

pestpp-ies

April 29, 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 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 \
grrech2		grrech2	log	705	0
grss4		grss4	log	705	0
sy7_cn		sy7_cn	log	1	0
ss6_cn		ss6_cn	log	1	0
grstrt3		grstrt3	log	705	0
grhk5		grhk5	log	705	0
strt6_cn		strt6_cn	log	1	0
welflux_k02	welflux_k02		log	6	0
grhk3		grhk3	log	705	0
pp_vka1	pp_vka1		log	32	0
ss7_cn	ss7_cn		log	1	0
welflux	welflux		log	2	0 to 0.176091
pp_strt1	pp_strt1		log	32	0
pp_vka2	pp_vka2		log	32	0
grsy5	grsy5		log	705	0
pp_ss0	pp_ss0		log	32	0
grsy3	grsy3		log	705	0

pp_rech0	pp_rech0	log	32	0
grvka4	grvka4	log	705	0
pp_hk1	pp_hk1	log	32	0
grhk4	grhk4	log	705	0
pp_strt2	pp_strt2	log	32	0
strt7_cn	strt7_cn	log	1	0
pp_rech1	pp_rech1	log	32	0
pp_hk0	pp_hk0	log	32	0
grss5	grss5	log	705	0
strt8_cn	strt8_cn	log	1	0
strk	strk	log	40	0
ss8_cn	ss8_cn	log	1	0
flow	flow	log	1	0
rech4_cn	rech4_cn	log	1	0
drncond_k00	drncond_k00	log	10	0
grss3	grss3	log	705	0
grstrt5	grstrt5	log	705	0
grstrt4	grstrt4	log	705	0
pp_ss1	pp_ss1	log	32	0
pp_strt0	pp_strt0	log	32	0
rech5_cn	rech5_cn	log	1	-0.39794
vka7_cn	vka7_cn	log	1	0
grsy4	grsy4	log	705	0
pp_vka0	pp_vka0	log	32	0
pp_sy2	pp_sy2	log	32	0
pp_ss2	pp_ss2	log	32	0
hk8_cn	hk8_cn	log	1	0
sy6_cn	sy6_cn	log	1	0
pp_hk2	pp_hk2	log	32	0
hk6_cn	hk6_cn	log	1	0
pp_sy0	pp_sy0	log	32	0
grvka5	grvka5	log	705	0
hk7_cn	hk7_cn	log	1	0
pp_sy1	pp_sy1	log	32	0
grrech3	grrech3	log	705	0
grvka3	grvka3	log	705	0
vka8_cn	vka8_cn	log	1	0
vka6_cn	vka6_cn	log	1	0
sy8_cn	sy8_cn	log	1	0
		upper bound	lower bound	standard deviation
grrech2		0.0413927	-0.0457575	0.0217875
grss4		1	-1	0.5
sy7_cn		0.243038	-0.60206	0.211275
ss6_cn		1	-1	0.5
grstrt3		0.0211893	-0.0222764	0.0108664
grhk5		1	-1	0.5
strt6_cn		0.0211893	-0.0222764	0.0108664

welflux_k02	1	-1	0.5
grhk3	1	-1	0.5
pp_vka1	1	-1	0.5
ss7_cn	1	-1	0.5
welflux	0.176091 to 0.30103	-0.30103 to 0	0.0752575 to 0.11928
pp_strt1	0.0211893	-0.0222764	0.0108664
pp_vka2	1	-1	0.5
grsy5	0.243038	-0.60206	0.211275
pp_ss0	1	-1	0.5
grsy3	0.243038	-0.60206	0.211275
pp_rech0	0.0413927	-0.0457575	0.0217875
grvka4	1	-1	0.5
pp_hk1	1	-1	0.5
grhk4	1	-1	0.5
pp_strt2	0.0211893	-0.0222764	0.0108664
strt7_cn	0.0211893	-0.0222764	0.0108664
pp_rech1	0.0413927	-0.0457575	0.0217875
pp_hk0	1	-1	0.5
grss5	1	-1	0.5
strt8_cn	0.0211893	-0.0222764	0.0108664
strk	2	-2	1
ss8_cn	1	-1	0.5
flow	0.09691	-0.124939	0.0554622
rech4_cn	0.0791812	-0.09691	0.0440228
drncond_k00	1	-1	0.5
grss3	1	-1	0.5
grstrt5	0.0211893	-0.0222764	0.0108664
grstrt4	0.0211893	-0.0222764	0.0108664
pp_ss1	1	-1	0.5
pp_strt0	0.0211893	-0.0222764	0.0108664
rech5_cn	-0.09691	-1	0.225772
vka7_cn	1	-1	0.5
grsy4	0.243038	-0.60206	0.211275
pp_vka0	1	-1	0.5
pp_sy2	0.243038	-0.60206	0.211275
pp_ss2	1	-1	0.5
hk8_cn	1	-1	0.5
sy6_cn	0.243038	-0.60206	0.211275
pp_hk2	1	-1	0.5
hk6_cn	1	-1	0.5
pp_sy0	0.243038	-0.60206	0.211275
grvka5	1	-1	0.5
hk7_cn	1	-1	0.5
pp_sy1	0.243038	-0.60206	0.211275
grrech3	0.0413927	-0.0457575	0.0217875
grvka3	1	-1	0.5
vka8_cn	1	-1	0.5
vka6_cn	1	-1	0.5

sy8_cn

0.243038

-0.60206

0.211275

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), "parname"]
        # pp pars
        #should_fix = par.loc[par.pargp.apply(lambda x: "pp" in x), "parname"]

        # 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

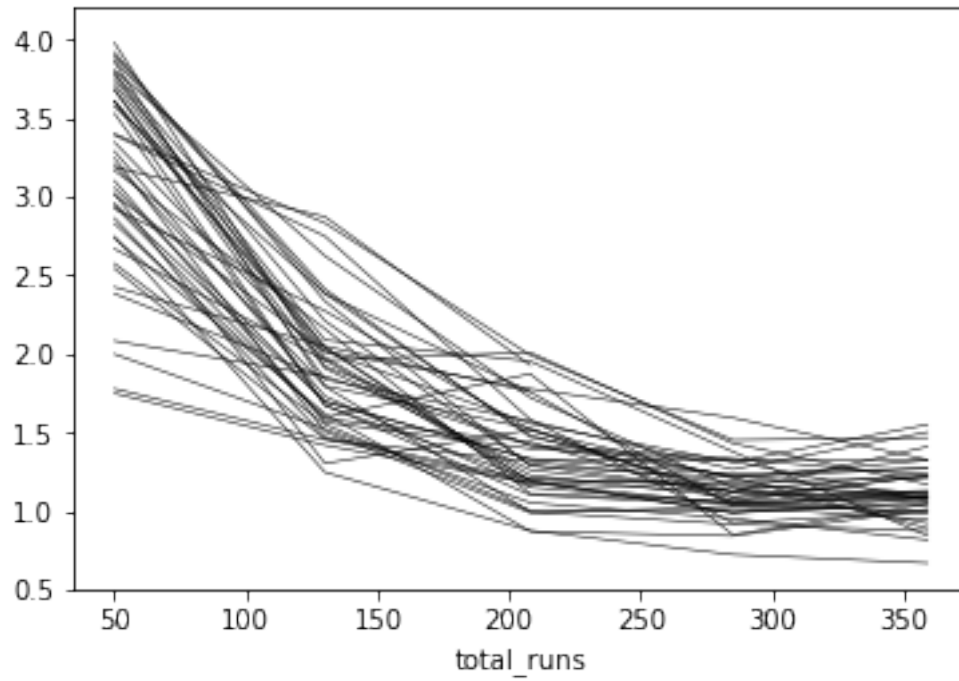
```
In [5]: pst.pestpp_options["ies_num_reals"] = 50
        pst.pestpp_options["ies_par_en"] = "prior.jcb"
        pst.pestpp_options["ies_bad_phi_sigma"] = 2.0
        pst.pestpp_options["overdue_giveup_fac"] = 10.0
        pst.control_data.noptmax = 4
```

