The CCRS Quicklook Swath Browser

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BIOGRAPHICAL SUMMARY

Michael Adair has a M.Sc. in physics from the University of Ottawa (1987) and a B.Sc. (Hon.) in physics from the University of Western Ontario (1984). He has been working at the Canada Centre for Remote Sensing since 1987 and is currently working in the User Systems Development Section of the Data Acquisition Division. This section is responsible for remote sensing systems development directed at the user. His current area of endeavour is in user-interface development for web based mapping.

ABSTRACT

This paper presents the argument that there is an existing remote sensing data source that is being under-utilized in the form of quicklook browse data. This represents a large, on-line low-cost data source that could be used for scientific and non-scientific applications. A new user interface has been developed to query the browse imagery archive at CCRS that presents the imagery as a full swath containing all data collected in a satellite acquisition segment. Given easy access to this data, it can then be geocoded and combined to create continental or planetary scale mosaics and time-series.

INTRODUCTION

There exists a huge, and continuously growing, archive of low-resolution remote sensing image data that is readily accessible over the internet in the form of quicklook data from a variety of sensors. Quicklook data, also known as browse data, is produced primarily as a quality control tool for receiving station operators and as a catalogue image for users of the full resolution imagery products. It is currently viewed as a by-product of the image acquisition process with little intrinsic value. This paper presents the argument that quicklook data are potentially useful as inputs to scientific and non-scientific real-world applications.

The advantages that quicklook data can offer are low cost, rapid processing turnaround, near real-time accessibility, large quantities of archived data on-line and low data volumes. The images are generally produced and recorded to disk during the acquisition process using real-time subsampling of the satellite downlink datastream. This means that the imagery can be viewed in real-time on a monitor at the receiving station as the data is transmitted to the earth. The data is available to be viewed remotely as soon as they can be transferred to a central database, although in practice a manual quality control or cloud cover assessment must be carried out beforehand.

In scientific applications, the main disadvantages of using browse imagery are the low-resolution and the radiometric distortions due to compression of the imagery. For the purposes of this work, low-resolution is defined as 250m and up. Low-resolution will always limit the information content of the data to studying large scale features, since the information content is tied to the pixel resolution. It is possible for current and future quicklook processors to generate medium-resolution browse imagery that may alleviate this problem to some degree, however full-resolution imagery will always be required for studying features on the earth at a large-scale.

This does not mean that real information cannot be derived from low-resolution imagery. As an example, the Canada Centre for Remote Sensing (CCRS) currently operates the Geocomp-n system which produces vegetation indices, various radiation corrected products and forest fire masks for global change research, all of which use 1km NOAA AVHRR data as input to measure continental scale forest health and carbon budgets. Similar systems are used in the NASA Pathfinder project for global change research on a planetary scale. Radarsat quicklook data should be useful for studying large-scale geological structures, in the same way that Magellan data of Venus was invaluable for studying the geology of Venus (Solomon, 1992). The imagery is useful in these cases only once it has been geocoded and assembled into a large area mosaic so that it may be tied to a particular location on the planet.

For some applications, loss of radiometric fidelity through lossy JPEG compression and radiometric enhancements may be acceptable. This includes the so-called “pretty picture” market, where an image is required for a poster, backdrop, base image layer in a GIS, etc. Again, it is possible for current and future quicklook processors to address scientific requirements by generating uncompressed imagery at the cost of handling larger data volumes. In fact, such imagery is generally already produced in generating the browse images. It is this imagery which gets compressed and is only then transferred to the central database in order to minimize its impact on network bandwidth. It is anticipated that such imagery will be available in the future, perhaps through a privileged access mechanism or through e-commerce.

Another barrier to using quicklook data in real-world applications is the effort required to assemble enough data to make a useable product. Currently, browse data is framed into roughly square pieces (~500x500 pixels), which makes using the imagery in this way cumbersome since each image covers a relatively small area on the ground. This practice is a relic of the early days of remote sensing when imagery was produced as a square sheet film product. Later with the introduction of computer technology, this practice was continued to limit data volumes. With even further advances in computer and network technology, it is now possible to generate and warehouse quicklook image products that have real value in themselves.

