20-03-2024

Documentation iMODValidator SIF-tool

Version: D1

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1 Introduction

Many of the Dutch regional groundwater models are built to be run with iMOD[1]. These regional models are also used to built smaller, local models. Because of the complexity of the models and the large number of model files, a complete, manual check for the validity of these models is no longer feasible. Therefore the risk of unnoticed issues, like inconsistencies in the layer model, is large. Sweco has been working for many years with these kind of models and started in 2013 with the development of a tool to automatically check iMOD-models for a number of known issues and to have an efficient method to test and increase the quality of these iMOD-models. This tool is known as the iMODValidator.

In the current version two main types of functionality are available:

- Validation of model input via a single RUN- or PRJ-file.
- Comparison of model input of two iMOD-models via two RUN- or PRJ-files.

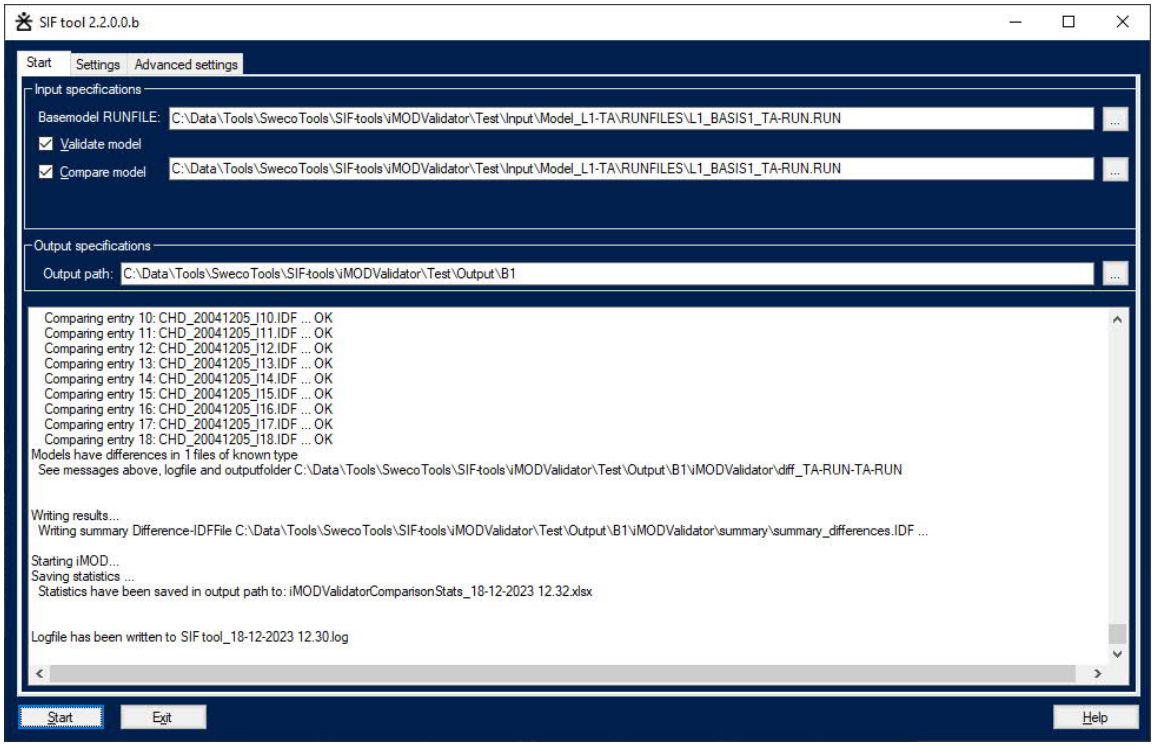

Figure 1.1 Screenshot of the main window of the current tool

[1] https://oss.deltares.nl/web/imod

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2 Tool description

2.1 Introduction

The tool can be started in GUI mode by starting the executable without command-line parameters. In the screen shown, a RUN- or PRJ-file can then be specified (this is a model file with the file locations of all input files of the model). This is sufficient to start the tool. If desired, various settings can be changed to tailor the controls to regional or local conditions. The tool then reads the RUN/PRJ-file, performs all checks on known file types and reports the results in both iMOD and Excel.

