FloPy Release Notes

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Introduction

FloPy is a Python package for developing, running, and post-processing models that are part of the MODFLOW family of codes. FloPy includes support for MODFLOW-2000, MODFLOW-2005, MODFLOW-NWT, and MODFLOW-USG. Other supported MODFLOW-based models include MODPATH (version 6), MT3DMS and SEAWAT.

If you think you have found a bug in FloPy, or if you would like to suggest an improvement or enhancement, please contact one of the points of contact identified on http://water.usgs.gov/ogw/modflow/flopy.html. Alternatively submit a new Issue through the Github Issue tracker. Pull requests will only be accepted on the develop branch of the repository.

Documentation

FloPy code documentation is available at http://modflowpy.github.io/flopydoc/

Installation

Python versions:

FloPy requires **Python** 2.7 or **Python** 3.3 (or higher)

Dependencies:

FloPy requires **NumPy** 1.9 (or higher) and **matplotlib** 1.4 (or higher). The mapping and cross-section capabilities in the `flopy.plot` submodule and shapefile export capabilities (`to_shapefile()`) require **Pyshp** 1.2 (or higher). The NetCDF export capabilities in the `flopy.export` submodule require **python-dateutil** 2.4 (or higher), **netcdf4** 1.1 (or higher), and **pyproj** 1.9 (or higher). Other NetCDF dependencies are detailed on the UniData website. The `get_dataframes` method in the `ListBudget` class in the `flopy.utils` submodule require **pandas** 0.15 (or higher).

Installation:

To install FloPy version 3.2.4 from the USGS flopy website:

```
pip install http://water.usgs.gov/ogw/modflow/FloPy_v3.2.4/flopy-3.2.4.zip
```

To update FloPy version 3.2.4 from the USGS flopy website:

```
pip install http://water.usgs.gov/ogw/modflow/FloPy_v3.2.4/flopy-3.2.4.zip --upgrade
```

FloPy Supported Packages

MODFLOW-2000, MODFLOW-2005, and MODFLOW-NWT

Package	Creation and Write	Load Available	Template Creation
Basic (BAS6)	Supported	Supported	Not supported
Block Centered Flow (BCF)	Supported	Supported	Not supported
Direct Solver (DE4)	Supported	Supported	Not supported
Discretization (DIS)	Supported	Supported	Not supported
Drain (DRN)	Supported	Supported	Not supported
Drain Return (DRT)	Not supported	Not supported	Not supported
Evapotranspiration (EVT)	Supported	Supported	Not supported
Evapotranspiration Segments (ETS)	Not supported	Not supported	Not supported
Flow and Head Boundary (FHB)	Not supported	Not supported	Not supported
General Head Boundary (GHB)	Supported	Supported	Not supported
Geometric Multi-Grid (GMG)	Supported	Supported	Not supported
Horizontal Flow Barrier (HFB)	Supported	Supported	Not supported
Hydrogeologic-Unit Flow (HUF)	Not supported	Not supported	Not supported
Flow and Head Boundary (FHB)	Not supported	Not supported	Not supported
Interbed-Storage (IBS)	Not supported	Not supported	Not supported
Layer Property Flow (LPF)	Supported	Supported	Supported
Link-AMG (LMG)	Not supported	Not supported	Not supported
MODFLOW Link-MT3DMS (LMT)	Supported	Supported	Not supported
Multipler (MULT)	Not supported	Supported	Not supported
Multi-Node Well 1 (MNW1)	Limited support	Not supported	Not supported
Multi-Node Well 2 (MNW1)	Limited support	Not supported	Not supported
Multi-Node Well Information (MNWI)	Limited support	Not supported	Not supported
Newton (NWT)	Supported	Supported	Not supported
Output Control (OC)	Supported	Supported	Not supported
Periodic Boundary Condition (PBC)	Supported	Not supported	Not supported
Preconditioned Conjugate Gradient (PCG)	Supported	Supported	Not supported
Preconditioned Conjugate Gradient Nonlinear (PCGN)	Supported	Not supported	Not supported
Parameter Value (PVAL)	Not supported	Supported	Not supported
Recharge (RCH)	Supported	Supported	Not supported
River (RIV)	Supported	Supported	Not supported
Streamflow Routing (SFR2)	Supported	Supported	Not supported
Strongly Implicit Procedure (SIP)	Supported	Not supported	Not supported
Slice-successive Overrelaxation (SOR)	Supported	Not supported	Not supported
Stream (STR)	Supported	Supported	Not supported
Seawater Intrusion (SWI)	Supported	Not supported	Not supported
Seawater Intrusion (SWI2)	Supported	Supported	Not supported
Surface-Water Routing (SWR)	Not supported	Not supported	Not supported
Subsidence (SUB)	Supported	Supported	Not supported
Subsidence and Aquifer-System Compaction (SWT)	Supported	Supported	Not supported
Upstream Weighted (UPW)	Supported	Supported	Not supported
Unzaturated Zone Flow (UZF)	Supported	Not supported	Not supported
Well (WEL)	Supported	Supported	Not supported
Zone (ZONE)	Not supported	Supported	Not supported

