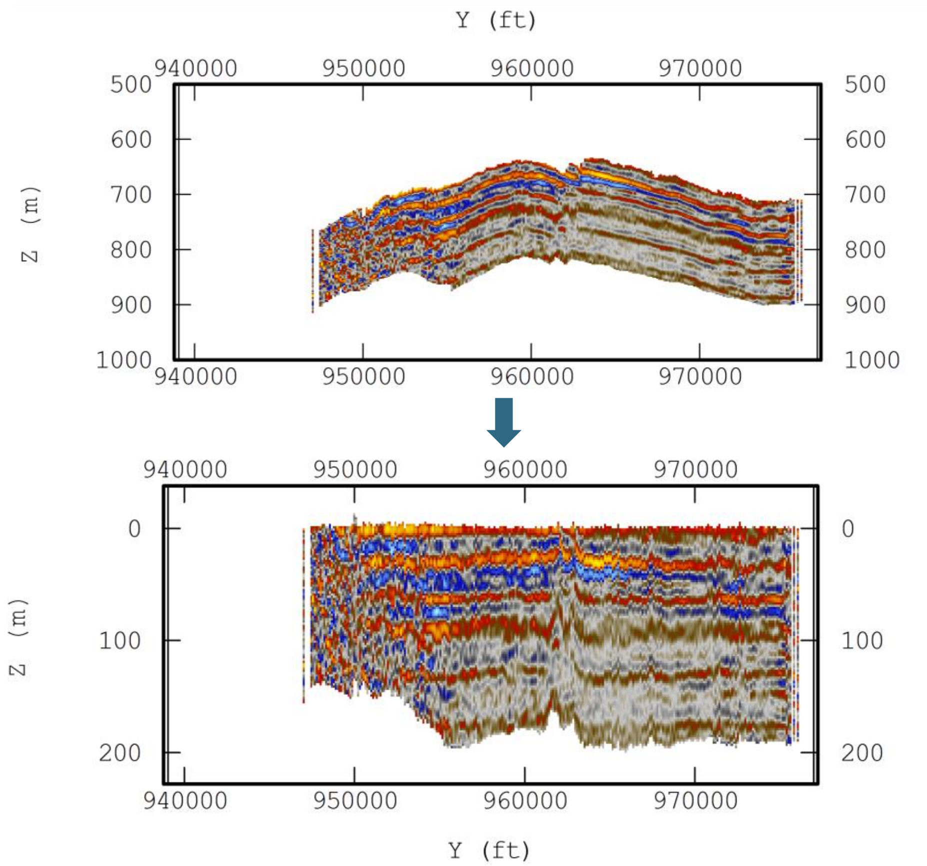
# OIL & GAS / HOW TO…

## WORK IN THE FLAT SPACE




Input data for quantitative geosciences (geology, geophysics) are in the real space or structural space. It corresponds to the current space after all the geological events up the recording date took place (deposition, erosion, subsidence, tectonics, etc.).

In reservoir characterization and modeling, it is important to work in the stratigraphic space, i.e. to reproduce the state of deposition before any distortion took place, in order to correctly populate the 3D reservoir grid with properties or perform geostatistical filtering. This is particularly necessary for coherent variogram analysis, factorial kriging and data integration.

This paper aims at explaining the various options available in Isatis to perform these tasks.

# 1. Structural vs stratigraphic space

The structural (folded) space corresponds to the present and the stratigraphic (unfolded) space to the space at the time of deposition. Most of the time, the difference between the two spaces is the reference stratum (for instance, Mean Sea Level in the structural space and a flooding surface in the stratigraphic space). The reference stratum is the surface at which each Z (or TWT) values are equal to 0. It is of interest to note that, with such a model, only the Z coordinates change between the two spaces. In the specific case of proportional layering, there is no reference stratum but layers are stretched and squeezed between two surfaces.

