

# setup\_pest\_interface

May 10, 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]: 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
```

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 = "mfwt"
```

```

# 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)

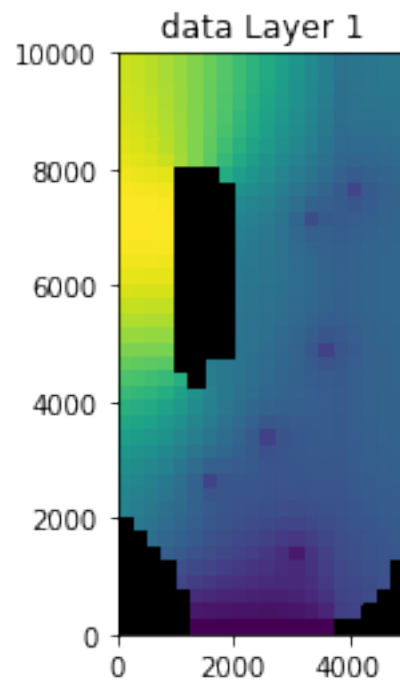
```
In [5]: pyemu.os_utils.run("{0} {1}".format("mfnewt",m.name+".nam"),cwd=m.model_ws)
```

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

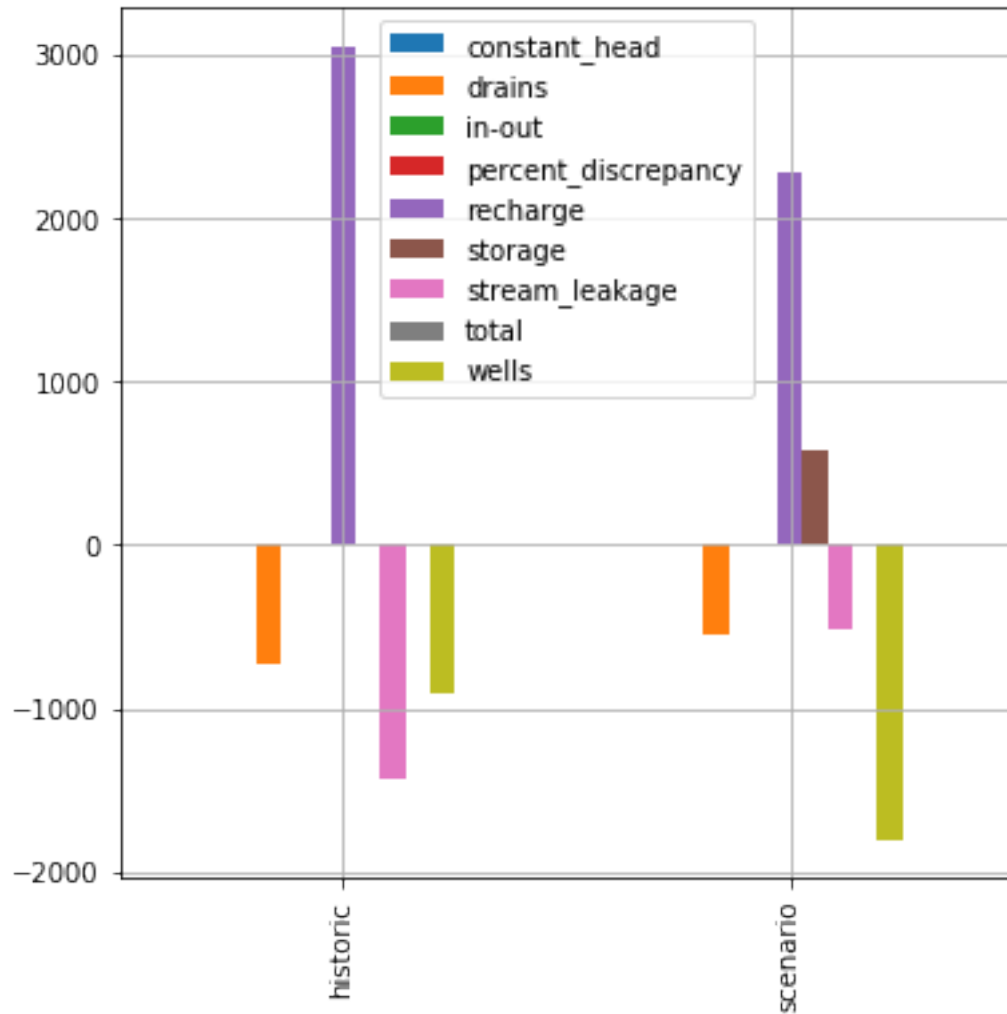
Note that there is a historic period and a scenario with future conditions that differ. For the future scenario, recharge is lower and pumping/abstraction is increased to make up for the presumed deficit in water for agriculture.

```
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"])
        plt.show()

```



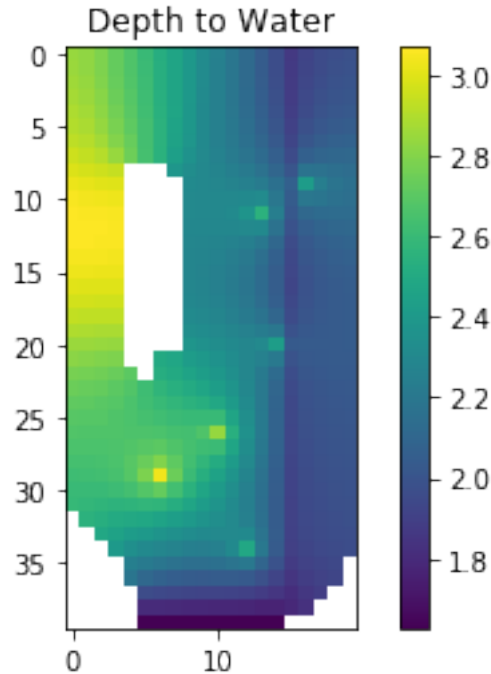
<Figure size 432x288 with 0 Axes>



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)
plt.show()
```

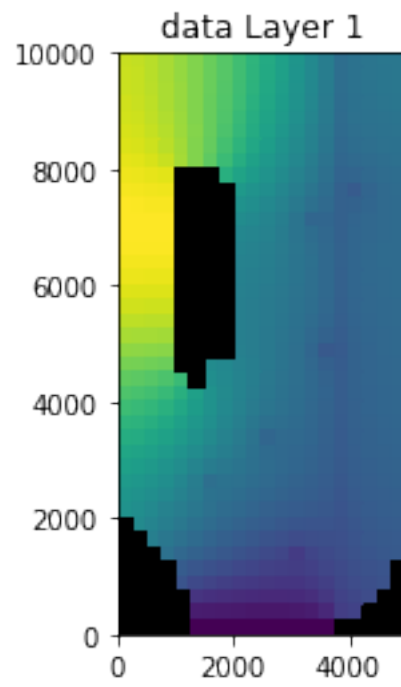


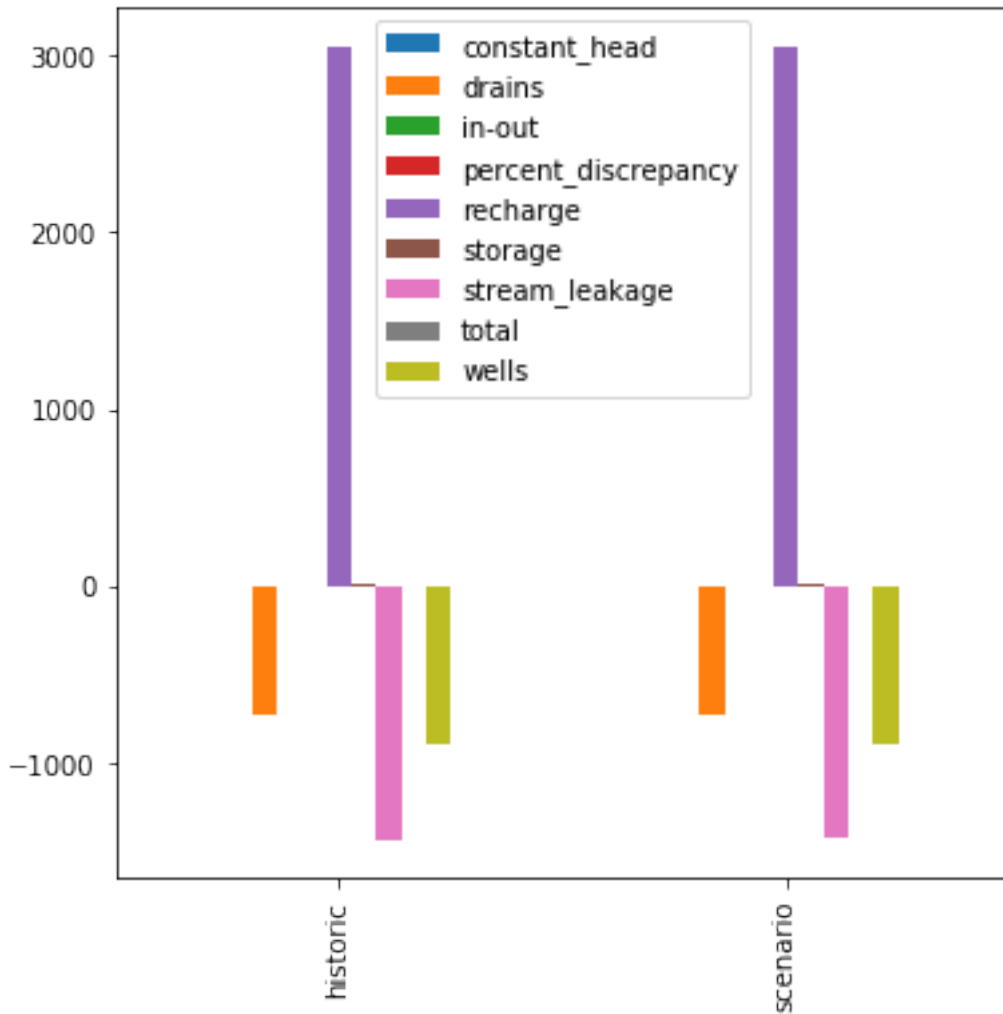
Clearly we can see the river and well locations expressed in the depth to water pattern.

**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:**

```
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("mfntw", 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))
ax.set_xticklabels(["historic", "scenario"])
plt.show()
```





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 covariance 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=
                                                    const_props=props,spatial_list_props=spat.
                                                    temporal_list_props=temporal_list_props,
                                                    grid_props=props,pp_props=props,sfr_pars=
                                                    sfr_obs=sfr_obs_dict,build_prior=False,m
                                                    pp_space=4)
        prep_deps.prep_template(t_d=pst_helper.new_model_ws)
```



2019-05-10 18:07:55.447316 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
2019-05-10 18:07:55.481709 finished: loading floppy model took: 0:00:00.034393
2019-05-10 18:07:55.481930 starting: updating model attributes
2019-05-10 18:07:55.482077 finished: updating model attributes took: 0:00:00.000147
2019-05-10 18:07:55.482182 WARNING: removing existing 'new_model_ws

creating model workspace...
    template

changing model workspace...
    template
2019-05-10 18:07:56.739397 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

2019-05-10 18:07:56.941495 finished: writing new modflow input files took: 0:00:00.202098

2019-05-10 18:07:56.942082 forward\_run line:pyemu.os\_utils.run('mf nwt freyberg.nam 1>freyberg.

2019-05-10 18:07:56.942184 starting: setting up 'template/arr\_org' dir

2019-05-10 18:07:56.943054 finished: setting up 'template/arr\_org' dir took: 0:00:00.000870

2019-05-10 18:07:56.943462 starting: setting up 'template/arr\_mlt' dir

2019-05-10 18:07:56.943968 finished: setting up 'template/arr\_mlt' dir took: 0:00:00.000506

2019-05-10 18:07:56.944141 starting: setting up 'template/list\_org' dir

2019-05-10 18:07:56.944762 finished: setting up 'template/list\_org' dir took: 0:00:00.000621

2019-05-10 18:07:56.945119 starting: setting up 'template/list\_mlt' dir

2019-05-10 18:07:56.945575 finished: setting up 'template/list\_mlt' dir took: 0:00:00.000456

2019-05-10 18:07:56.945807 starting: processing temporal\_list\_props

2019-05-10 18:07:56.969726 finished: processing temporal\_list\_props took: 0:00:00.023919

2019-05-10 18:07:56.970242 starting: processing spatial\_list\_props

2019-05-10 18:07:57.142858 finished: processing spatial\_list\_props took: 0:00:00.172616

2019-05-10 18:07:57.214613 forward\_run line:pyemu.helpers.apply\_list\_pars()

2019-05-10 18:07:57.246284 'extra' pak detected:extra.prsity

2019-05-10 18:07:57.292065 'extra' pak detected:extra.prsity

2019-05-10 18:07:57.332763 'extra' pak detected:extra.prsity

2019-05-10 18:07:57.381016 'extra' pak detected:extra.prsity

2019-05-10 18:07:57.415638 'extra' pak detected:extra.prsity

2019-05-10 18:07:57.451050 'extra' pak detected:extra.prsity

2019-05-10 18:07:57.508227 'extra' pak detected:extra.prsity

2019-05-10 18:07:57.541101 'extra' pak detected:extra.prsity

2019-05-10 18:07:57.571729 'extra' pak detected:extra.prsity

2019-05-10 18:07:57.652663 starting: writing grid tpl:hk3.dat\_gr.tpl

2019-05-10 18:07:57.661809 finished: writing grid tpl:hk3.dat\_gr.tpl took: 0:00:00.009146

2019-05-10 18:07:57.664840 starting: writing grid tpl:vka3.dat\_gr.tpl

2019-05-10 18:07:57.673092 finished: writing grid tpl:vka3.dat\_gr.tpl took: 0:00:00.008252

2019-05-10 18:07:57.675662 starting: writing grid tpl:ss3.dat\_gr.tpl

2019-05-10 18:07:57.684451 finished: writing grid tpl:ss3.dat\_gr.tpl took: 0:00:00.008789

2019-05-10 18:07:57.687153 starting: writing grid tpl:sy3.dat\_gr.tpl

2019-05-10 18:07:57.695956 finished: writing grid tpl:sy3.dat\_gr.tpl took: 0:00:00.008803

2019-05-10 18:07:57.698612 starting: writing grid tpl:str3.dat\_gr.tpl

2019-05-10 18:07:57.707580 finished: writing grid tpl:str3.dat\_gr.tpl took: 0:00:00.008968

2019-05-10 18:07:57.710386 starting: writing grid tpl:prsity3.dat\_gr.tpl

2019-05-10 18:07:57.722493 finished: writing grid tpl:prsity3.dat\_gr.tpl took: 0:00:00.012107

2019-05-10 18:07:57.725449 starting: writing grid tpl:hk4.dat\_gr.tpl

2019-05-10 18:07:57.734730 finished: writing grid tpl:hk4.dat\_gr.tpl took: 0:00:00.009281

2019-05-10 18:07:57.737582 starting: writing grid tpl:vka4.dat\_gr.tpl  
 2019-05-10 18:07:57.747182 finished: writing grid tpl:vka4.dat\_gr.tpl took: 0:00:00.009600  
 2019-05-10 18:07:57.750063 starting: writing grid tpl:ss4.dat\_gr.tpl  
 2019-05-10 18:07:57.760088 finished: writing grid tpl:ss4.dat\_gr.tpl took: 0:00:00.010025  
 2019-05-10 18:07:57.763089 starting: writing grid tpl:sy4.dat\_gr.tpl  
 2019-05-10 18:07:57.775056 finished: writing grid tpl:sy4.dat\_gr.tpl took: 0:00:00.011967  
 2019-05-10 18:07:57.778000 starting: writing grid tpl:strt4.dat\_gr.tpl  
 2019-05-10 18:07:57.787033 finished: writing grid tpl:strt4.dat\_gr.tpl took: 0:00:00.009033  
 2019-05-10 18:07:57.789977 starting: writing grid tpl:prsity4.dat\_gr.tpl  
 2019-05-10 18:07:57.801581 finished: writing grid tpl:prsity4.dat\_gr.tpl took: 0:00:00.011604  
 2019-05-10 18:07:57.804460 starting: writing grid tpl:hk5.dat\_gr.tpl  
 2019-05-10 18:07:57.813322 finished: writing grid tpl:hk5.dat\_gr.tpl took: 0:00:00.008862  
 2019-05-10 18:07:57.816175 starting: writing grid tpl:vka5.dat\_gr.tpl  
 2019-05-10 18:07:57.825537 finished: writing grid tpl:vka5.dat\_gr.tpl took: 0:00:00.009362  
 2019-05-10 18:07:57.829387 starting: writing grid tpl:ss5.dat\_gr.tpl  
 2019-05-10 18:07:57.838384 finished: writing grid tpl:ss5.dat\_gr.tpl took: 0:00:00.008997  
 2019-05-10 18:07:57.841455 starting: writing grid tpl:sy5.dat\_gr.tpl  
 2019-05-10 18:07:57.850403 finished: writing grid tpl:sy5.dat\_gr.tpl took: 0:00:00.008948  
 2019-05-10 18:07:57.853119 starting: writing grid tpl:strt5.dat\_gr.tpl  
 2019-05-10 18:07:57.862525 finished: writing grid tpl:strt5.dat\_gr.tpl took: 0:00:00.009406  
 2019-05-10 18:07:57.865330 starting: writing grid tpl:prsity5.dat\_gr.tpl  
 2019-05-10 18:07:57.876814 finished: writing grid tpl:prsity5.dat\_gr.tpl took: 0:00:00.011484  
 2019-05-10 18:07:57.879573 starting: writing grid tpl:rech2.dat\_gr.tpl  
 2019-05-10 18:07:57.888489 finished: writing grid tpl:rech2.dat\_gr.tpl took: 0:00:00.008916  
 2019-05-10 18:07:57.891181 starting: writing grid tpl:rech3.dat\_gr.tpl  
 2019-05-10 18:07:57.899732 finished: writing grid tpl:rech3.dat\_gr.tpl took: 0:00:00.008551  
 2019-05-10 18:07:57.902381 starting: writing const tpl:hk6.dat\_cn.tpl  
 2019-05-10 18:07:57.907534 finished: writing const tpl:hk6.dat\_cn.tpl took: 0:00:00.005153  
 2019-05-10 18:07:57.910020 starting: writing const tpl:vka6.dat\_cn.tpl  
 2019-05-10 18:07:57.915907 finished: writing const tpl:vka6.dat\_cn.tpl took: 0:00:00.005887  
 2019-05-10 18:07:57.918464 starting: writing const tpl:ss6.dat\_cn.tpl  
 2019-05-10 18:07:57.923870 finished: writing const tpl:ss6.dat\_cn.tpl took: 0:00:00.005406  
 2019-05-10 18:07:57.926337 starting: writing const tpl:sy6.dat\_cn.tpl  
 2019-05-10 18:07:57.932191 finished: writing const tpl:sy6.dat\_cn.tpl took: 0:00:00.005854  
 2019-05-10 18:07:57.934786 starting: writing const tpl:strt6.dat\_cn.tpl  
 2019-05-10 18:07:57.940380 finished: writing const tpl:strt6.dat\_cn.tpl took: 0:00:00.005594  
 2019-05-10 18:07:57.942868 starting: writing const tpl:prsity6.dat\_cn.tpl  
 2019-05-10 18:07:57.948381 finished: writing const tpl:prsity6.dat\_cn.tpl took: 0:00:00.005513  
 2019-05-10 18:07:57.951034 starting: writing const tpl:hk7.dat\_cn.tpl  
 2019-05-10 18:07:57.957334 finished: writing const tpl:hk7.dat\_cn.tpl took: 0:00:00.006300  
 2019-05-10 18:07:57.960024 starting: writing const tpl:vka7.dat\_cn.tpl  
 2019-05-10 18:07:57.965956 finished: writing const tpl:vka7.dat\_cn.tpl took: 0:00:00.005932  
 2019-05-10 18:07:57.968762 starting: writing const tpl:ss7.dat\_cn.tpl  
 2019-05-10 18:07:57.974580 finished: writing const tpl:ss7.dat\_cn.tpl took: 0:00:00.005818  
 2019-05-10 18:07:57.977214 starting: writing const tpl:sy7.dat\_cn.tpl  
 2019-05-10 18:07:57.982955 finished: writing const tpl:sy7.dat\_cn.tpl took: 0:00:00.005741  
 2019-05-10 18:07:57.985742 starting: writing const tpl:strt7.dat\_cn.tpl  
 2019-05-10 18:07:57.991772 finished: writing const tpl:strt7.dat\_cn.tpl took: 0:00:00.006030

