Balloon-borne Measurements of Cloud Particle Size over Asian Summer Monsoon Region during BATAL campaign: A Case Study

Amit Kumar Pandit[1]*, Jean-Paul Vernier[2,3], Harish Gadhavi[1], T. Duncan Fairlie[3], M. Venkat Ratnam[4], B. Suneel Kumar[5] and A. Jayaraman[4]

[1]Physical Research Laboratory, Ahmedabad, Gujarat, India; [2]Science Systems and Applications, Inc., Hampton, Virginia, USA; [3] NASA Langley Research Center, Hampton, Virginia, USA; [4]National Atmospheric Research Laboratory, Gadanki, A. P., India; [5]Tata Institute of Fundamental Research Balloon Facility, Hyderabad, India.

*Email: amitpandit@prl.res.in, amitkpandit86@gmail.com, Phone: +91-8978734911.

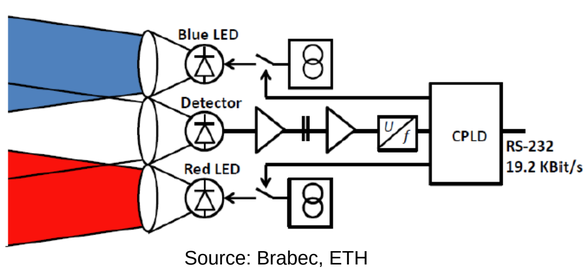
Background & Overview

• Clouds significantly impact Earth's radiation budget and hence its climate. Radiative effects of clouds depend on their macrophysical (altitude, coverage and thickness) and microphysical properties (number concentration, size and shape-distributions of cloud droplets/ice-crystals). However, the microphysical representation of clouds in global climate models is poor due to lack of reliable in-situ measurements especially for small ice-crystals having size less than 100 µm (*Heymsfield et al., 2017*).

• Under the framework of Balloon measurement campaigns of Asian Tropopause Aerosol Layer (BATAL), the size distribution of aerosols and cloud layers are measured over TIFR Balloon Facility, Hyderabad (17.47˚ N, 78.58˚ E,), India on 23 August 2017 using a suite of in-situ instruments (*Vernier et al., 2017*).

Instruments & Data Used

Compact Optical Backscatter AerosoL Detector (COBALD from ETH, Zurich)



Source: Brabec, ETH

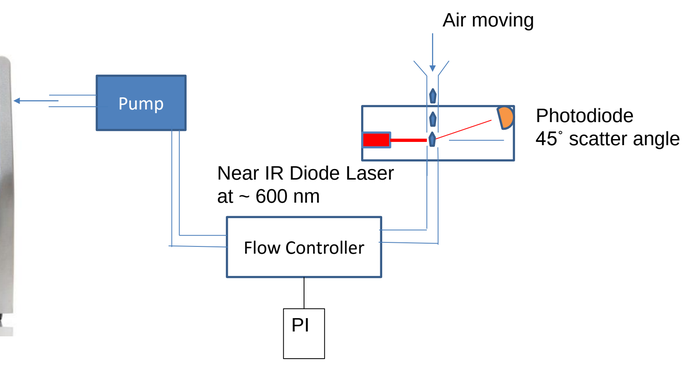
• COBALD consists of two high power (250 mW) LEDs at 455 (blue) and 940 nm (infra-red) wavelengths and a photo-detector in the centre to collect the backscattered radiation from the scatterers (molecules, aerosols & cloud particles).

• When connected to an iMet radiosonde, it provides in-situ measurements of met-parameters, backscatter ratio (BR) and colour index (CI) defined as:

