MELT ON THE MARGINS: Calibrated Enhanced-Resolution Brightness Temperatures to Map Melt Onset near Glacier Margins & Transition Zones

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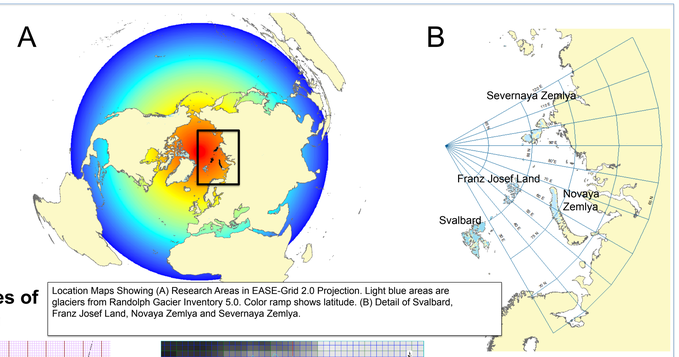
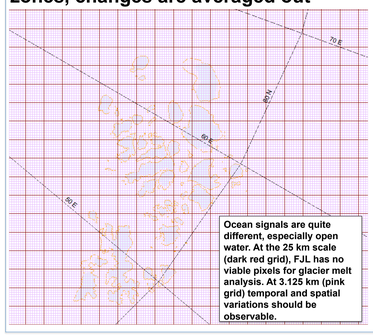
Abstract

Passive microwave (PM) observations from Special Sensor Microwave Imager/Sounder (SSMI and SSMIS), and Advanced Microwave Scanning Radiometer for EOS (AMSR-E) at 18-19 GHz and 36-37 GHz channels have been important sources of information about snow melt status in glacial environments, particularly at higher latitudes. PM data are sensitive to the changes in near-surface liquid water that accompany melt onset, melt intensification, and refreezing. Overpasses are frequent enough that in most areas multiple (2-8) observations per day are possible, yielding the potential for determining the dynamic state of the snow pack during transition seasons. Limitations to this approach include glacier-marginal zones where pixels may be only fractionally snow/ice covered, and areas where the glacier is near large bodies of water: even small regions of open water in a pixel severely impact the microwave signal. We use the enhanced-resolution prototype Calibrated Passive Microwave Daily EASE-Grid 2.0 Brightness Temperature Earth System Data Record (CETB) product to evaluate melt characteristics along glacier margins and melt zone boundaries during the melt seasons in 2003-2004 for Severnaya Zemlya, locations where legacy methods were successful that span a wide range of melt scenarios. Sites include pixels that were previously excluded due to mixed pixel effects. We anticipate that improvement from the original 25 km-scale EASE-Grid pixels to the enhanced resolution of 3.125 - 6.25 km will dramatically improve the ability to evaluate melt timing across gradients in glacier margins and transition zones in glacial environments.

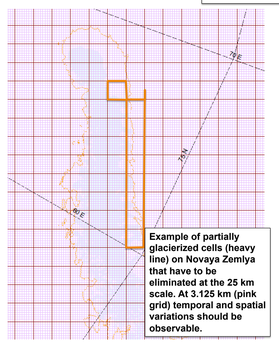


Location Maps Showing (A) Research Areas in EASE-Grid 2.0 Projection. Light blue areas are glaciers from Randolph Gacier Inventory 5.0. Color ramp shows latitude. (B) Detail of Svalbard, Franz Josef Land, Novaya Zemlya and Severnaya Zemlya.

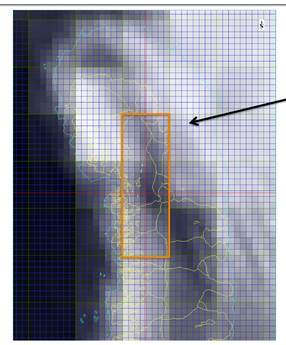
Limitations of 25 km data: On small ice caps or near bodies of water, boundary pixels are compromised and in transition zones, changes are averaged out



Ocean signals are quite different, especially open water. At the 25 km scale (dark red grid), FJL has no viable pixels for glacier melt analysis. At 3.125 km (pink grid) temporal and spatial variations should be observable.



