Kinematic and Microphysical Analysis of Two MC3E Cases

4 November 2013

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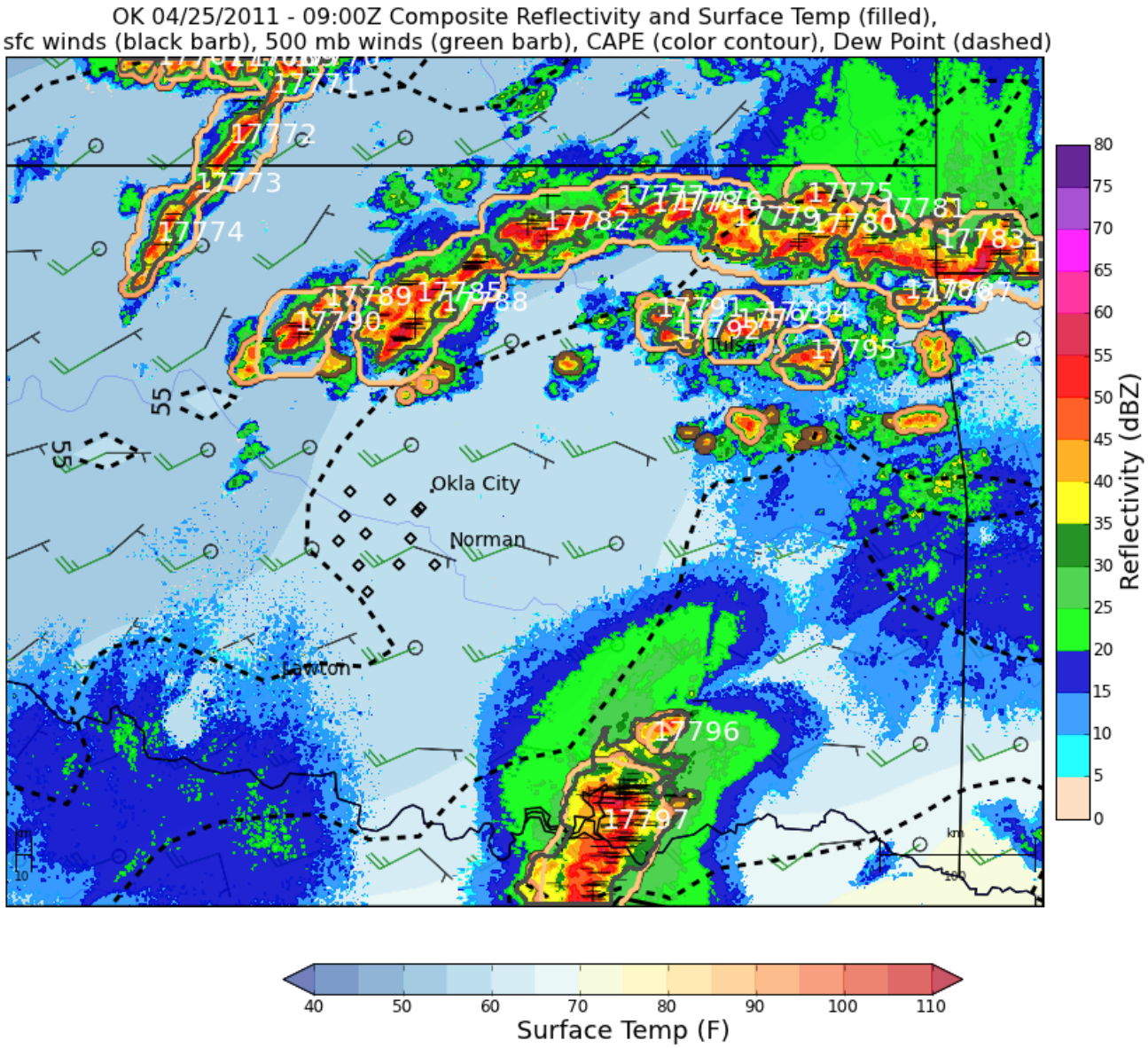
Goal

- Comprehensive case study of (precipitation) from two cases, April 25 and May 23
  - From ground to storm top
  - 2DVDs
  - X/C SAPRS 3D wind field (via dual-Doppler methods), microphysics
  - Profiler comparisons
- Develop a methodology that can be extended to long term dataset including winter
- Provide kinematic (e.g. w) and microphysical statistics useful for model comparison /validation

