ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

StratoClim

COBALD measurements of aerosol backscatter in the ASM: 2013-2015, and outlook on the StratoClim WP2 field campaign (2016)

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Institute for Atmospheric and Climate Science (IAC), ETH Zürich, Switzerland

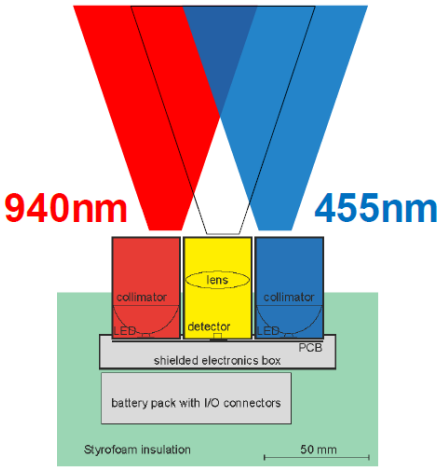
Workshop on dynamics, transport and chemistry of the UTLS Asian monsoon

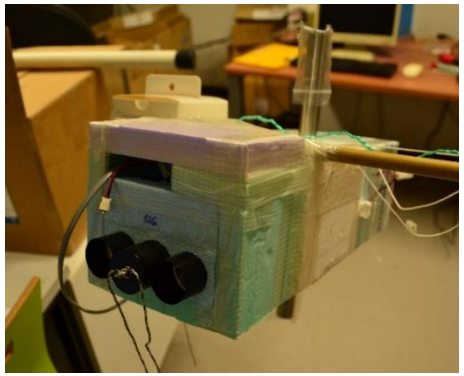
Foothills Laboratory, National Center for Atmospheric Research (NCAR), 9 March 2016, Boulder CO

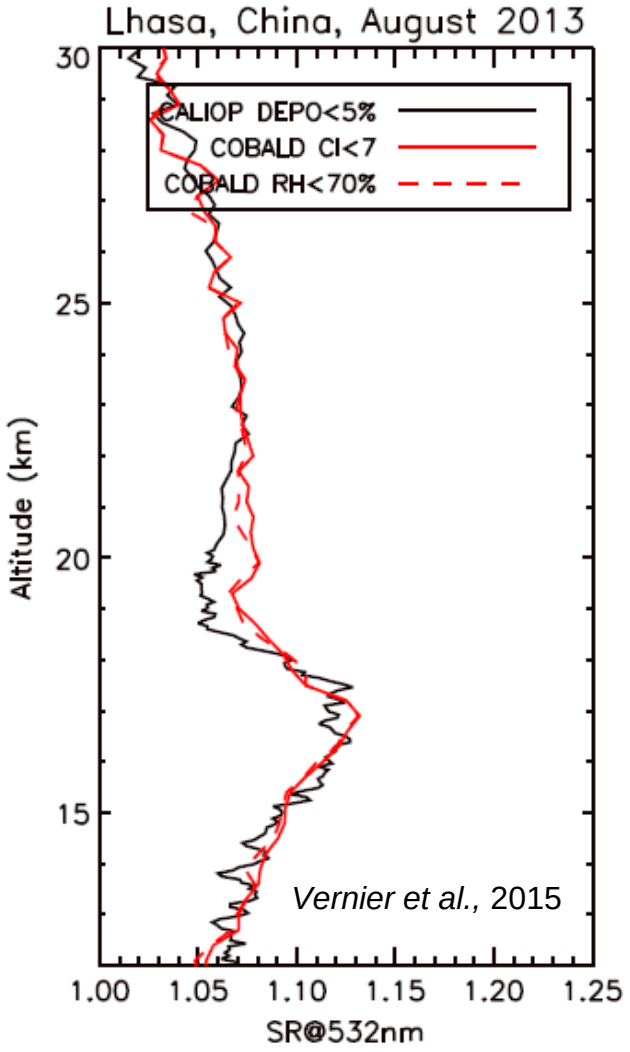
COBALD Compact Optical Backscatter Aerosol Detector

COBALD is a light-weight aerosol backscattering detector at two wavelengths (blue = 455 nm, red = 940 nm) for balloon measurements, developed at ETH Zürich.

Despite meant for high cloud research, COBALD can provide valuable information for the analysis of the **Asian tropopause aerosol layer (ATAL)** [*Vernier et al*., 2015].







Backscatter ratio (BSR) of ATAL vs. Cirrus clouds

$$\mathbf{CI} = \frac{\mathbf{RedBSR} - \mathbf{1}}{\mathbf{BlueBSR} - \mathbf{1}}$$

Cirrus (15 km)

BlueBSR ≈ 2-3

RedBSR > 10

CI ≥ 10

ATAL (16-17 km)

BlueBSR ≈ 1.1

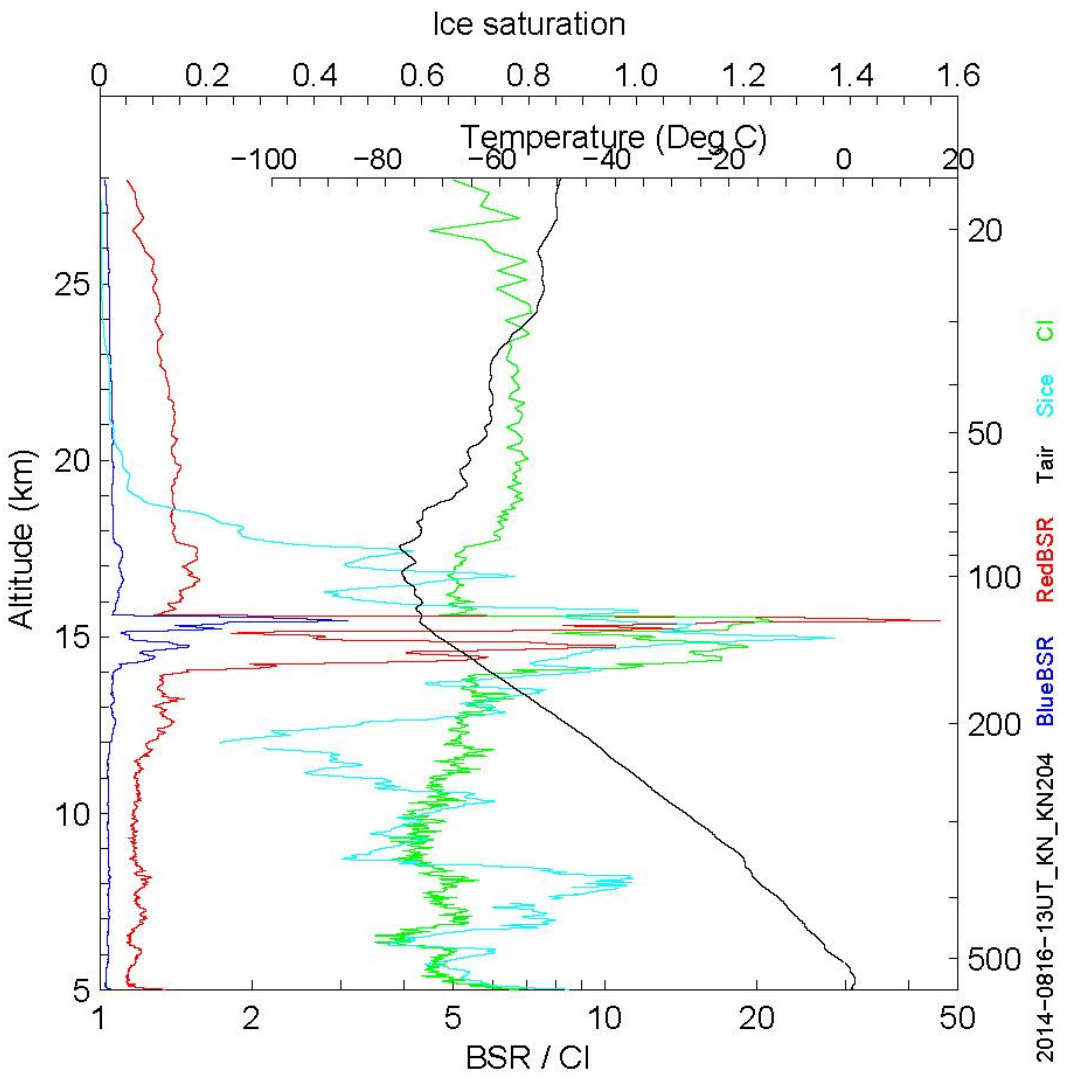
RedBSR ≈ 1.4

CI ≈ 5-6

Cloud-filtering criterion

CI < 7 & RedBSR < 2.5

(as in *Vernier et al*., 2015)



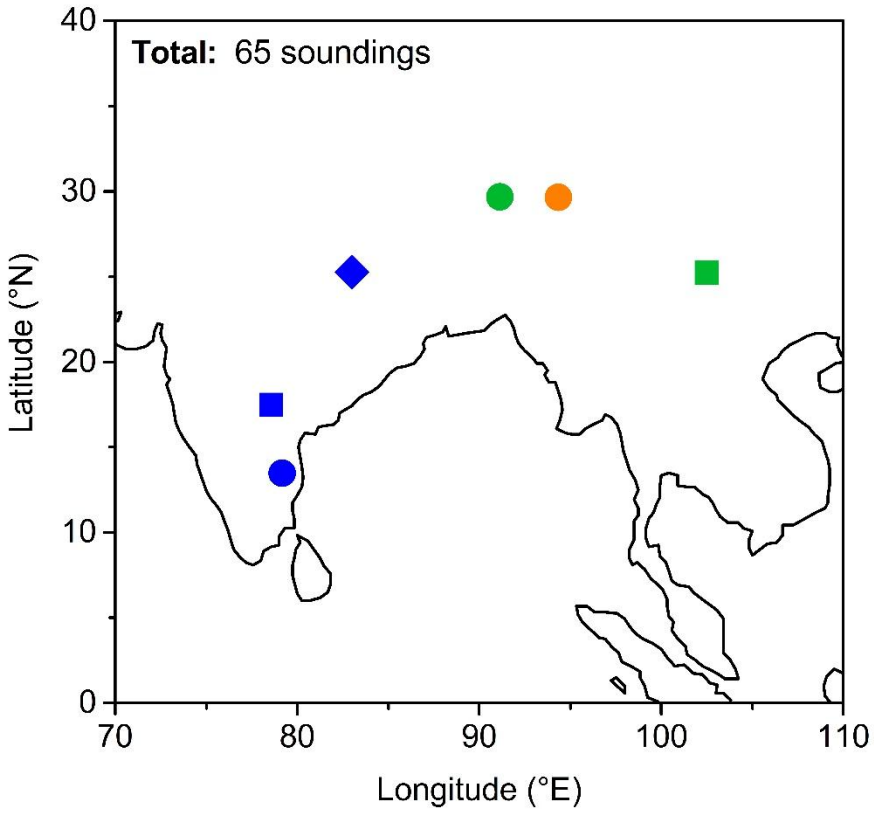
Outline

1. Overview of COBALD soundings in the ASM 2013-2015

2. Optical modeling: constraining particle number densities in ATAL from the COBALD measurements

3. Outlook on StratoClim 2016: campaign sites and strategy

COBALD in the ASM region: 2013 - 2015



SWOP campaign (IAP-CAS)

