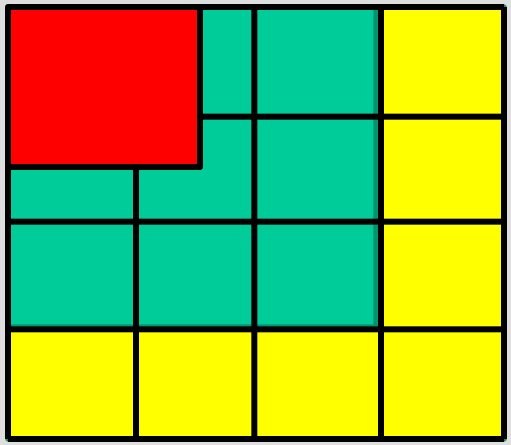
Satellite measurements of CCN: Using convective clouds as CCN chambers

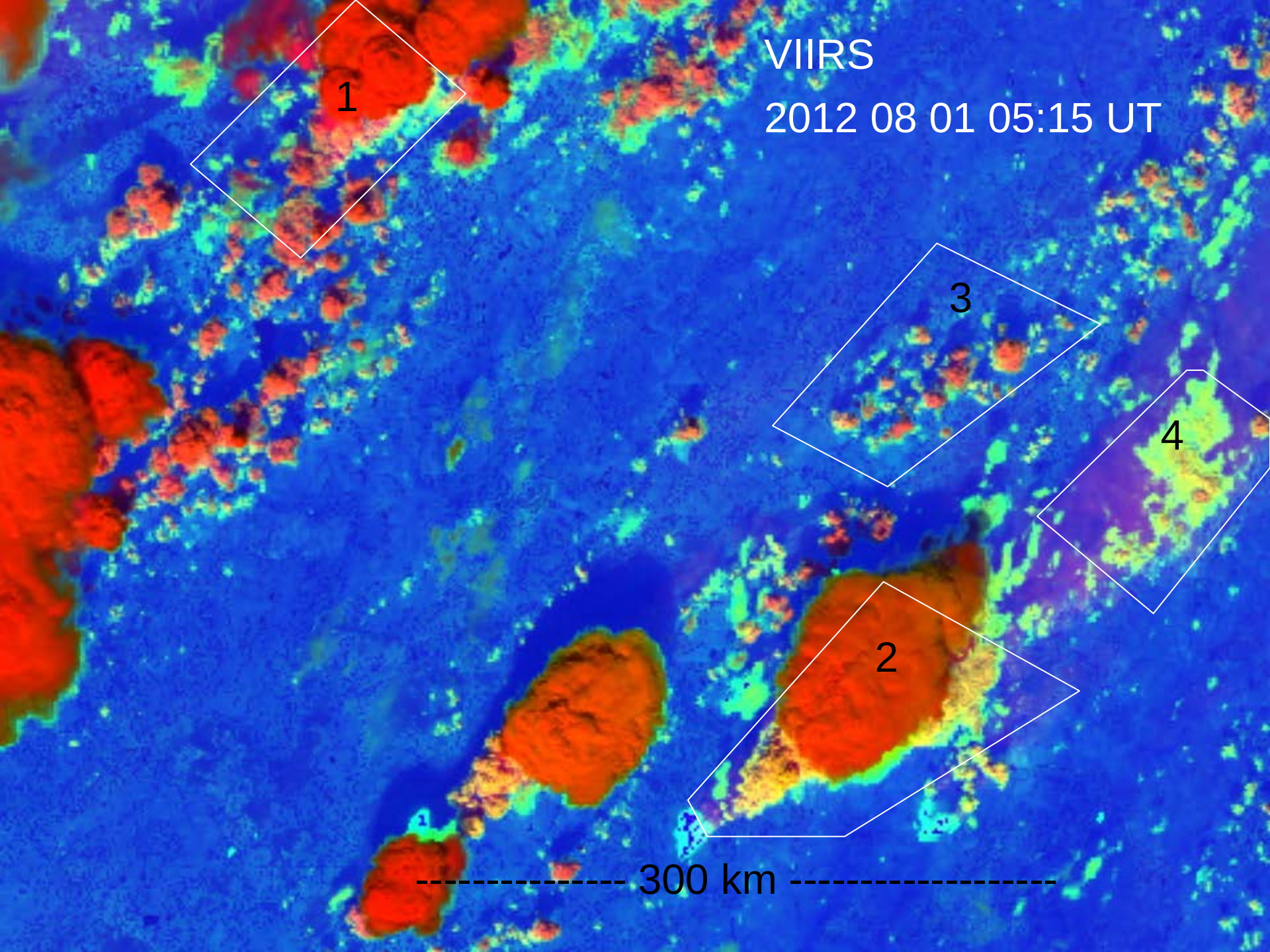
Daniel Rosenfeld, The Hebrew University of Jerusalem