25 April 2011 Environment

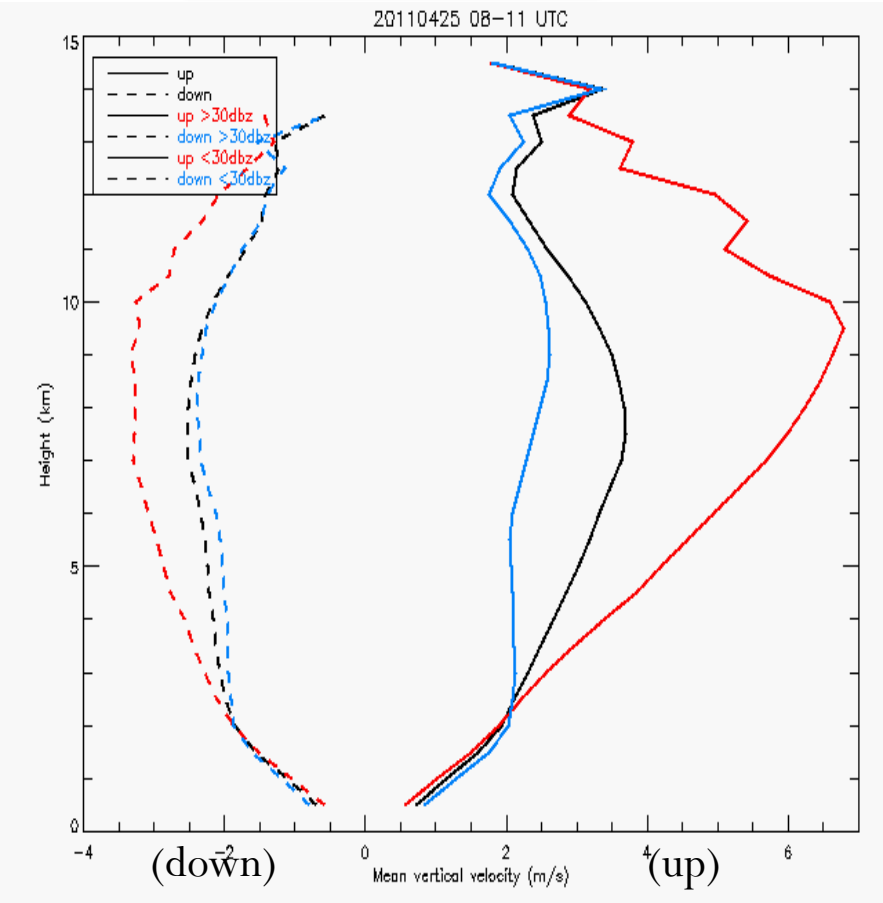


- Overnight case ~9 Z
- Cool sfc temps
- Moderate humidity
- Low cape
- Significant (over 250) big drops noted in both radar data and surface 2DVD observations
- Some corrupted XSW data?

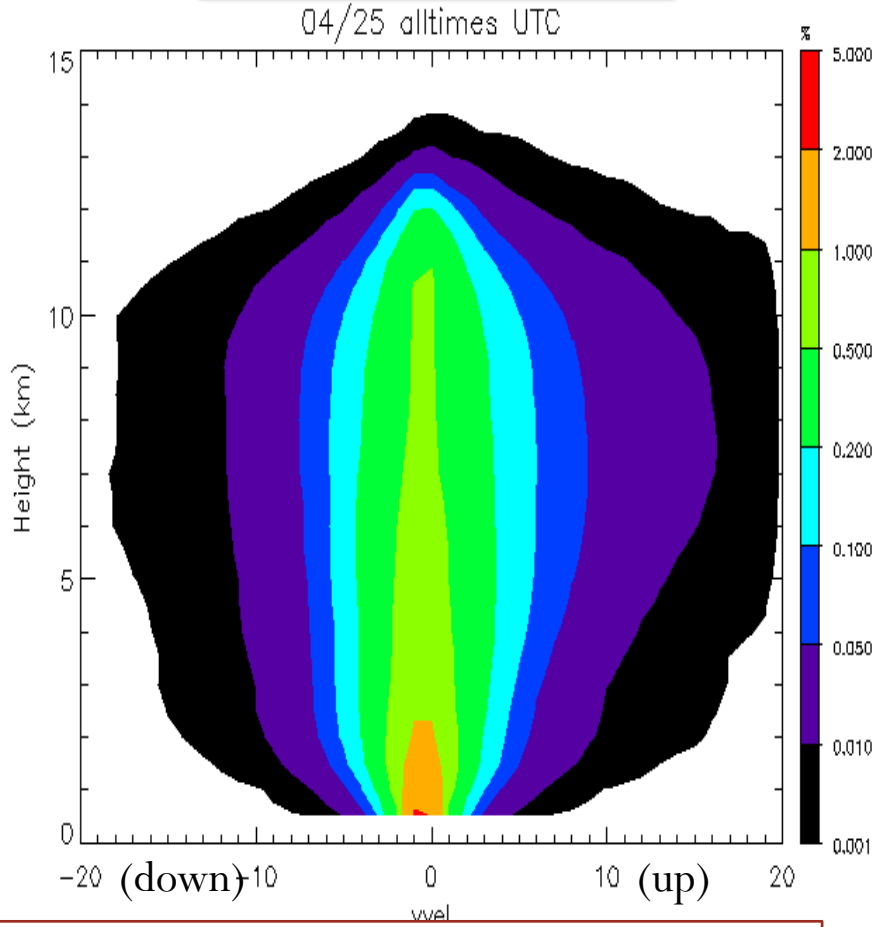
Courtesy Brody Fuchs

Dual-Doppler Derived Vertical Velocities 08-11 UTC

Mean vertical motion



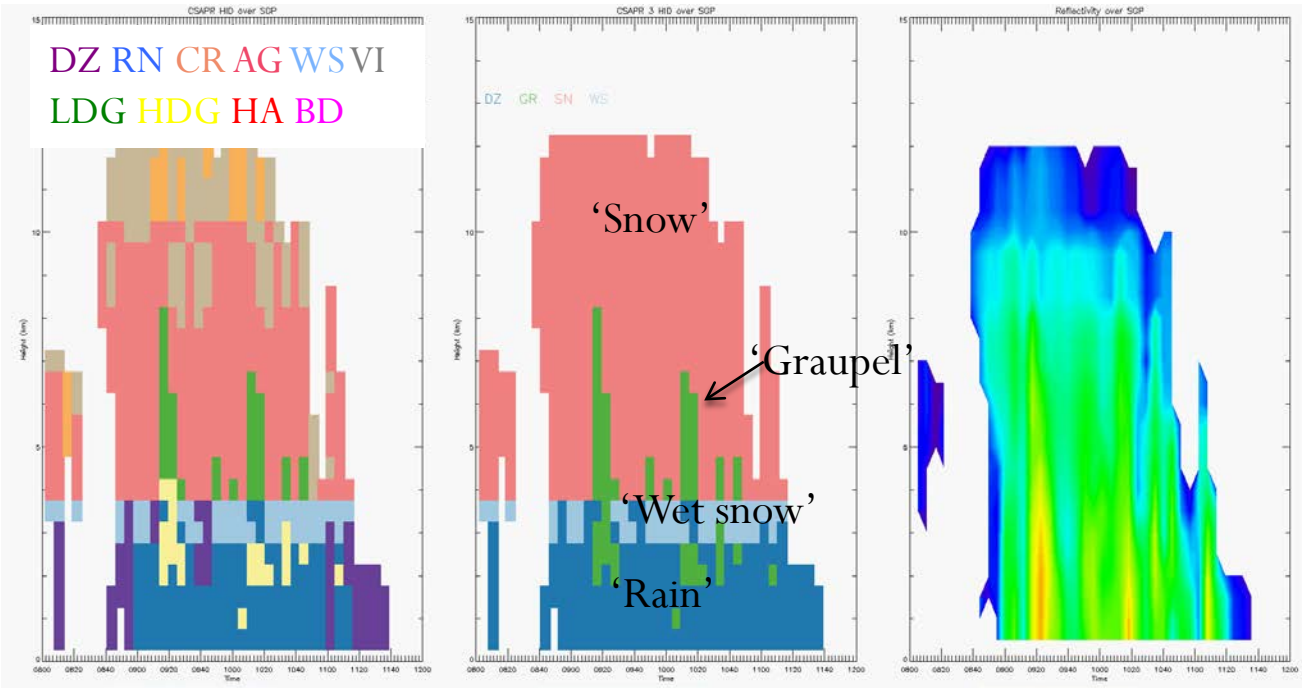
CFAD of vertical motion



- Convective updraft peaks between 9-10 km at >6 ms^{-1}
- Total mean updraft peaks around 7-8 km, widest breadth of updraft speeds above 5 km

