setup_pest_interface

May 11, 2019

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

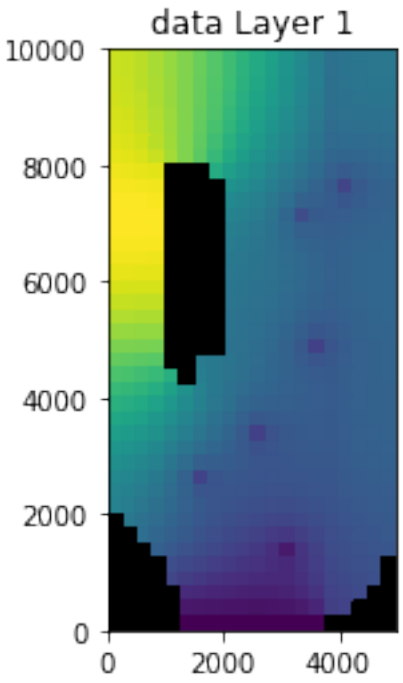
This helper is particularly useful if you run on more than one platform (e.g. Mac and Windows)

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

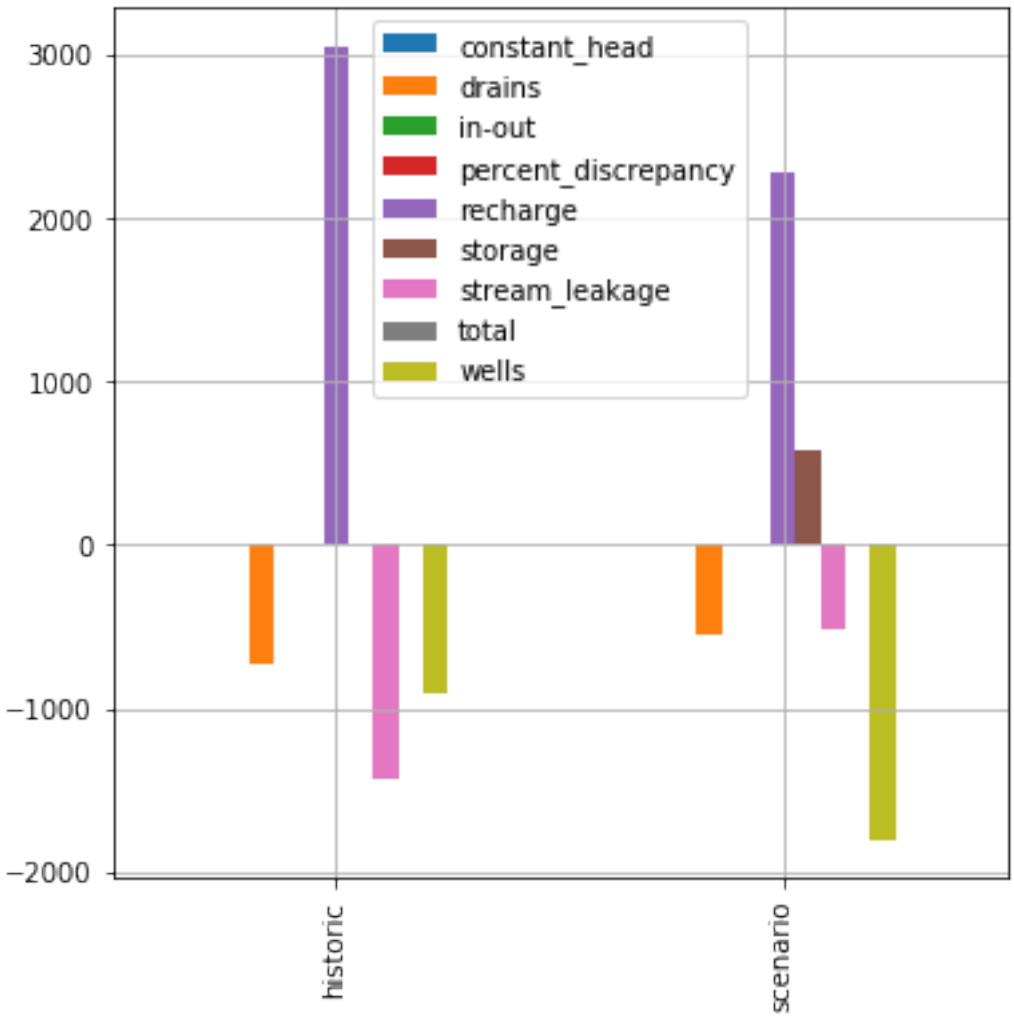
1.0.4 read in the heads and plot them up along with the budget components

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

```
In [6]: plt.figure()
        hds = flopy.utils.HeadFile(os.path.join(m.model_ws,m.name+".hds"),model=m)
        hds.plot(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()
```



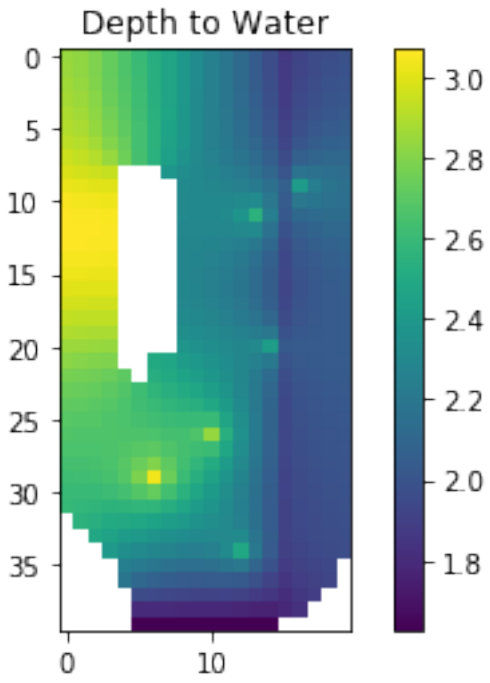

```
<Figure size 432x288 with 0 Axes>
```



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

1.0.5 Plot depth to water

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

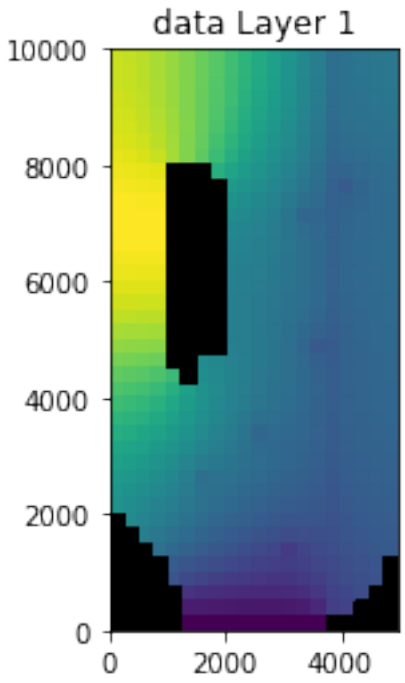


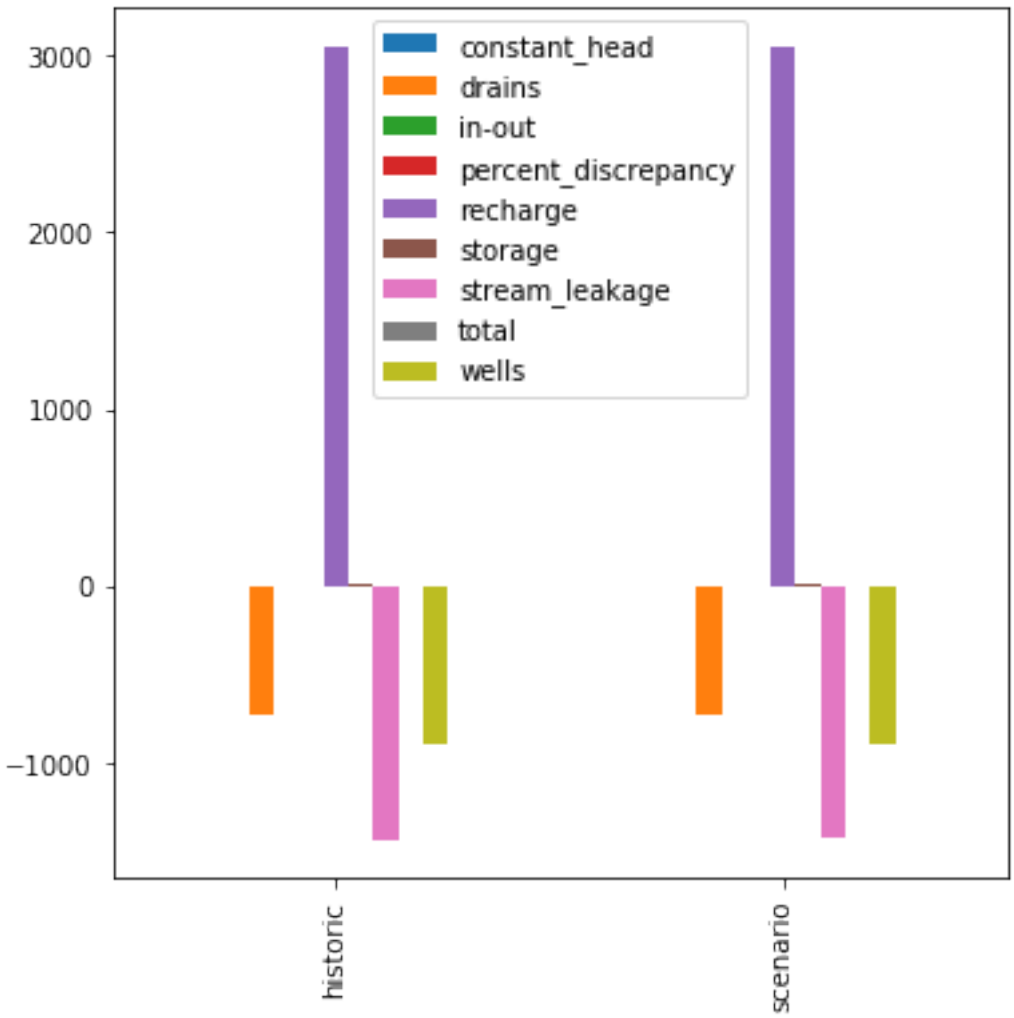
Clearly we can see the river and well locations expressed in the depth to water pattern.

1.0.6 What we are going to do is implement the scenario with parameters so we can more 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 [8]:
```
# reset scenario period recharge
m.rch.rech[1] = m.rch.rech[0]
# reset scenario period abstraction
m.wel.stress_period_data[1] = m.wel.stress_period_data[0]
m.write_input()
pyemu.os_utils.run("{0} {1}".format("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 Setup data structures related to what we want to parameterize and what we want to observe

1.1.1 first the parameterization of model inputs

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

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

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

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

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

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

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

1.1.4 then we setup monitoring of the SFR ASCII outputs.

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

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

1.1.5 here we go...

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

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

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

```
In [13]: pst_helper = pyemu.helpers.PstFromFlopyModel(nam_file,new_model_ws="template",org_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)
```

```
2019-05-11 09:09:55.609081 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
2019-05-11 09:09:55.648249 finished: loading flopy model took: 0:00:00.039168
2019-05-11 09:09:55.648387 starting: updating model attributes
2019-05-11 09:09:55.648470 finished: updating model attributes took: 0:00:00.000083
2019-05-11 09:09:55.648656 WARNING: removing existing 'new_model_ws

creating model workspace...
   template

changing model workspace...
   template
2019-05-11 09:09:56.947443 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

2019-05-11 09:09:57.057201 finished: writing new modflow input files took: 0:00:00.109758
2019-05-11 09:09:57.057709 forward_run line:pyemu.os_utils.run('mfnwt freyberg.nam 1>freyberg.
2019-05-11 09:09:57.058009 starting: setting up 'template/arr_org' dir
2019-05-11 09:09:57.058371 finished: setting up 'template/arr_org' dir took: 0:00:00.000362
2019-05-11 09:09:57.058628 starting: setting up 'template/arr_mlt' dir
2019-05-11 09:09:57.058949 finished: setting up 'template/arr_mlt' dir took: 0:00:00.000321
2019-05-11 09:09:57.059207 starting: setting up 'template/list_org' dir
2019-05-11 09:09:57.059513 finished: setting up 'template/list_org' dir took: 0:00:00.000306
2019-05-11 09:09:57.059774 starting: setting up 'template/list_mlt' dir
2019-05-11 09:09:57.060151 finished: setting up 'template/list_mlt' dir took: 0:00:00.000377
2019-05-11 09:09:57.060408 starting: processing temporal_list_props
2019-05-11 09:09:57.080549 finished: processing temporal_list_props took: 0:00:00.020141
2019-05-11 09:09:57.080945 starting: processing spatial_list_props
2019-05-11 09:09:57.161454 finished: processing spatial_list_props took: 0:00:00.080509
2019-05-11 09:09:57.224591 forward_run line:pyemu.helpers.apply_list_pars()

2019-05-11 09:09:57.261134 'extra' pak detected:extra.prsity
2019-05-11 09:09:57.302784 'extra' pak detected:extra.prsity
2019-05-11 09:09:57.341034 'extra' pak detected:extra.prsity
2019-05-11 09:09:57.385920 'extra' pak detected:extra.prsity
2019-05-11 09:09:57.417465 'extra' pak detected:extra.prsity
2019-05-11 09:09:57.449161 'extra' pak detected:extra.prsity
2019-05-11 09:09:57.490279 'extra' pak detected:extra.prsity
2019-05-11 09:09:57.522492 'extra' pak detected:extra.prsity
2019-05-11 09:09:57.553246 'extra' pak detected:extra.prsity
2019-05-11 09:09:57.632299 starting: writing grid tpl:hk3.dat_gr.tpl
2019-05-11 09:09:57.641256 finished: writing grid tpl:hk3.dat_gr.tpl took: 0:00:00.008957
2019-05-11 09:09:57.643755 starting: writing grid tpl:vka3.dat_gr.tpl
2019-05-11 09:09:57.652597 finished: writing grid tpl:vka3.dat_gr.tpl took: 0:00:00.008842
2019-05-11 09:09:57.655077 starting: writing grid tpl:ss3.dat_gr.tpl
2019-05-11 09:09:57.663924 finished: writing grid tpl:ss3.dat_gr.tpl took: 0:00:00.008847
2019-05-11 09:09:57.666499 starting: writing grid tpl:sy3.dat_gr.tpl
2019-05-11 09:09:57.674625 finished: writing grid tpl:sy3.dat_gr.tpl took: 0:00:00.008126
2019-05-11 09:09:57.677223 starting: writing grid tpl:strt3.dat_gr.tpl
2019-05-11 09:09:57.685867 finished: writing grid tpl:strt3.dat_gr.tpl took: 0:00:00.008644
2019-05-11 09:09:57.688378 starting: writing grid tpl:prsity3.dat_gr.tpl
2019-05-11 09:09:57.699321 finished: writing grid tpl:prsity3.dat_gr.tpl took: 0:00:00.010943
2019-05-11 09:09:57.701900 starting: writing grid tpl:hk4.dat_gr.tpl
2019-05-11 09:09:57.710633 finished: writing grid tpl:hk4.dat_gr.tpl took: 0:00:00.008733
```

