

# SPEC inc

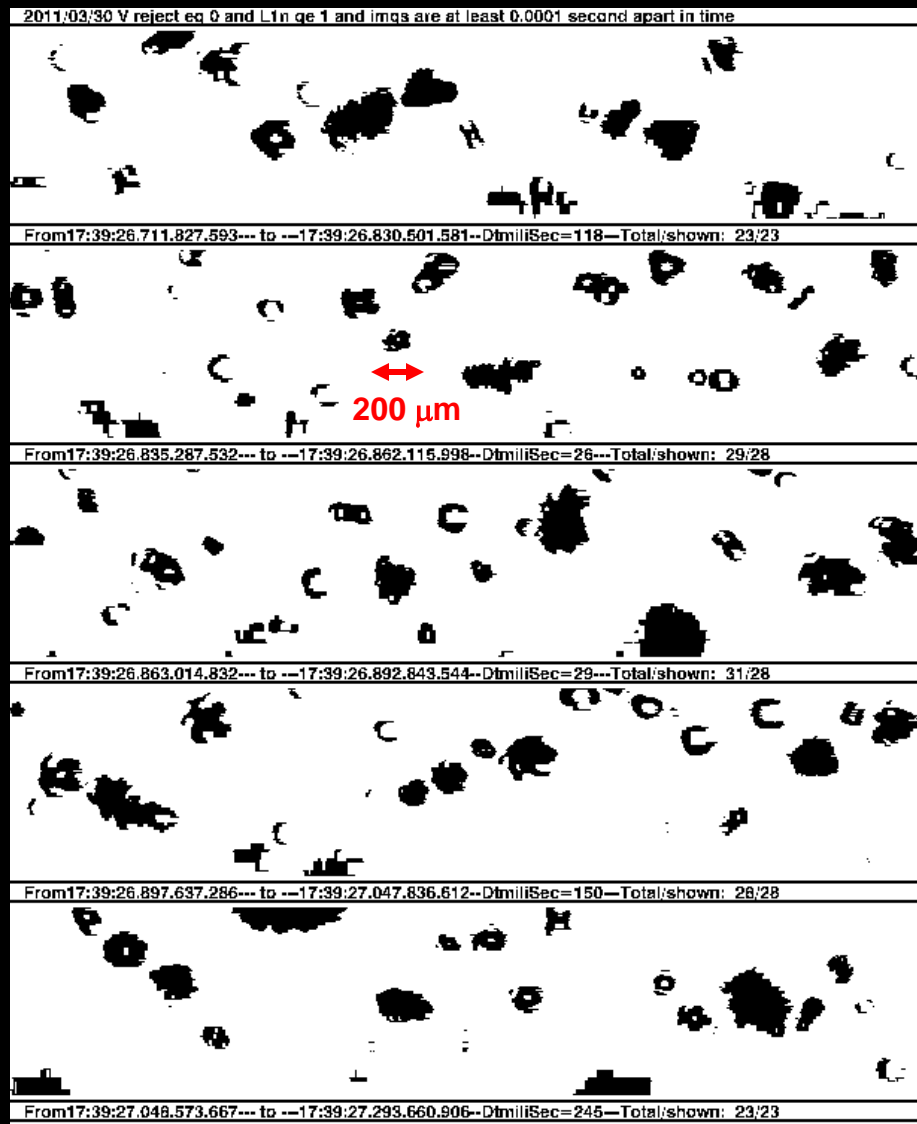
## Use of Tethered Balloons and UAV's to Measure Microphysics and Radiation in Polar Mixed-Phase Clouds

