WMO POLAR SPACE TASK GROUP - SAR COORDINATION WORKING GROUP

THIRD SESSION

ASI (AGENZIA SPAZIALE ITALIANA)
ROME, ITALY, 5 – 6 NOVEMBER 2014

FINAL REPORT

OPENING AND WELCOMING REMARKS

The third session of the Polar Space Task Group (PSTG) Synthetic Aperture Radar (SAR) Coordination Working Group (SAR-CWG) was held at the new facility building of the Agenzia Spaziale Italiana (ASI) in Rome, Italy, from 5 to 6 November 2014.

F. Battazza welcomed all participants and opened the meeting by noticing the importance of this session and pointing on the actions still opened. He reaffirmed the cooperation of ASI with PSTG and mentioned that ASI officially renewed its membership to Polar Space Task Group in December 2013 for another 3 years. F. Battazza noted that M. Shimada (JAXA) was not able to attend the meeting and also mentioned that M. Drinkwater would join the meeting remotely.

Y, Crevier also welcomed participants and noted that commercial partners were not represented in the meeting though some issues remained to be discussed. He warmly thanked science representatives for attending and for their fruitful contribution regarding the expression of scientific user requirements.

M. Drinkwater (remote participation) stressed the importance of this group and acknowledged the strong support received from ESA and the European Commission. He recalled that no individual space agency would be in position to respond to all user requirements and therefore a coordinated effort is needed. This is what PSTG SAR-CWG has to demonstrate. M. Drinkwater provided a brief summary of WMO Polar activities (EC-PORS, GCW) and reminded the importance of the next WMO Congress in May 2015.

Round table introduction of all participants was made to have a better understanding of the expertise of the participants. Attendance was mainly composed of space agency representatives in charge of SAR missions and representatives of scientific community. The list of participants is given in Annex 2.

1. MEETING OBJECTIVES AND APPROVAL OF AGENDA

Y. Crevier reviewed the objectives of this meeting (see below) and stressed the fact that the development of an Implementation Plan represents one of the key outcomes. The objectives of the meeting were defined as follows:

- Finalization of governance-related topics
- Finalization of ToR
- Discuss coordinated Announcements of Opportunity approach
- Review of achievements
- Review of the scientific requirements presented to PSTG
- Planning response for next phase – Current and future requirements
- Discussion of data inventory and outreach
- Draft Implementation Plan

The programme for the meeting was adopted with minor amendments to adjust with M. Drinkwater and A. Bartsch's timings. The final agenda is attached as Annex 1. All meeting documents are available at http://www.wmo.int/pages/prog/sat/meetings/PSTG-SARCWG-3.php

2. REVIEW OF ACTIONS

The Action items list from the previous meeting was discussed and updated (see table on next page).

ACTION SAR CWG-2.1: All SAR CWG-2 invitees to review revised Group Terms of Reference for adoption (deadline: 31 May 2013)	CLOSED. Finalized in session
ACTION SAR CWG-2.2: Investigate complementing single RADARSAT-1 acquisition dataset for Svalbard with acquisitions from RADARSAT-2 (Lead: B. Scheuchl and Y. Crevier; deadline: 1 October 2013)	CLOSED. Achieved in CSA response to ice sheet requirements
ACTION SAR CWG-2.3: E. Herland, Y. Crevier and B. Scheuchl to identify the data format KSAT is providing, and confirm subsequent processing with ASF/NASA, CSA; deadline: 1 November 2013)	OPEN. Format accepted by science communities. ASF/NASA is going to process the dataset (by the ebd of this month).
ACTION SAR CWG-2.4: Describe concisely what has been achieved in support of RADARSAT-2 ice sheet monitoring between Jan and May 2013 as a result of PSTG SARCWG coordination, and highlight the remaining gaps. (Lead: B Scheuchl; deadline: August 2013)	CLOSED. B Scheuchl reported to CSA and is working with Yves on a post-RADARSAT-2 eclipse campaign in Antarctica. For the remainder of the year; consider closed as of 14 August 2013
ACTION SAR CWG-2.5: Create a template for describing the various datasets that could be made available through an AO by agencies. (Lead: Y. Crevier; deadline: 1 November 2013)	CLOSED. The template has been sent to members to fill in.
ACTION SAR CWG-2.6: Group to respond to Yves regarding interest for special session at ASAR Workshop (deadline: 31 May 2013).	CLOSED.
ACTION SAR CWG-2.7: Develop a distributed observation strategy among all SAR agencies in PSTG covering the cold spot list provided in doc. PSTG-3_Doc_08-02-02 ("SAR Science Requirements for Ice Sheets") (Lead: A. Roth and F. Battazza; deadline: next PSTG SARCWG meeting)	CLOSED. Included in Action 2.9.
ACTION SAR CWG-2.8: Draft a compendium paper describing collective datasets available (such an activity is ongoing within the Geohazard supersites concept, which then could be duplicated for a Polar Ice Sheet exploitation portal) (Lead: Y. Crevier and H. Laur); CNES (S. Hosford) to contribute concepts related to common access and licensing (deadline: 31 December 2013)	OPEN. The template has been sent to the members. Once all contributions are collected, they will be put together to create the compendium.
ACTION SAR CWG-2.9: Y. Crevier to draft a 3-year work plan for the Group (deadline: next PSTG SARCWG meeting)	OPEN. To be completed by mid-January 2015.
ACTION SAR CWG-1.10: Development and adoption by Agencies of a joint preamble to Announcements of Opportunity (including thematic science components to be addressed collectively) (Lead: Roth and Battazza, with Crevier contributing; Deadline: October 2013)	OPEN. The draft joint preamble has been sent to the member agencies. The coordinated AO approach was discussed at the SAR CWG-3 meeting and will be finalized by the next PSTG SAR-CWG-4 meeting.

A summary of all open Action items, including those identified at third session is given in Annex 3.

