Core-Climax Coordination Meeting Towards a Global Archive of Historical *In Situ* Snow Data

Executive Summary

Responding to the invitation of the EU FP7 Core-Climax project to meet at ECMWF, scientists discussed the current status of historical *in situ* snow data, and how to advance towards a global archive, to support climate and hydrological studies and activities of the World Climate Research Programme (WCRP) core project on Climate and Cryosphere (CliC).

Reviewing existing datasets,

- the group identifies **more than 20 large historical *in situ* snow datasets**, of value for carrying out long-term studies of the snow pack, and encourages the community to enhance this list of datasets, available from http://globalcryospherewatch.org/reference/documents/;
- the group welcomes the availability of a **large historical snow dataset from China**, covering 212 stations, and the open access policy for this dataset;
- the group identifies **significant gaps in the publically available historical snow data records**, in wide areas including most of Western Europe and parts of Asia;
- the group stresses the important need for **historical snow data rescue**, as laid out by the Global Cryosphere Watch (GCW) Initiative, before hardcopy records are lost forever.

Regarding the current exchange of snow cover data on the GTS,

- the group regrets that **still today snow cover and state of the ground observations are not systematically exchanged** between all WMO members;
- the group urges all WMO members to **use the new BUFR template to its full capacity** to enrich current observations exchanged on the GTS, so these can feed future climate databases, studies, and applications within the Global Framework for Climate Services;
- the group recommends that WMO considers issuing a guideline for **systematic reporting of zero snow depths**.

Regarding the formation of a large international archive of historical snow cover data,

- the group recommends **separate management of the two groups of historical snow data;**
- **for point-wise (station) measurements**, the group supports the **emerging concept of a comprehensive land surface archive of *in situ* data, modelled after the ICOADS** for the marine surface, that would encompass all meteorological and related environmental variables measured at land stations, along with a characterization of the measurement site and equipment changes; such initiative should build on experience gained in various archives such as precipitation (GPCC), surface pressure (ISPD), and others.
- **for transect-based snow measurements (snow courses)**, the group recommends the establishment of a dedicated global archive, and **endorses the proposal for a prototype snow course data archive by FMI**; this archive may also collect near-real-time snow course data.

All presentations from the meeting are available from http://www.coreclimax.eu/?q=Snow
Unedited meeting minutes are available on request from the meeting hosts.

Goals of the meeting

- Review the historical *in situ* snow cover data holdings in national and international archives
- Review the access mechanism to the current archives
- Discuss ways forward to integrate a selection of this information into a global archive, and provide coordinated input for an ERA-CLIM2 prototype database
- Envisage other options that would avoid creating a new physical archive, in particular in the context of upcoming Climate Services

Outcome

The group assembled at the meeting recognizes the particular aspects of *in situ* observations of snow:

- as observations of the effects of global climate change, thus relevant to conduct climate and hydrological studies, and validate models, reanalyses, and other reconstructions of the Earth's climate and hydrological evolutions over the past century;
- as more difficult to interpret directly than large-scale meteorological parameters such as pressure, owing to a high spatio-temporal variability;
- as changing largely in observation coverage and practice over the course of the 20th century, with a general transition from manual observations to automated ones, except for snow course surveys; these ones, still being carried out today, are recognized as a unique type of *in situ* observations of our environment.

The group recommends:

- to encourage WMO members to transmit observations of the state of the ground,
  to recommend generalized assessment and publication of reports summarizing the state and changes of snow cover observation reporting and its global exchange,
  that WMO monitoring of surface synoptic observations be extended to include snow and state of the ground,
  and to advocate for WMO guidelines asking for systematic reporting of zero snow depth;
- to World Data Centres that they carry out regular exercises of "GTS archive merges" between each other, because these data are *de facto* used as input to climate studies worldwide;
- to WMO that it discusses with its Members the question of how to tag with unique identification the observations that are exchanged on the GTS to allow subsequent detection and traceability of missing data in archives or verification of the transmission;
- to ask CBS to remind WMO members to use the new BUFR template for transmitting observations as a new method of encoding additional information, not as a simple re-mapping of the earlier TAC;
- to highlight to GCW the importance of snow course observations as being special for the following reasons:
  - more representative of snow-covered areas,
  - carried out by expert personnel, and

