A TOOL FOR THE ESTIMATION OF THE DISTRIBUTION OF LANDSLIDE AREA

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I. INTRODUCTION

The assessement of the risk posed by population of landslides over large territories requires the estimation of landslide hazard and hence of the magnitude probability. The statistical models to estimate landslide magnitude are aimed at the estimation of the probability density of some specific variables characterizing landslides, taken as measures of the magnitude of landslide as an alternative to energy. Landslide size, and in particular landslide area, is commonly considered to be a proxy of landslide magnitude. Landslide area is preferred to volume since it can be measured objectively. The probability distributions of landslide area, at least for a given range or for values above a given threshold, can be described using power law models. In the literature two landslide area distribution models have been proposed Double Pareto distribution (Stark & Hovius, 2001) and Inverse Gamma distribution (Malamud et al., 2004). Despite this, no common tool exist to estimate and to compare the parameters of both distributions. In this work we present a tool to estimate both distributions parameters. The tool has a twofold interface: the first is an R (a free software environment for statistical computing and graphics) interface, while the second is a Web Processing Service (stardard WPS as defined by the Open Geospatial Consortium) interface. While the first require a local execution, the second can be accessed through the Web. We used this tool to estimate the size distribution (i.e. a proxy of the magnitude) for several landslide dataset obtained usign different mapping techniques.

II. STATISTICAL APPROACHES

The tool implements three landslide size distribution models:

DPS - Double Pareto Simplified

$$pdf(x|\alpha,\beta,t,c,m)=[\beta/t\ (1-(\frac{1+(m/t)^{-\alpha}}{1+(c/t)^{-\alpha}})^{(\beta/\alpha)})]\ [\frac{(1+(m/t)^{-\alpha})^{(\beta/\alpha)}}{(1+(x/t)^{-\alpha})^{(1+\beta/\alpha)}}\ (x/t)^{(-\alpha-1)}]$$

DP - Double Pareto

$$pdf(x|\alpha,\beta,t)=\frac{\beta\ (t/\alpha)}{(1+(x/t)^{-\alpha})^{(1+(\beta/\alpha))}\ (x^{(\alpha+1)})}$$

IG - Inverse Gamma

$$pdf(x|\alpha,\eta,\lambda)=[\frac{\lambda^{(2\alpha)}}{\Gamma(\alpha)}]\ [(\frac{1}{x+\eta^{2}})^{(\alpha+1)}\ ^{-(\frac{\lambda^{2}}{x+\eta^{2}})}]$$

The parameter α controls the slope of the distribution for high values tail, β and η the slope for low values, while *t* and λ the position of the maximum of the distribution functions (rollover, *r*). In the DPS distribution *c* and *m* are the minimum and maximum area values.

The tool is realized in R (a free software environment for statistical computing, http://www.r-project.org/) and implements parametric and non-parametric approaches to estimate the paramters of the three probability density function: (i) Histogram Density Estimation (HDE), (ii) Kernel Density Estimation (KDE), and (iii) Maximum Likelihood Estimation (MLE). The three approaches exploit different optimization procedure hence in some cases (particularly with biased or not representative landslide area samples) can give slightly different results.

For each parameter (see table in FIGURE 1) the tool gives: (i) an estimate of its value, (ii) standard errors (s.e.), (iii) the estimated error variance (t_value), and (iv) the correlations among the parameters (Pr(>|t|)). The latter in particular could be useful in case of difficulty in producing a solution: very high correlations between parameters are indicative of ill-conditioning.

