PSTG SAR Coordination Working Group
1st Meeting
ESA/ESRIN, Frascati, Italy
12-13 November 2012

Meeting Summary

The first meeting of the Polar Space Task Group (PSTG) Synthetic Aperture Radar (SAR) Coordination Working Group (henceforth: SAR Coordination WG) was held on the premises of ESA ESRIN on 12 and 13 November 2012, on the fringes of the collocated WCRP-CliC/EGU/ESA Earth Observation and Cryosphere Science Conference (13-16 November 2012). Annex I has the Agenda, Annex III the list of participants, consisting mainly of Space Agency representatives in charge of SAR missions (note that not all participants attended the full duration of the meeting). Annex II lists all Actions agreed at the meeting.

Providing continuity to the function of its predecessor operating under the International Polar Year Space Task Group (IPY-STG), the SAR Coordination WG will be tasked with requests for coordinated acquisition, dissemination, processing and analysis of satellite-based SAR data in response to requests by the user community. PSTG recommended establishment of the SAR Coordination WG at its second session in June 2012 (PSTG-2 Final Report). Draft terms of Reference for the SAR Coordination WG were discussed during the session and will be finalized for adoption by the 3rd session of PSTG in April 2013.

1. Opening remarks (Drinkwater)

M. Drinkwater as the Chair of PSTG welcomed all participants to the SAR Coordination WG, stressed the importance of its existence as a successor of the very successful predecessor group under IPY-STG. Based on its accomplishments and an established working culture of the WG, he pointed out that close working-level collaboration between all Agencies involved in the WG was more important than ever, given the recent end of lifetime of the ERS-2, ALOS and Envisat ASAR instruments, and an increasing demand by science and society for change monitoring (rather than just experiment-based snapshots) of polar regions and the cryosphere in general.

The SAR Coordination WG should become the focal point for prioritized, coordinated Agency responses to requests by the scientific user community, as well as by PSTG. The value of InSAR data, including wide-swath InSAR, for estimating the dynamics of change (e.g. of ice sheets) should be complemented by gravimetry (for estimating mass balance changes) and radar altimetry (for ascertaining volume/shape changes).

The WG noted with regret the absence of JAXA as a key player in SAR missions. Since WG membership was open, Agency representation should in the future also include emerging players from India and China.

2. Adoption of agenda ; Meeting objectives (Crevier)

After unanimous adoption of the agenda (Annex I), Y. Crevier as the designated Chair of the SAR Coordination WG introduced the three main objectives of the meeting:

- To establish a working framework for the Working Group, including its governance, work plan, and roles and responsibilities
- To provide an overview of current Space Agency's activities and plans
- To start its coordinating work for observing the ice sheets (Greenland, Antarctica)

He further emphasized the open nature of WG meetings and the goal to work by consensus.

3. Review of past SAR coordination activities, and potential areas of collaboration (Crevier)

Y. Crevier gave an overview of the coordination efforts of the SAR Coordination Group during IPY 2007-2008 which gave rise to a large heritage scientific dataset, only made possible through successful collaboration by all Agencies involved. This multi-polarization, multi-frequency, multi-temporal, multi-resolution datasets had a recognized and lasting scientific value, demonstrating the benefit of coordination (much in the spirit of the CEOS Virtual Constellations) that needed to be preserved through the PSTG SAR Coordination WG.

Guidance by the scientific community was essential for this success, as provided e.g. by the Global Inter-Agency IPY Polar Snapshot Year (GIIPSY) strategy where SAR imaging objectives were clearly delineated. Mapping science requirements against available space assets through a continuous dialogue resulted in most requirements being met during IPY (see Fig. 1 as overview).