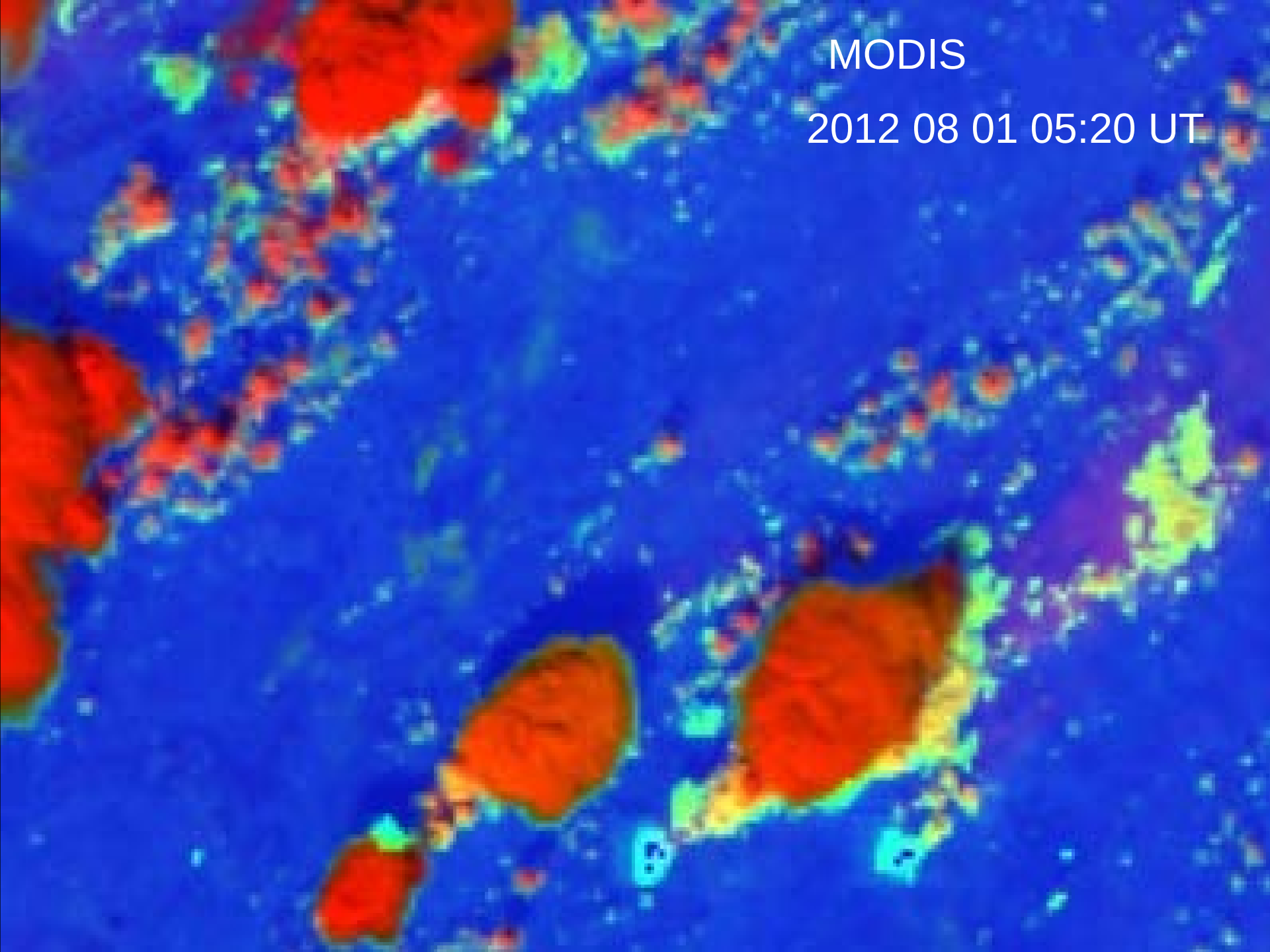
MODIS microphysical resolution: 1000 m

NPP/VIIRS products resolution: 750 m

NPP/VIIRS Imager resolution: 375 m

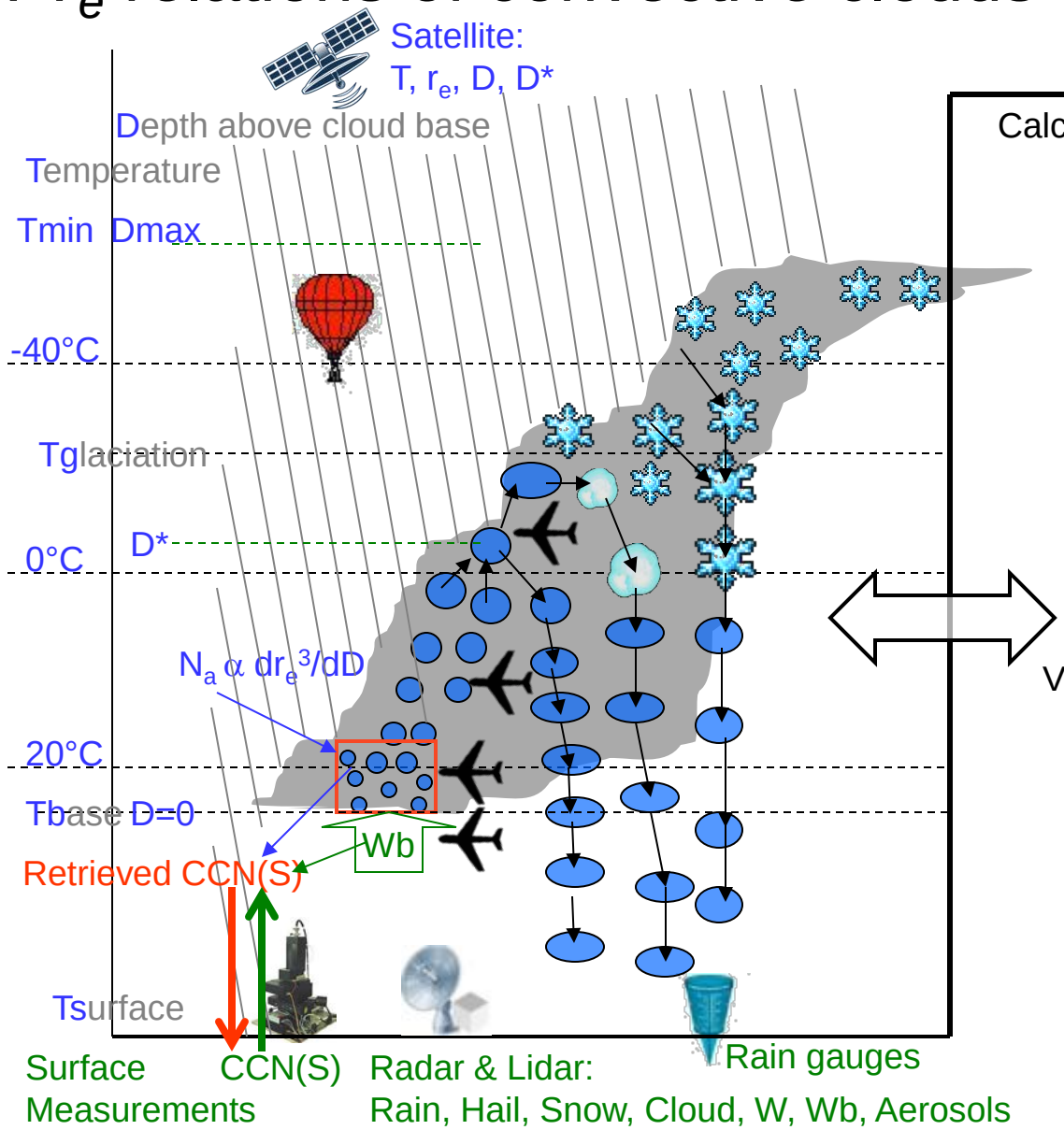



VIIRS
2012 08 01 05:15 UT
1
2
3
4
---------- 300 km ----------