```

2019-05-10 18:07:57.994411 starting: writing const tpl:prsity7.dat_cn.tpl
2019-05-10 18:07:58.000330 finished: writing const tpl:prsity7.dat_cn.tpl took: 0:00:00.005919
2019-05-10 18:07:58.003029 starting: writing const tpl:hk8.dat_cn.tpl
2019-05-10 18:07:58.008754 finished: writing const tpl:hk8.dat_cn.tpl took: 0:00:00.005725
2019-05-10 18:07:58.011247 starting: writing const tpl:vka8.dat_cn.tpl
2019-05-10 18:07:58.017282 finished: writing const tpl:vka8.dat_cn.tpl took: 0:00:00.006035
2019-05-10 18:07:58.020024 starting: writing const tpl:ss8.dat_cn.tpl
2019-05-10 18:07:58.025893 finished: writing const tpl:ss8.dat_cn.tpl took: 0:00:00.005869
2019-05-10 18:07:58.028579 starting: writing const tpl:sy8.dat_cn.tpl
2019-05-10 18:07:58.034281 finished: writing const tpl:sy8.dat_cn.tpl took: 0:00:00.005702
2019-05-10 18:07:58.037068 starting: writing const tpl:strt8.dat_cn.tpl
2019-05-10 18:07:58.042870 finished: writing const tpl:strt8.dat_cn.tpl took: 0:00:00.005802
2019-05-10 18:07:58.045501 starting: writing const tpl:prsity8.dat_cn.tpl
2019-05-10 18:07:58.051183 finished: writing const tpl:prsity8.dat_cn.tpl took: 0:00:00.005682
2019-05-10 18:07:58.053851 starting: writing const tpl:rech4.dat_cn.tpl
2019-05-10 18:07:58.059587 finished: writing const tpl:rech4.dat_cn.tpl took: 0:00:00.005736
2019-05-10 18:07:58.062307 starting: writing const tpl:rech5.dat_cn.tpl
2019-05-10 18:07:58.068556 finished: writing const tpl:rech5.dat_cn.tpl took: 0:00:00.006249
2019-05-10 18:07:58.092644 starting: setting up pilot point process
2019-05-10 18:07:58.092955 WARNING: pp_geostrcut is None, using ExpVario with contribution=1 and
2019-05-10 18:07:58.096206 pp_dict: {0: ['hk0', 'vka0', 'ss0', 'sy0', 'strt0', 'prsity0', 'rech0', 'rech1', 'prsity1']}
2019-05-10 18:07:58.096778 starting: calling setup_pilot_point_grid()
2019-05-10 18:07:58.809063 640 pilot point parameters created
2019-05-10 18:07:58.809768 pilot point 'pargp':hk0,vka0,ss0,sy0,strt0,prsity0,rech0,rech1,prsity1
2019-05-10 18:07:58.809828 finished: calling setup_pilot_point_grid() took: 0:00:00.713050
2019-05-10 18:07:58.811651 starting: calculating factors for p=hk0, k=0
2019-05-10 18:07:58.812853 saving krige variance file:template/pp_k0_general_zn.fac
2019-05-10 18:07:58.813003 saving krige factors file:template/pp_k0_general_zn.fac
starting interp point loop for 800 points
took 2.63765 seconds
2019-05-10 18:08:01.504360 finished: calculating factors for p=hk0, k=0 took: 0:00:02.692709
2019-05-10 18:08:01.505302 starting: calculating factors for p=vka0, k=0
2019-05-10 18:08:01.506483 finished: calculating factors for p=vka0, k=0 took: 0:00:00.001181
2019-05-10 18:08:01.507094 starting: calculating factors for p=ss0, k=0
2019-05-10 18:08:01.508140 finished: calculating factors for p=ss0, k=0 took: 0:00:00.001046
2019-05-10 18:08:01.508902 starting: calculating factors for p=sy0, k=0
2019-05-10 18:08:01.509616 finished: calculating factors for p=sy0, k=0 took: 0:00:00.000714
2019-05-10 18:08:01.510198 starting: calculating factors for p=strt0, k=0
2019-05-10 18:08:01.511027 finished: calculating factors for p=strt0, k=0 took: 0:00:00.000829
2019-05-10 18:08:01.511886 starting: calculating factors for p=prsity0, k=0
2019-05-10 18:08:01.512931 finished: calculating factors for p=prsity0, k=0 took: 0:00:00.001046
2019-05-10 18:08:01.513834 starting: calculating factors for p=rech0, k=0
2019-05-10 18:08:01.515115 finished: calculating factors for p=rech0, k=0 took: 0:00:00.001281
2019-05-10 18:08:01.515905 starting: calculating factors for p=rech1, k=0
2019-05-10 18:08:01.516612 finished: calculating factors for p=rech1, k=0 took: 0:00:00.000707
2019-05-10 18:08:01.517181 starting: calculating factors for p=prsity1, k=1
2019-05-10 18:08:01.517825 saving krige variance file:template/pp_k1_general_zn.fac
2019-05-10 18:08:01.518116 saving krige factors file:template/pp_k1_general_zn.fac

```

```

starting interp point loop for 800 points
took 2.597627 seconds
2019-05-10 18:08:04.169559 finished: calculating factors for p=prsity1, k=1 took: 0:00:02.6523
2019-05-10 18:08:04.170851 starting: calculating factors for p=hk1, k=1
2019-05-10 18:08:04.171929 finished: calculating factors for p=hk1, k=1 took: 0:00:00.001078
2019-05-10 18:08:04.172825 starting: calculating factors for p=ss1, k=1
2019-05-10 18:08:04.173828 finished: calculating factors for p=ss1, k=1 took: 0:00:00.001003
2019-05-10 18:08:04.174771 starting: calculating factors for p=sy1, k=1
2019-05-10 18:08:04.175755 finished: calculating factors for p=sy1, k=1 took: 0:00:00.000984
2019-05-10 18:08:04.176649 starting: calculating factors for p=vka1, k=1
2019-05-10 18:08:04.177792 finished: calculating factors for p=vka1, k=1 took: 0:00:00.001143
2019-05-10 18:08:04.178727 starting: calculating factors for p=strt1, k=1
2019-05-10 18:08:04.179896 finished: calculating factors for p=strt1, k=1 took: 0:00:00.001169
2019-05-10 18:08:04.180826 starting: calculating factors for p=vka2, k=2
2019-05-10 18:08:04.181991 saving krige variance file:template/pp_k2_general_zn.fac
2019-05-10 18:08:04.182256 saving krige factors file:template/pp_k2_general_zn.fac
starting interp point loop for 800 points
took 2.562508 seconds
2019-05-10 18:08:06.799380 finished: calculating factors for p=vka2, k=2 took: 0:00:02.618554
2019-05-10 18:08:06.800475 starting: calculating factors for p=ss2, k=2
2019-05-10 18:08:06.801950 finished: calculating factors for p=ss2, k=2 took: 0:00:00.001475
2019-05-10 18:08:06.802831 starting: calculating factors for p=hk2, k=2
2019-05-10 18:08:06.803844 finished: calculating factors for p=hk2, k=2 took: 0:00:00.001013
2019-05-10 18:08:06.804810 starting: calculating factors for p=prsity2, k=2
2019-05-10 18:08:06.805881 finished: calculating factors for p=prsity2, k=2 took: 0:00:00.0010
2019-05-10 18:08:06.806838 starting: calculating factors for p=sy2, k=2
2019-05-10 18:08:06.808466 finished: calculating factors for p=sy2, k=2 took: 0:00:00.001628
2019-05-10 18:08:06.809276 starting: calculating factors for p=strt2, k=2
2019-05-10 18:08:06.809926 finished: calculating factors for p=strt2, k=2 took: 0:00:00.000650
2019-05-10 18:08:06.810292 starting: processing pp_prefix:rech1
2019-05-10 18:08:06.821624 starting: processing pp_prefix:hk2
2019-05-10 18:08:06.830545 starting: processing pp_prefix:strt2
2019-05-10 18:08:06.838626 starting: processing pp_prefix:strt1
2019-05-10 18:08:06.846912 starting: processing pp_prefix:hk1
2019-05-10 18:08:06.854977 starting: processing pp_prefix:sy2
2019-05-10 18:08:06.863326 starting: processing pp_prefix:ss0
2019-05-10 18:08:06.871482 starting: processing pp_prefix:ss2
2019-05-10 18:08:06.880053 starting: processing pp_prefix:vka1
2019-05-10 18:08:06.888113 starting: processing pp_prefix:prsity1
2019-05-10 18:08:06.896589 starting: processing pp_prefix:vka0
2019-05-10 18:08:06.904542 starting: processing pp_prefix:prsity0
2019-05-10 18:08:06.912882 starting: processing pp_prefix:rech0
2019-05-10 18:08:06.921129 starting: processing pp_prefix:prsity2
2019-05-10 18:08:06.929195 starting: processing pp_prefix:sy1
2019-05-10 18:08:06.937415 starting: processing pp_prefix:strt0
2019-05-10 18:08:06.945475 starting: processing pp_prefix:ss1
2019-05-10 18:08:06.953725 starting: processing pp_prefix:vka2
2019-05-10 18:08:06.961908 starting: processing pp_prefix:sy0

```

