

Representation of snow in NWP

Introductory remarks

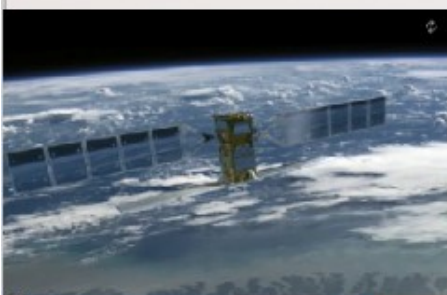
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COST ES1404 Pyry day seminar
Helsinki, 2. 11.2015



OBSERVATIONS



SNOW DATA
ASSIMILATION

Methods and
micromodels

OBSERVED
SNOW
VARIABLES

MODELS

snow parametrizations

NUMERICAL
WEATHER
PREDICTION
MODEL

HYDROLOGY
AND ICE
MODEL

CLIMATE
MODEL

DEDICATED
SNOW MODEL

Development
& validation
of models

APPLICATIONS

Weather forecast

Flooding

Avalanche

Water management

Traffic

Health and sport

Agriculture and
forestry

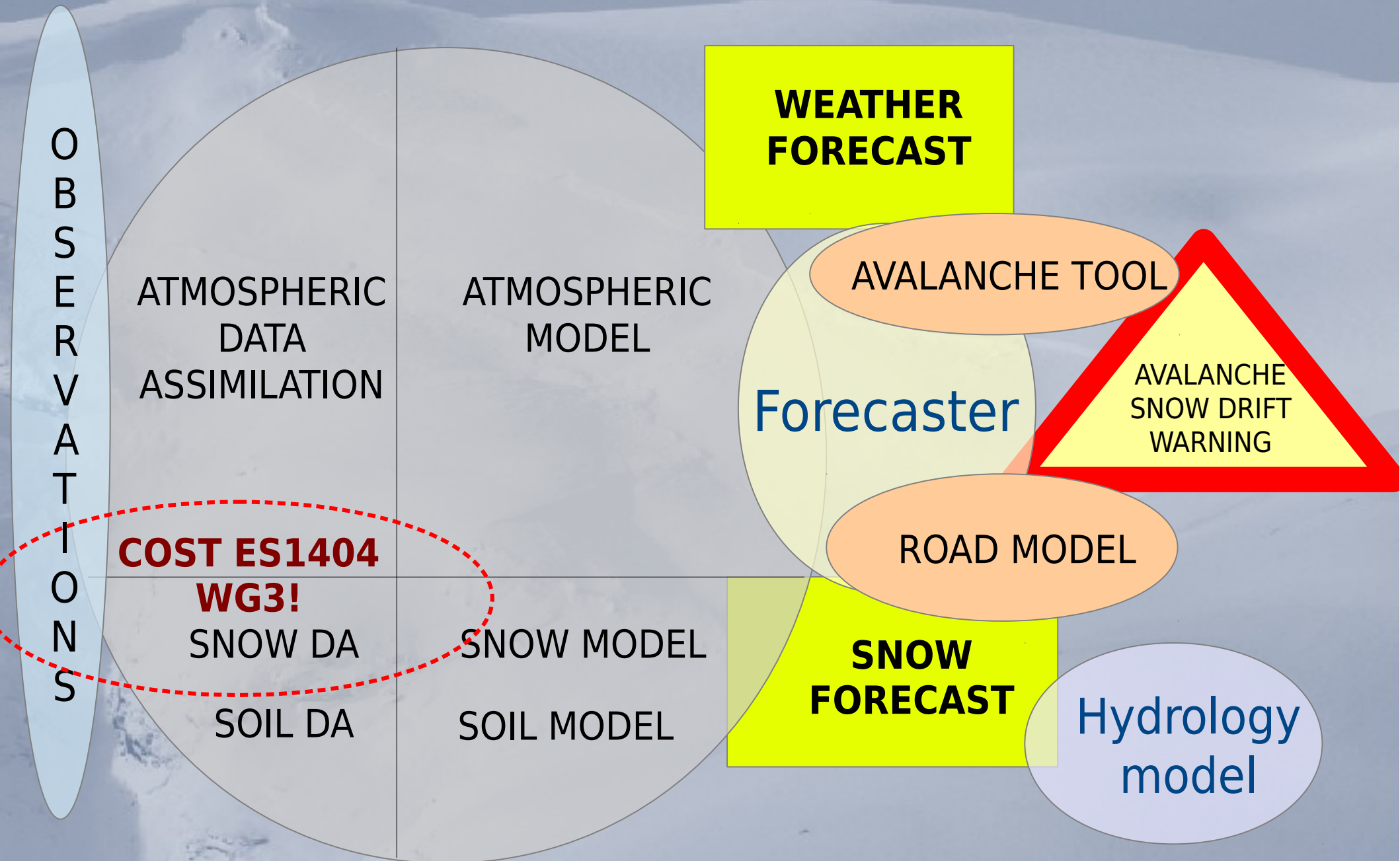
