Education evenings 2018

*Practical introduction
to groundwater modelling*

Computer exercises
03 04 What else?

ModelMuse

Much more functionality to be discovered!

Refer to:

✓ the ModelMuse manual 🔗

✓ the ModelMuse videos 🔗

✓ the ModelMuse help 🔗

ModelMuse and MODFLOW

✓ Many more packages available to use

✓ Compatibility with MODFLOW versions other than the core MODFLOW-2005

  ✓ MODFLOW-LGR 🔗

  ✓ MODFLOW-NWT 🔗

  ✓ MODFLOW-OWHM 🔗

 ✓ MODFLOW-CFP 🔗

MODFLOW packages

- Flow
  - ○ BCF6: Block-Centered Flow package
  - ⊙ LPF: Layer Property Flow package
  - ○ HUF2: Hydrogeologic Unit Flow package
  - ☐ HFB: Horizontal Flow Barrier package
  - ☐ UZF: Unsaturated-Zone Flow package
  - ☐ SWI2: Seawater Intrusion package
- Boundary conditions
  - Specified head
    - ☐ CHD: Time-Variant Specified-Head package
    - ☐ FHB: Flow and Head Boundary package
  - Specified flux
    - ☐ RCH: Recharge package
    - ☐ WEL: Well package
    - ☐ FHB: Flow and Head Boundary package
  - Head-dependent flux
    - ☐ DRN: Drain package
    - ☐ DRT: Drain Return package
    - ☐ ETS: Evapotranspiration Segments package
    - ☐ EVT: Evapotranspiration package
    - ☐ GHB: General-Head Boundary package
    - ☐ LAK: Lake package
    - ☐ MNW1: Multi-Node Well package
    - ☐ MNW2: Multi-Node Well package
    - ☐ RES: Reservoir package
    - ☐ RIV: River package
    - ☐ SFR: Stream-Flow Routing package
    - ☐ STR: Stream package

- Solvers
  - ⊙ PCG: Preconditioned Conjugate Gradient package
  - ○ PCGN: Preconditioned Conjugate Gradient Solver with Improved Nonlinear Control
  - ○ GMG: Geometric Multigrid package
  - ○ SIP: Strongly Implicit Procedure package
  - ○ DE4: Direct Solver package
- Subsidence
  - ☐ SUB: Subsidence and Aquifer-System Compaction Package
  - ☐ SWT: Subsidence and Aquifer-System Compaction Package for Water-Table Aquifers
- Observations
  - ☐ HOB: Head Observation package
  - ☐ CHOB: Specified-Head Flow Observation package
  - ☐ DROB: Drain Observation package
  - ☐ GBOB: General-Head-Boundary Observation package
  - ☐ RVOB: River Observation package
  - ☐ STOB: Stream Observation package
- Output
 - ☐ HYD: HYDMOD package

We only used a few...

4

MODFLOW-LGR

✓ MODFLOW-LGR allows smaller parts of a larger model domain to be refined without refining the entire model.
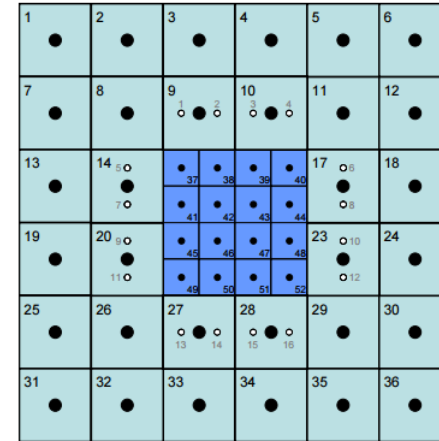
MODFLOW-NWT

✓ MODFLOW-NWT is a Newton-Raphson formulation for MODFLOW-2005 to improve solution of unconfined groundwater-flow problems.

