Satellite measurements of CCN using clouds as CCN chambers

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

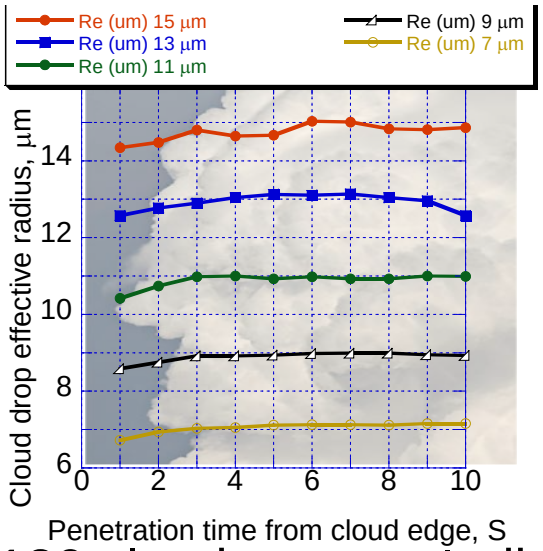
Measuring N_a and **S** **in clouds** can provide **CCN(S)**:

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.

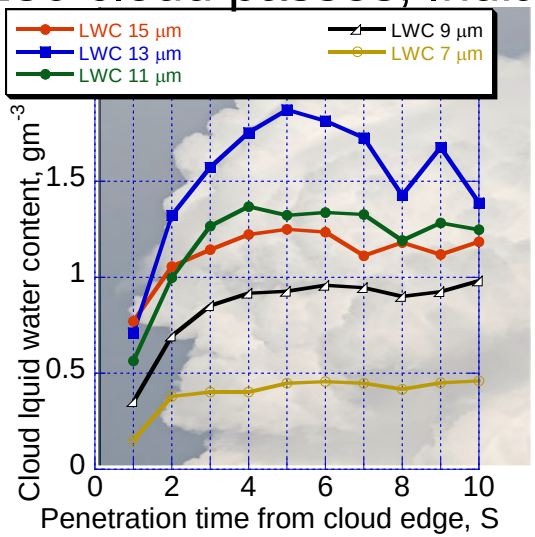
Having both **CCN(S)** and W_b provides us with the possibility to separate aerosol from meteorology effects on cloud radiative effects.