Climate scenarios

Interpretation of
results

PHYSICAL PROPERTIES OF SNOW COVER

snow water equivalent - temperature - density - grain size - albedo ...

Future NWP model for dedicated applications?



Local and remote sensing snow observations

SYNOP and climate stations:

Ultrasonic or manual snow depth measurements

- Represent local conditions

Satellite instruments:

Passive microwave sensors - e.g. SMSI

- Coarse resolution wide area snow water equivalent

Optical/NIR - e.g. MODIS

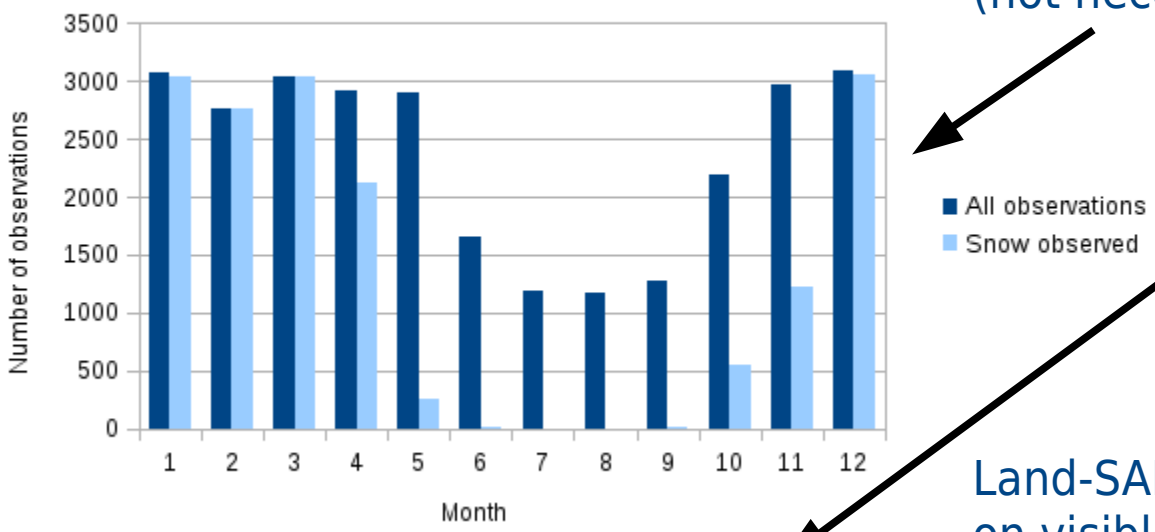
- High resolution snow extent
- Limited by cloud and light problems

