Time series of SMMR and SSM/I brightness temperatures over homogeneous targets: a preliminary look at variability/stability

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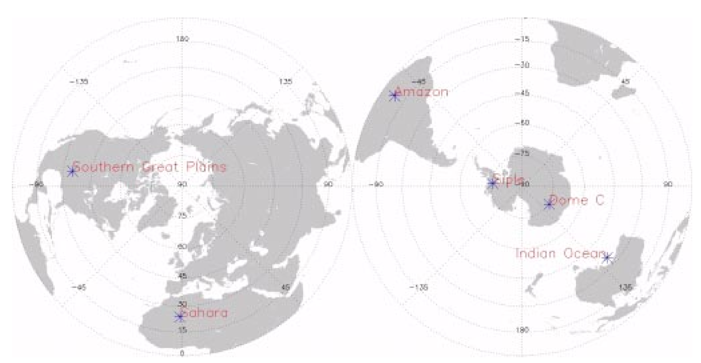
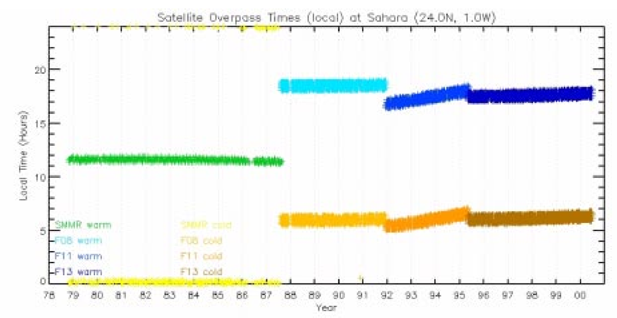
As an initial step in the selection and analysis of sites for future Advanced Microwave Scanning Radiometer (AMSR) validation studies we sampled the SMMR and SSM/I archives (NOAA/NASA Pathfinder brightness temperatures (T_Bs)) for geographic locations that could potentially represent long-term signature stability for the period 1978 to the present. Within a fixed earth grid, the Equal-Area Scalable Earth Grid (EASE-Grid), we selected several single pixel targets based on geographic diversity, assumed overall stability and expected seasonal behavior. Currently these include targets over cold and warm deserts, jungle, prairie, oceans and ice sheets. Selected examples are presented here. Where appropriate, corrections are made to the SMMR data according to the work of Jezek et al. (1993). Where available, T_B time series are combined with surface temperature at meteorological stations located within each pixel.



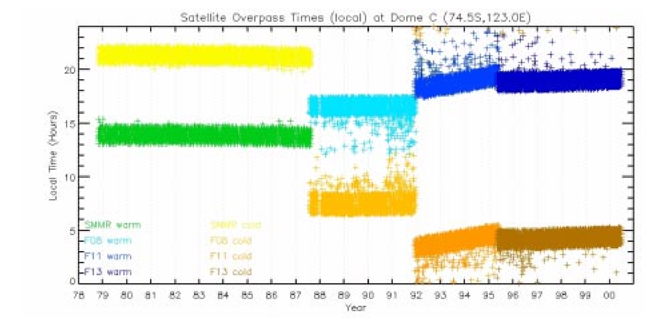
Northern Hemisphere study sites *Southern Hemisphere study sites*

Results indicate the response of the microwave data to the diurnal and seasonal cycle reflected in the physical temperatures. The responses are also affected by the variability of surface emissivity, depending on the nature of the surface. The physical temperature response is particularly evident at the Sahara Desert site, (below, far left), where it is assumed that there should be little or no seasonal pattern in emissivity resulting from precipitation or vegetation, and no significant changes in the surface texture of the target over time. At locations where exceptional scatter or bias does occur, there appears to be a reasonable physical explanation. In most cases any offsets between SMMR and SSM/I can be explained by physical temperature differences resulting from differing local overpass times.

