setup_pest_interface

July 17, 2019

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

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

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

```
flopy is installed in C:\Users\knowling\Dev\GW1876\activities_csiro\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 (and those to follow)

```
In [2]: os.getcwd()
```

```
Out[2]: 'C:\\Users\\knowling\\Dev\\GW1876\\activities_csiro\\notebooks'
```

```
In [3]: 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 [4]: # note that to load a model in a different folder, you supply the namefile without pat
        # 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 some visuals

In [5]:
```
# plot some model attributes
fig = plt.figure(figsize=(12,7))
ax = plt.subplot(111,aspect="equal")
mm = flopy.plot.ModelMap(model=m)
mm.plot_grid()
mm.plot_ibound()
mm.plot_bc('SFR')
ax = mm.ax
#m.wel.stress_period_data.plot(ax=ax,mflay=2)

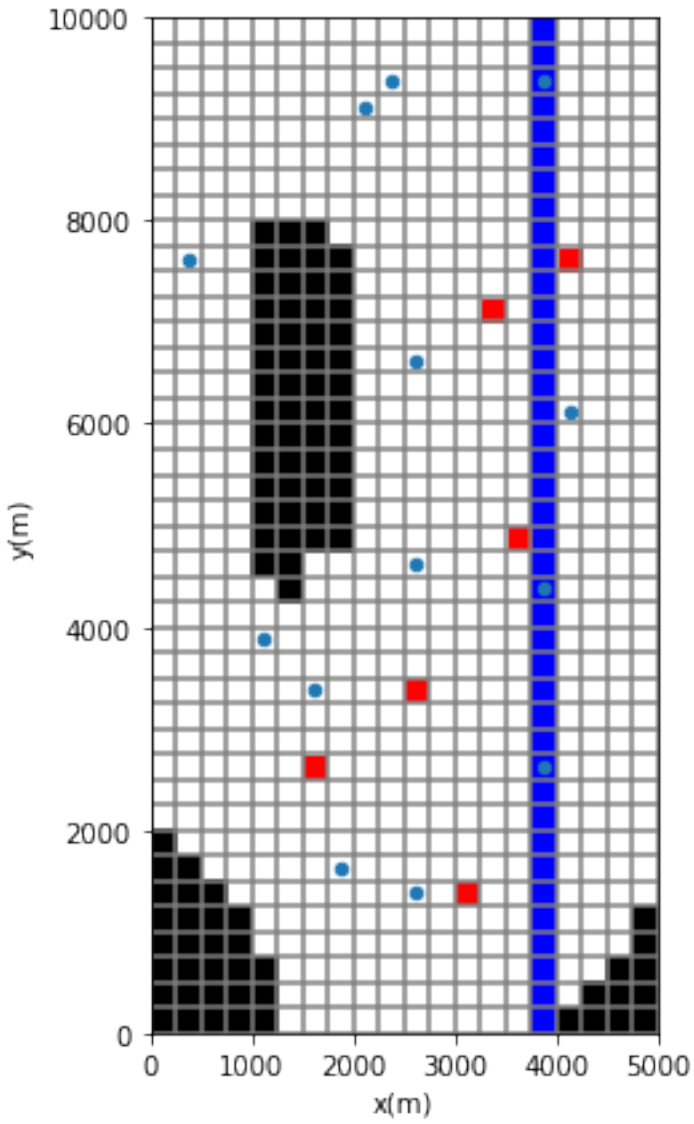
# plot obs locations
obs = pd.read_csv(os.path.join("..","base_model_files","obs_loc.csv"))

obs_x = [m.sr.xcentergrid[r-1,c-1] for r,c in obs.loc[:,["row","col"]].values]
obs_y = [m.sr.ycentergrid[r-1,c-1] for r,c in obs.loc[:,["row","col"]].values]
ax.scatter(obs_x,obs_y,marker='.',label="water-level obs",s=80)

#plot names on the pumping well locations
wel_data = m.wel.stress_period_data[0]
wel_x = m.sr.xcentergrid[wel_data["i"],wel_data["j"]]
wel_y = m.sr.ycentergrid[wel_data["i"],wel_data["j"]]
for i,(x,y) in enumerate(zip(wel_x,wel_y)):
    ax.scatter([x],[y],color="red",marker="s",s=50)
    #ax.text(x,y,"{0}".format(i+1),ha="center",va="center")

ax.set_ylabel("y(m)")
ax.set_xlabel("x(m)")
plt.show()
```

```
C:\Users\knowling\Dev\GW1876\activities_csiro\notebooks\flopy\plot\map.py:438: PendingDeprecati
  warnings.warn(err_msg, PendingDeprecationWarning)
```



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

In [6]:
```
# assign the executable name for the model
m.exe_name = "mfnwt"

# 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 dependecies (both python and executables) in the right p
prep_deps.prep_template(t_d="temp")
```

```
changing model workspace...
   temp
```

1.0.4 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 [7]: pyemu.os_utils.run("{0} {1}".format(m.exe_name,m.name+".nam"),cwd=m.model_ws)
```

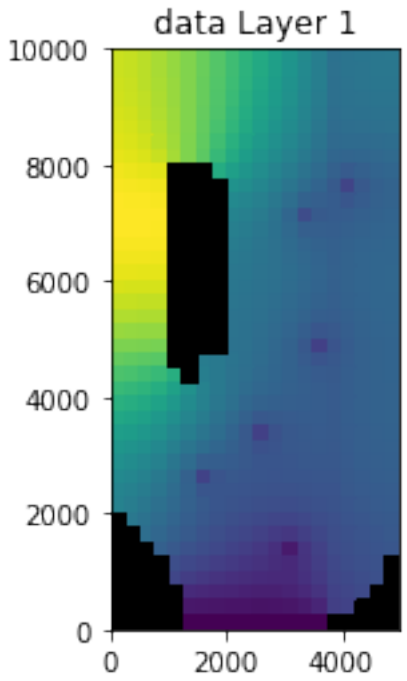
1.0.5 read in the heads and plot them up along with the budget components

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

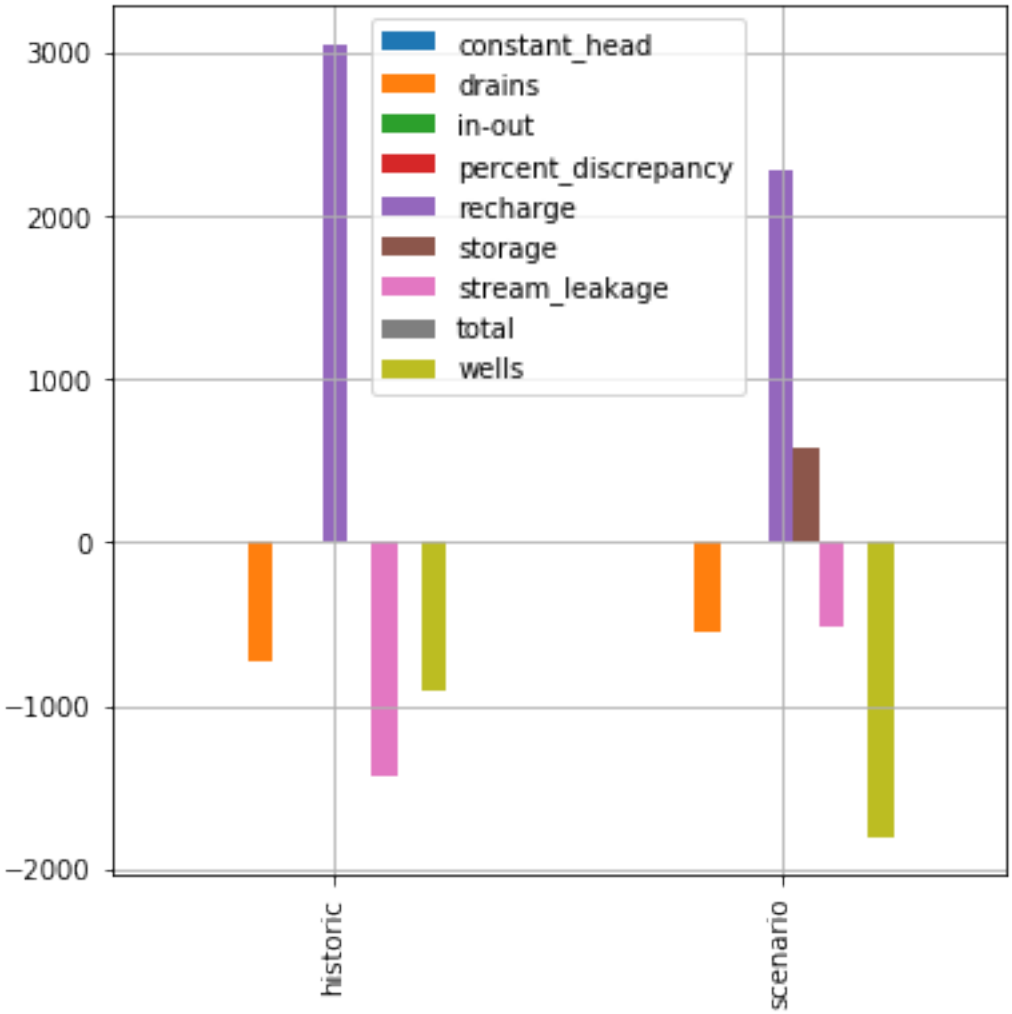
For the future scenario, a serious drought, recharge is lower and pumping/abstraction is increased to make up for the presumed deficite in water for agriculture.

```
In [8]: plt.figure()
        hds = flopy.utils.HeadFile(os.path.join(m.model_ws,m.name+".hds"),model=m)
        hds.plot(mflay=0)
        lst = flopy.utils.MfListBudget(os.path.join(m.model_ws,m.name+".list"))
        df = lst.get_dataframes(diff=True)[0]
        plt.figure()
        ax = df.plot(kind="bar",figsize=(6,6), grid=True)
        ax.set_xticklabels(["historic","scenario"])
```

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



```
<matplotlib.figure.Figure at 0x280ef113da0>
```

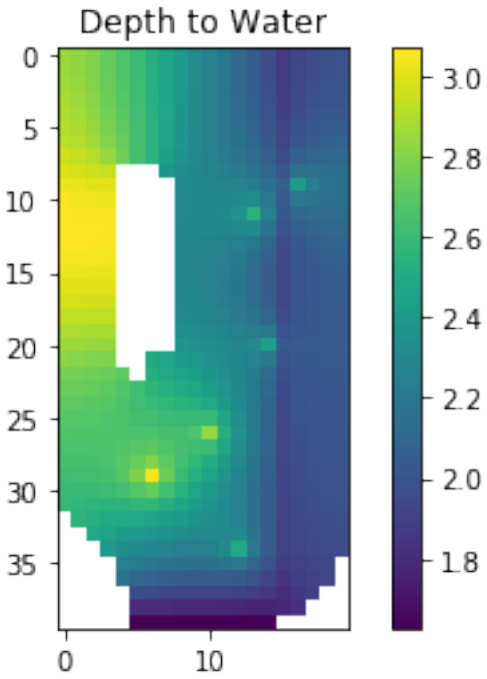


We can see the effect of the "scenario" in the second stress period with less recharge and more abstraction.

1.0.6 Plot depth to water

```
In [9]: dtw = m.dis.top.array - hds.get_data()[0,:,:]
        dtw = np.ma.masked_where(m.bas6.ibound[0].array==0,dtw)
        c = plt.imshow(dtw)
        plt.title('Depth to Water')
        plt.colorbar(c)
```

```
Out[9]: <matplotlib.colorbar.Colorbar at 0x280ef395d68>
```



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

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 [10]: 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"]  #"extra" be
         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])

         props

Out[10]: [['upw.hk', 0],
          ['upw.vka', 0],
          ['upw.ss', 0],
          ['upw.sy', 0],
```

```
['bas6.strt', 0],
['extra.prsity', 0],
['upw.hk', 1],
['upw.vka', 1],
['upw.ss', 1],
['upw.sy', 1],
['bas6.strt', 1],
['extra.prsity', 1],
['upw.hk', 2],
['upw.vka', 2],
['upw.ss', 2],
['upw.sy', 2],
['bas6.strt', 2],
['extra.prsity', 2],
['rch.rech', 0],
['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 [11]: spatial_list_props = [["wel.flux",2],["drn.cond",0]]  # spatially by each list entry,
         temporal_list_props = [["wel.flux",0],["wel.flux",1]]  # spatially uniform for each s

         spatial_list_props, temporal_list_props

Out[11]: ([['wel.flux', 2], ['drn.cond', 0]], [['wel.flux', 0], ['wel.flux', 1]])
```

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

```
In [12]: hds_kperk = [[0,k] for k in range(m.nlay)]
         hds_kperk.extend([[1,k] for k in range(m.nlay)])

         hds_kperk

Out[12]: [[0, 0], [0, 1], [0, 2], [1, 0], [1, 1], [1, 2]]
```

1.1.4 then we setup monitoring of the SFR ASCII outputs.

we will accumulate the first 20 reaches and last 20 reaches (corresponding to the top and bottom half of the model, respectively) 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 [13]: sfr_obs_dict = {}
         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 - writes a prior parameter covaraince matrix using geostatistical correlations - draws from the prior parameter covariance matrix to generate a prior parameter ensemble

WAT?!

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 [14]: pst_helper = pyemu.helpers.PstFromFlopyModel(nam_file,new_model_ws="template",org_mode
                                                      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)

2019-07-17 01:00:44.812250 starting: loading flopy model

Creating new model with name: freyberg
-----------------------------------------------------

Parsing the namefile --> temp\freyberg.nam

-----------------------------------------------------
External unit dictionary:
{2: filename:temp\freyberg.list, filetype:LIST, 11: filename:temp\freyberg.dis, filetype: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 'flopy.modflow.mfwel.ModflowWel'> for kper     1
   loading <class 'flopy.modflow.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 'flopy.modflow.mfdrn.ModflowDrn'> for kper     1
   loading <class 'flopy.modflow.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
2019-07-17 01:00:44.912337 finished: loading flopy model took: 0:00:00.100087
2019-07-17 01:00:44.912337 starting: updating model attributes
2019-07-17 01:00:44.912337 finished: updating model attributes took: 0:00:00
2019-07-17 01:00:44.912337 WARNING: removing existing 'new_model_ws

creating model workspace...
   template

changing model workspace...
   template
2019-07-17 01:00:47.313601 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

2019-07-17 01:00:47.818075 finished: writing new modflow input files took: 0:00:00.504474
2019-07-17 01:00:47.819076 forward_run line:pyemu.os_utils.run('mfnwt freyberg.nam 1>freyberg.r
2019-07-17 01:00:47.819076 starting: setting up 'template\arr_org' dir
2019-07-17 01:00:47.821077 finished: setting up 'template\arr_org' dir took: 0:00:00.002001
2019-07-17 01:00:47.821077 starting: setting up 'template\arr_mlt' dir
2019-07-17 01:00:47.823077 finished: setting up 'template\arr_mlt' dir took: 0:00:00.002000
2019-07-17 01:00:47.823077 starting: setting up 'template\list_org' dir
2019-07-17 01:00:47.826082 finished: setting up 'template\list_org' dir took: 0:00:00.003005
2019-07-17 01:00:47.826082 starting: setting up 'template\list_mlt' dir
```

```
2019-07-17 01:00:47.827082 finished: setting up 'template\list_mlt' dir took: 0:00:00.001000
2019-07-17 01:00:47.828083 starting: processing temporal_list_props
2019-07-17 01:00:47.876123 finished: processing temporal_list_props took: 0:00:00.048040
2019-07-17 01:00:47.877124 starting: processing spatial_list_props
2019-07-17 01:00:48.034254 finished: processing spatial_list_props took: 0:00:00.157130
2019-07-17 01:00:48.116325 forward_run line:pyemu.helpers.apply_list_pars()

2019-07-17 01:00:48.207402 'extra' pak detected:extra.prsity
2019-07-17 01:00:48.325501 'extra' pak detected:extra.prsity
2019-07-17 01:00:48.431588 'extra' pak detected:extra.prsity
2019-07-17 01:00:48.538679 'extra' pak detected:extra.prsity
2019-07-17 01:00:48.604734 'extra' pak detected:extra.prsity
2019-07-17 01:00:48.670789 'extra' pak detected:extra.prsity
2019-07-17 01:00:48.761865 'extra' pak detected:extra.prsity
2019-07-17 01:00:48.828921 'extra' pak detected:extra.prsity
2019-07-17 01:00:48.894976 'extra' pak detected:extra.prsity
2019-07-17 01:00:49.038096 starting: writing grid tpl:hk3.dat_gr.tpl
2019-07-17 01:00:49.061116 finished: writing grid tpl:hk3.dat_gr.tpl took: 0:00:00.023020
2019-07-17 01:00:49.065120 starting: writing grid tpl:vka3.dat_gr.tpl
2019-07-17 01:00:49.087138 finished: writing grid tpl:vka3.dat_gr.tpl took: 0:00:00.022018
2019-07-17 01:00:49.091141 starting: writing grid tpl:ss3.dat_gr.tpl
2019-07-17 01:00:49.111158 finished: writing grid tpl:ss3.dat_gr.tpl took: 0:00:00.020017
2019-07-17 01:00:49.115161 starting: writing grid tpl:sy3.dat_gr.tpl
2019-07-17 01:00:49.136179 finished: writing grid tpl:sy3.dat_gr.tpl took: 0:00:00.021018
2019-07-17 01:00:49.140182 starting: writing grid tpl:strt3.dat_gr.tpl
2019-07-17 01:00:49.163202 finished: writing grid tpl:strt3.dat_gr.tpl took: 0:00:00.023020
2019-07-17 01:00:49.167205 starting: writing grid tpl:prsity3.dat_gr.tpl
2019-07-17 01:00:49.192226 finished: writing grid tpl:prsity3.dat_gr.tpl took: 0:00:00.025021
2019-07-17 01:00:49.196229 starting: writing grid tpl:hk4.dat_gr.tpl
2019-07-17 01:00:49.218247 finished: writing grid tpl:hk4.dat_gr.tpl took: 0:00:00.022018
2019-07-17 01:00:49.222251 starting: writing grid tpl:vka4.dat_gr.tpl
2019-07-17 01:00:49.250273 finished: writing grid tpl:vka4.dat_gr.tpl took: 0:00:00.028022
2019-07-17 01:00:49.255278 starting: writing grid tpl:ss4.dat_gr.tpl
2019-07-17 01:00:49.276296 finished: writing grid tpl:ss4.dat_gr.tpl took: 0:00:00.021018
2019-07-17 01:00:49.280299 starting: writing grid tpl:sy4.dat_gr.tpl
2019-07-17 01:00:49.299315 finished: writing grid tpl:sy4.dat_gr.tpl took: 0:00:00.019016
2019-07-17 01:00:49.303318 starting: writing grid tpl:strt4.dat_gr.tpl
2019-07-17 01:00:49.323335 finished: writing grid tpl:strt4.dat_gr.tpl took: 0:00:00.020017
2019-07-17 01:00:49.327339 starting: writing grid tpl:prsity4.dat_gr.tpl
2019-07-17 01:00:49.349358 finished: writing grid tpl:prsity4.dat_gr.tpl took: 0:00:00.022019
2019-07-17 01:00:49.353361 starting: writing grid tpl:hk5.dat_gr.tpl
2019-07-17 01:00:49.371375 finished: writing grid tpl:hk5.dat_gr.tpl took: 0:00:00.018014
2019-07-17 01:00:49.375379 starting: writing grid tpl:vka5.dat_gr.tpl
2019-07-17 01:00:49.396397 finished: writing grid tpl:vka5.dat_gr.tpl took: 0:00:00.021018
2019-07-17 01:00:49.400400 starting: writing grid tpl:ss5.dat_gr.tpl
2019-07-17 01:00:49.420417 finished: writing grid tpl:ss5.dat_gr.tpl took: 0:00:00.020017
2019-07-17 01:00:49.424420 starting: writing grid tpl:sy5.dat_gr.tpl
2019-07-17 01:00:49.444436 finished: writing grid tpl:sy5.dat_gr.tpl took: 0:00:00.020016
```

