SMOS data over crop areas of Argentina: analysis of soil moisture and optical depth products

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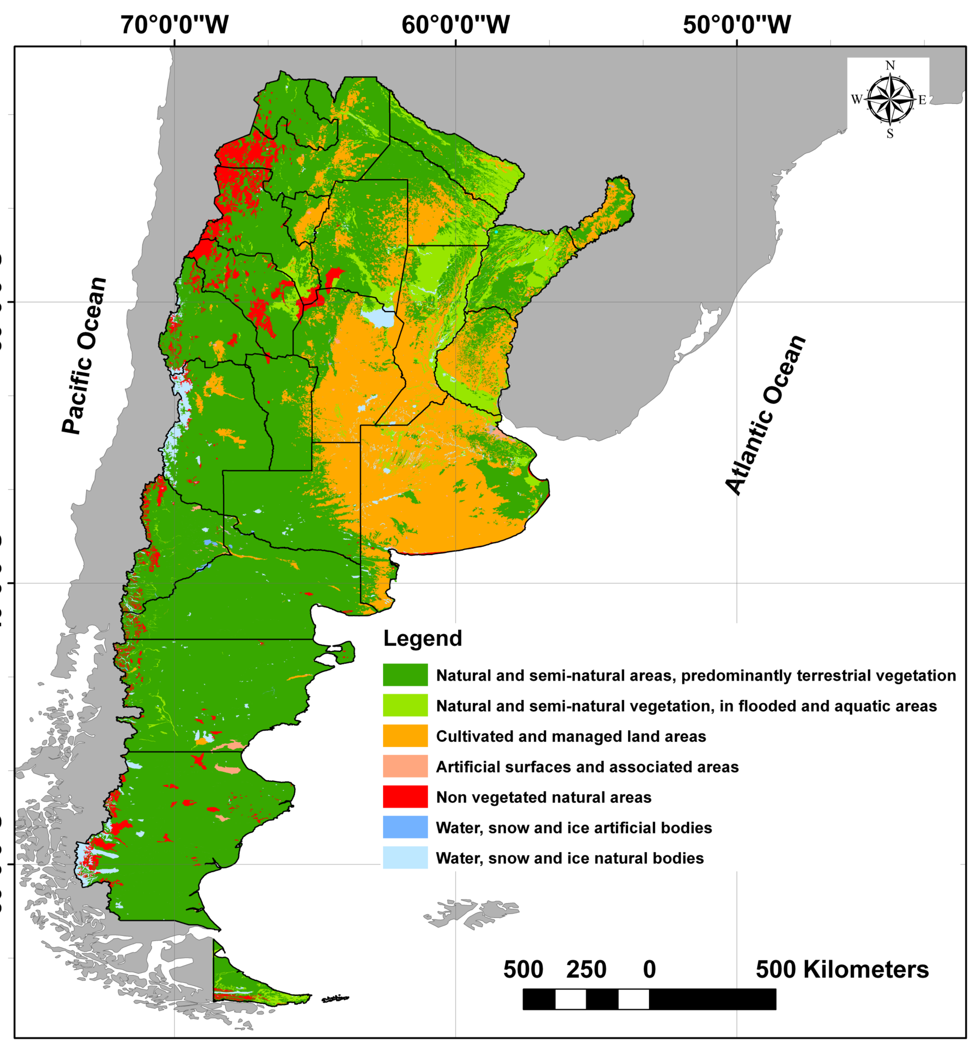
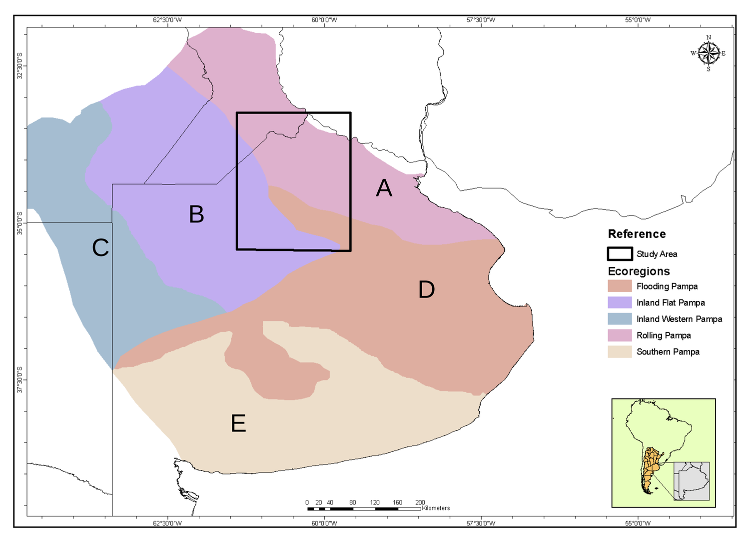
Framework & Data Description



