RADARSAT-1 Stereo Advisor on CCRS Web

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ABSTRACT

The selection of a stereo pair from RADARSAT-1 is a challenging process for most of the users because RADARSAT-1 is offering various beams and modes (look angles and spatial resolutions). The Canada Centre for Remote Sensing web-based Stereo Advisor helps the users to make his/her final decision based on recommendations of stereo images, explanations and comments depending of the applications and the study site.

1 Introduction

The launch of Canada's first earth observation satellite, RADARSAT-1, with the various operating modes of SAR and its specific geometric characteristic enabled true stereoscopic images and various stereo configurations to be generated from its wide range of look angles (from 10º to 60º). There is no unique choice of RADARSAT-1 image pairs that is perfect for stereo applications. For a specific study site different users could select different modes and beams because the stereo images are not only used for DEM generation but also for their radiometric and thematic content. The choice depends then on several factors such as the application domain, the type of relief and the required accuracy. Since the image pair selection is not an easy process for the user the RADARSAT-1 Stereo Advisor has been designed to guide the users in making this selection, considering their specific needs and constraints. It has been built in an user friendly environment on the Canada Centre for Remote Sensing web.

The RADARSAT-1 Stereo Advisor is intended for anyone interested in Earth sciences (hydrology, geology, forestry, agriculture, cartography, etc.) and/or in the three-dimensional representation of the land surface. Anyone who wants to create a digital elevation model from RADARSAT images, either to represent the land topography or to geometrically correct images for the extraction of thematic information, can benefit from using this advisor. It will assist the users, in an interactive way, in making the best choice of a RADARSAT image pair for creation of stereo pairs. However, it is not intended for people interested in selecting only one image. According to the type of thematic information the user wants to extract, the characteristics of the study site and the user-specified requirements or constraints related to image acquisition, the RADARSAT-1 Stereo Advisor makes one or two recommendations.

2 What is the Stereo Advisor?

The Stereo Advisor is web-based tool used to help in the selection of stereo RADARSAT images. The users have to input information related to the application and the study site (Figure 1). This advisor will then:
- define the user's needs and constraints in the matter of stereoscopy
- evaluate geometric and radiometric parameters involved and related to the sensor, to the observed terrain, to the application domain and to the user's focus of interest (type of information that the user wants to extract)
- suggest one or two stereo pair(s) most appropriate to the situation.

The suggested stereo configuration will be accompanied by explanations, comments and recommendations that will help the user understand the reasons why these stereo pairs are suggested. However the user will have to make the final choice according to his/her own criteria.

This advisor has the advantage of providing one or two solution(s) that are adapted to each situation and each user scenario. Then the user has to run the Stereo Advisor for each application. Therefore, different stereoscopic configurations could be suggested for the same study site as a function of the user-specified requirements. In the case where the user has already acquired one RADARSAT-1 image, the advisor will recommend a second image to complete the stereo pair.

Educators are invited to make use of this module to provide an interactive didactic tool to their students for studying the topic of radar imagery for stereo applications. The context-specific comments provided here with each stereo image pair recommendation will be found to be particularly useful for explaining the rationale of RADARSAT-1 beam mode selection. In addition, the "Further Study" section links this tool to other related and useful resources on the CCRS Web site, and to suggested bibliographic references.

Figure 1 – Input form to be completed by the user

While this advisor makes recommendations for selecting RADARSAT-1 images by specifying beam modes, if a user wishes to actually purchase imagery, the ordering mechanism is found at the Web site of RADARSAT International Inc. (www.rsi.ca).

3   How to use the Advisor?

Table 1 presents a list of specific criteria (application, sub-application, and focus of interest) with which the tool will produce a recommendation for stereo pairs. Some criteria were not selected because they do not require stereoscopic information, such as oceanography.

