Hands-on Session: Calibrate the CREST Model

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Background

- Hydrologic models often contain parameters that cannot be measured directly but which can only be inferred by a trial-and-error (calibration) process that adjusts the parameter values to closely match the input-output behavior of the model to the real system it represents.
- Traditional calibration procedures, which involve ‘‘manual’’ adjustment of the parameter values, are labor-intensive, and their success is strongly dependent on the experience of the modeler.
- Automatic methods for model calibration, which seek to take advantage of the speed and power of computers while being objective and relatively easy to implement

Vrugt, J. A., H. V. Gupta, W. Bouten, et al. (2003), A Shuffled Complex Evolution Metropolis algorithm for optimization and uncertainty assessment of hydrologic model parameters, Water Resources Research, 39.

Question!!!

- Did you calibrate a model?
- How complex the model? (Number Parameters/Variables…)
- Manually or Automatically?

Table of Contents

You need streamflow observations for the model calibration.

- Manual Calibration
- Automatic Calibration
  - SCE-UA (Shuffled Complex Evolution – The University of Arizona)

OBS Folder

- Wangchu_Obs.csv (Using .csv format by Excel)
- **Station Name + "_Obs.csv"**
- Date Column depends on the run options

  for example:

  Year + Month + Day + Hour + Minute + Second
- Runoff Column: "m^3/s"

Date	Wangchu
20010101	27
20010102	27
20010103	26.944
20010104	26.02
20010105	25.913
20010106	25.106
20010107	25.05
20010108	25.055
20010109	24.477
20010110	24.67
20010111	25.05
20010112	25.45
20010113	24.988
20010114	24.85
20010115	24.734
20010116	24.671
20010117	24.169
20010118	23.5
20010119	23.527
20010120	23.781
20010121	23.78
20010122	23.766
20010123	23.535
20010124	24.217
20010125	24
20010126	24.51
20010127	24.706
20010128	24
20010129	23.944
20010130	24.615
20010131	25.125
20010201	25.159
20010202	25.32
20010203	24.393
20010204	23
20010205	21.855
20010206	21.479
20010207	22.096
20010208	22.479
20010209	23.124
20010210	23.213

Try the Example Basin using Manual Calibration

- Let’s modify one of the parameter value to see how the results change, use the table here as the range of the parameters:
  - The NSCE increased or decreased?
  - Try others
  - Do you got a good results?
  - How long do you use?

Parameter	Min	Max
RainFact	0.5	1.2
Ksat	18	313.92
WM	0.1	232.5
B	0.05	1.5
IM	0	0.2
KE	0.1	1.5
coeM	1	150
coeR	1	3
coeS	0.001	1
KS	0	1
KI	0	1