✓ It is intended for solving problems involving drying and rewetting nonlinearities of the unconfined groundwater-flow equation.
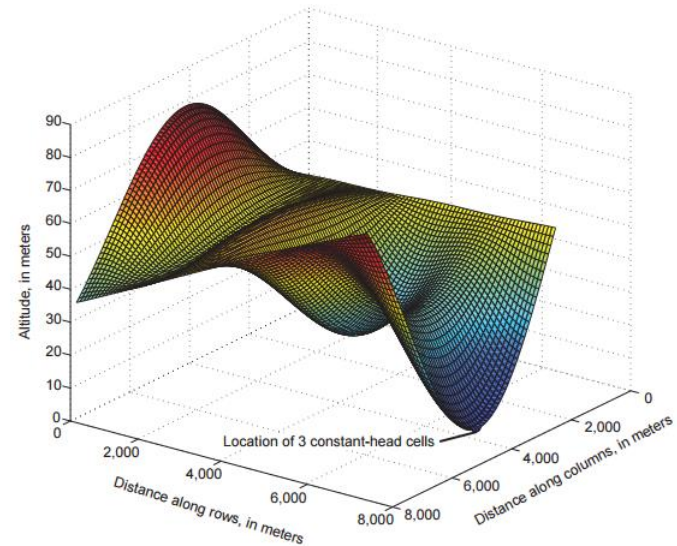
MODFLOW-OWHM

- ✓ MODFLOW-OWHM, or the One-Water Hydrologic Flow Model, is an integrated hydrologic flow model (IHM).

- ✓ It is designed for the analysis of a broad range of issues related to the combined use of groundwater and surface water.

- ✓ It allows the simulation, analysis, and management of human and natural water movement within a physically-based supply-and-demand framework.
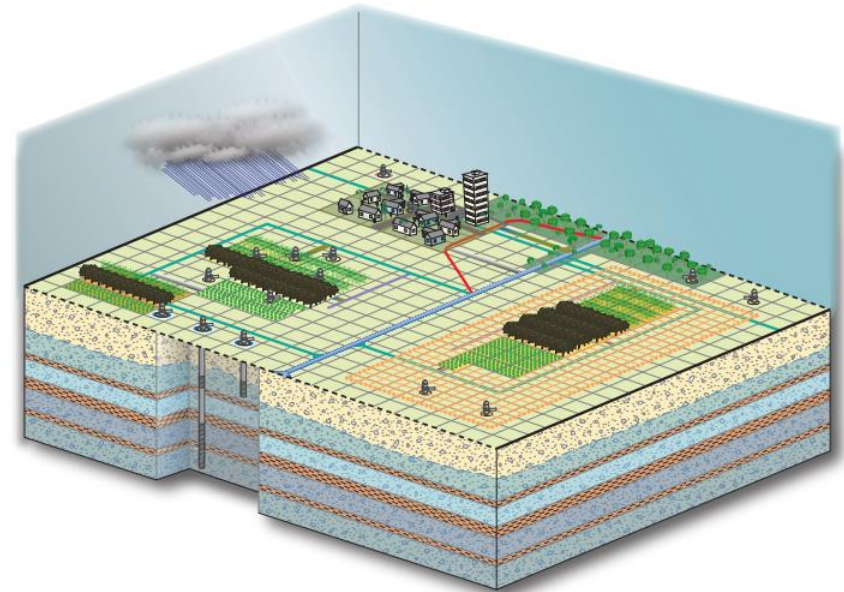
MODFLOW-CFP

MODFLOW-CFP has the ability to simulate turbulent or laminar groundwater
flow conditions by:

✓ coupling the traditional groundwater flow equation with formulations for a 1-dimensional discrete network of cylindrical pipes (Mode 1, CFPM1),

✓ inserting a high-conductivity flow layer that can switch between laminar and turbulent flow (Mode 2, CFPM2), or

