Working Group 3

Snow data assimilation and validation methods for NWP and hydrological models

in

COST ES1404

WG3

Models

Snow schemes

NWP

Hydrology

Climate

Observations

Assimilation

Conventional

Remote Sensing

High-res networks

WG1

WG2

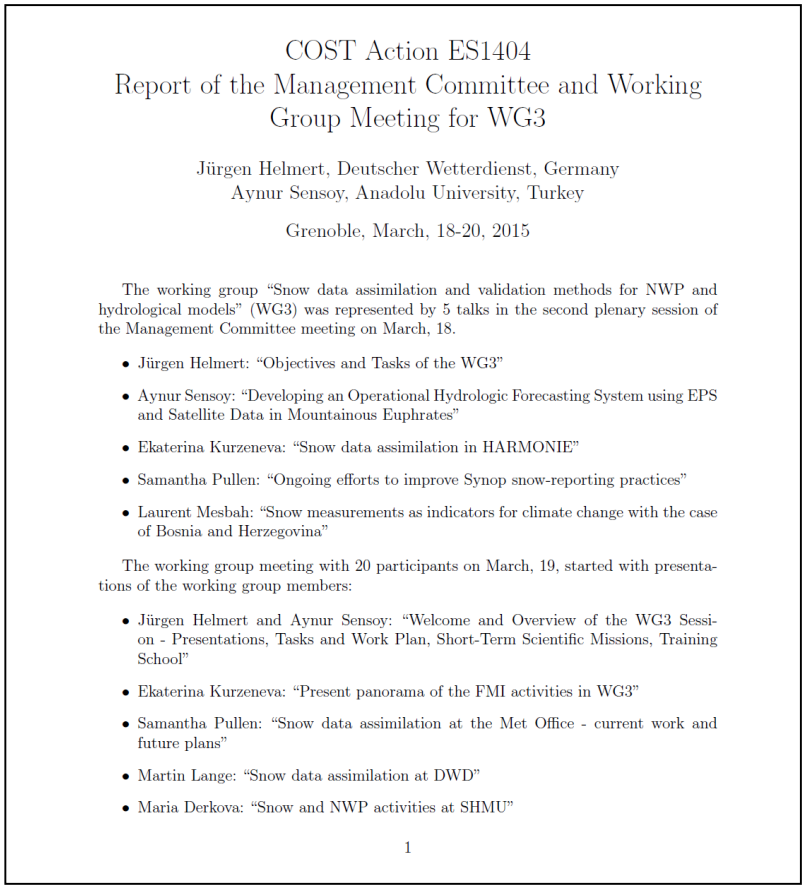
COST ES1404

Key questions for 2015:

- How many and which kind of snow observations are assimilated in numerical weather prediction and hydrological models?
- What are the data assimilation methods used in meteorology and hydrology for snow observations?

Meetings of the WG3

- First meeting of the WG3 in Grenoble, 18-20 March, 2015



COST Action ES1404
Report of the Management Committee and Working Group Meeting for WG3

Jürgen Helmert, Deutscher Wetterdienst, Germany
Aynur Sensoy, Anadolu University, Turkey

Grenoble, March, 18-20, 2015

The working group "Snow data assimilation and validation methods for NWP and hydrological models" (WG3) was represented by 5 talks in the second plenary session of the Management Committee meeting on March, 18.

- Jürgen Helmert: "Objectives and Tasks of the WG3"
- Aynur Sensoy: "Developing an Operational Hydrologic Forecasting System using EPS and Satellite Data in Mountainous Euphrates"
- Ekaterina Kurzeneva: "Snow data assimilation in HARMONIE"
- Samantha Pullen: "Ongoing efforts to improve Synop snow-reporting practices"
- Laurent Mesbah: "Snow measurements as indicators for climate change with the case of Bosnia and Herzegovina"

The working group meeting with 20 participants on March, 19, started with presentations of the working group members:

- Jürgen Helmert and Aynur Sensoy: "Welcome and Overview of the WG3 Session - Presentations, Tasks and Work Plan, Short-Term Scientific Missions, Training School"
- Ekaterina Kurzeneva: "Present panorama of the FMI activities in WG3"
- Samantha Pullen: "Snow data assimilation at the Met Office - current work and future plans"
- Martin Lange: "Snow data assimilation at DWD"
- Maria Derkova: "Snow and NWP activities at SHMU"

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- 20 participants
- 5 talks in plenum, 12 talks in WG
- Minutes of the meeting available

Tasks

- *Overview* of the various *snow observations* used in NWP, hydrology and climate studies for *different purposes* including validation and data assimilation (e.g. different snow observations are used in different environmental applications).

