Examination of atmospheric waves associated with 13 March 2003 bow echo

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14th Conf. on Mesoscale Processes

Acknowledgements

- Susan van den Heever of CSU
- Morris Weisman, George Bryan of NCAR

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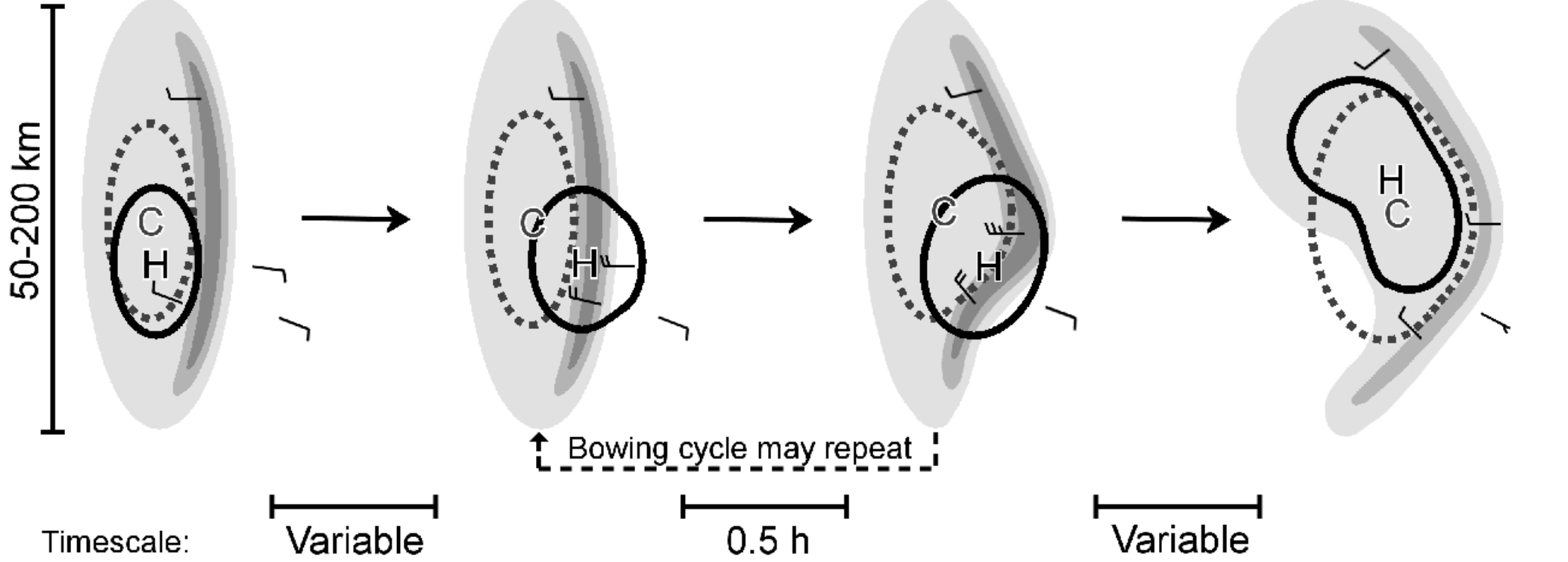
Motivation

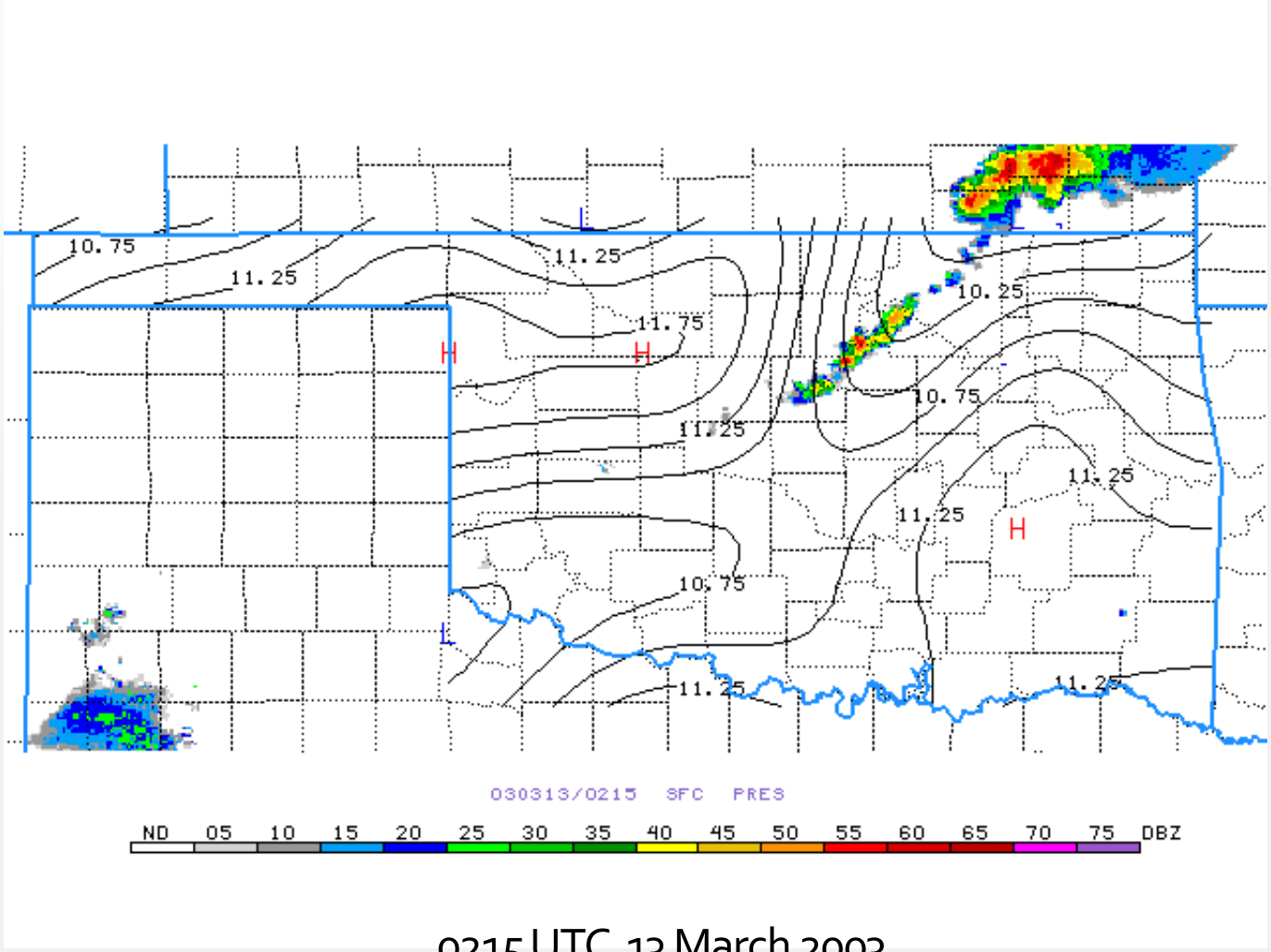
- Surface pressure features noted by Adams-Selin and Johnson (2010) in 13 March 2003 bow echo
  - low pressure region propagating swiftly away from newly forming convective line (approx. 30 m s^{-1})
  - mesohigh surge partially ahead of convection prior to bowing



(Adams-Selin and Johnson 2010)

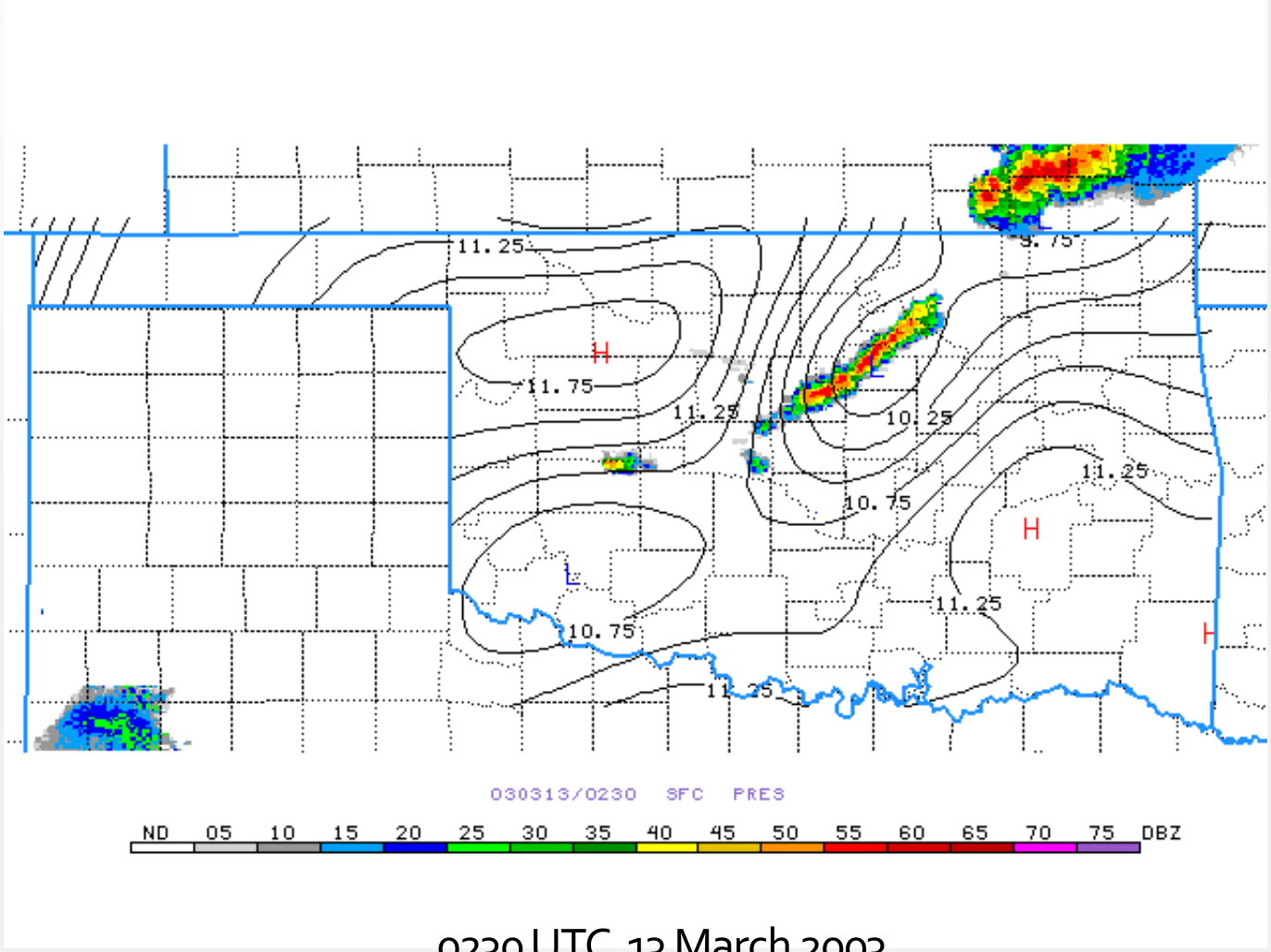
Observations

Oklahoma Mesonet data
- Lanczos high-pass Fourier filter
- time-to-space transformation (Fujita 1955)