Theme & Sensors	3-day Arctic Basin Snapshots	Pole-to-Coast InSAR, Antarctica	Greenland & Icefields	Supersites
PALSAR	**New L-band mosaic of sea ice.** Following fixed image acquisition plan.	**New L-band mosaic** Following fixed image acquisition plan *South pole hole not covered (see page 2)*	**Partial InSAR coverage in fine beam and polarimetric mode**	*Not possible.* Robust proposal required for augmentation of the baseline observation plan
ASAR	**Systematic wide swath coverage. Partial acquisition in Chukchi Sea and East Siberian Shelf**	**Intense InSAR acquisition plan for regions north of about 78 degrees S**	**Intense acquisition plan with second Tandem campaign ERS and ASAR over large supersites.** *No coverage over central Greenland; reception hole*	**Available for supersites.** *Multi-polarization SAR capabilities not exploited*
RADARSAT-1	*No satellite resources are available because of operational requirements.*	*Receiving station over Antarctica not available. See RADARSAT-2.*	**Three consecutive cycles of InSAR Fine beam mode**	**Canadian Arctic Islands covered with Canadian Interferometric Mission-2**
RADARSAT-2	**Seasonal coverages acquired, including minimum and maximum ice extent.** *Three-day snapshot not feasible*	**Entire continental coverge in Wide dual-co-pol mode. Three consecutive cycles of InSAR in Extended High and Wide Mode**	**Complete coverage with RADARSAT-1** *Not possible with RADARSAT-2 due to large number of imaging conflicts.*	**Coverage through RADARSAT-2 Background Mission**
TERRASAR-X	N-A	**Transantarctic Mts. glaciers and ice streams**	**Greenland: 22 outlet glaciers.**	**Greenland: 22 outlet glaciers during 2009. Antarctic Peninsula & Ice Shelves (part of Background Mission)**
COSMO-SKYMED	N-A	**Icestreams, Glaciers velocity fields. 'Pole hole' gaps (Background Mission)**	**Ice stream and glacier velocity field (Jaboshavn, Alaska, and Bering)**	**Both Wilkins Ice Shelf break-up and Perito Moreno glacier covered multiple times**
HIGHLIGHTS	Enhanced coord-ination required by space agencies to meet intense observation requirements	Multi-frequency and multi-date acquisitions; single- & multi-pol. data; high-resolution supersite and continental coverage	Multi-frequency and multi-date acquisitions; single- & multi-pol. data; high-resolution supersite, complete Greenland coverage	Multi-frequency and multi-date data acquisition at high spatial resolution

Figure 1: Coordinated IPY SAR Acquisition Plan, with achievements and shortcomings, by end 2009. Green: requirement met; yellow: requirement partially met; red: requirement not met or sensor not appropriate to meet requirement.

Coordination at the Space Agency level led to the following accomplishments during IPY, of which Y. Crevier showed some illustrations:

- Multi-agency coordination for a pole to coast and coast to coast InSAR acquisition campaign
- CSA/DLR/ESA/JAXA InSAR acquisitions over Greenland with NASA commitment to process and distribute velocity products
- CSA/MDA RADARSAT-2 mapping of Antarctica and multi-polarization map production
- USGS Landsat Image Mosaic of Antarctica (LIMA)
- ESA Envisat ASAR mapping of Antarctica margins and coastal ice
- ESA, DLR and ASI captured the break-up of the Wilkins Ice Shelf in great detail, spatially and temporally
- ASI COSMO-SkyMed velocity mapping of the Perito Moreno glaciers
- DLR TerraSAR-X repeat mapping of fast glaciers in Greenland and Antarctica
- Expanded JAXA ALOS coverage in the Arctic
- NRC Canada MODIS circumpolar mosaic of the Arctic
- Extension of CNES SPIRIT project to make more stereo image data available and to produce more DEMS

The WG noted that optical mission operators provided important complementary and sometimes unique information (e.g., the legacy perspective on ice sheets comes from optical imagery dating back to 1970s and earlier). Coordination with operators of optical imagery missions was needed, either at the level of PSTG or through a dedicated working group. The necessary coordination with NOAA and EUMETSAT, for example in defining roles and responsibilities for monitoring sea ice, also occurred at the level of PSTG.

Y. Crevier put forth the following elements for the SAR Coordination WG collaborative framework:

- Engage all relevant SAR-operating Space Agencies;
- Identify and prioritize user requirements;
- Engage the science community in a dialogue when responding to their requirements;
- Leverage resources of individual Space Agencies ("no contribution will be considered too small");
- Use Agency's existing programme resources to support products and applications development;
- Engage the Agency's commercial partners when necessary.

He stressed that the SAR Coordination WG should strive to respond to a broad range of user requirements (e.g., related to ice sheets, glaciers and ice caps, sea ice, coastal regions, snow-cryosphere) that may sometimes be in conflict with each other, taking into account different levels of maturity in these requirements. For example, sea ice monitoring requirements are well known, both from operational and research communities, whereas permafrost-related requirements for satellite observation are overall less mature. He emphasized that the initial focus on ice sheets should not come at the expense of other cryosphere-related user requirements. Complementary information in SAR data (e.g., X- and L-band) should be exploited wherever possible.

A session on day 2 focused on a coordinated response to a scientific request for near-term ice sheet observation (see section 7a).

4. Space Agency activities related to the Polar Regions and the Cryosphere

a. ESA (Laur, Engdahl, Potin)

H. Laur informed the WG on the strong support ESA has been providing to cryospheric science through its EO missions. Since the end of lifetime of Envisat, this was the first time since 1991 that no current SAR data were provided to community. He noted that, based on the heritage built especially through IPY, ESA was strongly interested in continuing the international collaboration in this area. Coordinated acquisition was considered important, whereas the SAR archive also

constituted a large asset for retrospective mapping of ice sheets, currently being exploited within the ESA Climate Change Initiative.

