setup_pest_interface

May 31, 2019

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

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

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

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

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

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

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

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

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

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

1

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

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

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

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

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

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

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

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

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

```python
In [6]: plt.figure()
        hds = flopy.utils.HeadFile(os.path.join(m.model_ws,m.name+".hds"),model=m)
        hds.plot(mflay=0)
        lst = flopy.utils.MfListBudget(os.path.join(m.model_ws,m.name+".list"))
        df = lst.get_dataframes(diff=True)[0]
        plt.figure()
        ax = df.plot(kind="bar",figsize=(6,6), grid=True)
        ax.set_xticklabels(["historic","scenario"])
        plt.show()
```
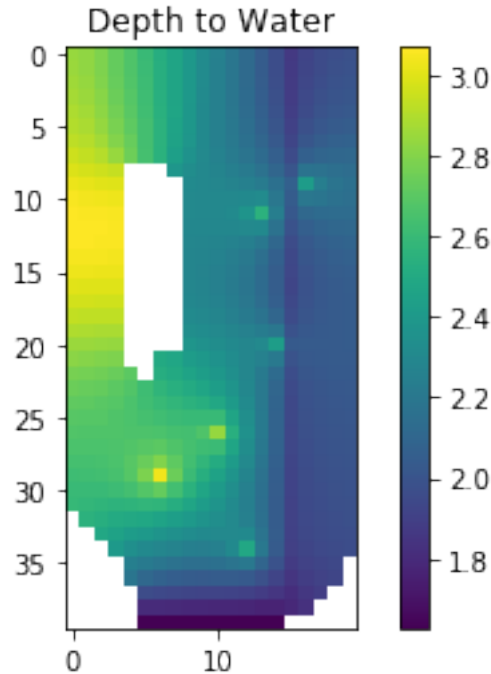
data Layer 1

<Figure size 432x288 with 0 Axes>
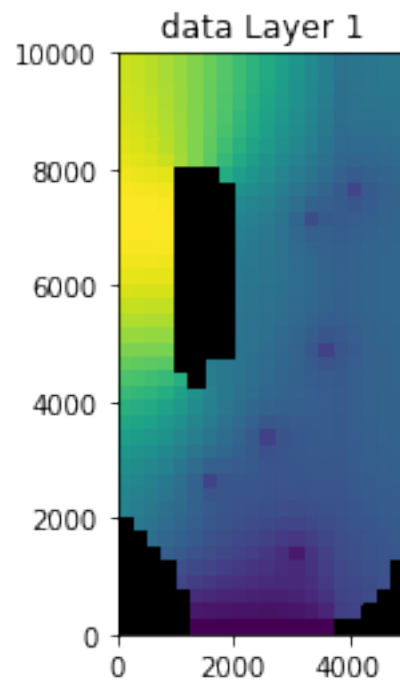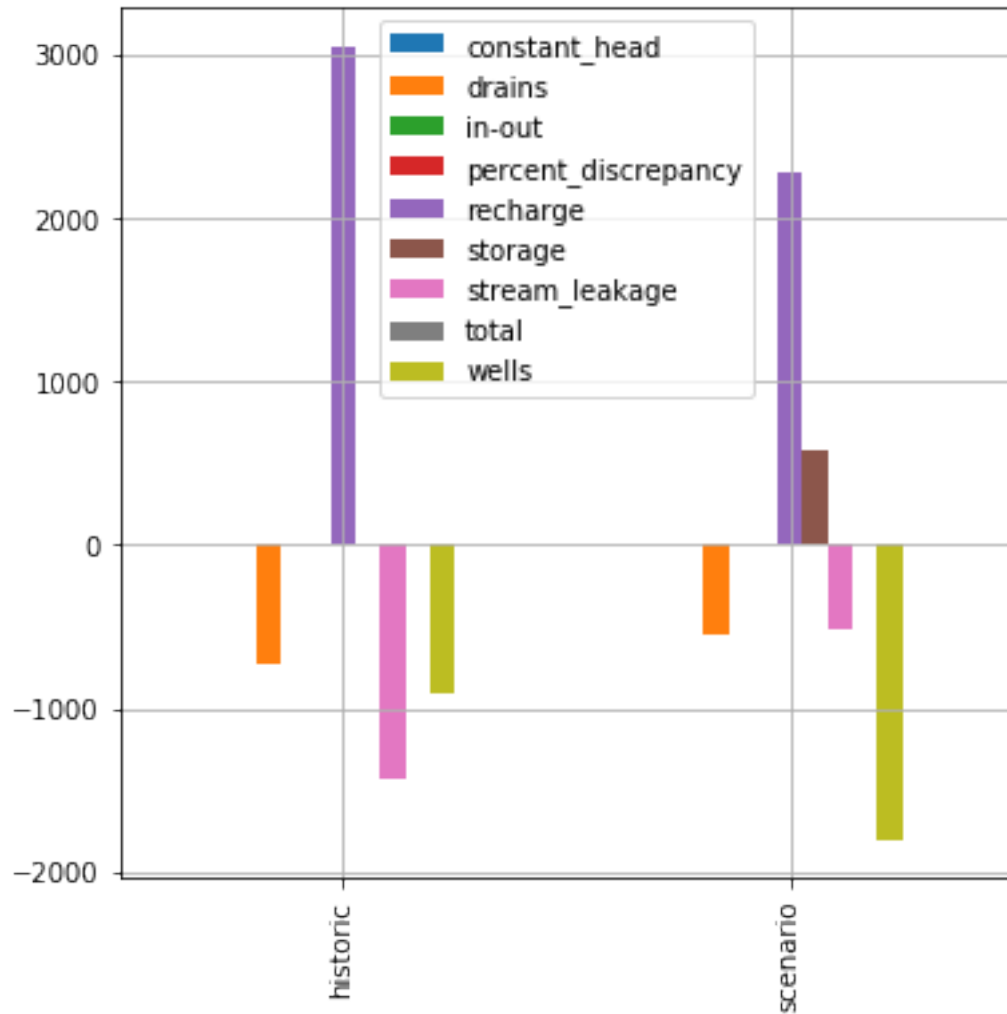
We can see the effect of the "scenario" in the second stress period with less recharge and more abstraction.

1.0.5 Plot depth to water

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

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

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

```
In [8]: # reset scenario period recharge
        m.rch.rech[1] = m.rch.rech[0]
        # reset scenario period abstraction
        m.wel.stress_period_data[1] = m.wel.stress_period_data[0]
        m.write_input()
        pyemu.os_utils.run("{0} {1}".format("mfnwt",m.name+".nam"),cwd=m.model_ws)
        hds = flopy.utils.HeadFile(os.path.join(m.model_ws,m.name+".hds"),model=m)
        axes = hds.plot(mflay=0)

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

data Layer 1
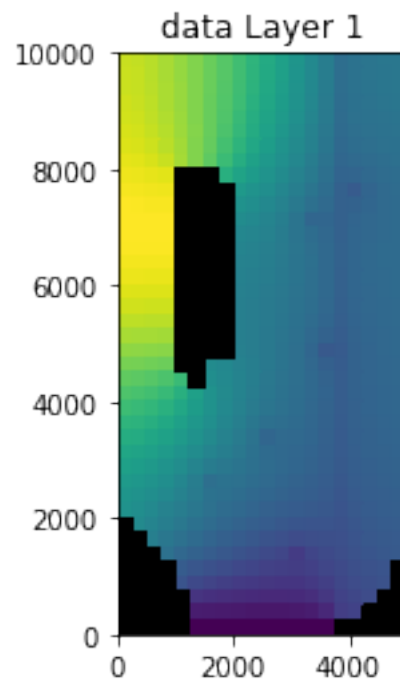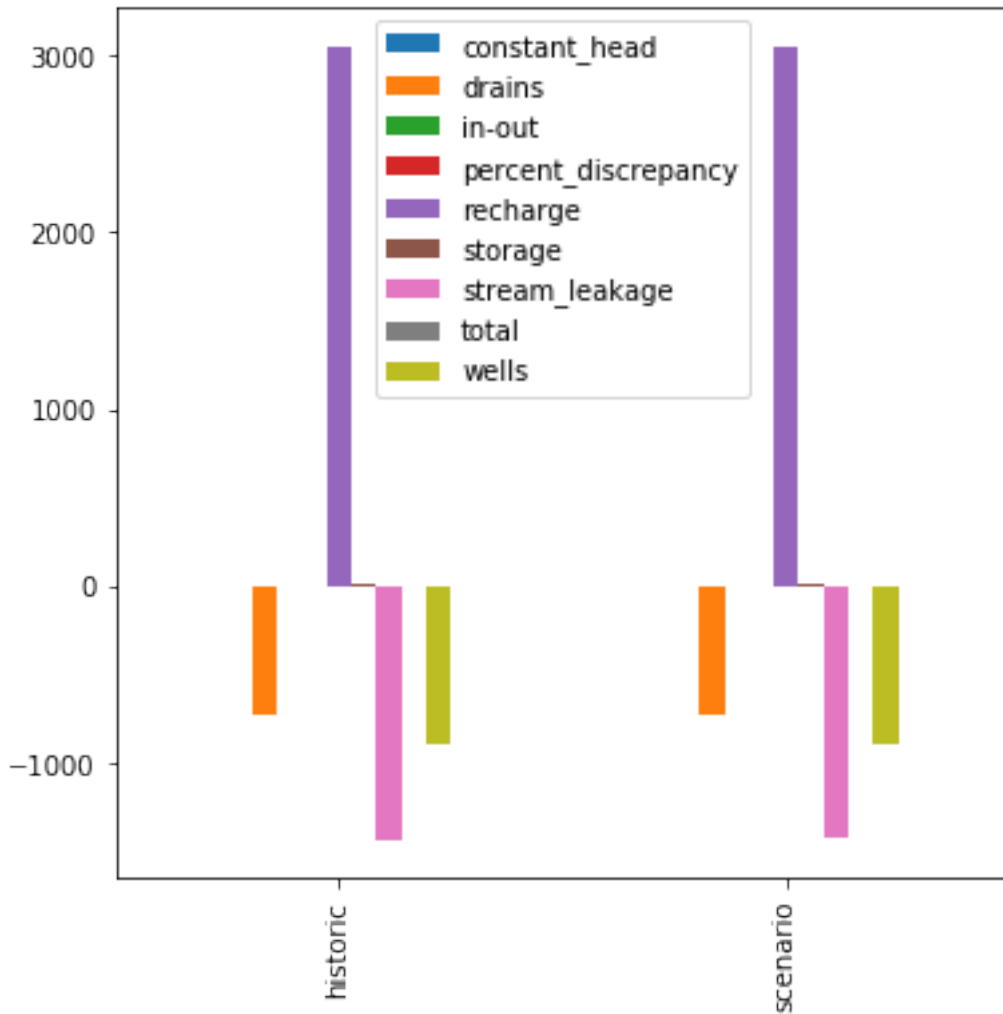
Now we see that the scenario and historic periods have the same water balance

1.1 Setup data structures related to what we want to parameterize and what we want to observe

1.1.1 first the parameterization of model inputs

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

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

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

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

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

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

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

1.1.4 then we setup monitoring of the SFR ASCII outputs.

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

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

1.1.5 here we go. . .

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

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

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

```
In [13]: pst_helper = pyemu.helpers.PstFromFlopyModel(nam_file,new_model_ws="template",org_mode
                                    const_props=props,spatial_list_props=spat:
                                     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)
```

```
2019-05-31 22:54:44.509784 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
2019-05-31 22:54:44.538496 finished: loading flopy model took: 0:00:00.028712
2019-05-31 22:54:44.538611 starting: updating model attributes
2019-05-31 22:54:44.538754 finished: updating model attributes took: 0:00:00.000143
2019-05-31 22:54:44.538881 WARNING: removing existing 'new_model_ws

creating model workspace...
   template

changing model workspace...
   template
2019-05-31 22:54:45.828668 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


2019-05-31 22:54:45.922153 finished: writing new modflow input files took: 0:00:00.093485
2019-05-31 22:54:45.922985 forward_run line:pyemu.os_utils.run('mfnwt freyberg.nam 1>freyberg.
2019-05-31 22:54:45.923222 starting: setting up 'template/arr_org' dir
2019-05-31 22:54:45.923784 finished: setting up 'template/arr_org' dir took: 0:00:00.000562
2019-05-31 22:54:45.923978 starting: setting up 'template/arr_mlt' dir
2019-05-31 22:54:45.924502 finished: setting up 'template/arr_mlt' dir took: 0:00:00.000524
2019-05-31 22:54:45.924707 starting: setting up 'template/list_org' dir
2019-05-31 22:54:45.925272 finished: setting up 'template/list_org' dir took: 0:00:00.000565
2019-05-31 22:54:45.925595 starting: setting up 'template/list_mlt' dir
2019-05-31 22:54:45.926025 finished: setting up 'template/list_mlt' dir took: 0:00:00.000430
2019-05-31 22:54:45.926366 starting: processing temporal_list_props
2019-05-31 22:54:45.959281 finished: processing temporal_list_props took: 0:00:00.032915
2019-05-31 22:54:45.959660 starting: processing spatial_list_props
2019-05-31 22:54:46.108614 finished: processing spatial_list_props took: 0:00:00.148954
2019-05-31 22:54:46.162959 forward_run line:pyemu.helpers.apply_list_pars()


2019-05-31 22:54:46.189209 'extra' pak detected:extra.prsity
2019-05-31 22:54:46.222270 'extra' pak detected:extra.prsity
2019-05-31 22:54:46.253453 'extra' pak detected:extra.prsity
2019-05-31 22:54:46.299043 'extra' pak detected:extra.prsity
2019-05-31 22:54:46.336543 'extra' pak detected:extra.prsity
2019-05-31 22:54:46.372382 'extra' pak detected:extra.prsity
2019-05-31 22:54:46.420203 'extra' pak detected:extra.prsity
2019-05-31 22:54:46.455851 'extra' pak detected:extra.prsity
2019-05-31 22:54:46.488756 'extra' pak detected:extra.prsity
2019-05-31 22:54:46.567860 starting: writing grid tpl:hk3.dat_gr.tpl
2019-05-31 22:54:46.577372 finished: writing grid tpl:hk3.dat_gr.tpl took: 0:00:00.009512
2019-05-31 22:54:46.580209 starting: writing grid tpl:vka3.dat_gr.tpl
2019-05-31 22:54:46.589029 finished: writing grid tpl:vka3.dat_gr.tpl took: 0:00:00.008820
2019-05-31 22:54:46.591460 starting: writing grid tpl:ss3.dat_gr.tpl
2019-05-31 22:54:46.600192 finished: writing grid tpl:ss3.dat_gr.tpl took: 0:00:00.008732
2019-05-31 22:54:46.602733 starting: writing grid tpl:sy3.dat_gr.tpl
2019-05-31 22:54:46.611861 finished: writing grid tpl:sy3.dat_gr.tpl took: 0:00:00.009128
2019-05-31 22:54:46.614382 starting: writing grid tpl:strt3.dat_gr.tpl
2019-05-31 22:54:46.623317 finished: writing grid tpl:strt3.dat_gr.tpl took: 0:00:00.008935
2019-05-31 22:54:46.626216 starting: writing grid tpl:prsity3.dat_gr.tpl
2019-05-31 22:54:46.637518 finished: writing grid tpl:prsity3.dat_gr.tpl took: 0:00:00.011302
2019-05-31 22:54:46.640350 starting: writing grid tpl:hk4.dat_gr.tpl
2019-05-31 22:54:46.649183 finished: writing grid tpl:hk4.dat_gr.tpl took: 0:00:00.008833
```

