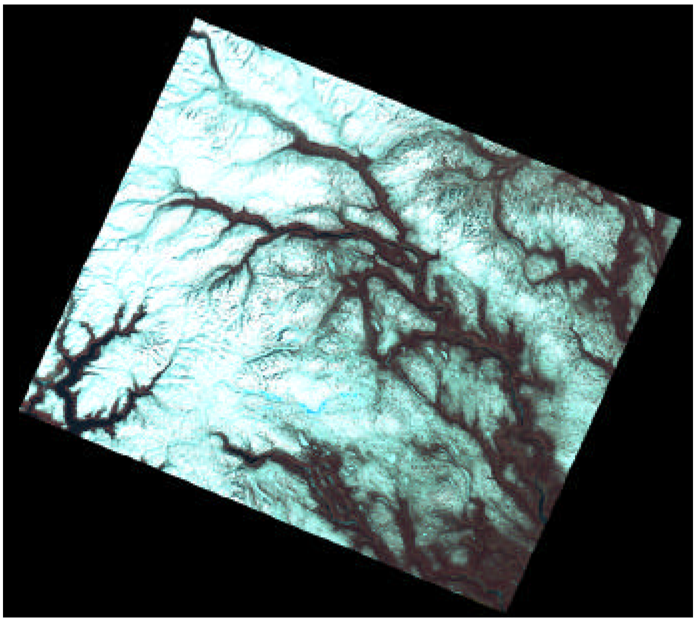
DemoSnow
Snow cover mapping with optical data

Norsk Regnesentral
ANVENDT DATAFORSKNING

NOTAT/NOTE

Norwegian Computing Center/Applied Research and Development



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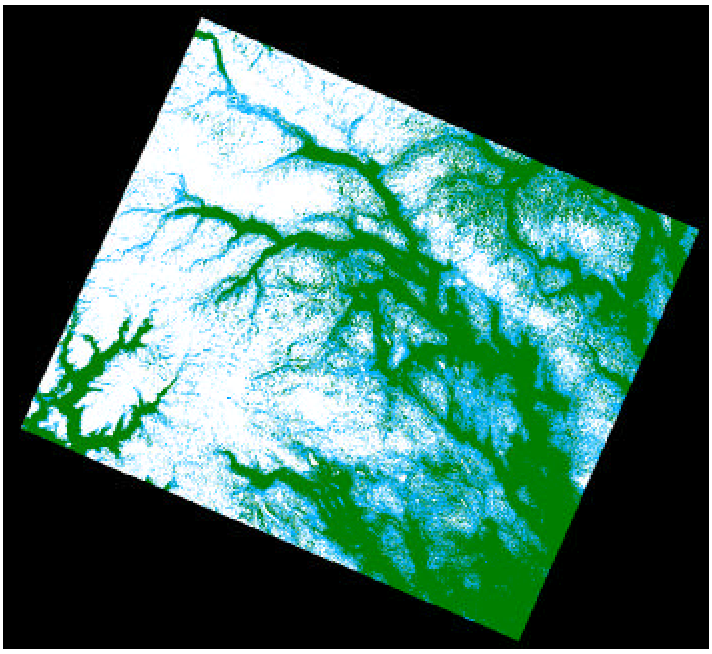

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Sammendrag/Abstract:

This report is a documentation of the work done by NR in the project DemoSnow (DemoSnø). The project is financed by the Norwegian Space Centre and is lead by The Norwegian Water Resources and Energy Directorate (NVE). NORUT IT is also a participant in the project. The report and the processed snow-products are the deliverables from NR in the project.

The objective of the project was to improve simulation of runoff using satellite-observed snow cover area (SCA) in an operational model. Both optical (NOAA AVHRR) and radar (ERS-2) images were used as input to the model made by NVE. NR was responsible for the optical SCA products and NORUT IT for the radar products.

In this project NR had three main tasks, which are described in this report.

- To make a collection of classified NOAA AVHRR images to be used as input to the runoff model.
- Creation of SCA map from a Landsat 7 ETM+ image to be used as "ground truth" for comparison with maps made from other satellites.
- Evaluation of SCA maps made from NOAA AVHRR and Terra MODIS images using the SCA map made from Landsat 7 as "ground truth".

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Contents

1 Introduction

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The tasks performed by NR:

1. Retrieval of a number SCA maps from classified AVHRR images from 1995 – 2001 to make a time series for each melting season. These time series have been used by NVE for calibration and simulation of runoff from three catchments in the mountainous regions in southern Norway.

2. Creation of SCA map from a Landsat 7 ETM+ image from 4 May 2000 to be used as "ground truth" for comparison with SCA maps created from NOAA AVHRR, Terra MODIS and ERS-2 images from the same date.

3. Evaluation of SCA maps made from NOAA AVHRR and Terra MODIS images from 4 May 2000, using the SCA map made from Landsat 7 as "ground truth".

2 Collection of AVHRR data

2.1 Activity

To get a time series of SCA maps from the melting seasons from 1995 until 2001, NR was going to supply a number of classified AVHRR images from this period.

NVE have some classified images from this time period, but needed many more to get a satisfying time series of SCA maps. From earlier and ongoing projects NR has a series of AVHRR-images from the period 1995-2001. Some of the original data from 1998-2000 has been lost, so we needed to supplement the collection with data from these years to get a satisfying series of data for the whole period. A search for usable images was done by inspecting quicklooks of AVHRR-scenes from the interesting time periods. A list was made with all existing and possible usable images for selection of a set of images for a time series of SCA maps. NVE has made selection from this list and also added new images to it. The list is found in Appendix A.

2.2 Data

The images at NR were provided by Kongsberg Satellite Services (KSAT) in a special format. From the original scenes there have been made sub-images covering South-, Mid- and North-Norway. In this project, only images covering South-Norway has been used. The images from the years 1995 – 1999 cover the same geographic area and been geometric corrected to projection UTM zone 32 ED50 having a size of 512 x 600 pixels, while the images from the recent years cover different areas and are in projection UTM zone 33 WGS84.

At NVE low resolution AVHRR quick-looks are browsed on a daily basis. All images of interest are transferred from the NERC Dundee Satellite Receiving Station in Scotland within a few hours as 5-band full-resolution data. Generally, images showing a low percentage of cloud cover and the area of interest located near the centre of the swath, are selected. However, during critical periods in the melt season every image believed to contain information is transferred.

2.3 Method

2.3.1 Pre-processing

The images go through a process of radiometric calibration using calibration parameters for the sensor found in the image header.

The images were automatically geometric corrected by an algorithm developed at NR (Huseby and Solberg 1998). The algorithm corrects satellite data by modelling the geometry of image acquisition. The model includes a Keplerian orbital model for the satellite motion, and estimates of the six orbital elements are given as input to the model from ephemeris data. A number of ground control points (GCPs) are then introduced to improve the estimates and correct for attitude angle variations.

Prior to the registration, the GCPs must be detected in the image to be corrected. This is done automatically. A GCP is located by matching a provisionally corrected sub-image with a reference image containing the GCP. An example of a geometric corrected image of South Norway from 18 May 1997 is shown in Figure 1.

Before the snow classification starts a cloud detection program is executed to find the areas covered by clouds. The cloud detection algorithm is based on data from the thermal and visual/near infrared bands.

Similar pre-processing is performed at NVE. The images are corrected for distortions due to panoramic effects and Earth curvature to improve the internal geometry. Registration of the images into an UTM-projection is performed, using a second order transformation and nearest neighbour resampling. The coefficients of the transformation are determined using manually selected ground control points.

A cloud detection algorithm is implemented, which masks the clouds using AVHRR band 3, 4 and 5. During the melt season, cloud cover represents a major obstacle to derive information from optical imagery. To reduce this problem, several images acquired close in time are merged using a mosaic technique. In this manner, national scale snow cover estimates are produced at an improved temporal resolution.

