

**WMO POLAR SPACE TASK GROUP**

**SAR COORDINATION WORKING GROUP**

**FIFTH SESSION**

**ESA ESTEC  
NOORDWIJK, The Netherlands, 12-13 September 2016**

***FINAL REPORT***

**(November 2016)**

## 1. Welcome and Opening Remarks

1.1. Mark Drinkwater, Chair of PSTG and local host, welcomed participants to ESA ESTEC facilities.

1.2. Yves Crevier, the Chair of SAR CWG, welcomed participants to the meeting of the SAR Working Group. He thanked the organizers and the attendees. The level of attendance is growing and this is very positive.

## 2. Introductions

2.1 During the round table participants introduced themselves, see the list of participants in Annex I

## 3. Meeting Objectives and Approval of Agenda<sup>1</sup>

3.1 Y. Crevier explained the objectives for the meeting, namely:

(a) Review of achievements;

(b) Consolidate response activities and agree on an actionable Coordinated Imaging Strategy,

(c) Update of a 3-year Implementation Plan.

Through the discussion, agencies aim to better understand the science requirements, and to respond accordingly.

3.2 F. Battazza appreciated the back-to-back organization of PSTG-6 and the SAR-CWG-5, and suggested that a next meeting be held in the spring timeframe (September is a very busy month).

3.3 M. Drinkwater reminded the group that PSTG coordinates across the scientific and operational agencies how best to address the needs of the scientists. This meeting is focused on the SAR requirements. We seek the members' commitments to produce a coherent set of information products.

3.4 Updated Agenda was approved as presented in Annex II.

## 4. Review of Action Items

4.1 The group reviewed the SAR CWG Action Items from SAR CWG-4 (held in 2015). Annex III(a) shows the status of these actions at the end of the meeting.

4.2 Regarding action 9.1, ("The chair of PSTG to develop credit statements for scientific papers/contributions to PSTG"), Mark Drinkwater has proposed the following wording: The combined *XX, YY and ZZ* SAR data sets used in this *paper/publication/report* were acquired through the inter-agency acquisition plans developed by the WMO Polar Space Task Group SAR Coordination Working Group. (The italicized parts can be modified as appropriate.)

**Action SAR CWG-5-1<sup>2</sup>:** Bernd Scheuchl will send an email with the status of the SEASAT data that was re-processed by ASF.

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<sup>1</sup> The presentations for this meeting can be found at <http://www.wmo.int/pages/prog/sat/meetings/PSTG-SARCWG-5.php>. This meeting summary does not intend to duplicate the presentations.

<sup>2</sup> Action items for SAR CWG meetings will be numbered as SAR CWG-n-m, where 'n' refers to the number of the meeting and 'm' refers to the mth action item for meeting 'n'. Since this is the fifth SAR CWG meeting, n=5 for this meeting.

## **5. SAR Coordination Working Group – Management, Communication and Coordination Business**

Y. Crevier gave an overview of the SAR Coordination Working Group. The Group is open to all agencies, to members of the science community, and partners from the commercial sector. Highlights of the inter-sessional period include a second brochure on the Group's work, development of the Data Compendium and poster, and the 3-year Implementation Plan. He mapped work plan activities against deliverables achieved and planned for 2017. There is a rolling data acquisition plan for 2016-2017 that will be updated at this meeting.

There was discussion of the Data Compendium. In the past, campaigns were limited in scope, compared to today, where operational missions approach continuous monitoring. Perhaps, SHP or KML files should be available on-line for readers to see coverage areas more accurately. C. Dobson suggested showing areas of coverage provided by the different sensors ("heatmap") over Polar Regions, to demonstrate the value of coordination, and to highlight gaps. In an electronic version, the Compendium could be a living, navigable collection of metadata; examples for science products and literature could also be collected. A. Roth stressed that data access links to the presented datasets were important to the audience. Agencies should investigate means to fund the creation of an electronic version of the Compendium. A publications list could be useful.

A digital, searchable version of the Data Compendium might be hosted by GCW (WMO), NSIDC or Polar Data Catalogue. The Data Compendium is intended to be a collection of metadata, not an archive.

**Action SAR CWG-5-2:** Each space agency will list the urls of their data sources for incorporation into the Data Compendium.

Regarding data access, Announcements of Opportunity and other data access mechanisms should be communicated and shared. Stephen Howell suggested that the AOs and data sets available through PSTG be communicated regularly, perhaps quarterly. Listservers showing lists of urls for data access could draw new users to our data.

**Action SAR CWG-5-3:** CSA will send an email to the members requesting specific activities that provide data access to scientists.

The position of the Chair of SAR-CWG is up for replacement or renewal at the next annual meeting.

The challenge for the next year will be to update the documents, continue to acquire data in support of the science and make sure that we communicate our activities.

## **6. Presentations of Special Projects, and discussion involving science leads and space agencies**

### **6.1 ISRO (Raj Kumar)**

ISRO talks about the 'Third Pole', which is the Himalayan glaciers. SAR data is used to support atmospheric and hydrological sciences, and to supplement optical data.

Raj presented the acquisition modes and image quality parameters of RISAT-1. It is a C-band SAR. The data is available for science. They provide ice advisories for ships visiting the ISRO Antarctic research stations at Bharati and Maitri.

He showed comparisons of RISAT MRS and AWIFS optical data. He also showed mapping of ice features and their temporal formation (e.g., using polarimetric products), snow structure, ice shelf. There is an ambition to put RISAT data into the context of longer-term monitoring of the cryosphere. He showed polarimetric acquisitions over cropland (interesting to combine with HR optical). RISAT-1 is operational for agriculture monitoring, since during the monsoon season, there is persistent cloud cover. An interferometric mode is not possible due to the baseline. Data policy: data can be made available for scientific purposes, for free.

A letter from the PSTG Chair to ISRO requesting access to these datasets for scientific purposes would be welcome. Mark pointed out that the third pole is very important as a water supply.

**Action** SAR CWG-5-4: Mark Drinkwater to write a letter to ISRO about collaboration and data access.

Raj introduced the NISAR mission and science goals. RISAT data is unique in its use of hybrid polarization, and its coverage of areas otherwise not well-covered.

## **6.2 CONAE (Marc Thibeault)**

Marc provided a brief on the SAOCOM mission (L-band). This is CONAE's first SAR mission. The main driver is agriculture and soil moisture of the Pampas region of Argentina. There is collaboration with ASI with COSMO-SkyMed. He presented the Integrated Mission Acquisition Scenario: components include national (Argentina) objectives, and international uses. This covered product definitions and cal/val. He showed the acquisition plan over Argentina (including the Antarctic Peninsula) and glaciers in the Andean Cordillera. ESA is planning to launch a SAOCOM Companion satellite with SAOCOM-1B, as a bistatic receiver (5 year mission).

Marc gave the group 2 pdf files, one focusing on the Acquisition Plan for Argentina and the other about all acquisition plans, both national and international, including external calibration, SIASGE, Global Background Mission and other applications (SMAP).<sup>3</sup>

There will be acquisitions of tropical forests, as part of the Forest Carbon Task (through CEOS Space Data Coordination Group)

Launch of SAOCOM-1A is planned for Oct 2017 from Vandenberg, and SAOCOM-1B in Sep 2018 (ESA Companion mission is planned to launch with 1B). However, the launch is planned on SpaceX Falcon-9, and it may slip because the launch failure evaluation may take 6 months.

## **6.3 NASA ABoVE (Craig Dobson)**

ABoVE (Arctic-Boreal Vulnerability Experiment) is a 7 year science program that aims to look at the resilience and vulnerability of the boreal forest in response to climate change. There are permafrost objectives too. See [above.nasa.gov](http://above.nasa.gov). There will be an extensive in situ and airborne campaign. We have an opportunity to conduct a SAR data campaign over ABoVE during the time they will deploy resources to support the work and validate information products. The area of interest is a big region in

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<sup>3</sup> These two pdf files can be found at <http://www.wmo.int/pages/prog/sat/meetings/PSTG-SARCWG-5.php>

the north-west portion of North America. Craig is presenting on behalf of the ABoVE team, specifically Hank Margolis and Eric Kasischke. The slides they gave Craig were more optical than SAR.