```
2019-07-17 01:00:49.448440 starting: writing grid tpl:strt5.dat_gr.tpl
2019-07-17 01:00:49.479467 finished: writing grid tpl:strt5.dat_gr.tpl took: 0:00:00.031027
2019-07-17 01:00:49.484471 starting: writing grid tpl:prsity5.dat_gr.tpl
2019-07-17 01:00:49.511493 finished: writing grid tpl:prsity5.dat_gr.tpl took: 0:00:00.027022
2019-07-17 01:00:49.515496 starting: writing grid tpl:rech2.dat_gr.tpl
2019-07-17 01:00:49.537514 finished: writing grid tpl:rech2.dat_gr.tpl took: 0:00:00.022018
2019-07-17 01:00:49.541518 starting: writing grid tpl:rech3.dat_gr.tpl
2019-07-17 01:00:49.564538 finished: writing grid tpl:rech3.dat_gr.tpl took: 0:00:00.023020
2019-07-17 01:00:49.568540 starting: writing const tpl:hk6.dat_cn.tpl
2019-07-17 01:00:49.584554 finished: writing const tpl:hk6.dat_cn.tpl took: 0:00:00.016014
2019-07-17 01:00:49.588558 starting: writing const tpl:vka6.dat_cn.tpl
2019-07-17 01:00:49.603570 finished: writing const tpl:vka6.dat_cn.tpl took: 0:00:00.015012
2019-07-17 01:00:49.607573 starting: writing const tpl:ss6.dat_cn.tpl
2019-07-17 01:00:49.625589 finished: writing const tpl:ss6.dat_cn.tpl took: 0:00:00.018016
2019-07-17 01:00:49.629592 starting: writing const tpl:sy6.dat_cn.tpl
2019-07-17 01:00:49.643603 finished: writing const tpl:sy6.dat_cn.tpl took: 0:00:00.014011
2019-07-17 01:00:49.647607 starting: writing const tpl:strt6.dat_cn.tpl
2019-07-17 01:00:49.663620 finished: writing const tpl:strt6.dat_cn.tpl took: 0:00:00.016013
2019-07-17 01:00:49.670631 starting: writing const tpl:prsity6.dat_cn.tpl
2019-07-17 01:00:49.684638 finished: writing const tpl:prsity6.dat_cn.tpl took: 0:00:00.014007
2019-07-17 01:00:49.688641 starting: writing const tpl:hk7.dat_cn.tpl
2019-07-17 01:00:49.701652 finished: writing const tpl:hk7.dat_cn.tpl took: 0:00:00.013011
2019-07-17 01:00:49.705656 starting: writing const tpl:vka7.dat_cn.tpl
2019-07-17 01:00:49.720668 finished: writing const tpl:vka7.dat_cn.tpl took: 0:00:00.015012
2019-07-17 01:00:49.724672 starting: writing const tpl:ss7.dat_cn.tpl
2019-07-17 01:00:49.737682 finished: writing const tpl:ss7.dat_cn.tpl took: 0:00:00.013010
2019-07-17 01:00:49.741686 starting: writing const tpl:sy7.dat_cn.tpl
2019-07-17 01:00:49.759701 finished: writing const tpl:sy7.dat_cn.tpl took: 0:00:00.018015
2019-07-17 01:00:49.763704 starting: writing const tpl:strt7.dat_cn.tpl
2019-07-17 01:00:49.779717 finished: writing const tpl:strt7.dat_cn.tpl took: 0:00:00.016013
2019-07-17 01:00:49.783721 starting: writing const tpl:prsity7.dat_cn.tpl
2019-07-17 01:00:49.799734 finished: writing const tpl:prsity7.dat_cn.tpl took: 0:00:00.016013
2019-07-17 01:00:49.803737 starting: writing const tpl:hk8.dat_cn.tpl
2019-07-17 01:00:49.816748 finished: writing const tpl:hk8.dat_cn.tpl took: 0:00:00.013011
2019-07-17 01:00:49.820752 starting: writing const tpl:vka8.dat_cn.tpl
2019-07-17 01:00:49.832762 finished: writing const tpl:vka8.dat_cn.tpl took: 0:00:00.012010
2019-07-17 01:00:49.836765 starting: writing const tpl:ss8.dat_cn.tpl
2019-07-17 01:00:49.848775 finished: writing const tpl:ss8.dat_cn.tpl took: 0:00:00.012010
2019-07-17 01:00:49.852779 starting: writing const tpl:sy8.dat_cn.tpl
2019-07-17 01:00:49.865790 finished: writing const tpl:sy8.dat_cn.tpl took: 0:00:00.013011
2019-07-17 01:00:49.869793 starting: writing const tpl:strt8.dat_cn.tpl
2019-07-17 01:00:49.885806 finished: writing const tpl:strt8.dat_cn.tpl took: 0:00:00.016013
2019-07-17 01:00:49.889810 starting: writing const tpl:prsity8.dat_cn.tpl
2019-07-17 01:00:49.908826 finished: writing const tpl:prsity8.dat_cn.tpl took: 0:00:00.019016
2019-07-17 01:00:49.913834 starting: writing const tpl:rech4.dat_cn.tpl
2019-07-17 01:00:49.930844 finished: writing const tpl:rech4.dat_cn.tpl took: 0:00:00.017010
2019-07-17 01:00:49.934848 starting: writing const tpl:rech5.dat_cn.tpl
2019-07-17 01:00:49.950861 finished: writing const tpl:rech5.dat_cn.tpl took: 0:00:00.016013
```

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2019-07-17 01:00:49.978884 starting: setting up pilot point process
2019-07-17 01:00:49.978884 WARNING: pp_geostruct is None, using ExpVario with contribution=1 ar
2019-07-17 01:00:49.982888 pp_dict: {0: ['hk0', 'prsity0', 'rech0', 'rech1', 'ss0', 'strt0', 's
2019-07-17 01:00:49.982888 starting: calling setup_pilot_point_grid()
error importing shapefile, try pip install pyshp...No module named 'shapefile'
2019-07-17 01:00:50.998788 640 pilot point parameters created
2019-07-17 01:00:50.999791 pilot point 'pargp':hk0,prsity0,rech0,rech1,ss0,strt0,sy0,vka0,hk1,p
2019-07-17 01:00:50.999791 finished: calling setup_pilot_point_grid() took: 0:00:01.016903
2019-07-17 01:00:51.002791 starting: calculating factors for p=hk0, k=0
2019-07-17 01:00:51.004793 saving krige variance file:template\pp_k0_general_zn.fac
2019-07-17 01:00:51.004793 saving krige factors file:template\pp_k0_general_zn.fac
starting interp point loop for 800 points
took 3.951309 seconds
2019-07-17 01:00:55.090214 finished: calculating factors for p=hk0, k=0 took: 0:00:04.087423
2019-07-17 01:00:55.092216 starting: calculating factors for p=prsity0, k=0
2019-07-17 01:00:55.093216 finished: calculating factors for p=prsity0, k=0 took: 0:00:00.0010
2019-07-17 01:00:55.095218 starting: calculating factors for p=rech0, k=0
2019-07-17 01:00:55.096219 finished: calculating factors for p=rech0, k=0 took: 0:00:00.001001
2019-07-17 01:00:55.097221 starting: calculating factors for p=rech1, k=0
2019-07-17 01:00:55.098221 finished: calculating factors for p=rech1, k=0 took: 0:00:00.001000
2019-07-17 01:00:55.099270 starting: calculating factors for p=ss0, k=0
2019-07-17 01:00:55.101223 finished: calculating factors for p=ss0, k=0 took: 0:00:00.001953
2019-07-17 01:00:55.102224 starting: calculating factors for p=strt0, k=0
2019-07-17 01:00:55.103226 finished: calculating factors for p=strt0, k=0 took: 0:00:00.001002
2019-07-17 01:00:55.104226 starting: calculating factors for p=sy0, k=0
2019-07-17 01:00:55.106228 finished: calculating factors for p=sy0, k=0 took: 0:00:00.002002
2019-07-17 01:00:55.107229 starting: calculating factors for p=vka0, k=0
2019-07-17 01:00:55.108230 finished: calculating factors for p=vka0, k=0 took: 0:00:00.001001
2019-07-17 01:00:55.109231 starting: calculating factors for p=hk1, k=1
2019-07-17 01:00:55.110232 saving krige variance file:template\pp_k1_general_zn.fac
2019-07-17 01:00:55.111232 saving krige factors file:template\pp_k1_general_zn.fac
starting interp point loop for 800 points
took 4.076412 seconds
2019-07-17 01:00:59.296736 finished: calculating factors for p=hk1, k=1 took: 0:00:04.187505
2019-07-17 01:00:59.298737 starting: calculating factors for p=prsity1, k=1
2019-07-17 01:00:59.299739 finished: calculating factors for p=prsity1, k=1 took: 0:00:00.0010
2019-07-17 01:00:59.300739 starting: calculating factors for p=ss1, k=1
2019-07-17 01:00:59.301740 finished: calculating factors for p=ss1, k=1 took: 0:00:00.001001
2019-07-17 01:00:59.302741 starting: calculating factors for p=strt1, k=1
2019-07-17 01:00:59.303742 finished: calculating factors for p=strt1, k=1 took: 0:00:00.001001
2019-07-17 01:00:59.304743 starting: calculating factors for p=sy1, k=1
2019-07-17 01:00:59.306744 finished: calculating factors for p=sy1, k=1 took: 0:00:00.002001
2019-07-17 01:00:59.307745 starting: calculating factors for p=vka1, k=1
2019-07-17 01:00:59.308746 finished: calculating factors for p=vka1, k=1 took: 0:00:00.001001
2019-07-17 01:00:59.309747 starting: calculating factors for p=hk2, k=2
2019-07-17 01:00:59.310747 saving krige variance file:template\pp_k2_general_zn.fac
2019-07-17 01:00:59.311748 saving krige factors file:template\pp_k2_general_zn.fac
starting interp point loop for 800 points
```

