

# Deltares

## Developments on the iMOD instrument

Joachim Hunink : presenting on behalf of a large iMOD team.

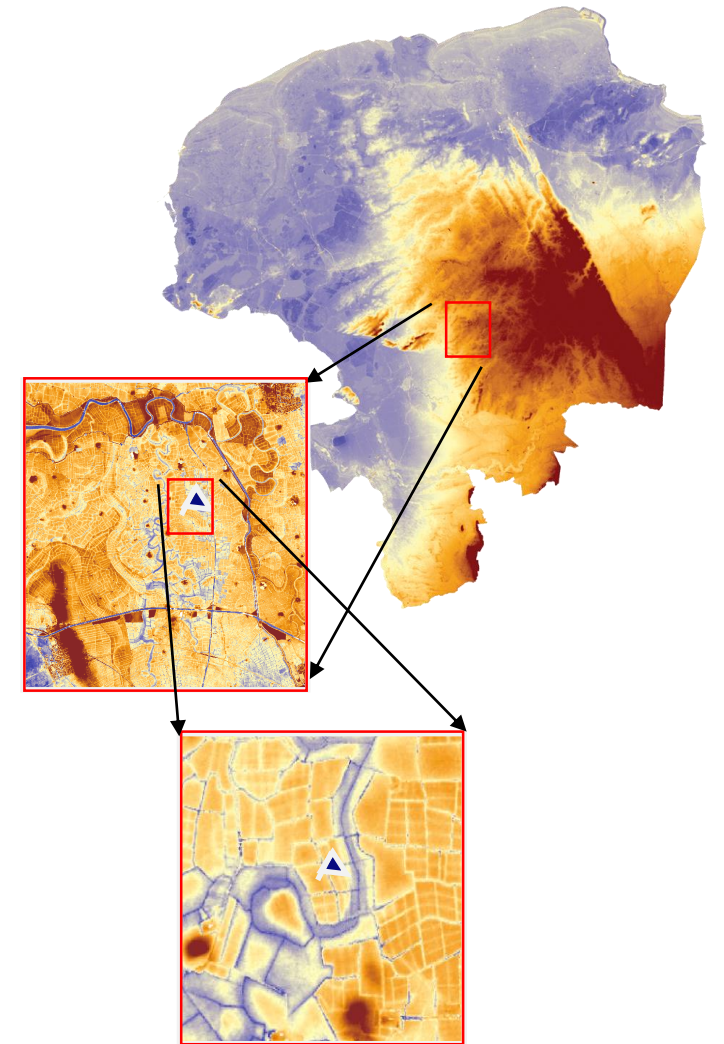
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# iMOD

- An accelerated Deltares-version of MODFLOW
- Support for Water Quality modelling
- GUI
- Tools for analyzing groundwater models and subsurface



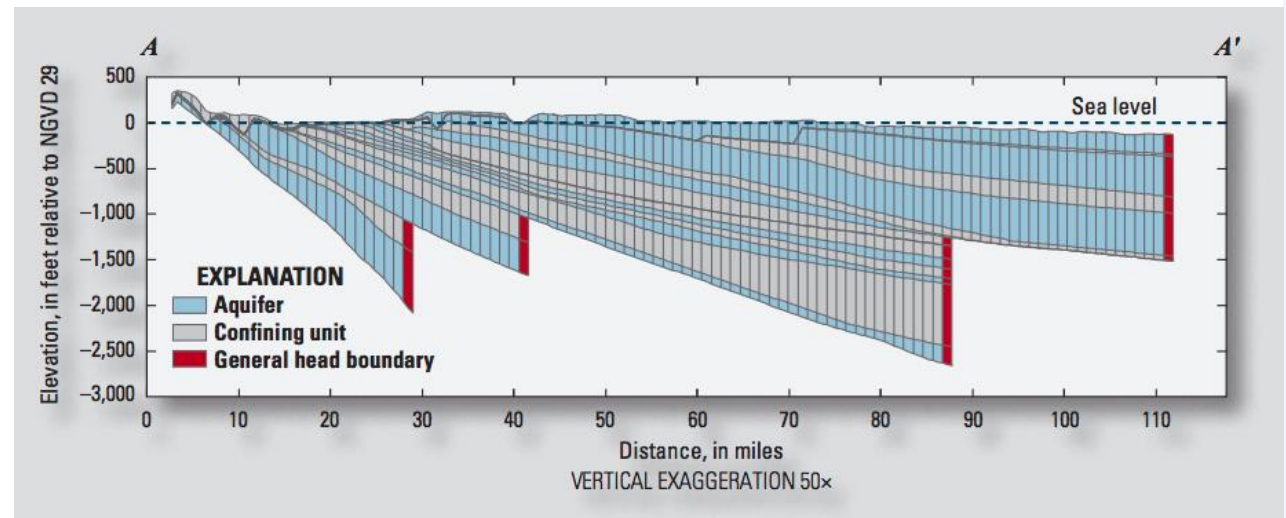
# The world of (groundwater) modelling is continuously changing

