

setup_pest_interface

May 14, 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"
```

```

# 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 dependencies (both python and executables) in the right p
prep_deps.prep_template(t_d="temp")

```

```

changing model workspace...
temp

```

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

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

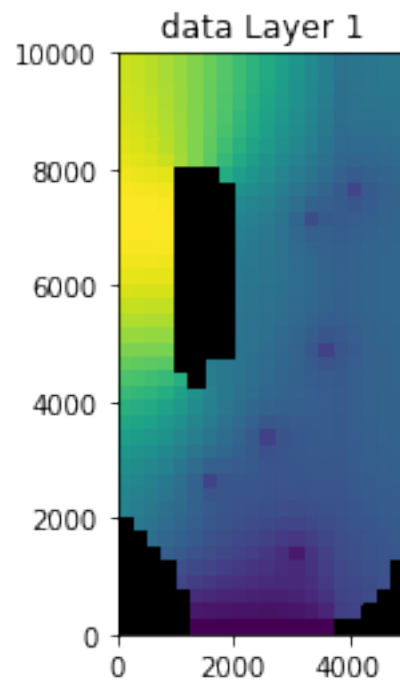
```
In [5]: pyemu.os_utils.run("{0} {1}".format("mfnewt",m.name+".nam"),cwd=m.model_ws)
```

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

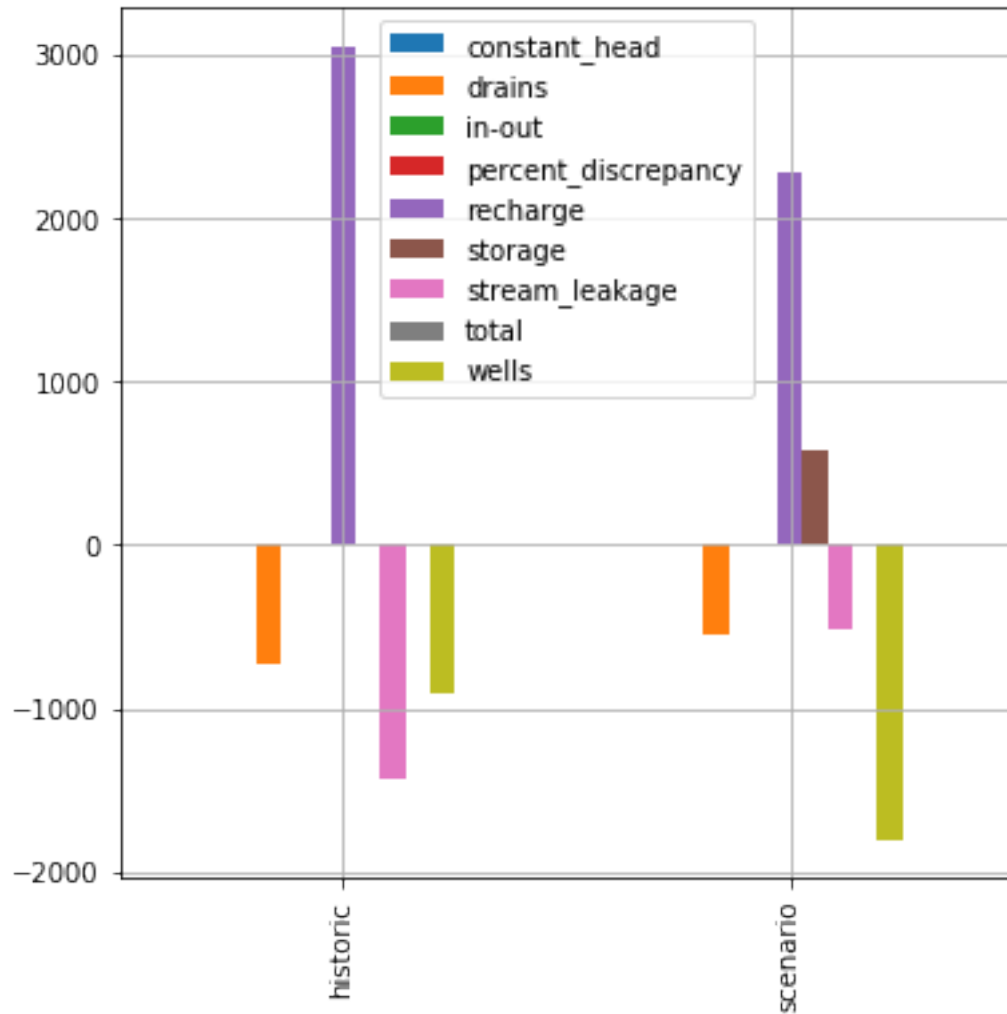
Note that there is a historic period and a scenario with future conditions that differ. For the future scenario, recharge is lower and pumping/abstraction is increased to make up for the presumed deficit in water for agriculture.

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

```



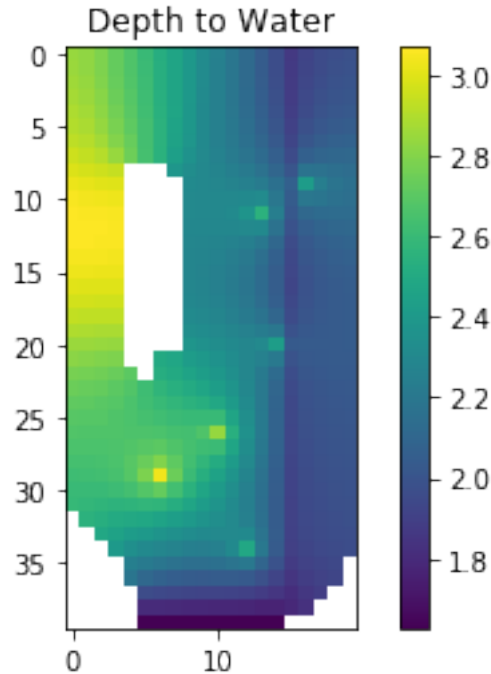
<Figure size 432x288 with 0 Axes>



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

1.0.5 Plot depth to water

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

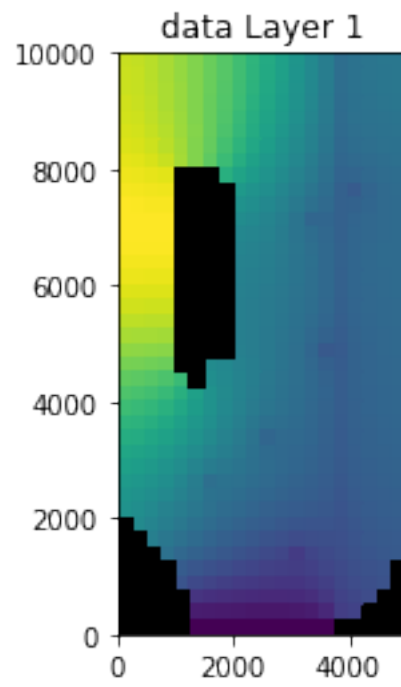


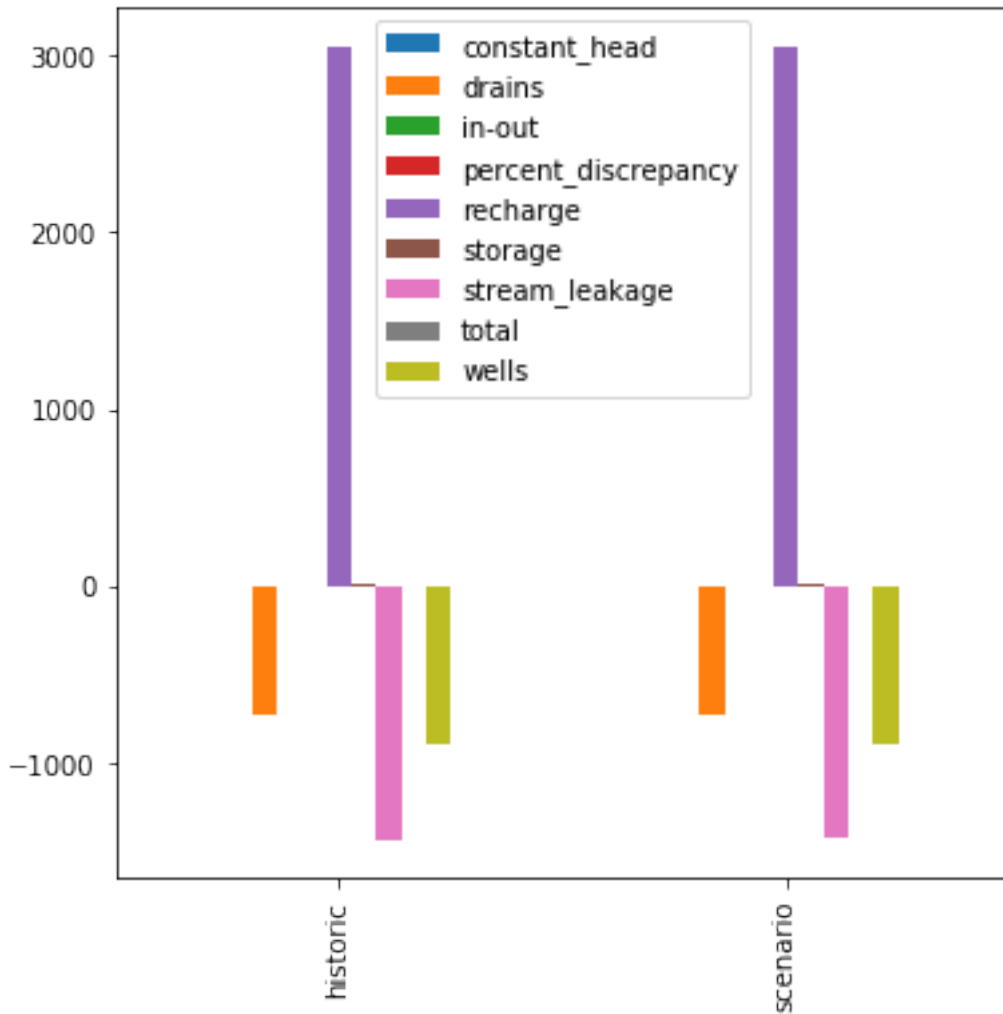
Clearly we can see the river and well locations expressed in the depth to water pattern.

1.0.6 What we are going to do is implement the scenario with parameters so we can more easily account for the stochastic nature of the forcing conditions during the scenario stress period and also make implementation 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("mfntw", 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(mflag=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()
```





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_model=
                                                    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)
```


2019-05-14 14:55:37.218453 starting: loading floppy 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 'flopymodflow.mfwel.ModflowWel'> for kper    1
    loading <class 'flopymodflow.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 'flopymodflow.mfdrn.ModflowDrn'> for kper    1
    loading <class 'flopymodflow.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
2019-05-14 14:55:37.252539 finished: loading flopy model took: 0:00:00.034086
2019-05-14 14:55:37.252701 starting: updating model attributes
2019-05-14 14:55:37.252796 finished: updating model attributes took: 0:00:00.000095
2019-05-14 14:55:37.252877 WARNING: removing existing 'new_model_ws

creating model workspace...
    template

changing model workspace...
    template
2019-05-14 14:55:38.332036 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

2019-05-14 14:55:38.485786 finished: writing new modflow input files took: 0:00:00.153750

2019-05-14 14:55:38.486355 forward_run line:pyemu.os_utils.run('mf nwt freyberg.nam 1>freyberg.

2019-05-14 14:55:38.486605 starting: setting up 'template/arr_org' dir

2019-05-14 14:55:38.487162 finished: setting up 'template/arr_org' dir took: 0:00:00.000557

2019-05-14 14:55:38.487496 starting: setting up 'template/arr_mlt' dir

2019-05-14 14:55:38.487906 finished: setting up 'template/arr_mlt' dir took: 0:00:00.000410

2019-05-14 14:55:38.488207 starting: setting up 'template/list_org' dir

2019-05-14 14:55:38.488537 finished: setting up 'template/list_org' dir took: 0:00:00.000330

2019-05-14 14:55:38.488894 starting: setting up 'template/list_mlt' dir

2019-05-14 14:55:38.489591 finished: setting up 'template/list_mlt' dir took: 0:00:00.000697

2019-05-14 14:55:38.489995 starting: processing temporal_list_props

2019-05-14 14:55:38.513640 finished: processing temporal_list_props took: 0:00:00.023645

2019-05-14 14:55:38.514079 starting: processing spatial_list_props

2019-05-14 14:55:38.611137 finished: processing spatial_list_props took: 0:00:00.097058

2019-05-14 14:55:38.680036 forward_run line:pyemu.helpers.apply_list_pars()

2019-05-14 14:55:38.718728 'extra' pak detected:extra.prsity

2019-05-14 14:55:38.768269 'extra' pak detected:extra.prsity

2019-05-14 14:55:38.818596 'extra' pak detected:extra.prsity

2019-05-14 14:55:38.878234 'extra' pak detected:extra.prsity

2019-05-14 14:55:38.917141 'extra' pak detected:extra.prsity

2019-05-14 14:55:38.955149 'extra' pak detected:extra.prsity

2019-05-14 14:55:39.005895 'extra' pak detected:extra.prsity

2019-05-14 14:55:39.044953 'extra' pak detected:extra.prsity

2019-05-14 14:55:39.082386 'extra' pak detected:extra.prsity

2019-05-14 14:55:39.173054 starting: writing grid tpl:hk3.dat_gr.tpl

2019-05-14 14:55:39.182817 finished: writing grid tpl:hk3.dat_gr.tpl took: 0:00:00.009763

2019-05-14 14:55:39.185657 starting: writing grid tpl:vka3.dat_gr.tpl

2019-05-14 14:55:39.195956 finished: writing grid tpl:vka3.dat_gr.tpl took: 0:00:00.010299

2019-05-14 14:55:39.198663 starting: writing grid tpl:ss3.dat_gr.tpl

2019-05-14 14:55:39.209740 finished: writing grid tpl:ss3.dat_gr.tpl took: 0:00:00.011077

2019-05-14 14:55:39.212728 starting: writing grid tpl:sy3.dat_gr.tpl

2019-05-14 14:55:39.223040 finished: writing grid tpl:sy3.dat_gr.tpl took: 0:00:00.010312

2019-05-14 14:55:39.226550 starting: writing grid tpl:str3.dat_gr.tpl

2019-05-14 14:55:39.236358 finished: writing grid tpl:str3.dat_gr.tpl took: 0:00:00.009808

2019-05-14 14:55:39.240424 starting: writing grid tpl:prsity3.dat_gr.tpl

2019-05-14 14:55:39.253321 finished: writing grid tpl:prsity3.dat_gr.tpl took: 0:00:00.012897

2019-05-14 14:55:39.257365 starting: writing grid tpl:hk4.dat_gr.tpl

2019-05-14 14:55:39.267637 finished: writing grid tpl:hk4.dat_gr.tpl took: 0:00:00.010272

