OBSERVATION OF STRATOSPHERIC AEROSOL BY COMBINED USE OF INFRARED AND MICROWAVE RADIOMETERS

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Abstract-A method of estimating the excess in optical thickness of stratospheric aerosol after a big volcanic eruption by combining use of ir 10 mm split-window data and microwave dual-frequency data taken from MOS-1 satellite is presented. The estimation method of stratospheric aerosol optical thickness is derived by simulation study, then its method is applied to satellite data. The method is feasible to detect the aerosol and also will be applied to correct the dense stratospheric aerosol absorption effect when sea surface temperature is derived from satellite.

Keywords: stratospheric aerosol, MOS-1, split-window, dual-frequency microwave.

INTRODUCTION

Dense stratospheric aerosol after a big volcanic eruption makes many issue in atmosphere such as a change in cooling rate of atmosphere, depression of ozone in stratosphere, and satellite remote sensing, through scattering and absorption processes for incident solar radiation and outgoing earth radiation or chemical reaction. Therefor the observation of the aerosol distribution is essential in monitoring earth environment. Though the observation of the stratospheric aerosol has been done by using LIDAR and satellite, their observation area or period is limited, then other monitoring method of the aerosol is required.

AFFECT OF STRATOSPHERIC AEROSOL TO RADIATION

After few months from the eruption it could be expected that stratospheric aerosol is consist of H_2SO_4 liquid aqueous solution with an acid weight percentage ranging between 60 and 80%[1]. The stratospheric aerosol modify the radiations in the infrared split-window region(two channels in 10 - 13μm ir spectral region) like as (e.g.[2]); an increase in the amount of the aerosol decrease more the transmittance in 11μm spectral region than in 12 μm spectral region, where 11μm is more transparent than 12μm in the tropospheric absorption gases. Therefore an increase in the amount of stratospheric aerosol decreases not only up-welling radiation in the split-window spectral region but also decrease the difference of radiance between 11μm and 12μm spectrum region. It is well known that this effect produces negative bias error of satellite sea surface temperature(SST) from split-window technique which use the difference in radiances between 11μm and 12μm spectral region to correct atmospheric absorption effect.

DERIVATION OF ALGORITHM

SST has been estimated by split-window technique as,

$$SSTespl = a_1 (T11-T12) + T11 + a_2 \qquad (1)$$

where T11 and T12 are observed brightness temperatures in 11μm and 12μm channels, respectively, and a_1 and a_2 are constants [e.g. 3]. By using infrared window data an d microwave dual-frequency data which one frequency is atmospheric window near 31GHz and another frequency is water vapor absor ption band near 23GHz, SST also estimate as,

$$SSTemic = b_1 T11 + b_2(T23 - T31) + b_3 \qquad (2)$$

where T11 is brightness temperature of ir 11μm channel, T23 and T31 are brightness temperature of microwave channels of 23GHz and 31GHz, respectively, and b_1 , b_2 and b_3 are constants[4]. Estimated SST by using both algorithms of (1) and (2) have nearly same quality for normal atmospheric condition. When dense stratospheric aerosol exist, estimated SSTs become different, because the aerosol reduce both terms of T11 and T11-T12 for (1), and the term of

T11 for (2). The aerosol absorb very little the microwave radiations. Fig.1 shows estimated SST temperature differences between with and without stratospheric aerosol for the different optical thickness τ(0.55) of the aerosol layer at the wavelength of λ =0.55μm and for model atmosphere compiled by McClatchey et al[5]. The deviation of SST from no aerosol condition is large for SST from split-window.

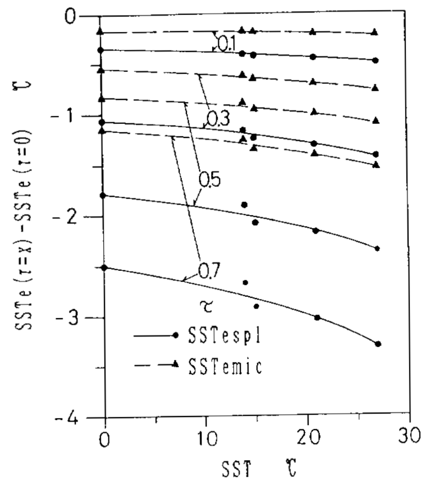

Fig. 1 Deviation of estimated sea surface temperatures with stratospheric aerosol (its optical thickness at λ =0.55μm are 0.1, 0.3, 0.5, and 0.7) from that in no stratospheric aerosol (t=0).