Land cover Classification (FAO) for Argentina available at [1]. Within the area of study, the main land covers are graminoid (wheat, maize and sunflower) and non graminoid (soybean).

The Argentina's Pampas region (aprox 50 million ha) is located in the center-east of Argentina where the main agricultural activities are cereal production and cattle-raising. It accounts for more than 90% of the national grain production. Soybean, wheat, maize and sunflower are the main crops. Weather is among the most important and uncontrollable elements affecting agriculture in this region.

The seasonal cycle of precipitation shows a maximum from October to April and a minimum from May to September.



Subdivisions of the Pampas region: A: rolling pampas, B. inland flat pampas, C: inland western pampas, D: flooding pampas, E: southern Pampas. Black contour indicates the area where specific sites were analyzed (aprox 400000 ha).

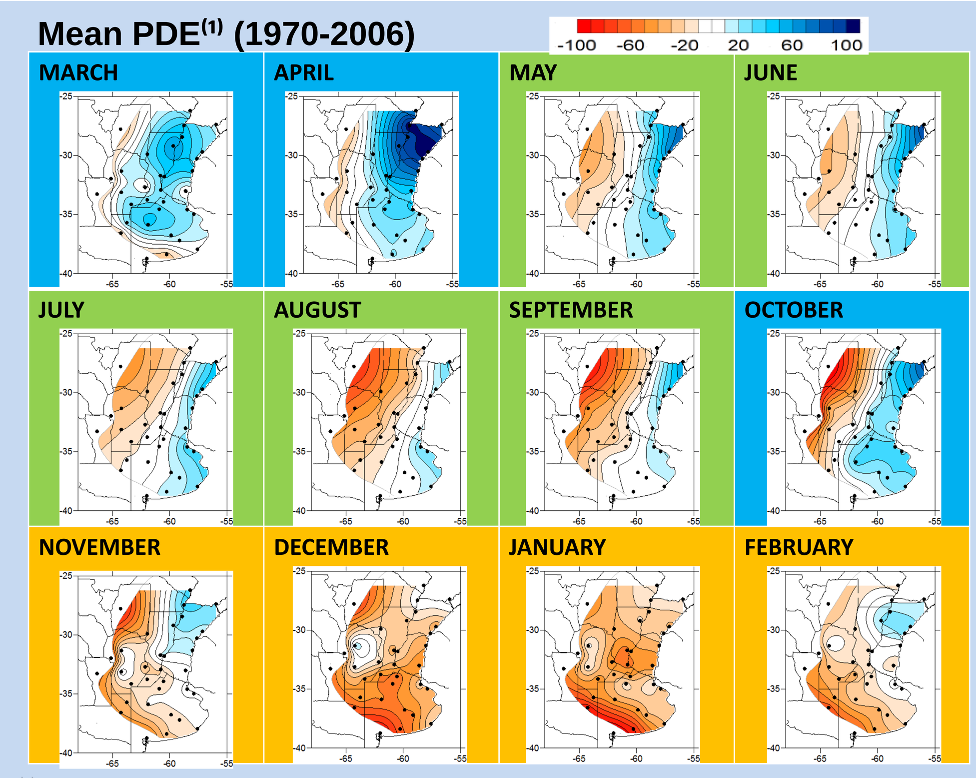
We use the Precipitation Deficit/Excess (PDE) as an indicator of the climatic variability of the region and as a reference for the soil moisture product analysis.

