Geomorphologic Impact of Outburst Flood Cycle in Braided Gravel-Bed Rivers: Confluence of Colonia and Baker Rivers, Patagonia, Chile

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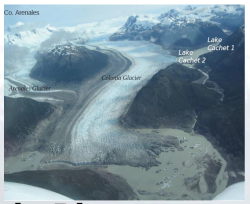
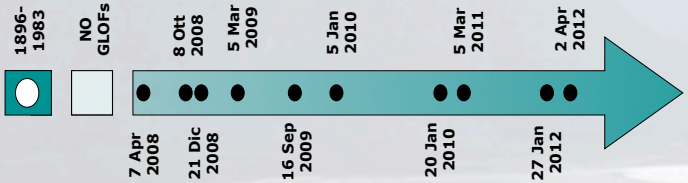
1 Glacial Lake Outburst Floods:

sudden and often catastrophic release of a considerable volume of glacial melt water, produced by the failure of an ice dam or by subglacial flow

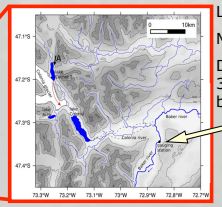


A NEW CYCLE OF GLOFs in Colonia River



AIM: to investigate changes of floodplain morphology due to extreme floods, using Colonia GLOFs as convenient case study ("field lab") monitored by ground & remote methods, and estimate (max) sediment flux via erosion/deposition data.

2 STUDY SITE



Modified from [1]

Characteristics of Rio Colonia:

Average discharge = 110 m^3/s

Length = 20 km

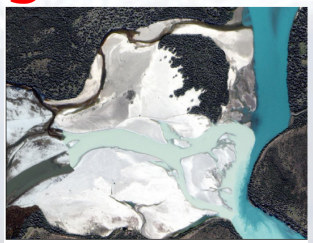
Maximum width ~1500 m

Discharge during GLOF ~ 3000-4000 m^3/s at Baker below Colonia (BbC) gauge

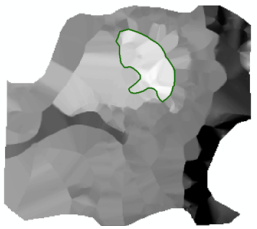
GLOF date	Q@BbC m3/s
7-Apr-08	3575
8-Oct-08	3007
22-Dec-08	3053
5-Mar-09	4114
17-Sep-09	3144
6-Jan-10	3014
21-Jan-10	2171
8-Oct-10	1100
5-Mar-11	2988
27-Jan-12	3746
2-Apr-12	3538

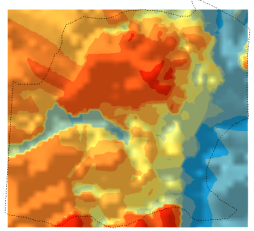
- US$7 billion mega dam project [2,3]: reservoir silting!
- GLOF frequency: opp. to study effects of extreme flows in Colonia River several times a year, which otherwise usually occur every hundreds of years in most rivers

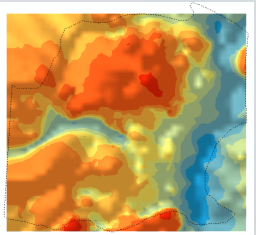
3 METHOD: confluence DTMs (IDW, kriging & TIN), for 2007, 2011, 2012



