

River slopes, techniques, accuracy and limitations

Daniel Medeiros Moreira, Felix Perosanz, Stéphane Calmant, Fabrice Papa, Adrien Paris, Otto Rotunno and many others



.... GRGS, UFRJ, UEA, UFAM, UFPE, IPH, UFOPA, UNB, UFMG, HYDRO METTERS, ANA and many Other institutions are giving support

SWOT for SOUTH AMERICA (ST 2020-2023) PIs : Fabrice Papa (IRD) and Daniel Moreira (CPRM-Brazil)

- An integrated proposal dealing with the Water Cycle and Hydrology in South America in the SWOT context.
- Organized around 5 WPs, each with a French and a South American PI

WP1: <u>Hydrodynamics of the Amazon estuary</u> PI: Fabien Durand and Otto Rotunno Filho (UFRJ)

WP2: <u>Water storage variability in South America</u> PI: F. Papa, F. Frappart and J. Tomasella (CEMADEN)

WP3: Lake Storage in the Andean chain

PI: J.-F. Crétaux and Rodrigo Abarca (Conception-Chile)

WP4: <u>Amazonian floodplains hydrodynamics</u>

PI: M.-P. Bonnet and Jeff Ferreira (Mamiraua-Brazil)

WP5: SWOT Cal/Val for Hydrology in South America

PI: Adrien Paris and Juan Gabriel Leon (Cali U.-Colombia)



ACTIVITIES in preparation of CAL/VAL

40- FIELD CAMPAINGS , 40.000 km of river profiles surveyed .

+90 gauges leveled

OCPR









We are using 3 techiques to obtain rivers slopes

1- Levelling water level gauges with GNSS receivers;

2- Using satellite altimetry data;

3- Using receivers abord boats and floating devices (nappe);

All these techniques are depedent of the quality of the geoid model





Exaggerated differences between an ellipsoid, geoid, and earth's surface in this image from the USGS (Source: earthquake.usgs.gov).

GNSS DATA PROCESSING

The specific methodology that we have developed consists in using the boats cruising the rivers to collect the GNSS data that can be used in postprocessing (using CNES' GINS-PC software) to get a rapid, cost-effective leveling of the gauge with an accuracy at the 2 cm level, including taking into account the crustal deformation due to the hydrological loading. Note that this technique also provides an estimate of the local slope of the free surface. Until the launch of SWOT, priority will be given to the stations included in the swaths of the fast sampling phase. Leveling the rest of the stations

will be performed after the launch.





Hydrological Loading observed form GNSS permanent Stations and satellites













Slopes gaves by gauge levelling



Dados de régua (média mensal 2001-2009) - Declividade dos Rios Negro e Amazonas



Water level profiles (in meters)

Slope of water (cm/km)

Slopes gaves by satellite altimetry





SLOPES GAVE BY GNNS RECEIVERS ABORD BOAT AND NAPPE®







Slopes gaves by gnss receivers abord boats



Water level profiles (in meters)

Slope of water (cm/km)

Boat profiles give a lot of data (normally at 1 second sampling) it's necessary to filter signal from noise



COMPARISION WITH OTHER GEOID MODELS



EIGEN-6C4 is a high-resolution global gravity field model. It is one of the first EIGEN (European Improved Gravity model of the Earth by New techniques) combination model that includes GOCE data. Its role is fundamental in geodesy and Earth sciences and ranges from practical purposes, like orbit determination, to scientific applications, like the investigation of the density structure of the Earth's interior. The new EIGEN released in 2014 is called EIGEN-6C4 and has been created from a combination of a multitude of data (see International Centre for Global Earth Models Website http://icgem.gfz-potsdam.de/home).

16

14

DRTO_VELHC

2500



ALL SLOPES PROFILES ARCHIVED BY GNNS RECEIVERS ABORD BOATS HAVE A SINUSOIDAL BEHAVIOR



Difference on geoid Heights EGM2008 to EIGEN6C4



Dados GPS a 25km / Declividade dos Rios Negro e Amazonas



Dados GPS a 25km / Declividade dos Rios Madeira e Amazonas



.....like the path of Amazon rivers



-1.113193

due the geoid resolution limitation we are having some difficults to estimate the water surface with hydrodynamic consitence at flood plains



Difference on geoid Heights EGM2008 to EIGEN6C4

PARAGUAY RIVER CAL/VAL SITE (1,700 km of Paraguay river at SWOT 1 day orbit)





CONCLUSIONS

- Our kinematic GNNS abord survey methodology are very accurate and able to archive river heights at 2cm accuracy (at ellipsoidal height reference) over remote zones such Amazon basin.
- Unfortunatly have a lack of accuracy in geoid models specially over Amazon and Africa. We try to make geophysical/gravimetric surveys over Amazon to evaluate and even try to improve the geoid accuracy over some areas of Amazon basin.
- Due geoid model limitations we expect some difficulties for swot to achieve high resolution hydrologic consistent slopes, specially overAmazon and over more flat water surfaces.
- In opposite way, if lack of geoid accuracy at some zones can bring challenges to get hydrologic information, maybe some hydrologic information bring by swot (+models) can be used to improve geoid models over continents?