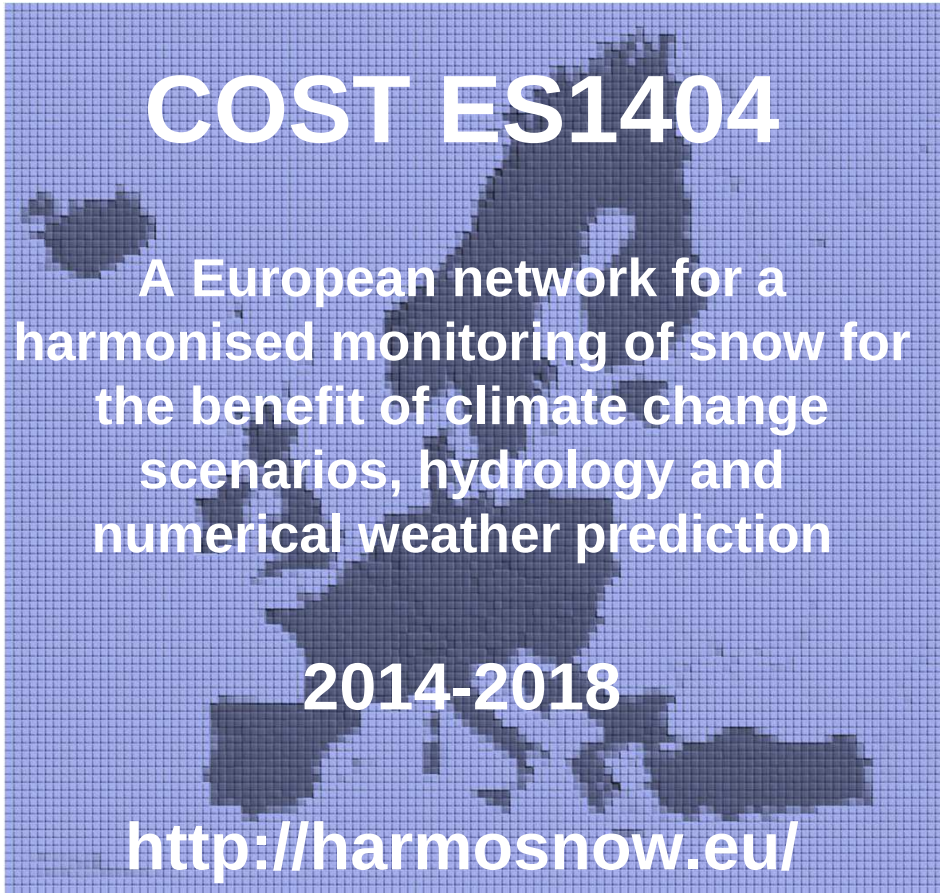
Deutscher Wetterdienst
Wetter und Klima aus einer Hand