Craig spoke about ABoVE and another airborne program, GLISTIN. Our airborne sensors are testbeds for development of new sensors, which have a path to space. They are also used to study target-sensor interactions, both atmospheric and land surface. They have extensive in situ data. The airborne data is used for cal/val test algorithms (comparing airborne with spaceborne instruments, also between spaceborne sensors.)

Craig talked about a family of instruments flown on aircraft with radar at different frequencies, including UAV-SAR (L-band with repeat pass capability), GLISTIN (single pass interferometer at Ku-band) and AirMOSS (P-band version of the repeat pass sensor.)

ABoVE is a major effort in the Terrestrial Ecosystem Program. It has links to fires and permafrost. There is Canadian collaboration, namely a group of Canadian government groups led by Polar Knowledge Canada. Airborne, spaceborne and ground truth data will be collected, and it will be available freely and openly.

A second activity is under the Earth Ventures Program. One sub-program is called OMG (Oceans Melting Greenland). It is looking at melting from the underside as well as the atmospheric side. The GLISTIN instrument will measure topographic data of the outflow glaciers.

A question was asked at NASA: in ten years, what data will we wish we had collected? One of these is mountain glaciers in Continental US other than Alaska. These will be flown shortly.

There is no intentional overlap between ABoVE and SnowEx.

Most SAR data is archived at the Alaska Satellite Facility. Data is available through the Oak Ridge DAAC.

Operation Ice Bridge will be extended because of problems with ICESat-2.

## **7. Thematic Science Session – Review of SAR Requirements, Achievements and Expected Data**

### **7.1 Permafrost**

Annett Bartsch presented the Permafrost theme.

The JAXA ALOS-2 PI workshop was a venue to express data requirements in the Arctic; the permafrost community indicated a subset of the “cold spots”, and 5 out of 49 sites were selected. The satellite was tasked to acquire data of these 5 new supersites.

Sentinel-1 IW data has been requested through ESA DUE Permafrost, and the first IW images were acquired this summer.

An Excel file showing the 50 permafrost sites can be downloaded from the Pangaea archive with KML files showing the extent of each site.

C-band is good for studying wetlands (summer soil moisture as well as winter roughness). Low backscatter indicates that there is low roughness which is typical for wetlands. Low roughness areas have shallower active layer. Where it is dry (higher winter roughness, volume scattering), there is a deeper active layer (> 60 cm).. To avoid impact of rain on snow events, it is best to use December data at C-band (C as well as Ku-band can help to identify ROS which also have an impact and heat flux). Active layer thickness itself is derived from InSAR subsidence or NDVI in 'shallow' areas. There is potential of X-band intensity (landcover) as proxy for deeper active layer estimation.

Soil organic carbon (SOC) is required to estimate carbon stocks; there is a relationship between C-band SAR HH and SOC in winter.

The RADARSAT-1 archive in the Polar Data Catalogue (PDC) ends in 2007. Annett wants RADARSAT-1 data from April 2008.

**Action** SAR CWG-5-5: Yves Crevier and Stephen Howell will check on availability of RADARSAT-1 data in the PDC beyond 2007, and extending 500 km inland.

Annett would like complete circumpolar coverage by Sentinel-1 in April every year for ground-fast lake ice versus floating ice (taliks, which are permafrost-free, are below). Environment and Climate Change Canada (ECCC) has data of lakes in winter. Each year, the coverage becomes more complete, with fewer gaps to piece together. The circumpolar ground-fast lake ice study which she mentioned at the meeting got recently published:

<http://journal.frontiersin.org/article/10.3389/feart.2017.00012/full>

Annett reported problems with EW HV data (data is stripey.) Circumpolar products are not possible. Pierre Potin said that de-noising on cross pol data causes other problems.

Annett talked about the GlobPermafrost project of ESA. See [www.globpermafrost.info](http://www.globpermafrost.info) It targets 10 of the cold spots and 5 mountain permafrost sites. All 'cold spots' are also investigated (varying purposes and techniques) by other teams than GlobPermafrost. GlobPermafrost fills in gaps regarding InSAR analyses for five of the 10 sites where it hasent been done yet (CS3, CS7-2, CS8, CS8, CS10).

The GTN-P archive hosts details of the in situ data of permafrost. INTERACT has been funded by the European Commission for the next four years; it sponsors travel funding for researchers doing in-situ measurements in the Arctic.

The review paper on Arctic Landcover which Annett mentioned in her last slide is now published: <http://www.mdpi.com/2072-4292/8/12/979>

There is strong high-level support to research and monitoring of the Arctic (and thus PSTG) through the EU Horizon2020 research programme, and the Arctic summit hosted by the U.S. later this month.

## **7.2 Floating Ice**

Stephen Howell presented the Floating Ice theme. Stephen has access to a lot of operational data through the Canadian Ice Service (CIS). He would like complete pan-arctic coverage every day!

ECCC provided RADARSAT-2 data support to Operation IceBridge (1 – 3 day coverage.)

Stephen can provide RADARSAT-2 data to scientists through a mechanism called MURF (multi-user request form), which is a special agreement between the scientists and the sponsor (ECCC).

Sentinel-1 has good arctic coverage, with a gap in the western arctic; they want to fill that with RS-2. However, there is still a gap in Chukchi Sea. Sentinel-1B may fill this gap. The operational requirements of ECCC do not include Chukchi. But documents from EU to the White House mention PSTG as a coordinating organization! We should keep passing the message that S-1B could ensure pan-Arctic coverage, filling the remaining gap over the Chukchi Sea; S-1B mission plans focus on the European Arctic in support of the Copernicus Marine Environment Monitoring Service (CMEMS; requirement: daily; current target: every 6 days), and do not feature pan-Arctic view for climate.

The upcoming RADARSAT Constellation Mission (RCM) will help, but tasking outside of Canadian waters will still be an issue.

ECCC is ordering new data (beyond the needs of CIS) to support the PSTG SAR CWG. By combining Sentinel-1 and RADARSAT-2, we will get 1 – 3 day coverage in the western Arctic.

RS-2 ScanSAR Wide 100 m HH data would help the permafrost science. For permafrost purposes, extending the frames further south in Canada would not be a problem; neither would data access; there would be no real-time access, but in delayed mode for science.

In future, we should plan for full coverage with no gaps. ICESat-2 is planned for 2018 launch, but is running late. We should also coordinate with field campaigns. E.g. MOSAIC in 2019/20. Yves said that next year, this requirement should be handled in a more tactical way.

RS-2 Extra Wide Fine Beam mode helped recently in planning flight lines. Spotlight mode is even higher resolution.

Pierre Potin said that for arctic surveillance, operational surveillance in the European arctic is top priority. The target is 1 coverage every 6 days with 2 satellites. They get pressure from NOAA to increase the coverage in the western arctic. Thanks to Canada for the help. Mark Drinkwater said that the climate dimension was not there at the beginning of Copernicus, but sea ice is now an ECV. Stephen's chart proves that a combination of satellites can be used for a single product.

Ice motion maps, produced every 3 days, are used for NWP model validation and to help better understand sea-ice dynamics. We have a lot to learn by combining SAR imagery with altimetry. NOAA does ice motion with VIIRS.

### **7.3 Ice sheets (Bernd Scheuchl and Thomas Nagler)**

Bernd Scheuchl presented the Ice Sheets theme.

We should talk about “continuous acquisitions” rather than “monitoring”.

Landsat-8 is a useful tool for ice sheet monitoring, because of spatial resolution but more importantly radiometric resolution. Sentinel-2 will be equally useful.

There are four ice sheet science issues: surface elevation change, ice velocity, grounding line location and calving front location; the latter three are available from SAR data. The over-arching question is mass balance and sea level changes.

Regular DEMs necessary over Antarctica (from TSX) for accuracy determination.

