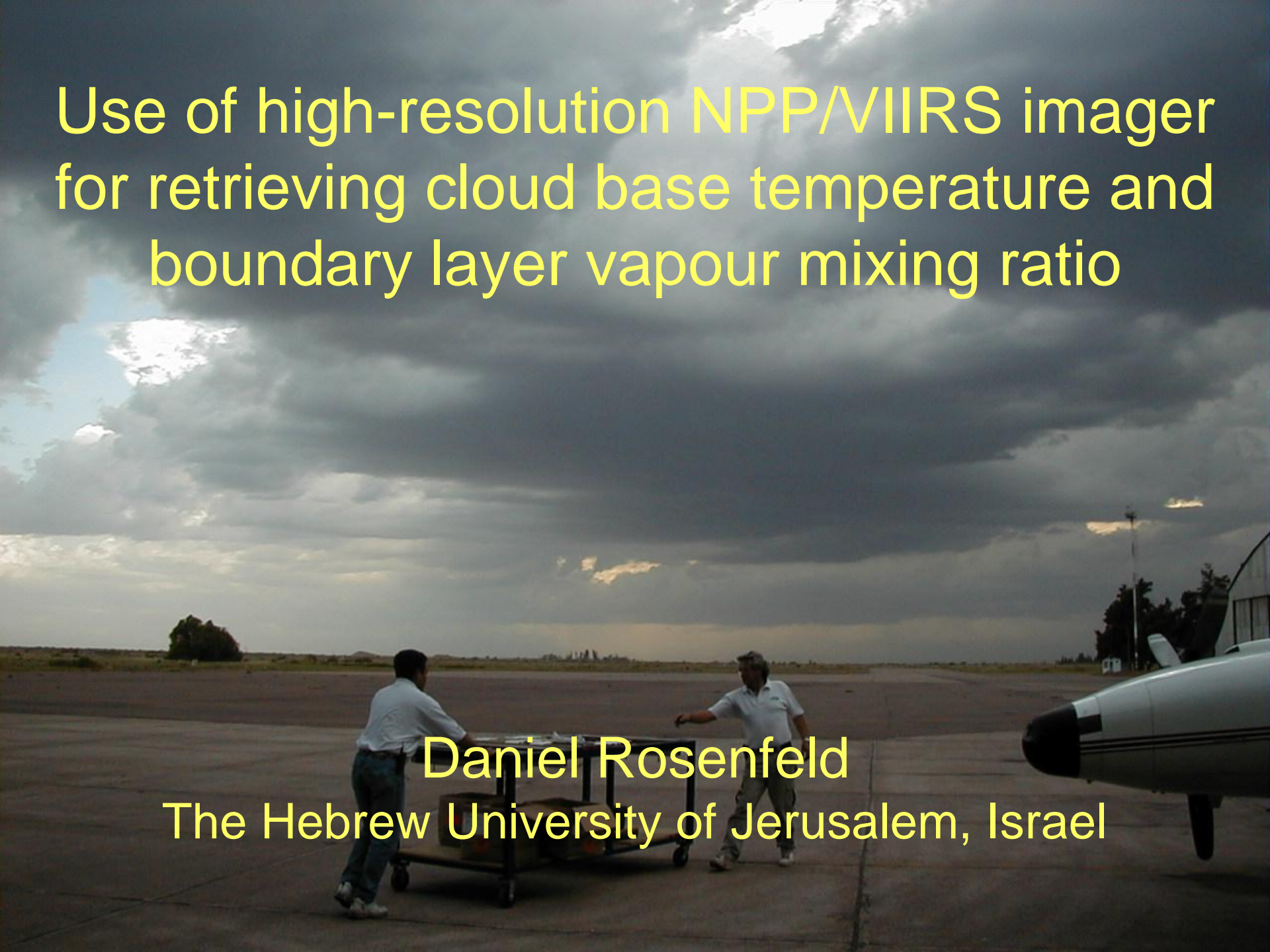
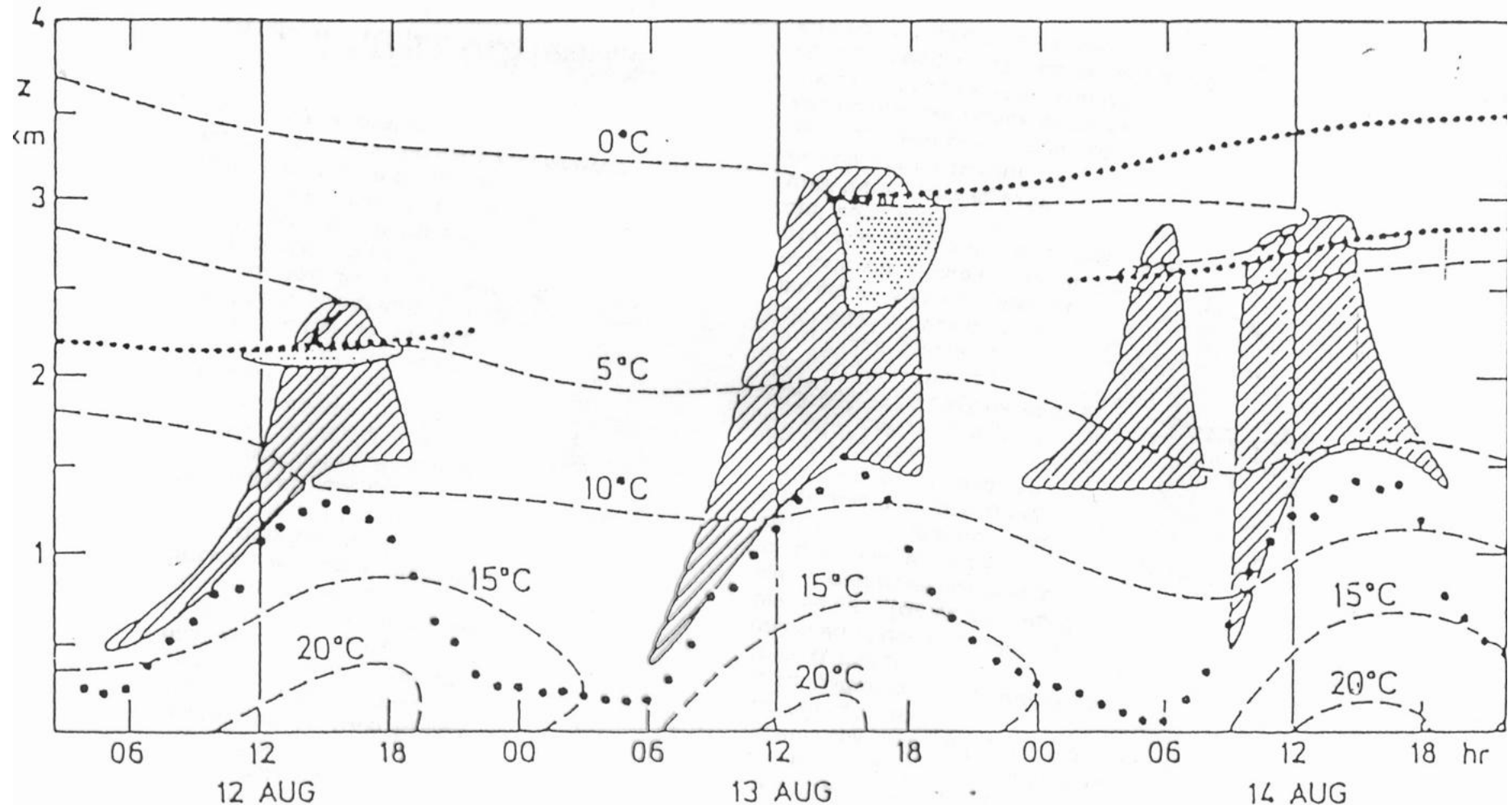


Use of high-resolution NPP/VIIRS imager
for retrieving cloud base temperature and
boundary layer vapour mixing ratio

Daniel Rosenfeld
The Hebrew University of Jerusalem, Israel



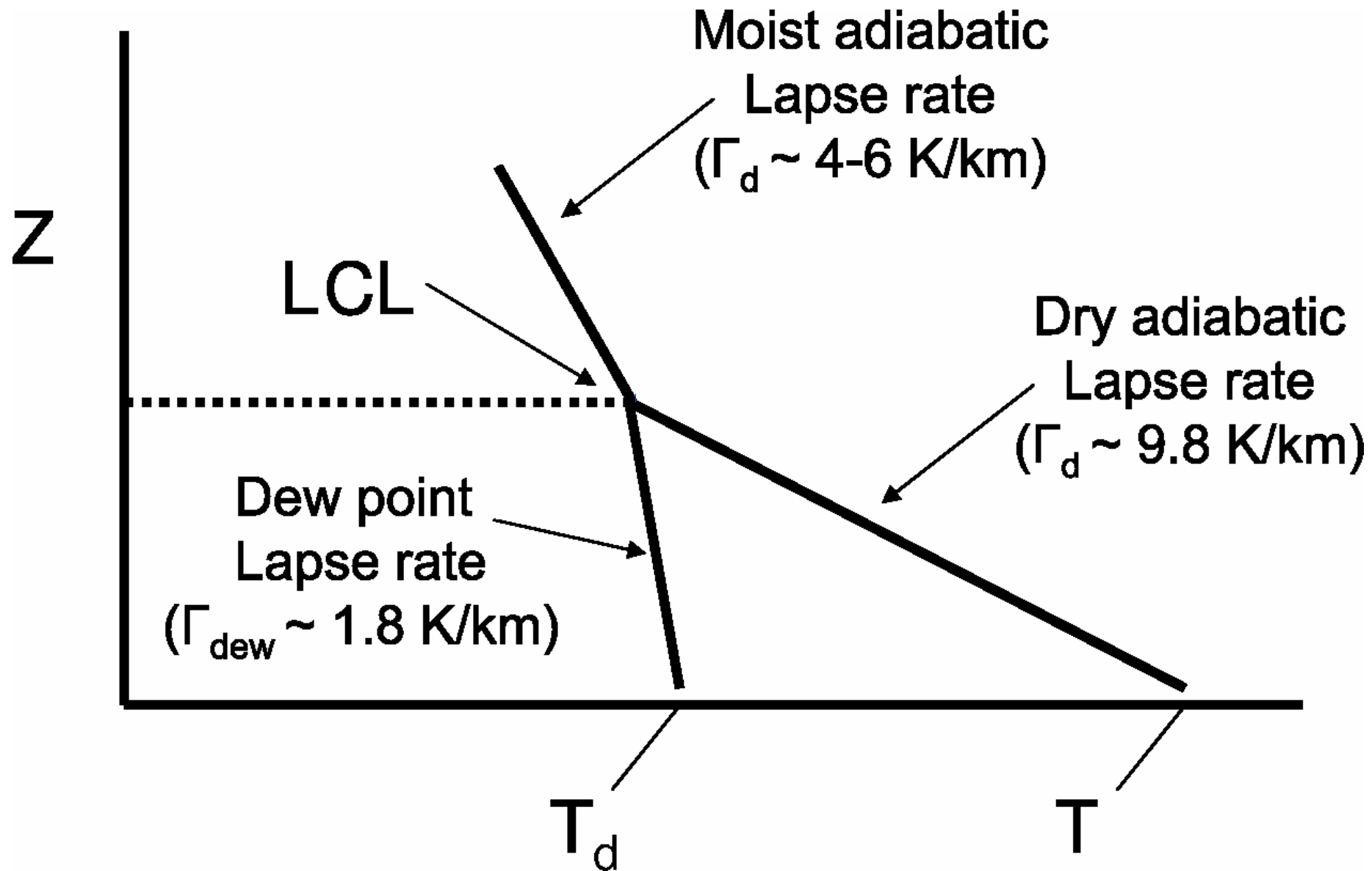
Why is retrieving Tbase important?