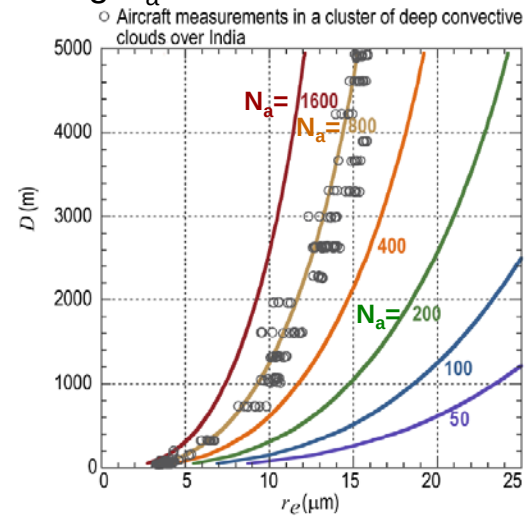

MODIS
2012 08 01 05:20 UT

Retrieving CCN from satellite-measured T-r_e relations of convective clouds

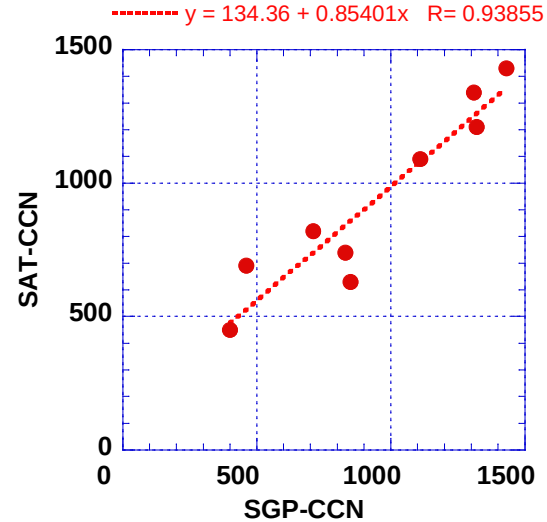
האוניברסיטה העברית בירושלים
The Hebrew University of Jerusalem
Daniel Rosenfeld