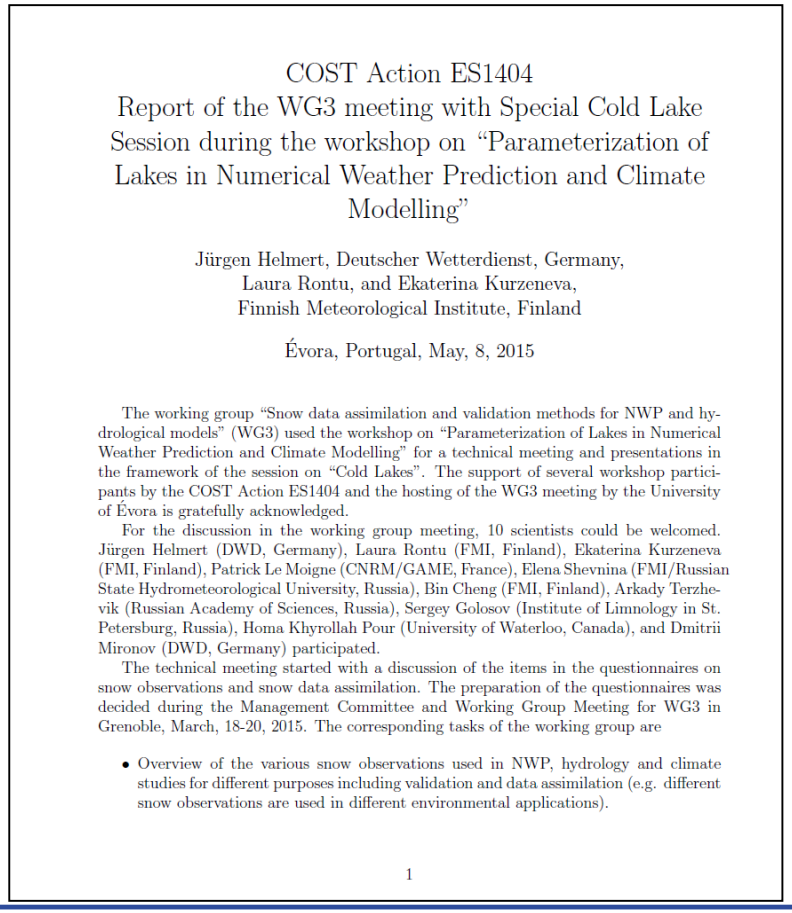
  Decision: Preparing a questionnaire for snow observations in meteorology and hydrology communities (categories of data types, parameters, frequency, scales, format, demands).

- For *data assimilation*, different methods are used in NWP and hydrology. The overview will allow to *assess* the current situation and to understand future *perspectives*.

  Decision: Preparing a questionnaire for data assimilation in meteorology and hydrology, Short description of methodology, example of application will provided.

Meetings of the WG3

- Second meeting with Special Cold Lake Session during the workshop on Lakes in NWP and Climate modelling in Evora, May 8, 2015



COST Action ES1404
Report of the WG3 meeting with Special Cold Lake Session during the workshop on "Parameterization of Lakes in Numerical Weather Prediction and Climate Modelling"

Jürgen Helmert, Deutscher Wetterdienst, Germany,
Laura Rontu, and Ekaterina Kurzeneva,
Finnish Meteorological Institute, Finland

Évora, Portugal, May, 8, 2015

The working group "Snow data assimilation and validation methods for NWP and hydrological models" (WG3) used the workshop on "Parameterization of Lakes in Numerical Weather Prediction and Climate Modelling" for a technical meeting and presentations in the framework of the session on "Cold Lakes". The support of several workshop participants by the COST Action ES1404 and the hosting of the WG3 meeting by the University of Évora is gratefully acknowledged.

For the discussion in the working group meeting, 10 scientists could be welcomed. Jürgen Helmert (DWD, Germany), Laura Rontu (FMI, Finland), Ekaterina Kurzeneva (FMI, Finland), Patrick Le Moigne (CNRM/GAME, France), Elena Shevnina (FMI/Russian State Hydrometeorological University, Russia), Bin Cheng (FMI, Finland), Arkady Terzhevik (Russian Academy of Sciences, Russia), Sergey Golosov (Institute of Limnology in St. Petersburg, Russia), Homa Khyrollah Pour (University of Waterloo, Canada), and Dmitrii Mironov (DWD, Germany) participated.

