setup_pest_interface

May 3, 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]:
```python
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')]
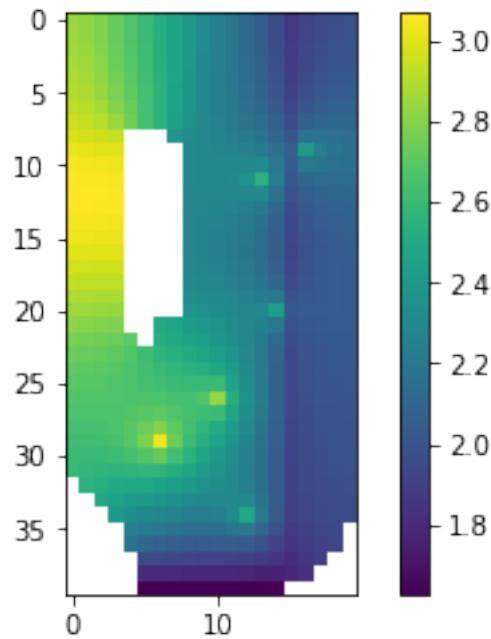

data Layer 1
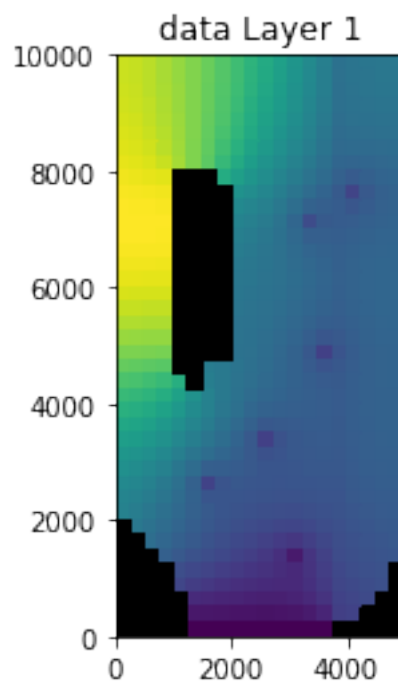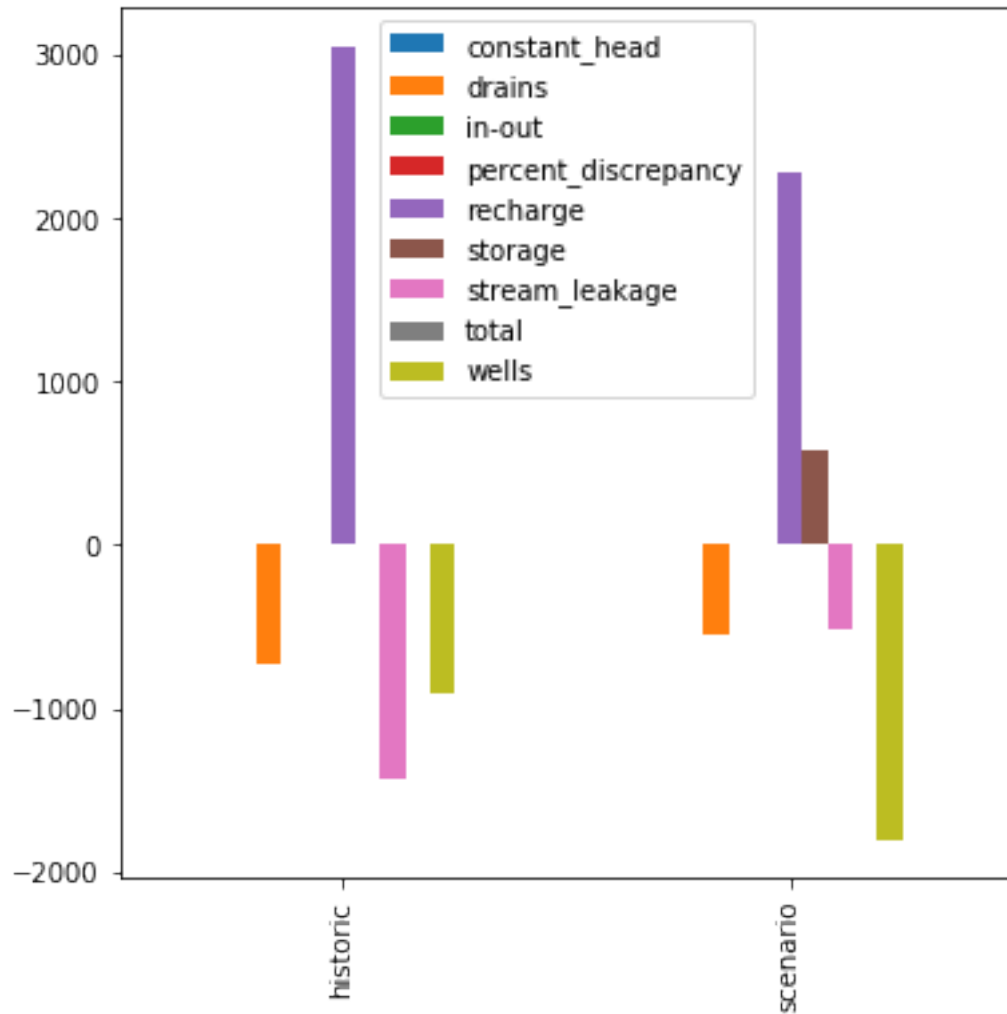
We can see the effect of the "scenario" in the second stress period with less recharge and more abstraction.

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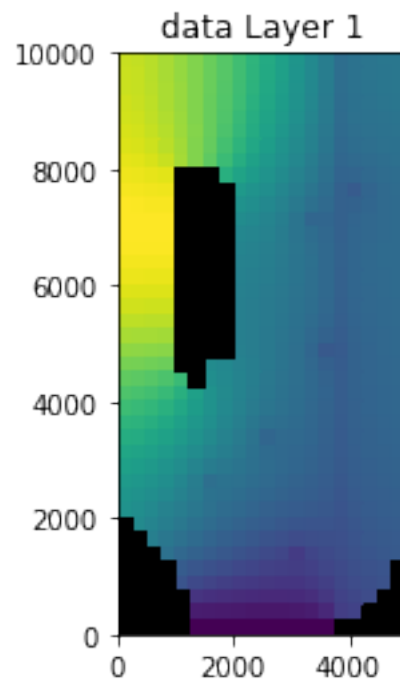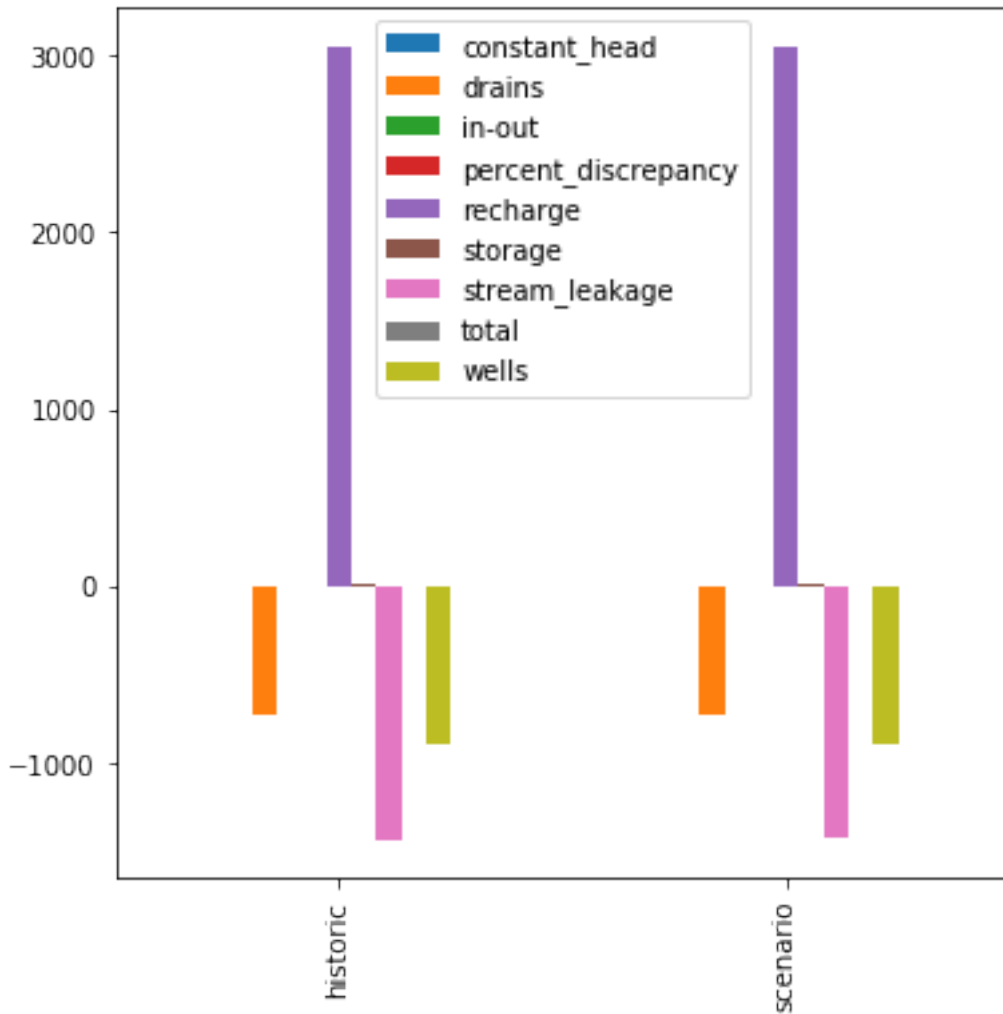
Now we see that the scenario and historic periods have the same water balance

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 tail-waters (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=spat:
                                    temporal_list_props=temporal_list_props,:
                                   grid_props=props,pp_props=props,sfr_pars=
                                    sfr_obs=sfr_obs_dict,build_prior=False,mo
                                   pp_space=4)
         prep_deps.prep_template(t_d=pst_helper.new_model_ws)

2019-05-03 12:39:53.845893 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
2019-05-03 12:39:53.886994 finished: loading flopy model took: 0:00:00.041101
2019-05-03 12:39:53.887147 starting: updating model attributes
2019-05-03 12:39:53.887318 finished: updating model attributes took: 0:00:00.000171
2019-05-03 12:39:53.887538 WARNING: removing existing 'new_model_ws

creating model workspace...
   template

changing model workspace...
