Preliminary Results of Seasonal Surface Water in Coatzacoalcos, Grijalva-Usumacinta, Panuco and Papaloapan low eco-hydrological regions in Mexico.

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Abstract

In this study we propose study four hydrological ecoregions near the Gulf of Mexico: Grijalva-Usumacinta, Panuco, Coatzacoalcos, and Papaloapan. These regions have different hydrology and these ecoregions have a high degree of flooding. Sentinel 1A images were used from 2015 to 2016, considering that the water surface may be detected by radar images. We obtained the water masks for each month, for 2015 and 2016. The results shows the seasonal behavior of water bodies and the most recurrent variation of areas affected by flooding during the 2015 year. The study shows the spatial-temporal behavior of the form, size, distribution of water bodies that allows for the description of rivers, connectivity and analysis of drainage patterns. We present preliminary results of seasonal surface water.

Introduction

Grijalva-Usumacinta, Papaloapan, Coatzacoalcos and Panuco are the most important hydrological systems in Mexico, and have at least one main permanent river and a system with several lagoons that cover the land surface. The rainy season gives way to the hurricane period, but this season may be early or late; for the study sites, the rainy season is considered to be from July to October. These ecoregions has a high degree of Flooding. Many of the data are reported in historial archives of each state. (only as a written report). This work shows advances in the field of water body monitoring with radar images. The identification of water bodies and the frequency of inundation were obtained by processing images periodically captured by Sentinel-1A during 2015. To monitor resources, we need to develop studies on the specific ecosystems in each region. The new technologies such as the Sentinel missions, give us valuable information for superficial water body monitoring. The Sentinel-1A images have a great potential to address problems in the Mexico country, which are expressed and have an effect on the territory's characteristics and dynamics.

Objectives

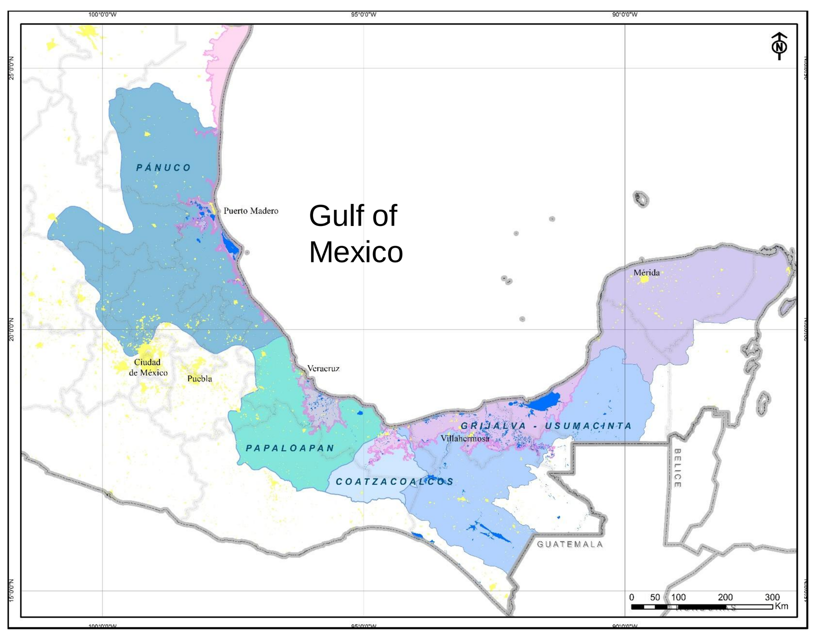
*Developing monthly and annual maps, annual water variation maps, and maps of anomalies (risk events).

*Working on automated water body segmentation algorithms.

