setup_pest_interface

May 7, 2019

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

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

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

```
flopy is installed in /Users/jeremyw/Dev/gw1876/activities_2day_mfm/notebooks/flopy
```

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

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

This seemingly simple function call will spatially rediscretize the original freyberg model by cutting each row and column by 3's. You can check out the code in the `redis_freyberg` function in the `redis.py` file. Leveraging the magic of `flopy`!

```
In [3]: #redis_fac = 3
        #mr = redis.redis_freyberg(fac=redis_fac,b_d=b_d)
        #b_d = mr.model_ws
```

1.1.1 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)
```

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

```
In [5]: # 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 sets up a template directory in which we will put files used in the re
        prep_deps.prep_template(t_d="temp")


changing model workspace...
   temp
```

1.1.3 now we can run the model once using a `pyemu` helper

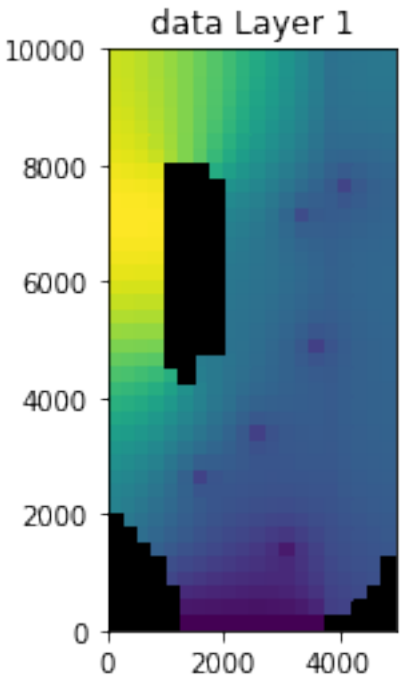
This helper is particularly useful if you run on more than one platform (e.g. Mac and Windows)

```
In [6]: pyemu.os_utils.run("{0} {1}".format("mfnwt",m.name+".nam"),cwd=m.model_ws)
```

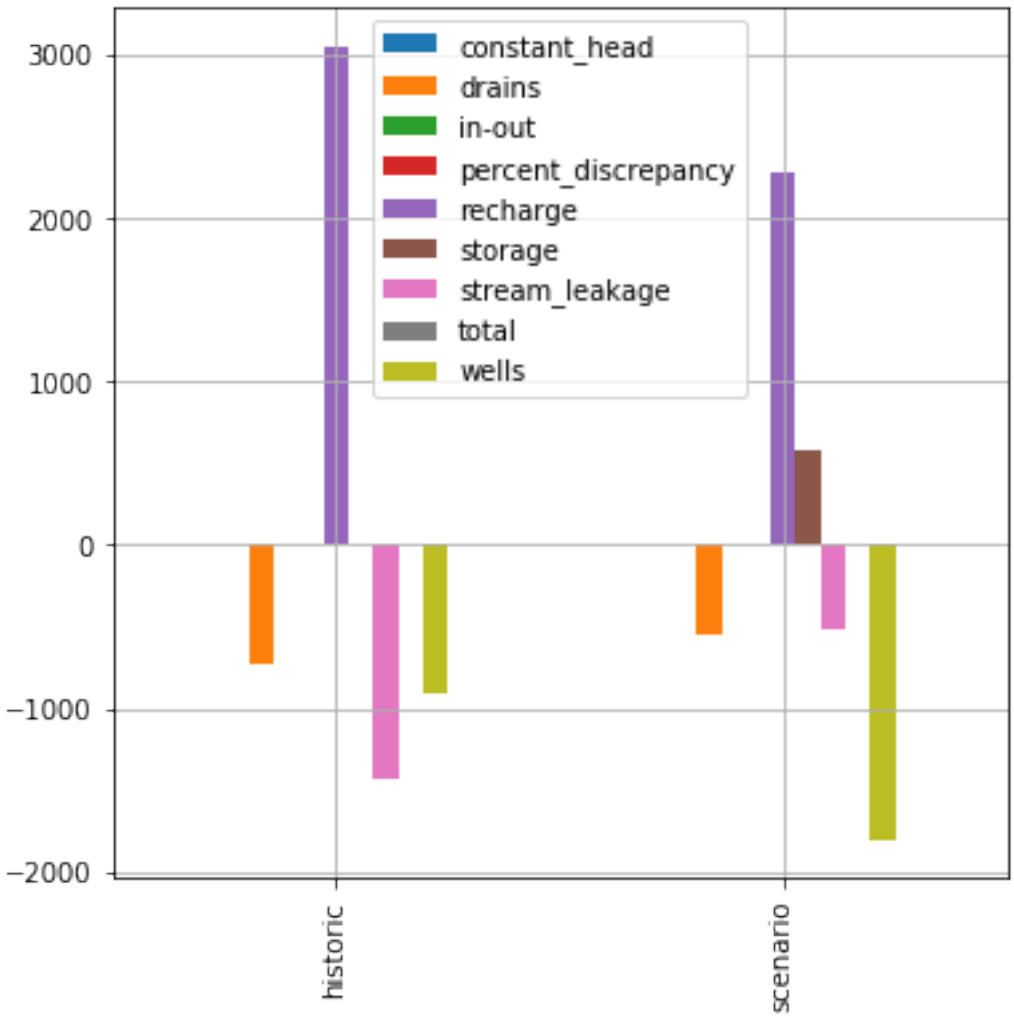
1.1.4 read in the heads and plot them up along with the budget components

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

```
In [7]: 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"])
        plt.show()
```



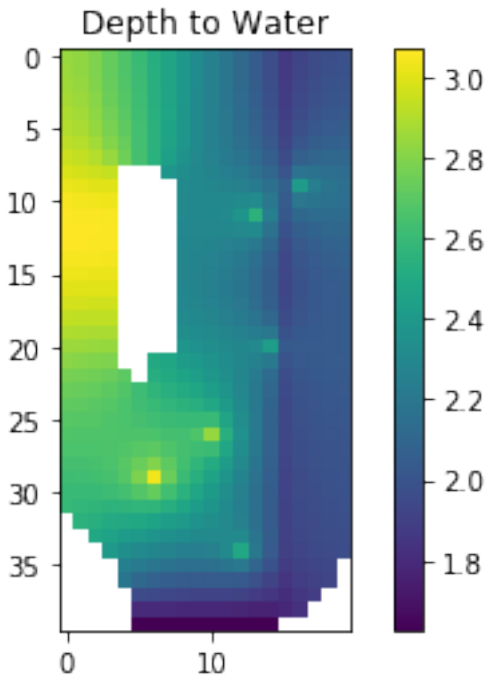

```
<Figure size 432x288 with 0 Axes>
```



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

1.1.5 Plot depth to water

```
In [8]: dtw = m.dis.top.array - hds.get_data()[0,:,:]
        dtw = np.ma.masked_where(m.bas6.ibound[0].array==0,dtw)
        c = plt.imshow(dtw)
        plt.title('Depth to Water')
        plt.colorbar(c)
        plt.show()
```

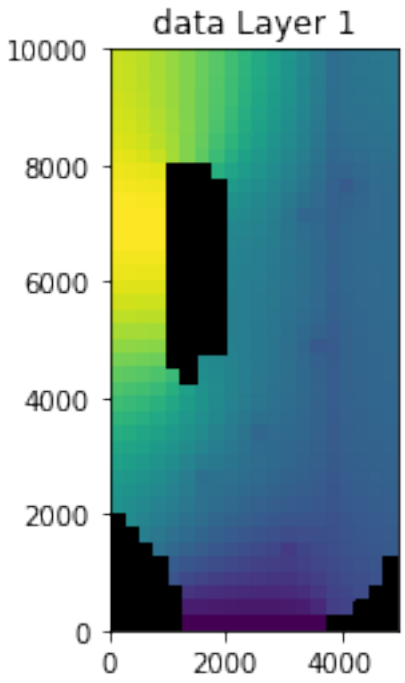


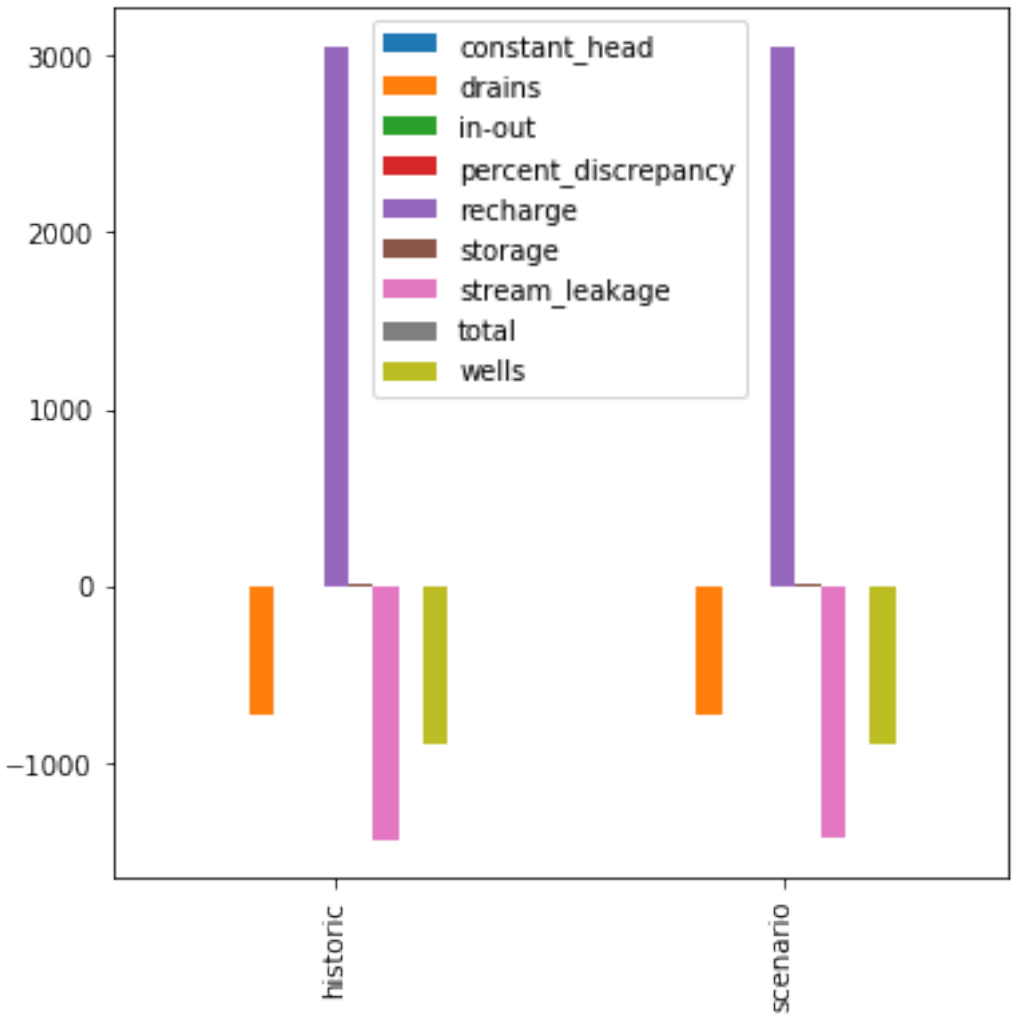
Clearly we can see the river and well locations expressed in the depth to water pattern.

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

In [9]:
```
# reset scenario period recharge
m.rch.rech[1] = m.rch.rech[0]
# reset scenario period abstraction
m.wel.stress_period_data[1] = m.wel.stress_period_data[0]
m.write_input()
pyemu.os_utils.run("{0} {1}".format("mfnwt",m.name+".nam"),cwd=m.model_ws)
hds = flopy.utils.HeadFile(os.path.join(m.model_ws,m.name+".hds"),model=m)
axes = hds.plot(mflay=0)

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


data Layer 1
10000
8000
6000
4000
2000
0
0
2000
4000



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

1.1.7 setup data structures related to what we want to parameterize and what we want to observe

1.1.8 first the parameterization of model inputs

```
In [10]: props = []
         # here we specify which packages we wish to parameterize, starting with those that do
         paks = ["upw.hk","upw.vka","upw.ss","upw.sy","bas6.strt","extra.prsity"]
         for k in range(m.nlay):
             props.extend([[p,k] for p in paks])
         # next we specify that we want to make parameters for recharge
         # in the first 2 stress periods (zero-based! Python style)
         props.append(["rch.rech",0])
         props.append(["rch.rech",1])
```

1.1.9 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]]
         temporal_list_props = [["wel.flux",0],["wel.flux",1]]
```

1.1.10 next we want to set up extracting observations (heads first)

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

1.1.11 then we setup monitoring of the SFR ASCII outputs.

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

```
In [13]: 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
```

1.1.12 here we go…

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

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

```
In [14]: pst_helper = pyemu.helpers.PstFromFlopyModel(nam_file,new_model_ws="template",org_mode
                                                      const_props=props,spatial_list_props=spati
                                                       temporal_list_props=temporal_list_props,
                                                      grid_props=props,pp_props=props,sfr_pars=
                                                       sfr_obs=sfr_obs_dict,build_prior=False,m
                                                      pp_space=4)
         prep_deps.prep_template(t_d=pst_helper.new_model_ws)