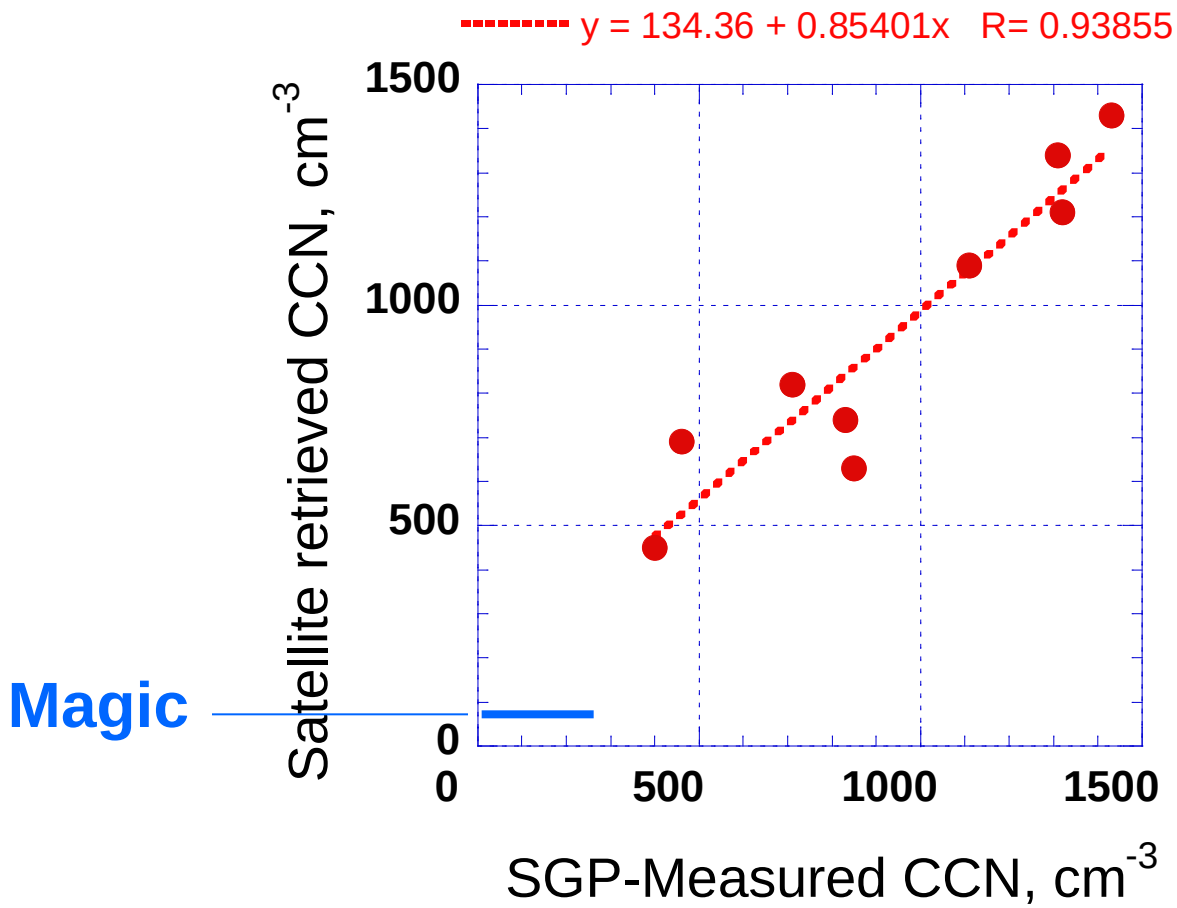


Calculating N_a from observed D- or T-r_e



Validation of the retrieved CCN over SGP



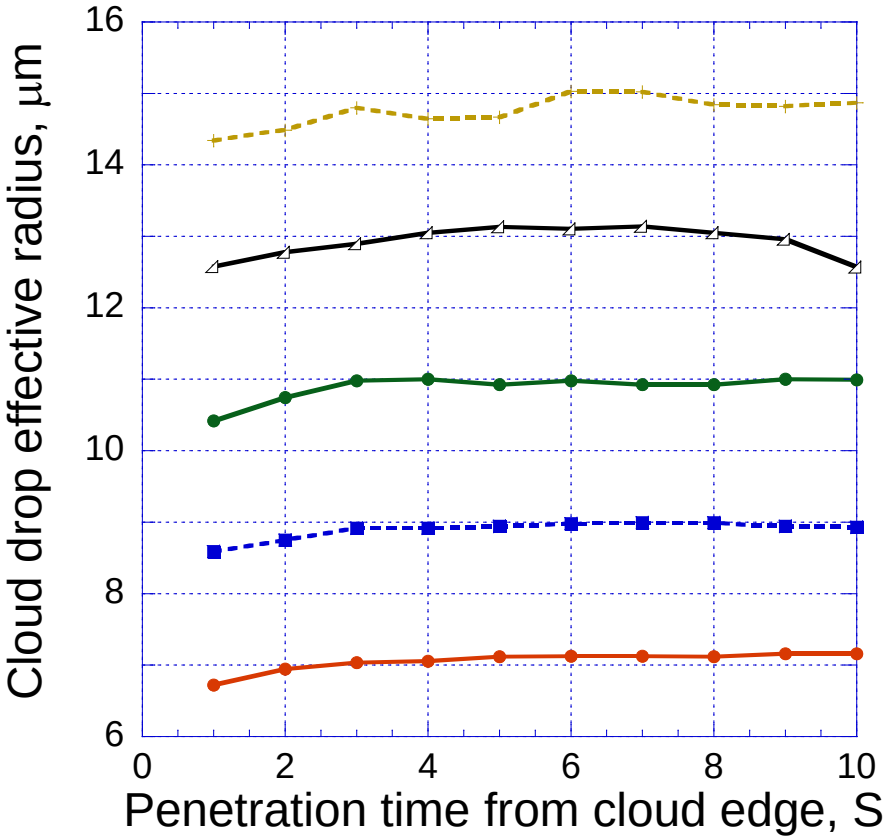


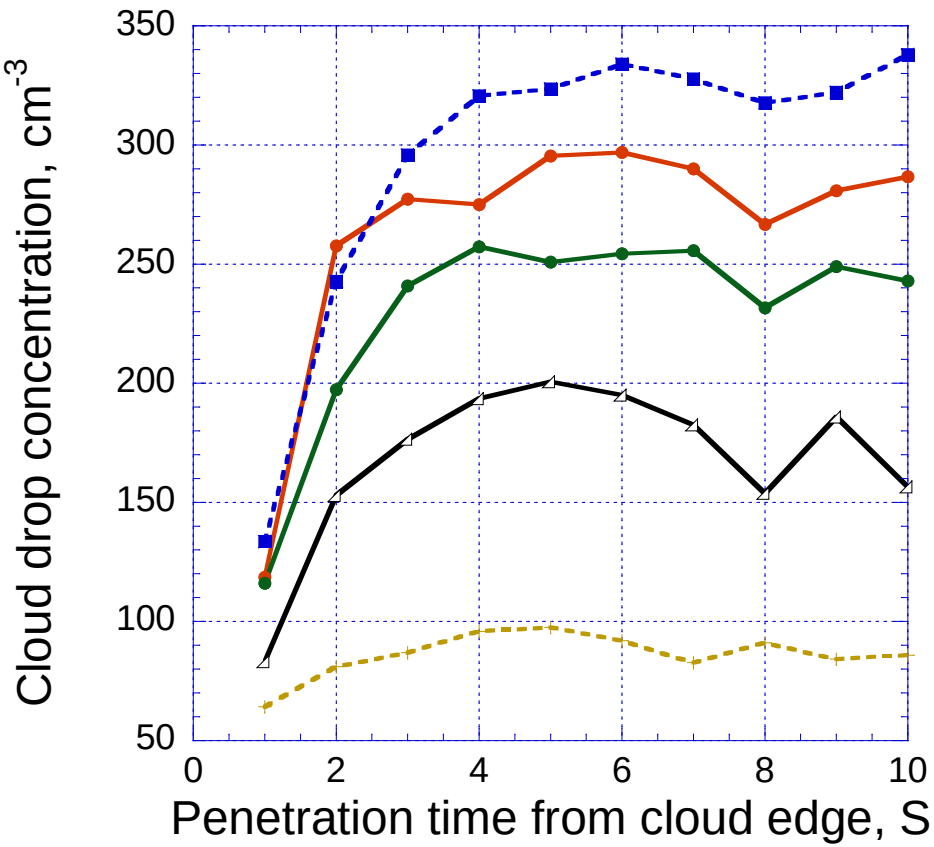
Validation of the VIIRS satellite-retrieved CCN by surface measurements at the SGP for all the available valid cases. The median r_e for a given T was used.

