

pestpp-ies

May 7, 2019

1 Run PESTPP-IES

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

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

```
In [2]: t_d = "template"
m_d = "master_ies"
```

```
In [3]: pst = pyemu.Pst(os.path.join(t_d,"freyberg.pst"))
pst.write_par_summary_table(filename="none")
```

```
Out[3]:
```

		type	transform	count	initial value	\
drncond_k00	drncond_k00	log	10	0		
gr_strt3	gr_strt3	log	705	0		
gr_sy4	gr_sy4	log	705	0		
pp_hk1	pp_hk1	log	32	0		
cn_prsity6	cn_prsity6	log	1	0		
gr_ss5	gr_ss5	log	705	0		
pp_strt0	pp_strt0	log	32	0		
gr_ss4	gr_ss4	log	705	0		
pp_rech0	pp_rech0	log	32	0		
gr_prsity3	gr_prsity3	log	705	0		
pp_ss2	pp_ss2	log	32	0		
pp_prsity1	pp_prsity1	log	32	0		
pp_prsity0	pp_prsity0	log	32	0		
cn_ss6	cn_ss6	log	1	0		
cn_vka7	cn_vka7	log	1	0		

gr_vka5	gr_vka5	log	705	0
gr_ss3	gr_ss3	log	705	0
pp_strt1	pp_strt1	log	32	0
pp_sy2	pp_sy2	log	32	0
cn_rech4	cn_rech4	log	1	0
cn_vka8	cn_vka8	log	1	0
gr_prsity4	gr_prsity4	log	705	0
cn_strt7	cn_strt7	log	1	0
pp_hk0	pp_hk0	log	32	0
pp_hk2	pp_hk2	log	32	0
pp_ss1	pp_ss1	log	32	0
pp_rech1	pp_rech1	log	32	0
cn_hk7	cn_hk7	log	1	0
welflux_k02	welflux_k02	log	6	0
gr_hk3	gr_hk3	log	705	0
...
flow	flow	log	1	0
gr_prsity5	gr_prsity5	log	705	0
cn_strt8	cn_strt8	log	1	0
pp_vka1	pp_vka1	log	32	0
cn_prsity8	cn_prsity8	log	1	0
gr_hk5	gr_hk5	log	705	0
cn_strt6	cn_strt6	log	1	0
gr_rech3	gr_rech3	log	705	0
pp_vka2	pp_vka2	log	32	0
pp_sy1	pp_sy1	log	32	0
gr_strt5	gr_strt5	log	705	0
strk	strk	log	40	0
cn_sy6	cn_sy6	log	1	0
cn_ss8	cn_ss8	log	1	0
pp_strt2	pp_strt2	log	32	0
cn_rech5	cn_rech5	log	1	-0.39794
gr_sy5	gr_sy5	log	705	0
gr_hk4	gr_hk4	log	705	0
cn_hk6	cn_hk6	log	1	0
pp_prsity2	pp_prsity2	log	32	0
gr_vka3	gr_vka3	log	705	0
gr_vka4	gr_vka4	log	705	0
welflux	welflux	log	2	0 to 0.176091
cn_sy8	cn_sy8	log	1	0
pp_ss0	pp_ss0	log	32	0
cn_prsity7	cn_prsity7	log	1	0
gr_rech2	gr_rech2	log	705	0
cn_ss7	cn_ss7	log	1	0
cn_hk8	cn_hk8	log	1	0
gr_strt4	gr_strt4	log	705	0
		upper bound	lower bound	standard deviation

drncond_k00	1	-1	0.5
gr_strt3	0.0211893	-0.0222764	0.0108664
gr_sy4	0.243038	-0.60206	0.211275
pp_hk1	1	-1	0.5
cn_prsity6	0	-1	0.25
gr_ss5	1	-1	0.5
pp_strt0	0.0211893	-0.0222764	0.0108664
gr_ss4	1	-1	0.5
pp_rech0	0.0413927	-0.0457575	0.0217875
gr_prsity3	0	-1	0.25
pp_ss2	1	-1	0.5
pp_prsity1	0	-1	0.25
pp_prsity0	0	-1	0.25
cn_ss6	1	-1	0.5
cn_vka7	1	-1	0.5
gr_vka5	1	-1	0.5
gr_ss3	1	-1	0.5
pp_strt1	0.0211893	-0.0222764	0.0108664
pp_sy2	0.243038	-0.60206	0.211275
cn_rech4	0.0791812	-0.09691	0.0440228
cn_vka8	1	-1	0.5
gr_prsity4	0	-1	0.25
cn_strt7	0.0211893	-0.0222764	0.0108664
pp_hk0	1	-1	0.5
pp_hk2	1	-1	0.5
pp_ss1	1	-1	0.5
pp_rech1	0.0413927	-0.0457575	0.0217875
cn_hk7	1	-1	0.5
welflux_k02	1	-1	0.5
gr_hk3	1	-1	0.5
...
flow	0.09691	-0.124939	0.0554622
gr_prsity5	0	-1	0.25
cn_strt8	0.0211893	-0.0222764	0.0108664
pp_vka1	1	-1	0.5
cn_prsity8	0	-1	0.25
gr_hk5	1	-1	0.5
cn_strt6	0.0211893	-0.0222764	0.0108664
gr_rech3	0.0413927	-0.0457575	0.0217875
pp_vka2	1	-1	0.5
pp_sy1	0.243038	-0.60206	0.211275
gr_strt5	0.0211893	-0.0222764	0.0108664
strk	2	-2	1
cn_sy6	0.243038	-0.60206	0.211275
cn_ss8	1	-1	0.5
pp_strt2	0.0211893	-0.0222764	0.0108664
cn_rech5	-0.09691	-1	0.225772
gr_sy5	0.243038	-0.60206	0.211275

gr_hk4	1	-1	0.5
cn_hk6	1	-1	0.5
pp_prsity2	0	-1	0.25
gr_vka3	1	-1	0.5
gr_vka4	1	-1	0.5
welflux	0.176091 to 0.30103	-0.30103 to 0	0.0752575 to 0.11928
cn_sy8	0.243038	-0.60206	0.211275
pp_ss0	1	-1	0.5
cn_prsity7	0	-1	0.25
gr_rech2	0.0413927	-0.0457575	0.0217875
cn_ss7	1	-1	0.5
cn_hk8	1	-1	0.5
gr_strt4	0.0211893	-0.0222764	0.0108664

[65 rows x 7 columns]

Should we fix either PP or grids?

```
In [4]: par = pst.parameter_data
        # grid pars
        #should_fix = par.loc[par.pargp.apply(lambda x: "gr" in x), "parnme"]
        # pp pars
        #should_fix = par.loc[par.pargp.apply(lambda x: "pp" in x), "parnme"]

        # if we want to fix some pars, do it here
        #pst.parameter_data.loc[should_fix, "partrans"] = "fixed"
        #pst.npar, pst.npar_adj
```

1.0.1 Run PESTPP-IES in original mode and post process

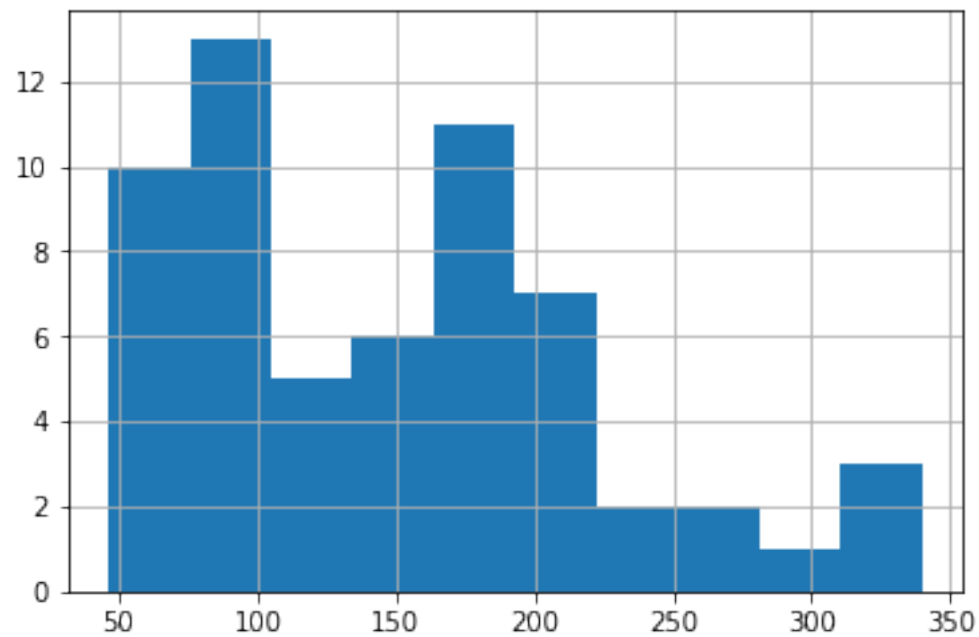
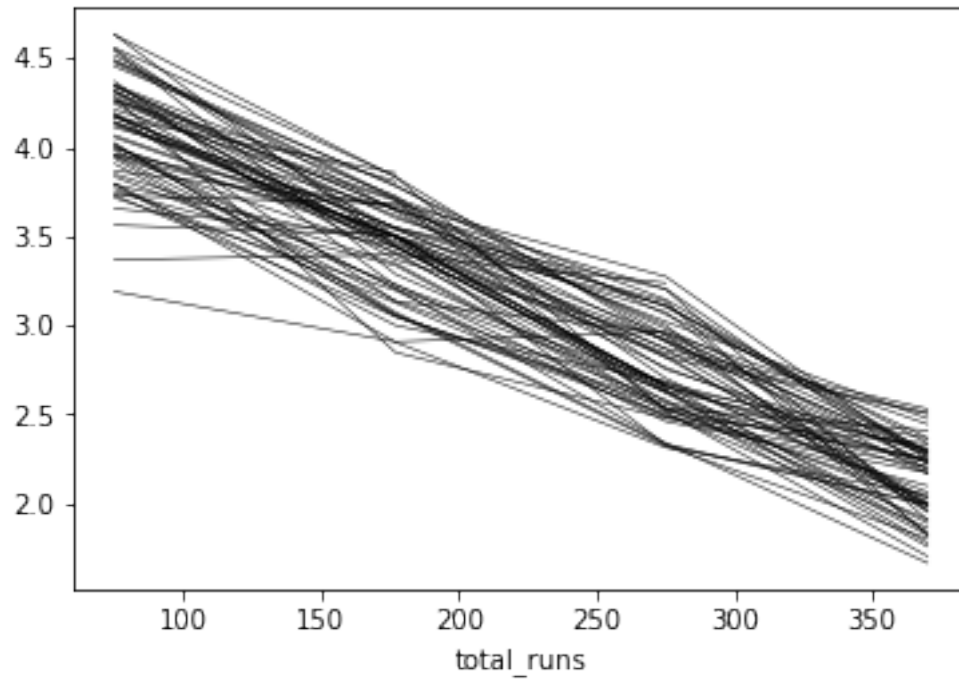
```
In [5]: pst.pestpp_options["ies_num_reals"] = 75
        pst.pestpp_options["ies_par_en"] = "prior.jcb"
        pst.pestpp_options["ies_bad_phi_sigma"] = 1.75
        pst.pestpp_options["overdue_giveup_fac"] = 10.0
        pst.control_data.noptymax = 3
```

```
In [6]: pst.write(os.path.join(t_d, "freyberg_ies.pst"))
```

```
In [7]: pyemu.os_utils.start_slaves(t_d, "pestpp-ies", "freyberg_ies.pst", num_slaves=20, master_d=)
```

A cheap phi progress plot

```
In [8]: phi = pd.read_csv(os.path.join(m_d, "freyberg_ies.phi.actual.csv"), index_col=0)
        phi.index = phi.total_runs
        phi.iloc[:, 6:].apply(np.log10).plot(legend=False, lw=0.5, color='k')
        plt.figure()
        phi.iloc[-1, 6:].hist()
        plt.show()
```



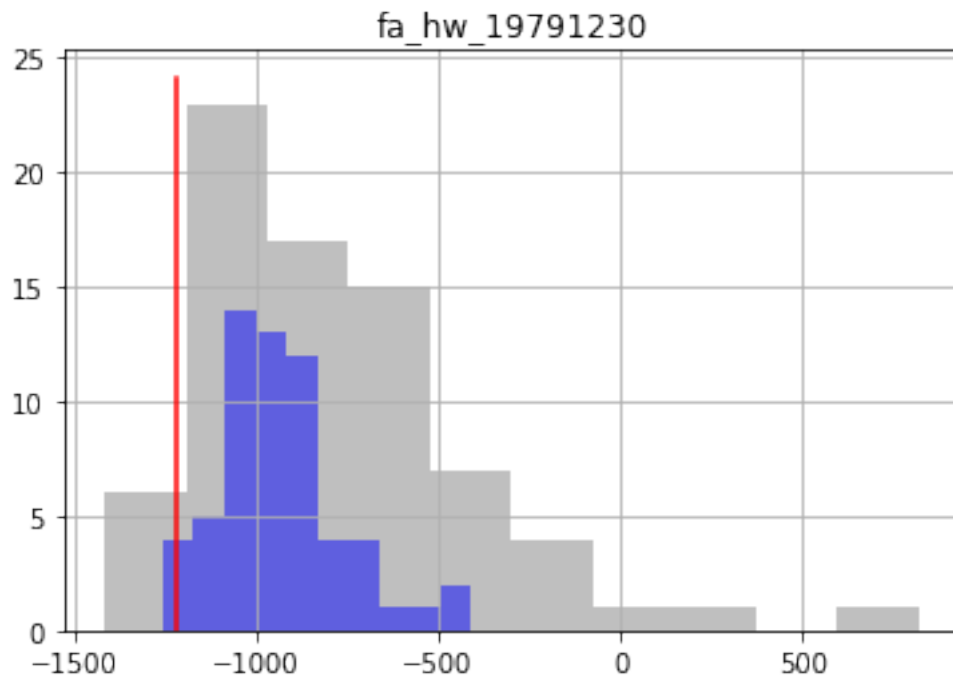
Plot forecast prior and posterior histograms with “truth” (red line)

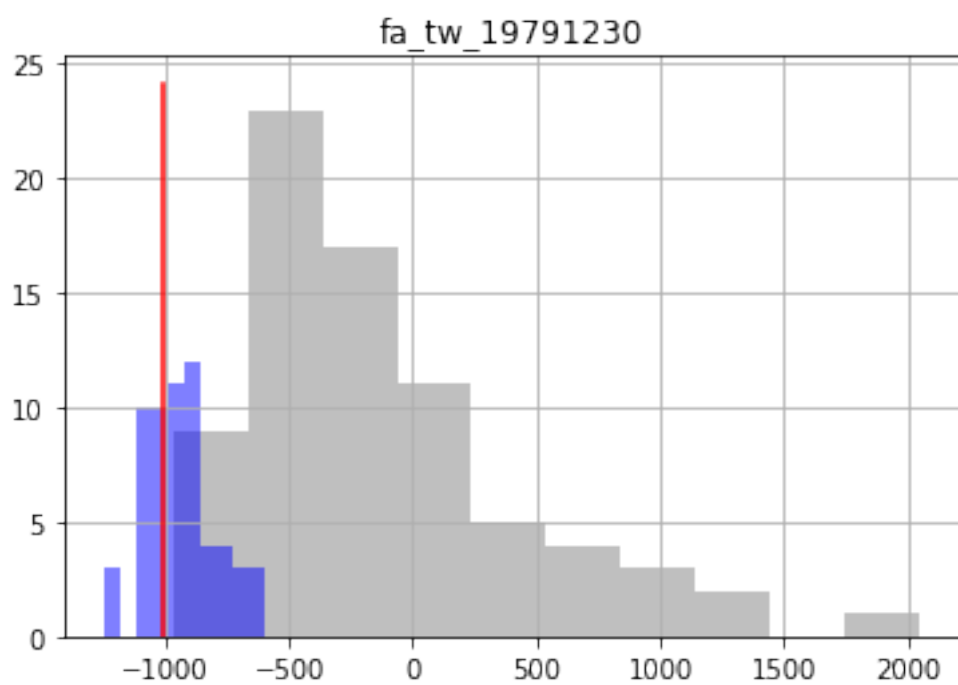
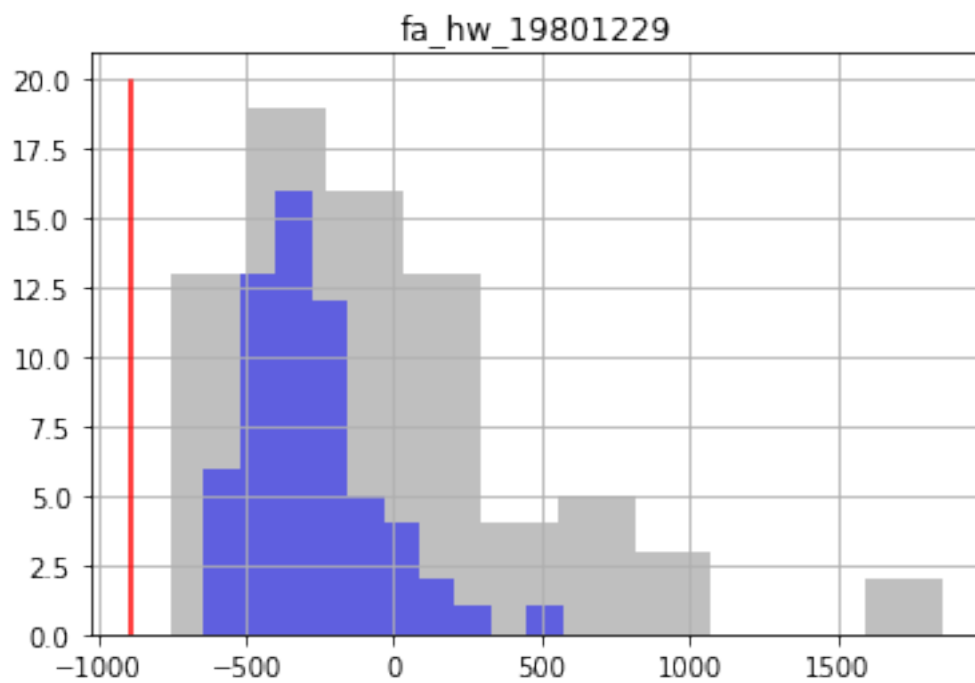
```
In [9]: oe_pr = pd.read_csv(os.path.join(m_d, "freyberg_ies.0.obs.csv"), index_col=0)
        oe_pt = pd.read_csv(os.path.join(m_d, "freyberg_ies.{0}.obs.csv".format(pst.control_data
```

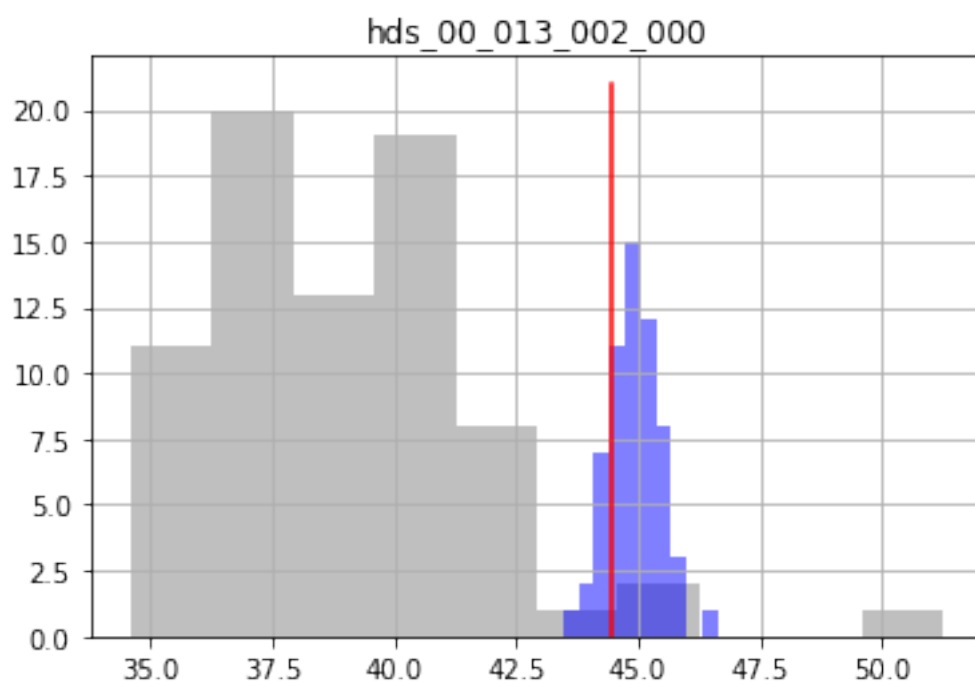
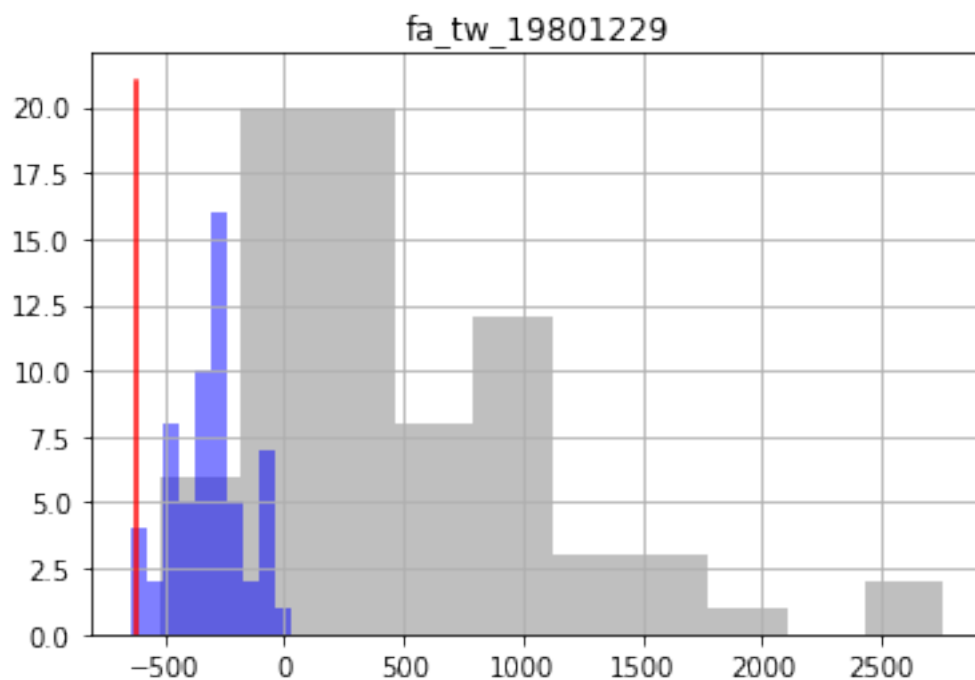
```

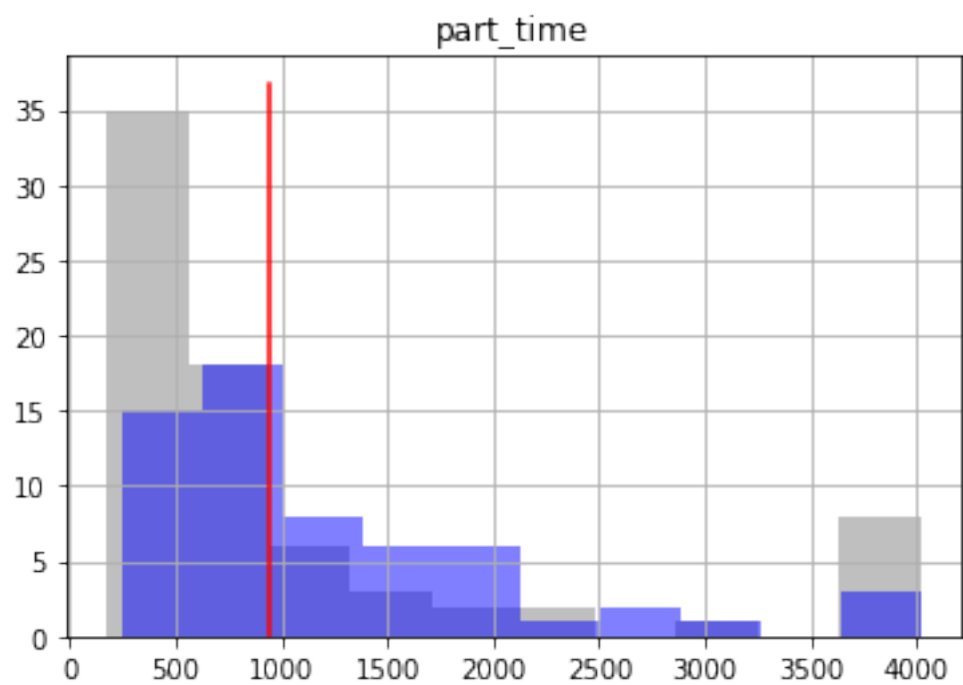
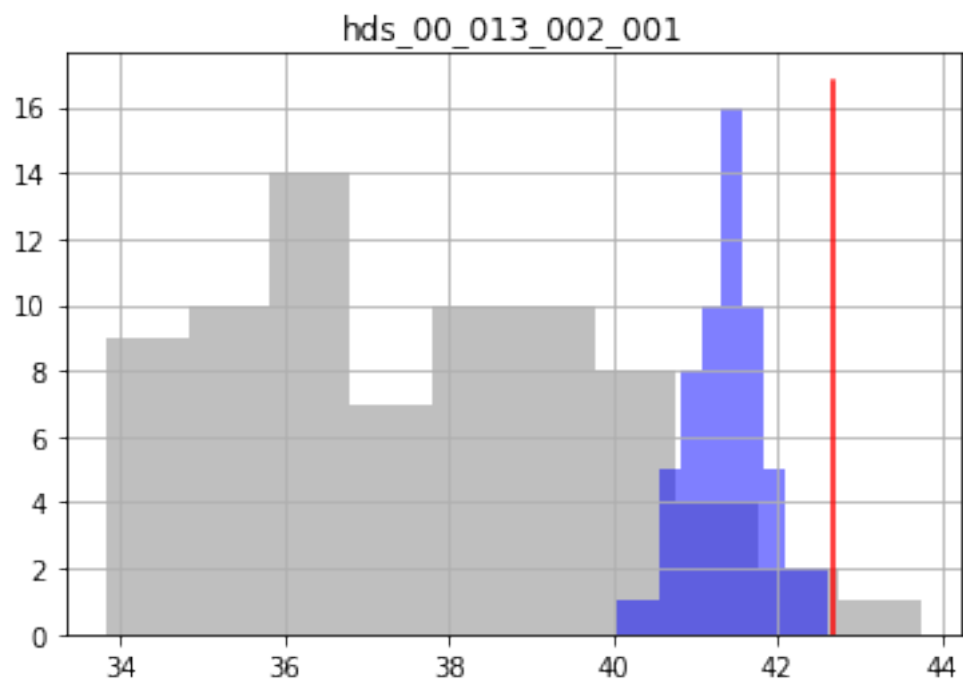
obs = pst.observation_data
fnames = pst.pestpp_options["forecasts"].split(",")
for forecast in fnames:
    ax = plt.subplot(111)
    oe_pr.loc[:,forecast].hist(ax=ax,color="0.5",alpha=0.5)
    oe_pt.loc[:,forecast].hist(ax=ax,color="b",alpha=0.5)
    ax.plot([obs.loc[forecast,"obsval"],obs.loc[forecast,"obsval"]],ax.get_ylim(),"r")
    ax.set_title(forecast)
plt.show()

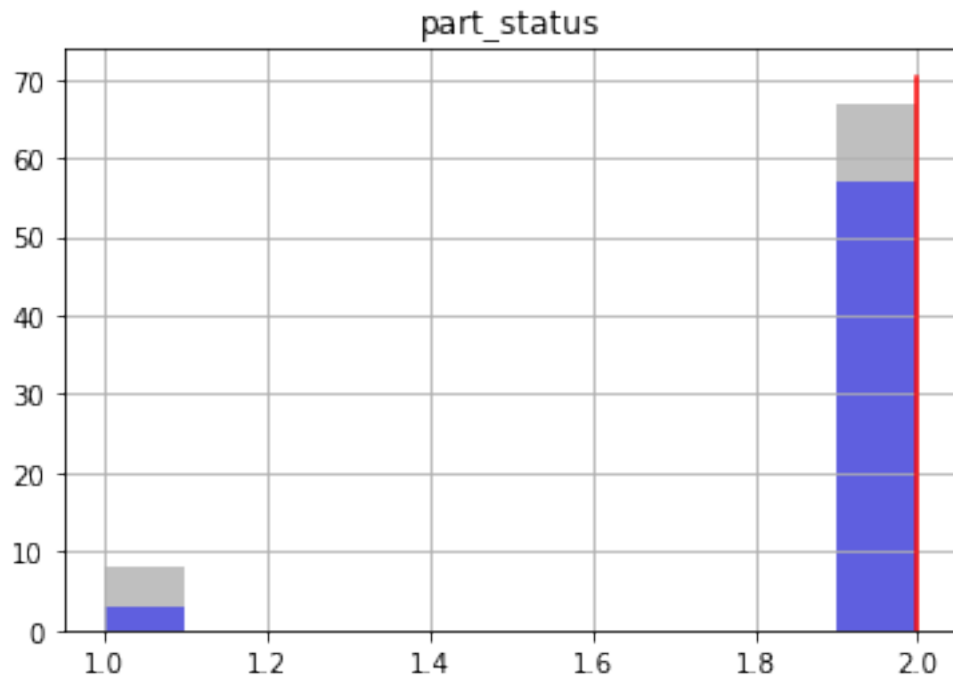
```