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

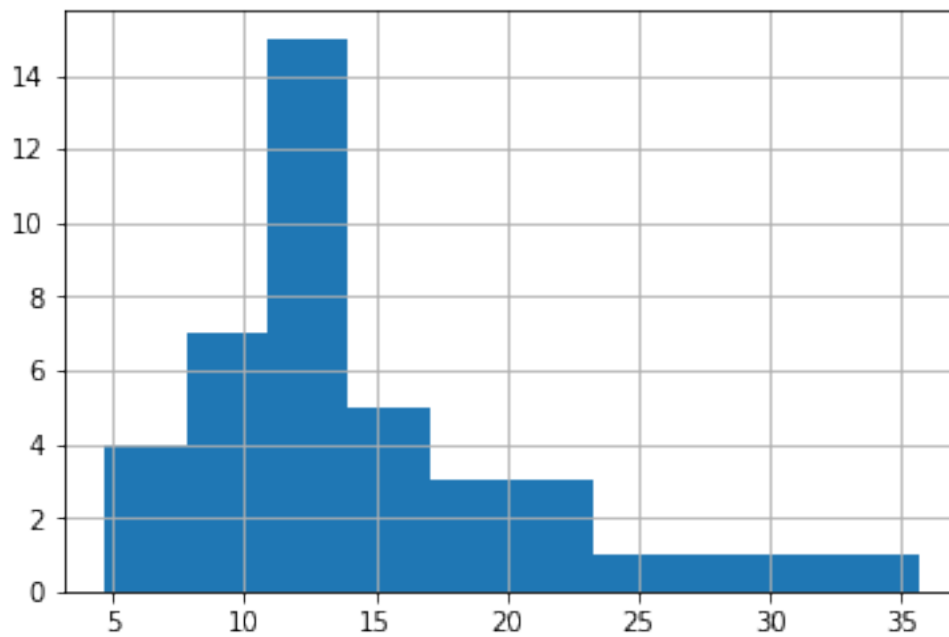
```
In [7]: pyemu.os_utils.start_slaves(t_d, "pestpp-ies", "freyberg_ies.pst", num_slaves=20, master_d=
```

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



Out[8]: <matplotlib.axes._subplots.AxesSubplot at 0x118793160>

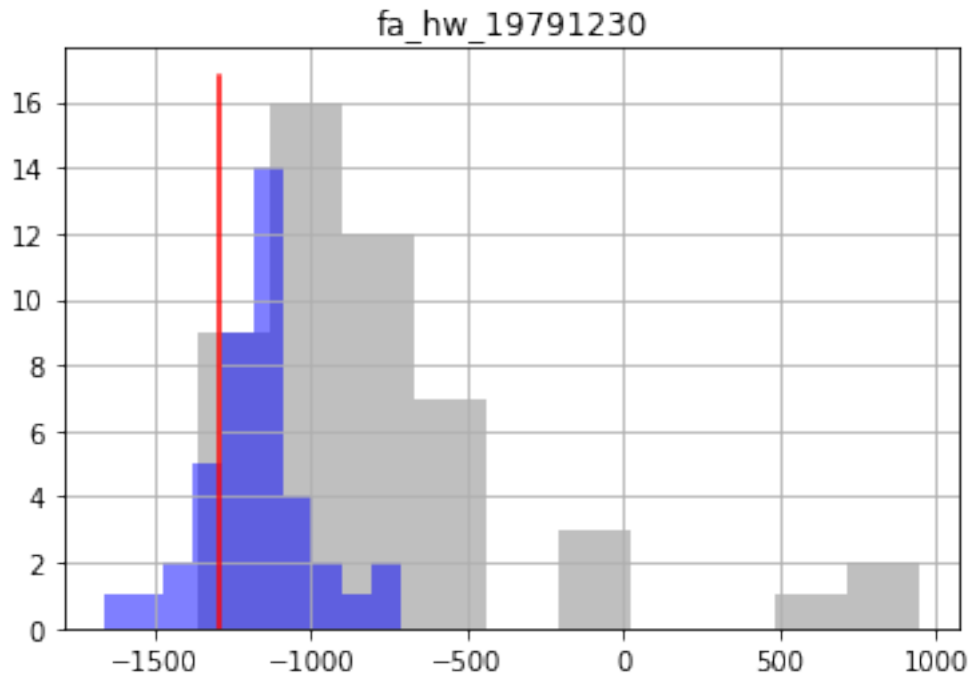


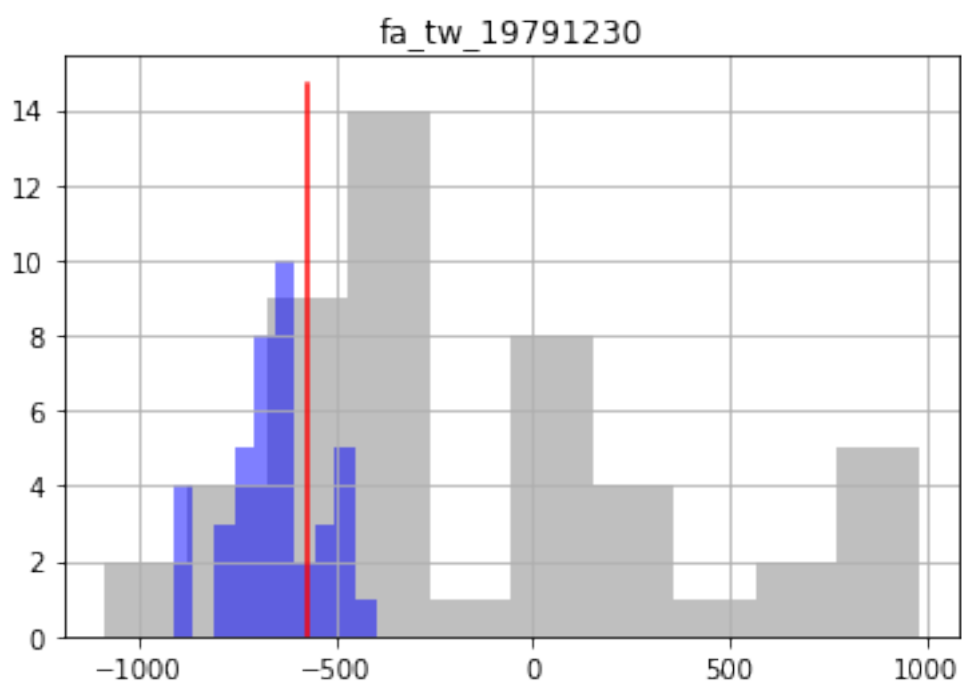
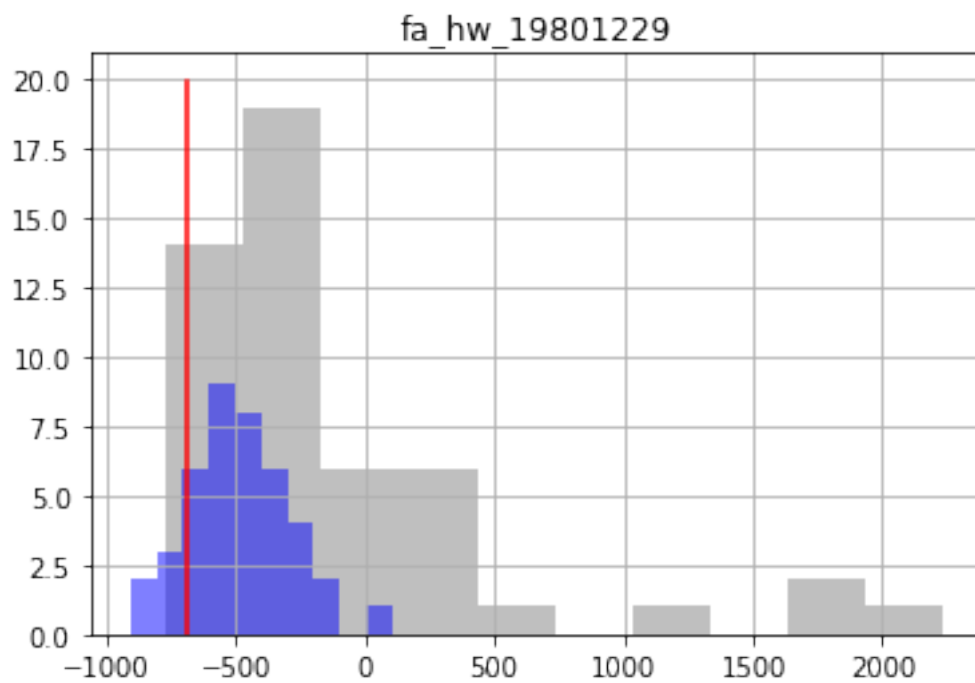
Plot forecast prior and posterior histograms with “truth” (red line)