   template
2019-05-03 12:39:55.107427 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


2019-05-03 12:39:55.306335 finished: writing new modflow input files took: 0:00:00.198908
2019-05-03 12:39:55.307255 forward_run line:pyemu.os_utils.run('mfnwt freyberg.nam 1>freyberg.r
2019-05-03 12:39:55.308044 starting: setting up 'template/arr_org' dir
2019-05-03 12:39:55.309031 finished: setting up 'template/arr_org' dir took: 0:00:00.000987
2019-05-03 12:39:55.309697 starting: setting up 'template/arr_mlt' dir
2019-05-03 12:39:55.310757 finished: setting up 'template/arr_mlt' dir took: 0:00:00.001060
2019-05-03 12:39:55.311513 starting: setting up 'template/list_org' dir
2019-05-03 12:39:55.313260 finished: setting up 'template/list_org' dir took: 0:00:00.001747
2019-05-03 12:39:55.313824 starting: setting up 'template/list_mlt' dir
2019-05-03 12:39:55.314757 finished: setting up 'template/list_mlt' dir took: 0:00:00.000933
2019-05-03 12:39:55.315248 starting: processing temporal_list_props
2019-05-03 12:39:55.358792 finished: processing temporal_list_props took: 0:00:00.043544
```

```
2019-05-03 12:39:55.359223 starting: processing spatial_list_props
2019-05-03 12:39:55.571032 finished: processing spatial_list_props took: 0:00:00.211809
2019-05-03 12:39:55.654394 forward_run line:pyemu.helpers.apply_list_pars()


2019-05-03 12:39:55.702777 'extra' pak detected:extra.prsity
2019-05-03 12:39:55.755051 'extra' pak detected:extra.prsity
2019-05-03 12:39:55.805556 'extra' pak detected:extra.prsity
2019-05-03 12:39:55.866858 'extra' pak detected:extra.prsity
2019-05-03 12:39:55.915856 'extra' pak detected:extra.prsity
2019-05-03 12:39:55.954845 'extra' pak detected:extra.prsity
2019-05-03 12:39:56.012706 'extra' pak detected:extra.prsity
2019-05-03 12:39:56.060788 'extra' pak detected:extra.prsity
2019-05-03 12:39:56.101061 'extra' pak detected:extra.prsity
2019-05-03 12:39:56.207454 starting: writing grid tpl:hk3.dat_gr.tpl
2019-05-03 12:39:56.220782 finished: writing grid tpl:hk3.dat_gr.tpl took: 0:00:00.013328
2019-05-03 12:39:56.224277 starting: writing grid tpl:vka3.dat_gr.tpl
2019-05-03 12:39:56.237404 finished: writing grid tpl:vka3.dat_gr.tpl took: 0:00:00.013127
2019-05-03 12:39:56.240147 starting: writing grid tpl:ss3.dat_gr.tpl
2019-05-03 12:39:56.250110 finished: writing grid tpl:ss3.dat_gr.tpl took: 0:00:00.009963
2019-05-03 12:39:56.252866 starting: writing grid tpl:sy3.dat_gr.tpl
2019-05-03 12:39:56.263377 finished: writing grid tpl:sy3.dat_gr.tpl took: 0:00:00.010511
2019-05-03 12:39:56.269290 starting: writing grid tpl:strt3.dat_gr.tpl
2019-05-03 12:39:56.282557 finished: writing grid tpl:strt3.dat_gr.tpl took: 0:00:00.013267
2019-05-03 12:39:56.285108 starting: writing grid tpl:prsity3.dat_gr.tpl
2019-05-03 12:39:56.302288 finished: writing grid tpl:prsity3.dat_gr.tpl took: 0:00:00.017180
2019-05-03 12:39:56.305430 starting: writing grid tpl:hk4.dat_gr.tpl
2019-05-03 12:39:56.318389 finished: writing grid tpl:hk4.dat_gr.tpl took: 0:00:00.012959
2019-05-03 12:39:56.321372 starting: writing grid tpl:vka4.dat_gr.tpl
2019-05-03 12:39:56.332603 finished: writing grid tpl:vka4.dat_gr.tpl took: 0:00:00.011231
2019-05-03 12:39:56.336355 starting: writing grid tpl:ss4.dat_gr.tpl
2019-05-03 12:39:56.349030 finished: writing grid tpl:ss4.dat_gr.tpl took: 0:00:00.012675
2019-05-03 12:39:56.351876 starting: writing grid tpl:sy4.dat_gr.tpl
2019-05-03 12:39:56.361641 finished: writing grid tpl:sy4.dat_gr.tpl took: 0:00:00.009765
2019-05-03 12:39:56.364429 starting: writing grid tpl:strt4.dat_gr.tpl
2019-05-03 12:39:56.373895 finished: writing grid tpl:strt4.dat_gr.tpl took: 0:00:00.009466
2019-05-03 12:39:56.377294 starting: writing grid tpl:prsity4.dat_gr.tpl
2019-05-03 12:39:56.395736 finished: writing grid tpl:prsity4.dat_gr.tpl took: 0:00:00.018442
2019-05-03 12:39:56.400429 starting: writing grid tpl:hk5.dat_gr.tpl
2019-05-03 12:39:56.412417 finished: writing grid tpl:hk5.dat_gr.tpl took: 0:00:00.011988
2019-05-03 12:39:56.418326 starting: writing grid tpl:vka5.dat_gr.tpl
2019-05-03 12:39:56.432299 finished: writing grid tpl:vka5.dat_gr.tpl took: 0:00:00.013973
2019-05-03 12:39:56.435034 starting: writing grid tpl:ss5.dat_gr.tpl
2019-05-03 12:39:56.446221 finished: writing grid tpl:ss5.dat_gr.tpl took: 0:00:00.011187
2019-05-03 12:39:56.451480 starting: writing grid tpl:sy5.dat_gr.tpl
2019-05-03 12:39:56.465182 finished: writing grid tpl:sy5.dat_gr.tpl took: 0:00:00.013702
2019-05-03 12:39:56.469277 starting: writing grid tpl:strt5.dat_gr.tpl
2019-05-03 12:39:56.479042 finished: writing grid tpl:strt5.dat_gr.tpl took: 0:00:00.009765
2019-05-03 12:39:56.481941 starting: writing grid tpl:prsity5.dat_gr.tpl
```

```
2019-05-03 12:39:56.495411 finished: writing grid tpl:prsity5.dat_gr.tpl took: 0:00:00.013470
2019-05-03 12:39:56.501311 starting: writing grid tpl:rech2.dat_gr.tpl
2019-05-03 12:39:56.516240 finished: writing grid tpl:rech2.dat_gr.tpl took: 0:00:00.014929
2019-05-03 12:39:56.520121 starting: writing grid tpl:rech3.dat_gr.tpl
2019-05-03 12:39:56.531416 finished: writing grid tpl:rech3.dat_gr.tpl took: 0:00:00.011295
2019-05-03 12:39:56.537273 starting: writing const tpl:hk6.dat_cn.tpl
2019-05-03 12:39:56.546874 finished: writing const tpl:hk6.dat_cn.tpl took: 0:00:00.009601
2019-05-03 12:39:56.551043 starting: writing const tpl:vka6.dat_cn.tpl
2019-05-03 12:39:56.559378 finished: writing const tpl:vka6.dat_cn.tpl took: 0:00:00.008335
2019-05-03 12:39:56.563006 starting: writing const tpl:ss6.dat_cn.tpl
2019-05-03 12:39:56.583543 finished: writing const tpl:ss6.dat_cn.tpl took: 0:00:00.020537
2019-05-03 12:39:56.587275 starting: writing const tpl:sy6.dat_cn.tpl
2019-05-03 12:39:56.595665 finished: writing const tpl:sy6.dat_cn.tpl took: 0:00:00.008390
2019-05-03 12:39:56.599617 starting: writing const tpl:strt6.dat_cn.tpl
2019-05-03 12:39:56.609641 finished: writing const tpl:strt6.dat_cn.tpl took: 0:00:00.010024
2019-05-03 12:39:56.613573 starting: writing const tpl:prsity6.dat_cn.tpl
2019-05-03 12:39:56.626962 finished: writing const tpl:prsity6.dat_cn.tpl took: 0:00:00.013389
2019-05-03 12:39:56.632509 starting: writing const tpl:hk7.dat_cn.tpl
2019-05-03 12:39:56.642076 finished: writing const tpl:hk7.dat_cn.tpl took: 0:00:00.009567
2019-05-03 12:39:56.646095 starting: writing const tpl:vka7.dat_cn.tpl
2019-05-03 12:39:56.654498 finished: writing const tpl:vka7.dat_cn.tpl took: 0:00:00.008403
2019-05-03 12:39:56.658497 starting: writing const tpl:ss7.dat_cn.tpl
2019-05-03 12:39:56.668584 finished: writing const tpl:ss7.dat_cn.tpl took: 0:00:00.010087
2019-05-03 12:39:56.673903 starting: writing const tpl:sy7.dat_cn.tpl
2019-05-03 12:39:56.683760 finished: writing const tpl:sy7.dat_cn.tpl took: 0:00:00.009857
2019-05-03 12:39:56.687009 starting: writing const tpl:strt7.dat_cn.tpl
2019-05-03 12:39:56.694726 finished: writing const tpl:strt7.dat_cn.tpl took: 0:00:00.007717
2019-05-03 12:39:56.701896 starting: writing const tpl:prsity7.dat_cn.tpl
2019-05-03 12:39:56.714831 finished: writing const tpl:prsity7.dat_cn.tpl took: 0:00:00.012935
2019-05-03 12:39:56.718189 starting: writing const tpl:hk8.dat_cn.tpl
2019-05-03 12:39:56.725860 finished: writing const tpl:hk8.dat_cn.tpl took: 0:00:00.007671
2019-05-03 12:39:56.728688 starting: writing const tpl:vka8.dat_cn.tpl
2019-05-03 12:39:56.736992 finished: writing const tpl:vka8.dat_cn.tpl took: 0:00:00.008304
2019-05-03 12:39:56.742478 starting: writing const tpl:ss8.dat_cn.tpl
2019-05-03 12:39:56.751046 finished: writing const tpl:ss8.dat_cn.tpl took: 0:00:00.008568
2019-05-03 12:39:56.754528 starting: writing const tpl:sy8.dat_cn.tpl
2019-05-03 12:39:56.760929 finished: writing const tpl:sy8.dat_cn.tpl took: 0:00:00.006401
2019-05-03 12:39:56.763798 starting: writing const tpl:strt8.dat_cn.tpl
2019-05-03 12:39:56.772774 finished: writing const tpl:strt8.dat_cn.tpl took: 0:00:00.008976
2019-05-03 12:39:56.776664 starting: writing const tpl:prsity8.dat_cn.tpl
2019-05-03 12:39:56.786501 finished: writing const tpl:prsity8.dat_cn.tpl took: 0:00:00.009837
2019-05-03 12:39:56.791762 starting: writing const tpl:rech4.dat_cn.tpl
2019-05-03 12:39:56.799204 finished: writing const tpl:rech4.dat_cn.tpl took: 0:00:00.007442
2019-05-03 12:39:56.803419 starting: writing const tpl:rech5.dat_cn.tpl
2019-05-03 12:39:56.810858 finished: writing const tpl:rech5.dat_cn.tpl took: 0:00:00.007439
2019-05-03 12:39:56.848779 starting: setting up pilot point process
2019-05-03 12:39:56.849471 WARNING: pp_geostruct is None, using ExpVario with contribution=1 an
2019-05-03 12:39:56.853057 pp_dict: {0: ['hk0', 'vka0', 'ss0', 'sy0', 'strt0', 'prsity0', 'rech
```

```
2019-05-03 12:39:56.854232 starting: calling setup_pilot_point_grid()
2019-05-03 12:39:57.698153 640 pilot point parameters created
2019-05-03 12:39:57.699393 pilot point 'pargp':hk0,vka0,ss0,sy0,strt0,prsity0,rech0,rech1,hk1,v
2019-05-03 12:39:57.699908 finished: calling setup_pilot_point_grid() took: 0:00:00.845676
2019-05-03 12:39:57.702507 starting: calculating factors for p=hk0, k=0
2019-05-03 12:39:57.703544 saving krige variance file:template/pp_k0_general_zn.fac
2019-05-03 12:39:57.703612 saving krige factors file:template/pp_k0_general_zn.fac
starting interp point loop for 800 points
took 3.543703 seconds
2019-05-03 12:40:01.305912 finished: calculating factors for p=hk0, k=0 took: 0:00:03.603405
2019-05-03 12:40:01.307043 starting: calculating factors for p=vka0, k=0
2019-05-03 12:40:01.309115 finished: calculating factors for p=vka0, k=0 took: 0:00:00.002072
2019-05-03 12:40:01.310190 starting: calculating factors for p=ss0, k=0
2019-05-03 12:40:01.311040 finished: calculating factors for p=ss0, k=0 took: 0:00:00.000850
2019-05-03 12:40:01.312086 starting: calculating factors for p=sy0, k=0
2019-05-03 12:40:01.313374 finished: calculating factors for p=sy0, k=0 took: 0:00:00.001288
2019-05-03 12:40:01.314468 starting: calculating factors for p=strt0, k=0
2019-05-03 12:40:01.315532 finished: calculating factors for p=strt0, k=0 took: 0:00:00.001064
2019-05-03 12:40:01.316575 starting: calculating factors for p=prsity0, k=0
2019-05-03 12:40:01.317724 finished: calculating factors for p=prsity0, k=0 took: 0:00:00.00114
2019-05-03 12:40:01.318516 starting: calculating factors for p=rech0, k=0
2019-05-03 12:40:01.319256 finished: calculating factors for p=rech0, k=0 took: 0:00:00.000740
2019-05-03 12:40:01.320309 starting: calculating factors for p=rech1, k=0
2019-05-03 12:40:01.321023 finished: calculating factors for p=rech1, k=0 took: 0:00:00.000714
2019-05-03 12:40:01.321600 starting: calculating factors for p=hk1, k=1
2019-05-03 12:40:01.322471 saving krige variance file:template/pp_k1_general_zn.fac
2019-05-03 12:40:01.322527 saving krige factors file:template/pp_k1_general_zn.fac
starting interp point loop for 800 points
took 3.184177 seconds
2019-05-03 12:40:04.562270 finished: calculating factors for p=hk1, k=1 took: 0:00:03.240670
2019-05-03 12:40:04.563550 starting: calculating factors for p=vka1, k=1
2019-05-03 12:40:04.564496 finished: calculating factors for p=vka1, k=1 took: 0:00:00.000946
2019-05-03 12:40:04.565461 starting: calculating factors for p=ss1, k=1
2019-05-03 12:40:04.566301 finished: calculating factors for p=ss1, k=1 took: 0:00:00.000840
2019-05-03 12:40:04.567646 starting: calculating factors for p=sy1, k=1
2019-05-03 12:40:04.569316 finished: calculating factors for p=sy1, k=1 took: 0:00:00.001670
2019-05-03 12:40:04.570489 starting: calculating factors for p=prsity1, k=1
2019-05-03 12:40:04.571725 finished: calculating factors for p=prsity1, k=1 took: 0:00:00.0012
2019-05-03 12:40:04.572431 starting: calculating factors for p=strt1, k=1
2019-05-03 12:40:04.573259 finished: calculating factors for p=strt1, k=1 took: 0:00:00.000828
2019-05-03 12:40:04.573848 starting: calculating factors for p=sy2, k=2
2019-05-03 12:40:04.575160 saving krige variance file:template/pp_k2_general_zn.fac
2019-05-03 12:40:04.575219 saving krige factors file:template/pp_k2_general_zn.fac
starting interp point loop for 800 points
took 3.149646 seconds
2019-05-03 12:40:07.781370 finished: calculating factors for p=sy2, k=2 took: 0:00:03.207522
2019-05-03 12:40:07.783313 starting: calculating factors for p=prsity2, k=2
2019-05-03 12:40:07.785157 finished: calculating factors for p=prsity2, k=2 took: 0:00:00.0018
```

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2019-05-03 12:40:07.786217 starting: calculating factors for p=vka2, k=2
2019-05-03 12:40:07.787330 finished: calculating factors for p=vka2, k=2 took: 0:00:00.001113
2019-05-03 12:40:07.787966 starting: calculating factors for p=strt2, k=2
2019-05-03 12:40:07.788873 finished: calculating factors for p=strt2, k=2 took: 0:00:00.000907
2019-05-03 12:40:07.790500 starting: calculating factors for p=hk2, k=2
2019-05-03 12:40:07.791659 finished: calculating factors for p=hk2, k=2 took: 0:00:00.001159
2019-05-03 12:40:07.792843 starting: calculating factors for p=ss2, k=2
2019-05-03 12:40:07.793914 finished: calculating factors for p=ss2, k=2 took: 0:00:00.001071
2019-05-03 12:40:07.794372 starting: processing pp_prefix:ss2
2019-05-03 12:40:07.807287 starting: processing pp_prefix:vka2
2019-05-03 12:40:07.818590 starting: processing pp_prefix:sy2
2019-05-03 12:40:07.829600 starting: processing pp_prefix:rech0
2019-05-03 12:40:07.838923 starting: processing pp_prefix:ss1
2019-05-03 12:40:07.847843 starting: processing pp_prefix:prsity1
2019-05-03 12:40:07.856823 starting: processing pp_prefix:ss0
2019-05-03 12:40:07.866786 starting: processing pp_prefix:rech1
2019-05-03 12:40:07.877815 starting: processing pp_prefix:hk1
2019-05-03 12:40:07.887576 starting: processing pp_prefix:hk2
2019-05-03 12:40:07.896448 starting: processing pp_prefix:hk0
2019-05-03 12:40:07.908039 starting: processing pp_prefix:strt2
2019-05-03 12:40:07.918180 starting: processing pp_prefix:vka0
2019-05-03 12:40:07.927103 starting: processing pp_prefix:prsity2
2019-05-03 12:40:07.938279 starting: processing pp_prefix:vka1
2019-05-03 12:40:07.948743 starting: processing pp_prefix:sy0
2019-05-03 12:40:07.958389 starting: processing pp_prefix:sy1
2019-05-03 12:40:07.967352 starting: processing pp_prefix:strt1
2019-05-03 12:40:07.976684 starting: processing pp_prefix:prsity0
2019-05-03 12:40:07.987820 starting: processing pp_prefix:strt0
2019-05-03 12:40:08.116241 finished: setting up pilot point process took: 0:00:11.267462
2019-05-03 12:40:08.116498 starting: setting up grid process
2019-05-03 12:40:08.116989 WARNING: grid_geostruct is None, using ExpVario with contribution=1
2019-05-03 12:40:08.117141 finished: setting up grid process took: 0:00:00.000643
2019-05-03 12:40:08.120063 starting: save test mlt array arr_mlt/hk0.dat_pp
2019-05-03 12:40:08.122513 finished: save test mlt array arr_mlt/hk0.dat_pp took: 0:00:00.0024!