    - characterizing at high spatial frequency the snow environment;
- to endorse the proposal made by FMI for an international archive of snow course data, adding to this proposal:
    - to enhance the proposed data model with snow course elevation and terrain variability, time of day, and measurement method
    - to encourage all countries to contribute snow course data to this archive
    - to apply best practices regarding dataset life cycle and stewardship for the long-term:
        - keeping traceability to the input data (source, identification…), which would help should the input data sources evolve with data recovery and reprocessing,
        - tagging each record with a unique identifier, so users could to trace the data they used in their applications, and
        - applying proper versioning of the entire archive, and use of Digital Object Identifier (DOI),
    - to consider from the start a data model that would allow enriching with user and model feedback (e.g. departures from a reanalysis or climate run, quality flags suggested by users…), in a similar way to that done in the ICOADS Value-Added Database (http://www.icoads.noaa.gov/ivad/)
- to advocate at international level for the establishment of "an ICOADS for the land", *i.e.* a comprehensive database of meteorological parameters observed at land stations
    - including not only snow data but all other meteorological parameters
    - recognizing that the observations of meteorological parameters are intricately related between each other and with the site environment (powerful quality controls can be made from the sum of these parameters)
    - bearing in mind that this development could build upon expertise in thematic elements (*e.g.* precipitation, pressure, temperature, snow)
    - leveraging on the prior experience from large archives that have attempted to characterize measurement sites over land, such as done by the GPCC;
- to encourage the international development of a metadata-base of station locations (station register) as a possible seed for a future "ICOADS for land", and, for this, to build on the expertise acquired over 25 years at GPCC regarding station locations
- to all operators of snow stations to keep a record of reporting practices in the metadata, as these changes affect the time homogeneity of the future data records;
- to all owners of snow station data, to contribute these to large international collections such as ISD or GHCN Daily;
- to consider enhancing existing large archives such as ISD and GHCN Daily a with a zero-snow information using the information found in the state of the ground;
- to all users of large snow data collections, such as the Former Soviet Union snow dataset from Roshydromet, to feed-back their findings regarding data quality to the source, so these findings can be exploited at the source and possibly reconciled with known measurement or environment issues and benefit future users in future releases of the dataset;
- to present the relevant recommendations at the next GCW meeting in January 2015.

The group identifies a list of more than 20 historical datasets of *in situ* snow, found in Annex 3 of the present report and to be posted on the Global Cryosphere Watch Initiative website at http://globalcryospherewatch.org/reference/documents/. The community is encouraged to contribute to this list by adding other known relevant available datasets.

This report, posted on http://www.coreclimax.eu/?q=Snow, along with the all meeting presentations, is to be distributed in the snow and reanalysis communities, and to provide input to the EU FP7 Core-Climax and ERA-CLIM2 projects.

Annex 1 Organizational details

Hosts / contacts

- Paul Poli, paul.poli@ecmwf.int
- David Tan, david.tan@ecmwf.int

Participants

Eric Brun	Météo-France, Centre National de Recherches Météorologiques (**CNRM**) *(Core-Climax visit D4.1-2)*
Matthew Menne	National Oceanic and Atmospheric Administration, National Climatic Data Center (**NOAA NCDC**) *(Core-Climax visit D4.2-3)*
Olga Bulygina	World Data Centre for Meteorology, Federal Service for Hydrometeorology and Environmental Monitoring of Russia (**Roshydromet**) *(Core-Climax visit D4.2-6) -- Could not attend but contributed presentations*
Steve Worley	National Center for Atmospheric Research (**NCAR**) *(Core-Climax visit D4.2-7)*
Yu Yu	Chinese Meteorological Administration (**CMA**) *(Core-Climax visit D4.3-2)*
Ross Brown	Environment Canada (**EC**) *(Core-Climax visit D4.3-4)*
Jouni Pulliainen	Ilmatieteen laitos (**FMI**)
Miia Salminen	Ilmatieteen laitos (**FMI**)
Alexander Sterin	World Data Centre for Meteorology, Federal Service for Hydrometeorology and Environmental Monitoring of Russia (**Roshydromet**)
Markus Ziese	Global Precipitation Climatology Centre (**GPCC**)
Adrian Simmons	Lead Author of the Status Report for the Global Climate Observing System (GCOS)
Sakari Uppala	Advisor to the ERA-CLIM2 project
Erik Andersson	**ECMWF**
Patricia de Rosnay	**ECMWF**
Gianpaolo Balsamo	**ECMWF**
Emanuel Dutra	**ECMWF**
Hans Hersbach	**ECMWF**
David Tan	**ECMWF**
Paul Poli	**ECMWF**

