

# setup\_pest\_interface

June 5, 2019

## 1 Setup the PEST(++) interface around the enhanced Freyberg model

In this notebook, we will construct a complex model independent (non-intrusive) interface around an existing MODFLOW-NWT model using the python/flopy/pyemu stack.

```
In [1]: %matplotlib inline
import os
import shutil
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import flopy
import pyemu
import prep_deps
import redis
import matplotlib as mpl
plt.rcParams['font.size']=12
%matplotlib inline
```

flopy is installed in /Users/jeremyw/Dev/gw1876/activities\_2day\_mfm/notebooks/flopy

First we define a base directory b\_d from which we will read in a model already created freyberg.nam. This will form the basis of the remainder of the exercise

```
In [2]: b_d = os.path.join("../", "base_model_files")
nam_file = "freyberg.nam"
```

### 1.0.1 load the existing Freyberg model. This version should run but is not yet connected with PEST++

```
In [3]: # note that to load a model in a different folder, you supply the namefile without path
# to it in the model_ws variable
m = flopy.modflow.Modflow.load(nam_file, model_ws=b_d, check=False, forgive=False)
```

### 1.0.2 we can do a couple flopy things to move where the new model will be written

```
In [4]: # assign the executable name for the model
        m.exe_name = "mfnewt"

        # now let's run this in a new folder called temp so we don't overwrite the original da
        m.change_model_ws("temp",reset_external=True)

        # this writes all the MODFLOW files in the new location
        m.write_input()

        # the following helps get the dependencies (both python and executables) in the right p
        prep_deps.prep_template(t_d="temp")
```

changing model workspace...  
temp

### 1.0.3 now we can run the model once using a pyemu helper

This helper is particularly useful if you run on more than one platform (e.g. Mac and Windows)

```
In [5]: pyemu.os_utils.run("{0} {1}".format("mfnewt",m.name+".nam"),cwd=m.model_ws)
```

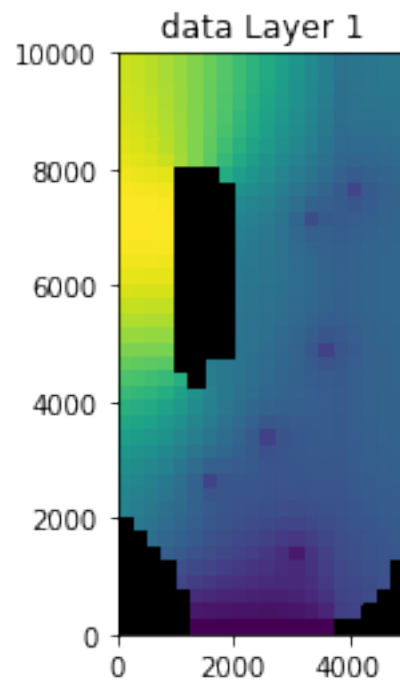
### 1.0.4 read in the heads and plot them up along with the budget components

Note that there is a historic period and a scenario with future conditions that differ.

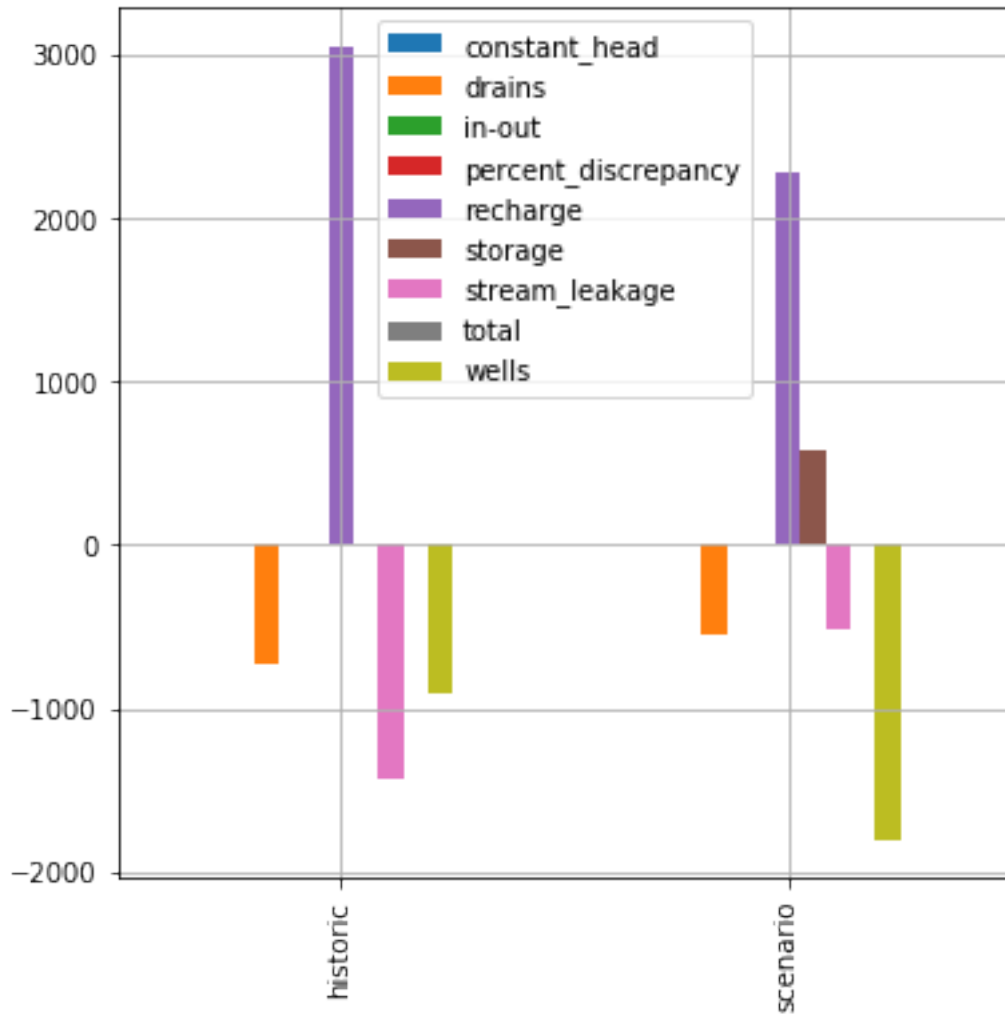
*For the future scenario, a serious drought, recharge is lower and pumping/abstraction is increased to make up for the presumed deficits in water for agriculture.*

```
In [6]: plt.figure()
        hds = flopy.utils.HeadFile(os.path.join(m.model_ws,m.name+".hds"),model=m)
        hds.plot(mfay=0)
        lst = flopy.utils.MfListBudget(os.path.join(m.model_ws,m.name+".list"))
        df = lst.get_dataframes(diff=True)[0]
        plt.figure()
        ax = df.plot(kind="bar",figsize=(6,6), grid=True)
        ax.set_xticklabels(["historic","scenario"])
```

```
Out[6]: [Text(0, 0, 'historic'), Text(0, 0, 'scenario')]
```



<Figure size 432x288 with 0 Axes>

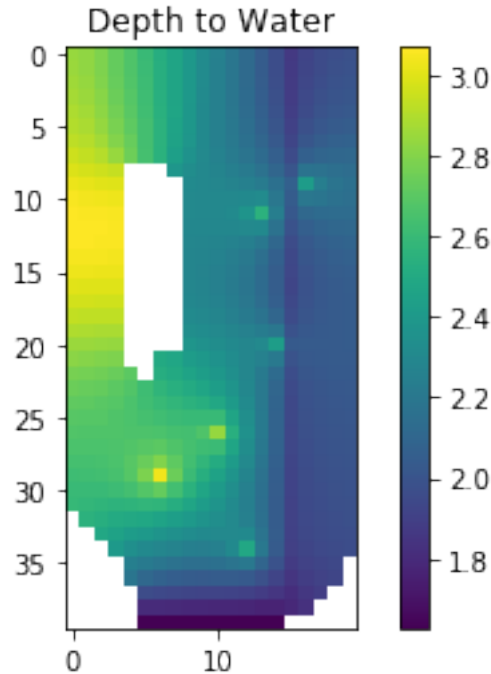


We can see the effect of the “scenario” in the second stress period with less recharge and more abstraction.

### 1.0.5 Plot depth to water

```
In [7]: dtw = m.dis.top.array - hds.get_data()[0,:,:]
        dtw = np.ma.masked_where(m.bas6.ibound[0].array==0,dtw)
        c = plt.imshow(dtw)
        plt.title('Depth to Water')
        plt.colorbar(c)
```

```
Out[7]: <matplotlib.colorbar.Colorbar at 0x102b64b38>
```



Clearly we can see the river and well locations expressed in the depth to water pattern.

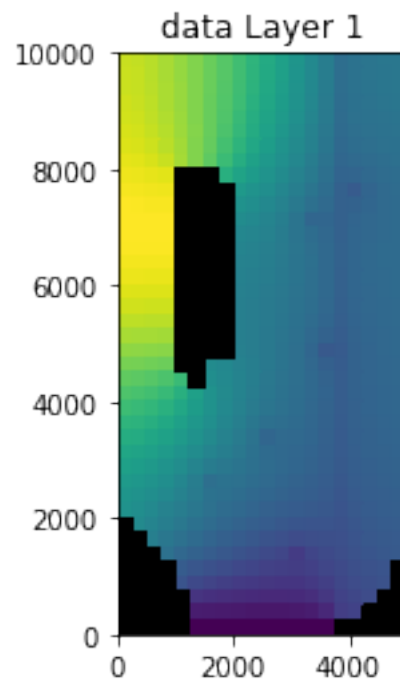
#### 1.0.6 What we are going to do is implement the scenario with parameters so we can more easily account for the stochastic nature of the forcing conditions during the scenario stress period and also make implementation of future scenarios work in this stochastic framework:

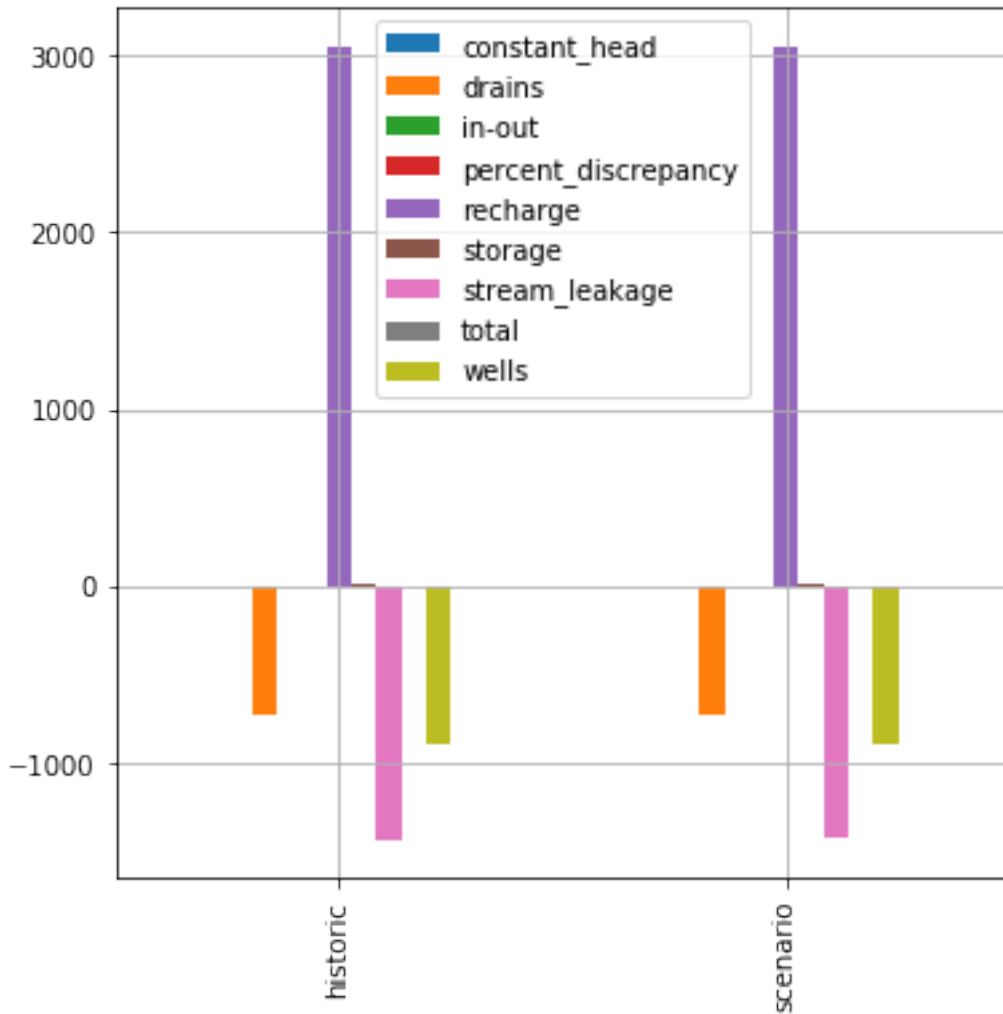
To do this, we reset the future condition to be the same as the calibration time. But...by setting the quantities up as parameters, we will be able to handle the stochastically and control their values using the PEST control file.

```
In [8]: # reset scenario period recharge
m.rch.rech[1] = m.rch.rech[0]
# reset scenario period abstraction
m.wel.stress_period_data[1] = m.wel.stress_period_data[0]
m.write_input()
pyemu.os_utils.run("{0} {1}".format("mfnt", m.name+".nam"), cwd=m.model_ws)
hds = flopy.utils.HeadFile(os.path.join(m.model_ws, m.name+".hds"), model=m)
axes = hds.plot(mflag=0)

lst = flopy.utils.MfListBudget(os.path.join(m.model_ws, m.name+".list"))
df = lst.get_dataframes(diff=True)[0]
ax = df.plot(kind="bar", figsize=(6,6), grid=True)
ax.set_xticklabels(["historic", "scenario"])
```

```
Out[8]: [Text(0, 0, 'historic'), Text(0, 0, 'scenario')]
```





Now we see that the scenario and historic periods have the same water balance

## 1.1 Setup data structures related to what we want to parameterize and what we want to observe

### 1.1.1 first the parameterization of model inputs

```
In [9]: props = []
        # here we specify which packages we wish to parameterize,
        # starting with those that do not change over time
        paks = ["upw.hk", "upw.vka", "upw.ss", "upw.sy", "bas6.strt", "extra.prsity"]
        for k in range(m.nlay):
            props.extend([[p,k] for p in paks])
        # next we specify that we want to make parameters for recharge
        # for both stress periods (zero-based! Python style)
        props.append(["rch.rech", 0])
        props.append(["rch.rech", 1])
```

### 1.1.2 we want to handle list-type parameters in two ways

for `spatial_list_props` this will apply a multiplier distributed spatially that applied in all stress periods throughout the model

for `temporal_list_props` this will apply a multiplier for each stress period applied to all the spatial locations

```
In [10]: spatial_list_props = [{"wel.flux",2}, {"drn.cond",0}]
        temporal_list_props = [{"wel.flux",0}, {"wel.flux",1}]
```

### 1.1.3 next we want to set up extracting observations. First, we will setup a post-processor that will read the heads for all active cells in both stress periods - why not?

```
In [11]: hds_kperk = [[0,k] for k in range(m.nlay)]
        hds_kperk.extend([[1,k] for k in range(m.nlay)])
```

### 1.1.4 then we setup monitoring of the SFR ASCII outputs.

we will accumulate the first 20 reaches and last 20 reaches together to form forecasts of sw-gw exchange in the headwaters (hw) and tailwaters (tw). Then we will also add each reach individually for monitoring as well

```
In [12]: sfr_obs_dict = {"hw":np.arange(1,int(m.nrow/2))}
        sfr_obs_dict["tw"] = np.arange(int(m.nrow/2),m.nrow)
        for i in range(m.nrow):
            sfr_obs_dict[i] = i+1
```

### 1.1.5 here we go...

This `pyemu` class has grown into a monster... it does (among other things): - sets up combinations of multiplier parameters for array inputs, including uniform, zones, pilot points, grids, and KL expansion types - sets up combinations of multiplier parameters for list inputs - handles several of the shitty modflow exceptions to the array and list style inputs - sets up large numbers of observations based on arrays or time series - writes `.tpl`, `.ins`, `.pst`, etc - writes a python forward run script (WAT?!) - writes a prior parameter covaraince matrix using geostatistical correlations - draws from the prior parameter covariance matrix to generate a prior parameter ensemble

This will be slow because the pure python kriging... but, hey, its free!

For our purposes, we will setup combinations of constant (by layer), pilot points and grid-scale parameters for each of the array-based properties we defined earlier. This lets us explore options for parameterization and also start to understand how information flows in the history matching problem

```
In [13]: pst_helper = pyemu.helpers.PstFromFlopyModel(nam_file,new_model_ws="template",org_model_ws=org_model_ws,
        const_props=props,spatial_list_props=spatial_list_props,temporal_list_props=temporal_list_props,
        grid_props=props,pp_props=props,sfr_pars=sfr_pars,sfr_obs=sfr_obs_dict,build_prior=False,mpp_space=4)
        prep_deps.prep_template(t_d=pst_helper.new_model_ws)
```



2019-06-05 22:24:30.047381 starting: loading floppy model

Creating new model with name: freyberg

Parsing the namefile --> temp/freyberg.nam

External unit dictionary:

OrderedDict([(2, filename:temp/freyberg.list, filetype:LIST), (11, filename:temp/freyberg.dis,

ModflowBas6 free format:True

loading dis package file...

Loading dis package with:

3 layers, 40 rows, 20 columns, and 2 stress periods

loading laycbd...

loading delr...

loading delc...

loading top...

loading botm...

for 3 layers and 0 confining beds

loading stress period data...

for 2 stress periods

adding Package: DIS

DIS package load...success

LIST package load...skipped

loading bas6 package file...

adding Package: BAS6

BAS6 package load...success

loading upw package file...

loading ipakcb, HDRY, NPUPW, IPHDRY...

loading LAYTYP...

loading LAYAVG...

loading CHANI...

loading LAYVKA...

loading LAYWET...

loading hk layer 1...

loading vka layer 1...

loading ss layer 1...

loading sy layer 1...

loading hk layer 2...

loading vka layer 2...

loading ss layer 2...

loading sy layer 2...

loading hk layer 3...

loading vka layer 3...

```

    loading ss layer    3...
    loading sy layer    3...
Adding freyberg.cbc (unit=50) to the output list.
adding Package:  UPW
    UPW  package load...success
loading rch package file...
    loading rech stress period    1...
    loading rech stress period    2...
adding Package:  RCH
    RCH  package load...success
loading nwt package file...
adding Package:  NWT
    NWT  package load...success
loading oc package file...
Adding freyberg.hds (unit=51) to the output list.
adding Package:  OC
    OC   package load...success
loading lmt package file...
adding Package:  LMT6
    LMT6 package load...success
loading wel package file...
    loading <class 'flopymodflow.mfwel.ModflowWel'> for kper    1
    loading <class 'flopymodflow.mfwel.ModflowWel'> for kper    2
adding Package:  WEL
    WEL  package load...success
loading sfr2 package file...
Adding freyberg.sfr.out (unit=60) to the output list.
adding Package:  SFR
    SFR  package load...success
loading drn package file...
    loading <class 'flopymodflow.mfdrn.ModflowDrn'> for kper    1
    loading <class 'flopymodflow.mfdrn.ModflowDrn'> for kper    2
adding Package:  DRN
    DRN  package load...success
    DATA(BINARY) file load...skipped
        freyberg.cbc
    DATA(BINARY) file load...skipped
        freyberg.hds
    DATA file load...skipped
        freyberg.sfr.out
Warning: external file unit 0 does not exist in ext_unit_dict.

