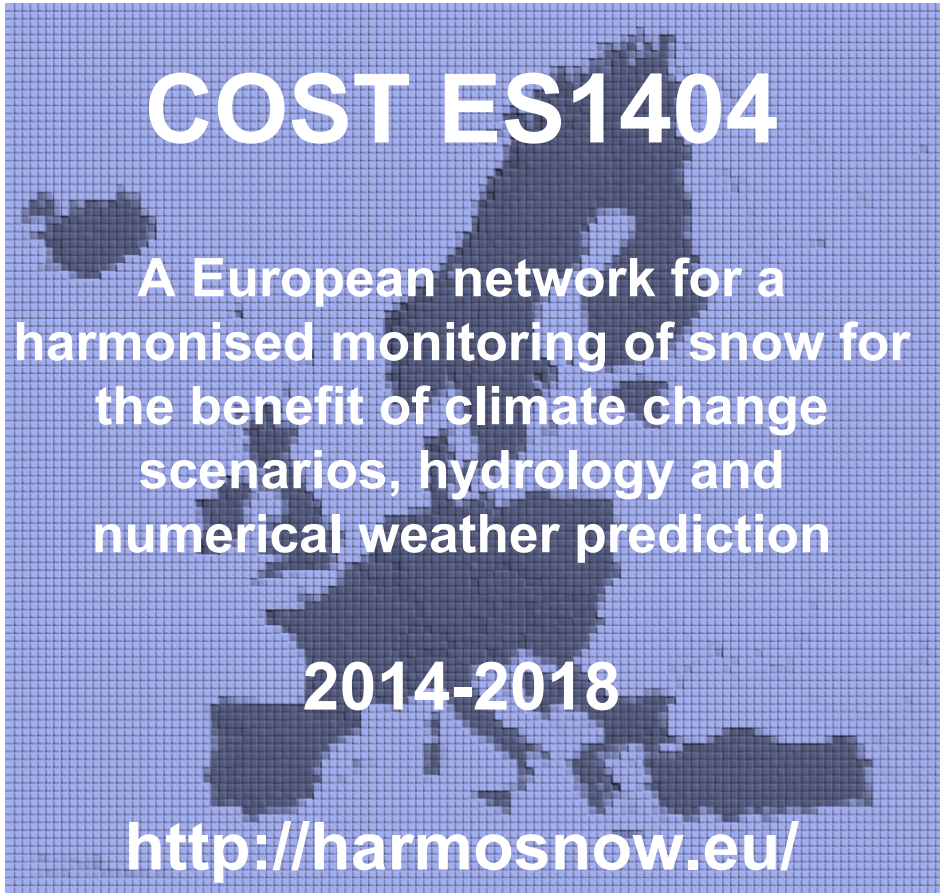
Deutscher Wetterdienst
Wetter und Klima aus einer Hand



Jürgen Helmert with contributions from Maxime Quenon et al., Samantha Pullen, Patricia de Rosnay, Marie Dumont et al., Vasco Conde et al., Pierfrancesco Da Ronco and Carlo De Michele

Aim of COST ES1404

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To enhance the capability of the *research community* and *operational services* to provide and exploit *quality-assured* and comparable regional and *global observation-based data* on the variability of the state and extent of *snow*.

Action Objectives & Benefits

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1) Establish a European-wide science network on snow measurements

2) Assess and harmonise practices, standards and retrieval algorithms applied to ground, air- and space-borne snow measurements

3) Develop a rationale and long term strategy for snow measurements, their dissemination and archiving.

4) Advance snow data assimilation in European NWP and hydrological models

5) Establish a validation strategy for climate, NWP and hydrological models against snow observations

6) Training of a new generation of scientists on snow science and measuring techniques