```

2019-05-10 18:08:06.970267 starting: processing pp_prefix:hk0
2019-05-10 18:08:07.079675 finished: setting up pilot point process took: 0:00:08.987031
2019-05-10 18:08:07.080013 starting: setting up grid process
2019-05-10 18:08:07.080387 WARNING: grid_geostruc is None, using ExpVario with contribution=1
2019-05-10 18:08:07.080624 finished: setting up grid process took: 0:00:00.000611
2019-05-10 18:08:07.085311 starting: save test mlt array arr_mlt/hk0.dat_pp
2019-05-10 18:08:07.088849 finished: save test mlt array arr_mlt/hk0.dat_pp took: 0:00:00.0035
2019-05-10 18:08:07.090297 starting: save test mlt array arr_mlt/vka0.dat_pp
2019-05-10 18:08:07.098499 finished: save test mlt array arr_mlt/vka0.dat_pp took: 0:00:00.008
2019-05-10 18:08:07.099561 starting: save test mlt array arr_mlt/ss0.dat_pp
2019-05-10 18:08:07.102243 finished: save test mlt array arr_mlt/ss0.dat_pp took: 0:00:00.0026
2019-05-10 18:08:07.103379 starting: save test mlt array arr_mlt/sy0.dat_pp
2019-05-10 18:08:07.107635 finished: save test mlt array arr_mlt/sy0.dat_pp took: 0:00:00.0042
2019-05-10 18:08:07.109015 starting: save test mlt array arr_mlt/strt0.dat_pp
2019-05-10 18:08:07.117971 finished: save test mlt array arr_mlt/strt0.dat_pp took: 0:00:00.00
2019-05-10 18:08:07.119475 starting: save test mlt array arr_mlt/prsity0.dat_pp
2019-05-10 18:08:07.126839 finished: save test mlt array arr_mlt/prsity0.dat_pp took: 0:00:00.
2019-05-10 18:08:07.128373 starting: save test mlt array arr_mlt/hk1.dat_pp
2019-05-10 18:08:07.137127 finished: save test mlt array arr_mlt/hk1.dat_pp took: 0:00:00.0087
2019-05-10 18:08:07.138219 starting: save test mlt array arr_mlt/vka1.dat_pp
2019-05-10 18:08:07.146351 finished: save test mlt array arr_mlt/vka1.dat_pp took: 0:00:00.008
2019-05-10 18:08:07.147528 starting: save test mlt array arr_mlt/ss1.dat_pp
2019-05-10 18:08:07.161339 finished: save test mlt array arr_mlt/ss1.dat_pp took: 0:00:00.0138
2019-05-10 18:08:07.162417 starting: save test mlt array arr_mlt/sy1.dat_pp
2019-05-10 18:08:07.164900 finished: save test mlt array arr_mlt/sy1.dat_pp took: 0:00:00.0024
2019-05-10 18:08:07.165680 starting: save test mlt array arr_mlt/strt1.dat_pp
2019-05-10 18:08:07.168555 finished: save test mlt array arr_mlt/strt1.dat_pp took: 0:00:00.00
2019-05-10 18:08:07.169515 starting: save test mlt array arr_mlt/prsity1.dat_pp
2019-05-10 18:08:07.171899 finished: save test mlt array arr_mlt/prsity1.dat_pp took: 0:00:00.
2019-05-10 18:08:07.172938 starting: save test mlt array arr_mlt/hk2.dat_pp
2019-05-10 18:08:07.177316 finished: save test mlt array arr_mlt/hk2.dat_pp took: 0:00:00.0043
2019-05-10 18:08:07.178547 starting: save test mlt array arr_mlt/vka2.dat_pp
2019-05-10 18:08:07.180762 finished: save test mlt array arr_mlt/vka2.dat_pp took: 0:00:00.002
2019-05-10 18:08:07.181619 starting: save test mlt array arr_mlt/ss2.dat_pp
2019-05-10 18:08:07.185324 finished: save test mlt array arr_mlt/ss2.dat_pp took: 0:00:00.0037
2019-05-10 18:08:07.186367 starting: save test mlt array arr_mlt/sy2.dat_pp
2019-05-10 18:08:07.189311 finished: save test mlt array arr_mlt/sy2.dat_pp took: 0:00:00.0029
2019-05-10 18:08:07.190442 starting: save test mlt array arr_mlt/strt2.dat_pp
2019-05-10 18:08:07.192907 finished: save test mlt array arr_mlt/strt2.dat_pp took: 0:00:00.00
2019-05-10 18:08:07.194368 starting: save test mlt array arr_mlt/prsity2.dat_pp
2019-05-10 18:08:07.197935 finished: save test mlt array arr_mlt/prsity2.dat_pp took: 0:00:00.
2019-05-10 18:08:07.199291 starting: save test mlt array arr_mlt/rech0.dat_pp
2019-05-10 18:08:07.202549 finished: save test mlt array arr_mlt/rech0.dat_pp took: 0:00:00.00
2019-05-10 18:08:07.203950 starting: save test mlt array arr_mlt/rech1.dat_pp
2019-05-10 18:08:07.207657 finished: save test mlt array arr_mlt/rech1.dat_pp took: 0:00:00.00
2019-05-10 18:08:07.209128 starting: save test mlt array arr_mlt/hk3.dat_gr
2019-05-10 18:08:07.212708 finished: save test mlt array arr_mlt/hk3.dat_gr took: 0:00:00.0035
2019-05-10 18:08:07.214303 starting: save test mlt array arr_mlt/vka3.dat_gr

```



2019-05-10 18:08:07.217917 finished: save test mlt array arr\_mlt/vka3.dat\_gr took: 0:00:00.0030  
 2019-05-10 18:08:07.219530 starting: save test mlt array arr\_mlt/ss3.dat\_gr  
 2019-05-10 18:08:07.223240 finished: save test mlt array arr\_mlt/ss3.dat\_gr took: 0:00:00.0037  
 2019-05-10 18:08:07.224787 starting: save test mlt array arr\_mlt/sy3.dat\_gr  
 2019-05-10 18:08:07.228553 finished: save test mlt array arr\_mlt/sy3.dat\_gr took: 0:00:00.0037  
 2019-05-10 18:08:07.229699 starting: save test mlt array arr\_mlt/strt3.dat\_gr  
 2019-05-10 18:08:07.232865 finished: save test mlt array arr\_mlt/strt3.dat\_gr took: 0:00:00.0030  
 2019-05-10 18:08:07.234211 starting: save test mlt array arr\_mlt/prsity3.dat\_gr  
 2019-05-10 18:08:07.237047 finished: save test mlt array arr\_mlt/prsity3.dat\_gr took: 0:00:00.0030  
 2019-05-10 18:08:07.238398 starting: save test mlt array arr\_mlt/hk4.dat\_gr  
 2019-05-10 18:08:07.241900 finished: save test mlt array arr\_mlt/hk4.dat\_gr took: 0:00:00.0035  
 2019-05-10 18:08:07.243129 starting: save test mlt array arr\_mlt/vka4.dat\_gr  
 2019-05-10 18:08:07.245817 finished: save test mlt array arr\_mlt/vka4.dat\_gr took: 0:00:00.0029  
 2019-05-10 18:08:07.246863 starting: save test mlt array arr\_mlt/ss4.dat\_gr  
 2019-05-10 18:08:07.250267 finished: save test mlt array arr\_mlt/ss4.dat\_gr took: 0:00:00.0034  
 2019-05-10 18:08:07.251858 starting: save test mlt array arr\_mlt/sy4.dat\_gr  
 2019-05-10 18:08:07.255542 finished: save test mlt array arr\_mlt/sy4.dat\_gr took: 0:00:00.0036  
 2019-05-10 18:08:07.257021 starting: save test mlt array arr\_mlt/strt4.dat\_gr  
 2019-05-10 18:08:07.260656 finished: save test mlt array arr\_mlt/strt4.dat\_gr took: 0:00:00.0030  
 2019-05-10 18:08:07.262308 starting: save test mlt array arr\_mlt/prsity4.dat\_gr  
 2019-05-10 18:08:07.265868 finished: save test mlt array arr\_mlt/prsity4.dat\_gr took: 0:00:00.0030  
 2019-05-10 18:08:07.267185 starting: save test mlt array arr\_mlt/hk5.dat\_gr  
 2019-05-10 18:08:07.270076 finished: save test mlt array arr\_mlt/hk5.dat\_gr took: 0:00:00.0028  
 2019-05-10 18:08:07.271503 starting: save test mlt array arr\_mlt/vka5.dat\_gr  
 2019-05-10 18:08:07.275065 finished: save test mlt array arr\_mlt/vka5.dat\_gr took: 0:00:00.0030  
 2019-05-10 18:08:07.276538 starting: save test mlt array arr\_mlt/ss5.dat\_gr  
 2019-05-10 18:08:07.279948 finished: save test mlt array arr\_mlt/ss5.dat\_gr took: 0:00:00.0034  
 2019-05-10 18:08:07.281368 starting: save test mlt array arr\_mlt/sy5.dat\_gr  
 2019-05-10 18:08:07.285209 finished: save test mlt array arr\_mlt/sy5.dat\_gr took: 0:00:00.0038  
 2019-05-10 18:08:07.286714 starting: save test mlt array arr\_mlt/strt5.dat\_gr  
 2019-05-10 18:08:07.290159 finished: save test mlt array arr\_mlt/strt5.dat\_gr took: 0:00:00.0030  
 2019-05-10 18:08:07.291221 starting: save test mlt array arr\_mlt/prsity5.dat\_gr  
 2019-05-10 18:08:07.294537 finished: save test mlt array arr\_mlt/prsity5.dat\_gr took: 0:00:00.0030  
 2019-05-10 18:08:07.296032 starting: save test mlt array arr\_mlt/rech2.dat\_gr  
 2019-05-10 18:08:07.299366 finished: save test mlt array arr\_mlt/rech2.dat\_gr took: 0:00:00.0030  
 2019-05-10 18:08:07.300643 starting: save test mlt array arr\_mlt/rech3.dat\_gr  
 2019-05-10 18:08:07.303899 finished: save test mlt array arr\_mlt/rech3.dat\_gr took: 0:00:00.0030  
 2019-05-10 18:08:07.305368 starting: save test mlt array arr\_mlt/hk6.dat\_cn  
 2019-05-10 18:08:07.308935 finished: save test mlt array arr\_mlt/hk6.dat\_cn took: 0:00:00.0035  
 2019-05-10 18:08:07.310253 starting: save test mlt array arr\_mlt/vka6.dat\_cn  
 2019-05-10 18:08:07.313349 finished: save test mlt array arr\_mlt/vka6.dat\_cn took: 0:00:00.0030  
 2019-05-10 18:08:07.314583 starting: save test mlt array arr\_mlt/ss6.dat\_cn  
 2019-05-10 18:08:07.318115 finished: save test mlt array arr\_mlt/ss6.dat\_cn took: 0:00:00.0035  
 2019-05-10 18:08:07.319719 starting: save test mlt array arr\_mlt/sy6.dat\_cn  
 2019-05-10 18:08:07.322995 finished: save test mlt array arr\_mlt/sy6.dat\_cn took: 0:00:00.0032  
 2019-05-10 18:08:07.323880 starting: save test mlt array arr\_mlt/strt6.dat\_cn  
 2019-05-10 18:08:07.326916 finished: save test mlt array arr\_mlt/strt6.dat\_cn took: 0:00:00.0030  
 2019-05-10 18:08:07.328368 starting: save test mlt array arr\_mlt/prsity6.dat\_cn

```

2019-05-10 18:08:07.331721 finished: save test mlt array arr_mlt/prsity6.dat_cn took: 0:00:00.
2019-05-10 18:08:07.332916 starting: save test mlt array arr_mlt/hk7.dat_cn
2019-05-10 18:08:07.336345 finished: save test mlt array arr_mlt/hk7.dat_cn took: 0:00:00.0034
2019-05-10 18:08:07.337849 starting: save test mlt array arr_mlt/vka7.dat_cn
2019-05-10 18:08:07.341464 finished: save test mlt array arr_mlt/vka7.dat_cn took: 0:00:00.003
2019-05-10 18:08:07.342976 starting: save test mlt array arr_mlt/ss7.dat_cn
2019-05-10 18:08:07.345669 finished: save test mlt array arr_mlt/ss7.dat_cn took: 0:00:00.0026
2019-05-10 18:08:07.346681 starting: save test mlt array arr_mlt/sy7.dat_cn
2019-05-10 18:08:07.350268 finished: save test mlt array arr_mlt/sy7.dat_cn took: 0:00:00.0035
2019-05-10 18:08:07.351788 starting: save test mlt array arr_mlt/strt7.dat_cn
2019-05-10 18:08:07.355326 finished: save test mlt array arr_mlt/strt7.dat_cn took: 0:00:00.003
2019-05-10 18:08:07.356973 starting: save test mlt array arr_mlt/prsity7.dat_cn
2019-05-10 18:08:07.360270 finished: save test mlt array arr_mlt/prsity7.dat_cn took: 0:00:00.
2019-05-10 18:08:07.361698 starting: save test mlt array arr_mlt/hk8.dat_cn
2019-05-10 18:08:07.365388 finished: save test mlt array arr_mlt/hk8.dat_cn took: 0:00:00.0036
2019-05-10 18:08:07.366493 starting: save test mlt array arr_mlt/vka8.dat_cn
2019-05-10 18:08:07.369000 finished: save test mlt array arr_mlt/vka8.dat_cn took: 0:00:00.002
2019-05-10 18:08:07.369974 starting: save test mlt array arr_mlt/ss8.dat_cn
2019-05-10 18:08:07.373394 finished: save test mlt array arr_mlt/ss8.dat_cn took: 0:00:00.0034
2019-05-10 18:08:07.375028 starting: save test mlt array arr_mlt/sy8.dat_cn
2019-05-10 18:08:07.378216 finished: save test mlt array arr_mlt/sy8.dat_cn took: 0:00:00.0031
2019-05-10 18:08:07.379601 starting: save test mlt array arr_mlt/strt8.dat_cn
2019-05-10 18:08:07.382904 finished: save test mlt array arr_mlt/strt8.dat_cn took: 0:00:00.003
2019-05-10 18:08:07.384511 starting: save test mlt array arr_mlt/prsity8.dat_cn
2019-05-10 18:08:07.387976 finished: save test mlt array arr_mlt/prsity8.dat_cn took: 0:00:00.
2019-05-10 18:08:07.389361 starting: save test mlt array arr_mlt/rech4.dat_cn
2019-05-10 18:08:07.392698 finished: save test mlt array arr_mlt/rech4.dat_cn took: 0:00:00.003
2019-05-10 18:08:07.394190 starting: save test mlt array arr_mlt/rech5.dat_cn
2019-05-10 18:08:07.397780 finished: save test mlt array arr_mlt/rech5.dat_cn took: 0:00:00.003
2019-05-10 18:08:08.070168 forward_run line:pyemu.helpers.apply_array_pars()

all zeros for runoff...skipping...
all zeros for hcond1...skipping...
all zeros for ppts...skipping...
2019-05-10 18:08:08.215211 starting: processing obs type mflist water budget obs
2019-05-10 18:08:08.340018 forward_run line:pyemu.gw_utils.apply_mflist_budget_obs('freyberg.l
2019-05-10 18:08:08.340574 finished: processing obs type mflist water budget obs took: 0:00:00
2019-05-10 18:08:08.340688 starting: processing obs type hyd file
2019-05-10 18:08:08.341338 finished: processing obs type hyd file took: 0:00:00.000650
2019-05-10 18:08:08.341565 starting: processing obs type external obs-sim smp files
2019-05-10 18:08:08.341682 finished: processing obs type external obs-sim smp files took: 0:00
2019-05-10 18:08:08.341762 starting: processing obs type hob
2019-05-10 18:08:08.341949 finished: processing obs type hob took: 0:00:00.000187
2019-05-10 18:08:08.342031 starting: processing obs type hds
[[0, 0], [0, 1], [0, 2], [1, 0], [1, 1], [1, 2]]
2019-05-10 18:08:08.786939 finished: processing obs type hds took: 0:00:00.444908
2019-05-10 18:08:08.787356 starting: processing obs type sfr
writing 'sfr_obs.config' to template/sfr_obs.config

```