2019-05-03 12:40:08.123509 starting: save test mlt array arr_mlt/vka0.dat_pp
2019-05-03 12:40:08.125854 finished: save test mlt array arr_mlt/vka0.dat_pp took: 0:00:00.0023
2019-05-03 12:40:08.126807 starting: save test mlt array arr_mlt/ss0.dat_pp
2019-05-03 12:40:08.133986 finished: save test mlt array arr_mlt/ss0.dat_pp took: 0:00:00.0071
2019-05-03 12:40:08.135453 starting: save test mlt array arr_mlt/sy0.dat_pp
2019-05-03 12:40:08.138329 finished: save test mlt array arr_mlt/sy0.dat_pp took: 0:00:00.0028
2019-05-03 12:40:08.139624 starting: save test mlt array arr_mlt/strt0.dat_pp
2019-05-03 12:40:08.143741 finished: save test mlt array arr_mlt/strt0.dat_pp took: 0:00:00.004
2019-05-03 12:40:08.145409 starting: save test mlt array arr_mlt/prsity0.dat_pp
2019-05-03 12:40:08.148774 finished: save test mlt array arr_mlt/prsity0.dat_pp took: 0:00:00.0
2019-05-03 12:40:08.149727 starting: save test mlt array arr_mlt/hk1.dat_pp
2019-05-03 12:40:08.152451 finished: save test mlt array arr_mlt/hk1.dat_pp took: 0:00:00.0027
2019-05-03 12:40:08.153534 starting: save test mlt array arr_mlt/vka1.dat_pp
2019-05-03 12:40:08.156116 finished: save test mlt array arr_mlt/vka1.dat_pp took: 0:00:00.002!
```

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2019-05-03 12:40:08.157220 starting: save test mlt array arr_mlt/ss1.dat_pp
2019-05-03 12:40:08.159665 finished: save test mlt array arr_mlt/ss1.dat_pp took: 0:00:00.00244
2019-05-03 12:40:08.160662 starting: save test mlt array arr_mlt/sy1.dat_pp
2019-05-03 12:40:08.163146 finished: save test mlt array arr_mlt/sy1.dat_pp took: 0:00:00.00248
2019-05-03 12:40:08.164191 starting: save test mlt array arr_mlt/strt1.dat_pp
2019-05-03 12:40:08.166753 finished: save test mlt array arr_mlt/strt1.dat_pp took: 0:00:00.002
2019-05-03 12:40:08.167844 starting: save test mlt array arr_mlt/prsity1.dat_pp
2019-05-03 12:40:08.170702 finished: save test mlt array arr_mlt/prsity1.dat_pp took: 0:00:00.0
2019-05-03 12:40:08.171673 starting: save test mlt array arr_mlt/hk2.dat_pp
2019-05-03 12:40:08.173967 finished: save test mlt array arr_mlt/hk2.dat_pp took: 0:00:00.00229
2019-05-03 12:40:08.174904 starting: save test mlt array arr_mlt/vka2.dat_pp
2019-05-03 12:40:08.177774 finished: save test mlt array arr_mlt/vka2.dat_pp took: 0:00:00.0028
2019-05-03 12:40:08.180178 starting: save test mlt array arr_mlt/ss2.dat_pp
2019-05-03 12:40:08.185749 finished: save test mlt array arr_mlt/ss2.dat_pp took: 0:00:00.00557
2019-05-03 12:40:08.186947 starting: save test mlt array arr_mlt/sy2.dat_pp
2019-05-03 12:40:08.193839 finished: save test mlt array arr_mlt/sy2.dat_pp took: 0:00:00.00689
2019-05-03 12:40:08.196176 starting: save test mlt array arr_mlt/strt2.dat_pp
2019-05-03 12:40:08.199818 finished: save test mlt array arr_mlt/strt2.dat_pp took: 0:00:00.003
2019-05-03 12:40:08.201186 starting: save test mlt array arr_mlt/prsity2.dat_pp
2019-05-03 12:40:08.210624 finished: save test mlt array arr_mlt/prsity2.dat_pp took: 0:00:00.0
2019-05-03 12:40:08.212350 starting: save test mlt array arr_mlt/rech0.dat_pp
2019-05-03 12:40:08.225186 finished: save test mlt array arr_mlt/rech0.dat_pp took: 0:00:00.012
2019-05-03 12:40:08.227272 starting: save test mlt array arr_mlt/rech1.dat_pp
2019-05-03 12:40:08.236725 finished: save test mlt array arr_mlt/rech1.dat_pp took: 0:00:00.009
2019-05-03 12:40:08.237935 starting: save test mlt array arr_mlt/hk3.dat_gr
2019-05-03 12:40:08.242584 finished: save test mlt array arr_mlt/hk3.dat_gr took: 0:00:00.00464
2019-05-03 12:40:08.244926 starting: save test mlt array arr_mlt/vka3.dat_gr
2019-05-03 12:40:08.249113 finished: save test mlt array arr_mlt/vka3.dat_gr took: 0:00:00.0041
2019-05-03 12:40:08.250823 starting: save test mlt array arr_mlt/ss3.dat_gr
2019-05-03 12:40:08.254465 finished: save test mlt array arr_mlt/ss3.dat_gr took: 0:00:00.00364
2019-05-03 12:40:08.256025 starting: save test mlt array arr_mlt/sy3.dat_gr
2019-05-03 12:40:08.259731 finished: save test mlt array arr_mlt/sy3.dat_gr took: 0:00:00.00370
2019-05-03 12:40:08.261288 starting: save test mlt array arr_mlt/strt3.dat_gr
2019-05-03 12:40:08.266397 finished: save test mlt array arr_mlt/strt3.dat_gr took: 0:00:00.005
2019-05-03 12:40:08.268910 starting: save test mlt array arr_mlt/prsity3.dat_gr
2019-05-03 12:40:08.272689 finished: save test mlt array arr_mlt/prsity3.dat_gr took: 0:00:00.0
2019-05-03 12:40:08.274349 starting: save test mlt array arr_mlt/hk4.dat_gr
2019-05-03 12:40:08.280912 finished: save test mlt array arr_mlt/hk4.dat_gr took: 0:00:00.00656
2019-05-03 12:40:08.283719 starting: save test mlt array arr_mlt/vka4.dat_gr
2019-05-03 12:40:08.287324 finished: save test mlt array arr_mlt/vka4.dat_gr took: 0:00:00.0036
2019-05-03 12:40:08.288573 starting: save test mlt array arr_mlt/ss4.dat_gr
2019-05-03 12:40:08.291677 finished: save test mlt array arr_mlt/ss4.dat_gr took: 0:00:00.00310
2019-05-03 12:40:08.292851 starting: save test mlt array arr_mlt/sy4.dat_gr
2019-05-03 12:40:08.296340 finished: save test mlt array arr_mlt/sy4.dat_gr took: 0:00:00.00348
2019-05-03 12:40:08.299785 starting: save test mlt array arr_mlt/strt4.dat_gr
2019-05-03 12:40:08.305049 finished: save test mlt array arr_mlt/strt4.dat_gr took: 0:00:00.005
2019-05-03 12:40:08.306858 starting: save test mlt array arr_mlt/prsity4.dat_gr
2019-05-03 12:40:08.313659 finished: save test mlt array arr_mlt/prsity4.dat_gr took: 0:00:00.0
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2019-05-03 12:40:08.315966 starting: save test mlt array arr_mlt/hk5.dat_gr
2019-05-03 12:40:08.324154 finished: save test mlt array arr_mlt/hk5.dat_gr took: 0:00:00.00818
2019-05-03 12:40:08.325786 starting: save test mlt array arr_mlt/vka5.dat_gr
2019-05-03 12:40:08.332589 finished: save test mlt array arr_mlt/vka5.dat_gr took: 0:00:00.0068
2019-05-03 12:40:08.334433 starting: save test mlt array arr_mlt/ss5.dat_gr
2019-05-03 12:40:08.343001 finished: save test mlt array arr_mlt/ss5.dat_gr took: 0:00:00.00856
2019-05-03 12:40:08.346733 starting: save test mlt array arr_mlt/sy5.dat_gr
2019-05-03 12:40:08.351460 finished: save test mlt array arr_mlt/sy5.dat_gr took: 0:00:00.00472
2019-05-03 12:40:08.353199 starting: save test mlt array arr_mlt/strt5.dat_gr
2019-05-03 12:40:08.357024 finished: save test mlt array arr_mlt/strt5.dat_gr took: 0:00:00.003
2019-05-03 12:40:08.358386 starting: save test mlt array arr_mlt/prsity5.dat_gr
2019-05-03 12:40:08.362469 finished: save test mlt array arr_mlt/prsity5.dat_gr took: 0:00:00.0
2019-05-03 12:40:08.364176 starting: save test mlt array arr_mlt/rech2.dat_gr
2019-05-03 12:40:08.368418 finished: save test mlt array arr_mlt/rech2.dat_gr took: 0:00:00.004
2019-05-03 12:40:08.372369 starting: save test mlt array arr_mlt/rech3.dat_gr
2019-05-03 12:40:08.378315 finished: save test mlt array arr_mlt/rech3.dat_gr took: 0:00:00.005
2019-05-03 12:40:08.380383 starting: save test mlt array arr_mlt/hk6.dat_cn
2019-05-03 12:40:08.386622 finished: save test mlt array arr_mlt/hk6.dat_cn took: 0:00:00.0062
2019-05-03 12:40:08.388136 starting: save test mlt array arr_mlt/vka6.dat_cn
2019-05-03 12:40:08.392980 finished: save test mlt array arr_mlt/vka6.dat_cn took: 0:00:00.0048
2019-05-03 12:40:08.396665 starting: save test mlt array arr_mlt/ss6.dat_cn
2019-05-03 12:40:08.402405 finished: save test mlt array arr_mlt/ss6.dat_cn took: 0:00:00.0057
2019-05-03 12:40:08.404355 starting: save test mlt array arr_mlt/sy6.dat_cn
2019-05-03 12:40:08.408786 finished: save test mlt array arr_mlt/sy6.dat_cn took: 0:00:00.0044
2019-05-03 12:40:08.410485 starting: save test mlt array arr_mlt/strt6.dat_cn
2019-05-03 12:40:08.414802 finished: save test mlt array arr_mlt/strt6.dat_cn took: 0:00:00.004
2019-05-03 12:40:08.416390 starting: save test mlt array arr_mlt/prsity6.dat_cn
2019-05-03 12:40:08.420389 finished: save test mlt array arr_mlt/prsity6.dat_cn took: 0:00:00.0
2019-05-03 12:40:08.422296 starting: save test mlt array arr_mlt/hk7.dat_cn
2019-05-03 12:40:08.426147 finished: save test mlt array arr_mlt/hk7.dat_cn took: 0:00:00.0038
2019-05-03 12:40:08.427706 starting: save test mlt array arr_mlt/vka7.dat_cn
2019-05-03 12:40:08.434229 finished: save test mlt array arr_mlt/vka7.dat_cn took: 0:00:00.006
2019-05-03 12:40:08.436126 starting: save test mlt array arr_mlt/ss7.dat_cn
2019-05-03 12:40:08.440682 finished: save test mlt array arr_mlt/ss7.dat_cn took: 0:00:00.0045
2019-05-03 12:40:08.444530 starting: save test mlt array arr_mlt/sy7.dat_cn
2019-05-03 12:40:08.451426 finished: save test mlt array arr_mlt/sy7.dat_cn took: 0:00:00.0068
2019-05-03 12:40:08.453309 starting: save test mlt array arr_mlt/strt7.dat_cn
2019-05-03 12:40:08.457405 finished: save test mlt array arr_mlt/strt7.dat_cn took: 0:00:00.004
2019-05-03 12:40:08.459351 starting: save test mlt array arr_mlt/prsity7.dat_cn
2019-05-03 12:40:08.463986 finished: save test mlt array arr_mlt/prsity7.dat_cn took: 0:00:00.0
2019-05-03 12:40:08.467060 starting: save test mlt array arr_mlt/hk8.dat_cn
2019-05-03 12:40:08.472291 finished: save test mlt array arr_mlt/hk8.dat_cn took: 0:00:00.0052
2019-05-03 12:40:08.474199 starting: save test mlt array arr_mlt/vka8.dat_cn
2019-05-03 12:40:08.481794 finished: save test mlt array arr_mlt/vka8.dat_cn took: 0:00:00.0075
2019-05-03 12:40:08.484201 starting: save test mlt array arr_mlt/ss8.dat_cn
2019-05-03 12:40:08.488534 finished: save test mlt array arr_mlt/ss8.dat_cn took: 0:00:00.0043
2019-05-03 12:40:08.490150 starting: save test mlt array arr_mlt/sy8.dat_cn
2019-05-03 12:40:08.494121 finished: save test mlt array arr_mlt/sy8.dat_cn took: 0:00:00.0039
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2019-05-03 12:40:08.495849 starting: save test mlt array arr_mlt/strt8.dat_cn
2019-05-03 12:40:08.502378 finished: save test mlt array arr_mlt/strt8.dat_cn took: 0:00:00.006
2019-05-03 12:40:08.504476 starting: save test mlt array arr_mlt/prsity8.dat_cn
2019-05-03 12:40:08.509699 finished: save test mlt array arr_mlt/prsity8.dat_cn took: 0:00:00.0
2019-05-03 12:40:08.512433 starting: save test mlt array arr_mlt/rech4.dat_cn
2019-05-03 12:40:08.517231 finished: save test mlt array arr_mlt/rech4.dat_cn took: 0:00:00.004
2019-05-03 12:40:08.519033 starting: save test mlt array arr_mlt/rech5.dat_cn
2019-05-03 12:40:08.522495 finished: save test mlt array arr_mlt/rech5.dat_cn took: 0:00:00.003
2019-05-03 12:40:09.354716 forward_run line:pyemu.helpers.apply_array_pars()

all zeros for runoff...skipping...
