CORINE LAND COVER 2000
The Norwegian CLC2000 project

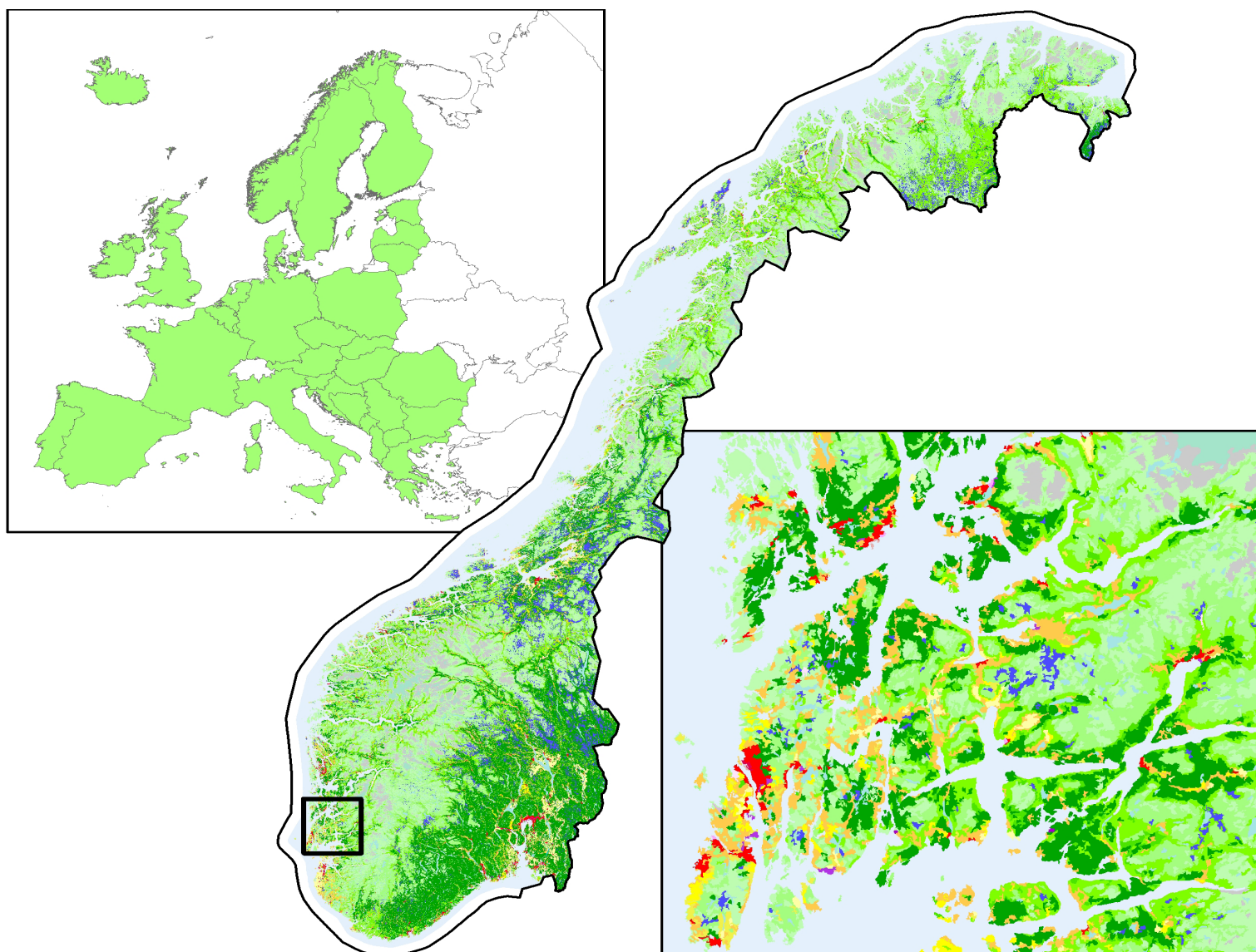Eva Solbjørg Flo Heggem and Geir-Harald Strand

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Eva Solbjørg Flo Heggem and Geir-Harald Strand

Illustration: Eva S. F. Heggem, Skog og landskap

SUMMARY

CORINE Land Cover (CLC) is a seamless European land cover vector database. The Norwegian CLC2000 was completed by the Norwegian Forest and Landscape Institute (Skog og landskap) in 2008 and was produced from existing national land cover datasets wherever available.

CLC has a standardized nomenclature with 44 classes. 31 classes are represented in the Norwegian dataset. CLC is a small scale map showing built up areas, agriculture, forest and semi-natural areas, wetlands and water bodies. CLC has a minimum mapping unit of 25 ha. CLC2000 can be used for visualization of the general land cover patterns in Norway at a scale 1:250 000 or smaller. CLC2000 is representing the land cover situation close to year 2000[1].

This report presents the Norwegian CLC2000 project and the methods and automatic generalization processes that were used in the project.

CORINE Land Cover is one of four land cover maps (AR5, AR50, AR250 and CLC) published by Skog og landskap. CLC2000 was produced with support from the European Environmental Agency (EEA) who has joint ownership to the product.

WARNING

The Norwegian CLC2000 data should not be used to assess the land cover of a particular location in Norway. Neither should it be used to compile statistics for Norway or parts of Norway.

CLC2000 is a generalized and simplified land cover dataset. Its purpose is to complete the EEA CORINE Land Cover database of Europe in order to serve the EEA, European institutions and the research establishment with a homogeneous European land cover dataset as input to pan-European and wider regional studies.

Statistics compiled from CLC2000 will always be biased due to the generalization involved in the production of the dataset. They will therefore be different from official statistics obtained by using registers, unbiased point samples or high resolution maps.

Norwegian official statistics are published by Statistics Norway (www.ssb.no). Land use and land cover statistics for agricultural, forest and mountain areas are published by Skog og landskap (www.skogoglandskap.no).

CLC2000 can be used for visualization of the general land cover patterns in Norway. More accurate land cover and land use maps for Norway are published by the Skog og landskap and distributed through Norway digital – the national geographical infrastructure (www.norgedigitalt.no).

Nøkkelord:	CORINE Land Cover, kart, arealressurser, arealdekke, generalisering
Key words:	CORINE Land Cover, map, land recourses, land cover, generalization
Other relevant documents from the project:	"CORINE LAND COVER 2006. The Norwegian CLC2006 project"
	"CORINE LAND COVER CLASSES. Examination of the content of the CLC classes in Norway"

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[1] Year 2000 is the official reference year of the dataset, as decided by the EEA, but some of the source data and satellite images used in the production were produced in other years.

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1. INTRODUCTION

The European Environment Agency (EEA) is an agency of the European Union. The main task of EEA is to provide independent information on the environment. Currently, the EEA has 32 member countries. The Norwegian Forest and Landscape Institute (Skog og landskap) is the Norwegian "National Reference Centre on Land Cover" for the EEA.

The CORINE (Coordination of information on the environment) programme of EEA, dating back to 1985, is a European commission which compiles information on the state of the environment (Land cover, Costal erosion, biotopes etc.). CORINE Land Cover (CLC) is a compilation of national land cover data sets, which are integrated into a seamless land cover map of Europe. The data base is based on a standard methodology (EEA 2002) and nomenclature. On the basis of satellite data, most of Europe was mapped with the help of computer assisted photo interpretation and a common nomenclature.

National needs for land cover data in Norway are covered by more detailed land cover data already produced or under production. The Ministry of Agriculture and Food[1] (MAF) has, however, recognised the need to meet the international demand for a CLC dataset for Norway to be used by EEA and other international agencies and institutions working on a pan European level.

Skog og landskap is an institution under MAF. Skog og landskap has the overall responsibility for land resource mapping, including land cover, in Norway. In 2005 the Ministry asked Skog og landskap to produce a CLC dataset for the conterminous Norway based on existing land cover data. The idea was to transform the existing land cover data for Norway into the format and nomenclature described in the specification of the CLC dataset (EEA 2002).

The Norwegian effort is a part of the European CLC2000 project aiming to represent the land cover in Europe in, or as close as possible to, year 2000. CLC2000 has been financed in the frame of a co-funding mechanism (up to 50 % European Commission (EC) and at least 50 % national contribution) leading to a joint ownership of the CLC products. The Norwegian co-funding was provided by MAF through its funding of the compilation of data used in the production of CLC2000. The Norwegian contribution to the project was thus in-kind, consisting of the input data used in the project. The co-funding from EC provided the additional resources necessary for the more rapid mapping of mountain areas than originally planned and for the integration of the various data sources and compilation of the CLC2000 product. The EC has also funded IMAGE2000 for Norway and the quality control of the CLC2000 product.