- New versions of MODFLOW by the USGS
- Data availability is increasing, results in increased demand for high resolution and flexible models
- Increase use of python for data processing, wish to link to external *Open Source* developments
- Wish to adopt standardized file formats (NetCDF, UGRID, QGIS formats)
- Increase importance of transparent, reproducible and transferable workflows (for model setup and postprocessing)
- Desire to link to external software components (unsaturated zone, surface water, ...)

# Improved functionality of MODFLOW 6

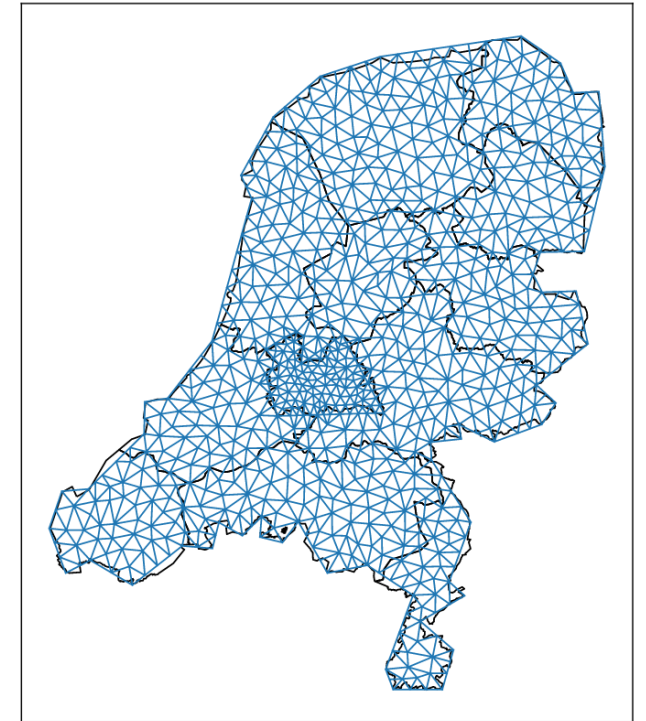
Multiple improvements and innovations in comparison with MODFLOW 2005

- Sub modelling in one simulation
- Improved wet-dry options
- Water mover package
- Callable a library (SO/DLL) via API
- Unstructured meshes
- iDOMAIN function: skip inactive cells / discontinuous layers



# Benefit of unstructured grids

- MODFLOW solves a system of equations
- This system consists of a system of equations for the water balance of a single cell: more cells -> longer computation.
- Refinement for structured model: Any local refinement has global repercussions
- Refinement for unstructured: local refinements has (mostly) local repercussions





# iMOD, towards a optimal use of MODFLOW 6

## Roadmap iMOD (2019-2022)

- Optimal use the benefits of MODFLOW 6.
- Flexible and robust tool
- Future proof
- Shared developments
- Stepwise developments