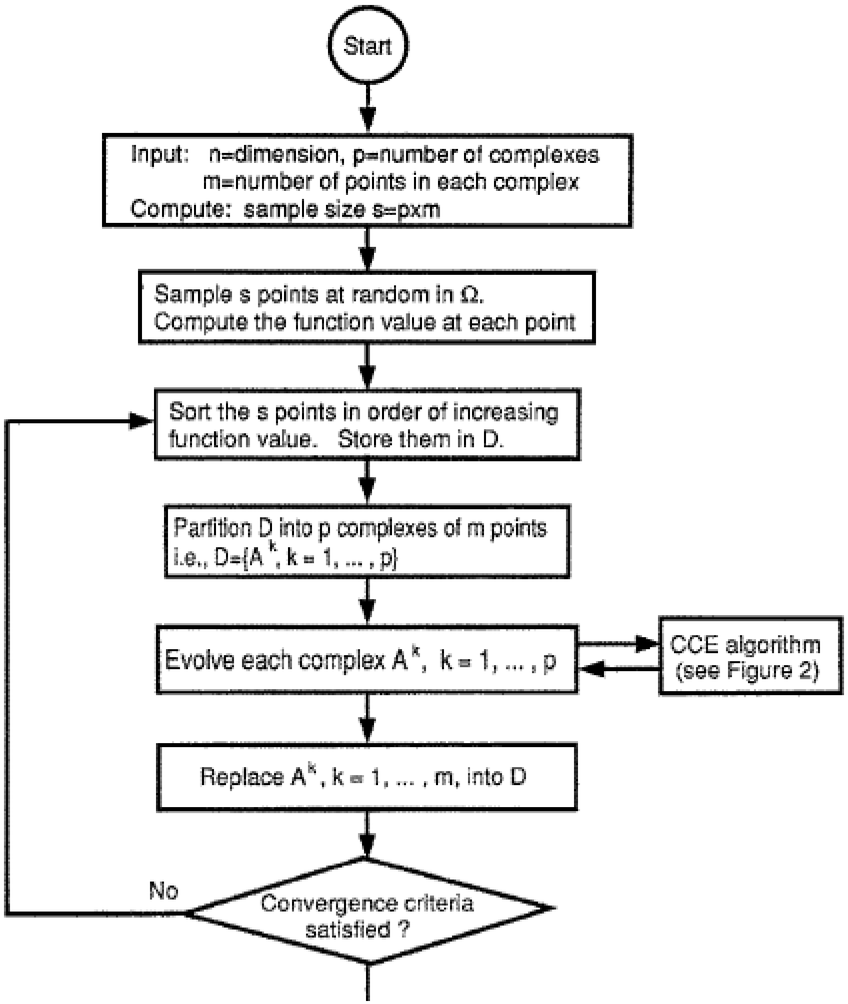
How do you feel?

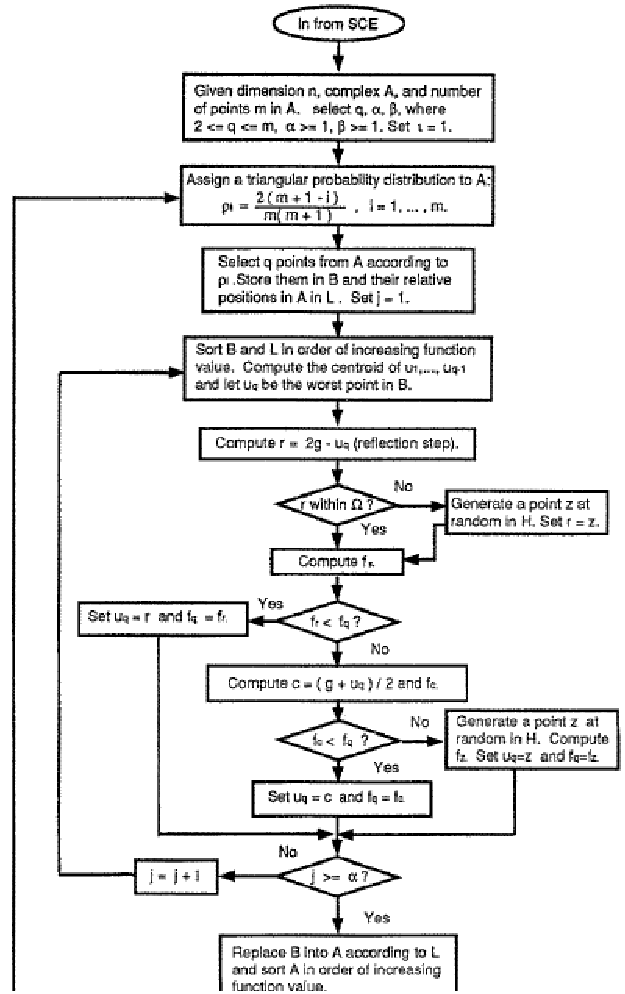
- Tired?
- Exhausted?
- Despaired?
- …

Do you want to calibrate the model manually?

Automatic Calibration!!!

- shuffled complex evolution (SCE) method





Duan, Q. Y., V. K. Gupta, and S. Sorooshian (1993), Shuffled complex evolution approach for effective and efficient global minimization, Journal Of Optimization Theory And Applications, 76(3), 501-521.

