The Arctic sea ice pack has experienced rapid changes over the last decade with well-documented losses in ice extent. More recently, observations show a decline in sea ice thickness leading to a basin-wide loss of ice volume. Fundamental to our capabilities to monitor and forecast these changes are observations from airborne and satellite-based laser and radar altimeters. The accurate mapping of sea ice thickness, using these instruments, requires the largest identified contributors to thickness errors to be better constrained: namely the uncertainties in sea ice freeboard and snow depth. The NASA Operation IceBridge airborne campaign is a six-year mission that is currently providing a yearly multiinstrument look at the cryosphere, including the Arctic sea ice pack. Airborne snow depth measurements on sea ice are obtained using the University of Kansas/CRESIS snow radar (a 2-8 GHz FMCW radar system). We present a new methodology for analyzing airborne snow radar data for the extraction of snow depth utilizing a novel wavelet-based layer-picking technique. The snow depths derived from the snow radar are compared with independent snow depth data sets measured in situ at the US Navy ICEX2011 ice camp in the Beaufort Sea and the ESA CryoVEx 2011 ice camp in the Lincoln Sea. The direct comparison between the radar-derived snow depths and those measured in situ allows the accuracy of the airborne data to be assessed. We describe the impact of sea ice surface morphology, particularly deformed ice blocks and pressure ridges, on our results. We discuss the implications of our results for the analyses of data from spaceborne and airborne radar altimetry systems over sea ice and other rough ice surfaces. We extend our analysis to IceBridge data gathered in the Western Arctic to provide a more detailed assessment of snow depth with respect to surface conditions. These measurements and their associated uncertainties will allow for the direct comparison with data from the ESA CryoSat-2 mission, particularly over the thicker, deformed ice north of Greenland, where discrepancies between IceBridge and CryoSat-2 thickness estimates have been observed.