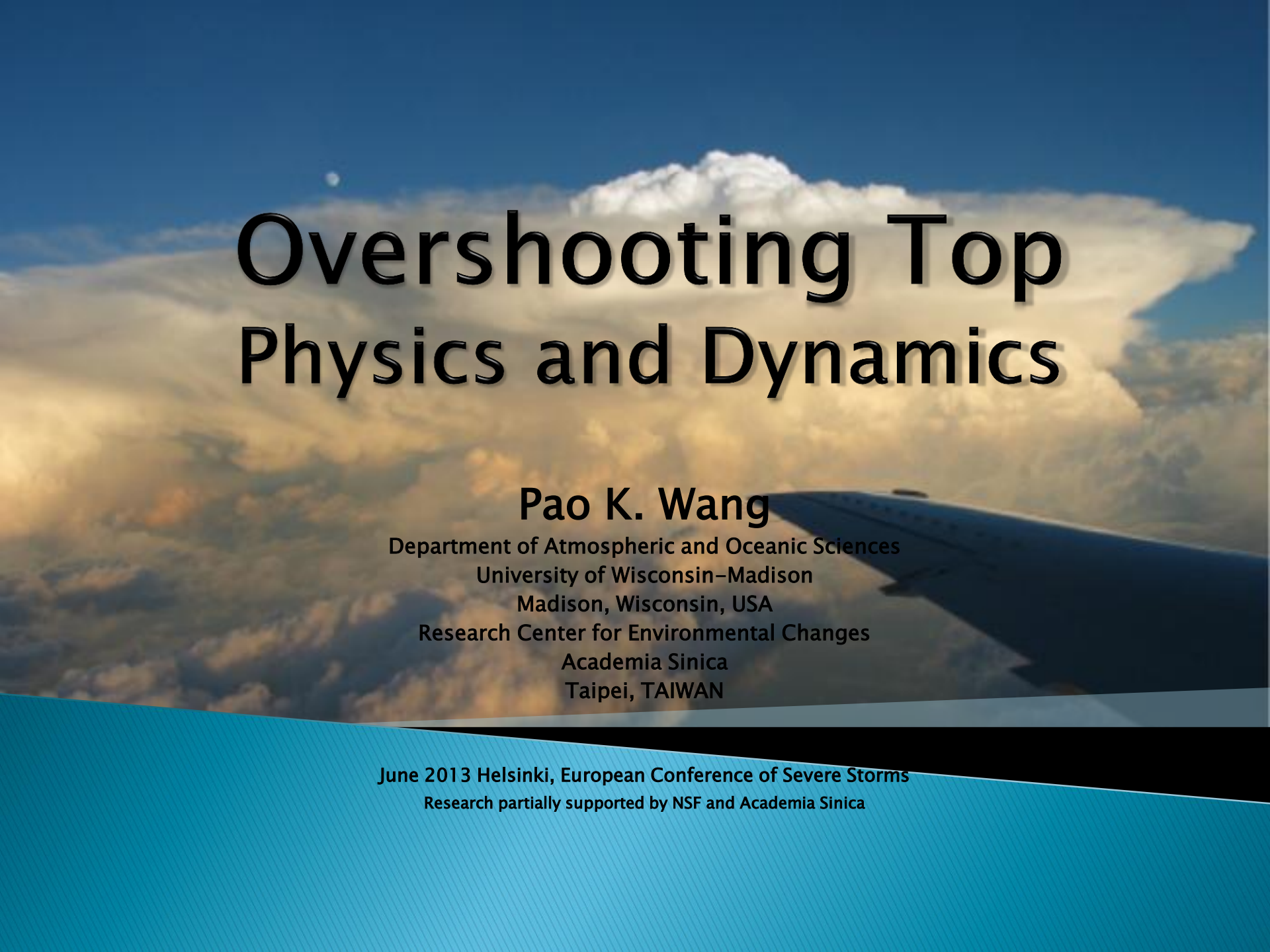

Overshooting Top
Physics and Dynamics

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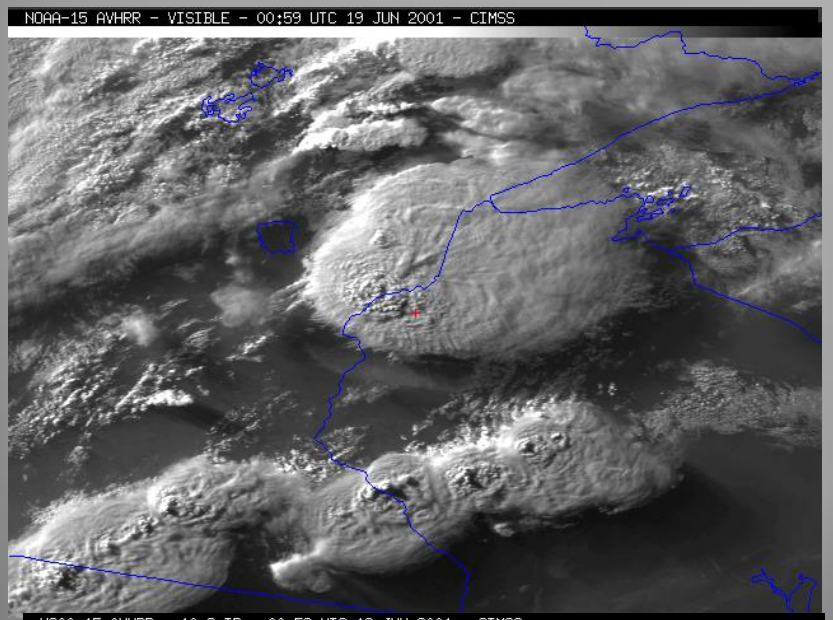
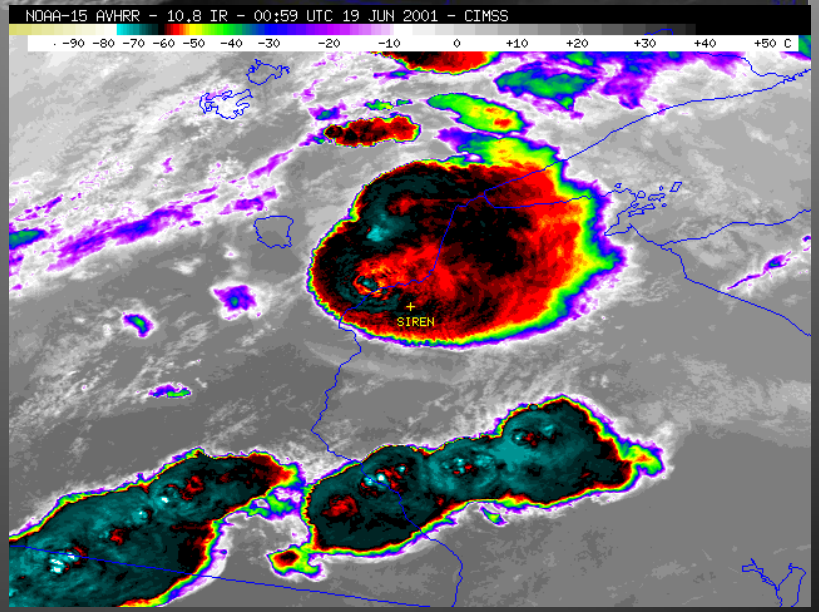
June 2013 Helsinki, European Conference of Severe Storms