```
2019-05-31 22:54:46.652004 starting: writing grid tpl:vka4.dat_gr.tpl
2019-05-31 22:54:46.661042 finished: writing grid tpl:vka4.dat_gr.tpl took: 0:00:00.009038
2019-05-31 22:54:46.664011 starting: writing grid tpl:ss4.dat_gr.tpl
2019-05-31 22:54:46.672874 finished: writing grid tpl:ss4.dat_gr.tpl took: 0:00:00.008863
2019-05-31 22:54:46.675678 starting: writing grid tpl:sy4.dat_gr.tpl
2019-05-31 22:54:46.685489 finished: writing grid tpl:sy4.dat_gr.tpl took: 0:00:00.009811
2019-05-31 22:54:46.688660 starting: writing grid tpl:strt4.dat_gr.tpl
2019-05-31 22:54:46.698087 finished: writing grid tpl:strt4.dat_gr.tpl took: 0:00:00.009427
2019-05-31 22:54:46.700697 starting: writing grid tpl:prsity4.dat_gr.tpl
2019-05-31 22:54:46.711792 finished: writing grid tpl:prsity4.dat_gr.tpl took: 0:00:00.011095
2019-05-31 22:54:46.714305 starting: writing grid tpl:hk5.dat_gr.tpl
2019-05-31 22:54:46.723041 finished: writing grid tpl:hk5.dat_gr.tpl took: 0:00:00.008736
2019-05-31 22:54:46.725953 starting: writing grid tpl:vka5.dat_gr.tpl
2019-05-31 22:54:46.734416 finished: writing grid tpl:vka5.dat_gr.tpl took: 0:00:00.008463
2019-05-31 22:54:46.736918 starting: writing grid tpl:ss5.dat_gr.tpl
2019-05-31 22:54:46.746399 finished: writing grid tpl:ss5.dat_gr.tpl took: 0:00:00.009481
2019-05-31 22:54:46.748915 starting: writing grid tpl:sy5.dat_gr.tpl
2019-05-31 22:54:46.757965 finished: writing grid tpl:sy5.dat_gr.tpl took: 0:00:00.009050
2019-05-31 22:54:46.760747 starting: writing grid tpl:strt5.dat_gr.tpl
2019-05-31 22:54:46.770108 finished: writing grid tpl:strt5.dat_gr.tpl took: 0:00:00.009361
2019-05-31 22:54:46.773037 starting: writing grid tpl:prsity5.dat_gr.tpl
2019-05-31 22:54:46.784542 finished: writing grid tpl:prsity5.dat_gr.tpl took: 0:00:00.011505
2019-05-31 22:54:46.787345 starting: writing grid tpl:rech2.dat_gr.tpl
2019-05-31 22:54:46.795990 finished: writing grid tpl:rech2.dat_gr.tpl took: 0:00:00.008645
2019-05-31 22:54:46.798657 starting: writing grid tpl:rech3.dat_gr.tpl
2019-05-31 22:54:46.808038 finished: writing grid tpl:rech3.dat_gr.tpl took: 0:00:00.009381
2019-05-31 22:54:46.810612 starting: writing const tpl:hk6.dat_cn.tpl
2019-05-31 22:54:46.816510 finished: writing const tpl:hk6.dat_cn.tpl took: 0:00:00.005898
2019-05-31 22:54:46.819132 starting: writing const tpl:vka6.dat_cn.tpl
2019-05-31 22:54:46.824819 finished: writing const tpl:vka6.dat_cn.tpl took: 0:00:00.005687
2019-05-31 22:54:46.827427 starting: writing const tpl:ss6.dat_cn.tpl
2019-05-31 22:54:46.833272 finished: writing const tpl:ss6.dat_cn.tpl took: 0:00:00.005845
2019-05-31 22:54:46.836176 starting: writing const tpl:sy6.dat_cn.tpl
2019-05-31 22:54:46.842479 finished: writing const tpl:sy6.dat_cn.tpl took: 0:00:00.006303
2019-05-31 22:54:46.845119 starting: writing const tpl:strt6.dat_cn.tpl
2019-05-31 22:54:46.851199 finished: writing const tpl:strt6.dat_cn.tpl took: 0:00:00.006080
2019-05-31 22:54:46.853912 starting: writing const tpl:prsity6.dat_cn.tpl
2019-05-31 22:54:46.859842 finished: writing const tpl:prsity6.dat_cn.tpl took: 0:00:00.005930
2019-05-31 22:54:46.862571 starting: writing const tpl:hk7.dat_cn.tpl
2019-05-31 22:54:46.868466 finished: writing const tpl:hk7.dat_cn.tpl took: 0:00:00.005895
2019-05-31 22:54:46.871140 starting: writing const tpl:vka7.dat_cn.tpl
2019-05-31 22:54:46.877108 finished: writing const tpl:vka7.dat_cn.tpl took: 0:00:00.005968
2019-05-31 22:54:46.879923 starting: writing const tpl:ss7.dat_cn.tpl
2019-05-31 22:54:46.885924 finished: writing const tpl:ss7.dat_cn.tpl took: 0:00:00.006001
2019-05-31 22:54:46.888645 starting: writing const tpl:sy7.dat_cn.tpl
2019-05-31 22:54:46.894522 finished: writing const tpl:sy7.dat_cn.tpl took: 0:00:00.005877
2019-05-31 22:54:46.897174 starting: writing const tpl:strt7.dat_cn.tpl
2019-05-31 22:54:46.903573 finished: writing const tpl:strt7.dat_cn.tpl took: 0:00:00.006399
```

```
2019-05-31 22:54:46.906790 starting: writing const tpl:prsity7.dat_cn.tpl
2019-05-31 22:54:46.913450 finished: writing const tpl:prsity7.dat_cn.tpl took: 0:00:00.006660
2019-05-31 22:54:46.916563 starting: writing const tpl:hk8.dat_cn.tpl
2019-05-31 22:54:46.922980 finished: writing const tpl:hk8.dat_cn.tpl took: 0:00:00.006417
2019-05-31 22:54:46.926102 starting: writing const tpl:vka8.dat_cn.tpl
2019-05-31 22:54:46.932266 finished: writing const tpl:vka8.dat_cn.tpl took: 0:00:00.006164
2019-05-31 22:54:46.935045 starting: writing const tpl:ss8.dat_cn.tpl
2019-05-31 22:54:46.941210 finished: writing const tpl:ss8.dat_cn.tpl took: 0:00:00.006165
2019-05-31 22:54:46.944310 starting: writing const tpl:sy8.dat_cn.tpl
2019-05-31 22:54:46.950740 finished: writing const tpl:sy8.dat_cn.tpl took: 0:00:00.006430
2019-05-31 22:54:46.953430 starting: writing const tpl:strt8.dat_cn.tpl
2019-05-31 22:54:46.959594 finished: writing const tpl:strt8.dat_cn.tpl took: 0:00:00.006164
2019-05-31 22:54:46.962281 starting: writing const tpl:prsity8.dat_cn.tpl
2019-05-31 22:54:46.968784 finished: writing const tpl:prsity8.dat_cn.tpl took: 0:00:00.006503
2019-05-31 22:54:46.971796 starting: writing const tpl:rech4.dat_cn.tpl
2019-05-31 22:54:46.979958 finished: writing const tpl:rech4.dat_cn.tpl took: 0:00:00.008162
2019-05-31 22:54:46.983908 starting: writing const tpl:rech5.dat_cn.tpl
2019-05-31 22:54:46.990696 finished: writing const tpl:rech5.dat_cn.tpl took: 0:00:00.006788
2019-05-31 22:54:47.014799 starting: setting up pilot point process
2019-05-31 22:54:47.015354 WARNING: pp_geostruct is None, using ExpVario with contribution=1 a
2019-05-31 22:54:47.018326 pp_dict: {0: ['hk0', 'prsity0', 'rech0', 'rech1', 'ss0', 'strt0', 's
2019-05-31 22:54:47.018748 starting: calling setup_pilot_point_grid()
2019-05-31 22:54:47.594781 640 pilot point parameters created
2019-05-31 22:54:47.595548 pilot point 'pargp':hk0,prsity0,rech0,rech1,ss0,strt0,sy0,vka0,hk1,
2019-05-31 22:54:47.595605 finished: calling setup_pilot_point_grid() took: 0:00:00.576857
2019-05-31 22:54:47.597486 starting: calculating factors for p=hk0, k=0
2019-05-31 22:54:47.598547 saving krige variance file:template/pp_k0_general_zn.fac
2019-05-31 22:54:47.598608 saving krige factors file:template/pp_k0_general_zn.fac
starting interp point loop for 800 points
took 2.423485 seconds
2019-05-31 22:54:50.078101 finished: calculating factors for p=hk0, k=0 took: 0:00:02.480615
2019-05-31 22:54:50.079314 starting: calculating factors for p=prsity0, k=0
2019-05-31 22:54:50.080511 finished: calculating factors for p=prsity0, k=0 took: 0:00:00.00119
2019-05-31 22:54:50.081548 starting: calculating factors for p=rech0, k=0
2019-05-31 22:54:50.082777 finished: calculating factors for p=rech0, k=0 took: 0:00:00.001229
2019-05-31 22:54:50.083620 starting: calculating factors for p=rech1, k=0
2019-05-31 22:54:50.084538 finished: calculating factors for p=rech1, k=0 took: 0:00:00.000918
2019-05-31 22:54:50.085209 starting: calculating factors for p=ss0, k=0
2019-05-31 22:54:50.086291 finished: calculating factors for p=ss0, k=0 took: 0:00:00.001082
2019-05-31 22:54:50.086907 starting: calculating factors for p=strt0, k=0
2019-05-31 22:54:50.087641 finished: calculating factors for p=strt0, k=0 took: 0:00:00.000734
2019-05-31 22:54:50.088489 starting: calculating factors for p=sy0, k=0
2019-05-31 22:54:50.089312 finished: calculating factors for p=sy0, k=0 took: 0:00:00.000823
2019-05-31 22:54:50.090015 starting: calculating factors for p=vka0, k=0
2019-05-31 22:54:50.090923 finished: calculating factors for p=vka0, k=0 took: 0:00:00.000908
2019-05-31 22:54:50.091582 starting: calculating factors for p=hk1, k=1
2019-05-31 22:54:50.092326 saving krige variance file:template/pp_k1_general_zn.fac
2019-05-31 22:54:50.092560 saving krige factors file:template/pp_k1_general_zn.fac
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starting interp point loop for 800 points
took 2.428084 seconds
2019-05-31 22:54:52.582241 finished: calculating factors for p=hk1, k=1 took: 0:00:02.490659
2019-05-31 22:54:52.583078 starting: calculating factors for p=prsity1, k=1
2019-05-31 22:54:52.583809 finished: calculating factors for p=prsity1, k=1 took: 0:00:00.00073
2019-05-31 22:54:52.585058 starting: calculating factors for p=ss1, k=1
2019-05-31 22:54:52.586414 finished: calculating factors for p=ss1, k=1 took: 0:00:00.001356
2019-05-31 22:54:52.586955 starting: calculating factors for p=strt1, k=1
2019-05-31 22:54:52.587588 finished: calculating factors for p=strt1, k=1 took: 0:00:00.000633
2019-05-31 22:54:52.588210 starting: calculating factors for p=sy1, k=1
2019-05-31 22:54:52.589349 finished: calculating factors for p=sy1, k=1 took: 0:00:00.001139
2019-05-31 22:54:52.590215 starting: calculating factors for p=vka1, k=1
2019-05-31 22:54:52.590950 finished: calculating factors for p=vka1, k=1 took: 0:00:00.000735
2019-05-31 22:54:52.591896 starting: calculating factors for p=hk2, k=2
2019-05-31 22:54:52.593006 saving krige variance file:template/pp_k2_general_zn.fac
2019-05-31 22:54:52.593238 saving krige factors file:template/pp_k2_general_zn.fac
starting interp point loop for 800 points
took 2.392168 seconds
2019-05-31 22:54:55.045793 finished: calculating factors for p=hk2, k=2 took: 0:00:02.453897
2019-05-31 22:54:55.047120 starting: calculating factors for p=prsity2, k=2
2019-05-31 22:54:55.048277 finished: calculating factors for p=prsity2, k=2 took: 0:00:00.0011
2019-05-31 22:54:55.049243 starting: calculating factors for p=ss2, k=2
2019-05-31 22:54:55.050132 finished: calculating factors for p=ss2, k=2 took: 0:00:00.000889
2019-05-31 22:54:55.051190 starting: calculating factors for p=strt2, k=2
2019-05-31 22:54:55.052863 finished: calculating factors for p=strt2, k=2 took: 0:00:00.001673
2019-05-31 22:54:55.053672 starting: calculating factors for p=sy2, k=2
2019-05-31 22:54:55.054676 finished: calculating factors for p=sy2, k=2 took: 0:00:00.001004
2019-05-31 22:54:55.055643 starting: calculating factors for p=vka2, k=2
2019-05-31 22:54:55.056571 finished: calculating factors for p=vka2, k=2 took: 0:00:00.000928
2019-05-31 22:54:55.056638 starting: processing pp_prefix:prsity2
2019-05-31 22:54:55.068393 starting: processing pp_prefix:strt2
2019-05-31 22:54:55.077037 starting: processing pp_prefix:ss0
2019-05-31 22:54:55.084947 starting: processing pp_prefix:prsity1
2019-05-31 22:54:55.092858 starting: processing pp_prefix:rech0
2019-05-31 22:54:55.100627 starting: processing pp_prefix:rech1
2019-05-31 22:54:55.108605 starting: processing pp_prefix:vka1
2019-05-31 22:54:55.116628 starting: processing pp_prefix:strt0
2019-05-31 22:54:55.124425 starting: processing pp_prefix:hk0
2019-05-31 22:54:55.132526 starting: processing pp_prefix:sy1
2019-05-31 22:54:55.140607 starting: processing pp_prefix:ss2
2019-05-31 22:54:55.148674 starting: processing pp_prefix:vka2
2019-05-31 22:54:55.156704 starting: processing pp_prefix:sy0
2019-05-31 22:54:55.164951 starting: processing pp_prefix:prsity0
2019-05-31 22:54:55.172764 starting: processing pp_prefix:ss1
2019-05-31 22:54:55.181215 starting: processing pp_prefix:hk1
2019-05-31 22:54:55.190159 starting: processing pp_prefix:hk2
2019-05-31 22:54:55.197854 starting: processing pp_prefix:sy2
2019-05-31 22:54:55.205538 starting: processing pp_prefix:strt1
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2019-05-31 22:54:55.213394 starting: processing pp_prefix:vka0
2019-05-31 22:54:55.315226 finished: setting up pilot point process took: 0:00:08.300427
2019-05-31 22:54:55.316270 starting: setting up grid process
2019-05-31 22:54:55.316350 WARNING: grid_geostruct is None, using ExpVario with contribution=1
2019-05-31 22:54:55.316481 finished: setting up grid process took: 0:00:00.000211
2019-05-31 22:54:55.319027 starting: save test mlt array arr_mlt/hk0.dat_pp
2019-05-31 22:54:55.320029 finished: save test mlt array arr_mlt/hk0.dat_pp took: 0:00:00.00100
2019-05-31 22:54:55.320891 starting: save test mlt array arr_mlt/vka0.dat_pp
2019-05-31 22:54:55.321838 finished: save test mlt array arr_mlt/vka0.dat_pp took: 0:00:00.0009
2019-05-31 22:54:55.322648 starting: save test mlt array arr_mlt/ss0.dat_pp
2019-05-31 22:54:55.323692 finished: save test mlt array arr_mlt/ss0.dat_pp took: 0:00:00.00104
2019-05-31 22:54:55.324521 starting: save test mlt array arr_mlt/sy0.dat_pp
2019-05-31 22:54:55.325658 finished: save test mlt array arr_mlt/sy0.dat_pp took: 0:00:00.00113
2019-05-31 22:54:55.326324 starting: save test mlt array arr_mlt/strt0.dat_pp
2019-05-31 22:54:55.327298 finished: save test mlt array arr_mlt/strt0.dat_pp took: 0:00:00.000
2019-05-31 22:54:55.328063 starting: save test mlt array arr_mlt/prsity0.dat_pp
2019-05-31 22:54:55.329498 finished: save test mlt array arr_mlt/prsity0.dat_pp took: 0:00:00.0
2019-05-31 22:54:55.330507 starting: save test mlt array arr_mlt/hk1.dat_pp
2019-05-31 22:54:55.331748 finished: save test mlt array arr_mlt/hk1.dat_pp took: 0:00:00.0012
2019-05-31 22:54:55.332654 starting: save test mlt array arr_mlt/vka1.dat_pp
2019-05-31 22:54:55.333717 finished: save test mlt array arr_mlt/vka1.dat_pp took: 0:00:00.0010
2019-05-31 22:54:55.334585 starting: save test mlt array arr_mlt/ss1.dat_pp
2019-05-31 22:54:55.335726 finished: save test mlt array arr_mlt/ss1.dat_pp took: 0:00:00.0011
2019-05-31 22:54:55.336558 starting: save test mlt array arr_mlt/sy1.dat_pp
2019-05-31 22:54:55.337591 finished: save test mlt array arr_mlt/sy1.dat_pp took: 0:00:00.0010
2019-05-31 22:54:55.338471 starting: save test mlt array arr_mlt/strt1.dat_pp
2019-05-31 22:54:55.339549 finished: save test mlt array arr_mlt/strt1.dat_pp took: 0:00:00.001
2019-05-31 22:54:55.340478 starting: save test mlt array arr_mlt/prsity1.dat_pp
2019-05-31 22:54:55.341551 finished: save test mlt array arr_mlt/prsity1.dat_pp took: 0:00:00.0
2019-05-31 22:54:55.342329 starting: save test mlt array arr_mlt/hk2.dat_pp
2019-05-31 22:54:55.343690 finished: save test mlt array arr_mlt/hk2.dat_pp took: 0:00:00.0013
2019-05-31 22:54:55.344563 starting: save test mlt array arr_mlt/vka2.dat_pp
2019-05-31 22:54:55.345628 finished: save test mlt array arr_mlt/vka2.dat_pp took: 0:00:00.0010
2019-05-31 22:54:55.346542 starting: save test mlt array arr_mlt/ss2.dat_pp
2019-05-31 22:54:55.347566 finished: save test mlt array arr_mlt/ss2.dat_pp took: 0:00:00.0010
2019-05-31 22:54:55.348505 starting: save test mlt array arr_mlt/sy2.dat_pp
2019-05-31 22:54:55.349591 finished: save test mlt array arr_mlt/sy2.dat_pp took: 0:00:00.0010
2019-05-31 22:54:55.350212 starting: save test mlt array arr_mlt/strt2.dat_pp
2019-05-31 22:54:55.351603 finished: save test mlt array arr_mlt/strt2.dat_pp took: 0:00:00.001
2019-05-31 22:54:55.352848 starting: save test mlt array arr_mlt/prsity2.dat_pp
2019-05-31 22:54:55.354276 finished: save test mlt array arr_mlt/prsity2.dat_pp took: 0:00:00.0
2019-05-31 22:54:55.355186 starting: save test mlt array arr_mlt/rech0.dat_pp
2019-05-31 22:54:55.356492 finished: save test mlt array arr_mlt/rech0.dat_pp took: 0:00:00.001
2019-05-31 22:54:55.357309 starting: save test mlt array arr_mlt/rech1.dat_pp
2019-05-31 22:54:55.358385 finished: save test mlt array arr_mlt/rech1.dat_pp took: 0:00:00.001
2019-05-31 22:54:55.359072 starting: save test mlt array arr_mlt/hk3.dat_gr
2019-05-31 22:54:55.360327 finished: save test mlt array arr_mlt/hk3.dat_gr took: 0:00:00.0012
2019-05-31 22:54:55.361205 starting: save test mlt array arr_mlt/vka3.dat_gr
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2019-05-31 22:54:55.362313 finished: save test mlt array arr_mlt/vka3.dat_gr took: 0:00:00.0011
2019-05-31 22:54:55.362977 starting: save test mlt array arr_mlt/ss3.dat_gr
2019-05-31 22:54:55.364437 finished: save test mlt array arr_mlt/ss3.dat_gr took: 0:00:00.00146
2019-05-31 22:54:55.365357 starting: save test mlt array arr_mlt/sy3.dat_gr
2019-05-31 22:54:55.366437 finished: save test mlt array arr_mlt/sy3.dat_gr took: 0:00:00.00108
2019-05-31 22:54:55.367307 starting: save test mlt array arr_mlt/strt3.dat_gr
2019-05-31 22:54:55.368322 finished: save test mlt array arr_mlt/strt3.dat_gr took: 0:00:00.001
2019-05-31 22:54:55.369323 starting: save test mlt array arr_mlt/prsity3.dat_gr
2019-05-31 22:54:55.370435 finished: save test mlt array arr_mlt/prsity3.dat_gr took: 0:00:00.0
2019-05-31 22:54:55.371309 starting: save test mlt array arr_mlt/hk4.dat_gr
2019-05-31 22:54:55.372557 finished: save test mlt array arr_mlt/hk4.dat_gr took: 0:00:00.00124
2019-05-31 22:54:55.373435 starting: save test mlt array arr_mlt/vka4.dat_gr
2019-05-31 22:54:55.374696 finished: save test mlt array arr_mlt/vka4.dat_gr took: 0:00:00.0012
2019-05-31 22:54:55.375501 starting: save test mlt array arr_mlt/ss4.dat_gr
2019-05-31 22:54:55.376755 finished: save test mlt array arr_mlt/ss4.dat_gr took: 0:00:00.00125
2019-05-31 22:54:55.377744 starting: save test mlt array arr_mlt/sy4.dat_gr
2019-05-31 22:54:55.378947 finished: save test mlt array arr_mlt/sy4.dat_gr took: 0:00:00.00120
2019-05-31 22:54:55.380083 starting: save test mlt array arr_mlt/strt4.dat_gr
2019-05-31 22:54:55.382082 finished: save test mlt array arr_mlt/strt4.dat_gr took: 0:00:00.001
2019-05-31 22:54:55.383383 starting: save test mlt array arr_mlt/prsity4.dat_gr
2019-05-31 22:54:55.385250 finished: save test mlt array arr_mlt/prsity4.dat_gr took: 0:00:00.0
2019-05-31 22:54:55.386516 starting: save test mlt array arr_mlt/hk5.dat_gr
2019-05-31 22:54:55.388406 finished: save test mlt array arr_mlt/hk5.dat_gr took: 0:00:00.00189
2019-05-31 22:54:55.389686 starting: save test mlt array arr_mlt/vka5.dat_gr
2019-05-31 22:54:55.391186 finished: save test mlt array arr_mlt/vka5.dat_gr took: 0:00:00.0015
2019-05-31 22:54:55.392596 starting: save test mlt array arr_mlt/ss5.dat_gr
2019-05-31 22:54:55.395149 finished: save test mlt array arr_mlt/ss5.dat_gr took: 0:00:00.00255
2019-05-31 22:54:55.397063 starting: save test mlt array arr_mlt/sy5.dat_gr
2019-05-31 22:54:55.399076 finished: save test mlt array arr_mlt/sy5.dat_gr took: 0:00:00.00201
2019-05-31 22:54:55.400671 starting: save test mlt array arr_mlt/strt5.dat_gr
2019-05-31 22:54:55.402519 finished: save test mlt array arr_mlt/strt5.dat_gr took: 0:00:00.001
2019-05-31 22:54:55.404072 starting: save test mlt array arr_mlt/prsity5.dat_gr
2019-05-31 22:54:55.406451 finished: save test mlt array arr_mlt/prsity5.dat_gr took: 0:00:00.0
2019-05-31 22:54:55.407506 starting: save test mlt array arr_mlt/rech2.dat_gr
2019-05-31 22:54:55.408667 finished: save test mlt array arr_mlt/rech2.dat_gr took: 0:00:00.001
2019-05-31 22:54:55.409589 starting: save test mlt array arr_mlt/rech3.dat_gr
2019-05-31 22:54:55.410712 finished: save test mlt array arr_mlt/rech3.dat_gr took: 0:00:00.001
2019-05-31 22:54:55.411435 starting: save test mlt array arr_mlt/hk6.dat_cn
2019-05-31 22:54:55.412820 finished: save test mlt array arr_mlt/hk6.dat_cn took: 0:00:00.00138
2019-05-31 22:54:55.413573 starting: save test mlt array arr_mlt/vka6.dat_cn
2019-05-31 22:54:55.414775 finished: save test mlt array arr_mlt/vka6.dat_cn took: 0:00:00.0012
2019-05-31 22:54:55.415726 starting: save test mlt array arr_mlt/ss6.dat_cn
2019-05-31 22:54:55.417000 finished: save test mlt array arr_mlt/ss6.dat_cn took: 0:00:00.0012
2019-05-31 22:54:55.417894 starting: save test mlt array arr_mlt/sy6.dat_cn
2019-05-31 22:54:55.418991 finished: save test mlt array arr_mlt/sy6.dat_cn took: 0:00:00.00109
2019-05-31 22:54:55.419770 starting: save test mlt array arr_mlt/strt6.dat_cn
2019-05-31 22:54:55.421095 finished: save test mlt array arr_mlt/strt6.dat_cn took: 0:00:00.001
2019-05-31 22:54:55.421990 starting: save test mlt array arr_mlt/prsity6.dat_cn
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2019-05-31 22:54:55.423130 finished: save test mlt array arr_mlt/prsity6.dat_cn took: 0:00:00.0
2019-05-31 22:54:55.424017 starting: save test mlt array arr_mlt/hk7.dat_cn
2019-05-31 22:54:55.425154 finished: save test mlt array arr_mlt/hk7.dat_cn took: 0:00:00.00113
2019-05-31 22:54:55.426056 starting: save test mlt array arr_mlt/vka7.dat_cn
2019-05-31 22:54:55.427261 finished: save test mlt array arr_mlt/vka7.dat_cn took: 0:00:00.0012
2019-05-31 22:54:55.428205 starting: save test mlt array arr_mlt/ss7.dat_cn
2019-05-31 22:54:55.429756 finished: save test mlt array arr_mlt/ss7.dat_cn took: 0:00:00.0015
2019-05-31 22:54:55.431017 starting: save test mlt array arr_mlt/sy7.dat_cn
2019-05-31 22:54:55.432881 finished: save test mlt array arr_mlt/sy7.dat_cn took: 0:00:00.0018
2019-05-31 22:54:55.434255 starting: save test mlt array arr_mlt/strt7.dat_cn
2019-05-31 22:54:55.436214 finished: save test mlt array arr_mlt/strt7.dat_cn took: 0:00:00.00
2019-05-31 22:54:55.438197 starting: save test mlt array arr_mlt/prsity7.dat_cn
2019-05-31 22:54:55.440869 finished: save test mlt array arr_mlt/prsity7.dat_cn took: 0:00:00.0
2019-05-31 22:54:55.442917 starting: save test mlt array arr_mlt/hk8.dat_cn
2019-05-31 22:54:55.445071 finished: save test mlt array arr_mlt/hk8.dat_cn took: 0:00:00.0021
2019-05-31 22:54:55.446233 starting: save test mlt array arr_mlt/vka8.dat_cn
2019-05-31 22:54:55.448485 finished: save test mlt array arr_mlt/vka8.dat_cn took: 0:00:00.002
2019-05-31 22:54:55.450113 starting: save test mlt array arr_mlt/ss8.dat_cn
2019-05-31 22:54:55.452011 finished: save test mlt array arr_mlt/ss8.dat_cn took: 0:00:00.0018
2019-05-31 22:54:55.453277 starting: save test mlt array arr_mlt/sy8.dat_cn
2019-05-31 22:54:55.455267 finished: save test mlt array arr_mlt/sy8.dat_cn took: 0:00:00.0019
2019-05-31 22:54:55.456820 starting: save test mlt array arr_mlt/strt8.dat_cn
2019-05-31 22:54:55.458247 finished: save test mlt array arr_mlt/strt8.dat_cn took: 0:00:00.00
2019-05-31 22:54:55.459168 starting: save test mlt array arr_mlt/prsity8.dat_cn
2019-05-31 22:54:55.460276 finished: save test mlt array arr_mlt/prsity8.dat_cn took: 0:00:00.0
2019-05-31 22:54:55.461162 starting: save test mlt array arr_mlt/rech4.dat_cn
2019-05-31 22:54:55.462452 finished: save test mlt array arr_mlt/rech4.dat_cn took: 0:00:00.00
2019-05-31 22:54:55.463365 starting: save test mlt array arr_mlt/rech5.dat_cn
2019-05-31 22:54:55.464610 finished: save test mlt array arr_mlt/rech5.dat_cn took: 0:00:00.00
2019-05-31 22:54:56.095163 forward_run line:pyemu.helpers.apply_array_pars()