The RUN/PRJ-file(s) and the settings can also be specified via the command line. Starting the tool with ‘help‘ or ‘info‘ on the command line displays the syntax screen with instructions for starting via the command line (e.g. iMODValidator.exe info):

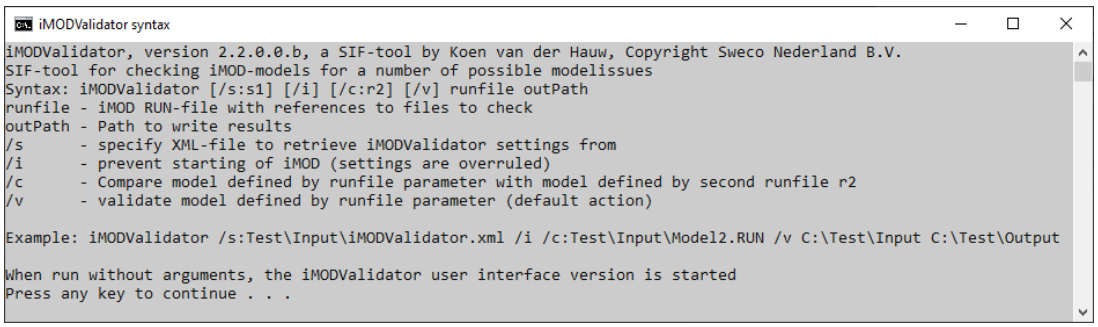


Figure 1.1 shows a screenshot of the main window that is displayed when the tool is launched via GUI mode. Here the RUN/PRJ-file can be defined and log messages are displayed during the execution of the tool.

The available functionality is broadly as follows:

- A RUN- or PRJ-file (for iMOD v5.x) can be read and validated or compared with another RUN- or PRJ-file.
- Both steady-state and transient models can be read
- Validation checks are available for many of the existing iMOD-packages. See section 2.3.2 for an overview of the supported iMOD-packages and see the Dutch ‘Achtergrondrapportage’ of iMODValidator for details of the checks.
- Differences between two iMOD models can be determined via comparison. Not only the paths and filenames that are present in the RUN/PRJ-file are compared, but also the actual data of known files (IDF, IPF, GEN, ISG) is compared.
- Results are presented spatially and in tabular form via:
  - iMOD: IMF-file (a GIS project file) with all data, legends, lines, etc.
  - Excel: formatted table with overview of issues or differences that are found.
- Extensive logging is available for all checks that are performed,
- The various settings can be adjusted flexibly via the GUI and via an XML-file.

2.2 Settings

The checks can be made specific for an area via settings in an XML-file (default this is iMODValidator.XML in the same folder as the tool). This concerns, for example, acceptable permeabilities, threshold levels or a selection of certain checks. Most numerical settings can also be varied spatially by specifying an IDF-file.

If too many invalid issues are reported, it may be worthwhile to adjust the iMODValidator settings. This can be done directly in the XML-file, but it is easier in the iMODValidator GUI

mode, since for each setting a short description is given and a check for valid input is provided. See figure 2.1 for an example of the 2nd tab, in which settings can be adjusted per check. In the 3rd tab (Advanced Settings) a number of general settings are available, such as a range of checked model layers, see figure 2.2. Optionally, you can refer to another XML-file via the /s option. Every adjustment to settings from the 2nd tab is immediately saved, without notification, in the used settings file. Settings from the 3rd tab must be manually adjusted in the XML-file to have them available as default for next time.

By deleting the XML-file iMODValidator.XML, which is located in the same directory as the iMODValidator.exe tool, a new XML-file is automatically created with default settings.

2.2.1 File locations

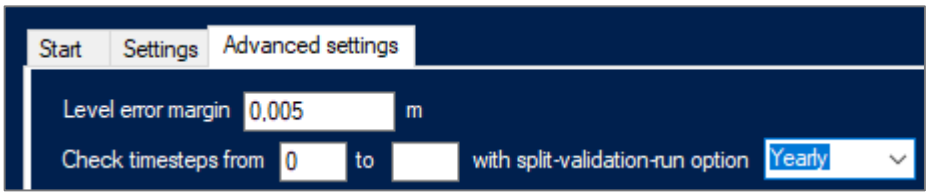
There are two settings that indicate the location of files that cannot necessarily be derived from the RUN/PRJ-file. These must be adjusted manually in the XML-file:

- iMODExecutablePath: Full file name of the iMOD executable;
- DefaultSurfaceLevelFilename: Full file name of a surface level grid.