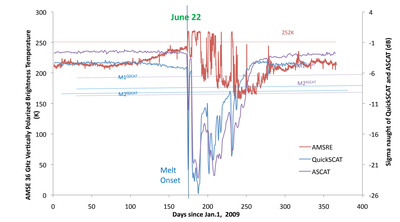
Example of partially glacierized cells (heavy line) on Novaya Zemlya that have to be eliminated at the 25 km scale. At 3.125 km (pink grid) temporal and spatial variations should be observable.



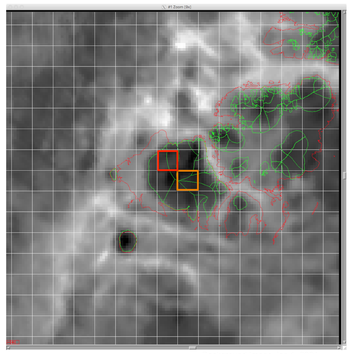
Note how the within pixel variations are not captured in the 25 km data, for this melt date on Novaya Zemlya (AMSRE2004170-evening-36GHz Vertically polarized)

Image shown is 3.125 kilometer scale with a semi-transparent 25 km overlay for the same date, time, frequency

T_b Time Series and Melt Detection – Comparison of 25 km and 3.125 km results

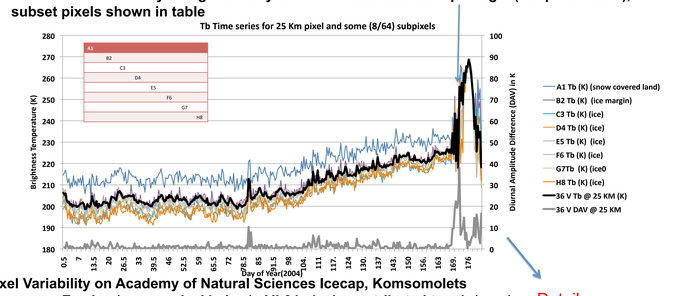


Example of Melt onset from AMSRE, Quickscat and ASCAT sensors showing published thresholds for detecting melt (Apgar 2007, Wang et al, 2005l

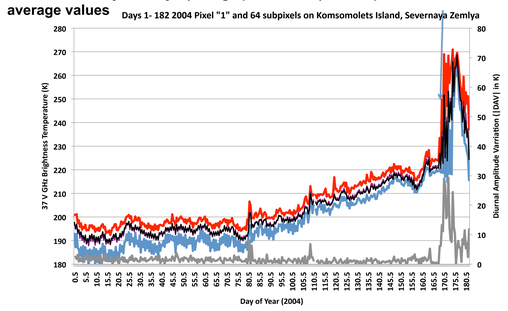


Background Image Jan 1, 2004

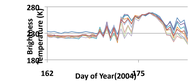
Within-Pixel Variability along Academy of Natural Sciences Icecap Margin (red pixel below), subset pixels shown in table



Within-Pixel Variability on Academy of Natural Sciences Icecap, Komsomolets Island, Severnaya Zemlya (orange pixel below), All 64 pixels contributed to min/max/ average values



