BATAL

The Balloon measurement campaigns of the Asian Tropopause Aerosol Layer

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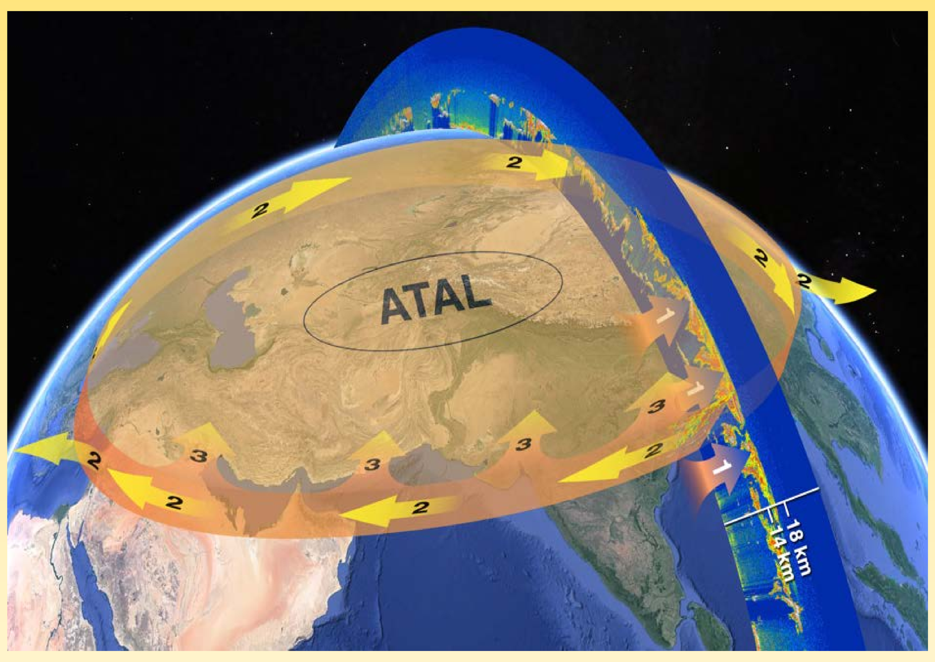
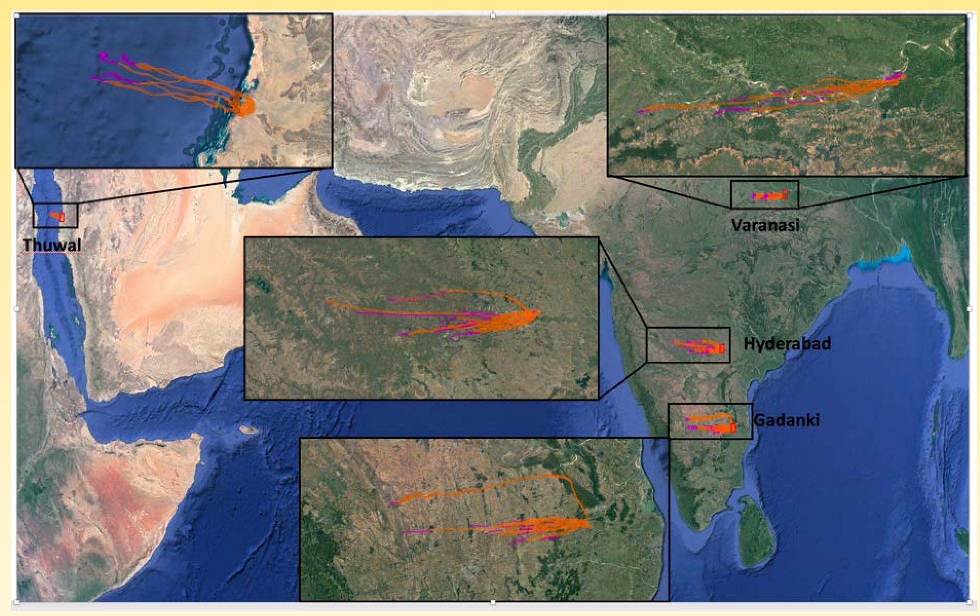
What is BATAL ?