2.2.2 Transient settings

Checks for transient models can take a long time and require a relatively large amount of disk space. This can be influenced via a number of settings:

- The number of stress periods that are checked can be limited via MaxTimestep (see figure 2.2). For example 365 can be specified as the maximum number of stress period or time step, to only check the first year with a (first) summer and winter period. By default the field is blank and all time steps are checked. If a maximum time step is specified and there are more stress periods, a warning will be given in the log file and resulting Excel file, see Figure 2.6.
- Checking ISG-files is handled by gridding them via iMOD. Each time step that refers to an ISG-file, as indicated in the RUN/PRJ file, is only gridded once. However, it can still take a long time for ISG-files with daily river levels. For the RIV-check, DRN-RIV-check and MetaSWAP-check, you can indicate via the IsISGConverted setting that the gridding of ISG files should be skipped for that specific check.
- To prevent the resulting IMF- and Excel-file from becoming too large and unworkable for a check of several years, you can specify in the Advanced Settings that the results must be split per year:



2.2.3 GEN-files shown in iMOD

GEN-files with lines or polygons can also be included in the XML-file to be shown in iMOD as background features. The file name, line size, line colour and selection can be specified per GEN-file. See the default XML-file for examples that can be modified and copied. Non-existent files are skipped with a warning.

```
<GENFiles>
  <Filename>C:\Tools\iMODValidator\Shapes\Provincies.GEN</Filename>
  <Thickness>2</Thickness>
  <Colors>100,100,100</Colors>
  <IsSelected>true</IsSelected>
</GENFiles>
<GENFiles>
  <Filename>Shapes\T250WTR_GEN</Filename>
```

Note: if the XML tag <IsSelected> or <Thickness> does not have a valid value, the XML-file is corrupt and the tool will not start. The same applies if the XML-file becomes corrupt for another reason. In that case, the XML file can be deleted to try again.

2.3 Validation

2.3.1 General description

With the validation functionality, input files of the model can be checked for various possible issues. Automatic checks will not find all issues in the model that are problematic. There are many issues that can only be identified with knowledge about the area and/or a visual inspection. Nevertheless, the iMODValidator-tool will save a significant amount of time and the tool keeps being developed to further improve the checks.

Below are some examples of checks:

• check RCH values to be within a plausible range;

• check for inconsistencies between layer thickness and k-values;

• check for incorrect filter settings in the WEL-package;

• check for NoData-values in the OLF-package at the location of RIV cells.

A distinction is made between consistency checks and plausibility checks:

- Consistency checks check for technical consistency and “hard” errors in the model. In principle, these checks result in error messages. These errors indicate inaccuracies in the model schematization.
- Plausibility checks are less hard, are based on rules of thumb and usually use user-adjustable check parameters. In principle, these checks result in warnings. Warnings are not necessarily a problem, it depends on the specific situation and model schematization.

Given the size and complexity of current regional models and the nature of automatic checks, there will also be false reports of potential issues. Likewise, sometimes no mention of an existing issue is made. This is especially important with plausibility checks. To avoid producing a huge list of incorrectly reported results, several settings are available that can be adjusted to initially focus on the largest problems. See figure 2.1 and section 2.2.

Most currently available checks systematically loop through all grid cells and analyse the model cell-by-cell. Related model cells are checked in the vertical direction, possibly in other model files, but most check to do analyse surrounding cells.