The value of the new Enveo CryoPortal (URL) was highlighted: <http://cryoportal.enveo.at/>

## **7.4 Wet snow (David Small and Thomas Nagler)**

David Small presented the Wet Snow theme.

The resolution requirement of 100 m is fine with SAR, but the revisit time of 1 day is still a challenge. The extent of the snow melt area is based on backscatter sensitivity to wet snow; however, SAR has very limited sensitivity to dry snow.

David showed examples of coverage of the Alps, Vancouver area, Ellesmere Island. They got almost complete 16 day coverage during the spring melt season in the Alps, except for an outage by Sentinel-1 in June.

Comparisons of Sentinel-1A with RS-2 in the offing; first David must acquire 16-bit radiometry.

Requirement R4 has been modified because David needs polarization consistency between Sentinel-1 and RS-2, so he specified HH/HV in the Arctic.

Geometric calibration of S-1B looks good; absolute location error the same as for S-1A; this will lead to strongly improved coverage.

## **7.5 Glaciers**

T. Nagler briefed on progress with addressing observation requirements related to glaciers. The products are: area, facies, elevation change (altimetry), elevation change (DEM), velocity. Techniques: velocity (automatic), elevation change (pre-processing manual) and area (post processing manual). Geocoding is important especially for mountain glaciers. Orthorectification should be done by the community using the same DEM which is provided and updated. We need a common time series of DEMs, freely and openly available. Regular updates are needed since glaciers change with time.

Examples were shown for glaciers on Spitsbergen, South Georgia, Karakorum, Pamir Mountains, and Novaya Zemlya.

Recommendations were presented regarding acquisitions by S-1, S-2, JERS-1, CryoSat-3 (2), CSK, DLR World DEM, TerraSAR-X, TanDEM-X, PALSAR-1 & 2 and Landsat-8. These recommendations were collected as part of the ESA Glaciers\_CCI project. The collection of requirements included the whole community, and the requirements should be endorsed by the community.

## **8. Agencies Imaging Activities over Polar Regions**

### **8.1 European Space Agency (ESA) (Pierre Potin)**

The operational schedule toward the two-satellite Sentinel-1 constellation is underway.

3.5TB /day of products is being generated by Sentinel-1A. The Sentinel-1A solar panel was hit by a space particle, leading to 5% reduction of power, but it is still above the margins.

S-1 is reaching full operational capacity: there is strong user pull (44 000 registered users with Sentinel Hub, and downloads are steadily increasing). EDRS (European Data Relay System) will provide additional access flexibility.



Pierre showed some details of the Antarctic and Greenland campaigns (target: 6 continuous revisits) in support of PSTG Ice Sheet requirements.

For Sea Ice and Permafrost monitoring, S-1 provided significant coverage of cold spots, and transects.

S-1 is providing 6-day continuous monitoring (grounding lines) of ice sheet margins with six identified tracks over Greenland and Antarctica.

Annual monitoring of margins could involve yearly acquisition over other critical areas, but not all and on a regular basis (due to resource constraints). S-1A and S-1B together will not double support to PSTG, but will lead a slight increase only, and provide more flexibility. Pierre showed the coverage map of S-1A and S-1B over the Arctic, acquired over three days.

## **8.2 Italian Space Agency (ASI) (Maria Girolamo Daraio)**

Maria Girolamo Daraio reviewed past data acquisitions of CSK over Greenland and Antarctica, as described in the Data Compendium. In response to current ice sheet data requirements, CSK has adjusted its acquisition plan, which led to datasets covering glaciers and ice sheets. The Announcement of Opportunity for scientific use of the datasets (free) presented is permanently open. The limit of 100 images per project can be negotiated with the mission manager. There is major interest in exploiting CSK data for studying glaciers. Contributing to PSTG helped ASI to improve their polar data archive.

## **8.3 Canadian Space Agency (CSA) (Yves Crevier)**

Yves Crevier described CSA contributions to PSTG. The operational use of SAR was first addressed by sea-ice charting agencies, to help navigation in polar regions. We are reminded of this by recent efforts which resulting in finding the two ships of the doomed Franklin expedition to investigate the North-West passage.

An update on the PCW (Polar Communications and Weather) mission: the Canadian Department of National Defense is currently only considering the communication payload, not the weather and climate monitoring payload. CSA and ECCC continue to consider the weather and climate monitoring requirements identified for PCW.

CSA and ECCC are currently working in partnership on a technical study for a terrestrial snow mass (radar) mission.

The RCM launch is currently scheduled for Q3/2018. The three satellites will be launched on one rocket. After one year, operations will be transferred from MDA to CSA.

The Polar Data Catalogue (PDC) developed better interfaces to access RADARSAT-1 & 2 datasets. CSA is exploring the ability of PDC to host the Data Compendium.

PSTG could have a role in joint mission planning (to address critical gaps).

#### **8.4 German Space Agency (DLR) (Dana Floricioiu, Achim Roth)**

Dana Floricioiu presented DLR support to the ice sheets, floating ice, and permafrost requirements. Within the ESA CCI Antarctic Ice Sheet project, focus is a time series of Grounding Line Location over key areas. TerraSAR-X is providing near-real time data acquisition to research vessels at GARS O'Higgins station.

Achim Roth described TerraSAR-X “cold spot” monitoring, ongoing since 2012 and providing observations of right-looking SAR data over 11 sites. A new AO for “special products” was released, acquired during the TanDEM-X pursuit monostatic phase.

TanDEM-X global DEM production is completed. The TanDEM-X DEM-AO has been released, and is open until 1 Dec 2016. There is ongoing development of TanDEM-L. They are also working on a new X-band mission proposal HRWS (High-Resolution Wide Swath).

**Action** SAR CWG-5-6: Achim Roth will contact the PSTG science leads to request scientific requirements for the proposed HRWS mission.

#### **8.5 National Aeronautics and Space Administration (NASA) (Craig Dobson)**

Craig Dobson expanded on NISAR mission science objectives and reminded participants that the mission had multiple driving requirements. To satisfy multiple and sometime conflicting requirements in different geographic locations, both left- and right-looking acquisition modes are needed. The pole hole could be reduced by synergistic use of missions coordinated by PSTG members. NISAR is going to be designed to look both ways; during the current design phase of the instrument, PSTG comments would be welcome. The current baseline is for 9 months right looking, 3 months left looking. Steve Howell said that the ice community wants the Antarctic summer melt information. Craig Dobson said that left looking cannot be during eclipse.

The NISAR mission is on schedule and has budgetary stability. The Level 1 baseline science requirements are stable. There will be a systematic observation strategy. The US and India science requirements (agriculture, coastal, ice sheets, ...) were presented. There will be culling of some acquisitions near the poles due to oversampling.

This will be a science mission: there are no provisions for an operational mission. There will be downlink stations in India and Antarctica, and two northern polar downlinks. Level 0 and 1 data will be freely available through NASA DAAC. Ice motion will be available every three days.

#### **8.6 Japan Space Agency (JAXA)**

Bernd Scheuchl presented on behalf of Masahiro Hori (JAXA) who provided slides. He showed the Basic Observation Scenario (BOS) and heat maps of PALSAR acquisitions over past two years. Access to data is an issue. Questions should be directed to JAXA.

At present, PALSAR-2 is the only L-band SAR, but in a few years, SAOCOM and NISAR will also be operating. There may be a coordination challenge in 2018 – 2020. L-band works well for velocity mapping.

## **9. Update of Coordinated Acquisition Plan (Y. Crevier, Agency Representatives and Science Leads)**

The Coordinated Acquisition Plan 2015-2016 was discussed and the Completion Status (i.e. completed/ partially completed/ not done) was entered for each item in the plan. The members have since reviewed this plan and completion status. See it in Annex IV.

**Action SAR CWG-5-7:** Fabrizio Battazza will check and clarify the NOAA agreement for routine ice charting of the pole hole.

**Action SAR CWG-5-8:** David Small will clarify the meaning of: “EU-DEM to be investigated for demonstrating capability in Scandinavia.”

