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THEATER SNOW DEPTH ESTIMATES FOR DEPARTMENT OF DEFENSE APPLICATIONS

Paul J. McCrone

Meteorological Satellite Applications Branch

Air Force Weather Agency (AFWA)

Offutt AFB, NE

Introduction

Department of Defense (DoD) contingency operation areas are often weather data sparse or denied. This creates a challenge for Air Force Weather Agency (AFWA) meteorologists to provide detailed snow depth products to our customers for trafficability analysis. To meet this challenge, AFWA exploits satellite imagery data to provide critical estimates for snow depth analysis in several overseas regions. In addition, analysts assess available surface observations and forecast model information in these theater support areas to derive a final product. By combining all data resources, we maximize information and produce a timely, value added product.

Data and Methodology

The data used in this effort comes from the Defense Meteorological Satellite Program (DMSP) at AFWA, Offutt AFB, Nebraska. Specifically, data is used from all 7 channels of the Special Sensor Microwave Imager (SSM/I) as well as the high-resolution (550 meter) visible imagery from the Operational Linescan System (OLS). Both are used in conjunction with any and all available snow depth observations from all regions. This discussion will illustrate the capability using data over one of our high interest areas – South Asia. Because this region ordinarily reveals only sparsely distributed observations in the areas of greatest interest, we rely on satellite-derived estimation methods for determining approximate snow depths.

** Corresponding author address:*
Paul J. McCrone, Air Force Weather Agency (Code XOGM), 106 Peacekeeper Dr. STE 2N3 Offutt AFB NE 68113-4039;
email: Paul.McCrone@afwa.af.mil .

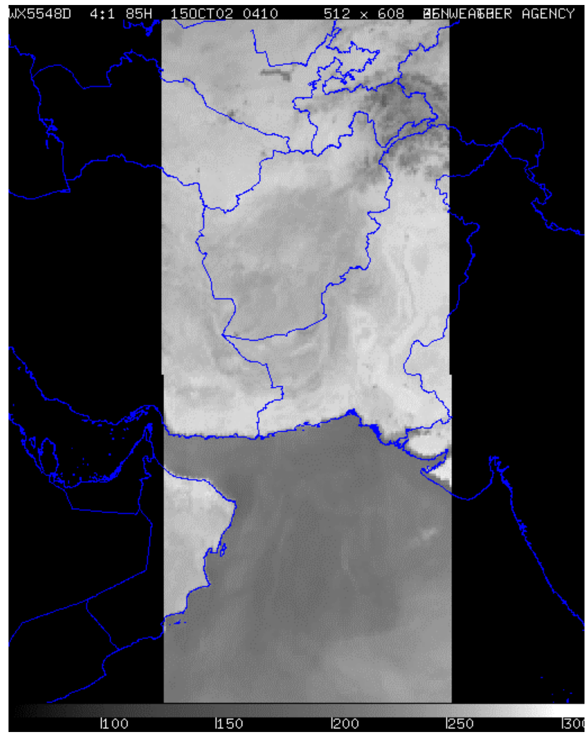

Figure 1. Oct 15, 2002, 06 GMT: DMSP SSM/I 85H imagery.

The heaviest reliance for numerical values of snow depth is placed on the SSM/I. The SSM/I has a capability to discriminate surface type (See figure 1). Notice that the 85H image in figure 1 shows colder brightness temperatures (darker gray-shades) eastern Tajikistan, northern Pakistan, Northeast Afghanistan, where higher snow depths are known to exist in the Hindu-Kush Mountains.

AFWA employs a combination of algorithms to determine snow depth. Initially, the approach is to determine the existence of snow (i.e. a “yes/no” determination of whether snow is present). This is accomplished through the classification algorithm developed by Grody

(1996). Afterwards, the algorithm computes two separate snow depth algorithms. One is the approach used by Nagler and Rott (1992), while the other uses the traditional 'cal/val' algorithm originally developed by Foster et al (1980); for more details, see Hollinger (1991). Our approach compares snow depth estimates from both the Nagler/Rott algorithm and the Foster algorithm and uses the largest in those areas where the Grody algorithm identifies the existence of snow. An example of the final integrated SSM/I product is shown in figure 2.

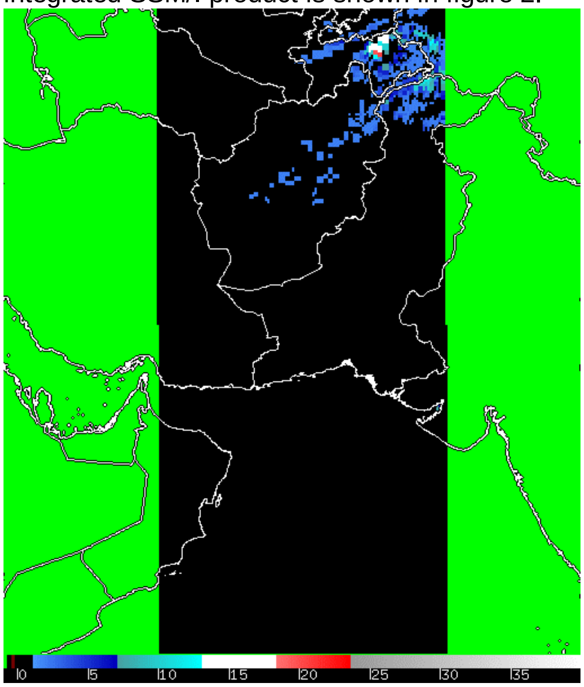

Figure 2. Oct 15, 2002, 06 GMT: DMSP SSM/I Snow Depth Estimate (inches).