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

Aim of COST ES1404

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

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

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

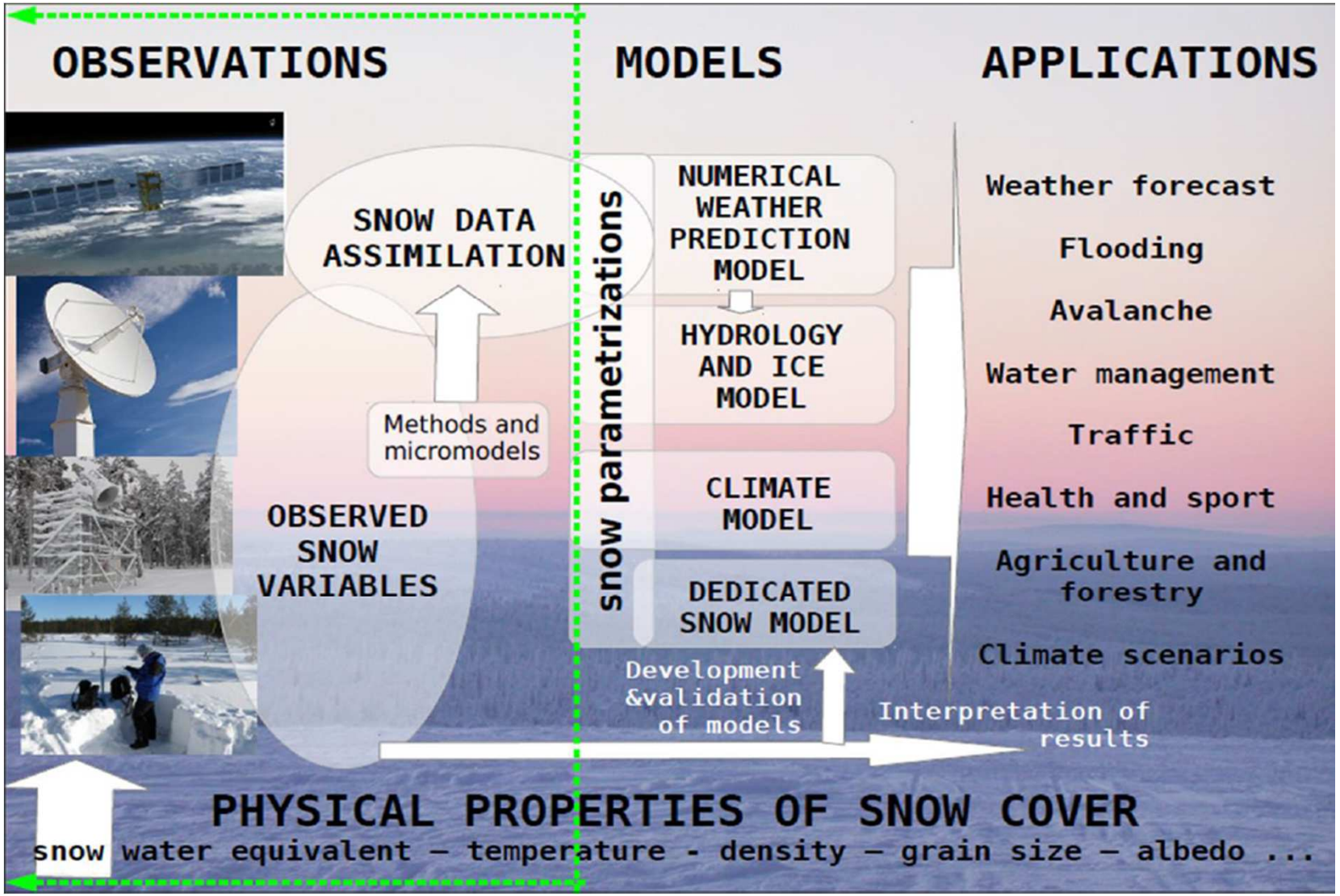
Structure – Working groups

