Verification of Soil Moisture estimation from AMSR-E and AMSR-2

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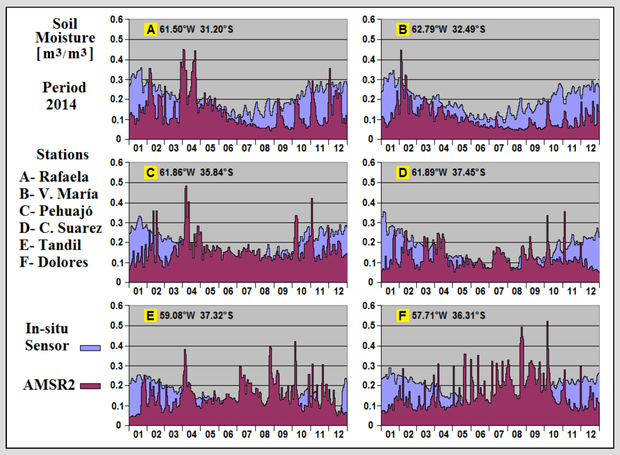
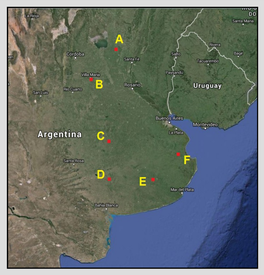
Abstract

Soil moisture is one of the most important hydro meteorological variables that characterizes the conditions of the soil and may be derived from passive microwave radiometer observations, such as from AMSR-E and SHIZUKU GCOM-W1-AMSR-2 on board the satellites AQUA (NASA) and SHIZUKU (JAXA). Twice a day, AMSR-E and AMSR-2 offer instantaneous soil moisture retrievals at the top 1.5 cm layer with 0.25 and 0.10 degrees spatial resolution, respectively. Soil moisture is obtained by using the Land Parameter Retrieval Model (LPRM), the Standard NASA Algorithm and the Polarization Ratio Variation Index (PRVI) for AMSRE, and Fuji algorithm 2009 algorithm is applied to AMSR2.
The aim of this study is to explore the usefulness of AMSR-E and AMSR-2 daily soil moisture estimations for large areas under wet and dry conditions both in 2014 and 2008. For that, soil moisture estimations were compared against field measurements carried out by the Argentinean Space Agency (CONAE), rainfall retrievals derived from Tropical Rainfall Measuring Mission (TRMM) and from observational data. Drought Severity Index (DSI) derived from the MODIS, and produced every 8 days by the Univ. of Montana, was also used. The results of these comparisons for the Argentine Pampas will be shown.





SOIL MOISTURE : AMSR2 / TELEMETRIC NETWORK

The AMSR2 is the new generation of instruments based on detection of passive microwave, used for estimation of surface soil moisture content, and it has been operational since March 2012. This sensor replaced the previous AMSR-E, mounted on the AQUA satellite, and stopped working in October 2011. Global data based on ascending and descending passes and monthly or daily basis are provided at different levels of processing and spatial resolutions (0.1 ° and 0.25 °) by Japan Aerospatiale Exploration Agency (JAXA).

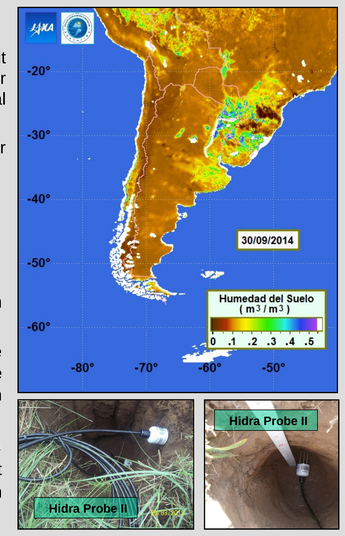
The estimation of the of surface soil moisture content can be used in various applications including: a) estimating soil porosity, b) surface runoff and water retention, c) seasonal incidence of the sun on the water content in surface.

The algorithm used by JAXA (previously by JAXA / NASA) provides normal soil conditions but has some significant limitations as follows:

1- Tendency to overestimate soil moisture under the condition such extreme dry desert and in some cases of severe droughts in agricultural areas.

