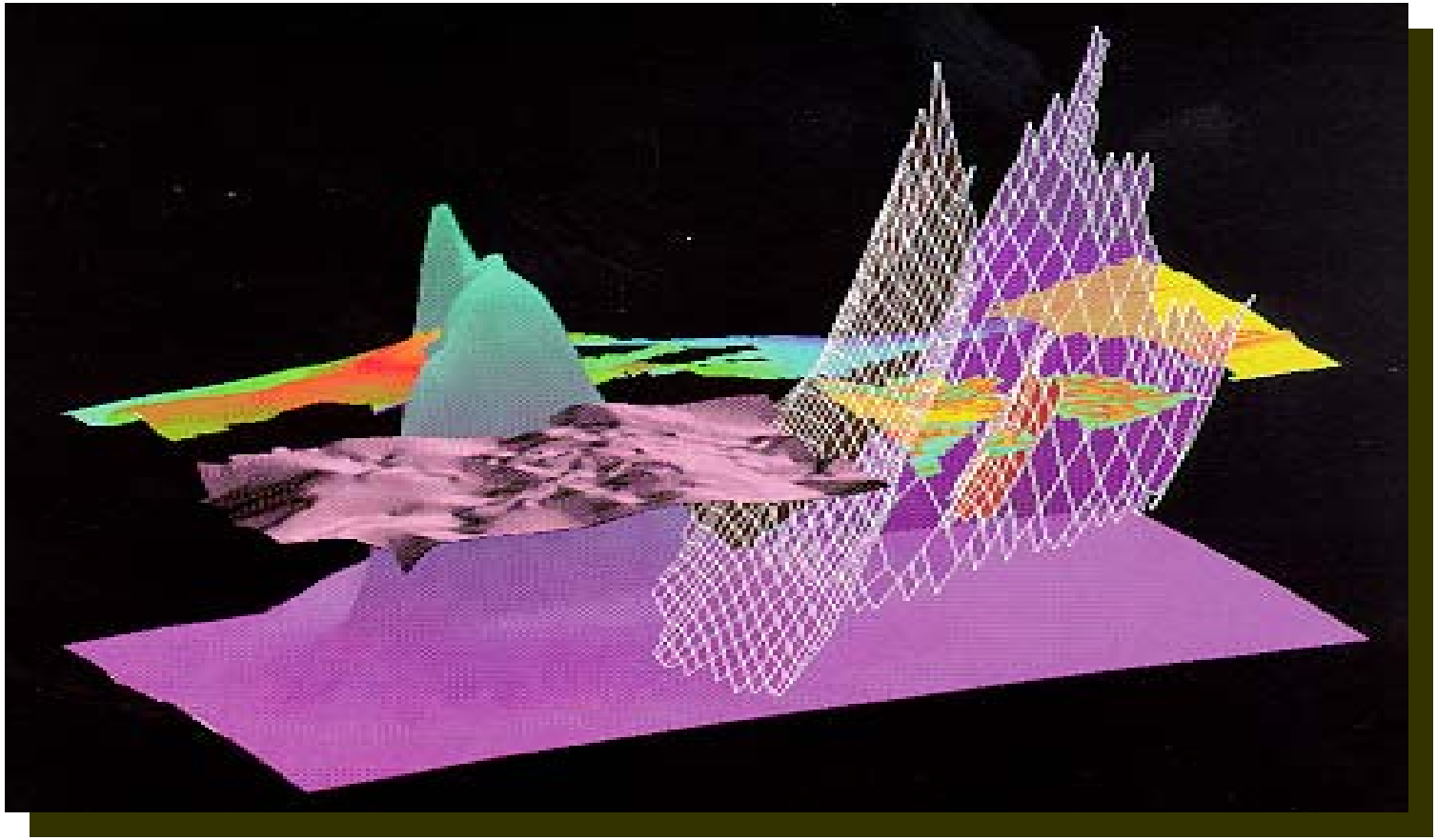
Introduction to Modeling



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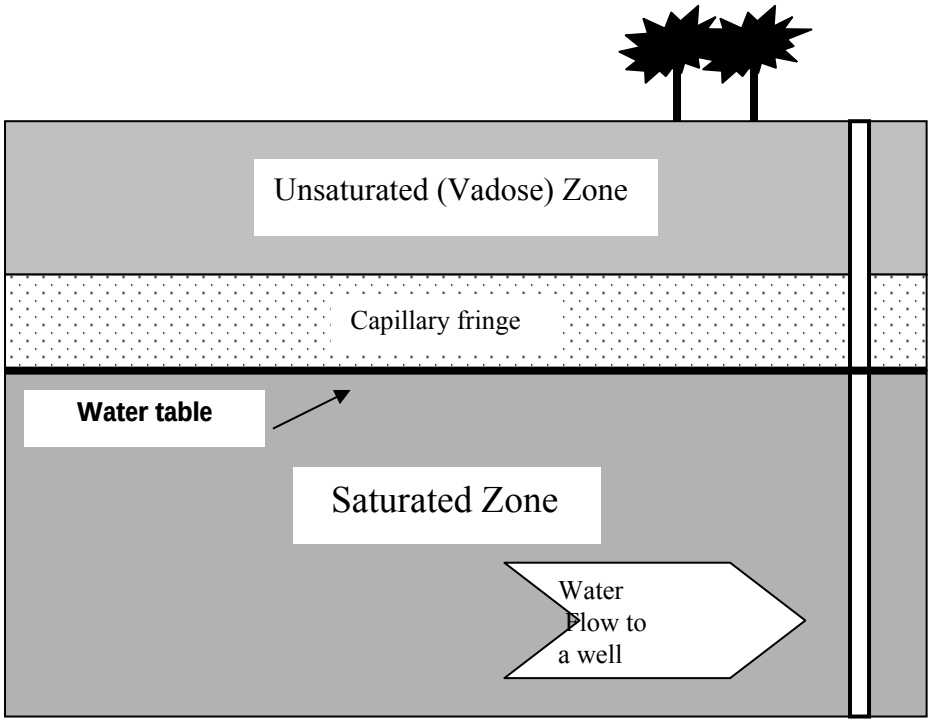
What is a Model?

- Model: is a an imitation tool that represents a real system.

- Major types of models:
  - Physical
  - Mathematical (Analytical and Numerical)
  - Geostatistical (Stochastic)



Why modeling?

- Understand the spatial continuity/heterogeneity of a variable in a geologic medium (e.g. permeability, porosity …)
- Predict the response of a flow system under pumping/injecting conditions (e.g. oil or water production)
- Enhance oil, gas, mineral and groundwater evaluation and productivity

- Choose the best scheme to install new wells or select new mining blocks.
- Design plans to protect and remedy contaminated aquifers (i.e. environmental risk assessment).
- Study the uncertainty associated with critical geological properties.
- Estimate the reserves of available natural resources.
- SAVE TIME and MONEY!

Why modeling?