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took 3.925293 seconds
2019-07-17 01:01:03.396175 finished: calculating factors for p=hk2, k=2 took: 0:00:04.086428
2019-07-17 01:01:03.399173 starting: calculating factors for p=prsity2, k=2
2019-07-17 01:01:03.402175 finished: calculating factors for p=prsity2, k=2 took: 0:00:00.00300
2019-07-17 01:01:03.404182 starting: calculating factors for p=ss2, k=2
2019-07-17 01:01:03.407184 finished: calculating factors for p=ss2, k=2 took: 0:00:00.003002
2019-07-17 01:01:03.409182 starting: calculating factors for p=strt2, k=2
2019-07-17 01:01:03.411187 finished: calculating factors for p=strt2, k=2 took: 0:00:00.002005
2019-07-17 01:01:03.414190 starting: calculating factors for p=sy2, k=2
2019-07-17 01:01:03.416192 finished: calculating factors for p=sy2, k=2 took: 0:00:00.002002
2019-07-17 01:01:03.419195 starting: calculating factors for p=vka2, k=2
2019-07-17 01:01:03.422197 finished: calculating factors for p=vka2, k=2 took: 0:00:00.003002
2019-07-17 01:01:03.422197 starting: processing pp_prefix:hk0
2019-07-17 01:01:03.441208 starting: processing pp_prefix:prsity0
2019-07-17 01:01:03.455220 starting: processing pp_prefix:rech0
2019-07-17 01:01:03.470232 starting: processing pp_prefix:rech1
2019-07-17 01:01:03.483243 starting: processing pp_prefix:ss0
2019-07-17 01:01:03.501258 starting: processing pp_prefix:strt0
2019-07-17 01:01:03.515270 starting: processing pp_prefix:sy0
2019-07-17 01:01:03.528281 starting: processing pp_prefix:vka0
2019-07-17 01:01:03.542037 starting: processing pp_prefix:hk1
2019-07-17 01:01:03.556041 starting: processing pp_prefix:prsity1
2019-07-17 01:01:03.569047 starting: processing pp_prefix:ss1
2019-07-17 01:01:03.583065 starting: processing pp_prefix:strt1
2019-07-17 01:01:03.597075 starting: processing pp_prefix:sy1
2019-07-17 01:01:03.610080 starting: processing pp_prefix:vka1
2019-07-17 01:01:03.624094 starting: processing pp_prefix:hk2
2019-07-17 01:01:03.637102 starting: processing pp_prefix:prsity2
2019-07-17 01:01:03.651119 starting: processing pp_prefix:ss2
2019-07-17 01:01:03.664118 starting: processing pp_prefix:strt2
2019-07-17 01:01:03.678142 starting: processing pp_prefix:sy2
2019-07-17 01:01:03.692145 starting: processing pp_prefix:vka2
2019-07-17 01:01:03.886319 finished: setting up pilot point process took: 0:00:13.907435
2019-07-17 01:01:03.887315 starting: setting up grid process
2019-07-17 01:01:03.887315 WARNING: grid_geostruct is None, using ExpVario with contribution=1
2019-07-17 01:01:03.887315 finished: setting up grid process took: 0:00:00
2019-07-17 01:01:03.904323 starting: save test mlt array arr_mlt\hk0.dat_pp
2019-07-17 01:01:03.920337 finished: save test mlt array arr_mlt\hk0.dat_pp took: 0:00:00.0160
2019-07-17 01:01:03.922342 starting: save test mlt array arr_mlt\vka0.dat_pp
2019-07-17 01:01:03.940356 finished: save test mlt array arr_mlt\vka0.dat_pp took: 0:00:00.018
2019-07-17 01:01:03.941354 starting: save test mlt array arr_mlt\ss0.dat_pp
2019-07-17 01:01:03.955371 finished: save test mlt array arr_mlt\ss0.dat_pp took: 0:00:00.0140
2019-07-17 01:01:03.956367 starting: save test mlt array arr_mlt\sy0.dat_pp
2019-07-17 01:01:03.970393 finished: save test mlt array arr_mlt\sy0.dat_pp took: 0:00:00.0140
2019-07-17 01:01:03.971393 starting: save test mlt array arr_mlt\strt0.dat_pp
2019-07-17 01:01:03.984409 finished: save test mlt array arr_mlt\strt0.dat_pp took: 0:00:00.013
2019-07-17 01:01:03.985409 starting: save test mlt array arr_mlt\prsity0.dat_pp
2019-07-17 01:01:03.998416 finished: save test mlt array arr_mlt\prsity0.dat_pp took: 0:00:00.0
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2019-07-17 01:01:03.999421 starting: save test mlt array arr_mlt\hk1.dat_pp
2019-07-17 01:01:04.012428 finished: save test mlt array arr_mlt\hk1.dat_pp took: 0:00:00.0130
2019-07-17 01:01:04.013433 starting: save test mlt array arr_mlt\vka1.dat_pp
2019-07-17 01:01:04.026439 finished: save test mlt array arr_mlt\vka1.dat_pp took: 0:00:00.013
2019-07-17 01:01:04.027445 starting: save test mlt array arr_mlt\ss1.dat_pp
2019-07-17 01:01:04.040459 finished: save test mlt array arr_mlt\ss1.dat_pp took: 0:00:00.0130
2019-07-17 01:01:04.042457 starting: save test mlt array arr_mlt\sy1.dat_pp
2019-07-17 01:01:04.055468 finished: save test mlt array arr_mlt\sy1.dat_pp took: 0:00:00.0130
2019-07-17 01:01:04.056475 starting: save test mlt array arr_mlt\strt1.dat_pp
2019-07-17 01:01:04.069479 finished: save test mlt array arr_mlt\strt1.dat_pp took: 0:00:00.013
2019-07-17 01:01:04.070482 starting: save test mlt array arr_mlt\prsity1.dat_pp
2019-07-17 01:01:04.083492 finished: save test mlt array arr_mlt\prsity1.dat_pp took: 0:00:00.0
2019-07-17 01:01:04.084500 starting: save test mlt array arr_mlt\hk2.dat_pp
2019-07-17 01:01:04.097503 finished: save test mlt array arr_mlt\hk2.dat_pp took: 0:00:00.0130
2019-07-17 01:01:04.098507 starting: save test mlt array arr_mlt\vka2.dat_pp
2019-07-17 01:01:04.115512 finished: save test mlt array arr_mlt\vka2.dat_pp took: 0:00:00.017
2019-07-17 01:01:04.117514 starting: save test mlt array arr_mlt\ss2.dat_pp
2019-07-17 01:01:04.130527 finished: save test mlt array arr_mlt\ss2.dat_pp took: 0:00:00.0130
2019-07-17 01:01:04.132532 starting: save test mlt array arr_mlt\sy2.dat_pp
2019-07-17 01:01:04.145540 finished: save test mlt array arr_mlt\sy2.dat_pp took: 0:00:00.0130
2019-07-17 01:01:04.146544 starting: save test mlt array arr_mlt\strt2.dat_pp
2019-07-17 01:01:04.159560 finished: save test mlt array arr_mlt\strt2.dat_pp took: 0:00:00.013
2019-07-17 01:01:04.160556 starting: save test mlt array arr_mlt\prsity2.dat_pp
2019-07-17 01:01:04.173567 finished: save test mlt array arr_mlt\prsity2.dat_pp took: 0:00:00.0
2019-07-17 01:01:04.175573 starting: save test mlt array arr_mlt\rech0.dat_pp
2019-07-17 01:01:04.189584 finished: save test mlt array arr_mlt\rech0.dat_pp took: 0:00:00.014
2019-07-17 01:01:04.190581 starting: save test mlt array arr_mlt\rech1.dat_pp
2019-07-17 01:01:04.203592 finished: save test mlt array arr_mlt\rech1.dat_pp took: 0:00:00.013
2019-07-17 01:01:04.204597 starting: save test mlt array arr_mlt\hk3.dat_gr
2019-07-17 01:01:04.217600 finished: save test mlt array arr_mlt\hk3.dat_gr took: 0:00:00.0130
2019-07-17 01:01:04.218605 starting: save test mlt array arr_mlt\vka3.dat_gr
2019-07-17 01:01:04.231624 finished: save test mlt array arr_mlt\vka3.dat_gr took: 0:00:00.013
2019-07-17 01:01:04.232616 starting: save test mlt array arr_mlt\ss3.dat_gr
2019-07-17 01:01:04.245636 finished: save test mlt array arr_mlt\ss3.dat_gr took: 0:00:00.0130
2019-07-17 01:01:04.246628 starting: save test mlt array arr_mlt\sy3.dat_gr
2019-07-17 01:01:04.260649 finished: save test mlt array arr_mlt\sy3.dat_gr took: 0:00:00.0140
2019-07-17 01:01:04.261637 starting: save test mlt array arr_mlt\strt3.dat_gr
2019-07-17 01:01:04.274652 finished: save test mlt array arr_mlt\strt3.dat_gr took: 0:00:00.013
2019-07-17 01:01:04.275652 starting: save test mlt array arr_mlt\prsity3.dat_gr
2019-07-17 01:01:04.290665 finished: save test mlt array arr_mlt\prsity3.dat_gr took: 0:00:00.0
2019-07-17 01:01:04.291666 starting: save test mlt array arr_mlt\hk4.dat_gr
2019-07-17 01:01:04.305673 finished: save test mlt array arr_mlt\hk4.dat_gr took: 0:00:00.0140
2019-07-17 01:01:04.307676 starting: save test mlt array arr_mlt\vka4.dat_gr
2019-07-17 01:01:04.322688 finished: save test mlt array arr_mlt\vka4.dat_gr took: 0:00:00.015
2019-07-17 01:01:04.323693 starting: save test mlt array arr_mlt\ss4.dat_gr
2019-07-17 01:01:04.335699 finished: save test mlt array arr_mlt\ss4.dat_gr took: 0:00:00.0120
2019-07-17 01:01:04.336707 starting: save test mlt array arr_mlt\sy4.dat_gr
2019-07-17 01:01:04.346712 finished: save test mlt array arr_mlt\sy4.dat_gr took: 0:00:00.0100
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2019-07-17 01:01:04.347709 starting: save test mlt array arr_mlt\strt4.dat_gr
2019-07-17 01:01:04.359727 finished: save test mlt array arr_mlt\strt4.dat_gr took: 0:00:00.012
2019-07-17 01:01:04.360731 starting: save test mlt array arr_mlt\prsity4.dat_gr
2019-07-17 01:01:04.370736 finished: save test mlt array arr_mlt\prsity4.dat_gr took: 0:00:00.0
2019-07-17 01:01:04.371733 starting: save test mlt array arr_mlt\hk5.dat_gr
2019-07-17 01:01:04.385751 finished: save test mlt array arr_mlt\hk5.dat_gr took: 0:00:00.0140
2019-07-17 01:01:04.386746 starting: save test mlt array arr_mlt\vka5.dat_gr
2019-07-17 01:01:04.396754 finished: save test mlt array arr_mlt\vka5.dat_gr took: 0:00:00.0100
2019-07-17 01:01:04.397748 starting: save test mlt array arr_mlt\ss5.dat_gr
2019-07-17 01:01:04.412762 finished: save test mlt array arr_mlt\ss5.dat_gr took: 0:00:00.0150
2019-07-17 01:01:04.413763 starting: save test mlt array arr_mlt\sy5.dat_gr
2019-07-17 01:01:04.422771 finished: save test mlt array arr_mlt\sy5.dat_gr took: 0:00:00.0090
2019-07-17 01:01:04.423771 starting: save test mlt array arr_mlt\strt5.dat_gr
2019-07-17 01:01:04.432784 finished: save test mlt array arr_mlt\strt5.dat_gr took: 0:00:00.009
2019-07-17 01:01:04.433785 starting: save test mlt array arr_mlt\prsity5.dat_gr
2019-07-17 01:01:04.445790 finished: save test mlt array arr_mlt\prsity5.dat_gr took: 0:00:00.0
2019-07-17 01:01:04.446791 starting: save test mlt array arr_mlt\rech2.dat_gr
2019-07-17 01:01:04.455797 finished: save test mlt array arr_mlt\rech2.dat_gr took: 0:00:00.009
2019-07-17 01:01:04.456799 starting: save test mlt array arr_mlt\rech3.dat_gr
2019-07-17 01:01:04.468818 finished: save test mlt array arr_mlt\rech3.dat_gr took: 0:00:00.012
2019-07-17 01:01:04.469810 starting: save test mlt array arr_mlt\hk6.dat_cn
2019-07-17 01:01:04.480817 finished: save test mlt array arr_mlt\hk6.dat_cn took: 0:00:00.0110
2019-07-17 01:01:04.481820 starting: save test mlt array arr_mlt\vka6.dat_cn
2019-07-17 01:01:04.491827 finished: save test mlt array arr_mlt\vka6.dat_cn took: 0:00:00.0100
2019-07-17 01:01:04.492829 starting: save test mlt array arr_mlt\ss6.dat_cn
2019-07-17 01:01:04.501837 finished: save test mlt array arr_mlt\ss6.dat_cn took: 0:00:00.0090
2019-07-17 01:01:04.502838 starting: save test mlt array arr_mlt\sy6.dat_cn
2019-07-17 01:01:04.515849 finished: save test mlt array arr_mlt\sy6.dat_cn took: 0:00:00.0130
2019-07-17 01:01:04.516848 starting: save test mlt array arr_mlt\strt6.dat_cn
2019-07-17 01:01:04.527863 finished: save test mlt array arr_mlt\strt6.dat_cn took: 0:00:00.011
2019-07-17 01:01:04.528865 starting: save test mlt array arr_mlt\prsity6.dat_cn
2019-07-17 01:01:04.537872 finished: save test mlt array arr_mlt\prsity6.dat_cn took: 0:00:00.0
2019-07-17 01:01:04.538873 starting: save test mlt array arr_mlt\hk7.dat_cn
2019-07-17 01:01:04.551877 finished: save test mlt array arr_mlt\hk7.dat_cn took: 0:00:00.0130
2019-07-17 01:01:04.552880 starting: save test mlt array arr_mlt\vka7.dat_cn
2019-07-17 01:01:04.563887 finished: save test mlt array arr_mlt\vka7.dat_cn took: 0:00:00.0110
2019-07-17 01:01:04.564895 starting: save test mlt array arr_mlt\ss7.dat_cn
2019-07-17 01:01:04.577901 finished: save test mlt array arr_mlt\ss7.dat_cn took: 0:00:00.0130
2019-07-17 01:01:04.578901 starting: save test mlt array arr_mlt\sy7.dat_cn
2019-07-17 01:01:04.587907 finished: save test mlt array arr_mlt\sy7.dat_cn took: 0:00:00.0090
2019-07-17 01:01:04.588910 starting: save test mlt array arr_mlt\strt7.dat_cn
2019-07-17 01:01:04.597917 finished: save test mlt array arr_mlt\strt7.dat_cn took: 0:00:00.009
2019-07-17 01:01:04.598918 starting: save test mlt array arr_mlt\prsity7.dat_cn
2019-07-17 01:01:04.608926 finished: save test mlt array arr_mlt\prsity7.dat_cn took: 0:00:00.0
2019-07-17 01:01:04.609927 starting: save test mlt array arr_mlt\hk8.dat_cn
2019-07-17 01:01:04.619940 finished: save test mlt array arr_mlt\hk8.dat_cn took: 0:00:00.0100
2019-07-17 01:01:04.620941 starting: save test mlt array arr_mlt\vka8.dat_cn
2019-07-17 01:01:04.631946 finished: save test mlt array arr_mlt\vka8.dat_cn took: 0:00:00.0110
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2019-07-17 01:01:04.632951 starting: save test mlt array arr_mlt\ss8.dat_cn
2019-07-17 01:01:04.644962 finished: save test mlt array arr_mlt\ss8.dat_cn took: 0:00:00.0120
2019-07-17 01:01:04.646963 starting: save test mlt array arr_mlt\sy8.dat_cn
2019-07-17 01:01:04.656967 finished: save test mlt array arr_mlt\sy8.dat_cn took: 0:00:00.0100
2019-07-17 01:01:04.657973 starting: save test mlt array arr_mlt\strt8.dat_cn
2019-07-17 01:01:04.670978 finished: save test mlt array arr_mlt\strt8.dat_cn took: 0:00:00.013
2019-07-17 01:01:04.671984 starting: save test mlt array arr_mlt\prsity8.dat_cn
2019-07-17 01:01:04.681988 finished: save test mlt array arr_mlt\prsity8.dat_cn took: 0:00:00.0
2019-07-17 01:01:04.682986 starting: save test mlt array arr_mlt\rech4.dat_cn
2019-07-17 01:01:04.693002 finished: save test mlt array arr_mlt\rech4.dat_cn took: 0:00:00.010
2019-07-17 01:01:04.694002 starting: save test mlt array arr_mlt\rech5.dat_cn
2019-07-17 01:01:04.703003 finished: save test mlt array arr_mlt\rech5.dat_cn took: 0:00:00.009
2019-07-17 01:01:05.902861 forward_run line:pyemu.helpers.apply_array_pars()

all zeros for runoff...skipping...
all zeros for hcond1...skipping...
all zeros for pptsw...skipping...
2019-07-17 01:01:06.115287 starting: processing obs type mflist water budget obs
2019-07-17 01:01:06.579671 forward_run line:pyemu.gw_utils.apply_mflist_budget_obs('freyberg.li
2019-07-17 01:01:06.580672 finished: processing obs type mflist water budget obs took: 0:00:00
2019-07-17 01:01:06.580672 starting: processing obs type hyd file
2019-07-17 01:01:06.580672 finished: processing obs type hyd file took: 0:00:00
2019-07-17 01:01:06.581673 starting: processing obs type external obs-sim smp files
2019-07-17 01:01:06.581673 finished: processing obs type external obs-sim smp files took: 0:00
2019-07-17 01:01:06.581673 starting: processing obs type hob
2019-07-17 01:01:06.582674 finished: processing obs type hob took: 0:00:00.001001
2019-07-17 01:01:06.582674 starting: processing obs type hds
[[0, 0], [0, 1], [0, 2], [1, 0], [1, 1], [1, 2]]
2019-07-17 01:01:07.333311 finished: processing obs type hds took: 0:00:00.750637
2019-07-17 01:01:07.333311 starting: processing obs type sfr
writing 'sfr_obs.config' to template\sfr_obs.config
2019-07-17 01:01:07.805703 finished: processing obs type sfr took: 0:00:00.472392
2019-07-17 01:01:07.805703 changing dir in to template
2019-07-17 01:01:07.807710 starting: instantiating control file from i/o files
2019-07-17 01:01:07.807710 tpl files: wel.csv.tpl,drn.csv.tpl,hk3.dat_gr.tpl,vka3.dat_gr.tpl,ss
2019-07-17 01:01:07.807710 ins files: flux.dat.ins,freyberg.hds.dat.ins,freyberg.sfr.out.proces
2019-07-17 01:01:08.991924 finished: instantiating control file from i/o files took: 0:00:01.18
2019-07-17 01:01:09.332252 starting: writing forward_run.py
2019-07-17 01:01:09.345260 finished: writing forward_run.py took: 0:00:00.013008
2019-07-17 01:01:09.345260 writing pst template\freyberg.pst
noptmax:0, npar_adj:14819, nnz_obs:4434
2019-07-17 01:01:13.127420 starting: running pestchek on freyberg.pst
2019-07-17 01:01:13.388647 WARNING: error running pestchek:run() returned non-zero
2019-07-17 01:01:13.406007 pestcheck:
2019-07-17 01:01:13.406007 pestcheck:PESTCHEK Version 14.02. Watermark Numerical Computing.
2019-07-17 01:01:13.406007 pestcheck:
2019-07-17 01:01:13.406007 pestcheck:Errors ----->
2019-07-17 01:01:13.407017 pestcheck:Line 2403 of file freyberg.pst: parameter name "prsity3000
```

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2019-07-17 01:01:13.407017 pestcheck:12 characters long.
2019-07-17 01:01:13.407017 pestcheck:Line 2404 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.407017 pestcheck:12 characters long.
2019-07-17 01:01:13.407017 pestcheck:Line 2404 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.407017 pestcheck:once.
2019-07-17 01:01:13.407017 pestcheck:Line 2405 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.408017 pestcheck:12 characters long.
2019-07-17 01:01:13.408017 pestcheck:Line 2405 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.408017 pestcheck:once.
2019-07-17 01:01:13.408017 pestcheck:Line 2406 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.408017 pestcheck:12 characters long.
2019-07-17 01:01:13.408017 pestcheck:Line 2406 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.408017 pestcheck:once.
2019-07-17 01:01:13.409019 pestcheck:Line 2407 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.409019 pestcheck:12 characters long.
2019-07-17 01:01:13.409019 pestcheck:Line 2407 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.409019 pestcheck:once.
2019-07-17 01:01:13.409019 pestcheck:Line 2408 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.409019 pestcheck:12 characters long.
2019-07-17 01:01:13.409019 pestcheck:Line 2408 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.409019 pestcheck:once.
2019-07-17 01:01:13.410019 pestcheck:Line 2409 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.410019 pestcheck:12 characters long.
2019-07-17 01:01:13.410019 pestcheck:Line 2409 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.410019 pestcheck:once.
2019-07-17 01:01:13.410019 pestcheck:Line 2410 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.410019 pestcheck:12 characters long.
2019-07-17 01:01:13.410019 pestcheck:Line 2410 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.410019 pestcheck:once.
2019-07-17 01:01:13.411020 pestcheck:Line 2411 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.411020 pestcheck:12 characters long.
2019-07-17 01:01:13.411020 pestcheck:Line 2411 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.411020 pestcheck:once.
2019-07-17 01:01:13.411020 pestcheck:Line 2412 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.411020 pestcheck:12 characters long.
2019-07-17 01:01:13.411020 pestcheck:Line 2412 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.412020 pestcheck:once.
2019-07-17 01:01:13.412020 pestcheck:Line 2413 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.412020 pestcheck:12 characters long.
2019-07-17 01:01:13.412020 pestcheck:Line 2414 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.412020 pestcheck:12 characters long.
2019-07-17 01:01:13.412020 pestcheck:Line 2414 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.412020 pestcheck:once.
2019-07-17 01:01:13.412020 pestcheck:Line 2415 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.413022 pestcheck:12 characters long.
2019-07-17 01:01:13.413022 pestcheck:Line 2415 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.413022 pestcheck:once.
2019-07-17 01:01:13.413022 pestcheck:Line 2416 of file freyberg.pst: parameter name "prsity300
```

