# Supplementary Information

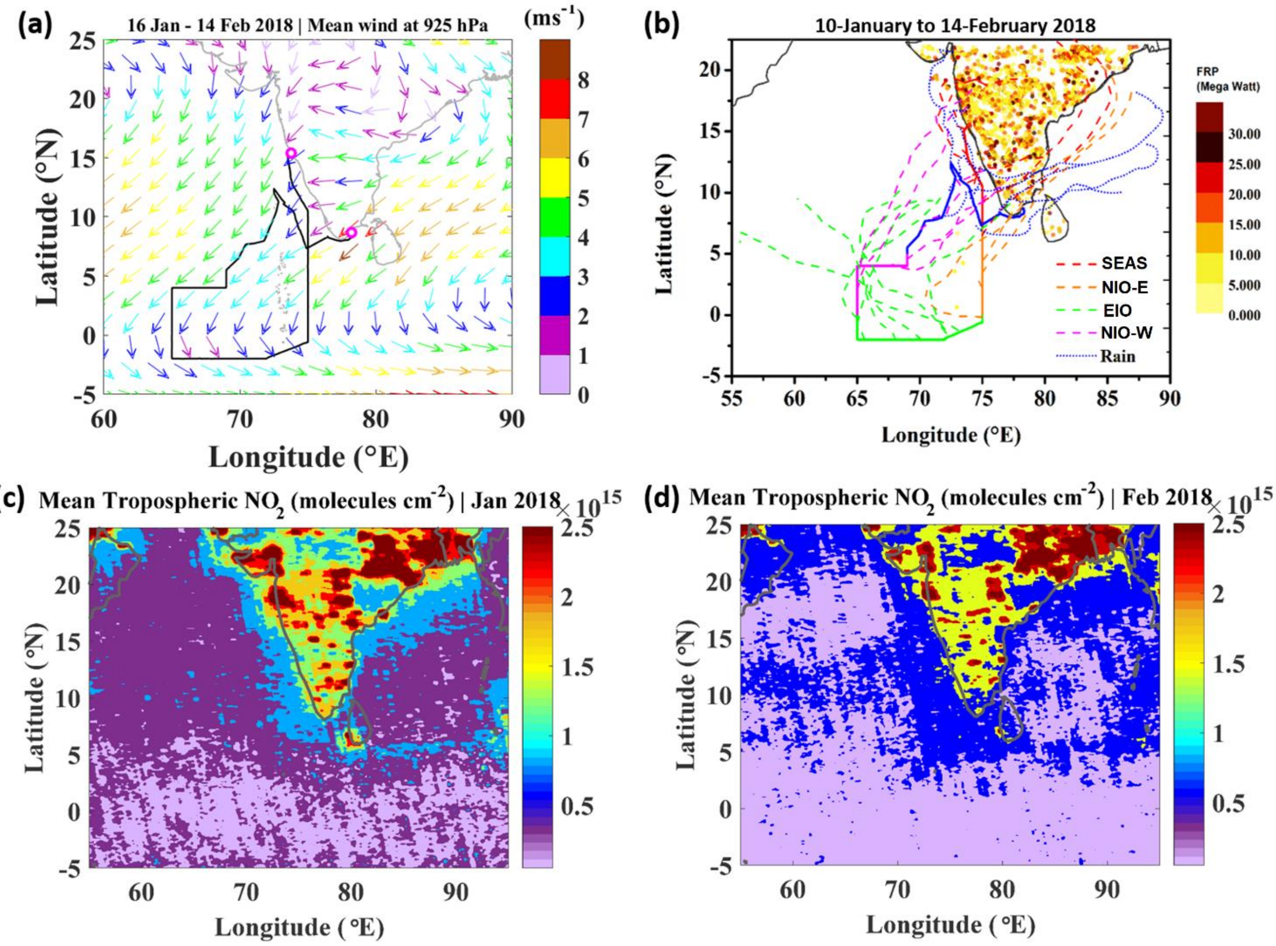


**Figure S1.(a) Mean wind vectors at 925 hPa for the experimental period derived from ERA-Interim wind data from ECMWF (European Center for Medium range Weather Forecasting (https://apps.ecmwf.int/datasets/data/interim-full-daily/levtype=sfc/) (b) Spatial distribution of Moderate Resolution Imaging Spectroradiometer (MODIS) fire radiative power (MODIS Thermal Anomalies / Fire locations Collection 6 product obtained from https://earthdata.nasa.gov/firms) for the period 10, January to 14, February 2018 along with 5-day air mass back trajectories and the ICARB-2018 cruise track, (c) mean tropospheric $NO_2$ obtained from TROPOspheric Monitoring Instrument (TROPOMI) for January -2018, (d) mean tropospheric $NO_2$ for February -2018 (http://www.temis.nl/airpollution/no2col/no2regio_tropomi.php).**

