IP_Prediction2D

Machine learning prediction using surface property or seismic traces waveform

User Manual

IPLAB LLC

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1. Introduction

The **IP_Prediction2D** IP_Seismic plug-in (version: 2019.1.0.1, release date: October 2019) can be used for sweet spot analysis based on wells production rate prediction or any wells log property prediction on map using a set of surface attributes or seismic trace waveform using machine learning algorithms (linear regression, ACE regression, nearest neighbor regression, random forest, classic neural network and T-neural networks). The result of this plug-in application is the maps (surface attributes) with average, standard deviation, min, max, P10, P50, P90 predictions according to several cross validations calculations

The **IP_Prediction2D** IP_Seismic plug-in allow to predict effective parameters of the rock in layers using a set of the surface attributes or seismic trace waveforms and a set of points in places of the layer intersection by the boreholes.

There are two main calculation studies to perform this prediction:

1. Training stage – to train machine learning according to the array of training pairs – points with a value of predictive parameters and values of surface attributes around the borehole points.
2. Calculation stage – to calculate values of predictive parameter for each node in the surface based on surface attributes or based on the trace waveform.

2. Start

Procedures -> Surface Attributes-> Machine Learning surface property prediction

3. Input parameters

Plug-in has two input options:

- **Surface attributes**
- **Seismic cubes for defined layer**

The first input option **Surface attributes** allows to define a set of maps like surface attributes to perform predictive analysis.
The second input option **Seismic cubes for defined layer** allows to define seismic trace waveform to perform predictive analysis.
According to the input options, input tab will be different like shown in Figure 1 and Figure2.