Calibrations.txt

```
################################################################################
# CREST Calibrations File (Version more than 2.0)
################################################################################
iseed                =              -3
maxn                 =              10000
kstop                =              10
pcento               =              0.0001
ngs                  =              2
################################################################################
NCalibStations       =              1
IsColRow             =              no     # yes: use Col& Row; No: Lan & Lati
################################################################################
[Station 1 Begin]
Name_1                 =              Wangchu
Value_1                =              1
Long_1      =    89.530485
Lati_1      =    27.108927
RainFact_1             = 0.5    0.95     1.2
Ksat_1                 = 18     23     313.92
WM_1                   = 0.1    165.20827244536   232.5
B_1                    = 0.05   0.25     1.5
IM_1                   = 0.0    0.05     0.2
KE_1                   = 0.1    0.95     1.5
coeM_1                 = 1.0    90.0     150
expM_1                 = 0.1    0.95     2
coeR_1                 = 1.0    2.00     3.0
coeS_1                 = 0.001  0.95     1
KS_1                   = 0.0    0.50     1.0              # Min    Value    Max
KI_1                   = 0.0    0.50     1.0
[Station 1 End]
```

Calibration Parameters

- **iseed** = initial random seed
- **maxn** = maximum number of trials allowed before optimization is terminated
- **kstop** = number of shuffling loops in which the criterion value must change by "pecnto" before optimization is terminated
- **pecnto** = percentage by which the criterion value must change in "kstop" shuffling loops
- **ngs** = number of complexes in a sample population

Parameters

Symbol	Description
Ksat	the Soil saturate hydraulic conductivity
RainFact	the multiplier on the precipitation field
WM	The Mean Water Capacity
B	the exponent of the variable infiltration curve
IM	Impervious area ratio
KE	The factor to convert the PET to local actual
coeM	overland runoff velocity coefficient
expM	overland flow speed exponent
coeR	multiplier used to convert overland flow speed to channel flow speed
coeS	multiplier used to convert overland flow speed to interflow flow speed
KS	Overland reservoir Discharge Parameter
KI	Interflow Reservoir Discharge Parameter

Evaluation indices

- Nash-Sutcliffe Coefficient of Efficiency

$$NSCE = 1 - \frac{\sum_{i=1}^{n}\left(R_{obs,i} - R_{sim,i}\right)^2}{\sum_{i=1}^{n}\left(R_{obs,i} - \overline{R_{obs}}\right)^2}$$