Research partially supported by NSF and Academia Sinica

Why OT?

- The presence of overshooting tops is believed to be related to storm severity
- There is an increasing activity of “OT hunting” among satellite folks
- It pays to understand what’s going on around an OT so that one can identify it correctly

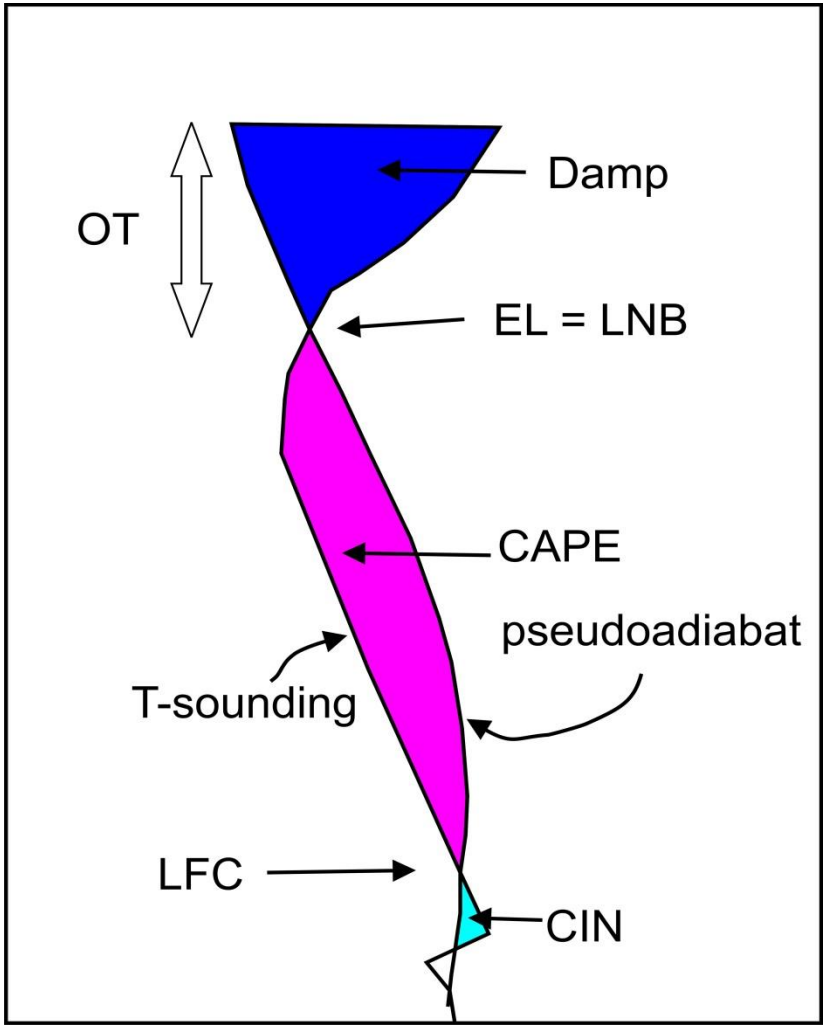




overshooting top
(*Or* anvil dome, penetrating top.)

- A domelike protrusion above a cumulonimbus anvil, representing the intrusion of an updraft through its equilibrium level (**EL**)
  - -- AMS Glossary
- **EL** = **LNB** (level of neutral buoyancy).
- **Where is LNB?**