all zeros for hcond1...skipping...
all zeros for pptsw...skipping...
2019-05-03 12:40:09.518520 starting: processing obs type mflist water budget obs
2019-05-03 12:40:09.704030 forward_run line:pyemu.gw_utils.apply_mflist_budget_obs('freyberg.l
2019-05-03 12:40:09.704464 finished: processing obs type mflist water budget obs took: 0:00:00
2019-05-03 12:40:09.704530 starting: processing obs type hyd file
2019-05-03 12:40:09.705211 finished: processing obs type hyd file took: 0:00:00.000681
2019-05-03 12:40:09.705278 starting: processing obs type external obs-sim smp files
2019-05-03 12:40:09.705339 finished: processing obs type external obs-sim smp files took: 0:00
2019-05-03 12:40:09.705380 starting: processing obs type hob
2019-05-03 12:40:09.705627 finished: processing obs type hob took: 0:00:00.000247
2019-05-03 12:40:09.705690 starting: processing obs type hds
[[0, 0], [0, 1], [0, 2], [1, 0], [1, 1], [1, 2]]
2019-05-03 12:40:10.230677 finished: processing obs type hds took: 0:00:00.524987
2019-05-03 12:40:10.230992 starting: processing obs type sfr
writing 'sfr_obs.config' to template/sfr_obs.config
2019-05-03 12:40:10.681464 finished: processing obs type sfr took: 0:00:00.450472
2019-05-03 12:40:10.682030 changing dir in to template
2019-05-03 12:40:10.682962 starting: instantiating control file from i/o files
2019-05-03 12:40:10.683296 tpl files: wel.csv.tpl,drn.csv.tpl,hk3.dat_gr.tpl,vka3.dat_gr.tpl,ss
2019-05-03 12:40:10.683544 ins files: freyberg.hds.dat.ins,vol.dat.ins,freyberg.sfr.out.process
2019-05-03 12:40:11.201361 finished: instantiating control file from i/o files took: 0:00:00.5
2019-05-03 12:40:11.549774 starting: writing forward_run.py
2019-05-03 12:40:11.550854 finished: writing forward_run.py took: 0:00:00.001080
2019-05-03 12:40:11.551218 writing pst template/freyberg.pst
2019-05-03 12:40:13.598878 starting: running pestchek on freyberg.pst
2019-05-03 12:40:13.705453 pestcheck:PESTCHEK Version 13.0. Watermark Numerical Computing.
2019-05-03 12:40:13.706265 pestcheck:
2019-05-03 12:40:13.706830 pestcheck:Errors ----->
2019-05-03 12:40:13.707063 pestcheck:Line 2403 of file freyberg.pst: parameter name "prsity300(
2019-05-03 12:40:13.707110 pestcheck:12 characters long.
2019-05-03 12:40:13.707147 pestcheck:Line 2404 of file freyberg.pst: parameter name "prsity300(
2019-05-03 12:40:13.707214 pestcheck:12 characters long.
2019-05-03 12:40:13.707268 pestcheck:Line 2404 of file freyberg.pst: parameter name "prsity300(
2019-05-03 12:40:13.707298 pestcheck:once.
2019-05-03 12:40:13.707332 pestcheck:Line 2405 of file freyberg.pst: parameter name "prsity300(
2019-05-03 12:40:13.707395 pestcheck:12 characters long.
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2019-05-03 12:40:13.707436 pestcheck:Line 2405 of file freyberg.pst: parameter name "prsity3000
2019-05-03 12:40:13.707627 pestcheck:once.
2019-05-03 12:40:13.707675 pestcheck:Line 2406 of file freyberg.pst: parameter name "prsity3000
2019-05-03 12:40:13.707717 pestcheck:12 characters long.
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2019-05-03 12:40:13.732168 pestcheck:Line 2477 of file freyberg.pst: parameter name "prsity300
2019-05-03 12:40:13.732214 pestcheck:once.
2019-05-03 12:40:13.732389 pestcheck:Line 2478 of file freyberg.pst: parameter name "prsity300
2019-05-03 12:40:13.732435 pestcheck:12 characters long.
2019-05-03 12:40:13.732472 pestcheck:Line 2478 of file freyberg.pst: parameter name "prsity300
2019-05-03 12:40:13.732570 pestcheck:once.
2019-05-03 12:40:13.732620 pestcheck:Line 2479 of file freyberg.pst: parameter name "prsity300
2019-05-03 12:40:13.732713 pestcheck:12 characters long.
2019-05-03 12:40:13.732762 pestcheck:Line 2479 of file freyberg.pst: parameter name "prsity300
2019-05-03 12:40:13.732800 pestcheck:once.
2019-05-03 12:40:13.732857 pestcheck:Line 2480 of file freyberg.pst: parameter name "prsity300
2019-05-03 12:40:13.732975 pestcheck:12 characters long.
2019-05-03 12:40:13.733031 pestcheck:Line 2480 of file freyberg.pst: parameter name "prsity300
2019-05-03 12:40:13.733134 pestcheck:once.
```

```
2019-05-03 12:40:13.733183 pestcheck:Line 2481 of file freyberg.pst: parameter name "prsity3003
2019-05-03 12:40:13.733378 pestcheck:12 characters long.
2019-05-03 12:40:13.733426 pestcheck:Line 2481 of file freyberg.pst: parameter name "prsity3003
2019-05-03 12:40:13.733465 pestcheck:once.
2019-05-03 12:40:13.733564 pestcheck:Line 2482 of file freyberg.pst: parameter name "prsity3003
2019-05-03 12:40:13.733616 pestcheck:12 characters long.
2019-05-03 12:40:13.733711 pestcheck:Line 2482 of file freyberg.pst: parameter name "prsity3003
2019-05-03 12:40:13.733757 pestcheck:once.
2019-05-03 12:40:13.733796 pestcheck:Line 2483 of file freyberg.pst: parameter name "prsity3004
2019-05-03 12:40:13.733928 pestcheck:12 characters long.
2019-05-03 12:40:13.734032 pestcheck:Line 2484 of file freyberg.pst: parameter name "prsity3004
2019-05-03 12:40:13.734078 pestcheck:12 characters long.
2019-05-03 12:40:13.734180 pestcheck:Line 2484 of file freyberg.pst: parameter name "prsity3004
2019-05-03 12:40:13.734299 pestcheck:once.
2019-05-03 12:40:13.734337 pestcheck:Line 2485 of file freyberg.pst: parameter name "prsity3004
2019-05-03 12:40:13.734436 pestcheck:12 characters long.
2019-05-03 12:40:13.734539 pestcheck:Line 2485 of file freyberg.pst: parameter name "prsity3004
2019-05-03 12:40:13.734617 pestcheck:once.
2019-05-03 12:40:13.734730 pestcheck:Line 2486 of file freyberg.pst: parameter name "prsity3004
2019-05-03 12:40:13.734844 pestcheck:12 characters long.
2019-05-03 12:40:13.734892 pestcheck:Line 2486 of file freyberg.pst: parameter name "prsity3004
2019-05-03 12:40:13.734931 pestcheck:once.
2019-05-03 12:40:13.735034 pestcheck:Line 2487 of file freyberg.pst: parameter name "prsity3004
2019-05-03 12:40:13.735140 pestcheck:12 characters long.
2019-05-03 12:40:13.735263 pestcheck:Line 2487 of file freyberg.pst: parameter name "prsity3004
2019-05-03 12:40:13.735369 pestcheck:once.
2019-05-03 12:40:13.735419 pestcheck:Line 2488 of file freyberg.pst: parameter name "prsity3004
2019-05-03 12:40:13.735458 pestcheck:12 characters long.
2019-05-03 12:40:13.735525 pestcheck:Line 2488 of file freyberg.pst: parameter name "prsity3004
2019-05-03 12:40:13.735598 pestcheck:once.
2019-05-03 12:40:13.735702 pestcheck:Line 2489 of file freyberg.pst: parameter name "prsity3004
2019-05-03 12:40:13.735751 pestcheck:12 characters long.
2019-05-03 12:40:13.735790 pestcheck:Line 2489 of file freyberg.pst: parameter name "prsity3004
2019-05-03 12:40:13.735890 pestcheck:once.
2019-05-03 12:40:13.735993 pestcheck:Line 2490 of file freyberg.pst: parameter name "prsity3004
2019-05-03 12:40:13.736159 pestcheck:12 characters long.
2019-05-03 12:40:13.736478 pestcheck:Line 2490 of file freyberg.pst: parameter name "prsity3004
2019-05-03 12:40:13.736594 pestcheck:once.
2019-05-03 12:40:13.736711 pestcheck:Line 2491 of file freyberg.pst: parameter name "prsity3004
2019-05-03 12:40:13.736816 pestcheck:12 characters long.
2019-05-03 12:40:13.736863 pestcheck:Line 2491 of file freyberg.pst: parameter name "prsity3004
2019-05-03 12:40:13.736901 pestcheck:once.
2019-05-03 12:40:13.737000 pestcheck:Line 2492 of file freyberg.pst: parameter name "prsity3004
2019-05-03 12:40:13.737103 pestcheck:12 characters long.
2019-05-03 12:40:13.737149 pestcheck:Line 2492 of file freyberg.pst: parameter name "prsity3004
2019-05-03 12:40:13.737332 pestcheck:once.
2019-05-03 12:40:13.737382 pestcheck:Line 2493 of file freyberg.pst: parameter name "prsity3004
2019-05-03 12:40:13.737506 pestcheck:12 characters long.
