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Total water vapour over polar regions from satellite microwave radiometer (AMSU-B) data and from a regional climate model (HIRHAM)

C. Melsheimer (1), A. Rinke (2), G. Heygster (1), K. Dethloff (2)

(1) Institute of Environmental Physics, University of Bremen, Germany, (2) Alfred Wegener Institute for Polar and Marine Research, Potsdam, Germany

Water vapour, comprising about 1 to 4% of the volume of the Earth's atmosphere, has a key role in the global climate system: Water vapour (1) is the most abundant and the most radiatively important greenhouse gas, (2) can transport large amounts of latent heat and thus strongly influences the dynamics of the atmosphere, and (3) is an important link connecting the various components of the hydrological cycle. There is hence a need for continuous global data of water vapour in the atmosphere, if possible as a function of height (water vapour profiles), or at least the vertically integrated water vapour content of the atmosphere, called column water vapour, precipitable water or total water vapour (TWV). The global network of meteorological stations that regularly measure vertical profiles of atmospheric humidity (among other variables) by radiosondes is very sparse in the Arctic and Antarctic. Satellite sensors such as the AMSU-B (Advanced Microwave Sounding Unit B) on the polar-orbiting satellites of NOAA are designed and operationally used for humidity sounding. They use several channels with different sensitivity to water vapour. This, however, fails over polar regions since there, (1) the total water vapour content of the atmosphere is so low that the contribution caused by surface emission is substantial and (2) the surface emission is poorly known and highly variable because of its strong dependence on the ice type and because of the variable ice cover of the seas.

Here we describe a method for the retrieval of total water vapour from AMSU-B which is complementary to operational humidity sounding in that it works exactly where the atmosphere is dry enough for the ground to be "seen" by the sensor, and which is mostly independent of the surface emissivity. The method uses the radiances at five channels: two window channels (no strong absorption lines) at 89 and 150 GHz, and three channels close to the strong water vapour absorption line at 183.3 GHz. It derives the TWV from ratios of channel differences, and is independent of most clouds. The method can only retrieve TWV values up to about 7 kg/m^2 (20 kg/m^2 over ice) which makes it suitable for the polar regions. Total coverage of the polar regions is achieved about two to four times daily, with a resolution of 15 to 50 km.

We compare TWV data for the Arctic retrieved from AMSU-B with from the high resolution regional climate model of the Arctic HIRHAM. The overall agreement is good, resolving the daily changing patterns mainly due to moisture advection by low pressure systems. However, it also shows deficiencies of the satellite-retrieved TWV data in summer.

Combination of water vapour data from different sources in order to achieve frequent global coverage is a significant tool for monitoring and understanding the weather and climate system.