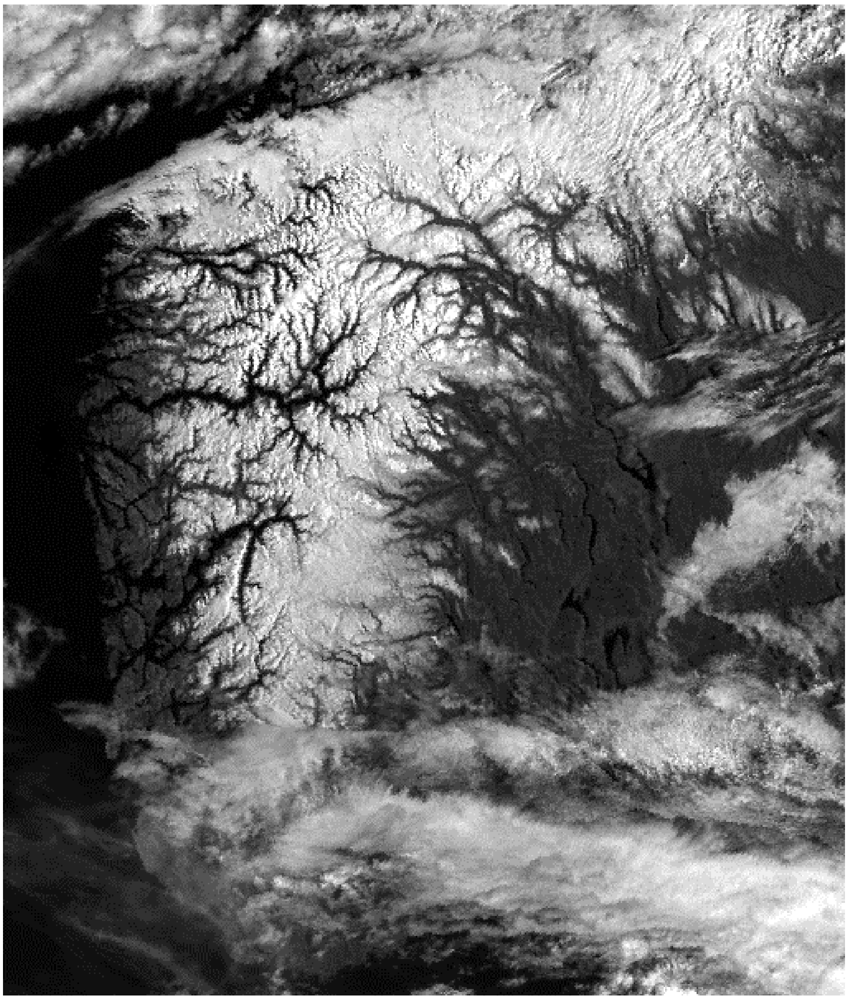

Figure 1 AVHRR image from 18 May 1997, band 2

2.3.2 Classification

For classification of the AVHRR- images the Norwegian Linear Reflectance to snow cover (NLR) algorithm was used on band 2. The algorithm is described in Solberg and Andersen 1994.

The basis of the NLR algorithm is the assumption that the measured value of a pixel corresponding to a given ground area is linear sum of a bare area fraction contribution and a snow area fraction contribution. If the pixel values (thresholds) corresponding to pure bare (T_l) and pure snow (T_h) areas are known, the fractional snow area f_{snow} in a pixel with measured value *val* is easily found using a linear mapping.

$$f_{snow} = \frac{val - T_l}{T_h - T_l}$$

The pure area values for snow and bare surface are found by statistical analysis of a set of predefined calibration areas within the image to be analyzed. The bare-ground value T_l is obtained by adding a constant offset value to the computed mean of the measured pixel values in a predefined region of forest. Similarly, the pure snow pixel value T_h is obtained by subtracting a constant offset from the mean value of a predefined region, known to be covered by snow (a glacier). The offset for the bare area corrects for the difference between typical melting region bare area pixel values and the values for forest, while the offset for the pure snow estimate is due to the lower values of reflection in melting area snow cover than on the glacier. Since the pure area values are estimated from the image to be classified, the requirement to calibration is reduced. Many of the effects that affect the measured values are implicitly corrected for by estimating the thresholds from the image itself.

The use of geographically defined calibration areas makes it necessary to perform a geographic localization of the image to the coordinate system in which the calibration areas are defined. Together with a radiometric correction and a cloud detection this constitutes the pre-processing of the data and is performed prior to the statistical analysis yielding the thresholds and subsequent snow fraction estimation.

A very similar classification based on AVHRR band 2 is used by NVE. The major objective of the classification procedure is to separate water bodies, clouds, bare ground, and a set of snow cover classes. The classification of snow cover is based on the fractional percentage of snow cover within each pixel. In order to derive snow cover fraction from reflectance, a simple linear relationship is assumed between reflectance values of the AVHRR band 2, and the snow cover fraction. A 100% snow cover is found on glaciers and in high mountain areas. Hence, typical pixel values of such areas are used for the 100% snow cover fraction. A lower limit for the pixel values is found by using typical values for water bodies. Open water shows little variation in band 2 during the year. The land surface, on the contrary, shows large annual variation in band 2. This effect is caused by snow cover giving high reflectance values in the winter. Low reflectance values are found in late autumn and early spring, with increasing reflectance as leaf and vegetation develop during the summer season.

The linear relationship can also be established by examining the histogram for AVHRR band 2. One point for this relationship is found between values representing water and land, identified as a minimum between two peaks (water and land) at the lower end of the histogram. The other extreme for the linear relationship (100% snow-cover) can be recognized as the point where the slope increases for the upper values of the histogram. Using this procedure gives reproducible classification results, even though the classification includes subjective evaluation. The classification procedure separates 8 classes of increasing snow-cover fraction.

2.4 Results

The classified images from 1995-1998 are showing the snow cover area described by the following pixel values:

0: Water (from water mask)
2: 0 - 10 %
4: 10 - 30 %
6: 30 - 50 %
8: 50 - 70 %
10: 70 - 90 %
12: 90 - 100 %
16: Clouds

An example of a classified image from 18 May 1997 is shown in Figure 2. Here 90 -100 % snow is shown in white and 0 -10 % in dark green with the other classes in different green colours. It may be difficult to separate the different green hues, so the same image is shown in different colours in Figure 3. Here it is easy to directly read the percentage of snow cover from the colour.

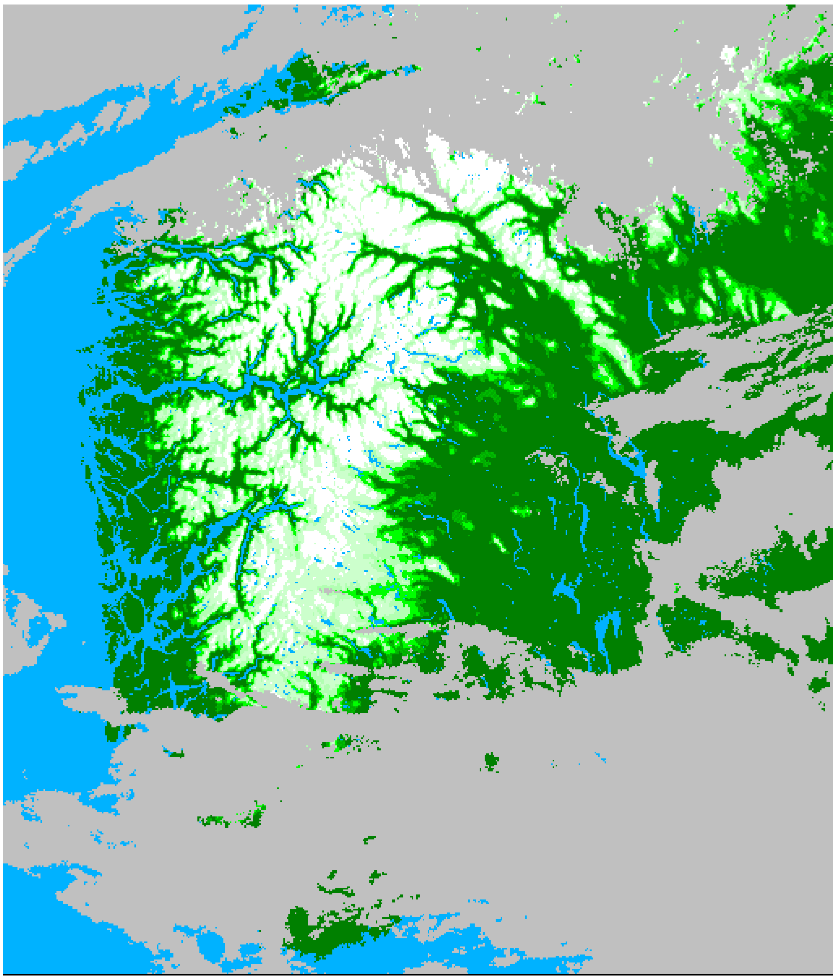

Figure 2 Classified AVHRR image from 18 May 1997 showing snow cover

In the images from the later years the snow cover is given in more detail. Here the pixel values in the classified images are:

0 - 100: Snow cover in %

128: Clouds

255: Water

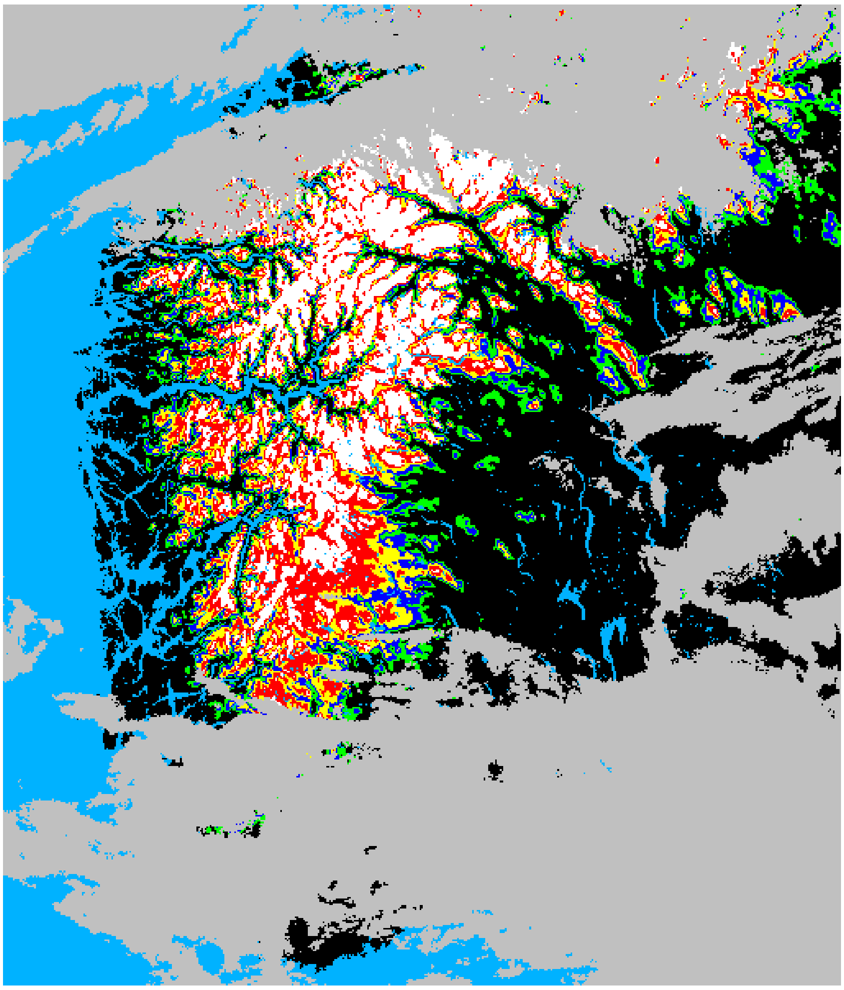

Figure 3 Classified AVHRR image 18 May 1997 showing snow cover

Black: 0 –10 %, Green: 10 – 30 %, Blue: 30 – 50 %, Yellow: 50 – 70 %, Red: 70 – 90 %, White: 90 – 100 %, Light Blue: Water, Grey: Clouds

3 Creating Ground truth for SCA from Landsat 7 ETM+

3.1 Activity

To compare the snow cover classification from different sensors, we tried to find a data set from the same date, covering the same area for all sensors. It was decided to let the snow cover estimated from a Landsat 7 ETM+ image represent the “ground truth” to be compared with the classification results from the other sensors. 4th of May 2000 was chosen as the date of comparison. The date was selected because there also existed ERS-2 radar images from this date and so NORUT IT could use these for evaluation of SCA maps based on SAR images. To get a ground truth, the Landsat image should be geographically rectified and classified.

3.2 Data

The image used for creating a snow cover “ground truth” is a Landsat 7 ETM+ image from 4 May 2000. The image is track 199, frame 17 taken at 10:30 GMT, covering the area shown in Figure 4.

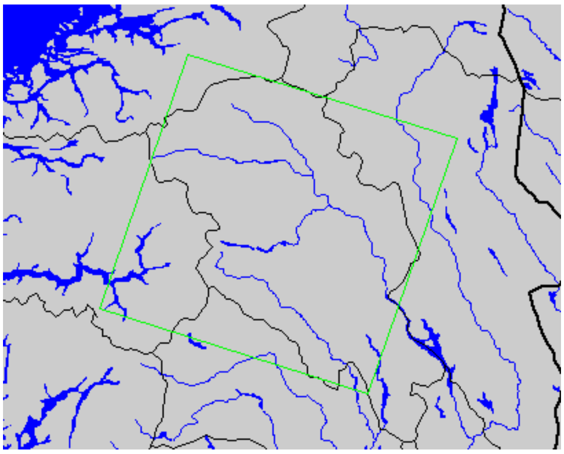

Figure 4 Coverage of Landsat 7 image track 199 frame 17

The image was delivered by Eurimage in HDF-format. The image was transformed to UTM zone 33, WGS84 using ERDAS IMAGINE, see Figure 5. The image was delivered with a change in gain for band 1, 2 and 3 in the lower part of the image. This part of the image was removed before classification

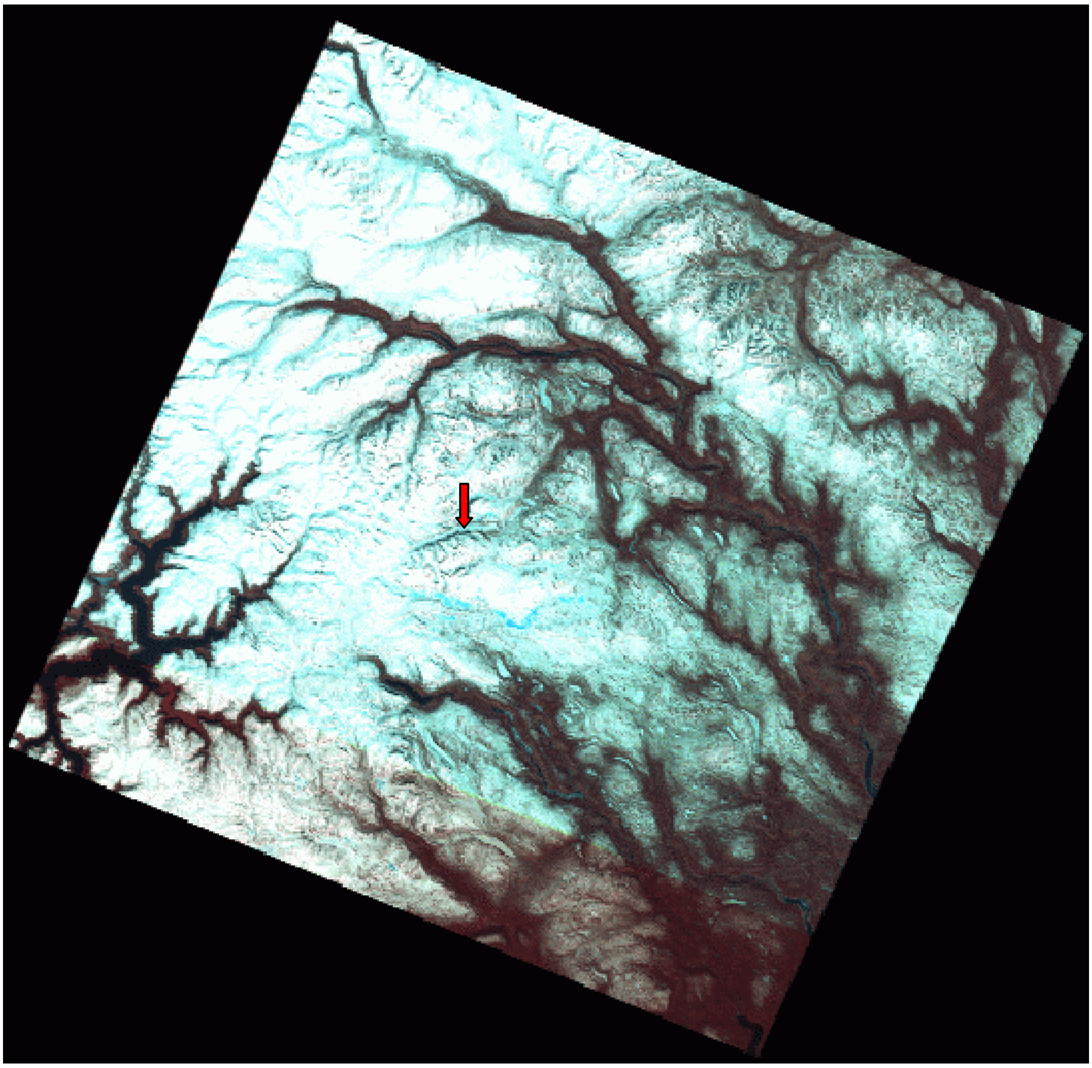

Figure 5 Landsat 7 image corrected to UTM zone 33 WGS84.