The EASE-Grid T_B data used in this study are separated into ascending and descending orbits. The selected T_B for a given ascending or descending sample is that which represents the local overpass time closest to the equator crossing time for the particular satellite. Given the most simplified pattern of diurnal surface heating and cooling, the physical temperature associated with the overpass times of the SMMR instrument (approximately 1200 "warm" and 2400 "cold" equator crossing) would be expected to be warmer in general than the SSM/I (approximately 1800 "warm" and 0600 "cold" equator crossing) at low- and mid-latitude



Satellite overpass times at Sahara site, exhibiting typical pattern at low and mid-latitudes: SMMR overpasses at noon and midnight, and SSM/I overpasses at 6 a.m. and 6 p.m.



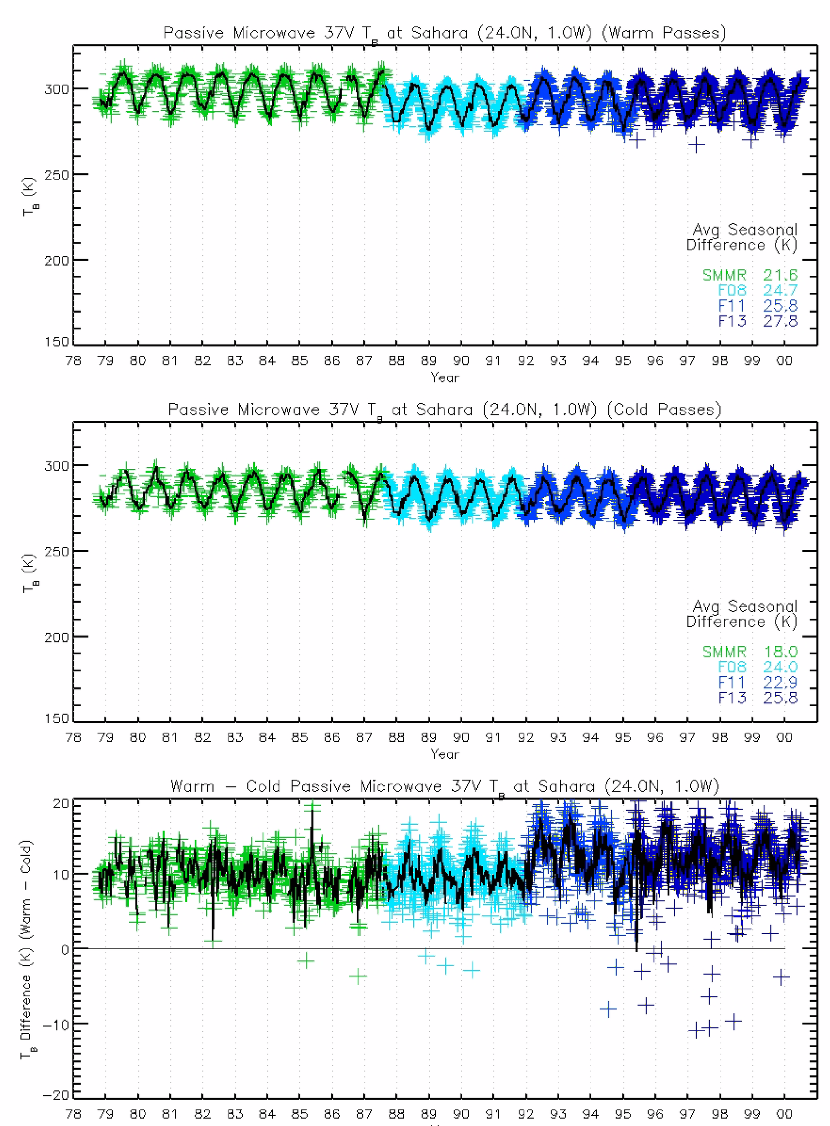
Satellite overpass times at Dome C, exhibiting deviations at high latitudes: SMMR overpasses at 2 p.m. and 8 p.m., and SSM/I overpasses at 4-7 a.m. and 4-7 p.m.

sites. Some differences between SMMR and SSM/I do persist. For example, at 37 GHz the lowest seasonal temperatures for a given target appear to be truncated in the SMMR time series compared to the SSM/I, especially during the "cold" orbits (Dome C, below, far right). At some locations the seasonal amplitude is slightly reduced for SMMR compared to SSM/I. In addition, over Antarctic targets the “warm” orbit minus “cold” orbit T_Bs can be negative. During the SMMR period, they are consistently negative at Dome C. The causes of this anomaly are being investigated.

