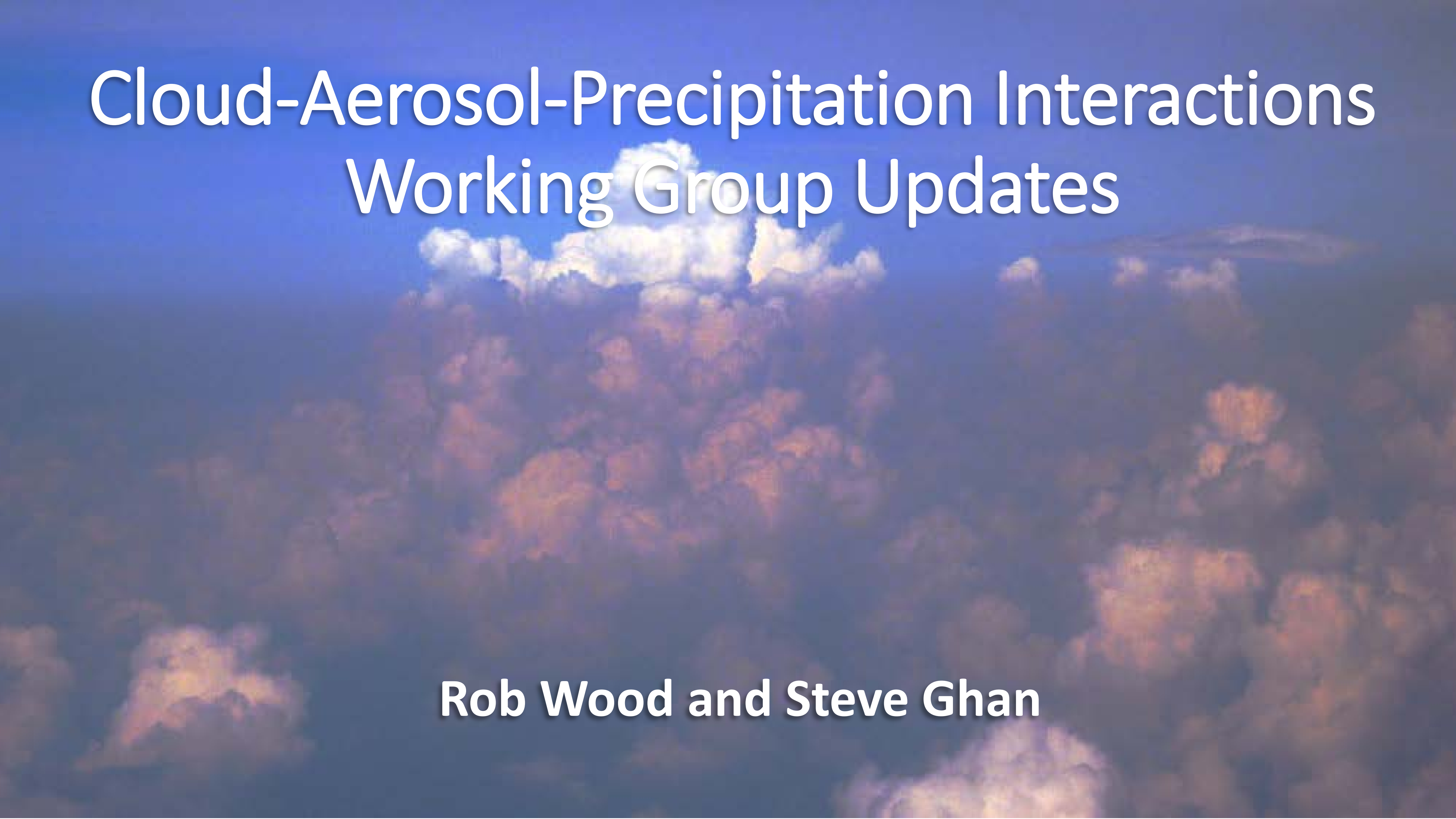
Cloud-Aerosol-Precipitation Interactions Working Group Updates



Rob Wood and Steve Ghan

CAPI Science Questions

1. What processes control diversity in the sensitivity of warm low clouds to aerosol perturbations, and why do GCMs seem to overestimate the sensitivity?
2. What aerosol-related processes control deep convective cloud properties relevant to climate (precipitation, cloud radiative forcing, latent heating profiles)?
3. What processes control ice nucleation and its impact on ice-containing clouds (e.g., Arctic stratus, altostratus, cirrus, convective clouds)?

Proposed Focus Groups

- Aerosol-deep-convection-interactions (ADCI)
  - Zhanqing Li
- Ice nucleation
  - Xiaohong Liu

Aerosol effects on deep convection

What aerosol-related processes control deep convective cloud properties relevant to climate (precipitation, cloud radiative forcing, latent heating profiles)?

Long-term Meteorological Data Revealing the Suppressing Effect of Absorbing Aerosol on Thunderstorms **(Li, University of Maryland)**

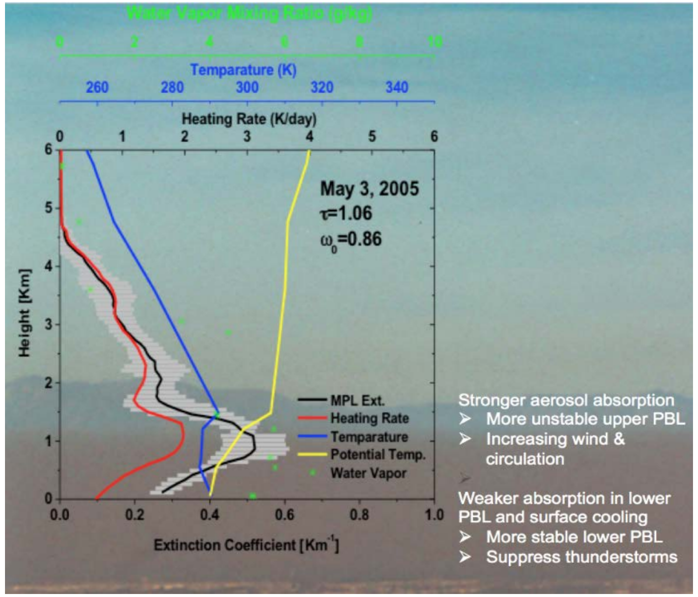
Science Question

What's the impact of the buildup of absorbing aerosol on local climate ?

Can the effect be detected to explain long-term climate changes in China?

Background

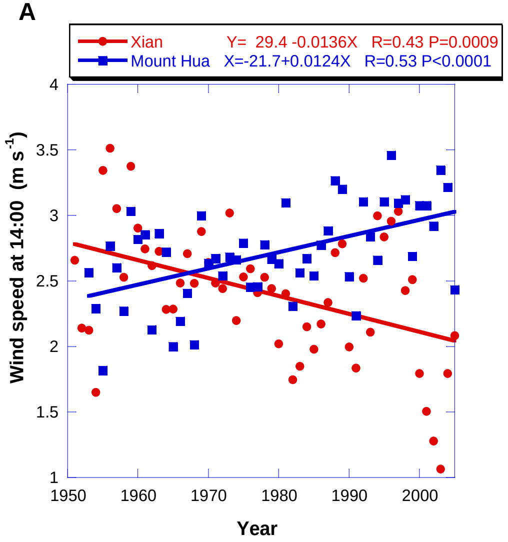
- Absorbing is being increasingly recognized for its multi-effects on climate
- Evaluating and separating the effects are possible over terrain-plain regions
- The high loading and rapid increasing trend of BC aerosol in China is an ideal testbed for the study.

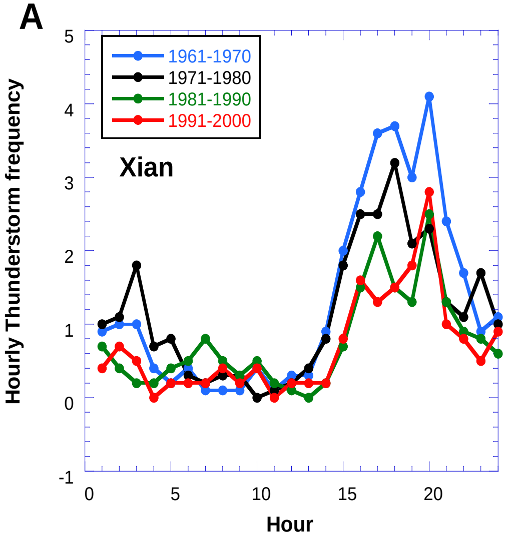


Stronger aerosol absorption
- ➢ More unstable upper PBL
- ➢ Increasing wind & circulation

Weaker absorption in lower PBL and surface cooling
- ➢ More stable lower PBL
- ➢ Suppress thunderstorms

50-year trends of wind speed and thunderstorms





Key Findings

- Wind speed has decreased steadily at Xi'an in the plain over the past 50 years when visibility has reduced by 50%, but an opposite trend mountain at a nearby mountain top station.
- The number of thunderstorms at Xi'an has declined from 1960s through 2000s.

Publication

Yang, et al., 2013, Heavy air pollution suppresses summer thunderstorms in central China, *J. Atmos. & Solar-Terrestrial Phy*. 28-40, doi:10.1016/j.jastp.2012.12.023.

