Morphometric analysis and identification of debris-flow susceptible alluvial fans in the Philippines after the Koppu and Melor typhoon events

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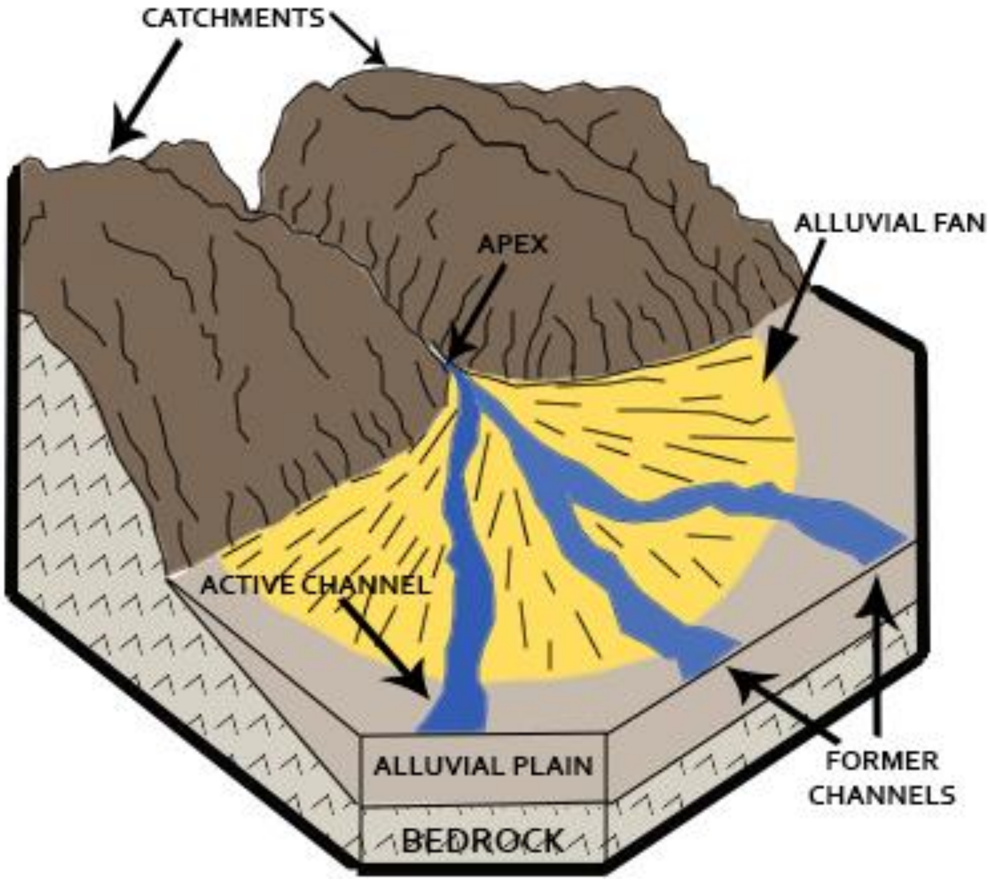
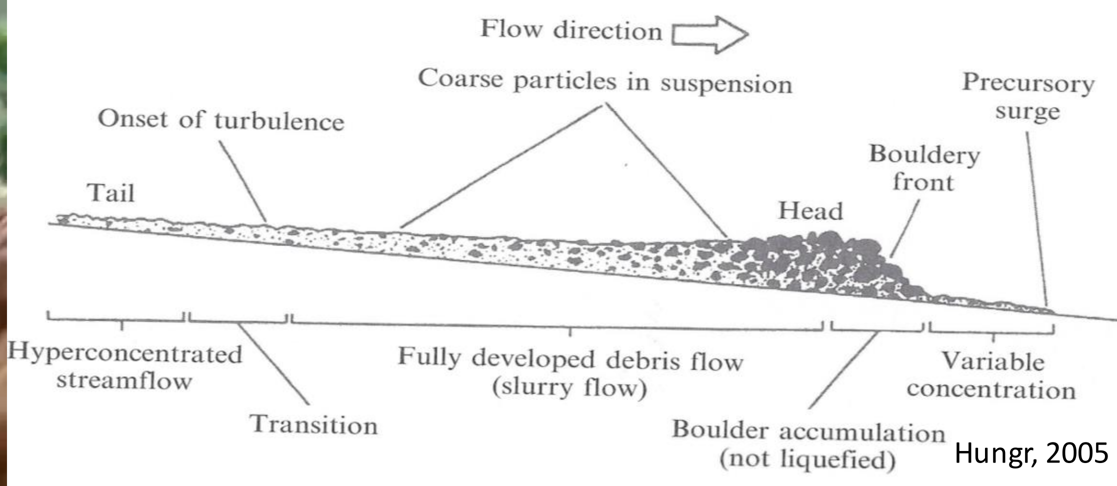
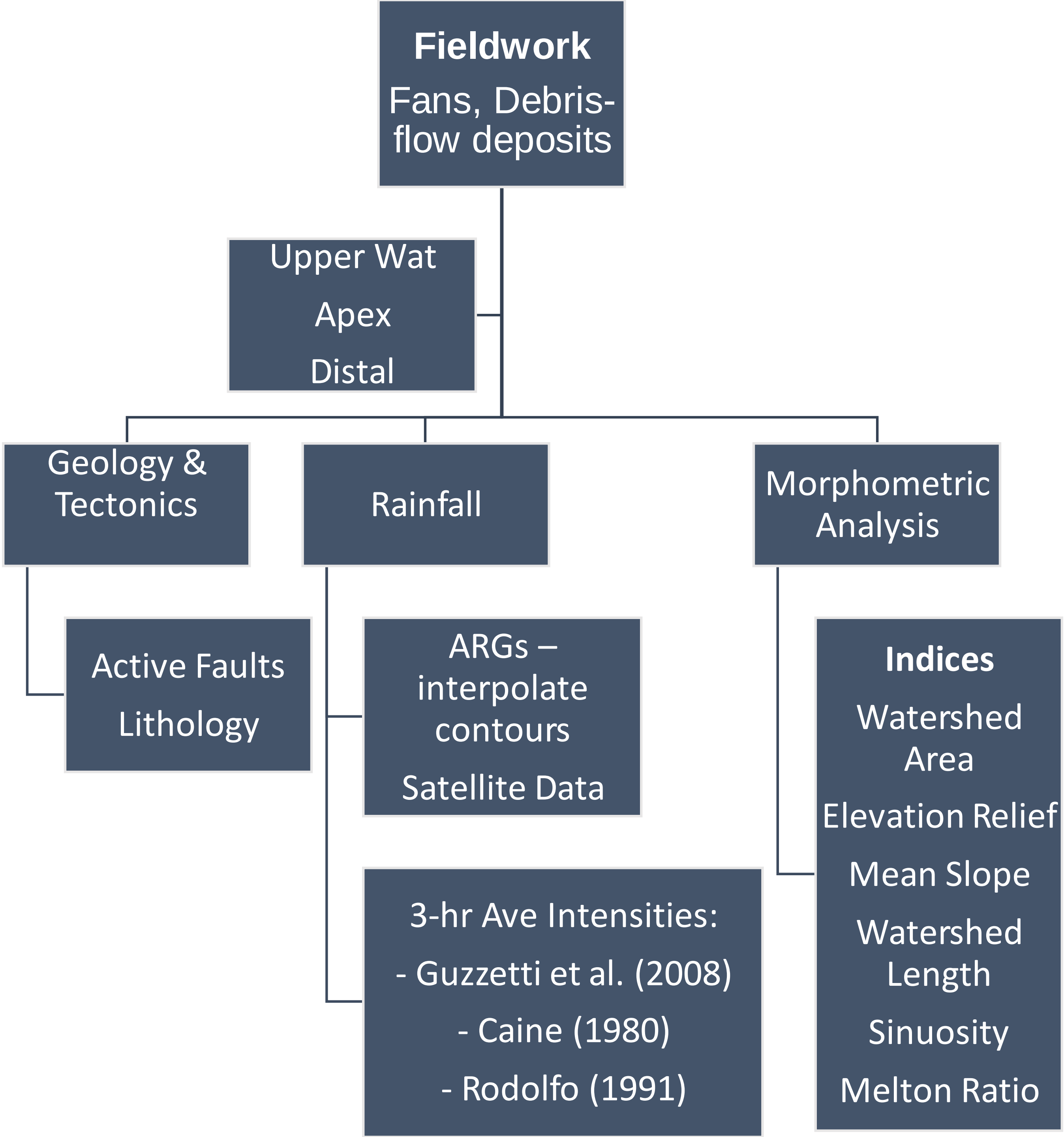