**Action SAR CWG-5-9:** David Small will clarify what is meant by the common polarization.

**Action SAR CWG-5-10:** Yves Crevier will send the ABoVE coverage to Annett Bartsch.

The new Coordinated Acquisition Plan 2016-2017 was discussed. It was left to the members to submit inputs by email after the meeting. The resulting plan appears in Annex V. Ice caps and mountain glaciers were moved out of the Ice Sheets theme to the Glaciers theme.

A third party agreement with Copernicus has been made for RISAT (Contributing Mission Agreement).

## **10. Update of Implementation Plan**

It was agreed to remove the Communications Appendix from the 3 Year Implementation Plan. It can be summarized in a few bullet points. It was agreed that deliverables would be specified in 2 year periods (e.g 2016-2017, not 2017).

Fabrizio talked about the Coordinated AO. He suggested that the term ‘scientist’, to distinguish public sector and private sector scientists. Yves said that the Coordinated AO has been put on the back burner, and should stay there unless the members are interested in prioritizing it. Achim pointed out that some agencies have more open data policies than others. He suggested that the Data Compendium or the web site should have links to the Data Access and Data Policies of the member agencies. Yves suggested that members should promote the branding of PSTG while also promoting their own datasets. He felt that this is more efficient than doing a Coordinated AO.

Yves said that we need an update of the Data Compendium and the poster. CSA will email the member agencies to request links or information on Data Access and Data Policy.

**Action SAR CWG-5-11:** Yves Crevier and Don Ball will send an email requesting members’ thoughts on brochure #3.

Mark pointed out that the brochure allows us to promote PSTG to CGMS and CEOS.

In discussing how often the 3 Year Implementation Plan should be updated, Mark suggested that the plan should be reviewed every year, and updated in synchronicity with the PSTG Strategic Plan. We can put out a bulletin of updates ready for the next revision.

## **11. Meeting Wrap-up (Actions and Next Meeting)**

The action items were reviewed. They are shown in Annex III(b).

Yves Crevier thanked ESA for hosting, and he thanked all participants for their efforts to contribute. The meeting was closed.

## List of Participants

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POLAR SPACE TASK GROUP – SAR COORDINATION WG  
FIFTH SESSION  
ESTEC  
NOORDWIJK, Netherlands, 12-13 SEPTEMBER 2016

PSTG-SARCWG-5,  
Doc 3-1  
(12 Sep 2016)

## AGENDA AND WORK SCHEDULE

Meeting Room: **NB 325 – Erasmus Building 30**

### Meeting Objectives:

1. Review of achievements and open dialogue on PSTG SAR CWG activities
2. Consolidate response activities and agree on an updated, actionable Coordinated Acquisition Plan
3. Update of 3-year Implementation Plan

### Day 1 – 12 Sept 2016

**8:30** *Site Entry/Registration*

**9:00** 1. **Welcome and Opening Remarks**  
Local host information / logistics (M. Drinkwater)

**9:15** 2. **Introductions (All)**

**9:30** 3. **Meeting Objectives and Approval of Agenda** (Y. Crevier)

**9:45** 4. **Review of Action Items** (D. Ball)

**10:00** 5. **SAR Coordination Working Group – Management, Communication and Coordination Business** (Y. Crevier and D. Ball)

**10:30** *Coffee Break*

**10:45** 6. **Presentations of Special Projects, and discussion involving science leads and space agencies**

Potential contribution:  
ISRO  
CONAE  
NASA ABoVE

**12:30** *Lunch*

**13:30** 7. **Thematic Science Session – Review of SAR Requirements, Achievements and Expected Data** (Thematic Science Leads)

Ice Sheets (B. Scheuchl, T. Nagler)  
Permafrost (A. Bartsch)  
Floating Ice (Stephen Howell)  
Snow (David Small, Thomas Nagler)  
Glaciers (Frank Paul or Alternate)  
Other

**15:30** *Coffee Break*

**16:00 8. Agencies Imaging Activities over Polar Regions (15 minutes / Space Agencies)**

Italian Space Agency (ASI)  
Canadian Space Agency (CSA)  
German Space Agency (DLR)  
European Space Agency (ESA)  
Japanese Aerospace Exploration Agency (JAXA)  
National Aeronautics and Space Administration (NASA)

**18:00** *Adjourn Day 1*

Evening Event (tbd)

## **Day 2 – 13 Sept 2016**

**9:00 9. Update of Coordinated Acquisition Plan** (Y. Crevier, Agency Representatives and Science Leads)

**11:00** *Coffee Break*

**11:15 10. Update of Implementation Plan** (All)

**11:30 11. Meeting Wrap-up (Actions and Next Meeting)** (D. Ball)

**12:00** *Adjourn Day 2*



## Status of Action Items from SAR CWG-4

ACTION SAR CWG-5.1.1: Pablo-Clemente Colon to provide a text on YOPP for the inclusion into the Three Year Implementation Plan. Deadline mid-December	CLOSED (deadline passed)
ACTION SAR CWG-5.1.2: The three year implementation plan will be reviewed by all members by end October	CLOSED (document was reviewed by all members)
ACTION SAR CWG-5.2.1: The PSTG Chair to provide inspiring words on behalf of PSTG for inclusion into the Compendium.	CLOSED (the Compendium was completed with help from the PSTG Chair)
ACTION SAR CWG-5.2.2: Bernd Scheuchl to provide information on the SeaSat data set.	CLOSED (replaced by new clarified action)
ACTION SAR CWG-5.2.3 Members of SAR CWG to provide shape files or KML files for data sets that would be included in the Compendium.	CLOSED (the Compendium has been issued)
ACTION SAR CWG-5.2.4: Members of SAR CWG to provide comments on the Data Compendium by mid-December 2016.	CLOSED (accomplished)
ACTION SAR CWG-5.2.5: Pablo-Clemente Colon to follow up on the PSTG letter to IICWG on data acquired to be accessible by science users.	CLOSED (no longer relevant)
ACTION SAR CWG-5.3.1: Members of SAR CWG to provide brief scientific articles/graphics/images for the SAR CWG Brochure by 2 November 2015. Specifically: (a) Bernd Scheuchl for ice sheets; (b) Dana Floricioiu for the Recovery Glacier; (c) Annett Bartsch for permafrost; (d) Steve Howell for floating ice; and (e) David Small and Thomas Nagler for snow.	CLOSED (accomplished)
ACTION SAR CWG-5.3.2: Members of SAR CWG to provide bullets for the achievements section of the Brochure by 2 November 2015.	CLOSED (accomplished)
ACTION SAR CWG-5.3.3: The PSTG Chair to provide inspiring words on behalf of PSTG for inclusion into the Brochure.	CLOSED (accomplished)
ACTION SAR CWG-5.3.4: An overarching review of the Brochure should be completed by all members by 2 November 2015.	CLOSED (accomplished)
ACTION SAR CWG-5.4.1: Members of SAR CWG to provide input to the Poster, namely the science results in a form of graphic/imagery/product for the Poster by mid-November 2015.	CLOSED (accomplished)
ACTION SAR CWG-5.4.2: Mark Drinkwater and the Secretariat to provide historical IPY STG archive material as a potential source for the Poster by end of October.	CLOSED (accomplished)
ACTION SAR CWG-7.1.1: The Ice Sheets Requirements Document will be updated by Bernd Scheuchl and Thomas Nagler by the end March 2016.	<b>OPEN</b>
ACTION SAR CWG-7.1.2: Frank Paul will provide a Glacier Requirements Document.	<b>OPEN</b> (The draft has been submitted, consultations are still ongoing.)