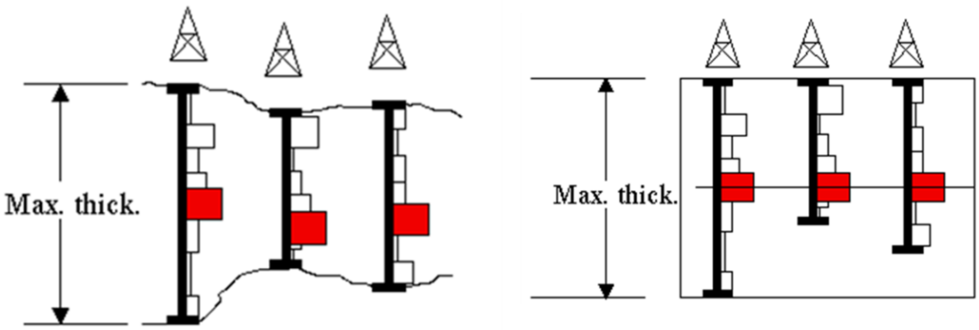



**Figure 1: Difference between the structural space (left) and the stratigraphic space (right).**

In Isatis, the reservoir model is considered as a group of one or several geological units (Figure 2). Each unit is bounded by two surfaces (top and bottom). Each unit may have a distinct reference surface.

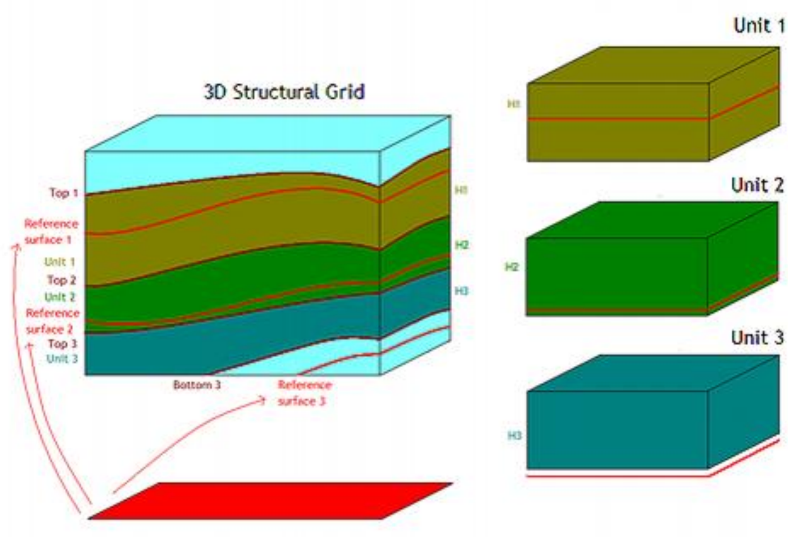



**Figure 2: Each unit is unfolded separately relatively to its reference surface and generates a separate stratigraphic grid**

Each unit is made of layers (Figure 3). Layers can be parallel to the top horizon, the bottom horizon or to any free reference surface. In such cases, the layer thickness is constant. Layers can also be proportional to a top horizon and a base (bottom) horizon. In this case, the ratio between the layer thickness and the total unit thickness is constant. The layering type depends on the geology.

