National Atmospheric Research Laboratory
Department of Space, Government of India.

Guest Researcher
Geo-sciences and Remote sensing

Balloon-borne Aerosol-Cloud Interaction Studies (BACIS)

Field campaigns to understand and quantify aerosol effects on clouds

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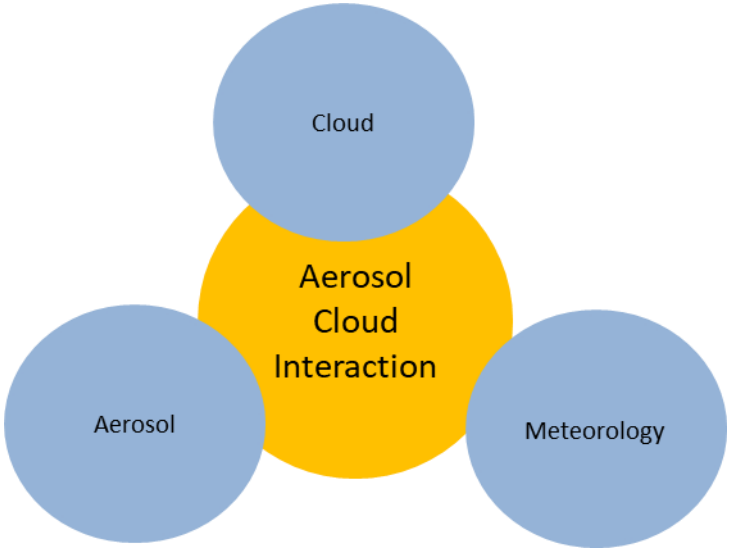
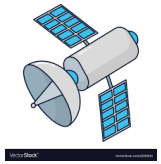


