Using active sensors in hydrogeomorphological modeling through landscape analysis in Brazil

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Geographic Information Systems and spatial analysis models are constantly being implemented in geomorphological and environmental studies. The recent advances in remote sensing using active and passive sensors brought important techniques and products which improved the spatio-temporal data quality for geological models. Landscape analysis has always been considered an essential step during the construction of conceptual models, and nowadays, it is also relevant in numerical models. As landscape characteristics reflect by any means the geological features and the soils, combined with climatological variations, we can extract valuable proxies that can be used in hydrogeomorphological models. Such models usually combine geological and geomorphological knowledge with at least the understanding of hydrological attributes such as hydrographic patterns, groundwater dynamics, precipitation, evapotranspiration, and land use and land cover changes. Fortunately, several of these elements can currently be analyzed and/or estimated by remote sensing, supported by in situ measurements. Some remote sensing products are essential for Brazilian studies, e.g., the Tropical Rainfall Measuring Mission (TRMM) to estimate precipitation patterns and the Moderate Resolution Imaging Spectroradiometer (MODIS) to estimate evapotranspiration, quantify land surface characteristics and monitor atmospheric properties. Besides all these well-known remote sensing products, active sensors such as LiDAR and radar are critical to map and model with a suitable topography on different scales.

Radar products have earned attention with some worldwide surveys, such as the NASA’s Shuttle Radar Topography Mission (SRTM) and the JAXA’s Advanced Land Observing Satellite-1 (ALOS) with the PALSAR’s L-band synthetic aperture radar. In Brazil, we also have a project called TOPODATA (INPE) that produced a topographic/geomorphologic countrywide database based on SRTM data. These data are being successfully implemented in geologic numerical models, especially the tridimensional ones since the model’s top layer is often the topography. Considering regions where unconfined aquifers occur, especially with shallow water levels, the watershed delimitation is a key-information to define hydrogeological model boundaries, and usually, there is an essential relation between drainages and aquifers, with the water flowing from one to another. Accordingly, these radar-specific applications are related to the superficial portion of the water system.

On the other hand, active sensors such as radars can be applied to map the bottom boundaries of
aquifer systems, especially shallow aquifers, since these limits are usually related to lithological contacts: a more permeable rock type (or soil) and a less permeable (or impermeable) material. The differences in permeability may also follow significant differences in erosion resistance, and in these cases, we may see a distinct slope, usually a steeper terrain. In our study, we assess the use of radar products to map the bottom boundary of a shallow unconfined aquifer (Rio Claro Aquifer, southeastern Brazil) and validate against in situ data, such as outcrops showing the lithological contact and springs revealing the groundwater dynamics that corroborates with the conceptual model. The results show the reliability of using active sensors and slope analysis to support hydrogeological models since the conceptualization of water resource systems to tridimensional numerical modeling.