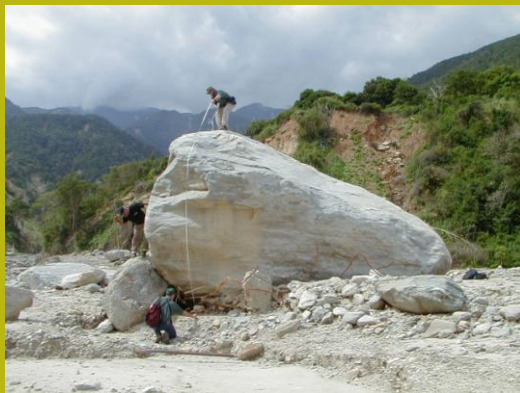
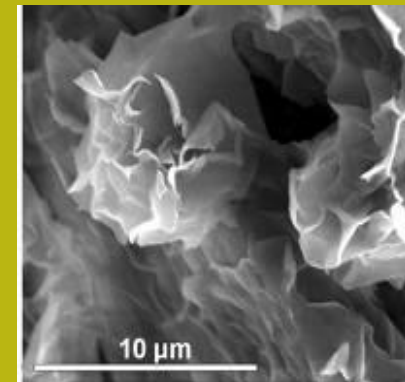


# Deconvolution of Mixture's Components Inside Particle Size Distributions



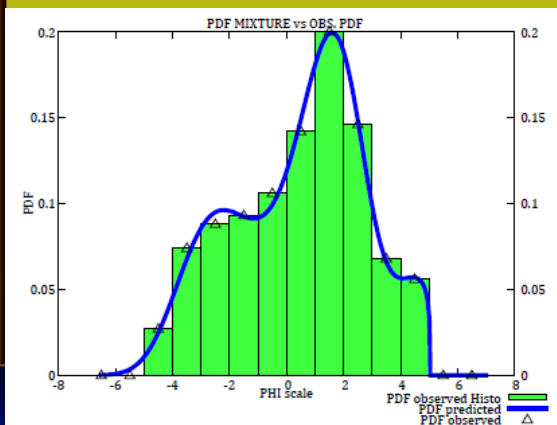
**Lorenzo Borselli\***

\*Instituto de Geología/fac. Ingeniería  
Universidad Autónoma de San Luis Potosí  
Av. M. Nava No 5, Zona Universitaria,  
San Luis Potosí, 78240, Mexico

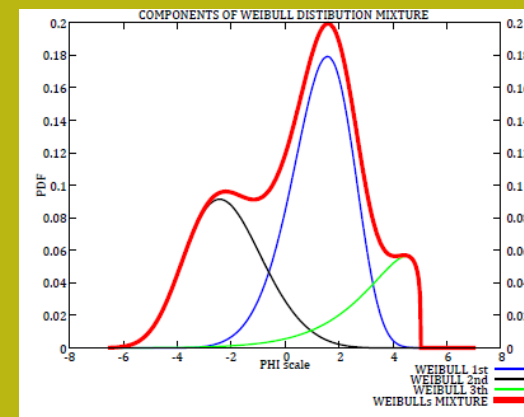


[lborselli@gmail.com](mailto:lborselli@gmail.com)

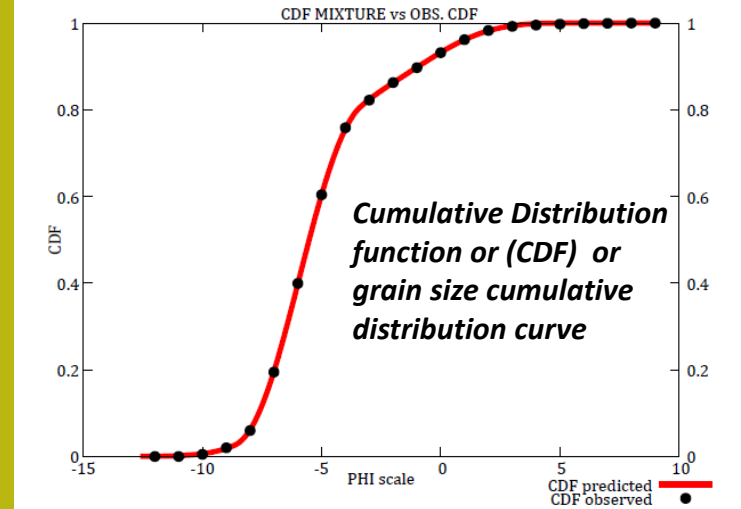
<http://www.lorenzo-borselli.eu>



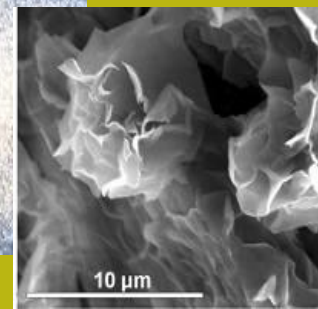
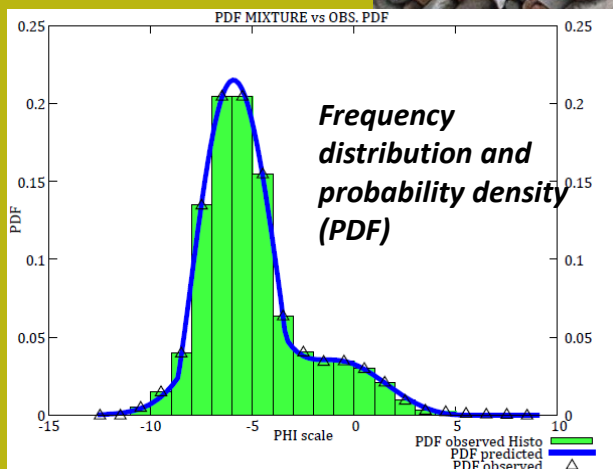
DICIM- UASLP



# How to describe quantitatively particles size distribution in natural deposits/outcrop of sediments, soil, rock mass, or geomaterials?



## How much is the information content inside CDFs y PDFs of Particle size distribution (PSD)?

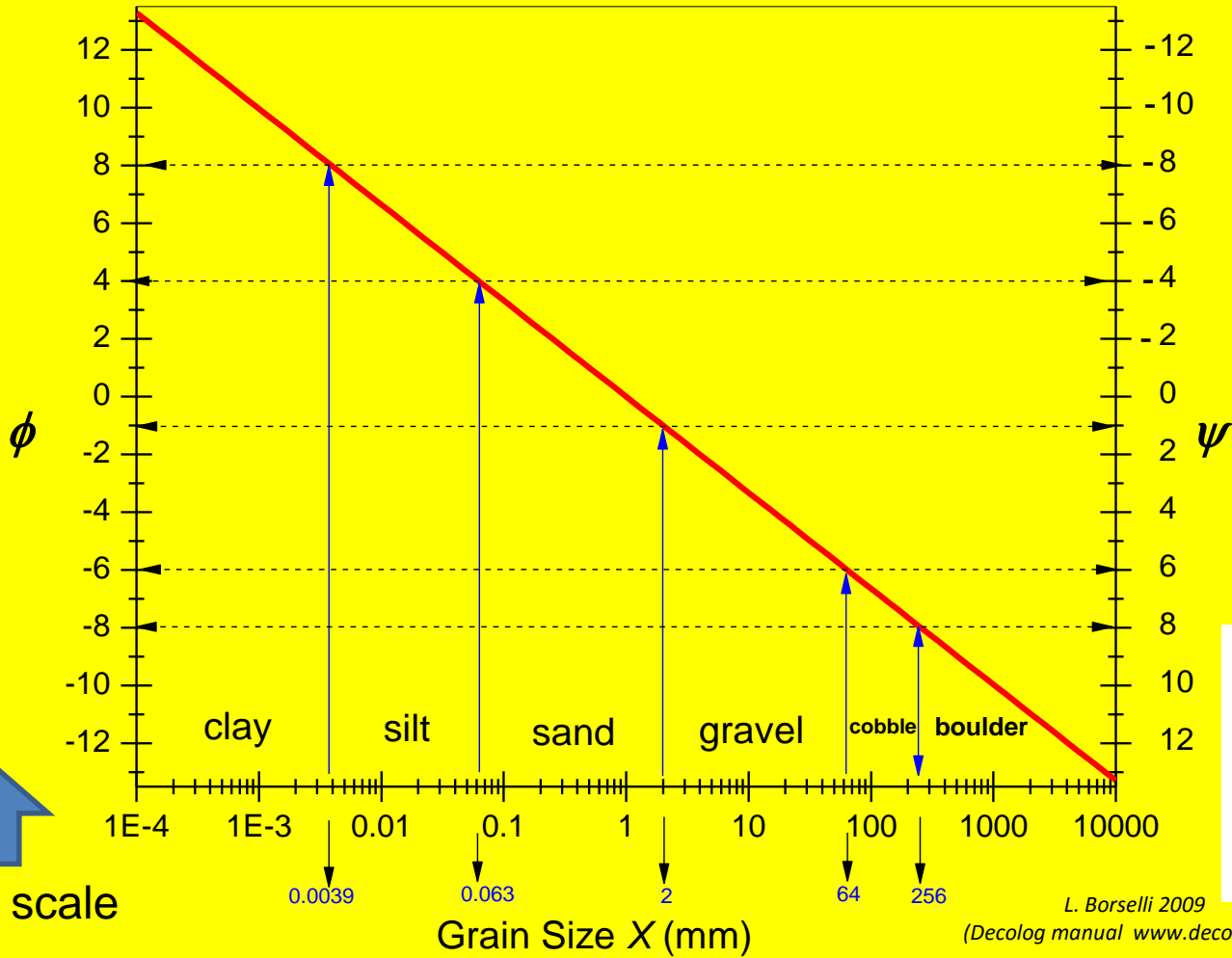


# PARTICLE SIZE AND SEDIMENTOLOGICAL SCALE

*PHI scale*  
 $\phi = -\log_2(x)$

Grain size (Wentworth Scale)

*PSI scale*  
 $\psi = \log_2(x)$



**Useful formulas:**

$$\psi = 3.3219 \log_{10} X$$

$$X = 10^{-0.301\phi}$$

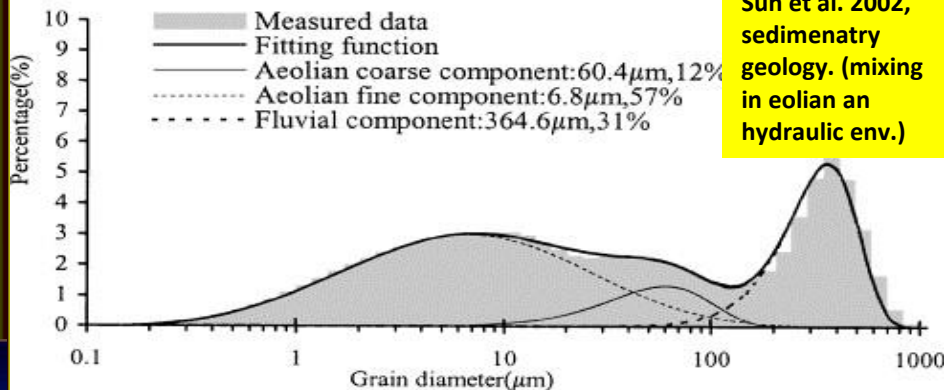
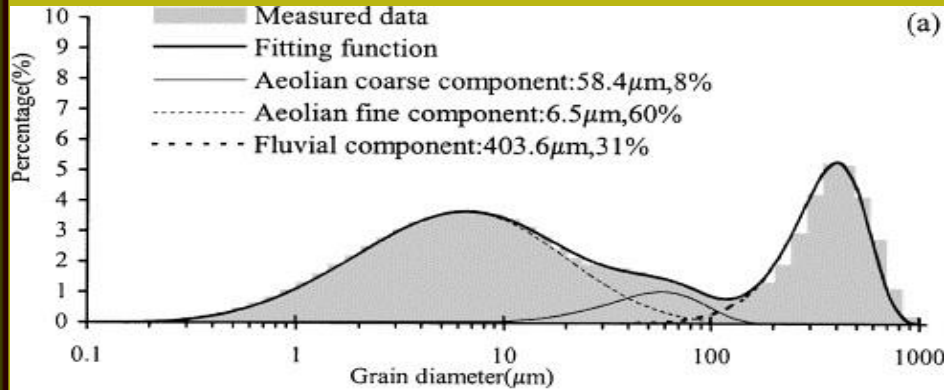
$$X = 10^{0.301\psi}$$

$$\phi = -\log_2 X$$

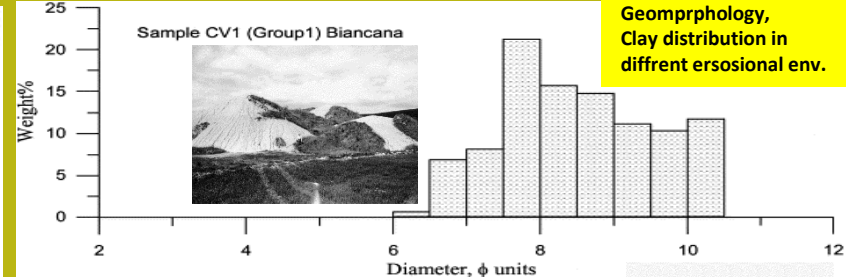
$$\phi = -3.3219 \log_{10} X$$

**Experimentally derived PSD often shown multimodal shape and this characteristic is usually interpreted as a mixture of two or more populations.** In geosciences the origin of these mixtures has been commonly interpreted as the result of complex processes: the different origin of the sediment ad clasts ; the transport and their final deposition. The geological cycle of sediment transport, the weathering or edaphological processes may affect the final PSD in the deposit.

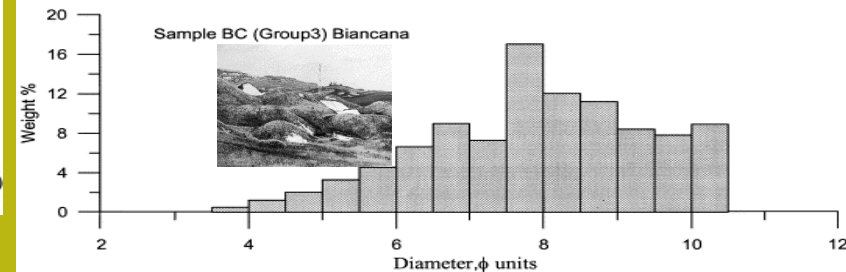
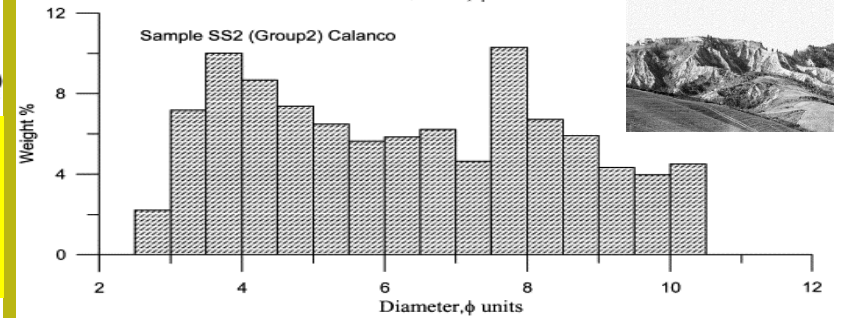
**The basic idea is that each type of process left a fingerprint inside the granulometric distribution and in the presence of different components.** In other words the whole properties of the mixture are coded in the properties of experimental PSD.



