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The turbulent structure of the polar stable boundary layer: Wavelet transform and multiresolution flux decomposition.

A.C. van den Kroonenberg (1), J. Bange (1)

(1) Technical University of Braunschweig, Institute of Aerospace Systems (a.kroonenberg@tu-bs.de)

This study focuses on small scale turbulence and the scale dependence of the turbulent fluxes in the polar stable boundary layer (PSBL). The large scales of a fully turbulent flow contain most of the energy and are responsible for the transport of heat, momentum and mass. The small scales include the dissipation range and the inertial range. Knowledge of small scale turbulence is mostly based on Kolmogorov's theory, but no global theory of turbulence is present. In this research the scale dependence of several covariances in the PSBL will be analysed.

Measurements were made by a sensitive and fast measurement system, the helicopter borne turbulence probe Helipod. The Helipod was developed for in-situ measurements of small-scale turbulent fluctuations of wind, temperature, humidity and the associated turbulent fluxes. The autonomously operating sensor package was carried by a helicopter on a rope of 15 meter length. The operation speed is 40 m/s and the data is stored at a rate of 100 Hz. The flights were performed at low altitudes above the surface (10 m) which is particularly useful in the shallow SBL.

The database used for this study consist of two Arctic campaigns (Jul-Sep 1996, Mar-Apr 2003) with the German research vessel Polarstern. Within these campaigns, Helipod flights were performed in the East Greenland sea, the Fram Strait, Kara Sea, Laptew Sea, East-Siberian Sea and the central Arctic sea. The surface consisted of sea which was covered with sea-ice. In total 13 flight days were analysed. The meteorological cases varied between deep SBL with weak stratification and shallow SBL with strong stratification as found from vertical profile flights.

Multiresolution (MR) decomposition is performed on time series of the kinematic heat and moisture flux. Studying the MR cospectra, a gap scale was defined which represents the averaging time scale corresponding to the devision of turbulence and meso scale motions. The cospectral gap scale for the kinematic heat and moisture flux for one particularly flight leg was found to be equal. The first peak in the cospectrum represents the scale of the main transporting eddies. The time scale of this peak showed a dependence on the measurement height and the bulk Richardson number.

Cross wavelet spectra and cross wavelet power spectra were used to verify the time scales found by MR cospectra. Analysing the wavelet covariance gave additional information on the sign of the flux. The nonorthogonal complex wavelet transform, named Morlet wavelet (6th order) was chosen for this purpose. The chosen order of 6 is optimal and provides good time localisation and frequency resolution. This good resolution in Fourier space is needed to define the gap between turbulence and meso scale.