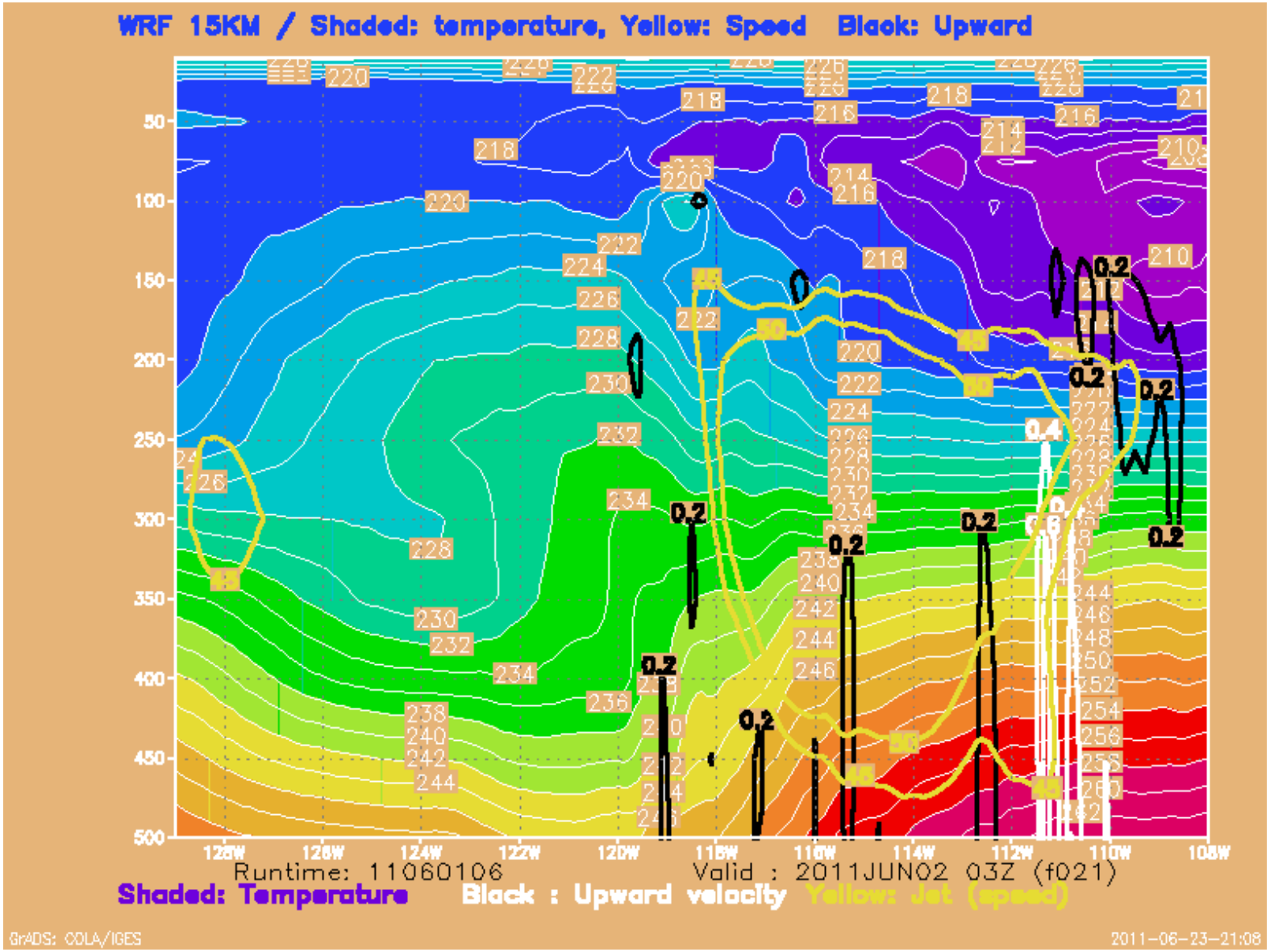
VPMW event: Fhr=18



VPMW event: Fhr=21