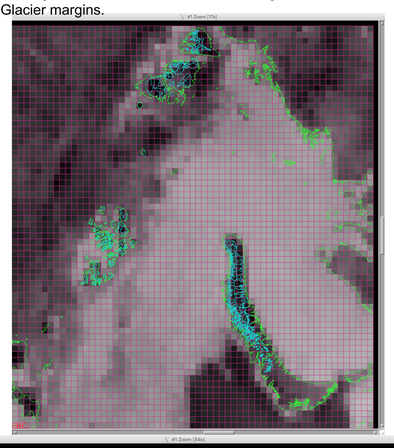
Detail



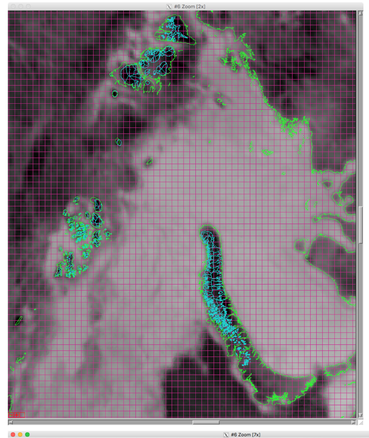
Calibrated Enhanced Brightness Temperature Data (CETB) for SSMI and AMSRE datasets provides twice daily observations of most areas at 3.125 km for (36/37 GHz) to 6.25 km (18/19 GHz) resolution

Winter images help illustrate the icecap boundaries and the major differences between the 25 km(left) and 3.125 km (right) resolutions. All Images AMSRE are Jan 1, 2004. Pink grid shows 25 km scale on both image resolutions. Lower panels are a detail of Severnaya Zemlya archipelago on the same date. Blue lines are RGI5.0 Glacier margins.

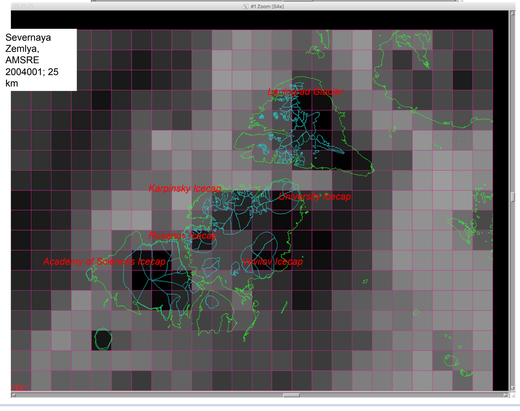
Russian High Arctic, AMSRE 2004001; 25 km



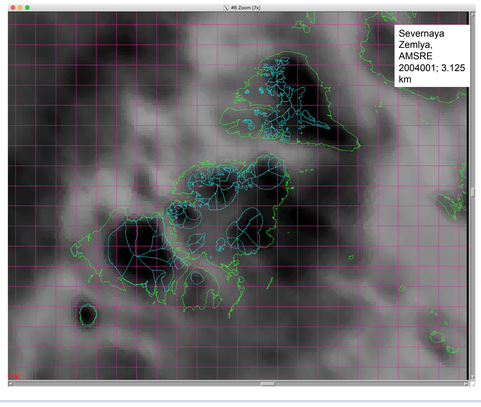
Russian High Arctic, AMSRE 2004001; 3.125 km