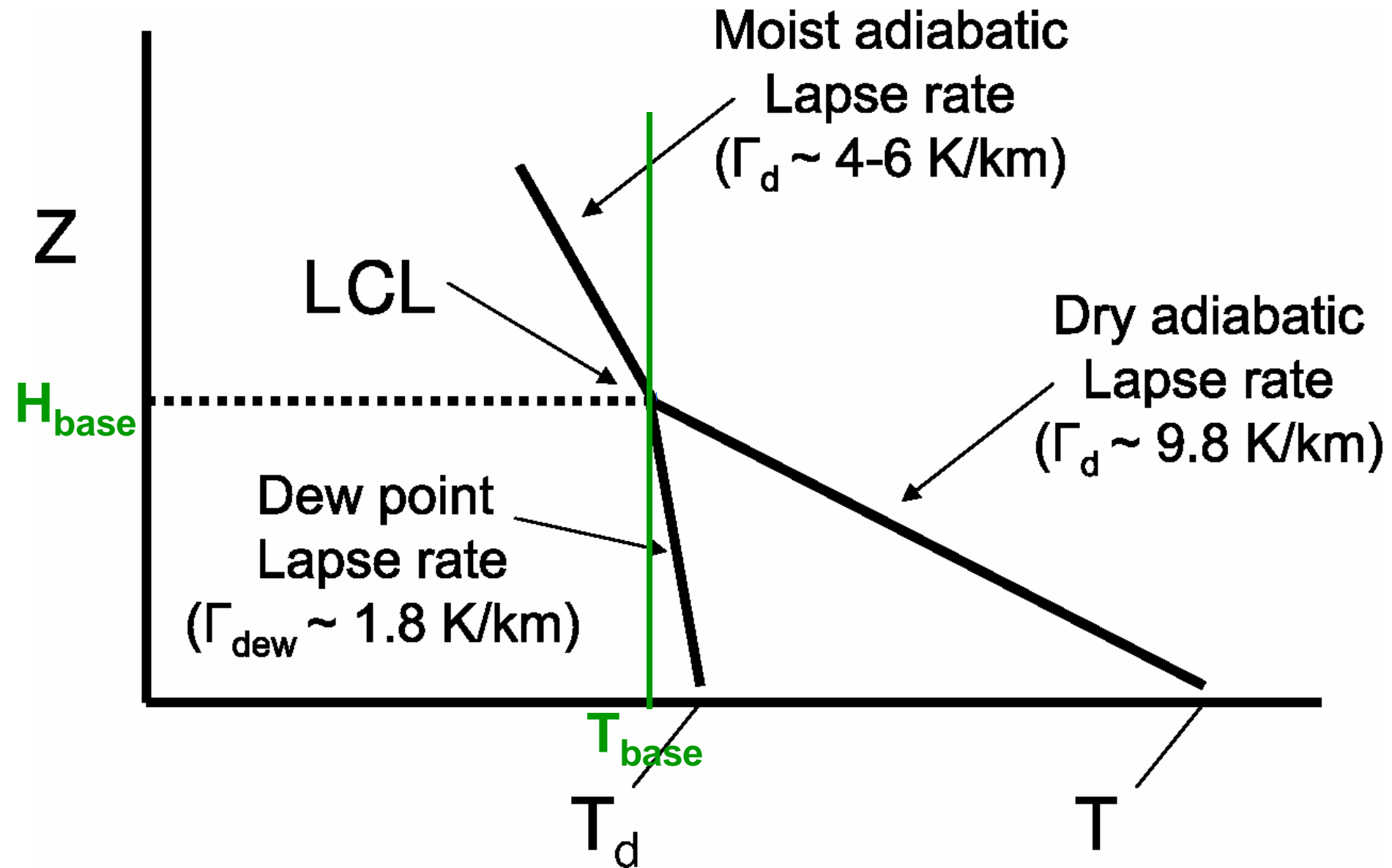
Tbase+NWP gridded data → H & P

From "The Physics of clouds". B.J.Mason

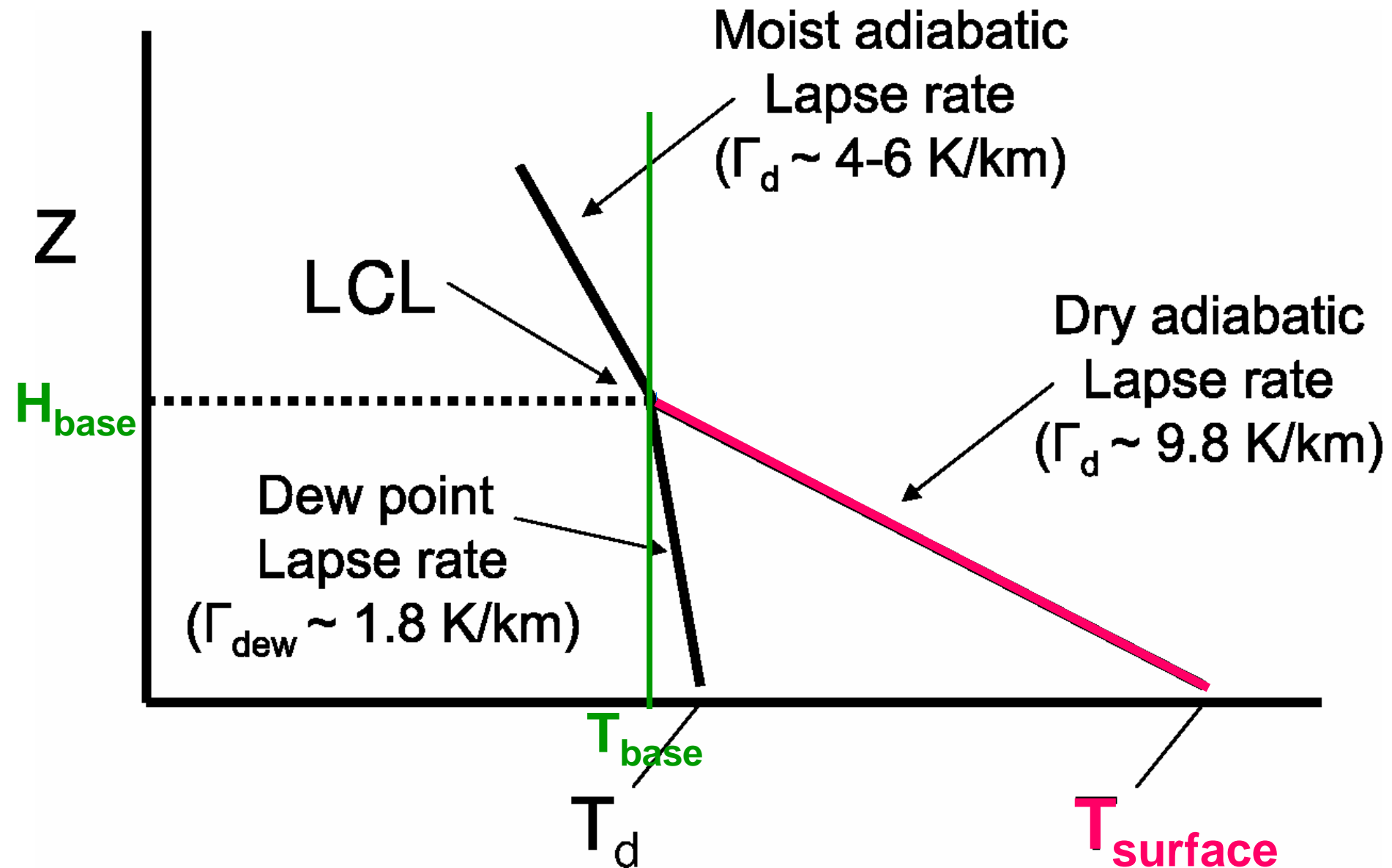
What else can we get from T, H, P base?



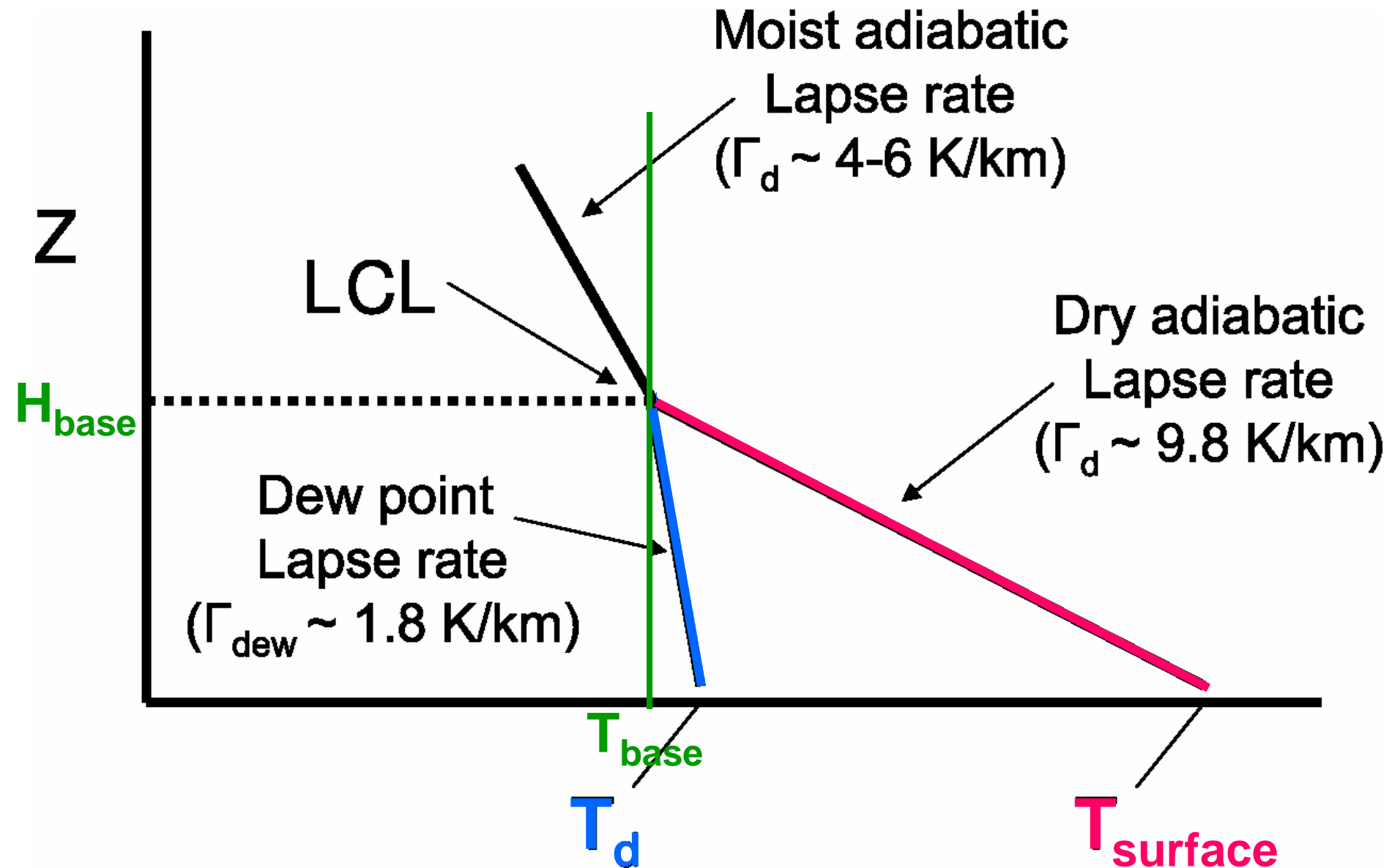
What else can we get from T, H, P base?