The technical meeting started with a discussion of the items in the questionnaires on snow observations and snow data assimilation. The preparation of the questionnaires was decided during the Management Committee and Working Group Meeting for WG3 in Grenoble, March, 18-20, 2015. The corresponding tasks of the working group are

- Overview of the various snow observations used in NWP, hydrology and climate studies for different purposes including validation and data assimilation (e.g. different snow observations are used in different environmental applications).

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- 10 participants
- 6 presentations
- Minutes of the meeting available

Tasks

Questionnaire on snow observations in working group 3

Overview of the various snow observations used in NWP, hydrology and climate studies for different purposes including validation and data assimilation (e.g. different snow observations are used in different environmental applications)

* Erforderlich

In which modeling field you are using snow observations? *

- Numerical Weather Prediction
- Hydrology
- Climate Simulations
- Special Snow model
- Sonstiges:

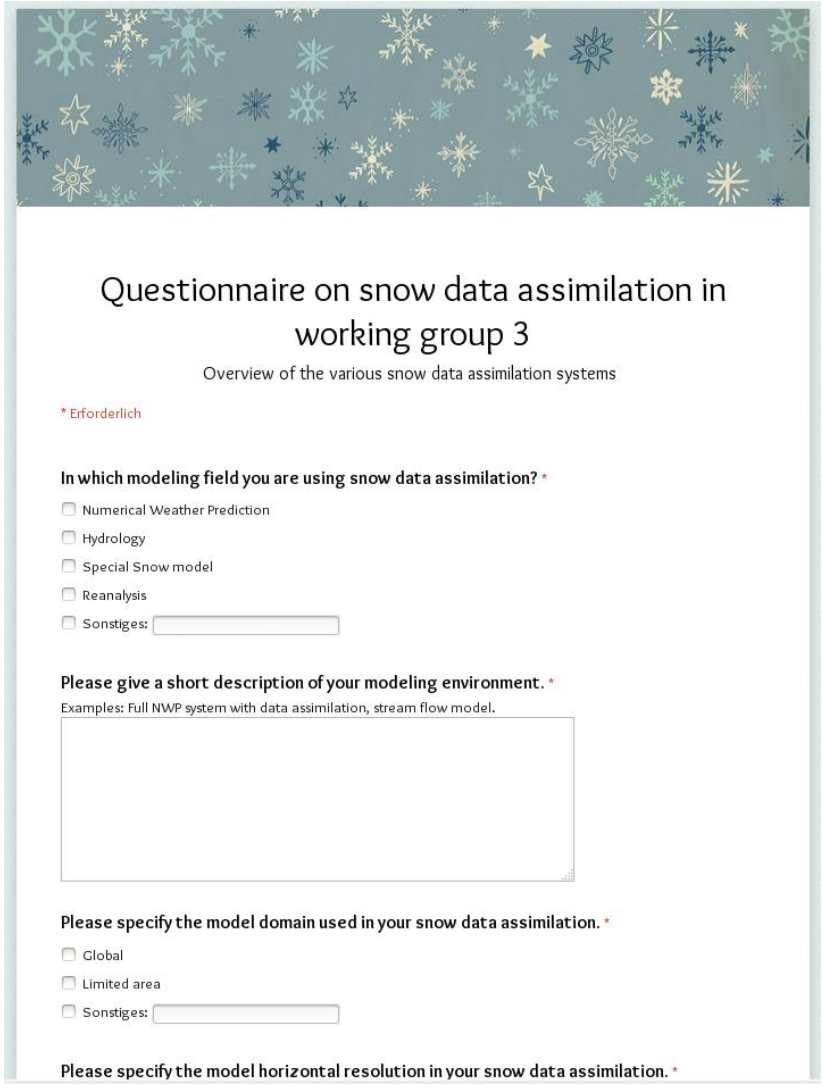
In which component of your modeling process you are using snow observations? *

- Data assimilation
- Validation
- Verification
- Calibration
- Sonstiges:

Which observations are used in your data sets. *

- SYNOP
- non-SYNOP ground-based
- Remote sensing ground-based
- Remote sensing satellite

+



Questionnaire on snow data assimilation in working group 3

Overview of the various snow data assimilation systems

* Erforderlich

In which modeling field you are using snow data assimilation? *

- Numerical Weather Prediction
- Hydrology
- Special Snow model
- Reanalysis
- Sonstiges:

Please give a short description of your modeling environment. *

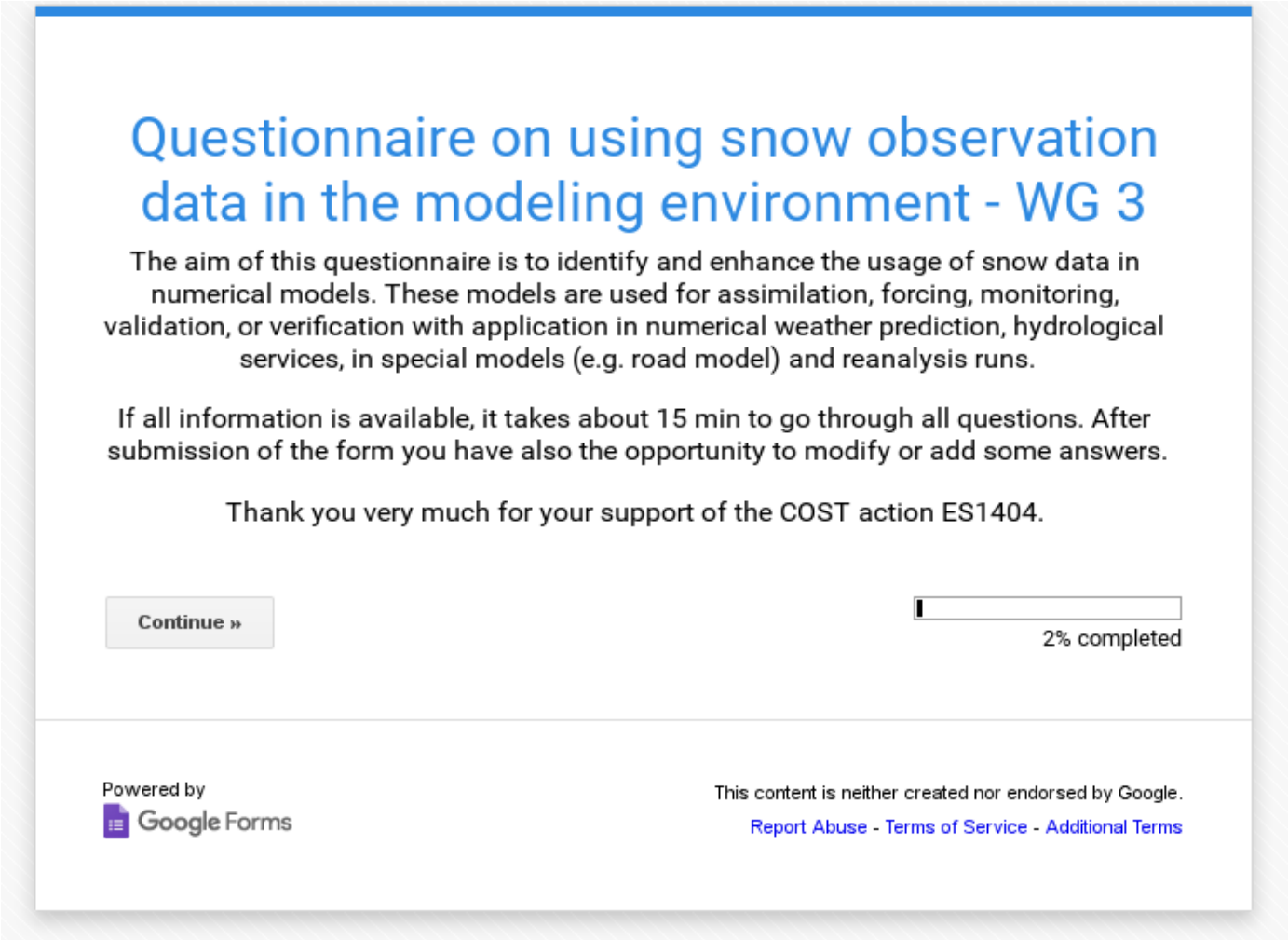
Examples: Full NWP system with data assimilation, stream flow model.

Please specify the model domain used in your snow data assimilation. *

- Global
- Limited area
- Sonstiges:

Please specify the model horizontal resolution in your snow data assimilation. *

Tasks



Questionnaire on using snow observation data in the modeling environment - WG 3

The aim of this questionnaire is to identify and enhance the usage of snow data in numerical models. These models are used for assimilation, forcing, monitoring, validation, or verification with application in numerical weather prediction, hydrological services, in special models (e.g. road model) and reanalysis runs.

If all information is available, it takes about 15 min to go through all questions. After submission of the form you have also the opportunity to modify or add some answers.

Thank you very much for your support of the COST action ES1404.

