pestpp-ies

May 12, 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  \
        cn_ss6            cn_ss6       log      1                  0
        pp_vka2          pp_vka2       log     32                  0
        cn_sy8            cn_sy8       log      1                  0
        gr_strt5        gr_strt5       log    705                  0
        cn_sy7            cn_sy7       log      1                  0
        pp_rech0        pp_rech0       log     32                  0
        drncond_k00  drncond_k00       log     10                  0
        pp_vka1          pp_vka1       log     32                  0
        cn_hk6            cn_hk6       log      1                  0
        gr_sy5            gr_sy5       log    705                  0
        pp_strt2        pp_strt2       log     32                  0
        pp_ss1            pp_ss1       log     32                  0
        pp_sy1            pp_sy1       log     32                  0
        pp_prsity0    pp_prsity0       log     32                  0
        cn_hk8            cn_hk8       log      1                  0
```

```
cn_strt8        cn_strt8       log       1                  0
gr_hk3            gr_hk3       log     705                  0
strk                strk       log      40                  0
cn_strt6        cn_strt6       log       1                  0
welflux          welflux       log       2      0 to 0.176091
cn_hk7            cn_hk7       log       1                  0
pp_rech1        pp_rech1       log      32                  0
gr_ss4            gr_ss4       log     705                  0
gr_prsity4    gr_prsity4       log     705                  0
cn_ss8            cn_ss8       log       1                  0
pp_vka0          pp_vka0       log      32                  0
gr_ss3            gr_ss3       log     705                  0
gr_sy3            gr_sy3       log     705                  0
cn_vka8          cn_vka8       log       1                  0
gr_prsity3    gr_prsity3       log     705                  0
...                  ...       ...     ...                ...
pp_prsity2    pp_prsity2       log      32                  0
welflux_k02  welflux_k02       log       6                  0
pp_ss0            pp_ss0       log      32                  0
cn_vka7          cn_vka7       log       1                  0
gr_hk5            gr_hk5       log     705                  0
cn_prsity8    cn_prsity8       log       1                  0
cn_rech5        cn_rech5       log       1           -0.39794
gr_strt4        gr_strt4       log     705                  0
gr_ss5            gr_ss5       log     705                  0
cn_vka6          cn_vka6       log       1                  0
gr_hk4            gr_hk4       log     705                  0
pp_hk1            pp_hk1       log      32                  0
cn_sy6            cn_sy6       log       1                  0
pp_hk0            pp_hk0       log      32                  0
flow                flow       log       1                  0
pp_strt0        pp_strt0       log      32                  0
gr_vka4          gr_vka4       log     705                  0
gr_prsity5    gr_prsity5       log     705                  0
cn_prsity7    cn_prsity7       log       1                  0
cn_ss7            cn_ss7       log       1                  0
gr_strt3        gr_strt3       log     705                  0
pp_sy2            pp_sy2       log      32                  0
gr_rech2        gr_rech2       log     705                  0
gr_vka3          gr_vka3       log     705                  0
pp_strt1        pp_strt1       log      32                  0
gr_sy4            gr_sy4       log     705                  0
pp_prsity1    pp_prsity1       log      32                  0
gr_vka5          gr_vka5       log     705                  0
cn_prsity6    cn_prsity6       log       1                  0
pp_ss2            pp_ss2       log      32                  0

                     upper bound        lower bound    standard deviation
```

```
cn_ss6                        1                 -1                   0.5
pp_vka2                       1                 -1                   0.5
cn_sy8                 0.243038           -0.60206              0.211275
gr_strt5              0.0211893         -0.0222764             0.0108664
cn_sy7                 0.243038           -0.60206              0.211275
pp_rech0              0.0413927         -0.0457575             0.0217875
drncond_k00                   1                 -1                   0.5
pp_vka1                       1                 -1                   0.5
cn_hk6                        1                 -1                   0.5
gr_sy5                 0.243038           -0.60206              0.211275
pp_strt2              0.0211893         -0.0222764             0.0108664
pp_ss1                        1                 -1                   0.5
pp_sy1                 0.243038           -0.60206              0.211275
pp_prsity0             0.176091           -0.30103               0.11928
cn_hk8                        1                 -1                   0.5
cn_strt8              0.0211893         -0.0222764             0.0108664
gr_hk3                        1                 -1                   0.5
strk                          2                 -2                     1
cn_strt6              0.0211893         -0.0222764             0.0108664
welflux       0.176091 to 0.30103  -0.30103 to     0  0.0752575 to 0.11928
cn_hk7                        1                 -1                   0.5
pp_rech1              0.0413927         -0.0457575             0.0217875
gr_ss4                        1                 -1                   0.5
gr_prsity4             0.176091           -0.30103               0.11928
cn_ss8                        1                 -1                   0.5
pp_vka0                       1                 -1                   0.5
gr_ss3                        1                 -1                   0.5
gr_sy3                 0.243038           -0.60206              0.211275
cn_vka8                       1                 -1                   0.5
gr_prsity3             0.176091           -0.30103               0.11928
...                         ...                ...                   ...
pp_prsity2             0.176091           -0.30103               0.11928
welflux_k02                   1                 -1                   0.5
pp_ss0                        1                 -1                   0.5
cn_vka7                       1                 -1                   0.5
gr_hk5                        1                 -1                   0.5
cn_prsity8             0.176091           -0.30103               0.11928
cn_rech5               -0.09691                 -1              0.225772
gr_strt4              0.0211893         -0.0222764             0.0108664
gr_ss5                        1                 -1                   0.5
cn_vka6                       1                 -1                   0.5
gr_hk4                        1                 -1                   0.5
pp_hk1                        1                 -1                   0.5
cn_sy6                 0.243038           -0.60206              0.211275
pp_hk0                        1                 -1                   0.5
flow                    0.09691          -0.124939             0.0554622
pp_strt0              0.0211893         -0.0222764             0.0108664
gr_vka4                       1                 -1                   0.5
```

```
gr_prsity5          0.176091         -0.30103             0.11928
cn_prsity7          0.176091         -0.30103             0.11928
cn_ss7                     1               -1                 0.5
gr_strt3           0.0211893       -0.0222764           0.0108664
pp_sy2              0.243038         -0.60206            0.211275
gr_rech2           0.0413927       -0.0457575           0.0217875
gr_vka3                    1               -1                 0.5
pp_strt1           0.0211893       -0.0222764           0.0108664
gr_sy4              0.243038         -0.60206            0.211275
pp_prsity1          0.176091         -0.30103             0.11928
gr_vka5                    1               -1                 0.5
cn_prsity6          0.176091         -0.30103             0.11928
pp_ss2                     1               -1                 0.5

[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 = {}
        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.noptmax = 3
```

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

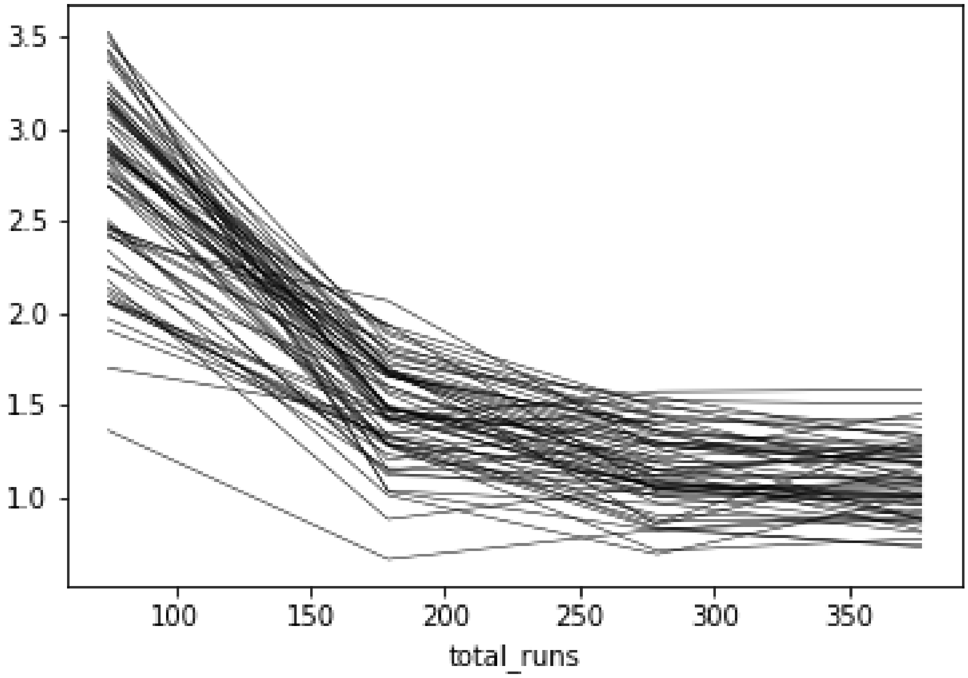
```
noptmax:3, npar_adj:14819, nnz_obs:14
```

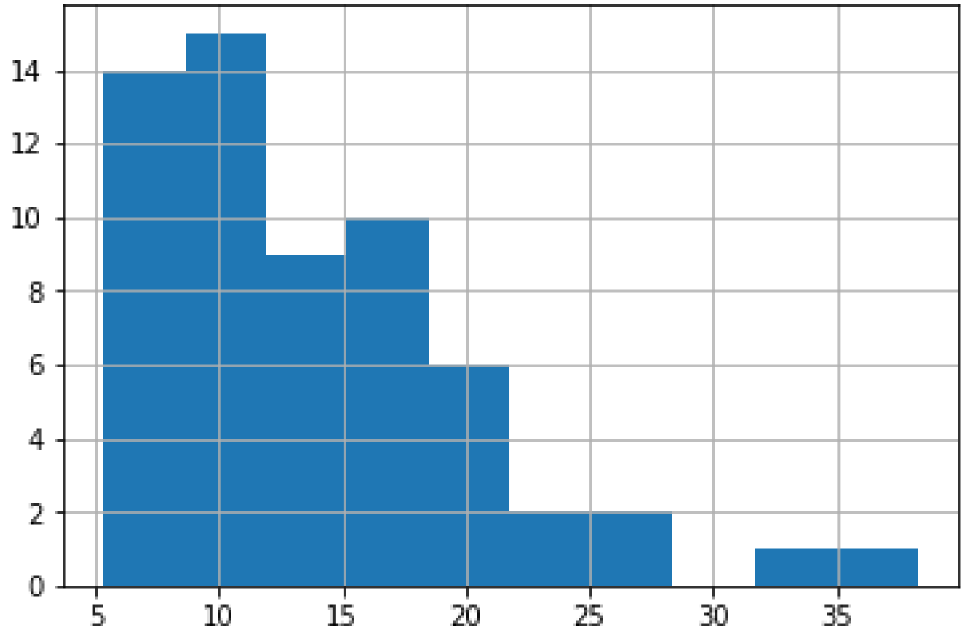
```
In [7]: pyemu.os_utils.start_slaves(t_d,"pestpp-ies","freyberg_ies.pst",num_slaves=20,master_d
```

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')
```

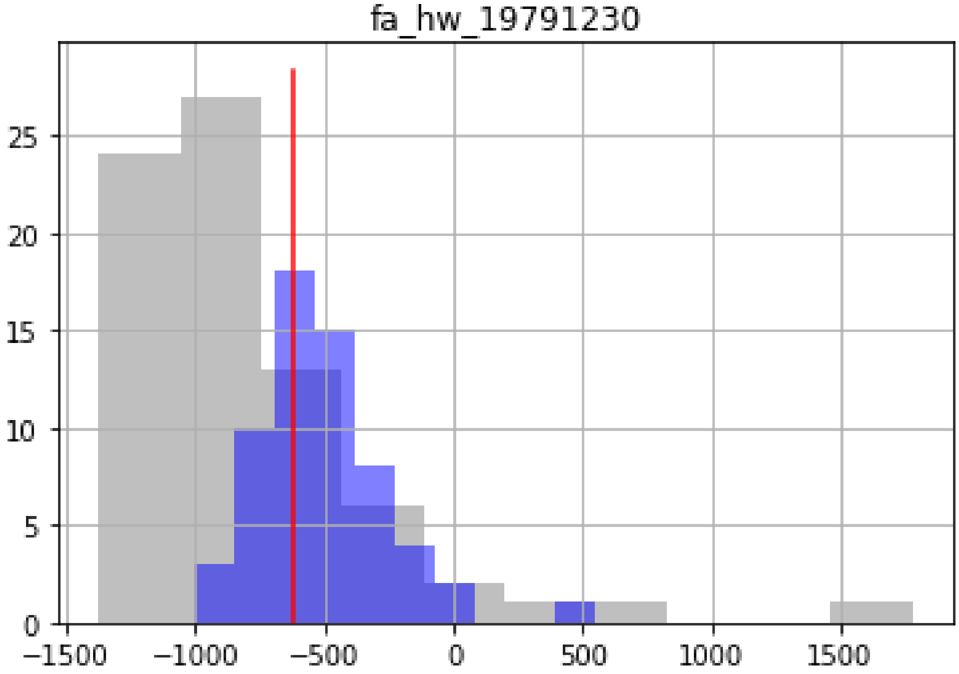
```
plt.figure()
phi.iloc[-1,6:].hist()
plt.show()
```

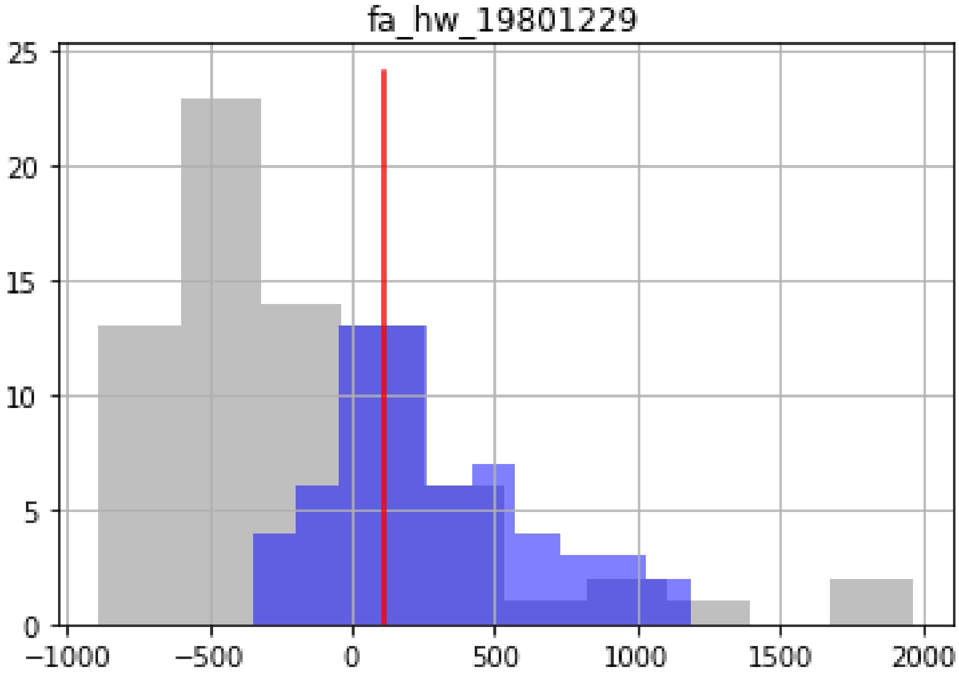


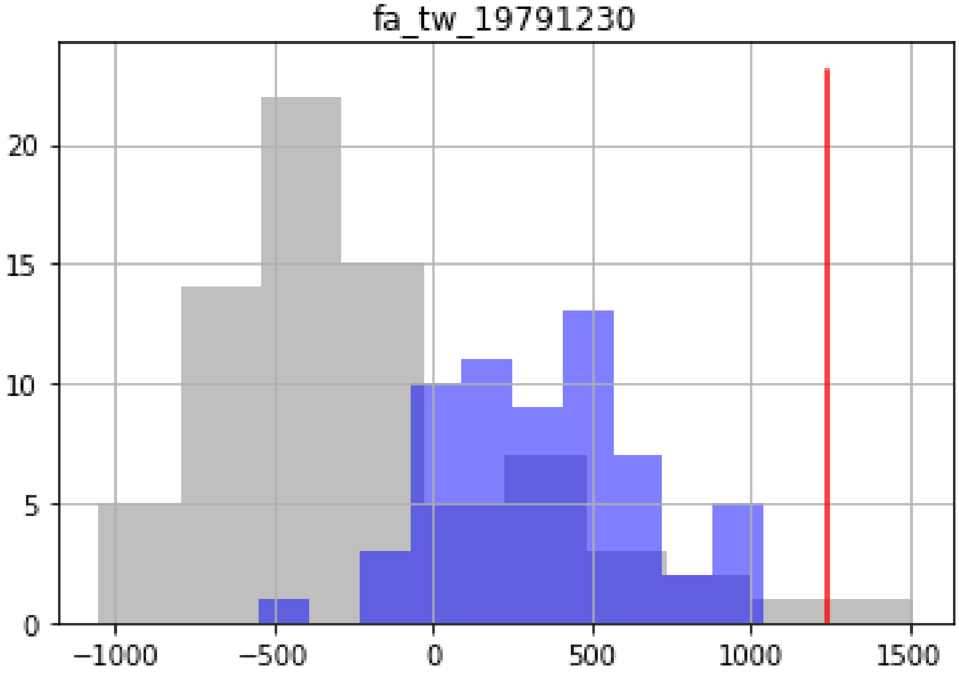


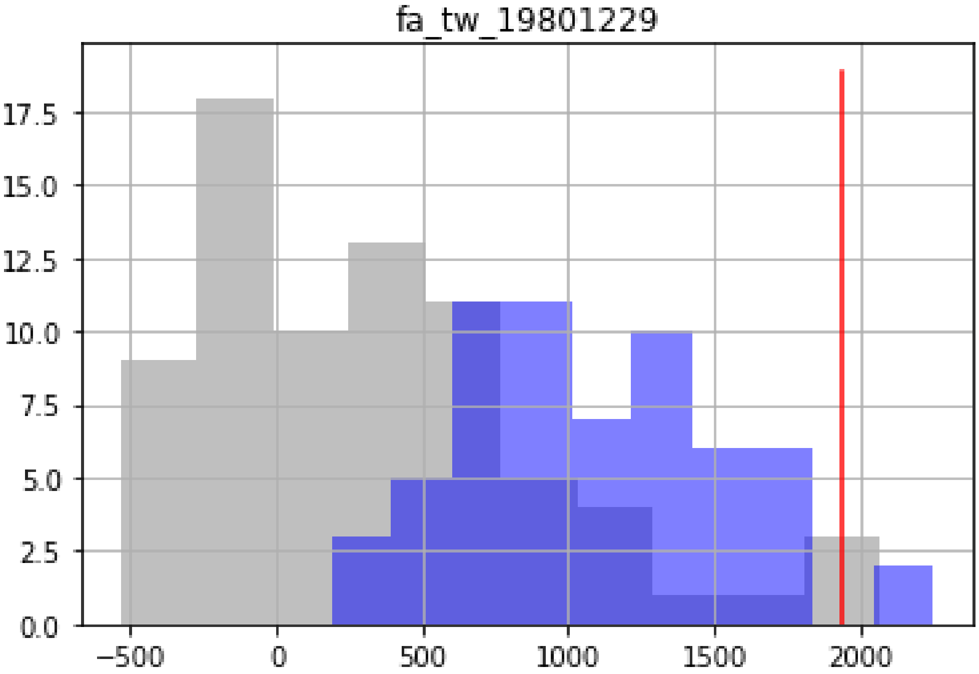
Plot forecast prior and posterior histograms with “truth” (red line)

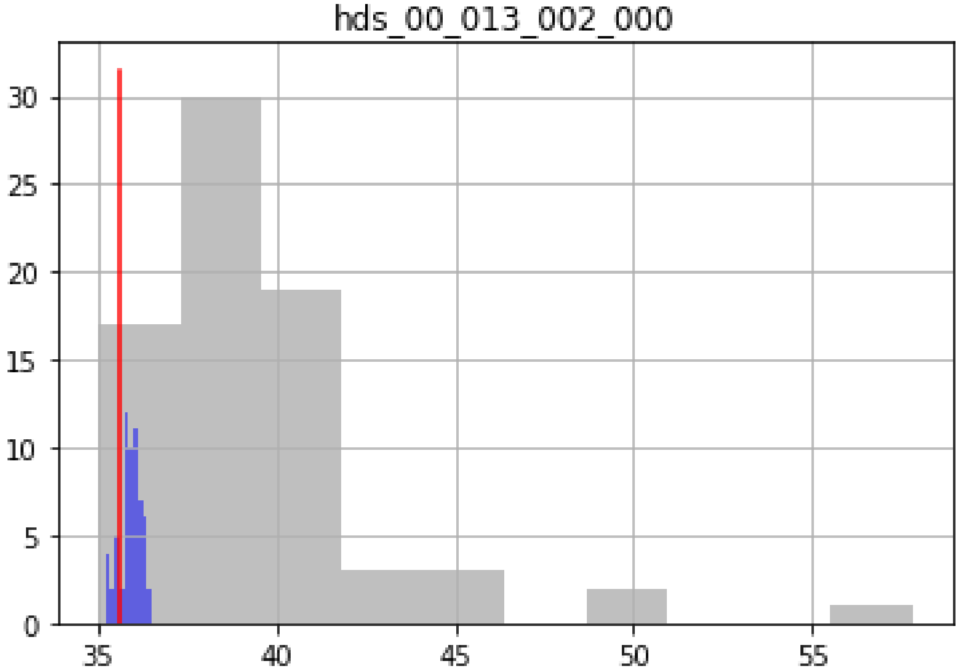
```
In [9]: oe_pr = pd.read_csv(os.path.join(m_d,"freyberg_ies.0.obs.csv"),index_col=0)
        oe_pt = pd.read_csv(os.path.join(m_d,"freyberg_ies.{0}.obs.csv".format(pst.control_data
        obs = pst.observation_data
        fnames = pst.pestpp_options["forecasts"].split(",")
        for forecast in 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()
```