Why does it work so well? Checking the assumptions:

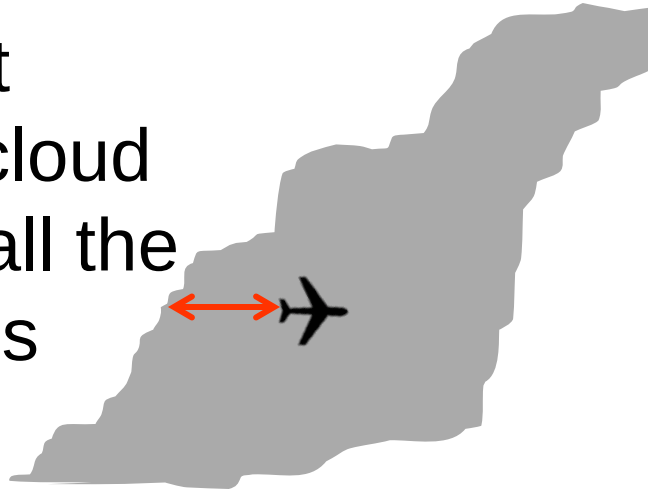
- Clouds mixing is nearly inhomogeneous →adiabatic vertical profile of r_e

- Boundary layer is well mixed and surface CCN reach the clouds in the thermals.





While cloud drop concentrations start decreasing 300 m from cloud edge, cloud drop effective radius remains stable all the way to the cloud edge, and decreases < 0.5 μm < 200 m from cloud edge.



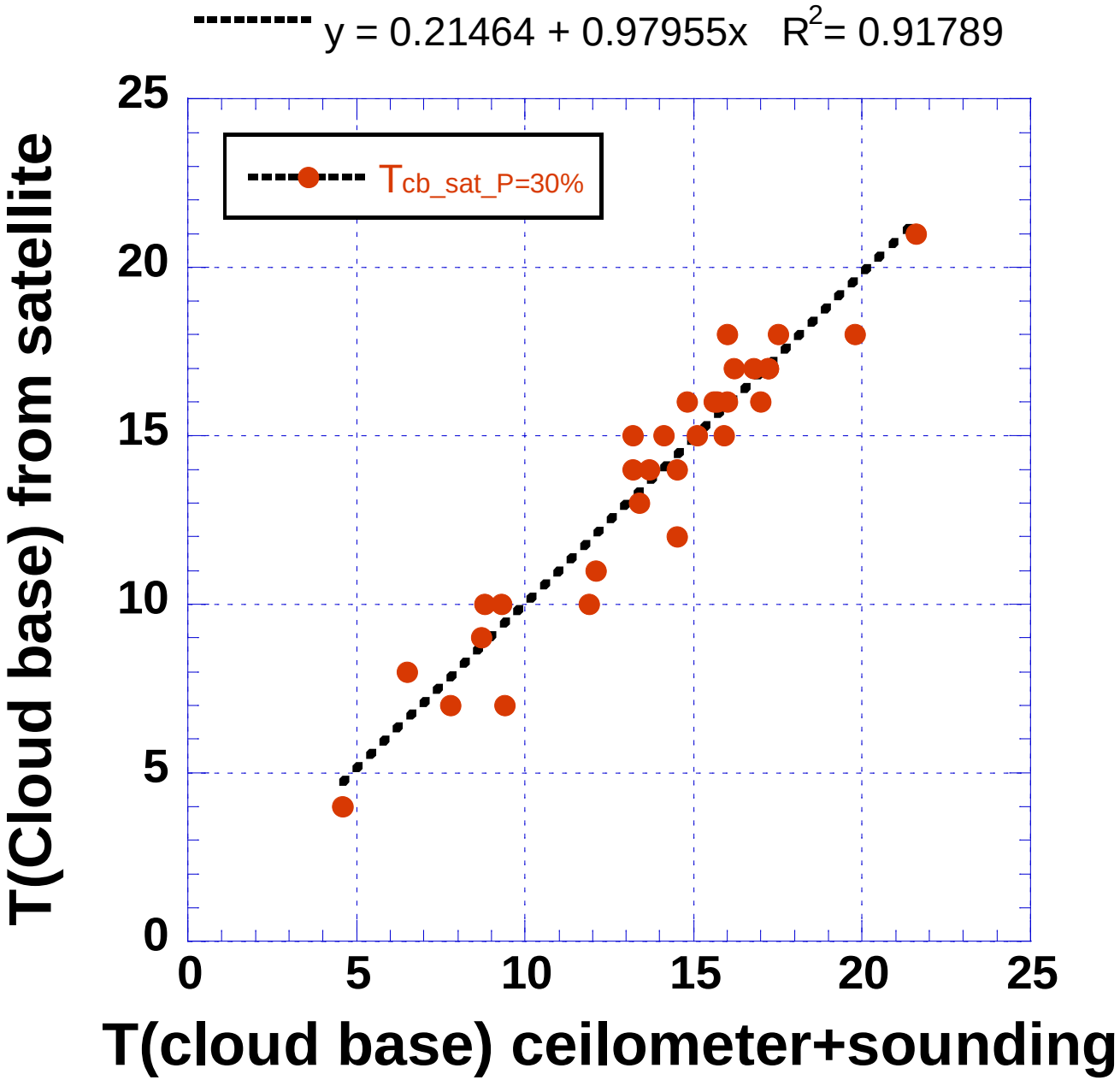
What else is needed for satellite retrievals of CCN?