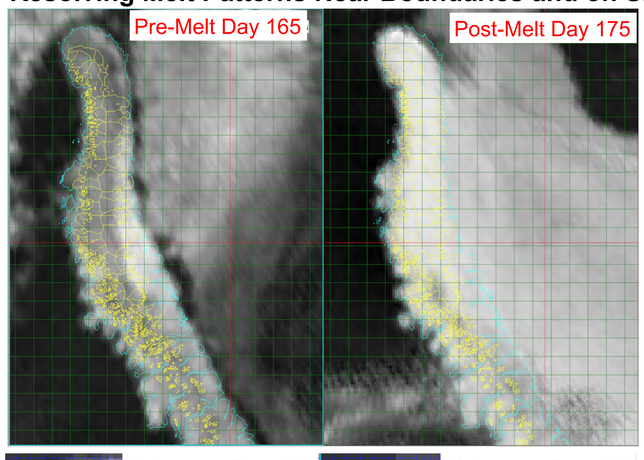
Severnaya Zemlya, AMSRE 2004001; 25 km

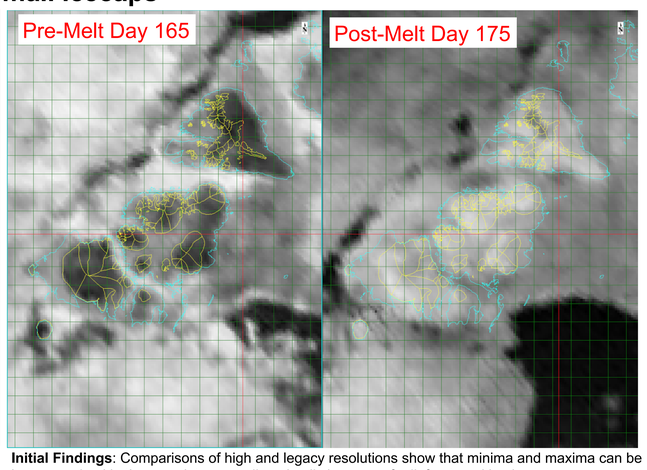


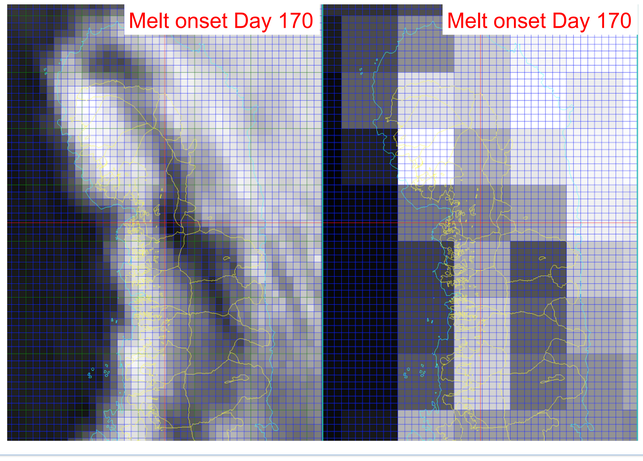
Severnaya Zemlya, AMSRE 2004001; 3.125 km



Resolving Melt Patterns Near Boundaries and on Small Icecaps







Initial Findings: Comparisons of high and legacy resolutions show that minima and maxima can be better resolved in the new data, as well as details in areas of relief or transition in state.

Prototype CETB data at 3.125 km resolution have tremendous potential to improve the spatial details for remote icecaps, especially in areas with topographic relief or irregular boundaries.

The 3km data will enable new analyses in areas that are too small to resolve at the legacy resolution.

References

Apgar, J.D, Ramage, J.M., McKenney, R.A, Maltais, P., 2007, Preliminary AMSR-E Algorithm for Snowmelt Onset Detection in Subarctic Heterogeneous Terrain, Hydrological Processes, Vol. 21, p. 1587-1596.

Brodzik, M. J., B. Billingsley, T. Haran, B. Raup, M. H. Savoie. 2012. EASE-Grid 2.0: Incremental but Significant Improvements for Earth-Gridded Data Sets. ISPRS International Journal of Geo-Information, 1(1):32-45. http://www.mdpi.com/2220-9964/1/1/32/.

Long, D. and M.J. Brodzik, 2016, Optimum Image Formation for Spaceborne Microwave Radiometer Products, IEEETransactions on Geoscience and Remote Sensing, vol 54, no5, p2763-2779, DOI: 10.1109/TGRS.2015.2505677.

Wang et al, 2005, Melt season duration on Canadian Arctic ice caps, 2000-204, Geophysical Research Letters, 32, F19502, doi:10.1029/2005GL023962.

Wessel, P., and W. H. F. Smith, A Global Self-consistent, Hierarchical, High-resolution Shoreline Database, *J. Geophys. Res., 101, #B4, pp. 8741-8743*, 1996.

Acknowledgements

For information on accessing the prototype data, please contact Mary Jo Brodzik or Molly Hardman at the email addresses above. Data are being processed as part of a NASA MEaSUREs Grant.[https://earthdata.nasa.gov/community/community-data-system-programs/measures-projects]. Glacier outlines come from Randolph Glacier Inventory. Coastlines come from GSHHG.