Science



(1) Deep convection from the Asian Summer Monsoon transports air masses from the boundary layer to the Upper Troposphere and Lower Stratosphere (UTLS). An overpass of the CALIPSO lidar on August 12th 2017at 19h30 UTC shows the vertical extension of convection through backscatter measurements. (2) The monsoonal outflow is transported through tropical easterlies prevailing in the UTLS along the southern branch of the Asian Anticyclone. (3) Air in the tropical upper troposphere along the southern edge of the Asian Anticyclone can be uplifted into the lower stratosphere via diabatic ascent. The Asian Tropopause Aerosol Layer (ATAL) is a pool of aerosols filling the Asian Anticyclone shown as light yellowish color.

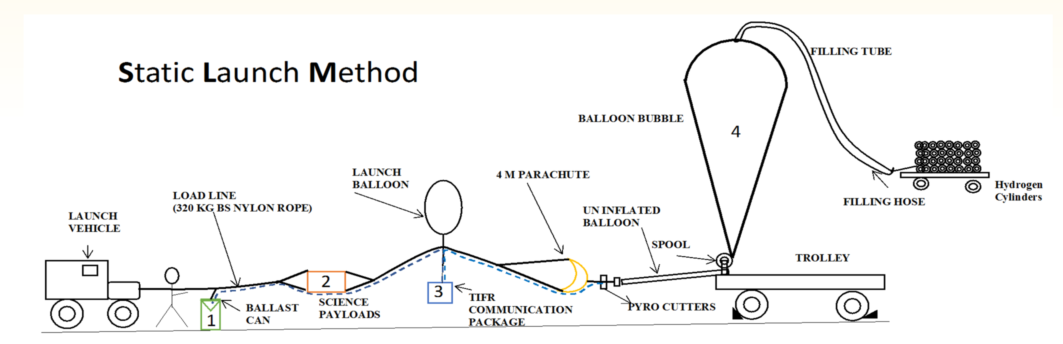
Locations



Balloon trajectories from Gadanki [13.46°N, 79.17°E], Hyderabad [17.47°N, 78.58°E], Varanasi [25.27°N, 82.99°E] and Thuwal [22.32°N, 39.10°E] during the BATAL campaigns between 2014 and 2017. The ascending and descending balloon profiles are shown in orange and magenta, respectively.

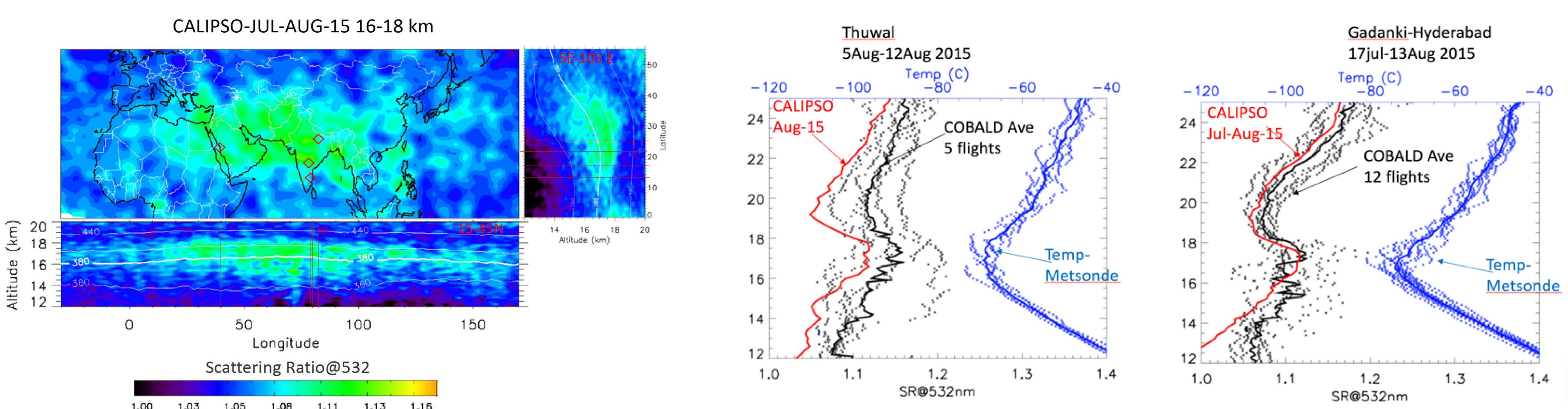
Ballooning

Ballooning during BATAL. Preparation of: (1) Heavy balloon Flights (HF) from Hyderabad using plastic balloons. (2) Regular Medium and Light-weight balloon Flights (MF/LF) with latex balloons. (3) Zero-pressure balloon Flight (ZF) using plastic balloon. (4) Controlled flight using the Boomerang system attached to the neck of the balloon.