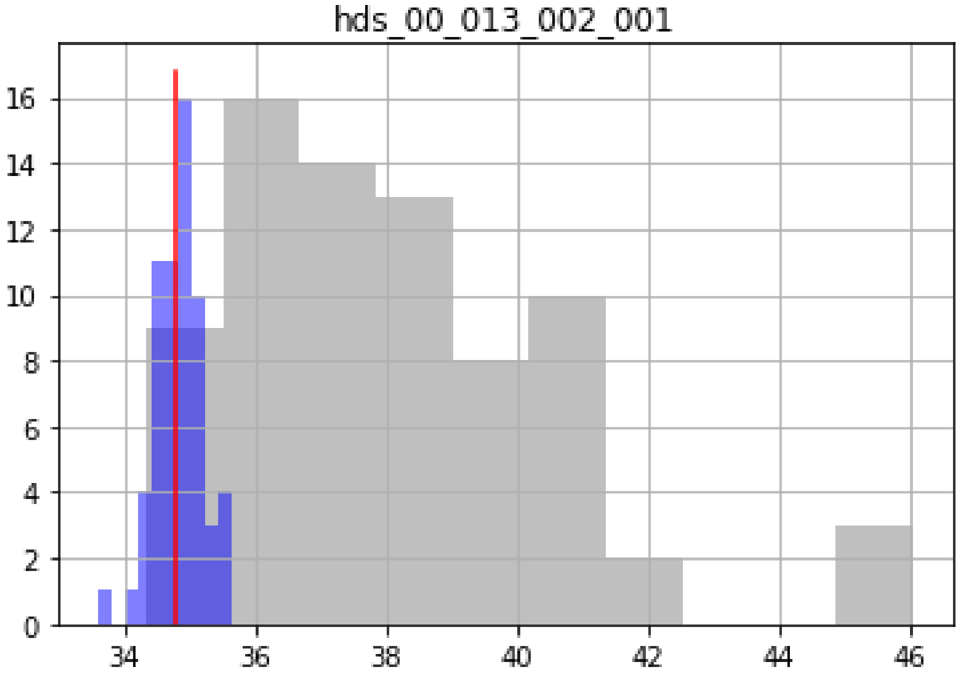


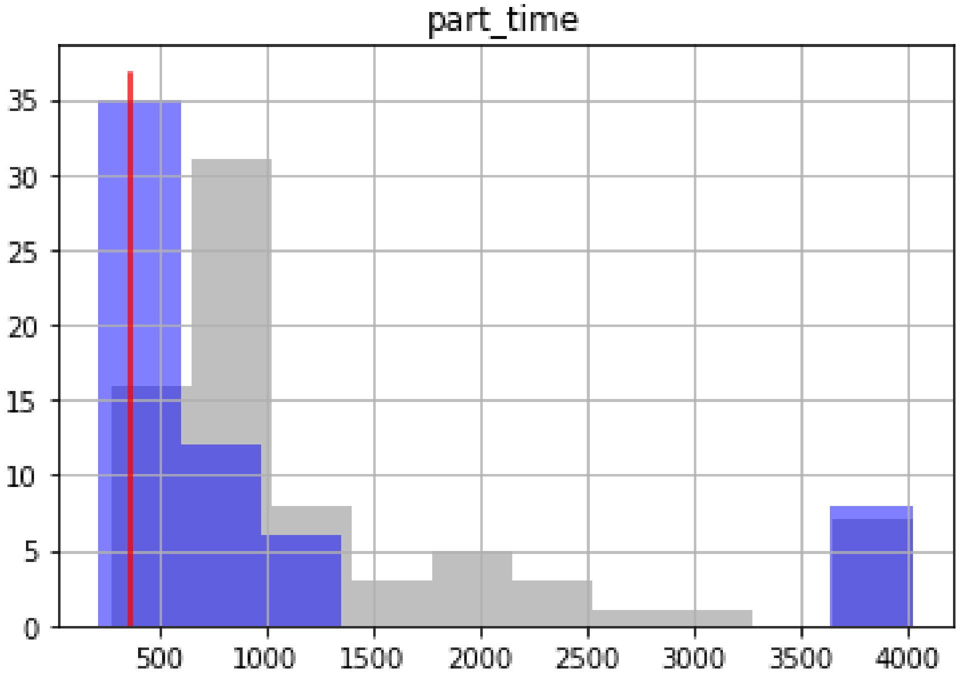

fa_hw_19801229
25
20
15
10
5
0
−1000
−500
0
500
1000
1500
2000

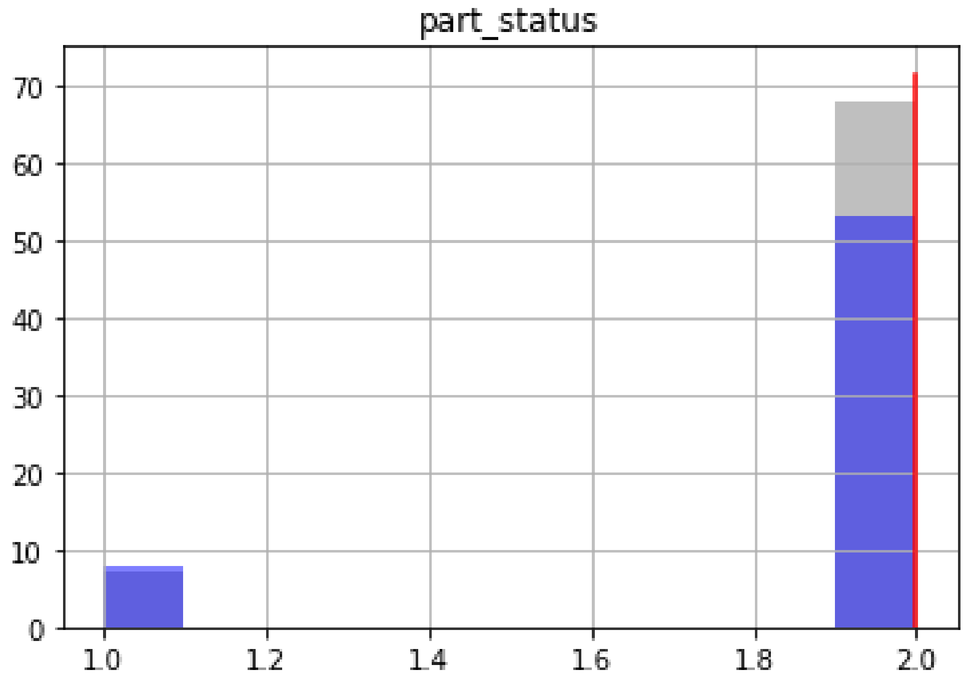

fa_tw_19791230
20
15
10
5
0
−1000
−500
0
500
1000
1500


fa_tw_19801229
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
−500
0
500
1000
1500
2000


hds_00_013_002_000
30
25
20
15
10
5
0
35
40
45
50
55


hds_00_013_002_001
0
2
4
6
8
10
12
14
16
34
36
38
40
42
44
46

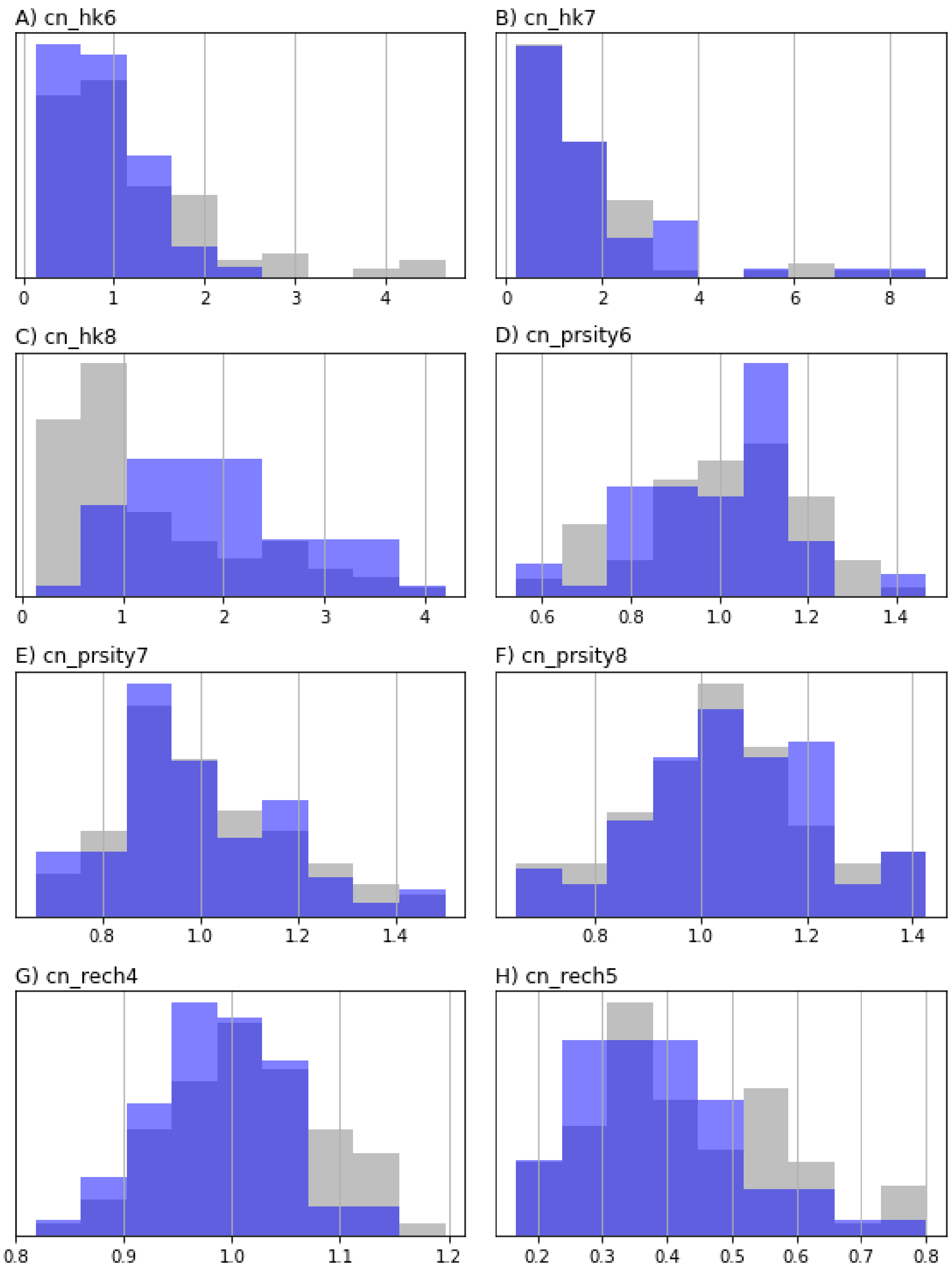

part_time
0
5
10
15
20
25
30
35
500
1000
1500
2000
2500
3000
3500
4000

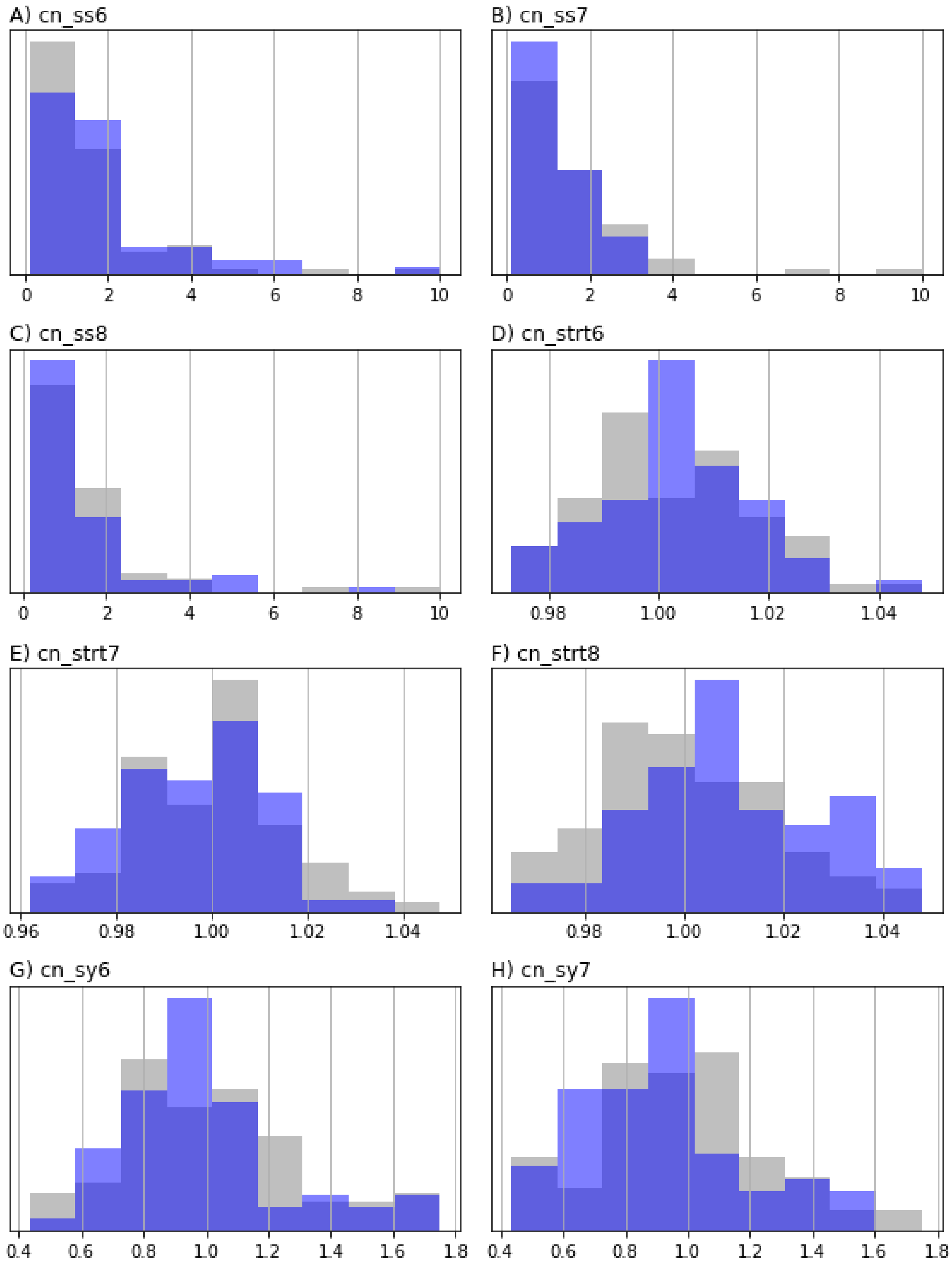


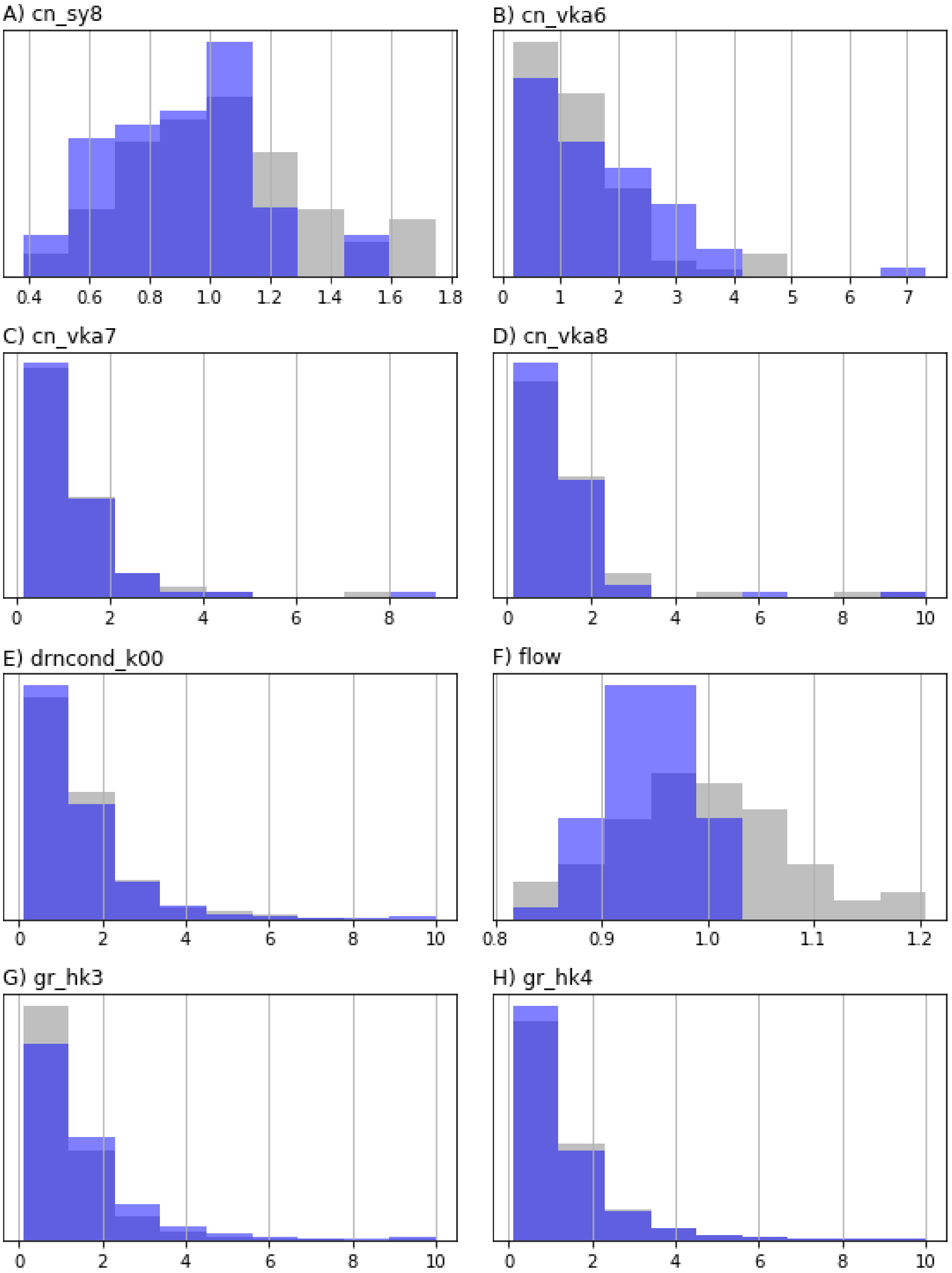
Plot parameter histograms by group

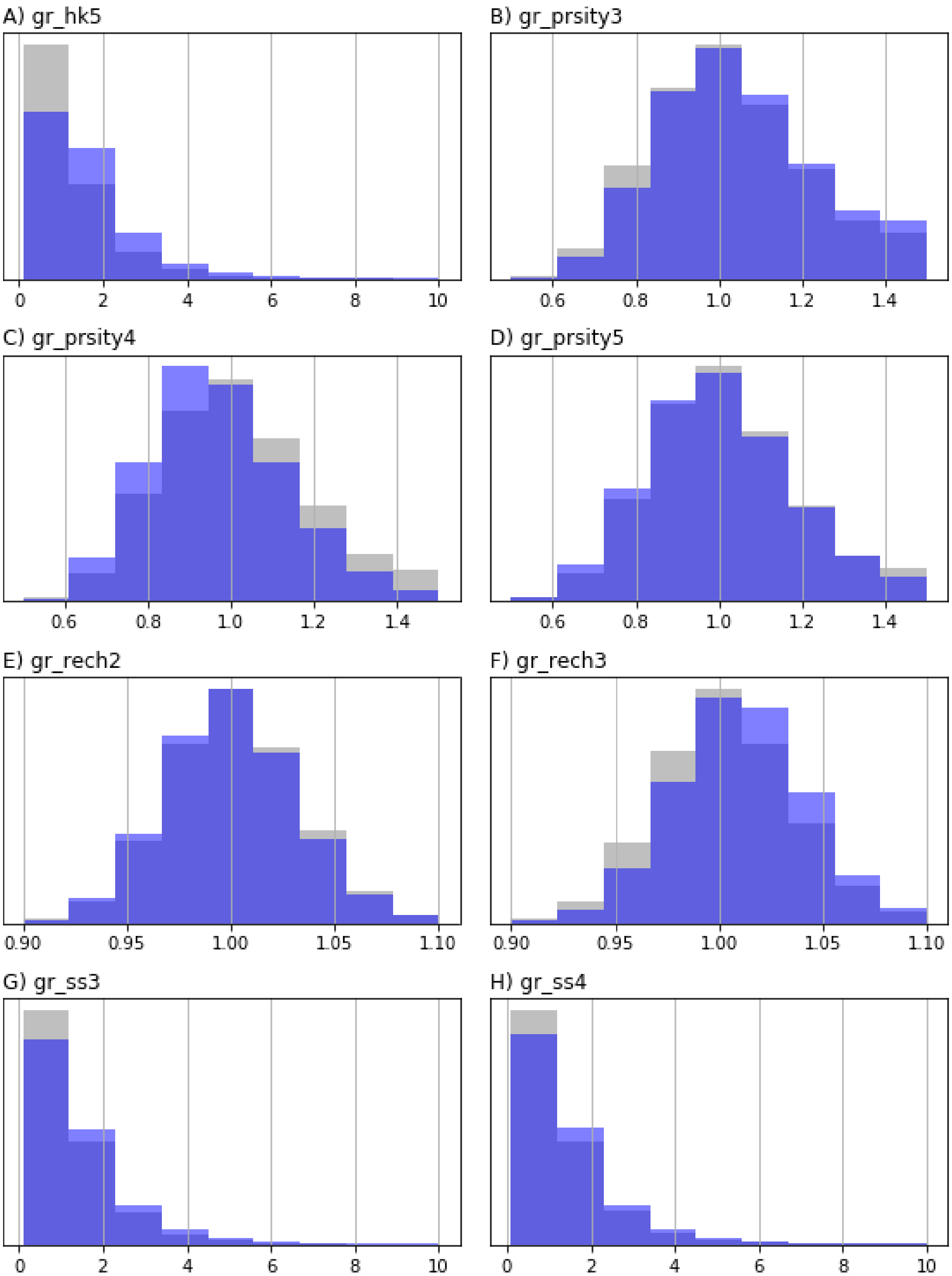
```
In [10]: pe_pr = pd.read_csv(os.path.join(m_d,"freyberg_ies.0.par.csv"),index_col=0)
         pe_pt = pd.read_csv(os.path.join(m_d,"freyberg_ies.{0}.par.csv".format(pst.control_da
         par = pst.parameter_data
         pdict = par.groupby("pargp").groups
         pyemu.plot_utils.ensemble_helper({"0.5":pe_pr,"b":pe_pt},plot_cols=pdict)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

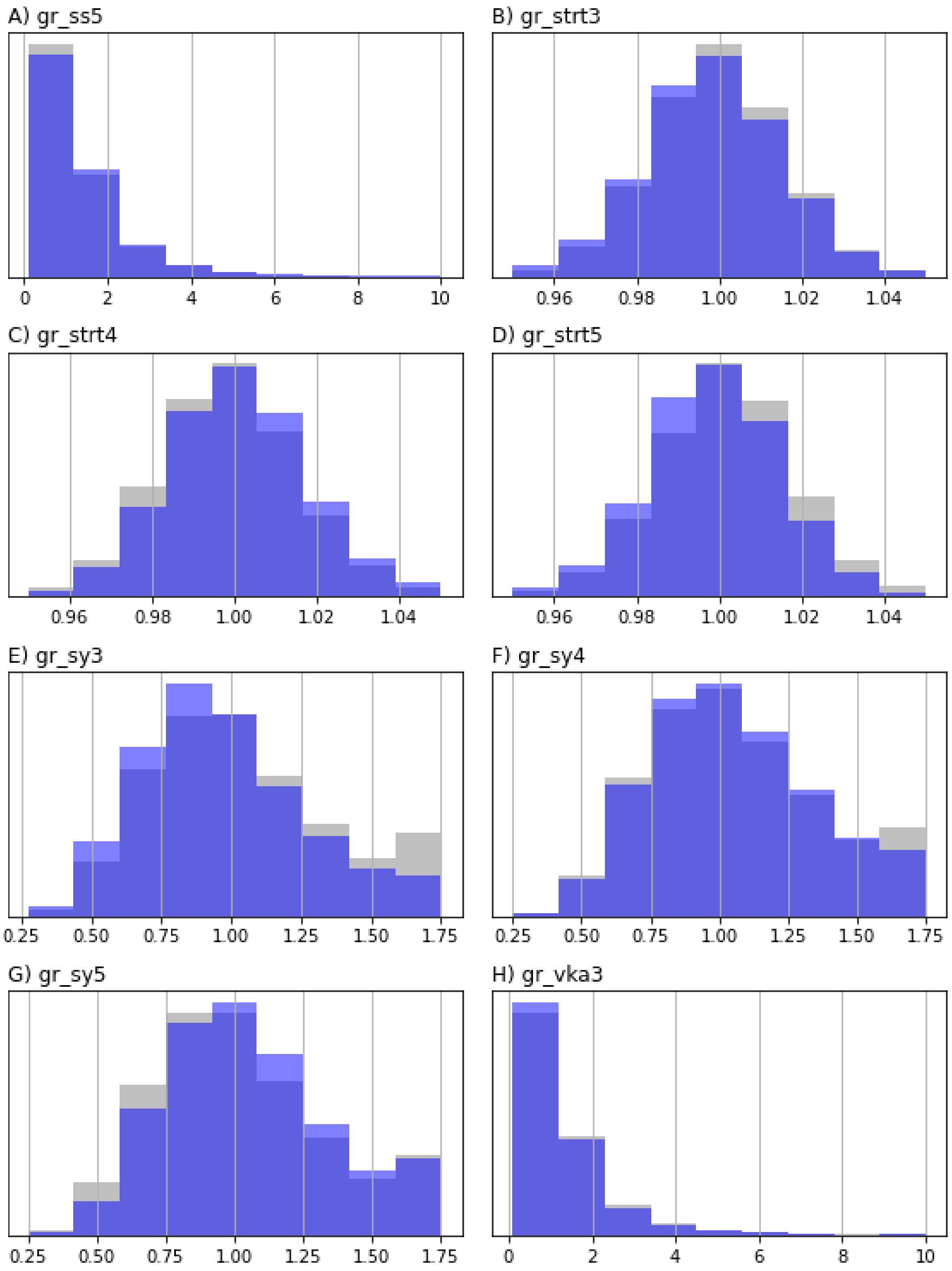
```
/Users/jeremyw/miniconda3/lib/python3.5/site-packages/IPython/core/interactiveshell.py:2785: D
  interactivity=interactivity, compiler=compiler, result=result)