$$BR = (\beta_{aersol}+\beta_{molecules})/\ \beta_{molecule}$$

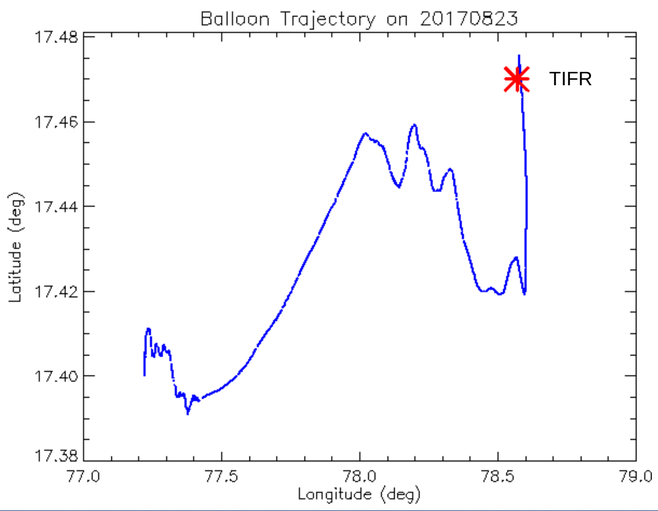
$$CI = (BR_{940}-1)/(BR_{455}-1)$$

Solair Boulder Counter (Lighthouse, USA)



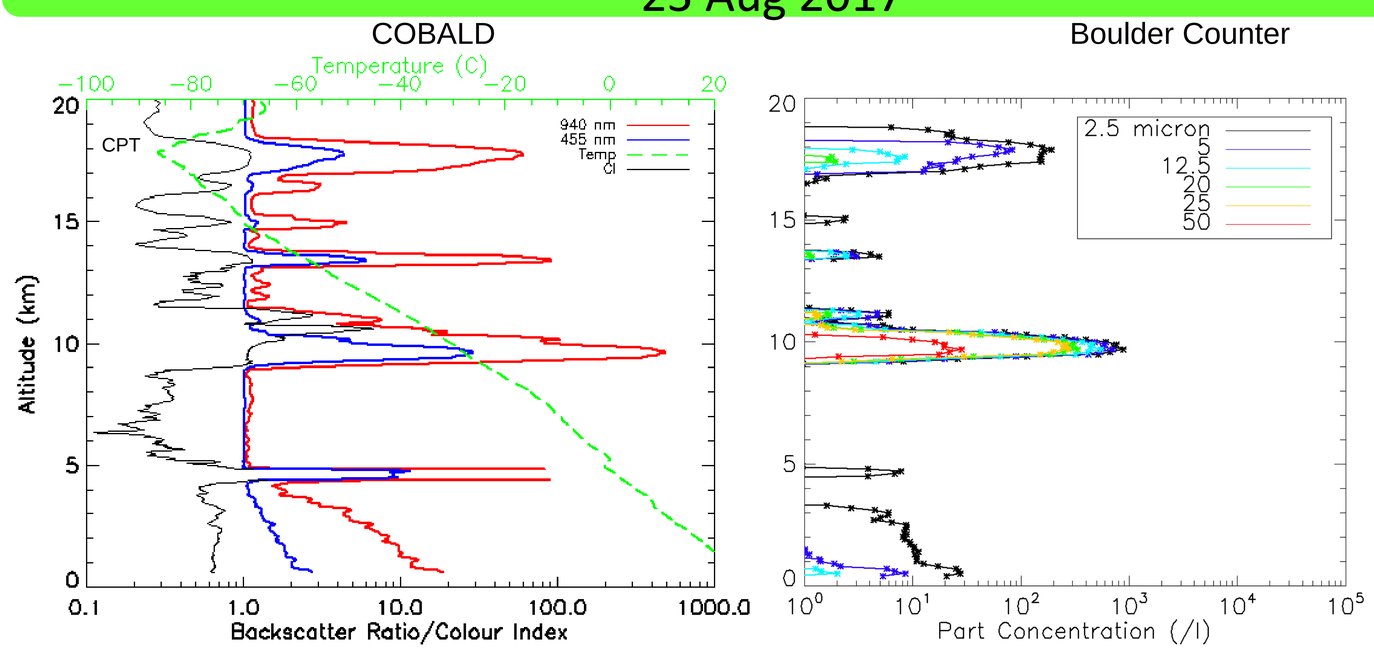
• A diode laser-based (at ~ 600 nm) optical particle counter for counting particles at size bins of 2.5, 5, 10, 25, 40 and 50 µm at every 5s interval. It consists of a pump and an external mass-flow control system to maintain a constant sample flow of 28.3 Litres per minute during the flight.

• Size-distribution of cloud droplets and ice-crystals are obtained.