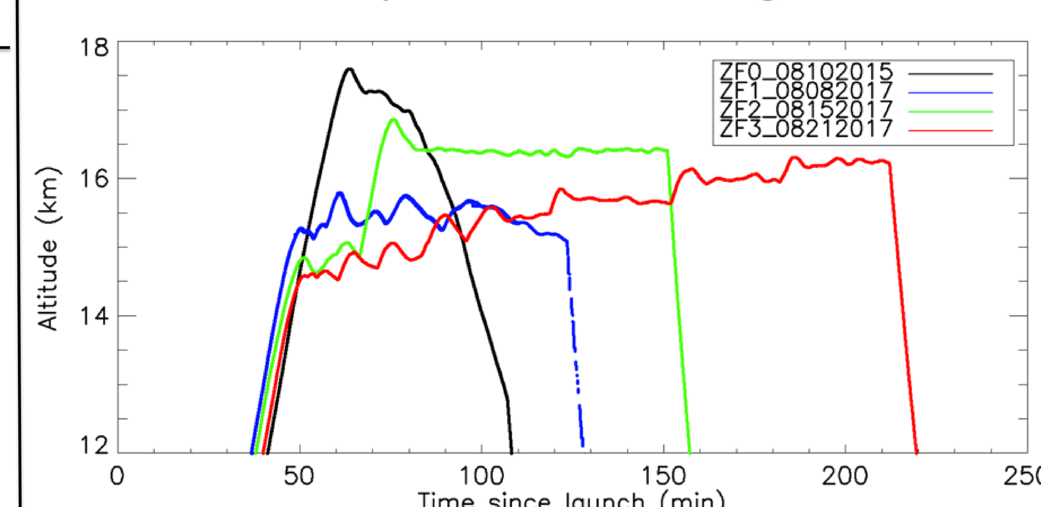
Sketch of the Static Launch Method used during the zero-pressure flights at the TIFR balloon facility, Hyderabad. (1)The ballast module holds up to 25 kg of fine metallic balls which are released per packet of 1 kg. (2)The science payloads include an aerosol impactor, a COBALD backscatter sonde, an ozonesonde, and an meteorological sondes. (3) The communication package is used to release ballast on commands, terminate the flight through the pyrocutter and send GPS data through radio-communication. (4)The plastic balloon is filled with hydrogen and has a volume of 300 m^3.

CALIPSO Satellite validation with COBALD



One of the primary objectives of the BATAL campaign was to validate CALIPSO observations of the ATAL using in situ balloon-borne data. The COBALD backscatter sondes were flown from multiple locations in India and Saudi-Arabia for that purpose. The figures (right) show a good agreement between CALIPSO and COBALD (within +/- 0.04) despite offsets which are likely due calibration issues.