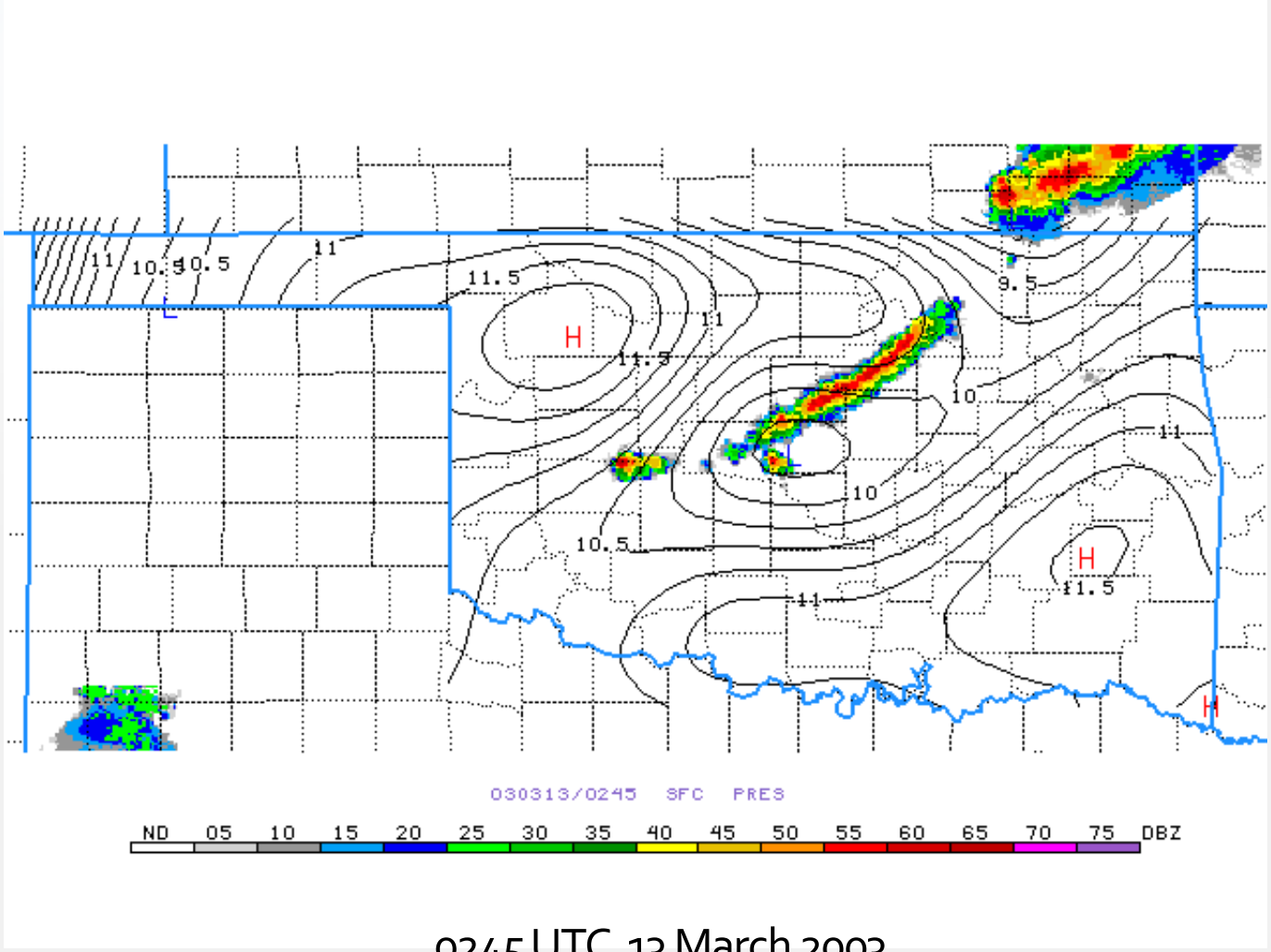
0215 UTC 13 March 2003

Observations



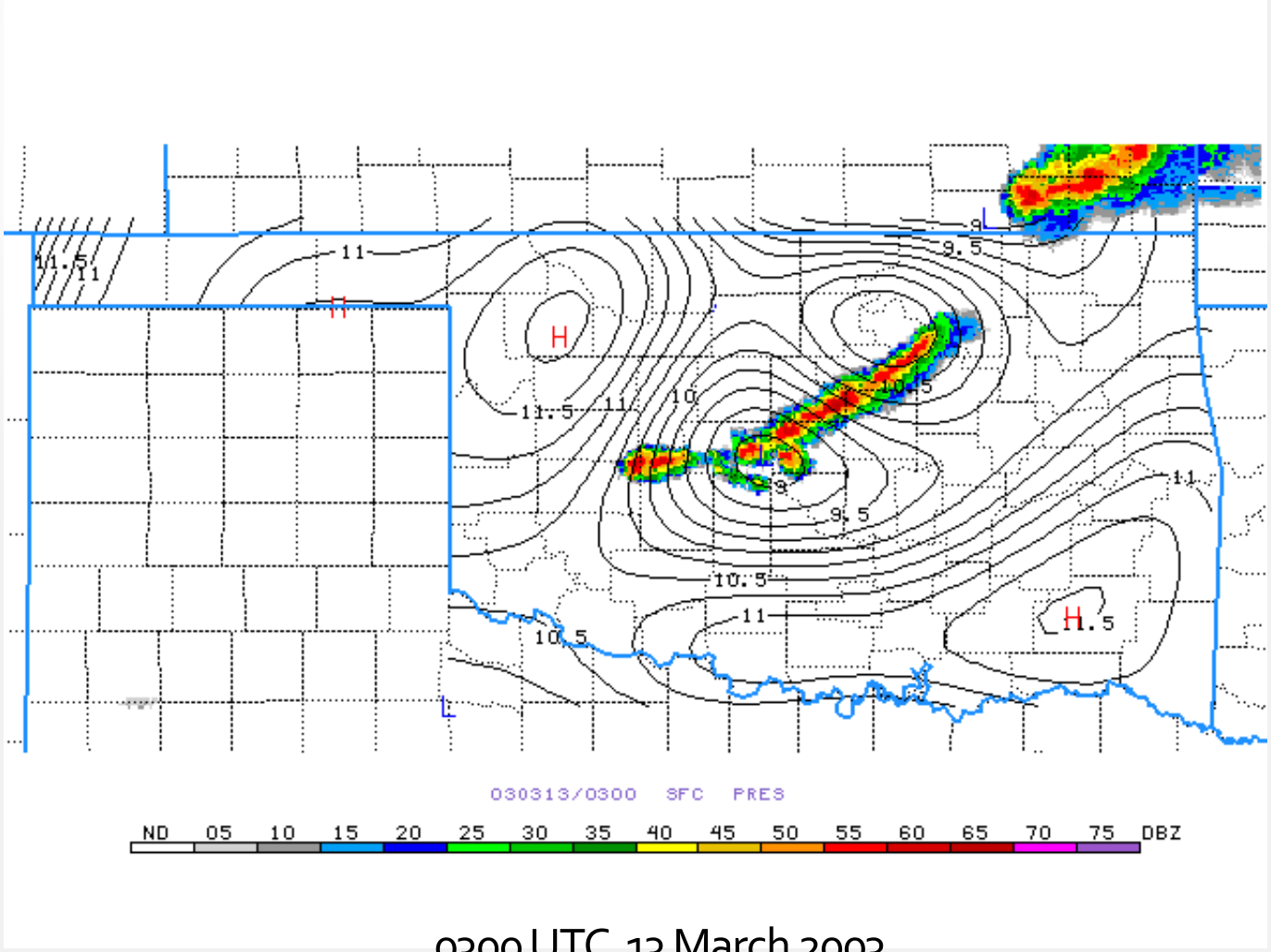
0230 UTC 13 March 2003

Observations



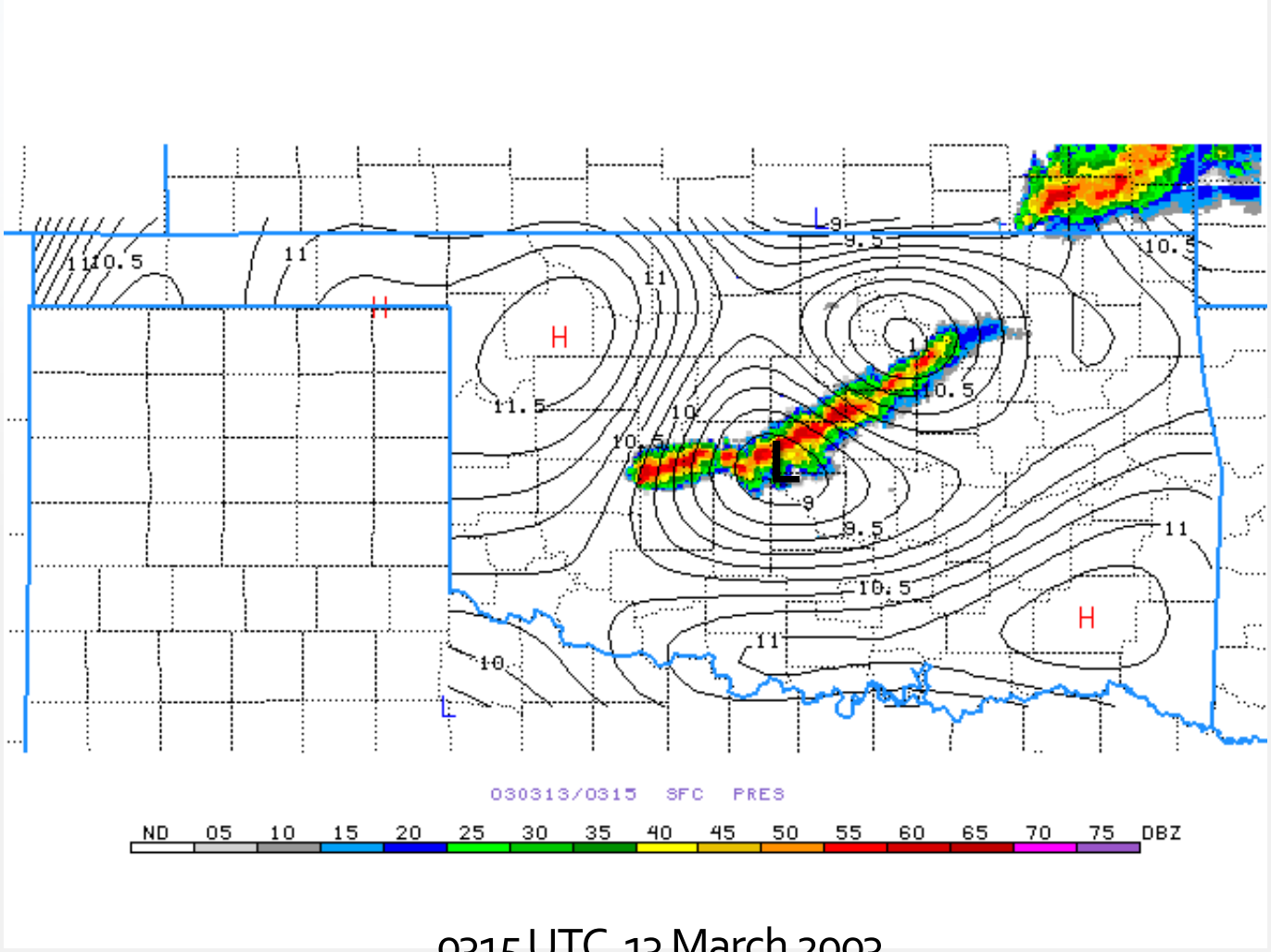
0245 UTC 13 March 2003

Observations



0300 UTC 13 March 2003

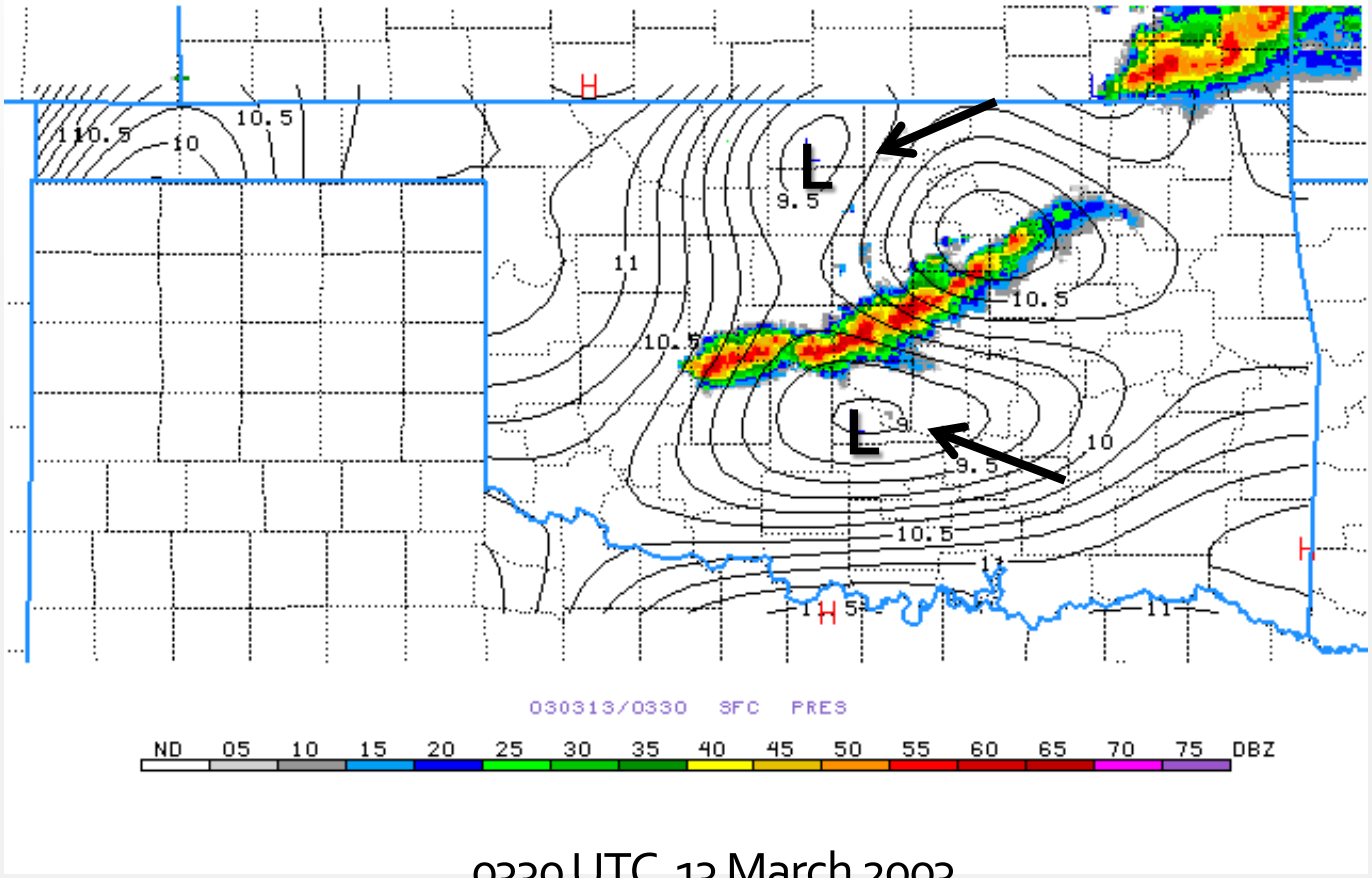
Observations



0315 UTC 13 March 2003

Observations

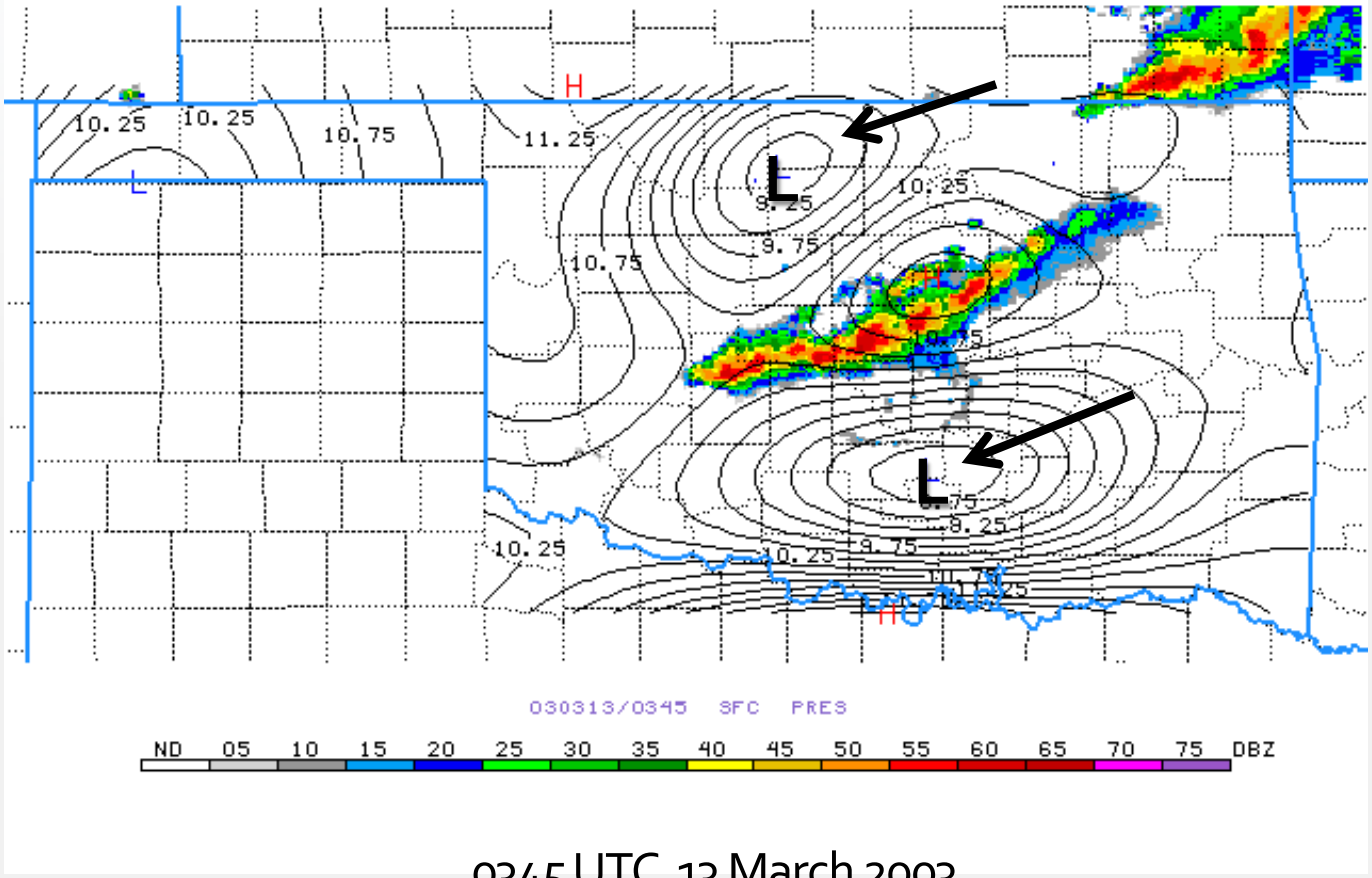
Low pressure regions moving swiftly away from convection



0330 UTC 13 March 2003

Observations

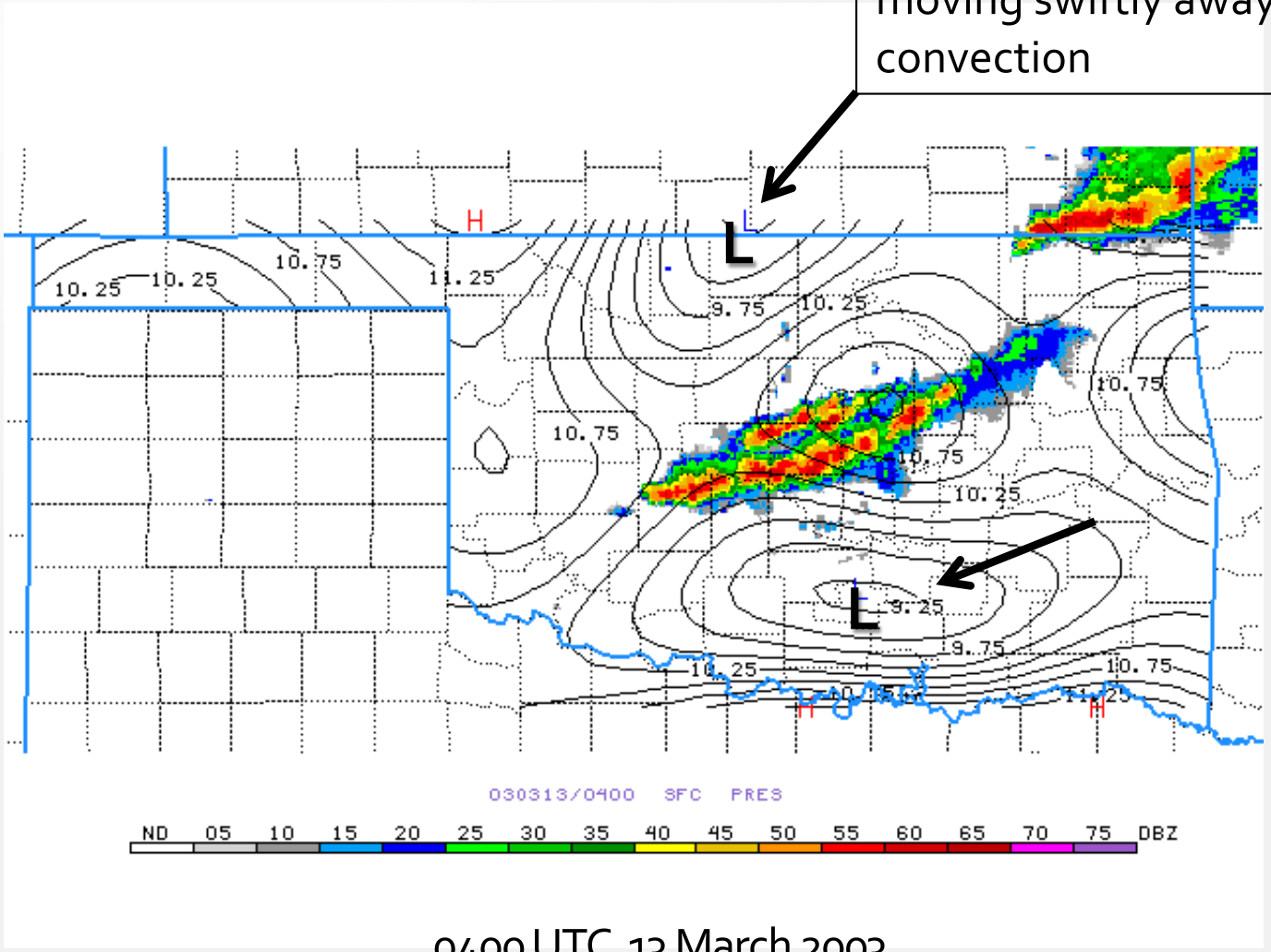
Low pressure regions moving swiftly away from convection



0345 UTC 13 March 2003

Observations

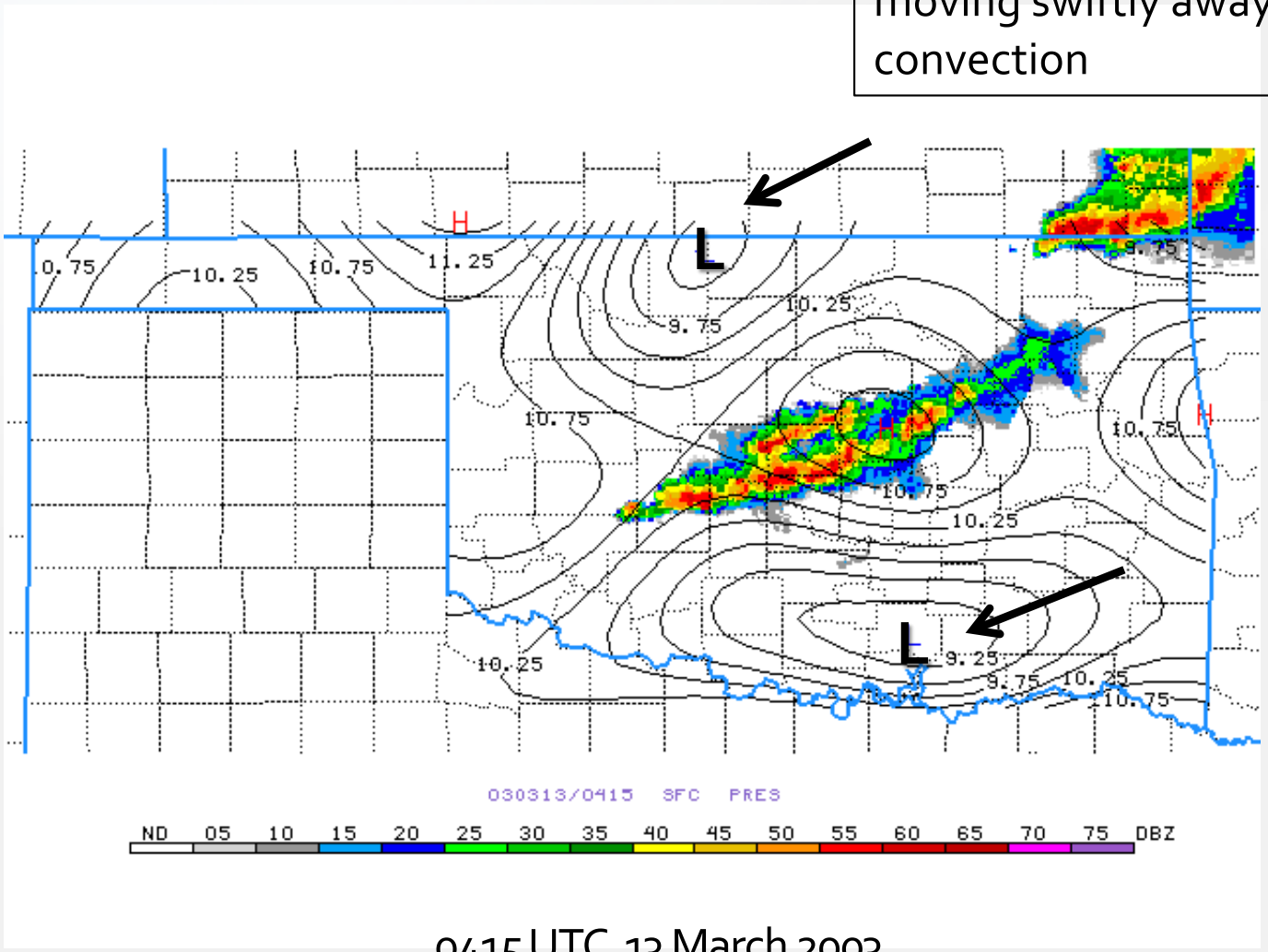
Low pressure regions moving swiftly away from convection



0400 UTC 13 March 2003

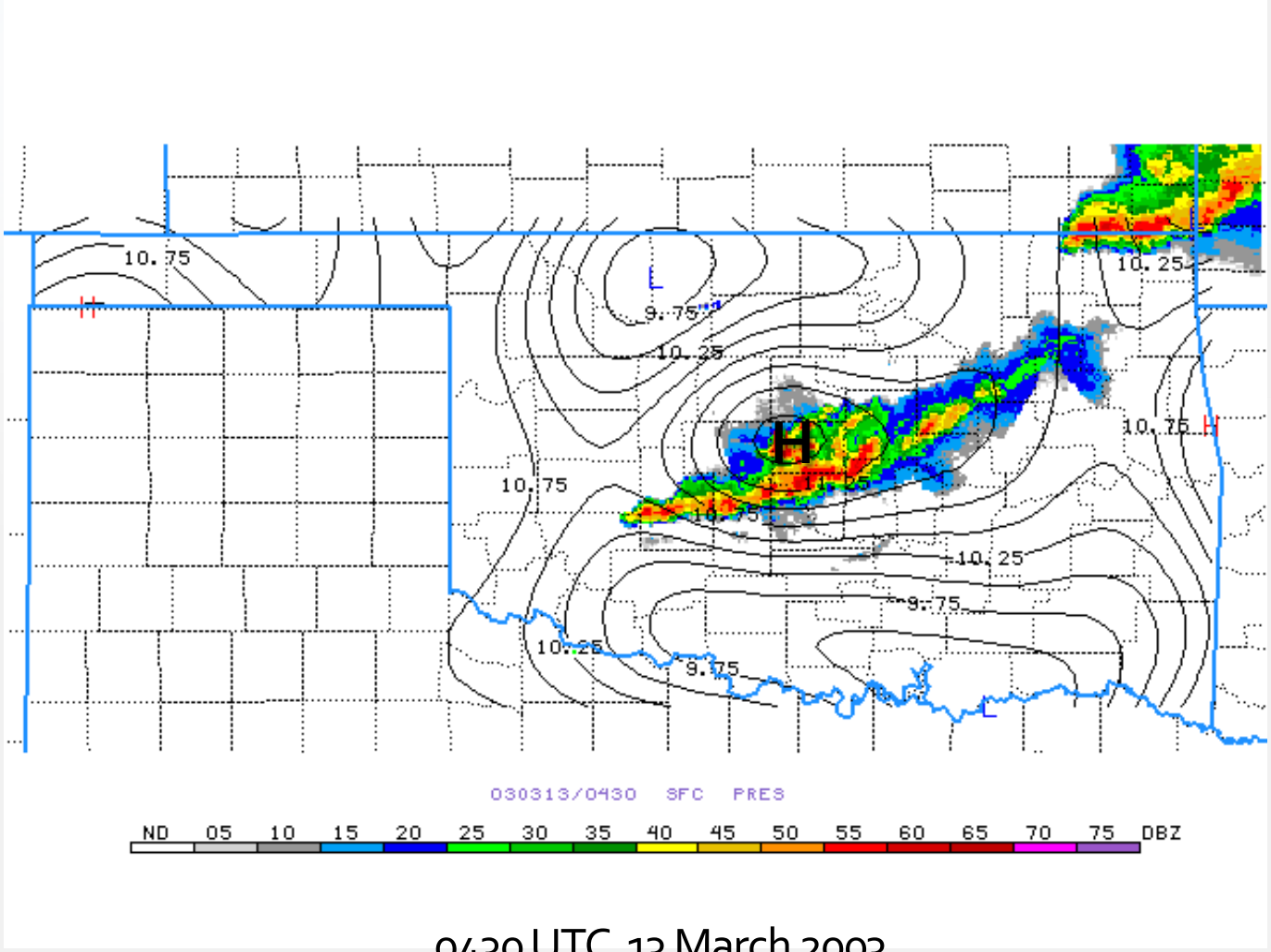
Observations

Low pressure regions moving swiftly away from convection



0415 UTC 13 March 2003

Observations



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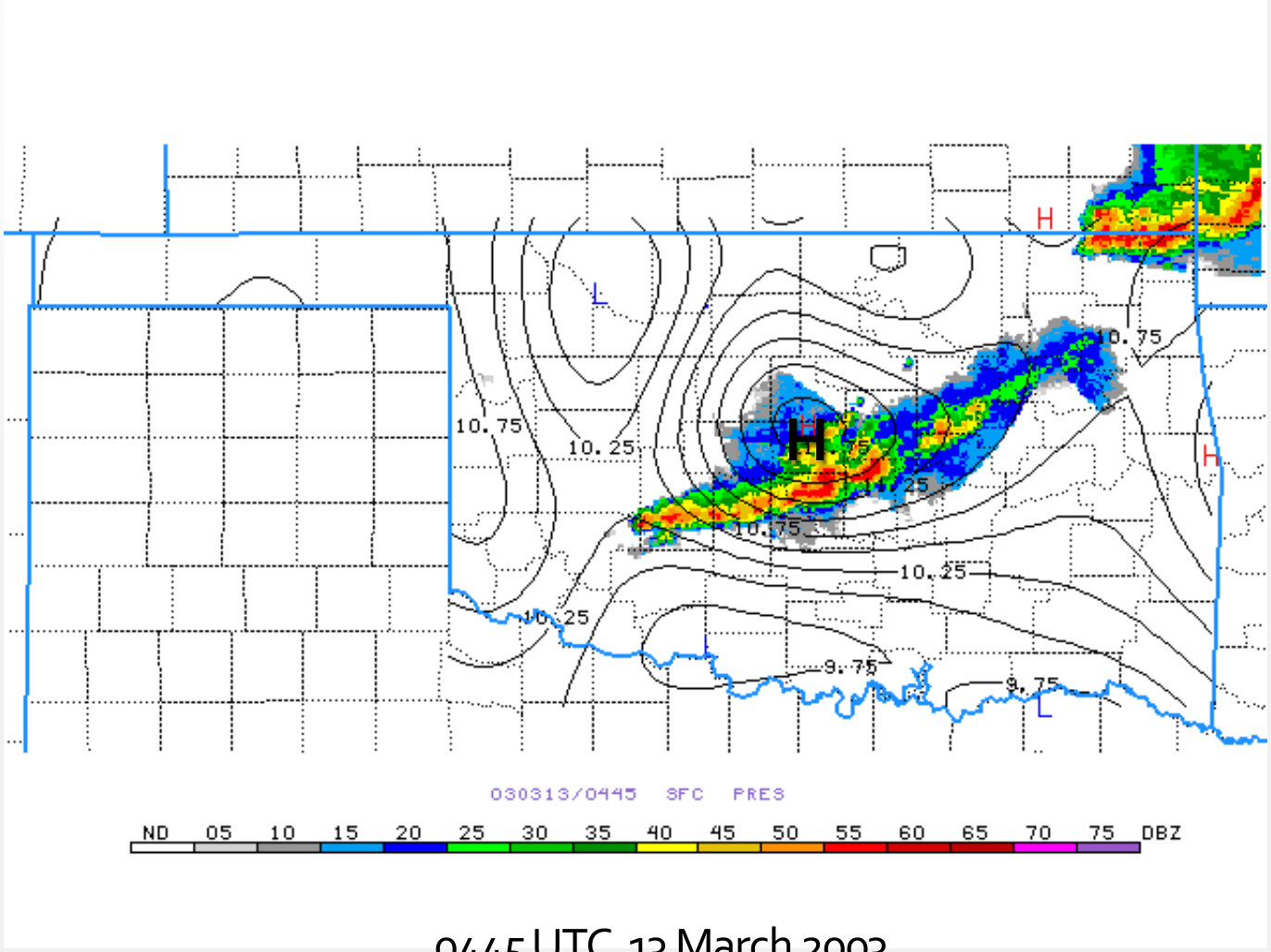
Observations



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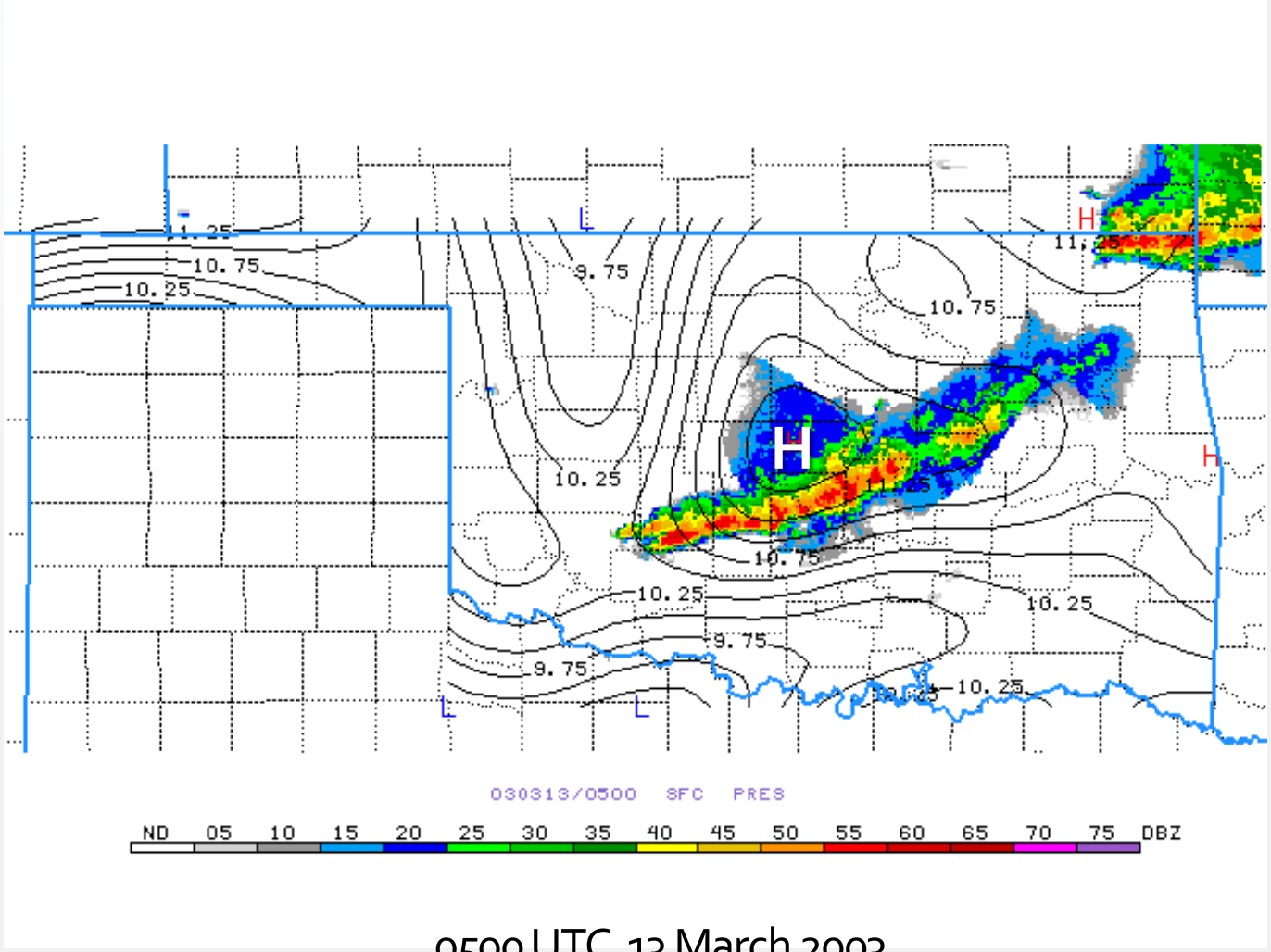
Observations