from parcel theory

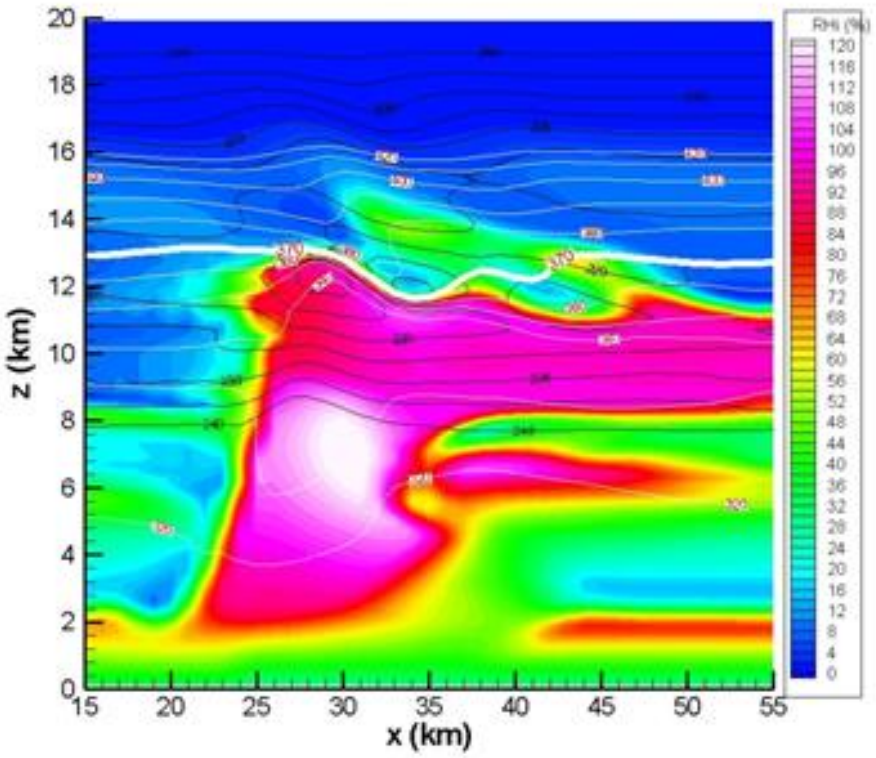


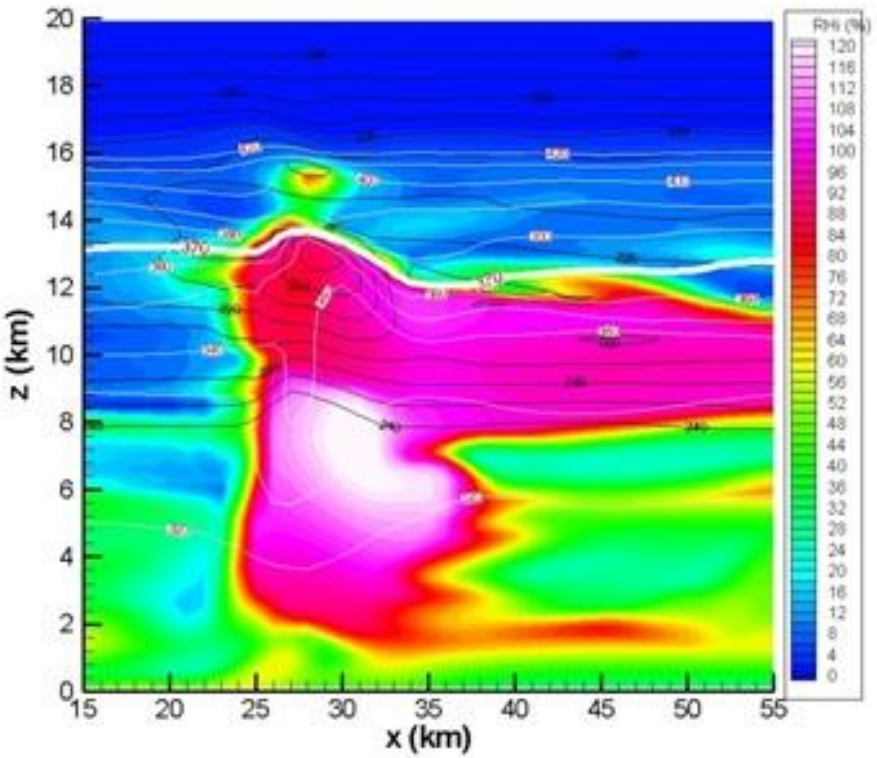
In reality, it's more complicated

- Where is EL during a strong convection?
  - Vertical T-profiles are different in different locations in and around the storm
  - It is often said that the EL of a severe storm is practically at the tropopause. But the tropopause is not a horizontal plane anymore.

- It's better to use an **isentropic surface** (constant θ-surface) to represent the **tropopause**. This surface is strongly influenced by the convection.

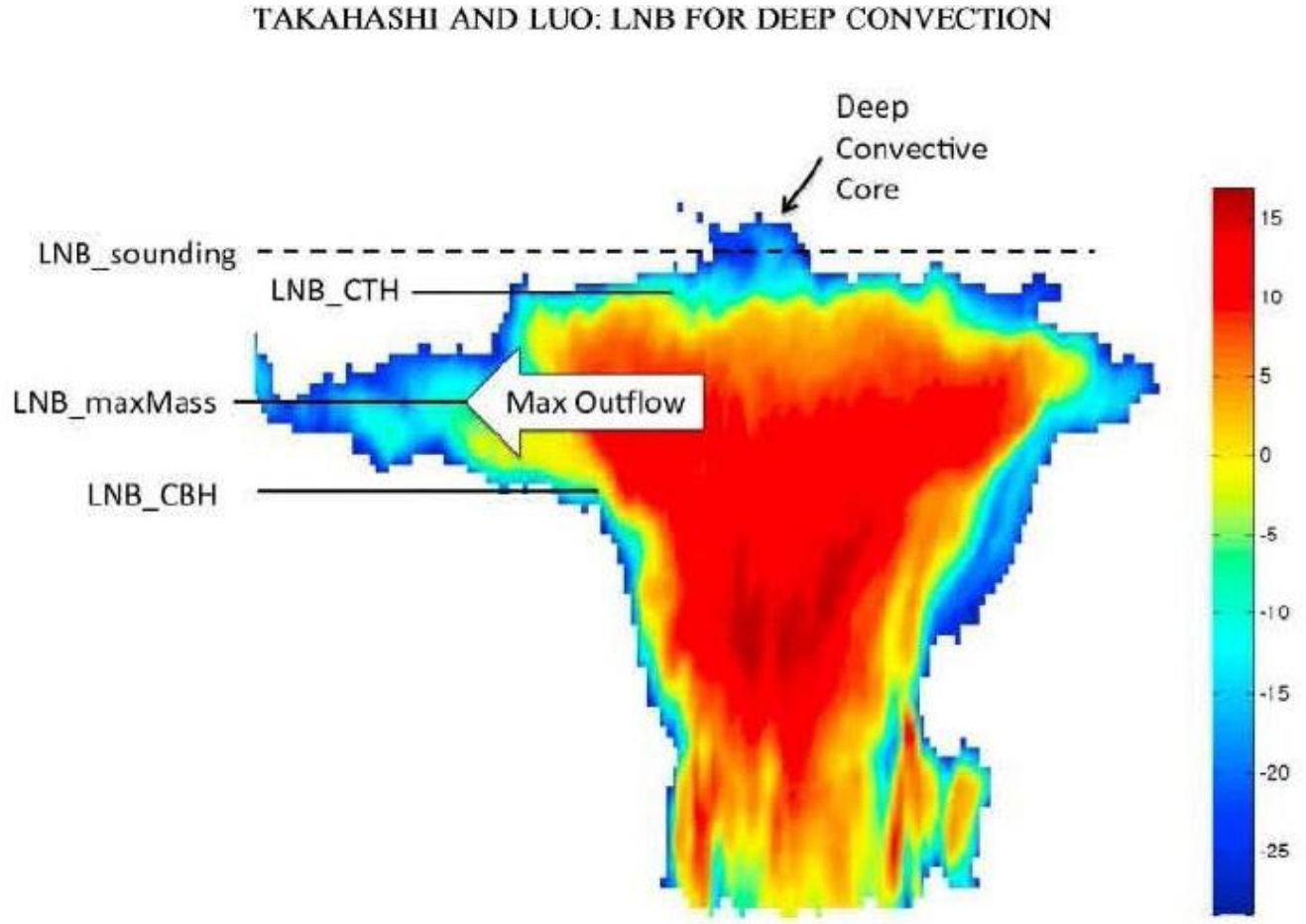
Processes going along the isentropic surfaces are adiabatic; those going through such surfaces are diabatic.