WG1: Physical characterization of snow properties

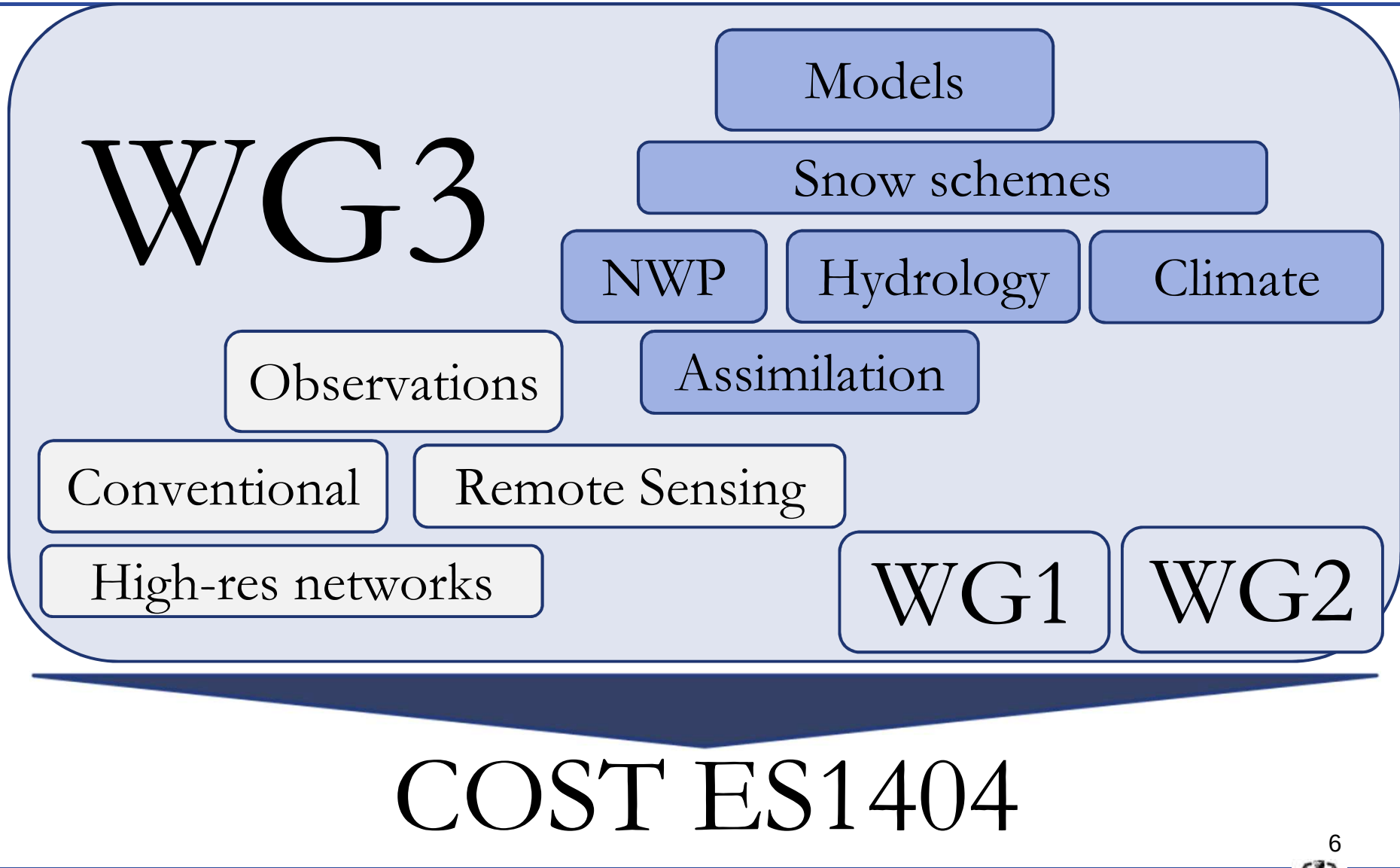
WG2: Instrument and method evaluation

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

Structure – Working groups

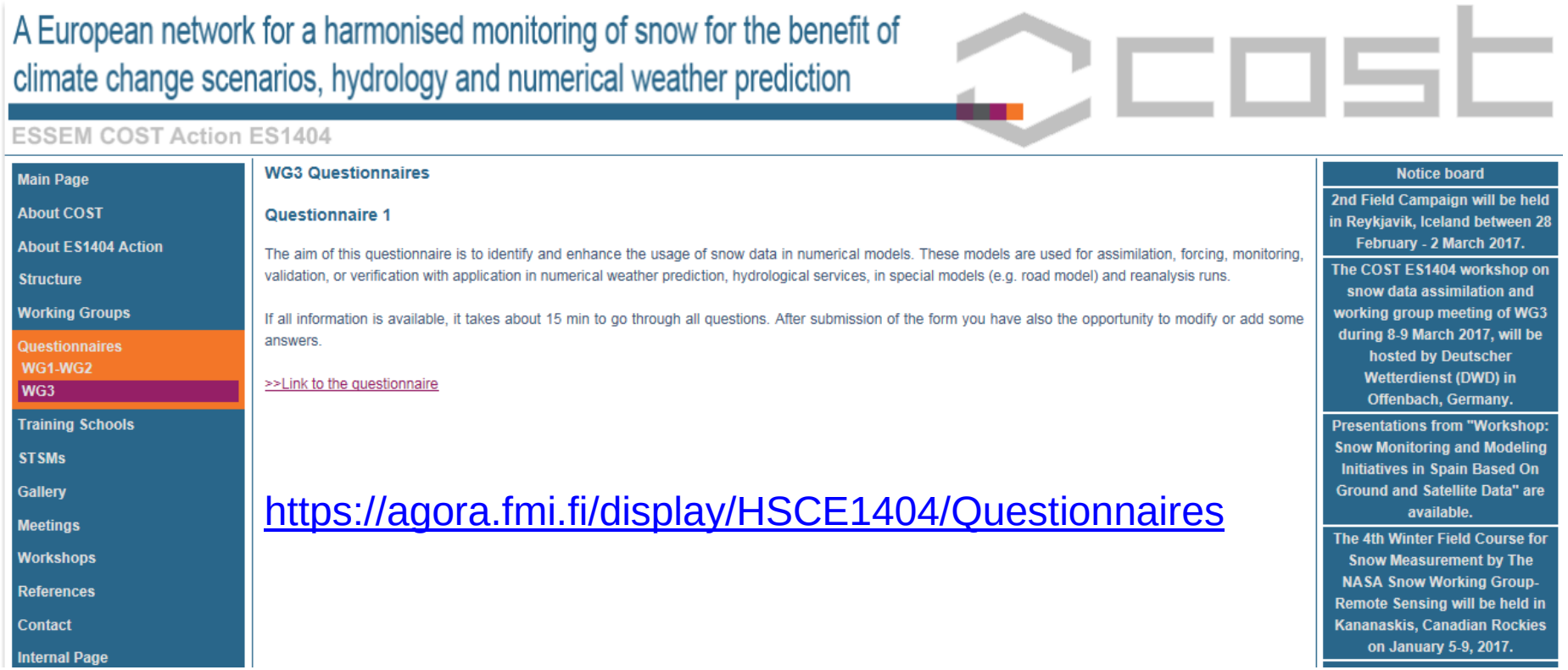


WG Structure



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.