Observations point of view: Multi-platform multi-instrumented



Space-borne
Remote sensing

Cloud

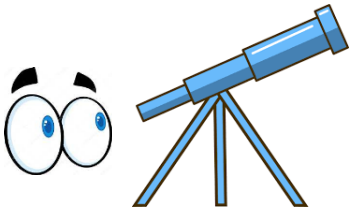
In-situ

Aerosol plume

LIDAR

RADIOMETER

RADAR



Ground-based
Remote sensing

Intense mode of operations

BACIS – Experimental approach

Space-borne
Remote sensing

CALIPSO

Aerosol layer above cloud

Cloud

Aerosol layer below cloud

Balloon passing Through cloud

Profile of Cloud, aerosol
Not possible in other in-situ
In-situ

T+4 hrs

Launch time

T-3 hrs

TIME

MST Radar → UVW

LAWP → UVW

Mie LIDAR → $\beta_a, Cbase$

MPL → $\beta_a, Cbase$

Balloon sounding

MWR → LWP

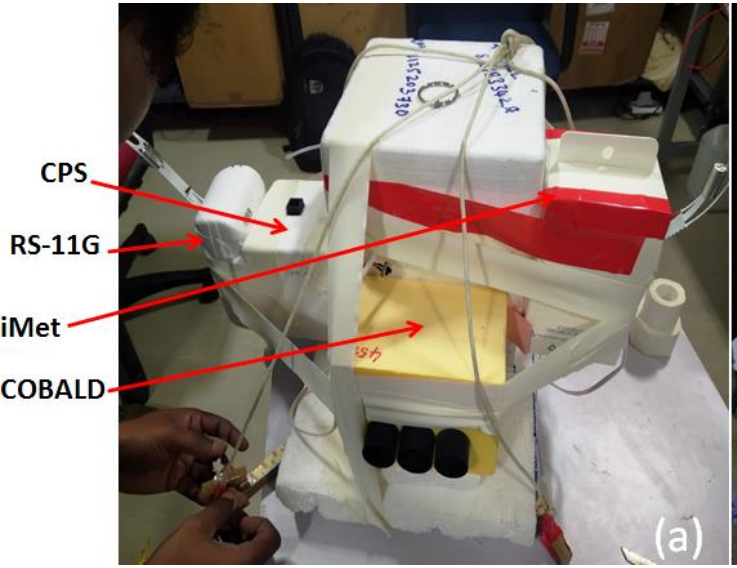
ICON → σ_a

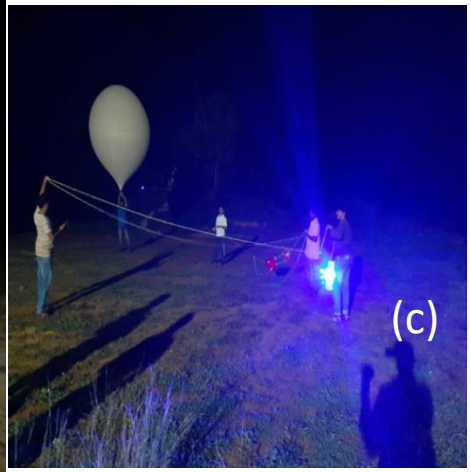
Ground-based
Remote sensing

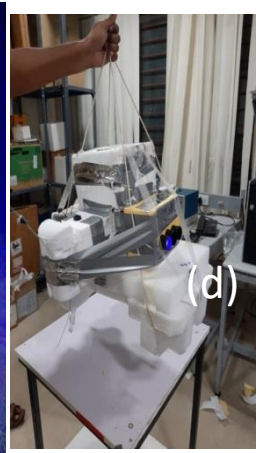
Advantage is the it can be more frequent

Intense mode of operations

Deployment of Balloon payload



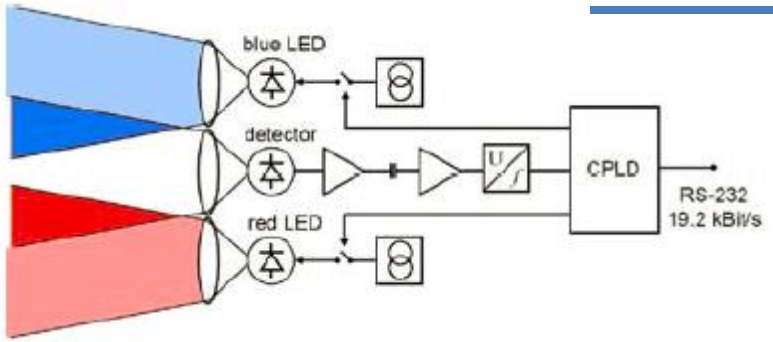


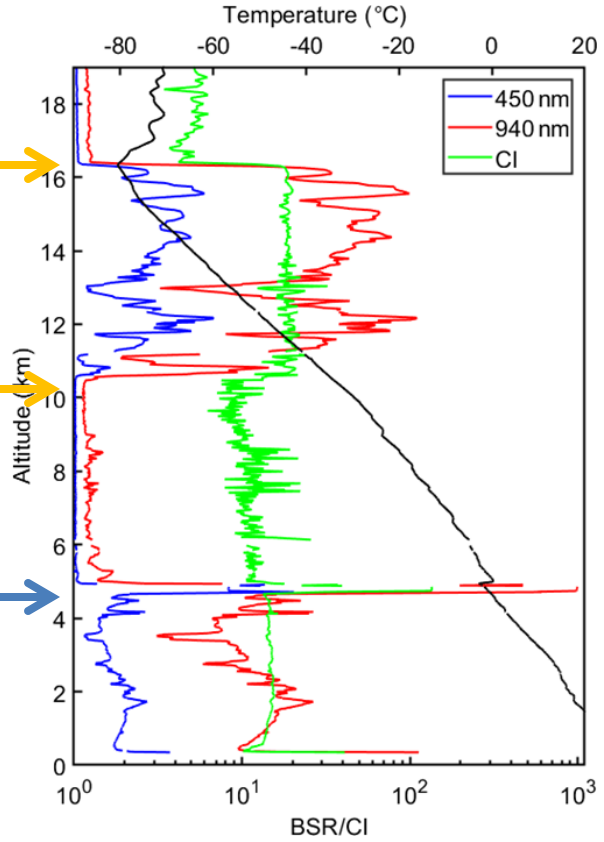


(a) Balloon payload with COBALD, CPS
(b) and (c) Pre-launch preparations at the launch field
(d) Payload ready for launch