```

```
2019-05-03 12:40:13.737612 pestcheck:Line 2494 of file freyberg.pst: parameter name "prsity3004
2019-05-03 12:40:13.737658 pestcheck:12 characters long.
2019-05-03 12:40:13.737696 pestcheck:Line 2494 of file freyberg.pst: parameter name "prsity3004
2019-05-03 12:40:13.737794 pestcheck:once.
2019-05-03 12:40:13.737896 pestcheck:Line 2495 of file freyberg.pst: parameter name "prsity3004
2019-05-03 12:40:13.738010 pestcheck:12 characters long.
2019-05-03 12:40:13.738111 pestcheck:Line 2495 of file freyberg.pst: parameter name "prsity3004
2019-05-03 12:40:13.738233 pestcheck:once.
2019-05-03 12:40:13.738336 pestcheck:Line 2496 of file freyberg.pst: parameter name "prsity3004
2019-05-03 12:40:13.738403 pestcheck:12 characters long.
2019-05-03 12:40:13.738454 pestcheck:Line 2496 of file freyberg.pst: parameter name "prsity3004
2019-05-03 12:40:13.738554 pestcheck:once.
2019-05-03 12:40:13.738656 pestcheck:Line 2497 of file freyberg.pst: parameter name "prsity3004
2019-05-03 12:40:13.738769 pestcheck:12 characters long.
2019-05-03 12:40:13.738871 pestcheck:Line 2497 of file freyberg.pst: parameter name "prsity3004
2019-05-03 12:40:13.738920 pestcheck:once.
2019-05-03 12:40:13.738959 pestcheck:Line 2498 of file freyberg.pst: parameter name "prsity3004
2019-05-03 12:40:13.739015 pestcheck:12 characters long.
2019-05-03 12:40:13.739187 pestcheck:Line 2498 of file freyberg.pst: parameter name "prsity3004
2019-05-03 12:40:13.739280 pestcheck:once.
2019-05-03 12:40:13.739455 pestcheck:Line 2499 of file freyberg.pst: parameter name "prsity3004
2019-05-03 12:40:13.739521 pestcheck:12 characters long.
2019-05-03 12:40:13.739586 pestcheck:Line 2499 of file freyberg.pst: parameter name "prsity3004
2019-05-03 12:40:13.739650 pestcheck:once.
2019-05-03 12:40:13.739714 pestcheck:Line 2500 of file freyberg.pst: parameter name "prsity3004
2019-05-03 12:40:13.739765 pestcheck:12 characters long.
2019-05-03 12:40:13.739845 pestcheck:Line 2500 of file freyberg.pst: parameter name "prsity3004
2019-05-03 12:40:13.739910 pestcheck:once.
2019-05-03 12:40:13.739973 pestcheck:Line 2501 of file freyberg.pst: parameter name "prsity3004
2019-05-03 12:40:13.740031 pestcheck:12 characters long.
2019-05-03 12:40:13.740085 pestcheck:Line 2501 of file freyberg.pst: parameter name "prsity3004
2019-05-03 12:40:13.740203 pestcheck:once.
2019-05-03 12:40:13.740334 pestcheck:Line 2502 of file freyberg.pst: parameter name "prsity3004
2019-05-03 12:40:13.740401 pestcheck:12 characters long.
2019-05-03 12:40:13.740518 pestcheck:Line 2502 of file freyberg.pst: parameter name "prsity3004
2019-05-03 12:40:13.740575 pestcheck:once.
2019-05-03 12:40:13.740680 pestcheck:Line 2503 of file freyberg.pst: parameter name "prsity3005
2019-05-03 12:40:13.740728 pestcheck:12 characters long.
