A Virtual Laboratory

NASA Astrobiology Institute
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Interdisciplinary work required by our current Astrobiology research conveys the necessity of sharing facilities that are available to some scientists but are completely inaccessible to others.

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We propose to create a virtual laboratory (VL) by combining unique facilities in the Americas. Such VL must:

- Satisfy the restrictions set by Export Control and other Federal and state regulations.
- Not infringe patents, trademarks or copyrights. Promote good technology and datasets.
- Reduce the down-time cost of facilities.

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A light-microscopy workstation is available at NASA ARC. A light microscope fitted with a high resolution CCD camera sends a split video signal to both, a high-resolution monitor and a PC. The first half produces a live image that facilitates analysis, and is printed at publication-quality. A frame grabber captures the second half and the image is analyzed with special software (measurements, density profile and the like).

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A unique instrument that brings satellite technology to microscopy is available at NASA ARC. The High Resolution Imaging Microspectrophotometer (HIRIM) developed by KAIROS, Inc. from Santa Clara, CA. consists of a xenon lamp connected to a monochromator that delivers light in tunable bandwidths to a microscope. A CCD camera collects the image and sends it to a dedicated PC with exclusive software. Spectral signatures at the ecosystem level down to small stands or individual trees can be traced to the cellular scale.

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We can link our remote sensing analysis computer to the Ecosystem Computer Facility, a world-class remote sensing analysis facility at NASA ARC.

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Other instruments are available, such as this spectroradiometer.

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The forthcoming TIMS (Tri-Spectroscopic Imaging Sensor) developed for NASA by MEDECO, Inc. from Saint Louis, Missouri. This instrument (with spatial resolution down to .25µm, and spectral resolution down to less than 1nm) will bring spectral signatures down to the "group-of-molecules" scale. In pollen grains, for example, the macromolecules within the pollen wall and immediately under it are used to "prove" kinship to the female part of the flower before fecundation is allowed. These molecules are directly linked to the genetic code of the species.

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Also forthcoming is a tunable instrument to separate single fibers of DNA coupled with a facility to mark them. I cannot disclose any further details of this instrument but I just wanted to mention it to show how far down in the molecular scale we can go.

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Given legal limitations, firewalls and other necessities posed by the current computational environment I suggest that the virtual laboratory should operate via servers placed outside the firewalls. The servers that will collect orders and data, screen them for virus and worm contamination, stop hackers, and then safely send orders and data through the firewalls to the selected instruments.

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Our Current Research

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- The Rapid Rates of Change project selected South America as an analog of a cooling and drying biosphere.

- New research has been developed in related areas and an international team has been formed.