Structure – Working groups

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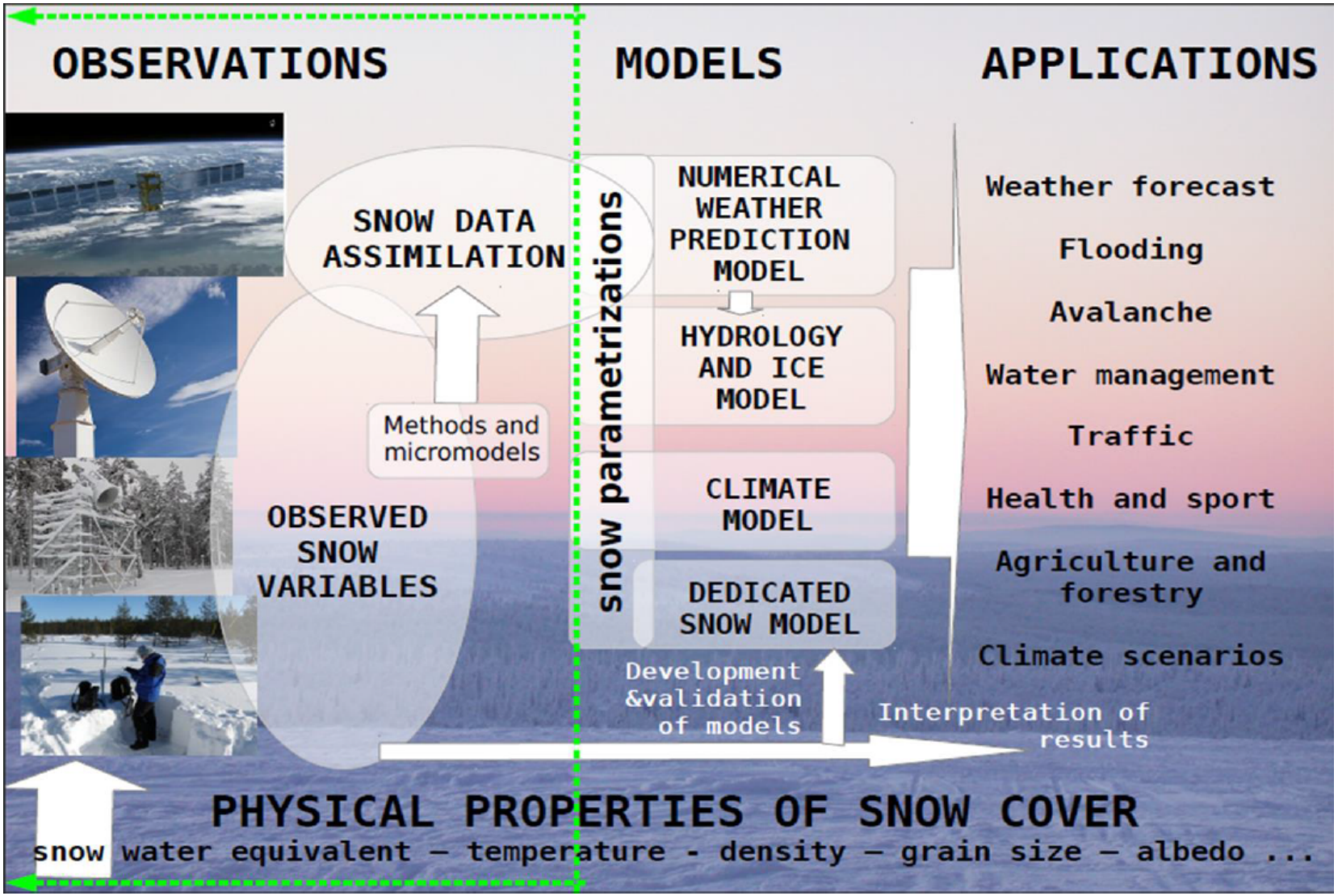
WG1: Physical characterization of snow properties