2019-05-14 14:55:39.270596 starting: writing grid tpl:vka4.dat_gr.tpl
 2019-05-14 14:55:39.280718 finished: writing grid tpl:vka4.dat_gr.tpl took: 0:00:00.010122
 2019-05-14 14:55:39.283618 starting: writing grid tpl:ss4.dat_gr.tpl
 2019-05-14 14:55:39.294734 finished: writing grid tpl:ss4.dat_gr.tpl took: 0:00:00.011116
 2019-05-14 14:55:39.297503 starting: writing grid tpl:sy4.dat_gr.tpl
 2019-05-14 14:55:39.308909 finished: writing grid tpl:sy4.dat_gr.tpl took: 0:00:00.011406
 2019-05-14 14:55:39.311848 starting: writing grid tpl:strt4.dat_gr.tpl
 2019-05-14 14:55:39.321759 finished: writing grid tpl:strt4.dat_gr.tpl took: 0:00:00.009911
 2019-05-14 14:55:39.325458 starting: writing grid tpl:prsity4.dat_gr.tpl
 2019-05-14 14:55:39.338046 finished: writing grid tpl:prsity4.dat_gr.tpl took: 0:00:00.012588
 2019-05-14 14:55:39.341901 starting: writing grid tpl:hk5.dat_gr.tpl
 2019-05-14 14:55:39.352074 finished: writing grid tpl:hk5.dat_gr.tpl took: 0:00:00.010173
 2019-05-14 14:55:39.355897 starting: writing grid tpl:vka5.dat_gr.tpl
 2019-05-14 14:55:39.366370 finished: writing grid tpl:vka5.dat_gr.tpl took: 0:00:00.010473
 2019-05-14 14:55:39.369324 starting: writing grid tpl:ss5.dat_gr.tpl
 2019-05-14 14:55:39.380002 finished: writing grid tpl:ss5.dat_gr.tpl took: 0:00:00.010678
 2019-05-14 14:55:39.382817 starting: writing grid tpl:sy5.dat_gr.tpl
 2019-05-14 14:55:39.393772 finished: writing grid tpl:sy5.dat_gr.tpl took: 0:00:00.010955
 2019-05-14 14:55:39.396712 starting: writing grid tpl:strt5.dat_gr.tpl
 2019-05-14 14:55:39.406986 finished: writing grid tpl:strt5.dat_gr.tpl took: 0:00:00.010274
 2019-05-14 14:55:39.410667 starting: writing grid tpl:prsity5.dat_gr.tpl
 2019-05-14 14:55:39.423900 finished: writing grid tpl:prsity5.dat_gr.tpl took: 0:00:00.013233
 2019-05-14 14:55:39.427069 starting: writing grid tpl:rech2.dat_gr.tpl
 2019-05-14 14:55:39.436888 finished: writing grid tpl:rech2.dat_gr.tpl took: 0:00:00.009819
 2019-05-14 14:55:39.440847 starting: writing grid tpl:rech3.dat_gr.tpl
 2019-05-14 14:55:39.450785 finished: writing grid tpl:rech3.dat_gr.tpl took: 0:00:00.009938
 2019-05-14 14:55:39.453854 starting: writing const tpl:hk6.dat_cn.tpl
 2019-05-14 14:55:39.461556 finished: writing const tpl:hk6.dat_cn.tpl took: 0:00:00.007702
 2019-05-14 14:55:39.464403 starting: writing const tpl:vka6.dat_cn.tpl
 2019-05-14 14:55:39.470488 finished: writing const tpl:vka6.dat_cn.tpl took: 0:00:00.006085
 2019-05-14 14:55:39.474589 starting: writing const tpl:ss6.dat_cn.tpl
 2019-05-14 14:55:39.481434 finished: writing const tpl:ss6.dat_cn.tpl took: 0:00:00.006845
 2019-05-14 14:55:39.484228 starting: writing const tpl:sy6.dat_cn.tpl
 2019-05-14 14:55:39.491976 finished: writing const tpl:sy6.dat_cn.tpl took: 0:00:00.007748
 2019-05-14 14:55:39.494879 starting: writing const tpl:strt6.dat_cn.tpl
 2019-05-14 14:55:39.501046 finished: writing const tpl:strt6.dat_cn.tpl took: 0:00:00.006167
 2019-05-14 14:55:39.503964 starting: writing const tpl:prsity6.dat_cn.tpl
 2019-05-14 14:55:39.511144 finished: writing const tpl:prsity6.dat_cn.tpl took: 0:00:00.007180
 2019-05-14 14:55:39.513919 starting: writing const tpl:hk7.dat_cn.tpl
 2019-05-14 14:55:39.519955 finished: writing const tpl:hk7.dat_cn.tpl took: 0:00:00.006036
 2019-05-14 14:55:39.524278 starting: writing const tpl:vka7.dat_cn.tpl
 2019-05-14 14:55:39.531001 finished: writing const tpl:vka7.dat_cn.tpl took: 0:00:00.006723
 2019-05-14 14:55:39.533839 starting: writing const tpl:ss7.dat_cn.tpl
 2019-05-14 14:55:39.541754 finished: writing const tpl:ss7.dat_cn.tpl took: 0:00:00.007915
 2019-05-14 14:55:39.545008 starting: writing const tpl:sy7.dat_cn.tpl
 2019-05-14 14:55:39.551459 finished: writing const tpl:sy7.dat_cn.tpl took: 0:00:00.006451
 2019-05-14 14:55:39.554600 starting: writing const tpl:strt7.dat_cn.tpl
 2019-05-14 14:55:39.561953 finished: writing const tpl:strt7.dat_cn.tpl took: 0:00:00.007353

```

2019-05-14 14:55:39.564866 starting: writing const tpl:prsity7.dat_cn.tpl
2019-05-14 14:55:39.571374 finished: writing const tpl:prsity7.dat_cn.tpl took: 0:00:00.006508
2019-05-14 14:55:39.575415 starting: writing const tpl:hk8.dat_cn.tpl
2019-05-14 14:55:39.581835 finished: writing const tpl:hk8.dat_cn.tpl took: 0:00:00.006420
2019-05-14 14:55:39.584772 starting: writing const tpl:vka8.dat_cn.tpl
2019-05-14 14:55:39.592607 finished: writing const tpl:vka8.dat_cn.tpl took: 0:00:00.007835
2019-05-14 14:55:39.595764 starting: writing const tpl:ss8.dat_cn.tpl
2019-05-14 14:55:39.601908 finished: writing const tpl:ss8.dat_cn.tpl took: 0:00:00.006144
2019-05-14 14:55:39.605020 starting: writing const tpl:sy8.dat_cn.tpl
2019-05-14 14:55:39.612589 finished: writing const tpl:sy8.dat_cn.tpl took: 0:00:00.007569
2019-05-14 14:55:39.615403 starting: writing const tpl:strt8.dat_cn.tpl
2019-05-14 14:55:39.622554 finished: writing const tpl:strt8.dat_cn.tpl took: 0:00:00.007151
2019-05-14 14:55:39.626192 starting: writing const tpl:prsity8.dat_cn.tpl
2019-05-14 14:55:39.632903 finished: writing const tpl:prsity8.dat_cn.tpl took: 0:00:00.006711
2019-05-14 14:55:39.635663 starting: writing const tpl:rech4.dat_cn.tpl
2019-05-14 14:55:39.643553 finished: writing const tpl:rech4.dat_cn.tpl took: 0:00:00.007890
2019-05-14 14:55:39.646290 starting: writing const tpl:rech5.dat_cn.tpl
2019-05-14 14:55:39.652073 finished: writing const tpl:rech5.dat_cn.tpl took: 0:00:00.005783
2019-05-14 14:55:39.680082 starting: setting up pilot point process
2019-05-14 14:55:39.680583 WARNING: pp_geostrcut is None, using ExpVario with contribution=1 and
2019-05-14 14:55:39.683408 pp_dict: {0: ['hk0', 'prsity0', 'rech0', 'rech1', 'ss0', 'strt0', 'sy0', 'vka0', 'hk1', 'sy1', 'rech2', 'rech3', 'ss1', 'strt1', 'sy2', 'vka1', 'hk2', 'sy3', 'rech4', 'rech5', 'ss2', 'strt2', 'sy4', 'vka2', 'hk3', 'sy5', 'rech6', 'rech7', 'ss3', 'strt3', 'sy6', 'vka3', 'hk4', 'sy7', 'rech8', 'rech9', 'ss4', 'strt4', 'sy8', 'vka4', 'hk5', 'sy9', 'rech10', 'rech11', 'ss5', 'strt5', 'sy10', 'vka5', 'hk6', 'sy11', 'rech12', 'rech13', 'ss6', 'strt6', 'sy12', 'vka6', 'hk7', 'sy13', 'rech14', 'rech15', 'ss7', 'strt7', 'sy14', 'vka7', 'hk8', 'sy15', 'rech16', 'rech17', 'ss8', 'strt8', 'sy16', 'vka8', 'hk9', 'sy17', 'rech18', 'rech19', 'ss9', 'strt9', 'sy18', 'vka9', 'hk10', 'sy19', 'rech20', 'rech21', 'ss10', 'strt10', 'sy20', 'vka10', 'hk11', 'sy21', 'rech22', 'rech23', 'ss11', 'strt11', 'sy22', 'vka11', 'hk12', 'sy23', 'rech24', 'rech25', 'ss12', 'strt12', 'sy24', 'vka12', 'hk13', 'sy25', 'rech26', 'rech27', 'ss13', 'strt13', 'sy26', 'vka13', 'hk14', 'sy27', 'rech28', 'rech29', 'ss14', 'strt14', 'sy28', 'vka14', 'hk15', 'sy29', 'rech30', 'rech31', 'ss15', 'strt15', 'sy30', 'vka15', 'hk16', 'sy31', 'rech32', 'rech33', 'ss16', 'strt16', 'sy32', 'vka16', 'hk17', 'sy33', 'rech34', 'rech35', 'ss17', 'strt17', 'sy34', 'vka17', 'hk18', 'sy35', 'rech36', 'rech37', 'ss18', 'strt18', 'sy36', 'vka18', 'hk19', 'sy37', 'rech38', 'rech39', 'ss19', 'strt19', 'sy38', 'vka19', 'hk20', 'sy39', 'rech40', 'rech41', 'ss20', 'strt20', 'sy40', 'vka20', 'hk21', 'sy41', 'rech42', 'rech43', 'ss21', 'strt21', 'sy42', 'vka21', 'hk22', 'sy43', 'rech44', 'rech45', 'ss22', 'strt22', 'sy44', 'vka22', 'hk23', 'sy45', 'rech46', 'rech47', 'ss23', 'strt23', 'sy46', 'vka23', 'hk24', 'sy47', 'rech48', 'rech49', 'ss24', 'strt24', 'sy48', 'vka24', 'hk25', 'sy49', 'rech50', 'rech51', 'ss25', 'strt25', 'sy50', 'vka25', 'hk26', 'sy51', 'rech52', 'rech53', 'ss26', 'strt26', 'sy52', 'vka26', 'hk27', 'sy53', 'rech54', 'rech55', 'ss27', 'strt27', 'sy54', 'vka27', 'hk28', 'sy55', 'rech56', 'rech57', 'ss28', 'strt28', 'sy56', 'vka28', 'hk29', 'sy57', 'rech58', 'rech59', 'ss29', 'strt29', 'sy58', 'vka29', 'hk30', 'sy59', 'rech60', 'rech61', 'ss30', 'strt30', 'sy60', 'vka30', 'hk31', 'sy61', 'rech62', 'rech63', 'ss31', 'strt31', 'sy62', 'vka31', 'hk32', 'sy63', 'rech64', 'rech65', 'ss32', 'strt32', 'sy64', 'vka32', 'hk33', 'sy65', 'rech66', 'rech67', 'ss33', 'strt33', 'sy66', 'vka33', 'hk34', 'sy67', 'rech68', 'rech69', 'ss34', 'strt34', 'sy68', 'vka34', 'hk35', 'sy69', 'rech70', 'rech71', 'ss35', 'strt35', 'sy70', 'vka35', 'hk36', 'sy71', 'rech72', 'rech73', 'ss36', 'strt36', 'sy72', 'vka36', 'hk37', 'sy73', 'rech74', 'rech75', 'ss37', 'strt37', 'sy74', 'vka37', 'hk38', 'sy75', 'rech76', 'rech77', 'ss38', 'strt38', 'sy76', 'vka38', 'hk39', 'sy77', 'rech78', 'rech79', 'ss39', 'strt39', 'sy78', 'vka39', 'hk40', 'sy79', 'rech80', 'rech81', 'ss40', 'strt40', 'sy80', 'vka40', 'hk41', 'sy81', 'rech82', 'rech83', 'ss41', 'strt41', 'sy82', 'vka41', 'hk42', 'sy83', 'rech84', 'rech85', 'ss42', 'strt42', 'sy84', 'vka42', 'hk43', 'sy85', 'rech86', 'rech87', 'ss43', 'strt43', 'sy86', 'vka43', 'hk44', 'sy87', 'rech88', 'rech89', 'ss44', 'strt44', 'sy88', 'vka44', 'hk45', 'sy89', 'rech90', 'rech91', 'ss45', 'strt45', 'sy90', 'vka45', 'hk46', 'sy91', 'rech92', 'rech93', 'ss46', 'strt46', 'sy92', 'vka46', 'hk47', 'sy93', 'rech94', 'rech95', 'ss47', 'strt47', 'sy94', 'vka47', 'hk48', 'sy95', 'rech96', 'rech97', 'ss48', 'strt48', 'sy96', 'vka48', 'hk49', 'sy97', 'rech98', 'rech99', 'ss49', 'strt49', 'sy98', 'vka49', 'hk50', 'sy99', 'rech100', 'rech101', 'ss50', 'strt50', 'sy100', 'vka50', 'hk51', 'sy101', 'rech102', 'rech103', 'ss51', 'strt51', 'sy102', 'vka51', 'hk52', 'sy103', 'rech104', 'rech105', 'ss52', 'strt52', 'sy104', 'vka52', 'hk53', 'sy105', 'rech106', 'rech107', 'ss53', 'strt53', 'sy106', 'vka53', 'hk54', 'sy107', 'rech108', 'rech109', 'ss54', 'strt54', 'sy108', 'vka54', 'hk55', 'sy109', 'rech110', 'rech111', 'ss55', 'strt55', 'sy110', 'vka55', 'hk56', 'sy111', 'rech112', 'rech113', 'ss56', 'strt56', 'sy112', 'vka56', 'hk57', 'sy113', 'rech114', 'rech115', 'ss57', 'strt57', 'sy114', 'vka57', 'hk58', 'sy115', 'rech116', 'rech117', 'ss58', 'strt58', 'sy116', 'vka58', 'hk59', 'sy117', 'rech118', 'rech119', 'ss59', 'strt59', 'sy118', 'vka59', 'hk60', 'sy119', 'rech120', 'rech121', 'ss60', 'strt60', 'sy120', 'vka60', 'hk61', 'sy121', 'rech122', 'rech123', 'ss61', 'strt61', 'sy122', 'vka61', 'hk62', 'sy123', 'rech124', 'rech125', 'ss62', 'strt62', 'sy124', 'vka62', 'hk63', 'sy125', 'rech126', 'rech127', 'ss63', 'strt63', 'sy126', 'vka63', 'hk64', 'sy127', 'rech128', 'rech129', 'ss64', 'strt64', 'sy128', 'vka64', 'hk65', 'sy129', 'rech130', 'rech131', 'ss65', 'strt65', 'sy130', 'vka65', 'hk66', 'sy131', 'rech132', 'rech133', 'ss66', 'strt66', 'sy132', 'vka66', 'hk67', 'sy133', 'rech134', 'rech135', 'ss67', 'strt67', 'sy134', 'vka67', 'hk68', 'sy135', 'rech136', 'rech137', 'ss68', 'strt68', 'sy136', 'vka68', 'hk69', 'sy137', 'rech138', 'rech139', 'ss69', 'strt69', 'sy138', 'vka69', 'hk70', 'sy139', 'rech140', 'rech141', 'ss70', 'strt70', 'sy140', 'vka70', 'hk71', 'sy141', 'rech142', 'rech143', 'ss71', 'strt71', 'sy142', 'vka71', 'hk72', 'sy143', 'rech144', 'rech145', 'ss72', 'strt72', 'sy144', 'vka72', 'hk73', 'sy145', 'rech146', 'rech147', 'ss73', 'strt73', 'sy146', 'vka73', 'hk74', 'sy147', 'rech148', 'rech149', 'ss74', 'strt74', 'sy148', 'vka74', 'hk75', 'sy149', 'rech150', 'rech151', 'ss75', '
```

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starting interp point loop for 800 points
took 4.875556 seconds
2019-05-14 14:55:48.824719 finished: calculating factors for p=hk1, k=1 took: 0:00:04.945406
2019-05-14 14:55:48.826793 starting: calculating factors for p=prsity1, k=1
2019-05-14 14:55:48.829448 finished: calculating factors for p=prsity1, k=1 took: 0:00:00.002681
2019-05-14 14:55:48.830948 starting: calculating factors for p=ss1, k=1
2019-05-14 14:55:48.832415 finished: calculating factors for p=ss1, k=1 took: 0:00:00.001467
2019-05-14 14:55:48.833724 starting: calculating factors for p=strt1, k=1
2019-05-14 14:55:48.834967 finished: calculating factors for p=strt1, k=1 took: 0:00:00.001243
2019-05-14 14:55:48.835995 starting: calculating factors for p=sy1, k=1
2019-05-14 14:55:48.838456 finished: calculating factors for p=sy1, k=1 took: 0:00:00.002461
2019-05-14 14:55:48.839982 starting: calculating factors for p=vka1, k=1
2019-05-14 14:55:48.841652 finished: calculating factors for p=vka1, k=1 took: 0:00:00.001670
2019-05-14 14:55:48.844469 starting: calculating factors for p=hk2, k=2
2019-05-14 14:55:48.847466 saving krige variance file:template/pp_k2_general_zn.fac
2019-05-14 14:55:48.847805 saving krige factors file:template/pp_k2_general_zn.fac
starting interp point loop for 800 points
took 4.34787 seconds
2019-05-14 14:55:53.265042 finished: calculating factors for p=hk2, k=2 took: 0:00:04.420573
2019-05-14 14:55:53.266342 starting: calculating factors for p=prsity2, k=2
2019-05-14 14:55:53.267486 finished: calculating factors for p=prsity2, k=2 took: 0:00:00.001111
2019-05-14 14:55:53.268425 starting: calculating factors for p=ss2, k=2
2019-05-14 14:55:53.269499 finished: calculating factors for p=ss2, k=2 took: 0:00:00.001074
2019-05-14 14:55:53.270347 starting: calculating factors for p=strt2, k=2
2019-05-14 14:55:53.271804 finished: calculating factors for p=strt2, k=2 took: 0:00:00.001457
2019-05-14 14:55:53.273502 starting: calculating factors for p=sy2, k=2
2019-05-14 14:55:53.275005 finished: calculating factors for p=sy2, k=2 took: 0:00:00.001503
2019-05-14 14:55:53.277060 starting: calculating factors for p=vka2, k=2
2019-05-14 14:55:53.279165 finished: calculating factors for p=vka2, k=2 took: 0:00:00.002105
2019-05-14 14:55:53.279379 starting: processing pp_prefix:prsity1
2019-05-14 14:55:53.298616 starting: processing pp_prefix:strt1
2019-05-14 14:55:53.313932 starting: processing pp_prefix:prsity2
2019-05-14 14:55:53.329135 starting: processing pp_prefix:vka0
2019-05-14 14:55:53.343297 starting: processing pp_prefix:sy2
2019-05-14 14:55:53.358951 starting: processing pp_prefix:hk2
2019-05-14 14:55:53.374213 starting: processing pp_prefix:hk1
2019-05-14 14:55:53.391515 starting: processing pp_prefix:strt2
2019-05-14 14:55:53.406126 starting: processing pp_prefix:ss2
2019-05-14 14:55:53.422112 starting: processing pp_prefix:vka1
2019-05-14 14:55:53.438915 starting: processing pp_prefix:ss0
2019-05-14 14:55:53.454838 starting: processing pp_prefix:prsity0
2019-05-14 14:55:53.471239 starting: processing pp_prefix:ss1
2019-05-14 14:55:53.488004 starting: processing pp_prefix:sy0
2019-05-14 14:55:53.504200 starting: processing pp_prefix:strt0
2019-05-14 14:55:53.518913 starting: processing pp_prefix:vka2
2019-05-14 14:55:53.536412 starting: processing pp_prefix:rech0
2019-05-14 14:55:53.551036 starting: processing pp_prefix:rech1
2019-05-14 14:55:53.565798 starting: processing pp_prefix:hk0