2- Soil moisture around coastline and large lake shows often erroneously high value due to water surface effects.

3- In the area covered with dense vegetation, soil moisture shows low value because the signal from soil surface will be absorbed by the vegetation layer.

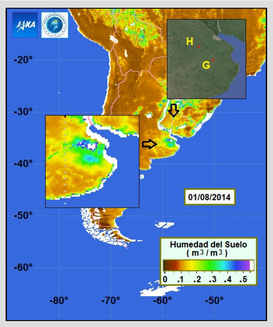


On the left margin, the **Fig. #1** shows some graphics comparing surface soil moisture retrievals from AMSRE2 (approx.1.5 cm of depth), with **in-situ** soil moisture measurements from Telemetric Network (at approx. 5 cm of depth), for some sites during 2014.

This comparison shows a greater variability of surface soil moisture content in relation to deeper levels, due to local rainfalls , evaporation and runoff. It can be seen especially during the summer months when, despite being the rainiest season, the increased evaporation dries the surface soil moisture faster, also influenced by natural runoff and soil characteristics. While in-situ measurements show, not only higher soil moisture content for nearly most of the year, but also possess a temporal inertia, not dependent on surface evaporation and vegetation cover.

In sites **A** and **B** (inland), the winter rainfalls are lower, this explains a sharp decline in the surface soil moisture content, recovering only with the summer rainfalls. The other sites have a more uniform rainfall regime.

Sites **C** and **D**, the annual rainfall was more constant and so the superficial soil moisture content has been stable and besides the relief facilitates the water runoff in case of rain excesses eventually. When analyzing sites **E** and **F**, from May to October, a significant increase in surface soil moisture is observed, as a result of excessive rainfall in the region. Site **E** corresponds to the agricultural zone next to the Sierra de Tandil, with good drainage and low chances of flooding. Moreover site **F** is located in the Rio Salado basin showing the decrease of the surface soil moisture after the spring rain by evaporation effect. The study of Soil moisture at different locations allows us to know the impact on agricultural productivity, runoff potential, flood control and reservoir management.



SOIL MOISTURE – AMSR2 – FLOODED SOILS

During the second and third quarter of 2014, the center of the Buenos Aires province was affected by atypical rainfalls. Most of the localities in the Rio Salado basin suffered this climatic event. A particular case is Las Flores locality where excessive rainfall flooded it, not only by the amount of rainfall but for its location in the lower sector. Anomalous rainfalls affected the flow of rivers and streams, reducing the natural runoff; and causing flooding in lowlands.

In this example, the variation of surface soil moisture content is analyzed by comparing soil moisture retrievals derived from AMSRE2 (depth 1.5 cm) and in-situ measurements (depth 5 cm) .

On the left, a picture of AMSR2 daily soil moisture, highlighting the flooded area, is shown. In this case, the phenomenon is noticed clearly reaching the saturation range.

Graphics on the right side, show a comparison between two sites located in the Rio Salado basin , in the Buenos Aires province (site **H** at 50m asl and site **G** at 30m asl).

Fig. #1 shows a comparison between in-situ measurements and surface soil moisture content from AMSRE2 in 2014. The behavior of the surface soil moisture can be related to rainfalls, evaporation and natural runoff. While deeper soil moisture less dependent on the evaporation.

As seen in the graph, the recovery in the lower site was slower than in the higher site, due to the continuous contribution of the upper basin that saturated the natural runoff.