3.1. Surface attributes input option

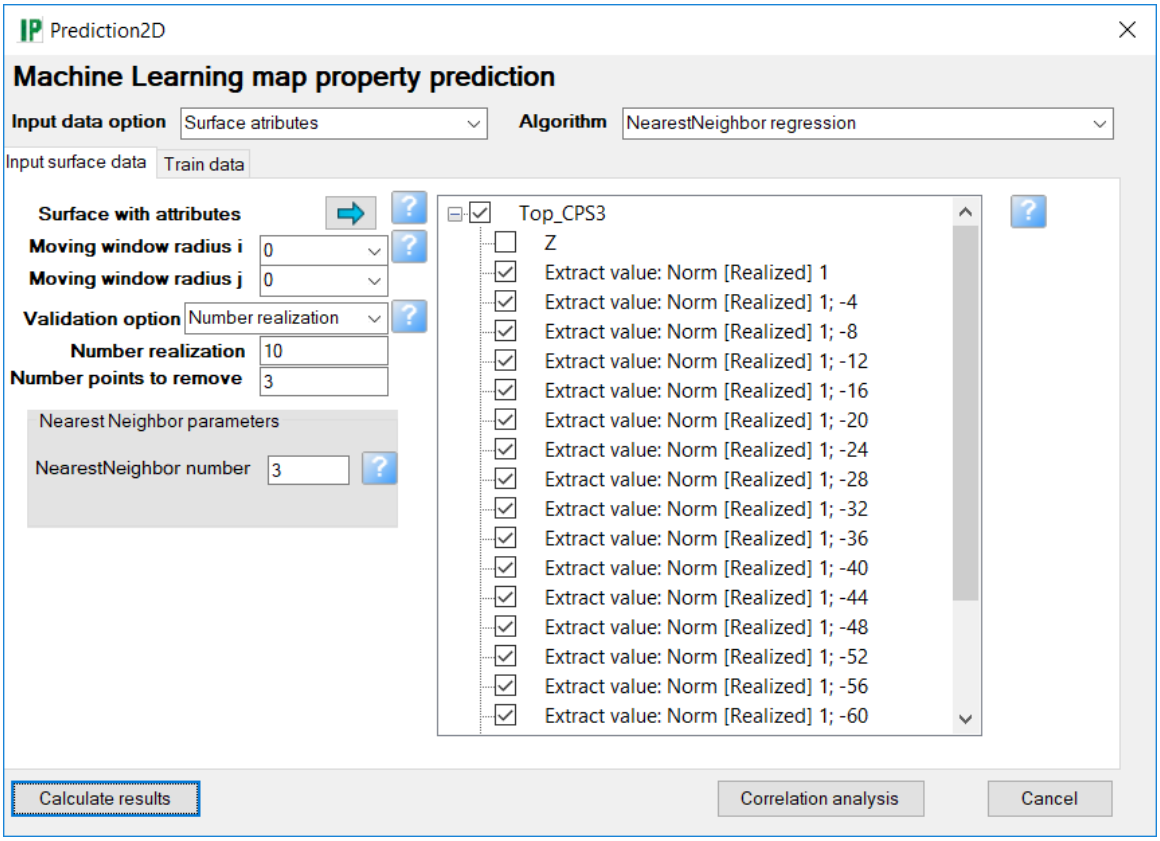


Figure 1: Input surface attributes data tab dialog view **IP_Prediction2D** for input option **Surface attributes** to define a set of surfaces for predictive analysis.

Input option Surface attributes

Parameters for the input option **Surface attributes** are defined before calculation:

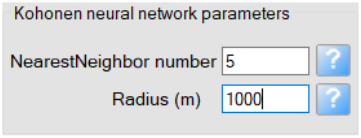
Algorithms: allow to select the following algorithms for predictive analysis:

Kohonen neural network regression

With parameters:

Nearest neighbor number allow to define number of points (wells) to current surface node with maximum similarity of set surface attributes or seismic traces form.

Radius allow to define Radius of influence of a point (well) for correction of values to the exact values. If radius = 0 then there is no any correction.



Linear regression

With parameters:

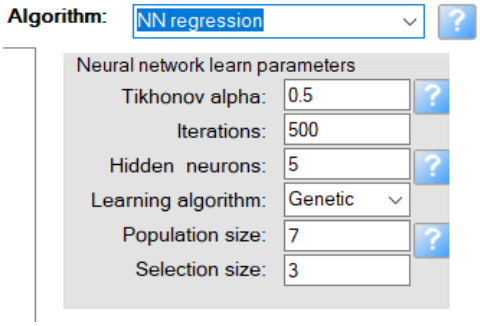
Tikhonov alpha: >0 and <1000 allow to avoid overlearning effect or instability for prediction. If alpha=0, then we can get very high approximation of the training set, but the predictability can be very low and results can be quite different for every realization. If alpha > 0, then training quality (correlation coefficient) will be less if to use alpha=0, but predictability will be much higher (quality control with "blend well" test).

ACE regression

Tikhonov alpha: 0 and <1000 allow to avoid overlearning effect or instability for prediction.

Maximum iterations

Neural network regression



Tikhonov alpha: 0 and <1000 allow to avoid overlearning effect or instability for prediction.

Iteration: Maximum iterations in the course of learning

Hidden layers neurons: define structure of neural network. If several hidden layers are required, it is necessary to use *comma: 10, 5, 3 mean 10 in first, 5 second and 4 in third hidden layers.*

Learning algorithm:

Genetic – use genetic algorithm

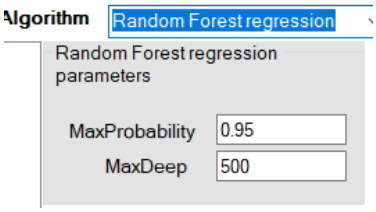
Gradient – use gradient algorithm

Hybrid – use genetic + gradient algorithms

Population size – used only for genetic algorithm

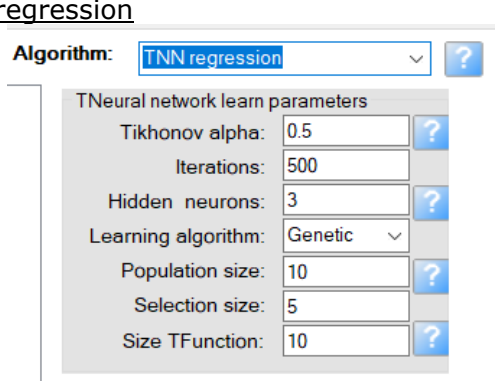
Selection size - used only for genetic algorithm