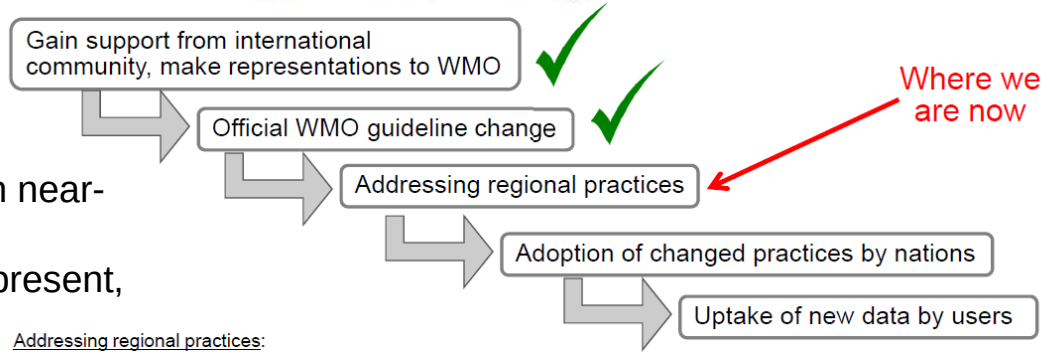
Task 3.4: Acquiring more information about observational errors relevant for DA by establishing links between the modelling and measurement communities via WG1 and WG2.

Studies

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

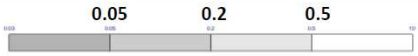
ECMWF EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS © ECMW

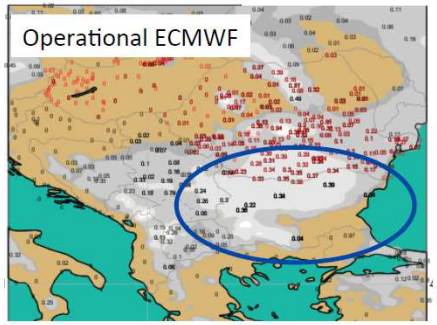
Snow reports from Bulgaria (NIMH)

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

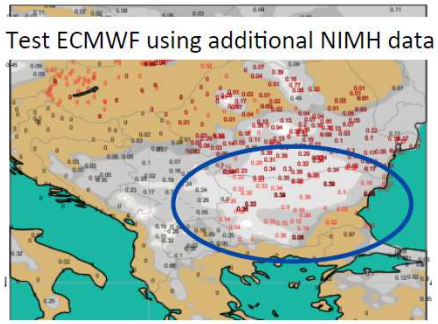
de Rosnay et al., ECMWF Res Memo RD16-178, June 2016

19 January 2016
Snow depth in m





Lack of observations in Bulgaria



39 more stations provided by NIMH

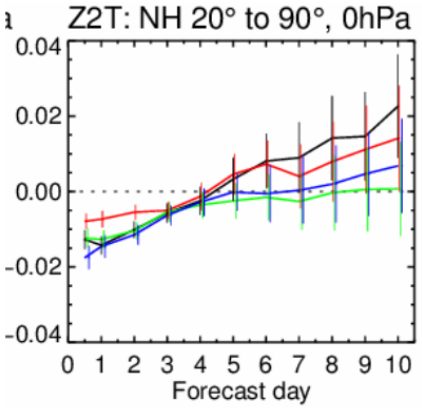
Technical aspects (data format, acquisition, assimilation) solved.
Waiting for NIMH to decide to make the data effectively available for NWP