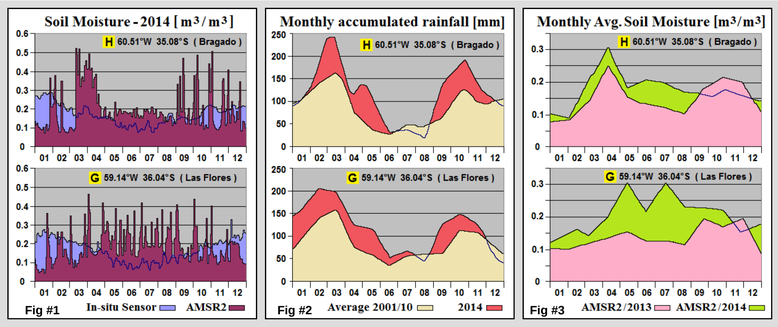
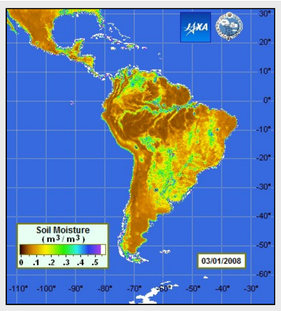
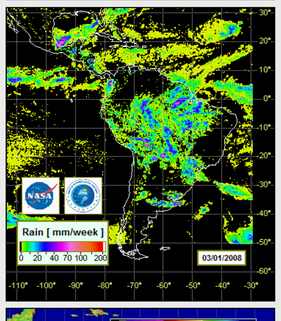
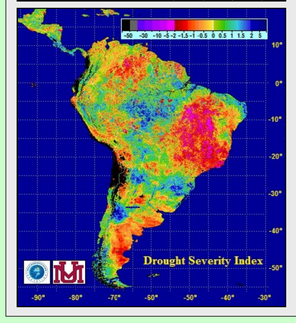


Fig. #2 the monthly accumulated rainfall and monthly average (2001-2010) are plotted. While, for both sites, the values are greater than the monthly average; flooding seems to have been more aggravated (site **G**) by the difficulty of drainage, due to the contribution of water from the upper basin. **Fig. #3** a graph of AMSR-2 monthly average retrievals shows a notable difference between 2013 vs. 2014. Site **G** (Las Flores – lower) the recovery to normal conditions was slower than in site **H** (Bragado – higher) due to the different drainage rate in spite of the similar rainfalls during 2014.

In case of flooding or soil saturation, the monitoring of surface soil moisture content is important; because it can shows the phenomenon evolution and the soil recovery tendency, and additionally, it would be a useful tool for the management of livestock and agricultural tasks.Moreover, a proper analysis of surface soil moisture content, would allow us to associate the natural and artificial drainge conditions and other factors from the entire watershed.







SOIL MOISTURE / DROUGHT SEVERITY INDEX – Drought 2007-2009

During the period June 2007 to October 2009, the core of agricultural production (mainly crops) in Argentina Pampas was affected by a severe drought, characterized by an unusual spatial extent and duration; these conditions began to improve in December 2009.

For studying the relationship between drought and surface soil moisture content, Drought Severity Index (DSI) produced by the Univ. of Montana every 8 days, at 0.05° spatial resolution, and Soil Moisture retrievals from AMSR2 available in monthly average at 0.1 ° spatial resolution, from the Japan Aerospace Exploration Agency / JAXA, were analyzed.

Furthermore, seven day cumulative rainfall derived from TRMM / NASA – JAXA, together with daily rainfall observations, from Argentina National Institute of Agricultural Technology (INTA) and monthly/average rainfalls, from Argentina National Meteorological Service (SMN) were also used.

AMSR2 retrievals were previously resampled to have a common spatial resolution at approx. 0.15 ° and then extracted and analyzed for three rural locations : sector **A** characterized by an undulating relief surrounded by rivers and streams, sector **B** corresponds to a plain without marine influence, and sector **C** is a plain with some marine influence.

On the left , an example of AMSR2 , Rain/TRMM and DSI retrievals and, besides, a map with geographic location of the analyzed locations, are shown.

On the right side, the graphics show the summary of the rainfall anomalies , surface soil moisture and drought severity index of the three analized locations in the period July 2007 to December 2009.

Figure **#1** shows the difference between the monthly cumulative rainfalls and the average 2001-2010 for each of the three studied sectors.

In sectors **A** and **B,** corresponding to the more continental areas, rainfall deficiency is clearly observed which began to regularize in the last quarter of 2009. The effect of drought in the sector **C** got worse in the second half of 2008 and its recovery started with the summer rains of 2009.