```

```

The following 10 packages were successfully loaded.
    freyberg.dis
    freyberg.bas
    freyberg.upw
    freyberg.rch
    freyberg.nwt

```

```

    freyberg.oc
    freyberg.lmt6
    freyberg.wel
    freyberg.sfr
    freyberg.drn
The following 1 packages were not loaded.
    freyberg.list
2019-06-05 22:24:30.086142 finished: loading floppy model took: 0:00:00.038761
2019-06-05 22:24:30.087610 starting: updating model attributes
2019-06-05 22:24:30.087762 finished: updating model attributes took: 0:00:00.000152
2019-06-05 22:24:30.088631 WARNING: removing existing 'new_model_ws

creating model workspace...
    template

changing model workspace...
    template
2019-06-05 22:24:31.401743 starting: writing new modflow input files

Writing packages:
    Package:  DIS
Util2d:delr: resetting 'how' to external
Util2d:delc: resetting 'how' to external
Util2d:model_top: resetting 'how' to external
Util2d:botm_layer_0: resetting 'how' to external
Util2d:botm_layer_1: resetting 'how' to external
Util2d:botm_layer_2: resetting 'how' to external
    Package:  BAS6
Util2d:ibound_layer_0: resetting 'how' to external
Util2d:ibound_layer_1: resetting 'how' to external
Util2d:ibound_layer_2: resetting 'how' to external
Util2d:strt_layer_0: resetting 'how' to external
Util2d:strt_layer_1: resetting 'how' to external
Util2d:strt_layer_2: resetting 'how' to external
    Package:  UPW
Util2d:hk: resetting 'how' to external
Util2d:vka: resetting 'how' to external
Util2d:ss: resetting 'how' to external
Util2d:sy: resetting 'how' to external
Util2d:hk: resetting 'how' to external
Util2d:vka: resetting 'how' to external
Util2d:ss: resetting 'how' to external
Util2d:sy: resetting 'how' to external
Util2d:hk: resetting 'how' to external
Util2d:vka: resetting 'how' to external
Util2d:ss: resetting 'how' to external
Util2d:sy: resetting 'how' to external
    Package:  RCH

```

Util2d:rech\_1: resetting 'how' to external

Util2d:rech\_2: resetting 'how' to external

Package: NWT

Package: OC

Package: LMT6

Package: WEL

Package: SFR

Package: DRN

2019-06-05 22:24:31.467329 finished: writing new modflow input files took: 0:00:00.065586

2019-06-05 22:24:31.467651 forward\_run line:pyemu.os\_utils.run('mf nwt freyberg.nam 1>freyberg.

2019-06-05 22:24:31.467724 starting: setting up 'template/arr\_org' dir

2019-06-05 22:24:31.468246 finished: setting up 'template/arr\_org' dir took: 0:00:00.000522

2019-06-05 22:24:31.468310 starting: setting up 'template/arr\_mlt' dir

2019-06-05 22:24:31.468488 finished: setting up 'template/arr\_mlt' dir took: 0:00:00.000178

2019-06-05 22:24:31.468540 starting: setting up 'template/list\_org' dir

2019-06-05 22:24:31.468764 finished: setting up 'template/list\_org' dir took: 0:00:00.000224

2019-06-05 22:24:31.468821 starting: setting up 'template/list\_mlt' dir

2019-06-05 22:24:31.468987 finished: setting up 'template/list\_mlt' dir took: 0:00:00.000166

2019-06-05 22:24:31.469034 starting: processing temporal\_list\_props

2019-06-05 22:24:31.517293 finished: processing temporal\_list\_props took: 0:00:00.048259

2019-06-05 22:24:31.517399 starting: processing spatial\_list\_props

2019-06-05 22:24:32.697974 finished: processing spatial\_list\_props took: 0:00:01.180575

2019-06-05 22:24:32.813018 forward\_run line:pyemu.helpers.apply\_list\_pars()

2019-06-05 22:24:32.853014 'extra' pak detected:extra.prsity

2019-06-05 22:24:32.898653 'extra' pak detected:extra.prsity

2019-06-05 22:24:32.946286 'extra' pak detected:extra.prsity

2019-06-05 22:24:33.015202 'extra' pak detected:extra.prsity

2019-06-05 22:24:33.054639 'extra' pak detected:extra.prsity

2019-06-05 22:24:33.101275 'extra' pak detected:extra.prsity

2019-06-05 22:24:33.148431 'extra' pak detected:extra.prsity

2019-06-05 22:24:33.194500 'extra' pak detected:extra.prsity

2019-06-05 22:24:33.226523 'extra' pak detected:extra.prsity

2019-06-05 22:24:33.304232 starting: writing grid tpl:hk3.dat\_gr.tpl

2019-06-05 22:24:33.312740 finished: writing grid tpl:hk3.dat\_gr.tpl took: 0:00:00.008508

2019-06-05 22:24:33.315457 starting: writing grid tpl:vka3.dat\_gr.tpl

2019-06-05 22:24:33.324916 finished: writing grid tpl:vka3.dat\_gr.tpl took: 0:00:00.009459

2019-06-05 22:24:33.327590 starting: writing grid tpl:ss3.dat\_gr.tpl

2019-06-05 22:24:33.336260 finished: writing grid tpl:ss3.dat\_gr.tpl took: 0:00:00.008670

2019-06-05 22:24:33.338958 starting: writing grid tpl:sy3.dat\_gr.tpl

2019-06-05 22:24:33.348273 finished: writing grid tpl:sy3.dat\_gr.tpl took: 0:00:00.009315

2019-06-05 22:24:33.351577 starting: writing grid tpl:str3.dat\_gr.tpl

2019-06-05 22:24:33.360900 finished: writing grid tpl:str3.dat\_gr.tpl took: 0:00:00.009323

2019-06-05 22:24:33.363434 starting: writing grid tpl:prsity3.dat\_gr.tpl

2019-06-05 22:24:33.374132 finished: writing grid tpl:prsity3.dat\_gr.tpl took: 0:00:00.010698

2019-06-05 22:24:33.377137 starting: writing grid tpl:hk4.dat\_gr.tpl

2019-06-05 22:24:33.385982 finished: writing grid tpl:hk4.dat\_gr.tpl took: 0:00:00.008845

2019-06-05 22:24:33.389074 starting: writing grid tpl:vka4.dat\_gr.tpl  
 2019-06-05 22:24:33.398225 finished: writing grid tpl:vka4.dat\_gr.tpl took: 0:00:00.009151  
 2019-06-05 22:24:33.401286 starting: writing grid tpl:ss4.dat\_gr.tpl  
 2019-06-05 22:24:33.410502 finished: writing grid tpl:ss4.dat\_gr.tpl took: 0:00:00.009216  
 2019-06-05 22:24:33.413089 starting: writing grid tpl:sy4.dat\_gr.tpl  
 2019-06-05 22:24:33.421993 finished: writing grid tpl:sy4.dat\_gr.tpl took: 0:00:00.008904  
 2019-06-05 22:24:33.425626 starting: writing grid tpl:strt4.dat\_gr.tpl  
 2019-06-05 22:24:33.434864 finished: writing grid tpl:strt4.dat\_gr.tpl took: 0:00:00.009238  
 2019-06-05 22:24:33.437622 starting: writing grid tpl:prsity4.dat\_gr.tpl  
 2019-06-05 22:24:33.449215 finished: writing grid tpl:prsity4.dat\_gr.tpl took: 0:00:00.011593  
 2019-06-05 22:24:33.451941 starting: writing grid tpl:hk5.dat\_gr.tpl  
 2019-06-05 22:24:33.460819 finished: writing grid tpl:hk5.dat\_gr.tpl took: 0:00:00.008878  
 2019-06-05 22:24:33.463765 starting: writing grid tpl:vka5.dat\_gr.tpl  
 2019-06-05 22:24:33.472812 finished: writing grid tpl:vka5.dat\_gr.tpl took: 0:00:00.009047  
 2019-06-05 22:24:33.476463 starting: writing grid tpl:ss5.dat\_gr.tpl  
 2019-06-05 22:24:33.485717 finished: writing grid tpl:ss5.dat\_gr.tpl took: 0:00:00.009254  
 2019-06-05 22:24:33.488362 starting: writing grid tpl:sy5.dat\_gr.tpl  
 2019-06-05 22:24:33.497691 finished: writing grid tpl:sy5.dat\_gr.tpl took: 0:00:00.009329  
 2019-06-05 22:24:33.500500 starting: writing grid tpl:strt5.dat\_gr.tpl  
 2019-06-05 22:24:33.509569 finished: writing grid tpl:strt5.dat\_gr.tpl took: 0:00:00.009069  
 2019-06-05 22:24:33.512538 starting: writing grid tpl:prsity5.dat\_gr.tpl  
 2019-06-05 22:24:33.524896 finished: writing grid tpl:prsity5.dat\_gr.tpl took: 0:00:00.012358  
 2019-06-05 22:24:33.527624 starting: writing grid tpl:rech2.dat\_gr.tpl  
 2019-06-05 22:24:33.536567 finished: writing grid tpl:rech2.dat\_gr.tpl took: 0:00:00.008943  
 2019-06-05 22:24:33.539267 starting: writing grid tpl:rech3.dat\_gr.tpl  
 2019-06-05 22:24:33.548377 finished: writing grid tpl:rech3.dat\_gr.tpl took: 0:00:00.009110  
 2019-06-05 22:24:33.551110 starting: writing const tpl:hk6.dat\_cn.tpl  
 2019-06-05 22:24:33.557181 finished: writing const tpl:hk6.dat\_cn.tpl took: 0:00:00.006071  
 2019-06-05 22:24:33.559969 starting: writing const tpl:vka6.dat\_cn.tpl  
 2019-06-05 22:24:33.565813 finished: writing const tpl:vka6.dat\_cn.tpl took: 0:00:00.005844  
 2019-06-05 22:24:33.568702 starting: writing const tpl:ss6.dat\_cn.tpl  
 2019-06-05 22:24:33.574841 finished: writing const tpl:ss6.dat\_cn.tpl took: 0:00:00.006139  
 2019-06-05 22:24:33.577558 starting: writing const tpl:sy6.dat\_cn.tpl  
 2019-06-05 22:24:33.583211 finished: writing const tpl:sy6.dat\_cn.tpl took: 0:00:00.005653  
 2019-06-05 22:24:33.585779 starting: writing const tpl:strt6.dat\_cn.tpl  
 2019-06-05 22:24:33.591436 finished: writing const tpl:strt6.dat\_cn.tpl took: 0:00:00.005657  
 2019-06-05 22:24:33.594236 starting: writing const tpl:prsity6.dat\_cn.tpl  
 2019-06-05 22:24:33.600009 finished: writing const tpl:prsity6.dat\_cn.tpl took: 0:00:00.005773  
 2019-06-05 22:24:33.602699 starting: writing const tpl:hk7.dat\_cn.tpl  
 2019-06-05 22:24:33.608443 finished: writing const tpl:hk7.dat\_cn.tpl took: 0:00:00.005744  
 2019-06-05 22:24:33.611104 starting: writing const tpl:vka7.dat\_cn.tpl  
 2019-06-05 22:24:33.617236 finished: writing const tpl:vka7.dat\_cn.tpl took: 0:00:00.006132  
 2019-06-05 22:24:33.620004 starting: writing const tpl:ss7.dat\_cn.tpl  
 2019-06-05 22:24:33.626004 finished: writing const tpl:ss7.dat\_cn.tpl took: 0:00:00.006000  
 2019-06-05 22:24:33.628662 starting: writing const tpl:sy7.dat\_cn.tpl  
 2019-06-05 22:24:33.635487 finished: writing const tpl:sy7.dat\_cn.tpl took: 0:00:00.006825  
 2019-06-05 22:24:33.638175 starting: writing const tpl:strt7.dat\_cn.tpl  
 2019-06-05 22:24:33.645396 finished: writing const tpl:strt7.dat\_cn.tpl took: 0:00:00.007221

```

2019-06-05 22:24:33.648308 starting: writing const tpl:prsity7.dat_cn.tpl
2019-06-05 22:24:33.654015 finished: writing const tpl:prsity7.dat_cn.tpl took: 0:00:00.005707
2019-06-05 22:24:33.656599 starting: writing const tpl:hk8.dat_cn.tpl
2019-06-05 22:24:33.662315 finished: writing const tpl:hk8.dat_cn.tpl took: 0:00:00.005716
2019-06-05 22:24:33.664897 starting: writing const tpl:vka8.dat_cn.tpl
2019-06-05 22:24:33.670593 finished: writing const tpl:vka8.dat_cn.tpl took: 0:00:00.005696
2019-06-05 22:24:33.673410 starting: writing const tpl:ss8.dat_cn.tpl
2019-06-05 22:24:33.679003 finished: writing const tpl:ss8.dat_cn.tpl took: 0:00:00.005593
2019-06-05 22:24:33.682580 starting: writing const tpl:sy8.dat_cn.tpl
2019-06-05 22:24:33.688206 finished: writing const tpl:sy8.dat_cn.tpl took: 0:00:00.005626
2019-06-05 22:24:33.691158 starting: writing const tpl:strt8.dat_cn.tpl
2019-06-05 22:24:33.696869 finished: writing const tpl:strt8.dat_cn.tpl took: 0:00:00.005711
2019-06-05 22:24:33.699475 starting: writing const tpl:prsity8.dat_cn.tpl
2019-06-05 22:24:33.705181 finished: writing const tpl:prsity8.dat_cn.tpl took: 0:00:00.005706
2019-06-05 22:24:33.707800 starting: writing const tpl:rech4.dat_cn.tpl
2019-06-05 22:24:33.713609 finished: writing const tpl:rech4.dat_cn.tpl took: 0:00:00.005809
2019-06-05 22:24:33.716196 starting: writing const tpl:rech5.dat_cn.tpl
2019-06-05 22:24:33.722970 finished: writing const tpl:rech5.dat_cn.tpl took: 0:00:00.006774
2019-06-05 22:24:33.748278 starting: setting up pilot point process
2019-06-05 22:24:33.748824 WARNING: pp_geostrcut is None, using ExpVario with contribution=1 and
2019-06-05 22:24:33.752322 pp_dict: {0: ['hk0', 'prsity0', 'rech0', 'rech1', 'ss0', 'strt0', 'sy0', 'vka0', 'hk1', 'ss1', 'strt1', 'sy1', 'vka1']}
2019-06-05 22:24:33.753129 starting: calling setup_pilot_point_grid()
2019-06-05 22:24:34.348351 640 pilot point parameters created
2019-06-05 22:24:34.349298 pilot point 'pargp':hk0,prsity0,rech0,rech1,ss0,strt0,sy0,vka0,hk1,ss1,strt1,sy1,vka1
2019-06-05 22:24:34.349665 finished: calling setup_pilot_point_grid() took: 0:00:00.596536
2019-06-05 22:24:34.352269 starting: calculating factors for p=hk0, k=0
2019-06-05 22:24:34.353702 saving krige variance file:template/pp_k0_general_zn.fac
2019-06-05 22:24:34.353977 saving krige factors file:template/pp_k0_general_zn.fac
starting interp point loop for 800 points
took 2.438796 seconds
2019-06-05 22:24:36.845254 finished: calculating factors for p=hk0, k=0 took: 0:00:02.492985
2019-06-05 22:24:36.846304 starting: calculating factors for p=prsity0, k=0
2019-06-05 22:24:36.847596 finished: calculating factors for p=prsity0, k=0 took: 0:00:00.001291
2019-06-05 22:24:36.848786 starting: calculating factors for p=rech0, k=0
2019-06-05 22:24:36.849669 finished: calculating factors for p=rech0, k=0 took: 0:00:00.000883
2019-06-05 22:24:36.851004 starting: calculating factors for p=rech1, k=0
2019-06-05 22:24:36.852320 finished: calculating factors for p=rech1, k=0 took: 0:00:00.001316
2019-06-05 22:24:36.853156 starting: calculating factors for p=ss0, k=0
2019-06-05 22:24:36.854063 finished: calculating factors for p=ss0, k=0 took: 0:00:00.000907
2019-06-05 22:24:36.854920 starting: calculating factors for p=strt0, k=0
2019-06-05 22:24:36.855952 finished: calculating factors for p=strt0, k=0 took: 0:00:00.001032
2019-06-05 22:24:36.856838 starting: calculating factors for p=sy0, k=0
2019-06-05 22:24:36.858004 finished: calculating factors for p=sy0, k=0 took: 0:00:00.001166
2019-06-05 22:24:36.858938 starting: calculating factors for p=vka0, k=0
2019-06-05 22:24:36.859846 finished: calculating factors for p=vka0, k=0 took: 0:00:00.000908
2019-06-05 22:24:36.860739 starting: calculating factors for p=hk1, k=1
2019-06-05 22:24:36.861586 saving krige variance file:template/pp_k1_general_zn.fac
2019-06-05 22:24:36.861635 saving krige factors file:template/pp_k1_general_zn.fac

```

```

starting interp point loop for 800 points
took 2.353443 seconds
2019-06-05 22:24:39.271904 finished: calculating factors for p=hk1, k=1 took: 0:00:02.411165
2019-06-05 22:24:39.273197 starting: calculating factors for p=prsity1, k=1
2019-06-05 22:24:39.274159 finished: calculating factors for p=prsity1, k=1 took: 0:00:00.000909
2019-06-05 22:24:39.275108 starting: calculating factors for p=ss1, k=1
2019-06-05 22:24:39.276090 finished: calculating factors for p=ss1, k=1 took: 0:00:00.000982
2019-06-05 22:24:39.276801 starting: calculating factors for p=strt1, k=1
2019-06-05 22:24:39.277692 finished: calculating factors for p=strt1, k=1 took: 0:00:00.000891
2019-06-05 22:24:39.279257 starting: calculating factors for p=sy1, k=1
2019-06-05 22:24:39.280164 finished: calculating factors for p=sy1, k=1 took: 0:00:00.000907
2019-06-05 22:24:39.281020 starting: calculating factors for p=vka1, k=1
2019-06-05 22:24:39.281934 finished: calculating factors for p=vka1, k=1 took: 0:00:00.000914
2019-06-05 22:24:39.282523 starting: calculating factors for p=hk2, k=2
2019-06-05 22:24:39.284259 saving krige variance file:template/pp_k2_general_zn.fac
2019-06-05 22:24:39.284459 saving krige factors file:template/pp_k2_general_zn.fac
starting interp point loop for 800 points
took 2.351857 seconds
2019-06-05 22:24:41.693694 finished: calculating factors for p=hk2, k=2 took: 0:00:02.411171
2019-06-05 22:24:41.694889 starting: calculating factors for p=prsity2, k=2
2019-06-05 22:24:41.696046 finished: calculating factors for p=prsity2, k=2 took: 0:00:00.001111
2019-06-05 22:24:41.697074 starting: calculating factors for p=ss2, k=2
2019-06-05 22:24:41.697949 finished: calculating factors for p=ss2, k=2 took: 0:00:00.000875
2019-06-05 22:24:41.698804 starting: calculating factors for p=strt2, k=2
2019-06-05 22:24:41.700227 finished: calculating factors for p=strt2, k=2 took: 0:00:00.001423
2019-06-05 22:24:41.701122 starting: calculating factors for p=sy2, k=2
2019-06-05 22:24:41.702068 finished: calculating factors for p=sy2, k=2 took: 0:00:00.000946
2019-06-05 22:24:41.702902 starting: calculating factors for p=vka2, k=2
2019-06-05 22:24:41.703884 finished: calculating factors for p=vka2, k=2 took: 0:00:00.000982
2019-06-05 22:24:41.704289 starting: processing pp_prefix:ss0
2019-06-05 22:24:41.714905 starting: processing pp_prefix:ss2
2019-06-05 22:24:41.723035 starting: processing pp_prefix:hk0
2019-06-05 22:24:41.731013 starting: processing pp_prefix:prsity1
2019-06-05 22:24:41.739337 starting: processing pp_prefix:vka0
2019-06-05 22:24:41.747118 starting: processing pp_prefix:strt0
2019-06-05 22:24:41.754888 starting: processing pp_prefix:rech1
2019-06-05 22:24:41.762688 starting: processing pp_prefix:ss1
2019-06-05 22:24:41.770744 starting: processing pp_prefix:sy0
2019-06-05 22:24:41.778477 starting: processing pp_prefix:sy1
2019-06-05 22:24:41.786781 starting: processing pp_prefix:vka2
2019-06-05 22:24:41.794864 starting: processing pp_prefix:hk2
2019-06-05 22:24:41.802665 starting: processing pp_prefix:sy2
2019-06-05 22:24:41.810919 starting: processing pp_prefix:rech0
2019-06-05 22:24:41.818682 starting: processing pp_prefix:vka1
2019-06-05 22:24:41.826483 starting: processing pp_prefix:hk1
2019-06-05 22:24:41.834376 starting: processing pp_prefix:prsity2
2019-06-05 22:24:41.842182 starting: processing pp_prefix:strt1
2019-06-05 22:24:41.849883 starting: processing pp_prefix:strt2