2019-05-07 17:28:32.578412 starting: loading flopy model

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

```
Parsing the namefile --> temp/freyberg.nam

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

ModflowBas6 free format:True

loading dis package file...
   Loading dis package with:
      3 layers, 40 rows, 20 columns, and 2 stress periods
   loading laycbd...
   loading delr...
   loading delc...
   loading top...
   loading botm...
      for 3 layers and 0 confining beds
   loading stress period data...
       for 2 stress periods
adding Package:  DIS
   DIS  package load...success
   LIST package load...skipped
loading bas6 package file...
adding Package:  BAS6
   BAS6 package load...success
loading upw package file...
   loading ipakcb, HDRY, NPUPW, IPHDRY...
   loading LAYTYP...
   loading LAYAVG...
   loading CHANI...
   loading LAYVKA...
   loading LAYWET...
   loading hk layer   1...
   loading vka layer   1...
   loading ss layer   1...
   loading sy layer   1...
   loading hk layer   2...
   loading vka layer   2...
   loading ss layer   2...
   loading sy layer   2...
   loading hk layer   3...
   loading vka layer   3...
   loading ss layer   3...
   loading sy layer   3...
Adding freyberg.cbc (unit=50) to the output list.
adding Package:  UPW
```

```
   UPW  package load...success
loading rch package file...
   loading rech stress period   1...
   loading rech stress period   2...
adding Package:  RCH
   RCH  package load...success
loading nwt package file...
adding Package:  NWT
   NWT  package load...success
loading oc package file...
Adding freyberg.hds (unit=51) to the output list.
adding Package:  OC
   OC   package load...success
loading lmt package file...
adding Package:  LMT6
   LMT6 package load...success
loading wel package file...
   loading <class '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
2019-05-07 17:28:32.612080 finished: loading flopy model took: 0:00:00.033668
2019-05-07 17:28:32.612205 starting: updating model attributes
2019-05-07 17:28:32.612360 finished: updating model attributes took: 0:00:00.000155
2019-05-07 17:28:32.612643 WARNING: removing existing 'new_model_ws

creating model workspace...
   template

changing model workspace...
   template
2019-05-07 17:28:33.876412 starting: writing new modflow input files

Writing packages:
   Package:  DIS
Util2d:delr: resetting 'how' to external
Util2d:delc: resetting 'how' to external
Util2d:model_top: resetting 'how' to external
Util2d:botm_layer_0: resetting 'how' to external
Util2d:botm_layer_1: resetting 'how' to external
Util2d:botm_layer_2: resetting 'how' to external
   Package:  BAS6
Util2d:ibound_layer_0: resetting 'how' to external
Util2d:ibound_layer_1: resetting 'how' to external
Util2d:ibound_layer_2: resetting 'how' to external
Util2d:strt_layer_0: resetting 'how' to external
Util2d:strt_layer_1: resetting 'how' to external
Util2d:strt_layer_2: resetting 'how' to external
   Package:  UPW
Util2d:hk: resetting 'how' to external
Util2d:vka: resetting 'how' to external
Util2d:ss: resetting 'how' to external
Util2d:sy: resetting 'how' to external
Util2d:hk: resetting 'how' to external
Util2d:vka: resetting 'how' to external
Util2d:ss: resetting 'how' to external
Util2d:sy: resetting 'how' to external
Util2d:hk: resetting 'how' to external
Util2d:vka: resetting 'how' to external
Util2d:ss: resetting 'how' to external
Util2d:sy: resetting 'how' to external
   Package:  RCH
Util2d:rech_1: resetting 'how' to external
Util2d:rech_2: resetting 'how' to external
   Package:  NWT
   Package:  OC
```

```
   Package:  LMT6
   Package:  WEL
   Package:  SFR
   Package:  DRN

2019-05-07 17:28:34.011611 finished: writing new modflow input files took: 0:00:00.135199
2019-05-07 17:28:34.012196 forward_run line:pyemu.os_utils.run('mfnwt freyberg.nam 1>freyberg.r
2019-05-07 17:28:34.012371 starting: setting up 'template/arr_org' dir
2019-05-07 17:28:34.012859 finished: setting up 'template/arr_org' dir took: 0:00:00.000488
2019-05-07 17:28:34.013083 starting: setting up 'template/arr_mlt' dir
2019-05-07 17:28:34.013423 finished: setting up 'template/arr_mlt' dir took: 0:00:00.000340
2019-05-07 17:28:34.013615 starting: setting up 'template/list_org' dir
2019-05-07 17:28:34.014041 finished: setting up 'template/list_org' dir took: 0:00:00.000426
2019-05-07 17:28:34.014249 starting: setting up 'template/list_mlt' dir
2019-05-07 17:28:34.014761 finished: setting up 'template/list_mlt' dir took: 0:00:00.000512
2019-05-07 17:28:34.014991 starting: processing temporal_list_props
2019-05-07 17:28:34.038548 finished: processing temporal_list_props took: 0:00:00.023557
2019-05-07 17:28:34.038974 starting: processing spatial_list_props
2019-05-07 17:28:34.117614 finished: processing spatial_list_props took: 0:00:00.078640
2019-05-07 17:28:34.175162 forward_run line:pyemu.helpers.apply_list_pars()

2019-05-07 17:28:34.208028 'extra' pak detected:extra.prsity
2019-05-07 17:28:34.251686 'extra' pak detected:extra.prsity
2019-05-07 17:28:34.291096 'extra' pak detected:extra.prsity
2019-05-07 17:28:34.338845 'extra' pak detected:extra.prsity
2019-05-07 17:28:34.371312 'extra' pak detected:extra.prsity
2019-05-07 17:28:34.405514 'extra' pak detected:extra.prsity
2019-05-07 17:28:34.453248 'extra' pak detected:extra.prsity
2019-05-07 17:28:34.487168 'extra' pak detected:extra.prsity
2019-05-07 17:28:34.522421 'extra' pak detected:extra.prsity
2019-05-07 17:28:34.606331 starting: writing grid tpl:hk3.dat_gr.tpl
2019-05-07 17:28:34.615139 finished: writing grid tpl:hk3.dat_gr.tpl took: 0:00:00.008808
2019-05-07 17:28:34.617789 starting: writing grid tpl:vka3.dat_gr.tpl
2019-05-07 17:28:34.626623 finished: writing grid tpl:vka3.dat_gr.tpl took: 0:00:00.008834
2019-05-07 17:28:34.629174 starting: writing grid tpl:ss3.dat_gr.tpl
2019-05-07 17:28:34.638028 finished: writing grid tpl:ss3.dat_gr.tpl took: 0:00:00.008854
2019-05-07 17:28:34.640579 starting: writing grid tpl:sy3.dat_gr.tpl
2019-05-07 17:28:34.649389 finished: writing grid tpl:sy3.dat_gr.tpl took: 0:00:00.008810
2019-05-07 17:28:34.651984 starting: writing grid tpl:strt3.dat_gr.tpl
2019-05-07 17:28:34.660863 finished: writing grid tpl:strt3.dat_gr.tpl took: 0:00:00.008879
2019-05-07 17:28:34.663720 starting: writing grid tpl:prsity3.dat_gr.tpl
2019-05-07 17:28:34.674633 finished: writing grid tpl:prsity3.dat_gr.tpl took: 0:00:00.010913
2019-05-07 17:28:34.677822 starting: writing grid tpl:hk4.dat_gr.tpl
2019-05-07 17:28:34.686867 finished: writing grid tpl:hk4.dat_gr.tpl took: 0:00:00.009045
2019-05-07 17:28:34.689649 starting: writing grid tpl:vka4.dat_gr.tpl
2019-05-07 17:28:34.699003 finished: writing grid tpl:vka4.dat_gr.tpl took: 0:00:00.009354
2019-05-07 17:28:34.701838 starting: writing grid tpl:ss4.dat_gr.tpl
2019-05-07 17:28:34.710856 finished: writing grid tpl:ss4.dat_gr.tpl took: 0:00:00.009018
```

```
2019-05-07 17:28:34.713622 starting: writing grid tpl:sy4.dat_gr.tpl
2019-05-07 17:28:34.722741 finished: writing grid tpl:sy4.dat_gr.tpl took: 0:00:00.009119
2019-05-07 17:28:34.725653 starting: writing grid tpl:strt4.dat_gr.tpl
2019-05-07 17:28:34.734789 finished: writing grid tpl:strt4.dat_gr.tpl took: 0:00:00.009136
2019-05-07 17:28:34.737476 starting: writing grid tpl:prsity4.dat_gr.tpl
2019-05-07 17:28:34.748615 finished: writing grid tpl:prsity4.dat_gr.tpl took: 0:00:00.011139
2019-05-07 17:28:34.751830 starting: writing grid tpl:hk5.dat_gr.tpl
2019-05-07 17:28:34.760616 finished: writing grid tpl:hk5.dat_gr.tpl took: 0:00:00.008786
2019-05-07 17:28:34.763202 starting: writing grid tpl:vka5.dat_gr.tpl
2019-05-07 17:28:34.771883 finished: writing grid tpl:vka5.dat_gr.tpl took: 0:00:00.008681
2019-05-07 17:28:34.774647 starting: writing grid tpl:ss5.dat_gr.tpl
2019-05-07 17:28:34.784002 finished: writing grid tpl:ss5.dat_gr.tpl took: 0:00:00.009355
2019-05-07 17:28:34.786662 starting: writing grid tpl:sy5.dat_gr.tpl
2019-05-07 17:28:34.795738 finished: writing grid tpl:sy5.dat_gr.tpl took: 0:00:00.009076
2019-05-07 17:28:34.798576 starting: writing grid tpl:strt5.dat_gr.tpl
2019-05-07 17:28:34.807367 finished: writing grid tpl:strt5.dat_gr.tpl took: 0:00:00.008791
2019-05-07 17:28:34.810490 starting: writing grid tpl:prsity5.dat_gr.tpl
2019-05-07 17:28:34.822145 finished: writing grid tpl:prsity5.dat_gr.tpl took: 0:00:00.011655
2019-05-07 17:28:34.824700 starting: writing grid tpl:rech2.dat_gr.tpl
2019-05-07 17:28:34.833526 finished: writing grid tpl:rech2.dat_gr.tpl took: 0:00:00.008826
2019-05-07 17:28:34.836049 starting: writing grid tpl:rech3.dat_gr.tpl
2019-05-07 17:28:34.844892 finished: writing grid tpl:rech3.dat_gr.tpl took: 0:00:00.008843
2019-05-07 17:28:34.847344 starting: writing const tpl:hk6.dat_cn.tpl
2019-05-07 17:28:34.853194 finished: writing const tpl:hk6.dat_cn.tpl took: 0:00:00.005850
2019-05-07 17:28:34.855837 starting: writing const tpl:vka6.dat_cn.tpl
2019-05-07 17:28:34.861771 finished: writing const tpl:vka6.dat_cn.tpl took: 0:00:00.005934
2019-05-07 17:28:34.864384 starting: writing const tpl:ss6.dat_cn.tpl
2019-05-07 17:28:34.870352 finished: writing const tpl:ss6.dat_cn.tpl took: 0:00:00.005968
2019-05-07 17:28:34.873055 starting: writing const tpl:sy6.dat_cn.tpl
2019-05-07 17:28:34.879426 finished: writing const tpl:sy6.dat_cn.tpl took: 0:00:00.006371
2019-05-07 17:28:34.882239 starting: writing const tpl:strt6.dat_cn.tpl
2019-05-07 17:28:34.888173 finished: writing const tpl:strt6.dat_cn.tpl took: 0:00:00.005934
2019-05-07 17:28:34.890798 starting: writing const tpl:prsity6.dat_cn.tpl
2019-05-07 17:28:34.896665 finished: writing const tpl:prsity6.dat_cn.tpl took: 0:00:00.005867
2019-05-07 17:28:34.899495 starting: writing const tpl:hk7.dat_cn.tpl
2019-05-07 17:28:34.905462 finished: writing const tpl:hk7.dat_cn.tpl took: 0:00:00.005967
2019-05-07 17:28:34.908310 starting: writing const tpl:vka7.dat_cn.tpl
2019-05-07 17:28:34.914158 finished: writing const tpl:vka7.dat_cn.tpl took: 0:00:00.005848
2019-05-07 17:28:34.916651 starting: writing const tpl:ss7.dat_cn.tpl
2019-05-07 17:28:34.922723 finished: writing const tpl:ss7.dat_cn.tpl took: 0:00:00.006072
2019-05-07 17:28:34.925941 starting: writing const tpl:sy7.dat_cn.tpl
2019-05-07 17:28:34.931976 finished: writing const tpl:sy7.dat_cn.tpl took: 0:00:00.006035
2019-05-07 17:28:34.934684 starting: writing const tpl:strt7.dat_cn.tpl
2019-05-07 17:28:34.940807 finished: writing const tpl:strt7.dat_cn.tpl took: 0:00:00.006123
2019-05-07 17:28:34.943545 starting: writing const tpl:prsity7.dat_cn.tpl
2019-05-07 17:28:34.949748 finished: writing const tpl:prsity7.dat_cn.tpl took: 0:00:00.006203
2019-05-07 17:28:34.952547 starting: writing const tpl:hk8.dat_cn.tpl
2019-05-07 17:28:34.958558 finished: writing const tpl:hk8.dat_cn.tpl took: 0:00:00.006011
```

```
2019-05-07 17:28:34.961333 starting: writing const tpl:vka8.dat_cn.tpl
2019-05-07 17:28:34.967339 finished: writing const tpl:vka8.dat_cn.tpl took: 0:00:00.006006
2019-05-07 17:28:34.970011 starting: writing const tpl:ss8.dat_cn.tpl
2019-05-07 17:28:34.976557 finished: writing const tpl:ss8.dat_cn.tpl took: 0:00:00.006546
2019-05-07 17:28:34.979666 starting: writing const tpl:sy8.dat_cn.tpl
2019-05-07 17:28:34.986706 finished: writing const tpl:sy8.dat_cn.tpl took: 0:00:00.007040
2019-05-07 17:28:34.989381 starting: writing const tpl:strt8.dat_cn.tpl
2019-05-07 17:28:34.995665 finished: writing const tpl:strt8.dat_cn.tpl took: 0:00:00.006284
2019-05-07 17:28:34.998612 starting: writing const tpl:prsity8.dat_cn.tpl
2019-05-07 17:28:35.004695 finished: writing const tpl:prsity8.dat_cn.tpl took: 0:00:00.006083
2019-05-07 17:28:35.007508 starting: writing const tpl:rech4.dat_cn.tpl
2019-05-07 17:28:35.013816 finished: writing const tpl:rech4.dat_cn.tpl took: 0:00:00.006308
2019-05-07 17:28:35.016772 starting: writing const tpl:rech5.dat_cn.tpl
2019-05-07 17:28:35.022989 finished: writing const tpl:rech5.dat_cn.tpl took: 0:00:00.006217
2019-05-07 17:28:35.046586 starting: setting up pilot point process
2019-05-07 17:28:35.046915 WARNING: pp_geostruct is None, using ExpVario with contribution=1 ar
2019-05-07 17:28:35.049857 pp_dict: {0: ['hk0', 'vka0', 'ss0', 'sy0', 'strt0', 'prsity0', 'rech
2019-05-07 17:28:35.049950 starting: calling setup_pilot_point_grid()
2019-05-07 17:28:35.655582 640 pilot point parameters created
2019-05-07 17:28:35.656344 pilot point 'pargp':hk0,vka0,ss0,sy0,strt0,prsity0,rech0,rech1,sy1,h
2019-05-07 17:28:35.656407 finished: calling setup_pilot_point_grid() took: 0:00:00.606457
2019-05-07 17:28:35.658937 starting: calculating factors for p=hk0, k=0
2019-05-07 17:28:35.659957 saving krige variance file:template/pp_k0_general_zn.fac
2019-05-07 17:28:35.660021 saving krige factors file:template/pp_k0_general_zn.fac
starting interp point loop for 800 points
took 2.409927 seconds
2019-05-07 17:28:38.121654 finished: calculating factors for p=hk0, k=0 took: 0:00:02.462717
2019-05-07 17:28:38.122934 starting: calculating factors for p=vka0, k=0
2019-05-07 17:28:38.124008 finished: calculating factors for p=vka0, k=0 took: 0:00:00.001074
2019-05-07 17:28:38.124768 starting: calculating factors for p=ss0, k=0
2019-05-07 17:28:38.126003 finished: calculating factors for p=ss0, k=0 took: 0:00:00.001235
2019-05-07 17:28:38.126879 starting: calculating factors for p=sy0, k=0
2019-05-07 17:28:38.127891 finished: calculating factors for p=sy0, k=0 took: 0:00:00.001012
2019-05-07 17:28:38.128902 starting: calculating factors for p=strt0, k=0
2019-05-07 17:28:38.129806 finished: calculating factors for p=strt0, k=0 took: 0:00:00.000904
2019-05-07 17:28:38.130922 starting: calculating factors for p=prsity0, k=0
2019-05-07 17:28:38.132024 finished: calculating factors for p=prsity0, k=0 took: 0:00:00.0011
2019-05-07 17:28:38.133096 starting: calculating factors for p=rech0, k=0
2019-05-07 17:28:38.134066 finished: calculating factors for p=rech0, k=0 took: 0:00:00.000970
2019-05-07 17:28:38.134860 starting: calculating factors for p=rech1, k=0
2019-05-07 17:28:38.135822 finished: calculating factors for p=rech1, k=0 took: 0:00:00.000962
2019-05-07 17:28:38.136649 starting: calculating factors for p=sy1, k=1
2019-05-07 17:28:38.137581 saving krige variance file:template/pp_k1_general_zn.fac
2019-05-07 17:28:38.137670 saving krige factors file:template/pp_k1_general_zn.fac
starting interp point loop for 800 points
took 2.350989 seconds
2019-05-07 17:28:40.539001 finished: calculating factors for p=sy1, k=1 took: 0:00:02.402352
2019-05-07 17:28:40.540246 starting: calculating factors for p=hk1, k=1
```