Paul Lawson

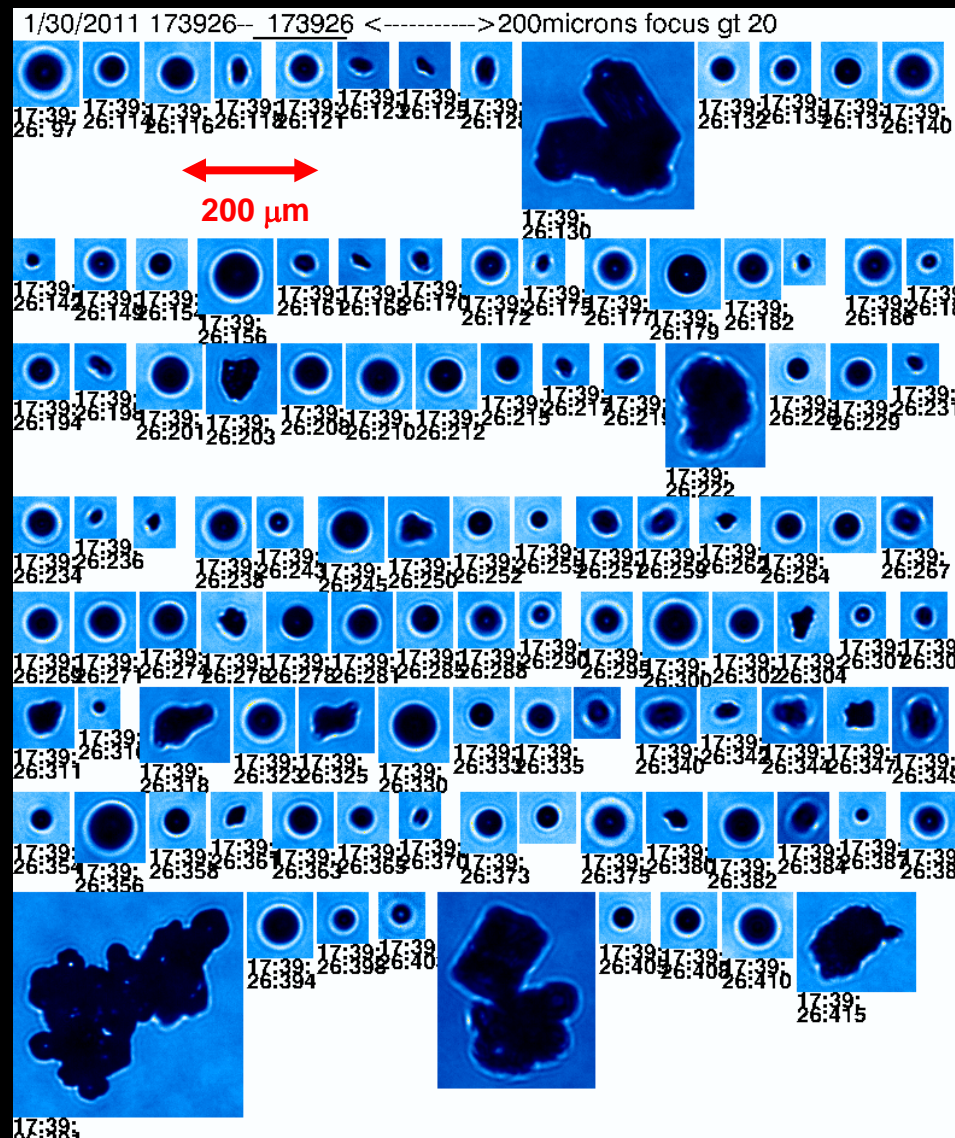


DOE ASR Science Team Meeting  
Washington, D.C. 2 - 6 May 2016

# An Example of 2D-S Images in (Mixed-phase?) Cloud



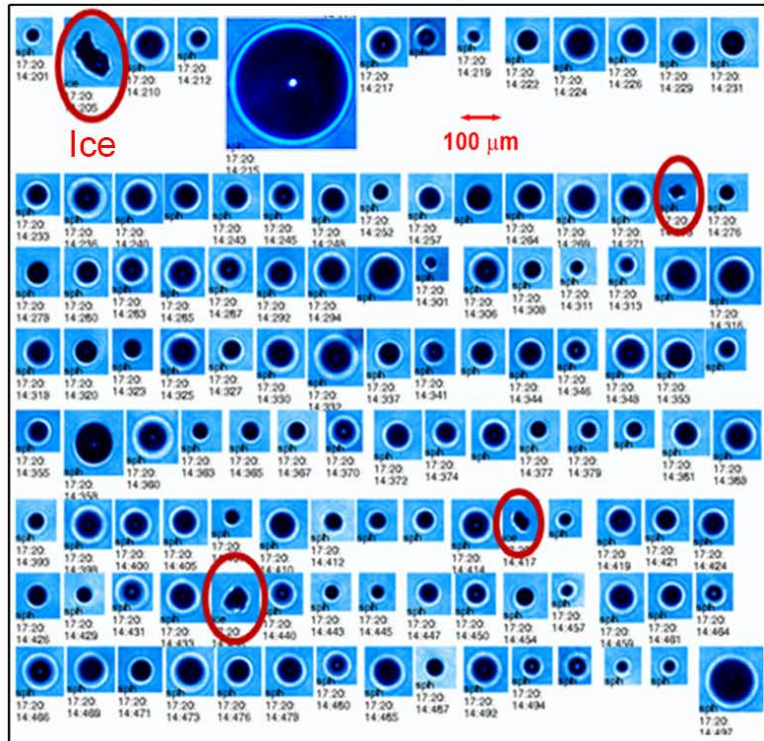
# Simultaneous CPI Images Show Several Supercooled Drops



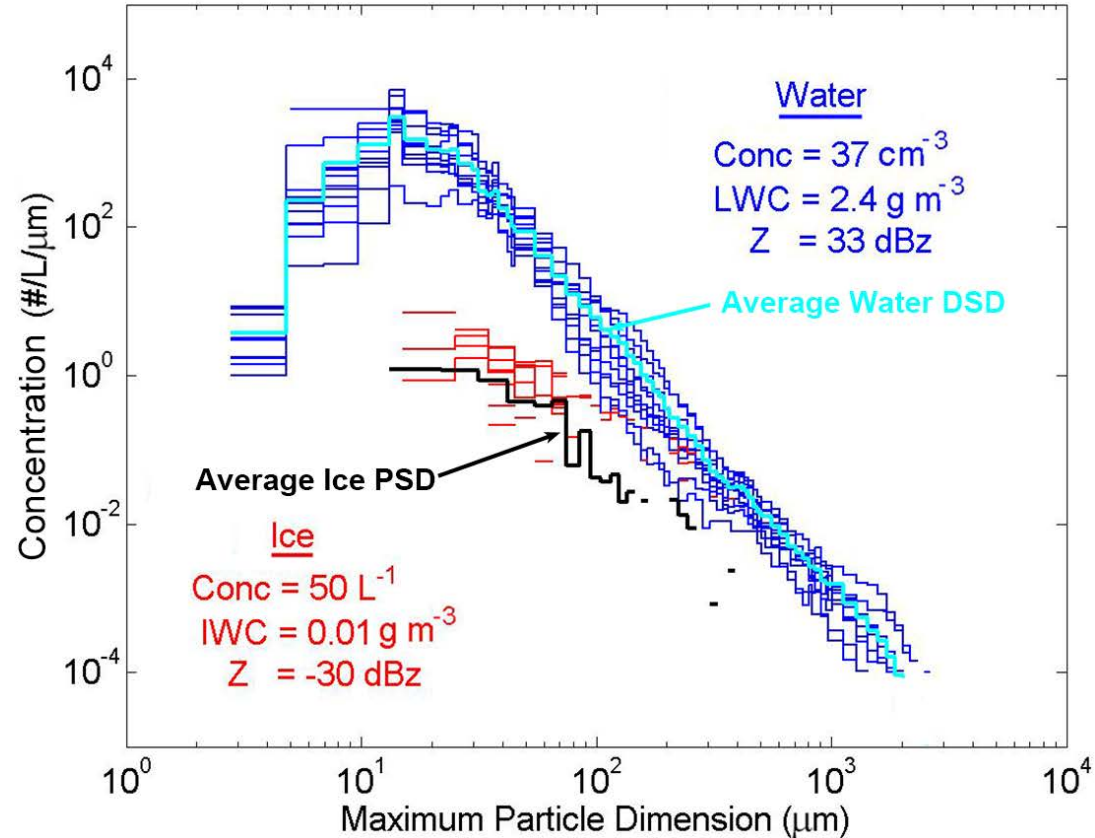
# The "Best" (and perhaps the only) way to Distinguish Ice and Water in Mixed-Phase is with High-Resolution Imagery

From Lawson et al. (2015) JAS

CPI Images in "First Ice Region" on 7-30-2011



Liquid and Ice PSD's in the "First Ice Region" (-8 to -12  $^{\circ}\text{C}$ )