```

```

2019-06-05 22:24:41.857900 starting: processing pp_prefix:prsity0
2019-06-05 22:24:41.959832 finished: setting up pilot point process took: 0:00:08.211554
2019-06-05 22:24:41.960001 starting: setting up grid process
2019-06-05 22:24:41.960068 WARNING: grid_geostruc is None, using ExpVario with contribution=1
2019-06-05 22:24:41.960182 finished: setting up grid process took: 0:00:00.000181
2019-06-05 22:24:41.962859 starting: save test mlt array arr_mlt/hk0.dat_pp
2019-06-05 22:24:41.963872 finished: save test mlt array arr_mlt/hk0.dat_pp took: 0:00:00.0010
2019-06-05 22:24:41.964776 starting: save test mlt array arr_mlt/vka0.dat_pp
2019-06-05 22:24:41.965782 finished: save test mlt array arr_mlt/vka0.dat_pp took: 0:00:00.0010
2019-06-05 22:24:41.966590 starting: save test mlt array arr_mlt/ss0.dat_pp
2019-06-05 22:24:41.967607 finished: save test mlt array arr_mlt/ss0.dat_pp took: 0:00:00.0010
2019-06-05 22:24:41.968402 starting: save test mlt array arr_mlt/sy0.dat_pp
2019-06-05 22:24:41.969514 finished: save test mlt array arr_mlt/sy0.dat_pp took: 0:00:00.0011
2019-06-05 22:24:41.970360 starting: save test mlt array arr_mlt/strt0.dat_pp
2019-06-05 22:24:41.971498 finished: save test mlt array arr_mlt/strt0.dat_pp took: 0:00:00.00
2019-06-05 22:24:41.972333 starting: save test mlt array arr_mlt/prsity0.dat_pp
2019-06-05 22:24:41.973984 finished: save test mlt array arr_mlt/prsity0.dat_pp took: 0:00:00.
2019-06-05 22:24:41.974917 starting: save test mlt array arr_mlt/hk1.dat_pp
2019-06-05 22:24:41.976274 finished: save test mlt array arr_mlt/hk1.dat_pp took: 0:00:00.0013
2019-06-05 22:24:41.977250 starting: save test mlt array arr_mlt/vka1.dat_pp
2019-06-05 22:24:41.978409 finished: save test mlt array arr_mlt/vka1.dat_pp took: 0:00:00.001
2019-06-05 22:24:41.979389 starting: save test mlt array arr_mlt/ss1.dat_pp
2019-06-05 22:24:41.980603 finished: save test mlt array arr_mlt/ss1.dat_pp took: 0:00:00.0012
2019-06-05 22:24:41.981549 starting: save test mlt array arr_mlt/sy1.dat_pp
2019-06-05 22:24:41.982775 finished: save test mlt array arr_mlt/sy1.dat_pp took: 0:00:00.0012
2019-06-05 22:24:41.983559 starting: save test mlt array arr_mlt/strt1.dat_pp
2019-06-05 22:24:41.985023 finished: save test mlt array arr_mlt/strt1.dat_pp took: 0:00:00.00
2019-06-05 22:24:41.985887 starting: save test mlt array arr_mlt/prsity1.dat_pp
2019-06-05 22:24:41.986986 finished: save test mlt array arr_mlt/prsity1.dat_pp took: 0:00:00.
2019-06-05 22:24:41.987855 starting: save test mlt array arr_mlt/hk2.dat_pp
2019-06-05 22:24:41.988949 finished: save test mlt array arr_mlt/hk2.dat_pp took: 0:00:00.0010
2019-06-05 22:24:41.989573 starting: save test mlt array arr_mlt/vka2.dat_pp
2019-06-05 22:24:41.990906 finished: save test mlt array arr_mlt/vka2.dat_pp took: 0:00:00.001
2019-06-05 22:24:41.991760 starting: save test mlt array arr_mlt/ss2.dat_pp
2019-06-05 22:24:41.992838 finished: save test mlt array arr_mlt/ss2.dat_pp took: 0:00:00.0010
2019-06-05 22:24:41.993667 starting: save test mlt array arr_mlt/sy2.dat_pp
2019-06-05 22:24:41.994846 finished: save test mlt array arr_mlt/sy2.dat_pp took: 0:00:00.0011
2019-06-05 22:24:41.995746 starting: save test mlt array arr_mlt/strt2.dat_pp
2019-06-05 22:24:41.997627 finished: save test mlt array arr_mlt/strt2.dat_pp took: 0:00:00.00
2019-06-05 22:24:41.998601 starting: save test mlt array arr_mlt/prsity2.dat_pp
2019-06-05 22:24:42.001198 finished: save test mlt array arr_mlt/prsity2.dat_pp took: 0:00:00.
2019-06-05 22:24:42.002159 starting: save test mlt array arr_mlt/rech0.dat_pp
2019-06-05 22:24:42.003487 finished: save test mlt array arr_mlt/rech0.dat_pp took: 0:00:00.00
2019-06-05 22:24:42.004416 starting: save test mlt array arr_mlt/rech1.dat_pp
2019-06-05 22:24:42.005651 finished: save test mlt array arr_mlt/rech1.dat_pp took: 0:00:00.00
2019-06-05 22:24:42.006875 starting: save test mlt array arr_mlt/hk3.dat_gr
2019-06-05 22:24:42.008609 finished: save test mlt array arr_mlt/hk3.dat_gr took: 0:00:00.0017
2019-06-05 22:24:42.010065 starting: save test mlt array arr_mlt/vka3.dat_gr

```



2019-06-05 22:24:42.011913 finished: save test mlt array arr\_mlt/vka3.dat\_gr took: 0:00:00.0019  
 2019-06-05 22:24:42.013313 starting: save test mlt array arr\_mlt/ss3.dat\_gr  
 2019-06-05 22:24:42.015219 finished: save test mlt array arr\_mlt/ss3.dat\_gr took: 0:00:00.0019  
 2019-06-05 22:24:42.016620 starting: save test mlt array arr\_mlt/sy3.dat\_gr  
 2019-06-05 22:24:42.018356 finished: save test mlt array arr\_mlt/sy3.dat\_gr took: 0:00:00.0017  
 2019-06-05 22:24:42.019603 starting: save test mlt array arr\_mlt/strt3.dat\_gr  
 2019-06-05 22:24:42.021495 finished: save test mlt array arr\_mlt/strt3.dat\_gr took: 0:00:00.0019  
 2019-06-05 22:24:42.022935 starting: save test mlt array arr\_mlt/prsity3.dat\_gr  
 2019-06-05 22:24:42.024717 finished: save test mlt array arr\_mlt/prsity3.dat\_gr took: 0:00:00.0019  
 2019-06-05 22:24:42.026177 starting: save test mlt array arr\_mlt/hk4.dat\_gr  
 2019-06-05 22:24:42.028118 finished: save test mlt array arr\_mlt/hk4.dat\_gr took: 0:00:00.0019  
 2019-06-05 22:24:42.029387 starting: save test mlt array arr\_mlt/vka4.dat\_gr  
 2019-06-05 22:24:42.031471 finished: save test mlt array arr\_mlt/vka4.dat\_gr took: 0:00:00.0020  
 2019-06-05 22:24:42.032855 starting: save test mlt array arr\_mlt/ss4.dat\_gr  
 2019-06-05 22:24:42.034814 finished: save test mlt array arr\_mlt/ss4.dat\_gr took: 0:00:00.0019  
 2019-06-05 22:24:42.036222 starting: save test mlt array arr\_mlt/sy4.dat\_gr  
 2019-06-05 22:24:42.038132 finished: save test mlt array arr\_mlt/sy4.dat\_gr took: 0:00:00.0019  
 2019-06-05 22:24:42.039437 starting: save test mlt array arr\_mlt/strt4.dat\_gr  
 2019-06-05 22:24:42.041495 finished: save test mlt array arr\_mlt/strt4.dat\_gr took: 0:00:00.0020  
 2019-06-05 22:24:42.042911 starting: save test mlt array arr\_mlt/prsity4.dat\_gr  
 2019-06-05 22:24:42.044937 finished: save test mlt array arr\_mlt/prsity4.dat\_gr took: 0:00:00.0020  
 2019-06-05 22:24:42.046299 starting: save test mlt array arr\_mlt/hk5.dat\_gr  
 2019-06-05 22:24:42.048374 finished: save test mlt array arr\_mlt/hk5.dat\_gr took: 0:00:00.0020  
 2019-06-05 22:24:42.049627 starting: save test mlt array arr\_mlt/vka5.dat\_gr  
 2019-06-05 22:24:42.051730 finished: save test mlt array arr\_mlt/vka5.dat\_gr took: 0:00:00.0020  
 2019-06-05 22:24:42.053154 starting: save test mlt array arr\_mlt/ss5.dat\_gr  
 2019-06-05 22:24:42.054924 finished: save test mlt array arr\_mlt/ss5.dat\_gr took: 0:00:00.0017  
 2019-06-05 22:24:42.056240 starting: save test mlt array arr\_mlt/sy5.dat\_gr  
 2019-06-05 22:24:42.058231 finished: save test mlt array arr\_mlt/sy5.dat\_gr took: 0:00:00.0019  
 2019-06-05 22:24:42.059790 starting: save test mlt array arr\_mlt/strt5.dat\_gr  
 2019-06-05 22:24:42.061642 finished: save test mlt array arr\_mlt/strt5.dat\_gr took: 0:00:00.0020  
 2019-06-05 22:24:42.063115 starting: save test mlt array arr\_mlt/prsity5.dat\_gr  
 2019-06-05 22:24:42.065204 finished: save test mlt array arr\_mlt/prsity5.dat\_gr took: 0:00:00.0020  
 2019-06-05 22:24:42.066448 starting: save test mlt array arr\_mlt/rech2.dat\_gr  
 2019-06-05 22:24:42.068464 finished: save test mlt array arr\_mlt/rech2.dat\_gr took: 0:00:00.0020  
 2019-06-05 22:24:42.070038 starting: save test mlt array arr\_mlt/rech3.dat\_gr  
 2019-06-05 22:24:42.072018 finished: save test mlt array arr\_mlt/rech3.dat\_gr took: 0:00:00.0020  
 2019-06-05 22:24:42.073340 starting: save test mlt array arr\_mlt/hk6.dat\_cn  
 2019-06-05 22:24:42.075404 finished: save test mlt array arr\_mlt/hk6.dat\_cn took: 0:00:00.0020  
 2019-06-05 22:24:42.076861 starting: save test mlt array arr\_mlt/vka6.dat\_cn  
 2019-06-05 22:24:42.079371 finished: save test mlt array arr\_mlt/vka6.dat\_cn took: 0:00:00.0020  
 2019-06-05 22:24:42.081030 starting: save test mlt array arr\_mlt/ss6.dat\_cn  
 2019-06-05 22:24:42.083040 finished: save test mlt array arr\_mlt/ss6.dat\_cn took: 0:00:00.0020  
 2019-06-05 22:24:42.084373 starting: save test mlt array arr\_mlt/sy6.dat\_cn  
 2019-06-05 22:24:42.086393 finished: save test mlt array arr\_mlt/sy6.dat\_cn took: 0:00:00.0020  
 2019-06-05 22:24:42.087909 starting: save test mlt array arr\_mlt/strt6.dat\_cn  
 2019-06-05 22:24:42.089941 finished: save test mlt array arr\_mlt/strt6.dat\_cn took: 0:00:00.0020  
 2019-06-05 22:24:42.091386 starting: save test mlt array arr\_mlt/prsity6.dat\_cn

```

2019-06-05 22:24:42.093213 finished: save test mlt array arr_mlt/prsity6.dat_cn took: 0:00:00.
2019-06-05 22:24:42.094670 starting: save test mlt array arr_mlt/hk7.dat_cn
2019-06-05 22:24:42.096686 finished: save test mlt array arr_mlt/hk7.dat_cn took: 0:00:00.0020
2019-06-05 22:24:42.097998 starting: save test mlt array arr_mlt/vka7.dat_cn
2019-06-05 22:24:42.100011 finished: save test mlt array arr_mlt/vka7.dat_cn took: 0:00:00.002
2019-06-05 22:24:42.101541 starting: save test mlt array arr_mlt/ss7.dat_cn
2019-06-05 22:24:42.103290 finished: save test mlt array arr_mlt/ss7.dat_cn took: 0:00:00.0017
2019-06-05 22:24:42.104931 starting: save test mlt array arr_mlt/sy7.dat_cn
2019-06-05 22:24:42.106795 finished: save test mlt array arr_mlt/sy7.dat_cn took: 0:00:00.0018
2019-06-05 22:24:42.108394 starting: save test mlt array arr_mlt/strt7.dat_cn
2019-06-05 22:24:42.110255 finished: save test mlt array arr_mlt/strt7.dat_cn took: 0:00:00.00
2019-06-05 22:24:42.111652 starting: save test mlt array arr_mlt/prsity7.dat_cn
2019-06-05 22:24:42.113705 finished: save test mlt array arr_mlt/prsity7.dat_cn took: 0:00:00.
2019-06-05 22:24:42.115062 starting: save test mlt array arr_mlt/hk8.dat_cn
2019-06-05 22:24:42.116904 finished: save test mlt array arr_mlt/hk8.dat_cn took: 0:00:00.0018
2019-06-05 22:24:42.118118 starting: save test mlt array arr_mlt/vka8.dat_cn
2019-06-05 22:24:42.119902 finished: save test mlt array arr_mlt/vka8.dat_cn took: 0:00:00.001
2019-06-05 22:24:42.121296 starting: save test mlt array arr_mlt/ss8.dat_cn
2019-06-05 22:24:42.123075 finished: save test mlt array arr_mlt/ss8.dat_cn took: 0:00:00.0017
2019-06-05 22:24:42.124477 starting: save test mlt array arr_mlt/sy8.dat_cn
2019-06-05 22:24:42.126397 finished: save test mlt array arr_mlt/sy8.dat_cn took: 0:00:00.0019
2019-06-05 22:24:42.127741 starting: save test mlt array arr_mlt/strt8.dat_cn
2019-06-05 22:24:42.129785 finished: save test mlt array arr_mlt/strt8.dat_cn took: 0:00:00.00
2019-06-05 22:24:42.131191 starting: save test mlt array arr_mlt/prsity8.dat_cn
2019-06-05 22:24:42.133244 finished: save test mlt array arr_mlt/prsity8.dat_cn took: 0:00:00.
2019-06-05 22:24:42.134494 starting: save test mlt array arr_mlt/rech4.dat_cn
2019-06-05 22:24:42.136390 finished: save test mlt array arr_mlt/rech4.dat_cn took: 0:00:00.00
2019-06-05 22:24:42.137843 starting: save test mlt array arr_mlt/rech5.dat_cn
2019-06-05 22:24:42.139605 finished: save test mlt array arr_mlt/rech5.dat_cn took: 0:00:00.00
2019-06-05 22:24:42.747136 forward_run line:pyemu.helpers.apply_array_pars()

all zeros for runoff...skipping...
all zeros for hcond1...skipping...
all zeros for ppts...skipping...
2019-06-05 22:24:42.901062 starting: processing obs type mflist water budget obs
2019-06-05 22:24:43.015152 forward_run line:pyemu.gw_utils.apply_mflist_budget_obs('freyberg.l
2019-06-05 22:24:43.015592 finished: processing obs type mflist water budget obs took: 0:00:00
2019-06-05 22:24:43.015662 starting: processing obs type hyd file
2019-06-05 22:24:43.015755 finished: processing obs type hyd file took: 0:00:00.000093
2019-06-05 22:24:43.016273 starting: processing obs type external obs-sim smp files
2019-06-05 22:24:43.016365 finished: processing obs type external obs-sim smp files took: 0:00
2019-06-05 22:24:43.016412 starting: processing obs type hob
2019-06-05 22:24:43.016678 finished: processing obs type hob took: 0:00:00.000266
2019-06-05 22:24:43.016738 starting: processing obs type hds
[[0, 0], [0, 1], [0, 2], [1, 0], [1, 1], [1, 2]]
2019-06-05 22:24:43.420118 finished: processing obs type hds took: 0:00:00.403380
2019-06-05 22:24:43.420630 starting: processing obs type sfr
writing 'sfr_obs.config' to template/sfr_obs.config

```

```

2019-06-05 22:24:43.836962 finished: processing obs type sfr took: 0:00:00.416332
2019-06-05 22:24:43.837494 changing dir in to template
2019-06-05 22:24:43.838269 starting: instantiating control file from i/o files
2019-06-05 22:24:43.838362 tpl files: drn.csv.tpl,wel.csv.tpl,hk3.dat_gr.tpl,vka3.dat_gr.tpl,s
2019-06-05 22:24:43.838407 ins files: freyberg.hds.dat.ins,vol.dat.ins,freyberg.sfr.out.proces
2019-06-05 22:24:44.174500 finished: instantiating control file from i/o files took: 0:00:00.3
2019-06-05 22:24:44.398912 starting: writing forward_run.py
2019-06-05 22:24:44.400627 finished: writing forward_run.py took: 0:00:00.001715
2019-06-05 22:24:44.401026 writing pst template/freyberg.pst
noptmax:0, npar_adj:14819, nnz_obs:4434
2019-06-05 22:24:46.057742 starting: running pestchek on freyberg.pst
2019-06-05 22:24:46.134984 pestcheck:PESTCHEK Version 13.0. Watermark Numerical Computing.
2019-06-05 22:24:46.135338 pestcheck:
2019-06-05 22:24:46.135395 pestcheck:Errors ----->
2019-06-05 22:24:46.135455 pestcheck:Line 2403 of file freyberg.pst: parameter name "prsity300
2019-06-05 22:24:46.135494 pestcheck:12 characters long.
2019-06-05 22:24:46.135555 pestcheck:Line 2404 of file freyberg.pst: parameter name "prsity300
2019-06-05 22:24:46.135988 pestcheck:12 characters long.
2019-06-05 22:24:46.136052 pestcheck:Line 2404 of file freyberg.pst: parameter name "prsity300
2019-06-05 22:24:46.136093 pestcheck:once.
2019-06-05 22:24:46.136141 pestcheck:Line 2405 of file freyberg.pst: parameter name "prsity300
2019-06-05 22:24:46.136194 pestcheck:12 characters long.
2019-06-05 22:24:46.136229 pestcheck:Line 2405 of file freyberg.pst: parameter name "prsity300
2019-06-05 22:24:46.136354 pestcheck:once.
2019-06-05 22:24:46.136390 pestcheck:Line 2406 of file freyberg.pst: parameter name "prsity300
2019-06-05 22:24:46.136441 pestcheck:12 characters long.
2019-06-05 22:24:46.136476 pestcheck:Line 2406 of file freyberg.pst: parameter name "prsity300
2019-06-05 22:24:46.136535 pestcheck:once.
2019-06-05 22:24:46.136572 pestcheck:Line 2407 of file freyberg.pst: parameter name "prsity300
2019-06-05 22:24:46.136637 pestcheck:12 characters long.
2019-06-05 22:24:46.136672 pestcheck:Line 2407 of file freyberg.pst: parameter name "prsity300
2019-06-05 22:24:46.136809 pestcheck:once.
2019-06-05 22:24:46.136846 pestcheck:Line 2408 of file freyberg.pst: parameter name "prsity300
2019-06-05 22:24:46.136897 pestcheck:12 characters long.
2019-06-05 22:24:46.136932 pestcheck:Line 2408 of file freyberg.pst: parameter name "prsity300
2019-06-05 22:24:46.137052 pestcheck:once.
2019-06-05 22:24:46.137093 pestcheck:Line 2409 of file freyberg.pst: parameter name "prsity300
2019-06-05 22:24:46.137131 pestcheck:12 characters long.
2019-06-05 22:24:46.137174 pestcheck:Line 2409 of file freyberg.pst: parameter name "prsity300
2019-06-05 22:24:46.137208 pestcheck:once.
2019-06-05 22:24:46.137270 pestcheck:Line 2410 of file freyberg.pst: parameter name "prsity300
2019-06-05 22:24:46.137388 pestcheck:12 characters long.
2019-06-05 22:24:46.137442 pestcheck:Line 2410 of file freyberg.pst: parameter name "prsity300
2019-06-05 22:24:46.137498 pestcheck:once.
2019-06-05 22:24:46.137654 pestcheck:Line 2411 of file freyberg.pst: parameter name "prsity300
2019-06-05 22:24:46.137998 pestcheck:12 characters long.
2019-06-05 22:24:46.138273 pestcheck:Line 2411 of file freyberg.pst: parameter name "prsity300
2019-06-05 22:24:46.138388 pestcheck:once.