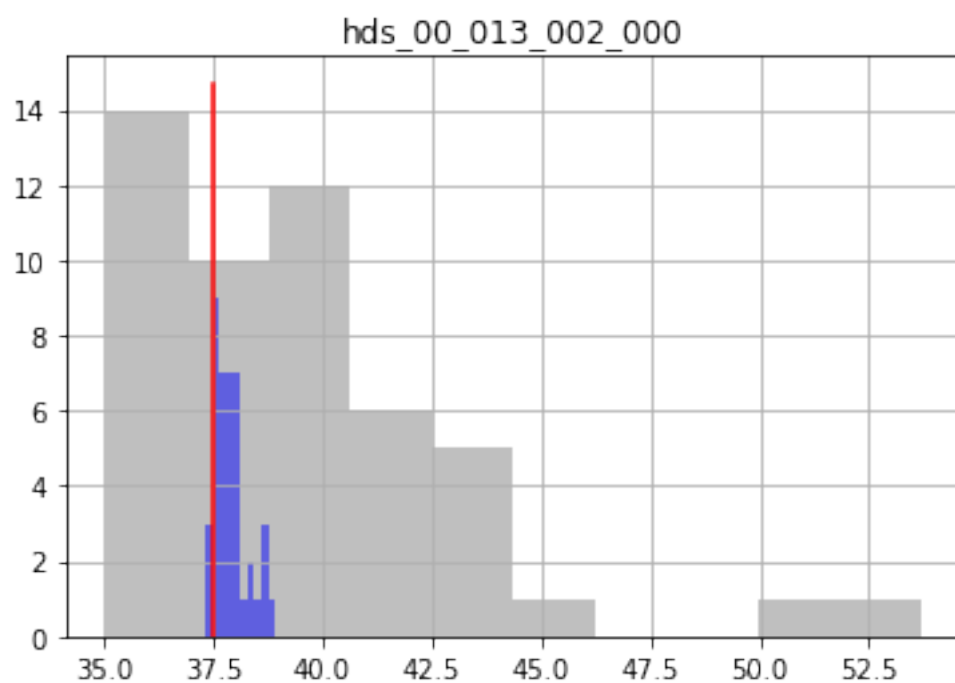
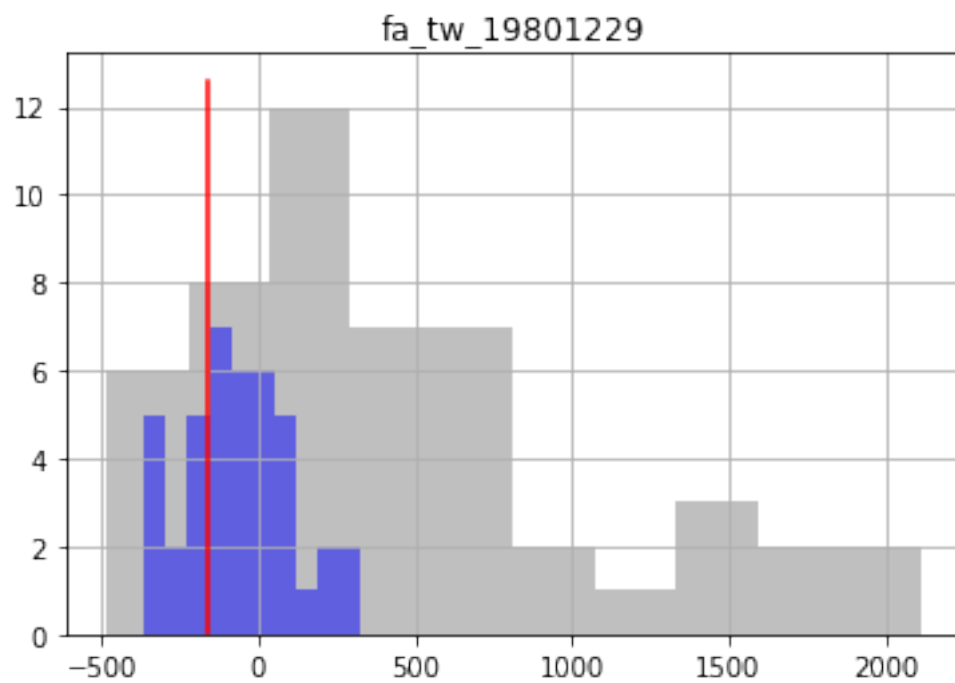
```

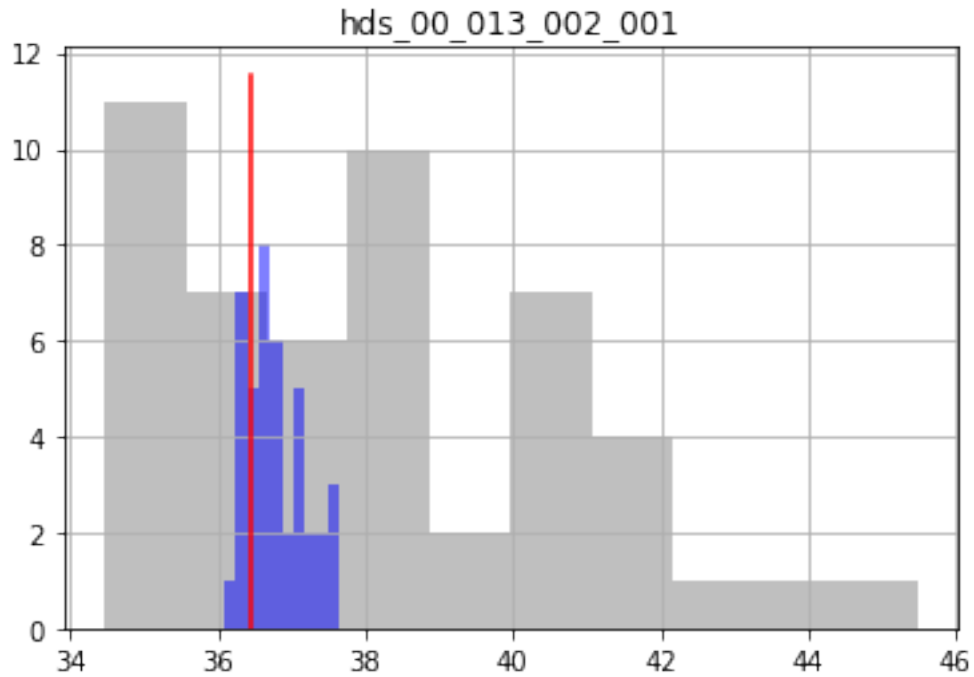
In [9]: oe_pr = pd.read_csv(os.path.join(m_d,"freyberg_ies.0.obs.csv"),index_col=0)
        oe_pt = pd.read_csv(os.path.join(m_d,"freyberg_ies.{0}.obs.csv".format(pst.control_data
        obs = pst.observation_data
        fnames = pst.pestpp_options["forecasts"].split(",")
        for forecast in fnames: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

