setup_pest_interface

May 2, 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
```

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

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

This seemingly simple function call will spatially rediscretize the original freyberg model by cutting each row and column by 3's

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

1.0.1 load the model and run once to make sure everything is good-to-go

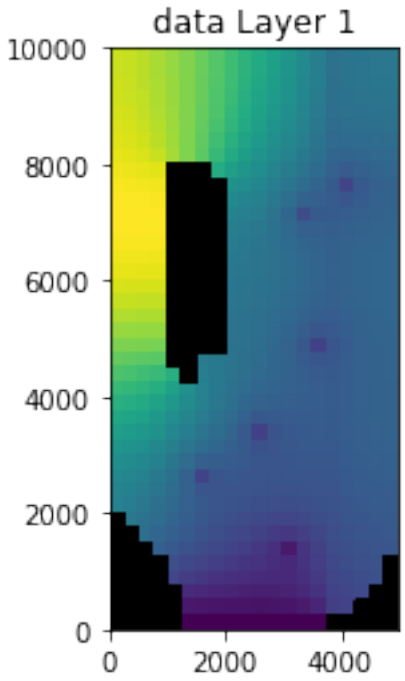
```
In [4]: m = flopy.modflow.Modflow.load(nam_file,model_ws=b_d,check=False,forgive=False)
```

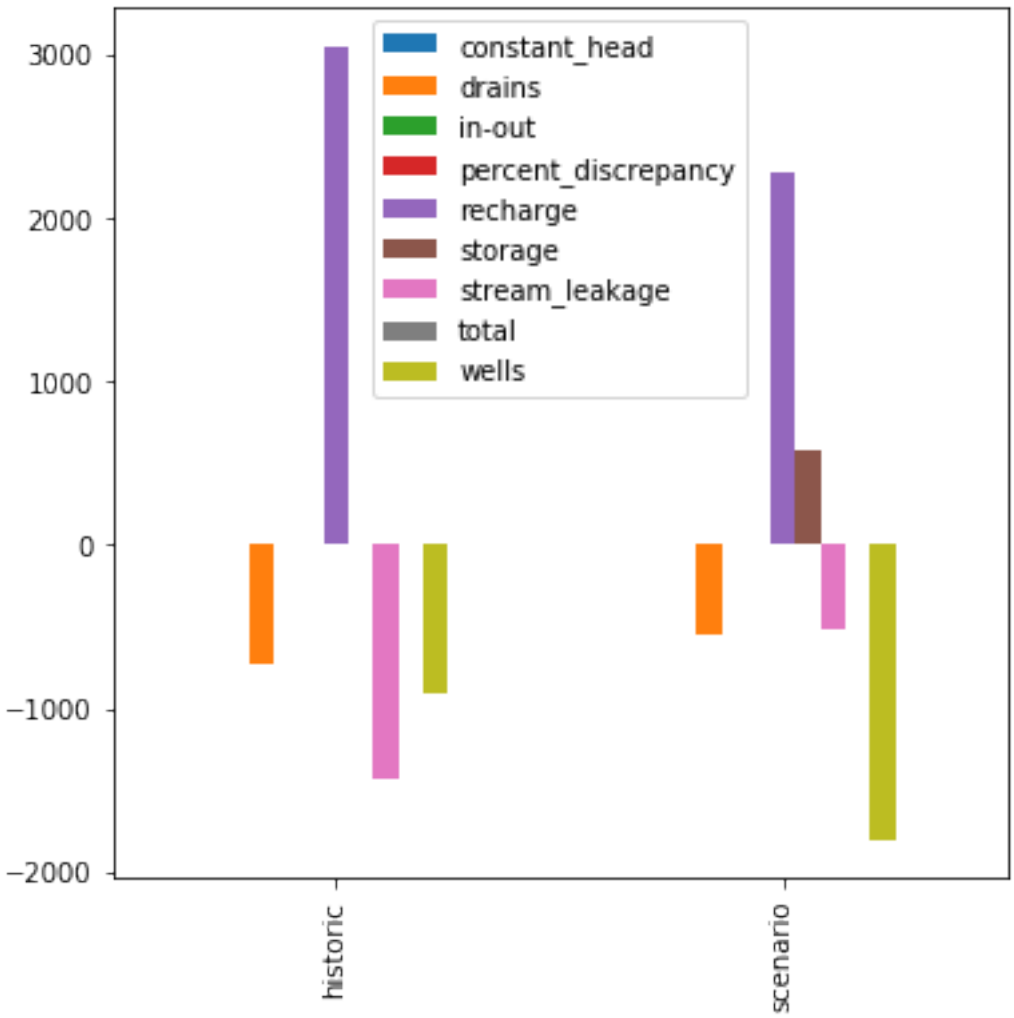
```
In [5]: m.exe_name = "mfnwt"
        m.change_model_ws("temp",reset_external=True)
        m.write_input()
        prep_deps.prep_template(t_d="temp")
        pyemu.os_utils.run("{0} {1}".format("mfnwt",m.name+".nam"),cwd=m.model_ws)
```

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

In [6]:
```
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]
ax = df.plot(kind="bar",figsize=(6,6))
ax.set_xticklabels(["historic","scenario"])
```

Out[6]:
```
[Text(0, 0, 'historic'), Text(0, 0, 'scenario')]
```

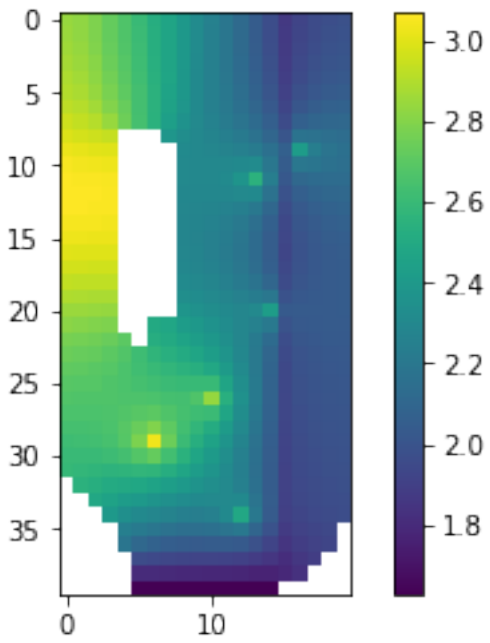




We can see the effect of the "scenario" in the second stress period with less recharge and more abstraction.

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.colorbar(c)
        plt.show()
```

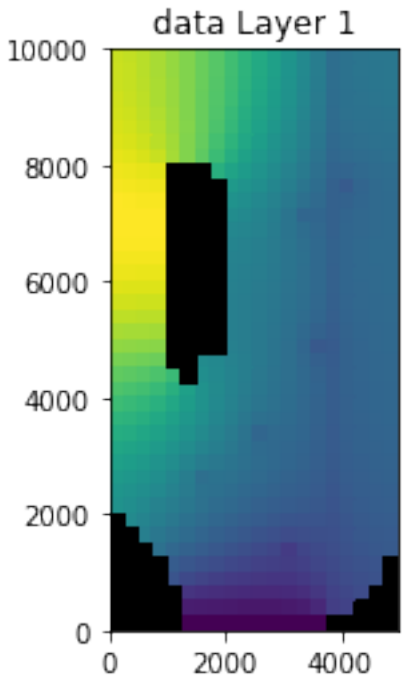


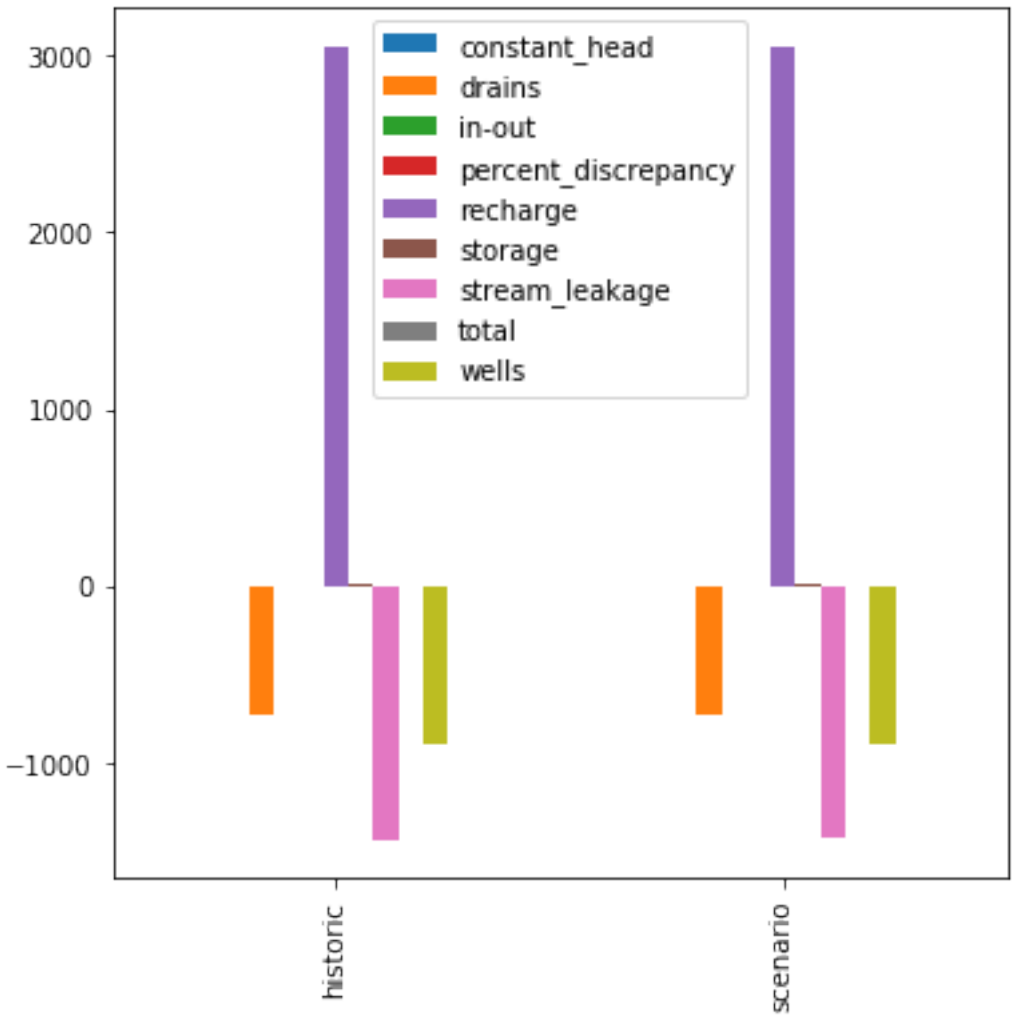
We are going to do is implement the scenario with parameters so we can more easy account for the stochastic nature of the forcing conditions during the scenario stress period and also make implemention of future scenarios work in this stochastic framework:

```
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"])

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


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

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

```
In [9]: props = []
        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])
        props.append(["rch.rech",0])
        props.append(["rch.rech",1])
```

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

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

Here 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
```

1.0.3 here we go...

This 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 parmaeters for list inputs - handles several of the shitty modflow exceptions to the array and list style inputs - sets up large numbers of observations based on arrays or time series - writes .tpl, .ins, .pst, etc - writes a python forward run script (WAT?!) - writes a prior parameter covaraince matrix using geostatistical correlations - draws from the prior parameter covariance matrix to generate a prior parameter ensemble

