Coordinated SAR Acquisition Planning for Terrestrial Snow Monitoring

A recommendation to the Polar Space Task Group (PSTG)

PSTG-SARCWG-SNOW-001

DRAFT Issue 0.9 – 18 Aug 2014

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Context

The Polar Space Task Group (PSTG) is succeeding the IPY as the coordinating body of international space agencies for cryosphere applications and issues. The PSTG SAR Coordination Working Group was created to address the issue of SAR data acquisitions in the cryosphere. This document covers the SAR data requirements for observing snow melt events. A summary of its findings was presented at the EARSeL LIS-SIG workshop in Bern, Switzerland in Feb. 2014. Further details were presented at the IGARSS 2014 session on "Multi-sensor Remote Sensing of Terrestrial Snow". Both general and sensor-specific recommendations are incorporated. The sensor-specific recommendations summarised in the Appendices will form the basis for on-going discussions of the SAR Coordination Working Group.

Document Change Record

Issue	*Date*	*Page(s)*	*Description of the Change*
0.1	21 Nov 2013		UZH preliminary draft & FMI review
0.2	2 Dec 2013		First release to broader review
0.5	19 Jan 2014		First release to wider community
	Feb 2014		Contents presented at EARSeL LISSIG Workshop
0.74	10 Jul 2014		Feedback from EARSeL workshop integrated: • In line with EARSeL LISSIG presentation/discussions of Feb. 2014, added specific S1/RCM recommendations on suggested harmonisations. • Updated info. on Sentinel-1, RCM, ALOS2 status. Formulated key general recommendations. Added mission-specific recommendations. Contents presented at IGARSS 2014.
0.9	18 Aug 2014		Following changes after IGARSS discussions: a) added general recommendation on open data, b) specified high temporal resolution seasonal window as Feb. 15 through May 30 at northern temperate latitudes.

Possible Future Changes

Issue	*Date*	*Page(s)*	*Description of the Possible Future Changes*
?	Sept. 2014?		Integration of further feedback from SAR snow community
?	?		Add further seasonal observation windows
?	?		Add ALOS2 recommendations
?	?		Addition of ERS, ALOS and Radarsat-1 for historical completeness

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1 Purpose

This white paper (currently in a draft version) aims to set out recommendations for a possible coordinated acquisition planning for SAR satellite observations of terrestrial snow. It was inspired by a similar effort oriented towards SAR science requirements for ice sheets [21]. A comprehensive overview of users and their needs is available in the companion document "*Perspectives for a European Satellite-based Snow Monitoring Strategy: A Community White Paper*" [13]. In contrast to that document, this white paper focuses on coordination of multiple satellite SAR instruments.

Synergetic combination of data from multiple providers would enable more frequent temporal revisit during critical melting periods, improving the quality of the snow parameter retrievals. After reviewing the satellite instruments and their modes, and listing the regions and seasons of principal interest, it concludes with recommendations for cooperation between satellite operators.

2 Introduction

The mapping of wet snow extent with satellite SAR sensors can be integrated into models of snow melt processes, and contribute to many hydrological applications, including flood forecasting and snow-runoff modelling. Because the snow melt period is often restricted to a relatively short time, the *temporal resolution* of repeated SAR observations is critical for monitoring changes to the snow wetness state. Monitoring the seasonally dynamic snow melt period in various regions around the world requires coordination of satellite measurements during the *main melt seasons*, while not unduly placing demands on satellite resources during the *snow free and dry snow seasons*. The challenges posed by coordination and image acquisition conflict-resolution with other applications have been formidable in the past, which has negatively influenced the success of large scale snow melt monitoring efforts.

2.1 Science Requirements

In a broad study of potential products from the Sentinel-1, -2, and -3 sensors, two snow-related products were highlighted in [14]. The products would have the following properties:

Variable	Extent	Spatial resolution	Temporal resolution	Sensor	Auxiliary Data
Snowmelt area	Regional	100m	1 to 5 days	Sentinel-1	Land cover, DEM
Snowmelt liquid water content	Regional	100m	1 to 5 days	Sentinel-1 dual polarisation	Land cover, DEM

Research is on-going into retrieving the snowmelt liquid water content, and into robustly differentiating between dry/wet/no snow and wet soil, as well as frozen/thawing soil. Melting can commence or stop on short time scales, tracking temperature changes. High temporal resolution (on the scale of a few days) is required to capture actual spatio-temporal variations and ensure coverage of short-duration events.