# New iMOD developments

- Computation
  - Coupling software
  - MODFLOW 6 kernel
- Development of the MODFLOW 6 API, needed to couple external model to MODFLOW 6
- Development of a python package for coupling unsaturated zone model MetaSWAP to MODFLOW 6
- Active collaboration with the USGS on parallelization MODFLOW 6

# New developments

- Computation
  - MODFLOW 6 kernel
  - Coupling software
- Scripting and workflows
  - Imod python package for:
    - Pre- and postprocessing for unstructured and structured MODFLOW 6 model

# Scripting (Python)

GUI actions are nearly always unrecorded, consequently:

- Mistakes are difficult to identify
- Rectifying mistakes is costly: re-do everything!



See also:

Bakker, M. (2014). *Python scripting: the return to programming*. *Groundwater* 52 (6): 821–822.

# Scripting (Python)

GUI actions are nearly always unrecorded, consequently:

- Mistakes are difficult to identify
- Rectifying mistakes is costly: re-do everything!



Scripts, instead:

- Explicit testimony of all actions
- Fix the line with the mistake, just re-run



See also:

Bakker, M. (2014). *Python scripting: the return to programming*. *Groundwater* 52 (6): 821–822.

# iMOD-python

iMOD-python:

*Pre- and postprocessing for structured iMODFLOW models  
and unstructured and structured MODFLOW 6 models*

But also part of a number of open source tools

-> modelling process more transparent, reproducible and transferable.

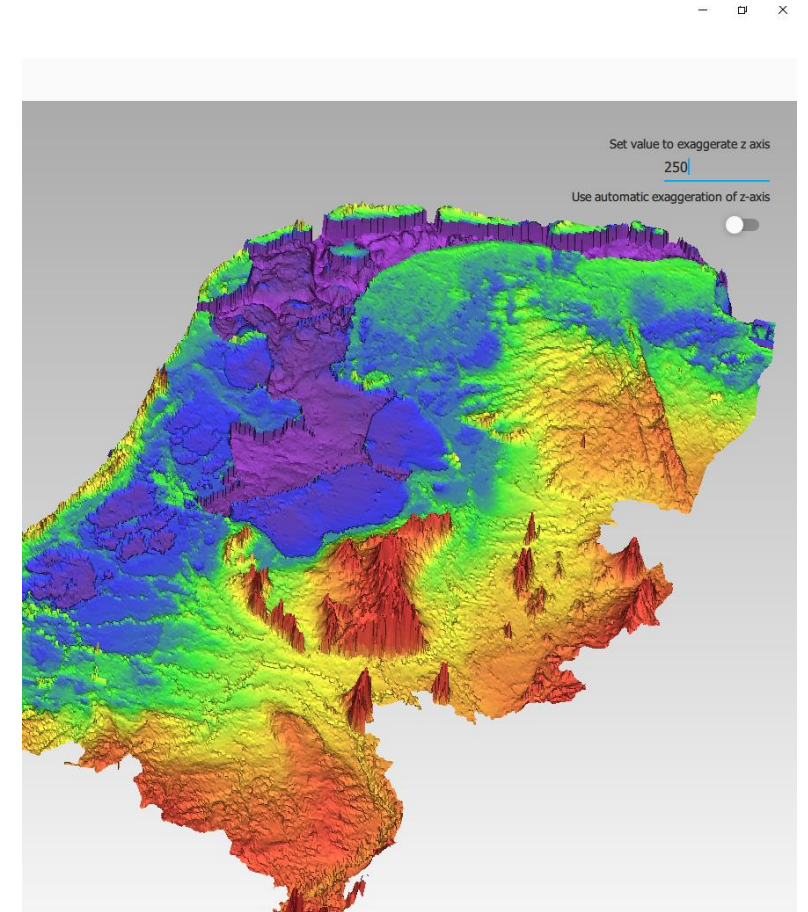


# New developments

- Computation
  - MODFLOW 6 kernel
  - Coupling software
- Scripting
  - Pre- and postprocessing for unstructured and structured MODFLOW 6 model
- Visualisation
  - QGIS plugin and 3D viewer with unstructured mesh support

# Visualisation: QGIS and 3D viewer

- Visualisation of unstructured data
- Combination commonly used GIS software QGIS and groundwater modelling.





