Snow Cover Assessment for Denied Areas Using AVHRR and SSM/I

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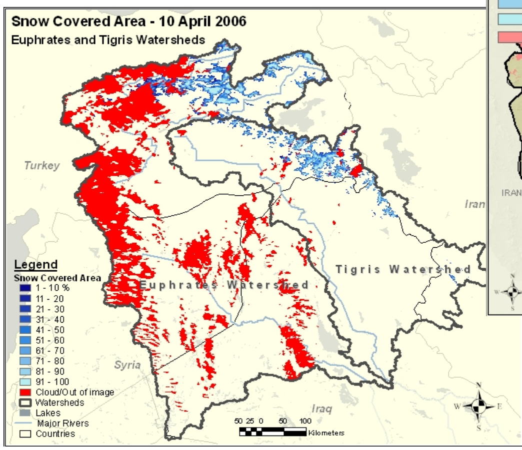
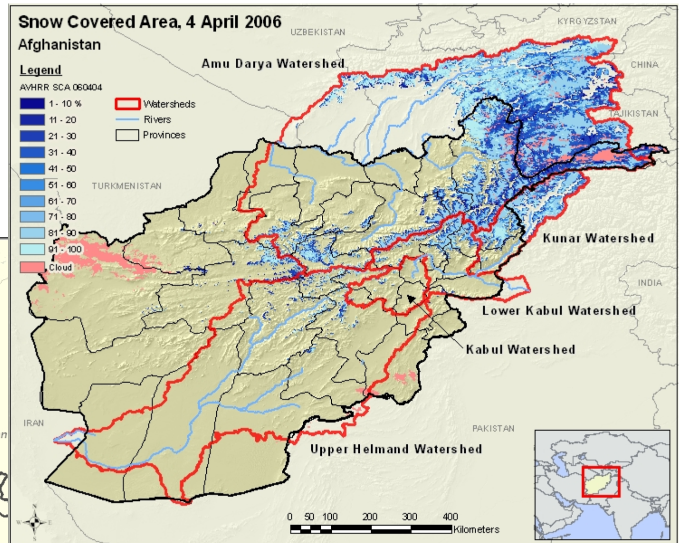
Introduction

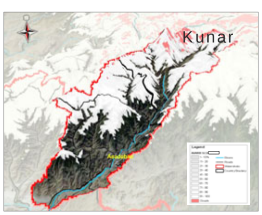
We prepared a series of assessments throughout the 2004-05 and 05-06 winter seasons describing the snow conditions in Eastern Turkey and Afghanistan using AVHRR and SSM/I satellite imagery. A number of different products were developed; client requirements determined the actual products included in each assessment. These products included a current Snow Covered Area (SCA) map with delineated cloud cover, watersheds and political boundaries; the current snowpack total Snow Water Equivalent (SWE) for each watershed with an historical perspective; a SCA map of each watershed with 3D visual; estimation of SCA by elevation band; a snow condition outlook by watershed, a general summary of snow conditions; and snow melt flooding advisory.

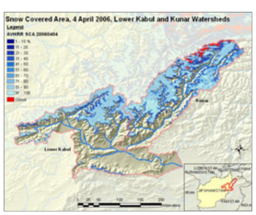




Snow Covered Area (SCA) maps

We produced snow covered area (SCA) maps with pixel sizes of 1.0 km using AVHRR imagery (Rosenthal and Dozier 1996). The AVHRR imagery is daylight only and SCA is obscured by clouds. The image processing involved a number of steps including geo-registration; spectral un-mixing, cloud masking, snow detection, and final pixel-by-pixel determination of SCA. The SCA information was combined with other GIS layers on political boundaries, cities, rivers, major roadways, etc. to produce the final maps. In some cases, two maps were produced for each watershed to provide insight into the location and elevation range of snow. The first map displayed the SCA along with political boundaries, watercourse, cities, etc; the second was an oblique view of the watershed shown in 3-D relief with the SCA “draped” over the raised topography.