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2019-05-07 17:28:40.541199 finished: calculating factors for p=hk1, k=1 took: 0:00:00.000953
2019-05-07 17:28:40.542350 starting: calculating factors for p=strt1, k=1
2019-05-07 17:28:40.543329 finished: calculating factors for p=strt1, k=1 took: 0:00:00.000979
2019-05-07 17:28:40.544202 starting: calculating factors for p=vka1, k=1
2019-05-07 17:28:40.545184 finished: calculating factors for p=vka1, k=1 took: 0:00:00.000982
2019-05-07 17:28:40.545944 starting: calculating factors for p=ss1, k=1
2019-05-07 17:28:40.547121 finished: calculating factors for p=ss1, k=1 took: 0:00:00.001177
2019-05-07 17:28:40.547906 starting: calculating factors for p=prsity1, k=1
2019-05-07 17:28:40.548941 finished: calculating factors for p=prsity1, k=1 took: 0:00:00.0010
2019-05-07 17:28:40.549638 starting: calculating factors for p=vka2, k=2
2019-05-07 17:28:40.551429 saving krige variance file:template/pp_k2_general_zn.fac
2019-05-07 17:28:40.551532 saving krige factors file:template/pp_k2_general_zn.fac
starting interp point loop for 800 points
took 2.384954 seconds
2019-05-07 17:28:43.001484 finished: calculating factors for p=vka2, k=2 took: 0:00:02.451846
2019-05-07 17:28:43.002637 starting: calculating factors for p=sy2, k=2
2019-05-07 17:28:43.003484 finished: calculating factors for p=sy2, k=2 took: 0:00:00.000847
2019-05-07 17:28:43.004138 starting: calculating factors for p=hk2, k=2
2019-05-07 17:28:43.004874 finished: calculating factors for p=hk2, k=2 took: 0:00:00.000736
2019-05-07 17:28:43.005468 starting: calculating factors for p=ss2, k=2
2019-05-07 17:28:43.006168 finished: calculating factors for p=ss2, k=2 took: 0:00:00.000700
2019-05-07 17:28:43.007124 starting: calculating factors for p=strt2, k=2
2019-05-07 17:28:43.008361 finished: calculating factors for p=strt2, k=2 took: 0:00:00.001237
2019-05-07 17:28:43.009233 starting: calculating factors for p=prsity2, k=2
2019-05-07 17:28:43.010143 finished: calculating factors for p=prsity2, k=2 took: 0:00:00.0009
2019-05-07 17:28:43.010216 starting: processing pp_prefix:prsity0
2019-05-07 17:28:43.023163 starting: processing pp_prefix:strt0
2019-05-07 17:28:43.031693 starting: processing pp_prefix:rech1
2019-05-07 17:28:43.040396 starting: processing pp_prefix:hk0
2019-05-07 17:28:43.048569 starting: processing pp_prefix:ss1
2019-05-07 17:28:43.056605 starting: processing pp_prefix:vka1
2019-05-07 17:28:43.064633 starting: processing pp_prefix:sy1
2019-05-07 17:28:43.072734 starting: processing pp_prefix:hk2
2019-05-07 17:28:43.080540 starting: processing pp_prefix:rech0
2019-05-07 17:28:43.088289 starting: processing pp_prefix:vka2
2019-05-07 17:28:43.096243 starting: processing pp_prefix:ss2
2019-05-07 17:28:43.103862 starting: processing pp_prefix:ss0
2019-05-07 17:28:43.111746 starting: processing pp_prefix:strt2
2019-05-07 17:28:43.119456 starting: processing pp_prefix:strt1
2019-05-07 17:28:43.127344 starting: processing pp_prefix:sy2
2019-05-07 17:28:43.135794 starting: processing pp_prefix:vka0
2019-05-07 17:28:43.143771 starting: processing pp_prefix:prsity2
2019-05-07 17:28:43.151510 starting: processing pp_prefix:sy0
2019-05-07 17:28:43.159261 starting: processing pp_prefix:hk1
2019-05-07 17:28:43.167748 starting: processing pp_prefix:prsity1
2019-05-07 17:28:43.271399 finished: setting up pilot point process took: 0:00:08.224813
2019-05-07 17:28:43.271908 starting: setting up grid process
2019-05-07 17:28:43.271992 WARNING: grid_geostruct is None, using ExpVario with contribution=1
```

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2019-05-07 17:28:43.272111 finished: setting up grid process took: 0:00:00.000203
2019-05-07 17:28:43.275039 starting: save test mlt array arr_mlt/hk0.dat_pp
2019-05-07 17:28:43.277178 finished: save test mlt array arr_mlt/hk0.dat_pp took: 0:00:00.0021
2019-05-07 17:28:43.278131 starting: save test mlt array arr_mlt/vka0.dat_pp
2019-05-07 17:28:43.280215 finished: save test mlt array arr_mlt/vka0.dat_pp took: 0:00:00.002
2019-05-07 17:28:43.281238 starting: save test mlt array arr_mlt/ss0.dat_pp
2019-05-07 17:28:43.287245 finished: save test mlt array arr_mlt/ss0.dat_pp took: 0:00:00.0060
2019-05-07 17:28:43.288280 starting: save test mlt array arr_mlt/sy0.dat_pp
2019-05-07 17:28:43.290385 finished: save test mlt array arr_mlt/sy0.dat_pp took: 0:00:00.0021
2019-05-07 17:28:43.291294 starting: save test mlt array arr_mlt/strt0.dat_pp
2019-05-07 17:28:43.293958 finished: save test mlt array arr_mlt/strt0.dat_pp took: 0:00:00.002
2019-05-07 17:28:43.294948 starting: save test mlt array arr_mlt/prsity0.dat_pp
2019-05-07 17:28:43.297459 finished: save test mlt array arr_mlt/prsity0.dat_pp took: 0:00:00.0
2019-05-07 17:28:43.298451 starting: save test mlt array arr_mlt/hk1.dat_pp
2019-05-07 17:28:43.300916 finished: save test mlt array arr_mlt/hk1.dat_pp took: 0:00:00.0024
2019-05-07 17:28:43.301904 starting: save test mlt array arr_mlt/vka1.dat_pp
2019-05-07 17:28:43.304386 finished: save test mlt array arr_mlt/vka1.dat_pp took: 0:00:00.0024
2019-05-07 17:28:43.305392 starting: save test mlt array arr_mlt/ss1.dat_pp
2019-05-07 17:28:43.307721 finished: save test mlt array arr_mlt/ss1.dat_pp took: 0:00:00.0023
2019-05-07 17:28:43.308757 starting: save test mlt array arr_mlt/sy1.dat_pp
2019-05-07 17:28:43.310963 finished: save test mlt array arr_mlt/sy1.dat_pp took: 0:00:00.0022
2019-05-07 17:28:43.311644 starting: save test mlt array arr_mlt/strt1.dat_pp
2019-05-07 17:28:43.313822 finished: save test mlt array arr_mlt/strt1.dat_pp took: 0:00:00.002
2019-05-07 17:28:43.314648 starting: save test mlt array arr_mlt/prsity1.dat_pp
2019-05-07 17:28:43.316799 finished: save test mlt array arr_mlt/prsity1.dat_pp took: 0:00:00.0
2019-05-07 17:28:43.317694 starting: save test mlt array arr_mlt/hk2.dat_pp
2019-05-07 17:28:43.319863 finished: save test mlt array arr_mlt/hk2.dat_pp took: 0:00:00.0021
2019-05-07 17:28:43.320589 starting: save test mlt array arr_mlt/vka2.dat_pp
2019-05-07 17:28:43.322775 finished: save test mlt array arr_mlt/vka2.dat_pp took: 0:00:00.002
2019-05-07 17:28:43.323662 starting: save test mlt array arr_mlt/ss2.dat_pp
2019-05-07 17:28:43.325685 finished: save test mlt array arr_mlt/ss2.dat_pp took: 0:00:00.0020
2019-05-07 17:28:43.326510 starting: save test mlt array arr_mlt/sy2.dat_pp
2019-05-07 17:28:43.328827 finished: save test mlt array arr_mlt/sy2.dat_pp took: 0:00:00.0023
2019-05-07 17:28:43.329614 starting: save test mlt array arr_mlt/strt2.dat_pp
2019-05-07 17:28:43.332425 finished: save test mlt array arr_mlt/strt2.dat_pp took: 0:00:00.002
2019-05-07 17:28:43.333564 starting: save test mlt array arr_mlt/prsity2.dat_pp
2019-05-07 17:28:43.335927 finished: save test mlt array arr_mlt/prsity2.dat_pp took: 0:00:00.0
2019-05-07 17:28:43.336884 starting: save test mlt array arr_mlt/rech0.dat_pp
2019-05-07 17:28:43.339123 finished: save test mlt array arr_mlt/rech0.dat_pp took: 0:00:00.002
2019-05-07 17:28:43.340061 starting: save test mlt array arr_mlt/rech1.dat_pp
2019-05-07 17:28:43.342254 finished: save test mlt array arr_mlt/rech1.dat_pp took: 0:00:00.002
2019-05-07 17:28:43.343618 starting: save test mlt array arr_mlt/hk3.dat_gr
2019-05-07 17:28:43.347130 finished: save test mlt array arr_mlt/hk3.dat_gr took: 0:00:00.0035
2019-05-07 17:28:43.348762 starting: save test mlt array arr_mlt/vka3.dat_gr
2019-05-07 17:28:43.352314 finished: save test mlt array arr_mlt/vka3.dat_gr took: 0:00:00.0035
2019-05-07 17:28:43.353899 starting: save test mlt array arr_mlt/ss3.dat_gr
2019-05-07 17:28:43.357319 finished: save test mlt array arr_mlt/ss3.dat_gr took: 0:00:00.0034
2019-05-07 17:28:43.358798 starting: save test mlt array arr_mlt/sy3.dat_gr
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2019-05-07 17:28:43.362062 finished: save test mlt array arr_mlt/sy3.dat_gr took: 0:00:00.0032
2019-05-07 17:28:43.363423 starting: save test mlt array arr_mlt/strt3.dat_gr
2019-05-07 17:28:43.366977 finished: save test mlt array arr_mlt/strt3.dat_gr took: 0:00:00.003
2019-05-07 17:28:43.368498 starting: save test mlt array arr_mlt/prsity3.dat_gr
2019-05-07 17:28:43.372159 finished: save test mlt array arr_mlt/prsity3.dat_gr took: 0:00:00.0
2019-05-07 17:28:43.373215 starting: save test mlt array arr_mlt/hk4.dat_gr
2019-05-07 17:28:43.376242 finished: save test mlt array arr_mlt/hk4.dat_gr took: 0:00:00.0030
2019-05-07 17:28:43.377781 starting: save test mlt array arr_mlt/vka4.dat_gr
2019-05-07 17:28:43.381216 finished: save test mlt array arr_mlt/vka4.dat_gr took: 0:00:00.0034
2019-05-07 17:28:43.382725 starting: save test mlt array arr_mlt/ss4.dat_gr
2019-05-07 17:28:43.386917 finished: save test mlt array arr_mlt/ss4.dat_gr took: 0:00:00.0041
2019-05-07 17:28:43.388253 starting: save test mlt array arr_mlt/sy4.dat_gr
2019-05-07 17:28:43.392099 finished: save test mlt array arr_mlt/sy4.dat_gr took: 0:00:00.0038
2019-05-07 17:28:43.393409 starting: save test mlt array arr_mlt/strt4.dat_gr
2019-05-07 17:28:43.397423 finished: save test mlt array arr_mlt/strt4.dat_gr took: 0:00:00.004
2019-05-07 17:28:43.398927 starting: save test mlt array arr_mlt/prsity4.dat_gr
2019-05-07 17:28:43.402647 finished: save test mlt array arr_mlt/prsity4.dat_gr took: 0:00:00.0
2019-05-07 17:28:43.404228 starting: save test mlt array arr_mlt/hk5.dat_gr
2019-05-07 17:28:43.407834 finished: save test mlt array arr_mlt/hk5.dat_gr took: 0:00:00.0036
2019-05-07 17:28:43.409285 starting: save test mlt array arr_mlt/vka5.dat_gr
2019-05-07 17:28:43.412876 finished: save test mlt array arr_mlt/vka5.dat_gr took: 0:00:00.0035
2019-05-07 17:28:43.414281 starting: save test mlt array arr_mlt/ss5.dat_gr
2019-05-07 17:28:43.417920 finished: save test mlt array arr_mlt/ss5.dat_gr took: 0:00:00.0036
2019-05-07 17:28:43.419472 starting: save test mlt array arr_mlt/sy5.dat_gr
2019-05-07 17:28:43.423101 finished: save test mlt array arr_mlt/sy5.dat_gr took: 0:00:00.0036
2019-05-07 17:28:43.424582 starting: save test mlt array arr_mlt/strt5.dat_gr
2019-05-07 17:28:43.428121 finished: save test mlt array arr_mlt/strt5.dat_gr took: 0:00:00.003
2019-05-07 17:28:43.429532 starting: save test mlt array arr_mlt/prsity5.dat_gr
2019-05-07 17:28:43.433104 finished: save test mlt array arr_mlt/prsity5.dat_gr took: 0:00:00.0
2019-05-07 17:28:43.434579 starting: save test mlt array arr_mlt/rech2.dat_gr
2019-05-07 17:28:43.438350 finished: save test mlt array arr_mlt/rech2.dat_gr took: 0:00:00.003
2019-05-07 17:28:43.440084 starting: save test mlt array arr_mlt/rech3.dat_gr
2019-05-07 17:28:43.443542 finished: save test mlt array arr_mlt/rech3.dat_gr took: 0:00:00.003
2019-05-07 17:28:43.445139 starting: save test mlt array arr_mlt/hk6.dat_cn
2019-05-07 17:28:43.448813 finished: save test mlt array arr_mlt/hk6.dat_cn took: 0:00:00.0036
2019-05-07 17:28:43.450249 starting: save test mlt array arr_mlt/vka6.dat_cn
2019-05-07 17:28:43.453928 finished: save test mlt array arr_mlt/vka6.dat_cn took: 0:00:00.0036
2019-05-07 17:28:43.455407 starting: save test mlt array arr_mlt/ss6.dat_cn
2019-05-07 17:28:43.459194 finished: save test mlt array arr_mlt/ss6.dat_cn took: 0:00:00.0037
2019-05-07 17:28:43.460790 starting: save test mlt array arr_mlt/sy6.dat_cn
2019-05-07 17:28:43.464381 finished: save test mlt array arr_mlt/sy6.dat_cn took: 0:00:00.0035
2019-05-07 17:28:43.465869 starting: save test mlt array arr_mlt/strt6.dat_cn
2019-05-07 17:28:43.469304 finished: save test mlt array arr_mlt/strt6.dat_cn took: 0:00:00.003
2019-05-07 17:28:43.470657 starting: save test mlt array arr_mlt/prsity6.dat_cn
2019-05-07 17:28:43.474295 finished: save test mlt array arr_mlt/prsity6.dat_cn took: 0:00:00.0
2019-05-07 17:28:43.475755 starting: save test mlt array arr_mlt/hk7.dat_cn
2019-05-07 17:28:43.479444 finished: save test mlt array arr_mlt/hk7.dat_cn took: 0:00:00.0036
2019-05-07 17:28:43.480948 starting: save test mlt array arr_mlt/vka7.dat_cn
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2019-05-07 17:28:43.484580 finished: save test mlt array arr_mlt/vka7.dat_cn took: 0:00:00.0030
2019-05-07 17:28:43.486129 starting: save test mlt array arr_mlt/ss7.dat_cn
2019-05-07 17:28:43.489616 finished: save test mlt array arr_mlt/ss7.dat_cn took: 0:00:00.00348
2019-05-07 17:28:43.491000 starting: save test mlt array arr_mlt/sy7.dat_cn
2019-05-07 17:28:43.494312 finished: save test mlt array arr_mlt/sy7.dat_cn took: 0:00:00.00331
2019-05-07 17:28:43.495395 starting: save test mlt array arr_mlt/strt7.dat_cn
2019-05-07 17:28:43.498222 finished: save test mlt array arr_mlt/strt7.dat_cn took: 0:00:00.002
2019-05-07 17:28:43.499748 starting: save test mlt array arr_mlt/prsity7.dat_cn
2019-05-07 17:28:43.503315 finished: save test mlt array arr_mlt/prsity7.dat_cn took: 0:00:00.0
2019-05-07 17:28:43.504723 starting: save test mlt array arr_mlt/hk8.dat_cn
2019-05-07 17:28:43.507770 finished: save test mlt array arr_mlt/hk8.dat_cn took: 0:00:00.00304
2019-05-07 17:28:43.509203 starting: save test mlt array arr_mlt/vka8.dat_cn
2019-05-07 17:28:43.512408 finished: save test mlt array arr_mlt/vka8.dat_cn took: 0:00:00.0032
2019-05-07 17:28:43.513906 starting: save test mlt array arr_mlt/ss8.dat_cn
2019-05-07 17:28:43.517036 finished: save test mlt array arr_mlt/ss8.dat_cn took: 0:00:00.00313
2019-05-07 17:28:43.519599 starting: save test mlt array arr_mlt/sy8.dat_cn
2019-05-07 17:28:43.522441 finished: save test mlt array arr_mlt/sy8.dat_cn took: 0:00:00.00284
2019-05-07 17:28:43.523876 starting: save test mlt array arr_mlt/strt8.dat_cn
2019-05-07 17:28:43.526828 finished: save test mlt array arr_mlt/strt8.dat_cn took: 0:00:00.002
2019-05-07 17:28:43.528301 starting: save test mlt array arr_mlt/prsity8.dat_cn
2019-05-07 17:28:43.531503 finished: save test mlt array arr_mlt/prsity8.dat_cn took: 0:00:00.0
2019-05-07 17:28:43.532677 starting: save test mlt array arr_mlt/rech4.dat_cn
2019-05-07 17:28:43.536153 finished: save test mlt array arr_mlt/rech4.dat_cn took: 0:00:00.003
2019-05-07 17:28:43.537549 starting: save test mlt array arr_mlt/rech5.dat_cn
2019-05-07 17:28:43.540537 finished: save test mlt array arr_mlt/rech5.dat_cn took: 0:00:00.002
2019-05-07 17:28:44.142893 forward_run line:pyemu.helpers.apply_array_pars()

all zeros for runoff...skipping...
all zeros for hcond1...skipping...
all zeros for pptsw...skipping...
2019-05-07 17:28:44.272536 starting: processing obs type mflist water budget obs
2019-05-07 17:28:44.397220 forward_run line:pyemu.gw_utils.apply_mflist_budget_obs('freyberg.li
2019-05-07 17:28:44.397646 finished: processing obs type mflist water budget obs took: 0:00:00
2019-05-07 17:28:44.397910 starting: processing obs type hyd file
2019-05-07 17:28:44.398636 finished: processing obs type hyd file took: 0:00:00.000726
2019-05-07 17:28:44.398734 starting: processing obs type external obs-sim smp files
2019-05-07 17:28:44.398981 finished: processing obs type external obs-sim smp files took: 0:00
2019-05-07 17:28:44.399059 starting: processing obs type hob
2019-05-07 17:28:44.399247 finished: processing obs type hob took: 0:00:00.000188
2019-05-07 17:28:44.399327 starting: processing obs type hds
[[0, 0], [0, 1], [0, 2], [1, 0], [1, 1], [1, 2]]
2019-05-07 17:28:44.816847 finished: processing obs type hds took: 0:00:00.417520
2019-05-07 17:28:44.817348 starting: processing obs type sfr
writing 'sfr_obs.config' to template/sfr_obs.config
2019-05-07 17:28:45.137615 finished: processing obs type sfr took: 0:00:00.320267
2019-05-07 17:28:45.138202 changing dir in to template
2019-05-07 17:28:45.139758 starting: instantiating control file from i/o files
2019-05-07 17:28:45.139849 tpl files: drn.csv.tpl,wel.csv.tpl,hk3.dat_gr.tpl,vka3.dat_gr.tpl,ss
```