```

2019-05-10 18:08:09.193567 finished: processing obs type sfr took: 0:00:00.406211
2019-05-10 18:08:09.193993 changing dir in to template
2019-05-10 18:08:09.194778 starting: instantiating control file from i/o files
2019-05-10 18:08:09.194874 tpl files: wel.csv.tpl,drn.csv.tpl,hk3.dat_gr.tpl,vka3.dat_gr.tpl,s
2019-05-10 18:08:09.194919 ins files: freyberg.hds.dat.ins,vol.dat.ins,freyberg.sfr.out.proces
2019-05-10 18:08:09.539147 finished: instantiating control file from i/o files took: 0:00:00.3
2019-05-10 18:08:09.791248 starting: writing forward_run.py
2019-05-10 18:08:09.791970 finished: writing forward_run.py took: 0:00:00.000722
2019-05-10 18:08:09.792341 writing pst template/freyberg.pst
noptmax:0, npar_adj:14819, nnz_obs:4434
2019-05-10 18:08:11.575121 starting: running pestchek on freyberg.pst
2019-05-10 18:08:11.678350 pestcheck:PESTCHEK Version 13.0. Watermark Numerical Computing.
2019-05-10 18:08:11.678707 pestcheck:
2019-05-10 18:08:11.678764 pestcheck:Errors ----->
2019-05-10 18:08:11.678824 pestcheck:Line 2403 of file freyberg.pst: parameter name "prsity300
2019-05-10 18:08:11.679270 pestcheck:12 characters long.
2019-05-10 18:08:11.679327 pestcheck:Line 2404 of file freyberg.pst: parameter name "prsity300
2019-05-10 18:08:11.679827 pestcheck:12 characters long.
2019-05-10 18:08:11.679887 pestcheck:Line 2404 of file freyberg.pst: parameter name "prsity300
2019-05-10 18:08:11.680024 pestcheck:once.
2019-05-10 18:08:11.680322 pestcheck:Line 2405 of file freyberg.pst: parameter name "prsity300
2019-05-10 18:08:11.680522 pestcheck:12 characters long.
2019-05-10 18:08:11.680922 pestcheck:Line 2405 of file freyberg.pst: parameter name "prsity300
2019-05-10 18:08:11.681073 pestcheck:once.
2019-05-10 18:08:11.681115 pestcheck:Line 2406 of file freyberg.pst: parameter name "prsity300
2019-05-10 18:08:11.681154 pestcheck:12 characters long.
2019-05-10 18:08:11.681184 pestcheck:Line 2406 of file freyberg.pst: parameter name "prsity300
2019-05-10 18:08:11.681218 pestcheck:once.
2019-05-10 18:08:11.681265 pestcheck:Line 2407 of file freyberg.pst: parameter name "prsity300
2019-05-10 18:08:11.681300 pestcheck:12 characters long.
2019-05-10 18:08:11.681336 pestcheck:Line 2407 of file freyberg.pst: parameter name "prsity300
2019-05-10 18:08:11.681452 pestcheck:once.
2019-05-10 18:08:11.681487 pestcheck:Line 2408 of file freyberg.pst: parameter name "prsity300
2019-05-10 18:08:11.681535 pestcheck:12 characters long.
2019-05-10 18:08:11.681569 pestcheck:Line 2408 of file freyberg.pst: parameter name "prsity300
2019-05-10 18:08:11.681602 pestcheck:once.
2019-05-10 18:08:11.681724 pestcheck:Line 2409 of file freyberg.pst: parameter name "prsity300
2019-05-10 18:08:11.681838 pestcheck:12 characters long.
2019-05-10 18:08:11.681890 pestcheck:Line 2409 of file freyberg.pst: parameter name "prsity300
2019-05-10 18:08:11.682081 pestcheck:once.
2019-05-10 18:08:11.682131 pestcheck:Line 2410 of file freyberg.pst: parameter name "prsity300
2019-05-10 18:08:11.682170 pestcheck:12 characters long.
2019-05-10 18:08:11.682277 pestcheck:Line 2410 of file freyberg.pst: parameter name "prsity300
2019-05-10 18:08:11.682386 pestcheck:once.
2019-05-10 18:08:11.682506 pestcheck:Line 2411 of file freyberg.pst: parameter name "prsity300
2019-05-10 18:08:11.682560 pestcheck:12 characters long.
2019-05-10 18:08:11.682661 pestcheck:Line 2411 of file freyberg.pst: parameter name "prsity300
2019-05-10 18:08:11.682799 pestcheck:once.

```

2019-05-10 18:08:11.682863 pestcheck:Line 2412 of file freyberg.pst: parameter name "prsity3000  
2019-05-10 18:08:11.683052 pestcheck:12 characters long.  
2019-05-10 18:08:11.683164 pestcheck:Line 2412 of file freyberg.pst: parameter name "prsity3000  
2019-05-10 18:08:11.683288 pestcheck:once.  
2019-05-10 18:08:11.683400 pestcheck:Line 2413 of file freyberg.pst: parameter name "prsity3000  
2019-05-10 18:08:11.683519 pestcheck:12 characters long.  
2019-05-10 18:08:11.683627 pestcheck:Line 2414 of file freyberg.pst: parameter name "prsity3000  
2019-05-10 18:08:11.683746 pestcheck:12 characters long.  
2019-05-10 18:08:11.683854 pestcheck:Line 2414 of file freyberg.pst: parameter name "prsity3000  
2019-05-10 18:08:11.683912 pestcheck:once.  
2019-05-10 18:08:11.684016 pestcheck:Line 2415 of file freyberg.pst: parameter name "prsity3000  
2019-05-10 18:08:11.684124 pestcheck:12 characters long.  
2019-05-10 18:08:11.684241 pestcheck:Line 2415 of file freyberg.pst: parameter name "prsity3000  
2019-05-10 18:08:11.684350 pestcheck:once.  
2019-05-10 18:08:11.684401 pestcheck:Line 2416 of file freyberg.pst: parameter name "prsity3000  
2019-05-10 18:08:11.684441 pestcheck:12 characters long.  
2019-05-10 18:08:11.684544 pestcheck:Line 2416 of file freyberg.pst: parameter name "prsity3000  
2019-05-10 18:08:11.684653 pestcheck:once.  
2019-05-10 18:08:11.684771 pestcheck:Line 2417 of file freyberg.pst: parameter name "prsity3000  
2019-05-10 18:08:11.684823 pestcheck:12 characters long.  
2019-05-10 18:08:11.684931 pestcheck:Line 2417 of file freyberg.pst: parameter name "prsity3000  
2019-05-10 18:08:11.684983 pestcheck:once.  
2019-05-10 18:08:11.685049 pestcheck:Line 2418 of file freyberg.pst: parameter name "prsity3000  
2019-05-10 18:08:11.685158 pestcheck:12 characters long.  
2019-05-10 18:08:11.685213 pestcheck:Line 2418 of file freyberg.pst: parameter name "prsity3000  
2019-05-10 18:08:11.685316 pestcheck:once.  
2019-05-10 18:08:11.685364 pestcheck:Line 2419 of file freyberg.pst: parameter name "prsity3000  
2019-05-10 18:08:11.685404 pestcheck:12 characters long.  
2019-05-10 18:08:11.685511 pestcheck:Line 2419 of file freyberg.pst: parameter name "prsity3000  
2019-05-10 18:08:11.685565 pestcheck:once.  
2019-05-10 18:08:11.685666 pestcheck:Line 2420 of file freyberg.pst: parameter name "prsity3000  
2019-05-10 18:08:11.685714 pestcheck:12 characters long.  
2019-05-10 18:08:11.685753 pestcheck:Line 2420 of file freyberg.pst: parameter name "prsity3000  
2019-05-10 18:08:11.685859 pestcheck:once.  
2019-05-10 18:08:11.685980 pestcheck:Line 2421 of file freyberg.pst: parameter name "prsity3000  
2019-05-10 18:08:11.686029 pestcheck:12 characters long.  
2019-05-10 18:08:11.686139 pestcheck:Line 2421 of file freyberg.pst: parameter name "prsity3000  
2019-05-10 18:08:11.686249 pestcheck:once.  
2019-05-10 18:08:11.686299 pestcheck:Line 2422 of file freyberg.pst: parameter name "prsity3000  
2019-05-10 18:08:11.686338 pestcheck:12 characters long.  
2019-05-10 18:08:11.686443 pestcheck:Line 2422 of file freyberg.pst: parameter name "prsity3000  
2019-05-10 18:08:11.686511 pestcheck:once.  
2019-05-10 18:08:11.686604 pestcheck:Line 2423 of file freyberg.pst: parameter name "prsity3000  
2019-05-10 18:08:11.686719 pestcheck:12 characters long.  
2019-05-10 18:08:11.686821 pestcheck:Line 2424 of file freyberg.pst: parameter name "prsity3000  
2019-05-10 18:08:11.686876 pestcheck:12 characters long.  
2019-05-10 18:08:11.686975 pestcheck:Line 2424 of file freyberg.pst: parameter name "prsity3000  
2019-05-10 18:08:11.687026 pestcheck:once.

2019-05-10 18:08:11.687119 pestcheck:Line 2425 of file freyberg.pst: parameter name "prsity300.  
2019-05-10 18:08:11.687165 pestcheck:12 characters long.  
2019-05-10 18:08:11.687202 pestcheck:Line 2425 of file freyberg.pst: parameter name "prsity300.  
2019-05-10 18:08:11.687301 pestcheck:once.  
2019-05-10 18:08:11.687351 pestcheck:Line 2426 of file freyberg.pst: parameter name "prsity300.  
2019-05-10 18:08:11.687443 pestcheck:12 characters long.  
2019-05-10 18:08:11.687490 pestcheck:Line 2426 of file freyberg.pst: parameter name "prsity300.  
2019-05-10 18:08:11.687527 pestcheck:once.  
2019-05-10 18:08:11.687625 pestcheck:Line 2427 of file freyberg.pst: parameter name "prsity300.  
2019-05-10 18:08:11.687727 pestcheck:12 characters long.  
2019-05-10 18:08:11.687775 pestcheck:Line 2427 of file freyberg.pst: parameter name "prsity300.  
2019-05-10 18:08:11.687813 pestcheck:once.  
2019-05-10 18:08:11.687930 pestcheck:Line 2428 of file freyberg.pst: parameter name "prsity300.  
2019-05-10 18:08:11.688021 pestcheck:12 characters long.  
2019-05-10 18:08:11.688067 pestcheck:Line 2428 of file freyberg.pst: parameter name "prsity300.  
2019-05-10 18:08:11.688103 pestcheck:once.  
2019-05-10 18:08:11.688200 pestcheck:Line 2429 of file freyberg.pst: parameter name "prsity300.  
2019-05-10 18:08:11.688302 pestcheck:12 characters long.  
2019-05-10 18:08:11.688408 pestcheck:Line 2429 of file freyberg.pst: parameter name "prsity300.  
2019-05-10 18:08:11.688510 pestcheck:once.  
2019-05-10 18:08:11.688555 pestcheck:Line 2430 of file freyberg.pst: parameter name "prsity300.  
2019-05-10 18:08:11.688593 pestcheck:12 characters long.  
2019-05-10 18:08:11.688691 pestcheck:Line 2430 of file freyberg.pst: parameter name "prsity300.  
2019-05-10 18:08:11.688792 pestcheck:once.  
2019-05-10 18:08:11.688922 pestcheck:Line 2431 of file freyberg.pst: parameter name "prsity300.  
2019-05-10 18:08:11.689014 pestcheck:12 characters long.  
2019-05-10 18:08:11.689061 pestcheck:Line 2431 of file freyberg.pst: parameter name "prsity300.  
2019-05-10 18:08:11.689099 pestcheck:once.  
2019-05-10 18:08:11.689196 pestcheck:Line 2432 of file freyberg.pst: parameter name "prsity300.  
2019-05-10 18:08:11.689398 pestcheck:12 characters long.  
2019-05-10 18:08:11.689482 pestcheck:Line 2432 of file freyberg.pst: parameter name "prsity300.  
2019-05-10 18:08:11.689562 pestcheck:once.  
2019-05-10 18:08:11.689662 pestcheck:Line 2433 of file freyberg.pst: parameter name "prsity300.  
2019-05-10 18:08:11.689769 pestcheck:12 characters long.  
2019-05-10 18:08:11.689888 pestcheck:Line 2434 of file freyberg.pst: parameter name "prsity300.  
2019-05-10 18:08:11.689936 pestcheck:12 characters long.  
2019-05-10 18:08:11.689974 pestcheck:Line 2434 of file freyberg.pst: parameter name "prsity300.  
2019-05-10 18:08:11.690077 pestcheck:once.  
2019-05-10 18:08:11.690183 pestcheck:Line 2435 of file freyberg.pst: parameter name "prsity300.  
2019-05-10 18:08:11.690231 pestcheck:12 characters long.  
2019-05-10 18:08:11.690269 pestcheck:Line 2435 of file freyberg.pst: parameter name "prsity300.  
2019-05-10 18:08:11.690369 pestcheck:once.  
2019-05-10 18:08:11.690472 pestcheck:Line 2436 of file freyberg.pst: parameter name "prsity300.  
2019-05-10 18:08:11.690519 pestcheck:12 characters long.  
2019-05-10 18:08:11.690621 pestcheck:Line 2436 of file freyberg.pst: parameter name "prsity300.  
2019-05-10 18:08:11.690725 pestcheck:once.  
2019-05-10 18:08:11.690771 pestcheck:Line 2437 of file freyberg.pst: parameter name "prsity300.  
2019-05-10 18:08:11.690946 pestcheck:12 characters long.

2019-05-10 18:08:11.691059 pestcheck:Line 2437 of file freyberg.pst: parameter name "prsity300  
2019-05-10 18:08:11.691161 pestcheck:once.  
2019-05-10 18:08:11.691207 pestcheck:Line 2438 of file freyberg.pst: parameter name "prsity300  
2019-05-10 18:08:11.691246 pestcheck:12 characters long.  
2019-05-10 18:08:11.691344 pestcheck:Line 2438 of file freyberg.pst: parameter name "prsity300  
2019-05-10 18:08:11.691446 pestcheck:once.  
2019-05-10 18:08:11.691492 pestcheck:Line 2439 of file freyberg.pst: parameter name "prsity300  
2019-05-10 18:08:11.691530 pestcheck:12 characters long.  
2019-05-10 18:08:11.691628 pestcheck:Line 2439 of file freyberg.pst: parameter name "prsity300  
2019-05-10 18:08:11.691730 pestcheck:once.  
2019-05-10 18:08:11.691847 pestcheck:Line 2440 of file freyberg.pst: parameter name "prsity300  
2019-05-10 18:08:11.691950 pestcheck:12 characters long.  
2019-05-10 18:08:11.691996 pestcheck:Line 2440 of file freyberg.pst: parameter name "prsity300  
2019-05-10 18:08:11.692102 pestcheck:once.  
2019-05-10 18:08:11.692205 pestcheck:Line 2441 of file freyberg.pst: parameter name "prsity300  
2019-05-10 18:08:11.692252 pestcheck:12 characters long.  
2019-05-10 18:08:11.692291 pestcheck:Line 2441 of file freyberg.pst: parameter name "prsity300  
2019-05-10 18:08:11.692389 pestcheck:once.  
2019-05-10 18:08:11.692491 pestcheck:Line 2442 of file freyberg.pst: parameter name "prsity300  
2019-05-10 18:08:11.692538 pestcheck:12 characters long.  
2019-05-10 18:08:11.692608 pestcheck:Line 2442 of file freyberg.pst: parameter name "prsity300  
2019-05-10 18:08:11.692680 pestcheck:once.  
2019-05-10 18:08:11.692782 pestcheck:Line 2443 of file freyberg.pst: parameter name "prsity300  
2019-05-10 18:08:11.692901 pestcheck:12 characters long.  
2019-05-10 18:08:11.693004 pestcheck:Line 2444 of file freyberg.pst: parameter name "prsity300  
2019-05-10 18:08:11.693052 pestcheck:12 characters long.  
2019-05-10 18:08:11.693090 pestcheck:Line 2444 of file freyberg.pst: parameter name "prsity300  
2019-05-10 18:08:11.693189 pestcheck:once.  
2019-05-10 18:08:11.693291 pestcheck:Line 2445 of file freyberg.pst: parameter name "prsity300  
2019-05-10 18:08:11.693337 pestcheck:12 characters long.  
2019-05-10 18:08:11.693441 pestcheck:Line 2445 of file freyberg.pst: parameter name "prsity300  
2019-05-10 18:08:11.693544 pestcheck:once.  
2019-05-10 18:08:11.693591 pestcheck:Line 2446 of file freyberg.pst: parameter name "prsity300  
2019-05-10 18:08:11.693630 pestcheck:12 characters long.  
2019-05-10 18:08:11.693727 pestcheck:Line 2446 of file freyberg.pst: parameter name "prsity300  
2019-05-10 18:08:11.693831 pestcheck:once.  
2019-05-10 18:08:11.693885 pestcheck:Line 2447 of file freyberg.pst: parameter name "prsity300  
2019-05-10 18:08:11.693982 pestcheck:12 characters long.  
2019-05-10 18:08:11.694085 pestcheck:Line 2447 of file freyberg.pst: parameter name "prsity300  
2019-05-10 18:08:11.694131 pestcheck:once.  
2019-05-10 18:08:11.694249 pestcheck:Line 2448 of file freyberg.pst: parameter name "prsity300  
2019-05-10 18:08:11.694352 pestcheck:12 characters long.  
2019-05-10 18:08:11.694398 pestcheck:Line 2448 of file freyberg.pst: parameter name "prsity300  
2019-05-10 18:08:11.694504 pestcheck:once.  
2019-05-10 18:08:11.694607 pestcheck:Line 2449 of file freyberg.pst: parameter name "prsity300  
2019-05-10 18:08:11.694653 pestcheck:12 characters long.  
2019-05-10 18:08:11.694691 pestcheck:Line 2449 of file freyberg.pst: parameter name "prsity300  
2019-05-10 18:08:11.694788 pestcheck:once.

2019-05-10 18:08:11.694891 pestcheck:Line 2450 of file freyberg.pst: parameter name "prsity3002  
2019-05-10 18:08:11.694945 pestcheck:12 characters long.  
2019-05-10 18:08:11.695042 pestcheck:Line 2450 of file freyberg.pst: parameter name "prsity3002  
2019-05-10 18:08:11.695165 pestcheck:once.  
2019-05-10 18:08:11.695213 pestcheck:Line 2451 of file freyberg.pst: parameter name "prsity3002  
2019-05-10 18:08:11.695328 pestcheck:12 characters long.  
2019-05-10 18:08:11.695430 pestcheck:Line 2451 of file freyberg.pst: parameter name "prsity3002  
2019-05-10 18:08:11.695477 pestcheck:once.  
2019-05-10 18:08:11.695515 pestcheck:Line 2452 of file freyberg.pst: parameter name "prsity3002  
2019-05-10 18:08:11.695645 pestcheck:12 characters long.  
2019-05-10 18:08:11.695747 pestcheck:Line 2452 of file freyberg.pst: parameter name "prsity3002  
2019-05-10 18:08:11.695828 pestcheck:once.  
2019-05-10 18:08:11.695866 pestcheck:Line 2453 of file freyberg.pst: parameter name "prsity3002  
2019-05-10 18:08:11.695983 pestcheck:12 characters long.  
2019-05-10 18:08:11.696090 pestcheck:Line 2454 of file freyberg.pst: parameter name "prsity3002  
2019-05-10 18:08:11.696135 pestcheck:12 characters long.  
2019-05-10 18:08:11.696174 pestcheck:Line 2454 of file freyberg.pst: parameter name "prsity3002  
2019-05-10 18:08:11.696273 pestcheck:once.  
2019-05-10 18:08:11.696376 pestcheck:Line 2455 of file freyberg.pst: parameter name "prsity3002  
2019-05-10 18:08:11.696423 pestcheck:12 characters long.  
2019-05-10 18:08:11.696461 pestcheck:Line 2455 of file freyberg.pst: parameter name "prsity3002  
2019-05-10 18:08:11.696560 pestcheck:once.  
2019-05-10 18:08:11.696661 pestcheck:Line 2456 of file freyberg.pst: parameter name "prsity3002  
2019-05-10 18:08:11.696708 pestcheck:12 characters long.  
2019-05-10 18:08:11.696748 pestcheck:Line 2456 of file freyberg.pst: parameter name "prsity3002  
2019-05-10 18:08:11.696847 pestcheck:once.  
2019-05-10 18:08:11.696966 pestcheck:Line 2457 of file freyberg.pst: parameter name "prsity3002  
2019-05-10 18:08:11.697067 pestcheck:12 characters long.  
2019-05-10 18:08:11.697170 pestcheck:Line 2457 of file freyberg.pst: parameter name "prsity3002  
2019-05-10 18:08:11.697217 pestcheck:once.  
2019-05-10 18:08:11.697319 pestcheck:Line 2458 of file freyberg.pst: parameter name "prsity3002  
2019-05-10 18:08:11.697423 pestcheck:12 characters long.  
2019-05-10 18:08:11.697469 pestcheck:Line 2458 of file freyberg.pst: parameter name "prsity3002  
2019-05-10 18:08:11.697507 pestcheck:once.  
2019-05-10 18:08:11.697605 pestcheck:Line 2459 of file freyberg.pst: parameter name "prsity3002  
2019-05-10 18:08:11.697707 pestcheck:12 characters long.  
2019-05-10 18:08:11.697753 pestcheck:Line 2459 of file freyberg.pst: parameter name "prsity3002  
2019-05-10 18:08:11.697791 pestcheck:once.  
2019-05-10 18:08:11.697889 pestcheck:Line 2460 of file freyberg.pst: parameter name "prsity3002  
2019-05-10 18:08:11.698007 pestcheck:12 characters long.  
2019-05-10 18:08:11.698046 pestcheck:Line 2460 of file freyberg.pst: parameter name "prsity3002  
2019-05-10 18:08:11.698142 pestcheck:once.  
2019-05-10 18:08:11.698245 pestcheck:Line 2461 of file freyberg.pst: parameter name "prsity3002  
2019-05-10 18:08:11.698291 pestcheck:12 characters long.  
2019-05-10 18:08:11.698329 pestcheck:Line 2461 of file freyberg.pst: parameter name "prsity3002  
2019-05-10 18:08:11.698428 pestcheck:once.  
2019-05-10 18:08:11.698531 pestcheck:Line 2462 of file freyberg.pst: parameter name "prsity3002  
2019-05-10 18:08:11.698577 pestcheck:12 characters long.

2019-05-10 18:08:11.698618 pestcheck:Line 2462 of file freyberg.pst: parameter name "prsity3003  
2019-05-10 18:08:11.698717 pestcheck:once.  
2019-05-10 18:08:11.698875 pestcheck:Line 2463 of file freyberg.pst: parameter name "prsity3003  
2019-05-10 18:08:11.699007 pestcheck:12 characters long.  
2019-05-10 18:08:11.699110 pestcheck:Line 2464 of file freyberg.pst: parameter name "prsity3003  
2019-05-10 18:08:11.699157 pestcheck:12 characters long.  
2019-05-10 18:08:11.699196 pestcheck:Line 2464 of file freyberg.pst: parameter name "prsity3003  
2019-05-10 18:08:11.699295 pestcheck:once.  
2019-05-10 18:08:11.699397 pestcheck:Line 2465 of file freyberg.pst: parameter name "prsity3003  
2019-05-10 18:08:11.699444 pestcheck:12 characters long.  
2019-05-10 18:08:11.699482 pestcheck:Line 2465 of file freyberg.pst: parameter name "prsity3003  
2019-05-10 18:08:11.699579 pestcheck:once.  
2019-05-10 18:08:11.699681 pestcheck:Line 2466 of file freyberg.pst: parameter name "prsity3003  
2019-05-10 18:08:11.699727 pestcheck:12 characters long.  
2019-05-10 18:08:11.699766 pestcheck:Line 2466 of file freyberg.pst: parameter name "prsity3003  
2019-05-10 18:08:11.699863 pestcheck:once.  
2019-05-10 18:08:11.699983 pestcheck:Line 2467 of file freyberg.pst: parameter name "prsity3003  
2019-05-10 18:08:11.700022 pestcheck:12 characters long.  
2019-05-10 18:08:11.700119 pestcheck:Line 2467 of file freyberg.pst: parameter name "prsity3003  
2019-05-10 18:08:11.700221 pestcheck:once.  
2019-05-10 18:08:11.700268 pestcheck:Line 2468 of file freyberg.pst: parameter name "prsity3003  
2019-05-10 18:08:11.700371 pestcheck:12 characters long.  
2019-05-10 18:08:11.700475 pestcheck:Line 2468 of file freyberg.pst: parameter name "prsity3003  
2019-05-10 18:08:11.700523 pestcheck:once.  
2019-05-10 18:08:11.700624 pestcheck:Line 2469 of file freyberg.pst: parameter name "prsity3003  
2019-05-10 18:08:11.700676 pestcheck:12 characters long.  
2019-05-10 18:08:11.700770 pestcheck:Line 2469 of file freyberg.pst: parameter name "prsity3003  
2019-05-10 18:08:11.700815 pestcheck:once.  
2019-05-10 18:08:11.700911 pestcheck:Line 2470 of file freyberg.pst: parameter name "prsity3003  
2019-05-10 18:08:11.701073 pestcheck:12 characters long.  
2019-05-10 18:08:11.701160 pestcheck:Line 2470 of file freyberg.pst: parameter name "prsity3003  
2019-05-10 18:08:11.701226 pestcheck:once.  
2019-05-10 18:08:11.701290 pestcheck:Line 2471 of file freyberg.pst: parameter name "prsity3003  
2019-05-10 18:08:11.701335 pestcheck:12 characters long.  
2019-05-10 18:08:11.701472 pestcheck:Line 2471 of file freyberg.pst: parameter name "prsity3003  
2019-05-10 18:08:11.701538 pestcheck:once.  
2019-05-10 18:08:11.701600 pestcheck:Line 2472 of file freyberg.pst: parameter name "prsity3003  
2019-05-10 18:08:11.701645 pestcheck:12 characters long.  
2019-05-10 18:08:11.701711 pestcheck:Line 2472 of file freyberg.pst: parameter name "prsity3003  
2019-05-10 18:08:11.701776 pestcheck:once.  
2019-05-10 18:08:11.701840 pestcheck:Line 2473 of file freyberg.pst: parameter name "prsity3003  
2019-05-10 18:08:11.701913 pestcheck:12 characters long.  
2019-05-10 18:08:11.701988 pestcheck:Line 2474 of file freyberg.pst: parameter name "prsity3003  
2019-05-10 18:08:11.702102 pestcheck:12 characters long.  
2019-05-10 18:08:11.702152 pestcheck:Line 2474 of file freyberg.pst: parameter name "prsity3003  
2019-05-10 18:08:11.702254 pestcheck:once.  
2019-05-10 18:08:11.702301 pestcheck:Line 2475 of file freyberg.pst: parameter name "prsity3003  
2019-05-10 18:08:11.702339 pestcheck:12 characters long.



2019-05-10 18:08:11.702444 pestcheck:Line 2475 of file freyberg.pst: parameter name "prsity3003  
2019-05-10 18:08:11.702550 pestcheck:once.  
2019-05-10 18:08:11.702596 pestcheck:Line 2476 of file freyberg.pst: parameter name "prsity3003  
2019-05-10 18:08:11.702634 pestcheck:12 characters long.  
2019-05-10 18:08:11.702736 pestcheck:Line 2476 of file freyberg.pst: parameter name "prsity3003  
2019-05-10 18:08:11.702841 pestcheck:once.  
2019-05-10 18:08:11.702962 pestcheck:Line 2477 of file freyberg.pst: parameter name "prsity3003  
2019-05-10 18:08:11.703067 pestcheck:12 characters long.  
2019-05-10 18:08:11.703182 pestcheck:Line 2477 of file freyberg.pst: parameter name "prsity3003  
2019-05-10 18:08:11.703287 pestcheck:once.  
2019-05-10 18:08:11.703333 pestcheck:Line 2478 of file freyberg.pst: parameter name "prsity3003  
2019-05-10 18:08:11.703371 pestcheck:12 characters long.  
2019-05-10 18:08:11.703470 pestcheck:Line 2478 of file freyberg.pst: parameter name "prsity3003  
2019-05-10 18:08:11.703576 pestcheck:once.  
2019-05-10 18:08:11.703622 pestcheck:Line 2479 of file freyberg.pst: parameter name "prsity3003  
2019-05-10 18:08:11.703659 pestcheck:12 characters long.  
2019-05-10 18:08:11.703759 pestcheck:Line 2479 of file freyberg.pst: parameter name "prsity3003  
2019-05-10 18:08:11.703864 pestcheck:once.  
2019-05-10 18:08:11.703922 pestcheck:Line 2480 of file freyberg.pst: parameter name "prsity3003  
2019-05-10 18:08:11.704022 pestcheck:12 characters long.  
2019-05-10 18:08:11.704126 pestcheck:Line 2480 of file freyberg.pst: parameter name "prsity3003  
2019-05-10 18:08:11.704174 pestcheck:once.  
2019-05-10 18:08:11.704213 pestcheck:Line 2481 of file freyberg.pst: parameter name "prsity3003  
2019-05-10 18:08:11.704314 pestcheck:12 characters long.  
2019-05-10 18:08:11.704419 pestcheck:Line 2481 of file freyberg.pst: parameter name "prsity3003  
2019-05-10 18:08:11.704473 pestcheck:once.  
2019-05-10 18:08:11.704576 pestcheck:Line 2482 of file freyberg.pst: parameter name "prsity3003  
2019-05-10 18:08:11.704682 pestcheck:12 characters long.  
2019-05-10 18:08:11.704729 pestcheck:Line 2482 of file freyberg.pst: parameter name "prsity3003  
2019-05-10 18:08:11.704768 pestcheck:once.  
2019-05-10 18:08:11.704868 pestcheck:Line 2483 of file freyberg.pst: parameter name "prsity3004  
2019-05-10 18:08:11.704989 pestcheck:12 characters long.  
2019-05-10 18:08:11.705028 pestcheck:Line 2484 of file freyberg.pst: parameter name "prsity3004  
2019-05-10 18:08:11.705129 pestcheck:12 characters long.  
2019-05-10 18:08:11.705236 pestcheck:Line 2484 of file freyberg.pst: parameter name "prsity3004  
2019-05-10 18:08:11.705283 pestcheck:once.  
2019-05-10 18:08:11.705322 pestcheck:Line 2485 of file freyberg.pst: parameter name "prsity3004  
2019-05-10 18:08:11.705421 pestcheck:12 characters long.  
2019-05-10 18:08:11.705526 pestcheck:Line 2485 of file freyberg.pst: parameter name "prsity3004  
2019-05-10 18:08:11.705573 pestcheck:once.  
2019-05-10 18:08:11.705612 pestcheck:Line 2486 of file freyberg.pst: parameter name "prsity3004  
2019-05-10 18:08:11.705711 pestcheck:12 characters long.  
2019-05-10 18:08:11.705816 pestcheck:Line 2486 of file freyberg.pst: parameter name "prsity3004  
2019-05-10 18:08:11.705863 pestcheck:once.  
2019-05-10 18:08:11.706043 pestcheck:Line 2487 of file freyberg.pst: parameter name "prsity3004  
2019-05-10 18:08:11.706089 pestcheck:12 characters long.  
2019-05-10 18:08:11.706131 pestcheck:Line 2487 of file freyberg.pst: parameter name "prsity3004  
2019-05-10 18:08:11.706232 pestcheck:once.

2019-05-10 18:08:11.706337 pestcheck:Line 2488 of file freyberg.pst: parameter name "prsity3004  
2019-05-10 18:08:11.706384 pestcheck:12 characters long.  
2019-05-10 18:08:11.706422 pestcheck:Line 2488 of file freyberg.pst: parameter name "prsity3004  
2019-05-10 18:08:11.706522 pestcheck:once.  
2019-05-10 18:08:11.706627 pestcheck:Line 2489 of file freyberg.pst: parameter name "prsity3004  
2019-05-10 18:08:11.706677 pestcheck:12 characters long.  
2019-05-10 18:08:11.706716 pestcheck:Line 2489 of file freyberg.pst: parameter name "prsity3004  
2019-05-10 18:08:11.706816 pestcheck:once.  
2019-05-10 18:08:11.706920 pestcheck:Line 2490 of file freyberg.pst: parameter name "prsity3004  
2019-05-10 18:08:11.706975 pestcheck:12 characters long.  
2019-05-10 18:08:11.707074 pestcheck:Line 2490 of file freyberg.pst: parameter name "prsity3004  
2019-05-10 18:08:11.707179 pestcheck:once.  
2019-05-10 18:08:11.707226 pestcheck:Line 2491 of file freyberg.pst: parameter name "prsity3004  
2019-05-10 18:08:11.707264 pestcheck:12 characters long.  
2019-05-10 18:08:11.707331 pestcheck:Line 2491 of file freyberg.pst: parameter name "prsity3004  
2019-05-10 18:08:11.707405 pestcheck:once.  
2019-05-10 18:08:11.707510 pestcheck:Line 2492 of file freyberg.pst: parameter name "prsity3004  
2019-05-10 18:08:11.707556 pestcheck:12 characters long.  
2019-05-10 18:08:11.707595 pestcheck:Line 2492 of file freyberg.pst: parameter name "prsity3004  
2019-05-10 18:08:11.707695 pestcheck:once.  
2019-05-10 18:08:11.707800 pestcheck:Line 2493 of file freyberg.pst: parameter name "prsity3004  
2019-05-10 18:08:11.707933 pestcheck:12 characters long.  
2019-05-10 18:08:11.708064 pestcheck:Line 2494 of file freyberg.pst: parameter name "prsity3004  
2019-05-10 18:08:11.708102 pestcheck:12 characters long.  
2019-05-10 18:08:11.708199 pestcheck:Line 2494 of file freyberg.pst: parameter name "prsity3004  
2019-05-10 18:08:11.708301 pestcheck:once.  
2019-05-10 18:08:11.708347 pestcheck:Line 2495 of file freyberg.pst: parameter name "prsity3004  
2019-05-10 18:08:11.708385 pestcheck:12 characters long.  
2019-05-10 18:08:11.708481 pestcheck:Line 2495 of file freyberg.pst: parameter name "prsity3004  
2019-05-10 18:08:11.708587 pestcheck:once.  
2019-05-10 18:08:11.708633 pestcheck:Line 2496 of file freyberg.pst: parameter name "prsity3004  
2019-05-10 18:08:11.708671 pestcheck:12 characters long.  
2019-05-10 18:08:11.708768 pestcheck:Line 2496 of file freyberg.pst: parameter name "prsity3004  
2019-05-10 18:08:11.708914 pestcheck:once.  
2019-05-10 18:08:11.709032 pestcheck:Line 2497 of file freyberg.pst: parameter name "prsity3004  
2019-05-10 18:08:11.709135 pestcheck:12 characters long.  
2019-05-10 18:08:11.709181 pestcheck:Line 2497 of file freyberg.pst: parameter name "prsity3004  
2019-05-10 18:08:11.709219 pestcheck:once.  
2019-05-10 18:08:11.709316 pestcheck:Line 2498 of file freyberg.pst: parameter name "prsity3004  
2019-05-10 18:08:11.709418 pestcheck:12 characters long.  
2019-05-10 18:08:11.709464 pestcheck:Line 2498 of file freyberg.pst: parameter name "prsity3004  
2019-05-10 18:08:11.709501 pestcheck:once.  
2019-05-10 18:08:11.709599 pestcheck:Line 2499 of file freyberg.pst: parameter name "prsity3004  
2019-05-10 18:08:11.709701 pestcheck:12 characters long.  
2019-05-10 18:08:11.709747 pestcheck:Line 2499 of file freyberg.pst: parameter name "prsity3004  
2019-05-10 18:08:11.709785 pestcheck:once.  
2019-05-10 18:08:11.709883 pestcheck:Line 2500 of file freyberg.pst: parameter name "prsity3004  
2019-05-10 18:08:11.710000 pestcheck:12 characters long.