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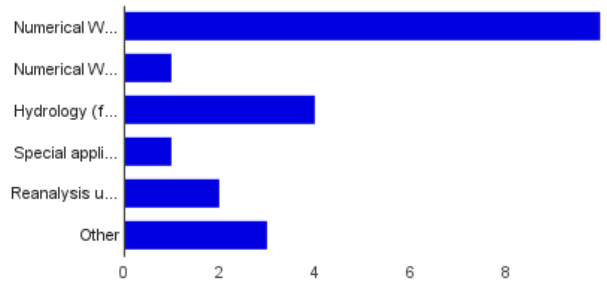
First results - 15 responses

Meteo-France
ZAMG - Institute for Meteorology and Geodynamics, Vienna
University of Edinburgh
Météo-France/CNRS
Norwegian Meteorological Institute
FMI
Met Office
Cukurova university
Deutscher Wetterdienst
MeteoSwiss
ECMWF

Modeling environment

In which modeling environment you are using snow observation data?

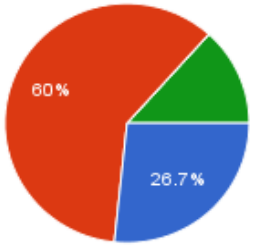


Numerical Weather Prediction with snow data assimilation	**10**	66.7%
Numerical Weather prediction without snow data assimilation	**1**	6.7%
Hydrology (forcing using snow data)	**4**	26.7%
Special application (e.g. road model with snow data)	**1**	6.7%
Reanalysis using snow data	**2**	13.3%
Other	**3**	20%

First results - 15 responses

Modeling domain

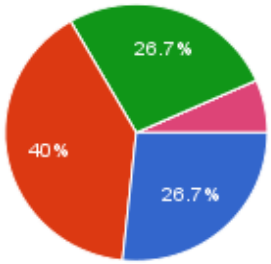
Please specify the modeling domain used in your application.



Global	4	26.7%
Limited area	9	60%
One-way/two-way nesting of domains	0	0%
Other	2	13.3%

Model resolution

Please specify the model horizontal resolution.

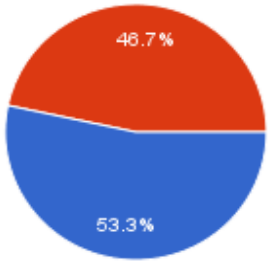


Below 1 km	4	26.7%
Between 1km and 5 km	6	40%
Between 5km and 10 km	0	0%
Between 10 km and 20 km	4	26.7%
Between 20km and 50 km	0	0%
Larger than 50 km	0	0%
Other	1	6.7%

First results - 15 responses

Data assimilation questions

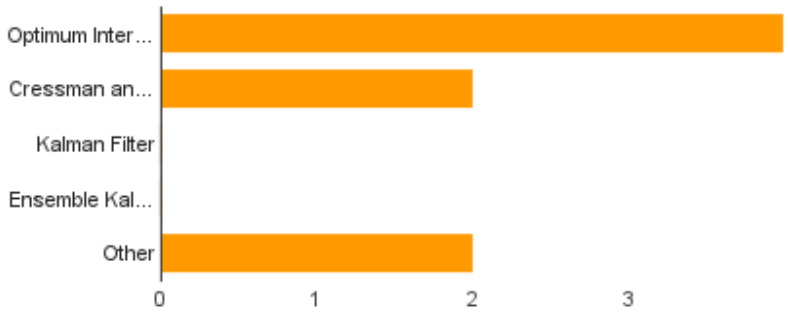
I would like to answer the questions regarding data assimilation



Yes	**8**	53.3%
No	**7**	46.7%

Data assimilation method

Which data assimilation method is used in your system for snow observations?

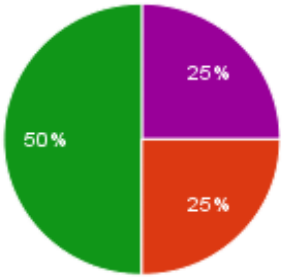


Optimum Interpolation	**4**	50%
Cressman analysis method	**2**	25%
Kalman Filter	**0**	0%
Ensemble Kalman Filter	**0**	0%
Other	**2**	25%

First results - 15 responses

Data assimilation update frequency

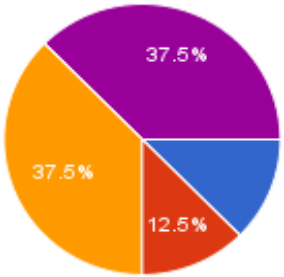
Which update frequency is used for your snow data assimilation?



1 hour	**0**	0%
6 hours	**2**	25%
12 hours	**0**	0%
1 day	**4**	50%
Other	**2**	25%

Data assimilation window

During which time interval (window) snow observations are considered in your snow data assimilation?