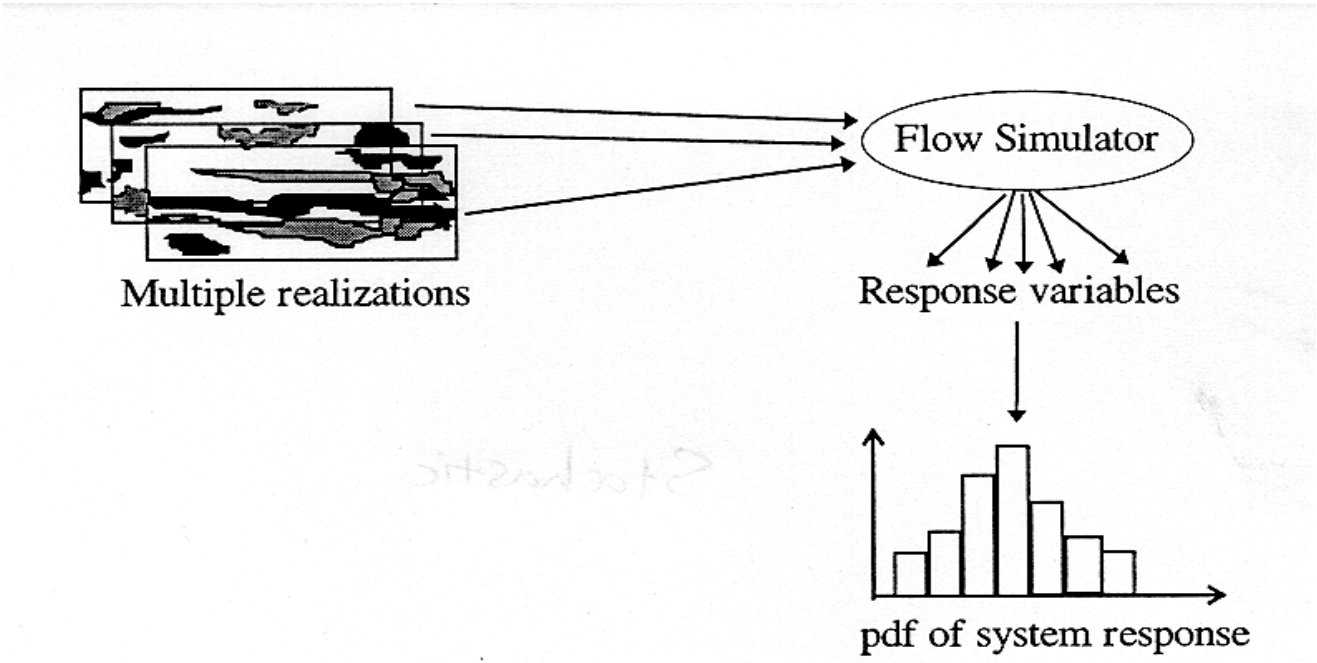


Fig. 1.1 Schematic representation of a stochastic flow simulator

Use of Models

- Saturated and unsaturated groundwater flow simulation
- Solute-transport & environmental issues
- Oil/gas movement and migration
- Mineral resources and ore deposits evaluation
- Heat transport in geological media
- Soil stability and rock mechanics

How to design a model?

- Collect data & build a conceptual model.
- Construct a spatial variability model
- Divide the domain and estimate values
- Run the simulator (i.e. flow, transport, oil, gas…) with proper boundary and initial conditions.
- Calibrate and verify (history matching)
- Run the simulator for forecasting or risk/uncertainty assessment purposes.

How to design a model?

