PARANA RIVER DELTA 2013 FLOOD AS SEEN BY AMSR-2, SMOS, AQUARIUS AND SAR SYSTEMS

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FRAMEWORK

The Paraná-Paraguay corridor (Fig. 1), is the larger sub-basin of La Plata basin, with 1,800,000 km^2. It has an extended floodplain consisting mostly on wetlands, from the Pantanal to Paraná River Delta.

Paraná-Paraguay floodplains provide irreplaceable ecological and hydrological functions such as:

- mitigating large floods and droughts
- recharging aquifers
- supplying high quality fresh water.

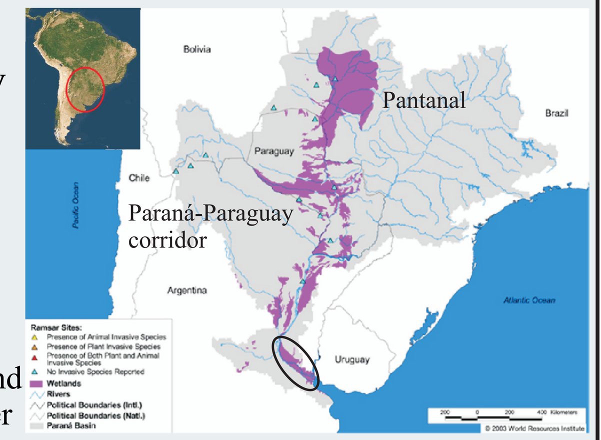

Fig. 1. Paraná River sub-basin and Paraná River Delta. Paraná River Delta is circled in black.

MOTIVATION

- Flooding is of major concern in the Plata Basin.
- Floodplains densely populated (70 million), and cultivated: one of the richest agricultural regions in South America.
- Losses by floods in Argentina during the 1983, 1992, 1998, 2007 and 2009-2010 episodes exceeded USD 1 billion each.
- Providing information on the current state of the basin hydrologic system on a systematic basis is critical to the regional economies and society.
- Any improvement in monitoring or prediction will have significant societal benefits.

OBSERVED EVENT

In April-June, 2013, strong rains fell over the upper Paraná Basin (South of Brazil and North-East of Argentina), leading to the occurrence of a moderate flood wave that reached the lower Paraná Basin (including Paraná River Delta) on July, 2013

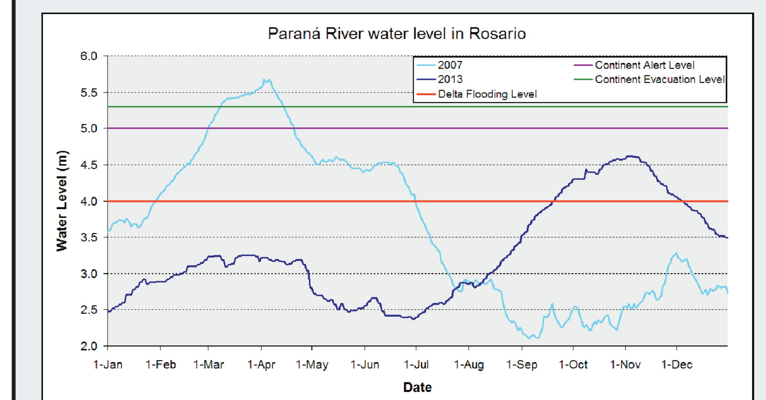

Fig. 2. Paraná River water level measured in Rosario Port.

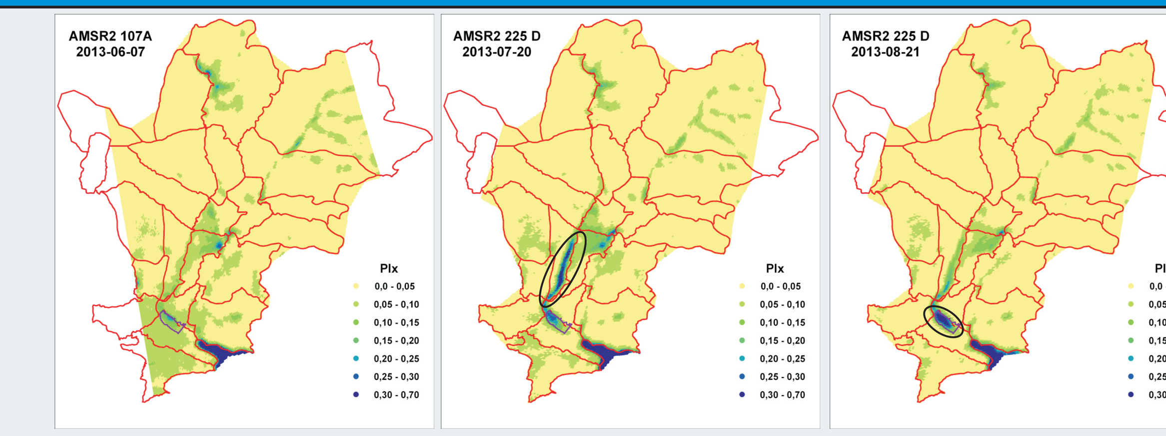

Fig. 3. La Plata Basin as seen by AMSR2 in 3 moments of the observed event. Left: before the event started. Center: flood wave in middle Paraná floodplain. Right: flood wave in Paraná River Delta.

