Appendix 1: Methodology

	Tasks	**Semester 1**	**Semester 2**	**Semester 3**	**Semester 4**	**Semester 5**	**Semester 6**
1	Data processing	**X**	**X**	**X**	**X**	**X**	**X**
2	Forward models	**X**	**X**				
3	Inverse models				**X**	**X**	**X**
4	Land cover land use maps and auxiliary data	**X**	**X**	**X**	**X**	**X**	**X**
5	**Protocols for Soil Moisture products**				**X**	**X**	**X**
6	Field Work						
7	**Floods and Drought monitoring**	**X**	**X**	**X**	**X**	**X**	**X**
8	Data assimilation and forecasting					**X**	**X**
9	Integrating results and products						**X**
10	Assimilation of soil moisture in epidemiology models					**X**	**X**

Table1. Main tasks distributed by semesters

The methodology is centered in the “**Floods and drought monitoring**” (**task 7)** which starts from the very beginning of the project. **Protocols for Soil Moisture products (task 6)** and **Hydrological models and data assimilation are** also discussed.

A. “**Floods and drought monitoring**”: **Retrieval of fraction of flooded area**

The following methodology constitutes an adaptation **(improved algorithm)** of Sippel *et al* 1998, Hamilton *et al* 2002.

The algorithms for estimation of the fractional area of inundation from the 37GHz ΔT_{obs} have been described by these authors. A linear mixing model with three end-members incorporates the contributions of water, non-fooded land, and inundated foodplain to the ΔT_{obs}:

(1)
$$\Delta T_{obs,\lambda} = f_w \Delta T_{w,\lambda} + f_{nf} \Delta T_{nf,\lambda} + f_f \Delta T_{f,\lambda}$$

(2)
$$1 = f_w + f_{nf} + f_f$$

where ΔT_{obs} is the ΔT observed by the radiometer for wavelength λ, f_w, f_{nf} and f_f are the fraccional areas of open water (rivers and permanent¯ foodplain lakes), non¯ fooded land, and seasonally flooded land, respectively, and ΔT_w, ΔT_{nf} and ΔT_f are the ΔT values for open water, non flooded land, and seasonally ¯ flooded land. As the floodplain becomes inundated, f_f increases with a concomitant decrease in f_{nf} . Simultaneous solution of equations (1) and (2) yields the following equation for the fraction of flooded area (f_f):

(3)
$$f_f = \frac{\Delta T_{obs,\lambda} - f_w \Delta T_w - \Delta T_{nf,\lambda} + f_w \Delta T_{nf,\lambda}}{\Delta T_{f,\lambda} - \Delta T_{nf,\lambda}}$$

This algorithm has been implemented for 37 GHz by these authors. It is being adapted for C and L bands.

Proposed changes:

1. Only three categories are being considered in this algorithm, this constitutes a limited assumption. The following changes are being considered:
    a. Different land covers where the ΔT for each category will be determined by forward models (**task 2**). Input variables to the models have been obtained from field work in the Delta of Paraná. For other sectors of the floodplain, field work has to be done and in situ data collected (**task 6**).
    b. Land cover maps are needed for this, MODIS land cover maps will be validated, and in specific regions, local maps will be used and or developed. For regions outside Argentina, contacts will be made with different institutions (Bolivia, Paraguay, Brazil) (**task 4**).
    c. Permanent water bodies are in reality quite variable in size due to seasonal phenomena and periods of flood or drought. This will be improved with updated maps of water bodies and their variability **(task 4**).
2. Different flooded scenarios (completed, covered by water, partially cover and only soil covered) will be considered for each land cover, this implies different values for ΔT_f . This also implies the use of water level and precipitation data. It is also being considered the use of active radar data for calibration of the algorithm (**tasks 1,2, 4 and 6)**).
3. Specific areas such as delta of Paraná River and Chaco Forest will be studied in detail since we have already land cover maps and biomass maps respectively. These areas will be also used as *test sites* for algorithms (most of tasks).
4. Due to the fact that De La Plata Basin is a very large area with a complex hydrological network and a variety of ecosystems, not all the area will be monitored with the same level of accuracy, this aspect will be addressed.
5. At this time, the original algorithm is being tested with AMSR-E data y improved algorithms will be applied with SMOS data (data will be provided through an approved ESA AO project in La Plata Basin). All this requires the use of optical data for land cover updating and radar data (**concurrent data**) for algorithm calibration.

B. “**Protocols for soil moisture**”

There is some work in progress where emission models are being used to establish the expected brightness temperatures (emissivities) for different land covers (forward models). In particular, the work in progress addresses a region of Forest name Chaco Forest where there is quite a lot of field work being done and preliminary biomass maps are available. Inventory data and biomass maps are being used as input to the emission models in forest (*Ferrazzoli, 1996*). This is a very large region, the most adequate considering Aquarius pixel. One of the ideas is to set meteorological stations in a reserve area for validation and upscaling/downscaling procedures.

Theoretical aspects of the models were developed by Dr. Ferrazzoli one of the partners of this project. Models code has being installed at IAFE and they are currently working with local input data. Up to now, we have used them to understand and make comparison with AMSR-E data collected over Chaco. SMOS data will be also available for this task.

Regarding the soil moistures retrieval algorithm for Aquarius, Dr. Jackson procedure will be tested and updated once the Aquarius data is available (*Jackson, 2009*). Comparison with SMOS product and algorithm is also part of the methodology.

One important aspect of the methodology is the analysis of SMOS data and algorithms over specific areas where we have been working with AMSR-E data and we already have land cover/land use maps and ancillary data.