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What else can we get from T, H, P base?

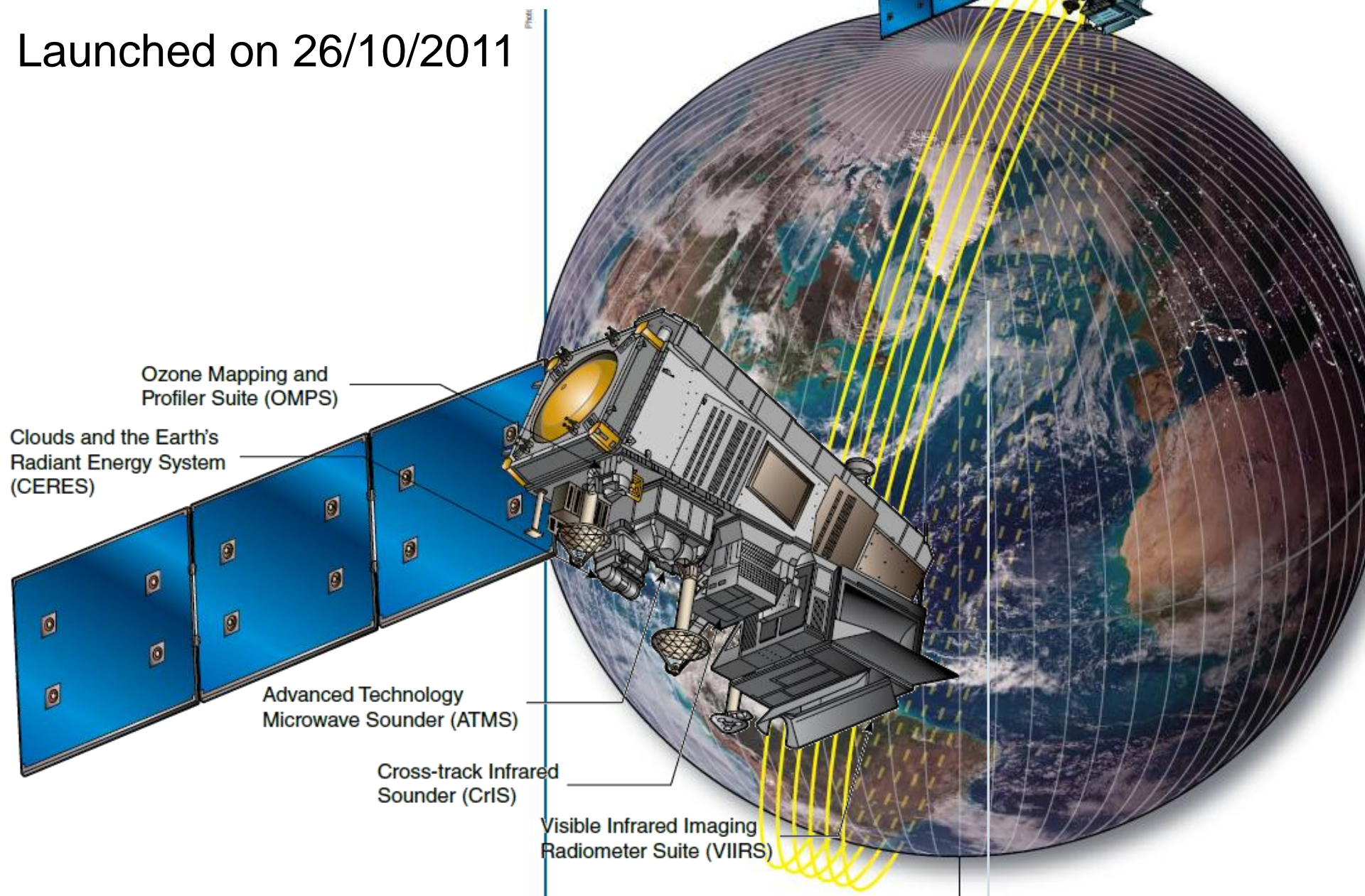


Why do we want to know Tbase?

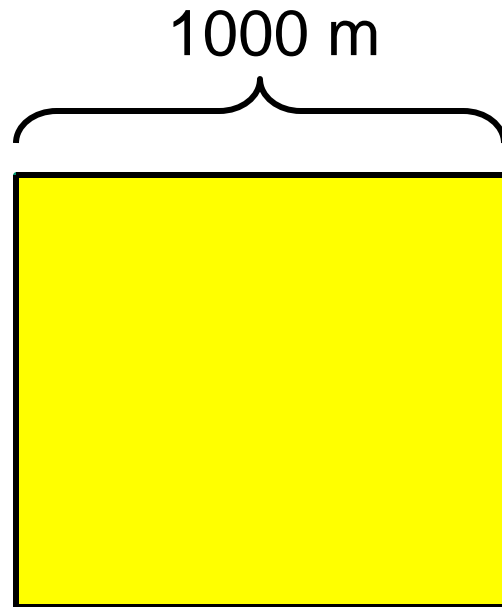
- Tbase + temperature sounding → Pbase & Hbase →
- PBL vapor mixing ratio
- Surface temperature
- CAPE
- Potential cloud water and precipitation

NPP: Building a Bridge to a New Era of Earth Observations

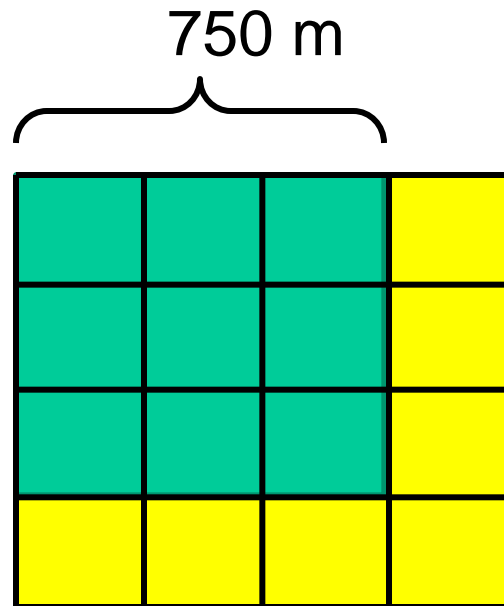
Launched on 26/10/2011



MODIS microphysical resolution: 1000 m



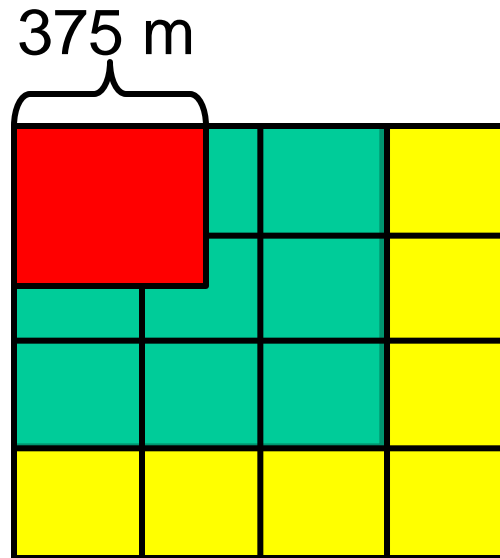
MODIS microphysical resolution: 1000 m
NPP/VIIRS products resolution: 750 m



MODIS microphysical resolution: 1000 m

NPP/VIIRS products resolution: 750 m

NPP/VIIRS Imager resolution: 375 m

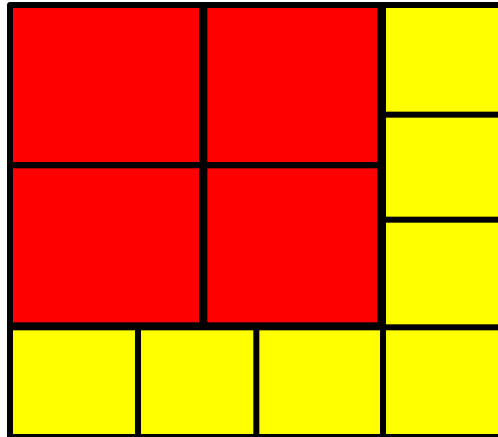


MODIS microphysical resolution: 1000 m

NPP/VIIRS products resolution: 750 m

NPP/VIIRS Imager resolution: 375 m

4 imager pixels in one moderate res. pixel

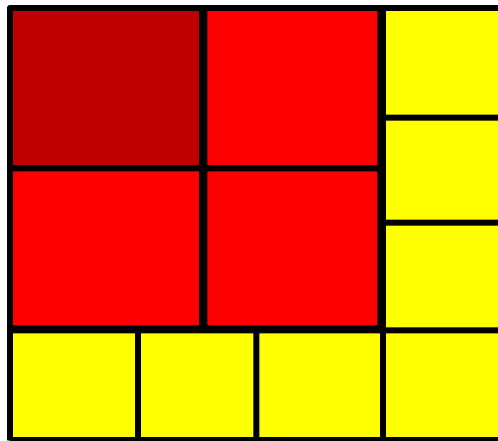


MODIS microphysical resolution: 1000 m

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NPP/VIIRS Imager resolution: 375 m