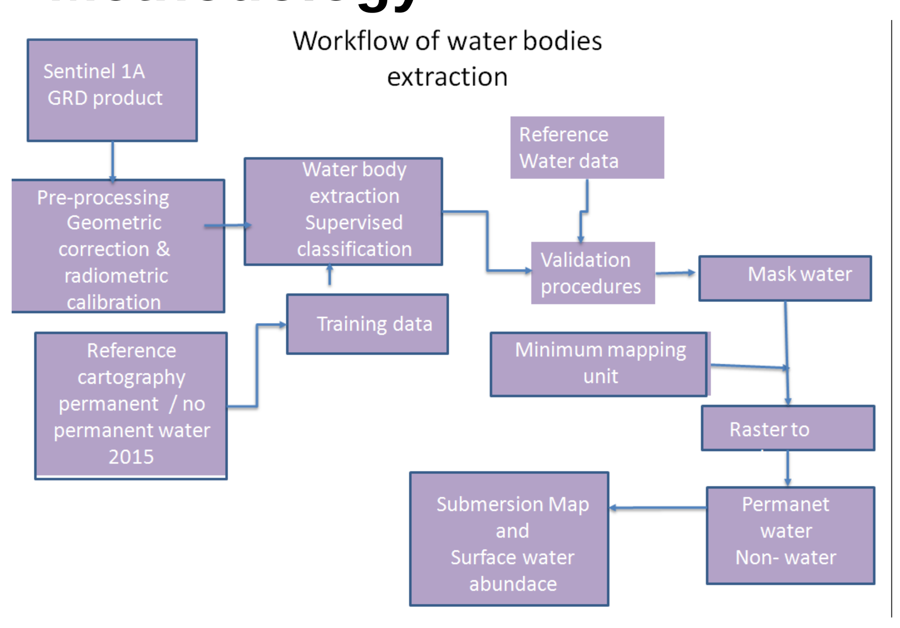
*Integrating this information into hydrological and climate change models.

*Show that radar technology (Sentinel-1A) is within reach and is useful in Mexico's water bodies knowledge.

The Freshwater Ecoregions of the world.



Methodology



The SAR data were obtained from the server of the Copernicus Open Access Hub.

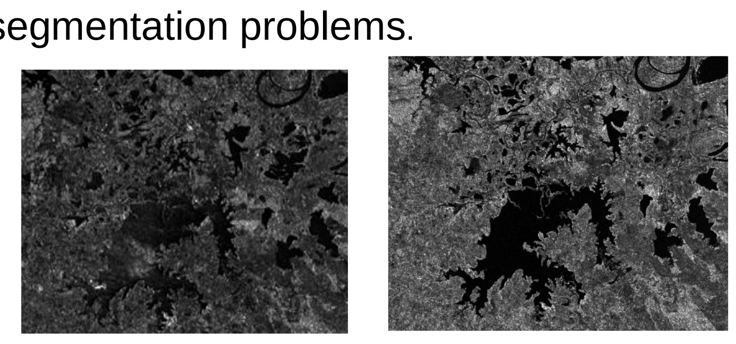
Reference Data.

i) Global 3-second Water Body Map (G3WBM) (November 2015) [37] is a global scale high-resolution water body map using multi-temporal Landsat data. This cartography shows the water body distribution at a global level, with a spatial resolution of 90 m.

ii) The cartography of water bodies was obtained from INEGI –Mex data (2015).

The radar's response in water bodies may be detected because there is a high land/water contrast and backscatter. The extraction of information was done using the Support Vector Machine algorithm in an automated manner. Before the segmentation process, the images were pre-processed and work was done using backscattering coefficients.

For the segmentation process, we took into account: the problems to delineate the water bodies due to the effect of shadows in the mountainous areas surrounding the water body, the wind's effect, the presence of aquatic vegetation that modifies the radar's return signal and produces unusual tones in the image, classification problems due to humidity gradients at the edges of lakes and sediments, and over-segmentation problems.