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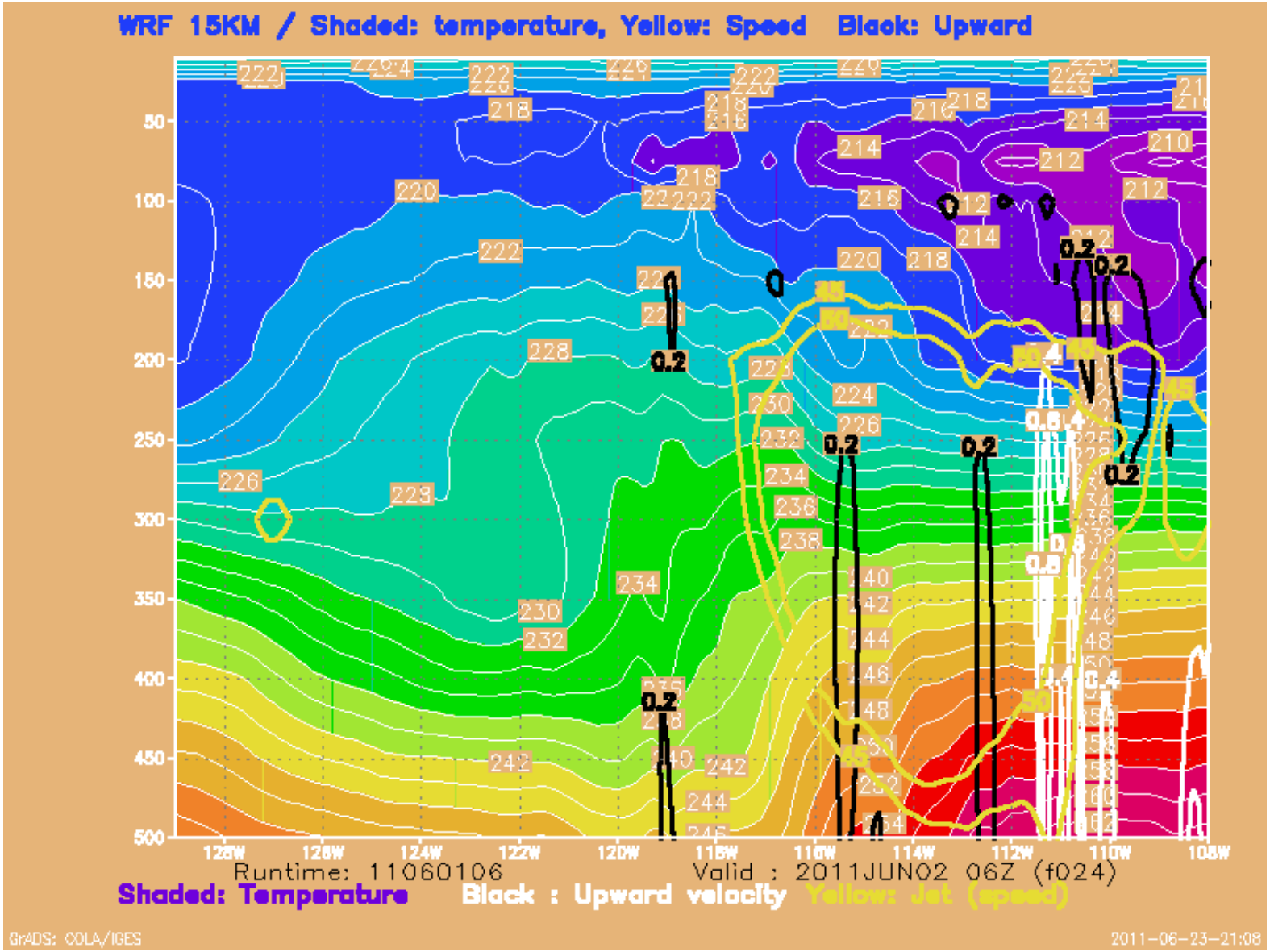
