

Fig. 7. Physical properties of the firm blocks at (a) DF, (b) DK190 and (c) MP. Density ρ with 3.3 mm resolution is shown as the green line with the top axis. Near-Infrared reflectance R is given as a purple line with a scale on the bottom axis. A scale of the specific surface area (SSA) is also given considering earlier empirical relations between R and SSA (Matzl and Schneebeli, 2006; Wiscombe and Warren, 1980). In this paper, SSA (mm^{-1}) is defined as the ratio between surface area and the volume of the ice phase (Matzl and Schneebeli, 2006). Two components of the microwave dielectric permittivity, ε_v and ε_h ($\varepsilon_v > \varepsilon_h$), are shown with a blue line and on the bottom axis. The dielectric anisotropy $\Delta\varepsilon (= |\varepsilon_v - \varepsilon_h|)$ is shown with a red line and the top axis. For DF, measured grain size from LASM images (see text) is given as yellow-brown lines and the bottom axis. An example of the LASM image at the depth portion with yellow shading is given in Fig. 9.

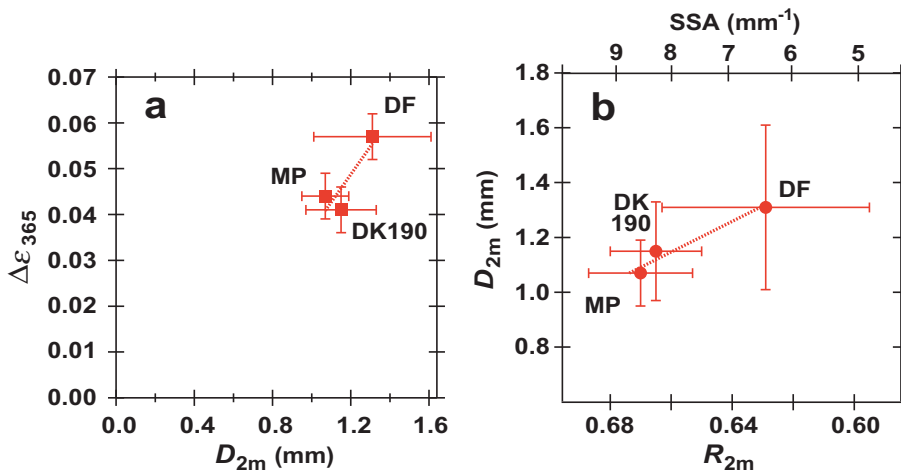


Fig. 12. (a) A relation between $\Delta\epsilon$ values for $\rho = 365 \text{ kgm}^{-3}$ ($\Delta\epsilon_{365}$ on the left axis) and the averaged D values at $z = 2$ (m) (D_{2m} on the abscissa) for the three sites. A linear correlation is suggested. (b) A relation between D_{2m} and the averaged R values at $z = 2$ (m) (R_{2m} on the abscissa) for the three sites. A scale of the specific surface area (SSA) converted from R (see Figure 7) is also given on the top axis.

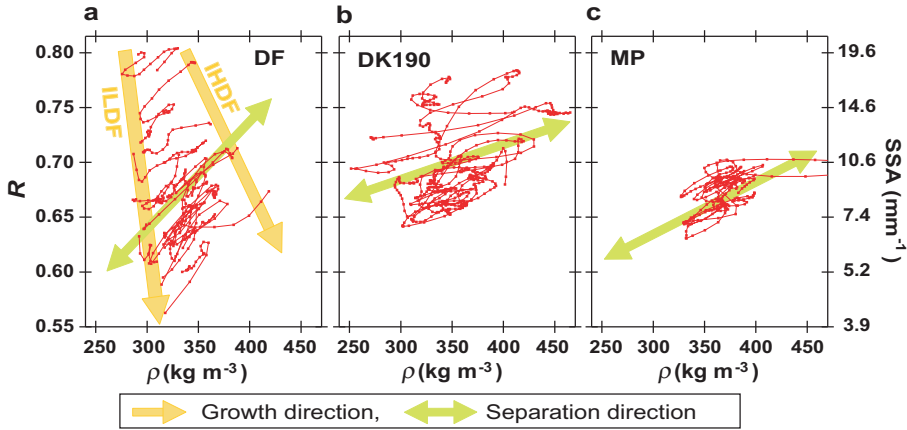


Fig. 13. Trajectories of R - ρ relation for the three pits. The abscissa is ρ . The ordinate in the left and the right axes are R and the SSA converted from R respectively. Data points (dots) are connected by lines along depths to emphasize how the R - ρ relation evolves with increasing depth. Raw data were smoothed over every 10 mm to remove noise in the original data. Light green arrows show suggested directions of separation (contrasted evolution) between IHDF with higher density and finer grains and ILDF with lower density and coarser grains. Light orange arrows show suggested direction of evolution of grain properties for IHDF and ILDF. At DF, a cyclic feature is more clearly observed in the trajectory. At DK190 and MP, gradients of the $\Delta R/\Delta \rho$, that is, the gradient of the light green arrows are apparently lower than that of DF. Cyclic features tend to be disturbed by very dense ($> 380 \text{ kg m}^{-3}$) layers caused by strong wind events. The gradients of $\Delta R/\Delta \rho$ are given in Table 4.