```

2019-06-05 22:24:46.138452 pestcheck:Line 2412 of file freyberg.pst: parameter name "prsity3000  
2019-06-05 22:24:46.138572 pestcheck:12 characters long.  
2019-06-05 22:24:46.138673 pestcheck:Line 2412 of file freyberg.pst: parameter name "prsity3000  
2019-06-05 22:24:46.138724 pestcheck:once.  
2019-06-05 22:24:46.138765 pestcheck:Line 2413 of file freyberg.pst: parameter name "prsity3000  
2019-06-05 22:24:46.138870 pestcheck:12 characters long.  
2019-06-05 22:24:46.139196 pestcheck:Line 2414 of file freyberg.pst: parameter name "prsity3000  
2019-06-05 22:24:46.139357 pestcheck:12 characters long.  
2019-06-05 22:24:46.139457 pestcheck:Line 2414 of file freyberg.pst: parameter name "prsity3000  
2019-06-05 22:24:46.139570 pestcheck:once.  
2019-06-05 22:24:46.139621 pestcheck:Line 2415 of file freyberg.pst: parameter name "prsity3000  
2019-06-05 22:24:46.139731 pestcheck:12 characters long.  
2019-06-05 22:24:46.139786 pestcheck:Line 2415 of file freyberg.pst: parameter name "prsity3000  
2019-06-05 22:24:46.139886 pestcheck:once.  
2019-06-05 22:24:46.139938 pestcheck:Line 2416 of file freyberg.pst: parameter name "prsity3000  
2019-06-05 22:24:46.140049 pestcheck:12 characters long.  
2019-06-05 22:24:46.140158 pestcheck:Line 2416 of file freyberg.pst: parameter name "prsity3000  
2019-06-05 22:24:46.140279 pestcheck:once.  
2019-06-05 22:24:46.140473 pestcheck:Line 2417 of file freyberg.pst: parameter name "prsity3000  
2019-06-05 22:24:46.140583 pestcheck:12 characters long.  
2019-06-05 22:24:46.140702 pestcheck:Line 2417 of file freyberg.pst: parameter name "prsity3000  
2019-06-05 22:24:46.140812 pestcheck:once.  
2019-06-05 22:24:46.140863 pestcheck:Line 2418 of file freyberg.pst: parameter name "prsity3000  
2019-06-05 22:24:46.140904 pestcheck:12 characters long.  
2019-06-05 22:24:46.141009 pestcheck:Line 2418 of file freyberg.pst: parameter name "prsity3000  
2019-06-05 22:24:46.141118 pestcheck:once.  
2019-06-05 22:24:46.141167 pestcheck:Line 2419 of file freyberg.pst: parameter name "prsity3000  
2019-06-05 22:24:46.141279 pestcheck:12 characters long.  
2019-06-05 22:24:46.141474 pestcheck:Line 2419 of file freyberg.pst: parameter name "prsity3000  
2019-06-05 22:24:46.141584 pestcheck:once.  
2019-06-05 22:24:46.141704 pestcheck:Line 2420 of file freyberg.pst: parameter name "prsity3000  
2019-06-05 22:24:46.141817 pestcheck:12 characters long.  
2019-06-05 22:24:46.141936 pestcheck:Line 2420 of file freyberg.pst: parameter name "prsity3000  
2019-06-05 22:24:46.141991 pestcheck:once.  
2019-06-05 22:24:46.142091 pestcheck:Line 2421 of file freyberg.pst: parameter name "prsity3000  
2019-06-05 22:24:46.142159 pestcheck:12 characters long.  
2019-06-05 22:24:46.142255 pestcheck:Line 2421 of file freyberg.pst: parameter name "prsity3000  
2019-06-05 22:24:46.142375 pestcheck:once.  
2019-06-05 22:24:46.142425 pestcheck:Line 2422 of file freyberg.pst: parameter name "prsity3000  
2019-06-05 22:24:46.142535 pestcheck:12 characters long.  
2019-06-05 22:24:46.142644 pestcheck:Line 2422 of file freyberg.pst: parameter name "prsity3000  
2019-06-05 22:24:46.142697 pestcheck:once.  
2019-06-05 22:24:46.142805 pestcheck:Line 2423 of file freyberg.pst: parameter name "prsity3000  
2019-06-05 22:24:46.142914 pestcheck:12 characters long.  
2019-06-05 22:24:46.143032 pestcheck:Line 2424 of file freyberg.pst: parameter name "prsity3000  
2019-06-05 22:24:46.143142 pestcheck:12 characters long.  
2019-06-05 22:24:46.143194 pestcheck:Line 2424 of file freyberg.pst: parameter name "prsity3000  
2019-06-05 22:24:46.143302 pestcheck:once.

2019-06-05 22:24:46.143435 pestcheck:Line 2425 of file freyberg.pst: parameter name "prsity300.  
2019-06-05 22:24:46.143543 pestcheck:12 characters long.  
2019-06-05 22:24:46.143654 pestcheck:Line 2425 of file freyberg.pst: parameter name "prsity300.  
2019-06-05 22:24:46.143703 pestcheck:once.  
2019-06-05 22:24:46.143743 pestcheck:Line 2426 of file freyberg.pst: parameter name "prsity300.  
2019-06-05 22:24:46.143849 pestcheck:12 characters long.  
2019-06-05 22:24:46.143962 pestcheck:Line 2426 of file freyberg.pst: parameter name "prsity300.  
2019-06-05 22:24:46.144014 pestcheck:once.  
2019-06-05 22:24:46.144073 pestcheck:Line 2427 of file freyberg.pst: parameter name "prsity300.  
2019-06-05 22:24:46.144169 pestcheck:12 characters long.  
2019-06-05 22:24:46.144278 pestcheck:Line 2427 of file freyberg.pst: parameter name "prsity300.  
2019-06-05 22:24:46.144402 pestcheck:once.  
2019-06-05 22:24:46.144512 pestcheck:Line 2428 of file freyberg.pst: parameter name "prsity300.  
2019-06-05 22:24:46.144564 pestcheck:12 characters long.  
2019-06-05 22:24:46.144604 pestcheck:Line 2428 of file freyberg.pst: parameter name "prsity300.  
2019-06-05 22:24:46.144722 pestcheck:once.  
2019-06-05 22:24:46.144828 pestcheck:Line 2429 of file freyberg.pst: parameter name "prsity300.  
2019-06-05 22:24:46.144878 pestcheck:12 characters long.  
2019-06-05 22:24:46.144982 pestcheck:Line 2429 of file freyberg.pst: parameter name "prsity300.  
2019-06-05 22:24:46.145089 pestcheck:once.  
2019-06-05 22:24:46.145137 pestcheck:Line 2430 of file freyberg.pst: parameter name "prsity300.  
2019-06-05 22:24:46.145242 pestcheck:12 characters long.  
2019-06-05 22:24:46.145354 pestcheck:Line 2430 of file freyberg.pst: parameter name "prsity300.  
2019-06-05 22:24:46.145402 pestcheck:once.  
2019-06-05 22:24:46.145442 pestcheck:Line 2431 of file freyberg.pst: parameter name "prsity300.  
2019-06-05 22:24:46.145543 pestcheck:12 characters long.  
2019-06-05 22:24:46.145649 pestcheck:Line 2431 of file freyberg.pst: parameter name "prsity300.  
2019-06-05 22:24:46.145764 pestcheck:once.  
2019-06-05 22:24:46.145870 pestcheck:Line 2432 of file freyberg.pst: parameter name "prsity300.  
2019-06-05 22:24:46.145918 pestcheck:12 characters long.  
2019-06-05 22:24:46.146023 pestcheck:Line 2432 of file freyberg.pst: parameter name "prsity300.  
2019-06-05 22:24:46.146128 pestcheck:once.  
2019-06-05 22:24:46.146244 pestcheck:Line 2433 of file freyberg.pst: parameter name "prsity300.  
2019-06-05 22:24:46.146370 pestcheck:12 characters long.  
2019-06-05 22:24:46.146410 pestcheck:Line 2434 of file freyberg.pst: parameter name "prsity300.  
2019-06-05 22:24:46.146511 pestcheck:12 characters long.  
2019-06-05 22:24:46.146618 pestcheck:Line 2434 of file freyberg.pst: parameter name "prsity300.  
2019-06-05 22:24:46.146669 pestcheck:once.  
2019-06-05 22:24:46.146774 pestcheck:Line 2435 of file freyberg.pst: parameter name "prsity300.  
2019-06-05 22:24:46.146883 pestcheck:12 characters long.  
2019-06-05 22:24:46.146999 pestcheck:Line 2435 of file freyberg.pst: parameter name "prsity300.  
2019-06-05 22:24:46.147107 pestcheck:once.  
2019-06-05 22:24:46.147224 pestcheck:Line 2436 of file freyberg.pst: parameter name "prsity300.  
2019-06-05 22:24:46.147309 pestcheck:12 characters long.  
2019-06-05 22:24:46.147382 pestcheck:Line 2436 of file freyberg.pst: parameter name "prsity300.  
2019-06-05 22:24:46.147430 pestcheck:once.  
2019-06-05 22:24:46.147537 pestcheck:Line 2437 of file freyberg.pst: parameter name "prsity300.  
2019-06-05 22:24:46.147644 pestcheck:12 characters long.

2019-06-05 22:24:46.147694 pestcheck:Line 2437 of file freyberg.pst: parameter name "prsity300  
2019-06-05 22:24:46.147734 pestcheck:once.  
2019-06-05 22:24:46.147837 pestcheck:Line 2438 of file freyberg.pst: parameter name "prsity300  
2019-06-05 22:24:46.147944 pestcheck:12 characters long.  
2019-06-05 22:24:46.147991 pestcheck:Line 2438 of file freyberg.pst: parameter name "prsity300  
2019-06-05 22:24:46.148031 pestcheck:once.  
2019-06-05 22:24:46.148133 pestcheck:Line 2439 of file freyberg.pst: parameter name "prsity300  
2019-06-05 22:24:46.148240 pestcheck:12 characters long.  
2019-06-05 22:24:46.148360 pestcheck:Line 2439 of file freyberg.pst: parameter name "prsity300  
2019-06-05 22:24:46.148466 pestcheck:once.  
2019-06-05 22:24:46.148581 pestcheck:Line 2440 of file freyberg.pst: parameter name "prsity300  
2019-06-05 22:24:46.148691 pestcheck:12 characters long.  
2019-06-05 22:24:46.148739 pestcheck:Line 2440 of file freyberg.pst: parameter name "prsity300  
2019-06-05 22:24:46.148851 pestcheck:once.  
2019-06-05 22:24:46.148958 pestcheck:Line 2441 of file freyberg.pst: parameter name "prsity300  
2019-06-05 22:24:46.149006 pestcheck:12 characters long.  
2019-06-05 22:24:46.149113 pestcheck:Line 2441 of file freyberg.pst: parameter name "prsity300  
2019-06-05 22:24:46.149223 pestcheck:once.  
2019-06-05 22:24:46.149344 pestcheck:Line 2442 of file freyberg.pst: parameter name "prsity300  
2019-06-05 22:24:46.149451 pestcheck:12 characters long.  
2019-06-05 22:24:46.149508 pestcheck:Line 2442 of file freyberg.pst: parameter name "prsity300  
2019-06-05 22:24:46.149599 pestcheck:once.  
2019-06-05 22:24:46.149706 pestcheck:Line 2443 of file freyberg.pst: parameter name "prsity300  
2019-06-05 22:24:46.149758 pestcheck:12 characters long.  
2019-06-05 22:24:46.149865 pestcheck:Line 2444 of file freyberg.pst: parameter name "prsity300  
2019-06-05 22:24:46.149971 pestcheck:12 characters long.  
2019-06-05 22:24:46.150019 pestcheck:Line 2444 of file freyberg.pst: parameter name "prsity300  
2019-06-05 22:24:46.150125 pestcheck:once.  
2019-06-05 22:24:46.150232 pestcheck:Line 2445 of file freyberg.pst: parameter name "prsity300  
2019-06-05 22:24:46.150353 pestcheck:12 characters long.  
2019-06-05 22:24:46.150463 pestcheck:Line 2445 of file freyberg.pst: parameter name "prsity300  
2019-06-05 22:24:46.150511 pestcheck:once.  
2019-06-05 22:24:46.150550 pestcheck:Line 2446 of file freyberg.pst: parameter name "prsity300  
2019-06-05 22:24:46.150652 pestcheck:12 characters long.  
2019-06-05 22:24:46.150759 pestcheck:Line 2446 of file freyberg.pst: parameter name "prsity300  
2019-06-05 22:24:46.150806 pestcheck:once.  
2019-06-05 22:24:46.150911 pestcheck:Line 2447 of file freyberg.pst: parameter name "prsity300  
2019-06-05 22:24:46.150963 pestcheck:12 characters long.  
2019-06-05 22:24:46.151059 pestcheck:Line 2447 of file freyberg.pst: parameter name "prsity300  
2019-06-05 22:24:46.151107 pestcheck:once.  
2019-06-05 22:24:46.151248 pestcheck:Line 2448 of file freyberg.pst: parameter name "prsity300  
2019-06-05 22:24:46.151365 pestcheck:12 characters long.  
2019-06-05 22:24:46.151470 pestcheck:Line 2448 of file freyberg.pst: parameter name "prsity300  
2019-06-05 22:24:46.151523 pestcheck:once.  
2019-06-05 22:24:46.151620 pestcheck:Line 2449 of file freyberg.pst: parameter name "prsity300  
2019-06-05 22:24:46.151668 pestcheck:12 characters long.  
2019-06-05 22:24:46.151707 pestcheck:Line 2449 of file freyberg.pst: parameter name "prsity300  
2019-06-05 22:24:46.151809 pestcheck:once.

2019-06-05 22:24:46.151861 pestcheck:Line 2450 of file freyberg.pst: parameter name "prsity3002  
2019-06-05 22:24:46.151958 pestcheck:12 characters long.  
2019-06-05 22:24:46.152006 pestcheck:Line 2450 of file freyberg.pst: parameter name "prsity3002  
2019-06-05 22:24:46.152045 pestcheck:once.  
2019-06-05 22:24:46.152147 pestcheck:Line 2451 of file freyberg.pst: parameter name "prsity3002  
2019-06-05 22:24:46.152254 pestcheck:12 characters long.  
2019-06-05 22:24:46.152374 pestcheck:Line 2451 of file freyberg.pst: parameter name "prsity3002  
2019-06-05 22:24:46.152428 pestcheck:once.  
2019-06-05 22:24:46.152525 pestcheck:Line 2452 of file freyberg.pst: parameter name "prsity3002  
2019-06-05 22:24:46.152573 pestcheck:12 characters long.  
2019-06-05 22:24:46.152678 pestcheck:Line 2452 of file freyberg.pst: parameter name "prsity3002  
2019-06-05 22:24:46.152730 pestcheck:once.  
2019-06-05 22:24:46.152826 pestcheck:Line 2453 of file freyberg.pst: parameter name "prsity3002  
2019-06-05 22:24:46.152874 pestcheck:12 characters long.  
2019-06-05 22:24:46.152914 pestcheck:Line 2454 of file freyberg.pst: parameter name "prsity3002  
2019-06-05 22:24:46.153016 pestcheck:12 characters long.  
2019-06-05 22:24:46.153069 pestcheck:Line 2454 of file freyberg.pst: parameter name "prsity3002  
2019-06-05 22:24:46.153166 pestcheck:once.  
2019-06-05 22:24:46.153214 pestcheck:Line 2455 of file freyberg.pst: parameter name "prsity3002  
2019-06-05 22:24:46.153253 pestcheck:12 characters long.  
2019-06-05 22:24:46.153377 pestcheck:Line 2455 of file freyberg.pst: parameter name "prsity3002  
2019-06-05 22:24:46.153474 pestcheck:once.  
2019-06-05 22:24:46.153586 pestcheck:Line 2456 of file freyberg.pst: parameter name "prsity3002  
2019-06-05 22:24:46.153640 pestcheck:12 characters long.  
2019-06-05 22:24:46.153737 pestcheck:Line 2456 of file freyberg.pst: parameter name "prsity3002  
2019-06-05 22:24:46.153785 pestcheck:once.  
2019-06-05 22:24:46.153824 pestcheck:Line 2457 of file freyberg.pst: parameter name "prsity3002  
2019-06-05 22:24:46.153926 pestcheck:12 characters long.  
2019-06-05 22:24:46.153977 pestcheck:Line 2457 of file freyberg.pst: parameter name "prsity3002  
2019-06-05 22:24:46.154073 pestcheck:once.  
2019-06-05 22:24:46.154189 pestcheck:Line 2458 of file freyberg.pst: parameter name "prsity3002  
2019-06-05 22:24:46.154296 pestcheck:12 characters long.  
2019-06-05 22:24:46.154355 pestcheck:Line 2458 of file freyberg.pst: parameter name "prsity3002  
2019-06-05 22:24:46.154457 pestcheck:once.  
2019-06-05 22:24:46.154563 pestcheck:Line 2459 of file freyberg.pst: parameter name "prsity3002  
2019-06-05 22:24:46.154611 pestcheck:12 characters long.  
2019-06-05 22:24:46.154650 pestcheck:Line 2459 of file freyberg.pst: parameter name "prsity3002  
2019-06-05 22:24:46.154753 pestcheck:once.  
2019-06-05 22:24:46.154805 pestcheck:Line 2460 of file freyberg.pst: parameter name "prsity3002  
2019-06-05 22:24:46.154901 pestcheck:12 characters long.  
2019-06-05 22:24:46.154949 pestcheck:Line 2460 of file freyberg.pst: parameter name "prsity3002  
2019-06-05 22:24:46.154988 pestcheck:once.  
2019-06-05 22:24:46.155090 pestcheck:Line 2461 of file freyberg.pst: parameter name "prsity3002  
2019-06-05 22:24:46.155197 pestcheck:12 characters long.  
2019-06-05 22:24:46.155245 pestcheck:Line 2461 of file freyberg.pst: parameter name "prsity3002  
2019-06-05 22:24:46.155284 pestcheck:once.  
2019-06-05 22:24:46.155407 pestcheck:Line 2462 of file freyberg.pst: parameter name "prsity3002  
2019-06-05 22:24:46.155503 pestcheck:12 characters long.

2019-06-05 22:24:46.155554 pestcheck:Line 2462 of file freyberg.pst: parameter name "prsity3003  
2019-06-05 22:24:46.155661 pestcheck:once.  
2019-06-05 22:24:46.155713 pestcheck:Line 2463 of file freyberg.pst: parameter name "prsity3003  
2019-06-05 22:24:46.155808 pestcheck:12 characters long.  
2019-06-05 22:24:46.155857 pestcheck:Line 2464 of file freyberg.pst: parameter name "prsity3003  
2019-06-05 22:24:46.155963 pestcheck:12 characters long.  
2019-06-05 22:24:46.156070 pestcheck:Line 2464 of file freyberg.pst: parameter name "prsity3003  
2019-06-05 22:24:46.156189 pestcheck:once.  
2019-06-05 22:24:46.156296 pestcheck:Line 2465 of file freyberg.pst: parameter name "prsity3003  
2019-06-05 22:24:46.156423 pestcheck:12 characters long.  
2019-06-05 22:24:46.156476 pestcheck:Line 2465 of file freyberg.pst: parameter name "prsity3003  
2019-06-05 22:24:46.156573 pestcheck:once.  
2019-06-05 22:24:46.156689 pestcheck:Line 2466 of file freyberg.pst: parameter name "prsity3003  
2019-06-05 22:24:46.156742 pestcheck:12 characters long.  
2019-06-05 22:24:46.156838 pestcheck:Line 2466 of file freyberg.pst: parameter name "prsity3003  
2019-06-05 22:24:46.156887 pestcheck:once.  
2019-06-05 22:24:46.156994 pestcheck:Line 2467 of file freyberg.pst: parameter name "prsity3003  
2019-06-05 22:24:46.157046 pestcheck:12 characters long.  
2019-06-05 22:24:46.157142 pestcheck:Line 2467 of file freyberg.pst: parameter name "prsity3003  
2019-06-05 22:24:46.157257 pestcheck:once.  
2019-06-05 22:24:46.157372 pestcheck:Line 2468 of file freyberg.pst: parameter name "prsity3003  
2019-06-05 22:24:46.157424 pestcheck:12 characters long.  
2019-06-05 22:24:46.157531 pestcheck:Line 2468 of file freyberg.pst: parameter name "prsity3003  
2019-06-05 22:24:46.157640 pestcheck:once.  
2019-06-05 22:24:46.157753 pestcheck:Line 2469 of file freyberg.pst: parameter name "prsity3003  
2019-06-05 22:24:46.157806 pestcheck:12 characters long.  
2019-06-05 22:24:46.157903 pestcheck:Line 2469 of file freyberg.pst: parameter name "prsity3003  
2019-06-05 22:24:46.157951 pestcheck:once.  
2019-06-05 22:24:46.158058 pestcheck:Line 2470 of file freyberg.pst: parameter name "prsity3003  
2019-06-05 22:24:46.158165 pestcheck:12 characters long.  
2019-06-05 22:24:46.158215 pestcheck:Line 2470 of file freyberg.pst: parameter name "prsity3003  
2019-06-05 22:24:46.158321 pestcheck:once.  
2019-06-05 22:24:46.158438 pestcheck:Line 2471 of file freyberg.pst: parameter name "prsity3003  
2019-06-05 22:24:46.158490 pestcheck:12 characters long.  
2019-06-05 22:24:46.158532 pestcheck:Line 2471 of file freyberg.pst: parameter name "prsity3003  
2019-06-05 22:24:46.158635 pestcheck:once.  
2019-06-05 22:24:46.158742 pestcheck:Line 2472 of file freyberg.pst: parameter name "prsity3003  
2019-06-05 22:24:46.158790 pestcheck:12 characters long.  
2019-06-05 22:24:46.158829 pestcheck:Line 2472 of file freyberg.pst: parameter name "prsity3003  
2019-06-05 22:24:46.158936 pestcheck:once.  
2019-06-05 22:24:46.159045 pestcheck:Line 2473 of file freyberg.pst: parameter name "prsity3003  
2019-06-05 22:24:46.159100 pestcheck:12 characters long.  
2019-06-05 22:24:46.159178 pestcheck:Line 2474 of file freyberg.pst: parameter name "prsity3003  
2019-06-05 22:24:46.159343 pestcheck:12 characters long.  
2019-06-05 22:24:46.159525 pestcheck:Line 2474 of file freyberg.pst: parameter name "prsity3003  
2019-06-05 22:24:46.159591 pestcheck:once.  
2019-06-05 22:24:46.159658 pestcheck:Line 2475 of file freyberg.pst: parameter name "prsity3003  
2019-06-05 22:24:46.159763 pestcheck:12 characters long.



