Optical properties of the Antarctic system and new radiation information

November 16 2009

The Antarctic system comprises of the continent itself, Antarctica, and the ocean surrounding it, the Southern Ocean. In a study for a doctoral degree by geophysicist Kai Rasmus, University of Helsinki, Finland, measurements were made during three Austral summers to study the optical properties of the Antarctic system and to produce radiation information for additional modeling studies.

The system has an important part in the global climate due to its size, its high latitude location and the negative radiation balance of its large ice sheets. Antarctica has also been in focus for several decades due to increased ultraviolet (UV) levels caused by stratospheric ozone depletion, and the disintegration of its ice shelves.

During the summer of 1997-1998, measurements of beam absorption and beam attenuation coefficients, and downwelling and upwelling irradiance were made in the Southern Ocean along a S-N transect at 6 degrees E. The attenuation of photosynthetically active radiation (PAR) was calculated and used together with hydrographic measurements to show that the phytoplankton in the investigated areas of the Southern Ocean are not light limited.

Variabilities in the spectral and total albedo of snow were studied in the Queen Maud Land region during the summers of 1999-2000 and 2000-2001. The measurement areas were the vicinity of the South African research station SANAE 4, and a traverse near the Finnish research station Aboa. The mean spectral albedo levels at Aboa and

SANAE 4 were very close to each other. The variations in the spectral albedos were due more to differences in ambient conditions than variations in snow properties.

A Monte-Carlo model was made to study the spectral albedo and to help in developing a novel nondestructive method to measure the diffuse attenuation coefficient of snow. The method was based on the decay of upwelling radiation moving horizontally away from a source of downwelling light. In the model, the attenuation coefficient obtained from the upwelling irradiance was higher than that obtained using vertical profiles of downwelling irradiance. The model results were compared to field measurements made on dry snow in Finnish Lapland and they correlated reasonably well.

Low-elevation (below 1000 m) blue-ice areas may experience substantial melt-freeze cycles due to absorbed solar radiation and the small heat conductivity in the ice. A two-dimensional (x-z) model was developed to simulate the formation and water circulation in the subsurface ponds. The model results show that for a physically reasonable parameter set the formation of liquid water within the ice can be reproduced. Vertical convection and a weak overturning circulation is generated stratifying the fluid and transporting warmer water downward, thereby causing additional melting at the base of the pond. In a 50-year integration, a global warming scenario mimicked by a decadal scale increase of 3 degrees per 100 years in air temperature, leads to a general increase in subsurface water volume.

Source: University of Helsinki

antarctic.html