Some alternatives to retrievals from satellite SAR sensors were discussed in [7]. Alternative data sources are listed briefly in Table 1.

The focus in this document lies on wet snow detection for non-forested regions, esp. alpine snow. Wet snow in forested areas is a topic of on-going research. Support for the "general case" of wet snow retrieval in alpine terrain, allows use of the same products in flat regions. Continental scale wet snow detection over all land cover classes will require pilot projects.

Further literature references to potential SAR-based snowmelt products are invited.

Table 1 Alternative data sources

Data Source	**Advantages**	**Disadvantages**
In situ (e.g. Swiss IMIS snow stations [9])	Near-continuous temporal resolution possible	Prohibitive cost Numerous sensors: cross calibration Sparse networks
Visible/IR	Strong snow/no snow contrast Variety of temporal/spatial resolutions available	Poor reliability: dependence on daylight and cloud-free weather Poor "best case" temporal resolution
Scatterometer	Historical time series	Coarse resolution
Passive Microwave	Historical time series	Extremely coarse resolution (25-50km)

Table 2 List of relevant operating and future upcoming SAR missions

Sensor	**Band**	**Mission Duration**	**Space Agency**	**Left-looking capability**	**# Satellites**	**Comments**
Radarsat-2	C	2007-ongoing	CSA	Yes	1	Commercial mission: may affect sensor availability.
TSX/TDX	X	2007-ongoing	DLR	Yes	2	Commercial mission: may affect sensor availability.
Cosmo-Skymed	X	2007-ongoing	ASI	No	4	Commercial mission: may affect sensor availability.
RISAT-1	C	2012-ongoing	ISRO	Information not available	1	Access to science data unclear.
RISAT-2	X	2009-ongoing	ISRO	Information not available	1	Access to science data unclear.
HJ-1C	S	2012-ongoing	NDRCC/SEPA	Information not available	1	Access to science data unclear.
KOMPSAT-5	X	2013-ongoing	KARI	Information not available	1	Access to science data unclear.
ALOS2	L	2014-ongoing	JAXA	Yes	1	Commercial mission: may affect sensor availability.
Sentinel-1	C	2014-ongoing S1A launched 3.4.2014; S1B launch planned in 2016	ESA	No	2	Government mission – **science access possible**.
RCM	C	Launches 2018+	CSA	No	3	Government mission – science access possible.
PAZ	X	Launch 2015	INTA	Yes	1 (constellation with TSX/TDX)	Access to science data unclear.
SAOCOM	L	Launches 2015+	CONAE	Information not available	2	Access to science data unclear.
NISAR	L, S	Launch 2020+	NASA/ISRO	Information not available	1	Access to science data unclear.

2.2 SAR Missions

Inspired by [21], Table 2 lists the set of relevant operating and future upcoming SAR missions. A significant step forward in C-band SAR coverage was made with the launch of the first Sentinel-1 satellite (S1A) on April 3, 2014. According to the high level operations plan [5], land acquisitions (e.g. over Europe) will mainly be in the Interferometric wide swath (IW) mode, initially at VV or VV/VH polarisations, a configuration well suited to wet-snow mapping. A revisit interval in Europe of less than 6 days is foreseen, and less than 3 days after S1B is launched in 2015.

Global high resolution daily coverage is likely for some time to remain a challenge, as less data will be acquired in regions outside of Europe. Even so, an average global revisit interval of 10 days (with S1A), and 5 days (with S1A & S1B) is generally foreseen for land surfaces outside of Europe and Canada.