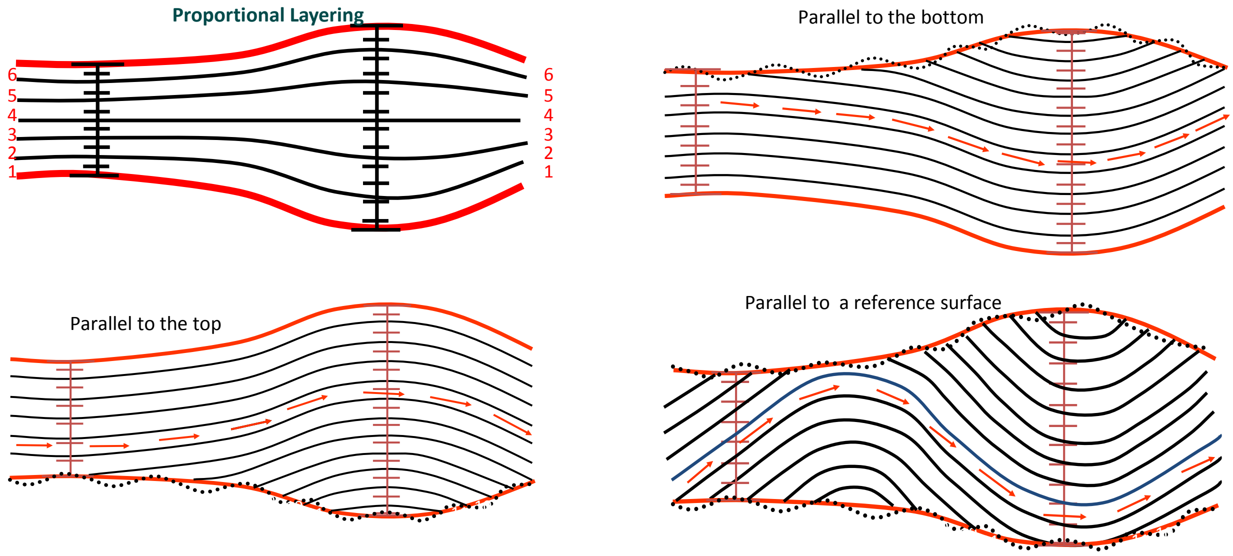



**Figure 3: Different layering options corresponding to different geology**

Note that in the proportional layering type, there is no bijection between the structural grid and the stratigraphic space. Therefore, one cell in the stratigraphic space can correspond to several cells in the structural space and vice versa.

## 2. Isatis data organization

Isatis duplicates the input grid when performing unfolding. In Isatis, a grid cell is referred by a unique sample number (corresponding to the variable called SN Sample Number). To know which cell (or file sample) of the folded grid corresponds to a given cell of the unfolded grid (and vice versa), Isatis uses a pointer variable which points (or links) the two corresponding samples. This pointer allows in particular a quick copy of data from a grid in one space to the grid in the other space.

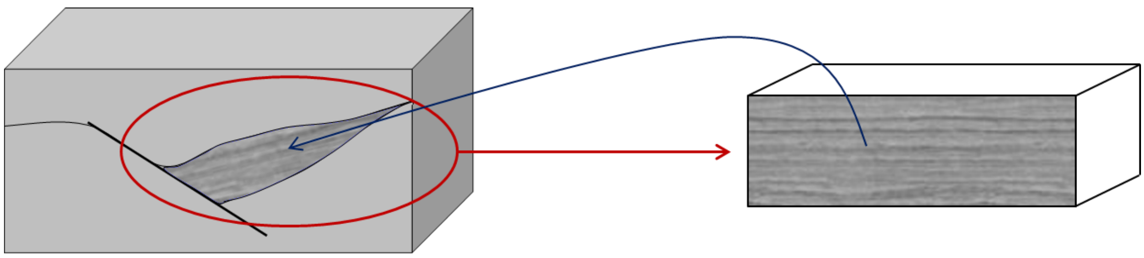


**Figure 4: Pointer principle in Isatis. A variable which contains a reference within each right hand side grid node to a grid node in the left hand side grid**

*Note: If you were to create your own pointer it should be a 64 bit length variable to cope with large integer values.*

# 3. Unfolding for data integration

## A. Unit unfolding

To flatten a seismic grid or any regular 3D grid (i.e. regular X, Y, Z or TWT spacing) on a reference horizon, use the Unit Unfolding panel in Tools → Folding/Unfolding → Unit Unfolding….

