Twenty Second Indian Expedition to Antarctica, Scientific Report, 2008
Ministry of Earth Sciences, Technical Publication No. 20, pp 103-108

Total Water Vapour Column Measurement Over Schirmacher Region, East Antarctica

S. L. Jain, B. C. Arya, Ashok Kumar and Sachin D. Ghude
Radio and Atmospheric Sciences Division
National Physical Laboratory, New Delhi-110012 (India)

ABSTRACT

Total Water Vapour Column has been measured at Maitri (70° 45'S, 11 44'E), Antarctica using Microtop Sun-photometer during 22nd Indian Scientific Expedition to Antarctica. The annual mean water vapor was found out to be 0.45 cm in the year 2003. Columnar water vapour has been observed maximum in the month of January during observational period. Day-to-day variation of water vapour and surface temperature showed positive correlation suggesting that day-to day variation of water vapour is highly related to local meteorological conditions. In the present communication obtained results are discussed in detail.

Key **Words:** Sun-photometer, Water Vapour and Antarctica

INTRODUCTION

Water in its various phases constitutes the critical ljnk between the chemical component of global change and the dynamics, radiation and climate components. It is the major absorber of infrared and thermal radiation in the Earths atmosphere and strongest contributor to greenhouse effect. The amount of water vapour varies widely throughout the atmosphere and the average content fluctuates about a mean, determined by the other greenhouse gasses, and the nature of the Earth land surface. Since the water vapour partial pressure increases with temperature, the action of water vapour as greenhouse gas in free troposphere lead to a further enhancement of greenhouse effect and is considered as a positive feedback.

In the upper troposphere and lower stratosphere the radiative[1] and chemical[2] effects of water vapor are large and atmospheric concentration varies considerably with the temperature and relative humidity. In global climate models, almost half of the projected increase in temperature due to a doubling of carbon dioxide in the atmosphere results from the effects of increased water vapour[3]. Recent studies have shown a stratospheric cooling in regions of H_20 increases, of magnitude similar to that due to stratospheric ozone loss indicating a significant additional cause of observed stratospheric temperature decrease. Total water vapour column amounts is very low in Antarctica, however it plays a significant role in ozone depletion[4]. A recent study has shown that water vapor concentration determines the effectiveness of the heterogeneous reaction and under stratospheric conditions affects the ozone chemistry and plays significant role in the Antarctic ozone depletion by providing reaction site as polar stratospheric clouds in the form of H_20 ice[5].

Measurements have been done at low and mid latitudes[6] but at the polar latitudes and high altitudes a little is known about the water vapor content and its seasonal variation. Also, surface measurement database for water vapor is in scarcity and therefore regular monitoring is of great importance for understanding the hydrological cycle in depth for global change studies[7]. In view of the above, Microtop-II[89] sun photometer has been used to measure total water vapour column at Maitri (Antarctica) during 2003 **and** summer period of year 2004. The observations **were** taken throughout the expedition on hourly basis during clear sunny days. Correlation of total water vapour column has also been made with surface temperature. In the present communications the results obtained are discussed in detail.

EXPERIMENTAL SETUP

The MICROTOP-II is a five channels hand held microprocessor based sun photometer. The Block diagram of the instrument is shown in Fig. 1. The instrument is equipped with five optical collimators having a full field of view of 2.5 °. All the channels are integrated with a narrow-band interference filter and a photodiode appropriate for the particular wavelength range. Each channel looks directly the solar disc at once when the image of the sun is centered at the cross hairs of the sun target. When the radiation falls onto the photodiodes through collimators, it gives an electrical current proportional to radiant power cut off by photodiode, which then amplified and converted into digital form in a high resolution A/D converter. Signals are processed in a series of 20 conversions per second. Out of the five channels at 300,305,312,940 and 1020 nm, the first three filter channels were used to derive atmospheric total column ozone and rest of the two for water vapour.

