Hydrological Characteristics of a Narrow and Shallow Part of Van Mijen Fjord on Spitsbergen

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ABSTRACT

The paper describes observed water current, pressures and temperatures beneath the ice in a narrow and shallow part of the Van Mijen Fjord, Spitsbergen during winter 2008. The survey instrumentation included an 3D Acoustic Doppler velocity meter and temperature and pressure sensors. The observations were used to calculate mean currents, tidal amplitudes, Reynold stresses, water–ice drag coefficients and turbulent heat fluxes. The maximal heat fluxes to ice bottom reached 10 W/m² during rising tides. The mean drag coefficients varied between 0.003 and 0.004. Water velocity oscillations directed transversally to the fjord and water pressure oscillation at bottom with periods multiples of 12.5 min were observed at low tide.

KEY WORDS

Hydrological measurements; sea ice; waves; drag coefficient; heat flux.

INTRODUCTION

The natural environment of large areas on the Arctic shelf is characterized by small water depth, long ice season, strong winds, low air temperatures, tides with current velocities up to 1 m/s and water level variations about few meters, regions with seasonal permafrost and variable river runoff, among others factors. The same shallow areas may contain oil and gas resources and for this reason more environmental information is required to ensure safe and efficient exploration. Estimates of design loads on arctic offshore structures are carried out using actual field data. Overestimates of design loads lead to a significant increase of the costs for the construction of engineering structures, while underestimates can cause catastrophic results.

Penetration of tidal currents in shallow water regions covered by ice creates high shear stresses in the water and therefore causes stronger sediment transport during an ice season. This effect was studied in several rivers (Hains and Zabilansky, 2004), where seabed scours created near bridge piers by the current in winter time were larger than in summer time. The influence of tidal currents on sediment transport in Arctic coastal zones is not well studied phenomenon. Zubov (1944) wrote about significant decreasing of tidal amplitudes in the mouth of several rivers flowing into the White Sea in winter time in comparison to ice free season. Voinov (1999) demonstrated delay of tidal phase in ice season in the Kara Sea.

The influence of water currents on the level ice is realised by drag force existing due to the transfer of liquid particles momentum to the ice bottom. Since water molecular viscosity is very small, the momentum transfer in natural conditions is mainly related to the production of vorticity in ice adjacent layer, and water currents below the ice is turbulent. Since the bottom surface of drifting sea ice is not level, total drag force can be decomposed into turbulent drag force and form drag force. Form drag force depends on the number of ice ridges per unit area of sea ice and their geometrical sizes, while turbulent drag depends mainly on the area covered by the level ice. The bottom of land fast ice is smooth. Therefore the influence of water currents on land fast ice is related mainly to turbulent drag force. The drag force creates internal ice stresses in land fast ice and can cause its break up. Direct measurements of turbulent drag forces at the bottom of drifting ice were carried out in (Langleben, 1980; McPhee, 2007; Gorbatsky and Marchenko, 2007)

Field observations of the landfast sea ice near Point Barrow, Alaska, recorded vertical displacements of several centimetres amplitude and periods of the order of 600 s (Bates and Shapiro,