Band 4, 3 and 2 are shown as RGB. Lake Gjende is marked with red arrow

3.3 Method

The geocorrection of the image was done interactively using ERDAS Imagine, which has a special tool for correction of Landsat images. The coordinates of a number of selected ground control points were found in digital map data supplied by NVE. In addition a digital terrain model from Statens Kartverk with spatial resolution of 25 meters was used to improve the correction model.

To determine the snow cover extent in the Landsat image, an unsupervised clustering was performed using ERDAS IMAGINE. The method used is the ISODATA algorithm, which uses a minimum spectral distance formula to form clusters. It begins with either arbitrary cluster means or means of an existing signature set. Each time the clustering repeats, the mean of these clusters are shifted. The new cluster means are used for the next iteration. The clustering is repeated until a maximum number of iterations have been performed, or a maximum percentage of unchanged pixels has been reached between two iterations. In this case we have used the algorithm on band 1-5 + 7 of the Landsat image with a convergence threshold of 0.95. This means that the process will stop as soon as 5 % or fewer of the pixels change clusters between iterations.

The first clustering was done with 6 classes. From visual inspection of the input image, these classes could describe the snow cover in the mountain areas pretty well, but in the lower areas it was difficult to make a clear separation between snow and no snow. The next clustering was done with 8 classes, which seemed to give a better result. The clustered image is shown in Figure 6.

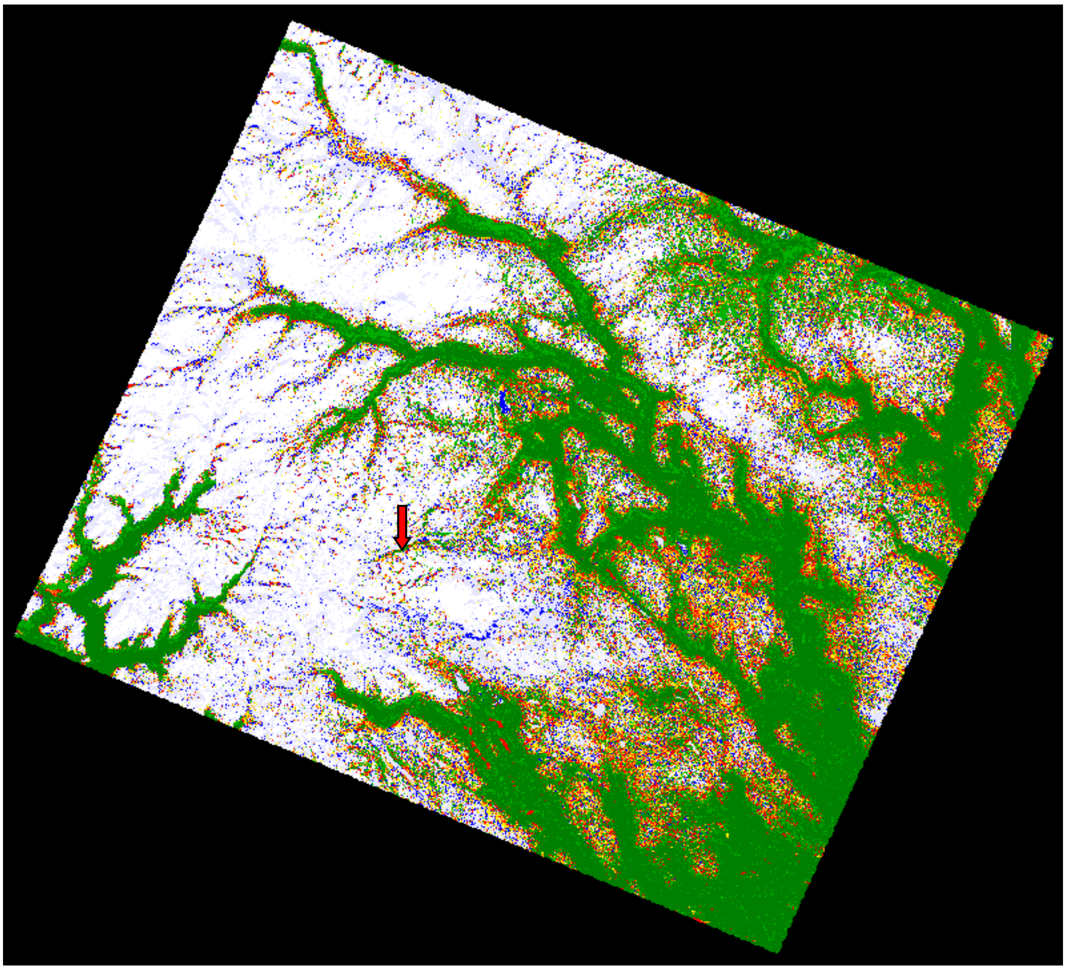

Figure 6 Landsat 7 image clustered to 8 classes. The red arrow is pointing at Lake Gjende.

From visual inspection it was decided to reduce the number of classes to three. Class 1 and 2 (dark green and light green) were combined to class "No snow", class 7 and 8 (light blue and white) were combined to class "Complete snow cover" and class, 3, 4, 5, and 6 (red, orange, yellow and dark blue) became "Partly snow cover". The pixels in the snow cover image were

given these values, to *indicate* the percent of snow cover area. The partly covered area is of course not 50% covered everywhere or as a mean..
No snow: 0
Partly snow cover: 50
Complete snow cover: 100
Background values: 255

The Landsat 7 image and the snow cover image have pixels of size 30 x 30 meters. In the Demosnø project a resolution of 100 x 100 meters was required.To create a snow cover image with pixels of 100 x 100 meters, the image was resampled to 10 x 10 meters pixels and then degraded by making 100 meters pixels with values equal to the mean value of the included 10 meters pixels. In the border areas of "Partly snow cover" there will be pixels with other values than 0, 50 and 100. These values will in some way give an indication of percentage snow coverage. But these figures are based on the assumption that all the partly covered areas in the 30 x 30 meter image have a snow cover of 50%, which they certainly have not.

3.4 Results

The snow cover image is shown in Figure 7 and a subset showing the areas of Heimdalen is found in Figure 8.

A visual inspection shows that the "Complete snow cover" class is correctly showing areas with complete snow cover in the areas in the high mountain region without trees.

The "Partly snow cover" class is correctly showing partly covered areas in the mountain region, except perhaps where steep mountains are making shadows. Here there may be areas with complete snow cover classified as partly covered. On some lakes, ice without snow is classified as "Partly snow cover". Inside forests it may also show areas with complete snow cover. It is difficult to decide from visual inspection if an area is complete or only partly covered with snow inside the forests.

"No snow" is correctly showing the areas without snow in the lower regions and also in the higher regions without forest. There does not seem to be misclassifications of areas with snow in these regions outside shadows. Inside shadows the "No snow" areas may actually be partly or even completely covered. But these are only very small areas. In the borders between partly covered and no snow areas, the "No snow" class somewhere extends into the partly covered region. This means that the total area of snow very likely is larger than shown in the image.