4 imager pixels in one moderate res. pixel

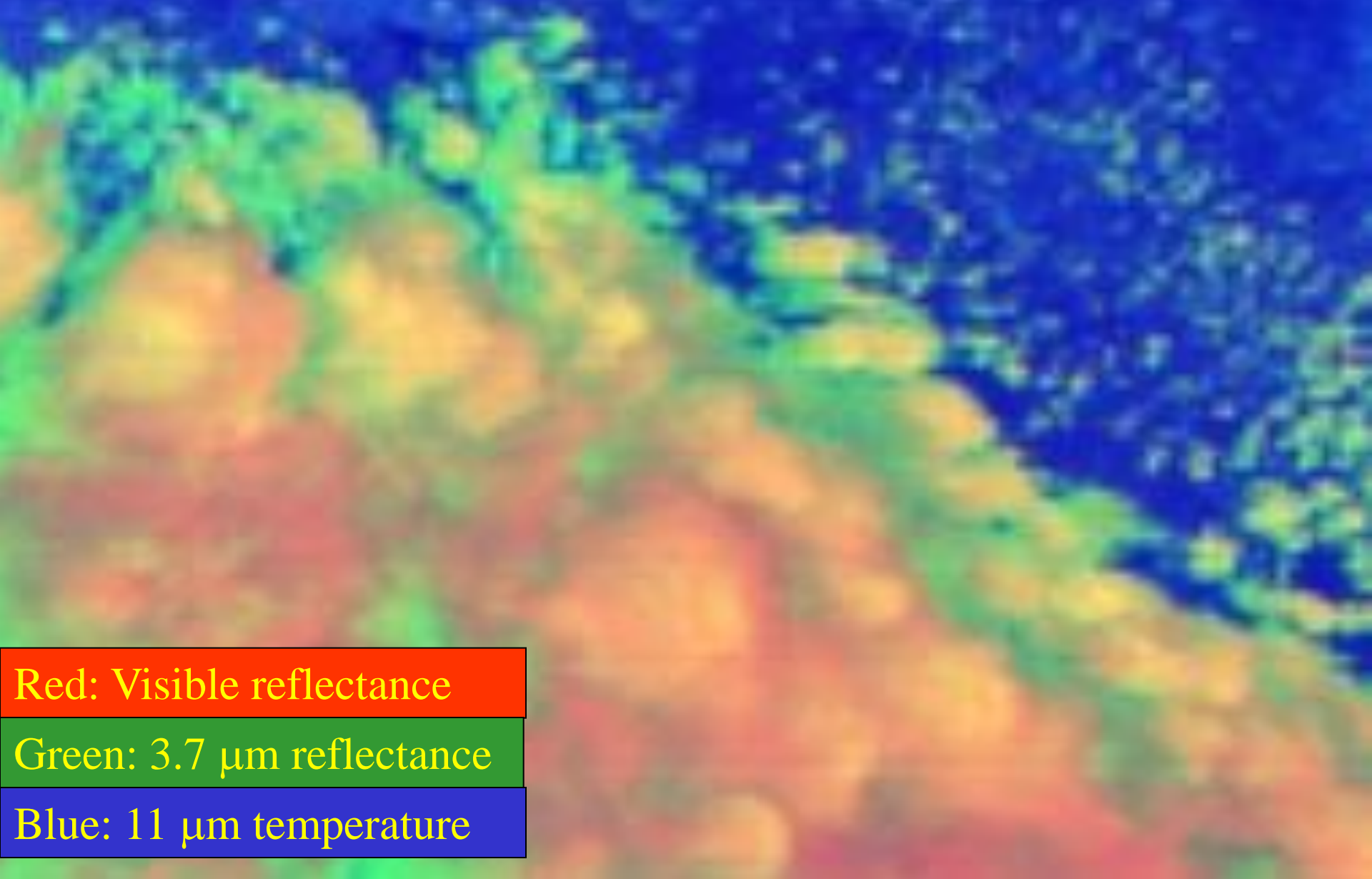


NPP/VIIRS Imager has 5 channels:

0.6, 0.8, 1.6, 3.7, 11 μm , but the imager was not planned for microphysical retrievals.

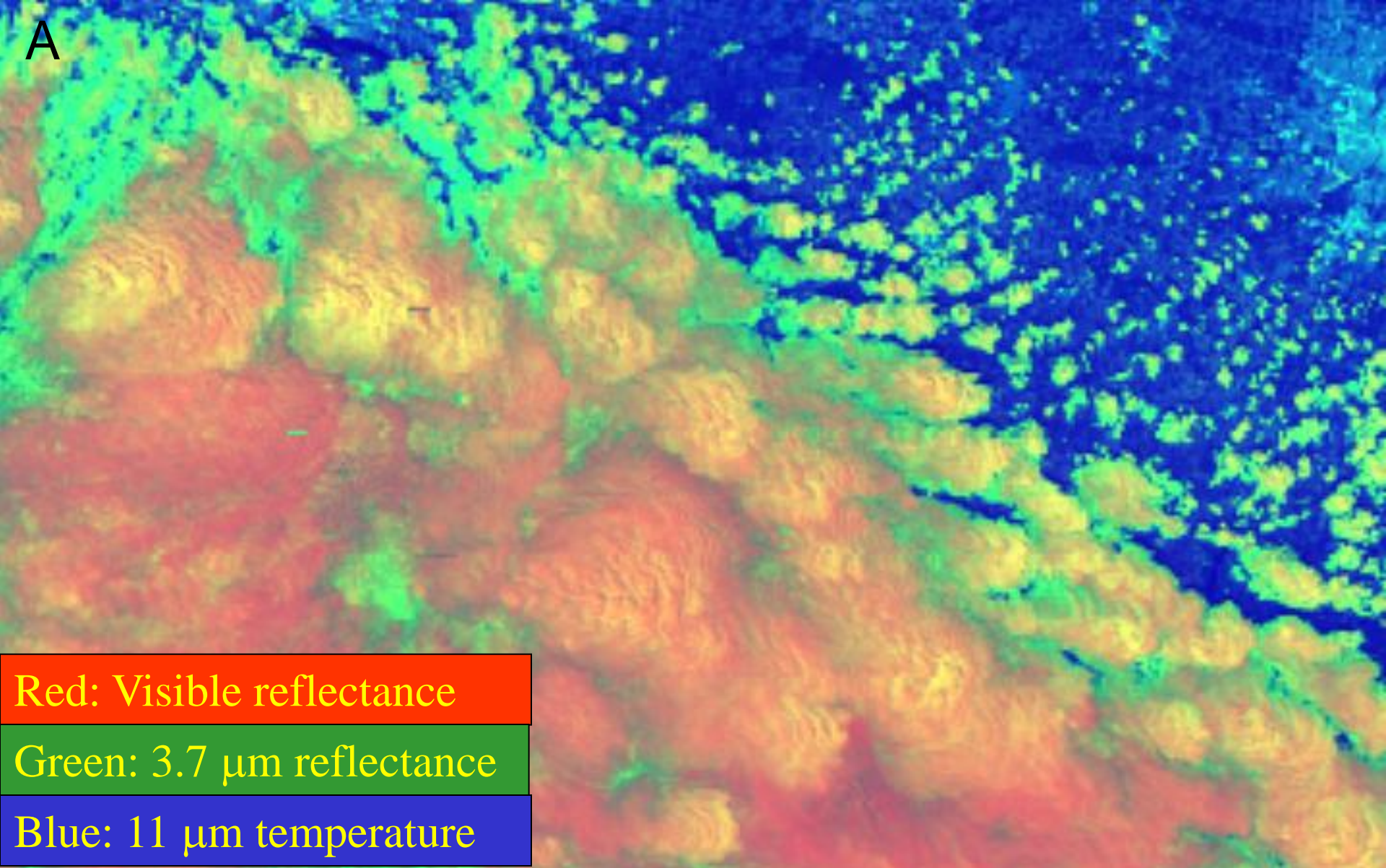
We found a way to do it.

The first results are provided here.



