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

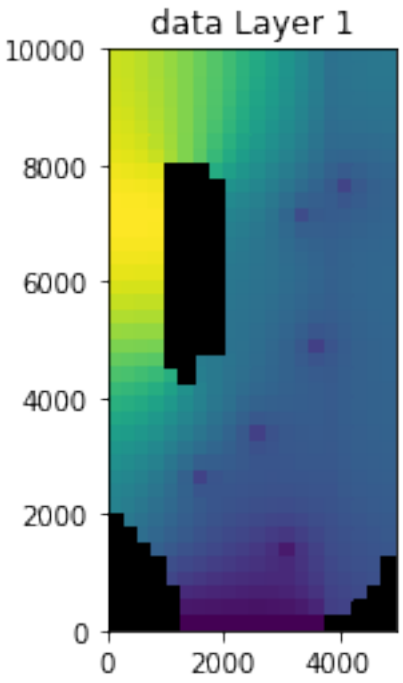
This helper is particularly useful if you run on more than one platform (e.g. Mac and Windows)

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

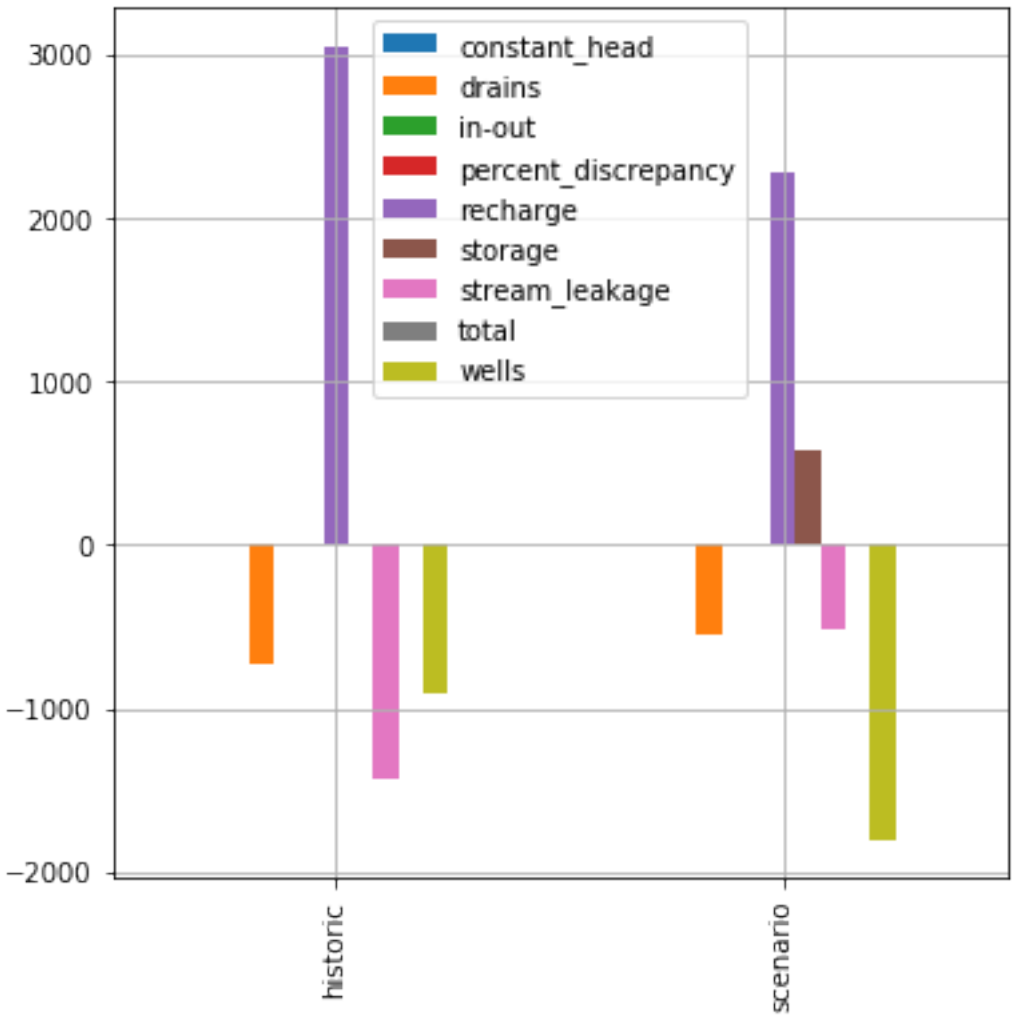
1.1.4 read in the heads and plot them up along with the budget components

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()
```



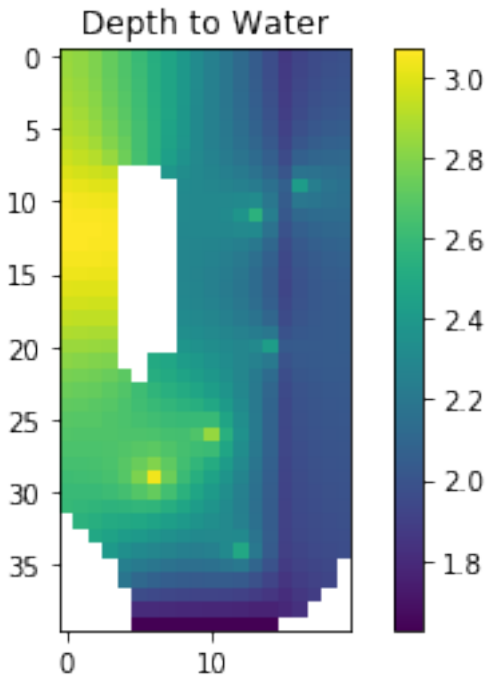

```
<Figure size 432x288 with 0 Axes>
```



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()
```

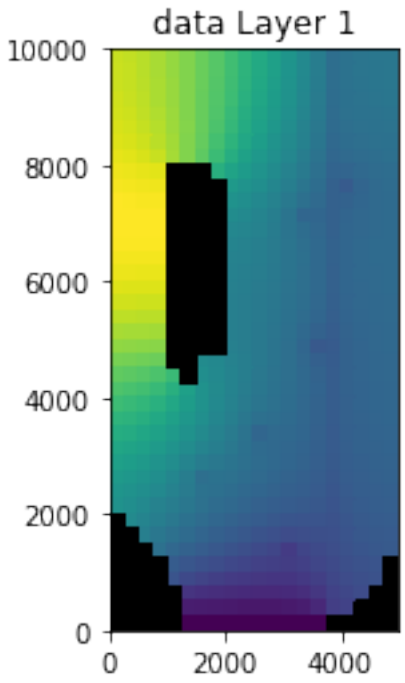


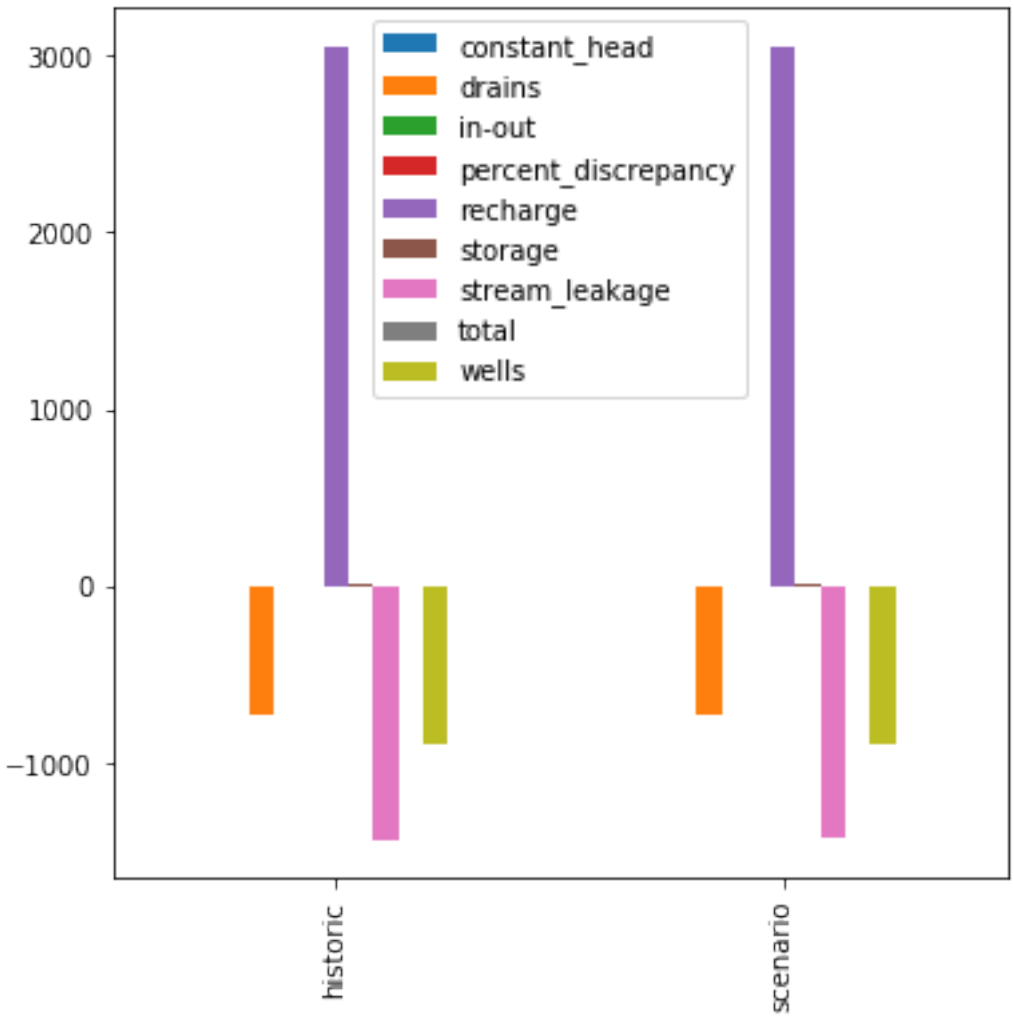
Clearly we can see the river and well locations expressed in the depth to water pattern.

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 09:54:22.078087 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 09:54:22.111432 finished: loading flopy model took: 0:00:00.033345
2019-05-07 09:54:22.111573 starting: updating model attributes
2019-05-07 09:54:22.111664 finished: updating model attributes took: 0:00:00.000091
2019-05-07 09:54:22.111790 WARNING: removing existing 'new_model_ws

creating model workspace...
   template

changing model workspace...
   template
2019-05-07 09:54:23.364342 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 09:54:23.505887 finished: writing new modflow input files took: 0:00:00.141545
2019-05-07 09:54:23.506642 forward_run line:pyemu.os_utils.run('mfnwt freyberg.nam 1>freyberg.r
2019-05-07 09:54:23.506903 starting: setting up 'template/arr_org' dir
2019-05-07 09:54:23.507479 finished: setting up 'template/arr_org' dir took: 0:00:00.000576
2019-05-07 09:54:23.507815 starting: setting up 'template/arr_mlt' dir
2019-05-07 09:54:23.508288 finished: setting up 'template/arr_mlt' dir took: 0:00:00.000473
2019-05-07 09:54:23.508503 starting: setting up 'template/list_org' dir
2019-05-07 09:54:23.509058 finished: setting up 'template/list_org' dir took: 0:00:00.000555
2019-05-07 09:54:23.509399 starting: setting up 'template/list_mlt' dir
2019-05-07 09:54:23.509857 finished: setting up 'template/list_mlt' dir took: 0:00:00.000458
2019-05-07 09:54:23.510200 starting: processing temporal_list_props
2019-05-07 09:54:23.547893 finished: processing temporal_list_props took: 0:00:00.037693
2019-05-07 09:54:23.548326 starting: processing spatial_list_props
2019-05-07 09:54:23.708586 finished: processing spatial_list_props took: 0:00:00.160260
2019-05-07 09:54:23.767976 forward_run line:pyemu.helpers.apply_list_pars()

2019-05-07 09:54:23.802489 'extra' pak detected:extra.prsity
2019-05-07 09:54:23.844519 'extra' pak detected:extra.prsity
2019-05-07 09:54:23.885180 'extra' pak detected:extra.prsity
2019-05-07 09:54:23.937782 'extra' pak detected:extra.prsity
2019-05-07 09:54:23.978344 'extra' pak detected:extra.prsity
2019-05-07 09:54:24.013952 'extra' pak detected:extra.prsity
2019-05-07 09:54:24.060565 'extra' pak detected:extra.prsity
2019-05-07 09:54:24.095003 'extra' pak detected:extra.prsity
2019-05-07 09:54:24.129356 'extra' pak detected:extra.prsity
2019-05-07 09:54:24.211804 starting: writing grid tpl:hk3.dat_gr.tpl
2019-05-07 09:54:24.222500 finished: writing grid tpl:hk3.dat_gr.tpl took: 0:00:00.010696
2019-05-07 09:54:24.225306 starting: writing grid tpl:vka3.dat_gr.tpl
2019-05-07 09:54:24.234091 finished: writing grid tpl:vka3.dat_gr.tpl took: 0:00:00.008785
2019-05-07 09:54:24.236632 starting: writing grid tpl:ss3.dat_gr.tpl
2019-05-07 09:54:24.245649 finished: writing grid tpl:ss3.dat_gr.tpl took: 0:00:00.009017
2019-05-07 09:54:24.248649 starting: writing grid tpl:sy3.dat_gr.tpl
2019-05-07 09:54:24.257582 finished: writing grid tpl:sy3.dat_gr.tpl took: 0:00:00.008933
2019-05-07 09:54:24.260647 starting: writing grid tpl:strt3.dat_gr.tpl
2019-05-07 09:54:24.269404 finished: writing grid tpl:strt3.dat_gr.tpl took: 0:00:00.008757
2019-05-07 09:54:24.271986 starting: writing grid tpl:prsity3.dat_gr.tpl
2019-05-07 09:54:24.283577 finished: writing grid tpl:prsity3.dat_gr.tpl took: 0:00:00.011591
2019-05-07 09:54:24.286365 starting: writing grid tpl:hk4.dat_gr.tpl
2019-05-07 09:54:24.296059 finished: writing grid tpl:hk4.dat_gr.tpl took: 0:00:00.009694
2019-05-07 09:54:24.299283 starting: writing grid tpl:vka4.dat_gr.tpl
2019-05-07 09:54:24.309271 finished: writing grid tpl:vka4.dat_gr.tpl took: 0:00:00.009988
2019-05-07 09:54:24.312279 starting: writing grid tpl:ss4.dat_gr.tpl
2019-05-07 09:54:24.321545 finished: writing grid tpl:ss4.dat_gr.tpl took: 0:00:00.009266
```