```

2019-05-10 18:08:11.710038 pestcheck:Line 2500 of file freyberg.pst: parameter name "prsity300
2019-05-10 18:08:11.710135 pestcheck:once.
2019-05-10 18:08:11.710236 pestcheck:Line 2501 of file freyberg.pst: parameter name "prsity300
2019-05-10 18:08:11.710282 pestcheck:12 characters long.
2019-05-10 18:08:11.710320 pestcheck:Line 2501 of file freyberg.pst: parameter name "prsity300
2019-05-10 18:08:11.710418 pestcheck:once.
2019-05-10 18:08:11.710520 pestcheck:Line 2502 of file freyberg.pst: parameter name "prsity300
2019-05-10 18:08:11.710565 pestcheck:12 characters long.
2019-05-10 18:08:11.710603 pestcheck:Line 2502 of file freyberg.pst: parameter name "prsity300
2019-05-10 18:08:11.710700 pestcheck:once.
2019-05-10 18:08:11.710801 pestcheck:Line 2503 of file freyberg.pst: parameter name "prsity300
2019-05-10 18:08:11.710847 pestcheck:12 characters long.
2019-05-10 18:08:11.710884 pestcheck:Line 2504 of file freyberg.pst: parameter name "prsity300
2019-05-10 18:08:11.711052 pestcheck:12 characters long.
2019-05-10 18:08:11.711097 pestcheck:Line 2504 of file freyberg.pst: parameter name "prsity300
2019-05-10 18:08:11.711135 pestcheck:once.
2019-05-10 18:08:11.711232 pestcheck:Line 2505 of file freyberg.pst: parameter name "prsity300
2019-05-10 18:08:11.711335 pestcheck:12 characters long.
2019-05-10 18:08:11.711380 pestcheck:Line 2505 of file freyberg.pst: parameter name "prsity300
2019-05-10 18:08:11.711418 pestcheck:once.
2019-05-10 18:08:11.711515 pestcheck:Line 2506 of file freyberg.pst: parameter name "prsity300
2019-05-10 18:08:11.711617 pestcheck:12 characters long.
2019-05-10 18:08:11.711662 pestcheck:Line 2506 of file freyberg.pst: parameter name "prsity300
2019-05-10 18:08:11.711700 pestcheck:once.
2019-05-10 18:08:11.711797 pestcheck:Line 2507 of file freyberg.pst: parameter name "prsity300
2019-05-10 18:08:11.711900 pestcheck:12 characters long.
2019-05-10 18:08:11.711953 pestcheck:Line 2507 of file freyberg.pst: parameter name "prsity300
2019-05-10 18:08:11.712050 pestcheck:once.
2019-05-10 18:08:11.712152 pestcheck:Line 2508 of file freyberg.pst: parameter name "prsity300
2019-05-10 18:08:11.712197 pestcheck:12 characters long.
2019-05-10 18:08:11.712446 finished: running pestchek on freyberg.pst took: 0:00:00.137325
2019-05-10 18:08:11.712624 starting: saving intermediate _setup_<> dfs into template
2019-05-10 18:08:11.845323 finished: saving intermediate _setup_<> dfs into template took: 0:0
2019-05-10 18:08:11.845577 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.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 !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' 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