3. GOVERNANCE - TERMS OF REFERENCE (FINAL APPROVAL)

Terms of Reference (ToR) sent last year were reviewed and updated with comments received by participants. Y. Crevier recalled that space agency' contributions are not specifically defined in time but rather based on a constant dialogue. He further mentioned that the work of the group should involve private companies.

The meeting noted that PSTG and SAR-CWG meetings do not necessarily have to be back to back (e.g. same week, same place). This would allow more flexibility for participants to attend. For governance, the meeting agreed to extend to a 3-year period the term of the Chair in order to be concomitant with the term of the Implementation Plan.

Comments and changes on Terms of Reference were made in-session. The meeting then adopted the Terms of Reference (see Annex 4). The document will be made available online through the PSTG web site.

4. BASELINE IMAGING ACTIVITIES

4.1 German Aerospace Centre (DLR)

D. Floricioiu presented an overview of DLR activities related to ice sheets monitoring with InSAR sensors. She outlined both the TerraSAR-X Greenland outlet glaciers 2009 – 2014 and the TerraSAR-X Antarctica 2008 – 2013 campaigns. In both regions, the aim was to provide InSAR data pairs for high resolution ice velocity measurements (approximately 25 major rapidly changing outlet glaciers in Greenland and several large outlet glaciers of the West Antarctic Ice Sheet (WAIS)).

The approach to monitor those glaciers is based on the TerraSAR-X sensor using the Stripmap mode (30 km swath width, < 3 m resolution) resulting in the production of InSAR pairs covering the glacier termini several times per year. D. Floricioiu highlighted the quantity of data generated from these campaigns noticing that a single scene (30 km x 50 km) as SLC (SSC) product is about 1.5 gigabytes (GB). In total, for Greenland, about 2000 scenes have been acquired between 2009 and now, which represents a disk space of about 3 terabytes (TB) of data. The data acquired over Antarctica between 2008 – 2013 amounts to ~10 TB.

Furthermore, she highlighted the TanDEM-X Greenland 2011/2012 campaign aiming to produce a high resolution InSAR Digital Elevation Model (DEM) of 90 m pixel spacing of the Greenland ice sheet. The TanDEM-X Antarctica 2013 & 2014 campaign has the same purpose over the Antarctica ice sheet. The approach has been divided into two distinct coverages in 2013 and 2014 both with left and right looking. The acquisitions will be combined in a post-processing step to a single DEM. These final DEMs (90 m pixel spacing) are planned to be available by 2016. The DEM of Antarctica will include ice shelves and circa 10 km of margins. Total size estimation is about 100 GB including various layers (backscattering amplitude, error and water masks).

D. Floricioiu also mentioned that satellite positions have been switched during the campaign in order to reduce layover effects over mountainous steep terrains.

4.2 Canadian Space Agency (CSA)

Y. Crevier recalled that the CSA contribution was delivered within the framework of an international collaboration through PSTG to provide a level of data continuity through space-borne data collection over ice sheets. The approach to monitor ice sheets in Greenland and Antarctica with InSAR instruments was done within an international collaboration first initiated as part of the International Polar Year (IPY) with a coordination of input from science community. The aim is also

to provide a continuous coverage and science products from ongoing and emerging projects and to make them available for free. Achievements made so far encompass, inter alia, ice velocity and grounding line products available to the science community.

Y. Crevier gave details on past and current SAR missions conducted by Canada over ice sheets and glaciers of Greenland and Antarctica. Thanks to the RADARSAT-1 Greenland (2005-2008 & 2000-2001) mission, a full interferometric coverage of the Greenland Ice Sheet with multiple (4) repeats was achieved. The data provided the basis for the generation of ice sheet velocity maps of the Greenland ice sheet.

The RADARSAT-1 Greenland 2013 campaign followed the IPY data coverage of the Greenland Ice Sheet. It represented the final large scale RADARSAT-1 science mission before the mission ended in March 2013 and was the CSA contribution to PSTG.

With the ongoing RADARSAT-2 Greenland 2014 mission the ascending acquisitions are planned for NW and SE coastal areas of Greenland to increase the chance of data coverage (first cycle was completed successfully). Standard mode coverage is used to reduce sensor load and probability for conflict as well as shorter tracks to increase chance of downlink success.

The RADARSAT-2 Antarctica 2009-2011 and 2013 missions respectively aimed to cover central (~ 78 degree south to South Pole) and coastal parts of Antarctica with interferometric SAR data (3 repeats). This represented the CSA contribution to IPY.

The RADARSAT-2 Antarctica 2014/16 mission is similar to the 2009 campaign (left looking). EH4 mode acquisitions for South Pole (campaign started in December 2013, ongoing). The S5 mode acquisitions plan to cover the Ross and Ronne Ice Shelves and other areas south of ~78° is currently under consideration and may be spread over multiple years.

Y. Crevier acknowledged the outstanding products already derived by scientific communities from the huge RADARSAT-1 and 2 archives and recalled that this large dataset is also available for sea-ice and potentially for permafrost studies. He also made mention of the DLR contribution to download the data through an international collaboration and reiterated his acknowledgements to them for their effort.

4.3 Italian Space Agency (ASI)

F. Battazza provided a summary of COSMO-SkyMed achievements with respect to ice sheets monitoring. These efforts, as for other space agencies contributions, are also underpinned within an international collaboration through PSTG to provide a level of data continuity through space-borne data collection over ice sheets. He also mentioned that ASI renewed its membership to the Polar Space Task Group in December 2013 for another three-year period.

In the Polar Regions high acquisition opportunities are offered with COSMO-SkyMed. Over the Greenland ice sheet observations are operated in the Stripmap mode (3-5 m res., 40 km swath), the ScanSAR wide region mode (30 m res., 100 km swath) and the ScanSAR huge region mode (100 m res., 200 km swath). The large dataset available in the CSK archive encompasses various glaciers and ice sheets located in Polar Regions as well as InSAR coverage with different time resolutions (i.e.: 1, 4, 8, 16 days).