all zeros for runoff...skipping...
all zeros for hcond1...skipping...
all zeros for pptsw...skipping...
2019-05-31 22:54:56.226155 starting: processing obs type mflist water budget obs
2019-05-31 22:54:56.352396 forward_run line:pyemu.gw_utils.apply_mflist_budget_obs('freyberg.l
2019-05-31 22:54:56.352833 finished: processing obs type mflist water budget obs took: 0:00:00
2019-05-31 22:54:56.352901 starting: processing obs type hyd file
2019-05-31 22:54:56.352989 finished: processing obs type hyd file took: 0:00:00.000088
2019-05-31 22:54:56.353031 starting: processing obs type external obs-sim smp files
2019-05-31 22:54:56.353287 finished: processing obs type external obs-sim smp files took: 0:00
2019-05-31 22:54:56.353345 starting: processing obs type hob
2019-05-31 22:54:56.353415 finished: processing obs type hob took: 0:00:00.000070
2019-05-31 22:54:56.353463 starting: processing obs type hds
[[0, 0], [0, 1], [0, 2], [1, 0], [1, 1], [1, 2]]
2019-05-31 22:54:56.766119 finished: processing obs type hds took: 0:00:00.412656
2019-05-31 22:54:56.766854 starting: processing obs type sfr
writing 'sfr_obs.config' to template/sfr_obs.config
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2019-05-31 22:54:57.168829 finished: processing obs type sfr took: 0:00:00.401975
2019-05-31 22:54:57.169275 changing dir in to template
2019-05-31 22:54:57.170312 starting: instantiating control file from i/o files
2019-05-31 22:54:57.170663 tpl files: drn.csv.tpl,wel.csv.tpl,hk3.dat_gr.tpl,vka3.dat_gr.tpl,ss
2019-05-31 22:54:57.171050 ins files: freyberg.hds.dat.ins,vol.dat.ins,freyberg.sfr.out.proces
2019-05-31 22:54:57.524830 finished: instantiating control file from i/o files took: 0:00:00.35
2019-05-31 22:54:57.751594 starting: writing forward_run.py
2019-05-31 22:54:57.752449 finished: writing forward_run.py took: 0:00:00.000855
2019-05-31 22:54:57.752823 writing pst template/freyberg.pst
noptmax:0, npar_adj:14819, nnz_obs:4434
2019-05-31 22:54:59.457417 starting: running pestchek on freyberg.pst
2019-05-31 22:54:59.567116 pestcheck:PESTCHEK Version 13.0. Watermark Numerical Computing.
2019-05-31 22:54:59.567656 pestcheck:
2019-05-31 22:54:59.568062 pestcheck:Errors ----->
2019-05-31 22:54:59.568524 pestcheck:Line 2403 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.569012 pestcheck:12 characters long.
2019-05-31 22:54:59.569463 pestcheck:Line 2404 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.569781 pestcheck:12 characters long.
2019-05-31 22:54:59.569883 pestcheck:Line 2404 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.569943 pestcheck:once.
2019-05-31 22:54:59.569994 pestcheck:Line 2405 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.570050 pestcheck:12 characters long.
2019-05-31 22:54:59.570651 pestcheck:Line 2405 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.571106 pestcheck:once.
2019-05-31 22:54:59.571216 pestcheck:Line 2406 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.571275 pestcheck:12 characters long.
2019-05-31 22:54:59.571326 pestcheck:Line 2406 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.571375 pestcheck:once.
2019-05-31 22:54:59.571428 pestcheck:Line 2407 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.571852 pestcheck:12 characters long.
2019-05-31 22:54:59.571951 pestcheck:Line 2407 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.572048 pestcheck:once.
2019-05-31 22:54:59.572194 pestcheck:Line 2408 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.572370 pestcheck:12 characters long.
2019-05-31 22:54:59.572443 pestcheck:Line 2408 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.572502 pestcheck:once.
2019-05-31 22:54:59.572657 pestcheck:Line 2409 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.572821 pestcheck:12 characters long.
2019-05-31 22:54:59.572891 pestcheck:Line 2409 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.572949 pestcheck:once.
2019-05-31 22:54:59.573095 pestcheck:Line 2410 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.573221 pestcheck:12 characters long.
2019-05-31 22:54:59.573287 pestcheck:Line 2410 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.573407 pestcheck:once.
2019-05-31 22:54:59.573533 pestcheck:Line 2411 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.573590 pestcheck:12 characters long.
2019-05-31 22:54:59.573636 pestcheck:Line 2411 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.573758 pestcheck:once.
```

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2019-05-31 22:54:59.573884 pestcheck:Line 2412 of file freyberg.pst: parameter name "prsity3000
2019-05-31 22:54:59.573941 pestcheck:12 characters long.
2019-05-31 22:54:59.573988 pestcheck:Line 2412 of file freyberg.pst: parameter name "prsity3000
2019-05-31 22:54:59.574108 pestcheck:once.
2019-05-31 22:54:59.574233 pestcheck:Line 2413 of file freyberg.pst: parameter name "prsity3000
2019-05-31 22:54:59.574299 pestcheck:12 characters long.
2019-05-31 22:54:59.574419 pestcheck:Line 2414 of file freyberg.pst: parameter name "prsity3000
2019-05-31 22:54:59.574544 pestcheck:12 characters long.
2019-05-31 22:54:59.574601 pestcheck:Line 2414 of file freyberg.pst: parameter name "prsity3000
2019-05-31 22:54:59.574648 pestcheck:once.
2019-05-31 22:54:59.574769 pestcheck:Line 2415 of file freyberg.pst: parameter name "prsity3000
2019-05-31 22:54:59.574901 pestcheck:12 characters long.
2019-05-31 22:54:59.574959 pestcheck:Line 2415 of file freyberg.pst: parameter name "prsity3000
2019-05-31 22:54:59.575006 pestcheck:once.
2019-05-31 22:54:59.575126 pestcheck:Line 2416 of file freyberg.pst: parameter name "prsity3000
2019-05-31 22:54:59.575189 pestcheck:12 characters long.
2019-05-31 22:54:59.575304 pestcheck:Line 2416 of file freyberg.pst: parameter name "prsity3000
2019-05-31 22:54:59.575450 pestcheck:once.
2019-05-31 22:54:59.575576 pestcheck:Line 2417 of file freyberg.pst: parameter name "prsity3000
2019-05-31 22:54:59.575633 pestcheck:12 characters long.
2019-05-31 22:54:59.575680 pestcheck:Line 2417 of file freyberg.pst: parameter name "prsity3000
2019-05-31 22:54:59.575801 pestcheck:once.
2019-05-31 22:54:59.575927 pestcheck:Line 2418 of file freyberg.pst: parameter name "prsity3000
2019-05-31 22:54:59.575984 pestcheck:12 characters long.
2019-05-31 22:54:59.576031 pestcheck:Line 2418 of file freyberg.pst: parameter name "prsity3000
2019-05-31 22:54:59.576151 pestcheck:once.
2019-05-31 22:54:59.576214 pestcheck:Line 2419 of file freyberg.pst: parameter name "prsity3000
2019-05-31 22:54:59.576328 pestcheck:12 characters long.
2019-05-31 22:54:59.576393 pestcheck:Line 2419 of file freyberg.pst: parameter name "prsity3000
2019-05-31 22:54:59.576513 pestcheck:once.
2019-05-31 22:54:59.576643 pestcheck:Line 2420 of file freyberg.pst: parameter name "prsity3000
2019-05-31 22:54:59.576701 pestcheck:12 characters long.
2019-05-31 22:54:59.576749 pestcheck:Line 2420 of file freyberg.pst: parameter name "prsity3000
2019-05-31 22:54:59.576868 pestcheck:once.
2019-05-31 22:54:59.576994 pestcheck:Line 2421 of file freyberg.pst: parameter name "prsity3000
2019-05-31 22:54:59.577050 pestcheck:12 characters long.
2019-05-31 22:54:59.577096 pestcheck:Line 2421 of file freyberg.pst: parameter name "prsity3000
2019-05-31 22:54:59.577218 pestcheck:once.
2019-05-31 22:54:59.577343 pestcheck:Line 2422 of file freyberg.pst: parameter name "prsity3000
2019-05-31 22:54:59.577408 pestcheck:12 characters long.
2019-05-31 22:54:59.577529 pestcheck:Line 2422 of file freyberg.pst: parameter name "prsity3000
2019-05-31 22:54:59.577654 pestcheck:once.
2019-05-31 22:54:59.577710 pestcheck:Line 2423 of file freyberg.pst: parameter name "prsity3001
2019-05-31 22:54:59.577759 pestcheck:12 characters long.
2019-05-31 22:54:59.577879 pestcheck:Line 2424 of file freyberg.pst: parameter name "prsity3001
2019-05-31 22:54:59.578004 pestcheck:12 characters long.
2019-05-31 22:54:59.578061 pestcheck:Line 2424 of file freyberg.pst: parameter name "prsity3001
2019-05-31 22:54:59.578109 pestcheck:once.
```