Conceptual model

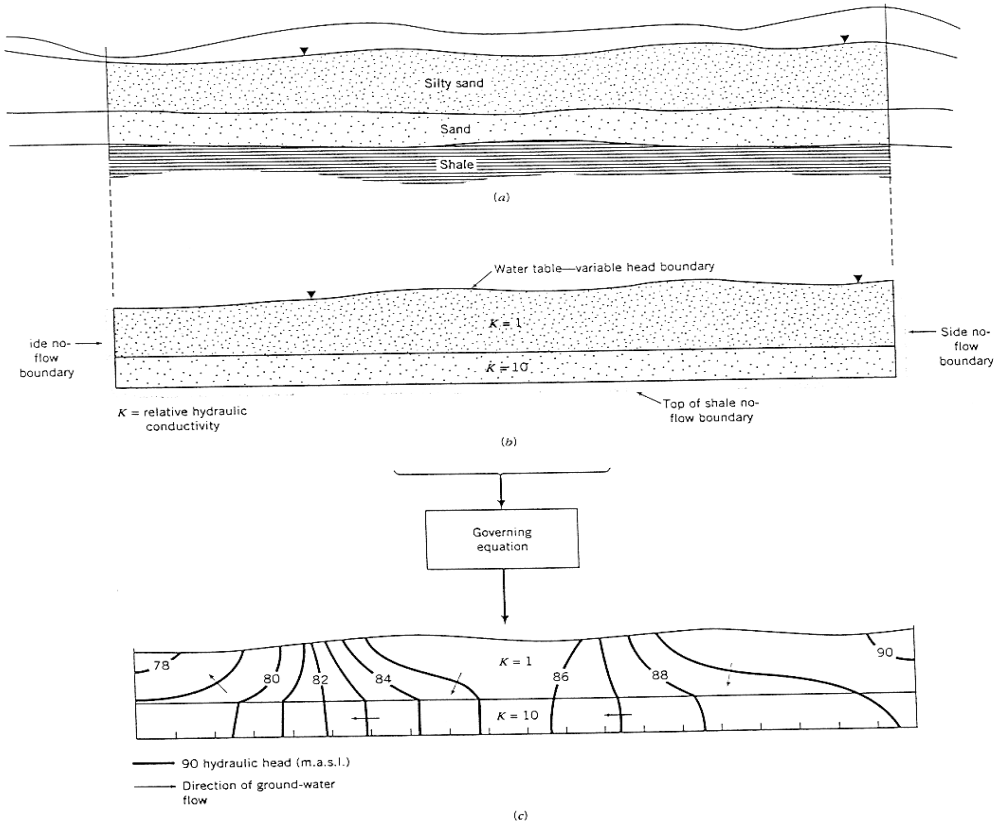


Figure 4.1 A geologic problem (*a*) is conceptualized onto a mathematical problem (*b*), which is ultimately solved in terms of the hydraulic head distribution (*c*).

How to design a model?

Divide the domain (FDM)

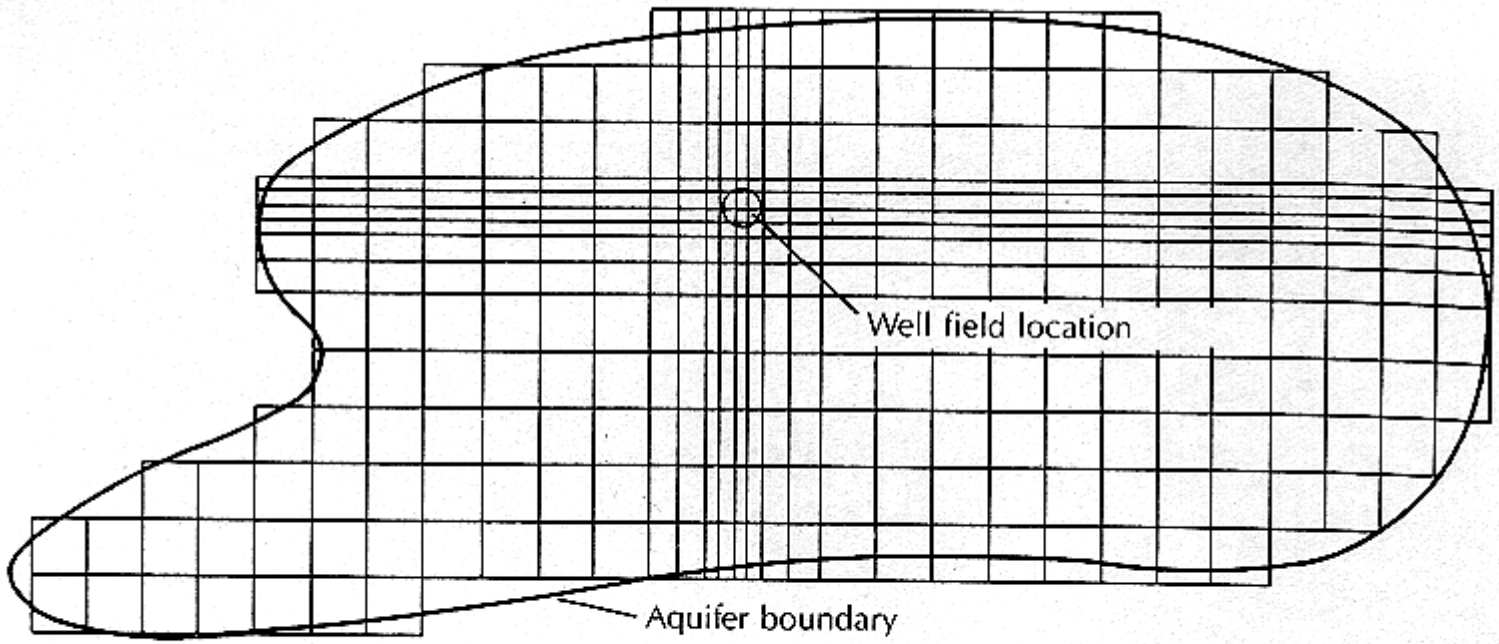


FIGURE 14.2 Variable-spacing finite-difference grid.

