
**Submission code: RP7JRLXK0V**

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# Correlation of GRACE-FO data and water levels in monitoring wells of northern Paraná Basin

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## Abstract Summary

This work investigates the temporal correlation between groundwater storage data estimated by GRACE satellites and water levels in wells of the RIMAS network in the northern portion of the Paraná Basin. The datasets were integrated both spatially and temporally for each well, and the results were evaluated using linear regression, which yielded Pearson and $R^2$ correlation coefficients. Approximately one-third of the wells exhibited a strong correlation between the analysed variables.

## Introduction

Gravity satellite data have contributed to detecting temporal variations in the Earth's gravitational field, aiming to study regional and global groundwater dynamics [Lakshmi, 2016]. The Gravity Recovery and Climate Experiment (GRACE) and GRACE Follow-On (GRACE-FO) space missions reveal changes in groundwater volume [Scanlon et al., 2021]. However, these analyses often rely on aggregated variations from groups of wells and gravimetric data, as demonstrated in Renna Camacho et al. [2023], indicating a need for more focused and localized studies using individual well assessments. This study investigates the potential correlation between temporal variations in groundwater levels from 76 wells in the Bauru-Caiuá and Guarani aquifers, located in the northern portion of the Paraná Basin, and gravimetric satellite data related to groundwater storage.

## Method and/or Theory

This research is on two datasets: groundwater level measurements from wells, provided by the Serviço Geológico do Brasil (SGB-CPRM) through the Rede Integrada de Monitoramento das Águas Subterrâneas (RIMAS) project [Mourão, 2009], and terrestrial mass variation data supplied by NASA in partnership with the German Research Centre for Geosciences (GFZ), processed by the Center for Space Research (CSR) at the University of Texas. These datasets are used within the Global Land Data Assimilation System (GLDAS), which has integrated satellite information and ground-based observations since 2001. The system aims to develop models of land surface states and fluxes, providing a wide range of hydrological data with a spatial resolution of 0.5° [Rodell et al., 2004]. The Total Water Storage (TWS), estimated by GLDAS, represents the total variation in stored water based on the difference between two consecutive GRACE satellite overpasses, including the groundwater fraction. By using the GLDAS Land Surface Model (Catchment Land Surface Model) [Rodell et al., 2004], which subtracts other water storage components—such as soil moisture, snow and ice, and surface water in rivers, lakes, and vegetation—from total water storage (TWS), we can determine the temporal variation of Groundwater Storage (GWS). To spatially and temporally align the datasets, we developed a Python script that identifies the geographically closest data point for each well and performs temporal merging with a 5-day latency. Based on this integration, we calculated correlation coefficients (Pearson and $R^2$) using linear regression applied to crossplot graphs that compare well water levels and GWS values. The wells were then ranked according to their respective correlation indices.

## Examples

Well 3100020033 serves as an example of highly correlated data, with a Pearson correlation coefficient of 0.85. The corresponding time series and crossplot, shown in Figure 1, illustrate a strong correlation between the well water level data and the estimated Groundwater Storage (GWS) values.

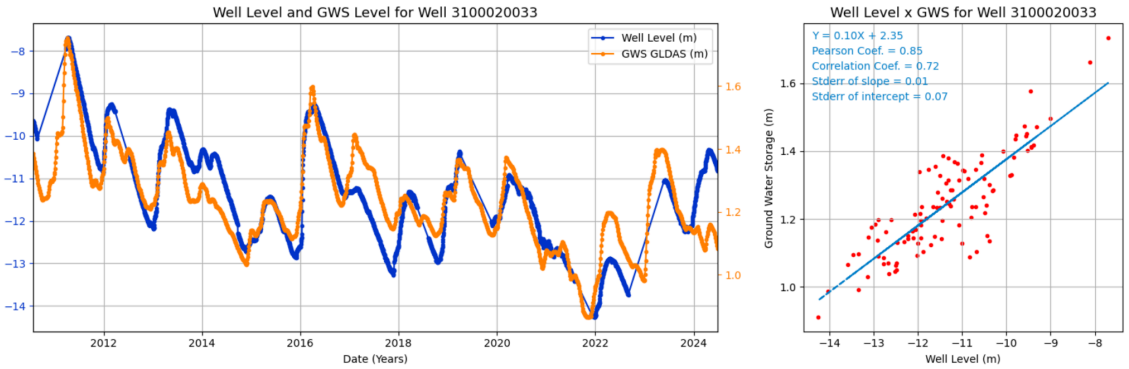


**Figure 1:** Time series and crossplot for well 3100020033, with data from 2010 to 2024.

## Results

Based on the ranking derived from the coefficient of determination ($R^2$) values, it was found that only one-third of the wells showed values within the 0.5 to 1.0 range. Most of these wells are located in the Bauru aquifer and the Bauru or Caiuá formations, which account for 31 of the 43 wells with a Pearson correlation coefficient greater than 0.5.

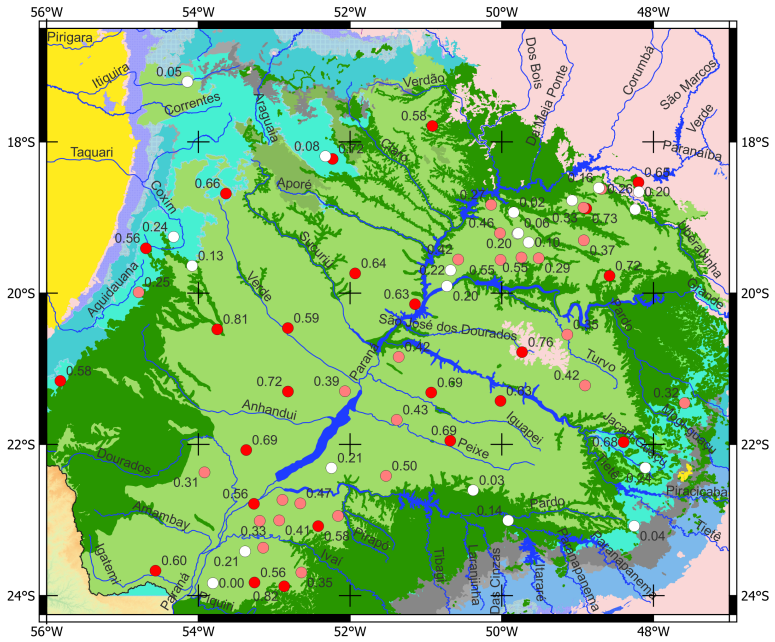


**Figure 2:** Location of the wells with the corresponding values of the Pearson coefficient calculated for each of them. In red, values greater than 0.5; pink for the range between 0.25 and 0.5; and white for the range between 0 and 0.25.

## Conclusions

The results indicate that the wells generally exhibit a low correlation. However, the spatial distribution of wells with higher correlation suggests a potential influence of local geological characteristics, particularly in the Bauru and Caiuá formations on the right bank of the Paraná River. For these correlated wells, the regional variation captured by GRACE-FO is confirmed at specific locations. The linear regression coefficient for these wells serves as a proxy for the specific storage coefficient required for recharge evaluations. Specific yield is a crucial parameter for groundwater models, enabling recharge estimates based on water level variation data. This specific yield can be independently verified against previous recharge studies and the mean porosity properties of the aquifer systems, as determined by direct sampling or geophysical well-logging data.

## Acknowledgments

This research is being conducted with the support of the Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP), Brazil. Process n°2024/14862-9. And support from the Department of Geophysics at IAG-USP.

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