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

```
In [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)
```

```
2019-05-02 08:15:37.576182 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
2019-05-02 08:15:37.609126 finished: loading flopy model took: 0:00:00.032944
2019-05-02 08:15:37.609254 starting: updating model attributes
2019-05-02 08:15:37.609388 finished: updating model attributes took: 0:00:00.000134
2019-05-02 08:15:37.609531 WARNING: removing existing 'new_model_ws

creating model workspace...
   template

changing model workspace...
   template
2019-05-02 08:15:38.844231 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

2019-05-02 08:15:38.991196 finished: writing new modflow input files took: 0:00:00.146965
2019-05-02 08:15:38.992034 forward_run line:pyemu.os_utils.run('mfnwt freyberg.nam 1>freyberg.r
2019-05-02 08:15:38.992342 starting: setting up 'template/arr_org' dir
2019-05-02 08:15:38.993037 finished: setting up 'template/arr_org' dir took: 0:00:00.000695
2019-05-02 08:15:38.993270 starting: setting up 'template/arr_mlt' dir
2019-05-02 08:15:38.993661 finished: setting up 'template/arr_mlt' dir took: 0:00:00.000391
2019-05-02 08:15:38.993996 starting: setting up 'template/list_org' dir
2019-05-02 08:15:38.994526 finished: setting up 'template/list_org' dir took: 0:00:00.000530
2019-05-02 08:15:38.994704 starting: setting up 'template/list_mlt' dir
2019-05-02 08:15:38.994990 finished: setting up 'template/list_mlt' dir took: 0:00:00.000286
2019-05-02 08:15:38.995139 starting: processing temporal_list_props
2019-05-02 08:15:39.023485 finished: processing temporal_list_props took: 0:00:00.028346
```

```
2019-05-02 08:15:39.023682 starting: processing spatial_list_props
2019-05-02 08:15:39.107029 finished: processing spatial_list_props took: 0:00:00.083347
2019-05-02 08:15:39.164016 forward_run line:pyemu.helpers.apply_list_pars()

2019-05-02 08:15:39.195618 'extra' pak detected:extra.prsity
2019-05-02 08:15:39.234638 'extra' pak detected:extra.prsity
2019-05-02 08:15:39.273791 'extra' pak detected:extra.prsity
2019-05-02 08:15:39.321818 'extra' pak detected:extra.prsity
2019-05-02 08:15:39.356629 'extra' pak detected:extra.prsity
2019-05-02 08:15:39.389239 'extra' pak detected:extra.prsity
2019-05-02 08:15:39.433527 'extra' pak detected:extra.prsity
2019-05-02 08:15:39.467359 'extra' pak detected:extra.prsity
2019-05-02 08:15:39.501667 'extra' pak detected:extra.prsity
2019-05-02 08:15:39.585461 starting: writing grid tpl:hk3.dat_gr.tpl
2019-05-02 08:15:39.594138 finished: writing grid tpl:hk3.dat_gr.tpl took: 0:00:00.008677
2019-05-02 08:15:39.596651 starting: writing grid tpl:vka3.dat_gr.tpl
2019-05-02 08:15:39.605514 finished: writing grid tpl:vka3.dat_gr.tpl took: 0:00:00.008863
2019-05-02 08:15:39.608674 starting: writing grid tpl:ss3.dat_gr.tpl
2019-05-02 08:15:39.617814 finished: writing grid tpl:ss3.dat_gr.tpl took: 0:00:00.009140
2019-05-02 08:15:39.620424 starting: writing grid tpl:sy3.dat_gr.tpl
2019-05-02 08:15:39.629590 finished: writing grid tpl:sy3.dat_gr.tpl took: 0:00:00.009166
2019-05-02 08:15:39.632201 starting: writing grid tpl:strt3.dat_gr.tpl
2019-05-02 08:15:39.640956 finished: writing grid tpl:strt3.dat_gr.tpl took: 0:00:00.008755
2019-05-02 08:15:39.643600 starting: writing grid tpl:prsity3.dat_gr.tpl
2019-05-02 08:15:39.655634 finished: writing grid tpl:prsity3.dat_gr.tpl took: 0:00:00.012034
2019-05-02 08:15:39.658324 starting: writing grid tpl:hk4.dat_gr.tpl
2019-05-02 08:15:39.667513 finished: writing grid tpl:hk4.dat_gr.tpl took: 0:00:00.009189
2019-05-02 08:15:39.670275 starting: writing grid tpl:vka4.dat_gr.tpl
2019-05-02 08:15:39.679442 finished: writing grid tpl:vka4.dat_gr.tpl took: 0:00:00.009167
2019-05-02 08:15:39.682219 starting: writing grid tpl:ss4.dat_gr.tpl
2019-05-02 08:15:39.691390 finished: writing grid tpl:ss4.dat_gr.tpl took: 0:00:00.009171
2019-05-02 08:15:39.694296 starting: writing grid tpl:sy4.dat_gr.tpl
2019-05-02 08:15:39.703344 finished: writing grid tpl:sy4.dat_gr.tpl took: 0:00:00.009048
2019-05-02 08:15:39.706158 starting: writing grid tpl:strt4.dat_gr.tpl
2019-05-02 08:15:39.715218 finished: writing grid tpl:strt4.dat_gr.tpl took: 0:00:00.009060
2019-05-02 08:15:39.718030 starting: writing grid tpl:prsity4.dat_gr.tpl
2019-05-02 08:15:39.729716 finished: writing grid tpl:prsity4.dat_gr.tpl took: 0:00:00.011686
2019-05-02 08:15:39.732464 starting: writing grid tpl:hk5.dat_gr.tpl
2019-05-02 08:15:39.741487 finished: writing grid tpl:hk5.dat_gr.tpl took: 0:00:00.009023
2019-05-02 08:15:39.744216 starting: writing grid tpl:vka5.dat_gr.tpl
2019-05-02 08:15:39.753375 finished: writing grid tpl:vka5.dat_gr.tpl took: 0:00:00.009159
2019-05-02 08:15:39.756387 starting: writing grid tpl:ss5.dat_gr.tpl
2019-05-02 08:15:39.765849 finished: writing grid tpl:ss5.dat_gr.tpl took: 0:00:00.009462
2019-05-02 08:15:39.768617 starting: writing grid tpl:sy5.dat_gr.tpl
2019-05-02 08:15:39.777798 finished: writing grid tpl:sy5.dat_gr.tpl took: 0:00:00.009181
2019-05-02 08:15:39.780572 starting: writing grid tpl:strt5.dat_gr.tpl
2019-05-02 08:15:39.790375 finished: writing grid tpl:strt5.dat_gr.tpl took: 0:00:00.009803
2019-05-02 08:15:39.793045 starting: writing grid tpl:prsity5.dat_gr.tpl
```

```
2019-05-02 08:15:39.805297 finished: writing grid tpl:prsity5.dat_gr.tpl took: 0:00:00.012252
2019-05-02 08:15:39.808018 starting: writing grid tpl:rech2.dat_gr.tpl
2019-05-02 08:15:39.817114 finished: writing grid tpl:rech2.dat_gr.tpl took: 0:00:00.009096
2019-05-02 08:15:39.819855 starting: writing grid tpl:rech3.dat_gr.tpl
2019-05-02 08:15:39.828898 finished: writing grid tpl:rech3.dat_gr.tpl took: 0:00:00.009043
2019-05-02 08:15:39.831750 starting: writing const tpl:hk6.dat_cn.tpl
2019-05-02 08:15:39.837558 finished: writing const tpl:hk6.dat_cn.tpl took: 0:00:00.005808
2019-05-02 08:15:39.840232 starting: writing const tpl:vka6.dat_cn.tpl
2019-05-02 08:15:39.846185 finished: writing const tpl:vka6.dat_cn.tpl took: 0:00:00.005953
2019-05-02 08:15:39.848998 starting: writing const tpl:ss6.dat_cn.tpl
2019-05-02 08:15:39.855462 finished: writing const tpl:ss6.dat_cn.tpl took: 0:00:00.006464
2019-05-02 08:15:39.858489 starting: writing const tpl:sy6.dat_cn.tpl
2019-05-02 08:15:39.864357 finished: writing const tpl:sy6.dat_cn.tpl took: 0:00:00.005868
2019-05-02 08:15:39.867055 starting: writing const tpl:strt6.dat_cn.tpl
2019-05-02 08:15:39.872988 finished: writing const tpl:strt6.dat_cn.tpl took: 0:00:00.005933
2019-05-02 08:15:39.875801 starting: writing const tpl:prsity6.dat_cn.tpl
2019-05-02 08:15:39.881847 finished: writing const tpl:prsity6.dat_cn.tpl took: 0:00:00.006046
2019-05-02 08:15:39.884680 starting: writing const tpl:hk7.dat_cn.tpl
2019-05-02 08:15:39.890430 finished: writing const tpl:hk7.dat_cn.tpl took: 0:00:00.005750
2019-05-02 08:15:39.893117 starting: writing const tpl:vka7.dat_cn.tpl
2019-05-02 08:15:39.899148 finished: writing const tpl:vka7.dat_cn.tpl took: 0:00:00.006031
2019-05-02 08:15:39.902079 starting: writing const tpl:ss7.dat_cn.tpl
2019-05-02 08:15:39.908226 finished: writing const tpl:ss7.dat_cn.tpl took: 0:00:00.006147
2019-05-02 08:15:39.911055 starting: writing const tpl:sy7.dat_cn.tpl
2019-05-02 08:15:39.917082 finished: writing const tpl:sy7.dat_cn.tpl took: 0:00:00.006027
2019-05-02 08:15:39.919793 starting: writing const tpl:strt7.dat_cn.tpl
2019-05-02 08:15:39.925979 finished: writing const tpl:strt7.dat_cn.tpl took: 0:00:00.006186
2019-05-02 08:15:39.928748 starting: writing const tpl:prsity7.dat_cn.tpl
2019-05-02 08:15:39.934914 finished: writing const tpl:prsity7.dat_cn.tpl took: 0:00:00.006166
2019-05-02 08:15:39.937780 starting: writing const tpl:hk8.dat_cn.tpl
2019-05-02 08:15:39.943620 finished: writing const tpl:hk8.dat_cn.tpl took: 0:00:00.005840
2019-05-02 08:15:39.946358 starting: writing const tpl:vka8.dat_cn.tpl
2019-05-02 08:15:39.952398 finished: writing const tpl:vka8.dat_cn.tpl took: 0:00:00.006040
2019-05-02 08:15:39.955286 starting: writing const tpl:ss8.dat_cn.tpl
2019-05-02 08:15:39.961567 finished: writing const tpl:ss8.dat_cn.tpl took: 0:00:00.006281
2019-05-02 08:15:39.964374 starting: writing const tpl:sy8.dat_cn.tpl
2019-05-02 08:15:39.970211 finished: writing const tpl:sy8.dat_cn.tpl took: 0:00:00.005837
2019-05-02 08:15:39.973066 starting: writing const tpl:strt8.dat_cn.tpl
2019-05-02 08:15:39.979135 finished: writing const tpl:strt8.dat_cn.tpl took: 0:00:00.006069
2019-05-02 08:15:39.981926 starting: writing const tpl:prsity8.dat_cn.tpl
2019-05-02 08:15:39.987926 finished: writing const tpl:prsity8.dat_cn.tpl took: 0:00:00.006000
2019-05-02 08:15:39.990727 starting: writing const tpl:rech4.dat_cn.tpl
2019-05-02 08:15:39.997501 finished: writing const tpl:rech4.dat_cn.tpl took: 0:00:00.006774
2019-05-02 08:15:40.000285 starting: writing const tpl:rech5.dat_cn.tpl
2019-05-02 08:15:40.006402 finished: writing const tpl:rech5.dat_cn.tpl took: 0:00:00.006117
2019-05-02 08:15:40.029995 starting: setting up pilot point process
2019-05-02 08:15:40.030364 WARNING: pp_geostruct is None, using ExpVario with contribution=1 ar
2019-05-02 08:15:40.033246 pp_dict: {0: ['hk0', 'vka0', 'ss0', 'sy0', 'strt0', 'prsity0', 'rech
```

```
2019-05-02 08:15:40.033616 starting: calling setup_pilot_point_grid()
2019-05-02 08:15:40.618480 640 pilot point parameters created
2019-05-02 08:15:40.619222 pilot point 'pargp':hk0,vka0,ss0,sy0,strt0,prsity0,rech0,rech1,vka1
2019-05-02 08:15:40.619333 finished: calling setup_pilot_point_grid() took: 0:00:00.585717
2019-05-02 08:15:40.621685 starting: calculating factors for p=hk0, k=0
2019-05-02 08:15:40.622770 saving krige variance file:template/pp_k0_general_zn.fac
2019-05-02 08:15:40.623000 saving krige factors file:template/pp_k0_general_zn.fac
starting interp point loop for 800 points
took 2.630932 seconds
2019-05-02 08:15:43.308139 finished: calculating factors for p=hk0, k=0 took: 0:00:02.686454
2019-05-02 08:15:43.309380 starting: calculating factors for p=vka0, k=0
2019-05-02 08:15:43.310116 finished: calculating factors for p=vka0, k=0 took: 0:00:00.000736
2019-05-02 08:15:43.310764 starting: calculating factors for p=ss0, k=0
2019-05-02 08:15:43.311652 finished: calculating factors for p=ss0, k=0 took: 0:00:00.000888
2019-05-02 08:15:43.312221 starting: calculating factors for p=sy0, k=0
2019-05-02 08:15:43.312863 finished: calculating factors for p=sy0, k=0 took: 0:00:00.000642
2019-05-02 08:15:43.313385 starting: calculating factors for p=strt0, k=0
2019-05-02 08:15:43.314747 finished: calculating factors for p=strt0, k=0 took: 0:00:00.001362
2019-05-02 08:15:43.315900 starting: calculating factors for p=prsity0, k=0
2019-05-02 08:15:43.316890 finished: calculating factors for p=prsity0, k=0 took: 0:00:00.0009
2019-05-02 08:15:43.317675 starting: calculating factors for p=rech0, k=0
2019-05-02 08:15:43.318757 finished: calculating factors for p=rech0, k=0 took: 0:00:00.001082
2019-05-02 08:15:43.319561 starting: calculating factors for p=rech1, k=0
2019-05-02 08:15:43.320227 finished: calculating factors for p=rech1, k=0 took: 0:00:00.000666
2019-05-02 08:15:43.320768 starting: calculating factors for p=vka1, k=1
2019-05-02 08:15:43.321409 saving krige variance file:template/pp_k1_general_zn.fac
2019-05-02 08:15:43.322254 saving krige factors file:template/pp_k1_general_zn.fac
starting interp point loop for 800 points
took 2.657727 seconds
2019-05-02 08:15:46.025320 finished: calculating factors for p=vka1, k=1 took: 0:00:02.704552
2019-05-02 08:15:46.026509 starting: calculating factors for p=strt1, k=1
2019-05-02 08:15:46.027390 finished: calculating factors for p=strt1, k=1 took: 0:00:00.000881
2019-05-02 08:15:46.028332 starting: calculating factors for p=sy1, k=1
2019-05-02 08:15:46.029240 finished: calculating factors for p=sy1, k=1 took: 0:00:00.000908
2019-05-02 08:15:46.030012 starting: calculating factors for p=ss1, k=1
2019-05-02 08:15:46.031261 finished: calculating factors for p=ss1, k=1 took: 0:00:00.001249
2019-05-02 08:15:46.031992 starting: calculating factors for p=hk1, k=1
2019-05-02 08:15:46.033589 finished: calculating factors for p=hk1, k=1 took: 0:00:00.001597
2019-05-02 08:15:46.034552 starting: calculating factors for p=prsity1, k=1
2019-05-02 08:15:46.035310 finished: calculating factors for p=prsity1, k=1 took: 0:00:00.0007
2019-05-02 08:15:46.036520 starting: calculating factors for p=vka2, k=2
2019-05-02 08:15:46.037728 saving krige variance file:template/pp_k2_general_zn.fac
2019-05-02 08:15:46.037826 saving krige factors file:template/pp_k2_general_zn.fac
starting interp point loop for 800 points
took 2.603962 seconds
2019-05-02 08:15:48.697936 finished: calculating factors for p=vka2, k=2 took: 0:00:02.661416
2019-05-02 08:15:48.699025 starting: calculating factors for p=sy2, k=2
2019-05-02 08:15:48.700429 finished: calculating factors for p=sy2, k=2 took: 0:00:00.001404
```

