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README.md

Getting Started

ModelFacet is a Matlab program allowing to model ^{36}Cl concentrations of rock samples belonging to the surface of a normal fault facet. The program allows to inverse the data using a Monte-Carlo Markov chain algorithm, to constrain two main parameters driving the ^{36}Cl concentrations within a sample: the fault slip-rate, and the duration of the post-glacial period. The forward model includes various factors that modulate the ^{36}Cl production rate within the rock, such as the site location, the shielding resulting from the geometry of the facet and associated colluvium, the chemical composition of the fault-plane rock, and the geomagnetic field temporal variations.

Prerequisites

Using **ModelFacet** requires Matlab (version >=2016), and an .xls file editor.

How to run an inversion ?

Data and site parameters

The samples data (chemistry and geographical information) and the parameters describing the site, must be provided by the user in the excel file named "**DATA_IN.xlsx**", saved in the "*Input*" folder. The sheet *Parameters* in this file is common to all sites, and describes the geometry of each site the inversion parameters, and the model. The name of each site must be provided in this sheet. The chemistry of the samples must be given for each site in a separate sheet. Each sheet must be called by the name of the site *NameOfTheSite*. This name must corresponds to the site name entered in the *Parameters* site. It allows the user to provide the chemistry analysis of each sample for a site, including ^{36}Cl concentration, major and traces, and the localization information.

Parameters for the modeling and the Inversion

The parameters used for the modeling of ^{36}Cl concentrations, and the inversion of the data are summurized in the sheet *Parameters* of the file "**DATA_IN.xlsx**".

Parameters of each site

- number of site : **must be the altitude of the post-glacial scarp top**
- name of the site : **must corresponds to the name of the sheet describing the chemistry of the site**
- Altitude of the site (m)
- Colluvial wedge slope (°)
- Fault-plane dip (°)
- Slope of the facet (°)
- Colluvial wedge density (g/cm2)

Modeling parameters

- Lambda_f_e : effective fast neutron attenuation coefficient
- Lambda_f_t : true fast neutron attenuation coefficient
- Lambda_mu : slow muon attenuation length
- Psi_mu_0 : slow negative muon stopping rate at land surface
- P_Cl36_Ca : spallation production rate for Ca, SLHL
- P_Cl36_K : spallation production rate for K, SLHL
- P_Cl36_Ti : spallation production rate for Ti, SLHL
- P_Cl36_Fe : spallation production rate for Fe, SLHL
- P_Cl36_Ca error : uncertainty on spallation production rate for Ca, SLHL
- P_Cl36_K error : uncertainty on spallation production rate for K, SLHL
- P_Cl36_Ti error : uncertainty on spallation production rate for Ti, SLHL
- P_Cl36_Fe error : uncertainty on spallation production rate for Fe, SLHL
- Geomag : Choice of the geomagnetic database (1: Mush; 2: GLOPIS; 3: LSD)
- Scaling : Choice of the scaling scheme (1: Time-dependant LAL-STONE with cutoff rigidity, 2: Time-dependant LSD, 3: Time-independant LAL-STONE 2000 no cutoff)
- Atm : Choice of the Atmospheric model (0: ERA40 (Uppala et al. 2005), 1: standard atmosphere equation (NOAA 1976))

Inversion parameters

- Age max : maximum age to compute ^{36}Cl concentrations produced in sample at depth
- PG_age_0 : initial guess for post-glacial age
- SR_0 : initial guess for the fault slip-rate
- SR_min : minimum slip-rate bound
- SR_max : maximum slip-rate bound
- SR_std : slip-rate standard deviation for proposal function (normal distribution)
- T_min : Inversion minimum post-glacial age bound
- T_max : Inversion maximum post-glacial age bound
- T_std : post-glacial age standartd deviation for proposal function (normal distribution)

- n_walker : number of chain
- n_models_inversion : number of models generated during the inversion
- parallel_computing : use of parallel computing (1:true,0: false)
- N_burnin : proportion of the chain removed, must be >= 0 and <1.
- n_plot : number of samples randomly picked to draw ^{36}Clconcentrations pdf from the inversion