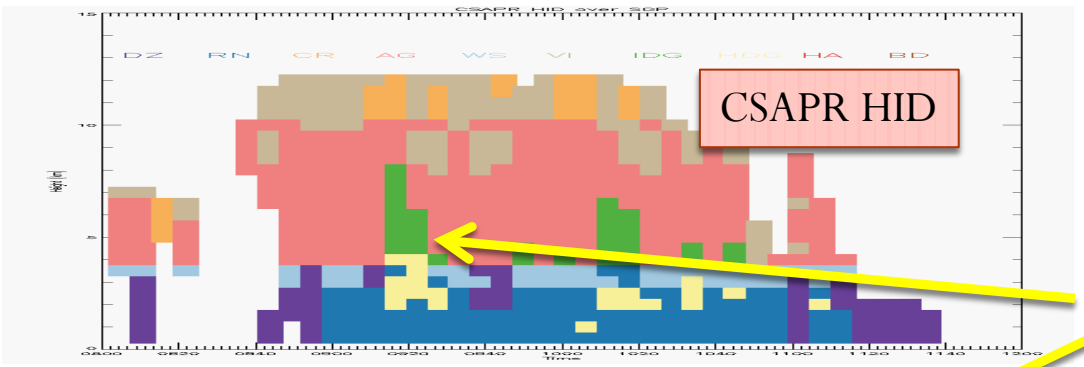
Comparison with Profiler at SGP

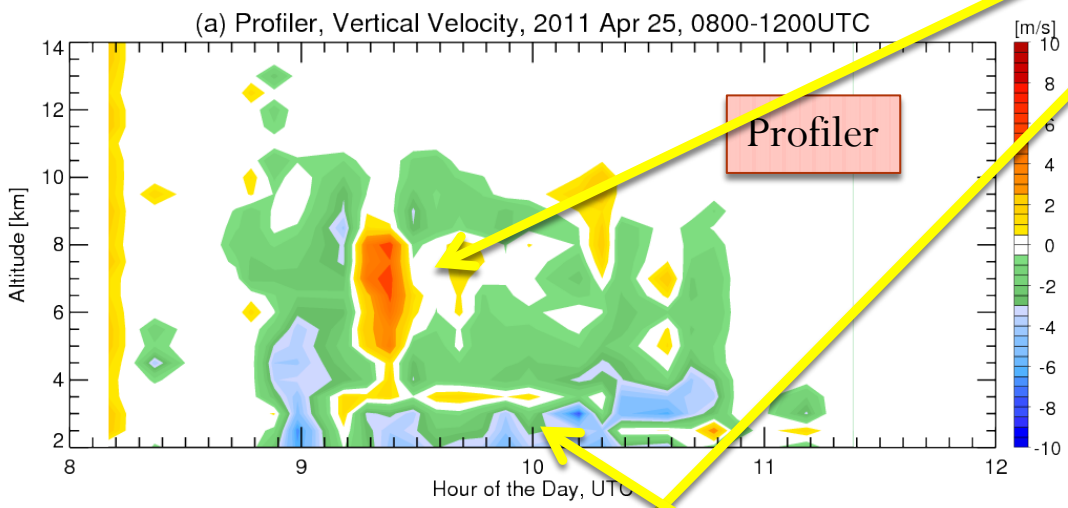
- Subtract fall-velocity (Vt) to compare vertical motions directly
  - Base fall-speed relations on Giangrande et al. (2013) for rain, graupel and snow (no correction made for wet snow)
  - Polarimetric hydrometeor identification based on CSAPR used to pick the fall speed relationship for a given point

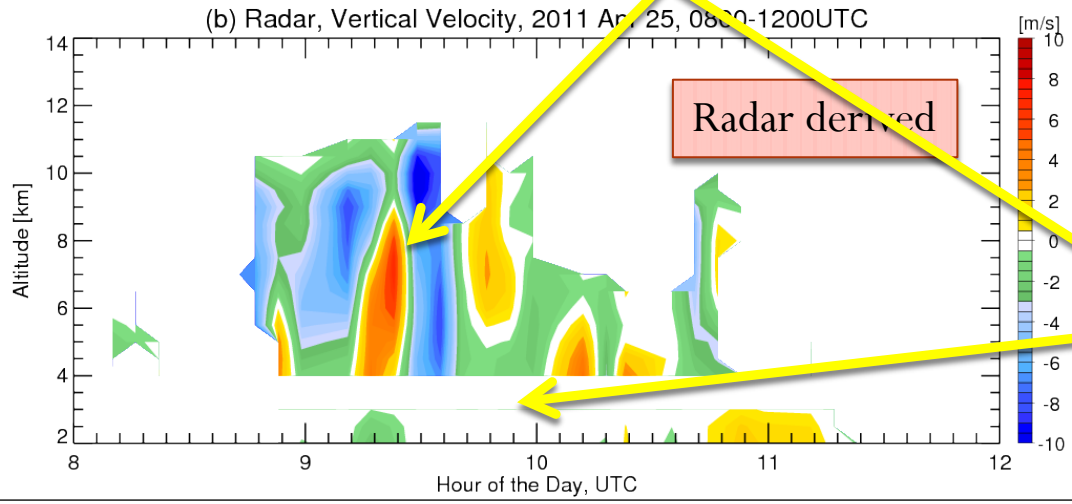


- Timeseries of CSAPR HID and reflectivity over the SGP profiler site from 08-11 UTC on April 25