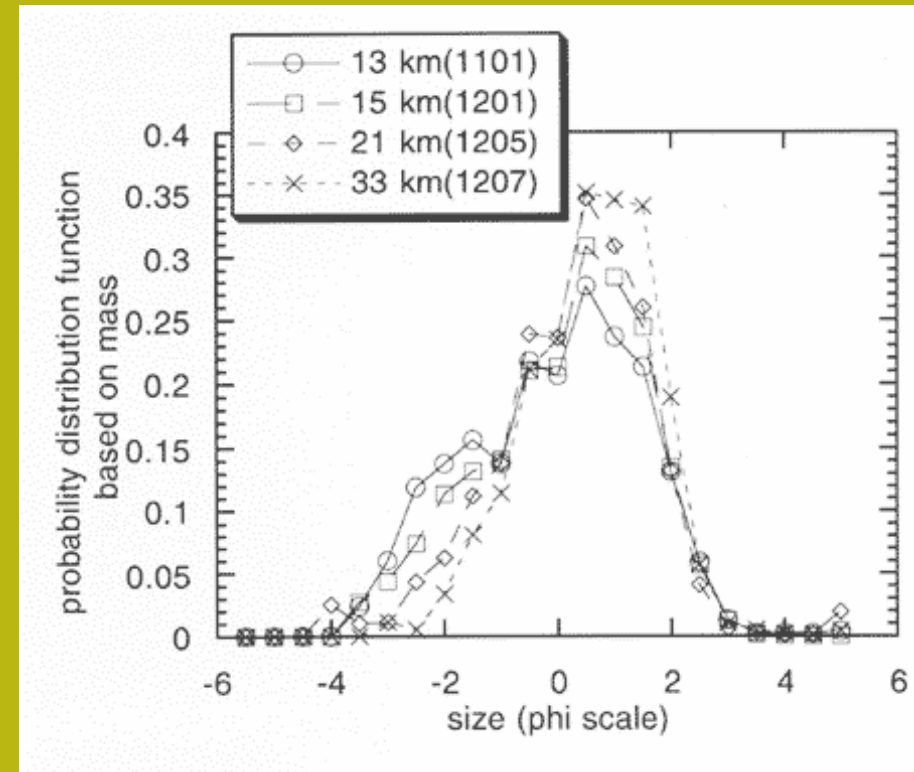
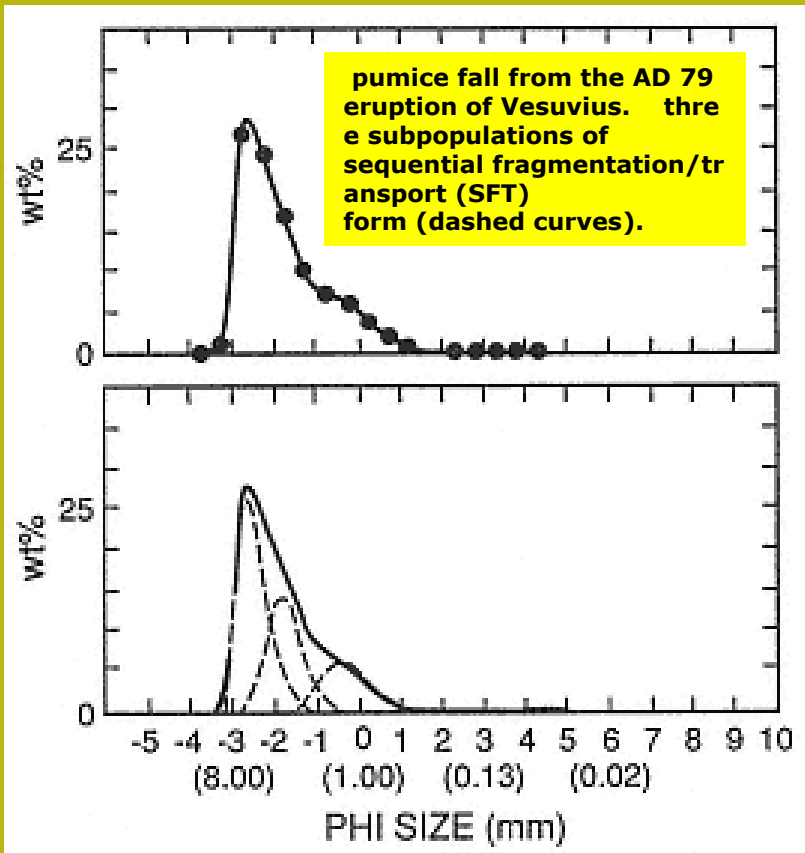
Sun et al. 2002, sedimentary geology. (mixing in eolian and hydraulic env.)



Battaglia et al.(2003), Geomorphology, Clay distribution in different erosional env.



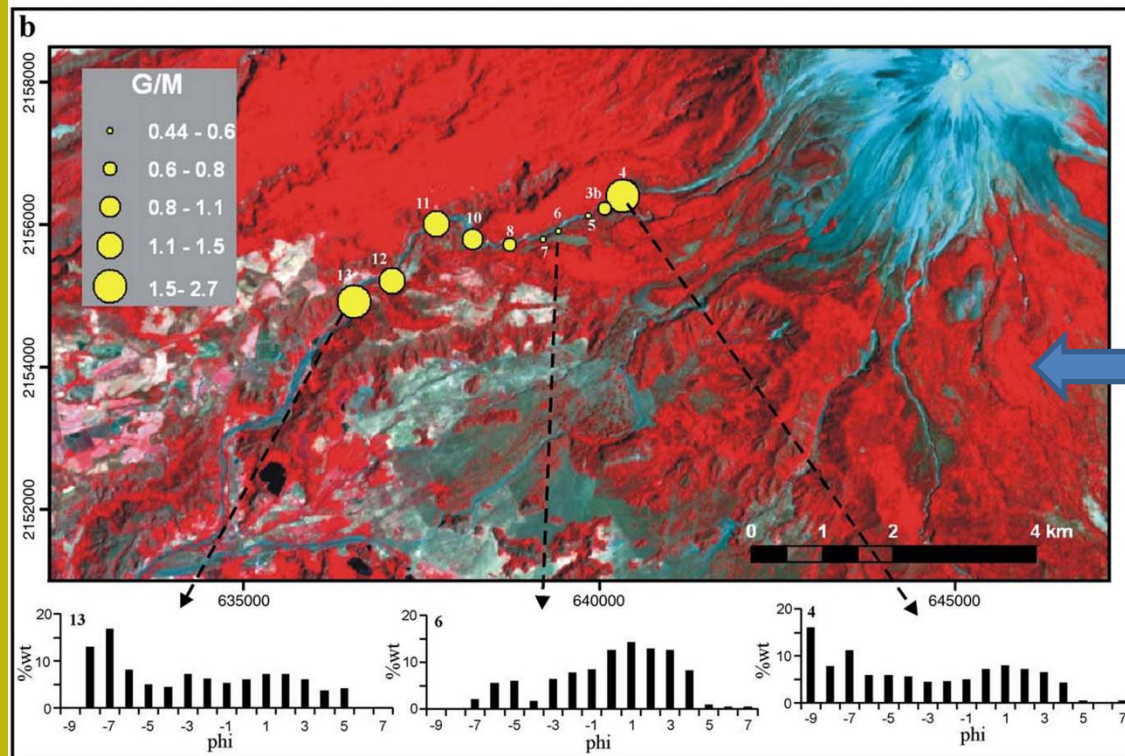
Each PSD may be interpreted as a mixture of different phase or separate components . The knowledge of these components is important in order to understand the processes (or their combination) which produced them. Application of this concept is important in geology, engineering geology and material science.



**Tephra-Fall Deposits from the Tephra deposits June 15, 1991, Eruption of Mount Pinatubo (Koyaguchi, 1999)**

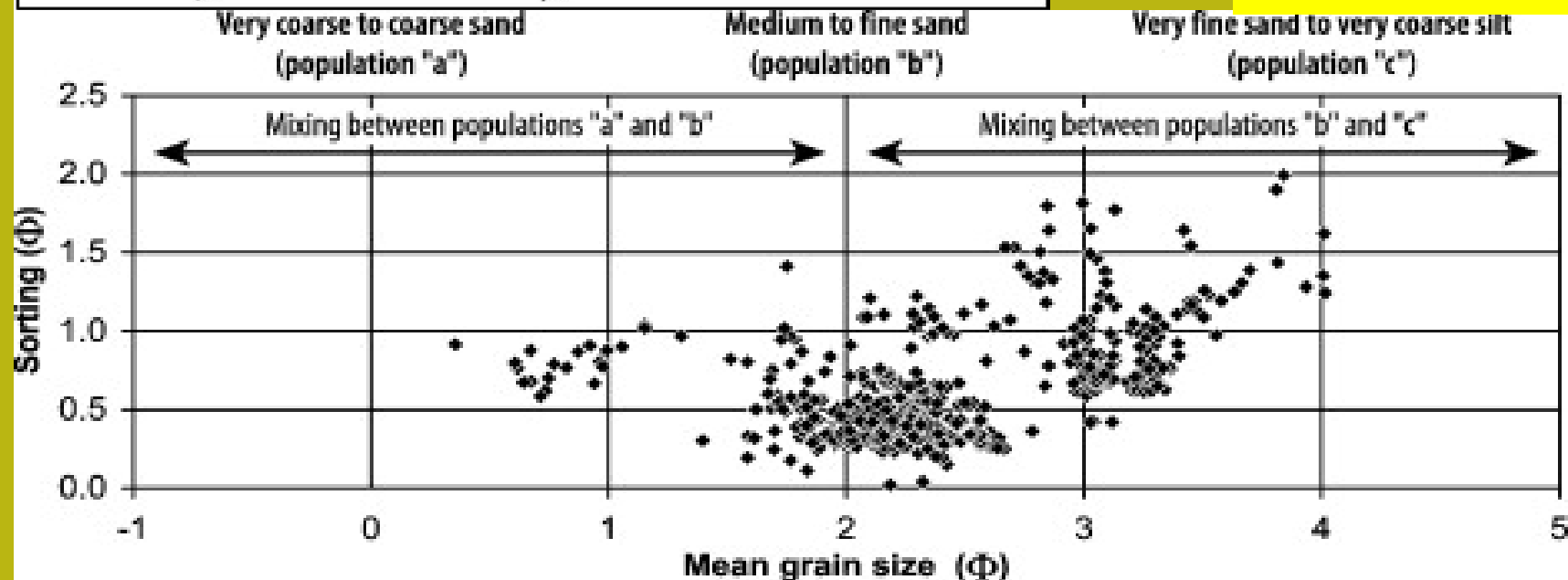
<http://pubs.usgs.gov/pinatubo/koya>

Wohletz, Kenneth, and Grant Heiken. *Volcanology and Geothermal Energy*. Berkeley: University of California Press, 1992.  
<http://ark.cdlib.org/ark:/13030/ft6v19p151/>



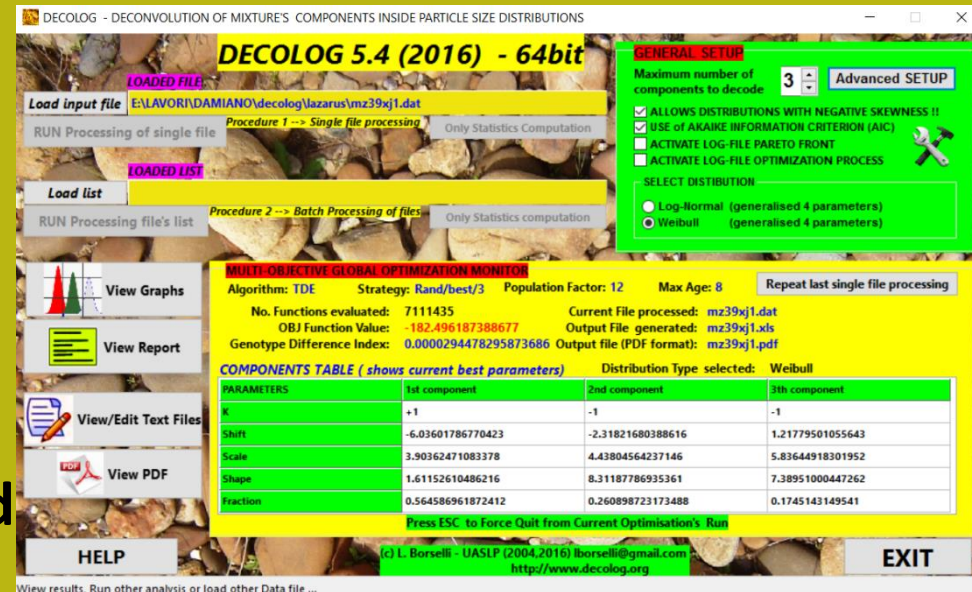
Total PSD in samples of Debris flow deposits at different distance from the source, with example of poly-modality (Volcan de Fuego, Colima, MX) (Capra et al., 2010, JVGR)

Antony & Héquette (2007) sedimentary Geology, (tides sediment sorting and mixing)



## DECOLOG's OBJECTIVES

- Problem solving for separating and decoding components inside a experimental PSD.
- Use as paradigm a mixture of Lognormal and Weibull distributions
- Automatic process by innovative non-linear multi-objectives optimization techniques
- It Do not requires (as other software does) the manual preliminary selection (by User) of the peaks of each component.



**DECOLOG 5.4 (2016) - 64bit**

**LOADING FILE:**  
 Load input file: E:\LAVORI\DAMIANO\decolog\azarus\mz39xj1.dat  
 RUN Processing of single file: Procedure 1 -> Single file processing Only Statistics Computation

**LOADING LIST:**  
 Load list: Procedure 2 -> Batch Processing of files Only Statistics computation

**GENERAL SETUP**  
 Maximum number of components to decode: 3 **Advanced SETUP**  
 ALLOWS DISTRIBUTIONS WITH NEGATIVE SKEWNESS II  
 USE OF AKAIKE INFORMATION CRITERION (AIC)  
 ACTIVATE LOG-FILE PARETO FRONT  
 ACTIVATE LOG-FILE OPTIMIZATION PROCESS

**MULTI-OBJECTIVE GLOBAL OPTIMIZATION MONITOR**  
 Algorithm: TDE Strategy: Rand/best/3 Population Factor: 12 Max Age: 8 Repeat last single file processing  
 No. Functions evaluated: 7111435 Current File processed: mz39xj1.dat  
 OBJ Function Value: -182.496187388677 Output File generated: mz39xj1.xls  
 Genotype Difference Index: 0.0000294478295873686 Output file (PDF format): mz39xj1.pdf

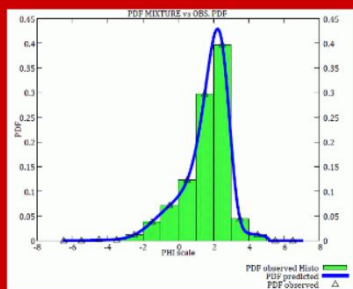
**COMPONENTS TABLE ( shows current best parameters)** Distribution Type selected: Weibull

PARAMETERS	1st component	2nd component	3th component
k	+1	-1	-1
Shift	-6.03601786770423	-2.31821680388616	1.21779501055643
Scale	3.90362471083378	4.43804564237146	5.83644918301952
Shape	1.61152610486216	8.31187786935361	7.38951000447262
Fraction	0.564586961872412	0.260898723173488	0.1745143149541

Press ESC. to Force Quit from Current Optimisation's Run

HELP (c) L. Borselli - UASLP (2004, 2016) lborselli@gmail.com http://www.decolog.org EXIT

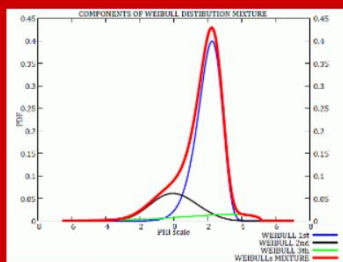
**WWW.DECOLOG.ORG**  
 DECOLOG 5.4 is fully free  
 (freeware) for scientific  
 community  
 (Windows 7/8.x/10 64bit)



DECOLOG 5.4 (last update 09/04/2016)

**Technical Informations**  
(PDF manual and version 3.0)

**Downloads DECLOG software**



**Authors:**

**Lorenzo Borselli**  
Instituto de Geología / Fac. De Ingeniería  
Universidad Autónoma de San Luis Potosí,  
Av. Dr. Manuel Nava 5, C.P. 78400 San Luis Potosí,  
México

**DECONVOLUTION OF MIXTURE'S COMPONENTS INSIDE PARTICLE SIZE DISTRIBUTIONS**

**DECOLOG. 5.4, Win 64 bit**  
(2004,2016)  
(last update 09/04/2016)

**CONACYT:**  
Proyecto Ciencia Basica CB-2012/184060

**What is DECLOG**

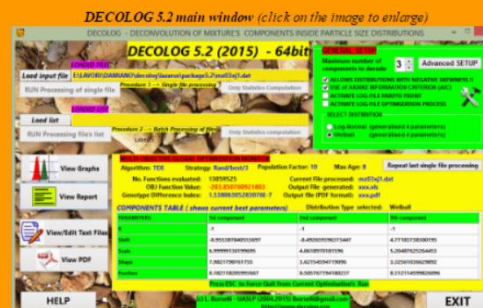
Experimentally derived particle size distribution often shown multimodal shape and this characteristic is usually interpreted as a mixture of two or more populations. The origin of these mixture has been commonly interpreted as due to the complex processes linked to the origin of the sediment ad clasts, to the transport and final deposition, or in other terms, the geological cycle of sediment transport and evolution, the weathering and soil process may affect the final distribution of particles present in the sampled deposit.

