Submission Information

SMOS Project

ID: 4664
Password: 52chefs

Title: **SMOS observations of La Plata Basin: analysis of products and their contribution to surface hydrology in Argentina**

Type: First SMOS Data Announcement of Opportunity
Class: Peer Review
Cost: Free of Charge
Primary Application Domain: Hydrology
Secondary Application Domain: Renewable Resources
Study Area: South America

Executive Summary: This proposal is aimed at exploiting SMOS Level2-SM and L1C data in a large South American Basin, named De La Plata. In particular, the plans are:

- To test he capability of SMOS Level2-SM data for improving the predictions made by atmospheric and hydrological models;
- To use radiometric data for monitoring vegetation variables in a large forest, characterized by a variety of climatic conditions;
- To improve prediction and monitoring of flooding events by L band radiometry.

The De La Plata Basin covers about 3.6 million km2. In terms of geographical extent, it is the fifth largest basin in the world. The principal sub-basins are those of the Paraná, Paraguay and Uruguay Rivers. > The annual mean total precipitation in the De La Plata Basin is about 1,100mm, of which only about 20% reaches the sea as surface water. The other 80% is evaporated and infiltrated into the ground. Consequently, any small change in the evaporation and infiltration rate may lead to greater changes in the runoff.

The variability in soil moisture, soil cover and soil use can have important impacts on the water cycle. For all these reasons, any improvement in the estimate of soil moisture leads to important benefits. The lower part of the basin is mostly covered by agricultural fields, and low vegetation, while the upper part is covered by the deciduous ChacoForest.

The main objective of the proposal is to improve the prediction of hydrological and atmospheric variables using SMOS L2-land data collected in the lower area (approximately 55W-65W, 28S-35S). For this area, the work will be subdivided into two phases. In the first phase, lasting one year, two test plots will be selected. Level2-SM, Level1C and ALOS-PALSAR data will be used to test the Level2 Soil Moisture Algorithm in the climatic conditions of the site. In particular, Level2-SM data will be compared with a-priori SM estimates obtained by the hydrologic VIC model,

which was already applied to De La Plata basin. Moreover, it will be checked that the multi-temporal series of optical depth shows a trend which does not contradict with the one expected by a knowledge of vegetation evolution. Level1C and ALOS-PALSAR data will be used to interpret the comparison results. One observation per month will be sufficient in this phase.

In the second phase, lasting two years, the Level2-SM data will be assimilated into the atmospheric ETA model, and the hydrological VIC model, which are used for weather forecasts and predictions of hydrological variables. The improvements achieved in the precision of the predictions will be estimated. The full 3-day SMOS time series will be used for this second phase.

In the Chaco forest (60W-65W, 22S-28S), three plots will be selected, belonging to areas with different climatic properties: humid, semiarid, arid. For the first year, we shall test the general performance of SMOS L2-SM algorithm over specific plots. In the two following years, we shall try to estimate forest variables, such as woody biomass and understory herbaceous biomass. To this aim, we shall use SMC information made available by Level2-SM data, Level1C data, higher frequency emissivity (from AMSR-E instrument), ALOS-PALSAR signatures and the forest emission model developed at Tor Vergata University. One sample per month will be sufficient for the Chaco forest work.

The capability of L band passive signatures in estimating the increase in water level in wetlands will be tested using also the microwave vegetation model available to us.

For the Tor Vergata University team, the manpower will be supported by public research funding (Italian Ministry of Research). For Argentine institutions, manpower and field work will be supported by the state institutions involved and by local research projects that have specific funds allocated for microwave remote sensing research.

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Team Composition, Experience, Innovation and Contribution

Team:
The overall team is integrated by very active researchers in the field of meteorology, hydrology, ecology, forests, computer science, physics and engineering. We have experts in different fields and the leading teams (IAFE and Tor Vergata) have been working for more than ten years in microwave remote sensing, and electromagnetic modelling. Some of the researchers belong to academic environments and they integrate national and international projects, and others, to government institutions involved in operational activities such as producing risk flooding maps, deforestation maps and others.

