

Thermodynamics of Glaciers

Exercise

1 Climate history

Air temperatures in Alaska was oscillating with a period of about 50 years and an amplitude of about 2°C between 1950 and 2000. How deep down would you be able to detect such temperature variation in stagnant ice if the accuracy of your temperature sensors are 0.01 K assuming an ice temperature of -3°C ?

2 Melting temperature depression

What is the pressure melting temperature at the base of Gornergletscher (Fig.9)? What does the Clausius-Clapeyron relation indicate in terms of air-saturation of the melt water? The pressure p is the sum of the hydrostatic pressure and the atmospheric pressure, $p = \rho gH + p_{\text{atm}}$. Assume $p_{\text{atm}} = 75'000\text{ Pa}$.

3 Lake Vostok

1. Describe 2 different ways how heat can be moved through a polar ice sheet.
2. What is the Péclet Number, and how is it useful?
3. The coldest temperature ever recorded is -89°C at Vostok in East Antarctica (in July 1983). The mean annual temperature is -55°C . However, deep under the ice is lake Vostok, a lake of the size of lake Ontario. Calculate the minimum geothermal flux needed for a lake to form. Possibly relevant quantities:
 - Surface elevation 3488 m
 - Ice thickness 3300 m
 - Snow accumulation rate 2 cm a^{-1} (water equivalent)
 - A reasonable average thermal conductivity for the cold temperatures of the East Antarctic Ice Sheet is $k = 2.5\text{ W m}^{-1}\text{ K}^{-1}$.