```







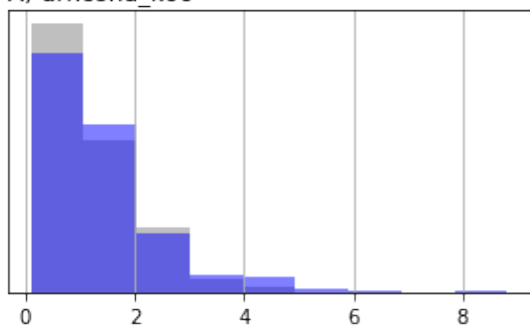


Plot parameter histograms by group

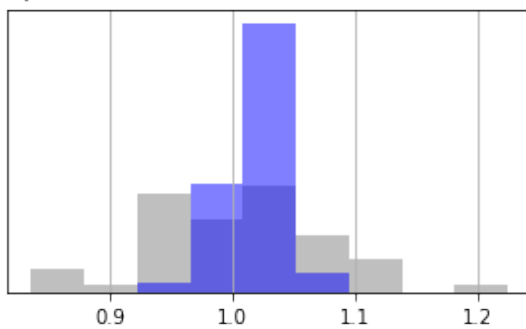
```
In [10]: pe_pr = pd.read_csv(os.path.join(m_d,"freyberg_ies.0.par.csv"),index_col=0)
         pe_pt = pd.read_csv(os.path.join(m_d,"freyberg_ies.{0}.par.csv".format(pst.control_da
         par = pst.parameter_data
         pdict = par.groupby("pargp").groups
         pyemu.plot_utils.ensemble_helper({"0.5":pe_pr,"b":pe_pt},plot_cols=pdict)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

<Figure size 576x756 with 0 Axes>

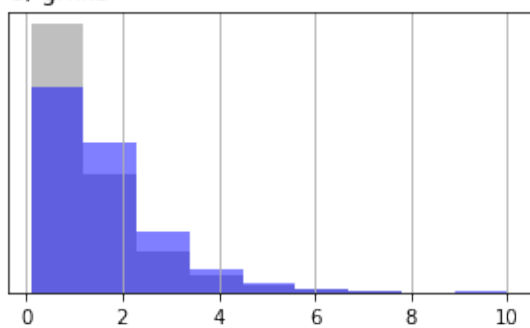
A) `drncond_k00`



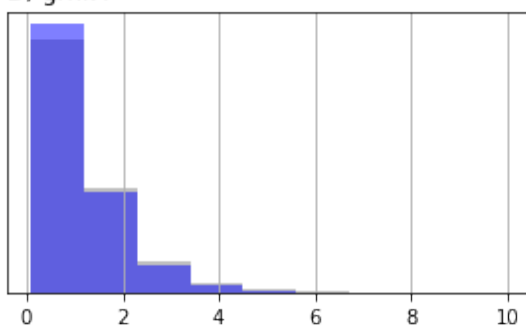