Number of sites :	4				
Name of the sites	**MA3**	**MA1**	**ARC**	**BAZ**	
Altitude of the top of the scarp (m)	1275	1280	815	643	
Colluvial wedge slope (°)	30	25	25	25	
Fault-dip (°)	45	40	55	65	
Slope of the facet (°)	35	30	30	35	
Colluvial wedge density (g/cm2)	1.6	1.5	1.5	1.5	
Cosmogenic parameters					
Lambda_f_e	160		(g.cm-2) effective fast neutron attenuation coefficient		
Lambda_f_t	208		(g.cm-2) True fast neutron attenuation coefficient		
Lambda_mu	1510		(g.cm-2) slow muon attenuation length		
Psi_mu_0	190		(muon/g/yr) slow negative muon stopping rate at land surface		
P Cl36 Ca	42.2		(at of Cl36 /g of Ca per yr) spallation production rate for Ca, SLHL		
P Cl36 K	148.1		(at of Cl36 /g of K per yr) spallation production rate for K, SLHL		
P Cl36 Ti	13		(at of Cl36 /g of Ti per yr) spallation production rate for Ti, SLHL		
P Cl36 Fe	1.9		(at of Cl36 /g of Fe per yr) spallation production rate for Fe, SLHL		
P Cl36 Ca error	4.8		(at of Cl36 /g of Ca per yr) uncertainty on spallation production rate for Ca, SLHL		
P Cl36 K error	7.8		(at of Cl36 /g of K per yr) uncertainty on spallation production rate for K, SLHL		
P Cl36 Ti error	3		(at of Cl36 /g of Ti per yr) uncertainty on spallation production rate for Ti, SLHL		
P Cl36 Fe error	0.2		(at of Cl36 /g of Fe per yr) uncertainty on spallation production rate for Fe, SLHL		
Geomagnetic database	1		1: Mush; 2: GLOPIS; 3: LSD;		
Scaling Scheme	3		1: LAL-STONE with cutoff rigidity, 2: LSD, 3: LAL-STONE 2000 no cutoff		
Atmospheric model	0		0: ERA40 (Uppala et al. 2005), 1: standard atmosphere equation (NOAA 1976)		

sample name	latitude (deg)	longitude (deg)	altitude (masl)	Depth (cm)	36Cl conc (at/g)	± 36Cl conc (at/g)
F_MA3_1	42.121783	13.4476715	1404	0	1.07E+06	3.46E+04
F_MA3_2	42.12164817	13.44783133	1393	0	1.21E+06	4.02E+04
F_MA3_3	42.12146583	13.4477533	1371	0	1.03E+06	3.55E+04
F_MA3_4	42.121216	13.4473733	1350	0	1.33E+06	4.38E+04
F_MA3_5	42.12097383	13.44723583	1324	0	1.43E+06	4.82E+04
F_MA3_6	42.120765	13.44706983	1314	0	8.55E+05	2.80E+04
F_MA3_7	42.12048133	13.447243	1297	0	1.11E+06	3.81E+04
F_MA3_8	42.12026683	13.44704983	1281	0	1.74E+06	5.58E+04
F_MA3_9	42.12055	13.44752717	1287	0	9.46E+05	3.15E+04
F_MA3_10	42.11984567	13.44866033	1282	0	1.21E+06	3.90E+04

Running a data inversion

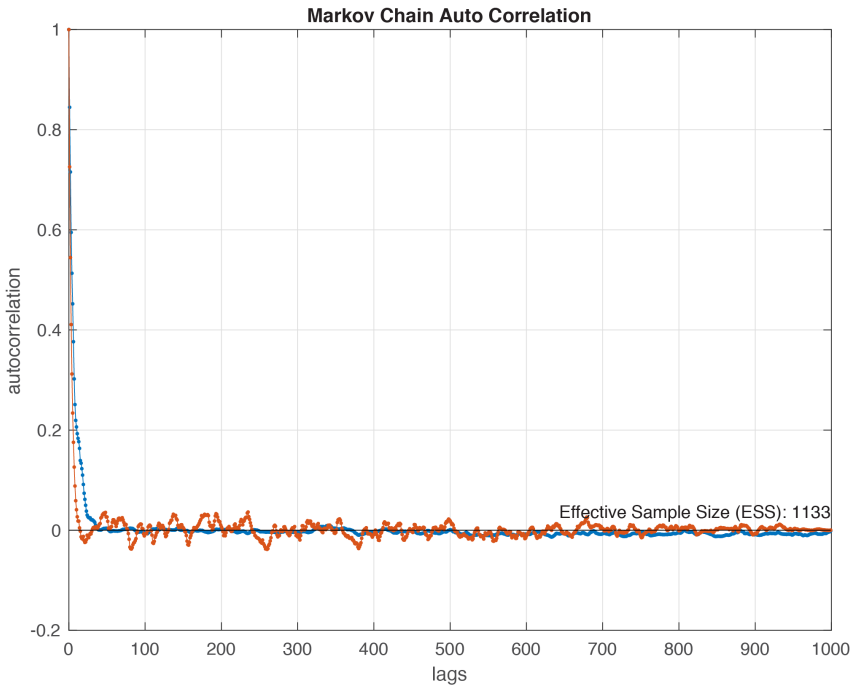
To run an inversion of ^{36}Cl concentrations, use the following command in the *Matlab* window:

```
Inversion_36Cl_Facet
```

