Mag3D Inversion

petros eikon …..

Data Inversion

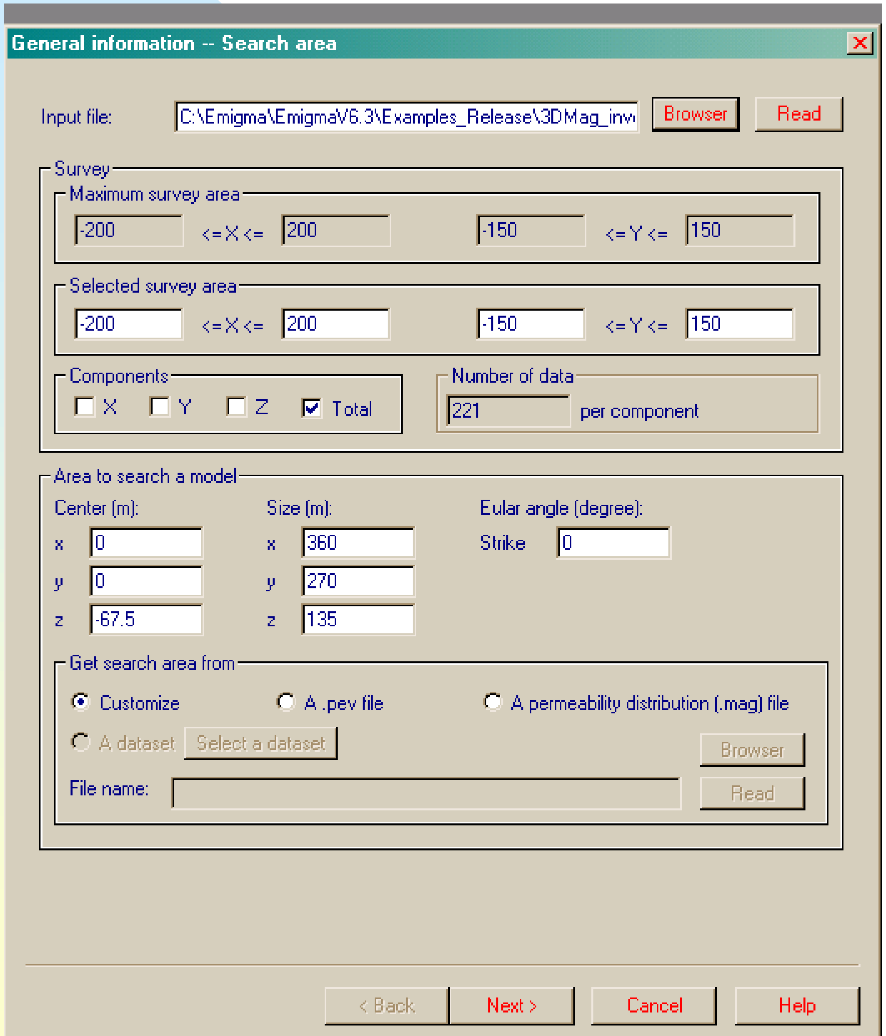
$$d = F(m)$$

$d \rightarrow$ ***data vector of dimension N***

$m \rightarrow$ **model vector of dimension M**

- F - physical relationship describing the data as a function of the earth model - *In practice an approximation*
- Approaches
  - Direct Matrix Inversion - historical
  - Optimized Inversion - modern practical approach

Data Selection and Search Area



- Data file .pev
- Survey Area
- Data Subset
- Data component
- Search Area
  - ***where is the anomaly expected ?***