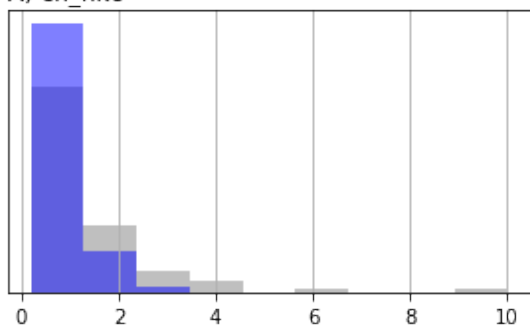
Plot parameter histograms by group

```
In [10]: pe_pr = pd.read_csv(os.path.join(m_d,"freyberg_ies.0.par.csv"),index_col=0)
         pe_pt = pd.read_csv(os.path.join(m_d,"freyberg_ies.{0}.par.csv".format(pst.control_da
         par = pst.parameter_data
         pdict = par.groupby("pargp").groups
         pyemu.plot_utils.ensemble_helper({"0.5":pe_pr,"b":pe_pt},plot_cols=pdict)

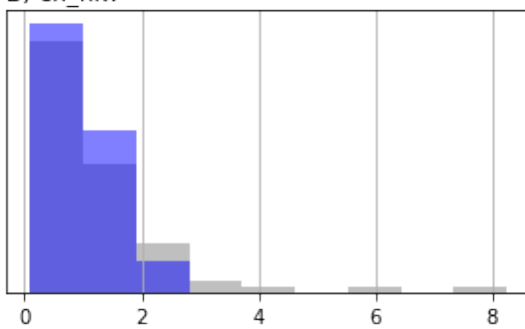
/Users/jeremyw/miniconda3/lib/python3.5/site-packages/IPython/core/interactiveshell.py:2785: D
interactivity=interactivity, compiler=compiler, result=result)
```