COBALD (balloon) Sonde

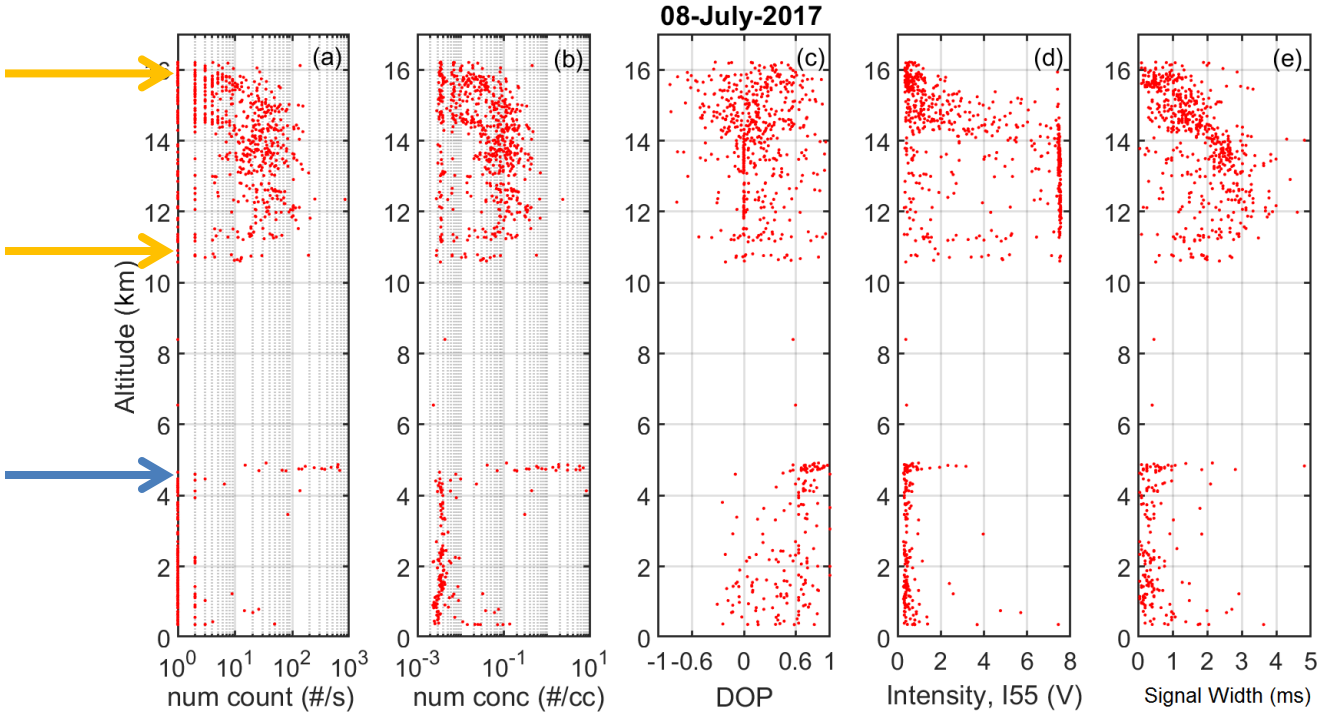
- Developed at ETH, Zurich to know ice-cloud process
- Backscatter ratio, BSR = $\frac{\beta t}{\beta m}$
- Contribution other than molecular is BSR-1.
- Color Index, CI = $\frac{BSR(940)-1}{BSR(450)-1}$

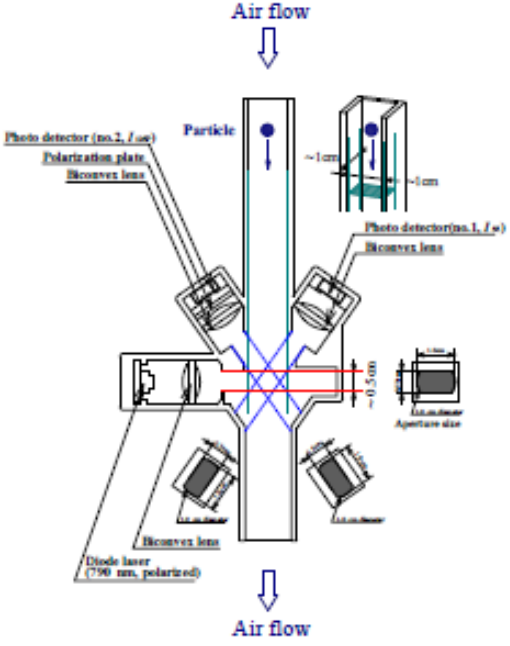




Cloud Particle Sensor (balloon) Sonde

- Commercially available with Meisei Electric, Japan.
- Developed to detect cloud particle and phase.
- Works with balloon ascent/descent