2019-06-05 22:24:46.159818 pestcheck:Line 2475 of file freyberg.pst: parameter name "prsity3003  
2019-06-05 22:24:46.159943 pestcheck:once.  
2019-06-05 22:24:46.160022 pestcheck:Line 2476 of file freyberg.pst: parameter name "prsity3003  
2019-06-05 22:24:46.160090 pestcheck:12 characters long.  
2019-06-05 22:24:46.160200 pestcheck:Line 2476 of file freyberg.pst: parameter name "prsity3003  
2019-06-05 22:24:46.160254 pestcheck:once.  
2019-06-05 22:24:46.160358 pestcheck:Line 2477 of file freyberg.pst: parameter name "prsity3003  
2019-06-05 22:24:46.160432 pestcheck:12 characters long.  
2019-06-05 22:24:46.160528 pestcheck:Line 2477 of file freyberg.pst: parameter name "prsity3003  
2019-06-05 22:24:46.160580 pestcheck:once.  
2019-06-05 22:24:46.160679 pestcheck:Line 2478 of file freyberg.pst: parameter name "prsity3003  
2019-06-05 22:24:46.160729 pestcheck:12 characters long.  
2019-06-05 22:24:46.160837 pestcheck:Line 2478 of file freyberg.pst: parameter name "prsity3003  
2019-06-05 22:24:46.160891 pestcheck:once.  
2019-06-05 22:24:46.160990 pestcheck:Line 2479 of file freyberg.pst: parameter name "prsity3003  
2019-06-05 22:24:46.161040 pestcheck:12 characters long.  
2019-06-05 22:24:46.161080 pestcheck:Line 2479 of file freyberg.pst: parameter name "prsity3003  
2019-06-05 22:24:46.161183 pestcheck:once.  
2019-06-05 22:24:46.161234 pestcheck:Line 2480 of file freyberg.pst: parameter name "prsity3003  
2019-06-05 22:24:46.161332 pestcheck:12 characters long.  
2019-06-05 22:24:46.161389 pestcheck:Line 2480 of file freyberg.pst: parameter name "prsity3003  
2019-06-05 22:24:46.161491 pestcheck:once.  
2019-06-05 22:24:46.161545 pestcheck:Line 2481 of file freyberg.pst: parameter name "prsity3003  
2019-06-05 22:24:46.161642 pestcheck:12 characters long.  
2019-06-05 22:24:46.161691 pestcheck:Line 2481 of file freyberg.pst: parameter name "prsity3003  
2019-06-05 22:24:46.161796 pestcheck:once.  
2019-06-05 22:24:46.161871 pestcheck:Line 2482 of file freyberg.pst: parameter name "prsity3003  
2019-06-05 22:24:46.161945 pestcheck:12 characters long.  
2019-06-05 22:24:46.161994 pestcheck:Line 2482 of file freyberg.pst: parameter name "prsity3003  
2019-06-05 22:24:46.162034 pestcheck:once.  
2019-06-05 22:24:46.162137 pestcheck:Line 2483 of file freyberg.pst: parameter name "prsity3004  
2019-06-05 22:24:46.162190 pestcheck:12 characters long.  
2019-06-05 22:24:46.162287 pestcheck:Line 2484 of file freyberg.pst: parameter name "prsity3004  
2019-06-05 22:24:46.162336 pestcheck:12 characters long.  
2019-06-05 22:24:46.162470 pestcheck:Line 2484 of file freyberg.pst: parameter name "prsity3004  
2019-06-05 22:24:46.162566 pestcheck:once.  
2019-06-05 22:24:46.162615 pestcheck:Line 2485 of file freyberg.pst: parameter name "prsity3004  
2019-06-05 22:24:46.162655 pestcheck:12 characters long.  
2019-06-05 22:24:46.162757 pestcheck:Line 2485 of file freyberg.pst: parameter name "prsity3004  
2019-06-05 22:24:46.162810 pestcheck:once.  
2019-06-05 22:24:46.162908 pestcheck:Line 2486 of file freyberg.pst: parameter name "prsity3004  
2019-06-05 22:24:46.162958 pestcheck:12 characters long.  
2019-06-05 22:24:46.163063 pestcheck:Line 2486 of file freyberg.pst: parameter name "prsity3004  
2019-06-05 22:24:46.163116 pestcheck:once.  
2019-06-05 22:24:46.163225 pestcheck:Line 2487 of file freyberg.pst: parameter name "prsity3004  
2019-06-05 22:24:46.163271 pestcheck:12 characters long.  
2019-06-05 22:24:46.163374 pestcheck:Line 2487 of file freyberg.pst: parameter name "prsity3004  
2019-06-05 22:24:46.163484 pestcheck:once.

2019-06-05 22:24:46.163530 pestcheck:Line 2488 of file freyberg.pst: parameter name "prsity3004  
 2019-06-05 22:24:46.163569 pestcheck:12 characters long.  
 2019-06-05 22:24:46.163667 pestcheck:Line 2488 of file freyberg.pst: parameter name "prsity3004  
 2019-06-05 22:24:46.163719 pestcheck:once.  
 2019-06-05 22:24:46.163813 pestcheck:Line 2489 of file freyberg.pst: parameter name "prsity3004  
 2019-06-05 22:24:46.163859 pestcheck:12 characters long.  
 2019-06-05 22:24:46.163962 pestcheck:Line 2489 of file freyberg.pst: parameter name "prsity3004  
 2019-06-05 22:24:46.164013 pestcheck:once.  
 2019-06-05 22:24:46.164107 pestcheck:Line 2490 of file freyberg.pst: parameter name "prsity3004  
 2019-06-05 22:24:46.164154 pestcheck:12 characters long.  
 2019-06-05 22:24:46.164192 pestcheck:Line 2490 of file freyberg.pst: parameter name "prsity3004  
 2019-06-05 22:24:46.164291 pestcheck:once.  
 2019-06-05 22:24:46.164342 pestcheck:Line 2491 of file freyberg.pst: parameter name "prsity3004  
 2019-06-05 22:24:46.164451 pestcheck:12 characters long.  
 2019-06-05 22:24:46.164491 pestcheck:Line 2491 of file freyberg.pst: parameter name "prsity3004  
 2019-06-05 22:24:46.164540 pestcheck:once.  
 2019-06-05 22:24:46.164631 pestcheck:Line 2492 of file freyberg.pst: parameter name "prsity3004  
 2019-06-05 22:24:46.164683 pestcheck:12 characters long.  
 2019-06-05 22:24:46.164776 pestcheck:Line 2492 of file freyberg.pst: parameter name "prsity3004  
 2019-06-05 22:24:46.164824 pestcheck:once.  
 2019-06-05 22:24:46.164862 pestcheck:Line 2493 of file freyberg.pst: parameter name "prsity3004  
 2019-06-05 22:24:46.164988 pestcheck:12 characters long.  
 2019-06-05 22:24:46.165081 pestcheck:Line 2494 of file freyberg.pst: parameter name "prsity3004  
 2019-06-05 22:24:46.165129 pestcheck:12 characters long.  
 2019-06-05 22:24:46.165168 pestcheck:Line 2494 of file freyberg.pst: parameter name "prsity3004  
 2019-06-05 22:24:46.165266 pestcheck:once.  
 2019-06-05 22:24:46.165315 pestcheck:Line 2495 of file freyberg.pst: parameter name "prsity3004  
 2019-06-05 22:24:46.165488 pestcheck:12 characters long.  
 2019-06-05 22:24:46.165605 pestcheck:Line 2495 of file freyberg.pst: parameter name "prsity3004  
 2019-06-05 22:24:46.165754 pestcheck:once.  
 2019-06-05 22:24:46.165821 pestcheck:Line 2496 of file freyberg.pst: parameter name "prsity3004  
 2019-06-05 22:24:46.165886 pestcheck:12 characters long.  
 2019-06-05 22:24:46.165951 pestcheck:Line 2496 of file freyberg.pst: parameter name "prsity3004  
 2019-06-05 22:24:46.166015 pestcheck:once.  
 2019-06-05 22:24:46.166067 pestcheck:Line 2497 of file freyberg.pst: parameter name "prsity3004  
 2019-06-05 22:24:46.166223 pestcheck:12 characters long.  
 2019-06-05 22:24:46.166273 pestcheck:Line 2497 of file freyberg.pst: parameter name "prsity3004  
 2019-06-05 22:24:46.166356 pestcheck:once.  
 2019-06-05 22:24:46.166446 pestcheck:Line 2498 of file freyberg.pst: parameter name "prsity3004  
 2019-06-05 22:24:46.166597 pestcheck:12 characters long.  
 2019-06-05 22:24:46.166674 pestcheck:Line 2498 of file freyberg.pst: parameter name "prsity3004  
 2019-06-05 22:24:46.166799 pestcheck:once.  
 2019-06-05 22:24:46.166869 pestcheck:Line 2499 of file freyberg.pst: parameter name "prsity3004  
 2019-06-05 22:24:46.166933 pestcheck:12 characters long.  
 2019-06-05 22:24:46.167031 pestcheck:Line 2499 of file freyberg.pst: parameter name "prsity3004  
 2019-06-05 22:24:46.167082 pestcheck:once.  
 2019-06-05 22:24:46.167181 pestcheck:Line 2500 of file freyberg.pst: parameter name "prsity3004  
 2019-06-05 22:24:46.167230 pestcheck:12 characters long.

```

2019-06-05 22:24:46.167269 pestcheck:Line 2500 of file freyberg.pst: parameter name "prsity300
2019-06-05 22:24:46.167383 pestcheck:once.
2019-06-05 22:24:46.167434 pestcheck:Line 2501 of file freyberg.pst: parameter name "prsity300
2019-06-05 22:24:46.167531 pestcheck:12 characters long.
2019-06-05 22:24:46.167579 pestcheck:Line 2501 of file freyberg.pst: parameter name "prsity300
2019-06-05 22:24:46.167619 pestcheck:once.
2019-06-05 22:24:46.167724 pestcheck:Line 2502 of file freyberg.pst: parameter name "prsity300
2019-06-05 22:24:46.167778 pestcheck:12 characters long.
2019-06-05 22:24:46.167876 pestcheck:Line 2502 of file freyberg.pst: parameter name "prsity300
2019-06-05 22:24:46.167924 pestcheck:once.
2019-06-05 22:24:46.167964 pestcheck:Line 2503 of file freyberg.pst: parameter name "prsity300
2019-06-05 22:24:46.168070 pestcheck:12 characters long.
2019-06-05 22:24:46.168120 pestcheck:Line 2504 of file freyberg.pst: parameter name "prsity300
2019-06-05 22:24:46.168217 pestcheck:12 characters long.
2019-06-05 22:24:46.168266 pestcheck:Line 2504 of file freyberg.pst: parameter name "prsity300
2019-06-05 22:24:46.168381 pestcheck:once.
2019-06-05 22:24:46.168434 pestcheck:Line 2505 of file freyberg.pst: parameter name "prsity300
2019-06-05 22:24:46.168531 pestcheck:12 characters long.
2019-06-05 22:24:46.168579 pestcheck:Line 2505 of file freyberg.pst: parameter name "prsity300
2019-06-05 22:24:46.168618 pestcheck:once.
2019-06-05 22:24:46.168721 pestcheck:Line 2506 of file freyberg.pst: parameter name "prsity300
2019-06-05 22:24:46.168774 pestcheck:12 characters long.
2019-06-05 22:24:46.168871 pestcheck:Line 2506 of file freyberg.pst: parameter name "prsity300
2019-06-05 22:24:46.168919 pestcheck:once.
2019-06-05 22:24:46.169036 pestcheck:Line 2507 of file freyberg.pst: parameter name "prsity300
2019-06-05 22:24:46.169139 pestcheck:12 characters long.
2019-06-05 22:24:46.169186 pestcheck:Line 2507 of file freyberg.pst: parameter name "prsity300
2019-06-05 22:24:46.169225 pestcheck:once.
2019-06-05 22:24:46.169339 pestcheck:Line 2508 of file freyberg.pst: parameter name "prsity300
2019-06-05 22:24:46.169450 pestcheck:12 characters long.
2019-06-05 22:24:46.169754 finished: running pestchek on freyberg.pst took: 0:00:00.112012
2019-06-05 22:24:46.169834 starting: saving intermediate _setup_<> dfs into template
2019-06-05 22:24:46.294057 finished: saving intermediate _setup_<> dfs into template took: 0:0
2019-06-05 22:24:46.294183 all done

```

The `pst_helper` instance contains the `pyemu.Pst` instance:

```

In [14]: # so, pull out the `pyemu.Pst` instance which
         #contains all the input that ultimately goes in the PEST control %%file
         pst = pst_helper.pst
         pst.npar,pst.nobs

```

```

Out[14]: (14819, 4434)

```

Oh snap!

### 1.1.6 Add modpath input files, instruction files and calls

First copy over all the MODPATH-related files from the base directory identified in the `b_d` variable. We will track a single particle for forecast purposes

```
In [15]: mp_files = [f for f in os.listdir(b_d) if "mp" in f or "location" in f]
          [shutil.copy2(os.path.join(b_d,f),os.path.join(pst_helper.new_model_ws,f)) for f in mp_files]

Out[15]: ['template/mp_ibound_1.ref',
          'template/mp_ibound_2.ref',
          'template/mp_ibound_3.ref',
          'template/freyberg.locations',
          'template/freyberg.mpsim',
          'template/freyberg.mpbas',
          'template/freyberg.mpnam']
```

The following `frun_post_lines` property adds statements at the end of the `forward_run.py` script. In this case, it runs MODPATH using `mp6`. We will also identify any additional temporary files that the forward run script should attempt to remove at the start of a run.

```
In [16]: #pst_helper.frun_post_lines.append("os.system('mp6 freyberg.mpsim >mp6.stdout')")
          pst_helper.frun_post_lines.append("pyemu.os_utils.run('mp6 freyberg.mpsim >mp6.stdout')")
          pst_helper.tmp_files.append("freyberg.mpenpt")
          pst_helper.write_forward_run()
```

Create and add instruction files and related observations for MODPATH

```
In [17]: out_file = "freyberg.mpenpt"
          ins_file = out_file + ".ins"
          with open(os.path.join(pst_helper.new_model_ws,ins_file),'w') as f:
              f.write("pif ~\n")
              f.write("l7 w w w !part_status! w w !part_time!\n")
          df = pst_helper.pst.add_observations(os.path.join(pst_helper.new_model_ws,ins_file),
                                              os.path.join(pst_helper.new_model_ws,out_file),
                                              pst_path=".")
```

error using inschek for instruction file ./freyberg.mpenpt.ins:File b'template/./freyberg.mpenpt.ins' does not exist.  
observations in this instruction file will have generic values.

Finally we need to copy the original `prsim` arrays to the `arr_org` dir for use in the multiplier parameterization scheme

```
In [18]: for k in range(m.nlay):
          np.savetxt(os.path.join(pst_helper.new_model_ws,"arr_org","prsim_layer_{0}.ref".format(k)),
```

### 1.1.7 Final bits and bobs

We need to set some realistic parameter bounds and account for expected (but stochastic) scenario conditions:

pyemu uses pandas data frame format for the parameter and observation data sections. This exposes plenty of querying and bulk editing options.

```
In [19]: par = pst.parameter_data
# properties
tag_dict = {"hk": [0.1, 10.0], "vka": [0.1, 10], "strt": [0.95, 1.05], "prsity": [0.5, 1.5]}
for t, [l, u] in tag_dict.items():
    t_pars = par.loc[par.parnme.apply(lambda x: t in x), "parnme"]
    par.loc[t_pars, "parubnd"] = u
    par.loc[t_pars, "parlbnd"] = l

# recharge - just change the constant recharge mult
# for the historic and scenario stress periods
scen_rch = ["cn_rech5"]
hist_rch = ["cn_rech4"]
par.loc[par.pargp.apply(lambda x: x in scen_rch), "parubnd"] = 0.8
par.loc[par.pargp.apply(lambda x: x in scen_rch), "parlbnd"] = 0.1
par.loc[par.pargp.apply(lambda x: x in scen_rch), "parval1"] = 0.4
par.loc[par.pargp.apply(lambda x: x in hist_rch), "parubnd"] = 1.2
par.loc[par.pargp.apply(lambda x: x in hist_rch), "parlbnd"] = 0.8
par.loc[par.pargp.apply(lambda x: x in hist_rch), "parval1"] = 1.0

# well abstraction - same idea here: change the historic and scenario pars
par.loc["welflux_001", "parval1"] = 1.5
par.loc["welflux_001", "parlbnd"] = 1.0
par.loc["welflux_001", "parubnd"] = 2.0
par.loc["welflux_000", "parval1"] = 1.0
par.loc["welflux_000", "parlbnd"] = 0.5
par.loc["welflux_000", "parubnd"] = 1.5
```

given the combinations of multipliers, we need to set a hard upper bound on porosity and sy since those have physical upper limits

```
In [20]: arr_csv = os.path.join(pst_helper.new_model_ws, "arr_pars.csv")
df = pd.read_csv(arr_csv, index_col=0)
pr_sy = df.model_file.apply(lambda x: "prsity" in x or "sy" in x)
df.loc[:, "upper_bound"] = np.NaN
df.loc[pr_sy, "upper_bound"] = 0.4
df.to_csv(arr_csv)
```

```
In [21]: # table can also be written to a .tex file
pst.write_par_summary_table(filename="none").sort_index()
```

```
Out[21]:
```

	type	transform	count	initial value \
cn_hk6	cn_hk6	log	1	0

cn_hk7	cn_hk7	log	1	0
cn_hk8	cn_hk8	log	1	0
cn_prsity6	cn_prsity6	log	1	0
cn_prsity7	cn_prsity7	log	1	0
cn_prsity8	cn_prsity8	log	1	0
cn_rech4	cn_rech4	log	1	0
cn_rech5	cn_rech5	log	1	-0.39794
cn_ss6	cn_ss6	log	1	0
cn_ss7	cn_ss7	log	1	0
cn_ss8	cn_ss8	log	1	0
cn_strt6	cn_strt6	log	1	0
cn_strt7	cn_strt7	log	1	0
cn_strt8	cn_strt8	log	1	0
cn_sy6	cn_sy6	log	1	0
cn_sy7	cn_sy7	log	1	0
cn_sy8	cn_sy8	log	1	0
cn_vka6	cn_vka6	log	1	0
cn_vka7	cn_vka7	log	1	0
cn_vka8	cn_vka8	log	1	0
drncond_k00	drncond_k00	log	10	0
flow	flow	log	1	0
gr_hk3	gr_hk3	log	705	0
gr_hk4	gr_hk4	log	705	0
gr_hk5	gr_hk5	log	705	0
gr_prsity3	gr_prsity3	log	705	0
gr_prsity4	gr_prsity4	log	705	0
gr_prsity5	gr_prsity5	log	705	0
gr_rech2	gr_rech2	log	705	0
gr_rech3	gr_rech3	log	705	0
...	...	...	...	...
gr_strt5	gr_strt5	log	705	0
gr_sy3	gr_sy3	log	705	0
gr_sy4	gr_sy4	log	705	0
gr_sy5	gr_sy5	log	705	0
gr_vka3	gr_vka3	log	705	0
gr_vka4	gr_vka4	log	705	0
gr_vka5	gr_vka5	log	705	0
pp_hk0	pp_hk0	log	32	0
pp_hk1	pp_hk1	log	32	0
pp_hk2	pp_hk2	log	32	0
pp_prsity0	pp_prsity0	log	32	0
pp_prsity1	pp_prsity1	log	32	0
pp_prsity2	pp_prsity2	log	32	0
pp_rech0	pp_rech0	log	32	0
pp_rech1	pp_rech1	log	32	0
pp_ss0	pp_ss0	log	32	0
pp_ss1	pp_ss1	log	32	0
pp_ss2	pp_ss2	log	32	0