<Figure size 576x756 with 0 Axes>

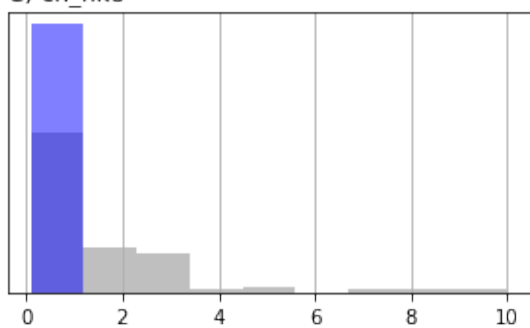
A) cn_hk6



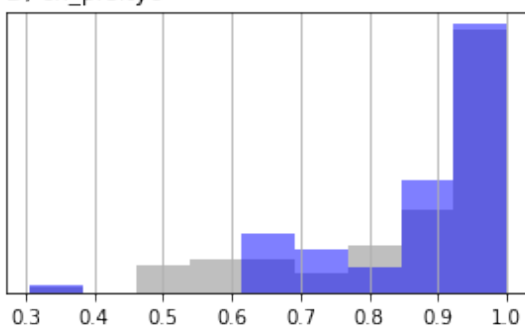
B) cn_hk7



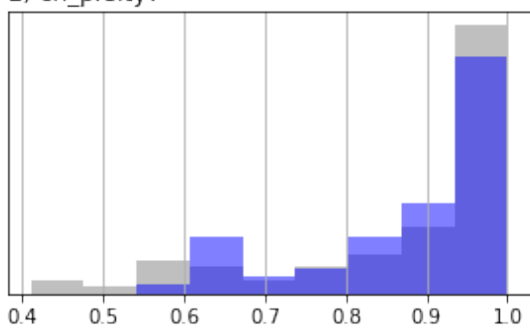
C) cn_hk8



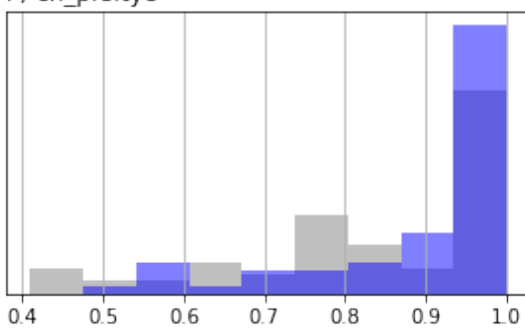
D) cn_prsity6



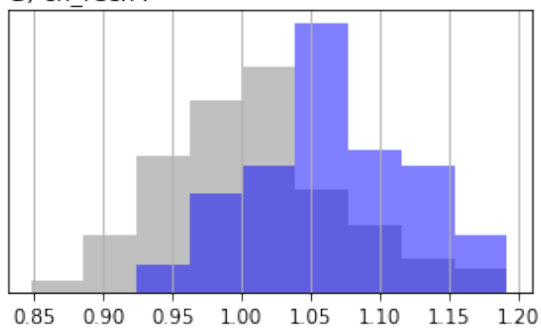
E) cn_prsity7



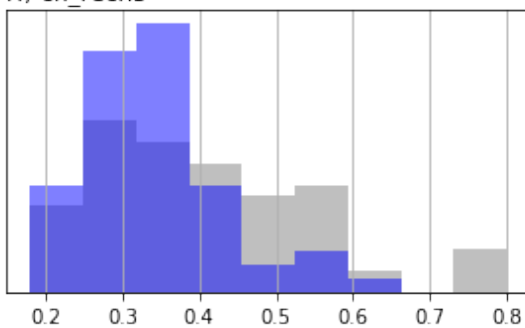
F) cn_prsity8



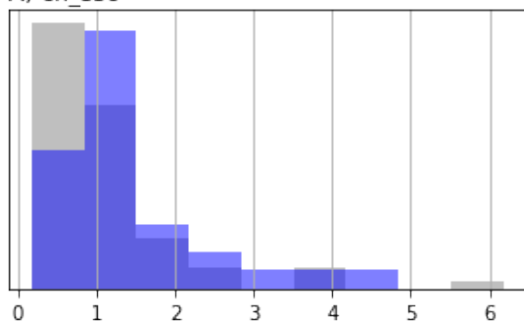
G) cn_rech4



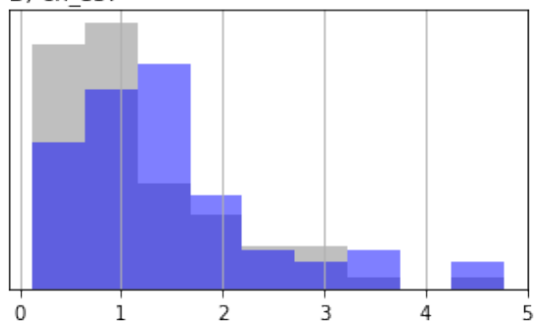
H) cn_rech5



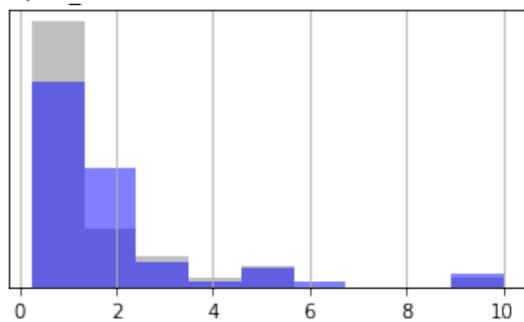
A) cn_ss6



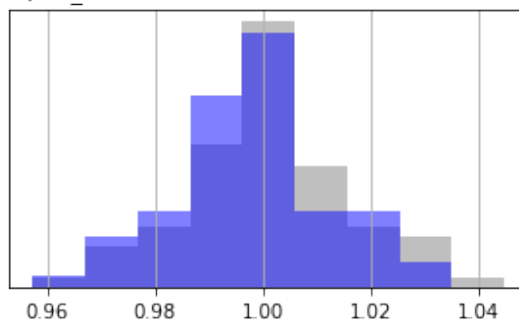
B) cn_ss7



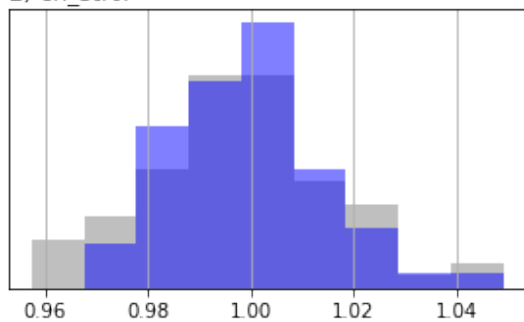
C) cn_ss8



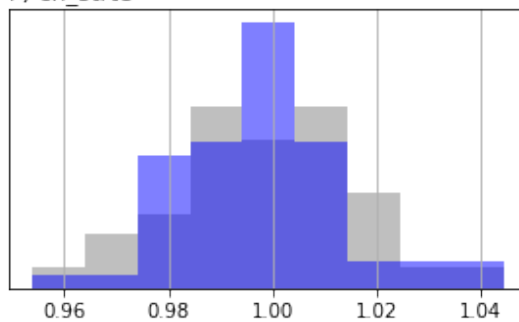
D) cn_strt6



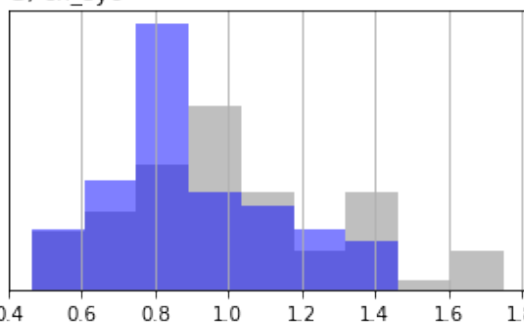
E) cn_strt7



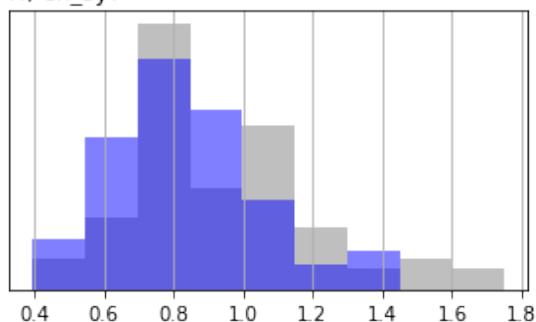
F) cn_strt8



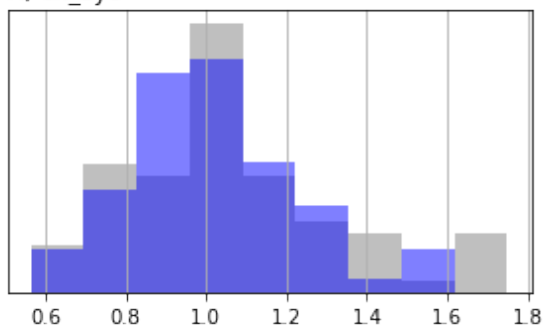
G) cn_sy6



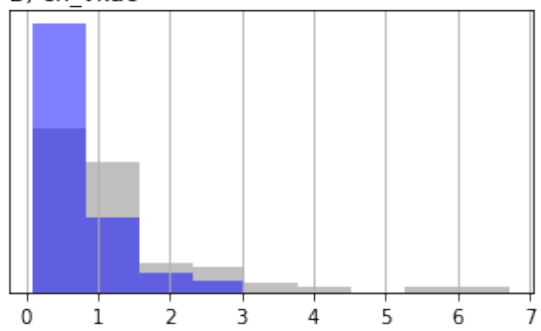
H) cn_sy7



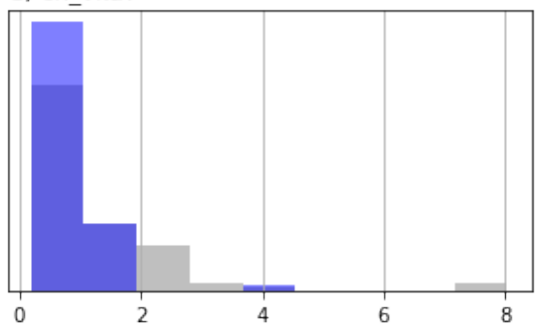
A) cn_sy8



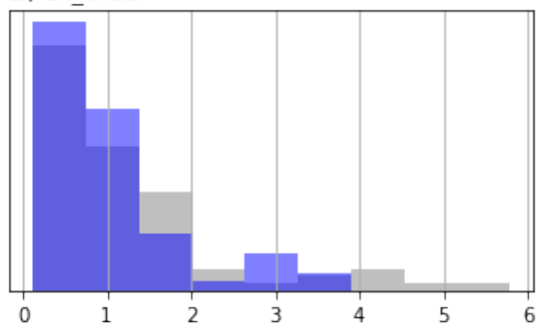
B) cn_vka6



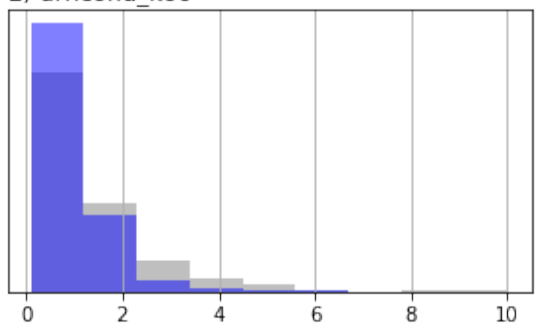
C) cn_vka7



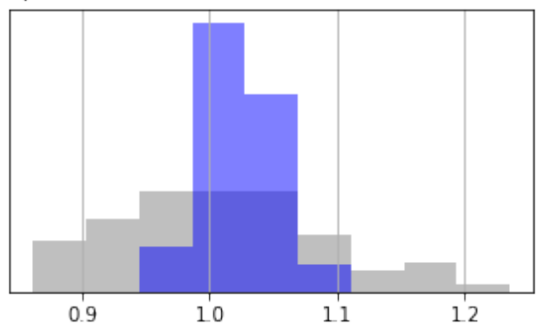
D) cn_vka8



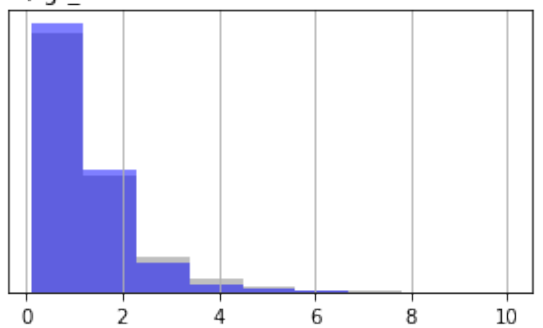
E) drncond_k00



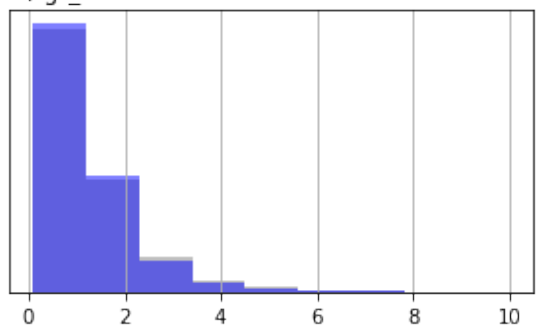
F) flow



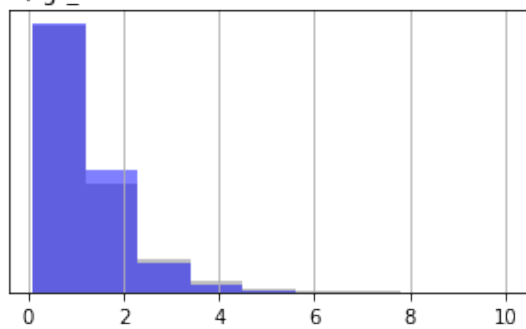
G) gr_hk3



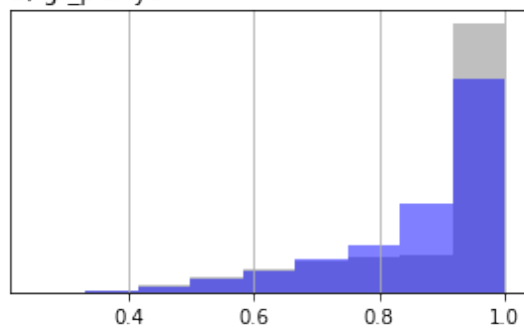
H) gr_hk4



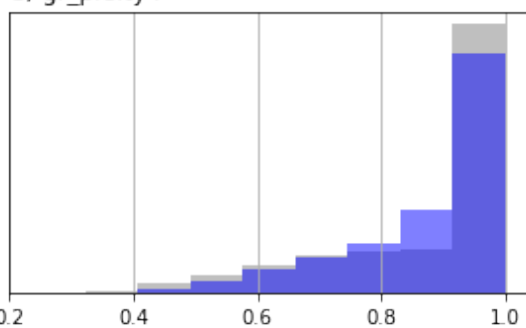
A) gr_hk5



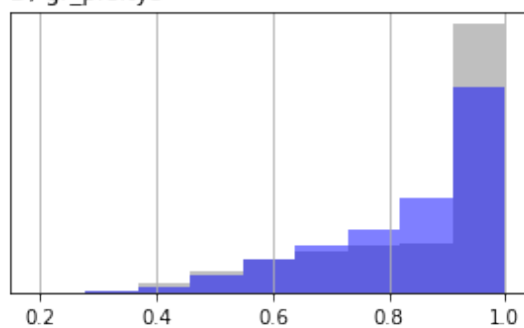
B) gr_prsity3



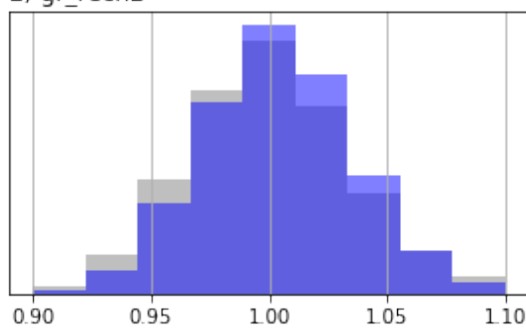
C) gr_prsity4



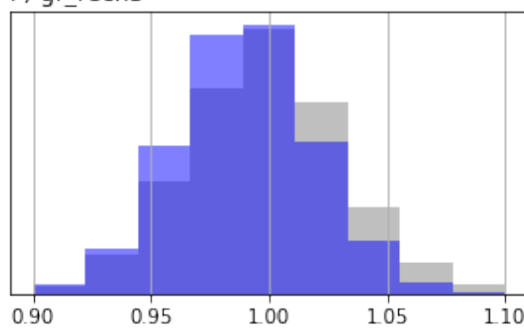
D) gr_prsity5



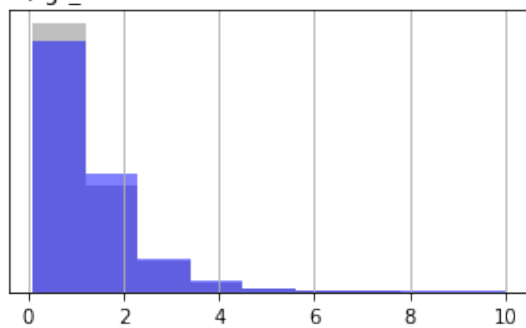
E) gr_rech2



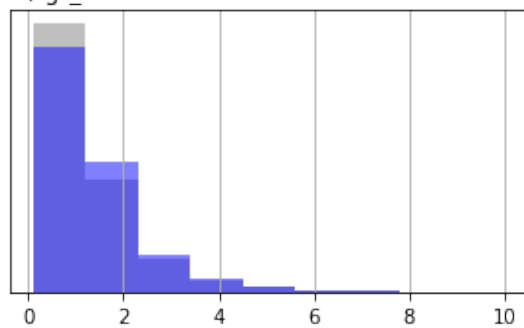
F) gr_rech3

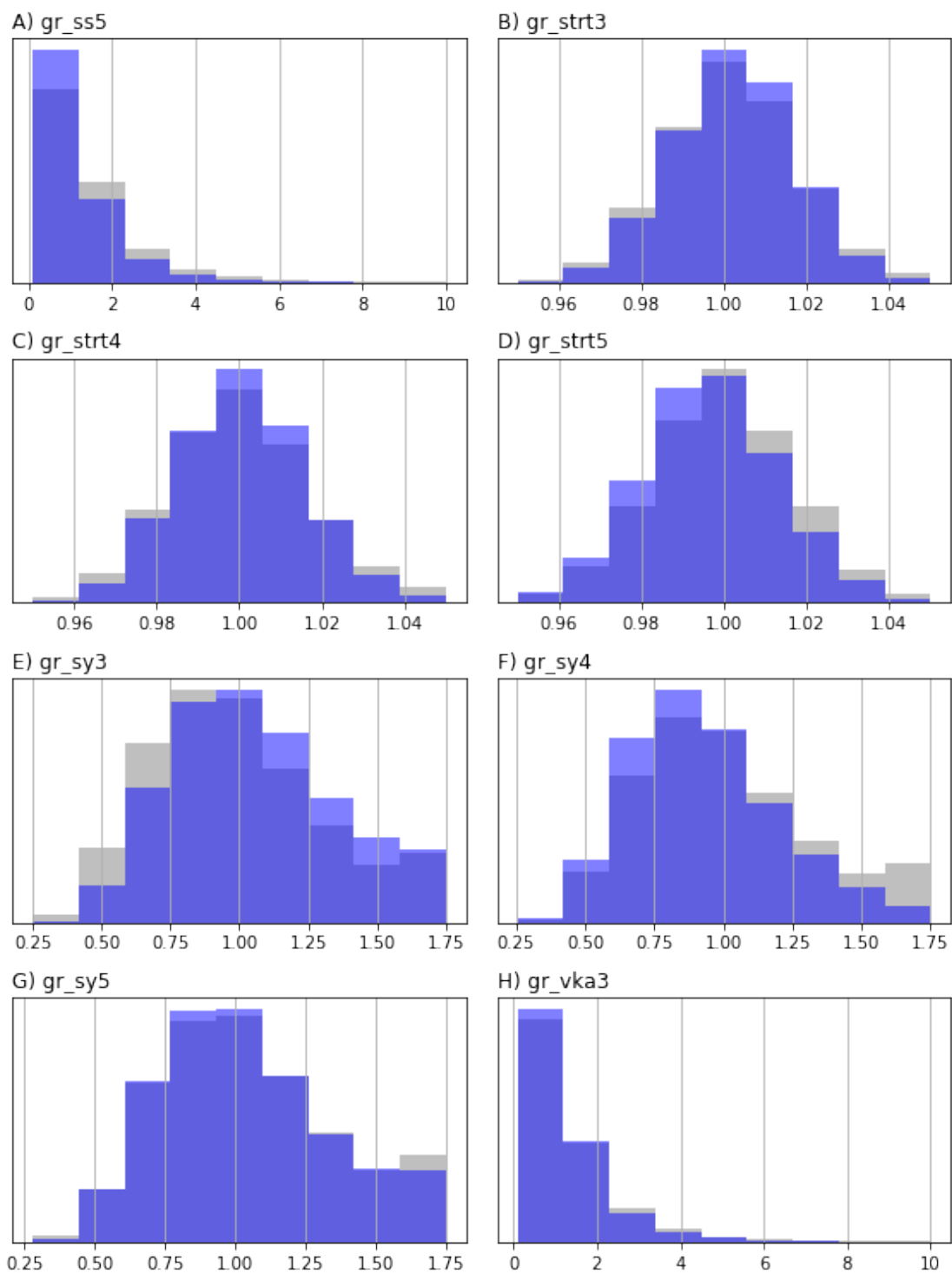


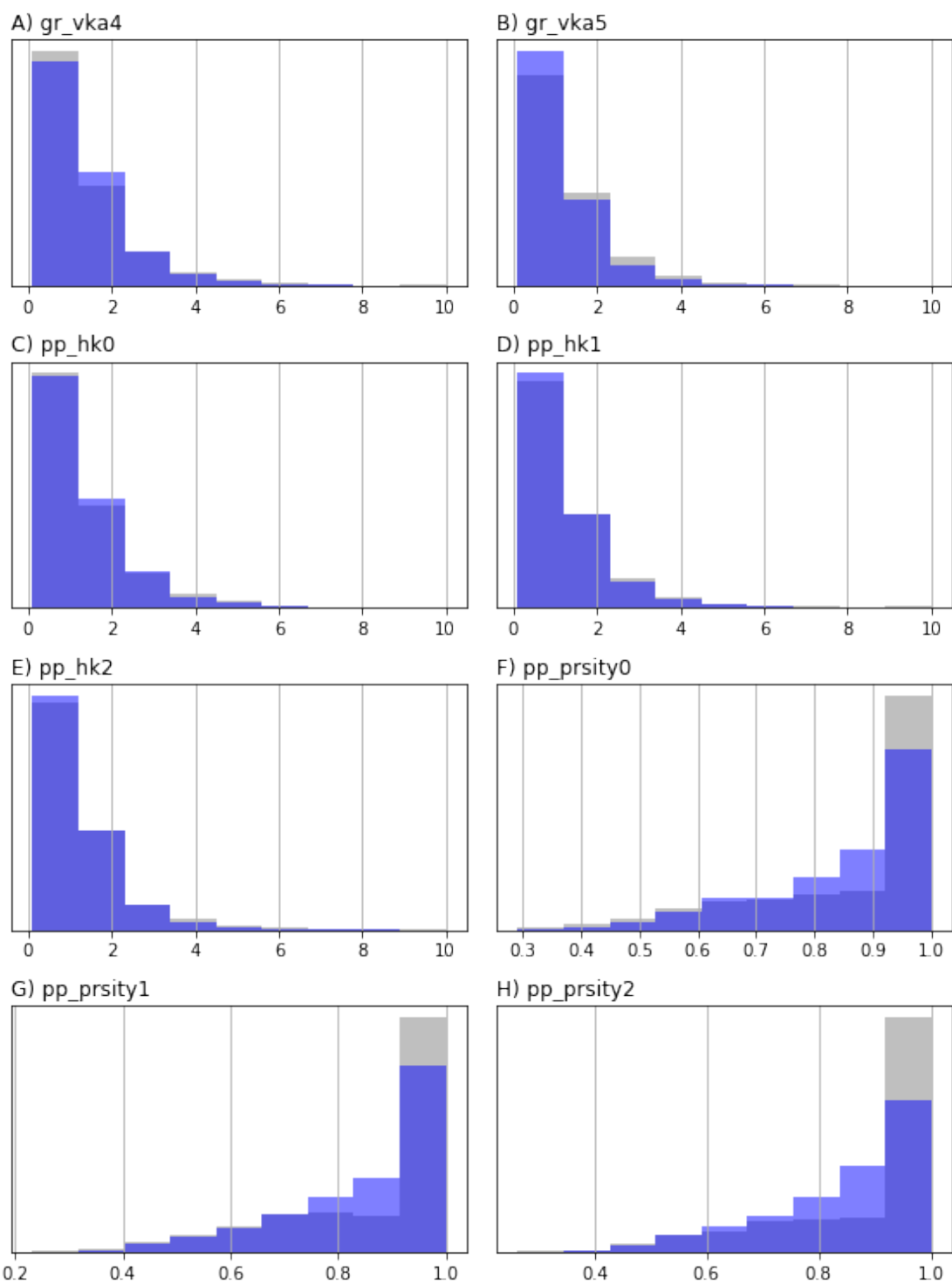
G) gr_ss3



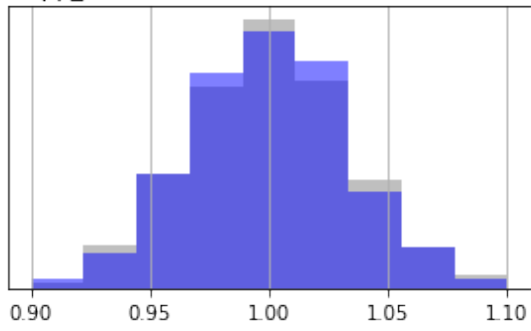
H) gr_ss4



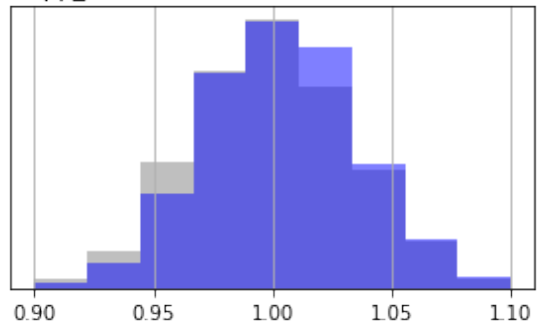




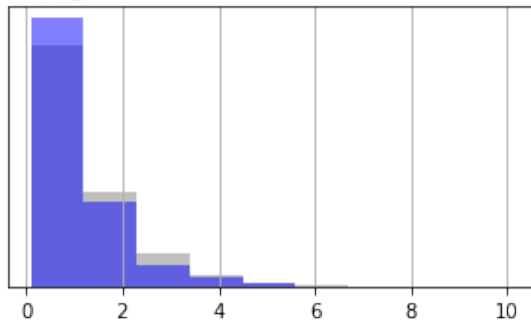
A) pp_rech0



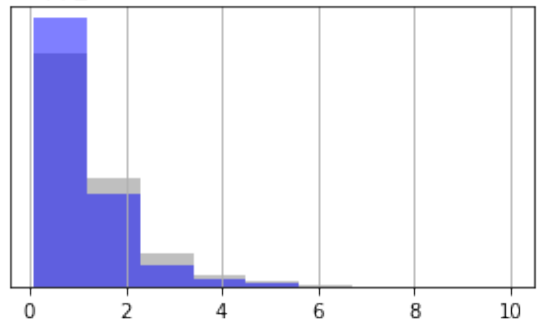
B) pp_rech1



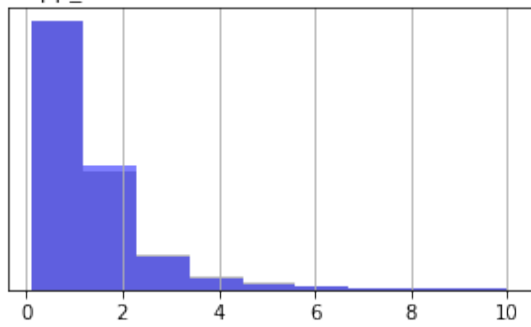
C) pp_ss0



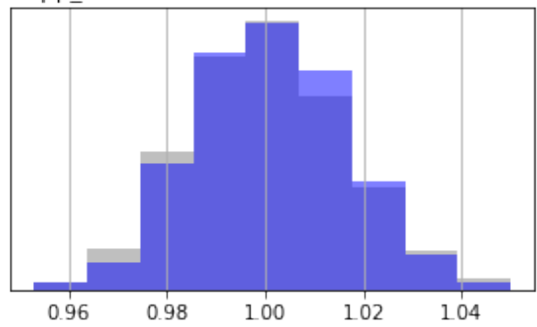
D) pp_ss1



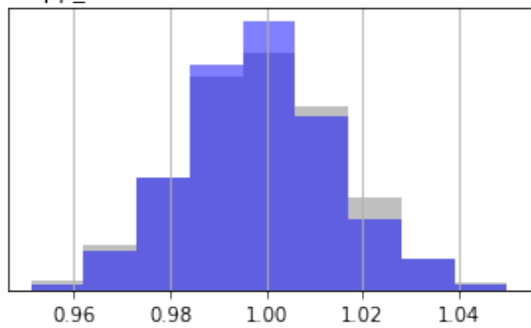
E) pp_ss2



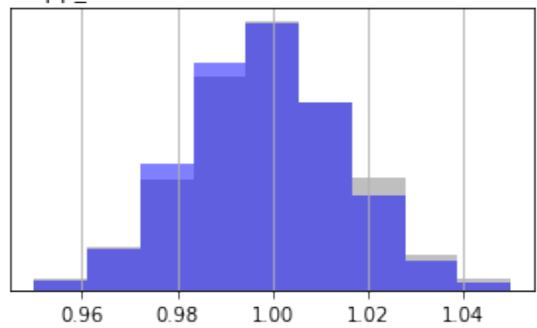
F) pp_strt0

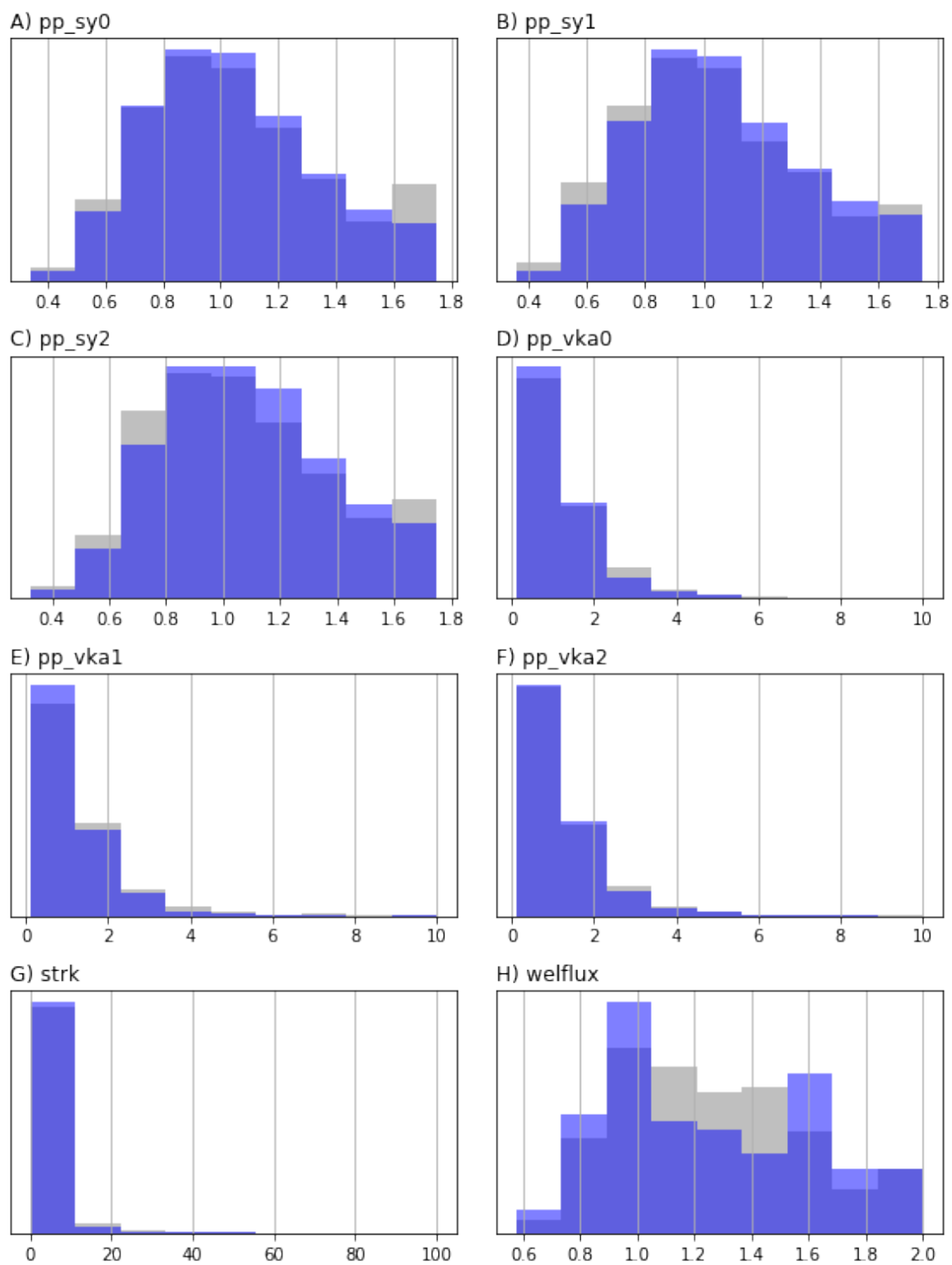


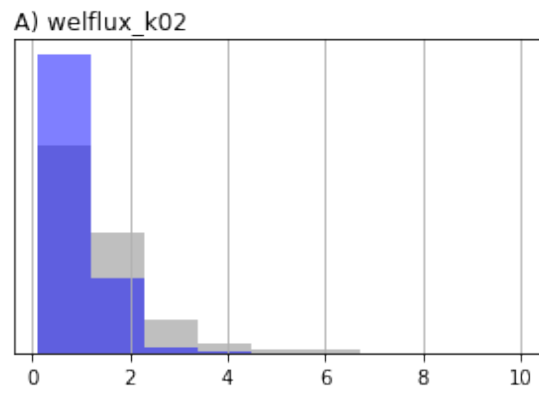
G) pp_strt1



H) pp_strt2







```
In [11]: # pyemu.plot_utils.ensemble_change_summary(pe_pr,pe_pt,pst=pst,bins=20)
          # par = pst.parameter_data
          # li = par.partrans=="log"
```

```
# pe_pr.loc[:,li] = pe_pr.loc[:,li].apply(np.log10)
# pe_pr.shape
```

1.0.2 PESTPP-IES with simple temporal localization (and common sense)

Now let's add some localization. The obvious stuff is temporal - scenario parameters can't influence historic observations (and the inverse is true) so let's tell PESTPP-IES about this. Also, should porosity be adjusted at all given the observations we have???

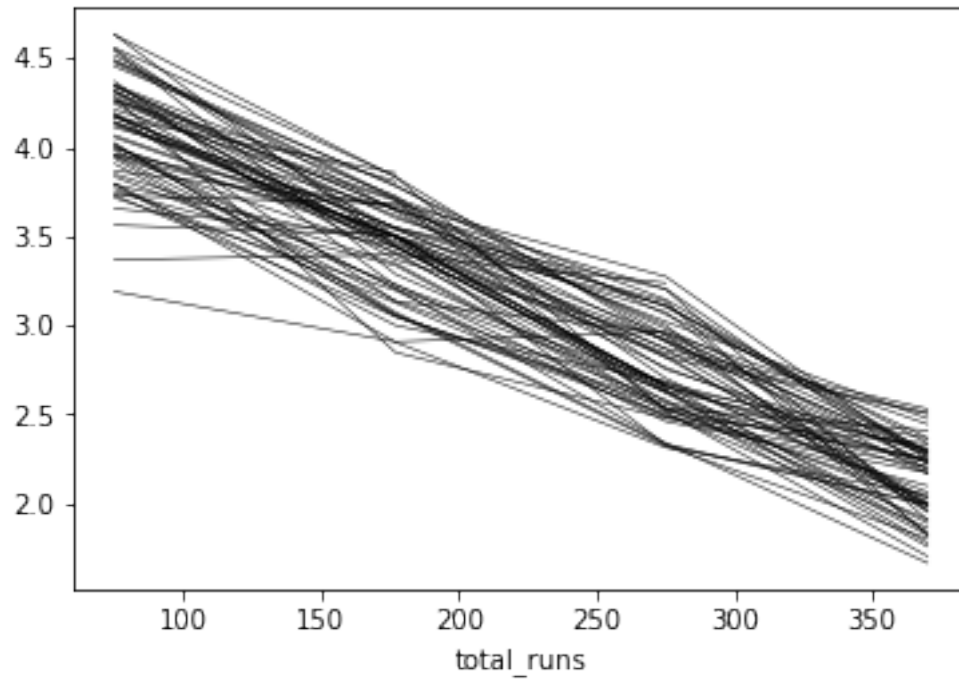
```
In [12]: par = pst.parameter_data
         #parameter groups for future recharge
         dont_groups = [g for g in pst.par_groups if "pr" in g]
         dont_groups.extend(["gr_rech3", "pp_rech1", "cn_rech5"])
         dont_groups = [g for g in dont_groups if g in pst.adj_par_groups]
         dont_pars = par.loc[par.pargp.apply(lambda x: x in dont_groups), "parnme"].tolist()
         dont_pars.append("welflux_001")
         dont_groups.append("welflux_001")
         dont_groups
```

```
Out[12]: ['cn_prsity6',
          'gr_prsity3',
          'pp_prsity1',
          'pp_prsity0',
          'gr_prsity4',
          'gr_prsity5',
          'cn_prsity8',
          'pp_prsity2',
          'cn_prsity7',
          'gr_rech3',
          'pp_rech1',
          'cn_rech5',
          'welflux_001']
```

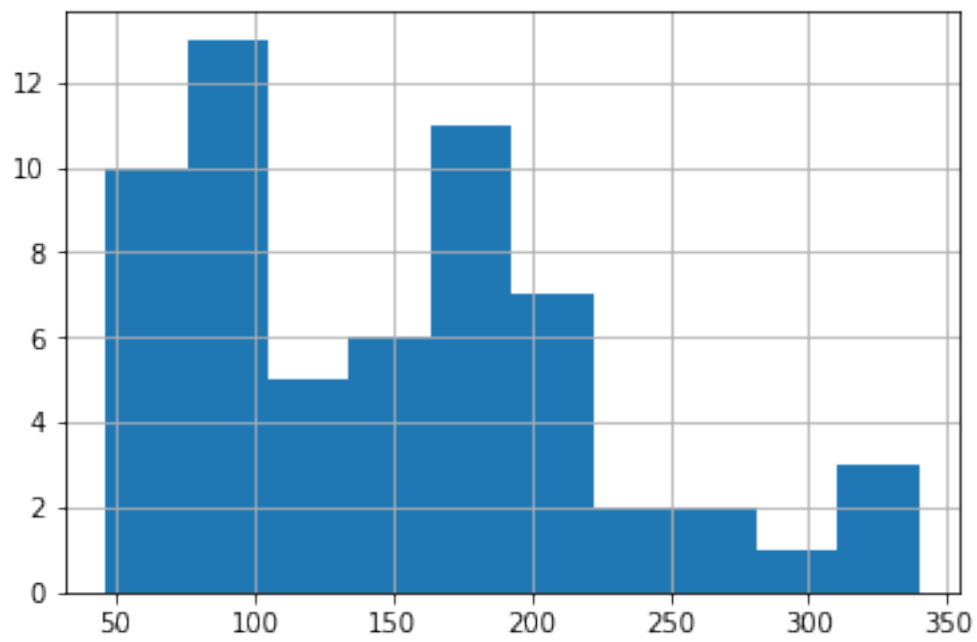
```
In [13]: cols = pst.adj_par_groups
         cols.remove("welflux")
         cols.extend(["welflux_000", "welflux_001"])
         loc = pyemu.Matrix.from_names(pst.nnz_obs_names, cols).to_dataframe()
         loc.loc[:, :] = 1.0
         loc.loc[:, dont_groups] = 0.0
         pyemu.Matrix.from_dataframe(loc).to_ascii(os.path.join(t_d, "loc.mat"))
```

```
In [14]: pst.pestpp_options["ies_localizer"] = "loc.mat"
         pst.write(os.path.join(t_d, "freyberg_ies.pst"))
         pyemu.os_utils.start_slaves(t_d, "pestpp-ies", "freyberg_ies.pst", num_slaves=20, master_c
```

```
In [15]: phi = pd.read_csv(os.path.join(m_d, "freyberg_ies.phi.actual.csv"), index_col=0)
         phi.index = phi.total_runs
         phi.iloc[:, 6:].apply(np.log10).plot(legend=False, lw=0.5, color='k')
         plt.show()
         phi.iloc[-1, 6:].hist()
```