PDE is the difference between precipitation and potential evapotranspiration. It was computed: (i) using daily precipitation and maximum and minimum temperatures data (National Weather Service and National Institute of Agricultural Technology) from 33 stations, located in the rain fed agriculture production region of Argentina for the period 1970-2006, and (ii) monthly potential evapotranspiration calculated following Thornthwaite, 1948, Camargo et al. 1999.

PDE shows: a) drier months in austral summer, b) wetter periods in austral autumn, spring and c) intermediate values and more variability in austral winter.

The spatial distribution of patterns follows a latitudinal gradient in austral winter and a NE-SW gradient in summer months in Buenos Aires Province.

Mean PDE[(1)] (1970-2006)



(1) Precipitation Deficit /Excess (PDE) = Precipitation – Potential Evapotranspiration

Data Description:

- **SMOS**: L2 V501 Dates:01/14/2010-09/30/2012 ASC: 7 AM DESC: 7 PM
- **MODIS (Terra)**: MOD13Q1 Dates:01/01/2010-09/30/2012 ASC: 11:30 PM

Acknowledgment

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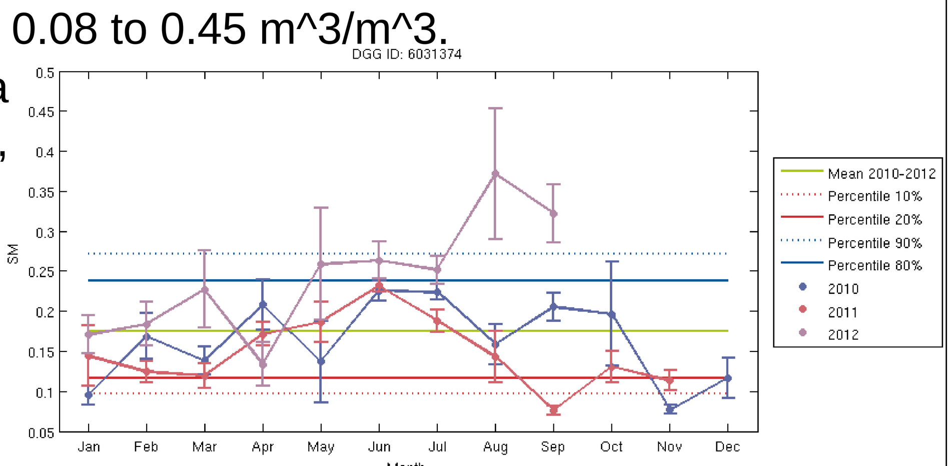
Soil Moisture (SM) seasonality & anomalies

Below average rainfall (1970-2006) prevailed in 2011. Anomalies were the lowest in August and November, reaching values below the 20% Percentile. Excess precipitation events occurred during both 2010 and 2011 summers. While 2012 was characterized by alternated wet and dry extremes.