C. "**Hydrological models and data assimilation**"

From hydrologic viewpoint, soil moisture controls the portioning of rainfall into runoff and infiltration and therefore has an important effect on the runoff behavior of catchments. An accurate assessment of the spatial and temporal variation of soil moisture may therefore be useful for improving the predictive capability of runoff models and for improving and validating hydrologic process representations. Nevertheless, concepts of how to integrate macroscale soil moisture data into hydrologic models are however still vague (*Scipal el al., 2005*). Classically, soil moisture observations are not used directly to address hydrologic problems such as runoff prediction, drought monitoring and flood forecasting, but are used in assimilation schemes of land surface hydrologic models or to constrain vegetation atmosphere transfer models.

Sales issues are among the factors to be addressed, since scale is one of the key subjects in hydrologic applications. In the ideal case, process scale, model scale and the measurement scale are compatible, but in reality this is not the case. Soil moisture is spatially and temporally highly variable, and several authors showed that the variability is driven by vegetation, soil type and topography and that that the spatial scale of soil moisture is of the order of tens of meters. Studies support also the two scale concept with a small scale component influenced by vegetation, soil type and topography on the range centimeters to hundreds of meters and a large scale component influenced by climatic conditions and atmospheric events such as precipitation and radiation acting on scales of kilometers and larger. It is therefore necessary to understand the scale dependency of processes as well as of the input data. This overall subject is not trivial and first of all a detailed bibliographic search and analysis will be done.

Another important subject is the study of the relationship between soil moisture and hydrometric parameters. When soils are close to saturation, runoff will be much higher compared with the situations when soils are dry. However, given the different nature of parameters, it can be expected that no linear relationship exists, but that a more complex interaction between the processes has to be considered. This is one of the issues to be studied, that is the relationship between soil moisture and hydrometric parameters (*Scipal et al.2005*).

It is also necessary to evaluate hydrologic models to be able to determine those models that are better suited to integrate/assimilate soil moisture information. If models area not adequate, soil moisture may offer no improvement in runoff estimation (*Goodrich et al.*, 1994).

The size of La Plata basin and the complexity of the subjects mentioned above, require that these subjects be analyzed first in rather well known sub-basins where we have reliable field data.

In addition, different assimilation techniques exist that correct the inputs and outputs of the models being able to contribute to model forecasting capabilities (*Auber et al., 2003, Crow et al., 2009, Troch et al., 2003*). This is an issue in itself.

At this stage, this is only an enumeration of the challenges foreseen ahead.

Finally, it is of great importance the Integration of Hydrological Information in a Geographical Information System. The assembly of hydrological data sets is the first step in applying these in hydrological analysis, but due to the spatial nature of hydrological processes it is essential that they be organized in a coherent way. The incorporation of gridded data into a geographic information system (GIS) context must give special attention to the co-registration of point data (discharge gauging stations or the location of reservoirs, water uptake, pollution sources, etc.) to gridded river networks. One advantage of linking different data sets within GIS is the ability to identify inconsistencies in the different data layers (*Wagtendonk et al, 2007*). This constitutes one of the anticipated tasks which considering the size of the basin, it is a major task that requires personnel investments and time.

References

1. D. Aubert, C. Loumagne, L. Oudin, “Sequential assimilation of soil moisture and streamflow data in a conceptual rainfall-runoff model”, *Journal of Hydrology*, 280, 2003.

2. W.T. Crow, D. Ryu, “A new data assimilation aopproach for improving runoo prediction using remotely-sensed soil moisture retrievals”, *Hydrol. Earth Syst. Scie*., 13, 1-16, 2009

3. P. Ferrazzoli and L. Guerriero, ``Passive microwave remote sensing of forests: a model investigation", *IEEE Trans. Geosci. Remote Sensing*, vol. 34, pp. 433-443, 1996.

4. D.C. Goodrich, T.J. Schmugge, T.J. Jackson, C.L. Unkrich, T.O. Keefer, R. Parry, S.A. Amer, “Runoff simulation sensitivity to remotely sensed initial soil water content”, *Water Resources Research*, vol 30, no, 5, May 1994

5. Hamilton, S. K., S. J. Sippel, and J. M. Melack (2002), Comparison of inundation patterns among major South American floodplains, J. Geophys. Res., 107(D20), 8038, doi:10.1029/2000JD000306

6. T. J. Jackson, R. Bindlish, M. Cosh, W. Crow, T. Colmes, P. E. O’Neill, “Development of a Soil Moisture Product Using Aquarius/SAC-D Observations”, presented at the 5TH Aquarius / SAC-D Science Meeting, 21-23 October, 2009, Buenos Aires, Argentina

7. K. Scipal, C. Schef, W. Wagner, “Soil moisture-runoff relation at the catchment scale as observed with course resolution microwave remote sensing”, *Hydrology and Earth System Sciences*, 9, 173-183, 2005.

8. Sippel, S.J., Hamilton, S.K., Melack, J.M., and Novo, E.M.M., 1998. Passive microwave observations of inundation area and the area/stage relation in the Amazon River floodplain. International Journal of Remote Sensing, 19: 3055-3074.

9. P.A. Troch, C. Paniconi, D. McLaughlin, “Catchment-scale hydrological modelling and data assimilation”, Preface, *Advances in Water Resources*, 26, 2003.

10. A.J. Wagtendonk and R. A.M. De Jeu, “Sensible Field Computing: Evaluating the Use of Mobile GIS Methods in Scientific Fieldwork”, *Photogrammetric Engineering & Remote Sensing* Vol. 73, No. 6, June 2007, pp. 651–662.