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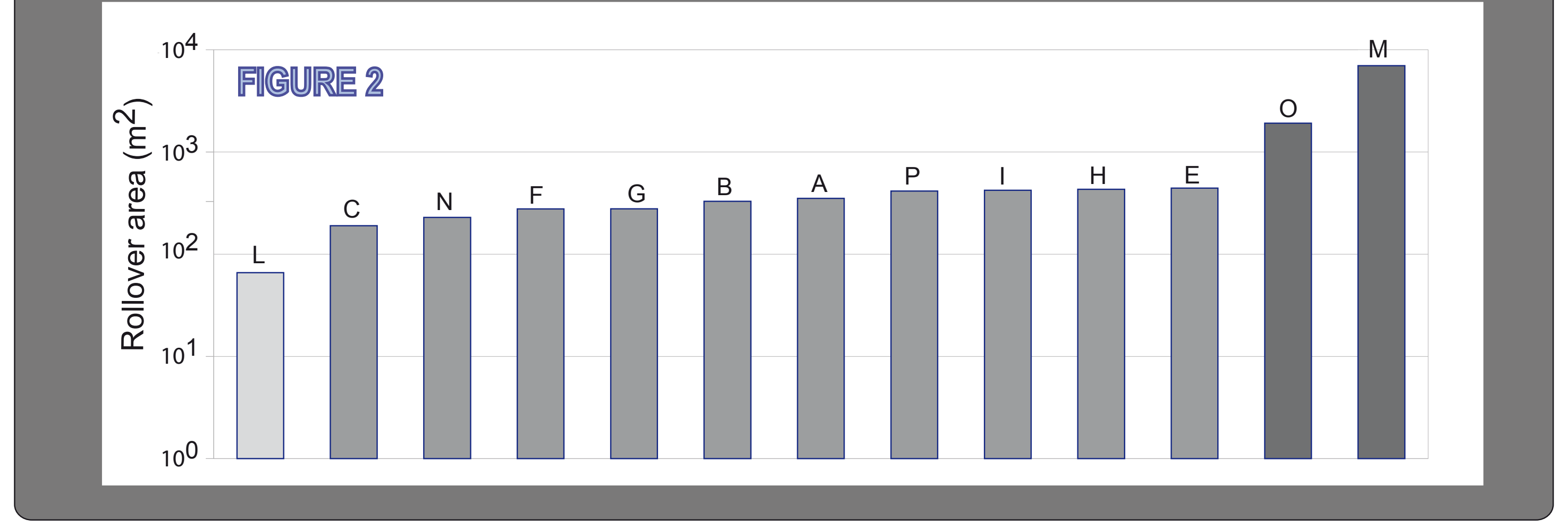
III. RESULTS & DISCUSSION

We used the tool to compare the two Double Pareto (DP, DPS) and Inverse Gamma (IG) model parameters estimated for landslide area datasets in different geological, morphological and climatological settings. Lanslide area values were calculated from landslide inventory maps prepared using different mapping techniques. The characteristics of the study areas and the relative results are summarized in the table. The following conclusion can be drawn:

- **A** Results show that the three models are applicable in geological, morphological and climatological settings. In most cases the models provided very similar results.
- **B** Non-parametric estimation methods (i.e., HDE and KDE) provided reasonable results for all the tested landslide datasets. For some of the datasets, MLE failed to provide a result, for convergence problems.
- **C** The two models (DP and IG) gave very similar results for large and very large datasets (> 150 values). Differences in the modeling results were Observed for small datasets affected by systematic biases.
- **D** A distinct rollover was observed in almost all the analyzed landslide datasets, except for a few datasets obtained from landslide inventories prepared through field mapping or by semi-automatic mapping from VHR imagery (study area L, D).
- **E** Limiting the analysis to α and to the rollover (*r*) the following conclusion can be drawn. α spans between 0.7 (study area L) and 2.2 (study area R), while *r* between 66 (study area L) and 6982 (study area M) (FIGURE 2).



IV. WEB PROCESSING SERVICE

The tool for the estimation of landslide size distribution is available as a standard Open Geospatial Consortium (OGC) Web Processing Service (WPS). This is a standard interface to make geo-spatial processes available through the web. Data requested by the services can be stored on the same server or passed to the process through the network. The service is exposed in a way that allow GIS clients to input data and execute the process without knowing the details of the interface (OGC, 2007).

Using this protocol we created an experimental WPS service (“areaStat”) to offer the estimation of the statistical distribution of landslide area. The WPS service is hosted by the IRPI spatial data infrastructure (Marchesini et al. 2010) on a virtual GNU/Linux server running Ubuntu 10.04.1 LTS, and is based on the PyWPS project:

(http://pywps.wald.intevation.org/),

a WPS 1.0.0 implementation written in the Python language (de Jesus et al., 2011). The process is implemented in the R statistical environment, while the RPy2 tool (http://rpy.sourceforge.net/rpy2.html) manage the communication between R and Python. To perform an “execute” request the process needs of a gml layer and the name of its attribute field containing the area values. The output of the process consist of coefficient and probability density plot of the Double Pareto, Double Pareto Simplified and Inverse Gamma distribution. Outputs are stored in a .pdf file. Information on the experimental process, called “areaStat”, and on the relative configuration can be found at:

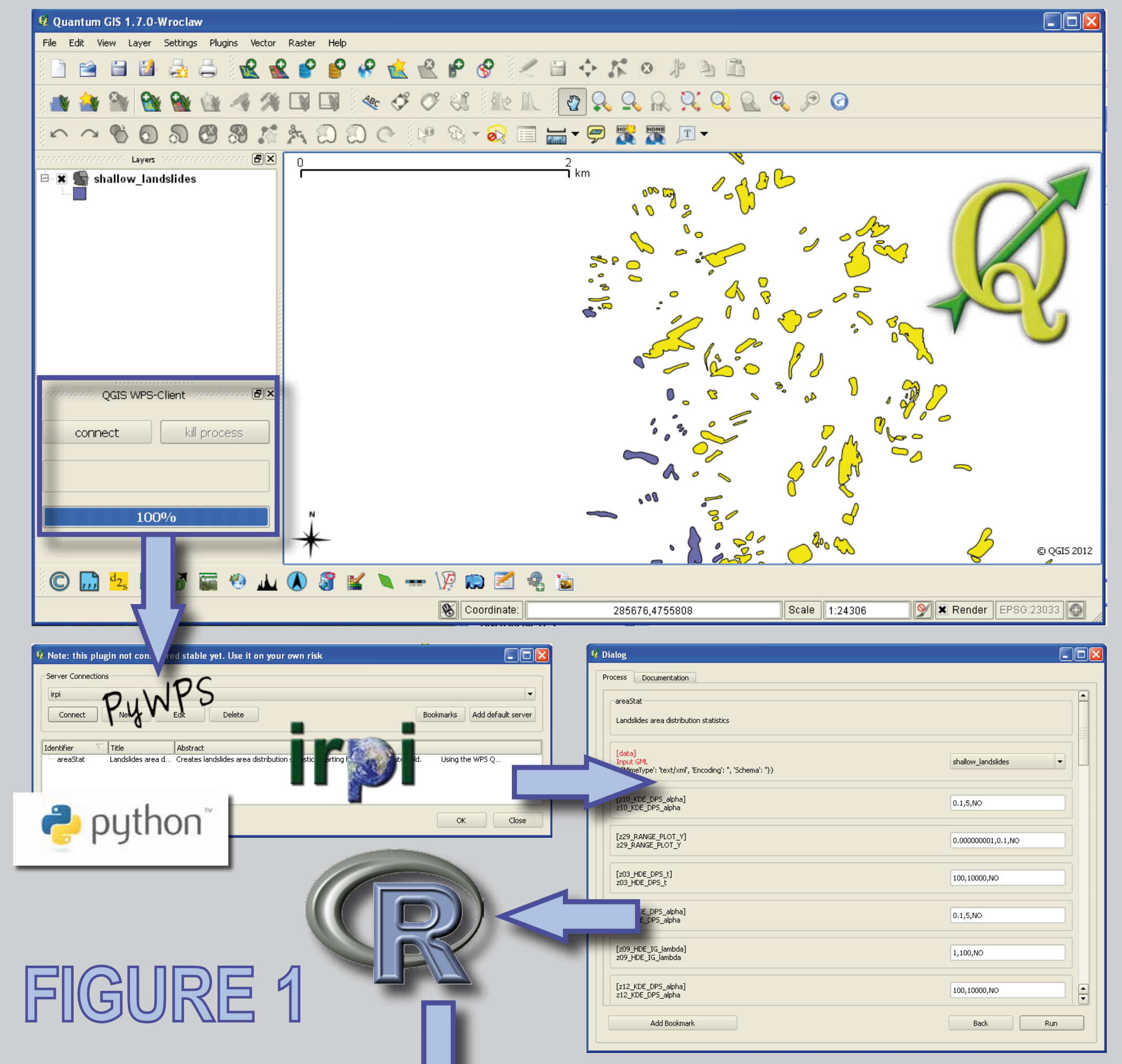
http://giida.irpi.cnr.it/index.php/en.

The “areaStat” process can be accessed by means of specific plugins of GISclients. We tested successfully the service using the QuantumGIS WPS Plugin 0.8.4 (FIGURE 1). The user first has to choose the layer (e.g. the landslide shapefiles) to analyze. Then he has to specify the name of the attribute field containing the landslide area values. Using this version of the QuantumGIS plugin the user could select just a subset of features. Data are sended via Python to the IRPI spatial data infrastructure, where an R code process them. Calculation time are strictly dependent on the number of landslides passed to the process.

Open Geospatial Consortium, Inc. (OGC), Web Processing Service (WPS) 1.0.0 (2007), http://www.opengeospatial.org/standards/wps.

de Jesus, J., Walker, P., Grant, M. &Groom, S. (2011), WPS orchestration using the Taverna workbench: The eScience approach. Computers & Geosciences.doi: 10.1016/j.cageo.2011.11.011.