The frequency time Py (w) is an average of the monthly mean of water surfaces Py, m(w) expressed in percent of year

$$P_{y,m}(w) = \left(\frac{1}{N_{y,m}}\sum_{t=1}^{N_{y,m}} w_{y,m,t}\right) x100$$

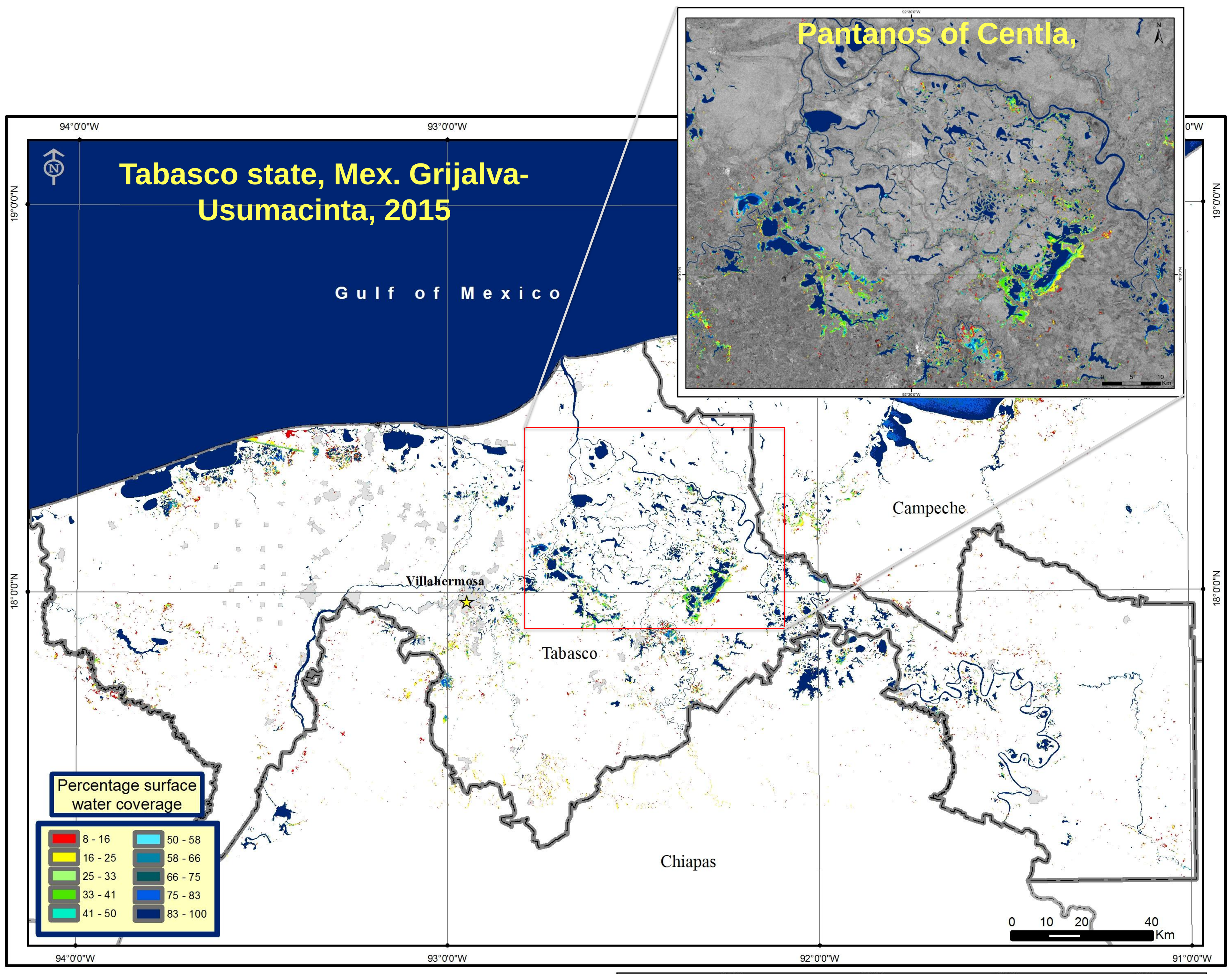
where,

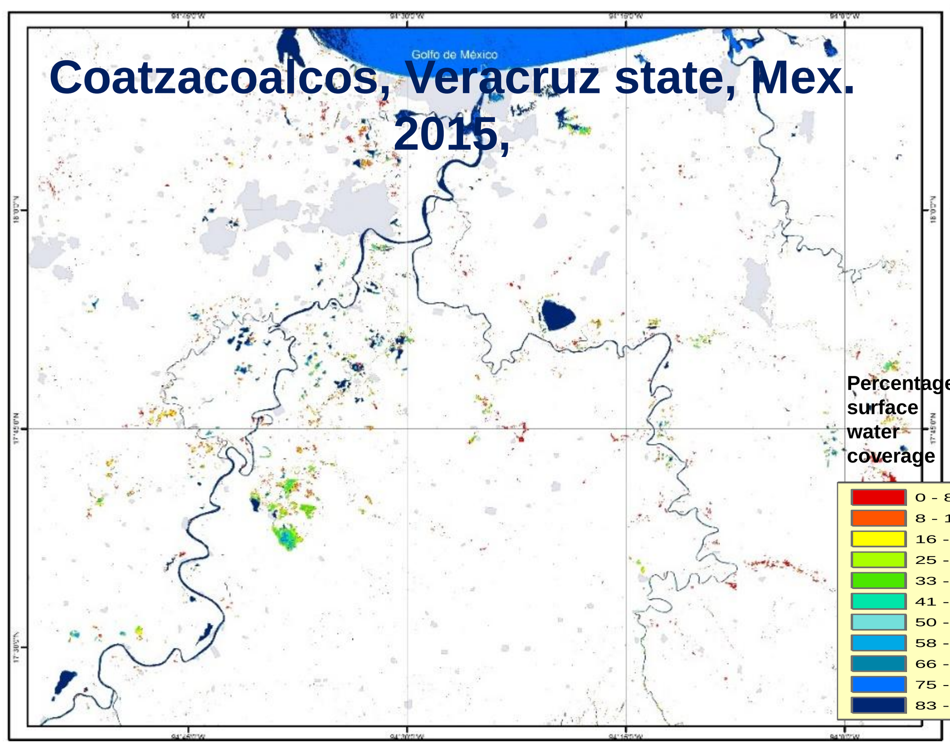
m: month of the year; y: year;