The basic idea is that all the processes responsible of the deposit leave some trace of them inside the special characteristics of the mixture and their populations. We assume that the mixture maintains encoded in its global distribution informations

Aim of DECLOG software is develop a solution to decode the information present in the natural mixture of particles/sediments using, as paradigm, the log-normal or weibull distributions and particularly a defined mixture of these distributions.

Decolog performs this operation using innovative techniques of optimization and in **automatic way, without the needs of special efforts from user, as the initial guessing of Peaks of the observed distribution ...**

The easiness of use is one of the most innovative and appreciated characteristics of current version of DECLOG



Web site DECOLOG

**WWW.DECOLOG.ORG**

**DECOLOG (rel 5.4, Win 64 bit - 2004-2016)**  
(a freeware software for scientific community)

**CONACYT:**  
Proyecto Ciencia Basica CB-2012/184060

**Downloads**

**Version 5.4**  
**Para descargar**



!! New !! DECOLOG 5.4 - freeware software (last update 09/04/2016) see <a href="#">changes in DECOLOG 5.0</a>	<a href="#">DECOLOG_install_5.zip</a>
Sample of input files for DECOLOG 54	<a href="#">Sample_input_files.zip</a>
DECOLOG 3.0 manual (still the old manual. )	<a href="#">decolog_manual.pdf</a>



## DECOLOG 5.4 (2016) - 64bit

**LOADED FILE**

**Load input file** E:\LAVORI\DAMIANO\decolog\lazarus\mz39xj1.dat

RUN Processing of single file *Procedure 1 --> Single file processing* Only Statistics Computation

**LOADED LIST**

**Load list**

RUN Processing file's list *Procedure 2 --> Batch Processing of files* Only Statistics computation

**GENERAL SETUP**

Maximum number of components to decode **3** **Advanced SETUP**

ALLOWS DISTRIBUTIONS WITH NEGATIVE SKEWNESS !!

USE of AKAIKE INFORMATION CRITERION (AIC)

ACTIVATE LOG-FILE PARETO FRONT

ACTIVATE LOG-FILE OPTIMIZATION PROCESS

SELECT DISTRIBUTION

Log-Normal (generalised 4 parameters)

Weibull (generalised 4 parameters)

**View Graphs**

**View Report**

**View/Edit Text Files**

**View PDF**

**MULTI-OBJECTIVE GLOBAL OPTIMIZATION MONITOR**

Algorithm: TDE    Strategy: Rand/best/3    Population Factor: 12    Max Age: 8    Repeat last single file processing

No. Functions evaluated: 7111435    Current File processed: mz39xj1.dat

OBJ Function Value: -182.496187388677    Output File generated: mz39xj1.xls

Genotype Difference Index: 0.0000294478295873686    Output file (PDF format): mz39xj1.pdf

**COMPONENTS TABLE ( shows current best parameters)**    Distribution Type selected: Weibull

PARAMETERS	1st component	2nd component	3th component
K	+1	-1	-1
Shift	-6.03601786770423	-2.31821680388616	1.21779501055643
Scale	3.90362471083378	4.43804564237146	5.83644918301952
Shape	1.61152610486216	8.31187786935361	7.38951000447262
Fraction	0.564586961872412	0.260898723173488	0.1745143149541

Press ESC to Force Quit from Current Optimisation's Run

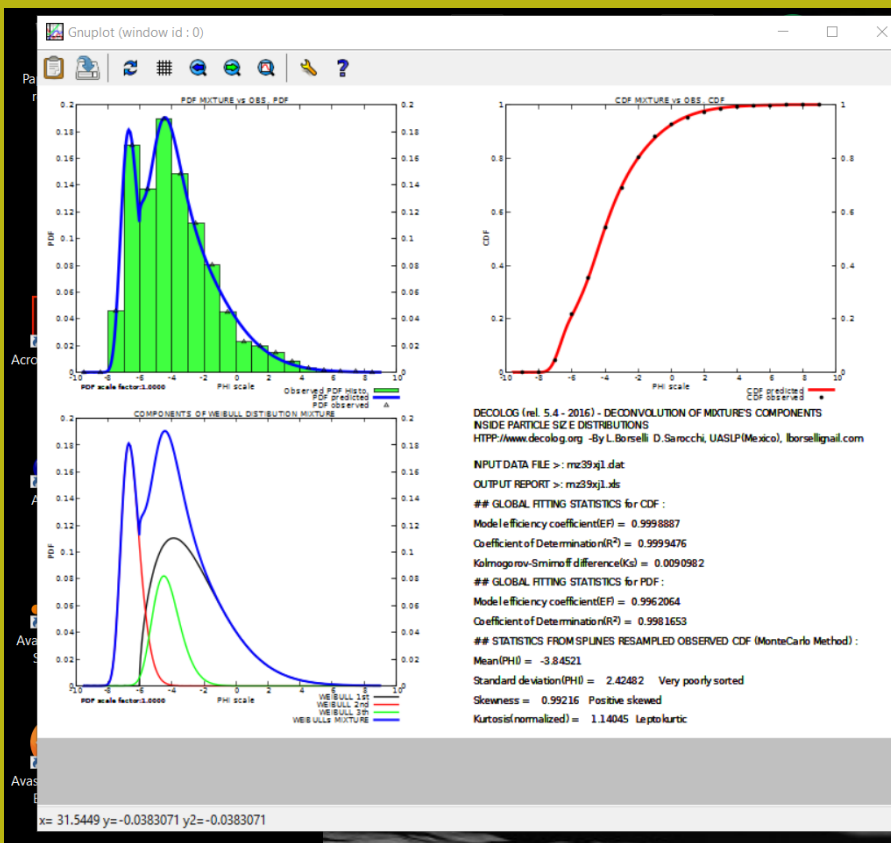
**HELP**

(c) L. Borselli - UASLP (2004,2016) lborselli@gmail.com  
<http://www.decolog.org>

**EXIT**

View results, Run other analysis or load other Data file ...

Graphical User Interface DECOLOG 5.4 (2016)



mz39xj1.xls - metapad

File Edit Favourites Options Help

DECOLOG 5.4 (2004,2016) by L. Borselli UASLP, (Mexico)  
 DECONVOLUTION OF MIXTURE'S COMPONENTS INSIDE PARTICLE SIZE DISTRIBUTIONS  
 MULTI-OBJECTIVE OPTIMIZATION ROUTINE BY DIFFERENTIAL EVOLUTION ALGORITHMS  
 AUTHORS:  
 LORENZO BORSELLI, Instituto de Geología(UASLP),(MEXICO), lborselli@gmail.com  
<http://www.lorenzo-borselli.eu>  
 DAMIANO SAROCCHI, Instituto de Geología(UASLP),(MEXICO), sarocchi@gmail.com

INPUT DATAFILE: E:\LAUORI\DAMIANO\decolog\lazarus\mz39xj1.dat

-----COMPONENTS' OPTIMUM FITTING PARAMETERS-----

PARAMETERS	1st	2nd	3th
K:	1	-1	-1
Shift (lambda):	-6.0360	-2.3182	1.2178
Scale (alpha):	3.9036	4.4380	5.8364
Shape (beta):	1.6115	8.3119	7.3895
Fraction :	0.5646	0.2609	0.1745

Total minimized Multi-Objective Function value: -182.4961874

-----STATISTICAL PARAMETERS OF THE DISTRIBUTIONS AND MIXTURE-----

STATISTICS	1st weibull	2nd weibull	3th weibull
Mean :	-2.5384	-6.5054	-4.2570
Mode :	-3.8964	-6.6883	-4.5809
Median :	-2.9265	-6.5648	-4.3362
Variance :	4.9439	0.3593	0.7651
Standard deviation :	2.2235	0.5994	0.8747
Skewness :	0.9502	0.5527	0.4926
Kurtosis :	4.0093	3.3688	3.2434
Kurtosis (normalized):	1.0093	0.3688	0.2434

GLOBAL STATISTICS FROM WEIGHED COMPONENTS OF THE DERIVED MIXTURE

Mean :	-3.8733
Standard deviation :	2.4203 Very poorly sorted
Skewness :	
Kurtosis :	
Kurtosis (normalized):	

DECOLOG - DECONVOLUTION OF MIXTURE'S COMPONENTS INSIDE PARTICLE SIZE DISTRIBUTIONS

### DECOLOG 5.4 (2016) - 64bit

Maximum number of components to deconvolve: **3** Advanced SETUP

Load input file: E:\LAUORI\DAMIANO\decolog\lazarus\mz39xj1.dat  
 RUN Processing of single file Procedure 1 -> Single file processing

Load list  
 RUN Processing file's list Procedure 2 -> Batch Processing of files

View Graphs  
 View Report  
 View/Edit Text Files  
 View PDF  
 HELP  
 EXIT

MULTIOBJECTIVE GLOBAL OPTIMIZATION MONITOR

Algorithm: TDE Strategy: Rand/best/3 Population Factor: 12 Max Age: 8 Repeat last single file processing

No. Functions evaluated: 7111435 Current File processed: mz39xj1.dat  
 OBJ Function Value: -182.496187388877 Output File generated: mz39xj1.xls  
 Genotype Difference Index: 0.000294470295873680 Output File (PDF Format): mz39xj1.pdf

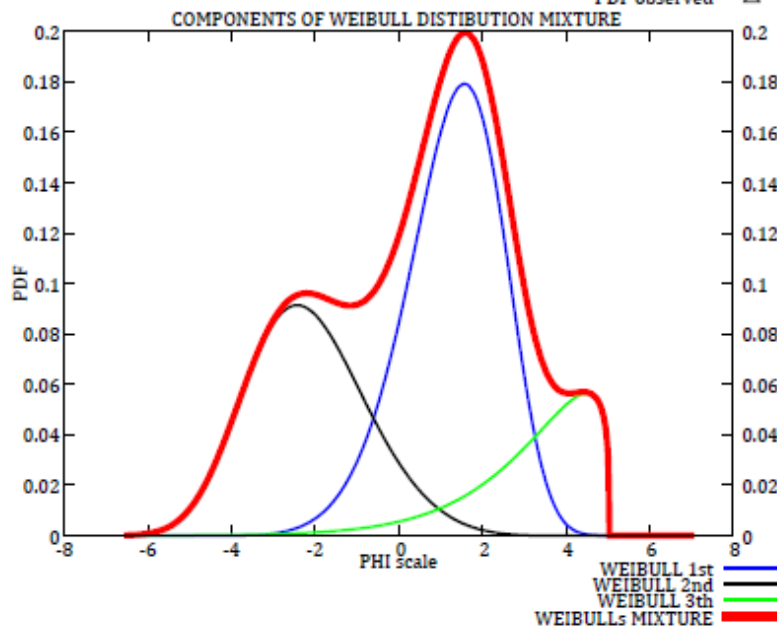
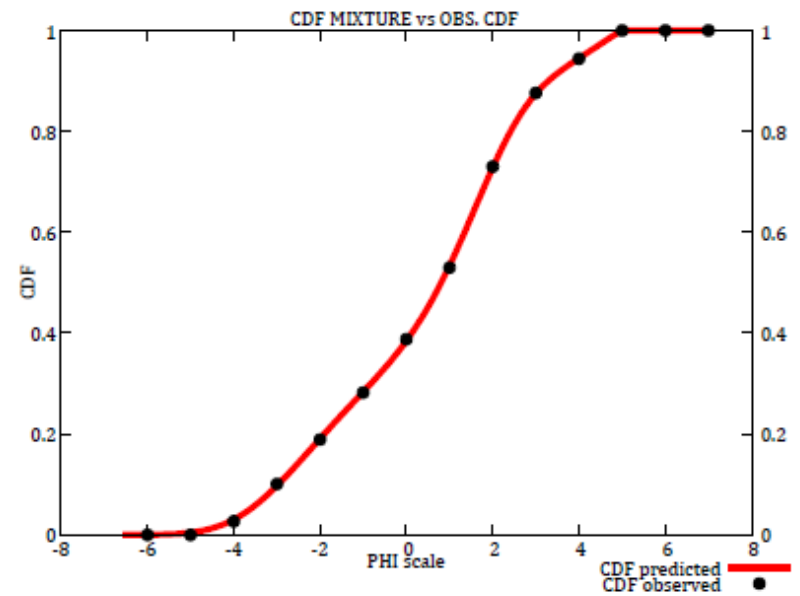
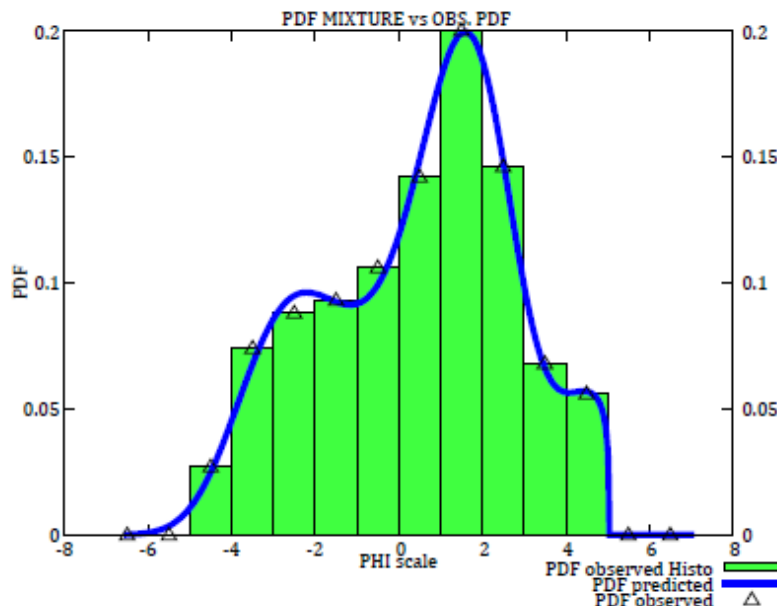
COMPONENTS TABLE (shows current best parameters) Distribution type selected: Weibull

PARAMETERS	1st component	2nd component	3th component
K:	+1	-1	-1
Shift	-6.036017785770423	-2.31821680388616	1.21779591055643
Scale	3.90362471083378	4.43804564237146	5.83644918301952
Shape	1.61152610406216	8.31187786953361	7.38951000447262
Fraction	0.56458961872412	0.26089872173488	0.1745143149541

Press ESC to Force Quit from Current Optimization's Run

L. Borselli - UASLP (2004,2016) lborselli@gmail.com  
<http://www.decolog.org>

## Graphical User Interface DECOLOG 5.4 (2016)



DECOLOG (rel. 5.0 - 2013) - DECONVOLUTION OF MIXTURE'S COMPONENTS  
INSIDE PARTICLE SIZE DISTRIBUTIONS  
HTTP://www.decolog.org -By L.Borselli % D.Sarocchi, UASLP(Mexico), lborselli@gmail.com

INPUT DATA FILE\_\_\_ sthelens81R-114b.dat

OUTPUT REPORT\_\_\_ mtshelens81tris2.xls

## GLOBAL FITTING STATISTICS for CDF:

Model efficiency coefficient(EF)\_\_\_\_\_ 0.9999614

Coefficient of Determination(R^2)\_\_\_\_\_ 0.9999828

Kolmogorov-Smirnoff difference(Ks)\_\_\_\_\_ 0.0045434

## GLOBAL FITTING STATISTICS for PDF:

Model efficiency coefficient(EF)\_\_\_\_\_ 0.9959659

Coefficient of Determination(R^2)\_\_\_\_\_ 0.9980127

## STATISTICS FROM SPLINES RESAMPLED OBSERVED CDF (MonteCarlo Method):

Mean(PHI)\_\_\_\_\_ 0.43117

Standard deviation(PHI)\_\_\_\_\_ 2.29695 Very poorly sorted

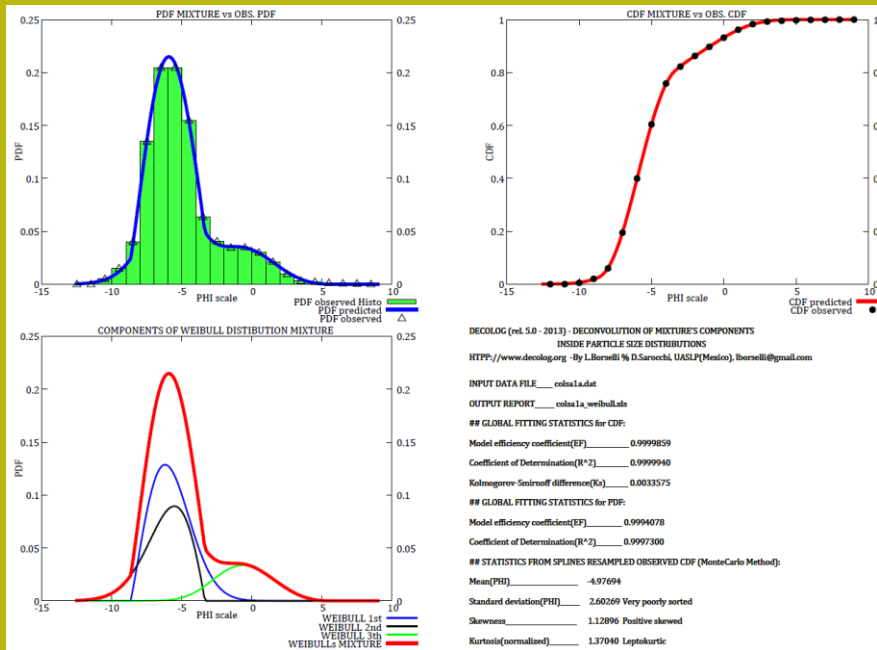
Skewness\_\_\_\_\_ -0.27800 Symmetrical

Kurtosis(normalized)\_\_\_\_\_ -0.76955 Platykurtic

## Reporte Grafico en formato generado en DECOLOG 5.4

# RESULTS

- Each distribution can be analyzed globally or by components
- Statistical parameters of each identified sub-population.
- global statistics by Monte Carlo “resampling” or Folk-Ward optimized
- Analysis’s report in text or graphical formats: CSV(XLS), PDF