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2019-05-07 17:28:45.139892 ins files: freyberg.hds.dat.ins,vol.dat.ins,freyberg.sfr.out.process
2019-05-07 17:28:45.471186 finished: instantiating control file from i/o files took: 0:00:00.33
2019-05-07 17:28:45.688222 starting: writing forward_run.py
2019-05-07 17:28:45.689321 finished: writing forward_run.py took: 0:00:00.001099
2019-05-07 17:28:45.689504 writing pst template/freyberg.pst
2019-05-07 17:28:47.437038 starting: running pestchek on freyberg.pst
2019-05-07 17:28:47.544932 pestcheck:PESTCHEK Version 13.0. Watermark Numerical Computing.
2019-05-07 17:28:47.545288 pestcheck:
2019-05-07 17:28:47.545345 pestcheck:Errors ----->
2019-05-07 17:28:47.545719 pestcheck:Line 2403 of file freyberg.pst: parameter name "prsity3000
2019-05-07 17:28:47.545781 pestcheck:12 characters long.
2019-05-07 17:28:47.545823 pestcheck:Line 2404 of file freyberg.pst: parameter name "prsity3000
2019-05-07 17:28:47.546351 pestcheck:12 characters long.
2019-05-07 17:28:47.546410 pestcheck:Line 2404 of file freyberg.pst: parameter name "prsity3000
2019-05-07 17:28:47.546449 pestcheck:once.
2019-05-07 17:28:47.546491 pestcheck:Line 2405 of file freyberg.pst: parameter name "prsity3000
2019-05-07 17:28:47.546818 pestcheck:12 characters long.
2019-05-07 17:28:47.546875 pestcheck:Line 2405 of file freyberg.pst: parameter name "prsity3000
2019-05-07 17:28:47.546916 pestcheck:once.
2019-05-07 17:28:47.547580 pestcheck:Line 2406 of file freyberg.pst: parameter name "prsity3000
2019-05-07 17:28:47.547642 pestcheck:12 characters long.
2019-05-07 17:28:47.547685 pestcheck:Line 2406 of file freyberg.pst: parameter name "prsity3000
2019-05-07 17:28:47.547732 pestcheck:once.
2019-05-07 17:28:47.547762 pestcheck:Line 2407 of file freyberg.pst: parameter name "prsity3000
2019-05-07 17:28:47.547937 pestcheck:12 characters long.
2019-05-07 17:28:47.547989 pestcheck:Line 2407 of file freyberg.pst: parameter name "prsity3000
2019-05-07 17:28:47.548025 pestcheck:once.
2019-05-07 17:28:47.548316 pestcheck:Line 2408 of file freyberg.pst: parameter name "prsity3000
2019-05-07 17:28:47.548366 pestcheck:12 characters long.
2019-05-07 17:28:47.548420 pestcheck:Line 2408 of file freyberg.pst: parameter name "prsity3000
2019-05-07 17:28:47.548453 pestcheck:once.
2019-05-07 17:28:47.548648 pestcheck:Line 2409 of file freyberg.pst: parameter name "prsity3000
2019-05-07 17:28:47.548687 pestcheck:12 characters long.
2019-05-07 17:28:47.548719 pestcheck:Line 2409 of file freyberg.pst: parameter name "prsity3000
2019-05-07 17:28:47.548781 pestcheck:once.
2019-05-07 17:28:47.548950 pestcheck:Line 2410 of file freyberg.pst: parameter name "prsity3000
2019-05-07 17:28:47.549011 pestcheck:12 characters long.
2019-05-07 17:28:47.549182 pestcheck:Line 2410 of file freyberg.pst: parameter name "prsity3000
2019-05-07 17:28:47.549313 pestcheck:once.
2019-05-07 17:28:47.549373 pestcheck:Line 2411 of file freyberg.pst: parameter name "prsity3000
2019-05-07 17:28:47.549437 pestcheck:12 characters long.
2019-05-07 17:28:47.549534 pestcheck:Line 2411 of file freyberg.pst: parameter name "prsity3000
2019-05-07 17:28:47.549661 pestcheck:once.
2019-05-07 17:28:47.549795 pestcheck:Line 2412 of file freyberg.pst: parameter name "prsity3000
2019-05-07 17:28:47.549859 pestcheck:12 characters long.
2019-05-07 17:28:47.549966 pestcheck:Line 2412 of file freyberg.pst: parameter name "prsity3000
2019-05-07 17:28:47.550012 pestcheck:once.
2019-05-07 17:28:47.550127 pestcheck:Line 2413 of file freyberg.pst: parameter name "prsity3000
```

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2019-05-07 17:28:47.550244 pestcheck:12 characters long.
2019-05-07 17:28:47.550355 pestcheck:Line 2414 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.550458 pestcheck:12 characters long.
2019-05-07 17:28:47.550585 pestcheck:Line 2414 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.550706 pestcheck:once.
2019-05-07 17:28:47.550826 pestcheck:Line 2415 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.550891 pestcheck:12 characters long.
2019-05-07 17:28:47.550998 pestcheck:Line 2415 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.551044 pestcheck:once.
2019-05-07 17:28:47.551148 pestcheck:Line 2416 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.551277 pestcheck:12 characters long.
2019-05-07 17:28:47.551332 pestcheck:Line 2416 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.551420 pestcheck:once.
2019-05-07 17:28:47.551522 pestcheck:Line 2417 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.551713 pestcheck:12 characters long.
2019-05-07 17:28:47.551825 pestcheck:Line 2417 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.551887 pestcheck:once.
2019-05-07 17:28:47.552004 pestcheck:Line 2418 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.552106 pestcheck:12 characters long.
2019-05-07 17:28:47.552154 pestcheck:Line 2418 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.552256 pestcheck:once.
2019-05-07 17:28:47.552359 pestcheck:Line 2419 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.552407 pestcheck:12 characters long.
2019-05-07 17:28:47.552446 pestcheck:Line 2419 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.552544 pestcheck:once.
2019-05-07 17:28:47.552659 pestcheck:Line 2420 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.552773 pestcheck:12 characters long.
2019-05-07 17:28:47.552934 pestcheck:Line 2420 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.553035 pestcheck:once.
2019-05-07 17:28:47.553138 pestcheck:Line 2421 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.553250 pestcheck:12 characters long.
2019-05-07 17:28:47.553379 pestcheck:Line 2421 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.553490 pestcheck:once.
2019-05-07 17:28:47.554280 pestcheck:Line 2422 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.554483 pestcheck:12 characters long.
2019-05-07 17:28:47.554592 pestcheck:Line 2422 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.554644 pestcheck:once.
2019-05-07 17:28:47.554684 pestcheck:Line 2423 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.554786 pestcheck:12 characters long.
2019-05-07 17:28:47.554895 pestcheck:Line 2424 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.555010 pestcheck:12 characters long.
2019-05-07 17:28:47.555118 pestcheck:Line 2424 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.555165 pestcheck:once.
2019-05-07 17:28:47.555270 pestcheck:Line 2425 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.555391 pestcheck:12 characters long.
2019-05-07 17:28:47.555431 pestcheck:Line 2425 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.555533 pestcheck:once.
2019-05-07 17:28:47.555648 pestcheck:Line 2426 of file freyberg.pst: parameter name "prsity300
```