An emerging trend on the Internet is web mapping, where users can create customized maps from various data layers. There are numerous web servers offering geo-referenced data and a number of web mapping companies have been recently created (MapQuest, Delorme, Vicinity, MapBlast, etc.) which offer free or for-fee mapping services. In order to bring some standardization to geographic data on the web and to make the various data sources interoperable, the Open GIS Consortium (OGC) was created in 1994 (http://www.opengis.org/) and is comprised of many of the major players in the web mapping business. Its mandate is to develop advanced open systems standards and techniques in the area of geoprocessing and related information technologies. Once fully implemented a user would be able to select any combination of layers, both vector and raster, from any number of physically disparate map servers and combine the results to produce a map tailored to the user's particular requirements. This represents an important step forward in realizing the "Digital Earth" concept advanced by Al Gore (Gore, 1998).

Browse has the potential for providing imagery layers in this scenario where it has the distinct advantage of low data volume given the current wide area network infrastructure where a large proportion of Internet users are using modem technology for access.

The target audience for this project is primarily the general public, however it is expected that scientific users, the education community and value-added service providers will also benefit from improved access to this data. This market is distinct from the full-resolution imagery market and is potentially very large, and possibly uneducated in the field of remote sensing.

BROWSE IMAGERY DATA SOURCES

CCRS operates two satellite recieveing stations: one in Prince Albert, Saskatchewan and the other in Cantley, Quebec. Quicklook imagery for all satellite data it receives has been produced since as early as 1983. Initially, the images were stored on microfilm and then in NTSC format on analog videodisk, and in digital format only since 1991 (Barkman, 1992). This represents a total data volume of digital products of 16 Gbytes, all accessible online. The breakdown of this data by satellite is given in Table 1 below.

Table 1 - CCRS browse statistics

Satellite	Quicklook imagery Start date	Volume (Gbytes) As of 31/1/2000
NOAA AVHRR (7 through 15)	July 1983	1.9
Landsat 5	March 1991	3.9
Spot 1,2,3,4	April 1991	7.9
Radarsat	April 1997	2.4
Landsat 7	April 2000	-

Radarsat quicklook is produced by a system called Fastscan installed at both Canadian receiving stations (Lam, 1995). The image data and catalogue metadata are transferred to the CEOCat archive immediately following the acquisition. At this point a manual quality control process must be carried out to identify scenes where the Doppler centroid estimator did not function properly on the real-time datastream resulting in images with a "scalloped" appearance as demonstrated in Figure 1. This does not indicate a problem with the signal data itself, but is an artefact of the real-time processing system. It is possible to re-process the data to eliminate the artefacts, however this is not done on a routine basis due to the costs involved.

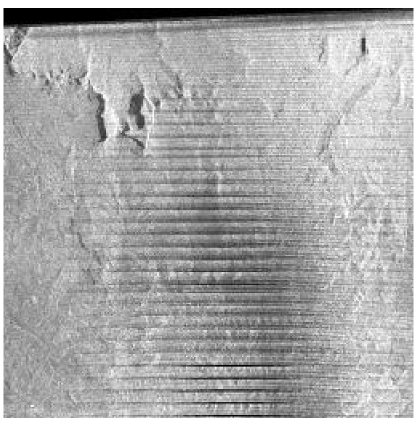

Figure 1 - Example of Fastscan "scalloping"

Spot quicklook is produced by the Spot Quicklook Image System (SQUIS) system at both stations. Immediately following the acquisition, the images are assessed for cloud cover and then transferred to the CEOCat archive. Landsat 5 quicklook were produced up until October 1999, and similar to Spot quicklook, they are assessed for cloud cover before being transferred to CEOCat. Both Spot and Landsat 5 browse have an earth rotation correction applied to them that must be removed before being assembled into a swath.

Landsat 7 acquisitions have replaced the Landsat 5 program and quicklook will be produced at CCRS receiving stations immediately following the overpass using a system currently under development and scheduled to be deployed in April, 2000.

NOAA AVHRR quicklook data is produced on the NATAS system (Leung, 1993) installed at Prince Albert Satellite station in real-time for data received at PASS. A receiving station in Halifax provides coverage of Canada's East Coast and ships the raw downlink data electronically to PASS for processing by NATAS.

A search of the Internet for similar resources offering low cost imagery is summarized in Table 2 below. This list does not intend to claim to include all sources of earth imagery data available on the web, however it is representative of what is available.