Figure **#2** shows the soil moisture behavior of the sectors in the analyzed period. The sectors A and B were highly affected by rain shortage. In the case of sector B, the soil moisture reached values below 0.06 m3 / m3 during the 2008 summer season, while in Sector **A** (less continental) the values were a bit higher than the other sector. The surface soil moisture content began to increase in early 2009 to regularize at the end of the same period. This slow recovery time can be seen clearly in the graph for both sectors.

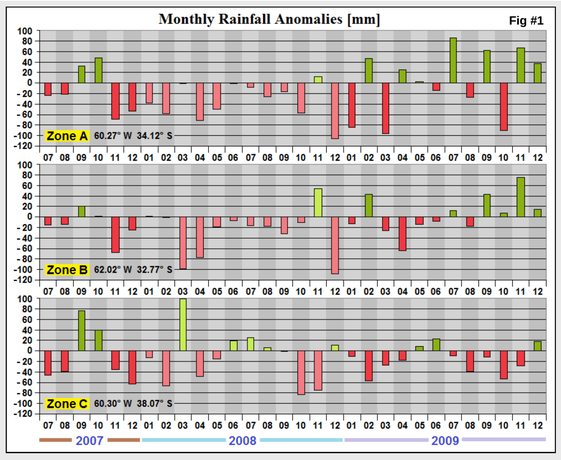
As the algorithm used by JAXA, tends to overestimate the soil moisture value in very dry soils, it is likely, that the negative gradient was somewhat higher.

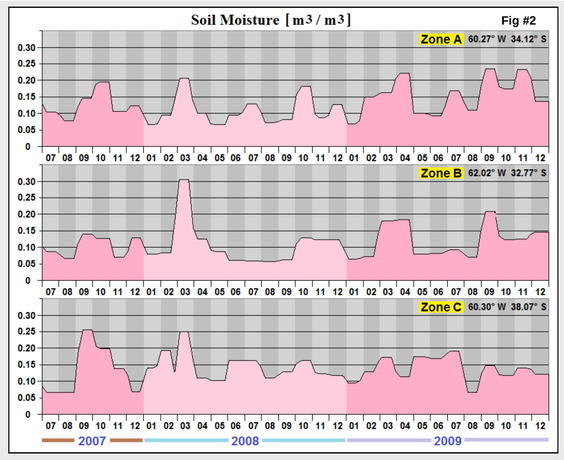
The sector **C** had a quite different behavior, although rainfalls were slightly more regular in the period, monthly cumulative rainfall was below the average 2001-2010, even so, the surface soil moisture kept more regularly , probably due to more humid air and some drizzles.

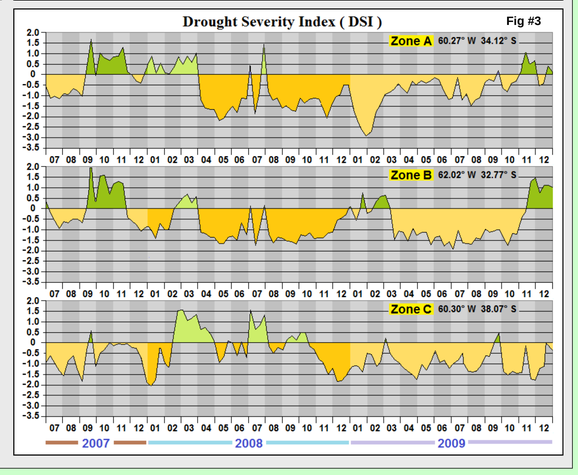
Fig. **#3** .The Drought Severity Index (DSI) is plotted showing negative and stable values that represent the severe drought period, mainly for the most affected sectors (**A** and **B**).

Some uncertainties can result when this index is used in agricultural exploitation regions, showing negative values (false DSI), especially, if the land use or some other factors affecting the vegetation negatively, are not taken into account. The reason is that the DSI calculation, among other variables, uses the NDVI, which is highly variable, depending on the period and condition of crop growth (sowing, flowering and harvest) and climate factors.

Both surface soil moisture content as the DSI could result in very useful indicators, but these should be complemented with other variables such as: rainfall regime, land use, soil characteristics, runoff , etc., for a more accurate interpretation.







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