Table 1 – List of User's Applications

APPLICATION	SUB-APPLICATION	FOCUS OF INTEREST
GEOLOGY	Morphology and Structures	Detailed Geology
		Regional Geology
		Enhance micro-relief
		Enhance coastlines or boundaries
	Lithology	Regional Lithology
		Enhance micro-relief
		Enhance surface roughness and textures
HYDROLOGY	Drainage Network	Small Scale Drainage Features
		General Drainage Features
		Enhance Coastlines or Cover Boundaries
	Snow Cover	Monitoring, timely coverage
		Snow Cover Information (or soil underneath)
		Enhance Surface Roughness and Textures
	Floods and Wetlands	Monitoring, timely coverage
		Flooded areas or wetlands delineation
		Wetland classification or vegetation structure
	Soil Moisture, Run-off and Erosion	Soil roughness
		Soil moisture or micro-relief
GLACIOLOGY	Glacier : snow/ice cover and Snowline	Monitoring, timely coverage
		Snow/ice cover information, snowline
		Enhance surface roughness and textures
AGRICULTURE	Crop Information	Small or fragmented fields
		Precision agriculture
		Crop monitoring
		Crop type discrimination
		Enhance coastlines or boundaries
	Soil information : Drainage, erosion, tillage	Enhance soil roughness or crop residus
		Small or fragmented fields
		Precision agriculture
		Monitoring, timely coverage
		Soil moisture or micro-relief
FORESTRY	Forest Cover	Small or fragmented forest covers
		Forest trails and roads
		Covers/clearcuts discrimination, forest disturbance
		Wetlands, flooded forests, mangroves
		Enhance boundaries between covers
LAND USE/ COVER	N/A	Small or fragmented zones
		Monitoring, timely coverage
		Covers discrimination, change detection
		Enhance boundaries between covers
TOPOGRAPHIC CARTOGRAPHY	Mapping at scale 1/50000	N/A
	Mapping at scale 1/250000	N/A
DEM ONLY	N/A	N/A
		N/A

A practical example of the use of the advisor is presented in figures 2 and 3. In figure 2 (input form), the user has to follow three steps. First, he/she has to specify the application:

- application domain in A, such as *Geology*
- sub-application in B, such as *Morphology & Structure*
- focus of interest or specific information to be enhanced in the images in C, such as *Enhance Micro-relief*.
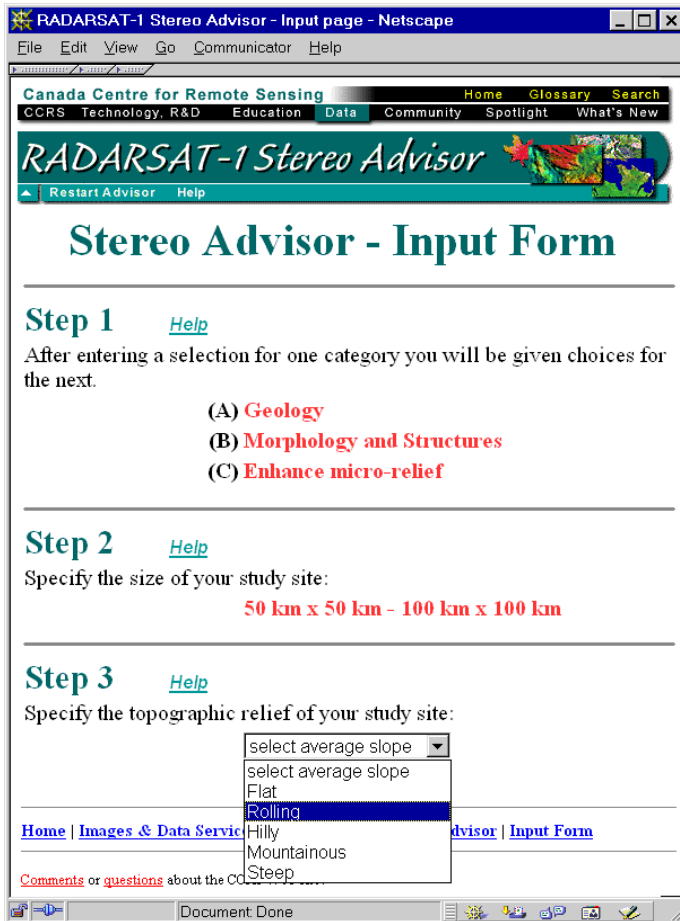
Figure 2 – Practical example of the use of the Advisor (Input form)

