Meta-data

General Meta-data

Title: Potentially navigable rivers in South America

Keywords: Rivers, Navigation, Infrastructure, Waterways, Accessibility

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Geographical Meta-data

Data-Format: GeoTIFF (Byte - Eight bit unsigned integer)

Coordinate-Reference System: WGS84

Spatial Resolution: 0.00416667 x 0.00416667 (degrees)

Encoding: UTF-8

Spatial Extent: *xmin: -93°, ymin-56°, xmax:-32°, ymax: 15°*

Dimensions: X: 14640 Y: 17040

Bands: 1

Data-Description

I. Summary

These two data-sets contain potentially navigable rivers for small and medium-sized boats in South-America depending on the topography, rainfall and potential evapotranspiration. Hence, it is an approximation of the location of navigable rivers, not an actual map of hidroways. Navigability is defined by the extent of a river which in this case (1) for small boats accounts to ~5-15 meters minimum extent and (2) for medium-sized boats ~30-40m meters minimum extent. The model data was parametrized and validated with high-resolution land-cover data from high-resolution satellite images.

II. Description of utilized input data and processing steps

Step 1: Creation of a corrected accumulated flow map

The base-data for this map is an accumulated flow map from the HydroSHEDS project (Lehner et al., 2006) in the same resolution an extent as the final data-set. The HydroSHEDS map exhibits values for flow accumulation based on a drainage model derived from topographic data. The flow accumulation is expressed as the sum of cells that are affluent to any given grid-cell. Hence, downstream cells of a river show higher values whereas upstream cells show lower values.

To correct this map with climatic information, a global map for Soil-water balance from CGIAR was used (Trabucco and Zomer 2010). This map shows average yearly soil water content (1950-

2000) which is a function of precipitation and potential evaportranspiration. Both raster maps where brought to the lowest possible resolution and minimum spatial extent (both based on the HydroSHEDS data). Then both rasters where multiplied, which results in a corrected accumulated flow map, where moist regions show higher values for (corrected) accumulated flows than dry regions.

Step 2: Sample River locations from remote-sensing data

Data containing the location of water-bodies based on Landsat (~30x30m resolution) and Rapid-Eye (~5x5m resolution) was obtained. The Landsat-based data was extracted from the PRODES project (INPE 2016) and covers waterbodies in the Brazilian Amazon region. The Rapid-Eye based data was obtained on request from the SEMA- Secretariat of the Environment in Acre/Brazil. The latter is limited to the state-boundaries of Acre in the Western Brazilian Amazon, which is advantageous because water-bodies represent in the great majority of cases natural rivers (no dams, no artificial lakes, no canals, etc.). Hence, a good match to the theoretical data from the accumulated flow mode is achieved.

From both data-sets small water-fragments where removed which are often either water holes for animal production or small natural lakes and parts of meandering rivers that where cut off at some point in time. Both data-set where rasterized on a 5km scale which creates a buffer around all rivers from the vector data. Than a random-sample from each rasterized data-set was taken with 650 river cell values. This sample comes in form of a point vector layer from that was then again buffered with a 5km radius. This buffer is used to account for the spatial miss-match between the sample locations and data from the hydrological model with a lower spatial accuracy. The buffer helps to cover at least some raster-cells from the model at any given sampling point.

Step 3: Extract flow values from sample-data and define a threshold to create a model of navigability.

The buffered layers from (2) were used to extract values from the corrected accumulated flow map for all sampling points. Those values cover theoretical rivers in the flow map as well as none-river areas. To get the flow-data from the rivers and exclude non-river values, the maximum of the cell-values within each buffered sampling point were extracted (which is always a river). The result is a vector of 650 randomly selected accumulated (and corrected) flow-values for both cases. These vectors are theoretical representation of (corrected) flow-accumulation in rivers that are detectable on Rapid-Eye data in Acre and Landsat data in the Brazilian Amazon. The low values within this distributions represent the thresholds where rivers of a 5x5m/30x30m extent can be still detected from the satellite images. However, since a lot of the parts of the upstream river areas are covered by dense rainforest's with forest crowns that span over the water-bodies, the actual extent of those rivers might be most closely to about 10-15 meters for Rapid-Eye data and 30-40 meters for Landsat-data.