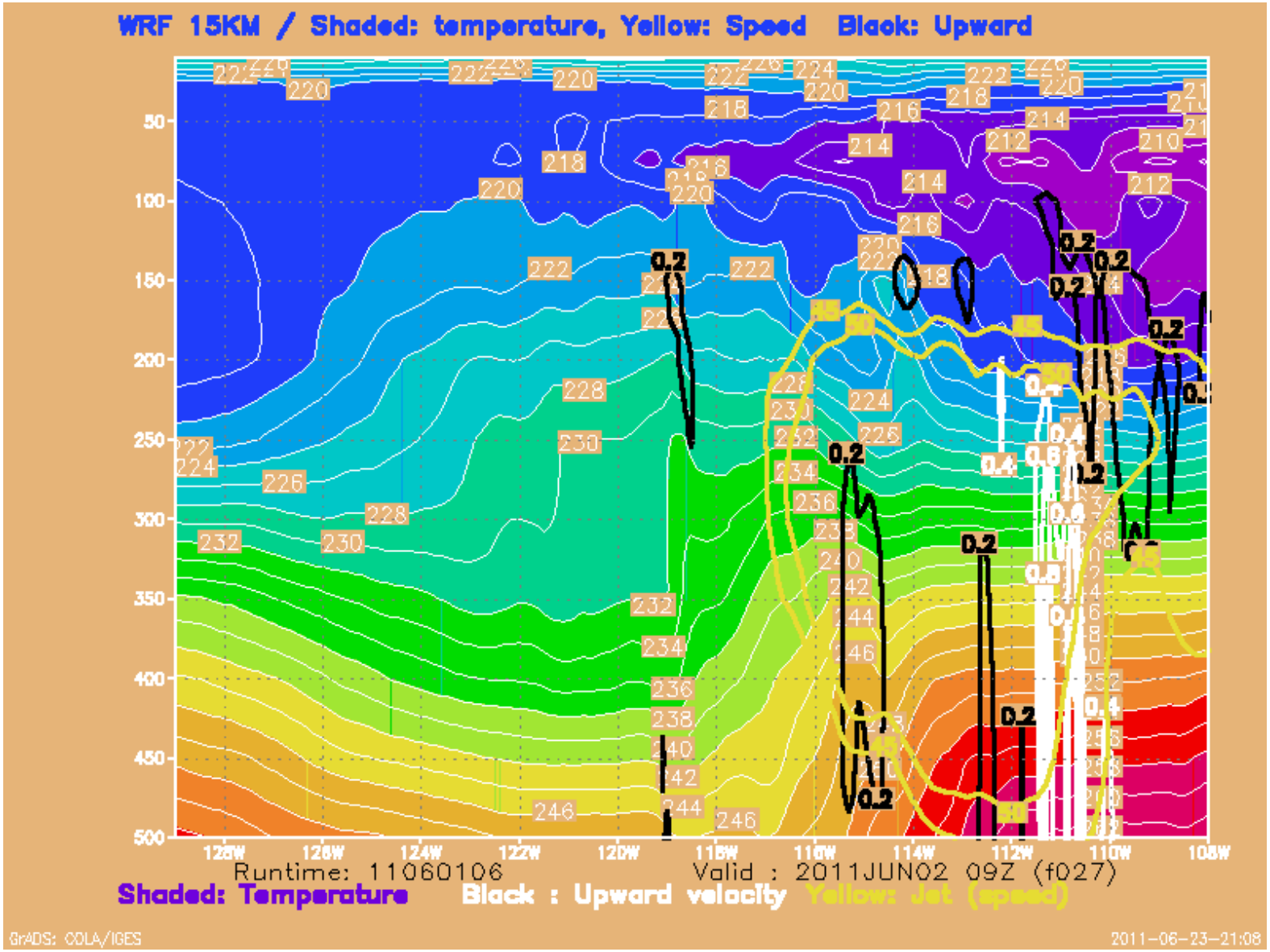
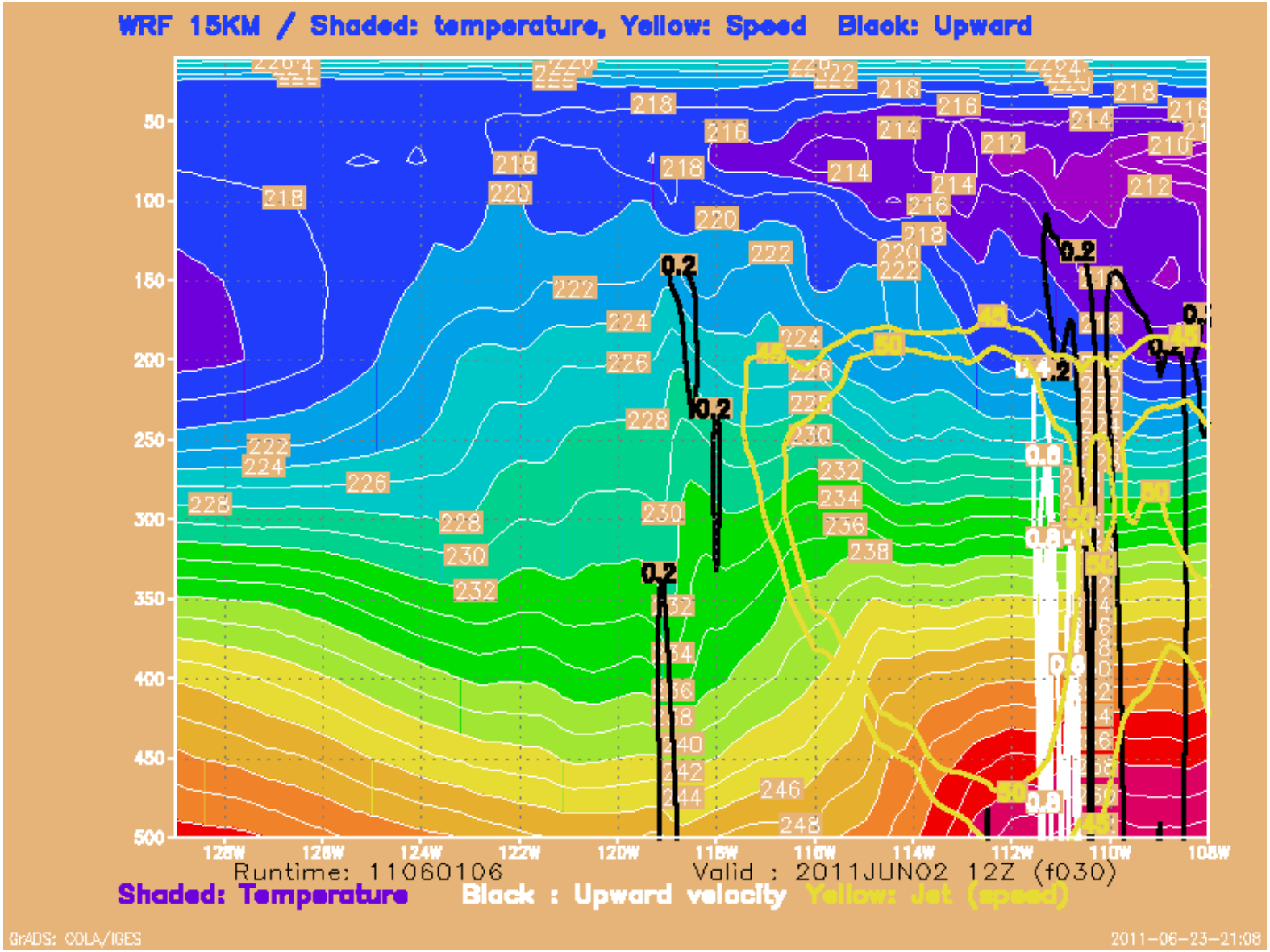
VPMW event: Fhr=24