MODIS 20120605 18:30

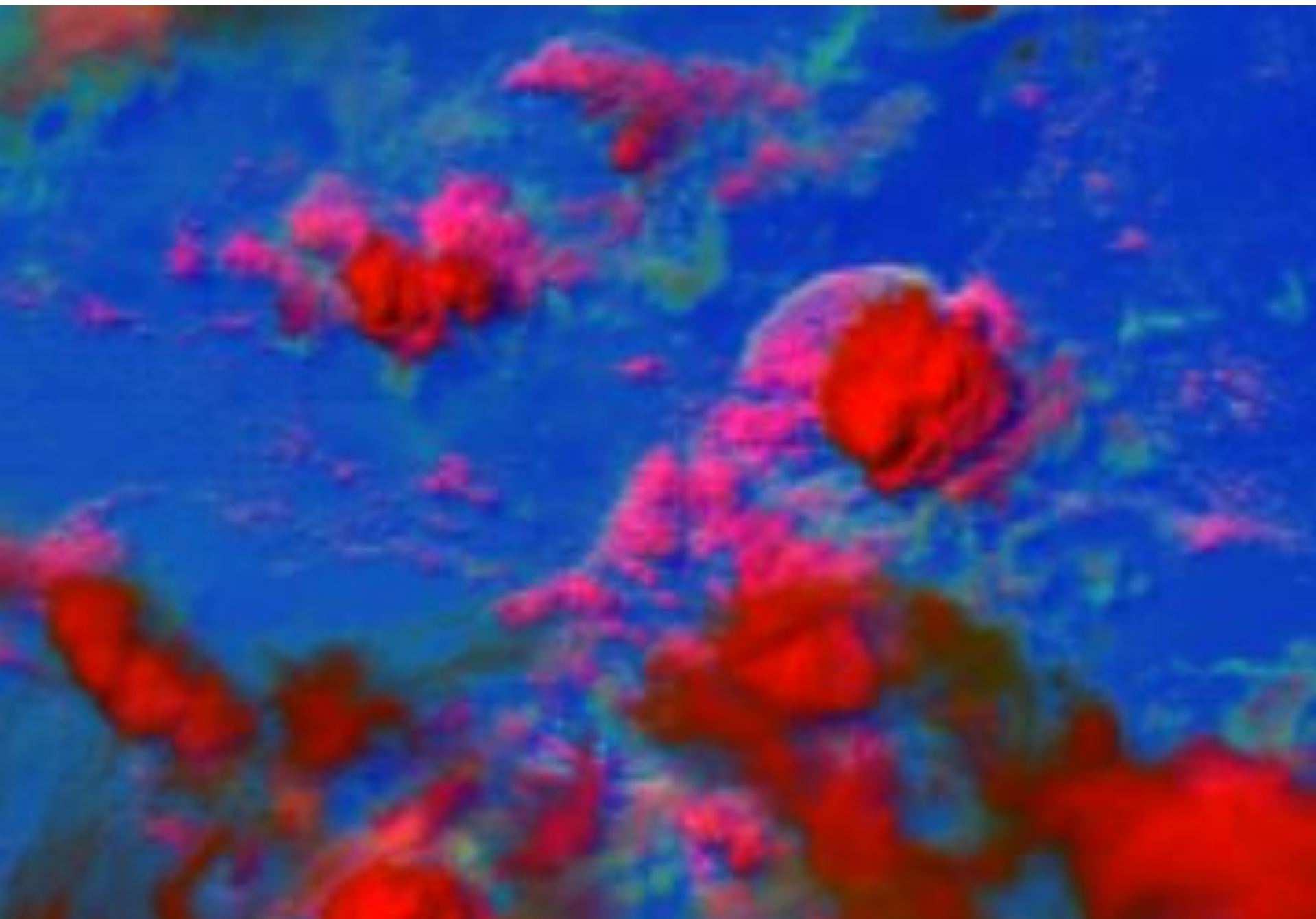
A



VIIRS 20120605 18:10

----- 160 km -----

MODIS 2012 04 27 05:00

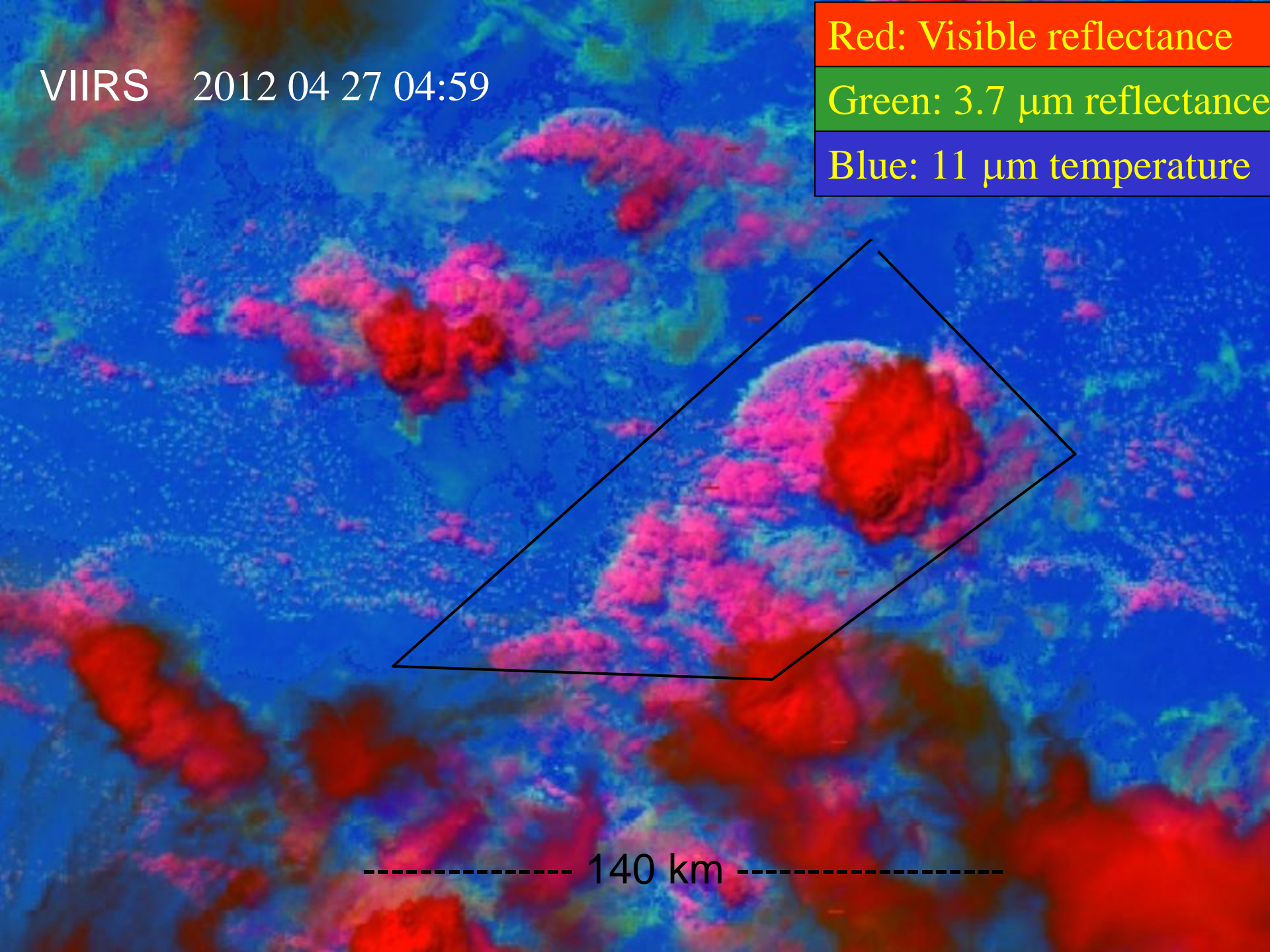


VIIRS 2012 04 27 04:59

Red: Visible reflectance

Green: 3.7 μm reflectance

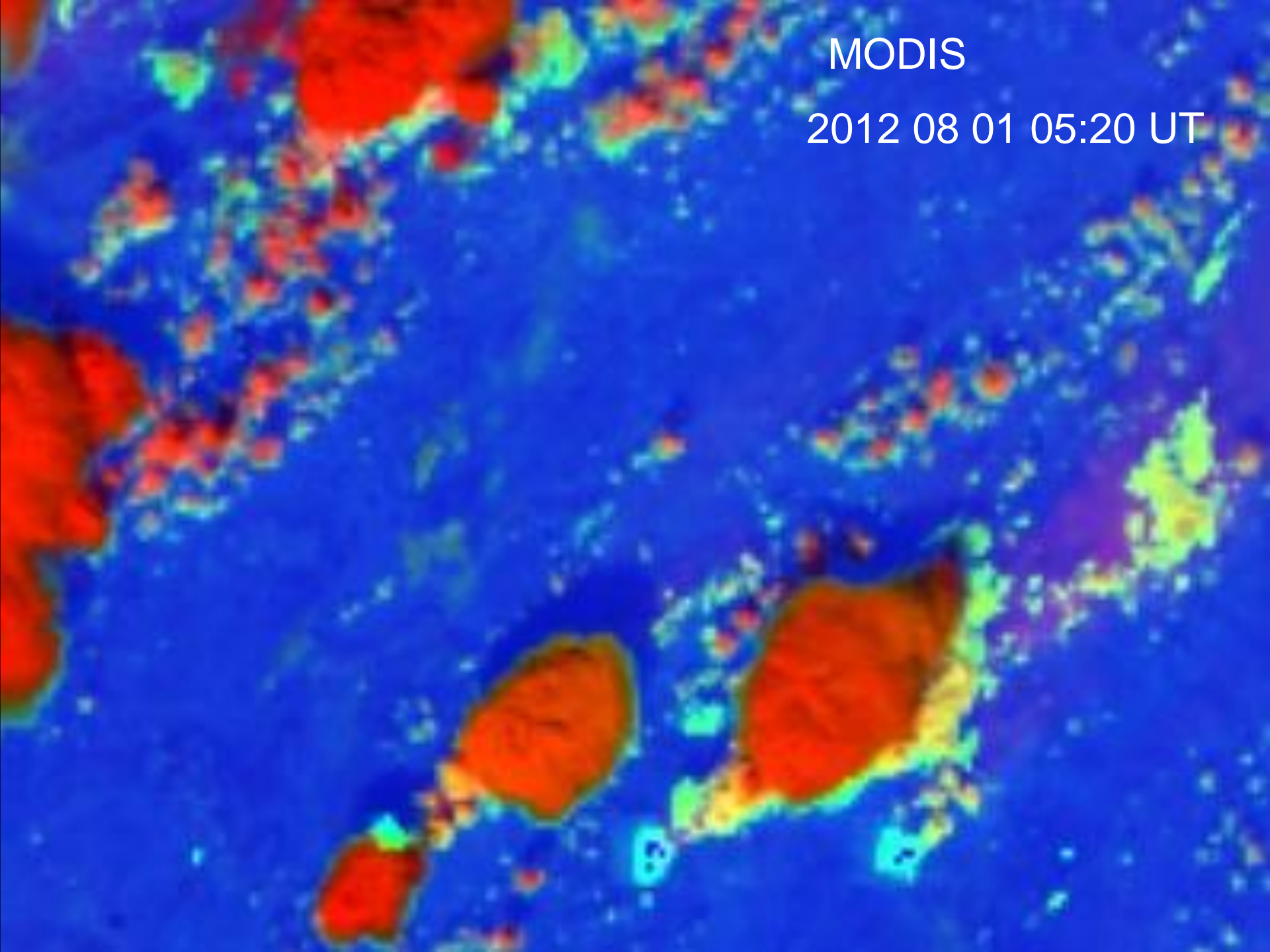
Blue: 11 μm temperature



----- 140 km -----

MODIS

2012 08 01 05:20 UT



VIIRS

2012 08 01 05:15 UT

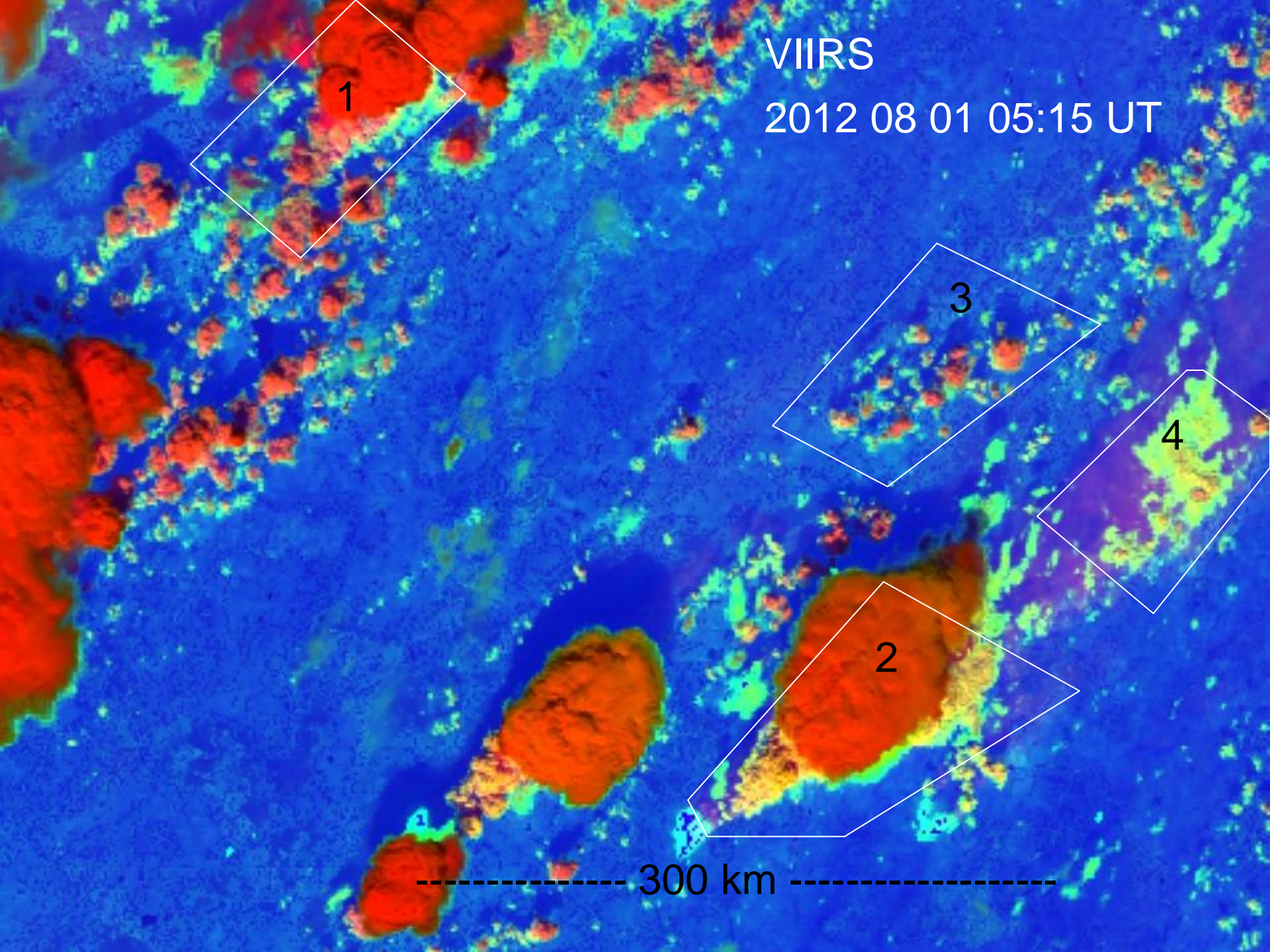
1

3

4

2

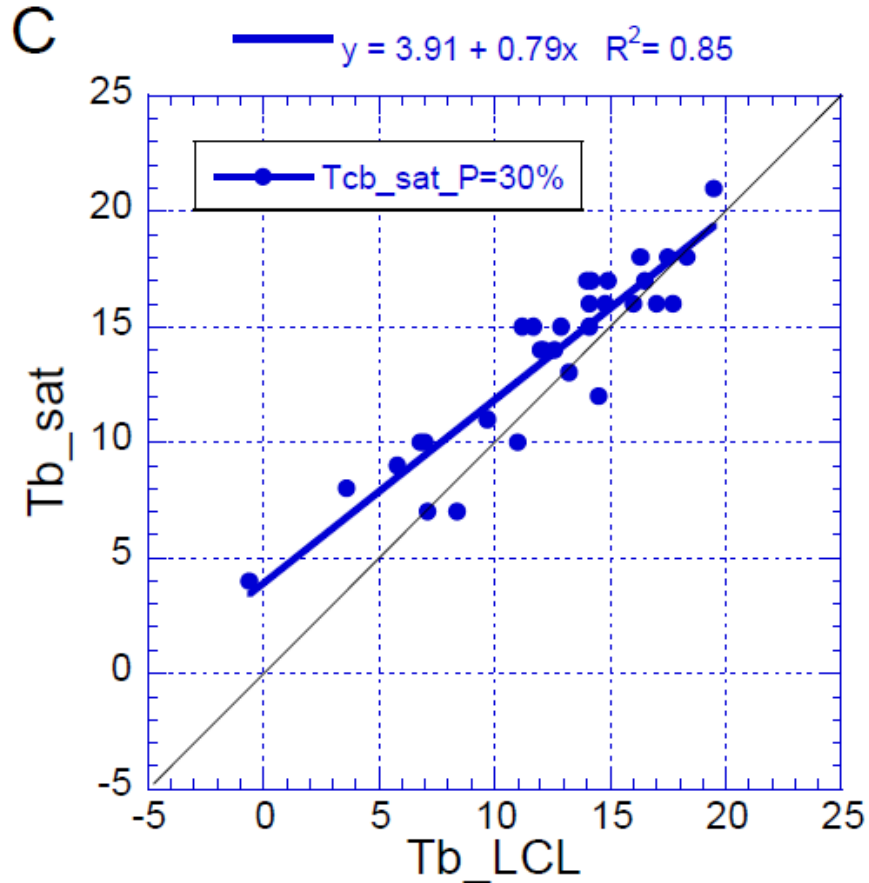
----- 300 km -----



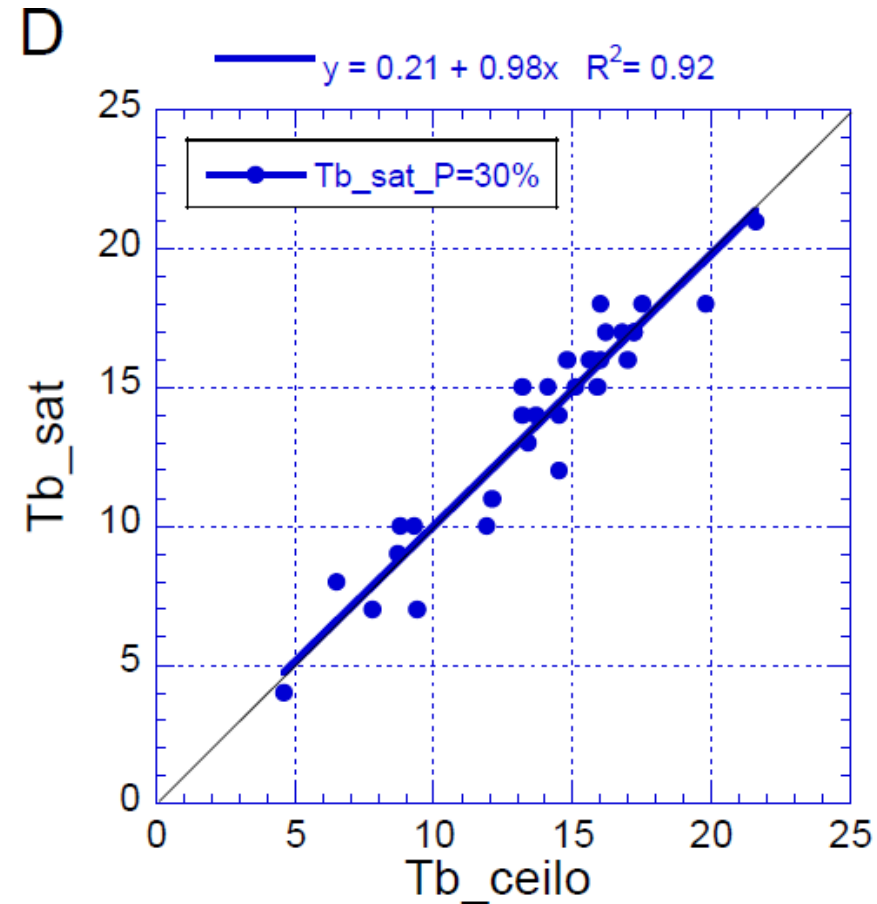
Calculating cloud base temperature

1. Select only clouds with visible reflectance > 0.4 .
2. Calculate cloud top temperature using BTD (11-12 μm), as for SST.