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2019-05-31 22:54:59.578227 pestcheck:Line 2425 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.578281 pestcheck:12 characters long.
2019-05-31 22:54:59.578378 pestcheck:Line 2425 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.578435 pestcheck:once.
2019-05-31 22:54:59.578539 pestcheck:Line 2426 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.578647 pestcheck:12 characters long.
2019-05-31 22:54:59.578696 pestcheck:Line 2426 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.578736 pestcheck:once.
2019-05-31 22:54:59.578839 pestcheck:Line 2427 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.578946 pestcheck:12 characters long.
2019-05-31 22:54:59.578995 pestcheck:Line 2427 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.579036 pestcheck:once.
2019-05-31 22:54:59.579139 pestcheck:Line 2428 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.579246 pestcheck:12 characters long.
2019-05-31 22:54:59.579294 pestcheck:Line 2428 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.579334 pestcheck:once.
2019-05-31 22:54:59.579438 pestcheck:Line 2429 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.579566 pestcheck:12 characters long.
2019-05-31 22:54:59.579670 pestcheck:Line 2429 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.579780 pestcheck:once.
2019-05-31 22:54:59.579829 pestcheck:Line 2430 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.579868 pestcheck:12 characters long.
2019-05-31 22:54:59.579971 pestcheck:Line 2430 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.580079 pestcheck:once.
2019-05-31 22:54:59.580128 pestcheck:Line 2431 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.580168 pestcheck:12 characters long.
2019-05-31 22:54:59.580270 pestcheck:Line 2431 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.580378 pestcheck:once.
2019-05-31 22:54:59.580426 pestcheck:Line 2432 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.580609 pestcheck:12 characters long.
2019-05-31 22:54:59.580658 pestcheck:Line 2432 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.580697 pestcheck:once.
2019-05-31 22:54:59.580800 pestcheck:Line 2433 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.580907 pestcheck:12 characters long.
2019-05-31 22:54:59.580955 pestcheck:Line 2434 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.580995 pestcheck:12 characters long.
2019-05-31 22:54:59.581098 pestcheck:Line 2434 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.581210 pestcheck:once.
2019-05-31 22:54:59.581260 pestcheck:Line 2435 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.581300 pestcheck:12 characters long.
2019-05-31 22:54:59.581403 pestcheck:Line 2435 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.581531 pestcheck:once.
2019-05-31 22:54:59.581571 pestcheck:Line 2436 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.581674 pestcheck:12 characters long.
2019-05-31 22:54:59.581782 pestcheck:Line 2436 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.581831 pestcheck:once.
2019-05-31 22:54:59.581870 pestcheck:Line 2437 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.581974 pestcheck:12 characters long.
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2019-05-31 22:54:59.582081 pestcheck:Line 2437 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.582129 pestcheck:once.
2019-05-31 22:54:59.582170 pestcheck:Line 2438 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.582273 pestcheck:12 characters long.
2019-05-31 22:54:59.582380 pestcheck:Line 2438 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.582436 pestcheck:once.
2019-05-31 22:54:59.582543 pestcheck:Line 2439 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.582651 pestcheck:12 characters long.
2019-05-31 22:54:59.582700 pestcheck:Line 2439 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.582739 pestcheck:once.
2019-05-31 22:54:59.582843 pestcheck:Line 2440 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.582950 pestcheck:12 characters long.
2019-05-31 22:54:59.583144 pestcheck:Line 2440 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.583290 pestcheck:once.
2019-05-31 22:54:59.583356 pestcheck:Line 2441 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.583480 pestcheck:12 characters long.
2019-05-31 22:54:59.583522 pestcheck:Line 2441 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.583629 pestcheck:once.
2019-05-31 22:54:59.583741 pestcheck:Line 2442 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.583789 pestcheck:12 characters long.
2019-05-31 22:54:59.583895 pestcheck:Line 2442 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.584009 pestcheck:once.
2019-05-31 22:54:59.584058 pestcheck:Line 2443 of file freyberg.pst: parameter name "prsity3002
2019-05-31 22:54:59.584097 pestcheck:12 characters long.
2019-05-31 22:54:59.584200 pestcheck:Line 2444 of file freyberg.pst: parameter name "prsity3002
2019-05-31 22:54:59.584308 pestcheck:12 characters long.
2019-05-31 22:54:59.584356 pestcheck:Line 2444 of file freyberg.pst: parameter name "prsity3002
2019-05-31 22:54:59.584539 pestcheck:once.
2019-05-31 22:54:59.584587 pestcheck:Line 2445 of file freyberg.pst: parameter name "prsity3002
2019-05-31 22:54:59.584626 pestcheck:12 characters long.
2019-05-31 22:54:59.584729 pestcheck:Line 2445 of file freyberg.pst: parameter name "prsity3002
2019-05-31 22:54:59.584836 pestcheck:once.
2019-05-31 22:54:59.584883 pestcheck:Line 2446 of file freyberg.pst: parameter name "prsity3002
2019-05-31 22:54:59.584923 pestcheck:12 characters long.
2019-05-31 22:54:59.585026 pestcheck:Line 2446 of file freyberg.pst: parameter name "prsity3002
2019-05-31 22:54:59.585134 pestcheck:once.
2019-05-31 22:54:59.585181 pestcheck:Line 2447 of file freyberg.pst: parameter name "prsity3002
2019-05-31 22:54:59.585255 pestcheck:12 characters long.
2019-05-31 22:54:59.585328 pestcheck:Line 2447 of file freyberg.pst: parameter name "prsity3002
2019-05-31 22:54:59.585452 pestcheck:once.
2019-05-31 22:54:59.585576 pestcheck:Line 2448 of file freyberg.pst: parameter name "prsity3002
2019-05-31 22:54:59.585685 pestcheck:12 characters long.
2019-05-31 22:54:59.585733 pestcheck:Line 2448 of file freyberg.pst: parameter name "prsity3002
2019-05-31 22:54:59.585773 pestcheck:once.
2019-05-31 22:54:59.585875 pestcheck:Line 2449 of file freyberg.pst: parameter name "prsity3002
2019-05-31 22:54:59.585983 pestcheck:12 characters long.
2019-05-31 22:54:59.586030 pestcheck:Line 2449 of file freyberg.pst: parameter name "prsity3002
2019-05-31 22:54:59.586070 pestcheck:once.
```

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2019-05-31 22:54:59.586172 pestcheck:Line 2450 of file freyberg.pst: parameter name "prsity3002
2019-05-31 22:54:59.586279 pestcheck:12 characters long.
2019-05-31 22:54:59.586329 pestcheck:Line 2450 of file freyberg.pst: parameter name "prsity3002
2019-05-31 22:54:59.586516 pestcheck:once.
2019-05-31 22:54:59.586627 pestcheck:Line 2451 of file freyberg.pst: parameter name "prsity3002
2019-05-31 22:54:59.586728 pestcheck:12 characters long.
2019-05-31 22:54:59.586774 pestcheck:Line 2451 of file freyberg.pst: parameter name "prsity3002
2019-05-31 22:54:59.586811 pestcheck:once.
2019-05-31 22:54:59.586907 pestcheck:Line 2452 of file freyberg.pst: parameter name "prsity3002
2019-05-31 22:54:59.586957 pestcheck:12 characters long.
2019-05-31 22:54:59.587049 pestcheck:Line 2452 of file freyberg.pst: parameter name "prsity3002
2019-05-31 22:54:59.587097 pestcheck:once.
2019-05-31 22:54:59.587134 pestcheck:Line 2453 of file freyberg.pst: parameter name "prsity3002
2019-05-31 22:54:59.587231 pestcheck:12 characters long.
2019-05-31 22:54:59.587280 pestcheck:Line 2454 of file freyberg.pst: parameter name "prsity3002
2019-05-31 22:54:59.587372 pestcheck:12 characters long.
2019-05-31 22:54:59.587424 pestcheck:Line 2454 of file freyberg.pst: parameter name "prsity3002
2019-05-31 22:54:59.587520 pestcheck:once.
2019-05-31 22:54:59.587621 pestcheck:Line 2455 of file freyberg.pst: parameter name "prsity3002
2019-05-31 22:54:59.587667 pestcheck:12 characters long.
2019-05-31 22:54:59.587703 pestcheck:Line 2455 of file freyberg.pst: parameter name "prsity3002
2019-05-31 22:54:59.587800 pestcheck:once.
2019-05-31 22:54:59.587901 pestcheck:Line 2456 of file freyberg.pst: parameter name "prsity3002
2019-05-31 22:54:59.587947 pestcheck:12 characters long.
2019-05-31 22:54:59.587984 pestcheck:Line 2456 of file freyberg.pst: parameter name "prsity3002
2019-05-31 22:54:59.588082 pestcheck:once.
2019-05-31 22:54:59.588132 pestcheck:Line 2457 of file freyberg.pst: parameter name "prsity3002
2019-05-31 22:54:59.588224 pestcheck:12 characters long.
2019-05-31 22:54:59.588269 pestcheck:Line 2457 of file freyberg.pst: parameter name "prsity3002
2019-05-31 22:54:59.588306 pestcheck:once.
2019-05-31 22:54:59.588403 pestcheck:Line 2458 of file freyberg.pst: parameter name "prsity3002
2019-05-31 22:54:59.588525 pestcheck:12 characters long.
2019-05-31 22:54:59.588563 pestcheck:Line 2458 of file freyberg.pst: parameter name "prsity3002
2019-05-31 22:54:59.588659 pestcheck:once.
2019-05-31 22:54:59.588762 pestcheck:Line 2459 of file freyberg.pst: parameter name "prsity3002
2019-05-31 22:54:59.588807 pestcheck:12 characters long.
2019-05-31 22:54:59.588844 pestcheck:Line 2459 of file freyberg.pst: parameter name "prsity3002
2019-05-31 22:54:59.588941 pestcheck:once.
2019-05-31 22:54:59.589042 pestcheck:Line 2460 of file freyberg.pst: parameter name "prsity3002
2019-05-31 22:54:59.589088 pestcheck:12 characters long.
2019-05-31 22:54:59.589127 pestcheck:Line 2460 of file freyberg.pst: parameter name "prsity3002
2019-05-31 22:54:59.589225 pestcheck:once.
2019-05-31 22:54:59.589392 pestcheck:Line 2461 of file freyberg.pst: parameter name "prsity3002
2019-05-31 22:54:59.589445 pestcheck:12 characters long.
2019-05-31 22:54:59.589576 pestcheck:Line 2461 of file freyberg.pst: parameter name "prsity3002
2019-05-31 22:54:59.589686 pestcheck:once.
2019-05-31 22:54:59.589734 pestcheck:Line 2462 of file freyberg.pst: parameter name "prsity3002
2019-05-31 22:54:59.589815 pestcheck:12 characters long.
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2019-05-31 22:54:59.589920 pestcheck:Line 2462 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.590022 pestcheck:once.
2019-05-31 22:54:59.590070 pestcheck:Line 2463 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.590108 pestcheck:12 characters long.
2019-05-31 22:54:59.590207 pestcheck:Line 2464 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.590315 pestcheck:12 characters long.
2019-05-31 22:54:59.590363 pestcheck:Line 2464 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.590546 pestcheck:once.
2019-05-31 22:54:59.590593 pestcheck:Line 2465 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.590631 pestcheck:12 characters long.
2019-05-31 22:54:59.590730 pestcheck:Line 2465 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.590832 pestcheck:once.
2019-05-31 22:54:59.590878 pestcheck:Line 2466 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.590919 pestcheck:12 characters long.
2019-05-31 22:54:59.591018 pestcheck:Line 2466 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.591120 pestcheck:once.
2019-05-31 22:54:59.591166 pestcheck:Line 2467 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.591205 pestcheck:12 characters long.
2019-05-31 22:54:59.591303 pestcheck:Line 2467 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.591405 pestcheck:once.
2019-05-31 22:54:59.591459 pestcheck:Line 2468 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.591556 pestcheck:12 characters long.
2019-05-31 22:54:59.591658 pestcheck:Line 2468 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.591704 pestcheck:once.
2019-05-31 22:54:59.591804 pestcheck:Line 2469 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.591857 pestcheck:12 characters long.
2019-05-31 22:54:59.591950 pestcheck:Line 2469 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.591997 pestcheck:once.
2019-05-31 22:54:59.592035 pestcheck:Line 2470 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.592132 pestcheck:12 characters long.
2019-05-31 22:54:59.592183 pestcheck:Line 2470 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.592276 pestcheck:once.
2019-05-31 22:54:59.592323 pestcheck:Line 2471 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.592361 pestcheck:12 characters long.
2019-05-31 22:54:59.592459 pestcheck:Line 2471 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.592570 pestcheck:once.
2019-05-31 22:54:59.592616 pestcheck:Line 2472 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.592655 pestcheck:12 characters long.
2019-05-31 22:54:59.592754 pestcheck:Line 2472 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.592859 pestcheck:once.
2019-05-31 22:54:59.592905 pestcheck:Line 2473 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.592943 pestcheck:12 characters long.
2019-05-31 22:54:59.593042 pestcheck:Line 2474 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.593146 pestcheck:12 characters long.
2019-05-31 22:54:59.593192 pestcheck:Line 2474 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.593231 pestcheck:once.
2019-05-31 22:54:59.593329 pestcheck:Line 2475 of file freyberg.pst: parameter name "prsity300
2019-05-31 22:54:59.593431 pestcheck:12 characters long.
```

```
2019-05-31 22:54:59.593485 pestcheck:Line 2475 of file freyberg.pst: parameter name "prsity3003
2019-05-31 22:54:59.593582 pestcheck:once.
2019-05-31 22:54:59.593684 pestcheck:Line 2476 of file freyberg.pst: parameter name "prsity3003
2019-05-31 22:54:59.593730 pestcheck:12 characters long.
2019-05-31 22:54:59.593768 pestcheck:Line 2476 of file freyberg.pst: parameter name "prsity3003
2019-05-31 22:54:59.593865 pestcheck:once.
2019-05-31 22:54:59.593917 pestcheck:Line 2477 of file freyberg.pst: parameter name "prsity3003
2019-05-31 22:54:59.594009 pestcheck:12 characters long.
2019-05-31 22:54:59.594055 pestcheck:Line 2477 of file freyberg.pst: parameter name "prsity3003
2019-05-31 22:54:59.594093 pestcheck:once.
2019-05-31 22:54:59.594191 pestcheck:Line 2478 of file freyberg.pst: parameter name "prsity3003
2019-05-31 22:54:59.594293 pestcheck:12 characters long.
2019-05-31 22:54:59.594339 pestcheck:Line 2478 of file freyberg.pst: parameter name "prsity3003
2019-05-31 22:54:59.594377 pestcheck:once.
2019-05-31 22:54:59.594475 pestcheck:Line 2479 of file freyberg.pst: parameter name "prsity3003
2019-05-31 22:54:59.594585 pestcheck:12 characters long.
2019-05-31 22:54:59.594632 pestcheck:Line 2479 of file freyberg.pst: parameter name "prsity3003
2019-05-31 22:54:59.594670 pestcheck:once.
2019-05-31 22:54:59.594767 pestcheck:Line 2480 of file freyberg.pst: parameter name "prsity3003
2019-05-31 22:54:59.594870 pestcheck:12 characters long.
2019-05-31 22:54:59.594916 pestcheck:Line 2480 of file freyberg.pst: parameter name "prsity3003
2019-05-31 22:54:59.594953 pestcheck:once.
2019-05-31 22:54:59.595051 pestcheck:Line 2481 of file freyberg.pst: parameter name "prsity3003
2019-05-31 22:54:59.595153 pestcheck:12 characters long.
2019-05-31 22:54:59.595199 pestcheck:Line 2481 of file freyberg.pst: parameter name "prsity3003
2019-05-31 22:54:59.595237 pestcheck:once.
2019-05-31 22:54:59.595332 pestcheck:Line 2482 of file freyberg.pst: parameter name "prsity3003
2019-05-31 22:54:59.595438 pestcheck:12 characters long.
2019-05-31 22:54:59.595491 pestcheck:Line 2482 of file freyberg.pst: parameter name "prsity3003
2019-05-31 22:54:59.595588 pestcheck:once.
2019-05-31 22:54:59.595691 pestcheck:Line 2483 of file freyberg.pst: parameter name "prsity3004
2019-05-31 22:54:59.595737 pestcheck:12 characters long.
2019-05-31 22:54:59.595776 pestcheck:Line 2484 of file freyberg.pst: parameter name "prsity3004
2019-05-31 22:54:59.595875 pestcheck:12 characters long.
2019-05-31 22:54:59.595977 pestcheck:Line 2484 of file freyberg.pst: parameter name "prsity3004
2019-05-31 22:54:59.596022 pestcheck:once.
2019-05-31 22:54:59.596059 pestcheck:Line 2485 of file freyberg.pst: parameter name "prsity3004
2019-05-31 22:54:59.596156 pestcheck:12 characters long.
2019-05-31 22:54:59.596258 pestcheck:Line 2485 of file freyberg.pst: parameter name "prsity3004
2019-05-31 22:54:59.596303 pestcheck:once.
2019-05-31 22:54:59.596341 pestcheck:Line 2486 of file freyberg.pst: parameter name "prsity3004
2019-05-31 22:54:59.596438 pestcheck:12 characters long.
2019-05-31 22:54:59.596558 pestcheck:Line 2486 of file freyberg.pst: parameter name "prsity3004
2019-05-31 22:54:59.596597 pestcheck:once.
2019-05-31 22:54:59.596693 pestcheck:Line 2487 of file freyberg.pst: parameter name "prsity3004
2019-05-31 22:54:59.596795 pestcheck:12 characters long.
2019-05-31 22:54:59.596842 pestcheck:Line 2487 of file freyberg.pst: parameter name "prsity3004
2019-05-31 22:54:59.596879 pestcheck:once.
```

```
2019-05-31 22:54:59.596976 pestcheck:Line 2488 of file freyberg.pst: parameter name "prsity3004
2019-05-31 22:54:59.597078 pestcheck:12 characters long.
2019-05-31 22:54:59.597123 pestcheck:Line 2488 of file freyberg.pst: parameter name "prsity3004
2019-05-31 22:54:59.597161 pestcheck:once.
2019-05-31 22:54:59.597259 pestcheck:Line 2489 of file freyberg.pst: parameter name "prsity3004
2019-05-31 22:54:59.597360 pestcheck:12 characters long.
2019-05-31 22:54:59.597406 pestcheck:Line 2489 of file freyberg.pst: parameter name "prsity3004
2019-05-31 22:54:59.597577 pestcheck:once.
2019-05-31 22:54:59.597622 pestcheck:Line 2490 of file freyberg.pst: parameter name "prsity3004
2019-05-31 22:54:59.597660 pestcheck:12 characters long.
2019-05-31 22:54:59.597757 pestcheck:Line 2490 of file freyberg.pst: parameter name "prsity3004
2019-05-31 22:54:59.597859 pestcheck:once.
2019-05-31 22:54:59.597905 pestcheck:Line 2491 of file freyberg.pst: parameter name "prsity3004
2019-05-31 22:54:59.597943 pestcheck:12 characters long.
2019-05-31 22:54:59.598040 pestcheck:Line 2491 of file freyberg.pst: parameter name "prsity3004
2019-05-31 22:54:59.598142 pestcheck:once.
2019-05-31 22:54:59.598189 pestcheck:Line 2492 of file freyberg.pst: parameter name "prsity3004
2019-05-31 22:54:59.598226 pestcheck:12 characters long.
2019-05-31 22:54:59.598323 pestcheck:Line 2492 of file freyberg.pst: parameter name "prsity3004
2019-05-31 22:54:59.598425 pestcheck:once.
2019-05-31 22:54:59.598479 pestcheck:Line 2493 of file freyberg.pst: parameter name "prsity3004
2019-05-31 22:54:59.598606 pestcheck:12 characters long.
2019-05-31 22:54:59.598698 pestcheck:Line 2494 of file freyberg.pst: parameter name "prsity3004
2019-05-31 22:54:59.598745 pestcheck:12 characters long.
2019-05-31 22:54:59.598782 pestcheck:Line 2494 of file freyberg.pst: parameter name "prsity3004
2019-05-31 22:54:59.598879 pestcheck:once.
2019-05-31 22:54:59.598980 pestcheck:Line 2495 of file freyberg.pst: parameter name "prsity3004
2019-05-31 22:54:59.599027 pestcheck:12 characters long.
2019-05-31 22:54:59.599130 pestcheck:Line 2495 of file freyberg.pst: parameter name "prsity3004
2019-05-31 22:54:59.599234 pestcheck:once.
2019-05-31 22:54:59.599279 pestcheck:Line 2496 of file freyberg.pst: parameter name "prsity3004
2019-05-31 22:54:59.599316 pestcheck:12 characters long.
2019-05-31 22:54:59.599382 pestcheck:Line 2496 of file freyberg.pst: parameter name "prsity3004
2019-05-31 22:54:59.599469 pestcheck:once.
2019-05-31 22:54:59.599576 pestcheck:Line 2497 of file freyberg.pst: parameter name "prsity3004
2019-05-31 22:54:59.599614 pestcheck:12 characters long.
2019-05-31 22:54:59.599711 pestcheck:Line 2497 of file freyberg.pst: parameter name "prsity3004
2019-05-31 22:54:59.599813 pestcheck:once.
2019-05-31 22:54:59.599859 pestcheck:Line 2498 of file freyberg.pst: parameter name "prsity3004
2019-05-31 22:54:59.599897 pestcheck:12 characters long.
2019-05-31 22:54:59.599994 pestcheck:Line 2498 of file freyberg.pst: parameter name "prsity3004
2019-05-31 22:54:59.600096 pestcheck:once.
2019-05-31 22:54:59.600142 pestcheck:Line 2499 of file freyberg.pst: parameter name "prsity3004
2019-05-31 22:54:59.600180 pestcheck:12 characters long.
2019-05-31 22:54:59.600278 pestcheck:Line 2499 of file freyberg.pst: parameter name "prsity3004
2019-05-31 22:54:59.600380 pestcheck:once.
2019-05-31 22:54:59.600425 pestcheck:Line 2500 of file freyberg.pst: parameter name "prsity3004
2019-05-31 22:54:59.600464 pestcheck:12 characters long.
```

```
2019-05-31 22:54:59.600635 pestcheck:Line 2500 of file freyberg.pst: parameter name "prsity3004
2019-05-31 22:54:59.600682 pestcheck:once.
2019-05-31 22:54:59.600721 pestcheck:Line 2501 of file freyberg.pst: parameter name "prsity3004
2019-05-31 22:54:59.600819 pestcheck:12 characters long.
2019-05-31 22:54:59.600921 pestcheck:Line 2501 of file freyberg.pst: parameter name "prsity3004
2019-05-31 22:54:59.600967 pestcheck:once.
2019-05-31 22:54:59.601072 pestcheck:Line 2502 of file freyberg.pst: parameter name "prsity3004
2019-05-31 22:54:59.601174 pestcheck:12 characters long.
2019-05-31 22:54:59.601219 pestcheck:Line 2502 of file freyberg.pst: parameter name "prsity3004
2019-05-31 22:54:59.601258 pestcheck:once.
2019-05-31 22:54:59.601355 pestcheck:Line 2503 of file freyberg.pst: parameter name "prsity3005
2019-05-31 22:54:59.601456 pestcheck:12 characters long.
2019-05-31 22:54:59.601511 pestcheck:Line 2504 of file freyberg.pst: parameter name "prsity3005
2019-05-31 22:54:59.601608 pestcheck:12 characters long.
2019-05-31 22:54:59.601714 pestcheck:Line 2504 of file freyberg.pst: parameter name "prsity3005
2019-05-31 22:54:59.601760 pestcheck:once.
2019-05-31 22:54:59.601798 pestcheck:Line 2505 of file freyberg.pst: parameter name "prsity3005
2019-05-31 22:54:59.601895 pestcheck:12 characters long.
2019-05-31 22:54:59.601995 pestcheck:Line 2505 of file freyberg.pst: parameter name "prsity3005
2019-05-31 22:54:59.602041 pestcheck:once.
2019-05-31 22:54:59.602146 pestcheck:Line 2506 of file freyberg.pst: parameter name "prsity3005
2019-05-31 22:54:59.602248 pestcheck:12 characters long.
2019-05-31 22:54:59.602294 pestcheck:Line 2506 of file freyberg.pst: parameter name "prsity3005
2019-05-31 22:54:59.602333 pestcheck:once.
2019-05-31 22:54:59.602429 pestcheck:Line 2507 of file freyberg.pst: parameter name "prsity3005
2019-05-31 22:54:59.602540 pestcheck:12 characters long.
2019-05-31 22:54:59.602586 pestcheck:Line 2507 of file freyberg.pst: parameter name "prsity3005
2019-05-31 22:54:59.602624 pestcheck:once.
2019-05-31 22:54:59.602721 pestcheck:Line 2508 of file freyberg.pst: parameter name "prsity3005
2019-05-31 22:54:59.602822 pestcheck:12 characters long.
2019-05-31 22:54:59.603125 finished: running pestchek on freyberg.pst took: 0:00:00.145708
2019-05-31 22:54:59.603257 starting: saving intermediate _setup_<> dfs into template
2019-05-31 22:54:59.735630 finished: saving intermediate _setup_<> dfs into template took: 0:00
2019-05-31 22:54:59.735817 all done
```