Facilitating the access to Agency archives of SAR data should be one of the main objectives of the WG, citing the GEO Hazards Supersites as a model. This should take into the account the potentially limited capacity of Agencies to maintain their archives if their support is contingent on projects, such as in the case of TerraSAR-X (as noted by A. Roth).

Furthermore, he showed examples for ERS ice phases, tandem phases (ERS-1/-2, and ERS-2/ASAR) and ASAR wide-swath mode acquisitions during IPY for extensive coverage of ice sheets.

M. Engdahl briefed the WG on objective and current status of the ESA Climate Change Initiative's Ice Sheet project. Focussing on Greenland, the project analyzes surface elevation change using radar altimetry from ERS-1 back to 1991, ice stream velocity using a combination of SAR techniques including InSAR, as well as grounding line and calving front location.

The Ice Mass Balance Intercomparison Exercise (IMBIE) had demonstrated the value of ESA-NASA collaboration in reconciling ice sheet mass balance estimates using different techniques; results of IMBIE were accepted for publication by the end of November 2012.

P. Potin informed the WG on planning of the ESA/European Commission Sentinel-1 mission, providing continuity to the ERS/Envisat missions and designed as a 2-satellite constellation. Currently with a launch window in late 2013 for Sentinel-1A, plans foresee a ramp-up period during which the mission and ground segment operational capacity will gradually increase, leading to the full operational capacity reached with the launch of Sentinel-1B in ~2015. Funding of the operational phase on the part of the European Commission is yet to be secured.

Potin showed the various planned acquisition modes (Default: Interferometric Wide Swath, Wave mode; Additional: Extra Wide Swath, Stripmap) in response to requirements provided by GMES services (e.g., MyOcean) and ESA/European Union Member states. Scientific requirements were also being considered, as collected for example through the 2011 FRINGE workshop[1]. These will include regular mapping of the ice sheets (Greenland, Antarctica), polar coastal regions, and of relevant areas for glaciers and snow monitoring. He also gave details on the requirements gathering process, including some points of clarification.

Sentinel-1 observation requirements are yet to be frozen in a High-Level Operations Plan that will be regularly updated in the course of the mission. Potin therefore invited further comments by the WG to accommodate the needs of users outside the scope of the GMES programme.

ESA adopted a data policy allowing free and open access to all Sentinel data.

b. ASI (Battazza, Pietranera)

F. Battazza and L. Pietranera (both ASI) presented an overview of current and planned ASI missions. These are:

- The COSMO-SkyMed constellation, fully operational since mid-2011, and its Second Generation (CSG)
- The ROSA (Radio Occultation for Sounding the Atmosphere) instruments flying on the ISRO/CNES Megha-Tropiques, ISRO Oceansat-2 and CONAE SAC-D missions
- PRISMA, a hyperspectral mission planned for ~2015
- OPSIS, a very high resolution optical mission planned for 2018

[1] Fringe 2011 Workshop "Advances in the Science and Applications of SAR Interferometry and Sentinel-1 Preparatory Workshop" organized 19-23 Sep 2011 at ESA-ESRIN, Frascati, Italy.

ASI is also involved in developing the CONAE SAOCOM mission, a SAR L-band mission planned for 2014 and beyond.

As for COSMO-SkyMed, he explained that the current constellation of four satellites was going to be replaced by Second Generation satellites by 2016, providing operational continuity until at least 2023. Second Generation satellites will have greater diversity in polarization modes, given that the first generation offered dual polarization only.

The COSMO-SkyMed ground segment is geographically distributed through receiving stations in Matera (Italy), Kiruna (Sweden), Cordoba (Argentina) and a mobile receiving unit, all equipped with S/X-band capability.

For commercial purposes, Finland (FMI) recently purchased a receiving station to downlinks the data at Sodankyla, Finland, which is operational in Jan 2013 under an agreement with e-geos. Agreements were in place to undertake operational services and science.

He further explained the capabilities of COSMO-SkyMed constellation, such as fast response acquisition with large coverage, fast large/long area mapping, and motion tracking, by way of several examples. The flexibility in acquisition was enabled through a range of operational modes.

An example over Sicily illustrated the multi-mode acquisition capability (scansar, stripmap, spotlight) of the constellation. In one day, it is possible to cover all circum-Arctic polar routes over the NW and NE passages. Mapping of the Peterman ice shelf iceberg, with monitoring of sea ice drift and other parameters around the iceberg was another example.

Monitoring the North Pole (> 89deg) was achieved using three images. Surveillance of icebreakers is possible. Distinction of wet snow from clouds was evident in the data. Android and iPhone apps for monitoring the North Pole region based on COSMO-SkyMed data are now available.

Background mission scientific projects supported by COSMO-SkyMed are:
- Jakobshavn glacier (Start June 2012 - 38 frames)
- Helheim (Start June 2012 - 38 frames)
- Rink Isbrae (Start May 2012 - 38 frames)
- Byrd Glacier (Antarctica) starting now.