-----COMPONENTS' OPTIMUM FITTING PARAMETERS -----				
PARAMETERS	1st	2nd	3th	
K:		1	-1	-1
Shift (lambda):		-8.6756	-3.3761	5.6786
Scale (alpha):		3.3375	3.205	6.9788
Shape (beta):		2.1241	1.9072	3.4806
Fraction :		0.4806	0.3444	0.175
-----				
Total minimised Multi-OI	743.1047119			
-----STATISTICAL PARAMETERS OF THE DISTRIBUTIONS AND MIXTURE----				
STATISTICS	1st weibull	2nd weibull	3th weibull	
Mean :	-5.7197	-6.2198	-0.5987	
Mode :	-6.202	-5.547	-0.6531	
Median :	-5.867	-6.0208	-0.6027	
Variance :	2.1424	2.407	3.9858	
Standard deviation :	1.4637	1.5515	1.9965	
Skewness :	0.5526	-0.6959	-0.03	
Kurtosis :	3.1084	3.3732	2.7122	
Kurtosis (normalized):	0.1084	0.3732	-0.2878	
GLOBAL STATISTICS FROM WEIGHED COMPONENTS OF THE DERIVED MIXTURE				
Mean :	-4.9957			
Standard deviation :	2.59 Very poorly sorted			
Skewness:	1.0352 Positive skewed			
Kurtosis :	3.9755			
Kurtosis (normalized):	0.9755 Leptokurtic			

## METHODS

DECOLOG 5.4 Contains a new optimization engines that allow to consider components of Lognormal and Weibull distribution with negative skewness (left tailed distribution) , a set of generalized 4 parameters distributions.

DECOLOG's internal engine was improved a lot considering a set of multi-objective optimization genetic algorithms: “Differential evolution” (DE) y “Trigonometric differential evolution (TDE). These algorithm produced a relevant increase of convergence to global minima, significance and reproducibility of final results.

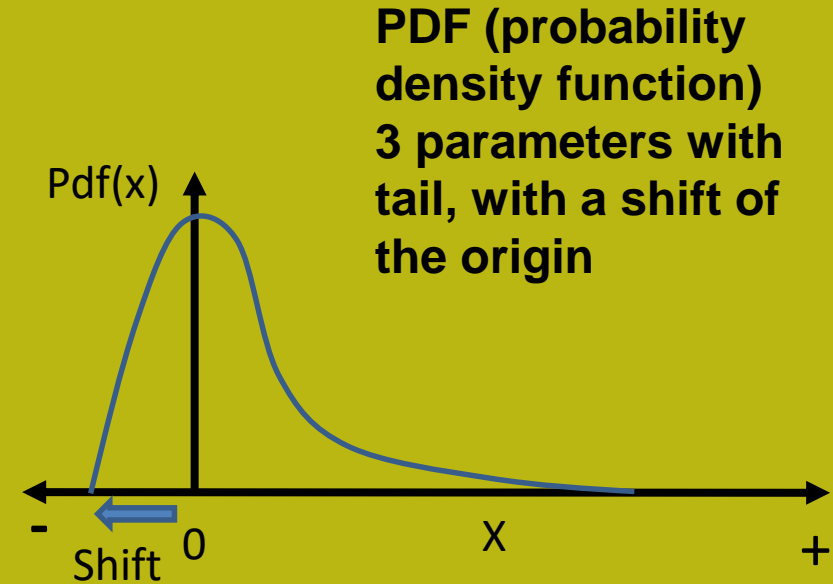
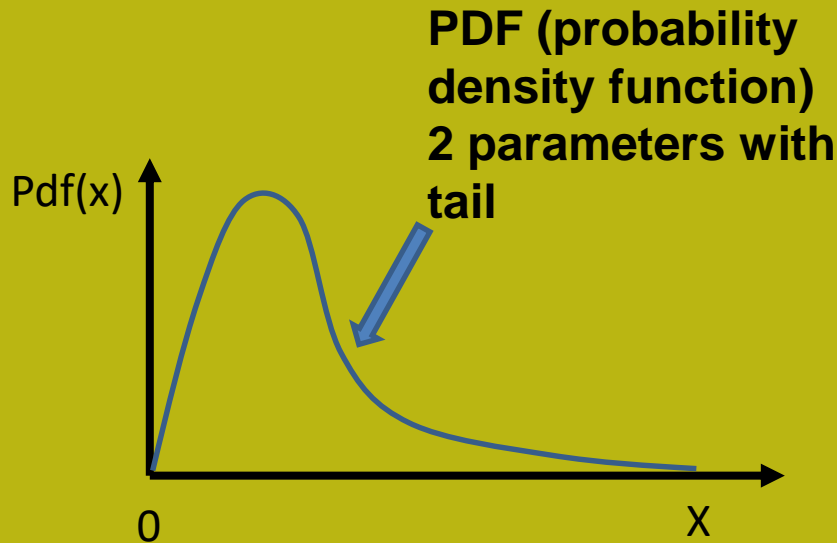
See [Differential Evolution Application In Earth Sciences\(2008\)](#)

[http://www.lorenzo-borselli.eu/presentations/DifferentialEvolutionApplicationInEarthSciences\\_Borselli2008.pdf](http://www.lorenzo-borselli.eu/presentations/DifferentialEvolutionApplicationInEarthSciences_Borselli2008.pdf)

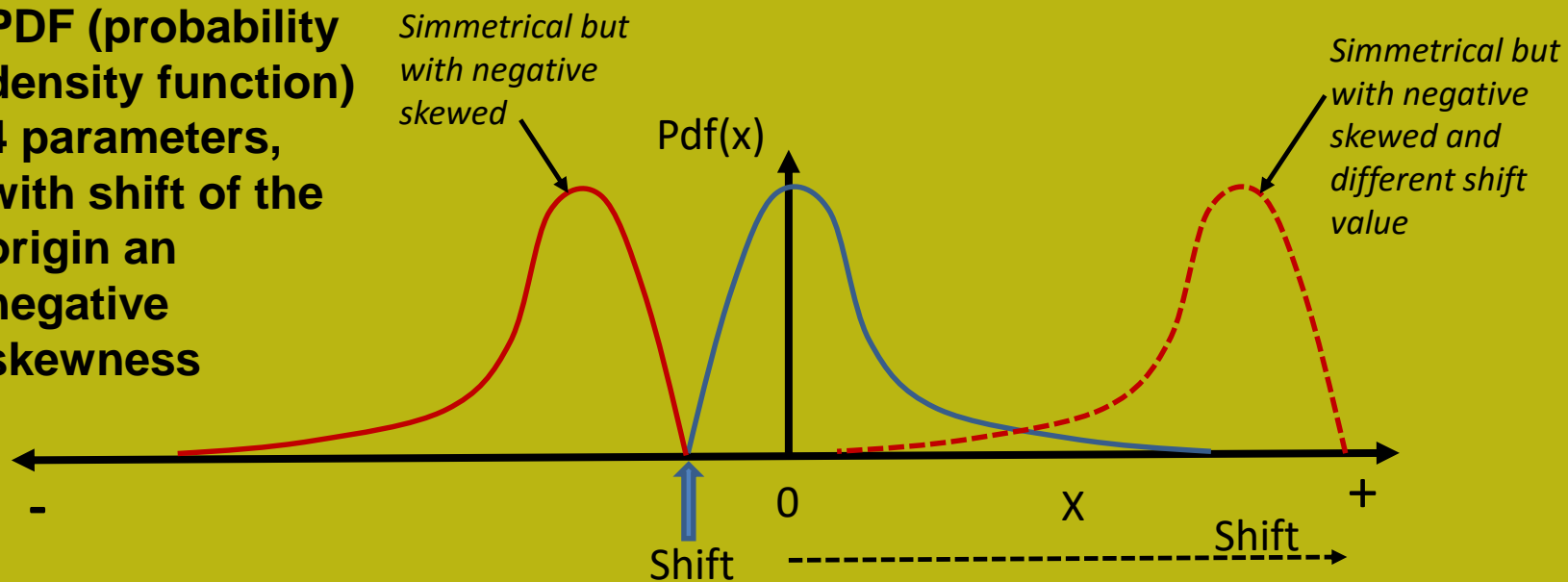
(Invited seminar Centro De Geociencias - UNAM, Queretaro (MEXICO) – May 7th 2008)

See at Presentation section, in the web site : [www.lorenzo-borselli.eu](http://www.lorenzo-borselli.eu)

# Continue distributions of 4,3 and 2 Parameters



**PDF (probability density function) 4 parameters, with shift of the origin an negative skewness**



# Details on Lognormal Dist. 4,3 and 2 Parameters

PDF (probability density function)

$$f(x) = \frac{e^{-\frac{(\ln(k(x-\lambda))-\alpha)^2}{2\beta^2}}}{\sqrt{2\pi}\beta(k(x-\lambda))}$$

CDF  
(Cumulative distribution function)

$$F(x) = \frac{1}{2} \left( 1 + \operatorname{erf} \left( \frac{k(\ln(k(x-\lambda))-\alpha)}{\beta\sqrt{2}} \right) \right)$$

**Note:**

**with  $K=+1$  we have a standard Lognormal 3 parameters, and with  $\lambda=0$  it became a standard Lognormal 2 Parameters**

*Notes: The value  $k=+1$  produces a classical right tailed distribution – (positive skewness), the value  $k=-1$  produces a left tailed distribution – (negative skewness) by Aitchison and Brown (1957) (reflected distribution).  $K$  assumes only integer values.*

*$\lambda$  is : the location/shift parameters related to the shifting on  $x$  axis with respect the origin of the axis. Valid values are in the interval  $[-\infty, +\infty]$*

*$\alpha$  the scale parameter v. valid values are in the interval  $[0, +\infty]$*

*$\beta$  is the shape parameter. Valid values are in the interval  $[0, +\infty]$*

# Details on Weibull Dist. 4,3 and 2 Parameters

PDF (probability density function)

$$f(x) = \frac{\beta}{\alpha} \left( \frac{k(x-\lambda)}{\alpha} \right)^{\beta-1} e^{-\left( \frac{k(x-\lambda)}{\alpha} \right)^\beta}$$

CDF (Cumulative distribution function)

$$F(x) = \frac{1+k}{2k} - ke^{-\left( \frac{k(x-\lambda)}{\alpha} \right)^\beta}$$

**Note:**

**with  $K=+1$  we have a standard weibull 3 parameters, y con  $\lambda =0$  it became a standard weibull 2 parámetros**

*Notes: The value  $k= +1$  produces a classical weibull distribution , the value  $k= -1$  produces ... reflected Weibull distribution Cohen(1973) –  $K$  assumes only integer values.  $[-\infty, +\infty]$*

*$\lambda$  is the location/shift parameters related to the shifting on  $x$  axis with respect the origin of the axis. Valid values are in the interval  $[-\infty, +\infty]$*

*$\alpha$  the scale parameter. valid values are in the interval  $[0, +\infty]$ .*

*$\beta$  is the shape parameter. Valid values are in th interval  $[0, +\infty]$*



# Deconvolution by not linear multi-objective global optimization

A Procedure for Global Optimization , not linear, multi-objectives has been developed (since 2004) in order to obtain a robust and efficient decoding of information inside PSD. We obtain 5 parameters identifying the fingerprint of each distribution and their relative importance in total PSD:  $\alpha_i, \beta_i, \lambda_i, k_i, w_i$

$$f(x)_{mix} = w_1 f_1(x) + w_2 f_2(x) + \dots + w_n f_n(x)$$

Mixture of PDFs

$$F(x)_{mix} = w_1 F_1(x) + w_2 F_2(x) + \dots + w_n F_n(x)$$

Mixture of CDFs

$$\sum_{i=1}^n w_i = 1$$

The multi-objective optimization we produce a concurrent fitting of observed PDF and CDF, or in other words on PDF function and on its integral (CDF). This is more efficient than on the PDF or CDF alone (Wanga et al. ,2004) The goal can be obtained transforming a multi-objective process in single objective optimization (Andersson, 2000 ), using the following eqs:

$$\min[obj] = \max[CEF_{cdf} + CEF_{pdf}]$$

Based on efficiency modelig parameter (EF)  
By Nash and Sutcliffe (1970)

Where

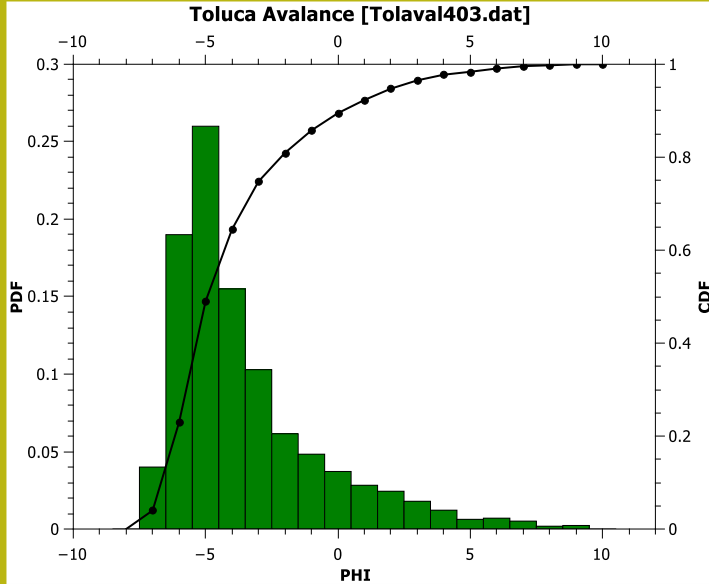
$$CEF_{cdf/pdf} = 1 - EF_{cdf/pdf}$$

Based on Akaike inf. criteria

$$\min[obj] = \max[Caik_{cdf} + Caik_{pdf}]$$

where :

$$Caik_{cdf/pdf} = \text{Akaike information criteria (AIC)}$$



#### Folk-Ward statistics

mean	-4.18608
std dev	2.56410
skewness	0.52551
Kurtosis (Folk-ward)	1.24688
kurtosis(normalised)	1.70032

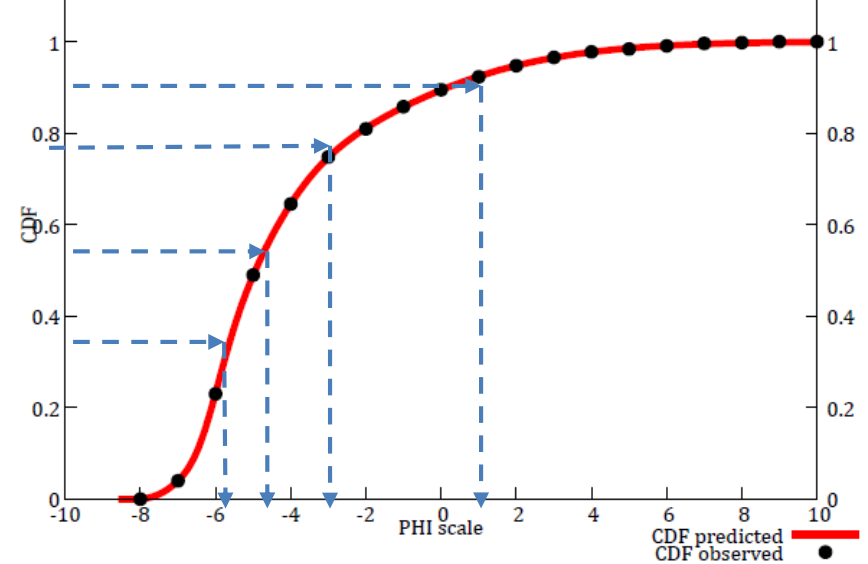
$$\text{Mean} = \frac{\phi_{16} + \phi_{50} + \phi_{84}}{3}$$

$$\text{Median} = \phi_{50}$$

$$\text{Sorting} = \frac{\phi_{16} + \phi_{84}}{4} + \frac{\phi_{95} - \phi_5}{6.6}$$

$$\text{Skewness} = \frac{\phi_{16} + \phi_{84} - 2\phi_{50}}{2(\phi_{84} - \phi_{16})} + \frac{\phi_5 + \phi_{95} - 2\phi_{50}}{2(\phi_{95} - \phi_5)}$$

$$\text{Kurtosis} = \frac{\phi_{95} - \phi_5}{2.44(\phi_{75} - \phi_{25})}$$



#### Statistics (method of the Moments) from resampled OBSERVED CDF (MONTE CARLO METHOD)

mean	-3.98504
std dev	2.83190
skewness	1.54300
kurtosis (normalised)	2.29259



**Monte carlo resampling of interpolated observed CDF.** Interpolation made with Convex Cubic Rational splines with tensión with C1 and C2 properties.

