Simulating variably-saturated solute transport with a coupled HYDRUS - MT3D-USGS tool

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Codes

The **HPM** package [1], which couples HYDRUS-1D [2] to MODFLOW [3], has been updated. A similar package is written to provide a **coupling between HYDRUS and MT3D-USGS** [4].

The PHREEQC [5] capabilities are added to MT3D-USGS through the new **MCP** package which is based on the existing **HPx** [6] code.

	Vadose zone		Saturated zone
Water flow	HYDRUS (1D)	⟺	MODFLOW
Solute transport	HYDRUS (1D)	⟺	MT3D-USGS
Geochemistry	PHREEQC	⟺	PHREEQC

Water flow and reactive solute transport **simulations are separate** conform the classic MODFLOW-MT3D interaction.

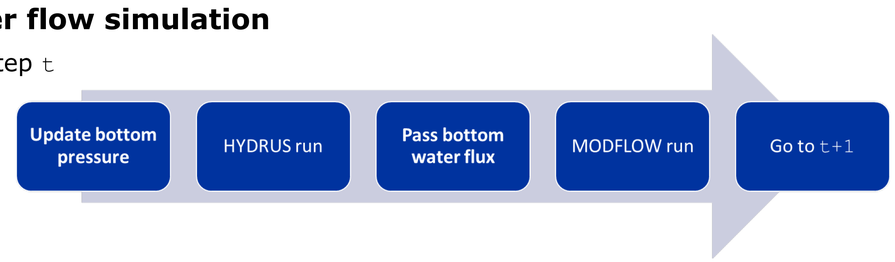
Backward compatibility is largely maintained. Exceptions to this include the native functions for geochemical reactions and dual-porosity capabilities found in HYDRUS.

HPM

HYDRUS as an add-on package for MODFLOW & MT3D-USGS, providing sequential interaction between vadose and saturated zones in a single time step.

Water flow simulation

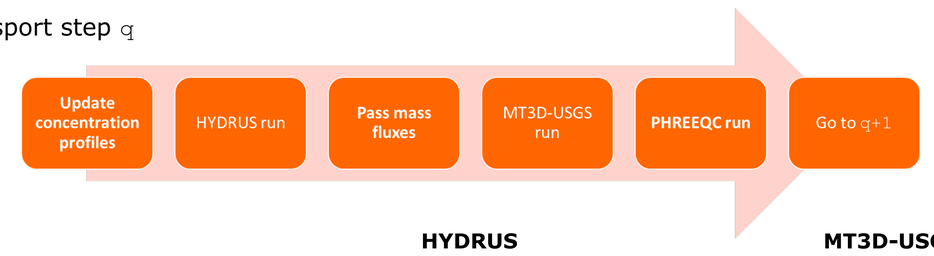
Flow step `t`



Corresponding MODFLOW cell(s) provide(s) **constant pressure head** at the bottom node of the profile. HYDRUS passes a **constant water flux** at the bottom of the profile to MODFLOW cell(s). HYDRUS information is stored in the **FTL file** for further use with MT3D-USGS.

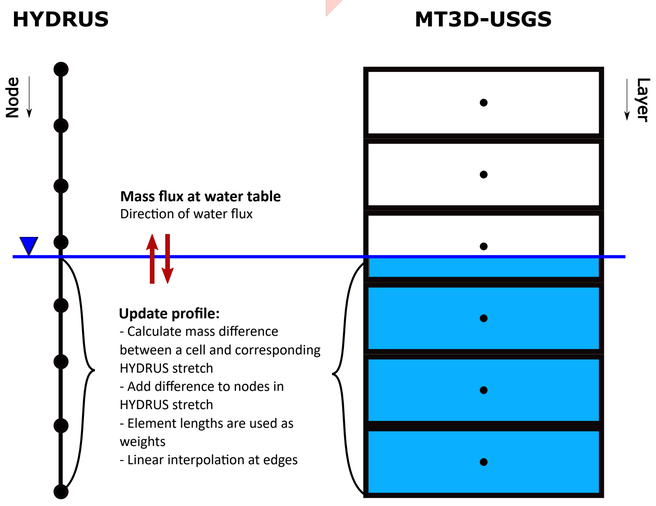
Solute transport simulation

Transport step `q`



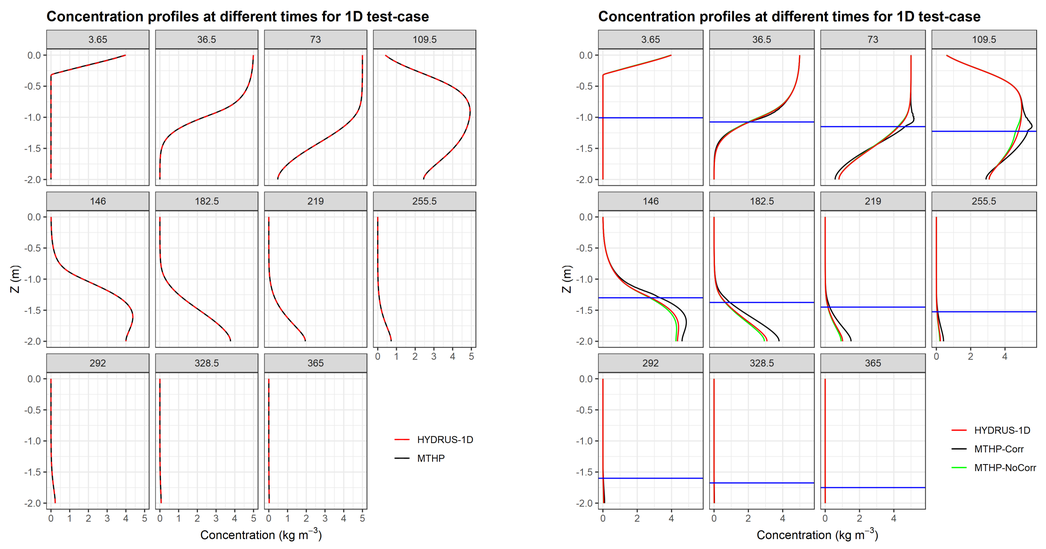
Saturated portion of the HYDRUS profile is **adjusted for mass fluxes** in corresponding MT3D-USGS cell(s) (e.g. lateral, sink/source).