```
2019-05-07 09:54:24.324460 starting: writing grid tpl:sy4.dat_gr.tpl
2019-05-07 09:54:24.333796 finished: writing grid tpl:sy4.dat_gr.tpl took: 0:00:00.009336
2019-05-07 09:54:24.336602 starting: writing grid tpl:strt4.dat_gr.tpl
2019-05-07 09:54:24.345681 finished: writing grid tpl:strt4.dat_gr.tpl took: 0:00:00.009079
2019-05-07 09:54:24.348435 starting: writing grid tpl:prsity4.dat_gr.tpl
2019-05-07 09:54:24.359876 finished: writing grid tpl:prsity4.dat_gr.tpl took: 0:00:00.011441
2019-05-07 09:54:24.362615 starting: writing grid tpl:hk5.dat_gr.tpl
2019-05-07 09:54:24.371766 finished: writing grid tpl:hk5.dat_gr.tpl took: 0:00:00.009151
2019-05-07 09:54:24.374491 starting: writing grid tpl:vka5.dat_gr.tpl
2019-05-07 09:54:24.383785 finished: writing grid tpl:vka5.dat_gr.tpl took: 0:00:00.009294
2019-05-07 09:54:24.386569 starting: writing grid tpl:ss5.dat_gr.tpl
2019-05-07 09:54:24.395801 finished: writing grid tpl:ss5.dat_gr.tpl took: 0:00:00.009232
2019-05-07 09:54:24.398504 starting: writing grid tpl:sy5.dat_gr.tpl
2019-05-07 09:54:24.408374 finished: writing grid tpl:sy5.dat_gr.tpl took: 0:00:00.009870
2019-05-07 09:54:24.411717 starting: writing grid tpl:strt5.dat_gr.tpl
2019-05-07 09:54:24.421327 finished: writing grid tpl:strt5.dat_gr.tpl took: 0:00:00.009610
2019-05-07 09:54:24.424199 starting: writing grid tpl:prsity5.dat_gr.tpl
2019-05-07 09:54:24.435921 finished: writing grid tpl:prsity5.dat_gr.tpl took: 0:00:00.011722
2019-05-07 09:54:24.438765 starting: writing grid tpl:rech2.dat_gr.tpl
2019-05-07 09:54:24.447901 finished: writing grid tpl:rech2.dat_gr.tpl took: 0:00:00.009136
2019-05-07 09:54:24.450630 starting: writing grid tpl:rech3.dat_gr.tpl
2019-05-07 09:54:24.459743 finished: writing grid tpl:rech3.dat_gr.tpl took: 0:00:00.009113
2019-05-07 09:54:24.462472 starting: writing const tpl:hk6.dat_cn.tpl
2019-05-07 09:54:24.468762 finished: writing const tpl:hk6.dat_cn.tpl took: 0:00:00.006290
2019-05-07 09:54:24.471501 starting: writing const tpl:vka6.dat_cn.tpl
2019-05-07 09:54:24.478189 finished: writing const tpl:vka6.dat_cn.tpl took: 0:00:00.006688
2019-05-07 09:54:24.481127 starting: writing const tpl:ss6.dat_cn.tpl
2019-05-07 09:54:24.488471 finished: writing const tpl:ss6.dat_cn.tpl took: 0:00:00.007344
2019-05-07 09:54:24.492395 starting: writing const tpl:sy6.dat_cn.tpl
2019-05-07 09:54:24.498939 finished: writing const tpl:sy6.dat_cn.tpl took: 0:00:00.006544
2019-05-07 09:54:24.501588 starting: writing const tpl:strt6.dat_cn.tpl
2019-05-07 09:54:24.507459 finished: writing const tpl:strt6.dat_cn.tpl took: 0:00:00.005871
2019-05-07 09:54:24.510666 starting: writing const tpl:prsity6.dat_cn.tpl
2019-05-07 09:54:24.516852 finished: writing const tpl:prsity6.dat_cn.tpl took: 0:00:00.006186
2019-05-07 09:54:24.519584 starting: writing const tpl:hk7.dat_cn.tpl
2019-05-07 09:54:24.525442 finished: writing const tpl:hk7.dat_cn.tpl took: 0:00:00.005858
2019-05-07 09:54:24.528133 starting: writing const tpl:vka7.dat_cn.tpl
2019-05-07 09:54:24.534253 finished: writing const tpl:vka7.dat_cn.tpl took: 0:00:00.006120
2019-05-07 09:54:24.537212 starting: writing const tpl:ss7.dat_cn.tpl
2019-05-07 09:54:24.543553 finished: writing const tpl:ss7.dat_cn.tpl took: 0:00:00.006341
2019-05-07 09:54:24.546238 starting: writing const tpl:sy7.dat_cn.tpl
2019-05-07 09:54:24.552855 finished: writing const tpl:sy7.dat_cn.tpl took: 0:00:00.006617
2019-05-07 09:54:24.555606 starting: writing const tpl:strt7.dat_cn.tpl
2019-05-07 09:54:24.562385 finished: writing const tpl:strt7.dat_cn.tpl took: 0:00:00.006779
2019-05-07 09:54:24.565171 starting: writing const tpl:prsity7.dat_cn.tpl
2019-05-07 09:54:24.571301 finished: writing const tpl:prsity7.dat_cn.tpl took: 0:00:00.006130
2019-05-07 09:54:24.573975 starting: writing const tpl:hk8.dat_cn.tpl
2019-05-07 09:54:24.580194 finished: writing const tpl:hk8.dat_cn.tpl took: 0:00:00.006219
```