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

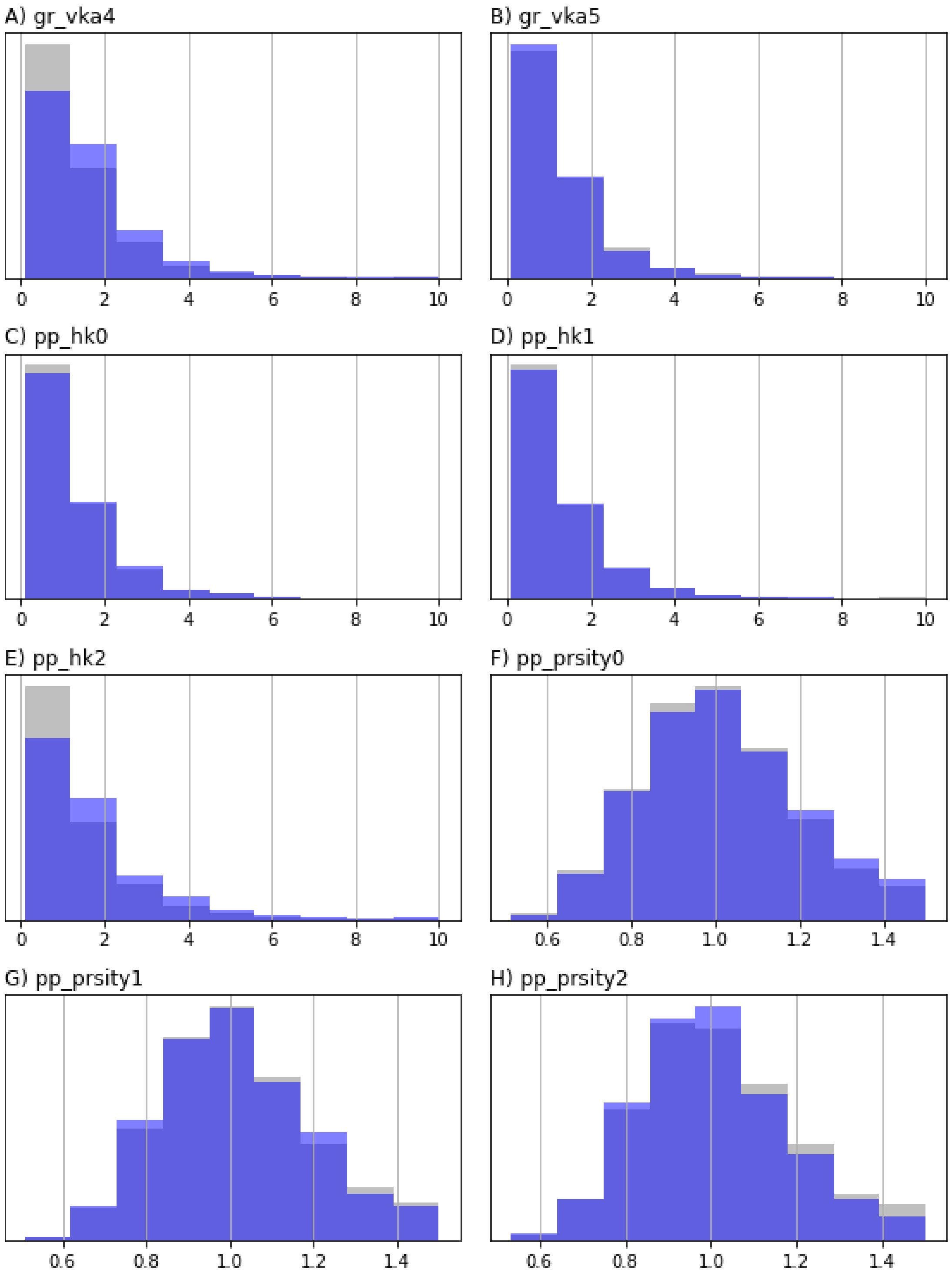

A) cn_hk6
0
1
2
3
4
B) cn_hk7
0
2
4
6
8
C) cn_hk8
0
1
2
3
4
D) cn_prsity6
0.6
0.8
1.0
1.2
1.4
E) cn_prsity7
0.8
1.0
1.2
1.4
F) cn_prsity8
0.8
1.0
1.2
1.4
G) cn_rech4
0.8
0.9
1.0
1.1
1.2
H) cn_rech5
0.2
0.3
0.4
0.5
0.6
0.7
0.8

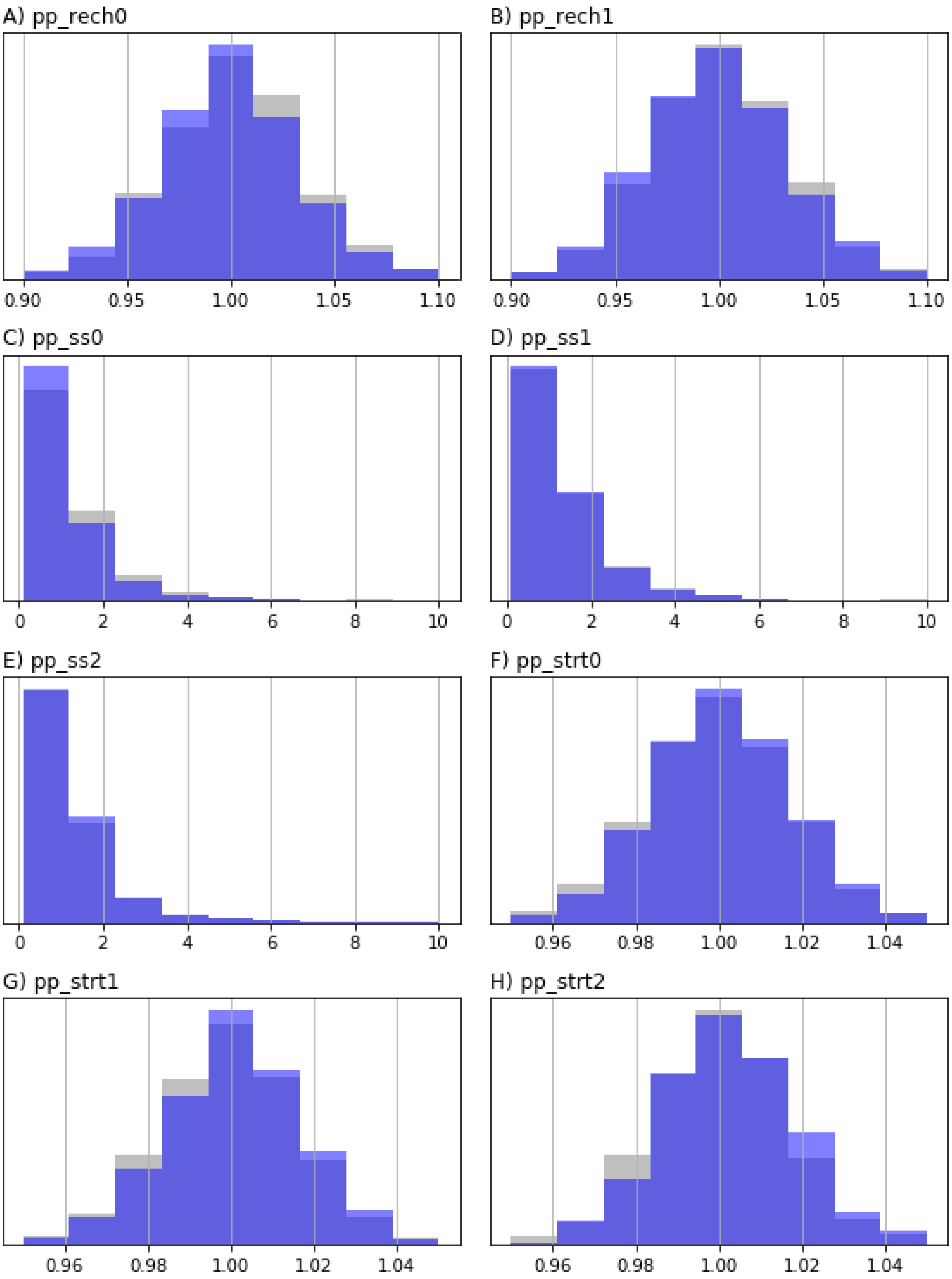

A) cn_ss6
0
2
4
6
8
10
B) cn_ss7
0
2
4
6
8
10
C) cn_ss8
0
2
4
6
8
10
D) cn_strt6
0.98
1.00
1.02
1.04
E) cn_strt7
0.96
0.98
1.00
1.02
1.04
F) cn_strt8
0.98
1.00
1.02
1.04
G) cn_sy6
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
H) cn_sy7
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8

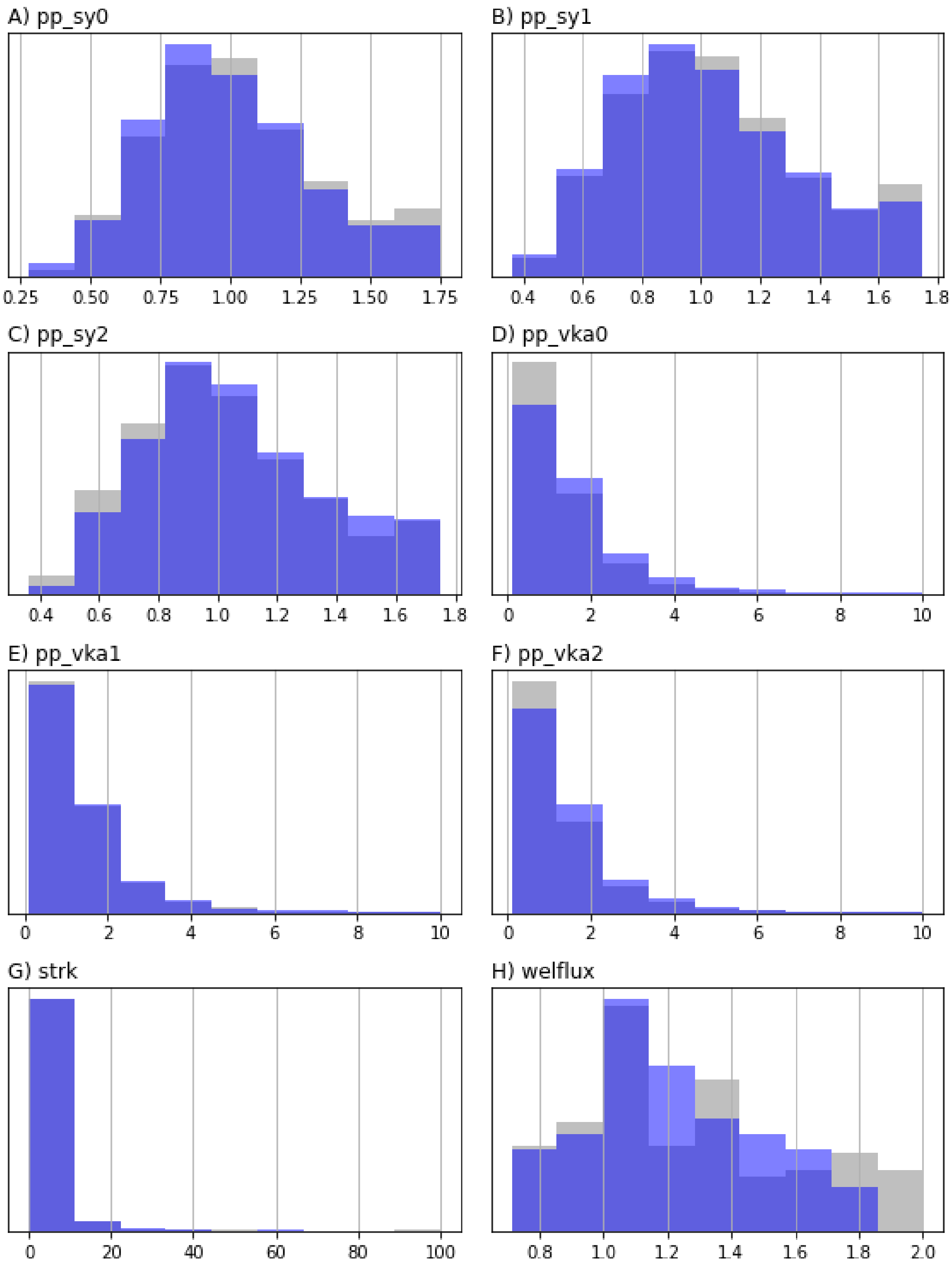

A) cn_sy8
0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8
B) cn_vka6
0 1 2 3 4 5 6 7
C) cn_vka7
0 2 4 6 8
D) cn_vka8
0 2 4 6 8 10
E) drncond_k00
0 2 4 6 8 10
F) flow
0.8 0.9 1.0 1.1 1.2
G) gr_hk3
0 2 4 6 8 10
H) gr_hk4
0 2 4 6 8 10

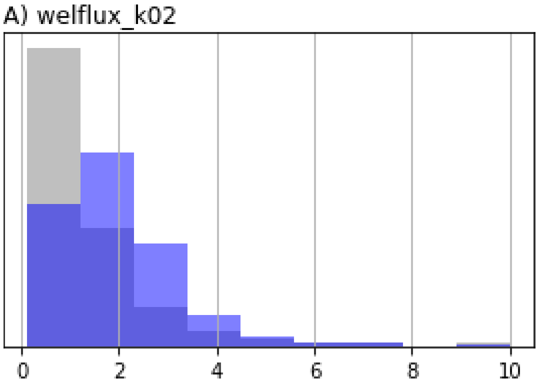

A) gr_hk5
0
2
4
6
8
10
B) gr_prsity3
0.6
0.8
1.0
1.2
1.4
C) gr_prsity4
0.6
0.8
1.0
1.2
1.4
D) gr_prsity5
0.6
0.8
1.0
1.2
1.4
E) gr_rech2
0.90
0.95
1.00
1.05
1.10
F) gr_rech3
0.90
0.95
1.00
1.05
1.10
G) gr_ss3
0
2
4
6
8
10
H) gr_ss4
0
2
4
6
8
10


A) gr_ss5
0
2
4
6
8
10
B) gr_strt3
0.96
0.98
1.00
1.02
1.04
C) gr_strt4
0.96
0.98
1.00
1.02
1.04
D) gr_strt5
0.96
0.98
1.00
1.02
1.04
E) gr_sy3
0.25
0.50
0.75
1.00
1.25
1.50
1.75
F) gr_sy4
0.25
0.50
0.75
1.00
1.25
1.50
1.75
G) gr_sy5
0.25
0.50
0.75
1.00
1.25
1.50
1.75
H) gr_vka3
0
2
4
6
8
10


A) gr_vka4
0
2
4
6
8
10
B) gr_vka5
0
2
4
6
8
10
C) pp_hk0
0
2
4
6
8
10
D) pp_hk1
0
2
4
6
8
10
E) pp_hk2
0
2
4
6
8
10
F) pp_prsity0
0.6
0.8
1.0
1.2
1.4
G) pp_prsity1
0.6
0.8
1.0
1.2
1.4
H) pp_prsity2
0.6
0.8
1.0
1.2
1.4


A) pp_rech0
0.90
0.95
1.00
1.05
1.10
B) pp_rech1
0.90
0.95
1.00
1.05
1.10
C) pp_ss0
0
2
4
6
8
10
D) pp_ss1
0
2
4
6
8
10
E) pp_ss2
0
2
4
6
8
10
F) pp_strt0
0.96
0.98
1.00
1.02
1.04
G) pp_strt1
0.96
0.98
1.00
1.02
1.04
H) pp_strt2
0.96
0.98
1.00
1.02
1.04


A) pp_sy0
0.25
0.50
0.75
1.00
1.25
1.50
1.75
B) pp_sy1
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
C) pp_sy2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
D) pp_vka0
0
2
4
6
8
10
E) pp_vka1
0
2
4
6
8
10
F) pp_vka2
0
2
4
6
8
10
G) strk
0
20
40
60
80
100
H) welflux
0.8
1.0
1.2
1.4
1.6
1.8
2.0



```
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
```

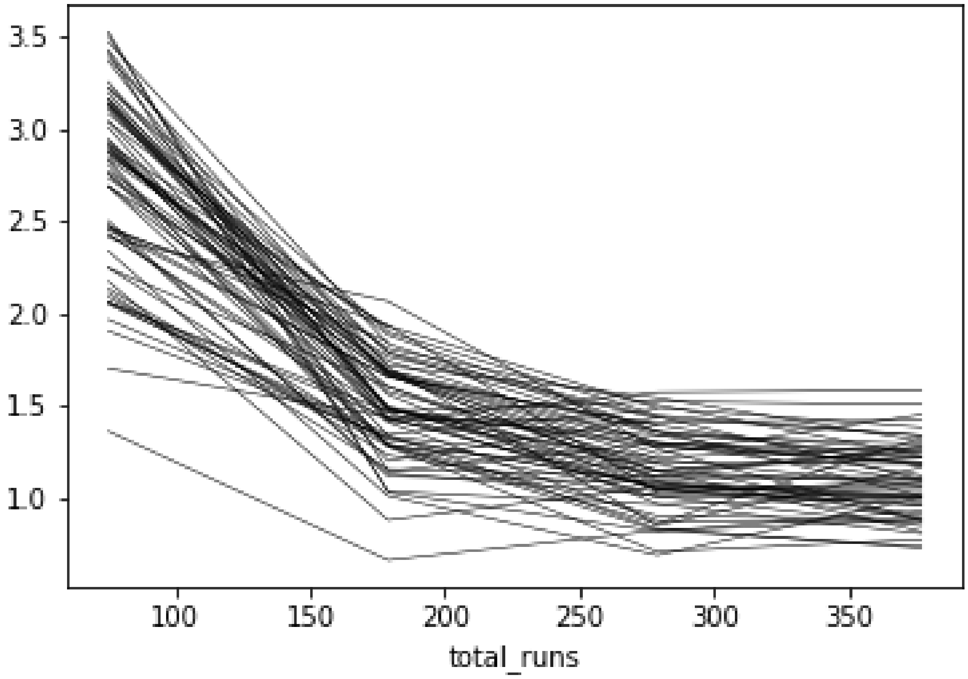
```
Out[12]: ['pp_prsity0',
          'gr_prsity4',
          'gr_prsity3',
          'pp_prsity2',
          'cn_prsity8',
          'gr_prsity5',
          'cn_prsity7',
          'pp_prsity1',
          'cn_prsity6',
          'gr_rech3',
          'pp_rech1',
          'cn_rech5',
          'welflux_001']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