F. Battazza noted that thanks to its agility the COSMO-SkyMed constellation is able (i) to monitor wide areas in relatively short time, (ii) to monitor the North Pole and (iii) to provide continuous monitoring of main glaciers and ice sheets. In fact, the COSMO-SkyMed Greenland 2008-2010 campaign aimed to acquire data of the Petermann Glacier from 2010 (twice-daily in specific period) whereas the COSMO-SkyMed Greenland 2011-2012 campaign provided the possibility to monitor polar routes in one day (using the ScanSAR huge region mode). The purpose of the COSMO-SkyMed Greenland 2013-2016 campaign is to monitor the Fram strait in order to provide information on the east Greenland current and sea ice drift.. This campaign has already started

and it is planned to continue acquisitions from 2014 onward using ScanSAR also inSAR acquisitions (using Stripmap) in at one / eight day revisit time could be used for specific cases if needed.

Over Antarctica, the COSMO-SkyMed Antarctica 2008-2012 mission aimed to monitor main glaciers (e.g. Drygalsky) and ice sheets, polynya in Ross Bay and to survey the Antarctic Peninsula (breaking of the Wilkins ice shelf). It also served to continuously monitor the French-Italian Concordia Station (Dome-C) and the M. Zucchelli Station from 2012. The whole Antarctic Coast and the Transantarctic Mountains are monitored through the COSMO-SkyMed Antarctica 2013-2016 campaign with possible acquisition revisit times of one and eight days.

4.4 European Space Agency (ESA)

P. Potin presented the planned ice sheet campaigns with Sentinel-1A over both Greenland and Antarctica, recalling that Sentinel-1 will constitute the ESA's contribution to the PSTG SAR CWG. The aim over Greenland is to provide full coverage in two or three consecutive twelve-day repeat cycles in a single campaign during the Arctic winter 2015. The approach is to use Interferometric Wide Swath (IWS) mode (250 km swath) with a single polarization HH (probably in both ascending and descending orbits) in coast to coast tracks. This campaign however, requires coordination with MyOcean sea-ice monitoring activities.

Over Antarctica, the aim is to provide coastal coverage in two or three consecutive twelve-day repeat cycles during austral winter (indicatively June-August 2015). However, partial coverage of priority areas may be possible in winter 2014-2015. Approach is similar to Greenland monitoring.

Despite its large coverage capability Sentinel-1A does not cover Poles. In fact, Sentinel-1A visibility is limited to about 87.4 degrees north and to 78.5 degrees south due to the right looking characteristic of the instrument. A contribution of Radarsat-2 is expected in order to cover Pole holes.

5. DATA ACQUISITION PLANS FOR SENTINEL-1 AND PALSAR -2

5.1 SENTINEL-1

P. Potin provided the audience with a comprehensive review of the Sentinel-1A satellite observation scenario along with the planned activities related to ice sheet monitoring (see above). He recalled the objectives of this scenario which would in priority, during the routine exploitation phase, fulfil the observation requirements of the Copernicus services and for use by member states. In addition, on a best effort basis, this scenario will aim to respond to other SAR user communities, (e.g. ice sheet monitoring) taking into account requirements from the scientific community. Further information is available in the SENTINEL-1 Observation Scenario web page.

Noting that Sentinel-1 constellation will be capable of extended area coverage, P. Potin displayed a map showing parts of the world that are covered by Sentinel-1A. While acquisition over Arctic sea-ice regions is mainly done in the Extra Wide Swath (EWS) mode with HH and HH-HV polarization, over land (e.g. Central Europe) the Interferometric Wide Swath (IWS) mode with VV-VH polarization constitutes the baseline operational mode.

P. Potin further demonstrated the steady Sentinel-1A contribution with continuous monitoring of fast flowing outlet glaciers over reference sites such as ice shelves and major outlet glaciers in both Greenland and Antarctica (respectively Jacobshavn and Upernavik Glaciers, and Pine Island and Thwaites Glaciers). Acquisitions are already on-going with a 12 days exact repeat interval for both regions. This exact repeat interval will decrease to 6 days with Sentinel-1B.

Routine operation within the Antarctica preliminary monitoring concept will be limited to Antarctica coastal regions following a proposal made to PSTG. However, preferred acquisition time windows over Antarctica might have to be extended later. Partial coverage of priority areas may be possible

in winter 2014-2015. For Greenland, a first performance test repeat-coverage was already included in the commissioning phase activities during August/September 2014. The implementation of a Greenland IWS campaign and its impact on sea-ice monitoring has already been tested.

5.2 PALSAR-2

The document provided to the PSTG SAR Working Group describes the first edition of the ALOS-2 Basic Observation Scenario (the launch date was 24 May 2014). The PALSAR-2 instrument onboard ALOS-2 has several observation modes (Spotlight, Stripmap, ScanSAR) and a right-and-left looking function to fulfil the mission requirements. Good acquisition planning is required to avoid conflicts among user requests, given the system's high flexibility. From experiences of ALOS operations, implementation of a systematic observation strategy to achieve consistent data acquisitions in time and space proved to be crucial, and a Basic Observation Scenario (BOS) has therefore been developed also for ALOS-2.

The Basic Observation Scenario includes repetition of global observations according to seasonality and geographical locations, with high priority to emergency observation and cal/val observations. The scenario is designed to fulfill the following general acquisition principles:

- Spatial and temporal consistency over regional scales, at coarse, fine and very fine resolution;
- Adequate revisit frequency (including accommodating InSAR);
- Accurate timing;
- Consistent sensor configuration;
- Long-term continuity.

The scenario comprises separate plans for Japan and for the rest of the world. For Japan, the Japan Base Map serves the objectives of "Disaster" and "Differential InSAR". It is based on observations in two modes: Stripmap 3m (resolution) and ScanSAR 350 km (swath width). Base Map for disaster applications includes observations at various incidence angles, to enable interferometric data analysis pre- and post-disaster. The Base Map for Differential InSAR encompasses observations for periodic collection of data for differential interferometry.

