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Evolution in geometry of firn in ice sheets detected by dielectric anisotropy

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Ice in polar ice sheets once experience a state of firn at near-surface depths. Therefore, it is important to understand physical processes of firn formation, metamorphism and deformation for ice core studies. We investigated firn through measurement of tensorial values of the dielectric permittivity at microwave and millimeter-wave frequencies. This method can detect presence and strength of anisotropic structure in the geometry of pore spaces and ice matrix. We applied the method to many firn cores drilled at both ice sheets. We find that firn that have shorter residence time at the near-surface depths does not form strong vertical anisotropy that is caused by vertical movement of moistures. In contrast, firn that have longer residence time at the near-surface depths tend to form vertical anisotropy. When density exceeds ~600 kg/m^3, a common feature of firn at many polar sites is that there are evolution of vertically elongated features of pore spaces in firn despite growth of vertical compression. We hypothesize an explanation as follows. As firn becomes denser, air within firn needs escape paths to upward directions as compared to sinking firn. In firn, porous structure tend to have vertically elongated structure because of this vertical escape movement of air. The observed phenomena of the grow th of the vertical dielectric anisotropy
can be understood by this vertical movement of the air w ithin firn.