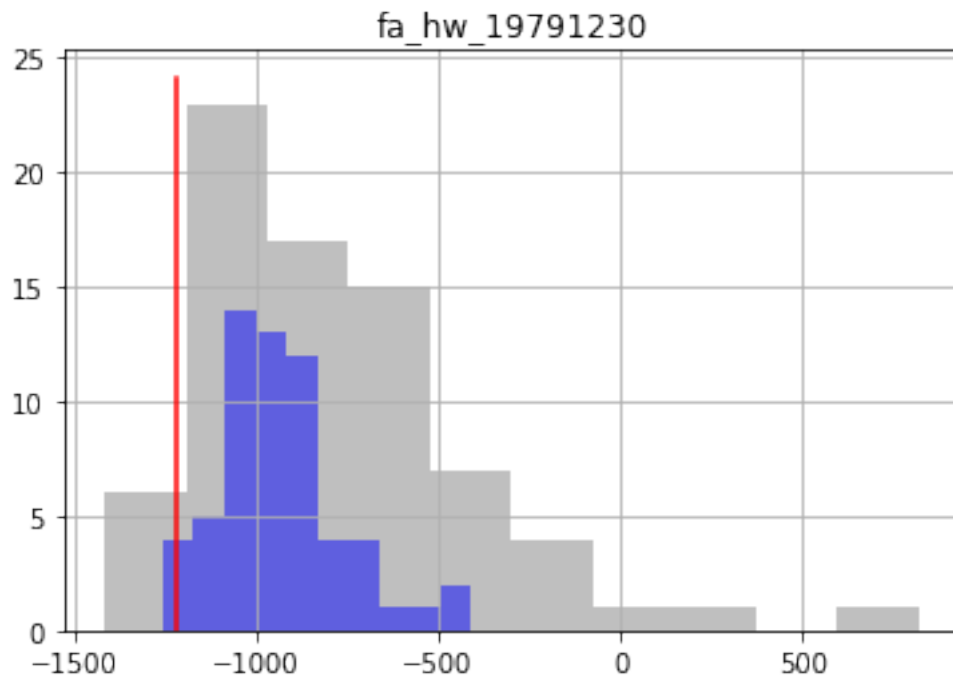
Out[15]: <matplotlib.axes._subplots.AxesSubplot at 0x181db0fef0>

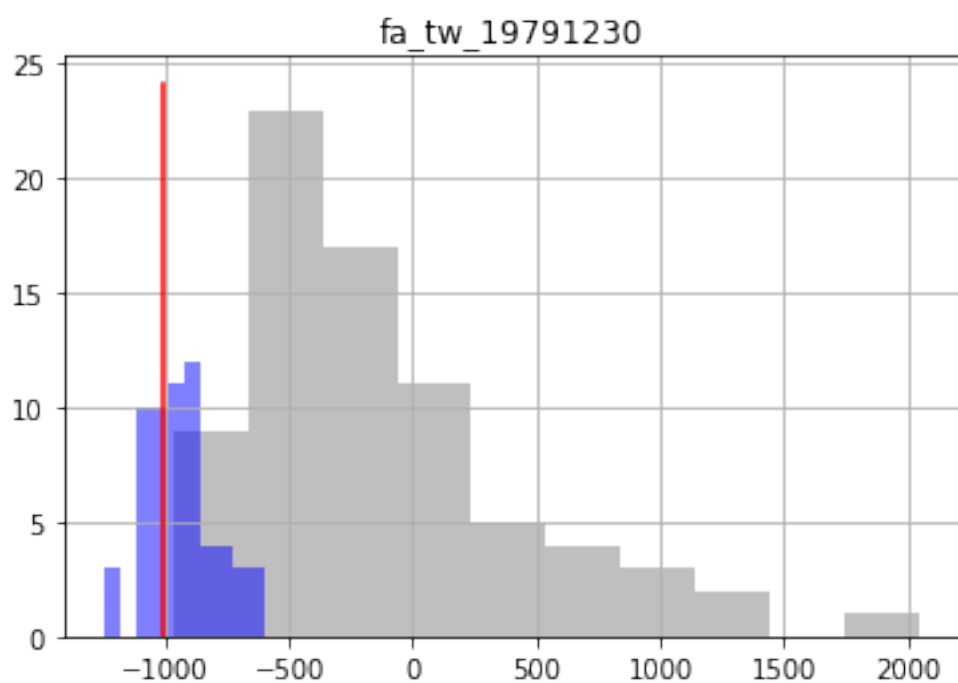
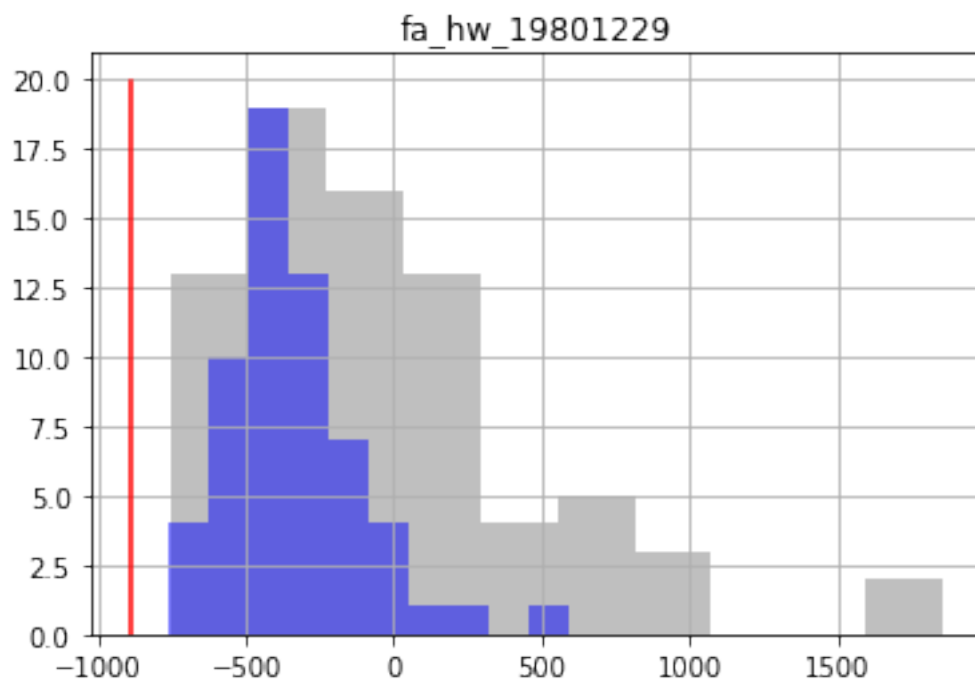


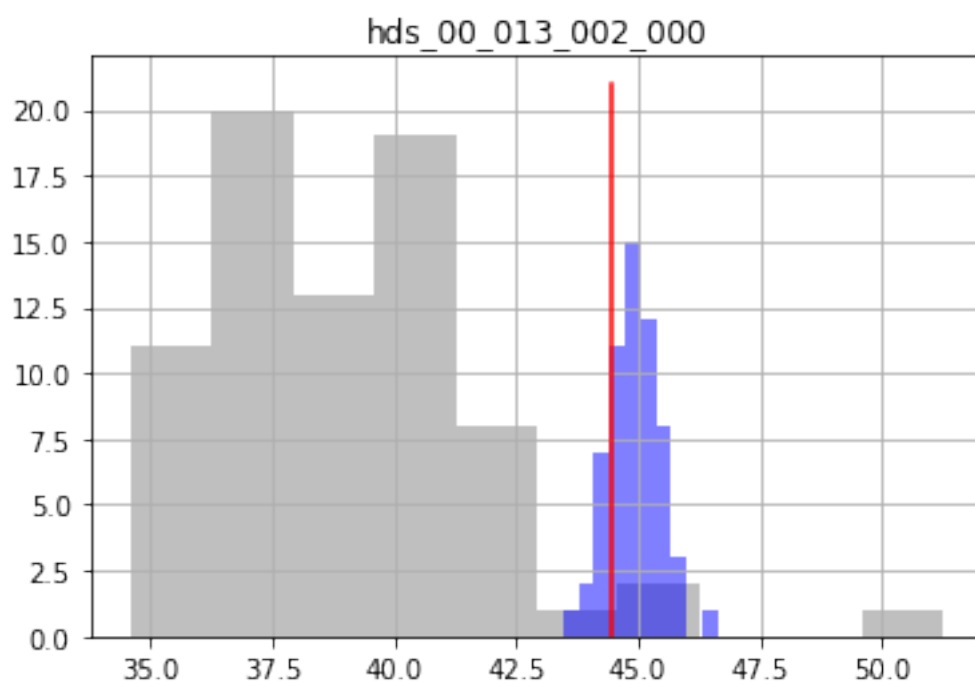
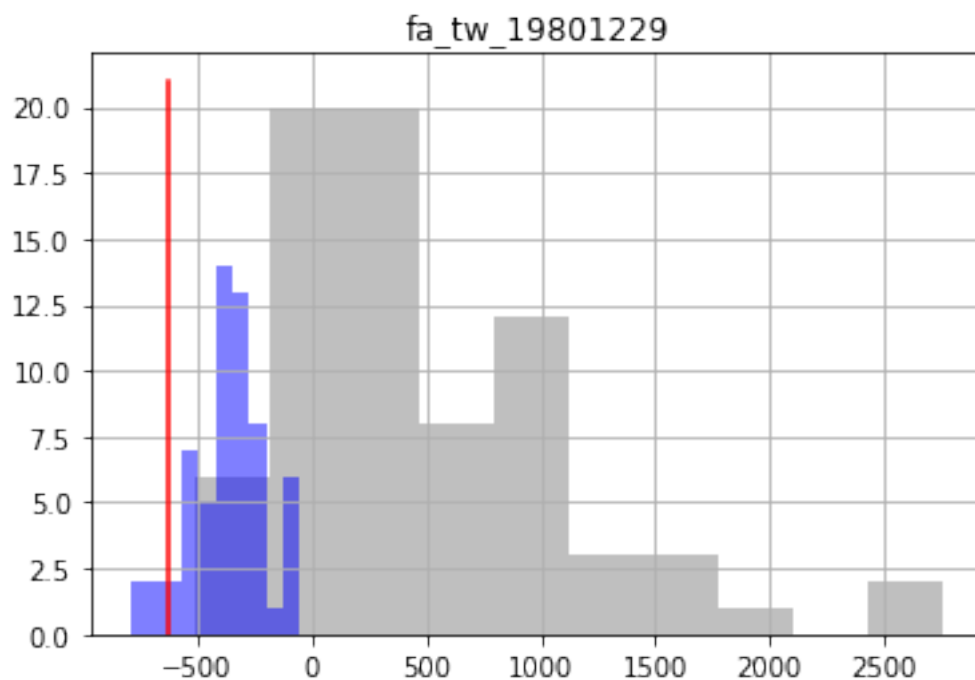
```

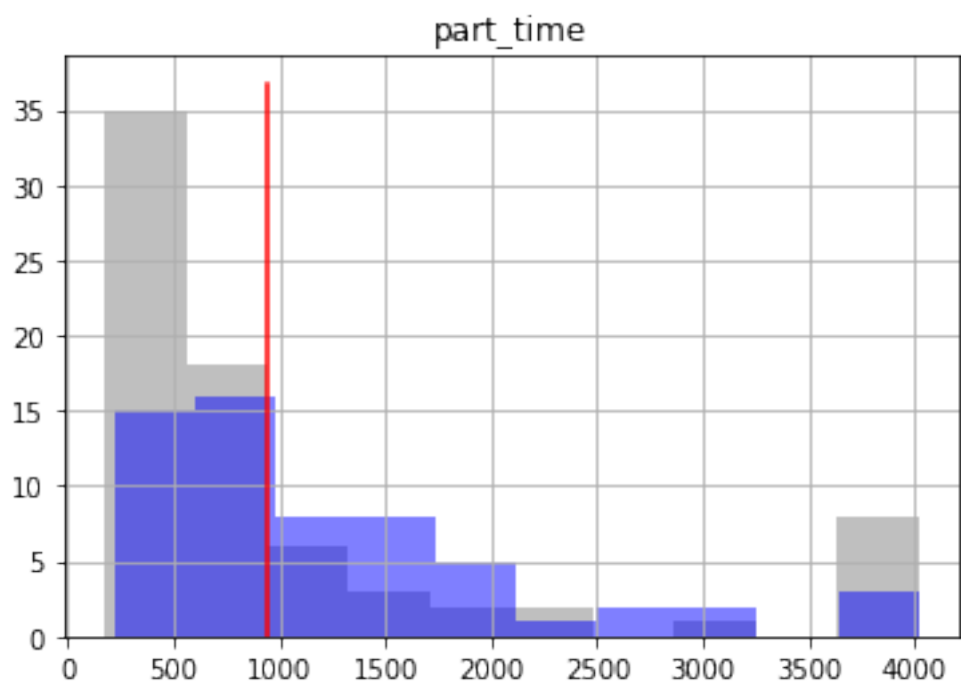
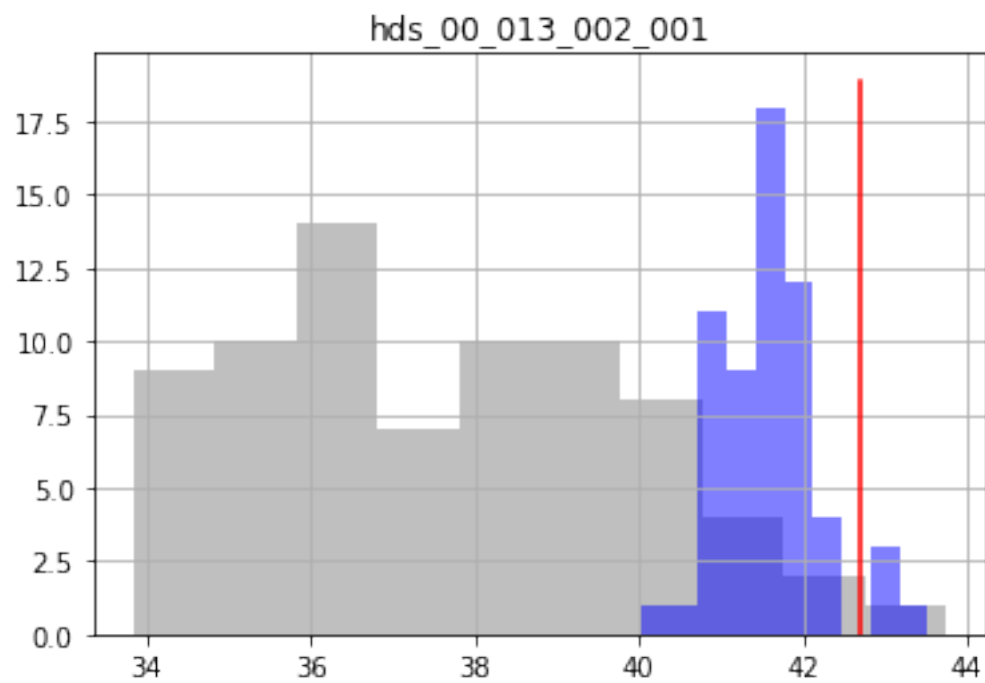
In [16]: oe_pr = pd.read_csv(os.path.join(m_d,"freyberg_ies.0.obs.csv"),index_col=0)
oe_pt = pd.read_csv(os.path.join(m_d,"freyberg_ies.{0}.obs.csv".format(pst.control_da
obs = pst.observation_data
fnames = pst.pestpp_options["forecasts"].split(",")
for forecast in fnames:
    ax = plt.subplot(111)
    oe_pr.loc[:,forecast].hist(ax=ax,color="0.5",alpha=0.5)
    oe_pt.loc[:,forecast].hist(ax=ax,color="b",alpha=0.5)
    ax.plot([obs.loc[forecast,"obsval"],obs.loc[forecast,"obsval"]],ax.get_ylim(),"r")
    ax.set_title(forecast)
    plt.show()

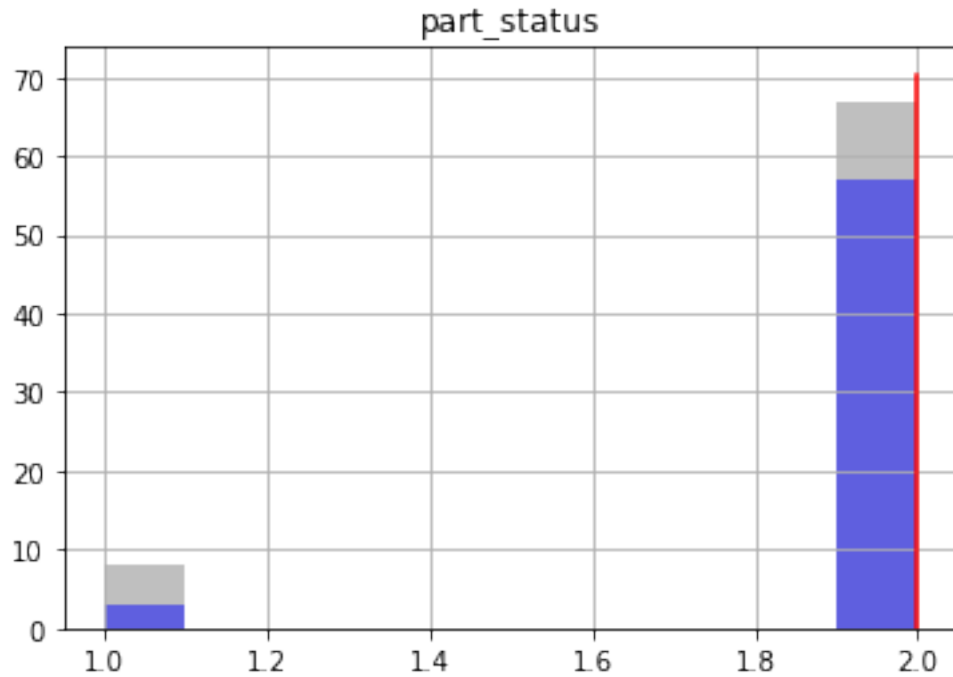
```











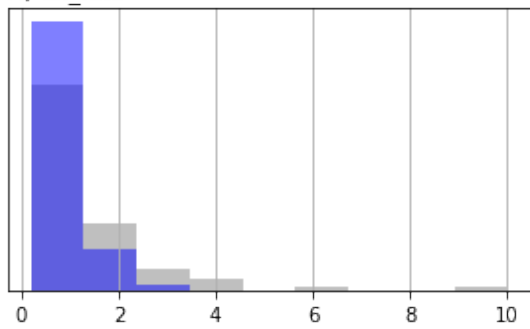
```
In [17]: pe_pr = pd.read_csv(os.path.join(m_d,"freyberg_ies.0.par.csv"),index_col=0)
pe_pt = pd.read_csv(os.path.join(m_d,"freyberg_ies.{0}.par.csv".format(pst.control_da
#pe_pr.index = pe_pt.index
#par = pst.parameter_data
print(pe_pr.shape,pe_pt.shape)
pdict = par.groupby("pargp").groups
pyemu.plot_utils.ensemble_helper({"0.5":pe_pr,"b":pe_pt},plot_cols=pdict)
#pyemu.plot_utils.ensemble_change_summary(pe_pr,pe_pt,pst=pst,bins=20)
```

```
/Users/jeremyw/miniconda3/lib/python3.5/site-packages/IPython/core/interactiveshell.py:2785: D
interactivity=interactivity, compiler=compiler, result=result)
```