VPMW event: Fhr=27



VPMW event: Fhr=30



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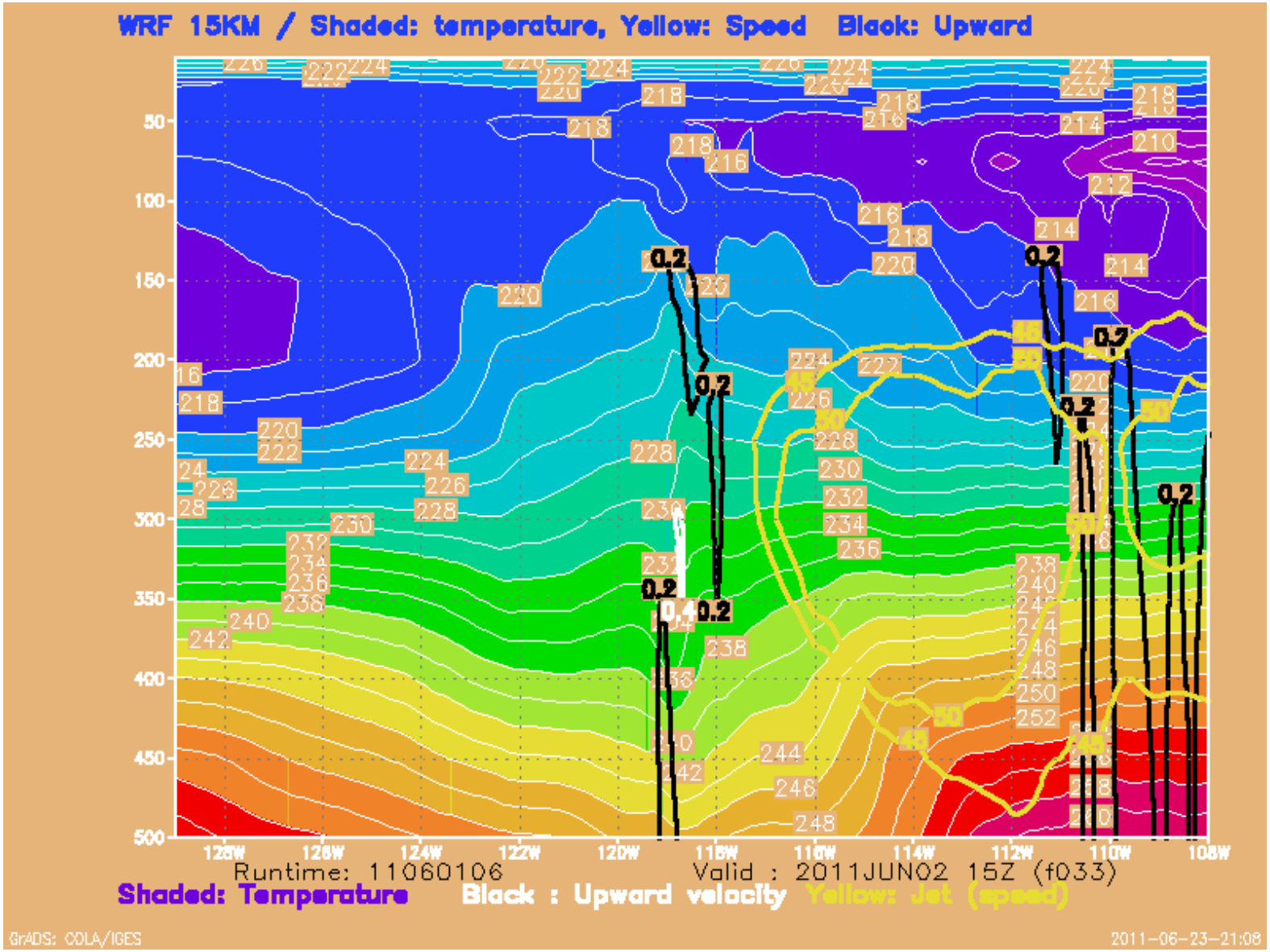
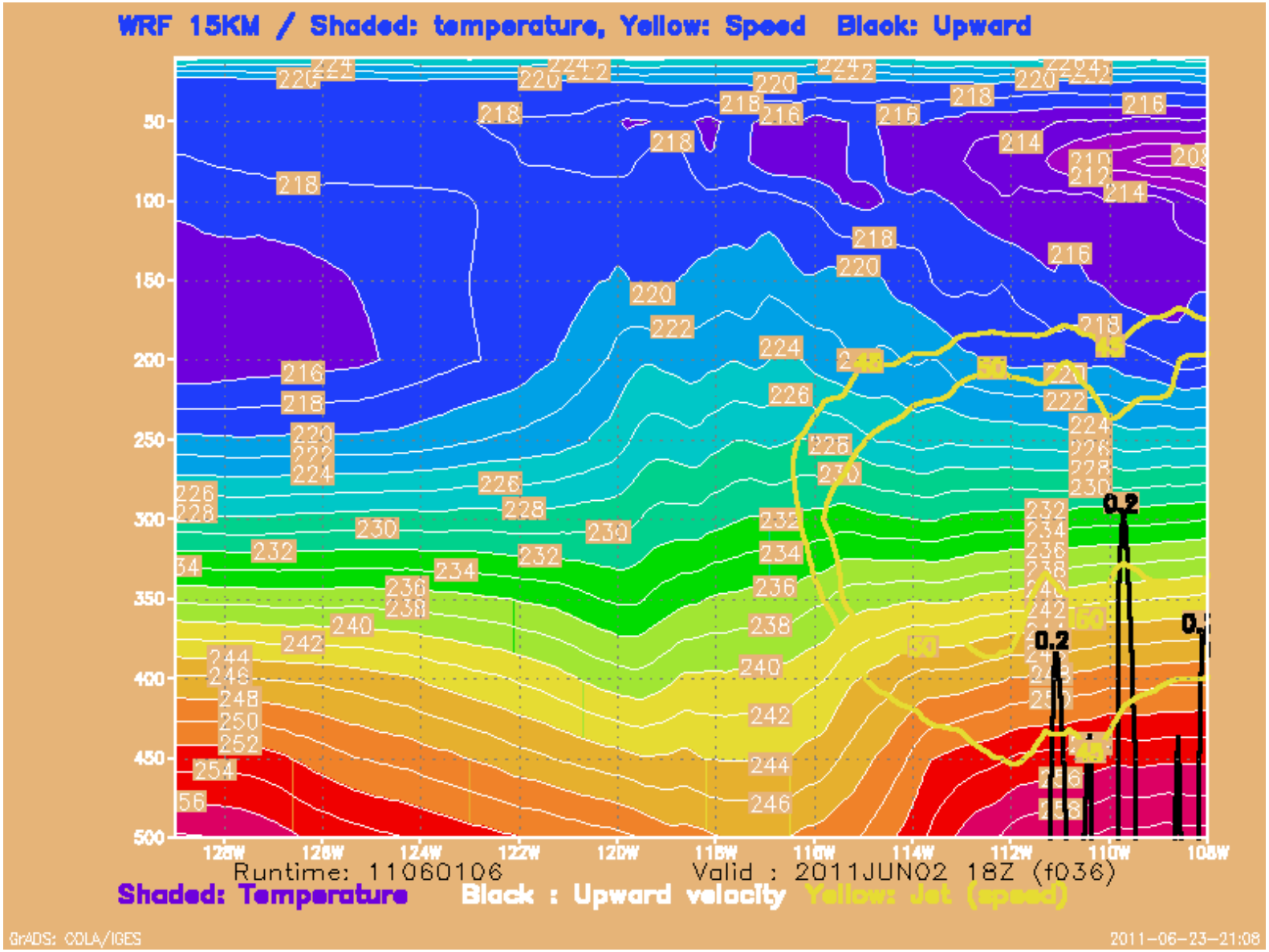
VPMW event: Fhr=33