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2019-05-07 17:28:47.555694 pestcheck:12 characters long.
2019-05-07 17:28:47.555795 pestcheck:Line 2426 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.555897 pestcheck:once.
2019-05-07 17:28:47.555943 pestcheck:Line 2427 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.556043 pestcheck:12 characters long.
2019-05-07 17:28:47.556144 pestcheck:Line 2427 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.556190 pestcheck:once.
2019-05-07 17:28:47.556227 pestcheck:Line 2428 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.556324 pestcheck:12 characters long.
2019-05-07 17:28:47.556434 pestcheck:Line 2428 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.556480 pestcheck:once.
2019-05-07 17:28:47.556518 pestcheck:Line 2429 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.556615 pestcheck:12 characters long.
2019-05-07 17:28:47.556715 pestcheck:Line 2429 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.556762 pestcheck:once.
2019-05-07 17:28:47.556800 pestcheck:Line 2430 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.556897 pestcheck:12 characters long.
2019-05-07 17:28:47.556998 pestcheck:Line 2430 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.557044 pestcheck:once.
2019-05-07 17:28:47.557081 pestcheck:Line 2431 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.557178 pestcheck:12 characters long.
2019-05-07 17:28:47.557278 pestcheck:Line 2431 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.557324 pestcheck:once.
2019-05-07 17:28:47.557496 pestcheck:Line 2432 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.557541 pestcheck:12 characters long.
2019-05-07 17:28:47.557579 pestcheck:Line 2432 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.557675 pestcheck:once.
2019-05-07 17:28:47.557776 pestcheck:Line 2433 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.557840 pestcheck:12 characters long.
2019-05-07 17:28:47.557929 pestcheck:Line 2434 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.557979 pestcheck:12 characters long.
2019-05-07 17:28:47.558040 pestcheck:Line 2434 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.558110 pestcheck:once.
2019-05-07 17:28:47.558156 pestcheck:Line 2435 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.558193 pestcheck:12 characters long.
2019-05-07 17:28:47.558290 pestcheck:Line 2435 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.558407 pestcheck:once.
2019-05-07 17:28:47.558509 pestcheck:Line 2436 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.558610 pestcheck:12 characters long.
2019-05-07 17:28:47.558720 pestcheck:Line 2436 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.558822 pestcheck:once.
2019-05-07 17:28:47.558867 pestcheck:Line 2437 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.558905 pestcheck:12 characters long.
2019-05-07 17:28:47.559002 pestcheck:Line 2437 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.559103 pestcheck:once.
2019-05-07 17:28:47.559148 pestcheck:Line 2438 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.559186 pestcheck:12 characters long.
2019-05-07 17:28:47.559283 pestcheck:Line 2438 of file freyberg.pst: parameter name "prsity300
```

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2019-05-07 17:28:47.559399 pestcheck:once.
2019-05-07 17:28:47.559436 pestcheck:Line 2439 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.559533 pestcheck:12 characters long.
2019-05-07 17:28:47.559634 pestcheck:Line 2439 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.559680 pestcheck:once.
2019-05-07 17:28:47.559780 pestcheck:Line 2440 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.559882 pestcheck:12 characters long.
2019-05-07 17:28:47.559929 pestcheck:Line 2440 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.559968 pestcheck:once.
2019-05-07 17:28:47.560064 pestcheck:Line 2441 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.560166 pestcheck:12 characters long.
2019-05-07 17:28:47.560211 pestcheck:Line 2441 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.560249 pestcheck:once.
2019-05-07 17:28:47.560414 pestcheck:Line 2442 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.560462 pestcheck:12 characters long.
2019-05-07 17:28:47.560562 pestcheck:Line 2442 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.560665 pestcheck:once.
2019-05-07 17:28:47.560711 pestcheck:Line 2443 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.560749 pestcheck:12 characters long.
2019-05-07 17:28:47.560845 pestcheck:Line 2444 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.560950 pestcheck:12 characters long.
2019-05-07 17:28:47.560996 pestcheck:Line 2444 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.561103 pestcheck:once.
2019-05-07 17:28:47.561154 pestcheck:Line 2445 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.561246 pestcheck:12 characters long.
2019-05-07 17:28:47.561300 pestcheck:Line 2445 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.561397 pestcheck:once.
2019-05-07 17:28:47.561498 pestcheck:Line 2446 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.561544 pestcheck:12 characters long.
2019-05-07 17:28:47.561582 pestcheck:Line 2446 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.561679 pestcheck:once.
2019-05-07 17:28:47.561781 pestcheck:Line 2447 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.561826 pestcheck:12 characters long.
2019-05-07 17:28:47.561864 pestcheck:Line 2447 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.561961 pestcheck:once.
2019-05-07 17:28:47.562091 pestcheck:Line 2448 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.562192 pestcheck:12 characters long.
2019-05-07 17:28:47.562293 pestcheck:Line 2448 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.562350 pestcheck:once.
2019-05-07 17:28:47.562447 pestcheck:Line 2449 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.562550 pestcheck:12 characters long.
2019-05-07 17:28:47.562597 pestcheck:Line 2449 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.562635 pestcheck:once.
2019-05-07 17:28:47.562731 pestcheck:Line 2450 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.562832 pestcheck:12 characters long.
2019-05-07 17:28:47.562877 pestcheck:Line 2450 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.562915 pestcheck:once.
2019-05-07 17:28:47.563011 pestcheck:Line 2451 of file freyberg.pst: parameter name "prsity300
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2019-05-07 17:28:47.563112 pestcheck:12 characters long.
2019-05-07 17:28:47.563161 pestcheck:Line 2451 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.563198 pestcheck:once.
2019-05-07 17:28:47.563295 pestcheck:Line 2452 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.563406 pestcheck:12 characters long.
2019-05-07 17:28:47.563451 pestcheck:Line 2452 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.563489 pestcheck:once.
2019-05-07 17:28:47.563586 pestcheck:Line 2453 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.563636 pestcheck:12 characters long.
2019-05-07 17:28:47.563727 pestcheck:Line 2454 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.563775 pestcheck:12 characters long.
2019-05-07 17:28:47.563813 pestcheck:Line 2454 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.563910 pestcheck:once.
2019-05-07 17:28:47.563960 pestcheck:Line 2455 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.564051 pestcheck:12 characters long.
2019-05-07 17:28:47.564163 pestcheck:Line 2455 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.564266 pestcheck:once.
2019-05-07 17:28:47.564384 pestcheck:Line 2456 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.564486 pestcheck:12 characters long.
2019-05-07 17:28:47.564532 pestcheck:Line 2456 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.564570 pestcheck:once.
2019-05-07 17:28:47.564667 pestcheck:Line 2457 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.564767 pestcheck:12 characters long.
2019-05-07 17:28:47.564877 pestcheck:Line 2457 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.564982 pestcheck:once.
2019-05-07 17:28:47.565093 pestcheck:Line 2458 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.565193 pestcheck:12 characters long.
2019-05-07 17:28:47.565240 pestcheck:Line 2458 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.565412 pestcheck:once.
2019-05-07 17:28:47.565523 pestcheck:Line 2459 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.565624 pestcheck:12 characters long.
2019-05-07 17:28:47.565670 pestcheck:Line 2459 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.565707 pestcheck:once.
2019-05-07 17:28:47.565804 pestcheck:Line 2460 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.565853 pestcheck:12 characters long.
2019-05-07 17:28:47.565944 pestcheck:Line 2460 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.565992 pestcheck:once.
2019-05-07 17:28:47.566030 pestcheck:Line 2461 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.566127 pestcheck:12 characters long.
2019-05-07 17:28:47.566228 pestcheck:Line 2461 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.566282 pestcheck:once.
2019-05-07 17:28:47.566379 pestcheck:Line 2462 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.566480 pestcheck:12 characters long.
2019-05-07 17:28:47.566528 pestcheck:Line 2462 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.566566 pestcheck:once.
2019-05-07 17:28:47.566663 pestcheck:Line 2463 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.566832 pestcheck:12 characters long.
2019-05-07 17:28:47.566894 pestcheck:Line 2464 of file freyberg.pst: parameter name "prsity300
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2019-05-07 17:28:47.567001 pestcheck:12 characters long.
2019-05-07 17:28:47.567106 pestcheck:Line 2464 of file freyberg.pst: parameter name "prsity3003
2019-05-07 17:28:47.567155 pestcheck:once.
2019-05-07 17:28:47.567195 pestcheck:Line 2465 of file freyberg.pst: parameter name "prsity3003
2019-05-07 17:28:47.567314 pestcheck:12 characters long.
2019-05-07 17:28:47.567408 pestcheck:Line 2465 of file freyberg.pst: parameter name "prsity3003
2019-05-07 17:28:47.567521 pestcheck:once.
2019-05-07 17:28:47.567624 pestcheck:Line 2466 of file freyberg.pst: parameter name "prsity3003
2019-05-07 17:28:47.567671 pestcheck:12 characters long.
2019-05-07 17:28:47.567711 pestcheck:Line 2466 of file freyberg.pst: parameter name "prsity3003
2019-05-07 17:28:47.567809 pestcheck:once.
2019-05-07 17:28:47.567911 pestcheck:Line 2467 of file freyberg.pst: parameter name "prsity3003
2019-05-07 17:28:47.567958 pestcheck:12 characters long.
2019-05-07 17:28:47.568000 pestcheck:Line 2467 of file freyberg.pst: parameter name "prsity3003
2019-05-07 17:28:47.568099 pestcheck:once.
2019-05-07 17:28:47.568151 pestcheck:Line 2468 of file freyberg.pst: parameter name "prsity3003
2019-05-07 17:28:47.568244 pestcheck:12 characters long.
2019-05-07 17:28:47.568302 pestcheck:Line 2468 of file freyberg.pst: parameter name "prsity3003
2019-05-07 17:28:47.568400 pestcheck:once.
2019-05-07 17:28:47.568500 pestcheck:Line 2469 of file freyberg.pst: parameter name "prsity3003
2019-05-07 17:28:47.568548 pestcheck:12 characters long.
2019-05-07 17:28:47.568651 pestcheck:Line 2469 of file freyberg.pst: parameter name "prsity3003
2019-05-07 17:28:47.568703 pestcheck:once.
2019-05-07 17:28:47.568796 pestcheck:Line 2470 of file freyberg.pst: parameter name "prsity3003
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2019-05-07 17:28:47.568881 pestcheck:Line 2470 of file freyberg.pst: parameter name "prsity3003
2019-05-07 17:28:47.568980 pestcheck:once.
2019-05-07 17:28:47.569086 pestcheck:Line 2471 of file freyberg.pst: parameter name "prsity3003
2019-05-07 17:28:47.569199 pestcheck:12 characters long.
2019-05-07 17:28:47.569250 pestcheck:Line 2471 of file freyberg.pst: parameter name "prsity3003
2019-05-07 17:28:47.569359 pestcheck:once.
2019-05-07 17:28:47.569461 pestcheck:Line 2472 of file freyberg.pst: parameter name "prsity3003
2019-05-07 17:28:47.569512 pestcheck:12 characters long.
2019-05-07 17:28:47.569605 pestcheck:Line 2472 of file freyberg.pst: parameter name "prsity3003
2019-05-07 17:28:47.569651 pestcheck:once.
2019-05-07 17:28:47.569691 pestcheck:Line 2473 of file freyberg.pst: parameter name "prsity3003
2019-05-07 17:28:47.569789 pestcheck:12 characters long.
2019-05-07 17:28:47.569840 pestcheck:Line 2474 of file freyberg.pst: parameter name "prsity3003
2019-05-07 17:28:47.569933 pestcheck:12 characters long.
2019-05-07 17:28:47.569981 pestcheck:Line 2474 of file freyberg.pst: parameter name "prsity3003
2019-05-07 17:28:47.570082 pestcheck:once.
2019-05-07 17:28:47.570189 pestcheck:Line 2475 of file freyberg.pst: parameter name "prsity3003
2019-05-07 17:28:47.570304 pestcheck:12 characters long.
2019-05-07 17:28:47.570413 pestcheck:Line 2475 of file freyberg.pst: parameter name "prsity3003
2019-05-07 17:28:47.570460 pestcheck:once.
2019-05-07 17:28:47.570500 pestcheck:Line 2476 of file freyberg.pst: parameter name "prsity3003
2019-05-07 17:28:47.570597 pestcheck:12 characters long.
2019-05-07 17:28:47.570649 pestcheck:Line 2476 of file freyberg.pst: parameter name "prsity3003
```

```
2019-05-07 17:28:47.570741 pestcheck:once.
2019-05-07 17:28:47.570788 pestcheck:Line 2477 of file freyberg.pst: parameter name "prsity3003
2019-05-07 17:28:47.570846 pestcheck:12 characters long.
2019-05-07 17:28:47.570936 pestcheck:Line 2477 of file freyberg.pst: parameter name "prsity3003
2019-05-07 17:28:47.571039 pestcheck:once.
2019-05-07 17:28:47.571086 pestcheck:Line 2478 of file freyberg.pst: parameter name "prsity3003
2019-05-07 17:28:47.571188 pestcheck:12 characters long.
2019-05-07 17:28:47.571236 pestcheck:Line 2478 of file freyberg.pst: parameter name "prsity3003
2019-05-07 17:28:47.571329 pestcheck:once.
2019-05-07 17:28:47.571445 pestcheck:Line 2479 of file freyberg.pst: parameter name "prsity3003
2019-05-07 17:28:47.571497 pestcheck:12 characters long.
2019-05-07 17:28:47.571559 pestcheck:Line 2479 of file freyberg.pst: parameter name "prsity3003
2019-05-07 17:28:47.571630 pestcheck:once.
2019-05-07 17:28:47.571677 pestcheck:Line 2480 of file freyberg.pst: parameter name "prsity3003
2019-05-07 17:28:47.571779 pestcheck:12 characters long.
2019-05-07 17:28:47.571831 pestcheck:Line 2480 of file freyberg.pst: parameter name "prsity3003
2019-05-07 17:28:47.571926 pestcheck:once.
2019-05-07 17:28:47.571972 pestcheck:Line 2481 of file freyberg.pst: parameter name "prsity3003
2019-05-07 17:28:47.572015 pestcheck:12 characters long.
2019-05-07 17:28:47.572113 pestcheck:Line 2481 of file freyberg.pst: parameter name "prsity3003
2019-05-07 17:28:47.572165 pestcheck:once.
2019-05-07 17:28:47.572259 pestcheck:Line 2482 of file freyberg.pst: parameter name "prsity3003
2019-05-07 17:28:47.572307 pestcheck:12 characters long.
2019-05-07 17:28:47.572430 pestcheck:Line 2482 of file freyberg.pst: parameter name "prsity3003
2019-05-07 17:28:47.572523 pestcheck:once.
2019-05-07 17:28:47.572570 pestcheck:Line 2483 of file freyberg.pst: parameter name "prsity3004
2019-05-07 17:28:47.572613 pestcheck:12 characters long.
2019-05-07 17:28:47.572713 pestcheck:Line 2484 of file freyberg.pst: parameter name "prsity3004
2019-05-07 17:28:47.572818 pestcheck:12 characters long.
2019-05-07 17:28:47.572866 pestcheck:Line 2484 of file freyberg.pst: parameter name "prsity3004
2019-05-07 17:28:47.572909 pestcheck:once.
2019-05-07 17:28:47.573007 pestcheck:Line 2485 of file freyberg.pst: parameter name "prsity3004
2019-05-07 17:28:47.573112 pestcheck:12 characters long.
2019-05-07 17:28:47.573223 pestcheck:Line 2485 of file freyberg.pst: parameter name "prsity3004
2019-05-07 17:28:47.573327 pestcheck:once.
2019-05-07 17:28:47.573443 pestcheck:Line 2486 of file freyberg.pst: parameter name "prsity3004
2019-05-07 17:28:47.573546 pestcheck:12 characters long.
2019-05-07 17:28:47.573593 pestcheck:Line 2486 of file freyberg.pst: parameter name "prsity3004
2019-05-07 17:28:47.573632 pestcheck:once.
2019-05-07 17:28:47.573730 pestcheck:Line 2487 of file freyberg.pst: parameter name "prsity3004
2019-05-07 17:28:47.573782 pestcheck:12 characters long.
2019-05-07 17:28:47.573875 pestcheck:Line 2487 of file freyberg.pst: parameter name "prsity3004
2019-05-07 17:28:47.573922 pestcheck:once.
2019-05-07 17:28:47.574024 pestcheck:Line 2488 of file freyberg.pst: parameter name "prsity3004
2019-05-07 17:28:47.574075 pestcheck:12 characters long.
2019-05-07 17:28:47.574169 pestcheck:Line 2488 of file freyberg.pst: parameter name "prsity3004
2019-05-07 17:28:47.574216 pestcheck:once.
2019-05-07 17:28:47.574318 pestcheck:Line 2489 of file freyberg.pst: parameter name "prsity3004
```

```
2019-05-07 17:28:47.574427 pestcheck:12 characters long.
2019-05-07 17:28:47.574475 pestcheck:Line 2489 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.574576 pestcheck:once.
2019-05-07 17:28:47.574628 pestcheck:Line 2490 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.574721 pestcheck:12 characters long.
2019-05-07 17:28:47.574765 pestcheck:Line 2490 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.574804 pestcheck:once.
2019-05-07 17:28:47.574902 pestcheck:Line 2491 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.574953 pestcheck:12 characters long.
2019-05-07 17:28:47.575046 pestcheck:Line 2491 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.575158 pestcheck:once.
2019-05-07 17:28:47.575264 pestcheck:Line 2492 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.575311 pestcheck:12 characters long.
2019-05-07 17:28:47.575438 pestcheck:Line 2492 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.575531 pestcheck:once.
2019-05-07 17:28:47.575578 pestcheck:Line 2493 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.575698 pestcheck:12 characters long.
2019-05-07 17:28:47.575752 pestcheck:Line 2494 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.575845 pestcheck:12 characters long.
2019-05-07 17:28:47.575891 pestcheck:Line 2494 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.575931 pestcheck:once.
2019-05-07 17:28:47.576032 pestcheck:Line 2495 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.576084 pestcheck:12 characters long.
2019-05-07 17:28:47.576178 pestcheck:Line 2495 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.576224 pestcheck:once.
2019-05-07 17:28:47.576263 pestcheck:Line 2496 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.576362 pestcheck:12 characters long.
2019-05-07 17:28:47.576471 pestcheck:Line 2496 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.576519 pestcheck:once.
2019-05-07 17:28:47.576558 pestcheck:Line 2497 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.576656 pestcheck:12 characters long.
2019-05-07 17:28:47.576706 pestcheck:Line 2497 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.576799 pestcheck:once.
2019-05-07 17:28:47.576846 pestcheck:Line 2498 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.576947 pestcheck:12 characters long.
2019-05-07 17:28:47.576998 pestcheck:Line 2498 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.577091 pestcheck:once.
2019-05-07 17:28:47.577137 pestcheck:Line 2499 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.577176 pestcheck:12 characters long.
2019-05-07 17:28:47.577273 pestcheck:Line 2499 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.577325 pestcheck:once.
2019-05-07 17:28:47.577431 pestcheck:Line 2500 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.577471 pestcheck:12 characters long.
2019-05-07 17:28:47.577568 pestcheck:Line 2500 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.577619 pestcheck:once.
2019-05-07 17:28:47.577712 pestcheck:Line 2501 of file freyberg.pst: parameter name "prsity300
2019-05-07 17:28:47.577758 pestcheck:12 characters long.
2019-05-07 17:28:47.577860 pestcheck:Line 2501 of file freyberg.pst: parameter name "prsity300
```

```
2019-05-07 17:28:47.577962 pestcheck:once.
2019-05-07 17:28:47.578009 pestcheck:Line 2502 of file freyberg.pst: parameter name "prsity3004
2019-05-07 17:28:47.578051 pestcheck:12 characters long.
2019-05-07 17:28:47.578148 pestcheck:Line 2502 of file freyberg.pst: parameter name "prsity3004
2019-05-07 17:28:47.578199 pestcheck:once.
2019-05-07 17:28:47.578292 pestcheck:Line 2503 of file freyberg.pst: parameter name "prsity3005
2019-05-07 17:28:47.578339 pestcheck:12 characters long.
2019-05-07 17:28:47.578462 pestcheck:Line 2504 of file freyberg.pst: parameter name "prsity3005
2019-05-07 17:28:47.578554 pestcheck:12 characters long.
2019-05-07 17:28:47.578601 pestcheck:Line 2504 of file freyberg.pst: parameter name "prsity3005
2019-05-07 17:28:47.578640 pestcheck:once.
2019-05-07 17:28:47.578739 pestcheck:Line 2505 of file freyberg.pst: parameter name "prsity3005
2019-05-07 17:28:47.578844 pestcheck:12 characters long.
2019-05-07 17:28:47.578891 pestcheck:Line 2505 of file freyberg.pst: parameter name "prsity3005
2019-05-07 17:28:47.578930 pestcheck:once.
2019-05-07 17:28:47.579029 pestcheck:Line 2506 of file freyberg.pst: parameter name "prsity3005
2019-05-07 17:28:47.579080 pestcheck:12 characters long.
2019-05-07 17:28:47.579173 pestcheck:Line 2506 of file freyberg.pst: parameter name "prsity3005
2019-05-07 17:28:47.579220 pestcheck:once.
2019-05-07 17:28:47.579258 pestcheck:Line 2507 of file freyberg.pst: parameter name "prsity3005
2019-05-07 17:28:47.579356 pestcheck:12 characters long.
2019-05-07 17:28:47.579465 pestcheck:Line 2507 of file freyberg.pst: parameter name "prsity3005
2019-05-07 17:28:47.579512 pestcheck:once.
2019-05-07 17:28:47.579553 pestcheck:Line 2508 of file freyberg.pst: parameter name "prsity3005
2019-05-07 17:28:47.579650 pestcheck:12 characters long.
2019-05-07 17:28:47.579883 finished: running pestchek on freyberg.pst took: 0:00:00.142845
2019-05-07 17:28:47.580018 starting: saving intermediate _setup_<> dfs into template
2019-05-07 17:28:47.709422 finished: saving intermediate _setup_<> dfs into template took: 0:0
2019-05-07 17:28:47.709626 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
         pst = pst_helper.pst
         pst.npar,pst.nobs
```

```
Out[15]: (14819, 4434)
```

Oh snap!

1.1.13 Add modpath input files, instruction files and calls

First copy over all the MODPATH-related filed from the base directory identified in the `b_d` variable

```
In [16]: 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[16]: ['template/mp_ibound_1.ref',
          'template/mp_ibound_2.ref',
          'template/mp_ibound_3.ref',
          'template/freyberg.locations',
          'template/freyberg.mpsim',
          'template/freyberg.mpbas',
          'template/freyberg.mpnam']
```

The following `frun_post_lines` property adds statements at the end of the `forward_run.py` script. In this case, it runs MODPATH using `mp6`

```
In [17]: pst_helper.frun_post_lines.append("os.system('mp6 freyberg.mpsim >mp6.stdout')")
         pst_helper.tmp_files.append("freyberg.mpenpt")
         pst_helper.write_forward_run()
```

Finally create and add instruction files and related observations for MODPATH

```
In [18]: out_file = "freyberg.mpenpt"
         ins_file = out_file + ".ins"
         with open(os.path.join(pst_helper.new_model_ws,ins_file),'w') as f:
             f.write("pif ~\n")
             f.write("l7 w w w !part_status! w w !part_time!\n")
         df = pst_helper.pst.add_observations(os.path.join(pst_helper.new_model_ws,ins_file),os
```

```
error using inschek for instruction file ./freyberg.mpenpt.ins:File b'template/./freyberg.mpenp
observations in this instruction file will havegeneric values.
```

```
In [19]: for k in range(m.nlay):
             np.savetxt(os.path.join(pst_helper.new_model_ws,"arr_org","prsity_layer_{0}.ref".
```

1.1.14 Final bits and bobs

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

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

```
In [20]: par = pst.parameter_data
         # properties
         tag_dict = {"hk":[0.1,10.0],"vka":[0.1,10],"strt":[0.95,1.05],"prsity":[0.1,1.0]}
         for t,[l,u] in tag_dict.items():
             t_pars = par.loc[par.parnme.apply(lambda x: t in x ),"parnme"]
             par.loc[t_pars,"parubnd"] = u
             par.loc[t_pars,"parlbnd"] = l

         # recharge - just change the uniform recharge mult
         scen_rch = ["cn_rech5"]
         hist_rch = ["cn_rech4"]
```

```
par.loc[par.pargp.apply(lambda x: x in scen_rch),"parubnd"] = 0.8
par.loc[par.pargp.apply(lambda x: x in scen_rch),"parlbnd"] = 0.1
par.loc[par.pargp.apply(lambda x: x in scen_rch),"parval1"] = 0.4
par.loc[par.pargp.apply(lambda x: x in hist_rch),"parubnd"] = 1.2
par.loc[par.pargp.apply(lambda x: x in hist_rch),"parlbnd"] = 0.8
par.loc[par.pargp.apply(lambda x: x in hist_rch),"parval1"] = 1.0

# well abstraction
par.loc["welflux_001","parval1"] = 1.5
par.loc["welflux_001","parlbnd"] = 1.0
par.loc["welflux_001","parubnd"] = 2.0
par.loc["welflux_000","parval1"] = 1.0
par.loc["welflux_000","parlbnd"] = 0.5
par.loc["welflux_000","parubnd"] = 1.5
```

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

Out[21]:

	type	transform	count	initial value	\
cn_hk6	cn_hk6	log	1	0	
cn_hk7	cn_hk7	log	1	0	
cn_hk8	cn_hk8	log	1	0	
cn_prsity6	cn_prsity6	log	1	0	
cn_prsity7	cn_prsity7	log	1	0	
cn_prsity8	cn_prsity8	log	1	0	
cn_rech4	cn_rech4	log	1	0	
cn_rech5	cn_rech5	log	1	-0.39794	
cn_ss6	cn_ss6	log	1	0	
cn_ss7	cn_ss7	log	1	0	
cn_ss8	cn_ss8	log	1	0	
cn_strt6	cn_strt6	log	1	0	
cn_strt7	cn_strt7	log	1	0	
cn_strt8	cn_strt8	log	1	0	
cn_sy6	cn_sy6	log	1	0	
cn_sy7	cn_sy7	log	1	0	
cn_sy8	cn_sy8	log	1	0	
cn_vka6	cn_vka6	log	1	0	
cn_vka7	cn_vka7	log	1	0	
cn_vka8	cn_vka8	log	1	0	
drncond_k00	drncond_k00	log	10	0	
flow	flow	log	1	0	
gr_hk3	gr_hk3	log	705	0	
gr_hk4	gr_hk4	log	705	0	
gr_hk5	gr_hk5	log	705	0	
gr_prsity3	gr_prsity3	log	705	0	
gr_prsity4	gr_prsity4	log	705	0	
gr_prsity5	gr_prsity5	log	705	0	
gr_rech2	gr_rech2	log	705	0	

gr_rech3	gr_rech3	log	705	0
...	...	...	...	...
gr_strt5	gr_strt5	log	705	0
gr_sy3	gr_sy3	log	705	0
gr_sy4	gr_sy4	log	705	0
gr_sy5	gr_sy5	log	705	0
gr_vka3	gr_vka3	log	705	0
gr_vka4	gr_vka4	log	705	0
gr_vka5	gr_vka5	log	705	0
pp_hk0	pp_hk0	log	32	0
pp_hk1	pp_hk1	log	32	0
pp_hk2	pp_hk2	log	32	0
pp_prsity0	pp_prsity0	log	32	0
pp_prsity1	pp_prsity1	log	32	0
pp_prsity2	pp_prsity2	log	32	0
pp_rech0	pp_rech0	log	32	0
pp_rech1	pp_rech1	log	32	0
pp_ss0	pp_ss0	log	32	0
pp_ss1	pp_ss1	log	32	0
pp_ss2	pp_ss2	log	32	0
pp_strt0	pp_strt0	log	32	0
pp_strt1	pp_strt1	log	32	0
pp_strt2	pp_strt2	log	32	0
pp_sy0	pp_sy0	log	32	0
pp_sy1	pp_sy1	log	32	0
pp_sy2	pp_sy2	log	32	0
pp_vka0	pp_vka0	log	32	0
pp_vka1	pp_vka1	log	32	0
pp_vka2	pp_vka2	log	32	0
strk	strk	log	40	0
welflux	welflux	log	2	0 to 0.176091
welflux_k02	welflux_k02	log	6	0