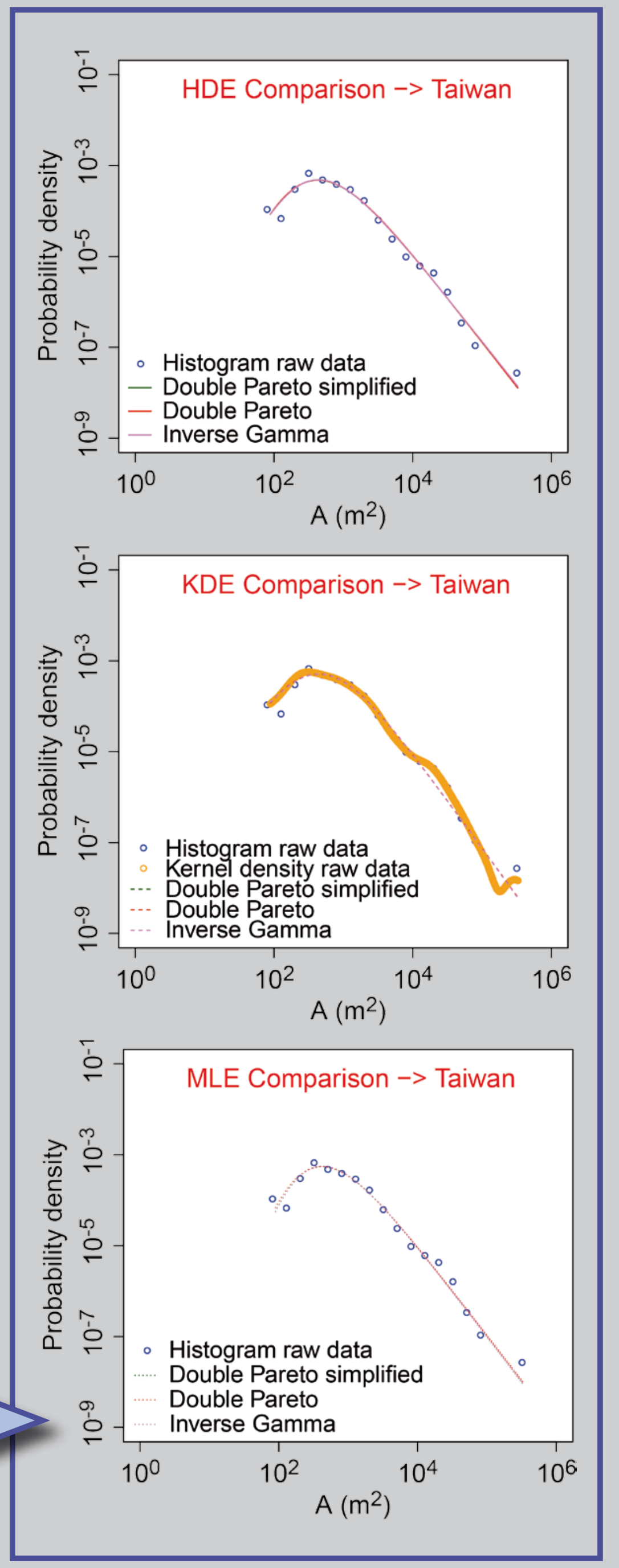
Marchesini, V. Balducci, G. Tonelli, M. Rossi, F. Guzzetti (2010), Geospatial information on landslides and floods in Italy. In: Proceedings of the International Symposium on Geo-information for Disaster Management (Gi4DM), 2-4 Feb 2010,Torino, Italy. Geomatics for Crisis Management. ISPRS. ISBN 978-88-903132-3-3.



areaStat
Landslides area distribution statistics
[data] Input GML: shallow_landslides
[z10_KDE_DPS_alpha]: 0.1,5,NO
[z29_RANGE_PLOT_Y]: 0.000000001,0.1,NO
[z03_HDE_DPS_t]: 100,10000,NO
[...DPS_alpha]: 0.1,5,NO
[z09_HDE_IG_lambda]: 1,100,NO
[z12_KDE_DPS_alpha]: 100,10000,NO