LNBs can differ by several km

according to a CloudSat study

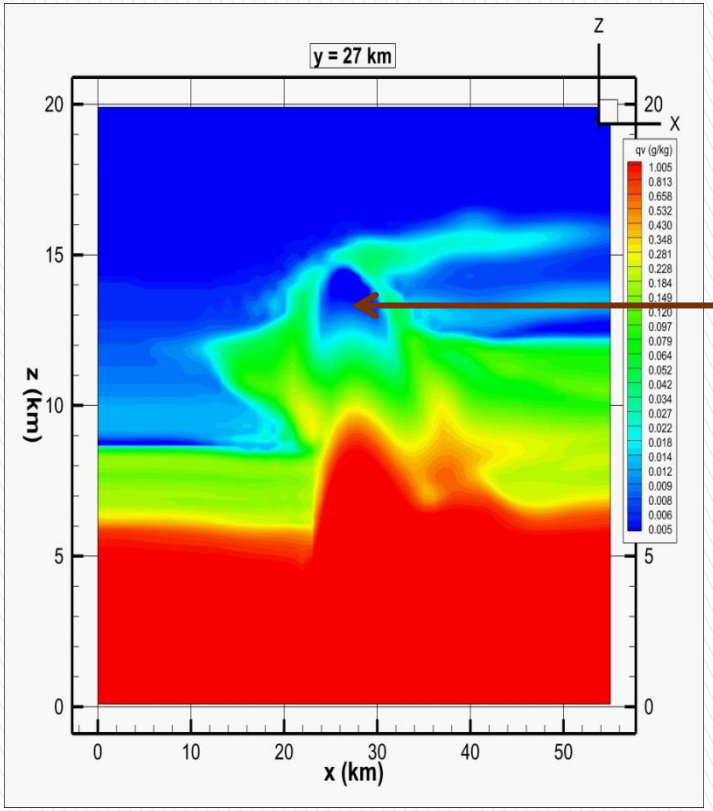


Takahashi and Luo (2012)