Future planning includes:
- Monitoring ice flow across Nares and Fram Straits
- New campaign on Ross Bay Polynya
- Sea ice formation in Bering Strait
- Russian sites for permafrost monitoring
- North Pole correlation with polar drifting stations.

Announcements of Opportunity (AO) projects allow the scientists to exploit COSMO-SkyMed data, in the first AO, a number of ongoing project teams had successfully responded.

ASI concluded that:
- activities in polar regions were ongoing,
- future Invitations to Tender (ITT) would offer opportunities to use data
- the use of multi-sensor data was considered valuable
- synergy between satellite and in-situ data should be better exploited

S. Bojinski remarked that given the near-term data gap in GNSS-based radio occultations (due to end of lifetime and declining capabilities in orbit, e.g. from COSMIC), ROSA data should be made available as openly as possible to the meteorological community.

c. DLR (Roth)

A. Roth reported on the utility of TerraSAR-X for supporting science and monitoring in the cryosphere. All systems are working nominal. Acquisition modes are StripMap, ScanSAR and Spotlight.

Mechanisms to make data available for science are in place (TerraSAR-X: A. Roth, TanDEM-X: I. Hajnsek, DLR, have details). Access to data is possible anytime upon request, through a proposal; some data distribution occurs free of charge upon proposal for specific international programmes and campaigns, such as in support of IPY, GEO, and UNESCO.

A current call for proposals was targeted at data older than 18 months. Some discussion evolved on the implications of such a call, and whether the "blackout period" on data should be longer for reasons of scientific use.

A. Roth showed statistics on the provenance of proposals for TerraSAR-X data. Since the mission was in operational state, 10% (67 in total) of research proposals addressed polar research, with the majority for land cover, risk management and security applications. Related to the cryosphere, the majority of proposals addressed feature tracking (ice flow velocity), glaciers and climate change in general.

He also showed an overview of archived data covering the period 2008-2012, as a function of the different acquisition modes, and described the generation of "background accounts", i.e. strategic filling of the data archive ahead in time of prospective user requests. Doing so contributes to systematic observation of the Arctic and Antarctic, with a number of focus areas and objectives.

Coverage of Antarctica for DEM generation was planned for May-July 2013.

The WG subsequently discussed the need to be accountable for which user requirements are being responded to by collaborative action, and that the related decision process needed to be documented.

d. CSA (Crevier)

Y. Crevier presented an overview of CSA's current activities and strategic interests as well as tactical needs. Current and planned CSA space assets are:

- RADARSAT-1: 1995-…; still operating; discussion on continuity of service ongoing; large archive available over the poles (hosted by the University of Waterloo, Canada);
- RADARSAT-2: 2007-…; owned and operated by MDA, with a Government of Canada data allocation;
- RADARSAT Constellation Mission: planned from 2016 onwards; regarding the public sector, an open data policy in line with RSSSA (Remote Sensing Space Systems Act, Canada) is envisaged; phase C of the Mission to be completed by the end of 2012;
- PCW (Polar Communication and Weather Mission): 2 satellites in Highly Elliptical Orbit are planned; phase A completed.

After covering coordination activities with national user communities, Crevier stressed the importance CSA attributed to international coordination activities, which include PSTG and its SAR Coordination Working Group, bilateral activities with NASA and ESA on enhancing the use of existing assets, involvement in SAON, and activities to enhance data access.

The strategic interests of CSA involved:
- The Arctic (through RADARSAT Constellation Mission, PCW)
- Thematic areas where SAR can make a unique contribution, such as glaciers and ice sheets monitoring, sea ice extent and concentration mapping, river and lake ice mapping, permafrost

- CEOS and its focus on climate change for polar regions (CSA will assume the Chair function of CEOS in 2013)
- The Arctic Council (Canada currently Chair)

In the discussion, Crevier stressed that CSA was open to suggestions in its commitment to respond to user needs best as possible.

The WG suggested that, in order to ensure access to data and scientific results, Announcements of Opportunity issued by Agencies should include a common preamble stating the appropriate requirements.

e. JAXA (Ochiai, Shimada; presented by Scheuchl)

On behalf of O. Ochiai and M. Shimada (JAXA), B. Scheuchl presented details on the upcoming ALOS-2 mission planned for launch in 2013. The strong contribution by JAXA to satellite data acquisition during IPY was recognized by the Working Group, and it anticipates an equally important contribution through ALOS-2. The different acquisition modes of the PALSAR-2 instrument were introduced. The basic observation scenario comprises acquisitions of global land areas, forests, wetlands, and to shed light on the Earth's crustal deformation. With an overview annual observation pattern in place, details of a global acquisition strategy are still under development; however, JAXA recognizes the importance of monitoring the ice sheets in their strategy which is highly valued by the ice sheet community.. A data access policy is yet to be determined.