ECMWF EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS © ECMWF

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

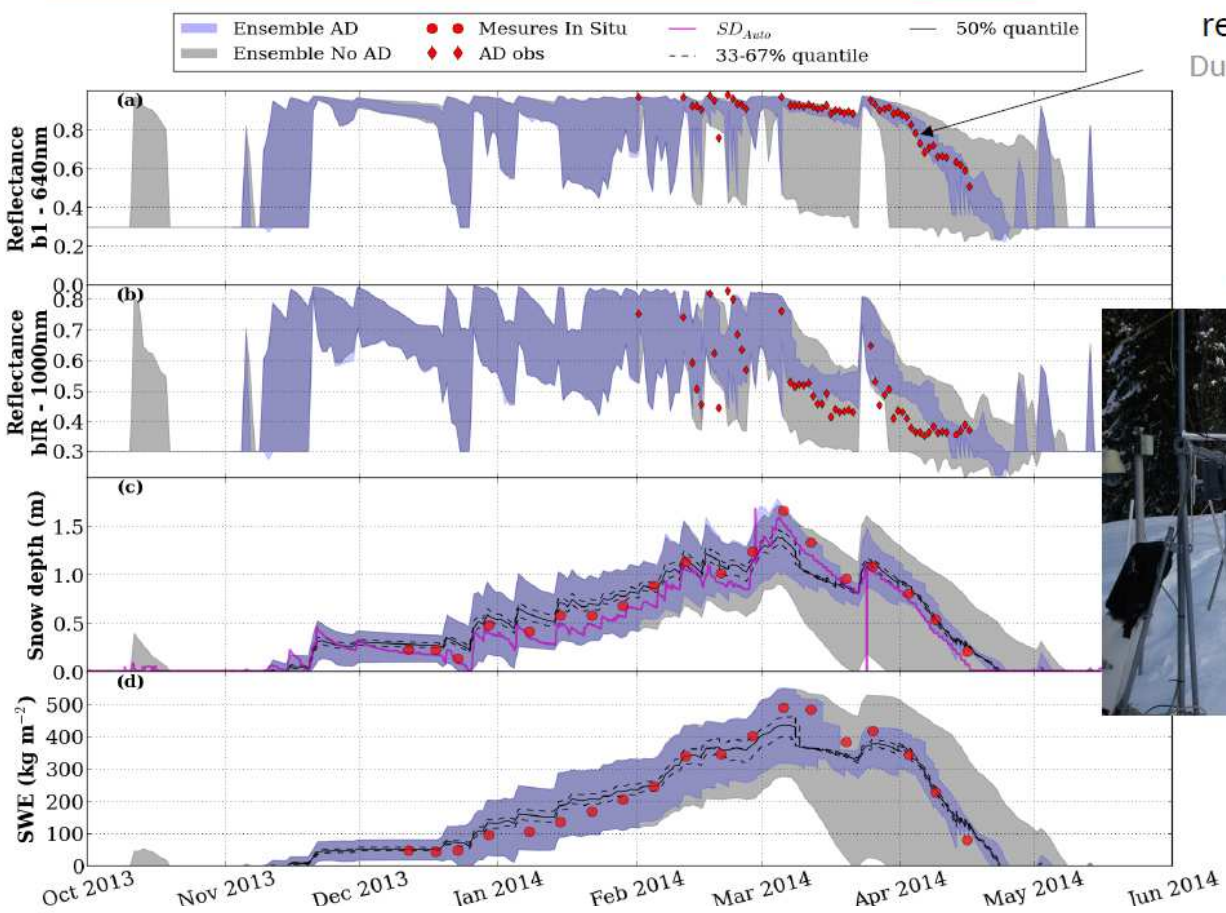
Best T2m Forecast when all observations, combining in situ and IMS, are assimilated.

P. de Rosnay

Studies

What happens in the real world?

… Crocus snow



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

Col de Porte

…ectance from …ey *et al.*, 2009)

…tion scheme

…mble snowpack …lations

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

M. Dumont et al.

Studies

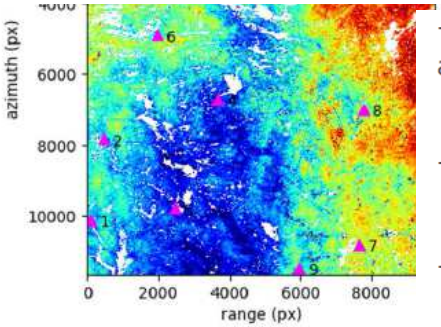
Snow water equivalent (SWE) retrieval by Sentinel-1 SAR data

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).

Studies

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Take home messages: MODIS snow cover data…

… improve hydrological simulations regardless of model complexity.

… has a bigger effect in areas with low glacierisation.

… allow validation of ungauged areas.

… allow an estimation of the hydropower potential.

Overall consis… complexity

Overall Consistency Performance P^{OAnorm} [-]

Q SC MB Q+SC Q+MB SC+MB Q+SC+MB

öll, 946 km²

vhm026

Pressure Line

R_H at 235m asl

> 280 m asl

al. 2011, 2015, WRR

Identifiability problems

(small) Model Complexity (large)

Finger et al., 2015

D. Finger

Studies

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Snow cover from MODIS

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

P Da
Cloud
Hydr

- The methodolc **steps**, develop actual pixel co by clouds. The **spatial and techniques**.
- Each step ren masked pixel **cloud-reduced** by each step w **the next step**, are removed.
- Subsequent s **cloud progress** dataset is comp

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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WG3 meetings

- First meeting of the WG3 in Grenoble (FR), 18-20 March, 2015
- Second meeting of the WG3 with Special Cold Lake Session during the workshop on Lakes in NWP and Climate modelling in Evora (PT), May 8, 2015
- Third meeting of the WG3 in Erzurum (TR), March 1st, 2016
- 4th WG3 meeting during the workshop on Remote Sensing Products of Cryosphere using Sentinels, in Vienna (AT), April 19, 2016
- 5th WG3 meeting during the COST ES1404 MC meeting in Granada (ES), November, 3, 2016
- 6th WG3 meeting during the COST ES1404 workshop on snow data assimilation, Offenbach (DE), March, 8/9, 2017
- 7th WG1/2/3 meeting during the COST ES1404 MC meeting in Smolenice