All channels of each sensor are being analyzed in this study but only examples from the 37 GHz vertical polarization channel are presented below. This selection was made because the 37 GHz channel is common to both SMMR and SSM/I and because it is considered the frequency which would correspond most directly with land surface temperature, and be least sensitive to changes in emissivity properties.

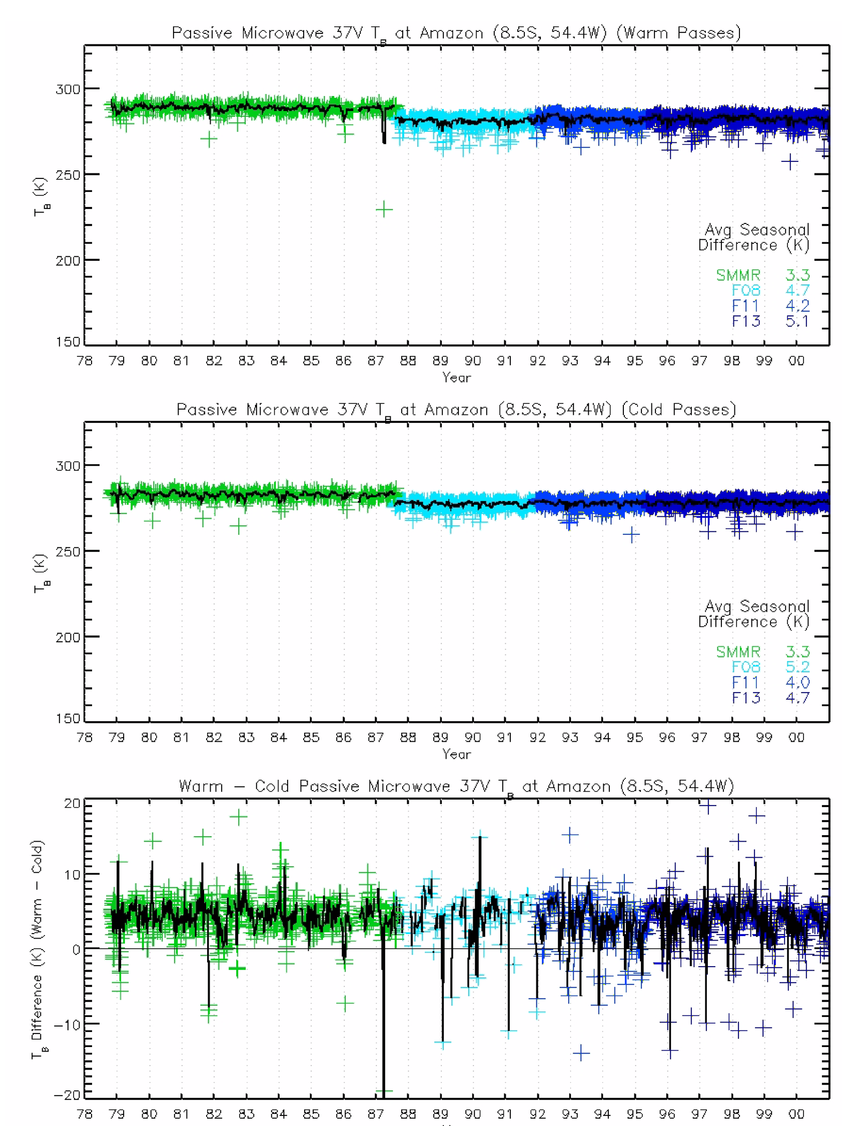
Conclusions: The multidecadal time series afforded by SMMR and SSM/I sensors provides a long-term baseline against which to assess the calibration stability of the AMSR and AMSR-E instruments to be launched in 2002. The SSM/I sensors are routinely cross-calibrated over the same warm and cold surfaces such that the T_B levels for warm (e.g. Amazon) and cold (e.g. Indian Ocean) sites are consistent between the SSM/I instruments on the different platforms. The SMMR and SSM/I sensors were cross-calibrated in a somewhat different manner and at different sites (Jezek et al., 1993). Biases between the SMMR and SSM/I are most evident at the warm end (land sites). This may be due to the fact that the Jezek cross-calibration did not include land sites, and may also reflect differences in surface physical temperature being sampled at the different orbital crossing times. These issues will be investigated further and must be taken into account in future AMSR calibration analyses for all radiometer channels.