Active microwave - e.g. SAR from ESA's Sentinel-1

- Very high resolution indication of wet snow
- Narrow swath – infrequent data

Availability of various snow observations over Finland

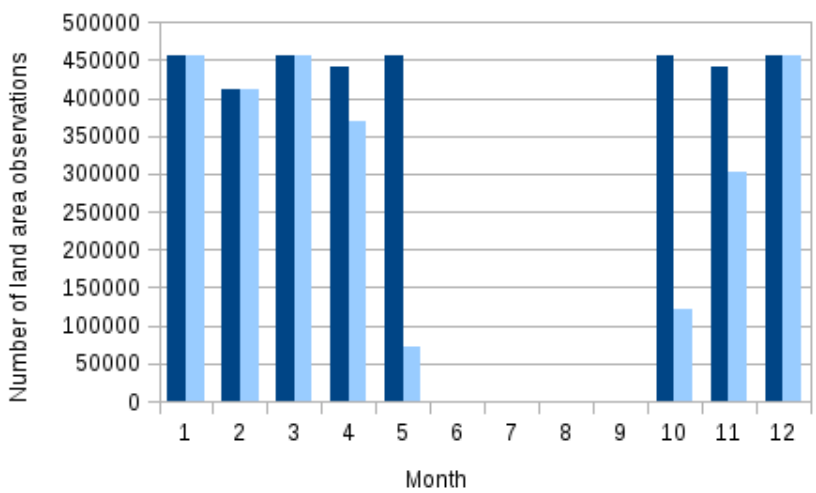
SYNOPSIS observations 1 July 2012 - 30 June 2013



Finnish SYNOPSIS snow depth observations which provide also no-snow information (not necessarily all transmitted via GTS)

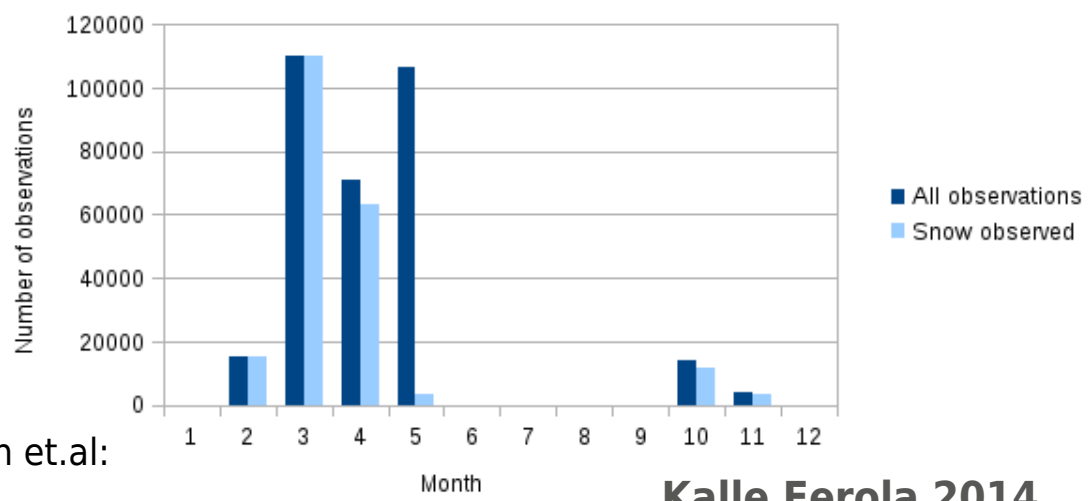
Snow extent from the Interactive Multisensor Snow and Ice Mapping System (IMS*): multi-sourced datasets such as passive microwave, visible imagery, operational ice charts and other ancillary data

IMS observations 1 July 2012 - 30 June 2013



Land-SAF snow extent from EUMETSAT is based on visible imagery from geostationary Meteosat second generation satellites (MSG)

Land-SAF observations 1 July 2012 - 30 June 2013



*National Snow and Ice Data Center (NSIDC), see Brown et.al: Remote Sensing of Environment 147 (2014) 65-78l,