```
2019-05-07 09:54:24.583017 starting: writing const tpl:vka8.dat_cn.tpl
2019-05-07 09:54:24.589156 finished: writing const tpl:vka8.dat_cn.tpl took: 0:00:00.006139
2019-05-07 09:54:24.591988 starting: writing const tpl:ss8.dat_cn.tpl
2019-05-07 09:54:24.598679 finished: writing const tpl:ss8.dat_cn.tpl took: 0:00:00.006691
2019-05-07 09:54:24.601493 starting: writing const tpl:sy8.dat_cn.tpl
2019-05-07 09:54:24.607953 finished: writing const tpl:sy8.dat_cn.tpl took: 0:00:00.006460
2019-05-07 09:54:24.610722 starting: writing const tpl:strt8.dat_cn.tpl
2019-05-07 09:54:24.617312 finished: writing const tpl:strt8.dat_cn.tpl took: 0:00:00.006590
2019-05-07 09:54:24.620233 starting: writing const tpl:prsity8.dat_cn.tpl
2019-05-07 09:54:24.627362 finished: writing const tpl:prsity8.dat_cn.tpl took: 0:00:00.007129
2019-05-07 09:54:24.630282 starting: writing const tpl:rech4.dat_cn.tpl
2019-05-07 09:54:24.636291 finished: writing const tpl:rech4.dat_cn.tpl took: 0:00:00.006009
2019-05-07 09:54:24.638929 starting: writing const tpl:rech5.dat_cn.tpl
2019-05-07 09:54:24.645063 finished: writing const tpl:rech5.dat_cn.tpl took: 0:00:00.006134
2019-05-07 09:54:24.671593 starting: setting up pilot point process
2019-05-07 09:54:24.671979 WARNING: pp_geostruct is None, using ExpVario with contribution=1 ar
2019-05-07 09:54:24.675084 pp_dict: {0: ['hk0', 'vka0', 'ss0', 'sy0', 'strt0', 'prsity0', 'rech
2019-05-07 09:54:24.675596 starting: calling setup_pilot_point_grid()
2019-05-07 09:54:25.266419 640 pilot point parameters created
2019-05-07 09:54:25.267111 pilot point 'pargp':hk0,vka0,ss0,sy0,strt0,prsity0,rech0,rech1,ss1,s
2019-05-07 09:54:25.267163 finished: calling setup_pilot_point_grid() took: 0:00:00.591567
2019-05-07 09:54:25.269396 starting: calculating factors for p=hk0, k=0
2019-05-07 09:54:25.270462 saving krige variance file:template/pp_k0_general_zn.fac
2019-05-07 09:54:25.270763 saving krige factors file:template/pp_k0_general_zn.fac
starting interp point loop for 800 points
took 2.517568 seconds
2019-05-07 09:54:27.842933 finished: calculating factors for p=hk0, k=0 took: 0:00:02.573537
2019-05-07 09:54:27.843982 starting: calculating factors for p=vka0, k=0
2019-05-07 09:54:27.845207 finished: calculating factors for p=vka0, k=0 took: 0:00:00.001225
2019-05-07 09:54:27.846122 starting: calculating factors for p=ss0, k=0
2019-05-07 09:54:27.847219 finished: calculating factors for p=ss0, k=0 took: 0:00:00.001097
2019-05-07 09:54:27.848149 starting: calculating factors for p=sy0, k=0
2019-05-07 09:54:27.849922 finished: calculating factors for p=sy0, k=0 took: 0:00:00.001773
2019-05-07 09:54:27.850538 starting: calculating factors for p=strt0, k=0
2019-05-07 09:54:27.851836 finished: calculating factors for p=strt0, k=0 took: 0:00:00.001298
2019-05-07 09:54:27.852748 starting: calculating factors for p=prsity0, k=0
2019-05-07 09:54:27.853820 finished: calculating factors for p=prsity0, k=0 took: 0:00:00.0010
2019-05-07 09:54:27.854681 starting: calculating factors for p=rech0, k=0
2019-05-07 09:54:27.855576 finished: calculating factors for p=rech0, k=0 took: 0:00:00.000895
2019-05-07 09:54:27.856583 starting: calculating factors for p=rech1, k=0
2019-05-07 09:54:27.857753 finished: calculating factors for p=rech1, k=0 took: 0:00:00.001170
2019-05-07 09:54:27.858529 starting: calculating factors for p=ss1, k=1
2019-05-07 09:54:27.859377 saving krige variance file:template/pp_k1_general_zn.fac
2019-05-07 09:54:27.859607 saving krige factors file:template/pp_k1_general_zn.fac
starting interp point loop for 800 points
took 2.462499 seconds
2019-05-07 09:54:30.374796 finished: calculating factors for p=ss1, k=1 took: 0:00:02.516267
2019-05-07 09:54:30.376004 starting: calculating factors for p=strt1, k=1
```

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2019-05-07 09:54:30.377154 finished: calculating factors for p=strt1, k=1 took: 0:00:00.001150
2019-05-07 09:54:30.378015 starting: calculating factors for p=sy1, k=1
2019-05-07 09:54:30.379046 finished: calculating factors for p=sy1, k=1 took: 0:00:00.001031
2019-05-07 09:54:30.379930 starting: calculating factors for p=hk1, k=1
2019-05-07 09:54:30.380891 finished: calculating factors for p=hk1, k=1 took: 0:00:00.000961
2019-05-07 09:54:30.381810 starting: calculating factors for p=vka1, k=1
2019-05-07 09:54:30.382788 finished: calculating factors for p=vka1, k=1 took: 0:00:00.000978
2019-05-07 09:54:30.383636 starting: calculating factors for p=prsity1, k=1
2019-05-07 09:54:30.384589 finished: calculating factors for p=prsity1, k=1 took: 0:00:00.0009
2019-05-07 09:54:30.385493 starting: calculating factors for p=sy2, k=2
2019-05-07 09:54:30.386464 saving krige variance file:template/pp_k2_general_zn.fac
2019-05-07 09:54:30.386782 saving krige factors file:template/pp_k2_general_zn.fac
starting interp point loop for 800 points
took 2.576814 seconds
2019-05-07 09:54:33.032780 finished: calculating factors for p=sy2, k=2 took: 0:00:02.647287
2019-05-07 09:54:33.033918 starting: calculating factors for p=ss2, k=2
2019-05-07 09:54:33.034696 finished: calculating factors for p=ss2, k=2 took: 0:00:00.000778
2019-05-07 09:54:33.035271 starting: calculating factors for p=prsity2, k=2
2019-05-07 09:54:33.035971 finished: calculating factors for p=prsity2, k=2 took: 0:00:00.0007
2019-05-07 09:54:33.036915 starting: calculating factors for p=strt2, k=2
2019-05-07 09:54:33.038014 finished: calculating factors for p=strt2, k=2 took: 0:00:00.001099
2019-05-07 09:54:33.038782 starting: calculating factors for p=vka2, k=2
2019-05-07 09:54:33.039658 finished: calculating factors for p=vka2, k=2 took: 0:00:00.000876
2019-05-07 09:54:33.040342 starting: calculating factors for p=hk2, k=2
2019-05-07 09:54:33.041052 finished: calculating factors for p=hk2, k=2 took: 0:00:00.000710
2019-05-07 09:54:33.041349 starting: processing pp_prefix:sy2
2019-05-07 09:54:33.053806 starting: processing pp_prefix:vka0
2019-05-07 09:54:33.062966 starting: processing pp_prefix:ss0
2019-05-07 09:54:33.070986 starting: processing pp_prefix:sy1
2019-05-07 09:54:33.080105 starting: processing pp_prefix:ss1
2019-05-07 09:54:33.090433 starting: processing pp_prefix:sy0
2019-05-07 09:54:33.099470 starting: processing pp_prefix:prsity0
2019-05-07 09:54:33.107992 starting: processing pp_prefix:strt2
2019-05-07 09:54:33.115935 starting: processing pp_prefix:rech1
2019-05-07 09:54:33.124146 starting: processing pp_prefix:ss2
2019-05-07 09:54:33.132785 starting: processing pp_prefix:strt0
2019-05-07 09:54:33.140928 starting: processing pp_prefix:hk2
2019-05-07 09:54:33.150359 starting: processing pp_prefix:strt1
2019-05-07 09:54:33.158895 starting: processing pp_prefix:vka1
2019-05-07 09:54:33.166900 starting: processing pp_prefix:vka2
2019-05-07 09:54:33.174878 starting: processing pp_prefix:rech0
2019-05-07 09:54:33.182773 starting: processing pp_prefix:hk0
2019-05-07 09:54:33.191815 starting: processing pp_prefix:prsity1
2019-05-07 09:54:33.199954 starting: processing pp_prefix:prsity2
2019-05-07 09:54:33.208534 starting: processing pp_prefix:hk1
2019-05-07 09:54:33.312718 finished: setting up pilot point process took: 0:00:08.641125
2019-05-07 09:54:33.313136 starting: setting up grid process
2019-05-07 09:54:33.313221 WARNING: grid_geostruct is None, using ExpVario with contribution=1
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2019-05-07 09:54:33.313342 finished: setting up grid process took: 0:00:00.000206
2019-05-07 09:54:33.316186 starting: save test mlt array arr_mlt/hk0.dat_pp
2019-05-07 09:54:33.319153 finished: save test mlt array arr_mlt/hk0.dat_pp took: 0:00:00.00296
2019-05-07 09:54:33.320209 starting: save test mlt array arr_mlt/vka0.dat_pp
2019-05-07 09:54:33.322502 finished: save test mlt array arr_mlt/vka0.dat_pp took: 0:00:00.002
2019-05-07 09:54:33.323301 starting: save test mlt array arr_mlt/ss0.dat_pp
2019-05-07 09:54:33.329319 finished: save test mlt array arr_mlt/ss0.dat_pp took: 0:00:00.0060
2019-05-07 09:54:33.330324 starting: save test mlt array arr_mlt/sy0.dat_pp
2019-05-07 09:54:33.332544 finished: save test mlt array arr_mlt/sy0.dat_pp took: 0:00:00.0022
2019-05-07 09:54:33.333692 starting: save test mlt array arr_mlt/strt0.dat_pp
2019-05-07 09:54:33.336321 finished: save test mlt array arr_mlt/strt0.dat_pp took: 0:00:00.002
2019-05-07 09:54:33.337338 starting: save test mlt array arr_mlt/prsity0.dat_pp
2019-05-07 09:54:33.340192 finished: save test mlt array arr_mlt/prsity0.dat_pp took: 0:00:00.0
2019-05-07 09:54:33.341380 starting: save test mlt array arr_mlt/hk1.dat_pp
2019-05-07 09:54:33.344149 finished: save test mlt array arr_mlt/hk1.dat_pp took: 0:00:00.00276
2019-05-07 09:54:33.345135 starting: save test mlt array arr_mlt/vka1.dat_pp
2019-05-07 09:54:33.347419 finished: save test mlt array arr_mlt/vka1.dat_pp took: 0:00:00.002
2019-05-07 09:54:33.348332 starting: save test mlt array arr_mlt/ss1.dat_pp
2019-05-07 09:54:33.350653 finished: save test mlt array arr_mlt/ss1.dat_pp took: 0:00:00.0023
2019-05-07 09:54:33.351668 starting: save test mlt array arr_mlt/sy1.dat_pp
2019-05-07 09:54:33.354049 finished: save test mlt array arr_mlt/sy1.dat_pp took: 0:00:00.00238
2019-05-07 09:54:33.354948 starting: save test mlt array arr_mlt/strt1.dat_pp
2019-05-07 09:54:33.357131 finished: save test mlt array arr_mlt/strt1.dat_pp took: 0:00:00.002
2019-05-07 09:54:33.358032 starting: save test mlt array arr_mlt/prsity1.dat_pp
2019-05-07 09:54:33.361283 finished: save test mlt array arr_mlt/prsity1.dat_pp took: 0:00:00.0
2019-05-07 09:54:33.362311 starting: save test mlt array arr_mlt/hk2.dat_pp
2019-05-07 09:54:33.364675 finished: save test mlt array arr_mlt/hk2.dat_pp took: 0:00:00.00236
2019-05-07 09:54:33.365589 starting: save test mlt array arr_mlt/vka2.dat_pp
2019-05-07 09:54:33.367943 finished: save test mlt array arr_mlt/vka2.dat_pp took: 0:00:00.0023
2019-05-07 09:54:33.368919 starting: save test mlt array arr_mlt/ss2.dat_pp
2019-05-07 09:54:33.371180 finished: save test mlt array arr_mlt/ss2.dat_pp took: 0:00:00.00226
2019-05-07 09:54:33.372091 starting: save test mlt array arr_mlt/sy2.dat_pp
2019-05-07 09:54:33.374326 finished: save test mlt array arr_mlt/sy2.dat_pp took: 0:00:00.00223
2019-05-07 09:54:33.375346 starting: save test mlt array arr_mlt/strt2.dat_pp
2019-05-07 09:54:33.378335 finished: save test mlt array arr_mlt/strt2.dat_pp took: 0:00:00.002
2019-05-07 09:54:33.379349 starting: save test mlt array arr_mlt/prsity2.dat_pp
2019-05-07 09:54:33.381881 finished: save test mlt array arr_mlt/prsity2.dat_pp took: 0:00:00.0
2019-05-07 09:54:33.382890 starting: save test mlt array arr_mlt/rech0.dat_pp
2019-05-07 09:54:33.385212 finished: save test mlt array arr_mlt/rech0.dat_pp took: 0:00:00.002
2019-05-07 09:54:33.386142 starting: save test mlt array arr_mlt/rech1.dat_pp
2019-05-07 09:54:33.390103 finished: save test mlt array arr_mlt/rech1.dat_pp took: 0:00:00.003
2019-05-07 09:54:33.391714 starting: save test mlt array arr_mlt/hk3.dat_gr
2019-05-07 09:54:33.395568 finished: save test mlt array arr_mlt/hk3.dat_gr took: 0:00:00.00385
2019-05-07 09:54:33.396813 starting: save test mlt array arr_mlt/vka3.dat_gr
2019-05-07 09:54:33.400257 finished: save test mlt array arr_mlt/vka3.dat_gr took: 0:00:00.0034
2019-05-07 09:54:33.401764 starting: save test mlt array arr_mlt/ss3.dat_gr
2019-05-07 09:54:33.405185 finished: save test mlt array arr_mlt/ss3.dat_gr took: 0:00:00.0034
2019-05-07 09:54:33.406515 starting: save test mlt array arr_mlt/sy3.dat_gr
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2019-05-07 09:54:33.410188 finished: save test mlt array arr_mlt/sy3.dat_gr took: 0:00:00.0036
2019-05-07 09:54:33.411640 starting: save test mlt array arr_mlt/strt3.dat_gr
2019-05-07 09:54:33.415460 finished: save test mlt array arr_mlt/strt3.dat_gr took: 0:00:00.003
2019-05-07 09:54:33.416894 starting: save test mlt array arr_mlt/prsity3.dat_gr
2019-05-07 09:54:33.420227 finished: save test mlt array arr_mlt/prsity3.dat_gr took: 0:00:00.0
2019-05-07 09:54:33.421899 starting: save test mlt array arr_mlt/hk4.dat_gr
2019-05-07 09:54:33.425556 finished: save test mlt array arr_mlt/hk4.dat_gr took: 0:00:00.0036
2019-05-07 09:54:33.426999 starting: save test mlt array arr_mlt/vka4.dat_gr
2019-05-07 09:54:33.430337 finished: save test mlt array arr_mlt/vka4.dat_gr took: 0:00:00.0033
2019-05-07 09:54:33.431495 starting: save test mlt array arr_mlt/ss4.dat_gr
2019-05-07 09:54:33.434466 finished: save test mlt array arr_mlt/ss4.dat_gr took: 0:00:00.0029
2019-05-07 09:54:33.435939 starting: save test mlt array arr_mlt/sy4.dat_gr
2019-05-07 09:54:33.439633 finished: save test mlt array arr_mlt/sy4.dat_gr took: 0:00:00.0036
2019-05-07 09:54:33.441380 starting: save test mlt array arr_mlt/strt4.dat_gr
2019-05-07 09:54:33.444694 finished: save test mlt array arr_mlt/strt4.dat_gr took: 0:00:00.003
2019-05-07 09:54:33.445904 starting: save test mlt array arr_mlt/prsity4.dat_gr
2019-05-07 09:54:33.449295 finished: save test mlt array arr_mlt/prsity4.dat_gr took: 0:00:00.0
2019-05-07 09:54:33.450601 starting: save test mlt array arr_mlt/hk5.dat_gr
2019-05-07 09:54:33.453955 finished: save test mlt array arr_mlt/hk5.dat_gr took: 0:00:00.0033
2019-05-07 09:54:33.455334 starting: save test mlt array arr_mlt/vka5.dat_gr
2019-05-07 09:54:33.458993 finished: save test mlt array arr_mlt/vka5.dat_gr took: 0:00:00.0036
2019-05-07 09:54:33.460492 starting: save test mlt array arr_mlt/ss5.dat_gr
2019-05-07 09:54:33.464444 finished: save test mlt array arr_mlt/ss5.dat_gr took: 0:00:00.0039
2019-05-07 09:54:33.466190 starting: save test mlt array arr_mlt/sy5.dat_gr
2019-05-07 09:54:33.469759 finished: save test mlt array arr_mlt/sy5.dat_gr took: 0:00:00.0035
2019-05-07 09:54:33.471353 starting: save test mlt array arr_mlt/strt5.dat_gr
2019-05-07 09:54:33.475008 finished: save test mlt array arr_mlt/strt5.dat_gr took: 0:00:00.003
2019-05-07 09:54:33.476648 starting: save test mlt array arr_mlt/prsity5.dat_gr
2019-05-07 09:54:33.480310 finished: save test mlt array arr_mlt/prsity5.dat_gr took: 0:00:00.0
2019-05-07 09:54:33.481884 starting: save test mlt array arr_mlt/rech2.dat_gr
2019-05-07 09:54:33.485494 finished: save test mlt array arr_mlt/rech2.dat_gr took: 0:00:00.003
2019-05-07 09:54:33.486992 starting: save test mlt array arr_mlt/rech3.dat_gr
2019-05-07 09:54:33.491141 finished: save test mlt array arr_mlt/rech3.dat_gr took: 0:00:00.004
2019-05-07 09:54:33.492699 starting: save test mlt array arr_mlt/hk6.dat_cn
2019-05-07 09:54:33.496814 finished: save test mlt array arr_mlt/hk6.dat_cn took: 0:00:00.0041
2019-05-07 09:54:33.498295 starting: save test mlt array arr_mlt/vka6.dat_cn
2019-05-07 09:54:33.502254 finished: save test mlt array arr_mlt/vka6.dat_cn took: 0:00:00.0039
2019-05-07 09:54:33.503777 starting: save test mlt array arr_mlt/ss6.dat_cn
2019-05-07 09:54:33.507044 finished: save test mlt array arr_mlt/ss6.dat_cn took: 0:00:00.0032
2019-05-07 09:54:33.508697 starting: save test mlt array arr_mlt/sy6.dat_cn
2019-05-07 09:54:33.512038 finished: save test mlt array arr_mlt/sy6.dat_cn took: 0:00:00.0033
2019-05-07 09:54:33.513526 starting: save test mlt array arr_mlt/strt6.dat_cn
2019-05-07 09:54:33.516695 finished: save test mlt array arr_mlt/strt6.dat_cn took: 0:00:00.003
2019-05-07 09:54:33.517973 starting: save test mlt array arr_mlt/prsity6.dat_cn
2019-05-07 09:54:33.521130 finished: save test mlt array arr_mlt/prsity6.dat_cn took: 0:00:00.0
2019-05-07 09:54:33.522501 starting: save test mlt array arr_mlt/hk7.dat_cn
2019-05-07 09:54:33.525945 finished: save test mlt array arr_mlt/hk7.dat_cn took: 0:00:00.0034
2019-05-07 09:54:33.527041 starting: save test mlt array arr_mlt/vka7.dat_cn
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2019-05-07 09:54:33.529764 finished: save test mlt array arr_mlt/vka7.dat_cn took: 0:00:00.002
2019-05-07 09:54:33.530858 starting: save test mlt array arr_mlt/ss7.dat_cn
2019-05-07 09:54:33.533663 finished: save test mlt array arr_mlt/ss7.dat_cn took: 0:00:00.0028
2019-05-07 09:54:33.534997 starting: save test mlt array arr_mlt/sy7.dat_cn
2019-05-07 09:54:33.538982 finished: save test mlt array arr_mlt/sy7.dat_cn took: 0:00:00.0039
2019-05-07 09:54:33.540411 starting: save test mlt array arr_mlt/strt7.dat_cn
2019-05-07 09:54:33.544453 finished: save test mlt array arr_mlt/strt7.dat_cn took: 0:00:00.004
2019-05-07 09:54:33.546126 starting: save test mlt array arr_mlt/prsity7.dat_cn
2019-05-07 09:54:33.549328 finished: save test mlt array arr_mlt/prsity7.dat_cn took: 0:00:00.0
2019-05-07 09:54:33.550781 starting: save test mlt array arr_mlt/hk8.dat_cn
2019-05-07 09:54:33.554185 finished: save test mlt array arr_mlt/hk8.dat_cn took: 0:00:00.0034
2019-05-07 09:54:33.555697 starting: save test mlt array arr_mlt/vka8.dat_cn
2019-05-07 09:54:33.559473 finished: save test mlt array arr_mlt/vka8.dat_cn took: 0:00:00.003
2019-05-07 09:54:33.561010 starting: save test mlt array arr_mlt/ss8.dat_cn
2019-05-07 09:54:33.564365 finished: save test mlt array arr_mlt/ss8.dat_cn took: 0:00:00.0033
2019-05-07 09:54:33.565737 starting: save test mlt array arr_mlt/sy8.dat_cn
2019-05-07 09:54:33.568656 finished: save test mlt array arr_mlt/sy8.dat_cn took: 0:00:00.0029
2019-05-07 09:54:33.569939 starting: save test mlt array arr_mlt/strt8.dat_cn
2019-05-07 09:54:33.573571 finished: save test mlt array arr_mlt/strt8.dat_cn took: 0:00:00.003
2019-05-07 09:54:33.575507 starting: save test mlt array arr_mlt/prsity8.dat_cn
2019-05-07 09:54:33.578768 finished: save test mlt array arr_mlt/prsity8.dat_cn took: 0:00:00.0
2019-05-07 09:54:33.580208 starting: save test mlt array arr_mlt/rech4.dat_cn
2019-05-07 09:54:33.583412 finished: save test mlt array arr_mlt/rech4.dat_cn took: 0:00:00.003
2019-05-07 09:54:33.584764 starting: save test mlt array arr_mlt/rech5.dat_cn
2019-05-07 09:54:33.587421 finished: save test mlt array arr_mlt/rech5.dat_cn took: 0:00:00.002
2019-05-07 09:54:34.220903 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 09:54:34.354092 starting: processing obs type mflist water budget obs
2019-05-07 09:54:34.465015 forward_run line:pyemu.gw_utils.apply_mflist_budget_obs('freyberg.li
2019-05-07 09:54:34.465653 finished: processing obs type mflist water budget obs took: 0:00:00
2019-05-07 09:54:34.466047 starting: processing obs type hyd file
2019-05-07 09:54:34.466516 finished: processing obs type hyd file took: 0:00:00.000469
2019-05-07 09:54:34.466850 starting: processing obs type external obs-sim smp files
2019-05-07 09:54:34.467279 finished: processing obs type external obs-sim smp files took: 0:00
2019-05-07 09:54:34.467675 starting: processing obs type hob
2019-05-07 09:54:34.467862 finished: processing obs type hob took: 0:00:00.000187
2019-05-07 09:54:34.467910 starting: processing obs type hds
[[0, 0], [0, 1], [0, 2], [1, 0], [1, 1], [1, 2]]
2019-05-07 09:54:34.906956 finished: processing obs type hds took: 0:00:00.439046
2019-05-07 09:54:34.907416 starting: processing obs type sfr
writing 'sfr_obs.config' to template/sfr_obs.config
2019-05-07 09:54:35.246183 finished: processing obs type sfr took: 0:00:00.338767
2019-05-07 09:54:35.246342 changing dir in to template
2019-05-07 09:54:35.247476 starting: instantiating control file from i/o files
2019-05-07 09:54:35.247581 tpl files: wel.csv.tpl,drn.csv.tpl,hk3.dat_gr.tpl,vka3.dat_gr.tpl,ss
```