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2019-05-14 14:55:53.580189 starting: processing pp_prefix:sy1
2019-05-14 14:55:53.730956 finished: setting up pilot point process took: 0:00:14.050874
2019-05-14 14:55:53.731601 starting: setting up grid process
2019-05-14 14:55:53.731927 WARNING: grid_geostruc is None, using ExpVario with contribution=1
2019-05-14 14:55:53.732080 finished: setting up grid process took: 0:00:00.000479
2019-05-14 14:55:53.735863 starting: save test mlt array arr_mlt/hk0.dat_pp
2019-05-14 14:55:53.738735 finished: save test mlt array arr_mlt/hk0.dat_pp took: 0:00:00.002874
2019-05-14 14:55:53.741330 starting: save test mlt array arr_mlt/vka0.dat_pp
2019-05-14 14:55:53.744697 finished: save test mlt array arr_mlt/vka0.dat_pp took: 0:00:00.003367
2019-05-14 14:55:53.745954 starting: save test mlt array arr_mlt/ss0.dat_pp
2019-05-14 14:55:53.750035 finished: save test mlt array arr_mlt/ss0.dat_pp took: 0:00:00.004081
2019-05-14 14:55:53.751158 starting: save test mlt array arr_mlt/sy0.dat_pp
2019-05-14 14:55:53.753749 finished: save test mlt array arr_mlt/sy0.dat_pp took: 0:00:00.002511
2019-05-14 14:55:53.755104 starting: save test mlt array arr_mlt/strt0.dat_pp
2019-05-14 14:55:53.760785 finished: save test mlt array arr_mlt/strt0.dat_pp took: 0:00:00.005681
2019-05-14 14:55:53.761980 starting: save test mlt array arr_mlt/prsity0.dat_pp
2019-05-14 14:55:53.764817 finished: save test mlt array arr_mlt/prsity0.dat_pp took: 0:00:00.002837
2019-05-14 14:55:53.765682 starting: save test mlt array arr_mlt/hk1.dat_pp
2019-05-14 14:55:53.768442 finished: save test mlt array arr_mlt/hk1.dat_pp took: 0:00:00.002760
2019-05-14 14:55:53.769539 starting: save test mlt array arr_mlt/vka1.dat_pp
2019-05-14 14:55:53.773020 finished: save test mlt array arr_mlt/vka1.dat_pp took: 0:00:00.003481
2019-05-14 14:55:53.774369 starting: save test mlt array arr_mlt/ss1.dat_pp
2019-05-14 14:55:53.778565 finished: save test mlt array arr_mlt/ss1.dat_pp took: 0:00:00.004196
2019-05-14 14:55:53.780220 starting: save test mlt array arr_mlt/sy1.dat_pp
2019-05-14 14:55:53.783830 finished: save test mlt array arr_mlt/sy1.dat_pp took: 0:00:00.003610
2019-05-14 14:55:53.785176 starting: save test mlt array arr_mlt/strt1.dat_pp
2019-05-14 14:55:53.788482 finished: save test mlt array arr_mlt/strt1.dat_pp took: 0:00:00.003306
2019-05-14 14:55:53.790155 starting: save test mlt array arr_mlt/prsity1.dat_pp
2019-05-14 14:55:53.794595 finished: save test mlt array arr_mlt/prsity1.dat_pp took: 0:00:00.004440
2019-05-14 14:55:53.796108 starting: save test mlt array arr_mlt/hk2.dat_pp
2019-05-14 14:55:53.799186 finished: save test mlt array arr_mlt/hk2.dat_pp took: 0:00:00.003078
2019-05-14 14:55:53.800402 starting: save test mlt array arr_mlt/vka2.dat_pp
2019-05-14 14:55:53.803775 finished: save test mlt array arr_mlt/vka2.dat_pp took: 0:00:00.003373
2019-05-14 14:55:53.805174 starting: save test mlt array arr_mlt/ss2.dat_pp
2019-05-14 14:55:53.809329 finished: save test mlt array arr_mlt/ss2.dat_pp took: 0:00:00.004155
2019-05-14 14:55:53.811106 starting: save test mlt array arr_mlt/sy2.dat_pp
2019-05-14 14:55:53.814761 finished: save test mlt array arr_mlt/sy2.dat_pp took: 0:00:00.003610
2019-05-14 14:55:53.816025 starting: save test mlt array arr_mlt/strt2.dat_pp
2019-05-14 14:55:53.819233 finished: save test mlt array arr_mlt/strt2.dat_pp took: 0:00:00.003208
2019-05-14 14:55:53.820761 starting: save test mlt array arr_mlt/prsity2.dat_pp
2019-05-14 14:55:53.824998 finished: save test mlt array arr_mlt/prsity2.dat_pp took: 0:00:00.004237
2019-05-14 14:55:53.826663 starting: save test mlt array arr_mlt/rech0.dat_pp
2019-05-14 14:55:53.830800 finished: save test mlt array arr_mlt/rech0.dat_pp took: 0:00:00.004137
2019-05-14 14:55:53.832420 starting: save test mlt array arr_mlt/rech1.dat_pp
2019-05-14 14:55:53.835469 finished: save test mlt array arr_mlt/rech1.dat_pp took: 0:00:00.003049
2019-05-14 14:55:53.837029 starting: save test mlt array arr_mlt/hk3.dat_gr
2019-05-14 14:55:53.841879 finished: save test mlt array arr_mlt/hk3.dat_gr took: 0:00:00.004850
2019-05-14 14:55:53.844116 starting: save test mlt array arr_mlt/vka3.dat_gr

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2019-05-14 14:55:53.847622 finished: save test mlt array arr_mlt/vka3.dat_gr took: 0:00:00.003
 2019-05-14 14:55:53.849235 starting: save test mlt array arr_mlt/ss3.dat_gr
 2019-05-14 14:55:53.852665 finished: save test mlt array arr_mlt/ss3.dat_gr took: 0:00:00.0034
 2019-05-14 14:55:53.854233 starting: save test mlt array arr_mlt/sy3.dat_gr
 2019-05-14 14:55:53.859174 finished: save test mlt array arr_mlt/sy3.dat_gr took: 0:00:00.0049
 2019-05-14 14:55:53.860931 starting: save test mlt array arr_mlt/strt3.dat_gr
 2019-05-14 14:55:53.864437 finished: save test mlt array arr_mlt/strt3.dat_gr took: 0:00:00.003
 2019-05-14 14:55:53.866054 starting: save test mlt array arr_mlt/prsity3.dat_gr
 2019-05-14 14:55:53.869286 finished: save test mlt array arr_mlt/prsity3.dat_gr took: 0:00:00.
 2019-05-14 14:55:53.870713 starting: save test mlt array arr_mlt/hk4.dat_gr
 2019-05-14 14:55:53.875840 finished: save test mlt array arr_mlt/hk4.dat_gr took: 0:00:00.0051
 2019-05-14 14:55:53.877818 starting: save test mlt array arr_mlt/vka4.dat_gr
 2019-05-14 14:55:53.881197 finished: save test mlt array arr_mlt/vka4.dat_gr took: 0:00:00.003
 2019-05-14 14:55:53.882497 starting: save test mlt array arr_mlt/ss4.dat_gr
 2019-05-14 14:55:53.886133 finished: save test mlt array arr_mlt/ss4.dat_gr took: 0:00:00.0036
 2019-05-14 14:55:53.887892 starting: save test mlt array arr_mlt/sy4.dat_gr
 2019-05-14 14:55:53.893010 finished: save test mlt array arr_mlt/sy4.dat_gr took: 0:00:00.0051
 2019-05-14 14:55:53.894926 starting: save test mlt array arr_mlt/strt4.dat_gr
 2019-05-14 14:55:53.898219 finished: save test mlt array arr_mlt/strt4.dat_gr took: 0:00:00.003
 2019-05-14 14:55:53.899400 starting: save test mlt array arr_mlt/prsity4.dat_gr
 2019-05-14 14:55:53.903128 finished: save test mlt array arr_mlt/prsity4.dat_gr took: 0:00:00.
 2019-05-14 14:55:53.904907 starting: save test mlt array arr_mlt/hk5.dat_gr
 2019-05-14 14:55:53.910774 finished: save test mlt array arr_mlt/hk5.dat_gr took: 0:00:00.0058
 2019-05-14 14:55:53.912158 starting: save test mlt array arr_mlt/vka5.dat_gr
 2019-05-14 14:55:53.915109 finished: save test mlt array arr_mlt/vka5.dat_gr took: 0:00:00.002
 2019-05-14 14:55:53.916607 starting: save test mlt array arr_mlt/ss5.dat_gr
 2019-05-14 14:55:53.920142 finished: save test mlt array arr_mlt/ss5.dat_gr took: 0:00:00.0035
 2019-05-14 14:55:53.922101 starting: save test mlt array arr_mlt/sy5.dat_gr
 2019-05-14 14:55:53.927213 finished: save test mlt array arr_mlt/sy5.dat_gr took: 0:00:00.0051
 2019-05-14 14:55:53.928721 starting: save test mlt array arr_mlt/strt5.dat_gr
 2019-05-14 14:55:53.932026 finished: save test mlt array arr_mlt/strt5.dat_gr took: 0:00:00.003
 2019-05-14 14:55:53.933997 starting: save test mlt array arr_mlt/prsity5.dat_gr
 2019-05-14 14:55:53.938658 finished: save test mlt array arr_mlt/prsity5.dat_gr took: 0:00:00.
 2019-05-14 14:55:53.941779 starting: save test mlt array arr_mlt/rech2.dat_gr
 2019-05-14 14:55:53.945719 finished: save test mlt array arr_mlt/rech2.dat_gr took: 0:00:00.003
 2019-05-14 14:55:53.947122 starting: save test mlt array arr_mlt/rech3.dat_gr
 2019-05-14 14:55:53.950765 finished: save test mlt array arr_mlt/rech3.dat_gr took: 0:00:00.003
 2019-05-14 14:55:53.952267 starting: save test mlt array arr_mlt/hk6.dat_cn
 2019-05-14 14:55:53.956769 finished: save test mlt array arr_mlt/hk6.dat_cn took: 0:00:00.0045
 2019-05-14 14:55:53.959593 starting: save test mlt array arr_mlt/vka6.dat_cn
 2019-05-14 14:55:53.963304 finished: save test mlt array arr_mlt/vka6.dat_cn took: 0:00:00.003
 2019-05-14 14:55:53.965013 starting: save test mlt array arr_mlt/ss6.dat_cn
 2019-05-14 14:55:53.969094 finished: save test mlt array arr_mlt/ss6.dat_cn took: 0:00:00.0040
 2019-05-14 14:55:53.970814 starting: save test mlt array arr_mlt/sy6.dat_cn
 2019-05-14 14:55:53.976648 finished: save test mlt array arr_mlt/sy6.dat_cn took: 0:00:00.0058
 2019-05-14 14:55:53.978393 starting: save test mlt array arr_mlt/strt6.dat_cn
 2019-05-14 14:55:53.981923 finished: save test mlt array arr_mlt/strt6.dat_cn took: 0:00:00.003
 2019-05-14 14:55:53.983651 starting: save test mlt array arr_mlt/prsity6.dat_cn

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2019-05-14 14:55:53.987715 finished: save test mlt array arr_mlt/prsity6.dat_cn took: 0:00:00.
2019-05-14 14:55:53.990020 starting: save test mlt array arr_mlt/hk7.dat_cn
2019-05-14 14:55:53.995450 finished: save test mlt array arr_mlt/hk7.dat_cn took: 0:00:00.0054
2019-05-14 14:55:53.997065 starting: save test mlt array arr_mlt/vka7.dat_cn
2019-05-14 14:55:54.000513 finished: save test mlt array arr_mlt/vka7.dat_cn took: 0:00:00.003
2019-05-14 14:55:54.001860 starting: save test mlt array arr_mlt/ss7.dat_cn
2019-05-14 14:55:54.006093 finished: save test mlt array arr_mlt/ss7.dat_cn took: 0:00:00.0042
2019-05-14 14:55:54.008671 starting: save test mlt array arr_mlt/sy7.dat_cn
2019-05-14 14:55:54.012826 finished: save test mlt array arr_mlt/sy7.dat_cn took: 0:00:00.0041
2019-05-14 14:55:54.014337 starting: save test mlt array arr_mlt/strt7.dat_cn
2019-05-14 14:55:54.017702 finished: save test mlt array arr_mlt/strt7.dat_cn took: 0:00:00.003
2019-05-14 14:55:54.019337 starting: save test mlt array arr_mlt/prsity7.dat_cn
2019-05-14 14:55:54.024131 finished: save test mlt array arr_mlt/prsity7.dat_cn took: 0:00:00.
2019-05-14 14:55:54.026687 starting: save test mlt array arr_mlt/hk8.dat_cn
2019-05-14 14:55:54.030351 finished: save test mlt array arr_mlt/hk8.dat_cn took: 0:00:00.0036
2019-05-14 14:55:54.031953 starting: save test mlt array arr_mlt/vka8.dat_cn
2019-05-14 14:55:54.035001 finished: save test mlt array arr_mlt/vka8.dat_cn took: 0:00:00.003
2019-05-14 14:55:54.036379 starting: save test mlt array arr_mlt/ss8.dat_cn
2019-05-14 14:55:54.041471 finished: save test mlt array arr_mlt/ss8.dat_cn took: 0:00:00.0050
2019-05-14 14:55:54.043310 starting: save test mlt array arr_mlt/sy8.dat_cn
2019-05-14 14:55:54.047104 finished: save test mlt array arr_mlt/sy8.dat_cn took: 0:00:00.0037
2019-05-14 14:55:54.048474 starting: save test mlt array arr_mlt/strt8.dat_cn
2019-05-14 14:55:54.052249 finished: save test mlt array arr_mlt/strt8.dat_cn took: 0:00:00.003
2019-05-14 14:55:54.054247 starting: save test mlt array arr_mlt/prsity8.dat_cn
2019-05-14 14:55:54.059312 finished: save test mlt array arr_mlt/prsity8.dat_cn took: 0:00:00.
2019-05-14 14:55:54.061116 starting: save test mlt array arr_mlt/rech4.dat_cn
2019-05-14 14:55:54.064817 finished: save test mlt array arr_mlt/rech4.dat_cn took: 0:00:00.003
2019-05-14 14:55:54.066117 starting: save test mlt array arr_mlt/rech5.dat_cn
2019-05-14 14:55:54.069234 finished: save test mlt array arr_mlt/rech5.dat_cn took: 0:00:00.003
2019-05-14 14:55:54.849542 forward_run line:pyemu.helpers.apply_array_pars()