Researchers and staff
Haydee Karszenbaum (physicist, remote sensing specialist, director of IAFE?s remote sensing group)
Paolo Ferrazzoli (electromagnetic modelling expert, responsible for analysis and interpretation of L1C data, and forest emission model)
Leila Guerriero (emission models)
Julio Jacobo (Computer, image processing)
Patricia Kandus (Ecology, field work and architectural vegetation models)
Ines Camilloni (Meteorologist, hydrologic modelling)
Moira Doyle (Meteorologist, atmospheric modelling)
Dora Gonizadski (Physicist, director of SIAH, responsible for producing hazard maps and prediction maps of hydrological variables)
Alvaro Sodano(Engineering, staff of SIAH, responsible of the GIS system)
Celina Montenegro (Engineering in Agronomy, responsible of producing rates of deforestation of native Chaco forest)
Gabriela Parmuchi (Biologist, remotes sensing and GIS expert)

Graduate students
Francisco Grings (IAFE, Physics, PhD subject in electromagnetic models)
Mercedes Salvia (IAFE, Biologist, PhD subject in wetlands ecology)
Pablo Perna (IAFE, Computer, PhD subject in interferometry)

Experience:

Paolo Ferrazzoli, His research is focused on microwave remote sensing of vegetated terrains, with emphasis on electromagnetic modelling. Within the SMOS program, he contributed to the ESA Soil Moisture Prototype Processor Development study, where he was responsible for the forward model of forests.
Leila Guerriero. Since 1994, she is a permanent researcher at Tor Vergata where her activities are modelling microwave backscattering and emissivity from agricultural and forested areas.
Haydee Karszenbaum Since 1983 she works in remote sensing and from 1997 on she is dedicated to microwave remote sensing. She is the director of the IAFE?s remote sensing group. She is currently PI of national projects and of ESA ENVISAT ASAR AO projects and of a future Radarsat 2 AO project. She is also coordinator of a technology transfer project related to quality analysis of the future Argentine SAOCOM SAR mission products.
Julio Jacobo, Since 1996 he is working on statistical models for Synthetic Aperture Radar data and on image processing, and computer vision.
Patricia Kandus Since 1985 she belongs to the Laboratory of Regional Ecology where at present her research is focused on remote sensing of wetland vegetation structure and dynamics.
Inés Camilloni, professor of the Department of Atmospheric and Oceanic Sciences, UBA. Her research area is climate variability and change over southern South America.
Moira Doyle Her research area is climate variability over southern South America.
Celina Montenegro She is technical coordinator of the Native Forest Division.
María Gabriela Parmuchi Since 2001, she is staff of the Native Forest Division where she is working in mapping native forests.
INA team (www.ina.gov.ar) (http://www.ina.gov.ar/alerta/index.htm)
Dora Goniadzki, she is currently director of the Center ?Sistemas de Información y Alerta Hidrológico? (SIAH) of the National Water Institute (INA). Alvaro Soldano, responsible of the Remote Sensing and GIS area of SIAH.

Innovation: The innovative character of the proposal is being addressed by:

1. The geographical area: a major river basin with extensive and important native forest, very productive agricultural areas, wetlands, and important human settlements and infrastructure developments. Projects addressing climate change in the area are right now in progress. Also, several projects addressing smaller areas within the basin are currently in progress related to radar remote sensing in wetlands. The use of L band radiometry for all these objectives is innovative.

2. The actual proposal: combines subjects related to important remote sensing themes such as interactions, modeling, exploitation of SMOS products, image processing and applications subjects such as the inclusion of soil moisture information in prediction meteorological and hydrological models, the use of soil moisture information in agriculture and the expertise in native forests products.

3. This project has very challenging characteristics because of the data (new data for the area) and the multiple application domains.

4. For forests, until now L band radiometry was tested only over small plots, by means of ground based or airborne experiments. In this proposal, L band radiometry is applied over an extended forest region, characterized by an interesting variability of climatic conditions, and for which significant ground information is available.

Contribution: The main objective of this proposal is fully in agreement with the general objectives indicated in Section 2.2.1.1 of AO Main Text. Our purpose is just to assimilate L2 SMC data in atmospheric and hydrological models, in order to evaluate the improvements achieved in whether forecasting, streamflow prediction, etc.

Secondary objectives are: re-use L1C data to estimate forest variables and test the potential of L band radiometry in predicting and monitoring strong flooding events in wetlands.

Forest applications agree with general objectives indicated in Sections 2.2.1.4 and 2.2.2.4.

Also flood monitoring is considered a fundamental objective of the SMOS mission (see Section 2.2.1.1, third item).