B) `flow`



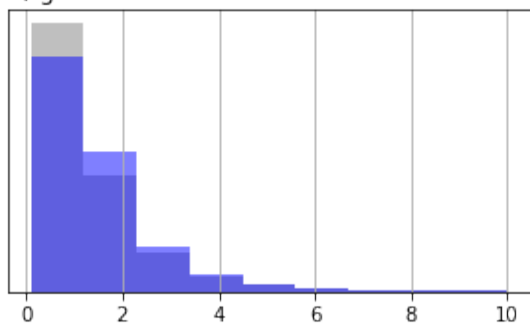
C) `grhk3`



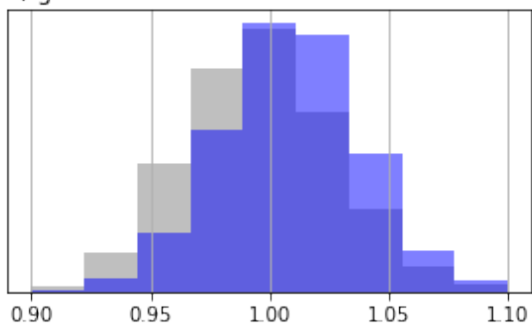
D) `grhk4`



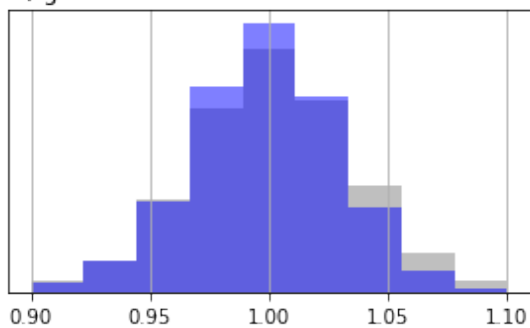
E) `grhk5`



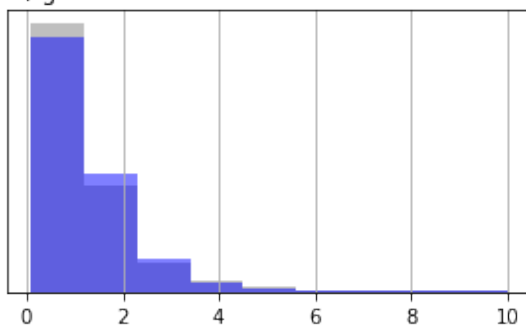
F) `grrech2`



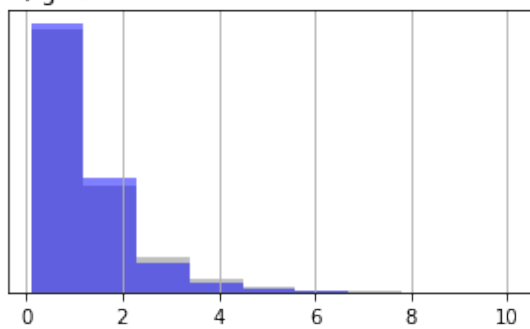
G) `grrech3`



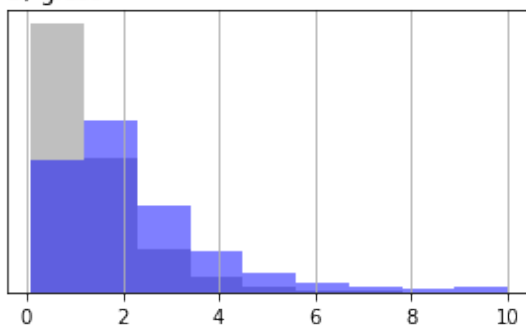
H) `grss3`



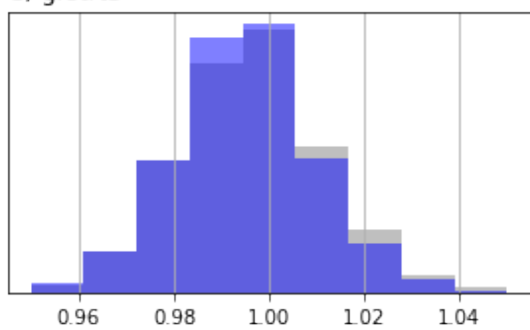
A) grss4



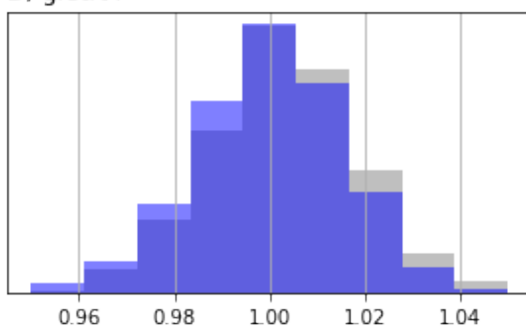
B) grss5



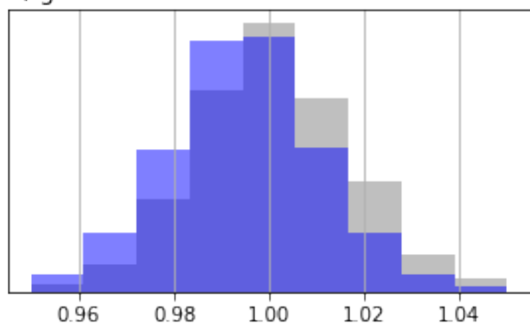
C) grstrt3



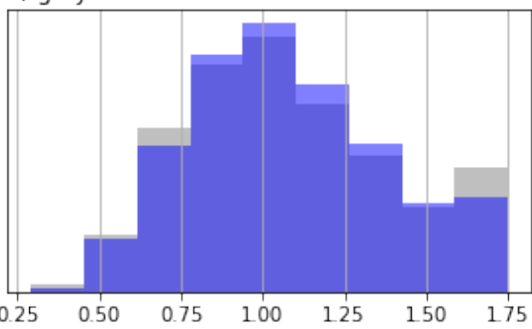
D) grstrt4



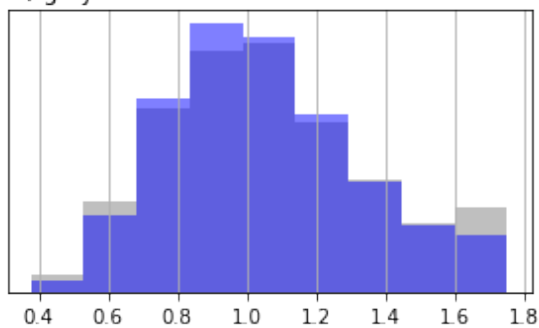
E) grstrt5



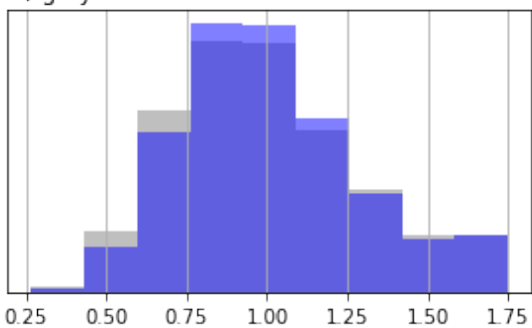
