# Mapping accumulation rate by observing the characteristic time scale of microwave emission

*E. J. Steig, D. P. Winebrenner, L. Koenig, Departhment of Earth and Space Sciences, University of Washington*

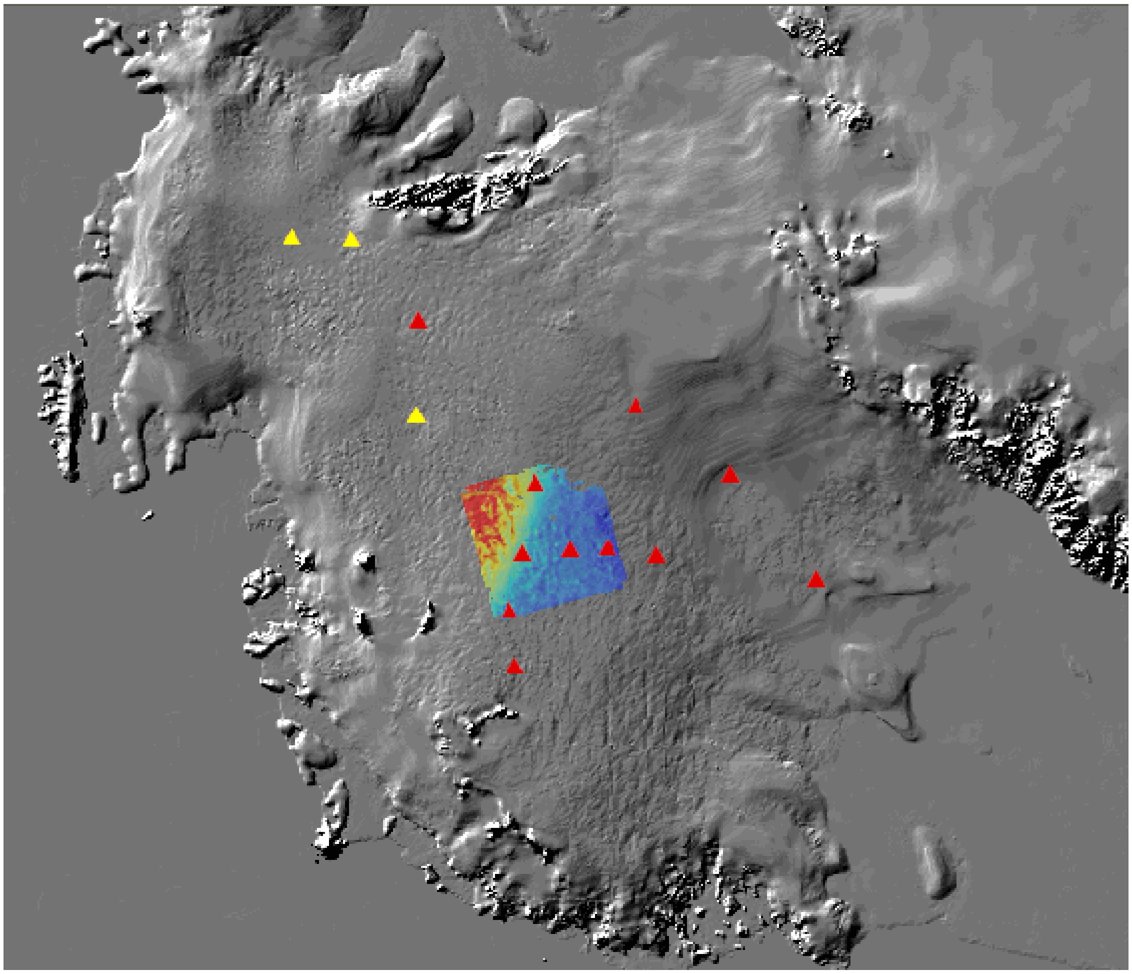
*T. A. Neumann, Department of Geology, University of Vermont*

Now that InSAR provides excellent velocity data, uncertainty in accumulation rates is one of the primary uncertainties in mass balance and ice dynamics calculations. West Antarctica is "small" enough for tracking of englacial layers using airborne sounding radar to provide accumulation rate fields for most areas of interest. East Antarctica is so big that the corresponding statement may never be true there. Moreover, accumulation rate variability in space and in time, on decadal scales or shorter, is of fundamental interest for altimetry, ice core interpretation, and meteorological studies. While it would be prohibitively expensive to do repeated radar measurements over all of Antarctica every few years, satellite measurements are taken continuously and provide nearly complete coverage over both West and East Antarctica. It is therefore of continued interest to pursue the use of satellite data to obtain accumulation rate fields.