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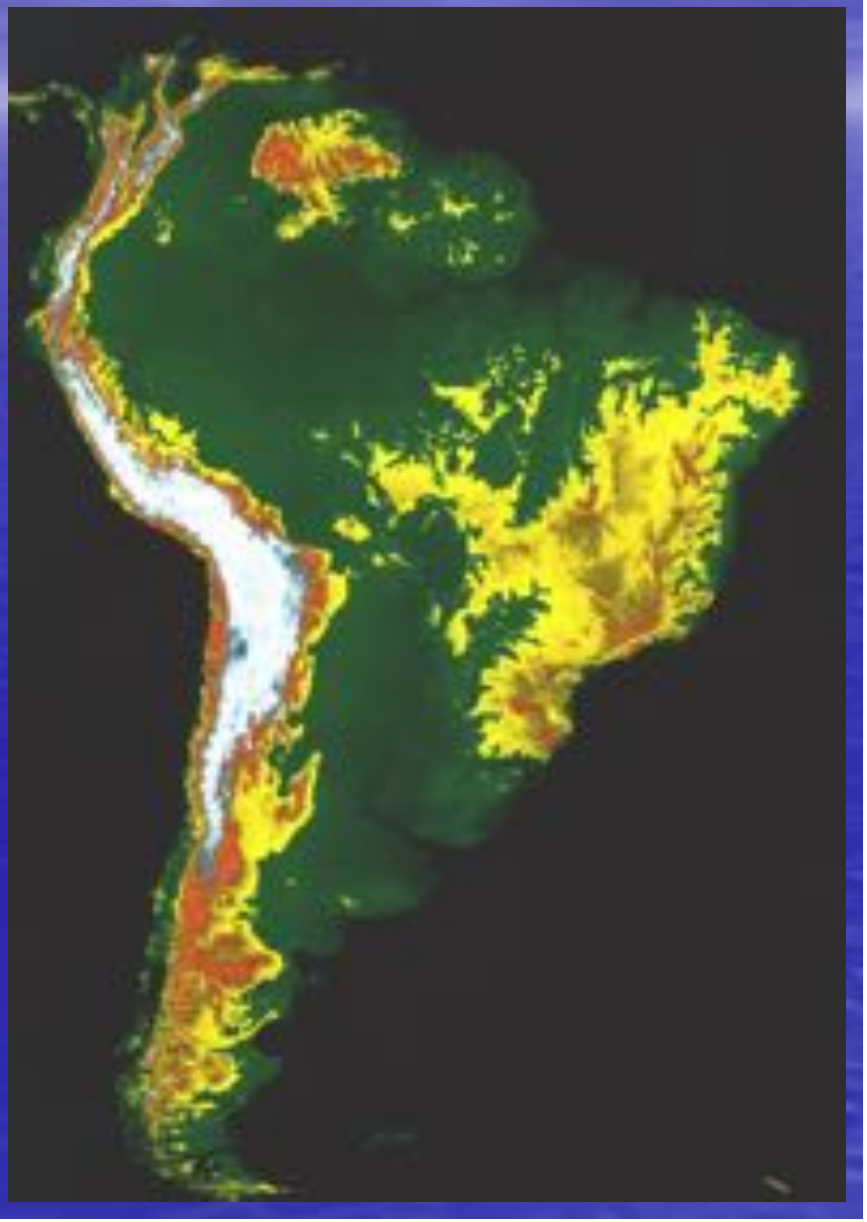
- Goal: To compare long- and short-term environmental changes and evaluate their effect on the spectral signature of vegetation.
- Research: Explore monthly Vegetation Indices at 30 research sites in South America over a 12-year period (1982-1993).
- Result: Sharp changes found in vegetation indices from ENSO to non-ENSO years.



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By contrasting long- and short-term environmental changes we showed that the latter affect the remotely sensed spectral signature of vegetation.

This enabled the retrogressive study of biogeochemical cycles that in turn will result in more precise prediction of change.

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Current Scientific Relationships of the Rapid Rates of Change Project

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NASA ARC Plant Science Lab is related with:

- The Marine Lab of University of Puerto Rico. They study the effects of increased solar UV-B on marine plant ecosystems with the same approach we use on terrestrial plant ecosystems.

- The Biochemistry Lab of the Ponce School of Medicine. They study UV-B effects on human DNA, eye and muscle tissues and we plan to share with them our new cellular/molecular facilities.

Health Effect of Environmental Levels of UV Radiation in Puerto Rico

Figure 1: Control human skin fibroblasts (CRL-2072) non-exposed to UVA/UVB Treatment visualized by immuno-fluorescence technique (100X). Photos by M.Morales, G. Chompré, Laboratory of Dr. J. Matta, Ponce School of Medicine, Ponce, P.R. Supported by NASA (NAG-21149).