FIGURE 1

		HISTOGRAM DENSITY ESTIMATION				KERNEL DENSITY ESTIMATION				MAXIMUM LIKELIHOOD ESTIMATION			
		Estimate	Std. Err.	t_value	Pr(>|t|)	Estimate	Std. Err.	t_value	Pr(>|t|)	Estimate	Std. Err.	t_value	Pr(>|t|)
DPS	α	0.96	0.1	11.35	0.000	0.96	0.1	11.35	0.000	0.96	0.1	11.35	0.000
	β	5.00	2.9	1.71	0.110	5.00	2.9	1.71	0.110	5.00	2.9	1.71	0.110
	t	206	203	1.02	0.327	206	203	1.02	0.327	206	203	1.02	0.327
	r	433	-	-	-	433	-	-	-	433	-	-	-
DP	α	0.96	0.1	11.41	0.000	0.96	0.1	11.41	0.000	0.96	0.1	11.41	0.000
	β	5.00	2.9	1.71	0.109	5.00	2.9	1.71	0.109	5.00	2.9	1.71	0.109
	t	207	203	1.02	0.324	207	203	1.02	0.324	207	203	1.02	0.324
	c	88	-	-	-	88	-	-	-	88	-	-	-
	m	328375	-	-	-	328375	-	-	-	328375	-	-	-
	r	434	-	-	-	434	-	-	-	434	-	-	-
IG	α	0.92	0.09	9.78	0.000	0.92	0.09	9.78	0.000	0.92	0.09	9.78	0.000
	η	9.22	2.71	3.41	0.004	9.22	2.71	3.41	0.004	9.22	2.71	3.41	0.004
	λ	31.73	3.89	8.17	0.000	31.73	3.89	8.17	0.000	31.73	3.89	8.17	0.000
	r	438	-	-	-	438	-	-	-	438	-	-	-



Study area	Location	Trigger	Year	Inventory type	Mapping methods	Spatial resolution/Scale	Landslide type	Geology/Lithology	Main cover/Land Use	Elevation range	Slope range	Climate type (Koppen)
A	Collazzone, Umbria, Central Italy	Intense rainfall, snow melting	1941-1999	Multitemporal	Photo-Interpretation Aerial stereo-photos (stereoscope)	1:30.000 to 1:13.000	Slides, Flows	Incoherent sedimentary deposits (clay, silts, sands), sandstones, marls	Coultivated field, wood	145 m to 634 m a.s.l	0° to 65° mean 10°	Cfa
B	Collazzone, Umbria, Central Italy	Intense rainfall	2005	Event	Photo-Interpretation Satellite images, Ikonos (Digital sytem)	1m × 1m	Slides, Flows	Incoherent sedimentary deposits (clay, silts, sands), sandstones, marls	Coultivated field, wood	145 m to 634 m a.s.l	0° to 65° mean 10°	Cfa
C	Collazzone, Umbria, Central Italy	Intense rainfall	2005	Event	Photo-Interpretation Aerial photos, Terra Italy (Digital sytem)	0.6m × 0.6m	Slides, Flows	Incoherent sedimentary deposits (clay, silts, sands), sandstones, marls	Coultivated field, wood	145 m to 634 m a.s.l	0° to 65° mean 10°	Cfa
D	Collazzone, Umbria, Central Italy	Intense rainfall	2005	Event	Field survey	-	Slides, Flows	Incoherent sedimentary deposits (clay, silts, sands), sandstones, marls	Coultivated field, wood	145 m to 634 m a.s.l	0° to 65° mean 10°	Cfa
E	Collazzone, Umbria, Central Italy	Snow melting	1997	Event 1996-1997	Photo-Interpretation Aerial stereo-photos (stereoscope)	1:20.000	Slides, Flows	Incoherent sedimentary deposits (clay, silts, sands), sandstones, marls	Coultivated field, wood	145 m to 634 m a.s.l	0° to 65° mean 10°	Cfa
F	Monte Castello di Vibio, Umbria, Central Italy	Intense rainfall, snow melting	1941-1997	Multitemporal	Photo-Interpretation Aerial stereo-photos (stereoscope)	1:30.000 to 1:13.000	Slides, Flows	Incoherent sedimentary deposits (clay, silts, sands), sandstones, marls	Coultivated field, wood	145 m to 634 m a.s.l	0° to 65° mean 10°	Cfa