Results of the inversion are placed in *Results/results_gwmcmc.mat*

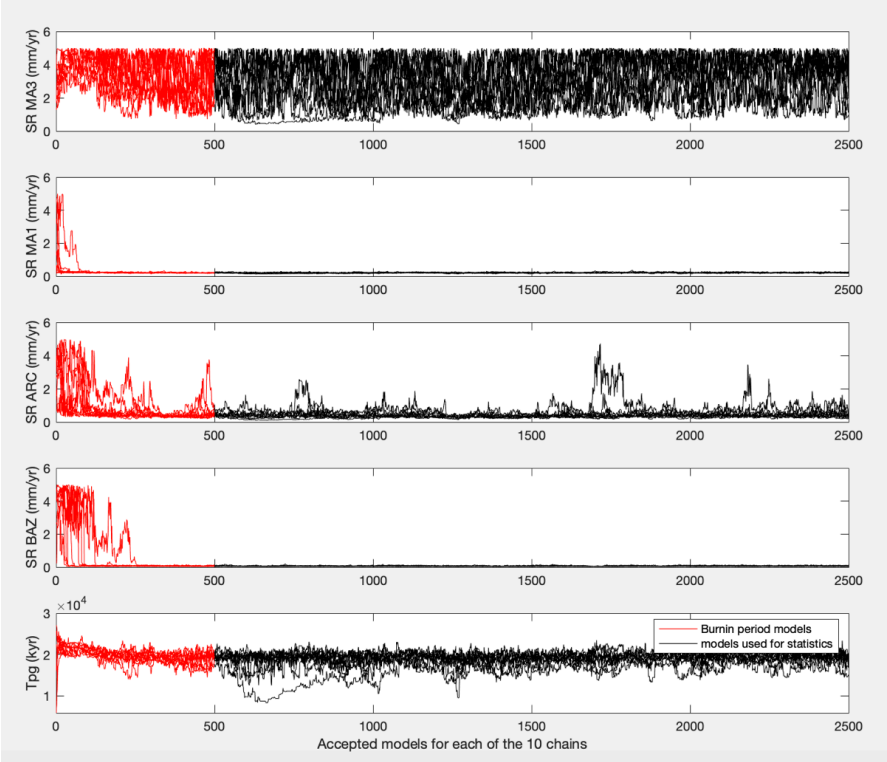
Autocorellation plot :

After the inversion, check the Markov chain autocorellation plot to be sure the algorithm has converged and produced uncorrelated models.



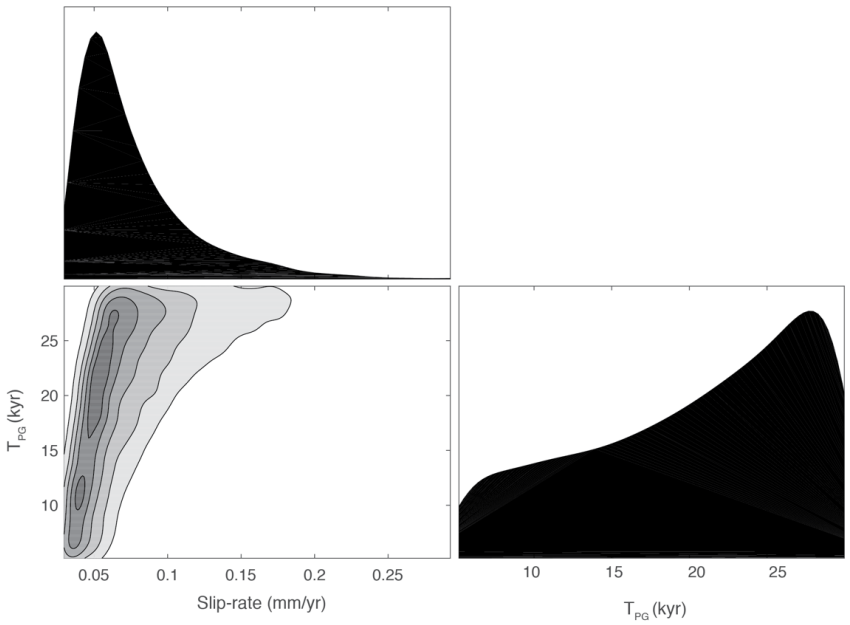
Burning period plot :

Be sure the proportion of models removed from the chains is large enough to remove the whole burnin period. Models from the burning period are figured in red in the plot. The burning period is the period during which the chains are converging, starting from high misfit area and reaching a stable behavior. After the burning period, the chain should sample the parameter space following a distribution that will corresponds to the final posterior distribution.