Detailed Description and Schedule

1. Introduction

The La Plata Basin covers about 3.6 million km2 and in terms of geographical extent, it is the fifth largest basin in the world. The principal sub-basins are those of the Paraná, Paraguay and Uruguay Rivers. A complete understanding of the La Plata Basin hydrology requires knowledge of the different components of the water cycle. The annual mean total precipitation in the La Plata Basin is about 1,100mm, of which only about 20% reaches the sea as surface water. The other 80% is evaporated and infiltrated into the ground. Consequently, any small change in the evaporation and infiltration rate may lead to greater changes in the runoff. The variability in soil moisture, soil cover and soil use can have important impacts on the water cycle.

The basin has been object of several environmental studies. In particular, its hydrology has been simulated by the Variable Infiltration Capacity (VIC) Macroscale Hydrological model (Su et al., 2005). This model can be used to produce a set of derived variables including evapotranspiration, runoff, soil moisture storage in the upper 1 m of the soil, and total terrestrial water storage. The latter term includes all water storage, including deeper soil layers, and canopy storage, in addition to the moisture stored in the upper 1 m of soil and the water stored as snow. However, the availability of a new soil moisture data set, to be derived by Level2-SM SMOS data, can substantially improve the performance of VIC.

Likewise, future climate change scenarios may be developed, to be used in different experiments, using the model to prepare hydrological scenarios for the region.

2. Objectives

2.1 General objective

To evaluate SMOS products validity in the area and analyze their contribution to surface hydrology and meteorology.

2.2 Specific objectives

Test the applicability of SMOS products in sites which are already known and critical for climatic change issues.

Examine the impact of a new soil moisture estimate, made available from SMOS, in weather forecasting and hydrological models.

Re-use Level1C data to retrieve information about forest variables. Investigate the capability of L band radiometry to predict and monitor flooding events in wetlands.

3. Identification of test areas

First of all, test areas within the La Plata Basin will be identified. These areas must have dimensions comparable to SMOS resolution. Moreover, they must be basically homogeneous. A preliminary a priori estimate of soil moisture and its dynamics may be extracted by presently available hydrological models. Also detailed information about land cover is available to us (Mechoso et al., 2001).

Three types of ecosystems (landcover types) representative of the regional environmental heterogeneity of the La Plata Basin will be considered.

1) AGRICULTURAL LAND (agro-ecosystem).
The agriculture occupies extensive areas mostly under conservation tillage programs where the dominant crops are transgenic soybean, corn and/or wheat. Two agricultural test plots will be selected.

2) FOREST. This type will include subtropical hardwood forest in the Chaco region . Three plots will be selected, representing Humid, Semiarid and Arid forest stands.

(http://www2.medioambiente.gov.ar/bosques/umsef/default.htm).

3) WETLAND The wetlands associated to the Paraná River conform the most important fluvial wetlands corridor of the world, from the Pantanal in

Brazil to the Paraná River Delta region in Argentina A plot within the Paraná River Delta Region will be selected for wetland analysis.

4. Preliminary tests

For the selected areas, excluding wetlands, soil moisture and optical depth will be extracted by SMOS Level2-SM data. First of all, we will check that there is a general consistency between SMOS Algorithm results and a-priori information, available by hydrological models. This work will last for the first year. Typically, we will check that the following conditions are satisfied.

- There is a general correspondence between the multi-temporal trend of soil moisture and what we expected by a-priori information of hydrological models.

- The higher values of optical depth correspond to areas characterized by dense vegetation or forests.

- The seasonal variations of optical depth follow a consistent trend (e.g. higher in Summer than in Winter).

In case of large discrepancy, the reasons of the discrepancy will be identified. These may be, e.g.; a) anomalous behaviour of the selected area with respect to the general assumptions of SMOS Level2 Algorithm, b) insufficient accuracy of our previous estimates. Then, a consequent action will be decided. This may be to exclude some areas and repeat the test in a different region. This test will be done using also ALOS PALSAR and Level1C-Dual-Land data.

For this test, a repetition time of two samples per month is sufficient.

5. Assimilation of Soil Moisture Information

This is the main objective of the work. If the previous tests are successful, in the whole basin or at least in most of the areas, Level2-SM data will be used to generate a full Soil Moisture map of the whole basin, possibly with the SMOS repetition time (3 days). Then soil moisture values, in conjunction with NRT data will be used as inputs to available models.

In particular, the VIC model will be used to predict important hydrological variables, such as evapotranspiration and runoff, and the improvements related to the availability of Level2-SM soil moisture data set will be estimated.