Lets run the process once (noptmax=0) to make sure its all plumbed up

```
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_ws,"cov.pst"))
         cov = np.ma.masked_where(cov.x==0,cov.x)
         fig = plt.figure(figsize=(10,10))
         ax = plt.subplot(111)
         ax.imshow(cov)
         plt.show()
```

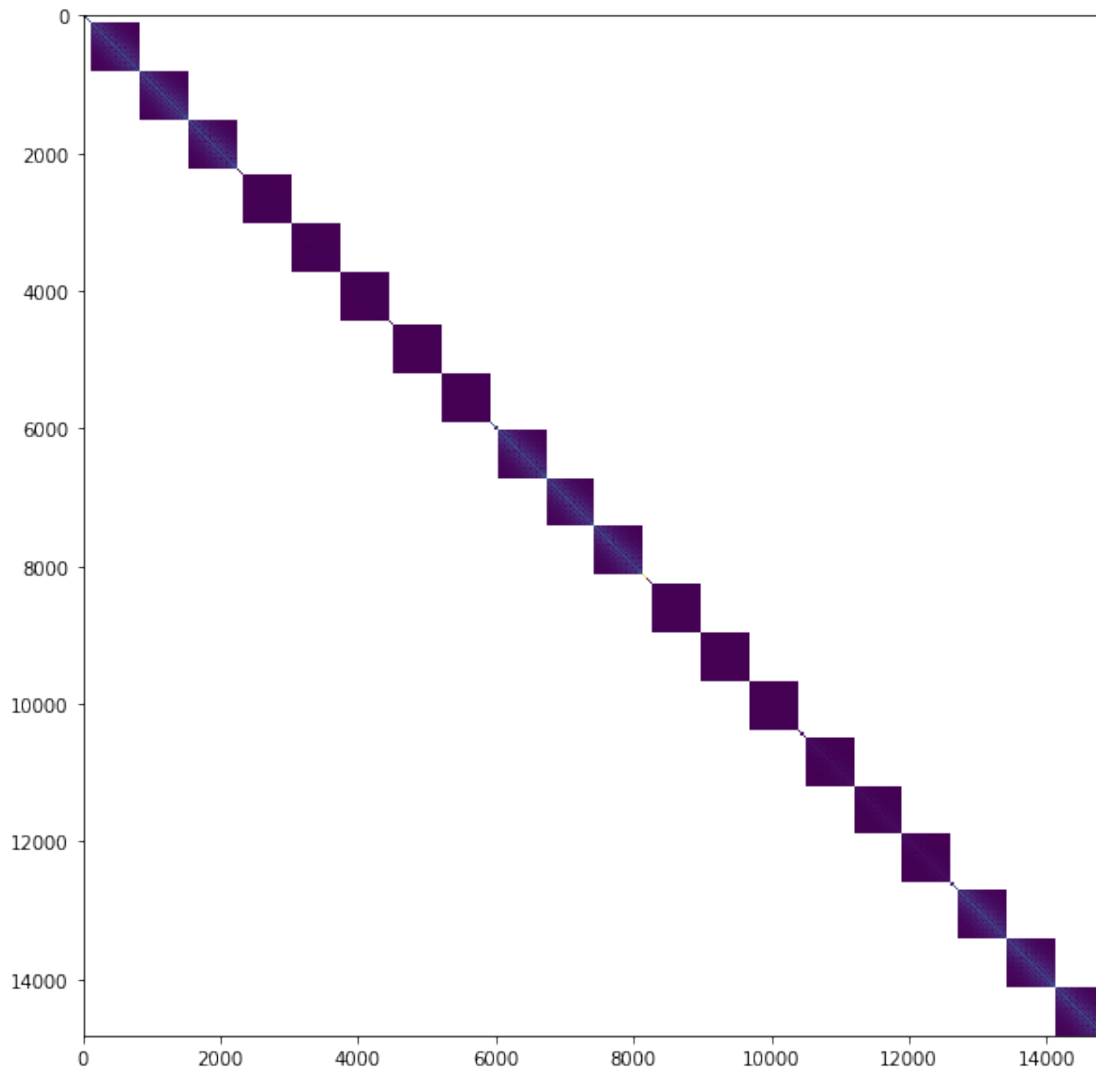
```
2019-05-10 18:08:20.910908 starting: building prior covariance matrix
2019-05-10 18:08:21.029870 WARNING: geospatial prior not implemented for SFR pars
```

```
/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
```

```
2019-05-10 18:08:27.288227 saving prior covariance matrix to file template/prior_cov.jcb
2019-05-10 18:08:31.580220 finished: building prior covariance matrix took: 0:00:10.669312
```



### 1.1.8 now we can make a draw of 200 from the prior parameter covariance matrix to form a prior parameter ensemble

```
In [25]: pe = pst_helper.draw(200)
```

```
2019-05-10 18:08:42.796178 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_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_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_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_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_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_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_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_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_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_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_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
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_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_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_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
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 ['welflux_k02']
build cov matrix
done
getting diag var cov 6
scaling full cov by diag var cov
making full cov draws with home-grown goodness
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

```

```

/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

```

```

processing name:temporal_list_geostruc,nugget:0.0,structures:
name:var1,contribution:1.0,a:180.0,anisotropy:1.0,bearing:0.0

```



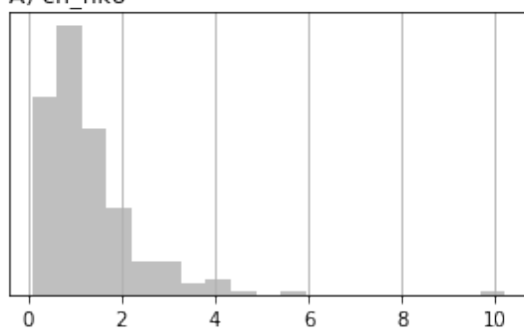
```
working on pargroups ['welflux']
build cov matrix
done
getting diag var cov 2
scaling full cov by diag var cov
making full cov draws with home-grown goodness
adding remaining parameters to diagonal
2019-05-10 18:08:50.121225 finished: drawing realizations took: 0:00:07.325047
```

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

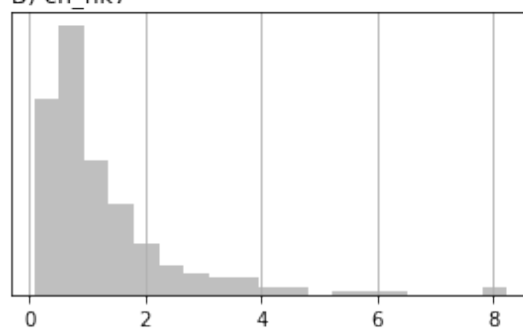
```
In [26]: par = pst_helper.pst.parameter_data
         pyemu.plot_utils.ensemble_helper(pe, plot_cols=par.groupby("pargp").groups, bins=20)
         plt.show()
```

