The Thermal Infrared Radiative Difference Between Fog and Asian Dust Aerosol Over Ocean

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Fog is a weather phenomenon with many water droplet flying in air and with low visibility less than 1km. Sea fog is a result of water vapor condensation at the bottom of the atmospheric boundary over ocean and its height is about 200-500m. It is the wide-ranging and low visibility nature of sea fog occurrence that makes satellite remote sensing monitoring be an effective and powerful tool, because that it is difficult to set instruments for station observation over ocean or do some fieldwork at the sea fog region by ship. Spring is the season of sea fog frequent occurrence, but also the season of Asian dust storms, which can long range transport and pass through the China Sea, often occurs. The present of Asian dust aerosols over ocean makes some difficult for sea fog detection at daytime, due to that they have some similar characteristics at visible and near-infrared bands [1]. The objective of this paper is to analysis the different thermal infrared radiation characteristics between the sea fog and Asian dust aerosols over ocean and to provide technical services for accurate monitoring sea fog from satellite. Some researcher have studied the difference between mid-infrared and infrared radiative properties for sea fog detection [2][3]. In this study, we mainly present and compare the thermal infrared brightness temperature (BT) characteristics combining some MODIS observations, which has 36 spectral channels including the 8.5 (Band29), 11 (Band31), 12μm (Band32) thermal infrared channels, and Streamer simulations, which is a radiative transfer model based on plane-parallel theory, and possesses ability to simulate radiances for a variety of cloud atmospheric situations [4]. The MODIS observations of the sea fog on 17 March, 2005 and the Asian dust aerosol over ocean on 16 April, 2006 are selected as the general case for expressing their different thermal infrared characteristics. Combining the MODIS band spectral response function, the Streamer model simulates the thermal infrared brightness temperature under different sea fog and dust aerosol physical characteristics, such as optical thickness, particle effective radius. We also analyzed the impact of solar zenith angle, view angle, while the surface temperature is only set as the average ocean surface temperature on spring, and the background atmospheric structure is considered as the mid-latitude summer/winter atmospheric profile. The simulations under different condition exhibit the thermal infrared characteristics of sea fog and dust aerosol in general and extensive. With the MODIS observations and Streamer simulations, in sea fog, the BT11 and BT12 are close, and they are greater than BT8.5 (see figure 1). In contrast, in Asian dust aerosol, BT12 is always greater than both BT11 and BT8.5, and BT8.5 is general greater than BT11, which is consistent with the tri-spectral method [5][6]. The sea fog is cling on the ocean surface while Asian dust aerosol over ocean is suspended in air about 1-3km height. Those thermal infrared differences will be caused by different mechanisms for sea fog and Asian dust aerosol over ocean. The primary factor is its emissivity at channels for sea fog, while it is the particle extinction that for Asian dust aerosols. By comparing the complex refractive index of the dust aerosol and the water and calculating theoretically the emissivity of water cloud at three infrared bands, those differences are explained. The sea fog has lower emissivity around 8.5μm than at both 11μm and 12μm, and the dust aerosol particles extinction is stronger in 11μm than in 12μm and 8.5μm. Hence the BT8.5 for sea fog is the smallest among the three thermal infrared channels, while the BT12 for Asian dust aerosol is greatest. By the MODIS case observation, the Streamer model general simulation and some theoretical explanation, those above thermal infrared brightness temperature characteristics with their visible and near-infrared reflectance relationship will be nice for sea fog monitoring accurately.

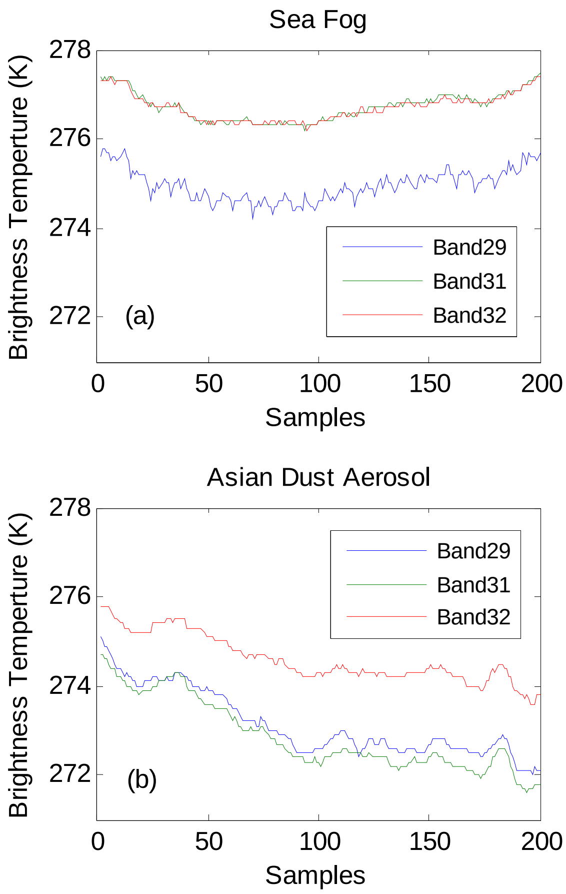

Fig1.The thermal infrared brightness temperatures vary with samples for sea fog and Asian dust aerosol over ocean in Band29 (8.5μm), Band31 (11μm), Band32 (12μm)

REFERENCE

[1] Hao Z. Z., Pan D.L.,Gong F.,Zhu Q.K.. "Optical Radiance Characteristics of Sea Fog Based on Remote Sensing". Acta Optica Sinica, 2008, 28(12), pp.2420～2426. (in chinese)

[2] Hunt, G., E., "Radiative properties of terrestrial clouds at visible and infrared thermal window wavelengths". Quarterly Journal of the Royal Meteorological Society, 1973, vol.99, pp.346-369.

[3] Eyre, J., R., Brownscombe, J., L., Allam, R., J. “Detection of fog at night using advanced very high resolution radiometer (AVHRR) imagery”. Meteorological Magazine, 1984, vol.113, pp.266-271.

[4] Key, J., A., J., Schweiger, “Tools for atmospheric radiative transfer: Streamer and FluxNet”. Computers and Geosciences, 1998, 24, pp.443-451.

[5] S. A. Ackerman, “Remote sensing aerosols using satellite infrared observations”. Journal of Geophysical Research, 1997, vol.102, pp.17069-17079.

[6] Liu S.C., Liu Q.H., Gao M.F., Chen L.F. “Detection of dust storms by using daytime and nighttime multi-spectral MODIS images”. 2006 IEEE International Geoscience and Remote Sensing Symposium (IGARSS 2006), vol.1, pp.294-296.