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The high altitude SSMIS channels: Validation of fast radiative transfer simulations by comparison with line-by-line simulations

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Channels 19-22 of the Special Sensor Microwave Imager/Sounder (SSMIS) on the DMSP satellite are simulated using a diverse atmospheric temperature profile dataset. These channels all measure the absorption spectra of the main isotope of molecular oxygen, and have pass-bands that are close in frequency to the center frequencies of four of the spectral lines. As a consequence, the channels measure high up in the atmosphere. The sensitivity of some channels even peak above the present upper levels of numerical weather prediction models at 80 km. The high altitude of the measurements in turn means that the molecular oxygen spectroscopy is noticeably affected by the Zeeman effect; this splits a line into frequency-separated polarized components as a function of the external magnetic field.

The simulations have been performed using both ARTS and RTTOV as forward radiative transfer simulators. ARTS uses a line-by-line approach to radiative transfer. For the Zeeman effect calculations, ARTS can read line data and 3D magnetism directly from databases and then performs the splitting and polarization for each finite layer to calculate polarized absorption that is input to the radiative transfer equation. RTTOV uses a fast approach to radiative transfer, pre-calculating scalar effective transmission predictors for a set of atmospheric scenarios for each channel. For the Zeeman effect calculations, an altitude independent magnetic field is required as input for the layered transmission for the radiative transfer equation.

Our results show that the differences between the models are small compared to sensor noise for all channels. The mean difference between models is larger for the lower altitude channels 21 and 22, but the standard deviation is small between the models. The mean simulated brightness temperatures of ARTS are closer to SSMIS than the RTTOV values, but it is not possible to tell which model is more accurate as temperature errors in the profiles are expected to be larger than the difference between the models. For the higher altitude channels 19 and 20, the mean differences between the models are small compared to the standard deviation. No comparison with SSMIS data is possible here, because the numerical weather prediction profiles miss a large part of the channels' weighting functions. We do, however, observe an error introduced by 2D magnetism near equatorial regions. It is recommended that simulations of these high peaking channels of SSMIS with RTTOV should include the Zeeman effect.