Supporting Online Material for Rosenfeld et al., 1073869

Figs. S1 to S8

References
**Fig. S1.** Clouds in the presence of anthropogenic haze over the equatorial Indian Ocean. The picture was taken on 24 February 1999 at 0.5°N, 73.3°E during the Indian Ocean Experiment Campaign. The brownish haze originates from South Asia. The haze reaches close to the top of cumulus clouds located around 5 km in this picture (From Ramanathan et al., 2001, S1).
**Fig. S2.** A composition of several SEAWIFS satellite orbit segments over south Asia and the Indian Ocean, on 21 March 1999, showing polluted air spilling off India and Indo-China into the ocean. The pollution particles serve as nucleation centers for the cloud droplets, so that they form clouds with many small droplets that would be slow to combine into raindrops. However, the sea spray salt particles form larger drops that collect the smaller polluted cloud droplets, and eventually grow into raindrops that precipitate with the pollution. The image was composed for the INDOEX project by Orbital Imaging Corporation.
Fig. S3. Maritime cumulus and aerosols observed with a Laser Radar (LiDar) on-board the R/V Mirai in the tropical western Pacific near Nauru Island, on 28 June 1999. The observed structure suggests that sea-salt aerosols are elevated by cumulus activity to above the boundary layer. The LiDar was vertically pointing, documenting with time (the abscissa) the aerosols and clouds passing overhead. The red colors represent returns from the aerosols at the boundary layer air, which are composed mostly of salt from sea spray (S4). The bright yellow returns are from the clouds developing at the top of the boundary layer, ingesting the aerosols. When the clouds disperse aloft they release back the sea spray aerosols, as evident by the red areas that spread from the tops of the highest clouds. The inset is a magnification of the time segment between 9 and 14 hours. The image is provided by Dr. Nobuo Sugimoto, National Institute for Environmental Studies, Japan.
It has been already documented by Tropical Rainfall Measuring Mission (TRMM) satellite that clouds forming in polluted air over land are composed of small drops that are slow to combine with each other into raindrops (S2, S3). How can TRMM measurements be used for documenting this effect? An example is shown for such a situation on 24 March 1999 over southern India in Figs. S4-S6.

**Fig. S4.** SEAWIFS image of the southern half of India shrouded in pollution haze, on 24 March 1999. A cloudy area along the black line is analyzed using TRMM observations in Figs. S5 and S6.

**Fig. S5.** Tropical Rainfall Measuring Mission (TRMM) satellite image on 24 March 1999, 09:10 UT, showing clouds developing in polluted air over southern India. The black line centered at the cloud band corresponds to the line in the SEAWIFS image shown in Fig. S4. The blue represents surface, orange represents the clouds, and the white dots in some of the clouds denote precipitation echoes as observed by the TRMM precipitation radar. The dependence of cloud droplets $r_{\text{eff}}$ on cloud top temperature is given in curve A of Fig. 1 in
the manuscript. It shows that the cloud tops had to grow above the height of -10ºC isotherm for the cloud droplets to grow beyond 14 µm, which is the precipitation threshold.

**Fig. S6.** Vertical cross section in the clouds along the line in Fig. S5. Radar echoes from precipitation occur only in clouds exceeding top height of 6 km. Clouds with lower tops still contain much water, as indicated by the TRMM Microwave Imager, but all the water is in small cloud drops that cannot be seen by the radar. The horizontal scale is distance along the line, with total length of about 300 km. The dark gray areas represent clouds. The vertical extent of the clouds is converted from the TRMM Visible Infra Red Scanner (VIRS) measured cloud-top temperatures. The colors represent the precipitation reflectivity in dBZ [mm⁶ m⁻³] as measured by the TRMM precipitation radar. The white line is the brightness temperature of the TRMM Microwave Imager (TMI) 85-GHz vertical polarization (T₈₅), plotted at the altitude of that temperature. A lower T₈₅ value is represented as greater height of the white line, and in non precipitating clouds it means greater cloud water content. The T₈₅ and actual cloud-top temperature have different physical meanings.
Fig. S7. Tropical Rainfall Measuring Mission (TRMM) satellite image on 11 February 1999, 05:13 UT, showing clouds developing in polluted air over northern Thailand (A) and Bay of Bengal (B-D). Images B-D correspond to frames 1-3 in the SEAWIFS image shown as Fig. 2 of the manuscript, respectively. More yellow coloring of the clouds represents smaller droplets. This is quantified by the T-r_{eff} relations in curves A-D of Fig. 3 in the manuscript, for images A-D respectively. The TRMM precipitation radar (PR) covered the areas below the white horizontal line in the images. White dots represent areas with observed precipitation by the PR.
Fig. S8. Same as Fig. S6, but for a vertical cross section in the clouds developing in polluted air over sea, along the line in Fig. S7C. Radar echoes from precipitation occur already in clouds reaching top height of 3 km.
References