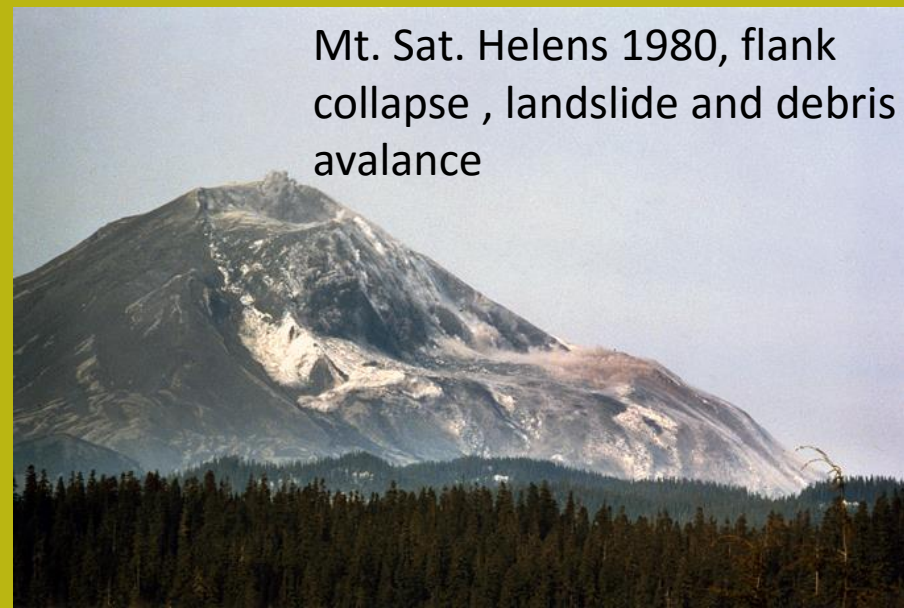
Usually **20000** random resampling on CDF.

**Global statistics calculations**

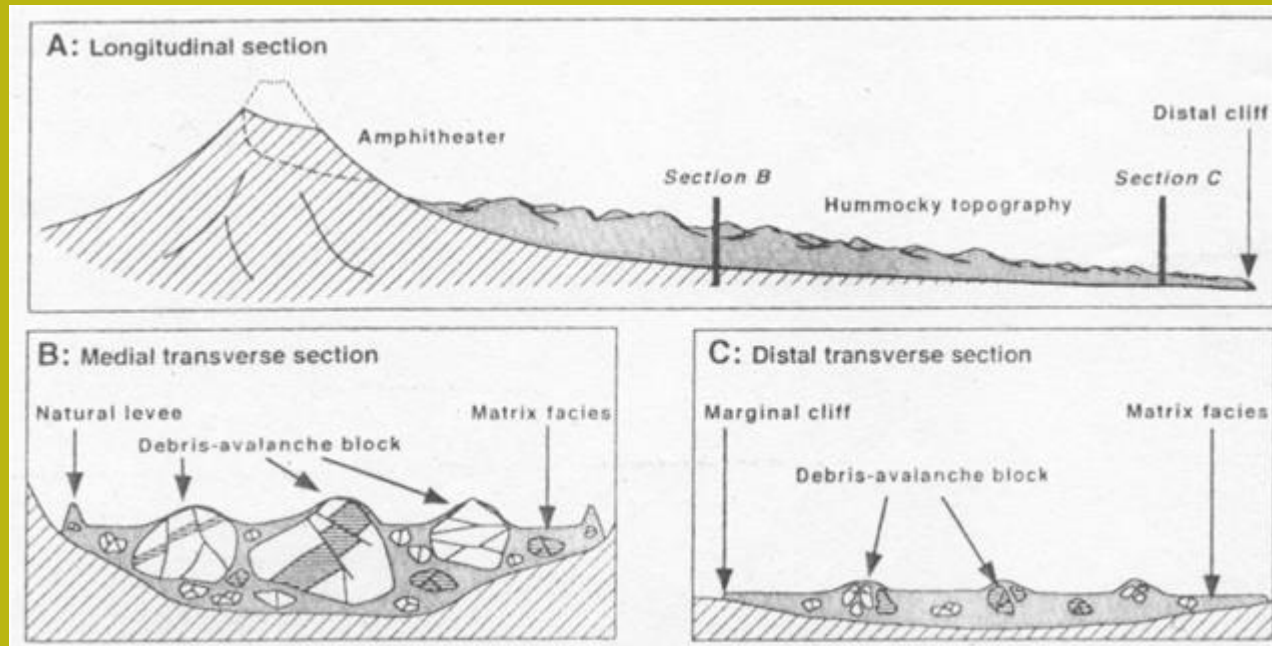
## Two example of aplication:

- Debris avalance in volcano, Nevado de Toluca, Mexico
- Olistostrome formation (large Deep-sea landslide deposits), Turkey

- Debris  
avalanche in  
volcano,  
Nevado de  
Toluca, Mexico

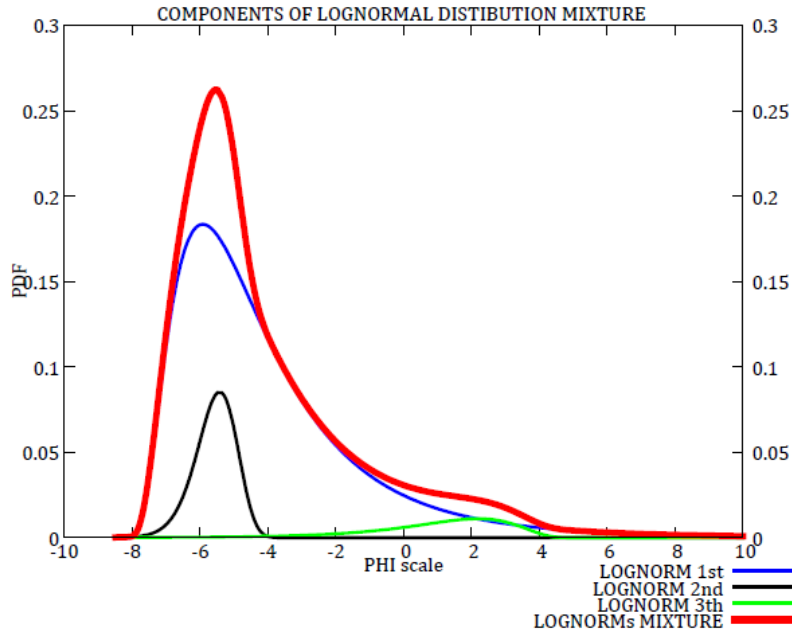
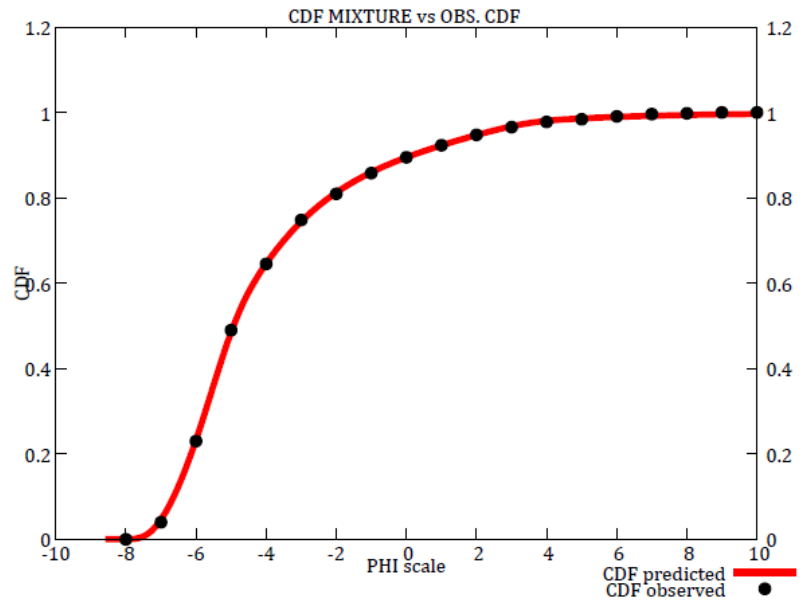
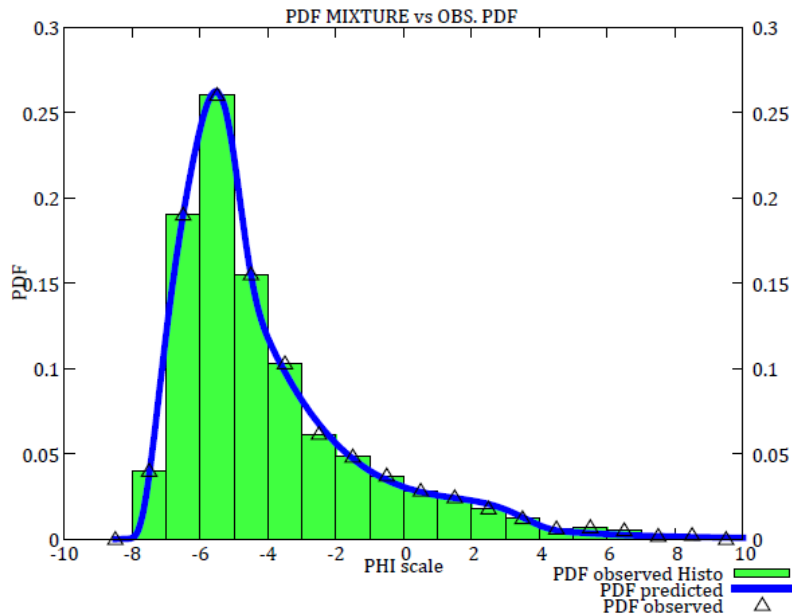


[http://www.mshslc.org/wp-content/uploads/2013/05/2\\_debris\\_avalanche\\_intro.jpg](http://www.mshslc.org/wp-content/uploads/2013/05/2_debris_avalanche_intro.jpg)



<https://volcaniccollapse.files.wordpress.com/2011/10/image8.png>

San Luis Potosi; Mexico, DICIM Seminar, 18 May 2016, Universidad autonoma de San Luis Potosi



DECOLOG (rel. 5.0 - 2013) - DECONVOLUTION OF MIXTURE'S COMPONENTS  
INSIDE PARTICLE SIZE DISTRIBUTIONS

HTTP://www.decolog.org - By L.Borselli % D.Sarocchi, UASLP(Mexico), lborselli@gmail.com

INPUT DATA FILE \_\_\_ tolaival0403.dat

OUTPUT REPORT \_\_\_ tolaival0403bis-lognorm.xls

## GLOBAL FITTING STATISTICS for CDF:

Model efficiency coefficient(EF) \_\_\_ 0.9999066

Coefficient of Determination( $R^2$ ) \_\_\_ 0.9999607

Kolmogorov-Smirnoff difference( $K_s$ ) \_\_\_ 0.0062678

## GLOBAL FITTING STATISTICS for PDF:

Model efficiency coefficient(EF) \_\_\_ 0.9989007

Coefficient of Determination( $R^2$ ) \_\_\_ 0.9994797

## STATISTICS FROM SPLINES RESAMPLED OBSERVED CDF (MonteCarlo Method):

Mean(PHI) \_\_\_ -3.98537

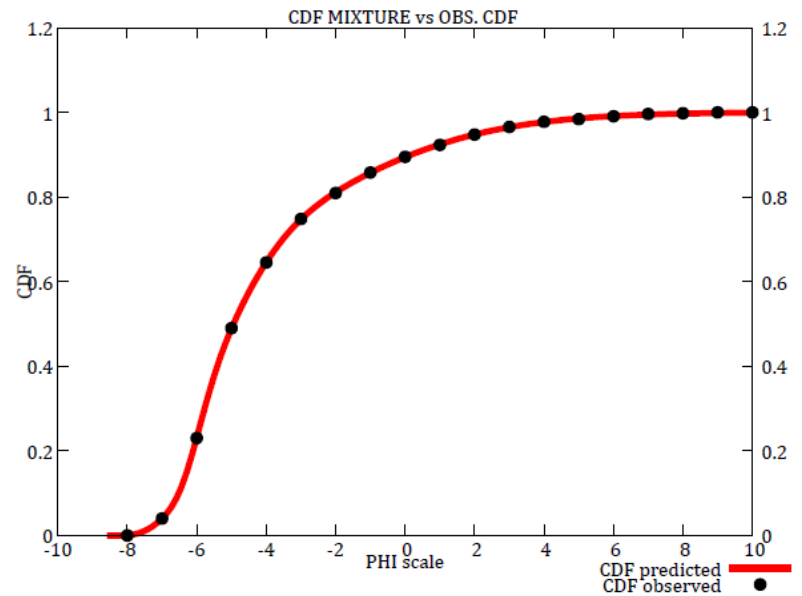
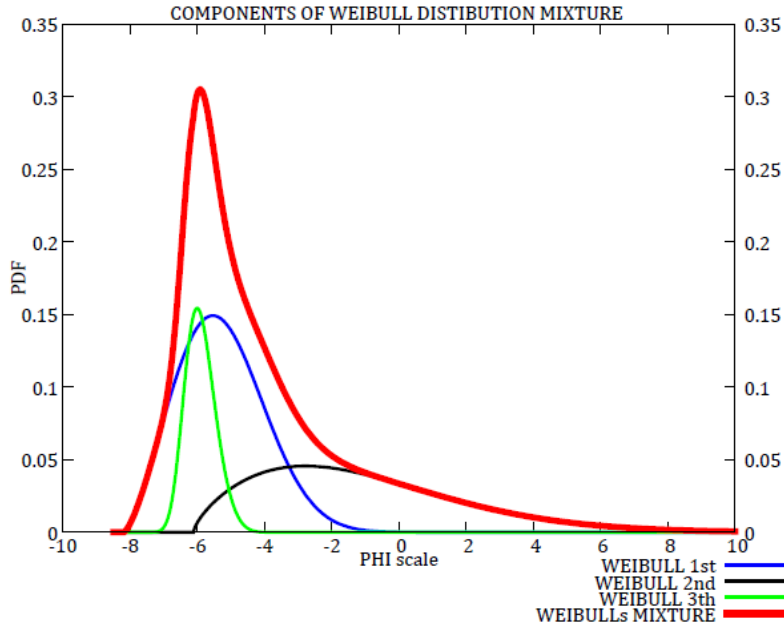
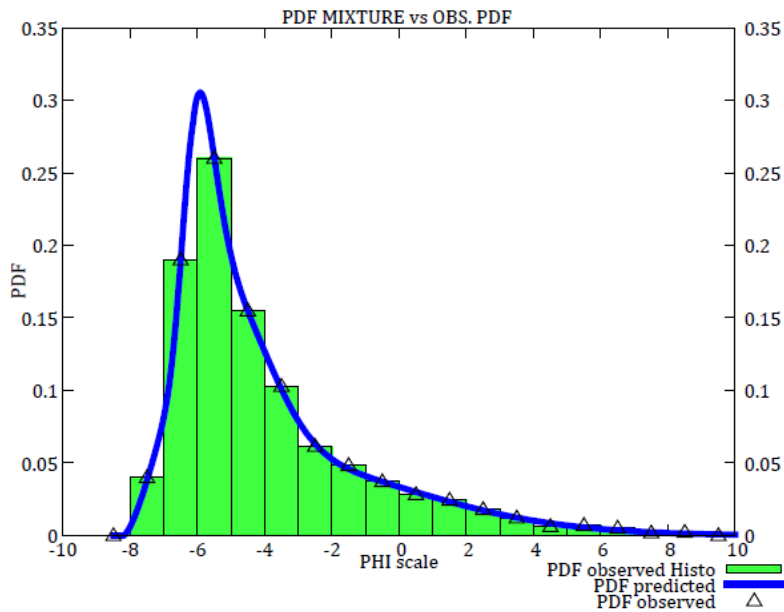
Standard deviation(PHI) \_\_\_ 2.84015 Very poorly sorted