Sahara



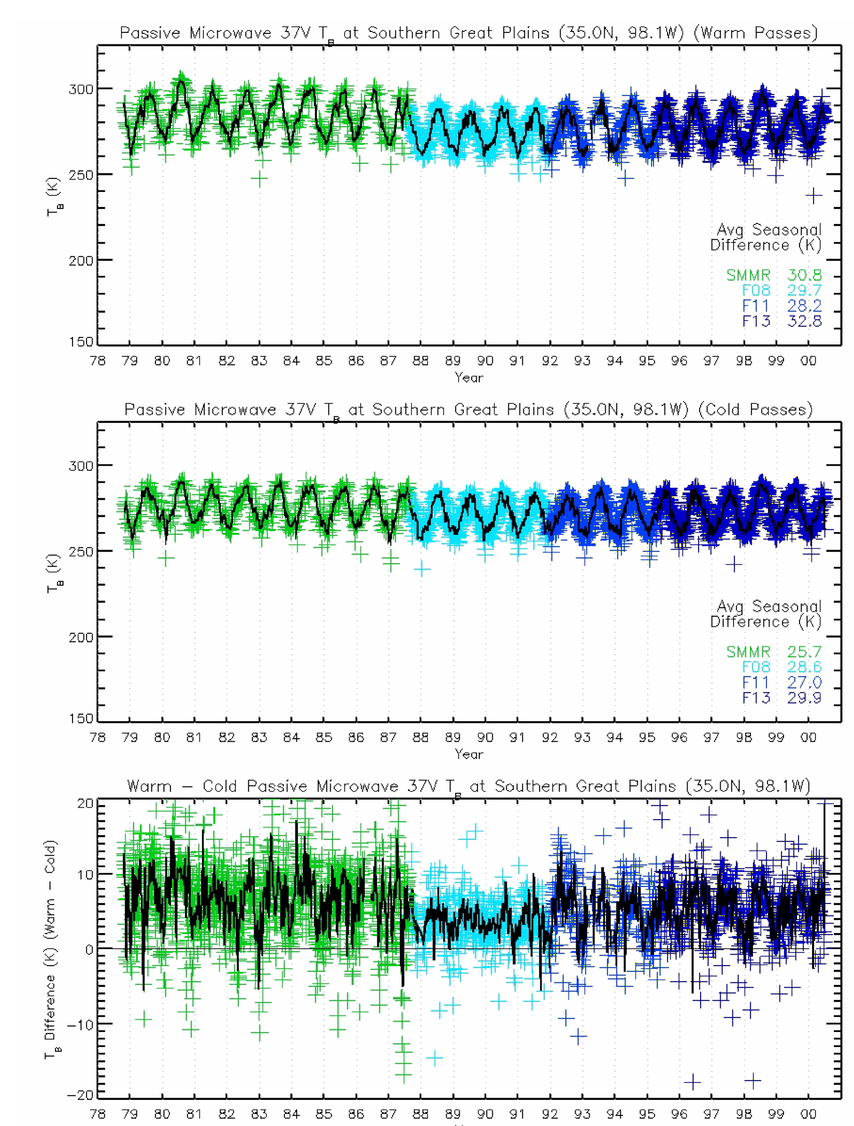
Sahara: Selected to represent a surface with a consistent emissivity with brightness varying over time primarily as a function of changes in physical temperature. At this site we would expect no seasonal pattern of surface emissivity change due to snow cover, soil moisture or vegetation and thus no significant changes in surface type or texture. The “warm” minus “cold” orbit values are positive and the largest differences occur in summer which makes physical sense. Local times for the respective overpass ("warm" versus "cold") for this site are displayed (top, center of poster) for SMMR and each of the sequential SSM/I sensors.