PARANA RIVER DELTA

Paraná River Delta is a herbaceous wetland (less than 20% forest) that covers 17,000 Km^2, located at the final 300 Km of Paraná River.

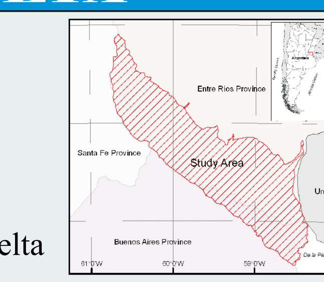

Fig. 4. Paraná River Delta

The objective of this work is to compare the capabilities of Aquarius, SMOS and AMSR2 data to estimate the fraction of flooded area inside a wetland, in combination with Cosmo Skymed data. The overall goal is to analyze floodplain behavior linking the dynamics between water level and flooded area.

DATA and METHODOLOGY

Sensor	Data used	Dates	Variable obtained
Aquarius (L Band)	L2 V2 Tb	2013/05 - 2013/11	$PI = \frac{2(Tb_V - Tb_H)}{(Tb_V + Tb_H)}$
SMOS (L Band)	SCLF1C Tb	2013/05 - 2013/11	PI (35 to 45º average)
AMSR2 (C, X and Ka Bands)	L1B Tb	2013/05 - 2013/11	PI
Cosmo Skymed (X Band)	HH σ^0	2013/07/05, 2013/07/25 2013/08/10, 2013/08/30 2013/09/15, 2013/10/08 2013/08/30, 2013/11/05	Flooded area maps
Auxiliary data	Water level in Rosario Port, Land cover map		
Emission model	Ferrazzoli and Guerriero, 1996		

Heritage algorithm and previous work

(Sippel, 1994; Hamilton, 2002; Ferrazzoli 2010; Salvia 2011)

$$1 = f_w + f_{nf} + f_f$$

$$PI_{obs} = f_w PI_w + f_{nf} PI_{nf} + f_f PI_f$$

$$f_f = \frac{PI_{obs} - f_w PI_w - (1 - f_w) PI_{nf}}{PI_f - PI_{nf}}$$

Flow chart of proposed algorithm (adapted from Salvia *et al.*, 2011)

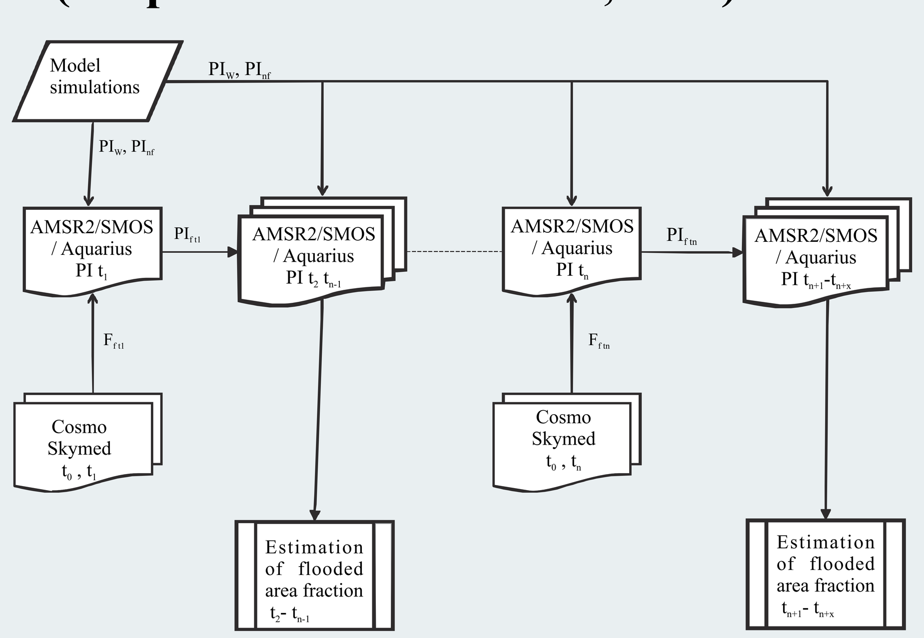

Fig. 5. Flowchart of proposed algorithm.