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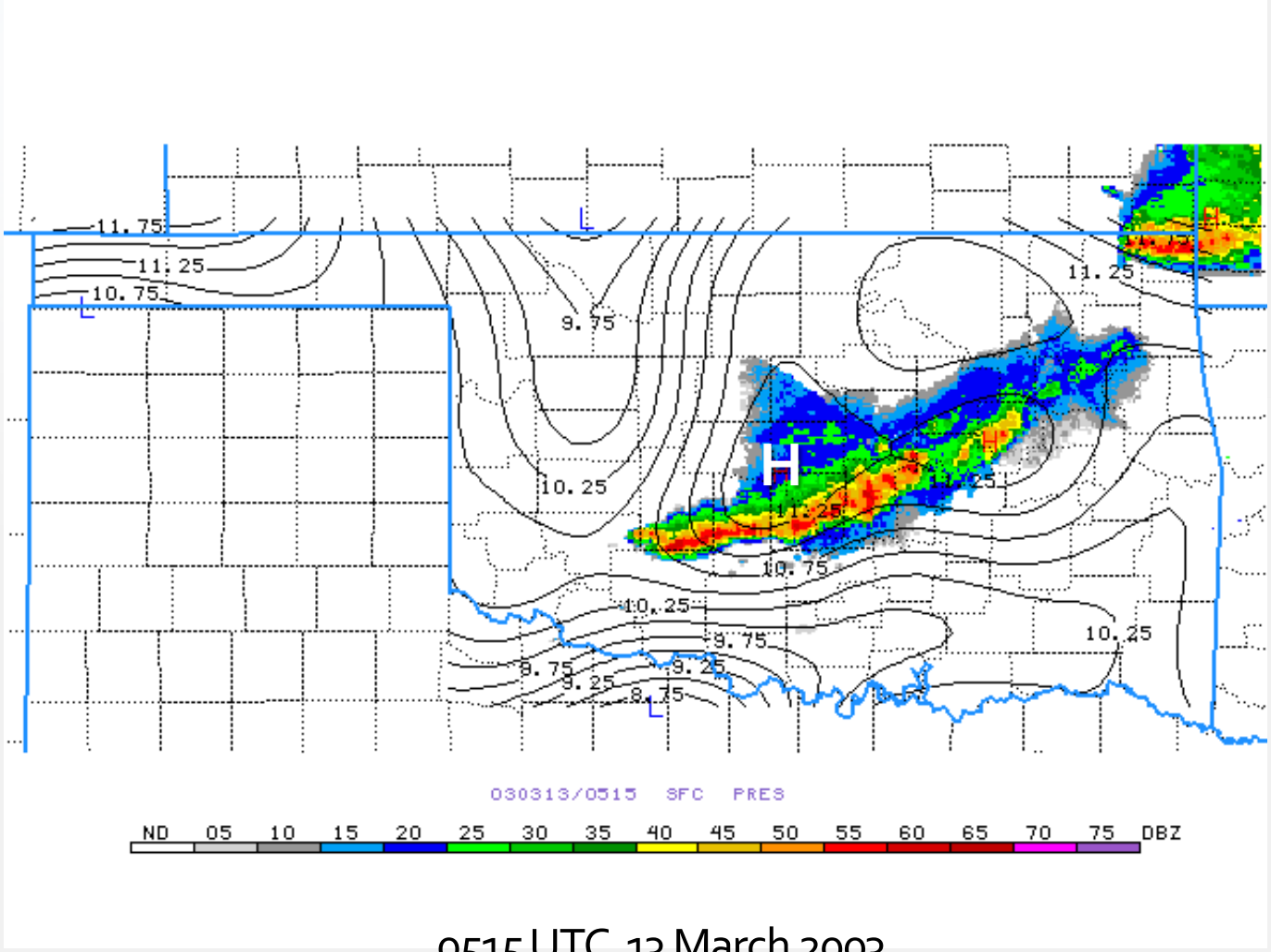
Observations



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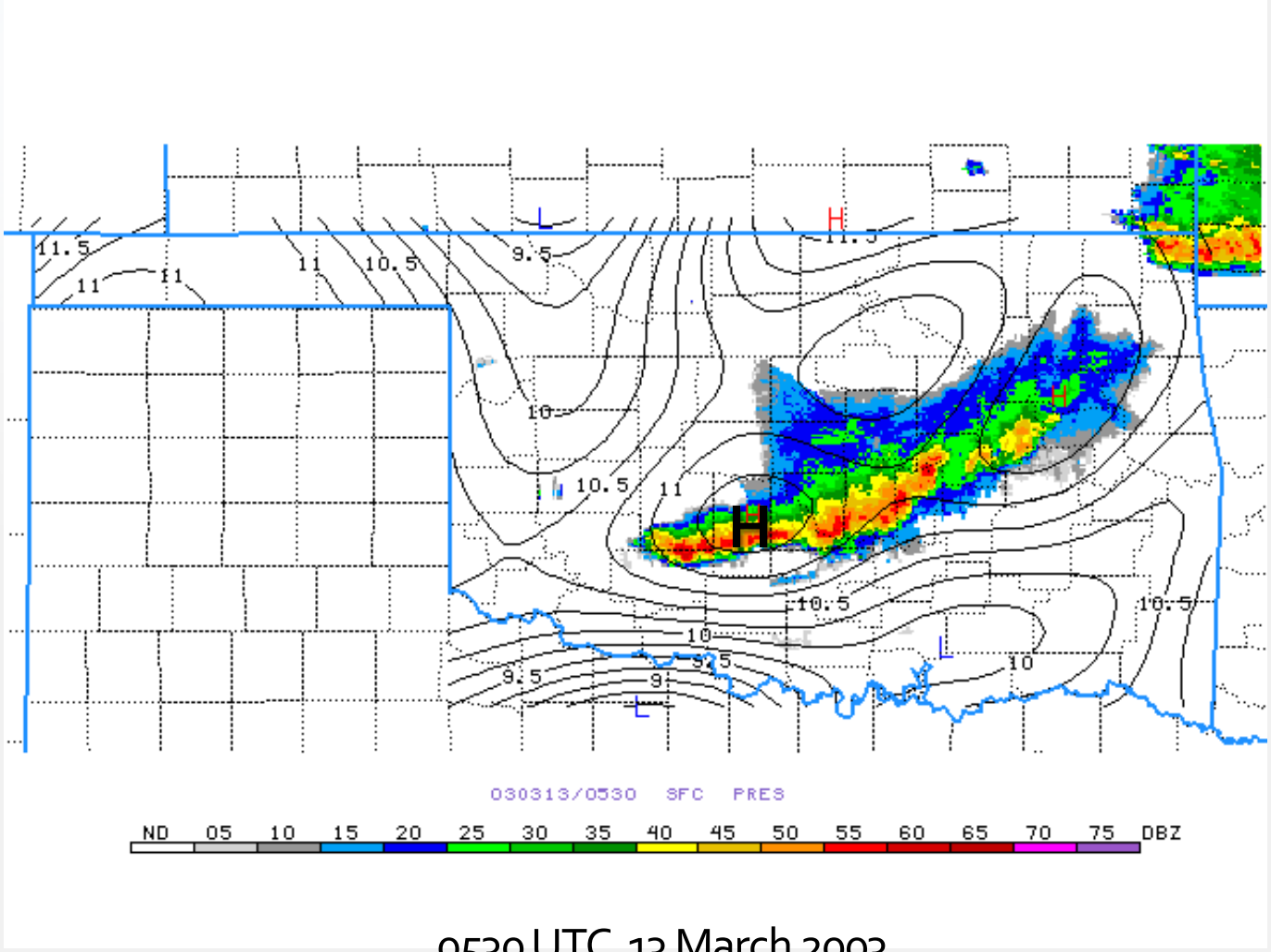
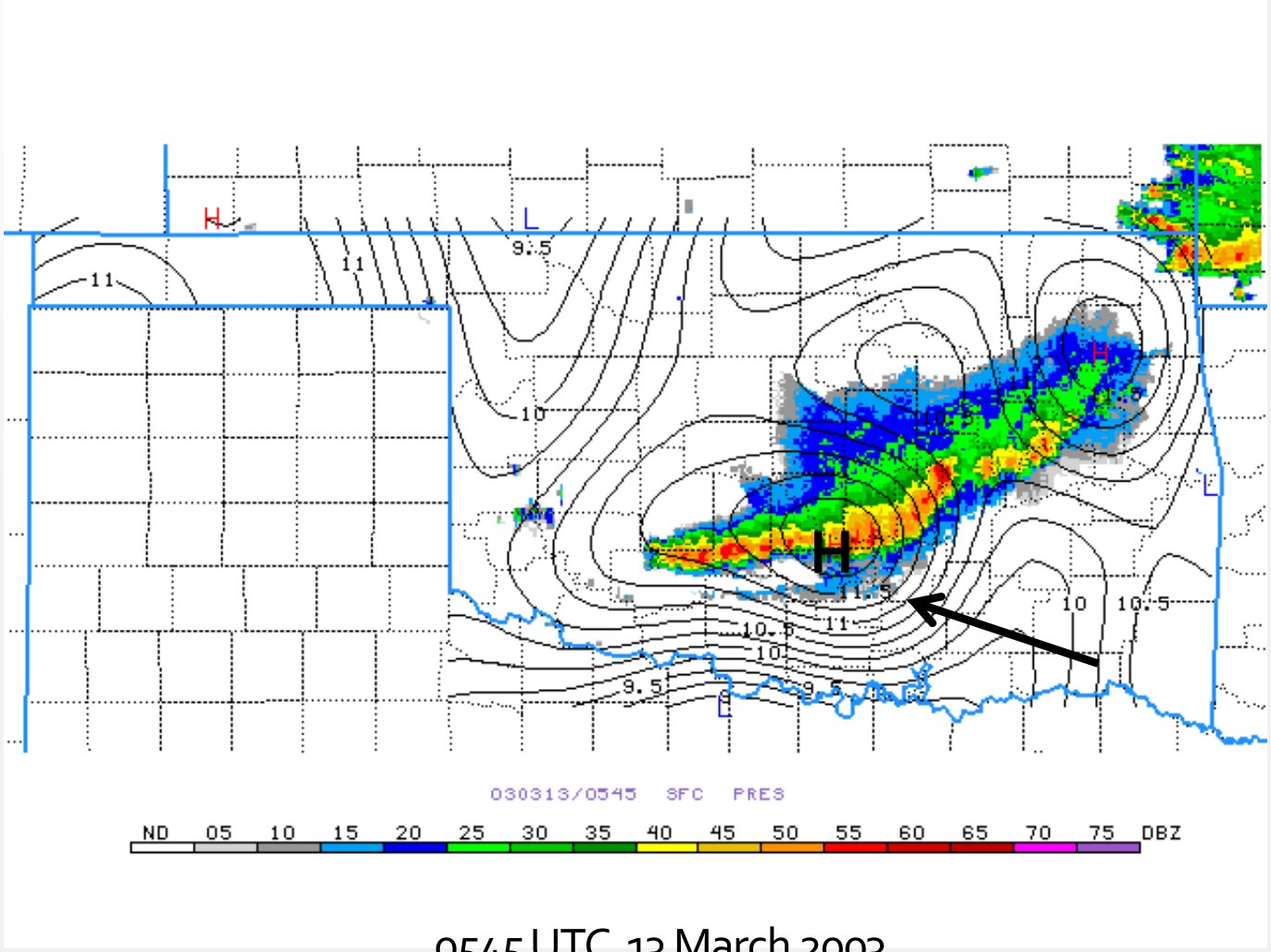
Observations



0530 UTC 13 March 2003

Observations

High pressure surge partially ahead of convective line



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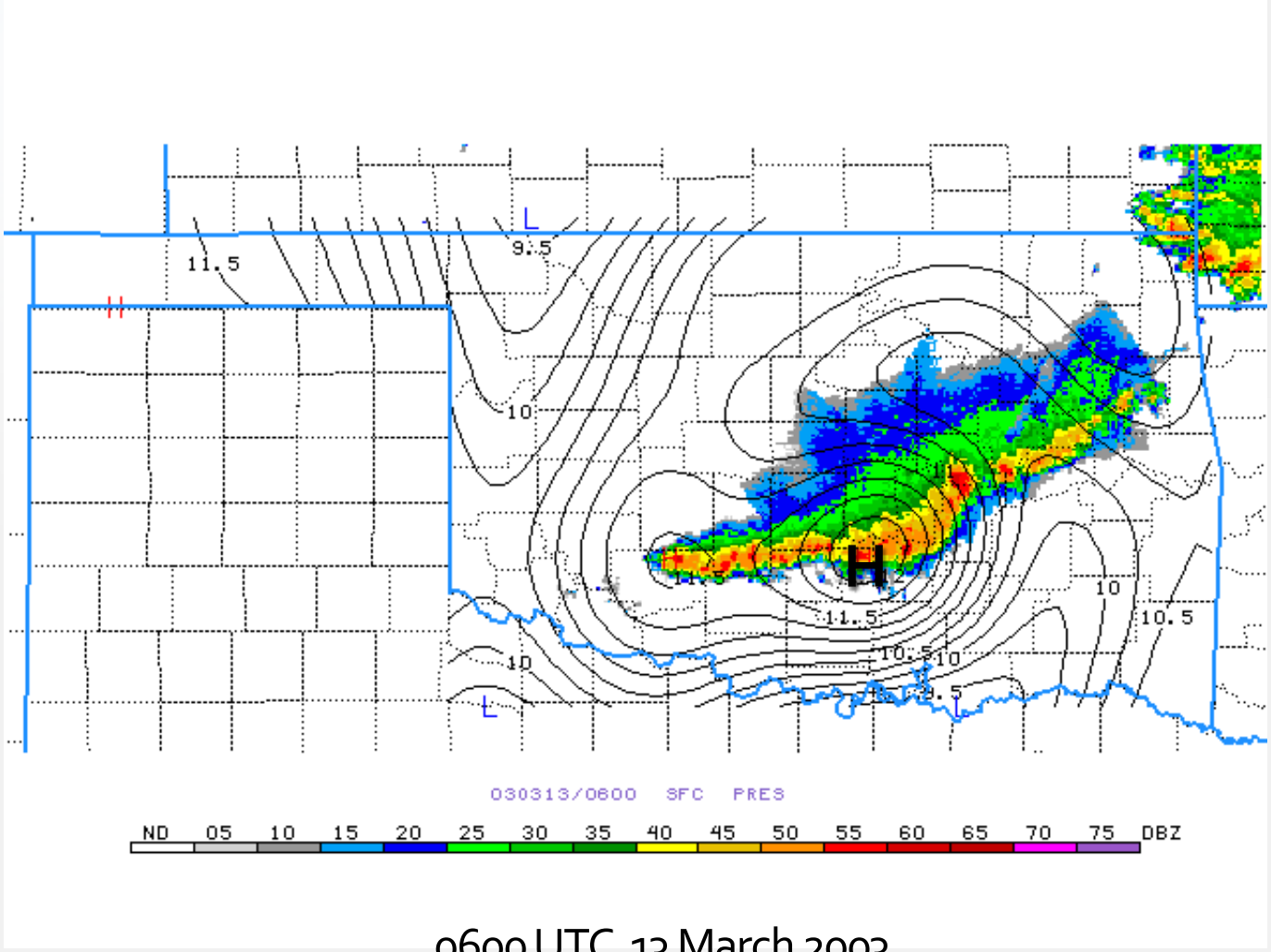
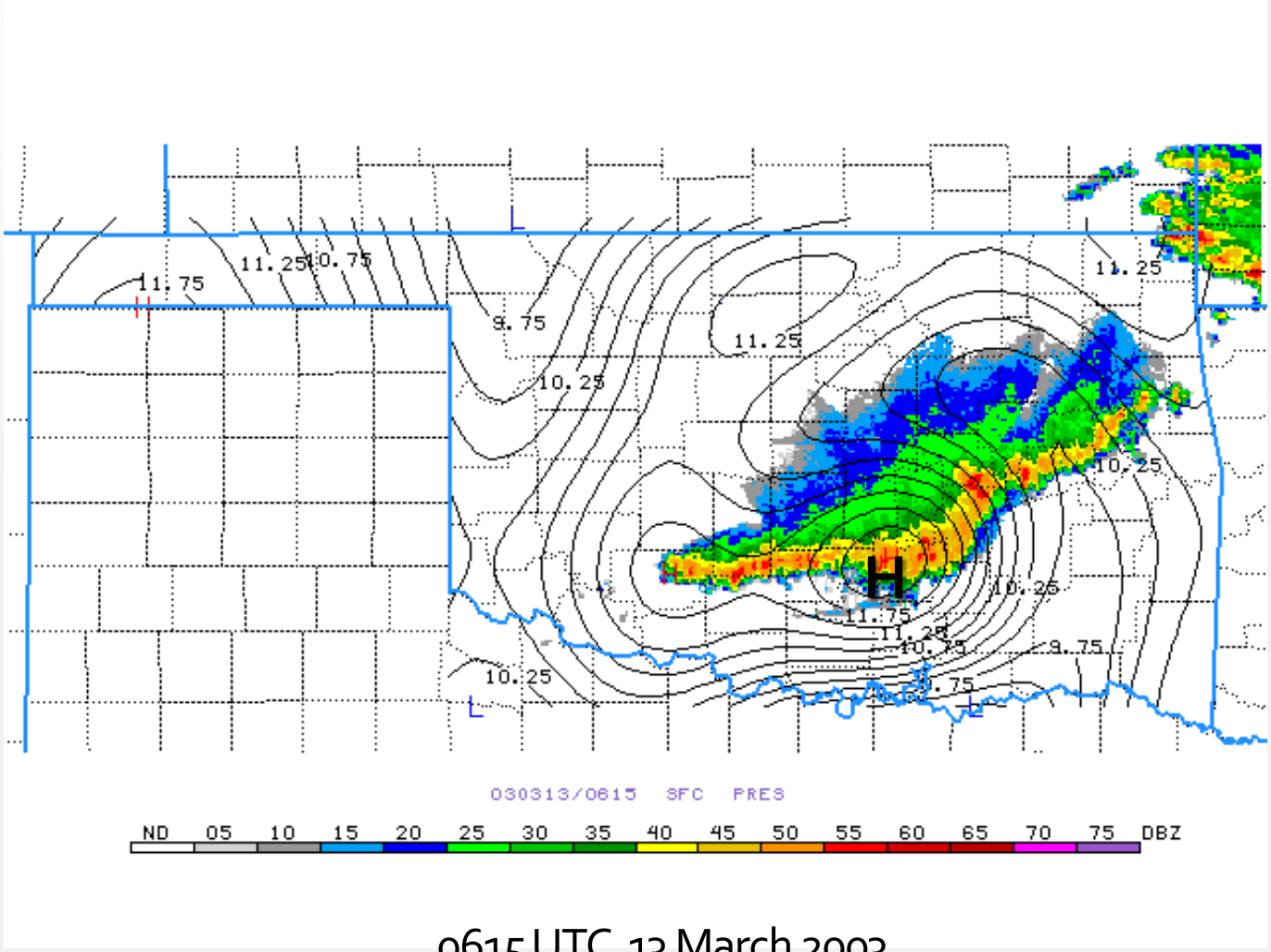
Observations



0600 UTC 13 March 2003

Observations



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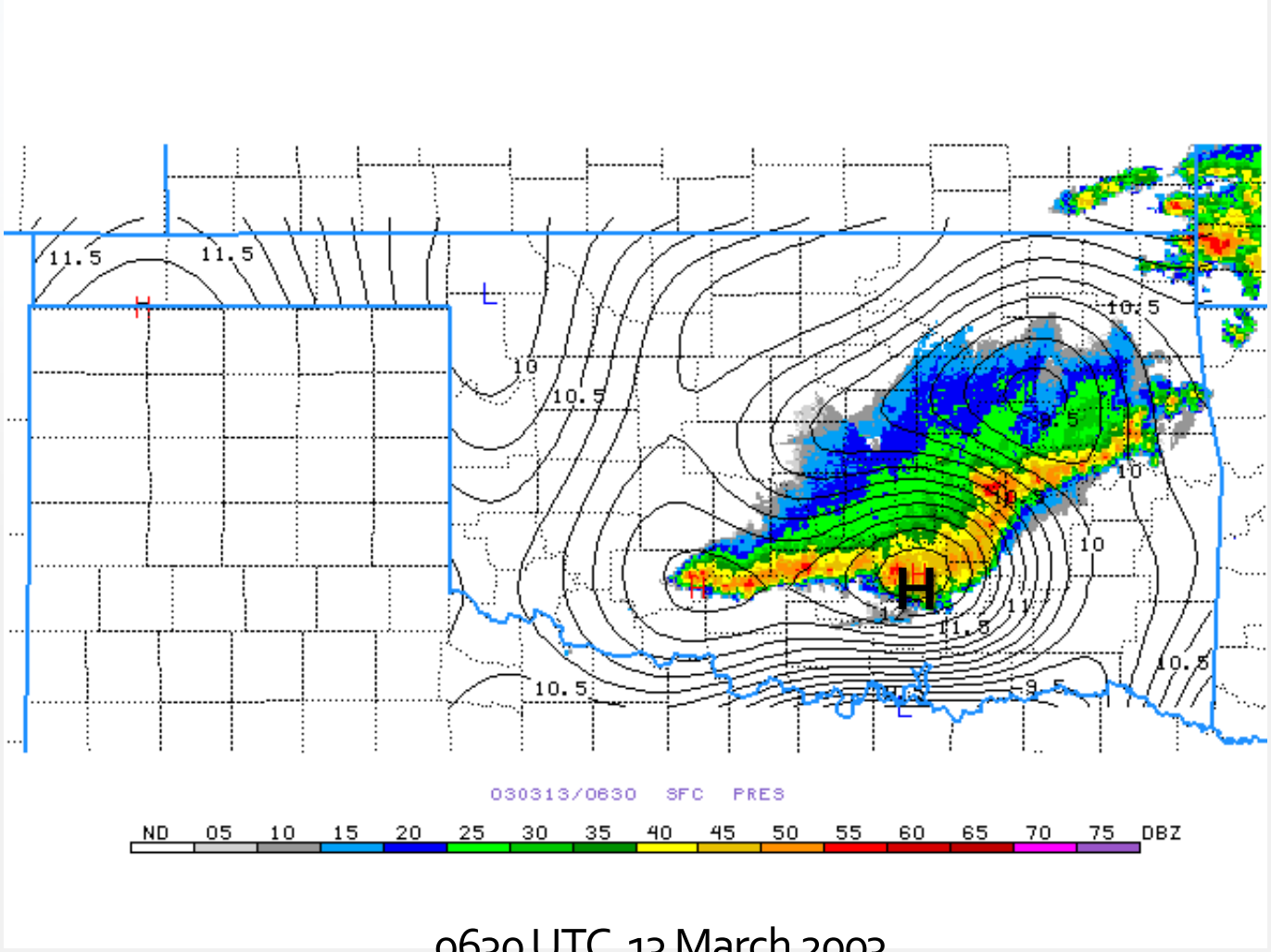
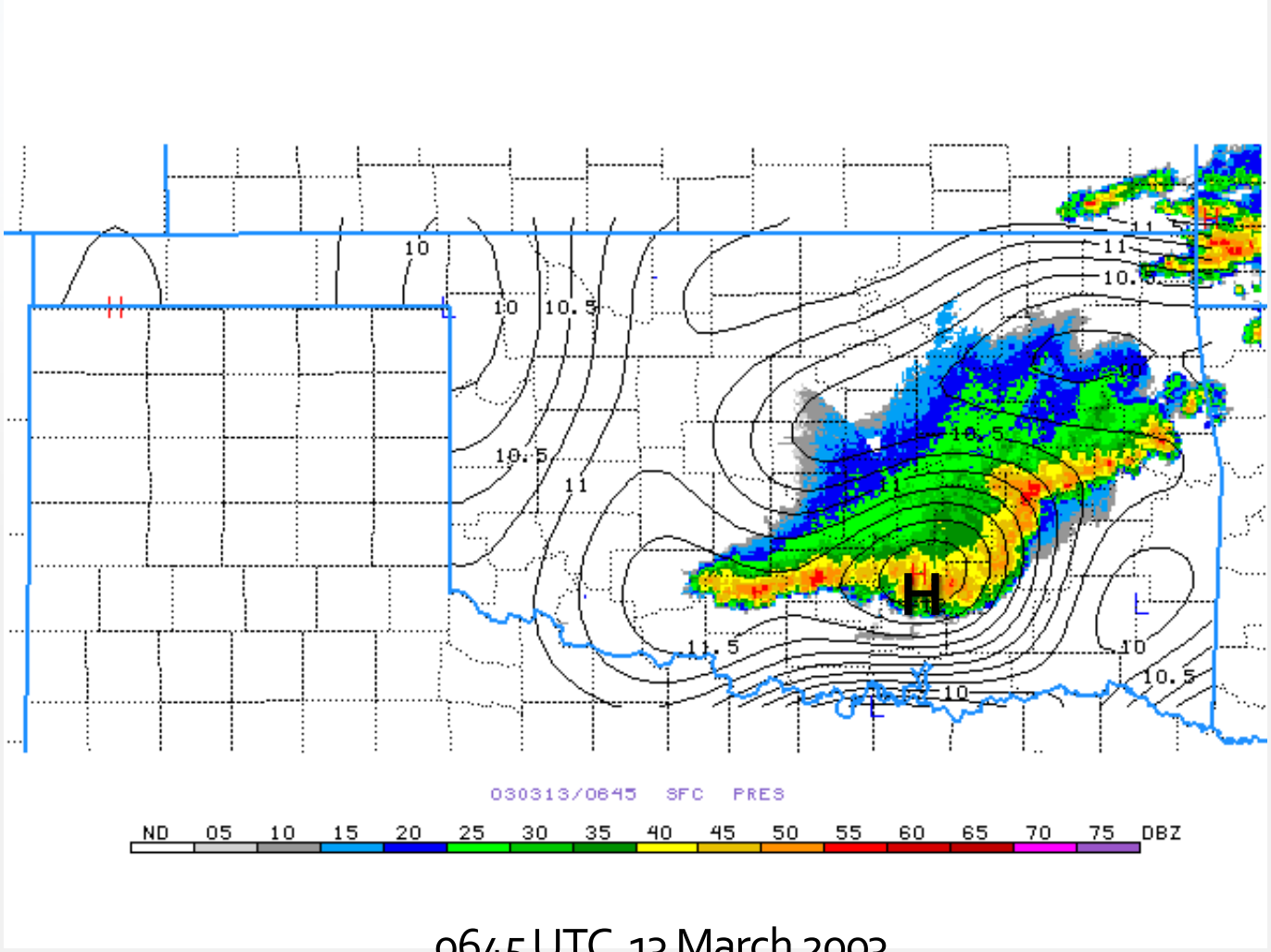