F) grsy3



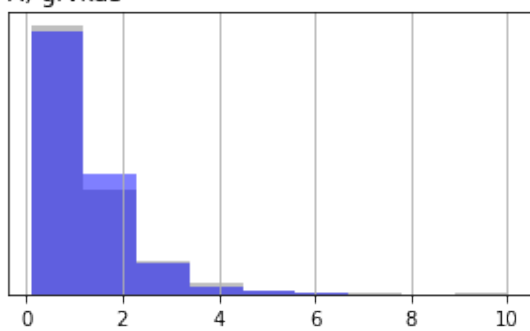
G) grsy4



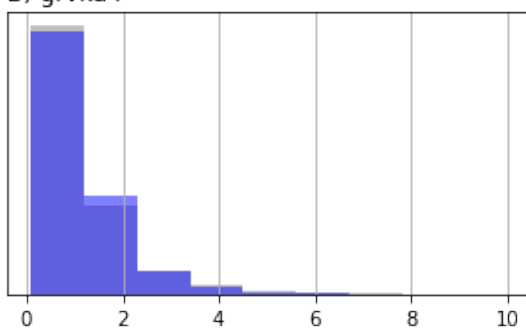
H) grsy5



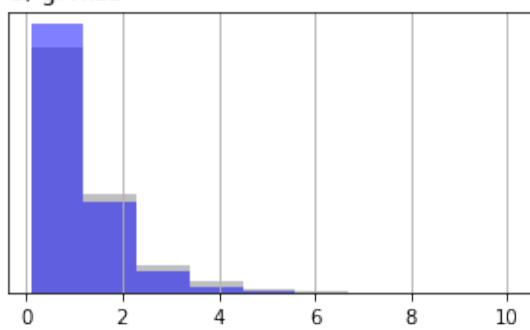
A) grvka3



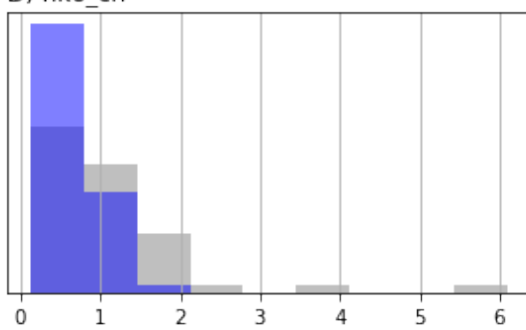
B) grvka4



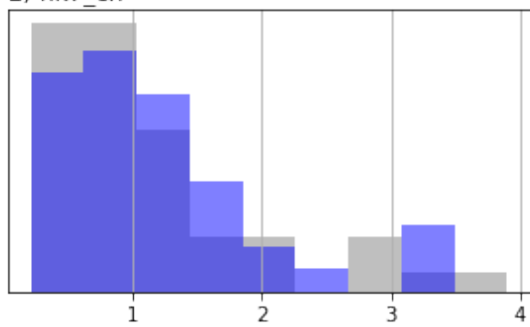
C) grvka5



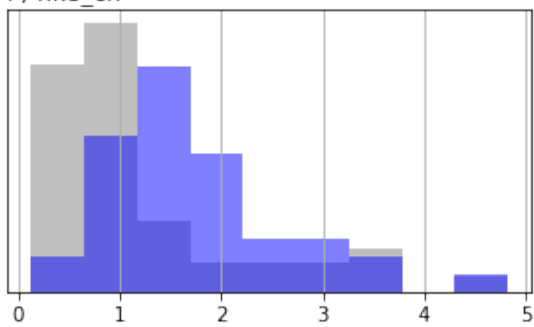
D) hk6_cn



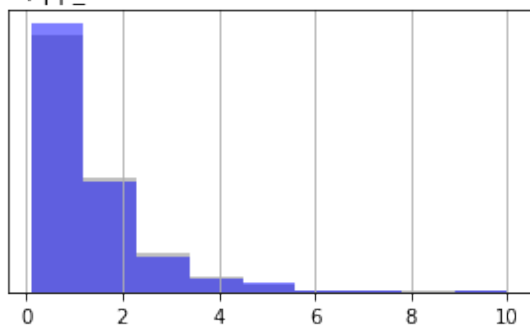
E) hk7_cn



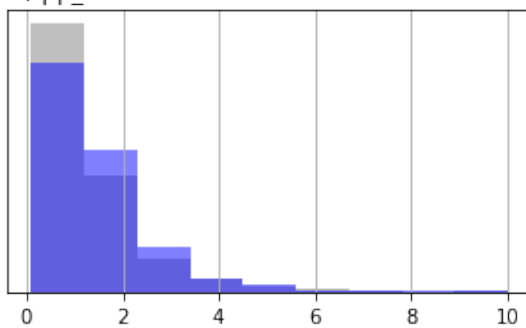
F) hk8_cn



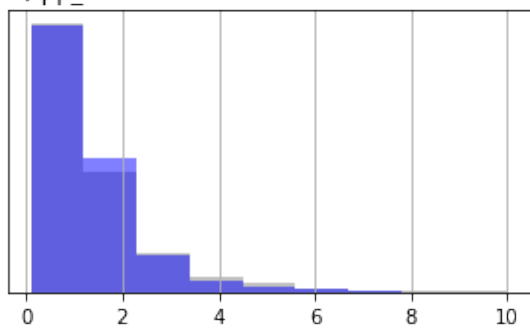
G) pp_hk0



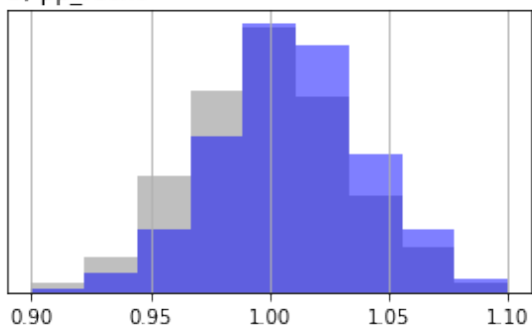
H) pp_hk1



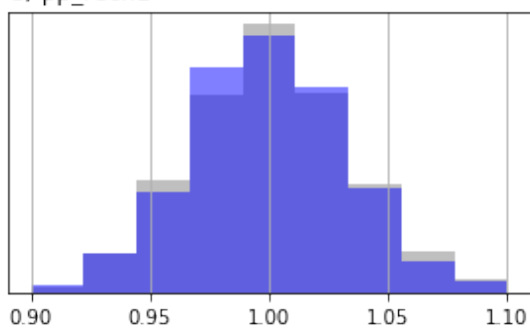
A) pp_hk2



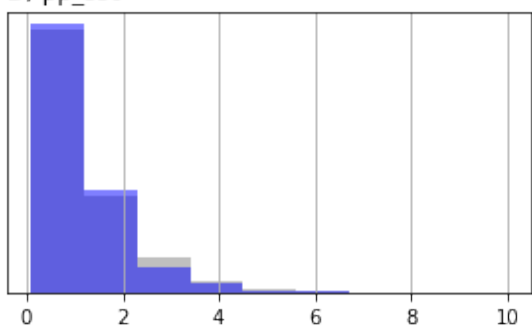