25 April 2011

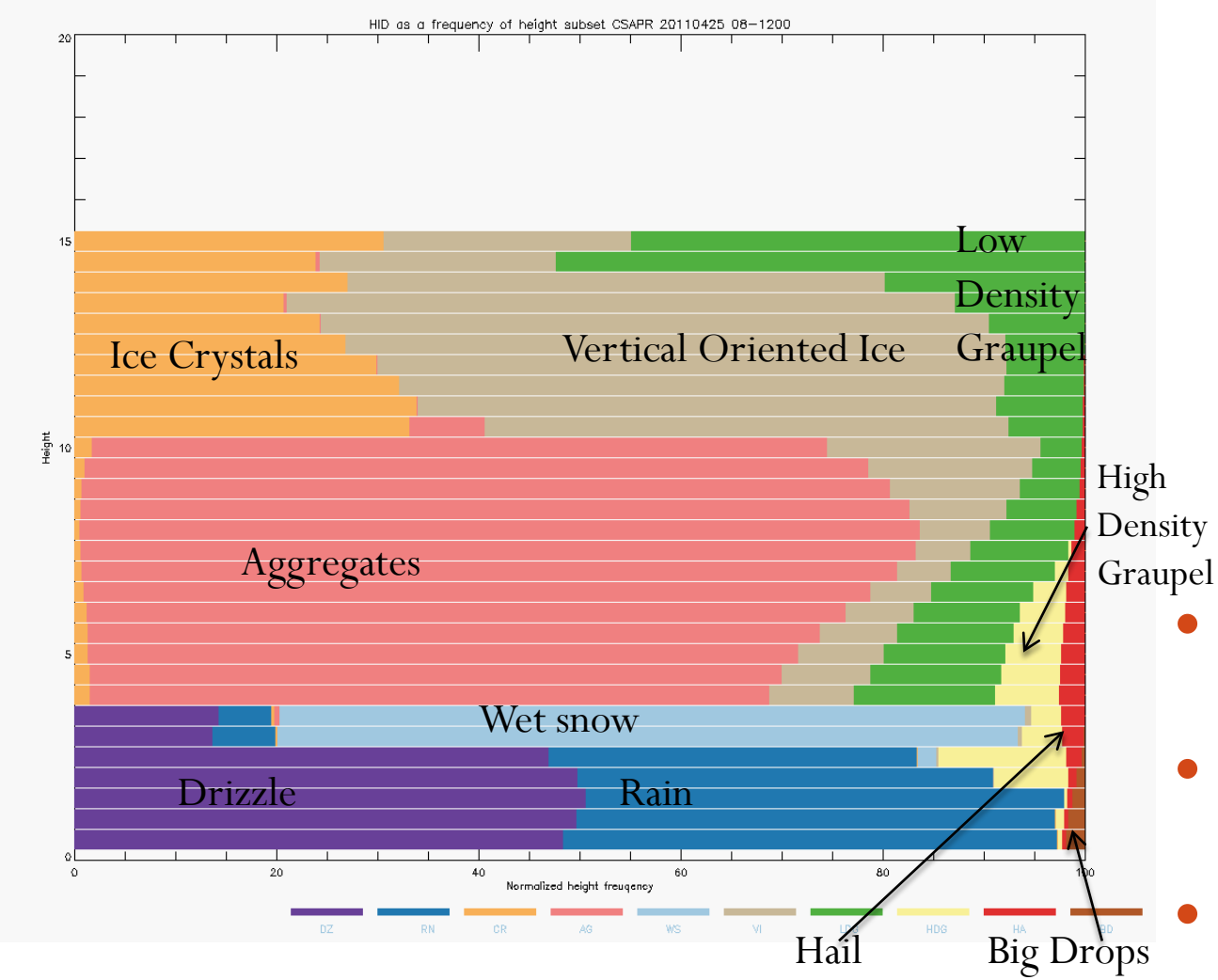






- Updrafts compare well
  - Main updraft passes around 9:15 UTC; magnitude of ~6 ms^{-1} located between 5 and 8 km
- Downdrafts more prominent in radar derived motion
  - Capturing surface divergence?
- Uncertainty in the melting layer (what is Vt?)

