SNOWTOOLS

RESEARCH AND DEVELOPMENT OF REMOTE SENSING METHODS FOR SNOW HYDROLOGY

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ABSTRACT

This paper describes the general frame, the aims and the organisation of the SNOWTOOLS project, with emphasis on the role of remote sensing.
The objectives of SNOWTOOLS project is to develop generic methods for correction and interpretation of optical and microwave data with the main aim of generating high-level products, improving the information extraction from microwave and optical data, and development of techniques for information extraction specific to snow hydrology.
The start of the three years project was October 1996, and the project is supported by the Commission of the European Community, Environment and Climate programme and end users.

The project has established close link with the user community represented by water resource management authorities, meteorology institutions and hydropower production companies, and they have been strongly involved in specification of high level snow hydrology products.
The user derived specification for high level snow products has been used to identify electromagnetic signature data gaps, required preprocessing algorithms to be implemented and definition of improvements in hydrological models. Electromagnetic signature gaps will be filled by updated information from dedicated field experiments using radiometers, scatterometers and ground truth sensors. By combining these data with snow structural measurement the development and validation of respective electromagnetic models will be performed, which also will take into account the effect of surface tilting and limited sky solid angle.
The models will be used in the evaluation and development of generic satellite multisensor classification algorithms.
Two dedicated remote sensing experiments, one for mountainous basins and one for boreal basins are carried out for both the development and validation of the project. HBV model has been chosen as candidate for enable maximum utilisation of remote sensing data. The performance of the developed generic methods will be determined and the improvements to existing methods quantified and evaluated by the end users.

1 INTRODUCTION

Snow cover has a substantial impact on processes regarding the interaction between atmosphere and surface, the knowledge of snow parameters is important in both climatology and weather forecast.
In the mountainous areas and in the whole North of Europe, snowfall is a substantial part of the overall precipitation. Both drought and flooding events cause severe damage and human suffering. Early forecasting and warning are important for preparatory actions in order to reduce damage. Better description of the hydrological status leads to improved hydrological forecasting for environmental hydrology (flood risk, low flows, freshwater habitat etc.) and operational purposes (hydropower, water supply, irrigation, river and canal navigation.

Snow is not only storage of water. A snow surface has a direct impact on micro- and macro-scale circulation models. Meteorological models, which take into account surface interactions, will benefit from more accurate snow parameters.

Models for global warming predicts a reduction in the area extent of snow cover and thus the global reflection of radiation, which in turn increases the total incoming energy. As a result of this positive feedback effect, the snow and ice bodies of the world are sensitive climatic indicators. Monitoring of these areas may provide early evidence of a possible climatic change

2 OUTLINE OF THE METHODOLOGY

The SNOWTOOLS project has established close link with the user community represented by Norwegian Water Resources and Energy Administration (N), Norwegian Meteorological Institute (N), Finnish Environment Agency (FIN), Environment Agency, Midland Region Water Resources (UK), UK Meteorological Office, Institut f”ur Schnee- und Lawinenforschung (CH) and the Norwegian Energy Corperation (Statkraft SF) (N). The users have been strongly involved in specification of high level snow hydrology products.
The user derived specification for high level snow products has been used to identify electromagnetic signature data gaps, required preprocessing algorithms to be implemented and definition of improvements in hydrological models. Electromagnetic signature gaps will be filled by updated information from dedicated field experiments using radiometers, scatterometers and ground truth sensors. By combining these data with snow structural measurement the development and validation of respective electromagnetic models will be performed, which also will take into account the effect of surface tilting and limited sky solid angle.
The models will be used in the evaluation and development of generic satelitte multisensor classification algorithms.
Two dedicated experiments, one for mountainous basins and one for boreal basins are carried out for both the development and validation of the project. Existing hydrological models has been reviewed. HBV model has been chosen as candidate for enable maximum utilisation of remote sensing data. The performance of the developed generic methods will be determined and the improvements to existing methods quantified and evaluated by the end users. There will be organised three major workshops during the project where scientists and representatives from end users will present and review the results of the project.

The activities in the project is broken down into seven workpackages.

WP100 Project management. The coordination, planning and communication with CEC is performed within this WP.

WP200 Preprocessing related to satellite data from passive microwave instruments, active microwave instruments and optical instruments are discussed. End user requirements to a satellite based snow data service are used to set the requirements for the geometric and radiometric accuracy of an image pixel.

WP300 Electromagnetic signature database assess the user needs for electromagnetic signatures of snowpacks. A database of electromagnetic signatures of natural land surface types, especially snow, is established.

WP400 Algorithms for analysis and classification
The aim of this part of the project is to develop methods for analysis and classification of remote sensing data for applications in snow hydrology (e.g. production of high-level products).

WP500 Integration with hydrological models Existing available hydrological models are reviewed . Modification to existing models will be performed in order to demonstrate the use of remote sensing data as one input data source.

WP600 Experiment and valdidation
The objective of the mountain and boreal basins campaigns is to acquire ground truth snow data for signature determination, algorithm development and result verification.

WP700 User Contacts and Dissemination maintain a close link to end users for requirement specification and evaluation.

3 PROGRESS TO DATE

The overall progress is according to plan and the major deliverables are accomplished.

Table 2 shows the contracted Milestones and deliverables as specified in the Project Work Programme.