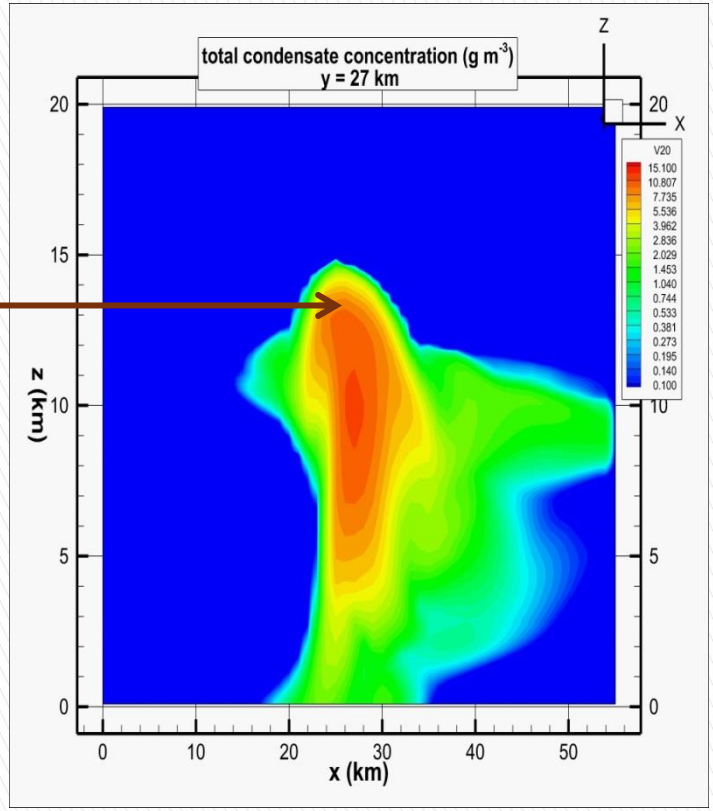
OT is a dry shell

very dry inside the OT (little water vapor), but plenty hydrometeors

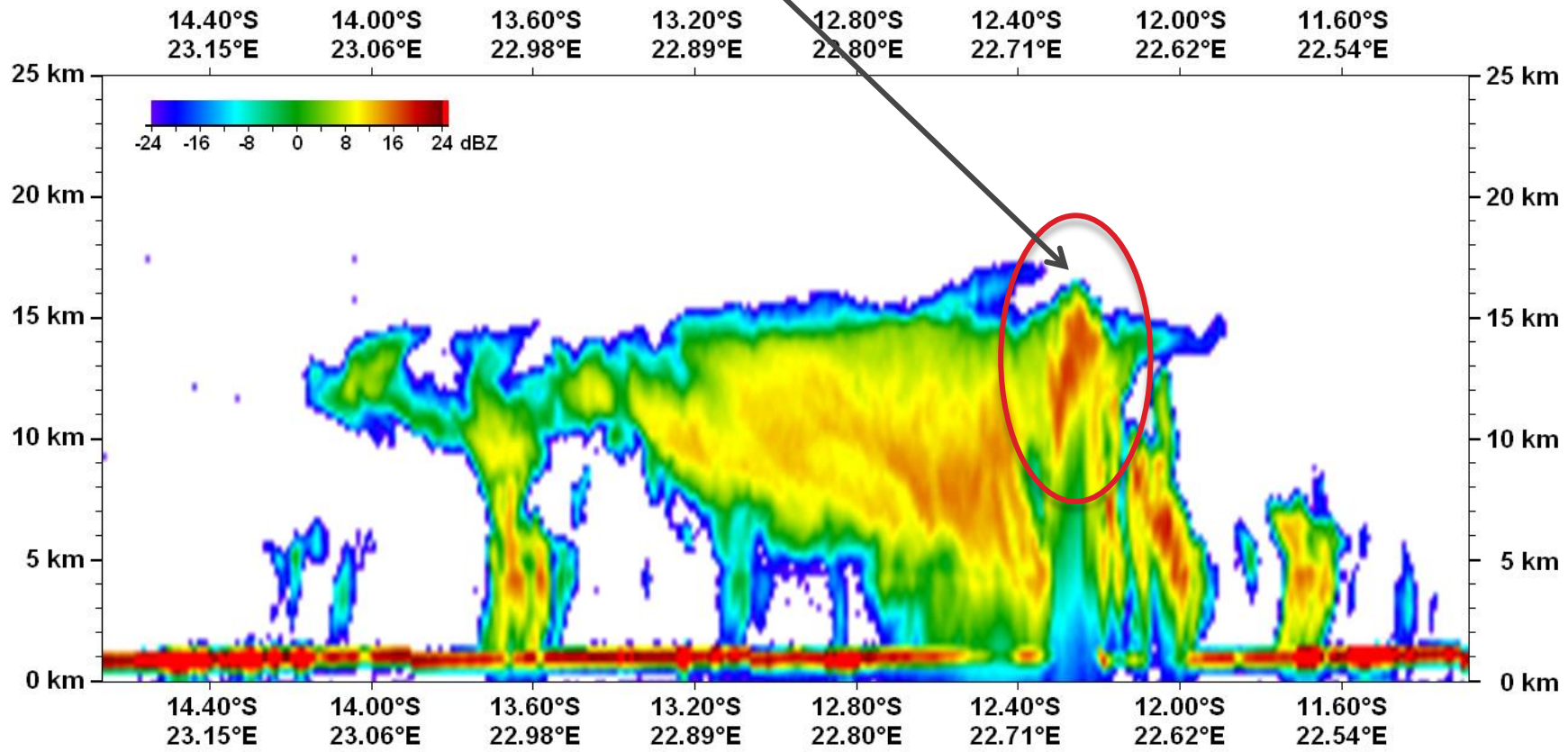
Vapor mixing ratio



Total condensate mixing ratio



OT seen by CloudSat's radar

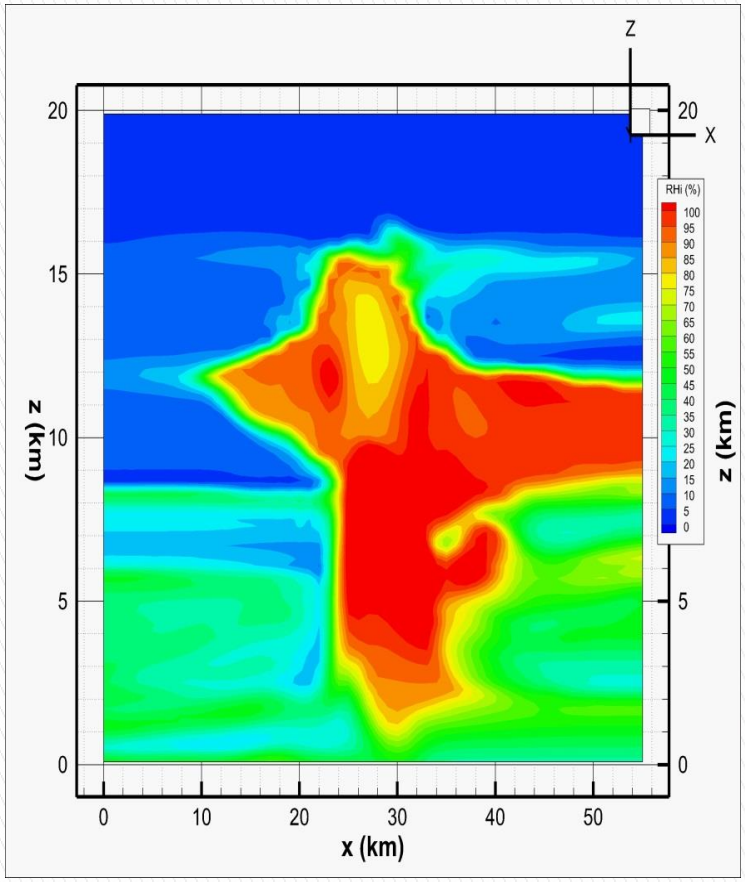


Courtesy of Zdenek Charvat

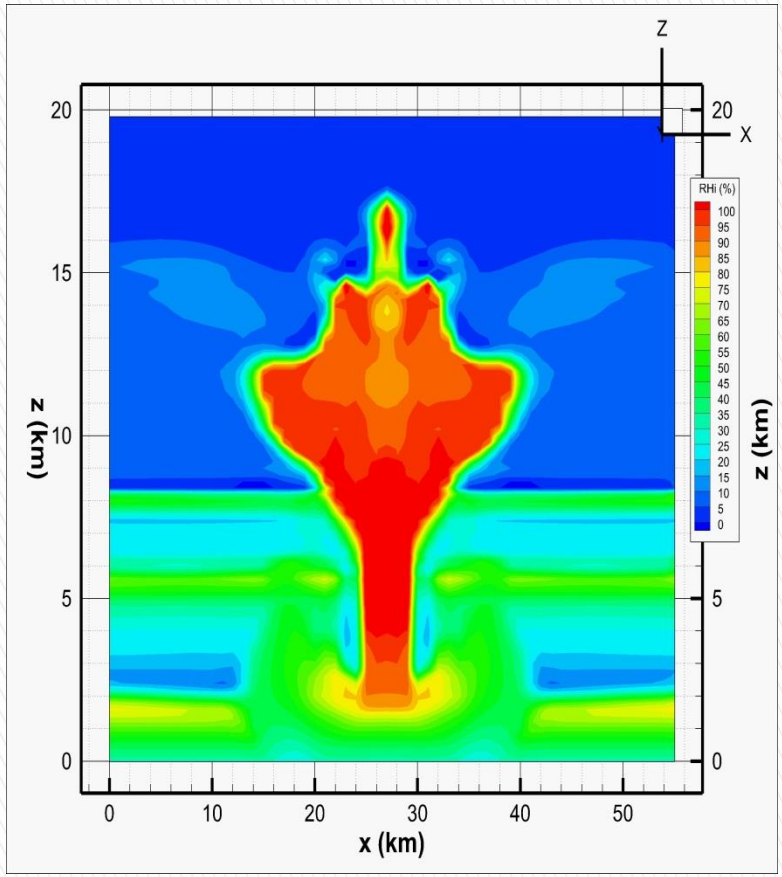
Other factors that may influence the OT

1. Wind shear effect (not well understood)