G	Darjeeling, Himalaya, India	Typhoons, Intense rainfall	-	Multitemporal	Photo-Interpretation Aerial stereo-photos (stereoscope)	1:10000 for Aerial Photo & imagery 2.5 m × 2.5 m	Slides, Flows	Crystallines (Granite Gneiss), Metapelites (Schists, quartzites, phyllite) & Sedimentary rocks (Sandstone & Siltstone)	Slightly vegetated land, Moderate forest, Barren land/Tea Plantation/roads/villages	236 m to 2189 m a.s.l	0 to 84	Cwb
H	Beichuan, China	Earthquake	1958 - 2008	Multitemporal and Event	Photo-Interpretation Aerial stereo-photos (stereoscope, Digital 3D sytem); Worldview 1 (Digital system); Cartosat 1 (Digital system); Spot 5 (Digital system); Corona (Digital system); ALOS (Digital system); ASTER (Digital system)	0.5m × 0.5m to 15m × 15m	Slides, Flows, and Falls	Basement rocks (Phyllite, Schist, and Slates) and differentiated Sedimentary suite (Shale, Mudstones, Silstones, Sandstones, and Limestone)	-	560m to 2340m a.s.l	0 to 310% or 0° to 72°	Cwa
I	Taiwan	Typhoons	-	Event	Semi-automatic recognition on satellite images, SPOT	panchromatic: 5m spatial resolution, multispectral sensors: 10m spatial resolution,supermode image: 2.5m	shallow landslide	Shale, argillite, slate, and phyllite,	Forest	830m - 3320 m a.s.l	15 - 80 deg	Cfa
L	Taiwan	Typhoons	-	Event	Semi-automatic recognition on satellite images, Formosat II	8m × 8m	Debris flows, shallow landslides	Early middle Miocene formation, composed of black to dark gray arigillite, slate, and phyllite, with sandstone interbeds	90% covered bynatural or plantation bamboo and 6% by ricreation area, the remaining area is classified as exposed or abandoned land, agricolture, road, and water	650m - 1800m a.s.l	from 0 to 40 degrees, 72% of study area between 20 to 40, average of 29	Cwb
M	Latronico, Basilicata, Southern Italy	Intense rainfall	-	Geomorphological	Photo-Interpretation Aerial stereo-photos (stereoscope), Field Survey	1:33.000	Slides, flows, rockfalls, debris flows	Basement rocks, siliciclastic rocks affected by low grade metamorphism, and non-metamorphic, calcarerous rocks, shales, Quaternary deposits.	Wooded area, grazing area, cultivated area, uncultivated area, built area	550m - 1950m a.s.l.	0° to 85°	Csa
N	Collazzone, Umbria, Central Italy	Intense rainfall	2010	Event	Photo-Interpretation Satellite images, Geo Eye (Digital 3D sytem) ?	0.5m × 0.5m	Slides, Flows	Incoherent sedimentary deposits (clay, silts, sands), sandstones, marls	Coultivated field, wood	145 m to 634 m a.s.l	0° to 65° mean 10°	Cfa
O	Staffora, Lombardia, Northern Italy	Intense rainfall	1955-1999	Event	Photo-Interpretation Aerial photos, (Stereoscope), Field survey	1:15.000 to 1:40.000	large rotational and translational slides	Layered limestone, marly-limestone, marl and clay,disorganized, and highly fractured and shallow marine sediments marl and clay, overlaid by massive sandstones		150 m to 1699 a.s.l		Cfb
P	Messina	-	2010	Geomorphological	Aerial photo-interpretation	1:3500 to 1:4.500	Slides, flows, rockfalls, debris flows	Phyllites, marbles, schysts, coastal deposits	Wooded area, grazing area, cultivated area, uncultivated area, built area	0m to 1300m a.s.l.	0° to 85°	Csa