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

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

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

Oh snap!

1.1.6 Add modpath input files, instruction files and calls

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

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

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

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

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

Create and add instruction files and related observations for MODPATH

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

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

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

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

1.1.7 Final bits and bobs

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

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

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

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

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

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

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

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

```
Out[21]:                       type transform  count       initial value  \
         cn_hk6              cn_hk6       log      1                   0
```

cn_hk7	cn_hk7	log	1	0
cn_hk8	cn_hk8	log	1	0
cn_prsity6	cn_prsity6	log	1	0
cn_prsity7	cn_prsity7	log	1	0
cn_prsity8	cn_prsity8	log	1	0
cn_rech4	cn_rech4	log	1	0
cn_rech5	cn_rech5	log	1	-0.39794
cn_ss6	cn_ss6	log	1	0
cn_ss7	cn_ss7	log	1	0
cn_ss8	cn_ss8	log	1	0
cn_strt6	cn_strt6	log	1	0
cn_strt7	cn_strt7	log	1	0
cn_strt8	cn_strt8	log	1	0
cn_sy6	cn_sy6	log	1	0
cn_sy7	cn_sy7	log	1	0
cn_sy8	cn_sy8	log	1	0
cn_vka6	cn_vka6	log	1	0
cn_vka7	cn_vka7	log	1	0
cn_vka8	cn_vka8	log	1	0
drncond_k00	drncond_k00	log	10	0
flow	flow	log	1	0
gr_hk3	gr_hk3	log	705	0
gr_hk4	gr_hk4	log	705	0
gr_hk5	gr_hk5	log	705	0
gr_prsity3	gr_prsity3	log	705	0
gr_prsity4	gr_prsity4	log	705	0
gr_prsity5	gr_prsity5	log	705	0
gr_rech2	gr_rech2	log	705	0
gr_rech3	gr_rech3	log	705	0
...	...	...	...	...
gr_strt5	gr_strt5	log	705	0
gr_sy3	gr_sy3	log	705	0
gr_sy4	gr_sy4	log	705	0
gr_sy5	gr_sy5	log	705	0
gr_vka3	gr_vka3	log	705	0
gr_vka4	gr_vka4	log	705	0
gr_vka5	gr_vka5	log	705	0
pp_hk0	pp_hk0	log	32	0
pp_hk1	pp_hk1	log	32	0
pp_hk2	pp_hk2	log	32	0
pp_prsity0	pp_prsity0	log	32	0
pp_prsity1	pp_prsity1	log	32	0
pp_prsity2	pp_prsity2	log	32	0
pp_rech0	pp_rech0	log	32	0
pp_rech1	pp_rech1	log	32	0
pp_ss0	pp_ss0	log	32	0
pp_ss1	pp_ss1	log	32	0
pp_ss2	pp_ss2	log	32	0

pp_strt0	pp_strt0	log	32	0
pp_strt1	pp_strt1	log	32	0
pp_strt2	pp_strt2	log	32	0
pp_sy0	pp_sy0	log	32	0
pp_sy1	pp_sy1	log	32	0
pp_sy2	pp_sy2	log	32	0
pp_vka0	pp_vka0	log	32	0
pp_vka1	pp_vka1	log	32	0
pp_vka2	pp_vka2	log	32	0
strk	strk	log	40	0
welflux	welflux	log	2	0 to 0.176091
welflux_k02	welflux_k02	log	6	0

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

```
      gr_sy5                 0.243038           -0.60206         0.211275
      gr_vka3                       1                 -1              0.5
      gr_vka4                       1                 -1              0.5
      gr_vka5                       1                 -1              0.5
      pp_hk0                        1                 -1              0.5
      pp_hk1                        1                 -1              0.5
      pp_hk2                        1                 -1              0.5
      pp_prsity0             0.176091           -0.30103          0.11928
      pp_prsity1             0.176091           -0.30103          0.11928
      pp_prsity2             0.176091           -0.30103          0.11928
      pp_rech0             0.0413927         -0.0457575        0.0217875
      pp_rech1             0.0413927         -0.0457575        0.0217875
      pp_ss0                        1                 -1              0.5
      pp_ss1                        1                 -1              0.5
      pp_ss2                        1                 -1              0.5
      pp_strt0             0.0211893         -0.0222764        0.0108664
      pp_strt1             0.0211893         -0.0222764        0.0108664
      pp_strt2             0.0211893         -0.0222764        0.0108664
      pp_sy0                 0.243038           -0.60206         0.211275
      pp_sy1                 0.243038           -0.60206         0.211275
      pp_sy2                 0.243038           -0.60206         0.211275
      pp_vka0                       1                 -1              0.5
      pp_vka1                       1                 -1              0.5
      pp_vka2                       1                 -1              0.5
      strk                          2                 -2                1
      welflux      0.176091 to 0.30103   -0.30103 to      0   0.0752575 to 0.11928
      welflux_k02                   1                 -1              0.5

      [65 rows x 7 columns]

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

Out[22]:                  group                         value   non-zero weight  \
      flaqx            flaqx             -977.239 to 32.171                84
      flout            flout               10069 to 226396                84
      flx_constan  flx_constan                           0                 2
      flx_drains    flx_drains          -723.325 to -723.028               2
      flx_in-out    flx_in-out          0.012695 to 0.046143               2
      flx_percent  flx_percent                           0                 2
      flx_recharg  flx_recharg                      3045.6                 2
      flx_storage  flx_storage            5.7734 to 8.01049               2
      flx_stream_  flx_stream_          -1430.27 to -1428.3               2
      flx_total     flx_total        0.0126953 to 0.0461426               2
      flx_wells     flx_wells                        -900                 2
      hds                 hds            32.5065 to 39.6612              4230
      obgnme           obgnme                       1E+10                 2
      vol_constan  vol_constan                           0                 2
      vol_drains    vol_drains  -2.90404E+06 to -2.64014E+06              2
```

```
       vol_in-out     vol_in-out                              45 to      63                      2
       vol_percent    vol_percent                                         0                      2
       vol_recharg    vol_recharg      1.11164E+07 to 1.22281E+07                                2
       vol_storage    vol_storage              29238.3 to 31345.6                                2
       vol_stream_    vol_stream_    -5.74182E+06 to -5.22049E+06                                2
       vol_total      vol_total                                45 to      63                      2
       vol_wells      vol_wells        -3.6135E+06 to -3.285E+06                                  2
```