- Relative Bias (%) was used to assess the systematic bias of runoff

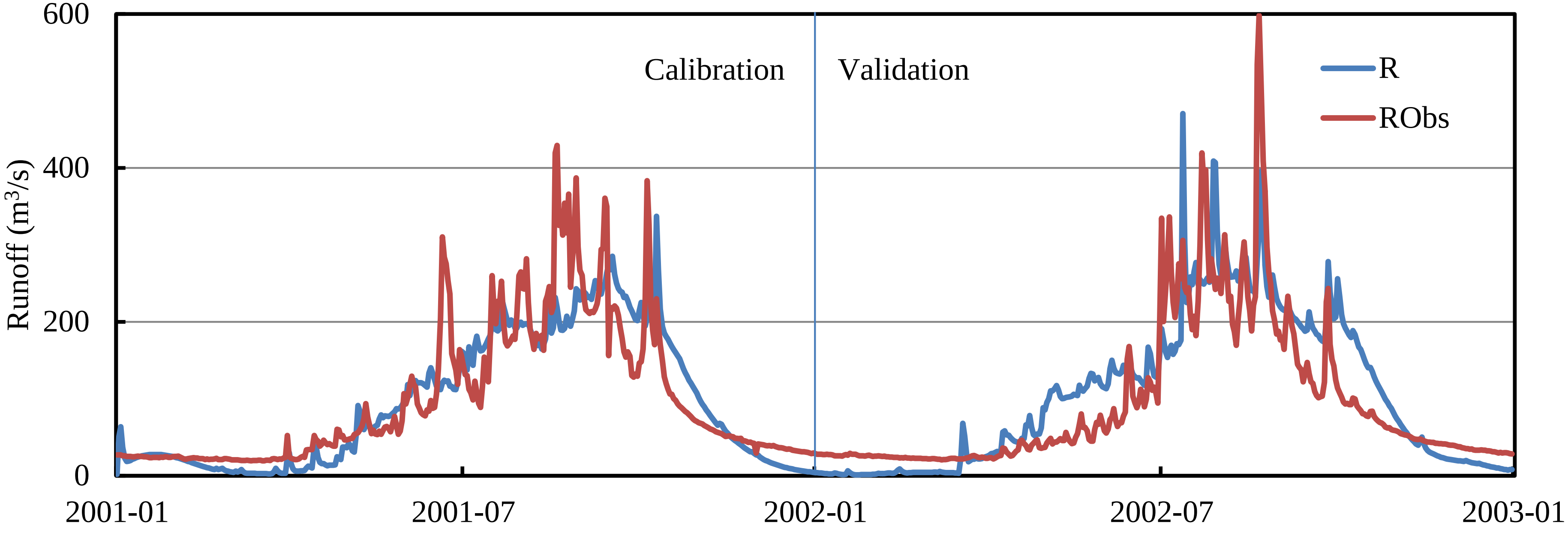
$$Bias = \left[\frac{\sum_{i=1}^{n} R_{sim,i} - \sum_{i=1}^{n} R_{obs,i}}{\sum_{i=1}^{n} R_{obs,i}}\right] \times 100$$

- The correlation coefficient (CC) is used to assess the agreement between simulated runoff and observed runoff

$$CC = \frac{\sum_{i=1}^{n}\left(R_{obs,i} - \overline{R_{obs}}\right)\left(R_{sim,i} - \overline{R_{sim}}\right)}{\sqrt{\sum_{i=1}^{n}\left(R_{obs,i} - \overline{R_{obs}}\right)^2 \sum_{i=1}^{n}\left(R_{sim,i} - \overline{R_{sim}}\right)^2}}$$

Validation of the Results

	Calibration (2001)	Validation (2002)
NSCE	0.75	0.72
Bias(%)	-4.76	2.78
CC	0.87	0.86



- Calibration Period: 2001.1.1-2001.12.31
- Validation Period: 2002.1.1-2002.12.31

Let's try the automatic calibration!

First Step: Modify the Parameter File

Modify the **KS** value to **1.0** in Parameters.txt and then **save** the file

```
BType           =      Uniform #
B               =      0.780130781396043    #0.2
##############################################
IMType          =      Uniform #
IM              =      0.199996144773270    #1.0
##############################################
KEType          =      Uniform #
KE              =      0.100087606044631    #0.8
##############################################
coeMType        =      Uniform   #Overland flow
coeM            =      95.991845343942302    #58
##############################################
expMType        =      Uniform #
expM            =      0.5
##############################################
coeRType        =      Uniform #
coeR            =      1.260870803674761    #0.7
##############################################
coeSType        =      Uniform #
coeS            =      0.336019367022371    #0.6
##############################################
KSType          =      Uniform #
KS              =      0.822762410971760    #0.4
##############################################
KIType          =      Uniform #
KI              =      0.188793914515398      #0
##############################################
```

```
BType           =      Uniform #
B               =      0.780130781396043    #0.25
#################################################################
IMType          =      Uniform #
IM              =      0.199996144773270    #1.0
#################################################################
KEType          =      Uniform #
KE              =      0.100087606044631    #0.845182
#################################################################
coeMType        =      Uniform   #Overland flow speed multiplier
coeM            =      95.991845343942302    #58.89378
#################################################################
expMType        =      Uniform #
expM            =      0.5
#################################################################
coeRType        =      Uniform #
coeR            =      1.260870803674761    #0.728891
#################################################################
coeSType        =      Uniform #
coeS            =      0.336019367022371    #0.627904
#################################################################
KSType          =      Uniform #
KS              =      1.0    #0.414064
#################################################################
KIType          =      Uniform #
KI              =      0.188793914515398      #0.215441
#################################################################
```

```
IsColRow            =                 no    # yes: use Col& Row; No:
###################################################################
[Station 1 Begin]
Name_1                =                 Wangchu
Value_1               =                 1
Long_1     =    89.530485
Lati_1     =    27.108927
#RainFact_1           = 0.5    0.95     1.2
#Ksat_1               = 18     23      313.92
#WM_1                 = 0.1    165.2082724536    232.5
#B_1                    = 0.05   0.25     1.5
#IM_1                 = 0.0    0.05     0.2
#KE_1                 = 0.1    0.95     1.5
#coeM_1               = 1.0    90.0     150
#expM_1               = 0.1    0.95     2
#coeR_1               = 1.0    2.00     3.0
#coeS_1               = 0.001  0.95     1
KS_1                  = 0.0    0.50     1.0             # Min    Val
#KI_1                 = 0.0    0.50     1.0
[Station 1 End]
```