Table 2 - Internet browse imagery resources

Title	URL
CEOCat on CEONet	http://ceonet.ccrs.nrcan.gc.ca/ Spot, Landsat, NOAA-AVHRR, Radarsat Browse imagery; scene-based, as well as search of other datasets and metadata.
CRISP - Singapore	http://www.crisp.nus.edu.sg/crisp.html Quicklook browse data received in Singapore (Spot, ERS, Radarsat) scene-based although Radarsat data stored in swaths.
Landsat 7 Homepage	http://landsat.gsfc.nasa.gov/ Landsat browse imagery as well as ordering of full resolution products; scene based image galleries.
NASA SIR-C Survey Images	http://edcwww.cr.usgs.gov/landdaac/sir-c/survey.html SAR imagery from the Space Shuttle taken in 1994. Browse and full-resolution imagery available; scene-based.
SeaWIFS Browse	http://seawifs.gsfc.nasa.gov/cgibrs/seawifs_browse.pl SeaWIFS imagery and composites. Swath-based presentation. Lots of good links to other global change datasets through the SeaWIFS project homepage.
Geocover	http://www.geocover.com/ Orthorectified Landsat TM scenes and mosaics from around the world. Not free ~$250/scene.
EDUSPOT	http://pc5.geo.ulg.ac.be/EduSpot/ Spot data and browse; limited number of scenes from around the world and a mosaic of Belgium.
Antarctica project	http://svs.gsfc.nasa.gov/imagewall/antarctica.html Mosaic of Antarctica from Radarsat data.
GIS Data Depot	http://www.gisdatadepot.com/ GIS layers from the Digital Chart of the World and other sources.
Portugal Mosaic	http://ortos.cnig.pt/ortofotos/indexp2.html Full resolution mosaic of Portugal from Landsat 5.
Mars global Surveyor	http://mars.jpl.nasa.gov/mgs/index.html Lots of imagery and mosaics of Mars from various Mars missions.
Venus Magellan image data	http://www-pdsimage.jpl.nasa.gov/PDS/public/magellan/midrcd_query.html Radar mosaic of Venus from the Magellan mission.
Planetary Photojournal	http://photojournal.jpl.nasa.gov/ Selected imagery of all planets (including the Earth) from various NASA missions.
Download Planet Earth	http://www.geocities.com/TimesSquare/1658/earth.html Links to earth imagery resources on the web including DCW, DEMs, mosaics of various countries.

QUICKLOOK SWATH BROWSER

An alternate user interface to the CEOCat database has been developed as a result of this project and can be found at the following URL:

http://ceocat.ccrs.nrcan.gc.ca/quicklook

This is a highly interactive, easy-to-use web interface for querying, selecting and downloading data from the CCRS browse imagery archive. It is supported under both Netscape 4 and MS Internet Explorer 4. Users must have JavaScript enabled in their browser.

Key to this interface, is presenting the imagery to the user as a full swath that better represents the image acquisition process and provides large contiguous imagery datasets. Displaying the imagery as a full swath also gives the user better geographic context and it goes a long way to solve the problem of assembling large numbers of browse images to create a usable product.

An overview map is provided for locating the imagery on the earth. The user can zoom-in and out, select swaths and define the region of interest on this image with mouse clicks. The search interface allows searches based on geographic region of interest, dates, and various sensor parameters, such as satellite, imaging mode orbit number and cloud cover. Once the user executes the search, an outline of the resulting swaths are displayed on the overview map. The default search parameters are set such that if the user executes a search without modifying or entering any extra information, the resulting swaths will be the most recent acquisitions added to the database.

Also provided by the interface is a predefined collection of swaths in the "In the News" section. This list contains imagery from places around the world making recent headlines. Some examples of newsworthy events would be hurricanes, floods, earthquakes, wars, etc.

The user can set various options such as the number of swath windows to be displayed at any one time, the maximum number of swaths to be returned for each sensor, a selection of overlays and so on.

The interface will eventually also allow for the gathering of auxiliary data inputs which cover the user's area of interest and user-selected swaths such as DCW vector data, DEM data from GTOPO30, ephemeris, metadata, etc. This will allow for further processing of the imagery by the user on his desktop.

The interface relies on JavaScript for user interaction with the web page and for creating instances of various objects. As a result of this project, a reusable JavaScript GeoImage object has been. This object gives access to geo-referencing information for geocoded images in JavaScript. It also allows for image overlays so that geocoded vector images may be overlaid on top of a base image layer. It is anticipated that the GeoImage object will conform to the specification of the OGC for exchange and display of geographic images. Also, the swath itself is defined as a JavaScript object, although it's reusability is limited since it is defined for the requirements of this application.