Study area	Estimation method		DPS				DP						IG			
			α	β	t	r	α	β	t	c	m	r	α	η	λ	r
A	HDE	value	1.3	1.4	1018	277	1.4	1.4	1027	37	18636	287	1.5	18.3	39.3	293
		s.e.	0.2	0.3	441	-	0.2	0.3	443	-	-	-	0.3	5.0	7.6	-
	KDE	value	1.2	1.7	696	3248	1.2	1.7	711	37	18636	3299	1.2	14.1	32.6	3347
		s.e.	0.1	0.1	6	-	0.1	0.1	6	-	-	-	0.1	0.1	0.1	-
	MLE	value	1.5	1.4	1215	352	1.3	1.3	1141	37	18636	257	1.5	15.1	39.2	384
		s.e.	0.2	0.3	394	-	0.2	0.4	585	-	-	-	0.2	2.5	5.3	-
B	HDE	value	1.5	2.0	863	467	1.5	2.0	871	81	25356	472	1.3	8.8	30.4	332
		s.e.	0.3	0.7	602	-	0.3	0.7	601	-	-	-	0.2	2.4	4.8	-
	KDE	value	1.2	2.0	568	2298	1.2	2.0	577	81	25356	2335	1.3	13.3	33.0	2337
		s.e.	0.1	0.1	8	-	0.1	0.1	7	-	-	-	0.1	0.1	0.1	-
	MLE	value	1.2	3.6	284	329	1.1	3.1	284	81	25356	284	1.2	8.4	29.8	325
		s.e.	0.1	1.9	209	-	0.2	2.6	336	-	-	-	0.2	2.7	3.7	-
C	HDE	value	1.5	1.3	804	171	1.5	1.3	801	29	25356	176	1.6	15.7	33.4	184
		s.e.	0.1	0.2	223	-	0.1	0.2	219	-	-	-	0.1	3.1	4.0	-
	KDE	value	1.4	1.1	845	2034	1.4	1.2	849	29	25356	2110	1.4	15.5	30.9	2472
		s.e.	0.1	0.1	6	-	0.1	0.1	6	-	-	-	0.1	0.1	0.1	-
	MLE	value	1.2	1.7	466	190	1.2	1.4	603	29	25356	134	1.2	10.0	26.2	206
		s.e.	0.1	0.3	145	-	0.1	0.3	246	-	-	-	0.1	1.3	2.3	-
D	HDE	value	1.5	0.7	2623	-	1.5	0.8	2577	52	47884	-	1.2	22.0	36.4	111
		s.e.	0.2	0.2	1245	-	0.2	0.2	1178	-	-	-	0.2	6.6	7.3	-
	KDE	value	2.2	0.7	3756	-	2.2	0.7	3707	52	47884	-	2.1	28.9	56.8	2103
		s.e.	0.1	0.1	22	-	0.1	0.1	20	-	-	-	0.1	0.2	0.3	-
	MLE	value	2.1	0.9	3079	-	2.7	0.5	4571	52	47884	-	1.7	20.9	49.5	466
		s.e.	0.2	0.1	1	-	0.4	0.1	1	-	-	-	0.3	3.5	8.7	-
E	HDE	value	1.6	1.4	1137	359	1.6	1.4	1123	78	44335	370	1.7	17.6	42.4	349
		s.e.	0.1	0.3	335	-	0.1	0.3	327	-	-	-	0.2	3.9	5.6	-
	KDE	value	1.8	1.2	1517	2239	1.8	1.2	1509	78	44335	2322	2.0	20.9	48.9	2444
		s.e.	0.1	0.1	6	-	0.1	0.1	6	-	-	-	0.1	0.1	0.1	-
	MLE	value	1.6	1.7	1029	443	1.9	1.0	1755	78	44335	-	1.8	14.6	41.9	426
		s.e.	0.1	0.3	234	-	0.2	0.2	365	-	-	-	0.2	1.8	4.0	-
F	HDE	value	1.4	1.4	1000	301	1.4	1.4	1000	36	50495	304	1.6	19.8	43.1	317
		s.e.	0.1	0.2	252	-	0.1	0.2	250	-	-	-	0.1	3.3	5.0	-
	KDE	value	1.3	1.3	1000	2626	1.4	1.3	1000	36	50495	2653	1.6	22.3	43.0	2530
		s.e.	0.1	0.1	7	-	0.1	0.1	7	-	-	-	0.1	0.1	0.1	-
	MLE	value	1.5	1.2	1500	277	1.7	0.9	2110	36	50495	-	1.4	15.8	38.7	367
		s.e.	0.1	0.1	264	-	0.2	0.1	385	-	-	-	0.1	1.4	3.0	-
G	HDE	value	1.3	1.3	1110	248	1.3	1.3	1106	42	119286	253	1.4	18.1	37.8	274
		s.e.	0.1	0.3	377	-	0.1	0.3	371	-	-	-	0.1	3.9	4.4	-
	KDE	value	1.2	1.6	751	2289	1.2	1.6	751	42	119286	2302	1.2	15.0	32.9	2383
		s.e.	0.1	0.1	5	-	0.1	0.1	5	-	-	-	0.1	0.1	0.1	-
	MLE	value	1.1	2.0	552	278	1.2	1.5	828	42	119286	218	1.1	11.2	29.8	300
		s.e.	0.1	0.2	110	-	0.1	0.2	186	-	-	-	0.1	0.8	1.3	-
