Integrating Geophysics, Geology, and Hydrology to Enhanced Hydrogeological Modelling

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HyGEM

Integrating geophysics, geology and Hydrology for improved Groundwater and Environmental Management

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Motivation

- Today the integration of geophysical and geological/hydrological data is
  - Subjective
  - Largely un-documented
  - Manual

- Possible information loss when combining different data sets through a chain of processes and people

- Information loss by changes in model discretization

- Need workable tools on large scale watershed investigations
Objectives

Geophysical data

Geological data

Hydrological data

HyGEM

Hydrological/Geological model
Objectives

- Create tools for direct and (semi-) automatic integration of geophysical and geological data into hydrological models

- Better water resources and environmental management

- Results must be
  - Reproducible
  - Documented
  - Objective
  - Uncertainties described
Tools

- Airborne Electromagnetic
- Magnetic Resonance Sounding
- Geophysical borehole logging
- Pump tests

- Borehole (lithology) and geophysics database “mining”

- Geophysical data inversion
- Groundwater modeling

- Joint/coupled geophysical and groundwater inversion
Danish Partners

• **Research institutions**
  • *Department of Geoscience, Aarhus University*
  • The Geological Survey of Denmark and Greenland
  • Department of Environmental Engineering, Technical University of Denmark

• **Industry partners**
  • Aarhus Vand A/S
  • Alectia A/S
  • SkyTEM Surveys ApS
  • Aarhus Geophysics ApS
International Partners

• **Research institutions**
  • The U.S. Geological Survey (USGS)
  • Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia.
  • Geological Survey of Holland (TNO)

• **International advisory board**
  • Professor Rosemary Knight
  • Professor Ty Ferré
Example

• Dense geophysical airborne data
Example

- Dense geophysical airborne data
  - Processed by a geophysicist to a resistivity model
Example

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Example

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  - Processed by a geophysicist to a resistivity model
  - Interpreted by a geologist to a geological model
• Dense geophysical airborne data
  • Processed by a geophysicist to a resistivity model
  • Interpreted by a geologist to a geological model
  • Translated into a hydrological model by a hydrogeologist (model reduction)
Example

- One option: automatic translation to clay/sand model
Tasks – the Hard Core Geophysics

• Development of instrumentation
  • Airborne electromagnetic – SkyTEM: Further enhance horizontal and vertical resolution by automated correction for early time data distortions
  • Magnetic Resonance Sounding: new wireless remote noise measuring system

• Development of algorithms
  • Octree grid based inversion of AEM and groundbased data.
  • Grid fits well with future joint inversion of groundwater models and geophysical data

• Surveys in Denmark, Holland, USA and Australia
Tasks – Spatial Correlation…

- Investigate spatial correlation between geophysical properties and lithology formations

- Borehole database with more than 200,000 boreholes and terabytes of geophysical data (mostly TEM and resistivity)

- Multivariate geostatistics
Tasks – Inversion – hydro and geophysics

- **Coupled inversion**
  - Geometry: Layer interfaces and thicknesses in groundwater model and geophysical model must be identical
  - Petrophysical: Correlation of electrical and hydraulic conductivity

- **Sequential inversion**
  - Invert geophysical data *then* invert for hydrological/geological parameters

- **Geostatistical approach**
  - Statistical links between e.g. lithology and resistivity used to build probable models
Tasks – Testing the Hypotheses

• Test-bench environment for accessing new ideas in a controlled environment for geophysical and hydrological modeling
Join Us

• **We can contribute with**
  • SkyTEM, MRS, boreholelogs, lithology logs
  • Modflow and MikeShe hydrological models
  • Engaged PhD’s and post docs
  • Advanced software packages for modeling of geophysical and hydrological data

• **The data can be made available for collaboration research projects**
Conclusion

- HyGEM will develop more automatic approaches for coupling geological, hydrological and geophysical data on large scale water shed scale
- Development of instrumentation, algorithms and concepts
- We are for sure not able to go all the way, but this is a start!

www.hygem.org