1.1.   The Norwegian CLC2000 project

The "CORINE Land Cover Technical Guide – Addendum 2000" (EEA 2000) and the "CORINE Land Cover Update I&CLC2000 Project Technical Guidelines – August 2002" (EEA 2002) prepared by the EEA are the basic documents for the project CLC2000. The Norwegian approach adds extensive use of auxiliary data from existing sources. These sources are described in detail in chapter 2 of this report. The project has used existing data where available, while ensuring that the final CLC product was in accordance with the European standard.

The principal workflow of the Norwegian CLC project was:

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[1] The Ministry of Agriculture and Food has financed the national contribution to CLC2000. From 2008, the Ministry of Environment is financing the national contribution to CLC2006.

Task 1: IMAGE2000 – Purchase and correction of satellite images

IMAGE2000 data as orthocorrected Landsat 7 ETM images were provided by EEA. The national team (NT) provided data for control points and a digital elevation model (Statens kartverk 2009) allowing for the orthocorrection by the Czech company GISAT. NT also checked the accuracy of the imagery (≤ 25 m RMSE).

Task 2: ARFJELL – Interpretation of land cover above the tree line

Mapping of land cover above the tree line (139 000 km^2 or 43 % of the land surface) was carried out by image interpretation using a combination of manual and computer assisted methods (Aune-Lundberg and Strand). The methodology provided more detailed land cover classification than required by CLC.

Task 3: Preparation of data from existing sources

A range of existing digital data was used in the Norwegian CLC production. The most important sources were land resource maps in scale 1:5 000 (AR5) and digital topographic maps in scale 1:50 000 (N50). A number of other sources were also used. These sources are described in chapter 2 below. An existing procedure (Gjertsen 2007) for forest classification using a combination of Landsat images, AR5 data and data from the National Forest Inventory was modified[2] and used to provide a map of forest under regeneration. The different data sets were brought together by the national team and underwent various preparatory procedures[3] in order to be ready for the generalization and integration into CLC2000.

Task 4: Data integration

CLC2000 was compiled by generalizing the input data received from tasks 2 and 3 and integrating the results into a single data set conform to the technical specification (EEA 2002) of CLC. An automatic procedure (described in chapter 3 below) was developed for this task. The resulting CLC dataset was subsequently subject to a final, manual editing described in chapter 3.5 below.

Task 5: Quality control and metadata

A validation and quality control was carried out by combining the CLC product with IMAGE2000 images followed by visual inspection. The CLC dataset was adjusted where discrepancies were found.

Thematic verification was also carried out by the CLC technical team according to EEA specifications (EEA 2002).

Metadata was produced according to the specification set by EEA (EEA 2002).

Task 6: Validation

Accuracy statistics for the areas below the tree line has been compiled from an overlay between CLC and the AR5 land resource map. Validation above the tree line is done using area frame samples of land cover mapping carried out in the field. The Norwegian AR18X18 statistical survey of land cover and land use (Strand and Rekdal 2006) was used for this task.

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[2] The modification implied that the method was used to search for young forest (ie < approximately 20 years) only, and not for other forest attributes.

[3] The preparatory procedures included downloading data to a local server, converting the datasets into a common physical format and identification and correction of errors.

Task 7: Dissemination

The CLC dataset is stored in the Skog og landskap seamless geospatial database (based on Oracle and ArcSDE technology) and published on the Internet as an integrated part of Norway digital – the national geographical infrastructure (www.norgedigitalt.no). The data is also delivered to EEA according to their requirements.

Task 8: Project management

Skog og landskap is the national authority for land resource information in Norway and was assigned as national project manager for CLC2000 by MAF.

1.2. Using existing data

The Norwegian CLC2000 project relies on existing data from national databases rather than a new mapping effort with interpretation of satellite images. There are several reasons for this:

- The existing data sources are more reliable than manual interpretation of satellite images. The existing data have been collected in the field and are updated from aerial photographs with a far better resolution than the satellite images.

- The existing data sources are far more detailed – thematically as well as geometrically – than CLC2000 data and can be generalized to comply with CLC2000 specifications.

- The CLC nomenclature is not well adjusted to the Norwegian environment. The link to existing data sources makes it easier to explain the actual content of the CLC classes in Norway.

- Manual interpretation of satellite images would to a large extent have to be financed as a national contribution to the project. No such national contribution was obtainable due to the lack of national needs for these data. By using existing data, the resources used to produce and maintain these data sets became the national contribution to the project.

1.3. Timeliness

The reference year for CLC2000 is the year 2000, but the actual information for particular areas can depart from this year. The sources used in the Norwegian CLC2000 project are updated on a regular basis, but not annually. Furthermore, the revision of the data is carried out on a patch by patch basis. Updating is, however, more frequent in areas of high human activity. Only 3 % of Norway is agricultural land and only 1 % is "urban" in any sense. Land cover changes are therefore a slow process in most of Norway.

Figure 1: Land cover changes. © Norge digitalt.

2. DATA   SOURCES

2.1.   Digital vector data

2.1.1. AR   5

AR5 is a Norwegian national land capability classification system and spatial dataset that describes land recourses, with emphasis on capability for agriculture and natural plant production. Minimum mapping unit is 0.2 ha. The dataset is produced and maintained by Skog og landskap. The following selection of data was used as input to CLC2000 (the Norwegian term in parenthesis):

- Surface type (Arealtype): Arable land (2 classes), pasture, forest, peat bogs, open land, urban area

- Forest cover type (Treslag): Broad-leaved forest, coniferous forest, mixed forest

- Soil conditions (Grunnforhold): Organic (3 classes), blocky or block field areas

AR5 covers the productive part of Norway. Areas close to, or above the tree line is not included in the dataset.

2.1.2.   N50

The digital topographic 1:50 000 map database (N50) is produced and maintained by the Norwegian Mapping Authority. The dataset consists of several themes which were used as input to CLC2000 (the Norwegian term in parenthesis):

- Surface cover (Arealdekke): Sea, water bodies, water courses, sand banks, forest, peat bogs, agriculture, glacier and perpetual snow, urban fabrics, airports, industrial units, sport arenas, quarries/gravel pits, cemeteries, parks, golf courses (polygon or points) and open areas (empty polygons)

- Transport (Samferdsel): Road and rail network

- Building and construction (Bygninger og anlegg): Buildings (large as polygons, small as points), camping ground (points) and ports (line)

Forest, peat bogs and agriculture was only used in areas without AR5 coverage. Road and rail network, buildings, camping ground, ports, airports and golf courses were edited by NT before use.

Urban fabric areas, industrial units, sport arenas, quarries/gravel pits, cemeteries and parks were used as a direct input.

2.1.3.   CADASTRE INFORMATION

The Cadastre information (GAB) is the official ground property, address and building register in Norway. It contains all building points and was used in the CLC2000 project to delineate classes under the artificial surfaces heading. All point older than 1 January 2001 was included in the dataset.

2.1.4.   DATASET ESTABLISHED OR MODIFIED

Some land use elements could not be retrieved completely from existing digital map datasets. Listed below are datasets that were established or edited by the NT during the CLC2000 project. (Classes derived from satellite images are not included in this list.)

- **Ports**
    Large ports were digitized and established as a new dataset. Potential port areas were extracted from the topographic N50 "Bygninger og anlegg" dataset, where ports exists as

line objects (LTEMA = 6601 Kai/brygge). Ports were then digitized by the NT using aerial photos and satellite images.

- **Airports**
  Airports are represented as polygons in the topographic N50 "Arealdekke" dataset (FTEMA = 7900 Flyplass). This dataset do not include the associated infrastructure (as required for CLC2000) and was therefore manually edited using aerial photos and satellite images and established as a new dataset by the NT.

- **Golf courses**
  Golf courses are represented as polygons in the topographic N50 "Arealdekke" dataset (FTEMA = 4134 Golfbaner). The golf courses dataset from N50 was not updated at all sites, nor did it include associated infrastructure. A new dataset was established by the NT using manual inspection of the N50 dataset together with aerial photos and satellite images.

- **Industry and construction sites**
  Large industrial areas (related to oil and offshore) and construction sites were located using internet searches and digitized by the NT into a new dataset using aerial photos and satellite images.