```
2019-05-11 09:09:57.713045 starting: writing grid tpl:vka4.dat_gr.tpl
2019-05-11 09:09:57.722494 finished: writing grid tpl:vka4.dat_gr.tpl took: 0:00:00.009449
2019-05-11 09:09:57.725233 starting: writing grid tpl:ss4.dat_gr.tpl
2019-05-11 09:09:57.734209 finished: writing grid tpl:ss4.dat_gr.tpl took: 0:00:00.008976
2019-05-11 09:09:57.736940 starting: writing grid tpl:sy4.dat_gr.tpl
2019-05-11 09:09:57.745729 finished: writing grid tpl:sy4.dat_gr.tpl took: 0:00:00.008789
2019-05-11 09:09:57.748467 starting: writing grid tpl:strt4.dat_gr.tpl
2019-05-11 09:09:57.756991 finished: writing grid tpl:strt4.dat_gr.tpl took: 0:00:00.008524
2019-05-11 09:09:57.759311 starting: writing grid tpl:prsity4.dat_gr.tpl
2019-05-11 09:09:57.770567 finished: writing grid tpl:prsity4.dat_gr.tpl took: 0:00:00.011256
2019-05-11 09:09:57.773388 starting: writing grid tpl:hk5.dat_gr.tpl
2019-05-11 09:09:57.781641 finished: writing grid tpl:hk5.dat_gr.tpl took: 0:00:00.008253
2019-05-11 09:09:57.784368 starting: writing grid tpl:vka5.dat_gr.tpl
2019-05-11 09:09:57.792801 finished: writing grid tpl:vka5.dat_gr.tpl took: 0:00:00.008433
2019-05-11 09:09:57.795198 starting: writing grid tpl:ss5.dat_gr.tpl
2019-05-11 09:09:57.804292 finished: writing grid tpl:ss5.dat_gr.tpl took: 0:00:00.009094
2019-05-11 09:09:57.806756 starting: writing grid tpl:sy5.dat_gr.tpl
2019-05-11 09:09:57.815258 finished: writing grid tpl:sy5.dat_gr.tpl took: 0:00:00.008502
2019-05-11 09:09:57.817665 starting: writing grid tpl:strt5.dat_gr.tpl
2019-05-11 09:09:57.826165 finished: writing grid tpl:strt5.dat_gr.tpl took: 0:00:00.008500
2019-05-11 09:09:57.828573 starting: writing grid tpl:prsity5.dat_gr.tpl
2019-05-11 09:09:57.840519 finished: writing grid tpl:prsity5.dat_gr.tpl took: 0:00:00.011946
2019-05-11 09:09:57.843547 starting: writing grid tpl:rech2.dat_gr.tpl
2019-05-11 09:09:57.852405 finished: writing grid tpl:rech2.dat_gr.tpl took: 0:00:00.008858
2019-05-11 09:09:57.855268 starting: writing grid tpl:rech3.dat_gr.tpl
2019-05-11 09:09:57.863948 finished: writing grid tpl:rech3.dat_gr.tpl took: 0:00:00.008680
2019-05-11 09:09:57.866562 starting: writing const tpl:hk6.dat_cn.tpl
2019-05-11 09:09:57.871911 finished: writing const tpl:hk6.dat_cn.tpl took: 0:00:00.005349
2019-05-11 09:09:57.874308 starting: writing const tpl:vka6.dat_cn.tpl
2019-05-11 09:09:57.880001 finished: writing const tpl:vka6.dat_cn.tpl took: 0:00:00.005693
2019-05-11 09:09:57.882402 starting: writing const tpl:ss6.dat_cn.tpl
2019-05-11 09:09:57.887918 finished: writing const tpl:ss6.dat_cn.tpl took: 0:00:00.005516
2019-05-11 09:09:57.890942 starting: writing const tpl:sy6.dat_cn.tpl
2019-05-11 09:09:57.896826 finished: writing const tpl:sy6.dat_cn.tpl took: 0:00:00.005884
2019-05-11 09:09:57.899639 starting: writing const tpl:strt6.dat_cn.tpl
2019-05-11 09:09:57.905535 finished: writing const tpl:strt6.dat_cn.tpl took: 0:00:00.005896
2019-05-11 09:09:57.908160 starting: writing const tpl:prsity6.dat_cn.tpl
2019-05-11 09:09:57.914001 finished: writing const tpl:prsity6.dat_cn.tpl took: 0:00:00.005841
2019-05-11 09:09:57.916773 starting: writing const tpl:hk7.dat_cn.tpl
2019-05-11 09:09:57.922492 finished: writing const tpl:hk7.dat_cn.tpl took: 0:00:00.005719
2019-05-11 09:09:57.925194 starting: writing const tpl:vka7.dat_cn.tpl
2019-05-11 09:09:57.931289 finished: writing const tpl:vka7.dat_cn.tpl took: 0:00:00.006095
2019-05-11 09:09:57.933985 starting: writing const tpl:ss7.dat_cn.tpl
2019-05-11 09:09:57.939855 finished: writing const tpl:ss7.dat_cn.tpl took: 0:00:00.005870
2019-05-11 09:09:57.942559 starting: writing const tpl:sy7.dat_cn.tpl
2019-05-11 09:09:57.948378 finished: writing const tpl:sy7.dat_cn.tpl took: 0:00:00.005819
2019-05-11 09:09:57.951033 starting: writing const tpl:strt7.dat_cn.tpl
2019-05-11 09:09:57.956996 finished: writing const tpl:strt7.dat_cn.tpl took: 0:00:00.005963
```