*Note: If you were to use the Grid Unfolding windows in the Special menu, be aware that these are considered as obsolete.*

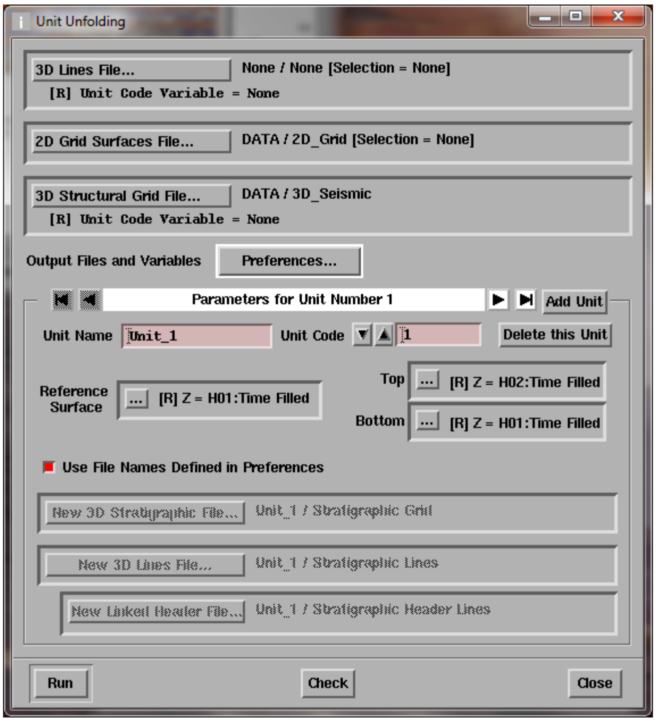



**Figure 5: Unit Unfolding application interface**

The reference horizon (or surface) works as a reference stratum and will be the new Z0 (or T0). All Z (or T) indices are relative to this new origin and are positive above and negative below the stratum. At this stage the grid does not contain any property. Each grid contains a pointer variable to the other grid allowing the software to link the two grids via the grid sample number as explained previously.

Top and bottom horizons can be specified to truncate the flattened grid outside of these limits. Note that if you work in depth, as the top surface vertical coordinates are greater than the bottom surface ones in Isatis, the horizon ordering need to be inverted.

Also it is possible to flatten several units at the same time in one go. In such a case, pointers in the structural grid are stored as macro variables. A macro variable, labelled name[xxxxx], is an array where the xxxxx can be replaced by an index (e.g. 1, 2, 3, …, N) corresponding to the unit number.

For more information on this panel as for any other Isatis panel, the online help can be accessed using the F1 key.

## B. Exchanging variable between grids

To populate a flattened grid with property from an unflattened grid, use the Copy Variable Using Id panel from Tools → Copy Variable → Using Id…. This option allows copying a variable from one grid to another one using a pointer variable.

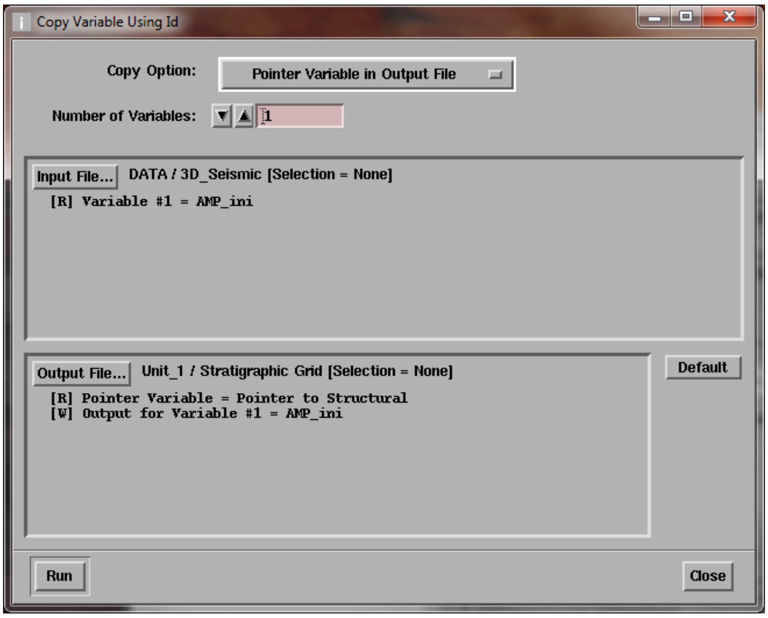



Figure 6: Copy Variable application interface to copy a variable from one grid to the other one using a pointer variable

This utility can be used in both directions, for instance to bring the original amplitude to the flat space for variogram analysis and seismic QC and filtering, and then, to bring back the filtered signal to the structural space.