all zeros for runoff...skipping...
all zeros for hcond1...skipping...
all zeros for ppts...skipping...
2019-05-14 14:55:55.014738 starting: processing obs type mflist water budget obs
2019-05-14 14:55:55.137274 forward_run line:pyemu.gw_utils.apply_mflist_budget_obs('freyberg.1
2019-05-14 14:55:55.138082 finished: processing obs type mflist water budget obs took: 0:00:00
2019-05-14 14:55:55.138419 starting: processing obs type hyd file
2019-05-14 14:55:55.139292 finished: processing obs type hyd file took: 0:00:00.000873
2019-05-14 14:55:55.139487 starting: processing obs type external obs-sim smp files
2019-05-14 14:55:55.139958 finished: processing obs type external obs-sim smp files took: 0:00
2019-05-14 14:55:55.140567 starting: processing obs type hob
2019-05-14 14:55:55.140805 finished: processing obs type hob took: 0:00:00.000238
2019-05-14 14:55:55.140890 starting: processing obs type hds
[[0, 0], [0, 1], [0, 2], [1, 0], [1, 1], [1, 2]]
2019-05-14 14:55:55.668645 finished: processing obs type hds took: 0:00:00.527755
2019-05-14 14:55:55.669026 starting: processing obs type sfr
writing 'sfr_obs.config' to template/sfr_obs.config

```

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2019-05-14 14:55:56.269023 finished: processing obs type sfr took: 0:00:00.599997
2019-05-14 14:55:56.269598 changing dir in to template
2019-05-14 14:55:56.270741 starting: instantiating control file from i/o files
2019-05-14 14:55:56.271248 tpl files: wel.csv.tpl,drn.csv.tpl,hk3.dat_gr.tpl,vka3.dat_gr.tpl,s
2019-05-14 14:55:56.271618 ins files: freyberg.hds.dat.ins,vol.dat.ins,freyberg.sfr.out.proces
2019-05-14 14:55:56.785535 finished: instantiating control file from i/o files took: 0:00:00.5
2019-05-14 14:55:57.204482 starting: writing forward_run.py
2019-05-14 14:55:57.205660 finished: writing forward_run.py took: 0:00:00.001178
2019-05-14 14:55:57.206264 writing pst template/freyberg.pst
noptmax:0, npar_adj:14819, nnz_obs:4434
2019-05-14 14:55:59.666498 starting: running pestchek on freyberg.pst
2019-05-14 14:55:59.779573 pestcheck:PESTCHEK Version 13.0. Watermark Numerical Computing.
2019-05-14 14:55:59.779962 pestcheck:
2019-05-14 14:55:59.780022 pestcheck:Errors ----->
2019-05-14 14:55:59.780424 pestcheck:Line 2403 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.780484 pestcheck:12 characters long.
2019-05-14 14:55:59.780524 pestcheck:Line 2404 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.780556 pestcheck:12 characters long.
2019-05-14 14:55:59.780618 pestcheck:Line 2404 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.781191 pestcheck:once.
2019-05-14 14:55:59.781335 pestcheck:Line 2405 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.781402 pestcheck:12 characters long.
2019-05-14 14:55:59.781459 pestcheck:Line 2405 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.781509 pestcheck:once.
2019-05-14 14:55:59.781549 pestcheck:Line 2406 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.781580 pestcheck:12 characters long.
2019-05-14 14:55:59.781615 pestcheck:Line 2406 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.781963 pestcheck:once.
2019-05-14 14:55:59.782243 pestcheck:Line 2407 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.782368 pestcheck:12 characters long.
2019-05-14 14:55:59.782431 pestcheck:Line 2407 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.782539 pestcheck:once.
2019-05-14 14:55:59.782668 pestcheck:Line 2408 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.782742 pestcheck:12 characters long.
2019-05-14 14:55:59.782783 pestcheck:Line 2408 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.782818 pestcheck:once.
2019-05-14 14:55:59.782941 pestcheck:Line 2409 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.782991 pestcheck:12 characters long.
2019-05-14 14:55:59.783030 pestcheck:Line 2409 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.783147 pestcheck:once.
2019-05-14 14:55:59.783198 pestcheck:Line 2410 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.783298 pestcheck:12 characters long.
2019-05-14 14:55:59.783346 pestcheck:Line 2410 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.783455 pestcheck:once.
2019-05-14 14:55:59.783564 pestcheck:Line 2411 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.783683 pestcheck:12 characters long.
2019-05-14 14:55:59.783798 pestcheck:Line 2411 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.783863 pestcheck:once.

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2019-05-14 14:55:59.784166 pestcheck:Line 2412 of file freyberg.pst: parameter name "prsity3000
2019-05-14 14:55:59.784284 pestcheck:12 characters long.
2019-05-14 14:55:59.784404 pestcheck:Line 2412 of file freyberg.pst: parameter name "prsity3000
2019-05-14 14:55:59.784543 pestcheck:once.
2019-05-14 14:55:59.784620 pestcheck:Line 2413 of file freyberg.pst: parameter name "prsity3000
2019-05-14 14:55:59.784843 pestcheck:12 characters long.
2019-05-14 14:55:59.784978 pestcheck:Line 2414 of file freyberg.pst: parameter name "prsity3000
2019-05-14 14:55:59.785104 pestcheck:12 characters long.
2019-05-14 14:55:59.785214 pestcheck:Line 2414 of file freyberg.pst: parameter name "prsity3000
2019-05-14 14:55:59.785267 pestcheck:once.
2019-05-14 14:55:59.785309 pestcheck:Line 2415 of file freyberg.pst: parameter name "prsity3000
2019-05-14 14:55:59.785413 pestcheck:12 characters long.
2019-05-14 14:55:59.785467 pestcheck:Line 2415 of file freyberg.pst: parameter name "prsity3000
2019-05-14 14:55:59.785564 pestcheck:once.
2019-05-14 14:55:59.785615 pestcheck:Line 2416 of file freyberg.pst: parameter name "prsity3000
2019-05-14 14:55:59.785655 pestcheck:12 characters long.
2019-05-14 14:55:59.785757 pestcheck:Line 2416 of file freyberg.pst: parameter name "prsity3000
2019-05-14 14:55:59.785865 pestcheck:once.
2019-05-14 14:55:59.785937 pestcheck:Line 2417 of file freyberg.pst: parameter name "prsity3000
2019-05-14 14:55:59.785992 pestcheck:12 characters long.
2019-05-14 14:55:59.786133 pestcheck:Line 2417 of file freyberg.pst: parameter name "prsity3000
2019-05-14 14:55:59.786209 pestcheck:once.
2019-05-14 14:55:59.786330 pestcheck:Line 2418 of file freyberg.pst: parameter name "prsity3000
2019-05-14 14:55:59.786414 pestcheck:12 characters long.
2019-05-14 14:55:59.786586 pestcheck:Line 2418 of file freyberg.pst: parameter name "prsity3000
2019-05-14 14:55:59.786731 pestcheck:once.
2019-05-14 14:55:59.786909 pestcheck:Line 2419 of file freyberg.pst: parameter name "prsity3000
2019-05-14 14:55:59.786990 pestcheck:12 characters long.
2019-05-14 14:55:59.787092 pestcheck:Line 2419 of file freyberg.pst: parameter name "prsity3000
2019-05-14 14:55:59.787149 pestcheck:once.
2019-05-14 14:55:59.787254 pestcheck:Line 2420 of file freyberg.pst: parameter name "prsity3000
2019-05-14 14:55:59.787303 pestcheck:12 characters long.
2019-05-14 14:55:59.787343 pestcheck:Line 2420 of file freyberg.pst: parameter name "prsity3000
2019-05-14 14:55:59.787451 pestcheck:once.
2019-05-14 14:55:59.787564 pestcheck:Line 2421 of file freyberg.pst: parameter name "prsity3000
2019-05-14 14:55:59.787613 pestcheck:12 characters long.
2019-05-14 14:55:59.787724 pestcheck:Line 2421 of file freyberg.pst: parameter name "prsity3000
2019-05-14 14:55:59.787775 pestcheck:once.
2019-05-14 14:55:59.787876 pestcheck:Line 2422 of file freyberg.pst: parameter name "prsity3000
2019-05-14 14:55:59.788003 pestcheck:12 characters long.
2019-05-14 14:55:59.788054 pestcheck:Line 2422 of file freyberg.pst: parameter name "prsity3000
2019-05-14 14:55:59.788194 pestcheck:once.
2019-05-14 14:55:59.788269 pestcheck:Line 2423 of file freyberg.pst: parameter name "prsity3000
2019-05-14 14:55:59.788323 pestcheck:12 characters long.
2019-05-14 14:55:59.788385 pestcheck:Line 2424 of file freyberg.pst: parameter name "prsity3000
2019-05-14 14:55:59.788529 pestcheck:12 characters long.
2019-05-14 14:55:59.788594 pestcheck:Line 2424 of file freyberg.pst: parameter name "prsity3000
2019-05-14 14:55:59.788656 pestcheck:once.

2019-05-14 14:55:59.788850 pestcheck:Line 2425 of file freyberg.pst: parameter name "prsity300.
 2019-05-14 14:55:59.788913 pestcheck:12 characters long.
 2019-05-14 14:55:59.789020 pestcheck:Line 2425 of file freyberg.pst: parameter name "prsity300.
 2019-05-14 14:55:59.789225 pestcheck:once.
 2019-05-14 14:55:59.789407 pestcheck:Line 2426 of file freyberg.pst: parameter name "prsity300.
 2019-05-14 14:55:59.789513 pestcheck:12 characters long.
 2019-05-14 14:55:59.789575 pestcheck:Line 2426 of file freyberg.pst: parameter name "prsity300.
 2019-05-14 14:55:59.789734 pestcheck:once.
 2019-05-14 14:55:59.789986 pestcheck:Line 2427 of file freyberg.pst: parameter name "prsity300.
 2019-05-14 14:55:59.790082 pestcheck:12 characters long.
 2019-05-14 14:55:59.790194 pestcheck:Line 2427 of file freyberg.pst: parameter name "prsity300.
 2019-05-14 14:55:59.790250 pestcheck:once.
 2019-05-14 14:55:59.790367 pestcheck:Line 2428 of file freyberg.pst: parameter name "prsity300.
 2019-05-14 14:55:59.790424 pestcheck:12 characters long.
 2019-05-14 14:55:59.790504 pestcheck:Line 2428 of file freyberg.pst: parameter name "prsity300.
 2019-05-14 14:55:59.790751 pestcheck:once.
 2019-05-14 14:55:59.790887 pestcheck:Line 2429 of file freyberg.pst: parameter name "prsity300.
 2019-05-14 14:55:59.791180 pestcheck:12 characters long.
 2019-05-14 14:55:59.791373 pestcheck:Line 2429 of file freyberg.pst: parameter name "prsity300.
 2019-05-14 14:55:59.791478 pestcheck:once.
 2019-05-14 14:55:59.791638 pestcheck:Line 2430 of file freyberg.pst: parameter name "prsity300.
 2019-05-14 14:55:59.791735 pestcheck:12 characters long.
 2019-05-14 14:55:59.791785 pestcheck:Line 2430 of file freyberg.pst: parameter name "prsity300.
 2019-05-14 14:55:59.791819 pestcheck:once.
 2019-05-14 14:55:59.791915 pestcheck:Line 2431 of file freyberg.pst: parameter name "prsity300.
 2019-05-14 14:55:59.791949 pestcheck:12 characters long.
 2019-05-14 14:55:59.791983 pestcheck:Line 2431 of file freyberg.pst: parameter name "prsity300.
 2019-05-14 14:55:59.792024 pestcheck:once.
 2019-05-14 14:55:59.792058 pestcheck:Line 2432 of file freyberg.pst: parameter name "prsity300.
 2019-05-14 14:55:59.792096 pestcheck:12 characters long.
 2019-05-14 14:55:59.792203 pestcheck:Line 2432 of file freyberg.pst: parameter name "prsity300.
 2019-05-14 14:55:59.792318 pestcheck:once.
 2019-05-14 14:55:59.792366 pestcheck:Line 2433 of file freyberg.pst: parameter name "prsity300.
 2019-05-14 14:55:59.792405 pestcheck:12 characters long.
 2019-05-14 14:55:59.792507 pestcheck:Line 2434 of file freyberg.pst: parameter name "prsity300.
 2019-05-14 14:55:59.792559 pestcheck:12 characters long.
 2019-05-14 14:55:59.792658 pestcheck:Line 2434 of file freyberg.pst: parameter name "prsity300.
 2019-05-14 14:55:59.792782 pestcheck:once.
 2019-05-14 14:55:59.792933 pestcheck:Line 2435 of file freyberg.pst: parameter name "prsity300.
 2019-05-14 14:55:59.793070 pestcheck:12 characters long.
 2019-05-14 14:55:59.793136 pestcheck:Line 2435 of file freyberg.pst: parameter name "prsity300.
 2019-05-14 14:55:59.793249 pestcheck:once.
 2019-05-14 14:55:59.793400 pestcheck:Line 2436 of file freyberg.pst: parameter name "prsity300.
 2019-05-14 14:55:59.793453 pestcheck:12 characters long.
 2019-05-14 14:55:59.793554 pestcheck:Line 2436 of file freyberg.pst: parameter name "prsity300.
 2019-05-14 14:55:59.793609 pestcheck:once.
 2019-05-14 14:55:59.793650 pestcheck:Line 2437 of file freyberg.pst: parameter name "prsity300.
 2019-05-14 14:55:59.793755 pestcheck:12 characters long.

2019-05-14 14:55:59.793863 pestcheck:Line 2437 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.793911 pestcheck:once.
2019-05-14 14:55:59.793950 pestcheck:Line 2438 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.794053 pestcheck:12 characters long.
2019-05-14 14:55:59.794162 pestcheck:Line 2438 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.794214 pestcheck:once.
2019-05-14 14:55:59.794402 pestcheck:Line 2439 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.794455 pestcheck:12 characters long.
2019-05-14 14:55:59.794495 pestcheck:Line 2439 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.794597 pestcheck:once.
2019-05-14 14:55:59.794647 pestcheck:Line 2440 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.794744 pestcheck:12 characters long.
2019-05-14 14:55:59.794792 pestcheck:Line 2440 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.794832 pestcheck:once.
2019-05-14 14:55:59.794932 pestcheck:Line 2441 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.794982 pestcheck:12 characters long.
2019-05-14 14:55:59.795078 pestcheck:Line 2441 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.795125 pestcheck:once.
2019-05-14 14:55:59.795164 pestcheck:Line 2442 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.795264 pestcheck:12 characters long.
2019-05-14 14:55:59.795486 pestcheck:Line 2442 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.795568 pestcheck:once.
2019-05-14 14:55:59.795683 pestcheck:Line 2443 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.795731 pestcheck:12 characters long.
2019-05-14 14:55:59.795770 pestcheck:Line 2444 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.795823 pestcheck:12 characters long.
2019-05-14 14:55:59.795922 pestcheck:Line 2444 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.795975 pestcheck:once.
2019-05-14 14:55:59.796075 pestcheck:Line 2445 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.796125 pestcheck:12 characters long.
2019-05-14 14:55:59.796165 pestcheck:Line 2445 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.796268 pestcheck:once.
2019-05-14 14:55:59.796401 pestcheck:Line 2446 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.796462 pestcheck:12 characters long.
2019-05-14 14:55:59.796598 pestcheck:Line 2446 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.796722 pestcheck:once.
2019-05-14 14:55:59.796785 pestcheck:Line 2447 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.796857 pestcheck:12 characters long.
2019-05-14 14:55:59.796972 pestcheck:Line 2447 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.797027 pestcheck:once.
2019-05-14 14:55:59.797207 pestcheck:Line 2448 of file freyberg.pst: parameter name "prsity300
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2019-05-14 14:55:59.797427 pestcheck:Line 2448 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.797521 pestcheck:once.
2019-05-14 14:55:59.797628 pestcheck:Line 2449 of file freyberg.pst: parameter name "prsity300
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2019-05-14 14:55:59.797851 pestcheck:Line 2449 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.797899 pestcheck:once.

2019-05-14 14:55:59.798010 pestcheck:Line 2450 of file freyberg.pst: parameter name "prsity3002
2019-05-14 14:55:59.798116 pestcheck:12 characters long.
2019-05-14 14:55:59.798164 pestcheck:Line 2450 of file freyberg.pst: parameter name "prsity3002
2019-05-14 14:55:59.798276 pestcheck:once.
2019-05-14 14:55:59.798404 pestcheck:Line 2451 of file freyberg.pst: parameter name "prsity3002
2019-05-14 14:55:59.798511 pestcheck:12 characters long.
2019-05-14 14:55:59.798617 pestcheck:Line 2451 of file freyberg.pst: parameter name "prsity3002
2019-05-14 14:55:59.798665 pestcheck:once.
2019-05-14 14:55:59.798770 pestcheck:Line 2452 of file freyberg.pst: parameter name "prsity3002
2019-05-14 14:55:59.798876 pestcheck:12 characters long.
2019-05-14 14:55:59.798992 pestcheck:Line 2452 of file freyberg.pst: parameter name "prsity3002
2019-05-14 14:55:59.799098 pestcheck:once.
2019-05-14 14:55:59.799214 pestcheck:Line 2453 of file freyberg.pst: parameter name "prsity3002
2019-05-14 14:55:59.799320 pestcheck:12 characters long.
2019-05-14 14:55:59.799440 pestcheck:Line 2454 of file freyberg.pst: parameter name "prsity3002
2019-05-14 14:55:59.799491 pestcheck:12 characters long.
2019-05-14 14:55:59.799587 pestcheck:Line 2454 of file freyberg.pst: parameter name "prsity3002
2019-05-14 14:55:59.799638 pestcheck:once.
2019-05-14 14:55:59.799744 pestcheck:Line 2455 of file freyberg.pst: parameter name "prsity3002
2019-05-14 14:55:59.799849 pestcheck:12 characters long.
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2019-05-14 14:55:59.800109 pestcheck:Line 2456 of file freyberg.pst: parameter name "prsity3002
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2019-05-14 14:55:59.800328 pestcheck:Line 2456 of file freyberg.pst: parameter name "prsity3002
2019-05-14 14:55:59.800449 pestcheck:once.
2019-05-14 14:55:59.800507 pestcheck:Line 2457 of file freyberg.pst: parameter name "prsity3002
2019-05-14 14:55:59.800541 pestcheck:12 characters long.
2019-05-14 14:55:59.800652 pestcheck:Line 2457 of file freyberg.pst: parameter name "prsity3002
2019-05-14 14:55:59.800685 pestcheck:once.
2019-05-14 14:55:59.800729 pestcheck:Line 2458 of file freyberg.pst: parameter name "prsity3002
2019-05-14 14:55:59.800788 pestcheck:12 characters long.
2019-05-14 14:55:59.800822 pestcheck:Line 2458 of file freyberg.pst: parameter name "prsity3002
2019-05-14 14:55:59.800933 pestcheck:once.
2019-05-14 14:55:59.800966 pestcheck:Line 2459 of file freyberg.pst: parameter name "prsity3002
2019-05-14 14:55:59.801014 pestcheck:12 characters long.
2019-05-14 14:55:59.801047 pestcheck:Line 2459 of file freyberg.pst: parameter name "prsity3002
2019-05-14 14:55:59.801075 pestcheck:once.
2019-05-14 14:55:59.801107 pestcheck:Line 2460 of file freyberg.pst: parameter name "prsity3002
2019-05-14 14:55:59.801241 pestcheck:12 characters long.
2019-05-14 14:55:59.801339 pestcheck:Line 2460 of file freyberg.pst: parameter name "prsity3002
2019-05-14 14:55:59.801446 pestcheck:once.
2019-05-14 14:55:59.801518 pestcheck:Line 2461 of file freyberg.pst: parameter name "prsity3002
2019-05-14 14:55:59.801625 pestcheck:12 characters long.
2019-05-14 14:55:59.801680 pestcheck:Line 2461 of file freyberg.pst: parameter name "prsity3002
2019-05-14 14:55:59.801783 pestcheck:once.
2019-05-14 14:55:59.801831 pestcheck:Line 2462 of file freyberg.pst: parameter name "prsity3002
2019-05-14 14:55:59.801874 pestcheck:12 characters long.

2019-05-14 14:55:59.801980 pestcheck:Line 2462 of file freyberg.pst: parameter name "prsity3003
2019-05-14 14:55:59.802034 pestcheck:once.
2019-05-14 14:55:59.802134 pestcheck:Line 2463 of file freyberg.pst: parameter name "prsity3003
2019-05-14 14:55:59.802182 pestcheck:12 characters long.
2019-05-14 14:55:59.802222 pestcheck:Line 2464 of file freyberg.pst: parameter name "prsity3003
2019-05-14 14:55:59.802327 pestcheck:12 characters long.
2019-05-14 14:55:59.802444 pestcheck:Line 2464 of file freyberg.pst: parameter name "prsity3003
2019-05-14 14:55:59.802492 pestcheck:once.
2019-05-14 14:55:59.802600 pestcheck:Line 2465 of file freyberg.pst: parameter name "prsity3003
2019-05-14 14:55:59.802722 pestcheck:12 characters long.
2019-05-14 14:55:59.802773 pestcheck:Line 2465 of file freyberg.pst: parameter name "prsity3003
2019-05-14 14:55:59.802824 pestcheck:once.
2019-05-14 14:55:59.802919 pestcheck:Line 2466 of file freyberg.pst: parameter name "prsity3003
2019-05-14 14:55:59.803077 pestcheck:12 characters long.
2019-05-14 14:55:59.803153 pestcheck:Line 2466 of file freyberg.pst: parameter name "prsity3003
2019-05-14 14:55:59.803243 pestcheck:once.
2019-05-14 14:55:59.803396 pestcheck:Line 2467 of file freyberg.pst: parameter name "prsity3003
2019-05-14 14:55:59.803570 pestcheck:12 characters long.
2019-05-14 14:55:59.803689 pestcheck:Line 2467 of file freyberg.pst: parameter name "prsity3003
2019-05-14 14:55:59.804217 pestcheck:once.
2019-05-14 14:55:59.804318 pestcheck:Line 2468 of file freyberg.pst: parameter name "prsity3003
2019-05-14 14:55:59.804633 pestcheck:12 characters long.
2019-05-14 14:55:59.804837 pestcheck:Line 2468 of file freyberg.pst: parameter name "prsity3003
2019-05-14 14:55:59.804953 pestcheck:once.
2019-05-14 14:55:59.805167 pestcheck:Line 2469 of file freyberg.pst: parameter name "prsity3003
2019-05-14 14:55:59.805264 pestcheck:12 characters long.
2019-05-14 14:55:59.805603 pestcheck:Line 2469 of file freyberg.pst: parameter name "prsity3003
2019-05-14 14:55:59.805682 pestcheck:once.
2019-05-14 14:55:59.805897 pestcheck:Line 2470 of file freyberg.pst: parameter name "prsity3003
2019-05-14 14:55:59.805961 pestcheck:12 characters long.
2019-05-14 14:55:59.806102 pestcheck:Line 2470 of file freyberg.pst: parameter name "prsity3003
2019-05-14 14:55:59.806154 pestcheck:once.
2019-05-14 14:55:59.806194 pestcheck:Line 2471 of file freyberg.pst: parameter name "prsity3003
2019-05-14 14:55:59.806248 pestcheck:12 characters long.
2019-05-14 14:55:59.806348 pestcheck:Line 2471 of file freyberg.pst: parameter name "prsity3003
2019-05-14 14:55:59.806402 pestcheck:once.
2019-05-14 14:55:59.806504 pestcheck:Line 2472 of file freyberg.pst: parameter name "prsity3003
2019-05-14 14:55:59.806562 pestcheck:12 characters long.
2019-05-14 14:55:59.806800 pestcheck:Line 2472 of file freyberg.pst: parameter name "prsity3003
2019-05-14 14:55:59.806903 pestcheck:once.
2019-05-14 14:55:59.806985 pestcheck:Line 2473 of file freyberg.pst: parameter name "prsity3003
2019-05-14 14:55:59.807290 pestcheck:12 characters long.
2019-05-14 14:55:59.807384 pestcheck:Line 2474 of file freyberg.pst: parameter name "prsity3003
2019-05-14 14:55:59.807628 pestcheck:12 characters long.
2019-05-14 14:55:59.807769 pestcheck:Line 2474 of file freyberg.pst: parameter name "prsity3003
2019-05-14 14:55:59.807822 pestcheck:once.
2019-05-14 14:55:59.808363 pestcheck:Line 2475 of file freyberg.pst: parameter name "prsity3003
2019-05-14 14:55:59.808453 pestcheck:12 characters long.

2019-05-14 14:55:59.808531 pestcheck:Line 2475 of file freyberg.pst: parameter name "prsity3003
2019-05-14 14:55:59.808763 pestcheck:once.
2019-05-14 14:55:59.809019 pestcheck:Line 2476 of file freyberg.pst: parameter name "prsity3003
2019-05-14 14:55:59.809257 pestcheck:12 characters long.
2019-05-14 14:55:59.809320 pestcheck:Line 2476 of file freyberg.pst: parameter name "prsity3003
2019-05-14 14:55:59.809376 pestcheck:once.
2019-05-14 14:55:59.809646 pestcheck:Line 2477 of file freyberg.pst: parameter name "prsity3003
2019-05-14 14:55:59.809708 pestcheck:12 characters long.
2019-05-14 14:55:59.809853 pestcheck:Line 2477 of file freyberg.pst: parameter name "prsity3003
2019-05-14 14:55:59.809920 pestcheck:once.
2019-05-14 14:55:59.810040 pestcheck:Line 2478 of file freyberg.pst: parameter name "prsity3003
2019-05-14 14:55:59.810099 pestcheck:12 characters long.
2019-05-14 14:55:59.810216 pestcheck:Line 2478 of file freyberg.pst: parameter name "prsity3003
2019-05-14 14:55:59.810330 pestcheck:once.
2019-05-14 14:55:59.810378 pestcheck:Line 2479 of file freyberg.pst: parameter name "prsity3003
2019-05-14 14:55:59.810417 pestcheck:12 characters long.
2019-05-14 14:55:59.810522 pestcheck:Line 2479 of file freyberg.pst: parameter name "prsity3003
2019-05-14 14:55:59.810633 pestcheck:once.
2019-05-14 14:55:59.810681 pestcheck:Line 2480 of file freyberg.pst: parameter name "prsity3003
2019-05-14 14:55:59.810788 pestcheck:12 characters long.
2019-05-14 14:55:59.810895 pestcheck:Line 2480 of file freyberg.pst: parameter name "prsity3003
2019-05-14 14:55:59.810943 pestcheck:once.
2019-05-14 14:55:59.811050 pestcheck:Line 2481 of file freyberg.pst: parameter name "prsity3003
2019-05-14 14:55:59.811173 pestcheck:12 characters long.
2019-05-14 14:55:59.811278 pestcheck:Line 2481 of file freyberg.pst: parameter name "prsity3003
2019-05-14 14:55:59.811384 pestcheck:once.
2019-05-14 14:55:59.811496 pestcheck:Line 2482 of file freyberg.pst: parameter name "prsity3003
2019-05-14 14:55:59.811641 pestcheck:12 characters long.
2019-05-14 14:55:59.811691 pestcheck:Line 2482 of file freyberg.pst: parameter name "prsity3003
2019-05-14 14:55:59.811734 pestcheck:once.
2019-05-14 14:55:59.811839 pestcheck:Line 2483 of file freyberg.pst: parameter name "prsity3004
2019-05-14 14:55:59.811946 pestcheck:12 characters long.
2019-05-14 14:55:59.812002 pestcheck:Line 2484 of file freyberg.pst: parameter name "prsity3004
2019-05-14 14:55:59.812222 pestcheck:12 characters long.
2019-05-14 14:55:59.812350 pestcheck:Line 2484 of file freyberg.pst: parameter name "prsity3004
2019-05-14 14:55:59.812409 pestcheck:once.
2019-05-14 14:55:59.812525 pestcheck:Line 2485 of file freyberg.pst: parameter name "prsity3004
2019-05-14 14:55:59.812658 pestcheck:12 characters long.
2019-05-14 14:55:59.812715 pestcheck:Line 2485 of file freyberg.pst: parameter name "prsity3004
2019-05-14 14:55:59.812822 pestcheck:once.
2019-05-14 14:55:59.812872 pestcheck:Line 2486 of file freyberg.pst: parameter name "prsity3004
2019-05-14 14:55:59.812911 pestcheck:12 characters long.
2019-05-14 14:55:59.812962 pestcheck:Line 2486 of file freyberg.pst: parameter name "prsity3004
2019-05-14 14:55:59.813060 pestcheck:once.
2019-05-14 14:55:59.813114 pestcheck:Line 2487 of file freyberg.pst: parameter name "prsity3004
2019-05-14 14:55:59.813214 pestcheck:12 characters long.
2019-05-14 14:55:59.813270 pestcheck:Line 2487 of file freyberg.pst: parameter name "prsity3004
2019-05-14 14:55:59.813375 pestcheck:once.

2019-05-14 14:55:59.813487 pestcheck:Line 2488 of file freyberg.pst: parameter name "prsity3004
2019-05-14 14:55:59.813535 pestcheck:12 characters long.
2019-05-14 14:55:59.813575 pestcheck:Line 2488 of file freyberg.pst: parameter name "prsity3004
2019-05-14 14:55:59.813679 pestcheck:once.
2019-05-14 14:55:59.813786 pestcheck:Line 2489 of file freyberg.pst: parameter name "prsity3004
2019-05-14 14:55:59.813834 pestcheck:12 characters long.
2019-05-14 14:55:59.813873 pestcheck:Line 2489 of file freyberg.pst: parameter name "prsity3004
2019-05-14 14:55:59.813976 pestcheck:once.
2019-05-14 14:55:59.814083 pestcheck:Line 2490 of file freyberg.pst: parameter name "prsity3004
2019-05-14 14:55:59.814130 pestcheck:12 characters long.
2019-05-14 14:55:59.814170 pestcheck:Line 2490 of file freyberg.pst: parameter name "prsity3004
2019-05-14 14:55:59.814272 pestcheck:once.
2019-05-14 14:55:59.814389 pestcheck:Line 2491 of file freyberg.pst: parameter name "prsity3004
2019-05-14 14:55:59.814437 pestcheck:12 characters long.
2019-05-14 14:55:59.814477 pestcheck:Line 2491 of file freyberg.pst: parameter name "prsity3004
2019-05-14 14:55:59.814580 pestcheck:once.
2019-05-14 14:55:59.814687 pestcheck:Line 2492 of file freyberg.pst: parameter name "prsity3004
2019-05-14 14:55:59.814734 pestcheck:12 characters long.
2019-05-14 14:55:59.814773 pestcheck:Line 2492 of file freyberg.pst: parameter name "prsity3004
2019-05-14 14:55:59.814842 pestcheck:once.
2019-05-14 14:55:59.814935 pestcheck:Line 2493 of file freyberg.pst: parameter name "prsity3004
2019-05-14 14:55:59.815093 pestcheck:12 characters long.
2019-05-14 14:55:59.815276 pestcheck:Line 2494 of file freyberg.pst: parameter name "prsity3004
2019-05-14 14:55:59.815406 pestcheck:12 characters long.
2019-05-14 14:55:59.815515 pestcheck:Line 2494 of file freyberg.pst: parameter name "prsity3004
2019-05-14 14:55:59.815632 pestcheck:once.
2019-05-14 14:55:59.815738 pestcheck:Line 2495 of file freyberg.pst: parameter name "prsity3004
2019-05-14 14:55:59.815788 pestcheck:12 characters long.
2019-05-14 14:55:59.815911 pestcheck:Line 2495 of file freyberg.pst: parameter name "prsity3004
2019-05-14 14:55:59.816019 pestcheck:once.
2019-05-14 14:55:59.816067 pestcheck:Line 2496 of file freyberg.pst: parameter name "prsity3004
2019-05-14 14:55:59.816173 pestcheck:12 characters long.
2019-05-14 14:55:59.816279 pestcheck:Line 2496 of file freyberg.pst: parameter name "prsity3004
2019-05-14 14:55:59.816402 pestcheck:once.
2019-05-14 14:55:59.816507 pestcheck:Line 2497 of file freyberg.pst: parameter name "prsity3004
2019-05-14 14:55:59.816623 pestcheck:12 characters long.
2019-05-14 14:55:59.816729 pestcheck:Line 2497 of file freyberg.pst: parameter name "prsity3004
2019-05-14 14:55:59.816779 pestcheck:once.
2019-05-14 14:55:59.816821 pestcheck:Line 2498 of file freyberg.pst: parameter name "prsity3004
2019-05-14 14:55:59.816923 pestcheck:12 characters long.
2019-05-14 14:55:59.817030 pestcheck:Line 2498 of file freyberg.pst: parameter name "prsity3004
2019-05-14 14:55:59.817145 pestcheck:once.
2019-05-14 14:55:59.817250 pestcheck:Line 2499 of file freyberg.pst: parameter name "prsity3004
2019-05-14 14:55:59.817373 pestcheck:12 characters long.
2019-05-14 14:55:59.817479 pestcheck:Line 2499 of file freyberg.pst: parameter name "prsity3004
2019-05-14 14:55:59.817673 pestcheck:once.
2019-05-14 14:55:59.817736 pestcheck:Line 2500 of file freyberg.pst: parameter name "prsity3004
2019-05-14 14:55:59.817969 pestcheck:12 characters long.