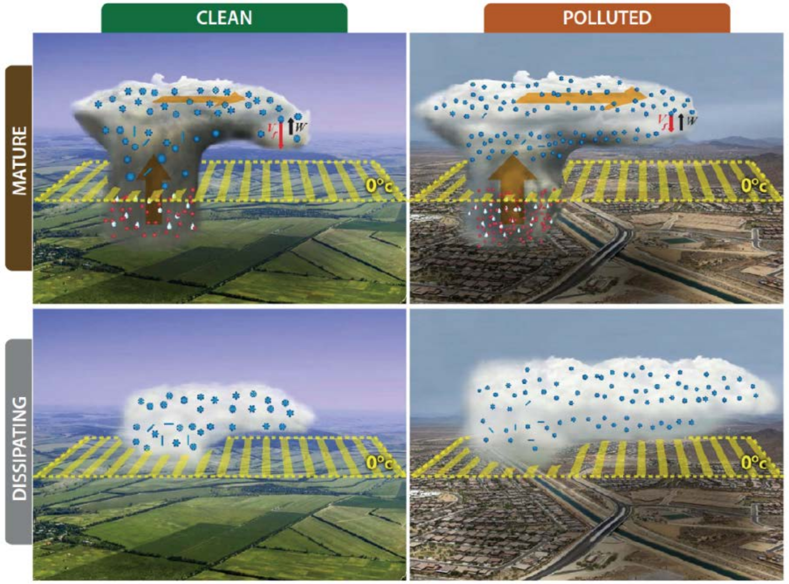
A New Mechanism Explaining Aerosol-Deep Convective Cloud Interactions

Objective

- Examine mechanisms for explaining observed ubiquitous invigoration of convection by aerosols in deep convective clouds

Approach

- Conduct cloud resolving model simulations with spectral-bin cloud microphysics at a long-time period over a large domain
- Examine typical summer convection over tropics and mid-latitudes at multiple locations
- Analyze observations from Atmospheric Radiation Measurement (ARM) Climate Research Facility long-term surface measurements



Schematic illustration of the differences in cloud top height, cloud fractions and thickness for the storms in clean and polluted environments.

Impact

- The microphysical effect induced by aerosols is a fundamental reason for the observed increases in cloud fraction, cloud top height, and cloud thickness in the polluted environment, even when thermodynamical invigoration is absent.
- Improve understanding of important mechanisms for aerosol impacts on storms and help parameterize aerosol impacts on convection clouds in climate models to reduce uncertainties in weather and climate predictions.

Fan J, LR Leung, D Rosenfeld, Q Chen, Z Li, J Zhang, and H Yan. 2013. “Microphysical Effects Determine Macrophysical Response for Aerosol Impacts on Deep Convective Clouds.” *Proceedings of the National Academy of Sciences, early online ahead of print, Nov 11, 2013.* DOI:10.1073/pnas.1316830110

Aerosol Effects on Convection in the NCAR CAM5, Invigoration or Not?

Guang Zhang / Scripps Institution of Oceanography, UCSD

Science Question

Do aerosols invigorate convection climatologically?

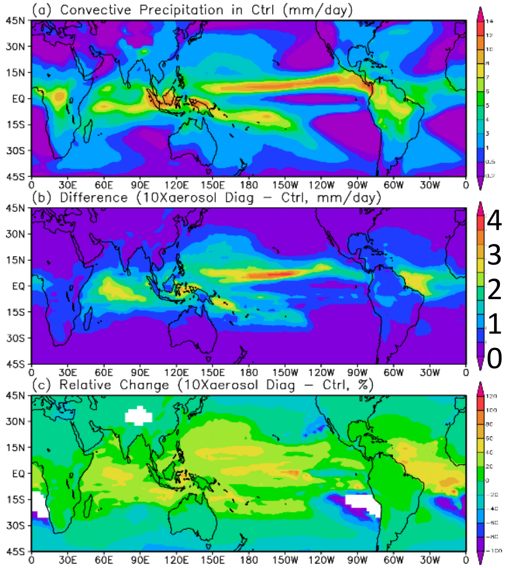
Approach

- Use NCAR CAM5 with a two-moment convective microphysics scheme coupled with convection parameterization

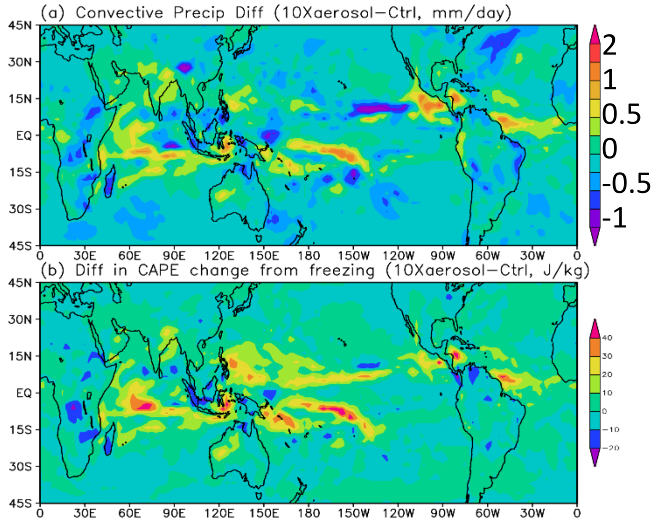
1. Multi-year simulation with prescribed aerosol distribution
2. At each time step of integration, also run convection parameterization and convective microphysics scheme diagnostically, but with 10xaerosol loading at each convective grid points.
3. Same as (1) but run the 10xaerosol loading, and the resultant latent heating is allowed to interact with large-scale circulation

(2)-(1) gives aerosol effect on convection under fixed large-scale conditions. (3)-(1) gives aerosol effect on convection incorporating large-scale feedbacks.

Aerosol effect on convection in fixed environment



Aerosol effect on convection in interactive environment



Key Accomplishment

Aerosols invigorate convection under fixed environmental conditions. However, if large-scale feedbacks from invigorated convection are considered, much of the invigoration effect is negated.

Publication

Zhang, G. and X. Song, 2014: Aerosol effects on convection in the NCAR CAM5, invigoration or not? Submitted to Geophys. Res. Lett.

Ice nucleation

What processes control ice nucleation and its impact on ice-containing clouds (e.g., Arctic stratus, altostratus, cirrus, convective clouds)?

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Ice Generation in Mixed-phase Clouds

Zhien Wang and Damao Zhang/ University of Wyoming

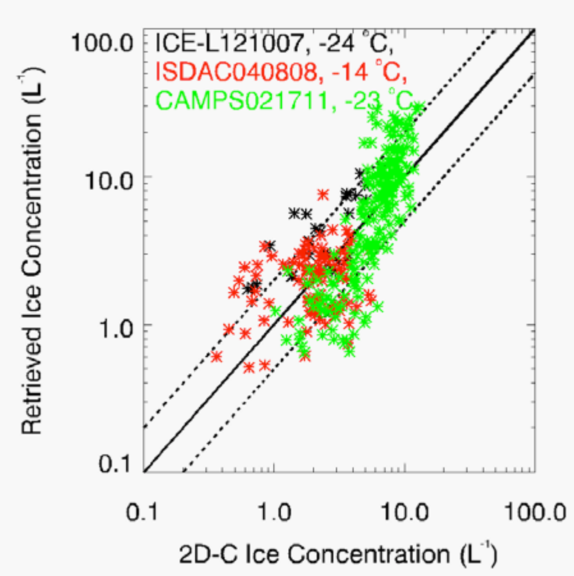
Science Question

How do ice crystal concentrations in mixed-phase clouds vary with aerosols, dynamics and temperature?

How to use these observations to improve mixed-phase cloud parameterization in weather and climate models?

Approach

- Develop an approach to retrieve ice crystal concentrations with radar measurements for stratiform mixed-phase clouds by combining collocated airborne in situ and remote sensing measurements with modeling.
- Apply the radar based approach to long-term ARM measurements as well as A-train satellite measurements.
- Study ice variation in convective clouds, using airborne in situ and remote sensing measurements.
- Use observational results to refine mixed-phase cloud parameterizations



A comparison of radar retrieved ice concentrations with 2D-C measurements for three stratiform mixed-phase clouds systems during ICE-L (black), ISDAC (red) and CAMPS (green) field campaigns.

Key Accomplishment

1. **A new approach to retrieve ice concentration in stratiform mixed-phase clouds.**
2. **Quantitative assessment of dust impact on ice generation in stratiform mixed-phase clouds.**

Publication

Zhang, D., Z. Wang, A. J. Heymsfield, J. Fan, D. Liu, and M. Zhao: 2012, Quantifying the impact of dust on heterogeneous ice generation in midlevel supercooled stratiform clouds, *Geophys. Res. Lett.*, 39, L18805, doi10.1029/2012GL052831.

Zhang, D., Z. Wang, A. Heymsfield, J. Fan, and T. Luo, 2014: Ice Concentration Retrieval in Stratiform Mixed-phase Clouds Using Cloud Radar Reflectivity Measurements and 1-D Ice Growth Model Simulations, *J. Atmos. Sci.*, (in revision).

Contrasting Ice Nucleating Aerosols over Marine Regions of Differing Biological Productivity

Paul J. DeMott, Thomas C. J. Hill/Colorado State University

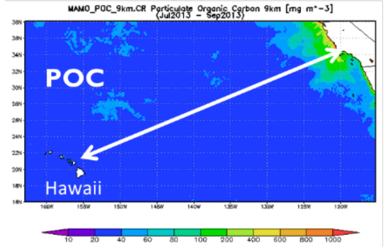
Science Question

To what extent are oceans sources of the nuclei for ice cloud formation, and do variations have implications for cloud ice phase transitions?