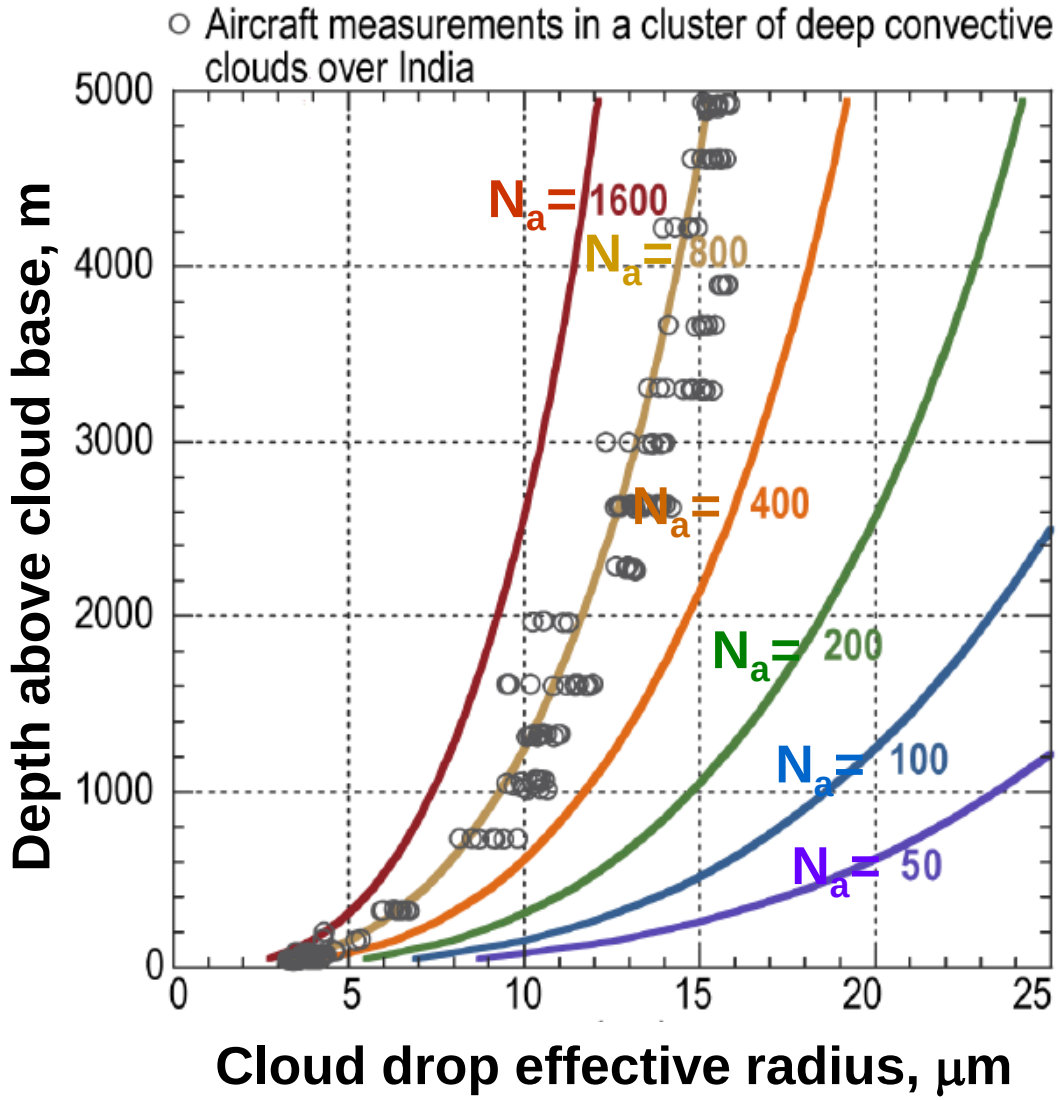
1. N_a is retrieved from the $T\text{-}r_e$ (cloud top temperature – drop effective radius), due to nearly inhomogeneous cloud mixing, resulting in nearly adiabatic r_e.

MsC of Hagai Kousevittski at the Hebrew University



180 cloud passes, India





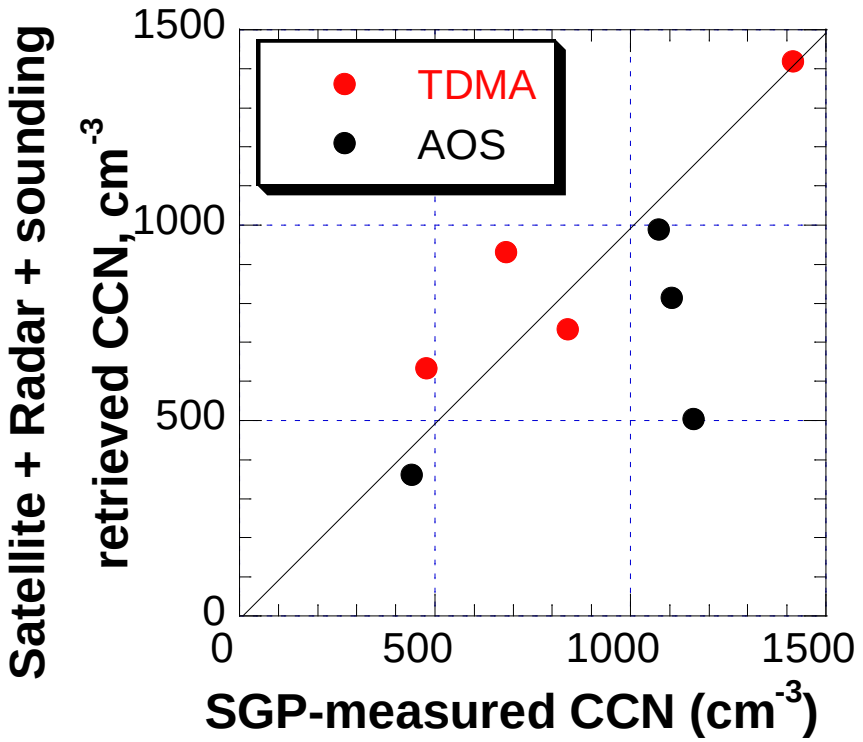
2. S is calculated from the knowledge of N_a and W_b (Cloud base updraft). $S = C(T,P)W_b^{3/4}N_a^{-1/2}$