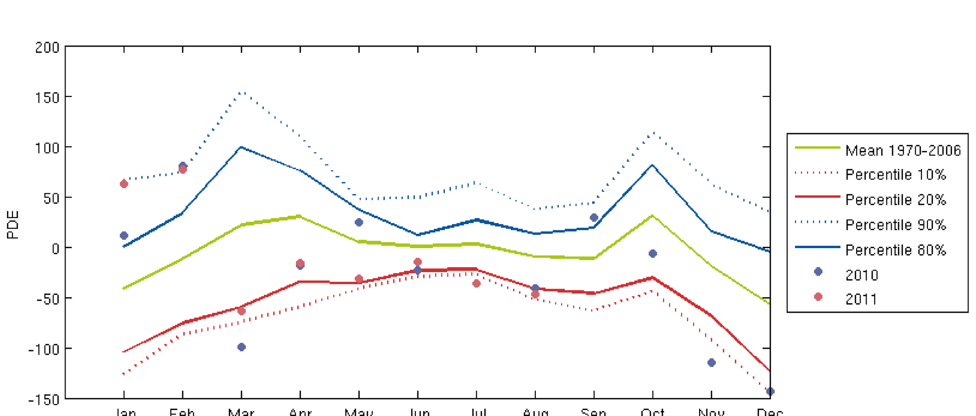
SM from SMOS

- In general, SM values ranged from 0.08 to 0.45 m^3/m^3.
- Over the northern part of the area of study (near the Delta wetland), SM values were significantly high.
- Whereas austral winter (followed by austral autumn) exhibited the highest soil moisture values, austral summer and austral spring displayed the lowest.

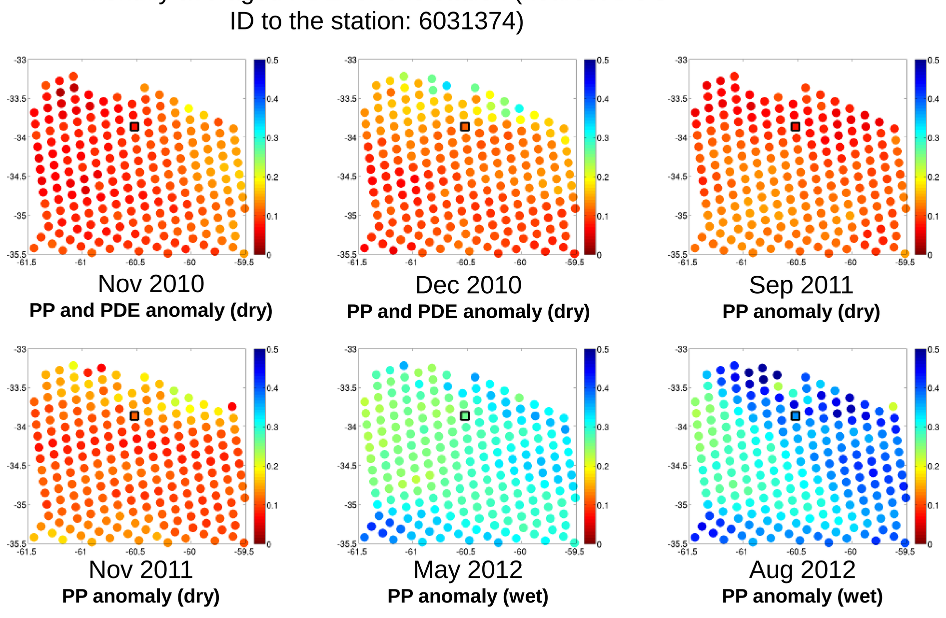


Monthly averaged SMOS L2 SM for DGG ID 6031374

SM from SMOS vs. PDE/PP



Monthly averaged PDE for one station (nearest DGG ID to the station: 6031374)



Examples of monthly averaged SMOS L2 SM maps for months where extremes (dry/wet) were seen by both SM and PP or PDE datasets. Black square indicates DGG ID 6031374.

- An analysis of SMOS SM seasonality and anomalies was performed using as frame the precipitation (PP), the climatic PDE and PDEs values for SMOS SM period analyzed.
- Wet and dry extremes were obtained for the DGG ID 6031374 using PP, PDE and SM datasets. Monthly values were considered extremes when they fell outside the Percentiles 20-80% of the 1970-2006 period.
- Definition of SM extremes where obtained taking the Percentiles 20-80% of the SM histogram of the DGG for the 2010-2012 time period.
- Six soil moisture maps are shown as examples of the spatial distribution of anomalies. PP and/or PDE are indicated in each case. Results for the complete period are summarized in the table.