Random Forest regression



Max probability – need to stop the iteration for the results.
Max deep – max deep for random forest

TNN regression



Tikhonov alpha: 0 and <1000 allow to avoid overlearning effect or instability for prediction.
Iteration: Maximum iterations in the course of learning
Hidden layers neurons: define structure of neural network. If several hidden layers are required, it is necessary to use comma*:* 10, 5, 3 mean 10 in the first, 5 in the second and 4 in the third hidden layers.
Learning algorithm:
Genetic – use genetic algorithm
Gradient – use gradient algorithm
Hybrid – use genetic + gradient algorithms
Population size – used only for genetic algorithm
Selection size - used only for genetic algorithm
Size TFunction – parameter for TNN >=5 and <=100

Surface: allow to select a surface with a set of surface attributes from the project tree. All marked attributes will be used for calculations.

Moving window radius i, Moving window radius j: allow to define moving window size around the production points in the course of training stage and around node for calculation in the course of calculation stage.

Validation option
No validation
Number realization
Number realization - number of stochastic realizations to calculate separate prediction on each to calc average, standard deviation, P10, P50, P90 predictions
Number points removing- this number of points will be randomly removed from learning for each realization

3.2. Surface attributes input option

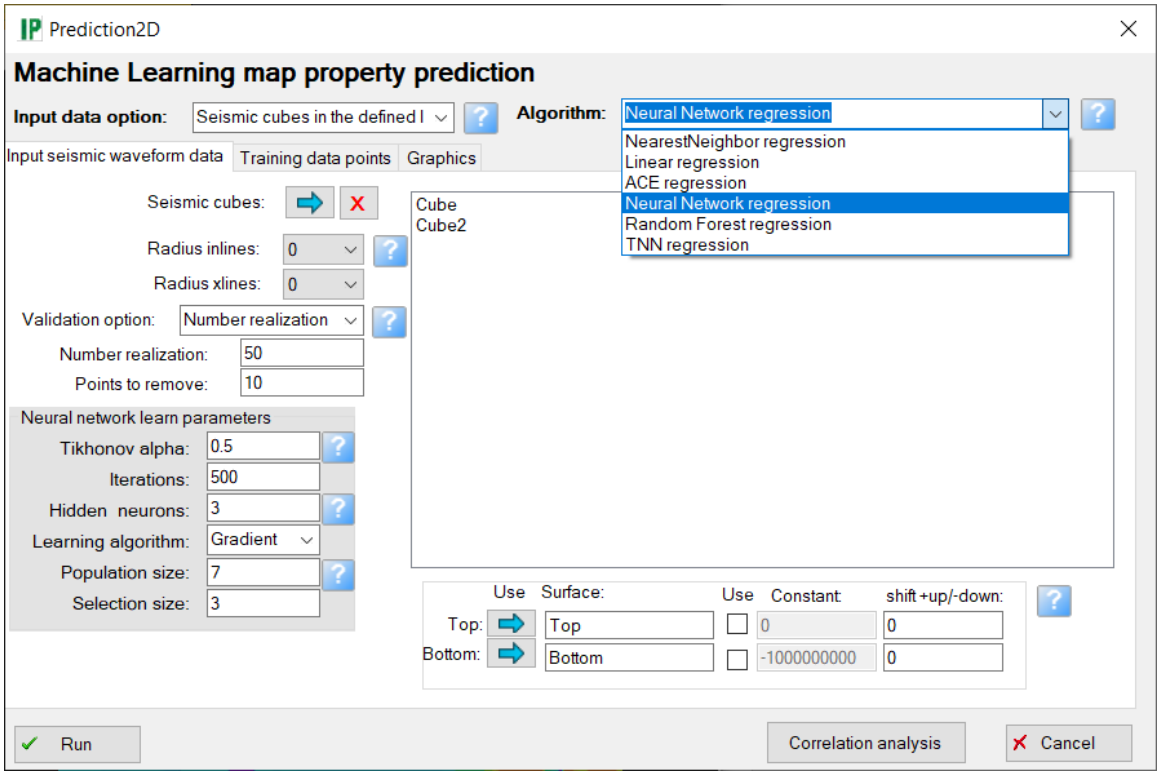


Figure 2: Input data tab dialog view **IP_Prediction2D** for input option **Seismic cube in the define layer** to define a set of seismic trace waveform for predictive analysis.