<Figure size 576x756 with 0 Axes>

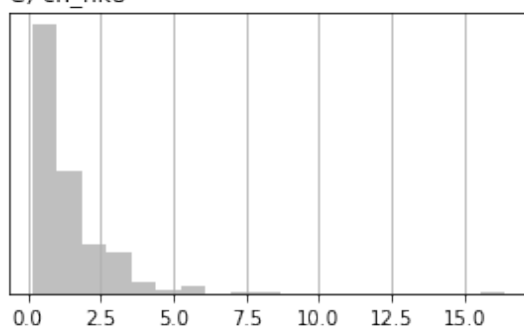
A) cn\_hk6



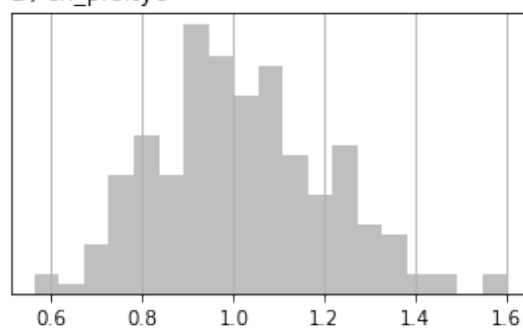
B) cn\_hk7



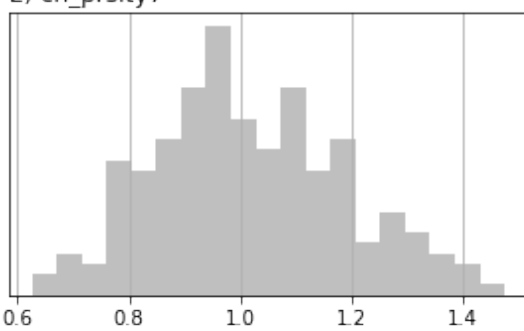
C) cn\_hk8



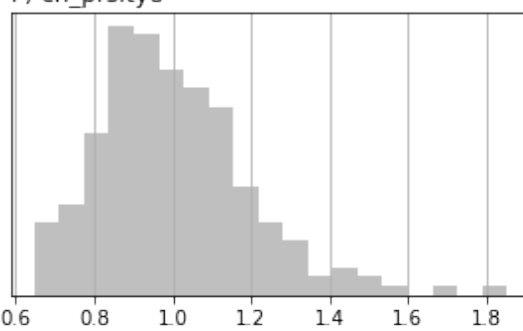
D) cn\_prsity6



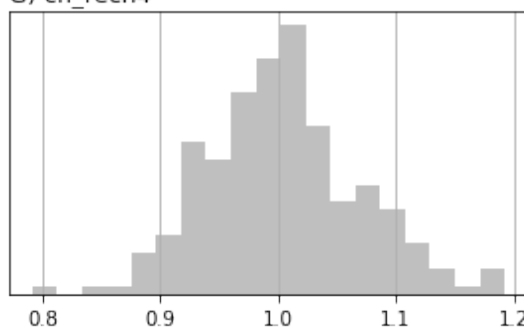
E) cn\_prsity7



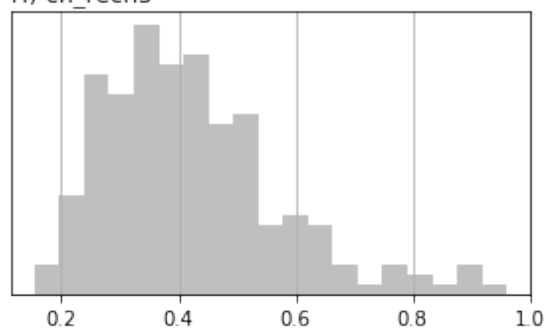
F) cn\_prsity8



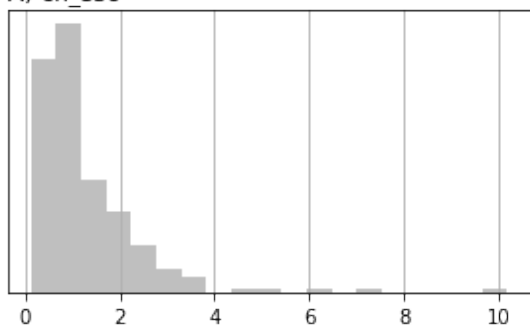
G) cn\_rech4



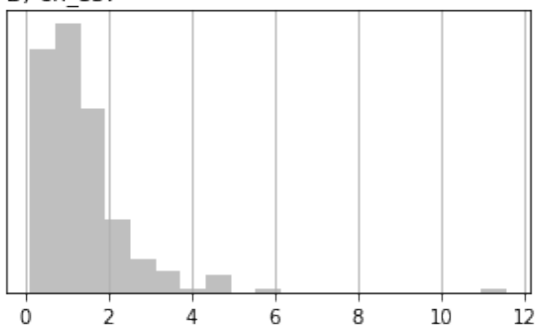
H) cn\_rech5



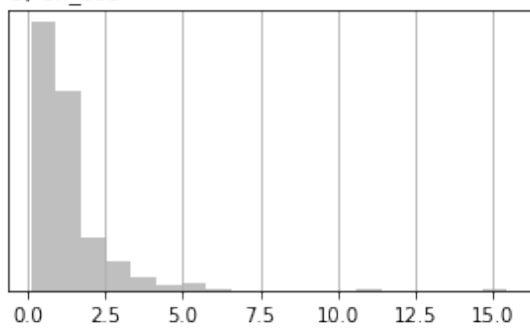
A) cn\_ss6



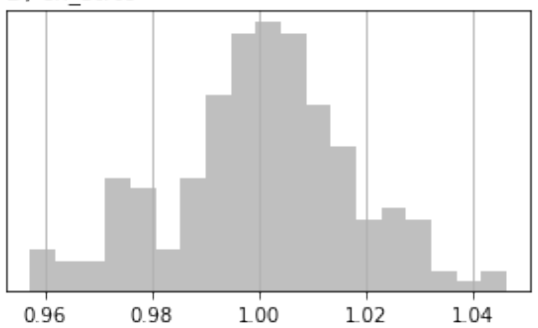
B) cn\_ss7



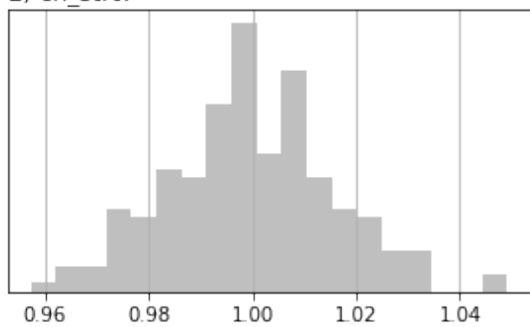
C) cn\_ss8



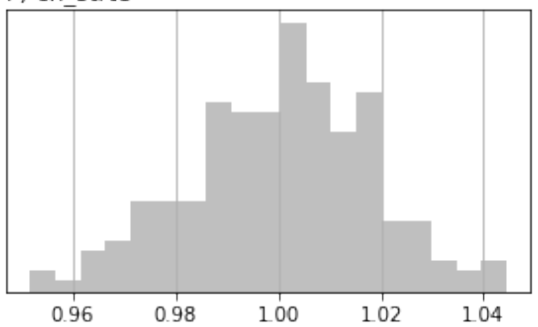
D) cn\_strt6



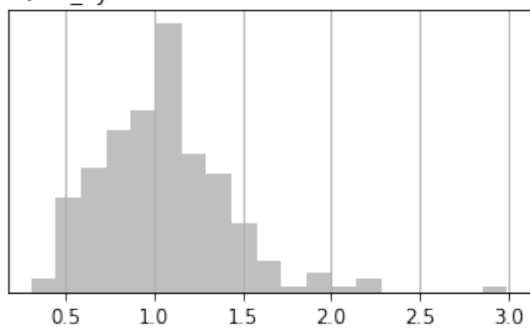
E) cn\_strt7



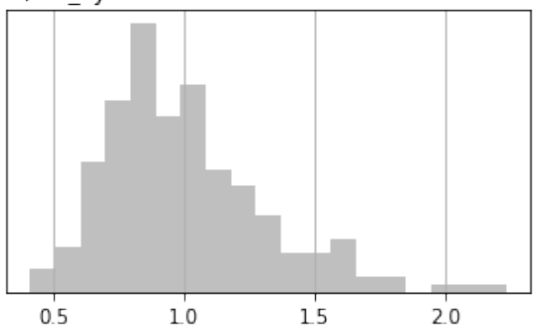
F) cn\_strt8



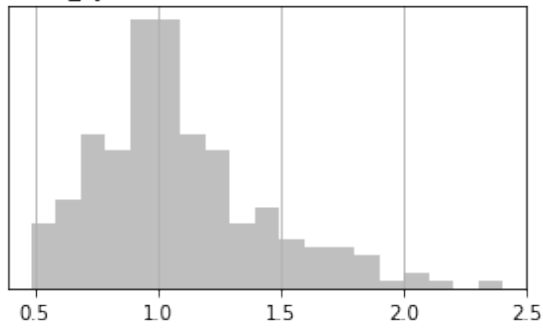
G) cn\_sy6



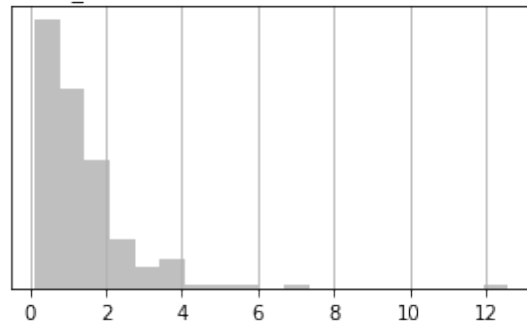
H) cn\_sy7



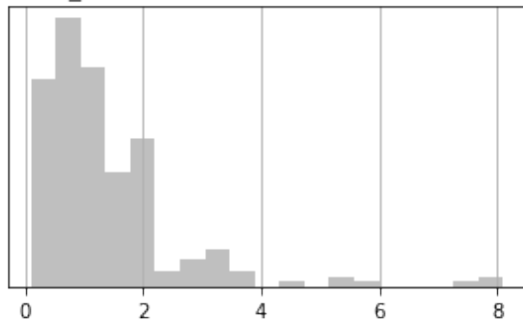
A) cn\_sy8



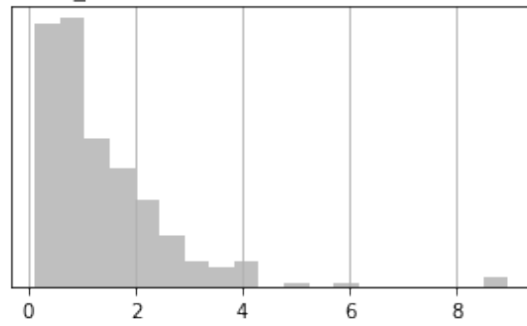
B) cn\_vka6



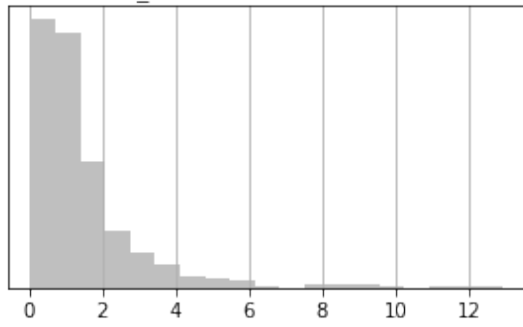
C) cn\_vka7



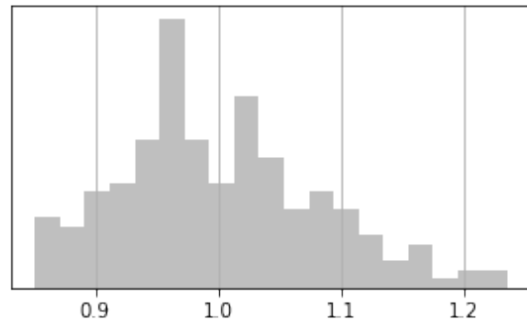
D) cn\_vka8



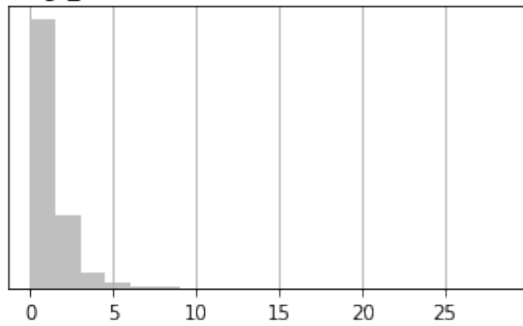
E) drncond\_k00



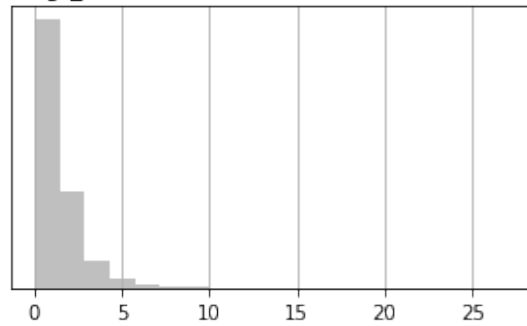
F) flow



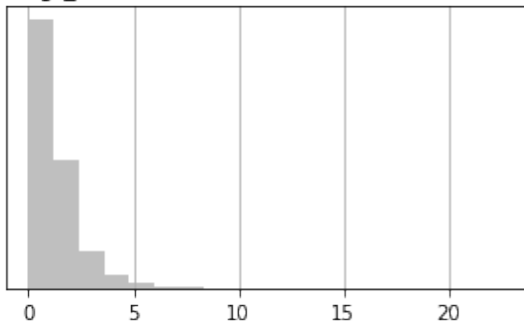
G) gr\_hk3



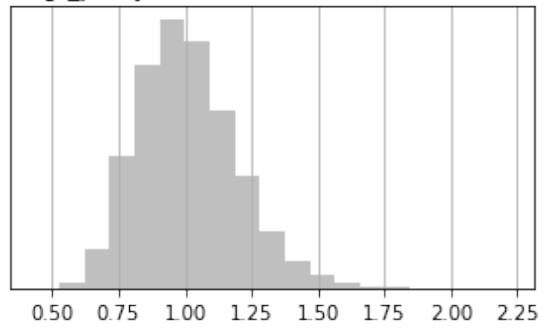
H) gr\_hk4



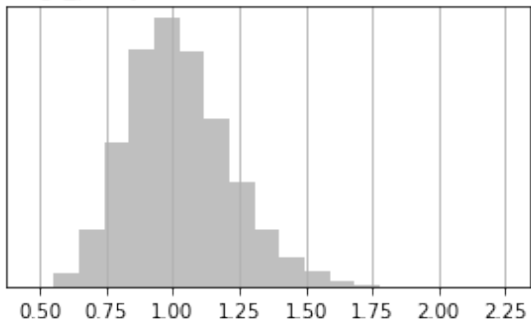
A) gr\_hk5



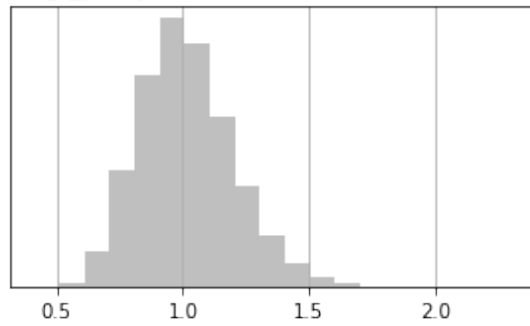
B) gr\_prsity3



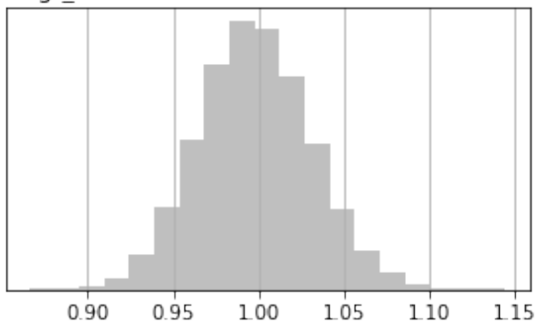
C) gr\_prsity4



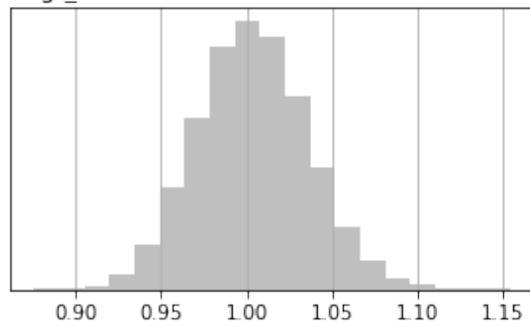
D) gr\_prsity5



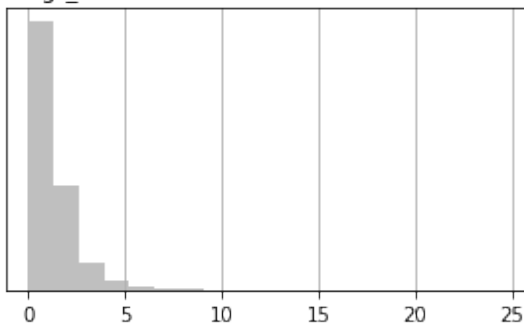
E) gr\_rech2



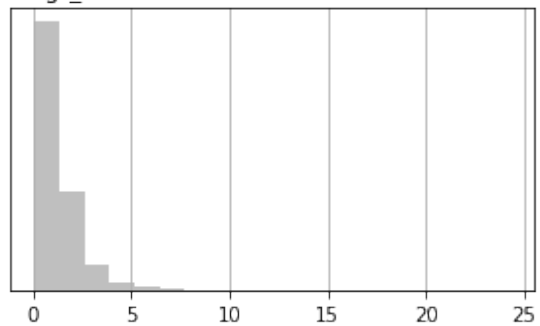
F) gr\_rech3



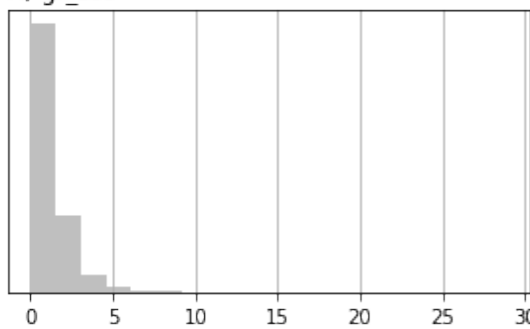
G) gr\_ss3



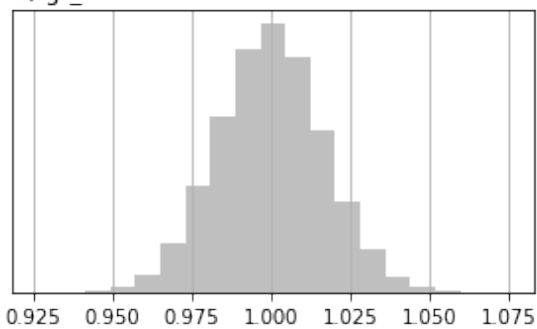
H) gr\_ss4



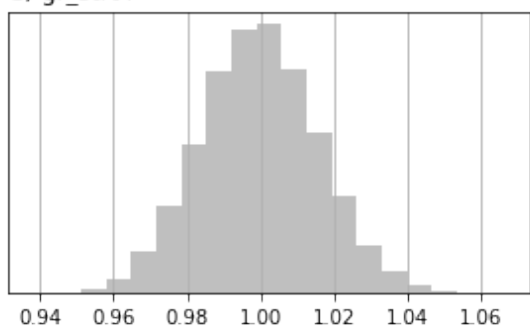
A) gr\_ss5



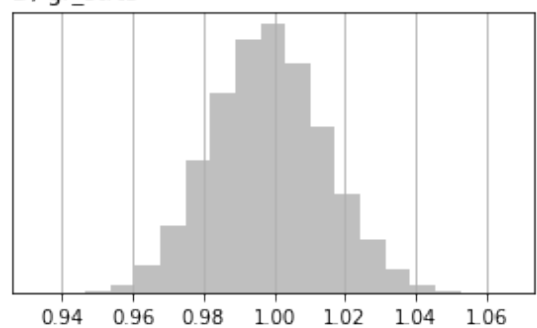
B) gr\_strt3



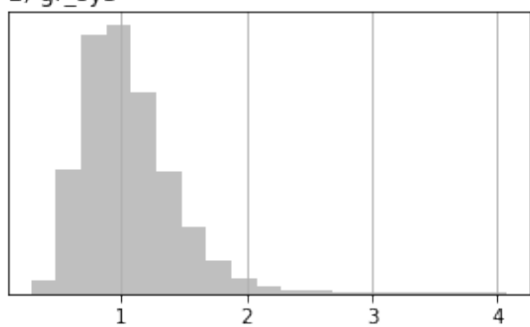
C) gr\_strt4



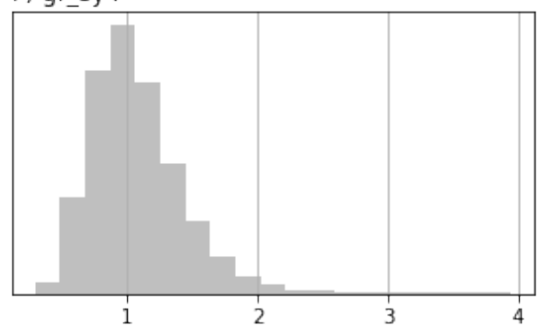
D) gr\_strt5



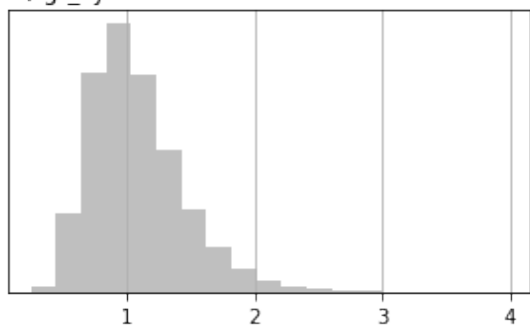