The sensors supported are Spot, Landsat, Radarsat and NOAA/AVHRR. Spot, Landsat and NOAA data is available over North America. Radarsat data is available from around the world since Radarsat has an on-board tape recorder which gives it the ability to capture imagery at any time in its orbit and later downlink the signal once it is over a receiving station. Figures 2 through 5 show sample swaths from the four satellites supported.

NEXT STEPS

Given easy access to quicklook imagery, the usability of the data can be improved through geocoding. This would allow for vector overlays to be generated and viewed on top of the swath itself as well as allowing for the swath to be resampled to a user specified map projection. The data volumes involved are moderate and manageable with current technology and given the low volume of data, processing time is minimal. Geocoding of the imagery can be accomplished either manually, using ground control points, or systematically without operator intervention using on-board ephemeris or a historical database of ephemeris. At this point, the geographic accuracy that can be achieved using systematic ephemeris is unknown and is an area for further research.

The next phase of this project is to develop an efficient orbit modelling and resampling engine to serve up geocoded browse imagery where the imagery may be resampled on-the-fly, or extracted from pre-computed large area mosaics.

A whole range of potential applications is then possible where large number of swaths could be assembled into mosaics or time series. Some applications where geocoded browse data might be useful are large scale (continental/planetary) mosaicking, disaster response, cross-sensor integration, etc. Non-scientific applications include the so-called "pretty picture" market where imagery is required for presentations, newscasts, posters, etc. As an example, a mosaic of Kosovo using Radarsat browse was created and is shown in Figure 6.

CONCLUSION

A new tool to access an existing remote sensing data source has been presented. It is hoped that wide range of users will now have convenient access to remote sensing imagery that they might not have had otherwise. The value of the imagery can be improved further through geocoding and mosaicking of the data.

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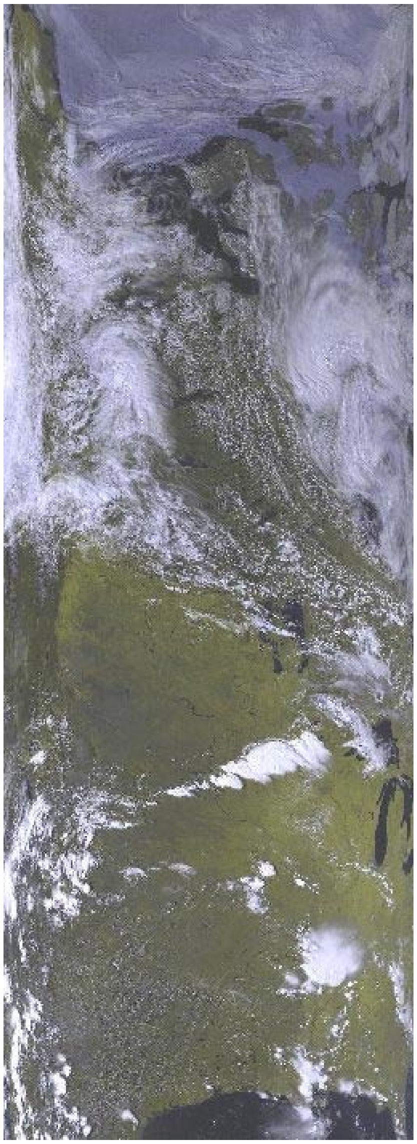

Figure 2 - sample NOAA AVHRR swath; central North America; original swath size 512 pixels by 1400 lines © CCRS/CCT 1999

Figure 3 - Sample Landsat 7 swath; Montreal-Ottawa-Kingston; original swath size 825 pixels by 2100 lines

Figure 4 - sample SPOT swath (with earth rotation correction applied); original swath size 350 pixels by 1600 lines.