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2019-05-07 09:54:35.247633 ins files: freyberg.hds.dat.ins,vol.dat.ins,freyberg.sfr.out.process
2019-05-07 09:54:35.585236 finished: instantiating control file from i/o files took: 0:00:00.33
2019-05-07 09:54:35.813859 starting: writing forward_run.py
2019-05-07 09:54:35.814774 finished: writing forward_run.py took: 0:00:00.000915
2019-05-07 09:54:35.815281 writing pst template/freyberg.pst
2019-05-07 09:54:37.578440 starting: running pestchek on freyberg.pst
2019-05-07 09:54:37.684411 pestcheck:PESTCHEK Version 13.0. Watermark Numerical Computing.
2019-05-07 09:54:37.684806 pestcheck:
2019-05-07 09:54:37.684861 pestcheck:Errors ----->
2019-05-07 09:54:37.685173 pestcheck:Line 2403 of file freyberg.pst: parameter name "prsity3000
2019-05-07 09:54:37.685783 pestcheck:12 characters long.
2019-05-07 09:54:37.686031 pestcheck:Line 2404 of file freyberg.pst: parameter name "prsity3000
2019-05-07 09:54:37.686084 pestcheck:12 characters long.
2019-05-07 09:54:37.686122 pestcheck:Line 2404 of file freyberg.pst: parameter name "prsity3000
2019-05-07 09:54:37.686393 pestcheck:once.
2019-05-07 09:54:37.686805 pestcheck:Line 2405 of file freyberg.pst: parameter name "prsity3000
2019-05-07 09:54:37.687099 pestcheck:12 characters long.
2019-05-07 09:54:37.687139 pestcheck:Line 2405 of file freyberg.pst: parameter name "prsity3000
2019-05-07 09:54:37.687184 pestcheck:once.
2019-05-07 09:54:37.687214 pestcheck:Line 2406 of file freyberg.pst: parameter name "prsity3000
2019-05-07 09:54:37.687246 pestcheck:12 characters long.
2019-05-07 09:54:37.687292 pestcheck:Line 2406 of file freyberg.pst: parameter name "prsity3000
2019-05-07 09:54:37.687325 pestcheck:once.
2019-05-07 09:54:37.687453 pestcheck:Line 2407 of file freyberg.pst: parameter name "prsity3000
2019-05-07 09:54:37.687486 pestcheck:12 characters long.
2019-05-07 09:54:37.687531 pestcheck:Line 2407 of file freyberg.pst: parameter name "prsity3000
2019-05-07 09:54:37.687579 pestcheck:once.
2019-05-07 09:54:37.687611 pestcheck:Line 2408 of file freyberg.pst: parameter name "prsity3000
2019-05-07 09:54:37.687664 pestcheck:12 characters long.
2019-05-07 09:54:37.687697 pestcheck:Line 2408 of file freyberg.pst: parameter name "prsity3000
2019-05-07 09:54:37.687808 pestcheck:once.
2019-05-07 09:54:37.687846 pestcheck:Line 2409 of file freyberg.pst: parameter name "prsity3000
2019-05-07 09:54:37.687878 pestcheck:12 characters long.
2019-05-07 09:54:37.687921 pestcheck:Line 2409 of file freyberg.pst: parameter name "prsity3000
2019-05-07 09:54:37.687954 pestcheck:once.
2019-05-07 09:54:37.688057 pestcheck:Line 2410 of file freyberg.pst: parameter name "prsity3000
2019-05-07 09:54:37.688090 pestcheck:12 characters long.
2019-05-07 09:54:37.688128 pestcheck:Line 2410 of file freyberg.pst: parameter name "prsity3000
2019-05-07 09:54:37.688161 pestcheck:once.
2019-05-07 09:54:37.688189 pestcheck:Line 2411 of file freyberg.pst: parameter name "prsity3000
2019-05-07 09:54:37.688240 pestcheck:12 characters long.
2019-05-07 09:54:37.688338 pestcheck:Line 2411 of file freyberg.pst: parameter name "prsity3000
2019-05-07 09:54:37.688389 pestcheck:once.
2019-05-07 09:54:37.688484 pestcheck:Line 2412 of file freyberg.pst: parameter name "prsity3000
2019-05-07 09:54:37.688529 pestcheck:12 characters long.
2019-05-07 09:54:37.688567 pestcheck:Line 2412 of file freyberg.pst: parameter name "prsity3000
2019-05-07 09:54:37.688715 pestcheck:once.
2019-05-07 09:54:37.688834 pestcheck:Line 2413 of file freyberg.pst: parameter name "prsity3000
```

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2019-05-07 09:54:37.688951 pestcheck:12 characters long.
2019-05-07 09:54:37.689002 pestcheck:Line 2414 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.689095 pestcheck:12 characters long.
2019-05-07 09:54:37.689142 pestcheck:Line 2414 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.689248 pestcheck:once.
2019-05-07 09:54:37.689350 pestcheck:Line 2415 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.689399 pestcheck:12 characters long.
2019-05-07 09:54:37.689441 pestcheck:Line 2415 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.689540 pestcheck:once.
2019-05-07 09:54:37.689642 pestcheck:Line 2416 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.689690 pestcheck:12 characters long.
2019-05-07 09:54:37.689795 pestcheck:Line 2416 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.689965 pestcheck:once.
2019-05-07 09:54:37.690036 pestcheck:Line 2417 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.690144 pestcheck:12 characters long.
2019-05-07 09:54:37.690196 pestcheck:Line 2417 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.690297 pestcheck:once.
2019-05-07 09:54:37.690343 pestcheck:Line 2418 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.690386 pestcheck:12 characters long.
2019-05-07 09:54:37.690490 pestcheck:Line 2418 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.690596 pestcheck:once.
2019-05-07 09:54:37.690644 pestcheck:Line 2419 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.690758 pestcheck:12 characters long.
2019-05-07 09:54:37.690863 pestcheck:Line 2419 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.691008 pestcheck:once.
2019-05-07 09:54:37.691112 pestcheck:Line 2420 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.691159 pestcheck:12 characters long.
2019-05-07 09:54:37.691263 pestcheck:Line 2420 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.691366 pestcheck:once.
2019-05-07 09:54:37.691431 pestcheck:Line 2421 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.691522 pestcheck:12 characters long.
2019-05-07 09:54:37.691625 pestcheck:Line 2421 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.691671 pestcheck:once.
2019-05-07 09:54:37.691774 pestcheck:Line 2422 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.691876 pestcheck:12 characters long.
2019-05-07 09:54:37.691993 pestcheck:Line 2422 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.692096 pestcheck:once.
2019-05-07 09:54:37.692208 pestcheck:Line 2423 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.692311 pestcheck:12 characters long.
2019-05-07 09:54:37.692356 pestcheck:Line 2424 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.692458 pestcheck:12 characters long.
2019-05-07 09:54:37.692560 pestcheck:Line 2424 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.692606 pestcheck:once.
2019-05-07 09:54:37.692707 pestcheck:Line 2425 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.692810 pestcheck:12 characters long.
2019-05-07 09:54:37.692921 pestcheck:Line 2425 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.693040 pestcheck:once.
2019-05-07 09:54:37.693142 pestcheck:Line 2426 of file freyberg.pst: parameter name "prsity300
```