1 hour	**1**	12.5%
3 hours	**1**	12.5%
6 hours	**3**	37.5%
12 hours	**0**	0%
Other	**3**	37.5%

First results - 15 responses

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

SYNOP information

Which information from SYNOP is used for your snow data assimilation?

Snow height, Precipitation in combination with T2M-temperature If missing information from ww reports is used to retrieve snow height increments

snow height, 6-hourly precipitation, T2m, weather type (ww)

Snow height

Snow depth

None

none

Snow depth, state of ground where available (for diagnosing snow-free) Probably also T2m for quality control.

Snow height. To my understanding there is no SWE in SYNOP!

Model variables

What model state variable(s) is/are analysed in your snow data assimilation system?

Snow Water Equivalent and snow density

Snow depth

Snow water equivalent

snow amount (kgm-2) - areal density

snow water equivalent, snow density, snow pack temeprature, interception water storage

all the snow variables

Snow amount (areal density, kgm-2)

SWE

First results - 15 responses

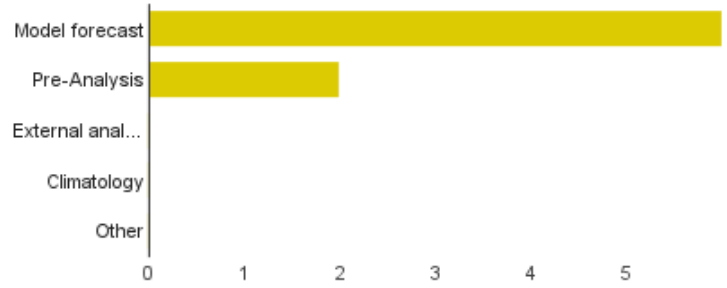
Processing

How is the key parameter/ How are the analysed variable(s) processed in your snow data assimilation system?

Update of absolute values	2	25%
Incremental update of first guess from model forecast	4	50%
Other	2	25%

Background field

Which background field is used in your snow data assimilation?



Model forecast	6	75%
Pre-Analysis	2	25%
External analysis	0	0%
Climatology	0	0%
Other	0	0%

First results - 15 responses

Background error estimates

Which estimates of the background error are used in your snow data assimilation?

Background error not accounted for

not applicable

Errors are not considered

distance weighted (horizontal and vertical)

Background error covariances specified as product of background error variance and horizontal and vertical structure functions Horizontal structure function: 2nd order autoregressive function of horizontal separation (of obs and grid point, and of pairs of obs) Vertical structure function: Gaussian function of vertical separation (of obs and grid point, and of pairs of obs) Background error variance: estimate based on other Centres' experience Assimilation scheme still under development, so parameter values not yet finalised

A fixed value of background error is used. Horizontal and vertical weighted functions are accounted for in the OI.

prescribed constant value (I think)

distance weighted (horizontal/vertical)

First results - 15 responses

Observation error estimates

Which estimates of observation errors are used in your snow data assimilation?

Assumed to be uncorrelated. Observation errors for SYNOP snow depth and snow depth diagnosed from satellite snow cover will be estimated, based on experience of ECMWF.

Errors are not considered

Observations are suposed to have uncorrelated errors. Standard deviations of observation and background errors are both 5 kg/ m2.

None

MODIS surface reflectance errors

Observation errors not accounted for. However, some anomalous observations are identified and rejected from the assimilation by quality control procedures.

A fixed observation error is used.

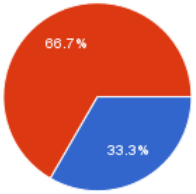
Prescribed constant value (in principle different for different observation types, but only SYNOP snow thickness is used)

First results - 15 responses

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Observation data

I would like to answer the questions on snow observations from WG1/WG2



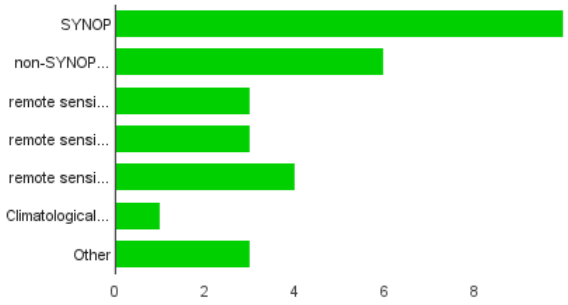
Yes	5	33.3%
No	10	66.7%

Observation data

Further questions on snow observation data

Snow observations and products used in the modeling system

Snow observations and products

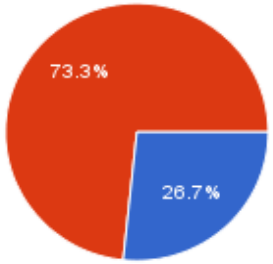


SYNOP	10	66.7%
non-SYNOP ground based	6	40%
remote sensing ground based (utrasonic, laser)	3	20%
remote sensing satellite (radiances)	3	20%
remote sensing satellite (preprocessed product - SAF)	4	26.7%
Climatological data sets	1	6.7%
Other	3	20%