WG2: Instrument and method evaluation

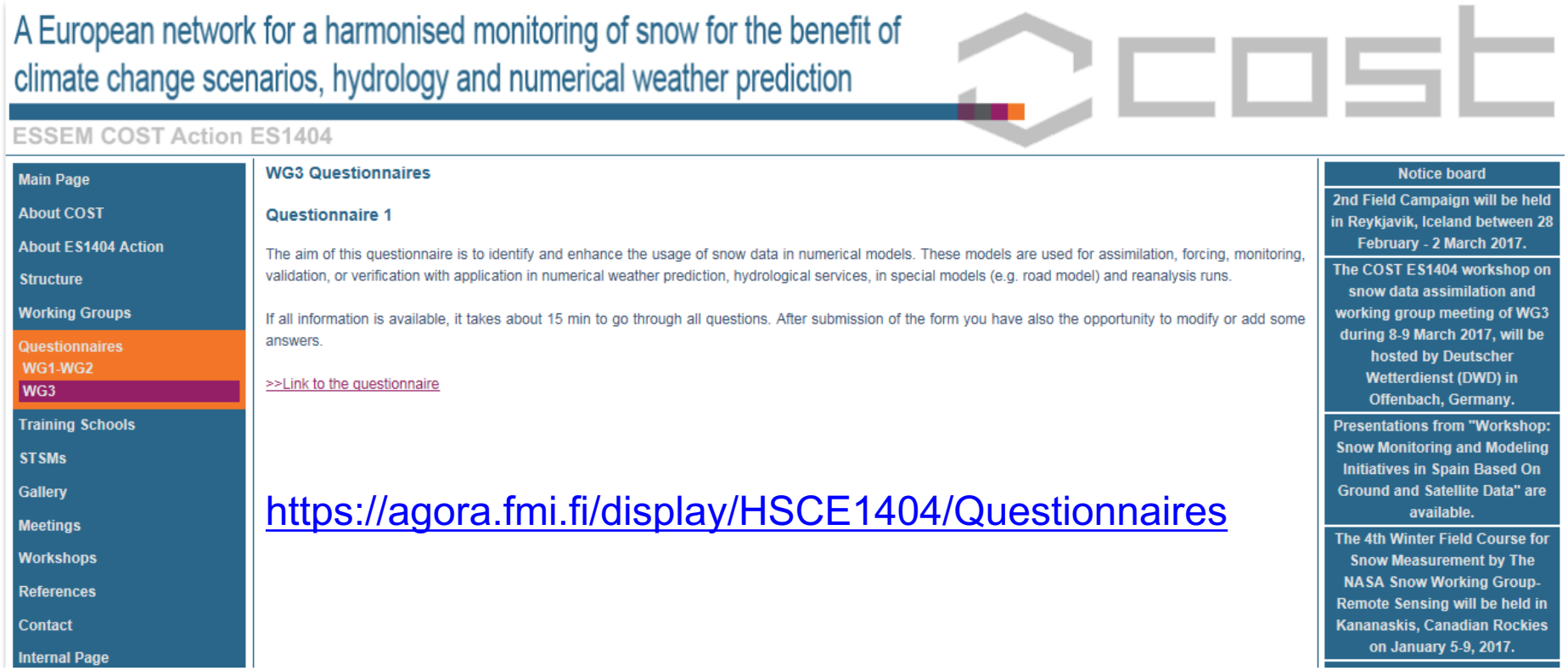
WG3: Snow data assimilation and validation methods for NWP and hydrological models

Structure – Working groups



Tasks

Task 3.1: Overview of the various snow observations used in NWP, hydrology and climate studies for different purposes including validation and data assimilation



Tasks

Task 3.2: Finding a new method for combining satellite observations with conventional in-situ snow measurements and modelling results.

Task 3.3: 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.

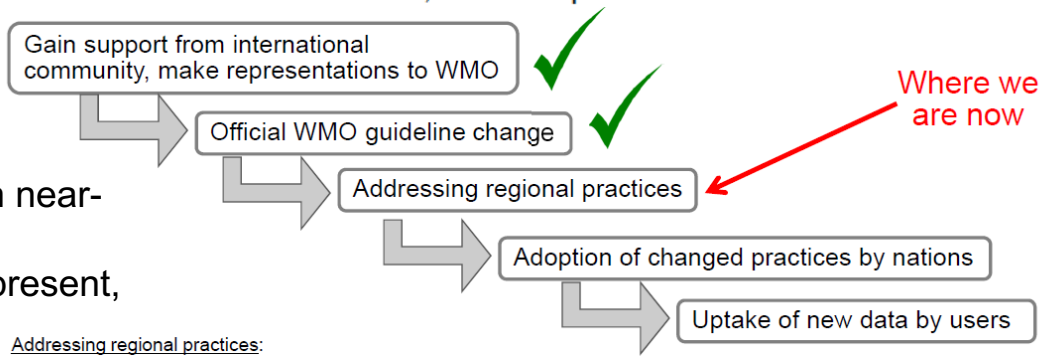
Task 3.4: Acquiring more information about observational errors relevant for DA by establishing links between the modelling and measurement communities via WG1 and WG2.