For the rest of the world, the Basic Observation Scenario (Global) has been designed to fulfill several requirements. Some of them are given below as examples: To avoid conflicts between observation requests;

- To ensure highest possible observation frequency;
- Observation requests with the same observation modes (beam mode, satellite flight direction, beam direction, polarization) should as far as possible be observed during the same cycles;
- Observations in right-looking mode are nominal, except over Antarctica;
- Observation time windows are repeated annually for all regions;
- Observations of Polar Regions mainly in ScanSAR mode;
- Observations of desert, snow and ice regions have lower priority.

Further information is available in the Basic Observation Scenario document.

6. REVIEW OF SCIENTIFIC USER REQUIREMENTS

6.1 Ice sheet monitoring project

B. Scheuchl gave an overview of the SAR Science Requirements for Ice Sheets document (this document was introduced at PSTG-3 in 2013). Motivation for this document reflects the fact that Ice sheets have been acknowledged by WMO and UNFCCC as Essential Climate Variable (ECV) needed to make significant progress in the generation of global climate products and derived information.

The document provides details on (i) Science Requirements, (ii) General Acquisition Recommendations and (iii) Sensor Specific Recommendations (observation, reduced observation and science mission requirements). As an example of general observation requirements for Antarctica, B. Scheuchl mentioned annual coverage of all of Antarctica with at least 3 consecutive cycles (winter observations). A reduced observation requirement (e.g., to be applied if sensor capacities require scale-down of acquisitions) would be to plan for a full Antarctic coverage at least every 3 (or 5) years and to provide annual coverage of coastal regions (right looking: all coastal areas; left looking: Transantarctic Mountain Range + Ross and Ronne Ice Shelves with their tributaries). Ongoing coverage of the visible area with coast-to-coast tracks (right looking: coastal areas; left looking: Central Antarctica) and acquisition of additional tracks covering large outlet glaciers with higher resolution modes could constitute the science mission requirements (assuming no conflicts with other priorities).

B. Scheuchl also made mention that the community has expressed high interest in both ongoing acquisitions of key areas as well as at least one coverage of all coastal areas. It is however, acknowledged that full coverage (Antarctica) or full ice sheet acquisition (Greenland) is not possible this time. Furthermore, due to observed changes, it is necessary to give the same priority to NW and NE parts of Greenland or to combine these regions. While four consecutive acquisitions would be an asset, three consecutive acquisitions are considered as minimum. B. Scheuchl reaffirmed that according to the plan agreed at PSTG-3, DLR will contribute with their X-band missions to provide dense coverage of Antarctica through 2016.

CSA will contemplate continued monitoring of Thwaites and Pine Island Glacier.

Further details are available in the SAR Science Requirements for Ice Sheets document.

ACTION SAR CWG-3.1: B. Scheuchl will evaluate the Ice Sheets Acquisition Plan and provide feedback on possible refinements if necessary. Deadline: PSTG SAR-CWG-4.

ACTION SAR CWG-3.2: CSA will evaluate the possibility of monitoring the centre of Antarctica and parts of Greenland. Deadline: PSTG SAR-CWG-4.

ACTION SAR CWG-3.3: B. Scheuchl will evaluate the quadrants division of Antarctica and suggest refinement if necessary. Deadline: PSTG SAR-CWG-4.

6.2 Snow and glaciers monitoring project

D. Small provided the meeting with a white paper on Snow User Requirements for observing wet snow, concentrating on the coordination of space-borne SAR sensors for this purpose (this paper was introduced at PSTG-4 in Sep/Oct 2014). D. Small first listed the relevant operating and future upcoming SAR missions and the science requirements for monitoring wet snow areas. He then described details of SAR image processing (i.e. Radiometric Terrain Correction) and defined how the revisiting interval could be shortened by applying a moving time-window concept that integrates information from all available tracks. This “Local resolution weighting” approach combines ascending and descending observations to generate a composite with improved local resolution compared to any single image or acquisitions of flat areas. This approach is compatible with sensors in different orbits (e.g. not only S1A+S1B, but also S1A+RS2, or S1A+S1B+RCM). He also made mention of the seasonal observation windows noting that snow melting regularly takes place within relatively narrow time windows which implies benefits from devoting maximum sensor resources to acquisitions during these highly dynamic periods (e.g., between 15 February and 30 May at northern temperate latitudes).

Key general recommendations for snow monitoring are listed herewith:

R1	**Use wide-swath modes** to enable wide area monitoring with high temporal resolution (i.e. RSAT2 SCNB, Sentinel-1 IW, TSX “SC Wide” & CSK “Huge Region” ScanSAR modes).
R2	Build combined **ascending/descending** coverage by default into acquisition plans covering mountainous regions. Favour asc./desc. Acquisition sets acquired within a **tight time window** (1-3 days) to allow a narrow time-attribution to composites generated from these sets.
R3	Concentrate snowmelt acquisitions on the **seasonal window** when the majority of snow melting occurs (Feb. 15 through May 30 at temperate northern latitudes). The *highest temporal resolution possible* is requested during this critical melting period. Although some further acquisitions are also requested *outside* of this seasonal window, lower temporal resolution at these less critical times is acceptable.
R4	Standardise dual-pol. mode acquisitions on **VV/VH** combination: a cross-platform consistent polarisation simplifies combination of datasets from multiple providers (e.g. S1/RSAT2/RCM or TSX/CSK).
R5	**Harmonise acquisition plans** of satellites with compatible calibrated backscatter values (e.g. S1/RSAT2/RCM or TSX/CSK). Utilise the available diversity of orbits to achieve the desired diversity of tracks – e.g. to achieve the fullest possible ascending/descending coverage.
R6	Assure **full coverage over land also in coastal regions** when other modes are by default programmed over ocean (e.g. favour Sentinel-1 IW or EW over WV).
R7	Maintain a **regular observation plan also during the winter** to assure frequent observations of other important snow parameters, and other phenomena related to the winter period such as avalanches and rain on snow events.
R8	Provide free and open access to SAR image data.

