# Floods in the Pampas: Insights from over a decade of satellite observations

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## Introduction

The Argentine Pampas form a wide subhumid eolian plain that experiences episodic flood events covering a significant fraction of the landscape for months or even years (Fig. 1), notably affecting the economy of this highly cultivated region (Aragón et al., 2010).
We explore the relative importance of possible hydrological pathways and the associated type of flood dynamics, from slow groundwater-driven ones to faster surface-water-driven flood episodes, by analyzing the spatio-temporal pattern of the Pampas floods together with other datasets of the water cycle during the 2000-2013 period .

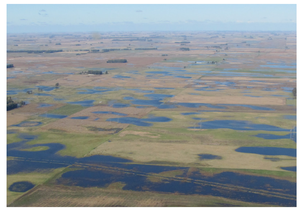

**Figure 1.** Flooded landscape in the Pampas.

## Main findings

The Pampas display sporadic flood cycles, 2 majors episodes in the last 14 years:
♦ 4 years (2000-2004), up to 30%-cover ← ~515-mm PPT anomaly (20 months)
♦ 13 months (2012-2013), up to 15%-cover ← ~330-mm PPT anomaly (8 months)

**Regional heterogeneity**
Western Pampa (groundwater-connected) // Lower Pampa (surface water-driven)

**Flood modes**

*Landscape with high hydrological connectivity ("Sandy" western Pampa)*

Large water excess, > several months → Lagged water table rise → Long-sustained flood (several years, up to 15% cover)

*Flood-prone Pampas in general*

Extreme water excess (weeks to months) → Surface water accumulation → "Flood pulse" (weeks to months, up to 30% cover)

## Outlook

♦ Flood risk anticipation and monitoring in the Pampas can benefit from remote sensing tools, together with a more extensive network of phreatic wells.

♦ Corresponding annual precipitation excesses were either unprecedented or exceptional (two occurrences) over the last century → is it only the rain?

♦ Where floods highly connect to groundwater dynamics (e.g. Western Pampa): potentially large impact of land-use/management ?

♦ Climate feedbacks of flood episodes ? (e.g. Jobbágy et al., poster H41C-0810)

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## Data sets & methods

**Surface water cover**
Threshold criterion applied to MODIS BRDF/albedo product MCD43A (500x500 m$^2$, 8-daily): if albedo < 0.09 → water-covered pixel. Spatially aggregated to give an area percentage and preliminarily evaluated against LANDSAT-derived estimates (30x30 m$^2$, few scenes a year).

**Terrestrial water storage**
Liquid water equivalent from the Gravity Recovery and Climate Experiment (GRACE, 1ºx1º, monthly), averaged between the release products (RL05) from CSR, JPL and GFZ.

**Evapotranspiration**
8-daily estimate at 1x1 km$^2$ resolution: empirical funcion using MODIS NDVI (from MOD09Q1) and surface temperature (MOD11A2) (Di Bella et al., 2000), restricted to non-flooded pixels.

**Precipitation**
Daily estimates from the Tropical Rainfall Measurements Mission (TRMM) Multisatellite Precipitation Analysis (TMPA) at 0.25ºx0.25º resolution (3B42V7).

**Groundwater depth (GWD)**
Regional monthly estimate using the averaged in situ GWD variation rates from 6 sites with long-term records, propagated from a reference GWD value.

## Study region - Flood map

600000 km$^2$, low elevation (< 200m) and flat topography (0.1%-slope).
Rainfall decreases from NE (~1100 mm/yr) to SW (~800 mm/yr).

Widespread intermittently-flooded areas // very scarce permanent water bodies → 700 km-long WNW-ESE corridor with 50000 km$^2$ flooded at least once

Focus on two widely flooded subregions: **Western Pampa** and **Lower Pampa**

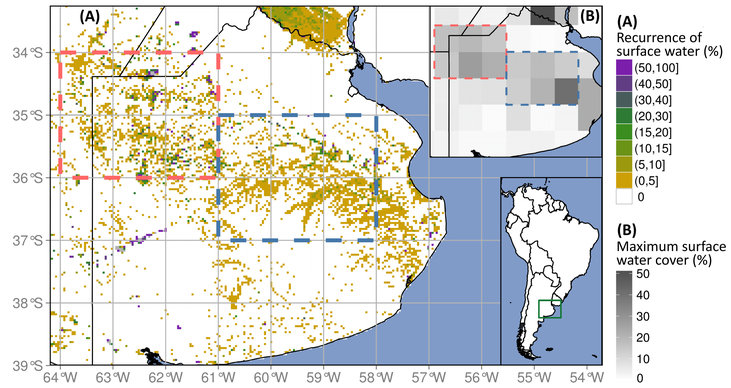


**Figure 2.** Study region. **(A)** Recurrence of surface water (500m x 500m resolution), as the relative time span under flooded conditions throughout the period Mar. 2000 – Dec. 2013. **(B)** Maximum surface water cover at 1ºx1º resolution during the same time period. The focus regions are delimited by the dashed red (Western Pampa) and blue (Lower Pampa) lines.