MODFLOW-USG

Package	Creation and Write	Load Available	Template Creation
Unstructured Discretization (DISU)	Supported	Supported	Not supported
Sparse Matrix Solver (SMS)	Supported	Supported	Not supported

MODPATH

Package	Creation and Write	Load Available	Template Creation
MODPATH Basic (MPBAS)	Supported	Not supported	Not supported
MODPATH Simulation (MPSIM)	Supported	Not supported	Not supported

MT3DMS

Package	Creation and Write	Load Available	Template Creation
Advection (ADV)	Supported	Supported	Not supported
Basic Transport (BTN)	Supported	Supported	Not supported
Dispersion (DSP)	Supported	Supported	Not supported
Generalized Conjugate Gradient (GCG)	Supported	Supported	Not supported
PHT3D-PHREEQC Interface (PHC)	Supported	Not supported	Not supported
Reaction (RCT)	Supported	Not supported	Not supported
Sink and Source Mixing (SSM)	Supported	Supported	Not supported
Transport Observation (TOB)	Supported	Not supported	Not supported

SEAWAT

Package	Creation and Write	Load Available	Template Creation
Variable Density Flow (VDF)	Supported	Supported	Not supported
Viscosity (VSC)	Supported	Not supported	Not supported

MODFLOW-2000, MODFLOW-2005, and MODFLOW-NWT Observations

Package	Creation and Write	Load Available	Template Creation
Drain Observation (DROB)	Not supported	Not supported	Not supported
HYDMOD (HYD)	Supported	Supported	Not supported
Gage (GAGE)	Not supported	Not supported	Not supported
General Head Boundary Observation (GBOB)	Not supported	Not supported	Not supported
Head Observation (HOB)	Not supported	Not supported	Not supported
River Observation (RVOB)	Not supported	Not supported	Not supported
Stream Observation (STOB)	Not supported	Not supported	Not supported
Specified-Head Flow Observation (CHOB)	Not supported	Not supported	Not supported

FloPy Model Checks

List of available FloPy model checks

Package	Check	Implemented	Type
NAM	unit number conflicts	Supported	Error
NAM	compatible solver package	Supported	Error
NAM	minimum packages needed to run the model	Not supported	Error
all BC packages	overlapping boundary conditions	Not supported	Error
all BC packages	NaN values in stress_period_data	Supported	Error
all BC packages	valid indices for stress_period_data	Supported	Error
LPF/UPW	hk or vka <=0	Supported	Error
LPF/UPW	hani < 0	Supported	Error
LPF/UPW	vkcb (quasi-3D kv values) <=0	Supported	Error