Results

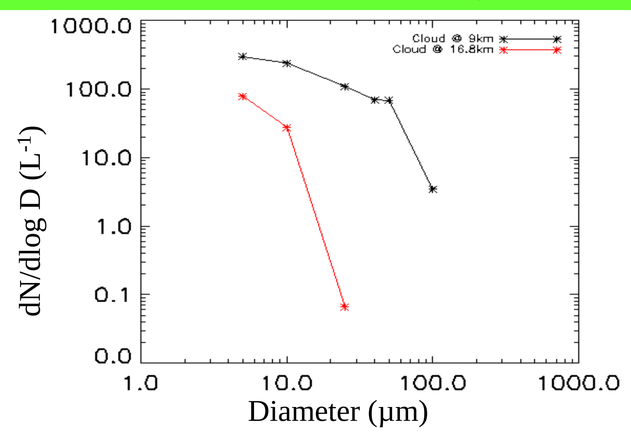
Simultaneous measurements from COBALD & Boulder Counter on 23 Aug 2017



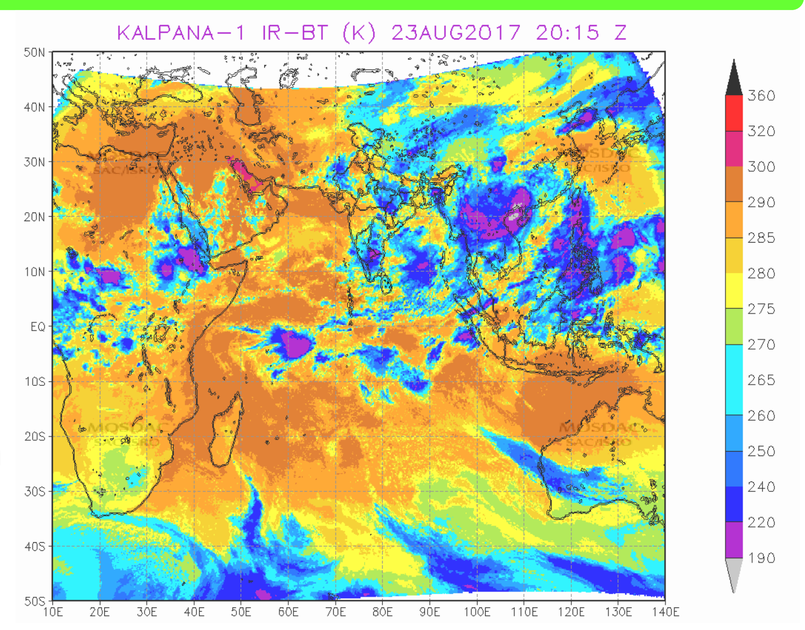
• Both the measurements reveal the presence of multi-layered ice-clouds with ice-crystals of varying sizes. Larger ice-particles are seen near the cloud base indicating sedimentation of ice-crystals.

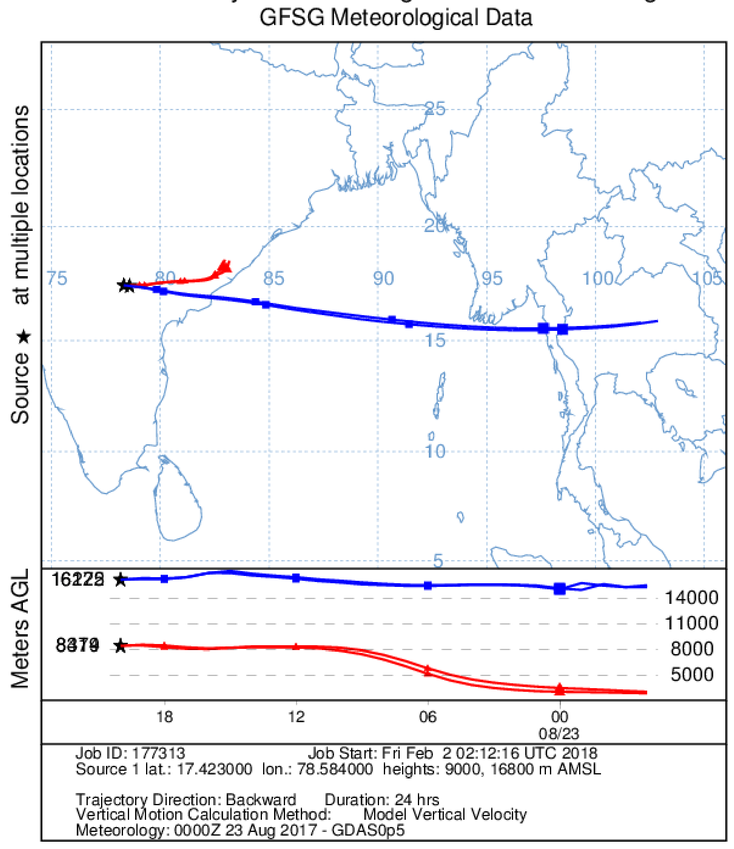
• A cloud layer consisting of very small ice-crystals is observed near the cold-point tropopause (CPT) at about 18 km at temperature less than -80˚ C which could be formed in-situ.