- A) User specified
- B) From a set of prisms
- C) From a distribution file

Inversion Style

Matrix or Optimizaton

<u>Matrix Inversion</u>

direct inversion

$$\mathbf{d} = \mathbf{F}\,\mathbf{m}$$

$\mathbf{d} \rightarrow$ **vector of N − dimension**

$\mathbf{F} \rightarrow$ **Matrix of N × M − dimension**

$\mathbf{m} \rightarrow$ **vector of M − dimension**

<u>Optimized Inversion</u>

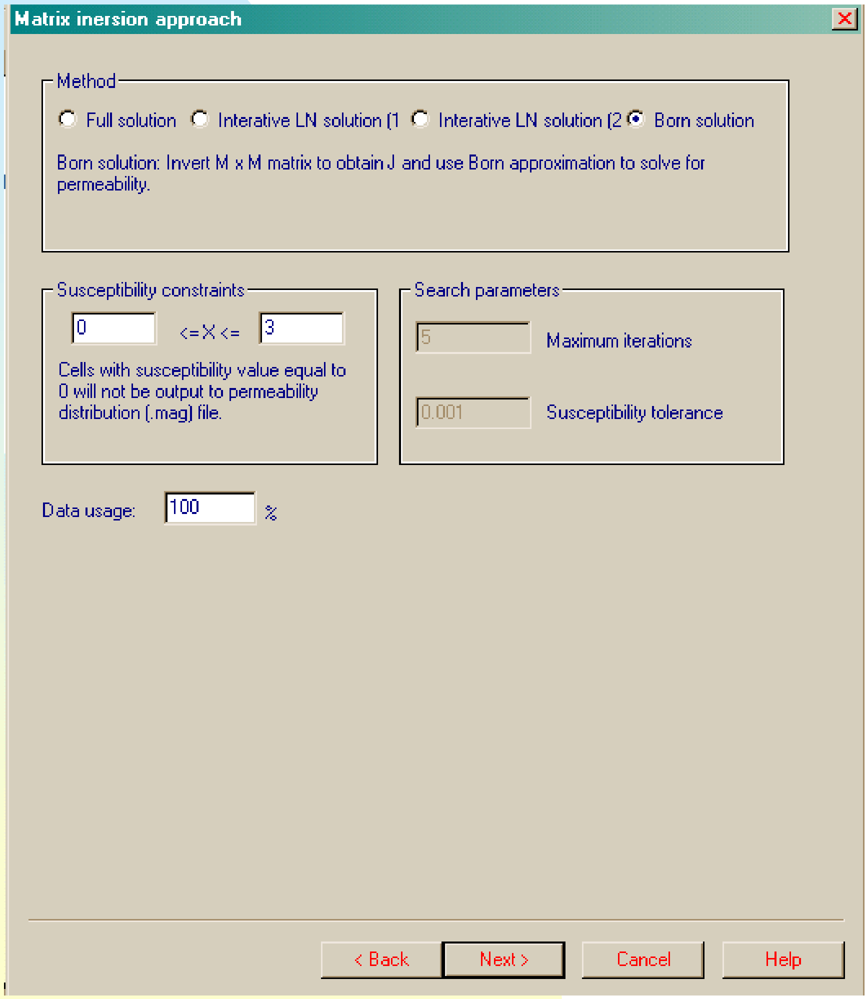
recursive inversion