- Lhasa (China): 18 launches in Aug 2013 (*)
- Kunming (China): 9 launches in Aug 2014
  11 launches in Aug 2015

BATAL campaign (NASA *et al.*)

- Gadanki (India): 7 launches in Aug 2014
  4 launches in Aug 2015
- Hyderabad (India): 9 launches in Aug 2015
- Varanasi (India): 6 launches in Aug 2015

Chinese Metereological Admin. (CAMS-CMA)

- Linzhi (China): 9 launches in Jun-Jul 2014

(*) *Vernier et al.*, 2015

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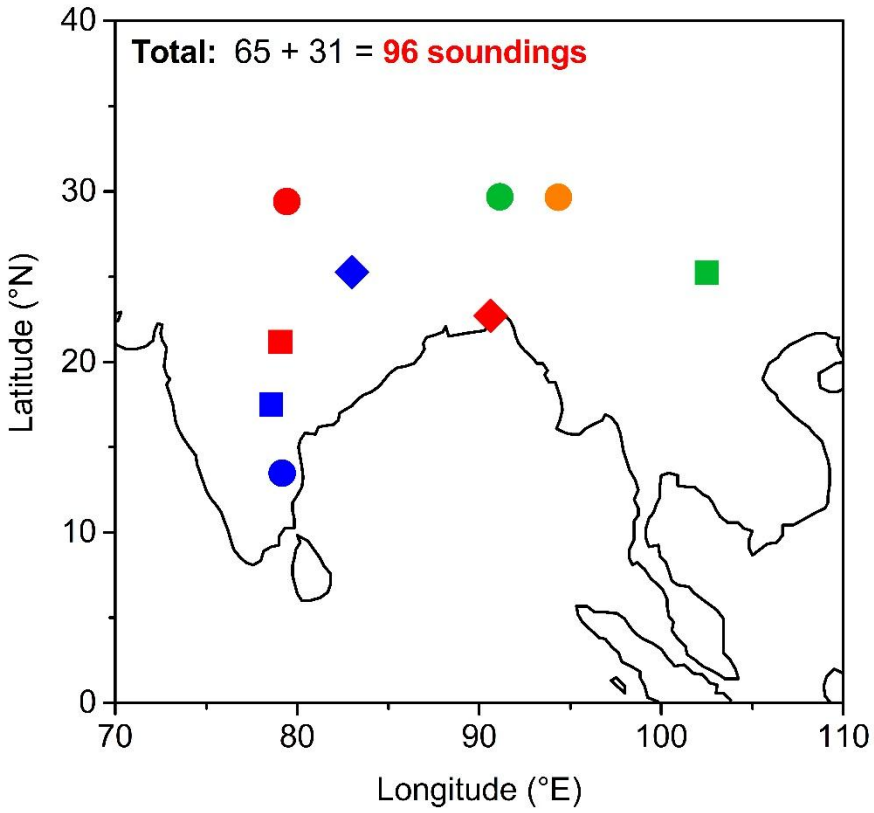

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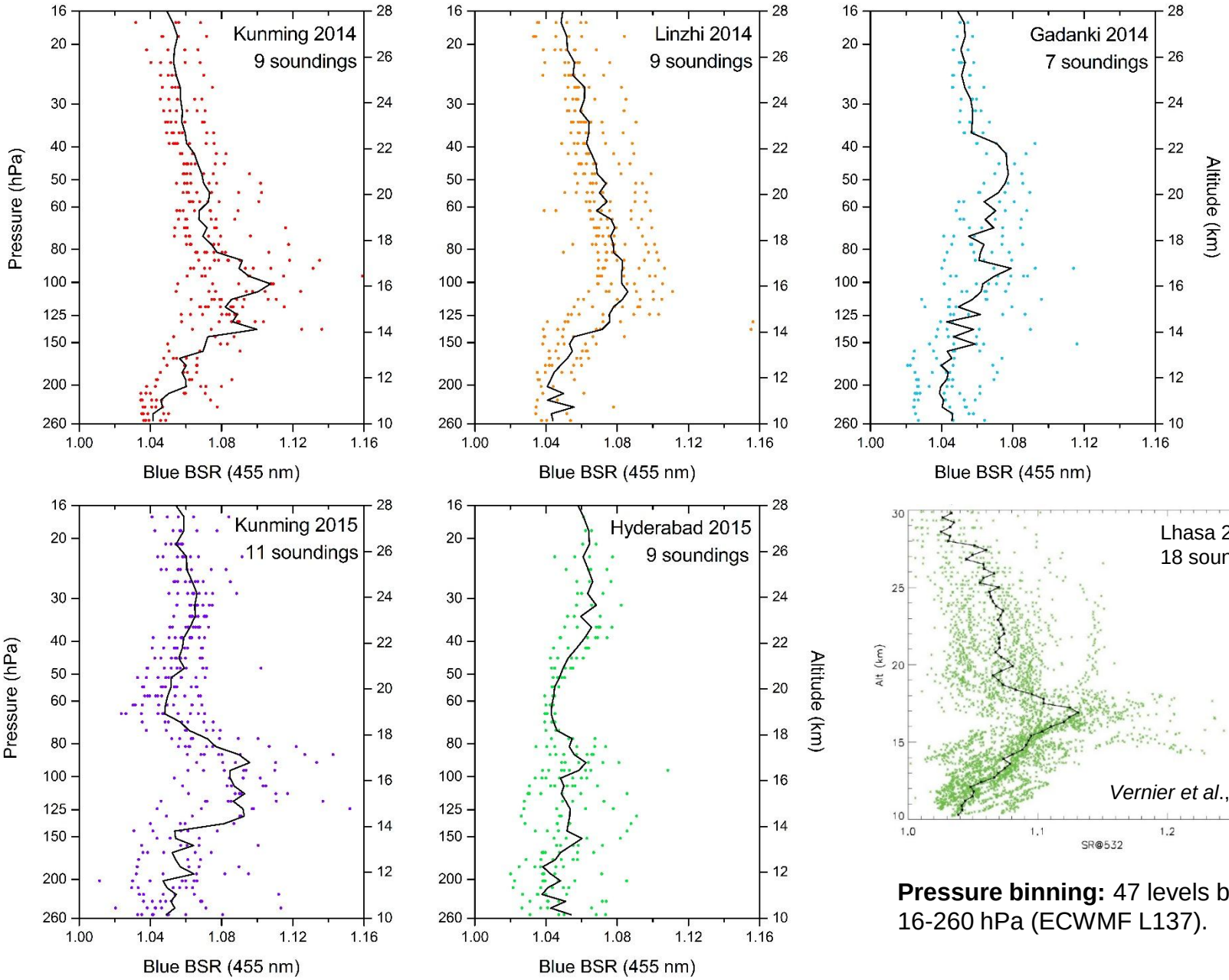
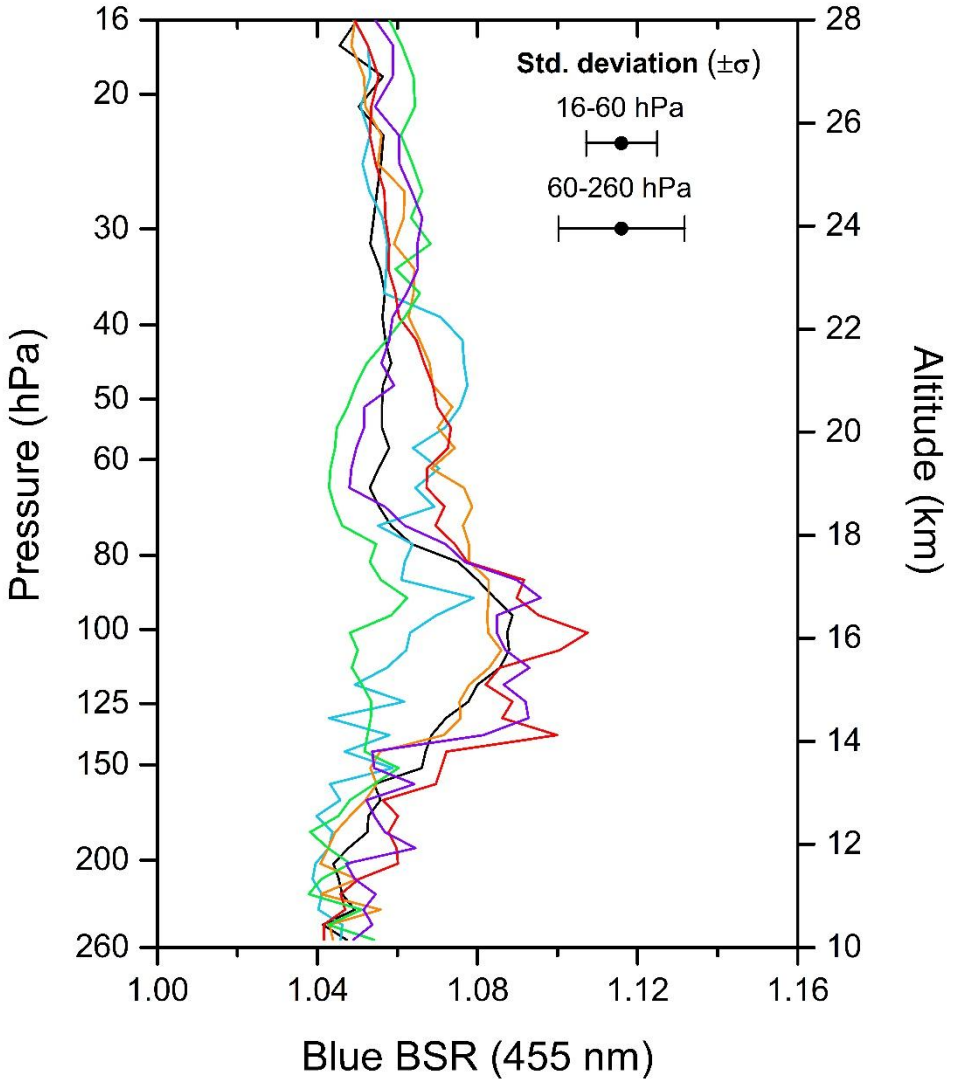
STRATOCLIM campaign (ETH / IITM / AWI)

- Nainital (India): 15 launches in Jul-Aug 2016
- Nagpur (India): 10 launches in Jul-Aug 2016
- Bhola (Bangladesh): 6 launches in Jul-Aug 2016



Pressure binning: 47 levels between 16-260 hPa (ECWMF L137).

