Hydro-sedimentary parameter measurements within the proglacial area of the Bossons glacier (France)

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This dataset presents hydro-sedimentary data within the Bossons glacier proglacial area. Bossons glacier is rapidly retreating and its proglacial area is deglaciated for ~ 30 years. It is an intriguing location to study periglacial, proglacial and subglacial erosion processes which requires estimating Total Dissolved Solid (TDS) and Total Suspended Solid (TSS) concentrations, and discharge. Measurements were performed at three distinct locations within Bosson glacier watershed : Bossons downstream (BDS), Bossons upstream (BUS) and Crosette (CRO). The latter is located at the glacier termini whereas BDS and BUS stations are farther downstream from the glacier, at 1.5 and 1.15 km, respectively

In 2009, TSS and electrical conductivity (EC) data were collected at BDS from July 1st to September 13th (75 days) by hand-made measurements every hour between 09h00 and 20h00 and by an automatic sampler (VIGILANT) every hour between 20h00 and 08h00. In 2010, TSS and EC data were collected at BDS from May 3rd to September 17th (137 days). From May 3rd to June 30th, data were acquired by hand-made measurements every 2

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hours between 09h00 and 20h00 and by an automatic sampler (VIGILANT) every 2 hours between 20h00 and 08h00. From July 1st 2010, data were collected every 3 hours by an automatic sampler (ISCO 3700). Each TSS sample was filtered with a void pump on preweighted filter made of glass microfiber Whatman (pore size 0.45 μm). Filter were dried, then took into oven and weighted again at the laboratory.

From July 1st to August 27th 2009, water height was measured on a scale every hour between 09h00 and 21h00. From August 27th 2009 to May 3rd 2010, then from October 22th 2010 to June 4th 2013, a pressure sensor (OTT Orpheus Mini) measured water level at the same location. Discharges between between May 3rd 2010 and September 17th 2010 were estimated from the empirical relation:

$$Q = 58.83 \cdot \sigma^{-1.292}$$
$$(R^2 = 0.9448,\ n = 1750)$$

where Q is the discharge in TDS in $\mathrm{m}^{-3}.\mathrm{s}^{-1}$ and σ is the EC in $\mu\mathrm{S.cm}^{-2}$.

Since 2011 a Campbell Scientific CR-800 logger is installed at BDS with a OBS-3+ turbidity sensor and a CS547A conductivy/temperature sensor with $\pm 2\%$ or 0.5 NTU (whichever the greater), and ± 5 % accuracies, respectively. A CS450 water height probe with a ± 0.1 % accuracy was added to the logger during June 2013 and the OTT Orpheus probe was retired.

Since June 26th 2013, a Campbell Scientific CR-800 logger is installed at CRO location with with a OBS-3+ turbidity sensor, a CS450 water height probe and a CS547A conductivy/temperature sensor with $\pm 2\%$ or 0.5 NTU (whichever the greater), ± 0.1 % and ± 5 % accuracies, respectively. At the same period, data teletransmission was set up both for CRO and BDS stations allowing day-to-day monitoring. Missing data during some winter month are linked to snow covering the solar pannel of the station, leading to power loss.

From May 6th to October 17th 2013, a Campbell Scientific CR-200 logger has been installed at BUS with a OBS-3+ turbidity sensor (same accuracy as above). Due to memory issues, data were lost between July 31st and August 24th.

Using rating curves, available direct measurements of EC, turbidity and water level can be used to estimate TDS, TSS and discharge, respectively. It is important to bear in mind that rating curves are a trade-off between direct, low frequency and indirect, high frequency measurements. Additionnaly, extreme values are often under-represented and estimations outside of the initial range of the calibration measurements are to be taken with caution. Anytime doubts arised about probe being clogged, frozen or fonctionning abnormally, data were cleaned accordingly.

Joint measurements of ionic content and conductivity were performed between May and September 2010 (covering low and high flow conditions). TDS measurements range from 2 to 22 mg.L^{-1} and conductivity measurements range from 6 to 55 μS.cm^{-2}. Data analysis gave the following relationship for TDS concentration:

$$[\mathrm{TDS}] = 0.656\,\sigma + 0.0725$$
$$(R^2 = 0.9874,\ n = 74)$$

where [TDS] is the concentration in TDS in mg.L^{-1} and σ is the EC in μS.cm^{-2}.

Joint measurements of TSS concentration and turbidity performed between July 17th 2011 and August 24th 2011 (covering low and high flow conditions). TSS measurements range from 0.001 to 0.57 g.L^{-1} and turbidity measurements range from 11 to 153 NTU. Data analysis gave the following relationship for TSS concentration:

$$[\mathrm{TSS}] = 0.002405\,T - 0.035098$$
$$(R^2 = 0.3633,\ n = 78)$$

where [TSS] is the concentration in TSS in g.L^{-1} and T in the turbidity in NTU. The rather low R^2 is counter-balanced by constrained confidence intervals on the slope of the relationship; t test value : 11.928 >> critical value.

Since turbidity measurements lower than 14.59 NTU have to be discarded from the dataset when using the previous relationship, a second fit was performed using turbidity data less or equal to 40 NTU and yielded the following relation :

$$[\mathrm{TSS}] = 2.579\,10^{-6}\,T^{2.78}$$
$$(R^2 = 0.9706,\ n = 71)$$

To ensure continuity, the relations are applied above and below, respectively, the intercept of the two curves : 17.806. These relations account for 78.5% and 21.5% of the dataset, respectively.

Material in the Crosette and Bossons stream are tought to have the same chemical and light scattering properties and the TSS and TDS rating curves were applied both at BDS, BUS and CRO .

Throughout the year 2009, 11 estimations of the discharge were carried out using salt dilution (n=16) or mechanical flow-meter (n=4) methods. The salt dilution gauging is based upon mass conservation and requires only to measure the mass of injected salt and the conductivity (Hudson, 2005). The mechanical estimation was performed using an OTT C2 current meter (propeller 2, 50 mm diameter) and an OTT Z400 digital counter. Each time, at least 5 velocity profiles were measured and discharge was evaluated from 12 to 38 points (mean : 20 points) during flow conditions ranging from 0.006 to 0.567 $m^3.s^{-1}$.

Analysis of these data stemed the following relationship :

$$Q = 2.917 \cdot 10^{-4} \cdot (H - 11.9)^{2.2787}$$
$$(R^2 = 0.9567,\ n = 11)$$

where H is the water level measured on the scale (in cm) and Q, discharge (in $m^3.s^{-1}$). Water level measurements lower than 11.9 cm have to be discarded from the dataset. The scale was set up in a stable environment (banks stabilized by boulders) and this rating curve was use to estimate discharge each year (2009-2014).

Flow condition at CRO measurement station are turbulent and prevent using a current meter. 15 discharges estimations were performed August 1st (n=9) and 18th October 2013 (n=6) (covering low and high flow conditions). Discharge was estimated following the dry injection methodology described in (Hudson, 2005). Laboratory calibration between conductivity and salt concentration yields a concentration factor of ~ 0.49. Conductivity was measured every seconds using a Campbell CR10X logger with a 247-L conductivy probe and injected salt masses were pre-weighted in the laboratory.

Analysis of the data yielded the following relationship:

$$Q = 0.06532 \exp(0.03823\, H)$$
$$(R^2 = 0.9955,\ n = 15)$$

where H is the water level measured on the scale (in cm) and Q, discharge (in $m^3.s^{-1}$).