```

2019-05-14 14:55:59.818123 pestcheck:Line 2500 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.818261 pestcheck:once.
2019-05-14 14:55:59.818806 pestcheck:Line 2501 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.819038 pestcheck:12 characters long.
2019-05-14 14:55:59.819127 pestcheck:Line 2501 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.819197 pestcheck:once.
2019-05-14 14:55:59.819246 pestcheck:Line 2502 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.819341 pestcheck:12 characters long.
2019-05-14 14:55:59.819435 pestcheck:Line 2502 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.819494 pestcheck:once.
2019-05-14 14:55:59.819707 pestcheck:Line 2503 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.819815 pestcheck:12 characters long.
2019-05-14 14:55:59.819943 pestcheck:Line 2504 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.820019 pestcheck:12 characters long.
2019-05-14 14:55:59.820066 pestcheck:Line 2504 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.820196 pestcheck:once.
2019-05-14 14:55:59.820275 pestcheck:Line 2505 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.820472 pestcheck:12 characters long.
2019-05-14 14:55:59.820678 pestcheck:Line 2505 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.820764 pestcheck:once.
2019-05-14 14:55:59.820956 pestcheck:Line 2506 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.821057 pestcheck:12 characters long.
2019-05-14 14:55:59.821144 pestcheck:Line 2506 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.821299 pestcheck:once.
2019-05-14 14:55:59.821478 pestcheck:Line 2507 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.821525 pestcheck:12 characters long.
2019-05-14 14:55:59.821653 pestcheck:Line 2507 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.821730 pestcheck:once.
2019-05-14 14:55:59.821868 pestcheck:Line 2508 of file freyberg.pst: parameter name "prsity300
2019-05-14 14:55:59.821926 pestcheck:12 characters long.
2019-05-14 14:55:59.822418 finished: running pestchek on freyberg.pst took: 0:00:00.155920
2019-05-14 14:55:59.822640 starting: saving intermediate _setup_<> dfs into template
2019-05-14 14:55:59.984776 finished: saving intermediate _setup_<> dfs into template took: 0:0
2019-05-14 14:55:59.984973 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 files 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_files]