ACTION SAR CWG-7.2.1: Annette Bartsch to update Requirements Document by the end of 2015.	CLOSED (Annett's project kicked off in Feb 2016. Consultations are ongoing.)
ACTION SAR CWG-7.2.2: Johannes Roeder (ESA) to provide S-1 planning zones to Annett Bartsch by the end of October.	CLOSED (accomplished)
ACTION SAR CWG-7.3.1: Pablo-Clement Colon to provide Johannes Roeder with logistic information for the Antarctica re-supply activities, such as location and time.	CLOSED (accomplished)
ACTION SAR CWG-8.1: Bernd Scheuchl to provide airborne SAR acquisition from NASA.	CLOSED
ACTION SAR CWG-8.2: SAR CWG Members should provide their comments on the draft Space Agency Acquisition Plan by end of October.	CLOSED (accomplished during the Data Compendium finalization)
ACTION SAR CWG-9.1: The chair of PSTG to develop credit statements for scientific papers/contributions to PSTG.	CLOSED (text was proposed by Mark Drinkwater.)

## Actions from SAR CWG-5

<b>Action SAR CWG-5-1:</b> Bernd Scheuchl will send an email with the status of the SEASAT data that was re-processed by ASF.	
<b>Action SAR CWG-5-2:</b> Each space agency will list the urls of their data sources for incorporation into the Data Compendium.	
<b>Action SAR CWG-5-3:</b> CSA will send an email to the members requesting specific activities that provide data access to scientists.	<b>Complete</b>
<b>Action SAR CWG-5-4:</b> Mark Drinkwater to write a letter to ISRO about collaboration and data access.	
<b>Action SAR CWG-5-5:</b> Yves Crevier and Stephen Howell will check on availability of RADARSAT-1 data in the PDC beyond 2007, and extending 500 km inland.	<b>Complete</b>
<b>Action SAR CWG-5-6:</b> Achim Roth will contact the PSTG science leads to request scientific requirements for the proposed HRWS mission.	
<b>Action SAR CWG-5-7:</b> Fabrizio Battazza will check and clarify the NOAA agreement for routine ice charting of the pole hole.	
<b>Action SAR CWG-5-8:</b> David Small will clarify the meaning of: "EU-DEM to be investigated for demonstrating capability in Scandinavia."	<b>Complete</b>
<b>Action SAR CWG-5-9:</b> David Small will clarify what is meant by the common polarization.	<b>Complete</b>
<b>Action SAR CWG-5-10:</b> Yves Crevier will send the ABoVE coverage to Annett Bartsch.	<b>Complete</b>
<b>Action SAR CWG-5-11:</b> Yves Crevier and Don Ball will send an email requesting members' thoughts on brochure #3.	<b>Complete</b>

## POLAR SPACE TASK GROUP - SAR COORDINATION WORKING GROUP

TABLE OF COORDINATED SPACE AGENCY 2015-2016 ACQUISITION PLAN AND COMPLETION STATUS

Science Theme	Strategic Priority	Agency	Location	Plan for 2015-16	Status/ Gaps	Completion Status
Permafrost	Routine high-resolution circumpolar coverage for monitoring variability in carbon pools				S-1 routine coverage not yet assured. Zonal mapping running, 2 – 3 revisits /year. Potential RS-2 support when the National Monitoring Framework is in place for Canadian portion.	
	Multi-sensor monitoring around key research locations where GTN-P and in-situ measurements are made (“cold spots”); (Bi-weekly InSAR for permafrost modeling)	DLR	10 cold spot sites	Routinely monitored by Terra-SAR-X In stripmap mode HH and HH/VV and spotlight mode HH/VV in 2015 to 2016.	Other cold spot sites not covered.	Complete
		ESA	Sample of cold spots and 5 mountain permafrost areas (with focus on rock glaciers) (TBC)	At least one complete Sentinel-1 IW mode VV-VH coverage of global permafrost zone during relevant season (within Sentinel-1 zonal mapping frame) + 2-3 local subsequent acquisitions over a total of 5+ cold spots in order to achieve pairs/triplets for time-series analysis.		Complete

Science Theme	Strategic Priority	Agency	Location	Plan for 2015-16	Status/ Gaps	Completion Status
				Global Permafrost ITT		With adaptation of the plan
		ASI		Evaluation of applicable acquisitions of the COSMO-SkyMed constellation, considering the acquisitions and information provided within CSK specific projects.		Yes, ongoing
	Quantify rates of pan Arctic coastal erosion (Annual circumpolar Arctic coastline mapping at < 10m optical resolution; InSAR estimates of erosion/degradation)	DLR	Limited areas	Demonstrations using Terra-SAR-X in 2015 to 2016.	No comprehensive coverage defined yet to observe changes.	Complete
		ASI		Evaluation of applicable acquisitions of the COSMO-SkyMed constellation, considering the acquisitions and information provided within CSK specific projects.		Complete
	Establish SAR monitoring of Arctic permafrost transects on routine basis to supplement existing 30-300m pan-Arctic multispectral	ESA	Transects as defined in Requirement Document	- Scandinavian transect: Complete Sentinel-1 coverage all year IW VV-VH, 12 d repeat acquisitions. - West Siberian Lowlands transect: Sentinel-1 all year EW HH- HV, 12 day repeat acquisitions north of 65.5 deg (Gulf of Ob and surrounding		Complete

Science Theme	Strategic Priority	Agency	Location	Plan for 2015-16	Status/ Gaps	Completion Status
	imaging (Antarctic Peninsula covered by sea ice requirements)			coastal areas); at least one complete IW VV-VH coverage during summer season (zonal mapping). - East Siberian transect: Sentinel-1 all year EW HH-HV, 12 day repeat acquisitions over Lena Delta and surrounding coastal areas; at least one complete IW VV-VH coverage during summer season (zonal mapping). - East Canada/Mackenzie Delta/Alaska Highway: Sentinel-1 all year EW HH-HV, 12 day repeat acquisitions over the northern coastal regions of the transects; southern parts of transects covered on routine basis in IW VV-VH or IW HH-HV (Mackenzie).		
		CSA	Coverage of NASA ABoVE transect in North America	National Terrestrial Ecosystem Monitoring System (NTEMS) implementation TBC		Partial
	Derive SAR DEM and land surface classification map suitable for permafrost community needs.	ESA		CCI Land cover TBC		No, recognized to be incompatible with permafrost needs
<b>Floating Ice</b>	Acquire contiguous (seamless) six days repeat pan-Arctic	CSA		Canadian Ice Service can provide RADARSAT-2 ScanSAR imagery (8-bit only) over	Aspects of the plan may require consent of MDA.	Complete

Science Theme	Strategic Priority	Agency	Location	Plan for 2015-16	Status/ Gaps	Completion Status
	and Southern Ocean SAR imaging at consistent polarization combination (with view to expanding to an intermediate goal of less than three days repeat in future with right-looking Sentinel-1 (S-1), RCM, etc.; and subsequently sub-daily data with C-, X-, S-, L-band SAR combined data sources).			Canadian Arctic waters during the operational monitoring period (July to late October). During the non-operational period (November to June), Stephen Howell of Environment Canada, Climate Research will program one to three coverages of the western Canadian Arctic from RADARSAT-2 (ScanSAR only) to complement Sentinel-1 (i.e. fill the western Canadian Arctic gap). Distribution will be via a MURF sponsored by Environment Canada, backdated to March 2015. This will be separate from RADARSAT-2 imagery used to support ice thickness and snow surveys during OIB (NASA).		
		DLR		Ice support in NRT for ships operating in ice (demonstration). Includes for example: <ul style="list-style-type: none"> <li>• Combination of sea ice parameters and meteo (concentration/winds) from Terra-SAR-X</li> <li>• Unique HH/VV combination for floe-size distribution.</li> <li>• Wind/wave interaction in</li> </ul>		Complete