2.3 Wet snow services

Pointers to past and existing snow monitoring services are briefly listed in the following. The GlobSnow project (www.globsnow.info) offered a SWE product covering non-alpine regions of the northern hemisphere based on assimilation of passive microwave and climate station measurements. In addition, fractional snow extent products were provided based on ERS-2 ATSR-2 and Envisat AATSR, and Suomi NPP/VIIRS (1995-ongoing). The PolarView project (www.polarview.org) offered 10d pan-European snow maps based on ASAR, Radarsat-1, MODIS, and AVHRR, as well as specialised products in central Europe, and the Baltic and Scandinavian regions. The EUMETSAT H-SAF (hsaf.meteoam.it), while providing regional passive microwave SWE and optical snow cover fraction products, does not yet offer snow products based on SAR observations. The SNAPS project (www.snaps-project.eu) provided snow maps for Scandinavia based on combining MODIS and ASAR data and studied wet snow monitoring in the context of avalanche monitoring. The CryoLand project (cryoland.eu) provides regional fractional snow extent [16] based on a combination of MODIS and Radarsat-2 data. Detailed descriptions of each project are available at www.snowmonitoring.info.

3 Revisit Interval

For a given region on the Earth, a satellite SAR's revisit interval has both theoretical and practical limitations.

The following givens limit the *theoretical* maximum rate of revisit:

- Orbit track exact repeat interval
- Accessibility swath
- Swath width
- Stability of scattering regime
- Latitude (satellites in polar orbits can see regions at high latitude more often)
- Instrument duty cycle (power and thermal considerations limit maximum "on-time" per orbit)
- Topography (radar shadow and layover can obstruct observations from some orbital tracks)

In addition, the following *practical* considerations generally further decrease the achievable revisit rate:

- Region's priority to operator (partly governing allocated regional "on-time")
- Conflicts with other users desiring a different instrument mode (e.g. spotlight vs. ScanSAR)

All of the above considerations combine to determine the effective revisit interval for any given *point* on the Earth. Only the last items listed (operator priority and user-conflicts) describe degrees of freedom available to a satellite operator. All others are givens determined by the SAR system under consideration.

The following sections review each individually.

3.1 Orbital Track Exact Repeat Interval

The orbital track exact repeat interval describes the time interval between consecutive acquisitions of a region from the same track, e.g. using the same mode and beam. It is the "temporal baseline" relevant for repeat-pass InSAR. It is usually listed for a single satellite. When considering data acquisitions from constellations such as S1A/S1B or CSK1-CSK4, shortened intervals can theoretically be achieved and become relevant.

3.2 *Accessibility Swath*

The accessibility swath describes the swath that *can* be imaged using a given beam, and is usually denoted by listing the minimum and maximum nominal incident angles. Most imaging modes (e.g. stripmap) typically only image a small fraction of the accessibility swath. It is therefore relevant to the revisit interval of a *single point* on the Earth's surface, but not to the revisit interval that can be achieved when the goal is monitoring a process over a *large area* on the Earth's surface.

In contrast to the accessibility swath, which is not directly relevant to achieving a small revisit interval when monitoring large areas, the *swath width* impacts directly on the revisit interval that is possible for wide area monitoring applications.

3.3 *Swath Width*

The swath width is for any given mode the width of the ground track imaged on the ground (in km).

Wider swath modes are generally preferred when optimizing for a minimum revisit interval. However, systematic radiometric trends within and between swaths must be adequately compensated to allow meaningful multi-track backscatter comparisons.

The Sentinel-1 interferometric wide swath (IW) and extra-wide swath (EW) modes offer 250km and 400km swath widths respectively. The Radarsat-2 (RS2) ScanSAR modes SCNB and SCWA offer 300km and 500km swaths. Each of these S1 and RS2 modes is able to provide dual-polarisation backscatter observations, either VV/VH or HH/HV. The cross-polarisation backscatter appears even more sensitive to wetness than do the co-polarised channels. Research on inter-mixing S1/RS2 C-band wet-snow backscatter with observations based on X-band TSX/TDX/PAZ data will become increasingly relevant as experience is gained with the new 200km swath width mode "*SC Wide*" recently introduced by DLR and with Cosmo-Skymed ScanSAR data.