0630 UTC 13 March 2003

Observations



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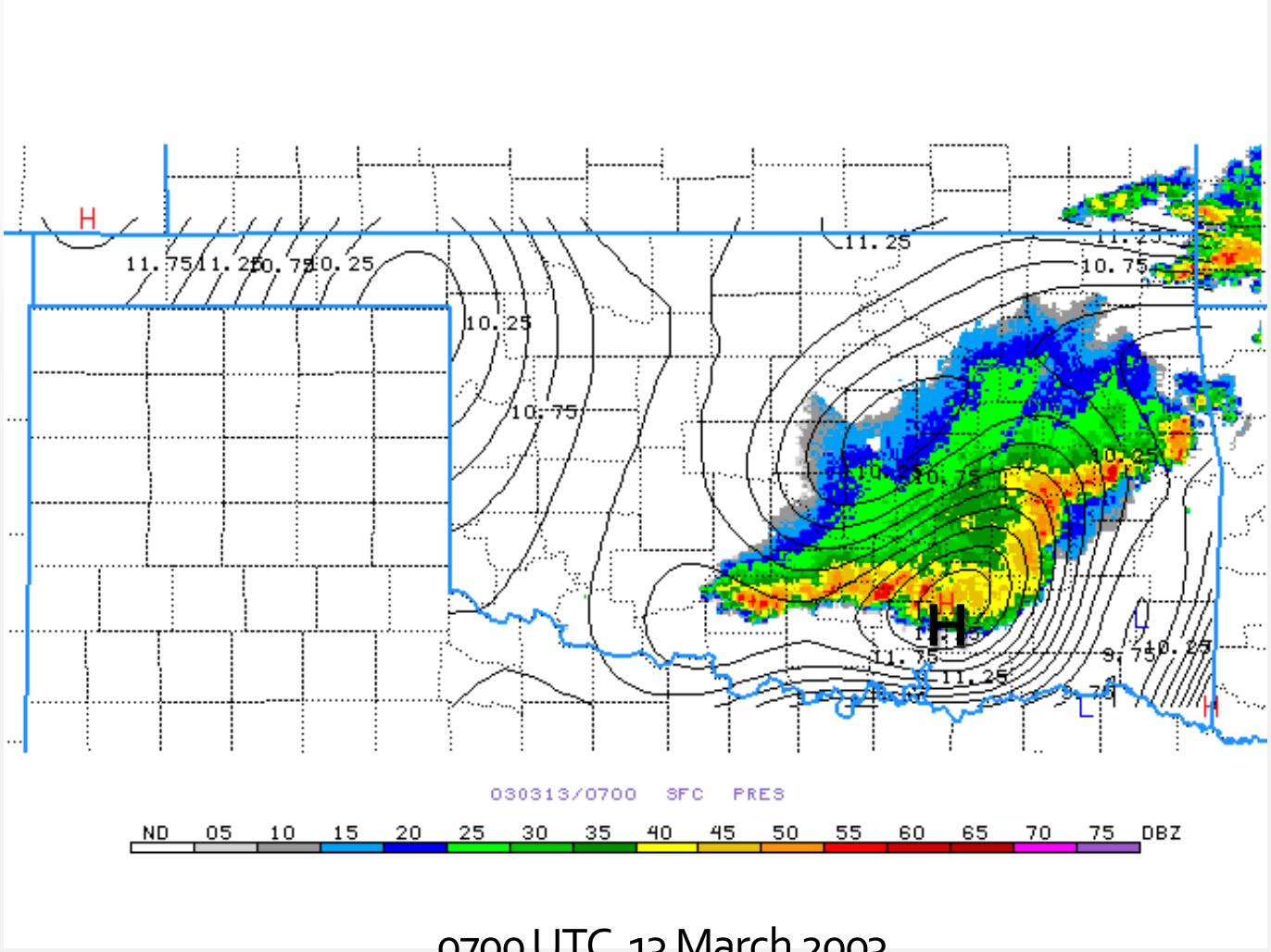
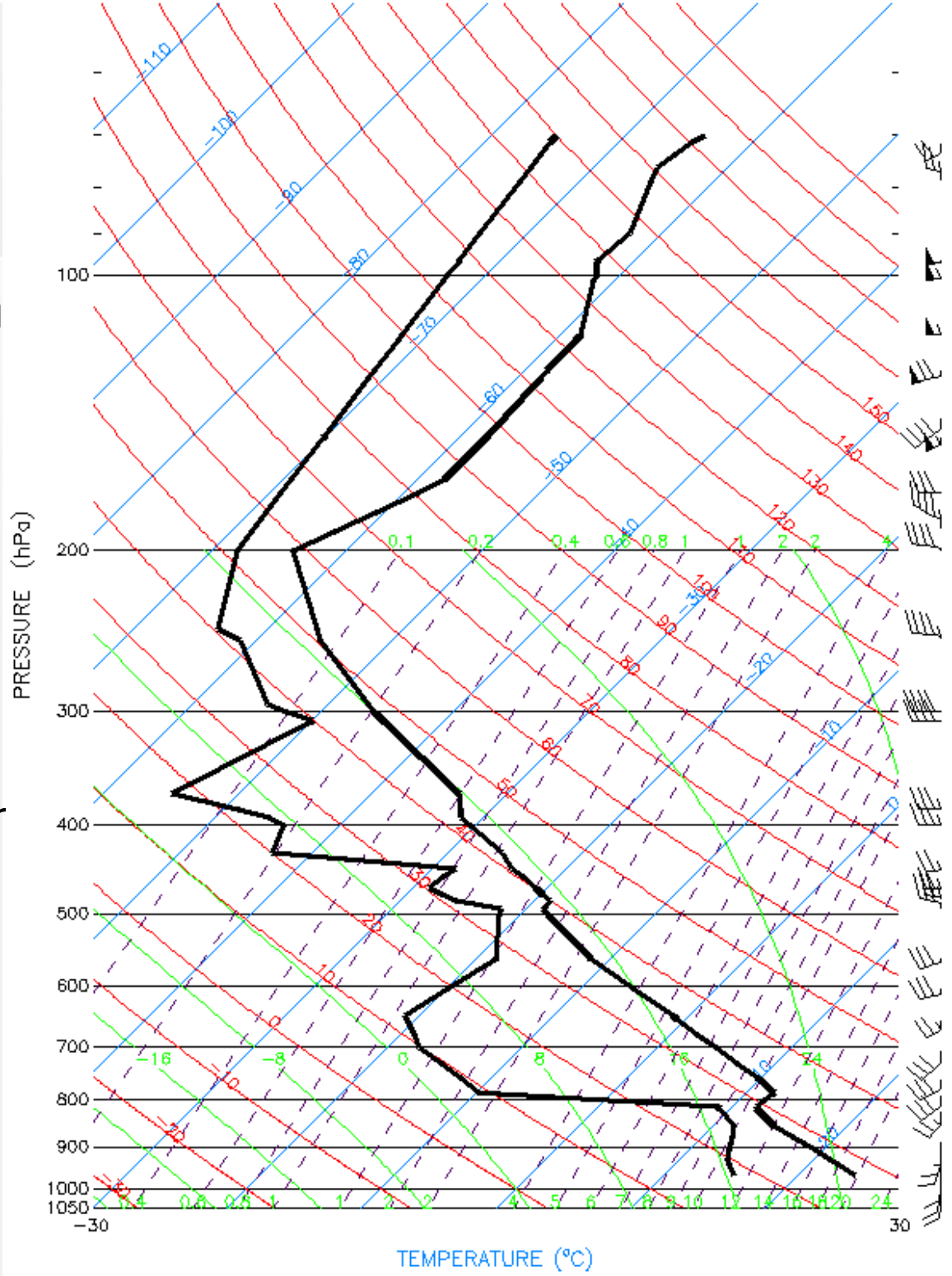
Observations



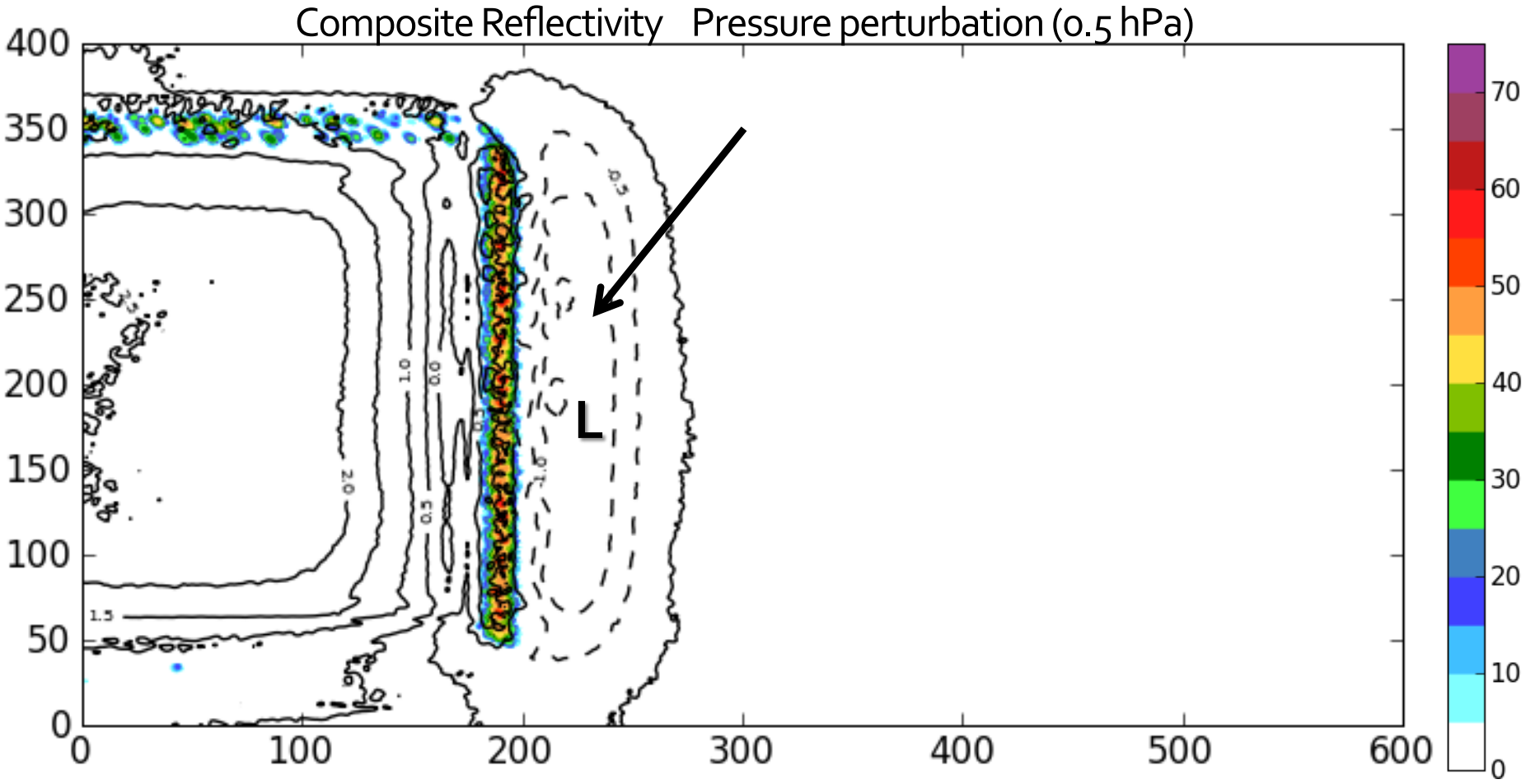
0700 UTC 13 March 2003

Idealized Simulation

- Cloud Model 1.15 (Bryan and Fritsch 2002)
  - 1 km horizontal resolution 250 m vertical resolution
  - 600 km x 400 km x 18 km domain
  - open-radiative boundaries
  - Thompson microphysics
  - no radiation or boundary layer parameterizations
  - Cold pool/dam break initialization (y=50 to 350 km)
  - 00 UTC 13 March 2003 KOUN sounding



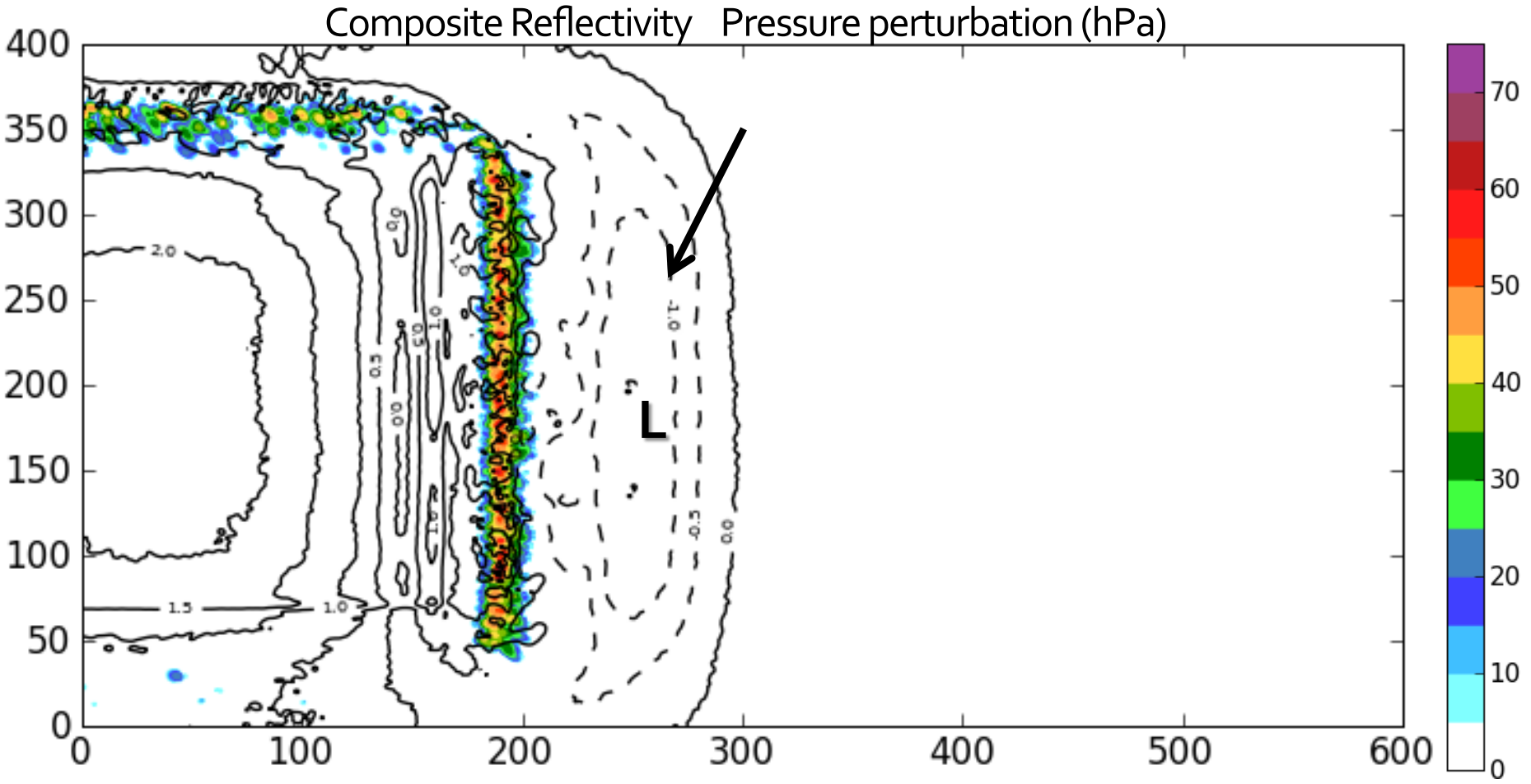
Low pressure response



0:45

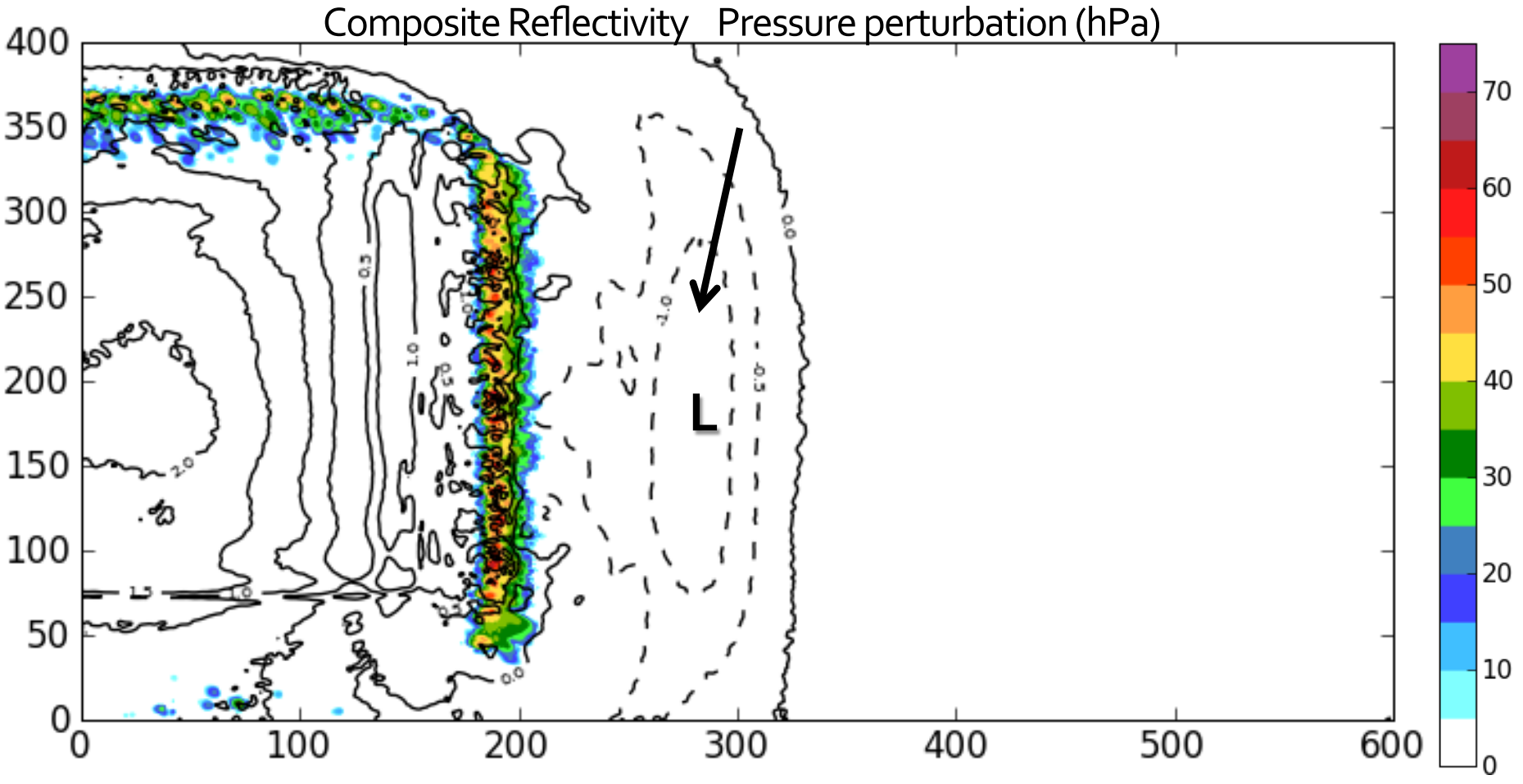
Motion of domain:
u: 15 m/s
v: 7.7 m/s

Low pressure response



01:00

Low pressure response



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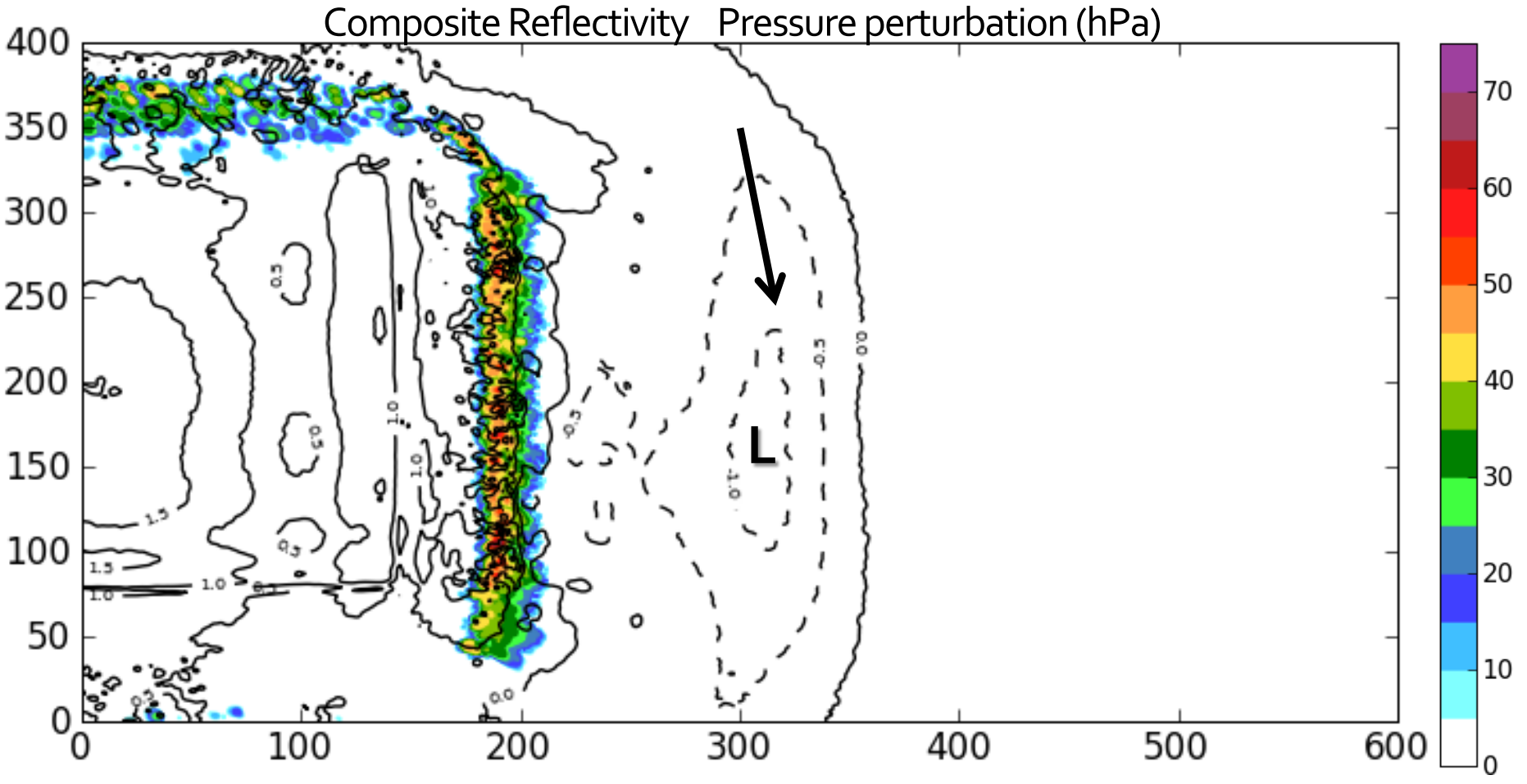
Low pressure response



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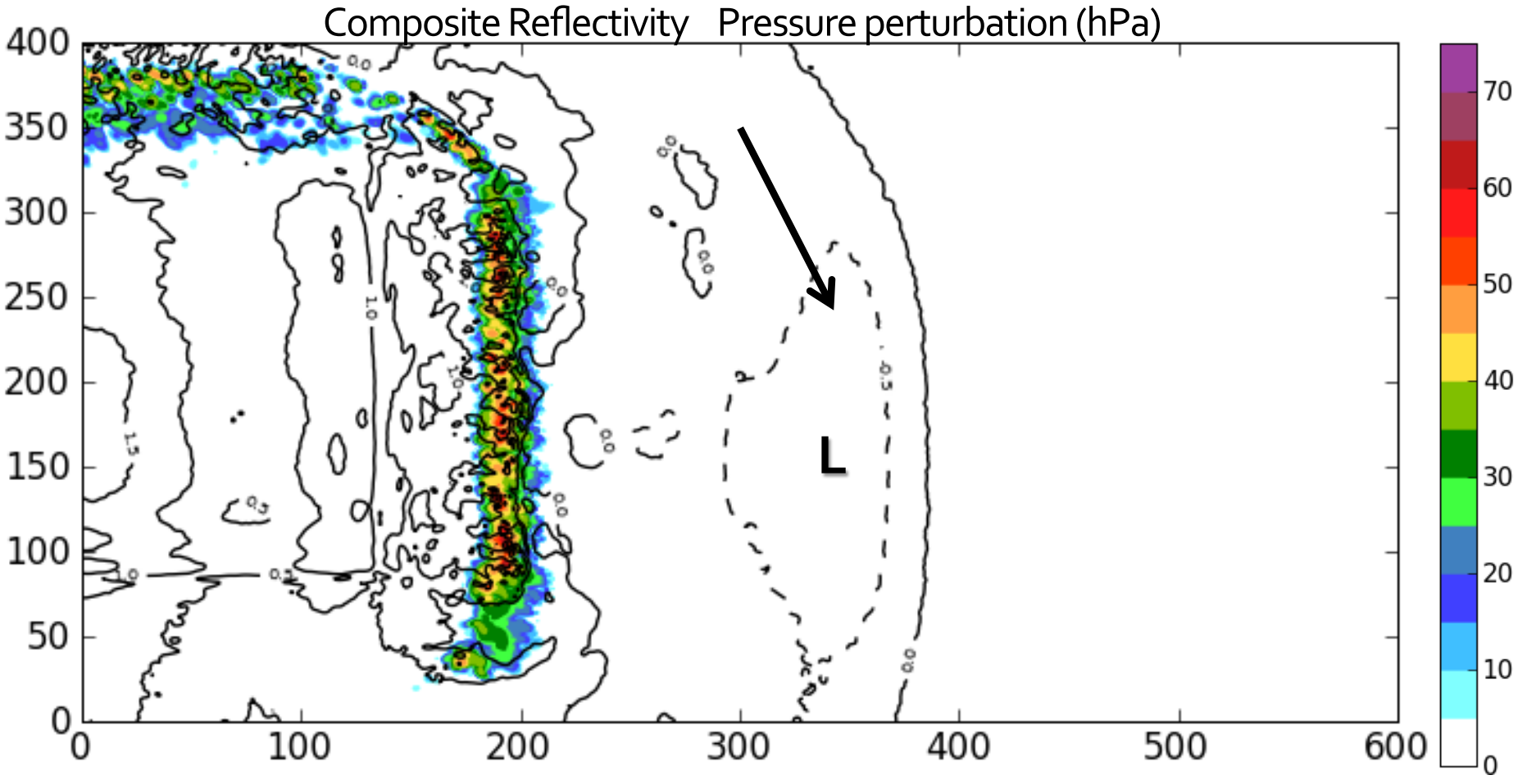
Low pressure response