minimizing a functional

Matrix Inversion

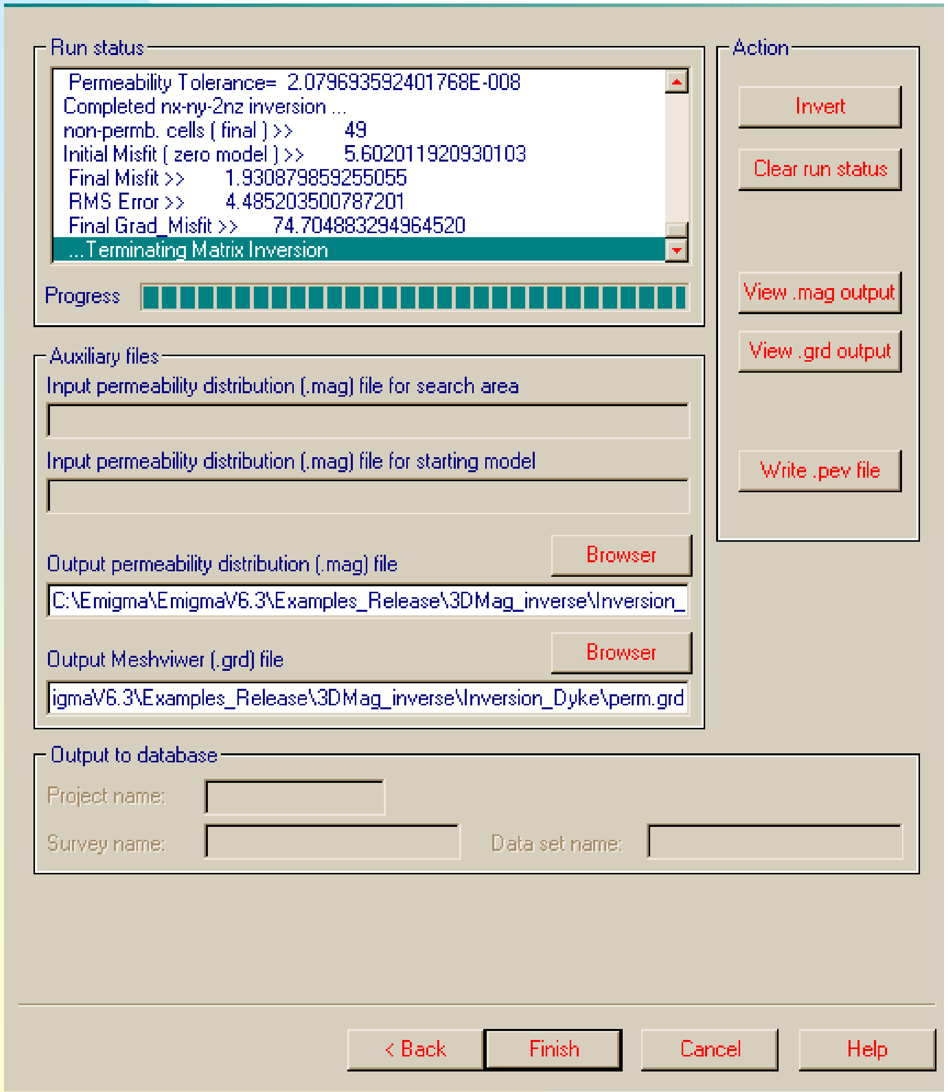
$$H_{ext}(r) = \int G(r,r')J(r')dr'$$

$$J(r') = (m(r') - m_0)H_{ins}(r') = \chi(r')H_{ins}(r')$$



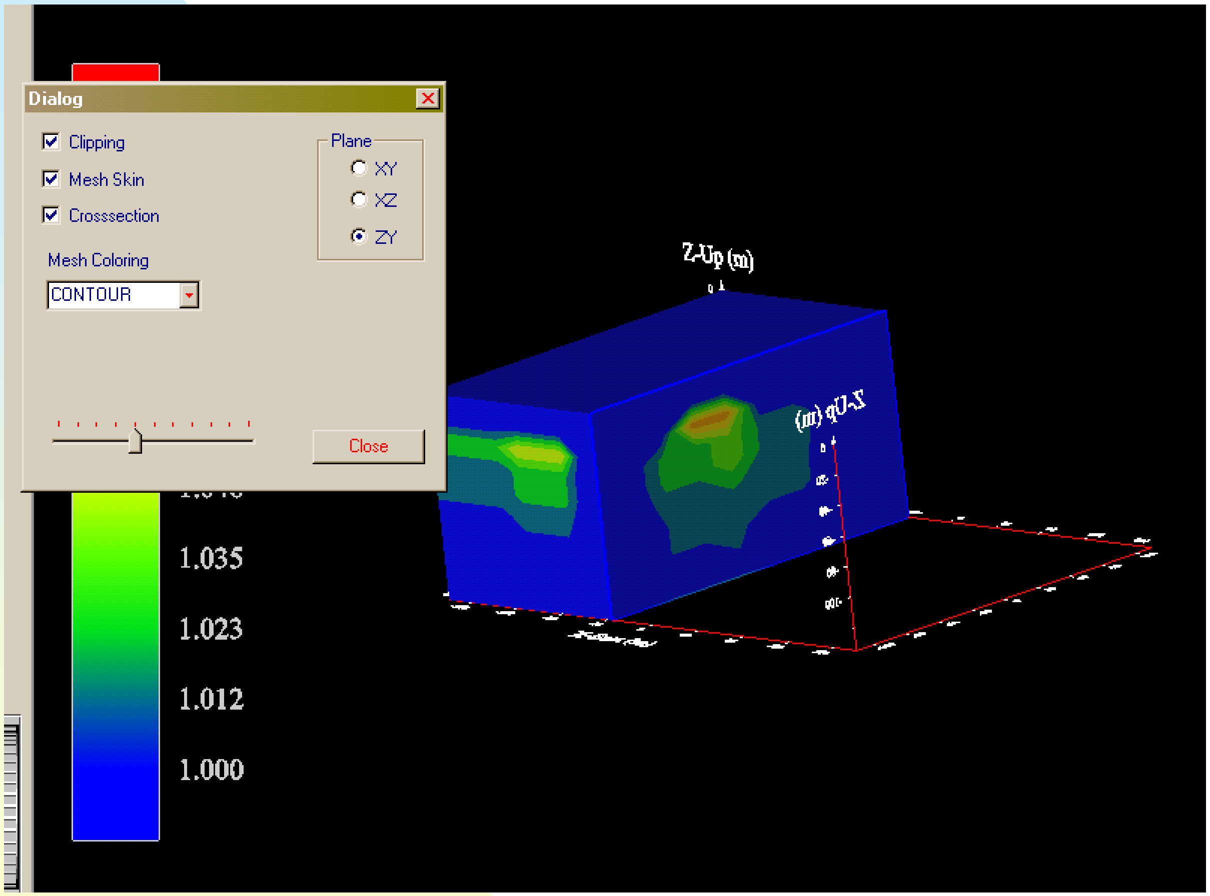
- Techniques
  - Full solution
    - no assumptions
  - Interative LN
    - removing non-permeable cells
  - Interative LN
    - Internal H = LN H
    - Born starting model
  - Born Solution
    - Internal H = Background H