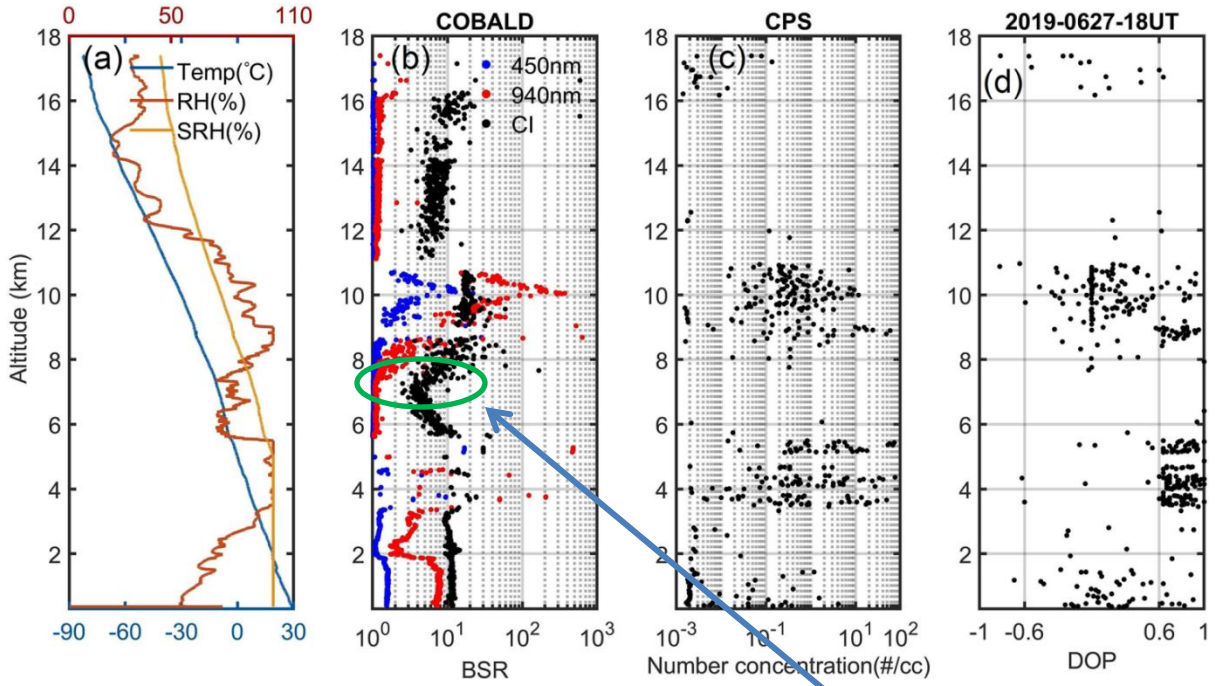




Fujiwara et al., 2012

Combined data from COBALD and CPS

- Identification of aerosol, cloud in a profile is primary to aerosol-cloud interaction