```
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"))
```

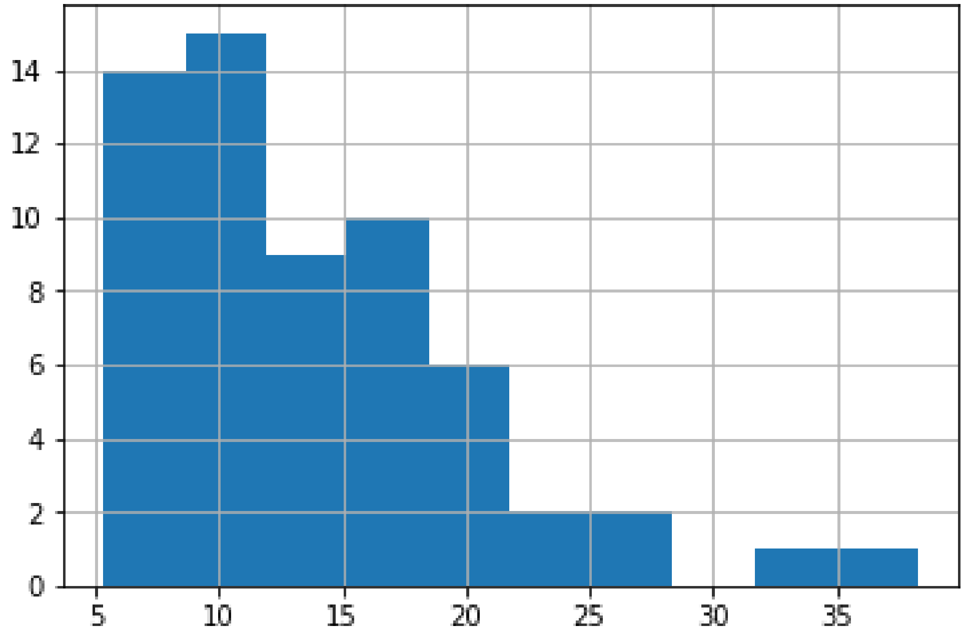
```
In [14]: pst.pestpp_options["ies_localizer"] = "loc.mat"
         pst.write(os.path.join(t_d,"freyberg_ies.pst"))
         pyemu.os_utils.start_slaves(t_d,"pestpp-ies","freyberg_ies.pst",num_slaves=20,master_
```

```
noptmax:3, npar_adj:14819, nnz_obs:14
```

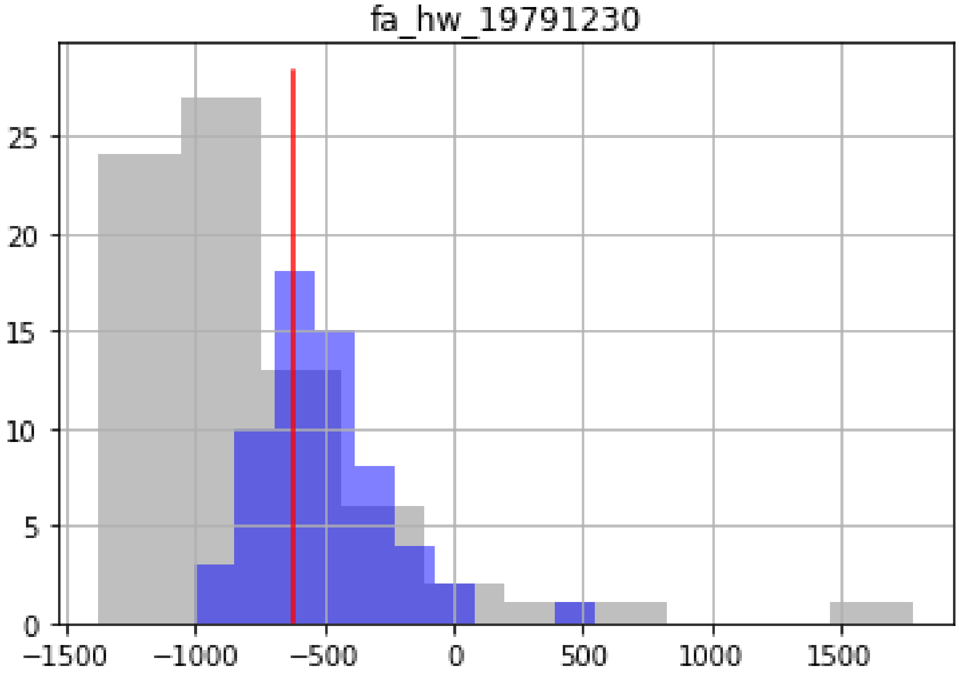
```
In [15]: phi = pd.read_csv(os.path.join(m_d,"freyberg_ies.phi.actual.csv"),index_col=0)
         phi.index = phi.total_runs
phi.iloc[:,6:].apply(np.log10).plot(legend=False,lw=0.5,color='k')
plt.show()
phi.iloc[-1,6:].hist()
```

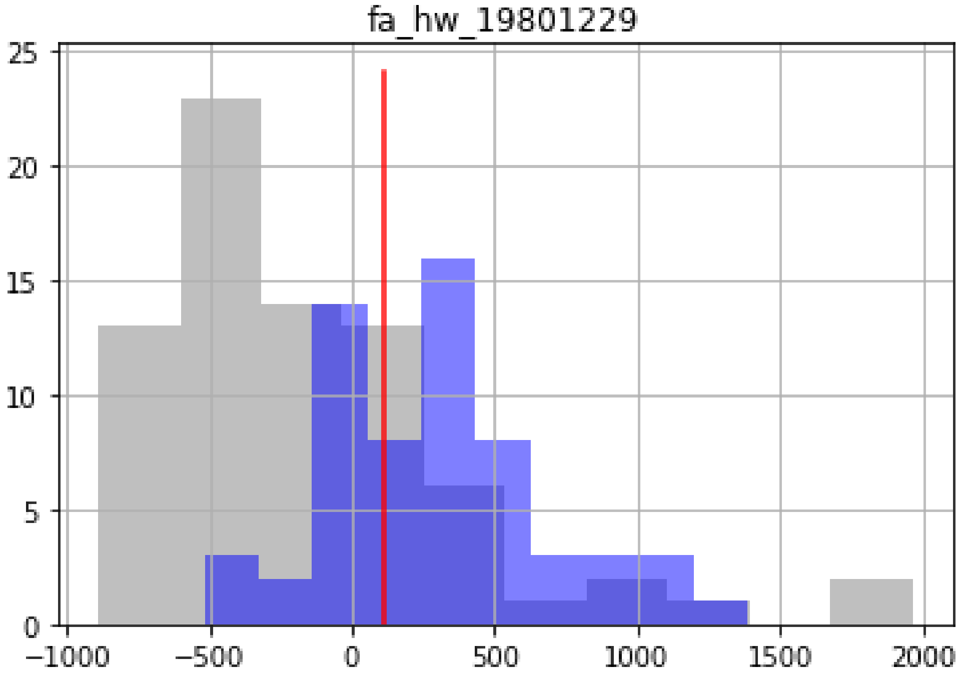


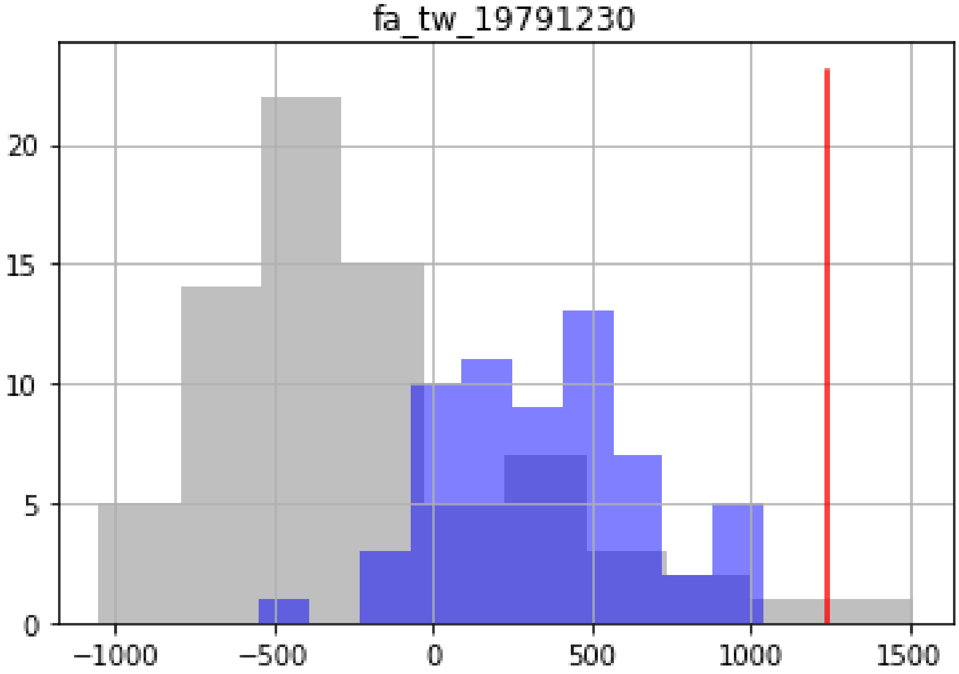
```
Out[15]: <matplotlib.axes._subplots.AxesSubplot at 0x182c3f9908>
```

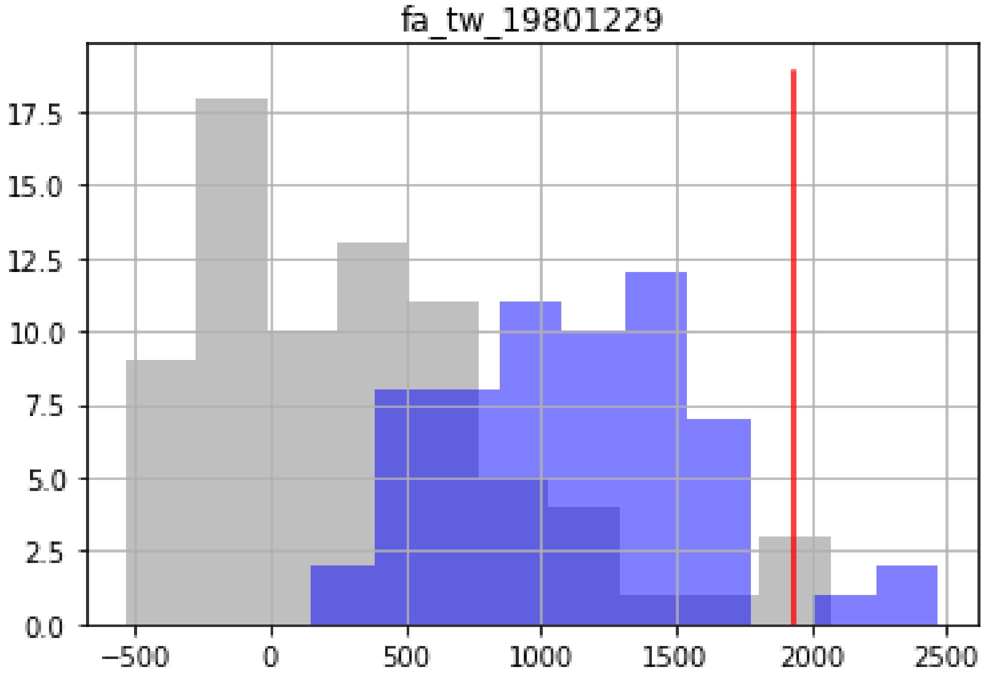


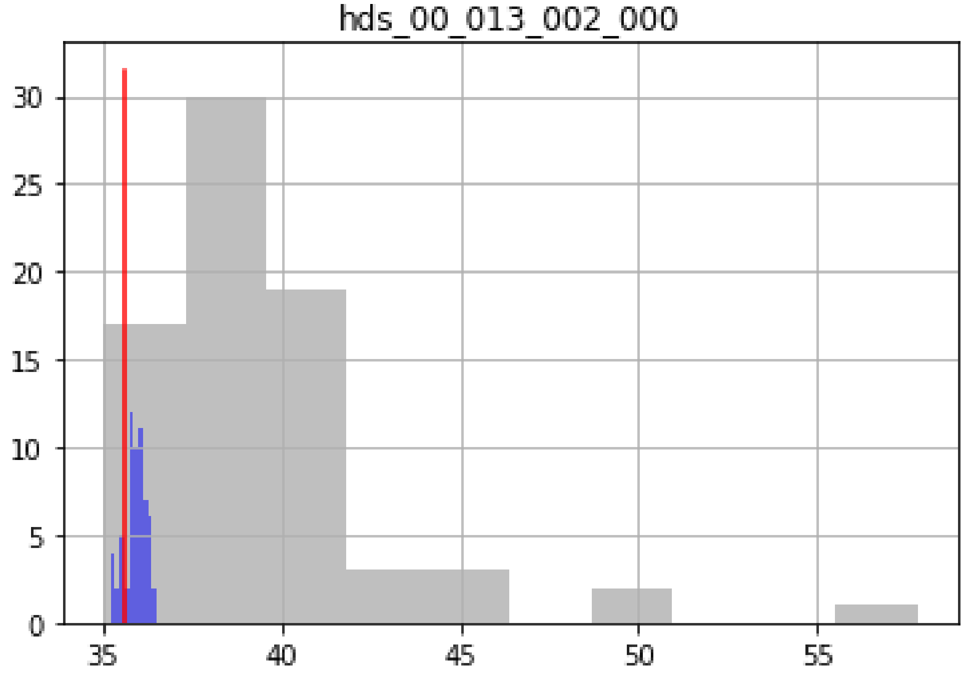
```
In [16]: oe_pr = pd.read_csv(os.path.join(m_d,"freyberg_ies.0.obs.csv"),index_col=0)
         oe_pt = pd.read_csv(os.path.join(m_d,"freyberg_ies.{0}.obs.csv".format(pst.control_da
         obs = pst.observation_data
         fnames = pst.pestpp_options["forecasts"].split(",")
         for forecast 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()
```

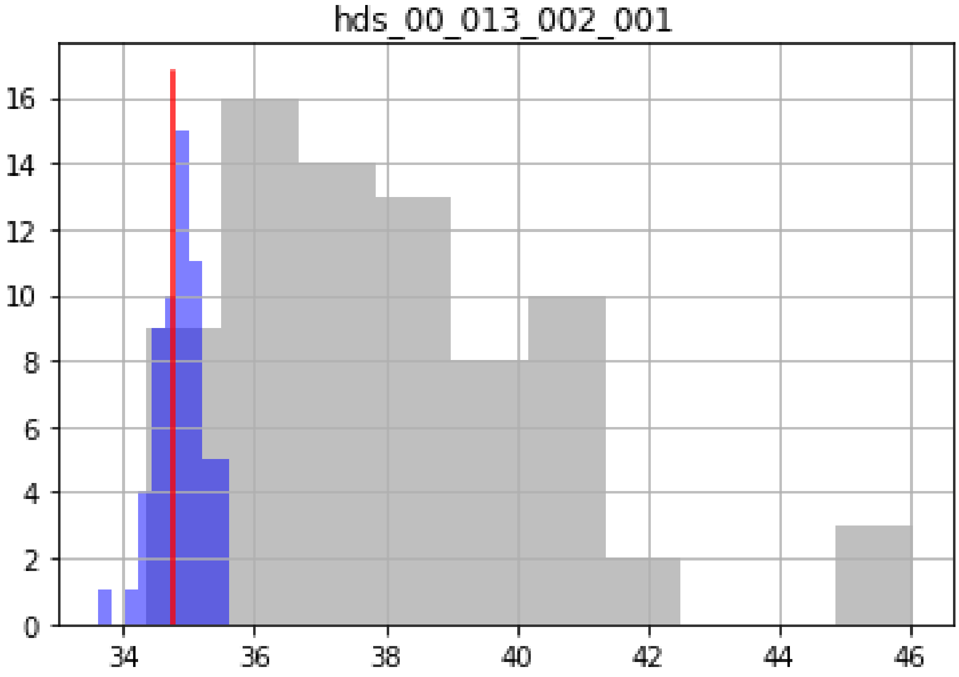


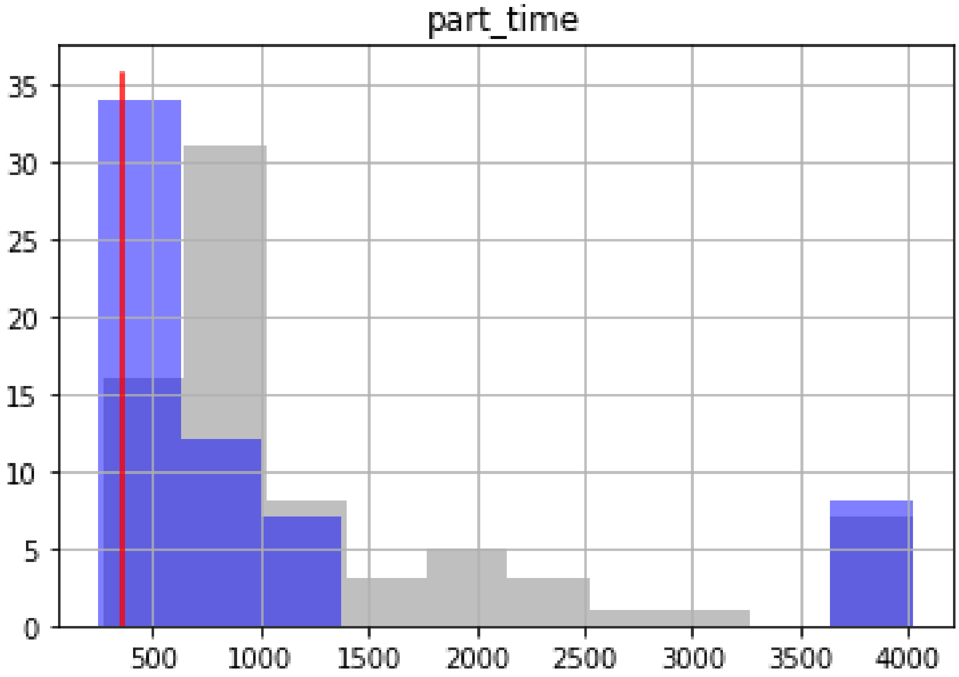

fa_hw_19801229
25
20
15
10
5
0
−1000
−500
0
500
1000
1500
2000

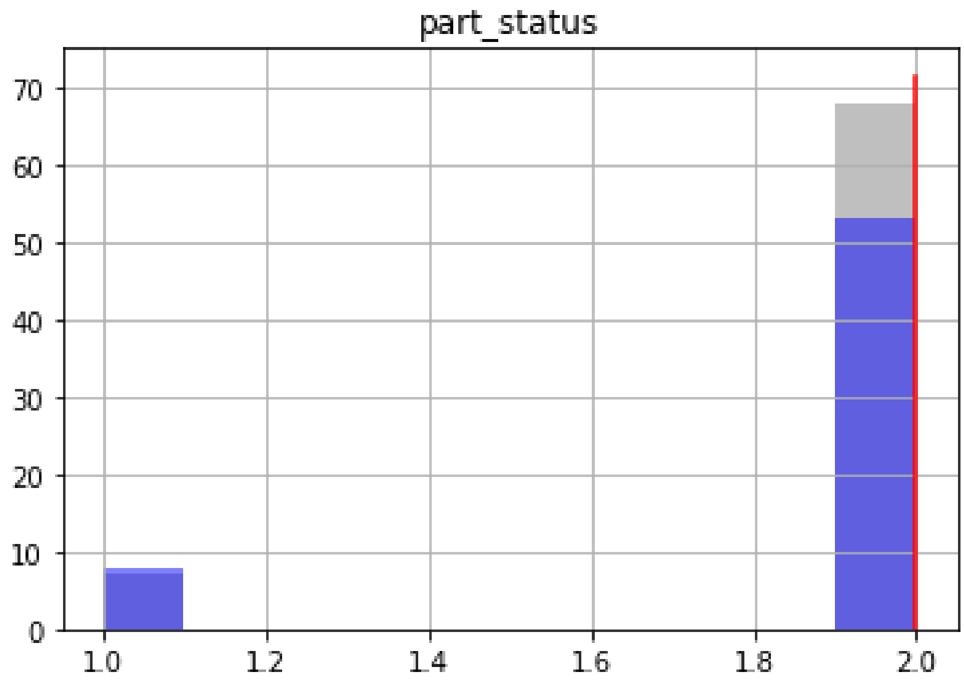

fa_tw_19791230
20
15
10
5
0
−1000
−500
0
500
1000
1500


fa_tw_19801229
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
−500
0
500
1000
1500
2000
2500


hds_00_013_002_000
30
25
20
15
10
5
0
35
40
45
50
55

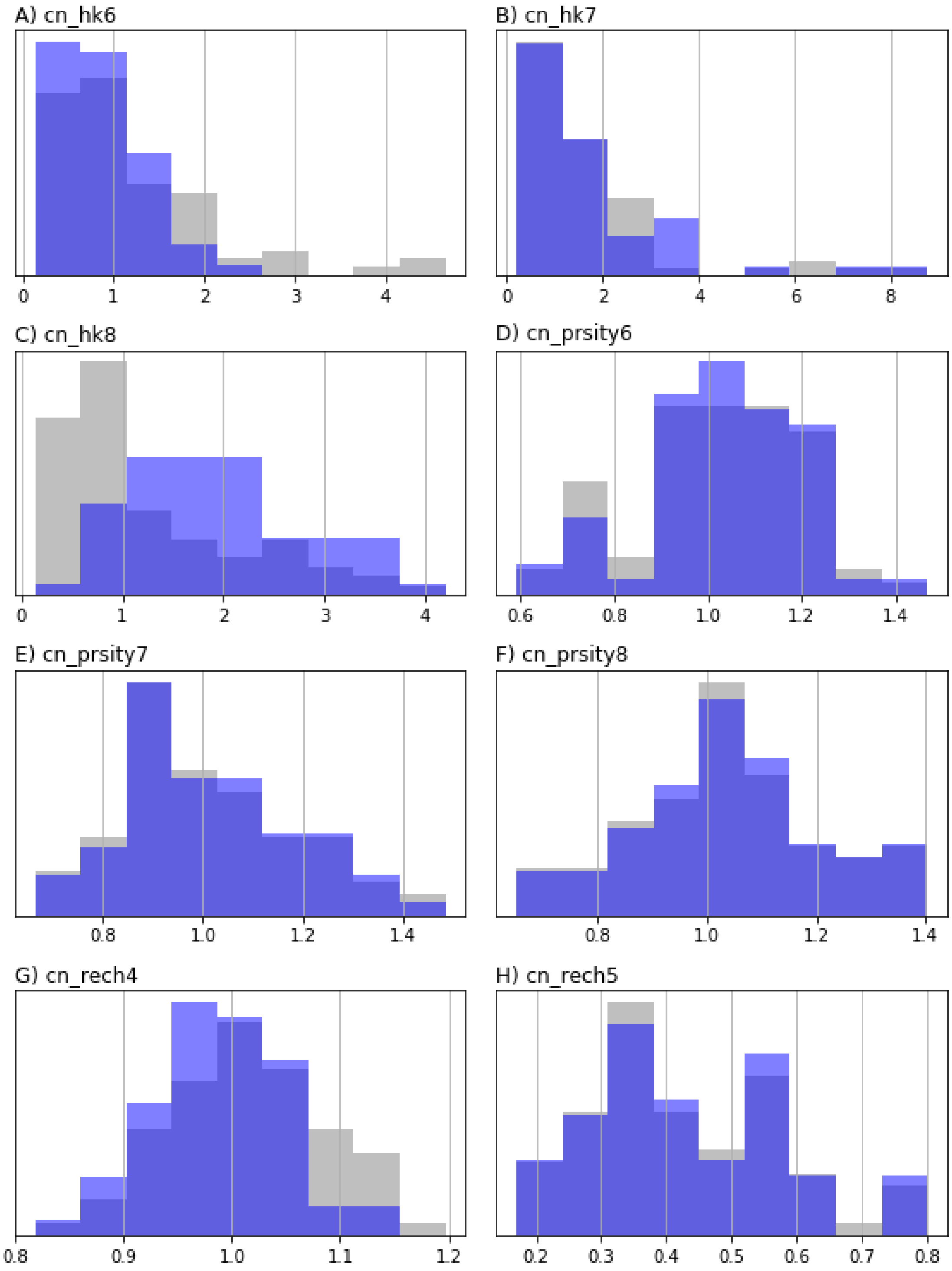

hds_00_013_002_001
16
14
12
10
8
6
4
2
0
34
36
38
40
42
44
46

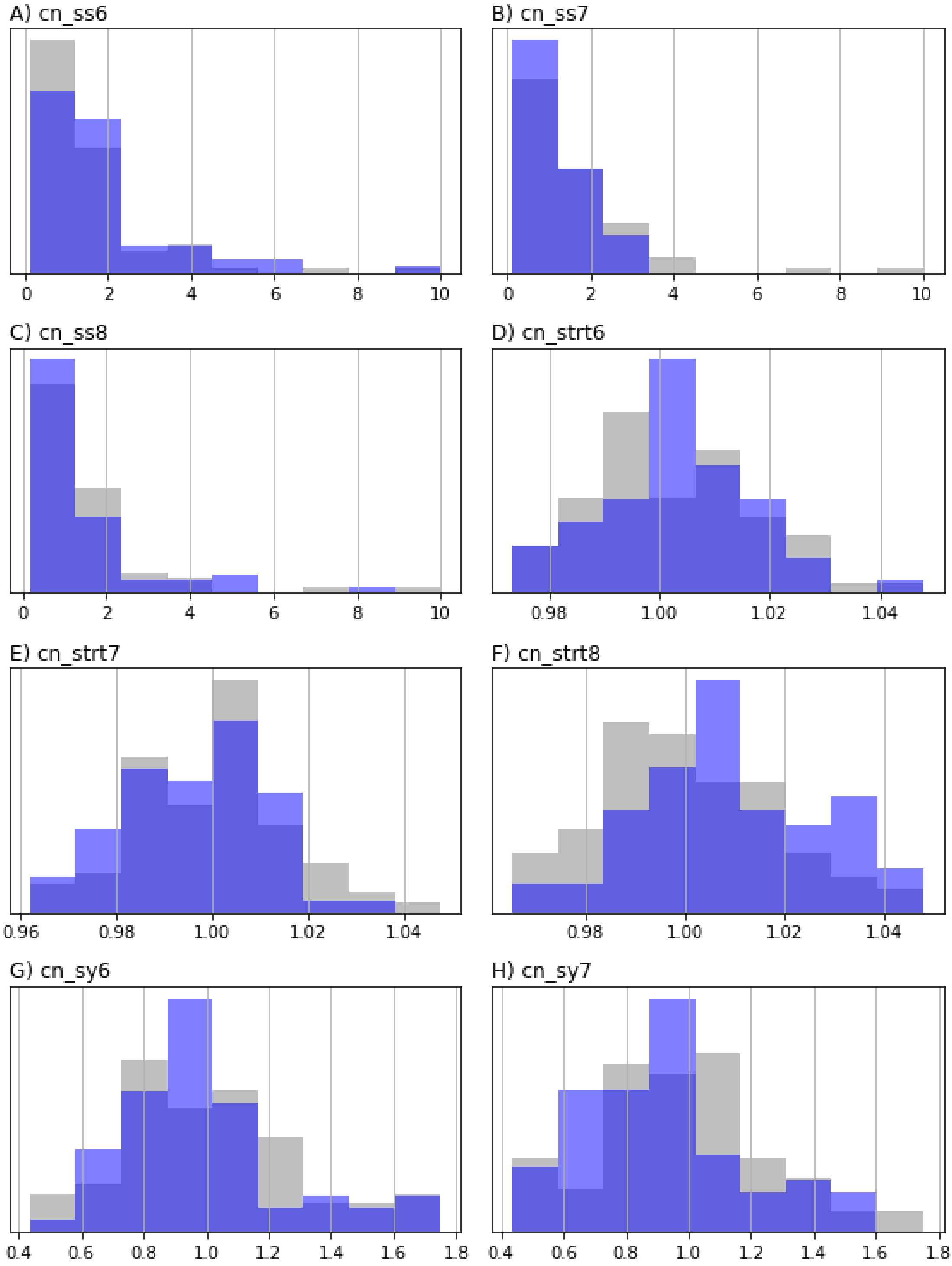

part_time
35
30
25
20
15
10
5
0
500
1000
1500
2000
2500
3000
3500
4000

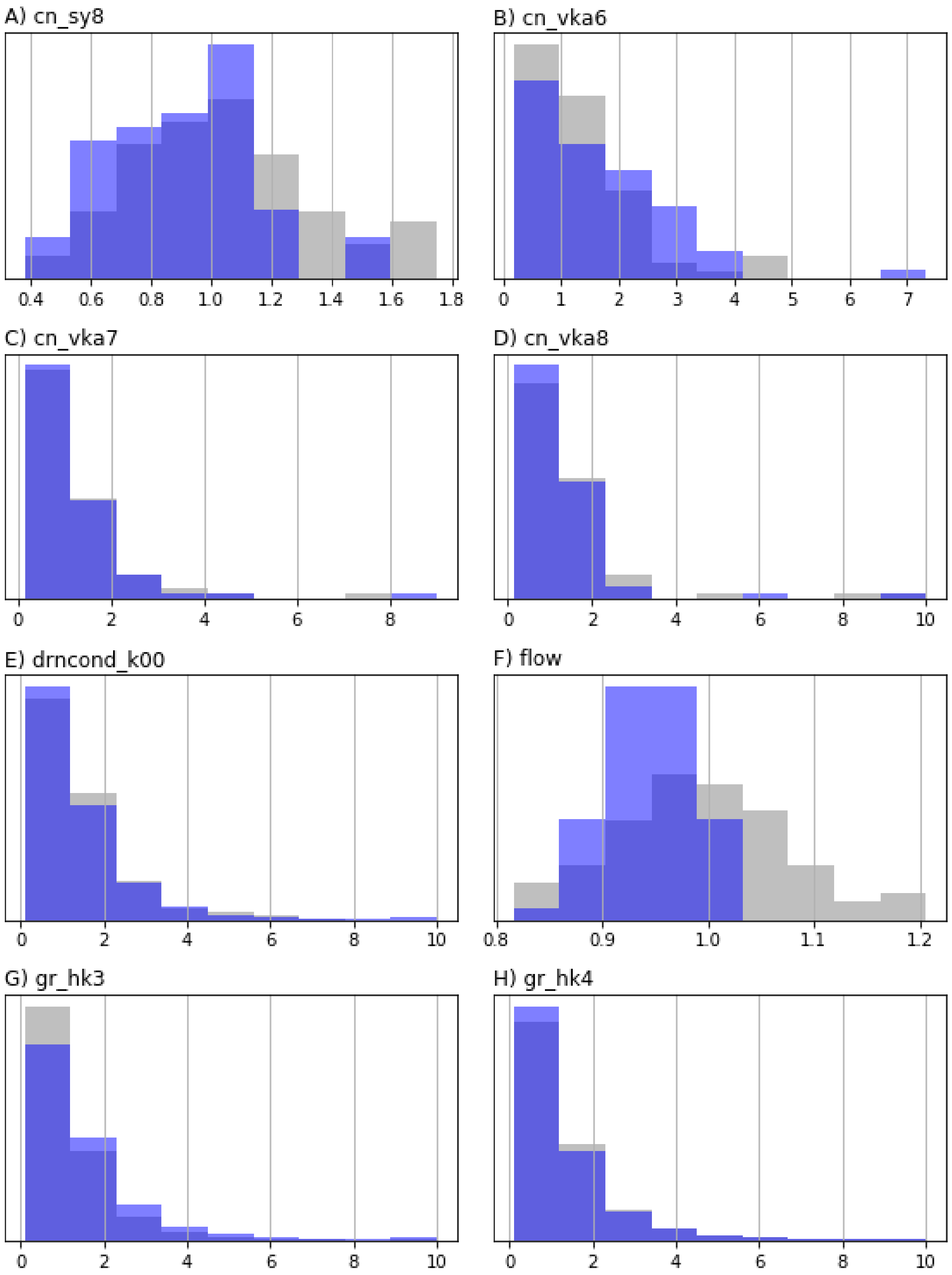


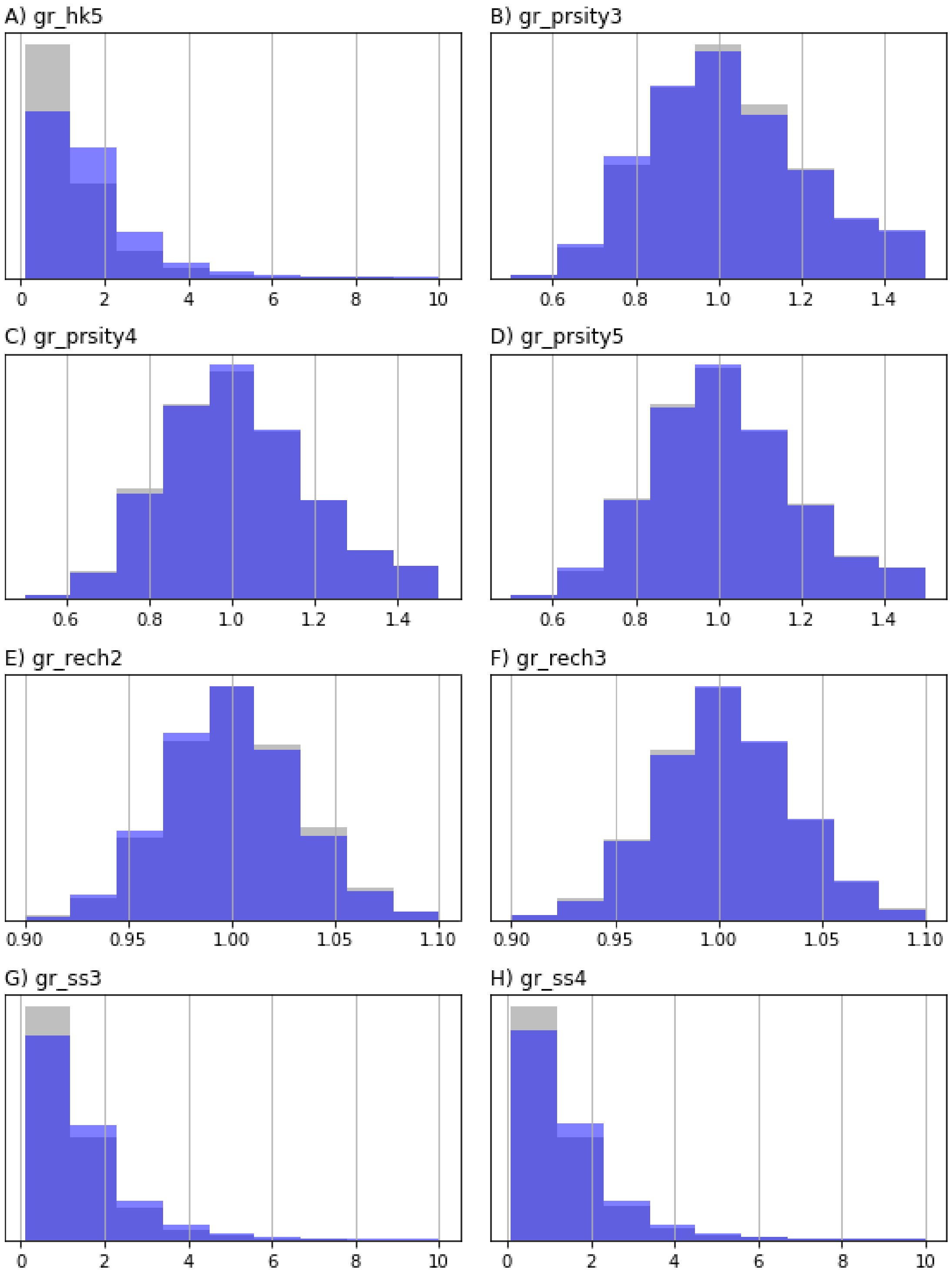
```
In [17]: pe_pr = pd.read_csv(os.path.join(m_d,"freyberg_ies.0.par.csv"),index_col=0)
         pe_pt = pd.read_csv(os.path.join(m_d,"freyberg_ies.{0}.par.csv".format(pst.control_da
         #pe_pr.index = pe_pt.index
         #par = pst.parameter_data
         print(pe_pr.shape,pe_pt.shape)
         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)
```

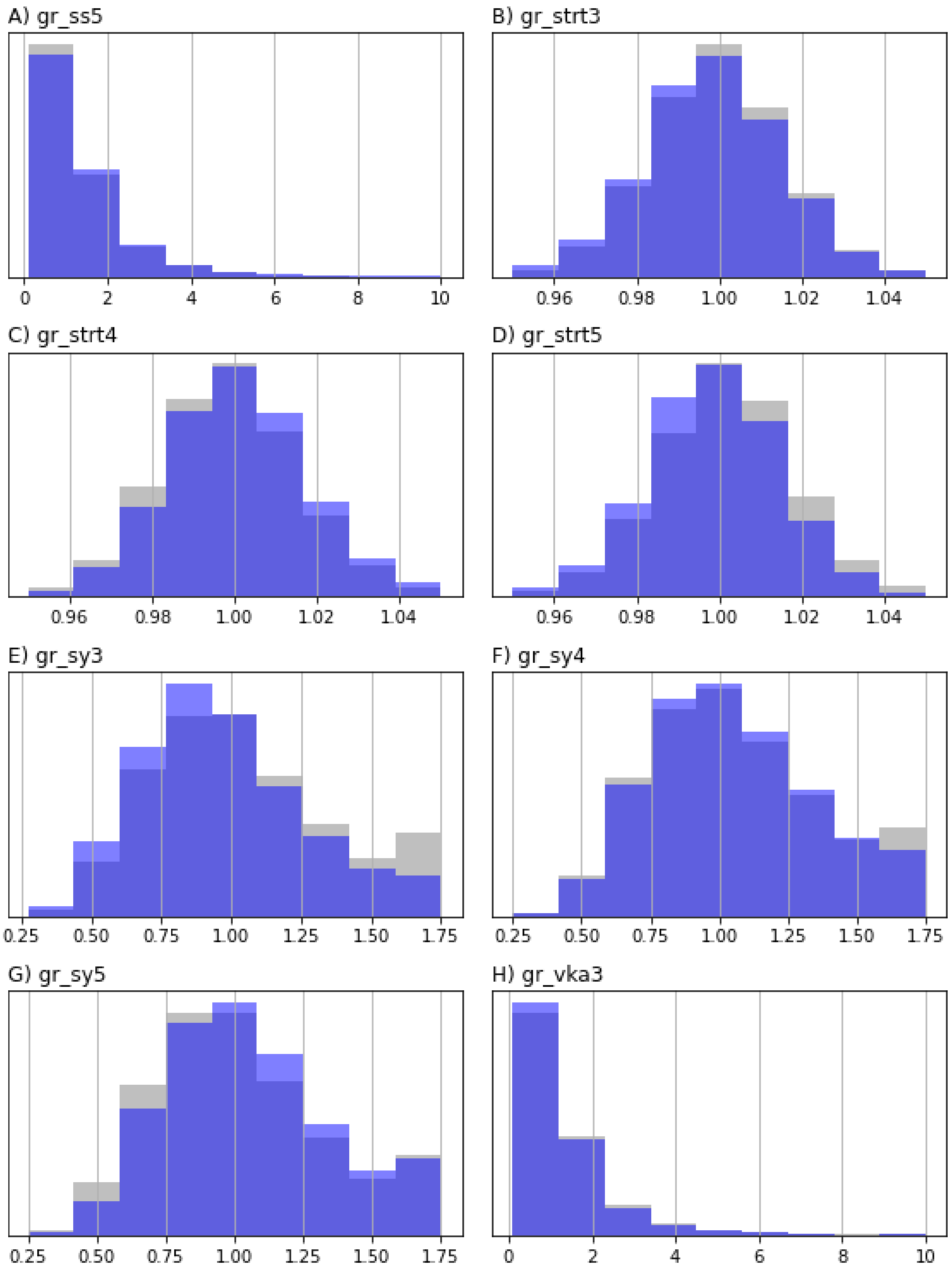
```
/Users/jeremyw/miniconda3/lib/python3.5/site-packages/IPython/core/interactiveshell.py:2785: D
  interactivity=interactivity, compiler=compiler, result=result)