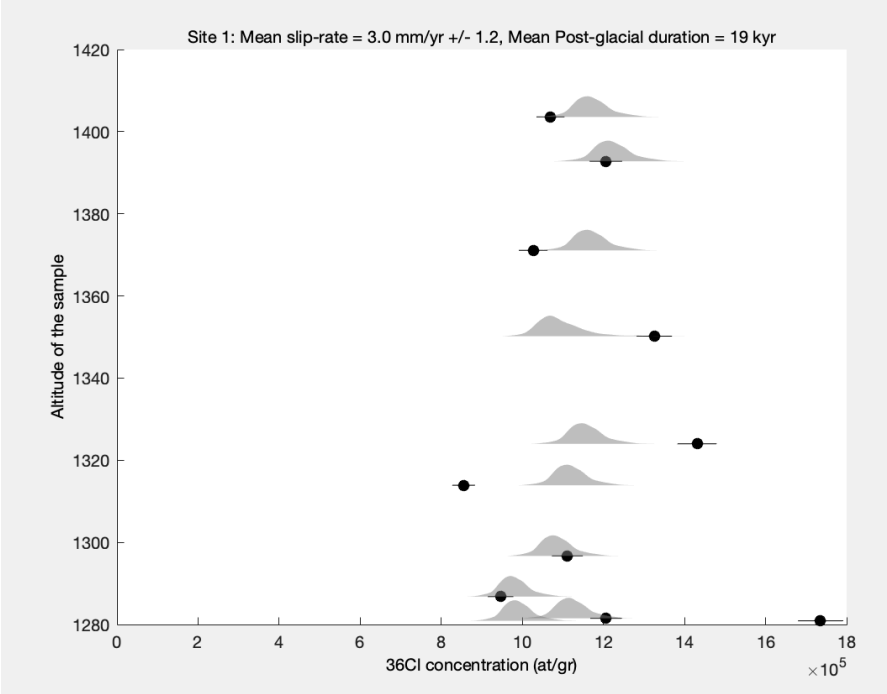
Posterior probability density plot :

The program will also produce the posterior pdf plot for each parameters:



Posterior probability density of modeled ^{36}Cl concentrations :

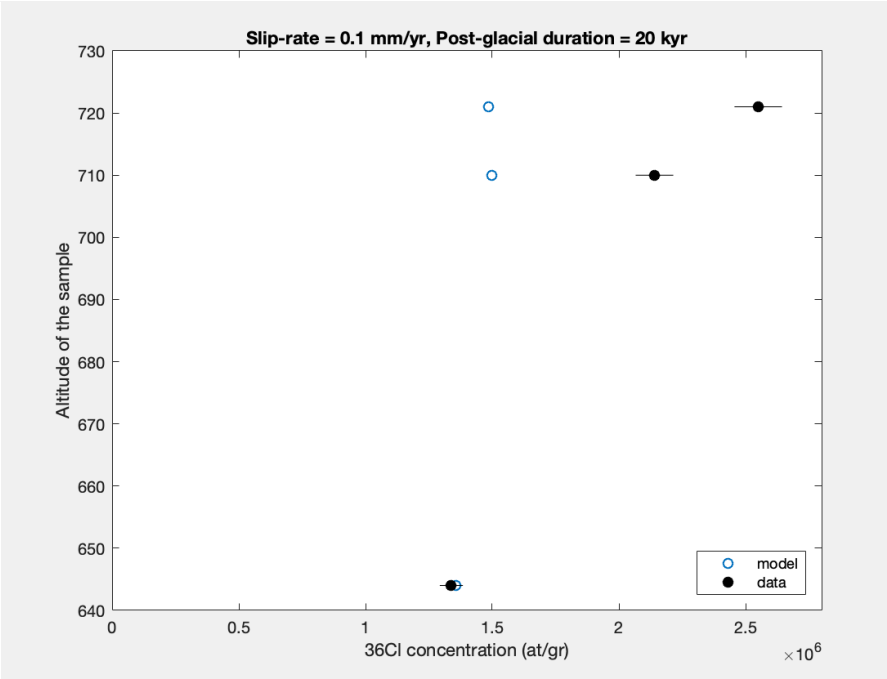
The program provide the plot of modeled ^{36}Cl concentrations of 1000 models randomly selected in the Markov chains.



How to test a forward model ?

To model the ^{36}Cl concentrations of a given model, indicates the input parameters (slip-rate and post-glacial duration) in the boxes *Test a forward model* in the sheet *Parameters* of the DATA_IN.xlsx setting file. Run the following command in the *Matlab* window:

```
Inversion_36Cl_Facet
```



How to plot results from an inversion ?

If needed, the results from an inversion can be plotted again using the following command:

```
Plot_results_inversion.m
```

Be sure the results from the inversion are present in the *Result* folder (file *results_gwmcmc.mat*).