Skewness \_\_\_ 1.55503 Very positive skewed

Kurtosis(normalized) \_\_\_ 2.37742 Leptokurtic

lognormal 4 parámetros – 3 componentes

Nevado de Toluca avalance - global Akaike inf criteria -196.53



DECOLOG (rel. 5.0 - 2013) - DECONVOLUTION OF MIXTURE'S COMPONENTS  
INSIDE PARTICLE SIZE DISTRIBUTIONS  
[HTTP://www.decolog.org](http://www.decolog.org) -By L.Borselli % D.Sarocchi, UASLP(Mexico), lborselli@gmail.com

INPUT DATA FILE\_\_\_tolaval0403.dat

OUTPUT REPORT\_\_\_tolaval0403bis.xls

## GLOBAL FITTING STATISTICS for CDF:

Model efficiency coefficient(EF)\_\_\_\_\_0.9999907

Coefficient of Determination(R^2)\_\_\_\_\_0.9999958

Kolmogorov-Smirnoff difference(Ks)\_\_\_\_\_0.0017719

## GLOBAL FITTING STATISTICS for PDF:

Model efficiency coefficient(EF)\_\_\_\_\_0.9996499

Coefficient of Determination(R^2)\_\_\_\_\_0.9998347

## STATISTICS FROM SPLINES RESAMPLED OBSERVED CDF (MonteCarlo Method):

Mean(PHI)\_\_\_\_\_ -3.98537

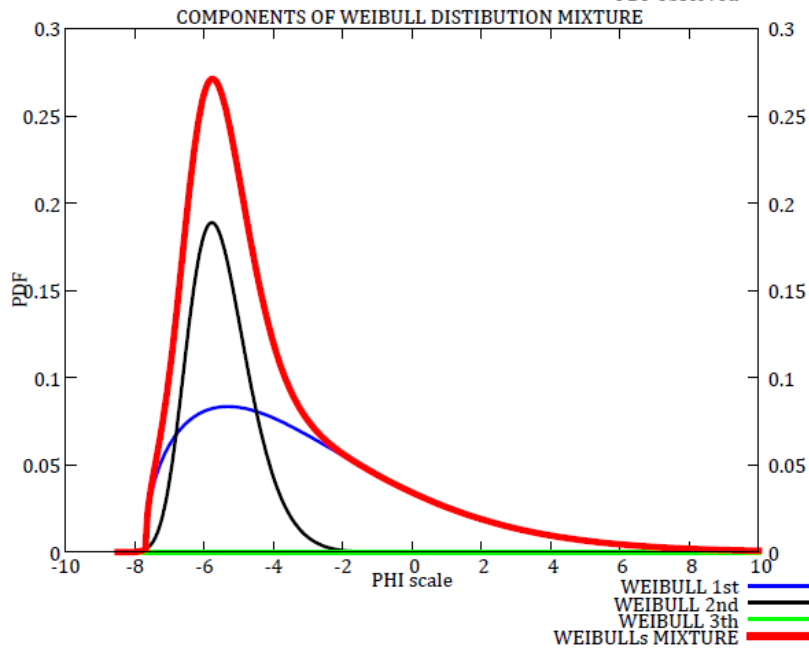
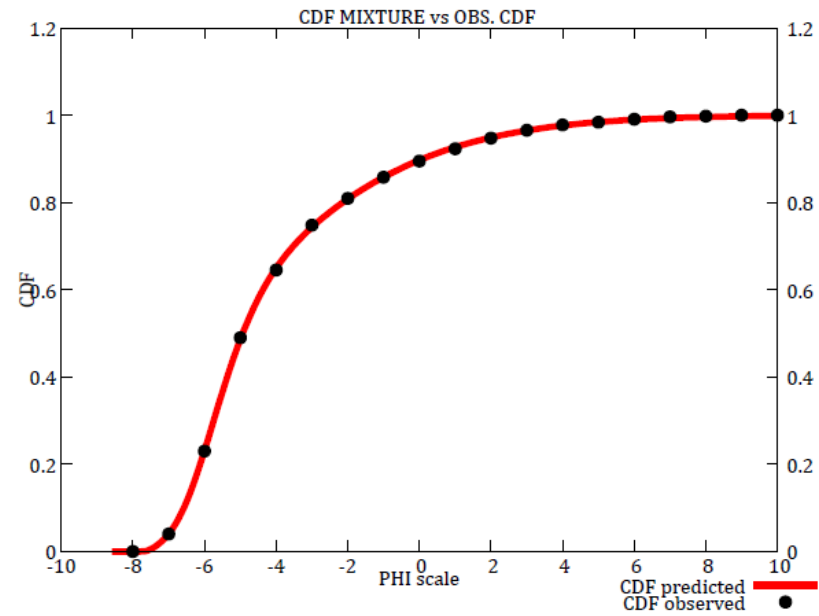
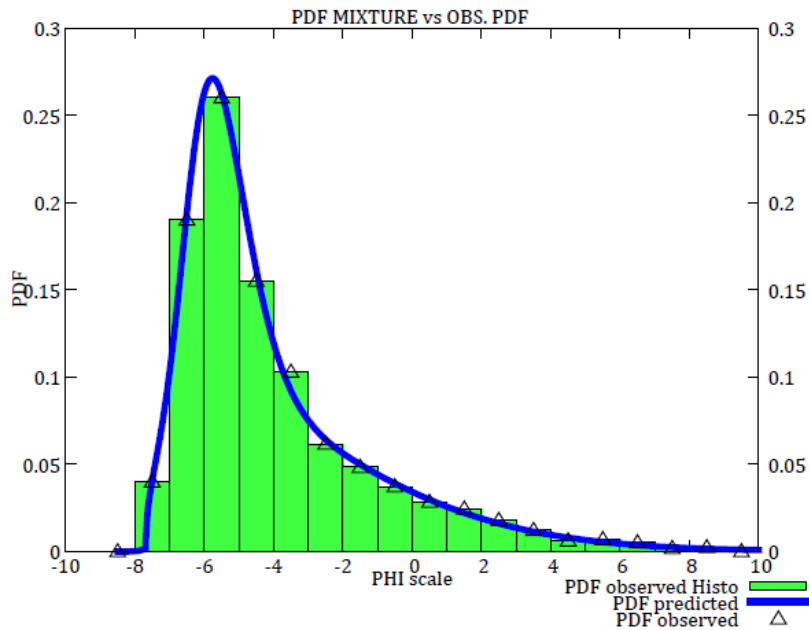
Standard deviation(PHI)\_\_\_\_\_ 2.84015 Very poorly sorted

Skewness\_\_\_\_\_ 1.55503 Very positive skewed

Kurtosis(normalized)\_\_\_\_\_ 2.37742 Leptokurtic

Weibull 4 parámetros – 3 componentes

Nevado de Toluca avalance - global Akaike inf. criteria -229.35



**DECOLOG (rel. 5.0 - 2013) - DECONVOLUTION OF MIXTURE'S COMPONENTS  
INSIDE PARTICLE SIZE DISTRIBUTIONS**

HTTP://www.decolog.org -By L.Borselli % D.Sarocchi, UASLP(Mexico), lborselli@gmail.com

INPUT DATA FILE\_\_\_tolaval0403.dat

OUTPUT REPORT\_\_\_tolaval0403bis-weibul\_only2.xls

## GLOBAL FITTING STATISTICS for CDF:

Model efficiency coefficient(EF)\_\_\_\_\_0.9999473

Coefficient of Determination(R^2)\_\_\_\_\_0.9999751

Kolmogorov-Smirnoff difference(Ks)\_\_\_\_\_0.0046800

## GLOBAL FITTING STATISTICS for PDF:

Model efficiency coefficient(EF)\_\_\_\_\_0.9977339

Coefficient of Determination(R^2)\_\_\_\_\_0.9990113

## STATISTICS FROM SPLINES RESAMPLED OBSERVED CDF (MonteCarlo Method):

Mean(PHI)\_\_\_\_\_ -3.98537

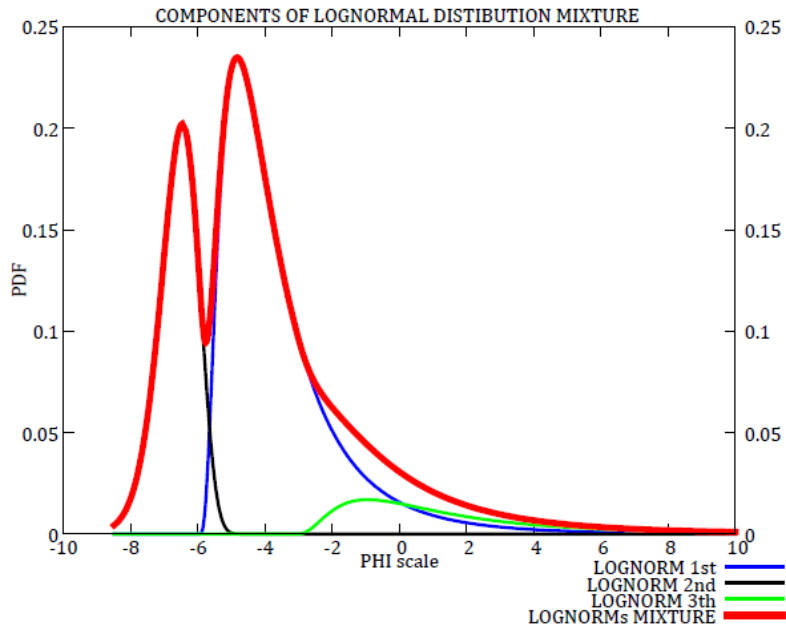
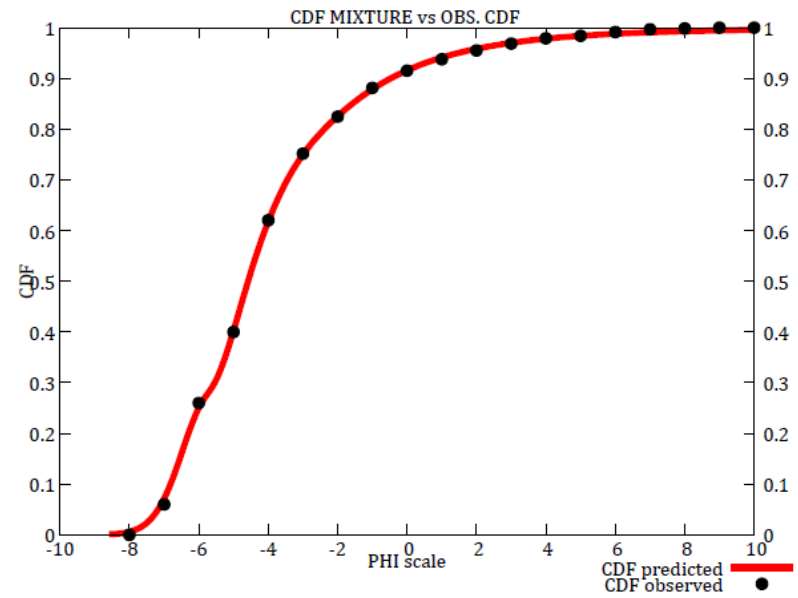
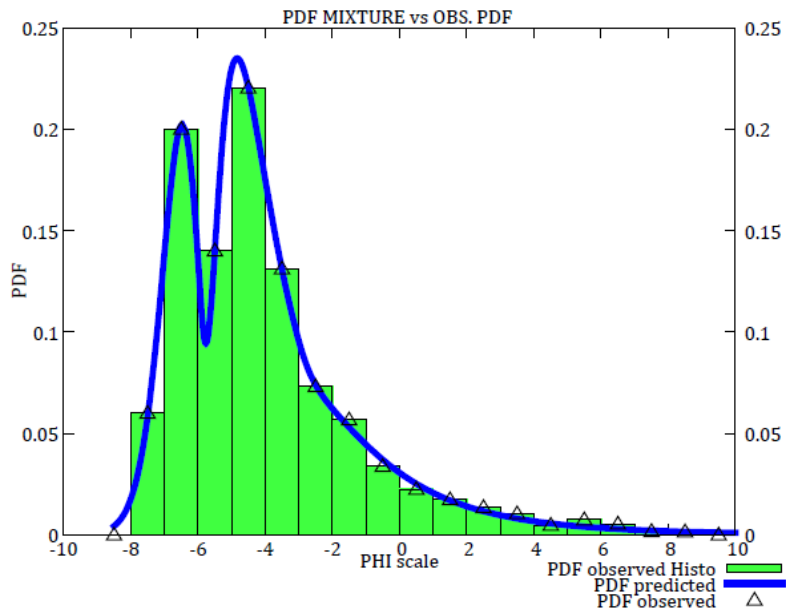
Standard deviation(PHI)\_\_\_\_\_ 2.84015 Very poorly sorted

Skewness\_\_\_\_\_ 1.55503 Very positive skewed

Kurtosis(normalized)\_\_\_\_\_ 2.37742 Leptokurtic

Weibull 4 parámetros – 2 componentes

Nevado de Toluca avalance - global Akaike inf criteria -205.10



DECOLOG (rel. 5.0 - 2013) - DECONVOLUTION OF MIXTURE'S COMPONENTS  
INSIDE PARTICLE SIZE DISTRIBUTIONS

HTTTP://www.decolog.org -By L.Borselli % D.Sarocchi, UASLP(Mexico), lborselli@gmail.com