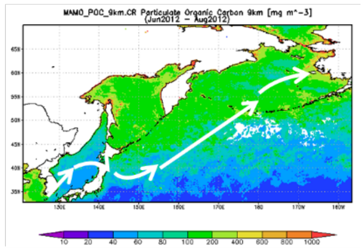
Approach

- Perform special ship-based collections of aerosol particles over different ocean regions (e.g., DOE-MAGIC).
- Process collected particles to determine ice nucleating particle (INP) number concentrations and infer sources via size, sensitivity to challenges, DNA analyses, etc.

MAGIC-IN (July-Sept 2013)



SHIPPO (July 2012)

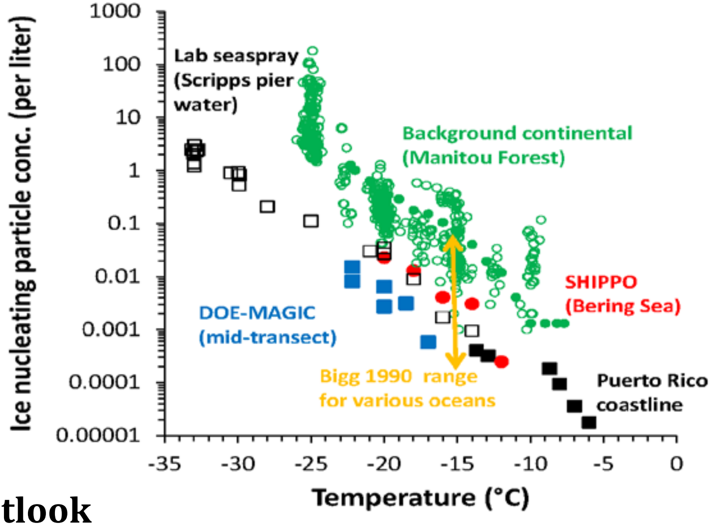


Preliminary Results

- Based on processing 5% of MAGIC samples, INP concentrations due to sea spray emissions over oligitrophic lower latitude oceans (low POC or Chl-a) appear to be much lower than over higher latitude, nutrient rich regions
- INP concentrations vary tremendously over oceans but they generally support a relative deficiency of INP compared to land regions.

Key Accomplishment:

Beginning to assemble new compilation constraining oceanic emissions of ice nuclei.



Outlook

- Continue to exploit sampling opportunities
- Develop understanding of INP sources that permits future model parameterization on basis of in-situ or satellite assessments of aerosol and seawater physical/ chemical/biological properties.

Publication

DeMott, P. J., T. C. J. Hill, K. A. Prather, D. B. Collins, R. C. Sullivan, M. J. Ruppel, R. Mason, T. Lee, C. Y. Hwang, J. I. Axson, A. P. Ault, M. J, Kim, M. Diaz Martiniez, C. Lee, C. Sultana, O. L. Mayol-Bracero, A. Bertram, T. Bertram, V. K. Grassian, G. D. Franc, and E. R. Lewis (2014). Ice nucleating particle concentrations from marine sources: Laboratory and atmospheric measurements. In preparation.

ISDAC Large-Eddy Simulation (LES) intercomparison: Importance of ice size distribution assumptions

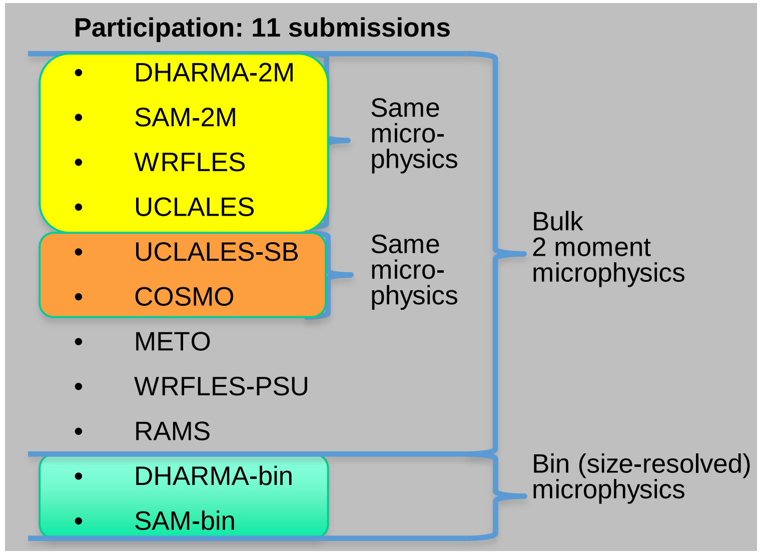
Mikhail Ovchinnikov / Pacific Northwest National Laboratory

Science Question

What causes the diverse sensitivities of liquid and ice water paths (LWP & IWP) to ice particle concentration in mixed-phase clouds simulated by different models ?

Approach

- LES of a mixed-phase stratus from Indirect and Semi-Direct Aerosol Campaign (ISDAC)
- Constrained ice particle properties (shape, density, and fall speed); Unified radiation scheme; Common domain size and resolution
- Three target ice concentrations (0, 1, and 4 L^{-1})



Participation: 11 submissions

- DHARMA-2M
- SAM-2M
- WRFLES
- UCLALES
- UCLALES-SB
- COSMO
- METO
- WRFLES-PSU
- RAMS
- DHARMA-bin
- SAM-bin

Same micro-physics

Same micro-physics

Bulk 2 moment microphysics

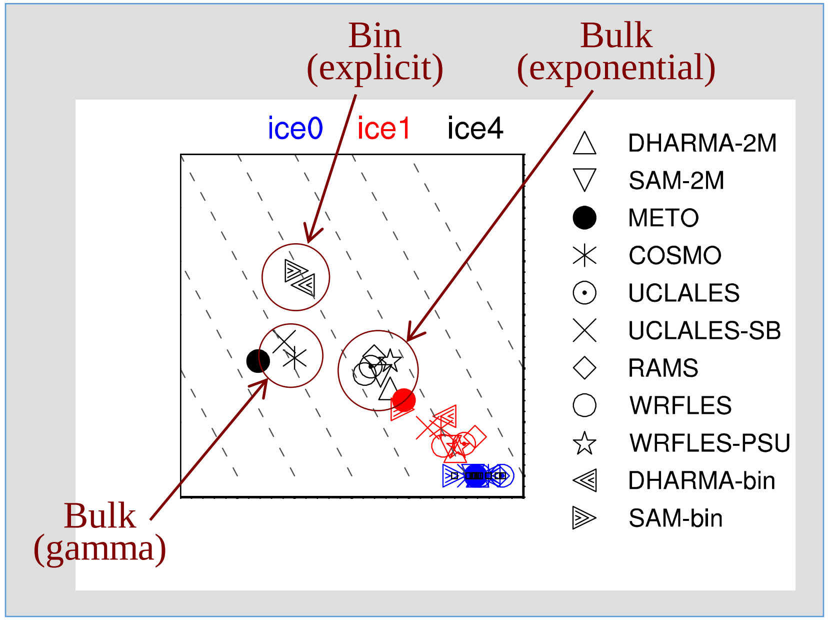
Bin (size-resolved) microphysics

Key Accomplishment

Liquid-to-ice partitioning is a strong function of ice particle size distribution (PSD) assumption

PSD effects on depositional growth rate and sedimentation can be equally important

Commonly assumed exponential PSD is too broad for shallow stratiform mixed-phase clouds



Publication

Ovchinnikov M., et al., 2014: Intercomparison of large-eddy simulations of Arctic mixed-phase clouds: Importance of ice size distribution assumptions. *J. Adv. Model. Earth Syst.*, doi:10.1002/2013MS000282.

Low, warm clouds

What processes control diversity in the sensitivity of warm low clouds to aerosol perturbations, and why do GCMs seem to overestimate the sensitivity?

Exploring the cloud-clear transition zone with ARM SW spectrometers

Alexander Marshak, Patrick J. McBride, Warren J. Wiscombe (NASA/GSFC)

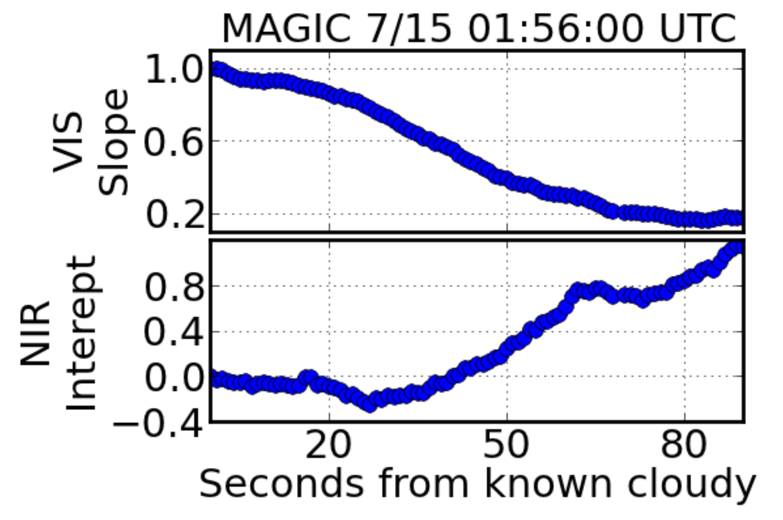
1) Science questions

Using ARM SW spectrometer measurements:

- what can be learned about the cloud-clear transition zone?
- can the hypothesis of cloud ***homogeneous and inhomogeneous mixing*** **be** tested?