Also the atmospheric ETA model will be run, using Level2-SM data as input. We expect benefits from this, since the availability of moisture, both in the soil and at different levels of the atmosphere, is a key element to

the development of convective clouds and storms given the appropriate atmospheric conditions. Initial conditions of the real soil moisture availability are liable to improve the forecasting of the development of severe weather systems. In particular, we plan to analyze the skill of the model under meteorological conditions favorable to the development of mesoscale convective systems, i.e., a complex of thunderstorms which becomes organized on a scale larger than the individual thunderstorms, and normally persists for several hours or more.

This work will last two years, after completion of the tests.

6. Specific study over Chaco Forest

In forest areas, the preliminary test is particularly critical, since it is expected to have a low sensitivity to soil moisture. In areas where a general consistency is observed, we get an insight into the data, in order to estimate the forest biomass in various regions of the Chaco Forest. Here a more detailed study is required, since the retrieved optical depth gives just a rough estimate of vegetation effects. In the case of forests, the overall emissivity depends on woody biomass, herbaceous understory biomass, soil and litter effects, forest geometry, etc. A more in depth analysis will be carried out using the forest emission model developed at Tor Vergata University (Ferrazzoli and Guerriero, 1996), which was already used to generate prior estimates in SMOS L2 Processor Prototype (ATBD, ESA, 2006). The model will be used in conjunction with these data sets:

- Soil Moisture content (SMC) and surface temperature retrieved by Level2-SM data

- L band brightness temperatures extracted by Level1C-Dual-Land data
- C and X band brightness temperatures measured by AMSR-E instrument.

The model will be run for a set of realistic assumptions about forest woody biomass and seasonal trends of understory biomass, leaf biomass, litter depth, etc. at L, C and X band. The already retrieved SMC and surface temperature will be used as input. By a comparison between the simulated multifrequency brightness temperatures and measured ones, the input data set producing the best fit will be considered and the values of woody and herbaceous biomass will be taken. The results will be critically compared with estimates based on optical remote sensing techniques (Gasparri et al., 2007). This work does not require a narrow sampling time. One acquisition per month may be sufficient.

7. Specific analysis over wetlands

Level1C-Dual-Land data will be used to estimate the water level in SMOS pixels affected by floodings during the flooding events of the 3 year period of the project. If water does not cover completely the vegetation,

this estimate will be done by using the water vegetation scattering model already used for studies with Envisat ASAR data (Grings et al., 2006). Since the model is bistatic, it may be easily re-adapted to estimate the emissivity. Rough simplifications will be applied, since we cannot have detailed information about vegetation, at SMOS pixel scale (to be discussed better).

Anyhow we shall consider two cases:

- water level in areas exceptionally flooded (e.g. agricultural)
- water level increase in normally flooded areas (wetlands)

Amount and type of requested data products.

It is planned to use SMOS and ALOS-PALSAR data, as indicated below. ALOS-PALSAR data add some value to the work, but is not strictly necessary for its success. It is planned that optical data and ALOS Palsar will be obtained from the Argentinian Space Agency, CONAE.

1) Lower basin box (55W-65W, 28S-35S)
For the first year (see justification in Section 4):

1 SMOS acquisition per month (both ascending and descending).
Kind of products:

Level 1C, Dual Polarization (MIR_SCLD1C) (possibly Level 2A), and NRT meteo products.

Level 2 Soil Moisture Science Data (MIR_SMUDP2)
ALOS-PALSAR images, 1 acquisition per month, over test areas which will be selected 3 months after notification of evaluation.

For the second and third year (see justification in Section 5 and 7):
Available SMOS data (ascending may be sufficient), with 3 days time sampling.
Kind of products:

Level 1C, Dual Polarization (MIR_SCLD1C) (possibly Level 2A), and NRT meteo products.

Level 2 Soil Moisture Science Data (MIR_SMUDP2)

2) Chaco forest box (60W-65W, 22S-28S)

For all 3 years (see justification in Section 4 and 6):
1 SMOS acquisition per month (both ascending and descending).
Kind of products:

Level 1C, Dual Polarization (MIR_SCLD1C) (possibly Level 2A), and NRT meteo products.

Level 2 Soil Moisture Science Data (MIR_SMUDP2) ALOS-PALSAR images, 1 acquisition per month, over test areas which will be selected 3 months after notification of evaluation.