3. Reject partly filled pixels by the local temperature variability.
4. Rely on the assumption that convective cloud base is flat, and reject the warm tail of the distribution.

Tbase Satellite validation over the DOE/SGP site in Oklahoma

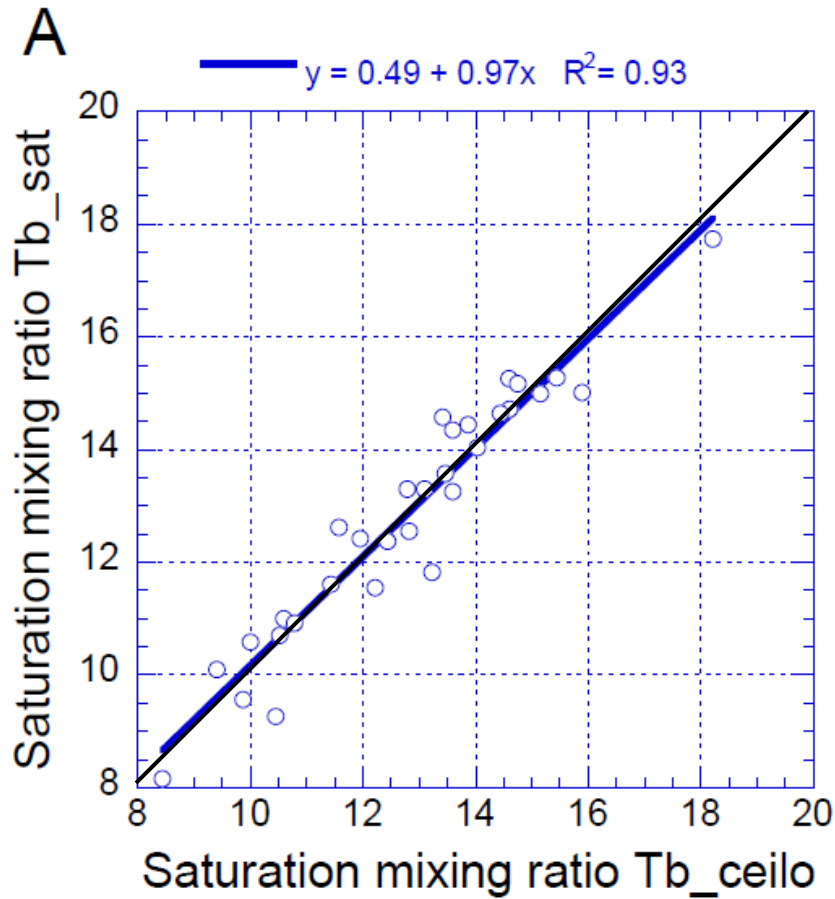


Tbase from sounding-based
Lifting Condensation level.
Sounding time is 1.5-2 hours
before satellite time.

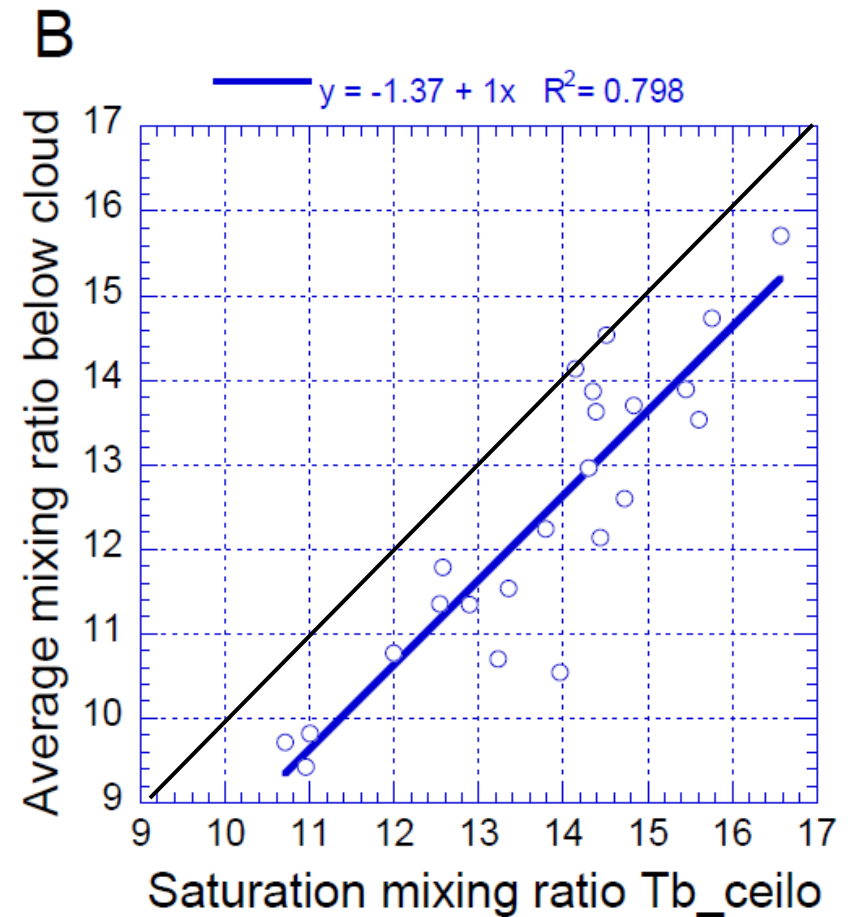


Tbase from sounding
temperature at the height of
cloud base as measured by
the ceilometer at the satellite
overpass time. RMSE = 1.1°C

Vapor validation over the DOE/SGP site in Oklahoma



Vapor saturation mixing ratio at cloud base, as obtained from combined ceilometer height and sounding temp.

