COMBINED HEMISPHERICAL SCALE SWE AND SNOW CLEARANCE MONITORING

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1. INTRODUCTION

Snow Water Equivalent (SWE) is the depth of the water layer left if the snowpack melts uniformly. SWE thus indicates the amount of snow in the region but it gives an estimate of the volume of the discharge when snow melts. Knowing also the snow clearance date the timing of the discharge can be estimated through hydrological modelling. Both SWE and snow clearance date are also important in weather forecasting and climate research. Once the snow covered terrain is flooded with water the biological processes begin and thus snow melt is related to the CO_2 cycle. Both SWE [1] and snow clearance date [2] can be estimated applying spaceborne radiometer data [3] in hemispherical scale. Integrating the knowledge of snow clearance date into the SWE product enchances the SWE quality in particular creating long time series.

2. METHODOLOGY AND RESULTS

The SWE algorithm [1] works as follows. First, the snow depth (SD) ground based measurements obtained by ECMWF are interpolated using kriging interpolation. The SD background field is obtained together with error variance estimate. Then the snow grain size is estimated at the station locations using HUT snow model [4] and also error variance estimate is obtained. The grain size and variance is then interpolated over the target area. SWE estimate is obtained weighing different data sources such as SD interpolated field, satellite data and auxiliary data like forest coverage fraction etc. Using the estimate from previous time step is optional. Satellite data is assimilated only if the pixel in questions is classified as dry snow. Example is presented in Fig. 1.

The snow clearance date [2] is estimated in following way. The channel difference $T_{B,19V}$-$T_{B,37V}$ time series is calculated for the pixel in question. The time series is averaged using a window typically having the length 8 days. The maximum and minimum value are determined. The threshold is determined as being (typically) 90% higher than minimum value or 10% less than maximum value. When the averaged time series has values greater than the threshold those incidents are considered as melt events. The last one in the time series considered as the snow clearance date. Example is presented in Fig. 2.

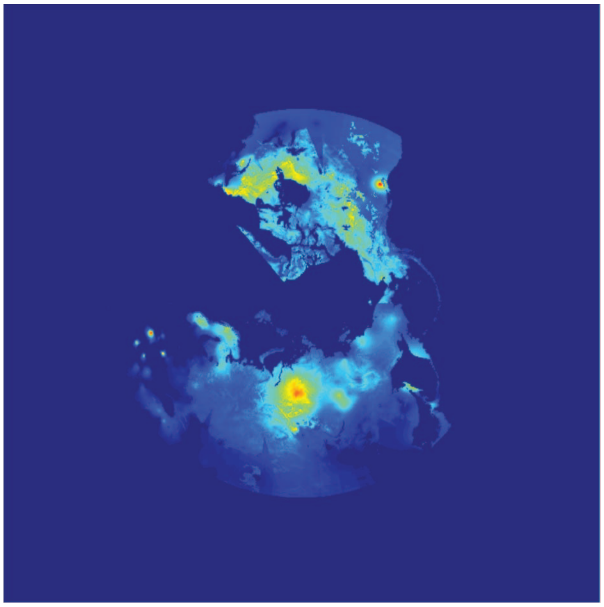

Figure 1. Map of Snow Water Equivalent (SWE) on the Northern Hemisphere in Jan 1 2008

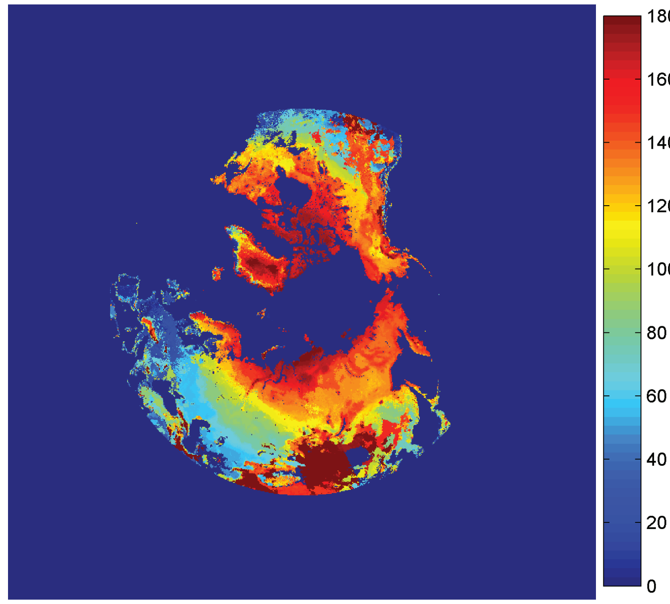

Figure 2. The snow clearance date on the Northern Hemisphere in 2008

Validation work with SWE product shows that the SWE assimilation algorithm does not go to zero value when there is no snow based on ground truth observations. This is partly due to the inefficiency of the dry snow detection algorithm and partly due to issues with kriging interpolation. Sometimes SD stations erroneously report snow even though the are is already snow free. Using the snow clearance date the areas already melted are flagged and the SWE value is explicitly set to zero. The area considered to be melting still has positive SWE value but it is determined from SD kriging background field only. When snow is considered to exist but not melting the dry snow algorithm is still applied.

A time series from 1979 to 2009 is created combining both SWE (example in Fig. 1) and snow clearance date (example in Fig. 2) in a combined product describing snow on the Northern Hemisphere. Integration enhances the quality of the SWE estimates and adds up additional value in the form of snow clearance dates. The time series will be available to interested parties via a web service.

3. REFERENCES

[1] J. Pulliainen, "Mapping of snow water equivalent and snow depth in boreal and sub-arctic zones by assimilating space-borne microwave radiometer data and ground-based observations", Remote Sensing of Environment 2006, vol. 101, no2, pp. 257-269.

[2] M. Takala, J. Pulliainen, S. Metsämäki and J. Koskinen, "Detection of Snow Melt Using Spaceborne Microwave Radiometer Data in Eurasia from 1979 to 2007", IEEE Trans. Geo. Sci. 2009, Vol 47, pp. 2996 - 3007.

[3] Knowles, K. W., M. H. Savoie, R. L. Armstrong, and M. J. Brodzik. 2006, updated current year. *AMSR-E/Aqua daily EASE-Grid brightness temperatures*, 2002-2008. Boulder, Colorado USA: National Snow and Ice Data Center. Digital media.

[4] Pulliainen, J., Grandell, J. and Hallikainen, M., "HUT Snow Emission Model and its Applicability to Snow Water Equivalent Retrieval". IEEE Trans. Geosci. Remote Sens., Vol. 37, No. 3, May, 1999.