- **Mineral extraction sites**
  A point dataset including active mines was obtained from Geological Survey of Norway. From this dataset, mine sites was manually checked and digitized by the NT using aerial photos and satellite images. The dataset was also compared to the topographic N50 "Arealdekke" dataset (FTEMA = 4102 Dagbrudd (i.e. open pit quarries) and FTEMA = 4152 Steintipp (i.e. boulder dump sites)).

- **Dump sites**
  A point dataset including dump sites was obtained from the Climate and Pollution Agency. Dump sites extracted from this dataset were manually checked and digitized by the NT using aerial photos and satellite images.

- **Camping grounds**
  All camping grounds were extracted as a point dataset from the topographic N50 "Bygninger og anlegg" dataset (PTEMA = 4132 Campingplasser). Camping sites were then digitized by the NT using aerial photos and satellite images.

- **Sport and leisure facilities**
  Major sport and leisure facilities were located using internet search and digitized by the NT using aerial photos and satellite images. Also sports airfields found in the N50 "Arealdekke" dataset (FTEMA = 7900 Flyplass) were included in this dataset.

- **Beaches**
  Beaches were digitized by the NT using aerial photos and satellite images. A priori knowledge was used to search for potential large beaches along the coast.

- **Inland marshes**
  Inland marshes were located using the River delta database (www.elvedelta.no) operated by the Directorate for Nature Management. A total of three sites were found to meet CLC criteria. These sites were digitized by the NT using aerial photos and satellite images in combination with the database.

- **Intertidal flats**
  Tidal flats were obtained from the Norwegian Hydrographic Service. Tidal flat area is defined as the area between mean high water and 0.5 m below lowest astronomical tide. Some areas were not included in this dataset and were manually digitized by the NT

using a WMS-service also provided by the Norwegian Hydrographic Service (www.norgedigitalt.no).

2.2.   Digital elevation model

A 50 m resolution Digital Elevation Model (DEM) (Statens kartverk 2009) is produced by Norwegian Mapping Authority. This model is interpolated from Norwegian 1:50 000 topographic maps which has an elevation accuracy of ±20 meters. The DEM was used in the CLC2000 project for topographic normalization of satellite images.

2.3.   Remote sensing

2.3.1. NOR   GE-I-BILDER

Norge-i-bilder (lit. "Norway in pictures") is a national database of orthorectified aerial photos and satellite images. During the project period approximately 50 % of Norway was covered with images with a resolution better than one meter. The service was available to the CLC2000 project as a WMS-service. See www.norgeibilder.no and www.norgedigitalt.no.

2.3.2. IM   AGE2000

Satellite images for CLC2000 production were selected and orthorectified by the Czech company GISAT (www.gisat.cz). The collection of ground control points (GCP) was done by GISAT, using ground control points (as on-line resources) provided by the NT. Only the Norwegian DEM provided by the NT was used in the orthorectification. GISAT delivered a total of 42 orthorectified Landsat 7 and 5 scenes (1999-2002); some of the scenes prepared for two UTM zones.

2.3.3.   ARFJELL – AREA ABOVE THE TREE LINE

ARFJELL is a dataset that covers mountains and unproductive areas above the tree line and includes a wide spectre of resource-types. It contains land cover ranging from unproductive boulder fields to high-productive meadows. Five classes are produced: abiotic, sparse vegetation, lichen, intermediate vegetation and vigorous vegetation. Some polygons are classified as mixed classes, i.e. a combination of two of the classes where the second largest class covers more than 20 % of the area. ARFJELL was produced from IMAGE2000 by Skog og landskap.

For CLC2000 three classes were extracted from ARFJELL:

- Moors and heath land (composed of intermediate vegetation and vigorous vegetation)
- Sparsely vegetated areas (composed of scattered and sparse vegetation and lichen dominated areas)
- Bare rock

ARFJELL was produced using a semi-automatic method developed at Skog og landskap. The input datasets for ARFJELL were the IMAGE2000 images, mountain area mask generated from the N50 dataset and a snow and cloud mask. Training areas were selected through a qualified image interpretation for each of the five result classes. The training areas were carefully selected in areas of varying illumination and the normalized difference vegetation index (NVDI) is used as a supplement for the interpretation. The aggregation of homogeneous polygons was done using Definiens Cognition Network Technology® software. Mosaic classes may appear where the second largest class inside a polygon covers more than 20 % of the total area. The classified polygons were given to trained interpreters who manually accepted or corrected the proposed class for each polygon. In areas where suitable IMAGE2000 scenes were unavailable, other

satellite images or aerial photos were used. As a result, the images used for ARFJELL are from the period 1994–2006 (see appendix, IMAGE2000 overview of images scenes).

A qualitative and informal assessment of the ARFJELL data was made by experts with long field experience from land cover mapping in Norwegian mountains. The experts judged that the dataset was a sensible source for CLC mapping in mountain areas, at the scale and accuracy prescribed in the CLC technical guidelines (EEA 2002)

2.3.4   YOUNG FOREST - TRANSITIONAL WOODLAND/SHRUB

The young forest dataset was extracted from IMAGE2000 and contains areas dominated by young forest and clear cuts. This was the input data source used as the basis for the transitional woodland/shrub class in CLC2000.

The first version of the young forest dataset was produced by Skog og landskap during the CLC2000 project. The input data sets were the IMAGE2000 images and training areas (young forest / not young forest) were selected manually for each scene. The aggregation of homogeneous polygons and spectral classifications was done using Definiens Cognition Network Technology® software.

3.   GENERATING CLC2000

3.1   Integration of the datasets

When all datasets were established and assembled and the satellite image interpretation was completed, the separate datasets could be integrated and generalized into CLC2000. AR5 was the main data source for the natural land cover classes below the tree line. ARFJELL was the main data source above the tree line. N50 data was used in areas where neither AR5 nor ARFJELL was available. N50 is also used to separate lakes, water courses and marine water. N50 and ancillary datasets were the main data sources in built-up areas. See Figure 2.

The combined data sources gave a complete dataset covering the whole of Norway and included most of the required information in order to generate a CLC classification. Some of the classes could, however, not be derived directly from any of the data sources. Separate analyses were needed in these cases, in order to extract the necessary information. Examples are the mixed agriculture classes in CLC. The composition of AR5 classes inside CLC polygons had to be considered in order to derive these classes. The various categories of built-up land in CLC were also arrived at through an analysis of the content of the CLC polygons in terms of buildings and roads.

All datasets collected were used as input in the generalization process. As some of the datasets were related to the same CLC class, or the same areas, a priority list was made according to accuracy and importance (as described in EEA 2000, 2002) of the datasets. The input features were ranked according to priority and the feature with the highest priority would be selected in cases where two or more features were present in the same area:

Urban fabric and industry

1. Ports
2. Mineral extraction sites
3. Dump sites
4. Topographic database N50 quarries
5. Industry and construction sites
6. Sport and leisure facilities
7. Camping grounds

8. Golf courses
9. Topographic database N50: parks
10. GAB: Sport and leisure themes
11. Topographic database N50: continuous urban fabric
12. Topographic database N50: discontinuous urban fabric
13. GAB: Building points
14. AR5: Urban areas

Agriculture and wet land

1. AR5 areas
2. Topographic database N50 areas (where AR5 is not established, i.e. mainly mountainous areas)

Forest

1. Young forest
2. AR5 forest
3. Topographic database N50 forest (where AR5 is not established, i.e. mainly mountainous areas)

Water bodies

1. Intertidal flats
2. Topographic database N50 water bodies

CLC classes not listed were generalized from one single data source.
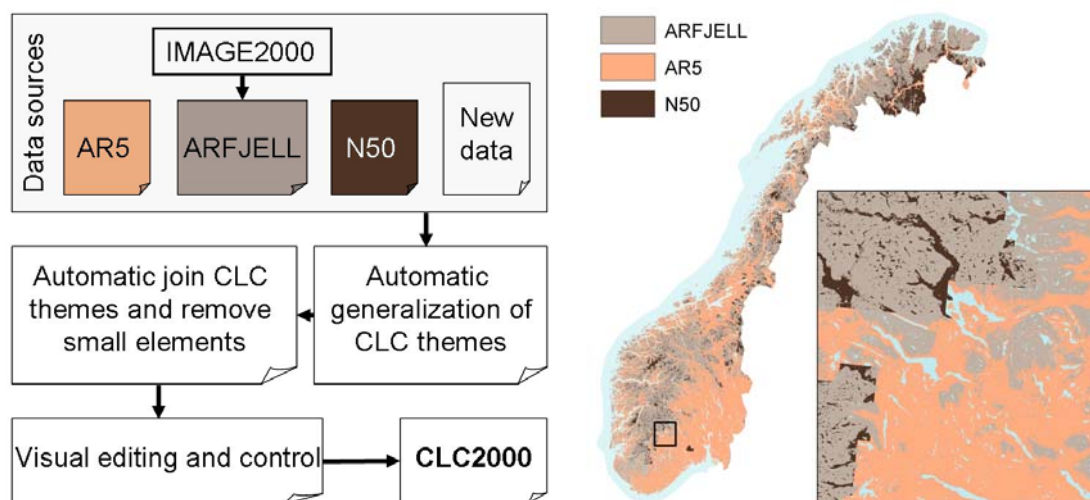
The CLC2000 data sources and process.