## Results

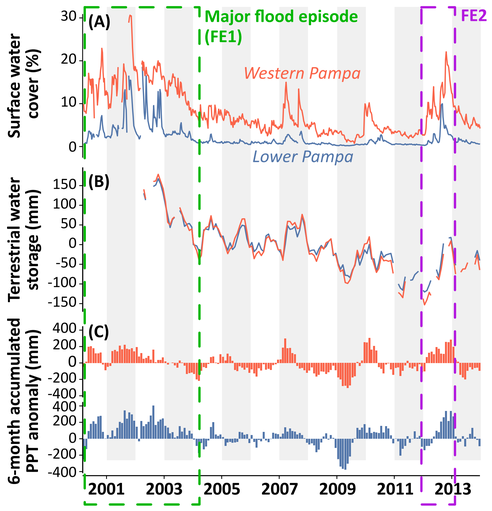


**Figure 3.** Time series of **(A)** surface water cover from March 6, 2000 to December 27, 2013 in the focus regions (Fig. 2), **(B)** terrestrial water storage (Apr. 2002 - Dec. 2013) and **(C)** 6-month-accumulated precipitation anomaly (current month + 5 preceding ones, with Mar. 2000 - Feb. 2014 as reference period).

**Figure 4.** Relation between the monthly-averaged surface water cover and terrestrial water storage. The recorded chronological sequence is shown during the main flood events (FE1 & FE2, Fig.3).

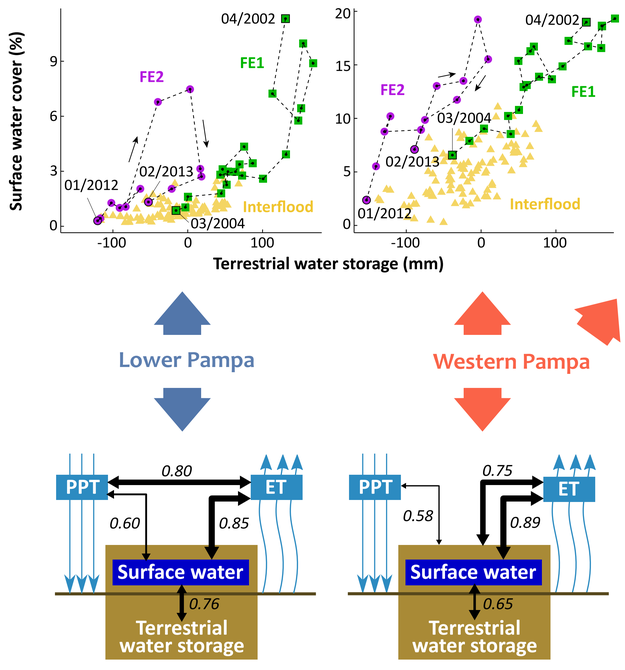


**Figure 5.** Statistically-significant connections between the components of the regional yearly water cycle. The thickness of black arrows is proportional to the Spearman's rank correlation factor.

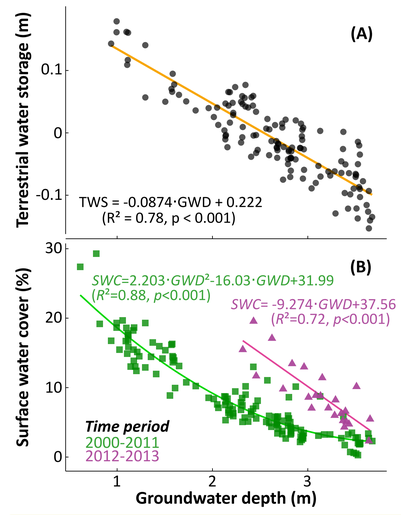


**Figure 6.** Relation between the groundwater level in the Western Pampa and **(A)** terrestrial water storage and **(B)** monthly surface water cover.

**Literature cited**

Aragón et al., Surface and groundwater dynamics in the sedimentary plains of the Western Pampas (Argentina). *Ecohydrology*, 4, 433–447 (2010).
Di Bella et al., Evapotranspiration estimates using NOAA AVHRR imagery in the Pampa region of Argentina. *Int. J. of Rem. Sens.*, 21, 791–797 (2000).