First results - 15 responses

Remote sensing ground-based

Do you use ground-based remote sensing measurements or products



Yes	**4**	26.7%
No	**11**	73.3%

Remote sensing ground-based

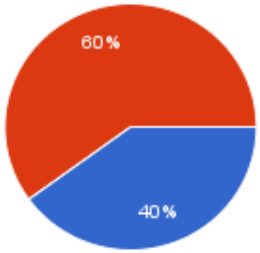
Please specify the system you use for ground-based remote sensing snow properties measurements

df
Lufft (Jenoptik) distance measurement with laser. Ground network of 50+ stations across all regions and altitudes in Austria.
ultra-sonic
ultrasonic depth gauges microwave radiometers

First results - 15 responses

Preprocessed product

Do you use preprocessed snow products



Yes	**6**	40%
No	**9**	60%

Preprocessed product

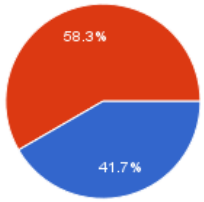
Please specify the system you use for preprocessed product of snow properties

Snow depth from IMS snow analysis
Snow extent from Meteosat (SEVIRI) and from NOAA (AVHRR).
MODIS fractional snow cover 250 m resolution
NOAA NESDIS Interactive Multisensor Snow and Ice Mapping System (IMS)
H-SAF daily snow cover product (H31)
IMS snow cover product

First results - 15 responses

Data consistency

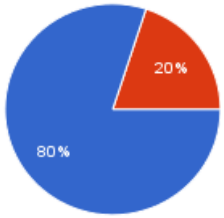
Do you perform a consistency check of snow observations or products



Yes	5	41.7%
No	7	58.3%

Processing - Quality control

Do you perform a quality control of snow observations or products



Yes	12	80%
No	3	20%

Data consistency

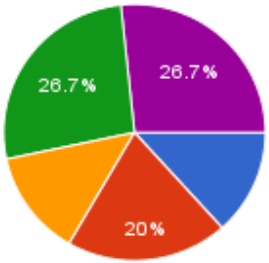
Which data consistency checks are performed in your modeling environment?

limit snow depth depending on air temperature
Calculation of sum of weights for snow depth (1) and snow depth increments calculated from precip and t2m (2) Use snow height only when weight from contributing obs (1) exceeds min value, use snow depth increment (2) else when average weight of (1) and (2) exceeds min value.
snow water equivalent only greather than zero when snow depth is greather than zero.
consistency of accumulated snow mass and snowfall
Analysis increments will only be added if surface T is below a threshold Snow-free state of ground reports will only be used if snow depth is absent

First results - 15 responses

Observation data latency

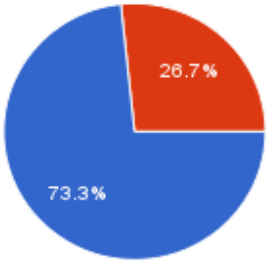
Which observation data latency is acceptable for your modeling environment?



Below 1 hour	2	13.3%
Below 3 hours	3	20%
Below 6 hours	2	13.3%
Below 12 hours	4	26.7%
Other	4	26.7%

Access requirements

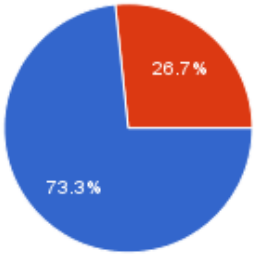
Is it possible to exchange the snow data used in your modeling environment with other groups