COBALD in the ASM region: 2013 - 2015



Lhasa 2013
18 soundings, 7-24 August

Kunming 2014
9 soundings, 13-23 August

Linzhi 2014
9 soundings, 8 June-30 July

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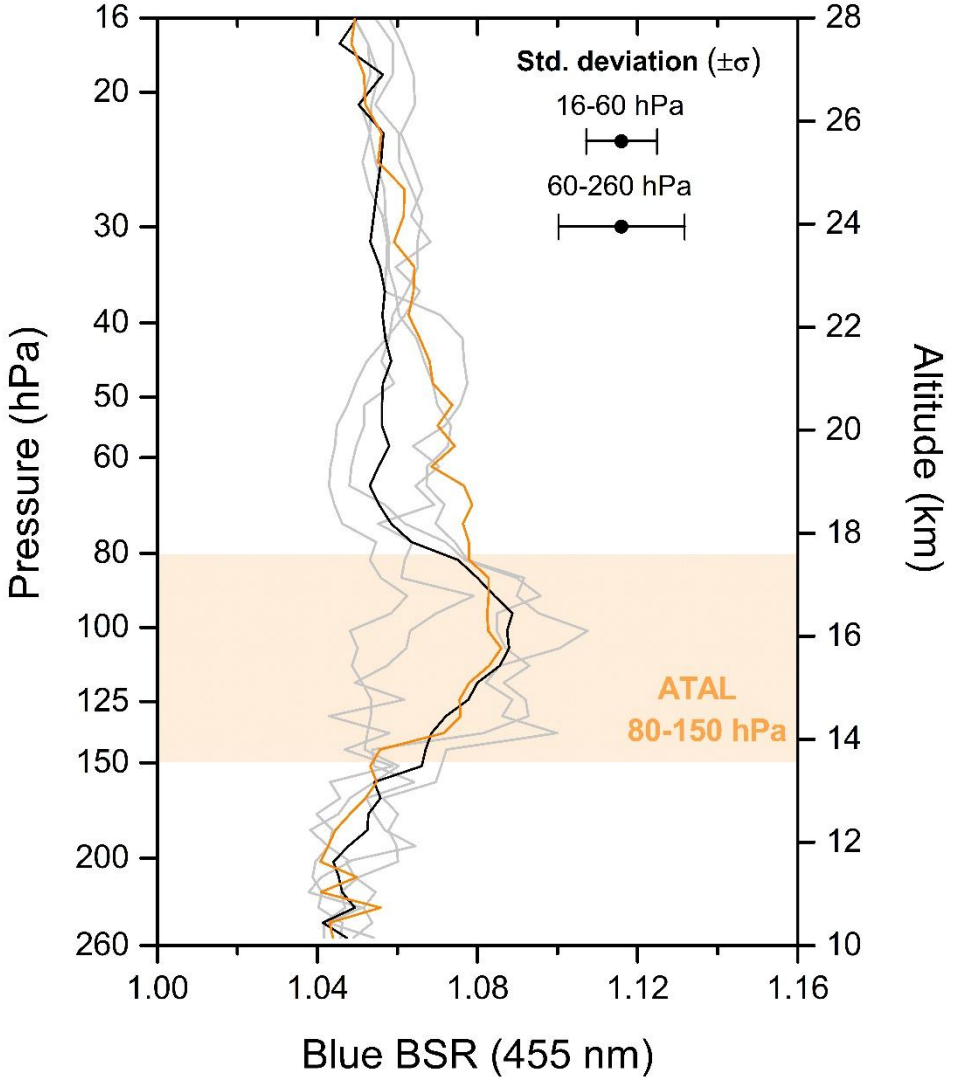
COBALD in the ASM region: 2013 - 2015



Tibetan plateau:

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18 soundings, 7-24 August

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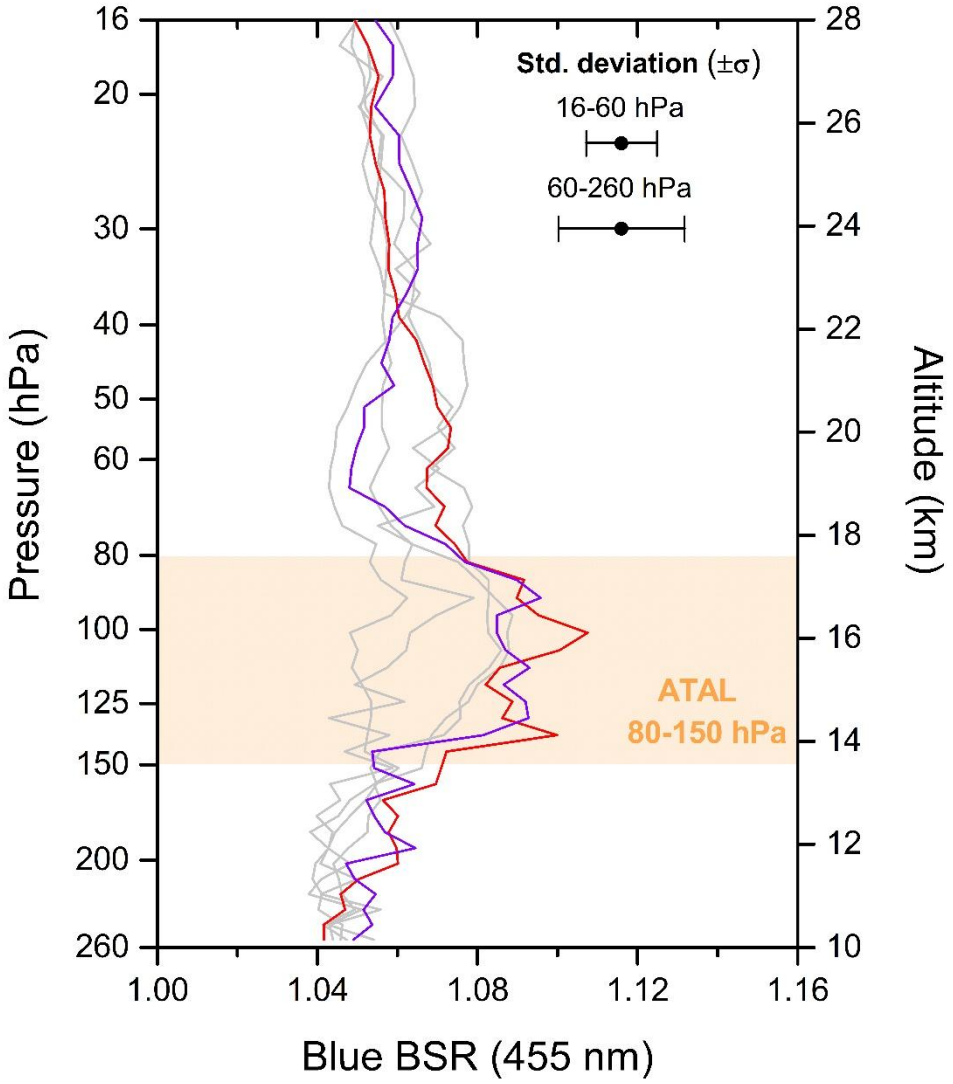
COBALD in the ASM region: 2013 - 2015



South-East China:

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18 soundings, 7-24 August

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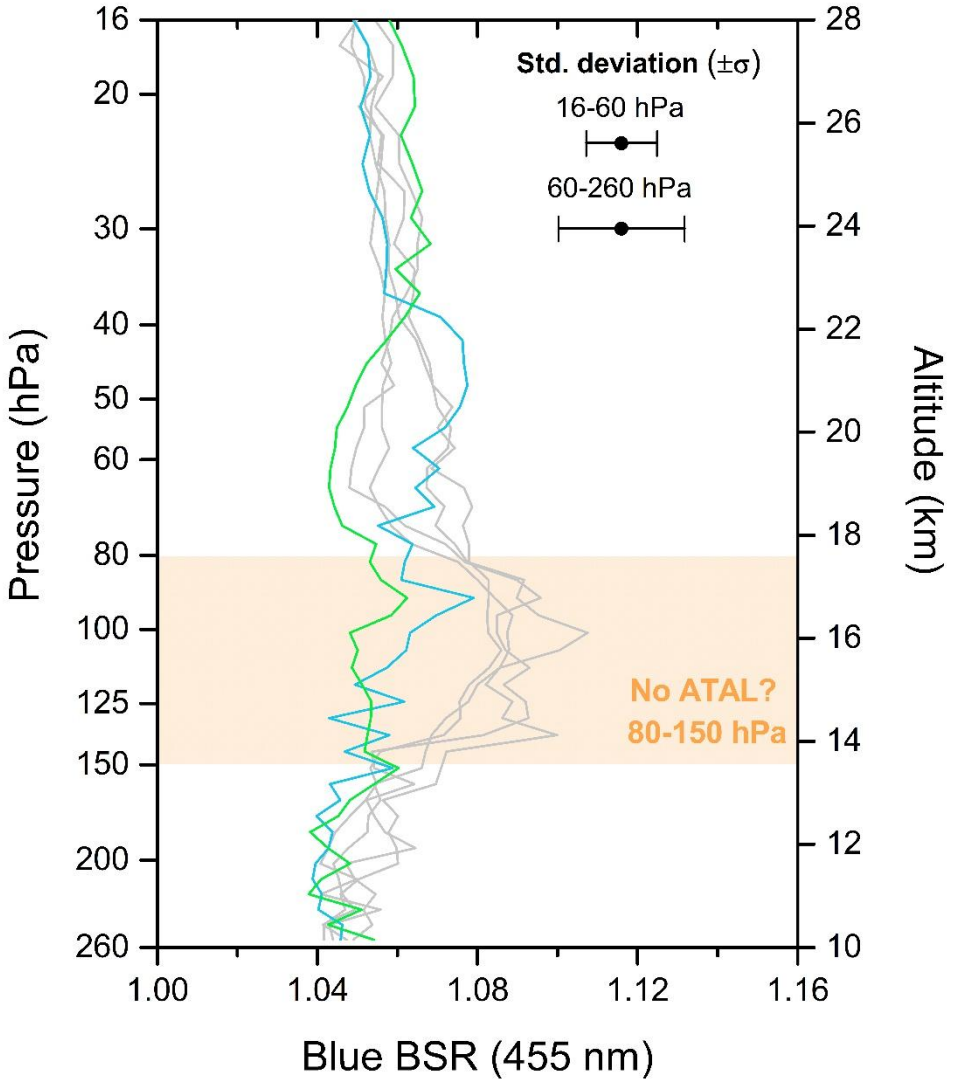

Southern India:

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Hyderabad 2015
9 soundings, 1-13 August