```
2019-05-11 09:09:57.959719 starting: writing const tpl:prsity7.dat_cn.tpl
2019-05-11 09:09:57.965576 finished: writing const tpl:prsity7.dat_cn.tpl took: 0:00:00.005857
2019-05-11 09:09:57.968207 starting: writing const tpl:hk8.dat_cn.tpl
2019-05-11 09:09:57.973774 finished: writing const tpl:hk8.dat_cn.tpl took: 0:00:00.005567
2019-05-11 09:09:57.976194 starting: writing const tpl:vka8.dat_cn.tpl
2019-05-11 09:09:57.982113 finished: writing const tpl:vka8.dat_cn.tpl took: 0:00:00.005919
2019-05-11 09:09:57.984740 starting: writing const tpl:ss8.dat_cn.tpl
2019-05-11 09:09:57.990341 finished: writing const tpl:ss8.dat_cn.tpl took: 0:00:00.005601
2019-05-11 09:09:57.992881 starting: writing const tpl:sy8.dat_cn.tpl
2019-05-11 09:09:57.998970 finished: writing const tpl:sy8.dat_cn.tpl took: 0:00:00.006089
2019-05-11 09:09:58.001445 starting: writing const tpl:strt8.dat_cn.tpl
2019-05-11 09:09:58.007360 finished: writing const tpl:strt8.dat_cn.tpl took: 0:00:00.005915
2019-05-11 09:09:58.009832 starting: writing const tpl:prsity8.dat_cn.tpl
2019-05-11 09:09:58.015688 finished: writing const tpl:prsity8.dat_cn.tpl took: 0:00:00.005856
2019-05-11 09:09:58.018403 starting: writing const tpl:rech4.dat_cn.tpl
2019-05-11 09:09:58.024124 finished: writing const tpl:rech4.dat_cn.tpl took: 0:00:00.005721
2019-05-11 09:09:58.026562 starting: writing const tpl:rech5.dat_cn.tpl
2019-05-11 09:09:58.032461 finished: writing const tpl:rech5.dat_cn.tpl took: 0:00:00.005899
2019-05-11 09:09:58.055562 starting: setting up pilot point process
2019-05-11 09:09:58.056085 WARNING: pp_geostruct is None, using ExpVario with contribution=1 ar
2019-05-11 09:09:58.058820 pp_dict: {0: ['hk0', 'vka0', 'ss0', 'sy0', 'strt0', 'prsity0', 'rech
2019-05-11 09:09:58.059001 starting: calling setup_pilot_point_grid()
2019-05-11 09:09:58.702070 640 pilot point parameters created
2019-05-11 09:09:58.702792 pilot point 'pargp':hk0,vka0,ss0,sy0,strt0,prsity0,rech0,rech1,strt1
2019-05-11 09:09:58.702850 finished: calling setup_pilot_point_grid() took: 0:00:00.643849
2019-05-11 09:09:58.705473 starting: calculating factors for p=hk0, k=0
2019-05-11 09:09:58.706493 saving krige variance file:template/pp_k0_general_zn.fac
2019-05-11 09:09:58.706556 saving krige factors file:template/pp_k0_general_zn.fac
starting interp point loop for 800 points
took 2.629023 seconds
2019-05-11 09:10:01.389036 finished: calculating factors for p=hk0, k=0 took: 0:00:02.683563
2019-05-11 09:10:01.389946 starting: calculating factors for p=vka0, k=0
2019-05-11 09:10:01.390719 finished: calculating factors for p=vka0, k=0 took: 0:00:00.000773
2019-05-11 09:10:01.391577 starting: calculating factors for p=ss0, k=0
2019-05-11 09:10:01.392666 finished: calculating factors for p=ss0, k=0 took: 0:00:00.001089
2019-05-11 09:10:01.393343 starting: calculating factors for p=sy0, k=0
2019-05-11 09:10:01.394063 finished: calculating factors for p=sy0, k=0 took: 0:00:00.000720
2019-05-11 09:10:01.395188 starting: calculating factors for p=strt0, k=0
2019-05-11 09:10:01.395960 finished: calculating factors for p=strt0, k=0 took: 0:00:00.000772
2019-05-11 09:10:01.397417 starting: calculating factors for p=prsity0, k=0
2019-05-11 09:10:01.398577 finished: calculating factors for p=prsity0, k=0 took: 0:00:00.0011
2019-05-11 09:10:01.399563 starting: calculating factors for p=rech0, k=0
2019-05-11 09:10:01.400616 finished: calculating factors for p=rech0, k=0 took: 0:00:00.001053
2019-05-11 09:10:01.401526 starting: calculating factors for p=rech1, k=0
2019-05-11 09:10:01.402741 finished: calculating factors for p=rech1, k=0 took: 0:00:00.001215
2019-05-11 09:10:01.403461 starting: calculating factors for p=strt1, k=1
2019-05-11 09:10:01.404258 saving krige variance file:template/pp_k1_general_zn.fac
2019-05-11 09:10:01.404343 saving krige factors file:template/pp_k1_general_zn.fac
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starting interp point loop for 800 points
took 2.647569 seconds
2019-05-11 09:10:04.107957 finished: calculating factors for p=strt1, k=1 took: 0:00:02.704496
2019-05-11 09:10:04.108857 starting: calculating factors for p=sy1, k=1
2019-05-11 09:10:04.109631 finished: calculating factors for p=sy1, k=1 took: 0:00:00.000774
2019-05-11 09:10:04.110827 starting: calculating factors for p=prsity1, k=1
2019-05-11 09:10:04.111731 finished: calculating factors for p=prsity1, k=1 took: 0:00:00.0009
2019-05-11 09:10:04.112733 starting: calculating factors for p=hk1, k=1
2019-05-11 09:10:04.113466 finished: calculating factors for p=hk1, k=1 took: 0:00:00.000733
2019-05-11 09:10:04.114042 starting: calculating factors for p=vka1, k=1
2019-05-11 09:10:04.115108 finished: calculating factors for p=vka1, k=1 took: 0:00:00.001066
2019-05-11 09:10:04.116046 starting: calculating factors for p=ss1, k=1
2019-05-11 09:10:04.116956 finished: calculating factors for p=ss1, k=1 took: 0:00:00.000910
2019-05-11 09:10:04.117707 starting: calculating factors for p=ss2, k=2
2019-05-11 09:10:04.118692 saving krige variance file:template/pp_k2_general_zn.fac
2019-05-11 09:10:04.118921 saving krige factors file:template/pp_k2_general_zn.fac
starting interp point loop for 800 points
took 2.972734 seconds
2019-05-11 09:10:07.145479 finished: calculating factors for p=ss2, k=2 took: 0:00:03.027772
2019-05-11 09:10:07.146528 starting: calculating factors for p=hk2, k=2
2019-05-11 09:10:07.147915 finished: calculating factors for p=hk2, k=2 took: 0:00:00.001387
2019-05-11 09:10:07.148487 starting: calculating factors for p=vka2, k=2
2019-05-11 09:10:07.149174 finished: calculating factors for p=vka2, k=2 took: 0:00:00.000687
2019-05-11 09:10:07.150117 starting: calculating factors for p=sy2, k=2
2019-05-11 09:10:07.151071 finished: calculating factors for p=sy2, k=2 took: 0:00:00.000954
2019-05-11 09:10:07.151655 starting: calculating factors for p=prsity2, k=2
2019-05-11 09:10:07.152347 finished: calculating factors for p=prsity2, k=2 took: 0:00:00.0006
2019-05-11 09:10:07.153056 starting: calculating factors for p=strt2, k=2
2019-05-11 09:10:07.153897 finished: calculating factors for p=strt2, k=2 took: 0:00:00.000841
2019-05-11 09:10:07.154323 starting: processing pp_prefix:sy2
2019-05-11 09:10:07.166640 starting: processing pp_prefix:rech0
2019-05-11 09:10:07.175029 starting: processing pp_prefix:sy1
2019-05-11 09:10:07.183518 starting: processing pp_prefix:prsity1
2019-05-11 09:10:07.191853 starting: processing pp_prefix:vka0
2019-05-11 09:10:07.201530 starting: processing pp_prefix:ss1
2019-05-11 09:10:07.210521 starting: processing pp_prefix:vka1
2019-05-11 09:10:07.219492 starting: processing pp_prefix:ss0
2019-05-11 09:10:07.228301 starting: processing pp_prefix:rech1
2019-05-11 09:10:07.236961 starting: processing pp_prefix:hk2
2019-05-11 09:10:07.245534 starting: processing pp_prefix:vka2
2019-05-11 09:10:07.254044 starting: processing pp_prefix:hk1
2019-05-11 09:10:07.262288 starting: processing pp_prefix:hk0
2019-05-11 09:10:07.271090 starting: processing pp_prefix:prsity2
2019-05-11 09:10:07.280478 starting: processing pp_prefix:strt0
2019-05-11 09:10:07.289554 starting: processing pp_prefix:prsity0
2019-05-11 09:10:07.298125 starting: processing pp_prefix:strt1
2019-05-11 09:10:07.307114 starting: processing pp_prefix:ss2
2019-05-11 09:10:07.315843 starting: processing pp_prefix:sy0
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2019-05-11 09:10:07.325034 starting: processing pp_prefix:strt2
2019-05-11 09:10:07.438558 finished: setting up pilot point process took: 0:00:09.382996
2019-05-11 09:10:07.438923 starting: setting up grid process
2019-05-11 09:10:07.439042 WARNING: grid_geostruct is None, using ExpVario with contribution=1
2019-05-11 09:10:07.439198 finished: setting up grid process took: 0:00:00.000275
2019-05-11 09:10:07.442442 starting: save test mlt array arr_mlt/hk0.dat_pp
2019-05-11 09:10:07.444715 finished: save test mlt array arr_mlt/hk0.dat_pp took: 0:00:00.0022
2019-05-11 09:10:07.445837 starting: save test mlt array arr_mlt/vka0.dat_pp
2019-05-11 09:10:07.448173 finished: save test mlt array arr_mlt/vka0.dat_pp took: 0:00:00.002
2019-05-11 09:10:07.449173 starting: save test mlt array arr_mlt/ss0.dat_pp
2019-05-11 09:10:07.451512 finished: save test mlt array arr_mlt/ss0.dat_pp took: 0:00:00.0023
2019-05-11 09:10:07.452519 starting: save test mlt array arr_mlt/sy0.dat_pp
2019-05-11 09:10:07.455869 finished: save test mlt array arr_mlt/sy0.dat_pp took: 0:00:00.0033
2019-05-11 09:10:07.457084 starting: save test mlt array arr_mlt/strt0.dat_pp
2019-05-11 09:10:07.459449 finished: save test mlt array arr_mlt/strt0.dat_pp took: 0:00:00.002
2019-05-11 09:10:07.460358 starting: save test mlt array arr_mlt/prsity0.dat_pp
2019-05-11 09:10:07.462477 finished: save test mlt array arr_mlt/prsity0.dat_pp took: 0:00:00.0
2019-05-11 09:10:07.463210 starting: save test mlt array arr_mlt/hk1.dat_pp
2019-05-11 09:10:07.465691 finished: save test mlt array arr_mlt/hk1.dat_pp took: 0:00:00.0024
2019-05-11 09:10:07.466634 starting: save test mlt array arr_mlt/vka1.dat_pp
2019-05-11 09:10:07.468776 finished: save test mlt array arr_mlt/vka1.dat_pp took: 0:00:00.002
2019-05-11 09:10:07.469646 starting: save test mlt array arr_mlt/ss1.dat_pp
2019-05-11 09:10:07.471963 finished: save test mlt array arr_mlt/ss1.dat_pp took: 0:00:00.0023
2019-05-11 09:10:07.472965 starting: save test mlt array arr_mlt/sy1.dat_pp
2019-05-11 09:10:07.475087 finished: save test mlt array arr_mlt/sy1.dat_pp took: 0:00:00.0021
2019-05-11 09:10:07.475980 starting: save test mlt array arr_mlt/strt1.dat_pp
2019-05-11 09:10:07.478299 finished: save test mlt array arr_mlt/strt1.dat_pp took: 0:00:00.002
2019-05-11 09:10:07.479255 starting: save test mlt array arr_mlt/prsity1.dat_pp
2019-05-11 09:10:07.481706 finished: save test mlt array arr_mlt/prsity1.dat_pp took: 0:00:00.0
2019-05-11 09:10:07.482646 starting: save test mlt array arr_mlt/hk2.dat_pp
2019-05-11 09:10:07.484799 finished: save test mlt array arr_mlt/hk2.dat_pp took: 0:00:00.0021
2019-05-11 09:10:07.485696 starting: save test mlt array arr_mlt/vka2.dat_pp
2019-05-11 09:10:07.487963 finished: save test mlt array arr_mlt/vka2.dat_pp took: 0:00:00.002
2019-05-11 09:10:07.488966 starting: save test mlt array arr_mlt/ss2.dat_pp
2019-05-11 09:10:07.491256 finished: save test mlt array arr_mlt/ss2.dat_pp took: 0:00:00.0022
2019-05-11 09:10:07.492192 starting: save test mlt array arr_mlt/sy2.dat_pp
2019-05-11 09:10:07.494278 finished: save test mlt array arr_mlt/sy2.dat_pp took: 0:00:00.0020
2019-05-11 09:10:07.495007 starting: save test mlt array arr_mlt/strt2.dat_pp
2019-05-11 09:10:07.497530 finished: save test mlt array arr_mlt/strt2.dat_pp took: 0:00:00.002
2019-05-11 09:10:07.498298 starting: save test mlt array arr_mlt/prsity2.dat_pp
2019-05-11 09:10:07.501125 finished: save test mlt array arr_mlt/prsity2.dat_pp took: 0:00:00.0
2019-05-11 09:10:07.502383 starting: save test mlt array arr_mlt/rech0.dat_pp
2019-05-11 09:10:07.505175 finished: save test mlt array arr_mlt/rech0.dat_pp took: 0:00:00.002
2019-05-11 09:10:07.506585 starting: save test mlt array arr_mlt/rech1.dat_pp
2019-05-11 09:10:07.509639 finished: save test mlt array arr_mlt/rech1.dat_pp took: 0:00:00.003
2019-05-11 09:10:07.511150 starting: save test mlt array arr_mlt/hk3.dat_gr
2019-05-11 09:10:07.514496 finished: save test mlt array arr_mlt/hk3.dat_gr took: 0:00:00.0033
2019-05-11 09:10:07.516118 starting: save test mlt array arr_mlt/vka3.dat_gr
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2019-05-11 09:10:07.519447 finished: save test mlt array arr_mlt/vka3.dat_gr took: 0:00:00.0033
2019-05-11 09:10:07.521077 starting: save test mlt array arr_mlt/ss3.dat_gr
2019-05-11 09:10:07.524925 finished: save test mlt array arr_mlt/ss3.dat_gr took: 0:00:00.0038
2019-05-11 09:10:07.526370 starting: save test mlt array arr_mlt/sy3.dat_gr
2019-05-11 09:10:07.530285 finished: save test mlt array arr_mlt/sy3.dat_gr took: 0:00:00.0039
2019-05-11 09:10:07.531626 starting: save test mlt array arr_mlt/strt3.dat_gr
2019-05-11 09:10:07.535184 finished: save test mlt array arr_mlt/strt3.dat_gr took: 0:00:00.003
2019-05-11 09:10:07.536717 starting: save test mlt array arr_mlt/prsity3.dat_gr
2019-05-11 09:10:07.539703 finished: save test mlt array arr_mlt/prsity3.dat_gr took: 0:00:00.0
2019-05-11 09:10:07.540997 starting: save test mlt array arr_mlt/hk4.dat_gr
2019-05-11 09:10:07.543808 finished: save test mlt array arr_mlt/hk4.dat_gr took: 0:00:00.0028
2019-05-11 09:10:07.545495 starting: save test mlt array arr_mlt/vka4.dat_gr
2019-05-11 09:10:07.549002 finished: save test mlt array arr_mlt/vka4.dat_gr took: 0:00:00.0035
2019-05-11 09:10:07.550526 starting: save test mlt array arr_mlt/ss4.dat_gr
2019-05-11 09:10:07.554115 finished: save test mlt array arr_mlt/ss4.dat_gr took: 0:00:00.00358
2019-05-11 09:10:07.555597 starting: save test mlt array arr_mlt/sy4.dat_gr
2019-05-11 09:10:07.559086 finished: save test mlt array arr_mlt/sy4.dat_gr took: 0:00:00.00348
2019-05-11 09:10:07.560562 starting: save test mlt array arr_mlt/strt4.dat_gr
2019-05-11 09:10:07.564023 finished: save test mlt array arr_mlt/strt4.dat_gr took: 0:00:00.003
2019-05-11 09:10:07.565462 starting: save test mlt array arr_mlt/prsity4.dat_gr
2019-05-11 09:10:07.568469 finished: save test mlt array arr_mlt/prsity4.dat_gr took: 0:00:00.0
2019-05-11 09:10:07.569694 starting: save test mlt array arr_mlt/hk5.dat_gr
2019-05-11 09:10:07.572827 finished: save test mlt array arr_mlt/hk5.dat_gr took: 0:00:00.00313
2019-05-11 09:10:07.573901 starting: save test mlt array arr_mlt/vka5.dat_gr
2019-05-11 09:10:07.576624 finished: save test mlt array arr_mlt/vka5.dat_gr took: 0:00:00.0027
2019-05-11 09:10:07.577835 starting: save test mlt array arr_mlt/ss5.dat_gr
2019-05-11 09:10:07.581288 finished: save test mlt array arr_mlt/ss5.dat_gr took: 0:00:00.00345
2019-05-11 09:10:07.582642 starting: save test mlt array arr_mlt/sy5.dat_gr
2019-05-11 09:10:07.585557 finished: save test mlt array arr_mlt/sy5.dat_gr took: 0:00:00.0029
2019-05-11 09:10:07.587087 starting: save test mlt array arr_mlt/strt5.dat_gr
2019-05-11 09:10:07.590412 finished: save test mlt array arr_mlt/strt5.dat_gr took: 0:00:00.003
2019-05-11 09:10:07.591838 starting: save test mlt array arr_mlt/prsity5.dat_gr
2019-05-11 09:10:07.595064 finished: save test mlt array arr_mlt/prsity5.dat_gr took: 0:00:00.0
2019-05-11 09:10:07.596507 starting: save test mlt array arr_mlt/rech2.dat_gr
2019-05-11 09:10:07.599925 finished: save test mlt array arr_mlt/rech2.dat_gr took: 0:00:00.003
2019-05-11 09:10:07.601455 starting: save test mlt array arr_mlt/rech3.dat_gr
2019-05-11 09:10:07.604974 finished: save test mlt array arr_mlt/rech3.dat_gr took: 0:00:00.003
2019-05-11 09:10:07.606647 starting: save test mlt array arr_mlt/hk6.dat_cn
2019-05-11 09:10:07.609861 finished: save test mlt array arr_mlt/hk6.dat_cn took: 0:00:00.0032
2019-05-11 09:10:07.611363 starting: save test mlt array arr_mlt/vka6.dat_cn
2019-05-11 09:10:07.615099 finished: save test mlt array arr_mlt/vka6.dat_cn took: 0:00:00.0037
2019-05-11 09:10:07.616570 starting: save test mlt array arr_mlt/ss6.dat_cn
2019-05-11 09:10:07.620108 finished: save test mlt array arr_mlt/ss6.dat_cn took: 0:00:00.00353
2019-05-11 09:10:07.621409 starting: save test mlt array arr_mlt/sy6.dat_cn
2019-05-11 09:10:07.624928 finished: save test mlt array arr_mlt/sy6.dat_cn took: 0:00:00.0035
2019-05-11 09:10:07.626242 starting: save test mlt array arr_mlt/strt6.dat_cn
2019-05-11 09:10:07.629001 finished: save test mlt array arr_mlt/strt6.dat_cn took: 0:00:00.002
2019-05-11 09:10:07.630058 starting: save test mlt array arr_mlt/prsity6.dat_cn
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2019-05-11 09:10:07.633236 finished: save test mlt array arr_mlt/prsity6.dat_cn took: 0:00:00.0
2019-05-11 09:10:07.634736 starting: save test mlt array arr_mlt/hk7.dat_cn
2019-05-11 09:10:07.637823 finished: save test mlt array arr_mlt/hk7.dat_cn took: 0:00:00.00308
2019-05-11 09:10:07.639271 starting: save test mlt array arr_mlt/vka7.dat_cn
2019-05-11 09:10:07.642662 finished: save test mlt array arr_mlt/vka7.dat_cn took: 0:00:00.0033
2019-05-11 09:10:07.644076 starting: save test mlt array arr_mlt/ss7.dat_cn
2019-05-11 09:10:07.647167 finished: save test mlt array arr_mlt/ss7.dat_cn took: 0:00:00.00309
2019-05-11 09:10:07.648200 starting: save test mlt array arr_mlt/sy7.dat_cn
2019-05-11 09:10:07.651185 finished: save test mlt array arr_mlt/sy7.dat_cn took: 0:00:00.00298
2019-05-11 09:10:07.652501 starting: save test mlt array arr_mlt/strt7.dat_cn
2019-05-11 09:10:07.655463 finished: save test mlt array arr_mlt/strt7.dat_cn took: 0:00:00.002
2019-05-11 09:10:07.656956 starting: save test mlt array arr_mlt/prsity7.dat_cn
2019-05-11 09:10:07.660167 finished: save test mlt array arr_mlt/prsity7.dat_cn took: 0:00:00.0
2019-05-11 09:10:07.661525 starting: save test mlt array arr_mlt/hk8.dat_cn
2019-05-11 09:10:07.664961 finished: save test mlt array arr_mlt/hk8.dat_cn took: 0:00:00.00343
2019-05-11 09:10:07.666360 starting: save test mlt array arr_mlt/vka8.dat_cn
2019-05-11 09:10:07.669845 finished: save test mlt array arr_mlt/vka8.dat_cn took: 0:00:00.0034
2019-05-11 09:10:07.671128 starting: save test mlt array arr_mlt/ss8.dat_cn
2019-05-11 09:10:07.673727 finished: save test mlt array arr_mlt/ss8.dat_cn took: 0:00:00.00259
2019-05-11 09:10:07.675062 starting: save test mlt array arr_mlt/sy8.dat_cn
2019-05-11 09:10:07.677887 finished: save test mlt array arr_mlt/sy8.dat_cn took: 0:00:00.00282
2019-05-11 09:10:07.679262 starting: save test mlt array arr_mlt/strt8.dat_cn
2019-05-11 09:10:07.682257 finished: save test mlt array arr_mlt/strt8.dat_cn took: 0:00:00.002
2019-05-11 09:10:07.683172 starting: save test mlt array arr_mlt/prsity8.dat_cn
2019-05-11 09:10:07.686305 finished: save test mlt array arr_mlt/prsity8.dat_cn took: 0:00:00.0
2019-05-11 09:10:07.687813 starting: save test mlt array arr_mlt/rech4.dat_cn
2019-05-11 09:10:07.691090 finished: save test mlt array arr_mlt/rech4.dat_cn took: 0:00:00.003
2019-05-11 09:10:07.692759 starting: save test mlt array arr_mlt/rech5.dat_cn
2019-05-11 09:10:07.695922 finished: save test mlt array arr_mlt/rech5.dat_cn took: 0:00:00.003
2019-05-11 09:10:08.311723 forward_run line:pyemu.helpers.apply_array_pars()

all zeros for runoff...skipping...
all zeros for hcond1...skipping...
all zeros for pptsw...skipping...
2019-05-11 09:10:08.449984 starting: processing obs type mflist water budget obs
2019-05-11 09:10:08.542531 forward_run line:pyemu.gw_utils.apply_mflist_budget_obs('freyberg.li
2019-05-11 09:10:08.543026 finished: processing obs type mflist water budget obs took: 0:00:00
2019-05-11 09:10:08.543091 starting: processing obs type hyd file
2019-05-11 09:10:08.543179 finished: processing obs type hyd file took: 0:00:00.000088
2019-05-11 09:10:08.543221 starting: processing obs type external obs-sim smp files
2019-05-11 09:10:08.543377 finished: processing obs type external obs-sim smp files took: 0:00
2019-05-11 09:10:08.543434 starting: processing obs type hob
2019-05-11 09:10:08.543920 finished: processing obs type hob took: 0:00:00.000486
2019-05-11 09:10:08.544616 starting: processing obs type hds
[[0, 0], [0, 1], [0, 2], [1, 0], [1, 1], [1, 2]]
2019-05-11 09:10:08.983065 finished: processing obs type hds took: 0:00:00.438449
2019-05-11 09:10:08.983494 starting: processing obs type sfr
writing 'sfr_obs.config' to template/sfr_obs.config
```

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2019-05-11 09:10:09.328443 finished: processing obs type sfr took: 0:00:00.344949
2019-05-11 09:10:09.328857 changing dir in to template
2019-05-11 09:10:09.329732 starting: instantiating control file from i/o files
2019-05-11 09:10:09.330033 tpl files: wel.csv.tpl,drn.csv.tpl,hk3.dat_gr.tpl,vka3.dat_gr.tpl,ss
2019-05-11 09:10:09.330370 ins files: freyberg.hds.dat.ins,vol.dat.ins,freyberg.sfr.out.process
2019-05-11 09:10:09.690099 finished: instantiating control file from i/o files took: 0:00:00.36
2019-05-11 09:10:09.938970 starting: writing forward_run.py
2019-05-11 09:10:09.939773 finished: writing forward_run.py took: 0:00:00.000803
2019-05-11 09:10:09.940038 writing pst template/freyberg.pst
noptmax:0, npar_adj:14819, nnz_obs:4434
2019-05-11 09:10:11.859691 starting: running pestchek on freyberg.pst
2019-05-11 09:10:11.936193 pestcheck:PESTCHEK Version 13.0. Watermark Numerical Computing.
2019-05-11 09:10:11.936572 pestcheck:
2019-05-11 09:10:11.936627 pestcheck:Errors ----->
2019-05-11 09:10:11.936680 pestcheck:Line 2403 of file freyberg.pst: parameter name "prsity3000
2019-05-11 09:10:11.936958 pestcheck:12 characters long.
2019-05-11 09:10:11.937212 pestcheck:Line 2404 of file freyberg.pst: parameter name "prsity3000
2019-05-11 09:10:11.938208 pestcheck:12 characters long.
2019-05-11 09:10:11.938395 pestcheck:Line 2404 of file freyberg.pst: parameter name "prsity3000
2019-05-11 09:10:11.938447 pestcheck:once.
2019-05-11 09:10:11.938482 pestcheck:Line 2405 of file freyberg.pst: parameter name "prsity3000
2019-05-11 09:10:11.938514 pestcheck:12 characters long.
2019-05-11 09:10:11.938916 pestcheck:Line 2405 of file freyberg.pst: parameter name "prsity3000
2019-05-11 09:10:11.939372 pestcheck:once.
2019-05-11 09:10:11.939590 pestcheck:Line 2406 of file freyberg.pst: parameter name "prsity3000
2019-05-11 09:10:11.939628 pestcheck:12 characters long.
2019-05-11 09:10:11.939661 pestcheck:Line 2406 of file freyberg.pst: parameter name "prsity3000
2019-05-11 09:10:11.939765 pestcheck:once.
2019-05-11 09:10:11.940026 pestcheck:Line 2407 of file freyberg.pst: parameter name "prsity3000
2019-05-11 09:10:11.940200 pestcheck:12 characters long.
2019-05-11 09:10:11.940280 pestcheck:Line 2407 of file freyberg.pst: parameter name "prsity3000
2019-05-11 09:10:11.940350 pestcheck:once.
2019-05-11 09:10:11.940539 pestcheck:Line 2408 of file freyberg.pst: parameter name "prsity3000
2019-05-11 09:10:11.940684 pestcheck:12 characters long.
2019-05-11 09:10:11.940803 pestcheck:Line 2408 of file freyberg.pst: parameter name "prsity3000
2019-05-11 09:10:11.940938 pestcheck:once.
2019-05-11 09:10:11.940984 pestcheck:Line 2409 of file freyberg.pst: parameter name "prsity3000
2019-05-11 09:10:11.941022 pestcheck:12 characters long.
2019-05-11 09:10:11.941120 pestcheck:Line 2409 of file freyberg.pst: parameter name "prsity3000
2019-05-11 09:10:11.941255 pestcheck:once.
2019-05-11 09:10:11.941303 pestcheck:Line 2410 of file freyberg.pst: parameter name "prsity3000
2019-05-11 09:10:11.941408 pestcheck:12 characters long.
2019-05-11 09:10:11.941510 pestcheck:Line 2410 of file freyberg.pst: parameter name "prsity3000
2019-05-11 09:10:11.941563 pestcheck:once.
2019-05-11 09:10:11.941660 pestcheck:Line 2411 of file freyberg.pst: parameter name "prsity3000
2019-05-11 09:10:11.941761 pestcheck:12 characters long.
2019-05-11 09:10:11.941904 pestcheck:Line 2411 of file freyberg.pst: parameter name "prsity3000
2019-05-11 09:10:11.942006 pestcheck:once.
```

