Amazon Rainforest Visualization/Classif ication by Orbiting Radar, Enabled by Supercomputers (ARVORES)

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ABSTRACT

This paper describes the work being performed under the auspices of the HPCC/ESS Grand Challenge Applications and Enabling Scaleable Computing Testbed applied to advancing computing technology to SAR interferometry and imaging science. The ARVORES project is a specific science task whose purpose is to develop SAR resources based on multi-seasonal coverage of the Amazon rainforest (using the JERS- 1 satellite) and to explore this resource using available state of the art computing technology. It is the goal of this project to use the science requirements related to the study of the Amazon region to guide the development of a flexible, large-scale computing environment.

INTRODLJCTION

The objective of the ARVORES project is to fold together two resources for the development and analysis of radar data over the Amazon region. The first of these is a basin-wide, dual season set of JERS- 1 (L-barrel HH) imagery collected during the months of Scptcn}bcr/October 1995 (low flood) and May/June 1996 (high flood) under the JAMMS project [Freeman et al., 1996]. The entire data set consists of 3000 1 -Mbyte low-resolution (100 m) images and 3000 64-Mbyte high-resolution (12.5 m) images. Initial, single-sccnc, analysis of the Rio Solimões near Manaus has indicated that the single band, single polarization data taken over two seasons provides enough information to discriminate between six classes, equivalent to a SIR-C analysis [Hess et al., 1995]. These preliminary results highlight the utility of this dual season resource, however the volume of data makes it difficult to fully explore its usefulness. For this reason, our approach is to develop our SAR tools in a computing environment that does not restrict the level of science analysis being performed, rather the science analysis will be used to draw upon the available resources to define which of these can be best used in achieving our scientific goals (Fig. 1). This is the opposite of the more common situation where our ability to process and analyze radar data is limited by the available computing resources. The results of this project will provide two benefits: i) they will provide valuable information related to the study of rainforest ecology and ii) will provide insight about which computational resources are the most important to efficiently process and analyze radar data to achieve science related ends.

COMPUTING RESOURCES

The computing resources at our disposal arc considerable. They consist of a 256 node Cray T3E, a 2m x 2m (2400x3200 pixel) SGI visualization power wall, 500 Gbytes of hard disk storage, 5 Tbytes of tape backup, and a high performance communications network (500 Mbytes/see). The sheer size and volume of these resources is sufficient to envision the accomplishment of even the most data/processing hungry tasks associated with SAR analysis.

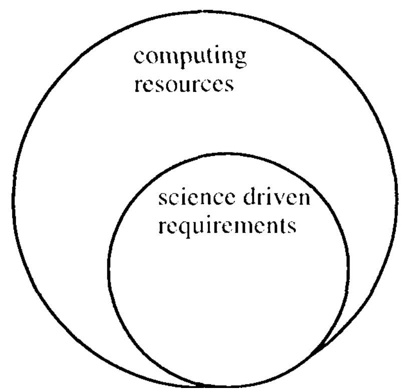

Figure 1: Conceptual diagram illustrating the superset of computing resources that the science driven requirements will be allowed to explore. 'l'he fact that the computer resources will be a superset of those required by the science demands will help determine which of those resources are most valuable in achieving our goals.

INTERMEDIATE STEPS

In the process of creating a resource of the two-season JERS-1 Amazon data, a number of tools have been created to facilitate future science analysis. These arc i) implementation of a high performance SAR processor on the computing network, ii) implementation of an automated method for correcting the scale, rotation and geo-location of individual processed scenes and iii) provide a method of smoothly mosaicking multiple scenes together to provide a seamless radar image product. The second of these steps, geocoding, has proved to be the most useful and value added, Using a suite of routines developed at JP1. [Shaffer and Hensley, 1996], common areas between adjacent scenes/cJrbits arc used to simultaneously solve for scale, rotation and offsets of a single-season's worth of radar imagery. By determining these transformation matrices simultaneously, an optimization algorithm may bc employed to minimize the correction applied to each scene. This process can bc contrasted against the more common "wall papering" method of fixing a scene in place (as if' to a wall) before adding further scenes. The wallpaper method has the undesired effect of propagating errors as the distance to the initially placed scene increases.

SCIENCE GOALS AND PRODUCTS

The driving force behind this project is to achieve high value added science products and to explore the JAMMS data set in new ways. For our mid- to long-term goals, we are in the process of developing our science goals to cover three critical areas i) land-cover classification, ii) quantitative analysis of river lengths and flooding extents and iii) forward modeling of the radar signal with specific targets of interest. Of these three goals, the first two have already provided useful results.