	upper bound	lower bound	standard deviation
cn_hk6	1	-1	0.5
cn_hk7	1	-1	0.5
cn_hk8	1	-1	0.5
cn_prsity6	0	-1	0.25
cn_prsity7	0	-1	0.25
cn_prsity8	0	-1	0.25
cn_rech4	0.0791812	-0.09691	0.0440228
cn_rech5	-0.09691	-1	0.225772
cn_ss6	1	-1	0.5
cn_ss7	1	-1	0.5
cn_ss8	1	-1	0.5
cn_strt6	0.0211893	-0.0222764	0.0108664
cn_strt7	0.0211893	-0.0222764	0.0108664
cn_strt8	0.0211893	-0.0222764	0.0108664

cn_sy6	0.243038	-0.60206	0.211275
cn_sy7	0.243038	-0.60206	0.211275
cn_sy8	0.243038	-0.60206	0.211275
cn_vka6	1	-1	0.5
cn_vka7	1	-1	0.5
cn_vka8	1	-1	0.5
drncond_k00	1	-1	0.5
flow	0.09691	-0.124939	0.0554622
gr_hk3	1	-1	0.5
gr_hk4	1	-1	0.5
gr_hk5	1	-1	0.5
gr_prsity3	0	-1	0.25
gr_prsity4	0	-1	0.25
gr_prsity5	0	-1	0.25
gr_rech2	0.0413927	-0.0457575	0.0217875
gr_rech3	0.0413927	-0.0457575	0.0217875
...	...	...	...
gr_strt5	0.0211893	-0.0222764	0.0108664
gr_sy3	0.243038	-0.60206	0.211275
gr_sy4	0.243038	-0.60206	0.211275
gr_sy5	0.243038	-0.60206	0.211275
gr_vka3	1	-1	0.5
gr_vka4	1	-1	0.5
gr_vka5	1	-1	0.5
pp_hk0	1	-1	0.5
pp_hk1	1	-1	0.5
pp_hk2	1	-1	0.5
pp_prsity0	0	-1	0.25
pp_prsity1	0	-1	0.25
pp_prsity2	0	-1	0.25
pp_rech0	0.0413927	-0.0457575	0.0217875
pp_rech1	0.0413927	-0.0457575	0.0217875
pp_ss0	1	-1	0.5
pp_ss1	1	-1	0.5
pp_ss2	1	-1	0.5
pp_strt0	0.0211893	-0.0222764	0.0108664
pp_strt1	0.0211893	-0.0222764	0.0108664
pp_strt2	0.0211893	-0.0222764	0.0108664
pp_sy0	0.243038	-0.60206	0.211275
pp_sy1	0.243038	-0.60206	0.211275
pp_sy2	0.243038	-0.60206	0.211275
pp_vka0	1	-1	0.5
pp_vka1	1	-1	0.5
pp_vka2	1	-1	0.5
strk	2	-2	1
welflux	0.176091 to 0.30103	-0.30103 to 0	0.0752575 to 0.11928
welflux_k02	1	-1	0.5

```
[65 rows x 7 columns]
```

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

Out[22]:

	group	value	non-zero weight	\
flaqx	flaqx	-977.239 to 32.171	84	
flout	flout	10069 to 226396	84	
flx_constan	flx_constan	0	2	
flx_drains	flx_drains	-723.325 to -723.028	2	
flx_in-out	flx_in-out	0.012695 to 0.046143	2	
flx_percent	flx_percent	0	2	
flx_recharg	flx_recharg	3045.6	2	
flx_storage	flx_storage	5.7734 to 8.01049	2	
flx_stream_	flx_stream_	-1430.27 to -1428.3	2	
flx_total	flx_total	0.0126953 to 0.0461426	2	
flx_wells	flx_wells	-900	2	
hds	hds	32.5065 to 39.6612	4230	
obgnme	obgnme	1E+10	2	
vol_constan	vol_constan	0	2	
vol_drains	vol_drains	-2.90404E+06 to -2.64014E+06	2	
vol_in-out	vol_in-out	45 to 63	2	
vol_percent	vol_percent	0	2	
vol_recharg	vol_recharg	1.11164E+07 to 1.22281E+07	2	
vol_storage	vol_storage	29238.3 to 31345.6	2	
vol_stream_	vol_stream_	-5.74182E+06 to -5.22049E+06	2	
vol_total	vol_total	45 to 63	2	
vol_wells	vol_wells	-3.6135E+06 to -3.285E+06	2	

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

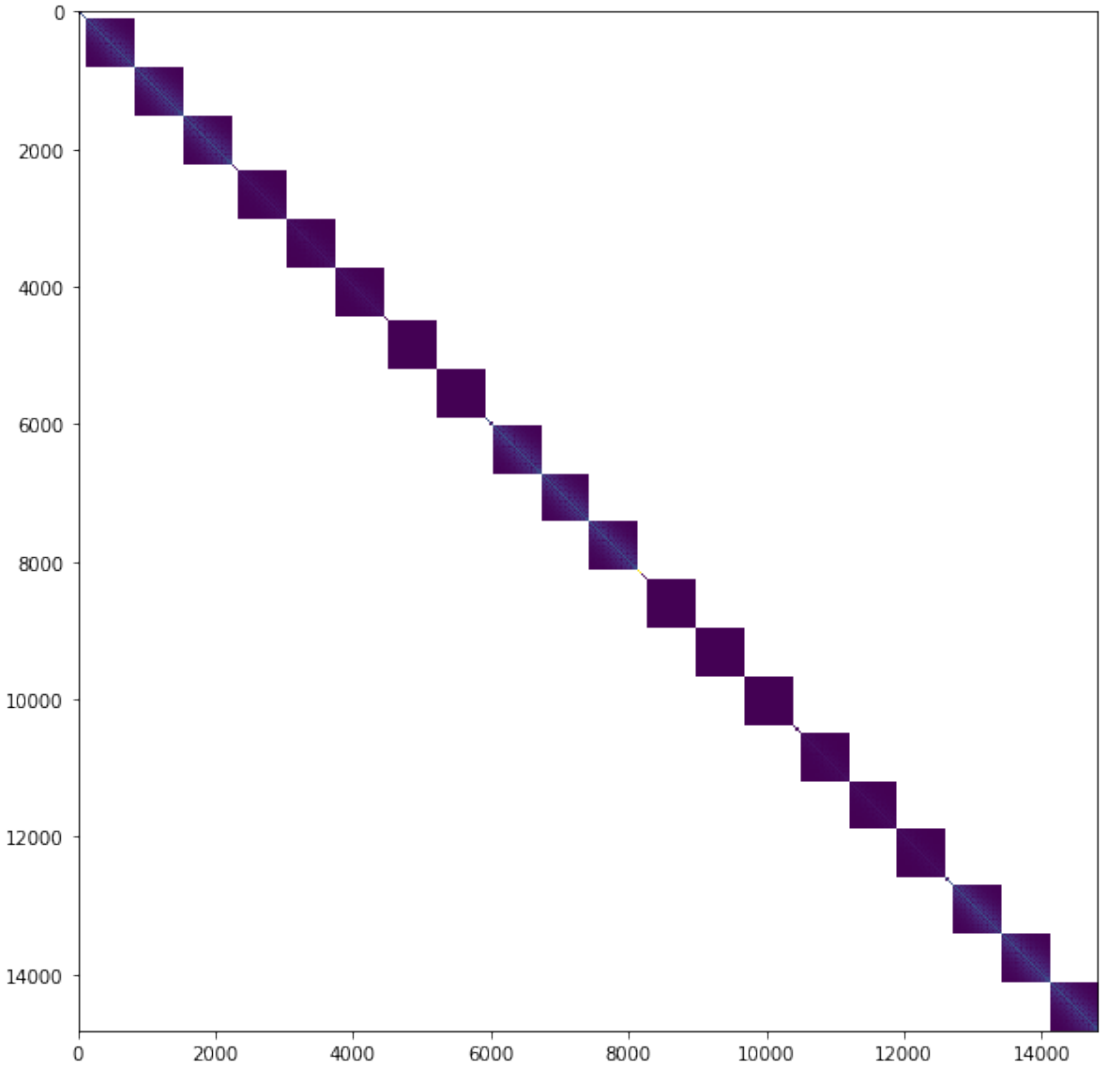
```
vol_stream_          0      1                 1  1.74161E-05 to 1.91553E-05
vol_total            0      1                 1           1.5873 to 2.22222
vol_wells            0      1                 1   2.7674E-05 to 3.04414E-05
```

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

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

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

```
In [24]: if pst_helper.pst.npar < 15000:
             cov = pst_helper.build_prior(fmt="coo",filename=os.path.join(pst_helper.new_model_
             cov = np.ma.masked_where(cov.x==0,cov.x)
             fig = plt.figure(figsize=(10,10))
             ax = plt.subplot(111)
             ax.imshow(cov)
             plt.show()

2019-05-07 17:28:56.973579 starting: building prior covariance matrix
2019-05-07 17:28:57.078340 WARNING: geospatial prior not implemented for SFR pars


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

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

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


2019-05-07 17:29:03.171747 saving prior covariance matrix to file template/prior_cov.jcb
2019-05-07 17:29:07.241756 finished: building prior covariance matrix took: 0:00:10.268177
```



1.1.15 now we can make a draw of 200 from the parameter ensemble

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

```
2019-05-07 17:29:21.455227 starting: drawing realizations
building diagonal cov
processing  name:struct1,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:struct1,nugget:0.0,structures:
name:var1,contribution:1.0,a:1000.0,anisotropy:1.0,bearing:0.0

working on pargroups ['pp_hk0']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_vka0']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_ss0']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_sy0']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_strt0']
build cov matrix
```

```
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_prsity0']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_rech0']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_rech1']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_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_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_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_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_ss1']
build cov matrix
```

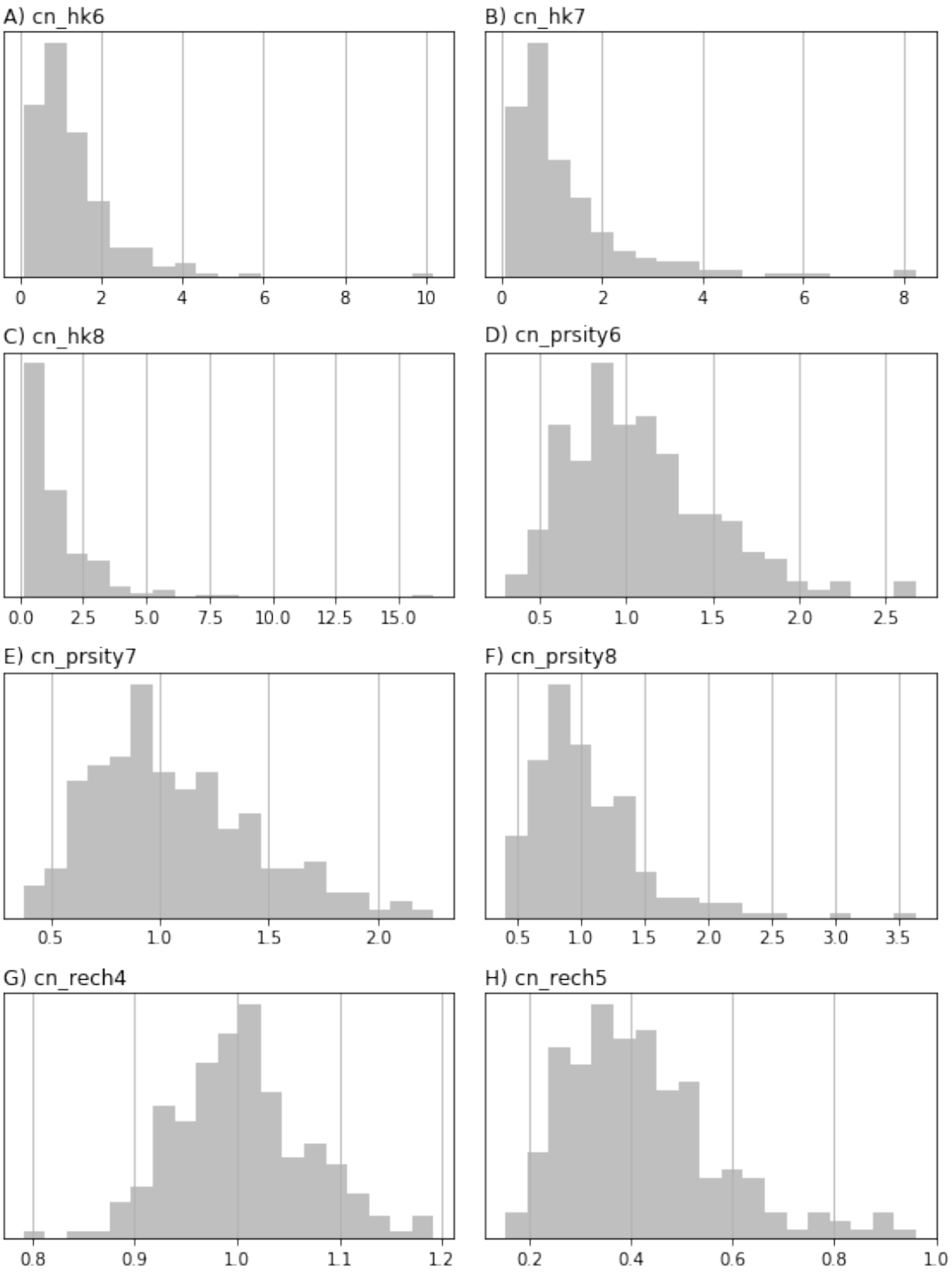
```
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_prsity1']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_vka2']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_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_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_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_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
processing  name:struct1,nugget:0.0,structures:
name:var1,contribution:1.0,a:2500.0,anisotropy:1.0,bearing:0.0
```

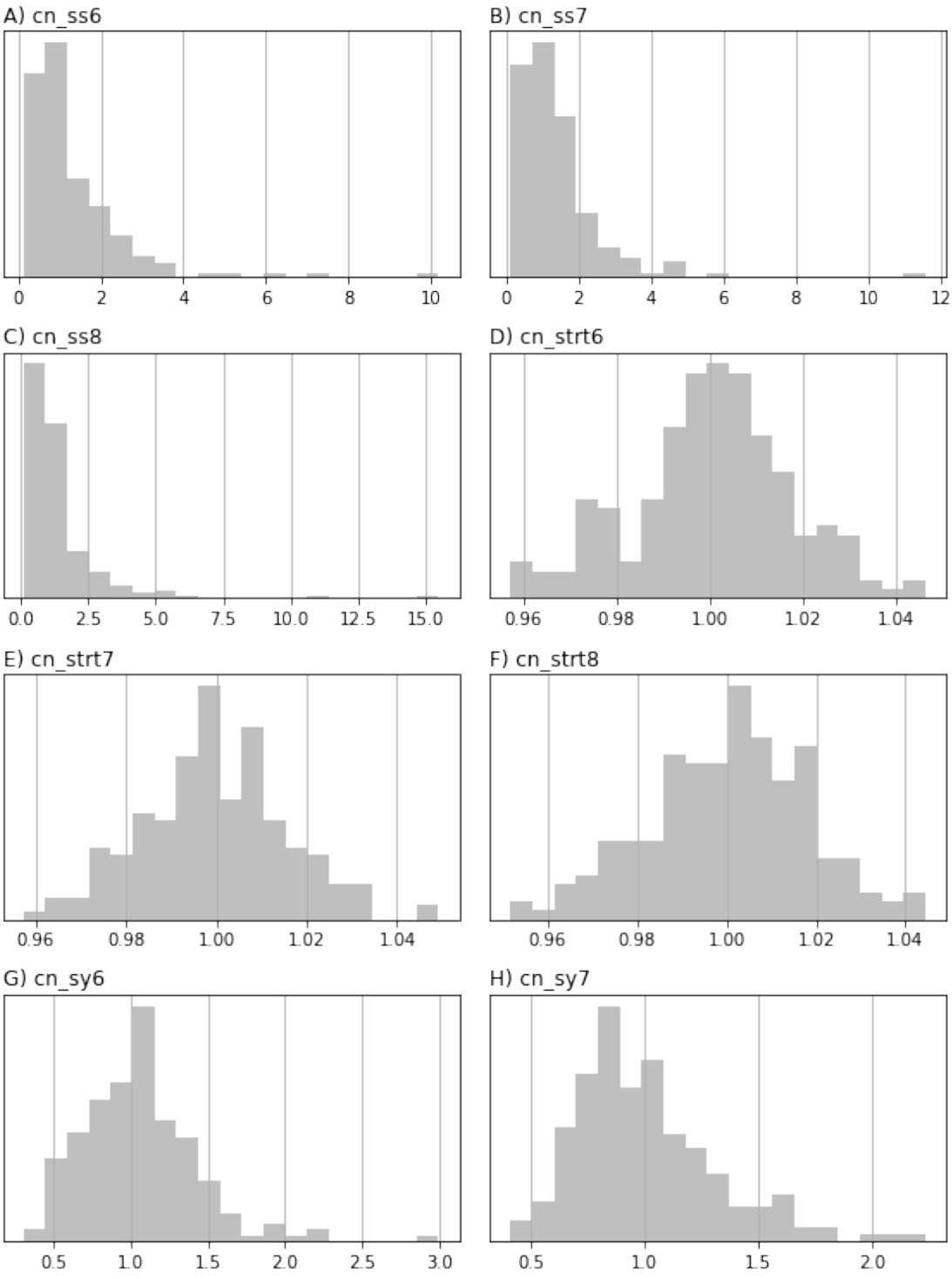
```
working on pargroups ['drncond_k00']


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

See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stable/indexing.html
  self.obj[key] = _infer_fill_value(value)
/Users/jeremyw/miniconda3/lib/python3.5/site-packages/pandas/core/indexing.py:543: SettingWithC
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
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
processing  name:struct1,nugget:0.0,structures:
name:var1,contribution:1.0,a:180.0,anisotropy:1.0,bearing:0.0

working on pargroups ['welflux']
build cov matrix
done
getting diag var cov 2
scaling full cov by diag var cov
making full cov draws with home-grown goodness
adding remaining parameters to diagonal
2019-05-07 17:29:28.725816 finished: drawing realizations took: 0:00:07.270589
```