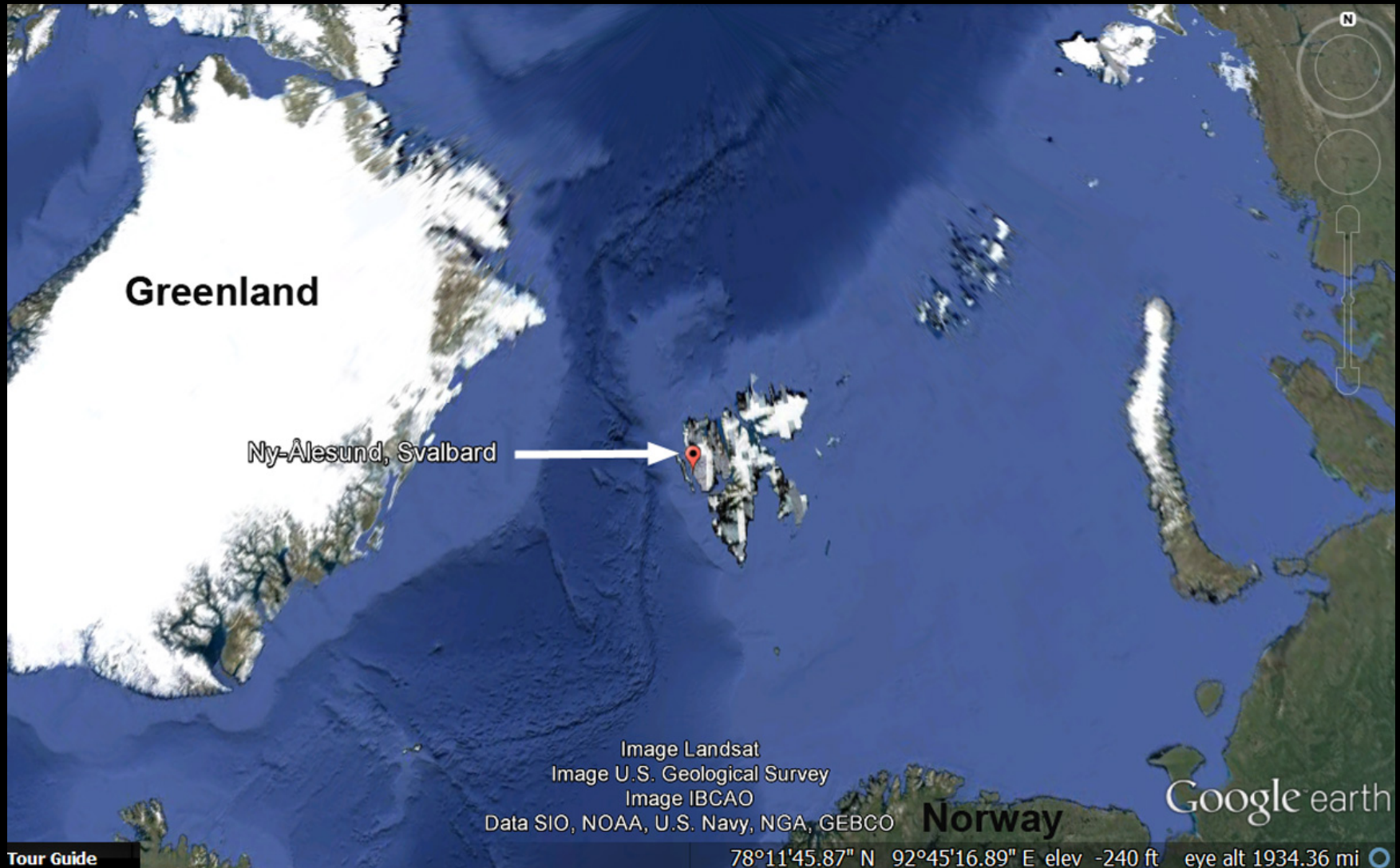


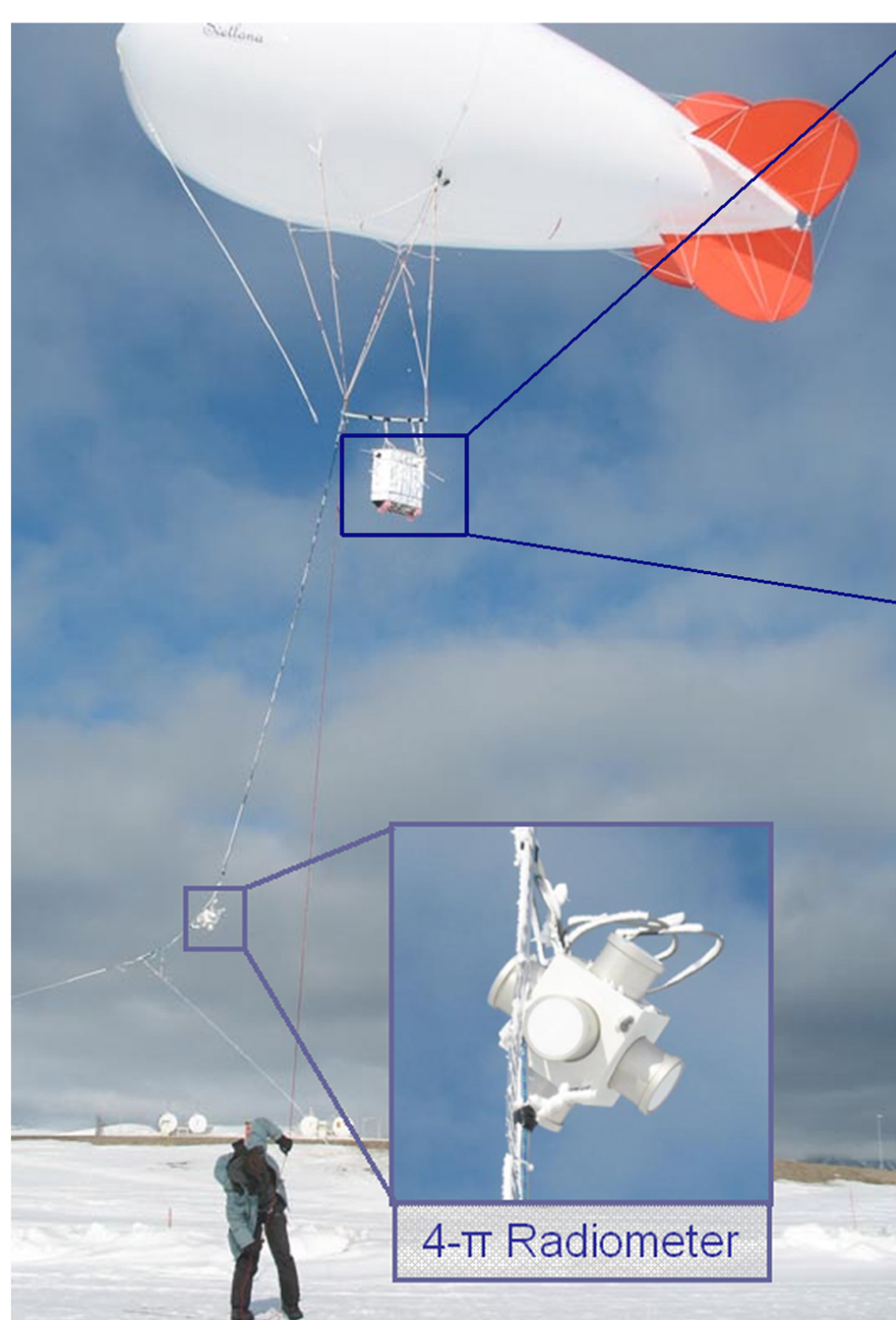
Other Techniques, i.e., SID, CAS-POL, AIITS all Produce "False Irregulars" in Warm All-Water Clouds