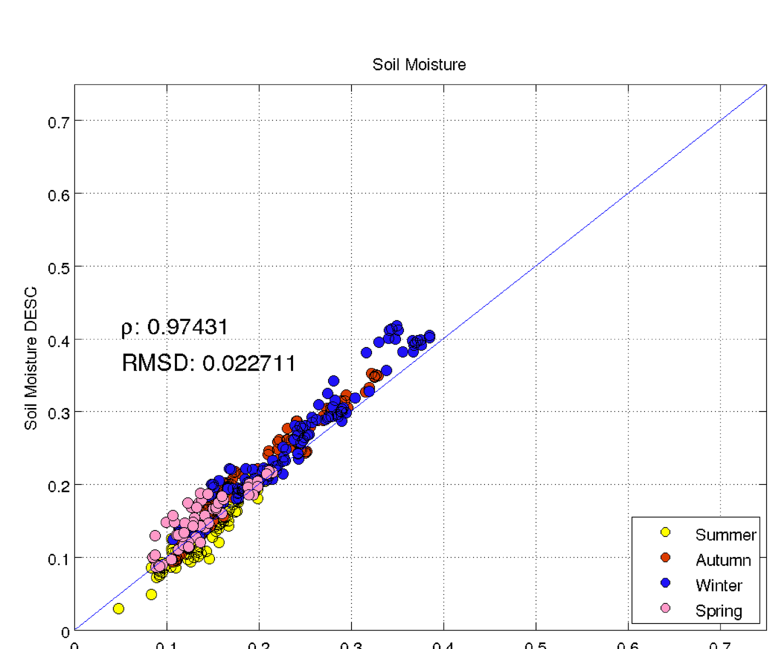
Legend
Wet Extreme
Mean-high values
Mean-low values
Dry Extreme
No Data

Table showing seasonality and anomalies for the DGG ID 6031374. For each month of the analyzed period, four categories were defined for PP (1st column), PDE (2nd column) and SM datasets (3rd column).

	Austral Summer			Austral Autumn			Austral Winter			Austral Spring		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2010	Wet Extreme / Wet Extreme / Dry Extreme	Wet Extreme / Wet Extreme / Mean-low	Dry Extreme / Dry Extreme / Mean-low	Mean-low / Mean-low / Mean-high	Mean-high / Mean-high / Mean-low	Mean-low / Dry Extreme / Mean-high	Mean-low / No Data / Mean-high	No Data / Dry Extreme / Mean-low	Wet Extreme / Wet Extreme / Mean-high	Mean-low / Mean-low / Mean-high	Dry Extreme / Dry Extreme / Dry Extreme	Mean-low / Dry Extreme / Dry Extreme
2011	Wet Extreme / Wet Extreme / Mean-low	Wet Extreme / Wet Extreme / Mean-low	Mean-low / Dry Extreme / Mean-low	Mean-low / Mean-low / Mean-low	Mean-low / Mean-low / Mean-high	Mean-low / Mean-low / Mean-high	Mean-low / Dry Extreme / Mean-high	Dry Extreme / Dry Extreme / Mean-low	Dry Extreme / No Data / Dry Extreme	Mean-low / No Data / Mean-low	Dry Extreme / No Data / Dry Extreme	No Data / No Data / No Data
2012	Mean-low / No Data / Mean-low	Wet Extreme / No Data / Mean-high	Mean-high / No Data / Mean-high	Dry Extreme / No Data / Mean-low	Wet Extreme / No Data / Wet Extreme	Dry Extreme / No Data / Wet Extreme	Dry Extreme / No Data / Wet Extreme	Wet Extreme / No Data / Wet Extreme	Mean-high / No Data / Wet Extreme	No Data / No Data / No Data	No Data / No Data / No Data	No Data / No Data / No Data

SM for ASC vs. DESC passes

- There are not significant differences in the soil moisture product between morning and evening passes. Soil moisture for descending passes (evening) were found to be (systematically) slightly higher than for ascending passes (morning). However, for the months of January and February, the relation was the opposite.
- A similar positive difference (evening soil moisture minus morning soil moisture) was previously seen in Rowlandson et al.