B) pp_rech0



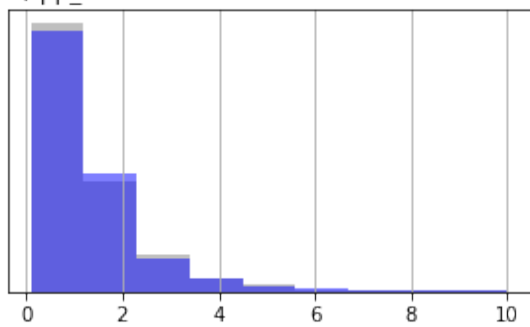
C) pp_rech1



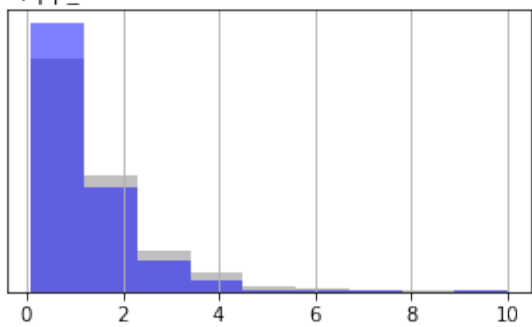
D) pp_ss0



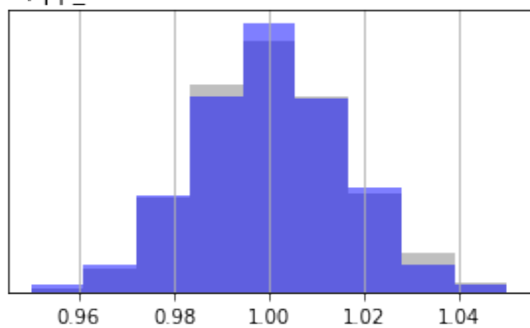
E) pp_ss1



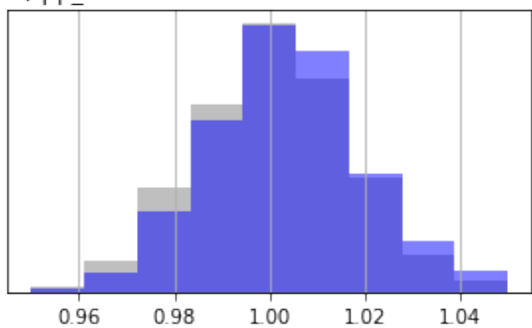
F) pp_ss2



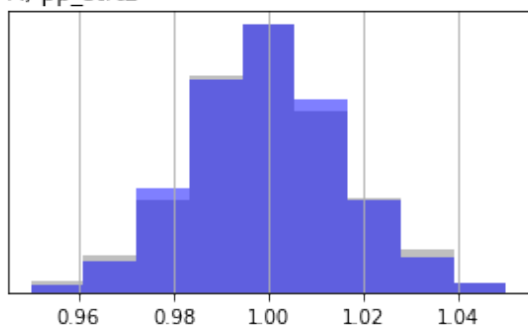
G) pp_strt0



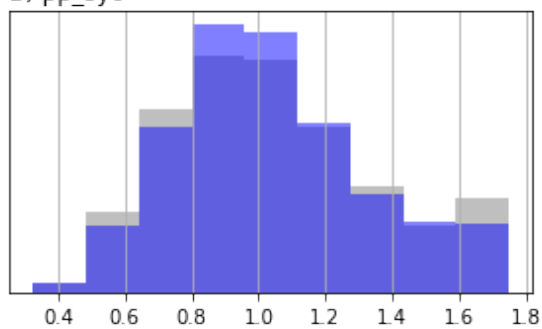
H) pp_strt1



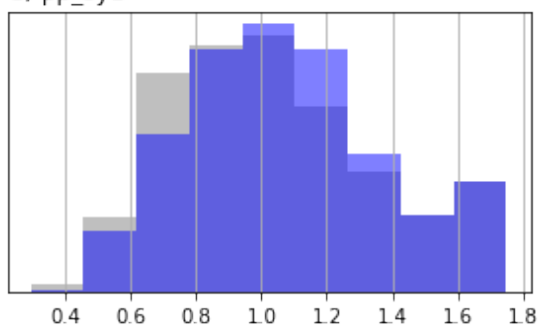
A) pp_strt2



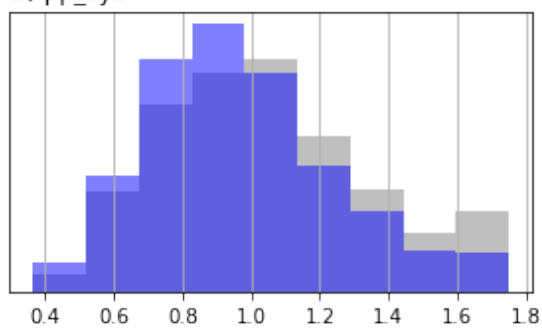
B) pp_sy0



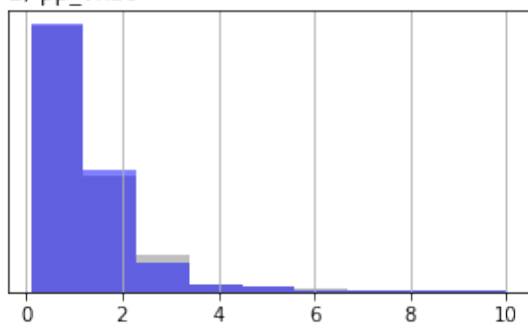
C) pp_sy1



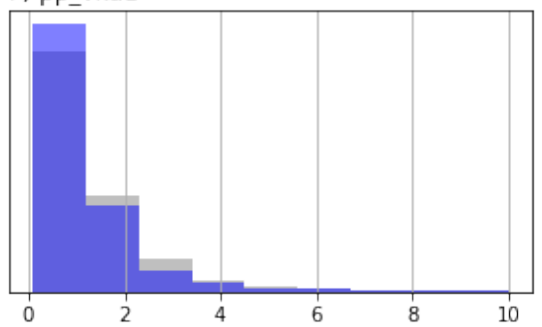
D) pp_sy2



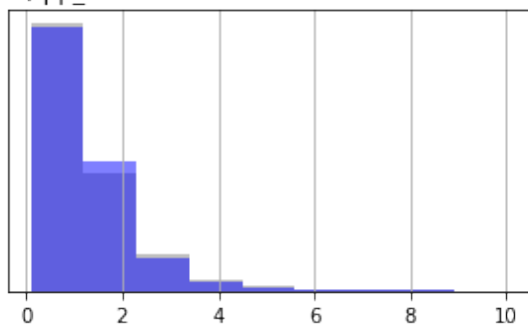
E) pp_vka0



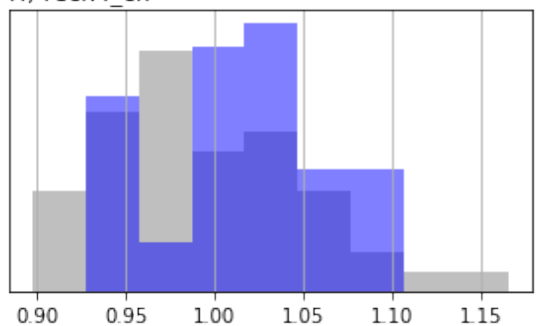
