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Observations of land surface emissivity with multispectral thermal infrared data from space

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Knowledge of the land surface emissivity is important for estimating the longwave radiation budget, a decrease of soil emissivity by 0.1 will decrease net and upward longwave radiation by about 6.6 and 8.1 Wmˆ2, respectively. In most atmospheric models the spatial variability of the emissivity is not accounted for because of a lack of data. The multi-spectral thermal infrared data from the Advanced Spaceborne Thermal Emission and Reflection (ASTER) radiometer and the Moderate Resolution Imaging Spectrometer (MODIS) provide new tools for observing the land surface emissivity. ASTER has 5 channels in the 8 to 12 micrometer wave band with 90 meter resolution. MODIS has 3 channels in this wave band with 1 km resolution and it provides almost daily coverage. Both sensors are onboard the NASA Earth Observing System (EOS) Terra satellite, which was launched in 1999. MODIS is also on the Aqua satellite. Data from ASTER can be used to assess the spectral and spatial variations of surface emissivity when used with the Temperature Emissivity Separation (TES) algorithm. TES makes use of an empirical relation between the range of observed emissivities and their minimum value to extract the temperature and 5 emissivities from the 5 channels of ASTER data. The approach was validated with ASTER data acquired over the Jornada Experimental Range and the White Sands National Monument in New Mexico between 2001 and 2005 yielding good agreement with ground measures of emissivity. The approach was extended to produce maps of emissivities over a 400 x 1200 km area for a desert region of North Africa, including the sand dunes of the Grand Erg Oriental. The spectra for the sand dunes showed good agreement with that expected for quartz sand based on laboratory and field measurements. A multiple regression approach was used to relate the emissivities of the 5 ASTER channels to the window channel emissivity. The results were compared with a classification based

emissivity map and significant differences were found, ranging between -0.08 and +0.06. The spatial variation of the window channel emissivity observed by ASTER is from 0.8 to 1, which corresponds to a range of 15 w/mˆ2 in the net surface longwave radiation under a dry atmosphere. These results show that ASTER data can be used to map the spatial and spectral variations of surface emissivity over large areas in particular the deserts of the world for which there is much exposed soil and sand. A broadband emissivity map for North Africa was generated using the coarser resolution MODIS data The range of the broadband emissivity was found to be between 0.80 and 0.96 for the desert area. The expected RMS error of the map is about 0.02. Such an emissivity map has been used as an input to a climate model and improves the prediction of surface and air temperatures by up to 1 degree C.