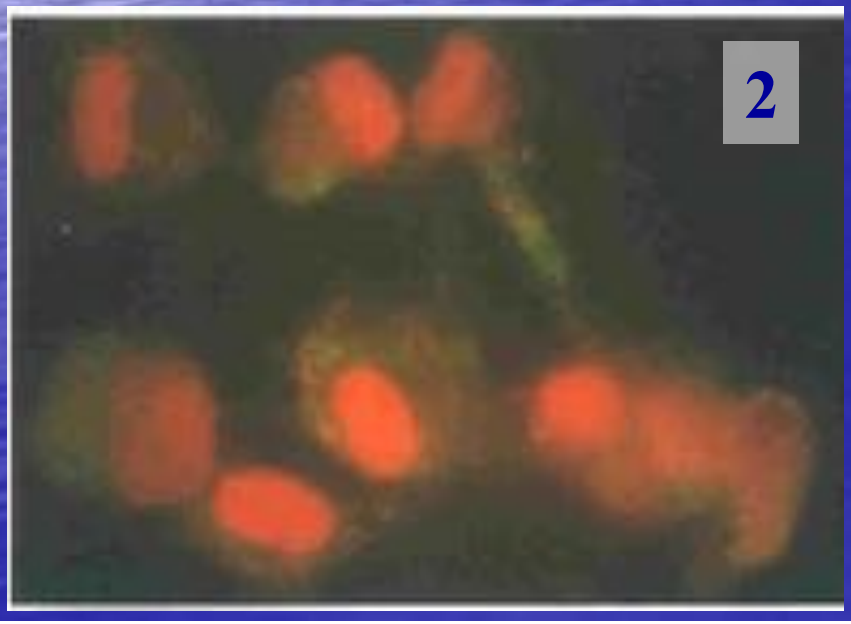

Figure 2: Irradiated human skin fibroblasts (CRL-2072) exposed to UVA/UVB treatment, 0.73J/cm^2 equivalent to 6 minutes of environmental UV levels in La Parguera, Lajas, P.R. UV data provided by Dr. R. Armstrong. This short-term exposure to environmental UV caused nearly 100% necrosis in all skin cells.

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- The Ethnographic Museum (Buenos Aires). Their research challenges the concept of cultural tradition in archeology and search for a systemic vision of the past that is compatible with our past climate and ecology reconstruction.

- The Polytechnical School (Guayaquil). Their eco-archeological research of Albarradas is combined with our study of the Carbon cycle and the human effect on it.

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"Alabarradas" Project Director,
Dr. Jorge Marcos.
Chirije Archeological Site, Ecuador.