# Tethered Balloon Deployments

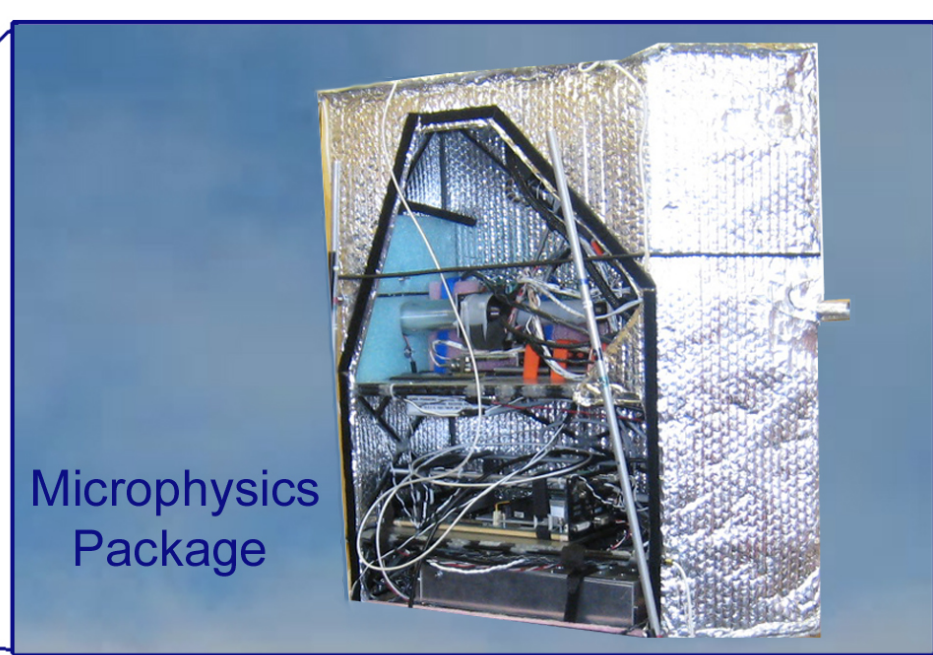
- 2008: Deployment of 43 m<sup>3</sup> Tethered Balloon System (TBS) with CPI and 4- $\pi$  SWL radiometer at Ny-Ålesund During Thorpex. First successful measurements of microphysics and radiative parameters in mixed-phase clouds.
- 2009: Deployment of TBS with CPI, frost point hygrometer and IN filters at South Pole in mixed-phase clouds.
- 2012: Deployment of 74 m<sup>3</sup> balloon at Oliktok Point (ALTOS) and loss of balloon.
- 2013 - 2014: DOE/SBIR-Funded Development of new deployment system and instrument package based on lessons learned from ALTOS with Successful Deployments at Ft. Carson Army Base.