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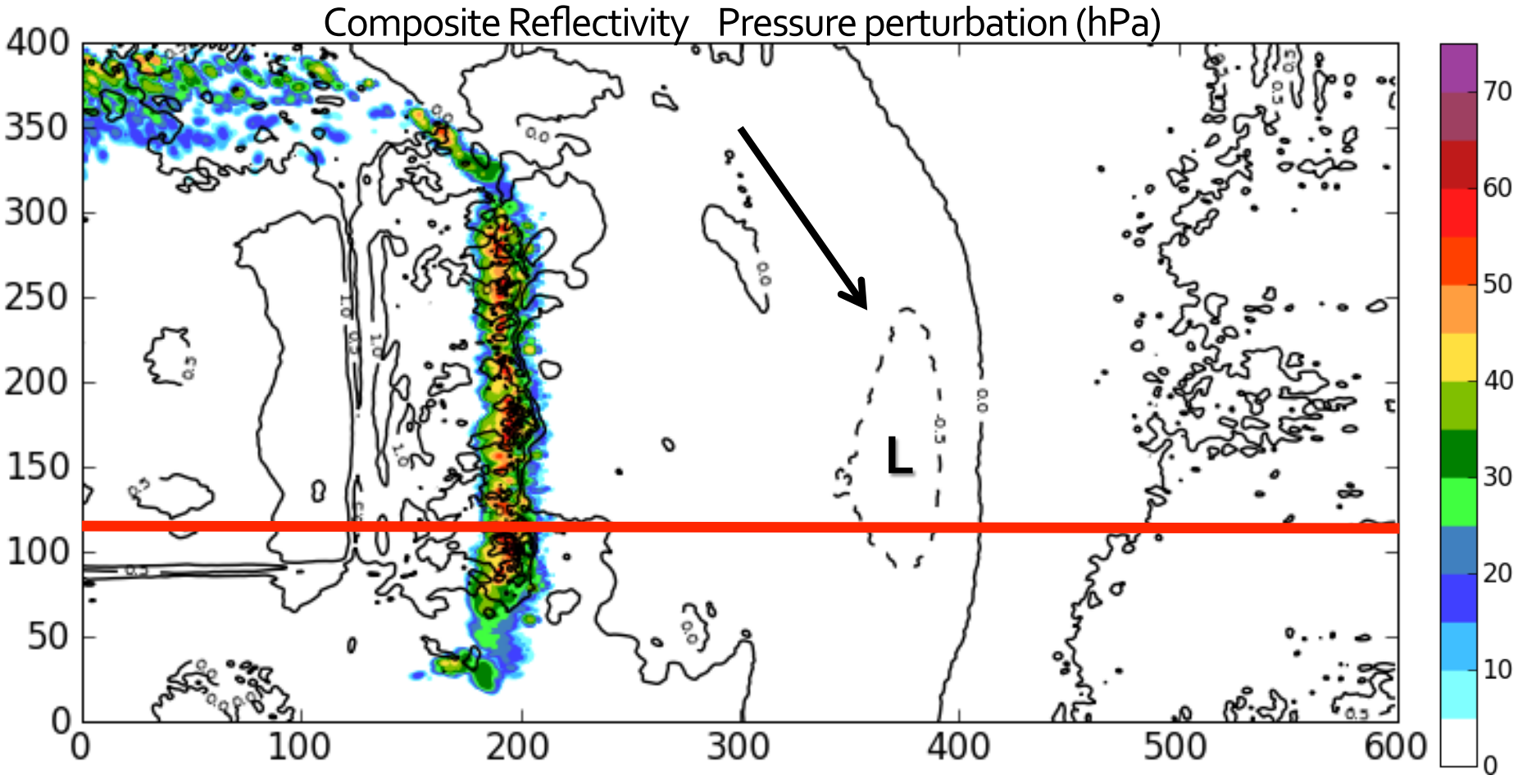
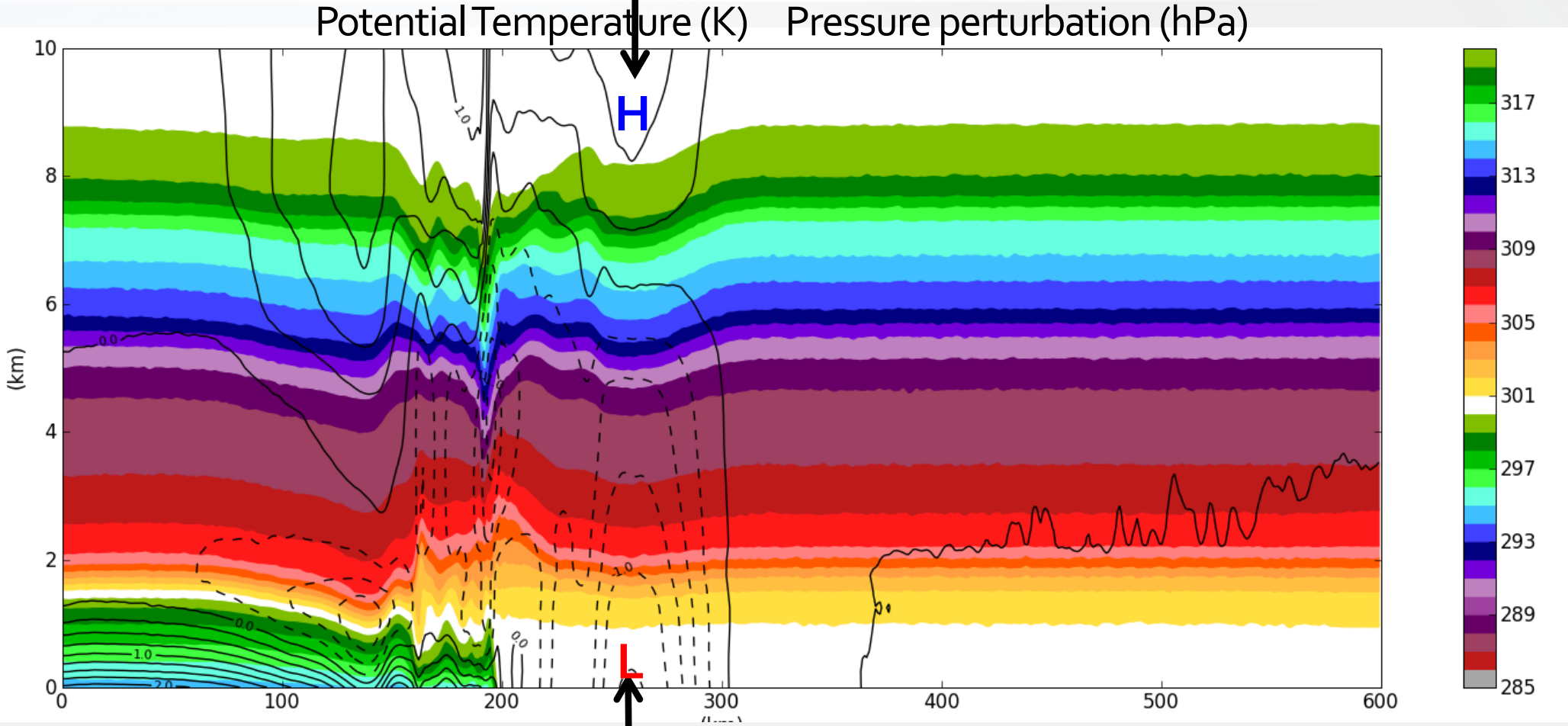


02:00

Low pressure response



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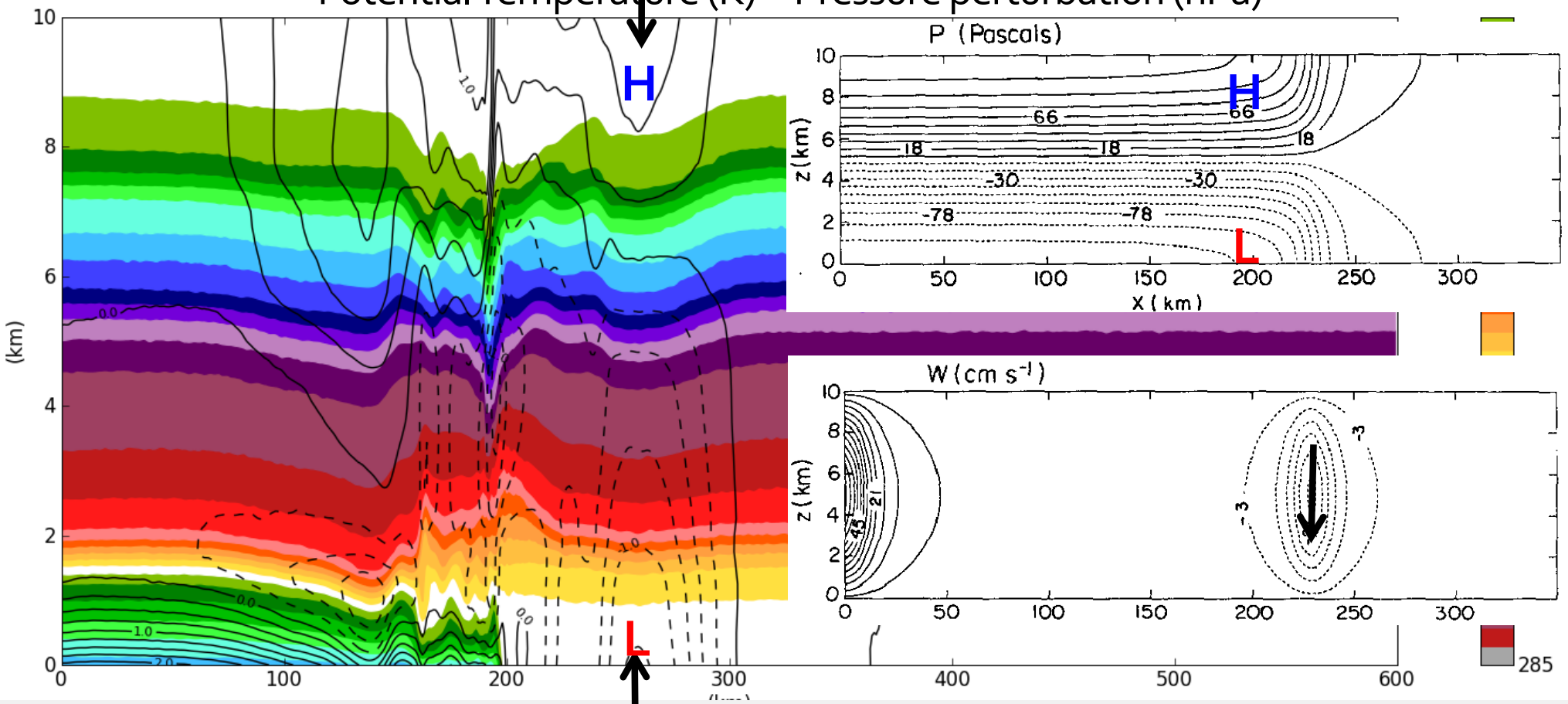
Low pressure response

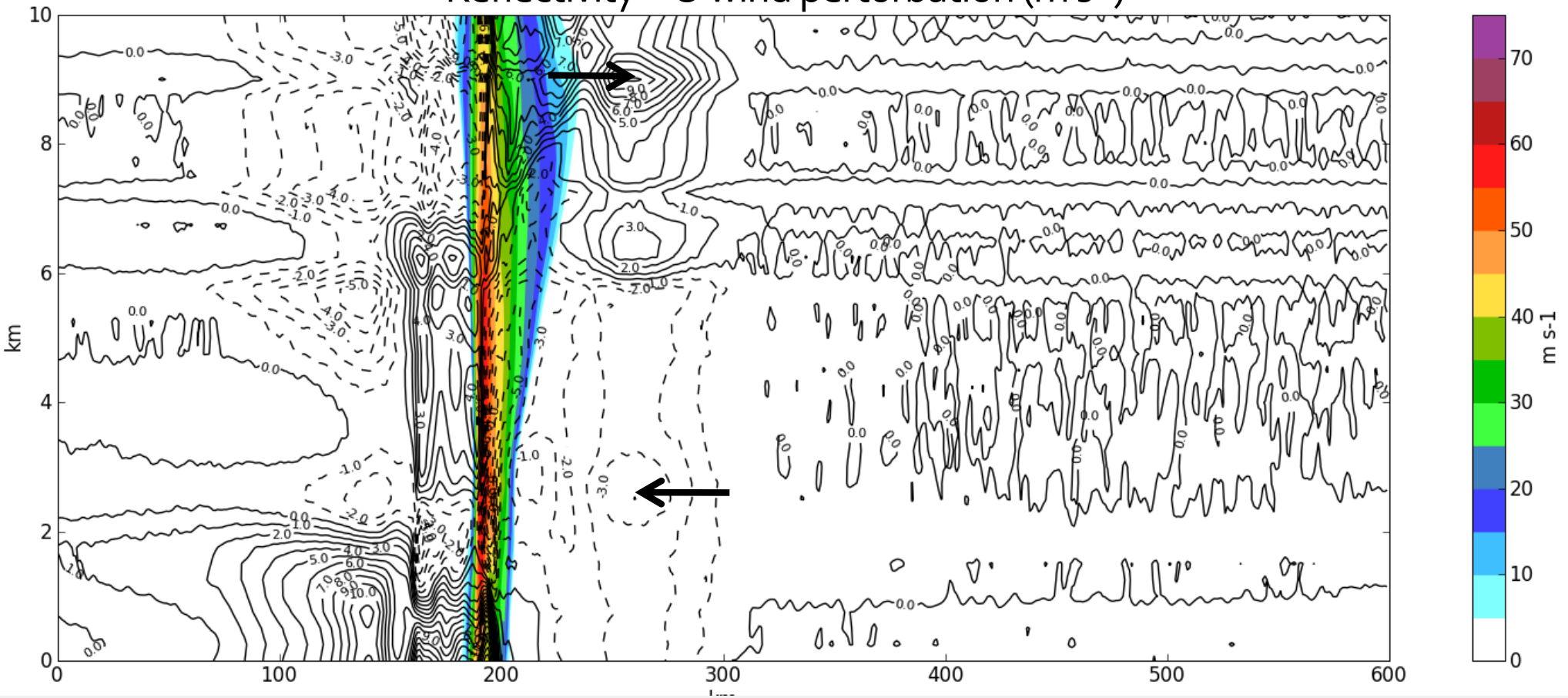


01:00

Nicholls et al., 1991

Low pressure response

Reflectivity U wind perturbation (m s^{-1})



01:00

Nicholls et al., 1991

Low pressure response

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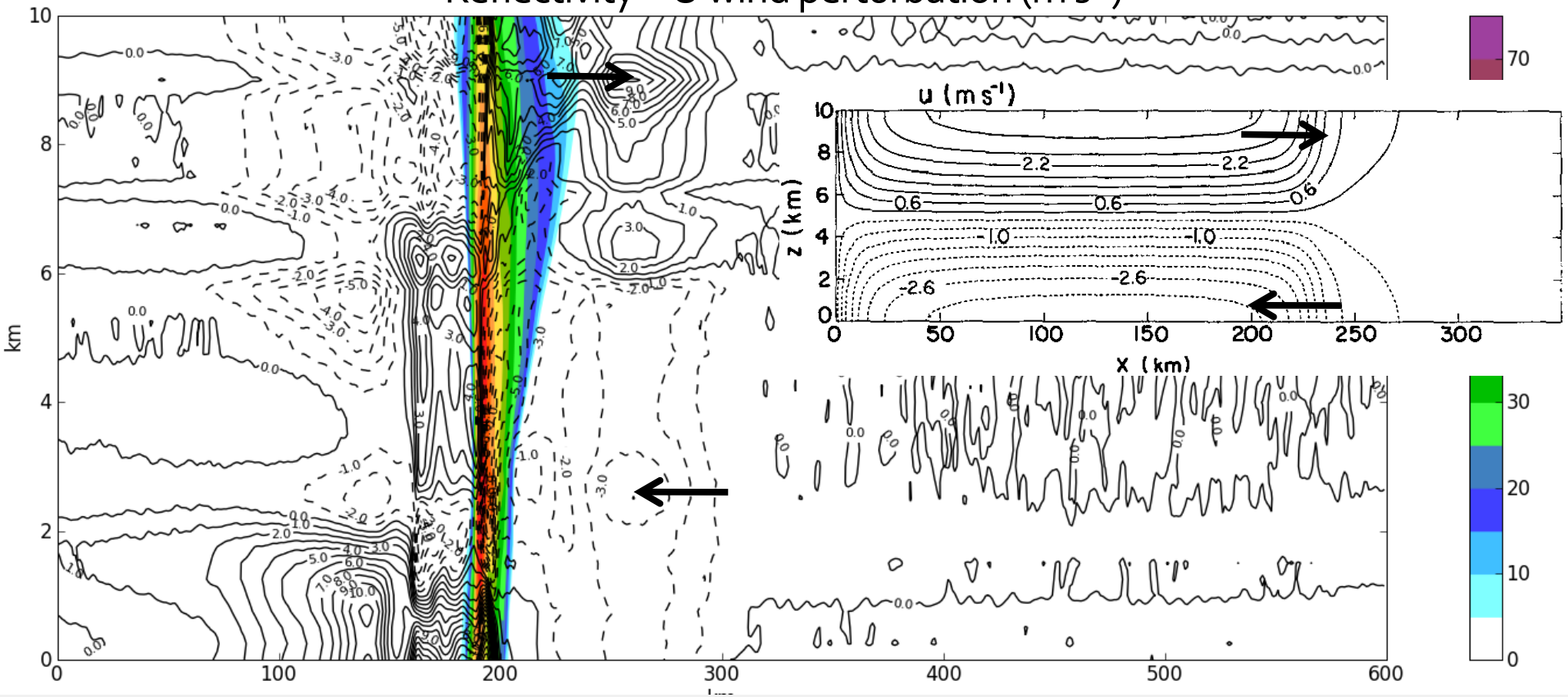
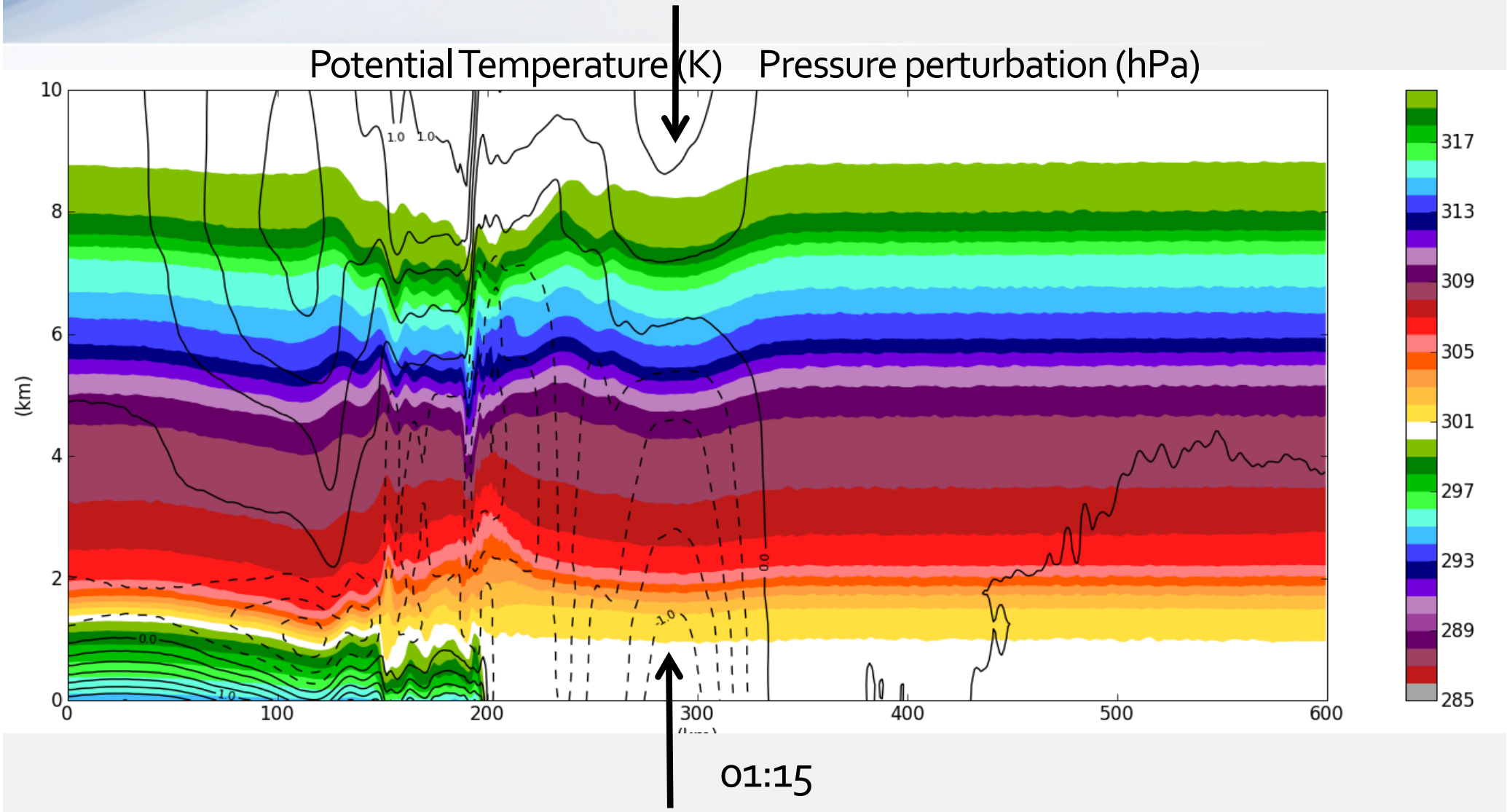