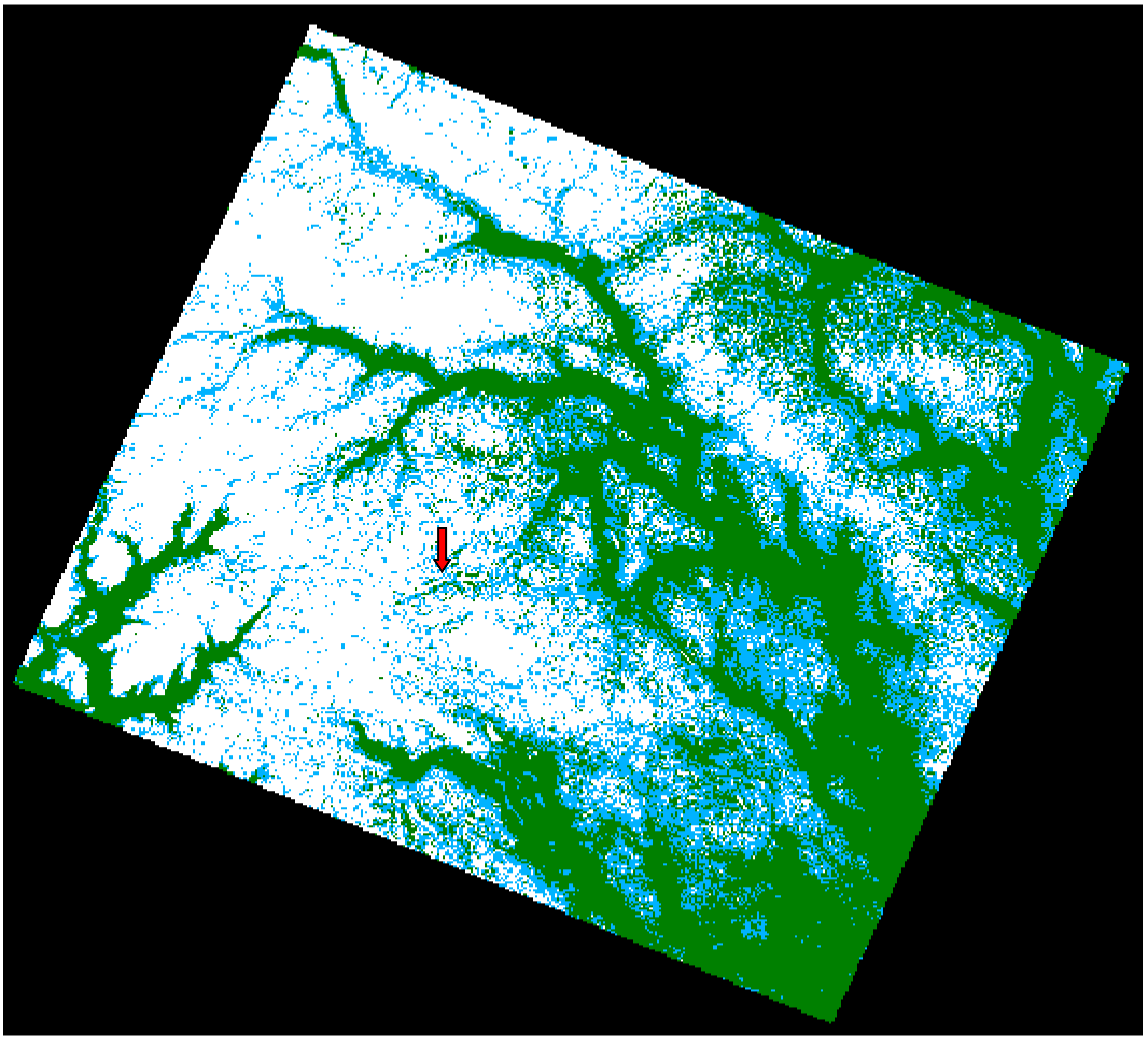

Figure 7 Snow cover estimated from Landsat 7 ETM+ image.

**White: Complete snow cover. Blue: Partly snow cover. Green: No snow.
Lake Gjende is marked with red arrow.**

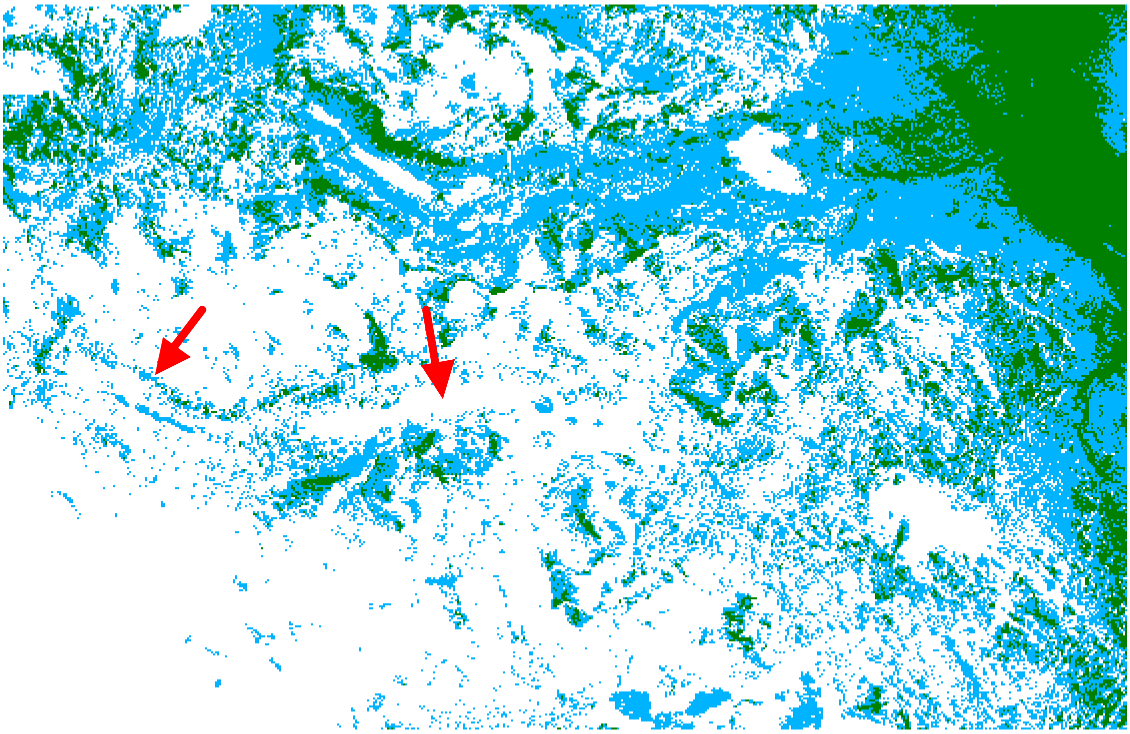

Figure 8 Estimated snow cover in Heimdalen area

White: Complete snow cover. Blue : Partly snow cover. Green: No snow. The red arrows are pointing to Øvre (left) and Nedre Heimalsvatn.

3.5 Problems and recommendations

The largest problems concerning estimation of snow cover lie in the forested areas. In the higher regions, the forests consist mainly of birch. The trees have no leaves and the snow can easily be found between the trees. In the lower regions, pine and spruce will cover the snow on the ground more or less. From a satellite image it is difficult to estimate the snow cover in such areas. For a better classification in these regions we need vegetation maps. We should also have proper ground truth in some areas with different types of forest and use this as training data for supervised classification.

4 Testing and validation of SCA maps from AVHRR and MODIS

4.1 Activity

For testing of snow cover classification programs for AVHRR and MODIS, classified AVHRR and MODIS images from 4 May 2000 were compared with the classified Landsat 7 image.

4.2 Data

NR has an AVHRR image from 4 May 2000 taken at 05.43 GMT. The automatic classification program has a routine for cloud classification, which aborted for this image due to low sun elevation angle. This program could be adjusted, but that has not been done because NVE had a classified image from 14.40 GMT the same day. A subset of the unclassified image (band 2), covering an area corresponding to the area covered by the Landsat 7 image, is shown in Figure 9. This image is taken some hours after the Landsat image, and clouds are moving in from the north west, as can be seen in the upper part of the image. Classified clouds are shown in white.

A MODIS image from 11.10 GMT is also covering the southern part of Norway. In Figure 10 a subset of this image is shown.

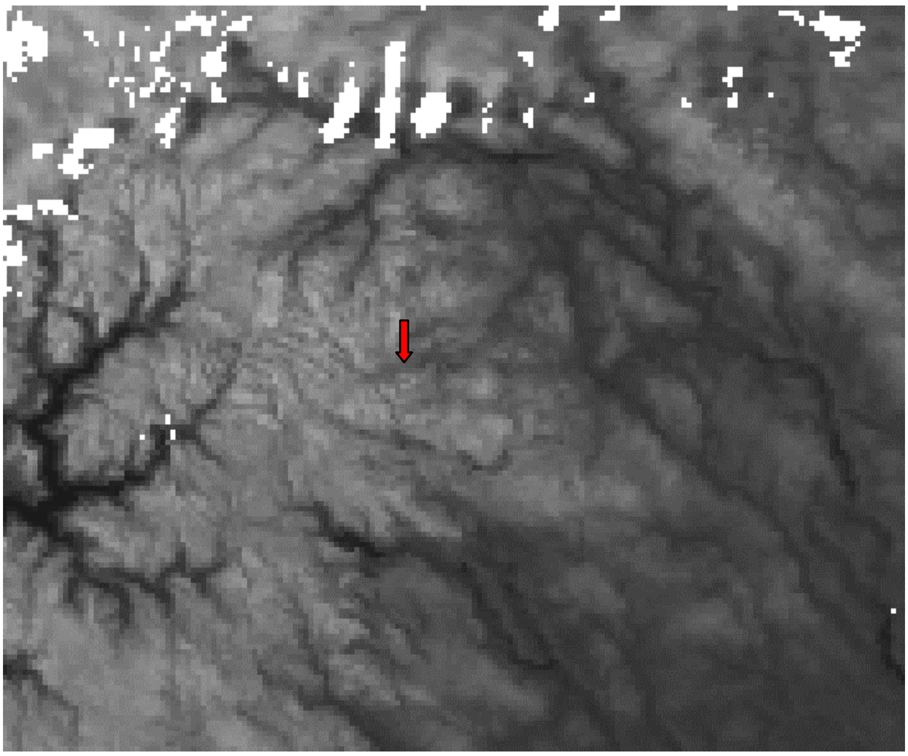

Figure 9 AVHRR image (band 2) from 4 May 2000. Lake Gjende is marked with red arrow.