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2019-05-07 09:54:37.693245 pestcheck:12 characters long.
2019-05-07 09:54:37.693291 pestcheck:Line 2426 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.693421 pestcheck:once.
2019-05-07 09:54:37.693523 pestcheck:Line 2427 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.693635 pestcheck:12 characters long.
2019-05-07 09:54:37.693737 pestcheck:Line 2427 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.693783 pestcheck:once.
2019-05-07 09:54:37.693885 pestcheck:Line 2428 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.694001 pestcheck:12 characters long.
2019-05-07 09:54:37.694102 pestcheck:Line 2428 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.694205 pestcheck:once.
2019-05-07 09:54:37.694251 pestcheck:Line 2429 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.694353 pestcheck:12 characters long.
2019-05-07 09:54:37.694453 pestcheck:Line 2429 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.694500 pestcheck:once.
2019-05-07 09:54:37.694603 pestcheck:Line 2430 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.694706 pestcheck:12 characters long.
2019-05-07 09:54:37.694818 pestcheck:Line 2430 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.694921 pestcheck:once.
2019-05-07 09:54:37.695038 pestcheck:Line 2431 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.695173 pestcheck:12 characters long.
2019-05-07 09:54:37.695221 pestcheck:Line 2431 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.695306 pestcheck:once.
2019-05-07 09:54:37.695432 pestcheck:Line 2432 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.695536 pestcheck:12 characters long.
2019-05-07 09:54:37.695650 pestcheck:Line 2432 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.695752 pestcheck:once.
2019-05-07 09:54:37.695801 pestcheck:Line 2433 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.695904 pestcheck:12 characters long.
2019-05-07 09:54:37.696023 pestcheck:Line 2434 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.696125 pestcheck:12 characters long.
2019-05-07 09:54:37.696227 pestcheck:Line 2434 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.696272 pestcheck:once.
2019-05-07 09:54:37.696374 pestcheck:Line 2435 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.696476 pestcheck:12 characters long.
2019-05-07 09:54:37.696587 pestcheck:Line 2435 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.696690 pestcheck:once.
2019-05-07 09:54:37.696801 pestcheck:Line 2436 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.696903 pestcheck:12 characters long.
2019-05-07 09:54:37.697018 pestcheck:Line 2436 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.697122 pestcheck:once.
2019-05-07 09:54:37.697233 pestcheck:Line 2437 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.697335 pestcheck:12 characters long.
2019-05-07 09:54:37.697381 pestcheck:Line 2437 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.697482 pestcheck:once.
2019-05-07 09:54:37.697555 pestcheck:Line 2438 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.697624 pestcheck:12 characters long.
2019-05-07 09:54:37.697669 pestcheck:Line 2438 of file freyberg.pst: parameter name "prsity300
```

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2019-05-07 09:54:37.697770 pestcheck:once.
2019-05-07 09:54:37.697873 pestcheck:Line 2439 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.697988 pestcheck:12 characters long.
2019-05-07 09:54:37.698090 pestcheck:Line 2439 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.698138 pestcheck:once.
2019-05-07 09:54:37.698240 pestcheck:Line 2440 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.698292 pestcheck:12 characters long.
2019-05-07 09:54:37.698396 pestcheck:Line 2440 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.698443 pestcheck:once.
2019-05-07 09:54:37.698481 pestcheck:Line 2441 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.698585 pestcheck:12 characters long.
2019-05-07 09:54:37.698688 pestcheck:Line 2441 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.698737 pestcheck:once.
2019-05-07 09:54:37.698775 pestcheck:Line 2442 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.698875 pestcheck:12 characters long.
2019-05-07 09:54:37.698985 pestcheck:Line 2442 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.699097 pestcheck:once.
2019-05-07 09:54:37.699199 pestcheck:Line 2443 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.699311 pestcheck:12 characters long.
2019-05-07 09:54:37.699412 pestcheck:Line 2444 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.699458 pestcheck:12 characters long.
2019-05-07 09:54:37.699560 pestcheck:Line 2444 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.699609 pestcheck:once.
2019-05-07 09:54:37.699700 pestcheck:Line 2445 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.699750 pestcheck:12 characters long.
2019-05-07 09:54:37.699846 pestcheck:Line 2445 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.699968 pestcheck:once.
2019-05-07 09:54:37.700009 pestcheck:Line 2446 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.700106 pestcheck:12 characters long.
2019-05-07 09:54:37.700205 pestcheck:Line 2446 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.700250 pestcheck:once.
2019-05-07 09:54:37.700350 pestcheck:Line 2447 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.700450 pestcheck:12 characters long.
2019-05-07 09:54:37.700497 pestcheck:Line 2447 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.700601 pestcheck:once.
2019-05-07 09:54:37.700731 pestcheck:Line 2448 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.700833 pestcheck:12 characters long.
2019-05-07 09:54:37.701010 pestcheck:Line 2448 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.701108 pestcheck:once.
2019-05-07 09:54:37.701158 pestcheck:Line 2449 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.701257 pestcheck:12 characters long.
2019-05-07 09:54:37.701303 pestcheck:Line 2449 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.701342 pestcheck:once.
2019-05-07 09:54:37.701392 pestcheck:Line 2450 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.701485 pestcheck:12 characters long.
2019-05-07 09:54:37.701535 pestcheck:Line 2450 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.701629 pestcheck:once.
2019-05-07 09:54:37.701674 pestcheck:Line 2451 of file freyberg.pst: parameter name "prsity300
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2019-05-07 09:54:37.701712 pestcheck:12 characters long.
2019-05-07 09:54:37.701811 pestcheck:Line 2451 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.701929 pestcheck:once.
2019-05-07 09:54:37.701970 pestcheck:Line 2452 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.702068 pestcheck:12 characters long.
2019-05-07 09:54:37.702170 pestcheck:Line 2452 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.702215 pestcheck:once.
2019-05-07 09:54:37.702254 pestcheck:Line 2453 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.702351 pestcheck:12 characters long.
2019-05-07 09:54:37.702451 pestcheck:Line 2454 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.702497 pestcheck:12 characters long.
2019-05-07 09:54:37.702598 pestcheck:Line 2454 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.702699 pestcheck:once.
2019-05-07 09:54:37.702809 pestcheck:Line 2455 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.702925 pestcheck:12 characters long.
2019-05-07 09:54:37.702964 pestcheck:Line 2455 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.703061 pestcheck:once.
2019-05-07 09:54:37.703161 pestcheck:Line 2456 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.703210 pestcheck:12 characters long.
2019-05-07 09:54:37.703250 pestcheck:Line 2456 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.703347 pestcheck:once.
2019-05-07 09:54:37.703449 pestcheck:Line 2457 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.703560 pestcheck:12 characters long.
2019-05-07 09:54:37.703662 pestcheck:Line 2457 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.703707 pestcheck:once.
2019-05-07 09:54:37.703811 pestcheck:Line 2458 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.703922 pestcheck:12 characters long.
2019-05-07 09:54:37.703968 pestcheck:Line 2458 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.704072 pestcheck:once.
2019-05-07 09:54:37.704174 pestcheck:Line 2459 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.704222 pestcheck:12 characters long.
2019-05-07 09:54:37.704327 pestcheck:Line 2459 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.704377 pestcheck:once.
2019-05-07 09:54:37.704470 pestcheck:Line 2460 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.704580 pestcheck:12 characters long.
2019-05-07 09:54:37.704683 pestcheck:Line 2460 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.704728 pestcheck:once.
2019-05-07 09:54:37.704766 pestcheck:Line 2461 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.704863 pestcheck:12 characters long.
2019-05-07 09:54:37.704979 pestcheck:Line 2461 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.705079 pestcheck:once.
2019-05-07 09:54:37.705128 pestcheck:Line 2462 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.705220 pestcheck:12 characters long.
2019-05-07 09:54:37.705265 pestcheck:Line 2462 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.705306 pestcheck:once.
2019-05-07 09:54:37.705403 pestcheck:Line 2463 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.705452 pestcheck:12 characters long.
2019-05-07 09:54:37.705568 pestcheck:Line 2464 of file freyberg.pst: parameter name "prsity300
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2019-05-07 09:54:37.705637 pestcheck:12 characters long.
2019-05-07 09:54:37.705809 pestcheck:Line 2464 of file freyberg.pst: parameter name "prsity3003
2019-05-07 09:54:37.706016 pestcheck:once.
2019-05-07 09:54:37.706123 pestcheck:Line 2465 of file freyberg.pst: parameter name "prsity3003
2019-05-07 09:54:37.706172 pestcheck:12 characters long.
2019-05-07 09:54:37.706265 pestcheck:Line 2465 of file freyberg.pst: parameter name "prsity3003
2019-05-07 09:54:37.706376 pestcheck:once.
2019-05-07 09:54:37.706478 pestcheck:Line 2466 of file freyberg.pst: parameter name "prsity3003
2019-05-07 09:54:37.706521 pestcheck:12 characters long.
2019-05-07 09:54:37.706626 pestcheck:Line 2466 of file freyberg.pst: parameter name "prsity3003
2019-05-07 09:54:37.706676 pestcheck:once.
2019-05-07 09:54:37.706770 pestcheck:Line 2467 of file freyberg.pst: parameter name "prsity3003
2019-05-07 09:54:37.706822 pestcheck:12 characters long.
2019-05-07 09:54:37.707006 pestcheck:Line 2467 of file freyberg.pst: parameter name "prsity3003
2019-05-07 09:54:37.707061 pestcheck:once.
2019-05-07 09:54:37.707195 pestcheck:Line 2468 of file freyberg.pst: parameter name "prsity3003
2019-05-07 09:54:37.707335 pestcheck:12 characters long.
2019-05-07 09:54:37.707413 pestcheck:Line 2468 of file freyberg.pst: parameter name "prsity3003
2019-05-07 09:54:37.707573 pestcheck:once.
2019-05-07 09:54:37.707695 pestcheck:Line 2469 of file freyberg.pst: parameter name "prsity3003
2019-05-07 09:54:37.707839 pestcheck:12 characters long.
2019-05-07 09:54:37.707928 pestcheck:Line 2469 of file freyberg.pst: parameter name "prsity3003
2019-05-07 09:54:37.708184 pestcheck:once.
2019-05-07 09:54:37.708271 pestcheck:Line 2470 of file freyberg.pst: parameter name "prsity3003
2019-05-07 09:54:37.708351 pestcheck:12 characters long.
2019-05-07 09:54:37.708427 pestcheck:Line 2470 of file freyberg.pst: parameter name "prsity3003
2019-05-07 09:54:37.708642 pestcheck:once.
2019-05-07 09:54:37.708772 pestcheck:Line 2471 of file freyberg.pst: parameter name "prsity3003
2019-05-07 09:54:37.708830 pestcheck:12 characters long.
2019-05-07 09:54:37.708962 pestcheck:Line 2471 of file freyberg.pst: parameter name "prsity3003
2019-05-07 09:54:37.709071 pestcheck:once.
2019-05-07 09:54:37.709120 pestcheck:Line 2472 of file freyberg.pst: parameter name "prsity3003
2019-05-07 09:54:37.709161 pestcheck:12 characters long.
2019-05-07 09:54:37.709319 pestcheck:Line 2472 of file freyberg.pst: parameter name "prsity3003
2019-05-07 09:54:37.709460 pestcheck:once.
2019-05-07 09:54:37.709596 pestcheck:Line 2473 of file freyberg.pst: parameter name "prsity3003
2019-05-07 09:54:37.709672 pestcheck:12 characters long.
2019-05-07 09:54:37.709791 pestcheck:Line 2474 of file freyberg.pst: parameter name "prsity3003
2019-05-07 09:54:37.709986 pestcheck:12 characters long.
2019-05-07 09:54:37.710047 pestcheck:Line 2474 of file freyberg.pst: parameter name "prsity3003
2019-05-07 09:54:37.710157 pestcheck:once.
2019-05-07 09:54:37.710263 pestcheck:Line 2475 of file freyberg.pst: parameter name "prsity3003
2019-05-07 09:54:37.710317 pestcheck:12 characters long.
2019-05-07 09:54:37.710425 pestcheck:Line 2475 of file freyberg.pst: parameter name "prsity3003
2019-05-07 09:54:37.710736 pestcheck:once.
2019-05-07 09:54:37.710872 pestcheck:Line 2476 of file freyberg.pst: parameter name "prsity3003
2019-05-07 09:54:37.710997 pestcheck:12 characters long.
2019-05-07 09:54:37.711048 pestcheck:Line 2476 of file freyberg.pst: parameter name "prsity3003
```

```
2019-05-07 09:54:37.711107 pestcheck:once.
2019-05-07 09:54:37.711251 pestcheck:Line 2477 of file freyberg.pst: parameter name "prsity3003
2019-05-07 09:54:37.711371 pestcheck:12 characters long.
2019-05-07 09:54:37.711421 pestcheck:Line 2477 of file freyberg.pst: parameter name "prsity3003
2019-05-07 09:54:37.711461 pestcheck:once.
2019-05-07 09:54:37.711588 pestcheck:Line 2478 of file freyberg.pst: parameter name "prsity3003
2019-05-07 09:54:37.711905 pestcheck:12 characters long.
2019-05-07 09:54:37.712126 pestcheck:Line 2478 of file freyberg.pst: parameter name "prsity3003
2019-05-07 09:54:37.712182 pestcheck:once.
2019-05-07 09:54:37.712292 pestcheck:Line 2479 of file freyberg.pst: parameter name "prsity3003
2019-05-07 09:54:37.712400 pestcheck:12 characters long.
2019-05-07 09:54:37.712452 pestcheck:Line 2479 of file freyberg.pst: parameter name "prsity3003
2019-05-07 09:54:37.712571 pestcheck:once.
2019-05-07 09:54:37.712719 pestcheck:Line 2480 of file freyberg.pst: parameter name "prsity3003
2019-05-07 09:54:37.713039 pestcheck:12 characters long.
2019-05-07 09:54:37.713179 pestcheck:Line 2480 of file freyberg.pst: parameter name "prsity3003
2019-05-07 09:54:37.713286 pestcheck:once.
2019-05-07 09:54:37.713337 pestcheck:Line 2481 of file freyberg.pst: parameter name "prsity3003
2019-05-07 09:54:37.713379 pestcheck:12 characters long.
2019-05-07 09:54:37.713486 pestcheck:Line 2481 of file freyberg.pst: parameter name "prsity3003
2019-05-07 09:54:37.713596 pestcheck:once.
2019-05-07 09:54:37.713732 pestcheck:Line 2482 of file freyberg.pst: parameter name "prsity3003
2019-05-07 09:54:37.713855 pestcheck:12 characters long.
2019-05-07 09:54:37.713912 pestcheck:Line 2482 of file freyberg.pst: parameter name "prsity3003
2019-05-07 09:54:37.714024 pestcheck:once.
2019-05-07 09:54:37.714148 pestcheck:Line 2483 of file freyberg.pst: parameter name "prsity3004
2019-05-07 09:54:37.714254 pestcheck:12 characters long.
2019-05-07 09:54:37.714362 pestcheck:Line 2484 of file freyberg.pst: parameter name "prsity3004
2019-05-07 09:54:37.714414 pestcheck:12 characters long.
2019-05-07 09:54:37.714455 pestcheck:Line 2484 of file freyberg.pst: parameter name "prsity3004
2019-05-07 09:54:37.714506 pestcheck:once.
2019-05-07 09:54:37.714613 pestcheck:Line 2485 of file freyberg.pst: parameter name "prsity3004
2019-05-07 09:54:37.714667 pestcheck:12 characters long.
2019-05-07 09:54:37.714768 pestcheck:Line 2485 of file freyberg.pst: parameter name "prsity3004
2019-05-07 09:54:37.714816 pestcheck:once.
2019-05-07 09:54:37.714926 pestcheck:Line 2486 of file freyberg.pst: parameter name "prsity3004
2019-05-07 09:54:37.715033 pestcheck:12 characters long.
2019-05-07 09:54:37.715154 pestcheck:Line 2486 of file freyberg.pst: parameter name "prsity3004
2019-05-07 09:54:37.715261 pestcheck:once.
2019-05-07 09:54:37.715305 pestcheck:Line 2487 of file freyberg.pst: parameter name "prsity3004
2019-05-07 09:54:37.715410 pestcheck:12 characters long.
2019-05-07 09:54:37.715516 pestcheck:Line 2487 of file freyberg.pst: parameter name "prsity3004
2019-05-07 09:54:37.715598 pestcheck:once.
2019-05-07 09:54:37.716021 pestcheck:Line 2488 of file freyberg.pst: parameter name "prsity3004
2019-05-07 09:54:37.716225 pestcheck:12 characters long.
2019-05-07 09:54:37.716338 pestcheck:Line 2488 of file freyberg.pst: parameter name "prsity3004
2019-05-07 09:54:37.716383 pestcheck:once.
2019-05-07 09:54:37.716489 pestcheck:Line 2489 of file freyberg.pst: parameter name "prsity3004
```

```
2019-05-07 09:54:37.716598 pestcheck:12 characters long.
2019-05-07 09:54:37.716642 pestcheck:Line 2489 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.716747 pestcheck:once.
2019-05-07 09:54:37.716853 pestcheck:Line 2490 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.716903 pestcheck:12 characters long.
2019-05-07 09:54:37.717018 pestcheck:Line 2490 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.717261 pestcheck:once.
2019-05-07 09:54:37.717416 pestcheck:Line 2491 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.717474 pestcheck:12 characters long.
2019-05-07 09:54:37.717590 pestcheck:Line 2491 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.717788 pestcheck:once.
2019-05-07 09:54:37.717862 pestcheck:Line 2492 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.717977 pestcheck:12 characters long.
2019-05-07 09:54:37.718105 pestcheck:Line 2492 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.718236 pestcheck:once.
2019-05-07 09:54:37.718284 pestcheck:Line 2493 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.718366 pestcheck:12 characters long.
2019-05-07 09:54:37.718465 pestcheck:Line 2494 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.718519 pestcheck:12 characters long.
2019-05-07 09:54:37.718617 pestcheck:Line 2494 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.718667 pestcheck:once.
2019-05-07 09:54:37.718775 pestcheck:Line 2495 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.718881 pestcheck:12 characters long.
2019-05-07 09:54:37.718949 pestcheck:Line 2495 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.719069 pestcheck:once.
2019-05-07 09:54:37.719194 pestcheck:Line 2496 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.719245 pestcheck:12 characters long.
2019-05-07 09:54:37.719286 pestcheck:Line 2496 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.719394 pestcheck:once.
2019-05-07 09:54:37.719449 pestcheck:Line 2497 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.719547 pestcheck:12 characters long.
2019-05-07 09:54:37.719666 pestcheck:Line 2497 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.719719 pestcheck:once.
2019-05-07 09:54:37.719816 pestcheck:Line 2498 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.719865 pestcheck:12 characters long.
2019-05-07 09:54:37.719971 pestcheck:Line 2498 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.720081 pestcheck:once.
2019-05-07 09:54:37.720203 pestcheck:Line 2499 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.720313 pestcheck:12 characters long.
2019-05-07 09:54:37.720360 pestcheck:Line 2499 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.720466 pestcheck:once.
2019-05-07 09:54:37.720571 pestcheck:Line 2500 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.720688 pestcheck:12 characters long.
2019-05-07 09:54:37.721277 pestcheck:Line 2500 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.721382 pestcheck:once.
2019-05-07 09:54:37.721961 pestcheck:Line 2501 of file freyberg.pst: parameter name "prsity300
2019-05-07 09:54:37.722092 pestcheck:12 characters long.
2019-05-07 09:54:37.722202 pestcheck:Line 2501 of file freyberg.pst: parameter name "prsity300
```

```
2019-05-07 09:54:37.722319 pestcheck:once.
2019-05-07 09:54:37.722435 pestcheck:Line 2502 of file freyberg.pst: parameter name "prsity3004
2019-05-07 09:54:37.722550 pestcheck:12 characters long.
2019-05-07 09:54:37.722654 pestcheck:Line 2502 of file freyberg.pst: parameter name "prsity3004
2019-05-07 09:54:37.722769 pestcheck:once.
2019-05-07 09:54:37.722873 pestcheck:Line 2503 of file freyberg.pst: parameter name "prsity3005
2019-05-07 09:54:37.722986 pestcheck:12 characters long.
2019-05-07 09:54:37.723037 pestcheck:Line 2504 of file freyberg.pst: parameter name "prsity3005
2019-05-07 09:54:37.723132 pestcheck:12 characters long.
2019-05-07 09:54:37.723247 pestcheck:Line 2504 of file freyberg.pst: parameter name "prsity3005
2019-05-07 09:54:37.723351 pestcheck:once.
2019-05-07 09:54:37.723470 pestcheck:Line 2505 of file freyberg.pst: parameter name "prsity3005
2019-05-07 09:54:37.723576 pestcheck:12 characters long.
2019-05-07 09:54:37.723690 pestcheck:Line 2505 of file freyberg.pst: parameter name "prsity3005
2019-05-07 09:54:37.723794 pestcheck:once.
2019-05-07 09:54:37.723842 pestcheck:Line 2506 of file freyberg.pst: parameter name "prsity3005
2019-05-07 09:54:37.723882 pestcheck:12 characters long.
2019-05-07 09:54:37.723981 pestcheck:Line 2506 of file freyberg.pst: parameter name "prsity3005
2019-05-07 09:54:37.724031 pestcheck:once.
2019-05-07 09:54:37.724126 pestcheck:Line 2507 of file freyberg.pst: parameter name "prsity3005
2019-05-07 09:54:37.724239 pestcheck:12 characters long.
2019-05-07 09:54:37.724342 pestcheck:Line 2507 of file freyberg.pst: parameter name "prsity3005
2019-05-07 09:54:37.724465 pestcheck:once.
2019-05-07 09:54:37.724569 pestcheck:Line 2508 of file freyberg.pst: parameter name "prsity3005
2019-05-07 09:54:37.724616 pestcheck:12 characters long.
2019-05-07 09:54:37.724878 finished: running pestchek on freyberg.pst took: 0:00:00.146438
2019-05-07 09:54:37.724999 starting: saving intermediate _setup_<> dfs into template
2019-05-07 09:54:37.858397 finished: saving intermediate _setup_<> dfs into template took: 0:0
2019-05-07 09:54:37.858575 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()

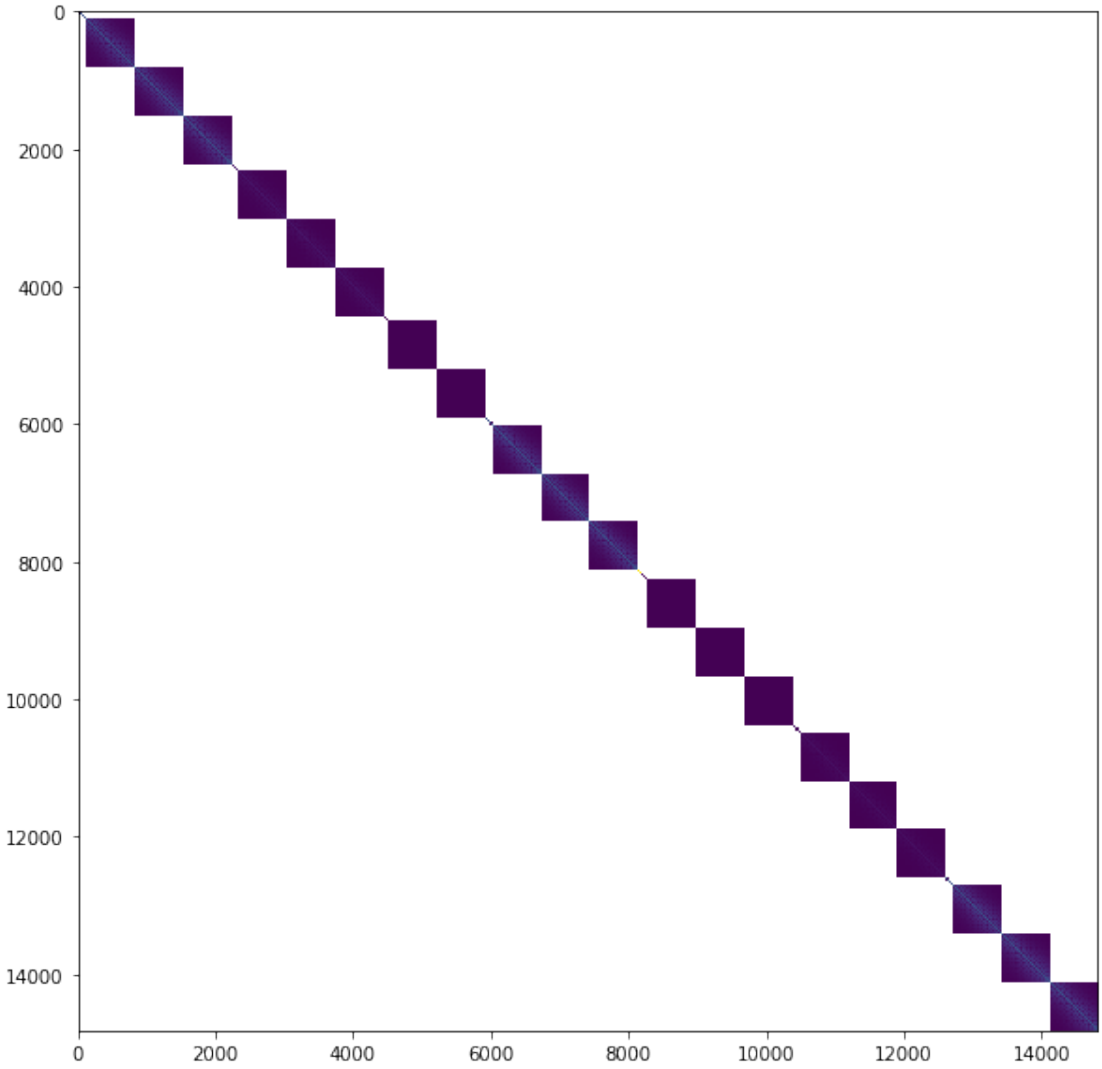
2019-05-07 09:54:47.538350 starting: building prior covariance matrix
2019-05-07 09:54:47.655190 WARNING: geospatial prior not implemented for SFR pars


/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 09:54:54.090200 saving prior covariance matrix to file template/prior_cov.jcb
2019-05-07 09:54:58.429830 finished: building prior covariance matrix took: 0:00:10.891480
```