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2019-05-02 08:15:48.701288 starting: calculating factors for p=ss2, k=2
2019-05-02 08:15:48.702261 finished: calculating factors for p=ss2, k=2 took: 0:00:00.000973
2019-05-02 08:15:48.703207 starting: calculating factors for p=hk2, k=2
2019-05-02 08:15:48.704106 finished: calculating factors for p=hk2, k=2 took: 0:00:00.000899
2019-05-02 08:15:48.704856 starting: calculating factors for p=strt2, k=2
2019-05-02 08:15:48.705827 finished: calculating factors for p=strt2, k=2 took: 0:00:00.000971
2019-05-02 08:15:48.706695 starting: calculating factors for p=prsity2, k=2
2019-05-02 08:15:48.708140 finished: calculating factors for p=prsity2, k=2 took: 0:00:00.0014
2019-05-02 08:15:48.708267 starting: processing pp_prefix:rech1
2019-05-02 08:15:48.720728 starting: processing pp_prefix:prsity2
2019-05-02 08:15:48.729721 starting: processing pp_prefix:prsity1
2019-05-02 08:15:48.737880 starting: processing pp_prefix:rech0
2019-05-02 08:15:48.746526 starting: processing pp_prefix:sy1
2019-05-02 08:15:48.755098 starting: processing pp_prefix:strt1
2019-05-02 08:15:48.763271 starting: processing pp_prefix:vka1
2019-05-02 08:15:48.771556 starting: processing pp_prefix:hk2
2019-05-02 08:15:48.779846 starting: processing pp_prefix:prsity0
2019-05-02 08:15:48.788599 starting: processing pp_prefix:strt2
2019-05-02 08:15:48.797382 starting: processing pp_prefix:hk1
2019-05-02 08:15:48.805506 starting: processing pp_prefix:sy2
2019-05-02 08:15:48.814376 starting: processing pp_prefix:sy0
2019-05-02 08:15:48.822290 starting: processing pp_prefix:strt0
2019-05-02 08:15:48.830364 starting: processing pp_prefix:ss1
2019-05-02 08:15:48.838868 starting: processing pp_prefix:vka0
2019-05-02 08:15:48.846948 starting: processing pp_prefix:hk0
2019-05-02 08:15:48.855623 starting: processing pp_prefix:ss2
2019-05-02 08:15:48.864050 starting: processing pp_prefix:ss0
2019-05-02 08:15:48.872576 starting: processing pp_prefix:vka2
2019-05-02 08:15:48.979777 finished: setting up pilot point process took: 0:00:08.949782
2019-05-02 08:15:48.980240 starting: setting up grid process
2019-05-02 08:15:48.980320 WARNING: grid_geostruct is None, using ExpVario with contribution=1
2019-05-02 08:15:48.980438 finished: setting up grid process took: 0:00:00.000198
2019-05-02 08:15:48.983421 starting: save test mlt array arr_mlt/hk0.dat_pp
2019-05-02 08:15:48.985906 finished: save test mlt array arr_mlt/hk0.dat_pp took: 0:00:00.0024
2019-05-02 08:15:48.986794 starting: save test mlt array arr_mlt/vka0.dat_pp
2019-05-02 08:15:48.988859 finished: save test mlt array arr_mlt/vka0.dat_pp took: 0:00:00.002
2019-05-02 08:15:48.989649 starting: save test mlt array arr_mlt/ss0.dat_pp
2019-05-02 08:15:48.995838 finished: save test mlt array arr_mlt/ss0.dat_pp took: 0:00:00.0061
2019-05-02 08:15:48.996940 starting: save test mlt array arr_mlt/sy0.dat_pp
2019-05-02 08:15:48.998967 finished: save test mlt array arr_mlt/sy0.dat_pp took: 0:00:00.0020
2019-05-02 08:15:49.000008 starting: save test mlt array arr_mlt/strt0.dat_pp
2019-05-02 08:15:49.002247 finished: save test mlt array arr_mlt/strt0.dat_pp took: 0:00:00.002
2019-05-02 08:15:49.002968 starting: save test mlt array arr_mlt/prsity0.dat_pp
2019-05-02 08:15:49.005142 finished: save test mlt array arr_mlt/prsity0.dat_pp took: 0:00:00.0
2019-05-02 08:15:49.006288 starting: save test mlt array arr_mlt/hk1.dat_pp
2019-05-02 08:15:49.008452 finished: save test mlt array arr_mlt/hk1.dat_pp took: 0:00:00.0021
2019-05-02 08:15:49.009394 starting: save test mlt array arr_mlt/vka1.dat_pp
2019-05-02 08:15:49.011641 finished: save test mlt array arr_mlt/vka1.dat_pp took: 0:00:00.002
```

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2019-05-02 08:15:49.012392 starting: save test mlt array arr_mlt/ss1.dat_pp
2019-05-02 08:15:49.014681 finished: save test mlt array arr_mlt/ss1.dat_pp took: 0:00:00.00228
2019-05-02 08:15:49.015415 starting: save test mlt array arr_mlt/sy1.dat_pp
2019-05-02 08:15:49.017813 finished: save test mlt array arr_mlt/sy1.dat_pp took: 0:00:00.00239
2019-05-02 08:15:49.018917 starting: save test mlt array arr_mlt/strt1.dat_pp
2019-05-02 08:15:49.021350 finished: save test mlt array arr_mlt/strt1.dat_pp took: 0:00:00.002
2019-05-02 08:15:49.022318 starting: save test mlt array arr_mlt/prsity1.dat_pp
2019-05-02 08:15:49.024648 finished: save test mlt array arr_mlt/prsity1.dat_pp took: 0:00:00.0
2019-05-02 08:15:49.025582 starting: save test mlt array arr_mlt/hk2.dat_pp
2019-05-02 08:15:49.027716 finished: save test mlt array arr_mlt/hk2.dat_pp took: 0:00:00.00213
2019-05-02 08:15:49.028753 starting: save test mlt array arr_mlt/vka2.dat_pp
2019-05-02 08:15:49.031155 finished: save test mlt array arr_mlt/vka2.dat_pp took: 0:00:00.0024
2019-05-02 08:15:49.032180 starting: save test mlt array arr_mlt/ss2.dat_pp
2019-05-02 08:15:49.034661 finished: save test mlt array arr_mlt/ss2.dat_pp took: 0:00:00.00248
2019-05-02 08:15:49.035661 starting: save test mlt array arr_mlt/sy2.dat_pp
2019-05-02 08:15:49.038095 finished: save test mlt array arr_mlt/sy2.dat_pp took: 0:00:00.00243
2019-05-02 08:15:49.039055 starting: save test mlt array arr_mlt/strt2.dat_pp
2019-05-02 08:15:49.041729 finished: save test mlt array arr_mlt/strt2.dat_pp took: 0:00:00.002
2019-05-02 08:15:49.042872 starting: save test mlt array arr_mlt/prsity2.dat_pp
2019-05-02 08:15:49.045851 finished: save test mlt array arr_mlt/prsity2.dat_pp took: 0:00:00.0
2019-05-02 08:15:49.047085 starting: save test mlt array arr_mlt/rech0.dat_pp
2019-05-02 08:15:49.049739 finished: save test mlt array arr_mlt/rech0.dat_pp took: 0:00:00.002
2019-05-02 08:15:49.050731 starting: save test mlt array arr_mlt/rech1.dat_pp
2019-05-02 08:15:49.053844 finished: save test mlt array arr_mlt/rech1.dat_pp took: 0:00:00.003
2019-05-02 08:15:49.055306 starting: save test mlt array arr_mlt/hk3.dat_gr
2019-05-02 08:15:49.058616 finished: save test mlt array arr_mlt/hk3.dat_gr took: 0:00:00.00331
2019-05-02 08:15:49.060575 starting: save test mlt array arr_mlt/vka3.dat_gr
2019-05-02 08:15:49.064268 finished: save test mlt array arr_mlt/vka3.dat_gr took: 0:00:00.0030
2019-05-02 08:15:49.065836 starting: save test mlt array arr_mlt/ss3.dat_gr
2019-05-02 08:15:49.069385 finished: save test mlt array arr_mlt/ss3.dat_gr took: 0:00:00.00354
2019-05-02 08:15:49.070918 starting: save test mlt array arr_mlt/sy3.dat_gr
2019-05-02 08:15:49.074295 finished: save test mlt array arr_mlt/sy3.dat_gr took: 0:00:00.00337
2019-05-02 08:15:49.076127 starting: save test mlt array arr_mlt/strt3.dat_gr
2019-05-02 08:15:49.079402 finished: save test mlt array arr_mlt/strt3.dat_gr took: 0:00:00.003
2019-05-02 08:15:49.080676 starting: save test mlt array arr_mlt/prsity3.dat_gr
2019-05-02 08:15:49.083447 finished: save test mlt array arr_mlt/prsity3.dat_gr took: 0:00:00.0
2019-05-02 08:15:49.084652 starting: save test mlt array arr_mlt/hk4.dat_gr
2019-05-02 08:15:49.088183 finished: save test mlt array arr_mlt/hk4.dat_gr took: 0:00:00.00353
2019-05-02 08:15:49.089609 starting: save test mlt array arr_mlt/vka4.dat_gr
2019-05-02 08:15:49.092506 finished: save test mlt array arr_mlt/vka4.dat_gr took: 0:00:00.0028
2019-05-02 08:15:49.093868 starting: save test mlt array arr_mlt/ss4.dat_gr
2019-05-02 08:15:49.096908 finished: save test mlt array arr_mlt/ss4.dat_gr took: 0:00:00.00304
2019-05-02 08:15:49.098173 starting: save test mlt array arr_mlt/sy4.dat_gr
2019-05-02 08:15:49.101944 finished: save test mlt array arr_mlt/sy4.dat_gr took: 0:00:00.00377
2019-05-02 08:15:49.103391 starting: save test mlt array arr_mlt/strt4.dat_gr
2019-05-02 08:15:49.106435 finished: save test mlt array arr_mlt/strt4.dat_gr took: 0:00:00.003
2019-05-02 08:15:49.107887 starting: save test mlt array arr_mlt/prsity4.dat_gr
2019-05-02 08:15:49.111423 finished: save test mlt array arr_mlt/prsity4.dat_gr took: 0:00:00.0
```

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2019-05-02 08:15:49.112903 starting: save test mlt array arr_mlt/hk5.dat_gr
2019-05-02 08:15:49.116053 finished: save test mlt array arr_mlt/hk5.dat_gr took: 0:00:00.0031
2019-05-02 08:15:49.117215 starting: save test mlt array arr_mlt/vka5.dat_gr
2019-05-02 08:15:49.120592 finished: save test mlt array arr_mlt/vka5.dat_gr took: 0:00:00.003
2019-05-02 08:15:49.122125 starting: save test mlt array arr_mlt/ss5.dat_gr
2019-05-02 08:15:49.125709 finished: save test mlt array arr_mlt/ss5.dat_gr took: 0:00:00.0035
2019-05-02 08:15:49.127239 starting: save test mlt array arr_mlt/sy5.dat_gr
2019-05-02 08:15:49.130593 finished: save test mlt array arr_mlt/sy5.dat_gr took: 0:00:00.0033
2019-05-02 08:15:49.132091 starting: save test mlt array arr_mlt/strt5.dat_gr
2019-05-02 08:15:49.135835 finished: save test mlt array arr_mlt/strt5.dat_gr took: 0:00:00.003
2019-05-02 08:15:49.137298 starting: save test mlt array arr_mlt/prsity5.dat_gr
2019-05-02 08:15:49.140433 finished: save test mlt array arr_mlt/prsity5.dat_gr took: 0:00:00.0
2019-05-02 08:15:49.141888 starting: save test mlt array arr_mlt/rech2.dat_gr
2019-05-02 08:15:49.145502 finished: save test mlt array arr_mlt/rech2.dat_gr took: 0:00:00.003
2019-05-02 08:15:49.147096 starting: save test mlt array arr_mlt/rech3.dat_gr
2019-05-02 08:15:49.150535 finished: save test mlt array arr_mlt/rech3.dat_gr took: 0:00:00.003
2019-05-02 08:15:49.152050 starting: save test mlt array arr_mlt/hk6.dat_cn
2019-05-02 08:15:49.155574 finished: save test mlt array arr_mlt/hk6.dat_cn took: 0:00:00.0035
2019-05-02 08:15:49.156974 starting: save test mlt array arr_mlt/vka6.dat_cn
2019-05-02 08:15:49.159533 finished: save test mlt array arr_mlt/vka6.dat_cn took: 0:00:00.0025
2019-05-02 08:15:49.160549 starting: save test mlt array arr_mlt/ss6.dat_cn
2019-05-02 08:15:49.163776 finished: save test mlt array arr_mlt/ss6.dat_cn took: 0:00:00.0032
2019-05-02 08:15:49.165231 starting: save test mlt array arr_mlt/sy6.dat_cn
2019-05-02 08:15:49.167858 finished: save test mlt array arr_mlt/sy6.dat_cn took: 0:00:00.0026
2019-05-02 08:15:49.169175 starting: save test mlt array arr_mlt/strt6.dat_cn
2019-05-02 08:15:49.172127 finished: save test mlt array arr_mlt/strt6.dat_cn took: 0:00:00.002
2019-05-02 08:15:49.173693 starting: save test mlt array arr_mlt/prsity6.dat_cn
2019-05-02 08:15:49.177025 finished: save test mlt array arr_mlt/prsity6.dat_cn took: 0:00:00.0
2019-05-02 08:15:49.178441 starting: save test mlt array arr_mlt/hk7.dat_cn
2019-05-02 08:15:49.181499 finished: save test mlt array arr_mlt/hk7.dat_cn took: 0:00:00.0030
2019-05-02 08:15:49.183019 starting: save test mlt array arr_mlt/vka7.dat_cn
2019-05-02 08:15:49.186744 finished: save test mlt array arr_mlt/vka7.dat_cn took: 0:00:00.0037
2019-05-02 08:15:49.188222 starting: save test mlt array arr_mlt/ss7.dat_cn
2019-05-02 08:15:49.191665 finished: save test mlt array arr_mlt/ss7.dat_cn took: 0:00:00.0034
2019-05-02 08:15:49.192822 starting: save test mlt array arr_mlt/sy7.dat_cn
2019-05-02 08:15:49.195834 finished: save test mlt array arr_mlt/sy7.dat_cn took: 0:00:00.0030
2019-05-02 08:15:49.197074 starting: save test mlt array arr_mlt/strt7.dat_cn
2019-05-02 08:15:49.200332 finished: save test mlt array arr_mlt/strt7.dat_cn took: 0:00:00.003
2019-05-02 08:15:49.201958 starting: save test mlt array arr_mlt/prsity7.dat_cn
2019-05-02 08:15:49.204999 finished: save test mlt array arr_mlt/prsity7.dat_cn took: 0:00:00.0
2019-05-02 08:15:49.206145 starting: save test mlt array arr_mlt/hk8.dat_cn
2019-05-02 08:15:49.209534 finished: save test mlt array arr_mlt/hk8.dat_cn took: 0:00:00.0033
2019-05-02 08:15:49.210994 starting: save test mlt array arr_mlt/vka8.dat_cn
2019-05-02 08:15:49.213648 finished: save test mlt array arr_mlt/vka8.dat_cn took: 0:00:00.0026
2019-05-02 08:15:49.214987 starting: save test mlt array arr_mlt/ss8.dat_cn
2019-05-02 08:15:49.217447 finished: save test mlt array arr_mlt/ss8.dat_cn took: 0:00:00.0024
2019-05-02 08:15:49.219119 starting: save test mlt array arr_mlt/sy8.dat_cn
2019-05-02 08:15:49.222857 finished: save test mlt array arr_mlt/sy8.dat_cn took: 0:00:00.0037
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2019-05-02 08:15:49.224236 starting: save test mlt array arr_mlt/strt8.dat_cn
2019-05-02 08:15:49.228217 finished: save test mlt array arr_mlt/strt8.dat_cn took: 0:00:00.003
2019-05-02 08:15:49.229833 starting: save test mlt array arr_mlt/prsity8.dat_cn
2019-05-02 08:15:49.233294 finished: save test mlt array arr_mlt/prsity8.dat_cn took: 0:00:00.0
2019-05-02 08:15:49.234888 starting: save test mlt array arr_mlt/rech4.dat_cn
2019-05-02 08:15:49.238449 finished: save test mlt array arr_mlt/rech4.dat_cn took: 0:00:00.003
2019-05-02 08:15:49.239780 starting: save test mlt array arr_mlt/rech5.dat_cn
2019-05-02 08:15:49.242690 finished: save test mlt array arr_mlt/rech5.dat_cn took: 0:00:00.002
2019-05-02 08:15:49.871623 forward_run line:pyemu.helpers.apply_array_pars()