Science Theme	Strategic Priority	Agency	Location	Plan for 2015-16	Status/ Gaps	Completion Status
				<p>marginal ice zone. (SWH and peak wavelength).</p> <ul style="list-style-type: none"> <li>Iceberg tracking- for IIP; insufficient repeat to track icebergs.</li> </ul>		
		NOAA		<p>NOAA is operationally processing any available SAR dataset for met-ocean and sea ice analyses; demonstration of capability to fill pole hole with COSMO-SkyMed (CSK) background data for sea ice analysis; pilot project to test CSK multi sat data to support IIP flights. NOAA request to test data from TanDEM-X, CSK and other SAR acquisitions in support of resupply/science cruise to McMurdo.</p>	Need routine sea ice information over North Pole.	Complete, but question of pole hole not addressed
		ASI		<p>COSMO-SkyMed coverage for providing information on eastern Greenland current and sea ice drift and northern circumpolar routes (also available in 1 day). CSK contribution to this priority is provided also through CSK AO specific projects and further contributions are under evaluation.</p>		Complete
		ESA	¼ of Arctic Basin with high frequency plus background	<p>In the Central European Arctic (-90 W to 110 E lat.) Sentinel-1 routine monitoring follows CMEMS requirements: ~ 1</p>	So far there are only summer and autumn consecutive acquisitions over Novaya Zemlya and	Complete



Science Theme	Strategic Priority	Agency	Location	Plan for 2015-16	Status/ Gaps	Completion Status
			coverage of western Arctic and Southern Ocean	complete coverage every 3-4 days (status 2016; goal with Sentinel-1 constellation 2017 onwards is daily coverage). Arctic outside CMEMS core areas: at least 1 coverage per 12 days revisit cycle (per 6 day envisaged with Sentinel-1 constellation). Southern Ocean: At least one coverage per 12 days revisit cycle. Increased revisit rate over Weddell- and Ross Sea bay to support ice drift metric measurements (Increased sampling density with Sentinel-1 constellation envisaged; further clarification of recommendations needed).	Franz Josef Land, but no consecutive acquisitions over Severnaya Zemlya, and in general no consecutive acquisitions in winter over Russian Arctic ice caps.	
	Establish tundra lakes and river monitoring sites	CSA	Canadian lakes	CSA will provide info on winter lake monitoring program to permafrost and floating ice communities and assess the value.		Complete
		DLR	The 10 DLR cold spots	Terra-SAR-X classification of river and lake ice – in tundra regions. Water; frozen to ground; consolidated ice; frazil ice. Classification of Sentinel-1 data using Kennaugh elements. All of the above are		Partially, not all 10 cold spots processed

Science Theme	Strategic Priority	Agency	Location	Plan for 2015-16	Status/ Gaps	Completion Status
				demonstrations.		
		ESA	Great Lakes and major Canadian lakes	All year EW mode HH-HV coverage of Great Lakes and major Canadian tundra lakes sites; ~ 1 coverage every 12 days .		Complete
<b>Ice sheets, Ice caps and Glaciers</b>	Follow coordinated ice sheet observation plan				<p>(General statement) Update to User requirements needed to refresh the requirements document – based on user survey for Antarctic and based on currently implemented acquisition plans.</p> <p>L-band SAR summer InSAR pairs/coherence needed for debris glacier mapping</p> <p>L-band SAR ice sheet coverage over the margins of Greenland and Antarctica in BOS Insufficient to meet user requirements.</p>	
		CSA		RADARSAT-2 left looking acquisition plan for Central Antarctica created; three-year scenario that would provide a full coverage and focus annually on critical regions (i.e. grounding line regions of Ross and Ronne Ice shelves).	The first two years have been acquired, year three acquisitions will be shifted forward to the second half or 2016 to attempt an early completion. Selected coastal areas are monitored using Fine Wide mode. A modified 2017 data plan is under	Complete

Science Theme	Strategic Priority	Agency	Location	Plan for 2015-16	Status/ Gaps	Completion Status
					consideration. It will include a gap filler campaign to ensure a second full data coverage of Central Antarctica following the IPY campaign (2009, 2011) as well as some ongoing coastal acquisitions. Some background acquisitions in Greenland are planned, due to high potential for resource conflict (acquisition and downlink) and ongoing acquisitions by other sensors, this is deemed lower priority.	
		DLR		<p>April 2015 – DLR joined Antarctic CCI with TerraSAR-X. The data will support the GLL and IV. TerraSAR-X coverage of 27 outlet glaciers of Greenland on-going.</p> <p>Regular TanDEM-X coverage of supersites, including Greenland and Antarctica</p> <p>TanDEM-X – 90m pixel spacing DEM planned to be available by 2016. A call for data will be established.</p>		<p>Complete, expanded to 53 outlet glaciers</p> <p>Complete</p> <p>Call established for 12, 30 and 90 m of restricted area. Global DEM pending.</p>

Science Theme	Strategic Priority	Agency	Location	Plan for 2015-16	Status/ Gaps	Completion Status
		ESA	Greenland	Annual winter campaign with 3-4 consecutive acquisitions, each ascending and descending.		Complete, exceeded the plan
			Antarctica	At least bi-annual extended winter campaign over the whole ice sheet up to Sentinel-1 visibility boundary at 78.5 degrees South. Reduced campaign in other years focusing on selected fast moving margin areas. Four consecutive acquisitions as a goal. Complementary and cooperative regular left looking campaigns south of 78 degree assumed to be conducted by Radarsat-2/ RCM. In addition, continuous all year Sentinel-1 coverage of key fast changing sub-regions, e.g. Antarctic Peninsula and Amundsen Sea embayment.		Complete
			Arctic Ice Caps	Canadian Icecaps associated with the Greenland Campaign. Iceland and Svalbard covered under the European coverage. Zonal mapping (repeat pairs several times per year).		Complete

Science Theme	Strategic Priority	Agency	Location	Plan for 2015-16	Status/ Gaps	Completion Status
		ASI		COSMO-SkyMed regular coverage of around 90 glaciers of Greenland and Antarctica including supersites in Greenland and Antarctica. Continuous coverage of the entire coast of Antarctica.		Complete
<b>Snow</b>	Plan SAR data as complement to passive microwave and 300m optical data for continental scale snow extent/SWE – and in Alpine regions and rugged topography where other methods fail.	CSA	British Columbia  Ellesmere Is.	Routine RADARSAT-2 coverage to test methods.	CSA provided comprehensive coverage of mountain snow in unified dual pol strategy over BC.  Environment Canada provided Canadian Ice Service 2015 archive data of Ellesmere Island (454 images, albeit in CIS 8-bit format). First RS2(SCWA)+S1A(EW) hybrid backscatter composite images generated.	Complete  Complete
		ESA	European Alps  British Columbia  Ellesmere Is.	Sentinel-1 routine coverage over European Alps.  British Columbia (IW mode) and Ellesmere Island (EW) (planned)	European coverage extended eastwards to Caucasus TBC.  BC coverage by S1A in 2016 denser until addition of S1B in Sept. 2016.  Ellesmere EW coverage was consistently HH+HV (DH mode) in 2015. In 2016, the northern part of Ellesmere	Complete

Science Theme	Strategic Priority	Agency	Location	Plan for 2015-16	Status/ Gaps	Completion Status
					saw much less coverage and most acquisitions were SH (HH only) rather than DH.	
	Establish less than three day repeat 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	ESA		Sentinel-1A alpine monitoring of European Alps, with Sentinel-1B in 2016 the monitoring will be more complete. Sentinel-1A acquisitions over British Columbia (IW VV/VH), offered 24d VV (SV) coverage in 2015. S1A coverage of Ellesmere Island (mainly EW HH/HV) offered 2-3d coverage. (Subdaily referred to partial Ellesmere coverage, not BC.)	Tight time series over Ellesmere allowed demonstration of 4-day temporal resolution. In more temperate latitudes, temporal resolution will be moving down towards these values with the addition of Sentinel-1B.  EU-DEM to be investigated for demonstrating capability in Scandinavia.	Complete, in progress.  Requirement not clear
	Establish common polarization/ mode observation strategy between SAR missions	CSA and ESA		RADARSAT-2 and Sentinel-1 wide swath acquisitions over Alps in VV/VH when possible.  Considering potential RADARSAT-2 data acquisition conflicts, having extra ScanSAR (SCNB preferably, best matching Sentinel-1 IW) during the springtime melt period would be beneficial.	More complete ascending / descending coverage over British Columbia.	Some RADARSAT-2 VV/VH imagery of Alps was acquired  NA

