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.
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 \( r_e \).
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 $W_b$

Validation of VIIRS retrieved cloud base temperature ($^\circ$C) against SGP cielometer and sounding based measurements.

$y = 0.21 + 0.98x \quad R^2 = 0.92$

$T_b$ RMS error = 1.1 °C

Zhu Y., D. Rosenfeld et al., GRL 2014
Satellite-only CCN(S) requires retrieving $T_b$ and $W_b$

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

$N_i$ 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

**NPP Satellite retrieved cloud base updraft, $W_b$**

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 \textbf{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.