# First Deployment in May 2008 at Ny-Ålesund in the Svalbard Archipelago





4- $\pi$  Radiometer

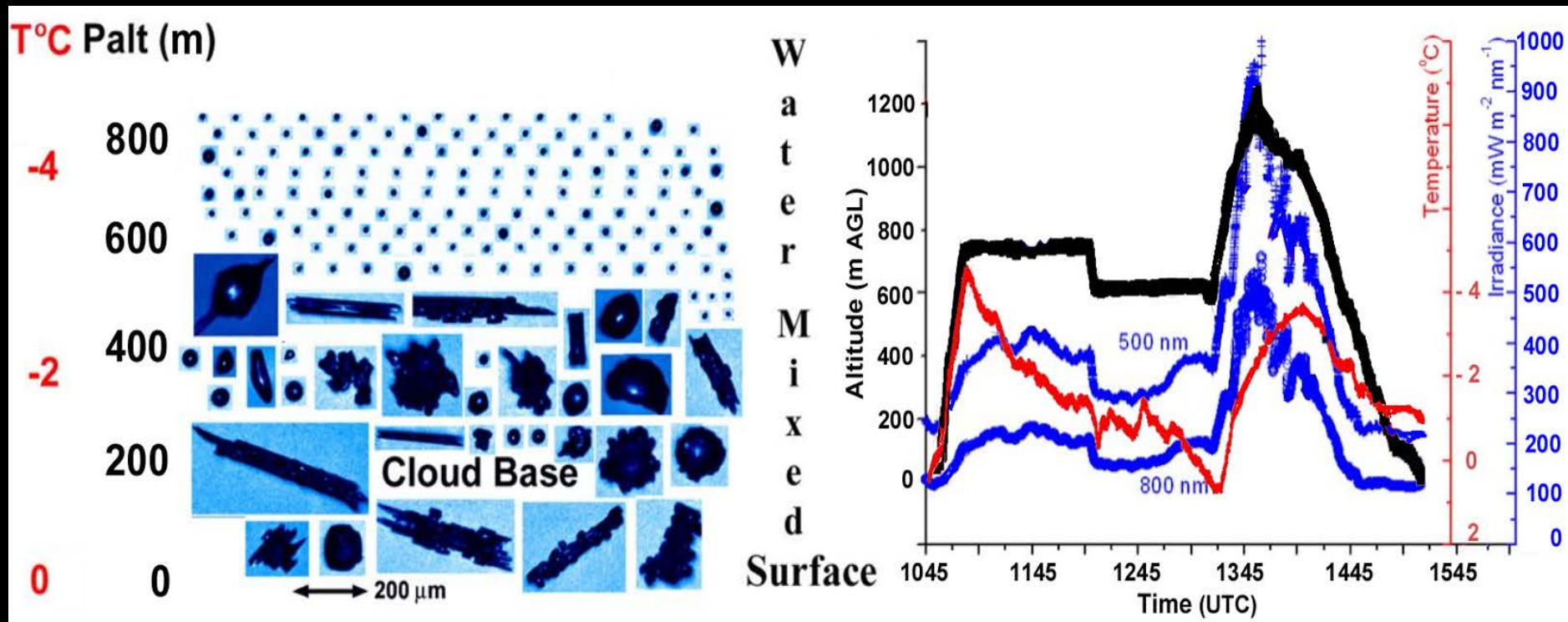


Microphysics Package

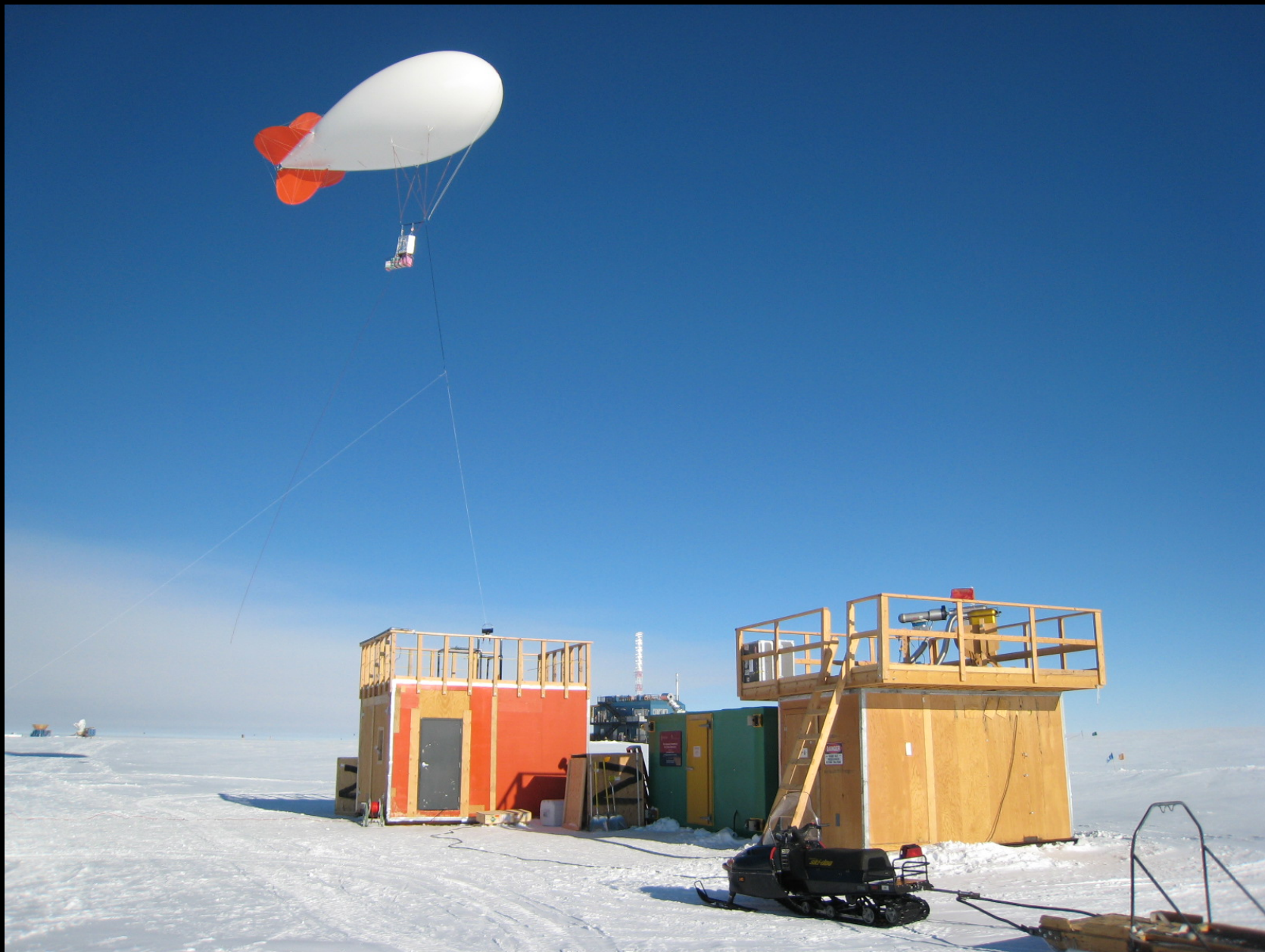


# May 29 Descent and then Ascent in Mixed-Phase Cloud at Ny-Alesund

Sikand et al. (2010)