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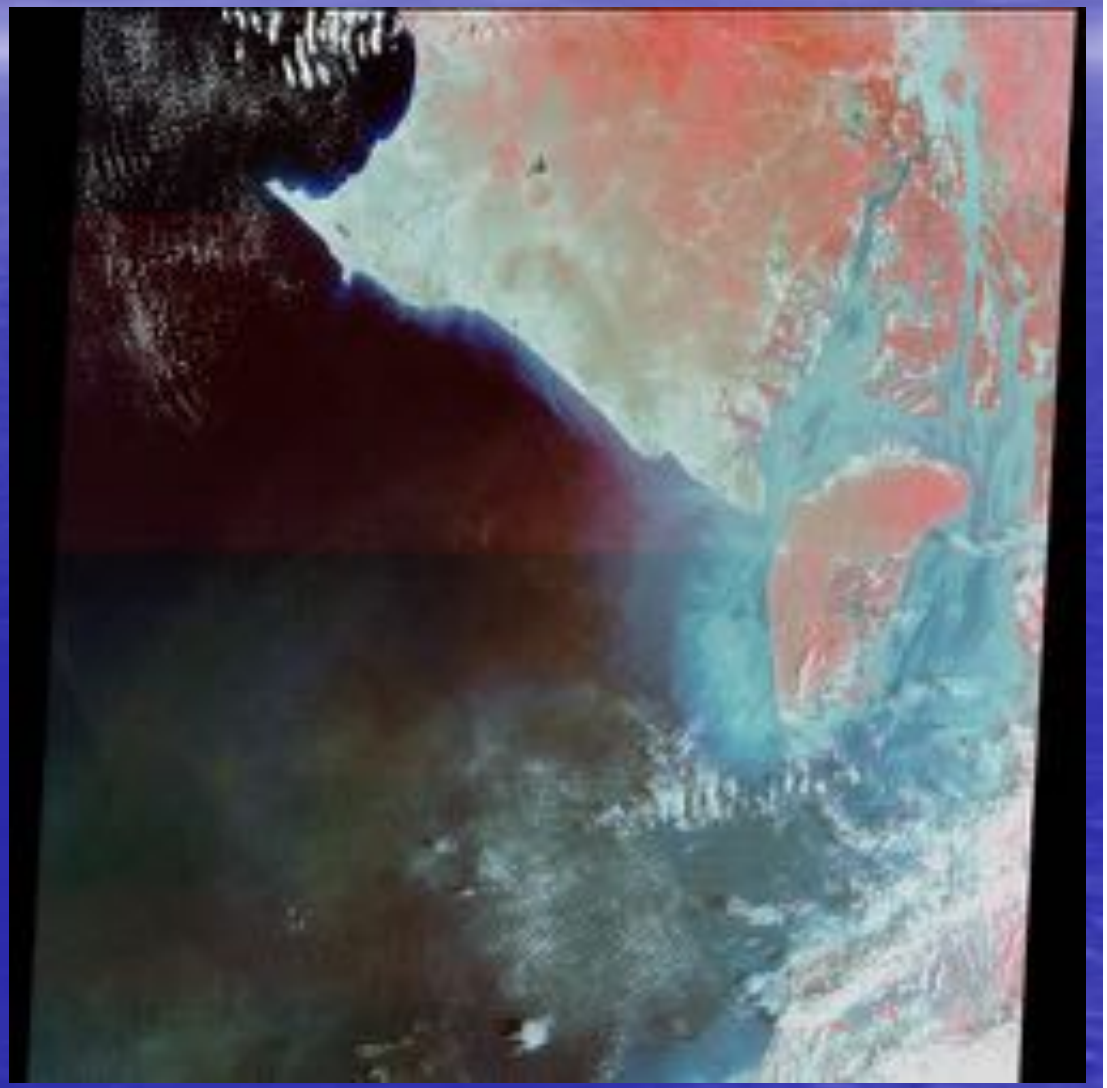
- Goal: To study change in time-scales that are relevant to human society.
- Research: Contrast spectral signatures in Ecuadorian Dry Forest locations with and without "albarradas".
- Status: AVHRR, Landsat and Radar data analyzed



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Historic “Albarrada”

Modern “Albarrada”

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- The INPA (National Institute for Research of Amazonia, Manaus). Their palynology research shares goals with our Astrobiology program.
- The IBAMA (Brazilian Institute for the Environment, Brasilia). Their modern environmental research coincides with our remote sensing research on Amazonia.
- The University of Mar del Plata (Argentina). A group of scientists is implementing our connection of remote sensing of vegetation and modern pollen dispersal.

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PAST CLIMATES OF AMAZONIA

Dr. Maria Lucia Absy,
Manaus, Brazil

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David Peterson with Brazilian ecologist Genebaldo Freire (IBAMA) in the natural reserve of Brasilia.

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ASTROBIOLOGY WORKSHOP
IN ARGENTINA

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- The Alihuen Association, Santa Rosa, Argentina shares with us their wetland research on the Atuel River.
- The School of Science, University of Buenos Aires, Argentina participates of our modeling research on past environments.
- The INIDEP (National Institute for R & D of Fisheries, Argentina) are developing a joint research project of the Rio de la Plata watershed.

