SMHI

Charlotta Pers

User Manual

HYPE – Hydrological Predictions for the Environment

Content

Part 1 Introduction to the HYPE model

This document gives an introduction to using HYPE and describes a few basic functions. The document contains information on installation and running the model, a brief model description, and an overview of input and output data.

The HYPE model

HYPE is a semi-distributed hydrological model for water and water quality. It simulates water and nutrient concentrations in the landscape at the catchment scale. Its spatial division is related to catchments and sub-catchments, land use or land cover, soil type and elevation. Within a catchment the model will simulate different compartments; soil including shallow groundwater, rivers and lakes. It is a dynamical model forced with time series of precipitation and air temperature, typically on a daily time step. Forcing in the form of nutrient loads is not dynamical. Example includes atmospheric deposition, fertilizers and waste water.

HYPE was developed at SMHI with focus on

- integrating water and water quality throughout the model compartments.

- predictions in ungauged catchments

- large model set-ups, eg. Europe.

In a HYPE model set-up the catchment(s) are divided into covering but not overlapping so called subbasins. These are coupled according to surface water path ways by a (main) river and possibly lake at the outlet of subbasins. A subbasin is further divided into fractions based on e.g. land use and soil type. These are called classes. The following functions are simulated, but the list is not all inclusive?; precipitation and snow pack, soil moisture and evapotranspiration, turnover of nutrient pools in the soil, soil runoff and nutrient leakage, surface runoff and erosion, local stream and lake, main river and outlet lake, river bank erosion, sedimentation and resuspension in rivers, denitrification and primary production in surface water, sedimentation in lakes. Nitrogen (N) is simulated partitioned into the fractions inorganic nitrogen (IN) and organic nitrogen (ON). Phosphorus (P) is similarly partitioned into soluble phosphorus (phosphate) (SP) and particulate phosphorus (PP). All fractions are transported with water. Together the fractions form total nitrogen (TN) and total phosphorus (TP).

Run the model

The model is run under Window or Linux. The code is written in Fortran and an open source under the Lesser GNU Public License. SMHI took the initiative for a HYPE Open Source Community to strengthen international collaboration in hydrological modelling. More information about the initiative can be found at hype.sourceforge.net.

Download the executable or compile the downloaded source files to get an executable for your system. The files are available for download on hype.sourceforge.net. Included in download are a ReadMe-file with instructions for compiling and examples of small model set-ups.

HYPE may be invoked from the command line with the path to the model simulation configuration file as argument. E.g. P:\> HYPE.exe D:\modelsetups\model1\ or $ ./hype /data/modelsetups/model1/ Note that the path ends with a slash.

HYPE model set-up

The structure of a HYPE model set-up is simple. All input and output are in the form of text files located in one or two folders. The input may be grouped into time series input data, which is forcing data and observation time series, and geographical input data, i.e. information about the landscape and human influence. The geographical data is coupled to the subbasin division. Output is simulated time series of water and nutrients, and performance criteria. In addition information to run the simulation is given as a text files.

The error checking is non-existing, so be careful to follow the file format as described in Part 4 File Description.

The model simulation configuration file **info.txt** determine the simulation period (*bdate*, *edate*) and what substances to simulate (*substance*). Water is always simulated, but nitrogen (*N*) and/or phosphorus (*P*) may be included. If the model set-up input files are located in another directory than the info-file, the path to this directory is given (*modeldir*). What output is to be written to file is determined in the info-file. For example to get a file with time series for simulated outflow from each subbasin a "timeoutput" is used (*timeoutput variable cout*). HYPE may calculate performance criteria if the variables to be compared is given in info.txt. For comparing simulated (*cout*) and observed (*rout*) discharge for example the variables need to be given in the file (*crit 1 cvariable cout <RETURN>crit 1 rvariable rout*).

The following five input files are mandatory; **Pobs.txt**, **Tobs.txt**, **par.txt**, **GeoData.txt**, and **GeoClass.txt**. The forcing time series of precipitation and temperature are given in the files Pobs.txt and Tobs.txt. Each subbasin must be coupled to one precipitation and temperature time series. This may be done one by one, then each time series has a column id number which is matched to the id number of a subbasin (*subid*), but other methods exist. Model parameters determine the simulation result and are given in the par.txt file. Some basic model parameters are described in next section.