Kunming 2014

9 soundings, 13-23 August

Strat. aerosols (40-60 hPa)

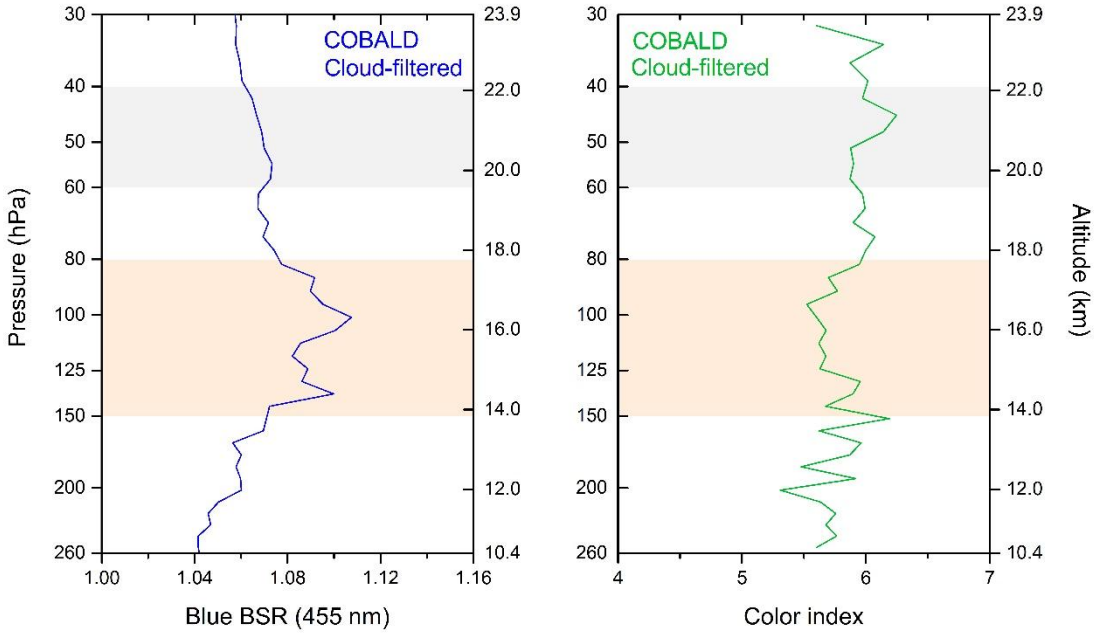
BlueBSR = 1.069, CI = 6.00

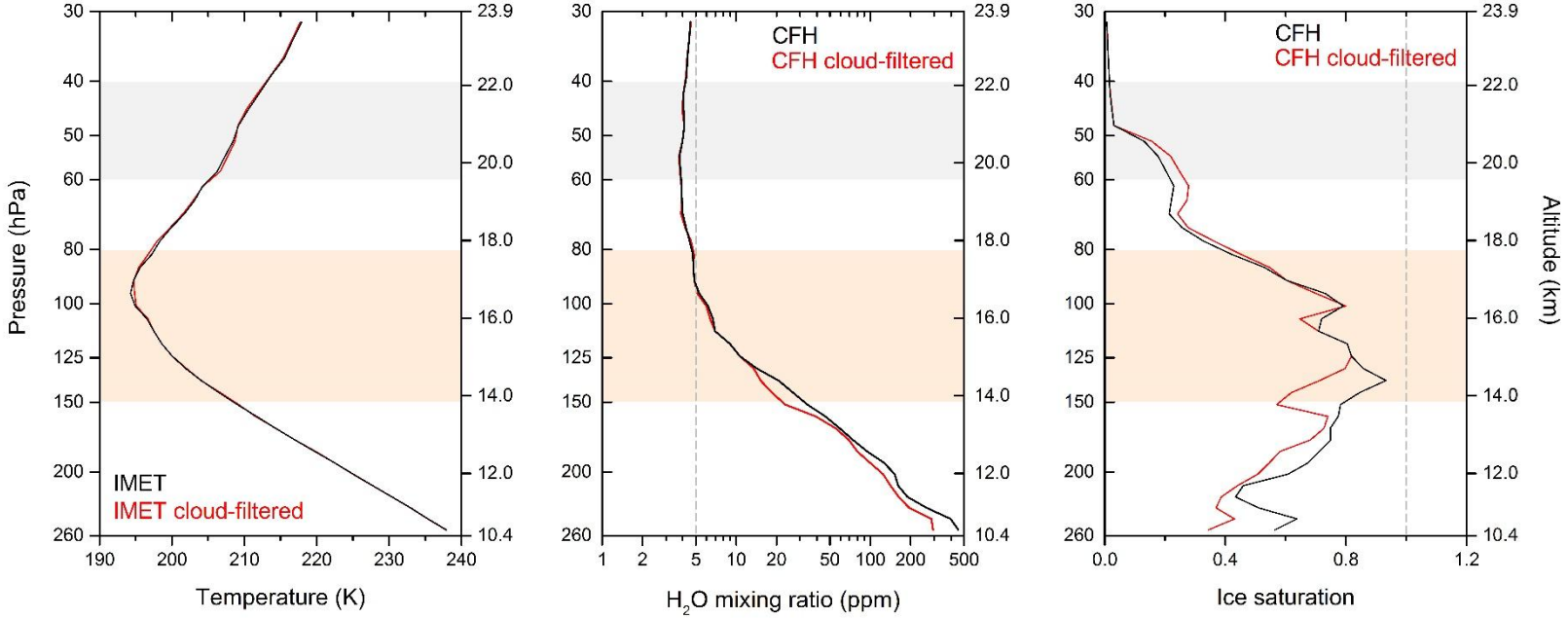
T = 209.0 K, Sice = 0.103

ATAL (80-150 hPa)

BlueBSR = 1.089, CI = 5.76

T = 199.3 K, Sice = 0.675



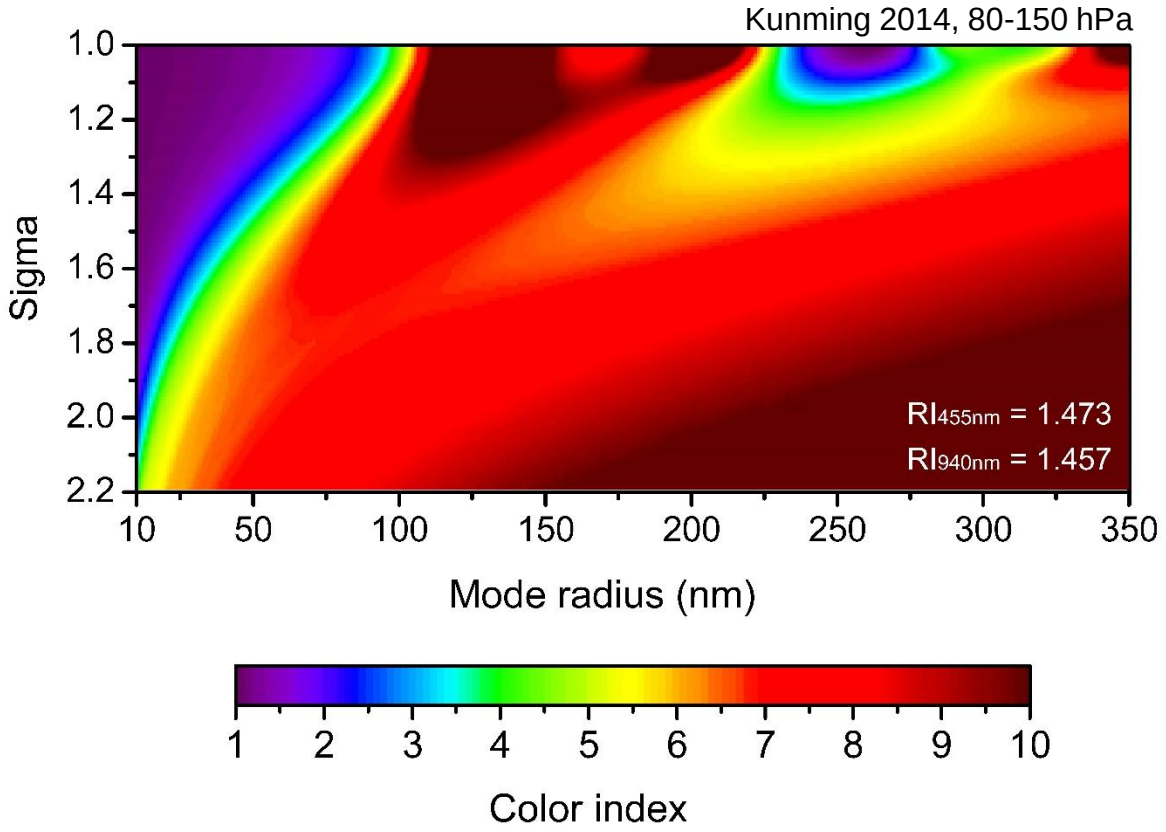


Optical modeling Method

Using a Mie scattering optical model, BlueBSR and Color Index can be calculated by prescribing a lognormal size distribution (i.e. mode radius, sigma, number density):

$$\mathbf{BlueBSR} = \mathrm{BlueBSR}(r, \sigma, N) \qquad \mathbf{CI} = \frac{\mathrm{RedBSR} - 1}{\mathrm{BlueBSR} - 1} = \mathrm{CI}(r, \sigma)$$

For a **single-mode** size distribution, CI is independent of number density and therefore it can be used as an «indicator» of particle size.