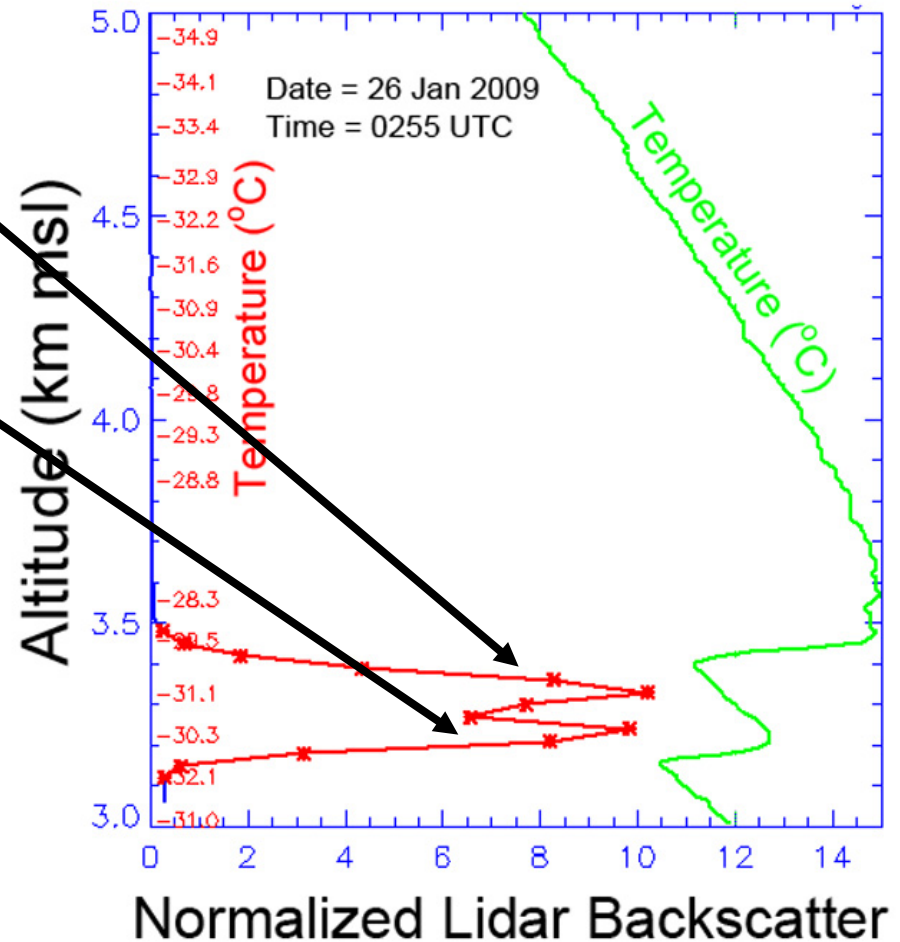
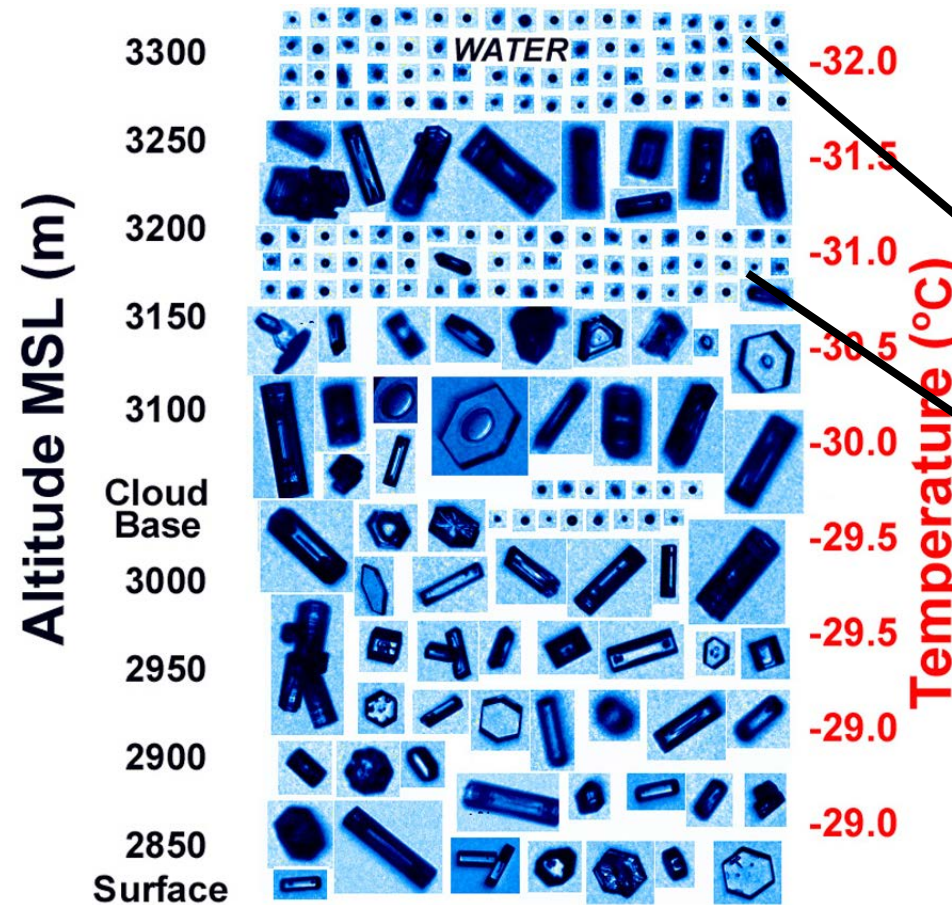
# January - February 2009 Deployment at the South Pole