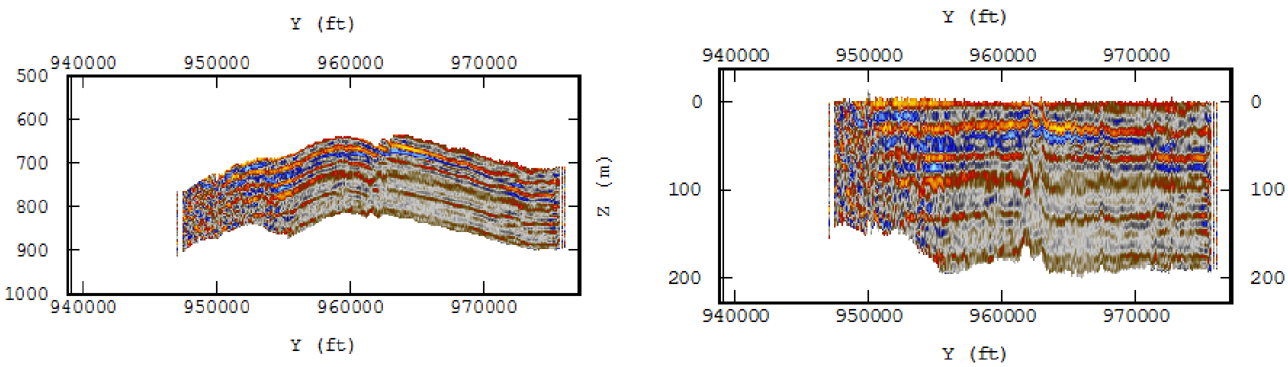



Figure 7: Seismic amplitude in the structural space (left) and the flattened space (right).

## C. Data integration (e.g. seismic and wells data)

When integrating data, it is possible to bring the wells into the stratigraphic space. As described in the diagram of Figure 1, the transformation consists in a shift applied to the vertical coordinates of the wells. In the Unit Unfolding panel, the 3D Lines File… selector allows to select a well file (called line file in Isatis). Running the Unit Unfolding shown in Figure 8 creates a new line file in the folder where the flat grid is stored. This new line file is flattened so that data integration using geostatistics can be done in the stratigraphic space, as both grid and wells are now in the same flat space.

We recommend upscaling the well logs to the same support size as the vertical grid cell thickness one. This can be done using the Regularization by Benches or Length panel (Tools → Regularization → Regularization by Benches or Length) as shown in Figure 9.