3) Accomplishments

As an example, data from the 15 July 2013 MAGIC case shows little change in droplet size through the first 20 sec. from a definitely cloudy region and then a ***decreasing trend*** through the rest of the cloud-clear transition zone supporting the homogeneous mixing hypothesis.

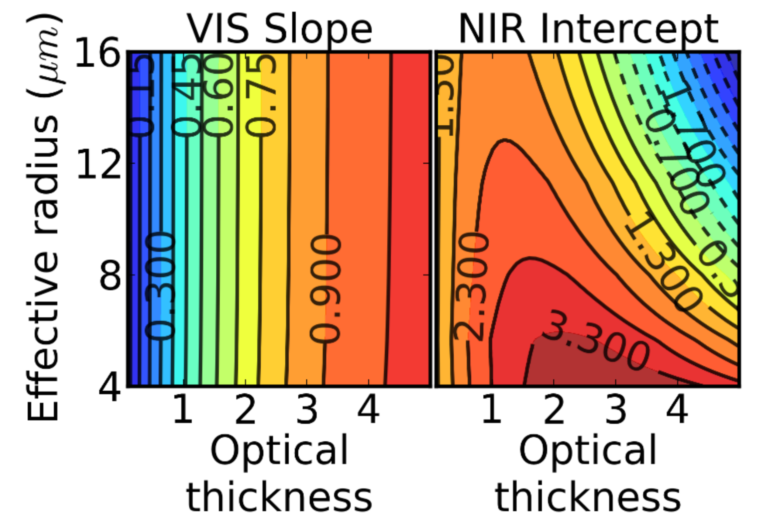


2) Approach

- Slope and intercept of a regression line in VIS and NIR provide ***quantitative*** information about cloud optical depth and droplet size.

$$\frac{I_\lambda(t_{\mathrm{transition\_zone}})}{I_\lambda(t_{\mathrm{known\_clear}})} = \frac{I_\lambda(t_{\mathrm{known\_cloudy}})}{I_\lambda(t_{\mathrm{known\_clear}})} a + b$$

- Using ratio to a known clear sky spectrum ***mitigates*** the spectral effects of aerosols and surface.
- The NIR intercept provides the qualitative change in cloud droplet size ***with ~75% confidence***.



4) Publication

McBride et al., *Study of droplet size variability between cloudy and clear air using ARM surface-based hyperspectral observations*, Journal of Geophysical Research, Submitted, 2014.

ASR
Atmospheric System Research

Impact of Indirect Effects and Mixing Mechanisms on Observed Cumulus Properties during RACORO

Greg McFarquhar and Hee-Jung Yang, University of Illinois

Science Question

How do droplet concentration (N_{CAS})/spectra, liquid water content and effective radius (r_{eff}) change with aerosol concentration (N_{PCASP}) and vertical velocity (w_{MAX}), & what processes explain how these changes occur?

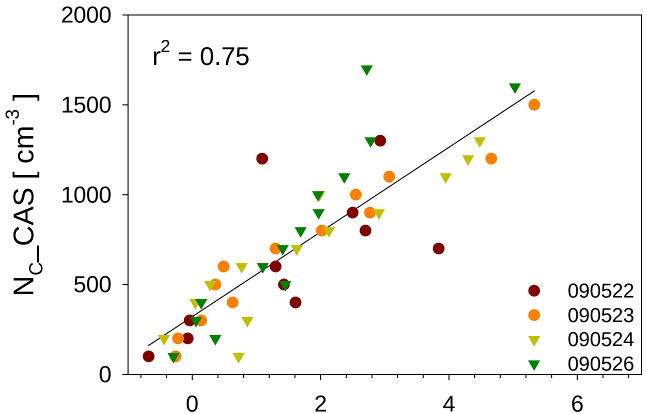
Approach

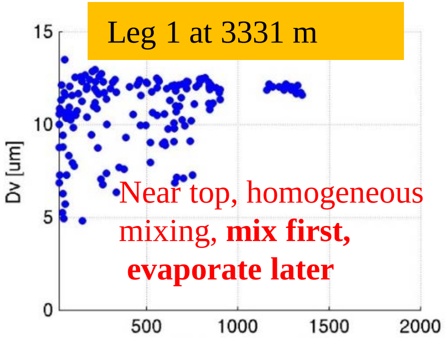
- Determine average property of 2,337 cumuli sampled during RACORO
- Determine aerosol properties unperturbed by cloud field (>150 m from cloud)
- Examine correlation between cloud properties with aerosol amount and vertical velocity for different meteorological regimes

Key Result

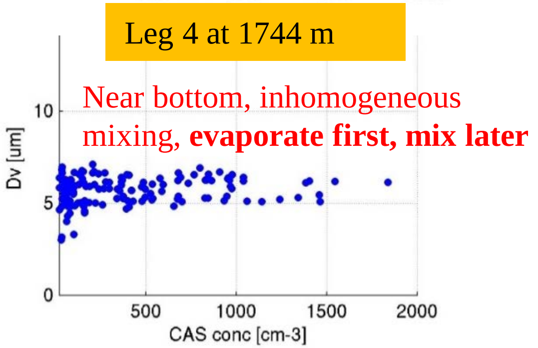
- As N_{PCASP} ↑, N_{CAS} →
- AS N_{PCASP} ↑, r_{eff} →
- As W_{MAX} ↑, N_{CAS} ↑
- Vertical velocity is more dominant than aerosol effect in determining cloud droplet number concentration !

Relationship between N_{CAS} & w_{MAX}





Near top, homogeneous mixing, **mix first, evaporate later**



Near bottom, inhomogeneous mixing, **evaporate first, mix later**

Mixing Mechanisms:

Mixing becomes more homogeneous with height

Future Work:

- Stratified RACORO data into 5 different meteorological regimes depending on air mass type
- Analysis to be conducted for each regime separately

Improving Estimates of Cloud Condensation Nuclei Concentration

Objective

To gain deep insight into the relationship between CCN concentration and aerosol quantities and improve the estimation of the CCN concentration from aerosol optical quantities measurements

Approach

- Study the relationship for some distinct aerosol types using data from five ARM CRF sites around world.
- Analyze the potential influential factors to determine their influences on the CCN-aerosol optical quantities relationship.

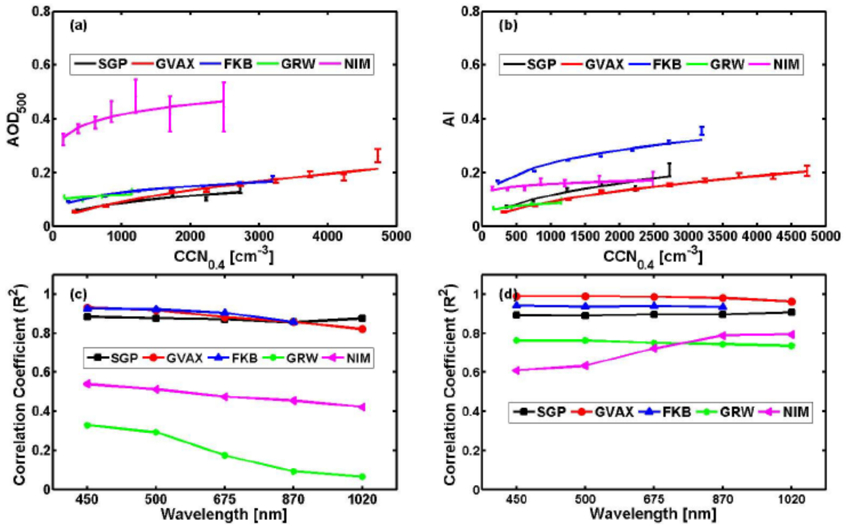


Fig. 1. (a) Relationship between AOD at 500 nm and $CCN_{0.4}$, **(b)** relationship between AI and $CCN_{0.4}$ **(c)** their correlation coefficients, and **(d)** same as **(c)**, but for AI in lieu of AOD.

Key Accomplishment

- Aerosol index (AI) at shorter wavelengths is a better proxy for CCN.
- The aerosol hygroscopicity has a weak effect on the relationship, while relative humidity and single scattering albedo has a significant influence.
- A parameterization of CCN concentration, valid for rural continental regions, is developed.

Publication

Liu, J., and Z. Li, 2014: Estimation of cloud condensation nuclei concentration from aerosol optical properties: influential factors and uncertainties, Atmos. Chem. Phys., 14, doi:10.5194/acp-14-471-2014.