Annex 2: Agenda of the Core-Climax Coordination Meeting Towards a Global Archive of Historical *In Situ* Snow Data

Meeting Location: ECMWF Council Room

Day 1: Monday 17 November 2014

13.30-13.50 **Introduction**
- Welcome address by Erland Källén, ECMWF Director of Research
- Tour de table, adoption of agenda, meeting practical arrangements

13.50-15.30 **Current data holdings of historical *in situ* snow cover observations, Chair: Matthew Menne**
- Setting the scene: Experience from GlobSnow, followed by Data holdings at FMI (Miia Salminen and Jouni Pulliainen)
- Data holdings at CMA (Yu Yu)
- Data holdings at Roshydromet (Olga Bulygina)

15.30-16.00 Session Break

16.00-18.00 **Current data holdings of historical *in situ* snow cover observations (continued)**
- Data holdings at NOAA NCDC (Matthew Menne)
- Data holdings at NCAR (Steve Worley)
- Data holdings at EC (Ross Brown)
- Data holdings at CNRM (Eric Brun)

Day 2: Tuesday 18 November 2014

9.30-10.50 **Current data access facilities, Chair: Alexander Sterin**
- Data access at CMA (Yu Yu)
- Data access at Roshydromet (Olga Bulygina)
- Data access at NOAA NCDC (Matthew Menne)
- Data access at NCAR (Steve Worley)

10.50-11.20 Session Break

11.20-13.00 **Current data access facilities (continued)**
- Data access at EC (Ross Brown)
- Data access at CNRM (Eric Brun)
- Data access at FMI, followed by Prototype snow cover database in development for ERA-CLIM2 (Miia Salminen and Jouni Pulliainen)

13.00-14.00 Lunch Break (ECMWF Cafeteria)

14.00-18.00 **Ways forward for better integration, Chair: Adrian Simmons**
- Experience from GPCC in serving precipitation data (Markus Ziese)
- Assimilation of snow observations at ECMWF (Patricia de Rosnay)
- Discussion (All), with a session break at 15.30

Day 3: Wednesday 19 November 2014

9.30-13.00 **Meeting wrap-up and report drafting, Chair: Erik Andersson**
Drawing from minutes taken during the meeting, a summary is to be drafted.
Session breaks at 10.50

Annex 3: List of snow datasets identified during the meeting

	Dataset Name	Where to get it	Ident.	How to get it	Data format	Station or Course	Major snow variables	Other variables	Frequency (Sub-daily, daily, monthly…)	Number of stations or courses	Years
1.	Former Soviet Union HSDSD	www.meteo.ru /climate		To register, free access	ASCII	Station	cover, depth, QC	Snow extent around station	Daily	600 stations	1881-present
2.	Russian route snow surveys	www.meteo.ru /climate		To register, free access	ASCII	Course	cover, depth, density, water equivalent, …	Set of additional snow parameters	One to several times/month	517 stations	1966-2013
3.	Daily snow cover datasets	NMIC	V1.0	FTP, DVD	ASCII	Station	depth, pressure, snowfall day flag	none	Daily	212	1951-2013

	Dataset Name	Where to get it	Ident.	How to get it	Data format	Station or Course	Major snow variables	Other variables	Frequency (Sub-daily, daily, monthly…)	Number of stations or courses	Years
4.	ISD	NCDC	Version controlled	FTP, interactive web service	ASCII/ database	Station	Largely depth, but some snowfall and swe	Many parameters	Primarily sub-daily, but daily summaries also present	20,000	1901-present
5.	GHCN Daily	NCDC	DOI	FTP/interactive web service	ASCII/ database	Station	Snowfall, snowdepth and swe	Primarily temp, precip, but other parameters for USA	Daily	40,000 with snow obs	1763-present
6.	Canada Snow CD	polardata.ca CCIN1744 update0203 FTP://ccrp.tor.ec.gc.ca/pub/RBrown/Cdn_Daily_Snow_Depth_Data	N/A	FTP	ASCII	Station	SD from mainly ruler measurements		Daily continuous	Network peaks of ~2000 stations in 1980s	1850-2003