- Cloud base height and temperature can be retrieved accurately from space (VIIRS)

- Cloud base updraft can be estimated from satellite measurements

Retrieving cloud base T and H

- Cloud base T (Tbase) is defined as the warmest cloudy pixel.
- Atmospheric correction due to vapor has to be applied using split window technique.
- Tbase is by definition a cloud edge from satellite point of view. There is a thermal contamination when large temperature difference exists between Tsurface and Tbase.
- This is corrected based on filtering pixels with local large variance of T.
- The T variability correction can reach 10°C over hot desert, but reduces to zero in low clouds over ocean.


y = 0.21464 + 0.97955x R2= 0.91789
Tcb_sat_P=30%
T(Cloud base) from satellite
T(cloud base) ceilometer+sounding
0
5
10
15
20
25

Implications of satellite Tbase capability

- A necessary step for retrieving CCN from space by using clouds as CCN chambers
- Retrieving boundary layer vapor mixing ratio, where satellite sounding retrievals are least accurate.
- Retrieving boundary layer height.
- The assimilation of such data in NWP can have very large impacts, especially for precipitation and severe convective storms.

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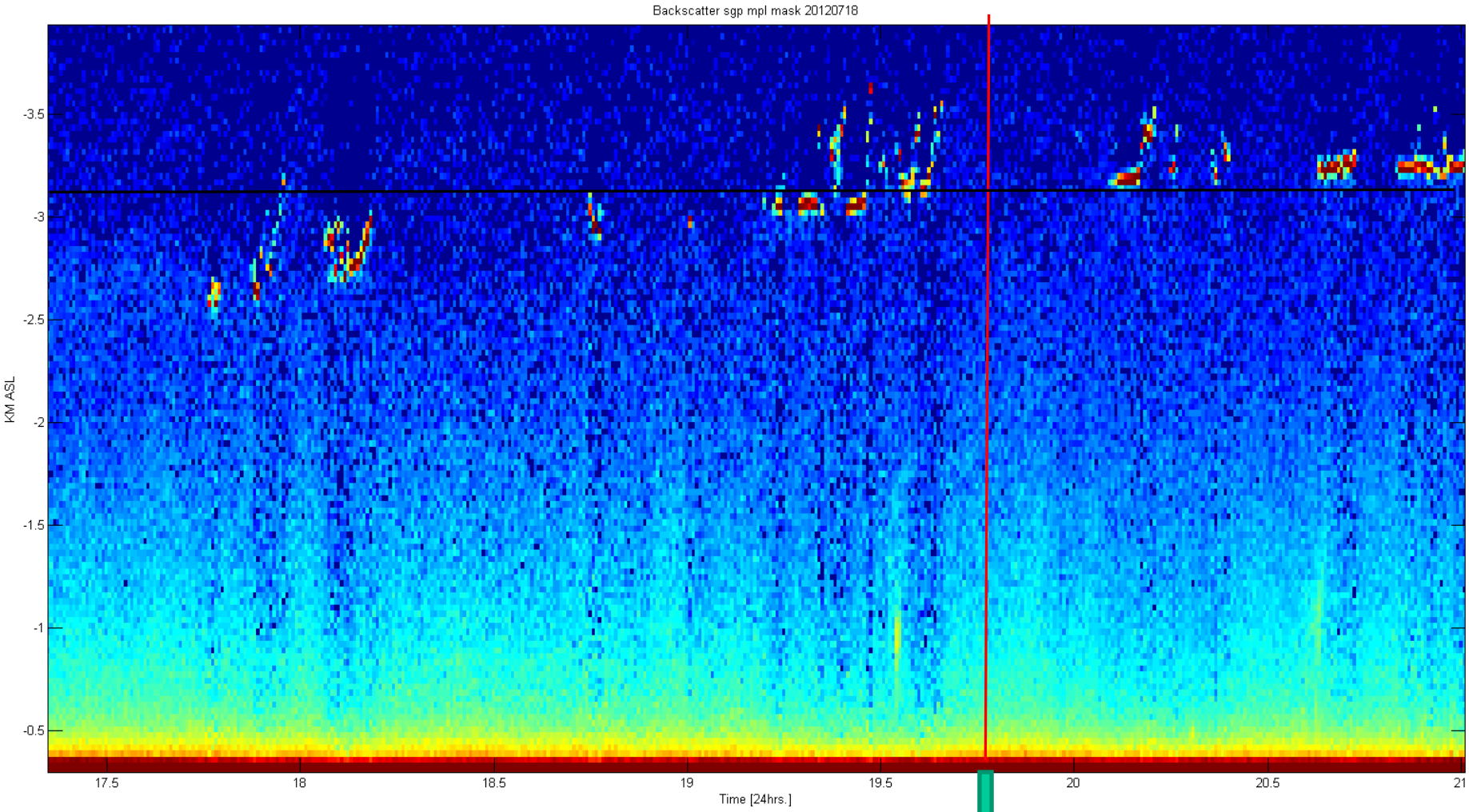
Updraft α (Skin – Air surface temperature)$^{0.5}$