(75, 14819) (61, 14819)


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

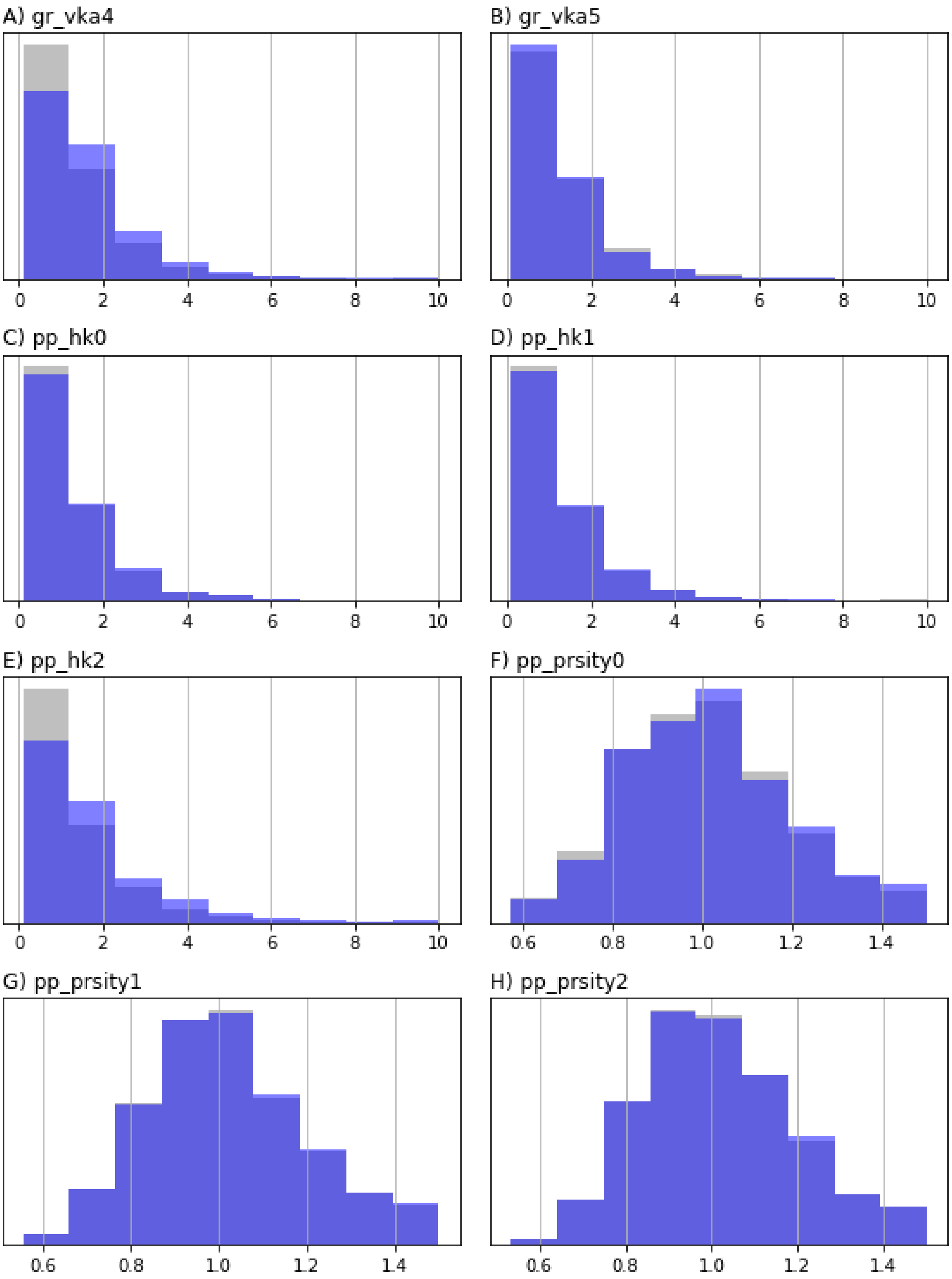

A) cn_hk6
0
1
2
3
4
B) cn_hk7
0
2
4
6
8
C) cn_hk8
0
1
2
3
4
D) cn_prsity6
0.6
0.8
1.0
1.2
1.4
E) cn_prsity7
0.8
1.0
1.2
1.4
F) cn_prsity8
0.8
1.0
1.2
1.4
G) cn_rech4
0.8
0.9
1.0
1.1
1.2
H) cn_rech5
0.2
0.3
0.4
0.5
0.6
0.7
0.8


A) cn_ss6
0 2 4 6 8 10
B) cn_ss7
0 2 4 6 8 10
C) cn_ss8
0 2 4 6 8 10
D) cn_strt6
0.98 1.00 1.02 1.04
E) cn_strt7
0.96 0.98 1.00 1.02 1.04
F) cn_strt8
0.98 1.00 1.02 1.04
G) cn_sy6
0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8
H) cn_sy7
0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8


A) cn_sy8
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
B) cn_vka6
0
1
2
3
4
5
6
7
C) cn_vka7
0
2
4
6
8
D) cn_vka8
0
2
4
6
8
10
E) drncond_k00
0
2
4
6
8
10
F) flow
0.8
0.9
1.0
1.1
1.2
G) gr_hk3
0
2
4
6
8
10
H) gr_hk4
0
2
4
6
8
10


A) gr_hk5
0
2
4
6
8
10
B) gr_prsity3
0.6
0.8
1.0
1.2
1.4
C) gr_prsity4
0.6
0.8
1.0
1.2
1.4
D) gr_prsity5
0.6
0.8
1.0
1.2
1.4
E) gr_rech2
0.90
0.95
1.00
1.05
1.10
F) gr_rech3
0.90
0.95
1.00
1.05
1.10
G) gr_ss3
0
2
4
6
8
10
H) gr_ss4
0
2
4
6
8
10


A) gr_ss5
0
2
4
6
8
10
B) gr_strt3
0.96
0.98
1.00
1.02
1.04
C) gr_strt4
0.96
0.98
1.00
1.02
1.04
D) gr_strt5
0.96
0.98
1.00
1.02
1.04
E) gr_sy3
0.25
0.50
0.75
1.00
1.25
1.50
1.75
F) gr_sy4
0.25
0.50
0.75
1.00
1.25
1.50
1.75
G) gr_sy5
0.25
0.50
0.75
1.00
1.25
1.50
1.75
H) gr_vka3
0
2
4
6
8
10