Met Office

In situ snow depth observations – improving reporting practices and data exchange

In situ measurements of snow depth are of vital importance for global Numerical Weather Prediction and are currently the only quantitative observation of snow depth of sufficient quality for assimilation into operational weather forecasting models.

There is an ongoing activity by GCW Snow Watch to improve the reporting practices for in situ snow observations, to promote exchange of real-time observations between member states, and to improve availability of in situ snow depth reports on the GTS.



Efforts aim to address 3 key issues:

- Many countries do not report snow routinely and consistently or make their observations available in near-real-time.
- Snow depth is often reported only when snow is present, with “missing data” (which could have a number of meanings) used otherwise. Active reports of zero snow depth provide extremely valuable data for assimilation in weather forecasting models
- Some countries have dense national (non-SYNOP) snow observing networks, which could provide valuable data for global forecasting centres, but do not exchange these data in near-real-time on the GTS

Addressing regional practices:

- Members should report snow cover and snow depth four times a day, shall report at least once a day
- Shall report values of zero snow depth (0 cm) from stations when snow is not present
- Snow cover should be reported in the state of ground field, where possible, and zero snow depth in the quantitative snow depth field

Studies

HarmoSnow COST Action
Workshop on Snow data assimilation, DWD, 8-9 March 2017

Snow data assimilation for Numerical Weather Prediction at ECMWF

Patricia de Rosnay

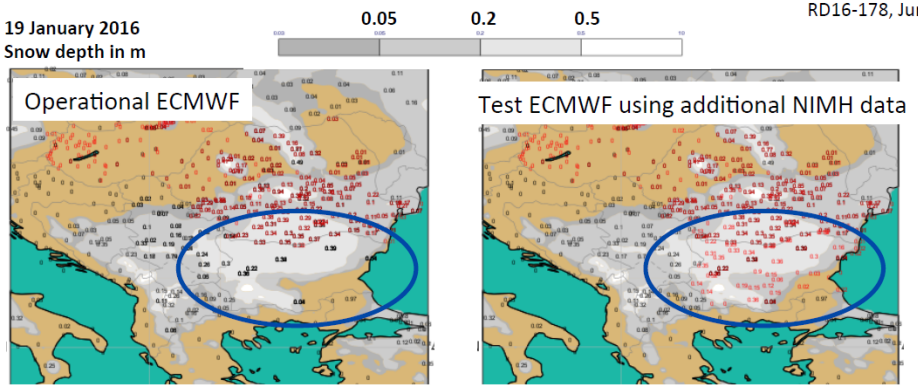
Thanks to many colleagues from ECMWF,
the HarmoSnow COST action and the SnowWatch Teams

Snow reports from Bulgaria (NIMH)

HarmoSnow COST action ES1404 → contribute to improve in situ data exchange for NWP
→ NIMH: 39 additional stations (BUFR format, routinely produced)
→ ECMWF data acquisition, 1-month assimilation test
→ Suitable for operational use

de Rosnay et al., ECMWF Res Memo RD16-178, June 2016

19 January 2016
Snow depth in m



Lack of observations in Bulgaria

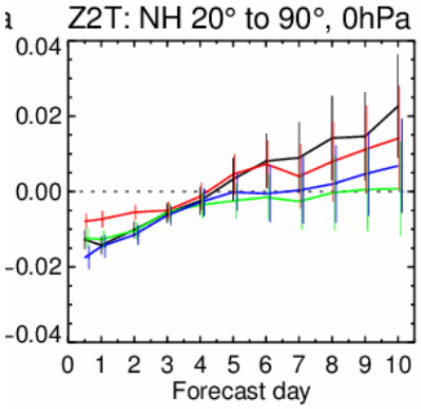
39 more stations provided by NIMH

Technical aspects (data format, acquisition, assimilation) solved.
Waiting for NIMH to decide to make the data effectively available for NWP

Observing System Experiments

Winter 2014-2015 (December to April) - Assess the impact of the snow observing s

Expts	SYNOP	National Data	IMS snow co
0- OL (no snow data assimilation)			
1- Snow DA: SYNOP+IMS	✓		✓
2- Snow DA: SYNOP+Nat (all in situ)	✓	✓	
3- Snow DA SYNOP+Nat+IMS (all)	✓	✓	✓



Impact on T2m Forecasts:
Normalized RMSE for T2m FC difference compared to the reference (OL)