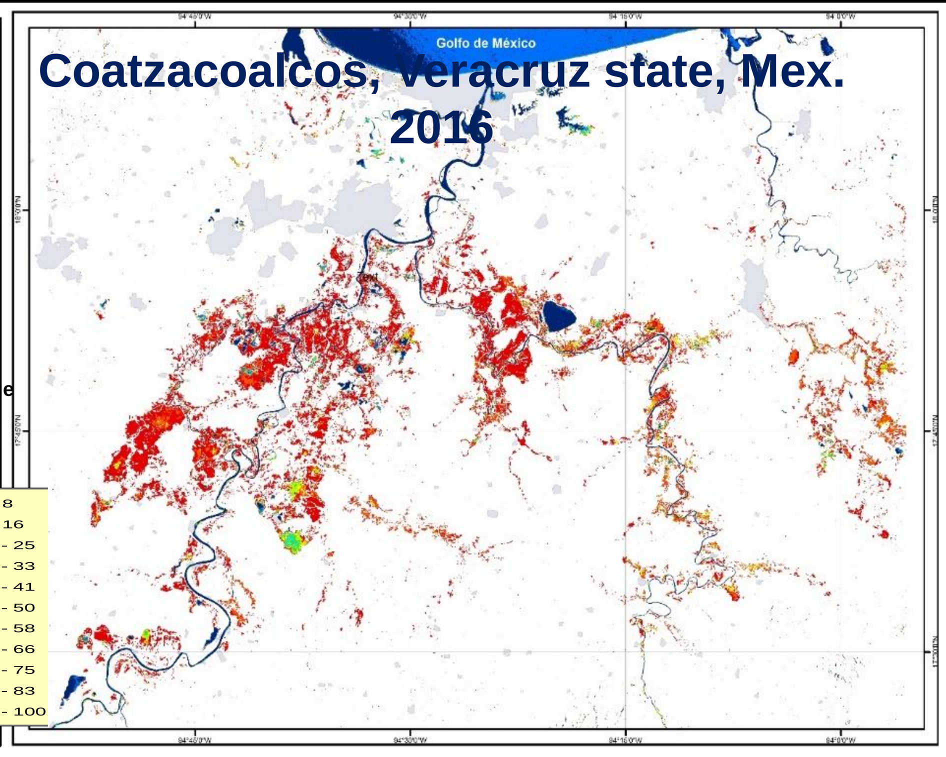
Ny,m : number of water extent layers of the month m of the year y number of pixels identified as water (Ny,m =12);

w y, m, t: pixel value of the water extent layer extracted from Sentinel 1A data for the month m of the year y; with t∈[1;nm] and

w(m,t)∈{0,1}; t : resolution of the data.