The WG discussion revolved around the flexibility of the (ambitious) observation pattern currently in place, and whether the provisions for responding comprehensively to user needs (e.g., observing Antarctica) were considered adequate.

Based on recent information from Masanobu Shimada (JAXA), the ScanSAR data to be acquired over Antarctica and Greenland will be exploitable interferometrically (there will be burst synchronisation of over 90%, which is crucial for interferometry used on a ScanSAR mode). This mode represents a lower resolution mode that is expected to be useful in the interior of the great ice sheets.

The super sites chosen for StripMap coverage include a large portion of the West Antarctic Ice Sheet and the North-West coast of Greenland. These regions were identified as crucial for ice sheet monitoring and the PALSAR-2 L-band data will make an important contribution.

B. Scheuchl asked if the South-East Greenland Coast could be considered as an additional super site. JAXA will consider this but pointed out that resources are limited given the already ambitious acquisition strategy.

f. NASA (Webb)

C. Webb covered the NASA contributions to polar science through dedicated NASA satellites (ICESat, GRACE) and satellites developed and operated in partnerships (e.g., TOPEX, Jason-1/2). He also made mention of PI-funded investigations under international agreements (using RADARSAT-1/2, ERS-1/2, Envisat and ALOS data). Webb briefed the Group on upcoming launches of LDCM, SMAP and ICESat-2 and the multi-year commitment to Operation IceBridge: validation campaigns. He presented the joint ESA-NASA validation campaign of Cryosat-2 (aiming at validation sea-ice freeboard, among other parameters) as a successful example of cross-Agency collaboration.

He elaborated on details of the planned ICESat-2 mission and its acquisition pattern (micro-pulse, multi-beam; 10m footprint size, 30m wide beams, 3 km separated). Launch of ICESat-2 was planned for July 2016.

Many MEaSUREs (NASA "Making Earth System Data Records for Use in Research Environments" program) awards rely heavily on SAR data, e.g. for estimating Antarctic outlet glacier velocity. Bernd Scheuchl pointed out the importance of ice sheet – ocean interaction and on the potential of using different observations (SAR, passive MW) jointly to better analyze ice sheet cavities.

5. Key strategic issues of the SAR Coordination WG

Based on the discussion up to this point, Y. Crevier presented the following components of a 3-year workplan for the WG, which would eventually be tabled for adoption at PSTG-3:

1. Access to data archives
2. Development and adoption by Agencies of a joint preamble to Announcements of Opportunity (including thematic science components to be addressed collectively)
3. Identification of "Cold Spots" based on consultation with scientific community ("supersites")
4. Fostering the requirements-setting process (stimulate use of datasets; gather requirements; be accountable on which requirements are being responded to; outreach), in coordination with PSTG
5. Linkage with other groups (CEOS in particular)

Some discussion evolved on whether the WG should also establish links with funding agencies, such as NSF and the European Commission.

Clarifying the relationship of the WG with CEOS was considered a priority (see also item 6), pending a report by Steven Hosford (CNES; PSTG member) on this matter from the 26th CEOS Plenary.

6. Governance

Y. Crevier presented draft Terms of Reference for the SAR Coordination Group (earlier referred to as "Charter") and all participants provided their comments while showing general agreement with the text. S. Bojinski stressed that the WG should respond to science as well as to application development needs for SAR data. Being a subsidiary group to PSTG, the WG Chair has to be member of PSTG.

The Chair of the SAR Coordination WG was to be nominated by consensus. The designated Chair Y. Crevier was yet to be confirmed by the WG.

Crevier was tasked to produce a revised version of the Terms of Reference, for WG review.

ACTION SAR CWG-1.1: Yves Crevier to circulate a revised SAR Coordination WG Terms of Reference to all participants. (Deadline: 15 Dec 2012)

ACTION SAR CWG-1.2: SAR Coordination WG to designate a Chair among its participants. (Lead: Crevier, Battazza; Co-Lead: Drinkwater; Deadline: 15 Dec 2012)

7. Coordinated response to continued ice sheet observation requirements (Scheuchl)

a. User requirements

B. Scheuchl presented the request by the scientific ice sheet community for a coordinated near-term Agency response to its SAR observation requirements. Ice sheets and their physical properties have been recognized by WMO and the UNFCCC as Essential Climate Variables, for which systematic observation was required to understand climate variability and the impacts of climate change. In addition to the GCOS reports[2], the importance of monitoring the ice sheets (Greenland, Antarctica) has been identified since 1999 by a number of international community events and documents.