Inversion Output

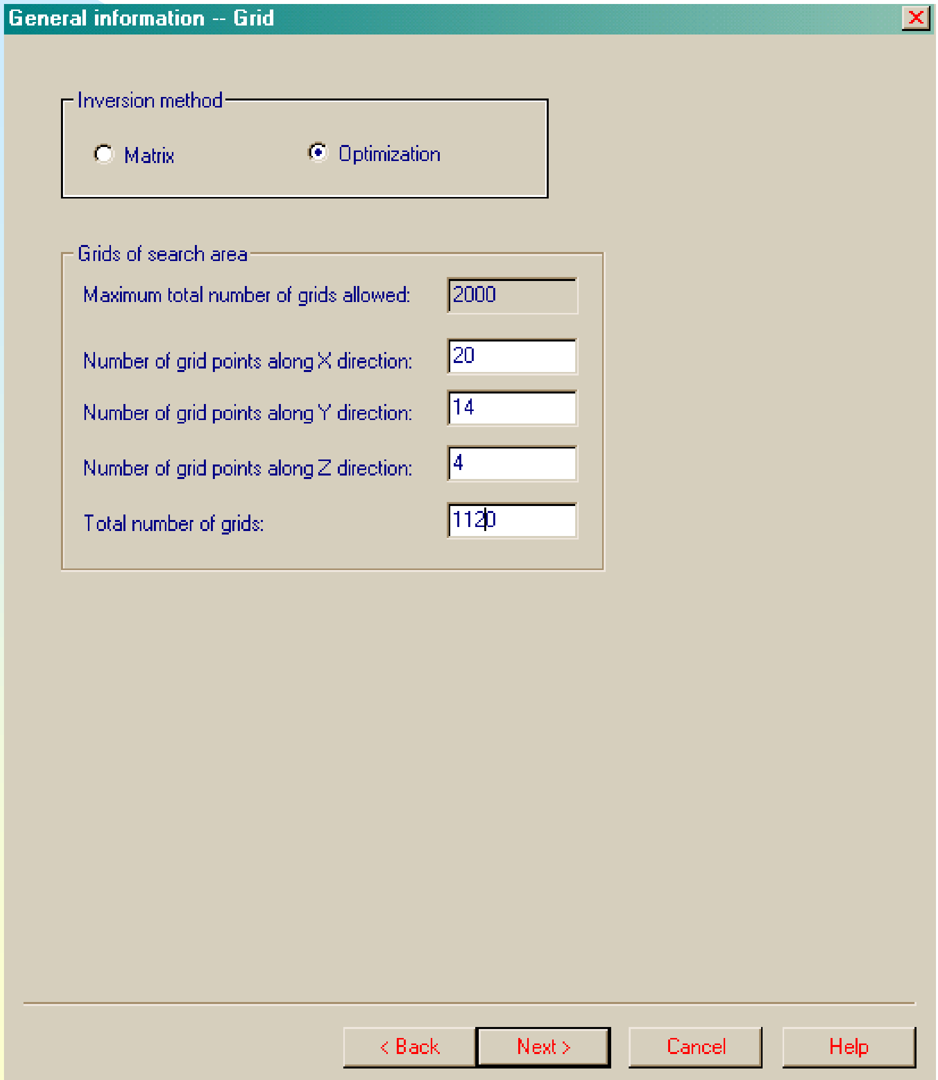


- Start Inversion
- Mag File
  - distribution of anomalies
- Grd File
  - for Meshviewer
- Output to .pev file
  - maximum 499 prisms

Meshviewer


Dialog
Clipping
Mesh Skin
Crosssection
Mesh Coloring
CONTOUR
Plane
XY
XZ
ZY
Close
1.035
1.023
1.012
1.000
Z-Up (m)