Adapted from Woods (2011) and Norini et al. (2016)



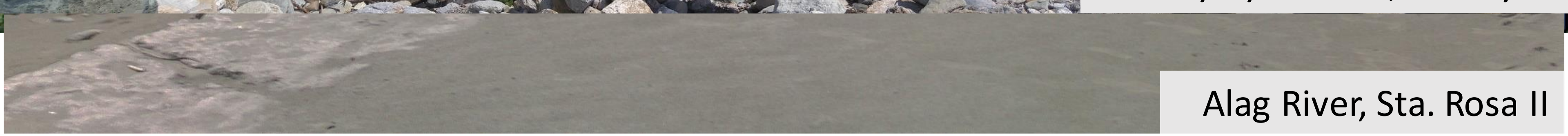
Hungr, 2005



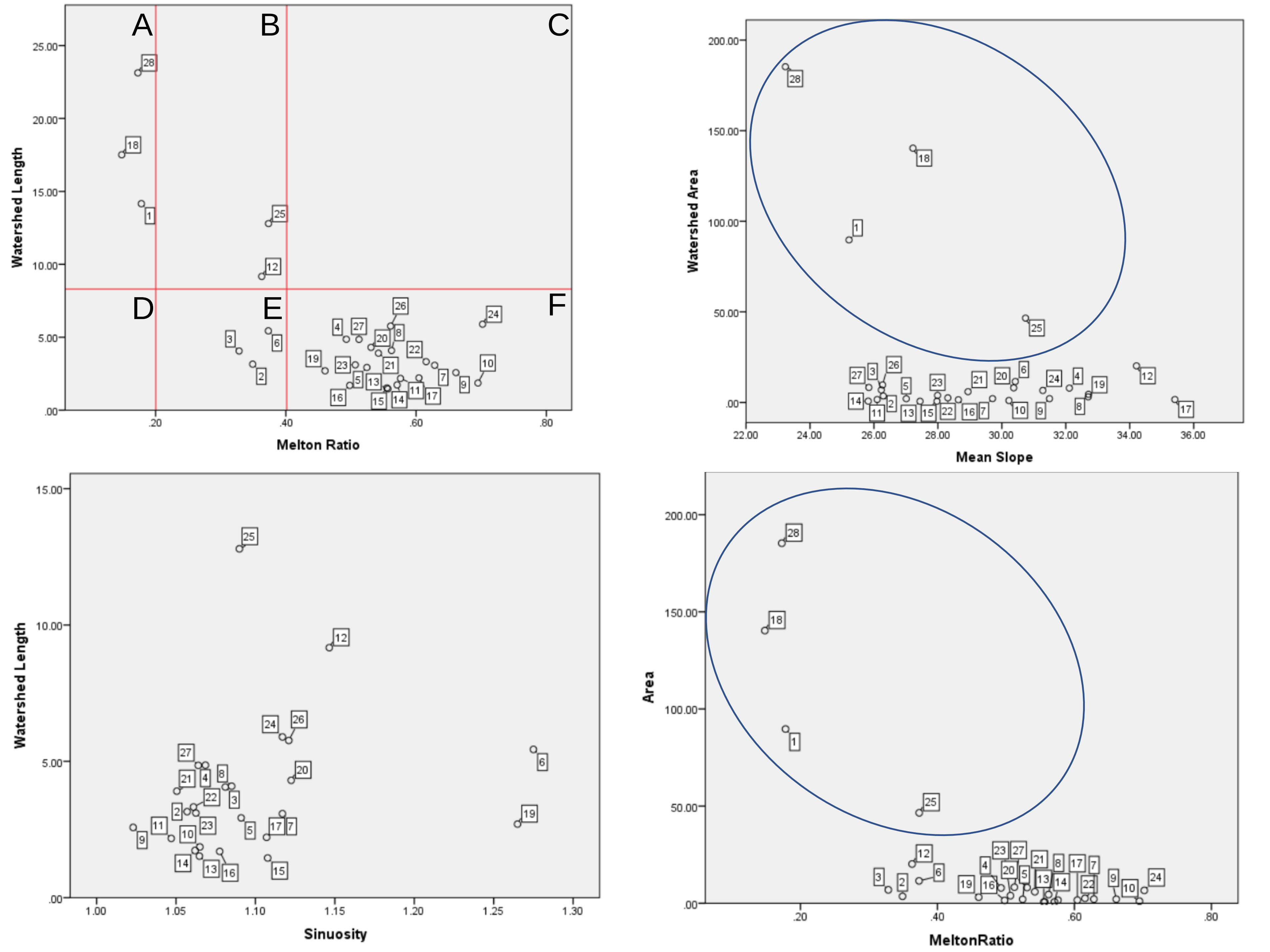
Fieldwork
Fans, Debris-flow deposits
Upper Wat
Apex
Distal
Geology & Tectonics
Rainfall
Morphometric Analysis
Active Faults
Lithology
ARGs – interpolate contours
Satellite Data
3-hr Ave Intensities:
- Guzzetti et al. (2008)
- Caine (1980)
- Rodolfo (1991)
Indices
Watershed Area
Elevation Relief
Mean Slope
Watershed Length
Sinuosity
Melton Ratio