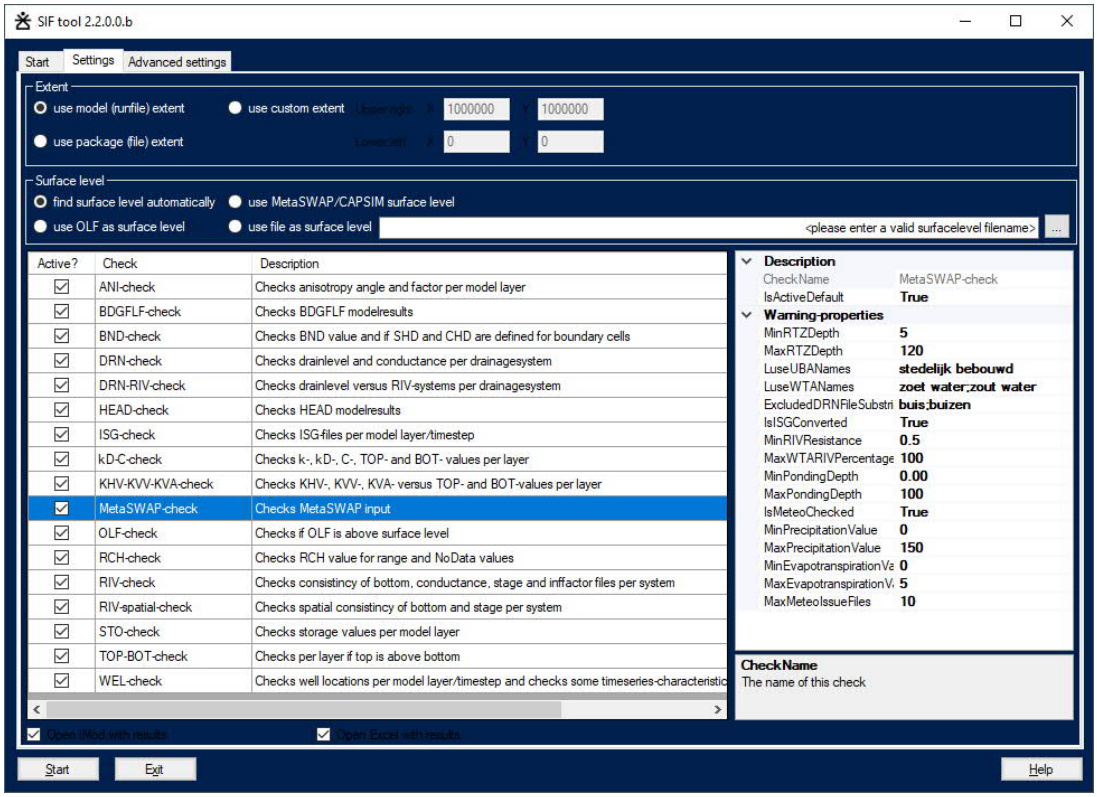


Figure 2.1 Screenshot of 2nd tab in which selected checks and settings per check can be defined