all zeros for runoff...skipping...
all zeros for hcond1...skipping...
all zeros for pptsw...skipping...
2019-05-02 08:15:50.003397 starting: processing obs type mflist water budget obs
2019-05-02 08:15:50.179739 forward_run line:pyemu.gw_utils.apply_mflist_budget_obs('freyberg.li
2019-05-02 08:15:50.179964 finished: processing obs type mflist water budget obs took: 0:00:00
2019-05-02 08:15:50.180848 starting: processing obs type hyd file
2019-05-02 08:15:50.181322 finished: processing obs type hyd file took: 0:00:00.000474
2019-05-02 08:15:50.181708 starting: processing obs type external obs-sim smp files
2019-05-02 08:15:50.181946 finished: processing obs type external obs-sim smp files took: 0:00
2019-05-02 08:15:50.182127 starting: processing obs type hob
2019-05-02 08:15:50.182357 finished: processing obs type hob took: 0:00:00.000230
2019-05-02 08:15:50.182472 starting: processing obs type hds
[[0, 0], [0, 1], [0, 2], [1, 0], [1, 1], [1, 2]]
2019-05-02 08:15:50.624931 finished: processing obs type hds took: 0:00:00.442459
2019-05-02 08:15:50.625414 starting: processing obs type sfr
writing 'sfr_obs.config' to template/sfr_obs.config
2019-05-02 08:15:50.965461 finished: processing obs type sfr took: 0:00:00.340047
2019-05-02 08:15:50.966008 changing dir in to template
2019-05-02 08:15:50.966939 starting: instantiating control file from i/o files
2019-05-02 08:15:50.967024 tpl files: drn.csv.tpl,wel.csv.tpl,hk3.dat_gr.tpl,vka3.dat_gr.tpl,ss
2019-05-02 08:15:50.967065 ins files: freyberg.hds.dat.ins,vol.dat.ins,freyberg.sfr.out.process
2019-05-02 08:15:51.312989 finished: instantiating control file from i/o files took: 0:00:00.34
2019-05-02 08:15:51.567946 starting: writing forward_run.py
2019-05-02 08:15:51.579261 finished: writing forward_run.py took: 0:00:00.011315
2019-05-02 08:15:51.580058 writing pst template/freyberg.pst
2019-05-02 08:15:53.392122 starting: running pestchek on freyberg.pst
2019-05-02 08:15:53.497592 pestcheck:PESTCHEK Version 13.0. Watermark Numerical Computing.
2019-05-02 08:15:53.497931 pestcheck:
2019-05-02 08:15:53.497986 pestcheck:Errors ----->
2019-05-02 08:15:53.498123 pestcheck:Line 2403 of file freyberg.pst: parameter name "prsity3000
2019-05-02 08:15:53.498175 pestcheck:12 characters long.
2019-05-02 08:15:53.498211 pestcheck:Line 2404 of file freyberg.pst: parameter name "prsity3000
2019-05-02 08:15:53.498821 pestcheck:12 characters long.
2019-05-02 08:15:53.499484 pestcheck:Line 2404 of file freyberg.pst: parameter name "prsity3000
2019-05-02 08:15:53.499535 pestcheck:once.
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2019-05-02 08:15:53.499659 pestcheck:12 characters long.
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2019-05-02 08:15:53.500668 pestcheck:Line 2409 of file freyberg.pst: parameter name "prsity3000
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2019-05-02 08:15:53.502627 pestcheck:Line 2414 of file freyberg.pst: parameter name "prsity3000
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2019-05-02 08:15:53.504121 pestcheck:once.
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2019-05-02 08:15:53.505948 pestcheck:once.
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2019-05-02 08:15:53.508468 pestcheck:Line 2430 of file freyberg.pst: parameter name "prsity300
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2019-05-02 08:15:53.508809 pestcheck:once.
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2019-05-02 08:15:53.517004 pestcheck:once.
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2019-05-02 08:15:53.523131 pestcheck:Line 2474 of file freyberg.pst: parameter name "prsity3003
2019-05-02 08:15:53.523170 pestcheck:once.
2019-05-02 08:15:53.523275 pestcheck:Line 2475 of file freyberg.pst: parameter name "prsity3003
2019-05-02 08:15:53.523382 pestcheck:12 characters long.
2019-05-02 08:15:53.523432 pestcheck:Line 2475 of file freyberg.pst: parameter name "prsity3003
2019-05-02 08:15:53.523615 pestcheck:once.
2019-05-02 08:15:53.523731 pestcheck:Line 2476 of file freyberg.pst: parameter name "prsity3003
2019-05-02 08:15:53.523835 pestcheck:12 characters long.
2019-05-02 08:15:53.523882 pestcheck:Line 2476 of file freyberg.pst: parameter name "prsity3003
2019-05-02 08:15:53.523921 pestcheck:once.
2019-05-02 08:15:53.524020 pestcheck:Line 2477 of file freyberg.pst: parameter name "prsity3003
2019-05-02 08:15:53.524125 pestcheck:12 characters long.
2019-05-02 08:15:53.524171 pestcheck:Line 2477 of file freyberg.pst: parameter name "prsity3003
2019-05-02 08:15:53.524213 pestcheck:once.
2019-05-02 08:15:53.524313 pestcheck:Line 2478 of file freyberg.pst: parameter name "prsity3003
2019-05-02 08:15:53.524418 pestcheck:12 characters long.
2019-05-02 08:15:53.524473 pestcheck:Line 2478 of file freyberg.pst: parameter name "prsity3003
2019-05-02 08:15:53.524572 pestcheck:once.
2019-05-02 08:15:53.524676 pestcheck:Line 2479 of file freyberg.pst: parameter name "prsity3003
2019-05-02 08:15:53.524723 pestcheck:12 characters long.
2019-05-02 08:15:53.524761 pestcheck:Line 2479 of file freyberg.pst: parameter name "prsity3003
2019-05-02 08:15:53.524861 pestcheck:once.
2019-05-02 08:15:53.524964 pestcheck:Line 2480 of file freyberg.pst: parameter name "prsity3003
2019-05-02 08:15:53.525011 pestcheck:12 characters long.
2019-05-02 08:15:53.525052 pestcheck:Line 2480 of file freyberg.pst: parameter name "prsity3003
2019-05-02 08:15:53.525153 pestcheck:once.
```

```
2019-05-02 08:15:53.525256 pestcheck:Line 2481 of file freyberg.pst: parameter name "prsity3003
2019-05-02 08:15:53.525370 pestcheck:12 characters long.
2019-05-02 08:15:53.525474 pestcheck:Line 2481 of file freyberg.pst: parameter name "prsity3003
2019-05-02 08:15:53.525562 pestcheck:once.
2019-05-02 08:15:53.525634 pestcheck:Line 2482 of file freyberg.pst: parameter name "prsity3003
2019-05-02 08:15:53.525738 pestcheck:12 characters long.
2019-05-02 08:15:53.525785 pestcheck:Line 2482 of file freyberg.pst: parameter name "prsity3003
2019-05-02 08:15:53.525824 pestcheck:once.
2019-05-02 08:15:53.525924 pestcheck:Line 2483 of file freyberg.pst: parameter name "prsity3004
2019-05-02 08:15:53.526028 pestcheck:12 characters long.
2019-05-02 08:15:53.526077 pestcheck:Line 2484 of file freyberg.pst: parameter name "prsity3004
2019-05-02 08:15:53.526183 pestcheck:12 characters long.
2019-05-02 08:15:53.526287 pestcheck:Line 2484 of file freyberg.pst: parameter name "prsity3004
2019-05-02 08:15:53.526400 pestcheck:once.
2019-05-02 08:15:53.526504 pestcheck:Line 2485 of file freyberg.pst: parameter name "prsity3004
2019-05-02 08:15:53.526622 pestcheck:12 characters long.
2019-05-02 08:15:53.526726 pestcheck:Line 2485 of file freyberg.pst: parameter name "prsity3004
2019-05-02 08:15:53.526841 pestcheck:once.
2019-05-02 08:15:53.526944 pestcheck:Line 2486 of file freyberg.pst: parameter name "prsity3004
2019-05-02 08:15:53.527009 pestcheck:12 characters long.
2019-05-02 08:15:53.527140 pestcheck:Line 2486 of file freyberg.pst: parameter name "prsity3004
2019-05-02 08:15:53.527249 pestcheck:once.
2019-05-02 08:15:53.527365 pestcheck:Line 2487 of file freyberg.pst: parameter name "prsity3004
2019-05-02 08:15:53.527470 pestcheck:12 characters long.
2019-05-02 08:15:53.527528 pestcheck:Line 2487 of file freyberg.pst: parameter name "prsity3004
2019-05-02 08:15:53.527629 pestcheck:once.
2019-05-02 08:15:53.527734 pestcheck:Line 2488 of file freyberg.pst: parameter name "prsity3004
2019-05-02 08:15:53.527851 pestcheck:12 characters long.
2019-05-02 08:15:53.527957 pestcheck:Line 2488 of file freyberg.pst: parameter name "prsity3004
2019-05-02 08:15:53.528071 pestcheck:once.
2019-05-02 08:15:53.528177 pestcheck:Line 2489 of file freyberg.pst: parameter name "prsity3004
2019-05-02 08:15:53.528227 pestcheck:12 characters long.
2019-05-02 08:15:53.528266 pestcheck:Line 2489 of file freyberg.pst: parameter name "prsity3004
2019-05-02 08:15:53.528368 pestcheck:once.
2019-05-02 08:15:53.528473 pestcheck:Line 2490 of file freyberg.pst: parameter name "prsity3004
2019-05-02 08:15:53.528592 pestcheck:12 characters long.
2019-05-02 08:15:53.528696 pestcheck:Line 2490 of file freyberg.pst: parameter name "prsity3004
2019-05-02 08:15:53.528745 pestcheck:once.
2019-05-02 08:15:53.528785 pestcheck:Line 2491 of file freyberg.pst: parameter name "prsity3004
2019-05-02 08:15:53.528885 pestcheck:12 characters long.
2019-05-02 08:15:53.528989 pestcheck:Line 2491 of file freyberg.pst: parameter name "prsity3004
2019-05-02 08:15:53.529039 pestcheck:once.
2019-05-02 08:15:53.529078 pestcheck:Line 2492 of file freyberg.pst: parameter name "prsity3004
2019-05-02 08:15:53.529179 pestcheck:12 characters long.
2019-05-02 08:15:53.529283 pestcheck:Line 2492 of file freyberg.pst: parameter name "prsity3004
2019-05-02 08:15:53.529332 pestcheck:once.
2019-05-02 08:15:53.529372 pestcheck:Line 2493 of file freyberg.pst: parameter name "prsity3004
2019-05-02 08:15:53.529554 pestcheck:12 characters long.
```