Package	Check	Implemented	Type
LPF/UPW	unusually high or low values in hk and vka arrays	Supported	Warning
LPF/UPW	unusually high or low values in vkcb (quasi-3D kv values)	Supported	Warning
LPF/UPW	storage values <=0 (transient only)	Supported	Error
LPF/UPW	unusual values of storage (transient only)	Supported	Error
RIV/SFR/STR	check for surface water BCs in confined layers	Not supported	Warning
BAS	isolated cells	Supported	Warning
BAS	NaN values	Supported	Error
DIS	cell thicknesses <= 0	Supported	Error
DIS	cell thicknesses < thin_cell_threshold (default 1.0)	Supported	Warning
DIS	NaN values in top and bottom arrays	Supported	Error
DIS	discretization that violates the 1.5 rule	Not supported	Warning
DIS	large changes in elevation	Not supported	Warning
DISU	large changes in elevation	Not supported	Warning
DISU	cell thicknesses <= 0	Not supported	Error
DISU	cell thicknesses < thin_cell_threshold (default 1.0)	Not supported	Warning
DISU	NaN values in top and bottom arrays	Not supported	Error
DISU	discretization that violates the 1.5 rule	Not supported	Warning
DISU	large changes in elevation	Not supported	Warning
RCH	unusually high or low R/T ratios	Supported	Warning
RCH	NRCHOP not specified as 3	Supported	Warning
SFR	continuity in segment and reach numbering	Supported	Error
SFR	segment number decreases in downstream direction	Supported	Warning
SFR	circular routing	Supported	Error
SFR	multiple non-zero conductances in a model cell	Supported	Warning
SFR	elevation increases in the downstream direction	Supported	Error
SFR	streambed elevations above model top	Supported	Warning
SFR	streambed elevations below cell bottom	Supported	Error
SFR	negative stream depth when icalc=0	Not supported	Error
SFR	slopes above or below specified threshold	Supported	Warning
SFR	unusual values for manning's roughness and unit constant	Not supported	Warning
SFR	gaps in segment and reach routing	Not supported	Warning
SFR	outlets in interior of model domain	Not supported	Warning
WEL	PHIRAMP is < 1 and should be close to recommended value of 0.001	Not supported	Warning

Visualizations

Package	Check	Implemented	Type
All	Shapefile with detected errors	Not supported	Information
All	Shapefile with detected warnings	Not supported	Information
SFR/STR	Segment Connectivity	Not supported	Information
SFR/STR	Identification of diversions	Not supported	Information
SFR/STR	Identification of outlet tributaries	Not supported	Information

Additional model checks and visualizations

Please submit additional proposed model checks as issues on the FloPy development branch on github.

FloPy Changes

Version 3.2.4

- Added basic model checking functionality (`.check()`).

- Added support for reading SWR Process observation, stage, budget, flow, reach-aquifer exchanges, and structure flows.
- `flopy.utils.HydmodObs` returns a numpy recarray. Previously numpy arrays were returned except when the `slurp()` method was used. The slurp method has been deprecated but the same functionality is available using the `get_data()` method. The recarray returned from the `get_data()` method includes the `totim` value and one or all of the observations (`HYDLBL`).
- Added support for MODFLOW-USG DISU package for unstructured grids.
- Added class (`Gridgen`) for creating layered quadtree grids using GRIDGEN (`flopy.utils.gridgen`). See the flopy3_gridgen notebook for an example of how to use the `Gridgen` class.
- Added user-specified control on use of `OPEN/CLOSE` array options (see flopy3_external_file_handling notebook).
- Added user-specified control for array output formats (see flopy3_array_outputformat_options IPython notebook).
- Added shapefile as optional output format to `.export()` method and deprecated `.to_shapefile()` method.
- Bug fixes:

1. Fixed issue with right justified format statement for array control record for MT3DMS.
2. Fixed bug writing PHIRAMP for MODFLOW-NWT well files.
3. Fixed bugs in NETCDF export methods.
4. Fixed bugs in LMT and BTN classes.