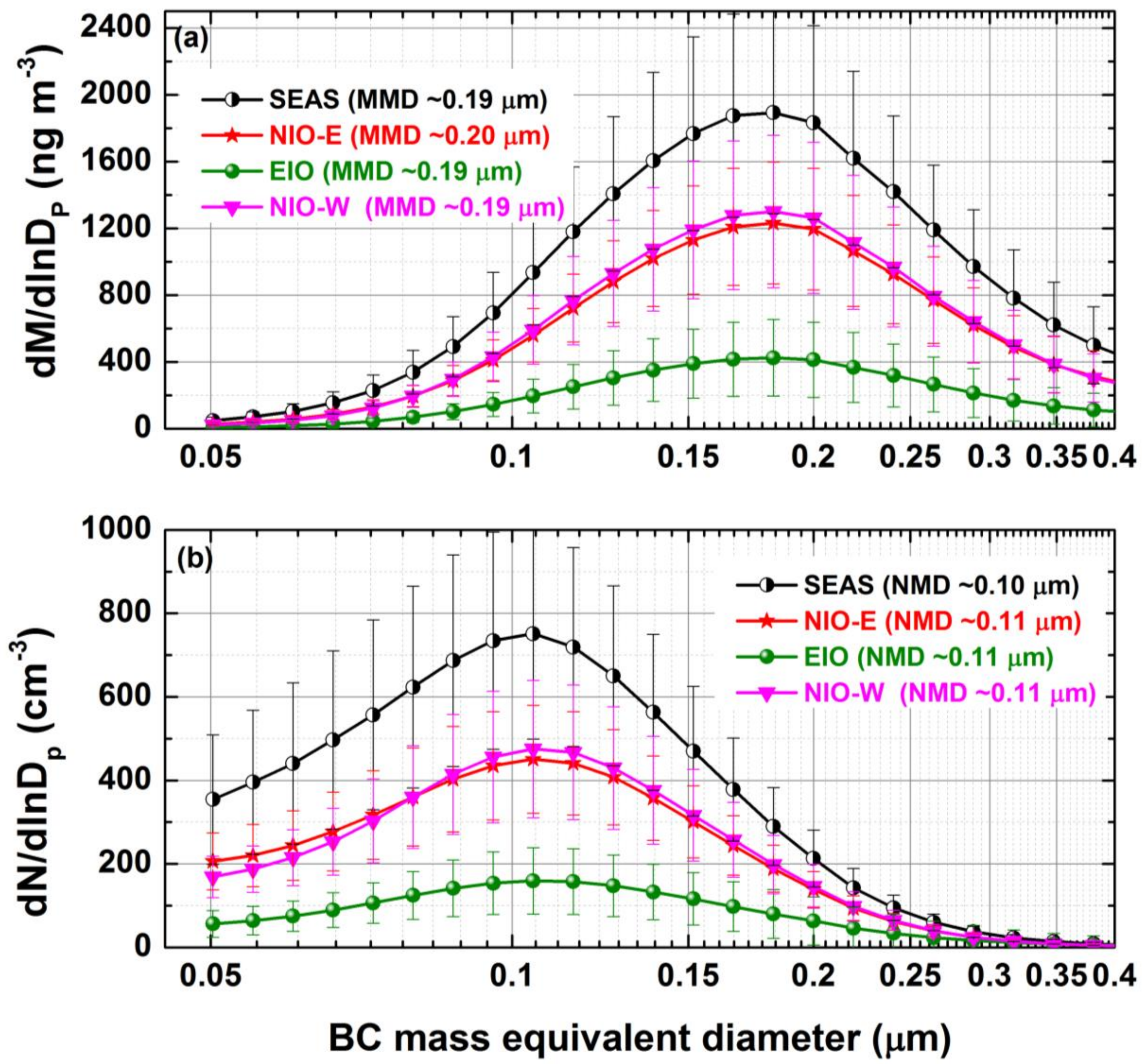


**Figure S2. The rBC mass and number size distributions over different regions during the ICARB-2018. The corresponding mean MMD and NMD values are also shown in the figure. The vertical bars indicate standard deviation.**