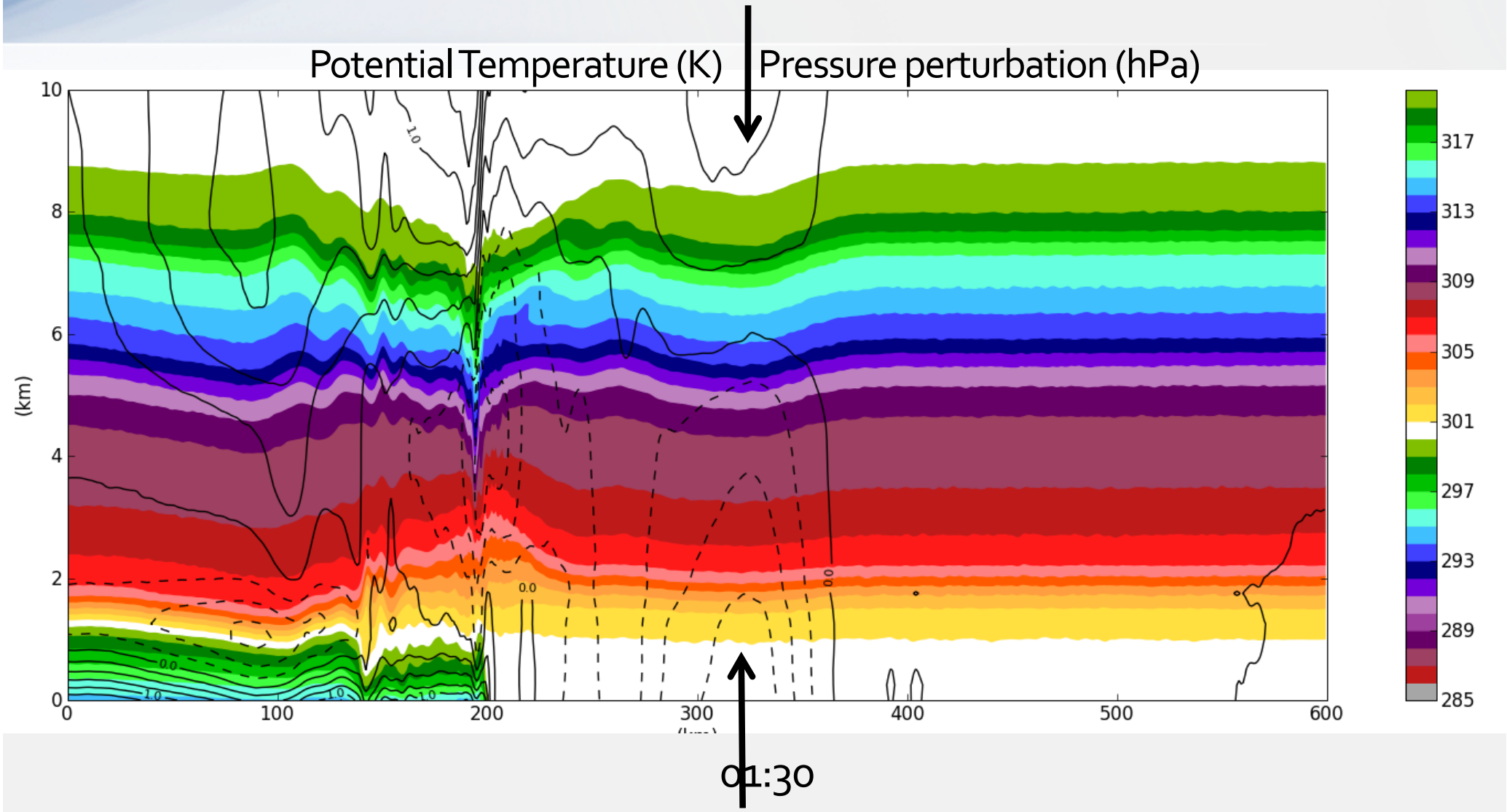
01:00

Nicholls et al., 1991

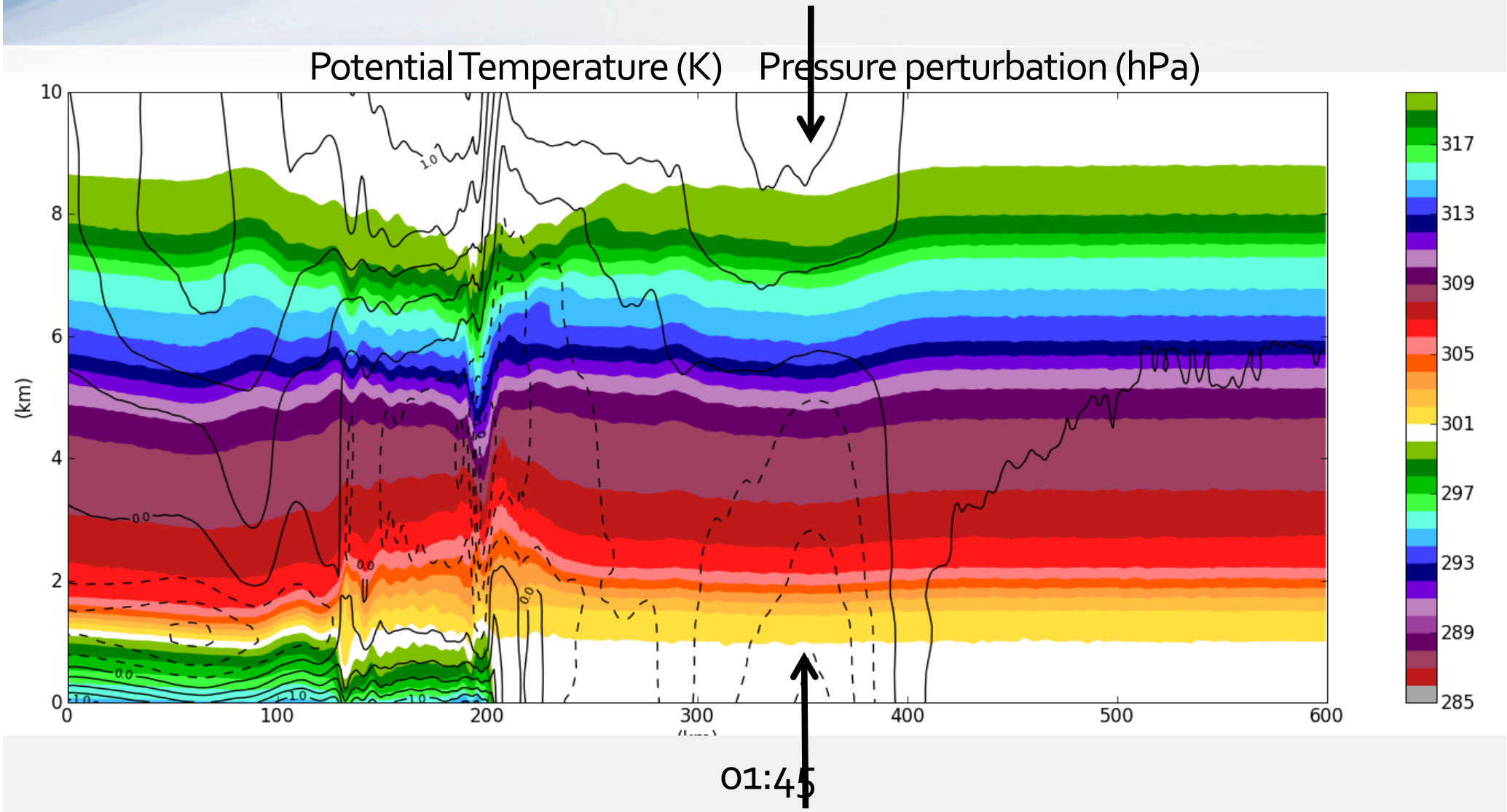
Low pressure response



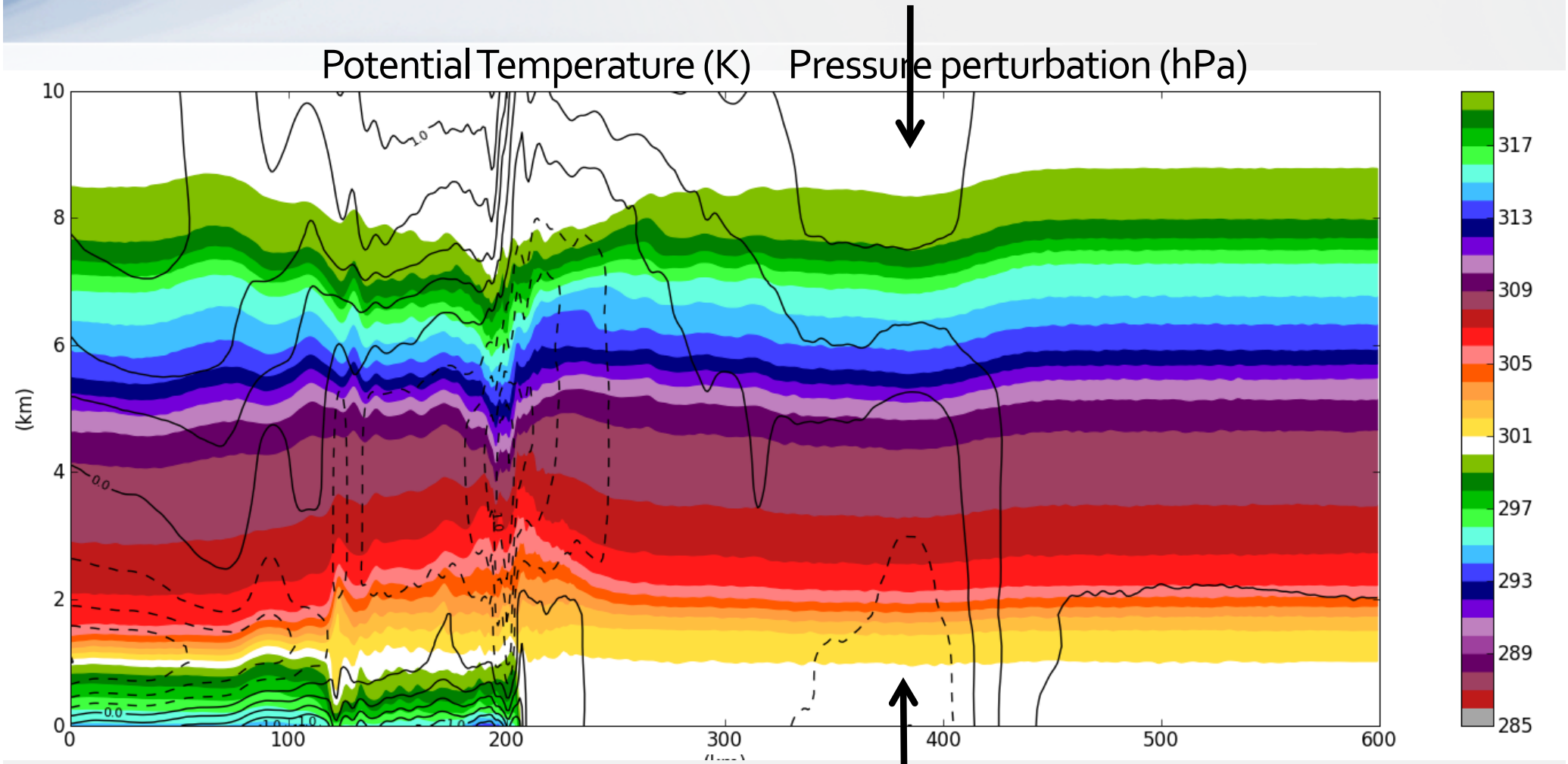
Low pressure response



Low pressure response



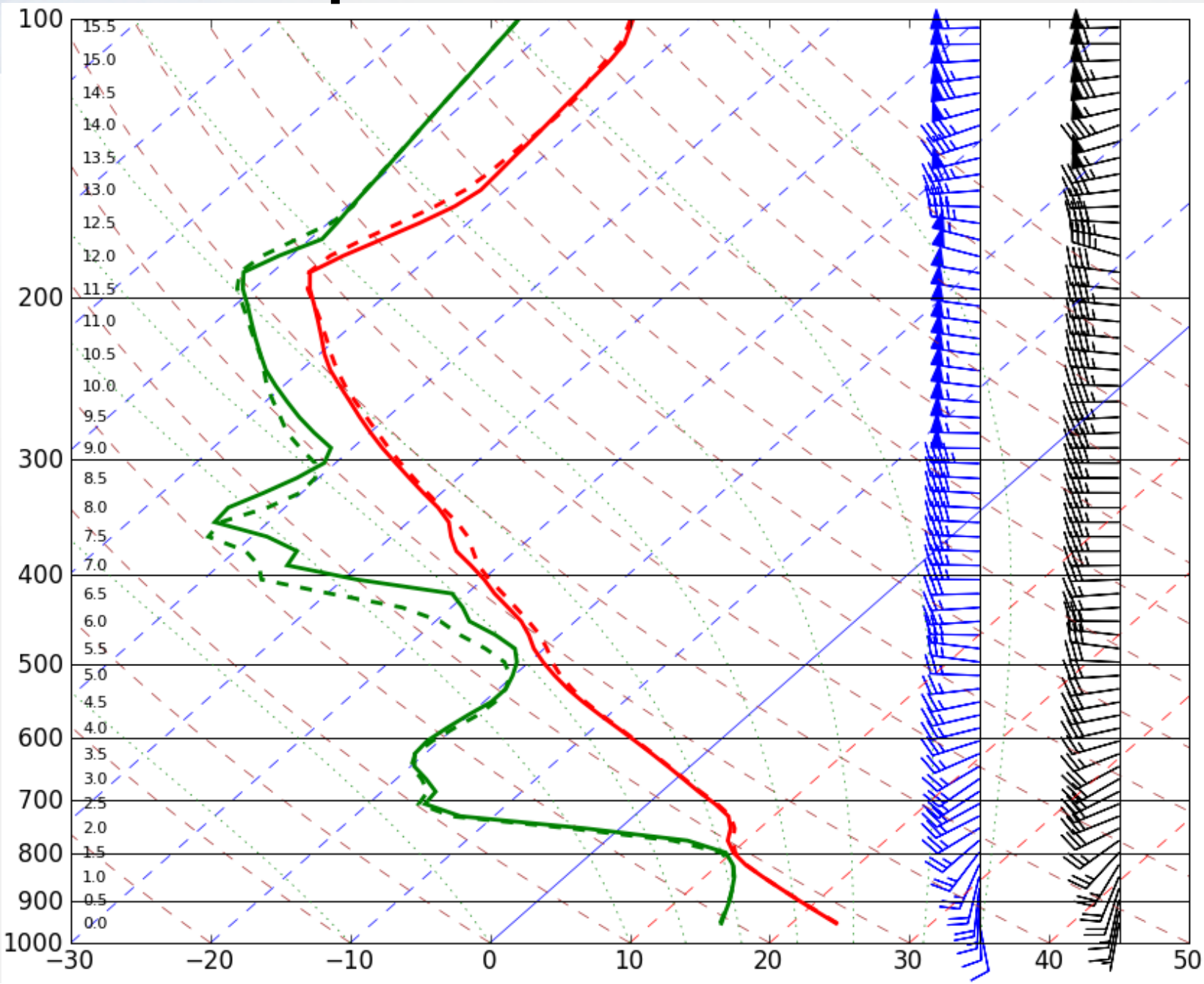
Low pressure response



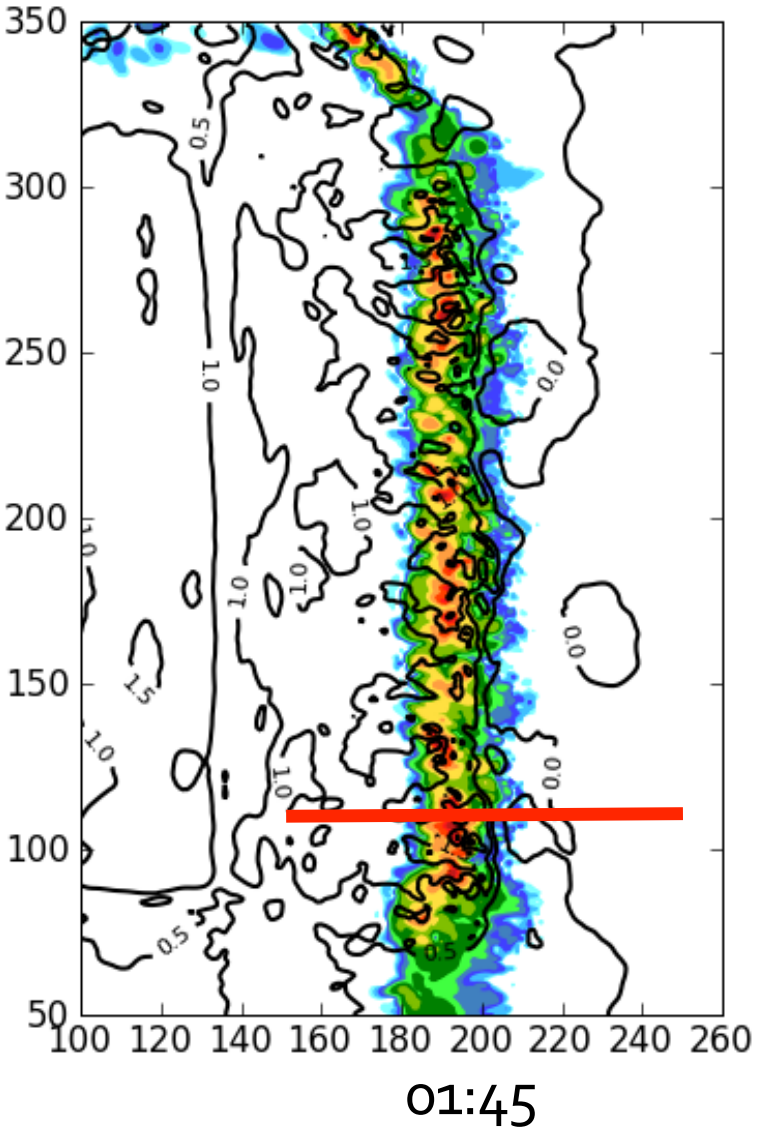
simulated gravity wave speed: 29.9 m s^{-1}
observed wave speed: 32.5 m s^{-1}

Low pressure response

solid – 1:20
dashed – 2:25



Mesohigh surge



01:45

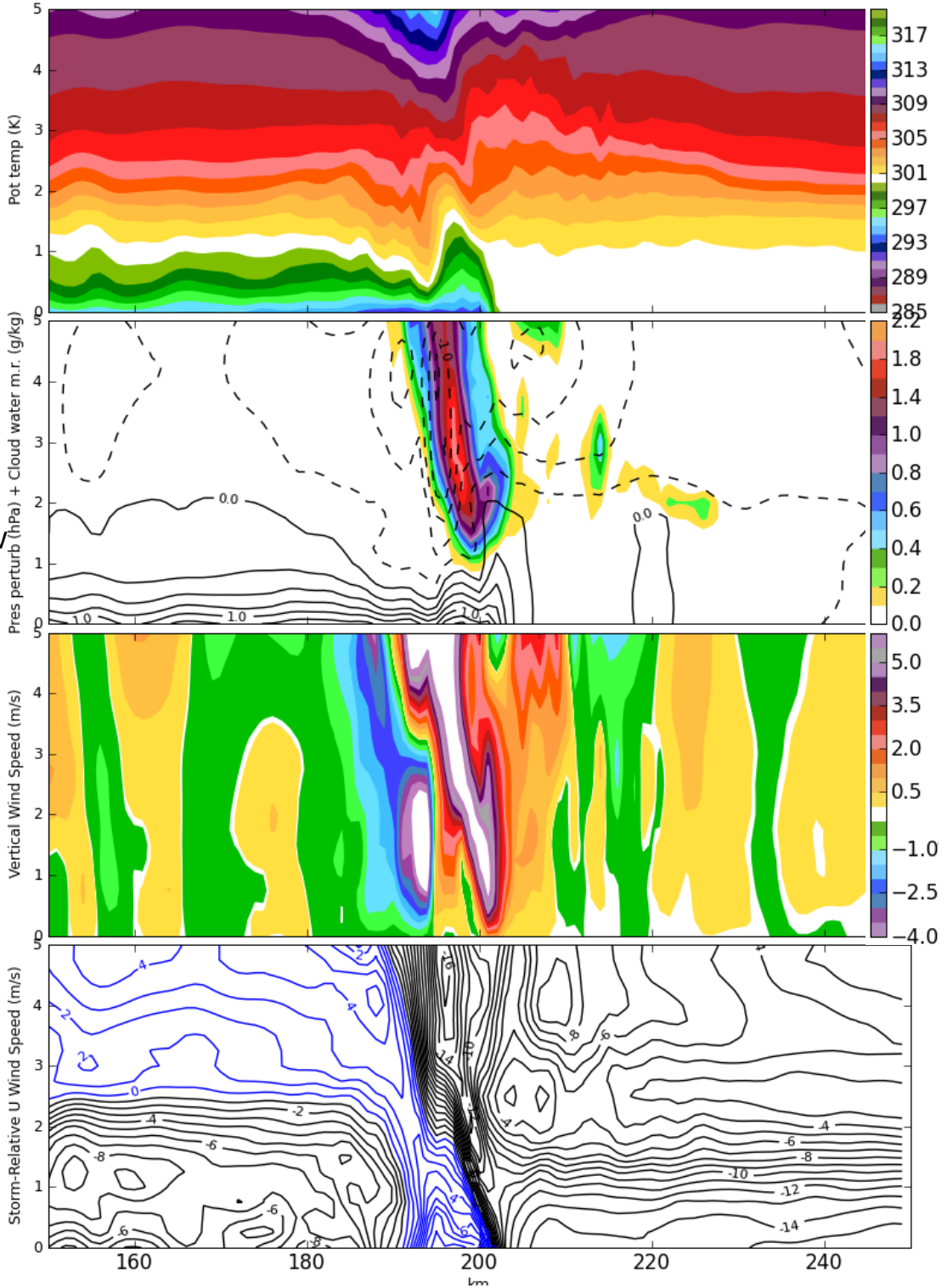
θ

p’