Parameters are defined before calculation:

Algorithms: - the same line like in previous input tab options.

Seismic cubes: allow to select one or several seismic cubes with similar geometry from the project tree.

> ***Radius inlines, Radius xlines:*** allow to define moving window size around central trace during training stage and for calculation during calculation stage.

Validation option
No validation
Number realization
Number realization - number of stochastic realizations to calculate separate prediction on each to calc average, standard deviation, P10, P50, P90 predictions
Number points removing- this number of points will be randomly removed from learning for each realization
Seismic waveform length can be defined by
Top surface or **constant**, both with **shifts**
Bottom surface or **constant**, both with shifts

3.3. Train **data tab**

To select production points attributes, it is necessary to use second tab:

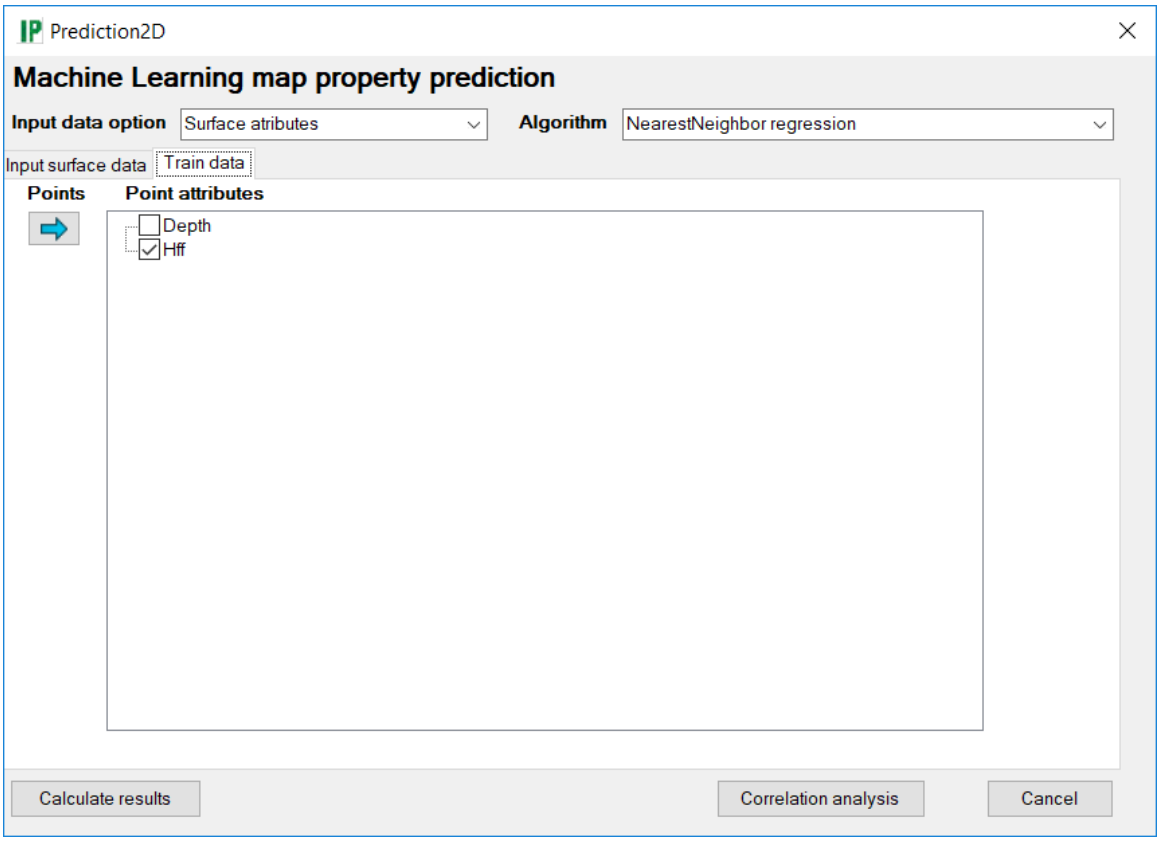
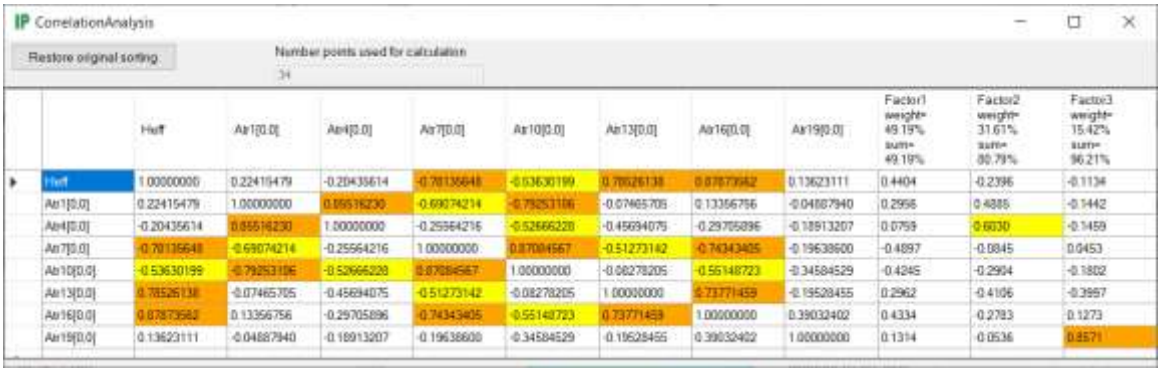