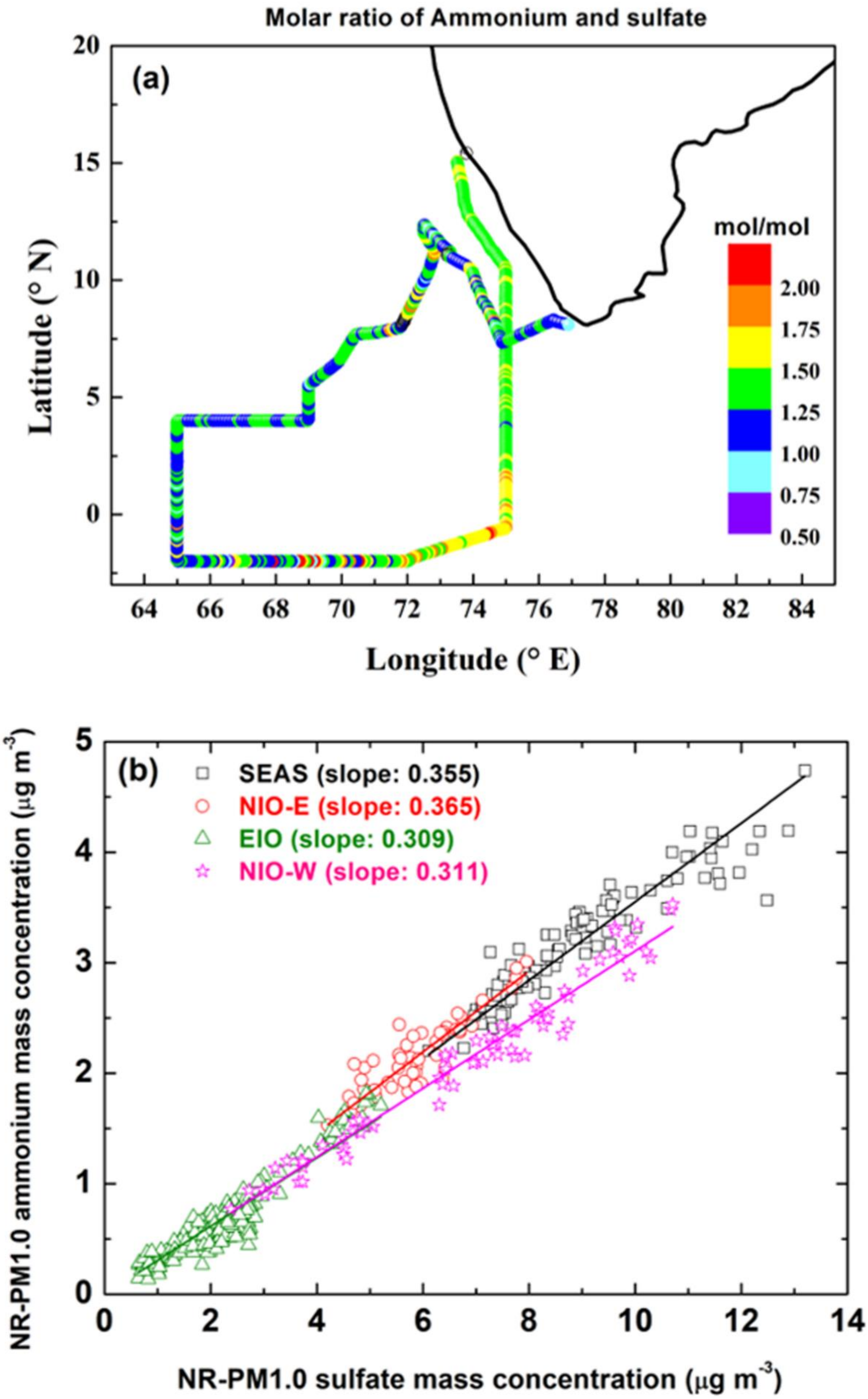


**Figure S3.(a) Spatial variation of the molar ratio of ammonium and sulfate (mol/mol);(b) Scatter plot between mass concentrations of NR-PM1.0 sulfate and ammonium during the ICARB-2018. Solid lines represent the linear least-squares fit to the points, and the value of slope also is written in the panel.**

**Case study: Effect of rainfall on BC characteristics**

The ICARB-2018 encountered significant weather events with an intense rain (total accumulated rainfall ~57.6 mm) affecting the in-situ aerosol measurements and air masses en-route when the cruise was revisiting the SEAS region (the region marked as SAS in Fig. 1) (Gogoi et al., 2019). The wet-scavenging mechanism is one of the effective limiting processes of the lifetime of aerosols (Radke et al., 1980), including BC (Liousseet al., 1996; Chaubey et al., 2010; Kompalli et al., 2014a,b). Given this, though the prevailing air masses still have signatures of the Indian subcontinent, the measurements over the SAS region were not considered as representative of either of the SEAS or the NIO-E regions but treated as a separate case study. The overall mean values of BC parameters over this region, shown in Table-S1, were interestingly comparable to the values over the SEAS/NIO-E.