Amazon



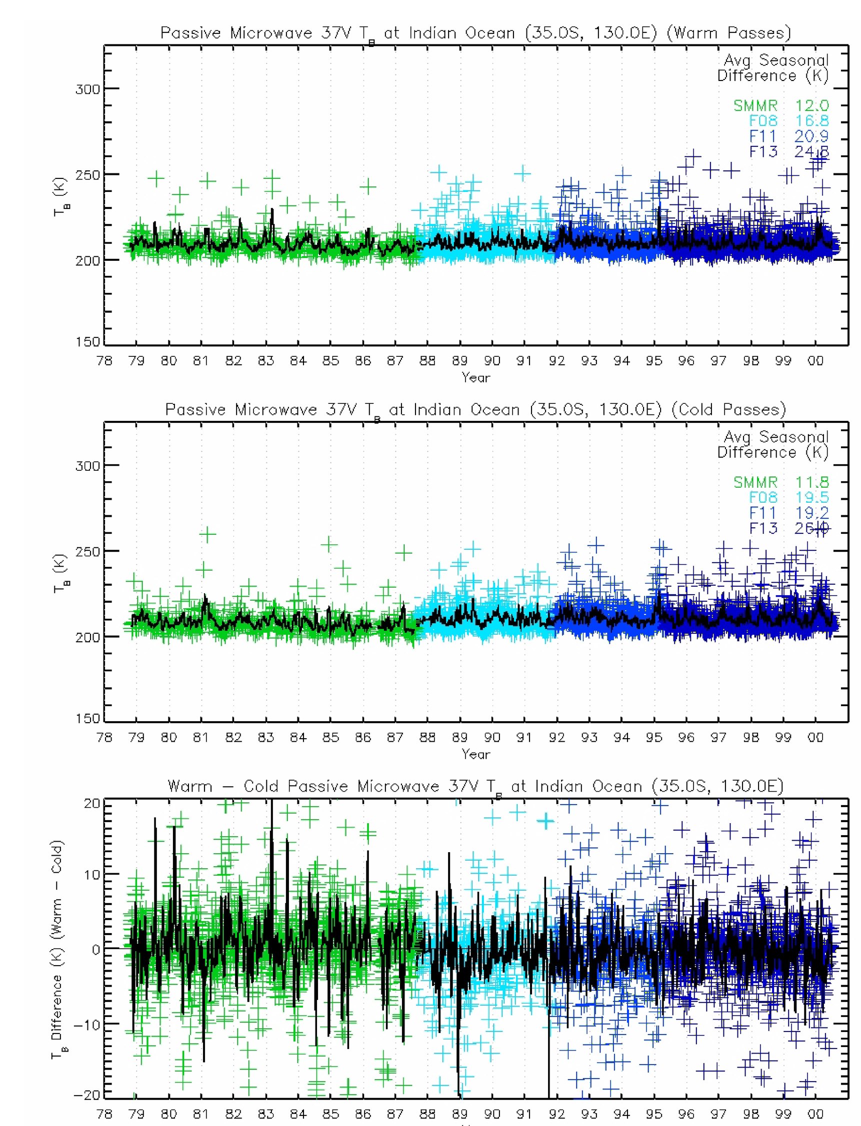
Amazon: Selected to represent a densely vegetated target with generally homogeneous emissivity characteristics. The emission originates entirely from the forest canopy, which has an emissivity close to that of a blackbody ($\varepsilon \approx 1$). The brightness temperature shows very little seasonal cycling (~5K or less), reflecting the stable emissivity and the small seasonal change in physical temperature. These characteristics, and the large-scale spatial homogeneity of the region, make it an excellent site for assessing the calibration stability of microwave sensors.