pp_strt0	pp_strt0	log	32	0
pp_strt1	pp_strt1	log	32	0
pp_strt2	pp_strt2	log	32	0
pp_sy0	pp_sy0	log	32	0
pp_sy1	pp_sy1	log	32	0
pp_sy2	pp_sy2	log	32	0
pp_vka0	pp_vka0	log	32	0
pp_vka1	pp_vka1	log	32	0
pp_vka2	pp_vka2	log	32	0
strk	strk	log	40	0
welflux	welflux	log	2	0 to 0.176091
welflux_k02	welflux_k02	log	6	0

	upper bound	lower bound	standard deviation
cn_hk6	1	-1	0.5
cn_hk7	1	-1	0.5
cn_hk8	1	-1	0.5
cn_prsity6	0.176091	-0.30103	0.11928
cn_prsity7	0.176091	-0.30103	0.11928
cn_prsity8	0.176091	-0.30103	0.11928
cn_rech4	0.0791812	-0.09691	0.0440228
cn_rech5	-0.09691	-1	0.225772
cn_ss6	1	-1	0.5
cn_ss7	1	-1	0.5
cn_ss8	1	-1	0.5
cn_strt6	0.0211893	-0.0222764	0.0108664
cn_strt7	0.0211893	-0.0222764	0.0108664
cn_strt8	0.0211893	-0.0222764	0.0108664
cn_sy6	0.243038	-0.60206	0.211275
cn_sy7	0.243038	-0.60206	0.211275
cn_sy8	0.243038	-0.60206	0.211275
cn_vka6	1	-1	0.5
cn_vka7	1	-1	0.5
cn_vka8	1	-1	0.5
drncond_k00	1	-1	0.5
flow	0.09691	-0.124939	0.0554622
gr_hk3	1	-1	0.5
gr_hk4	1	-1	0.5
gr_hk5	1	-1	0.5
gr_prsity3	0.176091	-0.30103	0.11928
gr_prsity4	0.176091	-0.30103	0.11928
gr_prsity5	0.176091	-0.30103	0.11928
gr_rech2	0.0413927	-0.0457575	0.0217875
gr_rech3	0.0413927	-0.0457575	0.0217875
...	...	...	...
gr_strt5	0.0211893	-0.0222764	0.0108664
gr_sy3	0.243038	-0.60206	0.211275
gr_sy4	0.243038	-0.60206	0.211275

gr_sy5	0.243038	-0.60206	0.211275
gr_vka3	1	-1	0.5
gr_vka4	1	-1	0.5
gr_vka5	1	-1	0.5
pp_hk0	1	-1	0.5
pp_hk1	1	-1	0.5
pp_hk2	1	-1	0.5
pp_prsity0	0.176091	-0.30103	0.11928
pp_prsity1	0.176091	-0.30103	0.11928
pp_prsity2	0.176091	-0.30103	0.11928
pp_rech0	0.0413927	-0.0457575	0.0217875
pp_rech1	0.0413927	-0.0457575	0.0217875
pp_ss0	1	-1	0.5
pp_ss1	1	-1	0.5
pp_ss2	1	-1	0.5
pp_strt0	0.0211893	-0.0222764	0.0108664
pp_strt1	0.0211893	-0.0222764	0.0108664
pp_strt2	0.0211893	-0.0222764	0.0108664
pp_sy0	0.243038	-0.60206	0.211275
pp_sy1	0.243038	-0.60206	0.211275
pp_sy2	0.243038	-0.60206	0.211275
pp_vka0	1	-1	0.5
pp_vka1	1	-1	0.5
pp_vka2	1	-1	0.5
strk	2	-2	1
welflux	0.176091 to 0.30103	-0.30103 to 0	0.0752575 to 0.11928
welflux_k02	1	-1	0.5

[65 rows x 7 columns]

In [22]: `pst.write_obs_summary_table(filename="none")`

Out [22]:

	group	value	non-zero weight \
flaqx	flaqx	-977.239 to 32.171	84
flout	flout	10069 to 226396	84
flx_constan	flx_constan	0	2
flx_drains	flx_drains	-723.325 to -723.028	2
flx_in-out	flx_in-out	0.012695 to 0.046143	2
flx_percent	flx_percent	0	2
flx_recharg	flx_recharg	3045.6	2
flx_storage	flx_storage	5.7734 to 8.01049	2
flx_stream_	flx_stream_	-1430.27 to -1428.3	2
flx_total	flx_total	0.0126953 to 0.0461426	2
flx_wells	flx_wells	-900	2
hds	hds	32.5065 to 39.6612	4230
obgnme	obgnme	1E+10	2
vol_constan	vol_constan	0	2
vol_drains	vol_drains	-2.90404E+06 to -2.64014E+06	2



vol_in-out	vol_in-out	45 to 63	2
vol_percent	vol_percent	0	2
vol_recharg	vol_recharg	1.11164E+07 to 1.22281E+07	2
vol_storage	vol_storage	29238.3 to 31345.6	2
vol_stream_	vol_stream_	-5.74182E+06 to -5.22049E+06	2
vol_total	vol_total	45 to 63	2
vol_wells	vol_wells	-3.6135E+06 to -3.285E+06	2

	zero weight	weight	standard deviation	percent error
flaqx	0	1	1	0.102329 to 833.333
flout	0	1	1	0.000441704 to 0.00993147
flx_constan	0	1	1	NA
flx_drains	0	1	1	0.13825 to 0.138307
flx_in-out	0	1	1	2167.18 to 7877.12
flx_percent	0	1	1	NA
flx_recharg	0	1	1	0.0328343
flx_storage	0	1	1	12.4836 to 17.3208
flx_stream_	0	1	1	0.0699167 to 0.0700133
flx_total	0	1	1	2167.2 to 7876.92
flx_wells	0	1	1	0.111111
hds	0	1	1	2.52136 to 3.07631
obgnme	0	1	1	1E-08
vol_constan	0	1	1	NA
vol_drains	0	1	1	3.44348E-05 to 3.78768E-05
vol_in-out	0	1	1	1.5873 to 2.22222
vol_percent	0	1	1	NA
vol_recharg	0	1	1	8.1779E-06 to 8.99569E-06
vol_storage	0	1	1	0.00319024 to 0.00342017
vol_stream_	0	1	1	1.74161E-05 to 1.91553E-05
vol_total	0	1	1	1.5873 to 2.22222
vol_wells	0	1	1	2.7674E-05 to 3.04414E-05

Let's run the process once (noptmax=0) to make sure its all plumbed up. Pro-tip: you can use any of the pestpp-### binaries/executables to run noptmax=0

```
In [23]: pst.control_data.noptmax = 0
         pst.write(os.path.join(pst_helper.new_model_ws,"freyberg.pst"))
         pyemu.os_utils.run("pestpp-ies freyberg.pst",cwd=pst_helper.new_model_ws)
```

```
noptmax:0, npar_adj:14819, nnz_obs:4436
```

Now we need to generate the prior parameter covariance matrix and stochastic realizations. We will use the geostatistical covariance information in the pst\_helper instance for this:

```
In [24]: if pst_helper.pst.npar < 15000:
         cov = pst_helper.build_prior(fmt="coo",filename=os.path.join(pst_helper.new_model_
         cov = np.ma.masked_where(cov.x==0,cov.x)
         try:
```

```

fig = plt.figure(figsize=(10,10))
ax = plt.subplot(111)
ax.imshow(cov)
plt.show()
except:
    pass

```

2019-06-05 22:24:55.664856 starting: building prior covariance matrix

2019-06-05 22:24:55.768917 WARNING: geospatial prior not implemented for SFR pars

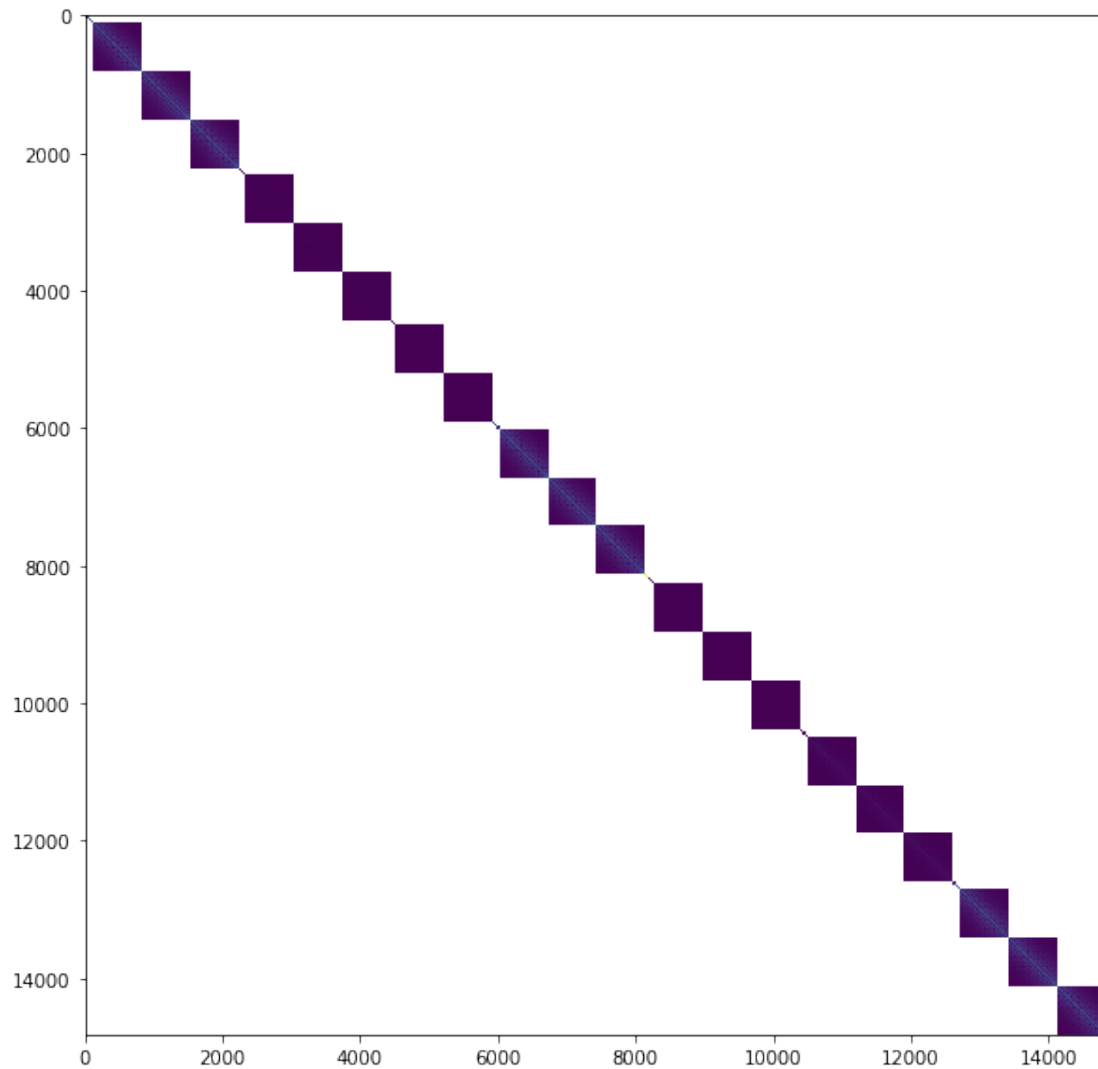
/Users/jeremyw/miniconda3/lib/python3.5/site-packages/pandas/core/indexing.py:362: SettingWithCopyWarning:  
A value is trying to be set on a copy of a slice from a DataFrame.  
Try using .loc[row\_indexer,col\_indexer] = value instead

See the caveats in the documentation: <http://pandas.pydata.org/pandas-docs/stable/indexing.html>  
 self.obj[key] = \_infer\_fill\_value(value)  
 /Users/jeremyw/miniconda3/lib/python3.5/site-packages/pandas/core/indexing.py:543: SettingWithCopyWarning:  
A value is trying to be set on a copy of a slice from a DataFrame.  
Try using .loc[row\_indexer,col\_indexer] = value instead

See the caveats in the documentation: <http://pandas.pydata.org/pandas-docs/stable/indexing.html>  
 self.obj[item] = s

2019-06-05 22:25:01.882924 saving prior covariance matrix to file template/prior\_cov.jcb

2019-06-05 22:25:05.943580 finished: building prior covariance matrix took: 0:00:10.278724



### 1.1.8 now we can make a draw from the prior parameter covariance matrix to form a prior parameter ensemble

```
In [25]: pe = pst_helper.draw(1000)
```

```
2019-06-05 22:25:16.682591 starting: drawing realizations
```

```
building diagonal cov
```

```
processing name:grid_geostruct,nugget:0.0,structures:
```

```
name:var1,contribution:1.0,a:2500.0,anisotropy:1.0,bearing:0.0
```

```
working on pargroups ['gr_hk3']
```

```
build cov matrix
```

```
done
```

```
getting diag var cov 705
```

```

scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_vka3']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_ss3']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_sy3']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_strt3']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_prsity3']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_hk4']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_vka4']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_ss4']
build cov matrix
done
getting diag var cov 705

```

```

scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_sy4']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_strt4']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_prsity4']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_hk5']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_vka5']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_ss5']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_sy5']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_strt5']
build cov matrix
done
getting diag var cov 705

```

```

scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_prsity5']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_rech2']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_rech3']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
processing name:pp_geostruct,nugget:0.0,structures:
name:var1,contribution:1.0,a:1000.0,anisotropy:1.0,bearing:0.0

working on pargroups ['pp_hk0']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_prsity0']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_rech0']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_rech1']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_ss0']

```

```

build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_strt0']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_sy0']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_vka0']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_hk1']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_prsity1']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_ss1']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_strt1']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_sy1']

```

```

build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_vka1']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_hk2']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_prsity2']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_ss2']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_strt2']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_sy2']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_vka2']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
processing name:spatial_list_geostruc,nugget:0.0,structures:

```



```
name:var1,contribution:1.0,a:2500.0,anisotropy:1.0,bearing:0.0
```

```
working on pargroups ['drncond_k00']
build cov matrix
done
getting diag var cov 10
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['welflux_k02']
```

```
/Users/jeremyw/miniconda3/lib/python3.5/site-packages/pandas/core/indexing.py:362: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead
```

```
See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stable/indexing.html
    self.obj[key] = _infer_fill_value(value)
/Users/jeremyw/miniconda3/lib/python3.5/site-packages/pandas/core/indexing.py:543: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead
```

```
See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stable/indexing.html
    self.obj[item] = s
```

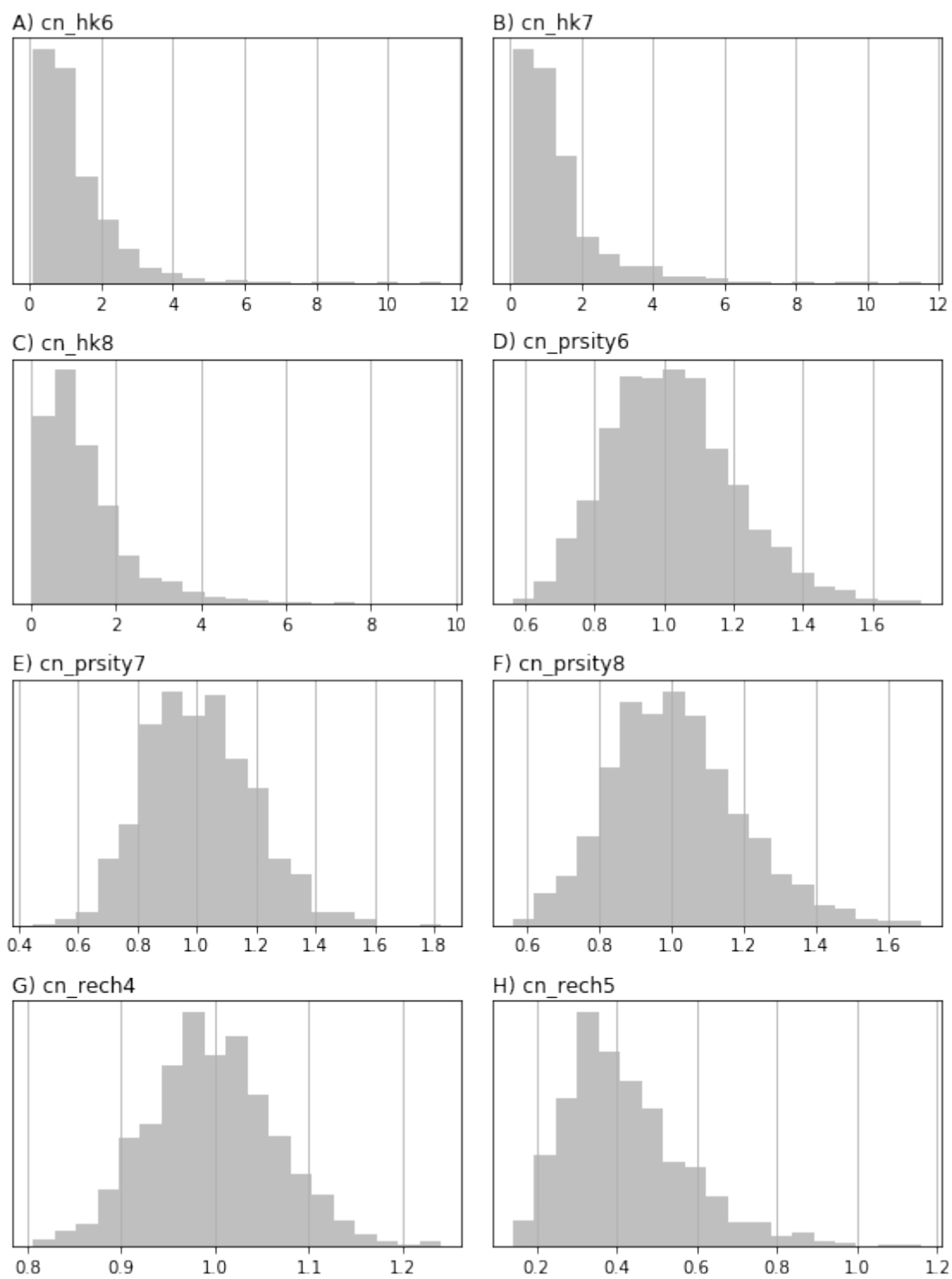
```
build cov matrix
done
getting diag var cov 6
scaling full cov by diag var cov
making full cov draws with home-grown goodness
processing  name:temporal_list_geostruct,nugget:0.0,structures:
name:var1,contribution:1.0,a:180.0,anisotropy:1.0,bearing:0.0
```

```
working on pargroups ['welflux']
build cov matrix
done
getting diag var cov 2
scaling full cov by diag var cov
making full cov draws with home-grown goodness
adding remaining parameters to diagonal
2019-06-05 22:25:29.744083 finished: drawing realizations took: 0:00:13.061492
```

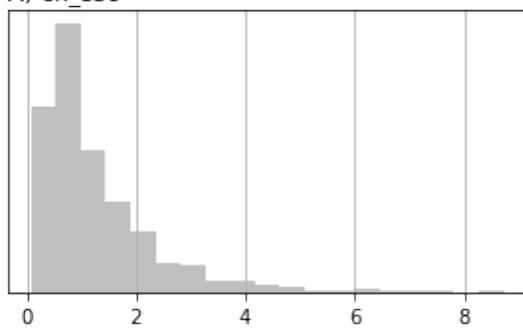
You can see that parameters are treated in parameter group (pargp) blocks for this ensemble generation. Let's plot one parameter:

```
In [26]: par = pst_helper.pst.parameter_data
         pyemu.plot_utils.ensemble_helper(pe,plot_cols=par.groupby("pargp").groups,bins=20)
         plt.show()
```