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2019-07-17 01:01:13.413022 pestcheck:12 characters long.
2019-07-17 01:01:13.413022 pestcheck:Line 2416 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.413022 pestcheck:once.
2019-07-17 01:01:13.414024 pestcheck:Line 2417 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.414024 pestcheck:12 characters long.
2019-07-17 01:01:13.414024 pestcheck:Line 2417 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.414024 pestcheck:once.
2019-07-17 01:01:13.414024 pestcheck:Line 2418 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.414024 pestcheck:12 characters long.
2019-07-17 01:01:13.414024 pestcheck:Line 2418 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.415023 pestcheck:once.
2019-07-17 01:01:13.415023 pestcheck:Line 2419 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.415023 pestcheck:12 characters long.
2019-07-17 01:01:13.415023 pestcheck:Line 2419 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.415023 pestcheck:once.
2019-07-17 01:01:13.415023 pestcheck:Line 2420 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.415023 pestcheck:12 characters long.
2019-07-17 01:01:13.415023 pestcheck:Line 2420 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.416024 pestcheck:once.
2019-07-17 01:01:13.416024 pestcheck:Line 2421 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.416024 pestcheck:12 characters long.
2019-07-17 01:01:13.416024 pestcheck:Line 2421 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.416024 pestcheck:once.
2019-07-17 01:01:13.416024 pestcheck:Line 2422 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.417027 pestcheck:12 characters long.
2019-07-17 01:01:13.417027 pestcheck:Line 2422 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.417027 pestcheck:once.
2019-07-17 01:01:13.417027 pestcheck:Line 2423 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.417027 pestcheck:12 characters long.
2019-07-17 01:01:13.417027 pestcheck:Line 2424 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.417027 pestcheck:12 characters long.
2019-07-17 01:01:13.417027 pestcheck:Line 2424 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.418026 pestcheck:once.
2019-07-17 01:01:13.418026 pestcheck:Line 2425 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.418026 pestcheck:12 characters long.
2019-07-17 01:01:13.418026 pestcheck:Line 2425 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.418026 pestcheck:once.
2019-07-17 01:01:13.418026 pestcheck:Line 2426 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.418026 pestcheck:12 characters long.
2019-07-17 01:01:13.419027 pestcheck:Line 2426 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.419027 pestcheck:once.
2019-07-17 01:01:13.419027 pestcheck:Line 2427 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.419027 pestcheck:12 characters long.
2019-07-17 01:01:13.419027 pestcheck:Line 2427 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.419027 pestcheck:once.
2019-07-17 01:01:13.420028 pestcheck:Line 2428 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.420028 pestcheck:12 characters long.
2019-07-17 01:01:13.420028 pestcheck:Line 2428 of file freyberg.pst: parameter name "prsity300
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2019-07-17 01:01:13.420028 pestcheck:once.
2019-07-17 01:01:13.420028 pestcheck:Line 2429 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.420028 pestcheck:12 characters long.
2019-07-17 01:01:13.420028 pestcheck:Line 2429 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.421028 pestcheck:once.
2019-07-17 01:01:13.421028 pestcheck:Line 2430 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.421028 pestcheck:12 characters long.
2019-07-17 01:01:13.421028 pestcheck:Line 2430 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.421028 pestcheck:once.
2019-07-17 01:01:13.421028 pestcheck:Line 2431 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.421028 pestcheck:12 characters long.
2019-07-17 01:01:13.421028 pestcheck:Line 2431 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.422029 pestcheck:once.
2019-07-17 01:01:13.422029 pestcheck:Line 2432 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.422029 pestcheck:12 characters long.
2019-07-17 01:01:13.422029 pestcheck:Line 2432 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.422029 pestcheck:once.
2019-07-17 01:01:13.422029 pestcheck:Line 2433 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.422029 pestcheck:12 characters long.
2019-07-17 01:01:13.423029 pestcheck:Line 2434 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.423029 pestcheck:12 characters long.
2019-07-17 01:01:13.423029 pestcheck:Line 2434 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.423029 pestcheck:once.
2019-07-17 01:01:13.423029 pestcheck:Line 2435 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.423029 pestcheck:12 characters long.
2019-07-17 01:01:13.423029 pestcheck:Line 2435 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.424030 pestcheck:once.
2019-07-17 01:01:13.424030 pestcheck:Line 2436 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.424030 pestcheck:12 characters long.
2019-07-17 01:01:13.424030 pestcheck:Line 2436 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.424030 pestcheck:once.
2019-07-17 01:01:13.424030 pestcheck:Line 2437 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.424030 pestcheck:12 characters long.
2019-07-17 01:01:13.424030 pestcheck:Line 2437 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.425031 pestcheck:once.
2019-07-17 01:01:13.425031 pestcheck:Line 2438 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.425031 pestcheck:12 characters long.
2019-07-17 01:01:13.425031 pestcheck:Line 2438 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.425031 pestcheck:once.
2019-07-17 01:01:13.425031 pestcheck:Line 2439 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.425031 pestcheck:12 characters long.
2019-07-17 01:01:13.426032 pestcheck:Line 2439 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.426032 pestcheck:once.
2019-07-17 01:01:13.426032 pestcheck:Line 2440 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.426032 pestcheck:12 characters long.
2019-07-17 01:01:13.426032 pestcheck:Line 2440 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.426032 pestcheck:once.
2019-07-17 01:01:13.426032 pestcheck:Line 2441 of file freyberg.pst: parameter name "prsity300
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2019-07-17 01:01:13.426032 pestcheck:12 characters long.
2019-07-17 01:01:13.427033 pestcheck:Line 2441 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.427033 pestcheck:once.
2019-07-17 01:01:13.427033 pestcheck:Line 2442 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.427033 pestcheck:12 characters long.
2019-07-17 01:01:13.427033 pestcheck:Line 2442 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.427033 pestcheck:once.
2019-07-17 01:01:13.427033 pestcheck:Line 2443 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.428033 pestcheck:12 characters long.
2019-07-17 01:01:13.428033 pestcheck:Line 2444 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.428033 pestcheck:12 characters long.
2019-07-17 01:01:13.428033 pestcheck:Line 2444 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.428033 pestcheck:once.
2019-07-17 01:01:13.428033 pestcheck:Line 2445 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.428033 pestcheck:12 characters long.
2019-07-17 01:01:13.429034 pestcheck:Line 2445 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.429034 pestcheck:once.
2019-07-17 01:01:13.429034 pestcheck:Line 2446 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.429034 pestcheck:12 characters long.
2019-07-17 01:01:13.429034 pestcheck:Line 2446 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.429034 pestcheck:once.
2019-07-17 01:01:13.429034 pestcheck:Line 2447 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.430035 pestcheck:12 characters long.
2019-07-17 01:01:13.430035 pestcheck:Line 2447 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.430035 pestcheck:once.
2019-07-17 01:01:13.430035 pestcheck:Line 2448 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.430035 pestcheck:12 characters long.
2019-07-17 01:01:13.430035 pestcheck:Line 2448 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.430035 pestcheck:once.
2019-07-17 01:01:13.431037 pestcheck:Line 2449 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.431037 pestcheck:12 characters long.
2019-07-17 01:01:13.431037 pestcheck:Line 2449 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.431037 pestcheck:once.
2019-07-17 01:01:13.431037 pestcheck:Line 2450 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.431037 pestcheck:12 characters long.
2019-07-17 01:01:13.431037 pestcheck:Line 2450 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.431037 pestcheck:once.
2019-07-17 01:01:13.432038 pestcheck:Line 2451 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.432038 pestcheck:12 characters long.
2019-07-17 01:01:13.432038 pestcheck:Line 2451 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.432038 pestcheck:once.
2019-07-17 01:01:13.432038 pestcheck:Line 2452 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.432038 pestcheck:12 characters long.
2019-07-17 01:01:13.433038 pestcheck:Line 2452 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.433038 pestcheck:once.
2019-07-17 01:01:13.433038 pestcheck:Line 2453 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.433038 pestcheck:12 characters long.
2019-07-17 01:01:13.433038 pestcheck:Line 2454 of file freyberg.pst: parameter name "prsity300
```

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2019-07-17 01:01:13.433038 pestcheck:12 characters long.
2019-07-17 01:01:13.433038 pestcheck:Line 2454 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.434039 pestcheck:once.
2019-07-17 01:01:13.434039 pestcheck:Line 2455 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.434039 pestcheck:12 characters long.
2019-07-17 01:01:13.434039 pestcheck:Line 2455 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.434039 pestcheck:once.
2019-07-17 01:01:13.434039 pestcheck:Line 2456 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.434039 pestcheck:12 characters long.
2019-07-17 01:01:13.435040 pestcheck:Line 2456 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.435040 pestcheck:once.
2019-07-17 01:01:13.435040 pestcheck:Line 2457 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.435040 pestcheck:12 characters long.
2019-07-17 01:01:13.435040 pestcheck:Line 2457 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.435040 pestcheck:once.
2019-07-17 01:01:13.435040 pestcheck:Line 2458 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.436041 pestcheck:12 characters long.
2019-07-17 01:01:13.436041 pestcheck:Line 2458 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.436041 pestcheck:once.
2019-07-17 01:01:13.436041 pestcheck:Line 2459 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.436041 pestcheck:12 characters long.
2019-07-17 01:01:13.436041 pestcheck:Line 2459 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.436041 pestcheck:once.
2019-07-17 01:01:13.437042 pestcheck:Line 2460 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.437042 pestcheck:12 characters long.
2019-07-17 01:01:13.437042 pestcheck:Line 2460 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.437042 pestcheck:once.
2019-07-17 01:01:13.437042 pestcheck:Line 2461 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.437042 pestcheck:12 characters long.
2019-07-17 01:01:13.437042 pestcheck:Line 2461 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.437042 pestcheck:once.
2019-07-17 01:01:13.438041 pestcheck:Line 2462 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.438041 pestcheck:12 characters long.
2019-07-17 01:01:13.438041 pestcheck:Line 2462 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.438041 pestcheck:once.
2019-07-17 01:01:13.438041 pestcheck:Line 2463 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.438041 pestcheck:12 characters long.
2019-07-17 01:01:13.438041 pestcheck:Line 2464 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.438041 pestcheck:12 characters long.
2019-07-17 01:01:13.439043 pestcheck:Line 2464 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.439043 pestcheck:once.
2019-07-17 01:01:13.439043 pestcheck:Line 2465 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.439043 pestcheck:12 characters long.
2019-07-17 01:01:13.439043 pestcheck:Line 2465 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.439043 pestcheck:once.
2019-07-17 01:01:13.440045 pestcheck:Line 2466 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.440045 pestcheck:12 characters long.
2019-07-17 01:01:13.440045 pestcheck:Line 2466 of file freyberg.pst: parameter name "prsity300
```

```
2019-07-17 01:01:13.440045 pestcheck:once.
2019-07-17 01:01:13.440045 pestcheck:Line 2467 of file freyberg.pst: parameter name "prsity3003
2019-07-17 01:01:13.440045 pestcheck:12 characters long.
2019-07-17 01:01:13.440045 pestcheck:Line 2467 of file freyberg.pst: parameter name "prsity3003
2019-07-17 01:01:13.440045 pestcheck:once.
2019-07-17 01:01:13.441045 pestcheck:Line 2468 of file freyberg.pst: parameter name "prsity3003
2019-07-17 01:01:13.441045 pestcheck:12 characters long.
2019-07-17 01:01:13.441045 pestcheck:Line 2468 of file freyberg.pst: parameter name "prsity3003
2019-07-17 01:01:13.441045 pestcheck:once.
2019-07-17 01:01:13.441045 pestcheck:Line 2469 of file freyberg.pst: parameter name "prsity3003
2019-07-17 01:01:13.441045 pestcheck:12 characters long.
2019-07-17 01:01:13.441045 pestcheck:Line 2469 of file freyberg.pst: parameter name "prsity3003
2019-07-17 01:01:13.441045 pestcheck:once.
2019-07-17 01:01:13.442045 pestcheck:Line 2470 of file freyberg.pst: parameter name "prsity3003
2019-07-17 01:01:13.442045 pestcheck:12 characters long.
2019-07-17 01:01:13.442045 pestcheck:Line 2470 of file freyberg.pst: parameter name "prsity3003
2019-07-17 01:01:13.442045 pestcheck:once.
2019-07-17 01:01:13.442045 pestcheck:Line 2471 of file freyberg.pst: parameter name "prsity3003
2019-07-17 01:01:13.442045 pestcheck:12 characters long.
2019-07-17 01:01:13.442045 pestcheck:Line 2471 of file freyberg.pst: parameter name "prsity3003
2019-07-17 01:01:13.443046 pestcheck:once.
2019-07-17 01:01:13.443046 pestcheck:Line 2472 of file freyberg.pst: parameter name "prsity3003
2019-07-17 01:01:13.443046 pestcheck:12 characters long.
2019-07-17 01:01:13.443046 pestcheck:Line 2472 of file freyberg.pst: parameter name "prsity3003
2019-07-17 01:01:13.443046 pestcheck:once.
2019-07-17 01:01:13.443046 pestcheck:Line 2473 of file freyberg.pst: parameter name "prsity3003
2019-07-17 01:01:13.443046 pestcheck:12 characters long.
2019-07-17 01:01:13.443046 pestcheck:Line 2474 of file freyberg.pst: parameter name "prsity3003
2019-07-17 01:01:13.444047 pestcheck:12 characters long.
2019-07-17 01:01:13.444047 pestcheck:Line 2474 of file freyberg.pst: parameter name "prsity3003
2019-07-17 01:01:13.444047 pestcheck:once.
2019-07-17 01:01:13.444047 pestcheck:Line 2475 of file freyberg.pst: parameter name "prsity3003
2019-07-17 01:01:13.444047 pestcheck:12 characters long.
2019-07-17 01:01:13.444047 pestcheck:Line 2475 of file freyberg.pst: parameter name "prsity3003
2019-07-17 01:01:13.444047 pestcheck:once.
2019-07-17 01:01:13.444047 pestcheck:Line 2476 of file freyberg.pst: parameter name "prsity3003
2019-07-17 01:01:13.445047 pestcheck:12 characters long.
2019-07-17 01:01:13.445047 pestcheck:Line 2476 of file freyberg.pst: parameter name "prsity3003
2019-07-17 01:01:13.445047 pestcheck:once.
2019-07-17 01:01:13.445047 pestcheck:Line 2477 of file freyberg.pst: parameter name "prsity3003
2019-07-17 01:01:13.445047 pestcheck:12 characters long.
2019-07-17 01:01:13.445047 pestcheck:Line 2477 of file freyberg.pst: parameter name "prsity3003
2019-07-17 01:01:13.445047 pestcheck:once.
2019-07-17 01:01:13.445047 pestcheck:Line 2478 of file freyberg.pst: parameter name "prsity3003
2019-07-17 01:01:13.446048 pestcheck:12 characters long.
2019-07-17 01:01:13.446048 pestcheck:Line 2478 of file freyberg.pst: parameter name "prsity3003
2019-07-17 01:01:13.446048 pestcheck:once.
2019-07-17 01:01:13.446048 pestcheck:Line 2479 of file freyberg.pst: parameter name "prsity3003
```

```
2019-07-17 01:01:13.446048 pestcheck:12 characters long.
2019-07-17 01:01:13.446048 pestcheck:Line 2479 of file freyberg.pst: parameter name "prsity3003
2019-07-17 01:01:13.446048 pestcheck:once.
2019-07-17 01:01:13.446048 pestcheck:Line 2480 of file freyberg.pst: parameter name "prsity3003
2019-07-17 01:01:13.447050 pestcheck:12 characters long.
2019-07-17 01:01:13.447050 pestcheck:Line 2480 of file freyberg.pst: parameter name "prsity3003
2019-07-17 01:01:13.447050 pestcheck:once.
2019-07-17 01:01:13.447050 pestcheck:Line 2481 of file freyberg.pst: parameter name "prsity3003
2019-07-17 01:01:13.447050 pestcheck:12 characters long.
2019-07-17 01:01:13.447050 pestcheck:Line 2481 of file freyberg.pst: parameter name "prsity3003
2019-07-17 01:01:13.447050 pestcheck:once.
2019-07-17 01:01:13.447050 pestcheck:Line 2482 of file freyberg.pst: parameter name "prsity3003
2019-07-17 01:01:13.447050 pestcheck:12 characters long.
2019-07-17 01:01:13.448051 pestcheck:Line 2482 of file freyberg.pst: parameter name "prsity3003
2019-07-17 01:01:13.448051 pestcheck:once.
2019-07-17 01:01:13.448051 pestcheck:Line 2483 of file freyberg.pst: parameter name "prsity3004
2019-07-17 01:01:13.448051 pestcheck:12 characters long.
2019-07-17 01:01:13.448051 pestcheck:Line 2484 of file freyberg.pst: parameter name "prsity3004
2019-07-17 01:01:13.448051 pestcheck:12 characters long.
2019-07-17 01:01:13.448051 pestcheck:Line 2484 of file freyberg.pst: parameter name "prsity3004
2019-07-17 01:01:13.448051 pestcheck:once.
2019-07-17 01:01:13.448051 pestcheck:Line 2485 of file freyberg.pst: parameter name "prsity3004
2019-07-17 01:01:13.449052 pestcheck:12 characters long.
2019-07-17 01:01:13.449052 pestcheck:Line 2485 of file freyberg.pst: parameter name "prsity3004
2019-07-17 01:01:13.449052 pestcheck:once.
2019-07-17 01:01:13.449052 pestcheck:Line 2486 of file freyberg.pst: parameter name "prsity3004
2019-07-17 01:01:13.449052 pestcheck:12 characters long.
2019-07-17 01:01:13.449052 pestcheck:Line 2486 of file freyberg.pst: parameter name "prsity3004
2019-07-17 01:01:13.449052 pestcheck:once.
2019-07-17 01:01:13.449052 pestcheck:Line 2487 of file freyberg.pst: parameter name "prsity3004
2019-07-17 01:01:13.449052 pestcheck:12 characters long.
2019-07-17 01:01:13.449052 pestcheck:Line 2487 of file freyberg.pst: parameter name "prsity3004
2019-07-17 01:01:13.450053 pestcheck:once.
2019-07-17 01:01:13.450053 pestcheck:Line 2488 of file freyberg.pst: parameter name "prsity3004
2019-07-17 01:01:13.450053 pestcheck:12 characters long.
2019-07-17 01:01:13.450053 pestcheck:Line 2488 of file freyberg.pst: parameter name "prsity3004
2019-07-17 01:01:13.450053 pestcheck:once.
2019-07-17 01:01:13.450053 pestcheck:Line 2489 of file freyberg.pst: parameter name "prsity3004
2019-07-17 01:01:13.450053 pestcheck:12 characters long.
2019-07-17 01:01:13.450053 pestcheck:Line 2489 of file freyberg.pst: parameter name "prsity3004
2019-07-17 01:01:13.450053 pestcheck:once.
2019-07-17 01:01:13.450053 pestcheck:Line 2490 of file freyberg.pst: parameter name "prsity3004
2019-07-17 01:01:13.451053 pestcheck:12 characters long.
2019-07-17 01:01:13.451053 pestcheck:Line 2490 of file freyberg.pst: parameter name "prsity3004
2019-07-17 01:01:13.451053 pestcheck:once.
2019-07-17 01:01:13.451053 pestcheck:Line 2491 of file freyberg.pst: parameter name "prsity3004
2019-07-17 01:01:13.451053 pestcheck:12 characters long.
2019-07-17 01:01:13.451053 pestcheck:Line 2491 of file freyberg.pst: parameter name "prsity3004
```

```
2019-07-17 01:01:13.451053 pestcheck:once.
2019-07-17 01:01:13.451053 pestcheck:Line 2492 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.451053 pestcheck:12 characters long.
2019-07-17 01:01:13.451053 pestcheck:Line 2492 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.452053 pestcheck:once.
2019-07-17 01:01:13.452053 pestcheck:Line 2493 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.452053 pestcheck:12 characters long.
2019-07-17 01:01:13.452053 pestcheck:Line 2494 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.452053 pestcheck:12 characters long.
2019-07-17 01:01:13.452053 pestcheck:Line 2494 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.452053 pestcheck:once.
2019-07-17 01:01:13.452053 pestcheck:Line 2495 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.452053 pestcheck:12 characters long.
2019-07-17 01:01:13.453055 pestcheck:Line 2495 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.453055 pestcheck:once.
2019-07-17 01:01:13.453055 pestcheck:Line 2496 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.453055 pestcheck:12 characters long.
2019-07-17 01:01:13.453055 pestcheck:Line 2496 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.453055 pestcheck:once.
2019-07-17 01:01:13.453055 pestcheck:Line 2497 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.453055 pestcheck:12 characters long.
2019-07-17 01:01:13.453055 pestcheck:Line 2497 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.453055 pestcheck:once.
2019-07-17 01:01:13.454055 pestcheck:Line 2498 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.454055 pestcheck:12 characters long.
2019-07-17 01:01:13.454055 pestcheck:Line 2498 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.454055 pestcheck:once.
2019-07-17 01:01:13.454055 pestcheck:Line 2499 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.454055 pestcheck:12 characters long.
2019-07-17 01:01:13.454055 pestcheck:Line 2499 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.454055 pestcheck:once.
2019-07-17 01:01:13.454055 pestcheck:Line 2500 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.454055 pestcheck:12 characters long.
2019-07-17 01:01:13.455056 pestcheck:Line 2500 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.455056 pestcheck:once.
2019-07-17 01:01:13.455056 pestcheck:Line 2501 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.455056 pestcheck:12 characters long.
2019-07-17 01:01:13.455056 pestcheck:Line 2501 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.455056 pestcheck:once.
2019-07-17 01:01:13.455056 pestcheck:Line 2502 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.455056 pestcheck:12 characters long.
2019-07-17 01:01:13.455056 pestcheck:Line 2502 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.456058 pestcheck:once.
2019-07-17 01:01:13.456058 pestcheck:Line 2503 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.456058 pestcheck:12 characters long.
2019-07-17 01:01:13.456058 pestcheck:Line 2504 of file freyberg.pst: parameter name "prsity300
2019-07-17 01:01:13.456058 pestcheck:12 characters long.
2019-07-17 01:01:13.456058 pestcheck:Line 2504 of file freyberg.pst: parameter name "prsity300
```

```
2019-07-17 01:01:13.456058 pestcheck:once.
2019-07-17 01:01:13.456058 pestcheck:Line 2505 of file freyberg.pst: parameter name "prsity3005
2019-07-17 01:01:13.456058 pestcheck:12 characters long.
2019-07-17 01:01:13.456058 pestcheck:Line 2505 of file freyberg.pst: parameter name "prsity3005
2019-07-17 01:01:13.457058 pestcheck:once.
2019-07-17 01:01:13.457058 pestcheck:Line 2506 of file freyberg.pst: parameter name "prsity3005
2019-07-17 01:01:13.457058 pestcheck:12 characters long.
2019-07-17 01:01:13.457058 pestcheck:Line 2506 of file freyberg.pst: parameter name "prsity3005
2019-07-17 01:01:13.457058 pestcheck:once.
2019-07-17 01:01:13.457058 pestcheck:Line 2507 of file freyberg.pst: parameter name "prsity3005
2019-07-17 01:01:13.457058 pestcheck:12 characters long.
2019-07-17 01:01:13.457058 pestcheck:Line 2507 of file freyberg.pst: parameter name "prsity3005
2019-07-17 01:01:13.457058 pestcheck:once.
2019-07-17 01:01:13.458061 pestcheck:Line 2508 of file freyberg.pst: parameter name "prsity3005
2019-07-17 01:01:13.458061 pestcheck:12 characters long.
2019-07-17 01:01:13.458061 finished: running pestchek on freyberg.pst took: 0:00:00.330641
2019-07-17 01:01:13.458061 starting: saving intermediate _setup_<> dfs into template
2019-07-17 01:01:13.763314 finished: saving intermediate _setup_<> dfs into template took: 0:0
2019-07-17 01:01:13.764315 all done
```