Table 3 Satellite SAR instruments and modes (swaths >100km, favoured modes in bold)

	Satellite Instrument	Exact Repeat Interval	Mode	Inc. Angle [°]	Swath Width [km]	Available Polarisations
C-band	ENVISAT ASAR	35d	IM: Image Mode AP: Alternating Polarisation **WS**: Wide Swath	15 – 45 15 – 45 17 – 44	56-100 56-100 400	Single: HH or VV Dual: HH/HV or VV/VH or HH/VV Single: HH or **VV**
	Sentinel-1: S1A & S1B	12d	SM: Strip-Map **IW**: Interferometric Wideswath EW: Extra Wideswath	18.3 – 46.7 29.2 – 46 18.2 – 47	up to 100 **250** 400	For all modes: Single-pol.: HH or VV or Dual-pol.: HH/HV or **VV/VH**
	Radarsat-2	24d	Wide or Wide-Fine SCNA: ScanSAR Narrow A **SCNB**: ScanSAR Narrow B SCWA: ScanSAR Wide A SCWB: ScanSAR Wide B	20 – 45 20 – 39 31 – 47 20 – 49 20 – 46	120-170 300 **300** 500 450	For all these modes: Single-pol.: HH or VV or HV or VH, or Dual-pol.: HH/HV or **VV/VH**
X-band	TerraSAR-X: TSX, TDX & PAZ	11d	ScanSAR (SC) Wide ScanSAR (**SC Wide**)	20 – 45 15.6 - 49	100 200-**270**	Single: HH or VV Single: HH or **VV** or (HV or **VH**) N.B. Cross-pol *experimental*
	Cosmo-Skymed: CSK1- CSK4	16d	ScanSAR Wide Region ScanSAR **Huge Region**	~20 - ~60 ~20 - ~60	100 **200**	For all modes: HH or **VV** or HV or **VH**

Table 3 lists C- and X-band instruments with data policies permitting scientific use of the data. Only modes with swath widths of 100km or higher are listed, as these are most relevant to dynamic snow monitoring aimed at covering large regions with high revisit rates.

Beam/mode and polarisation preferences for terrestrial snow observations are indicated in bold based on past experiences. Comments and experiences are invited from the SAR snow community.

Related to the swath width of each instrument mode is the *stability of the scattering regime* within the swath captured. Although wider swaths are better in that they enable shorter revisit intervals, extremely wide swaths can contain increasingly inhomogeneous scattering regimes, *particularly when very steep incident angles are included within the swath*. Narrower swaths also generally have less “noisy” backscatter (higher equivalent number of looks / ENL). For example, the Sentinel-1 EW mode offers a 400km swath and a slightly higher temporal resolution than the IW mode with its 250km swath. However, the scattering regime within an EW swath (18-47°) is less homogenous than is the case in an IW swath (29-46°), and a standard 90m EW-GRDM product will have an ENL of 13, while its IW-GRDM counterpart will boast an ENL of 106. In addition, use of IW mode generates fewer conflicts with InSAR users, resulting in a more homogenous acquisition pattern. These considerations balance out the slight loss in temporal resolution between EW and IW modes, making the current plans for VV and VV/VH Sentinel-1 IW acquisitions over European land an acceptable choice. Investigations are required to evaluate possible improvements in temporal resolution at peak melting periods were EW to be substituted for IW over short periods.

3.4 Latitude

As polar orbits cross at high latitudes, a given point on the Earth becomes visible to an increasing number of tracks as one moves toward the poles. This makes it possible to program much shorter revisit intervals at high latitudes if other issues (e.g. data rate) do not conflict.

3.5 Instrument Duty Cycle

Generally, SAR instruments are active for only a fraction of each orbit. Power availability, heat build-up, and data rate considerations constrain the amount of data that can be acquired every orbit. SAR modes with extremely low power requirements (e.g. ENVISAT ASAR Wave and Global Monitoring modes) could be made available continually without breaks, but that is not generally possible for most SAR modes on other missions.

3.6 Topography

For alpine regions with high topographic variability (important areas for snow applications) the effects of topography on the SAR radiometry need to be modelled and corrected.

Radar shadow and layover can obstruct observations from some orbital tracks when steep topography is present. Multi-track image acquisitions should be transformed into a common geometric and also radiometric reference frame [2][26] before backscatter comparisons are made. Such a transformation was demonstrated using Radarsat-2 ScanSAR data in [24]. Systematic combination of *ascending and descending* orbits yields optimal results. Ascending and descending composite backscatter products [28] are strongly recommended when monitoring mountainous regions, doubling the number of acquisitions required in comparison to flat regions.

3.7 Operator Priority

After consideration of all the parameters governing systematic revisit capability of a single or set of SAR sensors, the satellite operator is able (within the degrees of freedom available) to set priority to acquisitions over regions at times that are judged to be most fruitful.