3 DATASETS: 2007 1-m contour lines (LiDAR); 2011 rtk-GPS; 2012 rtk-GPS

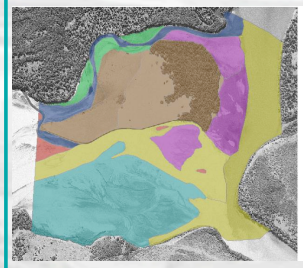

Island in IDW 2011

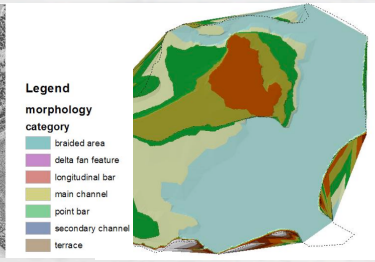

IDW 2011


kriging 2011

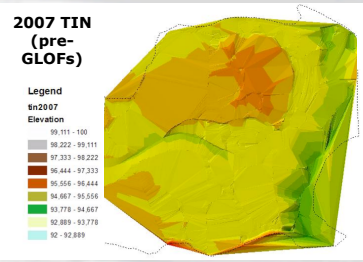
VALIDATION: using ground images, satellite imagery (ASTER)

4 RESULTS: morphology changes using DEMs of Difference & GCD [4]





2007 TIN (pre-GLOFs)



2011 TIN (after 7-8 events)

5 RESULTS: Erosion/deposition (GCD)

Morphological Features	Change Detection											
	Elevation Change m						Volumetric Change m^3					
	2007-2011				2011-2012		2007-2011				2011-2012	
	MinLoD 0.03m	error %	MinLoD 0.13m	error %	MinLoD 0.06m	error %	MinLoD 0.03m	error %	MinLoD0.13m	error %	MinLoD 0.06m	error %
Main Channel	-3.35	0.9	-3.44	3.78	-0.31	13.07	1,110,342	0.9	1,109,631	3.78	553	13.1
	0.68	4.4	0.84	15.39	-1.28	1.76	24,323	4.4	23,692	15.39	260,831.62	1.8
Secondary Channel	-0.8	3.8	-0.86	15.08	-0.11	37.17	33,897	3.8	33,707	15.08	30.99	37.17
	0.86	3.5	0.95	13.69	1.18	3.4	21,576	3.5	21,387	13.69	24,934	3.4
Braided Area	-0.42	7.06	-0.5	28.51	-1.32	3.03	35,676	7.06	34,446	25.81	31,380	3.03
	0.58	5.18	0.64	20.44	1.18	3.18	124,357	5.18	122,588	20.44	98,719	3.18
Bar	-0.53	5.71	-0.62	20.99	-0.61	6.51	12,150	5.71	11,844	20.99	442	6.51
	0.59	5.06	0.68	18.98	0.75	5.35	19,877	5.06	19,466	18.98	9,222	5.35
Delta Fan Features	-1.04	2.09	-1.12	11.56	-1.45	2.76	110,669	2.9	109,935	11.56	7,004	2.76
	0.38	7.83	0.44	29.6	3.67	1.09	19,650	7.83	18,972	29.6	206,349	1.09

2007-2011:

- net erosion, mostly in Colonia River main channel
- mean sediment transport ~$2.7x10^5$ m^3/y
- 7-8 GLOF events - if main transport agent, average of $1.5x10^5$ m^3 each

2011-2012:

- net deposition, mostly in main channel & delta fan
- mean sediment transport ~$5.6x10^5$ m^3/y
- 2 events, $2.8x10^5$ m^3 each if they transported most of the annual sediment

6 CONCLUSIONS

- After 40 years without GLOFs, confluence-stored sediment was eroded by initial GLOFs; subsequent events deposited sediment.
- This sequence of GLOFs is an ideal case to study the effect of different (and extreme) discharges on braiding [5], flood risk [1] and sediment flux.

ONGOING WORK

- River surveys, "frozen" palaeo-bars
- Suspended sediment monitoring, bedload
- Flood hazard analysis, palaeohydrology
- Floodplain vegetation studies [5]

[1] Dussaillant A, G Benito, W Buytaert, P Carling, C Meier, F Espinoza 2010. Repeated glacial-lake outburst floods in Patagonia: An increasing hazard? Natural Hazards 54 (2): 469-481
[2] Dussaillant A, Buytaert W, Meier C, Espinoza F 2012. Hydrological regime of remote catchments with extreme gradients under accelerated change: Baker basin, Patagonia, HSJ 57(8): 1530-42
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