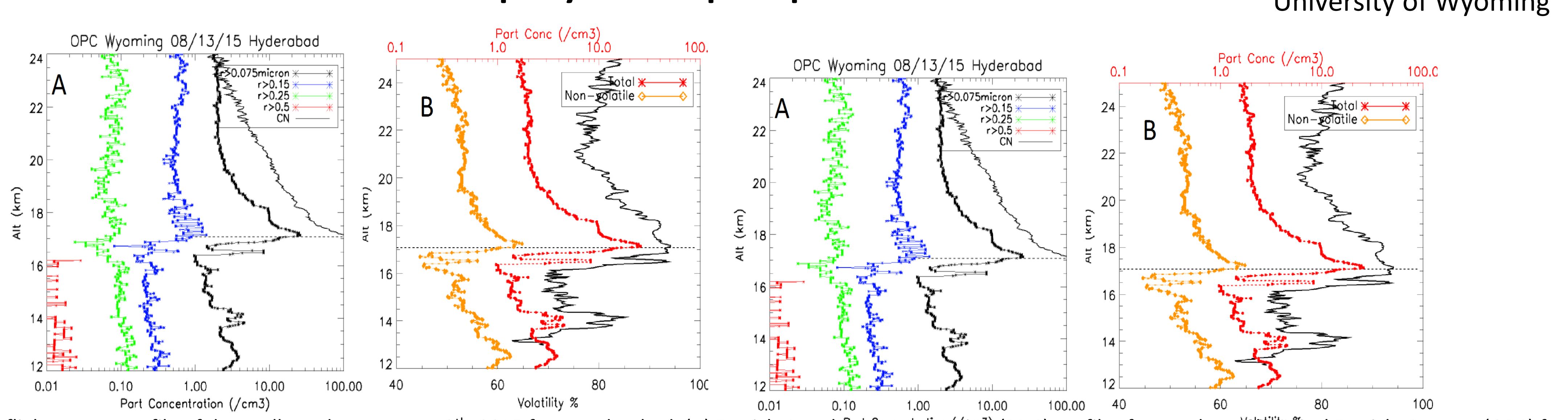
Zero-pressure flights



The Zero-pressure Flights (ZF) method aim to extend the duration of balloon flights in the UTLS region primary for aerosol sampling purposes. The first ZF was conducted in 2015 without ballast. The use of ballast for ZF1,2,3 allow to stay aloft for a longer time (up to 3h) to compensate for the cooling of the gas in the balloon and the reduction of buoyancy force.

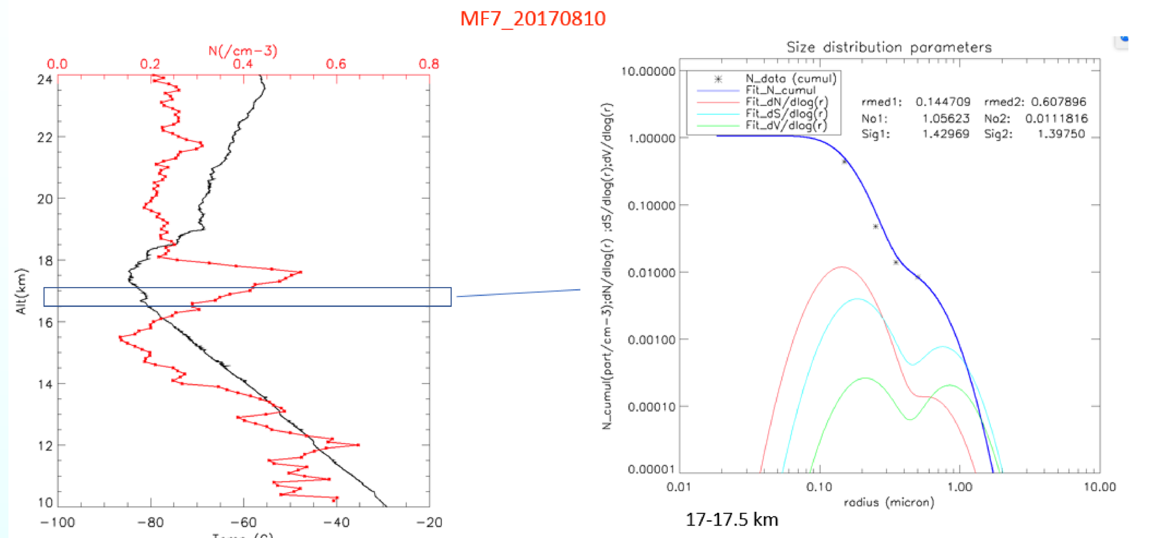
Microphysical properties of the ATAL

University of Wyoming



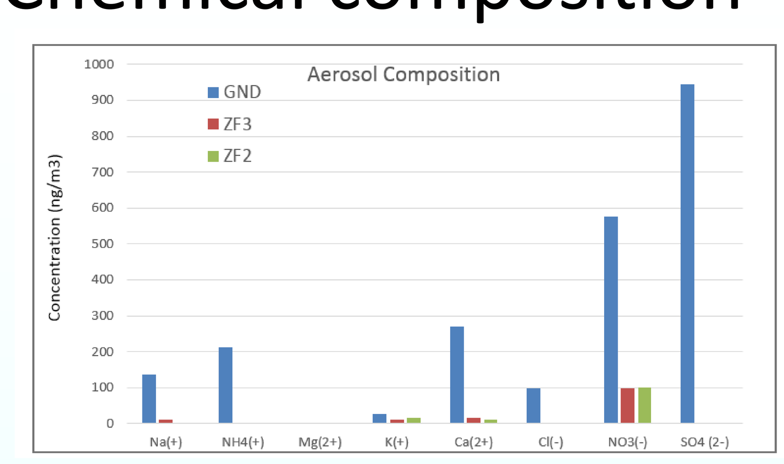
Heavy balloon flight ascent profile of data collected on August 13th, 2015 from Hyderabad. (A) Particle Number Concentration (PNC) profiles from unheated Optical Particle Counter (OPC) for radius: r >0.075, >0.15, >0.25, >0.5 µm and Condensation Nuclei (CN) profile. (B) PNC profiles for r>0.075 µm from heated (180°C) and unheated OPCs. (C) Temperature, ozone partial pressure and water vapor mixing ratio profiles. (D) SR at 940 nm and Color Index (CI=(SR_{940}-1)/(SR_{455}-1)) profiles from COBALD. High concentration of aerosol (up to ~25 part/cm^3) near the tropopause (16-19 km) with r > 0.075 µm, comparable to those observed in the boundary layer. Particle number concentration for r > 0.15 and r > 0.25 µm is smaller by a factor of 30 and 300, respectively. The volatility fraction, defined for a particular size as the difference between the unheated and heated number concentration devided by the unheated concentration, shows that 80-95 % of these aerosols have a volatile component, thus likely partially or totally liquid in the 16-18 km altitude range.