Lessons learned

- Future of snow DA – on long term to use radiances
- Snow-vegetation interaction is not well captured in many models
- Snow monitoring is performed at different centers (ECMWF, SMHI, DWD)
- Long way to adapt snow reporting practises and improve data exchange

Deliverables

- **D6 Review report** on *snow data assimilation* techniques and the use of snow observations in NWP, hydrology and climate models.
- **D7 Recommendations** on how to get and use conventional snow observations from national networks for *data assimilation and model validation.*
- **D8 Recommendations** about sustainable ways to create snow products for users by *combining* remote-sensing and conventional snow observations with modelling results.
- **D9 Report** on *spatial and temporal representativeness errors* of snow measurements for DA in NWP and hydrological models.
- **D10 Peer-reviewed publications** on advanced DA techniques for NWP and hydrological models.
- **D12 Two topical workshops** for addressing the different focuses of the Action
- **D13 Training school** on snow measurements and DA.
- **D14** Each of the three working groups will produce a **review paper** by the end of the Action.

Deliverables D6

D6 Review report on snow data assimilation techniques and the use of snow observations in NWP, hydrology and climate models.

Angelegt von Jürgen Helmert, zuletzt geändert am 16.02.2018

Deadline	Activity	Responsible persons	Working persons
Q4 2017	Collecting remaining answers in questionnaire completed	Jürgen Helmert, Aynur Sensoy	Jürgen Helmert, Aynur Sensoy
Q1 2018	First draft of the evaluation report completed	Jürgen Helmert, Aynur Sensoy	Martin Lange, Patricia de Rosnay, Samantha Pullen, Ekaterina Kurzeneva, David Finger, ...
Q2 2018	Iterate the evaluation report with MC members	Jürgen Helmert, Aynur Sensoy	MC Members
Q3 2018	Final version completed	Jürgen Helmert, Aynur Sensoy	Jürgen Helmert, Aynur Sensoy and contributing authors
Q4 2018	Publication of the final report completed	Jürgen Helmert, Aynur Sensoy	Jürgen Helmert, Aynur Sensoy and contributing authors

Collecting remaining answers in questionnaire									
	Completed								
		First draft of the evaluation							
			Completed						
				Iterate the review report with MC members					
					Completed				
						Final version			
							Completed		
								Publication of the final report	
									Completed
Q4 2017		**Q1 2018**		**Q2 2018**		**Q3 2018**		**Q4 2018**	

Deliverables D7

D7 Recommendations on how to get and use conventional snow observations from national networks for data assimilation and model validation.

Angelegt von Jürgen Helmert, zuletzt geändert am 16.11.2017

Deadline	Activity	Responsible persons	Working persons
Q4 2017	Collect work that has been performed	Jürgen Helmert, Aynur Sensoy	Jürgen Helmert, Aynur Sensoy
Q1 2018	First draft of the Recommendation report completed	Jürgen Helmert, Aynur Sensoy	Patricia de Rosnay, Samantha Pullen, Martin Lange David Finger, David Gustafsson, ...
Q2 2018	Iterate the report with MC members	Jürgen Helmert, Aynur Sensoy	MC Members
Q3 2018	Final version completed	Jürgen Helmert, Aynur Sensoy	Contributing authors
Q4 2018	Publication of the final report completed	Jürgen Helmert, Aynur Sensoy	Contributing authors

Collect work that has been performed									
	Completed								
		First draft of the Recommendation report							
			Completed						
				Iterate the report with MC members					
					Completed				
						Final version			
							Completed		
								Publication of the final report	
									Completed
Q4 2017		**Q1 2018**		**Q2 2018**		**Q3 2018**		**Q4 2018**	

Deliverables D8

D8 Recommendations about sustainable ways to create snow products for users by combining remote-sensing and conventional snow observations with modelling results.

Angelegt von Jürgen Helmert, zuletzt geändert am 16.11.2017

Deadline	Activity	Responsible persons	Working persons
Q4 2017	Collect work that has been performed	Jürgen Helmert, Aynur Sensoy	Jürgen Helmert, Aynur Sensoy
Q1 2018	First draft of the Recommendation report completed	Jürgen Helmert, Aynur Sensoy	Ekaterina Kurzeneva, Patricia de Rosnay, Martin Lange, Carlo de Michele, Marie Dumont, ...
Q2 2018	Iterate the report with MC members	Jürgen Helmert, Aynur Sensoy	MC Members
Q3 2018	Final version completed	Jürgen Helmert, Aynur Sensoy	Contributing authors
Q4 2018	Publication of the final report completed	Jürgen Helmert, Aynur Sensoy	Contributing authors

Collect work that has been performed									
	Completed								
		First draft of the Recommendation report							
			Completed						
				Iterate the report with MC members					
					Completed				
						Final version			
							Completed		
								Publication of the final report	
									Completed
Q4 2017		**Q1 2018**		**Q2 2018**		**Q3 2018**		**Q4 2018**	

Deliverables D9

D9 Report on spatial and temporal representativeness errors of snow measurements for DA in NWP and hydrological models.