Optimized Inversion



- General concept
  - *Start with an initial guess and go looking for the best fitting model*
- Critical factors
  - *Good forward simulation*
  - *good minimization technique*
  - *good starting model*
  - *good data*

Optimized Inversion

$$\phi(m) = \lambda\, \phi_d(m) + \phi_m(m)$$

$\phi(m)$ - functional to be minimized
$\phi_d(m)$ - data misfit
$\phi_m(m)$ - model misfit
λ - Lagrangian multiplier - regularization weight

Occam style model misfit function

$$\phi_m(m) = \alpha_0 \int w^2(z)\,[\, m(r)-m^0(r)\,]^2\, dv \quad +$$

$$\sum_{i=x,y,z} \alpha_i \int [\, w(z)\, \partial_i\, (\, m(r)-m^0(r)\,)\,]^2\, dv$$

α_I - weighting factors
w(z) - depth weighting

Physical Modes - *Forward Model*

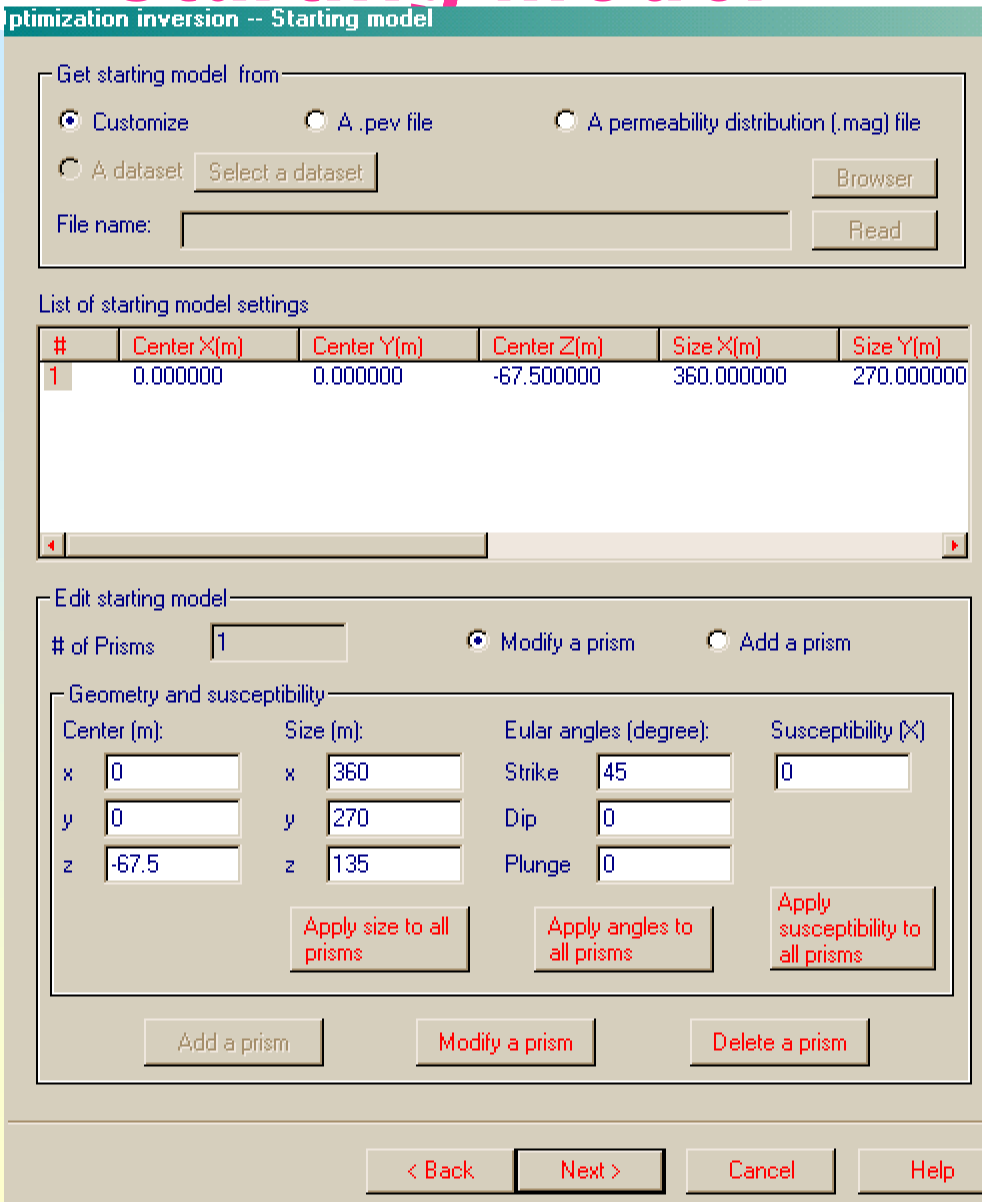
- M via LN
  - Internal Magnetization vector (M) derived via LN
- H via LN
  - Internal magnetic vector via LN
- H via Born
  - Internal H and therefore internal M derived via Born