Figure 3: Input production points attributes tab dialog

3.1. Correlation analysis

To perform correlation analysis, it is necessary to push *"Correlation Analysis" bottom. After calculation, a correlation table is displayed (see Figure 4)* with cross *correlation values and with Principal components (shift table to right). Table is sortable for every column (click on column name). Double click – sort from big to small. The "Restore original sorting" button restores the original view.*



		Heff	Ar1[0.0]	Ar4[0.0]	Ar7[0.0]	Ar10[0.0]	Ar13[0.0]	Ar16[0.0]	Ar19[0.0]	Factor1 weight= 49.19% sum= 49.19%	Factor2 weight= 31.61% sum= 80.79%	Factor3 weight= 15.42% sum= 96.21%
▶	Heff	1.00000000	0.22415479	-0.20435614	-0.70135648	-0.53630199	0.78526138	0.87873562	0.13623111	0.4404	-0.2396	-0.1134
	Ar1[0.0]	0.22415479	1.00000000	0.85516230	-0.69074214	-0.79253106	-0.07465705	0.13356756	-0.04887940	0.2956	0.4885	-0.1442
	Ar4[0.0]	-0.20435614	0.85516230	1.00000000	-0.25564216	-0.52666228	-0.45694075	-0.29705896	-0.18913207	0.0759	0.6030	-0.1459
	Ar7[0.0]	-0.70135648	-0.69074214	-0.25564216	1.00000000	0.87084567	-0.51273142	-0.74343405	-0.19638600	-0.4897	-0.0845	0.0453
	Ar10[0.0]	-0.53630199	-0.79253106	-0.52666228	0.87084567	1.00000000	-0.08278205	-0.55148723	-0.34584529	-0.4245	-0.2904	-0.1802
	Ar13[0.0]	0.78526138	-0.07465705	-0.45694075	-0.51273142	-0.08278205	1.00000000	0.73771459	-0.19528455	0.2962	-0.4106	-0.3997
	Ar16[0.0]	0.87873562	0.13356756	-0.29705896	-0.74343405	-0.55148723	0.73771459	1.00000000	0.39032402	0.4334	-0.2783	0.1273
	Ar19[0.0]	0.13623111	-0.04887940	-0.18913207	-0.19638600	-0.34584529	-0.19528455	0.39032402	1.00000000	0.1314	-0.0536	0.8571