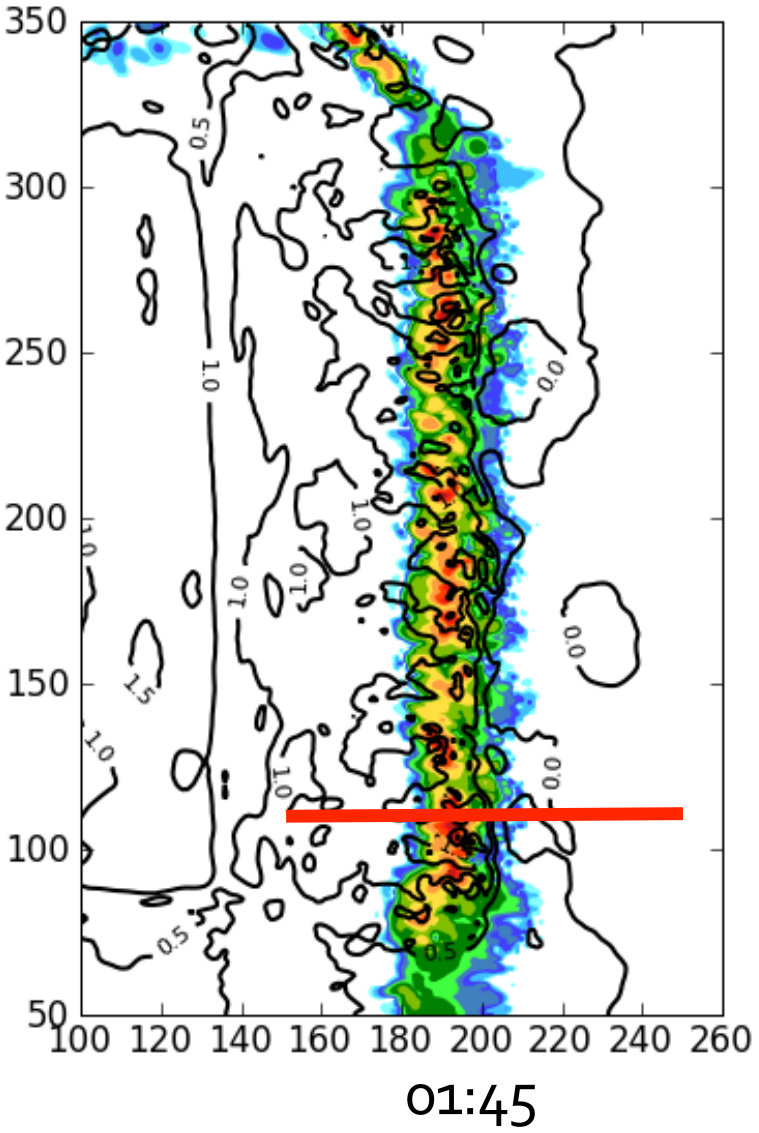
q_{cw}

w

U



Mesohigh surge



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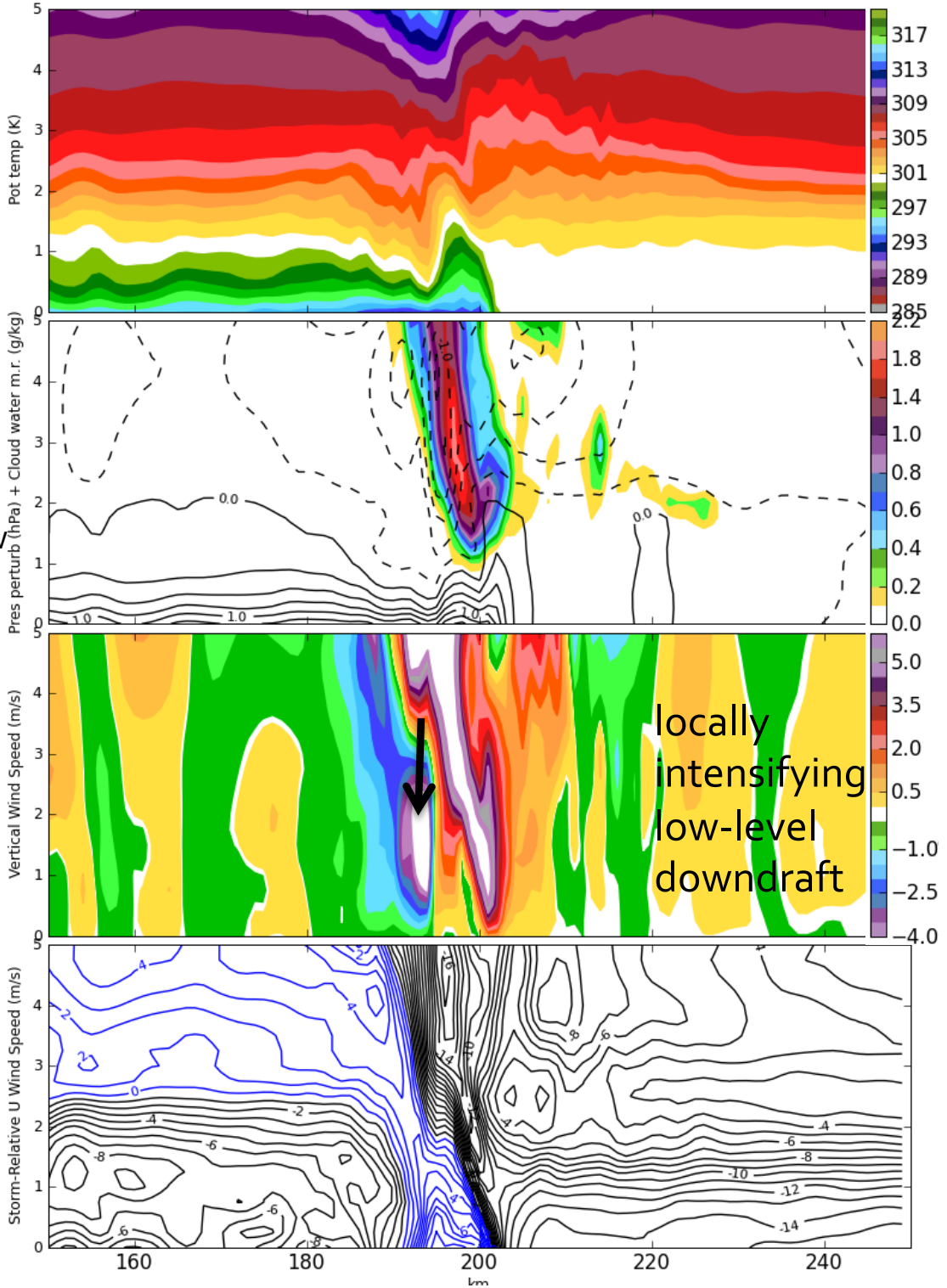
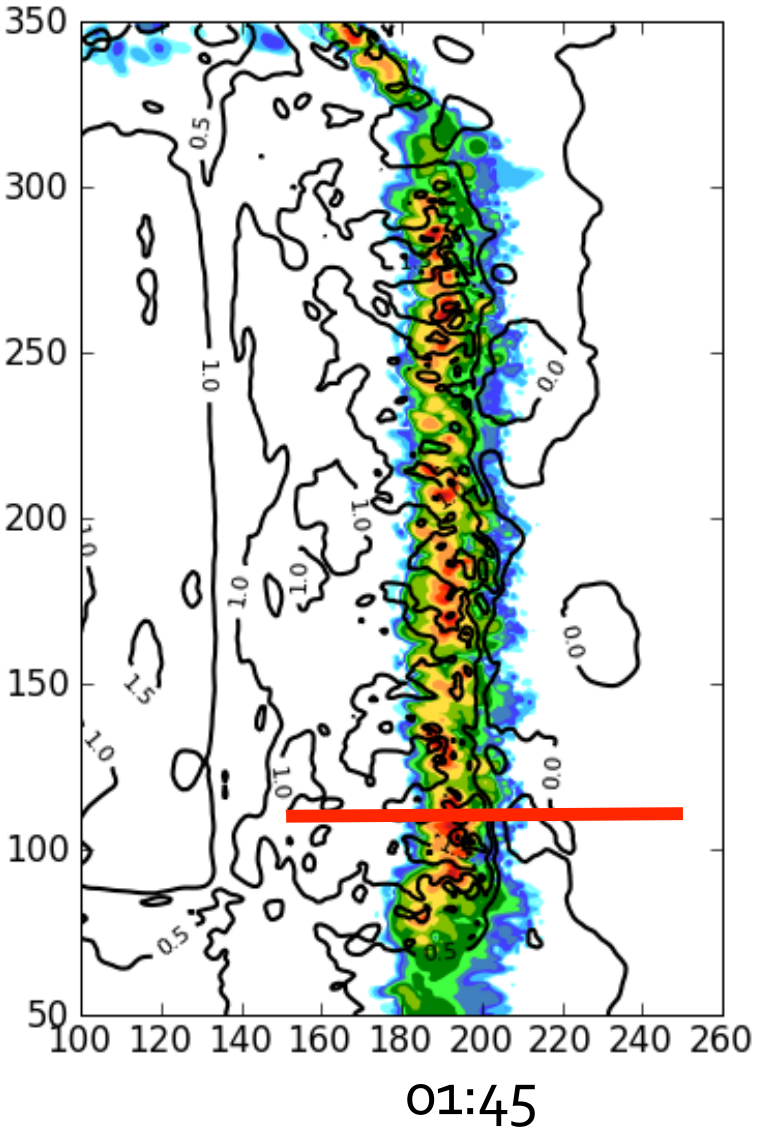


Mesohigh surge



θ

p′

q_{cw}

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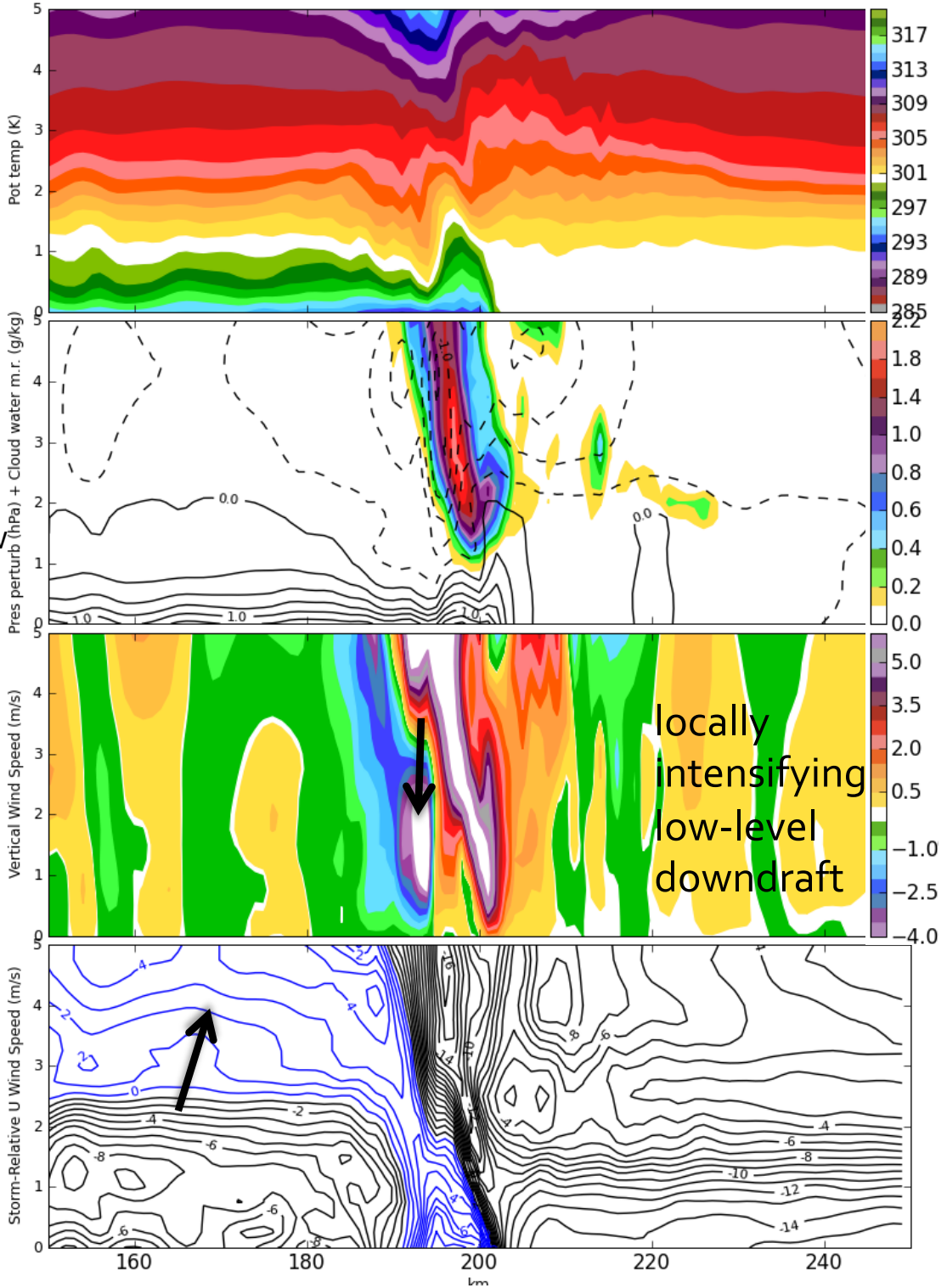
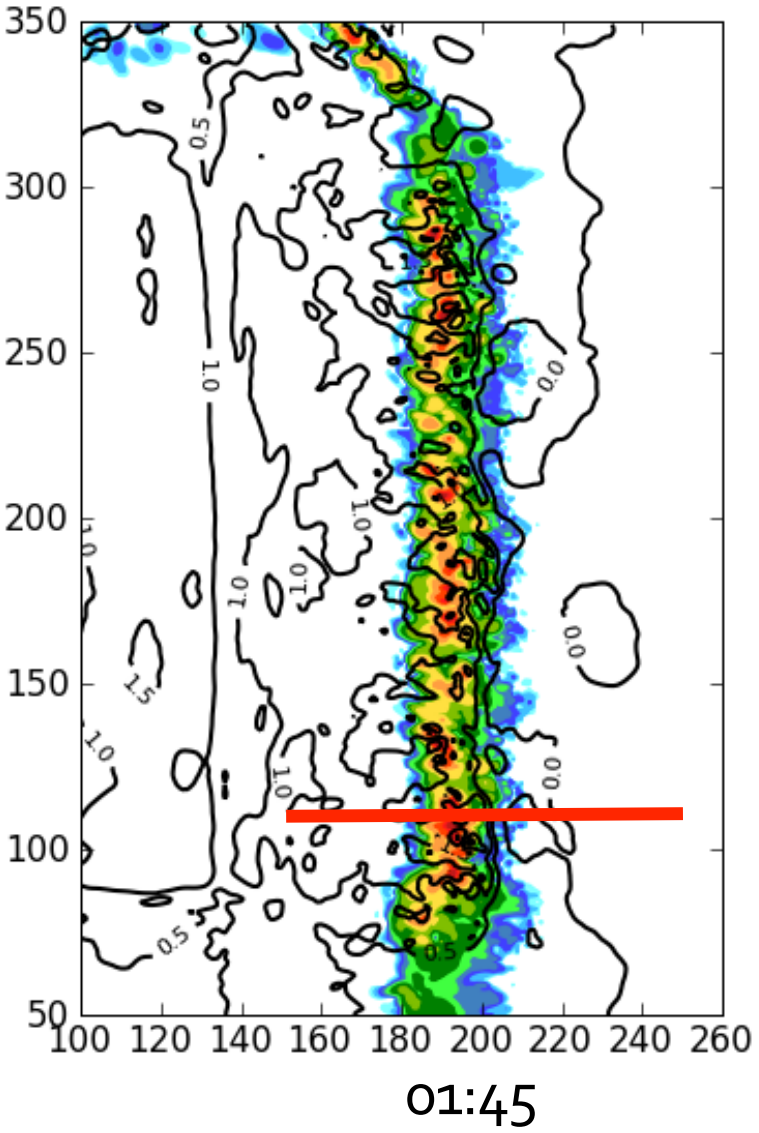


Mesohigh surge



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p′

q_{cw}

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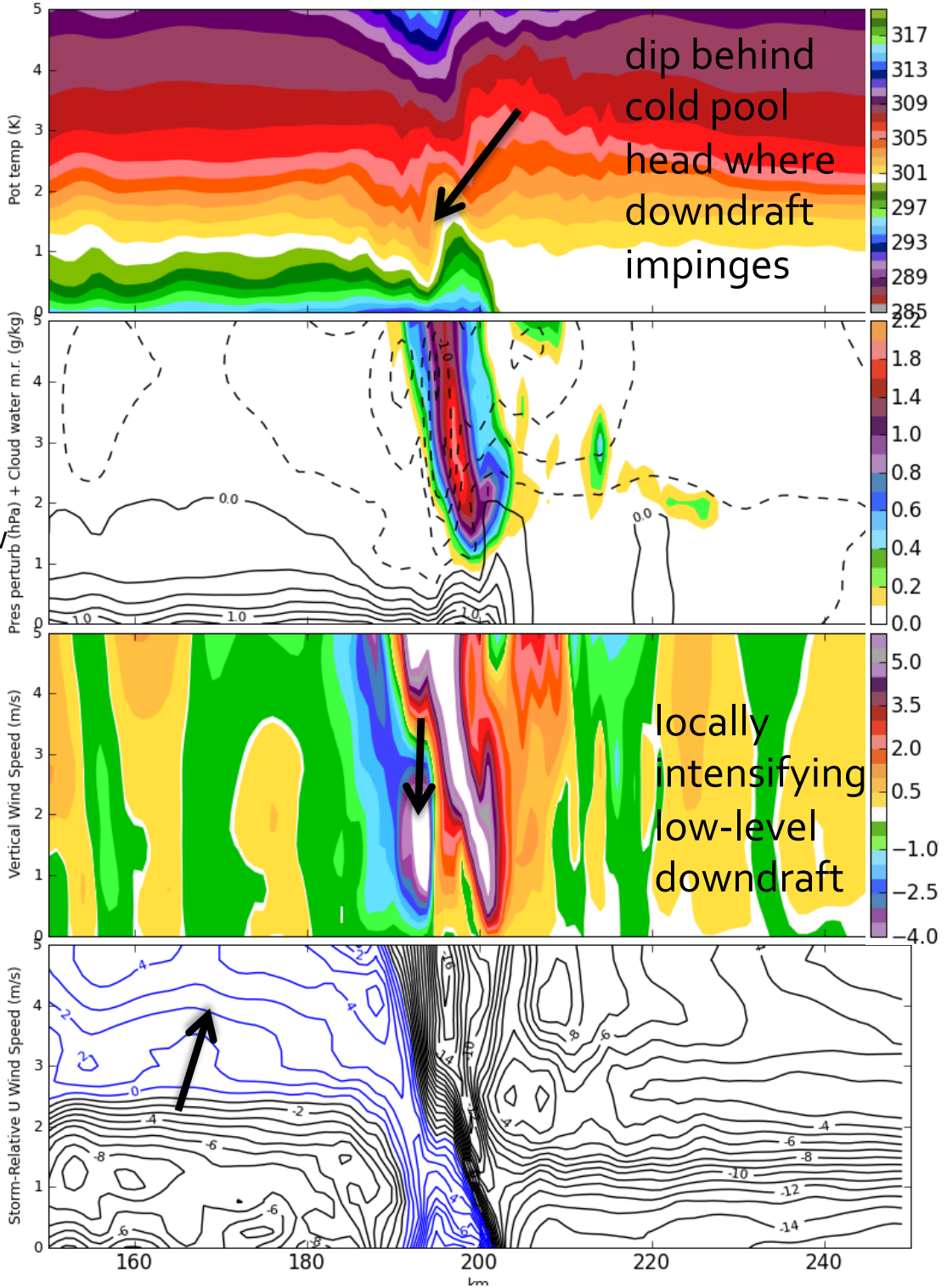
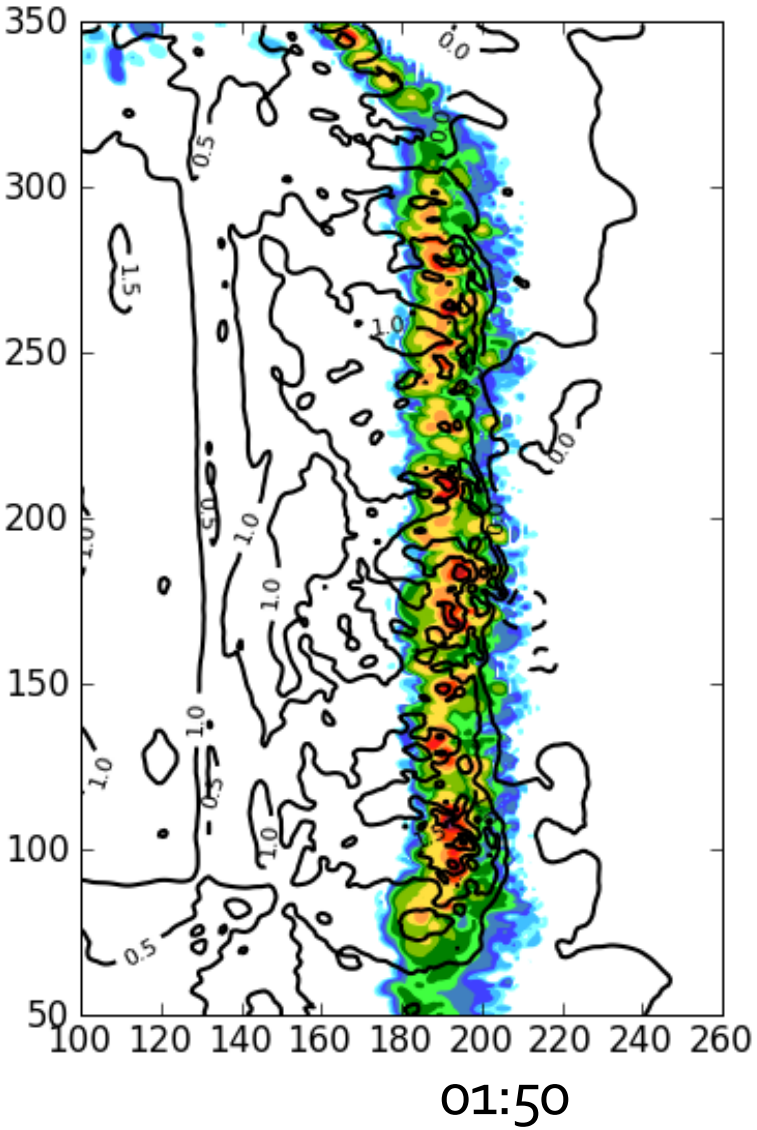


Mesohigh surge



01:50

θ

p’

q_{cw}

w

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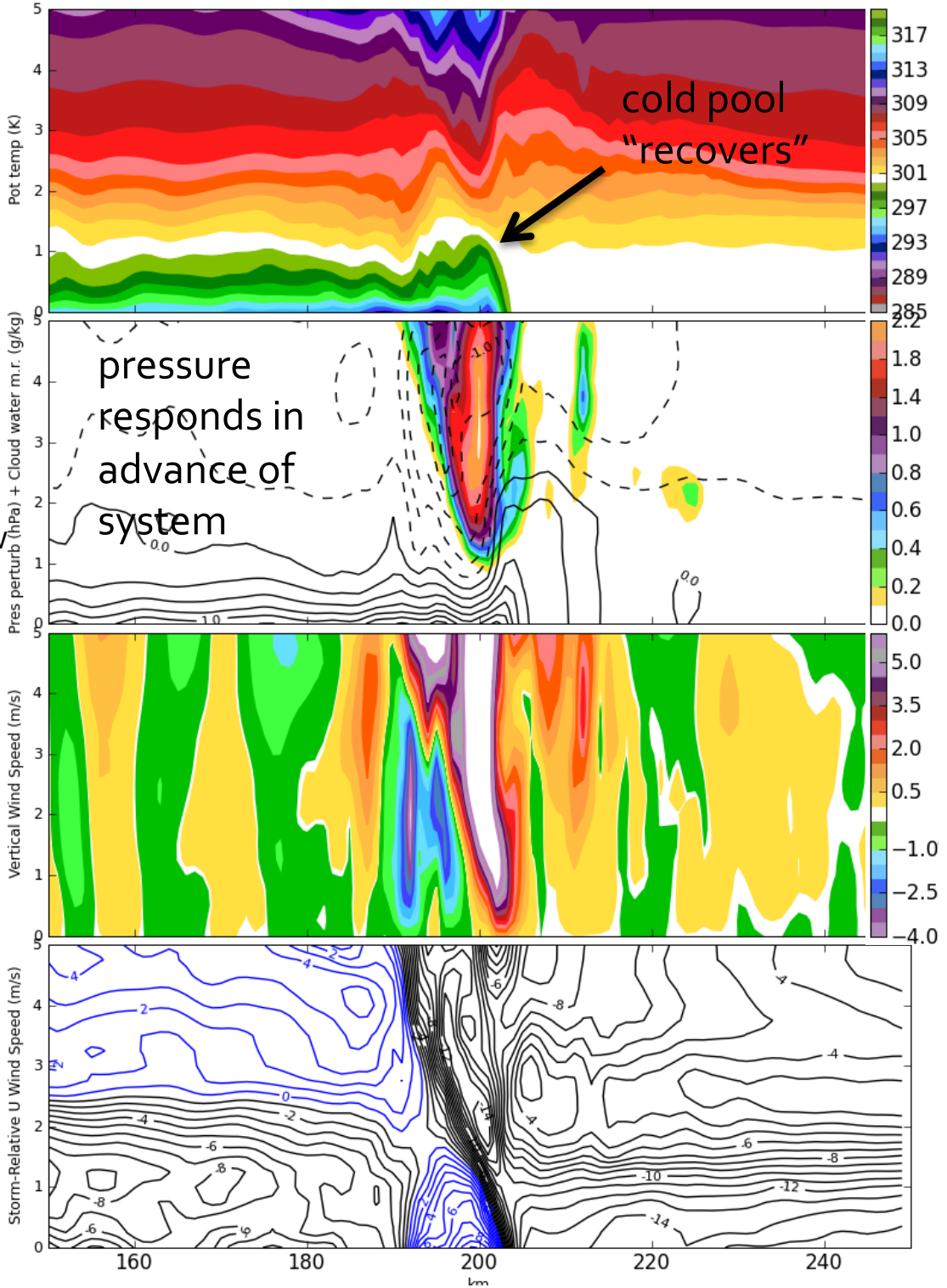
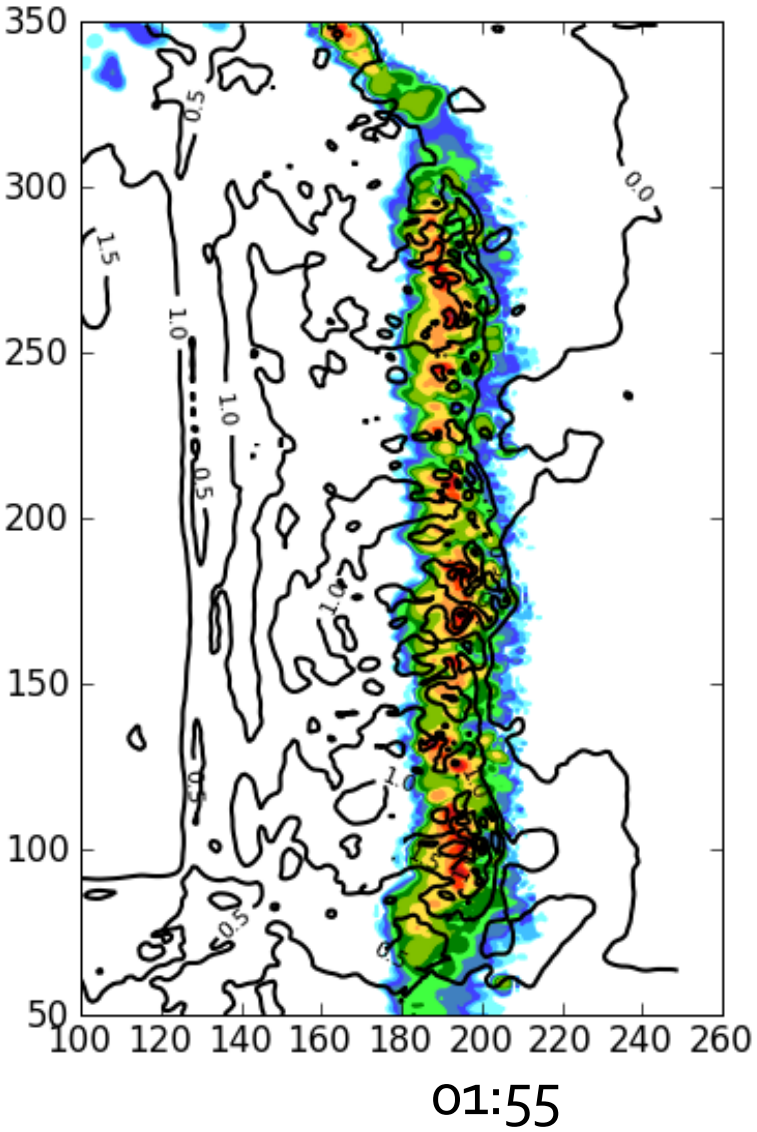