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2019-05-11 09:10:11.942116 pestcheck:Line 2412 of file freyberg.pst: parameter name "prsity3000
2019-05-11 09:10:11.942218 pestcheck:12 characters long.
2019-05-11 09:10:11.942329 pestcheck:Line 2412 of file freyberg.pst: parameter name "prsity3000
2019-05-11 09:10:11.942462 pestcheck:once.
2019-05-11 09:10:11.942510 pestcheck:Line 2413 of file freyberg.pst: parameter name "prsity3000
2019-05-11 09:10:11.942684 pestcheck:12 characters long.
2019-05-11 09:10:11.942730 pestcheck:Line 2414 of file freyberg.pst: parameter name "prsity3000
2019-05-11 09:10:11.942833 pestcheck:12 characters long.
2019-05-11 09:10:11.942966 pestcheck:Line 2414 of file freyberg.pst: parameter name "prsity3000
2019-05-11 09:10:11.943110 pestcheck:once.
2019-05-11 09:10:11.943245 pestcheck:Line 2415 of file freyberg.pst: parameter name "prsity3000
2019-05-11 09:10:11.943387 pestcheck:12 characters long.
2019-05-11 09:10:11.943489 pestcheck:Line 2415 of file freyberg.pst: parameter name "prsity3000
2019-05-11 09:10:11.943636 pestcheck:once.
2019-05-11 09:10:11.943738 pestcheck:Line 2416 of file freyberg.pst: parameter name "prsity3000
2019-05-11 09:10:11.943848 pestcheck:12 characters long.
2019-05-11 09:10:11.943948 pestcheck:Line 2416 of file freyberg.pst: parameter name "prsity3000
2019-05-11 09:10:11.944092 pestcheck:once.
2019-05-11 09:10:11.944195 pestcheck:Line 2417 of file freyberg.pst: parameter name "prsity3000
2019-05-11 09:10:11.944336 pestcheck:12 characters long.
2019-05-11 09:10:11.944437 pestcheck:Line 2417 of file freyberg.pst: parameter name "prsity3000
2019-05-11 09:10:11.944548 pestcheck:once.
2019-05-11 09:10:11.944761 pestcheck:Line 2418 of file freyberg.pst: parameter name "prsity3000
2019-05-11 09:10:11.944894 pestcheck:12 characters long.
2019-05-11 09:10:11.945005 pestcheck:Line 2418 of file freyberg.pst: parameter name "prsity3000
2019-05-11 09:10:11.945106 pestcheck:once.
2019-05-11 09:10:11.945216 pestcheck:Line 2419 of file freyberg.pst: parameter name "prsity3000
2019-05-11 09:10:11.945396 pestcheck:12 characters long.
2019-05-11 09:10:11.945884 pestcheck:Line 2419 of file freyberg.pst: parameter name "prsity3000
2019-05-11 09:10:11.946191 pestcheck:once.
2019-05-11 09:10:11.946321 pestcheck:Line 2420 of file freyberg.pst: parameter name "prsity3000
2019-05-11 09:10:11.946472 pestcheck:12 characters long.
2019-05-11 09:10:11.946578 pestcheck:Line 2420 of file freyberg.pst: parameter name "prsity3000
2019-05-11 09:10:11.946639 pestcheck:once.
2019-05-11 09:10:11.946777 pestcheck:Line 2421 of file freyberg.pst: parameter name "prsity3000
2019-05-11 09:10:11.946906 pestcheck:12 characters long.
2019-05-11 09:10:11.947039 pestcheck:Line 2421 of file freyberg.pst: parameter name "prsity3000
2019-05-11 09:10:11.947150 pestcheck:once.
2019-05-11 09:10:11.947270 pestcheck:Line 2422 of file freyberg.pst: parameter name "prsity3000
2019-05-11 09:10:11.947378 pestcheck:12 characters long.
2019-05-11 09:10:11.947426 pestcheck:Line 2422 of file freyberg.pst: parameter name "prsity3000
2019-05-11 09:10:11.947533 pestcheck:once.
2019-05-11 09:10:11.947639 pestcheck:Line 2423 of file freyberg.pst: parameter name "prsity3001
2019-05-11 09:10:11.947690 pestcheck:12 characters long.
2019-05-11 09:10:11.947796 pestcheck:Line 2424 of file freyberg.pst: parameter name "prsity3001
2019-05-11 09:10:11.947903 pestcheck:12 characters long.
2019-05-11 09:10:11.948023 pestcheck:Line 2424 of file freyberg.pst: parameter name "prsity3001
2019-05-11 09:10:11.948129 pestcheck:once.
```

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2019-05-11 09:10:11.948177 pestcheck:Line 2425 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.948282 pestcheck:12 characters long.
2019-05-11 09:10:11.948335 pestcheck:Line 2425 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.948455 pestcheck:once.
2019-05-11 09:10:11.948549 pestcheck:Line 2426 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.948636 pestcheck:12 characters long.
2019-05-11 09:10:11.948701 pestcheck:Line 2426 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.948816 pestcheck:once.
2019-05-11 09:10:11.948867 pestcheck:Line 2427 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.948986 pestcheck:12 characters long.
2019-05-11 09:10:11.949025 pestcheck:Line 2427 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.949132 pestcheck:once.
2019-05-11 09:10:11.949243 pestcheck:Line 2428 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.949290 pestcheck:12 characters long.
2019-05-11 09:10:11.949329 pestcheck:Line 2428 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.949432 pestcheck:once.
2019-05-11 09:10:11.949539 pestcheck:Line 2429 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.949586 pestcheck:12 characters long.
2019-05-11 09:10:11.949690 pestcheck:Line 2429 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.949796 pestcheck:once.
2019-05-11 09:10:11.949843 pestcheck:Line 2430 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.950020 pestcheck:12 characters long.
2019-05-11 09:10:11.950070 pestcheck:Line 2430 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.950175 pestcheck:once.
2019-05-11 09:10:11.950280 pestcheck:Line 2431 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.950329 pestcheck:12 characters long.
2019-05-11 09:10:11.950435 pestcheck:Line 2431 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.950540 pestcheck:once.
2019-05-11 09:10:11.950586 pestcheck:Line 2432 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.950624 pestcheck:12 characters long.
2019-05-11 09:10:11.950692 pestcheck:Line 2432 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.950765 pestcheck:once.
2019-05-11 09:10:11.950870 pestcheck:Line 2433 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.950924 pestcheck:12 characters long.
2019-05-11 09:10:11.951023 pestcheck:Line 2434 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.951127 pestcheck:12 characters long.
2019-05-11 09:10:11.951173 pestcheck:Line 2434 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.951212 pestcheck:once.
2019-05-11 09:10:11.951312 pestcheck:Line 2435 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.951416 pestcheck:12 characters long.
2019-05-11 09:10:11.951463 pestcheck:Line 2435 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.951568 pestcheck:once.
2019-05-11 09:10:11.951672 pestcheck:Line 2436 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.951788 pestcheck:12 characters long.
2019-05-11 09:10:11.951892 pestcheck:Line 2436 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.951946 pestcheck:once.
2019-05-11 09:10:11.952046 pestcheck:Line 2437 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.952151 pestcheck:12 characters long.
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2019-05-11 09:10:11.952197 pestcheck:Line 2437 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.952235 pestcheck:once.
2019-05-11 09:10:11.952335 pestcheck:Line 2438 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.952439 pestcheck:12 characters long.
2019-05-11 09:10:11.952488 pestcheck:Line 2438 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.952527 pestcheck:once.
2019-05-11 09:10:11.952700 pestcheck:Line 2439 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.952817 pestcheck:12 characters long.
2019-05-11 09:10:11.952951 pestcheck:Line 2439 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.953581 pestcheck:once.
2019-05-11 09:10:11.953763 pestcheck:Line 2440 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.953846 pestcheck:12 characters long.
2019-05-11 09:10:11.953911 pestcheck:Line 2440 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.955393 pestcheck:once.
2019-05-11 09:10:11.955537 pestcheck:Line 2441 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.955674 pestcheck:12 characters long.
2019-05-11 09:10:11.955733 pestcheck:Line 2441 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.955783 pestcheck:once.
2019-05-11 09:10:11.955829 pestcheck:Line 2442 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.956017 pestcheck:12 characters long.
2019-05-11 09:10:11.956213 pestcheck:Line 2442 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.956457 pestcheck:once.
2019-05-11 09:10:11.956562 pestcheck:Line 2443 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.956630 pestcheck:12 characters long.
2019-05-11 09:10:11.957011 pestcheck:Line 2444 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.957214 pestcheck:12 characters long.
2019-05-11 09:10:11.957296 pestcheck:Line 2444 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.957465 pestcheck:once.
2019-05-11 09:10:11.957619 pestcheck:Line 2445 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.957680 pestcheck:12 characters long.
2019-05-11 09:10:11.957726 pestcheck:Line 2445 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.957885 pestcheck:once.
2019-05-11 09:10:11.958197 pestcheck:Line 2446 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.958253 pestcheck:12 characters long.
2019-05-11 09:10:11.958291 pestcheck:Line 2446 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.958322 pestcheck:once.
2019-05-11 09:10:11.958355 pestcheck:Line 2447 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.958585 pestcheck:12 characters long.
2019-05-11 09:10:11.958649 pestcheck:Line 2447 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.958688 pestcheck:once.
2019-05-11 09:10:11.959612 pestcheck:Line 2448 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.959717 pestcheck:12 characters long.
2019-05-11 09:10:11.959846 pestcheck:Line 2448 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.959883 pestcheck:once.
2019-05-11 09:10:11.959925 pestcheck:Line 2449 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.960102 pestcheck:12 characters long.
2019-05-11 09:10:11.960453 pestcheck:Line 2449 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.960721 pestcheck:once.
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2019-05-11 09:10:11.961071 pestcheck:Line 2450 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.961171 pestcheck:12 characters long.
2019-05-11 09:10:11.961280 pestcheck:Line 2450 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.961470 pestcheck:once.
2019-05-11 09:10:11.961609 pestcheck:Line 2451 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.961676 pestcheck:12 characters long.
2019-05-11 09:10:11.961766 pestcheck:Line 2451 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.961882 pestcheck:once.
2019-05-11 09:10:11.961946 pestcheck:Line 2452 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.962065 pestcheck:12 characters long.
2019-05-11 09:10:11.962126 pestcheck:Line 2452 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.962196 pestcheck:once.
2019-05-11 09:10:11.962259 pestcheck:Line 2453 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.962375 pestcheck:12 characters long.
2019-05-11 09:10:11.962438 pestcheck:Line 2454 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.962555 pestcheck:12 characters long.
2019-05-11 09:10:11.962619 pestcheck:Line 2454 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.963073 pestcheck:once.
2019-05-11 09:10:11.963136 pestcheck:Line 2455 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.963176 pestcheck:12 characters long.
2019-05-11 09:10:11.963479 pestcheck:Line 2455 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.963534 pestcheck:once.
2019-05-11 09:10:11.963590 pestcheck:Line 2456 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.963627 pestcheck:12 characters long.
2019-05-11 09:10:11.963665 pestcheck:Line 2456 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.963699 pestcheck:once.
2019-05-11 09:10:11.964122 pestcheck:Line 2457 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.964183 pestcheck:12 characters long.
2019-05-11 09:10:11.964223 pestcheck:Line 2457 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.964281 pestcheck:once.
2019-05-11 09:10:11.964316 pestcheck:Line 2458 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.964349 pestcheck:12 characters long.
2019-05-11 09:10:11.964464 pestcheck:Line 2458 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.964512 pestcheck:once.
2019-05-11 09:10:11.964552 pestcheck:Line 2459 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.964663 pestcheck:12 characters long.
2019-05-11 09:10:11.964773 pestcheck:Line 2459 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.964821 pestcheck:once.
2019-05-11 09:10:11.964860 pestcheck:Line 2460 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.964964 pestcheck:12 characters long.
2019-05-11 09:10:11.965071 pestcheck:Line 2460 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.965119 pestcheck:once.
2019-05-11 09:10:11.965304 pestcheck:Line 2461 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.965355 pestcheck:12 characters long.
2019-05-11 09:10:11.965462 pestcheck:Line 2461 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.965569 pestcheck:once.
2019-05-11 09:10:11.965616 pestcheck:Line 2462 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.965655 pestcheck:12 characters long.
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2019-05-11 09:10:11.965756 pestcheck:Line 2462 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.965862 pestcheck:once.
2019-05-11 09:10:11.965909 pestcheck:Line 2463 of file freyberg.pst: parameter name "prsity3003
2019-05-11 09:10:11.965948 pestcheck:12 characters long.
2019-05-11 09:10:11.966051 pestcheck:Line 2464 of file freyberg.pst: parameter name "prsity3003
2019-05-11 09:10:11.966157 pestcheck:12 characters long.
2019-05-11 09:10:11.966278 pestcheck:Line 2464 of file freyberg.pst: parameter name "prsity3003
2019-05-11 09:10:11.966385 pestcheck:once.
2019-05-11 09:10:11.966470 pestcheck:Line 2465 of file freyberg.pst: parameter name "prsity3003
2019-05-11 09:10:11.966544 pestcheck:12 characters long.
2019-05-11 09:10:11.966651 pestcheck:Line 2465 of file freyberg.pst: parameter name "prsity3003
2019-05-11 09:10:11.966698 pestcheck:once.
2019-05-11 09:10:11.966738 pestcheck:Line 2466 of file freyberg.pst: parameter name "prsity3003
2019-05-11 09:10:11.966939 pestcheck:12 characters long.
2019-05-11 09:10:11.966998 pestcheck:Line 2466 of file freyberg.pst: parameter name "prsity3003
2019-05-11 09:10:11.967306 pestcheck:once.
2019-05-11 09:10:11.967445 pestcheck:Line 2467 of file freyberg.pst: parameter name "prsity3003
2019-05-11 09:10:11.967515 pestcheck:12 characters long.
2019-05-11 09:10:11.967628 pestcheck:Line 2467 of file freyberg.pst: parameter name "prsity3003
2019-05-11 09:10:11.967745 pestcheck:once.
2019-05-11 09:10:11.967795 pestcheck:Line 2468 of file freyberg.pst: parameter name "prsity3003
2019-05-11 09:10:11.967835 pestcheck:12 characters long.
2019-05-11 09:10:11.967941 pestcheck:Line 2468 of file freyberg.pst: parameter name "prsity3003
2019-05-11 09:10:11.968051 pestcheck:once.
2019-05-11 09:10:11.968109 pestcheck:Line 2469 of file freyberg.pst: parameter name "prsity3003
2019-05-11 09:10:11.968201 pestcheck:12 characters long.
2019-05-11 09:10:11.968309 pestcheck:Line 2469 of file freyberg.pst: parameter name "prsity3003
2019-05-11 09:10:11.968430 pestcheck:once.
2019-05-11 09:10:11.968537 pestcheck:Line 2470 of file freyberg.pst: parameter name "prsity3003
2019-05-11 09:10:11.968585 pestcheck:12 characters long.
2019-05-11 09:10:11.968690 pestcheck:Line 2470 of file freyberg.pst: parameter name "prsity3003
2019-05-11 09:10:11.968796 pestcheck:once.
2019-05-11 09:10:11.968911 pestcheck:Line 2471 of file freyberg.pst: parameter name "prsity3003
2019-05-11 09:10:11.969017 pestcheck:12 characters long.
2019-05-11 09:10:11.969068 pestcheck:Line 2471 of file freyberg.pst: parameter name "prsity3003
2019-05-11 09:10:11.969120 pestcheck:once.
2019-05-11 09:10:11.969269 pestcheck:Line 2472 of file freyberg.pst: parameter name "prsity3003
2019-05-11 09:10:11.969396 pestcheck:12 characters long.
2019-05-11 09:10:11.969456 pestcheck:Line 2472 of file freyberg.pst: parameter name "prsity3003
2019-05-11 09:10:11.969496 pestcheck:once.
2019-05-11 09:10:11.969602 pestcheck:Line 2473 of file freyberg.pst: parameter name "prsity3003
2019-05-11 09:10:11.969709 pestcheck:12 characters long.
2019-05-11 09:10:11.969760 pestcheck:Line 2474 of file freyberg.pst: parameter name "prsity3003
2019-05-11 09:10:11.969868 pestcheck:12 characters long.
2019-05-11 09:10:11.969974 pestcheck:Line 2474 of file freyberg.pst: parameter name "prsity3003
2019-05-11 09:10:11.970023 pestcheck:once.
2019-05-11 09:10:11.970129 pestcheck:Line 2475 of file freyberg.pst: parameter name "prsity3003
2019-05-11 09:10:11.970235 pestcheck:12 characters long.
```

```
2019-05-11 09:10:11.970350 pestcheck:Line 2475 of file freyberg.pst: parameter name "prsity3003
2019-05-11 09:10:11.970540 pestcheck:once.
2019-05-11 09:10:11.970646 pestcheck:Line 2476 of file freyberg.pst: parameter name "prsity3003
2019-05-11 09:10:11.970760 pestcheck:12 characters long.
2019-05-11 09:10:11.970866 pestcheck:Line 2476 of file freyberg.pst: parameter name "prsity3003
2019-05-11 09:10:11.970982 pestcheck:once.
2019-05-11 09:10:11.971087 pestcheck:Line 2477 of file freyberg.pst: parameter name "prsity3003
2019-05-11 09:10:11.971204 pestcheck:12 characters long.
2019-05-11 09:10:11.971310 pestcheck:Line 2477 of file freyberg.pst: parameter name "prsity3003
2019-05-11 09:10:11.971429 pestcheck:once.
2019-05-11 09:10:11.971572 pestcheck:Line 2478 of file freyberg.pst: parameter name "prsity3003
2019-05-11 09:10:11.971720 pestcheck:12 characters long.
2019-05-11 09:10:11.972036 pestcheck:Line 2478 of file freyberg.pst: parameter name "prsity3003
2019-05-11 09:10:11.972078 pestcheck:once.
2019-05-11 09:10:11.972115 pestcheck:Line 2479 of file freyberg.pst: parameter name "prsity3003
2019-05-11 09:10:11.972145 pestcheck:12 characters long.
2019-05-11 09:10:11.972177 pestcheck:Line 2479 of file freyberg.pst: parameter name "prsity3003
2019-05-11 09:10:11.972219 pestcheck:once.
2019-05-11 09:10:11.972253 pestcheck:Line 2480 of file freyberg.pst: parameter name "prsity3003
2019-05-11 09:10:11.972292 pestcheck:12 characters long.
2019-05-11 09:10:11.972331 pestcheck:Line 2480 of file freyberg.pst: parameter name "prsity3003
2019-05-11 09:10:11.972367 pestcheck:once.
2019-05-11 09:10:11.972396 pestcheck:Line 2481 of file freyberg.pst: parameter name "prsity3003
2019-05-11 09:10:11.972430 pestcheck:12 characters long.
2019-05-11 09:10:11.972458 pestcheck:Line 2481 of file freyberg.pst: parameter name "prsity3003
2019-05-11 09:10:11.972490 pestcheck:once.
2019-05-11 09:10:11.972619 pestcheck:Line 2482 of file freyberg.pst: parameter name "prsity3003
2019-05-11 09:10:11.972654 pestcheck:12 characters long.
2019-05-11 09:10:11.972699 pestcheck:Line 2482 of file freyberg.pst: parameter name "prsity3003
2019-05-11 09:10:11.972733 pestcheck:once.
2019-05-11 09:10:11.972842 pestcheck:Line 2483 of file freyberg.pst: parameter name "prsity3004
2019-05-11 09:10:11.972876 pestcheck:12 characters long.
2019-05-11 09:10:11.972922 pestcheck:Line 2484 of file freyberg.pst: parameter name "prsity3004
2019-05-11 09:10:11.972956 pestcheck:12 characters long.
2019-05-11 09:10:11.972984 pestcheck:Line 2484 of file freyberg.pst: parameter name "prsity3004
2019-05-11 09:10:11.973050 pestcheck:once.
2019-05-11 09:10:11.973153 pestcheck:Line 2485 of file freyberg.pst: parameter name "prsity3004
2019-05-11 09:10:11.973263 pestcheck:12 characters long.
2019-05-11 09:10:11.973697 pestcheck:Line 2485 of file freyberg.pst: parameter name "prsity3004
2019-05-11 09:10:11.973893 pestcheck:once.
2019-05-11 09:10:11.974073 pestcheck:Line 2486 of file freyberg.pst: parameter name "prsity3004
2019-05-11 09:10:11.974193 pestcheck:12 characters long.
2019-05-11 09:10:11.974313 pestcheck:Line 2486 of file freyberg.pst: parameter name "prsity3004
2019-05-11 09:10:11.974447 pestcheck:once.
2019-05-11 09:10:11.974558 pestcheck:Line 2487 of file freyberg.pst: parameter name "prsity3004
2019-05-11 09:10:11.974675 pestcheck:12 characters long.
2019-05-11 09:10:11.974781 pestcheck:Line 2487 of file freyberg.pst: parameter name "prsity3004
2019-05-11 09:10:11.974896 pestcheck:once.
```

```
2019-05-11 09:10:11.975003 pestcheck:Line 2488 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.975265 pestcheck:12 characters long.
2019-05-11 09:10:11.975377 pestcheck:Line 2488 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.975498 pestcheck:once.
2019-05-11 09:10:11.975606 pestcheck:Line 2489 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.975667 pestcheck:12 characters long.
2019-05-11 09:10:11.975775 pestcheck:Line 2489 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.975882 pestcheck:once.
2019-05-11 09:10:11.975930 pestcheck:Line 2490 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.975969 pestcheck:12 characters long.
2019-05-11 09:10:11.976071 pestcheck:Line 2490 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.976121 pestcheck:once.
2019-05-11 09:10:11.976218 pestcheck:Line 2491 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.976273 pestcheck:12 characters long.
2019-05-11 09:10:11.976338 pestcheck:Line 2491 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.976447 pestcheck:once.
2019-05-11 09:10:11.976568 pestcheck:Line 2492 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.976616 pestcheck:12 characters long.
2019-05-11 09:10:11.976656 pestcheck:Line 2492 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.976762 pestcheck:once.
2019-05-11 09:10:11.976871 pestcheck:Line 2493 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.977010 pestcheck:12 characters long.
2019-05-11 09:10:11.977117 pestcheck:Line 2494 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.977165 pestcheck:12 characters long.
2019-05-11 09:10:11.977204 pestcheck:Line 2494 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.977305 pestcheck:once.
2019-05-11 09:10:11.977410 pestcheck:Line 2495 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.977464 pestcheck:12 characters long.
2019-05-11 09:10:11.977564 pestcheck:Line 2495 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.977671 pestcheck:once.
2019-05-11 09:10:11.977790 pestcheck:Line 2496 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.977849 pestcheck:12 characters long.
2019-05-11 09:10:11.977948 pestcheck:Line 2496 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.978066 pestcheck:once.
2019-05-11 09:10:11.978173 pestcheck:Line 2497 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.978221 pestcheck:12 characters long.
2019-05-11 09:10:11.978329 pestcheck:Line 2497 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.978434 pestcheck:once.
2019-05-11 09:10:11.978552 pestcheck:Line 2498 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.978658 pestcheck:12 characters long.
2019-05-11 09:10:11.978708 pestcheck:Line 2498 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.978764 pestcheck:once.
2019-05-11 09:10:11.978828 pestcheck:Line 2499 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.978943 pestcheck:12 characters long.
2019-05-11 09:10:11.979000 pestcheck:Line 2499 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.979105 pestcheck:once.
2019-05-11 09:10:11.979154 pestcheck:Line 2500 of file freyberg.pst: parameter name "prsity300
2019-05-11 09:10:11.979193 pestcheck:12 characters long.
```

```
2019-05-11 09:10:11.979299 pestcheck:Line 2500 of file freyberg.pst: parameter name "prsity3004
2019-05-11 09:10:11.979351 pestcheck:once.
2019-05-11 09:10:11.979450 pestcheck:Line 2501 of file freyberg.pst: parameter name "prsity3004
2019-05-11 09:10:11.979506 pestcheck:12 characters long.
2019-05-11 09:10:11.979609 pestcheck:Line 2501 of file freyberg.pst: parameter name "prsity3004
2019-05-11 09:10:11.979716 pestcheck:once.
2019-05-11 09:10:11.979763 pestcheck:Line 2502 of file freyberg.pst: parameter name "prsity3004
2019-05-11 09:10:11.979869 pestcheck:12 characters long.
2019-05-11 09:10:11.979976 pestcheck:Line 2502 of file freyberg.pst: parameter name "prsity3004
2019-05-11 09:10:11.980023 pestcheck:once.
2019-05-11 09:10:11.980129 pestcheck:Line 2503 of file freyberg.pst: parameter name "prsity3005
2019-05-11 09:10:11.980235 pestcheck:12 characters long.
2019-05-11 09:10:11.980287 pestcheck:Line 2504 of file freyberg.pst: parameter name "prsity3005
2019-05-11 09:10:11.980367 pestcheck:12 characters long.
2019-05-11 09:10:11.980441 pestcheck:Line 2504 of file freyberg.pst: parameter name "prsity3005
2019-05-11 09:10:11.980564 pestcheck:once.
2019-05-11 09:10:11.980669 pestcheck:Line 2505 of file freyberg.pst: parameter name "prsity3005
2019-05-11 09:10:11.980776 pestcheck:12 characters long.
2019-05-11 09:10:11.980823 pestcheck:Line 2505 of file freyberg.pst: parameter name "prsity3005
2019-05-11 09:10:11.980929 pestcheck:once.
2019-05-11 09:10:11.980982 pestcheck:Line 2506 of file freyberg.pst: parameter name "prsity3005
2019-05-11 09:10:11.981079 pestcheck:12 characters long.
2019-05-11 09:10:11.981127 pestcheck:Line 2506 of file freyberg.pst: parameter name "prsity3005
2019-05-11 09:10:11.981232 pestcheck:once.
2019-05-11 09:10:11.981339 pestcheck:Line 2507 of file freyberg.pst: parameter name "prsity3005
2019-05-11 09:10:11.981389 pestcheck:12 characters long.
2019-05-11 09:10:11.981496 pestcheck:Line 2507 of file freyberg.pst: parameter name "prsity3005
2019-05-11 09:10:11.981685 pestcheck:once.
2019-05-11 09:10:11.981791 pestcheck:Line 2508 of file freyberg.pst: parameter name "prsity3005
2019-05-11 09:10:11.981838 pestcheck:12 characters long.
2019-05-11 09:10:11.982153 finished: running pestchek on freyberg.pst took: 0:00:00.122462
2019-05-11 09:10:11.982292 starting: saving intermediate _setup_<> dfs into template
2019-05-11 09:10:12.121313 finished: saving intermediate _setup_<> dfs into template took: 0:0
2019-05-11 09:10:12.122130 all done
```