VPMW event: Fhr=33



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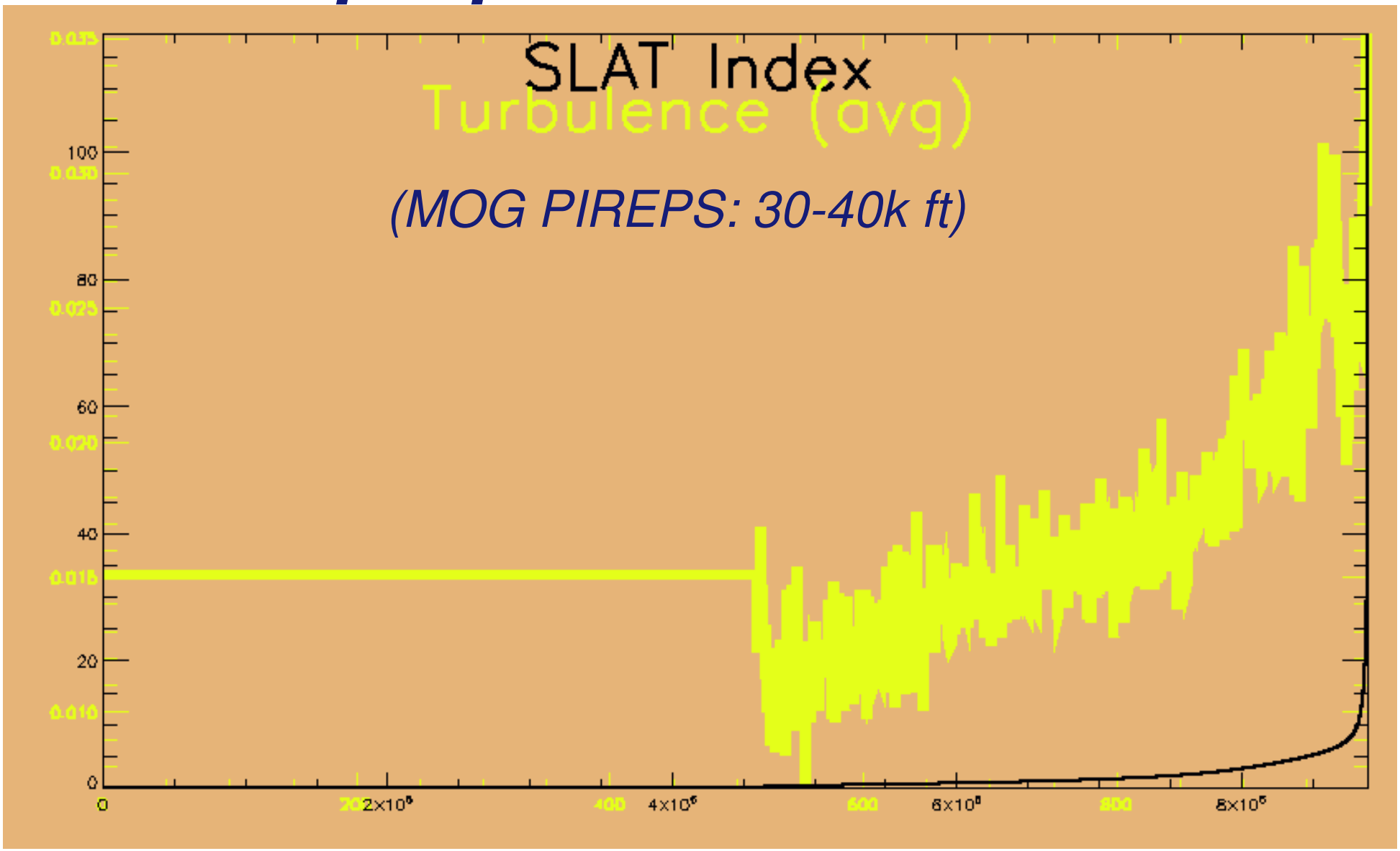
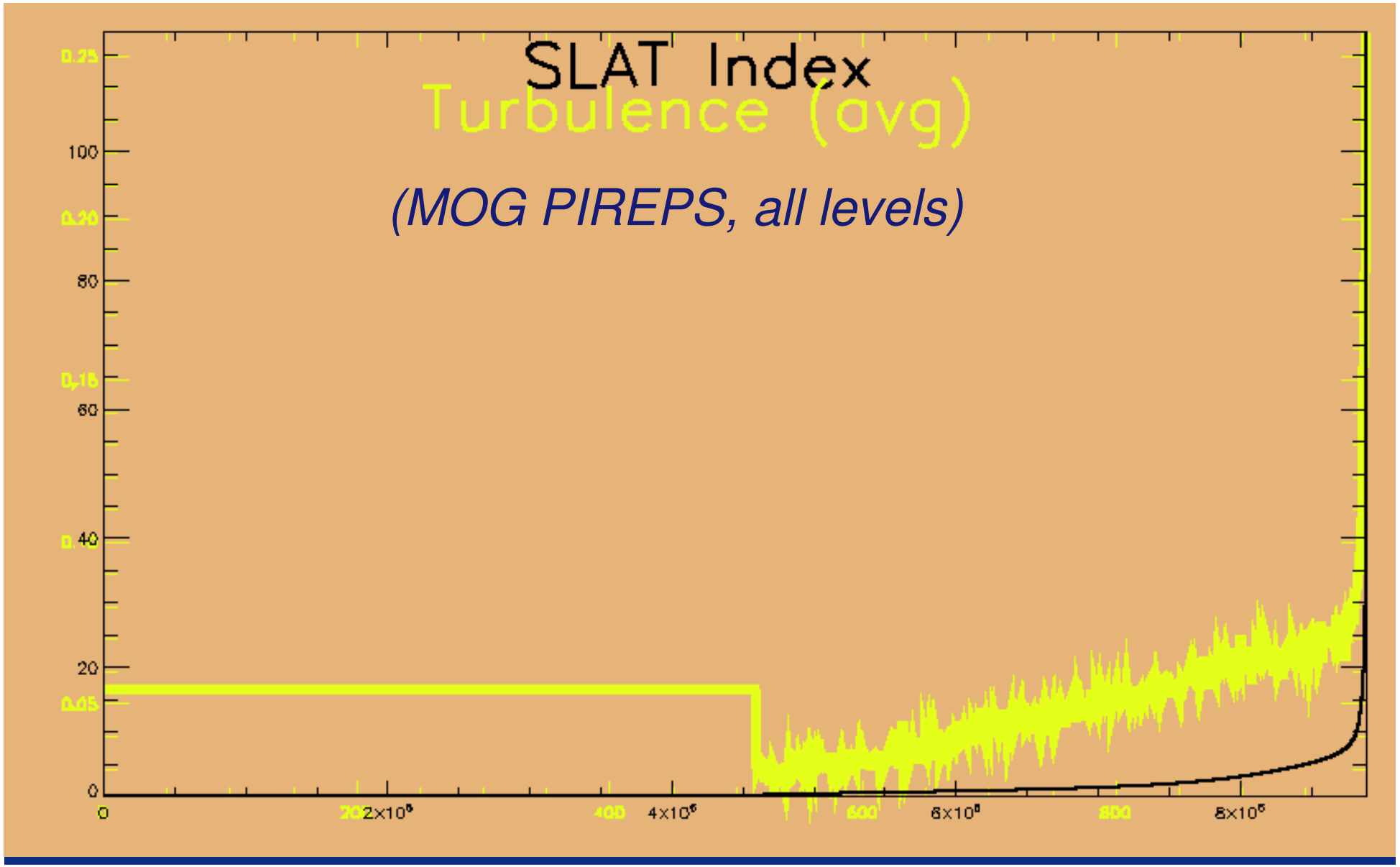
Does SLAT correspond to tropospheric turbulence?