This document makes recommendations to help optimise the use of available sensor resources. Feedback is requested from the snow community to help optimise the future sets of data that will be available from SAR satellites.

4 Polarisation

Coordination of the polarisation combinations used in observations from multiple satellites would enable unified parameter retrieval esp. when they share the same carrier frequency. For example, given a baseline set of Sentinel-1 IW VV/VH acquisitions, complementary Radarsat-2 SCNB datasets would best share the same polarisation combination. If co-temporal or interleaved SCNB backscatter values were instead acquired at HH/HV polarisations, interpretation of the multi-mission Sentinel-1/Radarsat-2 dataset would be made more complicated, with little benefit in exchange.

It is important that the snow community make a recommendation on preferred imaging modes to avoid introducing unnecessary polarimetric "noise" into wet snow extent estimates. We suggest using the dual pol. VV/VH standard embedded in the CoReH$_2$O mission proposal.

5 Wavelength

Dual-pol VV/VH backscatter values retrieved at shorter wavelengths, particularly X- and Ku-band have been studied recently in the context of the ESA Earth Explorer CoReH$_2$O mission candidate [22]. Studies using X-band data have indicated that dry snow can in some cases be identified (given snow depths greater than 50cm) [20]. L-band wet snow monitoring [25] was impaired in the case of "wide beam" WB products by the lack of annotation of slant/ground range polynomials in PALSAR ground range detected products, but may advance with data due to come soon from PALSAR-2.

6 Seasonal Observation Windows

All parts of the Earth of significant areal extent that are affected by snowmelt events are of potential interest here. In many places, snow melting is predominantly a seasonal phenomenon that takes place within a relatively narrow time window every year with regularity. By devoting more sensor resources to acquisitions within these highly dynamic periods, the evolution of the spatial distribution of the melting process can be captured.

At the same time, overly frequent observations of a static situation (e.g. in winter) can be avoided. The optimal time window will vary regionally. Acquisitions within a given region are of course desired *also outside of the specified time windows*, but a reduced sampling rate is acceptable. By setting seasonal boundaries, we can help to devote limited resources to the time periods with the greatest return on investment. Table 4 lists approximate start and stop dates for a few sample regions, noting relations to priorities and conflicts in specific missions. It is recognised that missions can and often do assign their own priorities to different regions of interest. Ice sheets and ice caps are not considered here; they are treated in [23]. Contributions with references for further regions are invited.

Table 4 Regional observation windows

Region	Window Start Date	Window End Date	Work published based on historical time series	Missions where region a priority	Missions with conflict potential
European Alps	Feb. 15	May 15	ERS [19], ASAR WS [10][29], CSK [20], RSAT2 [27]	ERS, ASAR, S1, CSK, TSX	ASAR: IM vs. WS; CSK/TSX/RSAT: mode choice
Canadian Rockies	April 1	July 15			
Finland	April 1	June 30	ERS [8], ASAR WS, RSAT-1 SCW [11]	ASAR, S1	
Norway	April 1	July 31	ASAR WS RS2 SCNA	ASAR, S1	
…					

7 Summary and Key General Recommendations

Arguments for coordinated acquisitions across space agencies would be helpful in further optimizing the use of available sensors. We present tentative results here, and request further evidence-based suggestions on "highest priority" acquisition start and finish dates by region in order to recommend high priority regional acquisition periods as well as recommendations for specific satellites.

Key general recommendations from the snow community for all satellite SAR platforms are listed in Table 5.

Table 5 Key general recommendations

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

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- … **Open to contributions!** …
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9 Appendix A: Recommendations for specific SAR missions

… (further recommendations can come out of community feedback) …

9.1 Sentinel-1

Recommendations for the Sentinel-1 mission, comprised of the S1A and S1B satellites, are collected in Table 6.