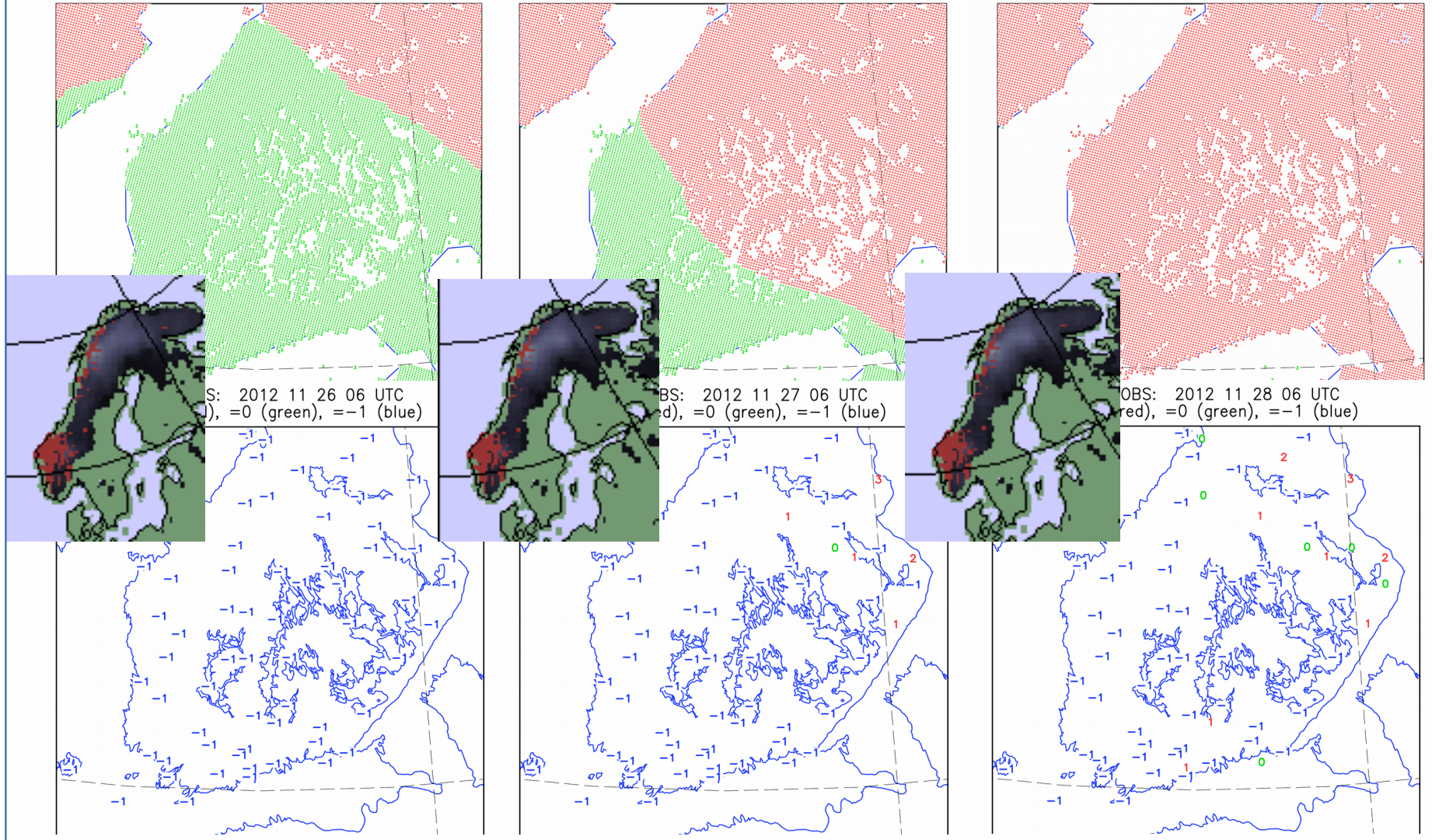
Example of the first snowfall in November 26-28 2012