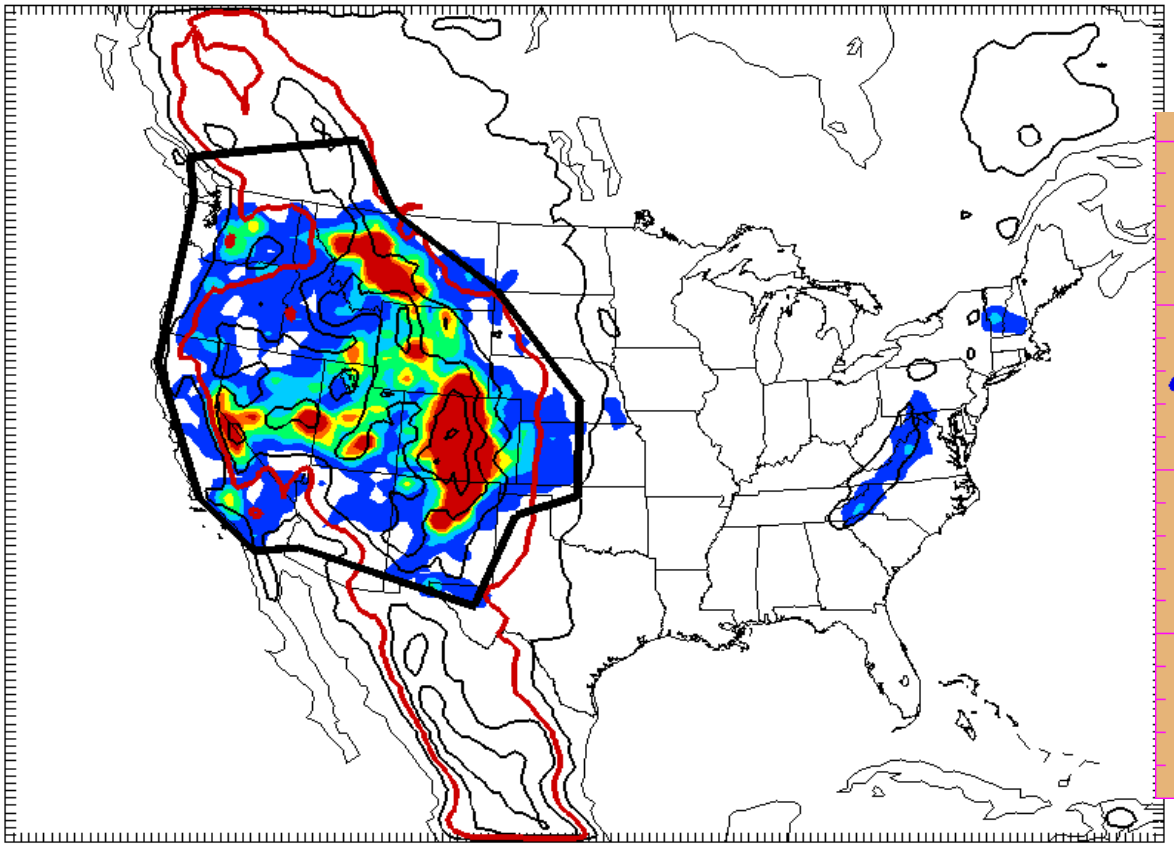


Does SLAT correspond to tropospheric turbulence?

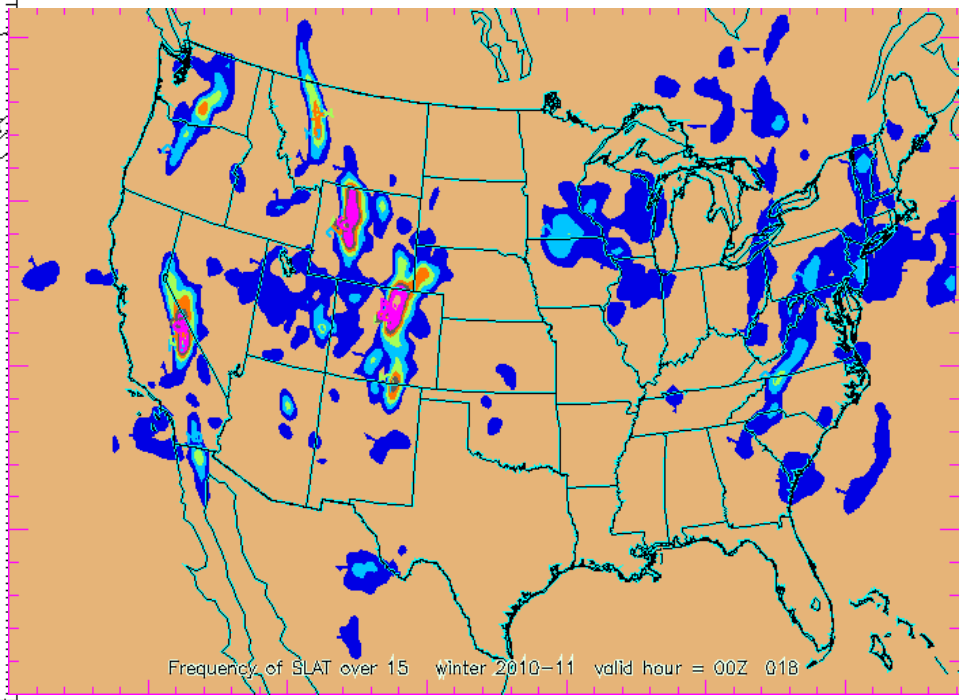


Connecting MOG turbulence with SLAT?

