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Classification of clear-sky and cloudy scenes over oceans solely based on hyperspectral infrared radiance measurements

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Modern satellite sensors such as Atmospheric Infrared Sounder (AIRS), the Cross-Track Infrared Sounder (CrIS), the Tropospheric Emission Spectrometer (TES), the Geosynchronous Imaging Fourier Transform Spectrometer (GIFTS) and the Infrared Atmospheric Sounding Interferometer (IASI) provide high spectral resolution infrared spectra with rich information about atmosphere, clouds and surface. One unique application of the spectra is to derive spectrally resolved flux at the top of atmosphere (TOA) for climate observations and model evaluations. Such transitions are usually done with auxiliary measurements and information to determine scene types. But the necessary collocated strategy greatly reduces the amount of available samples. Recently Song et al. (2012) has developed a solely radiance-based spectral anisotropic distribution model (ADM) and successfully derived spectral fluxes over tropical oceans from spectral radiance measurements. However, as an essential precondition of this kind of algorithm, the classification of clear-sky and cloudy scenes solely based on spectral radiances remains a challenging task.

Taking AIRS spectrums as an example, this study focuses on combining multiple spectral and spacial methodologies to develop a solely radiance-based algorithm for proper classification of clear-sky and cloudy scenes over oceans. One month of AIRS spectrums which have good calibration accuracy and stability are used together with collocated clouds and broadband flux products of Clouds and the Earth's Radiant Energy System (CERES) which onboard same spacecraft for comparisons and validations. Given that the most transparent channels of AIRS are at 2616 cm^{-1} in daytime and 1231 cm^{-1} in nighttime suggested by Aumann et al. (2004 and 2006), we set a threshold of the differences between the brightness temperatures of 2616/1231 cm^{-1} and corresponding sea surface temperatures that are from NOAA Optimum Interpolation (OI) Sea Surface Temperature V2 weekly mean products. The traditional spatial coherence test and tri-spectrum method are also discussed as supplements. Generally speaking, a stricter threshold can improve the accuracy of clear-sky estimation, but it also largely excludes the actual clear-sky samples which cannot be decided exactly. Detailed analysis of misclassification cases shows that low and broken clouds are the most complex parts due to the very small differences between cloud top and sea surface.

Next more spectral information including CO_2 absorbing band should be considered to improve the accuracy, especially for the low and broken cloudy scenes. Furthermore, different spectral methods should be explored for specific scenes. The solely radiance-based classification method is not only meaningful for deriving spectral fluxes, but can also be easily extended to other similar hyperspectral radiance measurements to make better usages of existing observational information.