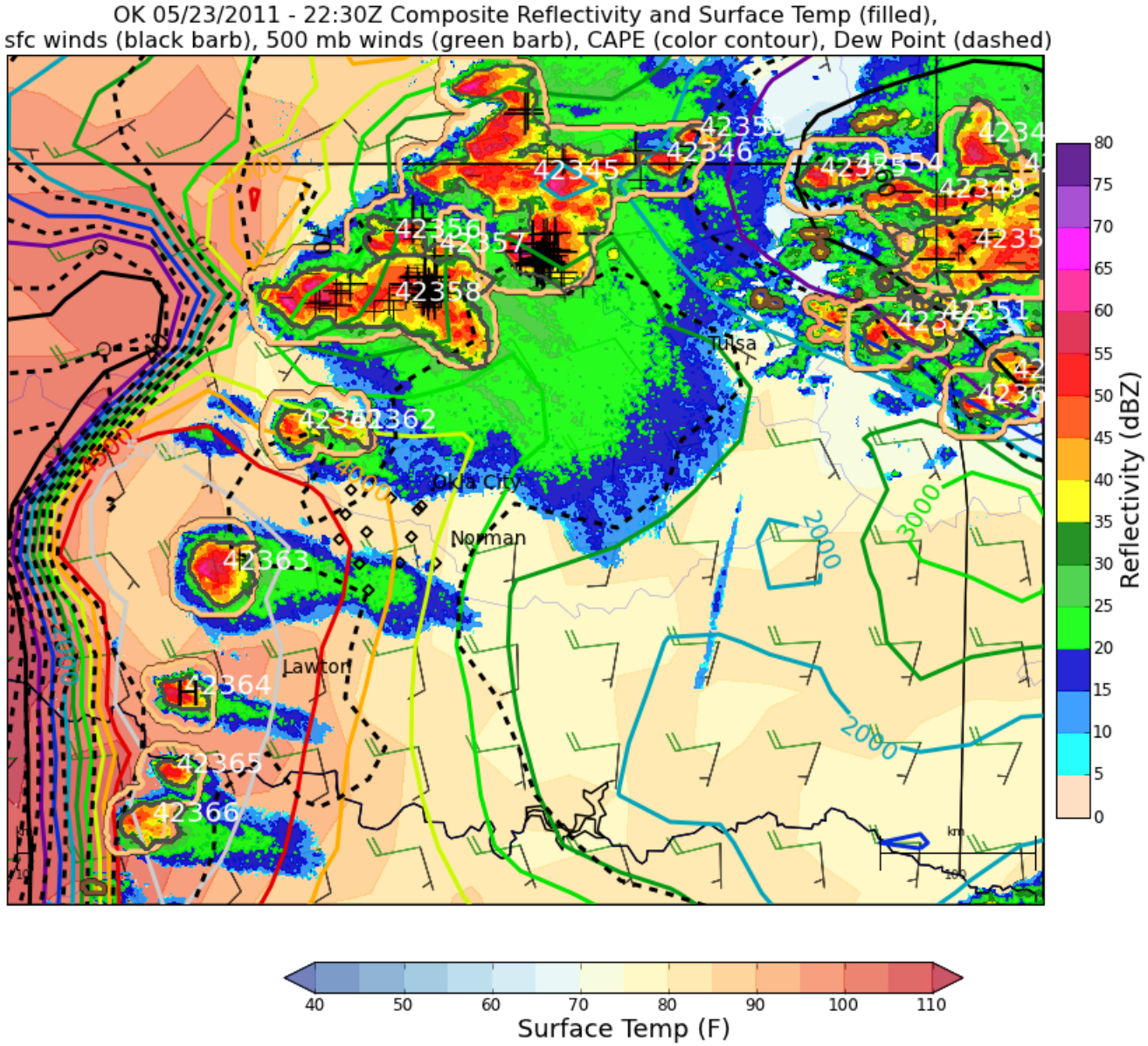
Hydrometeor Analysis 08-12



- Frequency of hydrometeor types by height

- Combine information from all available precipitation radar wavelengths (X, C, S) to form a multi-wavelength HID
  - Hopefully provides a more complete and accurate microphysical picture
- Hail peaks around 5 km, is <5% of volume
- Big drops maximize at sfc
- Distinct melting layer of wet snow

23 May 2011 Environment

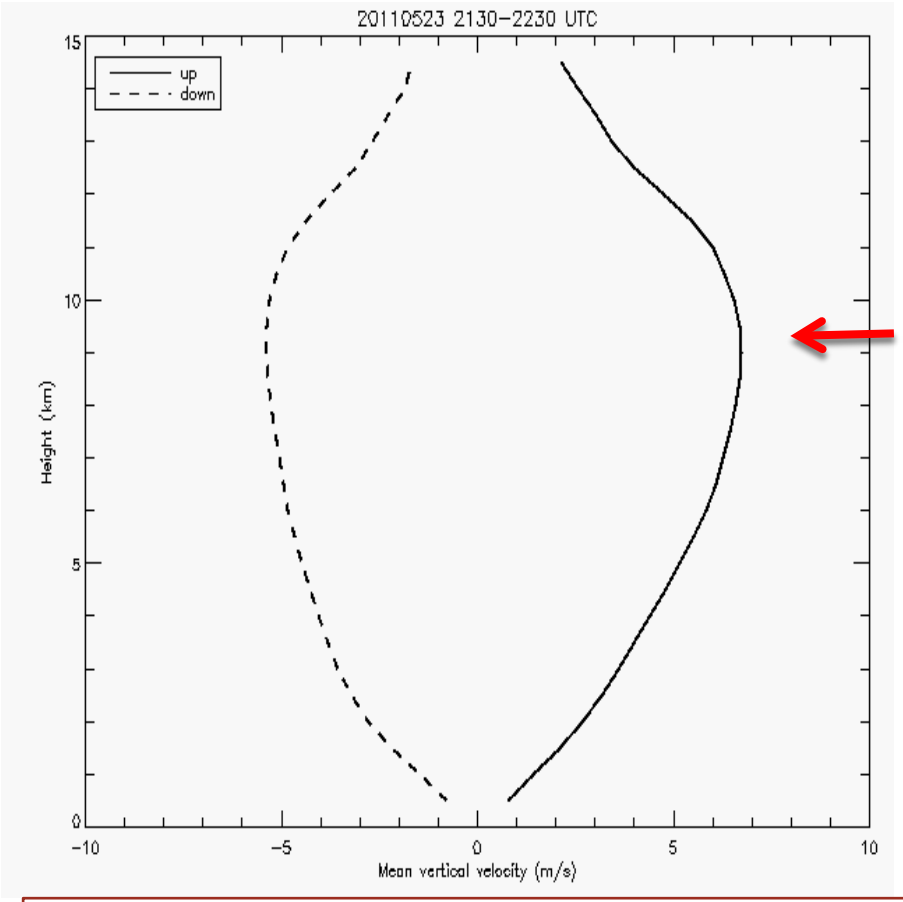


- Afternoon case ~22 Z
- Warm temps
- Dryline to the west
- Huge CAPE values
- Wind shear