Coverage for AR5 and ARFJELL. In addition both N50 and other data sources were used in the CLC2000 production.

Figure 2.   Data sources, products and coverage.

3.2   The generalization process

As the input datasets were more detailed than the CLC specification for minimum mapping area and minimum width, the datasets needed to be simplified. An automatic generalization method

was developed in order to produce the CLC2000 dataset. The conceptual steps in the generalization process are described in Figure 3.

The conceptual steps in the generalization process were repeated with some variety for most CLC groups or single themes. Separate methods were developed for extracting the mixed agriculture class ("Land principally occupied by agriculture, with significant areas of natural vegetation, class 2.4.3) and green urban areas (class 1.4.1). Areas that are naturally close together were joined into one parcel and small variation in border zones was ignored. The generalization method simulates a manual delineation and generalization.

All available input datasets was converted to raster and recoded into CLC classes. All generalizing was carried out on raster datasets. Very small pixel groups were removed from the dataset (right) and the geometry were slightly smoothened (left).	
Larger units were obtained by buffering: • All pixel groups were expanded 50 m. As a result they merge with adjacent objects. • All the expanded pixel groups were then shrunken 50 m. The buffering was done for each class separately. Areas closer than 100 m were then joined and narrow parts eliminated. Small (< 25 ha) pixel groups were finally removed from the dataset.	
All buffered classes were joined. A priority table was used to determine the correct class in areas where two or more buffered classes did overlap The dataset was then cleaned and remaining small areas were moved into neighbour areas. In the final step the dataset was converted into vector data.	

Figure 3.   The conceptual steps in the generalization process.

The automatic process was developed in ESRI® ArcGIS® software with the Spatial Analyst extension. The method was implemented as a Python script (www.python.org) where the geoprocessor object (ArcGIS® ArcObjects component) provides an access to the geoprocessing tools in ArcGIS®.

Due to limitations in the software and hardware the generalization process was run for smaller units, and the 19 Norwegian administrative counties (no. "Fylker") were considered suitable. The CLC2000 processing was done individual for each County and special care was taken for areas close to the district border edges in order to avoid sliver polygons along the boundaries.

3.3. Generalization of the CLC2000 classes

All generalizations follow the main principles described in Figure 3. Still, in order to get good results, slightly different implementations were used for the different classes.

Below is a description of the classes at the different CLC levels. (The numbers in parentheses show the CLC class code on the three different levels and are the same as used in the table in the annex).

3.3.1. ARTIFICIAL SURFACES (1)

Urban fabric (1.1)

Continuous urban fabric is rare in Norway but a small number of polygons were generalized from the N50 dataset. Discontinuous urban fabric was generalized from a combination of several datasets. The N50 dataset was combined with GAB building points and all GAB buildings greater than one cell (25 m x 25 m) were in addition buffered one cell to get an approximation of the urban areas. Small areas (< 25 ha) from the classes "Continuous urban fabric" (1.1.1), "Green urban areas" (1.4.1) and "Sport and leisure facilities" (1.4.2) were also included under this heading.

Industrial, commercial and transport units (1.2)

Port areas from the port dataset and airport from the airport dataset were generalized and polygons < 25 ha were moved to the industry class.

Transport units were generalized from N50 polygons, the industry and construction dataset and from GAB building points.

Mine, dump and construction sites (1.3)

Mine, dump and construction sites datasets were generalized from N50, and the mineral extraction and dumpsite datasets.

Artificial non-agriculture vegetated areas (1.4)

Sport and leisure facilities were generalized using N50 polygon, the golf courses dataset, and the sport and leisure dataset.

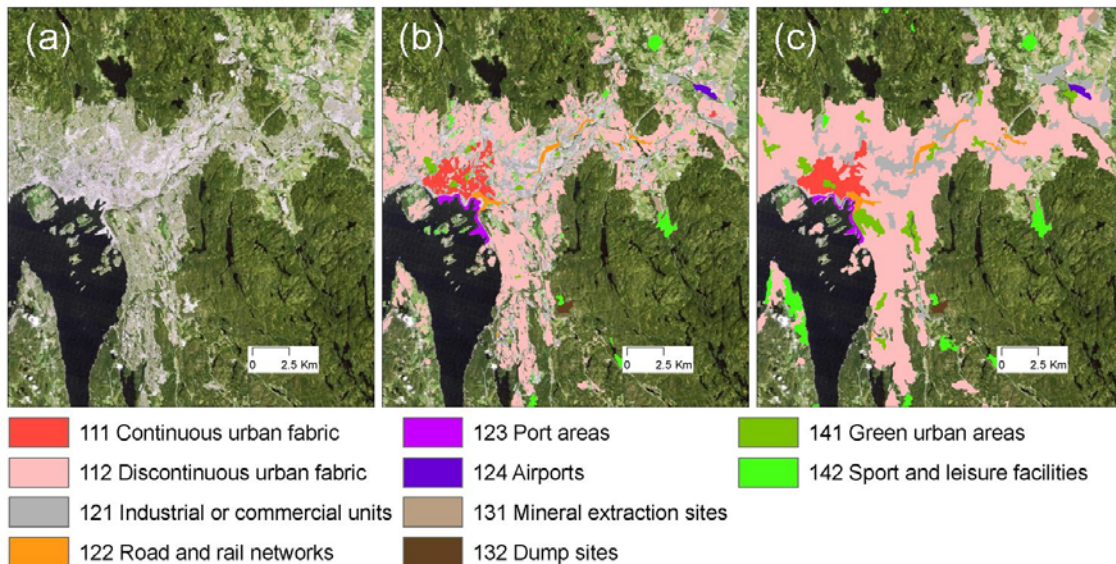|		
🟥 111 Continuous urban fabric	🟪 123 Port areas	🟩 141 Green urban areas
🟪 112 Discontinuous urban fabric	🟪 124 Airports	🟩 142 Sport and leisure facilities
⬜ 121 Industrial or commercial units	🟫 131 Mineral extraction sites	
🟧 122 Road and rail networks	🟫 132 Dump sites	

Figure 4.   a) Satellite image showing urban area. b) Not generalized urban area. All build up dataset is shown except some urban green areas that were automatically extracted from the datasets. c) Generalized urban area.

3.3.2 AGRICULTURAL AREAS (2)

Agriculture covers approximately 3 % of Norway and consists mainly of non-irrigated land and pastures. As large parts of the Norwegian agriculture area consist of small, scattered parcels of arable land the heterogeneous CLC classes are dominating the results.

Arable land (2.1) and pastures (2.3) were joined with small water bodies, wetlands and forest areas that were excluded from their original classes. This new mosaic dataset was buffered 100 m in order to merge all nearby agricultural land. Homogeneous land and pasture were generalized separately from this dataset. An area where neither arable land nor pasture was dominating was moved to the mixed class depending on content.

- Areas containing more than 75 % arable land were classified as CLC class "Non-irrigated arable land" (2.1.1).

- Areas containing more than 75 % pasture were classified as CLC class "Pastures" (2.3.1).

- Areas containing more than 75 % arable land and pasture together were classified as CLC class "Complex cultivation" (2.4.2).

- All other agriculture land with a total of more than 33 % arable land and pastures was classified as CLC class " Land principally occupied by agriculture, with significant areas of natural vegetation" (2.4.3). 33 % was used after recommendations from the EEA technical team who decided that 25 % (as originally suggested by the NT) was too low when automatic generalization techniques were applied.