Southern Great Plains



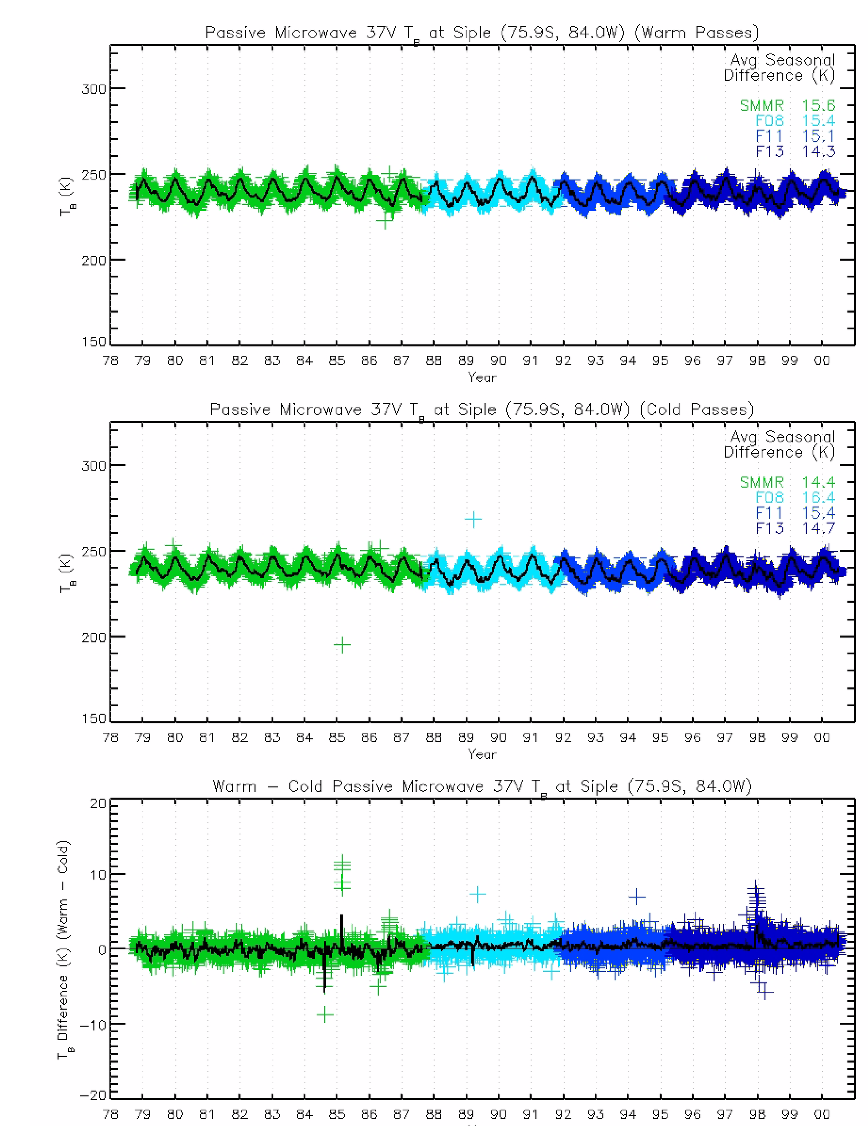
Southern Great Plains (Little Washita, OK): Selected to correspond with the primary site selected for AMSR-E soil moisture validation. This is a site at which a series of field experiments have been conducted in the past involving *in situ* sampling and airborne microwave radiometer measurements. The surface characteristics are mostly pasture and agricultural crops, with little topographic variability.