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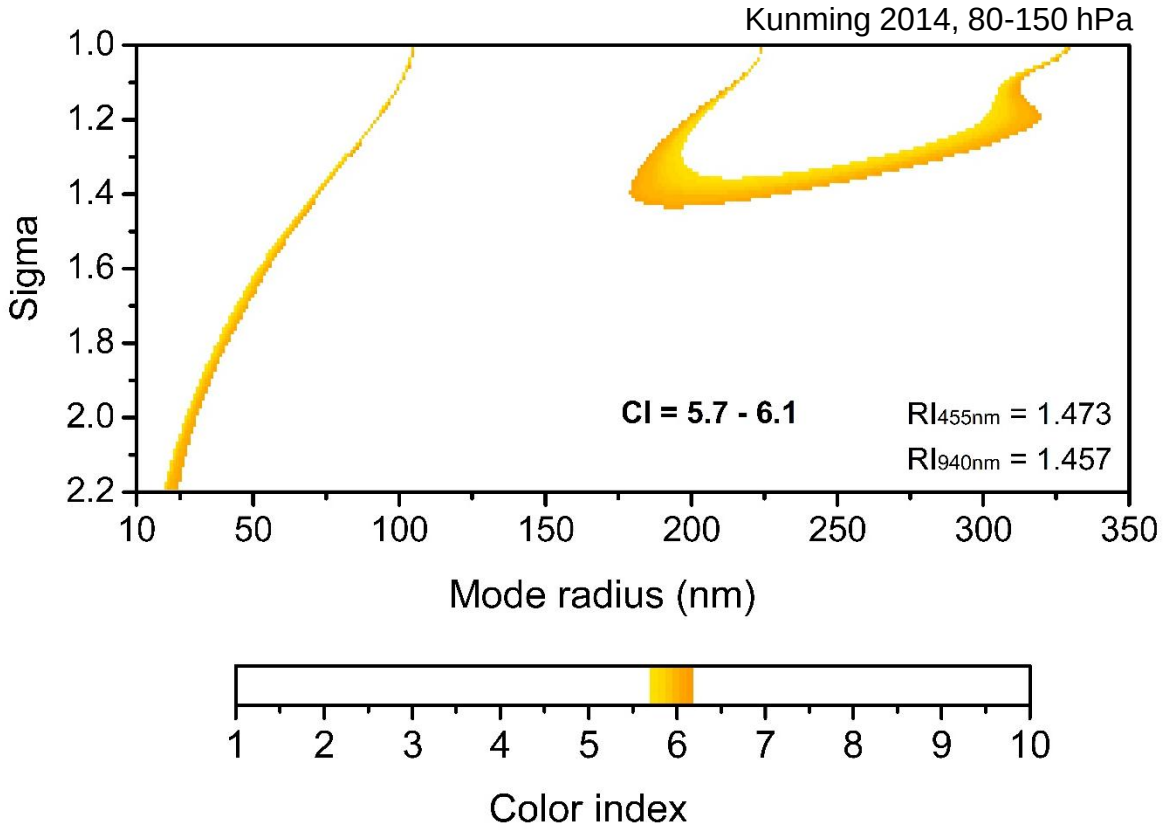
Step 1: constrain mode radius and sigma using CI from measurements

Step 2: apply BlueBSR constraint → calculate number density of each possible solution



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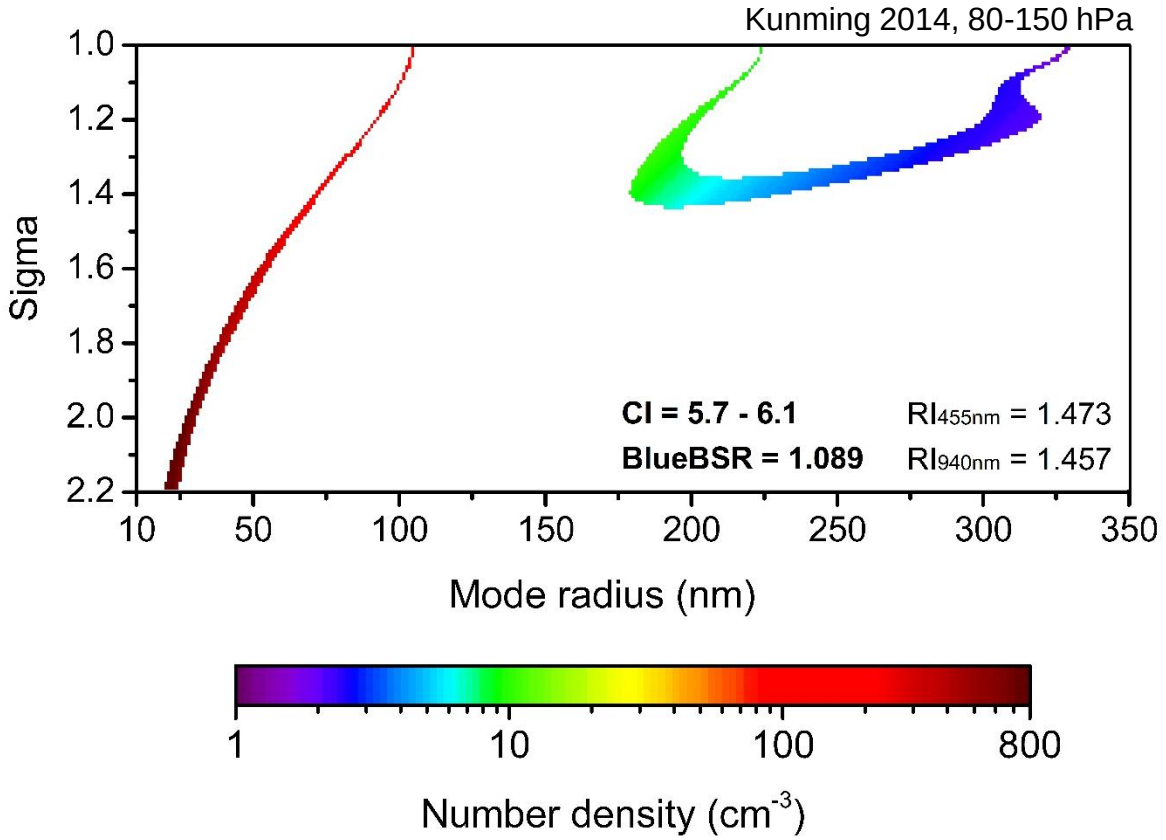
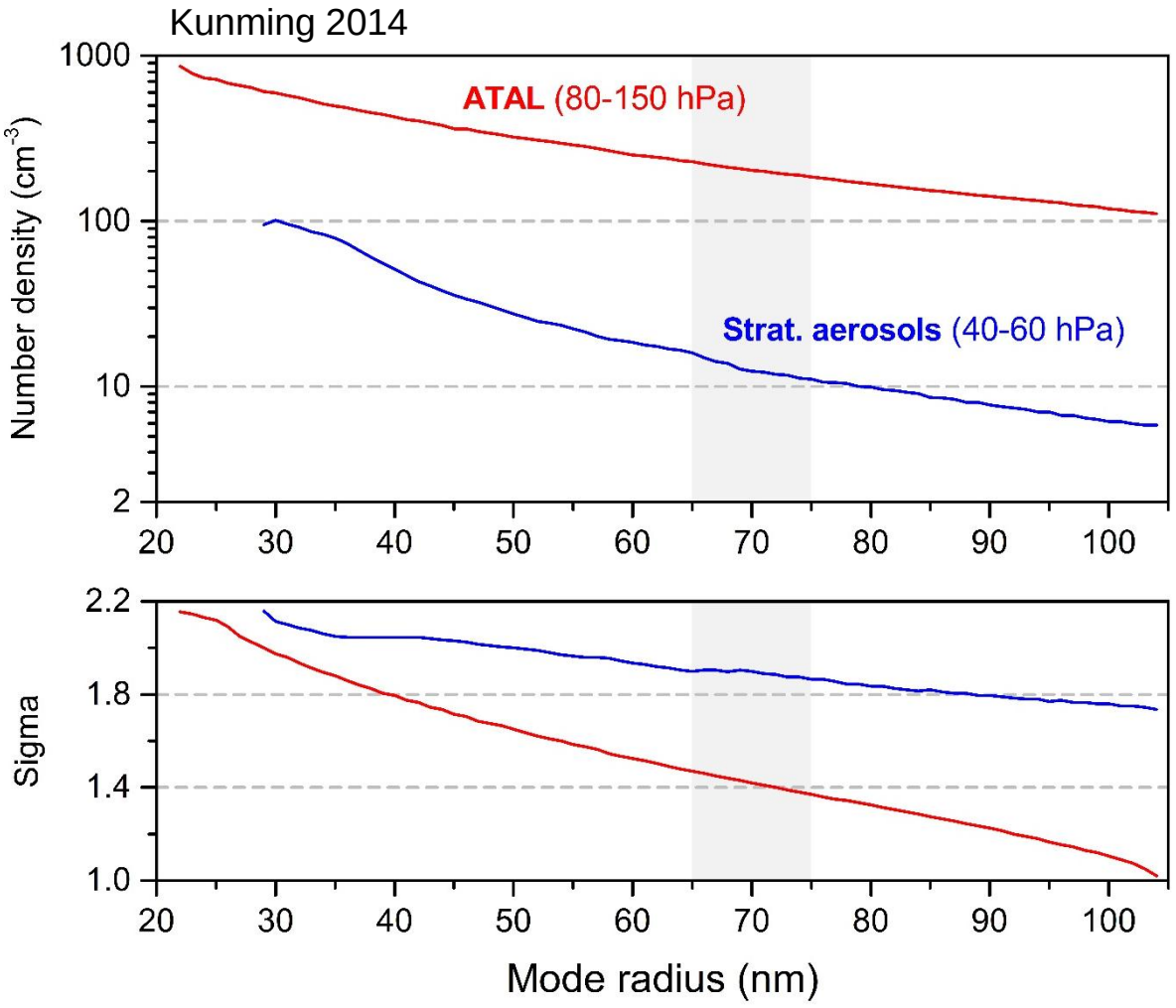


Optical modeling ATAL vs. Stratospheric aerosols



Stratospheric aerosols

Assuming mode radius ≈ 70 nm

→ Sigma ≈ 1.85

→ Number density ≈ 10 cm^{-3}

Consistent with literature (e.g. *Hamill et al.,* 1997).

ATAL (80-150 hPa)