Algorithm hypothesis

H.1. PI_w, is known (estimated from model simulations).
H.2. f_w is constant and known (0.197).
H.3. PI_{nf}, must be a constant value and can be estimated, in our case, from model simulations.
H.4. PI_f, must be a constant value, have a negligible dependence on flood condition and can be estimated from images.

H.4 is not valid in our study area (Salvia et al., 2010), since the increase of water level reduces the emerged vegetation, causing a decrease in emission but an increase in PI

RESULTS

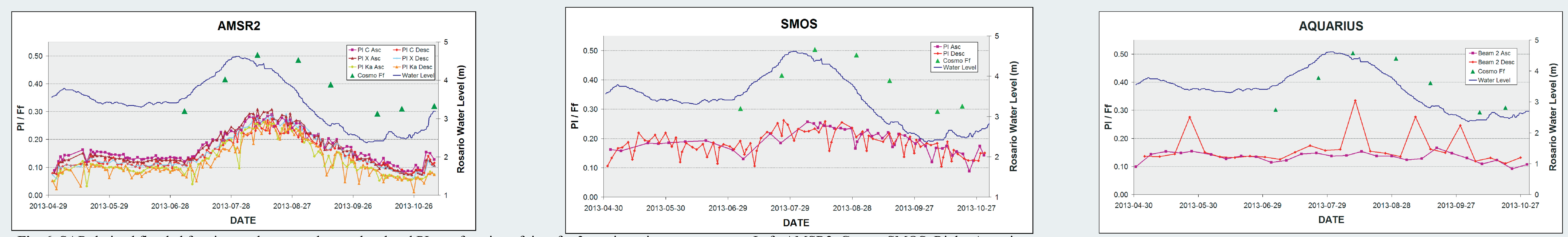

Fig. 6. SAR derived flooded fraction and measured water level and PI as a function of time for 3 passive microwave sensors. Left: AMSR2, Center: SMOS, Right: Aquarius.

- AMSR2 derived PI shows a good agreement with flooded area fraction estimations from Cosmo Skymed higher resolution SAR images.
- Both PI and FF follow the trend of river water level, but show a delay of approximately 10 to 15 days.
- Higher frequencies are noisier (Ka band is noisier than X and C bands).

- Even though SMOS data are much noisier than AMSR2, we can still see some agreement between PI and flooded area fraction estimated from Cosmo Skymed data, especially in the case of Ascending passes of SMOS.
- Descending passes are noisier than ascending passes (although this could be an effect of the different amount of available data.

- Aquarius data show low sensitivity to flooded area fraction from Cosmo Skymed data.
- This could be due to footprint size, that causes observed PI to include a range of continent/wetland area ratio.
- Descending passes are noisier than ascending passes.

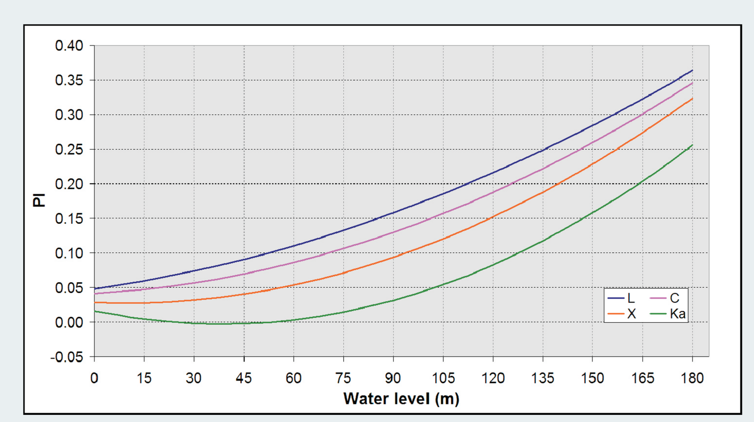

Fig. 7. Emission model results. For each frequency PI values for wl=0 and wl=180 are used as PI_{nf} and PI_w respectively.