Angelegt von Jürgen Helmert, zuletzt geändert am 02.10.2017

Deadline	Activity	Responsible persons	Working persons
Q4 2017	Collect work that has been performed	Jürgen Helmert, Aynur Sensoy	Jürgen Helmert, Aynur Sensoy
Q1 2018	First draft of the report completed	Jürgen Helmert, Aynur Sensoy	Ekaterina Kurzeneva, Patricia de Rosnay, Martin Lange, Marie Dumont, David Gustafsson, David Finger,...
Q2 2018	Iterate the report with MC members	Jürgen Helmert, Aynur Sensoy	MC Members
Q3 2018	Final version completed	Jürgen Helmert, Aynur Sensoy	Contributing authors
Q4 2018	Publication of the final report completed	Jürgen Helmert, Aynur Sensoy	Contributing authors

Collect work that has been performed									
	Completed								
		First draft of the report							
			Completed						
				Iterate the report with MC members					
					Completed				
						Final version			
							Completed		
								Publication of the final report	
									Completed
Q4 2017		**Q1 2018**		**Q2 2018**		**Q3 2018**		**Q4 2018**	

Deliverables D10

D10 Peer-reviewed publications on advanced DA techniques for NWP and hydrological models.

Angelegt von Jürgen Helmert, zuletzt geändert am 24.10.2017

Deadline	Activity	Responsible persons	Working persons
Q4 2017	Collect work that has been performed	Jürgen Helmert, Aynur Sensoy	Jürgen Helmert, Aynur Sensoy, Patricia de Rosnay
Q1 2018	First draft of the report completed	Jürgen Helmert, Aynur Sensoy	MC and WG members
Q2 2018	Iterate the report with MC members	Jürgen Helmert, Aynur Sensoy	MC Members
Q3 2018	Final version completed	Jürgen Helmert, Aynur Sensoy	Contributing authors
Q4 2018	Publication of the final report completed	Jürgen Helmert, Aynur Sensoy	Contributing authors

Collect work that has been performed									
	Completed								
		First draft of the report							
			Completed						
				Iterate the report with MC members					
					Completed				
						Final version			
							Completed		
								Publication of the final report	
									Completed
Q4 2017		**Q1 2018**		**Q2 2018**		**Q3 2018**		**Q4 2018**	

Deliverables D12

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D12 Two topical workshops for addressing the different focuses of the Action

Angelegt von Jürgen Helmert, zuletzt geändert am 30.01.2018

2. Emphasis on snow data assimilation in NWP and hydrology models

Deadline	Activity	Responsible persons	Working persons
Q4/2017	**Draft** report of the workshop on snow data assimilation in Offenbach 2017 completed	Jürgen Helmert	Jürgen Helmert, workshop participants
Q1/2018	Report of the workshop on snow data assimilation in Offenbach 2017 completed	Jürgen Helmert	Jürgen Helmert, workshop participants

Deliverables D13

D13 Training school on snow measurements and DA.

Erstellt von Jürgen Helmert, zuletzt geändert von Leena Leppänen am 07.11.2017

Deadline	Activity	Responsible persons	Working persons
Q4/2017	Planning in Helsinki meeting	Chair, WG leaders	...
Q2/2018	Training school organization	Laura Rontu	Training school organization committee

Deliverables D14

Deutscher Wetterdienst
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D14 Each of the three working groups will produce a review paper by the end of the Action.

Angelegt von Jürgen Helmert, zuletzt geändert am 16.11.2017

Deadline	Activity	Responsible persons	Working persons
Q4/2017	Report of the WG1&2 questionnaire	Roberta Pirazzini	Leena Leppänen, Cemal Melih Tanis ...
Q4/2017	Draft version of white paper based on albedo workshop in Helsinki in August 2016	Roberta Pirazzini, Ghislain Picard	...
Q4/2017	Finalize report of the 1st field campaign based on recommendations of mid-term evaluation report	Nacho Lopez Moreno, Leena Leppänen, Charles Fierz	Aynur Sensoy ...
Q4/2017	Finalize report of the 2nd field campaign	Ladislav Holko, Nacho Lopez Moreno, Leena Leppänen, Christoph Marty	Bartek Luks, Pavla Dagsson-Waldhauserova, David Finger ...
Q2/2018	Publication based on report of the WG1&2 questionnaire	Roberta Pirazzini	Leena Leppänen, Ali Nadir Arslan ...
Q2/2018	Final version of white paper based on albedo workshop in Helsinki in August 2016	Roberta Pirazzini, Ghislain Picard	...
Q2/2018	White paper based on the field campaigns ?	?	?
Q2/2018	Report of grain size measurement methods ? (WG2 Task 4)	Ghislain Picard	Katalin Gillemot ...
Q2/2018	Review of space-borne instruments/sensors (WG2 Task 1)	Ali Nadir Arslan	Simon Gascoin ...
Q2/2018	Report of mechanical properties of snow for avalanche purposes (WG2 Task 5)	Pavol Nejedlik, Charles Garcia Selles	?
Q3/2018	Final version of snow booklet	Anna Haberkorn	?