The forward model or estimated data is derived via an approximation which is either Born or Non-Linear Approximator. For the LN, one can assume that H is derived by LN or M is derived by LN.

Minimization Technique
How to find the minima

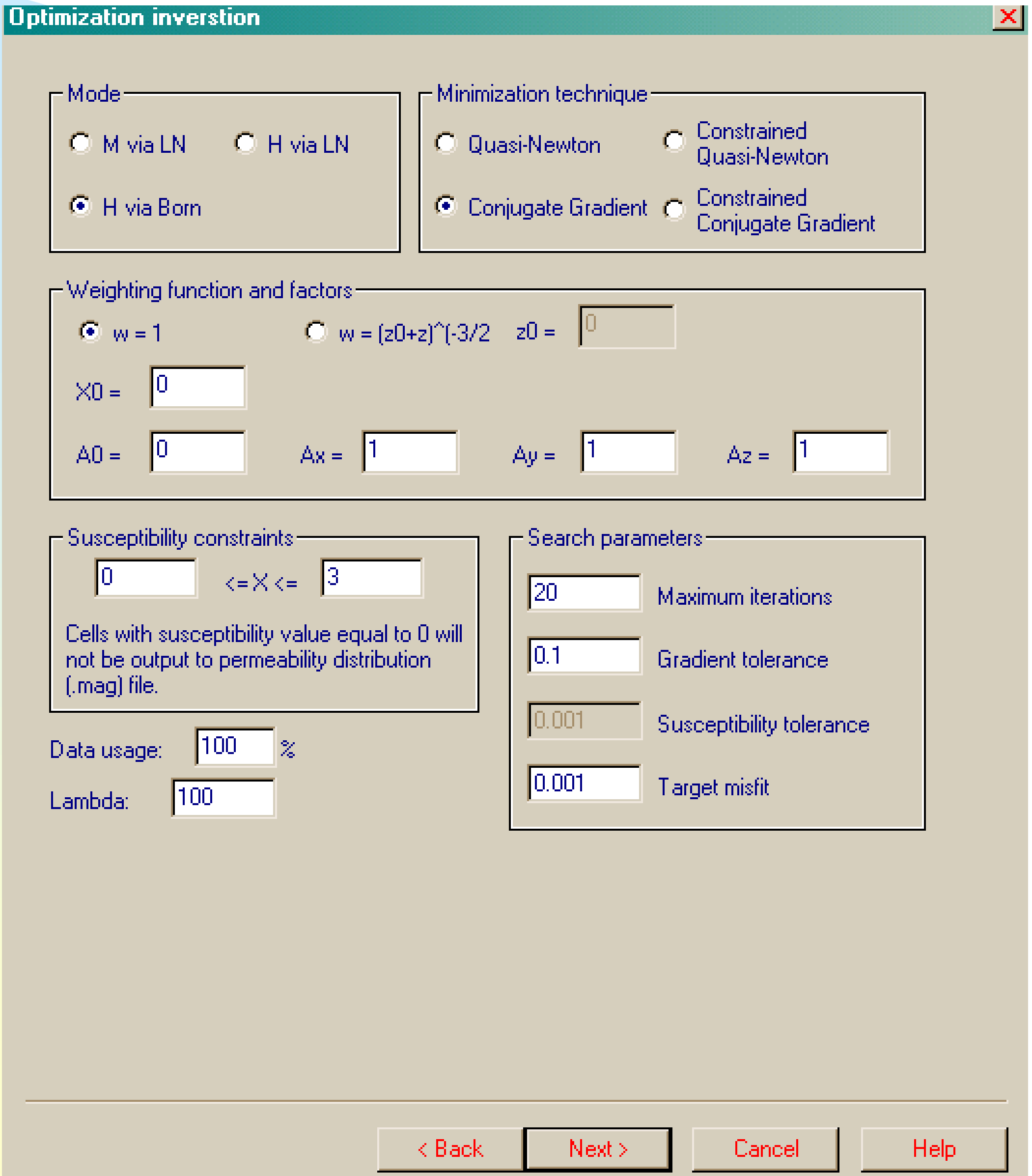
- Quasi-Newton
  - approximate 2nd derivatives for Hessian matrix
  - efficient when Hessian of previous iteration utilized
  - poor results if Hessians from sequential iterations very different
- Conjugate Gradient
  - gradients used to define search direction
  - minima by line search
  - terminates when gradient reaches a minimum value