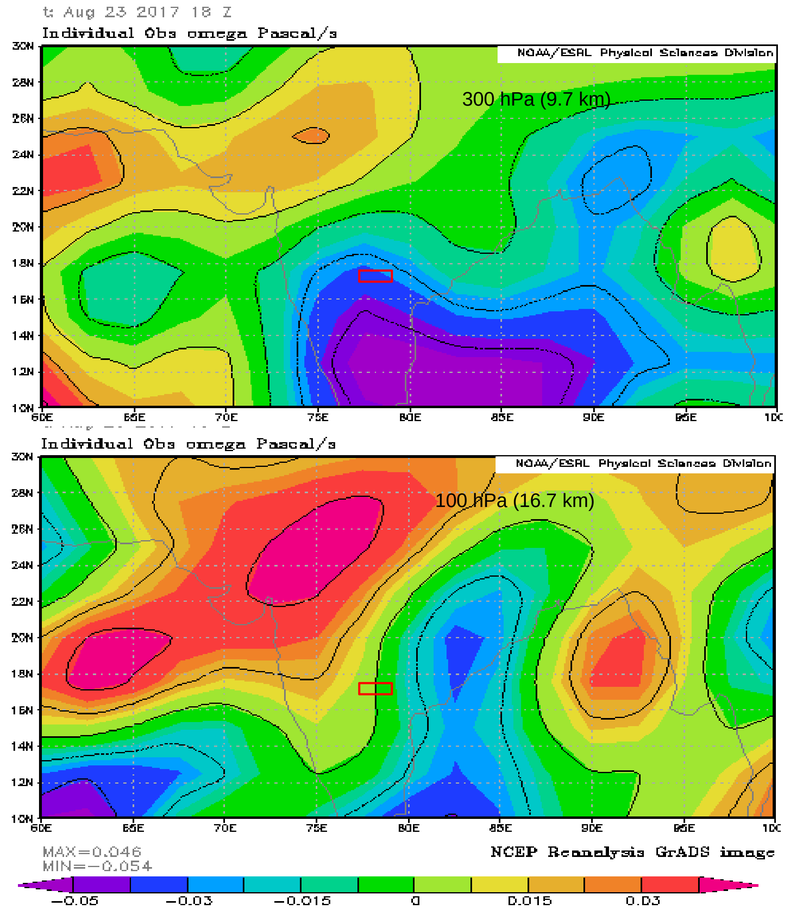
Size distribution of ice-particles and their formation mechanism



Cloud layer at 9 km has bimodal size-distribution while cloud layer at 16.8 km shows mono-modal size distribution.







Summary & Conclusions

• Boulder counter measurements provide unique measurements of size-distribution of cloud particles.

• Cloud layer at about 9 km is formed due to local convection while cloud layer at 16.8 km seems to be formed in-situ.

References

Vernier, J., T.D. Fairlie, T. Deshler, M.V. Ratnam, H. Gadhavi, S. Kumar, M. Natarajan, A.K. Pandit, et al.,: BATAL: The Balloon measurement campaigns of the Asian Tropopause Aerosol Layer. *Bull. Amer. Meteor. Soc.,* **0**, https://doi.org/10.1175/BAMS-D-17-0014.1

Heymsfield, A.J., M. Krämer, A. Luebke, P. Brown, D.J. Cziczo, C. Franklin, P. Lawson, U. Lohmann, G. McFarquhar, Z. Ulanowski, and K. Van Tricht, 2017: Cirrus Clouds.*Meteorological Monographs,* **58**, 2.1–2.26, https://doi.org/10.1175/AMSMONOGRAPHS-D-16-0010.1

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