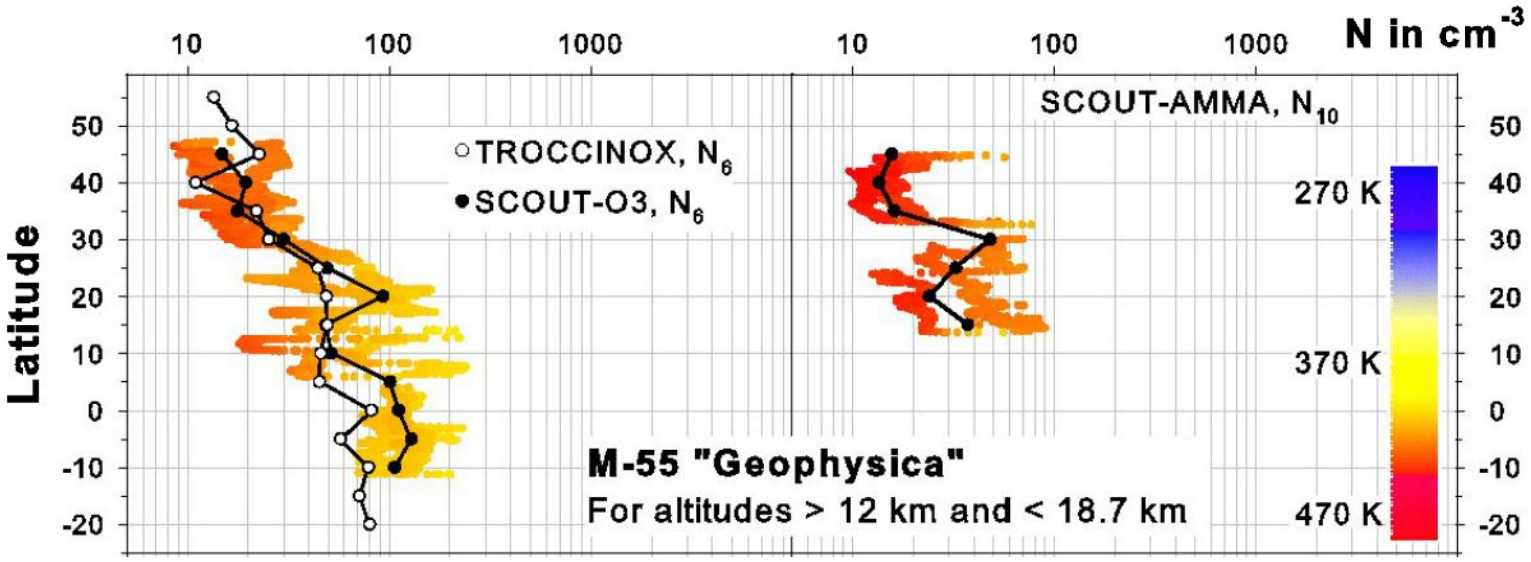
Assuming mode radius ≈ 50 nm

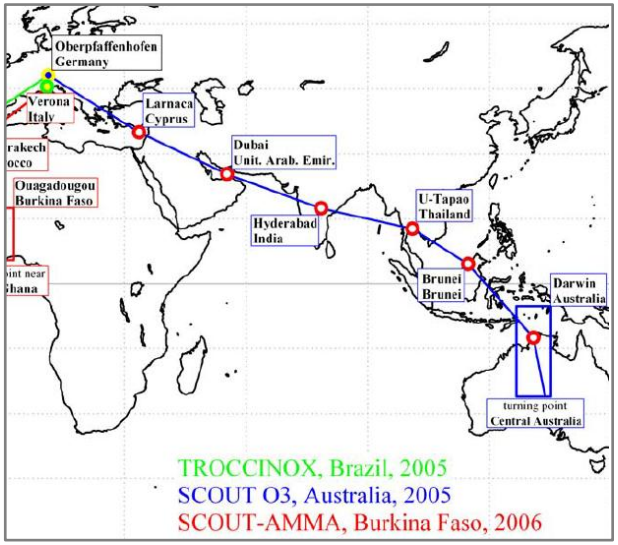
→ Sigma ≈ 1.6

→ **Number density** ≈ 500 cm^{-3}

Factor of 5 higher than the background concentration by the SCOUT-O3 campaign (*Borrmann et al*., 2010)

SCOUT-O3: Background UTLS aerosols

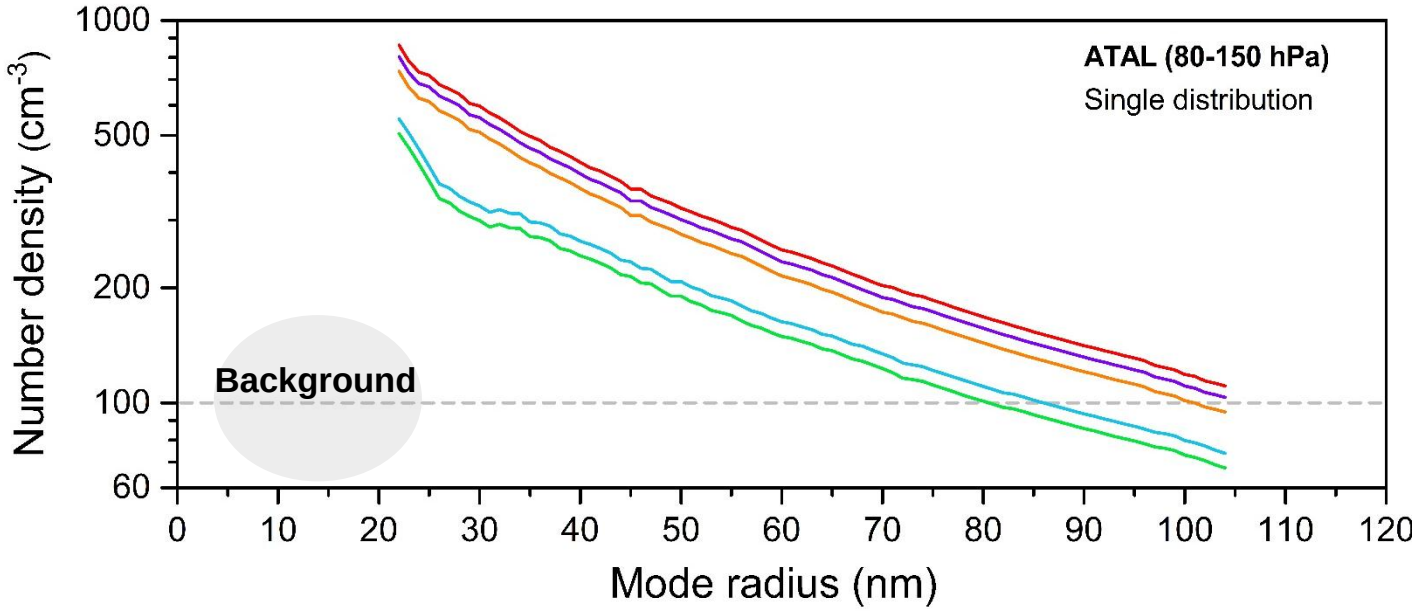




Aircraft measurements of submicron (> 6 nm) particle concentration at the Southern Indian UTLS (20°N) during **November-December** 2005.

Borrmann et al., ACP, 2010

Optical modeling Single vs. bimodal size distribution



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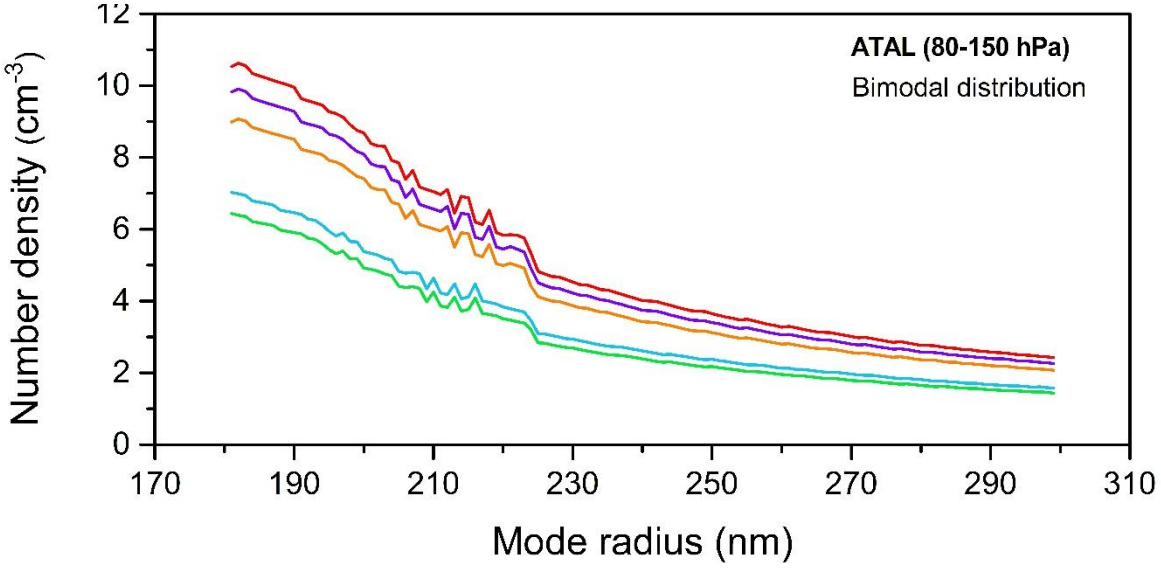
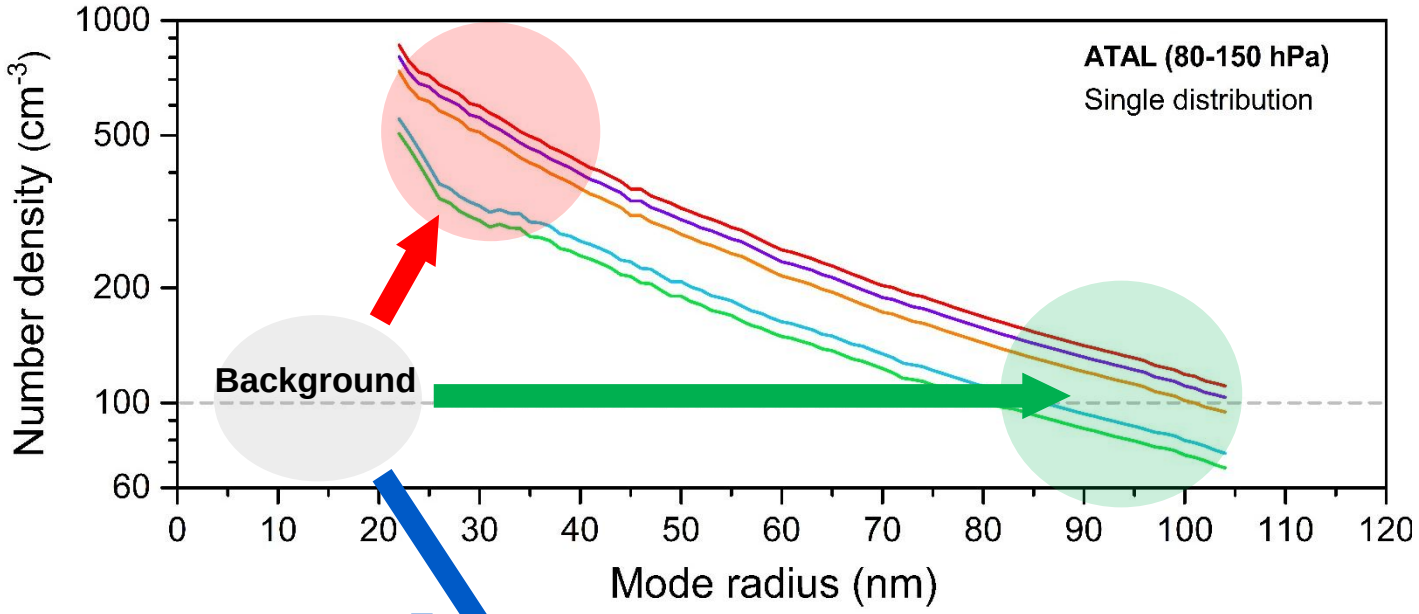