<u>Landcover Classification</u>

The availability of an addition season of radar data increases the dimension of the data analysis that can bc performed on the JERS- 1 data in much the same way as another polarization might. Collection of L-band HH imagery during the peak of the low and high flood seasons maximizes our ability to map inundation regions and to investigate other time-varying phenomena, Using a maximum likelihood supervised classification, wc were able to discriminate between six classes (Fig. 2). These results arc very comparable to those achieved using LHH, LHV and CHH polarizations of the SIR-C instrument [Hess et al., 1995]. The addition of a second season had the effect of improving the classification accuracy from 65% for any single season to 92% for the combined data set. A "confusion" matrix describing the classifier's accuracy for any particular class of landcover is given in Table 1.

<u>Metrics of River Length and Flooded Regions</u>

Once a method has been developed for mosaicking the satellite imagery and discriminating between landcover types, the next step is to quantify the data into a meaningful set of numbers. A simple summation of the flooded forest region will provide an estimate of the extent of the forest that goes through annual landcover change or a thinning algorithm can bc used to mark the path of tbc river and determine its length (Fig. 3). Critical to both of these applications is to have an accurate geocoding for each processed scene so as to remove the effects of scene overlap and warping due to projection.

Figure 2: Classified region of the Amazon including both the Rio Negro (south) and the Rio Solimões. This image is the result of a maximum likelihood classification using the dual season, L-HH JERS-1 data. Class results arc i) open water (black), ii) sandbar (dark gray), iii) flooded forest (white) iv) unflooded forest (med. gray), v) flooded shrubs (not shown) and vi) unflooded fields (light gray).

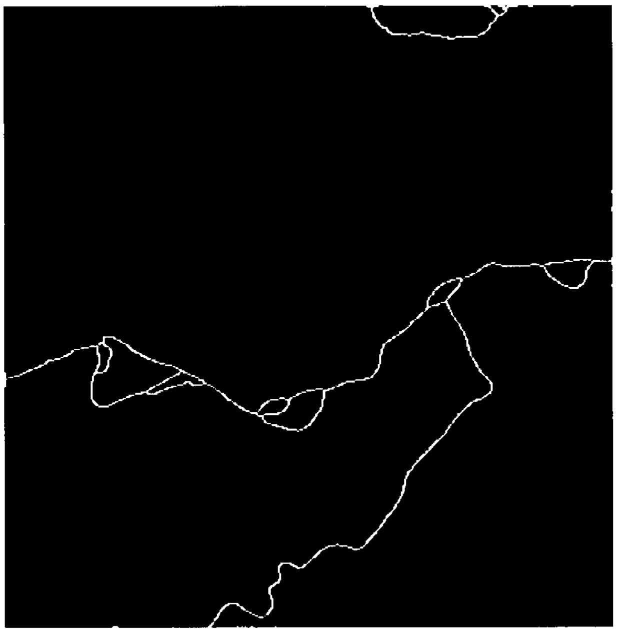

Figure 3: Single-pixel wide river contours derived from a classified image (not shown) using a thinning algorithm to determine the mean path of the river. This particular mosaicked image can bc used for historical analysis of the changing nature of the river, to measure the river length and to monitor landcover change.

CONCLUSION

This paper reviews the work being performed to integrate krrge-scale computing resources with radar science applied to the Amazon rainforest. The front to end approach for developing this resource has been instrumental in integrating a number of important processing tools as well as providing valuable science data products. The most important application of this integrated system however will be to the entire Amazon region. By working on a region wide scale we will able to develop tools for studying the ecology of the area as well as to provide a historical record of landcover change.

REFERENCES

[1] Hess, L., Melack, J., Filoso, S., and Wang, Y., Delineation of Inundated Area and Vegetation Along the Amazon Floodplain with SIR-C Synthetic Aperture Radar, IEEE Trans. Geosci. Rem. Seas., Vol. 33, No 4, pp 896-904.

[2] Freeman, A., Chapman, B., and Alves, M., The JERS-1 Amazon Multi-Season Mapping Study (JAMMS), Proc. of 1996 Intnl. Geosci. Rem. Sens., pp830-833, Lincoln, Nebraska 1996.

[3] Shaffer, S. and Hensley, S, personal communication regarding the "Multimosaic" algorithm suite, 1996.

ACKNOWLEDGMENTS

The research described in this paper was carried out by the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.

Class	Water	Forest	Flooded Forest	Flooded Shrubs	Fields	Sandbar
Water	0.99	0.00	0.00	0.00	0.01	0.00
Forest	0.00	0.93	0.07	0.00	0.00	0.00
Flooded Forest	0.00	0.04	0.96	0.00	0.00	0.00
Flooded Shrubs	0.00	0.18	0.16	0.66	0.00	0.00
Fields	0.02	0.03	().04	().00	0.86	0.05
Sandbar	0.03	0.00	0.00	0.00	0.19	0,78

Table 1: Confusion matrix describing the accuracy of the supervised maximum likelihood classifier applied to the dual-season JERS- 1 data.