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

```
In [15]: # 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[15]: (14819, 4434)
```

1.1.6 Oh snap!

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

Let's stop for a moment to get a better feel for what just happened! Let's dig in..

```
In [16]: # check out hydraulic conductivity parameters
         pst.parameter_data.loc[pst.parameter_data.parnme.apply(lambda x: "hk" in x),:]

Out[16]:              parnme partrans parchglim  parval1  parlbnd  parubnd   pargp  \
         hk000         hk000      log    factor      1.0     0.01    100.0  pp_hk0
         hk001         hk001      log    factor      1.0     0.01    100.0  pp_hk0
         hk002         hk002      log    factor      1.0     0.01    100.0  pp_hk0
         hk003         hk003      log    factor      1.0     0.01    100.0  pp_hk0
         hk004         hk004      log    factor      1.0     0.01    100.0  pp_hk0
         hk005         hk005      log    factor      1.0     0.01    100.0  pp_hk0
         hk006         hk006      log    factor      1.0     0.01    100.0  pp_hk0
         hk007         hk007      log    factor      1.0     0.01    100.0  pp_hk0
         hk008         hk008      log    factor      1.0     0.01    100.0  pp_hk0
```

```
hk009          hk009      log    factor      1.0     0.01    100.0  pp_hk0
hk010          hk010      log    factor      1.0     0.01    100.0  pp_hk0
hk011          hk011      log    factor      1.0     0.01    100.0  pp_hk0
hk012          hk012      log    factor      1.0     0.01    100.0  pp_hk0
hk013          hk013      log    factor      1.0     0.01    100.0  pp_hk0
hk014          hk014      log    factor      1.0     0.01    100.0  pp_hk0
hk015          hk015      log    factor      1.0     0.01    100.0  pp_hk0
hk016          hk016      log    factor      1.0     0.01    100.0  pp_hk0
hk017          hk017      log    factor      1.0     0.01    100.0  pp_hk0
hk018          hk018      log    factor      1.0     0.01    100.0  pp_hk0
hk019          hk019      log    factor      1.0     0.01    100.0  pp_hk0
hk020          hk020      log    factor      1.0     0.01    100.0  pp_hk0
hk021          hk021      log    factor      1.0     0.01    100.0  pp_hk0
hk022          hk022      log    factor      1.0     0.01    100.0  pp_hk0
hk023          hk023      log    factor      1.0     0.01    100.0  pp_hk0
hk024          hk024      log    factor      1.0     0.01    100.0  pp_hk0
hk025          hk025      log    factor      1.0     0.01    100.0  pp_hk0
hk026          hk026      log    factor      1.0     0.01    100.0  pp_hk0
hk027          hk027      log    factor      1.0     0.01    100.0  pp_hk0
hk028          hk028      log    factor      1.0     0.01    100.0  pp_hk0
hk029          hk029      log    factor      1.0     0.01    100.0  pp_hk0
...              ...      ...       ...      ...      ...      ...     ...
hk5037013  hk5037013      log    factor      1.0     0.01    100.0  gr_hk5
hk5037014  hk5037014      log    factor      1.0     0.01    100.0  gr_hk5
hk5037015  hk5037015      log    factor      1.0     0.01    100.0  gr_hk5
hk5037016  hk5037016      log    factor      1.0     0.01    100.0  gr_hk5
hk5037017  hk5037017      log    factor      1.0     0.01    100.0  gr_hk5
hk5038005  hk5038005      log    factor      1.0     0.01    100.0  gr_hk5
hk5038006  hk5038006      log    factor      1.0     0.01    100.0  gr_hk5
hk5038007  hk5038007      log    factor      1.0     0.01    100.0  gr_hk5
hk5038008  hk5038008      log    factor      1.0     0.01    100.0  gr_hk5
hk5038009  hk5038009      log    factor      1.0     0.01    100.0  gr_hk5
hk5038010  hk5038010      log    factor      1.0     0.01    100.0  gr_hk5
hk5038011  hk5038011      log    factor      1.0     0.01    100.0  gr_hk5
hk5038012  hk5038012      log    factor      1.0     0.01    100.0  gr_hk5
hk5038013  hk5038013      log    factor      1.0     0.01    100.0  gr_hk5
hk5038014  hk5038014      log    factor      1.0     0.01    100.0  gr_hk5
hk5038015  hk5038015      log    factor      1.0     0.01    100.0  gr_hk5
hk5038016  hk5038016      log    factor      1.0     0.01    100.0  gr_hk5
hk5039005  hk5039005      log    factor      1.0     0.01    100.0  gr_hk5
hk5039006  hk5039006      log    factor      1.0     0.01    100.0  gr_hk5
hk5039007  hk5039007      log    factor      1.0     0.01    100.0  gr_hk5
hk5039008  hk5039008      log    factor      1.0     0.01    100.0  gr_hk5
hk5039009  hk5039009      log    factor      1.0     0.01    100.0  gr_hk5
hk5039010  hk5039010      log    factor      1.0     0.01    100.0  gr_hk5
hk5039011  hk5039011      log    factor      1.0     0.01    100.0  gr_hk5
hk5039012  hk5039012      log    factor      1.0     0.01    100.0  gr_hk5
hk5039013  hk5039013      log    factor      1.0     0.01    100.0  gr_hk5
```

```
hk5039014  hk5039014      log    factor      1.0     0.01    100.0  gr_hk5
hk6_cn        hk6_cn      log    factor      1.0     0.01    100.0  cn_hk6
hk7_cn        hk7_cn      log    factor      1.0     0.01    100.0  cn_hk7
hk8_cn        hk8_cn      log    factor      1.0     0.01    100.0  cn_hk8
```

	scale	offset	dercom
hk000	1.0	0.0	1
hk001	1.0	0.0	1
hk002	1.0	0.0	1
hk003	1.0	0.0	1
hk004	1.0	0.0	1
hk005	1.0	0.0	1
hk006	1.0	0.0	1
hk007	1.0	0.0	1
hk008	1.0	0.0	1
hk009	1.0	0.0	1
hk010	1.0	0.0	1
hk011	1.0	0.0	1
hk012	1.0	0.0	1
hk013	1.0	0.0	1
hk014	1.0	0.0	1
hk015	1.0	0.0	1
hk016	1.0	0.0	1
hk017	1.0	0.0	1
hk018	1.0	0.0	1
hk019	1.0	0.0	1
hk020	1.0	0.0	1
hk021	1.0	0.0	1
hk022	1.0	0.0	1
hk023	1.0	0.0	1
hk024	1.0	0.0	1
hk025	1.0	0.0	1
hk026	1.0	0.0	1
hk027	1.0	0.0	1
hk028	1.0	0.0	1
hk029	1.0	0.0	1
...	...	...	...
hk5037013	1.0	0.0	1
hk5037014	1.0	0.0	1
hk5037015	1.0	0.0	1
hk5037016	1.0	0.0	1
hk5037017	1.0	0.0	1
hk5038005	1.0	0.0	1
hk5038006	1.0	0.0	1
hk5038007	1.0	0.0	1
hk5038008	1.0	0.0	1
hk5038009	1.0	0.0	1
hk5038010	1.0	0.0	1

```
hk5038011    1.0     0.0       1
hk5038012    1.0     0.0       1
hk5038013    1.0     0.0       1
hk5038014    1.0     0.0       1
hk5038015    1.0     0.0       1
hk5038016    1.0     0.0       1
hk5039005    1.0     0.0       1
hk5039006    1.0     0.0       1
hk5039007    1.0     0.0       1
hk5039008    1.0     0.0       1
hk5039009    1.0     0.0       1
hk5039010    1.0     0.0       1
hk5039011    1.0     0.0       1
hk5039012    1.0     0.0       1
hk5039013    1.0     0.0       1
hk5039014    1.0     0.0       1
hk6_cn       1.0     0.0       1
hk7_cn       1.0     0.0       1
hk8_cn       1.0     0.0       1

[2214 rows x 10 columns]
```

In [17]:
```
# what about observations? in particular, the sfr flow-out observations in the last s
pst.observation_data.loc[(pst.observation_data.obgnme.apply(lambda x: "flout" in x)) &
                         (pst.observation_data.obsnme.apply(lambda x: "1980" in x)),:]
```

Out[17]:

	obsnme	obsval	weight	obgnme
fo_0_19801229	fo_0_19801229	10054.0	1.0	flout
fo_10_19801229	fo_10_19801229	10374.0	1.0	flout
fo_11_19801229	fo_11_19801229	10376.0	1.0	flout
fo_12_19801229	fo_12_19801229	10385.0	1.0	flout
fo_13_19801229	fo_13_19801229	10401.0	1.0	flout
fo_14_19801229	fo_14_19801229	10422.0	1.0	flout
fo_15_19801229	fo_15_19801229	10444.0	1.0	flout
fo_16_19801229	fo_16_19801229	10466.0	1.0	flout
fo_17_19801229	fo_17_19801229	10486.0	1.0	flout
fo_18_19801229	fo_18_19801229	10501.0	1.0	flout
fo_19_19801229	fo_19_19801229	10506.0	1.0	flout
fo_1_19801229	fo_1_19801229	10108.0	1.0	flout
fo_20_19801229	fo_20_19801229	10499.0	1.0	flout
fo_21_19801229	fo_21_19801229	10504.0	1.0	flout
fo_22_19801229	fo_22_19801229	10516.0	1.0	flout
fo_23_19801229	fo_23_19801229	10532.0	1.0	flout
fo_24_19801229	fo_24_19801229	10550.0	1.0	flout
fo_25_19801229	fo_25_19801229	10567.0	1.0	flout
fo_26_19801229	fo_26_19801229	10584.0	1.0	flout
fo_27_19801229	fo_27_19801229	10600.0	1.0	flout
fo_28_19801229	fo_28_19801229	10615.0	1.0	flout

```
fo_29_19801229  fo_29_19801229   10627.0     1.0  flout
fo_2_19801229    fo_2_19801229   10162.0     1.0  flout
fo_30_19801229  fo_30_19801229   10637.0     1.0  flout
fo_31_19801229  fo_31_19801229   10643.0     1.0  flout
fo_32_19801229  fo_32_19801229   10643.0     1.0  flout
fo_33_19801229  fo_33_19801229   10637.0     1.0  flout
fo_34_19801229  fo_34_19801229   10624.0     1.0  flout
fo_35_19801229  fo_35_19801229   10607.0     1.0  flout
fo_36_19801229  fo_36_19801229   10584.0     1.0  flout
fo_37_19801229  fo_37_19801229   10552.0     1.0  flout
fo_38_19801229  fo_38_19801229   10512.0     1.0  flout
fo_39_19801229  fo_39_19801229   10512.0     1.0  flout
fo_3_19801229    fo_3_19801229   10213.0     1.0  flout
fo_4_19801229    fo_4_19801229   10262.0     1.0  flout
fo_5_19801229    fo_5_19801229   10306.0     1.0  flout
fo_6_19801229    fo_6_19801229   10343.0     1.0  flout
fo_7_19801229    fo_7_19801229   10370.0     1.0  flout
fo_8_19801229    fo_8_19801229   10382.0     1.0  flout
fo_9_19801229    fo_9_19801229   10375.0     1.0  flout
fo_hw_19801229  fo_hw_19801229  196430.0     1.0  flout
fo_tw_19801229  fo_tw_19801229  211539.0     1.0  flout
```

1.1.7 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 [18]: 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
```

```
Out[18]: ['template\\freyberg.locations',
          'template\\freyberg.mpbas',
          'template\\freyberg.mpnam',
          'template\\freyberg.mpsim',
          'template\\mp_ibound_1.ref',
          'template\\mp_ibound_2.ref',
          'template\\mp_ibound_3.ref']
```

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 will attempt to remove at the start of a run.

```
In [19]: #pst_helper.frun_post_lines.append("os.system('mp6 freyberg.mpsim >mp6.stdout')")
         pst_helper.frun_post_lines.append("pyemu.os_utils.run('mp6 freyberg.mpsim >mp6.stdout
         pst_helper.tmp_files.append("freyberg.mpenpt")  # placed at top of `forward_run.py`
         pst_helper.write_forward_run()
```

Create and add instruction files and related observations for MODPATH

```
In [20]: out_file = "freyberg.mpenpt"
         ins_file = out_file + ".ins"
         with open(os.path.join(pst_helper.new_model_ws,ins_file),'w') as f:
             f.write("pif ~\n")
             f.write("l7 w w w !part_status! w w !part_time!\n")

In [21]: 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:run() returned non-zero
observations in this instruction file will havegeneric values.
```

We also need to copy the original prsity arrays to the `arr_org` dir for use in the multiplier parameterization scheme

```
In [22]: for k in range(m.nlay):
             np.savetxt(os.path.join(pst_helper.new_model_ws,"arr_org","prsity_layer_{0}.ref".
                        np.zeros((m.nrow,m.ncol))+0.001,fmt="%15.6E")
```

1.1.8 Final bits and bobs

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

```
In [23]: par = pst.parameter_data  # we inspected this guy earlier
         # properties
         tag_dict = {"hk":[0.1,10.0],"vka":[0.1,10],"strt":[0.95,1.05],"pr":[0.8,1.2]}
         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
```

given the combinations of multipliers, we need to set a hard upper bound on sy since it has a physical upper limit (note: seperate to bounds handled explicitly by pest)

```
In [24]: arr_csv = os.path.join(pst_helper.new_model_ws,"arr_pars.csv")
         df = pd.read_csv(arr_csv,index_col=0)
         df.head()
```