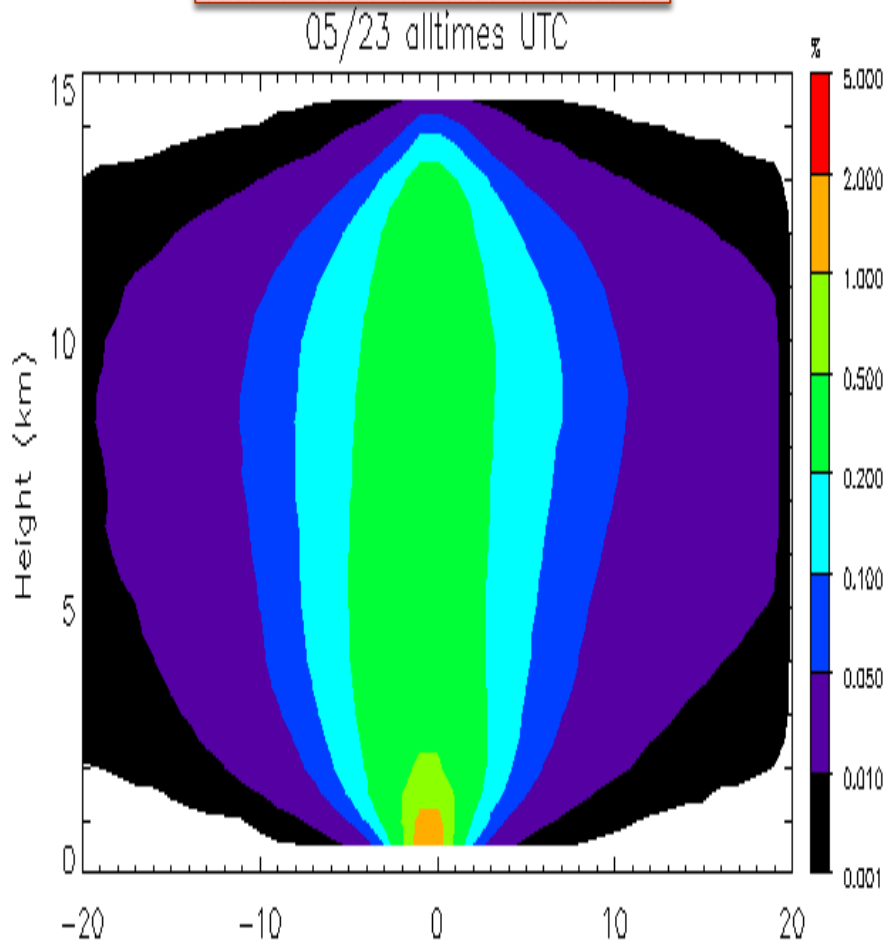
Courtesy Brody Fuchs

Vertical Velocities 2130-2230 UTC

Mean vertical motion

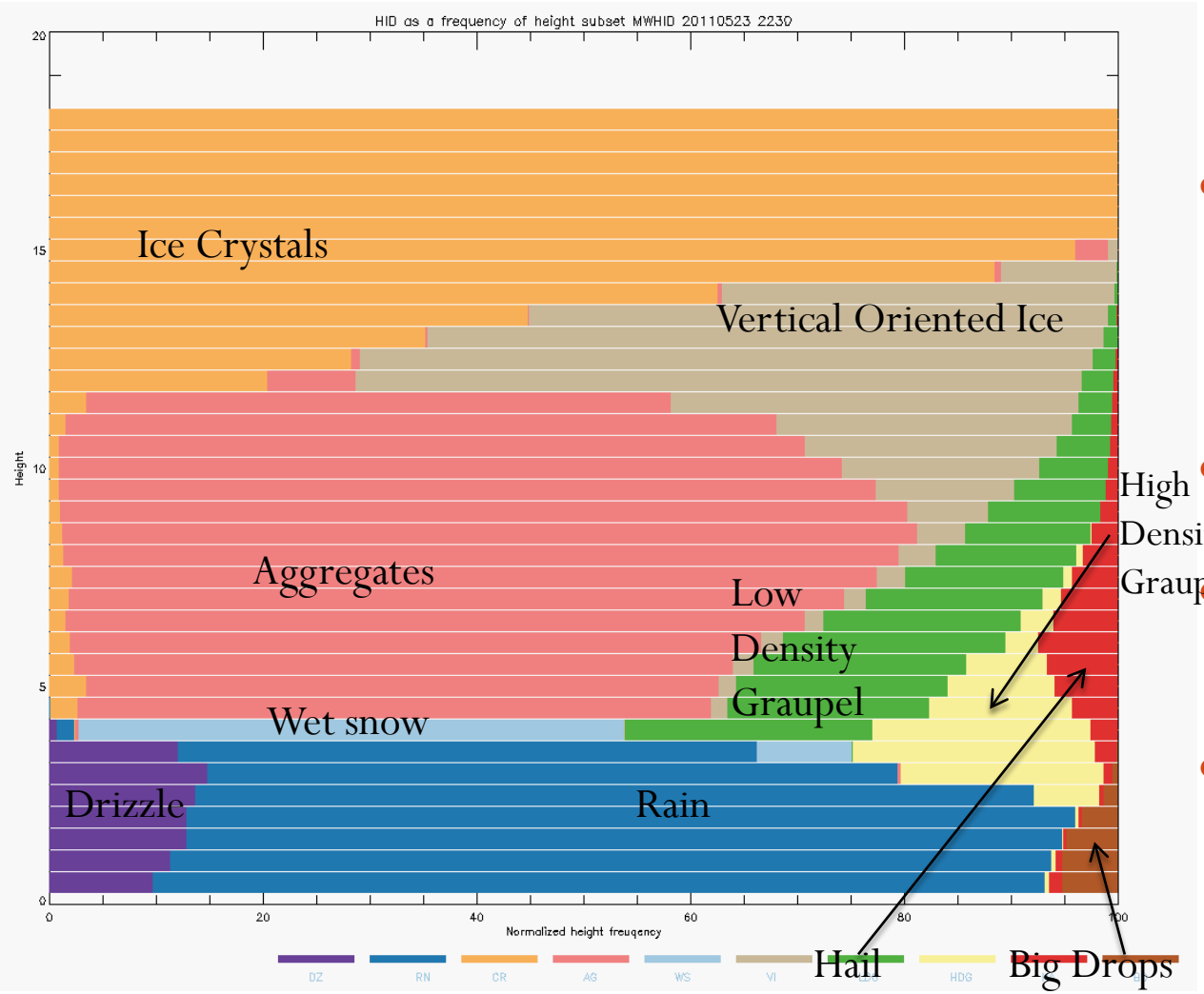


CFAD of vertical motion



- Mean upward motion again peaks around 9-10 km
- Generally stronger vertical motions compared with 25 April case
- Large span of vertical velocities from (< -20 ms^{-1} to > 20 ms^{-1})