Third Step: Modify the Project File

Select “cali_SCEUA” in “Wangchu_CREST_V6_Daily.Project” file and then **save** the file

```
Version             =     2.0
##################################################################################
# MODEL AREA
###############################
NCols               =     81
NRows               =     92
xllCorner           =     89.091
yllCorner           =     27.099
CellSize            =     0.0083
NODATA_value        =     -9999.
###############################
# MODEL Run Time Information
###############################
TimeMark            =     d #y(y
TimeStep            =     1
StartDate           =     200101
LoadState           =     no
WarmupDate          =     200101
EndDate             =     200112
SaveState           =     no
###############################
# MODEL Directory
###############################
RunStyle            =     simu
###############################
BasicFormat         =     asc #a
BasicPath           =     ".\Bas
###############################
```

```
Version             =     2.0
##################################################################################
# MODEL AREA
##################################################################################
NCols               =     81               # Number of columns
NRows               =     92               # Number of rows
xllCorner           =     89.0916666666657
yllCorner           =     27.0999999999996
CellSize            =     0.00833333333333333      # Grid resolution in m
NODATA_value        =     -9999.
##################################################################################
# MODEL Run Time Information
##################################################################################
TimeMark            =     d #y(year);m(month);d(day);h(hour);u(minute);s(second)
TimeStep            =     1
StartDate           =     20010101
LoadState           =     no
WarmupDate          =     20010101
EndDate             =     20011231
SaveState           =     no
##################################################################################
# MODEL Directory
##################################################################################
RunStyle            =     cali_SCEUA     # simu, cali_SCEUA, RealTime
##################################################################################
BasicFormat         =     asc #asc,txt,biffit, dbif,ASBIMO,BIBIMO,TRMMRT,TRMMV6,NMQBI
BasicPath           =     ".\Basics\"
##################################################################################
```

Final Step: Calibrate the model

C:\Windows\system32\cmd.exe

```
        356   2001-12-22
        357   2001-12-23
        358   2001-12-24
        359   2001-12-25
        360   2001-12-26
        361   2001-12-27
        362   2001-12-28
        363   2001-12-29
        364   2001-12-30
        365   2001-12-31

   The results of the Outlet is:
        NSCE:       0.74946393
     Bias(%):      -4.76486689
          CC:       0.86970468


 Run end date and time (yyyy/mm/dd hh:mm:ss): 2012/04/03  6:58:12
 Elapsed run time: 55.817 Seconds

 Project: Wangchu_CREST_V6_Daily is finished!

E:\XXW_CREST_Workshop\PPTs\Day Two PM  Calibration\Wangchu_CREST_V6_Daily_AutoCa
libration>pause
Press any key to continue . . .
```

Take Exercises

- Try the manual calibration and automatic calibration using the example basin

- If you have other questions, please feel free to ask me

Thank you for your attention!