Inasan Creek, Gabaldon

Carayrayan River, Lantuyan

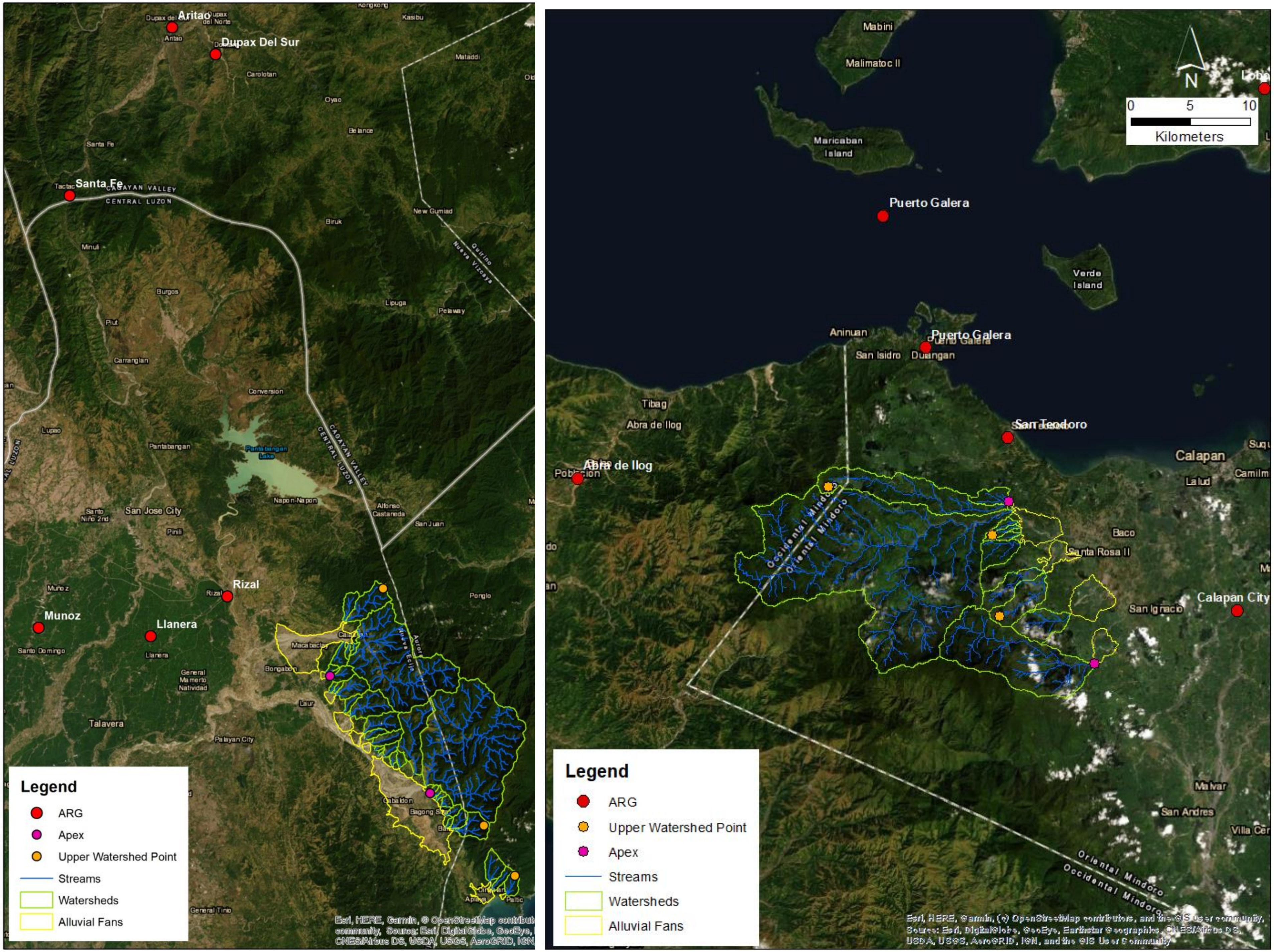


Alag River, Sta. Rosa II


A
B
C
D
E
F
Watershed Length
Melton Ratio
.00
5.00
10.00
15.00
20.00
25.00
.20
.40
.60
.80
Watershed Area
Mean Slope
.00
50.00
100.00
150.00
200.00
22.00
24.00
26.00
28.00
30.00
32.00
34.00
36.00
Watershed Length
Sinuosity
.00
5.00
10.00
15.00
1.00
1.05
1.10
1.15
1.20
1.25
1.30
Area
MeltonRatio
.00
50.00
100.00
150.00
200.00
.20
.40
.60
.80