2019-05-03 12:40:13.740768 pestcheck:Line 2504 of file freyberg.pst: parameter name "prsity3005
2019-05-03 12:40:13.740873 pestcheck:12 characters long.
2019-05-03 12:40:13.740980 pestcheck:Line 2504 of file freyberg.pst: parameter name "prsity3005
2019-05-03 12:40:13.741028 pestcheck:once.
2019-05-03 12:40:13.741067 pestcheck:Line 2505 of file freyberg.pst: parameter name "prsity3005
2019-05-03 12:40:13.741170 pestcheck:12 characters long.
2019-05-03 12:40:13.741357 pestcheck:Line 2505 of file freyberg.pst: parameter name "prsity3005
2019-05-03 12:40:13.741463 pestcheck:once.
2019-05-03 12:40:13.741514 pestcheck:Line 2506 of file freyberg.pst: parameter name "prsity3005
2019-05-03 12:40:13.741554 pestcheck:12 characters long.
```

```
2019-05-03 12:40:13.741656 pestcheck:Line 2506 of file freyberg.pst: parameter name "prsity300!
2019-05-03 12:40:13.741760 pestcheck:once.
2019-05-03 12:40:13.741810 pestcheck:Line 2507 of file freyberg.pst: parameter name "prsity300!
2019-05-03 12:40:13.741849 pestcheck:12 characters long.
2019-05-03 12:40:13.741950 pestcheck:Line 2507 of file freyberg.pst: parameter name "prsity300!
2019-05-03 12:40:13.742009 pestcheck:once.
2019-05-03 12:40:13.742122 pestcheck:Line 2508 of file freyberg.pst: parameter name "prsity300!
2019-05-03 12:40:13.742170 pestcheck:12 characters long.
2019-05-03 12:40:13.742572 finished: running pestchek on freyberg.pst took: 0:00:00.143694
2019-05-03 12:40:13.742655 starting: saving intermediate _setup_<> dfs into template
2019-05-03 12:40:13.890496 finished: saving intermediate _setup_<> dfs into template took: 0:00
2019-05-03 12:40:13.892288 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.mpenpt
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)
```

```
2019-05-03 12:40:26.724231 starting: building prior covariance matrix
2019-05-03 12:40:26.873720 WARNING: geospatial prior not implemented for SFR pars


/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

2019-05-03 12:40:33.944764 saving prior covariance matrix to file template/prior_cov.jcb
2019-05-03 12:40:39.311493 finished: building prior covariance matrix took: 0:00:12.587262
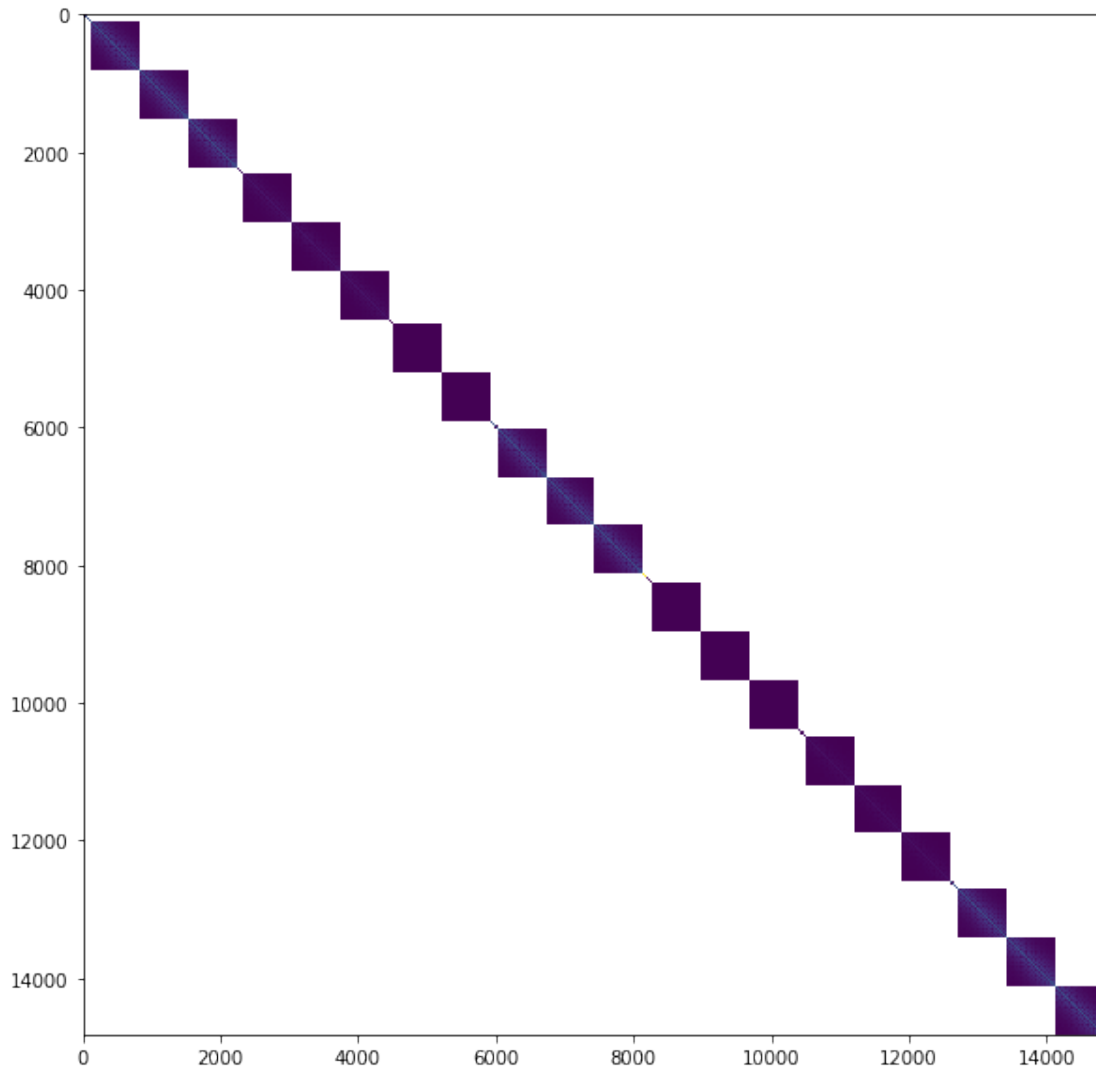
In [24]: pe = pst_helper.draw(200)

2019-05-03 12:41:03.627205 starting: drawing realizations
building diagonal cov
processing name:struct1,nugget:0.0,structures:
name:var1,contribution:1.0,a:1000.0,anisotropy:1.0,bearing:0.0
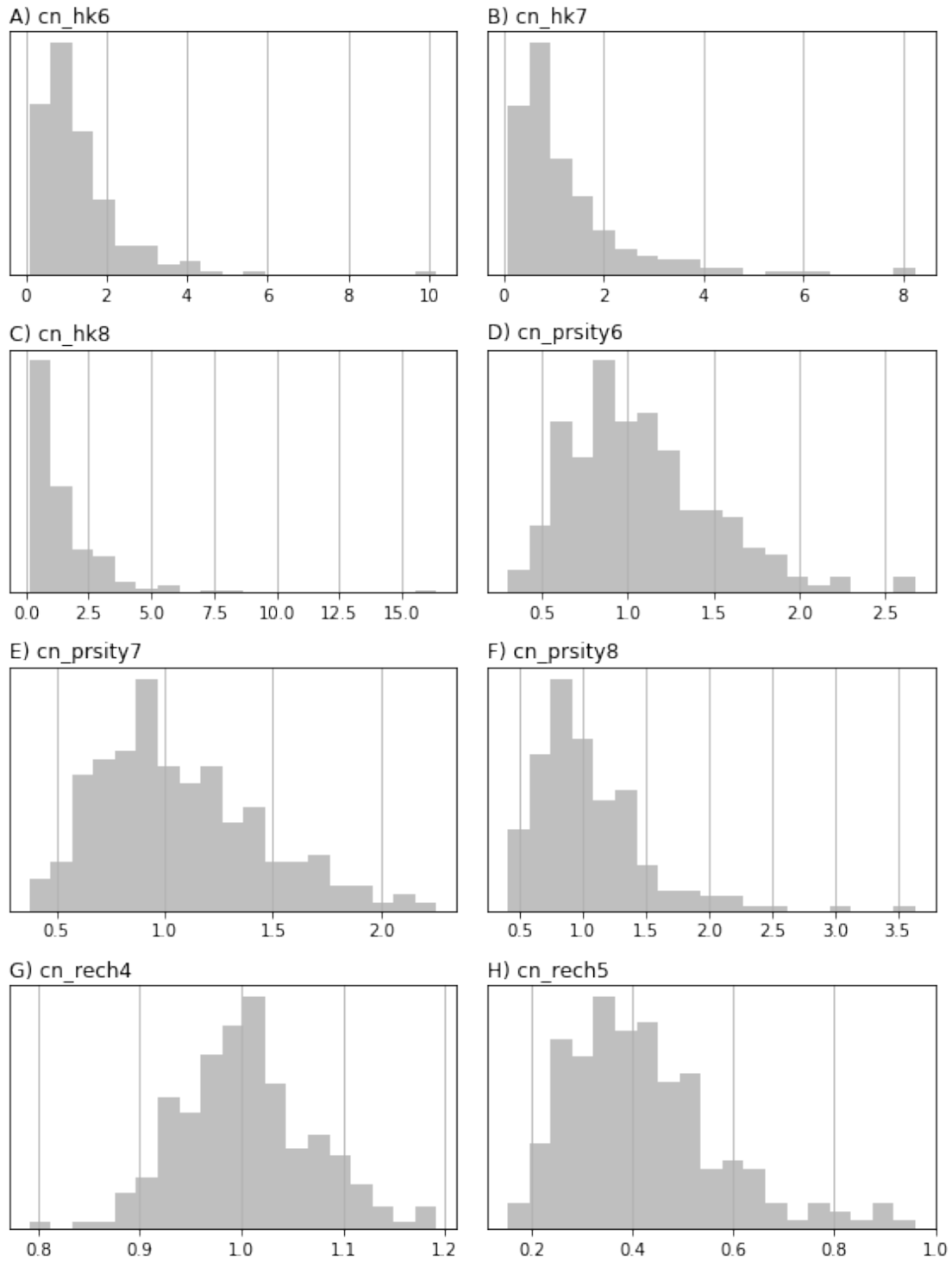
```