Mesohigh surge



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p’

q_{cw}

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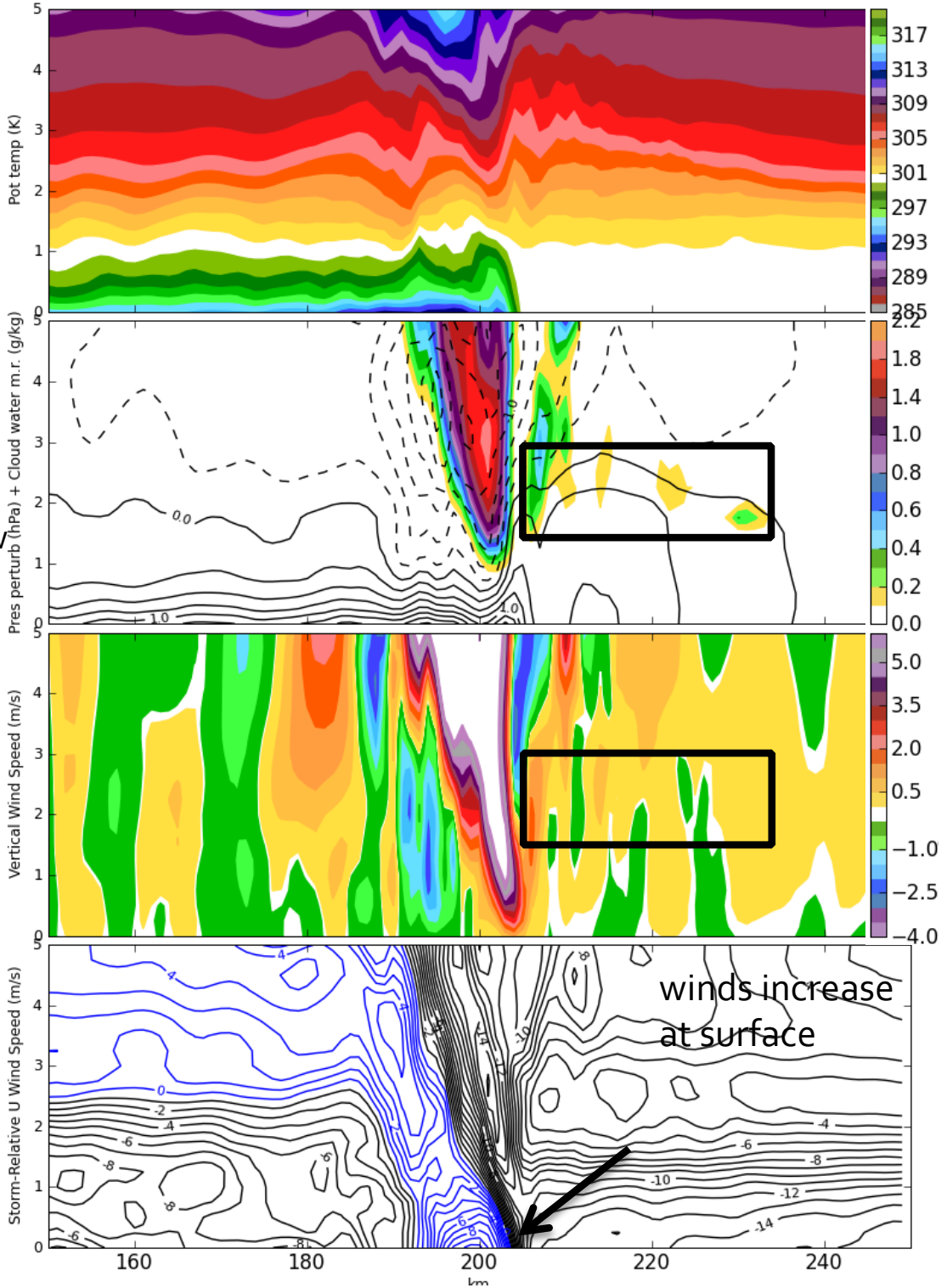
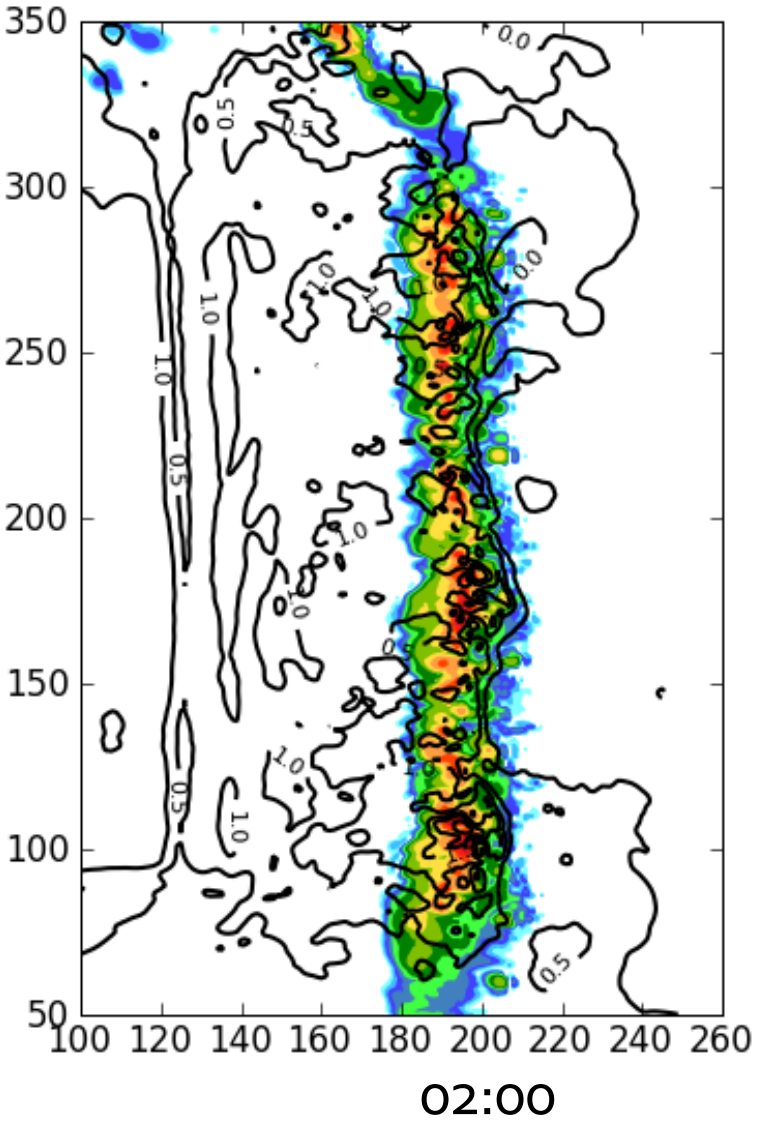


Mesohigh surge



02:00

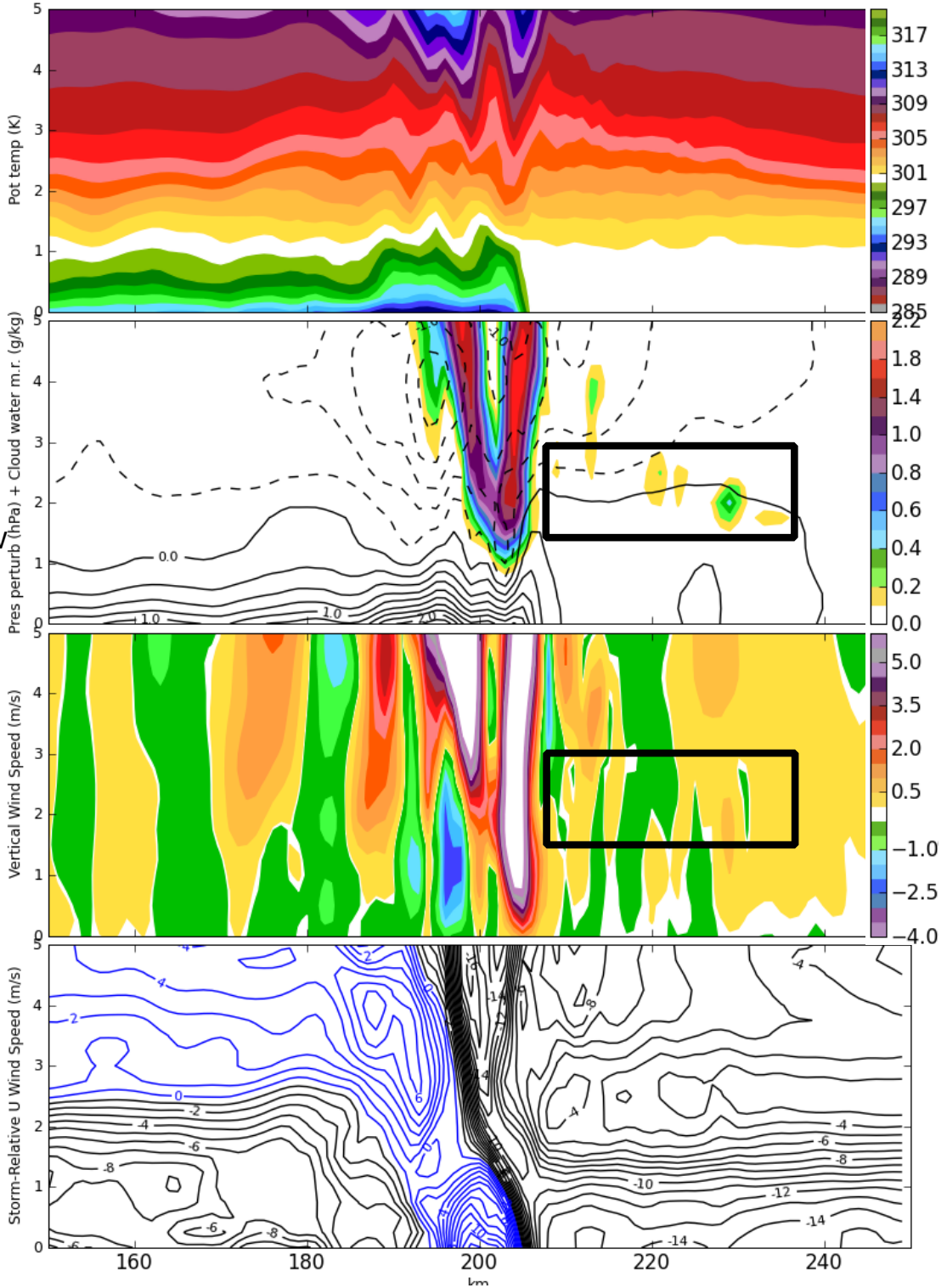
θ

p’

q_{cw}

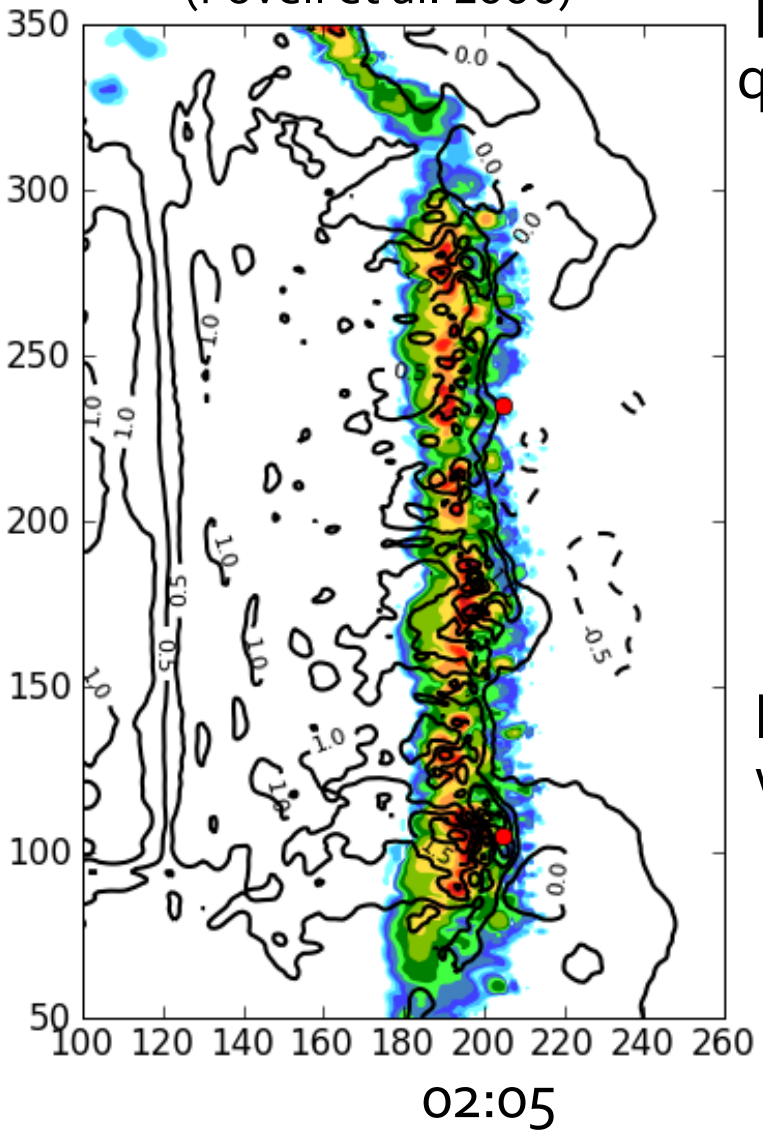
w

U

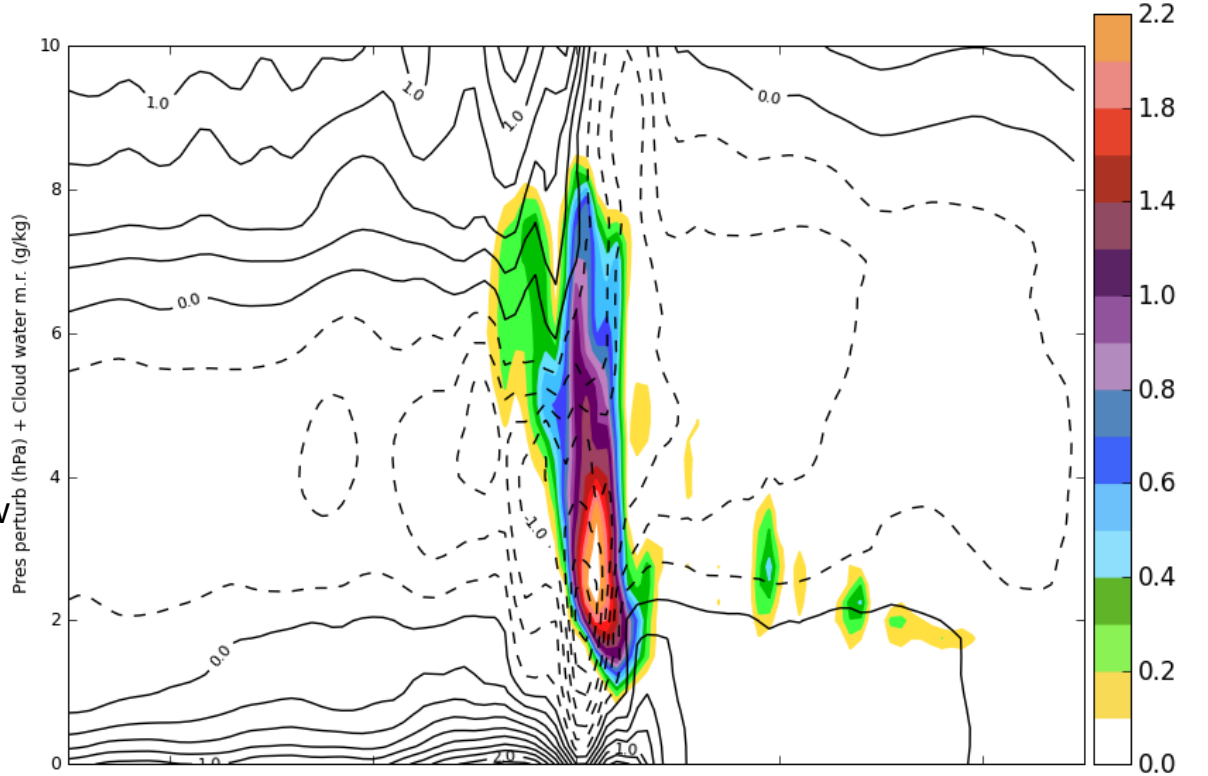


Mesohigh surge

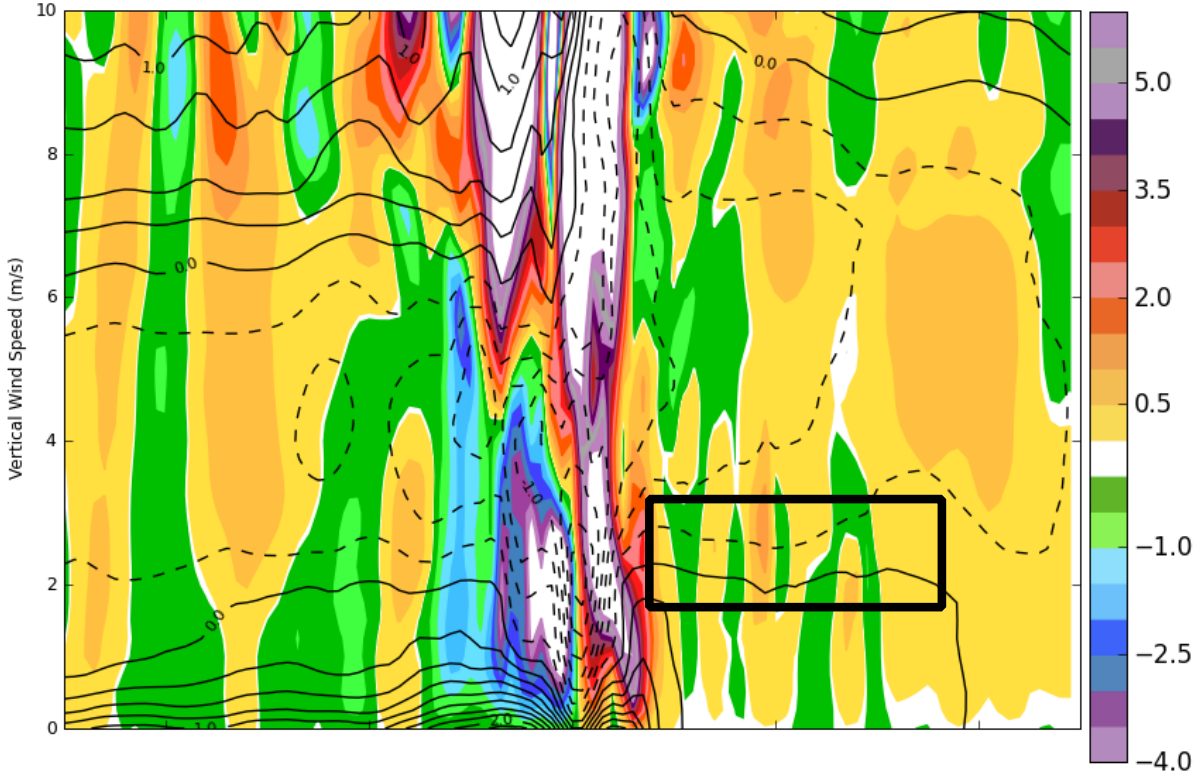
Discrete cloud formation
(Fovell et al. 2006)



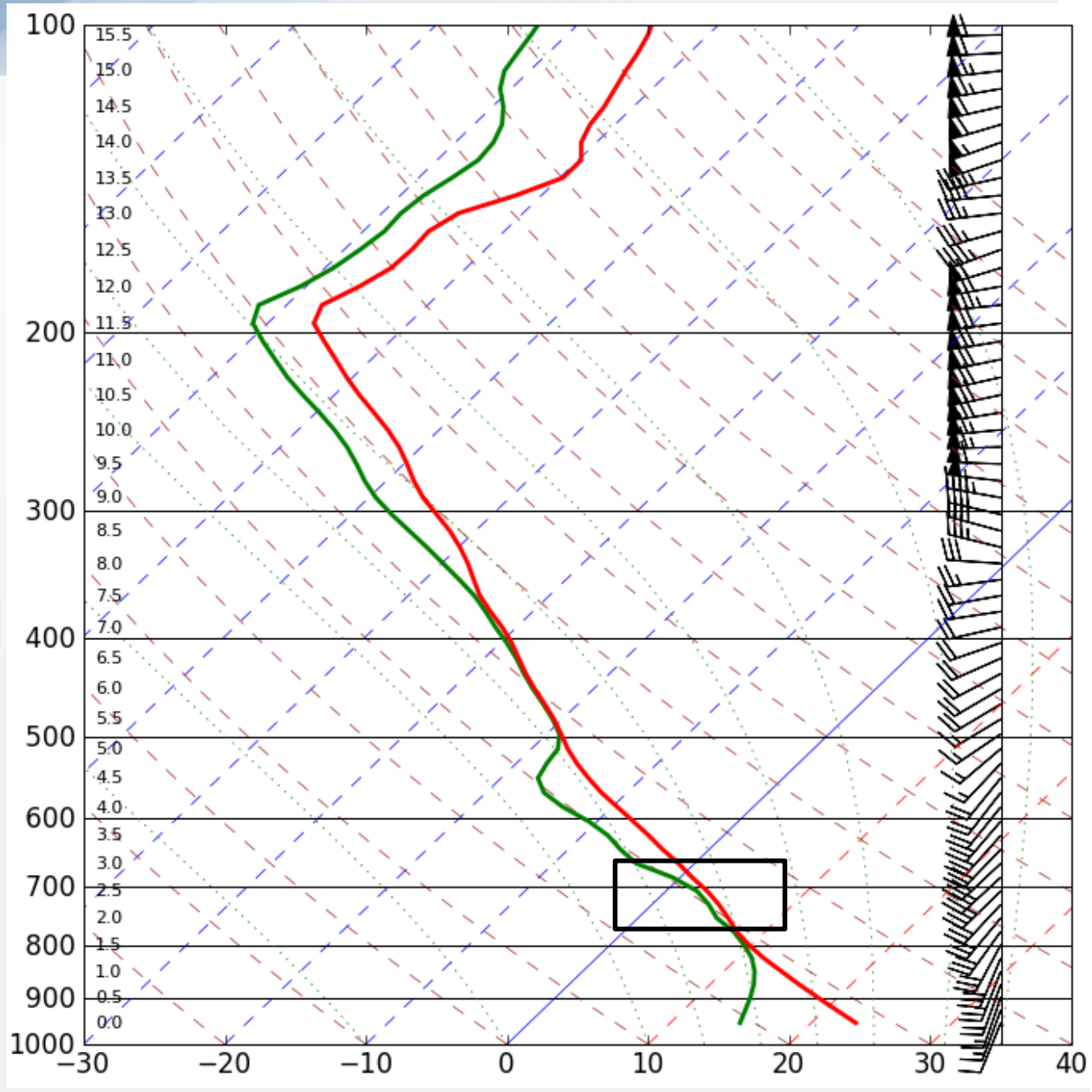
p'
q_{cw}

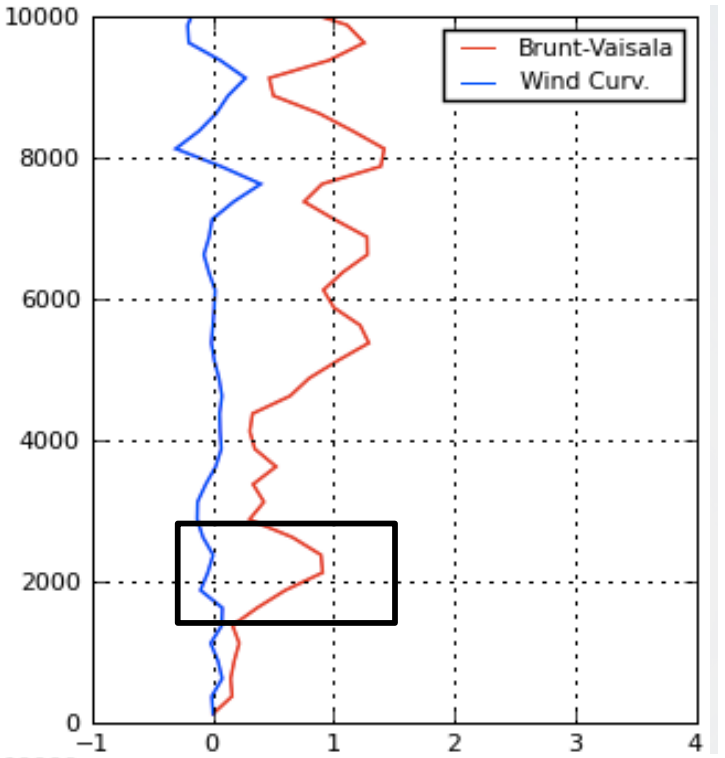


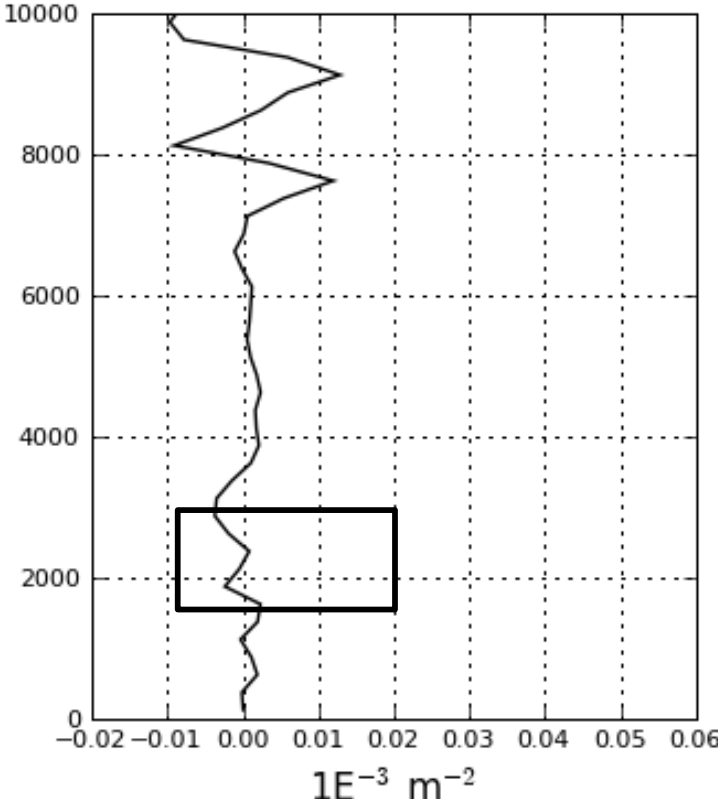
p'
w



Wave Trapping – CM1







Conclusions

- Surface pressure features associated with 13 March 2003 bow echo generated by:
  - fast-moving n=1 gravity wave
  - trapped low-level gravity waves
- Waves modified pre-storm environment
  - warming and drying; more favorable wind profile
  - discrete cloud formation
    - positive feedback to convective line
- Future work:
  - Effects of radiation cooling and increasing stability on wave/bore generation
  - Diabatic gravity wave and bore generation – microphysical sources?