Starting Model



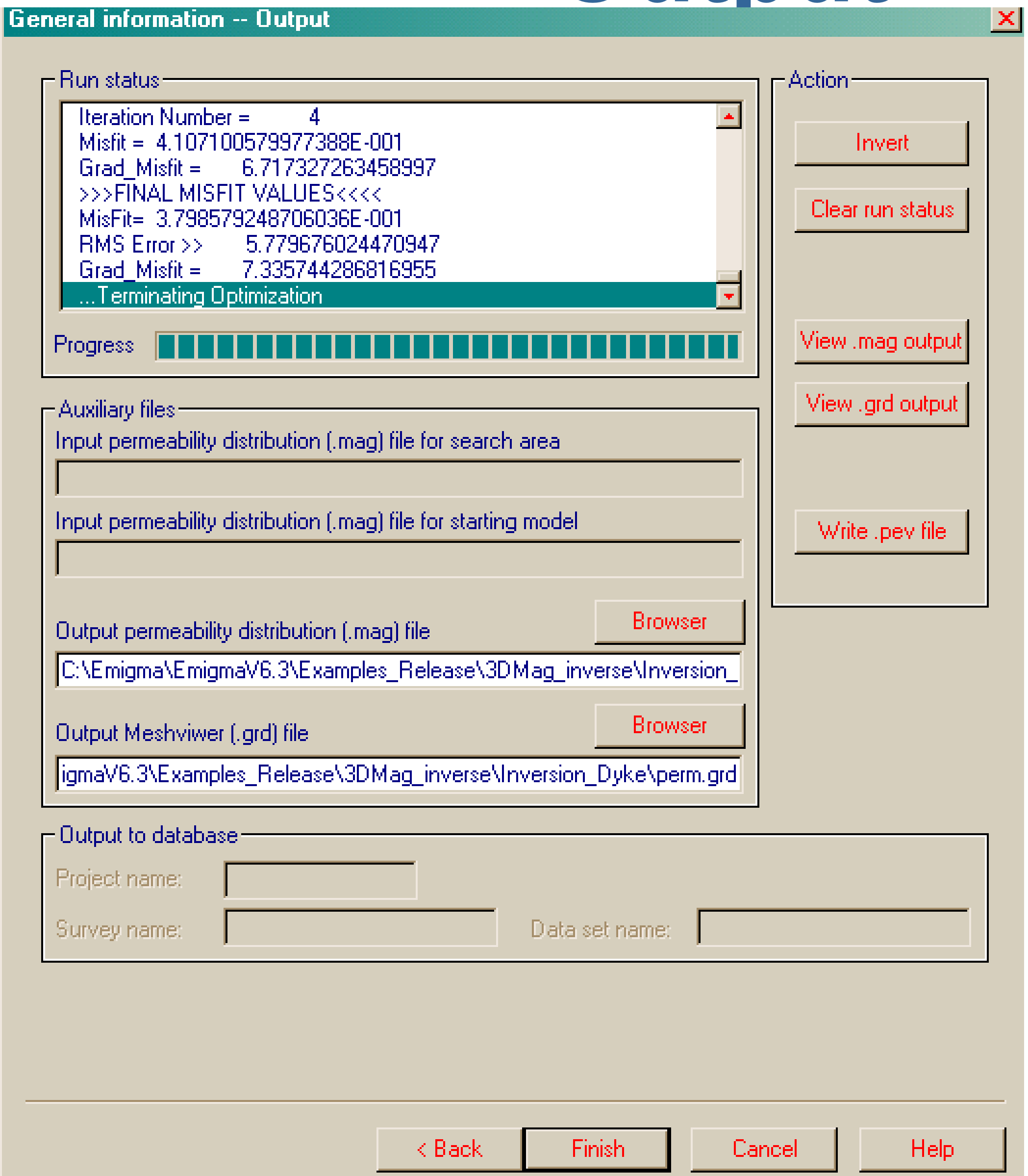
- User defined prisms
- From a forward model
- From a previous inversion