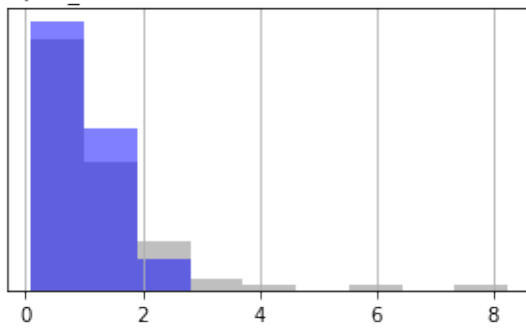
```
(75, 14819) (60, 14819)
```

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

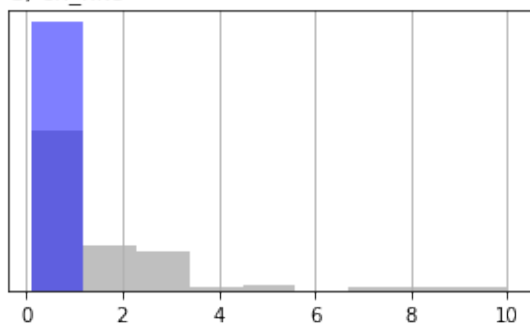
A) cn_hk6



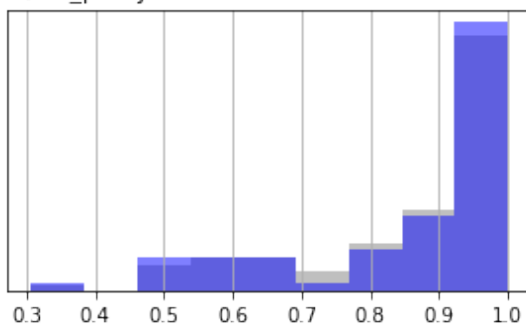
B) cn_hk7



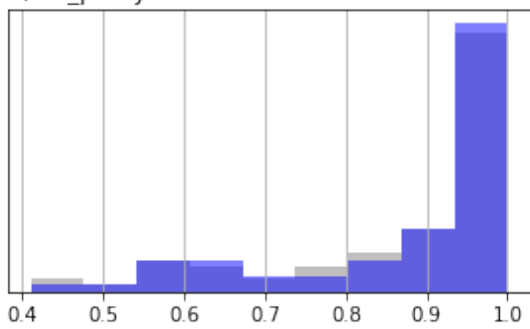
C) cn_hk8



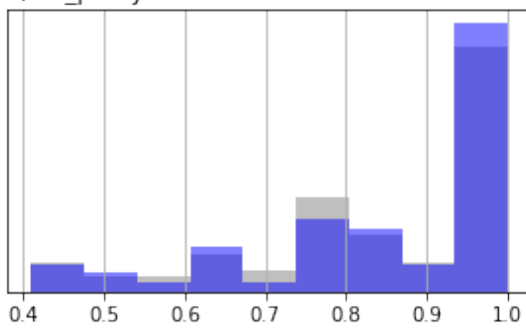
D) cn_prsity6



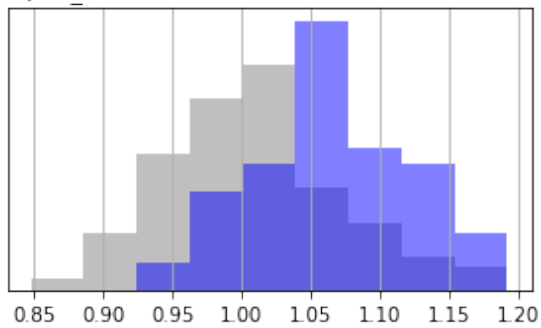
E) cn_prsity7



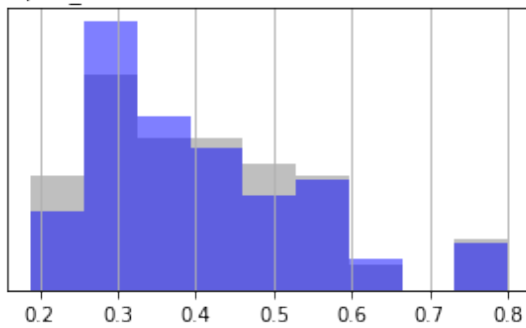
F) cn_prsity8



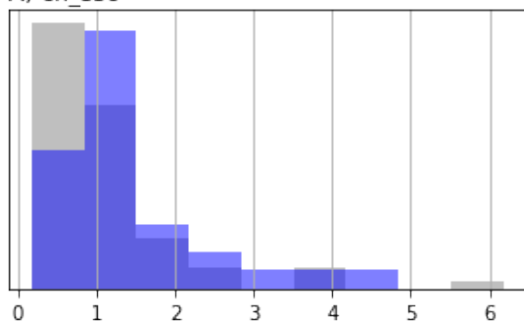
G) cn_rech4



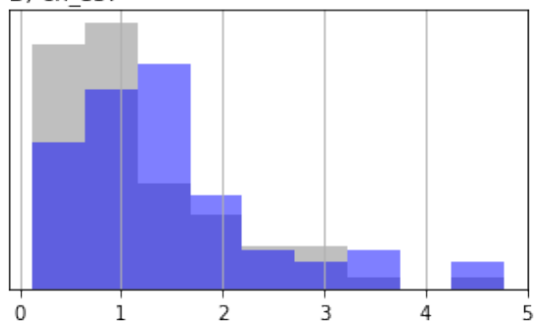
H) cn_rech5



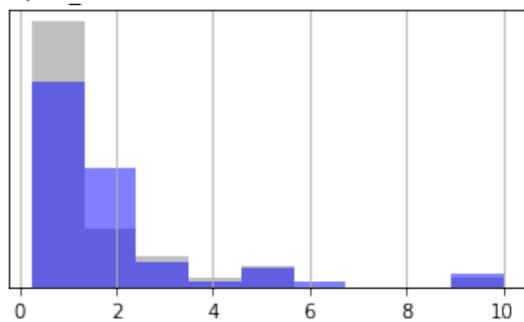
A) cn_ss6



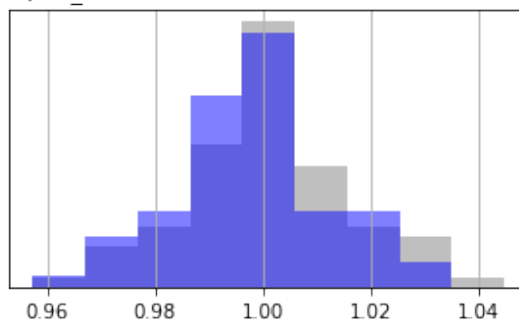
B) cn_ss7



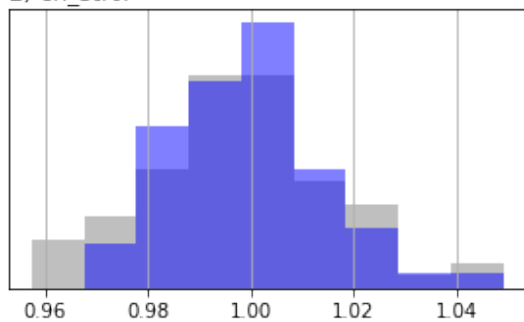
C) cn_ss8



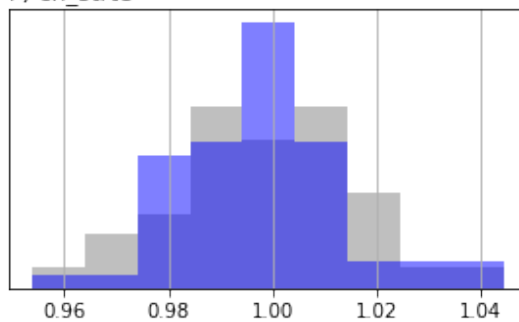
D) cn_strt6



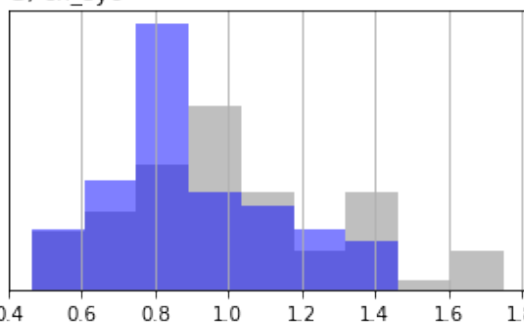
E) cn_strt7



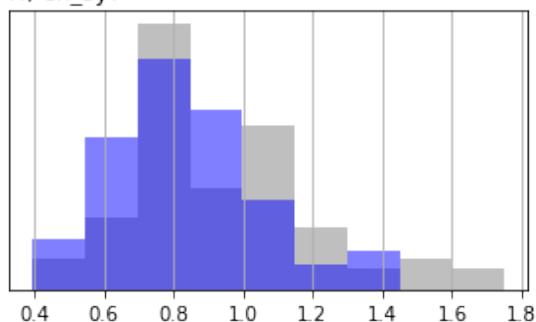
F) cn_strt8



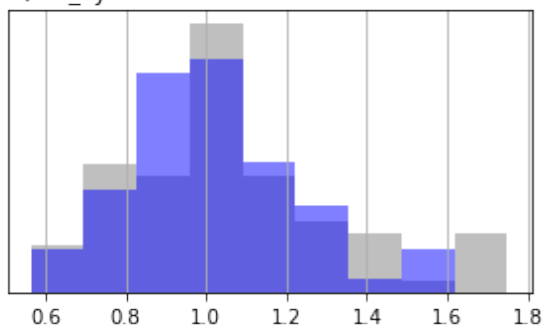
G) cn_sy6



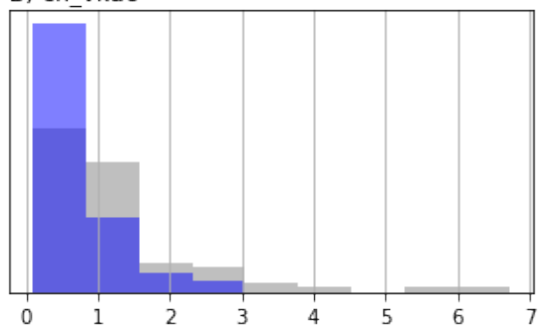
H) cn_sy7



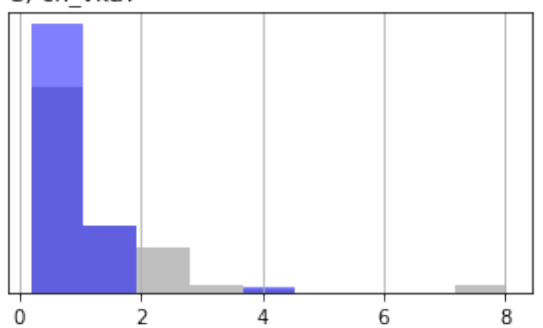
A) cn_sy8



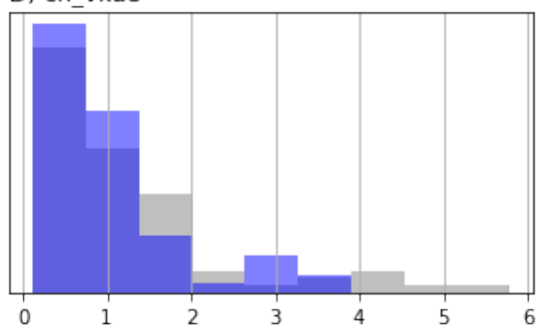
B) cn_vka6



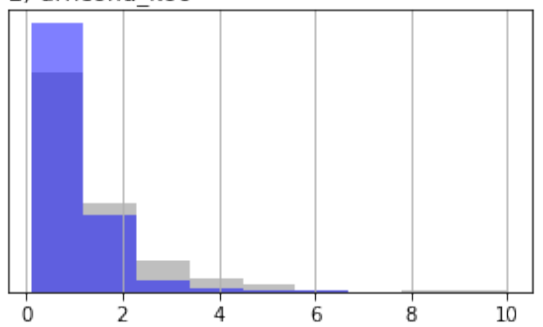
C) cn_vka7



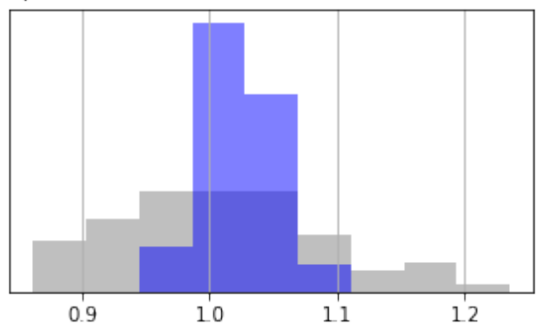
D) cn_vka8



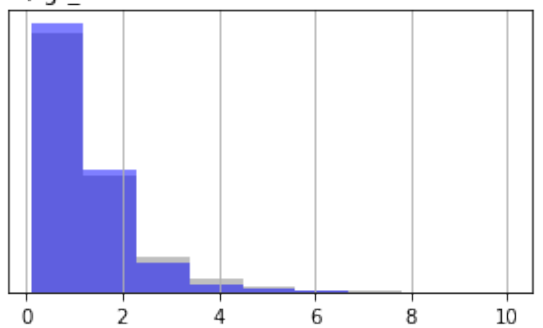
E) drncond_k00



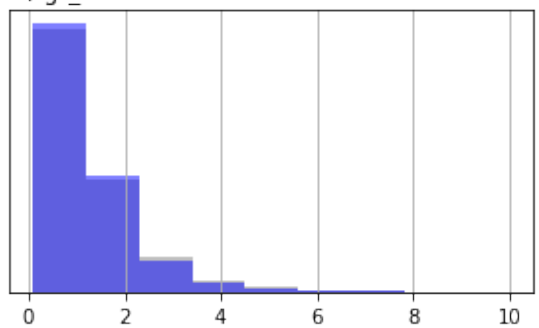
F) flow



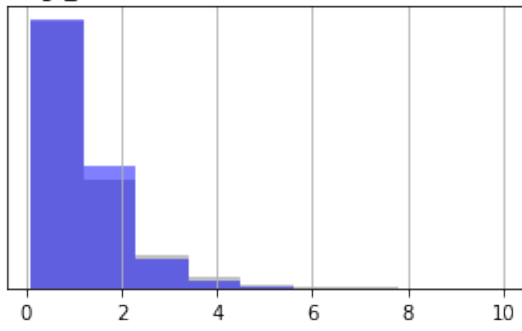
G) gr_hk3



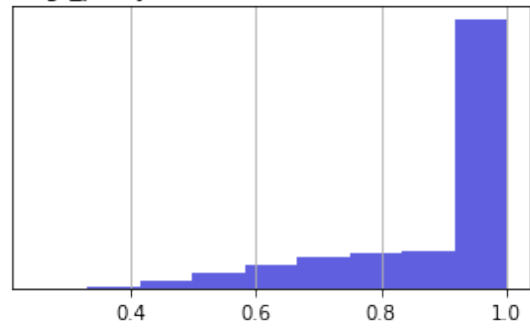
H) gr_hk4



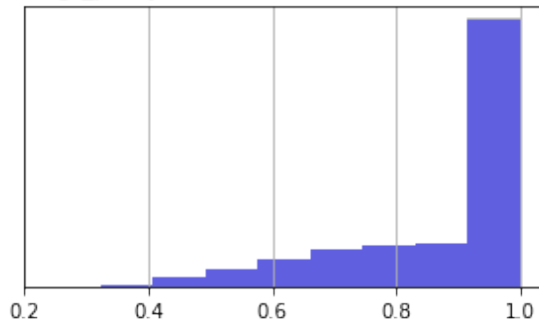
A) gr_hk5



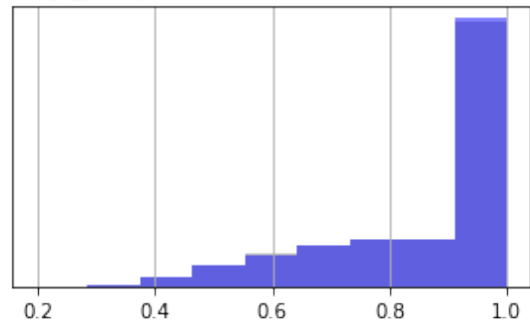
B) gr_prsity3



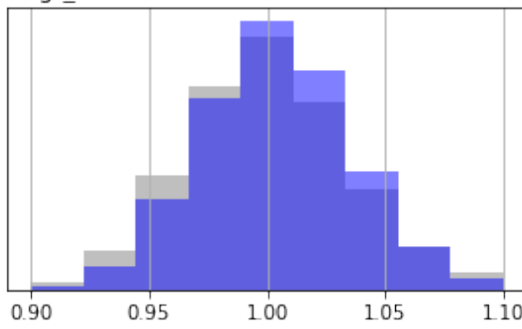
C) gr_prsity4



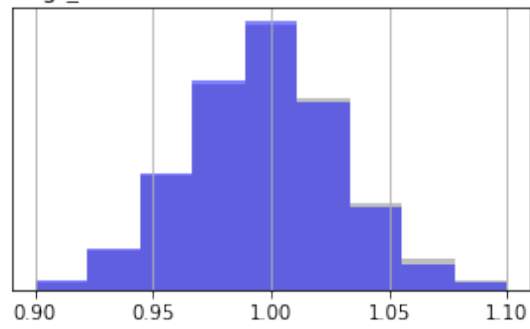
D) gr_prsity5



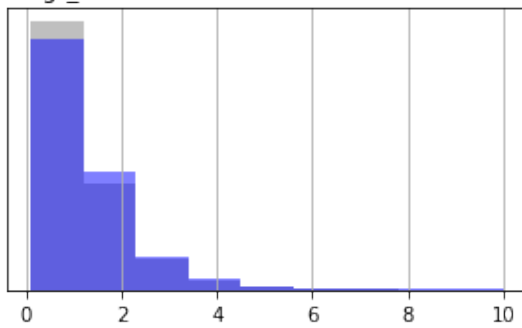
E) gr_rech2



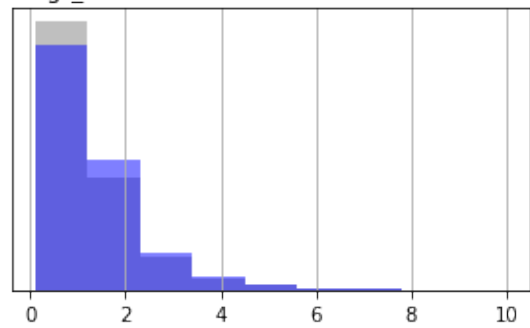
F) gr_rech3

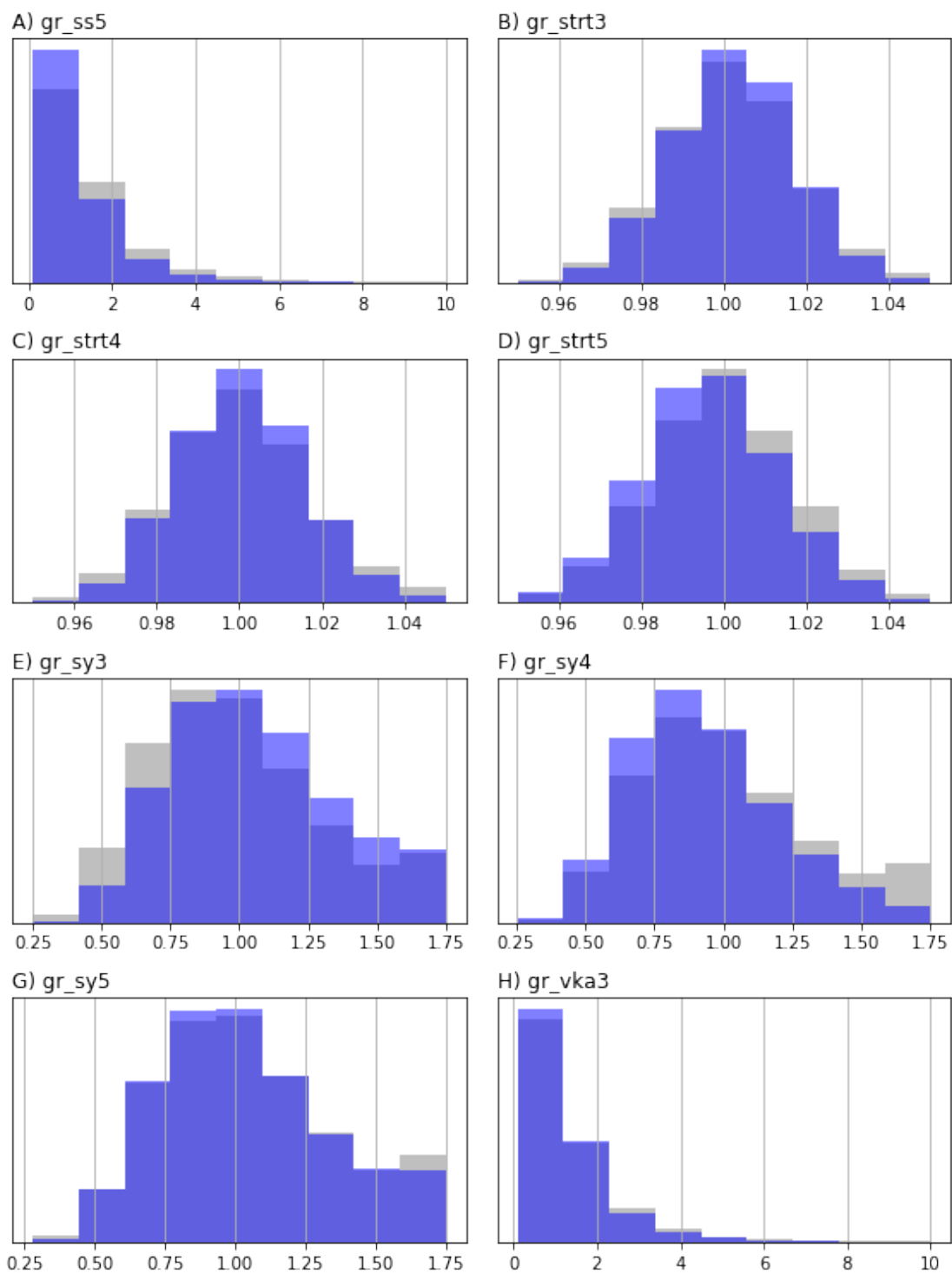


G) gr_ss3

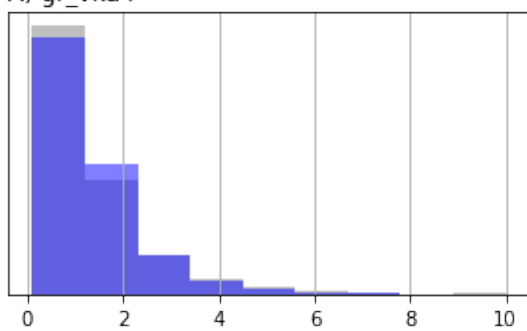


H) gr_ss4

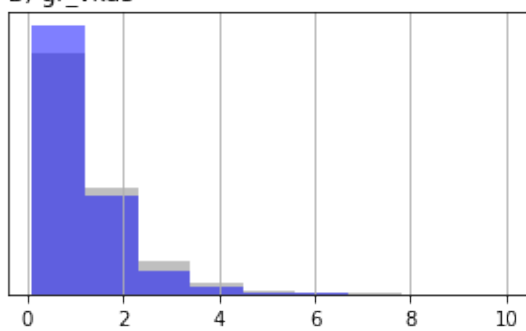




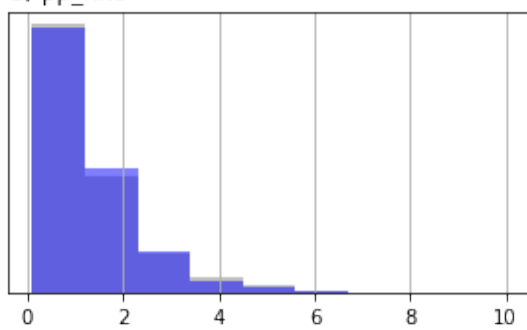
A) gr_vka4



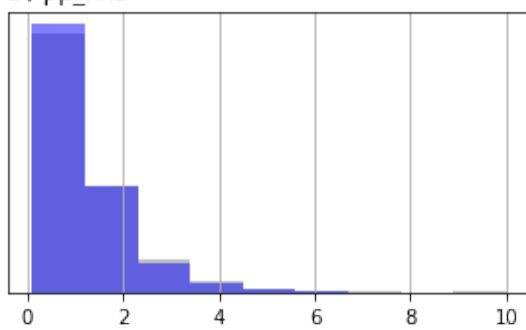
B) gr_vka5



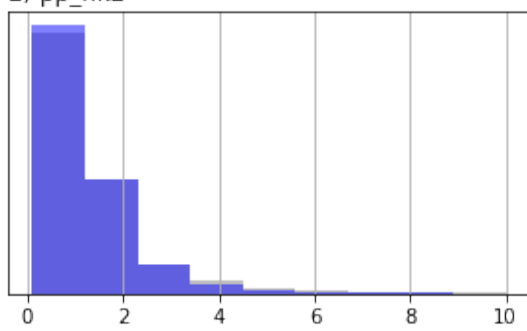
C) pp_hk0



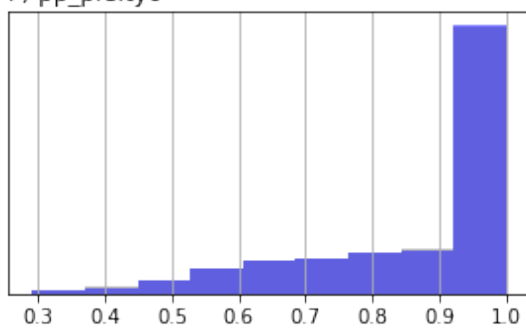
D) pp_hk1



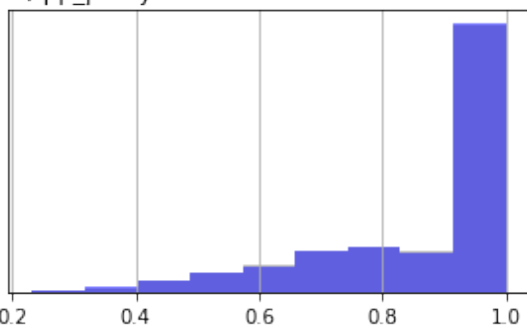
E) pp_hk2



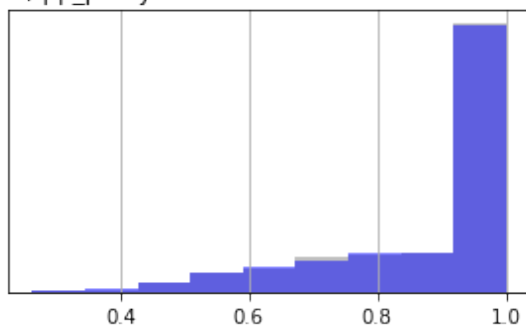
F) pp_prsity0



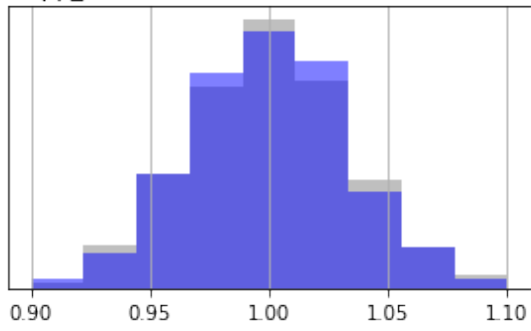
G) pp_prsity1



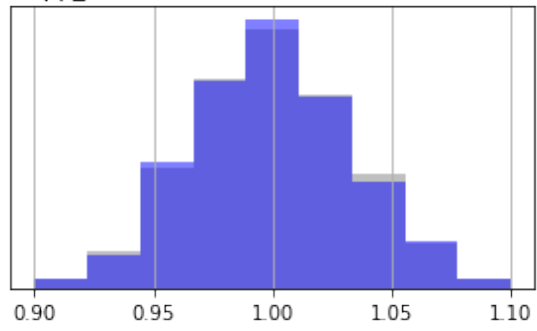
H) pp_prsity2



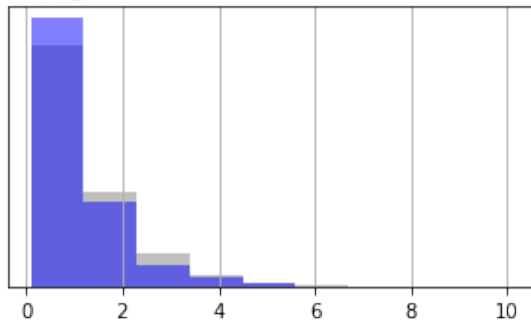
A) pp_rech0



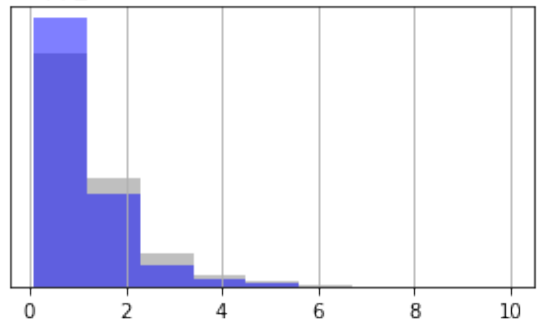
B) pp_rech1



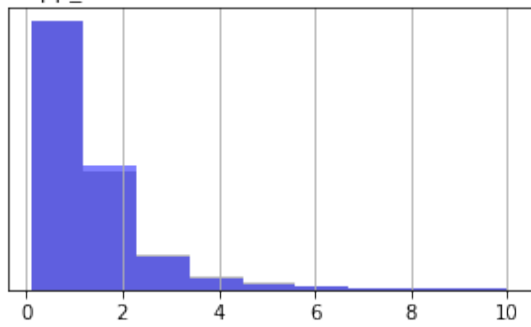
C) pp_ss0



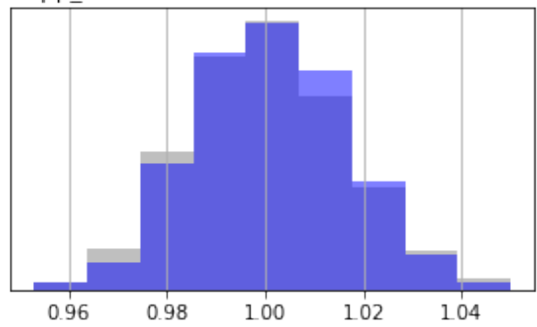
D) pp_ss1



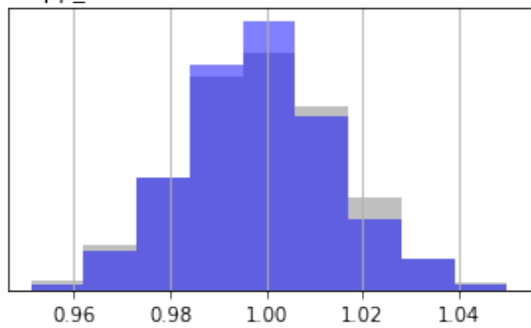
E) pp_ss2



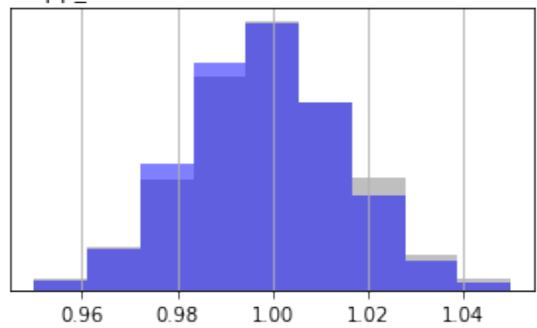
F) pp_strt0



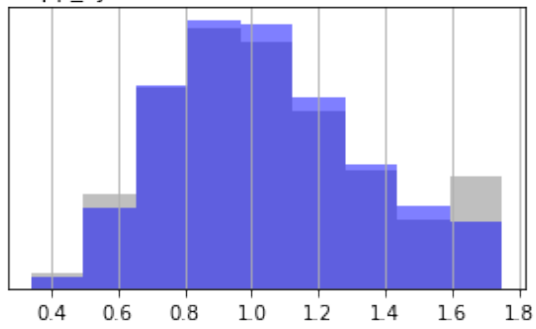
G) pp_strt1



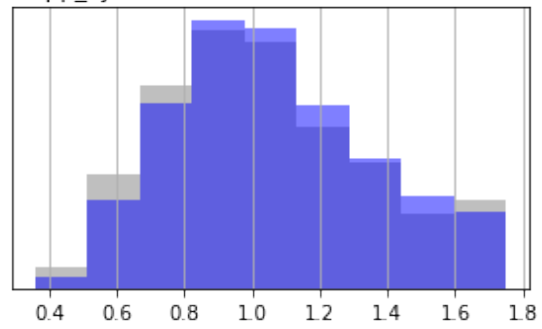
H) pp_strt2



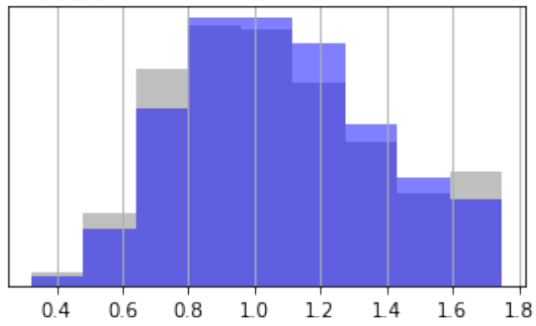
A) pp_sy0



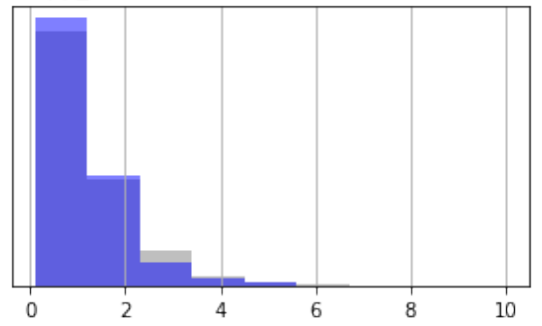
B) pp_sy1



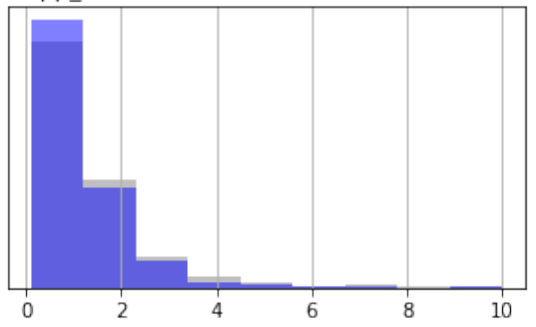
C) pp_sy2



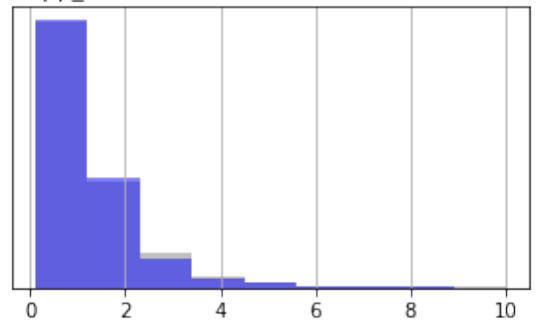
D) pp_vka0



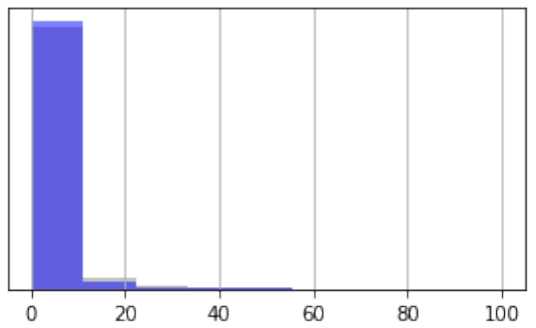
E) pp_vka1



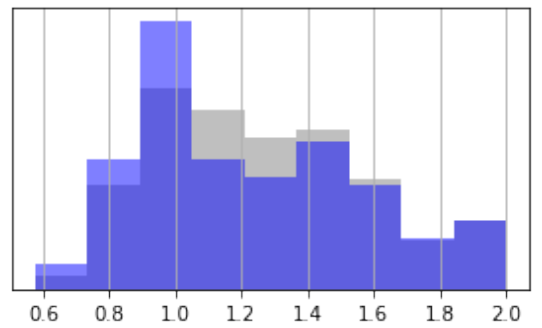
F) pp_vka2

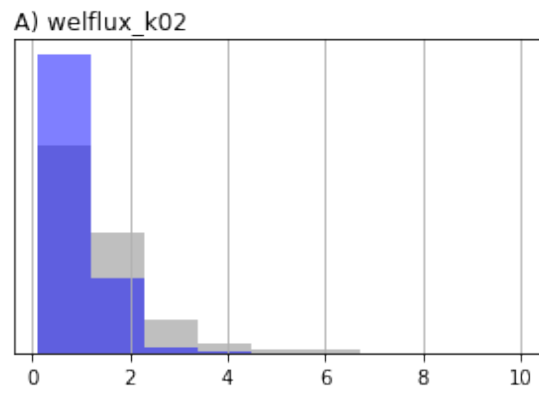


G) strk



H) welflux





1.0.3 PESTPP-IES with par-by-par distance based localization

```
In [18]: m = flopy.modflow.Modflow.load("freyberg.nam", model_ws="template")
```

```
In [19]: par = pst.parameter_data
```

```
gr_par = par.loc[par.pargp.apply(lambda x: "gr" in x and "prcity" not in x),:].copy()
print(gr_par.pargp.unique())
gr_par.groupby("pargp").groups
gr_par.loc[:, "i"] = gr_par.parnme.apply(lambda x: int(x[-6:-3]))
gr_par.loc[:, "j"] = gr_par.parnme.apply(lambda x: int(x[-3:]))
gr_par.loc[:, "x"] = gr_par.apply(lambda x: m.sr.xcentergrid[x.i, x.j], axis=1)
gr_par.loc[:, "y"] = gr_par.apply(lambda x: m.sr.ycentergrid[x.i, x.j], axis=1)
```

```
obs = pst.observation_data