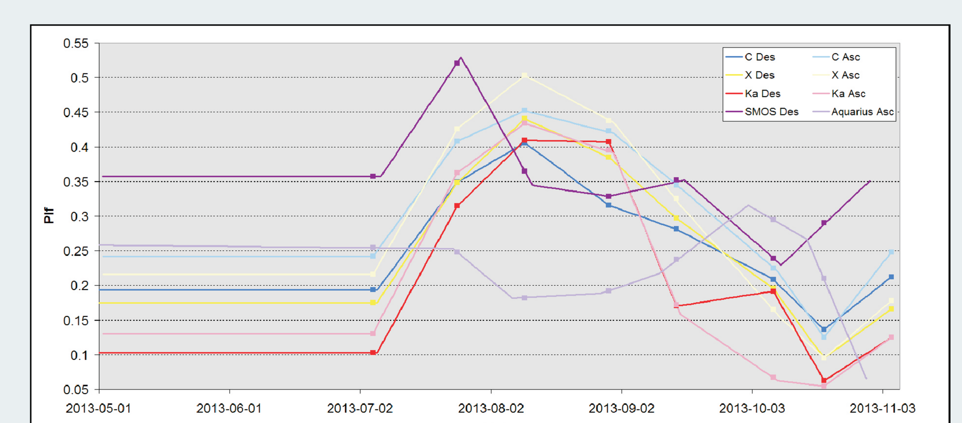

Fig. 8. Linear interpolation of estimated PI_f (lines). PI_f for dates of Cosmo availability are marked with squares.

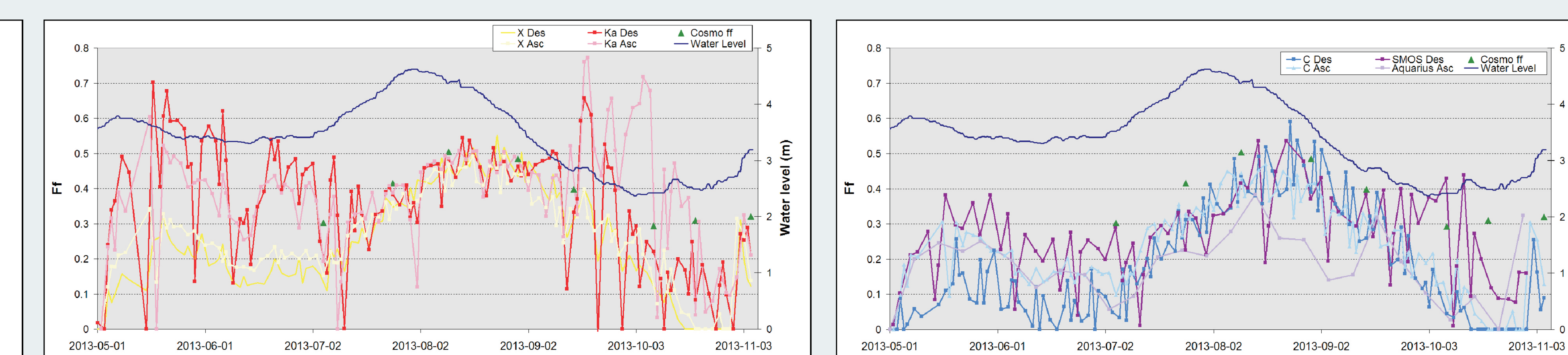

Fig. 9. Estimated fraction of flooded area (f_f) for AMSR2 (Ka, X and C bands), SMOS (L band) and Aquarius (L band). Cosmo based f_f and Paraná River water level are shown for comparison. Zero values of ff are set when algorithm resulted in negative values.

- Estimated and interpolated PI_f shows good agreement for C and X bands of AMSR2, as well as between ascending and descending passes, Ka band estimation shows differences on this trend from september on. This could be due to the fact that Ka band observed PI is much noisier than C and X band data.
- In the case of Aquarius, PI_f shows a decrease in the dates of higher Cosmo ff instead of the expected increase. This could be due to the large footprint size, as explained previously.
- In the case of SMOS, PI_f shows a strong increase at the begining of the event (for date 2013-07-25), but then PI_f decreases to previous values, showing low sensitivity to the progression of the event.

- AMSR2 derived f_f shows good agreement with Cosmo f_f from July to September. Much noisier f_f estimations previous to July could be due to the assumption of constant PI_f. Estimated values from September on do not follow the trend of Cosmo derived f_f, showing that our linear interpolation of PI_f could be an oversimplification.
- SMOS derived f_f shows a similar trend to the described for AMSR2, but is much noisier all over the study period, as was expected from noisier observed PI with lower sensitivity to flooding.
- Aquarius derived f_f show lower values along the whole study period, they show some agreement with Cosmo derived f_f at the begining of the event, but they diverge after the flooding peak (end of August).

CONCLUSIONS and FUTURE WORK

- The proposed algorithm applied in this work showed good results for AMSR2 at the rising stage of the flooding event. However, further work is needed on the falling stage, since estimated ff values deviate from those obtained with Cosmo Skymed higher resolution SAR images.
- In particular, we are considering a more refined interpolation method for PI_f, this could greatly improve our results.
- More detailed preprocessing might be needed for SMOS data to better avoid RFI induced noise.
- Given the large footprint of Aquarius, a preprocesing scheme to eliminate continental influence is needed.
- Future work will also include the use of distributions for the input parameters instead of their mean values.
- The use of combined L band active/passive data from SMAP is promising for the overall goal.