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 09:55:12.624792 starting: drawing realizations
building diagonal cov
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
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_ss1']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_strt1']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_sy1']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_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_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_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_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_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_prsity2']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_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_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_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
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:2500.0,anisotropy:1.0,bearing:0.0

working on pargroups ['welflux_k02']


/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

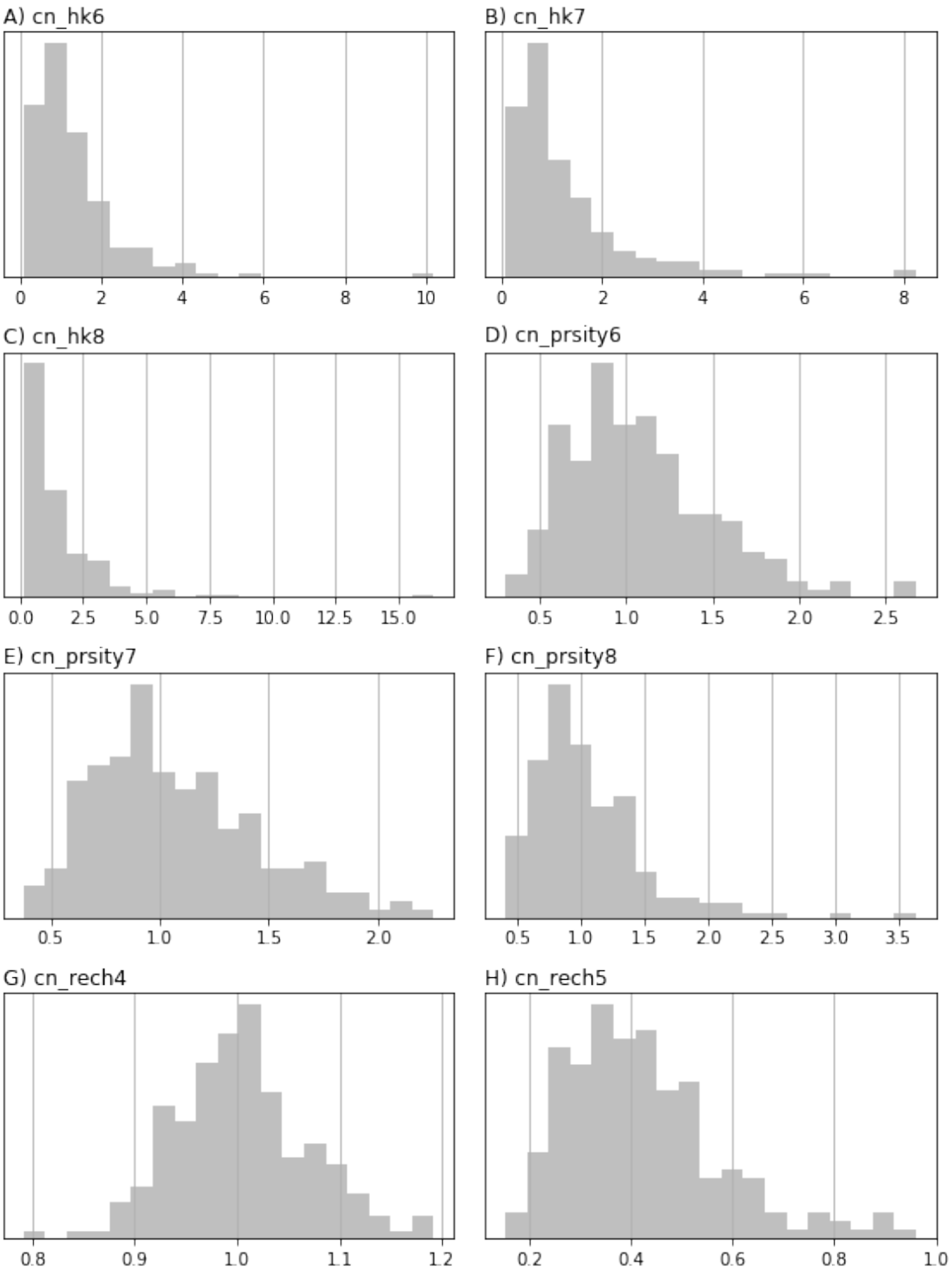
See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stable/indexing.html
  self.obj[item] = s