TABLE 2:Project Milestones and Deliverable as specified in Project Work Programme

Date month	WP link	Mile stone	Leader	Deliverable
0	WP100/ all	M-1	NORUT	Project plan
3	WP 100		NORUT	-Status report to CEC -SNOW-TOOLS Electronic information on Internet
6	WP 100			-Status report to CEC
9	WP 100			-Status report to CEC
12	WP 100	M-2	NORUT	Technical progress report to CEC
15	WP 100			-Status report to CEC
18	WP 100		NORUT	-Status report to CEC
21	WP 100			-Status report to CEC
24	WP 100	M-3	NORUT	Technical progress report to CEC
27	WP 100			-Status report to CEC
30	WP 100		NORUT	-Status report to CEC
34	WP 100	M-4	NORUT	-Final report CEC -Confidential Exploitation possibilities report to CEC
6	WP 210 WP 210		NORUT	-Geometric and radiometric accuracy requirements. -State-of-the-art review report on correction algorithms.
18	WP 220		NORUT	Geocoding algorithms and products for optical and microwave data to CEC
3	WP 310		IAP	- User needs for electromagnetic signatures - Identified insufficient knowledge of electromagnetic signatures
4	WP 312		HUT	-List and short description of datasets and campaigns
24	WP 330		IAP	-Technical note to describe the impact of tilted surfaces.
24	WP 320		IAP	-Electromagnetic signatures to be implemented in the signature data base
24	WP 340	M-3		An electromagnetic signature catalogue to CEC
9	WP 400		NR	High level remote sensing snow products -review and reuirements to CEC
24	WP 400	M-3	NR	Data exploration and feature extraction for generation of high-level snow products
30	WP 400		NR	Classification algorithmms and inversion models for generation of high level snow products to CEC
34	WP 400	M4	NR	The optimal sensor for snow monitoring - recommandation to CEC.
4	WP 510		SINTEF	List of models, classified by application and user requirements, with remote sensing potential and requirements for each model type
12 12 30	WP 520		SINTEF	Specification of necessary model properties needed to make use of remotely sensed data to accomplish different modeling tasks. Specifications of selected modelsÕ sensitivity to remotely sensed data and their inaccuracy. Guidelines for future models
24	WP 530	M-3	SINTEF	-A prototype information system for operational monitoring and forecasting in hydrology adapted for utilizations of high level RS products to CEC.

	WP 610			
12 24	WP 620	M-2 M-3	SINTEF	Field reports stating measurement program and degree of success. Documented data sets to for each campaign to CEC.
24	WP 630	M-3	HUT	Detailed in situ and remote sensing (airborne and spaceborne) data sets for algorithm development and verification from boreal basins to CEC.
34	WP 640	M-4	SINTEF	Report on applicability of methods developed in the project for local and regional snow hydrology monitoring and management. A report evaluating the value of high level remote sensing products by comparison of model results with and without RS data to CEC.
3	WP 710		SINTEF	User survey report to CEC
34	WP 720	M-4	NORUT	User evaluation and recommendation report to CEC.

In Table 1 the achieved deliverables are marked.

4 PRELIMINARY CONCLUSION

WP200 Preprocessing.

- Snow covered area product using active microwave data requires a radiometic acuracy better than 0.5 dB.

WP300 Electromagnetic signature database

A few examples of data gaps are identified

- Active microwave measurements of snow-free and snow-covered, frozen, rocky or grassy ground at 5.3 and 35 GHz are missing in the catalogue.
- The influence of the vegetation (grass, shrubs, short vegetation and trees) on the radar measurements of snow cover was never studied in detail.
- The influence of the underlying ground is very important. The existing experiments tend to concentrate only on the snow, and little attention is given to the ground.
- There are virtually no signatures of naturally disturbed snow, e.g. by wind drift, precipitation (rain, hail) and avalanches.

The reviews of existing campaign have given the following conclusions:

- Many of the campaigns are concentrated on only one snow situation.
- The airborne measurements include normally only one overflight, and so the deviation due to repeated measurements in the same situation is not measured.
- The reliability and quality of the ground truth measurements is not considered in many cases.
- The influence of vegetation is not studied in detail
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WP400 Algorithms for analysis and classification

- Snow products have been defined based on user requirements, technology available currently and in the near future, and methodology expected feasible to develop within this project.
- Steered by the snow product specifications, the algorithms needed to be developed have been identified.
- Work has started on analysing multi-frequency/multi polarisation SAR data in order to develop algorithms for this type of data.
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WP500 Integration with hydrological models

The HBVmodel, extensively used in the Nordic countries, is selected for demonstration use within SNOWTOOLS. Severals improvements will be made to HBV in order to take remotely sensed snow data into use.

WP600 Experiments and validation

The mountain basin filed campaign in 1997 have establised a multi-temporal/sensor dataset for algorithm development. In the first year the mountain basin focused on acquisition of ERS and RADARSAT data combined with optical space and ariborne data..

The airborne campaigns over boreal basins provided an opportunity to train the necessary procedures but, did not provide data under snow-covered conditions.

WP700 User Contacts and Dissemination

The end users have been strongly involved in the high level product specification. Some of the results from the projects have been reported in international conferences. A WEB site is established for the SNOWTOOLS