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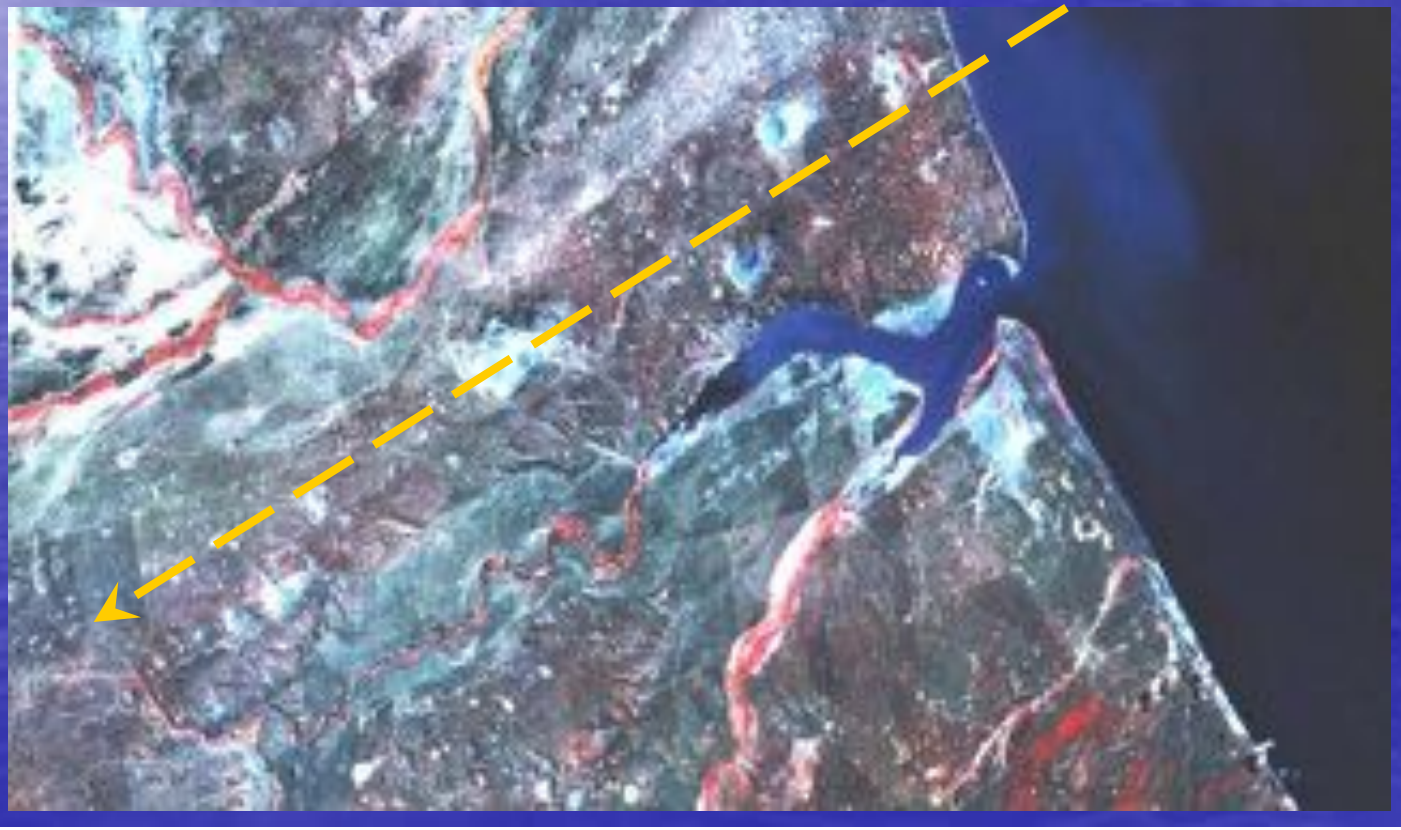
- San Jose State University (USA), University of Patagonia, and the National Center of Patagonia (Argentina) participate in our research project on impact craters.



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Concluding Remarks

- The relations I discussed earlier would be greatly enhanced by linking all participating labs via Internet 2.
- Interdisciplinary research will be possible on relatively small budgets and enhanced by unlimited access to facilities.
- Requested work will be performed by specialists at the participant laboratories.
- Collaboration, teamwork, and group discussion will be greatly enhanced by the proposed VL.
- We recommend that NSF and other agencies sponsor efforts to create and maintain VLs throughout the Americas.