Optimized Inversion Style



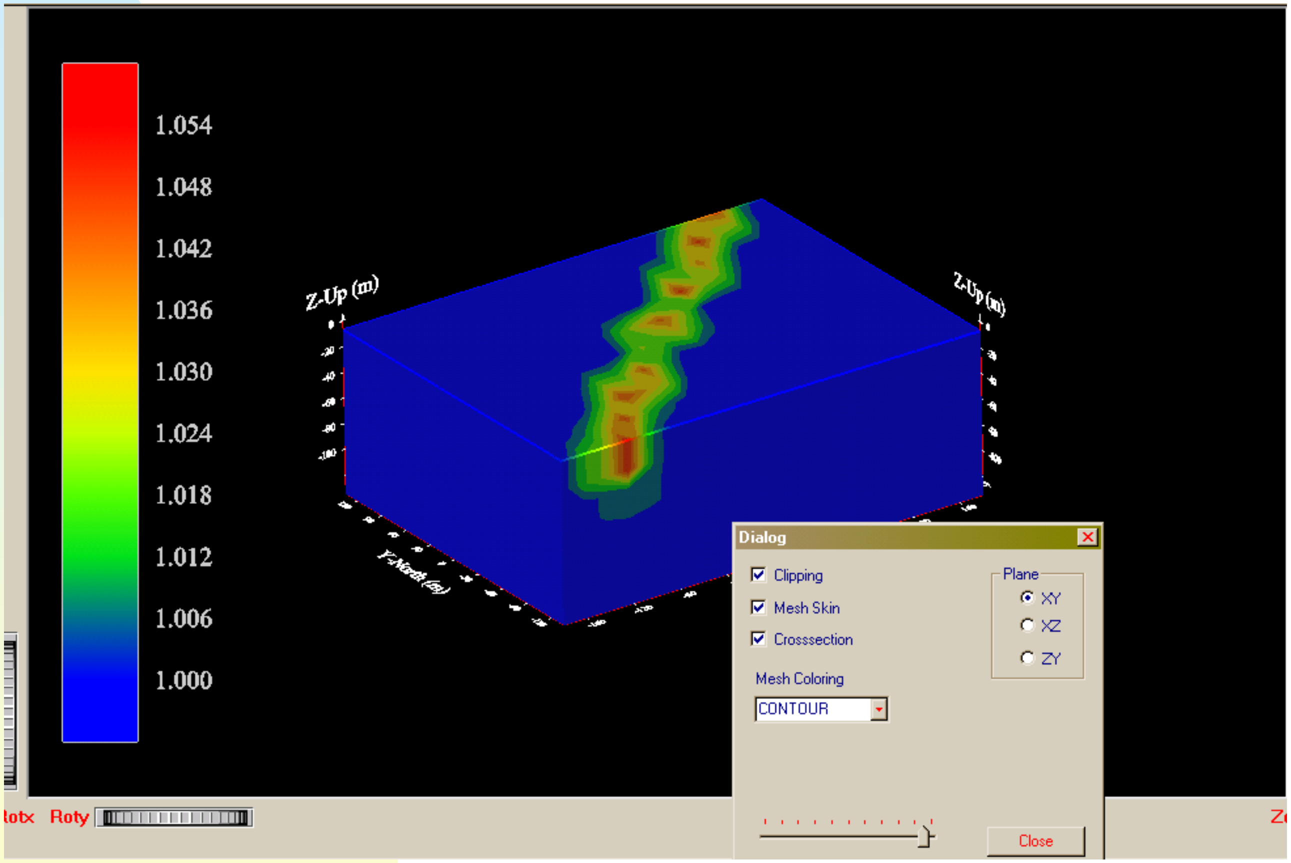
- Physical Mode
  - internal scattering assumption
- Minimization Technique
  - mathematical technique for minimizing the functional
- Model weights
  - regularization weights
- Susceptibility Constraints
- Gradient tolerance
- Susceptibility tolerance
- Target Misfit
- Lambda - data misfit vs model characteristics

Output



- Misfit parameter progress

Meshviewer



1.054
1.048
1.042
1.036
1.030
1.024
1.018
1.012
1.006
1.000
Z-Up (m)
Z-Up (m)
Y-North (m)
Dialog
Clipping
Mesh Skin
Crosssection
Plane
XY
XZ
ZY
Mesh Coloring
CONTOUR
Close
Roty