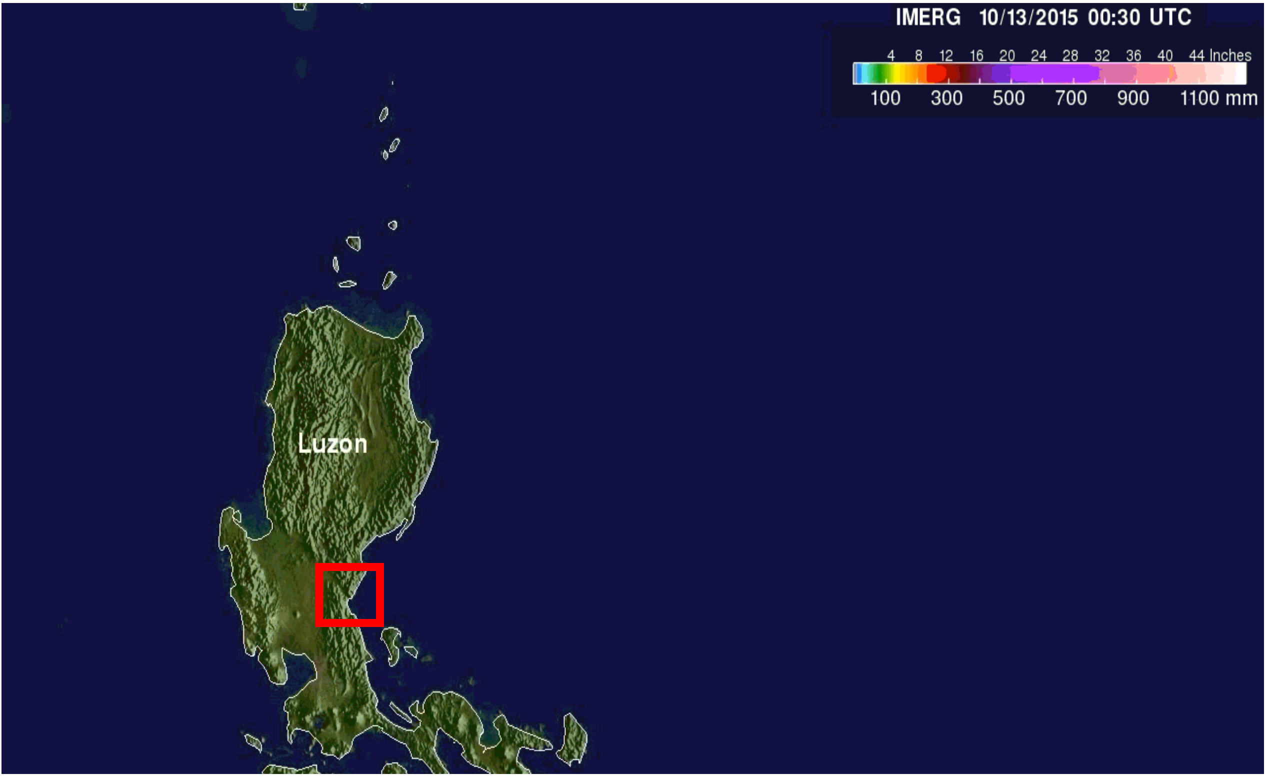
	A	B	C	D	E	F	G	H	I	J	K	L
1	Name	Fan	Basin		River	TWI DEG	SPI DEG	MEAN SLC	ELEVATIOI	AREA (KM)	MRN	MBG_Leng
2	A	yes, from s	yes, from s	Bongabon	not visited	5.63	5.63	31.48	0.555706	12.02893	0.23189	6.37801
3	B	yes, from s	yes, from s	Bongabon	not visited	5.45	5.44	28.53	0.462321	3.769213	0.29079	3.789734
4	C	hyperconc	yes	Bongabon	NW Bongabon 3	5.77	5.78	25.22	0.386849	89.68942	0.178217	14.15859
5	H	yes	yes	Bongabon	Sapang Pantso	5.81	5.81	26.29	0.465163	3.580116	0.34908	3.155311
6	K	yes	yes	Laur	Matian Creek	5.79	5.79	26.23	0.498937	6.898312	0.328268	4.058348
7	L	yes	yes	Gabaldon	Segum Munti Creek	5.94	5.92	32.11	0.466048	7.90562	0.492838	4.859305
8	M	yes	yes	Laur	Kamumu Creek	5.79	5.80	27.01	0.398357	2.056541	0.524405	2.927475
9	N	yes	yes	Gabaldon	Alitutuan Creek	5.91	5.91	30.42	0.455016	11.52789	0.373137	5.438122
10	O	yes	yes	Gabaldon	Amalungan Creek	5.70	5.69	29.71	0.415503	2.13579	0.628457	3.080772
11	P	yes	yes	Gabaldon	Calabasa Creek	5.88	5.87	32.71	0.482095	4.497101	0.562267	4.089088
12	S	yes	yes	Gabaldon	Bitunin Creek	5.88	5.90	31.49	0.505573	2.103965	0.661106	2.578125
13	T	no	yes	Gabaldon	Creek 2	5.74	5.72	30.22	0.47125	1.073507	0.694971	1.859724
14	U	no	yes	Gabaldon	Creek 1	5.86	5.87	26.10	0.526147	1.604224	0.575998	2.175261
15	V	yes	yes	Gabaldon	Inasan River	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