E) gr\_sy3



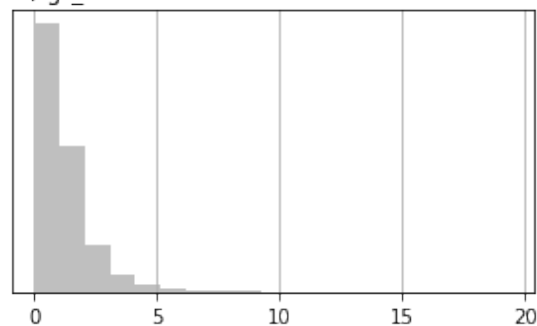
F) gr\_sy4



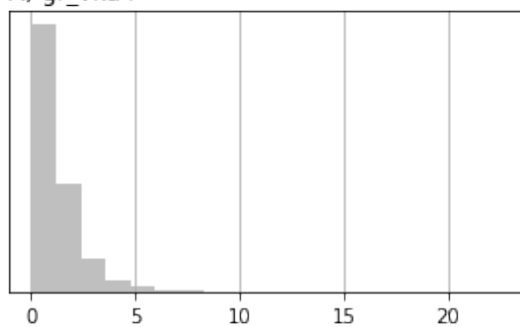
G) gr\_sy5



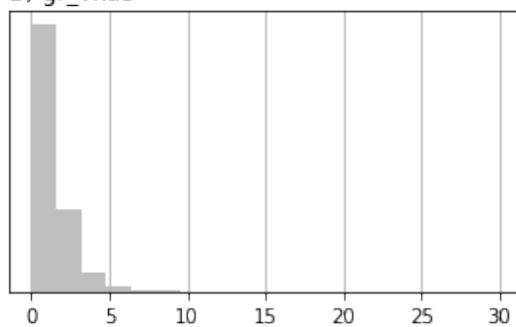
H) gr\_vka3



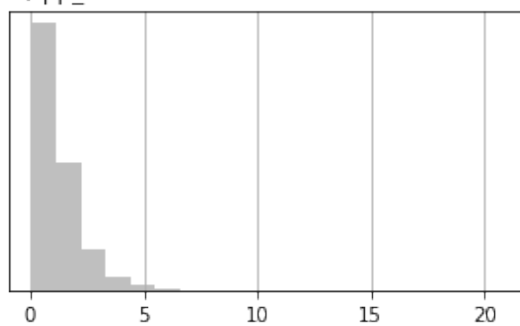
A) gr\_vka4



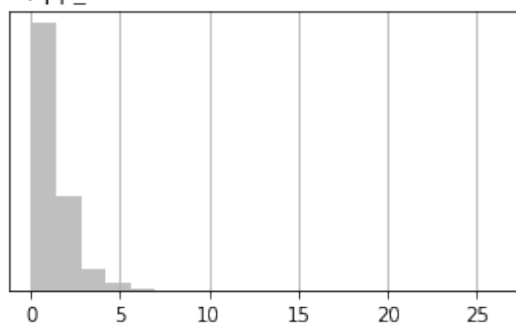
B) gr\_vka5



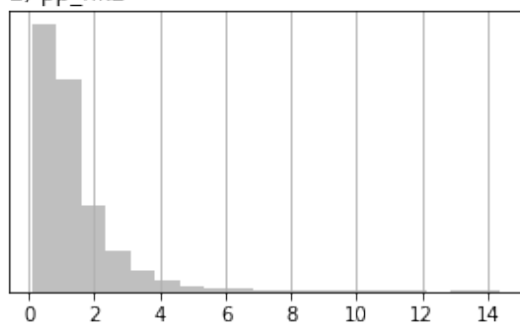
C) pp\_hk0



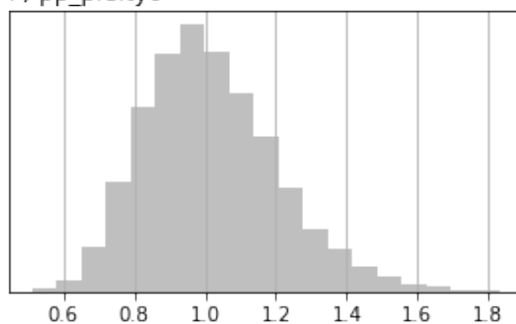
D) pp\_hk1



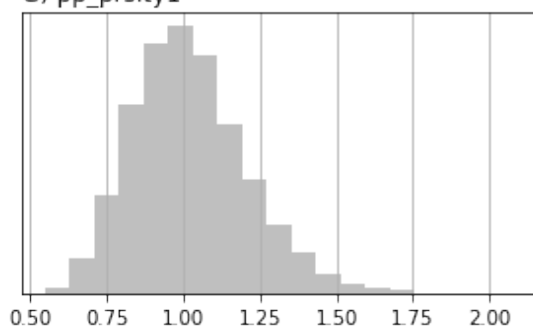
E) pp\_hk2



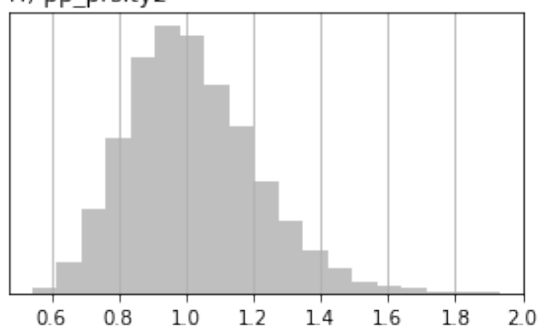
F) pp\_prsity0



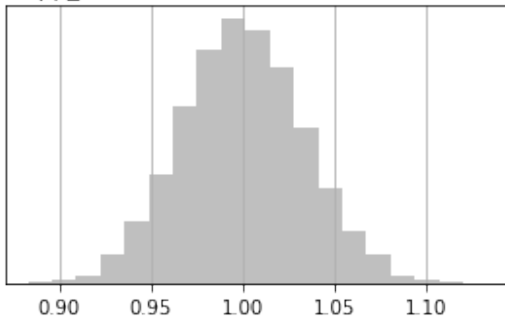
G) pp\_prsity1



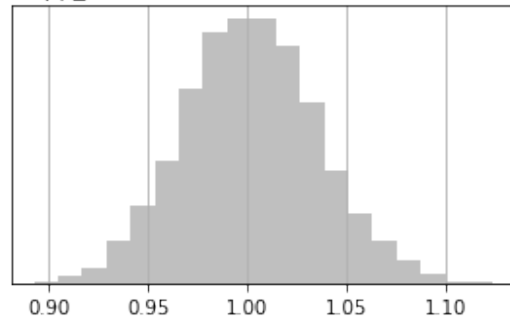
H) pp\_prsity2



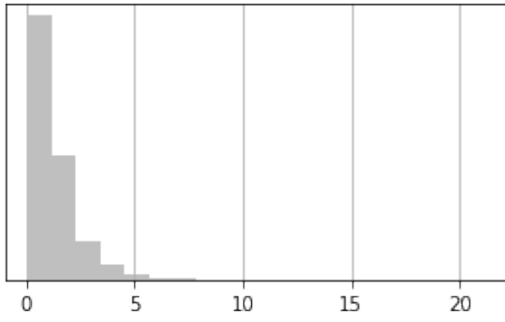
A) pp\_rech0



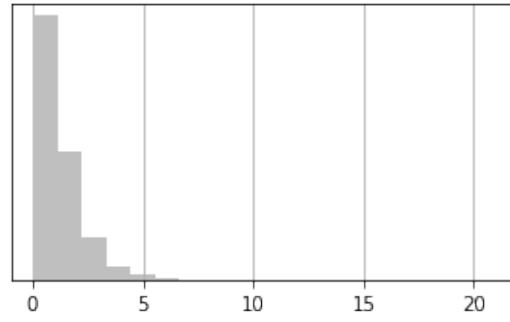
B) pp\_rech1



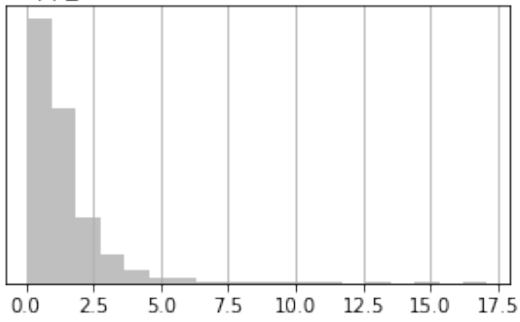
C) pp\_ss0



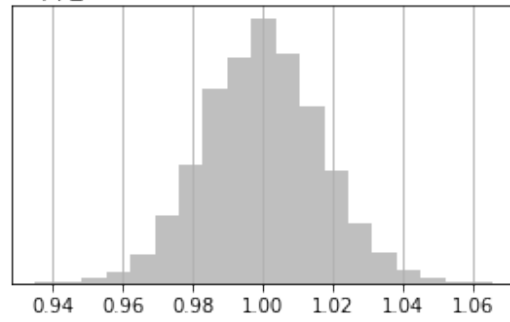
D) pp\_ss1



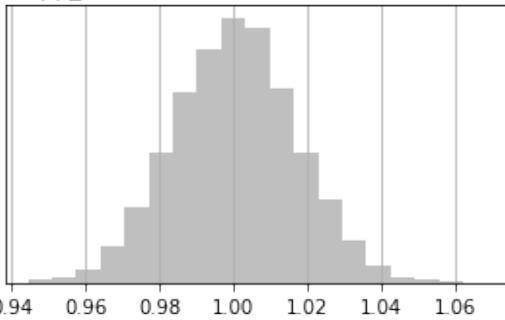
E) pp\_ss2



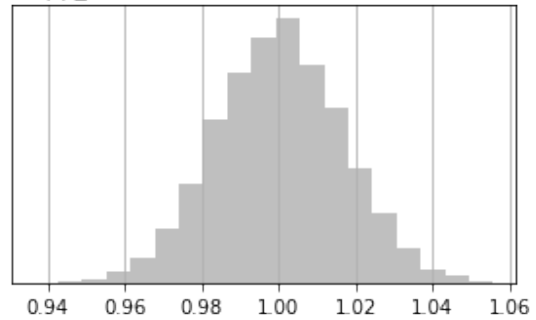
F) pp\_strt0



G) pp\_strt1

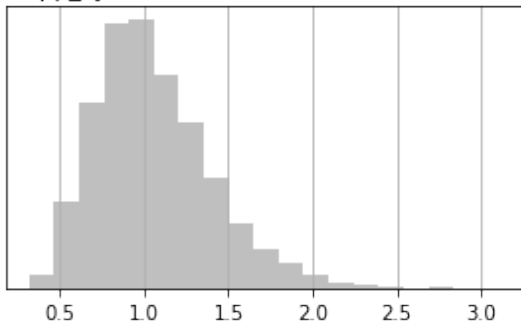


H) pp\_strt2

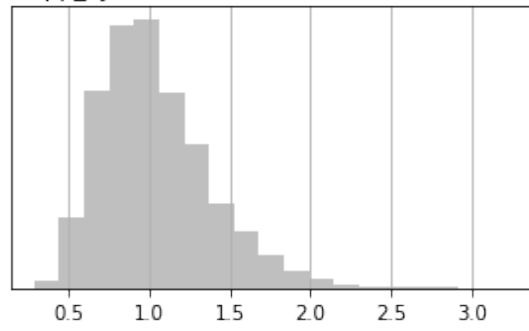




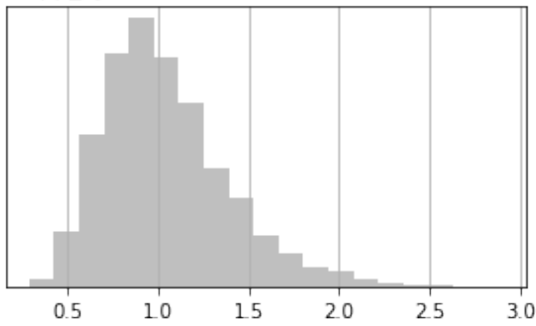
A) pp\_sy0



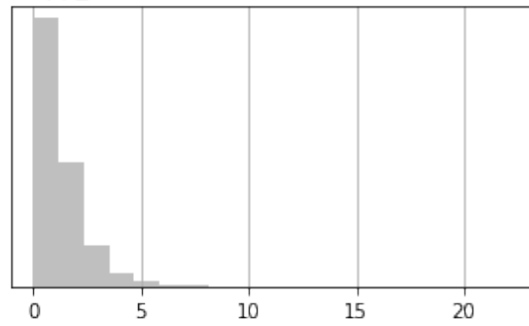
B) pp\_sy1



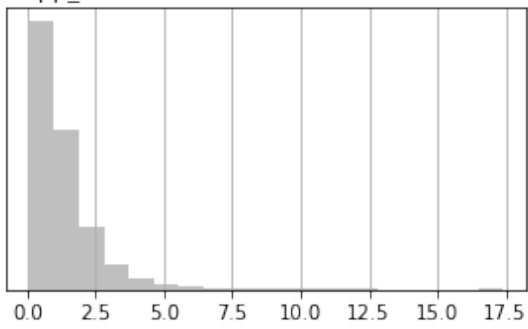
C) pp\_sy2



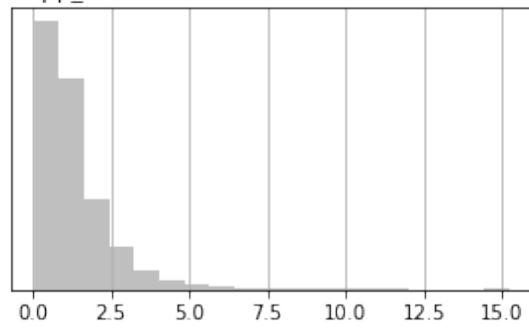
D) pp\_vka0



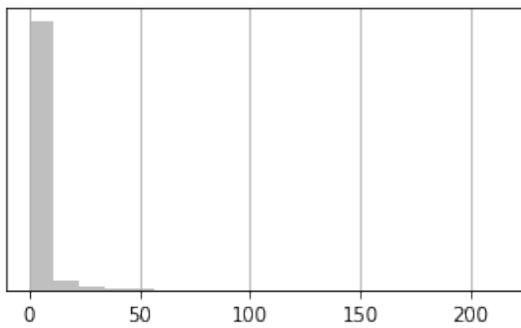
E) pp\_vka1



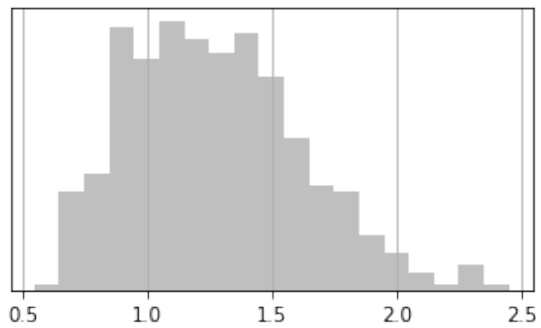
F) pp\_vka2

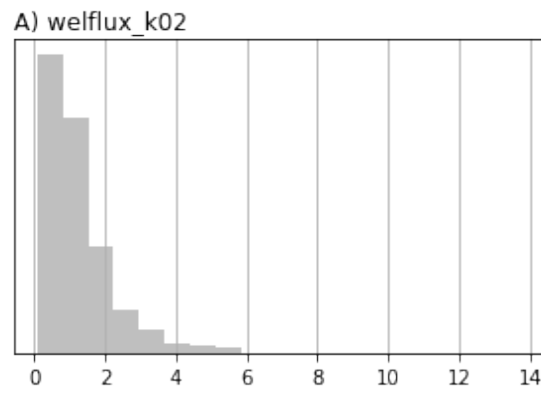


G) strk



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"))
```

### 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 [28]: 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[28]:
```

	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 [29]: 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[29]: ['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 [30]: 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 [31]: 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

```

```

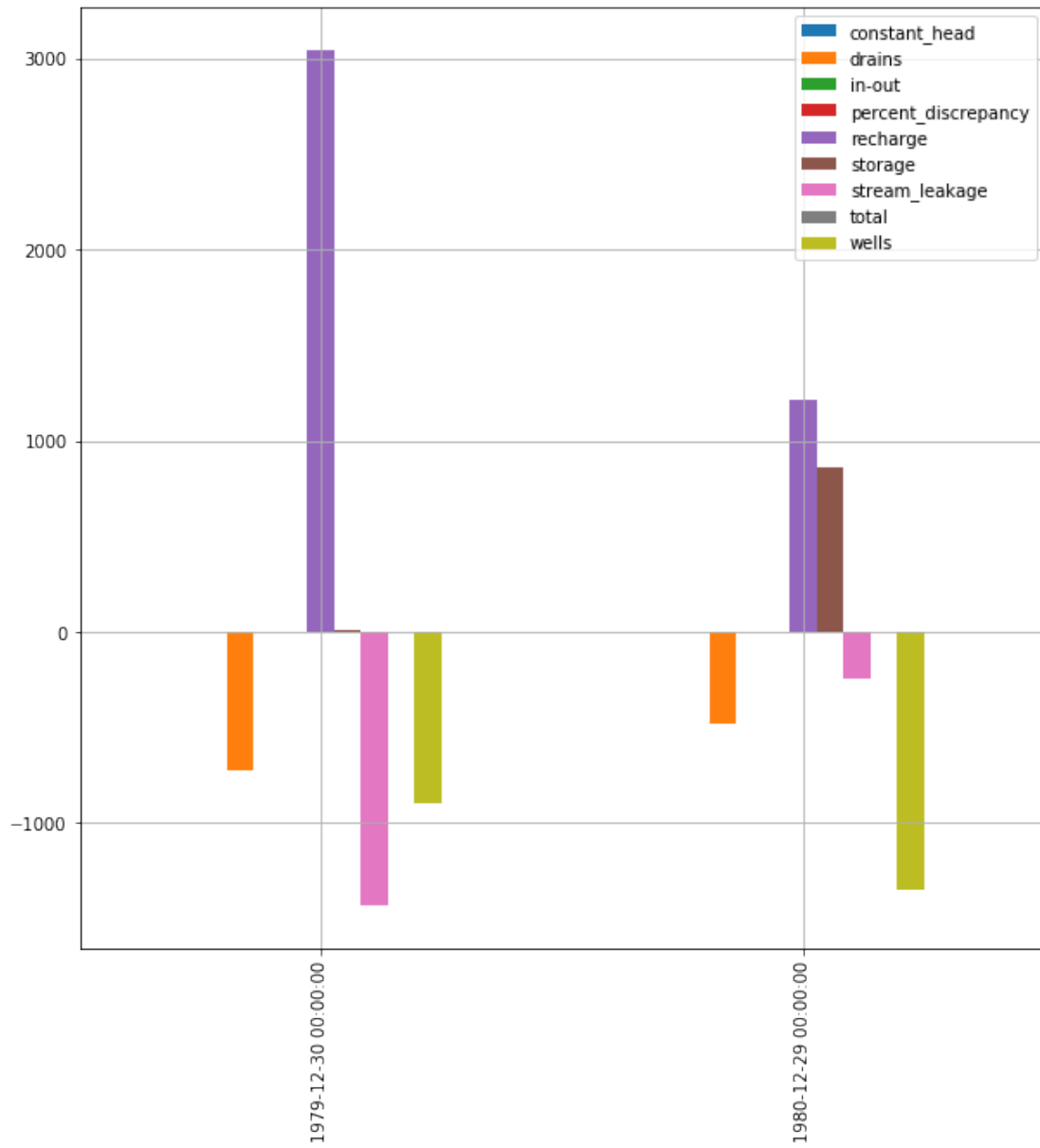
Out[31]: 9.456182577320024e-19

```

```

In [32]: 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.