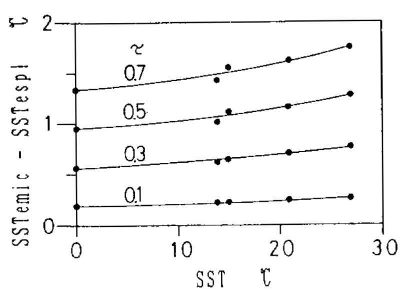

Fig. 2 Dependence of estimated SST difference between derived by dual-frequency and by split-window method upon the aerosol optical thickness.

The difference in estimated SST between from split-window method and dual frequency method is depend on the optical thickness of stratospheric layer(see fig. 2). Therefore stratospheric aerosol optical thickness may be estimated from ir split-window data and microwave dual-frequency data.

Fig. 3 shows the plots of the relations among the optical thickness τ(0.55) of stratospheric aerosol layer and estimated SST difference between derived by microwave dual-frequency method and ir split-window method. The stratospheric optical thickness relates linearly with the estimated SST difference, but the slope of the relation depend on SST. Thus optical thickness of stratosphere τ may be written as,

$\tau(0.55)=k_1(SST)*(SSTemic-SSTespl)+k_2$ (4),

where SSTemic and SSTespl are estimated

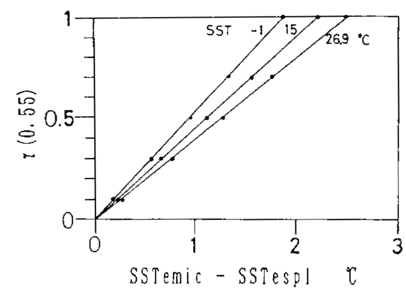

Fig. 3 Relation between optical thickness of the aerosol layer and temperature difference among estimated SST by split-window and by dual-frequency method.

SSTs by microwave dual-frequency method (2) and ir split-window method (1) respectively, k_1 and k_2 are constants. Now to estimate t(0.55) it is necessary to know SST.

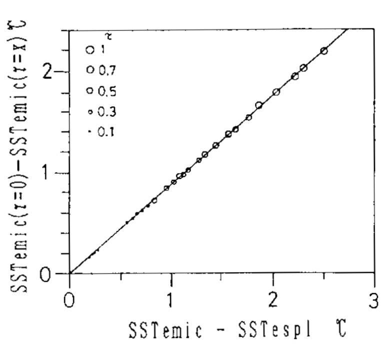

Fig. 4 Relation between estimated SST deficit(SST without aerosol minus SST with aerosol) and temperature difference among estimated SST by dual-frequency and by split-window method.

Fig. 4 shows the relation between SST-SSTemic and SSTemic-SSTespl for various optical thicknesses of stratospheric aerosol layer. Both values are related linearly, then estimation of SST under the atmosphere having dense stratospheric aerosol would be improved by using the linear relation of estimated SSTs by microwave dual-frequency method and ir split-window method, as,

SST = SSTemic+0.75(SSTemic - SSTespl) (5),

where SSTemic and SSTeslp are given by (2) and (1). By using (5) and (4), stratospheric aerosol and SST would be derived.

MOS-1 SATELLITE DATA

MOS-1 satellite carries both ir radiometer VTIR with split-window channels and microwave radiometer MSR with dual-frequency channels. It is suitable to verify the algorithms of (4) and (5). Fig. 5 shows an example of derived stratospheric aerosol area (white dot in the figure) from data taken Aug. 15 1991 by MOS-1 satellite over ocean area in fine weather condition after eruption of Mt. Pinatubo about four month after. Though result is noisy due to mainly VTIR's noisy characteristics, white dot distribution seems vary corresponding to stratospheric aerosol variation.

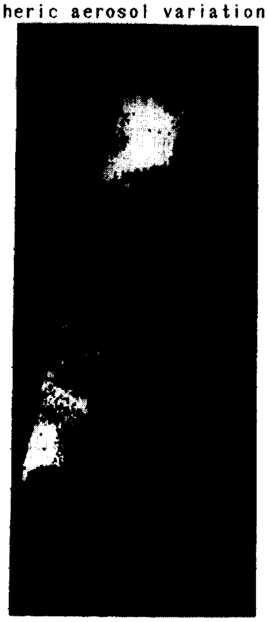

Fig. 5 Derived dense stratospheric aerosol area from MOS-1 satellite data.

Estimated SST in the area by split-window is about 2℃ lower than SST analysed from ship data. By applying (5) to derive SST in the area, improvement in SST estimation is made.

Therefore algorithms of (4) and (5) would be feasible to estimate stratospheric aerosol optical thickness and to improve SST estimation.

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