3D observations of clouds using scanning radar and radiances

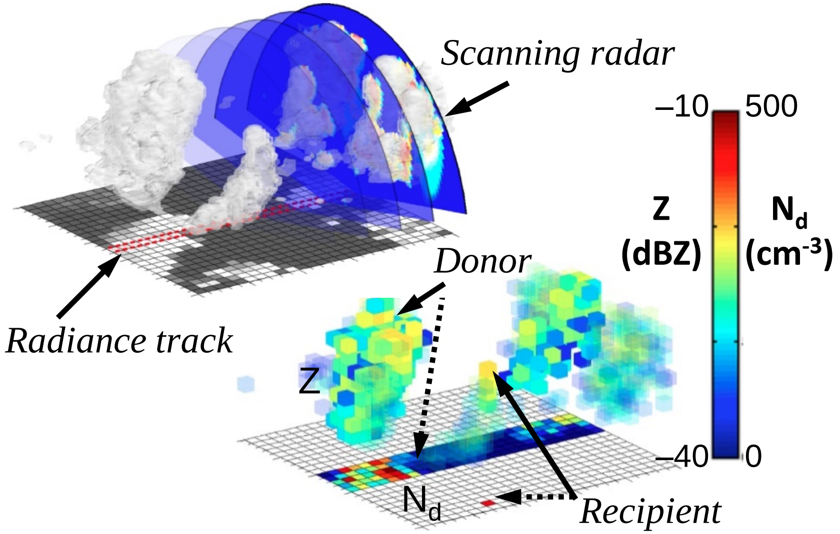
Mark Fielding, Christine Chiu, Robin Hogan / University of Reading
Graham Feingold / NOAA

Science Question

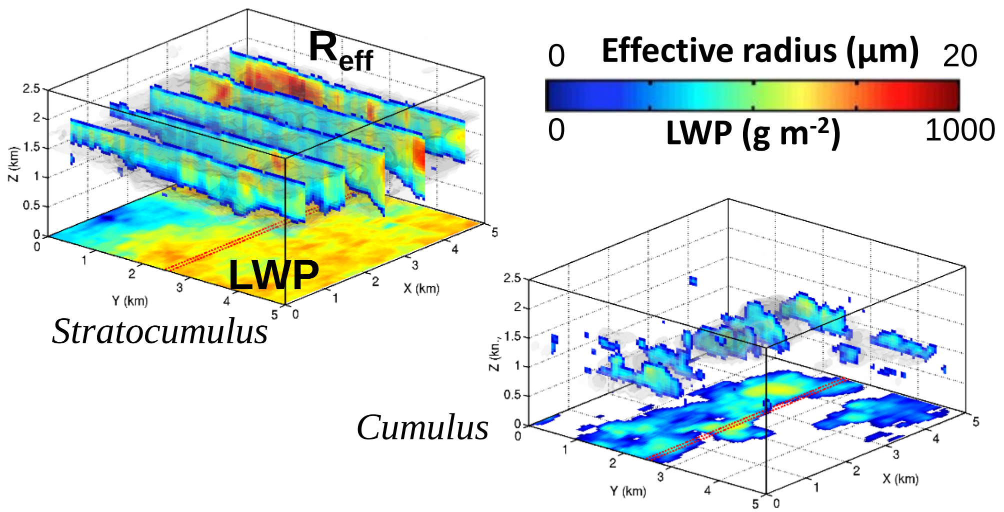
- How do 3D observations of warm clouds reshape our understanding of interactions between aerosol, cloud, precipitation and radiation?

Method

- Novel approach that combines scanning ARM cloud radars (SACR) and zenith radiances (SAS-Ze/2NFOV)
- Uses an iterative Ensemble Kalman Filter, which provides full error statistics, with a 3D radiative transfer forward model



Example: 3D cloud fields on 21 Nov. AMF1 (Azores)



Key Accomplishment

New **3D LWC, Reff** and **2D N_d** retrievals in both overcast and broken sky conditions – critical observables for studying cloud processes and aerosol indirect effects

Publication

Fielding et al., 2013: 3D cloud reconstructions: Evaluation of scanning radar scan strategy with a view to surface shortwave radiation closure, *J. Geophys. Res.*

Fielding et al., 2014: A novel ensemble method for measuring cloud properties in 3D using ground-based scanning radar and radiances, submitted to *J. Geophys. Res.*

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System Research

Marine and continental Low cloud properties

Xiquan Dong / University of North Dakota

Science Question

- What are similarities and differences of low cloud properties between marine and continent?

Key Accomplishment

At Azores: MBL cloud layer is shallow, thin and warm with large *LWP* and *LWC* during summer. During winter, however, it is deep, thick and cold with less *LWP* and *LWC*. (ARM PI product)

At SGP: Opposite to those at Azores

Low-level cloud layer is deeper, thicker, and warmer with less *LWP* and *LWC* during summer than those during winter.

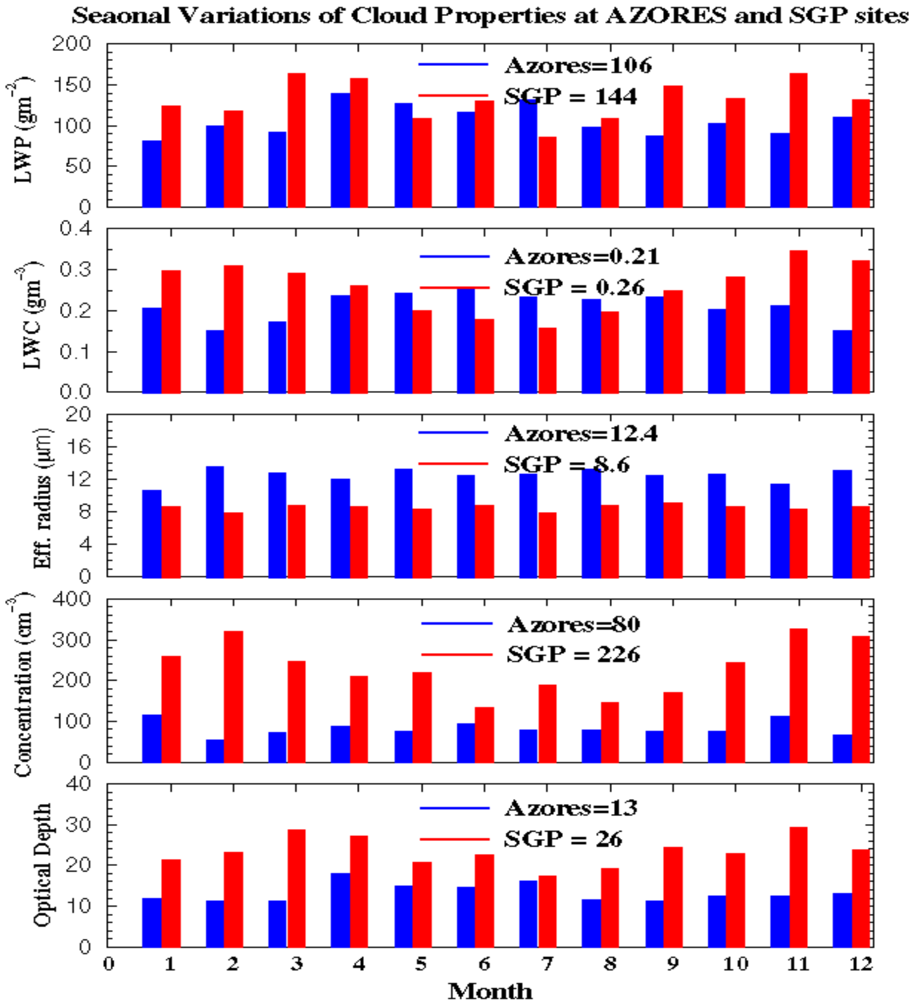
Challenge: What processes control these similarities/differences? Can we model them?

Publication

Dong et al. (2014): A 19-month Record of Marine Aerosol-Cloud-Radiation Properties derived from DOE ARM AMF deployment at the Azores: Part I: Cloud Fraction and Single-layered MBL cloud Properties. J. Clim. DOI: 10.1175/JCLI-D-13-00553.1.

Dong et al. (2005): A climatology of midlatitude continental clouds from ARM SGP site. Part I: Low-level Cloud Macrophysical, microphysical and radiative properties. *J. Climate*. 18, 1391-1410.

Seasonal Variation of cloud microphysical properties at Azores and SGP sites



A New WRF-Chem Treatment for Studying Cloud-Aerosol Interactions in Parameterized Cumuli

Larry Berg/Pacific Northwest National Laboratory

Change in Column Integrated Aerosol Mass Loading

BC

Sulfate

Increase in sulfate due to shallow cumuli

OA

46°N
44°N
42°N
40°N
38°N
36°N
°N

Reduction in BC due to wet removal

Fractional Difference in Column Integrated mass Loading

WRF-Chem simulations valid at 20 UTC on 25 June, 2007

Science Question

What are the regional scale impacts of cloud-aerosol interactions?

Approach

Develop a new treatment of cloud-aerosol interactions in WRF-Chem for both shallow and deep cumuli. Modifications to the model include calculations for:

- Cloud droplet number mixing ratio
- Cloud microphysical (conversion rates, and cloud water and cloud ice mixing ratios) and macrophysical (updraft fractional area, updraft and downdraft mass fluxes, and entrainment) properties
- Vertical transport, activation/resuspension, aqueous chemistry and wet removal of aerosol and trace gases.

Key Accomplishments

- A new tool for studying regional scale impacts of cloud-aerosol interactions has been developed.
- Results show that cloud-aerosol interactions leads to a: decrease in BC, sulfate and OA in precipitating clouds due to wet removal and an increase in sulfate aerosol in regions with shallow, nonprecipitating cumuli.
- Simulated aerosol chemical composition and indirect effects are consistent with observations.

Publication

Berg, L.K., et al., 2014: A new WRF-Chem treatment for studying regional scale impacts of cloud-aerosol interactions in parameterized cumuli. Submitted to *Geophysical Model Development Discussions*.

CAPI Science Questions

1. What processes control diversity in the sensitivity of warm low clouds to aerosol perturbations, and why do GCMs seem to overestimate the sensitivity?
2. What aerosol-related processes control deep convective cloud properties relevant to climate (precipitation, cloud radiative forcing, latent heating profiles)?
3. What processes control ice nucleation and its impact on ice-containing clouds (e.g., Arctic stratus, altostratus, cirrus, convective clouds)?