Step 4: Choose adequate thresholds from the lower boundary to define which rivers are still navigable.

The last step consisted of creating new raster maps of navigable rivers based on different thresholds from the flow distribution vectors. Binary raster maps where created based on an ifelse condition that reclassifies values above that threshold to 1 and below to 0/NA. Four values where compared to serve as a threshold: The median, the first quantile, the first decile and the first ventile. These maps where than compared to high resolution satellite images from Googleearth (in most cases TerraMetrics data in 15m resolution) to see whether a river still exists where they were theoretically mapped. It was found that the first ventile is the most adequate representation for both layers, hence only the lowest 5% of values from the sampled points are excluded from the analysis. Furthermore, the river models were compared to deforestation data from the PRODES project (INPE,2016) and riverine settlements in Acre, where river-transportation determines how far into the forest settlers

can migrate. All results indicate a good fit of the model. Maps in the annex show the results of this visual comparison.

Notes:
The resolution of the presented data-set is very large especially for small rivers which influences the spatial accuracy of the data. It is a course approximation of where potentially navigable rivers are to be found rather than a high resolution map. Please compare this data to actually satellite imagery to understand the impact of this effect. Therefore, the present data-set can neither be used for fine-resolution mapping exercises nor can extent and length or a river be estimated correctly. To correctly map the extent and actual course of (often meandering) rivers, it is advisable to use high-resolution satellite images in combination with this data.
Furthermore, the reliable of the term navigable is higher in flat topographies that in mountainous regions due to waterfalls, fast currents, etc. Mapping of potentially navigable rivers could be improved by accounting for several additional factors that influence navigability such as deep topographic cuts that lead to waterfalls, sandbanks, climatic variability and others.

Code to replicate results

The code to replicate the results can be obtained on request.

Literature

Lehner, Bernhard, Kris Verdin, and Andy Jarvis (2006): "HydroSHEDS technical documentation, version 1.0." World Wildlife Fund US, Washington, DC (2006): 1-27. Published online, available from USGS at: https://hydrosheds.cr.usgs.gov/

Trabucco, A., and Zomer, R.J. (2010): Global Soil Water Balance Geospatial Database. CGIAR Consortium for Spatial Information. Published online, available from the CGIAR-CSI GeoPortal at: http://www.cgiar-csi.orgINPE (2016): Projeto PRODES: Montitoramento da Floresta Amazônica por Satélite.