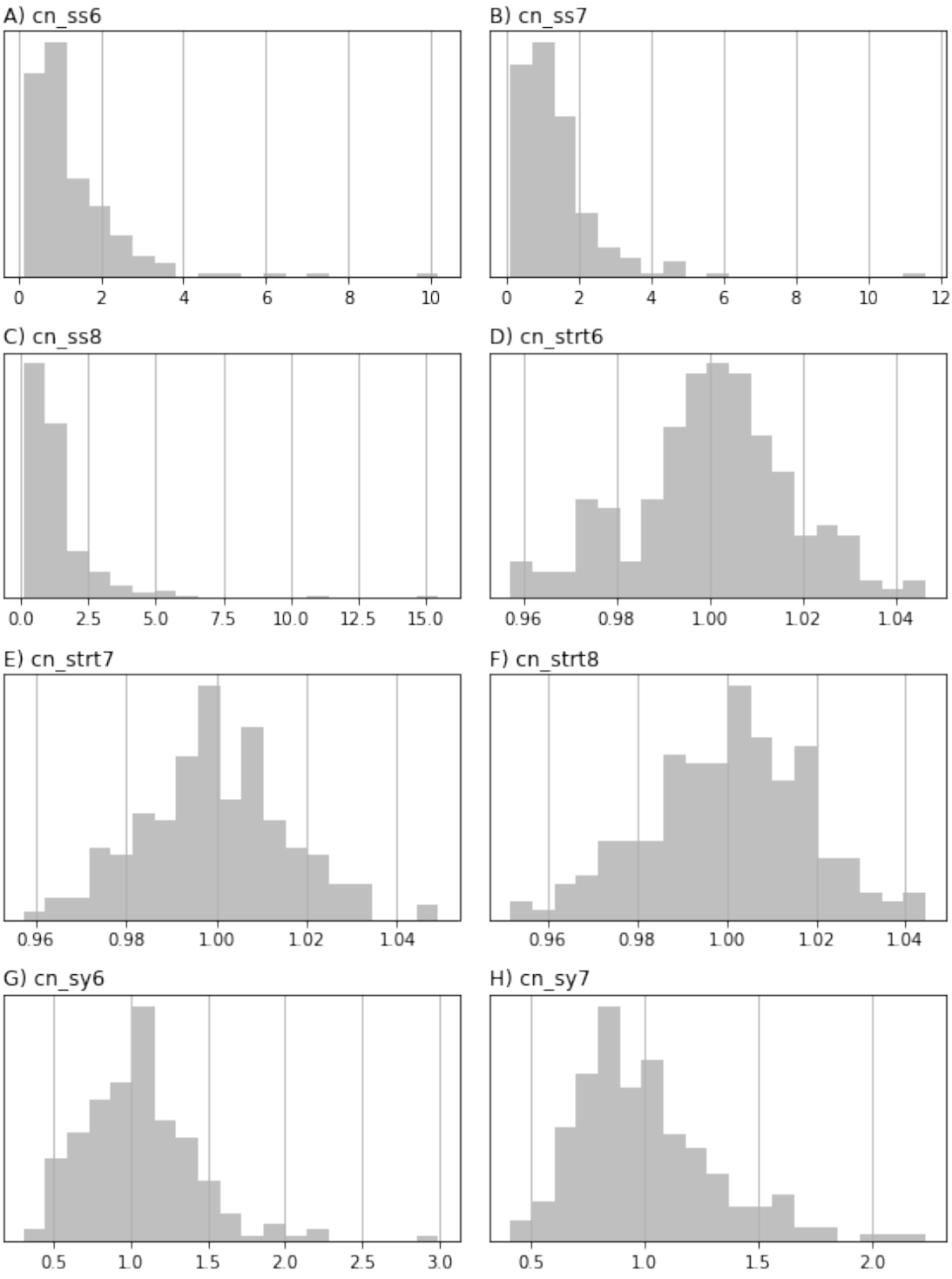

build cov matrix
done
getting diag var cov 6
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['drncond_k00']
build cov matrix
done
getting diag var cov 10
scaling full cov by diag var cov
making full cov draws with home-grown goodness
adding remaining parameters to diagonal
2019-05-07 09:55:19.824867 finished: drawing realizations took: 0:00:07.200075
```

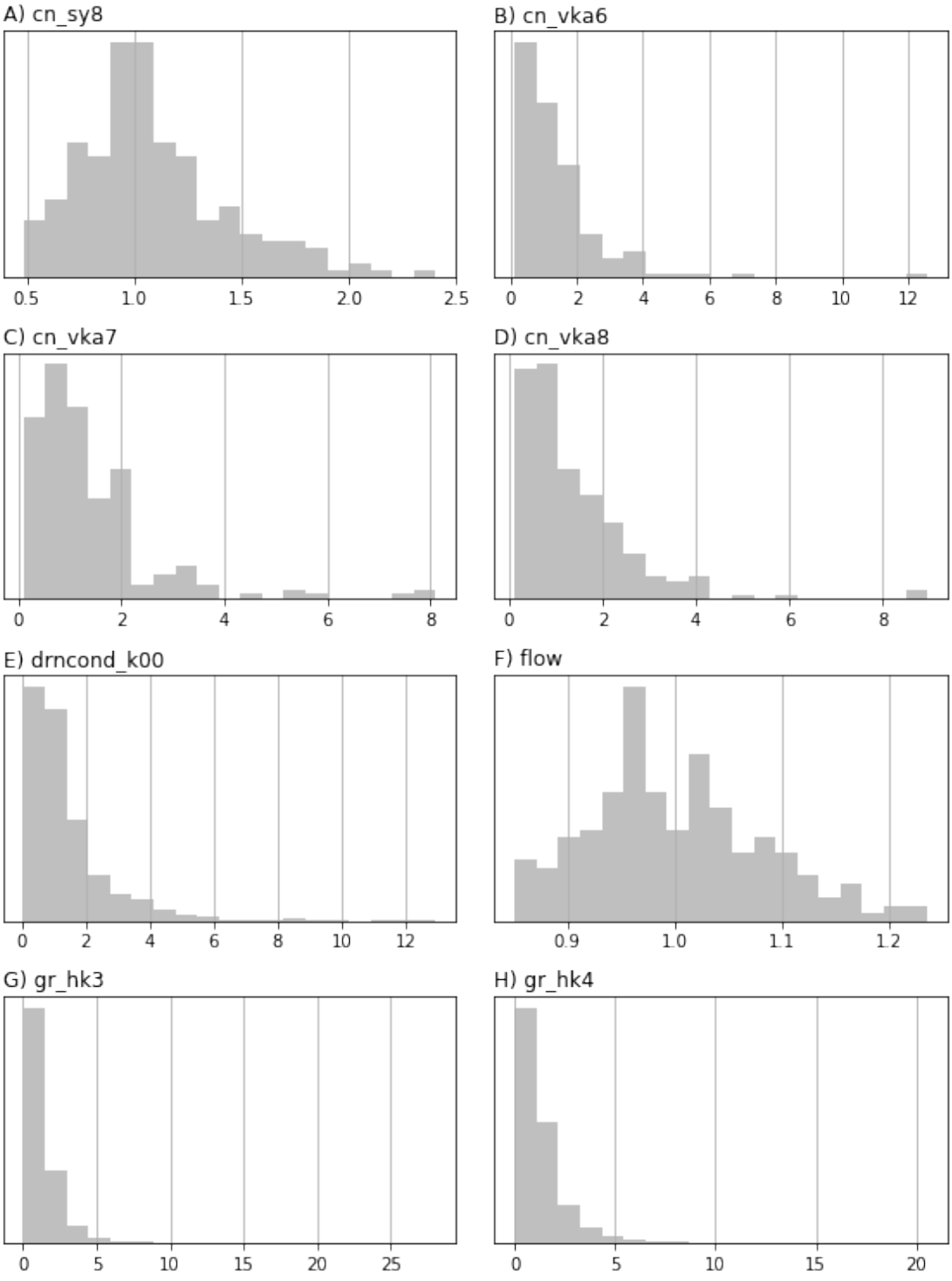
You can see that parameters are treated in parameter group (pargp) blocks for this ensemble generation. Let's plot one parameter:

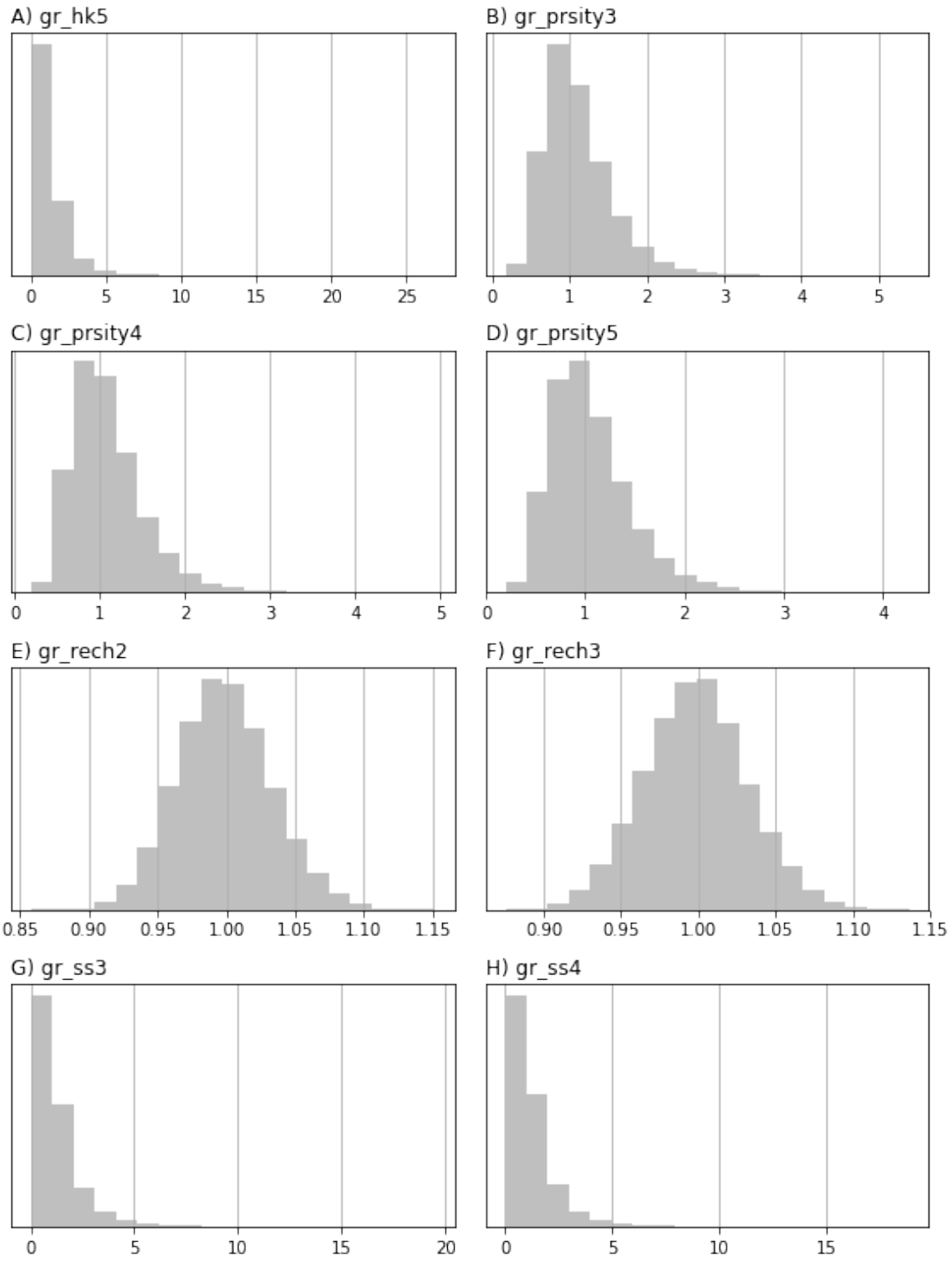
```
In [26]: par = pst_helper.pst.parameter_data
         pyemu.plot_utils.ensemble_helper(pe,plot_cols=par.groupby("pargp").groups,bins=20)
         plt.show()
```

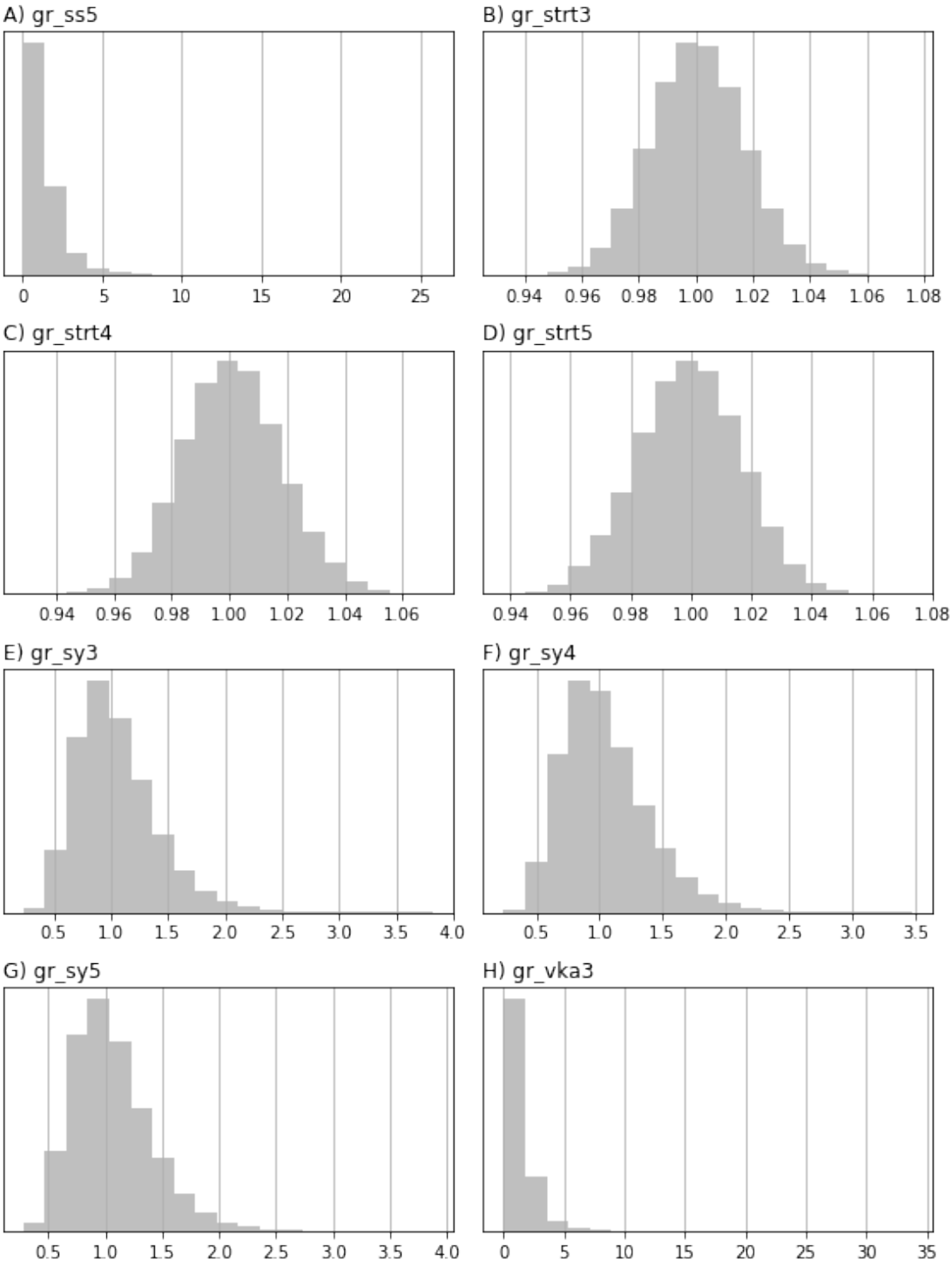
```
<Figure size 576x756 with 0 Axes>
```

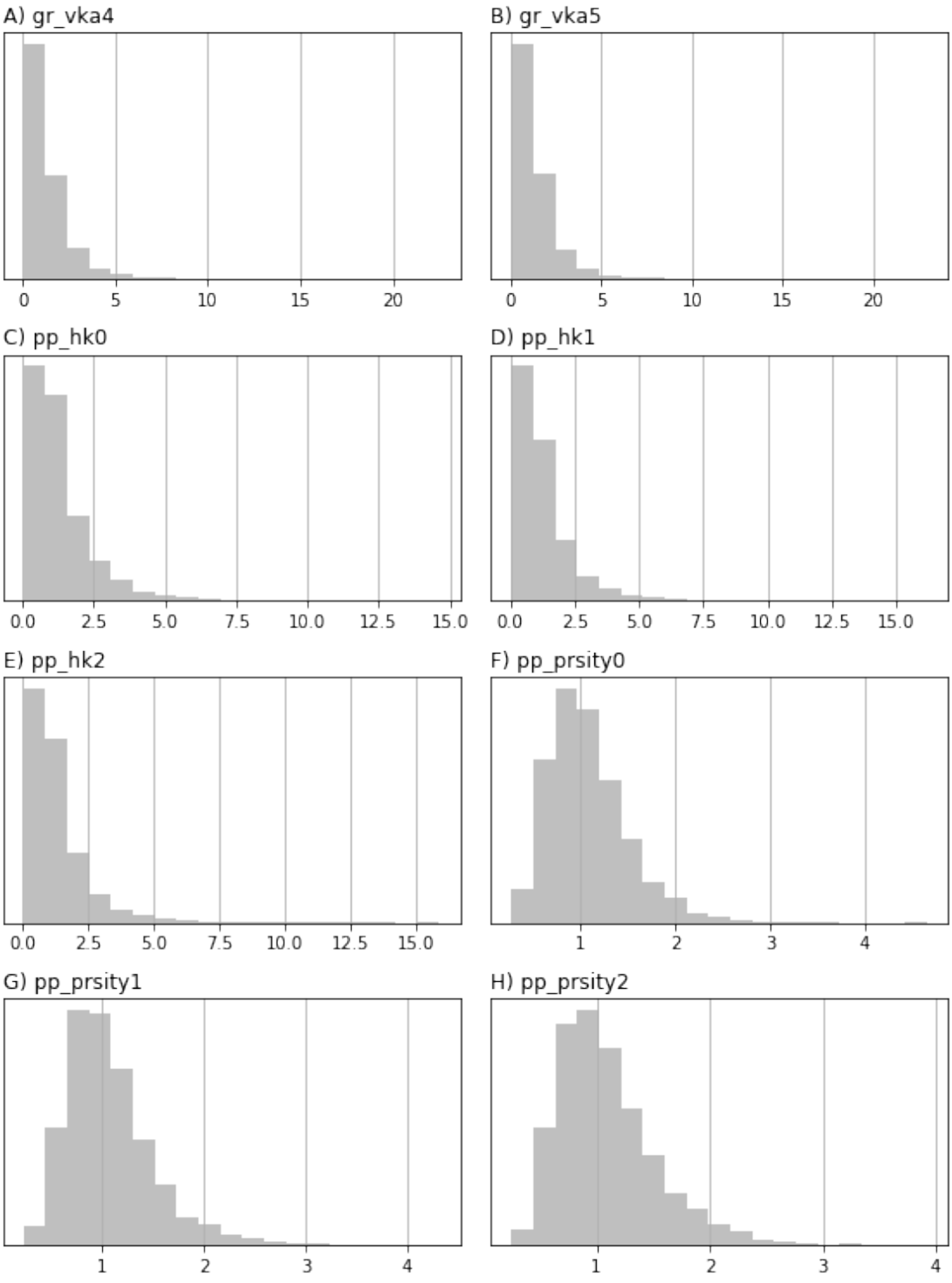


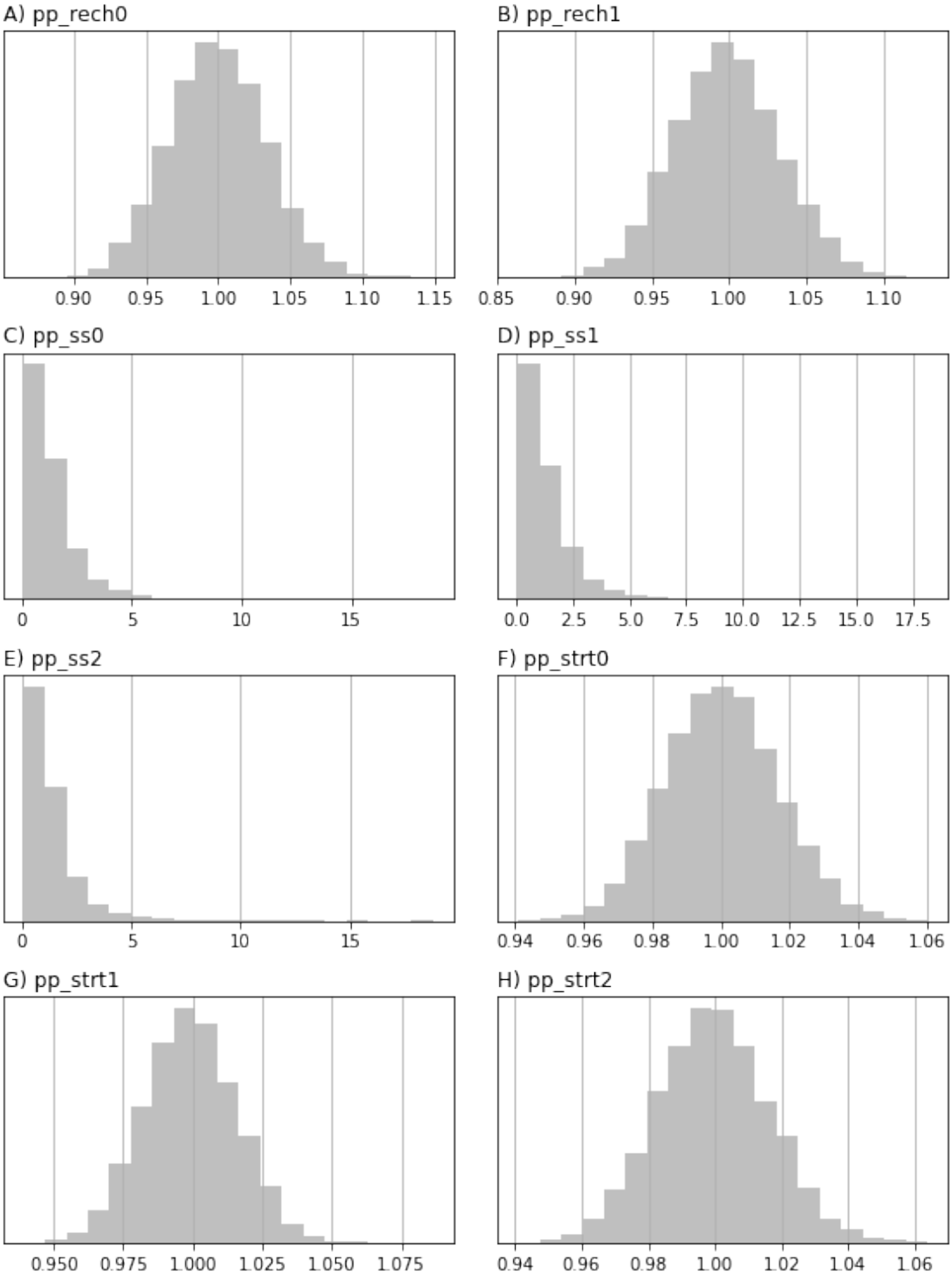

A) cn_ss6
0
2
4
6
8
10
B) cn_ss7
0
2
4
6
8
10
12
C) cn_ss8
0.0
2.5
5.0
7.5
10.0
12.5
15.0
D) cn_strt6
0.96
0.98
1.00
1.02
1.04
E) cn_strt7
0.96
0.98
1.00
1.02
1.04
F) cn_strt8
0.96
0.98
1.00
1.02
1.04
G) cn_sy6
0.5
1.0
1.5
2.0
2.5
3.0
H) cn_sy7
0.5
1.0
1.5
2.0

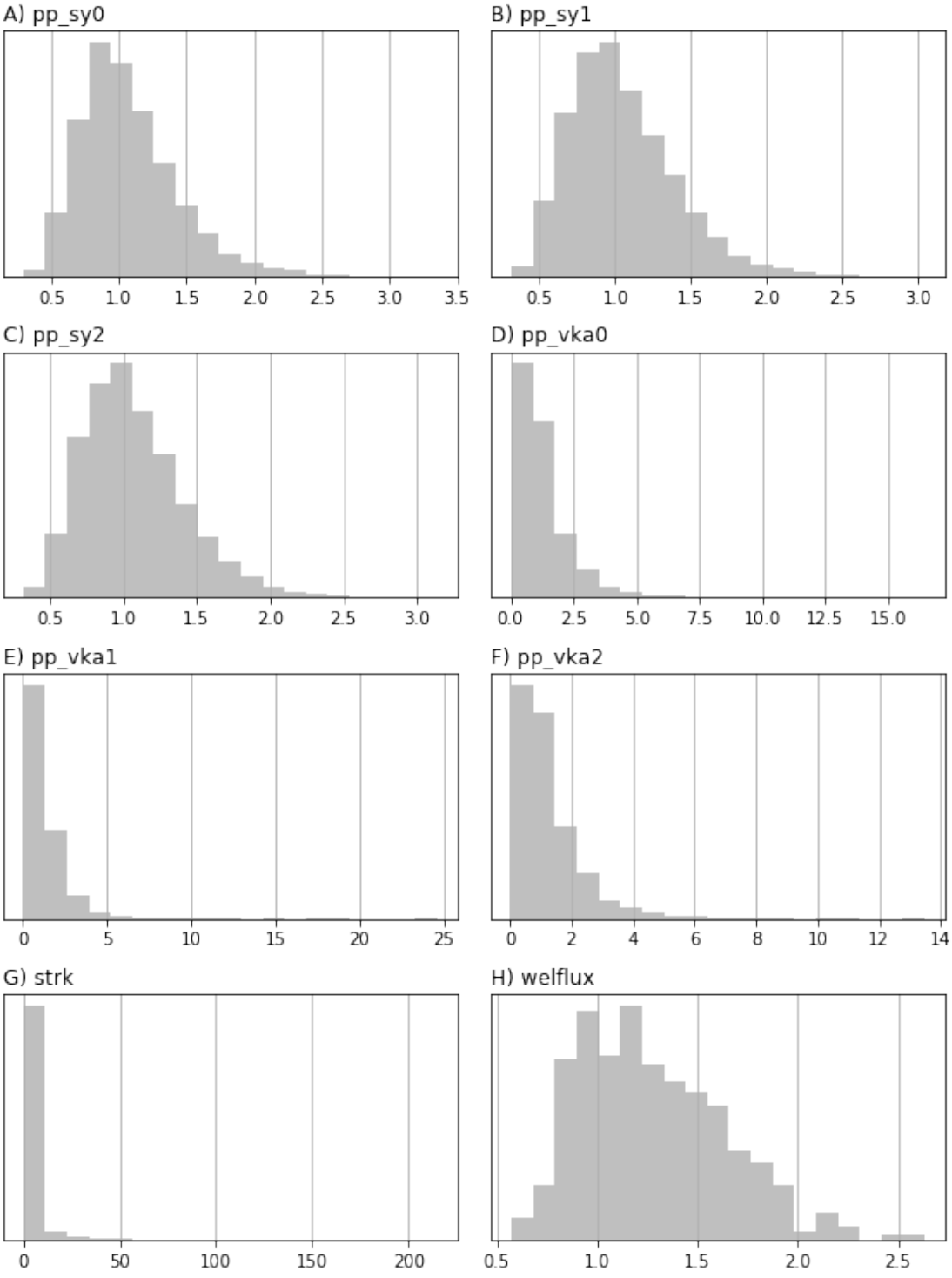

A) cn_sy8
0.5
1.0
1.5
2.0
2.5
B) cn_vka6
0
2
4
6
8
10
12
C) cn_vka7
0
2
4
6
8
D) cn_vka8
0
2
4
6
8
E) drncond_k00
0
2
4
6
8
10
12
F) flow
0.9
1.0
1.1
1.2
G) gr_hk3
0
5
10
15
20
25
H) gr_hk4
0
5
10
15
20

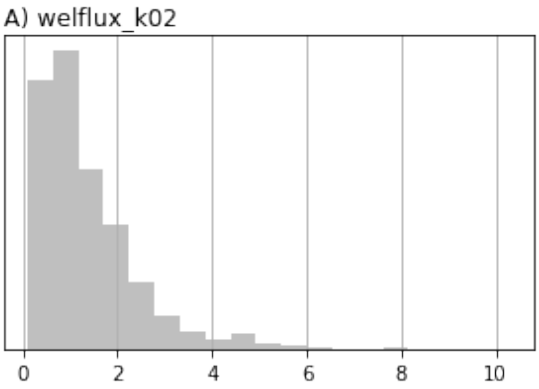

A) gr_hk5
0
5
10
15
20
25
B) gr_prsity3
0
1
2
3
4
5
C) gr_prsity4
0
1
2
3
4
5
D) gr_prsity5
0
1
2
3
4
E) gr_rech2
0.85
0.90
0.95
1.00
1.05
1.10
1.15
F) gr_rech3
0.90
0.95
1.00
1.05
1.10
1.15
G) gr_ss3
0
5
10
15
20
H) gr_ss4
0
5
10
15


A) gr_ss5
0
5
10
15
20
25
B) gr_strt3
0.94
0.96
0.98
1.00
1.02
1.04
1.06
1.08
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
1.08
E) gr_sy3
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
F) gr_sy4
0.5
1.0
1.5
2.0
2.5
3.0
3.5
G) gr_sy5
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
H) gr_vka3
0
5
10
15
20
25
30
35


A) gr_vka4
0
5
10
15
20
B) gr_vka5
0
5
10
15
20
C) pp_hk0
0.0
2.5
5.0
7.5
10.0
12.5
15.0
D) pp_hk1
0.0
2.5
5.0
7.5
10.0
12.5
15.0
E) pp_hk2
0.0
2.5
5.0
7.5
10.0
12.5
15.0
F) pp_prsity0
1
2
3
4
G) pp_prsity1
1
2
3
4
H) pp_prsity2
1
2
3
4


A) pp_rech0
0.90
0.95
1.00
1.05
1.10
1.15
B) pp_rech1
0.85
0.90
0.95
1.00
1.05
1.10
C) pp_ss0
0
5
10
15
D) pp_ss1
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
E) pp_ss2
0
5
10
15
F) pp_strt0
0.94
0.96
0.98
1.00
1.02
1.04
1.06
G) pp_strt1
0.950
0.975
1.000
1.025
1.050
1.075
H) pp_strt2
0.94
0.96
0.98
1.00
1.02
1.04
1.06


A) pp_sy0
0.5 1.0 1.5 2.0 2.5 3.0 3.5
B) pp_sy1
0.5 1.0 1.5 2.0 2.5 3.0
C) pp_sy2
0.5 1.0 1.5 2.0 2.5 3.0
D) pp_vka0
0.0 2.5 5.0 7.5 10.0 12.5 15.0
E) pp_vka1
0 5 10 15 20 25
F) pp_vka2
0 2 4 6 8 10 12 14
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"))
```