Additional accomplishments

Constraining links between aerosols and deep convection properties

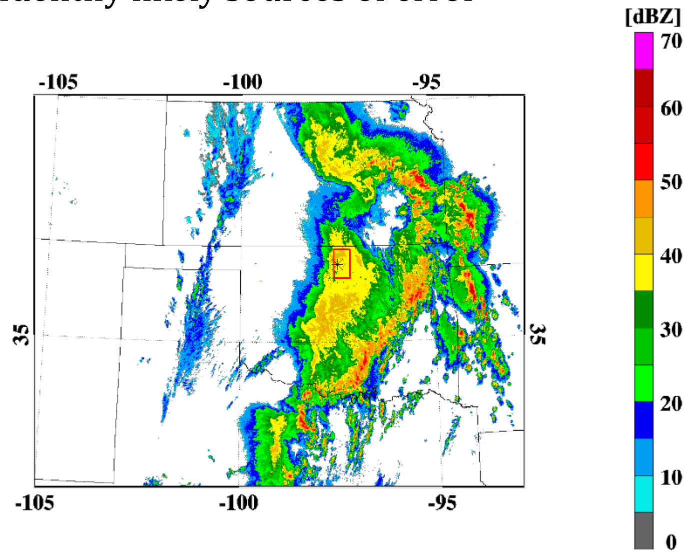
Wei-Kuo Tao and Ann Fridlind / NASA GSFC

Science Question

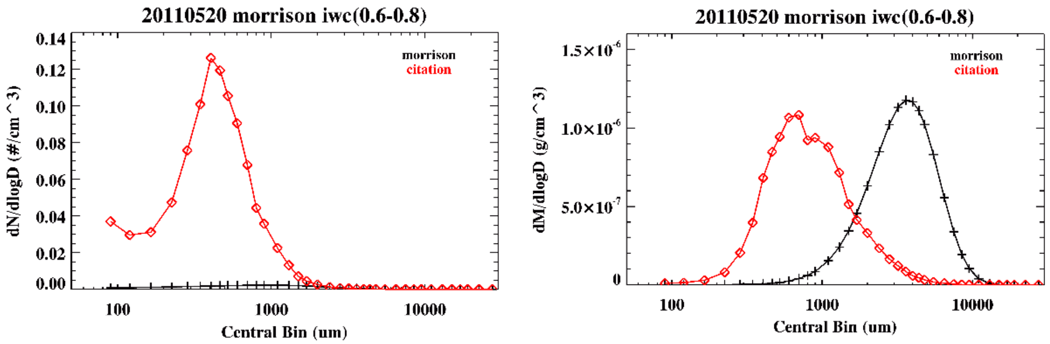
Are state-of-the-art cloud-resolving models accurately simulating the fundamental links between aerosol and microphysical properties of deep convection?

Approach

- Simulate cases of deep convection observed during MC3E
- Compare simulated ice size distributions over extensive stratiform rain regions that are robustly sampled by aircraft
- Identify likely sources of error



Example simulation biased towards too few and too large ice



Key Accomplishment

Comparison of NU-WRF simulated versus observed ice size distribution properties in objectively identified stratiform regions in May 20th case. Future work: test likely sources of error in sensitivity test simulations.

Publication in preparation

Co-authors: GSFC—Tao, Xiaowen, Wu; GISS—Fridlind; UND—Dong; UIUC—McFarquhar, Wu

ASR Atmospheric System Research

Model evaluation of aerosol wet scavenging in deep convective clouds based on observations collected during the DC3 campaign

Qing Yang / Pacific Northwest National Laboratory

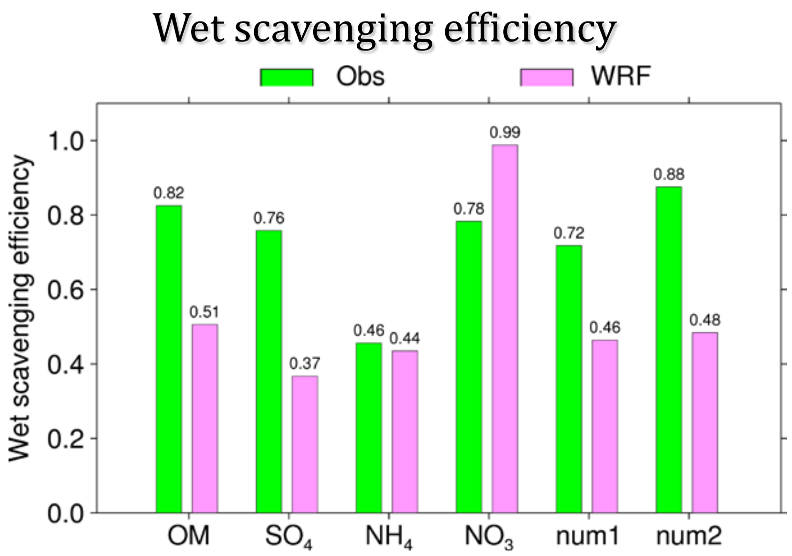
Science Question

What are the aerosol wet scavenging efficiencies of convective storms and how to estimate them from flight observations.

How well does WRF-Chem simulate aerosol wet scavenging efficiency during convective storms.

Approach

- Build a novel four layer framework to estimate the mass transport of long-lived insoluble gases during convection.
- Estimate wet scavenging efficiency using one minus the ratio of the observed concentration to the estimated aerosol concentration (using the budget analysis) at the anvil.
- Compare wet scavenging efficiencies between observations and the simulations.


Wet scavenging efficiency

Key Accomplishment

High scavenging efficiencies (~80%) for aerosol number (Dp<2.5µm) and mass (Dp<1µm) are obtained from the observations. There is little chemical selectivity to wet scavenging, and slightly higher scavenging efficiency is found for larger particle sizes (0.15-2.5µm versus 0.03-0.15 µm). The scavenging efficiency is comparable between aerosol mass and number.

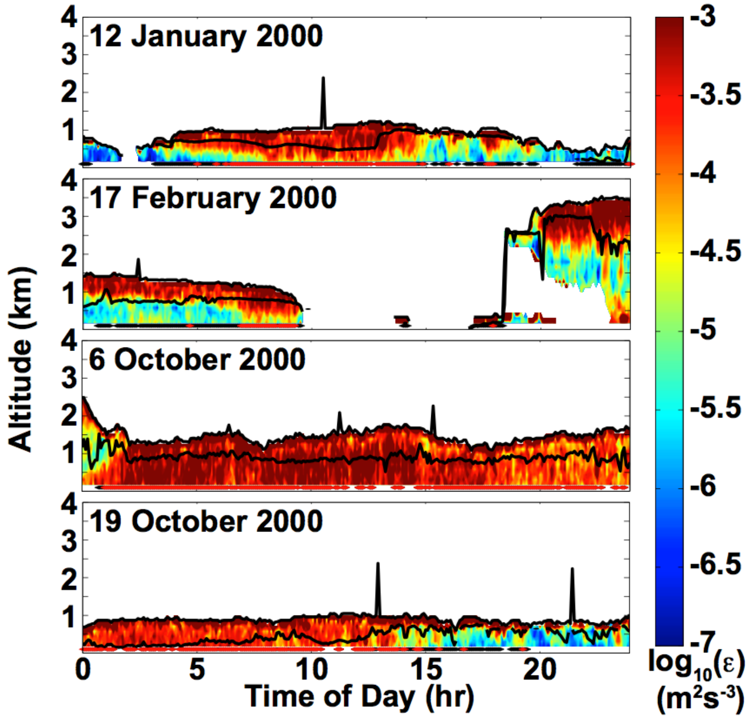
The model underestimates the wet scavenging efficiency, in general, which is quite likely due to neglect of secondary activation above cloud base, which will be implemented.

Evaluating Aerosol Effects in Thin, Liquid-Containing Arctic Clouds

Gijs de Boer/ University of Colorado

Science Question

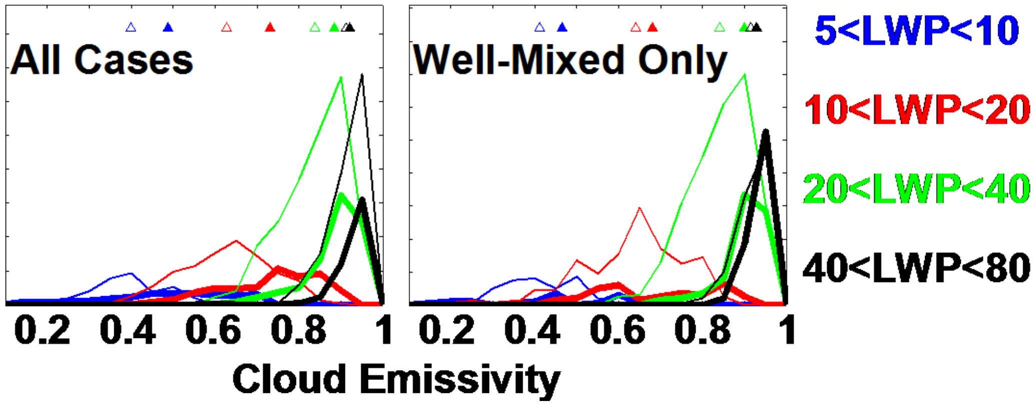
Are previous attempts to quantify the impact of aerosol concentration on liquid cloud emissivity at high latitudes hampered by a disconnect between surface aerosol measurements and in-cloud processing?



