USGS SWOT ST Progress and Plans for FY 2017

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- Participate in SWOT Sagavanirktok (Sag) River Field effort.
    - **Suggestion for 2017 Sagavanirktok River Field Work** – Include the distributary channels where the river enters the Beaufort Sea in the measurements and discharge estimation. The Sag River splits into two main channels approximately 30 miles upstream from its mouth. The amount of discharge carried in each channel has been shifting over a period of years. It would be a good exercise to see if the flow estimates in each channel can add up to the flow in the single channel upstream, thereby confirming continuity in the estimates, and whether the proper distribution of discharge in each channel can be achieved. Dave Bjerklie has sent to Tamlin Pavelsky data measured in the two channels from 1987 to 1995 that can be used to evaluate the apportioning of flow in the two channels.
- Update HYDRoSWOT data base with slope information.
- Prepared draft paper on HYDRoSWOT data implications for generalizing the channel shape and flow resistance in the channel.
- Participate in SWOT ST meetings and Discharge Algorithm Working Group contributing to publications, calibration/validation (Cal/Val) activities, and develop work plans.
- Conduct systematic measurements of reach-based discharge from a small Unmanned Aircraft System (sUAS) to assist with the Cal/Val of SWOT-like measurements.
    - Deploy two, non-contact sensors from a sUAS to measure channel geometry and river metrics and compute reach-based discharge.
    - Sensors include FluidCam + MiDAR imaging system for measuring non-contact bathymetry and MEaSuRE for measuring surface-water velocities.
        - FluidCam is a passive, portable imaging system for remote sensing applications. It comes with a fully integrated onboard computing system to collect and process channel bathymetry utilizing a theoretical model and algorithm called Fluid Lensing. MiDAR is a next-generation, real-time, multispectral, active sensor for underwater imaging.
        - MEaSuRE is coherent, continuous-wave surface-velocity (CCW) radar for measuring surface-water velocities, which are translated into a mean-channel velocity using the Probability Concept, an efficient computational algorithm derived from Information Entropy.
        - River discharge is computed using the reach-based area provided from FluidCam + MiDAR and MEaSuRE.

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    - MEaSuRE flights will be conducted in Aug/Sep 2017, and MiDAR flights will be conducted in Feb 2018. All flights will be collocated at a USGS streamgage to provide truth data for stage, area (bathymetry and width), velocity, and discharge.
- Use Structure from Motion (SfM) and lidar from a sUAS to measure the hydraulic grade of a river reach. A test case was completed in Jan 2017, and data was processed for Fountain Creek, which is located in southeast Colorado, USA.
- Prepared draft of peer-reviewed journal article, *"SWOT-based River Discharge: Ground-truthing using the Probability Concept and Continuous-wave Velocity Radars."*
- Published a peer-reviewed journal paper on a new entropy methodology to estimate discharge based on surface-water velocities, which are influenced by secondary currents. Translating surface-water velocities into depth-averaged velocities that consider secondary currents could support the development of SWOT discharge algorithms. The "dip phenomenon" is a fundamental concept, which must be addressed when computing depth-averaged velocities and river discharge, and is quantified using the entropy procedure.
- Draft paper describing the capabilities of radar sensors for ground measurements of surface-water velocities and satellite observations for computing discharge by coupling the altimetry and the spectroradiometer from MODIS. River discharge was evaluated at ungaged sites using surface-velocity measurements in the absence of channel bathymetry. Surface-water velocities were used to initialize the entropy model, which allowed us to simulate the river bathymetry without a priori knowledge of the channel bottom. A sensitivity analysis was performed. To-date, the analysis has been conducted for two gage sites on Tiber River, Ponte Nuovo (4,100 km^2) and Po River, Pontelagoscuro (70,000 km^2). It is worth noting the latter is a candidate site of USGS SWOT ST, where a fixed-mount radar is planned to measure stage and surface-water velocities, and discharge for Cal/Val applications. Indeed, the analysis is also of considerable interest for developing strategies aiming to combine remote sensing products (e.g., MODIS and altimeters) and hydrologic models for estimating discharge at sites where the bathymetry is unknown.
- Improvement of the algorithm for estimating river discharge as the product of the mean flow velocity and area. The flow velocity is derived by multispectral sensors, whereas the flow area is estimated using water level data derived by radar altimetry data and the cross section geometry. The Po River exhibited good performance with respect to velocities derived by MODIS and MERIS, where the two satellites ENVISAT and SARAL overpass the river. Underestimates of discharge are due to the altimetry quality and the inability to capture peak flow is an issue that required further investigation due to the fact that during high streamflow events the optical sensors are not able to measure land/water features because of the clouds interference.
- Development of artificial neural networks (ANN) to assess river discharge by the joint use of optical and altimetry data. The availability of densified water levels derived from of multi-mission approaches and the deployment of different optical sensors (MODIS, MERIS and Landsat) within the ANN framework is demonstrated as a valid tool to estimate daily discharges that can be conveniently used for water resources management or for flood forecasting.