W_b is retrieved from SGP radar;

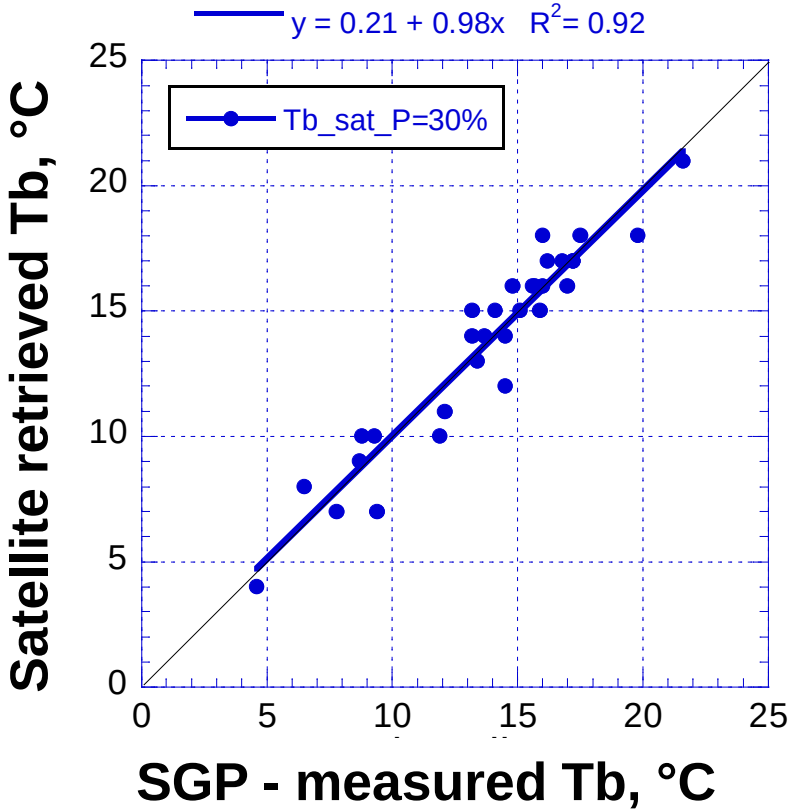
N_a calculation is based on calculated adiabatic water (LWC_a) vs. Satellite retrieved assumed-adiabatic r_e.