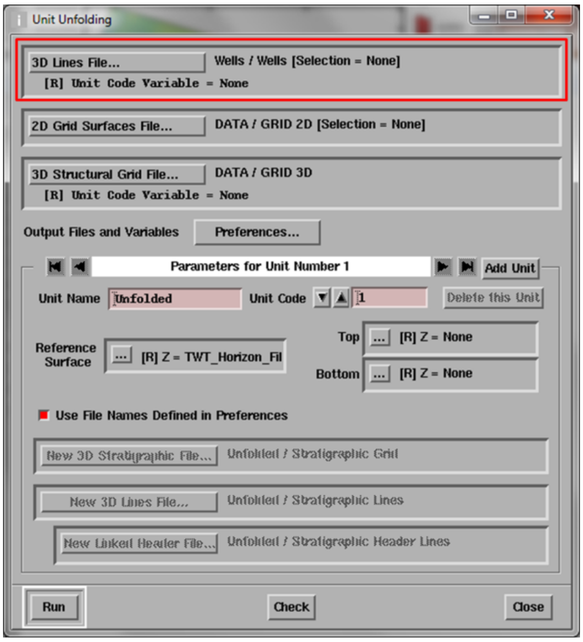



**Figure 8: Unit Unfolding using Wells application interface**

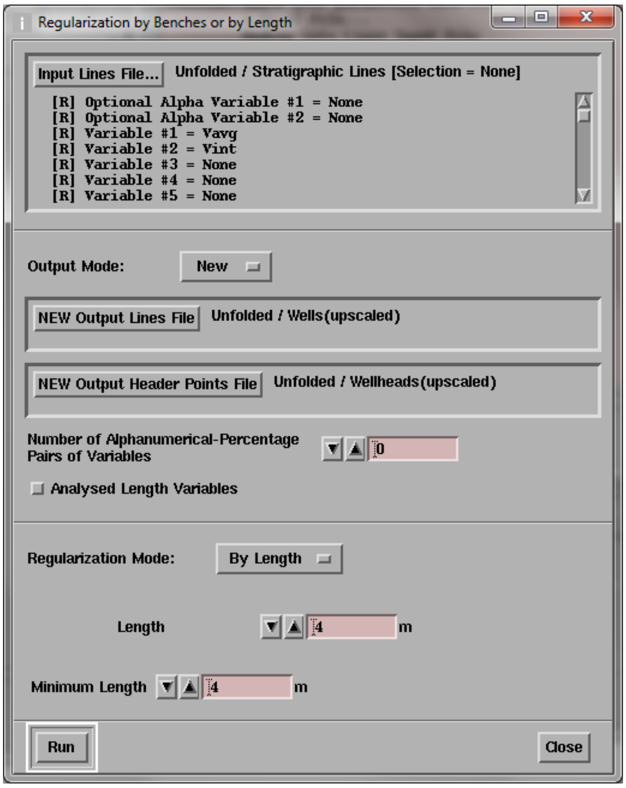



**Figure 9: Regularization application interface**
**(upscaling from the well support to the grid support)**

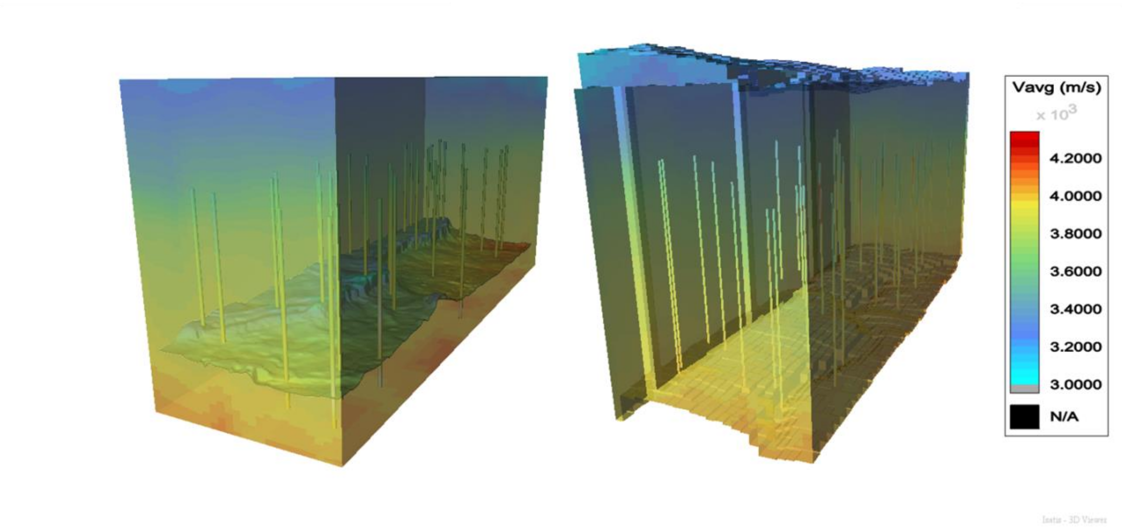



**Figure 10: A data integration example to calibrate seismic Vrms velocities with wells Vavg velocities.**
**Left: wells and seismic in the structural space. Right: wells and seismic in the stratigraphic space**

# 4. Flattening for reservoir modeling

For reservoir models, it is necessary to do more than just an unfolding of the structural grid. It is also required to transform the cell geometry as shown with the proportional layering (Figure 3). The Discretization and Flattening panel (Tools → Discretization & Flattening…) is designed for this purpose.