SYNOP+IMS (1-0)
SYNOP+Nat (2-0)
SYNOP+Nat+IMS (3-0) -> oper

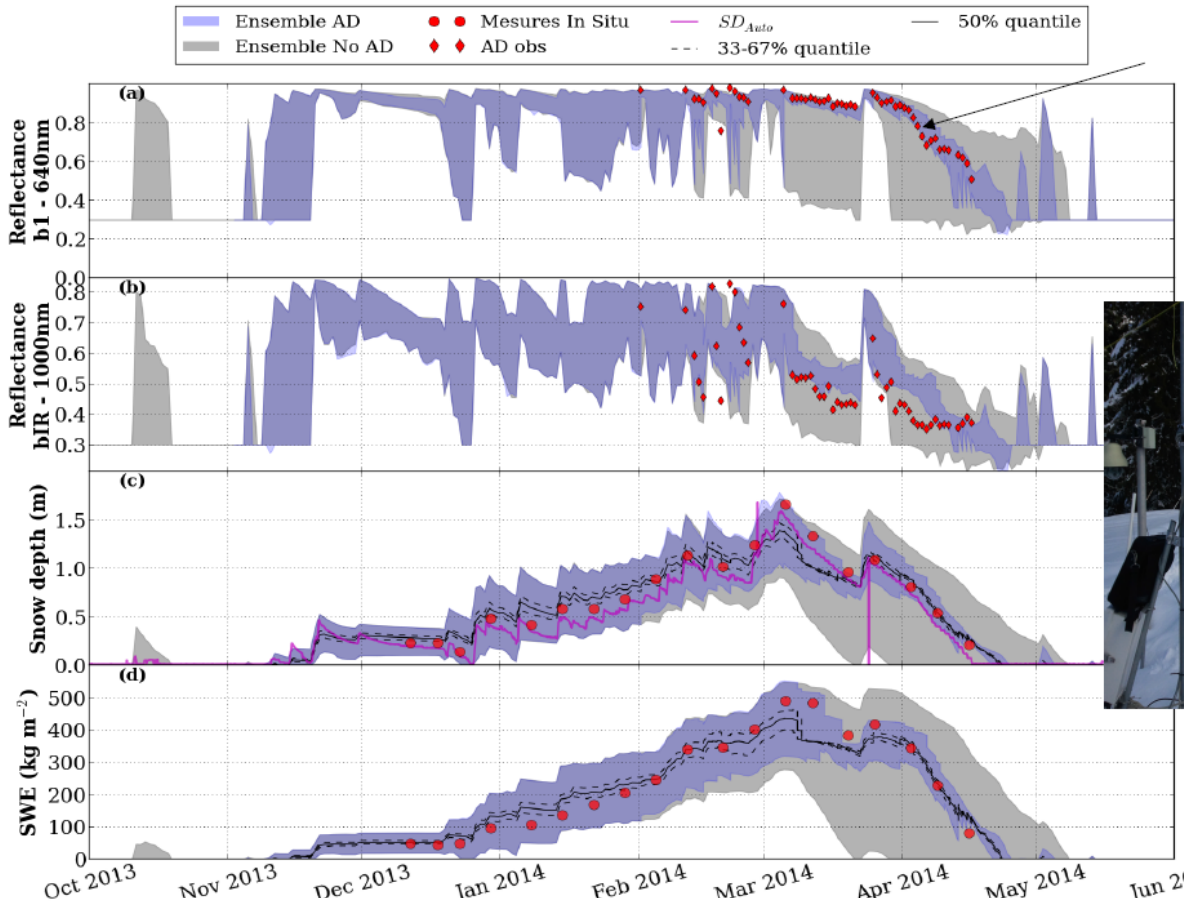
Best T2m Forecast when all observations, combining in situ and IMS, are assimilated.

P. de Rosnay

Studies

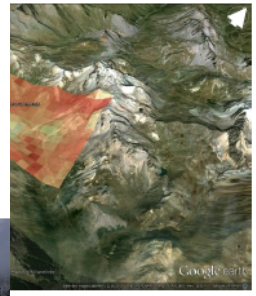
What happens in the real world?

l Crocus snow



Measured reflectance from Dumont *et al.*, 2016, TCD

Col de Porte



ectance from
ey *et al.*, 2009)

tion scheme

mble snowpack
ations

Assimilation of visible and near-infrared reflectances from satellite can improve the simulation of SWE and SD.