2. Lee waves (usually considered adiabatic)
3. IGW by updraft (usually considered adiabatic)
4. Non-adiabatic processes (condensation, evaporation, wave breaking, turbulent mixing, …)
5. In the following, we will examine the nature of an OT based on model simulation results.

Wind shear *may* decrease the maximum height of OT (if other factors remain the same…)



Z_{max} ~ 15.5 km (t = 61)

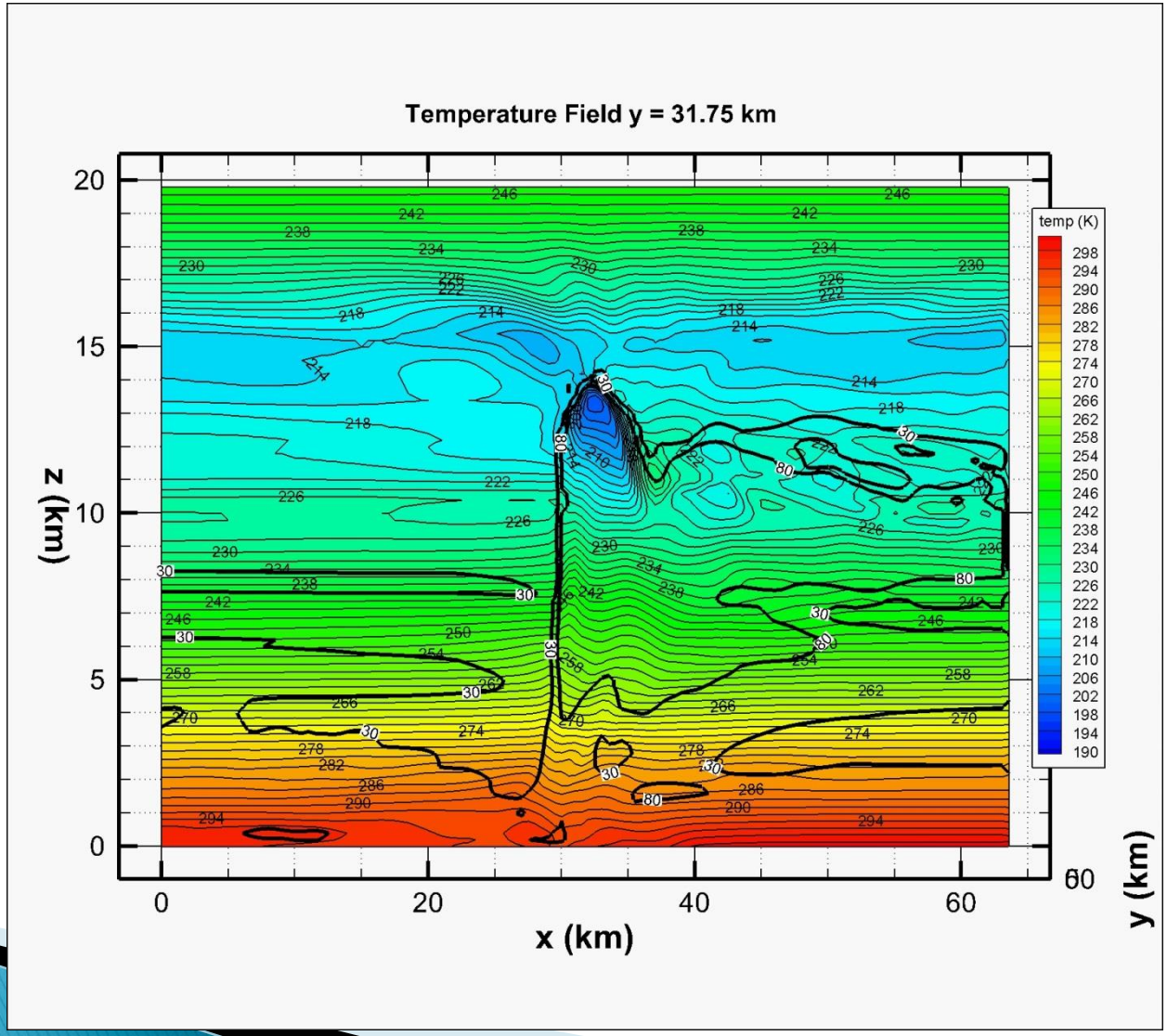


Z_{max} ~ 17.5 km (t = 140)