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

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

```
Out[14]: (14819, 4434)
```

Oh snap!

1.1.6 Add modpath input files, instruction files and calls

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

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

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

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

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

Create and add instruction files and related observations for MODPATH

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

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

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

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

1.1.7 Final bits and bobs

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

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

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

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

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

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

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

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

Out[21]:

	type	transform	count	initial value	\
cn_hk6	cn_hk6	log	1	0	
cn_hk7	cn_hk7	log	1	0	
cn_hk8	cn_hk8	log	1	0	
cn_prsity6	cn_prsity6	log	1	0	
cn_prsity7	cn_prsity7	log	1	0	
cn_prsity8	cn_prsity8	log	1	0	
cn_rech4	cn_rech4	log	1	0	
cn_rech5	cn_rech5	log	1	-0.39794	

cn_ss6	cn_ss6	log	1	0
cn_ss7	cn_ss7	log	1	0
cn_ss8	cn_ss8	log	1	0
cn_strt6	cn_strt6	log	1	0
cn_strt7	cn_strt7	log	1	0
cn_strt8	cn_strt8	log	1	0
cn_sy6	cn_sy6	log	1	0
cn_sy7	cn_sy7	log	1	0
cn_sy8	cn_sy8	log	1	0
cn_vka6	cn_vka6	log	1	0
cn_vka7	cn_vka7	log	1	0
cn_vka8	cn_vka8	log	1	0
drncond_k00	drncond_k00	log	10	0
flow	flow	log	1	0
gr_hk3	gr_hk3	log	705	0
gr_hk4	gr_hk4	log	705	0
gr_hk5	gr_hk5	log	705	0
gr_prsity3	gr_prsity3	log	705	0
gr_prsity4	gr_prsity4	log	705	0
gr_prsity5	gr_prsity5	log	705	0
gr_rech2	gr_rech2	log	705	0
gr_rech3	gr_rech3	log	705	0
...	...	...	...	...
gr_strt5	gr_strt5	log	705	0
gr_sy3	gr_sy3	log	705	0
gr_sy4	gr_sy4	log	705	0
gr_sy5	gr_sy5	log	705	0
gr_vka3	gr_vka3	log	705	0
gr_vka4	gr_vka4	log	705	0
gr_vka5	gr_vka5	log	705	0
pp_hk0	pp_hk0	log	32	0
pp_hk1	pp_hk1	log	32	0
pp_hk2	pp_hk2	log	32	0
pp_prsity0	pp_prsity0	log	32	0
pp_prsity1	pp_prsity1	log	32	0
pp_prsity2	pp_prsity2	log	32	0
pp_rech0	pp_rech0	log	32	0
pp_rech1	pp_rech1	log	32	0
pp_ss0	pp_ss0	log	32	0
pp_ss1	pp_ss1	log	32	0
pp_ss2	pp_ss2	log	32	0
pp_strt0	pp_strt0	log	32	0
pp_strt1	pp_strt1	log	32	0
pp_strt2	pp_strt2	log	32	0
pp_sy0	pp_sy0	log	32	0
pp_sy1	pp_sy1	log	32	0
pp_sy2	pp_sy2	log	32	0
pp_vka0	pp_vka0	log	32	0