```
Out[24]:    layer             mlt_file          model_file                  org_file  \
         0      0    arr_mlt\hk0.dat_pp    .\hk_Layer_1.ref    arr_org\hk_Layer_1.ref
         1      0   arr_mlt\vka0.dat_pp          .\vka1.ref          arr_org\vka1.ref
         2      0    arr_mlt\ss0.dat_pp    .\ss_Layer_1.ref    arr_org\ss_Layer_1.ref
         3      0    arr_mlt\sy0.dat_pp    .\sy_Layer_1.ref    arr_org\sy_Layer_1.ref
         4      0  arr_mlt\strt0.dat_pp  .\strt_layer_1.ref  arr_org\strt_layer_1.ref

           suffix prefix attr_name tpl_file             fac_file      pp_file
```

```
0    _pp    hk0        hk      NaN  pp_k0_general_zn.fac    hk0pp.dat
1    _pp   vka0       vka      NaN  pp_k0_general_zn.fac   vka0pp.dat
2    _pp    ss0        ss      NaN  pp_k0_general_zn.fac    ss0pp.dat
3    _pp    sy0        sy      NaN  pp_k0_general_zn.fac    sy0pp.dat
4    _pp  strt0      strt      NaN  pp_k0_general_zn.fac  strt0pp.dat
```

In [25]:
```
sy_pr = df.model_file.apply(lambda x: "sy" in x or "pr" in x)
df.loc[:,"upper_bound"] = np.NaN
df.loc[sy_pr,"upper_bound"] = 0.4
df.to_csv(arr_csv)
```

In [26]:
```
# table can also be written to a .tex file (report-ready!)
pst.write_par_summary_table(filename="none").sort_index()
```

Out[26]:

	type	transform	count	initial value	upper bound	\
cn_hk6	cn_hk6	log	1	0	1	
cn_hk7	cn_hk7	log	1	0	1	
cn_hk8	cn_hk8	log	1	0	1	
cn_prsity6	cn_prsity6	log	1	0	0.0791812	
cn_prsity7	cn_prsity7	log	1	0	0.0791812	
cn_prsity8	cn_prsity8	log	1	0	0.0791812	
cn_rech4	cn_rech4	log	1	0	0.0413927	
cn_rech5	cn_rech5	log	1	0	0.0413927	
cn_ss6	cn_ss6	log	1	0	1	
cn_ss7	cn_ss7	log	1	0	1	
cn_ss8	cn_ss8	log	1	0	1	
cn_strt6	cn_strt6	log	1	0	0.0211893	
cn_strt7	cn_strt7	log	1	0	0.0211893	
cn_strt8	cn_strt8	log	1	0	0.0211893	
cn_sy6	cn_sy6	log	1	0	0.243038	
cn_sy7	cn_sy7	log	1	0	0.243038	
cn_sy8	cn_sy8	log	1	0	0.243038	
cn_vka6	cn_vka6	log	1	0	1	
cn_vka7	cn_vka7	log	1	0	1	
cn_vka8	cn_vka8	log	1	0	1	
drncond_k00	drncond_k00	log	10	0	1	
flow	flow	log	1	0	0.09691	
gr_hk3	gr_hk3	log	705	0	1	
gr_hk4	gr_hk4	log	705	0	1	
gr_hk5	gr_hk5	log	705	0	1	
gr_prsity3	gr_prsity3	log	705	0	0.0791812	
gr_prsity4	gr_prsity4	log	705	0	0.0791812	
gr_prsity5	gr_prsity5	log	705	0	0.0791812	
gr_rech2	gr_rech2	log	705	0	0.0413927	
gr_rech3	gr_rech3	log	705	0	0.0413927	
...	...	...	...	...	...	
gr_strt5	gr_strt5	log	705	0	0.0211893	
gr_sy3	gr_sy3	log	705	0	0.243038	

gr_sy4	gr_sy4	log	705	0	0.243038
gr_sy5	gr_sy5	log	705	0	0.243038
gr_vka3	gr_vka3	log	705	0	1
gr_vka4	gr_vka4	log	705	0	1
gr_vka5	gr_vka5	log	705	0	1
pp_hk0	pp_hk0	log	32	0	1
pp_hk1	pp_hk1	log	32	0	1
pp_hk2	pp_hk2	log	32	0	1
pp_prsity0	pp_prsity0	log	32	0	0.0791812
pp_prsity1	pp_prsity1	log	32	0	0.0791812
pp_prsity2	pp_prsity2	log	32	0	0.0791812
pp_rech0	pp_rech0	log	32	0	0.0413927
pp_rech1	pp_rech1	log	32	0	0.0413927
pp_ss0	pp_ss0	log	32	0	1
pp_ss1	pp_ss1	log	32	0	1
pp_ss2	pp_ss2	log	32	0	1
pp_strt0	pp_strt0	log	32	0	0.0211893
pp_strt1	pp_strt1	log	32	0	0.0211893
pp_strt2	pp_strt2	log	32	0	0.0211893
pp_sy0	pp_sy0	log	32	0	0.243038
pp_sy1	pp_sy1	log	32	0	0.243038
pp_sy2	pp_sy2	log	32	0	0.243038
pp_vka0	pp_vka0	log	32	0	1
pp_vka1	pp_vka1	log	32	0	1
pp_vka2	pp_vka2	log	32	0	1
strk	strk	log	40	0	2
welflux	welflux	log	2	0	1
welflux_k02	welflux_k02	log	6	0	1

	lower bound	standard deviation
cn_hk6	-1	0.5
cn_hk7	-1	0.5
cn_hk8	-1	0.5
cn_prsity6	-0.09691	0.0440228
cn_prsity7	-0.09691	0.0440228
cn_prsity8	-0.09691	0.0440228
cn_rech4	-0.0457575	0.0217875
cn_rech5	-0.0457575	0.0217875
cn_ss6	-1	0.5
cn_ss7	-1	0.5
cn_ss8	-1	0.5
cn_strt6	-0.0222764	0.0108664
cn_strt7	-0.0222764	0.0108664
cn_strt8	-0.0222764	0.0108664
cn_sy6	-0.60206	0.211275
cn_sy7	-0.60206	0.211275
cn_sy8	-0.60206	0.211275
cn_vka6	-1	0.5

```
cn_vka7              -1               0.5
cn_vka8              -1               0.5
drncond_k00          -1               0.5
flow          -0.124939         0.0554622
gr_hk3               -1               0.5
gr_hk4               -1               0.5
gr_hk5               -1               0.5
gr_prsity3     -0.09691         0.0440228
gr_prsity4     -0.09691         0.0440228
gr_prsity5     -0.09691         0.0440228
gr_rech2     -0.0457575         0.0217875
gr_rech3     -0.0457575         0.0217875
...                 ...               ...
gr_strt5     -0.0222764         0.0108664
gr_sy3         -0.60206          0.211275
gr_sy4         -0.60206          0.211275
gr_sy5         -0.60206          0.211275
gr_vka3              -1               0.5
gr_vka4              -1               0.5
gr_vka5              -1               0.5
pp_hk0               -1               0.5
pp_hk1               -1               0.5
pp_hk2               -1               0.5
pp_prsity0     -0.09691         0.0440228
pp_prsity1     -0.09691         0.0440228
pp_prsity2     -0.09691         0.0440228
pp_rech0     -0.0457575         0.0217875
pp_rech1     -0.0457575         0.0217875
pp_ss0               -1               0.5
pp_ss1               -1               0.5
pp_ss2               -1               0.5
pp_strt0     -0.0222764         0.0108664
pp_strt1     -0.0222764         0.0108664
pp_strt2     -0.0222764         0.0108664
pp_sy0         -0.60206          0.211275
pp_sy1         -0.60206          0.211275
pp_sy2         -0.60206          0.211275
pp_vka0              -1               0.5
pp_vka1              -1               0.5
pp_vka2              -1               0.5
strk                 -2                 1
welflux              -1               0.5
welflux_k02          -1               0.5

[65 rows x 7 columns]
```

In [27]:
```
pst.write_obs_summary_table(filename="none").head()
```

Out[27]:
```
                    group                 value  non-zero weight  zero weight  \
```

```
flaqx              flaqx    -977.239 to 40.562              84           0
flout              flout       10054 to 226396              84           0
flx_constan  flx_constan                     0               2           0
flx_drains    flx_drains  -723.325 to -548.613               2           0
flx_in-out    flx_in-out     0.012695 to 0.467               2           0

            weight standard deviation             percent error
flaqx            1                  1        0.102329 to 833.333
flout            1                  1  0.000441704 to 0.00994629
flx_constan      1                  1                         NA
flx_drains       1                  1        0.13825 to 0.182278
flx_in-out       1                  1         214.133 to 7877.12
```

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

```
In [28]: 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 let's take it up a notch. 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 [29]: if pst_helper.pst.npar < 15000:
             cov = pst_helper.build_prior(fmt="coo",filename=os.path.join(pst_helper.new_model
             cov = np.ma.masked_where(cov.x==0,cov.x)
             try:
                 fig = plt.figure(figsize=(10,10))
                 ax = plt.subplot(111)
                 ax.imshow(cov)
                 plt.show()
             except:
                 pass
```

```
2019-07-17 01:01:40.901302 starting: building prior covariance matrix
2019-07-17 01:01:41.060434 WARNING: geospatial prior not implemented for SFR pars

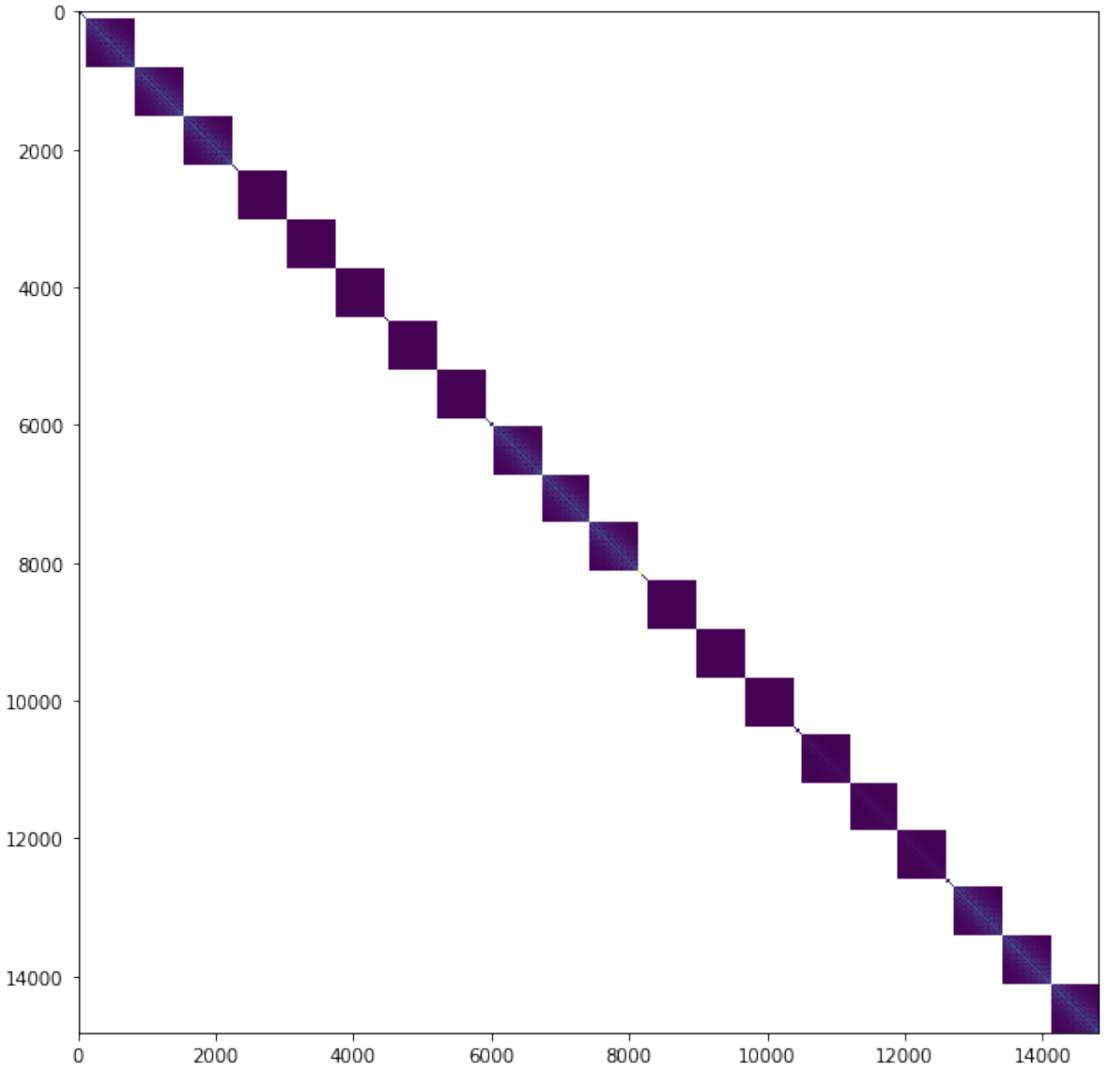

C:\Users\knowling\AppData\Local\Continuum\anaconda3\lib\site-packages\pandas\core\indexing.py:3
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stable/indexing.html
  self.obj[key] = _infer_fill_value(value)
C:\Users\knowling\AppData\Local\Continuum\anaconda3\lib\site-packages\pandas\core\indexing.py:5
```

```
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


2019-07-17 01:01:51.026781 saving prior covariance matrix to file template\prior_cov.jcb
2019-07-17 01:01:57.300902 finished: building prior covariance matrix took: 0:00:16.399600
```



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

```
In [30]: pe = pst_helper.draw(500)
```

```
2019-07-17 01:02:32.431322 starting: drawing realizations
building diagonal cov
processing  name:grid_geostruct,nugget:0.0,structures:
name:var1,contribution:1.0,a:2500.0,anisotropy:1.0,bearing:0.0

working on pargroups ['gr_hk3']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_vka3']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_ss3']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_sy3']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_strt3']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_prsity3']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_hk4']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_vka4']
```

```
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_ss4']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_sy4']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_strt4']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_prsity4']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_hk5']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_vka5']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_ss5']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_sy5']
```

```
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_strt5']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_prsity5']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_rech2']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_rech3']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
processing  name:pp_geostruct,nugget:0.0,structures:
name:var1,contribution:1.0,a:1000.0,anisotropy:1.0,bearing:0.0

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

```
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_rech1']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_ss0']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_strt0']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_sy0']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_vka0']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_hk1']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_prsity1']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_ss1']
build cov matrix
done
getting diag var cov 32
```

```
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_strt1']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_sy1']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_vka1']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_hk2']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_prsity2']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_ss2']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_strt2']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_sy2']
build cov matrix
done
getting diag var cov 32
```

```
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_vka2']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
processing  name:spatial_list_geostruct,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']


C:\Users\knowling\AppData\Local\Continuum\anaconda3\lib\site-packages\pandas\core\indexing.py:3
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)
C:\Users\knowling\AppData\Local\Continuum\anaconda3\lib\site-packages\pandas\core\indexing.py:5
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

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


build cov matrix
done
getting diag var cov 10
scaling full cov by diag var cov
making full cov draws with home-grown goodness
processing  name:temporal_list_geostruct,nugget:0.0,structures:
name:var1,contribution:1.0,a:180.0,anisotropy:1.0,bearing:0.0

working on pargroups ['welflux']
build cov matrix
done
getting diag var cov 2
scaling full cov by diag var cov
making full cov draws with home-grown goodness
```

```
adding remaining parameters to diagonal
2019-07-17 01:02:48.420265 finished: drawing realizations took: 0:00:15.988943
```

You can see that parameters are treated in parameter group (pargp) blocks for this ensemble generation.

Always a good idea to inspect the parameter ensemble for reasonableness! Can do via slicing and dicing...

```
In [31]: pe.iloc[-10:-5,:10]
```

Out[31]:

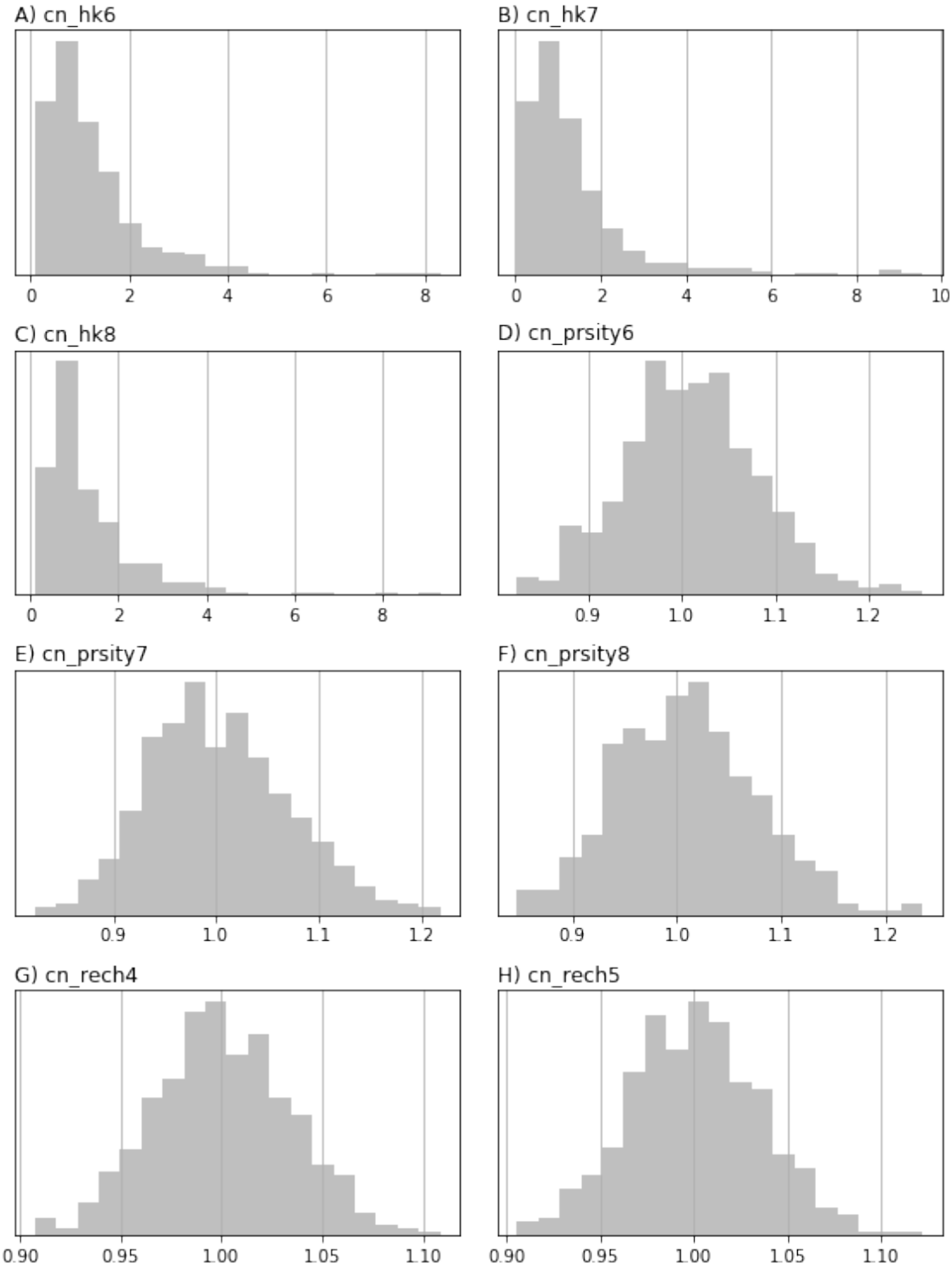
	hk3000000	hk3000001	hk3000002	hk3000003	hk3000004	hk3000005	\
490	1.206221	1.968932	2.698087	2.027151	2.443490	1.734673	
491	1.255867	2.040476	1.549545	1.479577	2.519808	2.998529	
492	0.697824	0.738241	1.508115	1.697770	1.847771	1.757112	
493	0.449850	0.510057	0.475973	0.519650	0.802379	0.735356	
494	1.796640	1.383561	1.716070	1.584088	1.600322	1.803785	