Dr. Sharman:
MOG turbulence frequency:
"Mountain Wave"



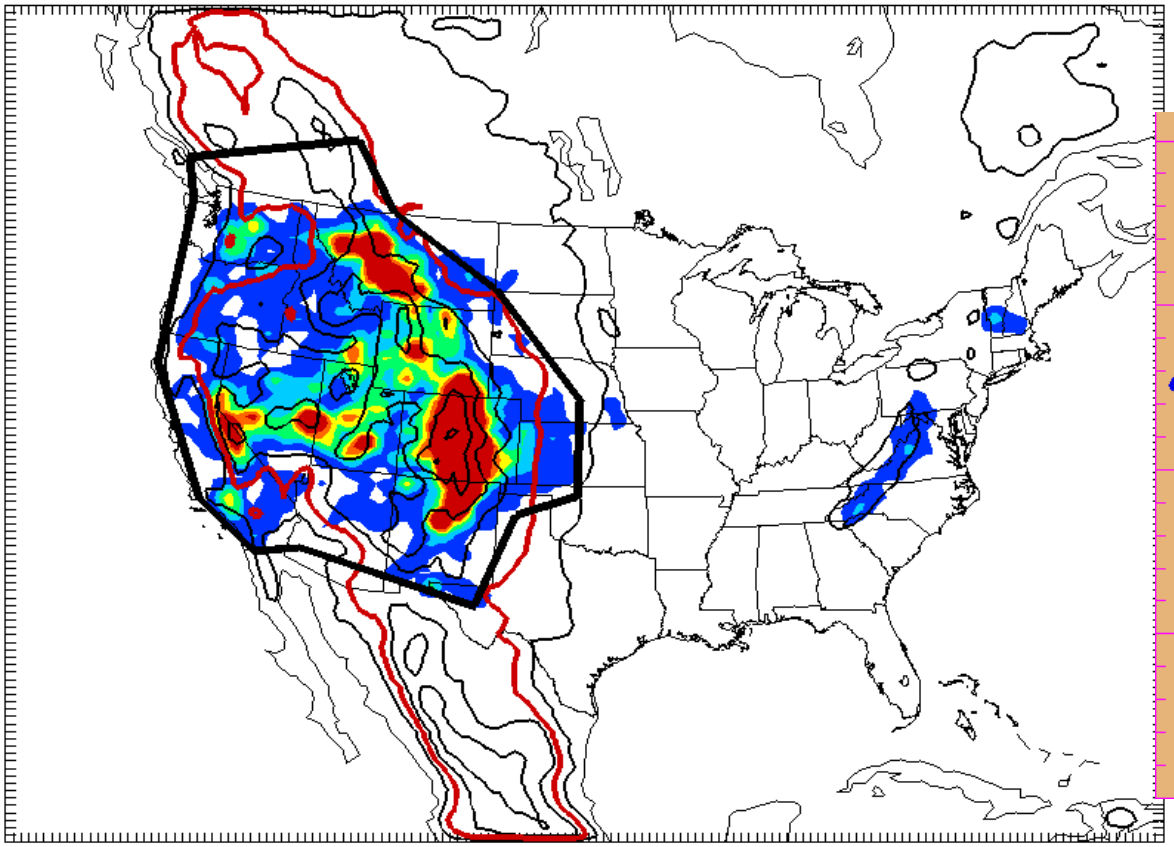
SLAT > 15: frequency



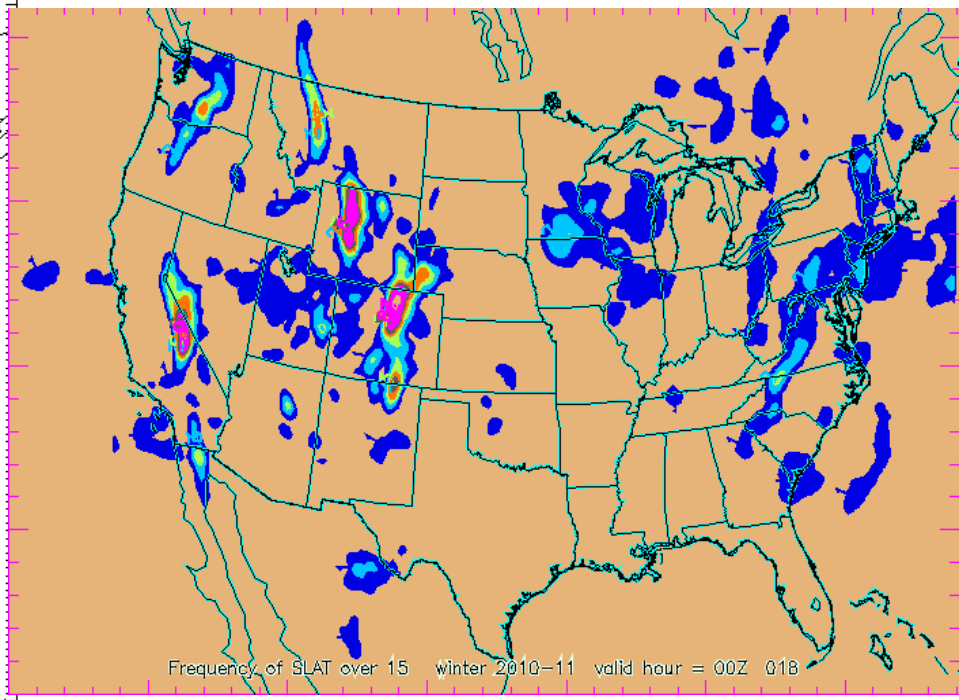
Connecting MOG turbulence with SLAT?