## A. Discretization and Flattening vs Unfolding

The main difference with the previous unfolding utility is that it can handle more complex geometry and is specifically designed for reservoir modeling. However, due to this added complexity, the Discretization and Flattening application is sometime less easy to use, especially for data integration.

For instance, with proportional layering, there is no more a bijective application (i.e. one to one equivalence) of the grid cells between the two spaces. Therefore, there is no automatically generated pointer to go from the structural space to the flattened space. The workflow to bring seismic data to the flattened grid is more complex and is beyond the scope of this document. Users willing to do such operation should contact our consultants for help.

The interface looks more complex as it allows accounting for categorical variables (i.e. facies). Facies in Isatis need to be stored in a line of "core" type. For other properties, such as elastics or petrophysical properties, this line can be of "gravity" type. Users not familiar with Isatis line formats should read the 1.4 Isatis File System chapter of the Isatis documentation. The Modify into Lines utility may also be used to convert 3D scatters to lines (using a Data File Manager operation accessible by the right hand click contextual menu of the file). Also of interest is the option to convert Gravity Lines to Core Lines (Tools → Convert Gravity Lines to Core Lines).

Logs are specified in the tab *Input* tab of the Discretization and Flattening window. Facies handling and upscaling is reflected in the tabs *Inputs*, *Lithotype Definitions*, *Discretization* of the window as shown below.

**Figure 11: Facies handling in Discretization and Flattening**

In the case where no facies data are available, it is possible to specify it in the interface.

The flattening parameters are specified in the *Grid & Geometry* tab of the Discretization and Flattening panel and are very similar to the Unit Unfolding one but for the possibility to have a proportional layering type.

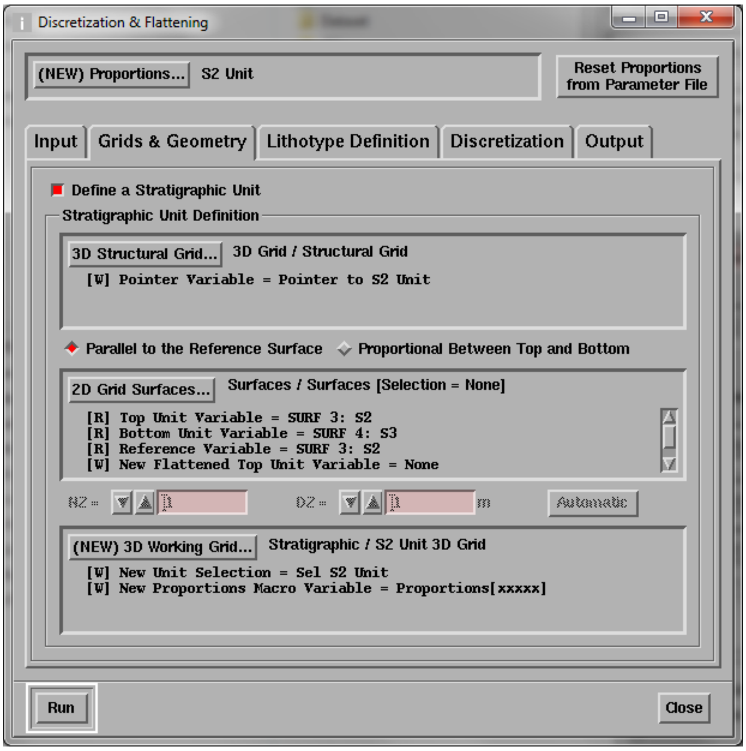



**Figure 12: Discretization and Flattening application interface**

Unlike the Unit Unfolding, the Discretization and Flattening application works unit per unit and saves for each unit its settings in a Proportion parameter file that can be printed from the Parameter Files panel (File → Parameter Files…).

As for Unit Unfolding, the utility creates new flat grid and wells files in the directory specified. File names and folders are specified in the *Output* tab.

