Towards obtaining operative soil moisture products using SAR data from the SAOCOM mission

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SAOCOM Project

The National Space Activities Commission (CONAE) promotes and implements all activities related to the spatial area in Argentina. The SAOCOM Mission is an end-to-end Earth Observation System dedicated to the remote sensing and data exploitation. It consists on a constellation of two L band polarimetric Synthetic Aperture Radar (SAR) satellites, SAOCOM 1A and SAOCOM 1B.

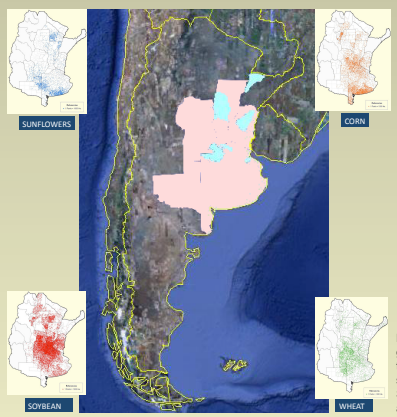
Each satellite will provide global coverage and a repeat cycle of 16 days, with 8 days for the whole constellation. The two SAOCOM satellites integrate the SIASGE constellation (Italo-Argentine Satellite System for Emergency Management) implemented jointly by CONAE and the Italian Space Agency (ASI, Agenzia Spaziale Italiana). This System consists of the Argentinean SAOCOM 1 constellation and the Italian COSMO-SkyMed constellation composed of four satellites carrying each one, an X-band SAR as a main payload.

One of the main drivers of the SAOCOM mission is to develop soil moisture map products for giving support to agricultural, hydrological, health applications, and emergencies in general.

Satellite:	Two SAOCOM 1A y 1B
Mode:	StripMap, TopSAR
Ground Range Coverage:	about 350 km
Incident angles:	approximately from 20 to 50 [deg] (nominal)
Spatial Resolution:	from 10 to 100 m

Central Frequency:	1275 MHz (L-Band)
Bandwidth:	up to 50 MHz
Pulsewidth:	up to 60 µs
PRF:	up to 2500 Hz per chanel
RF peak Power:	5600 W.
Antenna irradiating area:	3.468m x 9.968m

The SAOCOM satellites shall be injected in a sun synchronous, nearly circular frozen polar orbit (SSO), with Local Time Ascending Node (LTAN) in a range centered at 06:12 am and an orbit altitude of about 620 km.



Study Area: "LLanura Pampeana" (pink), and Basins, (light blue) *~70.000.000 ha*

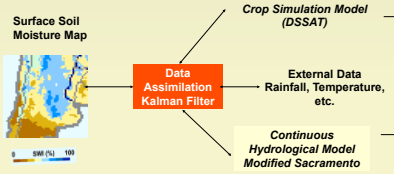
Regions of Interest

The Argentinean Pampas, covers different combinations of soil, weather and environmental conditions. If land surface is homogeneous regional parameterization can be scaled invariant (i.e. empirical relations developed from point observations can be used for large areas); but for commonly heterogeneous land surfaces this condition is difficult to satisfy (Hu & Islam, 1997).

The climate is warn with adequate to less than adequate rainfall for normal crop production. The mean temperatures are 18ºC and 14ºC in the North and the South of the Pampas respectively. In part of these regions, the temperature and the frost-free period are adequate for growing double crops (i.e. soybean or maize planted after wheat). Rainfall amounts show high inter-annual variability. Most rainfall occurs between October and April (spring to fall seasons), and the long term annual average is 500 and 1000 mm in the South West and in the North East regions, respectively.

Most of the region was originally covered by grasslands, interrupted only by gallery forest. In terms of the areas cultivated, the main crops are soybean, wheat, maize and sunflower, in that order. Secondary crops are sorghum, barley, groundnuts and flax.

Example of SAOCOM Applications and Products

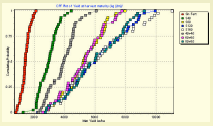


Support System for Decision Making in Agriculture

Superficial Soil Moisture Thematic Map: This map shows regions classified by superficial soil water content within fixed ranges.

Soil Moisture Profile Thematic Map: This map shows regions classified by average soil water content in the vertical profile within fixed ranges.

Decision Support Data: This is a georeferenced database with yield estimations, and wet and dry biomass, considering different fertilization dosage and management practices.