M. Dumont et al.

Studies

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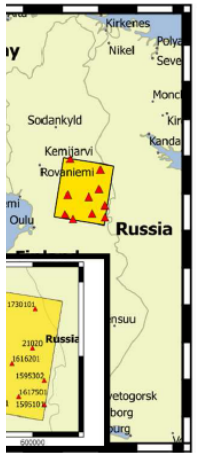
Snow water equivalent (SWE) retrieval by Sentinel-1 SAR data

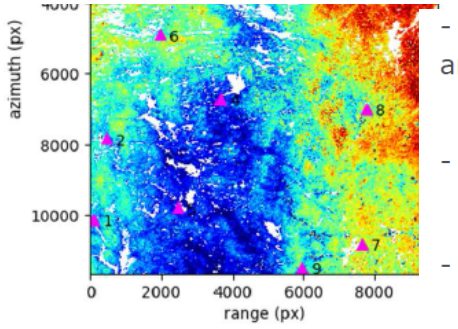
Vasco Conde[1], Giovanni Nico[2], Pedro Mateus[1], Joao Catalão[1], Anna Kontu[3], Maria Gritsevich[4, 5]

$\Delta SWE_{In\text{-}Situ}$ vs ΔSWE_{InSAR} (vs Coherence)

Master: 29-12-2015
Slave: 10-01-2016

Station ID	$\Delta SWE_{in\text{-}situ}$ [mm]	ΔSWE_{INSAR} [mm]	Difference [mm]	Difference [%]	Coherence
1	10,8	12,6	1,8	17	0,41
2	12,7	11,2	-1,5	-12	0,56
3	14,7	18,1	3,4	23	0,33
4	23,6	7,5	-16,1	-68	0,37
5	17,6	9,9	-7,7	-44	0,44
6	17,3	12,4	-4,9	-28	0,45
7	6,6	15,8	9,3	141	0,59
8	11,1	14,8	3,6	33	0,23
9	11,7	12,7	1,0	8	0,27
10	8,1	12,6	4,4	55	0,59





29-12-2015 (master)
10-01-2016 (slave)

- A methodology to exploit S-1 InSAR images in order to get ΔSWE maps over large areas was successfully implemented.

- A few in-situ measurements are needed.

- The loss of coherence is the major limiting factor.
  - Snow must be dry.

- Vegetation is a very important limiting factor for the Sentinel-1 (C-band).

Snow cover from MODIS

A cloud removal methodology [Da Ronco and De Michele, 2014]

- The methodolo
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  techniques.
- Each step rem
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  cloud-reduced
  by each step w
  the next step,
  are removed.
- Subsequent s
  cloud progress
  dataset is comp

P Da
Cloud
Hydr

Output products

Cloud-free snow cover maps with daily temporal resolution represent a powerful dataset from which one can derive:

- Information on **snow duration** at 500 m resolution (number of days with snow on the ground);
- Inter-annual variations of large scale **snow-duration**;
- Inter-annual and inter-seasonal variations of **snow-covered area**;

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Results from survey

- Differences in the used snow data assimilation method between numerical weather prediction models and hydrological models as well as in the update frequency of snow observations and the required time interval for consideration of the measurement.
- Most important snow parameters used in data assimilation are **snow depth and snow water equivalent**, which are processed by incremental update for NWP or update of absolute values in hydrology and other snow models.
- Snow observations from SYNOP and additional ground-based measurements are the most important data sources for NWP and hydrology. For the latter, also ground-based remote sensing data are very important. In agreement with NWP preprocessed remote sensing satellite products are often used in hydrology. Satellite radiances are used much less and climatological data are appropriated for hydrological applications.
- Most user with model environment in hydrology use ground-based remote sensing measurements or products, while this is not the case for NWP or reanalysis. The employed measurement system includes in many cases ultrasonic or laser distance sensors, but also camera, COSMIC ray or radiation sensors.
- Preprocessed snow products are used in all model environments but have special importance in NWP without DA, reanalysis and other snow models.