```

```
nobs = obs.loc[obs.obgnme=="calhead",:].copy()
nobs.loc[:, "i"] = nobs.obsnme.apply(lambda x: int(x.split('_')[2]))
nobs.loc[:, "j"] = nobs.obsnme.apply(lambda x: int(x.split('_')[3]))
nobs.loc[:, "x"] = nobs.apply(lambda x: m.sr.xcentergrid[x.i, x.j], axis=1)
nobs.loc[:, "y"] = nobs.apply(lambda x: m.sr.ycentergrid[x.i, x.j], axis=1)
```

```
pp_tpl = [f for f in os.listdir(t_d) if "pp" in f and f.endswith(".tpl")]
pp_tpl_dfs = [pyemu.pp_utils.pp_tpl_to_dataframe(os.path.join(t_d, f)) for f in pp_tpl]
pp_par = pd.concat(pp_tpl_dfs)
pp_par.index = pp_par.parnme
#pp_par = par.loc[par.pargp.apply(lambda x: "pp" in x),:].copy()
```

```
['gr_hk3' 'gr_hk4' 'gr_hk5' 'gr_rech2' 'gr_rech3' 'gr_ss3' 'gr_ss4'
'gr_ss5' 'gr_strt3' 'gr_strt4' 'gr_strt5' 'gr_sy3' 'gr_sy4' 'gr_sy5'
'gr_vka3' 'gr_vka4' 'gr_vka5']
```

```
In [20]: loc = pyemu.Matrix.from_names(pst.nnz_obs_names, pst.adj_par_names).to_dataframe()
loc.loc[:, :] = 1.0
loc_dist = 5000.0
sadj = set(pst.adj_par_names)
for oname in obs.loc[obs.obgnme=="calhead", "obsnme"]:
    xx, yy = nobs.loc[oname, ['x', 'y']]
```

```
gr_par.loc[:, "dist"] = gr_par.apply(lambda x: (x.x - xx)**2 + (x.y - yy)**2, axis=1)
gr_too_far = gr_par.loc[gr_par.dist > loc_dist, "parname"]
gr_too_far = gr_too_far.loc[gr_too_far.apply(lambda x: x in sadj)]
loc.loc[:, gr_too_far] = 0.0
```

```
pp_par.loc[:, "dist"] = pp_par.apply(lambda x: (x.x - xx)**2 + (x.y - yy)**2, axis=1)
pp_too_far = pp_par.loc[pp_par.dist > loc_dist, "parname"]
pp_too_far = pp_too_far.loc[pp_too_far.apply(lambda x: x in sadj)]
loc.loc[oname, pp_too_far] = 0.0
print(oname, gr_too_far.shape[0]/gr_par.shape[0], pp_too_far.shape[0]/pp_par.shape[0])
```

```
loc.loc[:, dont_pars] = 0.0
```

```

#spars = par.loc[par.parnme.apply(lambda x: "ss" in x or "sy" in x), "parnme"]
#loc.loc[:, spars] = 0.0
loc.sum(axis=1)

```

```

hds_00_002_009_000 0.46382978723404256 0.46875
hds_00_002_015_000 0.4794326241134752 0.5
hds_00_003_008_000 0.43829787234042555 0.34375
hds_00_009_001_000 0.3304964539007092 0.25
hds_00_013_010_000 0.15319148936170213 0.09375
hds_00_015_016_000 0.13900709219858157 0.0625
hds_00_021_010_000 0.06950354609929078 0.03125
hds_00_022_015_000 0.12198581560283688 0.15625
hds_00_024_004_000 0.17872340425531916 0.15625
hds_00_026_006_000 0.2198581560283688 0.21875
hds_00_029_015_000 0.29929078014184396 0.28125
hds_00_033_007_000 0.3829787234042553 0.375
hds_00_034_010_000 0.4 0.40625

```

```

Out [20]: fo_39_19791230      1786.0
          hds_00_002_009_000    1546.0
          hds_00_002_015_000    1530.0
          hds_00_003_008_000    1610.0
          hds_00_009_001_000    1658.0
          hds_00_013_010_000    1738.0
          hds_00_015_016_000    1754.0
          hds_00_021_010_000    1770.0
          hds_00_022_015_000    1706.0
          hds_00_024_004_000    1706.0
          hds_00_026_006_000    1674.0
          hds_00_029_015_000    1642.0
          hds_00_033_007_000    1594.0
          hds_00_034_010_000    1578.0
          dtype: float64

```

```

In [21]: pyemu.Matrix.from_dataframe(loc).to_coo(os.path.join(t_d, "loc.jcb"))
          pst.pestpp_options["ies_localizer"] = "loc.jcb"
          pst.write(os.path.join(t_d, "freyberg_ies.pst"))

```

```

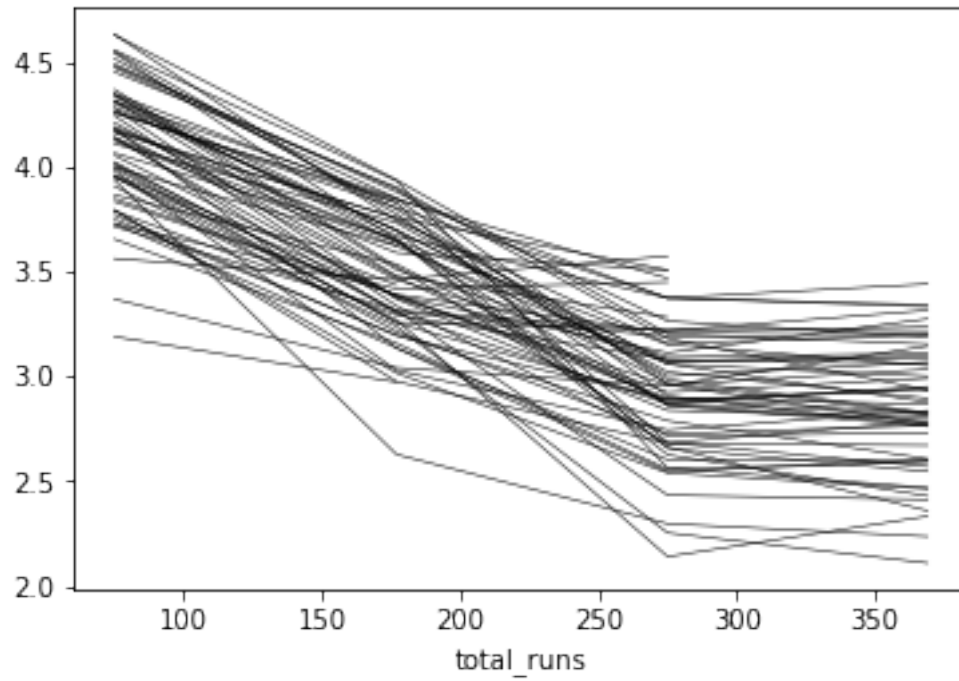
In [22]: pyemu.os_utils.start_slaves(t_d, "pestpp-ies", "freyberg_ies.pst", num_slaves=20, master_

```

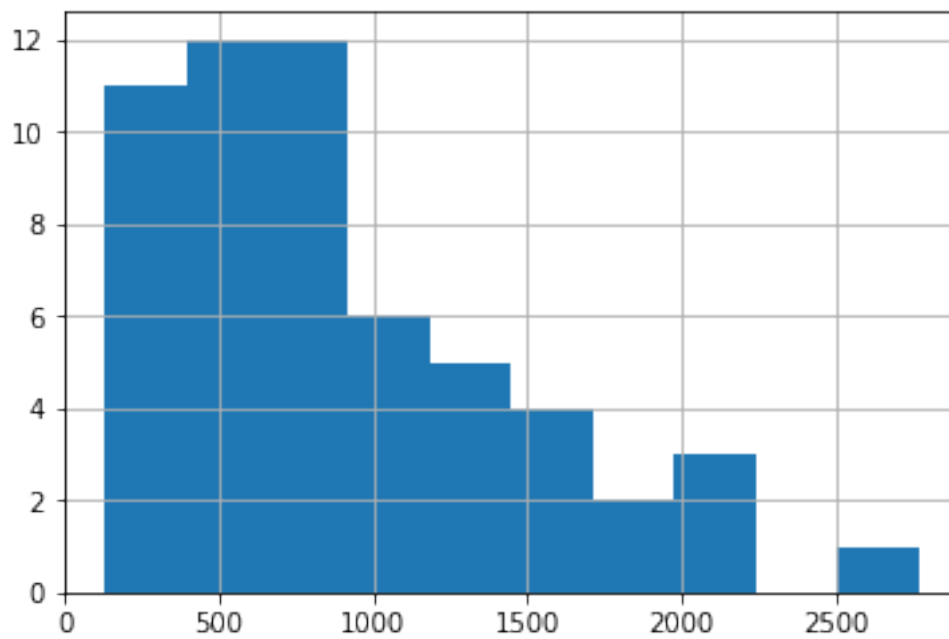
```

In [23]: phi = pd.read_csv(os.path.join(m_d, "freyberg_ies.phi.actual.csv"), index_col=0)
          phi.index = phi.total_runs
          phi.iloc[:, 6:].apply(np.log10).plot(legend=False, lw=0.5, color='k')
          plt.show()
          phi.iloc[-1, 6:].hist()

```



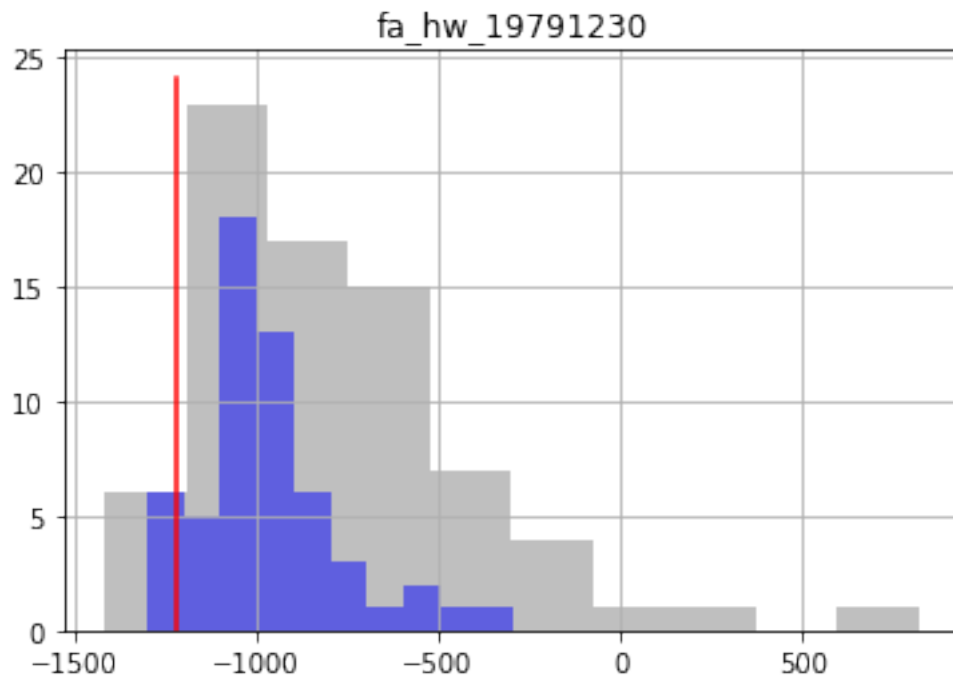
Out[23]: <matplotlib.axes._subplots.AxesSubplot at 0x18183077b8>

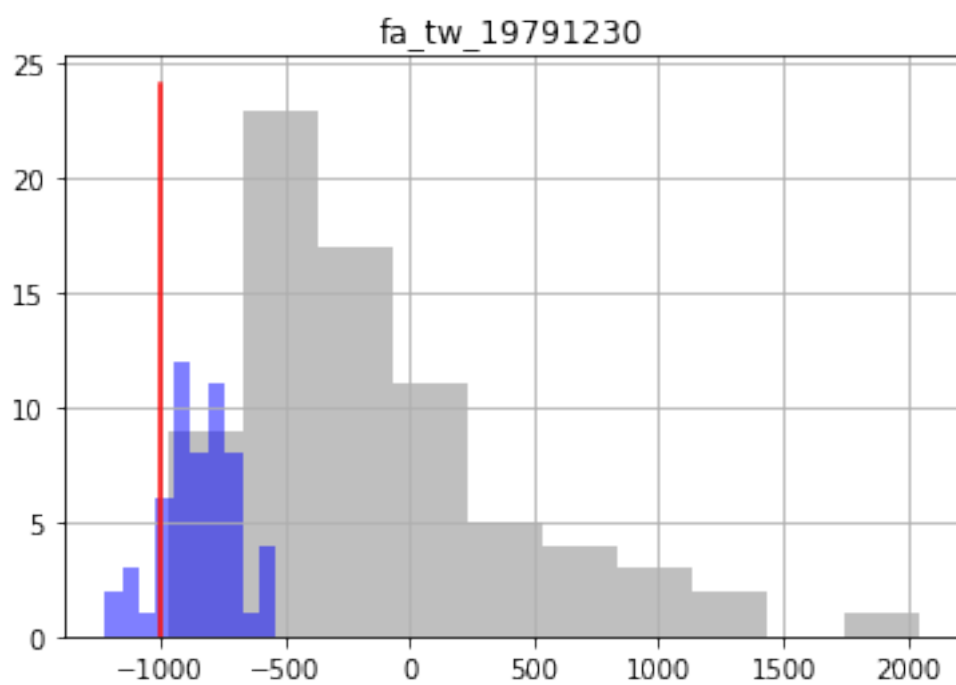
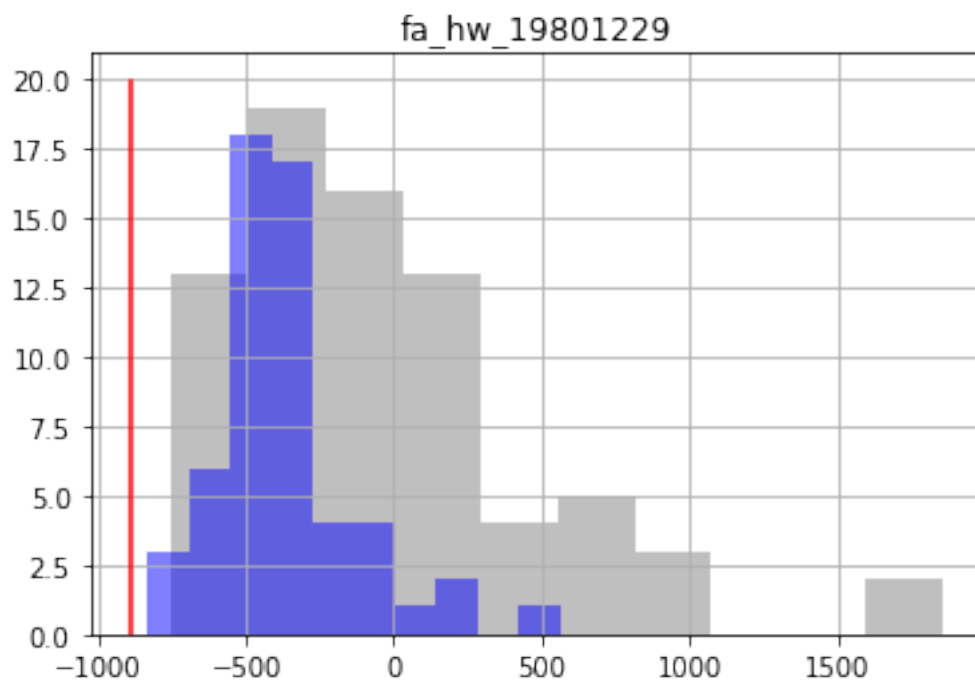