Version 3.2.3

- Added template creation support for several packages for used with PEST (and UCODE).
- Added support for the SEAWAT viscosity (VSC) package.
- Added support for the MODFLOW Stream (STR), Streamflow-Routing (SFR2), Subsidence (SUB), and Subsidence and Aquifer-System Compaction Package for Water-Table Aquifers (SWT) Packages.
- Mt3d model was redesigned based on recent changes to the Modflow model. Mt3d packages rewritten to support multi-species. Primary packages can be loaded (btn, adv, dsp, ssm, gcg). Array utilities modified to read some MT3D RARRAY formats.
- Fixed array loading functionality for case when the CNSTNT value is zero. If CNSTNT is zero and is used as an array multiplier, it is changed to 1 (as done in MODFLOW).
- Added support for the MODFLOW HYDMOD (HYD) Package and reading binary files created by the HYDMOD Package (`HydmodObs` Class) in the `flopy.utils` submodule.
- `flopy.utils.CellBudgetFile` returns a numpy recarray for list based budget data. Previously a dictionary with the `node` number and `q` were returned. The recarray will return the `node` number, `q`, and the `aux` variables for list based budget data.
- Added travis-ci automated testing.

Version 3.2.2

- FloPy now supports some simple plotting capabilities for two- and three-dimensional model input data array classes and transient two-dimensional stress period input data using the `.plot()` methods associated with the data array classes (`util_2d`, `util_3d`, and `transient_2d`). The model results reader classes (`HeadFile`, `UcnFile`, and `CellBudgetFile`) have also been extended to include a `.plot()` method that can be used to create simple plots of model output data. See the notebook flopy3_PlotArrayExample.

- Added `.to_shapefile()` method to two- and three-dimensional model input data array classes (`util_2d` and `util_3d`), transient two-dimensional stress period input data classes (`transient_2d`), and model output data classes (`HeadFile`, `UcnFile`, and `CellBudgetFile`) that allows model data to be exported as polygon shapefiles with separate attribute columns for each model layer.
- Added support for ASCII model results files.
- Added support for reading MODPATH version 6 pathline and endpoint output files and plotting MODPATH results using mapping capabilities in `flopy.plot` submodule.
- Added `load()` method for MODFLOW GMG solver.
- Bug fixes:

1. Multiplier in array control record was not being applied to arrays
2. vani parameter was not supported

Version 3.2.1

- FloPy can now be used with **Python 3.x**
- Revised setters for package class variables stored using the `util_2d` or `util_3d` classes.
- Added option to load a subset of MODFLOW packages in a MODFLOW model name file using `load_only=` keyword.

Version 3.1

- FloPy now supports some simple mapping and cross-section capabilities through the `flopy.plot` submodule. See the notebook flopy3_MapExample.
- Full support for all Output Control (OC) options including DDREFERENCE, SAVE IBOUND, and layer lists. All Output Control Input is specified using words. Output Control Input using numeric codes is still available in the ModflowOc88 class. The ModflowOc88 class is currently deprecated and no longer actively maintained.
- Added support for standard MULT package FUNCTION and EXPRESSION functionality are supported. MODFLOW parameters are not supported in `write()` methods.

Version 3.0

FloPy is significantly different from earlier versions of FloPy (previously hosted on googlecode). The main changes are:

- FloPy is fully zero-based. This means that layers, rows and columns start counting at *zero*. The reason for this is consistency. Arrays are zero-based by default in Python, so it was confusing to have a mix.
- Input for packages that take *layer, row, column, data* input (like the wel or ghb package) has changed and is much more flexible now. See the notebook flopy3boundaries
- Input for the MT3DMS Source/Sink Mixing (SSM) Package has been modified to be consistent with the new MODFLOW boundary package input and is more flexible than previous versions of FloPy. See the notebook flopy3ssm
- Support for use of EXTERNAL and OPEN/CLOSE array specifiers has been improved.
- *load()* methods have been developed for all of the standard MODFLOW packages and a few less used packages (*e.g.* SWI2).
- MODFLOW parameter support has been added to the `load()` methods. MULT, PVAL, and ZONE packages are now supported and parameter data are converted to arrays in the `load()` methods. MODFLOW parameters are not supported in `write()` methods.