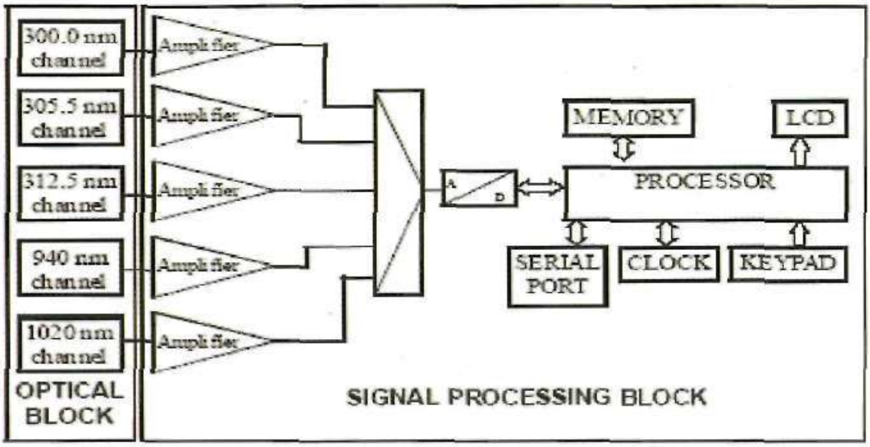

Fig. 1 : Block diagram of Microtop-II Sun-Photometer

RESULTS

Scattered plot of daily averaged total water vapor column observed during 2003 is depicted in Fig. 2. MICROTOP-II instrument can be used to get data only for daylight-viewing conditions. Therefore, total water vapour column data are not available for the months of May, June and July when there is no sunlight (Polar Night Period). Day-to-day water vapor concentration at observational site, Maitri was found to be highly variable. Columnar water vapour concentration has been observed maximum during polar summer and minimum during polar later winter-early spring. Total Water vapour column was observed to be less than 0.1 cm during late winter, while it is observed up to 0.90 cm in the month January.

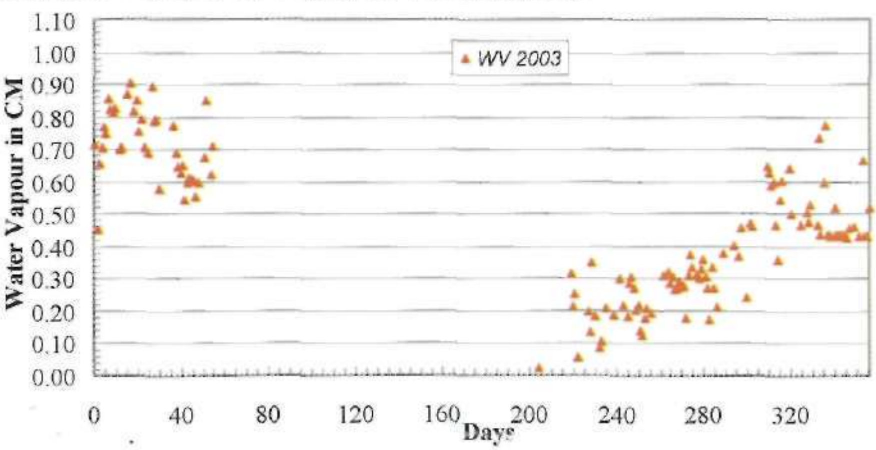

Fig. 2 : Water vapour variation at Maitri, Antarctica during 2003

Columnar water vapour averaged for every month during 2003 is depicted in Table 1, which show the maximum concentration in January and minimum in August. Higher water vapour concentration during polar summer can be attributed to increased surface temperature during due to higher solar radiation. Another region could be and advection of warm moist air from subtropics, due to reduced strength of polar vortex during polar summer. The low temperatures during winter over Antarctica lead to formation of a region with high velocity circumpolar winds during winter and spring season, generally called as polar vortex. This vortex limits the exchange of air between its interior and exterior and leads to extremely low temperatures, which reduces water capacity of the air, and make it dry. This lead to the low columnar water vapour concentration during winter-spring season.

Table 1: Monthly averaged water vapour during 2003 at Maitri, Antarctica

Months	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Avg
Year 2003 AVGWV	0.71	0.63	-	-	-	-	-	0.23	0.24	0.33	0.55	0.48	0.45