✓ simultaneously coupling a discrete pipe network while inserting a high-conductivity flow layer that can switch between laminar and turbulent flow (Mode 3, CFPM3).
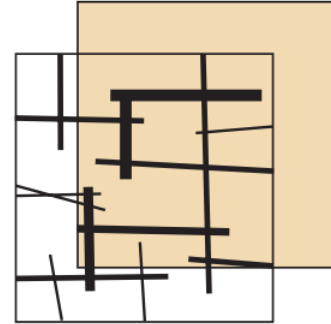
Beyond the GUI

Several scripting language interfaces to MODFLOW exist, or are in development:

- ✓ Flopy (python) 🔗
- ✓ Mflab (matlab) 🔗
- ✓ RMODFLOW (R) 🔗

These are useful for:

- ✓ Parameter estimation or uncertainty quantification that goes beyond MODFLOW parameters and/or UCODE algorithms
- ✓ Geostatistical simulation for *e.g.* material properties
- ✓ Quickly converting database information to input files
- ✓ Reproducible research/reporting
- ✓ …

ModelMuse and PHAST 🔗

PHAST is a Computer Program for Simulating

✓ Groundwater Flow,

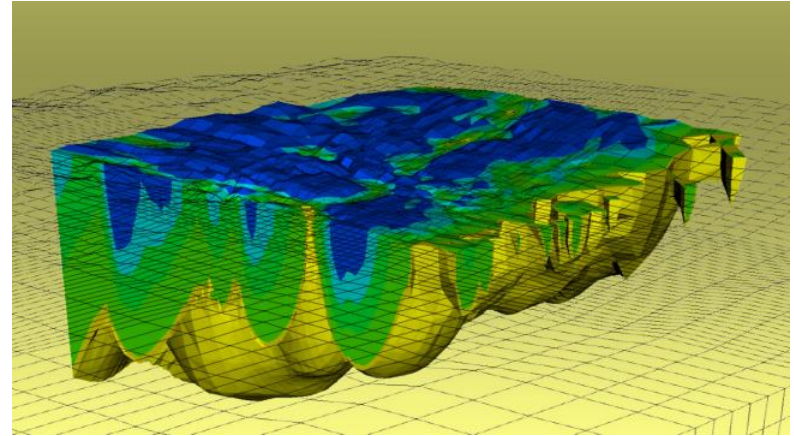✓ Solute Transport, and

✓ Multicomponent Geochemical Reactions,

for which it uses PHREEQC. 🔗
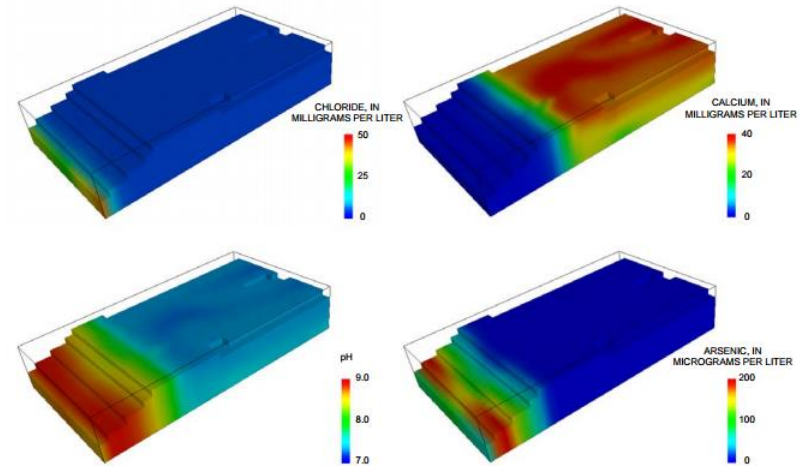
ModelMuse and SUTRA 🔗

SUTRA is a model for

- ✓ saturated-unsaturated,
- ✓ variable-density ground-water flow,
- ✓ with solute
- ✓ or energy transport.

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Questions? Found an error?
Please contact B. Rogiers at brogiers@sckcen.be.