Figure 4: Correlation table results according to Correlation Analysis bottom

4. Calculation

To start the prediction, it is necessary to push "Calculate result" bottom (in the course of the training stage, error and correlation curves will be calculated in Graphics window, only for Neural network or for TNN algorithms options, see Figure 5)

If ***Cross validation*** =0, only two curves will be calculated and ***Cross validation*** >0 four curves additionally with error and correlation according to cross validation set of points (see Figure 6). Dispersion of quality controls curves around main curves allow to estimate predictability of the DNN operator.

If to use ***Number realization*** >3 prediction results will be calculated several times according to this number.

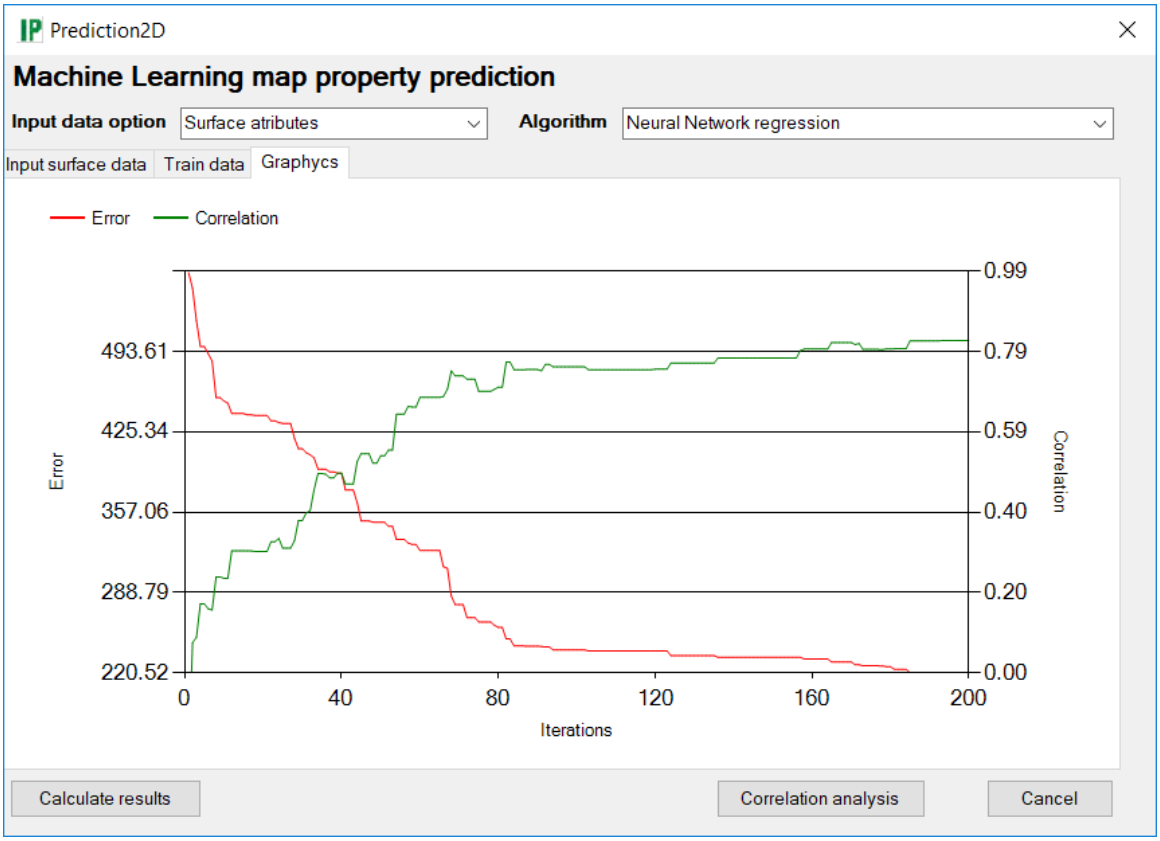


Figure 5: Output graphics window with error and correlation values during learning iterations

