Karstolution Instruction Manual

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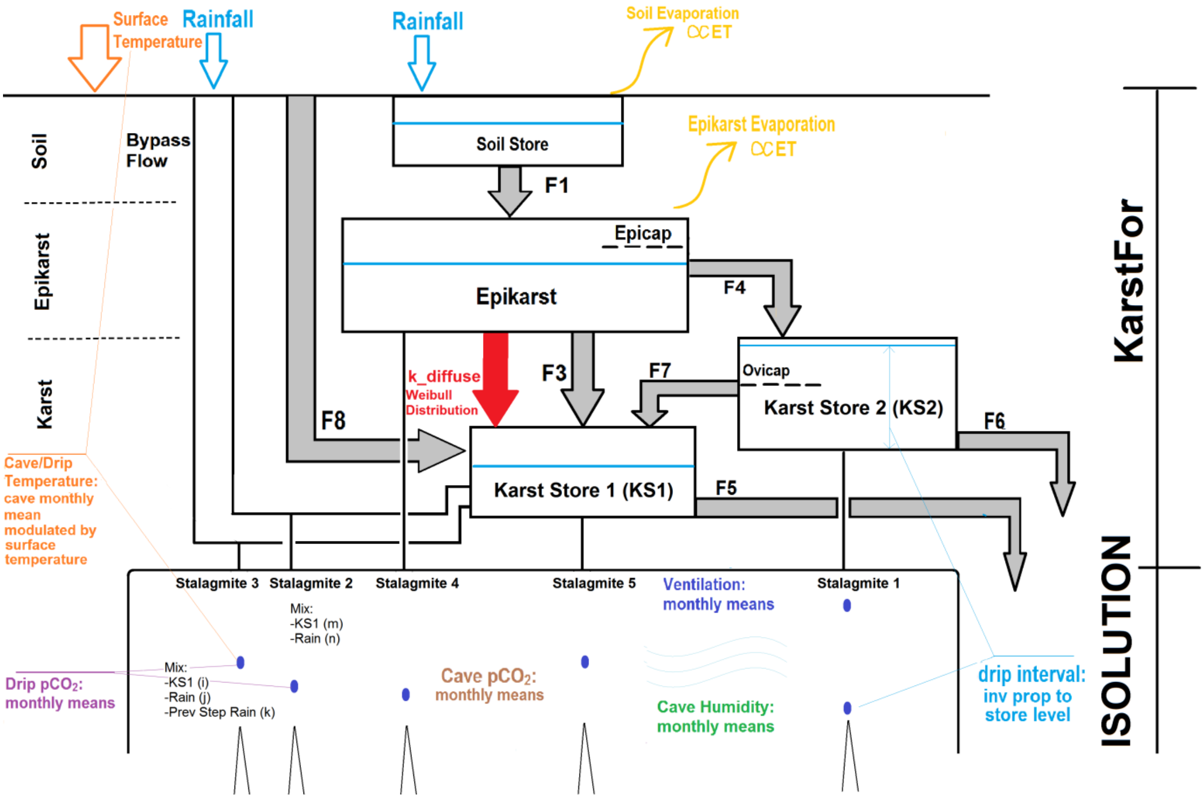

Important Links

Download Instruction Manual, Karstolution exe:
https://www.connectedwaters.unsw.edu.au/karstolution
GitHub depository (python scripts): https://github.com/mukhlis-mah/karstolution
YouTube GUI tutorial: https://youtu.be/-pj1793ePxI
JAMES Paper: Pending

Introduction

Karstolution is a model that allows the analysis of karst and in-cave processes affecting $\delta^{18}O$. This is a forward model, taking an input time series of climate (rain amount, surface temperature, evapotranspiration and rainfall $\delta^{18}O$: at a monthly time-step) and takes a configuration of karst and in-cave conditions to output stalagmite $\delta^{18}O$.

Karstolution was developed primarily to allow numerical analysis of the assumptions that:

- $\delta^{18}O$ from rainfall to cave drip-water is linear: whilst this may often not be the case
- In-cave evaporative or non-equilibrium fractionation processes do not occur

These two aspects are embodied in Karstolution's origins in KarstFor[1] and ISOLUTION[2] respectively.

Karstolution is hence a proxy system model (PSM)[3], taking an understanding of our system and trying to numerically model these processes.

For more detailed information, see the recommended reading section.

Who is Karstolution useful for?