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

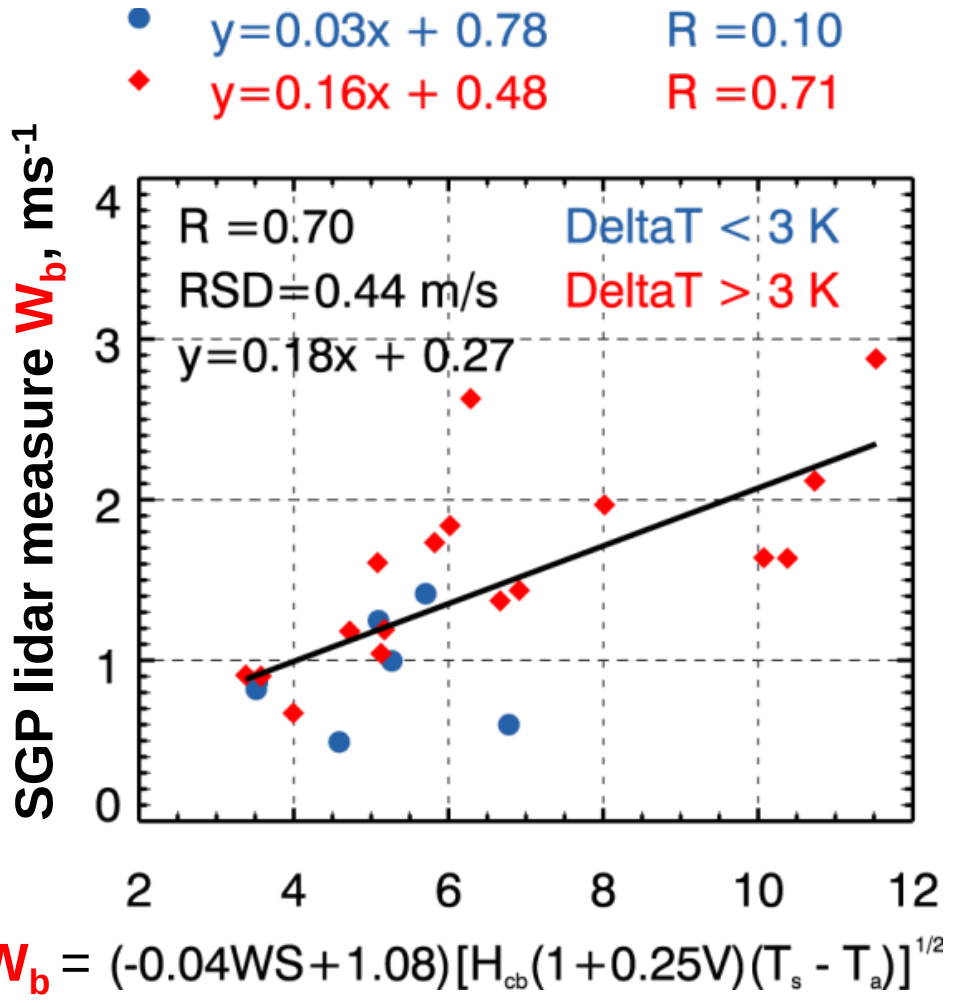


T_b RMS error = 1.1 °C

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

Zhu Y., D. Rosenfeld et al., GRL 2014

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



NPP Satellite retrieved cloud base updraft, W_b

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

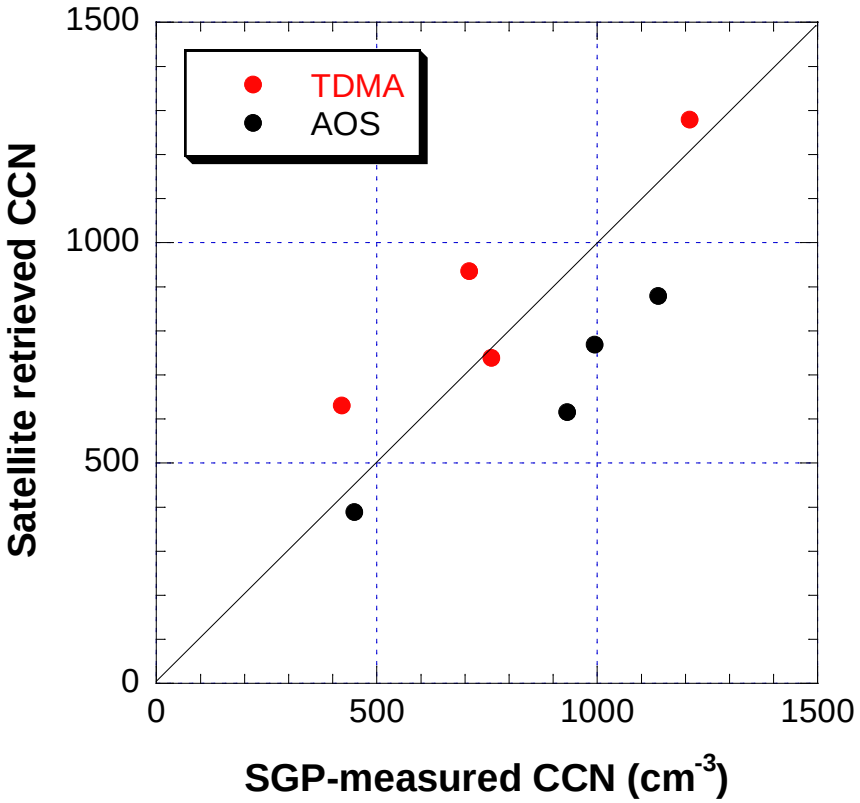
N_i stands for the frequency of occurrence of W_i.

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

PhD of Youtong Zheng at the Hebrew University

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, $\mathbf{N_a}$.
  - Cloud base temperature, $\mathbf{T_b}$, which allows the calculation of boundary layer vapor mixing ratio.
  - Cloud base updraft, $\mathbf{W_b}$, 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.