Indian Ocean



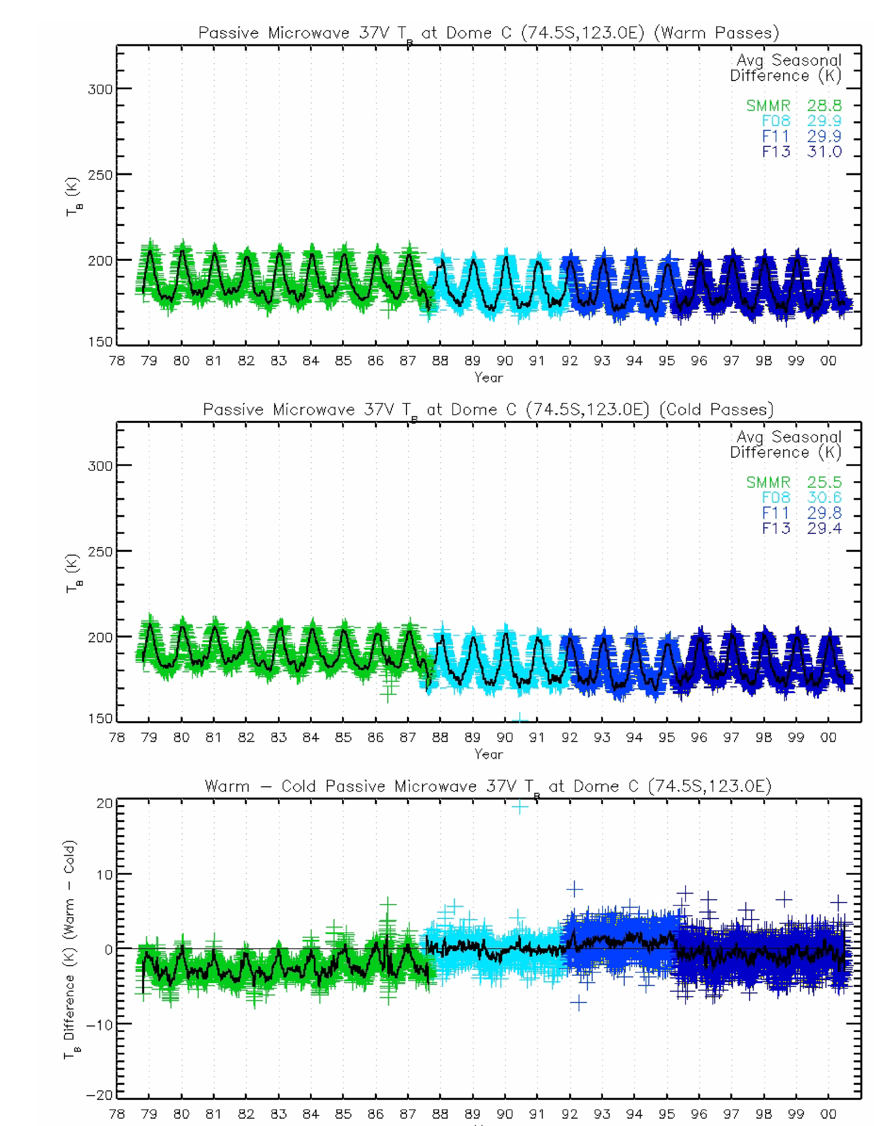
Indian Ocean: Selected to represent a relatively cold and calm ocean surface. The scatter over the ocean target is higher than at the land sites and is biased towards higher T_B values. This is likely due to periods of high winds where the turbulent ocean surface tends to respond more like a blackbody as foam is generated on the surface. This phenomenon is the basis for microwave ocean wind speed algorithms.

Antarctica (Siple)



Siple: The greater variability in T_Bs shown here during winter is attributed to the prevalence of katabatic winds which break up the surface temperature inversion causing extreme variability in surface physical temperatures (this is more apparent in the next example, at Dome C). To some degree this could also result from systematic seasonal changes in snow texture influencing emissivity but this has not yet been investigated in any detail. The annual cycle of physical temperature is compressed compared to Dome C which is due to the fact that Siple is a more maritime site. The “warm” minus “cold” orbit values are very close to zero.

Antarctica (Dome C)



Dome C: Dome C is the most anomalous site investigated thus far. Seasonal ranges are compressed for SMMR T_Bs with respect to SSM/I T_Bs. In contrast with the Siple example, SMMR midnight passes are warmer than noon passes and the difference is greatest in winter (April to August). The bias is closer to zero during the warm season. During the SSM/I period, “warm” minus “cold” orbit differences are both negative and positive, and do not exhibit the seasonal pattern evident in the SMMR data. We looked at data from surrounding pixels to determine that the results from Dome C were not caused by any local or specific positioning errors with respect to the either surface features or the way in which T_Bs were interpolated from swath space to the EASE-Grid.

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http://nsidc.org

National Snow and Ice Data Center

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