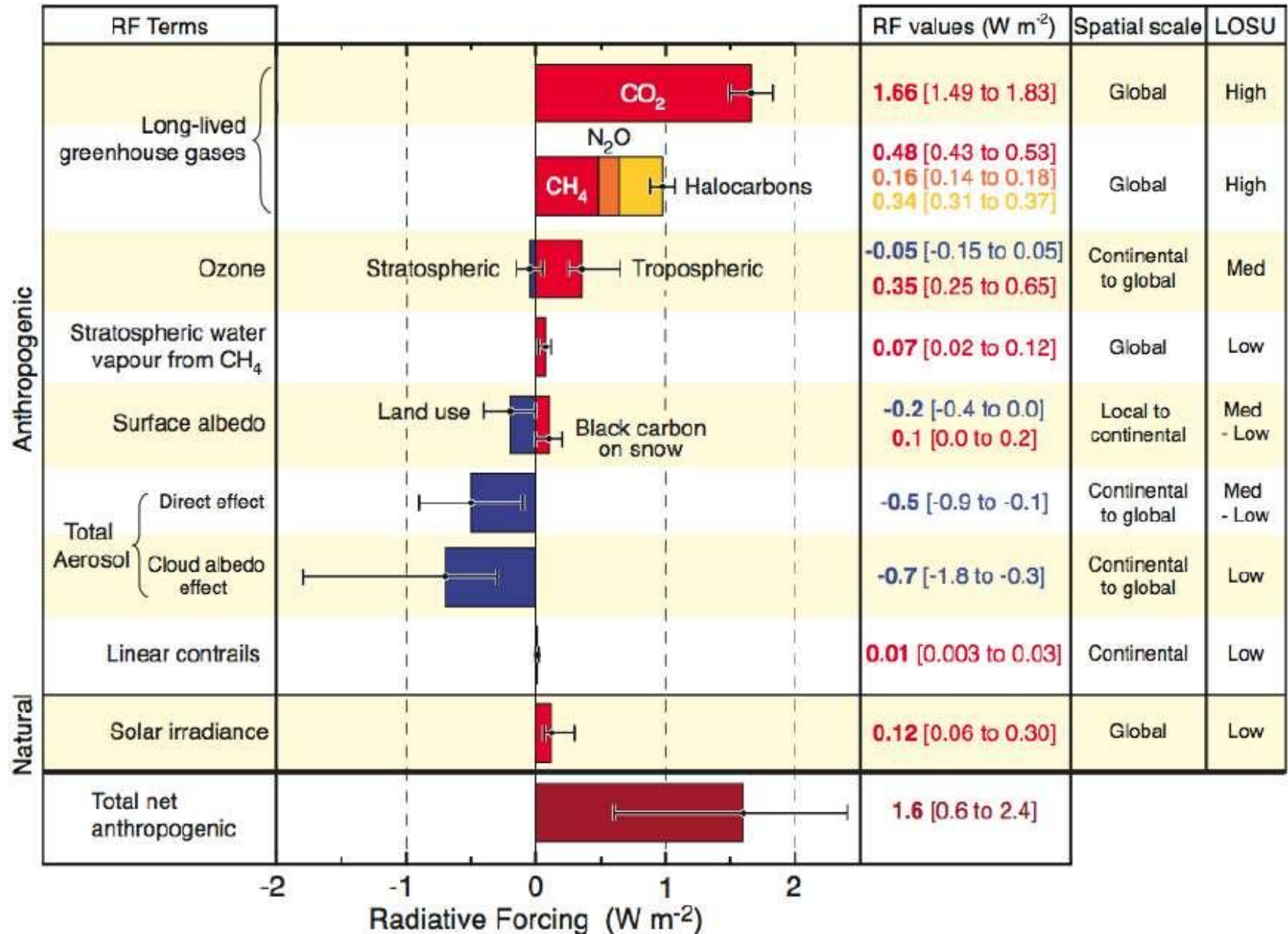


Vapor average mixing ratio in the boundary layer, as measured by the sounding. RMSE = 0.77 g/kg (5.6%).

- How much would a 5% RMS error in boundary layer mixing ratio improve estimated instability indices?
- What is the improvement in surface air temperature, and how much further skill does it add to the prediction?
- What are the potential impacts to NWP and QPF?

What can we achieve when
combining cloud base temperatures
and updrafts?

Radiative Forcing Components



Satellite measurements of CCN using clouds as CCN chambers



Daniel Rosenfeld, The Hebrew University of Jerusalem

CCN chambers measure the number of activated CCN (N_a) for a given super-saturation (S).

Measuring N_a and S in clouds can provide $CCN(S)$:

It will be shown here that both N_a and S can be retrieved from high resolution (375 m) NPP/VIIRS satellite data, and validated against the SGP measurements.

Having both $CCN(S)$ and W_b provides us with the possibility to separate aerosol from meteorology effects on cloud radiative effects.

CCN chambers measure the number of activated CCN (N_a) for a given super-saturation (S).

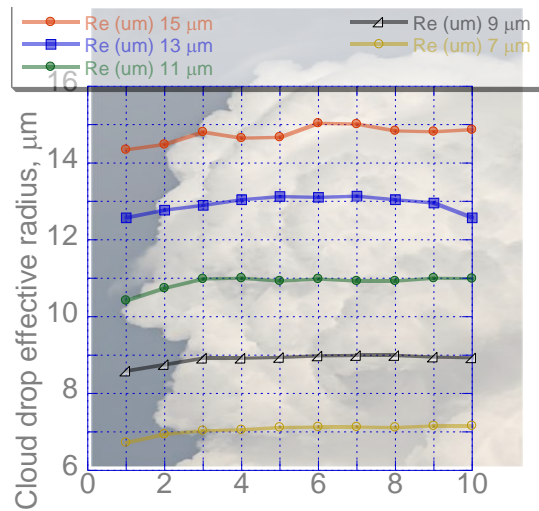
Measuring N_a and S in clouds can provide $CCN(S)$:

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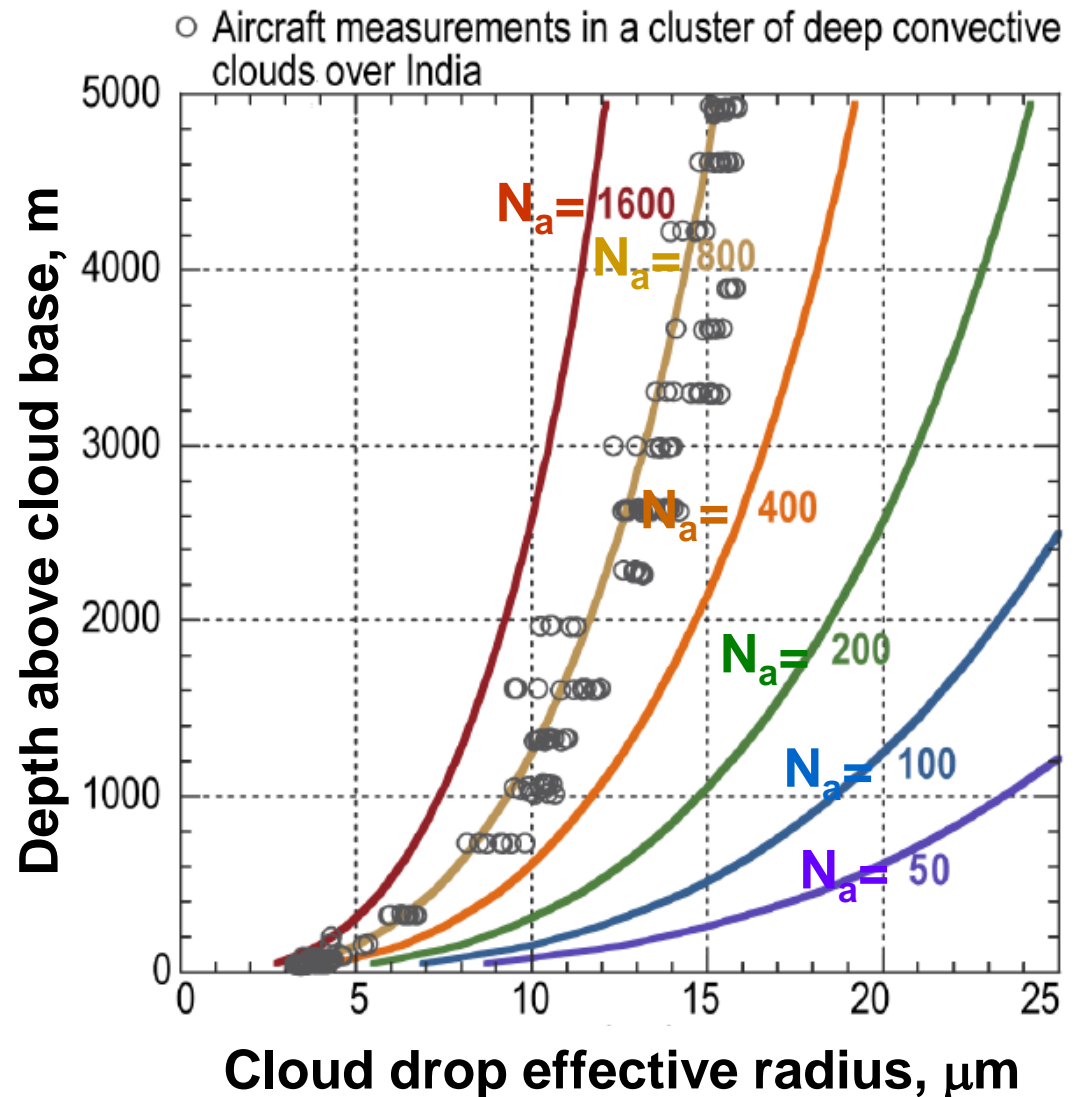
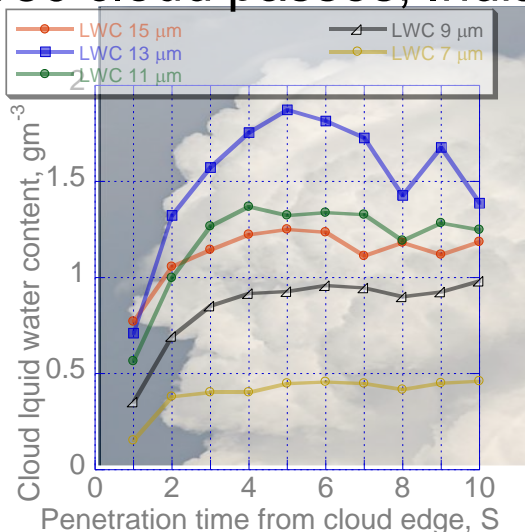
Having both $CCN(S)$ and W_b provides us with the possibility to separate aerosol from meteorology effects on cloud radiative effects.



1. N_a is retrieved from the $T-r_e$ (cloud top temperature – drop effective radius), due to nearly inhomogeneous cloud mixing, resulting in nearly adiabatic r_e .