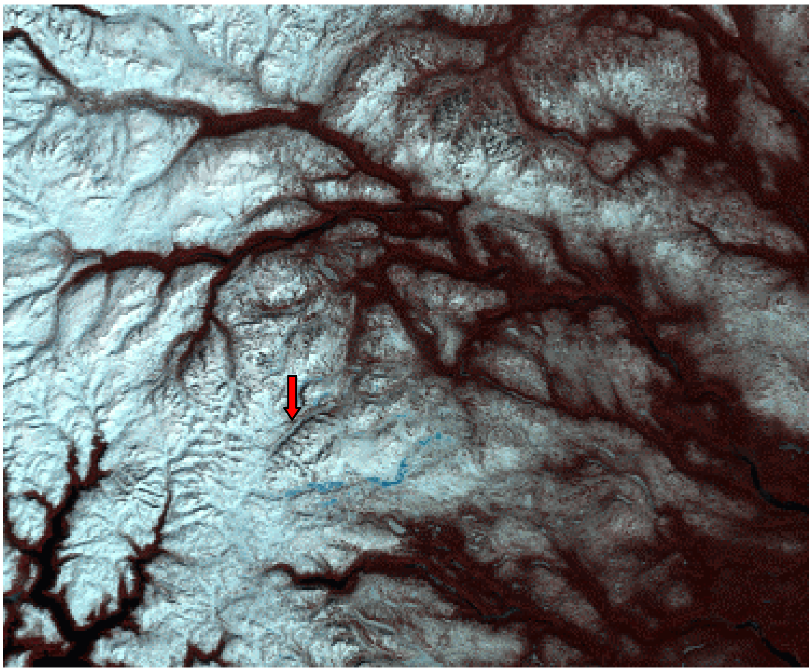

Figure 10 MODIS image from 4 May 2000, bands 2, 1, and 4 as RGB. Lake Gjende is marked with red arrow.

4.3 Method

The classification algorithm for AVHRR used by NVE is not exactly the same as used by NR. There are certain differences in the calibration methods, described in section 2.3.2.

Experience from Landsat TM has been the foundation for the algorithm developed for EOS-AM MODIS named SNOWMAP (Riggs et al. 1996). It maps global snow cover, cloud-cover permitting, at 500-m spatial resolution using MODIS data. The MODIS cloud mask at 1-km resolution is used as input to the snow-mapping algorithm, as well as land-cover maps developed from 1 km AVHRR data. The SNOWMAP algorithm is constrained to pixels that have nominal radiance data (MODIS L1B), are on land or inland water, are in daylight and are unobstructed by clouds. After these constraints are applied, only pixels having a daylight clear sky view of land surface are further processed. Usable calibrated radiance data is converted to at-satellite reflectance. The method uses band 1, 2, 4,and 6.

The SNOWMAP algorithm was used to classify the MODIS image. First we tried with the MODIS cloud mask and land cover mask. But the results were not satisfying. The 1-km resolution land cover mask produced lakes covering too large areas and the cloud mask showed clouds where there should not be any (Figure 11). Therefore we ran the algorithm with a dummy land mask without water and cloud mask without clouds to get a better snow cover map.

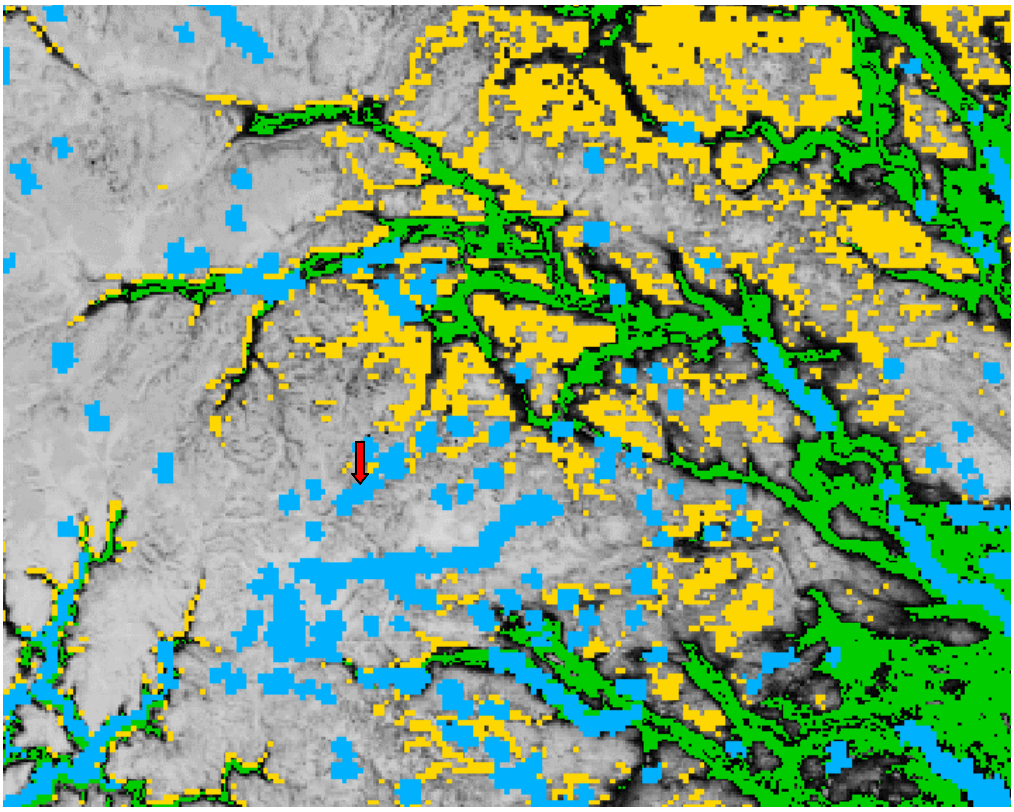

Figure 11 Snow cover map from MODIS image 4 May 2000, using MODIS cloud mask and water mask. Blue: water, Yellow: clouds, Green: bare land, Grey: snow. Lake Gjende is marked with red arrow.

4.4 Results

The result of the snow cover classification done at NVE is presented in a different way than the NR snow cover maps. The pixel values are as follows:

1: Water
2 - 3: No snow
4: 0 - 10 %
5: 10 - 25 %
6: 25 - 35 %
7: 35 - 50 %
8: 50 - 60 %
9: 60 - 75 %
10: 75 - 85 %
11: 85 - 100 %
12: Clouds

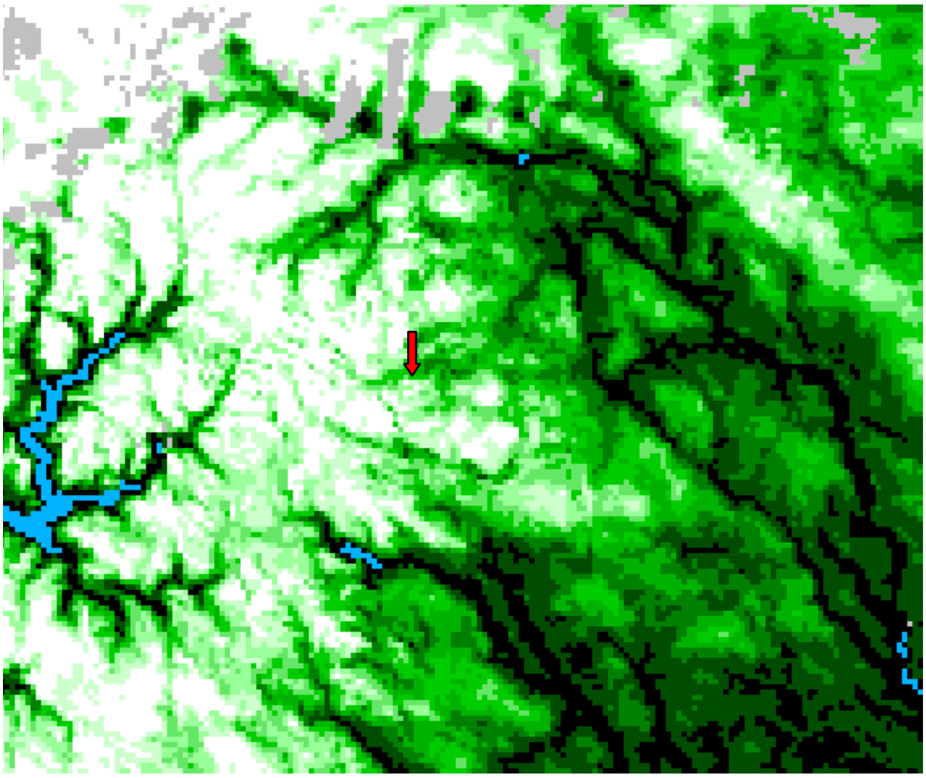

Figure 12 Snow cover map made from AVHRR image 4 May 2000. Classification performed at NVE. Lake Gjende is marked with red arrow.