Size distribution derived from small OPC



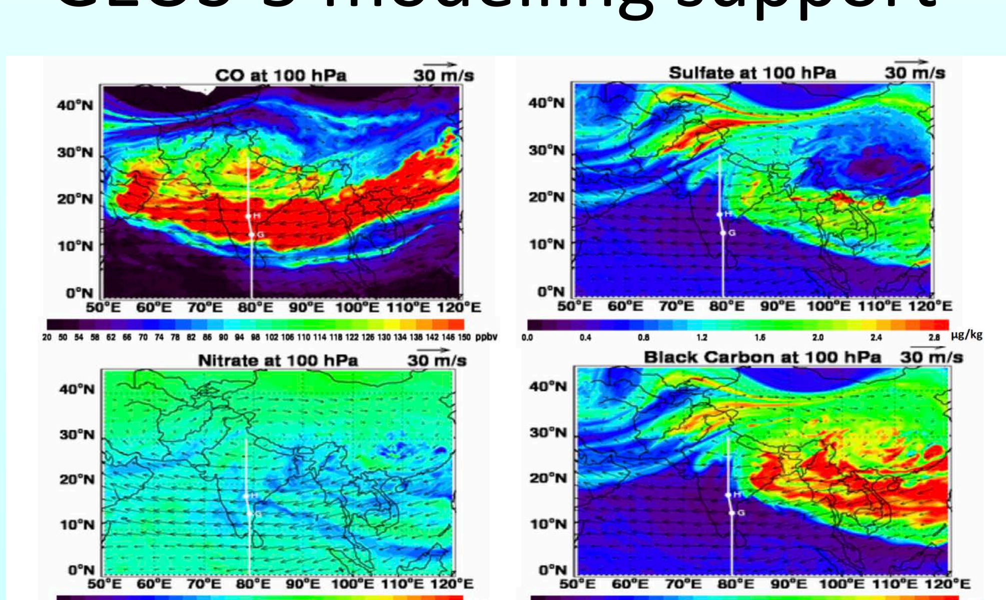
We developed a medium-to-light weight (<4kg) Optical Particle Counter (OPC) to be flown under latex balloons for the batal campaigns. Concentration profile of aerosols with r>0.15 µm is shown on the left together with the temperature profile. Enhanced concentration is observed near the cold point tropopause near Hyderabad on August,10th 2017. The corresponding size distribution parameters derived from the OPC data using a bi-modal lognormal function is shown on the right,

Chemical composition



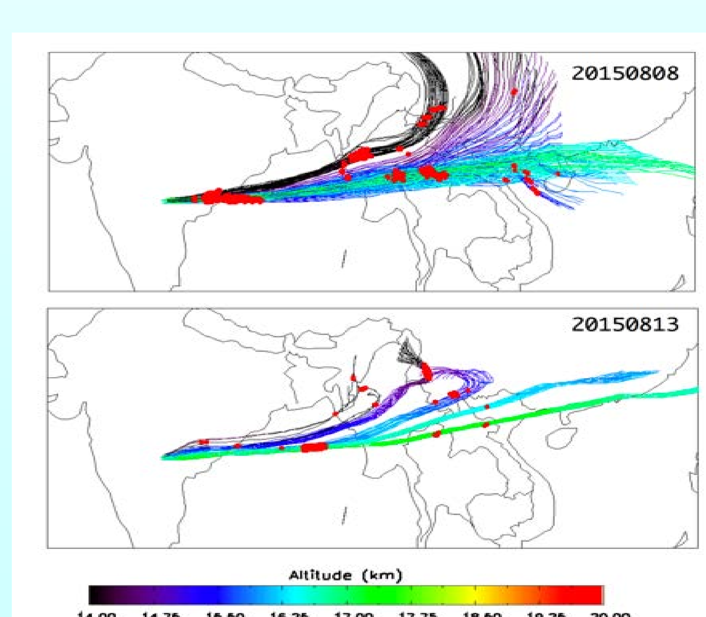
The composition of aerosol collected by a balloon-borne aerosol impactor during ZF2 and ZF3 show the dominate presence of nitrate aerosol with trace of calcium and potassium in the UTLS region.