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

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

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

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

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

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

```
            ax = plt.subplot(111)
            ax.imshow(cov)
            plt.show()
        except:
            pass
```

2019-05-31 22:55:09.020852 starting: building prior covariance matrix
2019-05-31 22:55:09.130325 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)
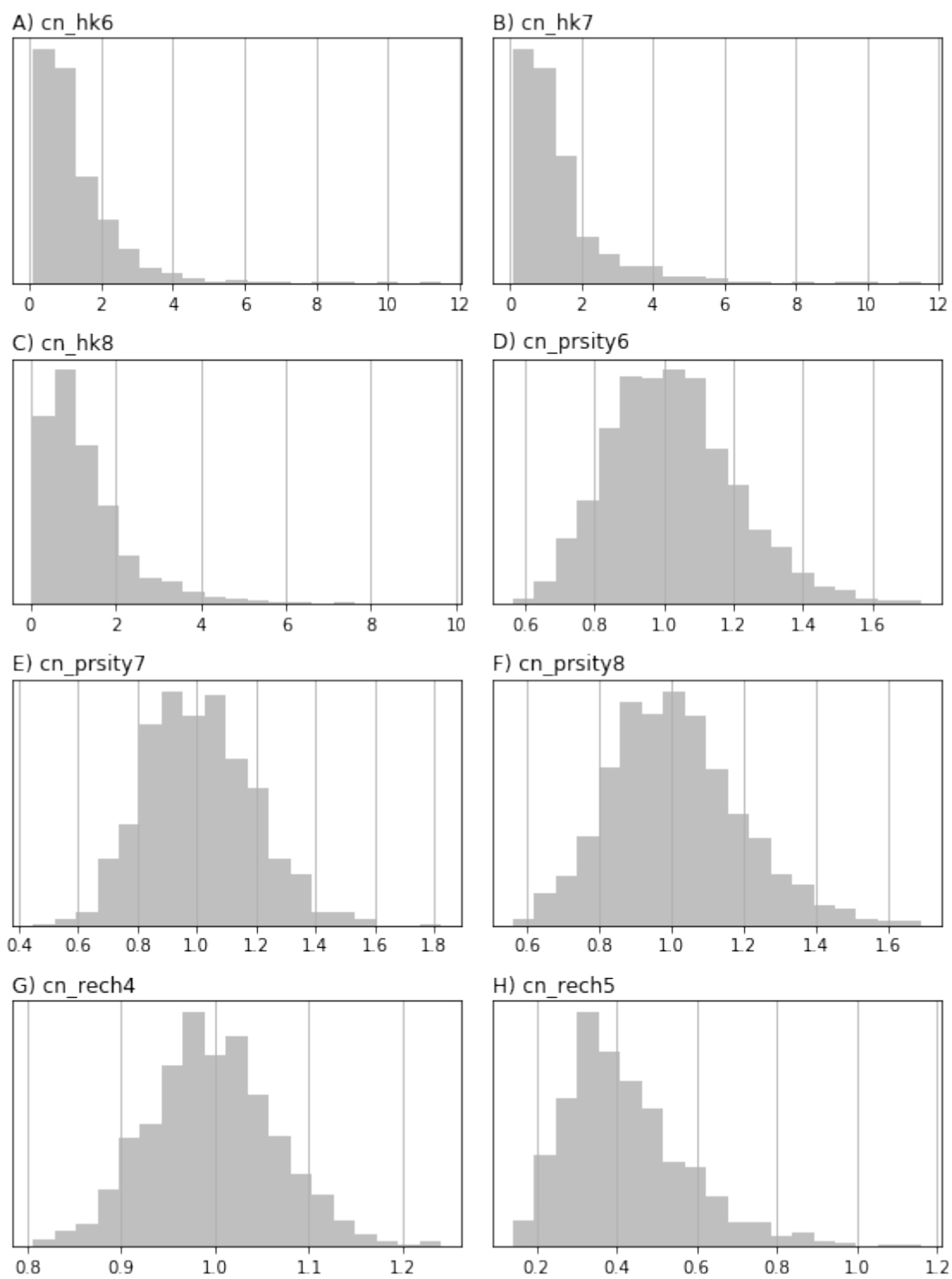/Users/jeremyw/miniconda3/lib/python3.5/site-packages/pandas/core/indexing.py:543: SettingWithC
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

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

2019-05-31 22:55:15.160590 saving prior covariance matrix to file template/prior_cov.jcb
2019-05-31 22:55:19.124823 finished: building prior covariance matrix took: 0:00:10.103971
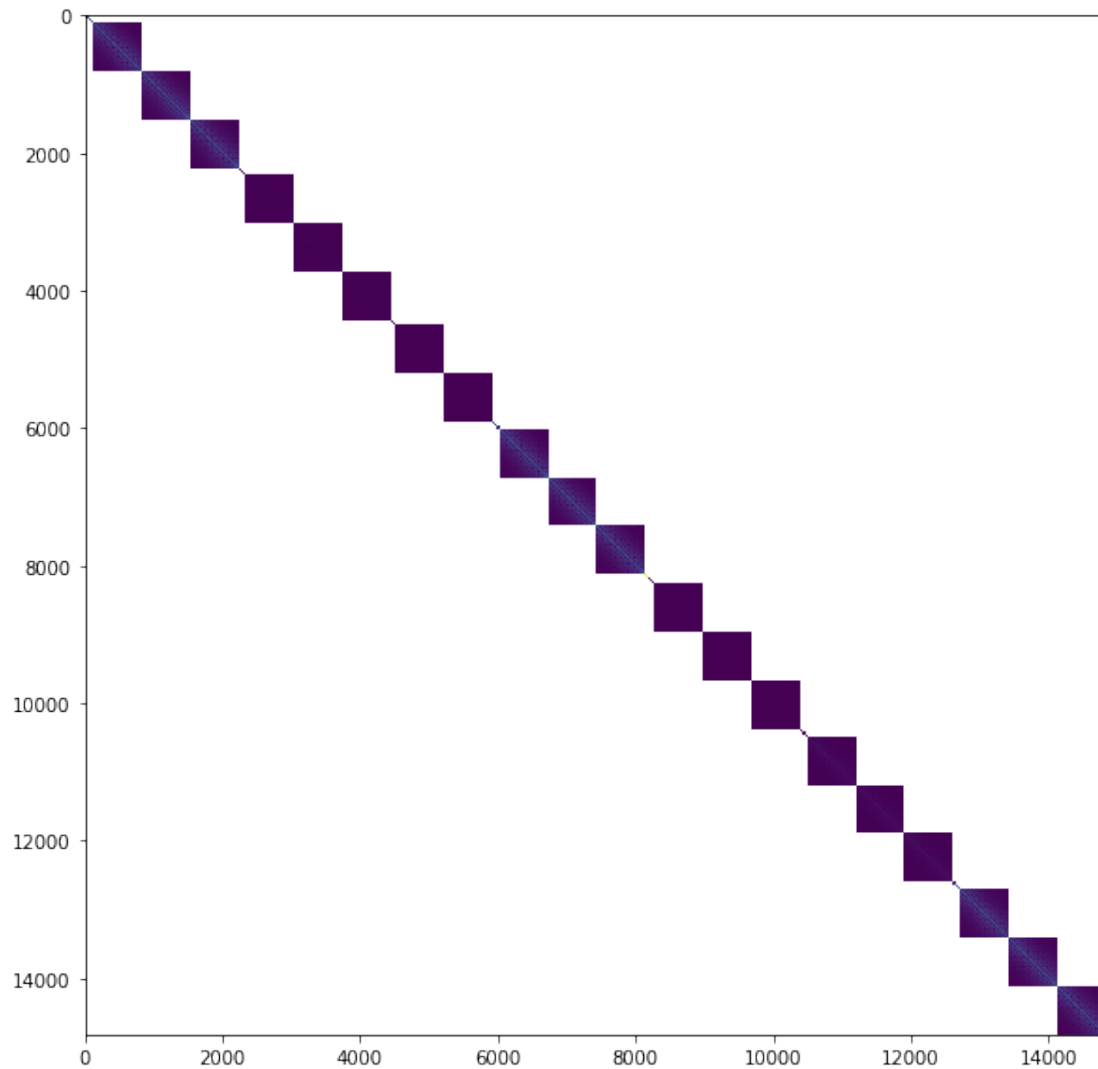
1.1.8 now we can make a draw from the prior parameter covariance matrix to form a prior parameter ensemble

```
In [25]: pe = pst_helper.draw(1000)

2019-05-31 22:55:30.355246 starting: drawing realizations
building diagonal cov
processing  name:grid_geostruct,nugget:0.0,structures:
name:var1,contribution:1.0,a:2500.0,anisotropy:1.0,bearing:0.0

working on pargroups ['gr_hk3']
build cov matrix
done
getting diag var cov 705
```

```
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_vka3']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_ss3']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_sy3']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_strt3']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_prsity3']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_hk4']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_vka4']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_ss4']
build cov matrix
done
getting diag var cov 705
```

```
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_sy4']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_strt4']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_prsity4']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_hk5']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_vka5']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_ss5']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_sy5']
build cov matrix
done
getting diag var cov 705
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['gr_strt5']
build cov matrix
done
getting diag var cov 705
```

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

working on pargroups ['pp_hk0']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_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_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_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_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_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_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_ss1']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_strt1']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_sy1']
```

```
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_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_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_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_ss2']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_strt2']
build cov matrix
done
getting diag var cov 32
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['pp_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_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
processing  name:spatial_list_geostruct,nugget:0.0,structures:
```

```
name:var1,contribution:1.0,a:2500.0,anisotropy:1.0,bearing:0.0

working on pargroups ['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: 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
processing  name:temporal_list_geostruct,nugget:0.0,structures:
name:var1,contribution:1.0,a:180.0,anisotropy:1.0,bearing:0.0