Examples of turbulent dissipation rates derived using ground based remote sensors. These dissipation rates are used to define "well-mixed" lower atmospheres.

Approach

- Use surface-based remote sensors to evaluate the lower atmospheric mixing state (Shupe et al., 2013) for 2000-2003 liquid-containing cloud cases at NSA.
- Estimate cloud emissivity using AERI and other instrumentation (Garrett and Zhao, 2013)
- Evaluate the influence of lower atmospheric mixing on estimation of AIE for Arctic clouds



PDFs of cloud emissivity, binned by LWP, for all cases observed at NSA between 2000-2003 (left), and for cases characterized as having a well-mixed lower atmosphere (right)

Preliminary Results

Initial evaluations reveal little difference in calculated AIE when using surface-based aerosol measurements in well-mixed and stable environments. This is puzzling and requires further study.

ASR Atmospheric System Research

Implications of new IN parameterizations using CAM5

Gourihar Kulkarni/ Pacific Northwest National Laboratory

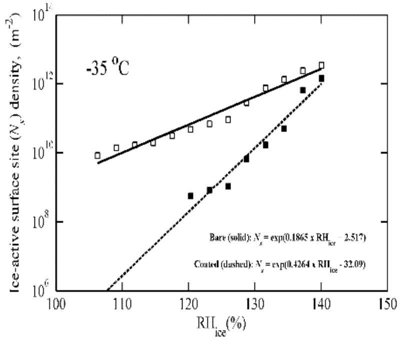
Science Question

It is unknown how coated dust particles influence ice cloud properties such as ice number concentration and ice water content, and are important to understand in order to simulate accurate ice phase in a cloud model.

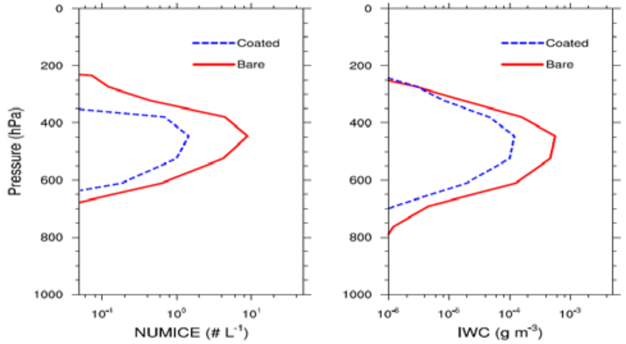
Approach (measurements to model)

- ✓ Laboratory experiments on various acid coated dust species were performed to derive ice nucleation parameterizations (a).
- ✓ Structural (lattice) properties of bare and coated dust particles were calculated.
- ✓ Single column model of CAM5 was used to test these new parameterizations.
- ✓ Ice number concentration and ice water content were simulated (b).

Sensitivity of cloud properties (N_{ice} and IWC) towards bare and coated dust particles



(a)



(b)

Key Accomplishment

Simulations show that coated dust had reduced cloud properties compared to bare dust particles in deposition mode of ice nucleation. This may influence ice optical depth and precipitation.

Publication

Kulkarni et al., (2014) Ice nucleation of bare and sulfuric acid coated mineral dust particles and implication for cloud properties, J. Geophys. Res., (under review).

Cloud Processing of CCN

Jim Hudson, Desert Research Institute

Science Question

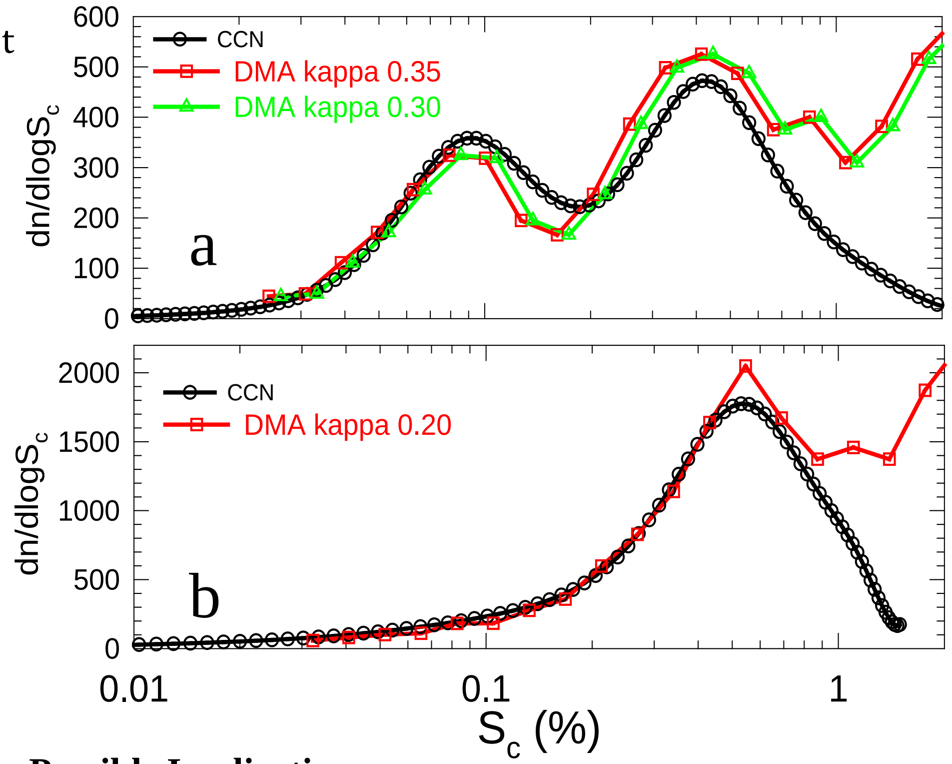
What might below-cloud CCN spectra reveal about cloud microphysics and aerosol composition?

Observations

DMA spectra have been used to infer cloud S from bimodal spectra often found below maritime stratus. The larger mode is thought to be due to chemical or physical cloud processing. However, to transpose size to S particle solubility (kappa) is required. Panel A shows that detailed CCN spectra also reveal bimodality that provides cloud S directly from the minimum (0.18%) between the modes without knowledge of composition. Kappa that produces the best agreement of simultaneous DMA spectra with CCN spectra provides particle solubility. Chemical processing should increase solubility of the cloud processed mode but here kappa appears lower for the cloud processed mode (lower S_c).

Panel B shows that bimodality was not always observed below these solid stratus. Measurements in cumulus projects (RICO, ICE-T) show that cloud processing (bimodality) is not restricted to stratus clouds.

MASE under stratus decks off California, July 2005



Possible Implications

1. Cloud droplet conc. can be inferred from subcloud CCN spec.
2. CCN solubility can be continuously monitored from CCN and DMA.
3. All types of clouds seem to process CCN.
4. Air below clouds may not be so well-mixed.
5. Lower S_c cloud-processed CCN might preclude other CCN from forming droplets, thus reducing droplet concentrations.
6. Cloud processing may be more physical than chemical.

Manuscript is being written

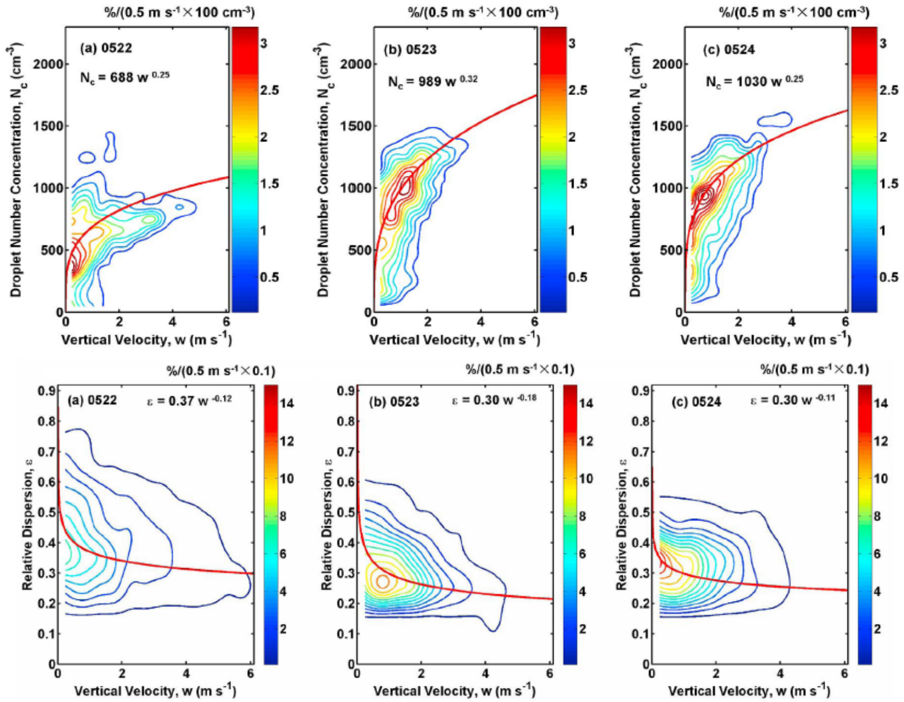
Impacts of Vertical Velocity on Microphysics and Implications for Aerosol Indirect Effects

Yangang Liu/Brookhaven National Laboratory

Motivation: One reason for the uncertainty in aerosol indirect effects is that aerosol effects are intertwined with changes in other factors, such as vertical velocity. Separating aerosol effects from dynamical effects poses a confounding challenge, esp. to observational studies.