Then, in the second and third steps, the user is asked to specify the characteristics of his or her study site: size of the site in square kilometres and type of relief, respectively. For each drop-down list (steps 1,2 & 3), only one choice is possible. If more than one choice corresponds to the user's situation (example: micro-relief and coastline; morphology and structures and lithology), the user should choose the one that has priority. The user will always be able to enter the information for another scenario by re-starting The Advisor. Note that ScanSAR and Extended modes of RADARSAT are not offered as suggested image pairs. Some other factors are not considered in the stereo pair recommendations, such as:

➢ Image costs and other financial aspects;
➢ Processing time and processing system capabilities;
➢ Acquisition date difference between the two images;
➢ Overlap percentage between the two images; and
➢ Choice of look direction (ascending or descending).

4 What are the results?

Figure 3 presents the results of the Stereo Advisor with the user's inputs shown in Figure 2. These inputs are summarised at the top of the output form. The "Primary Recommendation" for a stereo pair is the best appropriate solution, but it is not the only solution. The "Secondary Recommendation" stereoscopic configuration is also suggested to give a certain amount of flexibility in the choice of images. Thus, in the case that one or the other "Primary Recommendation" images is not available (e.g. at the desired date, etc.), or in the case that the two images do not overlay properly, the user would be able to choose from another optimal pair. In addition, some geometric parameters (vertical parallax ratio, intersection and mean look angles) are given and explained with drawings.

The trade-off that has been made between geometric and radiometric parameters to determine these optimal stereo configurations is also emphasized. The Comments and Cautions buttons that accompany the proposed recommendations help the user to better understand the process and implications of the available choices according to the principles and limitations of stereoscopy and the specific application at hand.

The Comments button (Figure 3) gives the comments related to the advisor's recommendations (they are presented in three sections):

1. Stereoscopy:
   - This size of area suggests the use of Standard Mode. This mode is favoured as long as it satisfies the needs of the desired thematic information.

   - For rolling terrain, we recommend to maximize the VPR without using an intersection angle that may be too large. The geometric aspect of the stereo pair is important, but the relief-induced radiometric disparities associated with large intersection angles can have an effect on the accuracy of the DEM.

   - For certain areas of the site where slopes are steep, foreshortening or layover can affect the images. To reduce these effects, the recommended images have radar look angles larger than the maximum slopes.

   - The second recommendation (Wide mode) gives almost the same stereo configuration, but a larger coverage of the area.

2. Application:
   - When the terrain is relatively flat, a small look angle (20° to 30° i.e.: S1, S2, W1) is recommended to enhance, depending on the situation, the following phenomena:
     - micro-relief (small topographical variations);
     - soil or snow information (soil moisture/frost, snow water content, etc.);
     - flooded areas or wetlands delineation.

     However, the enhancement of this type of information can be affected by the presence of vegetation.