211 Non-irrigated arable land 231 Pastures 242 Complex cultivation patterns
243 Land pricipally occupied by agriculture, with significant areas of natural vegetation
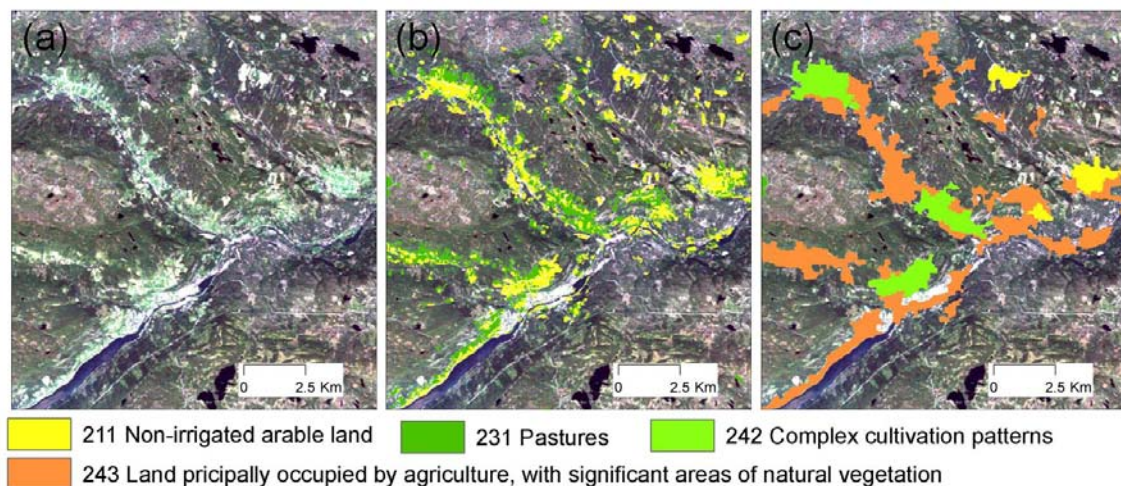
Figure 5.   a) Satellite image showing an agricultural area. b) Not generalized agricultural land. Two classes were input; arable land and pastures. c) Generalized agriculture. In the generalization process two more classes appeared; complex cultivation pattern and mixed agriculture.

3.3.3. FOREST AND SEMI-NATURAL AREAS (3)

Forest and semi natural areas cover close to 90 % of the total land area in Norway and are the overall dominating land cover type.

Forests (3.1)

Coniferous forest dominates in lowland areas and broad leaved forest dominates in the highlands. In the original dataset coniferous, broad leaved and mixed forest were separate classes. Forest was generalized by buffering every forest polygon by 50 m to merge with nearby forest areas. Mixed forest occurs when the original polygon was classified as mixed forest or when neither coniferous nor broad leaved forest dominates the new polygon created.

Shrub and/or herbaceous vegetation associations (3.2)

Transitional woodland/shrub (3.2.4) was extracted from the generalized forest polygons. The class consists of clear cuts and young forest under regeneration.

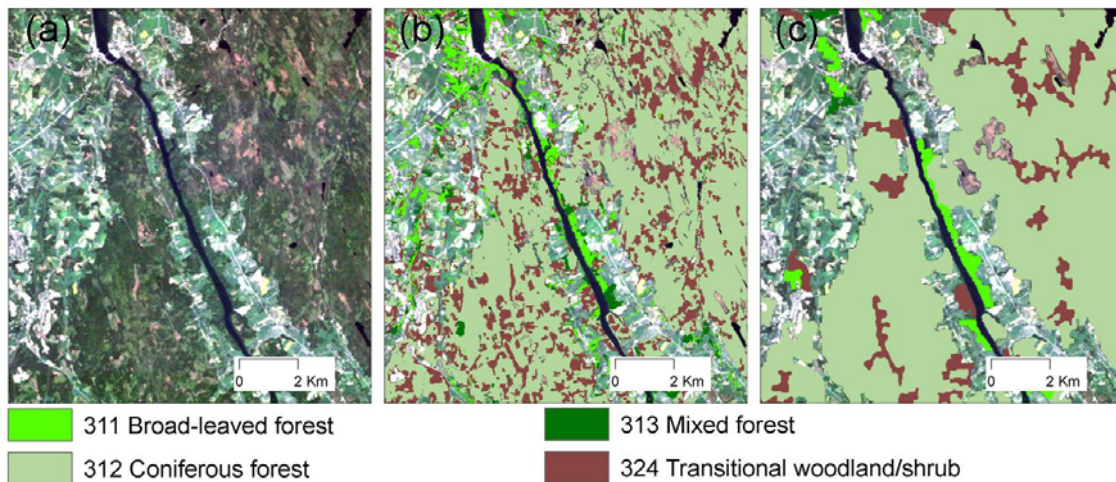|	
311 Broad-leaved forest	313 Mixed forest
312 Coniferous forest	324 Transitional woodland/shrub

Figure 6.   a) Satellite image showing an area with forest. b) Not generalized forest and transitional woodland/shrub. c) Generalized forest and transitional woodland/shrub.

Open spaces with little or no vegetation (3.3)

Glaciers and perpetual snow (3.3.5) were generalized from the N50 dataset.

Burnt areas (3.3.4) were not present in the first release of CLC for Norway in 2000, but three areas where later identified and included during the revision of CLC2000 that was carried out as part of CLC2006. Bare rock (3.3.2), sparsely vegetated areas (3.3.3) and moors and heath land (3.2.2) were extracted and generalized from the ARFJELL dataset. Each class was buffered 50 m in order to join nearby areas. Small areas of peat and forest that were excluded from the forest and wetland datasets, were included in the moors and heath land class.

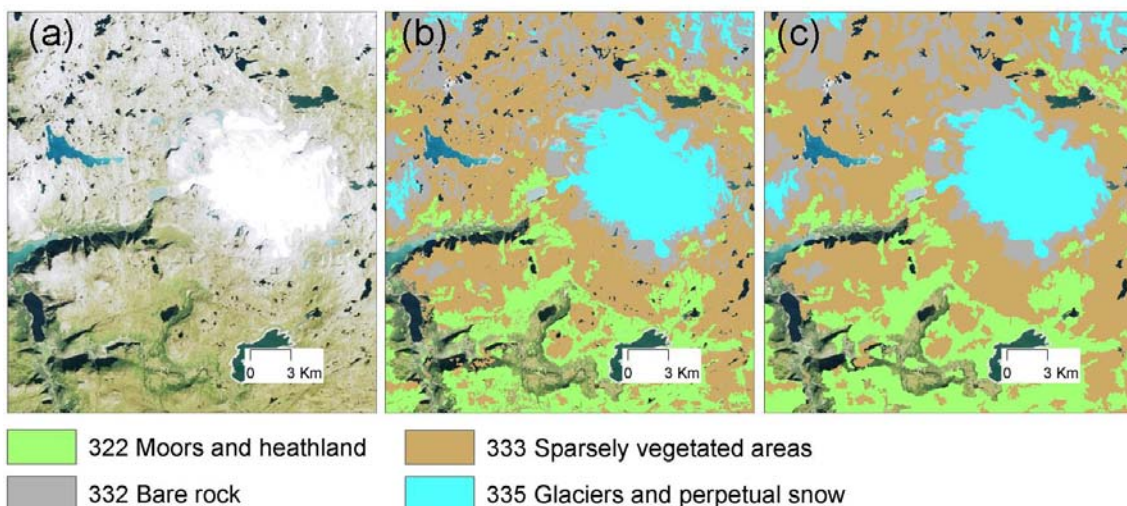|	
322 Moors and heathland	333 Sparsely vegetated areas
332 Bare rock	335 Glaciers and perpetual snow

Figure 7.   a) Satellite image showing mountain area. b) Not generalized mountain area and glacier. c) Generalized mountain area.

3.3.4.   WETLANDS (4)

Inland wetlands (4.1)

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Inland marshes (4.1.1) are rare and only three areas were large enough to be included in CLC2000. Salt marshes are not represented at all. From the database of 129 river deltas connected to the sea, only 54 daa was classified as salt marshes (www.elvedelta.no/brakkliste.htm). No area was large enough to be included in CLC2000.
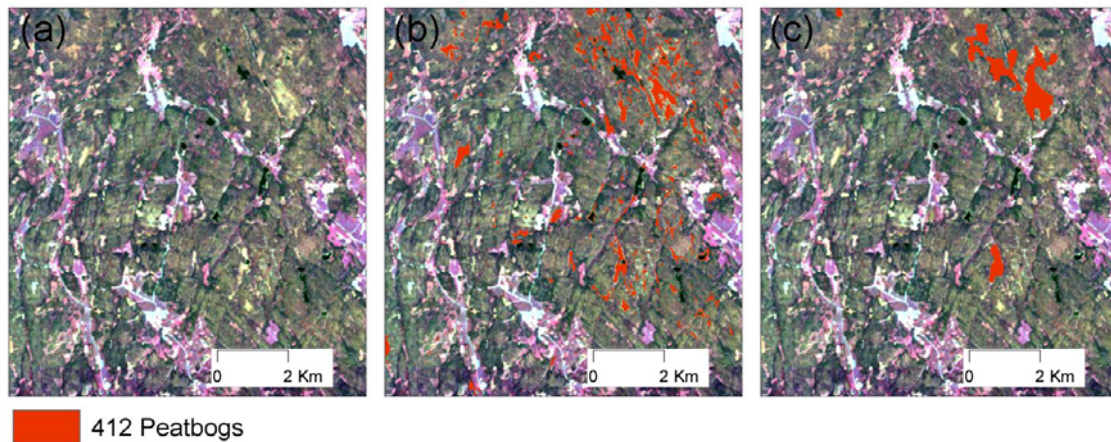

412 Peatbogs

Figure 8.   a) Satellite image showing an area with peat bogs. b) Not generalized peat bogs. c) Generalized peat bogs.