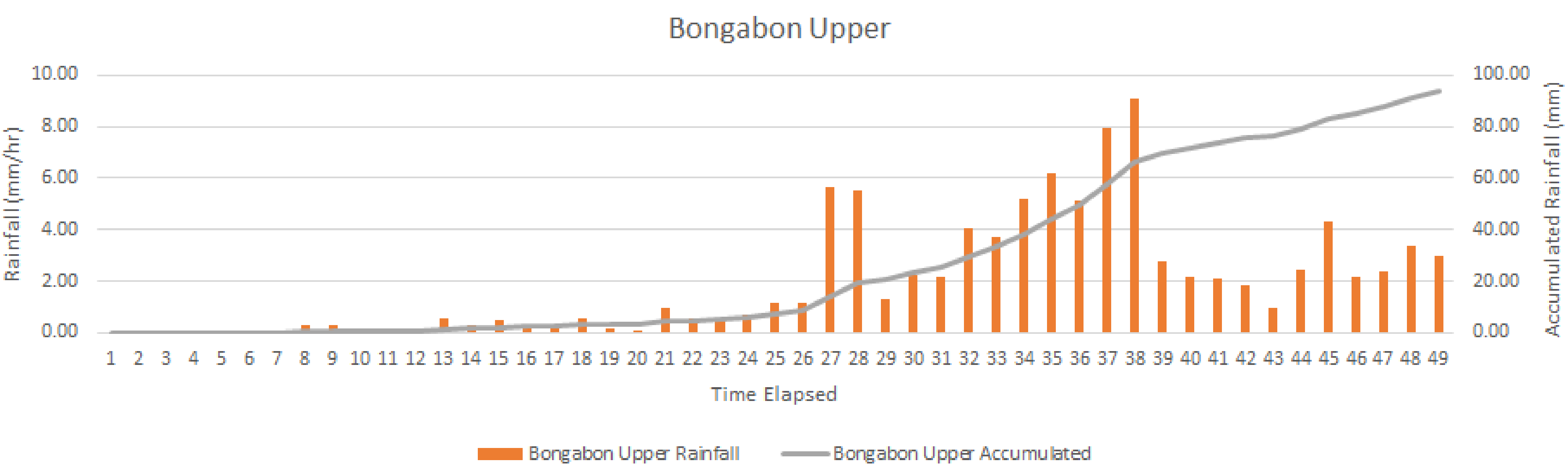
Indices	New Zealand (Welsh, 2007; Welsh and Davies, 2011)	Canada (Jackson et al., 1987; de Scally and Owens, 2004; Wilford et al., 2004)	Philippines
Watershed Length (WL)		WL < 2.7 km	WL < 8 km
Melton Ratio (R)	R > 0.5 (DF)	R > 0.75 (DF) R > 0.60 (DF) 0.30 < R < 0.60 (HC)	R > 0.40 (DF)
Mean Area (A_b)			2 km^2 < A_b < 25 km^2
Mean Slope (S_{ave})		S_{ave} > 7.5°	S_{ave} > 24°