**Table-S1:** Mean values of rBC characteristics, including its mixing state parameters in the SAS region affected by the rain due to a significant weather system.

| **Parameter** | **Mean ±standard deviation** |
|---|---|
| rBC mass concentration (ng m$^{-3}$) | 594 ±167 |
| rBC number concentration (cm$^{-3}$) | 228 ± 63 |
| Scattering particle concentration (cm$^{-3}$) | 572 ± 114 |
| Mass median diameter (μm) | 0.190 ± 0.006 |
| Number median diameter (μm) | 0.104 ± 0.004 |
| Relative coating thickness | 1.77 ± 0.13 |
| Absolute coating thickness (nm) | 73 ± 14 |

Further, a severe rainfall event with a total accumulated rainfall of 54.2 mm was recorded on 07 February 2018 (00:00-09:30 hrs). We have examined rBC microphysical properties prior to the rain event (termed as 'Before', period: 06 February 2018 18:00-23:00 hrs) and compared them to the values during and after the episode. Temporal variation of the various BC and associated parameters depicting the impact of rainfall are shown in Fig.S4.

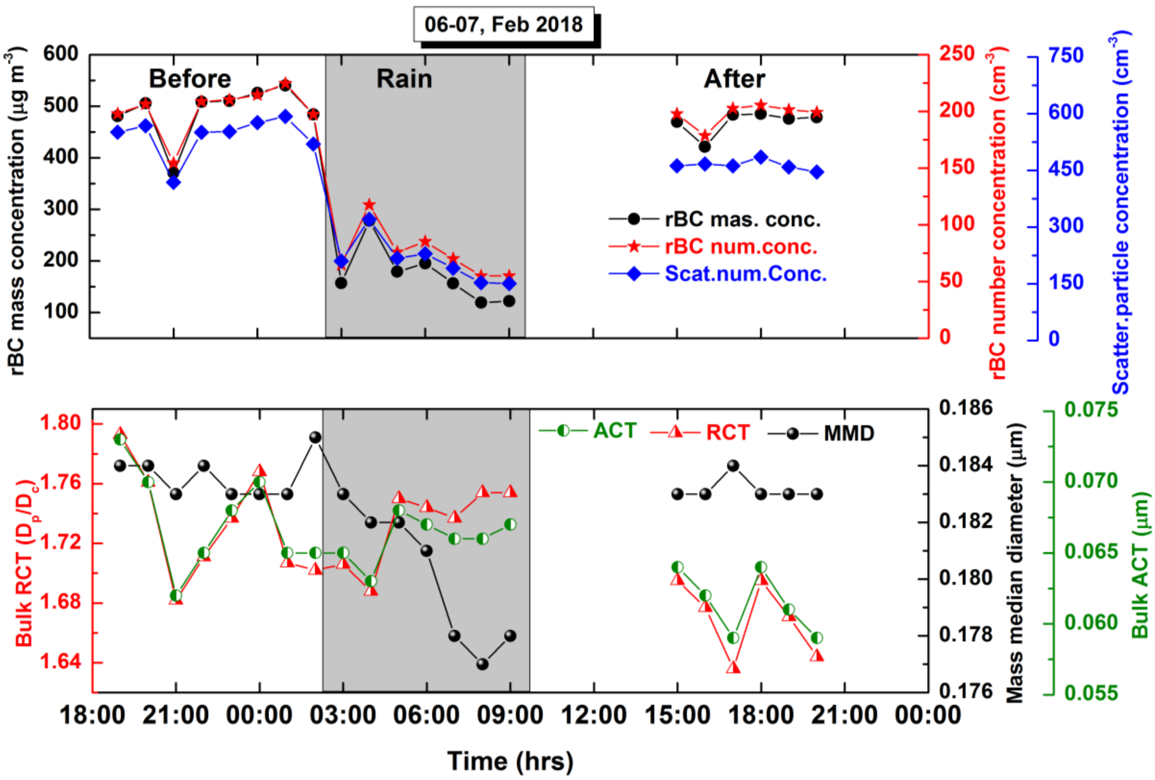

**Figure S4. Temporal variation of hourly mean rBC mass, number concentrations, and scattering particle number concentrations (top panel), along with bulk RCT, ACT, and mass median diameters (bottom panel). The shaded portion highlights the rainfall period.**