Scatter plot of SM_{ASC} vs. SM_{DESC} for DGG ID 6035982.

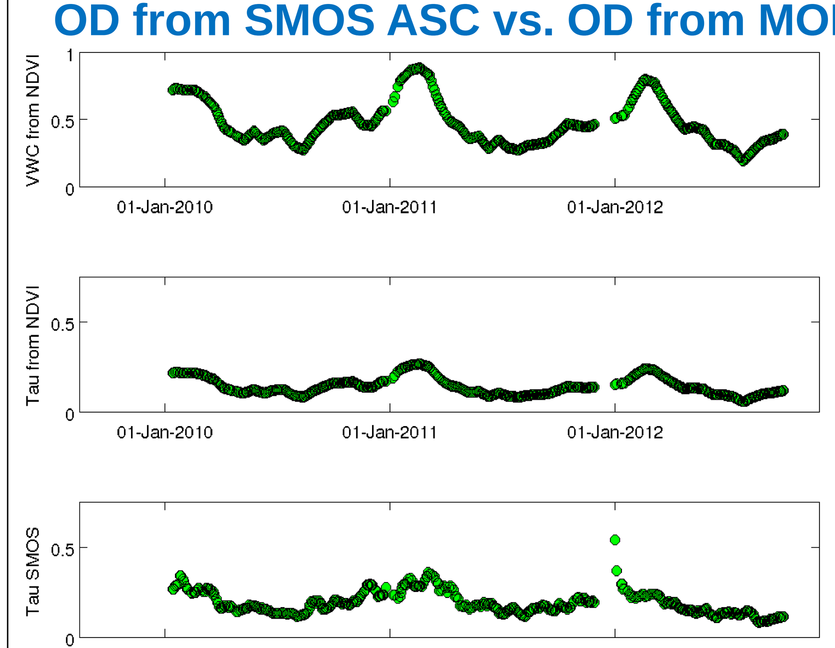
Optical Depth behavior

Vegetation optical depth (OD) is simultaneously retrieved with soil moisture from SMOS brightness temperature. Identifying errors on the retrieved OD can give valuable information on possible errors on the soil moisture retrieval.

The following is a summarized list of OD features seen in the analysis:

- In general, OD ranged from 0.06 to 0.45 kg/m^2, exhibiting mean values around 0.25 kg/m^2. Therefore, the dynamic range observed is consistent with OD values found in the literature for low vegetation areas. (Wigneron et al. 2007)
- Over the northern part of the area of study (near the Delta wetland), OD values were significantly low.
- As expected, since the area of study is covered with crops, a clear seasonal pattern was captured in OD temporal series. It consisted of an increase from austral spring until austral summer and a decrease in austral autumn during harvesting. Therefore, consistent with the typical vegetation phenology of land covers in Pampas Plains, December, January, February and March displayed the highest OD values. On the other hand, July, August and September (austral winter) were the months with lowest OD values.