pp_vka1	pp_vka1	log	32	0
pp_vka2	pp_vka2	log	32	0
strk	strk	log	40	0
welflux	welflux	log	2	0 to 0.176091
welflux_k02	welflux_k02	log	6	0

	upper bound	lower bound	standard deviation
cn_hk6	1	-1	0.5
cn_hk7	1	-1	0.5
cn_hk8	1	-1	0.5
cn_prsity6	0.176091	-0.30103	0.11928
cn_prsity7	0.176091	-0.30103	0.11928
cn_prsity8	0.176091	-0.30103	0.11928
cn_rech4	0.0791812	-0.09691	0.0440228
cn_rech5	-0.09691	-1	0.225772
cn_ss6	1	-1	0.5
cn_ss7	1	-1	0.5
cn_ss8	1	-1	0.5
cn_strt6	0.0211893	-0.0222764	0.0108664
cn_strt7	0.0211893	-0.0222764	0.0108664
cn_strt8	0.0211893	-0.0222764	0.0108664
cn_sy6	0.243038	-0.60206	0.211275
cn_sy7	0.243038	-0.60206	0.211275
cn_sy8	0.243038	-0.60206	0.211275
cn_vka6	1	-1	0.5
cn_vka7	1	-1	0.5
cn_vka8	1	-1	0.5
drncond_k00	1	-1	0.5
flow	0.09691	-0.124939	0.0554622
gr_hk3	1	-1	0.5
gr_hk4	1	-1	0.5
gr_hk5	1	-1	0.5
gr_prsity3	0.176091	-0.30103	0.11928
gr_prsity4	0.176091	-0.30103	0.11928
gr_prsity5	0.176091	-0.30103	0.11928
gr_rech2	0.0413927	-0.0457575	0.0217875
gr_rech3	0.0413927	-0.0457575	0.0217875
...	...	...	...
gr_strt5	0.0211893	-0.0222764	0.0108664
gr_sy3	0.243038	-0.60206	0.211275
gr_sy4	0.243038	-0.60206	0.211275
gr_sy5	0.243038	-0.60206	0.211275
gr_vka3	1	-1	0.5
gr_vka4	1	-1	0.5
gr_vka5	1	-1	0.5
pp_hk0	1	-1	0.5
pp_hk1	1	-1	0.5
pp_hk2	1	-1	0.5

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

[65 rows x 7 columns]
```

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

Out[22]:

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

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

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

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

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

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

```
In [24]: if pst_helper.pst.npar < 15000:
             cov = pst_helper.build_prior(fmt="coo",filename=os.path.join(pst_helper.new_model
             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()
```

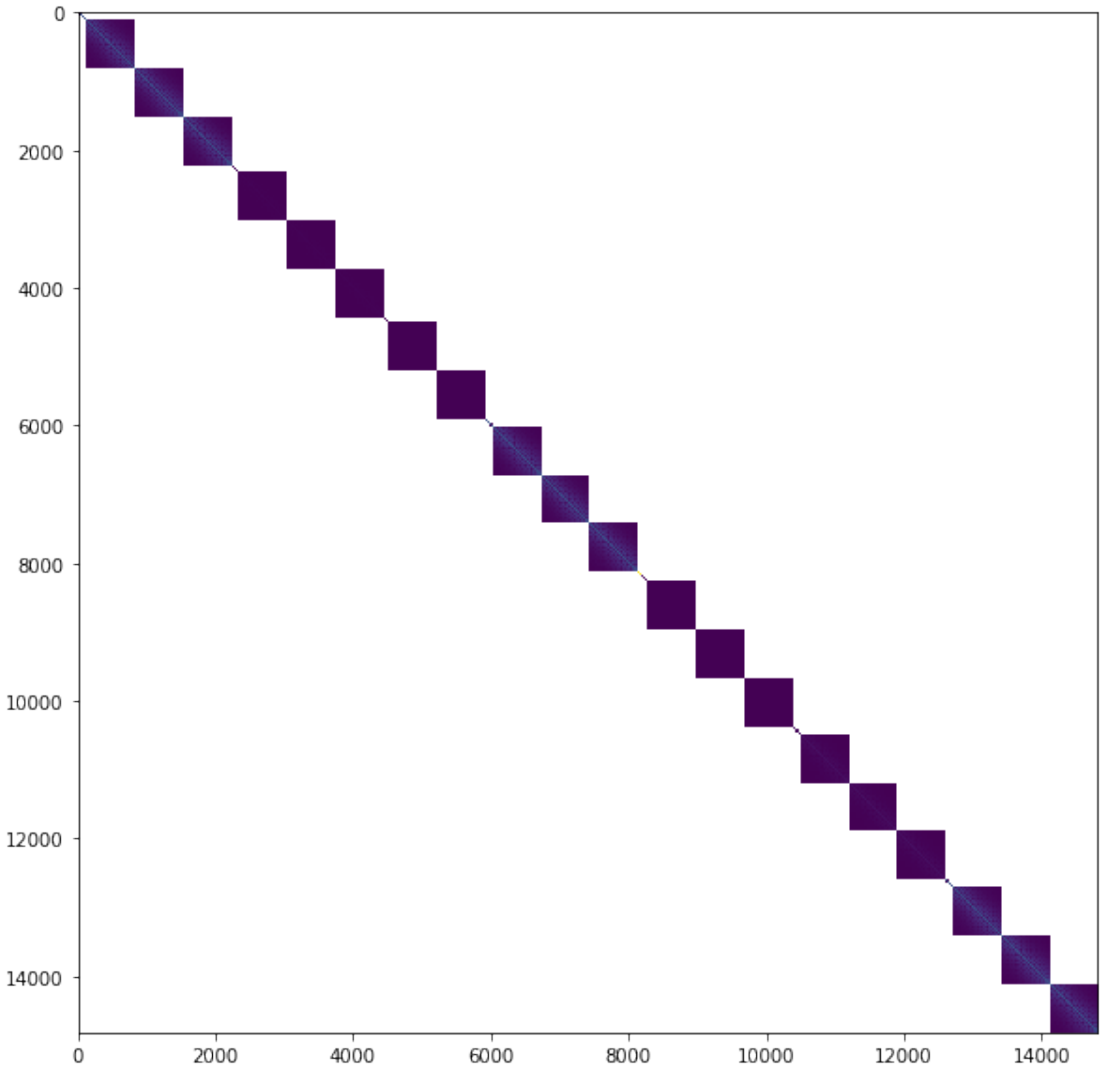
```
2019-05-11 09:10:21.726184 starting: building prior covariance matrix
2019-05-11 09:10:21.853950 WARNING: geospatial prior not implemented for SFR pars
```

```
/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


2019-05-11 09:10:28.220555 saving prior covariance matrix to file template/prior_cov.jcb
2019-05-11 09:10:32.580809 finished: building prior covariance matrix took: 0:00:10.854625
```



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

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

```
2019-05-11 09:10:44.621101 starting: drawing realizations
building diagonal cov
processing  name:grid_geostruct,nugget:0.0,structures:
name:var1,contribution:1.0,a:2500.0,anisotropy:1.0,bearing:0.0

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

```
making full cov draws with home-grown goodness
working on pargroups ['gr_hk4']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_vka4']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_ss4']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_sy4']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_strt4']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_prsity4']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_hk5']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_vka5']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
```

```
making full cov draws with home-grown goodness
working on pargroups ['gr_ss5']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_sy5']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_strt5']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_prsity5']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_rech2']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_rech3']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
processing  name:pp_geostruct,nugget:0.0,structures:
name:var1,contribution:1.0,a:1000.0,anisotropy:1.0,bearing:0.0

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

```
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_ss0']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_sy0']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_strt0']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_prsity0']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_rech0']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_rech1']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_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_prsity1']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_hk1']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_vka1']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_ss1']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_ss2']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_hk2']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_vka2']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_sy2']
build cov matrix
```

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

working on pargroups ['welflux_k02']
build cov matrix
done
getting diag var cov 6
scaling full cov by diag var cov
making full cov draws with home-grown goodness


/Users/jeremyw/miniconda3/lib/python3.5/site-packages/pandas/core/indexing.py:362: SettingWith
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: SettingWith
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


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

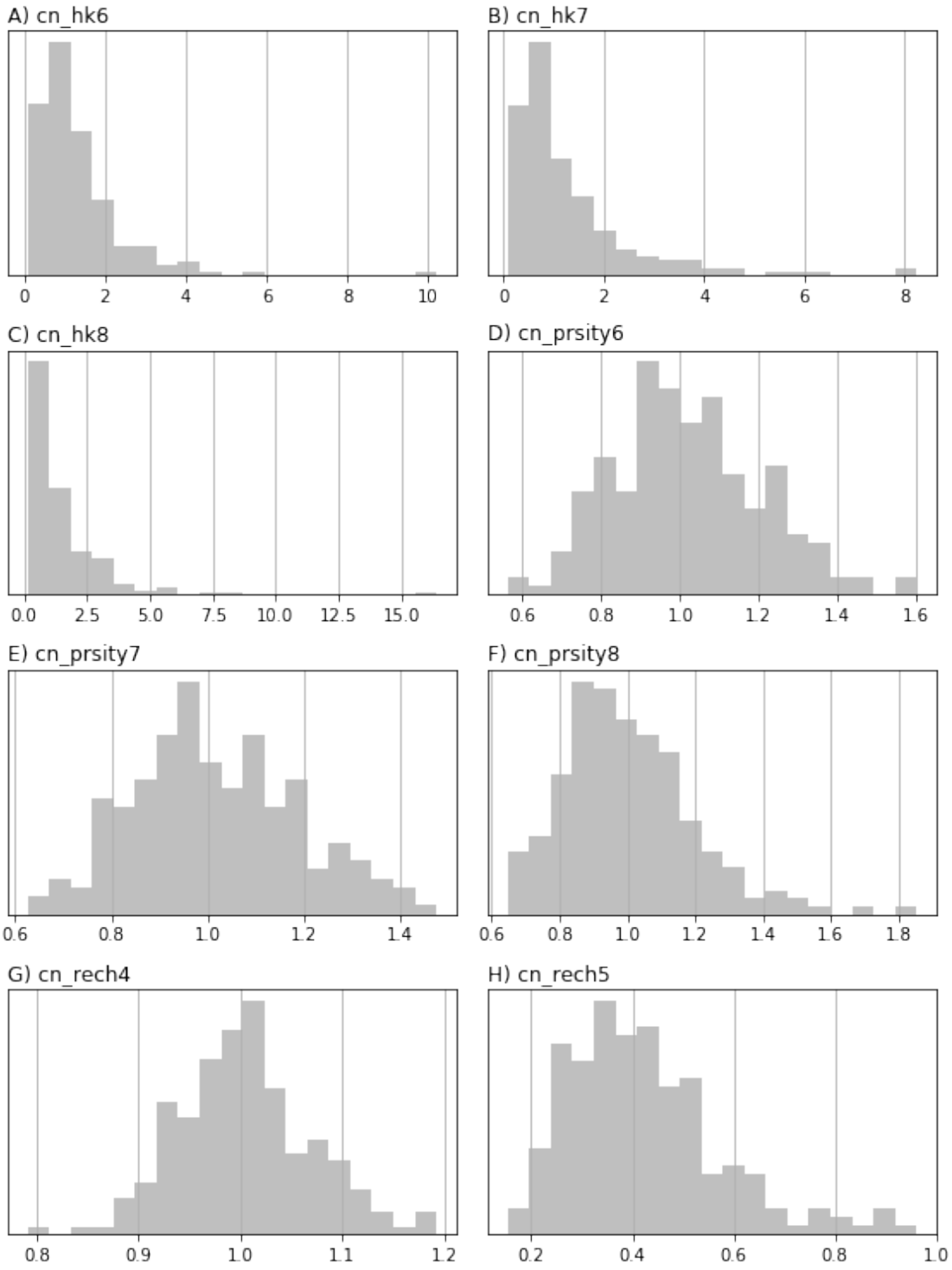
```
name:var1,contribution:1.0,a:180.0,anisotropy:1.0,bearing:0.0