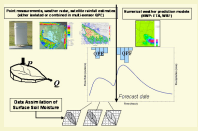


Risk and Hydrological Emergency Management

Flood Guidance: the amount (in mm) of total rainfall to be accumulated during a time interval T over a given basin with a certain soil moisture content, required for causing bank-full flow at its outlet. Comparison of the quantitative precipitation forecast for the subsequent time interval T (QPF_T) over a given basin with its current FLG will determine the need of a warning.

Deterministic hydrologic forecasts: Continuous physically-inspired lumped conceptual hydrologic models perform the soil moisture accounting in the soil, for assessing the rainfall-runoff transformation.

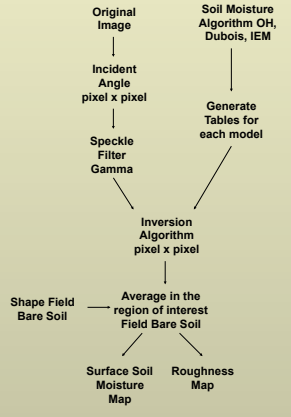
Medium and long term probabilistic forecasts: Probabilistic forecast with the ESP technique consists in fitting a probability distribution function of the hydrologic variable under study for each future "instant". For instance, the distributions may be fitted for each one of the twelve months (or 52 weeks, or 26 fortnights, etc.) subsequent to the elaboration of the forecast.



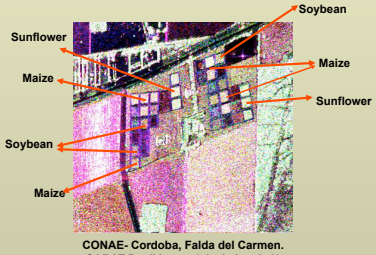
Surface Soil Moisture Map
Bare Soil Inversion Method

In order to invert to the soil moisture model, the Look-Up-Table model (LUT) will be used . The LUT model was applied to these data using both HH and VV polarizations. For each band the relationships between the backscatter coefficient, soil moisture, incidence angle and different surface roughness cases were generated with a forward simulation of the soil moisture model. These relationships were consequently put in a look-up table, which could then be used to invert the backscatter coefficient to soil moisture.

The IEM and Dubois models work with the dielectric constant, therefore Topp model' s. (Topp et. al. 1980) was used to obtain soil moisture. A set of 30 look-up tables were generated for each incident angle (25-55 degree), considering a radar configuration for λ=23cm. For IEM model the exponential autocorrelation function was used, with a roughness parameter of s/l=0.13.



Experimental Fields



CONAE- Cordoba, Falda del Carmen. SARAT Pauli Image (pixel size=3x3)

Field experiments will be conducted in representative sites of the Argentine Pampas and Basins. During the first growing season we are concentrate on one specific site where the complete list of variables will be measured. CONAE-Cordoba, Falda del Carmen.

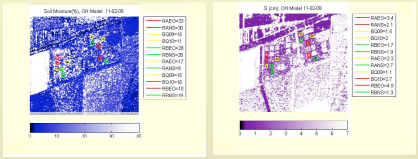
During the second growing season, once all the information acquired in the first campaign would by then be analyzed, we will repeat the set of experiments on different sites encompassing contrasting environmental situations characteristic of the Pampas region.

Treatments is a factorial combination of: i) different soil tillage methods, ii) 4 crops (wheat, maize soybean and sunflower) iii) soil irrigations (no irrigation, irrigated) and iv) canopy irrigations (again no irrigation, irrigated). Each treatment will be established in 50 x 50 m plots with a separation of at least 10 meters in between

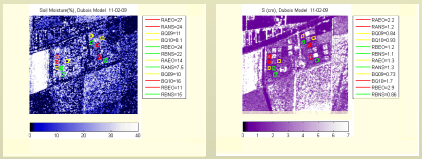
Soil Moisture and Roughness Map

Soil Moisture Bare Soil **Roughness Bare Soil**

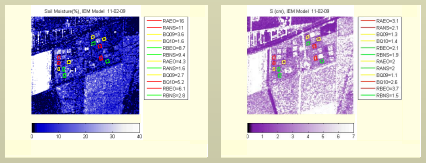
OH Model

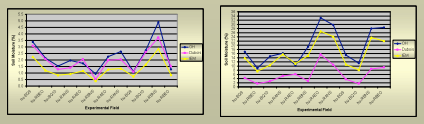


Dubois Model



IEM Model





Model prediction: Soil Moisture and Roughness in the experimental field for bare soil