OD from SMOS ASC vs. OD from MODIS



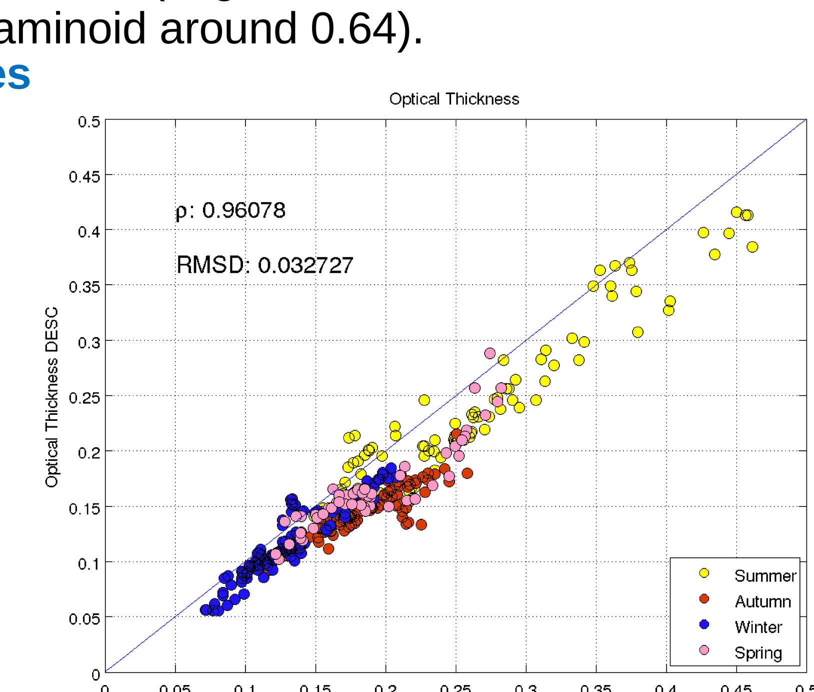
Time series of VWC and OD from MODIS and SMOS L2 OD for DGG ID 6035982.

From MODIS NDVI, it was derived VWC (Jackson et al. 2002). Assuming b parameter 0.3, MODIS OD (OD_{NDVI}) was achieved and compared with ascending OD_{SMOS}. Results obtained were the following:

- Near the wetland, correlation between OD_{SMOS} and OD_{NDVI} was significantly low.
- Over the rest of the area under study, OD_{SMOS} and OD_{NDVI} exhibited a fairly strong correlation, ranging from 0.5 to 0.8.
- Correlation was found to be stronger for graminoid vegetation than for non graminoid (in general mean correlation for graminoid was around 0.69 and for non graminoid around 0.64).

OD from SMOS for ASC vs. DESC passes

- In general, OD values for ascending passes (OD_{ASC}) were found to be greater than for descending passes (OD_{DESC}) (i.e. there was a systematic positive bias between OD_{ASC} and OD_{DESC} for all DGGs over the area of study).
- This difference between OD values for ASC and DESC passes increased for the months from January to March (austral summer).
- However, the opposite behavior was present over non graminoid areas for November and December months.



Scatter plot of OD_{ASC} vs. OD_{DESC} for DGG ID 6033941.

Final Comments

We analyzed the monthly behavior of SMOS SM product in a relevant area of the rolling pampas to study the linkage between soil moisture values and precipitation and PDE seasonality and anomalies.

On average, in the considered three years SMOS SM follows a regular seasonal cycle, with higher values in June-August (Austral winter) and lower values in November-January (Austral spring-summer). SMOS SM captures well dry extremes occurring in summer and wet extreme occurring in winter. However, for dry extremes occurring in winter and wet extremes occurring in summer the influence on retrieved SM is not evident, since the seasonal and interannual effects act in the opposite sense.

For the optical depth product a good correlation was found with respect to the optical depth computed using MODIS WVC, while no significant correlation with SM was observed. Other authors reported high correlation between SM and OD due to RFI contamination, while no RFI problems were identified by us.

Before analysis both products were smoothed using a 21 days time window.

Work in Progress

- Analysis of precipitation induced soil moisture peaks, API, R value.
- Spatialization of anomalies.

Longer Term Objectives

- Generate a soil moisture algorithm for Pampas Plains, Argentina.
- Create an experimental CAL/VAL site for SMAP scale in the area analyzed in this paper.
- Create a LSM for Pampas Plains.

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