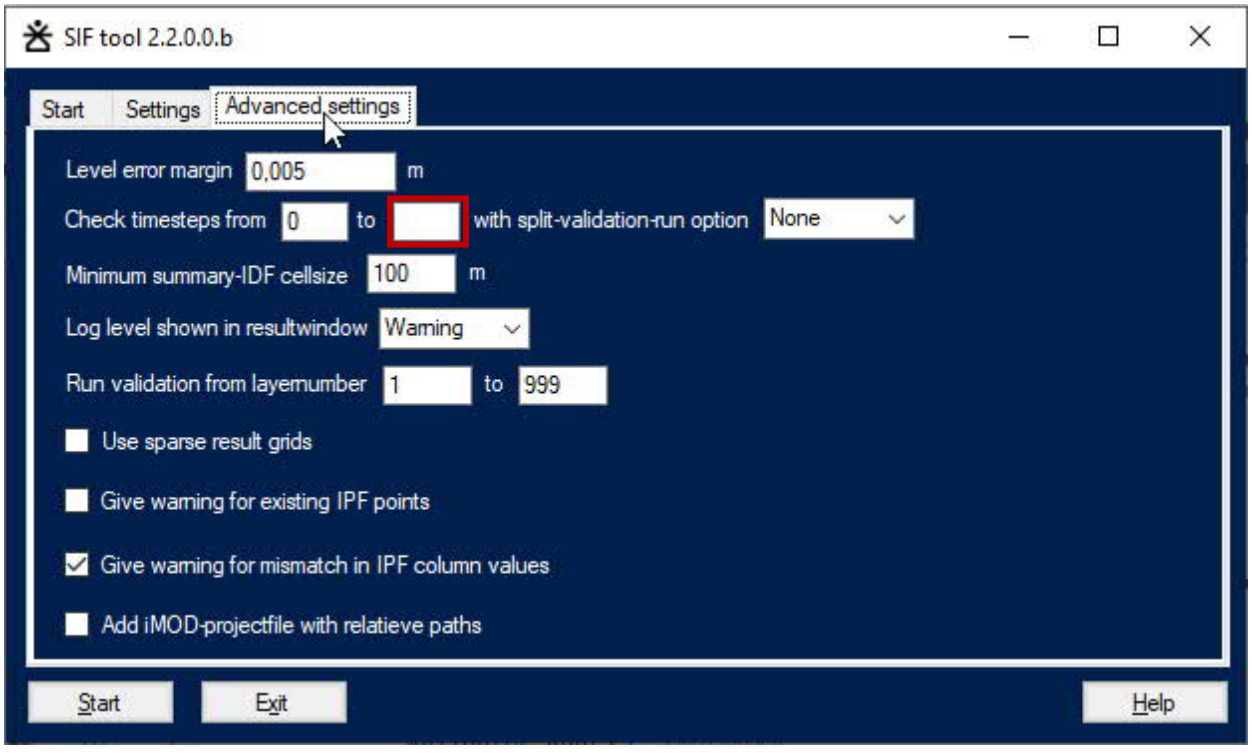


Figure 2.2 3rd tab with general settings. The red marked setting defines the maximally checked stress period in transient checks.

2.3.2 Supported iMOD-packages

Currently, for the following iMOD-packages checks are available in the tool:

- BND, SHD, CHD
- TOP, BOT
- VCW (C-waarden), KDW (kD-values)
- KVV, KHV
- KVA
- ANI
- OLF
- DRN
- RIV
- ISG
- WEL
- MetaSWAP
- STO
- Model results: HEAD, BDGFLF

2.3.3 Analysis of results

In figure 2.3 a screenshot of a generated IMF-file with various warnings, is shown, opened in iMOD. At the top of the IMF-file is two IDF-files are present with the total number of errors and warnings found per cell. Below these two IDF-files, are the iMOD-files per check with the errors and warnings found per layer/system. Below these are the associated model input files that relate to the issues found. By selecting these iMOD-files together and analysing them with the iMOD Value Inspector (F3 key), you can check what an issue is about. A brief description of the issue can be seen in the legend. Further explanation can be found in Chapter 3.

Figure 2.3 shows that there are also issue legend classes with a 'Combined result'. This applies to cells with multiple issues. Because all issue values are an exponent of 2, they can be added together and traced back afterwards. For example, the combined value 11 indicates that the issues with values 1, 2 and 8 are present.

In addition, a summary table is created in an Excel-file with the number of issues found per check (see figure 2.4). This makes it possible to see which issues occur most often and in which input files they occur. Always check warnings in the 2nd Excel tab (see figure 2.5), for errors in the RUN/PRJ-file or files that were not found, which will influence the issues found.