## POLAR SPACE TASK GROUP - SAR COORDINATION WORKING GROUP

TABLE OF COORDINATED SPACE AGENCY 2016-2017 ACQUISITION PLAN

Science Theme	Strategic Priority	Agency	Location	Plan for 2016-17	Status/ Gaps
<b>Permafrost</b>	Routine high-resolution circumpolar coverage for monitoring variability in carbon pools	ESA, CSA	Entire Circumpolar Arctic north of tree-line	ESA: gaps will be covered by Sentinel-1A and B combination in regular intervals, but mostly VV. CSA: Extended cover to the south over North America by Radarsat HH initialized (Howell).	Early winter (Dec) coverage in C-band HH. Partially possible with Sentinel-1.
	Multi-sensor monitoring around key research locations where GTN-P and in-situ measurements are made (“cold spots”); (Bi-weekly InSAR for permafrost modeling)	DLR	10 cold spot sites	Routinely monitored by Terra-SAR-X In stripmap mode HH and HH/VV and spotlight mode HH/VV in 2015 to 2016.	CS1 <sup>4</sup> Barrow (Alaska, USA) CS2 Toolik Fieldstation Arctic Foothills (Alaska, USA) CS3 Teshekpuk (Alaska North Slope, USA) CS4 Mackenzie Delta (Canada) CS5 Umiaq (Canada) CS6 Kytalyk (Russia) CS7 Lena Delta (Russia) CS7 - 1 Kurunjakh CS7 - 2 Sobo CS7 - 3 Bykovsky Island CS8 Yamal (Russia) CS9 Disco Island (Greenland) CS10 South Shetland Islands

<sup>4</sup> The Kml/kmz of the mentioned sites can be downloaded here:

<http://www.globpermafrost.info/cms/documents/products/cold-spots-with-subsites>

<http://www.globpermafrost.info/cms/documents/products/hot-spot-transects>

<http://www.globpermafrost.info/cms/documents/products/mountain-permafrost>

Science Theme	Strategic Priority	Agency	Location	Plan for 2016-17	Status/ Gaps
					(Antarctica) CS10 – 1 Deception Island CS10 – 2 Hurd Peninsula
		ESA	Sample of cold spots and 5 mountain permafrost areas (with focus on rock glaciers)	At least one complete Sentinel-1 IW mode VV-VH coverage of global permafrost zone during relevant season (within Sentinel-1 regular mapping frame) + 2-3 local subsequent acquisitions over a total of 5+ cold spots in order to achieve pairs/triplets for time-series analysis.	Running with Sentinel-1 IW, performed by regular mapping with the S1 constellation
		ASI		Evaluation of applicable acquisitions of the COSMO- SkyMed constellation, considering the acquisitions and information provided within CSK specific projects.	Ongoing, to be improved.
	Quantify rates of pan Arctic coastal erosion (Annual circumpolar Arctic coastline mapping at < 10m optical resolution; InSAR estimates of erosion/degradation)	DLR	Limited areas	Demonstrations using Terra-SAR-X in 2015 to 2016.	No comprehensive coverage defined yet to observe changes. Relevant cold spots with coasts: CS3 Teshekpuk (Alaska North Slope, USA) CS4 Mackenzie Delta (Canada) CS7 Lena Delta (Russia) CS7 - 1 Kurunjakh CS7 - 2 Sobo CS7 - 3 Bykovsky Island CS9 Disco Island (Greenland)
		ASI		Evaluation of applicable acquisitions of the COSMO- SkyMed constellation, considering the acquisitions and information provided within CSK specific projects.	



Science Theme	Strategic Priority	Agency	Location	Plan for 2016-17	Status/ Gaps
	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)	ESA	Transects as defined in Requirement Document. Transects have been slightly extended to the south in response to user requests. Revised transects available as kml.	<ul style="list-style-type: none"> <li>- Scandinavian transect: Complete Sentinel-1 coverage all year IW VV-VH, 12 d repeat acquisitions.</li> <li>- West Siberian Lowlands transect: Sentinel-1 all year EW HH- HV, 12 day repeat acquisitions north of 65.5 deg (Gulf of Ob and surrounding coastal areas); at least one complete IW VV-VH coverage during summer season (as part of regular mapping).</li> <li>- East Siberian transect: Sentinel-1 all year EW HH-HV, 12 day repeat acquisitions over Lena Delta and surrounding coastal areas; at least one complete IW VV-VH coverage during summer season (as part of regular mapping).</li> <li>- East Canada/Mackenzie Delta/Alaska Highway: Sentinel-1 all year EW HH-HV, 12 day repeat acquisitions over the northern coastal regions of the transects; southern parts of transects covered on routine basis in IW VV-VH or IW HH-HV (Mackenzie).</li> </ul>	
		CSA	Coverage of NASA ABoVE transect in North America	National Terrestrial Ecosystem Monitoring System (NTEMS) implementation TBC	
	Derive land surface classification map suitable for permafrost community needs.	Any agencies volunteer???		Please fill in	Land cover classification can be improved by provision of C H-H from Dec at 30m res at different incidence angles (shallow to steep) north of the tree-line. Aim to identify shrubs.
	Derive SAR DEM	Any		Please fill in	

Science Theme	Strategic Priority	Agency	Location	Plan for 2016-17	Status/ Gaps
	suitable for permafrost community needs.	agencies volunteer???			
<b>Floating Ice</b>	Acquire contiguous (seamless) six days repeat pan-Arctic and Southern Ocean SAR imaging at consistent polarization combination (with view to expanding to an intermediate goal of less than three days repeat in future with right-looking Sentinel-1 (S-1), RCM, etc.; and subsequently sub-daily data with C-, X-, S-, L-band SAR combined data sources).	CSA		Canadian Ice Service can provide RADARSAT-2 ScanSAR imagery (8-bit only) over Canadian Arctic waters during the operational monitoring period (July to late October). During the non-operational period (November to June), Stephen Howell of Environment Canada, Climate Research will program one to three coverages of the western Canadian Arctic from RADARSAT-2 (ScanSAR only) to complement Sentinel-1 (i.e. fill the western Canadian Arctic gap). Distribution will be via a MURF sponsored by Environment Canada, backdated to March 2015. This will be separate from RADARSAT-2 imagery used to support ice thickness and snow surveys during OIB (NASA).	Aspects of the plan may require consent of MDA.
		DLR		Ice support in NRT for ships operating in ice (demonstration). Includes for example: <ul style="list-style-type: none"> <li>• Combination of sea ice parameters and meteo (concentration/winds) from Terra-SAR-X</li> <li>• Unique HH/VV combination for floe-size distribution.</li> <li>• Wind/wave interaction in marginal</li> </ul>	

Science Theme	Strategic Priority	Agency	Location	Plan for 2016-17	Status/ Gaps
				ice zone. (SWH and peak wavelength). <ul style="list-style-type: none"> <li>Iceberg tracking- for IIP; insufficient repeat to track icebergs.</li> </ul>	
		NOAA		NOAA is operationally processing any available SAR dataset for met-ocean and sea ice analyses; demonstration of capability to fill pole hole with COSMO-SkyMed (CSK) background data for sea ice analysis; pilot project to test CSK multi sat data to support IIP flights. NOAA request to test data from TanDEM-X, CSK and other SAR acquisitions in support of resupply/science cruise to McMurdo.	Need routine sea ice information over North Pole.
		ASI		COSMO-SkyMed coverage for providing information on eastern Greenland current and sea ice drift and northern circumpolar routes (also available in 1 day). CSK contribution to this priority is provided also through CSK AO specific projects and further contributions are under evaluation.	
		ESA	¾ of Arctic Basin with high frequency plus background coverage of western Arctic and Southern Ocean	In the Central European Arctic (-90 W to 110 E lat.) Sentinel-1 routine monitoring follows CMEMS requirements: ~ 1 complete coverage every 3-4 days (status 2016; goal with Sentinel-1 constellation and full operations capacity in the course of 2017 onwards is daily coverage). Arctic outside CMEMS core areas: at least 1 coverage per 6 days constellation revisit cycle.	