Peat bogs (4.1.2) are generally large in numbers, but small in areal extension. To aggregate nearby peat bogs into one continuous area, a peat intensity map was made. Areas with more than 30 % peat within 100 m radius were selected as potential peat areas. Forested peat was included in the CLC2000 dataset although some of these sites also could have been mapped as forest according to the CLC definitions. Small lakes excluded from the water dataset were used as additional input in the peat dataset. Resulting peat areas larger than 25 ha were transferred to the lake class if more than 50 % of the area was covered with surface water.

3.3.5.   WATER BODIES (5)

Inland waters (5.1)

Inland waters and water courses (5.1.1) were buffered by 25 m in order to only smoothly change the shorelines. Inland islands were treated like marine islands. Rivers narrower than 100 m were kept if the distance between wider parts was shorter than 200 m. Rives and lakes were combined if the distance between two parts was less than 150 m. River sand banks were generalized separately and moved to class "Beaches, dunes and sand plains" (3.3.1) if larger than 25 ha.

Marine waters (5.2)

All islands smaller than 25 ha were buffered with a distance of 75 m. All other coast and islands were buffered with distance 25 m. This joined smaller islands to the coast or to larger islands if the distance was smaller than 100 m. Small islands were merged together if the distance was less than 150 m. The coastline was thus only slightly simplified and narrow fjords and straits were kept if wider than approximately 50 m in narrow parts. Intertidal flats were generalized and areas larger than 25 ha were included. Beaches were also included when large enough.
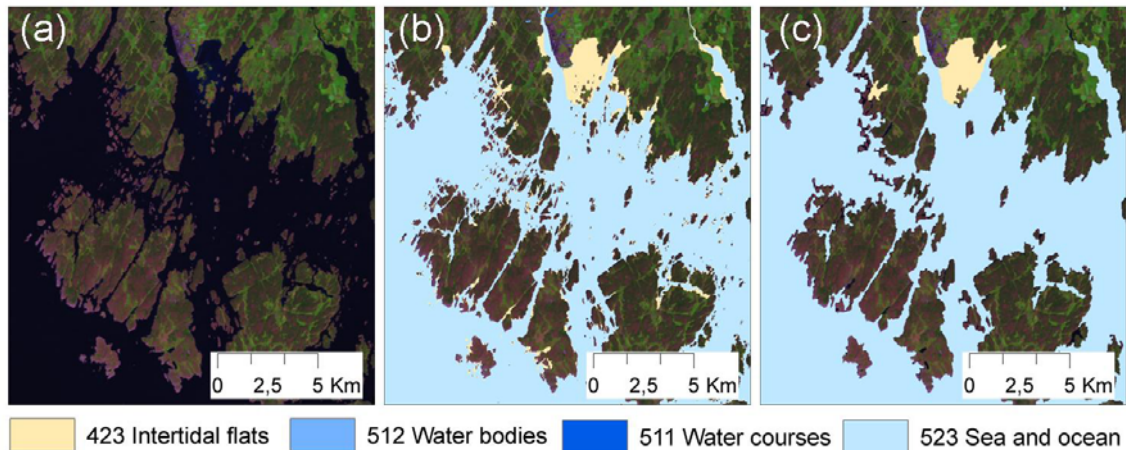
Figure 9.   a) Satellite image showing an area with complex marine water. b) Not generalized marine waters and intertidal flats. c) Generalized marine waters. Small islands were joined and narrow straits kept.
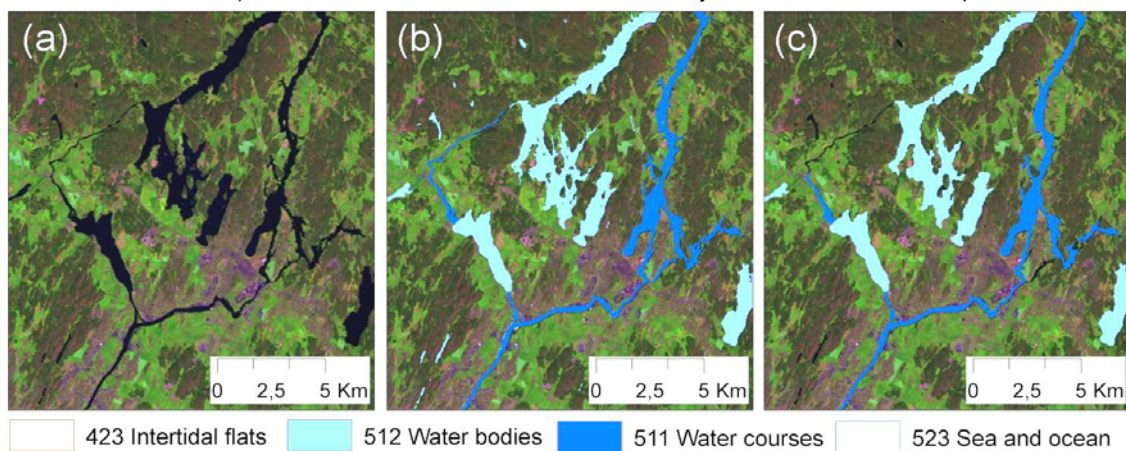
Figure 10.   Figure 4 a) Satellite image showing an area with lakes and rivers. b) Not generalized lakes and rivers. c) Generalized lakes and rivers. Small lakes and narrow rivers are now removed.

3.4.   Integration of generalized CLC2000 classes and management of small areas

All CLC2000 themes were generalized and then joined into one dataset using raster overlay. During the generalization process, buffering and merging lead to larger, more continuous areas. When the generalization is carried out on single themes separately, multiple data will in many areas cover the same space. To get the land cover theme as correct as possible, a priority list was used in the overlay. The priority is according to the importance of the themes (high to low):

1. Glaciers and perpetual snow
2. Water bodies and sand dunes
3. Mine and dump sites
4. Agriculture areas
5. All artificial surfaces (except mine and dump sites)
6. Wet lands
7. Semi natural areas (except glacier)
8. Forest
9. (Other semi natural areas generated from AR5)

The new, overlay dataset contained gaps with no assigned class and areas with an extension less than 25 ha area. These were removed in a two step process. The first step was to merge the

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empty areas with neighbour polygons based on the thematic content of the gaps (found in the input data). The priority table used was a simplified version of the CLC standard priority table. This simplified table included all the most important priorities and was selected due to implementation and run time issues. Finally, remaining parcels less than 25 ha were allowed to split and transferred into neighbour areas and the automatic generalization was completed.

3.5.   Post processing of the automatic generalized CLC2000 dataset

The dataset resulting from the automatic generalization process required post processing in order to meet the CLC2000 specifications. This was a three-step process. Step one converted the raster datasets into vector files (both ESRI shape files and Norwegian standard SOSI files). The second step was a visual control and manual editing. The final step was to assemble the 19 regional tiles into one CLC2000 dataset.

As the CLC2000 generalization process was carried out separately for each of the 19 counties in Norway, special care was taken along the border zones in order to mach classification and avoid slivers. Small CLC2000 polygons along each of the county were not removed, but temporarily allowed in order to obtain homogeneity of the dataset across borders. Also, in the raster to vector conversion process, shrink or split effects appears for some polygons and slivers did appear. In addition, the dataset still had some irregularities inherited from the input datasets, or produced by the generalization process itself. These occurrences were manually checked using SOSI files and the Norwegian software FYSAK:

- Areas without a legal CLC code were controlled and edited. This was mostly semi-natural areas that were absent in ARFJELL due to problems like cloud cover.