He illustrated the value of various SAR datasets for ice sheet mapping by way of several examples, such as the five available ice sheet products through the NASA MEaSUREs programme (including product utilization statistics), and multi-sensor products: Greenland ice mapping using RADARSAT/ALOS/Envisat for broad spatial coverage, and TerraSAR-X/COSMO-SkyMed for fine resolution; the Antarctica ice velocity map using RADARSAT-1/2, ALOS, ERS-1/2 and Envisat ASAR. The latter product had received particular attention at highest Agency level (demonstrating collaborative international effort), as well as in the media.

Scheuchl also showed results for mapping the Antarctic grounding line (boundary between grounded and floating ice) and highlighted the scientific value of historical datasets for mapping ice velocity in the Ross and Ronne sectors.

He then discussed Post-IPY Fringe 2011 workshop recommendations related to Sentinel-1 and Third Party mission coordination including RADARSAT. Regarding the selection of "supersites" ("cold spots") for systematic acquisition by (In)SAR missions, participants stressed the need to consider national requirements (e.g., related to TerraSAR-X) when selecting such sites for Sentinel-1.

Regarding observations requirements for Greenland and Antarctica, the high scientific interest in immediate, monitoring in 2012/2013 (e.g., given the record extent of surface melting area over Greenland in summer 2012 – "the acquisition window is now") and the concurrent gap in SAR observational capability was stressed. B. Scheuchl made reference to the ESA CCI Ice Sheet project user survey with 67 responses which showed, inter alia, results for spatial and temporal resolution requirements for measuring surface elevation change, ice sheet velocity, grounding line and calving front location. Priorities for s/t coverage of ice sheets were also identified – the WG however stressed that data acquisition plans need to recognize the possibility of shifting priorities over time depending on the evolution of ice sheet changes.

In summary, general recommendations for ice sheet monitoring were:

- Polarization: HH
- Acquisition mode: stripmap preferred; S-1 Interferometric Wide-Swath mode should be discussed more, pending analysis results for InSAR applications
- Incidence angle range: 25-45° fine, 57° over flat terrain also acceptable
- Acquire long tracks (coast to coast, i.e. rock to rock)

For the individual ice sheets, the user community expressed its observation requirements in three categories: general ("target"), reduced ("minimum") and science mission requirements (related to "continuous monitoring", i.e. continuous in time, with full coverage of an ice sheet for every repeat orbit of the satellite), identified as follows:

[2] The most recent update of satellite-related GCOS requirements is given by: GCOS (2011): *Systematic Observation Requirements for Satellite-based Data Products for Climate (2011 Update)*, GCOS-154.

Antarctica:

General observation requirement:
- Annual coverage of all of Antarctica, with at least 3 consecutive cycles – winter observations
- More frequent observations of critical areas with every possible acquisition of selected tracks (Pine Island / Thwaites Glacier region; Antarctic Peninsula; Totten Glacier)
- All glaciers

Reduced observation requirement:
- Full coverage every 3 years
- Annual coverage of coastal regions (right looking: all coastal areas; left looking: Transantarctic Mountains, Ross and Ronne sectors)
- More frequent observations of critical areas

Science mission requirement:
- Ongoing coverage of visible area with coast-to-coast tracks (right looking: coastal areas; left looking: Central Antarctica)
- Additional tracks covering large outlet glaciers with higher resolution modes
- Switch left looking from ascending to descending every year (or acquire long tracks asc+dsc)

Greenland:

General observation requirement:
- Annual coverage with at least 3 consecutive cycles – winter observations; Dec-Mar timeframe
- Secondary full coverage each year would be asset; Jul-Sep timeframe
- More frequent observations of critical areas; acquire ascending and descending coverages, to improve accuracy in the interior where InSAR can be used in both directions

Reduced observation requirement:
- Annual coverage of coastal Greenland with at least 3 consecutive cycles
- Full coverage every second year
- Additional coverage of coastal regions

Science observation requirement:
- Ongoing coverage of entire area
- Acquisition of additional tracks covering large outlet glaciers with high resolution modes (e.g., Jacobshavn, Helheim, Kanger)

A similarly-structured set of requirements were also provided for the *Canadian Arctic*, which is, as other areas (see below), not the initial focus of the Working Group, but stated here for information:

General observation requirement (example modes):
- Ongoing coverage of the entire AOI each year from October to May.
- RADARSAT-2 Fine Wide HH polarization is preferred.
- High resolution (e.g., RADARSAT-2 Ultrafine wide 3 m) monitoring of 15 target glaciers (tidewater/surge) within the AOI each year from October to May.

Reduced observation requirement (given sensor capacities):
- Annual coverage (RADARSAT-2 fide wide beam) of the entire AOI with at least 4 consecutive cycles – January to May. More cycles are considered an asset.
- Ongoing acquisitions (RADARSAT-2 Ultrafine wide) over 15 target glaciers (tidewater/surge) within the AOI from October to May.