ACTION SAR CWG-3.4: D. Small will send prioritized acquisition areas to DLR (beam, resolution and other parameters required) for observations in X and C bands. This will include the geographic extent of an alternate site (other than the Swiss Alps). Deadline: 20 February 2015.

6.3 Permafrost Monitoring Project

A. Bartsch provided an overview of the SAR scientific requirements for permafrost monitoring (this document was introduced at PSTG-4 in Sep/Oct 2014). She briefly described some basic characteristics of permafrost (What is permafrost, How it is measured, Regions of interest etc.). She described how permafrost changes in response to climate change and to variations in local seasonal factors (e.g. snow cover, vegetation). She provided the meeting with information on the current WMO Observing Systems Capability Analysis and Review (OSCAR) data base requirements specifications. She showed maps underlining where in-situ measurements are performed through international collaborations and networks (e.g. GTN-P/CALM (IPA – International Permafrost Association); Global Cryosphere Watch (GCW)). She pointed out several important permafrost monitoring projects (i.e. ESA DUE Permafrost – EO products service (2009-2012); ESA STSE ALANIS Methane (2010-2012); FP7 PAGE21 – Changing Permafrost in the Arctic and its global impact in the 21st century – GTNP/CALM data portal implementation (2011-2015); NASA Above (Alaska, Canada); ADAPT (Canada); DEFROST (Scandinavia)). A. Bartsch recalled the general observation requirements (all regions underlain by permafrost), the reduced observation requirements (transects across permafrost zones as well as arctic coasts) as well as the science mission requirements (acquisitions with higher resolution modes over long term in situ monitoring sites (‘cold’ spots).

SAR group specific requirements:

Parameter	Spatial res.	Temporal res.	Band	Polarization	Comment
Subsidence	10-20 m	Bi-weekly during snow free season	L, C, X	Single (HH or VV)	InSAR
Rock glaciers	3-10 m	Bi-weekly during snow free season	L, C, X	Single (HH or VV)	InSAR
Surface status	< 30 m	Better than weekly, shoulder seasons	L, C, X	any	
Wetlands and lakes	< 30 m	Weekly, shoulder and snow free seasons	L, C, X	HH plus HV/VH, HH/VV or quad	
Coastal erosion	1 m	Annually during the ice and snow free season	L, C, X	Single (HH or VV)	Be-weekly for highly active areas
Lake depth and thawed zone characteristics	1-30 m	Weekly during winter	C, X	Single (HH or VV)	Detecting whether lakes have grounded or floating ice; indication of thermokarst activity under lakes
Methane emissions from lakes	1-20 m	Weekly during should seasons (freeze-up, ice-out)	L, C	Single (HH or VV), HH/VV, quadpol	Quantification of methane ebullition bubbles

A. Bartsch summarized the content of the White Paper on Permafrost monitoring (General requirements are listed in the table below):

Science (cold spots= current in-situ monitoring sites)	
R1	bi-weekly SAR acquisitions of all 'cold spots' for InSAR applications
R2	annual high resolution optical (<1m) acquisitions of all 'cold spots' (July-August)
Reduced spatial extent but on long term required for all permafrost areas	
R3	bi-annual (early and late summer) high (<1m pan, <5m ms) to medium resolution (<30m ms) optical and SAR of all monitoring transects for land cover applications
R4	once per year high resolution SAR and optical acquisitions of arctic coast line (high activity areas) in consistent polarization and frequency, and orbit (with differentiation between actual exposition of slope)
R5	annual coverage of all rock glacier-characterized regions with high-resolution optical (1 good image) and SAR (2-3 cycles for interferometry) for general inventory and hot spot identification
R6	annual circumpolar lake inventory (<30m) in thermokarst dominated lowland regions (**with time stamp for each pixel!** in case of higher level product, consistent frequency and resolution)

R7	annual lake ice status for monitoring transects (grounded versus floating ice at the end of winter)

ACTION SAR CWG-3.5: S. Bojinski will provide link on the PSTG website to transect (KML files) and “cold spots” for permafrost.

6.4 Sea Ice Monitoring Project

S. Howell presented a summary of the observation requirements for floating ice focusing on the use of Synthetic Aperture Radar (this document was introduced at PSTG-4 in Sep/Oct 2014). The objectives of this document are to identify the required set of satellite measurements to address key science questions relevant to the assessment of the impacts of climate change in the Polar Regions:

- Focusing on Synthetic Aperture Radar
- Identify the properties of sea ice, icebergs and freshwater ice that are of greatest scientific interest with respect to the impacts of climate change
- Recommend strategies to monitor and measure these properties with SAR from space.

More than 150 scientists were contacted to seek input on the observational needs of science and on the type of satellite SAR observations of floating ice that would be most useful. A draft document was circulated broadly in the scientific community and comments incorporated.

Most important parameters related to floating ice are:
- Thickness and thickness distribution
- Snow cover on sea ice
- Ice deformation
- Other characteristics (e.g. ice concentration, ice drift).

For Icebergs:
- Are iceberg distribution patterns changing and, if so, what are the causes and likely future changes?
- How to better understand the behavior of icebergs, particularly their drift and deterioration?

For Freshwater ice (both lake and river ice):
- The timing of freeze-up and break-up (ice phenology)
- Ice classification
- Ice and snow thickness

The document defines geographic areas of importance (e.g. Arctic Ocean, from the Beaufort Sea to Fram Strait; Canadian Arctic Archipelago; the entire marine area around Antarctica and extending to the limit of iceberg drift) and further provides a comprehensive satellite SAR acquisition strategy for science applications.

A significant concern of the scientific community is underlined in the document about the need to acquire data for commercial activities which subsequently will reduce the quantity and variety of data available for research. In the other hand, data providers have legitimate concerns that making commitments to supply data for science will hurt their business cases (known and repeatable data, processing and analysis techniques). However, SAR data providers should recognize the benefits of working together and seek ways to maximize the collaboration between the commercial and scientific communities.