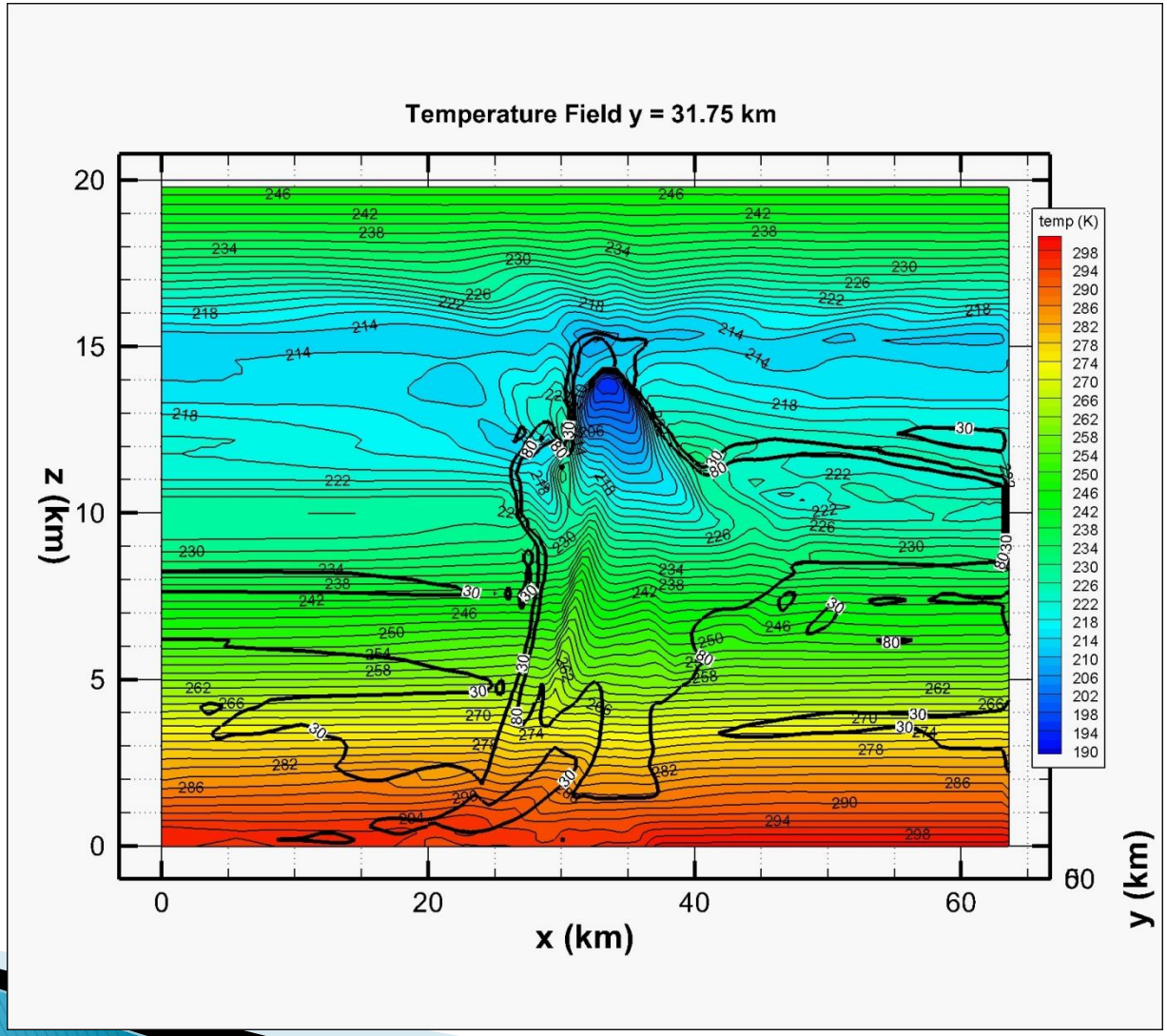
Effects of gravity waves

- Gravity waves not only influence the shape of the storm top, including the OT, but may also impact its thermal properties, a point often neglected in the research community.
- IR remote sensing techniques depend very much on thermal properties (real T, not θ)
- Many complications of the features associated with the storm top IR brightness temperatures are caused by gravity waves.