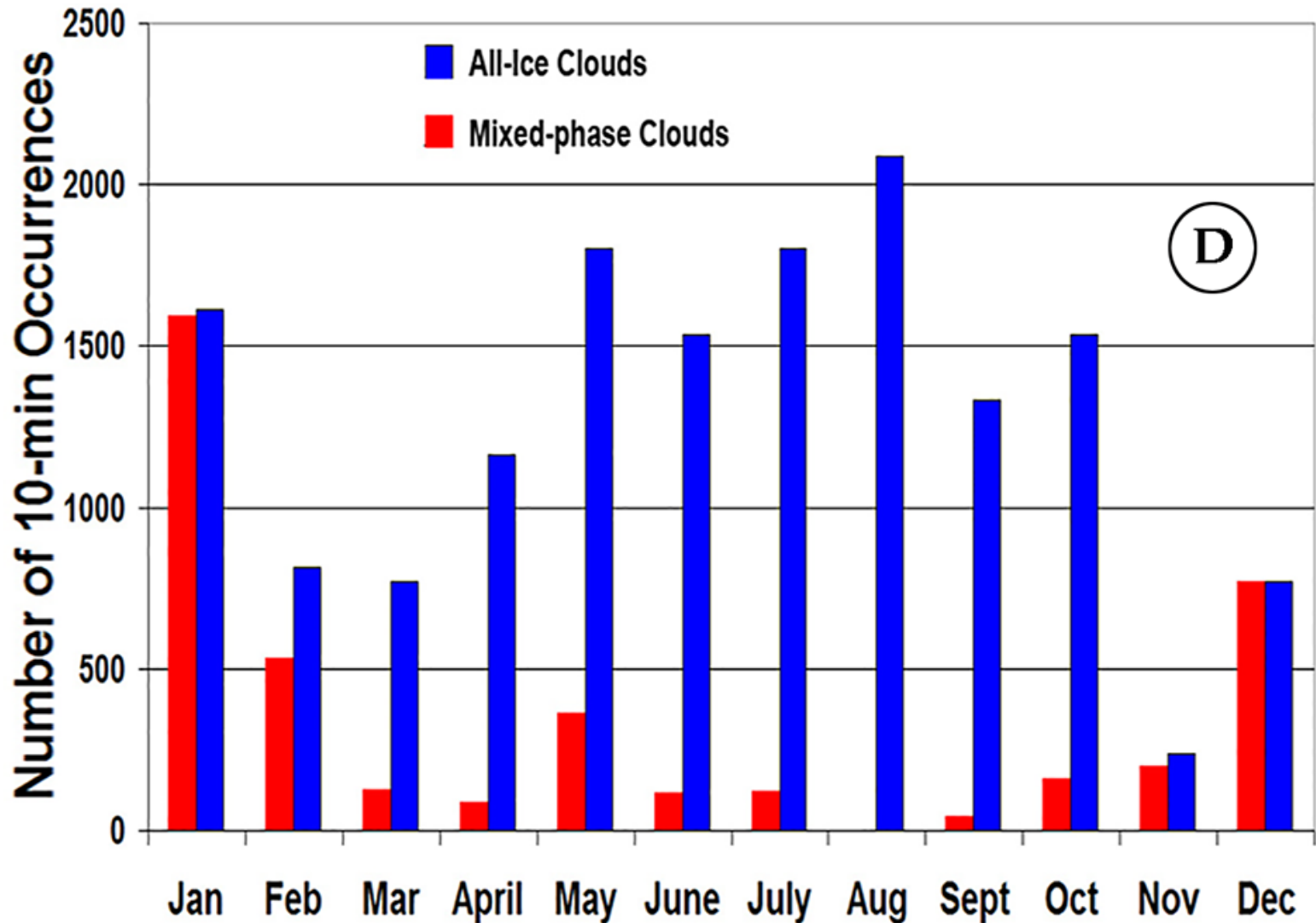


## CPI Images of Mixed-Phase Cloud at -30 to -32°C at South Pole

## Lidar Return from Mixed-Phase Cloud at -30 to -32°C (Lawson et al. 2011)



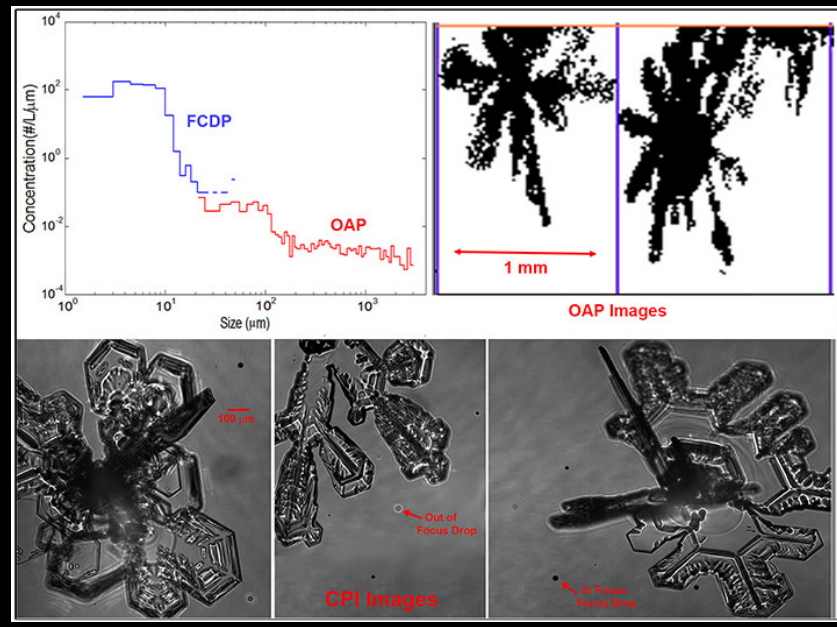
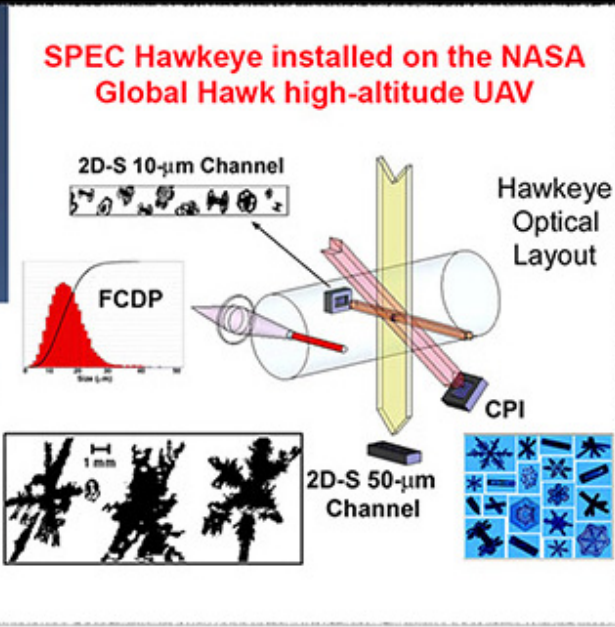
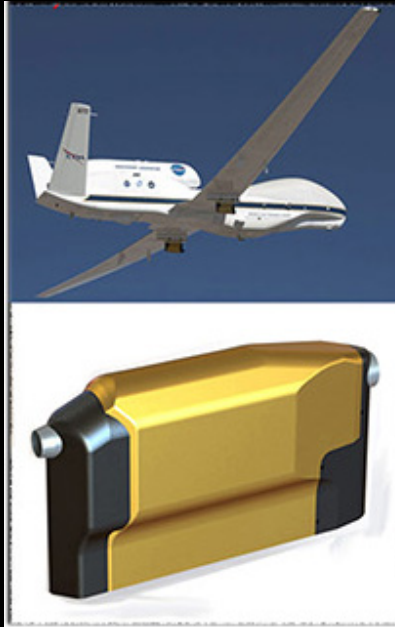
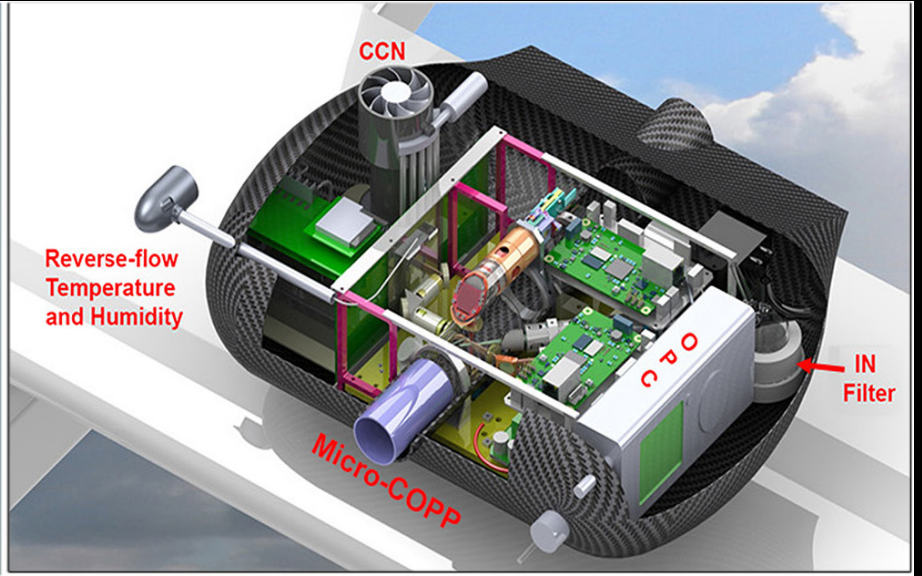
# TBS Comparisons with Ground-Base Lidar Extrapolated to Show Occurrence of Mixed-Phase from Jan - Dec 2009 at the South Pole (Lawson and Gettelman 2014 - PNAS)



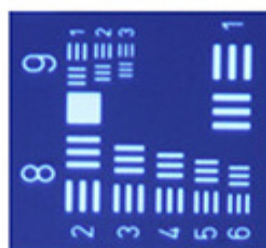
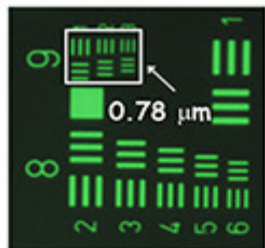
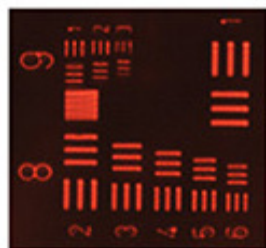
# TBS Publications Resulting from Deployments at Ny-Ålesund and South Pole