After having populated the grid using some of the comprehensive Isatis geostatistical algorithms, use the Merge Stratigraphic Units (Tools → Merge Stratigraphic Units…) utility to bring back the properties to the structural space.

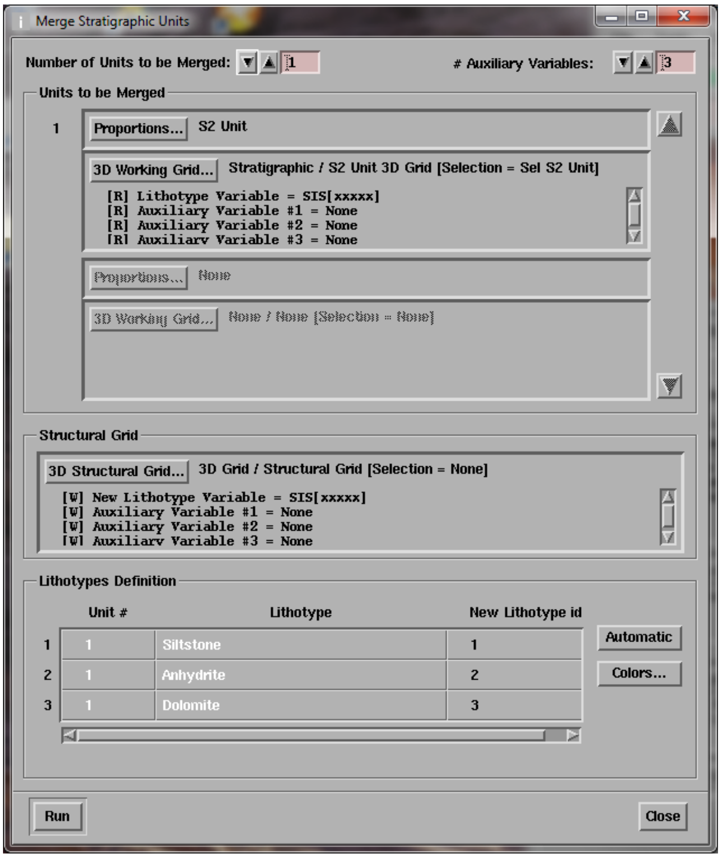



Figure 13: Discretization and Flattening interface

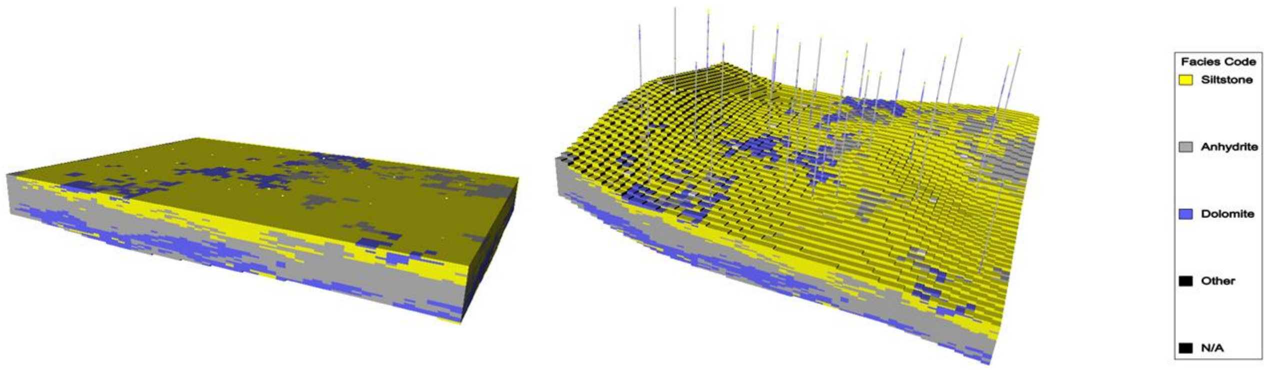



Figure 14: Facies simulation using Discretization and Flattening and SIS. Left: Flat space; Right: Structural space

For more information, contact our consultants at consult-oil@geovariances.com. They can help you implementing this workflow.