There could be many reasons one would find Karstolution useful. Some applications may include:

- Better understand what is happening at the site
- Analyse assumptions of karst linearity and in-cave isotopic fractionation
- Students trying to gain an understanding of how karst and in-cave processes work
- Attempt to interpret 'tricky' sites with challenging hydrology and 'non-equilibrium' cave conditions (e.g. arid sites, those with lower humidity)
- GCM and large climate-reconstuction modellers (data assimilation)

How does Karstolution work?

Karstolution requires a climatic input series + configuration for karst and cave conditions. These are site-specific. The following sections

Input file

Karstolution requires uses the same input file as previous KarstFor models. However, the format is in a much easier to use csv format. All data (except for the headers in the first row) has to be numeric (no text).

An example input file (artificial data) is provided to demonstrate the required format. The easiest way is to add your own data in a copy of the example input file.

Note: The model requires input without any gaps. Hence, as the month of each entry needs to be specified, one is required to guess or interpolate any missing input data.

The columns in order are:

1. tt: ID column: integers starting with 1
2. mm: month: (integers 1-12) which month of the year each entry corresponds to, so things correspond with the user-inputted seasonality of cave-parameters
3. evpt: evapotranspiration (mm)
4. prp: rainfall amount (mm)
5. tempp: surface temperature (°C)
6. d18o: the average $\delta^{18}O$ value for rainfall (‰)

Karst Model:
The Karst Model closes follows the previously published KarstFor model, Baker et al. (2013). This takes a simple lumped parameter approach: modelling the water balance by inflows and outflows from reservoirs, then the $\delta^{18}O$ of each reservoir is calculated from their sources assuming complete mixing.

ISOLUTION:
Models evaporation, the kinetic exchange and precipitation of $\delta^{18}O$ in a film of water on-top of a stalagmite. This allows to account for often ignore 'disequilibria' effects.

Download and Installation

Karstolution can be run and modified directly from it's python scripts. The GUI scripts (wxpython) are also available on GitHub. However, a windows executable file is available. Installation requires the following files:

- karstolution.exe
- input.csv: this is requires the site-specific climatic input series (see above for details)
- config.csv: contains the karst and cave configuration parameters. This does not need to be edited as the GUI is designed to edit this file.

The file name of the last two cannot be changed; example files are available.

Notes:

- a youtube tutorial is available online
- The included example configuration has a default karst configuration taken from Baker et al. (2013){Baker, 2013 #73}

Basic/Advanced View

To simplify use of Karstolution for users without a much site-monitoring data, a basic view has is available, which hides many of the parameters. This allows use of the main features of Karstolution. The advanced view however allows all the features of the model to be fully utilised.

This can be changed in the file drop-down menu.

Batch Mode

Also available for use in the GUI is a batch mode which will run the model multiple times iterating over a single parameter. This allows sensitivity analysis and manual configuration of the model.

The batch mode is found by Karstolution to full-screen mode.

Notes:

For Cave Parameters, a special case is implemented to preserve the (potentially) user inputted seasonality in the cave parameters:

- CaveTemp
- Mindripint
- Drip_pCO2
- Cave_pCO2
- Rel_Humdity
- Ventilation

Now as the batch mode normally specifies the value of the parameter (regardless of what the original value is in the configuration file), for the cave parameters a different procedure is made to preserve seasonality; it takes the step (max-min)/(iteration-1) and adds that to each month's value.

Example: if for f1, you specify minimum value 0, max 0.1 and iterations of 2, first run will run with 0 and second run with have 0.1. This is regardless is you already set f1 as 0.5 in the GUI
However, for e.g. cave ventilation, if the existing value is 0.3 and you specify minimum value 0, max 0.1 and iterations of 2, the first run will be 0.3 and second run 0.4

So, these cave parameters are the only parameters that for batch mode want need to have negative values.

Example: min value of -100 and max value 100 with iterations of 3, for drip pCO2 set to 500
Will run:

1. 400
2. 500
3. 600

Also, note that for the bypass_i and bypass_m parameters on batch run, they will auto adjust the remaining parameters such that everything adds to 1.