Approach: Use different influences of updraft and aerosols on cloud droplet number concentration, relative dispersion and their relationships to untangle the dominant effects. Simultaneous measurements of vertical velocity and cloud droplet size distributions in cumuli collected during the RACORO field campaign are analyzed.

Key Result: Effect of vertical velocity on relative dispersion and its relationship with droplet concentration is opposite to that associated with aerosol loading. The opposing relationships can be used to help discern the relative importance of aerosol and dynamical effects.

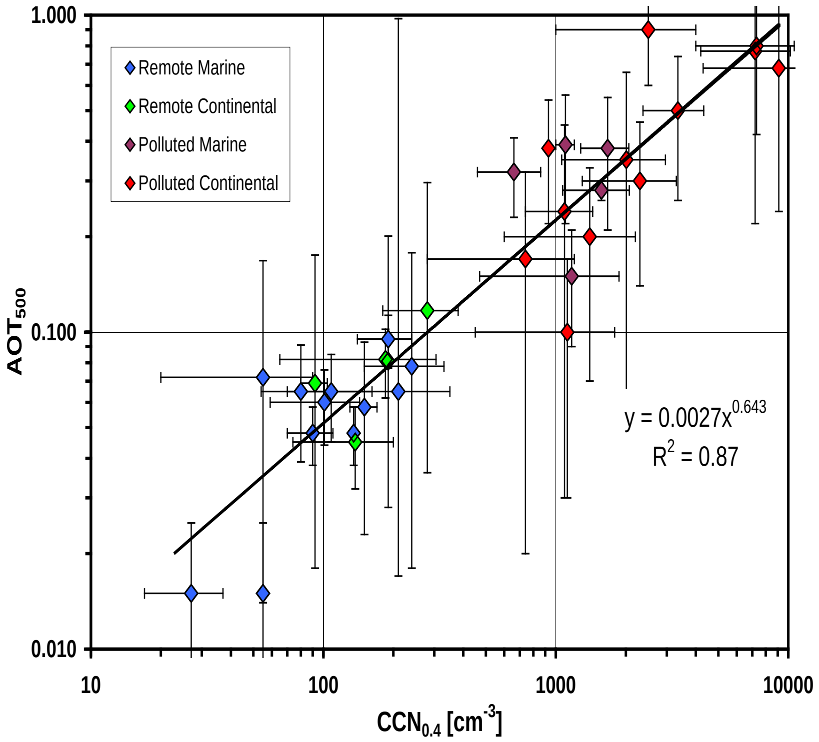


Droplet concentration (top) and relative dispersion (bottom) as a function of vertical velocity. The data are from cumulus flights during the RACORO experiment. Color (contour) represents frequency of occurrence; red lines denote weighted least squares power-law fits of the data. The results agree with the theoretical prediction of updraft effects on droplet concentration and relative dispersion, leading a relationship contrasting that induced by aerosol-dominated variation.

Publication: Lu, C., Y. Liu, S. Niu, and A. M. Vogelmann (2012), Observed impacts of vertical velocity on cloud microphysics and implications for aerosol indirect effects, Geophys. Res. Lett., 39, L21808, doi:10.1029/2012GL053599

Use of Multiple AMF Data for Improving Estimation of Cloud Condensation Nuclei Concentration (Li, University of Maryland)

To gain a deep insight into the relationship between CCN concentration and aerosol quantities for improving the estimation of the CCN concentration from aerosol optical quantities measurements



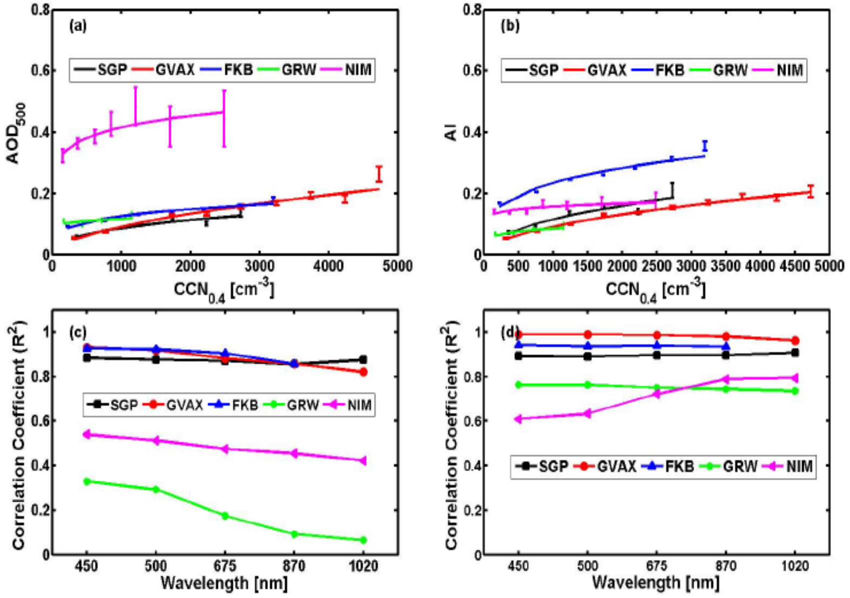


Fig. 1. (a) Relationship between AOD at 500 nm and CCN$_{0.4}$, **(b)** relationship between AI and CCN$_{0.4}$ **(c)** their correlation coefficients, and **(d)** same as **(c)**, but for AI in lieu of AOD.

Publication

Liu, J., and Z. Li, 2014: Estimation of cloud condensation nuclei concentration from aerosol optical properties: influential factors and uncertainties, Atmos. Chem. Phys., 14, doi:10.5194/acp-14-471-2014.

Satellite Retrieving CCN using convective clouds as CCN Chambers

Daniel Rosenfeld, The Hebrew University of Jerusalem

CCN chambers measure the supersaturation (**S**) and number of activated CCN (N_a).

Clouds provide **CCN(S)** along the following steps:

1. N_a is retrieved from the shape of **T-r_e** (cloud top temperature – drop effective radius) relationships and cloud base temperature, T_b.
2. **S** is calculated from the knowledge of **Na** and **Wb** (Cloud base updraft). **Wb** is retrieved from the difference between surface skin and air temperatures and wind speed.

We have validated N_a and W_b against the SGP measurements, thus approaching proving the concept of satellite retrieving CCN(S).

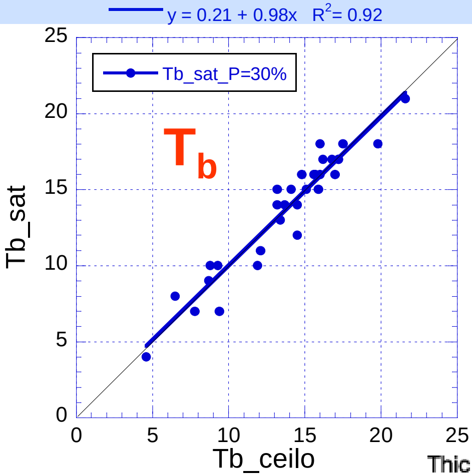


Figure 2: Validation of VIIRS retrieved cloud base temperature (°C) (Tb_sat) against SGP cielometer and sounding measurements.

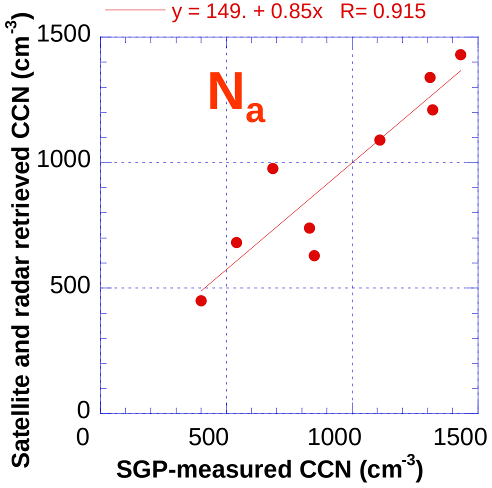


Figure 1: Validation of the retrieved CCN against surface measurements at the SGP for all the available cases. N_a is retrieved by satellite. Cloud base T and W_b are still measured by SGP lidar, sounding and radar.

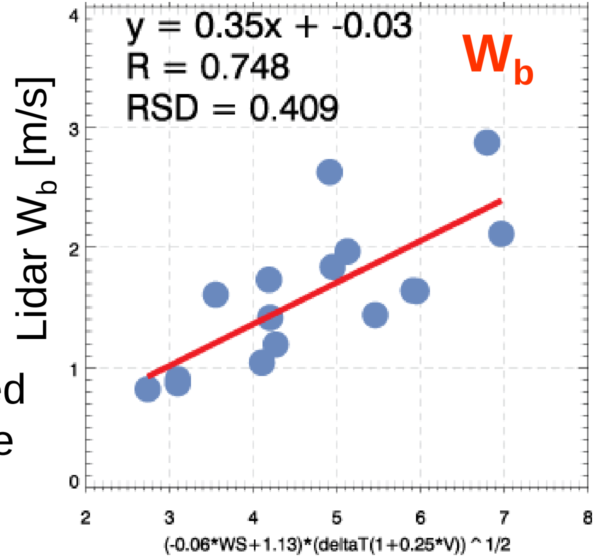


Figure 3: Variation of lidar-Measured Cu cloud base updraft with Ground-air temperature difference (Ts-Ta) and with the surface and cloud base wind speeds.