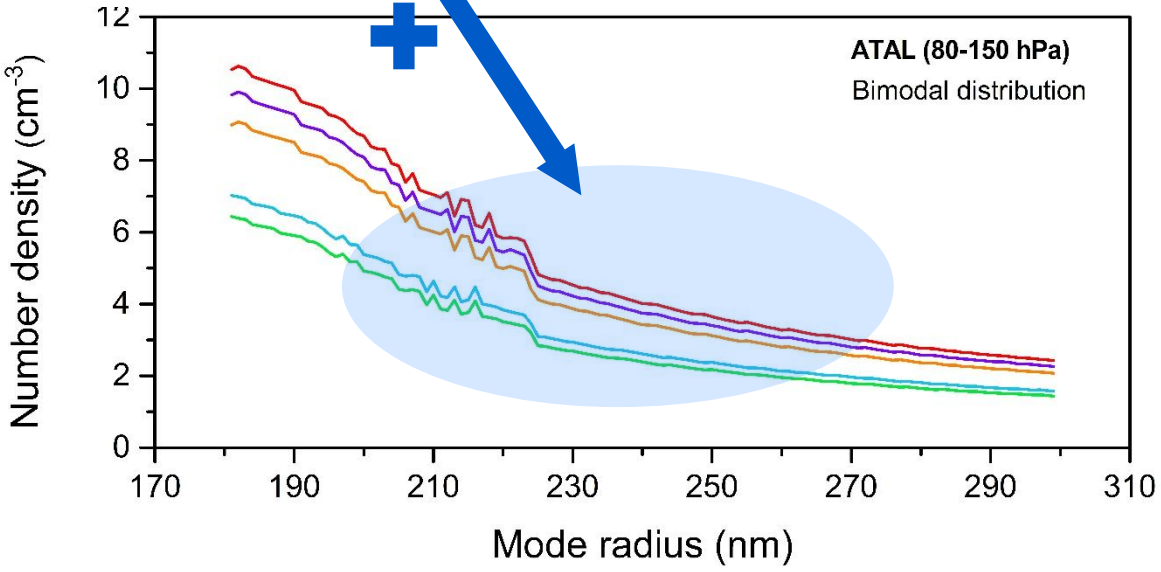
Bimodal distribution

Calculated as single lognormal distribution after subtracting the BSR from a "background mode" defined as:

Mode radius = 30 nm
Sigma = 1.6
Number density = 100 cm^{-3}

Optical modeling Single vs. bimodal size distribution





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Solution 1
More background particles

Solution 2
Larger background particles

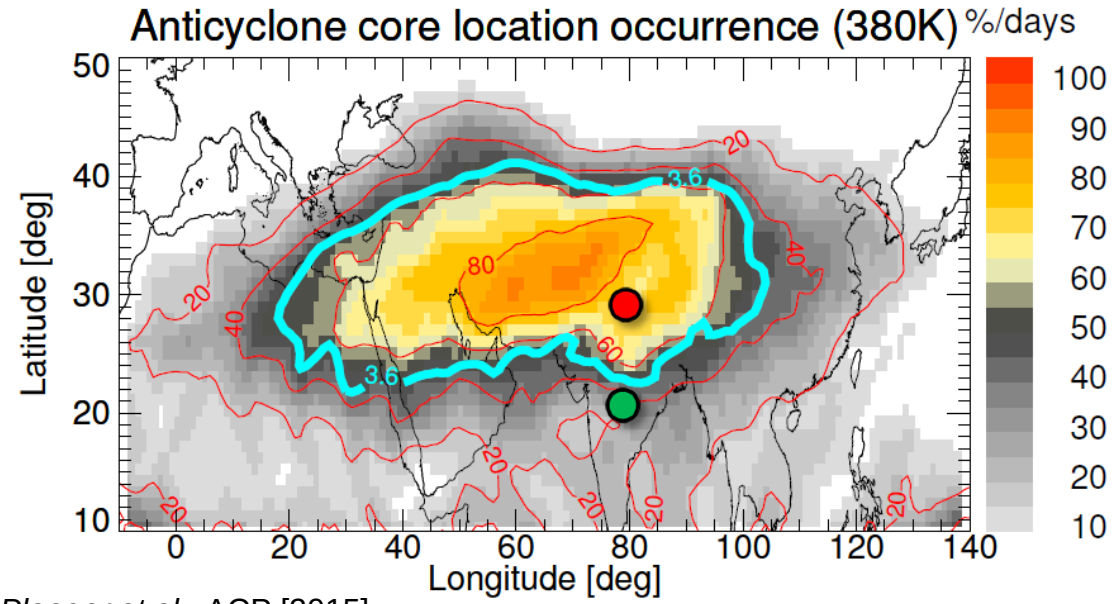
Solution 3
Background + larger particles

StratoClim WP2 field campaign, summer 2016

Within the StratoClim project, ETH Zürich together with the Indian Institute of Tropical Metereology (IITM) will perform:

- 25x night-time launches with: **COBALD / CFH / ECC / RS41**
- 5-10x day-time launches with payload: **CFH / RS41 / RS92**

from two stations in India, simultaneously with the *Geophysica-M55* aircraft campaign (approx. 18 Jul - 18 Aug 2016)

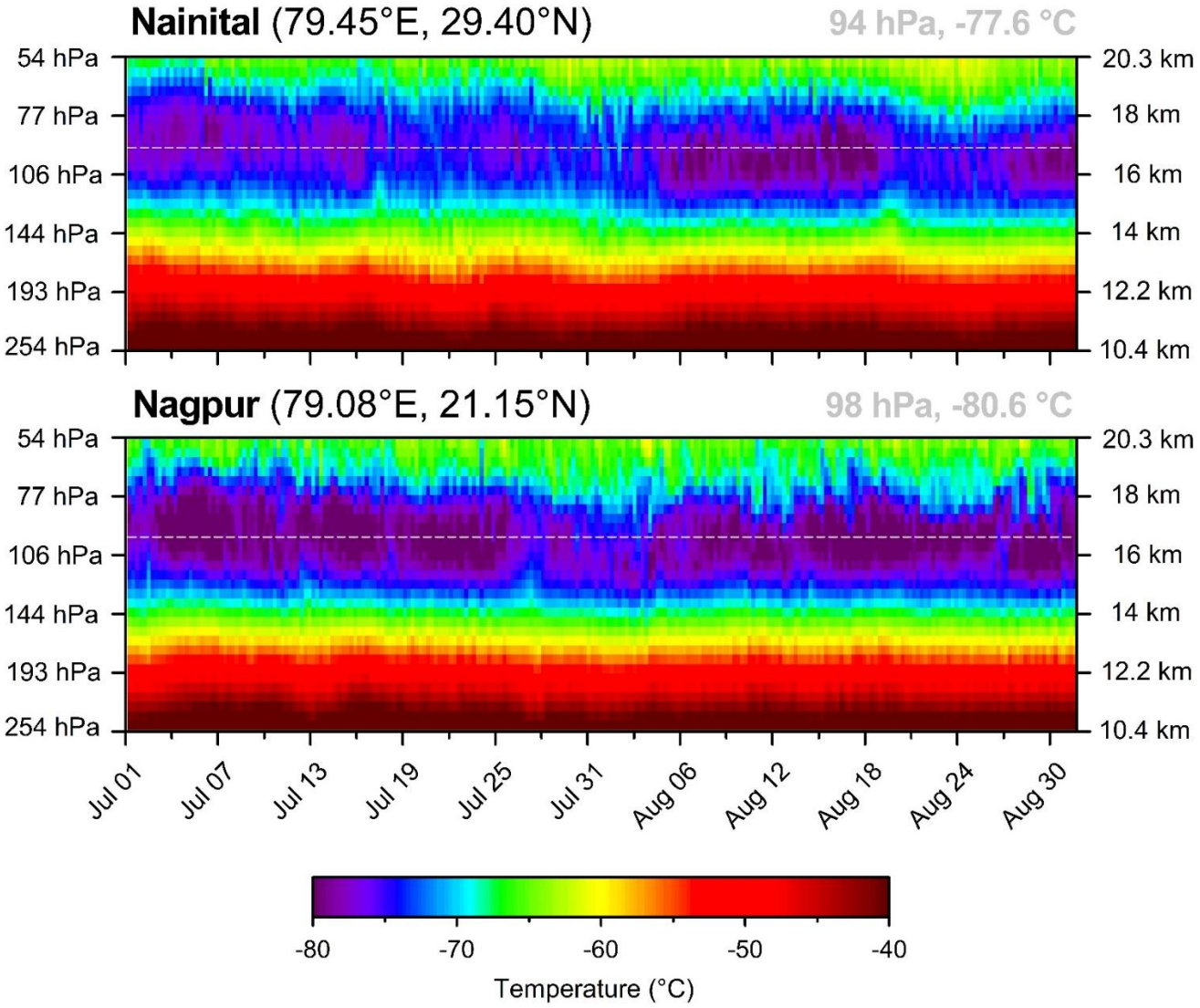


Ploeger et al., ACP [2015]

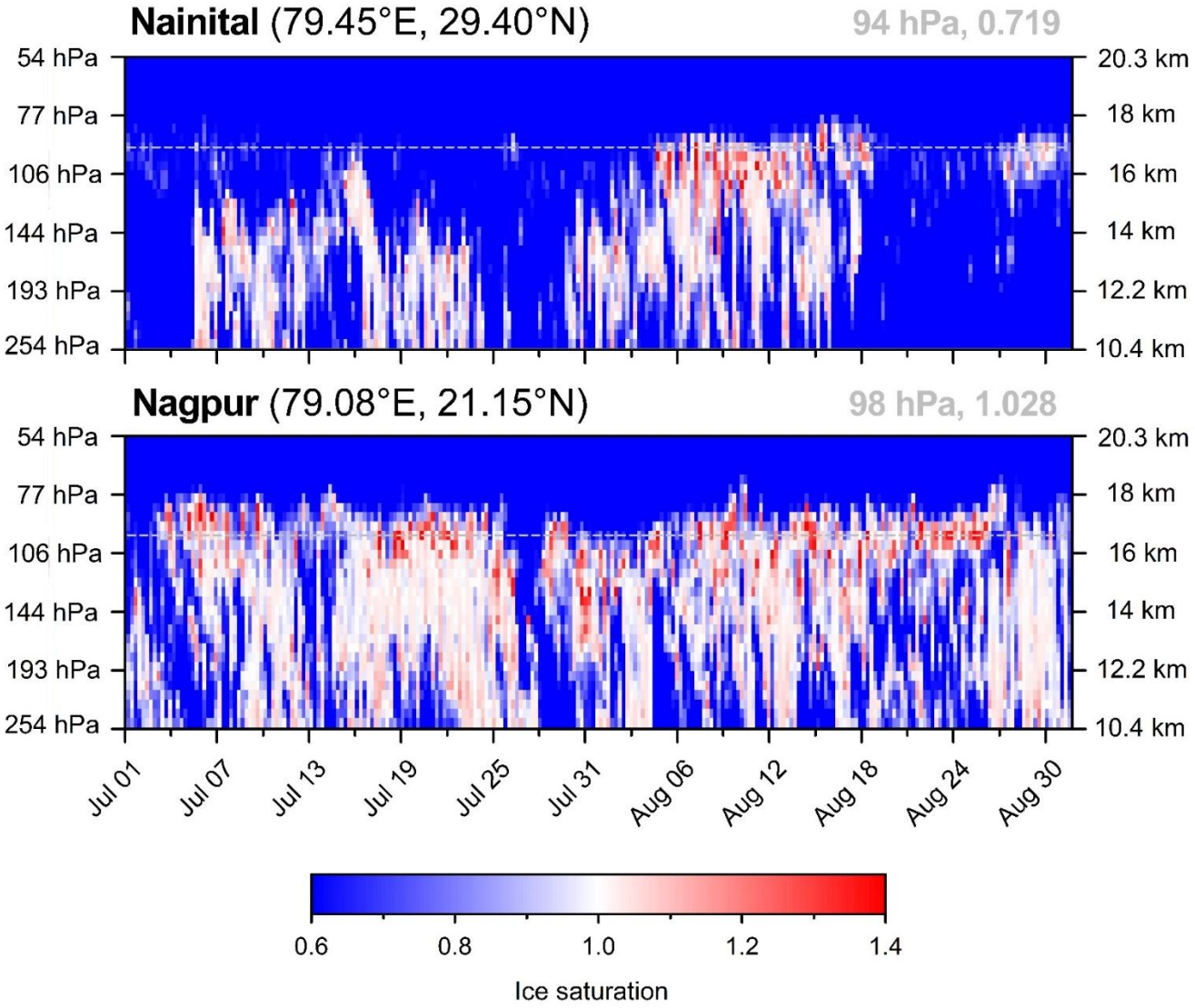
Campaign stations:

- **Nainital**, northern India
  79.45°E, 29.40°N
- **Nagpur**, central India
  79.08°E, 21.15°N

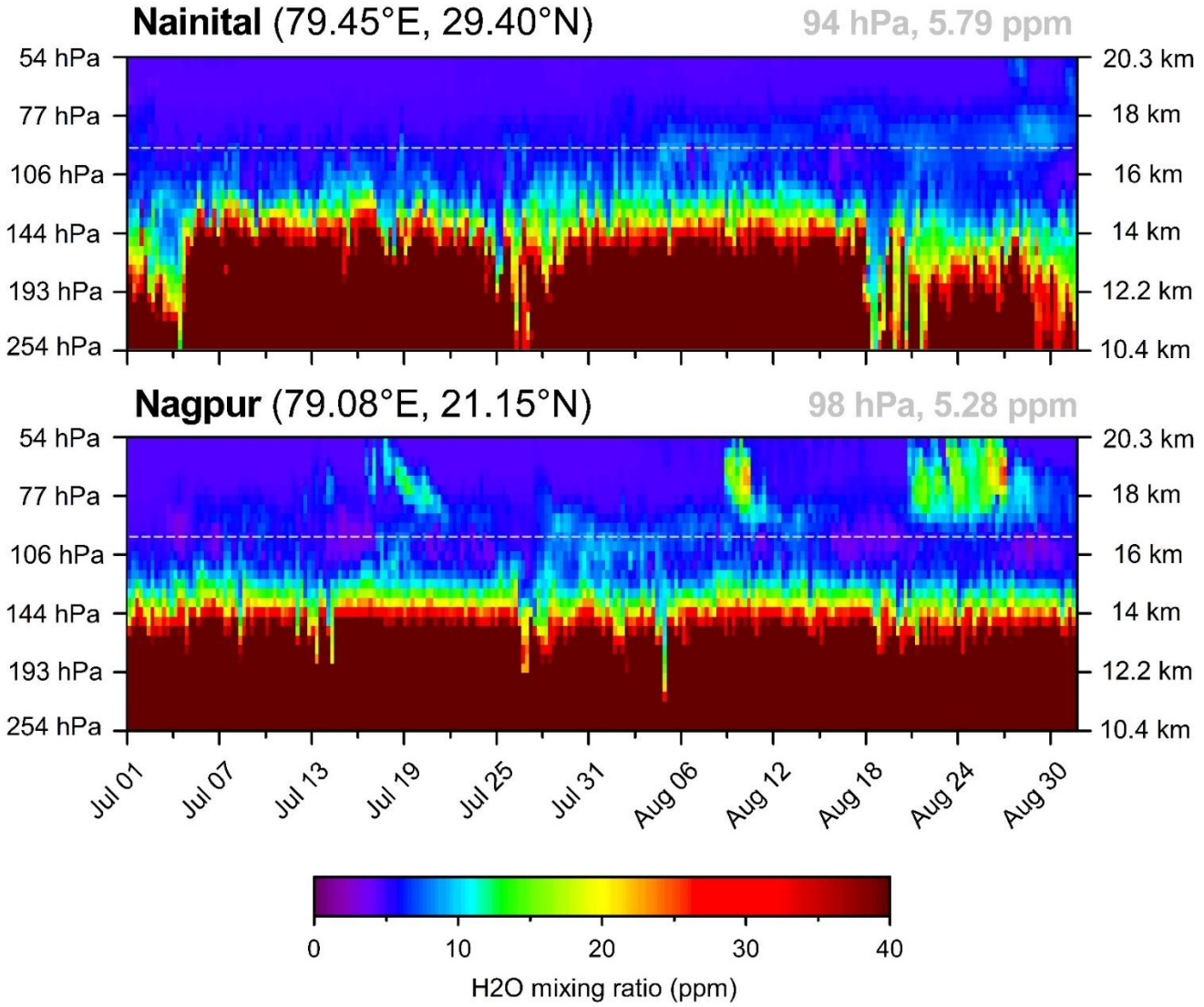
ECMWF analysis (0.15°x0.15°) Jul-Aug 2015: Temperature



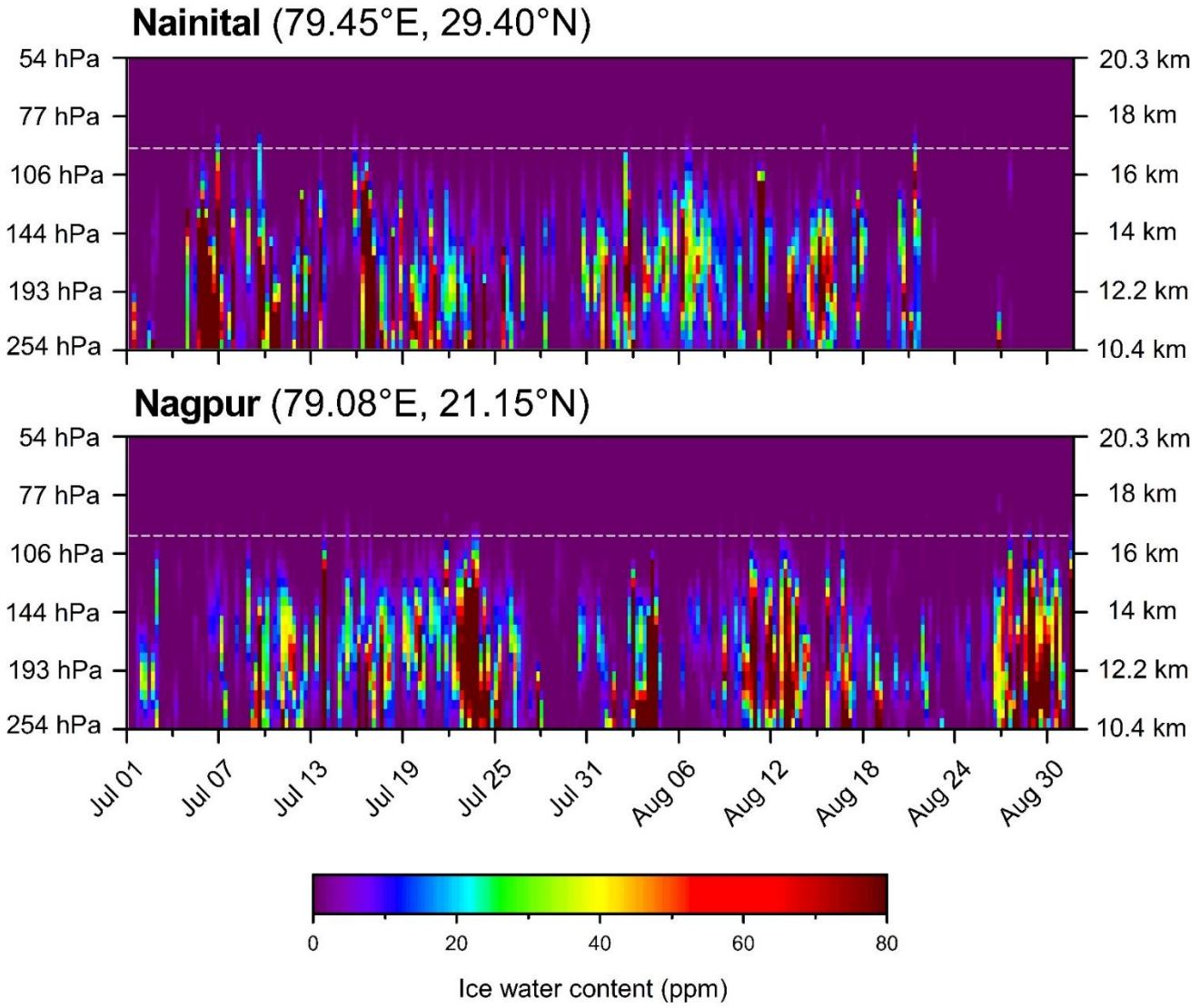
ECMWF analysis (0.15°x0.15°) Jul-Aug 2015: Ice saturation



ECMWF analysis (0.15°x0.15°) Jul-Aug 2015: H_2O mixing ratio



ECMWF analysis (0.15°x0.15°) Jul-Aug 2015: Ice water content



StratoClim 2016 field campaign: summary

Nainital (79°E, 29°N)

More likely **inside** the transport barrier [*Ploeger et al*., 2015] and the *conduit* [*Bergman et al*., 2013].

Warmer UTLS, lower ice saturations at the cold-point tropopause.

→ Enhanced water vapour and aerosols (ATAL) at the UTLS.

Nagpur (79°E, 21°N)

More likely **outside** the transport barrier [*Ploeger et al.*, 2015] and the *conduit* [*Bergman et al*., 2013].

Colder UTLS, higher ice saturations at the cold-point tropopause.

→ More cirrus clouds, more dehydration, less water vapour in the LS.

Draft campaign strategy:

Nainital: 15 night-time + 5 day-time launches, between approx. 18 Jul -18 Aug

Nagpur: 10 night-time launches, during the *Geophysica* in-situ flights (01-20 Aug)