The geographical input data for each subbasin is given in GeoData.txt, while information about classes is given in GeoClass.txt. The same classes exist for all subbasins in a model set-up, but they can be zero in area for some subbasins. One subbasin's information is given on a row in GeoData.txt. Necessary information is an identification number (*subid*), subbasin area (*area*), and class area fractions (*slc_nn*). Other information that is often included in GeoData.txt is the coupling, i.e. subid of downstream subbasin (*maindown*), main river length (*rivlen*), and outlet lake average depth (*lake_depth*). For nutrient simulations also crop region (*region*), atmospheric deposition (e.g. precipitation concentration of inorganic nitrogen, *wetdep_n*) and diffuse sources from rural households are common. For each class land use type, soil type, stream drainage depth, number of soil layers and soillayer thickness is necessary. This information is given in GeoClass.txt with one class per row. For lake classes, which are special from land classes, this also need to be given in GeoClass.txt. GeoClass.txt is column order dependent, so the information needs to be put in the right column (see Part 4 File Description). Other column contains information that can be used, but is not necessary. For nutrient simulation crop type is also necessary in GeoClass.txt, and information about crops for different crop regions is given in the file CropData.txt. Data on point sources (e.g. total phosphorus concentration *ps1_tp*, outlet volume per day *ps1_vol*, and SP fraction *ps1_sp*) are given in the file PointSources.txt.

Basic model parameters

Model parameters determine the function of the model. These are given in the file **par.txt**. The model parameters may depend on land use type, soil type or be a general value. The model parameters to be presented make up a rudimentary water flow model, but many more exist and include other functions to the model. The model parameters are described in more detail in Part 3 and 4 of the User manual.

For a soil runoff model compartment: In a cold climate snow melt is necessary (*cmlt*). It is a land use dependent parameter and need one value per land use defined in GeoClass .txt. Evapotranspiration is governed by a land use dependent parameter (*cevp*). The default value of all model parameters are zero, so if these are not set no snow melt or evapotranspiration will occur. For a model with more than one soil layer the maximum amount of percolation (*mperc1*, *mperc2*) need to be set for percolation to occur. The available storage of water in the soil needs to be set. The model parameters for "field capacity" (*wcfc*) and effective porosity (*wcep*) depend on soil type. Runoff from the soil is determined by runoff coefficients. The runoff coefficient of the top soil layer is necessary (*rrcs1*), and depend on soil type.

For surface water model compartment: Flow in rivers has a peak velocity (*rivvel*). This parameter determines the delay in the system. If you have lakes you can give a general lake depth (*gldepi*) and rating curve coefficients (*gratp*, *gratk*). They will be used for internal lakes. They will also be used for outlet lakes if no other data is given for them. E.g. outlet lakes may have their lake depth given in GeoData.txt.

Typical intervals for above mentioned model parameters: *cmlt*=2-5, *cevp*=0.1-0.3, *mperc1*,*mperc2*=5-100, *wcfc*=0.05-0.5, *wcep*=0.05-0.5, *rrcs1*=0.05-0.5, *rivvel*=0.5-2, *gldepi*=5-10, *gratp*=1-100, *gratk*=1-2

Result

With no special settings given for output the only result will be the log-file (**hyss_xxx.log**) with information about runtime and files used. There are several options for output of simulation result. The example given above (*timeoutput variable cout*) will produce a text file called **timeCOUT.txt** with time series for simulated outflow (*cout*) from each subbasin in the model set-up as columns (defined by *subid*). There are options for printing time series of several variables for one subbasin in one file and printing period mean values of a variable for example. When observations are given as input to the model set-up, e.g file **Qobs.txt** with observed discharge (see Part 4 File Description), HYPE may calculate performance criteria. The variables given in info.txt for criteria calculation are compared. Performance criteria will be calculated for every subbasin (with existing observations) and are printed in the **subass1.txt** file, one subbasin per row. Example of performance criteria; *NSE* – Nash-Sutcliffe Efficiency, *CC* – correlation coefficient, and *MAE* – mean absolute error. Some performance criteria for the whole model set-up are also printed in the log-file and the **simass.txt** file.

Further information

For an introduction to the model and concepts behind it read the Hydrology Research paper Development and testing of the HYPE water quality model for different spatial scales (Lindström, G., C. Pers, J. Rosberg, J. Strömqvist, and B. Arheimer (2010) 41(3-4):295-319). For a thorough and up to date description of the HYPE model get the latest version of the model description (User Manual Part 3 or HYPEmodelDescription.odt). It contains all functions available in the model with descriptions of equations and parameters to govern them. Format of input and output files may be found in the file description document (User Manual Part 4 or FileDescription.odt). This document contains all model parameters and output variables for HYPE.