	Dataset Name	Where to get it	Ident.	How to get it	Data format	Station or Course	Major snow variables	Other variables	Frequency (Sub-daily, daily, monthly…)	Number of stations or courses	Years
7.	Canada snow courses	FTP://ccrp.tor.ec.gc.ca/pub/RBrown/Cdn_Snow_Course_Data		FTP	ASCII	Course	SWE, SD from manual snow core samples (average of 5-10 points)	Snow density can be derived from SWE SD pairs	Mainly bi-weekly; obs tend to be concentrated in 2nd half of snow season to capture SWEmax	Number of courses peaks ~2000 in 1975-1985 period	1935-2003
8.	Canada daily snow depth	http://climate.weather.gc.ca/	DLY04, DLY02, DLY044	web	csv	station	Mainly ruler measured SD up to 2000; increasing autostation ultrasonic measurements from 2000 (¯50% of network in 2014)	Other daily climate elements available (T, P, RH, U)	daily	Variable network over time; peak of ~2000 stations in late-1980s	~1950-present

	Dataset Name	Where to get it	Ident.	How to get it	Data format	Station or Course	Major snow variables	Other variables	Frequency (Sub-daily, daily, monthly…)	Number of stations or courses	Years
9.	French snow data	https://donneespubliques.meteofrance.fr/?fond=produit&id_produit=94&id_rubrique=32			ASCII	station	SD		Daily during snow season	156	1971-present
10.	INTAS-SCCONE	FMI	V1	FTP	ASCII	Course	Water equivalent	Snow density, snow depth	Bi-monthly	Max. 1200	1966-2009
11.	SYKE	FMI		FTP	ASCII	Course	Water equivalent	Snow density, snow depth, FSC	Bi-monthly or monthly	Max. 170 /year	1979-2014
12.	INTAS-SCCONE	FMI	V1	FTP	ASCII	Station	Depth	FSC	Daily	Max 223	1881-2001
13.	FMI	FMI		FTP	ASCII	Station	Depth	E-code	daily	Max 223 per year	1900-present

	Dataset Name	Where to get it	Ident.	How to get it	Data format	Station or Course	Major snow variables	Other variables	Frequency (Sub-daily, daily, monthly…)	Number of stations or courses	Years
14.	SNOTEL	RDA	DOI			Station	Depth, Water equivalent, …			831	1963-present
15.	SNOlite	RDA	DOI			station	Depth, water equivalent, …			29	2003-present
16.	USDA snow courses	RDA	DOI			Course	Depth, water equivalent			956	1910-present
17.	SCAN	RDA	DOI			Station	Depth, water equivalent			24	1986-present
18.	Alaska reserves	RDA	DOI			Station	Depth, …			17	1998-2011
19.	Estonian	NSIDC	DOI			Station	Depth			255	1891-1990

	Dataset Name	Where to get it	Ident.	How to get it	Data format	Station or Course	Major snow variables	Other variables	Frequency (Sub-daily, daily, monthly…)	Number of stations or courses	Years
20.	Central Asian Uzbekistan	NSIDC	DOI			Station	Depth, density,water equivalent, …			100+	1932-1990
21.	Western Italian Alps	NSIDC	DOI			Station	Depth			18	1877-1996
22.	Aircraft landing FSU	NSIDC	DOI			station	Depth, cover, density, …			Max. 200/ year	1928-1989
23.	Climobase Canada	NSIDC	DOI			Station	177 parameters			24	1984-1998
24.	IASOA	NOAA ESRL				Station	Depth, …			3	

	Dataset Name	Where to get it	Ident.	How to get it	Data format	Station or Course	Major snow variables	Other variables	Frequency (Sub-daily, daily, monthly…)	Number of stations or courses	Years
25.	Climate data from Germany	FTP://FTP-cdc.dwd.de/pub/CDC/observations_germany/climate/daily/more_precip/recent/ FTP://FTP-cdc.dwd.de/pub/CDC/observations_germany/climate/daily/more_precip/historical/		FTP	ASCII	Station	Depth	Precipitation, kind of precipitation (0=no precip, 1 or 6 = rain, 7=snow, 8=mixed, 9=missing value, 4=precip observed, but not kind)	daily	1946 recent, 5510 historical	End of 19th century until today, depending on station (opening, closing date)