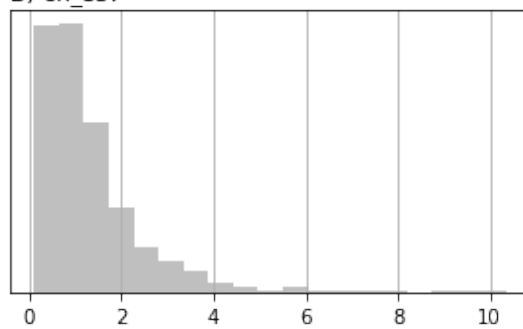
<Figure size 576x756 with 0 Axes>



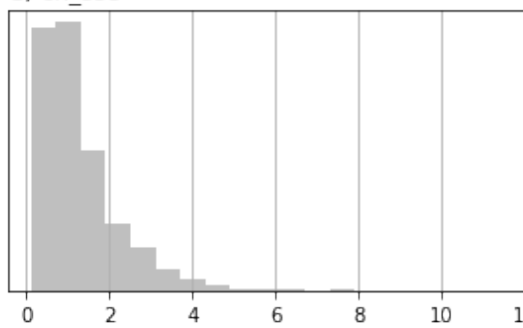
A) cn\_ss6



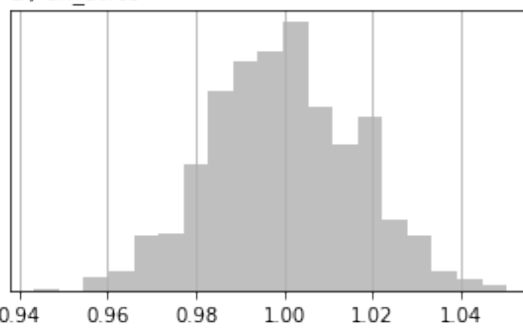
B) cn\_ss7



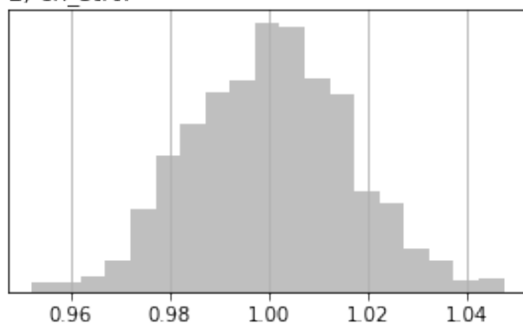
C) cn\_ss8



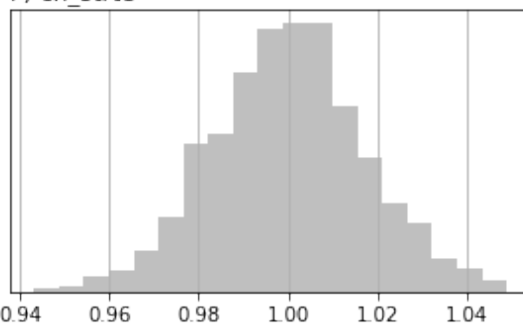
D) cn\_strt6



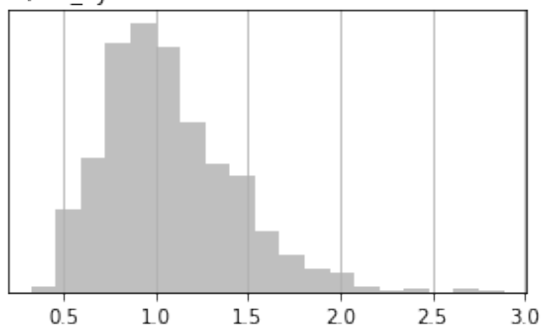
E) cn\_strt7



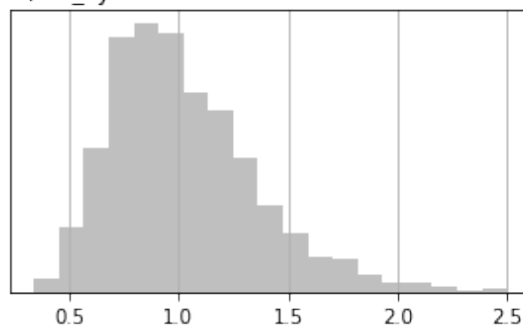
F) cn\_strt8



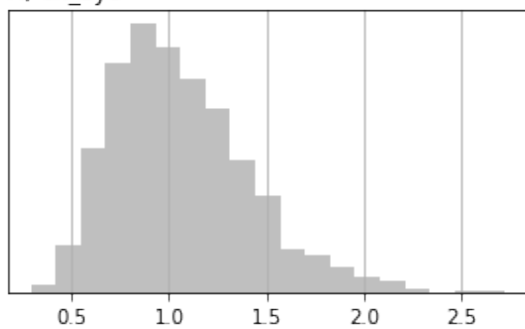
G) cn\_sy6



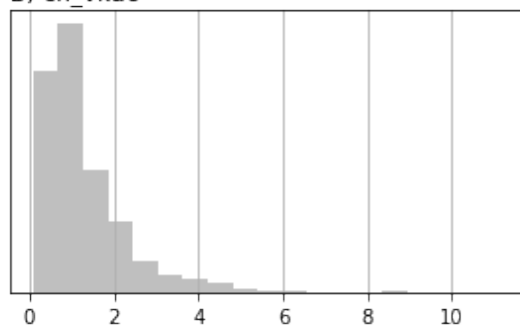
H) cn\_sy7



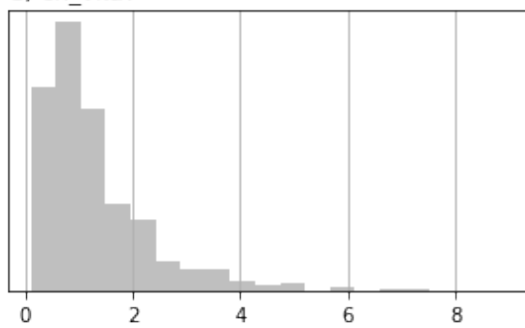
A) cn\_sy8



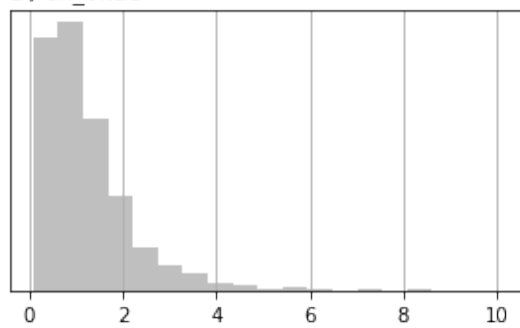
B) cn\_vka6



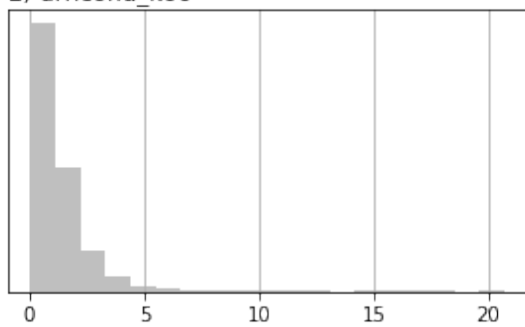
C) cn\_vka7



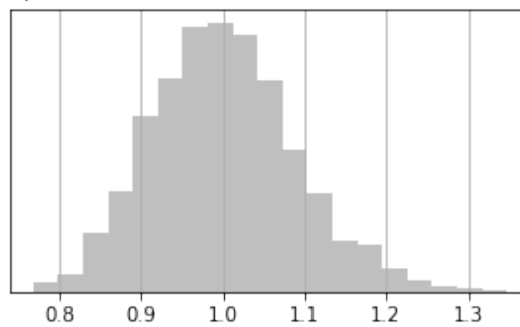
D) cn\_vka8



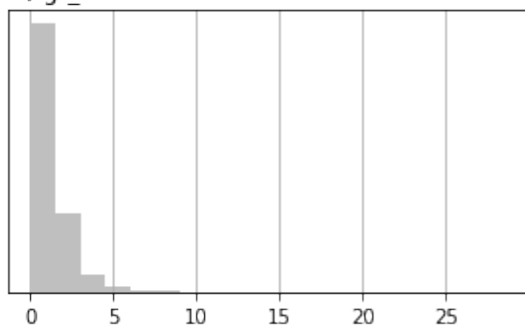
E) drncond\_k00



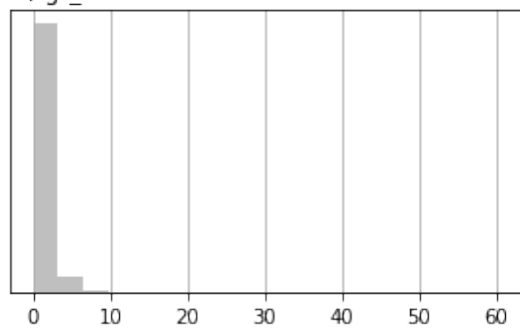
F) flow



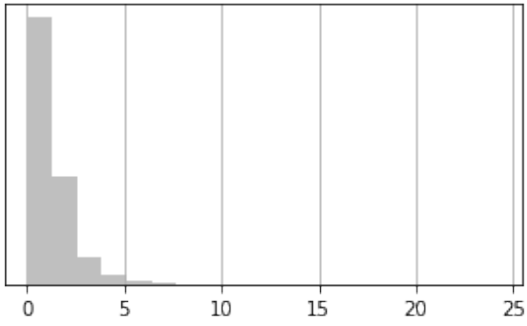
G) gr\_hk3



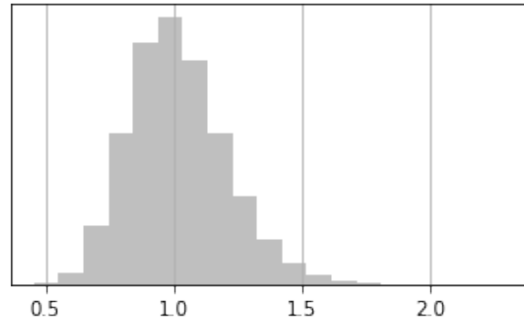
H) gr\_hk4



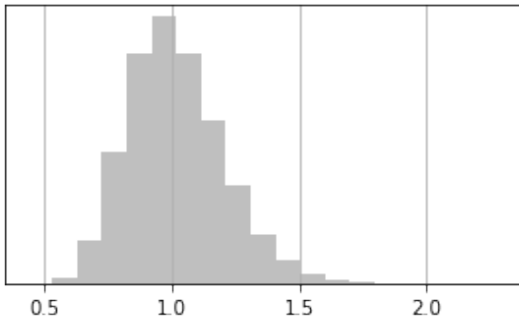
A) gr\_hk5



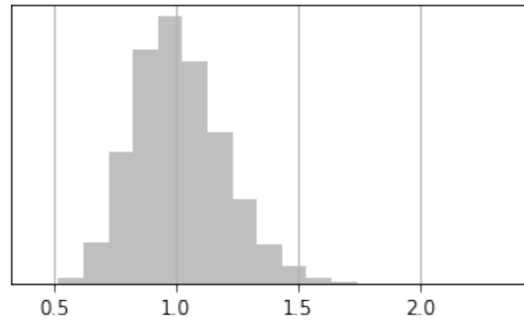
B) gr\_prsity3



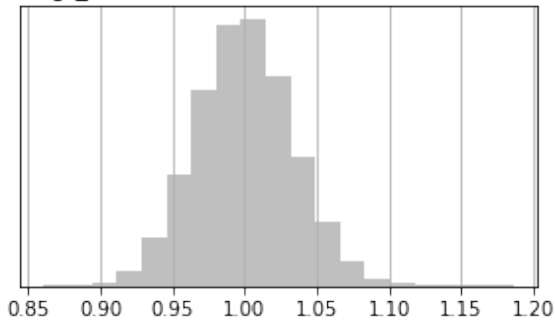
C) gr\_prsity4



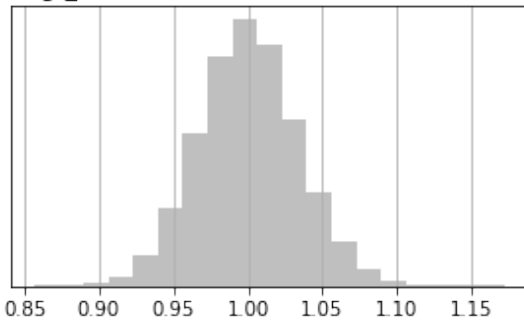
D) gr\_prsity5



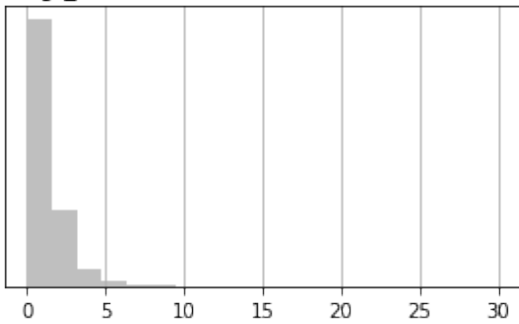
E) gr\_rech2



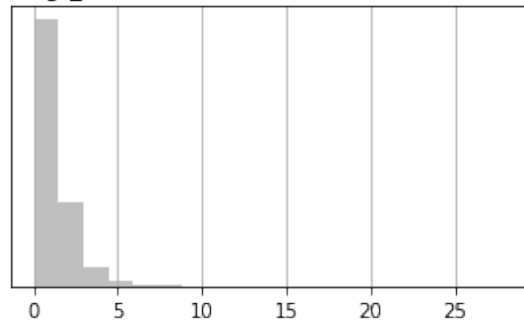
F) gr\_rech3



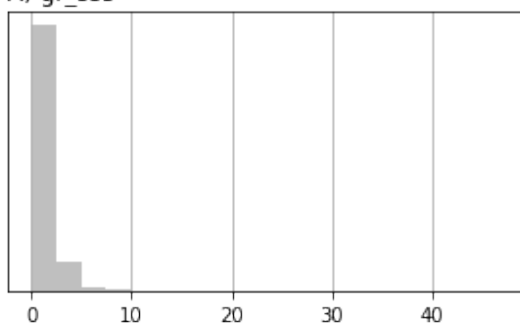
G) gr\_ss3



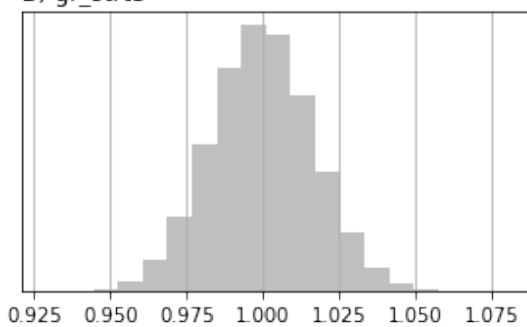
H) gr\_ss4



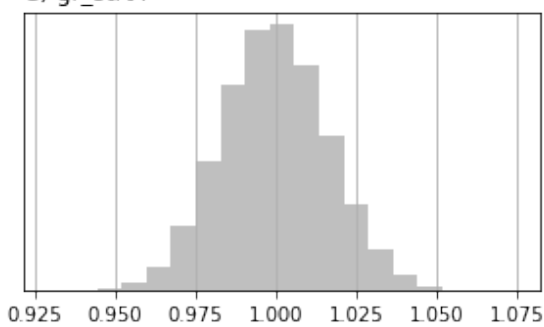
A) gr\_ss5



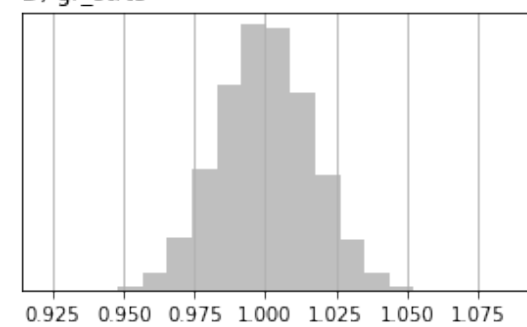
B) gr\_strt3



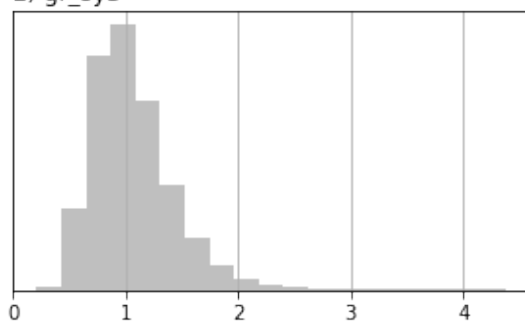
C) gr\_strt4



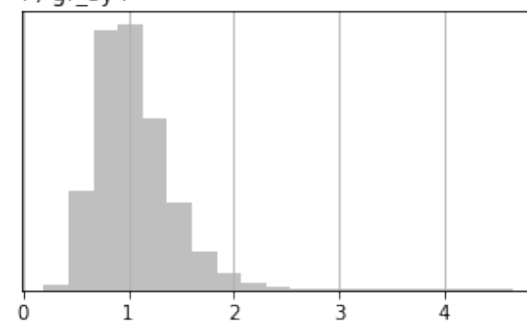
D) gr\_strt5



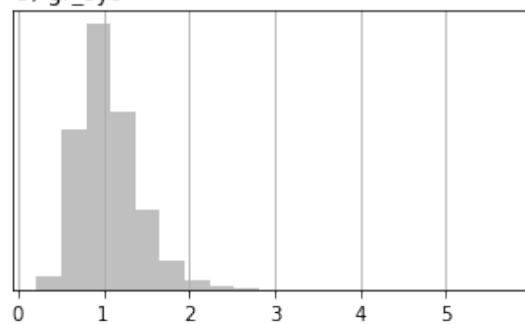
E) gr\_sy3



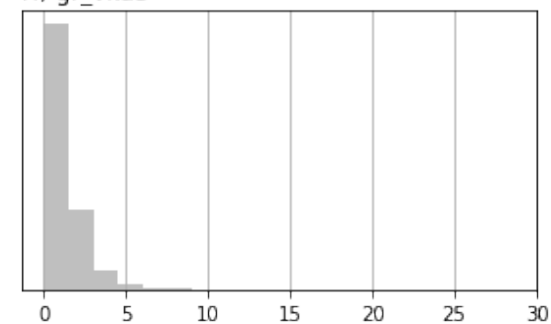
F) gr\_sy4



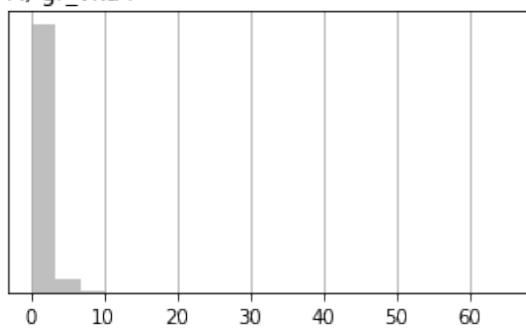
G) gr\_sy5



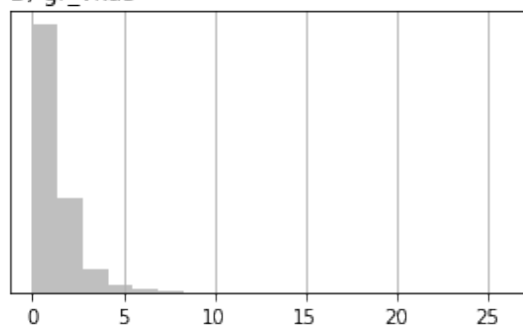
H) gr\_vka3



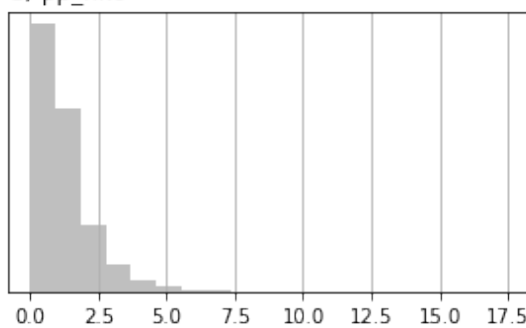
A) gr\_vka4



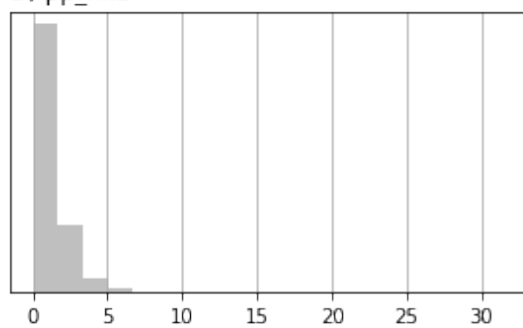
B) gr\_vka5



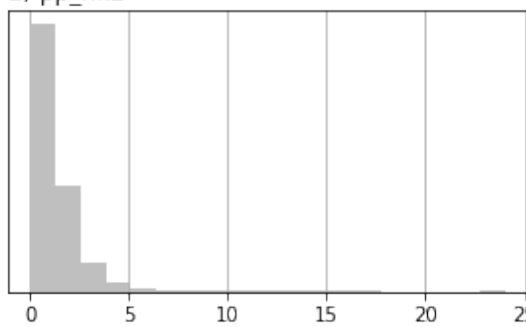
C) pp\_hk0



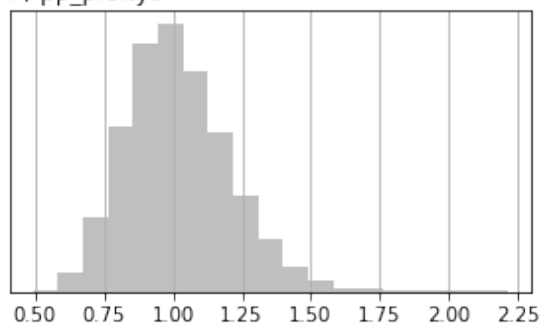
D) pp\_hk1



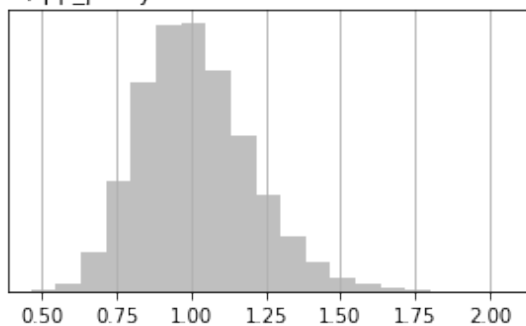
E) pp\_hk2



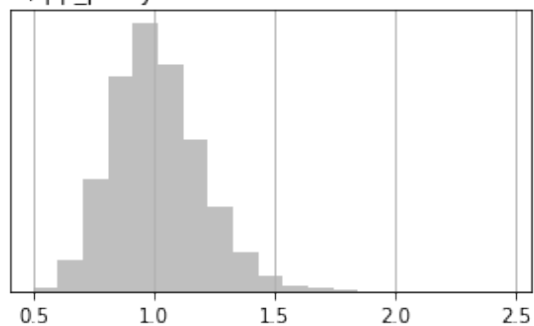
F) pp\_prsity0



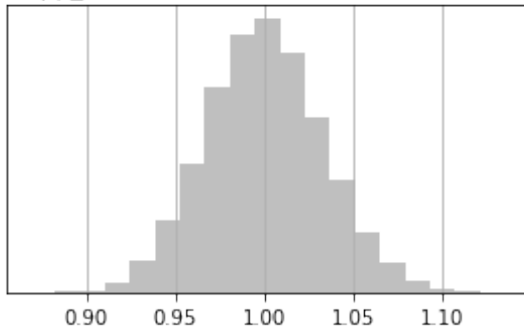
G) pp\_prsity1



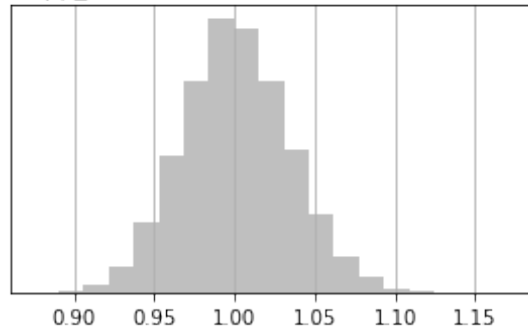
H) pp\_prsity2



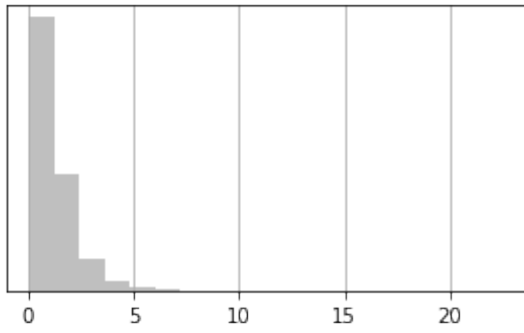
A) pp\_rech0



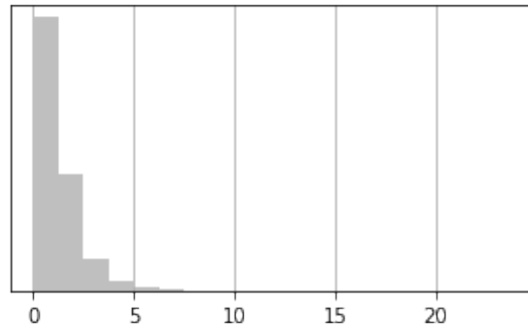
B) pp\_rech1



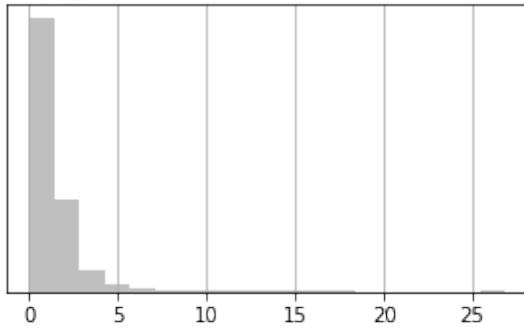
C) pp\_ss0



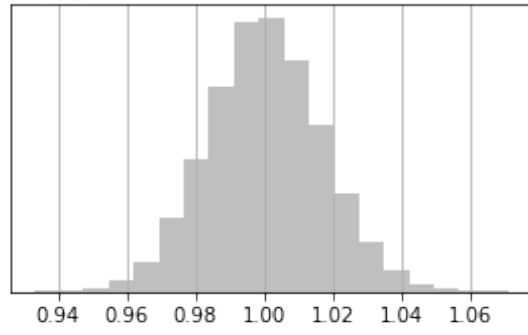
D) pp\_ss1



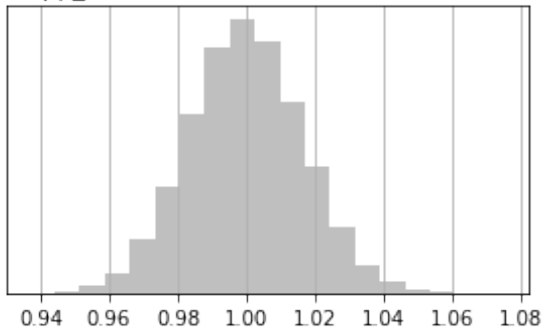
E) pp\_ss2



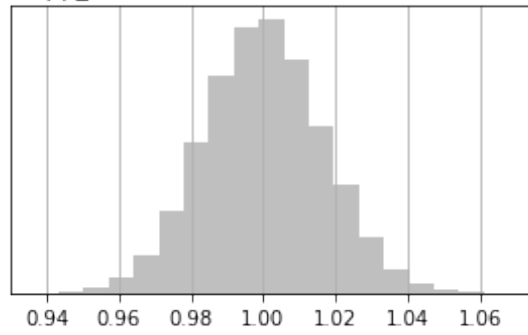
F) pp\_strt0



G) pp\_strt1

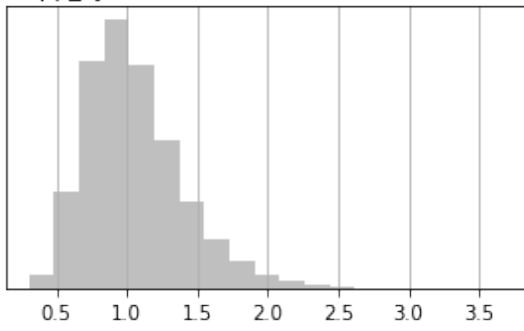


H) pp\_strt2

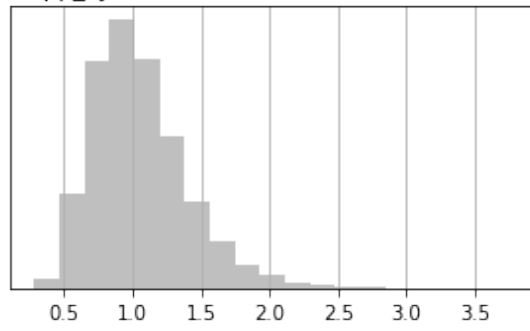




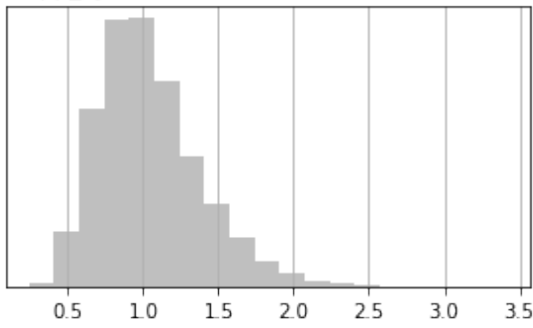
A) pp\_sy0



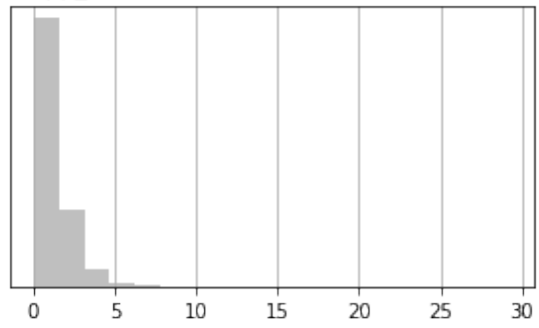
B) pp\_sy1



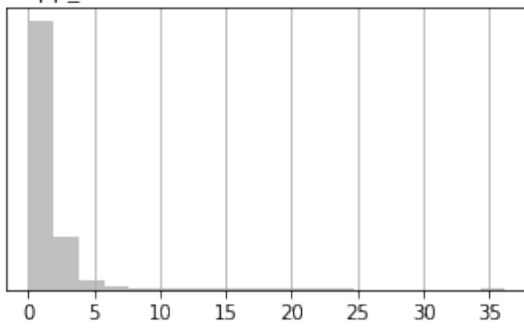
C) pp\_sy2



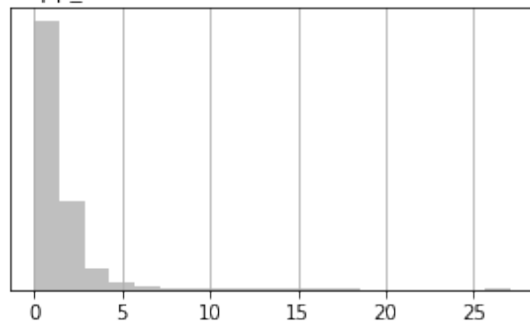
D) pp\_vka0



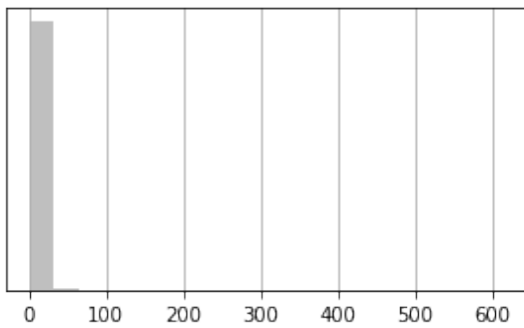
E) pp\_vka1



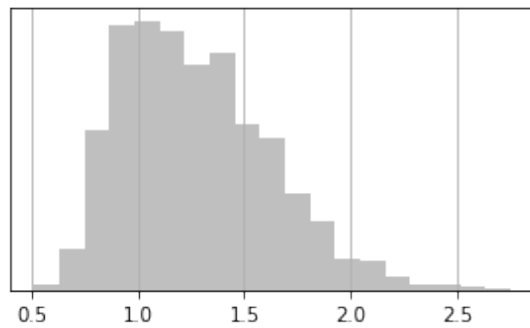
F) pp\_vka2

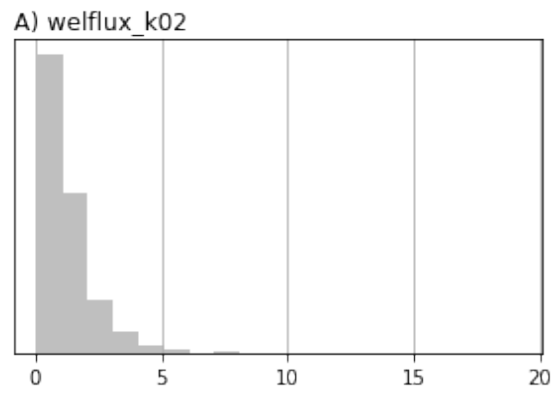


G) strk



H) welflux





Now we need to enforce parameter bounds and save this ensemble for later

```
In [27]: pe.enforce()  
         pe.to_binary(os.path.join(pst_helper.new_model_ws, "prior.jcb"))
```

```
In [28]: pe.iloc[-1,-1]
```

```
Out[28]: 1.2795487817916409
```