- Polygons smaller than 25 ha (always > 24 ha) were checked manually and slightly enlarged to 25 ha if possible.

- The border between AR5 and N50 datasets were checked and adjusted using IMAGE2000. This affected the forested areas.

- Agricultural areas were investigated in order to find areas missing due to backlog in the updating of AR5 or left out through the generalization process. Some new heterogeneous agriculture polygons were digitized inside the mixed classes.

- All build up areas were checked and assigned to correct CLC classes if necessary. Special attention was given to industrial areas. Also polygon borders were checked and edited if the extension was different from the generalized product.

- Rivers with gaps shorter than approximately 300 m were reconnected even if partly narrower than the 100 m minimum polygon width.

- All sea polygons were connected to the ocean. Small sea polygons (in fiords or between islands) are not allowed in CLC2000. It happened that very narrow straits (width < 50 m) extended one kilometre or more from the general coast line before reopening into a bay.

- The dataset was checked for artefacts like sliver polygons.

- A visual check was performed along the County borders in order to prepare the merging. Deviation between the two datasets was corrected when necessary.

In the final step all the 19 edited vector datasets where converted to shape files and merged into one dataset. In this step small areas with identical code across the County border were joined and remaining small polygons were eliminated by merging them with the neighbouring polygon having the longest shared border. Finally, updated area figures were calculated and the dataset was converted into coverage format. The dataset and its attributes were named according to guidelines.

3.6 Updated version of CLC2000

During the CLC2006 (Aune-Lundberg and Strand 2010) project an updated version of CLC2000 was generated. The CLC2006 project was completed in 2009 and had three results:

- A land cover change dataset including areas with changes greater than 5 ha.

- A new CORINE Land Cover dataset CLC2006 which is a corrected version of the CLC2000 where changes greater than 5 ha are included along with corrections of the original CLC2000 dataset.

- A corrected CLC2000 dataset where errors found during the CLC2006 project is corrected.

The updated version of CLC2000 from 2009 replaces the one from 2008 as the official Norwegian CLC2000 dataset.

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APPENDIX

National project team

<u>Norwegian Forest and Landscape Institute</u>

Geir-Harald Strand, Director of Land resource surveys, EEA steering committee member
Hanne Gro Wallin, Head of remote sensing
Barbi Nilsen, Project coordinator
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Finn-Arne Haugen, Image interpretation and field surveys
Linda Aune-Lundberg, Image interpretation
Kristian Berg, Image interpretation
Roar Lågbu, Software development and spatial data engineering
Britt Lindstad, Spatial data engineering
Ragnhild Hyggen, Spatial data engineering
Yngve Rekdal, field surveys and verification
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Per Bjørklund, field surveys and verification
Anders Bryn, field surveys and verification

<u>Other contributing national institutions</u>

Norwegian Mapping Authority (www.statkart.no)
The Climate and Pollution Agency (www.klif.no)

Workflow

2005 Jan.:   First draft proposal for the national project submitted to EEA for comments
2005 Jun.:   The final, revised proposal was submitted to EEA
2006 Apr.:   First IMAGINE2000 satellite scene received
2006 Nov.:   The Framework Contract with EEA (EEA/IDS/06/004) was signed
2006 Nov.:   The first Specific Agreement with EEA (3601/B2006.EEA.52666) was signed
2006 Dec.:   First national interim report submitted to EEA
2007 Mar.:   In total 15 IMAGINE2000 satellite scenes received
2007 Mar.:   First training by EEA technical team in Ås, 3 days
2007 Mar.:   Final report for the first phase submitted to EEA
2007 Jul.:   Final delivery of IMAGINE2000 satellite scenes, in total 27 scenes received
2007 Oct.:   The second Specific Agreement with EEA (3601/B2007.EEA.53085) was signed
2007 Nov.:   Verification in Ås by EEA technical team on preliminary results
2007 Dec.:   Final report for the second phase submitted to EEA
2008 May: The third Specific Agreement with EEA (3601/B2008.EEA.53337) was signed
2008 Nov.:   Second verification in Ås by EEA technical team on preliminary results
2008 Dec.:   CLC2000 data and final report for the third (and final) phase submitted to EEA
2009 Apr.**:**   Final revised CLC2000 data submitted to EEA

The Norwegian CORINE Land Cover nomenclature

The names are based on a list suggested by a project group established by the Norwegian Ministry of Environment (NIJOS report 11/1997 part 4), but revised according to the experience from the Norwegian CLC2000 project and input from the EEA technical team. Categories marked "No" are not expected in Norway. A number of other categories may have too small area coverage to be represented in the Norwegian CORINE Land Cover map (marked "Ts" – Too small).

CLC level 1

Class		
1	Bebygd og annet opparbeidet areal	Artificial surfaces
2	Jordbruksareal	Agricultural areas
3	Skog og annen fastmark	Forests and semi-natural areas
4	Myr og våtmark	Wetlands
5	Vann	Water bodies

CLC level 2

Class		
1.1	Tettbygd areal	Urban fabric
1.2	Industri, handels- og transportområde	Industrial, commercial and transport
1.3	Massetak, deponi og byggeplass	Mine, dump and construction sites
1.4	Anlagt grøntområde	Artificial non-agricultural vegetated areas
2.1	Fulldyrka mark	Arable land
2.2	Frukt- og bærhage	Permanent crops
2.3	Eng og beite	Pastures
2.4	Heterogent jordbruksareal	Heterogeneous agricultural areas
3.1	Skog	Forests
3.2	Åpen fastmark med vegetasjon	Shrub and/or herbaceous vegetation associations
3.3	Fastmark med sparsom eller ingen vegetasjon	Open spaces with little or no vegetation
4.1	Myr	Inland wetlands
4.2	Salt- og brakkvannsvåtmark	Coastal wetlands
5.1	Ferskvann	Inland waters
5.2	Hav	Marine waters

CLC level 3

Class			
1.1.1	Bymessig tettbebyggelse	Continuous urban fabric	
1.1.2	Tettbygd areal med åpen struktur	Discontinuous urban fabric	
1.2.1	Industri og handelsområde	Industrial or commercial units	
1.2.2	Veg og jernbane	Road and rail network and associated land	
1.2.3	Havn	Port areas	
1.2.4	Flyplass	Airports	
1.3.1	Gruver og massetak	Mineral extraction sites	
1.3.2	Deponi	Dump sites	
1.3.3	Byggeplass	Construction sites	
1.4.1	Grønt tettstedsareal	Green urban areas	
1.4.2	Idretts- og rekreasjonsområde	Sport and leisure facilities	
2.1.1	Fulldyrka mark	Non-irrigated arable land	
2.1.2	Permanent vannet jordbruksareal	Permanently irrigated land	No
2.1.3	Rismark	Rice fields	No
2.2.1	Vingård	Vineyards	No

2.2.2	Frukt- og bærhage	Fruit trees and berry plantations	Ts
2.2.3	Olivenlund	Olive groves	No
2.3.1	Eng og beite	Pastures	
2.4.1	Jordbruksareal med blanding av ett-årige og flerårige vekster	Annual crops associated with permanent crops	No
2.4.2	Blandet jordbruksareal	Complex cultivation	
2.4.3	Spredt jordbruksareal	Land principally occupied by agriculture, with significant areas of natural vegetation	
2.4.4	Agroforestry	Agro-forestry areas	No
3.1.1	Lauvskog	Broad-leaved forest	
3.1.2	Barskog	Coniferous forest	
3.1.3	Blandingsskog	Mixed forest	
3.2.1	Gras og urterik mark	Natural grassland	Ts
3.2.2	Hei og lyngmark	Moors and heath land	
3.2.3	Sklerofyll vegetasjon	Sclerophyllous vegetation	No
3.2.4	Hogst- og gjengroingsflater	Transitional woodland/shrub	
3.3.1	Strand og sanddyner	Beaches, dunes and sand plains	
3.3.2	Bart fjell	Bare rock	
3.3.3	Sparsomt vegetert areal	Sparsely vegetated areas	
3.3.4	Brannflate	Burnt areas	
3.3.5	Varig is og snø	Glaciers and perpetual snow	
4.1.1	Ferskvannsvåtmark	Inland marshes	
4.1.2	Myr	Peat bogs	
4.2.1	Strandsump	Salt marshes	Ts
4.2.2	Saline	Salines	No
4.2.3	Tidevannsflate	Intertidal flats	
5.1.1	Elv	Water courses	
5.1.2	Innsjø	Water bodies	
5.2.1	Lagune	Coastal lagoons	Ts
5.2.2	Elvemunning	Estuaries	Ts
5.2.3	Hav	Sea and ocean	

No = the class is not present in the Norwegian dataset, Ts = occurs in Norway, but they represent too small continuously areas to be included.