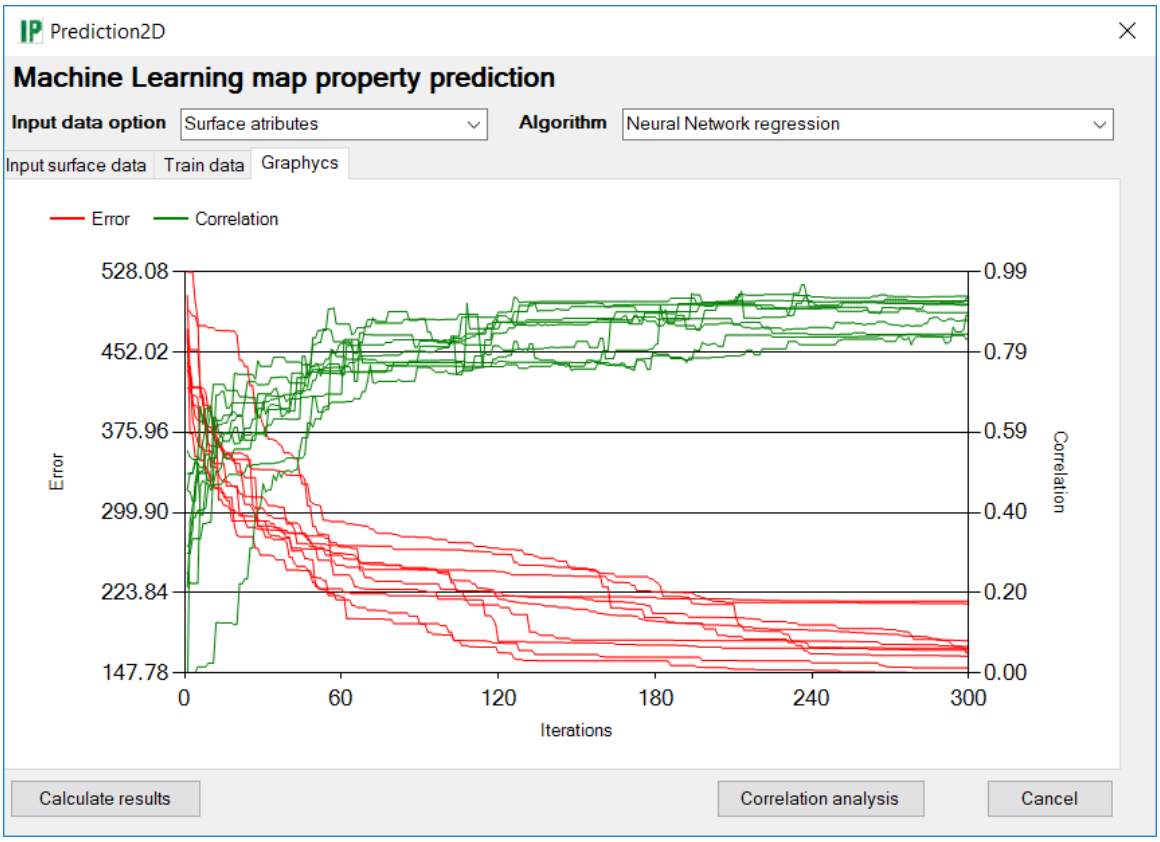


Figure 6: Output graphics window with error and correlation in the course of learning iterations for number realization =10 and number points to remove =5.

5. Results

Predicted surfaces will be added like surface with attributes in folder IP_Prediction2D. The result surface will be named like **P_<algorithm>**
Number of results attributes will be according **Validation option**

If the option = ***No validation,*** only one attribute will be added to the results surface with name **default(propertyName)**.
If the option = ***Use validation calculation,*** several resulting attributes will be added – Mean, Standard, Minimum, Maximum, P10, P50, P90.

