Comments on "Trends in Global Marine Cloudiness and Anthropogenic Sulfur"

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Parungo et al. (1994) point out a significant increase in global average total cloud cover over the oceans during the period 1952–81. They use the ship observation dataset compiled by Hahn et al. (1988) and Warren et al. (1988; hereafter W88) to show that the "altostratus" group of W88, consisting of all nonprecipitating midlevel clouds, shows a consistent upward trend in the global annual average. The largest increases occurred in the latitude band 30°–50°N, with negligible trends outside of 10°–60°N. No other nonprecipitating cloud-type group showed consistent upward trends, and Parungo et al. did not examine precipitating cloud types over the ocean or continental clouds. They suggest that the total and altostratus cloud amount changes were due largely to increased concentrations of sulfate aerosol of anthropogenic origin over the 1952–81 period, hypothesizing that increases in sulfate aerosol led to increased CCN concentrations, reduced precipitation efficiency, and longer cloud lifetimes. The fact that cloud trends are greatest for midlevel clouds is attributed to the long lifetime of aerosols reaching the midtroposphere compared to aerosols in the boundary layer and hence to an extension of observable effects on midlevel clouds far downstream from the sources. However, midlevel cloudiness in the 30°–50°N latitude band is primarily generated by extratropical cyclones, so possible changes in the location and/or intensity of synoptic activity should be examined first.

Figure 1a shows the distribution of change in nonprecipitating midlevel cloud amount during 1952–81 obtained by a linear fit to the data of W88. Annual averages for each grid box were calculated only for years in which W88 gave data for all four seasons. Similar trends are present in all four seasons. The greatest increases occurred in the central northern oceans, far downstream from continental sources of anthropogenic aerosols, and far downstream from the expected locations of the largest atmospheric burden of anthropogenic aerosol (e.g., Charlson et al. 1991). Figure 1b, derived from the W88 dataset in the same way as Fig. 1a, shows that annual average nimbostratus amount has increased over the same regions during the same time period. Nimbostratus usually extends through midlevels and often develops as the base of an altostratus layer lowers sufficiently for precipitation to reach the surface. Thus, these data suggest that the frequency of midlevel clouds and the frequency of precipitation from midlevel clouds have increased together over northern midlatitude oceans. They fail to support the hypothesis of Parungo et al. that aerosols have suppressed precipitation in midlevel clouds over the northern midlatitude oceans. They do suggest that the trends in cloudiness are related to a change in synoptic activity, perhaps through a shift in the location of the midlatitude storm tracks.

We have shown elsewhere that warm season anomalies of low-level stratiform clouds, midlevel nonprecipitating clouds, and nimbostratus are all negatively correlated with SST over the northern midlatitude oceans, and that these correlations are unlikely to arise from a radiative effect of cloud anomalies on SST, although radiative effects may contribute to the persistence of the anomalies (Norris and Leovy 1994). The latitude of the band of strongest SST gradient in the northern midlatitude oceans shifts slightly from year to year, and the cloud pattern tends to follow these shifts. Interdecadal shifts in SST over the North Pacific and North Atlantic are well documented for recent decades, and they have been shown to be related to variations in atmospheric large-scale circulation. For example, Namias et al. (1988) show that a downward trend in SST over the central North Pacific is associated with a significant upward trend in the positive phase of the Pacific/North American (PNA) pattern index corresponding to a shift toward relatively low surface pressure over the central North Pacific. Similarly, Shabbar et al. (1990) find that annual mean 500-hPa height and 500–1000-hPa thickness decreased over the midlatitude North Pacific between the periods 1946–62 and 1963–85. The main seasonal contribution to this change came from the cold season and can also be attributed to an increase in the frequency and/or amplitude of positive phase events of the PNA pattern.

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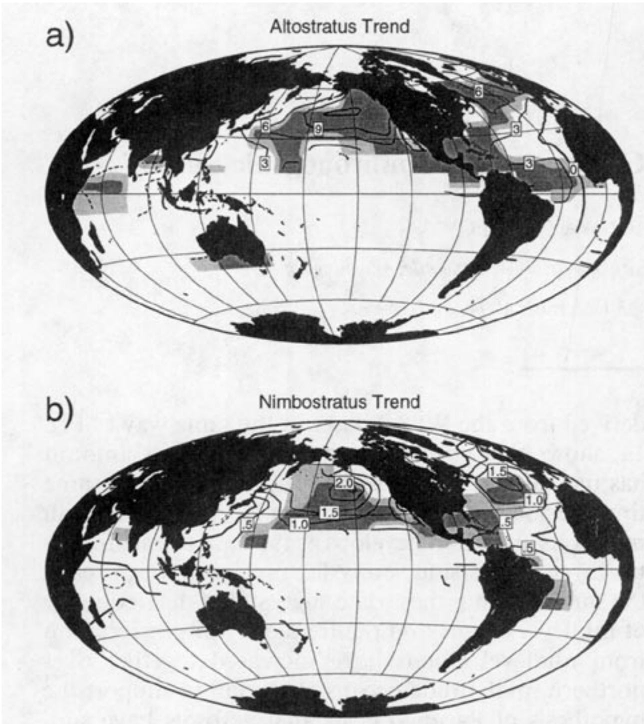

FIG. 1. (a) Change in annual average altostratus cloud amount over 1952–81. Units are percent sky-cover, and the contour interval is 3%. Positive trends are drawn with solid lines, negative trends dotted, and zero trend bold. Shading indicates 95% (light) and 99% (dark) significance. (b) Change in annual average nimbostratus cloud amount over 1952–81. The contour interval is 0.5%; otherwise as in (a).

Large-scale circulation pattern changes are less clear over the North Atlantic than over the North Pacific (Shabbar et al. 1990), but Cayan (1992) has shown that cold season anomalies in North Atlantic SST are closely related to changes in latent and sensible heat fluxes that in turn are closely connected with changes in low-level circulation patterns and storm tracks.

These studies do not demonstrate that SST changes are the cause of the observed cloudiness change, but taken together, they do indicate that the SST distribution, lower tropospheric circulation, and storm tracks have shifted in a mutually consistent fashion over the northern midlatitude oceans between 1952 and 1981. They suggest that these shifts are primarily responsible for the observed trends in midlevel cloud amount in the same regions. Thus, it is more plausible that the increases in marine midlevel cloud amount noted by Parungo et al. arise from the internal dynamics of the atmosphere–ocean system rather than from modification of cloud microphysical structure due to increasing sulfate aerosol concentrations.

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