A) gr_vka4

B) gr_vka5

C) pp_hk0

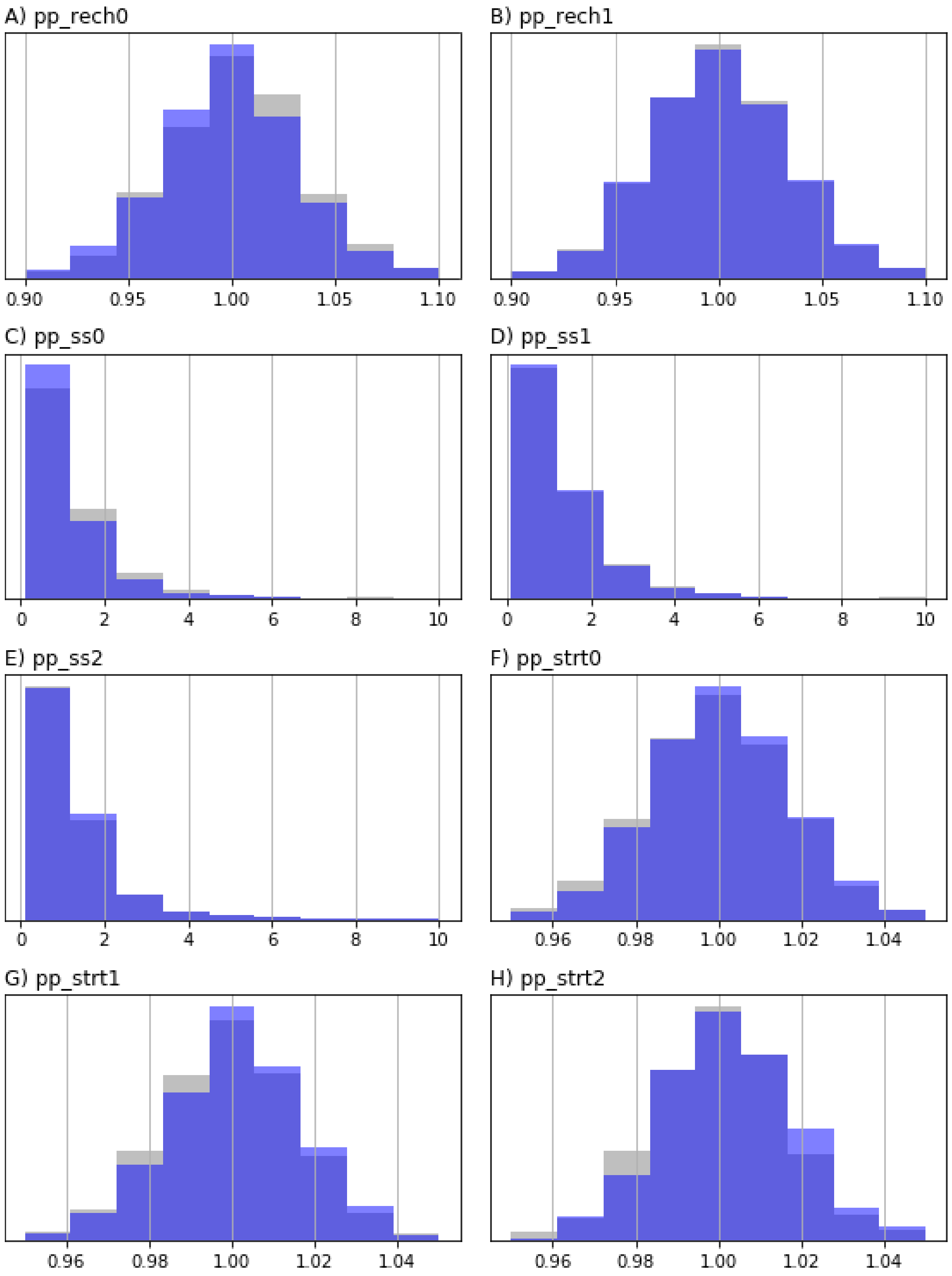
D) pp_hk1

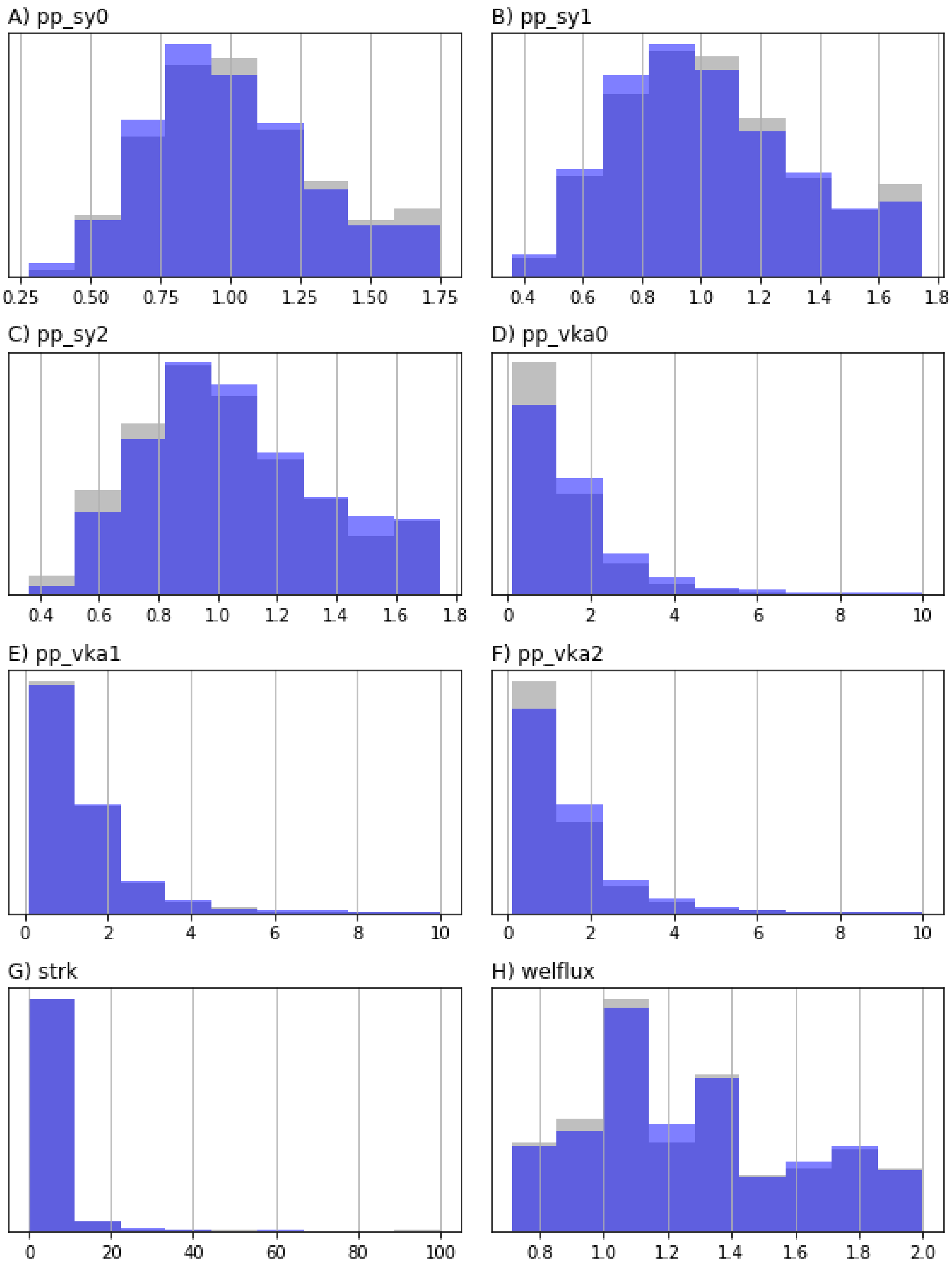
E) pp_hk2

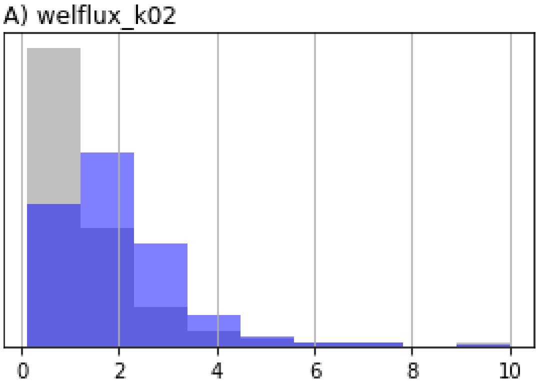
F) pp_prsity0

G) pp_prsity1

H) pp_prsity2


A) pp_rech0
0.90
0.95
1.00
1.05
1.10
B) pp_rech1
0.90
0.95
1.00
1.05
1.10
C) pp_ss0
0
2
4
6
8
10
D) pp_ss1
0
2
4
6
8
10
E) pp_ss2
0
2
4
6
8
10
F) pp_strt0
0.96
0.98
1.00
1.02
1.04
G) pp_strt1
0.96
0.98
1.00
1.02
1.04
H) pp_strt2
0.96
0.98
1.00
1.02
1.04


A) pp_sy0
0.25
0.50
0.75
1.00
1.25
1.50
1.75
B) pp_sy1
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
C) pp_sy2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
D) pp_vka0
0
2
4
6
8
10
E) pp_vka1
0
2
4
6
8
10
F) pp_vka2
0
2
4
6
8
10
G) strk
0
20
40
60
80
100
H) welflux
0.8
1.0
1.2
1.4
1.6
1.8
2.0



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 "prsity" 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=
             gr_too_far = gr_par.loc[gr_par.dist > loc_dist,"parnme"]
             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=
             pp_too_far = pp_par.loc[pp_par.dist > loc_dist,"parnme"]
             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[