Hydrometeor Analysis – 2230 UTC



- Frequency of hydrometeor types by height

- Here we see a peak in hail at 7 km with hail nearly 10% of the hydrometeor volume at that level
- Big drops comprising up to 5% of the volume
- Substantial amount of graupel (up to 40%) in the mid-levels
- Large region of vertical ice between 10-15 km, possibly linked to enhanced electric fields and lightning

Products

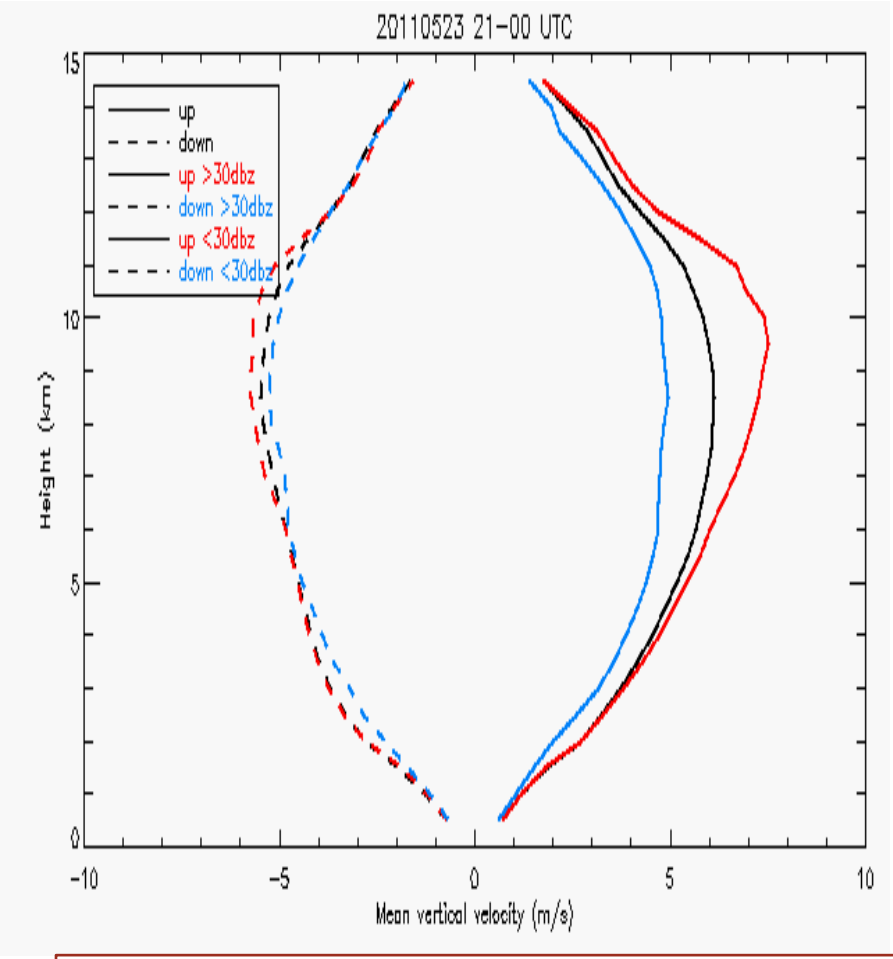
- 3D wind field
  - Statistics of up and down velocities (CFADS, convective / stratiform divisions)
  - Divergence and Convergence profiles
- HID
  - 10 categories: Drizzle, Rain, Ice Crystals, Aggregates, Vertical Ice, High density Graupel, Low-Density Graupel, Hail, Big Drops / Melting Hail, Wet Snow
  - Hydrometeor frequencies by height
  - 3D volumes of hydrometeor types at 0.5 km^3 resolution
- We are open for suggestions!

Future Work

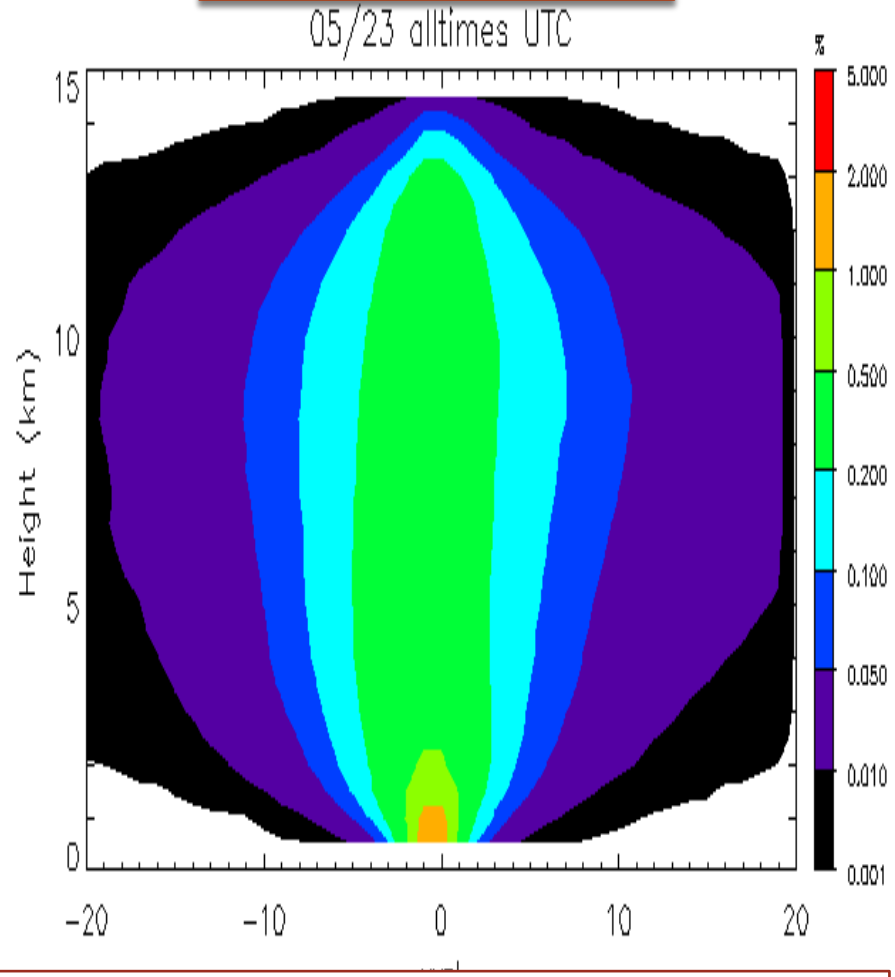
- Tie the microphysics and kinematics to lightning, environmental and aerosol observations for these two case studies
- Further comparison and estimation of uncertainties in dual-Doppler wind retrievals through comparisons with ER-2 downward looking radar and profiler 'spot-checking'
- Apply methodology to data beyond MC3E, including winter
- Validation of hydrometeor identification algorithm
  - Comparisons with 2DVDs (e.g. big drops)
  - Comparisons with aircraft data from the UND Citation
  - Radar forward models to simulate polarimetric radar observations from different situations at X, C and S-band
- Compare results from radar-based analysis with CRMs