```
2019-05-02 08:15:53.529677 pestcheck:Line 2494 of file freyberg.pst: parameter name "prsity3004
2019-05-02 08:15:53.529782 pestcheck:12 characters long.
2019-05-02 08:15:53.529896 pestcheck:Line 2494 of file freyberg.pst: parameter name "prsity3004
2019-05-02 08:15:53.530000 pestcheck:once.
2019-05-02 08:15:53.530113 pestcheck:Line 2495 of file freyberg.pst: parameter name "prsity3004
2019-05-02 08:15:53.530217 pestcheck:12 characters long.
2019-05-02 08:15:53.530327 pestcheck:Line 2495 of file freyberg.pst: parameter name "prsity3004
2019-05-02 08:15:53.530434 pestcheck:once.
2019-05-02 08:15:53.530484 pestcheck:Line 2496 of file freyberg.pst: parameter name "prsity3004
2019-05-02 08:15:53.530524 pestcheck:12 characters long.
2019-05-02 08:15:53.530695 pestcheck:Line 2496 of file freyberg.pst: parameter name "prsity3004
2019-05-02 08:15:53.530810 pestcheck:once.
2019-05-02 08:15:53.530917 pestcheck:Line 2497 of file freyberg.pst: parameter name "prsity3004
2019-05-02 08:15:53.530967 pestcheck:12 characters long.
2019-05-02 08:15:53.531007 pestcheck:Line 2497 of file freyberg.pst: parameter name "prsity3004
2019-05-02 08:15:53.531107 pestcheck:once.
2019-05-02 08:15:53.531211 pestcheck:Line 2498 of file freyberg.pst: parameter name "prsity3004
2019-05-02 08:15:53.531261 pestcheck:12 characters long.
2019-05-02 08:15:53.531300 pestcheck:Line 2498 of file freyberg.pst: parameter name "prsity3004
2019-05-02 08:15:53.531404 pestcheck:once.
2019-05-02 08:15:53.531510 pestcheck:Line 2499 of file freyberg.pst: parameter name "prsity3004
2019-05-02 08:15:53.531629 pestcheck:12 characters long.
2019-05-02 08:15:53.531733 pestcheck:Line 2499 of file freyberg.pst: parameter name "prsity3004
2019-05-02 08:15:53.531780 pestcheck:once.
2019-05-02 08:15:53.531820 pestcheck:Line 2500 of file freyberg.pst: parameter name "prsity3004
2019-05-02 08:15:53.531919 pestcheck:12 characters long.
2019-05-02 08:15:53.532024 pestcheck:Line 2500 of file freyberg.pst: parameter name "prsity3004
2019-05-02 08:15:53.532138 pestcheck:once.
2019-05-02 08:15:53.532243 pestcheck:Line 2501 of file freyberg.pst: parameter name "prsity3004
2019-05-02 08:15:53.532289 pestcheck:12 characters long.
2019-05-02 08:15:53.532328 pestcheck:Line 2501 of file freyberg.pst: parameter name "prsity3004
2019-05-02 08:15:53.532428 pestcheck:once.
2019-05-02 08:15:53.532533 pestcheck:Line 2502 of file freyberg.pst: parameter name "prsity3004
2019-05-02 08:15:53.532655 pestcheck:12 characters long.
2019-05-02 08:15:53.532761 pestcheck:Line 2502 of file freyberg.pst: parameter name "prsity3004
2019-05-02 08:15:53.532875 pestcheck:once.
2019-05-02 08:15:53.532979 pestcheck:Line 2503 of file freyberg.pst: parameter name "prsity3005
2019-05-02 08:15:53.533096 pestcheck:12 characters long.
2019-05-02 08:15:53.533201 pestcheck:Line 2504 of file freyberg.pst: parameter name "prsity3005
2019-05-02 08:15:53.533250 pestcheck:12 characters long.
2019-05-02 08:15:53.533299 pestcheck:Line 2504 of file freyberg.pst: parameter name "prsity3005
2019-05-02 08:15:53.533431 pestcheck:once.
2019-05-02 08:15:53.533569 pestcheck:Line 2505 of file freyberg.pst: parameter name "prsity3005
2019-05-02 08:15:53.533700 pestcheck:12 characters long.
2019-05-02 08:15:53.533808 pestcheck:Line 2505 of file freyberg.pst: parameter name "prsity3005
2019-05-02 08:15:53.533857 pestcheck:once.
2019-05-02 08:15:53.533897 pestcheck:Line 2506 of file freyberg.pst: parameter name "prsity3005
2019-05-02 08:15:53.534000 pestcheck:12 characters long.
```

```
2019-05-02 08:15:53.534106 pestcheck:Line 2506 of file freyberg.pst: parameter name "prsity3005
2019-05-02 08:15:53.534156 pestcheck:once.
2019-05-02 08:15:53.534269 pestcheck:Line 2507 of file freyberg.pst: parameter name "prsity3005
2019-05-02 08:15:53.534377 pestcheck:12 characters long.
2019-05-02 08:15:53.534425 pestcheck:Line 2507 of file freyberg.pst: parameter name "prsity3005
2019-05-02 08:15:53.534532 pestcheck:once.
2019-05-02 08:15:53.534656 pestcheck:Line 2508 of file freyberg.pst: parameter name "prsity3005
2019-05-02 08:15:53.534699 pestcheck:12 characters long.
2019-05-02 08:15:53.534956 finished: running pestchek on freyberg.pst took: 0:00:00.142834
2019-05-02 08:15:53.535076 starting: saving intermediate _setup_<> dfs into template
2019-05-02 08:15:53.666013 finished: saving intermediate _setup_<> dfs into template took: 0:0
2019-05-02 08:15:53.666390 all done
```

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

```
In [14]: pst = pst_helper.pst
         pst.npar,pst.nobs
```

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

Oh snap!

1.0.4 Add modpath input files, instruction files and calls

```
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']
```

```
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()
```

```
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
```

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

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

1.0.5 Final bits and bobs

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

In [19]:
```
par = pst.parameter_data
# properties
tag_dict = {"hk":[0.1,10.0],"vka":[0.1,10],"strt":[0.95,1.05],"prsity":[0.1,1.0]}
for t,[l,u] in tag_dict.items():
    t_pars = par.loc[par.parnme.apply(lambda x: t in x ),"parnme"]
    par.loc[t_pars,"parubnd"] = u
    par.loc[t_pars,"parlbnd"] = l

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

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

In [20]:
```
# table can also be written to a .tex file
pst.write_par_summary_table(filename="none").sort_index()
```

Out[20]:

	type	transform	count	initial value	\
cn_hk6	cn_hk6	log	1	0	
cn_hk7	cn_hk7	log	1	0	
cn_hk8	cn_hk8	log	1	0	
cn_prsity6	cn_prsity6	log	1	0	
cn_prsity7	cn_prsity7	log	1	0	
cn_prsity8	cn_prsity8	log	1	0	
cn_rech4	cn_rech4	log	1	0	
cn_rech5	cn_rech5	log	1	-0.39794	
cn_ss6	cn_ss6	log	1	0	
cn_ss7	cn_ss7	log	1	0	
cn_ss8	cn_ss8	log	1	0	
cn_strt6	cn_strt6	log	1	0	
cn_strt7	cn_strt7	log	1	0	
cn_strt8	cn_strt8	log	1	0	

cn_sy6	cn_sy6	log	1	0
cn_sy7	cn_sy7	log	1	0
cn_sy8	cn_sy8	log	1	0
cn_vka6	cn_vka6	log	1	0
cn_vka7	cn_vka7	log	1	0
cn_vka8	cn_vka8	log	1	0
drncond_k00	drncond_k00	log	10	0
flow	flow	log	1	0
gr_hk3	gr_hk3	log	705	0
gr_hk4	gr_hk4	log	705	0
gr_hk5	gr_hk5	log	705	0
gr_prsity3	gr_prsity3	log	705	0
gr_prsity4	gr_prsity4	log	705	0
gr_prsity5	gr_prsity5	log	705	0
gr_rech2	gr_rech2	log	705	0
gr_rech3	gr_rech3	log	705	0
...	...	...	...	...
gr_strt5	gr_strt5	log	705	0
gr_sy3	gr_sy3	log	705	0
gr_sy4	gr_sy4	log	705	0
gr_sy5	gr_sy5	log	705	0
gr_vka3	gr_vka3	log	705	0
gr_vka4	gr_vka4	log	705	0
gr_vka5	gr_vka5	log	705	0
pp_hk0	pp_hk0	log	32	0
pp_hk1	pp_hk1	log	32	0
pp_hk2	pp_hk2	log	32	0
pp_prsity0	pp_prsity0	log	32	0
pp_prsity1	pp_prsity1	log	32	0
pp_prsity2	pp_prsity2	log	32	0
pp_rech0	pp_rech0	log	32	0
pp_rech1	pp_rech1	log	32	0
pp_ss0	pp_ss0	log	32	0
pp_ss1	pp_ss1	log	32	0
pp_ss2	pp_ss2	log	32	0
pp_strt0	pp_strt0	log	32	0
pp_strt1	pp_strt1	log	32	0
pp_strt2	pp_strt2	log	32	0
pp_sy0	pp_sy0	log	32	0
pp_sy1	pp_sy1	log	32	0
pp_sy2	pp_sy2	log	32	0
pp_vka0	pp_vka0	log	32	0
pp_vka1	pp_vka1	log	32	0
pp_vka2	pp_vka2	log	32	0
strk	strk	log	40	0
welflux	welflux	log	2	0 to 0.176091
welflux_k02	welflux_k02	log	6	0

	upper bound	lower bound	standard deviation
cn_hk6	1	-1	0.5
cn_hk7	1	-1	0.5
cn_hk8	1	-1	0.5
cn_prsity6	0	-1	0.25
cn_prsity7	0	-1	0.25
cn_prsity8	0	-1	0.25
cn_rech4	0.0791812	-0.09691	0.0440228
cn_rech5	-0.09691	-1	0.225772
cn_ss6	1	-1	0.5
cn_ss7	1	-1	0.5
cn_ss8	1	-1	0.5
cn_strt6	0.0211893	-0.0222764	0.0108664
cn_strt7	0.0211893	-0.0222764	0.0108664
cn_strt8	0.0211893	-0.0222764	0.0108664
cn_sy6	0.243038	-0.60206	0.211275
cn_sy7	0.243038	-0.60206	0.211275
cn_sy8	0.243038	-0.60206	0.211275
cn_vka6	1	-1	0.5
cn_vka7	1	-1	0.5
cn_vka8	1	-1	0.5
drncond_k00	1	-1	0.5
flow	0.09691	-0.124939	0.0554622
gr_hk3	1	-1	0.5
gr_hk4	1	-1	0.5
gr_hk5	1	-1	0.5
gr_prsity3	0	-1	0.25
gr_prsity4	0	-1	0.25
gr_prsity5	0	-1	0.25
gr_rech2	0.0413927	-0.0457575	0.0217875
gr_rech3	0.0413927	-0.0457575	0.0217875
...	...	...	...
gr_strt5	0.0211893	-0.0222764	0.0108664
gr_sy3	0.243038	-0.60206	0.211275
gr_sy4	0.243038	-0.60206	0.211275
gr_sy5	0.243038	-0.60206	0.211275
gr_vka3	1	-1	0.5
gr_vka4	1	-1	0.5
gr_vka5	1	-1	0.5
pp_hk0	1	-1	0.5
pp_hk1	1	-1	0.5
pp_hk2	1	-1	0.5
pp_prsity0	0	-1	0.25
pp_prsity1	0	-1	0.25
pp_prsity2	0	-1	0.25
pp_rech0	0.0413927	-0.0457575	0.0217875
pp_rech1	0.0413927	-0.0457575	0.0217875
pp_ss0	1	-1	0.5

```
pp_ss1                          1                -1                 0.5
pp_ss2                          1                -1                 0.5
pp_strt0                0.0211893        -0.0222764            0.0108664
pp_strt1                0.0211893        -0.0222764            0.0108664
pp_strt2                0.0211893        -0.0222764            0.0108664
pp_sy0                   0.243038          -0.60206             0.211275
pp_sy1                   0.243038          -0.60206             0.211275
pp_sy2                   0.243038          -0.60206             0.211275
pp_vka0                         1                -1                 0.5
pp_vka1                         1                -1                 0.5
pp_vka2                         1                -1                 0.5
strk                            2                -2                   1
welflux      0.176091 to 0.30103  -0.30103 to     0  0.0752575 to 0.11928
welflux_k02                     1                -1                 0.5

[65 rows x 7 columns]
```

```
In [21]: pst.write_obs_summary_table(filename="none")
```

```
Out[21]:                   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 [22]: pst.control_data.noptmax = 0
         pst.write(os.path.join(pst_helper.new_model_ws,"freyberg.pst"))
         pyemu.os_utils.run("pestpp-ies freyberg.pst",cwd=pst_helper.new_model_ws)
```

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

```
In [23]: 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)

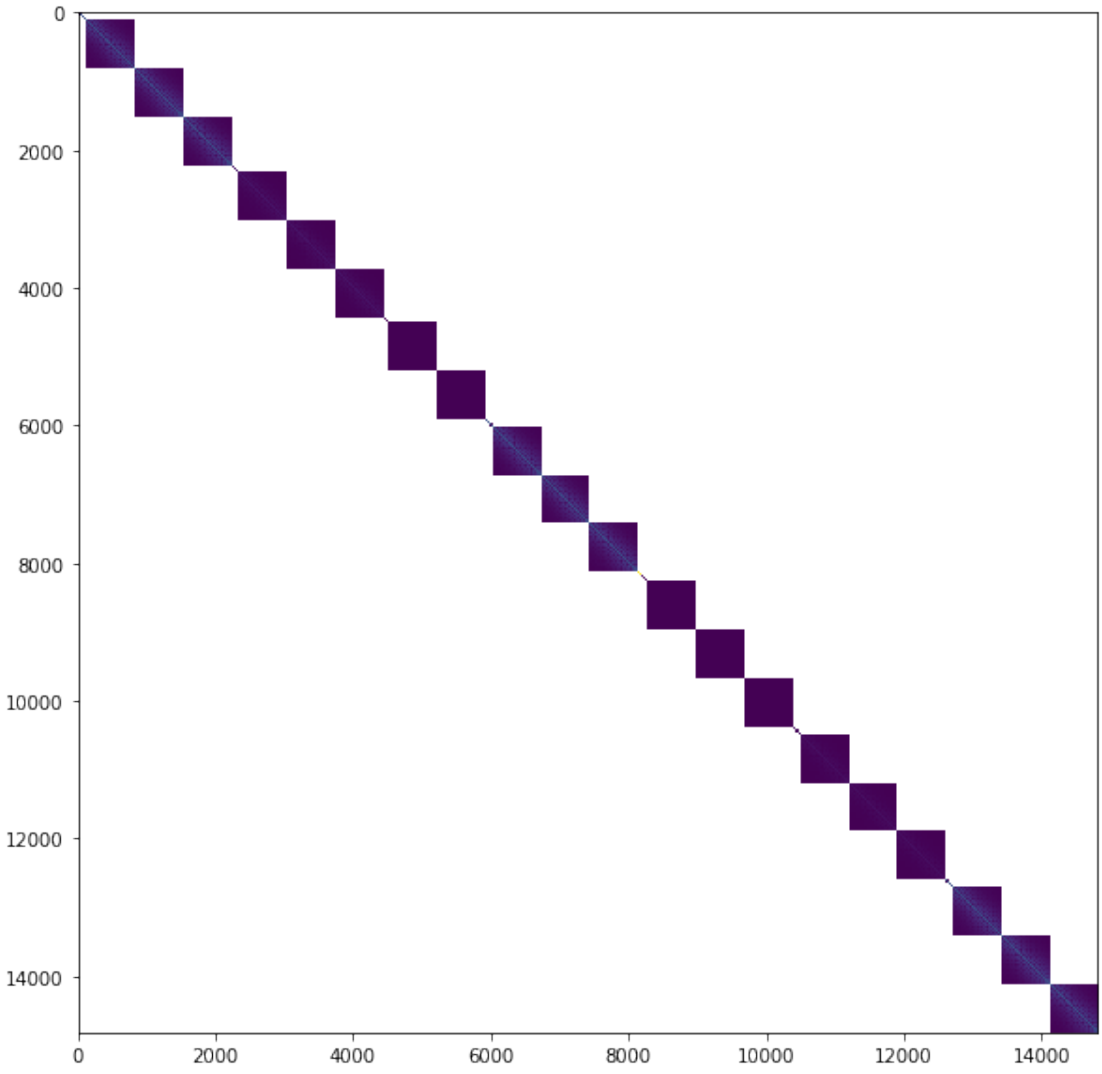
2019-05-02 08:16:03.073474 starting: building prior covariance matrix
2019-05-02 08:16:03.191804 WARNING: geospatial prior not implemented for SFR pars


/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


2019-05-02 08:16:09.664961 saving prior covariance matrix to file template/prior_cov.jcb
2019-05-02 08:16:14.109225 finished: building prior covariance matrix took: 0:00:11.035751
```




```
In [24]: pe = pst_helper.draw(200)

2019-05-02 08:16:32.798651 starting: drawing realizations
building diagonal cov
processing  name:struct1,nugget:0.0,structures:
name:var1,contribution:1.0,a:2500.0,anisotropy:1.0,bearing:0.0
```

```
working on pargroups ['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
working on pargroups ['welflux_k02']


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

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

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


build cov matrix
done
getting diag var cov 6
scaling full cov by diag var cov
making full cov draws with home-grown goodness
processing  name:struct1,nugget:0.0,structures:
name:var1,contribution:1.0,a:180.0,anisotropy:1.0,bearing:0.0

working on pargroups ['welflux']
build cov matrix
done
getting diag var cov 2
scaling full cov by diag var cov
making full cov draws with home-grown goodness
processing  name:struct1,nugget:0.0,structures:
name:var1,contribution:1.0,a:1000.0,anisotropy:1.0,bearing:0.0

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