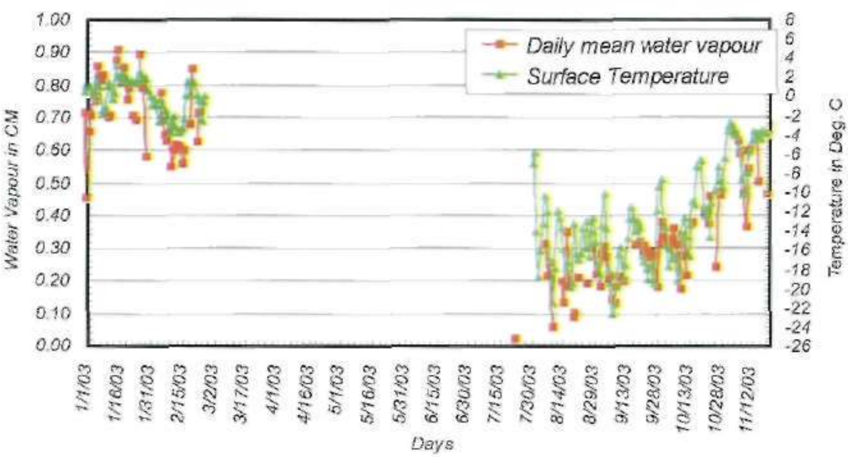

Fig. 3 : Comparison of Water Vapour with Surface Temperature at Maitri, Antarctica during 2003

Comparison of daily averaged water vapour with daily averaged surface temperature during 2003 is depicted in Fig. 3. A strong positive correlation (R=0.81) has been observed between columnar water vapour values and surface temperature. Maximum surface temperature was observed to be 2.9°C on 16 January 2003 with corresponding water vapour concentration of 0.87 cm and minimum surface temperature was observed to be - 22.8° C on 22 September 2003 with corresponding water vapour concentration of 0.14 cm. The correlation between surface temperature and water vapour reveals that most of the variation in water vapour concentration took place probably in lower troposphere due to variation in surface temperature. This suggests that the day-to day variation of water vapour is highly related to local meteorological conditions over Antarctica.

CONCLUSION

Measurements of columnar water vapour during 2003 show the maximum concentration in January and minimum in August. A strong positive correlation *(R=0.81)* has been observed between columnar water vapour values and surface temperature. This suggests that the day-to day variation of water vapour is highly related to local meteorological conditions over the Indian research base Maitri, Antarctica.

ACKNOWLEDGEMENT

Authors express their sense of gratitude to the Director, NPL and Head, RASD, for their encouragement during the progress of the work. Authors are also grateful to the NCAOR (Department of Ocean Development) and CSIR (Council of Scientific and Industrial Research) for logistic and financial assistance. We are also thankful to Leader 22nd Indian Antarctic Expedition for his encouragement at Maitri, Antarctica, and all the members of the expedition for all sort of cooperation and help. Thanks are also due to India Meteorology Department fro providing surface temperature data.

REFERENCES

1. Shine, K.P., Derwent, R.G., Wuebbles, D.J. and Morcrette, J.J. in Climate Change: The IPCC Scientific Assessment Houghton, J.T., Jenkins, G.J. and Ephraums, J.J.(Eds.) Cambridge University Press, (1990).

2. Brasseur, G., and S. Solomon, Aeronomy of the Middle Atmospher, 2nd ed.. D. Reidel Publishing Company, Norwell, Mass., (1986).

3. Hansen, J., A. Lacis, and M. Prather., Greenhouse effect of chlorofluorocarbons and other trace gases. *J. Geophys. Res.,* 94, 16417-16421, (1989).

4. Hofmann, D.J. & Oltmans, S.J. *Geophys. Res. Lett,* 19, 2211-2214, (1992).

5. Cadle, R.D., Crutzen, P. J., Ehhalt, D.H., Heterogeneous chemical reactions in the stratophere, *J. Geophys.Res.,* 80, 3381, (1975).

6. Hartogh, P., and C. Jarchow, Groundbased., Detection of Middle Atmospheric Water Vapor, in Global Process Monitoring and Remote Sensing of the Ocean and Sea Ice, D.W. Deering and P. Gudmandsen (Eds.), 2586,188-195, (1995).

7. Asrar, G. J., A. Kaye, and P. Morel, NASA research strategy for earth system science: Climate component. *Bull. Amer. Meteor. Soc„* 82, 309-1329, (2001).

8. Jain, S. L., Monitoring of ozone, water vaponetc during voyage to Antarctica., *Asian JPhys,,* 10,315,(2001)

9. Jain, S.L. & Tripathi, O.P. Monitoring of water vapor at Maitri Antarctica Sixteenth Indian Expedition to Antarctica, Scientific Report Department of Ocean development, Technical Publication No. 14, 113-117, (2000).