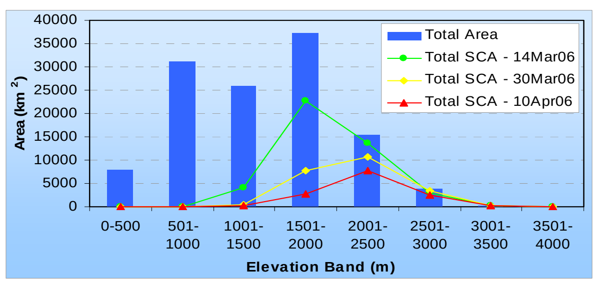


SCA by Elevation Band

We determined the distribution of SCA by 500m elevation bands for selected watersheds and presented the information in table and chart form. The elevation band distributions from prior assessments were also displayed on the chart for comparison. The total area of each elevation band was included to place the SCA in context.

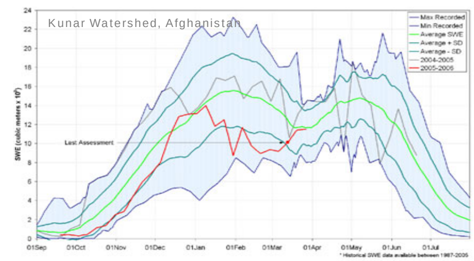
Elevation Band (m)	Area (km^2)	SCA (km^2) 26-Dec-05	SCA (km^2) 3-Jan-06	SCA (km^2) 21-Jan-06	SCA (km^2) 29-Jan-06	SCA (km^2) 19-Feb-06	SCA (km^2) 5-Mar-06	SCA (km^2) 14-Mar-06	SCA (km^2) 30-Mar-06	SCA (km^2) 10-Apr-06
0-500	8025	0	0	16	0	0	0	0	0	0
501-1000	31215	2452	315	17493	8096	919	26	110	0	0
1001-1500	25838	18778	9223	24834	23192	16592	5996	4167	372	145
1501-2000	37295	31896	18285	35038	36638	35274	26987	22676	7832	2692
2001-2500	15438	12114	10459	14185	15092	13028	13757	13681	10737	7765
2501-3000	3811	2809	3434	2940	3757	2720	3369	3033	3343	2514
3001-3500	260	194	260	198	251	160	215	137	239	116
3501-4000	3	1	3	3	3	3	3	3	1	1

* Significant portions of the elevation bands likely to contain snow were obscured by cloud cover.

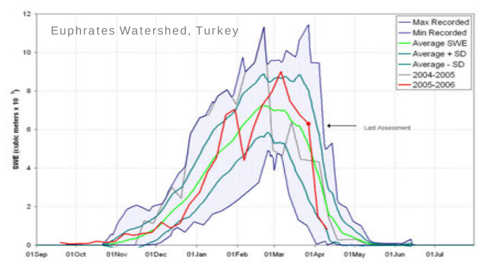


Watershed SWE Volume with Historical Perspective

We estimated the total SWE volume of each watershed snowpack based on gridded estimates of SWE determined from SSM/I passive microwave imagery (Mary Jo Brodzik, personnel communication). Each SSM/I image provides daily measurements of passive microwave radiation in 25 km pixels that are not affected by clouds. The imagery is processed to estimate daily gridded SWE (Armstrong et al 2001). It has been found that wet snow is not detected well and is underestimated; higher accuracy is expected at greater snow depths. We processed the daily gridded SWE estimates into a weekly product using each group of seven daily grids that spanned from a Monday to a Sunday. We then used GIS techniques to sum the grids over each watershed to arrive at a weekly estimate of total SWE volume.



We produced a chart of the total SWE volume that covered the entire winter season. Each SWE estimate was plotted on the first day of the 7-day period. Total SWE volume, in itself, has relatively little operational value unless it can be placed into an historical context. We provide historical context on the charts so that the total SWE volume can be placed as “above normal”, “normal”, or “below normal” and compared to historical extremes and the previous year’s value. Weekly historical SWE data, derived from SSM/I passive microwave measurements, was used to determine the historical mean, normal ranges, and extremes for each day of the winter season. This data extends from the winter of 1987-88 through June 2005 (Armstrong et al 2005).



General Snow Assessment and Flood Forecast

We provided a narrative that described the current snow conditions, placed them in their historical context based on the historic total SWE derived from SSM/I passive microwave measurements, provided short term general snow pack forecasts, and described the general flood potential, based on SWE distribution, time of year, and past flooding. (Brakenridge et al 2006).

Summary

This effort will see continual product improvement based on feedback from users and new requests.

Acknowledgements

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References

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Rosenthal, W., and J. Dozier (1996) Automated mapping of montane snow cover at subpixel resolution from the Landsat Thematic Mapper. Water Resources Research, 32(1): 115-130.