```
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_ss0']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_sy0']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_strt0']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_prsity0']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_rech0']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_rech1']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_vka1']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_strt1']
build cov matrix
```

```
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_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_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_hk1']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_prsity1']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_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_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_strt2']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_prsity2']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
processing  name:struct1,nugget:0.0,structures:
name:var1,contribution:1.0,a:2500.0,anisotropy:1.0,bearing:0.0

working on pargroups ['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
```

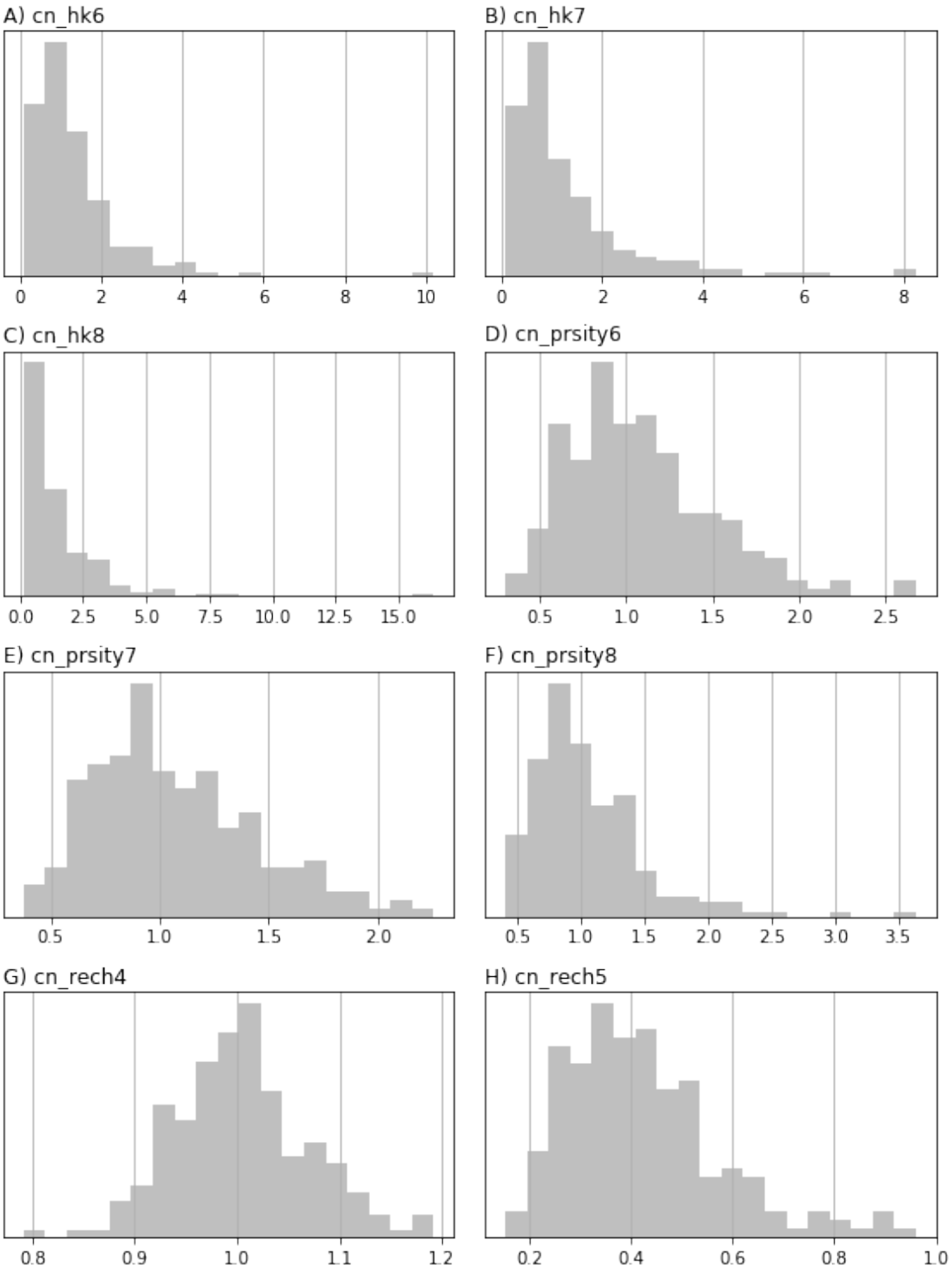
```
making full cov draws with home-grown goodness
working on pargroups ['gr_vka5']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_ss5']
build cov matrix
done
getting diag var cov 705
scaling full 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
adding remaining parameters to diagonal
2019-05-02 08:16:40.467270 finished: drawing realizations took: 0:00:07.668619
```

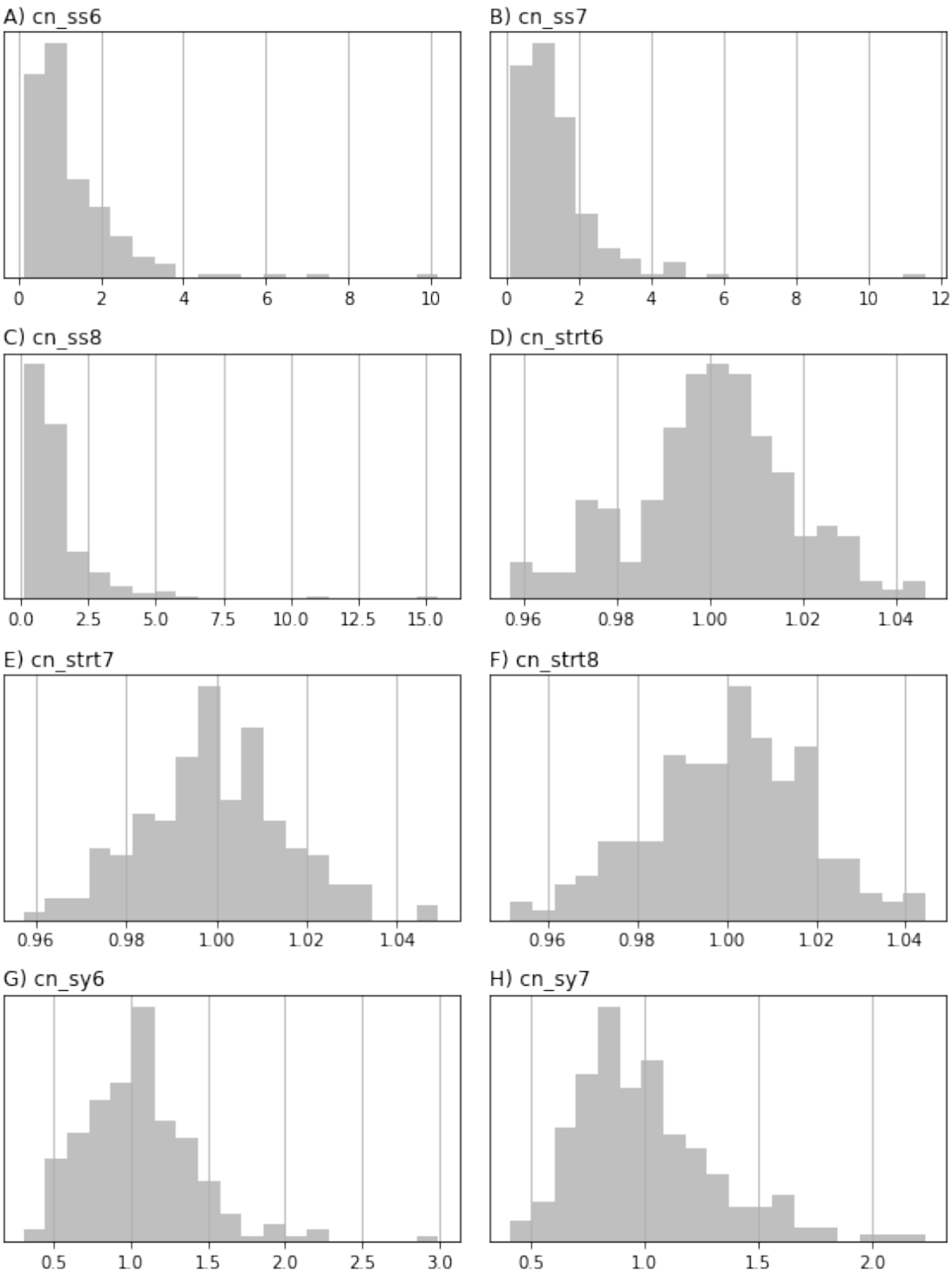
You can see that parameters are treated in parameter group (pargp) blocks for this ensemble

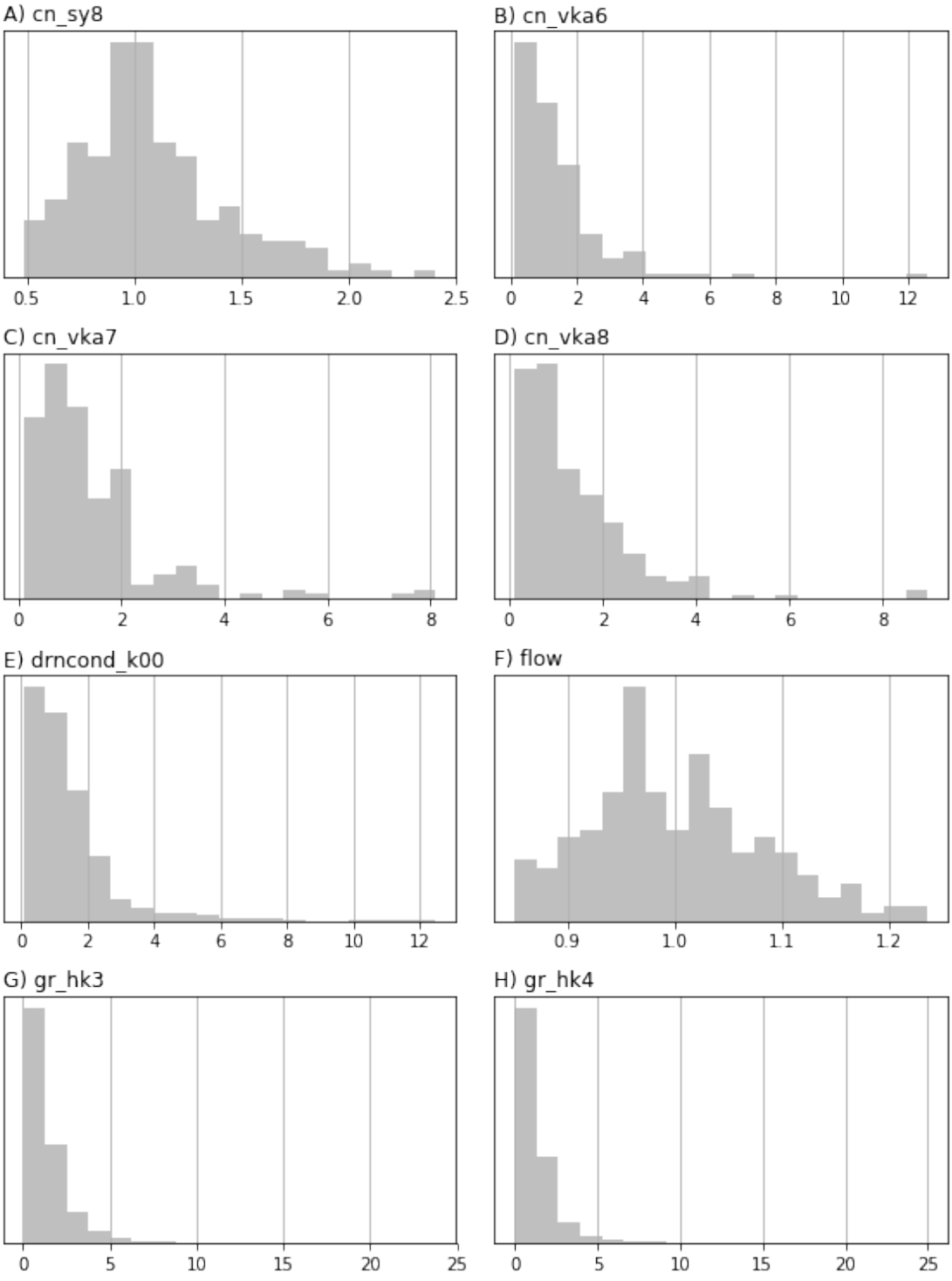
generation. Let's plot one parameter:

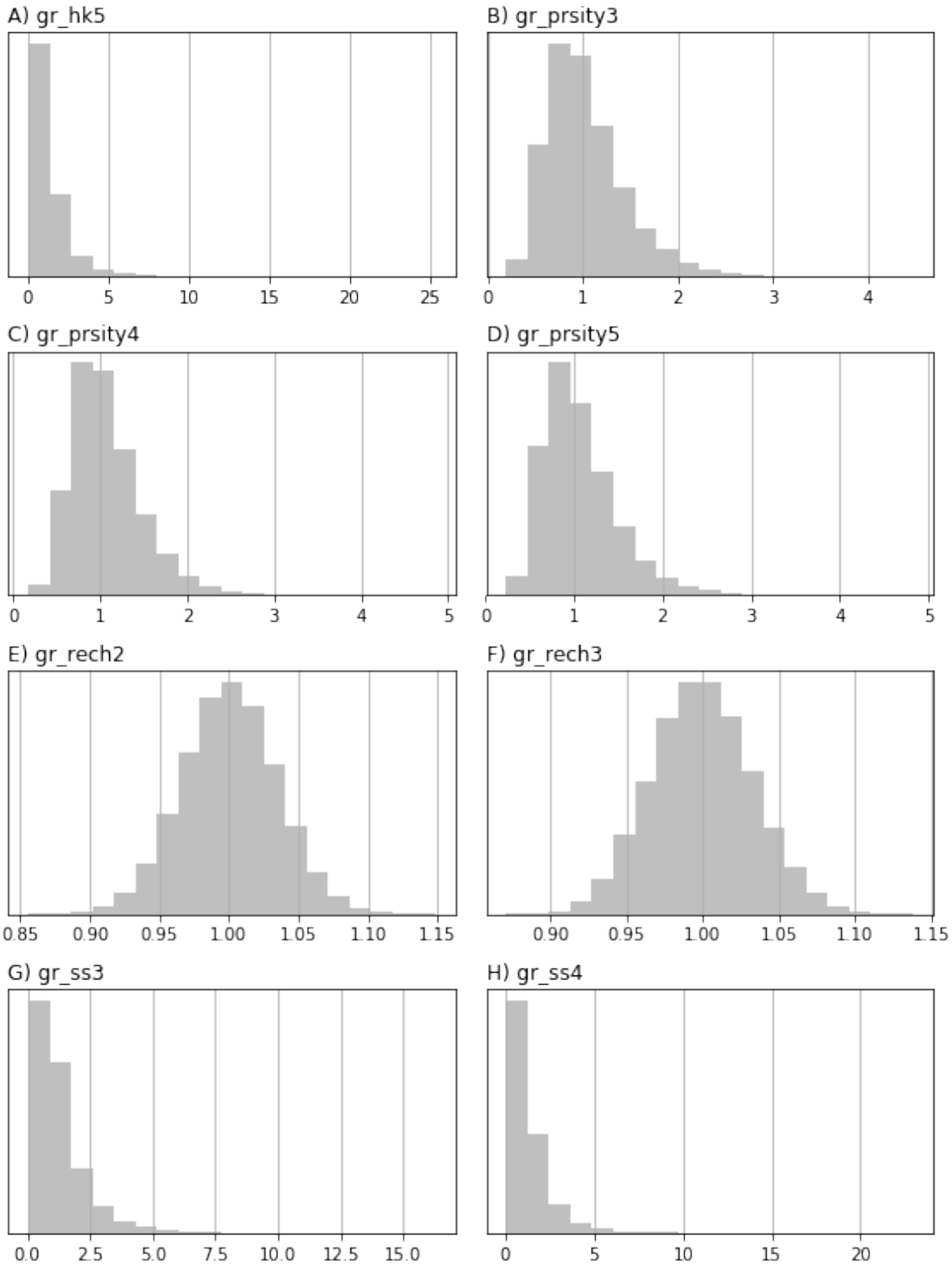
```
In [25]: par = pst_helper.pst.parameter_data
         pyemu.plot_utils.ensemble_helper(pe,plot_cols=par.groupby("pargp").groups,bins=20)
```

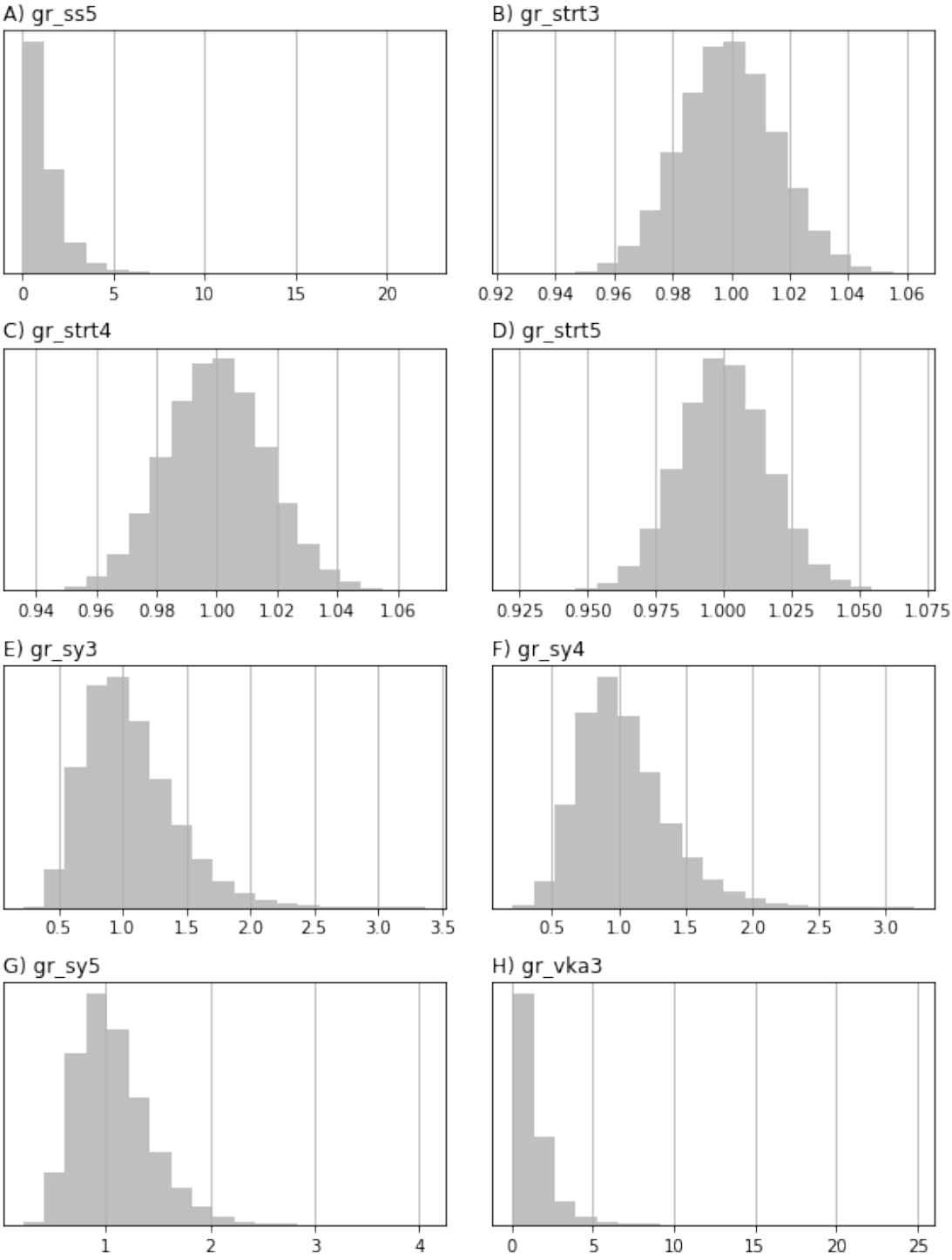
```
<Figure size 576x756 with 0 Axes>