Figure 3 – Results from the Stereo Advisor with the input shown in figure 2

3. Equivalent pairs
   - The beam modes of the two recommended images (first stereo pair) can vary by +/- 1 mode as long as a difference of at least 4 beam modes is kept and as long as the recommendations for the look angle is followed. It is however better to keep a small look angle so that the VPR value will be relatively high.
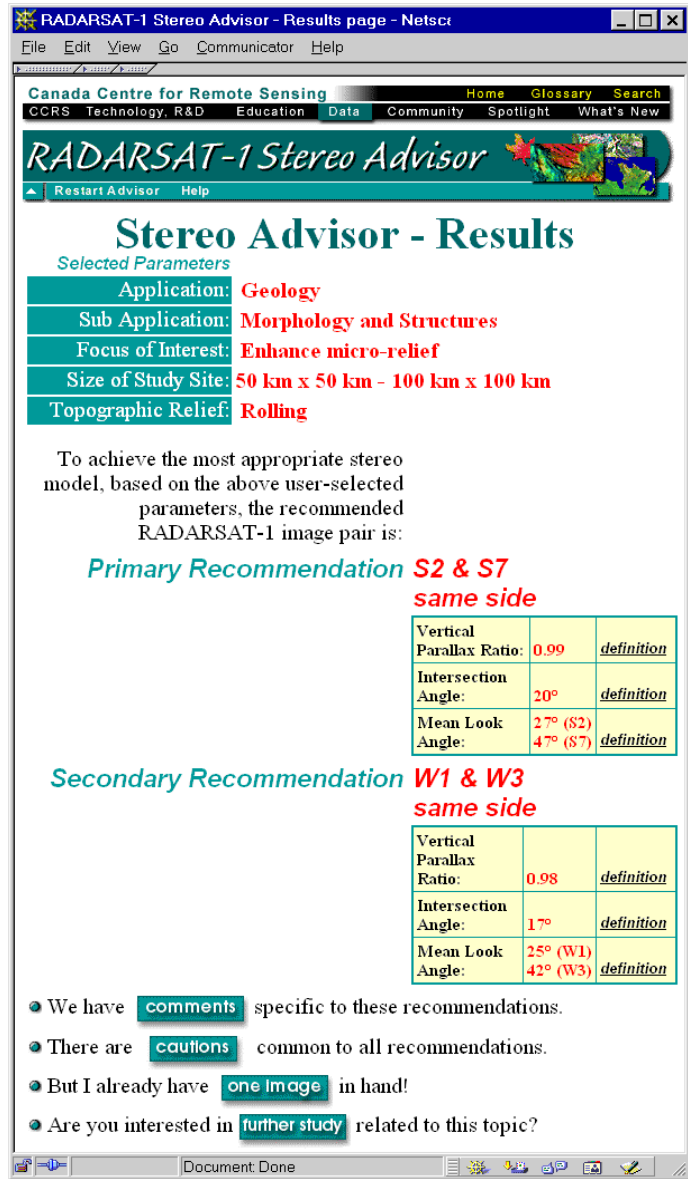
- The second recommended pair is unique since no other Wide mode image pair gives a better geometric stereo configuration (high enough VPR).

Cautions also accompany all the recommendations.

- VPR should not be the only parameter to consider in your final choice of beam modes. Other geometric (look angles and direction, overlap, etc.) and radiometric (backscatter, differences between the images, etc.) parameters should be considered depending on the user's requirements.

- The look direction (westward for descending orbit and eastward for ascending orbit) is not considered in the "Recommendations".

- The acquisition dates of the two images are not considered in the "Recommendations". It could be a key point in the final choice of beam modes. Example: close acquisition dates facilitate image matching during automatic DEM generation.

- The overlap percentage between the two images is not considered in the "Recommendations".

- The variation of +/- one beam mode for the recommended image(s) enables the users to address the previous two points.

- Image costs are only considered to reduce the number of stereo image pairs to one, when possible.

- Other data costs and financial aspects, such as those related to processing system capabilities any time, etc. are not considered.

The One Image button is useful when a RADARSAT-1 image has already been acquired over the study site. The advisor can thus handle this case. It will recommend a second image to complete the stereo pair. Sometimes two Recommendations are given. Other Comments are given to explain the selection of this second image.

The Further Study button enables the user to obtain information on the terminology and the bibliographic references used to design the data base, that are closely related to this topic. It also gives a direct link to two CCRS Tutorials related to radar and/or stereoscopy, and to the general CCRS Bibliographic Database.

Based on these Recommendations, explanations, comments, cautions and access to further study, the user should have all the pertinent information to make the final choice. The user must also integrate some of the factors (date, overlap, look direction, processing, etc.) not considered in the Stereo Advisor.

5   Conclusion

The selection of an appropriate stereo pair is not unique since most of the times the RADARSAT stereo images are generally not only used for DEM generation. The projected application requirements of the DEM and the thematic use of the images are thus elements to consider by the user in the selection process. Sometimes, the users do not have all relevant information to make an appropriate choice. The RADARSAT-1 Stereo Advisor has then been built to help the users make this selection. From general information related to the user's application and study site, the Stereo Advisor recommends one or two stereo images. If the user already has an image the Stereo Advisor recommends the second image to the stereo pair. All image selections are accompanied with explanations, comments, cautions, etc., which enable the user to make the final choice.

Acknowledgements

References

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