How to design a model?

Divide the domain (FEM)

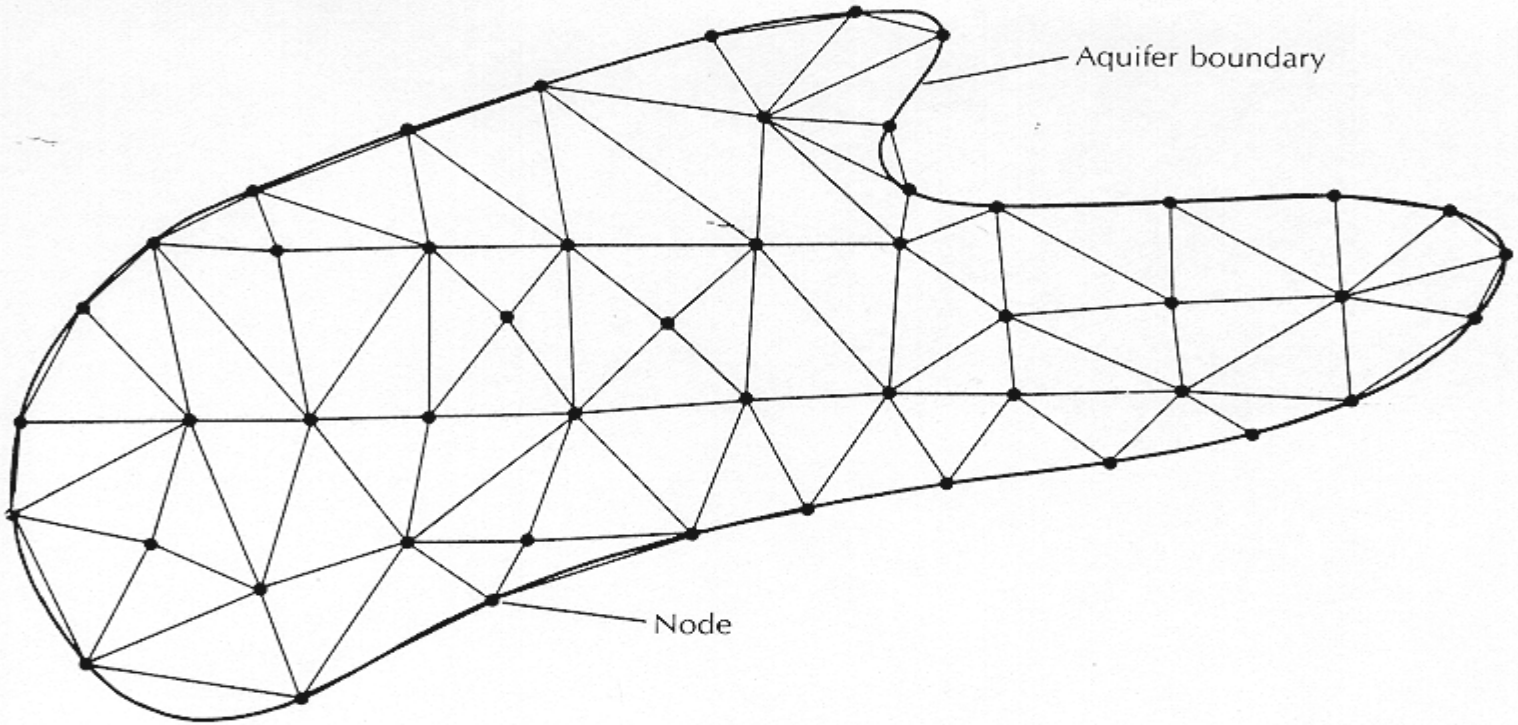
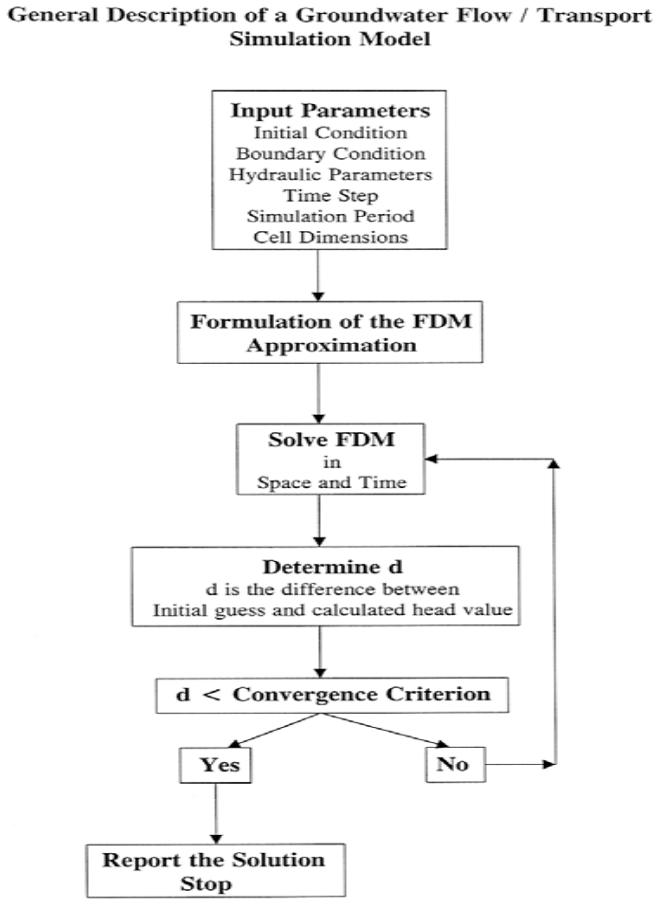


