16.6 VARIABILITY OF ATMOSPHERIC DIMETHYLSULPHIDE OVER THE SOUTHERN INDIAN OCEAN DUE TO CHANGES IN ULTRAVIOLET RADIATION

D.R.Kniveton
School of Chemistry Physics and Environmental Science, University of Sussex, Falmer, Brighton, UK*
M.C. Todd
Department of Geography, University College London, London, UK
J. Sciare
LSCE, Orme des Merisiers, Gif-sur-Yvette, France

1. INTRODUCTION

The main source of cloud condensation nuclei (CCN) in the marine troposphere is sulphate aerosol produced from the oxidation of marine derived dimethylsulphide (DMS). The flux of DMS from the ocean to the atmosphere is related to the [1]difference in chemical potential across the sea surface, and wind induced turbulence in the upper ocean (Kettle and Andreae 2000). In seawater DMS comes from its precursor, dimethylsulphoniopropionate (DMSP) with the catalytic help of the enzyme DMSP-lyase found in some phytoplankton and bacteria (Liss et al 1997). Evidence exists that DMS production is influenced by physical turbulence, osmotic shock, pathogen attack by virus and bacteria, and zooplankton grazing (Malin et al 1994). DMSP is produced by macro- and micro-algae, which in turn are influenced by nutrient supply, light, temperature and salinity. Once in seawater DMS can be consumed by the biota, be ventilated into the atmosphere or be photochemically removed. Thus the amount of DMS in the atmosphere is a function of a number of interrelated biophysical processes. In this paper we look at the influence of one of these factors, ultraviolet light, on atmospheric DMS levels over a daily timescale.

2. DATA AND METHOD

Daily atmospheric DMS measurements were made at the Pointe Benedicte sampling station at Amsterdam Island (37°50'S, 77°30'E) in the temperate southern Indian Ocean from 1990-2000 (Sciare et al 2000). Sea surface temperature (SST) and wind speed data were obtained from the local meteorological station. Estimates of ultraviolet and photosynthetically active radiation (PAR) in the region was obtained from satellite based datasets produced by the NASA Goddard Space Flight Centre and the PAR Project Department of Meteorology, University of Maryland, respectively. The UV data are in the form of Erythemal Exposure data (EUV) which are an estimate of the integrated daily UV irradiance that is likely to cause erythema. The EUV product can be interpreted as an index of the potential for biological damage due to solar irradiation.

The effect, if any, of UV radiation on atmospheric DMS volumes is likely to be smaller than the effect of other biophysical variables. Thus, we adopt a compositing methodology in which we select a sample of events (days) when extreme changes in EUV are observed. An extreme event is defined as an increase (decrease) greater (less) than two standard deviation from the mean daily change of EUV. The day on which the extreme change in EUV is observed is referred to as the key date and mean change in DMS (and other variables) on key days is compared to the mean of the day preceding the key date. The mean difference is tested for significance using a t-test.

3. RESULTS

Table 1 shows the mean daily changes in atmospheric DMS, windspeed and temperature for extreme increases and decreases in EUV. There are statistically significant decreases (increases) in daily atmospheric DMS for extreme changes increases (decreases) in EUV. Noticeably, no significant change in SST is observed. No significant change in windspeed is observed during extreme increases in EUV, although during extreme decreases in EUV, windspeed increases significantly.
In order to test whether the changes in DMS are likely to be due to EUV alone, daily changes in windspeed and DMS are shown for extreme decreases in EUV only when the windspeed changes were minimal, defined as being within 0.5 standard deviations of the average windspeed change. The results show that a significant increase in daily DMS volumes occurs, in the absence of substantial windspeed changes.

At a daily timescale PAR and UV radiation would be expected to be closely matched. In an attempt to separate the effects of PAR from that of EUV a sample of events was defined where extreme changes in EUV were observed (as defined above)

*Corresponding author address: D. Kniveton, CPES, Univ. of Sussex, Falmer, Brighton, BN1 9QJ, UK; e-mail: d.r.kniveton@sussex.ac.uk

coincident with minimal changes in PAR (within 0.5 standard deviations of the mean PAR change). Unfortunately due to the limited PAR dataset this left only 6 events of extreme increase in EUV (and not in PAR) and 13 of extreme decreases. The results are shown in Table 2. Also shown are the results using samples of key days where the change in EUV is greater than one standard deviation from the mean change.

Table 1. Mean daily changes in atmospheric DMS, windspeed, sea surface temperature (SST) for extreme EUV events (see text for definition). Statistically significant changes are shown in bold italics.

	DMS (ppbv)		**Windspeed (ms^{-1})**		**SST (°Cx10)**	
	Day before	**Key date**	**Day before**	**Key date**	**Day before**	**Key date**
Increases in EUV.	***505.55***	***301.20*****	6.722	6.194	161.97	162.61
Decreases in EUV.	***341.64***	***475.24*****	***5.703***	***7.595*****	165	164.51
Decreases in EUV with minimal windspeed change.	***405.04***	***524.09****	5.778	5.611	N/A	N/A

Table 2. Mean daily changes in atmospheric DMS, PAR and EUV for extreme EUV events (see text for definition). Statistically significant changes are shown in bold italics.

	DMS (ppbv)		**PAR (Wm^{-2})**		**EUV**	
	Day before	**Key date**	**Day before**	**Key date**	**Day before**	**Key date**
Decreases in EUV and minimal change in PAR.	***206.26***	***433.55*****	129.05	128.72	***5730***	***3315*****
Decreases in EUV (-1 SD) & minimal change in PAR.	***262.48***	***384.67*****	***115.86***	***113.98****	***4813***	***2918*****
Increases in EUV (+1 SD) & minimal change in PAR.	***310.52***	***209.69*****	***120.48***	***122.74****	***3250***	***4858*****

** Indicates statistical significance at 0.05 level
* Indicates statistical significance at 0.1 level

4. DISCUSSION AND CONCLUSION

In this study we have focused on extreme changes, both positive and negative, in daily UV radiation using satellite based estimates of the Erythemal Exposure. The results show a 40% average decrease in atmospheric DMS concentration when there was a 66% average daily increase in EUV. There were no statistically significant changes in windspeed or STT associated with this. It is further shown that there was an a 29% increase in atmospheric DMS associated with an average daily decrease in EUV of 46%, irrespective of changes in the windspeed.

Further, we have tried to separate the influence of UV from PAR using a similar methodology. The strong correlation between these datasets restricts the analysis to few events but the results suggest that an average increase of 110% in atmospheric DMS is associated with an average 42% decreases in UV, irrespective of changes in PAR. When reducing the threshold of UV defined extreme events and still trying to take only small changes in PAR there is both a significant increase and decrease in DMS with decreases and increases (respectively) in UV (at 0.05 level). However at this threshold the strong relationship between PAR and UV does not allow us to eliminate the role of PAR.

The results suggest that, at daily timescales, UV radiation has a statistically significant inverse relationship with atmospheric DMS concentrations. Whether this can be attributed to processes in the atmosphere or processes in the ocean is not clear and needs further study of coincident measurements of DMS in seawater and the atmosphere

5. REFERENCES

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