```

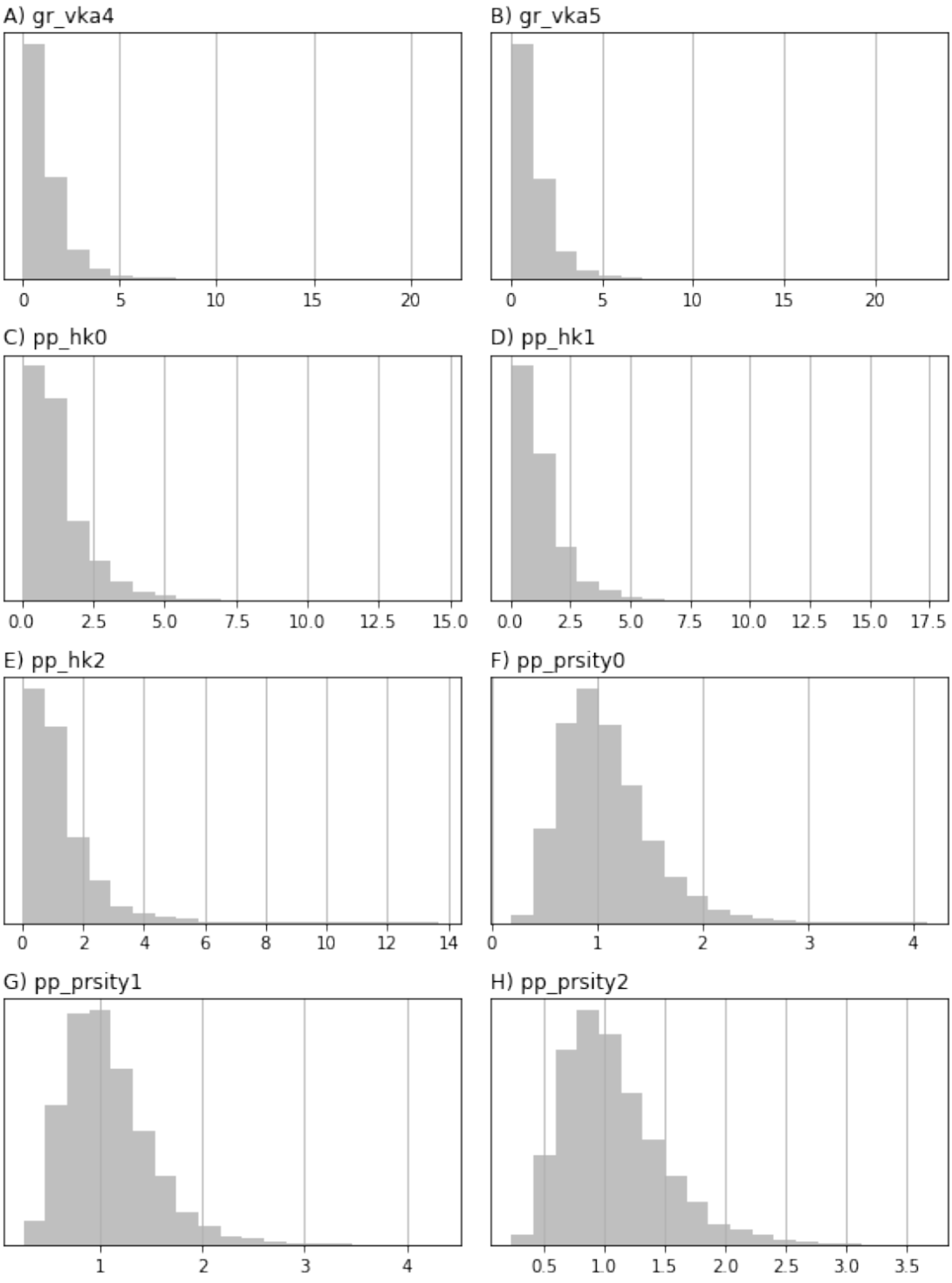


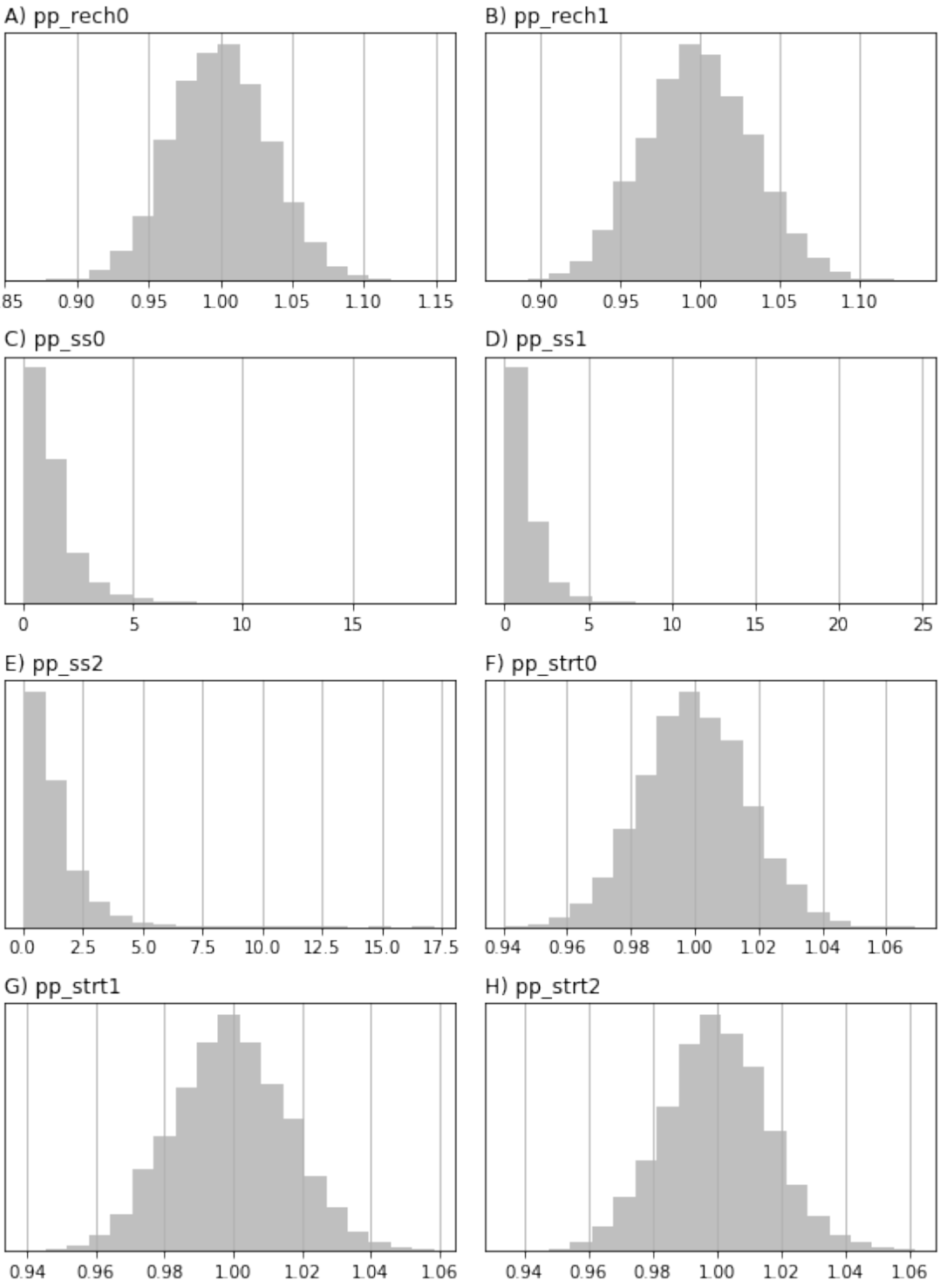

A) cn_ss6
0
2
4
6
8
10
B) cn_ss7
0
2
4
6
8
10
12
C) cn_ss8
0.0
2.5
5.0
7.5
10.0
12.5
15.0
D) cn_strt6
0.96
0.98
1.00
1.02
1.04
E) cn_strt7
0.96
0.98
1.00
1.02
1.04
F) cn_strt8
0.96
0.98
1.00
1.02
1.04
G) cn_sy6
0.5
1.0
1.5
2.0
2.5
3.0
H) cn_sy7
0.5
1.0
1.5
2.0

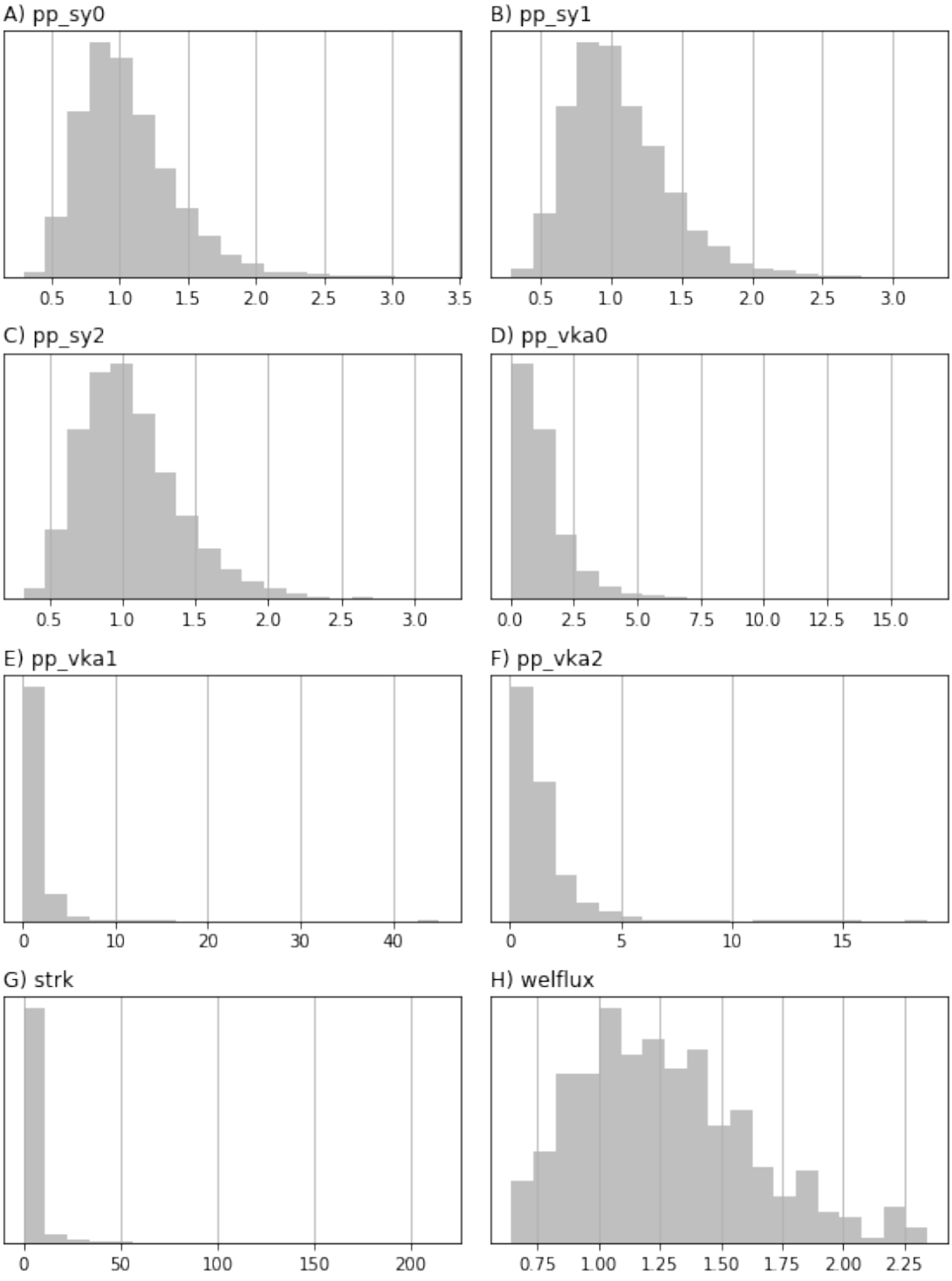

A) cn_sy8
0.5
1.0
1.5
2.0
2.5
B) cn_vka6
0
2
4
6
8
10
12
C) cn_vka7
0
2
4
6
8
D) cn_vka8
0
2
4
6
8
E) drncond_k00
0
2
4
6
8
10
12
F) flow
0.9
1.0
1.1
1.2
G) gr_hk3
0
5
10
15
20
25
H) gr_hk4
0
5
10
15
20
25

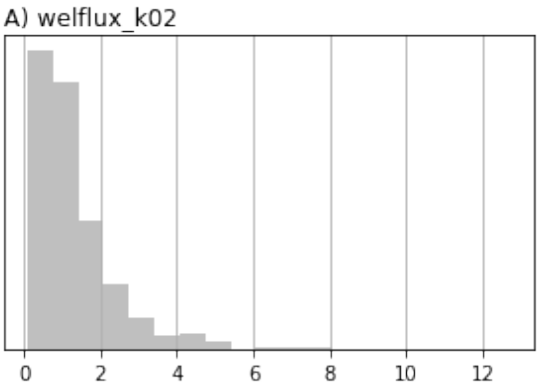

A) gr_hk5
0
5
10
15
20
25
B) gr_prsity3
0
1
2
3
4
C) gr_prsity4
0
1
2
3
4
5
D) gr_prsity5
0
1
2
3
4
5
E) gr_rech2
0.85
0.90
0.95
1.00
1.05
1.10
1.15
F) gr_rech3
0.90
0.95
1.00
1.05
1.10
1.15
G) gr_ss3
0.0
2.5
5.0
7.5
10.0
12.5
15.0
H) gr_ss4
0
5
10
15
20


A) gr_ss5
0
5
10
15
20
B) gr_strt3
0.92
0.94
0.96
0.98
1.00
1.02
1.04
1.06
C) gr_strt4
0.94
0.96
0.98
1.00
1.02
1.04
1.06
D) gr_strt5
0.925
0.950
0.975
1.000
1.025
1.050
1.075
E) gr_sy3
0.5
1.0
1.5
2.0
2.5
3.0
3.5
F) gr_sy4
0.5
1.0
1.5
2.0
2.5
3.0
G) gr_sy5
1
2
3
4
H) gr_vka3
0
5
10
15
20
25


A) gr_vka4
0
5
10
15
20
B) gr_vka5
0
5
10
15
20
C) pp_hk0
0.0
2.5
5.0
7.5
10.0
12.5
15.0
D) pp_hk1
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
E) pp_hk2
0
2
4
6
8
10
12
14
F) pp_prsity0
0
1
2
3
4
G) pp_prsity1
1
2
3
4
H) pp_prsity2
0.5
1.0
1.5
2.0
2.5
3.0
3.5


A) pp_rech0
0.85 0.90 0.95 1.00 1.05 1.10 1.15
B) pp_rech1
0.90 0.95 1.00 1.05 1.10
C) pp_ss0
0 5 10 15
D) pp_ss1
0 5 10 15 20 25
E) pp_ss2
0.0 2.5 5.0 7.5 10.0 12.5 15.0 17.5
F) pp_strt0
0.94 0.96 0.98 1.00 1.02 1.04 1.06
G) pp_strt1
0.94 0.96 0.98 1.00 1.02 1.04 1.06
H) pp_strt2
0.94 0.96 0.98 1.00 1.02 1.04 1.06


A) pp_sy0
0.5 1.0 1.5 2.0 2.5 3.0 3.5
B) pp_sy1
0.5 1.0 1.5 2.0 2.5 3.0
C) pp_sy2
0.5 1.0 1.5 2.0 2.5 3.0
D) pp_vka0
0.0 2.5 5.0 7.5 10.0 12.5 15.0
E) pp_vka1
0 10 20 30 40
F) pp_vka2
0 5 10 15
G) strk
0 50 100 150 200
H) welflux
0.75 1.00 1.25 1.50 1.75 2.00 2.25



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