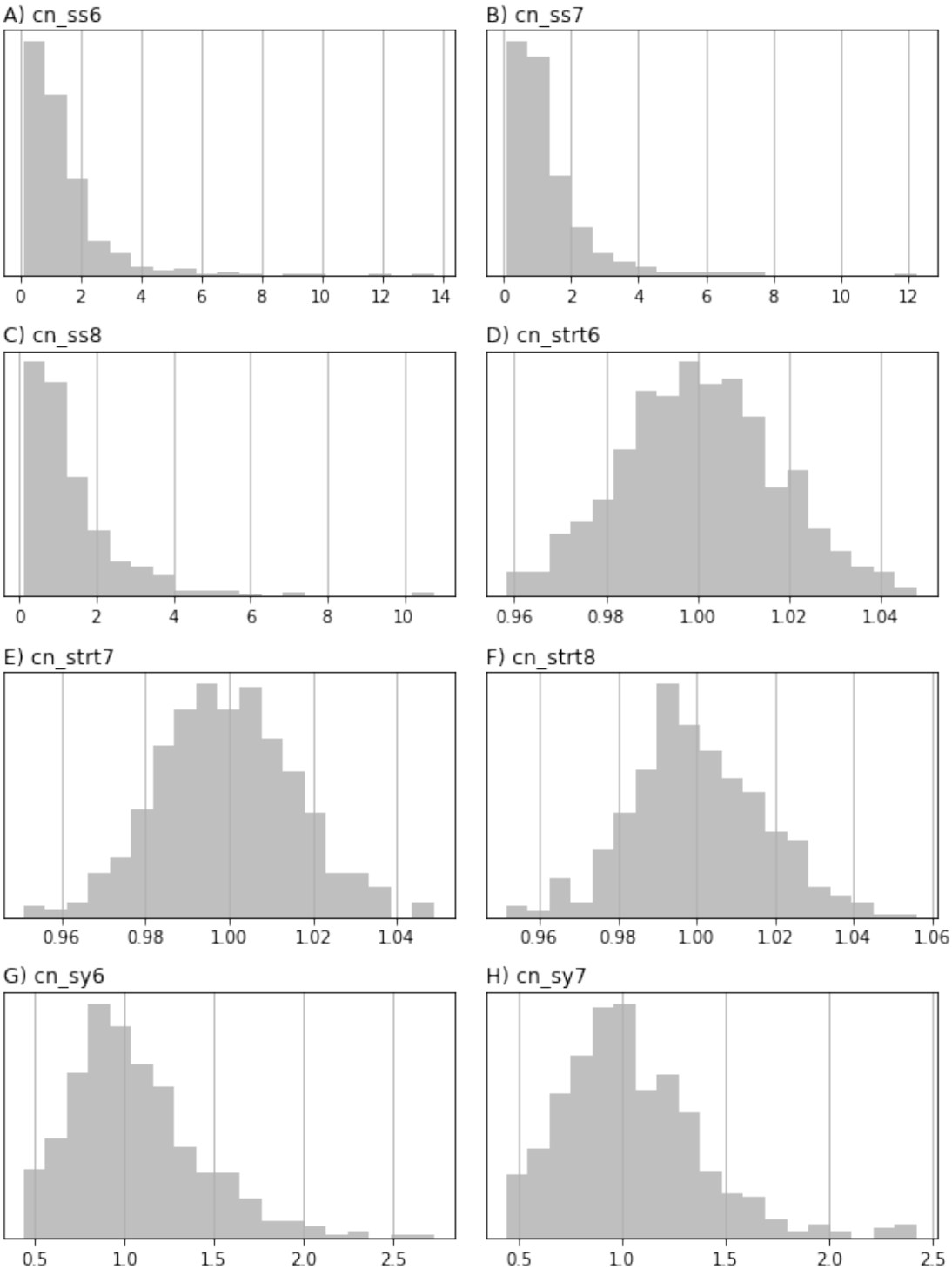
	hk3000006	hk3000007	hk3000008	hk3000009
490	1.074304	0.615059	0.625267	0.721397
491	3.821978	2.996158	3.128706	3.265180
492	1.881248	1.798628	1.465892	1.953400
493	0.455645	0.274035	0.377106	0.263564
494	1.196490	1.519277	1.115009	2.334526

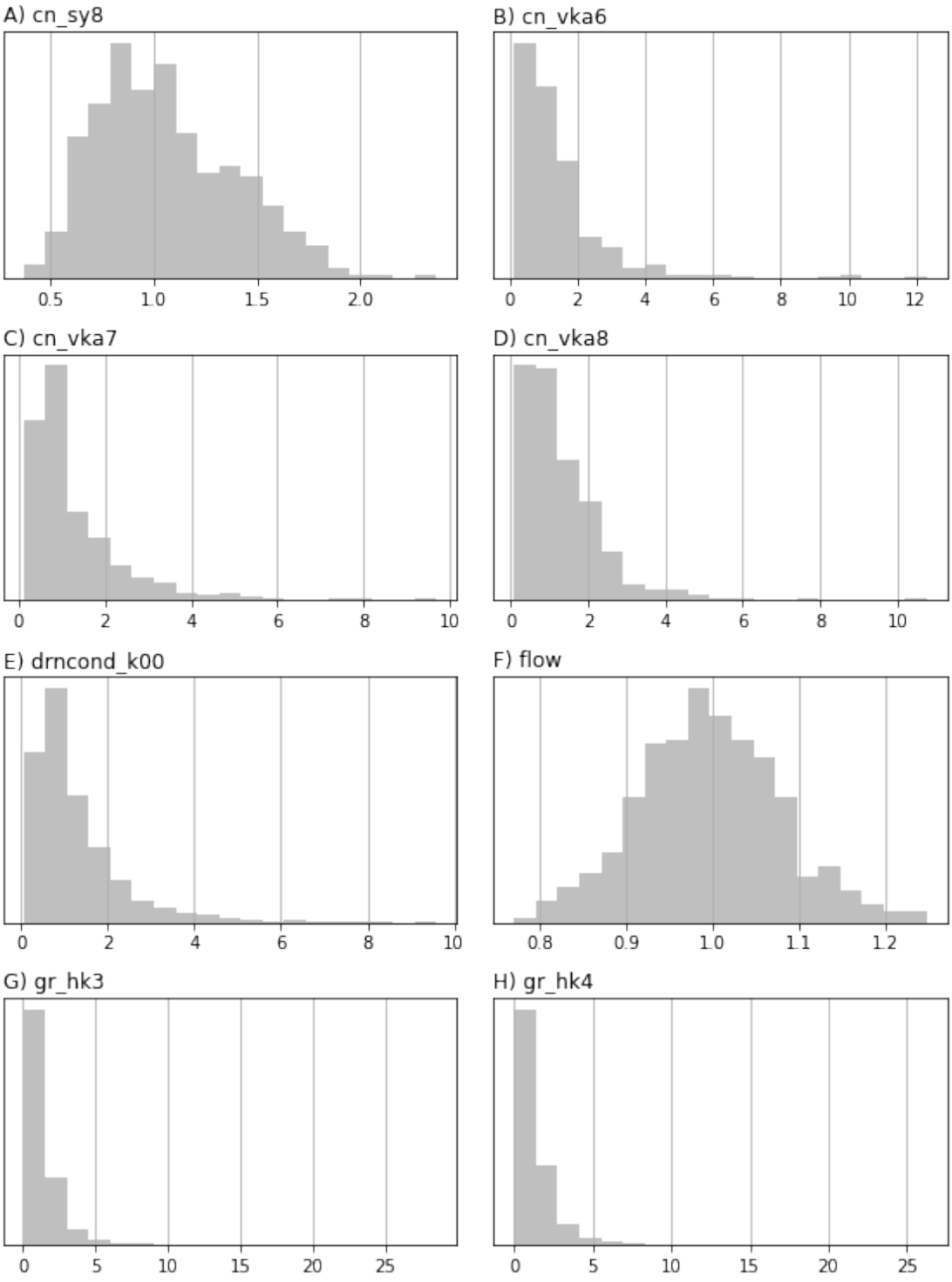
Let's plot one parameter:

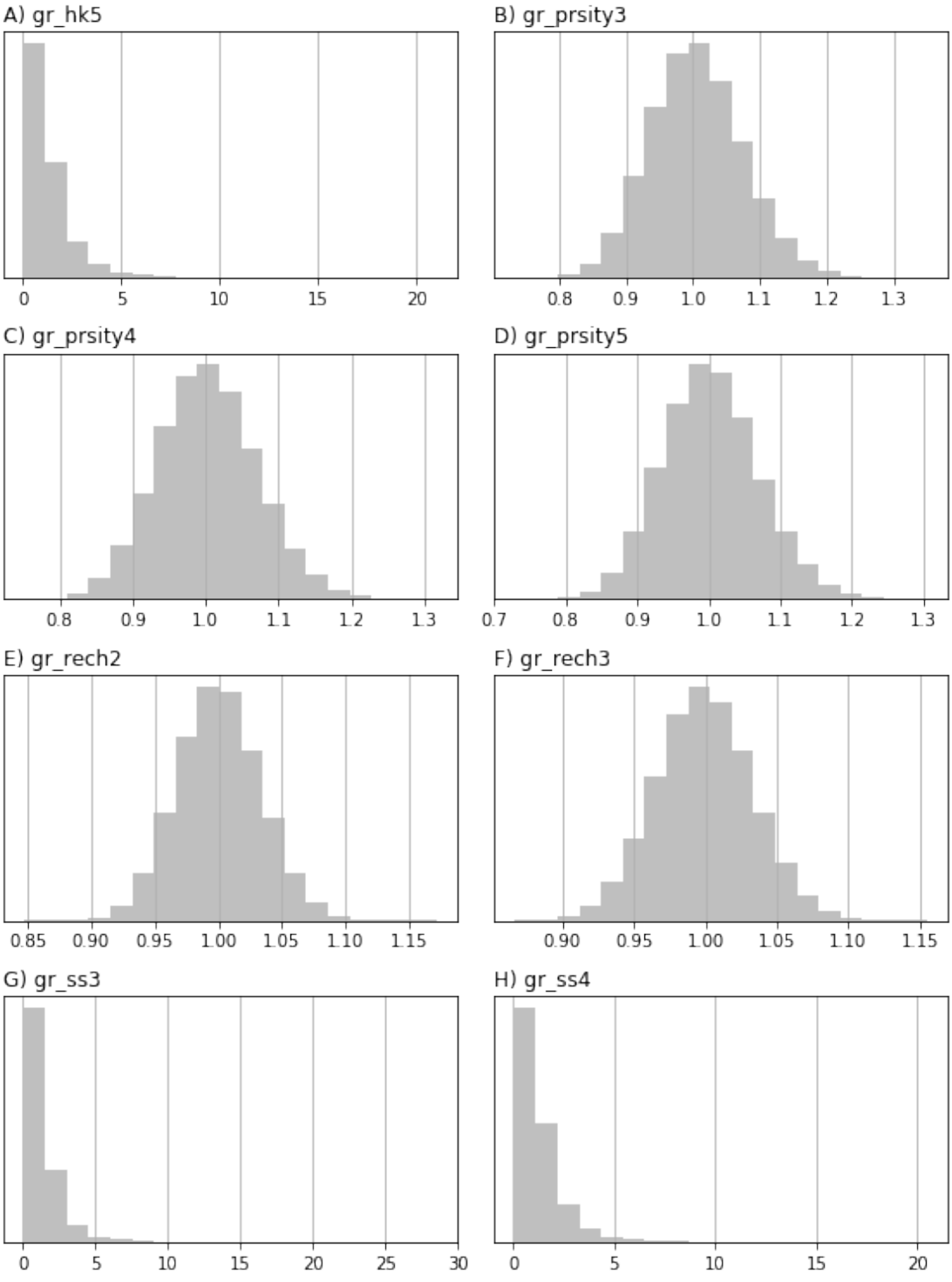
```
In [32]: par = pst_helper.pst.parameter_data
         pyemu.plot_utils.ensemble_helper(pe,plot_cols=par.groupby("pargp").groups,bins=20)
         plt.show()
```

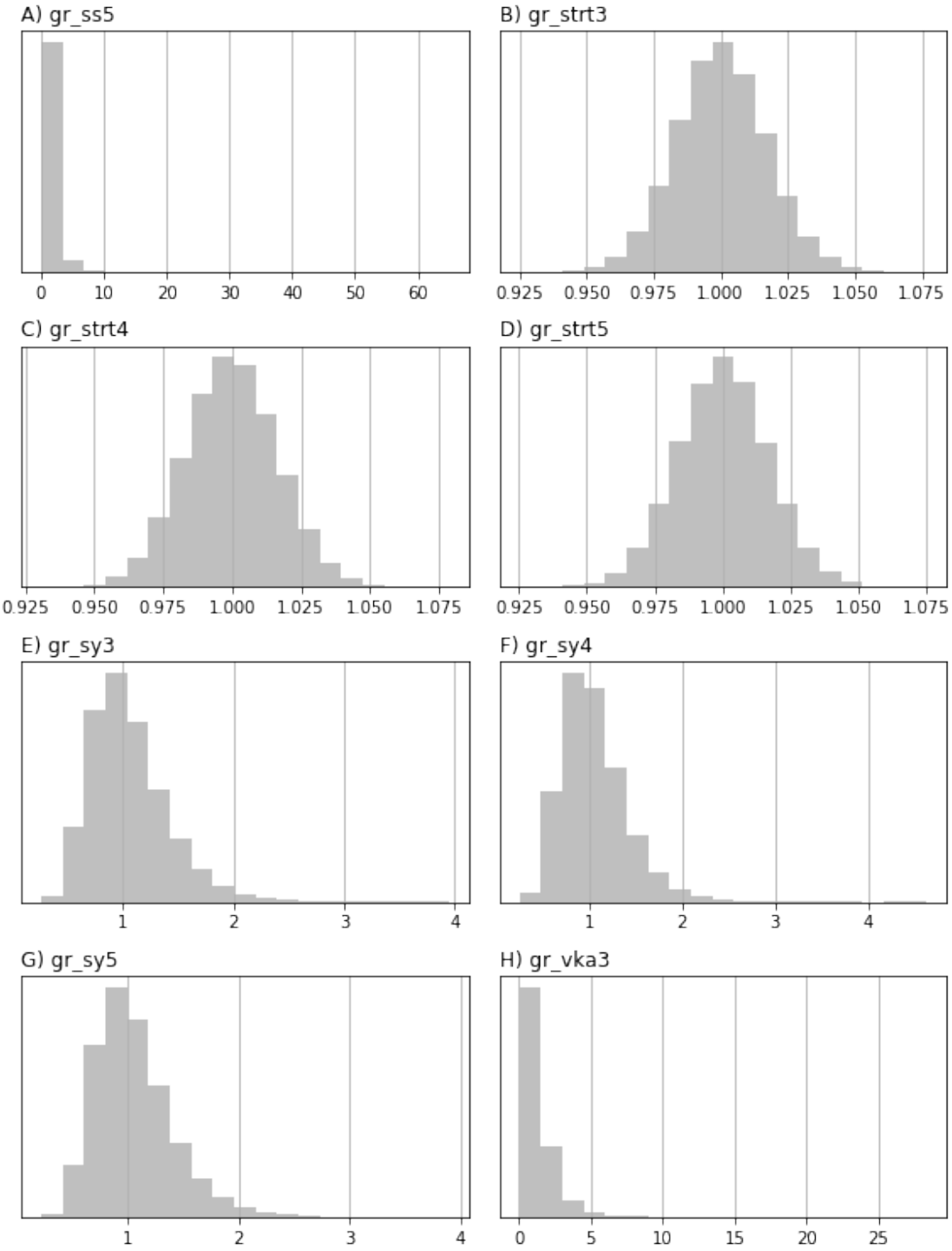
```
<matplotlib.figure.Figure at 0x280f01da2b0>
```

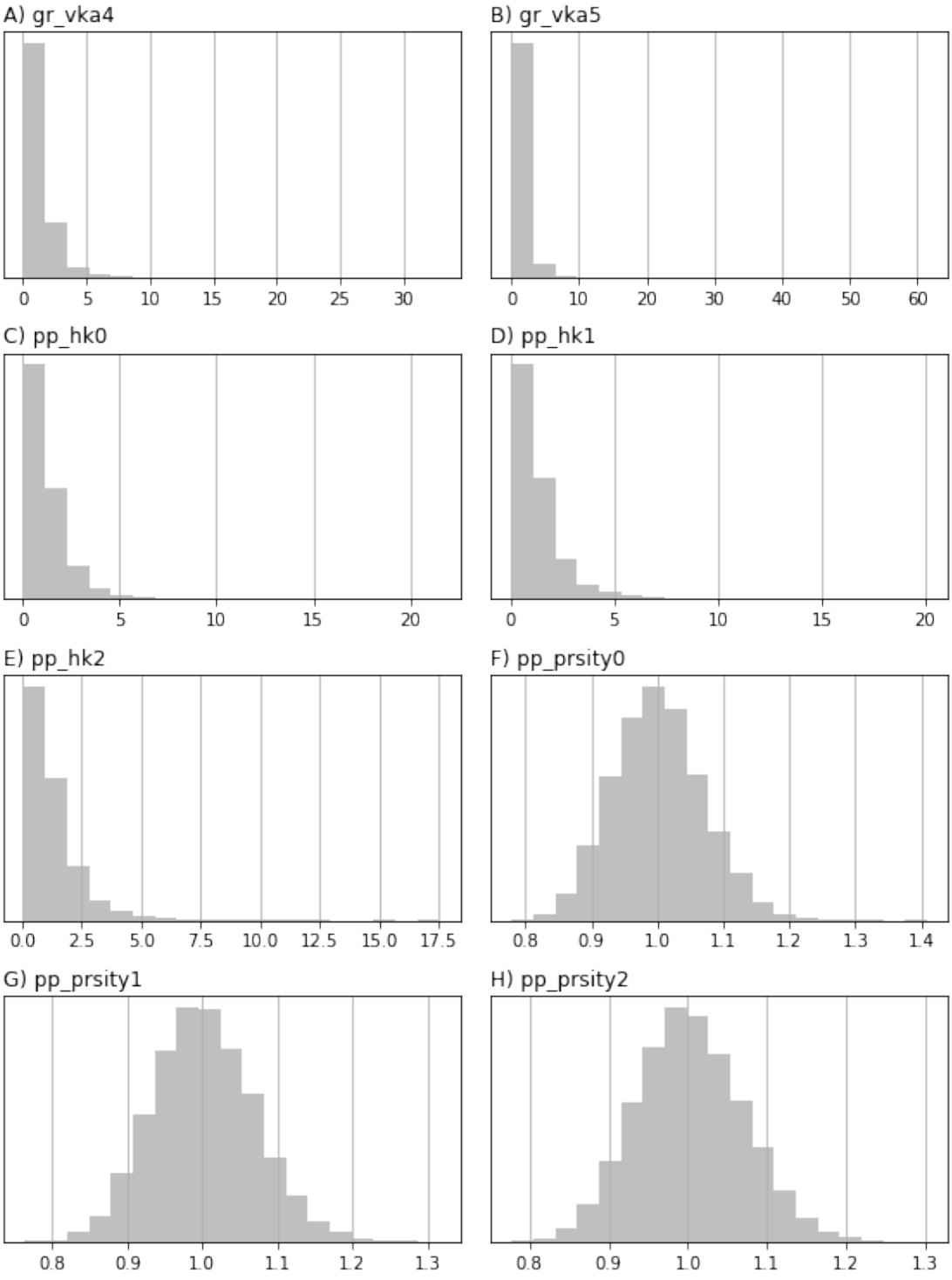

A) cn_hk6
0
2
4
6
8
B) cn_hk7
0
2
4
6
8
10
C) cn_hk8
0
2
4
6
8
D) cn_prsity6
0.9
1.0
1.1
1.2
E) cn_prsity7
0.9
1.0
1.1
1.2
F) cn_prsity8
0.9
1.0
1.1
1.2
G) cn_rech4
0.90
0.95
1.00
1.05
1.10
H) cn_rech5
0.90
0.95
1.00
1.05
1.10