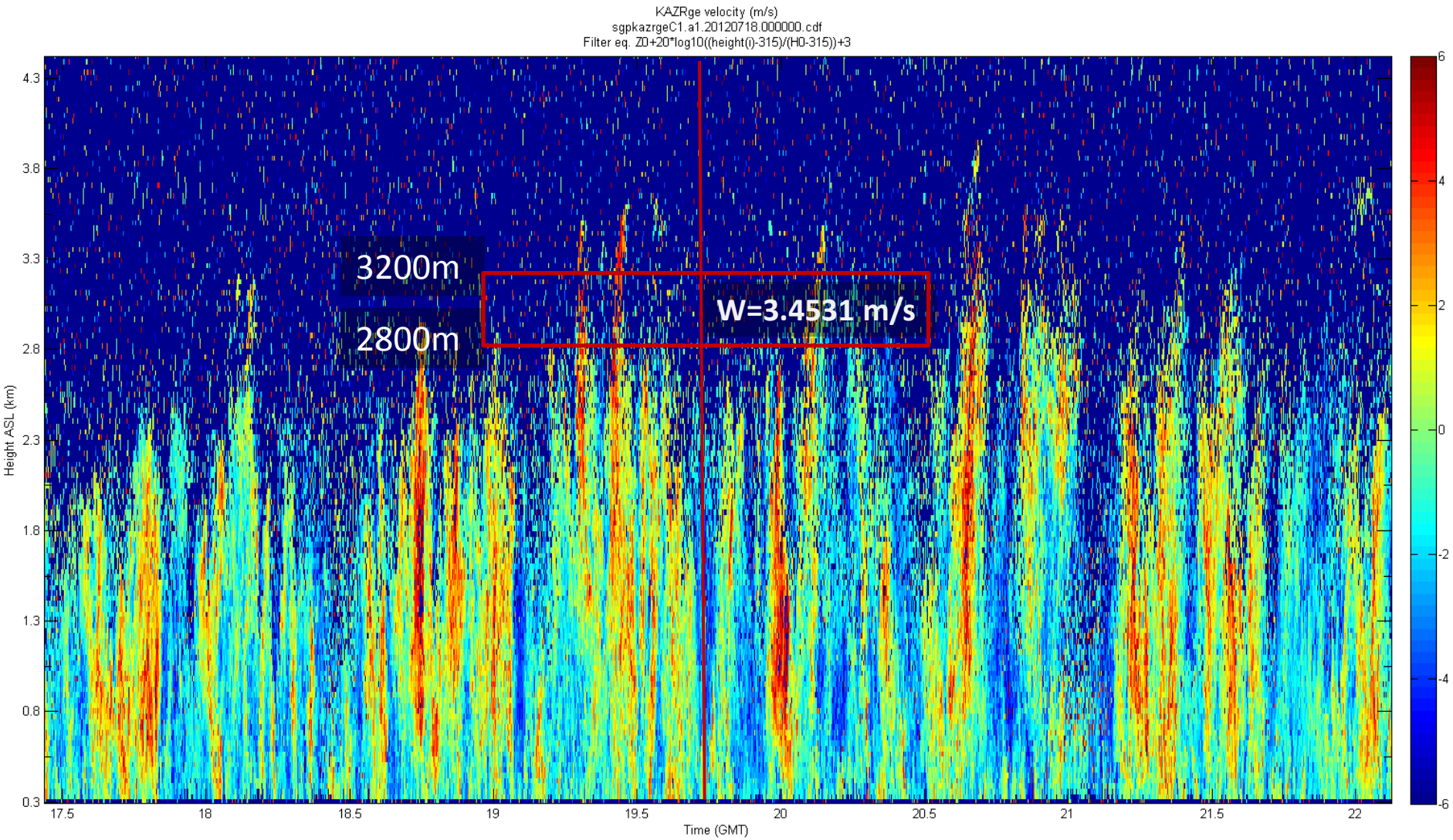


July 18 2012
NPP-VIIRS 19:45 UTC

MPL cloud base height: ~3.1KM

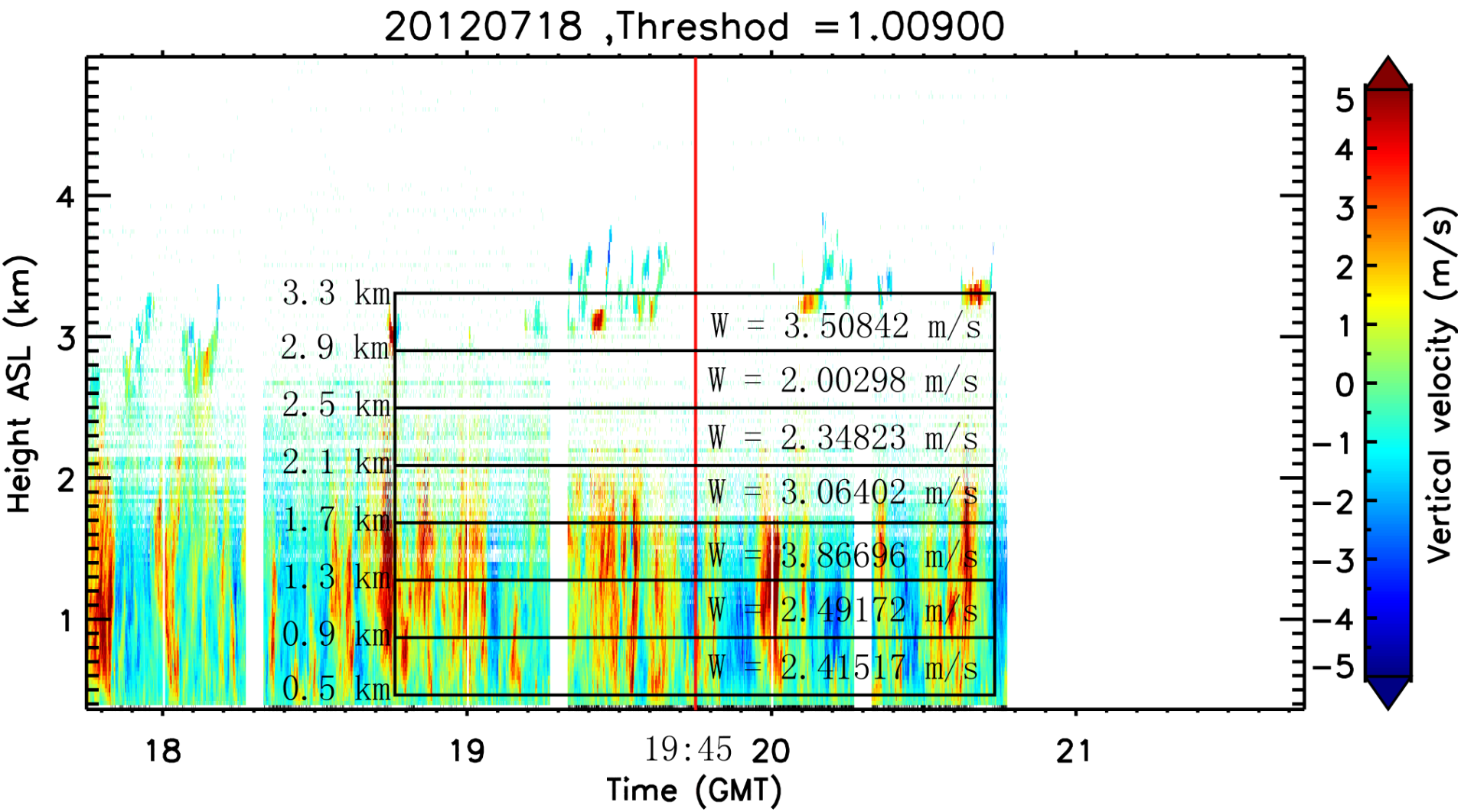
Filter eq. +3dBZ

Radar

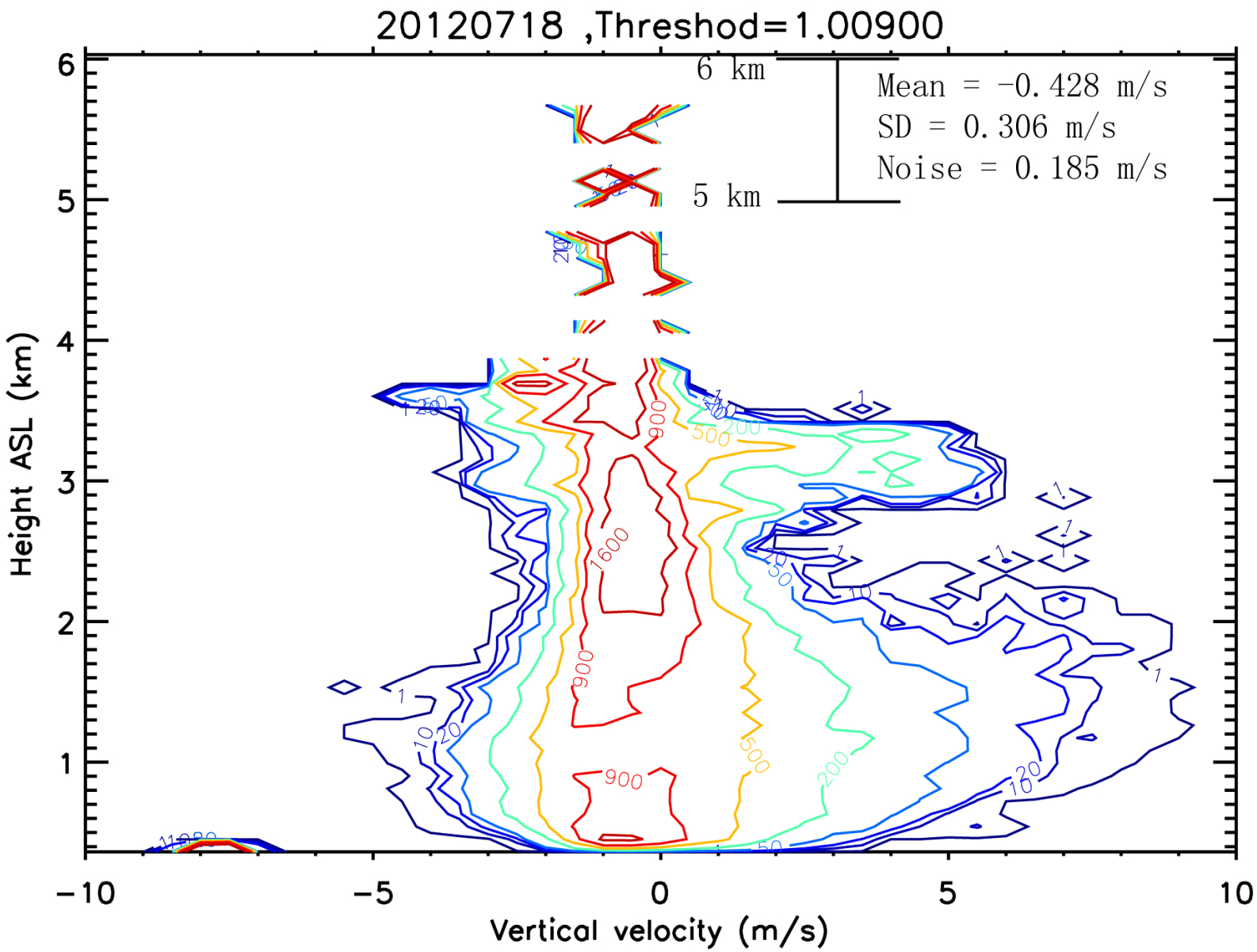


Radar Nyquist interval = 6 ms^{-2}

Lidar



Lidar Nyquist interval = 19 ms^{-2}


20120718 ,Threshod=1.00900
Mean = -0.428 m/s
SD = 0.306 m/s
Noise = 0.185 m/s
6 km
5 km
Height ASL (km)
Vertical velocity (m/s)
-10
-5
0
5
10
1
2
3
4
5
6

Can cloud base updraft be estimated from satellite measurements?

Updraft α (Skin – Air surface temperature)$^{0.5}$

- Skin temperature can be measured by satellite
- Air temperature can be calculated when knowing cloud base height and temperature in a well mixed boundary layer.

Testing this over the SGP is our next major challenge

Satellite measurements of CCN: Using convective clouds as CCN chambers

- Satellite retrieval of Na is shown feasible
- Satellite retrieval of Tbase shown possible
- Combining with radar measured updraft gave CCN in agreement with measurements
- The remaining challenge is satellite estimates of cloud base updrafts, which is now work in progress.