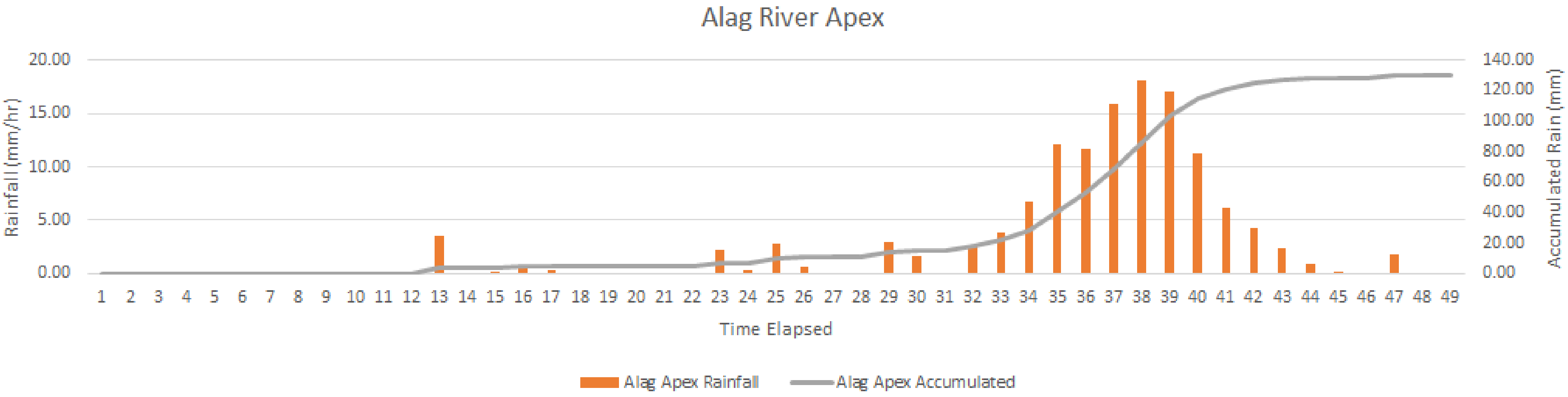
Aritao
Dupax Del Sur
Santa Fe
Rizal
Munoz
Llanera
Pantabangan Lake
San Jose City
Talavera
Legend
ARG
Apex
Upper Watershed Point
Streams
Watersheds
Alluvial Fans
Mabini
Malimatoc II
Maricaban Island
Puerto Galera
Verde Island
San Teodoro
Abra de Ilog
Calapan
Calapan City
Baco
Santa Rosa II
San Ignacio
Oriental Mindoro
Occidental Mindoro
N
0
5
10
Kilometers
Legend
ARG
Upper Watershed Point
Apex
Streams
Watersheds
Alluvial Fans