The integrated DMSP SSM/I snow depth product depicts snow over Pakistan, Afghanistan and Tajikistan (Fig.2). Note that the algorithms that are employed for this product were, in fact, developed over regions where the terrain is relatively smooth and homogenous. They assume that the snow is freshly fallen snow. South Asia presents a number of challenges in determining snow depth due to the complexity of the terrain, variations in vegetation, as well as the fact that some of the snow in South Asia is actually glaciated snow, rather than being fresh fallen snow. An added complication stems from the coarse scan-spot size of the SSM/I at 37 GHz channel. The SSM/I algorithm utilizes data with 25nm scan-spot resolution. This is resolution does not possess the detail needed to identify snow along some geographic features.

As a result, our analysis procedure incorporates a forecaster driven interactive analysis with high-resolution visible imagery from the DMSP OLS. See figure 3 below for an example.

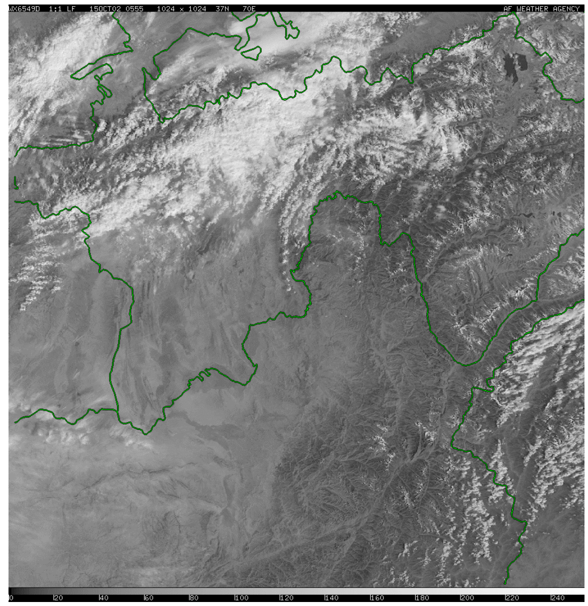

Figure 3. October 15, 2002, 06 GMT: DMSP OLS visible image of the analysis area.

The final step of the process, then, is to use subjective analysis techniques to further fine-tune the snow depth analysis. As mentioned above, high-resolution polar imagery is the main tool, supplemented with animated geostationary imagery over the region to help discriminate between multi-layered clouds and actual snow on the ground.

Results and Discussion

An example of the resulting product of this effort is displayed in figure 4. This shows the high-resolution polar imagery with manually drawn isopleths of snow depth over the region. Isopleths are drawn to incorporate areas with only a trace to six inches, then 7 to 12 inches, then 13 to 20 inches, then finally 21 inches and higher.

The analyst makes no specific attempt to account for the potentially high variability of snow on specific mountain peaks and ridges – only an area of 'trace to 6 inches is drawn' unless other information indicates otherwise. In questionable areas, the product is tended toward climatological values.

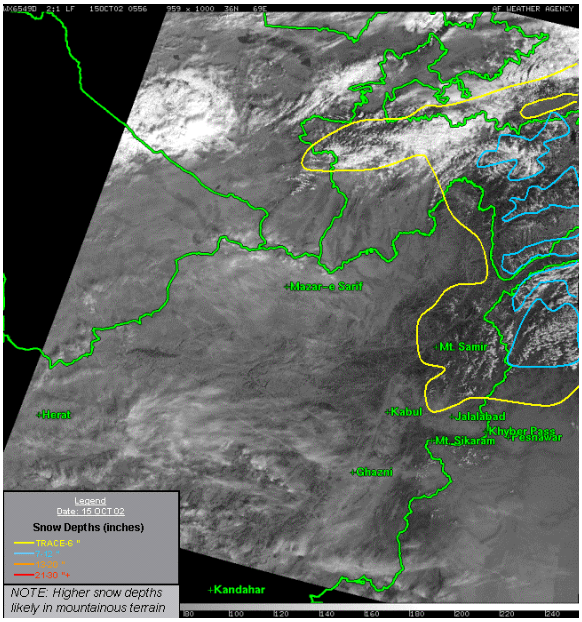

Figure 4. October 15, 2002, 06 GMT: AFWA Snow Depth estimate analysis product .

This product is disseminated via AFWA's operational web site – the Joint Army Air Force Weather Information Network (JAAWIN).

Conclusion:

Air Force Weather Agency is providing a high-resolution, satellite-derived snow-depth estimate product. The product uses a combination of DMSP OLS and SSMI data, as well as some sparse surface observations. An operational forecaster then merges these data sources manually. This product is then posted to the web for use by operational decision makers in the Department of Defense.

References

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