Working Group 3

Deadline	**Activity**	**Responsible persons**	**Working persons**
Q4/2017	Report of the WG3 questionnaire - see D6	Jürgen Helmert, Aynur Sensoy	see D6
Q4/2017	Draft version of white paper based on data assimilation workshop in Offenbach completed	Jürgen Helmert, Martin Lange	see D12
Q2/2018	Publication based on report of the WG3 questionnaire completed - see D6	Jürgen Helmert, Aynur Sensoy	see D6
Q2/2018	Final version of white paper based on data assimilation workshop in Offenbach completed	Jürgen Helmert, Martin Lange	see D12
Q2/2018	Report of snow models?	Jürgen Helmert, Patricia de Rosnay, Marc Olefs	...
Q2/2018	Report of hydrological models?	Aynur Sensoy, David Finger	...

Ongoing activities

- DA experiments at ECMWF for COST on sensitivity of background error for snow measurements (P. de Rosnay, S. Pullen, M. Lange) – Link to WG1 and WG2 results from field campaigns
- Snow DA workshop report in review
- Review paper – Abstract formulated
- Exchange with DLR: remote sensing products for snow
- Exchange with DWD snow measurement group: new sensors

Risks

- First results from experiments not as expected
- Reviewer comments on DA workshop paper
- Review GCW activities on snow DA
- Review paper and reports – Participation from WG

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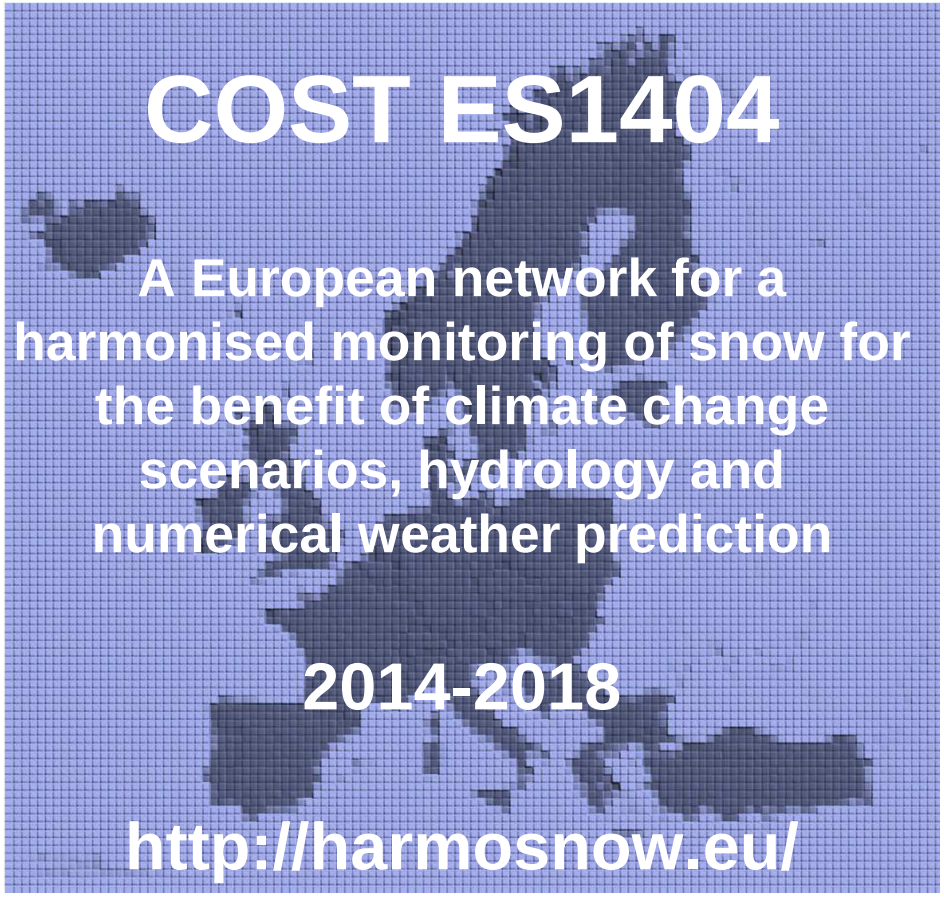

Thank you