Annex: Visual comparison of the model results with different thresholds

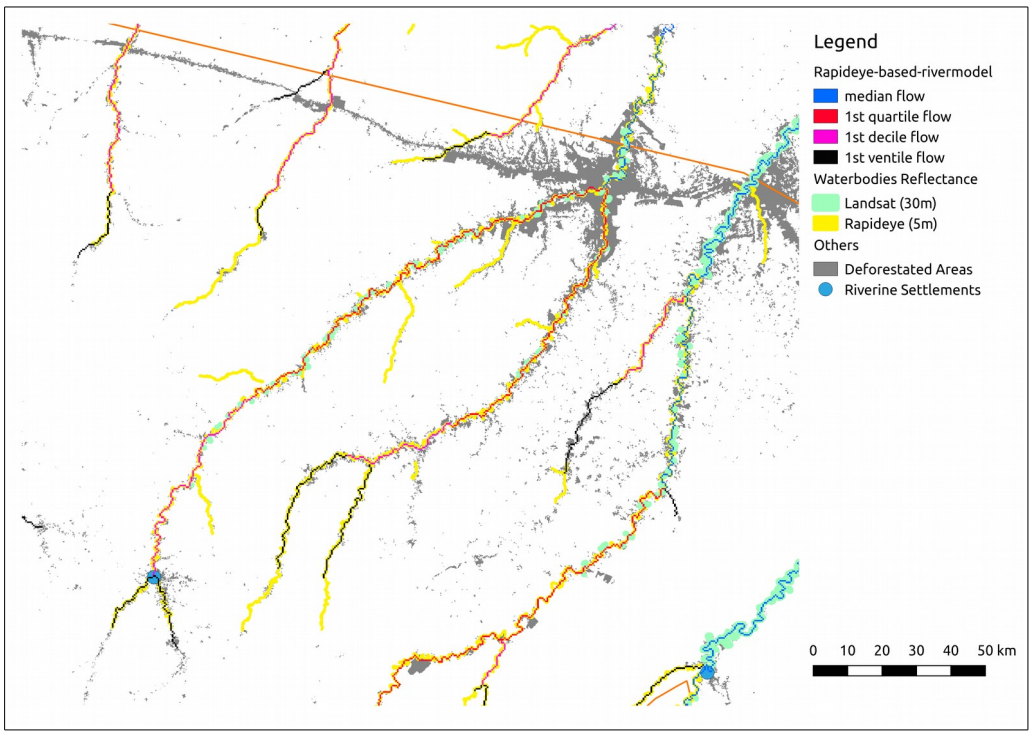

Illustration 1: Comparision of modeled data to Waterbodies from Remote Sensing and Deforestation data

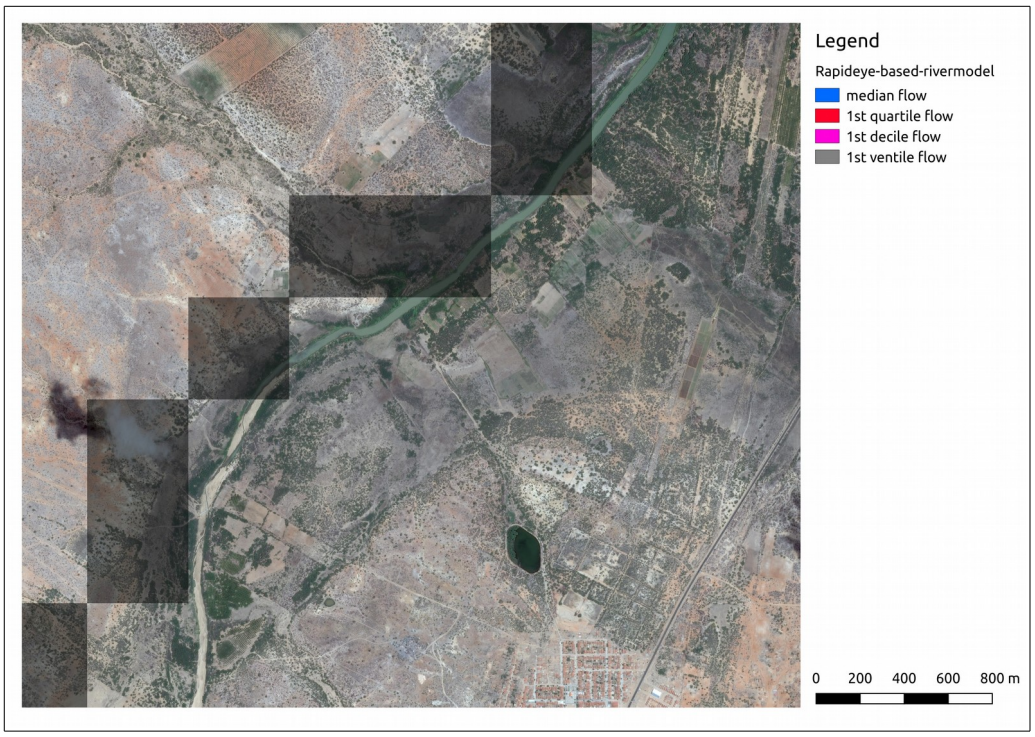

Illustration 2: Comparision of 1st ventile Flow to satellite images in the dry northeast of Brazil.Remark: This illustratios shows the end of a river of the 1st ventile flow model from Rapideye data which coincides with the end of a navigable river in the dry northeast of Brazil.