Output

Output is written to a csv file, giving values of fluxes, store levels, compositions, stalagmite outputs, drip-intervals and cave temperature. A preliminary plot from this output.csv is also plotted

Karstolution Parameters

The following is a list and short description of all input parameters, using the names used in the python scripts. These are all adjustable via the advanced view of the GUI; the parameters in the basic view are indicated by 'y' in the last column

Input	**Units**	**Description**	**Example**	**Category**	**Basic?**
k_f1	1/month	f1 flux from soilstore to epikarst	0.2	Fluxes	y
k_f3	1/month	f3 from epikarst to KS1	0.008	Fluxes	y
k_f5	1/month	f5 from KS1 to stal5	0.005	Fluxes	
k_f6	1/month	f6 from KS2 to stal1	0.002	Fluxes	
k_f7	1/month	f8 from overflow (surface) to KS1	1	Fluxes	
k_f8	1/month	f8 from overflow (surface) to stal6	0.001	Fluxes	y
k_diffuse	1/month	diffuse flow from Epikarst to KS1	0.008	Fluxes	y
soilstorxp	mm	Initial storage volume in the soil store	50.	Store Initial Values	y
epxstorxp	mm	Initial storage volume in the epikarst	100.	Store Initial Values	y
kststor1xp	mm	Initial storage volume in karst store 1	230.	Store Initial Values	y
kststor2xp	mm	Initial storage volume in karst store 2	50.	Store Initial Values	y
dpdf	mm	Initial flow values (12) in diffuse flow pdf	30.	Store Initial Values	
soil18oxp	‰	Initial d18O of the soil store	-5.	d18O Initial Values	
epx18oxp	‰	Initial d18O of the epikarst	-4.	d18O Initial Values	
kststor118oxp	‰	Initial d18O of karst store 1	-5.	d18O Initial Values	
kststor218oxp	‰	Initial d18O of karst store 2	-4.	d18O Initial Values	
d18o	‰	Artificial d18O of the 'last' rain step (ie month before model starts)	-5.	d18O Initial Values	
epdf	‰	Initial d18o values (12) in diffuse flow pdf	-4.0	d18O Initial Values	

Input	Units	Description	Example	Category	Basic?
Soil size	mm	Max volume of soil store	200.	Store Sizes	y
Epikarst size	mm	Max volume of epikarst	400.	Store Sizes	y
KS1 size	mm	Max volume of KS1	400.	Store Sizes	y
KS2 size	mm	Max volume of KS2	200	Store Sizes	y
epicap	mm	Cap over which overflow to Karst Store 2 begins (F4)	400.	Overflow Limits	y
ovcap	mm	Cap over which overflow to Karst Store 1 begins (F7)	100.	Overflow Limits	y
Lambda,k	-	Weibull distribution parameters (scale, shape)	1.5,1	Weibull Distribution	
k_e_evap	1/month	epikarst evap (funct of ET for timestep)	0.03	Evaporation Coeffs	
k_evapf	‰*month/mm	soil evap d18o fractionation from somepaper	0.03	Evaporation Coeffs	
k_e_evapf	‰*month/mm	epikarst evap d18o fractionation	0.03	Evaporation Coeffs	
i	%	epikarst in bypass flow mixture to stal1, (<1 & i+j+k=1)	0.5	Bypass Composition	
j	%	rain in bypass flow mixture to stal1, (<1 & i+j+k=1)	0.25	Bypass Composition	
k	%	rain from last step in bypass flow mixture to stal1, (<1 & i+j+k=1)	0.25	Bypass Composition	
m	%	epikarst in bypass flow mixture to stal2, (<1 & m+n=1)	0.75	Bypass Composition	
n	%	rain in bypass flow mixture to stal2, (<1 & m+n=1)	0.25	Bypass Composition	
phi	%	Mixing parameter, 0<phi<=1, can account for 'splashing'	1	Cave Mixing (phi)	
drip_interval	s	Minimum drip interval	100	Min Drip Interval	y*
drip_pco2	ppmv	Drip water pCO2	4000	Drip pCO_2	y*
cave_pco2	ppmv	Cave air pCO2	1000	Cave pCO_2	y*
h	%	Relative humidity, 0<h<=1	0.95	Rel Humidity	y*
v	m/s	Wind velocity in the cave	0	Ventilation	y*
t_12	°C	Cave Temperature	10.0	Cave Temperature	y*

Notes: The program is not run on the multiple thread thingy, so will freeze while the model is running. So don't worry if this happens, its normal!

References and Recommended Reading

1. Bradley, C., et al., *Hydrological uncertainties in the modelling of cave drip-water δ18O and the implications for stalagmite palaeoclimate reconstructions.* Quaternary Science Reviews, 2010. **29**(17-18): p. 2201-2214.
2. Deininger, M., et al., *Isotope disequilibrium effects: The influence of evaporation and ventilation effects on the carbon and oxygen isotope composition of speleothems – A model approach.* Geochimica et Cosmochimica Acta, 2012. **96**: p. 57-79.
3. Evans, M.N., et al., *Applications of proxy system modeling in high resolution paleoclimatology.* Quaternary Science Reviews, 2013. **76**: p. 16-28.