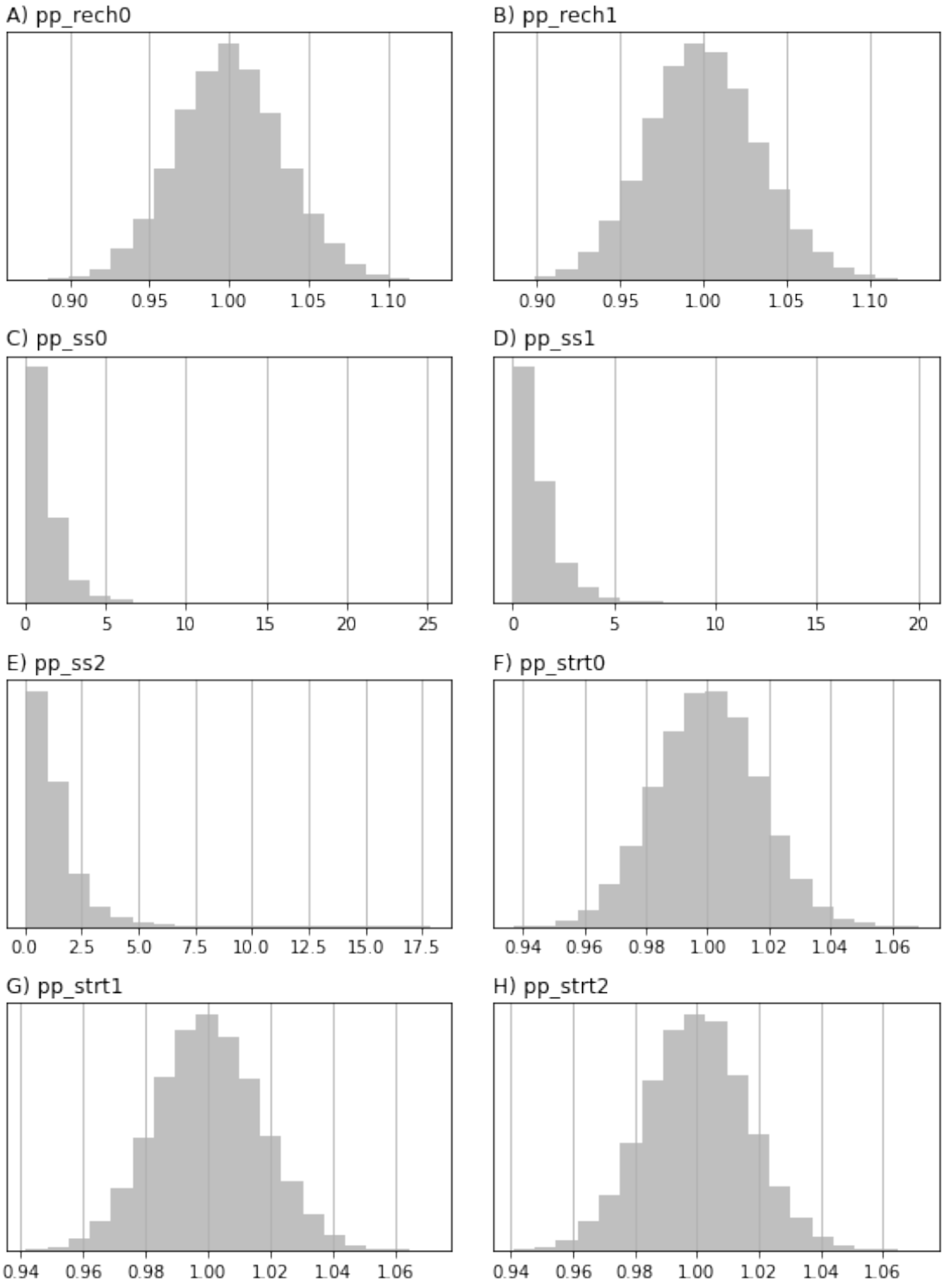

A) cn_ss6
0 2 4 6 8 10 12 14
B) cn_ss7
0 2 4 6 8 10 12
C) cn_ss8
0 2 4 6 8 10
D) cn_strt6
0.96 0.98 1.00 1.02 1.04
E) cn_strt7
0.96 0.98 1.00 1.02 1.04
F) cn_strt8
0.96 0.98 1.00 1.02 1.04 1.06
G) cn_sy6
0.5 1.0 1.5 2.0 2.5
H) cn_sy7
0.5 1.0 1.5 2.0 2.5

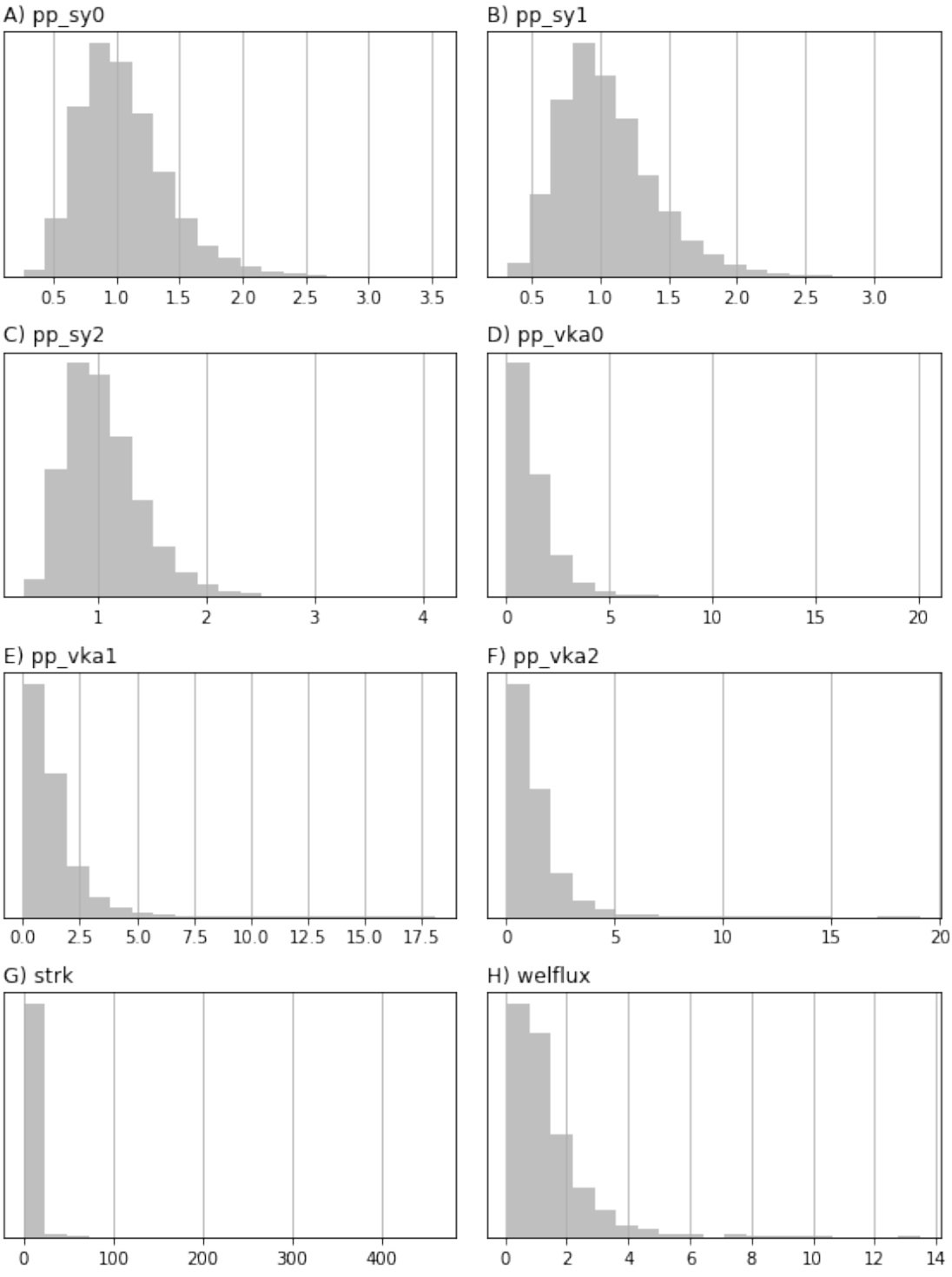

A) cn_sy8
0.5
1.0
1.5
2.0
B) cn_vka6
0
2
4
6
8
10
12
C) cn_vka7
0
2
4
6
8
10
D) cn_vka8
0
2
4
6
8
10
E) drncond_k00
0
2
4
6
8
10
F) flow
0.8
0.9
1.0
1.1
1.2
G) gr_hk3
0
5
10
15
20
25
H) gr_hk4
0
5
10
15
20
25

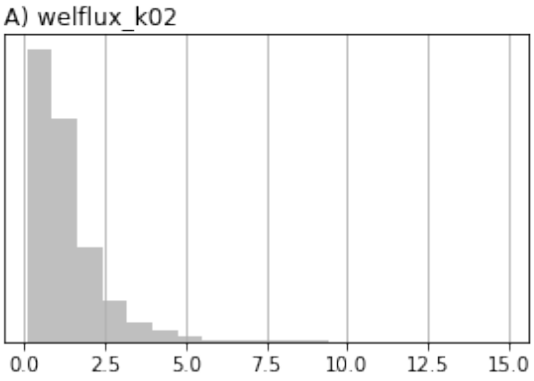

A) gr_hk5
0
5
10
15
20
B) gr_prsity3
0.8
0.9
1.0
1.1
1.2
1.3
C) gr_prsity4
0.8
0.9
1.0
1.1
1.2
1.3
D) gr_prsity5
0.7
0.8
0.9
1.0
1.1
1.2
1.3
E) gr_rech2
0.85
0.90
0.95
1.00
1.05
1.10
1.15
F) gr_rech3
0.90
0.95
1.00
1.05
1.10
1.15
G) gr_ss3
0
5
10
15
20
25
30
H) gr_ss4
0
5
10
15
20


A) gr_ss5
0
10
20
30
40
50
60
B) gr_strt3
0.925
0.950
0.975
1.000
1.025
1.050
1.075
C) gr_strt4
0.925
0.950
0.975
1.000
1.025
1.050
1.075
D) gr_strt5
0.925
0.950
0.975
1.000
1.025
1.050
1.075
E) gr_sy3
1
2
3
4
F) gr_sy4
1
2
3
4
G) gr_sy5
1
2
3
4
H) gr_vka3
0
5
10
15
20
25


A) gr_vka4
0
5
10
15
20
25
30
B) gr_vka5
0
10
20
30
40
50
60
C) pp_hk0
0
5
10
15
20
D) pp_hk1
0
5
10
15
20
E) pp_hk2
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
F) pp_prsity0
0.8
0.9
1.0
1.1
1.2
1.3
1.4
G) pp_prsity1
0.8
0.9
1.0
1.1
1.2
1.3
H) pp_prsity2
0.8
0.9
1.0
1.1
1.2
1.3


A) pp_rech0
0.90 0.95 1.00 1.05 1.10
B) pp_rech1
0.90 0.95 1.00 1.05 1.10
C) pp_ss0
0 5 10 15 20 25
D) pp_ss1
0 5 10 15 20
E) pp_ss2
0.0 2.5 5.0 7.5 10.0 12.5 15.0 17.5
F) pp_strt0
0.94 0.96 0.98 1.00 1.02 1.04 1.06
G) pp_strt1
0.94 0.96 0.98 1.00 1.02 1.04 1.06
H) pp_strt2
0.94 0.96 0.98 1.00 1.02 1.04 1.06


A) pp_sy0
0.5 1.0 1.5 2.0 2.5 3.0 3.5
B) pp_sy1
0.5 1.0 1.5 2.0 2.5 3.0
C) pp_sy2
1 2 3 4
D) pp_vka0
0 5 10 15 20
E) pp_vka1
0.0 2.5 5.0 7.5 10.0 12.5 15.0 17.5
F) pp_vka2
0 5 10 15 20
G) strk
0 100 200 300 400
H) welflux
0 2 4 6 8 10 12 14



Thoughts? Do these look reasonable? We see log-normal distributions for log-transformed parameters, e.g., hk... looking good!

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

```
In [33]: pe.enforce()  # always a good idea!
```

```
pe.to_binary(os.path.join(pst_helper.new_model_ws,"prior.jcb"))
```

1.1.10 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 [34]:
```
obs_locs = pd.read_csv(os.path.join("..","base_model_files","obs_loc.csv"))
#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".forma
obs_locs
```

Out[34]:

	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 excercise

In [35]:
```
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[35]:
```
['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"

```
In [36]: swgw_forecasts = obs.loc[obs.obsnme.apply(lambda x: "fa" in x and ("hw" in x or "tw" i

         hds_fore_name = "hds_00_{0:03d}_{1:03d}".format(int(pst_helper.m.nrow/3),int(pst_helpe
         hds_forecasts = obs.loc[obs.obsnme.apply(lambda x: hds_fore_name in x),"obsnme"].tolis
         forecasts = swgw_forecasts
         forecasts.extend(hds_forecasts)
         forecasts.append("part_time")
         forecasts.append("part_status")
         pst_helper.pst.pestpp_options["forecasts"] = forecasts
         forecasts

Out[36]: ['fa_hw_19791230',
          'fa_hw_19801229',
          'fa_tw_19791230',
          'fa_tw_19801229',
          'hds_00_013_002_000',
          'hds_00_013_002_001',
          'part_time',
          'part_status']
```

After all these changes to the pst object, we need to re-write the pcf!

```
In [37]: pst.write(os.path.join(pst_helper.new_model_ws,"freyberg.pst"))

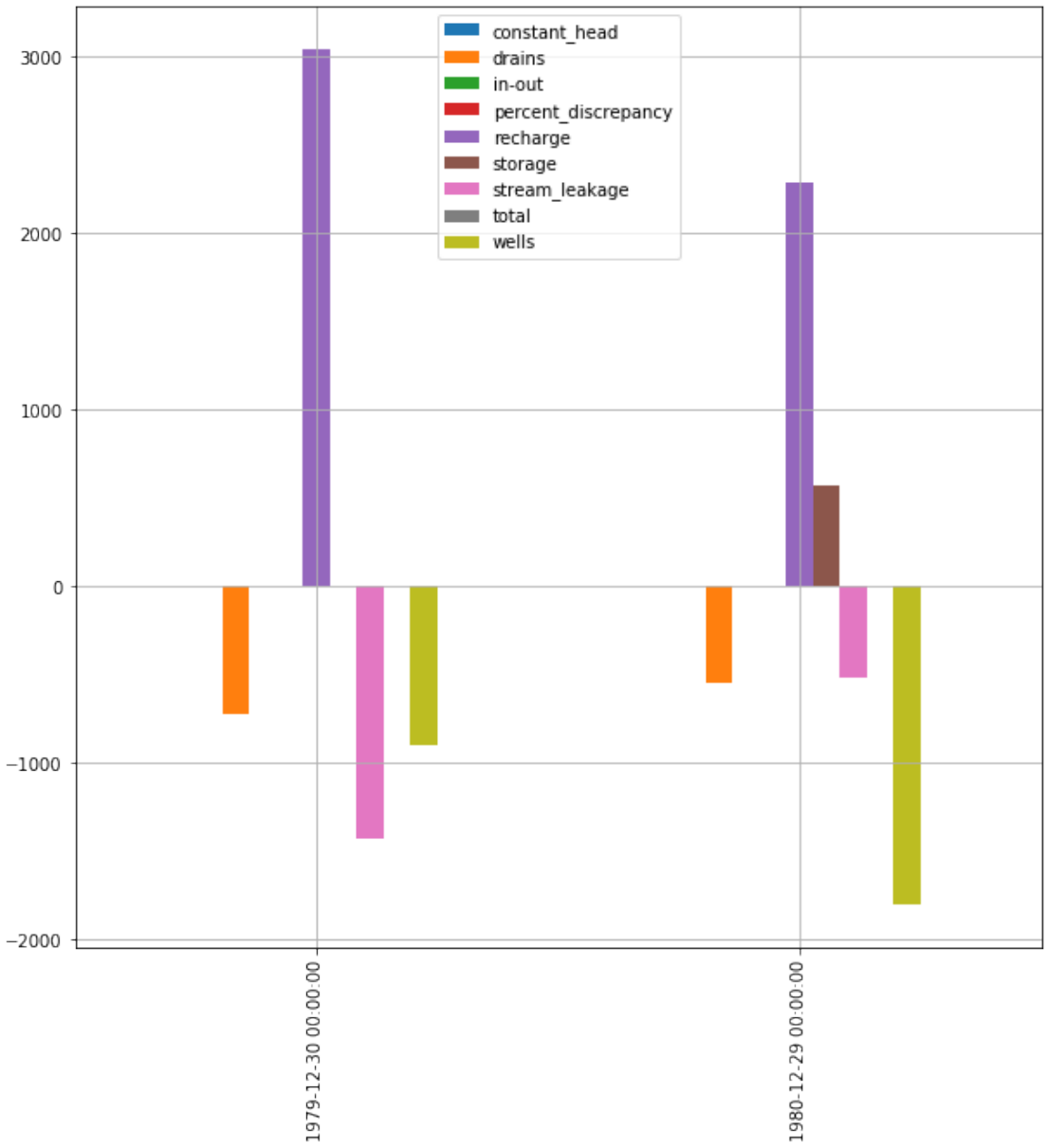
noptmax:0, npar_adj:14819, nnz_obs:14
```

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 [38]: 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[38]: 9.456182577320024e-19

In [39]: 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()
```


constant_head
drains
in-out
percent_discrepancy
recharge
storage
stream_leakage
total
wells
3000
2000
1000
0
−1000
−2000
1979-12-30 00:00:00
1980-12-29 00:00:00