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

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

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

Create and add instruction files and related observations for MODPATH

```
In [17]: out_file = "freyberg.mpenpt"
          ins_file = out_file + ".ins"
          with open(os.path.join(pst_helper.new_model_ws,ins_file),'w') as f:
              f.write("pif ~\n")
              f.write("l7 w w !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.mpenpt.ins' observations in this instruction file will have generic values.

Finally we need to copy the original `prsim` 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","prsim_layer_{0}.ref".format(k)),
```

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_ws, "cov.coo"))
cov = np.ma.masked_where(cov.x==0, cov.x)
fig = plt.figure(figsize=(10,10))
ax = plt.subplot(111)
ax.imshow(cov)
plt.show()
```

2019-05-14 14:56:11.974123 starting: building prior covariance matrix

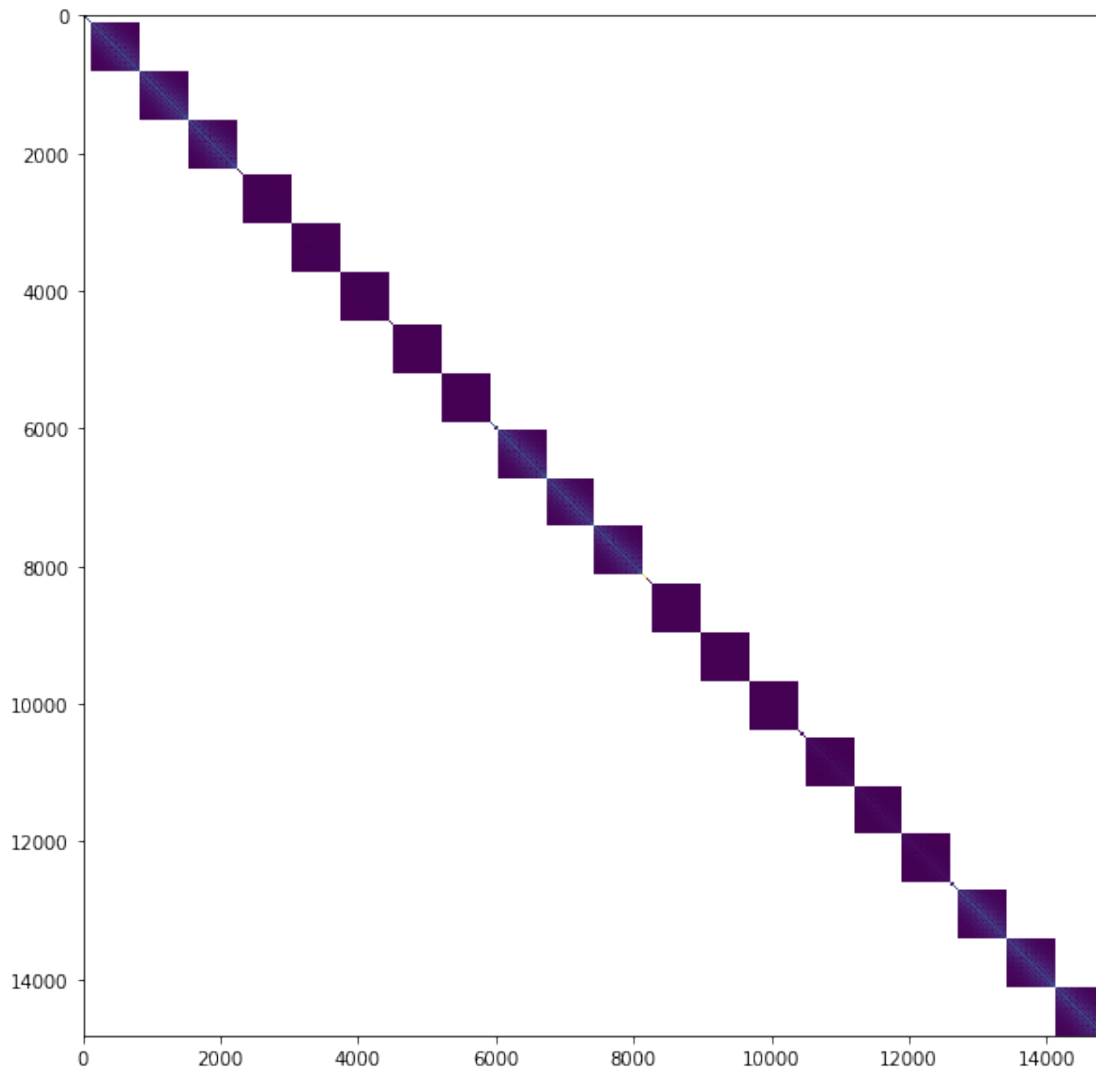
2019-05-14 14:56:12.189346 WARNING: geospatial prior not implemented for SFR pars

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

```
2019-05-14 14:56:20.141604 saving prior covariance matrix to file template/prior_cov.jcb
2019-05-14 14:56:25.782446 finished: building prior covariance matrix took: 0:00:13.808323
```



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(500)
```

```
2019-05-14 14:56:44.837662 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_geostruc,nugget:0.0,structures:
name:var1,contribution:1.0,a:2500.0,anisotropy:1.0,bearing:0.0

working on pargroups ['welflux_k02']

```

```

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

```

```

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

```

```

build cov matrix
done
getting diag var cov 6
scaling full cov by diag var cov
making full cov draws with home-grown goodness
working on pargroups ['drncond_k00']
build cov matrix
done
getting diag var cov 10
scaling full cov by diag var cov
making full cov draws with home-grown goodness
processing name:temporal_list_geostruc,nugget:0.0,structures:

```



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

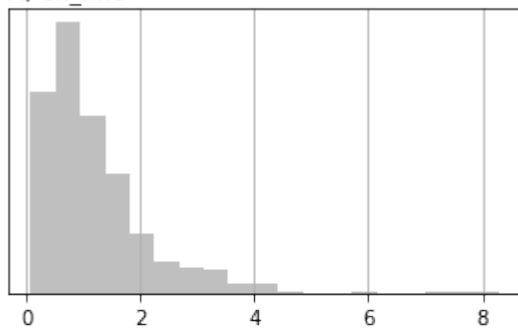
working on pargroups ['welflux']
build cov matrix
done
getting diag var cov 2
scaling full cov by diag var cov
making full cov draws with home-grown goodness
adding remaining parameters to diagonal
2019-05-14 14:56:58.154552 finished: drawing realizations took: 0:00:13.316890
```

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

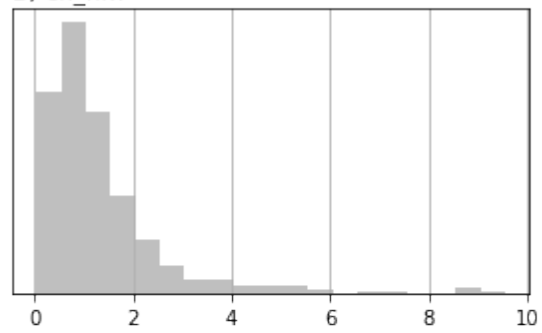
```
In [26]: par = pst_helper.pst.parameter_data
         pyemu.plot_utils.ensemble_helper(pe,plot_cols=par.groupby("pargp").groups,bins=20)
         plt.show()
```

<Figure size 576x756 with 0 Axes>

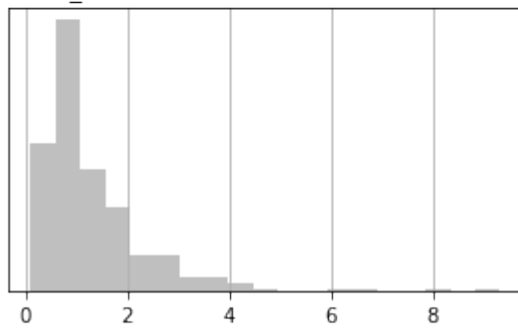
A) cn_hk6



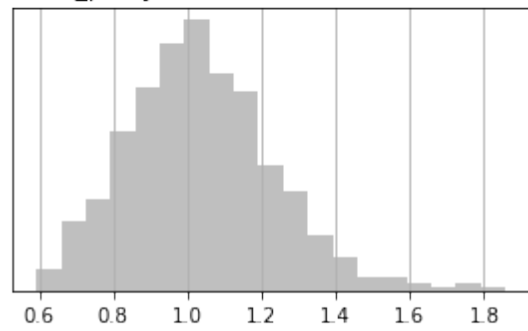
B) cn_hk7



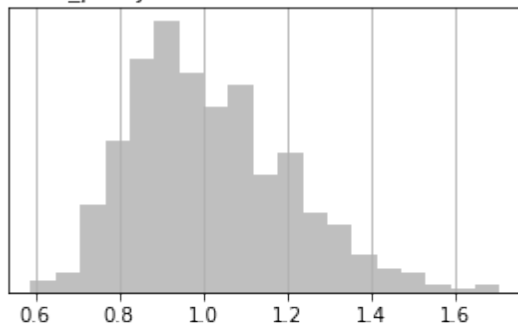
C) cn_hk8



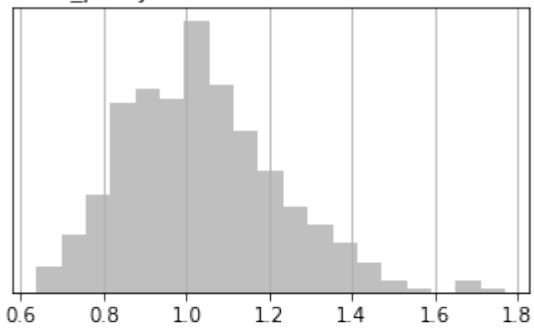
D) cn_prsity6



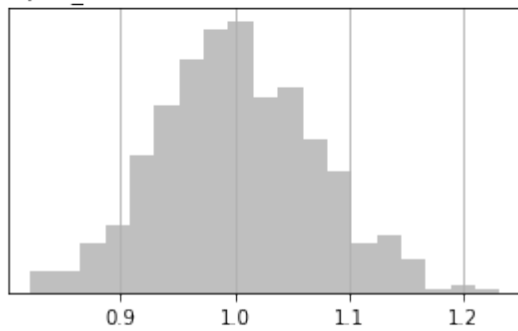
E) cn_prsity7



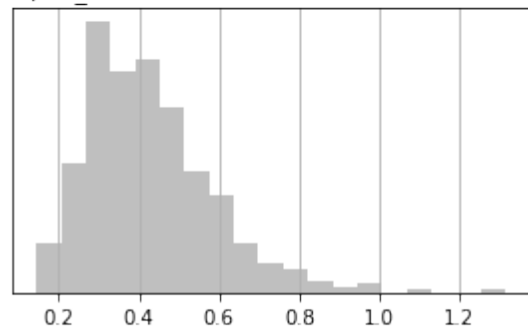
F) cn_prsity8



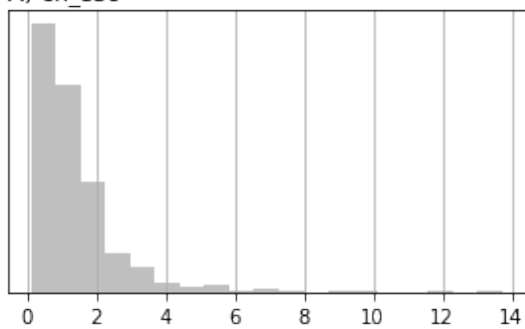
G) cn_rech4



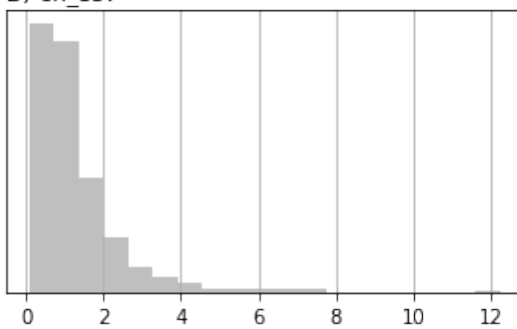
H) cn_rech5



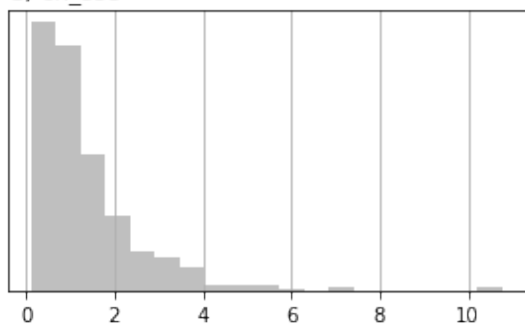
A) cn_ss6



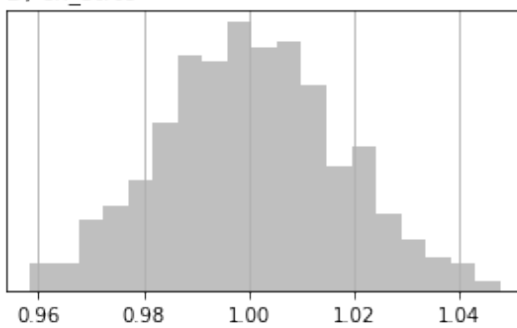
B) cn_ss7



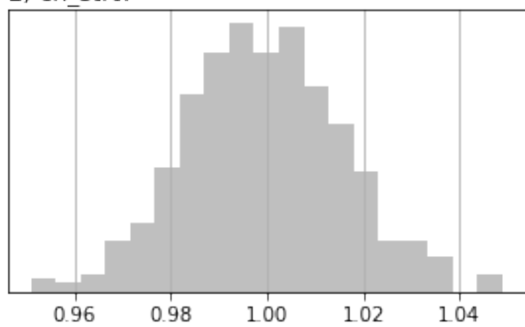
C) cn_ss8



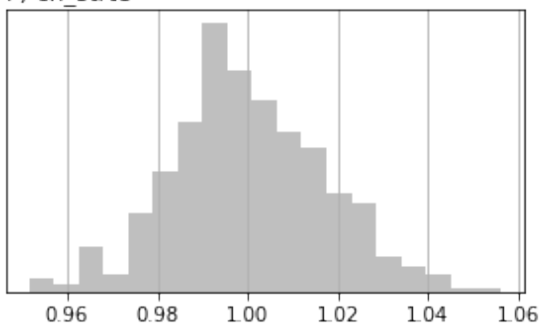
D) cn_strt6



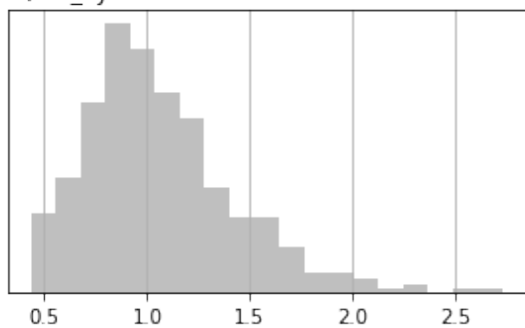
E) cn_strt7



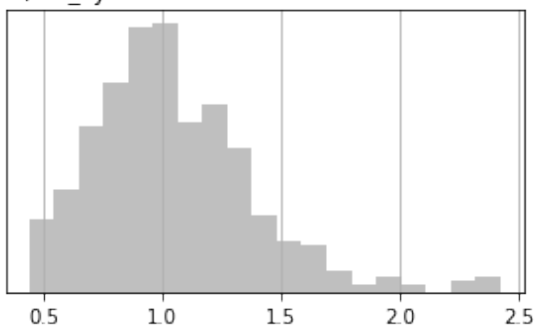
F) cn_strt8



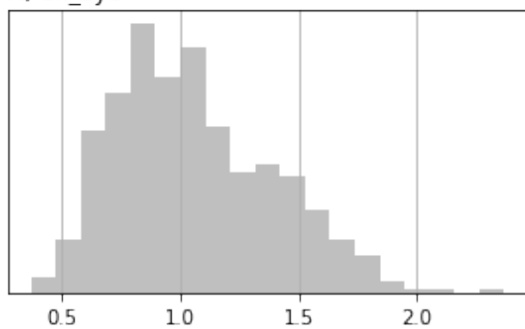
G) cn_sy6



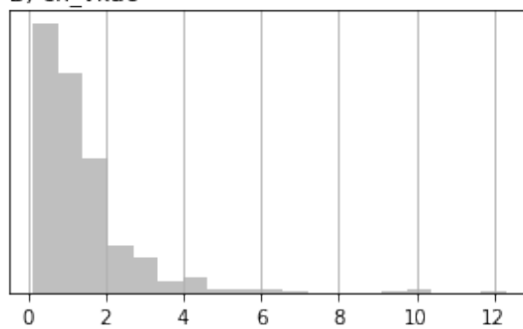
H) cn_sy7



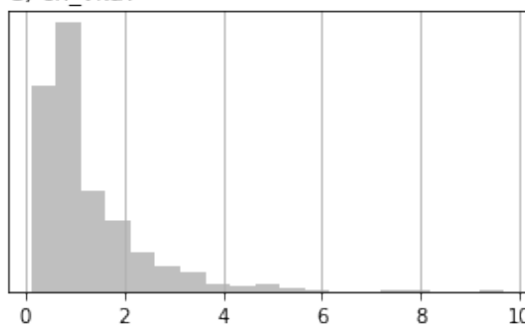
A) cn_sy8



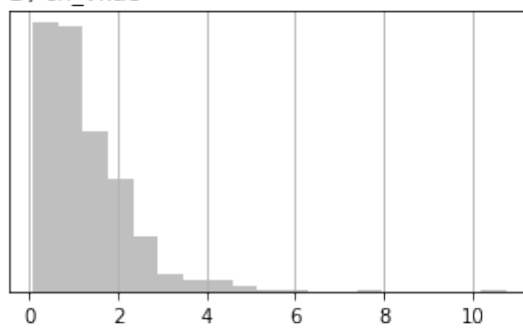
B) cn_vka6



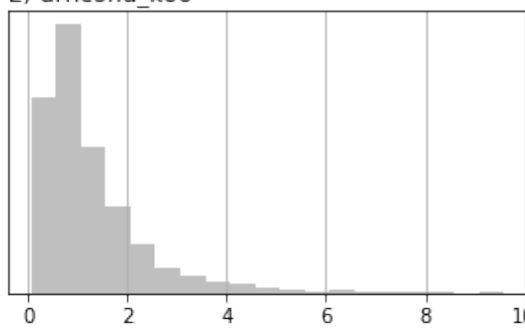
C) cn_vka7



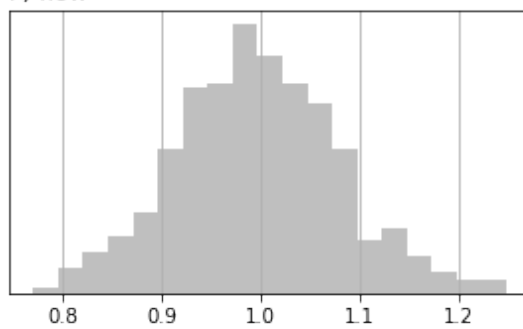
D) cn_vka8



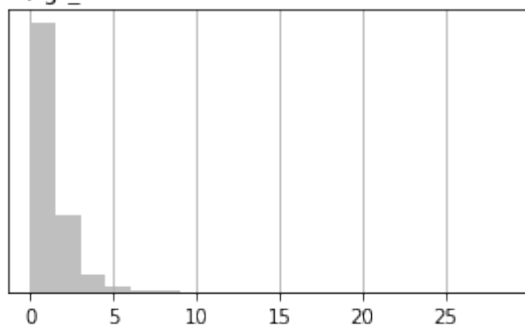
E) drncond_k00



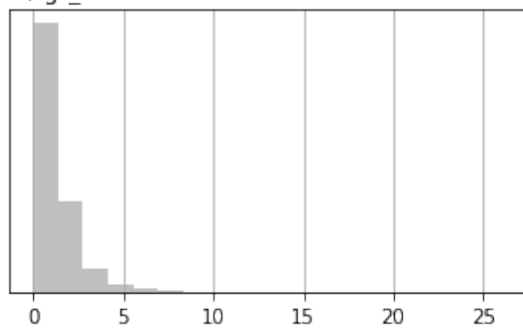
F) flow



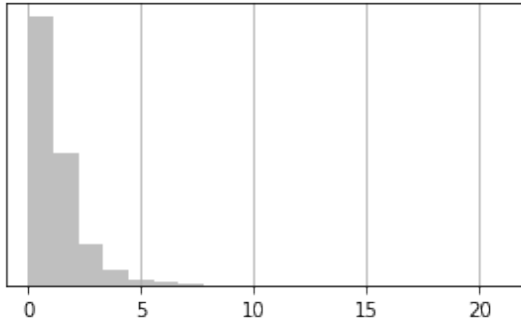
G) gr_hk3



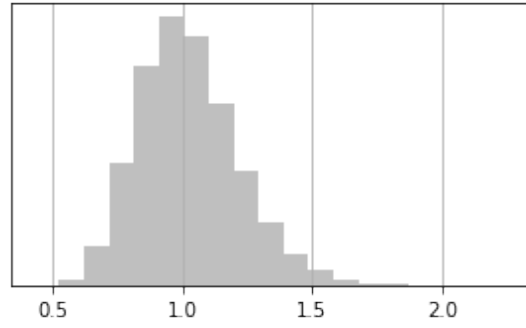
H) gr_hk4



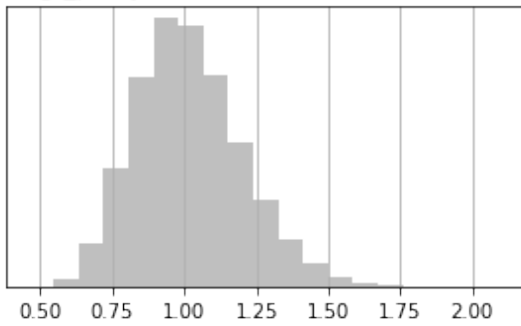
A) gr_hk5



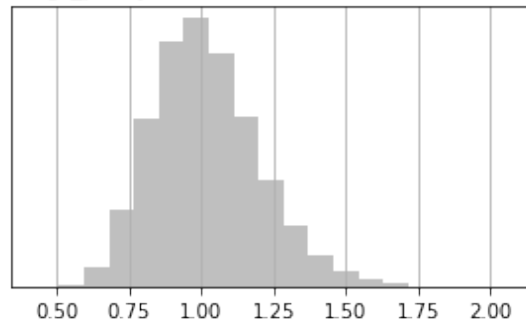
B) gr_prsity3



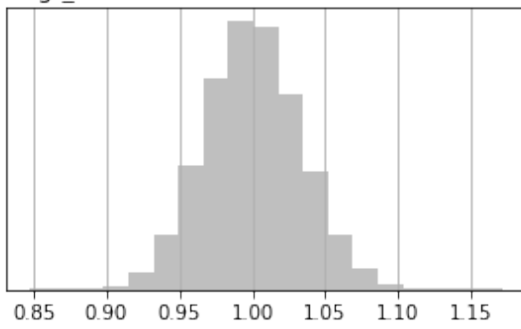
C) gr_prsity4



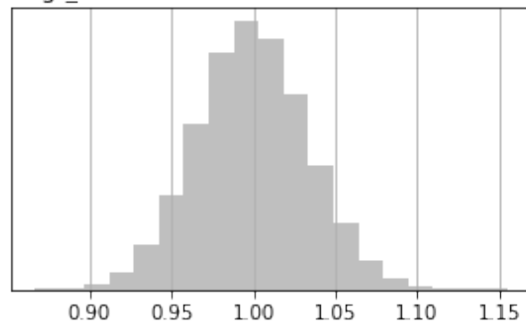
D) gr_prsity5



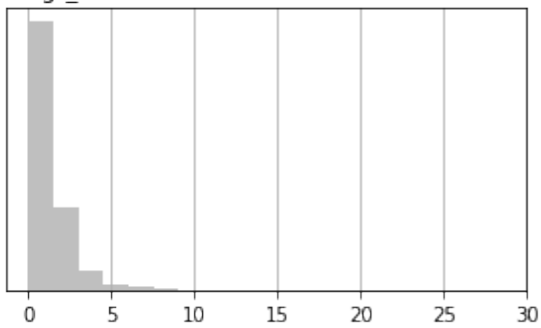
E) gr_rech2



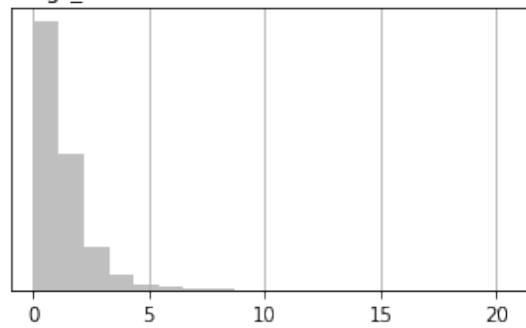
F) gr_rech3



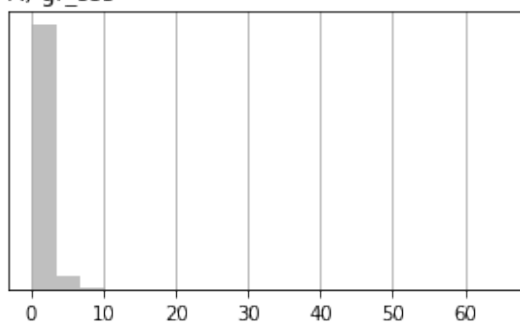
G) gr_ss3



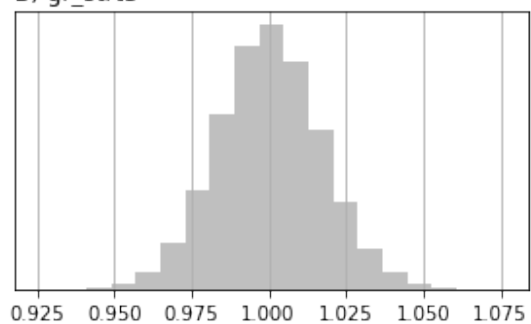
H) gr_ss4



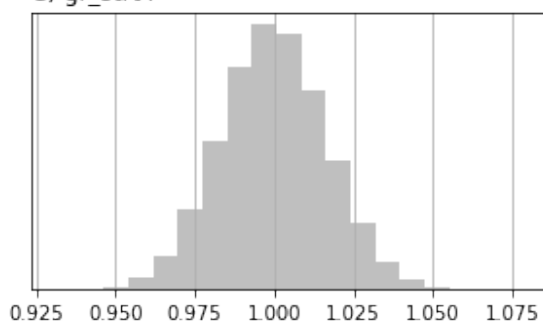
A) gr_ss5



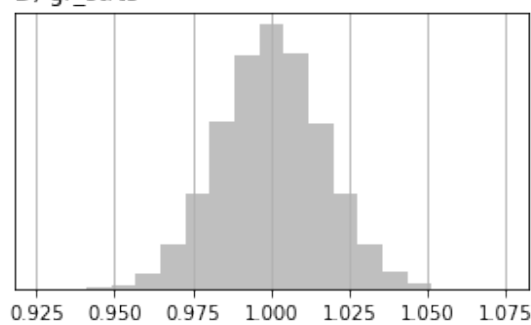
B) gr_strt3



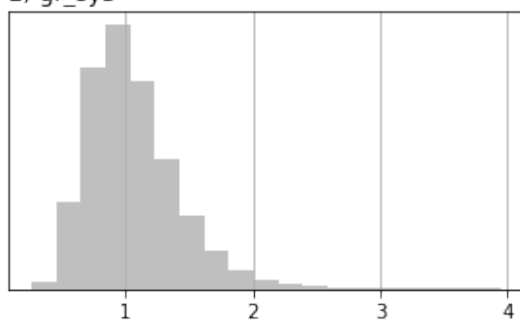
C) gr_strt4



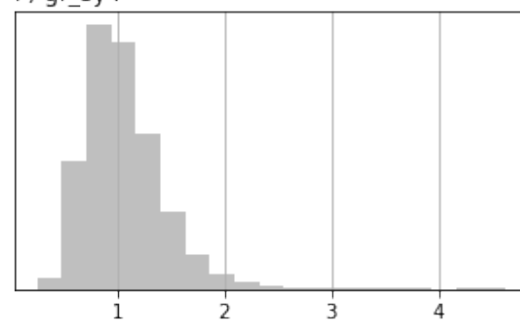
D) gr_strt5



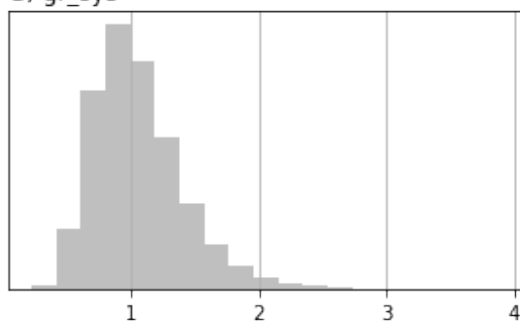
E) gr_sy3



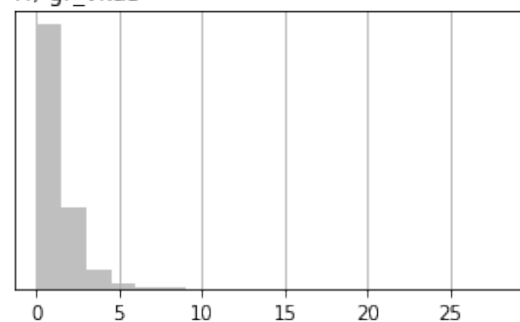
F) gr_sy4



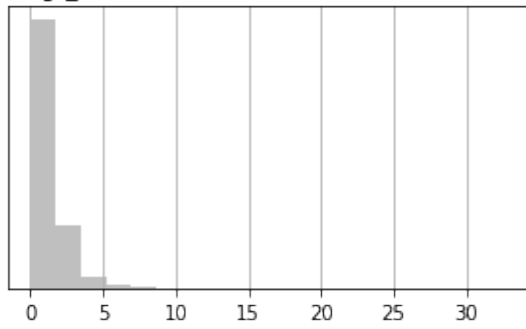
G) gr_sy5



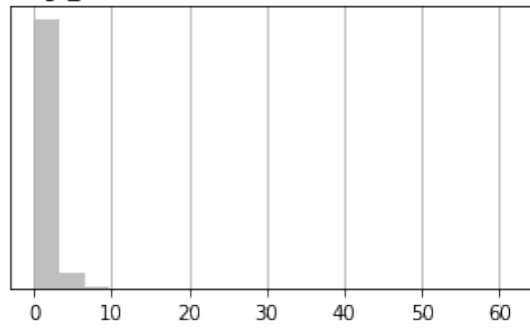
H) gr_vka3



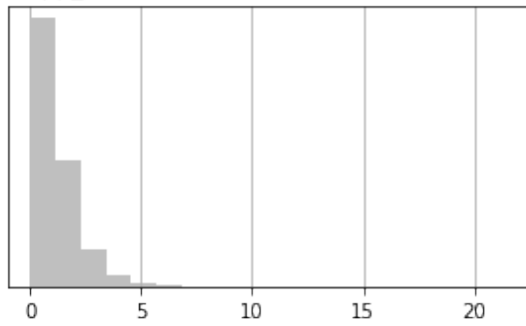
A) gr_vka4



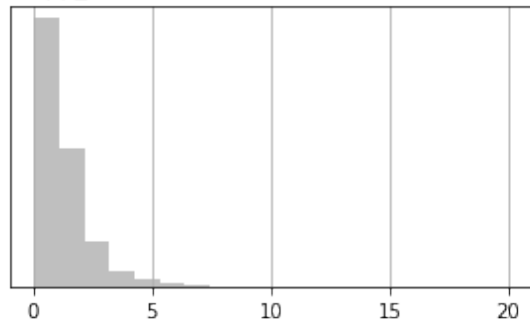
B) gr_vka5



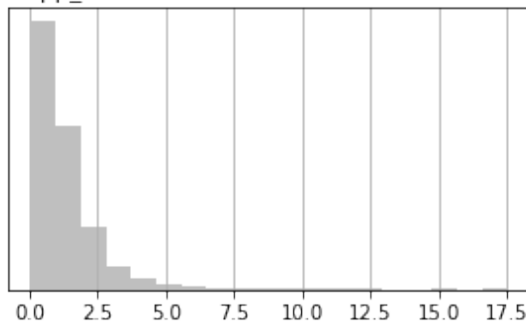
C) pp_hk0



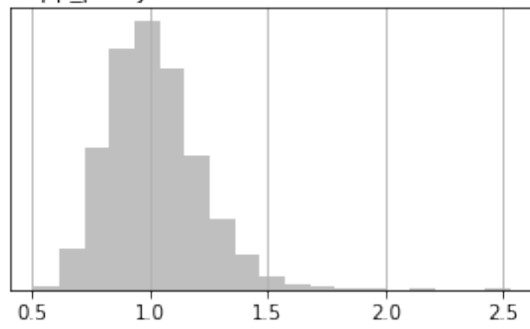
D) pp_hk1



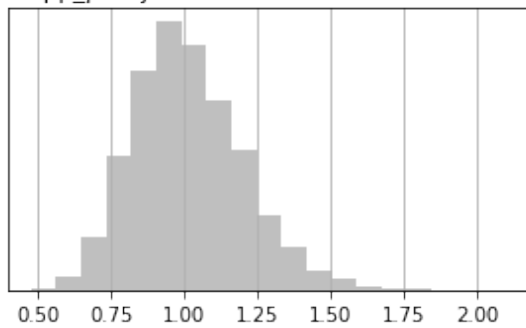
E) pp_hk2



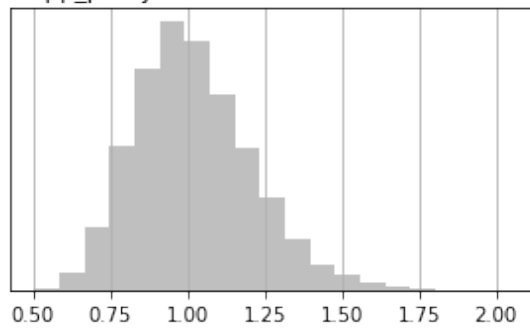
F) pp_prsity0



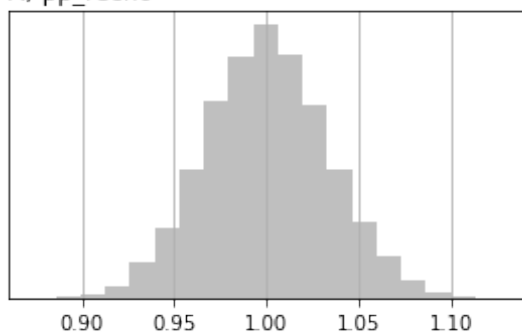
G) pp_prsity1



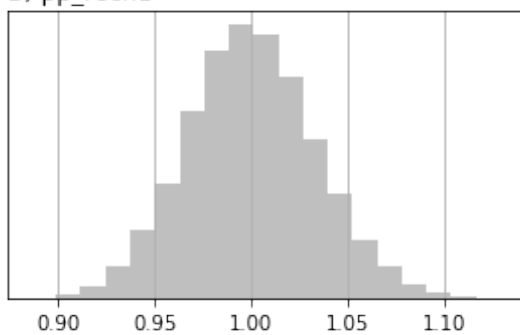
H) pp_prsity2



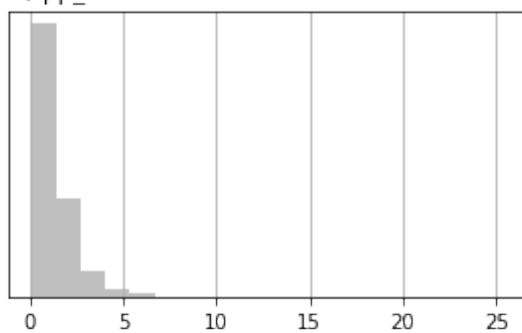
A) pp_rech0



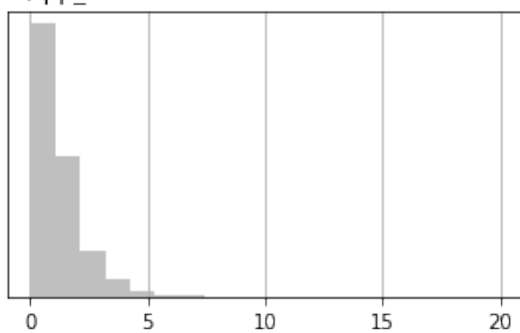
B) pp_rech1



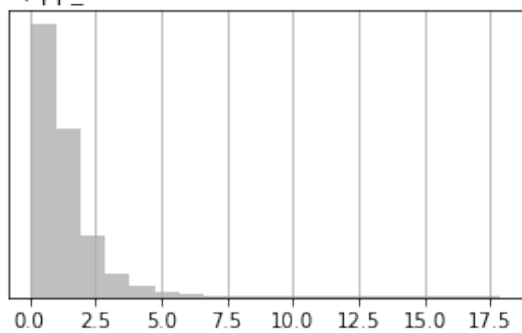
C) pp_ss0



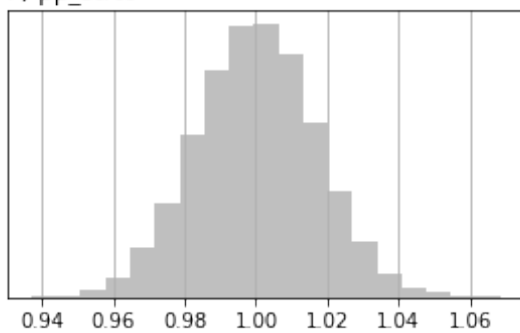
D) pp_ss1



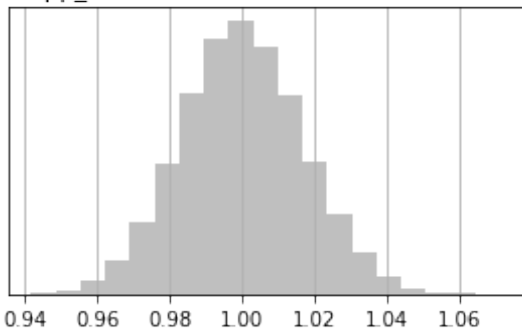
E) pp_ss2



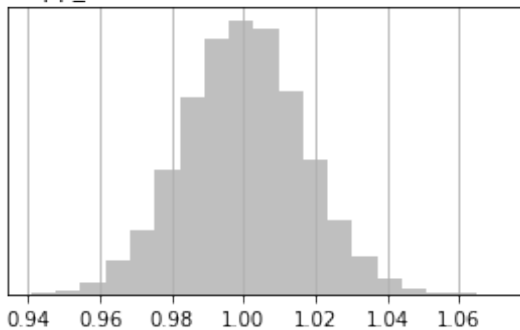
F) pp_strt0



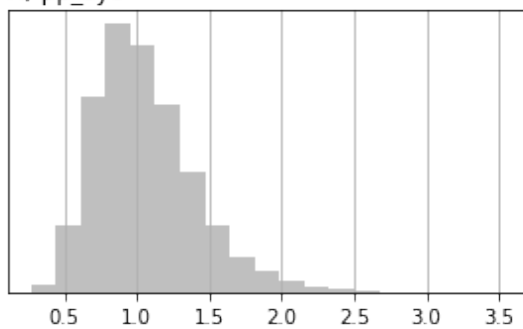
G) pp_strt1



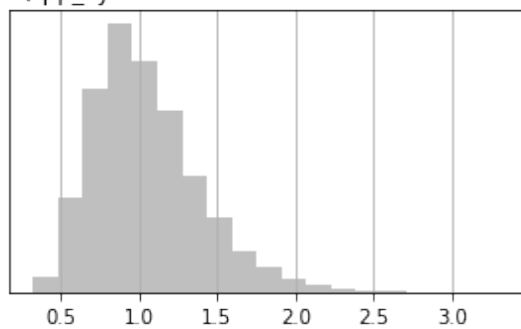
H) pp_strt2



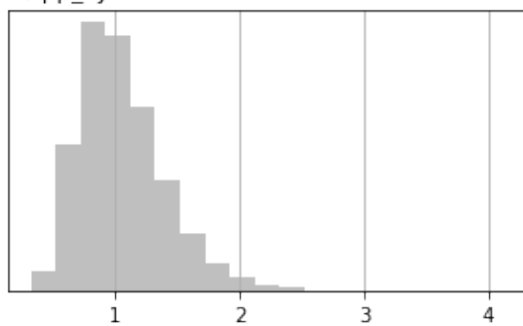
A) pp_sy0



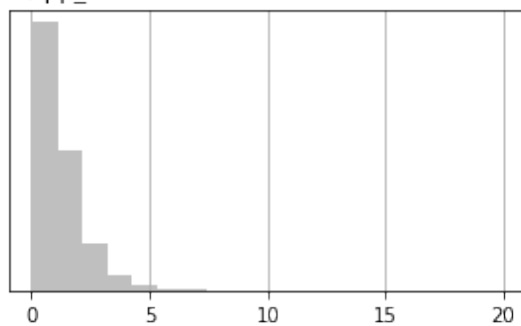
B) pp_sy1



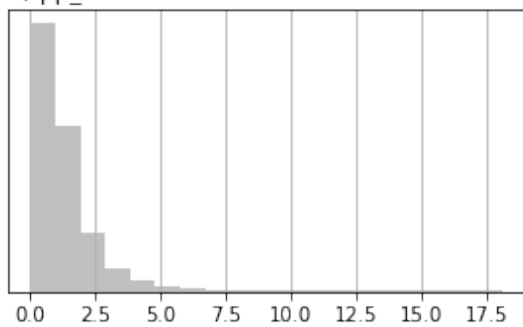
C) pp_sy2



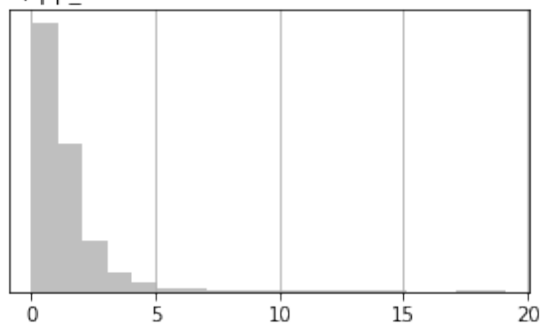
D) pp_vka0



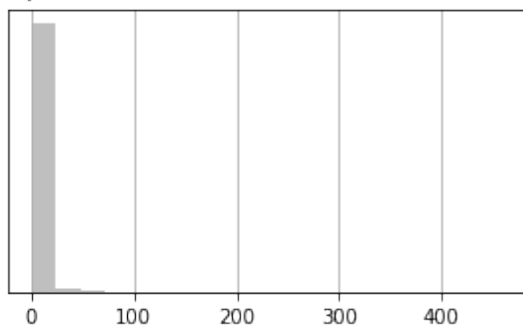
E) pp_vka1



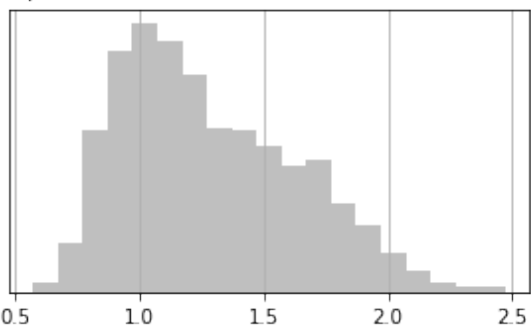
F) pp_vka2

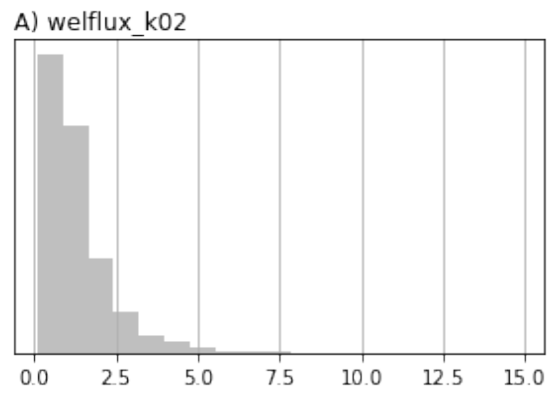


G) strk



H) welflux





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]: 0.6527402126700846
```