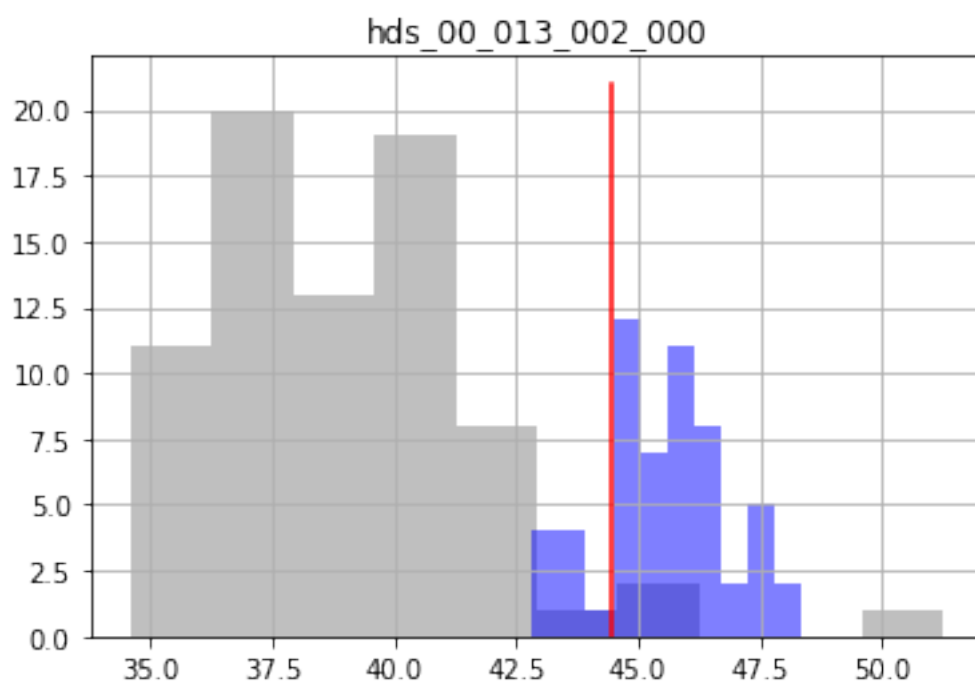
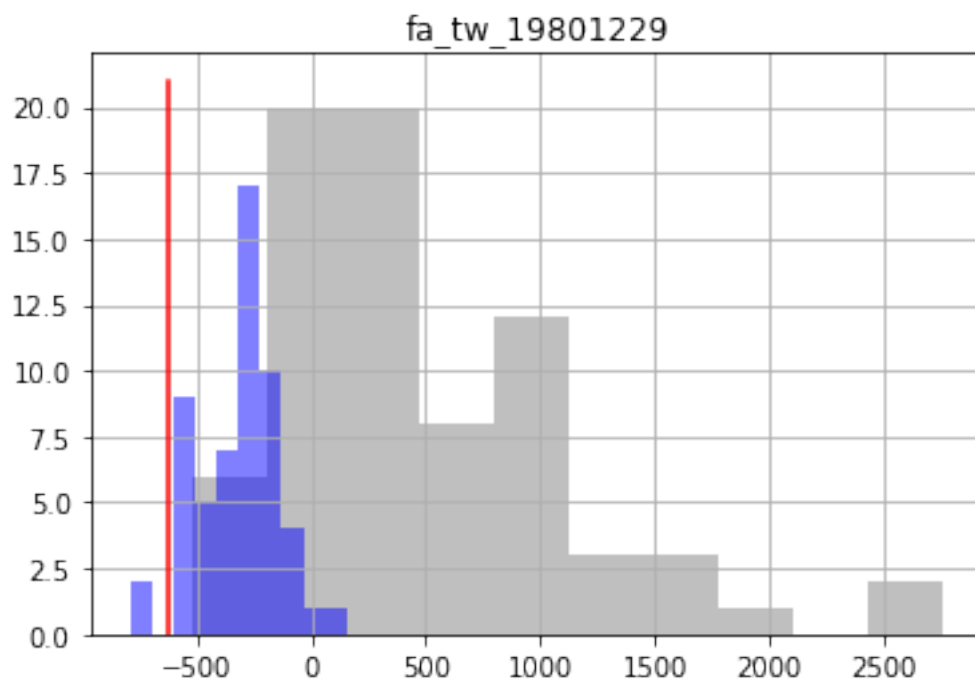
```

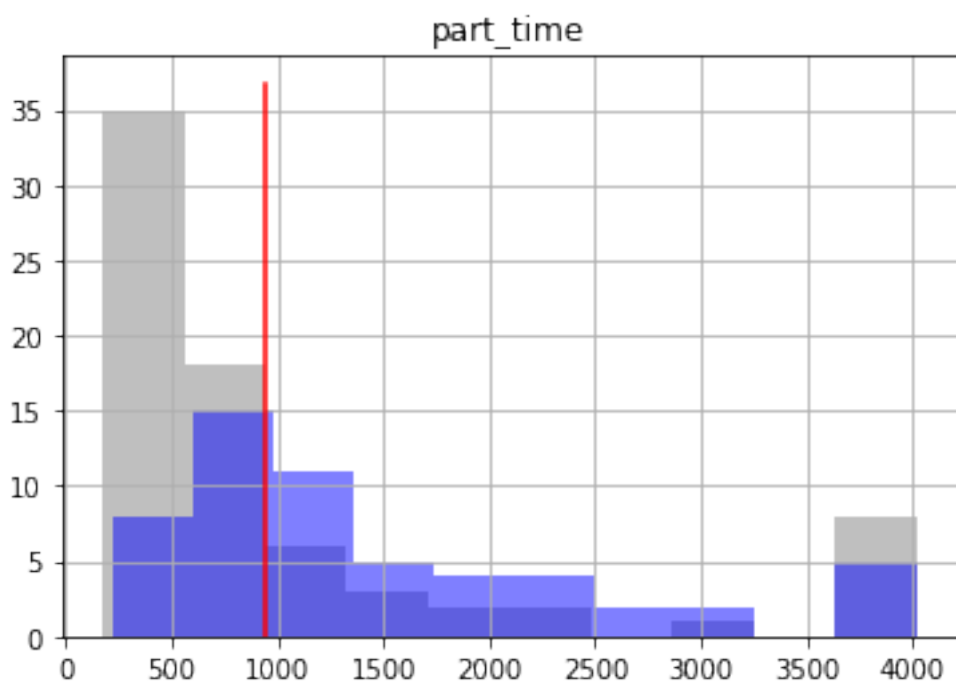
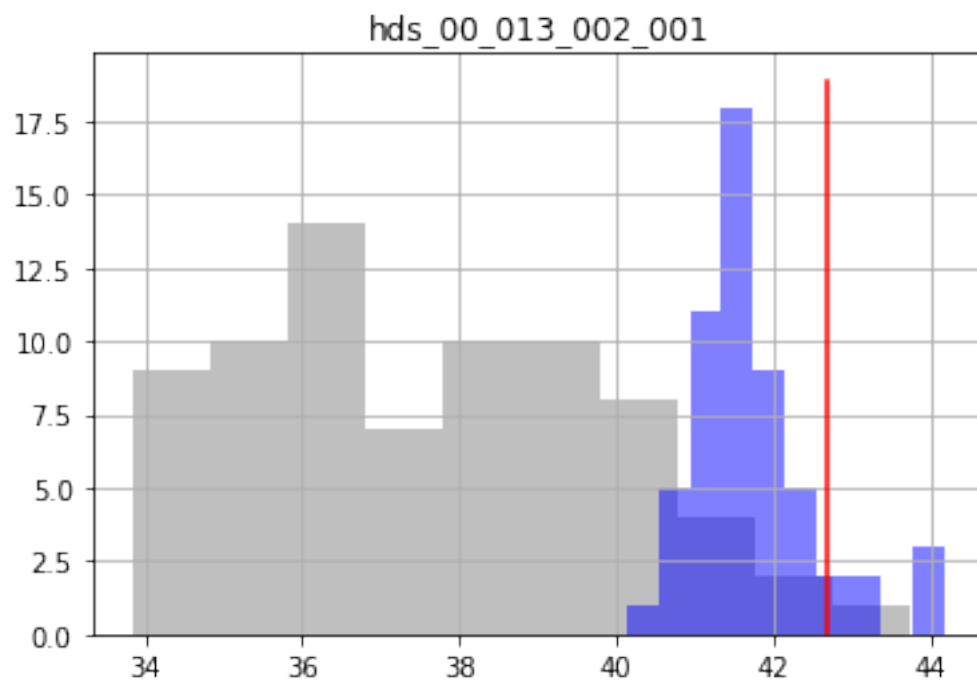
In [24]: oe_pr = pd.read_csv(os.path.join(m_d,"freyberg_ies.0.obs.csv"),index_col=0)
oe_pt = pd.read_csv(os.path.join(m_d,"freyberg_ies.{0}.obs.csv".format(pst.control_da
obs = pst.observation_data
fnames = pst.pestpp_options["forecasts"].split(",")
for forecast in fnames:
    ax = plt.subplot(111)
    oe_pr.loc[:,forecast].hist(ax=ax,color="0.5",alpha=0.5)
    oe_pt.loc[:,forecast].hist(ax=ax,color="b",alpha=0.5)
    ax.plot([obs.loc[forecast,"obsval"],obs.loc[forecast,"obsval"]],ax.get_ylim(),"r")
    ax.set_title(forecast)
plt.show()

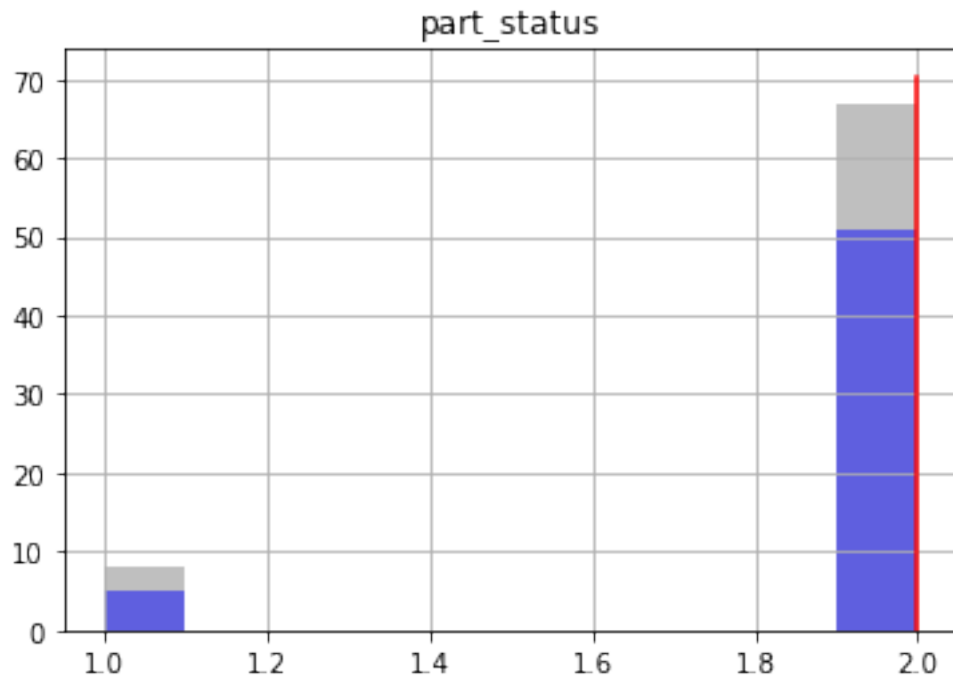
```







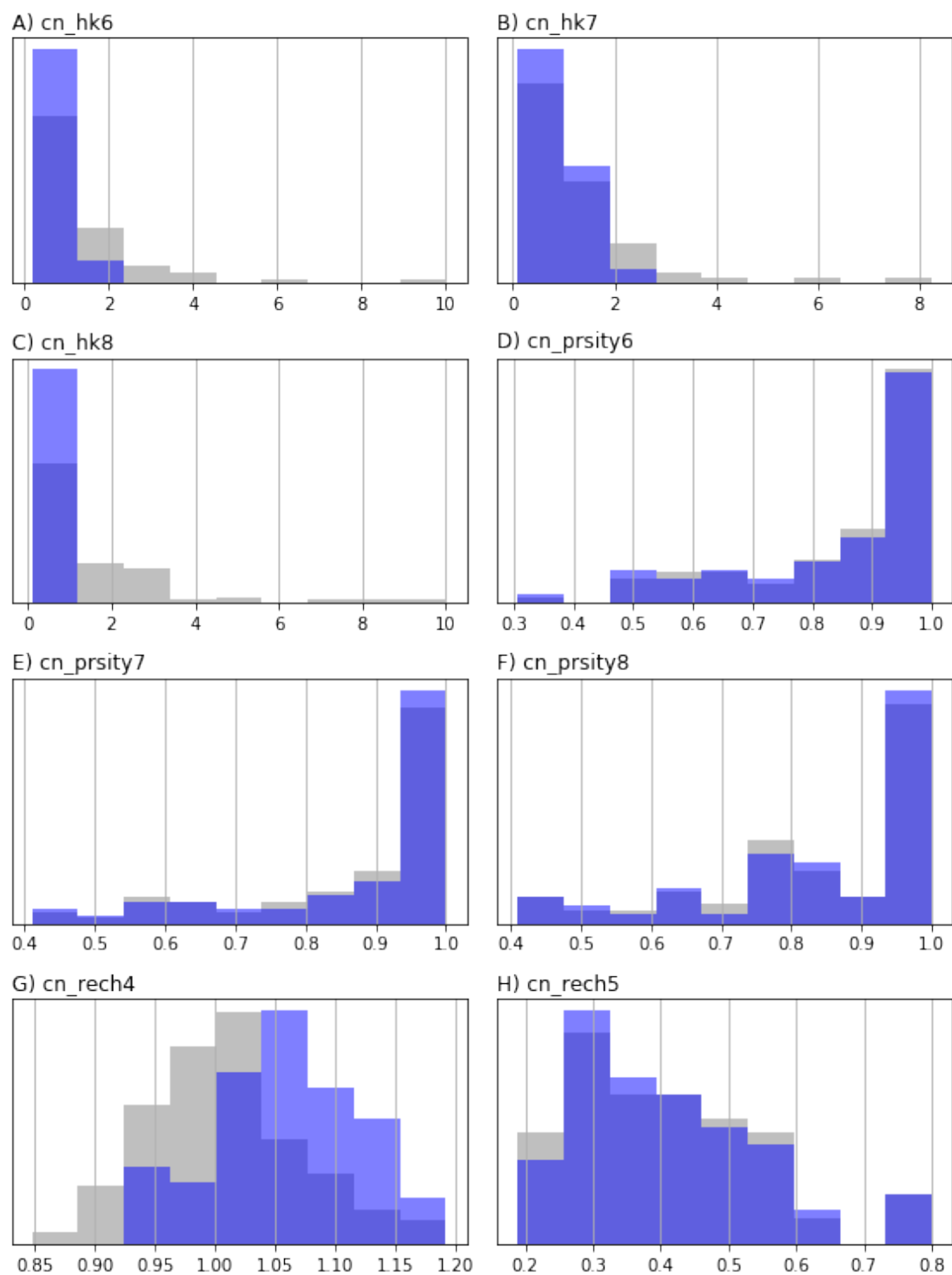




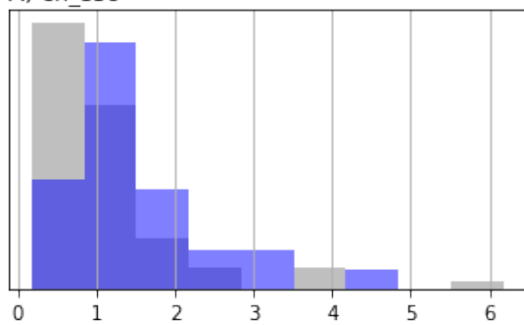
```
In [25]: pe_pr = pd.read_csv(os.path.join(m_d,"freyberg_ies.0.par.csv"),index_col=0)
         pe_pt = pd.read_csv(os.path.join(m_d,"freyberg_ies.{0}.par.csv".format(pst.control_da
         par = pst.parameter_data
         pdict = par.groupby("pargp").groups
         pyemu.plot_utils.ensemble_helper({"0.5":pe_pr,"b":pe_pt},plot_cols=pdict)
         #pyemu.plot_utils.ensemble_change_summary(pe_pr,pe_pt,pst=pst,bins=20)
```

```
/Users/jeremyw/miniconda3/lib/python3.5/site-packages/IPython/core/interactiveshell.py:2785: D
interactivity=interactivity, compiler=compiler, result=result)
```