FIGURE 14.5 Finite-element grid for an aquifer.

Numerical Modeling Mechanism

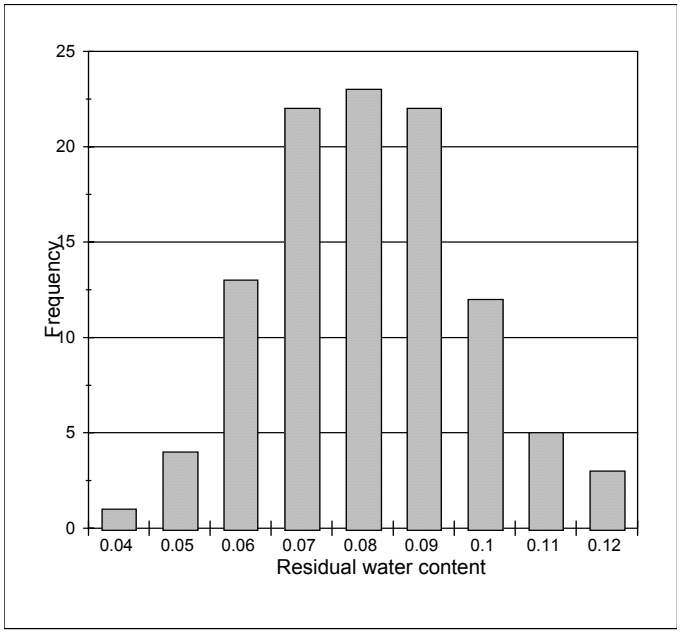


Nature of Geological Data

- Collected / interpreted by different techniques (e.g. lab analysis, field measurements, log interpretations…)
- Regularly / irregularly spaced
- Qualitative ==> Geological modeling and interpretation
- Quantitative ==> Statistical, geostatistical, and numerical modeling

What is Statistics?

- It is the science of collecting, analyzing, and interpreting data in order to draw valid conclusions
- Applications to geology since 1930's



What is geostatistics?

- It is the application of statistical methods to solve the problem of estimating geological parameters that vary in space.
- Applications to geology since 1963.
- It integrates quantitative geology with statistical, mathematical and engineering concepts.