In Figure 12 a subset of the classified image is shown with water as blue, clouds are grey and areas without snow are black. Areas with 85 - 100 % snow are white and the other classes are nuances of green from dark for 0 - 10 % and very light for 75 - 85 %. If you compare this image with the classified Landsat map (Figure 7) the overall impression is that they are quite similar. As expected, the areas partly covered by snow are larger in the AVHRR image, because the pixels are much larger and one pixel showing less than 100 % snow cover may include many Landsat pixels with 100 % snow cover. The areas of no snow in the Landsat map corresponds to the areas of no snow and parts of the areas of 0 - 10 % snow in the AVHRR map. This could indicate that the AVHRR classification estimates some snow in areas where there seem to be no snow in the Landsat image. The 0 - 10 % class in the AVHRR map in many cases correctly indicates partly snow cover, which can be seen in the Landsat image. In areas with dense forests it is difficult to tell if there is snow or not. But there are many areas, clearly without snow, which have been put into this class. A typical example is open agricultural fields with a light colour. Such areas were even classified as having snow cover of 10 - 25 %.

The classification of clouds is not perfect. There are more clouds in the upper part of the image than have been detected by the classification algorithm for AVHRR..

In Figure 13 we show the classified MODIS image without using the MODIS cloud mask and water mask. The snow cover is shown in values from 0 to 100. This could be interpreted as percent snow cover, but the values do not fit perfectly into such a scheme. Value 0 is obviously no snow. This value is found on bare land as well as open lakes and fjords. The highest values in the area covered by the Landsat image seem to be around 85 on Valdresflya. On Jostedalsbreen there are areas with 100 % snow cover, which have values of around 75. In the valleys around the glacier the values are higher. This seems a bit strange and indicates that one cannot directly associate the pixel value with the snow cover percentage. It has to be further investigated.

An interesting effect is that the borders of the lakes and fjords with no snow on the shores are detected and have values between 0 and 40. The same values are found in open rivers.

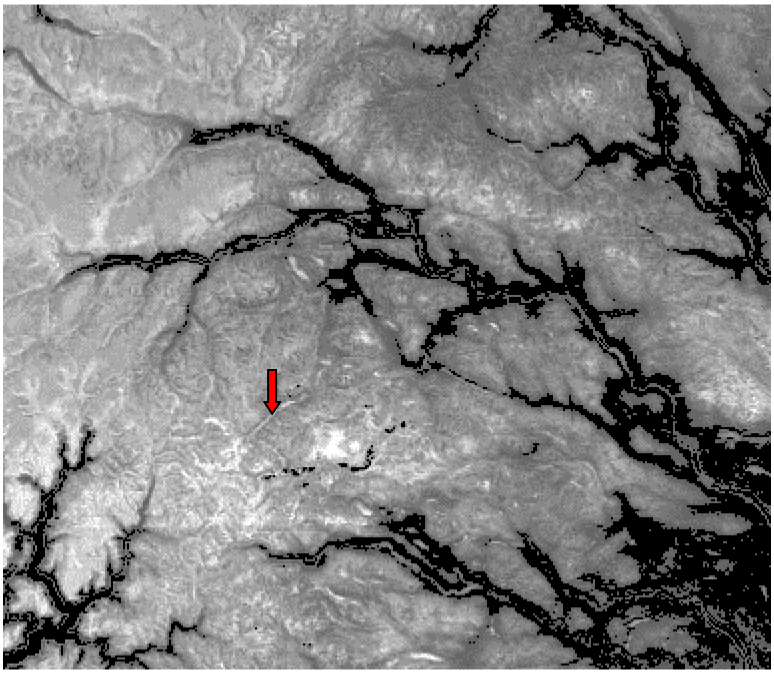

Figure 13 Snow cover map from MODIS image 4 May 2000 without using MODIS cloud mask and water mask. Lake Gjende is marked with red arrow.

4.5 Problems and recommendations

The MODIS SNOWMAP algorithm is using the MODIS 1km cloud mask and water mask. The cloud mask is showing clouds in large areas where obviously are no clouds. Some of these areas are partly snow covered. Along valleys, on the border between snow and bare land, the algorithm also finds stripes of clouds, especially on the sunny side of the valleys. The water mask is showing the lakes far too large. Alternative data sources for cloud/water mask should be considered as well as improved algorithm for cloud detection.

5 Conclusions

This report documents the work that has been performed by NR in the project DemoSnow (DemoSnø).

We have made a collection of maps showing snow cover area (SCA) from classified NOAA AVHRR images from the period 1995 – 2001. These maps have been used as input for calibration and simulation in the HBV-model to improve simulation of runoff in an operational model (Engeset and Udnæs 2002).

A "ground truth" map showing snow cover area has been made from a Landsat 7 ETM+ image from 4 may 2000. The map has been created by unsupervised classification using the ISODATA algorithm. From visual inspection, the map is describing the snow coverage in a close to correct way, especially in open, non-forested areas. For a better result in forested areas vegetation maps should be used, and a supervised classification should be performed. In the area covered by the map, there are regions with steep mountains creating shadows. Inside the shaded areas, there may be more snow than found by the unsupervised classification. A digital elevation model could be used to identify the shadows and create better results. To make a better method for classification of snow cover from Landsat images we also could need aerial photographs to have a precise ground truth.

The snow cover map derived from the Landsat7 ETM+ image has been compared with snow cover maps derived from NOAA AVHRR and Terra MODIS images from the same day. The AVHRR image was classified at NVE and shows larger areas with partly snow cover than the Landsat map. It seems that the snow covered area is being overestimated in the AVHRR image. Also too many clouds are found by the AVHRR method.

The MODIS/SNOWMAP algorithm was used on the MODIS image together with the MODIS 1 km cloud and water masks. The cloud mask showed clouds in large areas where there were no clouds. The water mask was too coarse and disturbed the result significantly. A classification without the cloud and water masks gave a better result, but we need to investigate how to interpret the output values for the snow covered areas.

The Landsat snow cover map was also used in the DemoSnow project as a comparison with snow classification from ERS-2 SAR images. This work was done by NORUT IT and is described in Malnes and Guneriussen 2002.

6 References

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Appendix A

AVHRR images of South Norway 1995-2001

This is an extract of a list of AVHRR images of Norway from 1979-2001. This list includes images from South Norway stored at NR and Statkraft (SK). To reduce the list of images, most of the images are classified images. This means that they probably are taken on days without a severe cloud cover. Images taken at other times on the same days as the classified ones have also been included. In addition to stored images, quicklooks have been studied to find additional images without too many clouds in interesting areas. If a scene, probably usable, has been found, not all quicklooks of scenes from the same day have been studied. Some classified images stored at NVE are also included.

Area: All images are covering the interesting parts of South Norway. The images at NR and SK are special scenes covering an area of 512 x 600 km with a pixel size of 1 x 1 km. The projection used is UTM zone 32, ED50. The corner coordinates of the images are
UL: 219250 7018500 LR: 730250 6419500. These images are marked S.

Clouds: The cloud cover has been estimated from quicklooks.
0 - Probably no clouds
1 - Mostly clear, but some interesting areas may be covered by clouds
2 - Mostly clear, some interesting areas seem to be covered by clouds.
3 - Scattered clouds, interesting areas may be covered by clouds.
4 - More clouds, interesting areas probably covered by clouds.

Classified: Classified images are marked with x.