Penetration time from cloud edge, S
180 cloud passes, India



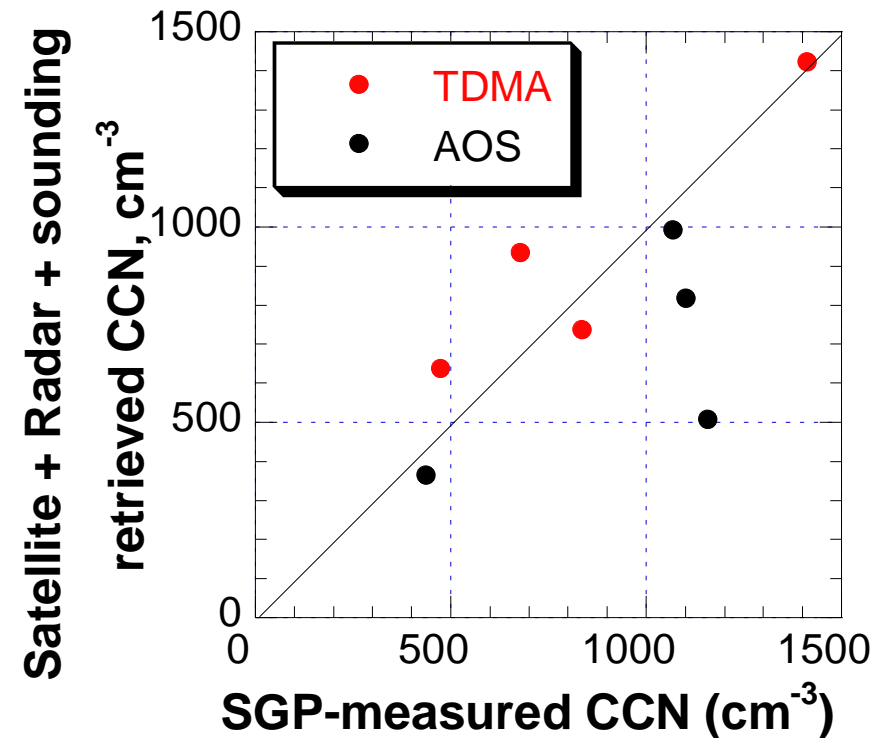
2. **S** is calculated from the knowledge of **N_a** and **W_b**
(Cloud base updraft). **S** = **C(T,P)W_b^{3/4}N_a^{-1/2}**

W_b is retrieved from SGP radar;

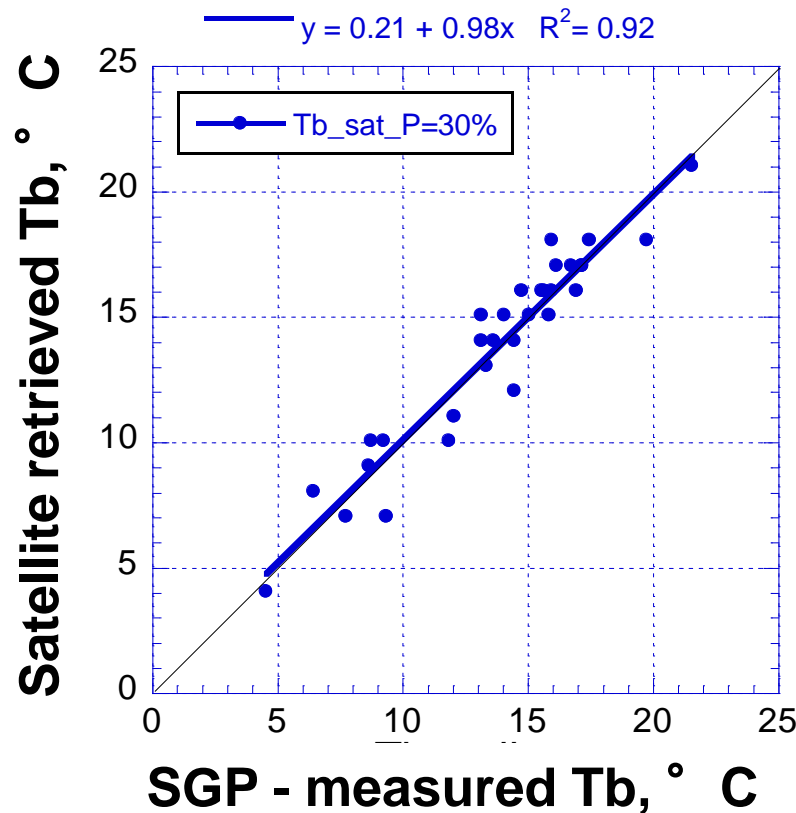
N_a calculation is based on
calculated adiabatic water
(**LWC_a**) vs. Satellite retrieved
assumed-adiabatic **r_e**.

LWC_a is based on radiosonde
and ceilometer retrieved
cloud base temperature (**T_b**).

CCN(S) is validated against SGP
measured AOS and TDMA.



Satellite-only **CCN(S)** requires retrieving **T_b** and **W_b**



T_b RMS error = 1.1 ° C

Validation of VIIRS retrieved cloud base temperature (° C) against SGP ceilometer and sounding based measurements.

Satellite-only **CCN(S)** requires retrieving T_b and **W_b**

$$W_{\max_est} = 0.27(z_i(1 + 0.25V)(T_s - T_a))^{1/2} + 0.54$$

- Cloudy scenes
- Clear air scenes

$$W_b = \sum \frac{N_i W_i^2}{N_i W_i} |W_i > 0$$

N_i stands for the frequency of occurrence of W_i .

DeltaT: Temperature difference between cloud base and cloud top.

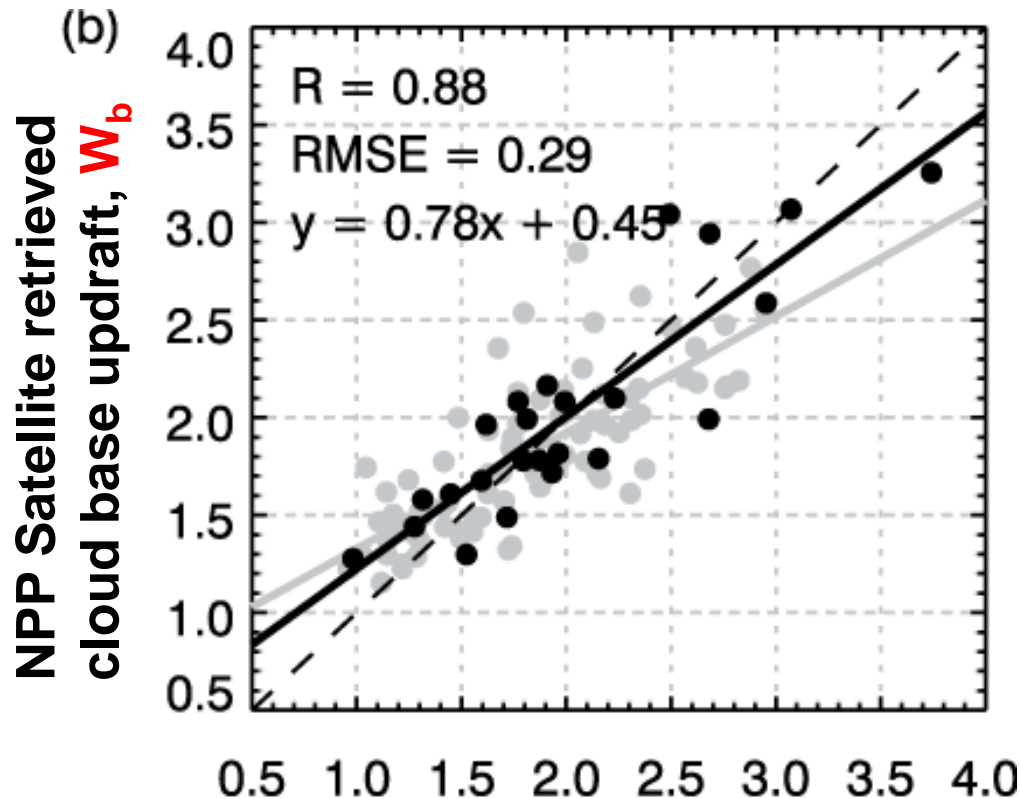
T_s : surface skin temp.

T_a : 2-m air temperature

V : surface wind speed

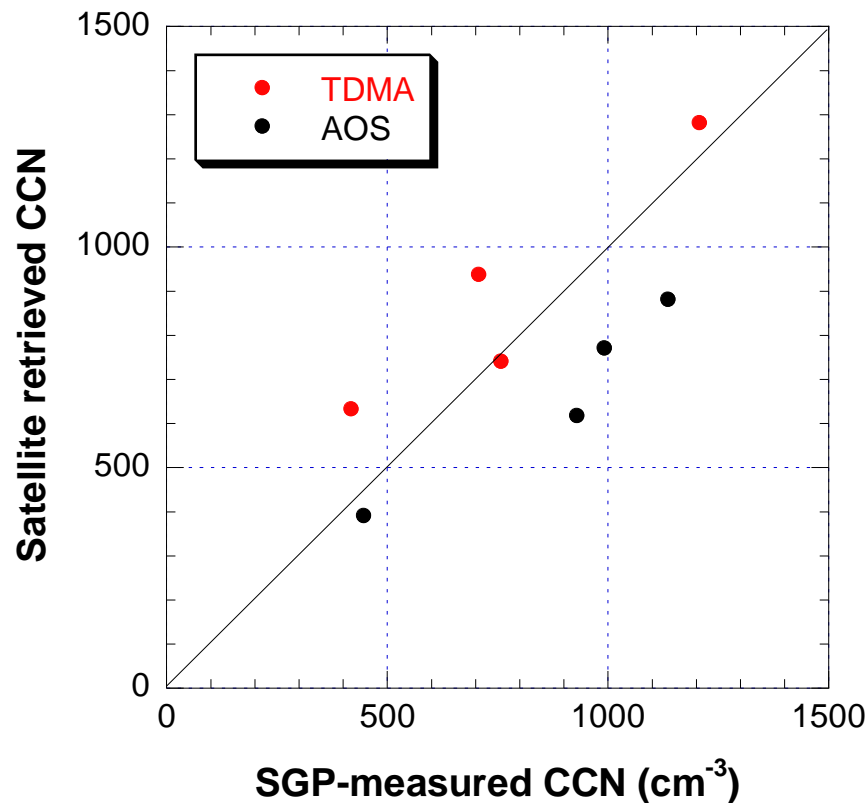
WS: vertical wind shear

H_{cb} : cloud base height



SGP lidar measure W_b , ms^{-1}

Validation of Satellite-only CCN(S)



These are all the cases for which full validation data are available so far during times of convective clouds and NPP/VIIRS overpass at a viewing angle of nearly solar back scatter.

Conclusions and next steps

- We have proved the concept of retrieving **CCN(S)** by using clouds as CCN chambers.
- Other important results are the satellite retrievals of:
 - Convective cloud base drop concentrations, **N_a** .
 - Cloud base temperature, **T_b** , which allows the calculation of boundary layer vapor mixing ratio.
 - Cloud base updraft, **W_b** , based on satellite retrieved surface skin and air temperatures.
- Next, this has to be expanded to other areas.
- Eventually to be applied to the ultimate goal of disentangling the updraft from aerosol effects on cloud radiative effects.

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