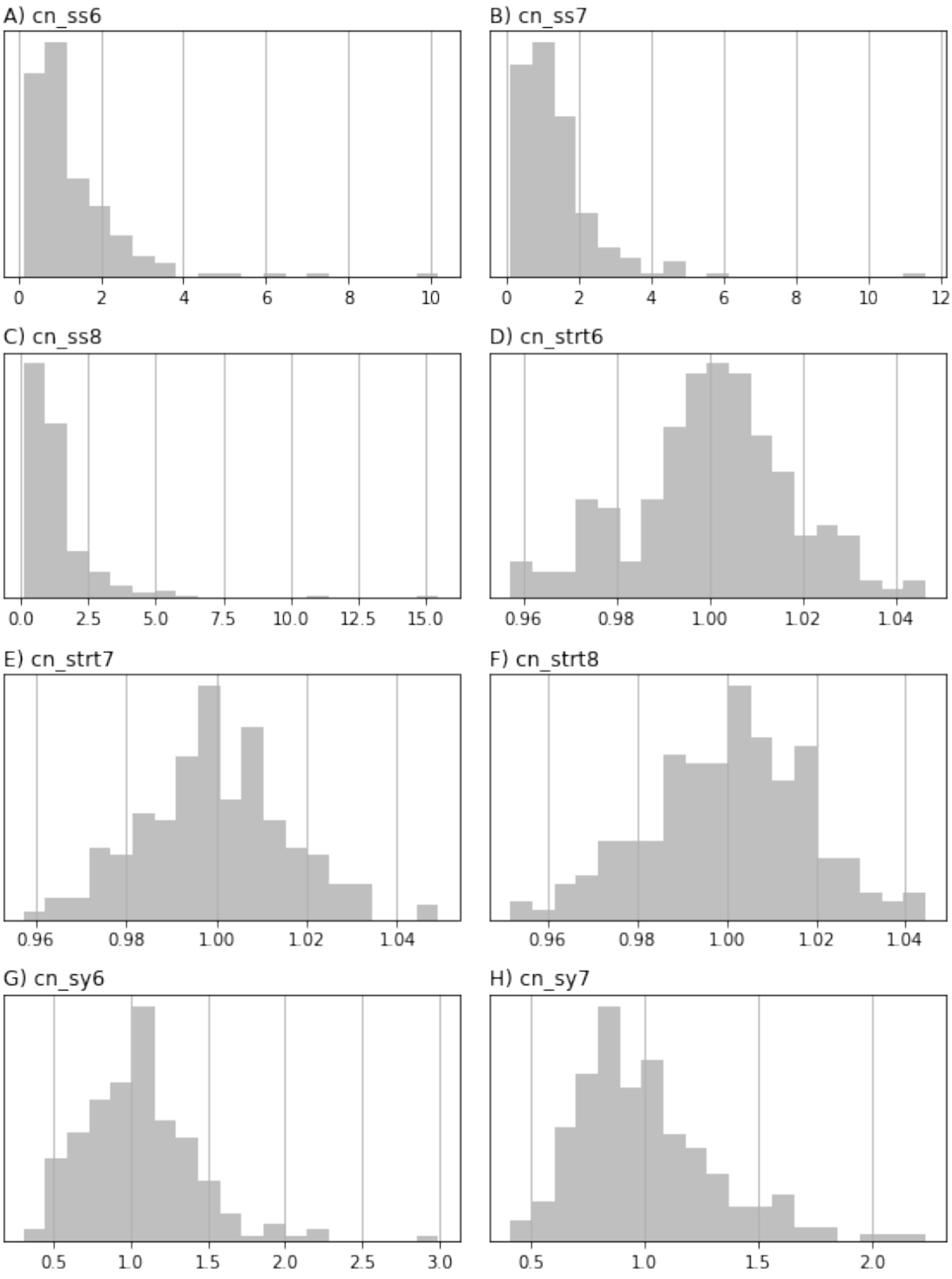
working on pargroups ['welflux']
build cov matrix
done
getting diag var cov 2
scaling full cov by diag var cov
making full cov draws with home-grown goodness
adding remaining parameters to diagonal
2019-05-11 09:10:52.227425 finished: drawing realizations took: 0:00:07.606324
```

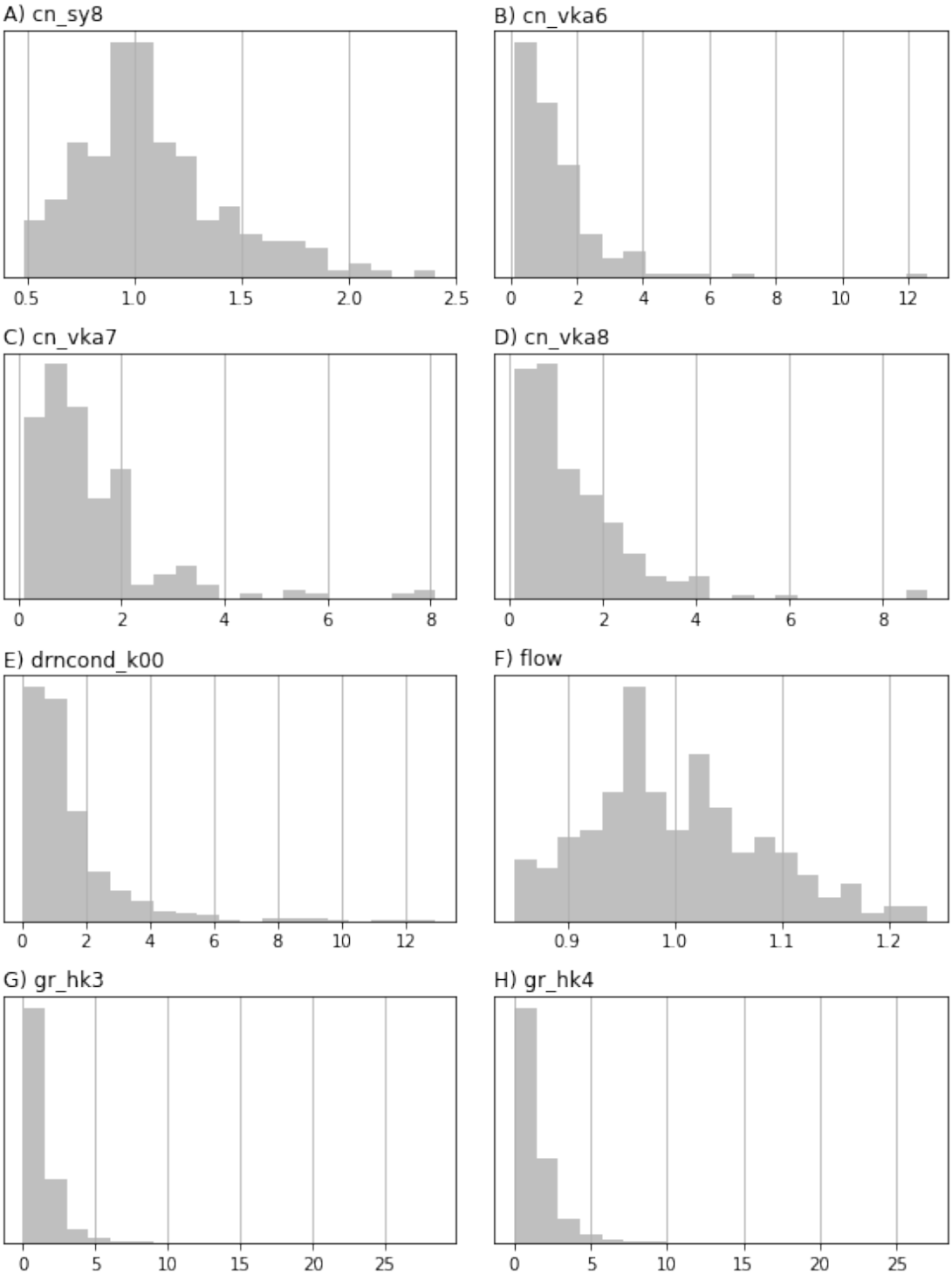
You can see that parameters are treated in parameter group (pargp) blocks for this ensemble generation. Let's plot one parameter:

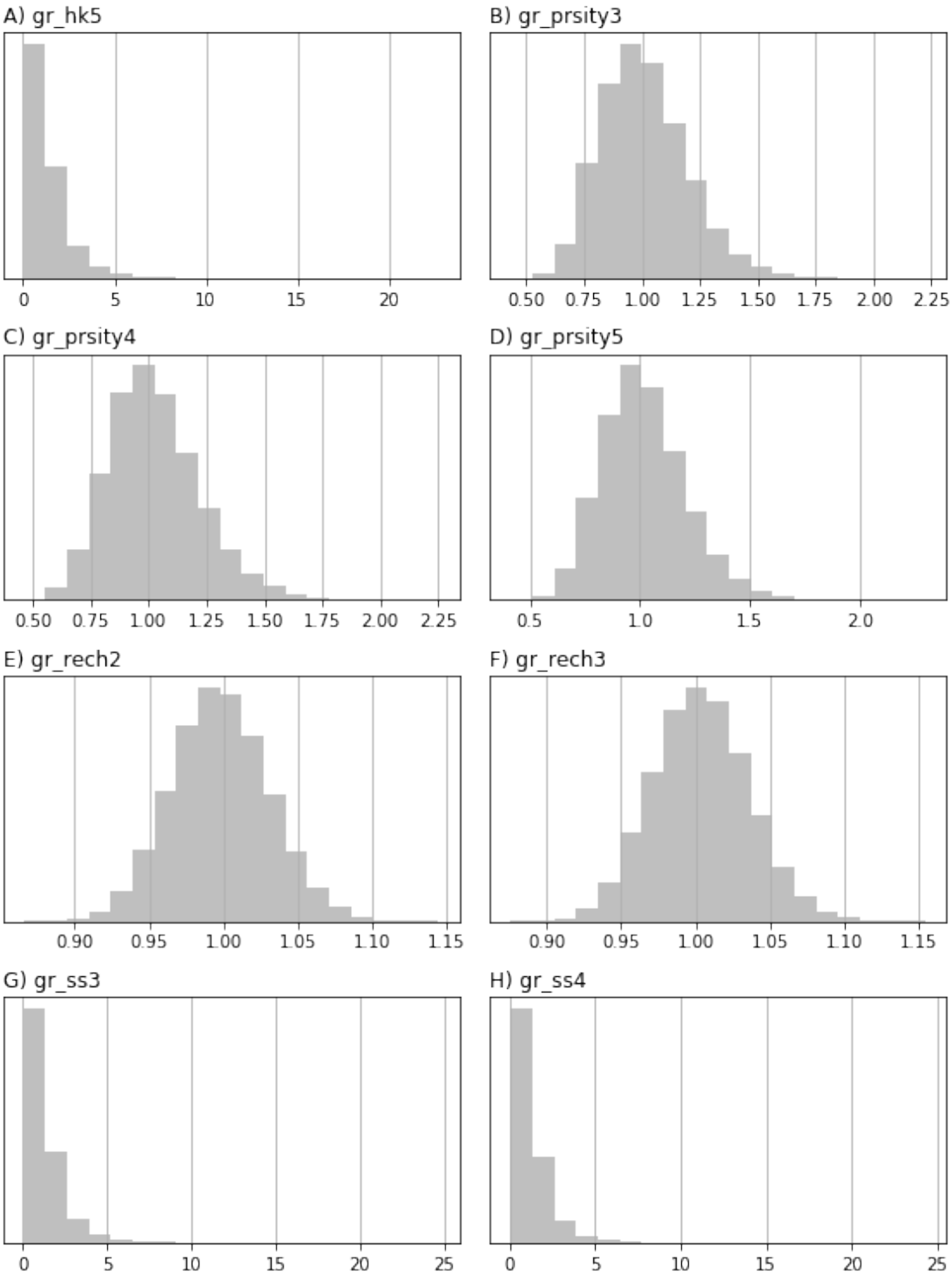
```
In [26]: par = pst_helper.pst.parameter_data
         pyemu.plot_utils.ensemble_helper(pe,plot_cols=par.groupby("pargp").groups,bins=20)
         plt.show()