CLC2000 data sources

Class	Class description and data sources	
1.1.1	Continuous urban fabric	N50
1.1.2	Discontinuous urban fabric	N50, GAB and AR5
1.2.1	Industrial or commercial units	N50 and GAB, digitalized industry
1.2.2	Road and rail networks and associated land	N50 and GAB
1.2.3	Port Areas	Digitalized port areas dataset
1.2.4	Airports	Digitalized airport dataset
1.3.1	Mineral extraction sites	N50 and digitalized mineral extraction sites dataset
1.3.2	Dump sites	Digitalized dump sites dataset
1.3.3	Construction sites	Digitalized construction sites dataset
1.4.1	Green urban areas	N50 and AR5
1.4.2	Sport and leisure facilities	N50, digitalised sport, digitalized golf courses, digitalized camping sites
2.1.1	Non-irrigated arable land	AR5
2.1.2	Permanently irrigated land	Class not represented in Norway
2.1.3	Rice fields	Class not represented in Norway
2.2.1	Vineyards	Class not represented in Norway
2.2.2	Fruit trees and berry plantations	No areas ≥ 25 ha

2.2.3	Olive groves	Class not represented in Norway
2.3.1	Pastures	AR5 and N50
2.4.1	Annual crops associated with permanent crops	Class not represented in Norway
2.4.2	Complex cultivation	AR5 and N50
2.4.3	Land principally occupied by agriculture, with significant areas of natural vegetation	AR5 and N50
2.4.4	Agro-forestry areas	Class not represented in Norway
3.1.1	Broad-leaved forest	AR5 and N50
3.1.2	Coniferous forest	AR5
3.1.3	Mixed forest	AR5 and N50
3.2.1	Natural grassland	No areas ≥ 25 ha
3.2.2	Moors and heath land	ARFJELL
3.2.3	Sclerophyllous vegetation	Class not represented in Norway
3.2.4	Transitional woodland/shrub	Young forest dataset
3.3.1	Beaches, dunes and sand plains	N50 and digitalized beaches
3.3.2	Bare rock	ARFJELL
3.3.3	Sparsely vegetated areas	ARFJELL
3.3.4	Burnt areas	IMAGE2000/IMAGE2006[4]
3.3.5	Glaciers and perpetual snow	N50
4.1.1	Inland marshes	Digitalized inland marshes dataset
4.1.2	Peat bogs	AR5 and N50
4.2.1	Salt marshes	No areas ≥ 25 ha
4.2.2	Salines	Class not represented in Norway
4.2.3	Intertidal flats	Intertidal flats dataset
5.1.1	Water courses	N50
5.1.2	Water bodies	N50
5.2.1	Coastal lagoons	No areas ≥ 25 ha
5.2.2	Estuaries	No areas ≥ 25 ha
5.2.3	Sea and ocean	N50

IMAGE2000 overview of image scenes

Orthorectified IMAGEINE2000 scenes				
Satellite	UTM zone	Path	Row	Date
Landsat	32	198	18	05072001
Landsat	32	196	19	05072001
Landsat	32	197	17	26082000
Landsat	32 + 33	198	11	20082001
Landsat	32 + 33	198	14	08092002
Landsat	32	198	15	04062002
Landsat	32	198	16	23082002
Landsat	32	198	17	30071999
Landsat	32	198	18	30071999
Landsat	32	198	19	30071999
Landsat	32 + 33	199	14	07091999
Landsat	32	199	15	06081999
Landsat	32	199	16	06081999
Landsat	32	199	17	25092000
Landsat	32	199	19	06081999
Landsat	32	200	17	12071999

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[4] Burnt areas were not present in the first release of CLC for Norway in 2000, but three areas where later identified and included during the revision of CLC2000 that was carried out as part of CLC2006.

Landsat	32	200	18	28071999
Landsat	32	200	19	12071999
Landsat	32	201	15	22062001
Landsat	32	201	16	21072000
Landsat	32	201	17	21072000
Landsat	32	201	18	04081999
Landsat	33 + 35	196	11	19091999
Landsat	33 + 35	197	11	25091999
Landsat	33	197	12	25072000
Landsat	33	197	13	25072000
Landsat	33	197	14	25072000
Landsat	33	199	12	24062001
Landsat	33	199	13	07091999
Landsat	33	200	11	15082000
Landsat	35	191	10	15091999
Landsat	35	191	11	15091999
Landsat	35	192	12	26082001
Landsat	35	193	10	15092000
Landsat	35	193	11	29072000
Landsat	35	193	12	29072000
Landsat	35	195	10	27072000
Landsat	35	195	11	27072000

Satellite images used in the segmentation and manual interpretation of ARFJELL.

Usage	Priority	County	Satellite	Year	Month	Scene
Segmentation	1	Troms	L7	2000	7	L7195_11_27juli2000
Segmentation	1	Hordaland	L5	2003	8	L5_199_018_09aug03
Segmentation	2	Troms	S4	2006	8	S4_46-207_20aug2006
Segmentation	2	Agder	L5	2003	8	L5199_19_9aug2003
Segmentation	3	Troms	L7	2001	8	L7198_11_20aug2001
Segmentation	3	Oppland	L7	1999	7	L7_198_017_NOR2_30jul99
Segmentation	4	Nordland	L7	2001	6	L7_199_012_NOR3_24jun01
Segmentation	4	Oppland	L5	1997	8	L5_200_017_15aug97
Segmentation	5	Troms	L7	1999	8	L7_198_012_15aug99
Segmentation	5	Sogn og Fjordane	S4	2006	7	S4_34-225_19juli2006
Segmentation	6	Nordland	L7	1999	9	L7_199_013_NOR3_07sep99
Segmentation	6	Sogn og Fjordane	S4	2007	8	S4_33-224_22aug2007
Segmentation	7	Hordaland	L7	1999	8	L7_201_018_NOR2_04aug99
Segmentation	7	Nordland	L7	2002	9	L7_198_014_NOR3_08sept02
Segmentation	8	Finnmark	L7	2000	7	L7193_11_29juli2000
Segmentation	8	Sør-Trøndelag	L7	1999	8	L7199_16_6aug1999
Segmentation	9	Finnmark	L7	2000	7	L7_195_010_NOR5_27jul00
Segmentation	9	Sør-Trøndelag	L5	1998	8	L5_199_015_11aug98
Segmentation	10	Finnmark	L7	1999	9	L7_191_10_15sep99
Segmentation	10	Sør-Trøndelag	L7	2002	8	L7198_16_23aug2002
Segmentation	11	Finnmark	L7	1999	9	L7_191_11_15sep99
Segmentation	11	Møre og Romsdal	L7	2000	7	L7_201_016_NOR2_21jul00

Segmentation	12	Sogn og Fjordane	L7	2000	7	L7_201_017_NOR2_21jul00
InterpretUTM32		Møre og Romsdal	L7	2001	6	L7_201_015_NOR2_22jun01
InterpretUTM32		Rogaland	L7	2000	8	L7b_200_019_29aug00
InterpretUTM33		Nordland	L5	1994	7	L519912_31juli1994
InterpretUTM33		Nordland	S4	2006	8	S4_42-211_20aug06
InterpretUTM33		Nordland	S4	2006	8	S4_42-208_15aug06
InterpretUTM33		Nordland	IRS	2005	7	IRS_1020_19jul2005
InterpretUTM33		Troms	L7	2000	7	L7_197_012_NOR3_25jul00
InterpretUTM33		Troms	L7	1999	9	L7_197_12_25sept1999
InterpretUTM33		Troms	L7	1999	9	L7_197_11_25sept1999
InterpretUTM33		Troms	L7	1999	9	L7_197_11_9sept1999
InterpretUTM34		Finnmark	IRS	2005	7	IRS1006_01jul2005
InterpretUTM34		Troms	S4	2006	8	S4_42-207_15aug06
InterpretUTM35		Finnmark	L7	2000	9	L7_193_010_NOR5_15sep00
InterpretUTM35		Finnmark	L7	2000	7	L7_193_012_NOR5_29jul00
InterpretUTM35		Finnmark	IRS	2005	7	IRS1017_06juli2005
InterpretUTM35		Finnmark	IRS	2005	7	IRS1009_02jul2005