Project References

-Algorithm Theoretical Basis Document (ATBD) for the SMOS Level 2 Soil Moisture Prototype Processor Development (SMPPD), Document ESA No.: SO-TN-ARR-L2PP-0037, 2006.

-P. Ferrazzoli, L. Guerriero, ?Passive microwave remote sensing of forests: a model investigation?, IEEE Trans. Geoscience and Remote Sensing, Vol. 34, pp. 433-443, 1996.

-N. I. Gasparri; M. G. Parmuchi, J. Bono, H. Karszenbaum and C. Montenegro, Exploring multi-temporal Landsat 7 ETM+ images to estimate above-ground biomass in subtropical dry forests of Argentina?, sent to Forest Ecology and Management, 2007.

-F. M. Grings, P. Ferrazzoli, J. C. Jacobo-Berlles , H. Karszenbaum, J. Tiffenberg, P Pratolongo, P. Kandus, ?Monitoring flood condition in marshes using EM models and ENVISAT ASAR observations?. IEEE Transactions on Geoscience and Remote Sensing, Vol. 44, N. 4, April 2006.

-C. R. Mechoso, P. Silva Dias, W. Baethgen, V. Barros, E. H. Berbery, R. Clarke, Heidi Cullen, C. Ereño, B. Grassi, D. Lettenmaier, Climatology and Hydrology of the Plata Basin. A Document of VAMOS Scientific Study Group on the Plata Basin (The Variability of American Monsoon Systems (VAMOS) Panel is a component of the Climate Variability Program (CLIVAR), under the World Climate Research Programme (WCRP)).

-Su, F., D. P. Lettenmaier, V. R. Barros, C. E. Tucci, and E. H. Berbery, 2005 : Modeling of land surface processes in La Plata basin. Proceedings of the AGU fall meeting, San Francisco, CA, USA.

Schedule: After notification of evaluation results, before data delivery: identification of test areas, preparation of software to include SMOS L2 data into models, preparation of software to analyze data from ALOS-PALSAR. Test areas will be selected 3 months after notification. After start of SMOS data delivery (Times are counted from start of data delivery).

12 months: preliminary tests will be completed. Acquisition of data for exploitation study over the whole area, with a sampling time of 3 days, will start.

15 months: a report on preliminary tests will be issued. It includes:

results, comparisons between L2 SMC products and a priori estimates over selected plots, evaluations of optical depth trends, decisions for further analysis

24 months: first year of exploitation studies will be completed.

27 months: a report about first year of exploitation studies will be completed. It includes: comparisons between L2 SMC products and a priori estimates over the whole basin, preliminary evaluation of improvements in hydrological and weather forecasting, preliminary estimates of forest variables.

36 months: the final report will be issued. It includes refinements of previous results, based on two years of data collection and analysis.

Other Data Comment

Other Data Comment:

Upload a file

Upload comment: Current PI projects and recent team publications.
Upload filename: karszenbaum_info.pdf

Products

Products:
Level 1C
Level 2 (Soil Moisture)
Level 2A
NRT Meteo Product

Data Requirements

Data Requirements:

Dear Mrs. Haydee Karszenbaum,

We are pleased to inform you that your SMOS Data AO proposal nr.4664 “SMOS observations of La Plata Basin: analysis of products and their contribution to surface hydrology in Argentina” has been accepted by ESA, therefore you will be entitled to access SMOS data, free of charge.

To receive your data you should sign the Terms and Conditions for Category-1 data, available at http://eopi.esa.int/terms and fax it duly completed to the ESA EO Help and Order Desk (+39 06 94 180 292, Email: EOHelp@esa.int).
The ESA EO Help and Order Desk is now going to be your interface for all issues regarding data access. When the signed Terms and Conditions will be received, the ESA

EO Help and Order Desk will confirm the project registration and send you the instructions to place your orders/access the data.

According to the Terms and Conditions:

The PI shall submit a progress report describing the status of the projects every year. Reports can be scientific publications and shall be submitted using the EOPI Portal, at http://eopi.esa.int => Reporting (left navigation bar), using your login (project id = 4664; password = 52chefs)
The PI shall attend and present his results at dedicated Workshops and Symposia organized by the Agency

In addition, as per Terms and Conditions (B.20), in any scientific publication the PI shall clearly state "Data provided by the European Space Agency".

Should you need further information, you can contact the ESA EO Help and Order Desk.

With best regards,

The ESA EO R&D Section