Accuracy Segmentation

Tables 1 and 2 present the results from the validation of the classifications based on confusion matrices and the kappa index. As can be seen, the kappa was in all cases very high, 0.92 for the comparison against INEGI-MEX data and 0.97 for the comparison against G3WBM water body maps.

Table 1: Confusion matrix of the water / non-water classification using Sentinel radar data and adjusted INEGI's 2015 land cover data as reference data.

Marzo 2005		Reference data: Non-water	Reference data: Water	Totals	% Commission error	Estimated kappa
Predicted class	Non-water	172937	12875	185812	6.9	0.88
	Water	2416	229618	232034	1.0	0.97
	Totals	175353	242493	417846		
	% Omission error	1.4	5.3			

Overall accuracy: 96.34 %, Kappa Statistic (standard): 0.92

Table 2: Confusion matrix of the water / non-water classification using Sentinel radar data and G3WBM version 1.2 DAI water body maps as reference data.

Marzo 2005		Reference data: Non-water	Reference data: Water	Totals	% Commission error	Estimated kappa
Predicted class	Non-water	292013286	3230447	295243733	1.1	0.97
	Water	5943121	301431080	307374201	1.9	0.96
	Totals	297956407	304661527	602617934		
	% Omission error	1.9	1.06			

Overall accuracy: 98.47 %, Kappa Statistic (standard): 0.97

Tables 3 and 4 present the results from the validation of the classifications based on confusion matrices and the kappa index. As can be seen, the kappa was high, 0.92 for the comparison against DAI water body maps. For the comparison against INEGI-MEX data the kappa index was very low although the overall accuracy was 80.86%

Table 3: Confusion matrix of the water / non-water classification using Sentinel radar data and adjusted INEGI's 2015 land cover data as reference data.

Marzo 2005		Reference data: Non-water	Reference data: Water	Totals	% Commission error	Estimated kappa
Predicted class	Non-water	22	115	137	83.9	0.12
	Water	0	464	464	0	1.0
	Totals	22	579	601		
	% Omission error	0	19.86			

Overall accuracy: 80.86 %, Kappa Statistic (standard): 0.29

Table 4: Confusion matrix of the water / non-water classification using Sentinel radar data and G3WBM version 1.2 DAI water body maps as reference data.

Marzo 2005		Reference data: Non-water	Reference data: Water	Totals	% Commission error	Estimated kappa
Predicted class	Non-water	1134502	4676	1139178	0.41	0.91
	Water	5030	50198	55228	9.1	0.90
	Totals	1139532	54874	1194406		
	% Omission error	0.4	8.5			

Overall accuracy: 99.18 %, Kappa Statistic (standard): 0.91

The supervised classification technique was adequate, as shown by the results section. The procedure had very good performance (kappa >0.9, and overall accuracy >90%). This is relevant considering that it was applied to a flatland area with a dynamic hydrological regime composed of many lakes and rivers formed by rainfall and runoff. Using this technique, the

Conclusion

The results of this study show the potential for monitoring superficial water bodies, providing basic information for planning land and water management as well as other activities such as flood control programs.

The study shows the spatial-temporal behavior of form, size, distribution of water bodies that allows for the description of rivers, connectivity and drainage patterns.

Because of the ecological, economic and cultural importance of these regions in Mexico, this preliminary analysis allows us to make progress in terms of inputs for hydrologic and climatic models. The potential for monitoring water bodies and their seasonal behavior and definition of flood zones may help epidemiological surveillance of dengue and cholera.This type of analysis allows us to help communities by making information available to them, with respect to the behavior of their neighboring water bodies in terms of the increases or decreases in their extension and storage capacity.

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