Other areas with ice caps also needed attention, such as the Himalayas, Alaska, Patagonia, Iceland, and Svalbard.

b. Agency response

The WG recalled a letter sent by the Chair of PSTG to Dr Steve MacLean, President of CSA, on 29 June 2012, with a strong request for using Canadian space assets in securing the acquisition of periodic (at intervals of 3-5 years) continental ice sheet surveys (in particular Antarctica) using satellite SAR. This should in particular include consideration of executing a further RADARSAT-2 ice sheet InSAR mapping campaign of Antarctica within the next year. The response by Luc Brûlé, CSA Director General for Space Utilization, received on 27 September 2012 was positive, indicating the start of discussions with MDA (owner and operator of RADARSAT-2) and also stressing the need to engage other Space Agencies in a multi-agency approach in response to this request by the user community. Y. Crevier continued to be the CSA focal point on this matter.

It was recognized that the SAR Coordination WG was the place to formulate a multi-Agency response.

The WG then discussed the specifics of a near-term response to the user request stated in item 7a, using RADARSAT-1/-2:

RADARSAT coverage of Greenland ice sheet

B. Scheuchl introduced RADARSAT-related recommendations as a result of discussions with CSA and MDA in October 2012.

The WG discussion revolved around the following elements:
- The need for a direct data downlink, given no on-board storage capacity of RADARSAT-1
- Using RADARSAT-2 not considered an option given the many associated conflicts with commercial requests
- Receiving station coverage options include: Canada, Norway
- Norway ground station downlink coverage appears most suitable, based on ascending/descending mode acquisition maps; the southern tip of Greenland could be covered by Canadian station
- Data processing could potentially be provided by MDA
- Delayed data access was not major problem from the users' perspective
- Fine mode data acquisition is required
- Potential conflicts in covering coastal regions (e.g., when including sea ice) needed to be avoided

The WG agreed on the following way forward:

ACTION SAR CWG-1.3: Collect planning information to enable a decision by Norwegian Space Centre (NSC) on whether a direct downlink to RADARSAT-1 and potentially other contributions can be provided (Lead: Scheuchl, MDA; Deadline: 28 Nov 2012)

ACTION SAR CWG-1.4: Explore options for resourcing data reception and processing, either within existing NSC-KSAT agreement, or by NASA (Lead: Crevier; Co-Leads: Herland, Rigby, Webb; Deadline: 3 Dec 2012)

Crevier further stressed the need that the WG identify "cold spots" for priority acquisition that could be vetted by community, for example within the ESA CCI Ice Sheets project.

ACTION SAR CWG-1.5: Identify and confirm the list of "cold spots" to be monitored through a dense time series approach (Lead: Scheuchl; Deadline: 1 Dec 2012)

ACTION SAR CWG-1.6: X-Band SAR missions to communicate their list of existing sites they are already covering through their current imaging activities (Lead: Roth, Floricioiu and Battazza; Deadline: 3 Dec 2012)

ACTION SAR CWG-1.7: Send consolidated list of "cold spots" to X-Band mission managers and request planning for dense time series image collection (Lead: Crevier; Co-Lead: Battazza, Roth, and Floricioiu; Deadline: 10 Dec 2012)

Any data acquired as a result of SAR Coordination WG decisions should be made broadly available where possible.

RADARSAT coverage of Antarctic ice sheet

As for monitoring Antarctica using:

RADARSAT-2:
- Using the US McMurdo station as a downlink option requires further investigation; the station hardware is in need of upgrading;
- CSA and MDA are exploring other options;

RADARSAT-1:
- Could complement RADARSAT-2 in providing coverage;
- McMurdo certified for providing direct downlink; would require further clarification (see above).

The WG further discussed details of the geographical scope of acquisition (ice sheet vs sea ice), timing of acquisitions, the use of different acquisition modes of RADARSAT-2 (left vs right looking), the trade-off between immediate versus long-time monitoring needs, downlink options and data processing, distribution and archiving options.

The priority user requirements were considered regarding the level of acquisition effort required. The need to develop detailed acquisition scenarios for consideration by the WG was identified.

ACTION SAR-WG-1.8: Develop three detailed acquisition scenarios in response to the ice sheet community requirement for monitoring Antarctica, including (i) level of effort (e.g., number of scenes; data distribution and processing), (ii) downlinking options, (iii) delineation of scope (e.g., sea ice, coastal regions, ice sheet), (iv) timing options (immediate vs mid-term response). Lead: Rigby; Deadline: February 2013)

CSA and MDA highlighted their willingness to invest significant resources to respond to the observation requirement of the ice sheet community. In a subsequent tour-de-table, all Agencies present (NASA, ASI, NSC, ESA, DLR) pledged their strong support for complementing CSA and MDA in this regard to the best of their ability.