- 1) Sikand, M., J. Koskulics, K. Stamnes, B. Hamre, J. J. Stamnes, and R. P. Lawson, 2013: Estimation of Mixed-Phase Cloud Optical Depth and Position Using In Situ Radiation and Cloud Microphysical Measurements Obtained from a Tethered-Balloon Platform, *J. Atmos. Sci.*, 70, 317 - 329.
- 2) Lawson, R. P., K. Stamnes, J. Stamnes, P. Zmarzly, J. Koskulics, C. Roden, Q. Mo, M. Carrithers, 2011: Deployment of a Tethered Balloon System for Cloud Microphysics and Radiative Measurements at Ny-Ålesund and South Pole, *J. Atmos. Oceanic Technol.* 28, 656 - 670
- 3) Ardon-Dryer, K., Z. Levin, and R. P. Lawson, 2011: Characteristics of immersion freezing nuclei at the South Pole station in Antarctica. *Atmos. Chem. Phys.*, 11, 4015-4024.
- 4) Sikand, M., J. Koskulics, K. Stamnes, B. Hamre, J. J. Stamnes, and R. P. Lawson, 2010: Optical properties of mixed phase boundary layer clouds observed from a tethered balloon platform in the Arctic. *J. Quant. Spect. Rad. Trans.*, 111, 1921- 1930.
- 5) Lawson, R. P. and A. Gettelman, Impact of Antarctic mixed-phase clouds on climate, 2014: *Proc. Nat. Acad. Sci.*, 111, 18156-18161

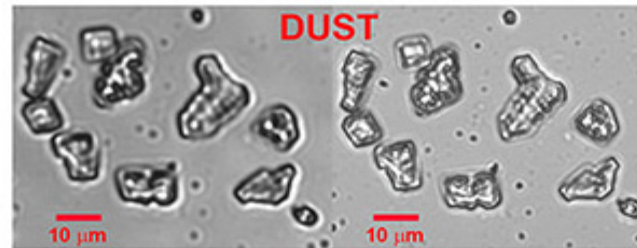
# A New Miniature Combined Optical Particle Probe (micro-COPP) Incorporates an FCDP, 2D-S and CPI into a 3-Kg Instrument



# New High-Resolution (0.7 $\mu\text{m}$ pixel) CPI will Improve Ice/Water Identification in Mixed-Phase Clouds

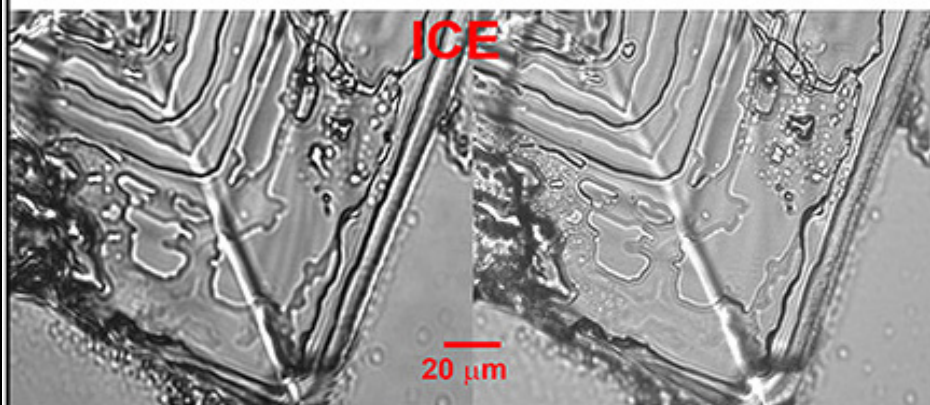


1951 USAF Reticle



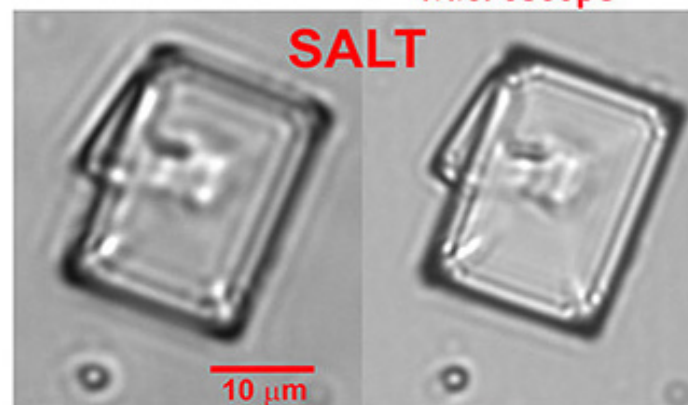
Submicron CPI

400X Lab  
Microscope



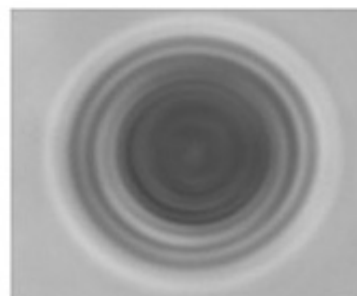
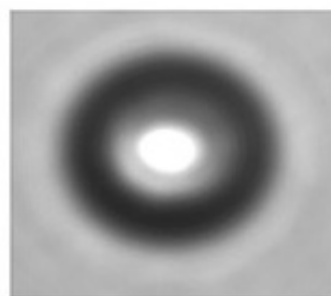
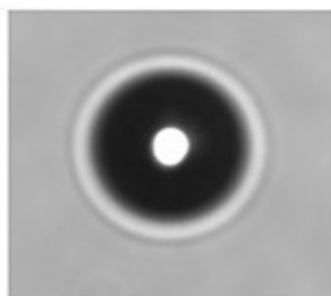
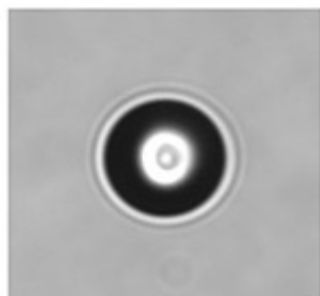
Submicron CPI

400X Lab  
Microscope



Submicron CPI

400X Lab  
Microscope



20- $\mu\text{m}$  Drop at Various Focus Points

## The Plan:

Deploy the Tethered Balloon System and Penguin UAV, both Equipped with Miniature Instrument Packages, to either Oliktok Point or Ny-Ålesund in the Spring of 2008 for a Demonstration Project in Mixed-Phase Clouds.

## Acknowledgements

Development of the Miniature Sensors for UAS and Field Deployment are supported under DOE SBIR Grant No. DE-SC0013193