# New release of iMOD

First release of **2 iMOD product** lines

## 1. iMOD 5 (developments 2007-2021)

- Can be used for iMODFLOW (based on MF2005) and limited functionality MODFLOW 6
- Can be used with the unsaturated zone model MetaSWAP
- Will be supported for the coming years (in consultation with users)
- Support Water quality (iMOD-WQ)



## 2. iMOD Suite (new)

- Includes new developments in visualization, model building, pre and post processing
- Supports structured and unstructured grids MODFLOW 6 and pre- en post processing iMOD5
- Now mainly (still) suitable for experienced modelers with experience in scripting.

New developments will be part of iMOD Suite

**Deltares**



# Overview of iMOD Components

## iMOD 5

- iMOD5 GUI
  - Visualisation
  - iMOD batch
- Computational cores
  - iMODFLOW (with MetaSWAP)
  - iMOD-WQ
  - MODFLOW 6 executable
  - MODFLOW 6 and MetaSWAP \*.dll
  - iMOD coupler (imod\_coupler)

## iMOD Suite 2022.01

- New iMOD Viewer
  - QGIS plugin
  - 3D viewer
- Computation cores
  - MODFLOW 6 executable
  - MODFLOW 6 and MetaSWAP \*.dll
  - iMOD coupler (imod\_coupler)
- iMOD-python
  - Pre- en postprocessing
  - Modelconversion (structured and unstructured MODFLOW 6)
  - Supports also iMOD 5 file formats (idf, ipf, prj)
  - Connection to open source python packages

# Roadmap iMOD - perspective 2022

- Make iMOD Suite scripting functions (imod\_python) available for less experienced (python) developers.
- Support of Groundwater Transport (GWT) MODFLOW 6 (expected release USGS medio 2022)
- Support streamlines (calculation and viewer)
- Extend coupling MetaSWAP coupling (flexible layer coupling, unconfined calculations).
- ...
- Link to the USGS MODFLOW 6 developments
  - <https://github.com/MODFLOW-USGS/modflow6/wiki>
  - MODFLOW 6.3.0 (Fall 2021), MODFLOW 6.4.0 (Early 2021)a.o.:
  - Parallelization
  - Adaptive time stepping
  - Variable Hydraulic Conductivity and Storage

# Planning releases of iMOD 5 and iMOD Suite

- December 2021
  - iMOD Suite 2022.01
  - No changes in iMOD 5.3 (release of summer 2021)
- Short term developments
  - Beta release iMOD 5.4 January 2022
    - Leveled controlled drainage with infiltration in MODFLOW - MetaSWAP
    - Improvements iMOD-WQ
    - Bugfixes

# How to use the software, next presentations:

## Technical backgrounds

- Technical backgrounds on the new viewer and the imod\_python developments, including unstructured MF6 support, will be given in the following presentations:
  - Joeri van Engelen: iMOD Suite: viewing
  - Huite Bootsma: iMOD Suite: scripting

## Workflows

The two products can be used individual, but components can be used in different workflows.

- Example workflow in the following presentations of:
  - Joeri van Engelen: iMOD-WQ
  - Frans Roelofsen: Demo case Brabant

# Feedback

- All contributions are welcome!
  - bug reports,
  - bug fixes,
  - documentation improvements,
  - enhancements,
  - and ideas
- Please contact Deltares at [support.imod@deltares.nl](mailto:support.imod@deltares.nl) or use the gitlab issueboards. More information on via the website of iMOD:  
<https://oss.deltares.nl/nl/web/imod/>