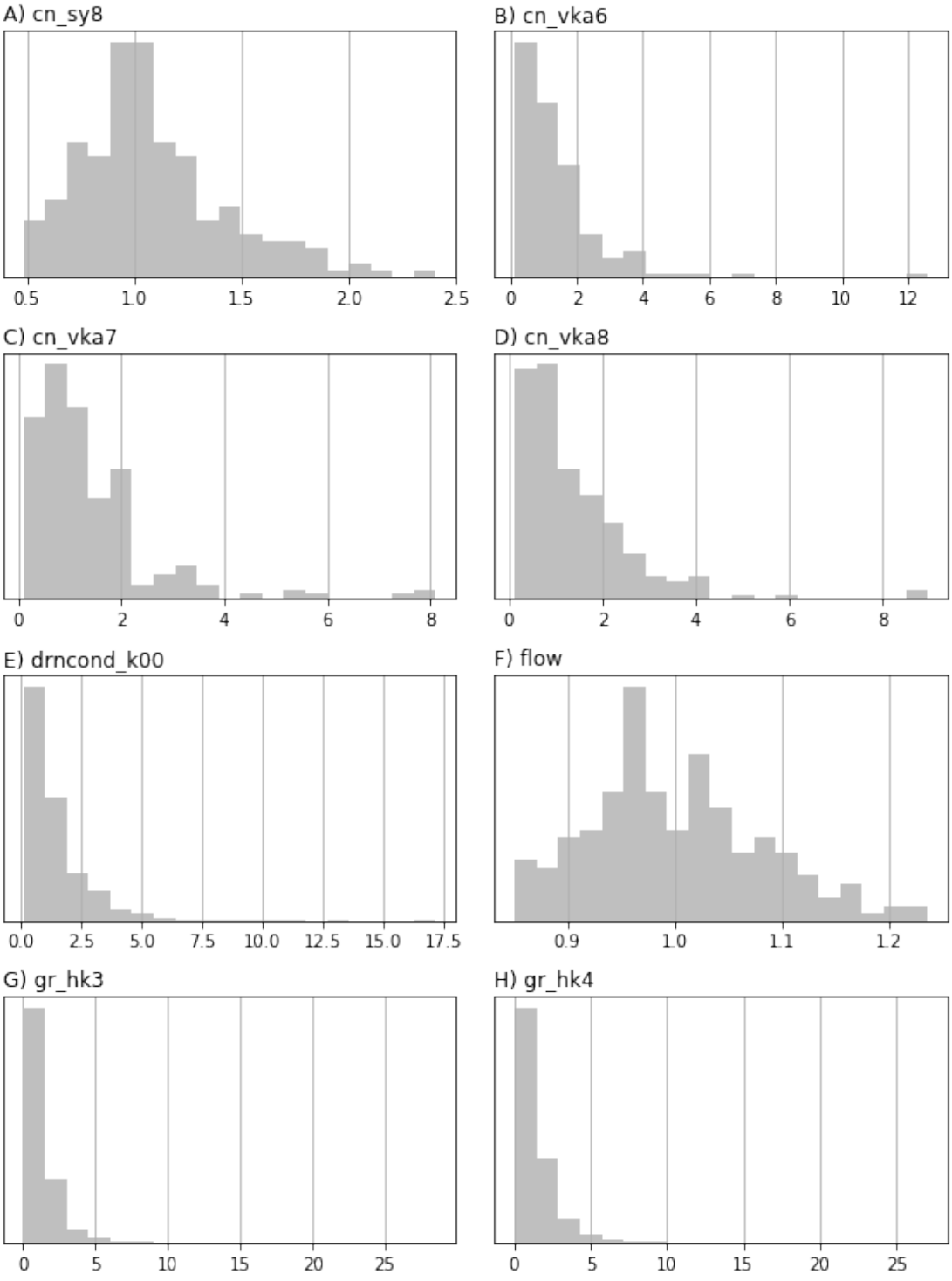
You can see that parameters are treated in parameter group (pargp) blocks for this ensemble generation. Let's plot one parameter:

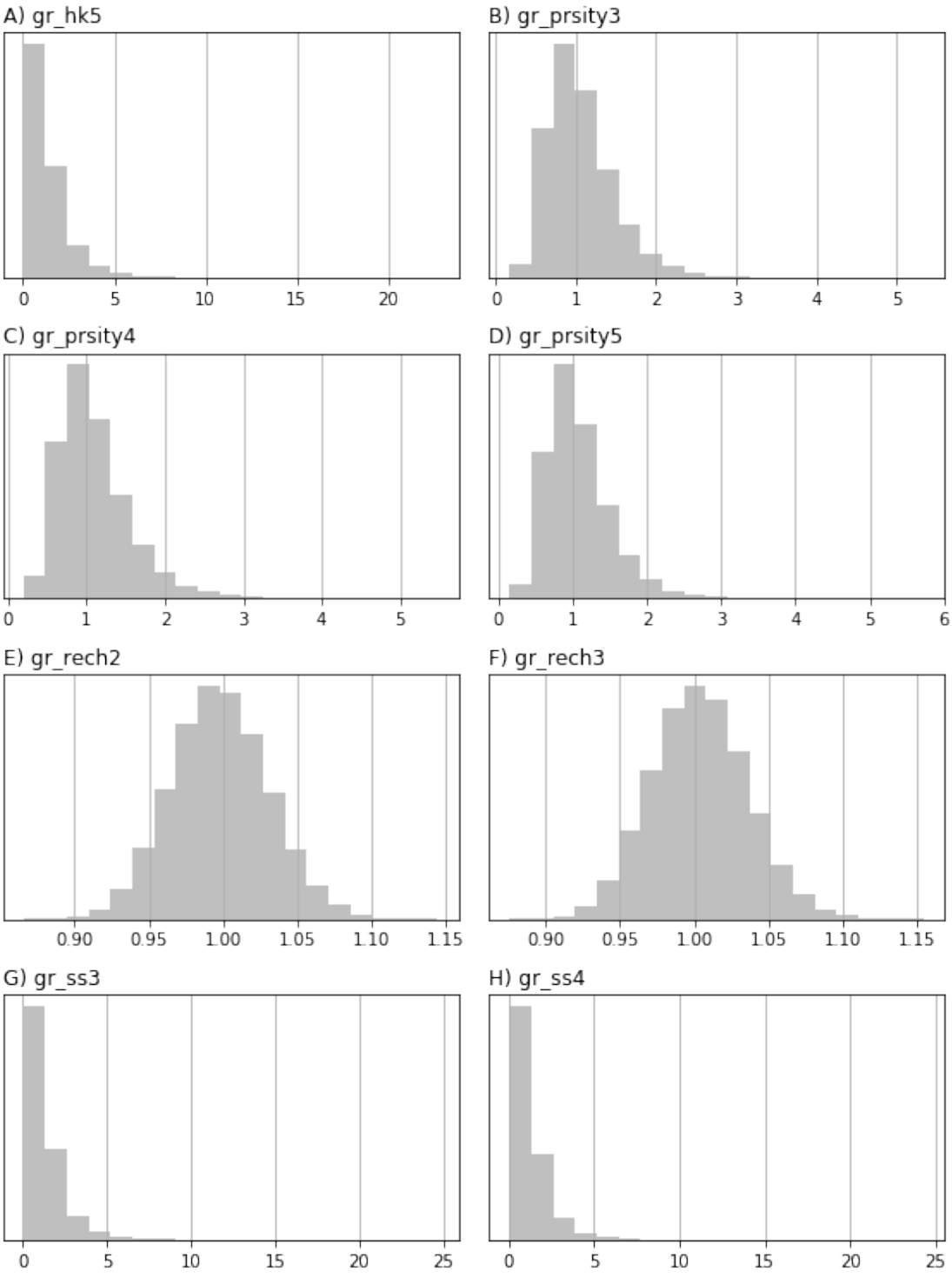
```
In [26]: par = pst_helper.pst.parameter_data
         pyemu.plot_utils.ensemble_helper(pe,plot_cols=par.groupby("pargp").groups,bins=20)
         plt.show()
```

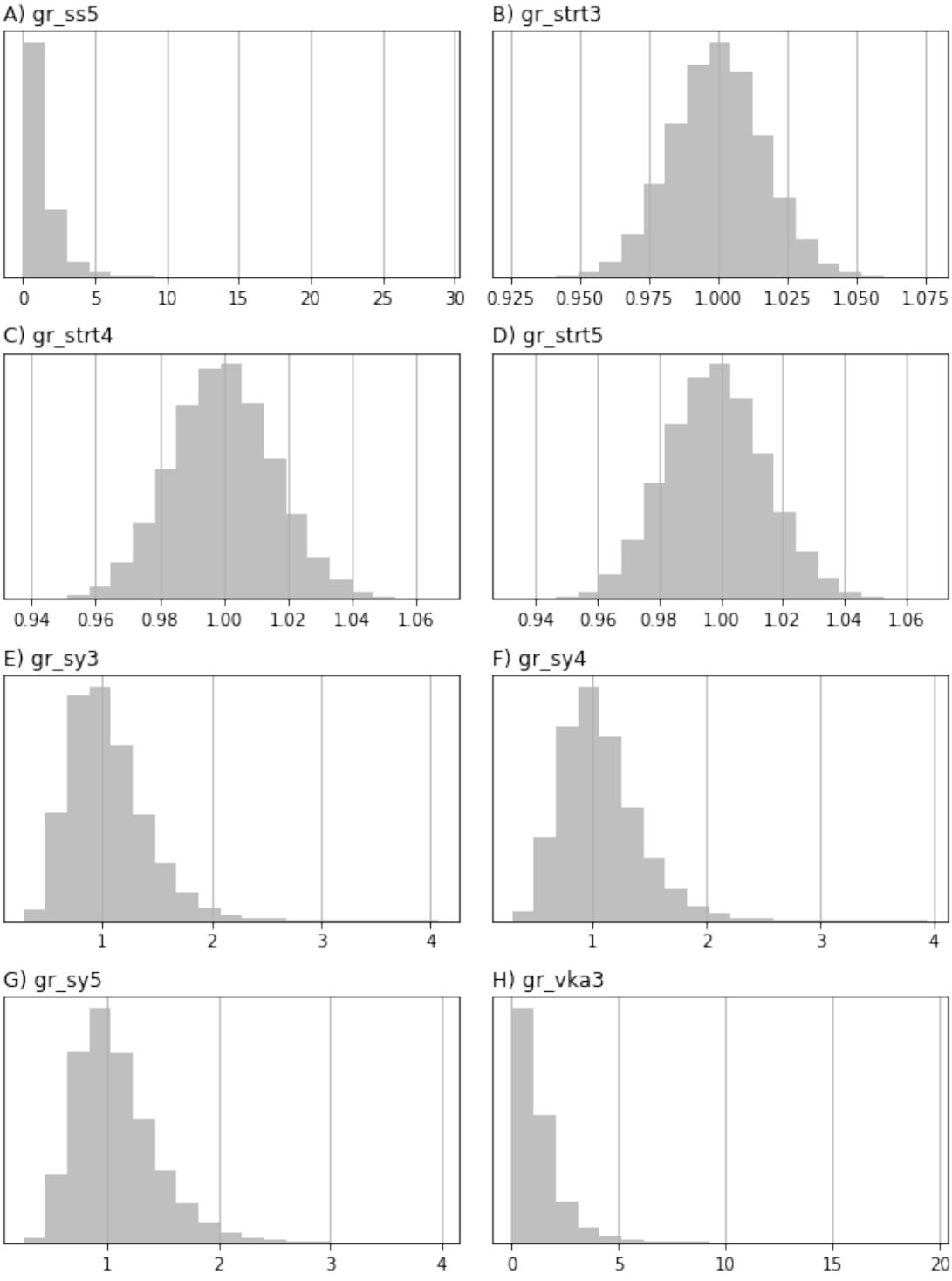
```
<Figure size 576x756 with 0 Axes>
```