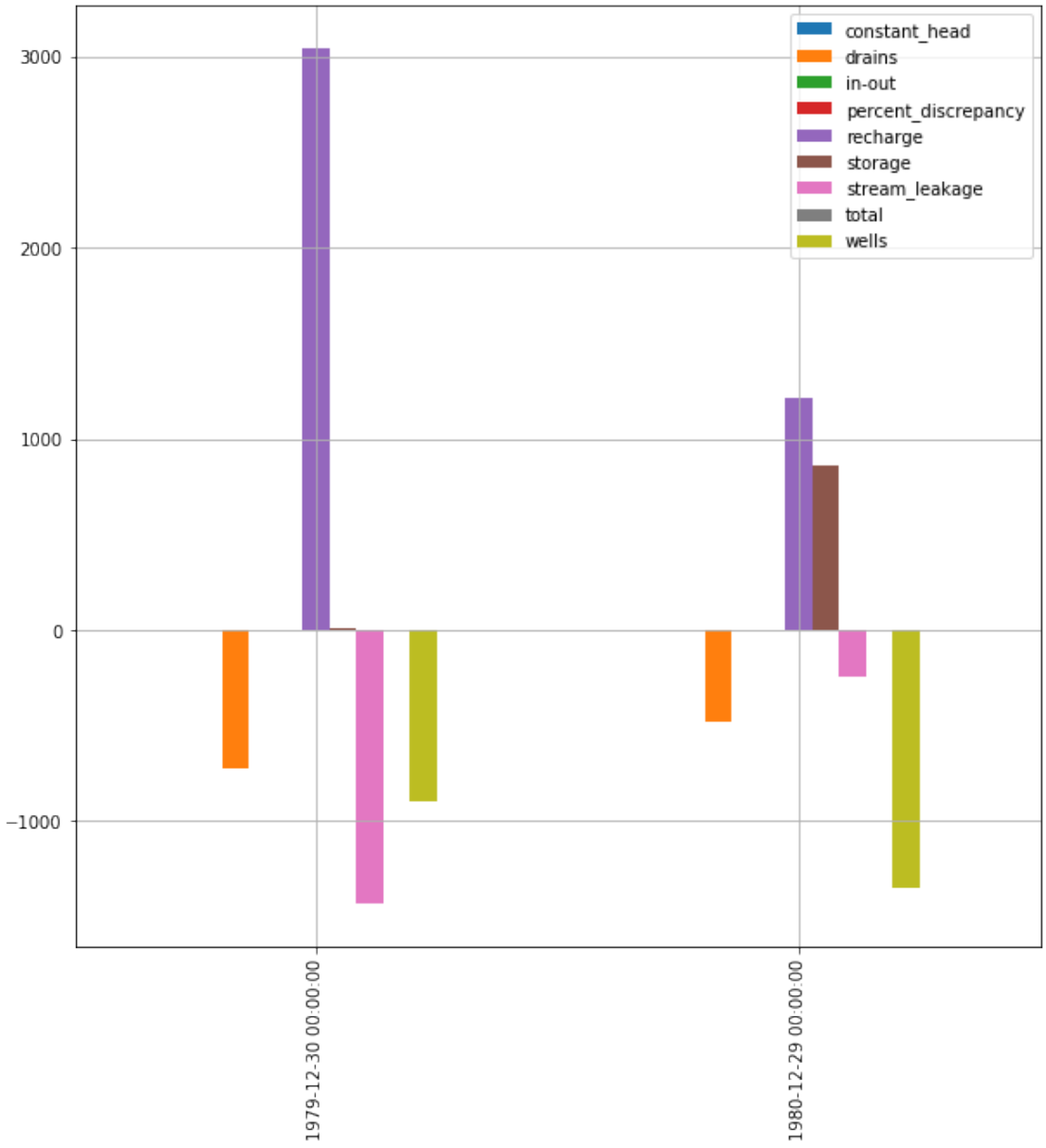
```
['fa_hw_19791230', 'fa_hw_19801229', 'fa_tw_19791230', 'fa_tw_19801229']
```

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.