Science Theme	Strategic Priority	Agency	Location	Plan for 2016-17	Status/ Gaps
				Southern Ocean: At least one coverage per 6 days revisit cycle. Increased revisit rate over Weddell- and Ross Sea bay to support ice drift metric measurements (Increased sampling density with Sentinel-1 constellation; further clarification of recommendations needed, related discussions with CMEMS as well).	
	Establish tundra lakes and river monitoring sites	CSA	Canadian lakes	CSA will provide info on winter lake monitoring program to permafrost and floating ice communities and assess the value.	
		DLR	The 10 DLR cold spots	Terra-SAR-X classification of river and lake ice – in tundra regions. Water; frozen to ground; consolidated ice; frazil ice. Classification of Sentinel-1 data using Kennaugh elements. All of the above are demonstrations.	
		ESA	Great Lakes and major Canadian lakes	All year EW mode HH-HV coverage of Great Lakes and major Canadian tundra lakes sites; 1 coverage every 12 days, frequency to be potentially increased once in full operations capacity in the course of 2017.	

Science Theme	Strategic Priority	Agency	Location	Plan for 2016-17	Status/ Gaps
		ESA & CSA	Every April, Arctic C-band coverage for all areas with lakes 100m or more in size, over the entire circumpolar area where there are lakes.	ESA: A full mapping by the Sentinel-1 constellation every April can be performed, as part of the regular global mapping activities.  Environment & Climate Change Canada (ECCC)/CSA: All archived April RADARSAT-2 ScanSAR imagery from 2008-2016 for Canadian Arctic lakes will be provided for distribution via a MURF. List of available imagery should be available by December 2016.	Need to study grounded lake ice
<b>Ice sheets and Ice Caps</b>	Follow coordinated ice sheet observation plan				(General statement) Update to User requirements needed to refresh the requirements document – based on user survey for Antarctic and based on currently implemented acquisition plans.  L-band SAR summer InSAR pairs/coherence needed for debris glacier mapping  L-band SAR ice sheet coverage over the margins of Greenland and Antarctica in BOS Insufficient to meet user requirements.
		CSA		RADARSAT-2 left looking acquisition plan for Central Antarctica created; three-year scenario that would provide a full coverage and focus annually on critical regions (i.e. grounding line regions of	The first two years have been acquired, year three acquisitions will be shifted forward to the second half or 2016 to attempt an early completion. Selected coastal

Science Theme	Strategic Priority	Agency	Location	Plan for 2016-17	Status/ Gaps
				Ross and Ronne Ice shelves).	areas are monitored using Fine Wide mode. A modified 2017 data plan is under consideration. It will include a gap filler campaign to ensure a second full data coverage of Central Antarctica following the IPY campaign (2009, 2011) as well as some ongoing coastal acquisitions. Some background acquisitions in Greenland are planned, due to high potential for resource conflict (acquisition and downlink) and ongoing acquisitions by other sensors, this is deemed lower priority.
		DLR		<p>April 2015 – DLR joined Antarctic CCI with TerraSAR-X. The data will support the GLL and IV. TerraSAR-X coverage of 27 outlet glaciers of Greenland on-going.</p> <p>Regular TanDEM-X coverage of supersites, including Greenland and Antarctica</p> <p>TanDEM-X – 90m pixel spacing DEM planned to be available by 2016. A call for data will be established.</p>	
		ESA	Greenland	<p>Annual winter campaign in IW HH with 4 to 6 consecutive acquisitions at 6 days interval, using S1A and S1B, each ascending and descending.</p> <p>6 long passes in IW HH, specifically selected to cover almost completely the Greenland margins systematically</p>	

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			Antarctica	<p>acquired every 6 days using both S1 satellites.</p> <p>At least tri-annual extended winter campaign in IW HH over the whole ice sheet up to Sentinel-1 visibility boundary at 78.5 degrees South, with 3 to 4 consecutive passes, using both satellites. Complementary and cooperative regular left looking campaigns south of 78 degree assumed to be conducted by Radarsat-2/ RCM.</p> <p>Reduced campaign in IW HH in other years focusing on Antarctica ice sheet margins, made of 4 to 6 consecutive repeat cycles of 12 days or possibly 6 days.</p> <p>In addition, continuous all year Sentinel-1 coverage in IW HH of key fast changing sub-regions, e.g. Antarctic Peninsula and Amundsen Sea embayment, at 6 days interval, using both satellites.</p>	
			Arctic Ice Caps (Canadian)	<p>Canadian Icecaps associated with the Greenland Campaign. Iceland and Svalbard covered under the European coverage. Regular mapping (repeat pairs several times per year).</p> <p>New requirement, to be assessed: Evaluate the possibility of having two dedicated Tracks also along the descending orbits.</p>	
			Russian Arctic ice	New requirement, to be assessed:	

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			caps	Annual winter campaign with 2-3 consecutive acquisitions, ascending or descending over Russian Arctic ice caps, i.e. Novaya Zemlya, Franz Josef Land and Severnaya Zemlya.	
		ASI		COSMO-SkyMed regular coverage of around 90 glaciers of Greenland and Antarctica including supersites in Greenland and Antarctica. Continuous coverage of the entire coast of Antarctica.	
<b>Snow</b>	Plan SAR data as complement to passive microwave and 300m optical data for continental scale snow extent/SWE – and in Alpine regions and rugged topography where other methods fail.	CSA	British Columbia  Ellesmere Is.	Routine RADARSAT-2 coverage to test methods.  Dual pol data (co and cross) – applies to all test areas for RS and Sentinel	CSA provided comprehensive coverage of mountain snow in unified dual pol strategy over BC.  ECCC provided Canadian Ice Service archive data of Ellesmere Island (454 images, albeit in CIS 8-bit format). ECCC will also provide CIS 8-bit for 2016. They will discuss the possibility of reprocessing the data to 16-bit. They will attempt to provide 16-bit for the 2017 melt season over Ellesmere Island.
		ESA	European mountain regions (Alps, Pyrenees, Iceland). Highest temporal sampling during melting season (Feb – July)	Sentinel-1 routine coverage over Europe EEA-39 in IW VV+VH, every constellation cycle (6 days), both in ascending and descending passes (ie 3 days in average). New requirement, to be assessed: European coverage extended eastwards to Caucasus  Coverage of British Columbia (IW mode)	European coverage extended eastwards to Caucasus TBC.



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				planned every 12 days in one pass Coverage Ellesmere Island (EW) frequently covered as within areas of CMEMS activities	
	Establish less than three day repeat 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	ESA		See above	Tight time series over Ellesmere allowed demonstration of 4-day temporal resolution. In more temperate latitudes, temporal resolution are moving down towards these values with the addition of Sentinel-1B.
	Establish common polarization/ mode observation strategy between SAR missions	CSA and ESA		RADARSAT-2 and Sentinel-1 wide swath acquisitions over Alps in VV/VH when possible. → systematically implemented by Sentinel-1 in IW VV+VH  British Columbia: coverage ensured by the S1 constellation has a 12 days repeat.  Considering potential RADARSAT-2 data acquisition conflicts, having extra ScanSAR (SCNB preferably, best matching Sentinel-1 IW) during the springtime melt period would be beneficial.	More complete ascending / descending coverage over British Columbia.

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<b>Glaciers and Ice Caps</b>	Routine SAR imaging of high mountain regions.		Karakoram, sub Antarctic ice caps, selected glaciers on ice caps, Patagonia	T-X and CSK and RISAT: 3 m resolution single polarization, temporal aspect TBD	Requires clarification from glacier community. No formal Requirement Document has been received yet.
				ASI	
				CSA	
				ESA: With the start of the Sentinel-1 constellation operations, the first target is to provide a full mapping of global land areas every 12 days (except Antarctica and Greenland which are subject to specific campaigns) in IW VV+VH, with a combined use of S1A and S1B. Some global tectonic areas may remain observed in single polarisation VV, the full coverage in dual-pol is expected to be reached once in full operations capacity, by mid 2017.	
				DLR	
				ISRO	
				JAXA	