working on pargroups ['pp_hk0']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_vka0']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with 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_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_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_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_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_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_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_hk2']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_ss2']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
processing  name:struct1,nugget:0.0,structures:
name:var1,contribution:1.0,a:2500.0,anisotropy:1.0,bearing:0.0

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

```
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_strt3']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_prsity3']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_hk4']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_vka4']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_ss4']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_sy4']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_strt4']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_prsity4']
build cov matrix
done
```

```
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_hk5']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_vka5']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_ss5']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_sy5']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_strt5']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_prsity5']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_rech2']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_rech3']
build cov matrix
done
```

```
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
processing  name:struct1,nugget:0.0,structures:
name:var1,contribution:1.0,a: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:2500.0,anisotropy:1.0,bearing:0.0

working on pargroups ['welflux_k02']


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


build cov matrix
done
getting diag var cov 6
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['drncond_k00']
build cov matrix
done
getting diag var cov 10
scaling full cov by diag var cov
making full cov draws with home-grown goodness
adding remaining parameters to diagonal
2019-05-03 12:41:12.263146 finished: drawing realizations took: 0:00:08.635941
```

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_hk6
B) cn_hk7
C) cn_hk8
D) cn_prsity6
E) cn_prsity7
F) cn_prsity8
G) cn_rech4
H) cn_rech5
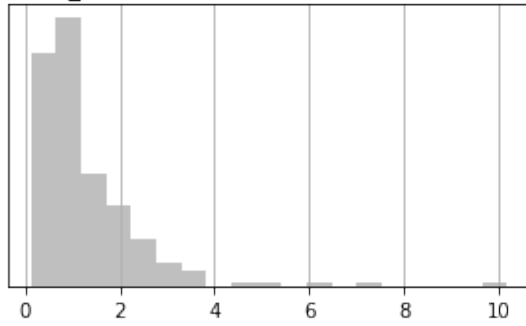
A) cn_ss6   B) cn_ss7
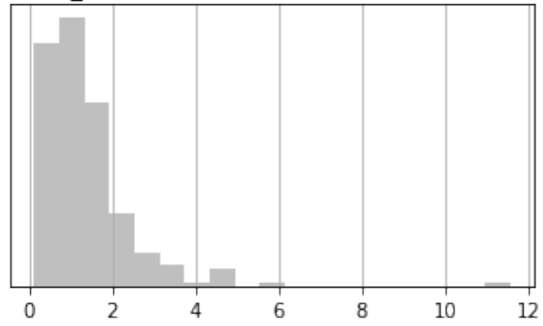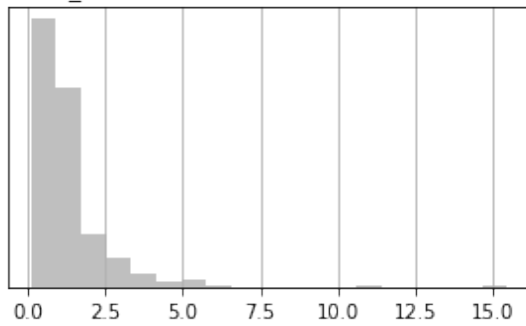
C) cn_ss8   D) cn_strt6
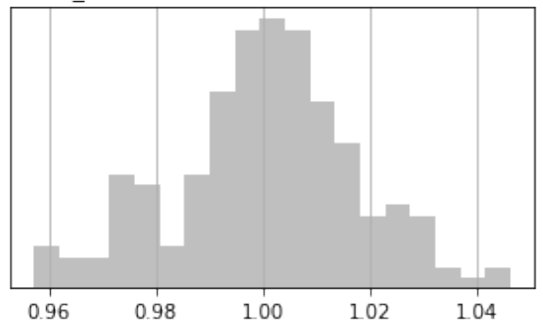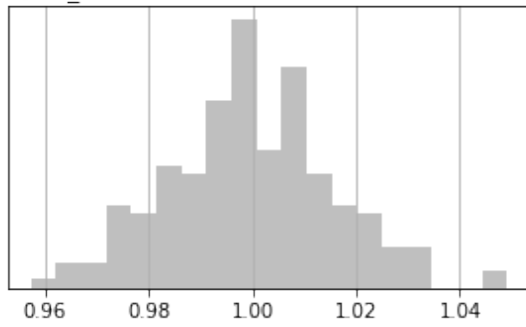
E) cn_strt7   F) cn_strt8
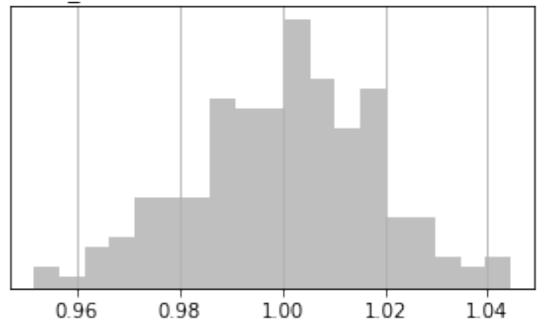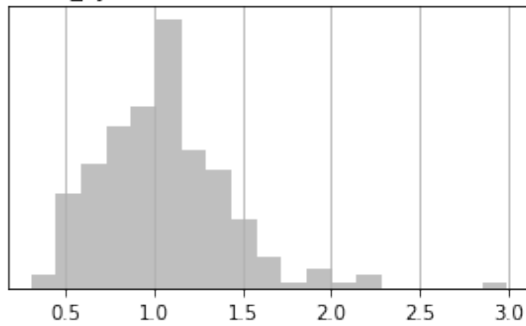
G) cn_sy6   H) cn_sy7
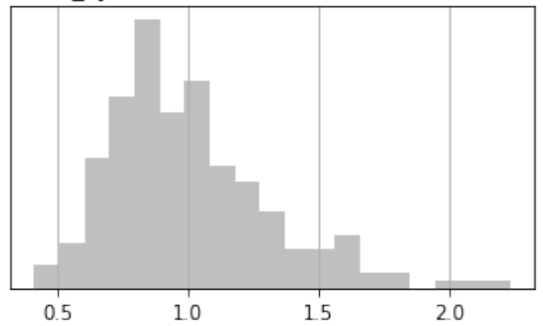