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".format(x["row"], x["col"]), axis=1)
        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 exercise

```
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" in x))]
print(swgw_forecasts)
hds_fore_name = "hds_00_{0:03d}_{1:03d}".format(int(pst_helper.m.nrow/3),int(pst_helper.m.nrow/3))
hds_forecasts = obs.loc[obs.obsnme.apply(lambda x: hds_fore_name in x), "obsnme"].tolist()
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

```

```

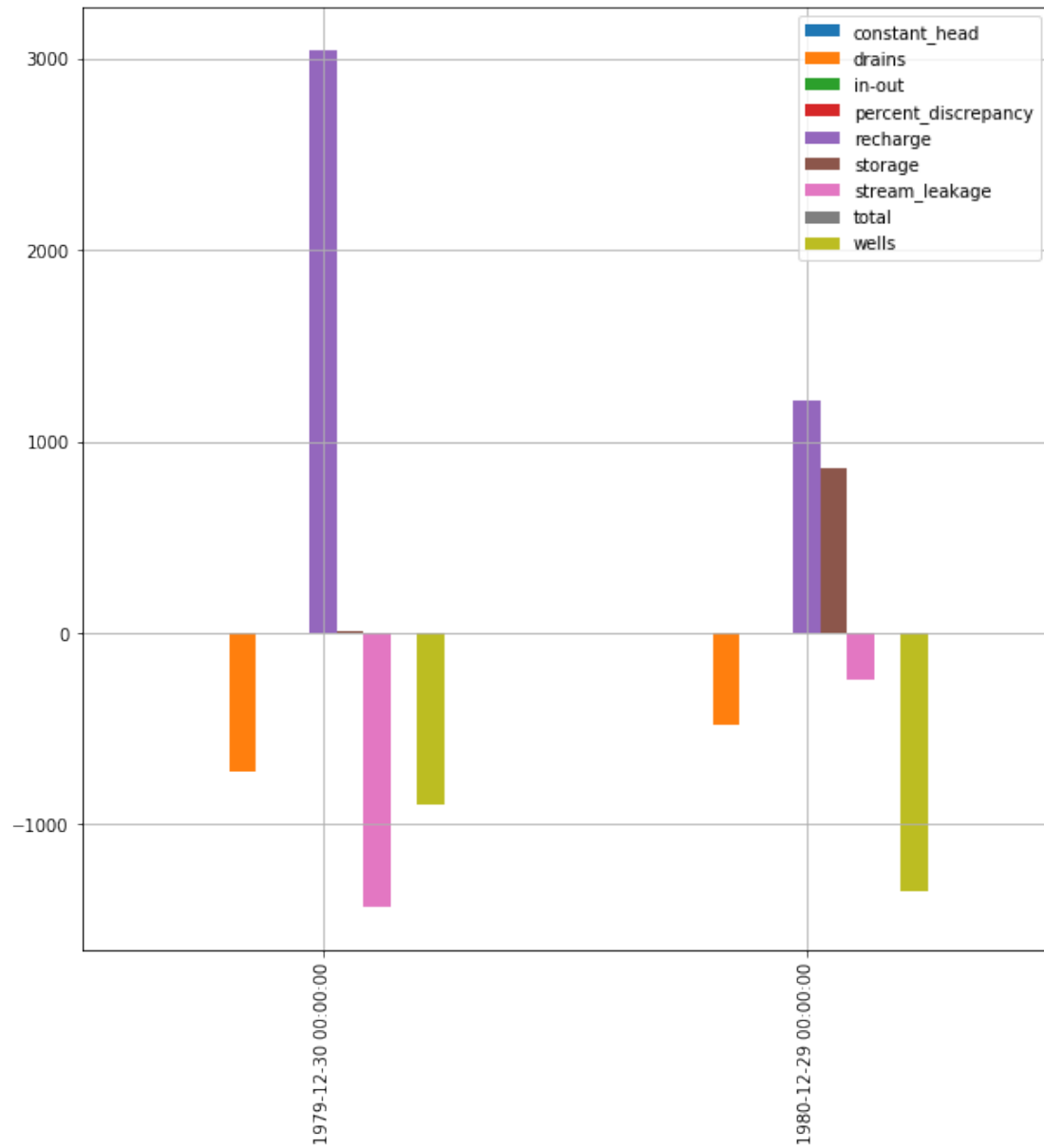
Out[32]: 9.456182577320024e-19

```

```

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.