A **constant mass flux at the water table** is passed to/from the MT3D-USGS cell(s) depending on the direction of the water flux.



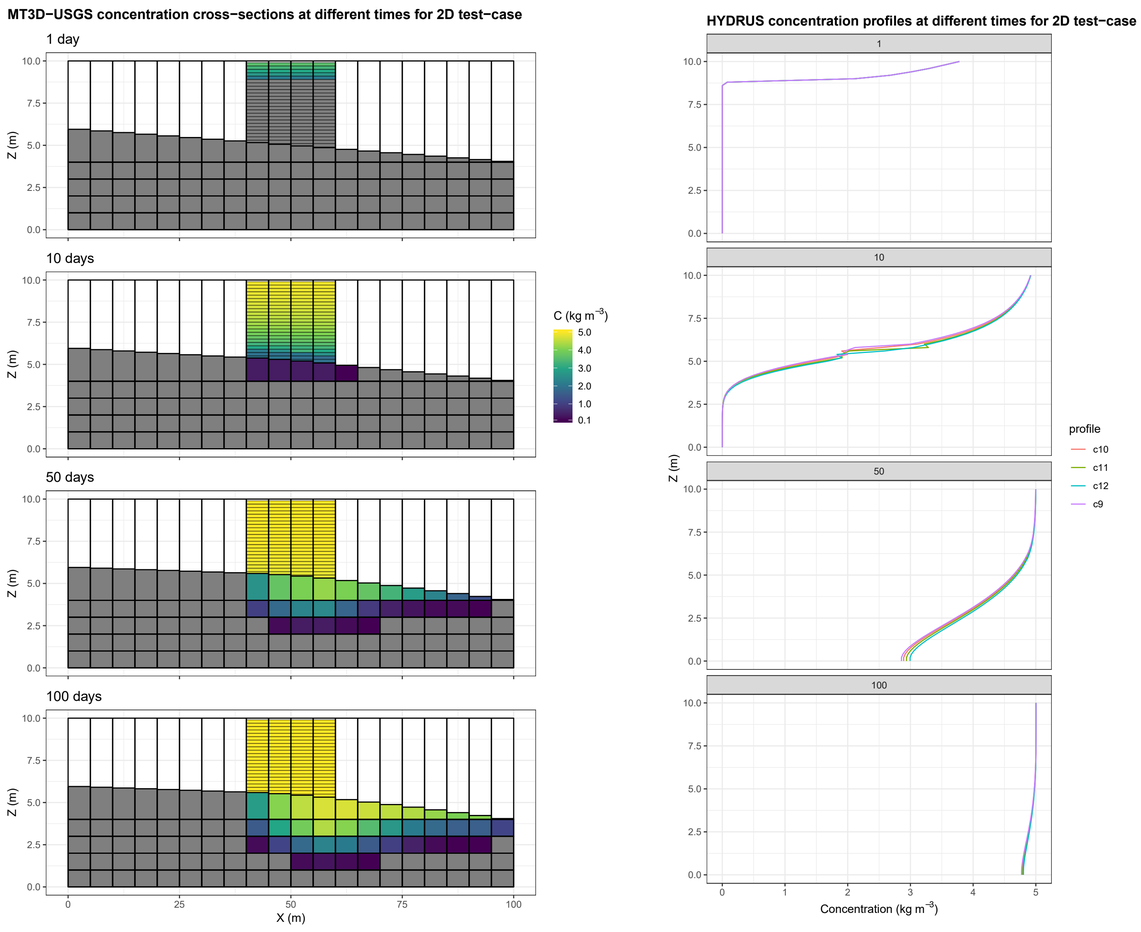
1D test-case

- 2 m HYDRUS profile with a 2 layer 1D MT3D model
- Constant top flux for 365 days
- Concentration of 5 mg/L for first 100 days
- Water-table fixed at -1 m (left)
- Water-table decrease from -1 m to -1.75 m (right)



2D test-case

- Constant head at left & right columns
- Profiles 9-12: top flux of 0.04 m/d + 5.0 mg/L
- 100 days
- Profile update not active (still debugging)



Future steps

The code is still **in development**. **Further testing** is required to check the validity and implementation of the coupling. This also includes benchmarking against existing codes.

Applying the tool **to selected sites** in the RESPONSE project to assess the effect of water table fluctuations on plume evolution of shallow point source contaminations.

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