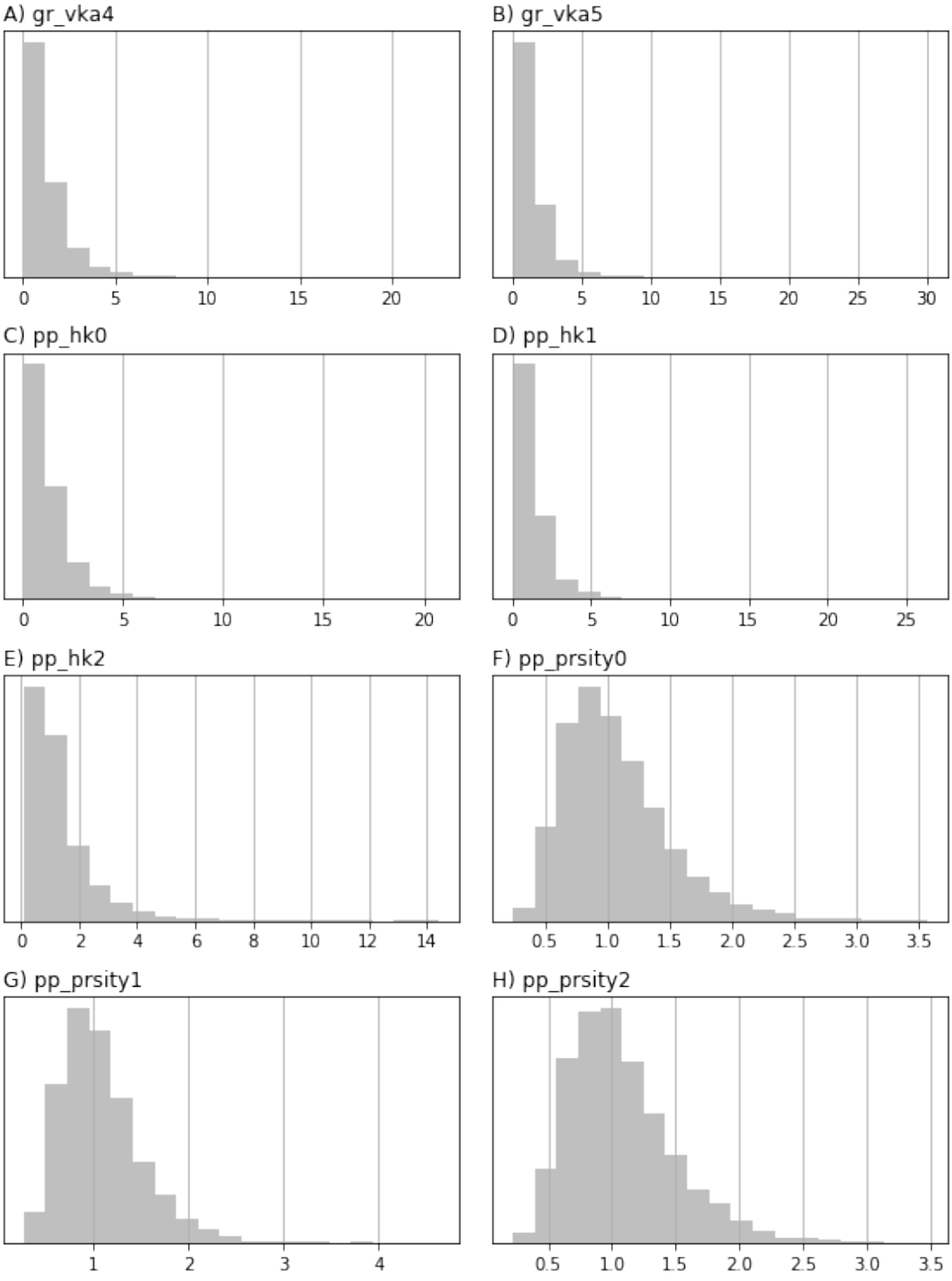


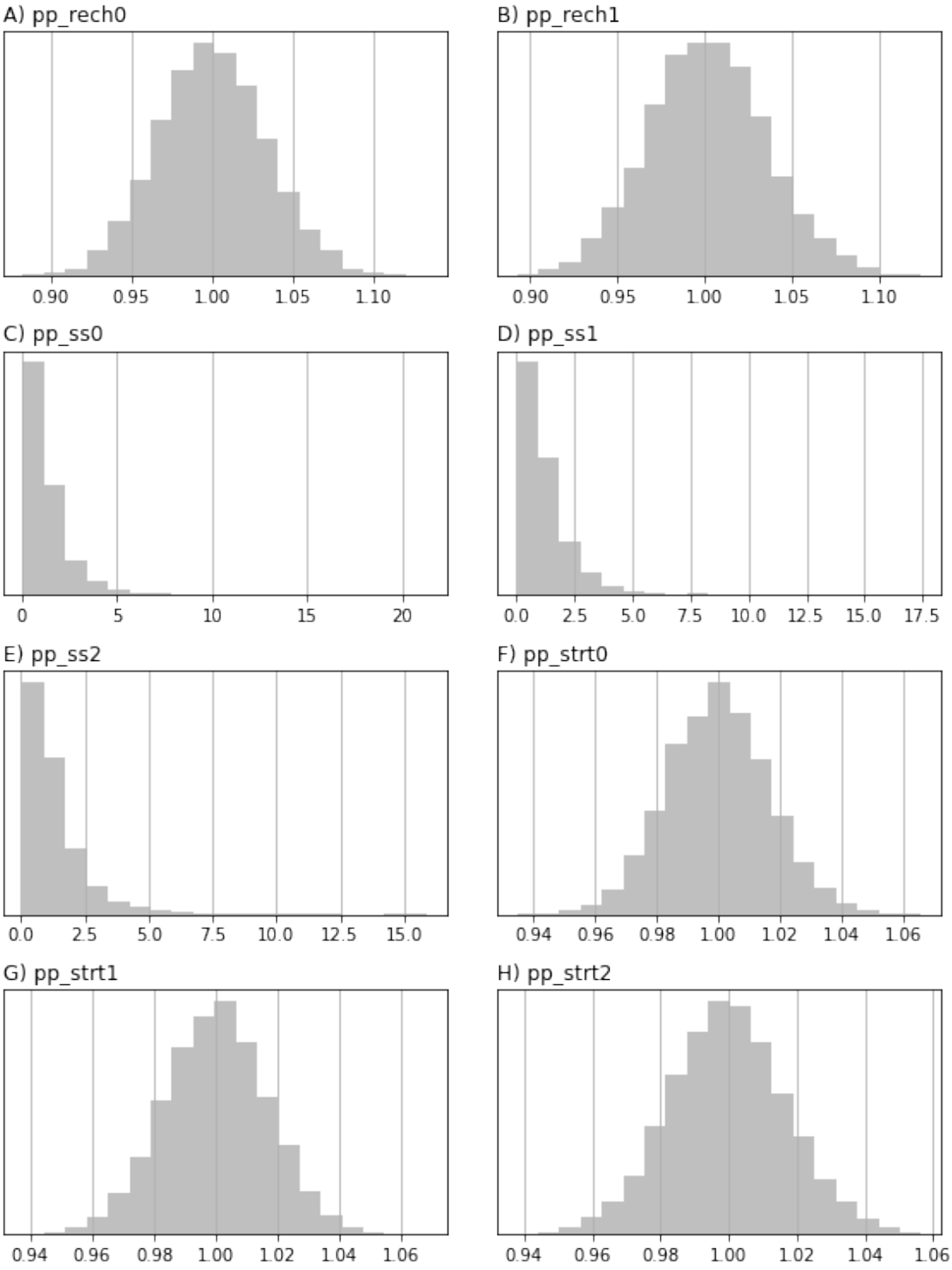

A) cn_ss6
0
2
4
6
8
10
B) cn_ss7
0
2
4
6
8
10
12
C) cn_ss8
0.0
2.5
5.0
7.5
10.0
12.5
15.0
D) cn_strt6
0.96
0.98
1.00
1.02
1.04
E) cn_strt7
0.96
0.98
1.00
1.02
1.04
F) cn_strt8
0.96
0.98
1.00
1.02
1.04
G) cn_sy6
0.5
1.0
1.5
2.0
2.5
3.0
H) cn_sy7
0.5
1.0
1.5
2.0

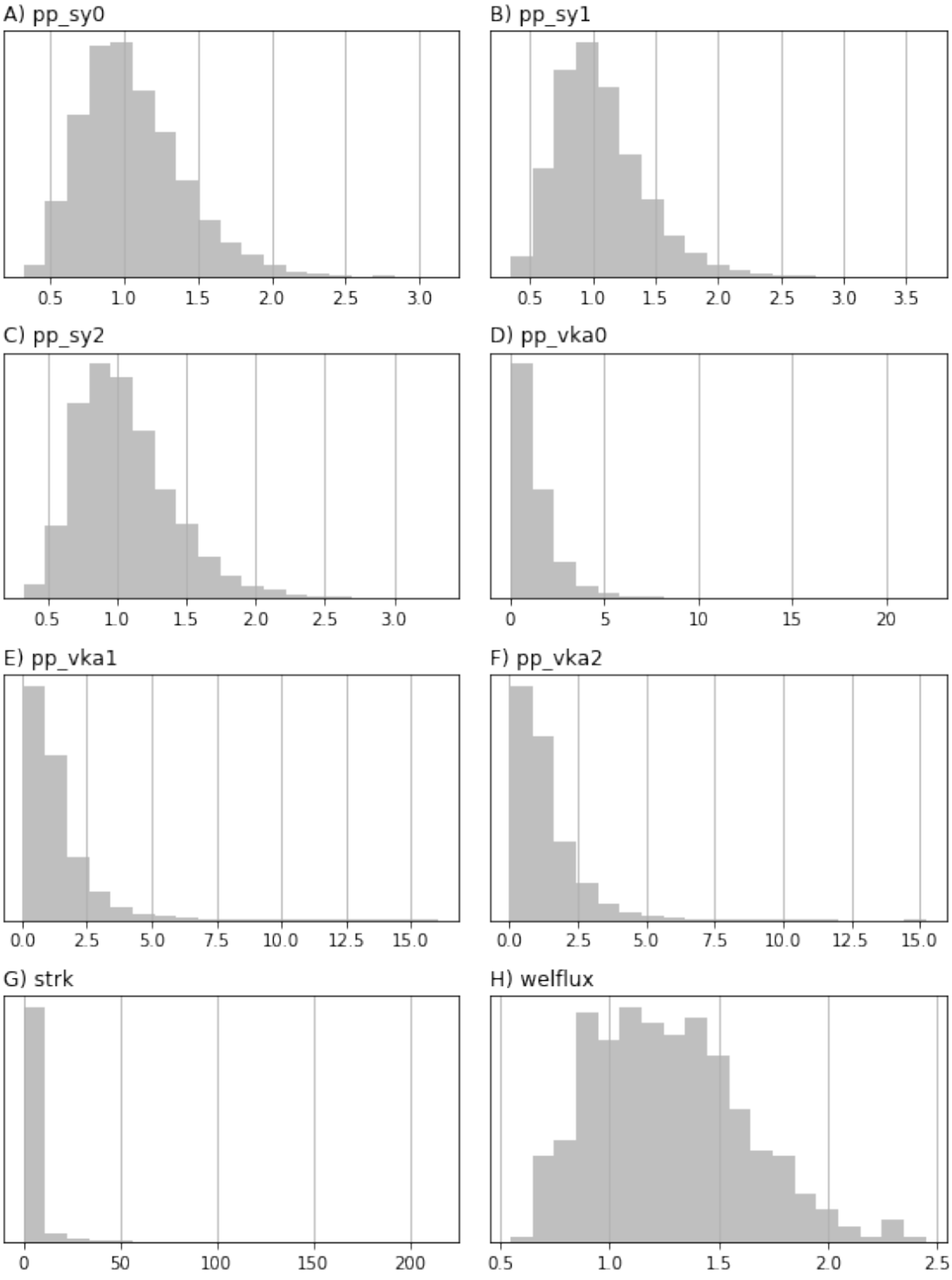

A) cn_sy8
0.5
1.0
1.5
2.0
2.5
B) cn_vka6
0
2
4
6
8
10
12
C) cn_vka7
0
2
4
6
8
D) cn_vka8
0
2
4
6
8
E) drncond_k00
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
F) flow
0.9
1.0
1.1
1.2
G) gr_hk3
0
5
10
15
20
25
H) gr_hk4
0
5
10
15
20
25

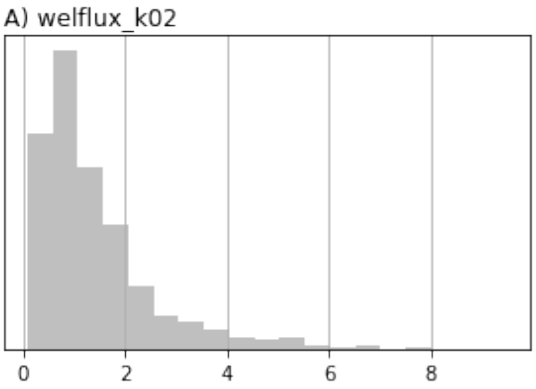

A) gr_hk5
0
5
10
15
20
B) gr_prsity3
0
1
2
3
4
5
C) gr_prsity4
0
1
2
3
4
5
D) gr_prsity5
0
1
2
3
4
5
6
E) gr_rech2
0.90
0.95
1.00
1.05
1.10
1.15
F) gr_rech3
0.90
0.95
1.00
1.05
1.10
1.15
G) gr_ss3
0
5
10
15
20
25
H) gr_ss4
0
5
10
15
20
25


A) gr_ss5
0
5
10
15
20
25
30
B) gr_strt3
0.925
0.950
0.975
1.000
1.025
1.050
1.075
C) gr_strt4
0.94
0.96
0.98
1.00
1.02
1.04
1.06
D) gr_strt5
0.94
0.96
0.98
1.00
1.02
1.04
1.06
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


A) gr_vka4
0
5
10
15
20
B) gr_vka5
0
5
10
15
20
25
30
C) pp_hk0
0
5
10
15
20
D) pp_hk1
0
5
10
15
20
25
E) pp_hk2
0
2
4
6
8
10
12
14
F) pp_prsity0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
G) pp_prsity1
1
2
3
4
H) pp_prsity2
0.5
1.0
1.5
2.0
2.5
3.0
3.5


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
D) pp_ss1
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
E) pp_ss2
0.0
2.5
5.0
7.5
10.0
12.5
15.0
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
B) pp_sy1
0.5 1.0 1.5 2.0 2.5 3.0 3.5
C) pp_sy2
0.5 1.0 1.5 2.0 2.5 3.0
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
F) pp_vka2
0.0 2.5 5.0 7.5 10.0 12.5 15.0
G) strk
0 50 100 150 200
H) welflux
0.5 1.0 1.5 2.0 2.5



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

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

1.1.16 set weights for "observations" and identify forecasts

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

```
In [28]: obs_locs = pd.read_csv(os.path.join("..","base_model_files","obs_loc.csv"))
         if pst_helper.m.nrow != 40:
             obs_locs.loc[:,"row"] = (obs_locs.row * redis_fac) + int(redis_fac / 2.0)
             obs_locs.loc[:,"col"] = (obs_locs.col * redis_fac) + int(redis_fac / 2.0)
         #build obs names that correspond to the obsnme values in the control file
         obs_locs.loc[:,"obsnme"] = obs_locs.apply(lambda x: "hds_00_{0:03d}_{1:03d}_000".forma
         obs_locs
```

Out[28]:

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

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

```
In [29]: obs = pst.observation_data
         obs.loc[:,"weight"] = 0.0
         obs.loc[obs_locs.obsnme,"weight"] = 1.0
         obs.loc[obs_locs.obsnme,"obgnme"] = "calhead"
         fo_obs = "fo_{0}_19791230".format(pst_helper.m.nrow-1)
         obs.loc[fo_obs,"weight"] = 1.0
         obs.loc[fo_obs,"obgnme"] = "calflux"
         pst.nnz_obs_names
```

```
Out[29]: ['fo_39_19791230',
          'hds_00_002_009_000',
          'hds_00_002_015_000',
          'hds_00_003_008_000',
          'hds_00_009_001_000',
          'hds_00_013_010_000',
          'hds_00_015_016_000',
```

```
 'hds_00_021_010_000',
 'hds_00_022_015_000',
 'hds_00_024_004_000',
 'hds_00_026_006_000',
 'hds_00_029_015_000',
 'hds_00_033_007_000',
 'hds_00_034_010_000']
```

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

```
In [30]: swgw_forecasts = obs.loc[obs.obsnme.apply(lambda x: "fa" in x and ("hw" in x or "tw" i
         print(swgw_forecasts)
         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
         pst.write(os.path.join(pst_helper.new_model_ws,"freyberg.pst"))
```

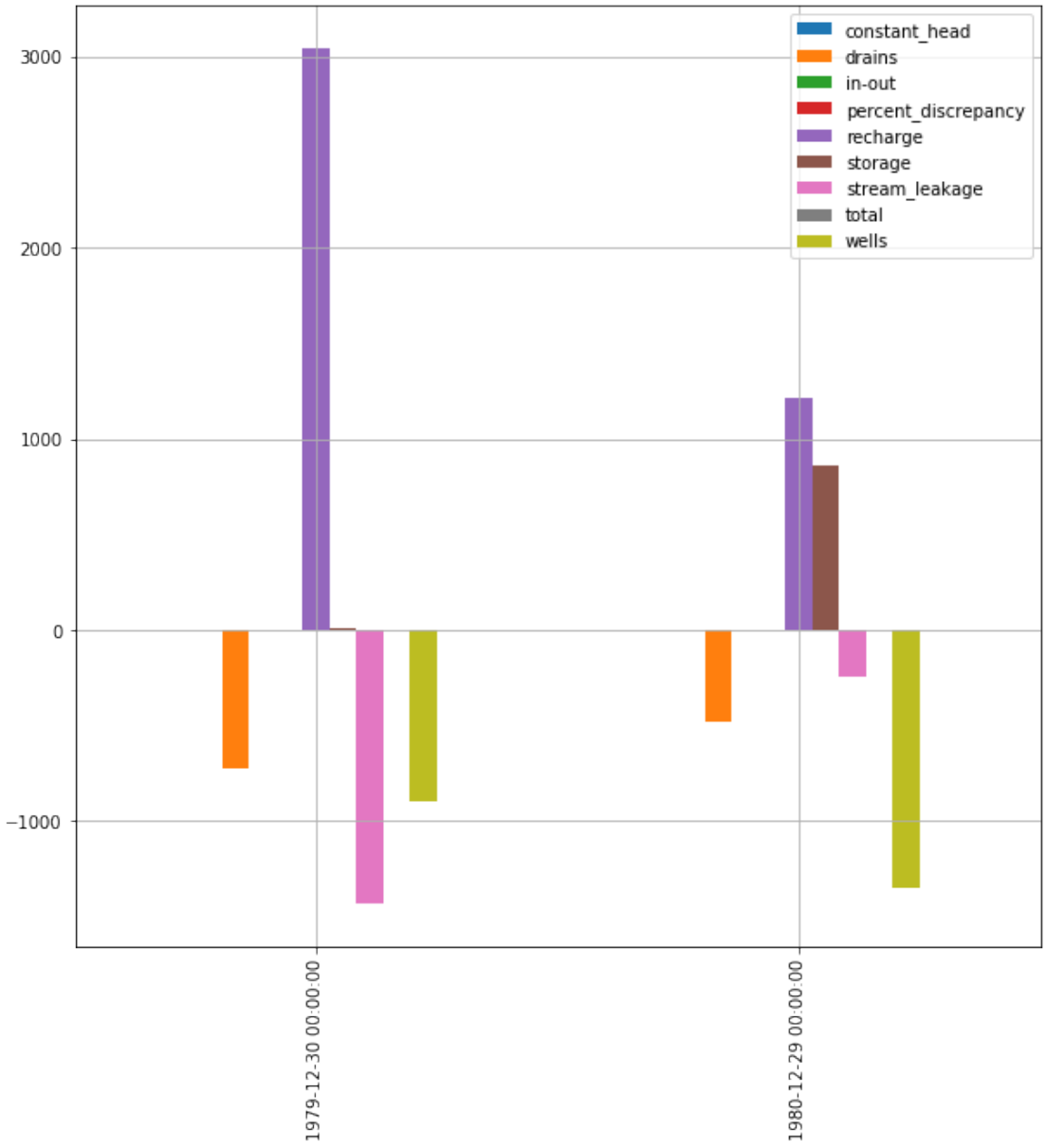
```
['fa_hw_19791230', 'fa_hw_19801229', 'fa_tw_19791230', 'fa_tw_19801229']
```

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

```
In [31]: pyemu.os_utils.run("pestpp-ies.exe freyberg.pst",cwd=pst_helper.new_model_ws)
         pst = pyemu.Pst(os.path.join(pst_helper.new_model_ws,"freyberg.pst"))
         pst.phi
```

```
Out[31]: 9.456182577320024e-19
```

```
In [32]: lst = flopy.utils.MfListBudget(os.path.join("template","freyberg.list"))
         df = lst.get_dataframes(diff=True)[0]
         df.plot(kind="bar",figsize=(10,10), grid=True)
         plt.show()
```



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