### 1.1.9 set weights for “observations” and identify forecasts

The next major task is to set the weights on the observations. So far, in the `pst_helper` process, we simply identified what outputs from the model we want to observe. We now use a pre-cooked csv file to set nonzero weights only for GW level observation locations used in the original Freyberg model. We will also use the SFR flow out of the last reach (`fo` in the last row in 19791230)

```
In [29]: obs_locs = pd.read_csv(os.path.join("../", "base_model_files", "obs_loc.csv"))
        if pst_helper.m.nrow != 40:
            obs_locs.loc[:, "row"] = (obs_locs.row * redis_fac) + int(redis_fac / 2.0)
            obs_locs.loc[:, "col"] = (obs_locs.col * redis_fac) + int(redis_fac / 2.0)
        #build obs names that correspond to the obsnme values in the control file
        obs_locs.loc[:, "obsnme"] = obs_locs.apply(lambda x: "hds_00_{0:03d}_{1:03d}_000".format(x["row"], x["col"]), axis=1)
        obs_locs
```

```
Out[29]:
```

	row	col	obsnme
0	3	16	hds_00_002_015_000
1	3	10	hds_00_002_009_000
2	4	9	hds_00_003_008_000
3	10	2	hds_00_009_001_000
4	14	11	hds_00_013_010_000
5	16	17	hds_00_015_016_000
6	22	11	hds_00_021_010_000
7	23	16	hds_00_022_015_000
8	25	5	hds_00_024_004_000
9	27	7	hds_00_026_006_000
10	30	16	hds_00_029_015_000
11	34	8	hds_00_033_007_000
12	35	11	hds_00_034_010_000

Set all weights to zero first, then turn on the weights at only a few locations. These nonzero obs will be given meaningful weights in the prior monte carlo exercise

```
In [30]: obs = pst.observation_data
        obs.loc[:, "weight"] = 0.0
        obs.loc[obs_locs.obsnme, "weight"] = 1.0
        obs.loc[obs_locs.obsnme, "obgnme"] = "calhead"
        fo_obs = "fo_{0}_19791230".format(pst_helper.m.nrow-1)
        obs.loc[fo_obs, "weight"] = 1.0
        obs.loc[fo_obs, "obgnme"] = "calflux"
        pst.nnz_obs_names
```

```
Out[30]: ['fo_39_19791230',
          'hds_00_002_009_000',
          'hds_00_002_015_000',
```

```

'hds_00_003_008_000',
'hds_00_009_001_000',
'hds_00_013_010_000',
'hds_00_015_016_000',
'hds_00_021_010_000',
'hds_00_022_015_000',
'hds_00_024_004_000',
'hds_00_026_006_000',
'hds_00_029_015_000',
'hds_00_033_007_000',
'hds_00_034_010_000']

```

Now we will define which model outputs are going to be treated as “forecasts” and save the control file

```

In [31]: swgw_forecasts = obs.loc[obs.obsnme.apply(lambda x: "fa" in x and ("hw" in x or "tw" in x))]
print(swgw_forecasts)
hds_fore_name = "hds_00_{0:03d}_{1:03d}".format(int(pst_helper.m.nrow/3),int(pst_helper.m.nrow/3))
hds_forecasts = obs.loc[obs.obsnme.apply(lambda x: hds_fore_name in x), "obsnme"].tolist()
forecasts = swgw_forecasts
forecasts.extend(hds_forecasts)
forecasts.append("part_time")
forecasts.append("part_status")
pst_helper.pst.pestpp_options["forecasts"] = forecasts
pst.write(os.path.join(pst_helper.new_model_ws, "freyberg.pst"))

['fa_hw_19791230', 'fa_hw_19801229', 'fa_tw_19791230', 'fa_tw_19801229']
noptmax:0, npar_adj:14819, nnz_obs:14

```

Run one last time. phi should be near zero since we haven’t change the parval1 values for historic stress period and only the 13 gw level obs have nonzero weights

```

In [32]: pyemu.os_utils.run("pestpp-ies.exe freyberg.pst", cwd=pst_helper.new_model_ws)
pst = pyemu.Pst(os.path.join(pst_helper.new_model_ws, "freyberg.pst"))
pst.phi

```

```

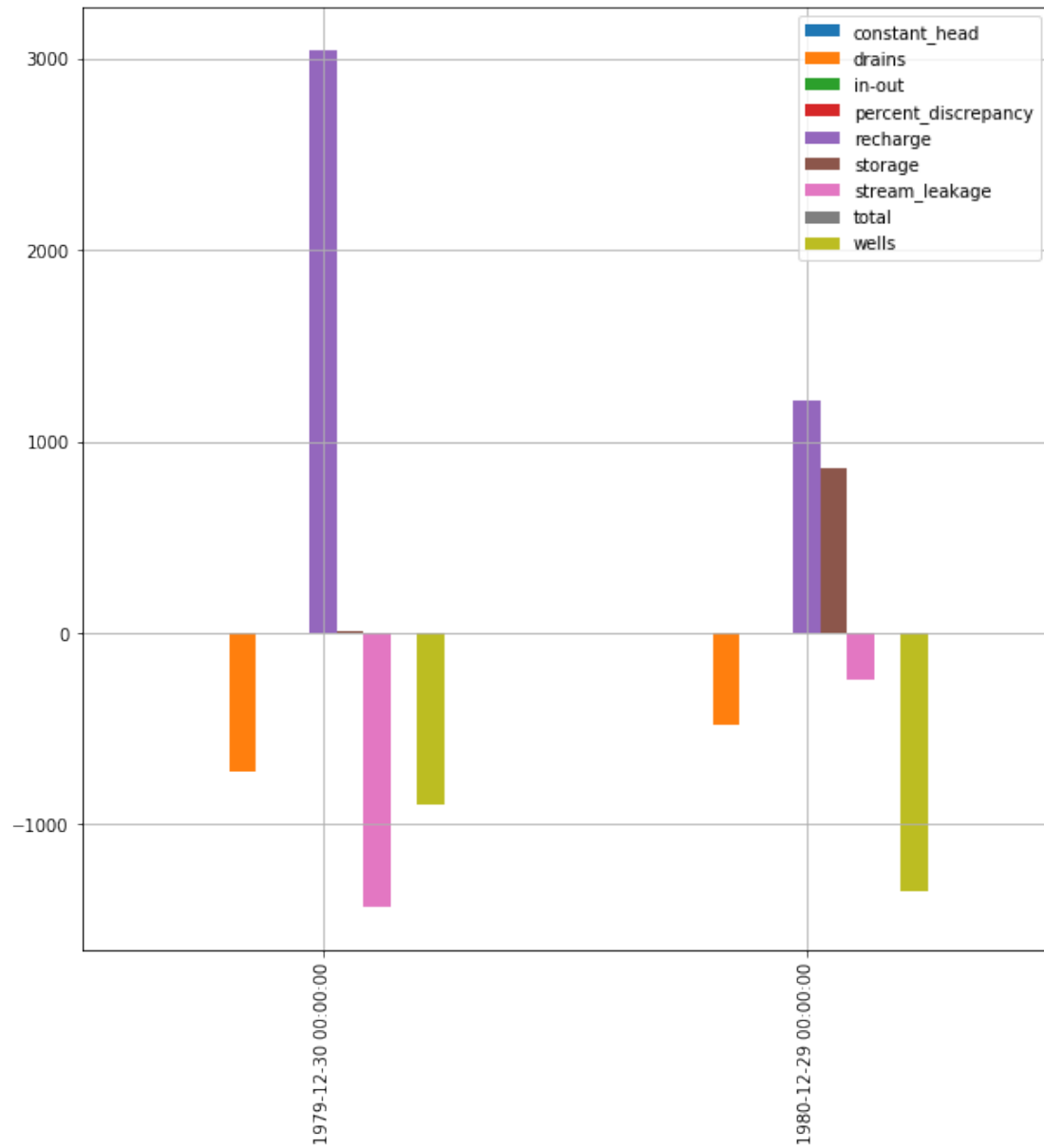
Out[32]: 9.456182577320024e-19

```

```

In [33]: lst = flopy.utils.MfListBudget(os.path.join("template", "freyberg.list"))
df = lst.get_dataframes(diff=True)[0]
df.plot(kind="bar", figsize=(10,10), grid=True)
plt.show()

```



We see the effect of our parameterized scenario - a large drop in recharge and more abstraction.