THE DMS-CLOUD ALBEDO FEEDBACK EFFECT: GREATLY UNDERESTIMATED?

Correspondence

SHERWOOD B. IDSO
U.S. Water Conservation Laboratory, Phoenix, AZ 85040, U.S.A.

Abstract. There are a number of ways by which the biosphere may counter any impetus for global warming that might be produced by the rising CO₂ content of earth's atmosphere. Evidence for one of these phenomena, the DMS-cloud feedback effect, is discussed in light of recent claims that it is not of sufficient strength to be of much importance.

Foley et al. (1991) have made what they call 'a first attempt to estimate the strength of the DMS-cloud albedo feedback mechanism', which is of great significance to world climate (Charlson et al., 1990), as it has been represented as having the capacity to largely counterbalance the CO₂ greenhouse effect and mute global warming (Lovelock, 1988; Idso, 1989). Based on an empirical relationship between the evolution of DMS from the surface of the ocean and the sea's receipt of solar radiation (Bates et al., 1987), Foley et al.'s model indicates that the DMS-cloud albedo feedback is 'of relatively minor importance'. However, their model ignores a number of important biological phenomena that call this conclusion into question.

First of all, Foley et al. state that DMS concentrations in surface sea water are only weakly correlated with phytoplanktonic productivity. Although this may well have appeared to be the case at the time that Bates et al. developed their DMS-solar radiation relationship, subsequent studies have suggested otherwise. Gibson et al. (1989), for example, found a strong correlation between surface water DMS levels and cell numbers of the alga Phaeocystis pouchetii in the Southern Ocean near Antarctica; while Thompson et al. (1990) were able to closely reproduce the sea-to-air flux of DMS observed by Barnard et al. (1982) in the North Atlantic, based on an empirical relationship between surface water DMS and chlorophyll a concentrations developed by Andreae and Barnard (1984). Likewise, Burgermeister et al. (1990) observed surface water concentrations of DMS during an Atlantic cruise from 40° S to 50° N to have 'a good coherence with several biological indicators', including both chlorophyll and the amount of phytoplanktonic cells. As a result of these and a number of other observations, Erickson et al. (1990) have concluded that 'in areas of high biologic productivity, the Bates et al. (1987) relationship may underestimate the [ocean-to-atmosphere] flux and subsequently the surface ocean DMS concentration'.

Secondly, Foley et al. repeatedly state that the DMS-cloud albedo feedback 'does not become active in direct response to a change in temperature'. However, just the opposite is almost certainly true. It is a well-known fact, for example, that phytoplanktonic productivity is generally stimulated by rising water temperatures...
(Eppley, 1972; Goldman and Carpenter, 1974; Rhea and Gotham, 1981). And high DMS concentrations are typically observed in warm surface waters (Andreae, 1986). Hence, if the oceans were ever to experience a widespread surface warming, such as is theorized to result from increasing atmospheric CO₂ concentrations, the DMS-cloud albedo feedback mechanism would surely be set in motion.

One set of evidence that may appear contradictory to this conclusion is the observation that two oxidation products of DMS (sulfate and methanesulfonic acid) both decreased in concentration during the transition from the last ice age to the present interglacial, as inferred from East Antarctic ice core data (Legrand et al., 1988; Saigne and Legrand, 1987). In this case, however, the temperature dependency of DMS production was in all likelihood overwhelmed by another more important factor: the availability of elemental iron (Idso, 1989).

During a glacial to interglacial transition, for example, there is typically a several-fold decrease in exposed arid land areas (Petit et al., 1981; CLIMAP, 1981), a significant reduction in wind speeds (Parkin and Shackleton, 1973; Sarnthein et al., 1981), and an order-of-magnitude decrease in atmospheric dust loads (DeAngelis et al., 1984; Gaudichet et al., 1988). Such a decline in the delivery of dust to the sea greatly reduces the amount of iron available to phytoplankton living in surface ocean waters, possibly depleting its concentration there by as much as a factor of fifty (DeAngelis et al., 1987; Legrand et al., 1988). And as Martin and Fitzwater (1988) have demonstrated by direct experimental means, such a reduction in iron availability greatly reduces phytoplanktonic productivity rates.

In harmony with this scenario are the results of studies of organic carbon burial rates in both the Atlantic and Pacific Oceans (Pedersen, 1983; Muller et al., 1983; Morris et al., 1984; Lyle et al., 1988), where two to five times higher organic carbon accumulation rates have been observed for the 18 kyr BP glacial maximum than for the Holocene in several short sediment cores from both oceans (Lyle, 1988). This latter observation and the findings of Legrand et al. (1988) and Saigne and Legrand (1987) also provide strong evidence for the validity of the phytoplanktonic productivity and DMS concentration correlation that Foley et al. dismiss.

Another shortcoming of the analysis of Foley et al. is their non-treatment of land surface processes. In considering the total sulfur budget of the atmosphere, for example, it is clear that the volatilization of reduced sulfur gases from soils may be equally as important as marine DMS emissions in modulating global climate (Idso, 1990). And here the temperature dependence of the pertinent phenomena is clear and unequivocal: between 10 and 25 °C, Staubeset et al. (1989) found DMS emission rates from a number of soils to rise by a factor of 2 for each 5 °C increase in surface temperature, due to the enhanced sulfur-emitting microbial activity generally associated with greater warmth (Hill et al., 1978; MacTaggart et al., 1987). In fact, the observations of Adams et al. (1981) suggest a 25-fold increase in soil-to-air sulfur flux between 25° N and the equator.

Perhaps even more interesting in this regard is a non-climate-modulated effect of atmospheric CO₂ enrichment on soil DMS emissions. Just by adding organic