General Recommendations to monitor floating ice:

- Near-simultaneous observation by different sensor types (passive and active, operating in the optical, thermal, and microwave parts of the electromagnetic spectrum) is necessary to characterize many important sea ice processes,
- It is at the regional modeling level with high spatial and temporal resolution that SAR products provide their greatest support to human infrastructure,
- Scientific advancement in the use of SAR data could benefit from closer collaboration between operational ice services and research institutes dealing with floating ice,
- A vast quantity of satellite SAR data has been collected and saved but much of it remains,
- Inaccessible to the research community. Government and private holders of SAR data should be encouraged to make their data accessible to the scientific community,
- Field data, while challenging to acquire, are an essential component of remote sensing research,
- International collaboration is of great benefit in these efforts but needs continuing support,
- Closer coordination of data acquisition and distribution among satellite operators and data providers would be highly beneficial to the scientific community (central portal for access to data?).

Further details are available in the Global Satellite Observation Requirements for Floating Ice document (PSTG-4/Doc. 8.4).

7. STRATEGIC IMAGING GOALS IN RESPONSE TO KEY / PRIORITY SCIENCE QUESTIONS

7.1 Strategic Scientific Foci

M. Drinkwater summarized the requirements presented by representatives of scientific communities and proposed to focus on strategic goals of PSTG for the 2015-2018 period in response to priority science questions. The key science questions that PSTG should respond to are:

- Sea ice mass balance and mass variability
- Ice sheet mass balance contribution to sea level
- Atmospheric products to facilitate improved polar NWP
- Freshwater budget closure at high latitudes (snow and permafrost impact on polar hydrological cycle)
- Circumpolar changes in permafrost and terrestrial biosphere (consequences for Carbon and hydrological cycles)
- Physical forcing of atmospheric chemistry in polar atmosphere (surface/troposphere, and troposphere/stratosphere coupling in the UTLS)
- Ecosystem response to variability and change

The Chair of PSTG then proposed specific goals in response to the user requirements for permafrost, floating ice and wet snow:

7.2 Permafrost goals

- Routine high resolution circumpolar coverage for monitoring variability in carbon pools;
- Establish SAR monitoring of Arctic permafrost transects on routine basis to supplement existing 30-300m pan-Arctic multispectral imaging (Antarctic Peninsula covered by sea ice requirements);
- Establish bi-weekly multi-sensor monitoring (including SAR) around key research locations where GTN-P and in-situ measurements are made (“cold spots”) (supplement existing T-SAR-X acquisitions; Bi-weekly InSAR for permafrost modeling);

- Obtain <1m summer (July-Aug) optical images around each Arctic Cold Spot for up-scaling/downscaling of local periglacial processes;
- Quantify rates of pan Arctic coastal erosion (Annual circumpolar Arctic coastline mapping at < 10m resolution (optical); InSAR estimates of erosion/degradation);
- Derive SAR DEM and custom land surface properties map of relevance to permafrost community needs;
- Use snow extent/SWE, frost depth, soil moisture, LST, products developed elsewhere.

ACTION SAR CWG-3.6: A. Bartsch to analyse the strategic goals for the SAR- CWG related to permafrost proposed by M. Drinkwater. Deadline: PSTG SAR-CWG-4.

ACTION SAR CWG-3.7: DLR and ASI will work together to assess their joint capability to monitor the prioritized list of cold spots and transects proposed by A. Bartsch. (cf. PSTG-4 Action 4.8) Deadline: PSTG SAR-CWG-4.

7.3 Floating ice goals

- Establish multi-agency plan for acquiring contiguous (seamless) six days repeat pan-Arctic SAR imaging at consistent polarization combination (with view to expanding to intermediate goal of less than three days repeat in future with right-looking S-1A, RCM, etc.; and subsequently less than one day data with C-, X-, S-, L-band SAR combined data sources;
- Establish Arctic Tundra lakes and river monitoring sites, as extension of sea ice coverage.

ACTION SAR CWG-3.8: CSA will assess the release of the CIS and NAIS operational data to scientists Deadline: PSTG SAR-CWG-4.

7.4 SAR wet snow

- Strategic goal to establish less than three days SAR monitoring (ascending/descending combinations) of European Alpine region and other selected mountain regions (Scandinavia, Canadian Pacific mountains) during seasonally limited snow melt time window;
- SAR data shall complement passive microwave, and 300m optical data for continental scale snow extent/SWE – particularly in rugged zones where other methods fail;
- Establish common polarization/mode strategy between missions;
- Demonstrate routine snow melt data processing & publish results;
- Pilot snow melt service (seasonal snow melt/runoff/hydropower/water resource availability);
- Expand temporal/spatial revisit to operationalize services.

ACTION SAR CWG-3.9: A. Roth will send the proposal that D. Small submitted to DLR to F. Battazza. Deadline: PSTG SAR-CWG-4.

ACTION SAR CWG-3.10: P. Potin will explore the possibility of extending coverage by Sentinel-1 of the European alpine region during the seasonal melt window (mid-February – end May). Deadline: Next PSTG

All space agencies representatives agreed to these strategic goals, and to explore the possibility to respond to user requirements through an imaging strategy, first individually, then collectively (in collaboration with other space agencies within the framework of PSTG SAR CWG). Furthermore, ASI will look at possibilities for monitoring coastal erosion in Antarctica; CSA will explore monitoring of the ABOVE project transect (see Fig. 2 of the PSTG-4 report) and ESA will explore extensions of their acquisition plans for coastal erosion. Note that the small Norwegian transect is already covered by ESA.

8. IMPLEMENTATION PLAN: PLANNING AND RESPONSE TO REQUIREMENTS, INCLUDING ACCESS TO DATA (capabilities, constraints, approaches, coordination, etc.)

Although attendees recognized the need to develop a SAR CWG Implementation Plan (IP) that would defined, inter alia, time frame, nominal contribution from space agencies within a specific framework, no significant improvement in developing such an IP has been achieved during the session. The meeting agreed to develop a 3-year Implementation Plan (see Action 2.9). Strategic goals defined during the session and summarized by M. Drinkwater will be included in the SAR CWG-IP.