INPUT DATA FILE \_\_\_tolaval0401.dat

OUTPUT REPORT \_\_\_tolaval0401\_lognormal3.xls

## GLOBAL FITTING STATISTICS for CDF:

Model efficiency coefficient(EF) \_\_\_\_\_ 0.9997794

Coefficient of Determination( $R^2$ ) \_\_\_\_\_ 0.9999125

Kolmogorov-Smirnoff difference( $K_s$ ) \_\_\_\_\_ 0.0115849

## GLOBAL FITTING STATISTICS for PDF:

Model efficiency coefficient(EF) \_\_\_\_\_ 0.9990028

Coefficient of Determination( $R^2$ ) \_\_\_\_\_ 0.9995068

## STATISTICS FROM SPLINES RESAMPLED OBSERVED CDF (MonteCarlo Method):

Mean(PHI) \_\_\_\_\_ -4.02092

Standard deviation(PHI) \_\_\_\_\_ 2.72428 Very poorly sorted

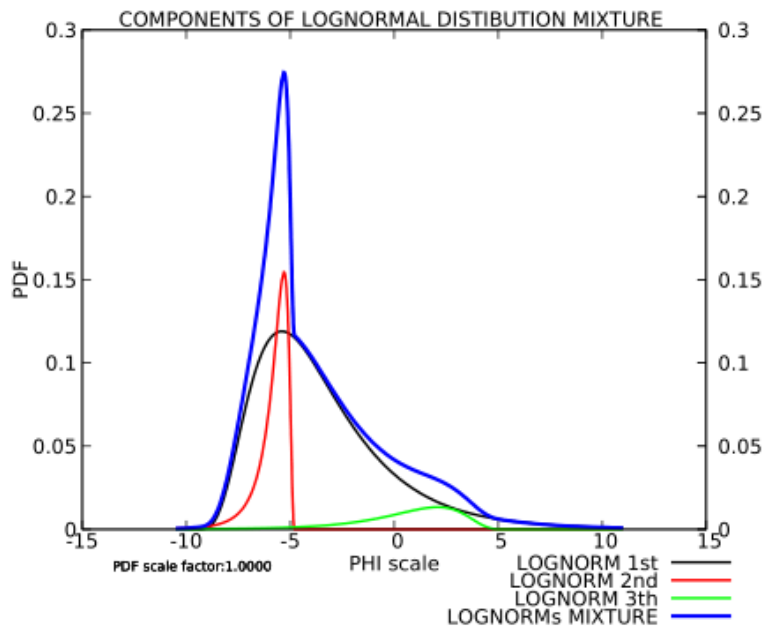
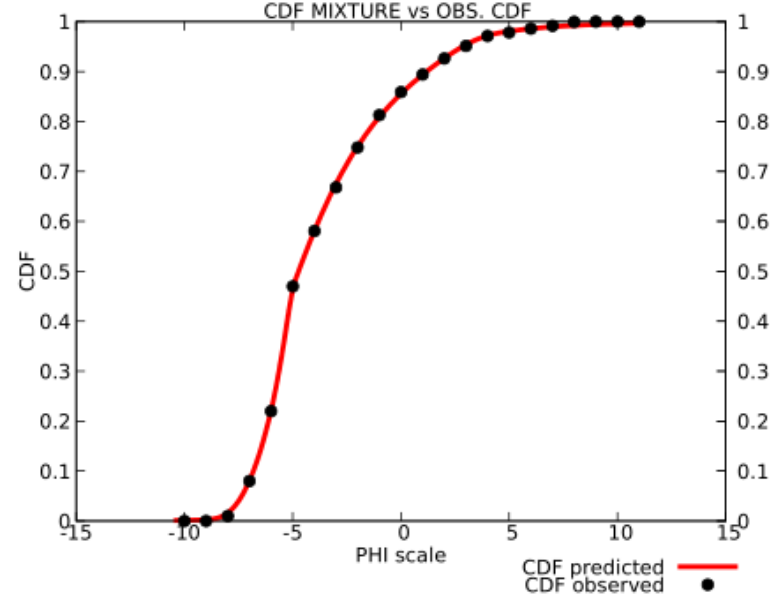
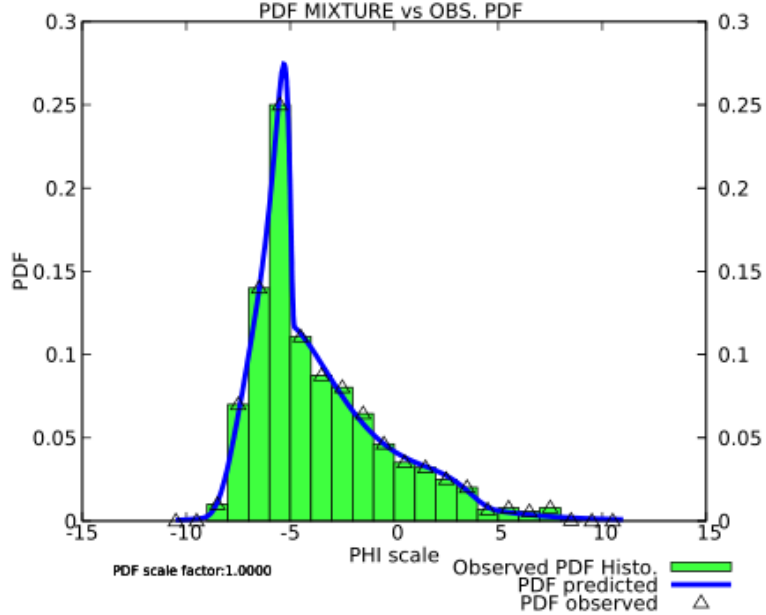
Skewness \_\_\_\_\_ 1.50172 Very positive skewed

Kurtosis(normalized) \_\_\_\_\_ 2.74593 Leptokurtic

lognormal 4 parámetros – 3 componentes

Nevado de Toluca avalance - global Akaike inf criteria -190.15





DECOLOG (rel. 5.4 - 2016) - DECONVOLUTION OF MIXTURE'S COMPONENTS  
 INSIDE PARTICLE SIZE DISTRIBUTIONS  
[HTTP://www.decolog.org](http://www.decolog.org) -By L.Borselli D.Sarocchi, UASLP(Mexico), lborselligmail.com

INPUT DATA FILE >: tolaival0408.dat

OUTPUT REPORT >: tolaival0408.xls

## GLOBAL FITTING STATISTICS for CDF :

Model efficiency coefficient(EF) = 0.9998961

Coefficient of Determination( $R^2$ ) = 0.9999575

Kolmogorov-Smirnoff difference(Ks) = 0.0072604

## GLOBAL FITTING STATISTICS for PDF :

Model efficiency coefficient(EF) = 0.9959844

Coefficient of Determination( $R^2$ ) = 0.9983303

## STATISTICS FROM SPLINES RESAMPLED OBSERVED CDF (MonteCarlo Method) :

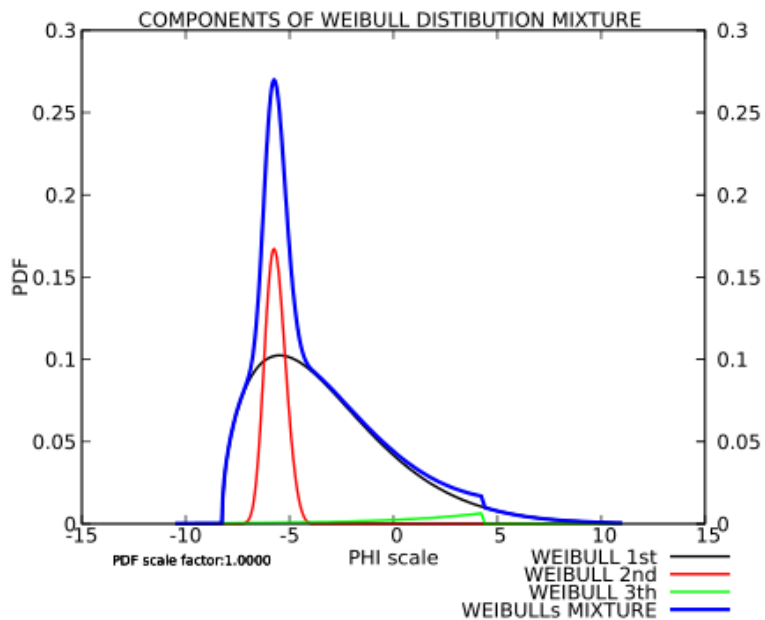
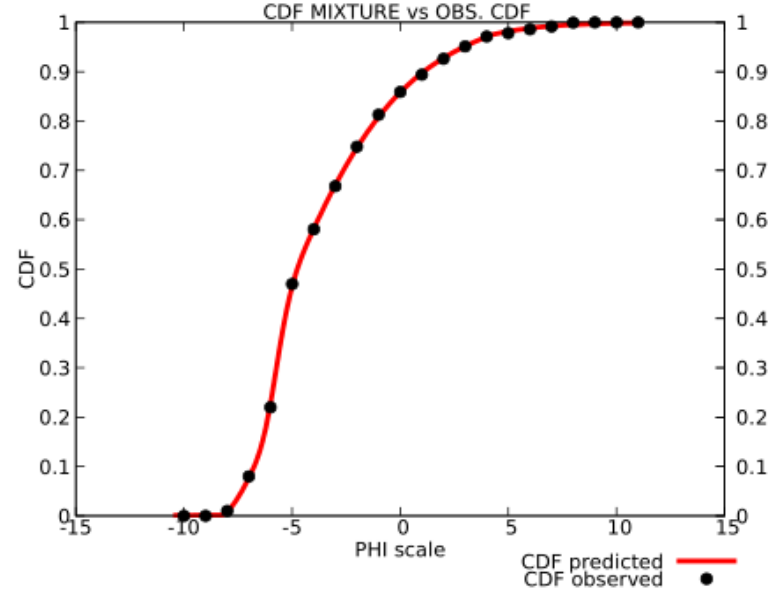
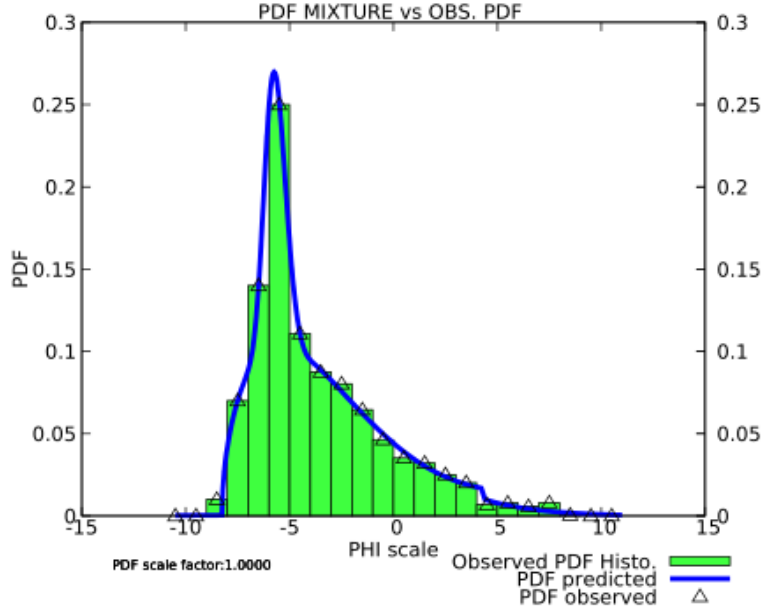
Mean(PHI) = -3.64004

Standard deviation(PHI) = 3.19899 Very poorly sorted

Skewness = 1.19434 Positive skewed

Kurtosis(normalized) = 1.04242 Leptokurtic

LogNormal 4 parámetros – 3 componentes :algorithm TDE  
 Nevado de Toluca avalance - global Akaike inf. criteria -227.43



DECOLOG (rel. 5.4 - 2016) - DECONVOLUTION OF MIXTURE'S COMPONENTS INSIDE PARTICLE SIZE DISTRIBUTIONS  
[HTTP://www.decolog.org](http://www.decolog.org) -By L.Borselli D.Sarocchi, UASLP(Mexico), lborselligmail.com

INPUT DATA FILE >: tolaval0408.dat

OUTPUT REPORT >: tolaval0408.xls

## GLOBAL FITTING STATISTICS for CDF :

Model efficiency coefficient(EF) = 0.9999338

Coefficient of Determination(R<sup>2</sup>) = 0.9999672

Kolmogorov-Smirnoff difference(Ks) = 0.0078636

## GLOBAL FITTING STATISTICS for PDF :

Model efficiency coefficient(EF) = 0.9974407

Coefficient of Determination(R<sup>2</sup>) = 0.9988103

## STATISTICS FROM SPLINES RESAMPLED OBSERVED CDF (MonteCarlo Method) :

Mean(PHI) = -3.64004

Standard deviation(PHI) = 3.19899 Very poorly sorted

Skewness = 1.19434 Positive skewed

Kurtosis(normalized) = 1.04242 Leptokurtic

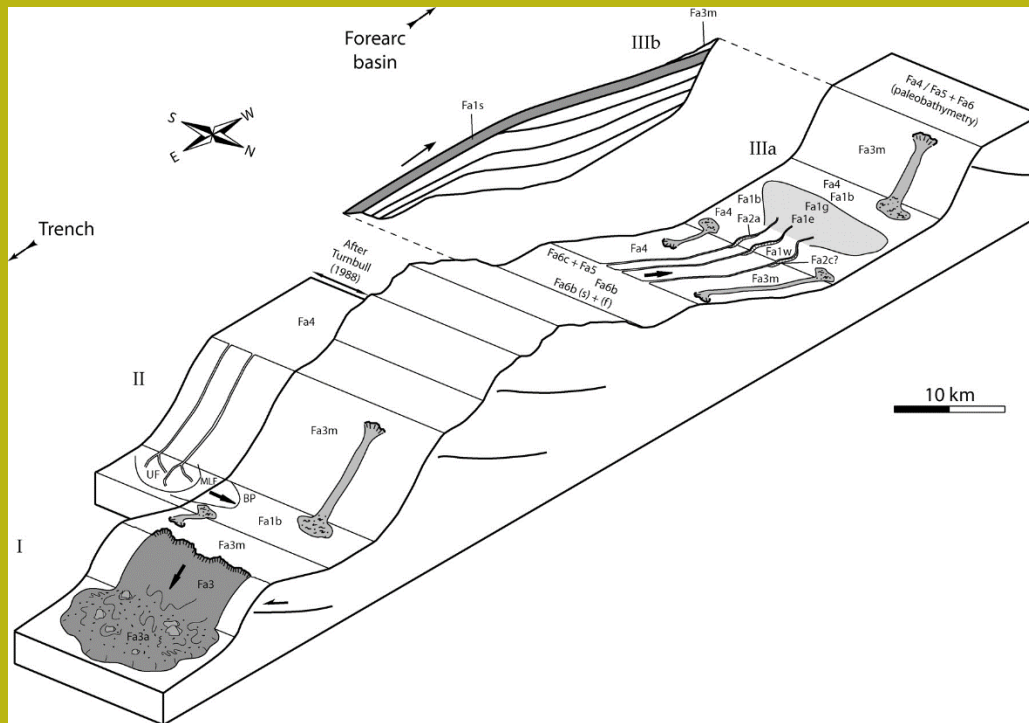
Weibull 4 parámetros – 3 componentes :algorithm TDE

Nevado de Toluca avalance - global Akaike inf. criteria -227.43

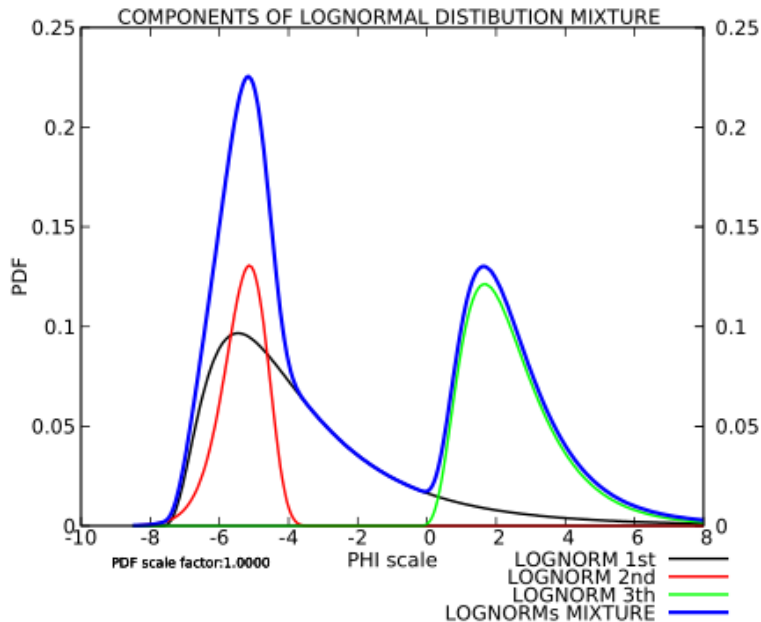
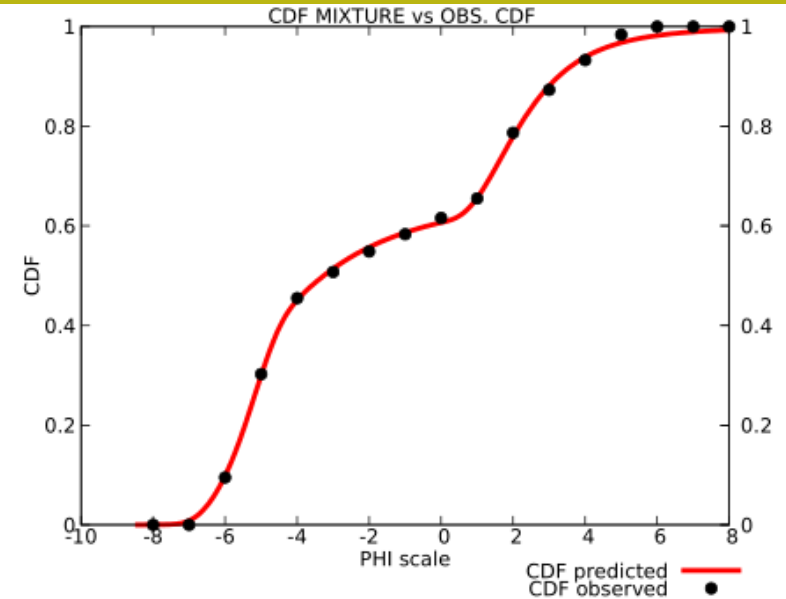
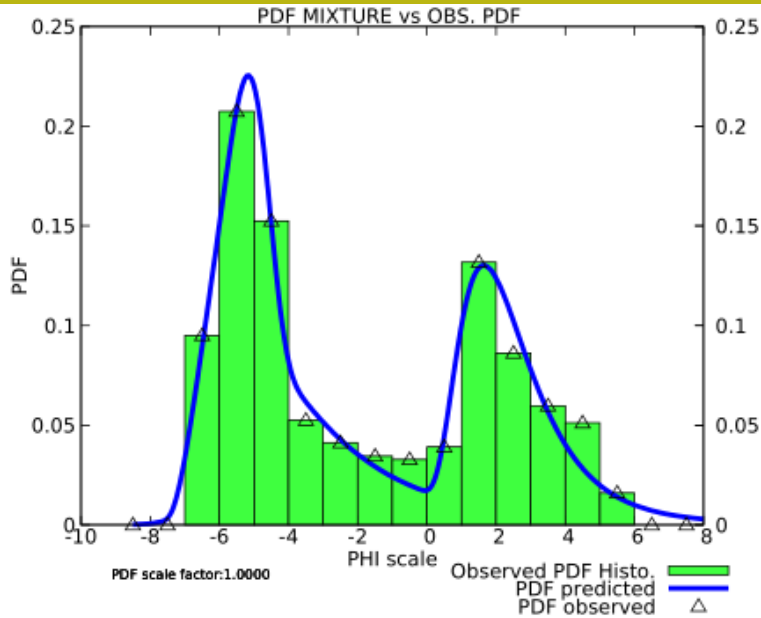
- Olistostrome formation (large Deep-sea landslide deposits, usually then tectonized by orogenic process), Turkey