While there is a substantial drop in mass and number concentrations (~ 50 % drop during the episode), surprisingly, the BC mixing state parameters (RCT and ACT) showed no such dramatic differences 'before' and during 'rain' events. Even apparent changes in MMD values were minimal (dropped down to 0.177 µm from 0.184 µm before the event, thus suggesting larger particles were effectively removed due to rain). We have estimated the apparent scavenging efficiency, which is the ratio of the value of the parameter that has been scavenged and its value before the rain (scavenging process) (Gogoi et al., 2019) for different parameters. These are tabulated in Table-S2.

**Table-S2:** Mean values of BC parameters observed during the period of 06th-07th February 2018, along with the values of apparent scavenging efficiencies during the rain episode.

| Parameter | Before rain | During rain | Scavenging efficiency |
|---|---|---|---|
| rBC mass concentration (ng $m^{-3}$) | 491 ±93 | 212 ± 122 | 0.43 |
| rBC number concentration ($cm^{-3}$) | 202 ± 36 | 90 ± 48 | 0.46 |
| Scattering particle concentration ($cm^{-3}$) | 544 ± 91 | 249 ± 122 | 0.46 |
| Mass median diameter (µm) | 0.183 ± 0.003 | 0.180 ± 0.006 | -- |
| Number median diameter (µm) | 0.103 ± 0.000 | 0.101 ± 0.002 | -- |
| Relative coating thickness | 1.74 ± 0.05 | 1.73 ± 0.04 | -- |
| Absolute coating thickness (nm) | 68 ± 5 | 66 ± 3 | -- |

In Fig.S5 in the Supplement, mean BC mass size distributions, before, during, and after the rain period are shown along with the loss in mass concentrations (% drop) in each size bin. Except for changes in magnitudes, there were no noticeable changes in the MMD of the size distributions due to rain episode.

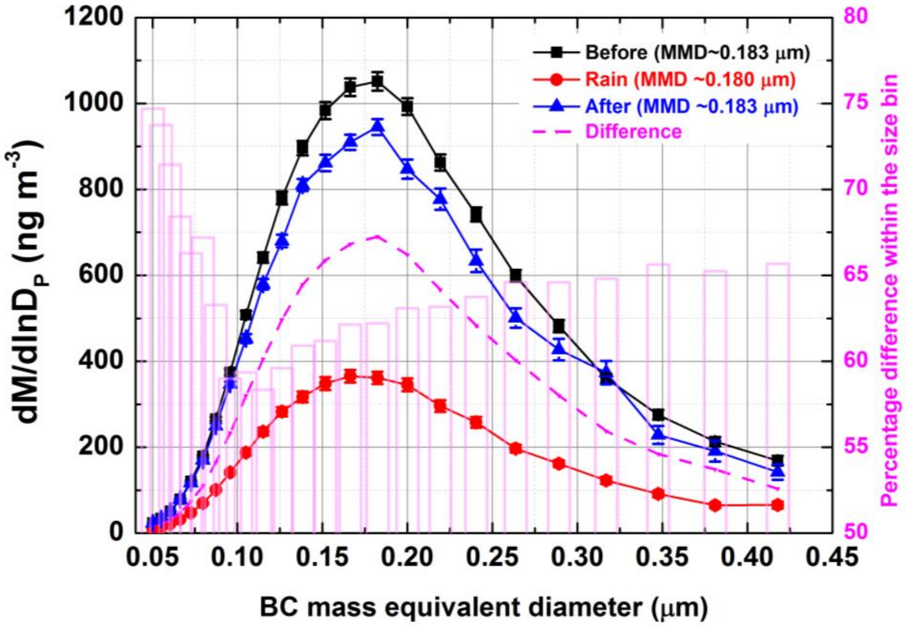


**Figure S5**. **BC Mass size distribution before, during, and after the rainfall episode. The bars show the percentage drop in the BC mass concentrations due to the rain event.**

Even though below-cloud scavenging is a vital sink mechanism for aerosol BC (it reduced the concentrations by almost half), it was less effective in altering the microphysical properties like MMD and mixing state parameters during the present study.

Detailed analysis of the rainfall characteristics like drop size distributions along with the collection efficiency of the falling raindrop to capture the submicrometre sized BC particles and prevailing condensable species is required to explain this.

**References:**


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