GEOS-5 modelling support



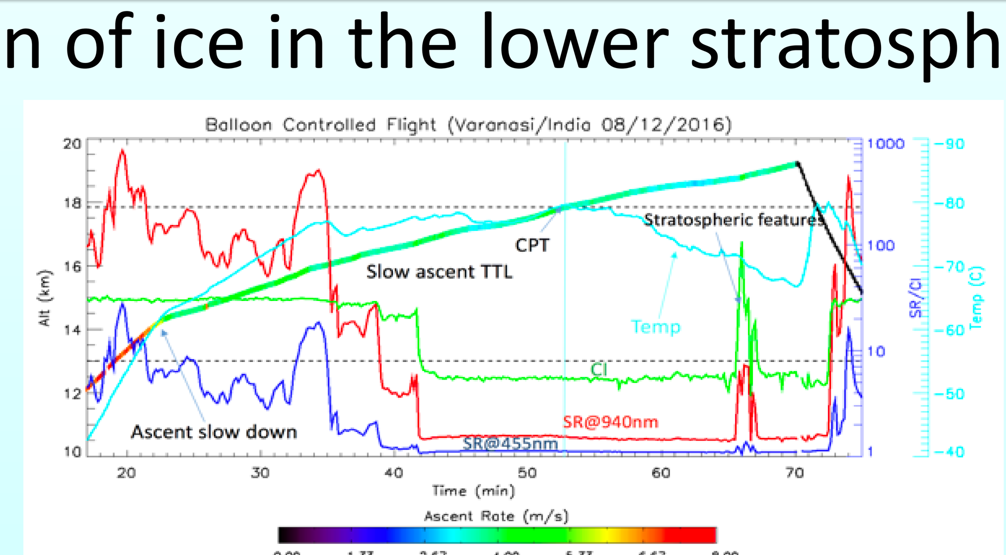
Concentrations of carbon monoxide (CO), sulfate, nitrate, and black carbon (BC) at 100 hPa on 21 UTC, August 3, 2017, as predicted by the NASA GEOS-5 Forward Processing (FP) forecasting system on 00 UTC, July 30, 2017. Arrows denote winds. White dots along the white line (G and H) indicate two balloon sounding locations, Gadanki and Hyderabad.

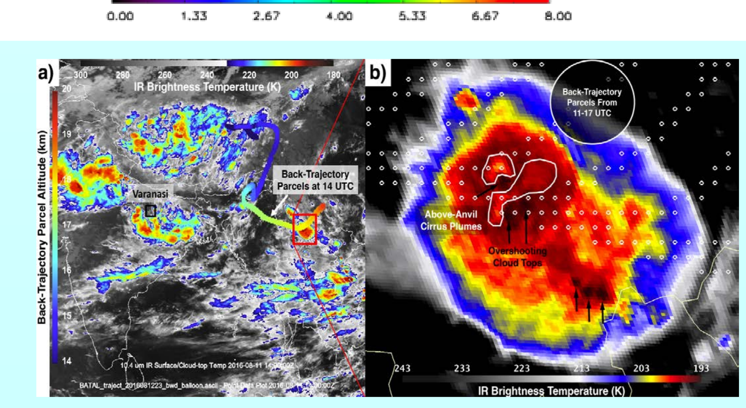
Trajectory analysis



Back trajectories initialized from the balloon flights on 08/13/2015 (top) and 08/08/2015 (bottom) from Hyderabad. Red dots along these trajectories correspond to the presence of convection reaching the upper troposphere as seen by the HIMAWARI-8 geostationary satellite.

Injection of ice in the lower stratosphere





We used a light-weight balloon controlled system (boomerang) to extend balloon flight duration in the UTLS region and within convective clouds. Injection of ice in the lower stratosphere was found in Varanasi during batal 2016.

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