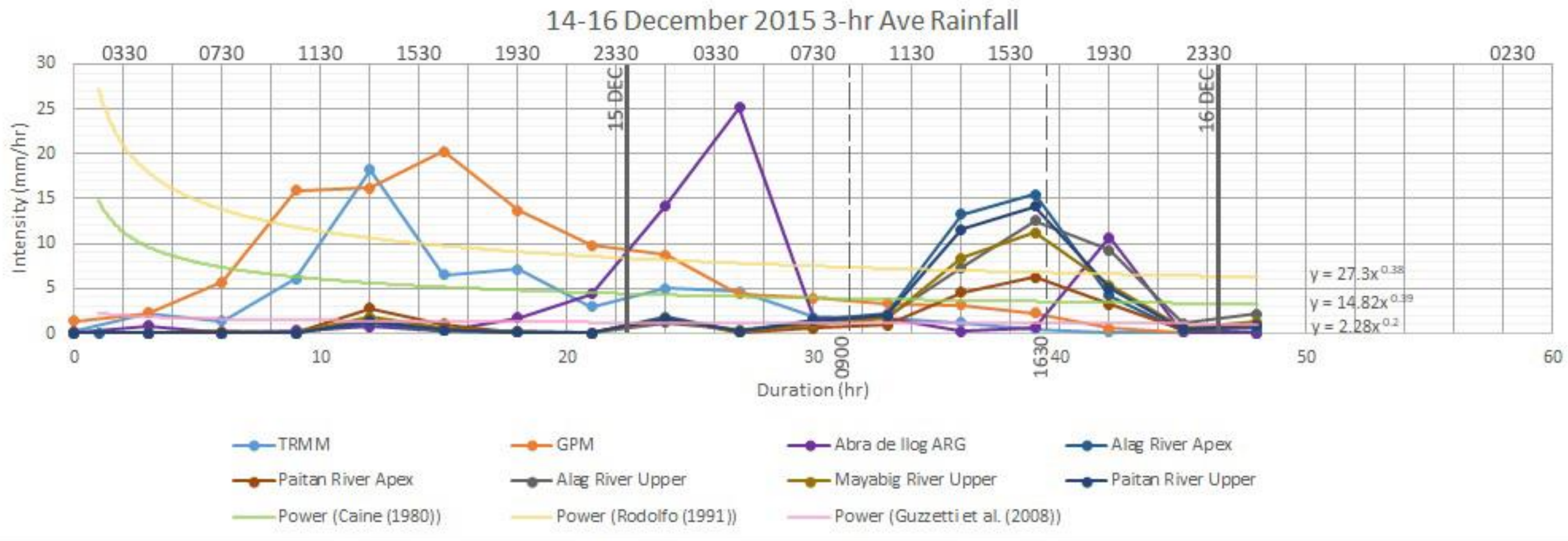
Typhoon Koppu (Lando) Rainfall



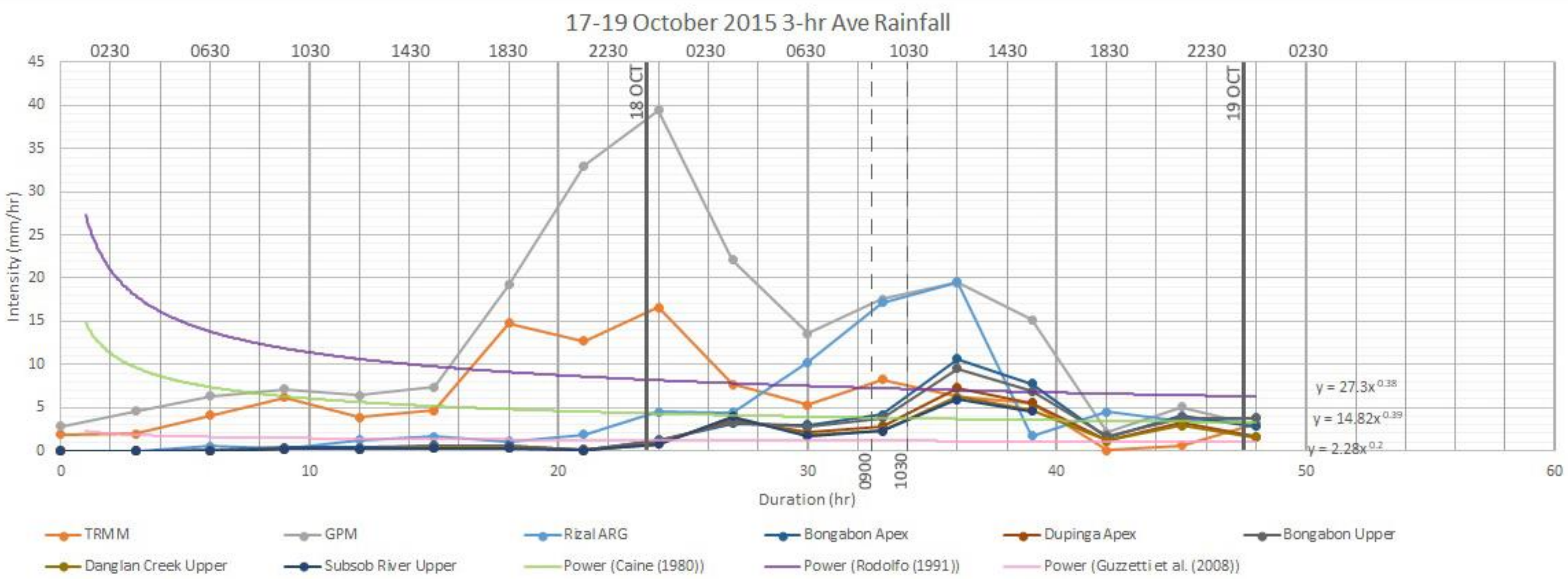


Typhoon Melor (Nona)





14-16 December 2015 3-hr Ave Rainfall
0330 0730 1130 1530 1930 2330 0330 0730 1130 1530 1930 2330 0230
15 DEC
16 DEC
0900
1630
Intensity (mm/hr)
Duration (hr)
y = 27.3x^-0.38
y = 14.82x^-0.39
y = 2.28x^-0.2
TRMM
GPM
Abra de Ilog ARG
Alag River Apex
Paitan River Apex
Alag River Upper
Mayabig River Upper
Paitan River Upper
Power (Caine (1980))
Power (Rodolfo (1991))
Power (Guzzetti et al. (2008))



17-19 October 2015 3-hr Ave Rainfall
0230 0630 1030 1430 1830 2230 0230 0630 1030 1430 1830 2230 0230
18 OCT
19 OCT
0900
1030
Intensity (mm/hr)
Duration (hr)
y = 27.3x^-0.38
y = 14.82x^-0.39
y = 2.28x^-0.2
TRMM
GPM
Rizal ARG
Bongabon Apex
Dupinga Apex
Bongabon Upper
Danglan Creek Upper
Subsob River Upper
Power (Caine (1980))
Power (Rodolfo (1991))
Power (Guzzetti et al. (2008))

In Summary

- Fans at tectonically active regions are prone to debris flows
- Fans with $S_{ave} > 24°$, $R > 0.40$, $WL < 8$ km, and 2 $km^2 < A_b < 25$ km^2 are most likely to have "true" debris-flows reach past the fan apex
- The critical rainfall for debris-flow initiation for watersheds must also be taken into account

Next Steps

- Installing automated rain gauges in the upper watersheds
- Dating old debris-flow deposits can be useful to find out the recurrence interval of the hazard

Thank you!

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