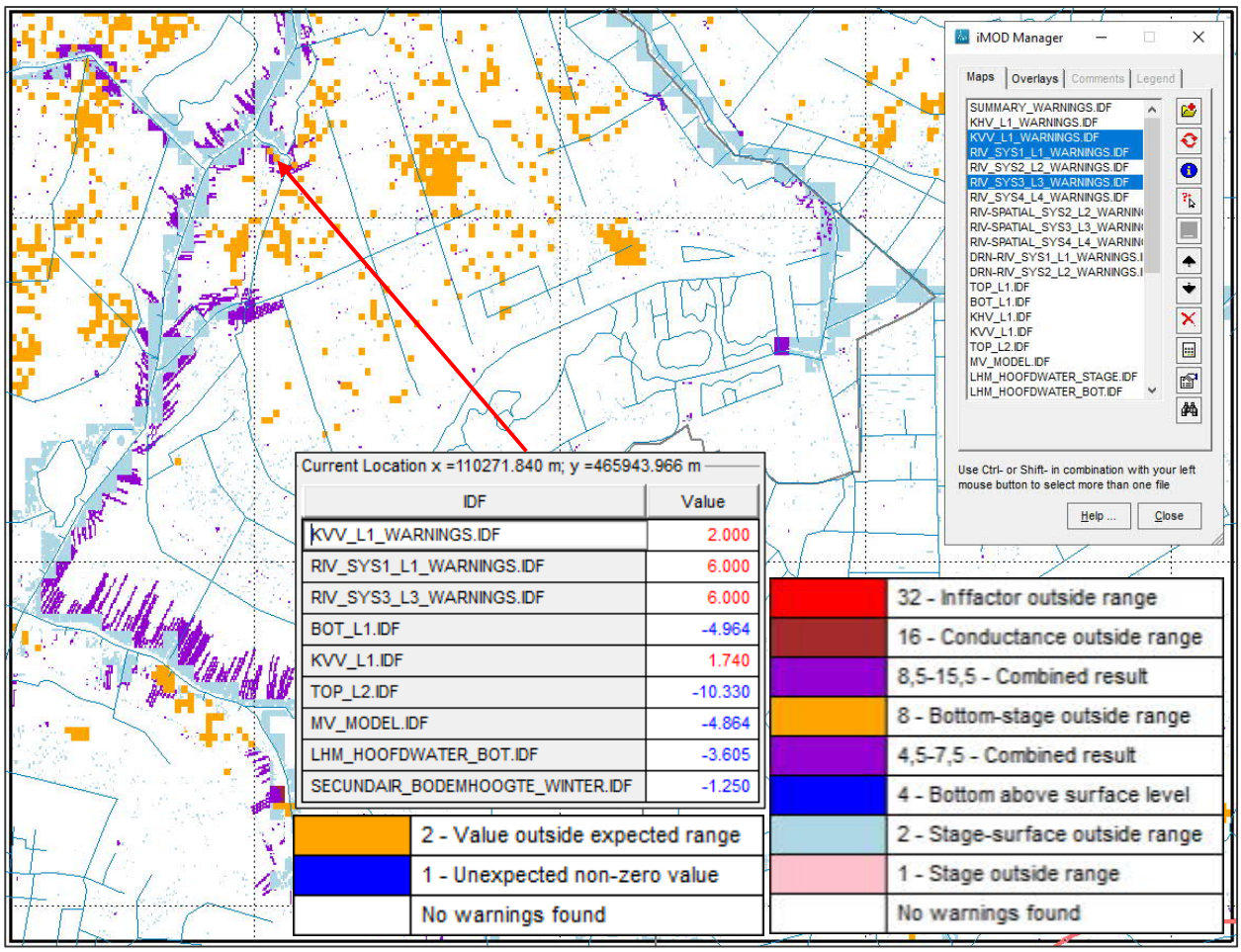


Figure 2.3 Screenshot with iMODValidator warnings for three layers: KVV_L1, RIV_SYS1 and RIV_SYS3

iMODValidator Validation

Author: iMODValidator-tool, 1.2.1.0.b

Statistics for model: NHI-WNL1_BASIS1_STAT-RUN.RUN
Modelpath: C:\Data\Tools\SwecoTools\SIF-tools\iMODValidator\Test\Input\WNL1\RUNFILES
Validationdate: 25-6-2023
Extent: [(106000,454500),(126000,468000)]

Additional issues reported in the logfile: 11 warnings and 33 errors

Summary per check

Checkname	Package	Stress period	Layer nr	Total warning	Total warningloc's
RIV-check	RIV	steady-st	1	20153	19147
RIV-check	RIV	steady-st	2	16810	12533
RIV-check	RIV	steady-st	3	22472	14651
RIV-check	RIV	steady-st	4	376	188

Summary per warningmessage

Package	Layernr	Warningfile	Warningmessage	Total warnings
RIV	1	RIV_SYS1_L1_warnings.IDF	Bottom above surface level	940
RIV	1	RIV_SYS1_L1_warnings.IDF	Conductance outside range	100
RIV	1	RIV_SYS1_L1_warnings.IDF	Stage-surface outside range	19113
RIV	2	RIV_SYS2_L2_warnings.IDF	Bottom above surface level	4277
RIV	2	RIV_SYS2_L2_warnings.IDF	Stage-surface outside range	12533
RIV	3	RIV_SYS3_L3_warnings.IDF	Bottom above surface level	7821
RIV	3	RIV_SYS3_L3_warnings.IDF	Bottom-stage outside range	4
RIV	3	RIV_SYS3_L3_warnings.IDF	Stage-surface outside range	14647
RIV	4	RIV_SYS4_L4_warnings.IDF	Bottom above surface level	180
RIV	4	RIV_SYS4_L4_warnings.IDF	Bottom-stage outside range	15
RIV	4	RIV_SYS4_L4_warnings.IDF	Stage-surface outside range	181