Degree Of Polarization

$$DOP = \frac{I_{55} - I_{125}}{I_{55} + I_{125}}$$

Ice cloud

Super cooled liquid

Liquid cloud

Non-spherical particle
Or aerosol

Below cloud humidity/aerosol

A Scheme to look for aerosol, liquid cloud layers in balloon data

#/s >10
#/cc > 10^{-3}
DOP > 0.6
RH > 95%
T > 0

Particle back scatter

100m

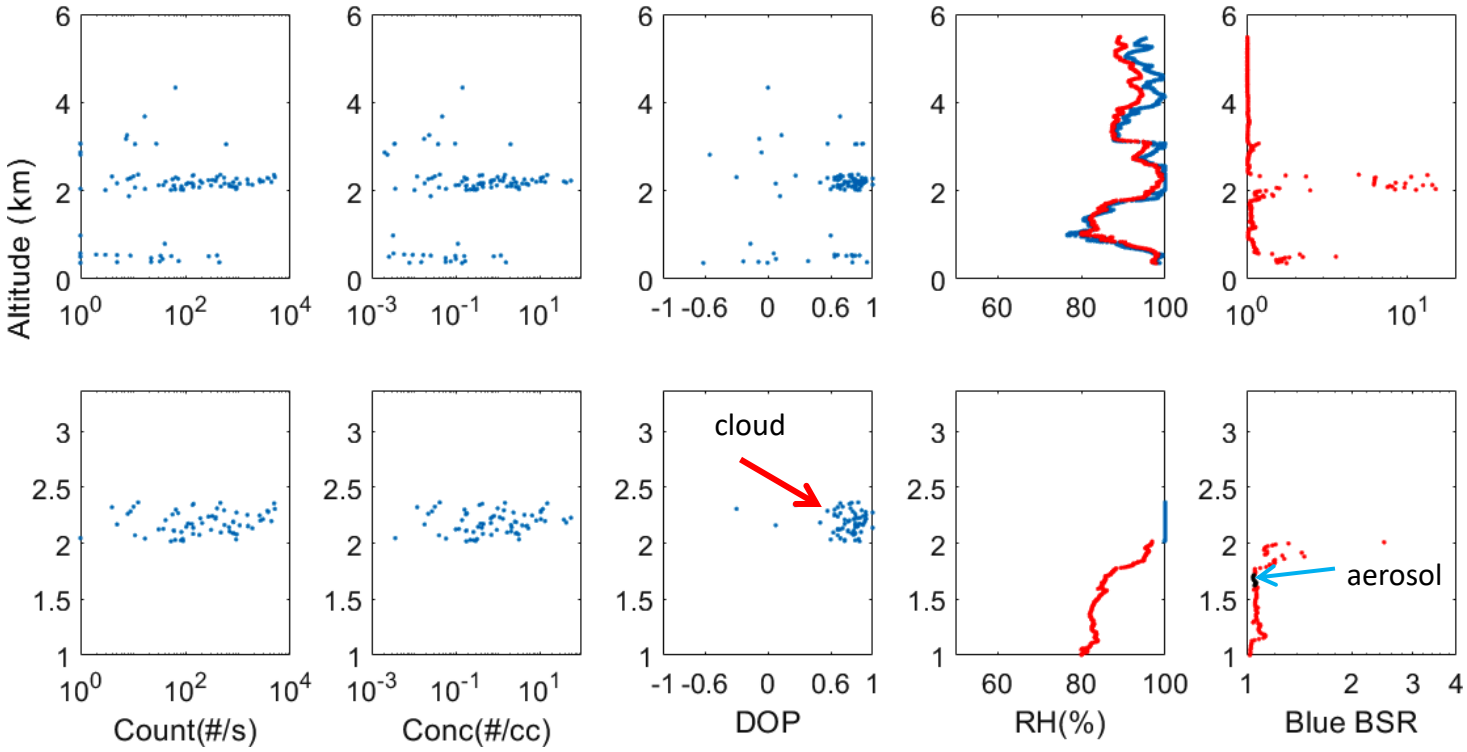
200m

300m

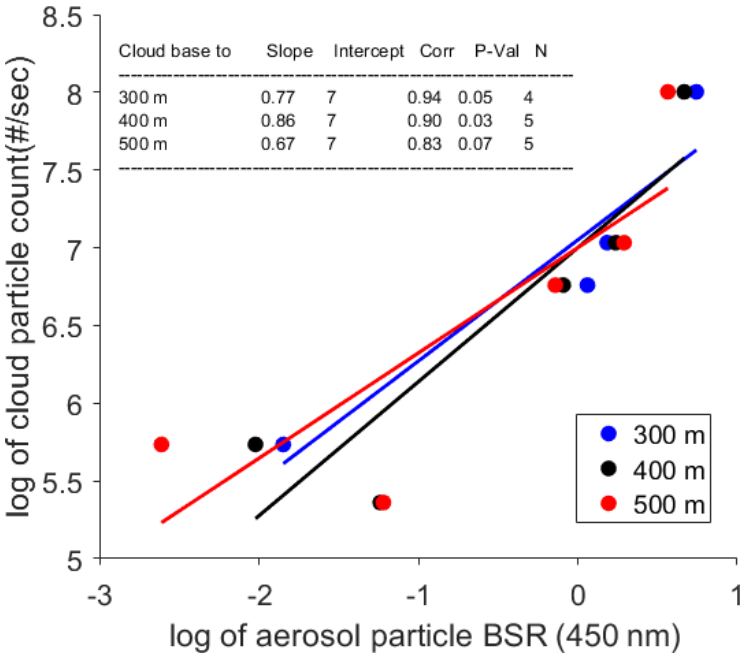
400m

500m

A typical example from the scheme



Aerosol-Cloud Interaction Index



$$ACI = \frac{d \log N_c}{d \log BSR_b}$$

Based on the empirical relation given by Feingold

$$IE = ACI_N = \frac{d \ln N_d}{d \ln \alpha} 0 < ACI_N < 1,$$

No need to constrain LWP for activation process

For more details …..

Ravi Kiran, V., et, al., Balloon-borne aerosol–cloud interaction studies (BACIS): field campaigns to understand and quantify aerosol effects on clouds, **Atmos. Meas. Tech**., 15, 4709–4734, 2022.
https://doi.org/10.5194/amt-15-4709-2022

Way Forward

- Ground-based remote sensing (multi-instrumental set-up) for ‘aerosol-invigoration of cloud’

Ceilometer

MWR

Cloud Radar

- $\beta_{aerosol}$
- LWC
- r_{eff}
- N_c

\+ Meteorology

THANK YOU