```
In [26]: pe.enforce()
         pe.to_binary(os.path.join(pst_helper.new_model_ws,"prior.jcb"))
```

1.0.6 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 [27]: 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[27]:

	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 excersize |

```
In [28]: 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[28]: ['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 [29]: swgw_forecasts = obs.loc[obs.obsnme.apply(lambda x: "fa" in x and ("hw" in x or "tw" i
         print(swgw_forecasts)
         hds_fore_name = "hds_00_{0:03d}_{1:03d}".format(int(pst_helper.m.nrow/3),int(pst_helpe
         hds_forecasts = obs.loc[obs.obsnme.apply(lambda x: hds_fore_name in x),"obsnme"].tolis
         forecasts = swgw_forecasts
         forecasts.extend(hds_forecasts)
         forecasts.append("part_time")
         forecasts.append("part_status")
         pst_helper.pst.pestpp_options["forecasts"] = forecasts
         pst.write(os.path.join(pst_helper.new_model_ws,"freyberg.pst"))
```

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

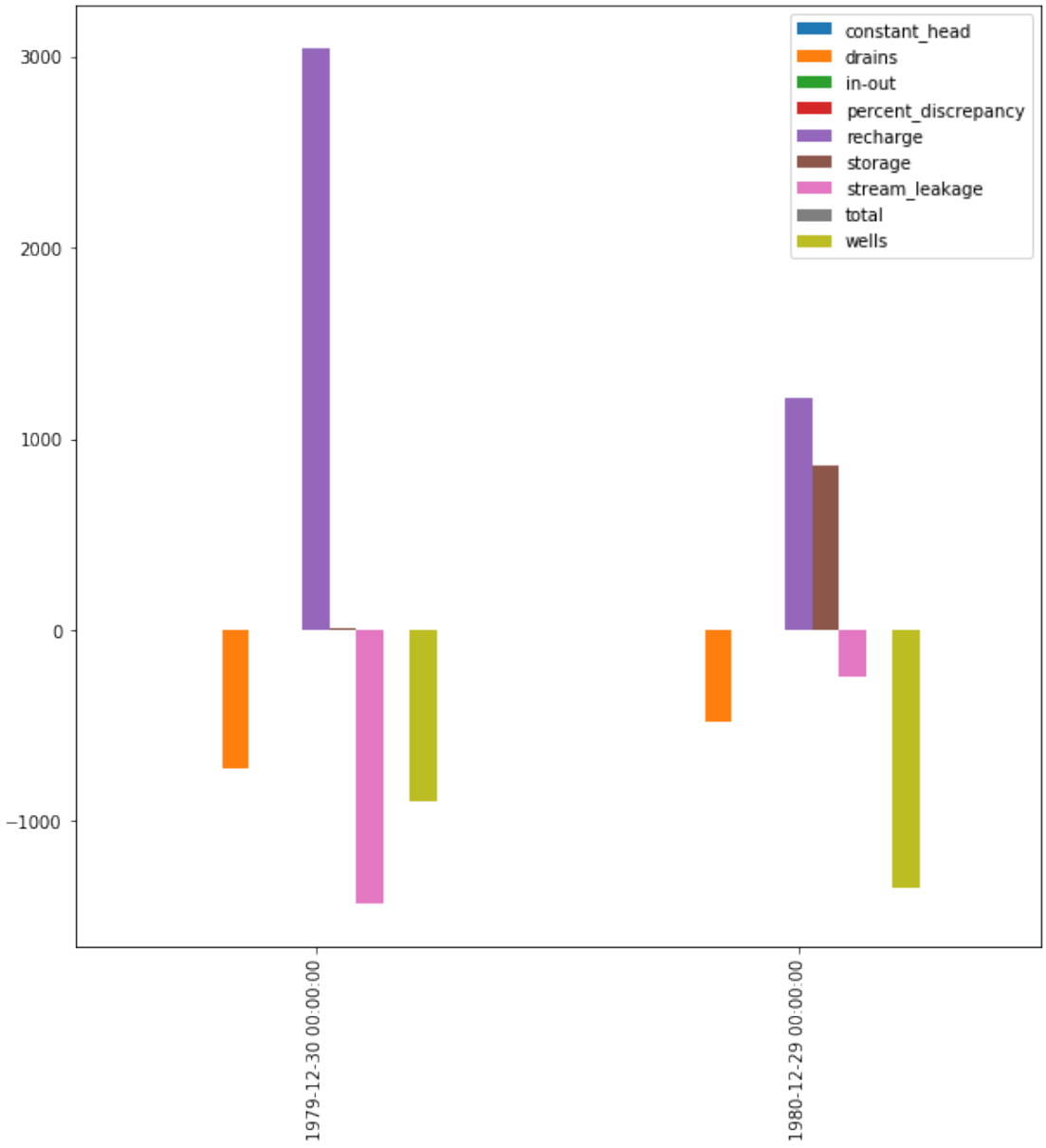
Run one last time. `phi` should be near zero since we haven't change the `parval1` values for historic stress period and only the 13 gw level obs have nonzero weights

```
In [30]: 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[30]: 9.456182577320024e-19
```

```
In [31]: lst = flopy.utils.MfListBudget(os.path.join("template","freyberg.list"))
         df = lst.get_dataframes(diff=True)[0]
         df.plot(kind="bar",figsize=(10,10))
```

```
Out[31]: <matplotlib.axes._subplots.AxesSubplot at 0x1824042518>
```



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