Figure 2.4 Screenshot iMODValidator Excel summary with issues found per check

Issues from logfile that ask for attention

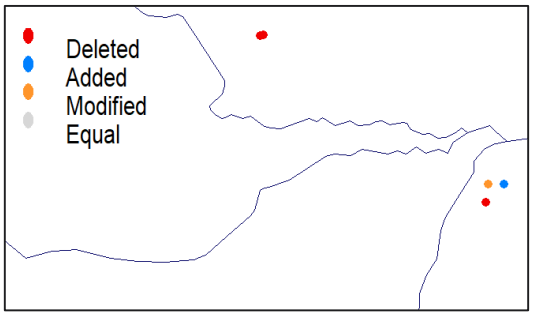
Type	Package	Filename	Message
Error	MetaSWA	para_sim	unsa_svat_path in para_sim.inp does not exist: f:\IBRAHYM\IBR3.0.0\ModelTempl
Error	MetaSWA	para_sim	No SFU-codes found, MetaSWAP-DB may be missing. SFU-checks are skipped.
Error	MetaSWA	precipitat	Meteo file not found: f:\IBRAHYM\IBR3.0.0\ModelTemplate-BASISDATA\Meteo\200
Error	MetaSWA	evaporati	Meteo file not found: f:\IBRAHYM\IBR3.0.0\ModelTemplate-BASISDATA\Meteo\200
Warning	CHD	L1_BASIS1	More than 100 missing files for CHD-package, other missing files are not logged
Warning	RUN-file	L1_BASIS1	Stressperiod 366 is larger than specified maximum number of stressperiods maxK
Warning	CHD	L1_BASIS1	More than 100 missing files for CHD-package, other missing files are not logged

Figure 2.5 Example of errors and warnings in log and Excel-file which may influence results, but are not spatial and cannot be shown via the IMF-file.

2.4 Comparison

With the comparison functionality, the model input of two iMOD models can be compared via the corresponding RUN- or PRJ-files. The contents of both files are also compared. Not only IDF-files, but also the IPF-files of the WEL-package, the GEN-files of the HFB-package and the ISG-files of the ISG-package are compared. For ISG-files, only the whole segments are currently compared. and for segments that one or more differences, a GEN-file with the whole segments is written.

For the WEL-package, for each IPF-point it is indicated with a specific colour whether there has been a change in the data or that is was deleted or new.



For a number of packages, no specific order is defined for the entries in the RUN/PRJ-file. The method to find a corresponding entry in the other RUN/PRJ-file is as follows:

- If the number of entries in both models for a particular package is exactly the same, the corresponding entry is found by order.
- If the number of entries is different for a package, first entries are matched by file name. If any unmatched files remain, they will be matched by content and, for transient models, when they are present for the same time step and layer number.
- Entries with constant values are always matched by order.
- Remaining files are matched based on position in the package definition. Files that are at the same position, but have different filename/content will be marked as removed and/or added in the results.

It is possible to compare PRJ-files with RUN-files, but the definition of time steps (stress periods) differs for both formats and the current iMODValidator version does not offer the functionality to map time steps of both formats. For time-dependent RUN-files this can cause many differences and is not recommended.

An IMF-file and an Excel-file with the differences are also created and shown for the comparison function.

2.5 Hardware and software specifications

The tool requires a 64-bit processor, but otherwise there are no specific hardware constraints. Many memory usage optimizations have been included in the tool so that memory is released as soon as it can. In this way, checking relatively large models is still possible.

For very large models, large input files, and time-dependent checks, tool runs on 8 or 16 Gb computers can become very slow (and may appear to be stuck) due to the large amount of virtual memory required via permanent storage (hard drive). It is therefore recommended that you use a system with at least 32 GB of memory and a fast drive (like an SSD drive).

The tool works under Windows. No specific installation is required. To start iMOD automatically to shown the results, the location of an iMOD executable must be included in the settings. To show Excel files automatically, an Excel file viewer (such as Excel, Open Office or Libre Office) must be installed and linked to xlsx files. It is not necessary to have Excel installed to generate Excel-files. This requires that the EPPlus dll-file is present in the directory with the iMODValidator executable.

The iMODValidator is available open source from version 2.x under the GPL v3 license via https://github.com/SIF-framework/SIF-tools. Updates can also be downloaded there.

3 iMODValidator License

iMODValidator is an open source tool that can be used and distributed as specified in the GNU General Public License v3.0[2] (GPLv3) or later. iMODValidator makes use of EPPlus, but is not linked to it[3]. The licences of Graphviz can be found under the Bin-directory.

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