Table 6 Recommendations for Sentinel-1

S1-R1	Emphasise use of Interferometric Wide swath (IW) or Extra Wide Swath (EW) modes over land.
S1-R2	Build combined **ascending/descending** coverage by default into acquisition plans covering mountainous regions.
S1-R3	Concentrate snowmelt acquisitions on the **seasonal window** when the majority of snow melting occurs (Feb. 15 through May 30 at temperate northern latitudes). The *highest temporal resolution possible* is requested during this critical melting period. Although some further acquisitions are also requested *outside* of this seasonal window, lower temporal resolution at these less critical times is acceptable.
S1-R4	Standardise dual-pol. mode acquisitions on **VV/VH** combination.
S1-R5	**Harmonise** acquisition plans of satellites with RSAT2 and RCM. For example, emphasise coordinated acquisitions using compatible S1-IW and RSAT2-SCNB modes.
S1-R6	Assure full coverage over land also in **coastal** regions when other modes are by default programmed over ocean (i.e. favour Sentinel-1 IW or EW over WV).

9.2 Radarsat-2 and Radarsat Constellation Mission

Recommendations for the Radarsat-2 and Radarsat Constellation Mission (RCM) are collected in Table 7.

Table 7 Recommendations for Radarsat-2 and Radarsat Constellation Mission

CSA-R1	Emphasise use of ScanSAR modes (SCN and SCW) over land.
CSA-R2	Build combined **ascending/descending** coverage by default into acquisition plans covering mountainous regions.
CSA-R3	Concentrate snowmelt acquisitions on the **seasonal window** when the majority of snow melting occurs (Feb. 15 through May 30 at temperate northern latitudes). The *highest temporal resolution possible* is requested during this critical melting period. Although some further acquisitions are also requested *outside* of this seasonal window, lower temporal resolution at these less critical times is acceptable.
CSA-R4	Standardise dual-pol. mode acquisitions on **VV/VH** combination.
CSA-R5	**Harmonise** acquisition plans of satellites with S1A and S1B. For example, emphasise coordinated acquisitions using compatible RSAT2-SCNB and S1-IW modes.
CSA-R6	Assure full coverage over land also in **coastal** regions when other modes are by default programmed over ocean (i.e. favour SCN/SCW VV/VH over modes optimised for ocean).

9.3 TerraSAR-X Constellation

Recommendations for the TerraSAR-X constellation of satellites (TSX, TDX, PAZ) are collected in Table 8.

Table 8 Recommendations for TerraSAR-X Constellation

TSX-R1	Emphasise use of ScanSAR modes (SC Wide) over land.
TSX-R2	Build combined **ascending/descending** coverage by default into acquisition plans covering mountainous regions.
TSX-R3	Concentrate snowmelt acquisitions on the **seasonal window** when the majority of snow melting occurs (Feb. 15 through May 30 at temperate northern latitudes). The *highest temporal resolution possible* is requested during this critical melting period. Although some further acquisitions are also requested *outside* of this seasonal window, lower temporal resolution at these less critical times is acceptable.
TSX-R4	Standardise ScanSAR acquisitions on **VV**, with VH over some test sites for further study.
TSX-R5	**Harmonise** acquisition plans of all satellites in constellation (e.g. SC Wide left and right-looking for TanDEM pair if possible); fill gaps and increase temporal resolution with PAZ. Explore cooperation with Cosmo-Skymed constellation for creation of co-temporal mosaics covering large regions.
TSX-R6	Assure full coverage over land also in **coastal** regions when other modes are by default programmed over ocean.

9.4 Cosmo-Skymed Constellation

Recommendations for the Cosmo-Skymed satellite constellation are collected in Table 9.

Table 9 Recommendations for Cosmo-Skymed Constellation

CSK-R1	Emphasise use of ScanSAR modes (Huge Region) over land.
CSK-R2	Build combined **ascending/descending** coverage by default into acquisition plans covering mountainous regions.
CSK-R3	Concentrate snowmelt acquisitions on the **seasonal window** when the majority of snow melting occurs (Feb. 15 through May 30 at temperate northern latitudes). The *highest temporal resolution possible* is requested during this critical melting period. Although some further acquisitions are also requested *outside* of this seasonal window, lower temporal resolution at these less critical times is acceptable.
CSK-R4	Standardise ScanSAR acquisitions on **VV,** with VH over some test sites for further study.
CSK-R5	**Harmonise** acquisition plans of all satellites in constellation (e.g. plan co-temporal Huge Region ascending/descending pairs) and explore cooperation with TSX constellation for creation of co-temporal mosaics covering large regions.
CSK-R6	Assure full coverage over land also in **coastal** regions when other modes are by default programmed over ocean.

10 Appendix B: Contributing Authors and Affiliations

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