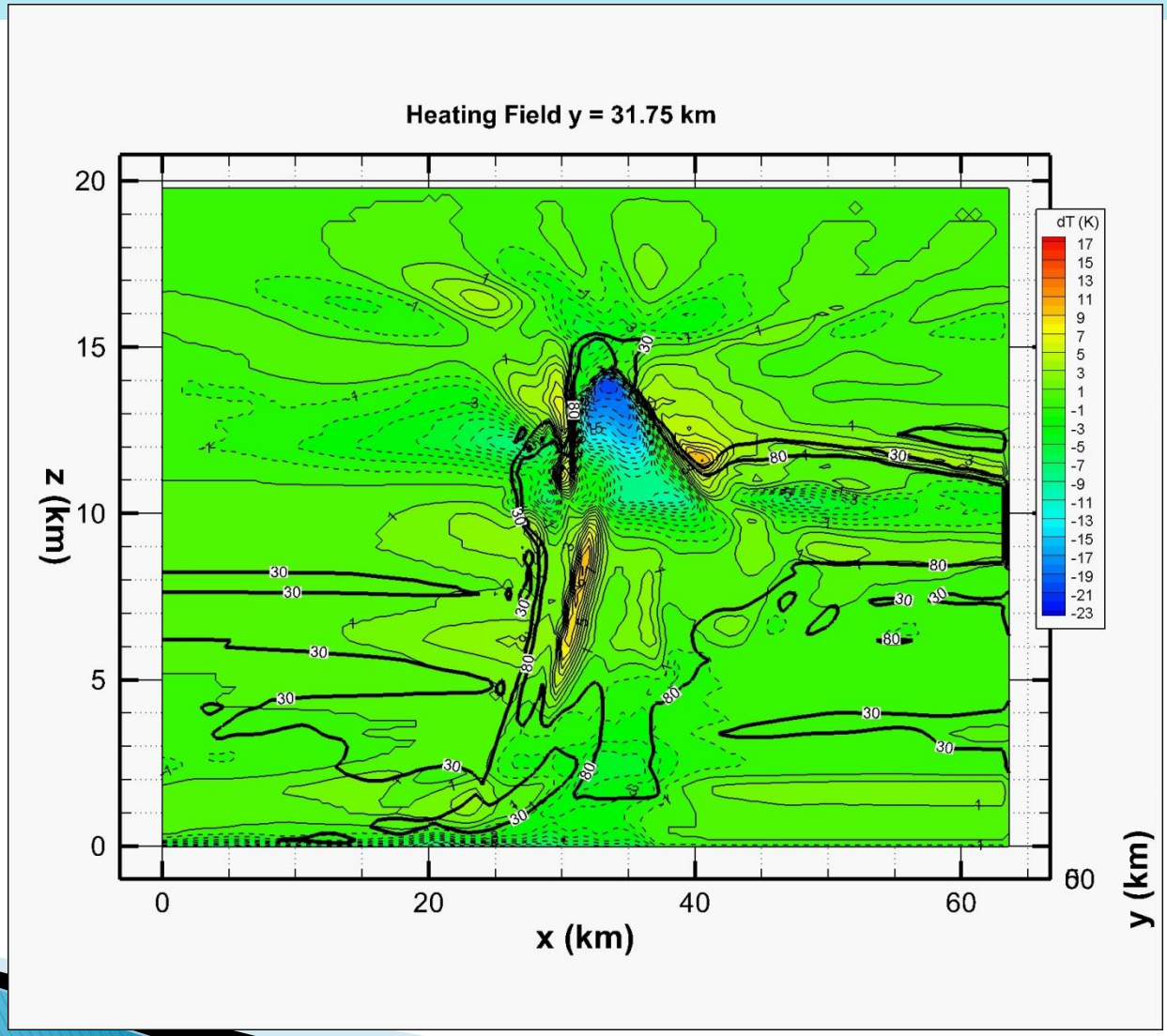
Temperature field in a storm



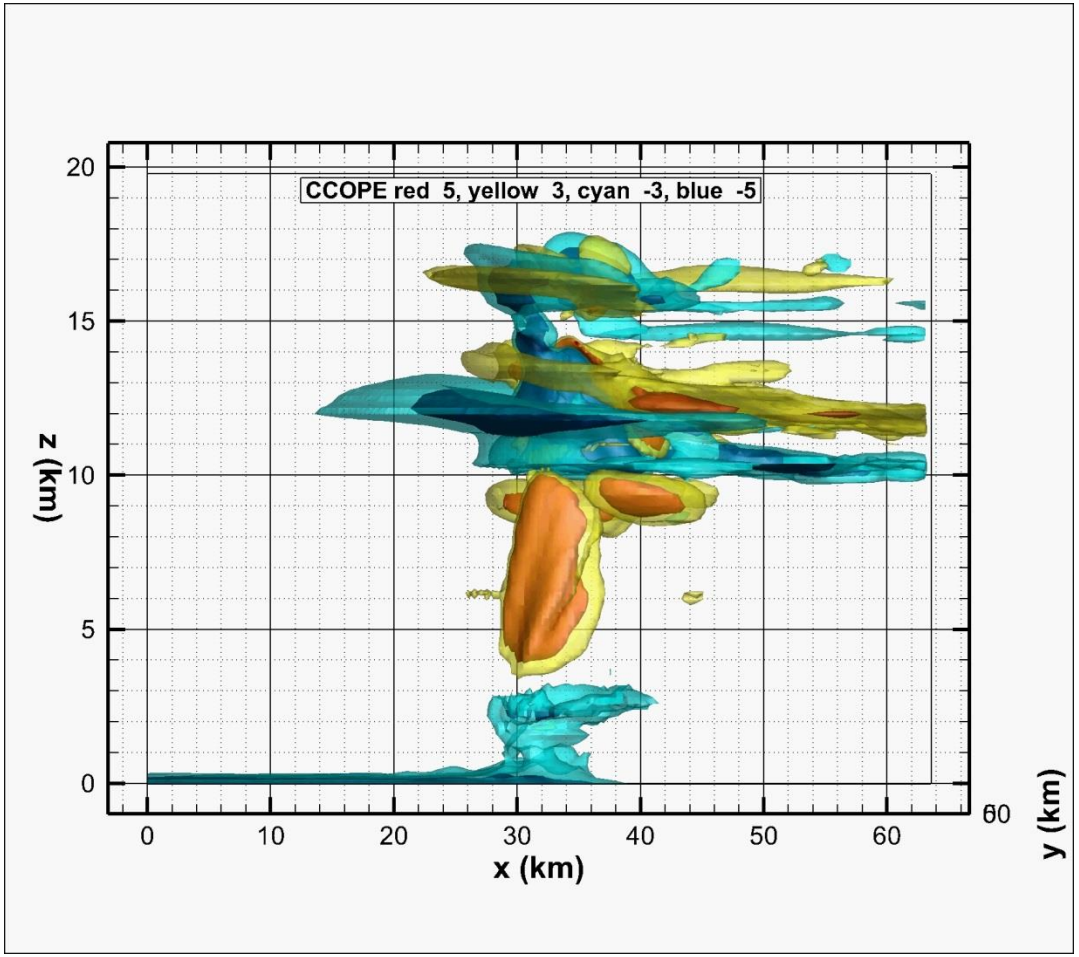
Which one is the real OT?



Heating-field (dT) in a severe storm shows the thermodynamic and dynamic processes



3D temperature field around an OT



Conclusions

- Need to clarify more about OT
  - What an OT is and is not
- Thermal field around OT is mostly controlled by wave activities (lee waves and IGW by convective core) and turbulent mixing
- Pre-existing moisture or above-anvil plumes can mask the OT signature. They themselves can be heated or cooled by the IGW process