Format: The early images at NR and SK are stored in biff format (Special Ifi format). The later images have Khoros-format. These are marked kdf.

* : Only classified image or other lacking data.

Satellite NOAA	Date	Time	Area	Clouds	Classified	Format	NR	SK	NVE	RE QUI RED
14	95.05.04		S		x			x		
12	95.05.22		S		x			x		
	95.05.22	12.34			x				x	
12	95.05.27		S		x			x		
12	95.05.31	07.52	S				x			
14	95.05.31	12.34	S				x			
12	95.06.04		S		x			x		
	95.06.04	11.55			x				x	

	95.06.13	11.58			x				x	
14	95.06.23		S		x			x		
12	95.06.25		S		x			x		
14	95.06.25		S		x			x		
14	95.06.25	11.25	S				x			
	95.06.25	11.30			x				x	
14	95.06.26	12.56	S		x		x			
14	95.06.27		S		x			x		
12	95.06.27		S		x			x		
12	95.06.29	07.23	S				x			
14	95.06.29	12.25	S				x			
12	95.07.05		S		x			x		
14	95.07.10		S		x			x		
12	95.07.12		S		x			x		
14	95.07.19		S		x			x		
12	95.07.27		S		x			x		
12	95.07.31		S		x			x		
12	95.08.08		S		x			x		
12	95.08.11		S		x			x		
12	95.08.28		S		x			x		
12	96.03.18*		S				x			
12	96.04.14		S		x			x		
	96.04.18	13.01								**X**
	96.04.26	07.51								**X**
14	96.05.09		S		x			x		
12	96.05.10		S		x			x		
12	96.05.30		S		x			x		
12	96.05.30	07.03	S		x		x			
	96.06.03	13.04								**X**
12	96.06.09	06.40	S		x		x			
12	96.06.09		S		x			x		
12	96.06.14	06.36	S		x		x			
12	96.07.10		S		x			x		
12	96.07.19	?	S				x			
12	96.07.20	06.54	S		x		x			
12	96.08.12	06.51	S				x			
12	96.08.15	07.26	S				x			
12	96.08.15		S		x			x		
12	97.04.29	07.04	S		x		x			
12	97.04.29		S		x			x		
12	97.04.30	06.36	S		x		x			
12	97.04.30		S		x			x		
12	97.05.17	07.06	S				x			
12	97.05.18	06.48	S		x		x			
12	97.05.18		S		x			x		
12	97.06.01	06.34	S				x			

12	97.06.01		S		x			x		
12	97.06.04	07.09	S		x		x			
12	97.06.04		S		x			x		
	97.06.04	11.50			x				x	
12	97.06.11	06.18	S		x		x			
12	97.06.11		S		x			x		
12	97.07.03	06.32	S				x			
12	97.07.03		S		x			x		
	97.07.03	11.40			x				x	
12	97.07.10	07.19	S		x		x			
12	97.07.10		S		x			x		
	97.07.13	08.00								**X**
12	97.07.19	07.25	S				x			
12	97.07.19		S		x			x		
12	97.07.30	06.41	S				x			
12	97.07.30		S		x			x		
14	97.08.14	12.17	S		x		x			
14	97.08.14		S		x			x		
12	97.08.15	07.30	S		x		x			
12	97.08.15		S		x			x		
12	98.05.03	06.55	S				x			
12	98.05.03		S		x			x		
12	98.05.06	07.29	S				x			
12	98.05.06		S		x			x		
	98.05.15	12.23			x				x	
12	98.05.15		S		x			x		
	98.05.17	12.01			x				x	
12	98.05.17		S		x			x		
12	98.05.29		S		x			x		
	98.05.31	12.47			x				x	
12	98.06.05	06.40		1						**X**
14	98.06.05	11.52		3						
12	98.06.06	06.18		1						**X**
14	98.06.06	11.41		3						
14	98.06.06	13.21		3						
12	98.06.12	07.26		4						
12	98.06.14	06.42		1						**X**
14	98.06.15	05.08		1						
12	98.06.15	06.20		0?						**X**
14	98.06.15	11.42		4						
14	98.06.15	13.22		3						
12	98.06.19	06.32		1						**X**
12	98.06.21		S		x			x		
12	98.06.21	07.28		1						**X**
14	98.06.21	12.16		3						
12	98.07.17		S		x			x		

14	99.04.03	12.51		0						**X**
14	99.04.03	14.31		1						
15	99.04.04	07.49		0						
14	99.04.04	12.40		0						
14	99.04.04	14.20		0						**X**
14	99.04.15	12.17		2						
15	99.04.21	08.13		1						
14	99.04.21	12.50		0						**X**
14	99.04.26	11.55		1						**X**
14	99.04.26	15.15		1						
14	99.05.05	13.34		0						**X**
14	99.05.06	13.23		0						**X**
14	99.05.07	13.11		0						**X**
14	99.05.17	13.00		1						
14	99.05.18	12.49		0						**X**
14	99.05.19	12.38		0						
	99.05.19	14.18			x				x	
14	99.05.20	12.26		0						**X**
14	99.05.30	13.54		3						
	99.06.02	13.21			x				x	
	99.06.14	12.47			x				x	
12	99.06.14	17.00		3						
12	99.06.18	07.22		1						**X**
12	99.06.25	06.26		0						**X**
14	99.06.25	12.24		3						
	99.07.08									**X**
14	00.04.05	13.41		3						
14	00.04.09	12.55		4						
14	00.04.25	13.11		4						
14	00.04.28	14.16		4+						
14	00.04.29	14.05		3						
14	00.04.30	11.12		4						
12	00.05.04	05.43	S				x			
	00.05.08	14.02			x				x	
12	00.05.12	06.02	S		x		x			
	00.05.15	14.21			x				x	
	00.05.20	06.21	S		x	kdf	x			
	00.05.21	05.58	S		x	kdf	x			
	00.05.25	06.07	S		x	kdf	x			
	00.05.26	05.44	S		x	kdf	x			
	00.06.05	13.39			x				x	
	00.06.09	14.33			x				x	
	00.06.20	14.06			x				x	
14	01.04.01	13.24								
14	01.04.01	15.02								
14	01.04.12	14.32								

14	01.04.12	16.12								
14	01.04.13	06.06								
14	01.04.13	14.21								**X**
14	01.04.13	16.00								
12	01.04.20	05.07								
14	01.04.20	14.37								**X**
14	01.04.21	14.25								**X**
14	01.04.21	16.05								
	01.05.06	11.22		1						
	01.05.06	13.02		1						
	01.05.07	11.11		0						
	01.05.07	12.51		0						
	01.05.07	14.38	S		x	kdf	x			
	01.05.08	04.49	S			kdf	x			
	01.05.08	11.01		0						
	01.05.08	12.41		0						
	01.05.08	14.26	S		x	kdf	x			
	01.05.09	04.26	S			kdf	x			
	01.05.09	10.51		0						
	01.05.09	12.30		0						
	01.05.09	14.14	S			kdf	x			
	01.05.09	15.55	S		x	kdf	x			
	01.05.10	05.43	S			kdf	x			
	01.05.10	14.02	S			kdf	x			
	01.05.10	15.43	S		x	kdf	x			
	01.05.11	05.20	S				x			
12	01.05.11	05.31		1						
	01.05.11	12.10		1						
	01.05.11	13.50	S	3		kdf	x			
	01.05.11	15.30	S		x	kdf	x			
	01.05.12	04.57	S			kdf	x			
	01.05.12	13.38	S			kdf	x			
	01.05.12	15.18	S		x	kdf	x			
	01.05.13	15.07	S		x	kdf	x			
	01.05.20	05.11	S			kdf	x			
	01.05.20	13.42	S			kdf	x			
	01.05.20	15.23	S		x	kdf	x			
	01.05.21	04.48	S			kdf	x			
	01.05.21	13.30	S			kdf	x			
	01.05.21	15.11	S		x	kdf	x			
	01.05.24	05.18	S			kdf	x			
	01.05.24	14.38	S			kdf	x			
	01.05.24	16.17	S		x	kdf	x			
	01.06.04									**X**
	01.06.10	05.24	S			kdf	x			
	01.06.10	14.02	S			kdf	x			

	01.06.10	16.15	S		x	kdf	x			
	01.06.13	05.54	S		x	kdf	x			
	01.06.13	13.57	S			kdf	x			
	01.06.13	15.38	S			kdf	x			
	01.06.14	05.31	S			kdf	x			
	01.06.14	13.45	S			kdf	x			
	01.06.14	15.25	S		x	kdf	x			
	01.06.19	12.05			x				x	
	01.07.04	12.49			x				x	