15 years of PIREPS -------- 1 season WRF data

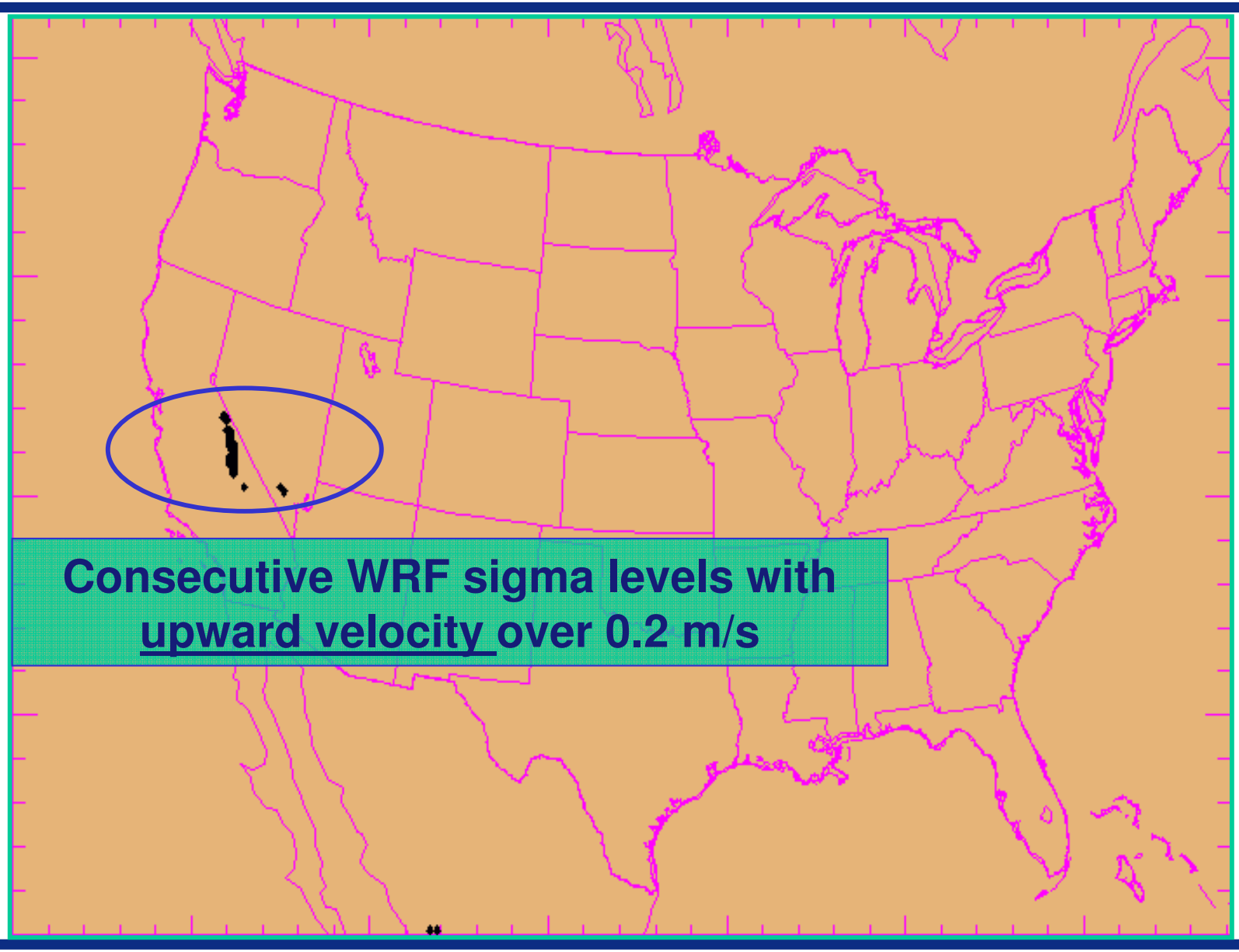
MOG turbulence frequency:
"Mountain Wave"



SLAT > 15 frequency



Operationalize?



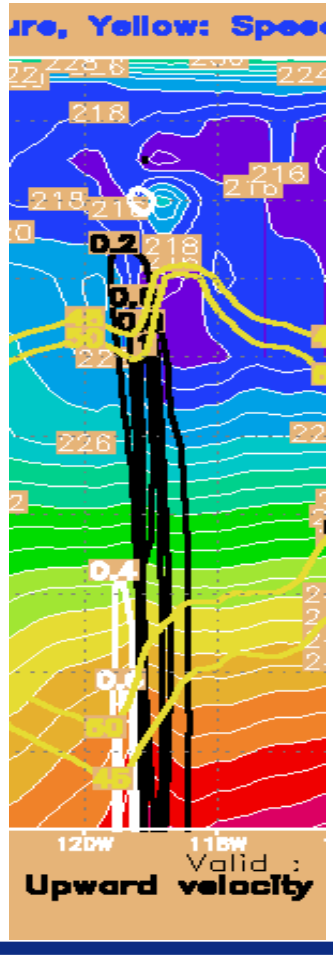
Summary

- The SLAT index: An “S” shaped temperature profile in the stratosphere believed to correspond to turbulence
- Bands of high SLAT values over mountain ranges seen in AFWA WRF 15km output
- WRF 15km model cross sections
  - Jet maxes over mountain ranges
  - Consistent with high-resolution models
  - Show good relation between vertical velocity signature and SLAT

Summary

- Difficult to relate SLAT and/or VPMW to everyday turbulence reports
- Can SLAT be an operational tropospheric turbulence forecast product, using operational 15km WRF?
- Can the “vertical velocity signature” be an operational tropospheric turbulence forecast product, using operational 15km WRF?

Summary



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