Results from survey

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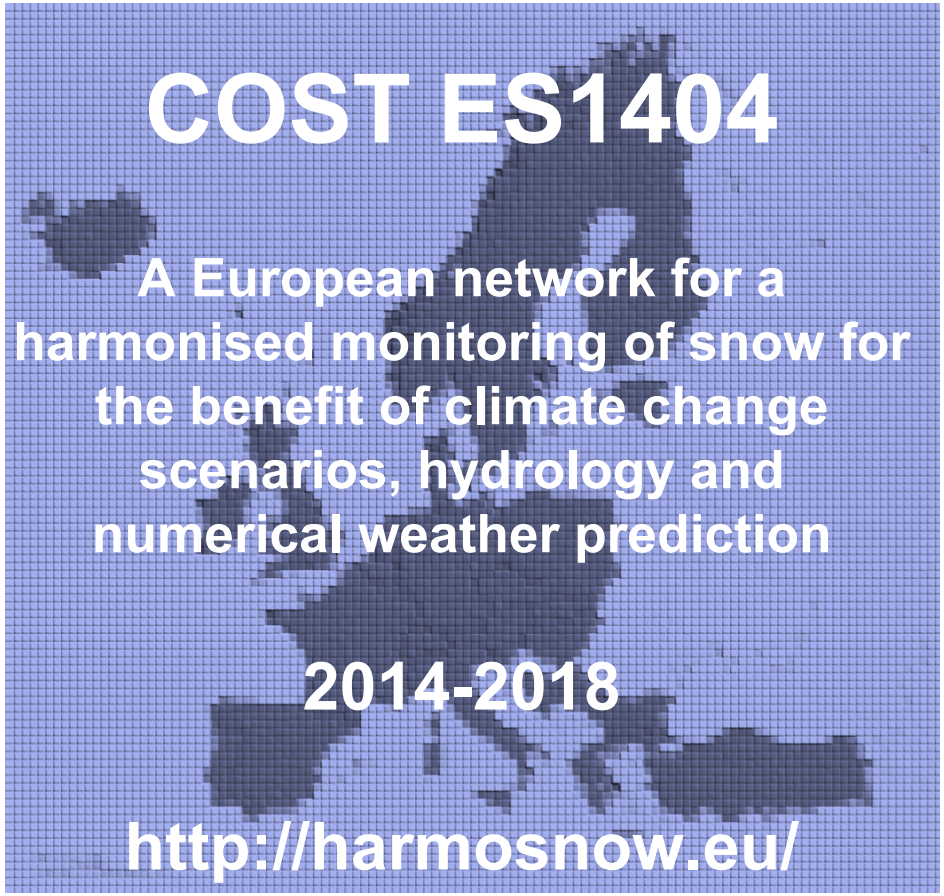
- Quality control of snow observations and products as well as consistency checks are performed manual or automatic in large majority of the model environments. Snow cover field is of particular importance.
- Depending on the application, the observation data latency becomes important
- Concrete plans for using new or upcoming data sources of snow observations exist for all model environments. Usage of more satellite data (optical, microwave) but also more ground-based remote sensing data, GPS or COSMIC ray sensors, or additional non-SYNOP networks.
- Current barriers and limitations for the use of these data are in particular independent of the model environment data availability and ressources to integrate the data in the model environment.
- Present-day measurement networks, instruments, and techniques fit to the existing data assimilation systems.
- The increasing automatization of the measurments is a task for data management in the DA system (quality control, consistency) but also the demand for snow data in regions with sparse measurement networks, which could remote sensing from satellite solve is a task for DA development (forward operator) and instrument development (e.g. automatic measurement of snow microphysical parameters).

Deliverables

- **Review report** on *snow data assimilation* techniques and the use of snow observations in NWP, hydrology and climate models.
- **Recommendations** on how to get and use conventional snow observations from national networks for *data assimilation and model validation.*
- **Recommendations** about sustainable ways to create snow products for users by *combining* remote-sensing and conventional snow observations with modelling results.
- **Report** on *spatial and temporal representativeness errors* of snow measurements for DA in NWP and hydrological models.
- **Peer-reviewed publications** on advanced DA techniques for NWP and hydrological models.
- **Two topical workshops** for addressing the different focuses of the Action
- **Training school** on snow measurements and DA.
- Each of the three working groups will produce a **review paper** by the end of the Action.


COST ES1404
A European network for a harmonised monitoring of snow for the benefit of climate change scenarios, hydrology and numerical weather prediction
2014-2018
http://harmosnow.eu/

Thank you