working on pargroups ['welflux']
build cov matrix
done
getting diag var cov 2
scaling full cov by diag var cov
making full cov draws with home-grown goodness
adding remaining parameters to diagonal
2019-05-31 22:55:43.586836 finished: drawing realizations took: 0:00:13.231590
```

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

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

A) cn_hk6
B) cn_hk7
C) cn_hk8
D) cn_prsity6
E) cn_prsity7
F) cn_prsity8
G) cn_rech4
H) cn_rech5
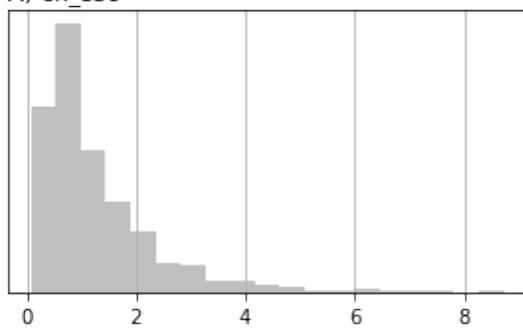
A) cn_ss6   B) cn_ss7
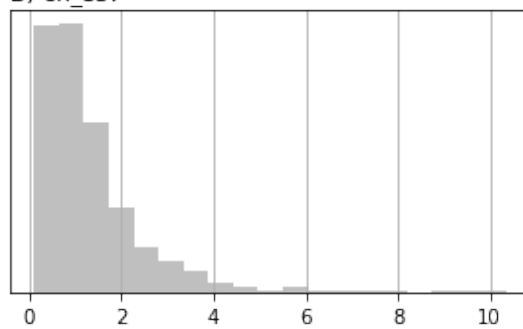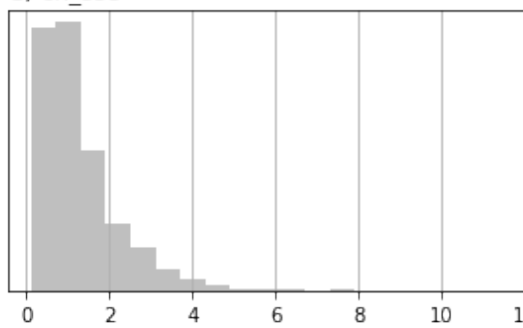
C) cn_ss8   D) cn_strt6
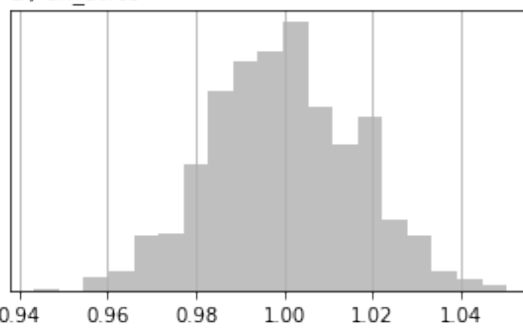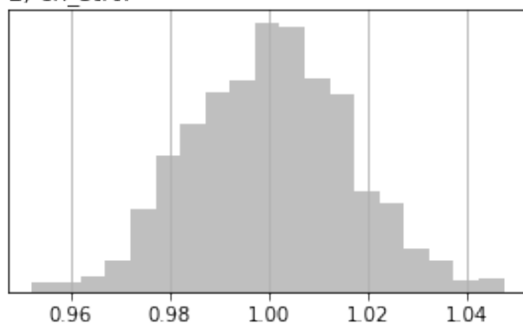
E) cn_strt7   F) cn_strt8
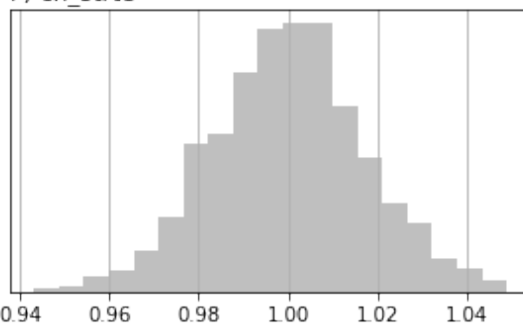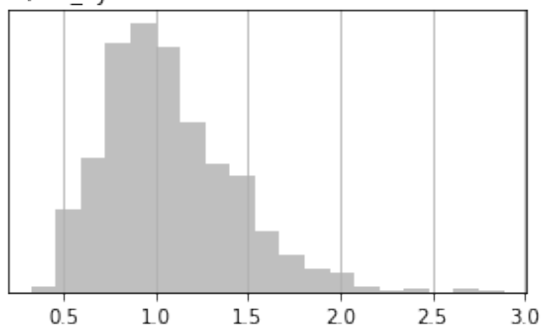
G) cn_sy6   H) cn_sy7
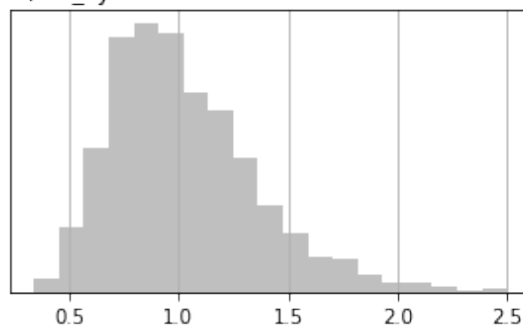
A) cn_sy8
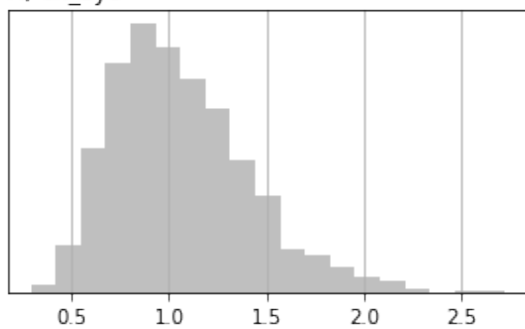
B) cn_vka6
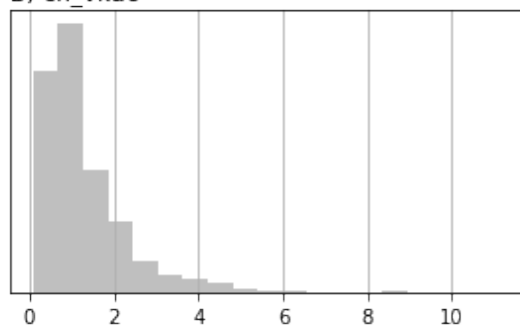
C) cn_vka7
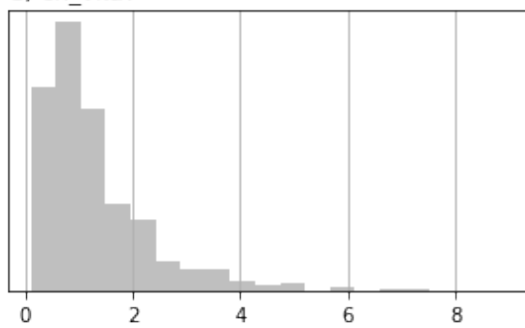
D) cn_vka8
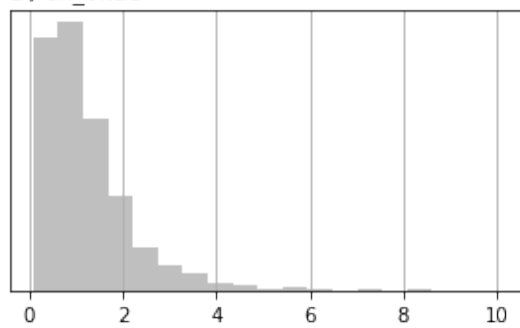
E) drncond_k00
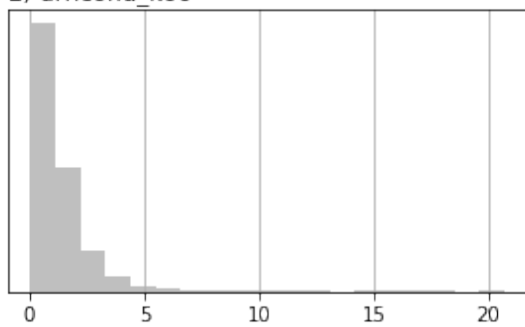
F) flow
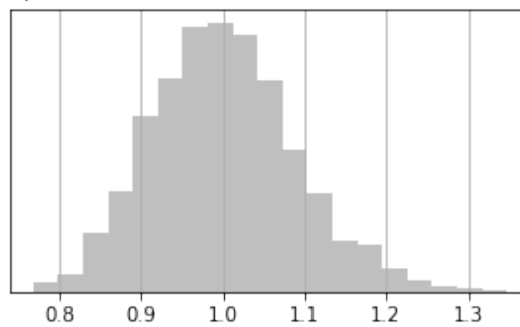
G) gr_hk3
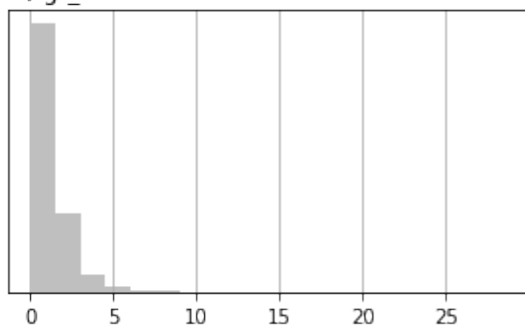
H) gr_hk4
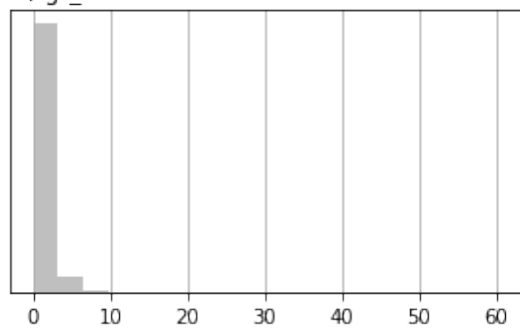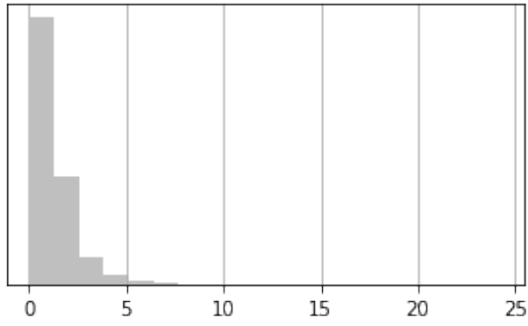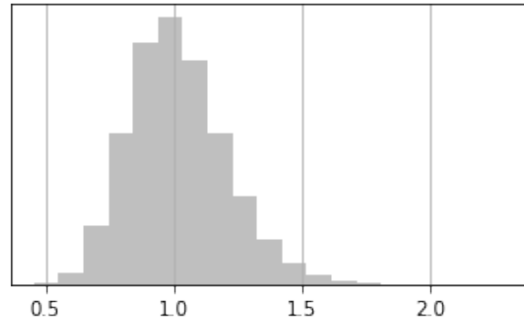
A) gr_hk5   B) gr_prsity3   C) gr_prsity4   D) gr_prsity5   E) gr_rech2   F) gr_rech3   G) gr_ss3   H) gr_ss4
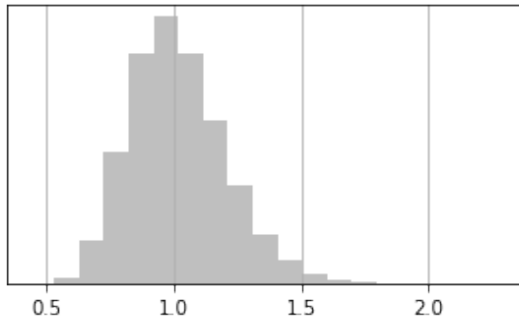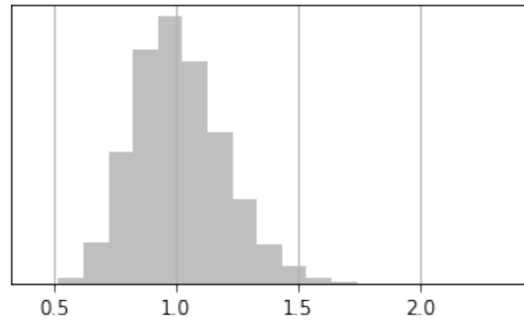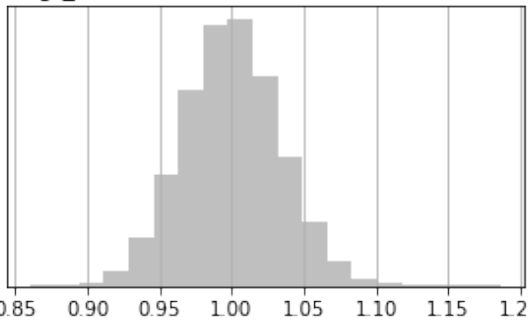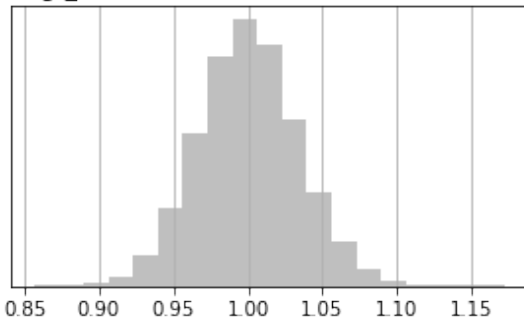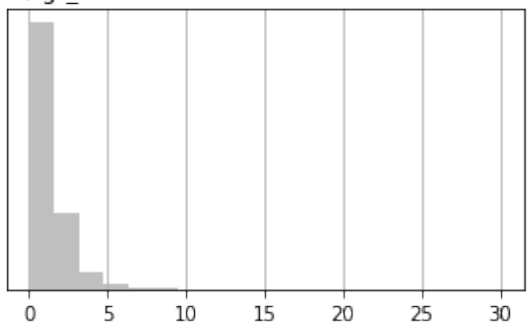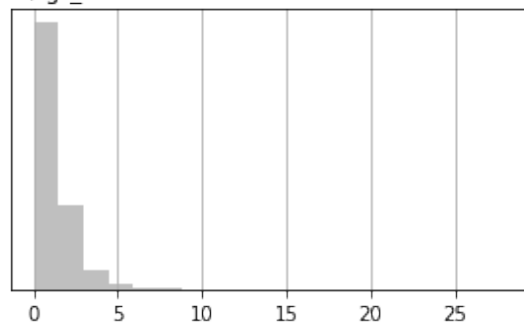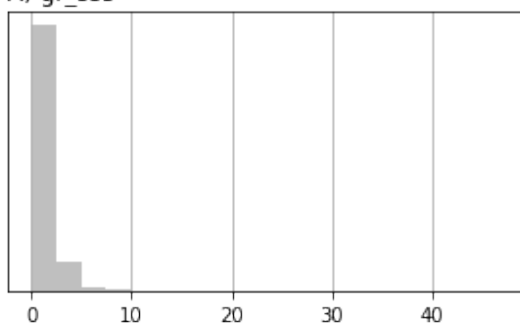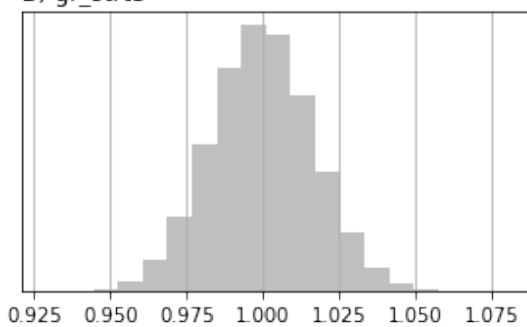
A) gr_ss5 B) gr_strt3 C) gr_strt4 D) gr_strt5 E) gr_sy3 F) gr_sy4 G) gr_sy5 H) gr_vka3
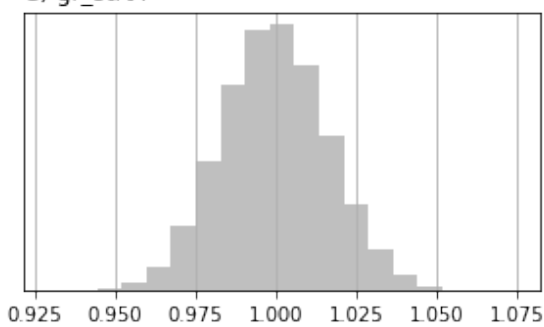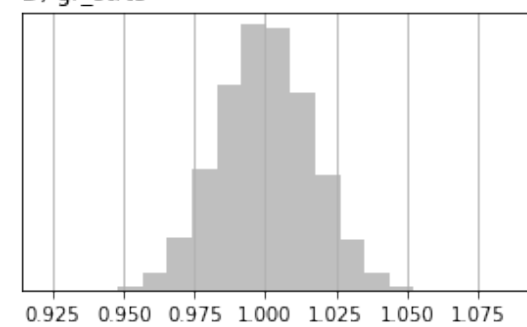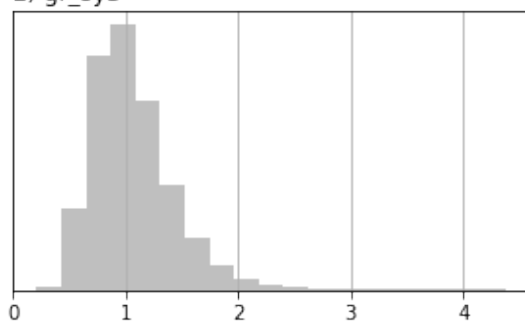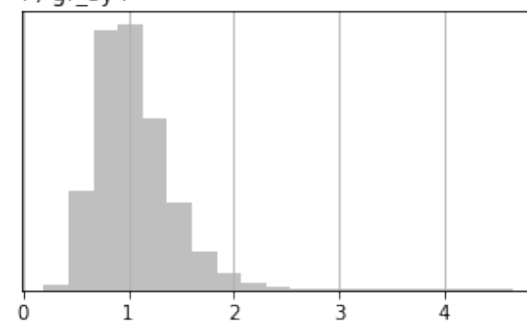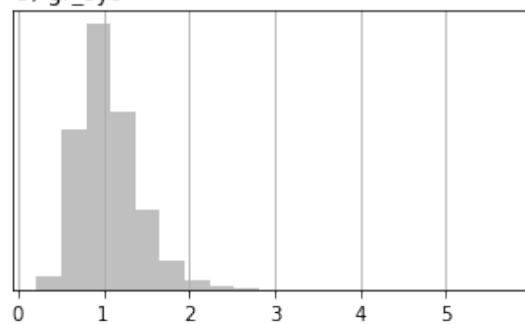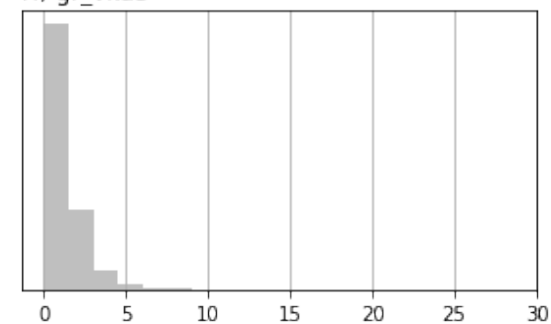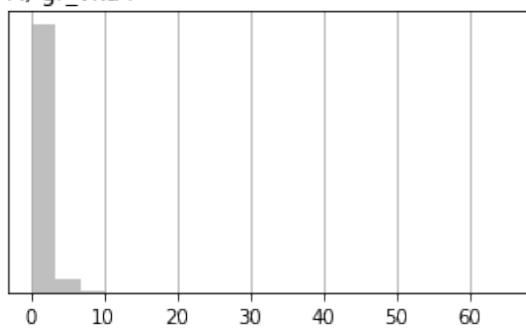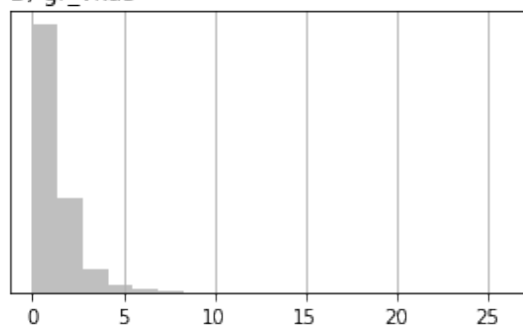
A) gr_vka4 B) gr_vka5 C) pp_hk0 D) pp_hk1 E) pp_hk2 F) pp_prsity0 G) pp_prsity1 H) pp_prsity2
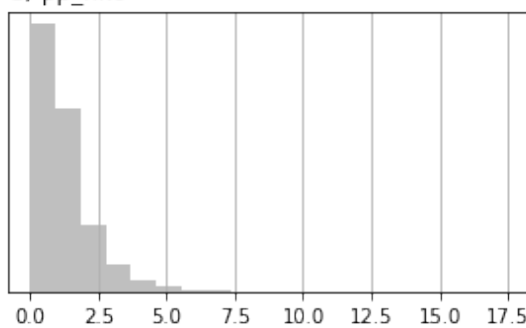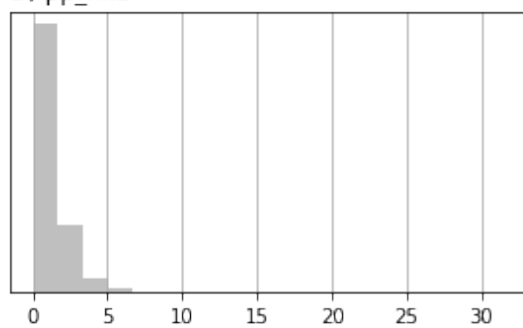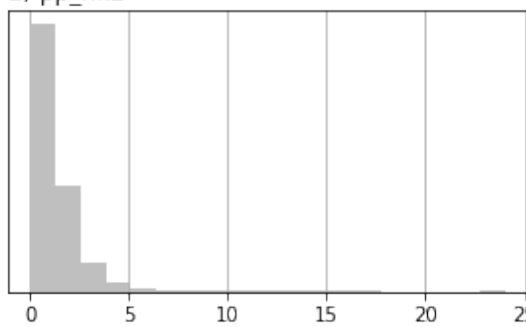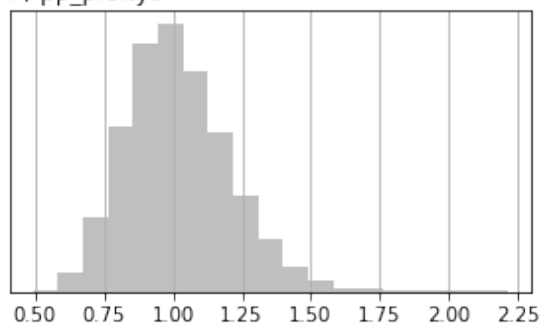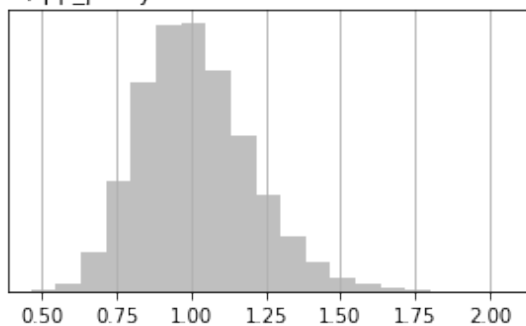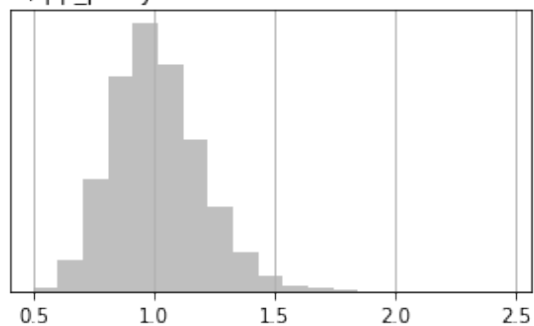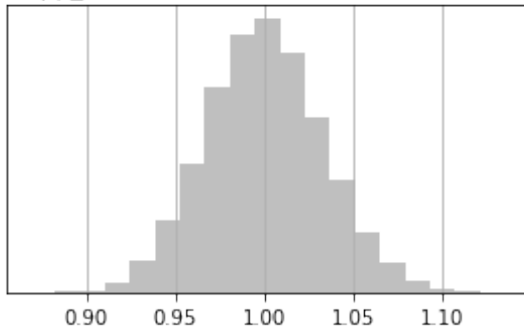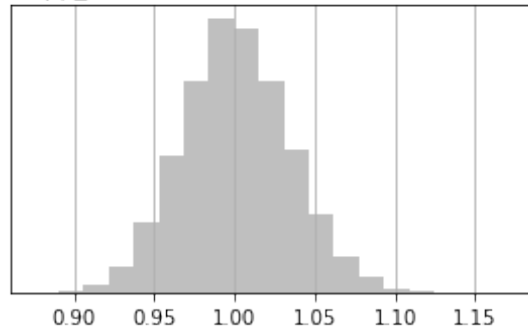
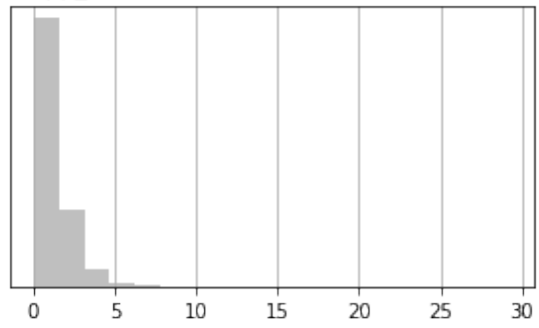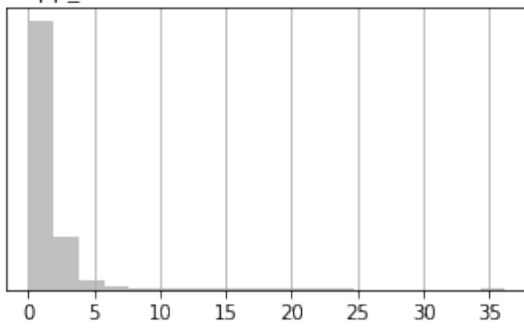A) pp_rech0 B) pp_rech1 C) pp_ss0 D) pp_ss1 E) pp_ss2 F) pp_strt0 G) pp_strt1 H) pp_strt2
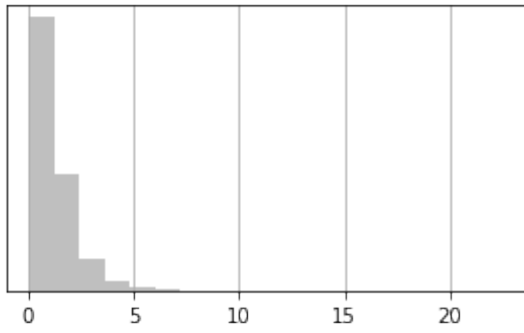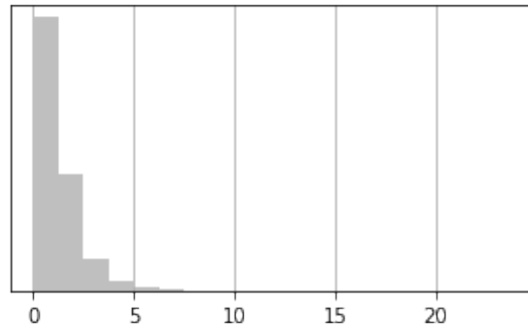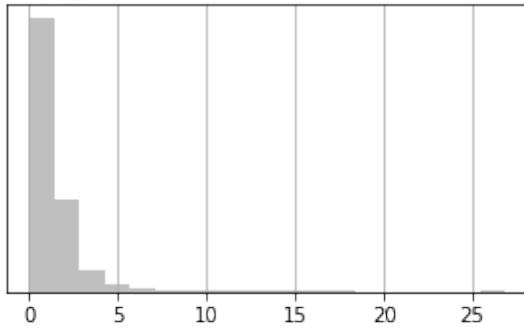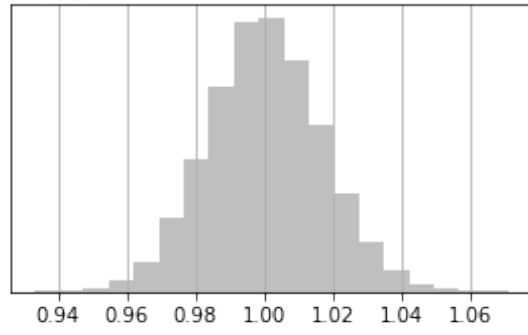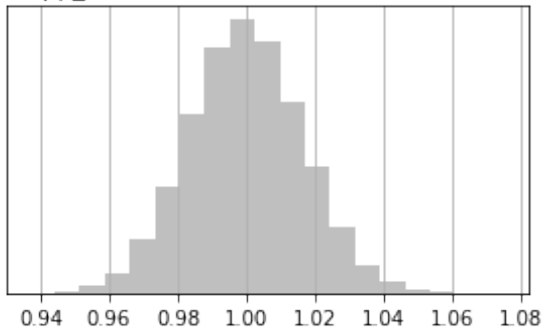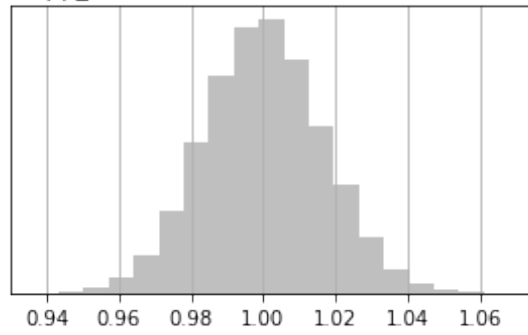
A) pp_sy0
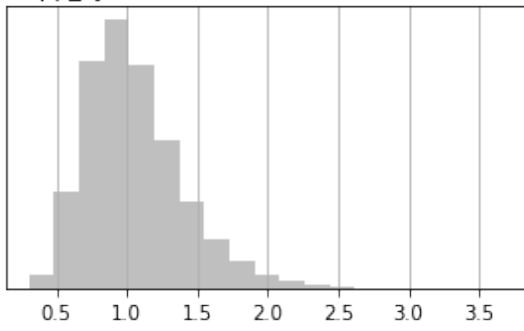
B) pp_sy1
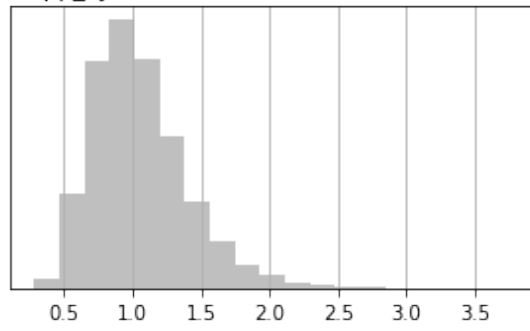
C) pp_sy2
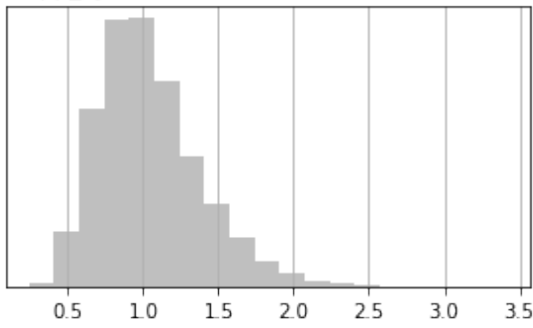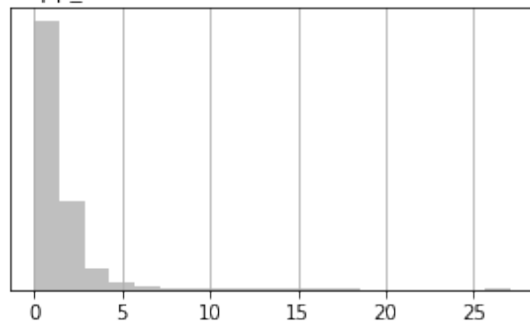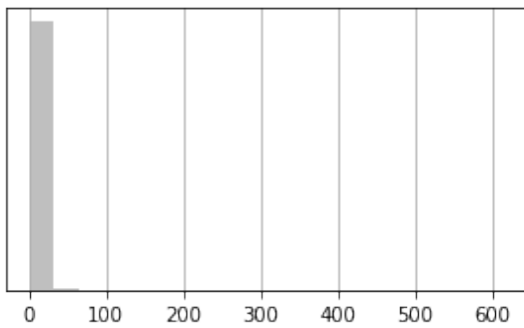
D) pp_vka0

E) pp_vka1

F) pp_vka2

G) strk

H) welflux
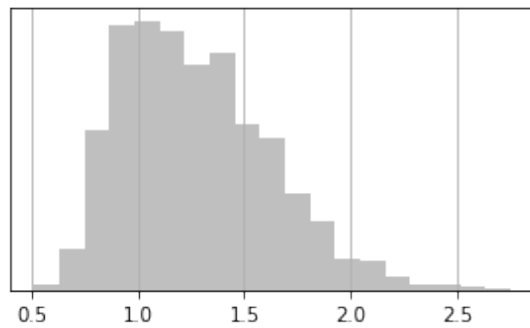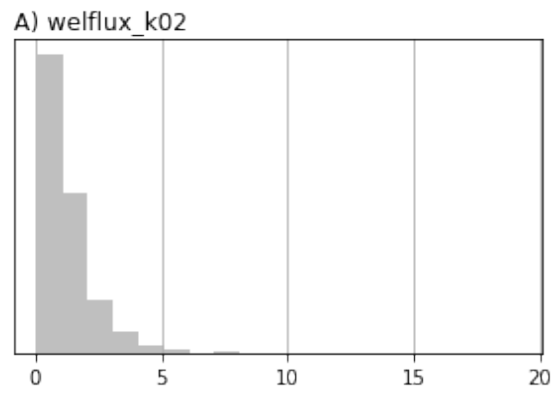
A) welflux_k02

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

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