<http://www.ub.edu/ggac/images/olistostrome.jpg>



<http://jsedres.sepmonline.org/content/77/4/263/F10.large.jpg>



DECOLOG (rel. 5.4 - 2016) - DECONVOLUTION OF MIXTURE'S COMPONENTS INSIDE PARTICLE SIZE DISTRIBUTIONS  
[HTTP://www.decolog.org](http://www.decolog.org) -By L.Borselli D.Sarocchi, UASLP(Mexico), lborselli@gmail.com

INPUT DATA FILE >: oli2.dat

OUTPUT REPORT >: oli2.xls

## GLOBAL FITTING STATISTICS for CDF :

Model efficiency coefficient(EF) = 0.9993700

Coefficient of Determination( $R^2$ ) = 0.9997679

Kolmogorov-Smirnoff difference(Ks) = 0.0178862

## GLOBAL FITTING STATISTICS for PDF :

Model efficiency coefficient(EF) = 0.9781112

Coefficient of Determination( $R^2$ ) = 0.9891733

## STATISTICS FROM SPLINES RESAMPLED OBSERVED CDF (MonteCarlo Method) :

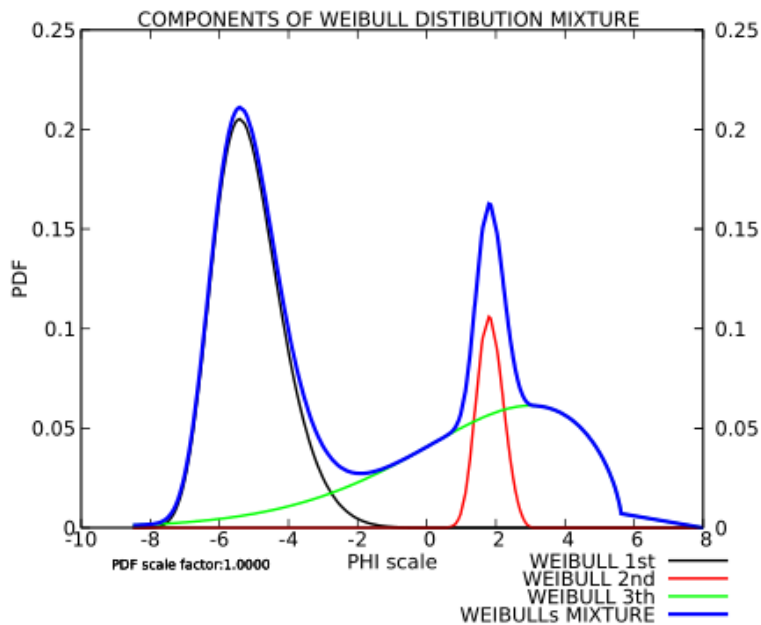
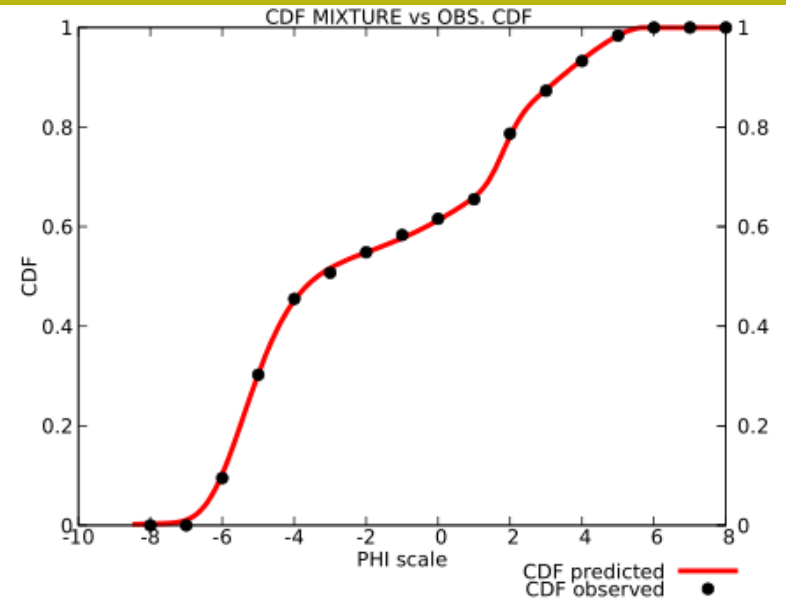
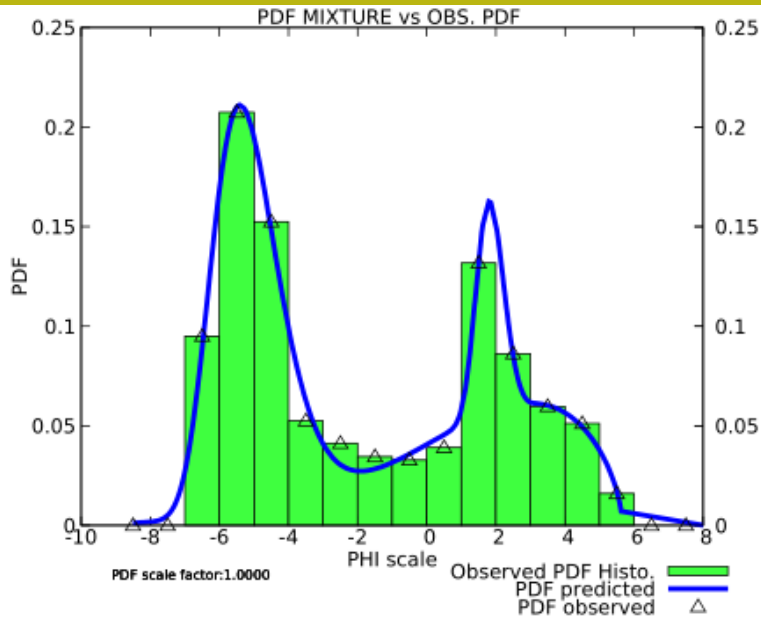
Mean(PHI) = -1.82910

Standard deviation(PHI) = 3.73188 Very poorly sorted

Skewness = 0.35674 Symmetrical

Kurtosis(normalized) = -1.42413 Very platykurtic

lognormal 4 parámetros – 3 componentes – algorithm: DE classic  
 Olistostrome formation Turkey - global Akaike inf criteria -134.13



DECOLOG (rel. 5.4 - 2016) - DECONVOLUTION OF MIXTURE'S COMPONENTS  
INSIDE PARTICLE SIZE DISTRIBUTIONS  
HTTP://www.decolog.org -By L.Borselli D.Sarocchi, UASLP(Mexico), lborsellignail.com

INPUT DATA FILE >: oli2.dat

OUTPUT REPORT >: oli2.xls

## GLOBAL FITTING STATISTICS for CDF :

Model efficiency coefficient(EF) = 0.9997953

Coefficient of Determination( $R^2$ ) = 0.9999260

Kolmogorov-Smirnoff difference(Ks) = 0.0109127

## GLOBAL FITTING STATISTICS for PDF :

Model efficiency coefficient(EF) = 0.9928880

Coefficient of Determination( $R^2$ ) = 0.9964424

## STATISTICS FROM SPLINES RESAMPLED OBSERVED CDF (MonteCarlo Method) :

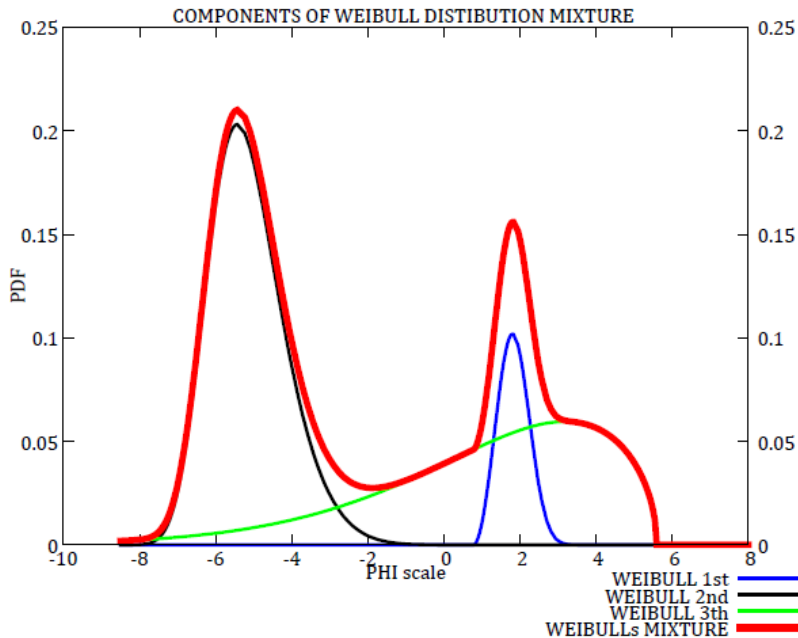
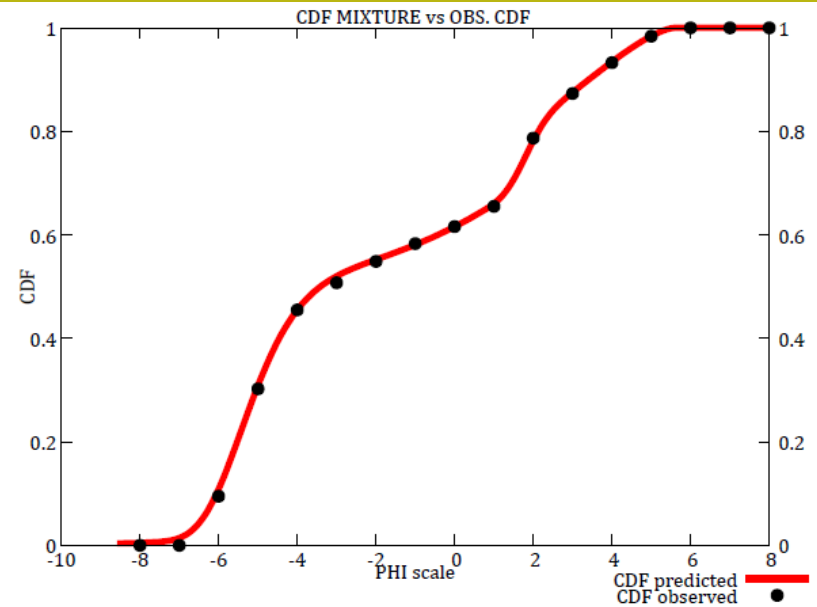
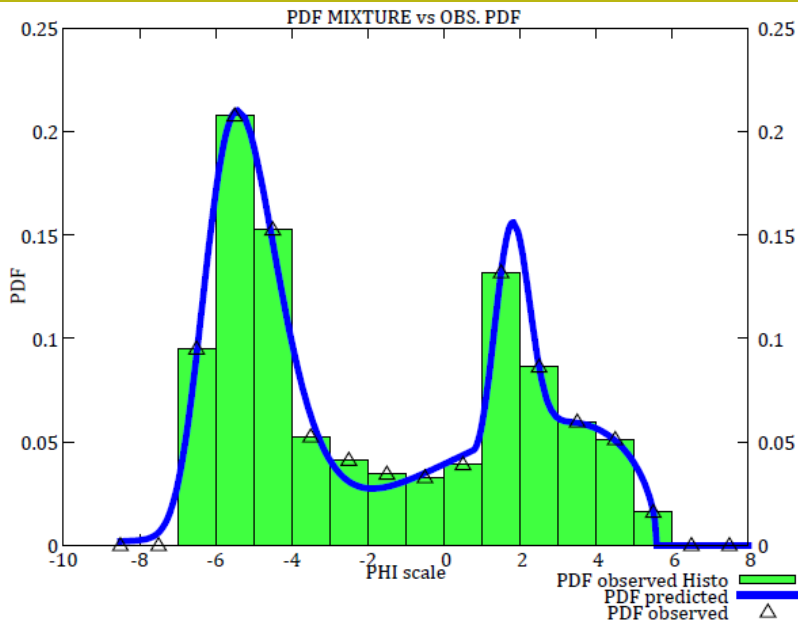
Mean(PHI) = -1.82910

Standard deviation(PHI) = 3.73188 Very poorly sorted

Skewness = 0.35674 Symmetrical

Kurtosis(normalized) = -1.42413 Very platykurtic

Weibull 4 parámetros – 3 componentes – algoritmo: DE classic  
Olistostrome formation Turkey - global Akaike inf criteria -153.24



**DECOLOG (rel. 5.0 - 2013) - DECONVOLUTION OF MIXTURE'S COMPONENTS  
INSIDE PARTICLE SIZE DISTRIBUTIONS**

HTTP://www.decolog.org -By L.Borselli % D.Sarocchi, UASLP(Mexico), lborselli@gmail.com

INPUT DATA FILE \_\_\_ oli2.dat

OUTPUT REPORT \_\_\_ oli2\_weibull3\_ef.xls

## GLOBAL FITTING STATISTICS for CDF:

Model efficiency coefficient(EF) \_\_\_\_\_ 0.9996391

Coefficient of Determination(R<sup>2</sup>) \_\_\_\_\_ 0.9999305

Kolmogorov-Smirnoff difference(Ks) \_\_\_\_\_ 0.0142404

## GLOBAL FITTING STATISTICS for PDF:

Model efficiency coefficient(EF) \_\_\_\_\_ 0.9935265

Coefficient of Determination(R<sup>2</sup>) \_\_\_\_\_ 0.9967832

## STATISTICS FROM SPLINES RESAMPLED OBSERVED CDF (MonteCarlo Method):

Mean(PHI) \_\_\_\_\_ -1.82910

Standard deviation(PHI) \_\_\_\_\_ 3.73188 Very poorly sorted

Skewness \_\_\_\_\_ 0.35674 Symmetrical

Kurtosis(normalized) \_\_\_\_\_ -1.42413 Very platykurtic

Weibull 4 parámetros – 3 componentes

Olistostrome formation Turkey – estrategia de optimización “Eficiencia modeling”

# Now two practical real time examples of application of DECOLOG :

- Debris flow deposits, Motozintla, Chiapas, Mexico ↓



[http://4.bp.blogspot.com/-D\\_v00Nzz65w/VdAxi5T2FHI/AAAAAAAAABFY/EBSHgYoUhZc/s1600/IMG\\_7882.jpg](http://4.bp.blogspot.com/-D_v00Nzz65w/VdAxi5T2FHI/AAAAAAAAABFY/EBSHgYoUhZc/s1600/IMG_7882.jpg)



[http://images.volcanodiscovery.com/fileadmin/photos/guatemala/gua\\_1215/fuego/fuego\\_j17499.jpg](http://images.volcanodiscovery.com/fileadmin/photos/guatemala/gua_1215/fuego/fuego_j17499.jpg)

- Block and ash flow (pyroclastic flow with large blocks due to dome collapse), Colima Volcano, Colima Mexico ↑

# Conclusions

- DECOLOG is a tool able to decode part of the information usually blind inside total particle size distribution PSD).
- DECOLOG allows the easy calculation of global statistic of using the el modelo optimized folk-Ward and by new Montecarlo resampling method (much better in complex polymodal distributions).
- A lot of options for deconvolution engine applied to the PSD that is in many cases a Mixture of components (phases)
- Algorithm of Multi-objective optimization by de combined non-linear fitting of experimental PDF y CDF using self-organizing and self evolving genetic algorithm: Trigonometric differential evolution (Fan y Lampinen 2003)..
- Software fully FREeware for scientific community (WWW.DECOLOG.ORG)

## REFERENCES

- Anderson J. 2000. *A Survey of Multiobjective Optimization in Engineering Design*, Technical Report No. LiTH-IKP-R-1097, Department of Mechanical Engineering, Linköping University. pp.34 ([www.lania.mx/~ccoello/EMOO/anderson00.pdf.gz](http://www.lania.mx/~ccoello/EMOO/anderson00.pdf.gz))
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**Gracias por Su atención !!!**



**Many thanks for Yours attention !!!**