9. DISCUSSION – COORDINATED AOs

Y. Crevier recalled that the preamble is common to the Announcements of Opportunity (AO) of all of the SAR Coordination Working Group members and especially underlined that SAR CWG supports principles of open data distribution and sharing, as well as load sharing. He further reminded the objectives of the AO which aims “to develop and demonstrate techniques where the rich store of archived SAR data of polar ice sheets contributes useful information, either alone or integrated with other data sources, to respond to the Key Science Questions”. The meeting decided to circulate a common preamble of AO along with questions to collect ideas from participants.

10. DISCUSSION – DATA COMPENDIUM AND OUTREACH

The meeting recognized the need to have a document that describes the sort of data produced within SAR CWG. They agreed that the SAR Dataset Compendium should include one page describing space agency missions (with links to specific mission web pages); to include a draft paragraph (as recommendation) to be used to acknowledge PSTG in publications and; to include synoptic quad sheets provided by Space Agency representatives.

Y. Crevier asked all participants to provide contributions to develop such compendium document. He also mentioned that PSTG will continue to produce brochures to advertise activities of the group and continue to inform CEOS on its activities.

11. WARP-UP AND CLOSURE OF THE MEETING

Y. Crevier once more thanked the science community representatives for the work accomplished in producing important documents that precisely describes the scientific requirements for SAR monitoring and reiterated his thankfulness to the space agency representatives for their willingness to explore the possibility to address those requirements. He further underlined the importance to have such a framework to share the load recognizing the usefulness of this group which fosters the collaboration between space agencies.

On the behalf of DLR, A. Roth proposed that the next PSTG SAR CWG meeting could be held in the premises of the Germany Space Agency in Bonn.

The meeting was adjourned Thursday 6 November 2014 at 01:00 PM.

ANNEXES

Annex 1: Agenda

Day 1	**November 5, 2014**	
9:00	Opening and Welcoming Remarks	Fabrizio Battazza, Yves Crevier
9:10	Meeting Objectives and Approval of Agenda	Yves Crevier
9:20	Review of Actions	Secretariat
9:30	Governance - Terms of Reference (Final Approval)	Yves Crevier, All
10:15	*Break*	
10:45	Baseline imaging activities	All
11:45	Data Acquisition Plans for Sentinel-1 and Palsar-2	Pierre Potin, JAXA rep. TBD
12:30	*Lunch*	
13:30	Ice Sheet Monitoring Project Overview of achievements and “next” phase requirements	Bernd Scheuchl, All
14:20	Snow and Glaciers Monitoring Project Review of requirements a. Regional snow requirements b. Global snow requirements c. Glacier requirements	David Small, Bernd Scheuchl, All
15:10	*Break*	
15:30	Permafrost Monitoring Project Review of requirements	Annett Bartsch, All
16:20	Sea Ice Monitoring Project Review of requirements	Stephen Howell, All
17:10	Synopsis	
17:30	*Adjourn*	
Day 2	**November 6, 2014**	
9:00	Strategic imaging goals in response to key / priority science questions	All
9:45	Implementation Plan: planning and response to requirements, including access to data (capabilities, constraints, approaches, coordination, etc.)	All
10:45	*Break*	
11:00	Discussion – Coordinated AOs	All

12:00	Discussion – Data compendium and Outreach	All
13:00	*Lunch*	
14:00	Refinement and completion of Implementation Plan	All
16:30	Meeting Wrap-up (Actions and Next Meeting)	Secretariat
17:00	*Adjourn*	

Annex 2: List of Participants

PSTG, SAR CWG meeting#3: List of Participants (5-6 Nov 2014)

Last name First name	Affiliation	Email
Ball Don	DB Geoservices Inc	don.ball@rogers.com
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Scheuchl Bernd	University of California, Irvine	bscheuch@uci.edu
Small David	University of Zurich	david.small@geo.uzh.ch

*Jointed the meeting remotely via a web-based application.

Annex 3: SAR-CWG Actions

ACTION SAR CWG-1.10: Development and adoption by Agencies of a joint preamble to Announcements of Opportunity (including thematic science components to be addressed collectively) (Lead: Roth and Battazza, with Crevier contributing; Deadline: October 2013)	OPEN. The draft joint preamble has been sent to the member agencies. The coordinated AO approach was discussed at the SAR CWG-3 meeting and will be finalized by the next PSTG SAR-CWG-4 meeting.
ACTION SAR CWG-2.3: E. Herland, Y. Crevier and B. Scheuchl to identify the data format KSAT is providing, and confirm subsequent processing with ASF/NASA, CSA; deadline: 1 November 2013)	OPEN. Format accepted by science communities. ASF/NASA is going to process the dataset (by the ebd of this month).
ACTION SAR CWG-2.8: Draft a compendium paper describing collective datasets available (such an activity is ongoing within the Geohazard supersites concept, which then could be duplicated for a Polar Ice Sheet exploitation portal) (Lead: Y. Crevier and H. Laur); CNES (S. Hosford) to contribute concepts related to common access and licensing (deadline: 31 December 2013)	OPEN. The template has been sent to the members. Once all contributions are collected, they will be put together to create the compendium.
ACTION SAR CWG-2.9: Y. Crevier to draft a 3-year work plan for the Group (deadline: next PSTG SAR CWG meeting)	OPEN. To be completed by mid-January 2015.
ACTION SAR CWG-3.1: B. Scheuchl will evaluate the Ice Sheets Acquisition Plan and provide feedback on possible refinements if necessary. Deadline: PSTG SAR-CWG-4.	OPEN.
ACTION SAR CWG-3.2: CSA will evaluate the possibility of monitoring the centre of Antarctica and parts of Greenland. Deadline: PSTG SAR-CWG-4.	OPEN
ACTION SAR CWG-3.3: B. Scheuchl will evaluate the quadrants division of Antarctica and suggest refinement if necessary. Deadline: PSTG SAR-CWG-4.	OPEN
ACTION SAR CWG-3.4: D. Small will send prioritized acquisition areas to DLR (KML file including beam, resolution and other parameters required) for observations in X and C bands. This will include the geographic extent of an alternate site (other than the Swiss Alps). (deadline: 20 February 2015).	OPEN
ACTION SAR CWG-3.5: S. Bojinski will provide link on the PSTG website to transect (KML files) and “cold spots” for permafrost.	CLOSED
ACTION SAR CWG-3.6: A. Bartsch to analyse the strategic goals for the SAR- CWG related to permafrost proposed by M. Drinkwater. Deadline: PSTG SAR-CWG-4.	OPEN