```
In [28]: pe.iloc[-1,-1]

Out[28]: 1.2795487817916409
```

1.1.9 set weights for "observations" and identify forecasts

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

```
In [29]: 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[29]:     row  col              obsnme
         0     3   16  hds_00_002_015_000
         1     3   10  hds_00_002_009_000
         2     4    9  hds_00_003_008_000
         3    10    2  hds_00_009_001_000
         4    14   11  hds_00_013_010_000
         5    16   17  hds_00_015_016_000
         6    22   11  hds_00_021_010_000
         7    23   16  hds_00_022_015_000
         8    25    5  hds_00_024_004_000
         9    27    7  hds_00_026_006_000
         10   30   16  hds_00_029_015_000
         11   34    8  hds_00_033_007_000
         12   35   11  hds_00_034_010_000
```

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

```
In [30]: 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[30]: ['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 [31]: swgw_forecasts = obs.loc[obs.obsnme.apply(lambda x: "fa" in x and ("hw" in x or "tw" i
         print(swgw_forecasts)
         hds_fore_name = "hds_00_{0:03d}_{1:03d}".format(int(pst_helper.m.nrow/3),int(pst_helpe
         hds_forecasts = obs.loc[obs.obsnme.apply(lambda x: hds_fore_name in x),"obsnme"].tolis
         forecasts = swgw_forecasts
         forecasts.extend(hds_forecasts)
         forecasts.append("part_time")
         forecasts.append("part_status")
         pst_helper.pst.pestpp_options["forecasts"] = forecasts
         pst.write(os.path.join(pst_helper.new_model_ws,"freyberg.pst"))
```

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

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

```
In [32]: 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
```
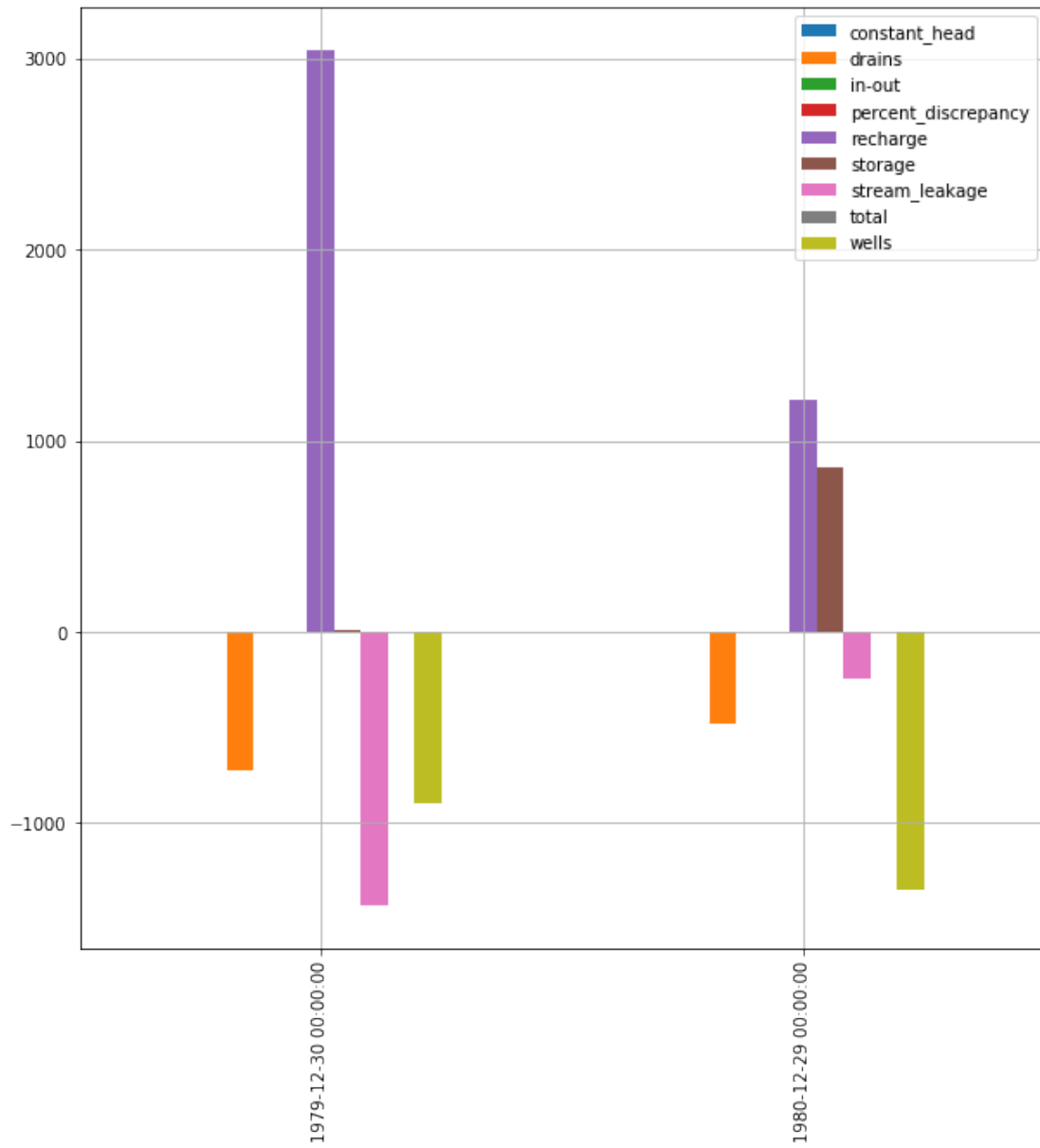
```
Out[32]: 9.456182577320024e-19
```

```
In [33]: lst = flopy.utils.MfListBudget(os.path.join("template","freyberg.list"))
         df = lst.get_dataframes(diff=True)[0]
         df.plot(kind="bar",figsize=(10,10), grid=True)
         plt.show()
```

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