We have found that the relationship between time series of surface temperature (which can be taken from thermal infrared data) and microwave brightness temperature provides a useful probe of snow properties that is governed by two parameters: the first is the emissivity, which relates long-term mean surface and brightness temperatures (and does not vary in time); the second is a characteristic time scale that describes, roughly speaking, how long into the past brightness temperature "remembers" past surface temperature variations.

For emission at 37 GHz (vertical polarization), the characteristic time scale varies from about 7 days to a couple of months. In much of West Antarctica, this characteristic time scale covaries linearly with accumulation rate (see the figures). The covariance is so strong that, for accumulation rates less than 40 cm of ice per year, we can infer accumulation rates near Byrd to an accuracy of approximately 10%. When we use 37 GHz (vertically polarized) emission data, the signal originates from roughly the upper meter of firn. This suggests that we may be able to track accumulation rate variations over times as short as the time necessary to accumulate about a meter of firn i.e., a few years in most locations. Moreover, we observe variations in the characteristic time scale over periods of a few years that are mostly likely due to accumulation rate variability.

These results suggest that mapping the characteristic time scale of emission over East Antarctica could refine accumulation rate estimates there and provide the first spatially extensive look at patterns of variability in accumulation in space and time. A priority will be to better understand the observed relationship between the accumulation rate and the characteristic timescale. The latter is a function of both emission length (relating to absorption and scattering properties in the snow) and of thermal diffusivity. Both of these can and should be measured in situ in as many locations as possible, for comparison with the satellite based measurements.



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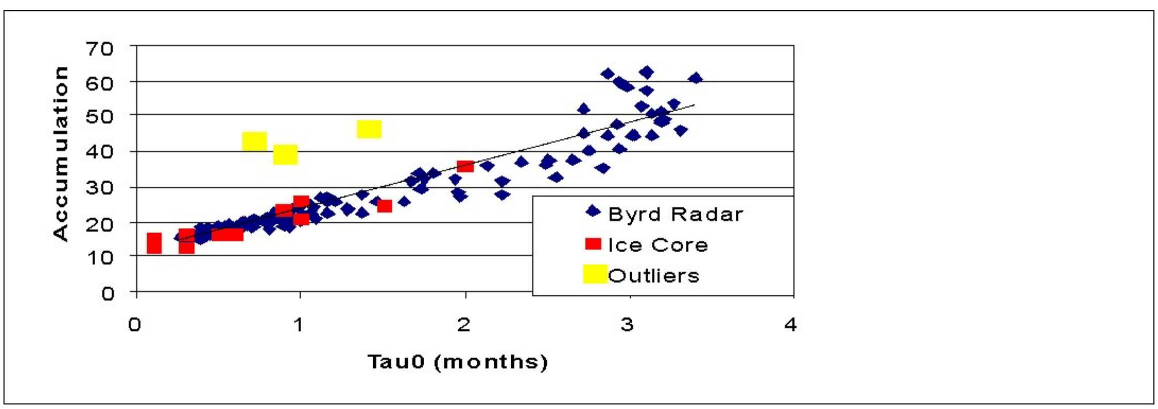


SteigFig1b

Figure 1. a) Map of West Antarctica showing the radar-based accumulation rates from Morse et al. (2002), and the locations of ITASE and other ice cores with measured accumulation rates.  b) Accumulation rates and calculated characteristic timescales for the locations in (a).  Clear outliers to the general relationship are shown in yellow, and are all from very high accumulation sites.