8. Any other business (Crevier)

Referring to the key strategic issues to be addressed by the WG (identified in section 5), Y. Crevier stressed again the need for close Agency collaboration in the area of data acquisition ("Cold Spots", see Action SAR CWG-1.5) and data access (facilitated access to archives, through coordinate AOs).

In this regard, the following strategy-related Actions were agreed:

1. Access to data archives:
   ACTION SAR CWG-1.9: Prepare "white paper" on facilitated access to SAR data archives, to be submitted for the 3rd PSTG meeting (Lead: Laur; Deadline: 28 Feb 2013)

2. Joint AO preamble:
   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; Deadline: 28 Feb 2013)

The need for a SAR Coordination WG website was identified. It should be linked from the PSTG website hosted at http://www.wmo.int/pages/prog/sat/pstg_en.php.

In his closing remarks, Crevier expressed his gratitude to all participants for having actively participated in the first meeting of the PSTG SAR Coordination WG. He looked forward to future collaboration with all Agencies, stressing that the objectives of Group could only be achieved through collaboration. He also thanked ESA for having hosted this first meeting on its ESRIN premises.

Dates for future telephone conferences and face-to-face meetings were yet to be determined by Y. Crevier, in coordination with WMO Secretariat.

The meeting closed on 13 November 2012 at 13.30.

Annex I

AGENDA of 1st PSTG SAR Coordination Working Group Meeting

12-13 November 2012
ESA-ESRIN, Frascati, Italy

12 November 2012

0. 10:00 – Welcome address (ESA)

1. 10:05 – Opening remarks (Chair PSTG)

2. 10:15 – adoption of agenda and meeting objectives (Crevier)

3. 10:30 – Review of past SAR coordination activities and potential areas of collaboration – presentation and discussion (Crevier, All)

4. 11:00 – Space agencies activities related to Polar and Cryosphere issues (All)

   4a. ESA
   4b. ASI
   4c. DLR
   4d. CSA
   4e. JAXA
   4f. NASA

13:00 – Lunch

5. 14:30 - Discussion and adoption of key strategic issues to be addressed by WG (All)
   15:30 – Definition of the components of a 3-year workplan (tasks and task leads)

6. 16:30 – Discussion on the governance (All)

17:30 – adjourn for the day

19:30 or TBD – Non-host diner

13 November 2012

9:00 - Review of previous day discussions

7. 9:30 – Session focused on addressing the near-term tactical needs for a coordinated response to the continued ice sheet requirements

   a. History of the request
   b. Review of the requirements (Scheuchl)
   c. Summary of what can be contributed – All, tour de table
   d. Identification of gaps
   e. Definition of response plan

8. 12:00 – AOB
   13:00 – meeting adjourn

Annex II

ACTIONS

ACTION SAR CWG-1.1: Yves Crevier to circulate a revised SAR Coordination WG Terms of Reference to all participants. (Deadline: 15 Dec 2012)

ACTION SAR CWG-1.2: SAR Coordination WG to designate a Chair among its participants. (Lead: Crevier, Battazza; Co-Lead: Drinkwater; Deadline: 15 Dec 2012)

ACTION SAR CWG-1.3: Collect planning information to enable a decision by Norwegian Space Centre (NSC) on whether a direct downlink to RADARSAT-1 and potentially other contributions can be provided (Lead: Scheuchl, MDA; Deadline: 28 Nov 2012)

ACTION SAR CWG-1.4: Explore options for resourcing data reception and processing, either within existing NSC-KSAT agreement, or by NASA (Lead: Crevier; Co-Leads: Herland, Rigby, Webb; Deadline: 3 Dec 2012)

ACTION SAR CWG-1.5: Identify and confirm the list of "cold spots" to be monitored through a dense time series approach (Lead: Scheuchl; Deadline: 1 Dec 2012)

ACTION SAR CWG-1.6: X-Band SAR missions to communicate their list of existing sites they are already covering through their current imaging activities (Lead: Roth, Floricioiu and Battazza; Deadline: 3 Dec 2012)

ACTION SAR CWG-1.7: Send consolidated list of "cold spots" to X-Band mission managers and request planning for dense time series image collection (Lead: Crevier; Co-Lead: Battazza, Roth, and Floricioiu; Deadline: 10 Dec 2012)

ACTION SAR-WG-1.8: Develop three detailed acquisition scenarios in response to the ice sheet community requirement for monitoring Antarctica, including (i) level of effort (e.g., number of scenes; data distribution and processing), (ii) downlinking options, (iii) delineation of scope (e.g., sea ice, coastal regions, ice sheet), (iv) timing options (immediate vs mid-term response). Lead: Rigby; Deadline: February 2013)

ACTION SAR CWG-1.9: – Prepare "white paper" on facilitated access to SAR data archives, to be submitted in advance of the next PSTG meeting (Lead: Laur; Deadline: 28 Feb 2013)

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; Deadline: 28 Feb 2013)

Annex III

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