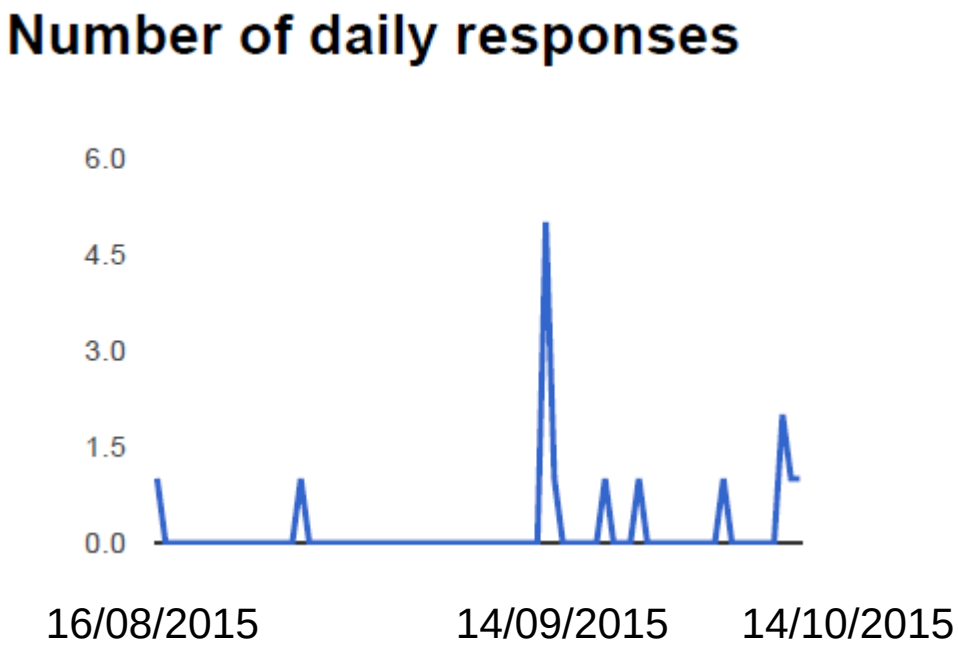
Yes	11	73.3%
No	4	26.7%

First results - 15 responses

Do you have concrete plans to use the new or upcoming observation sources that could be interesting for your modeling environment?



Yes	**11**	73.3%
No	**4**	26.7%



Discussion

- Number of responses, more/other questions, evaluation
- Connection to WG1/WG2, user demand

Items and subjects from WG3 members

- Information exchange
- Discussion

Working group topics for 2016

Next Tasks

- A critical review of *snow models* utilizing physical snow *parameters* as input and used as parametrization schemes or for downstream applications (CROCUS, Snowpack, SNTHERM) will be included.

  Preparing a questionnaire, using existing model intercomparison experience (e.g. SNOWMIP2), investigating interoperability of snow models with data assimilation, consider model sophistication.

- Establish *links* between different *communities* of users of snow observation.

  Two-way feedback between working groups, preparing a guide for end users.

Models

Snow schemes

CROCUS | TERRA | JULES | Snowpack | SNTHERM

- Treatment of snow processes (metamorphism, liquid water)
- Considered complexity (one-layer, multi-layer schemes)
- Grid-scale and subgrid-scale features (snow tiles)
- Interaction with other land-surface properties (e.g. vegetation)

Next Tasks

Key question for next phase of the project :

- How could the assimilation of snow observations be improved?

Next Tasks

- Finding a *new* method for combining *satellite* observations with *conventional* in-situ snow measurements and *modelling* results: Microwave satellite observations are combined with conventional in-situ observations in some products (Hydro-SAF), while optical satellite observations together with conventional in-situ observations are assimilated into NWP models.
  Will be considered in a later stage of the project.

- *Sustainable* principles to *combine* all types of information should be found. This will allow *advanced assimilation* of new and forthcoming satellite observations of different snow properties (snow-melt, snow extent and SWE).
  Will be considered in a later stage of the project.

- This approach will also need *new methods* to update *non-observed* simulated physical snow variables (such as snow wetness, density profiles and mechanical properties) based on the observed ones (such as snow depth and extent).
  Will be considered in a later stage of the project.

Next Tasks

- Looking for *strategies* towards a more *extended usage* of *conventional* snow observations to include observations from high-resolution *national networks* into NWP, hydrological and climate models, as the use of data from national networks is currently very limited.

  Considering a Web-Portal solution for data exchange (e.g. similar to OPERA for radar data); taking into account zero snow height information; Inform national and international institutions about COST action needs.

- Their *impact* will be assessed and *recommendations* how to increase their availability will be given.

  Will be considered in a later stage of the project.

- *Acquiring* more information about *observational errors* relevant for DA by establishing *links* between the *modelling* and *measurement* communities via *WG1* and *WG2*. These links will also provide the *users' feedback* to the measurement community by reporting about the *quality of data* and potential problems.

  Exchange of information about representativeness of data, making realistic estimation of observation errors, managing deficiencies of observations.

Working group topics for 2016

Discussion

- Review of snow models, connecting to WG1/2 and user communities
- First steps for next phase of the project (Improving data assimilation)
- Others