         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
```

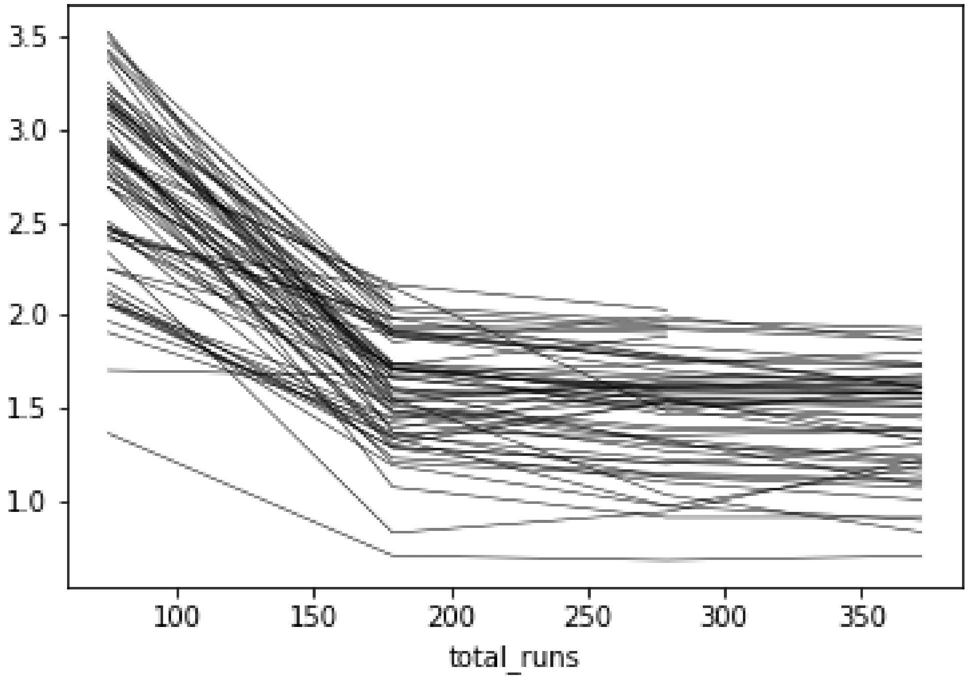
```
Out[20]: fo_39_19791230        1786.0
         hds_00_002_009_000    1546.0
         hds_00_002_015_000    1530.0
         hds_00_003_008_000    1610.0
         hds_00_009_001_000    1658.0
         hds_00_013_010_000    1738.0
         hds_00_015_016_000    1754.0
         hds_00_021_010_000    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"))
```

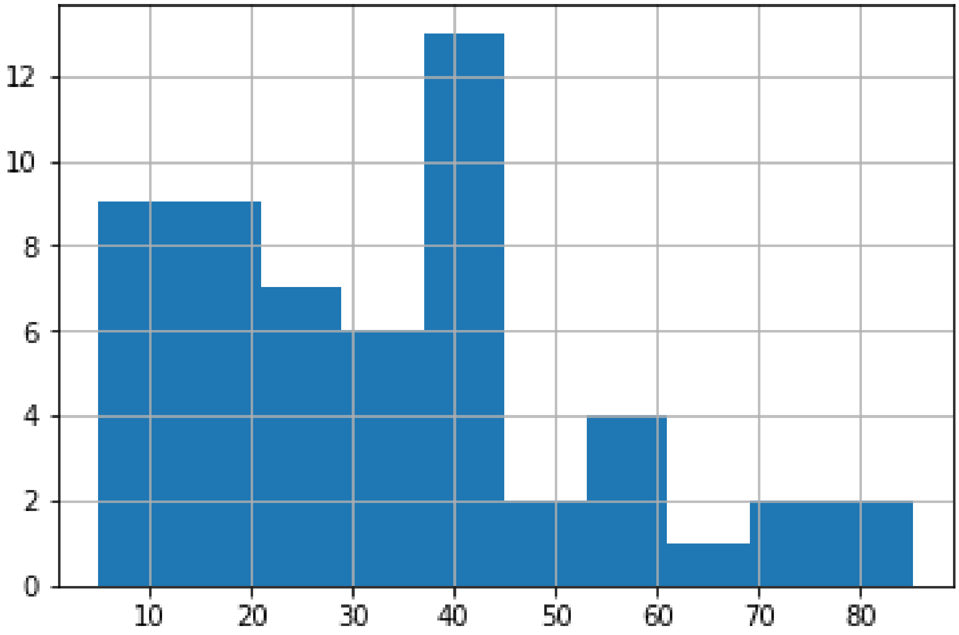
```
noptmax:3, npar_adj:14819, nnz_obs:14
```

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

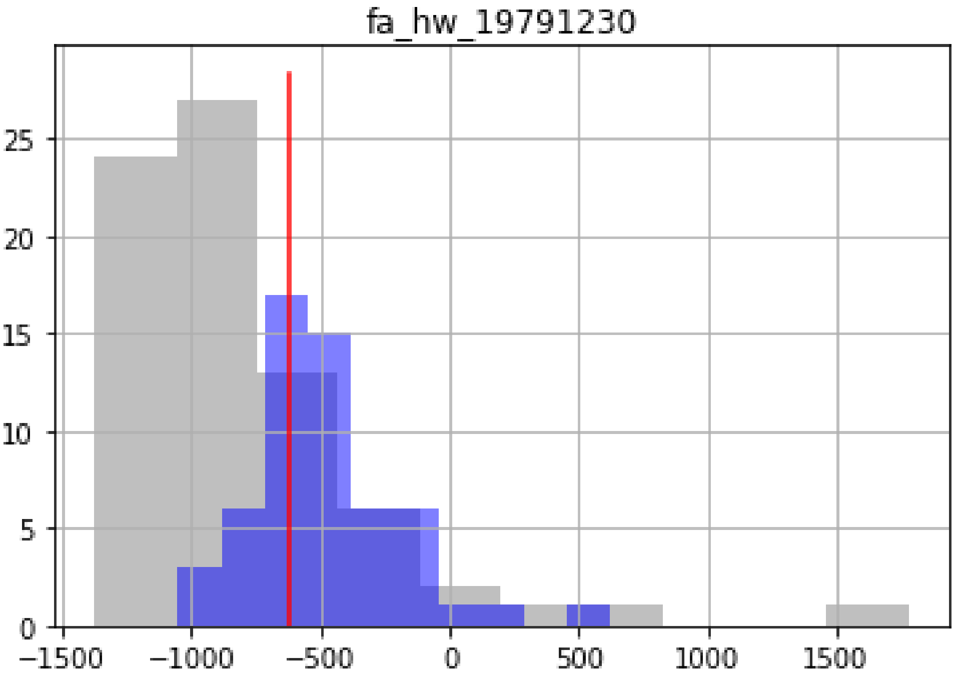
```
In [23]: phi = pd.read_csv(os.path.join(m_d,"freyberg_ies.phi.actual.csv"),index_col=0)
         phi.index = phi.total_runs
         phi.iloc[:,6:].apply(np.log10).plot(legend=False,lw=0.5,color='k')
         plt.show()
         phi.iloc[-1,6:].hist()
```

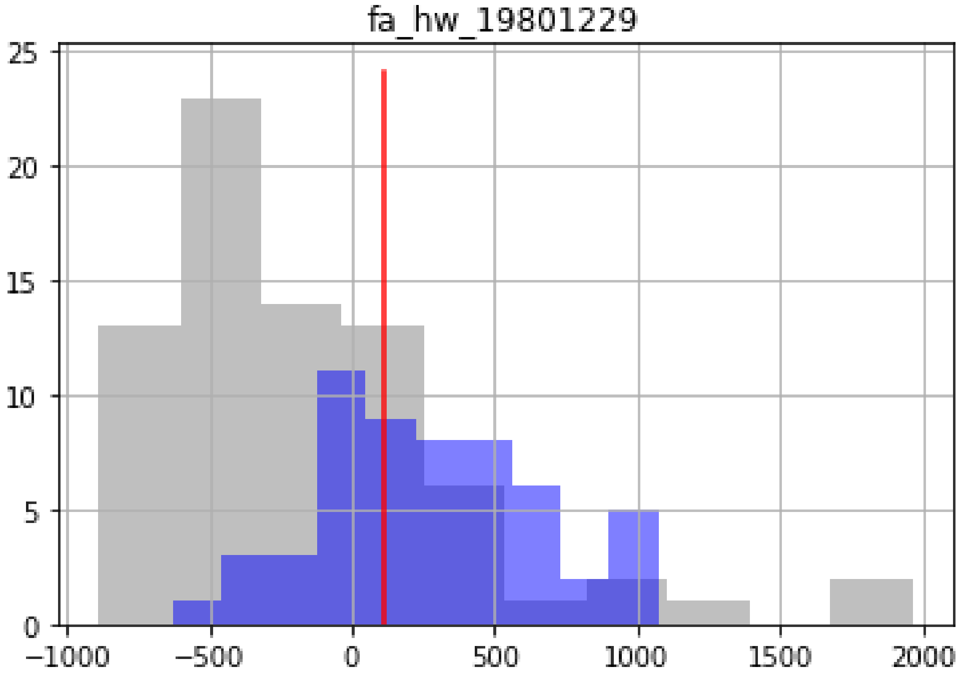

3.5
3.0
2.5
2.0
1.5
1.0
100
150
200
250
300
350
total_runs

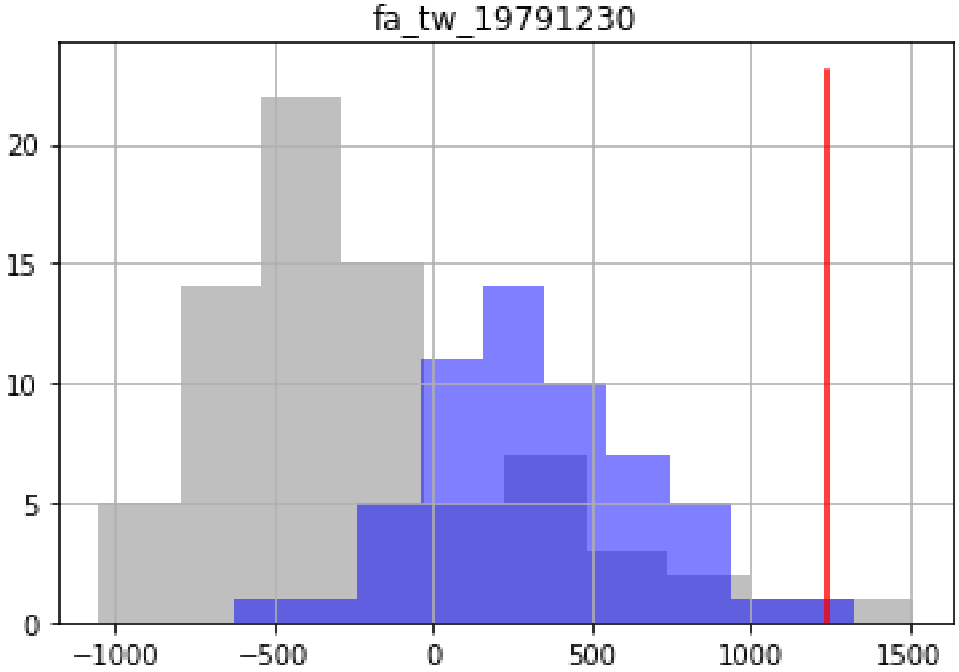
```
Out[23]: <matplotlib.axes._subplots.AxesSubplot at 0x182c13d5f8>
```

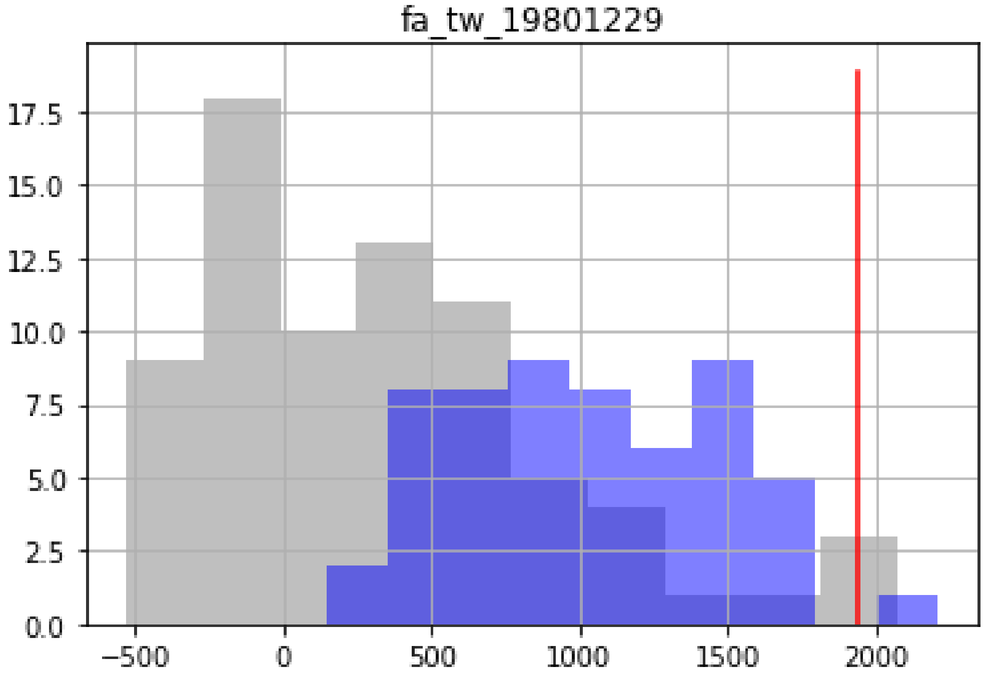

0
2
4
6
8
10
12
10
20
30
40
50
60
70
80

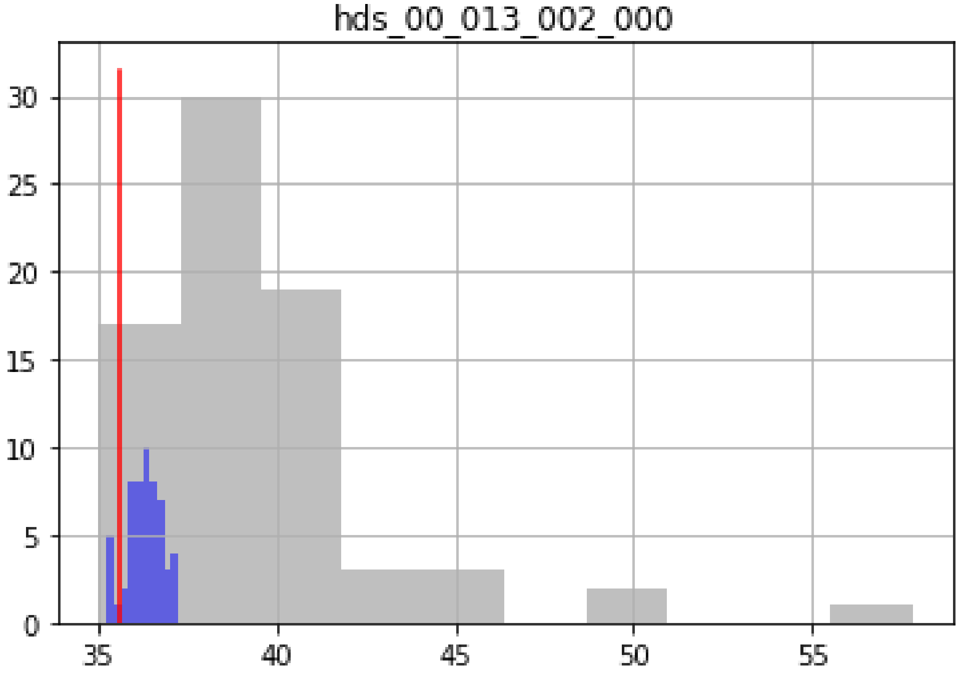
```
In [24]: oe_pr = pd.read_csv(os.path.join(m_d,"freyberg_ies.0.obs.csv"),index_col=0)
         oe_pt = pd.read_csv(os.path.join(m_d,"freyberg_ies.{0}.obs.csv".format(pst.control_da
         obs = pst.observation_data
         fnames = pst.pestpp_options["forecasts"].split(",")
         for forecast 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()
```

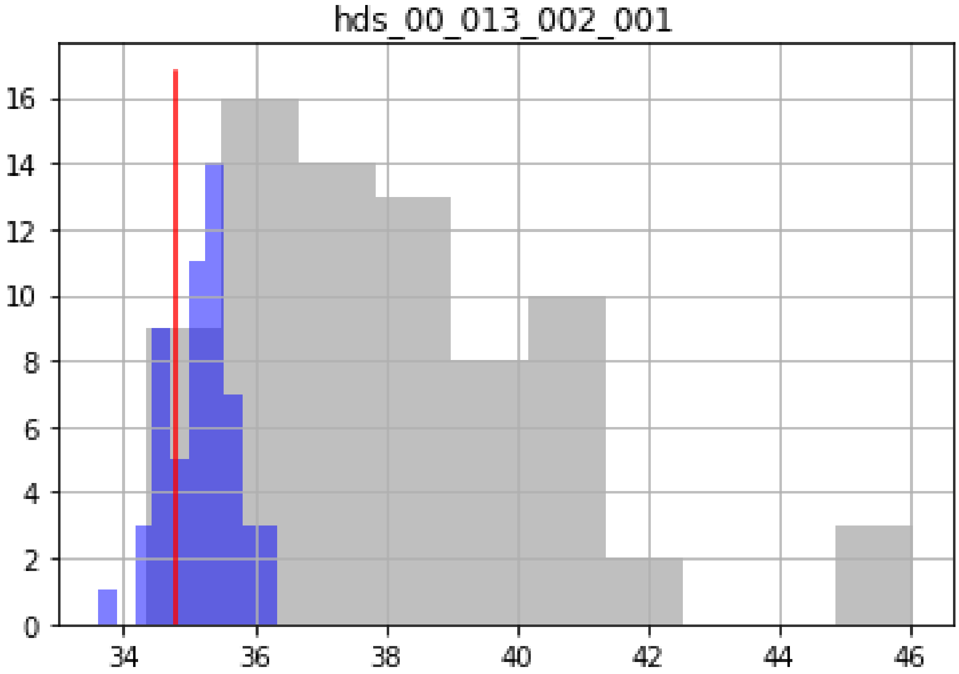


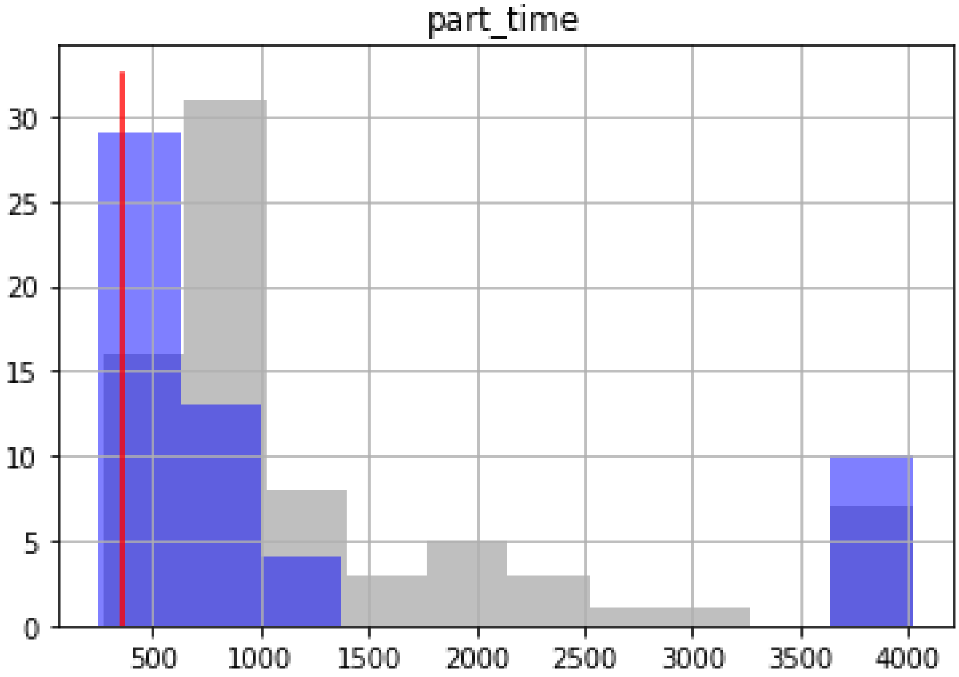

fa_hw_19801229
0
5
10
15
20
25
−1000
−500
0
500
1000
1500
2000

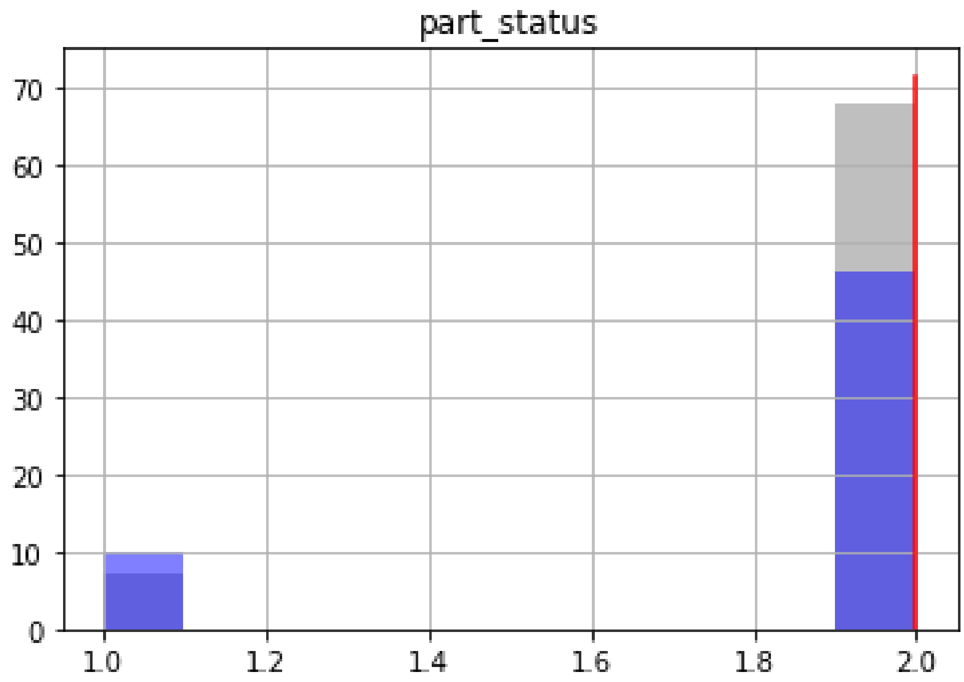

fa_tw_19791230
0
5
10
15
20
−1000
−500
0
500
1000
1500


fa_tw_19801229


hds_00_013_002_000


hds_00_013_002_001

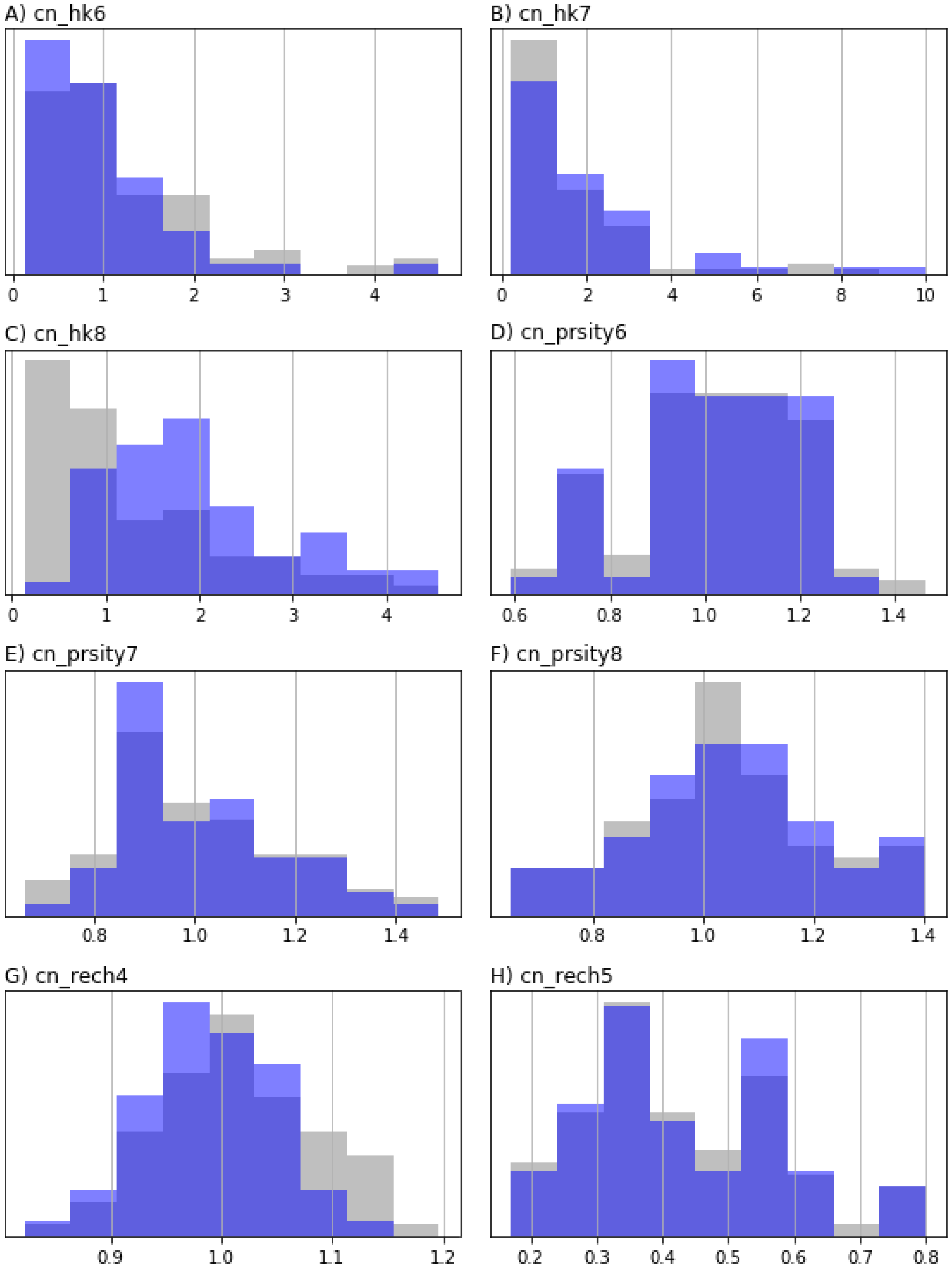

part_time

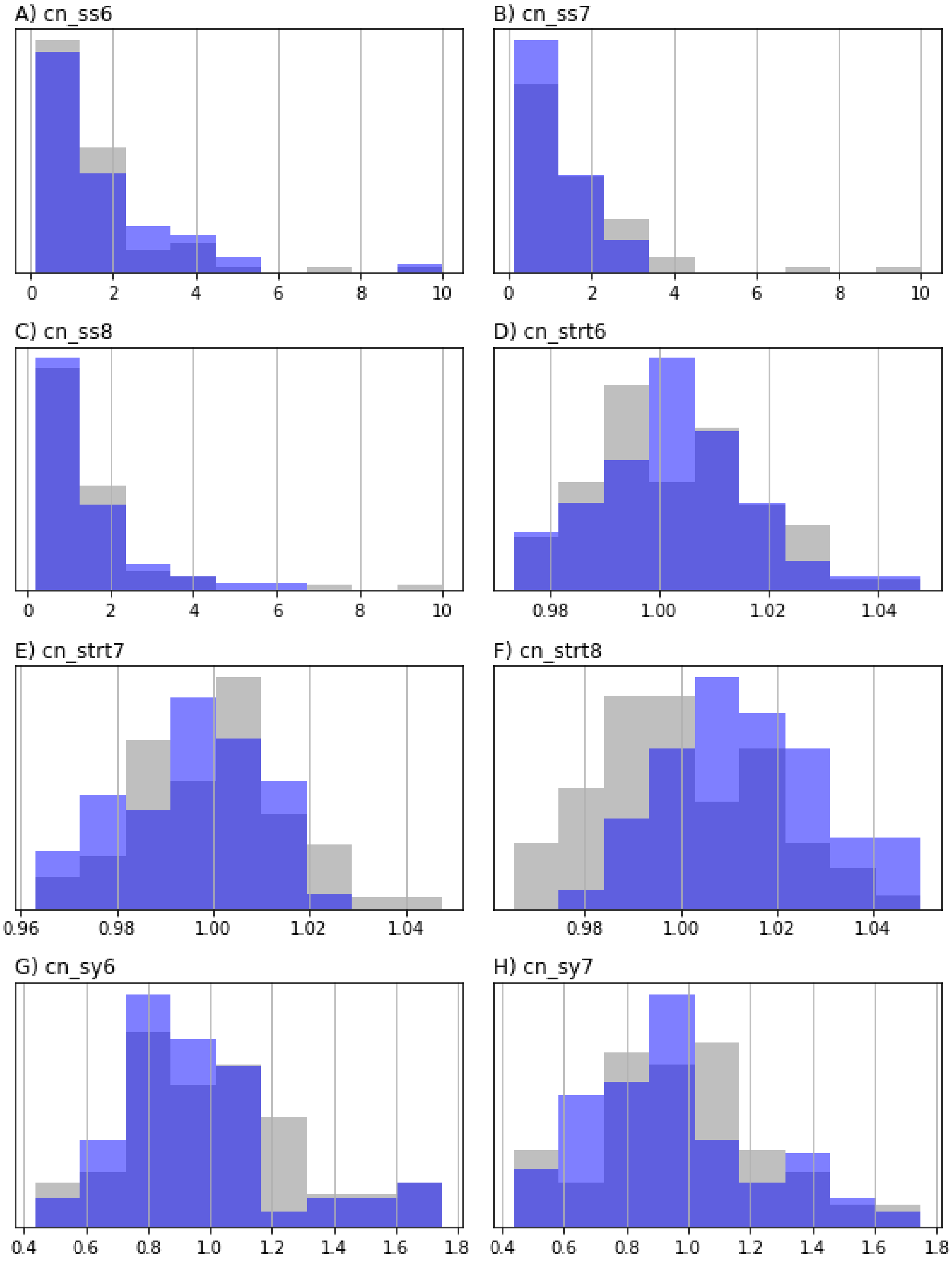


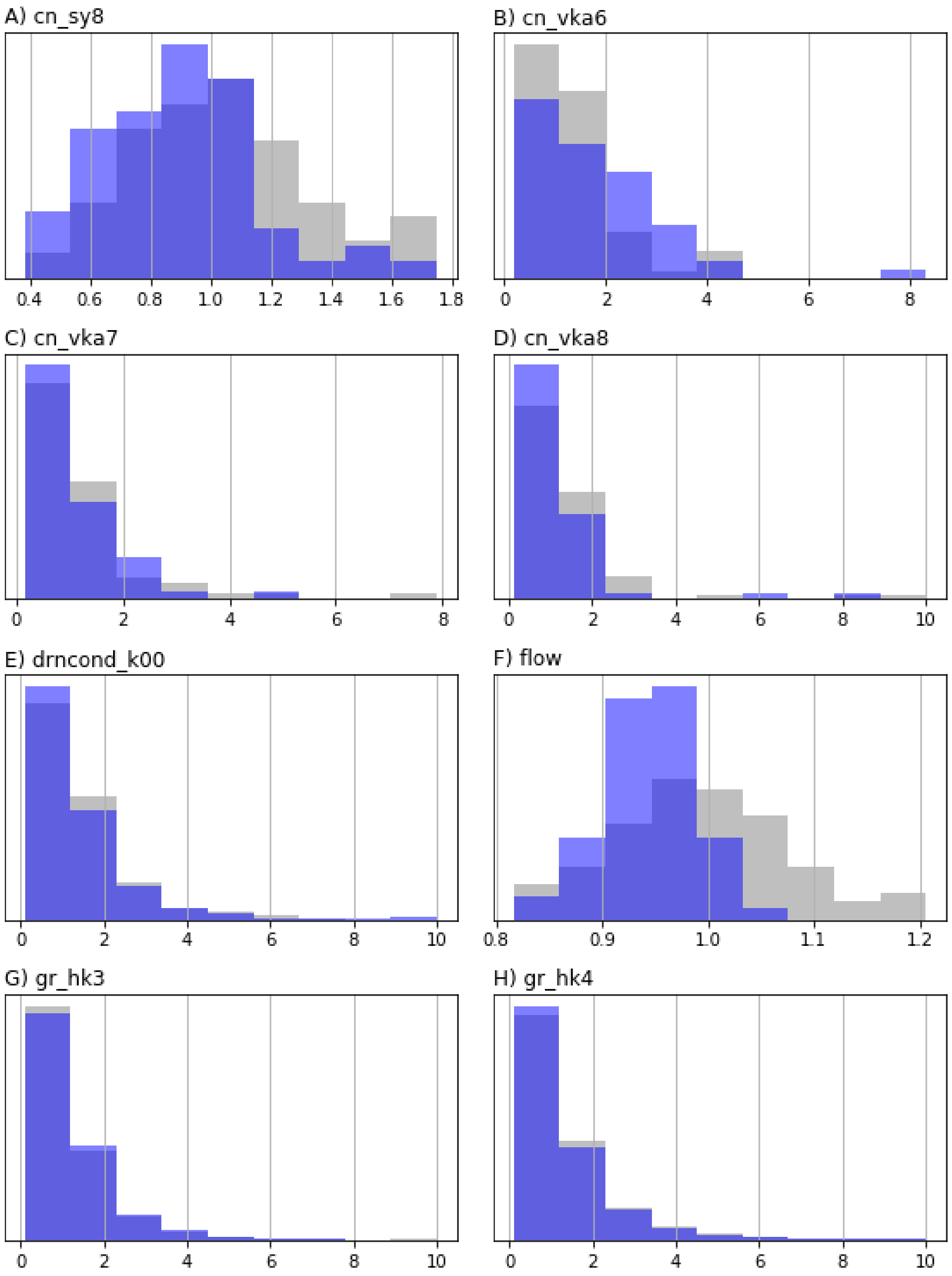
```
In [25]: pe_pr = pd.read_csv(os.path.join(m_d,"freyberg_ies.0.par.csv"),index_col=0)
         pe_pt = pd.read_csv(os.path.join(m_d,"freyberg_ies.{0}.par.csv".format(pst.control_da
         par = pst.parameter_data
         pdict = par.groupby("pargp").groups
         pyemu.plot_utils.ensemble_helper({"0.5":pe_pr,"b":pe_pt},plot_cols=pdict)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