IMS

IMS-NESDIS: 2012 11 26 Orig. 4km, Plotted 4km
1 (sea), 2 (land,green),3 (ice,blue),4 (snow,red)

IMS-NESDIS: 2012 11 27 Orig. 4km, Plotted 4km
1 (sea), 2 (land,green),3 (ice,blue),4 (snow,red)

IMS-NESDIS: 2012 11 28 Orig. 4km, Plotted 4km
1 (sea), 2 (land,green),3 (ice,blue),4 (snow,red)



Glob-
snow
SWE

SYNOP

(Land-SAF was not available those days)

What are the most valuable snow observations for NWP?

SYNOP + climate station snow observations, which provide also no-snow information

- Should be more widely available via GTS
- Should include the national group with no-snow information
- NWP models should read correctly the extended SYNOP code

Remote sensing observations

- 1) Snow water equivalent by passive microwave sensors
- 2) Snow extent seen by visible and derived from passive and active microwave signals
- 3) Snow wetness indicated by SAR instruments

Dilemma of using satellite data: ready-made products or spatialization + assimilation of the signals within the surface DA of NWP models?

- Satellites with varying instrument specifications come and go – building long-lasting operational systems is difficult
- Products contain assumptions and rely on additional data sources different from those applied in NWP framework
- NWP model may provide up-to date background based on prognostic snow parametrizations – for quality control, for assimilation

e.g. IMS and Globsnow SWE are products, while SAR backscattering from the just launched Sentinel-1 would represent a raw signal

How to use advanced snow schemes in NWP?

Our aim:

Multilayer prognostic **soil** + Soil data assimilation +
Multilayer prognostic **snow** - **vegetation** + Snow data assimilation

The problem:

Multilayer soil and snow schemes and MEB have been developed
for climate models without any data assimilation

Solution would require some work:

Soil Scheme	Soil DA	Snow scheme	Snow-veg scheme	Snow DA	Application
Force-restore	OI/EKF +OI (Canari)	D95	none	snowOI (Canari)	NWP
		ES	MEB	[[snowOI/VAR/EKF]] +snowOI (Canari)	NWP
			none	[{snowOI/VAR/EKF}] +snowOI (Canari)	NWP
			CRO	MEB	[{snowOI/VAR/EKF}] +snowOI (Canari)
			none	[{snowOI/VAR/EKF}] +snowOI (Canari)	NWP
	none	D95	none	none	climate
		ES	MEB	none	climate
			none	none	climate
		CRO	MEB	none	climate
			none	none	climate
Multi-layer	{OI/VAR/EKF} +OI (Canari)	D95	none	snowOI (Canari)	NWP
		ES	MEB	[[snowOI/VAR/EKF]] +snowOI (Canari)	NWP
			none	[{snowOI/VAR/EKF}] +snowOI (Canari)	NWP
		CRO	MEB	[{snowOI/VAR/EKF}] +snowOI (Canari)	NWP
			none	[{snowOI/VAR/EKF}] +snowOI (Canari)	NWP
	none	D95	none	none	climate
		ES	MEB	none	climate/ NWP?
			none	none	climate
		CRO	MEB	none	climate
			none	none	climate
September 2014 / EK					

BLUE: exists RED: does not exist { }: not started yet []: not absolutely necessary

Table by Ekaterina Kurzeneva, 2014

On the status of snow in NWP

Simple snow schemes are used in present NWP models,
with snow mass, density, albedo in one layer
but advanced multilayer prognostic snow schemes exist

Horizontal interpolation via optimal interpolation is
applied to conventional snow depth observations
but a lot more remote sensing and local snow cover
observations exist

Advanced data assimilation methods will be needed
to combine multilayer prognostic snow and soil
parametrizations with various types of remote-sensing
observations in operational NWP models