Vertical Velocities 2130-2230 UTC

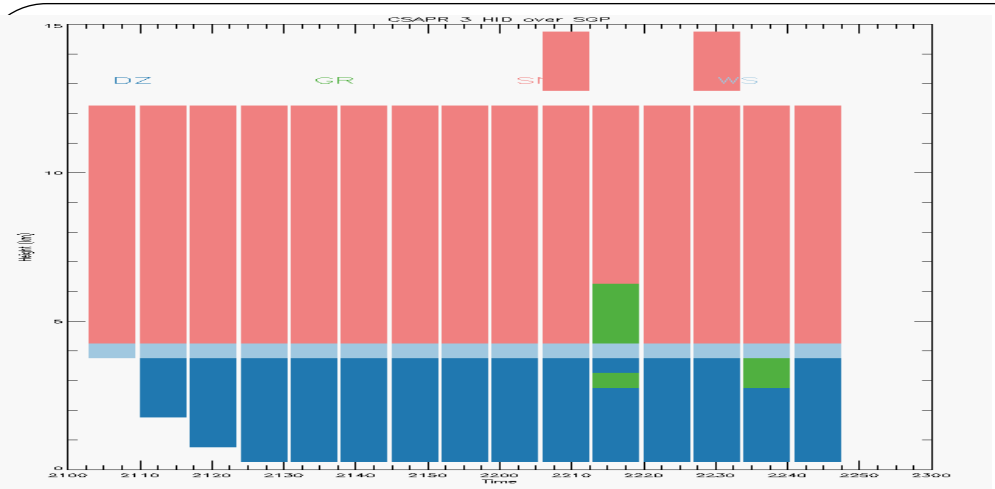
Mean vertical motion

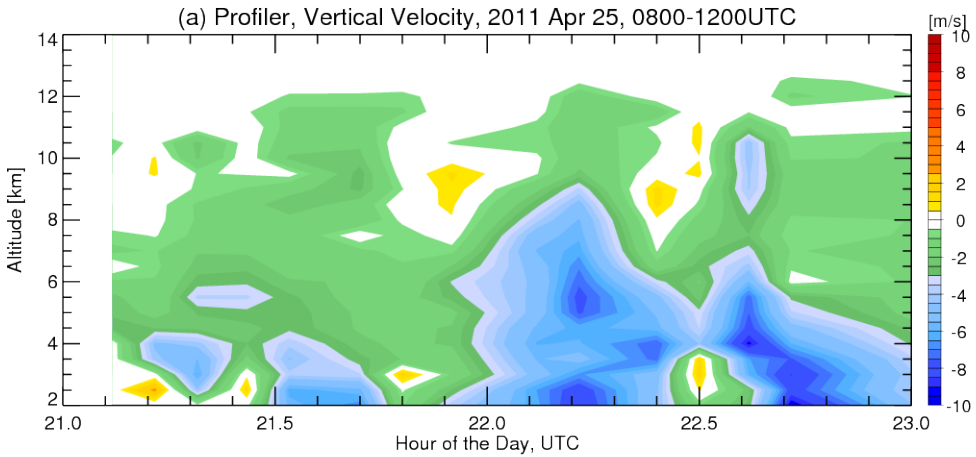


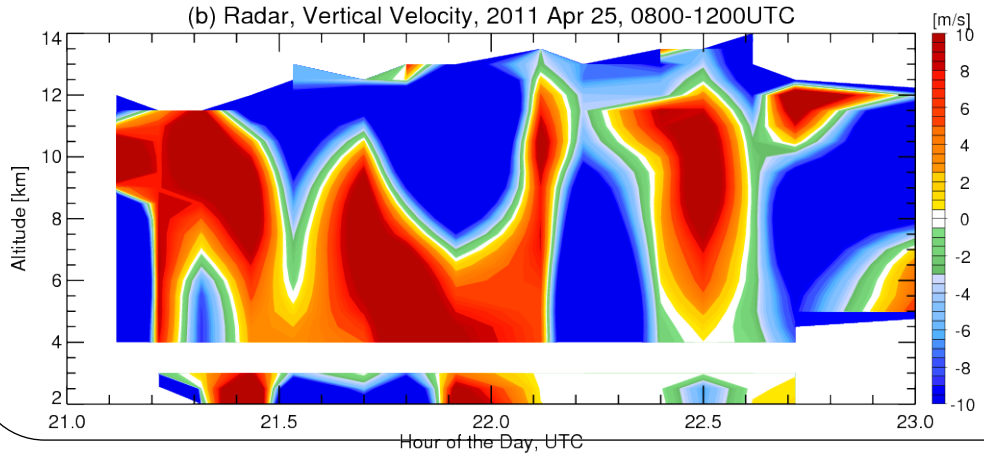
CFAD of vertical motion



- Convective updraft peaks at around 10 km
- Generally stronger vertical motions compared with 25 April case
- Large span of vertical velocities from (< -20 ms^{-1} to > 20 ms^{-1})
- Refine the partitioning


CSAPR 3 HID over SGP
DZ
GR
SN
WS
Height [km]
Time


(a) Profiler, Vertical Velocity, 2011 Apr 25, 0800-1200UTC
[m/s]
Altitude [km]
Hour of the Day, UTC


(b) Radar, Vertical Velocity, 2011 Apr 25, 0800-1200UTC
[m/s]
Altitude [km]
Hour of the Day, UTC