ACTION SAR CWG-3.7: DLR and ASI will work together to assess their joint capability to monitor the prioritized list of cold spots and transects proposed by A. Bartsch. (cf. PSTG-4 Action 4.8) Deadline: PSTG SAR-CWG-4.	OPEN
ACTION SAR CWG-3.8: CSA will assess the release of the CIS and NAIS operational data to scientists. Deadline: PSTG SAR-CWG-4.	OPEN
ACTION SAR CWG-3.9: A. Roth will send the proposal that D. Small submitted to DLR to F. Battazza.	CLOSED
ACTION SAR CWG-3.10: P. Potin will explore the possibility of extending coverage by Sentinel-1 of the European alpine region during the seasonal melt window (mid-February – end May). Deadline: Next PSTG	OPEN

Annex 4:

Terms of Reference
Polar Space Task Group (PSTG) SAR Coordination Working Group

November 2014

One of the major successes of the International Polar Year (IPY) in 2007-2008 was the unprecedented amount of high-resolution synthetic aperture radar (SAR) satellite imagery collected over the polar regions and the high quality data products that have since been generated. This outstanding accomplishment relied on a well-coordinated effort on the part of several space agencies, satellite operators and the science community.

Mandate

Building on the successful International Polar Year Space Task Group (IPY-STG) SAR Coordination Working Group, and in order to fulfill the need for inter-Agency mission acquisition planning and to carry out implementation actions at agency level, the Polar Space Task Group (PSTG) is re- enacting the SAR Coordination Working Group with the aim to provide coordination across space agencies with SAR missions, to facilitate acquisition and distribution of fundamental SAR satellite datasets, and to contribute to or support development of specific derived products in support of cryospheric scientific research and applications.

The SAR Coordination Working Group (hereafter: SAR CWG) shall be a subsidiary group to PSTG and coordinate its activities and membership with the PSTG.

The SAR CWG shall have the following mandates:

1. Identification and prioritization of multi-frequency SAR acquisitions on polar regions on the basis of the needs coming from scientific and related applications communities.
2. Maintain constant dialogue with these communities.
3. Maintain constant dialogue with private sector data provider partners.
4. Sharing of information on the current status of the SAR missions and the activities on polar regions.
5. Ensure that data are being made available to end-users.

Benefits

The SAR CWG will provide the following benefits to science communities and policy makers:

• A source of the highest quality and highest volume SAR data available, driven by science and, as appropriate, related application requirements, and be responsive to these requirements.

The SAR CWG will provide the following benefits to public space agencies:

• Optimal utilization, on polar regions, of space assets by responding to the requirements of the international science community;

• Efficiency through collaboration with other space agencies and commercial satellite data providers, to exploit the advantages of each mission and share the load.

The SAR CWG will provide the following benefits to commercial satellite data providers:

• A reference point for remote sensing acquisitions on polar regions;

• Efficiency through collaboration with other space agencies and commercial satellite data providers, to exploit the advantages of each mission and share the load;

• Recognition for their contribution to this global science initiative.

Activities

The SAR CWG shall undertake the following activities:

- Through its link to the PSTG, identification of the main science requirements;
- Definition of a multi-frequency SAR acquisition plan on polar regions on the basis of the needs coming from scientific community;
- Identification of a series of individual or collective approaches to ensure data dissemination. In this context, a set of unilateral mechanism, bi- and multi-lateral agreements will be put in place to meet the broad dissemination objectives.
- A 3-year Implementation Plan will be developed by the group. This plan will follow the strategic direction of the PSTG Strategic Plan, and it will comply with the capacities and constraints of the member agencies. Annual revision of this 3-year rolling plan.
- Acquisition of multi-frequency SAR datasets according to this plan;
- Based on agency capacity and mandate, coordinated creation and dissemination of processed information products of societal benefit.

Key Success Factors

The key success factors are identified as follows:

1. Get the commitment of the science community and engagement throughout the entire process.
2. Ensure engagement of SAR operating agencies and commercial satellite data providers.
3. Define milestones and calendar (meetings, definition of requirements, progress reports, etc.)
4. Identify members' roles and responsibilities (Space and Ground segment organizations, Science Community, Commercial Satellite Data Providers).
5. Identify outreach and communication opportunities in coordination with PSTG.

Governance

Policy Framework

The PSTG SAR Coordination Working Group has been established as a sub-group of the PSTG and so it supports the PSTG policy framework, as documented in the PSTG Terms of Reference.

Reporting Framework

The PSTG SAR Coordination Working Group shall informally report to the PSTG, and shall support that body's reporting to WMO.

Membership

The membership of the PSTG SAR Coordination Working Group will be as inclusive as possible and will include:

- All SAR Operating Agencies (thematic experts and mission managers)
- Other agencies (i.e. optical) to ensure availability complementary datasets
- Members of the science community representing thematic sectors of priority
- Members of the “commercial arm” of SAR missions.

Chair

The Chair of the PSTG SAR Coordination Working Group will be a representative of a space agency with a SAR mission. The Chair will rotate to another such agency every three years. The Chair is a Member of PSTG.

Meetings

Meetings will take place at least once per year, and will be hosted by the member space agencies.

Secretariat
Secretariat will be provided by the WMO Space Programme office.

Reference:
PSTG Terms of Reference
PSTG#1 Final Report
PSTG#2 Final Report
IGOS Cryosphere Theme Report 2007