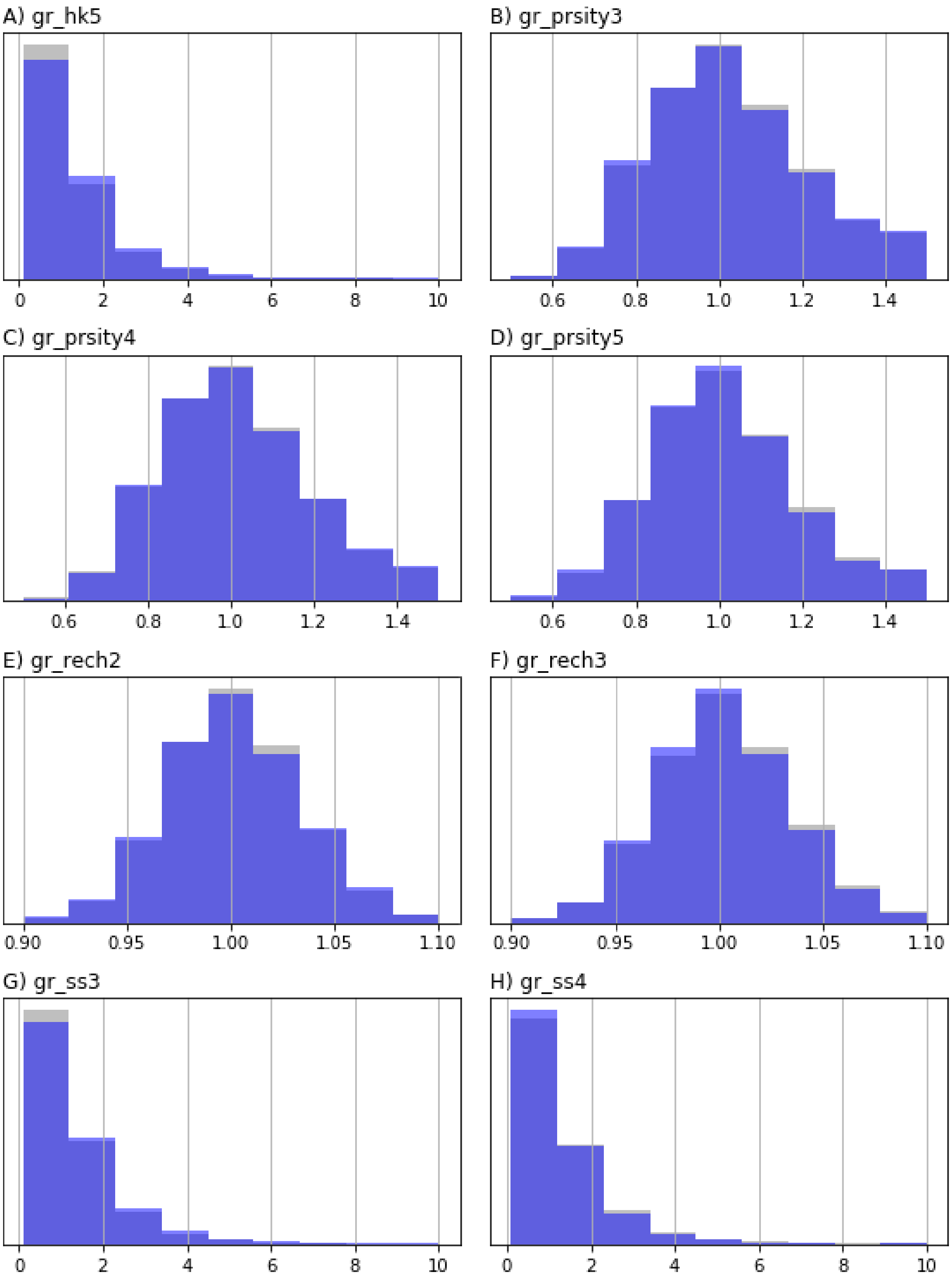
```
/Users/jeremyw/miniconda3/lib/python3.5/site-packages/IPython/core/interactiveshell.py:2785: D
  interactivity=interactivity, compiler=compiler, result=result)
```

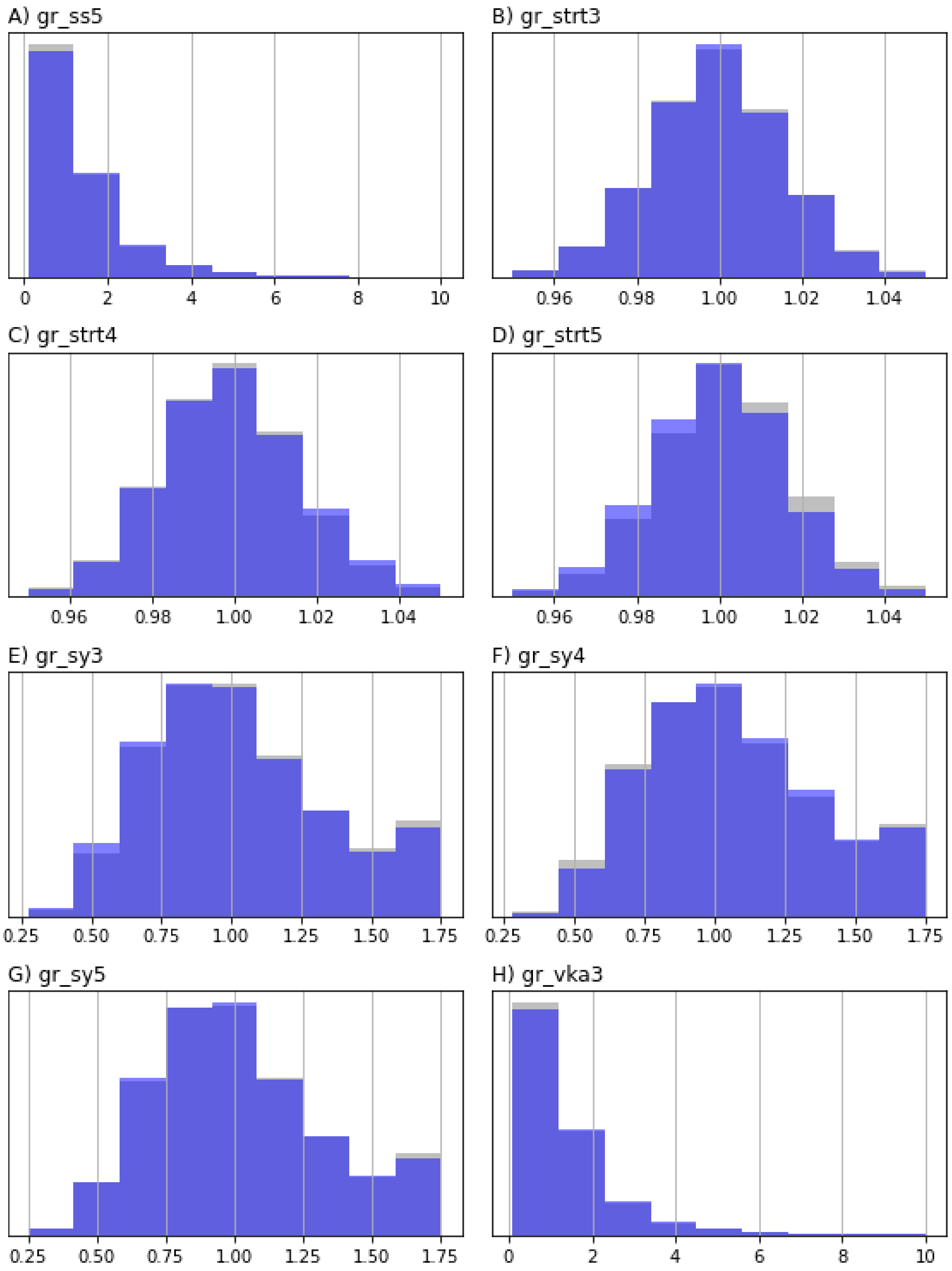
```
<Figure size 576x756 with 0 Axes>
```

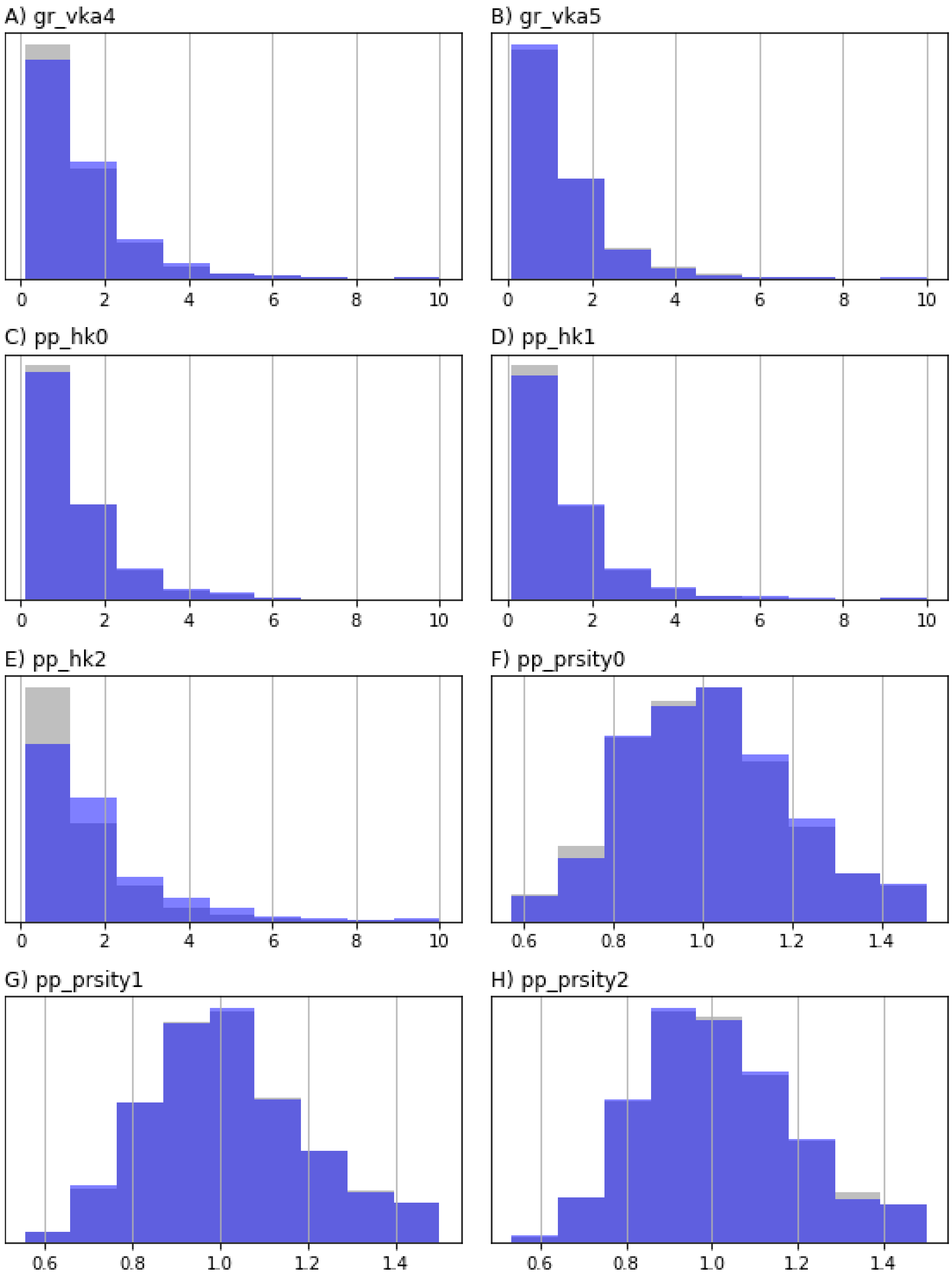

A) cn_hk6
0
1
2
3
4
B) cn_hk7
0
2
4
6
8
10
C) cn_hk8
0
1
2
3
4
D) cn_prsity6
0.6
0.8
1.0
1.2
1.4
E) cn_prsity7
0.8
1.0
1.2
1.4
F) cn_prsity8
0.8
1.0
1.2
1.4
G) cn_rech4
0.9
1.0
1.1
1.2
H) cn_rech5
0.2
0.3
0.4
0.5
0.6
0.7
0.8

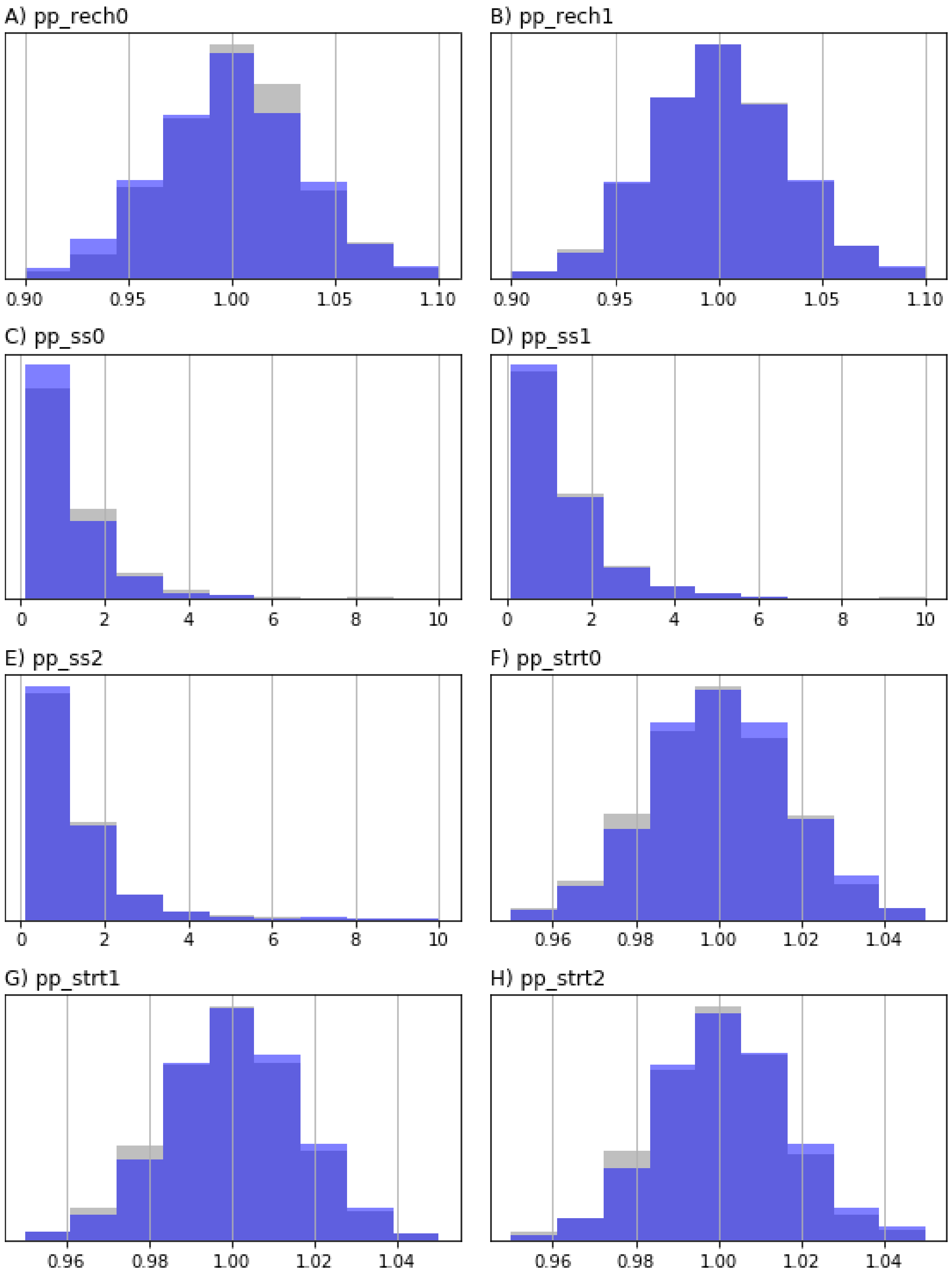

A) cn_ss6
0
2
4
6
8
10
B) cn_ss7
0
2
4
6
8
10
C) cn_ss8
0
2
4
6
8
10
D) cn_strt6
0.98
1.00
1.02
1.04
E) cn_strt7
0.96
0.98
1.00
1.02
1.04
F) cn_strt8
0.98
1.00
1.02
1.04
G) cn_sy6
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
H) cn_sy7
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8

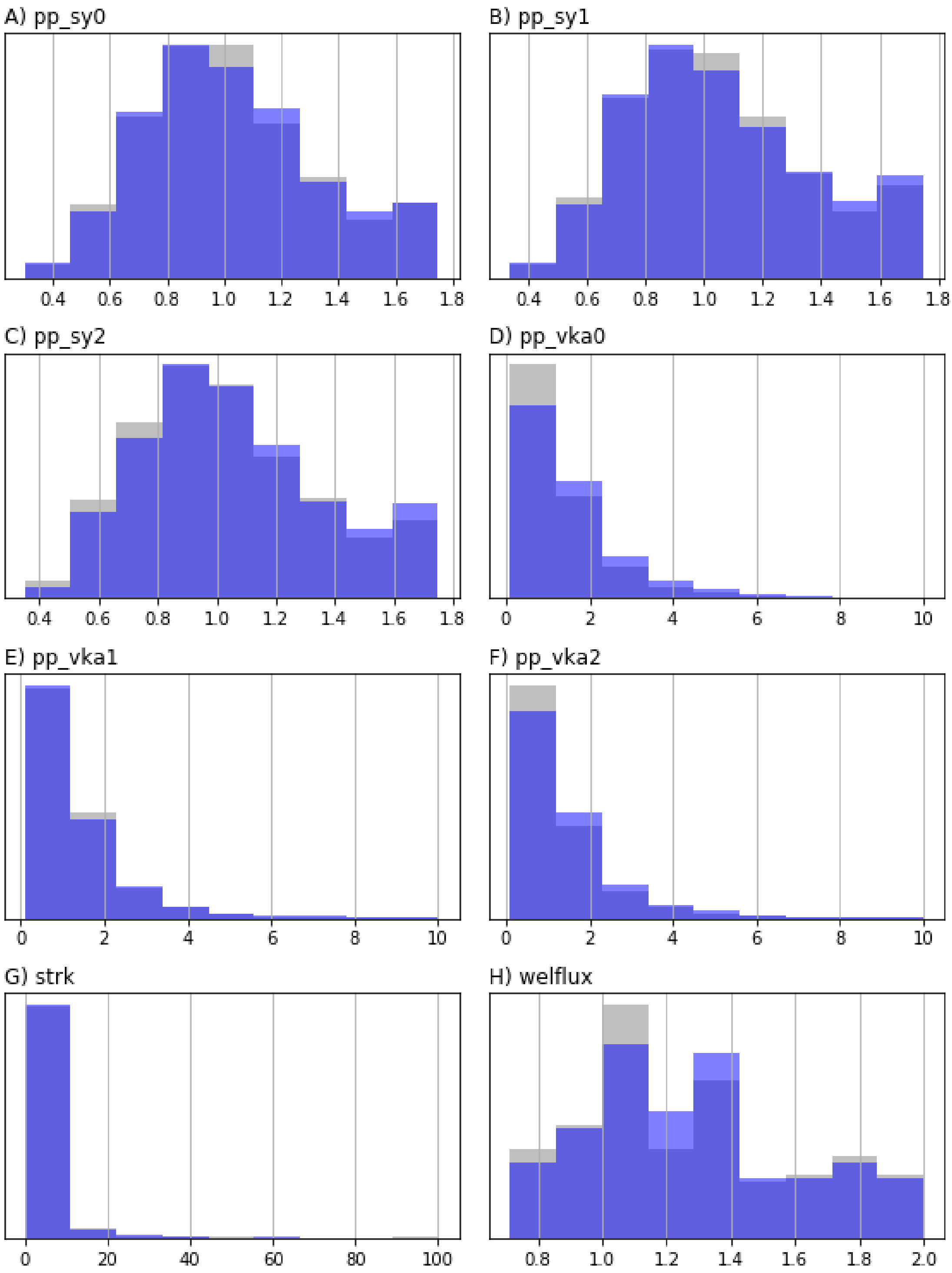

A) cn_sy8
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
B) cn_vka6
0
2
4
6
8
C) cn_vka7
0
2
4
6
8
D) cn_vka8
0
2
4
6
8
10
E) drncond_k00
0
2
4
6
8
10
F) flow
0.8
0.9
1.0
1.1
1.2
G) gr_hk3
0
2
4
6
8
10
H) gr_hk4
0
2
4
6
8
10

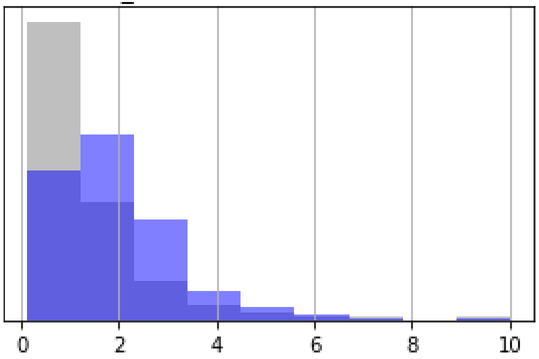

A) gr_hk5
0
2
4
6
8
10
B) gr_prsity3
0.6
0.8
1.0
1.2
1.4
C) gr_prsity4
0.6
0.8
1.0
1.2
1.4
D) gr_prsity5
0.6
0.8
1.0
1.2
1.4
E) gr_rech2
0.90
0.95
1.00
1.05
1.10
F) gr_rech3
0.90
0.95
1.00
1.05
1.10
G) gr_ss3
0
2
4
6
8
10
H) gr_ss4
0
2
4
6
8
10


A) gr_ss5
0
2
4
6
8
10
B) gr_strt3
0.96
0.98
1.00
1.02
1.04
C) gr_strt4
0.96
0.98
1.00
1.02
1.04
D) gr_strt5
0.96
0.98
1.00
1.02
1.04
E) gr_sy3
0.25
0.50
0.75
1.00
1.25
1.50
1.75
F) gr_sy4
0.25
0.50
0.75
1.00
1.25
1.50
1.75
G) gr_sy5
0.25
0.50
0.75
1.00
1.25
1.50
1.75
H) gr_vka3
0
2
4
6
8
10


A) gr_vka4
0
2
4
6
8
10
B) gr_vka5
0
2
4
6
8
10
C) pp_hk0
0
2
4
6
8
10
D) pp_hk1
0
2
4
6
8
10
E) pp_hk2
0
2
4
6
8
10
F) pp_prsity0
0.6
0.8
1.0
1.2
1.4
G) pp_prsity1
0.6
0.8
1.0
1.2
1.4
H) pp_prsity2
0.6
0.8
1.0
1.2
1.4


A) pp_rech0
0.90
0.95
1.00
1.05
1.10
B) pp_rech1
0.90
0.95
1.00
1.05
1.10
C) pp_ss0
0
2
4
6
8
10
D) pp_ss1
0
2
4
6
8
10
E) pp_ss2
0
2
4
6
8
10
F) pp_strt0
0.96
0.98
1.00
1.02
1.04
G) pp_strt1
0.96
0.98
1.00
1.02
1.04
H) pp_strt2
0.96
0.98
1.00
1.02
1.04


A) pp_sy0
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
B) pp_sy1
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
C) pp_sy2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
D) pp_vka0
0
2
4
6
8
10
E) pp_vka1
0
2
4
6
8
10
F) pp_vka2
0
2
4
6
8
10
G) strk
0
20
40
60
80
100
H) welflux
0.8
1.0
1.2
1.4
1.6
1.8
2.0

A) welflux_k02