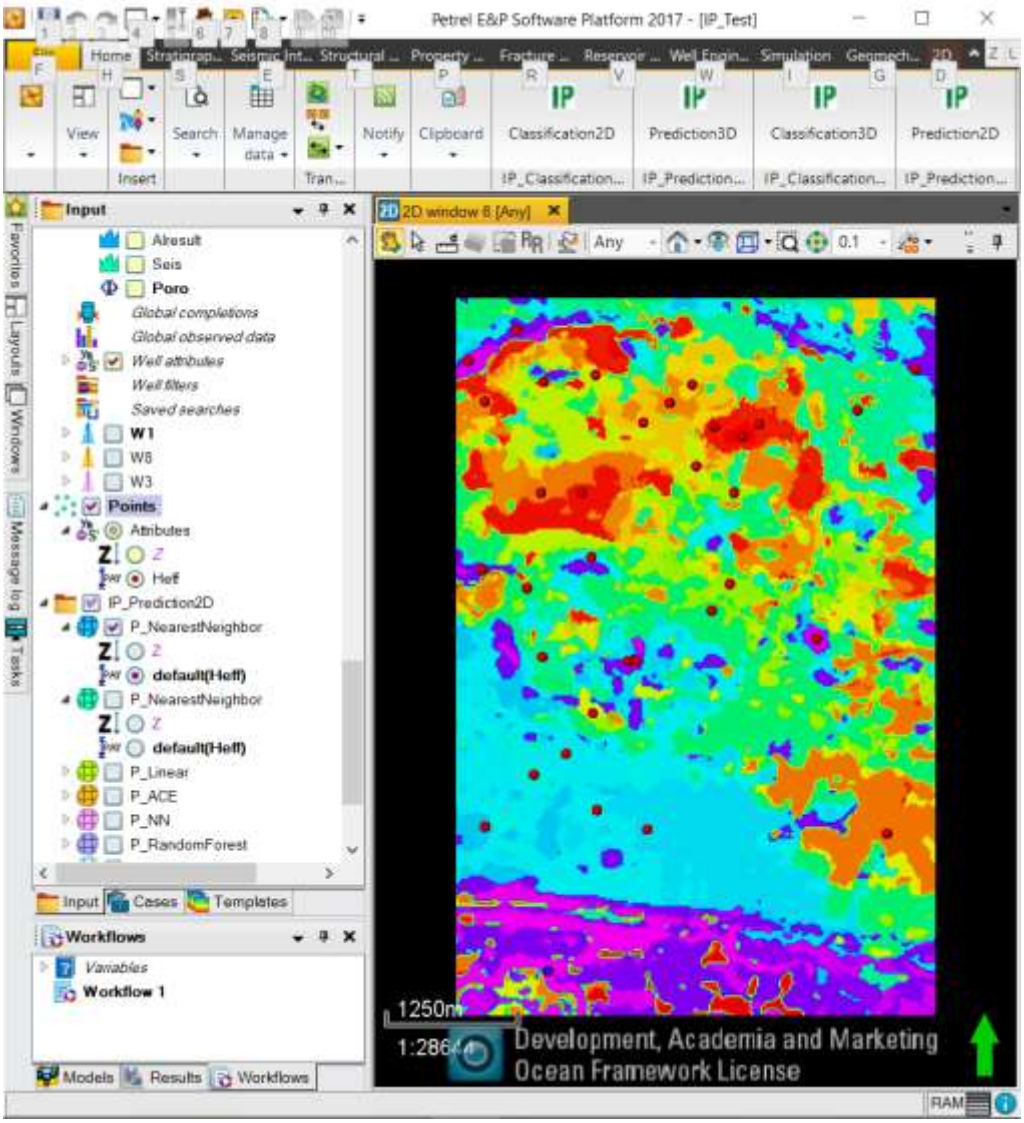


Figure 7: Result predictive map.