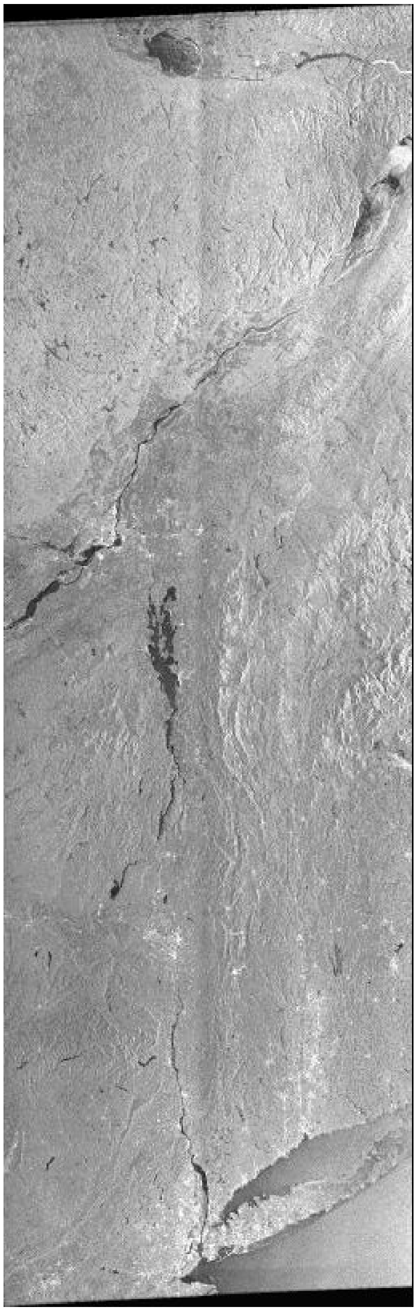

Figure 5 - sample Radarsat SCANSAR swath; New York city-Montreal; original swath size 256 pixels by 814 lines

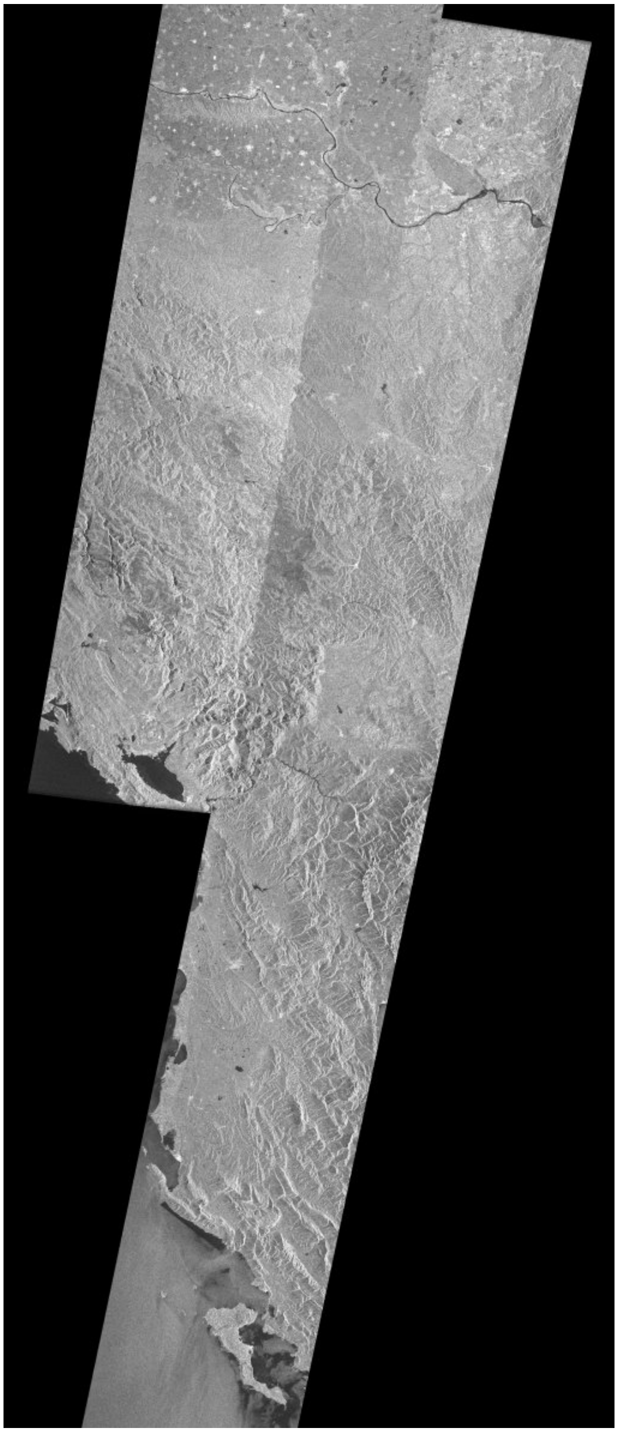

Figure 6 - sample mosaic image from Radarsat (Kosovo); comprised of 2 Wide beam swaths plus 2 fine beam swaths.