H	HDE	value	0.9	2.0	1000	472	0.9	2.0	1000	24	1311400	473	0.9	19.8	44.8	684
		s.e.	0.1	0.2	343	-	0.1	0.2	342	-	-	-	0.1	2.8	4.6	-
	KDE	value	0.9	1.9	1000	2737	0.9	1.9	1000	24	1311400	2739	1.1	33.4	60.6	3077
		s.e.	0.1	0.1	18	-	0.1	0.1	18	-	-	-	0.1	0.3	0.3	-
	MLE	value	0.8	1.9	1000	432	0.8	1.9	1000	24	1311400	392	0.8	20.3	43.3	661
		s.e.	0.1	0.1	1	-	0.1	0.1	1	-	-	-	0.1	1.1	1.7	-
I	HDE	value	1.0	5.0	206	433	1.0	5.0	207	88	328375	434	0.9	9.2	31.7	438
		s.e.	0.1	2.9	203	-	0.1	2.9	203	-	-	-	0.1	2.7	3.9	-
	KDE	value	1.1	3.3	400	2049	1.1	3.3	401	88	328375	2052	1.1	11.3	34.8	2056
		s.e.	0.0	0.1	11	-	0.1	0.1	11	-	-	-	0.1	0.1	0.2	-
	MLE	value	1.0	7.5	129	422	1.0	7.1	131	88	328375	411	1.0	7.3	30.8	424
		s.e.	0.1	5.8	135	-	0.1	6.6	164	-	-	-	0.1	2.7	2.7	-
L	HDE	value	0.7	2.0	32	-	0.6	0.2	62	64	517248	-	0.6	1.0	8.8	-
		s.e.	0.1	3.2	92	-	0.1	4.0	724	-	-	-	0.1	12.7	1.4	-
	KDE	value	0.7	2.0	41	-	0.7	0.6	100	64	517248	-	0.6	2.5	9.9	-
		s.e.	0.0	0.1	2	-	0.1	0.1	13	-	-	-	0.1	0.1	0.0	-
	MLE	value	0.8	6.9	16	66	0.6	0.1	16	64	517248	-	0.7	0.0	10.6	67
		s.e.	0.0	-	-	-	0.1	0.2	-	-	-	-	0.1	0.5	0.3	-
M	HDE	value	1.3	1.0	47542	1762	1.3	1.0	47303	402	4054834	1982	1.3	121.4	203.2	3582
		s.e.	0.1	0.2	21627	-	0.1	0.2	21493	-	-	-	0.1	38.8	29.8	-
	KDE	value	1.2	1.2	35463	2912	1.2	1.2	35441	402	4054834	2932	1.1	100.7	182.1	3242
		s.e.	0.0	0.0	1085	-	0.1	0.1	1083	-	-	-	0.1	1.9	1.9	-
	MLE	value	1.3	1.3	31451	6982	1.2	1.3	33338	402	4054834	5932	1.2	76.0	179.7	9222
		s.e.	0.1	0.1	1	-	0.1	0.1	1	-	-	-	0.1	6.6	12.7	-
N	HDE	value	1.3	1.3	881	192	1.3	1.3	902	37	15119	204	1.3	16.3	32.9	213
		s.e.	0.2	0.3	373	-	0.2	0.3	364	-	-	-	0.3	4.4	6.8	-
	KDE	value	1.3	1.0	1284	121	1.4	1.0	1300	37	15119	750	1.2	16.8	31.1	2475
		s.e.	0.0	0.0	8	-	0.1	0.1	7	-	-	-	0.1	0.1	0.1	-
	MLE	value	1.5	1.2	1263	229	1.4	0.9	1511	37	15119	-	1.4	14.4	35.3	305
		s.e.	0.2	0.2	438	-	0.2	0.1	1	-	-	-	0.2	2.6	5.5	-
O	HDE	value	1.4	2.7	3094	2429	1.4	2.7	3095	144	826648	2430	1.5	25.7	85.6	2227
		s.e.	0.2	0.7	1704	-	0.2	0.7	1703	-	-	-	0.2	6.2	14.7	-
	KDE	value	1.6	2.3	4504	490	1.6	2.3	4505	144	826648	490	1.7	31.5	99.4	479
		s.e.	0.0	0.0	185	-	0.1	0.1	185	-	-	-	0.1	0.6	1.4	-
	MLE	value	1.1	4.1	1362	1912	1.1	3.7	1547	144	826648	1912	1.2	20.3	70.9	1923
		s.e.	0.0	0.1	1	-	0.1	0.1	1	-	-	-	0.1	1.3	1.7	-
P	HDE	value	1.1	1.1	4207	178	1.1	1.1	4231	58	221270	199	1.0	34.3	53.4	282
		s.e.	0.1	0.1	1099	-	0.1	0.1	1134	-	-	-	0.1	6.3	5.1	-
	KDE	value	1.1	0.9	5814	-	1.2	0.9	5800	58	221270	-	0.9	32.6	49.9	233
		s.e.	0.0	0.0	145	-	0.1	0.1	143	-	-	-	0.1	0.6	0.5	-
	MLE	value	1.2	1.2	4066	415	1.1	1.0	4475	58	221270	63	1.0	25.1	55.1	888
		s.e.	0.1	0.1	1	-	0.1	0.1	1	-	-	-	0.1	3.9	7.2	-