A) cn_sy8
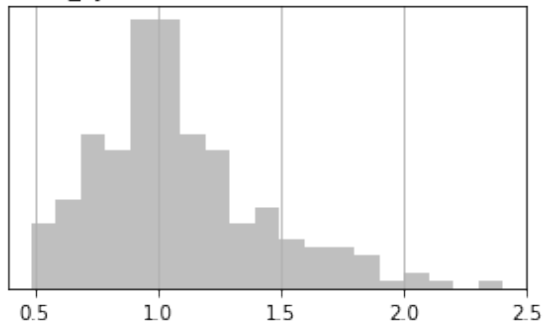
B) cn_vka6
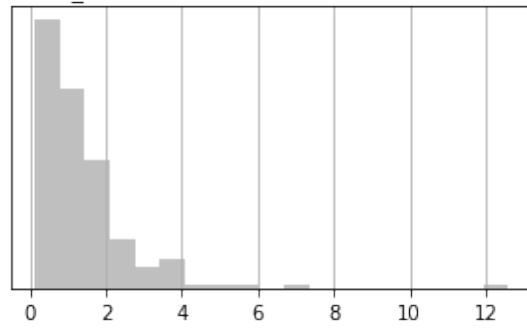
C) cn_vka7
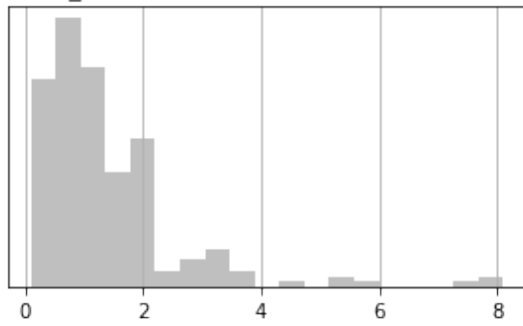
D) cn_vka8
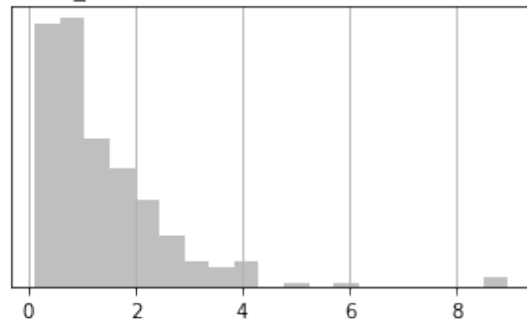
E) drncond_k00
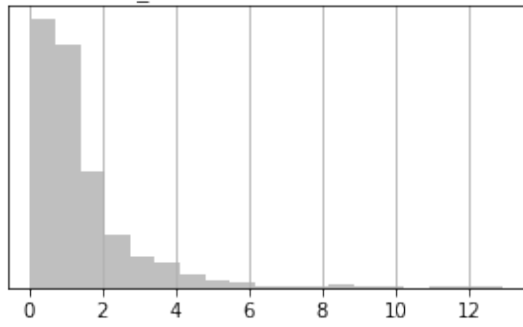
F) flow
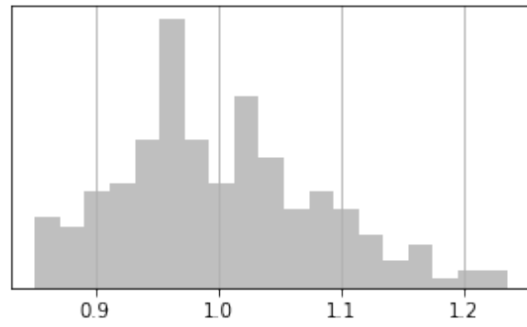
G) gr_hk3
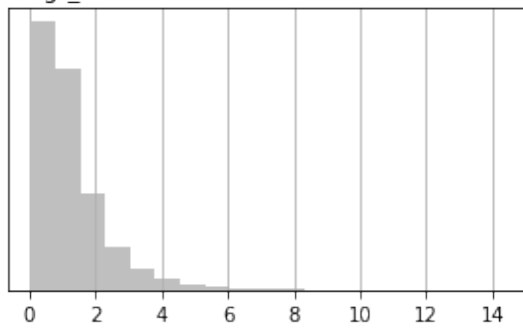
H) gr_hk4
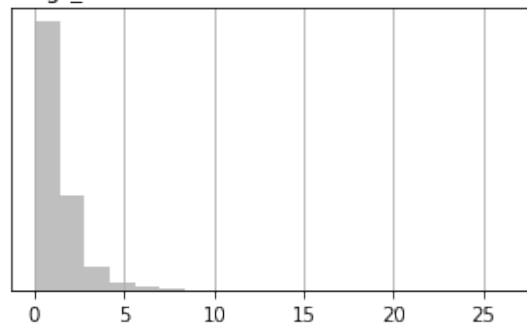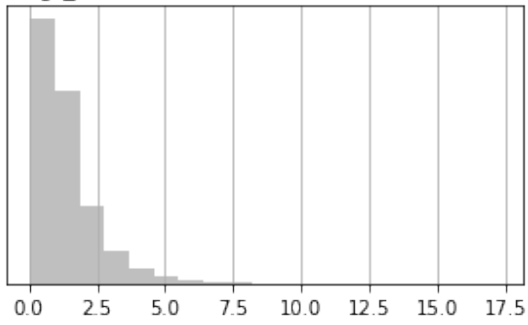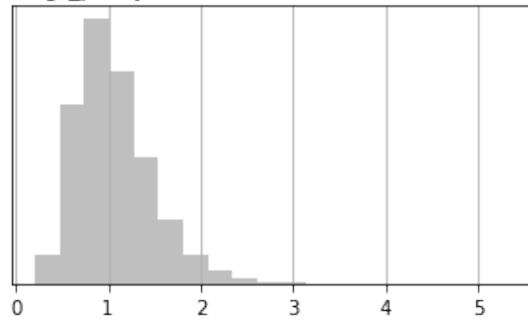
A) gr_hk5   B) gr_prsity3   C) gr_prsity4   D) gr_prsity5   E) gr_rech2   F) gr_rech3   G) gr_ss3   H) gr_ss4
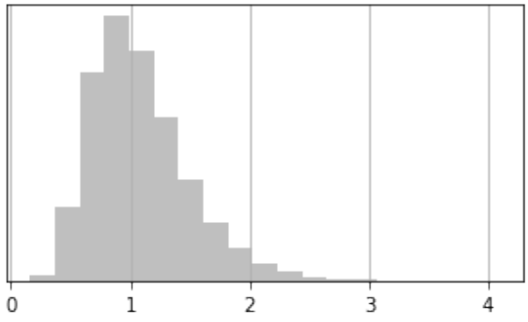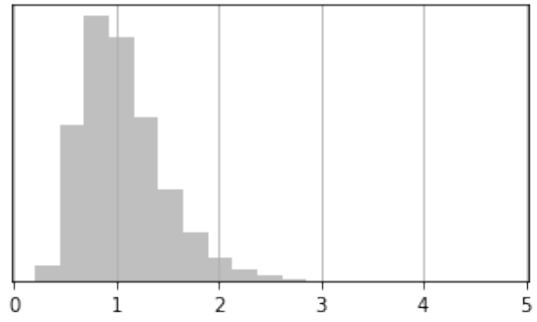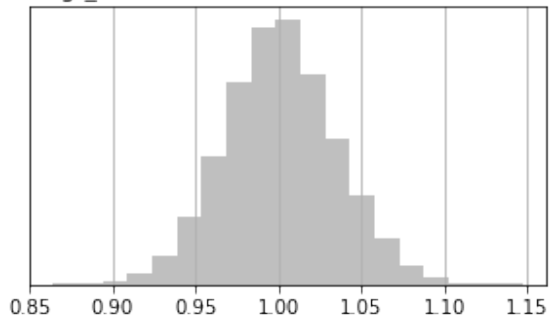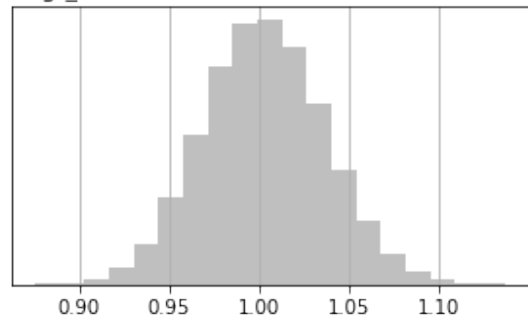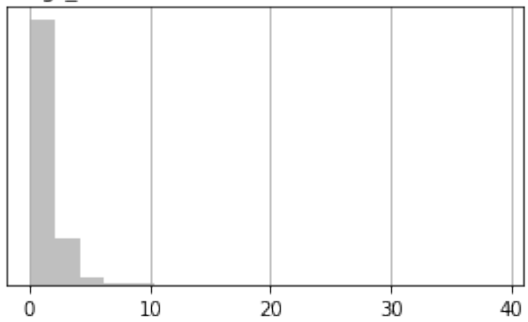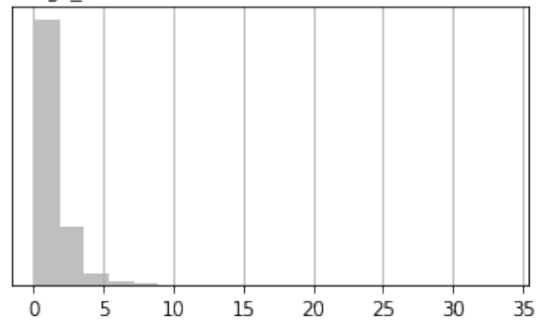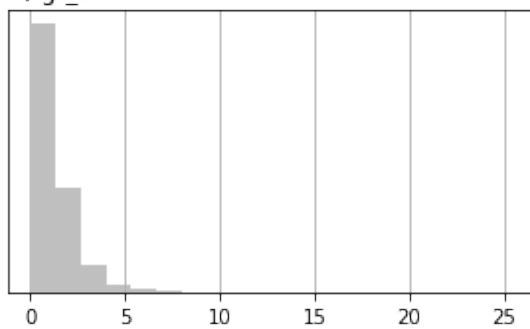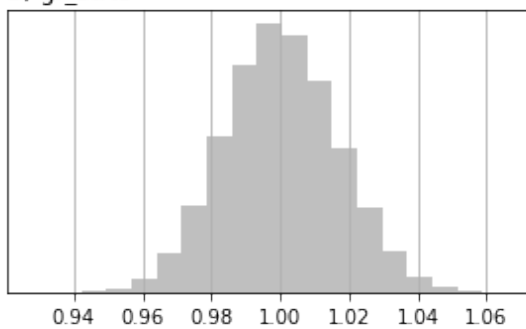
A) gr_ss5 B) gr_strt3 C) gr_strt4 D) gr_strt5 E) gr_sy3 F) gr_sy4 G) gr_sy5 H) gr_vka3
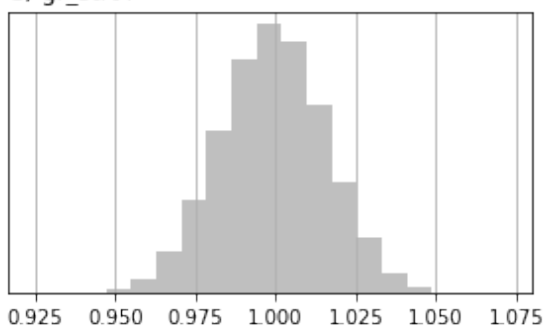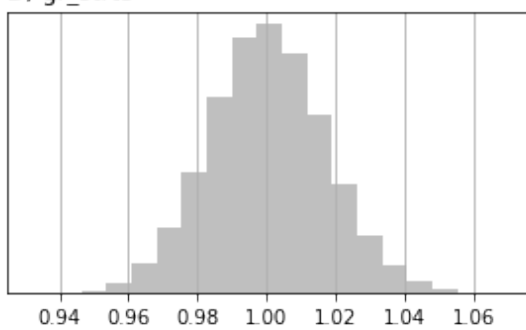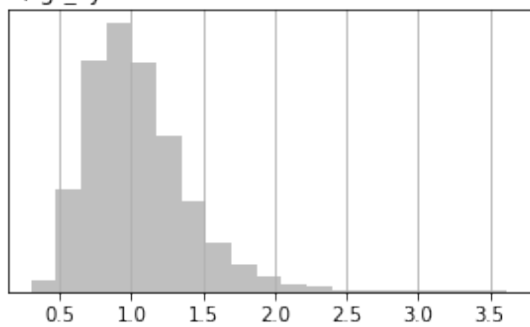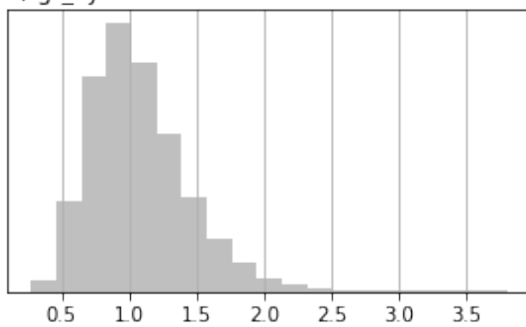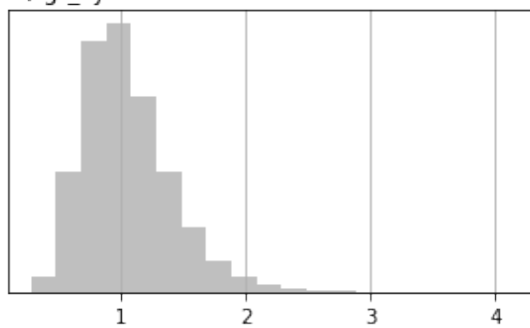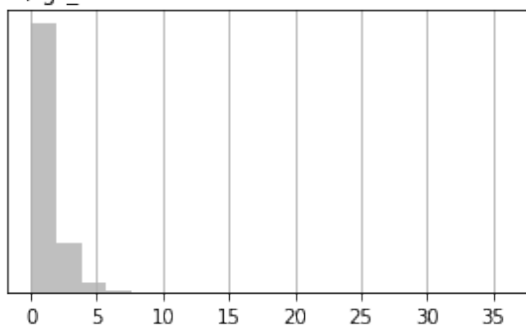
A) gr_vka4
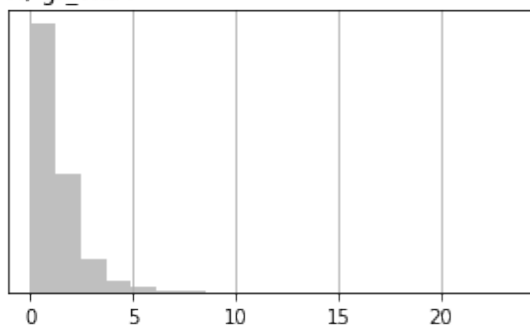
B) gr_vka5
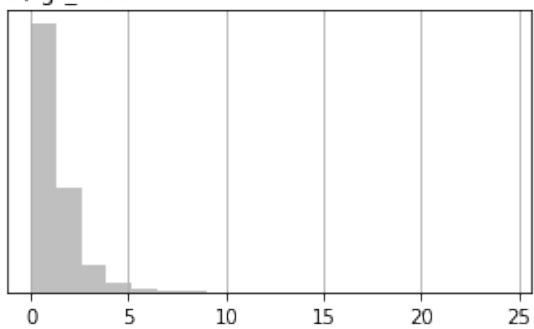
C) pp_hk0
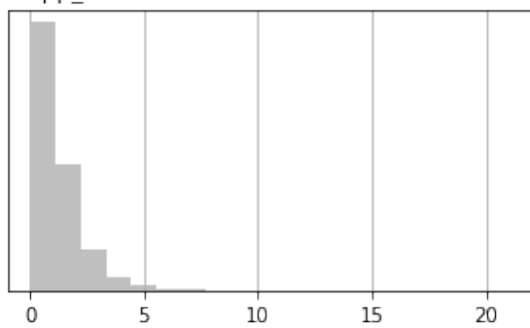
D) pp_hk1
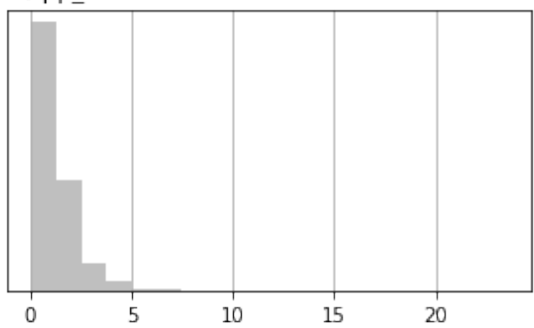
E) pp_hk2
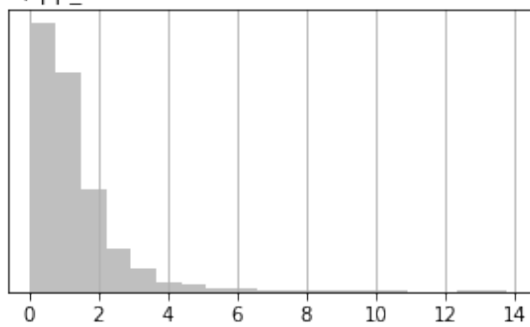
F) pp_prsity0
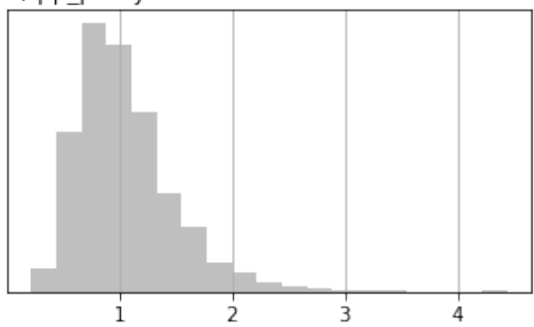
G) pp_prsity1
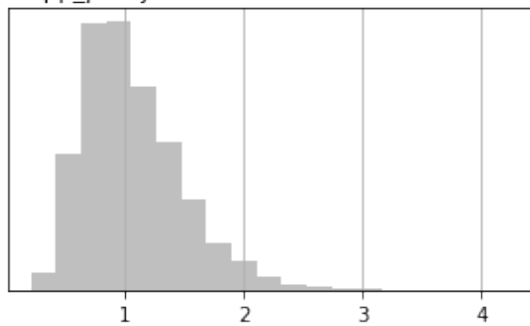
H) pp_prsity2

A) pp_sy0

B) pp_sy1

C) pp_sy2

D) pp_vka0

E) pp_vka1

F) pp_vka2

G) strk

H) welflux
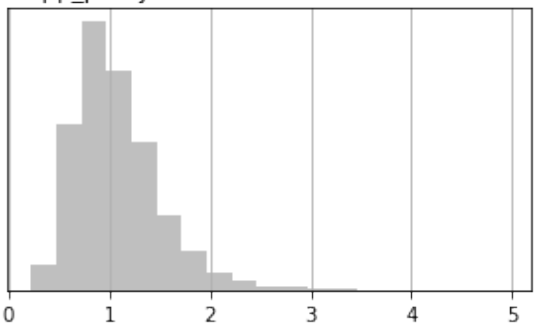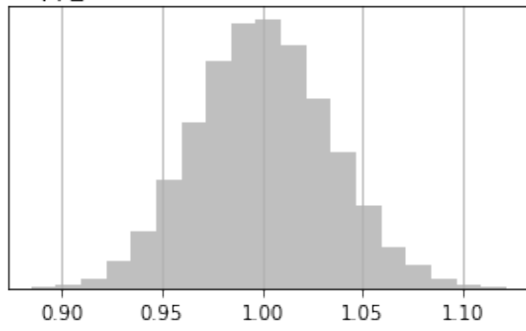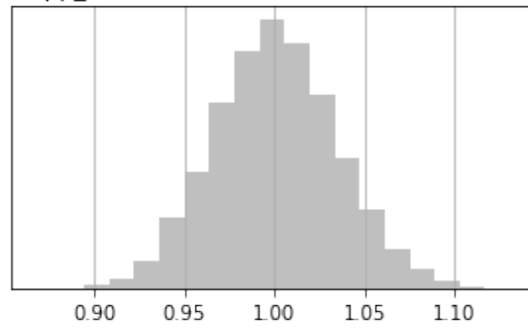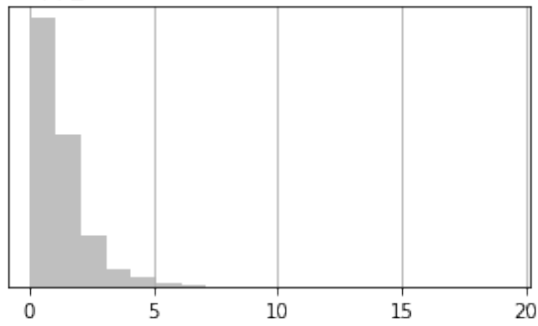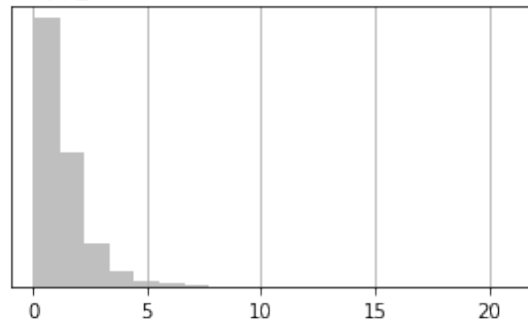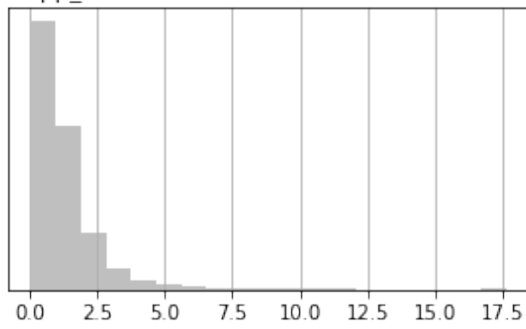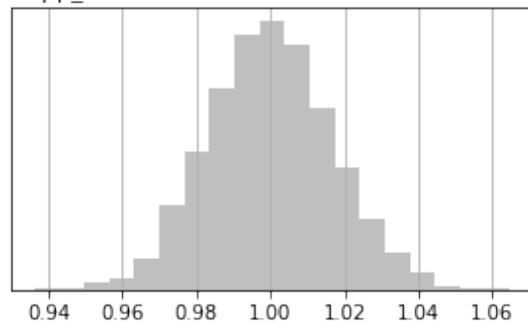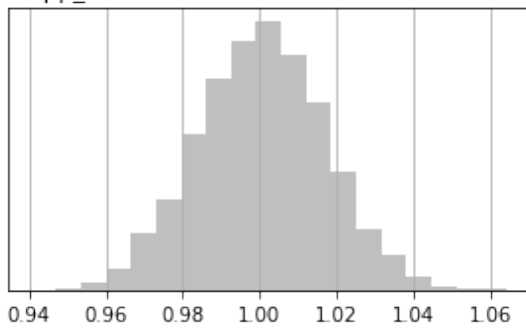
A) welflux_k02
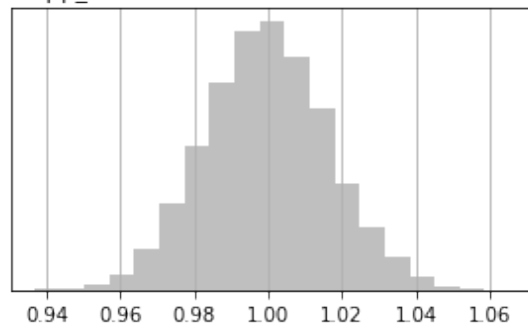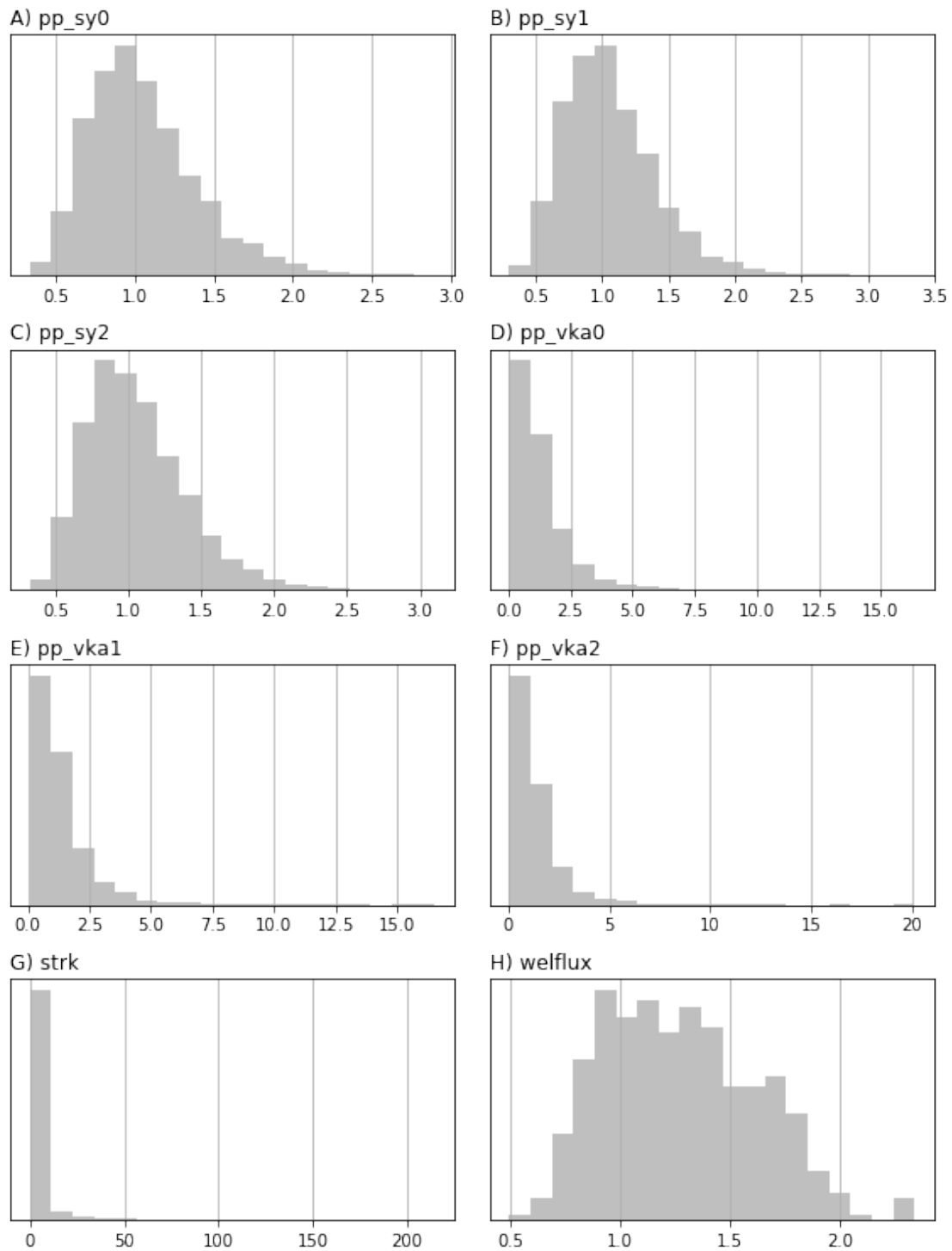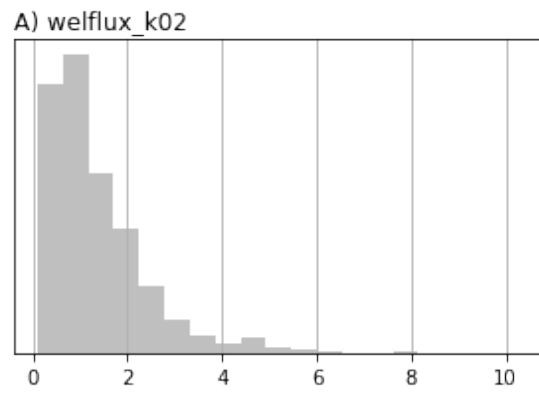

Now we need to enforce parameter bounds and save this ensemble for later

```
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"
         print(swgw_forecasts)
         hds_fore_name = "hds_00_{0:03d}_{1:03d}".format(int(pst_helper.m.nrow/3),int(pst_help
         hds_forecasts = obs.loc[obs.obsnme.apply(lambda x: hds_fore_name in x),"obsnme"].toli
         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 0x181815f2b0>
```
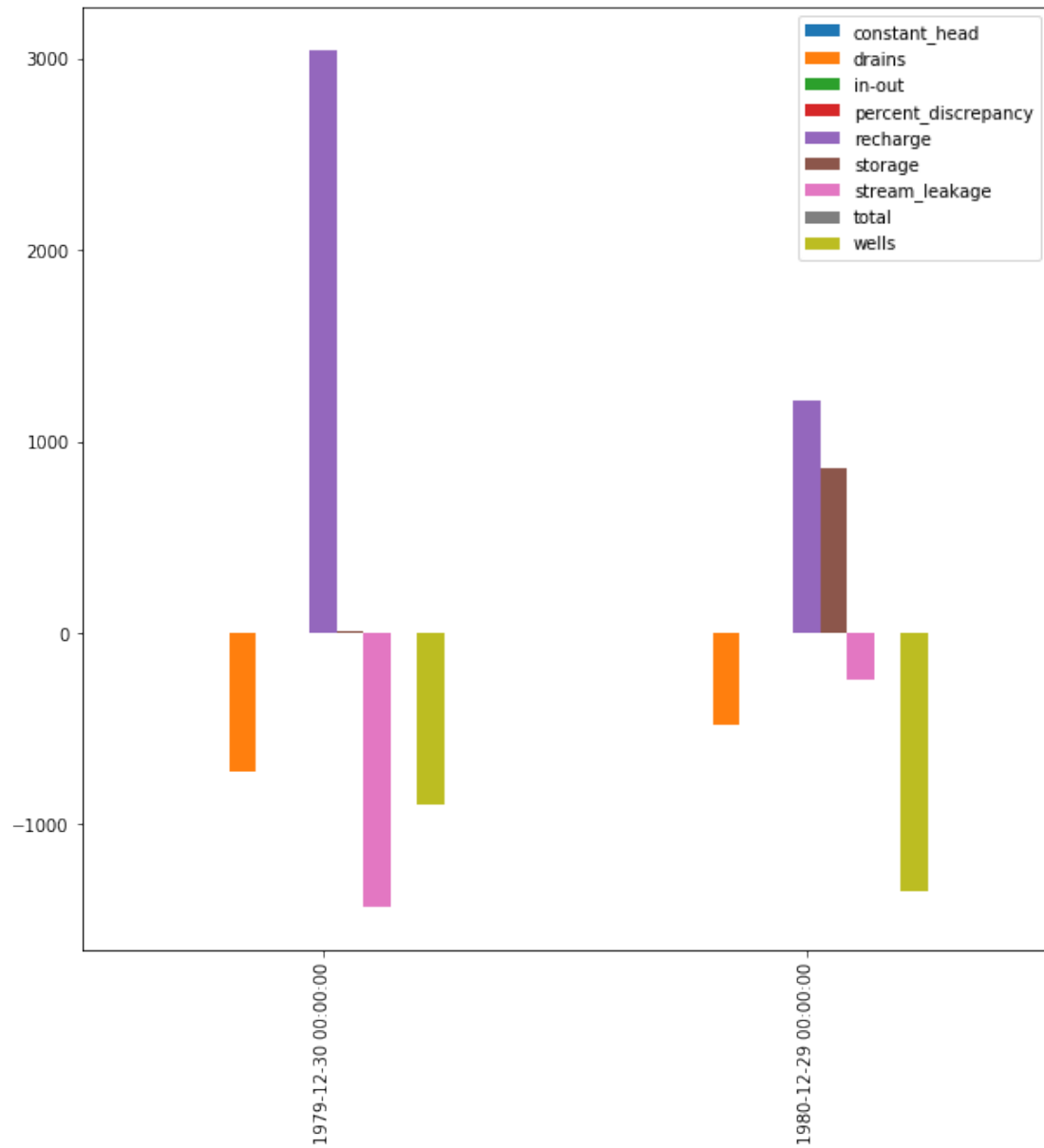
We see the effect of our parameterized scenario - a large drop in recharge and more abstraction.