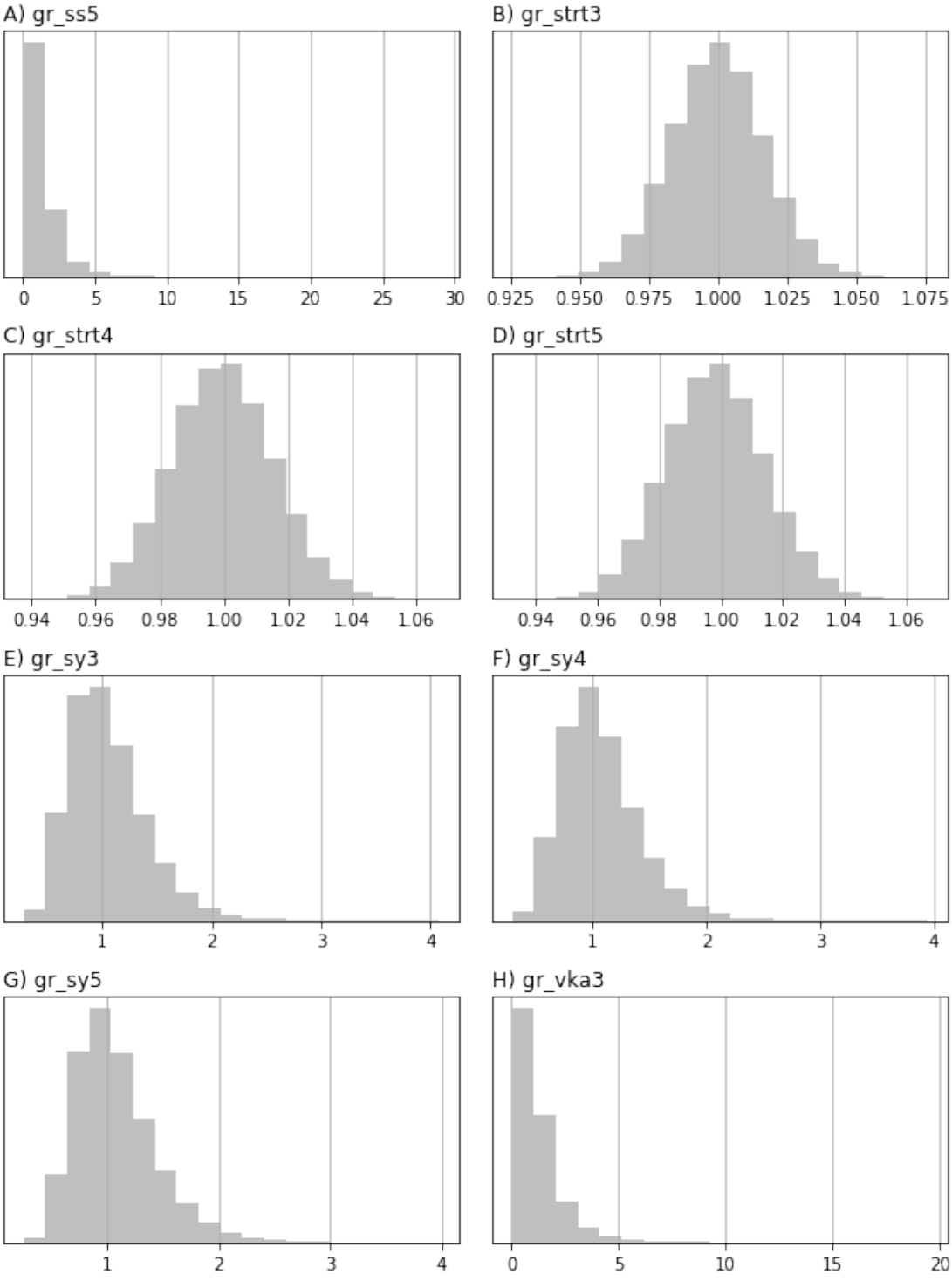
<Figure size 576x756 with 0 Axes>
```

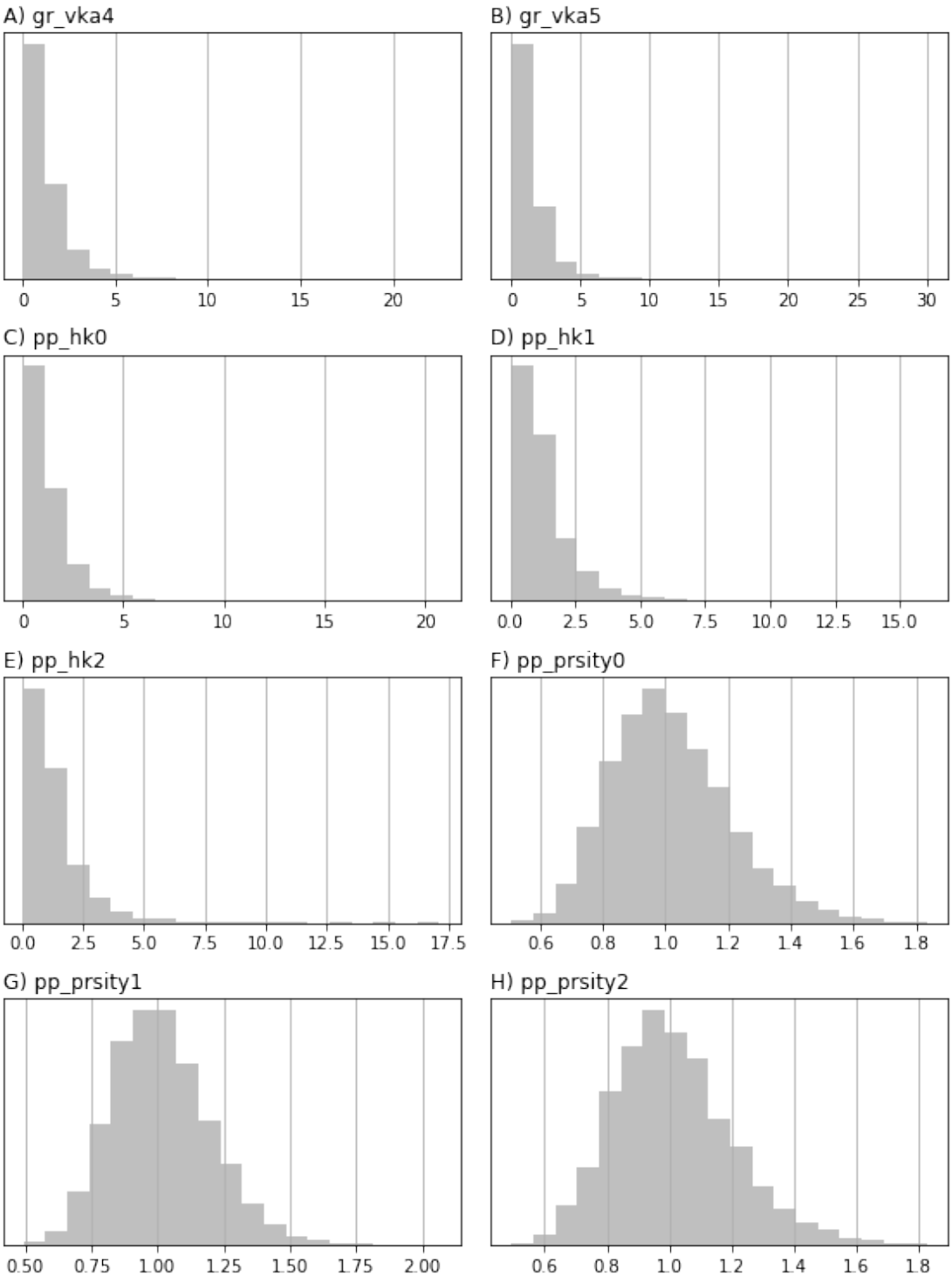

A) cn_hk6
0
2
4
6
8
10
B) cn_hk7
0
2
4
6
8
C) cn_hk8
0.0
2.5
5.0
7.5
10.0
12.5
15.0
D) cn_prsity6
0.6
0.8
1.0
1.2
1.4
1.6
E) cn_prsity7
0.6
0.8
1.0
1.2
1.4
F) cn_prsity8
0.6
0.8
1.0
1.2
1.4
1.6
1.8
G) cn_rech4
0.8
0.9
1.0
1.1
1.2
H) cn_rech5
0.2
0.4
0.6
0.8
1.0

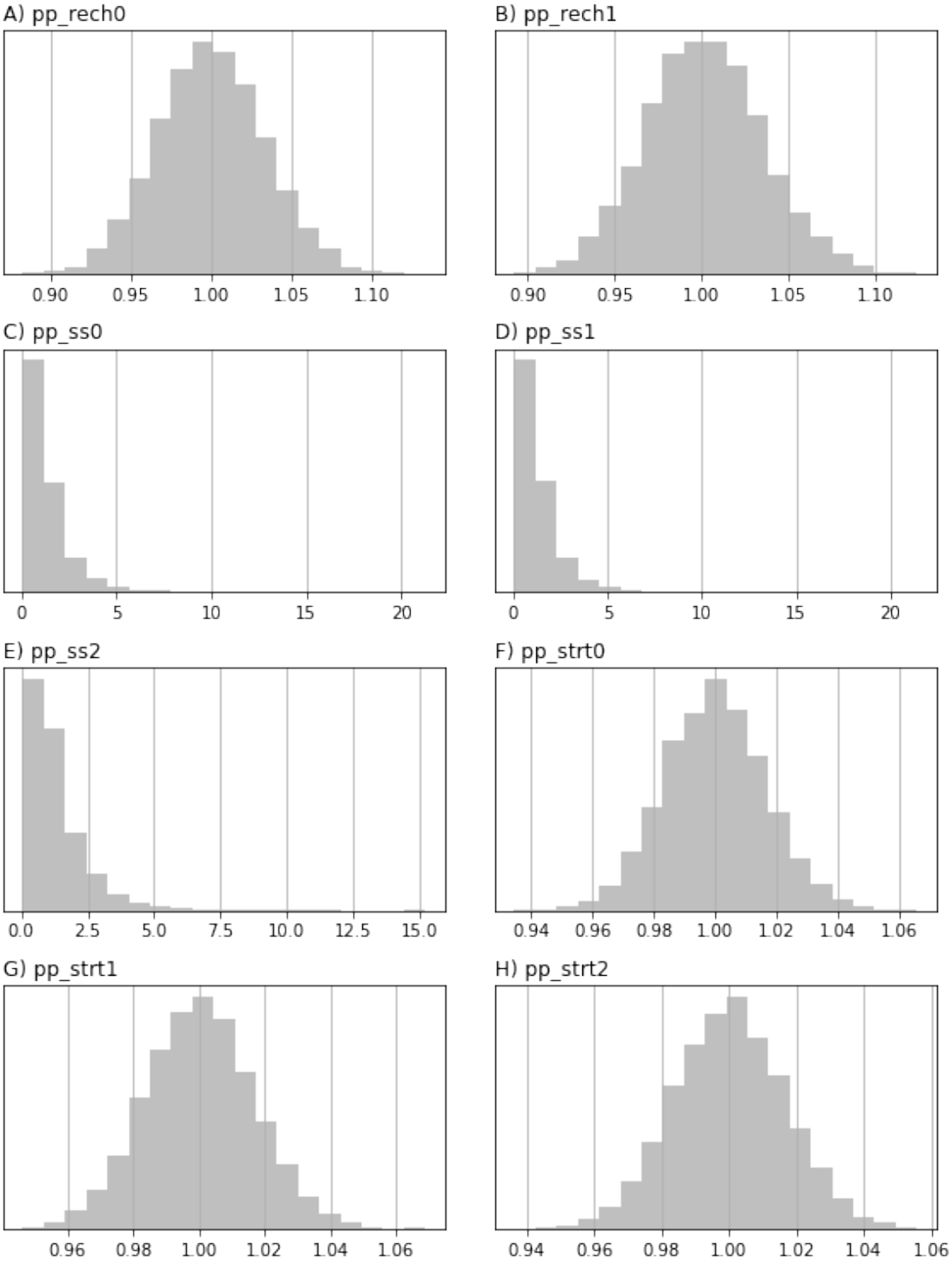

A) cn_ss6
0
2
4
6
8
10
B) cn_ss7
0
2
4
6
8
10
12
C) cn_ss8
0.0
2.5
5.0
7.5
10.0
12.5
15.0
D) cn_strt6
0.96
0.98
1.00
1.02
1.04
E) cn_strt7
0.96
0.98
1.00
1.02
1.04
F) cn_strt8
0.96
0.98
1.00
1.02
1.04
G) cn_sy6
0.5
1.0
1.5
2.0
2.5
3.0
H) cn_sy7
0.5
1.0
1.5
2.0

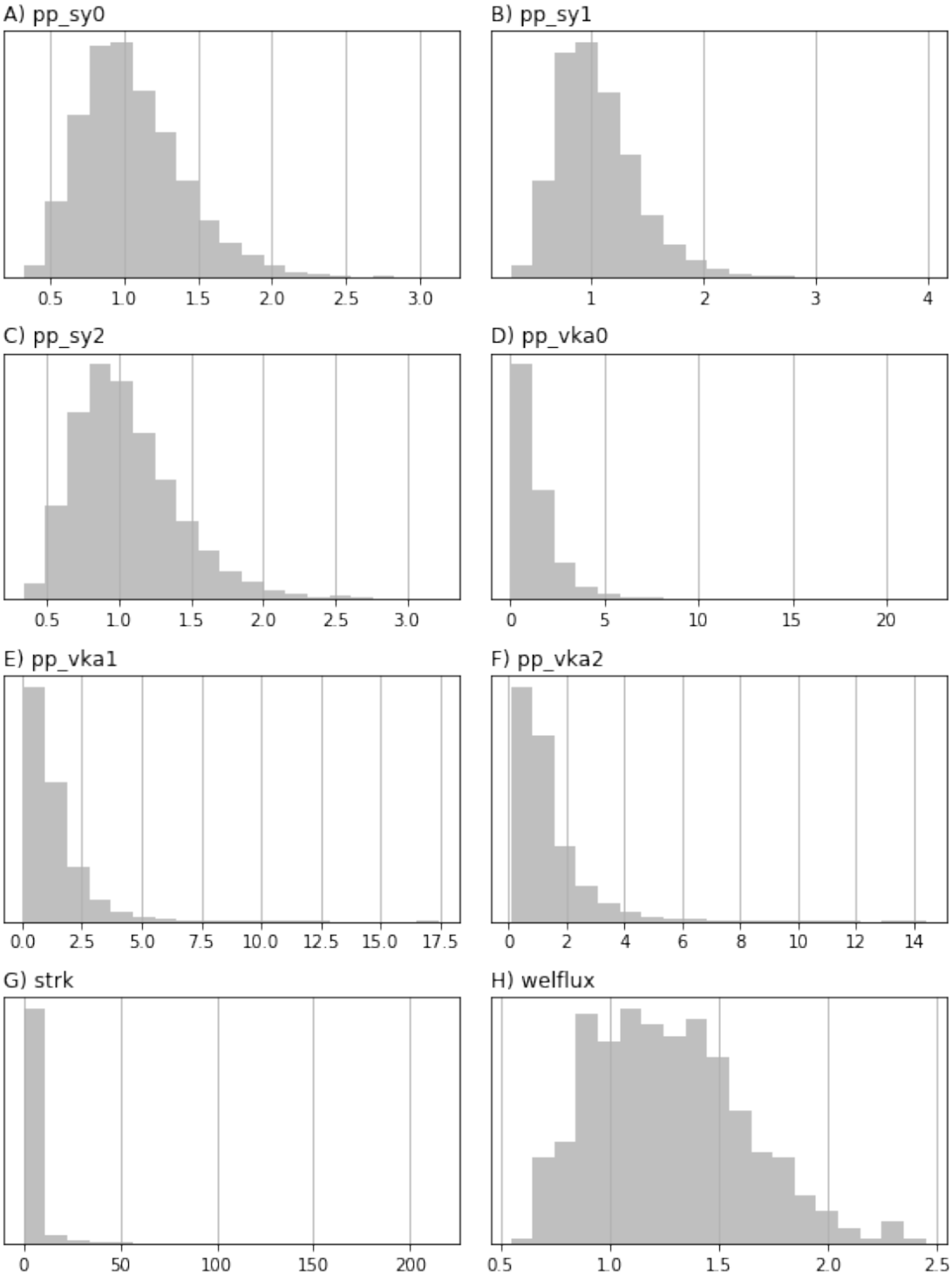

A) cn_sy8
0.5
1.0
1.5
2.0
2.5
B) cn_vka6
0
2
4
6
8
10
12
C) cn_vka7
0
2
4
6
8
D) cn_vka8
0
2
4
6
8
E) drncond_k00
0
2
4
6
8
10
12
F) flow
0.9
1.0
1.1
1.2
G) gr_hk3
0
5
10
15
20
25
H) gr_hk4
0
5
10
15
20
25

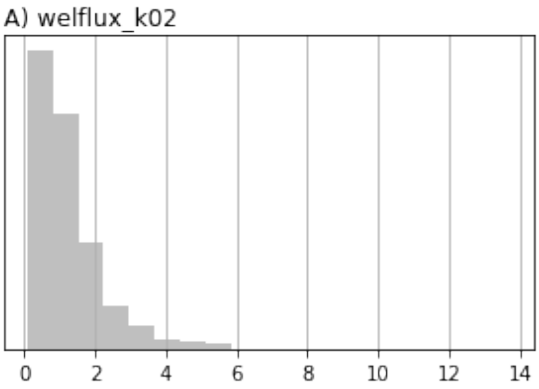

A) gr_hk5
0
5
10
15
20
B) gr_prsity3
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25
C) gr_prsity4
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25
D) gr_prsity5
0.5
1.0
1.5
2.0
E) gr_rech2
0.90
0.95
1.00
1.05
1.10
1.15
F) gr_rech3
0.90
0.95
1.00
1.05
1.10
1.15
G) gr_ss3
0
5
10
15
20
25
H) gr_ss4
0
5
10
15
20
25


A) gr_ss5
0
5
10
15
20
25
30
B) gr_strt3
0.925
0.950
0.975
1.000
1.025
1.050
1.075
C) gr_strt4
0.94
0.96
0.98
1.00
1.02
1.04
1.06
D) gr_strt5
0.94
0.96
0.98
1.00
1.02
1.04
1.06
E) gr_sy3
1
2
3
4
F) gr_sy4
1
2
3
4
G) gr_sy5
1
2
3
4
H) gr_vka3
0
5
10
15
20


A) gr_vka4
0
5
10
15
20
B) gr_vka5
0
5
10
15
20
25
30
C) pp_hk0
0
5
10
15
20
D) pp_hk1
0.0
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
17.5
F) pp_prsity0
0.6
0.8
1.0
1.2
1.4
1.6
1.8
G) pp_prsity1
0.50
0.75
1.00
1.25
1.50
1.75
2.00
H) pp_prsity2
0.6
0.8
1.0
1.2
1.4
1.6
1.8


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


A) pp_sy0
0.5
1.0
1.5
2.0
2.5
3.0
B) pp_sy1
1
2
3
4
C) pp_sy2
0.5
1.0
1.5
2.0
2.5
3.0
D) pp_vka0
0
5
10
15
20
E) pp_vka1
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
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"))
```

1.1.9 set weights for "observations" and identify forecasts

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

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

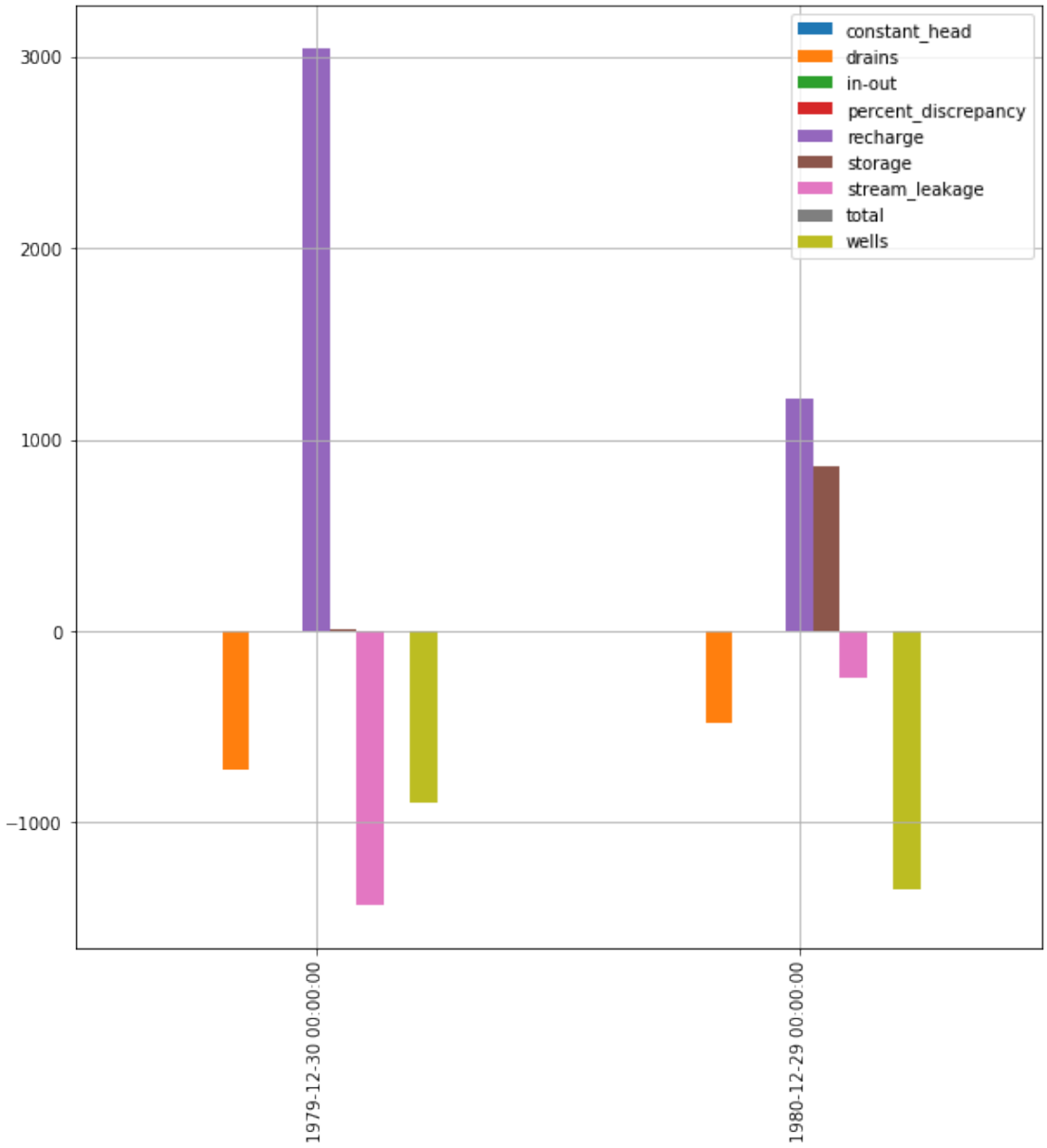
```
['fa_hw_19791230', 'fa_hw_19801229', 'fa_tw_19791230', 'fa_tw_19801229']
noptmax:0, npar_adj:14819, nnz_obs:14
```

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

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

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

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



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