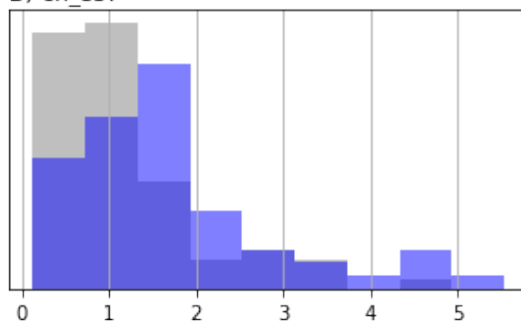
<Figure size 576x756 with 0 Axes>



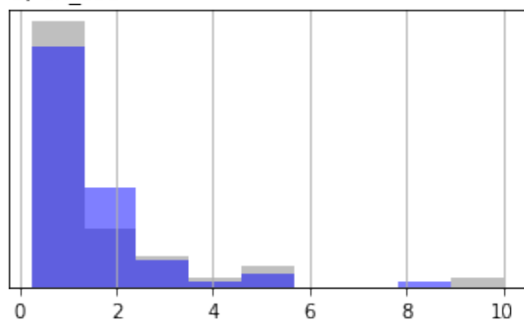
A) cn_ss6



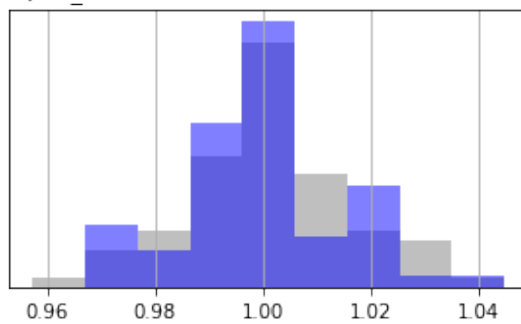
B) cn_ss7



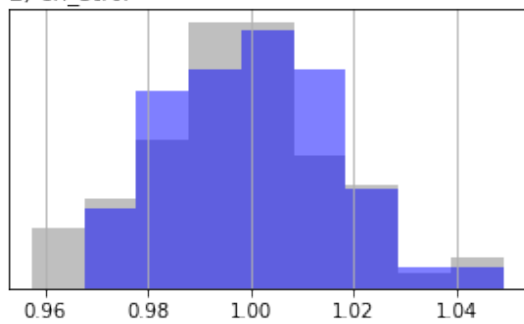
C) cn_ss8



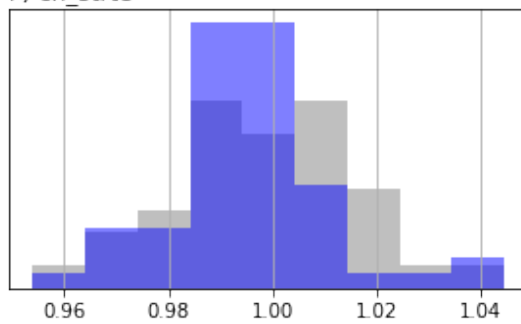
D) cn_strt6



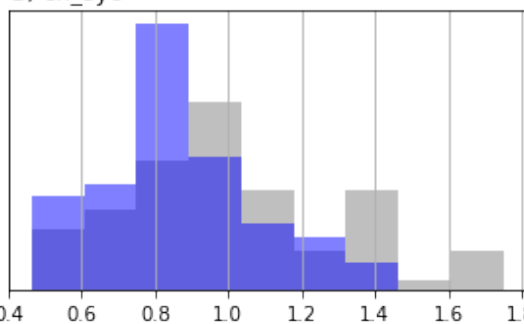
E) cn_strt7



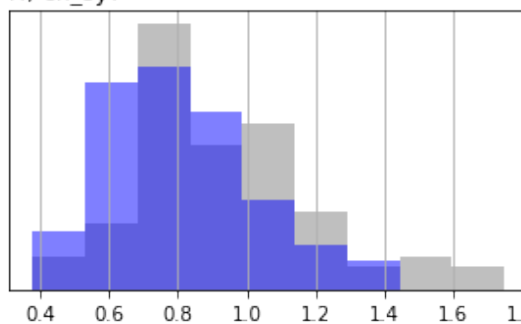
F) cn_strt8



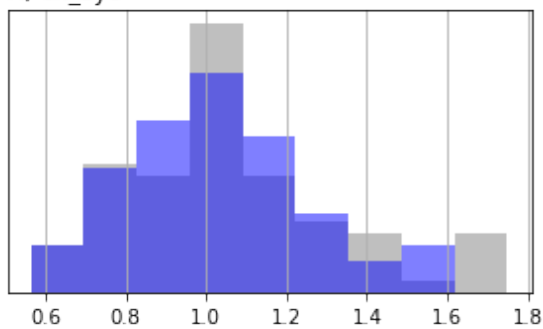
G) cn_sy6



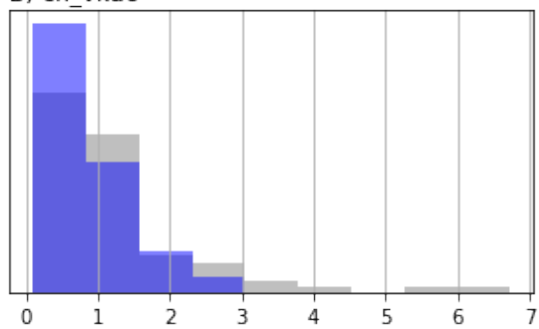
H) cn_sy7



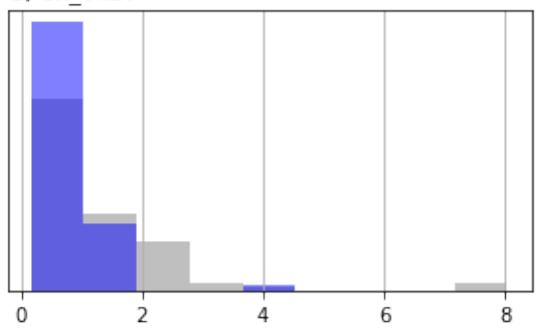
A) cn_sy8



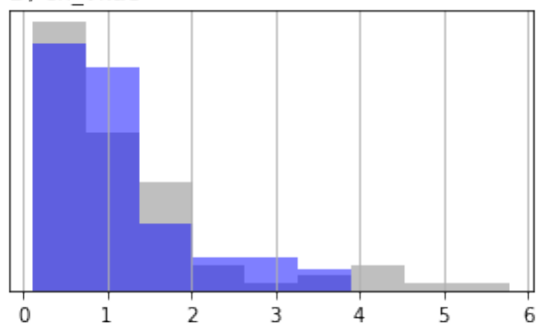
B) cn_vka6



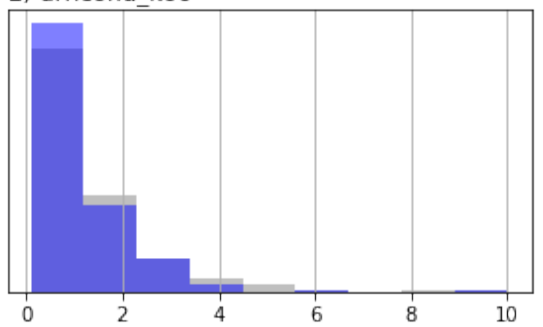
C) cn_vka7



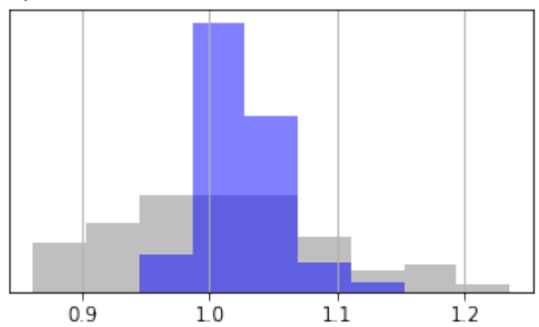
D) cn_vka8



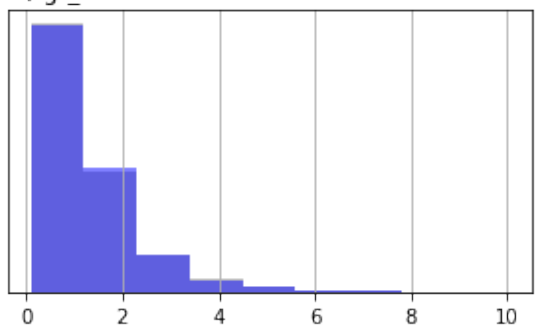
E) drncond_k00



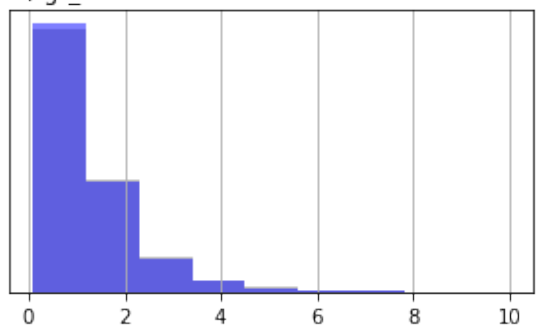
F) flow



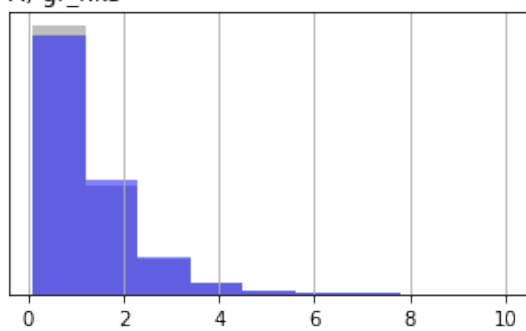
G) gr_hk3



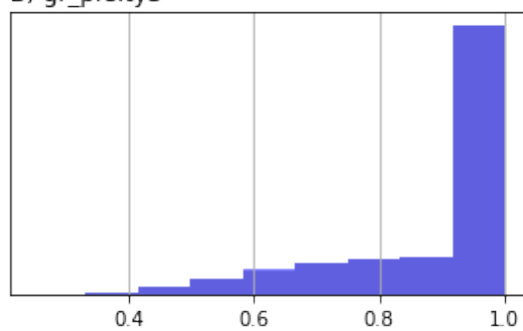
H) gr_hk4



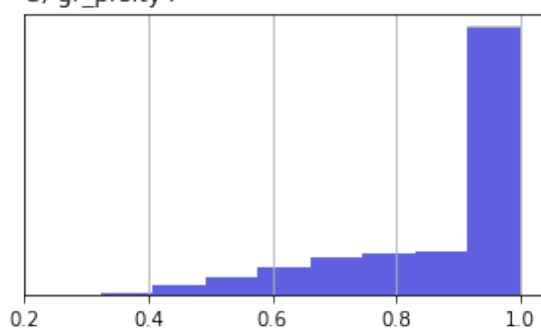
A) gr_hk5



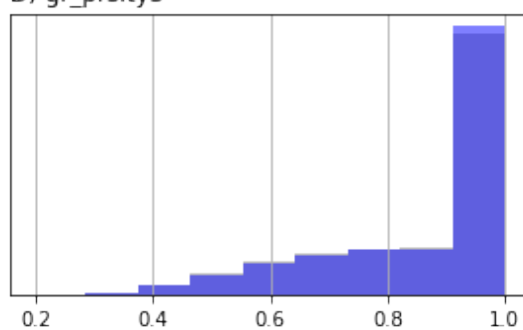
B) gr_prsity3



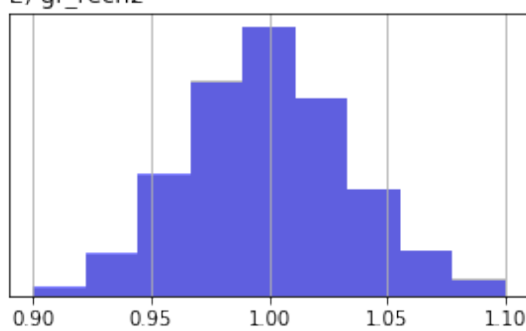
C) gr_prsity4



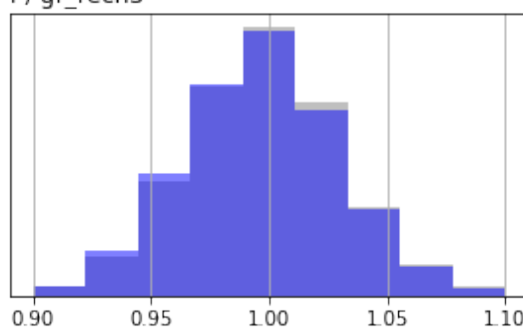
D) gr_prsity5



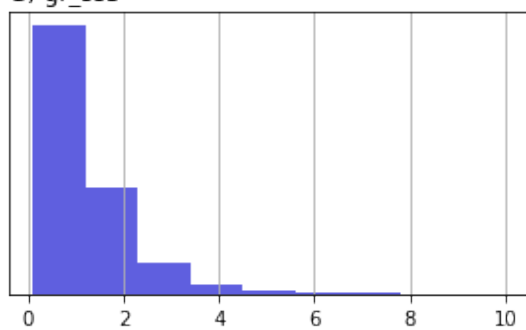
E) gr_rech2



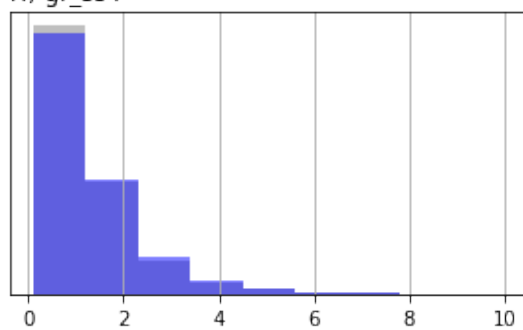
F) gr_rech3

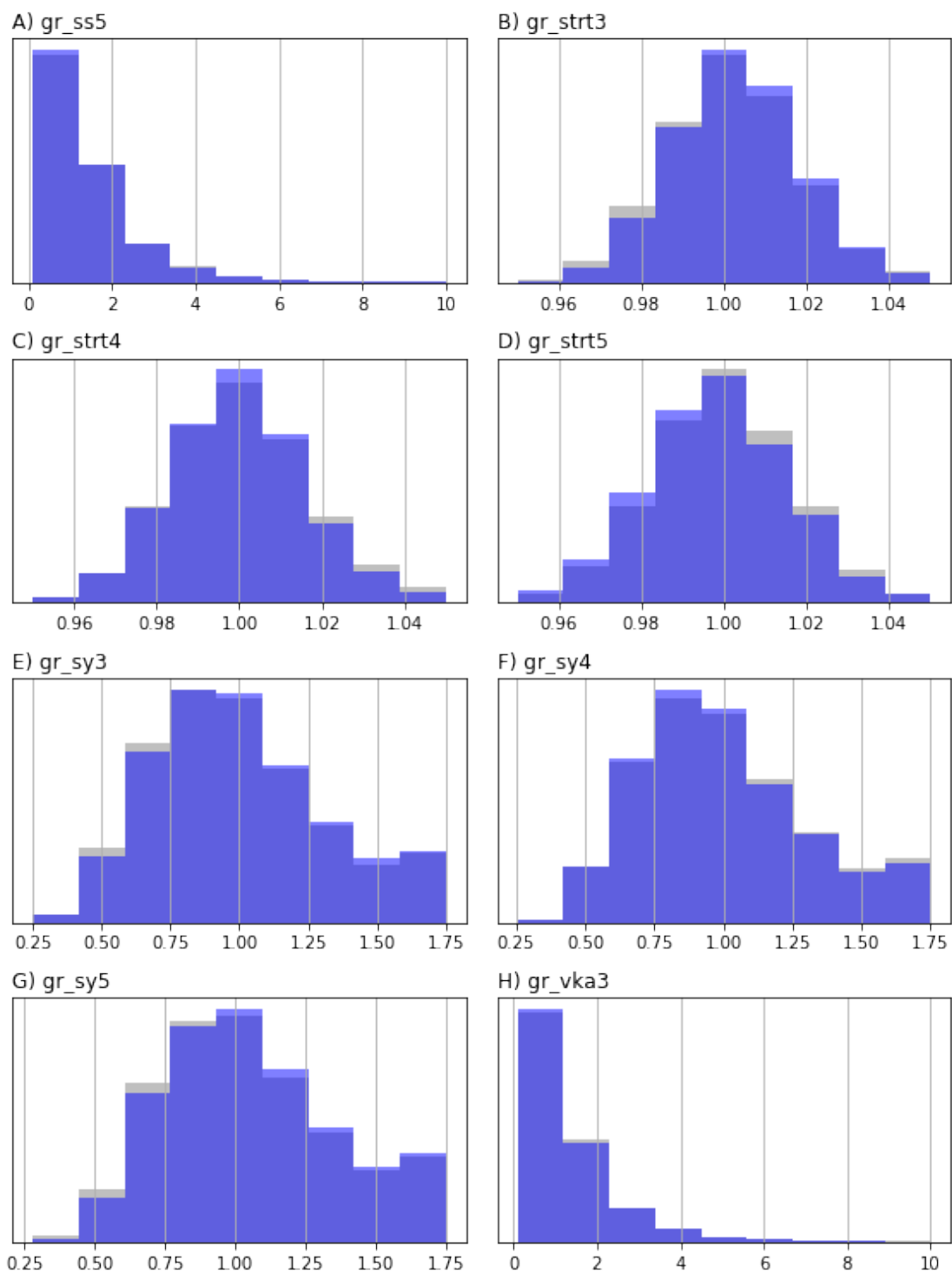


G) gr_ss3

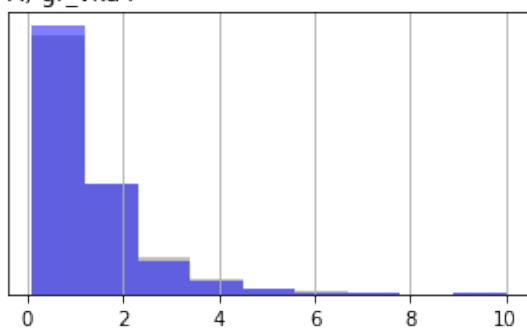


H) gr_ss4

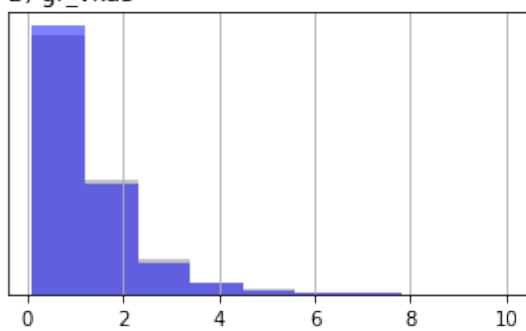




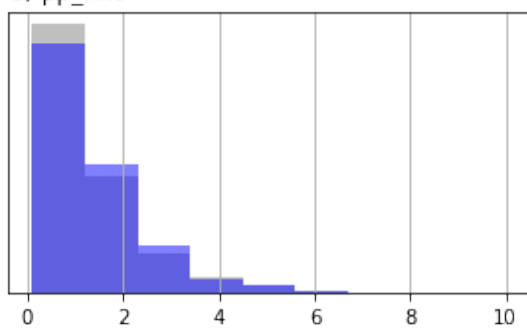
A) gr_vka4



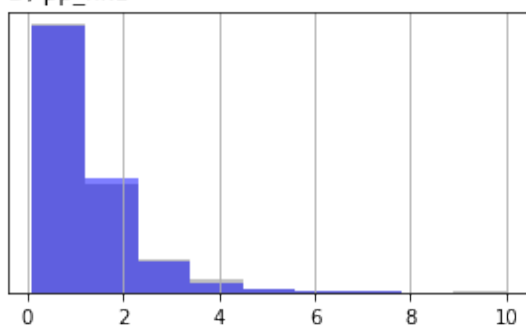
B) gr_vka5



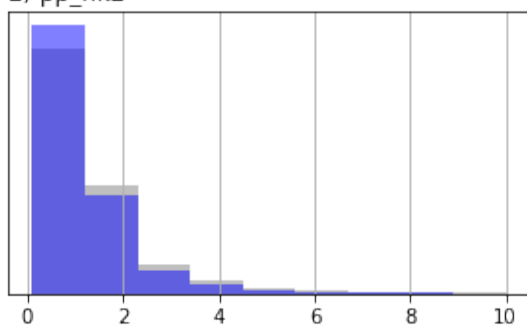
C) pp_hk0



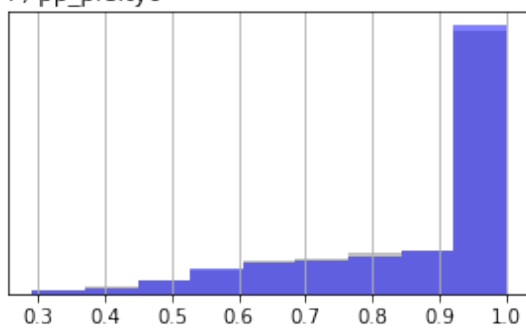
D) pp_hk1



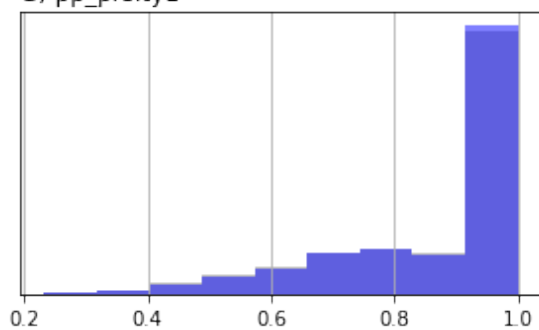
E) pp_hk2



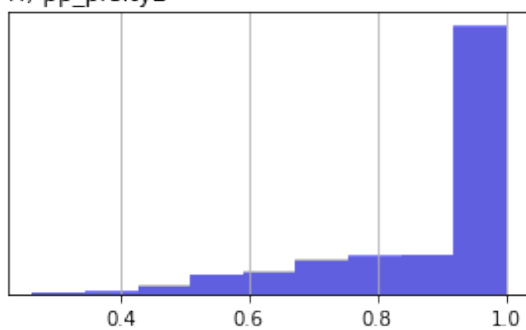
F) pp_prsity0



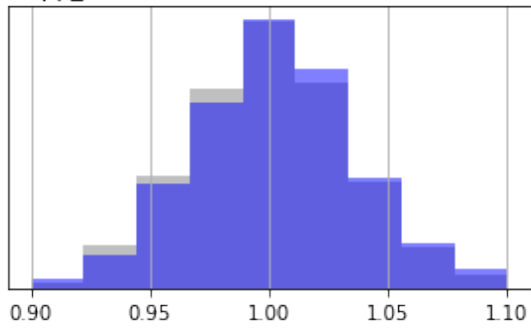
G) pp_prsity1



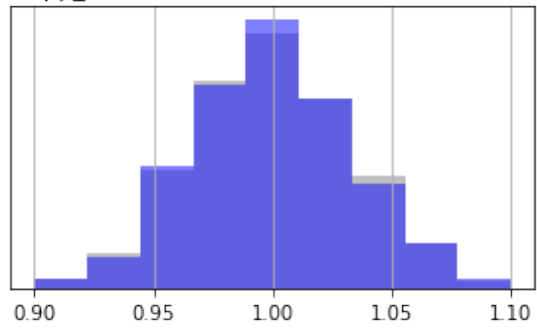
H) pp_prsity2



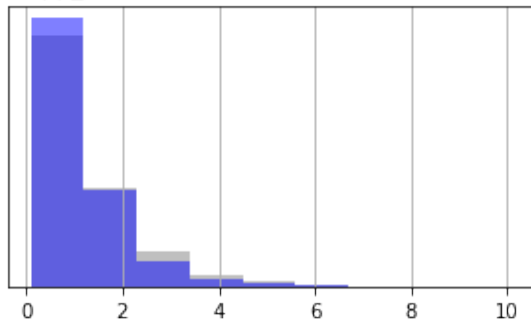
A) pp_rech0



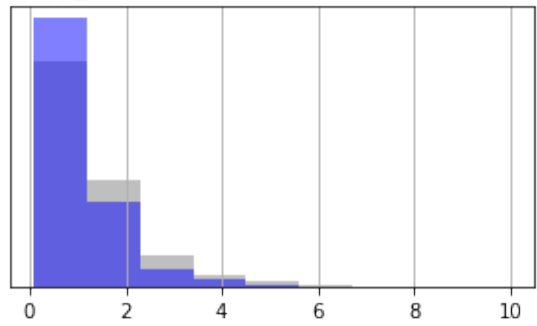
B) pp_rech1



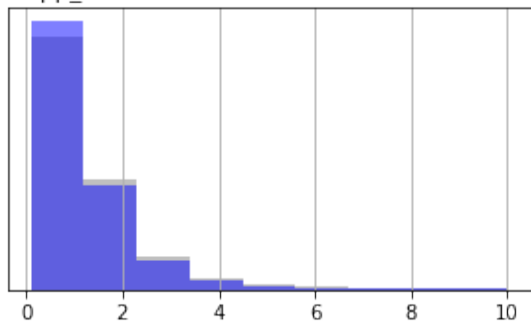
C) pp_ss0



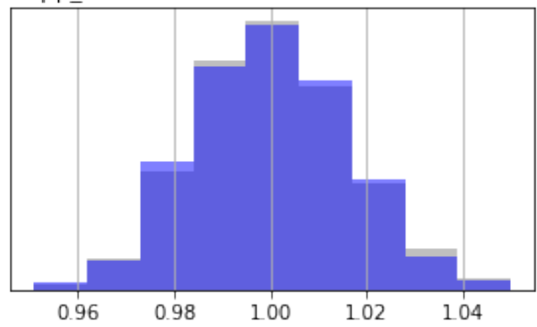
D) pp_ss1



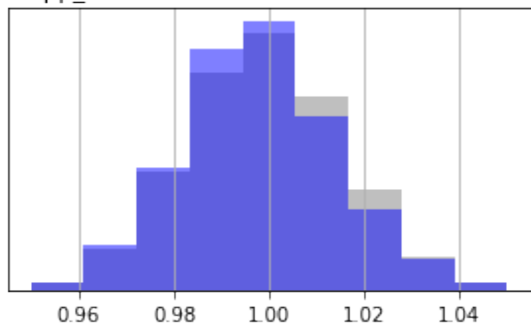
E) pp_ss2



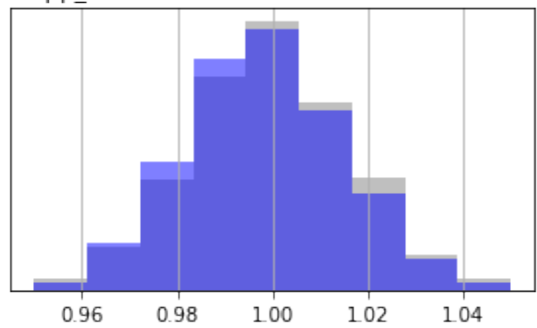
F) pp_strt0

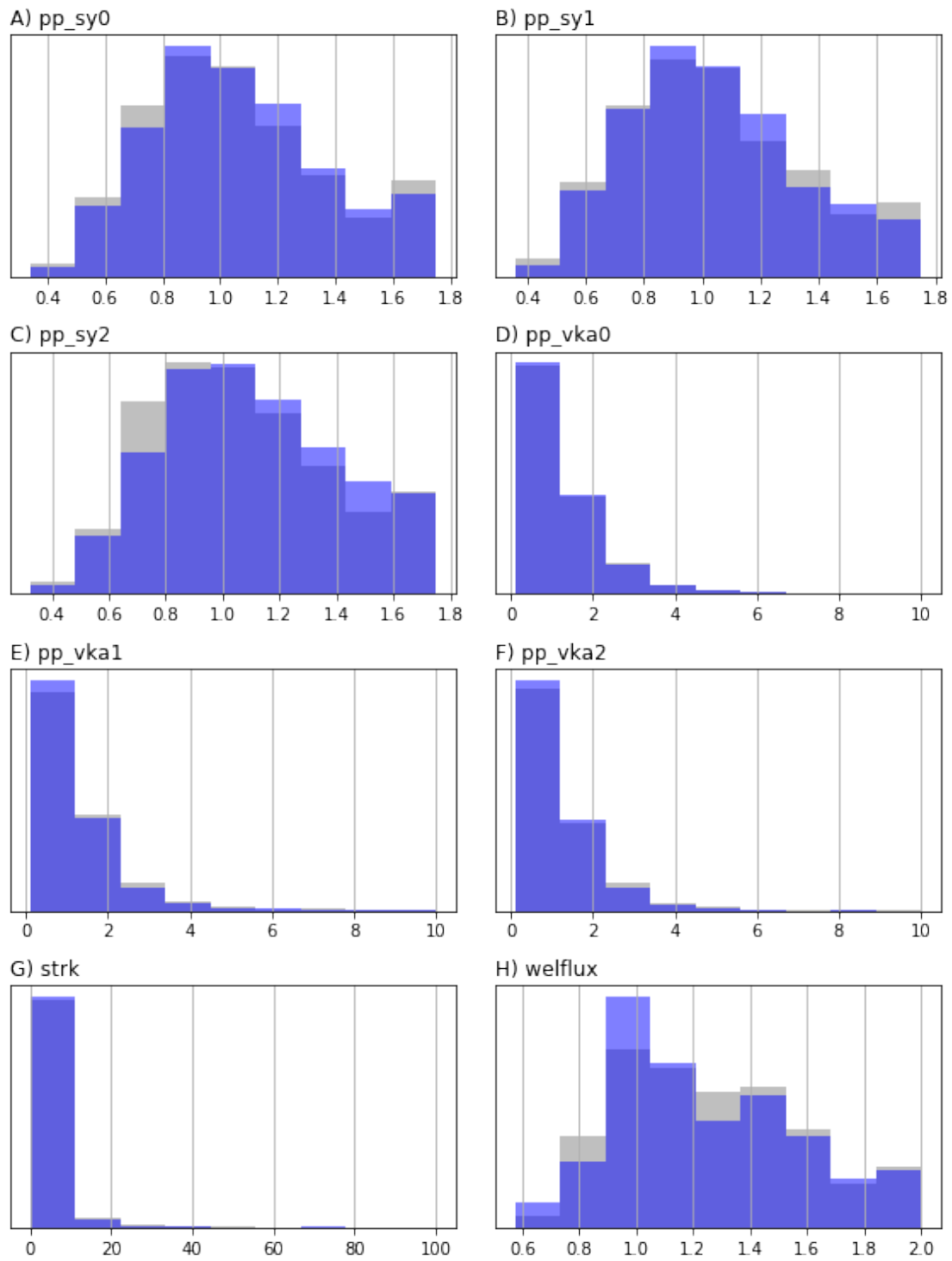


G) pp_strt1



H) pp_strt2





A) welflux_k02