F) pp_vka1

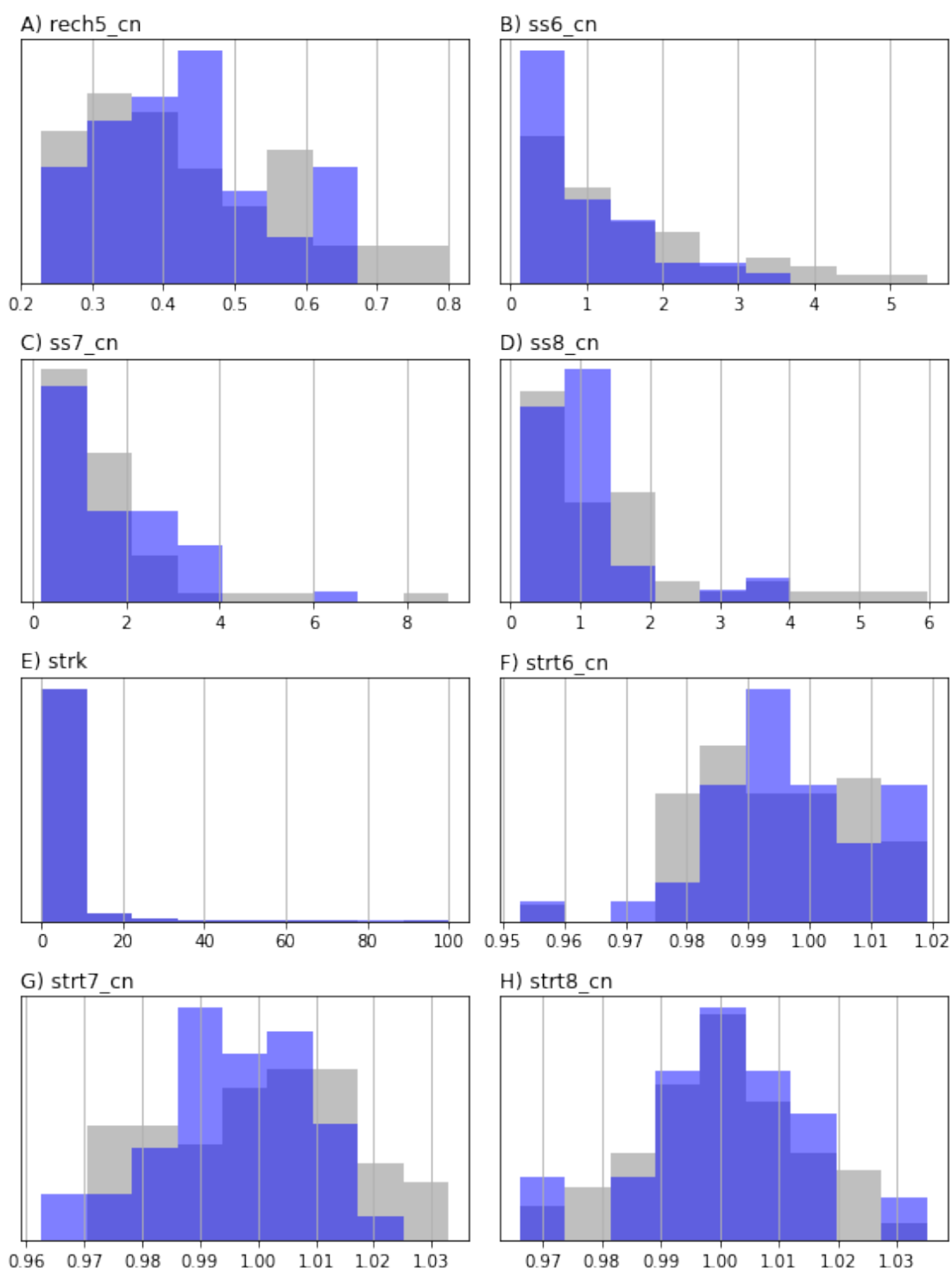


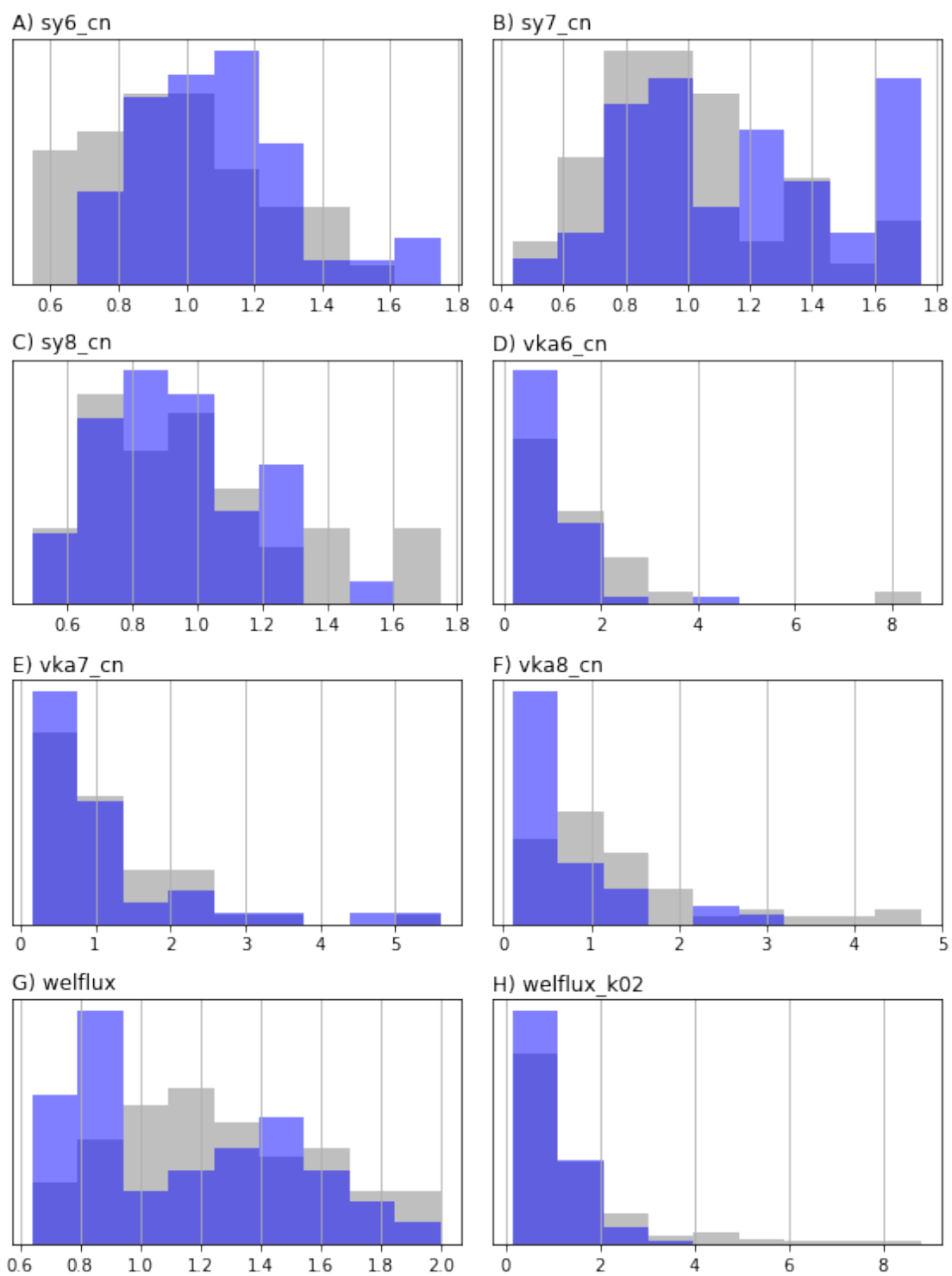
G) pp_vka2



H) rech4_cn







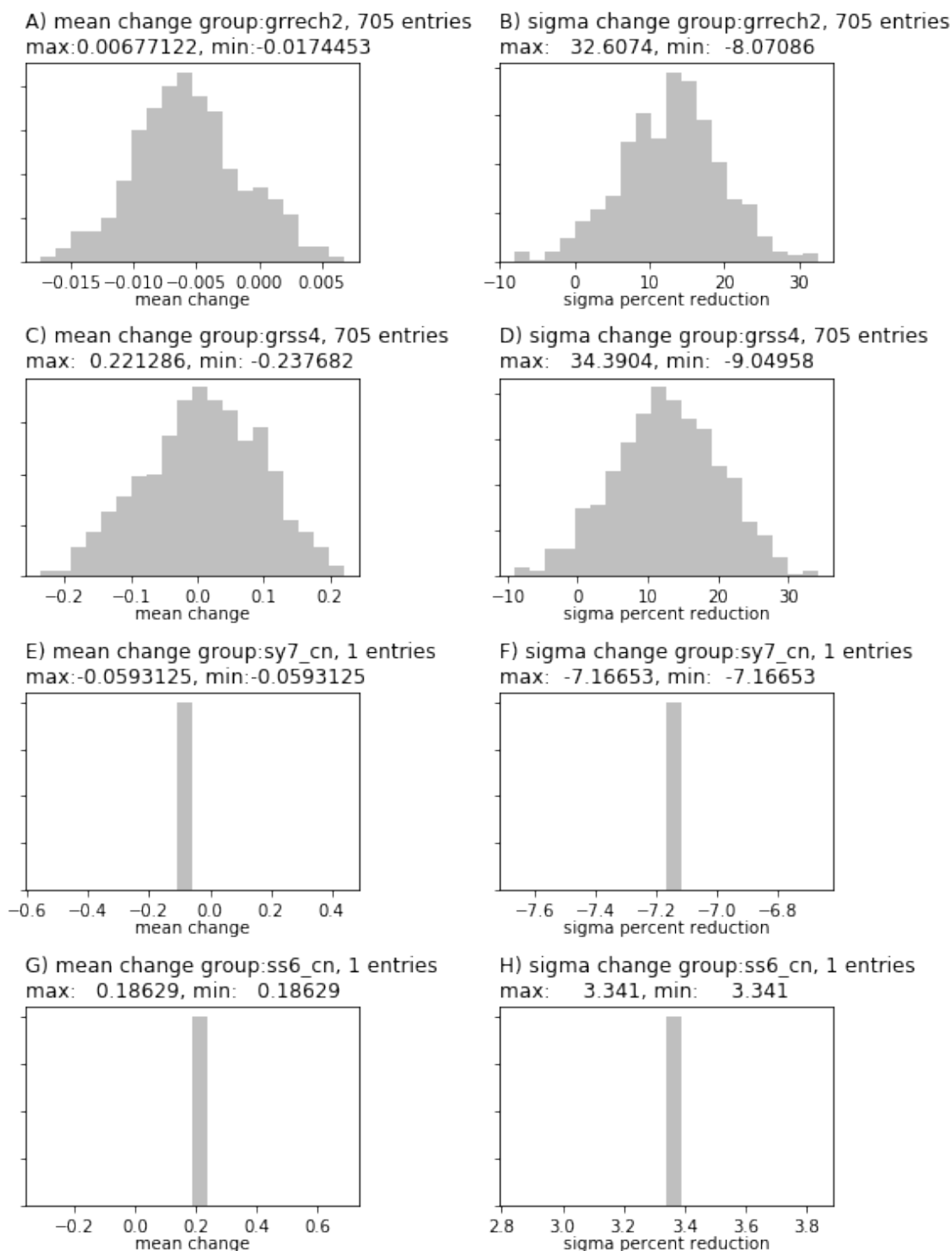
```
In [11]: pyemu.plot_utils.ensemble_change_summary(pe_pr,pe_pt,pst=pst,bins=20)
          par = pst.parameter_data
          li = par.partrans=="log"
```



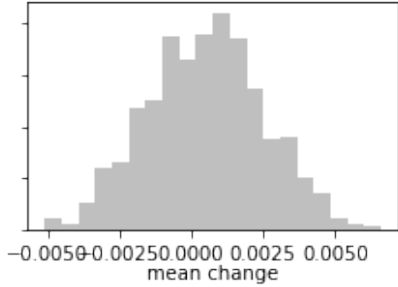
```
pe_pr.loc[:,li] = pe_pr.loc[:,li].apply(np.log10)
pe_pr.shape
```

Out[11]: (50, 12605)

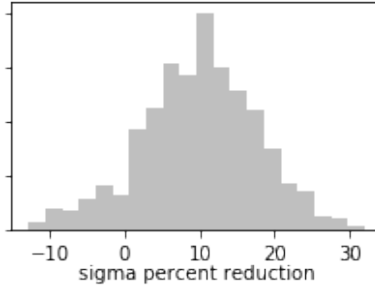
<Figure size 576x756 with 0 Axes>



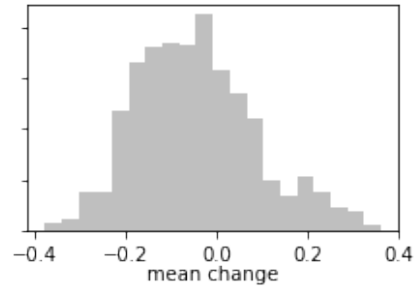
A) mean change group:grstrt3, 705 entries
max:0.00659681, min:-0.00510234



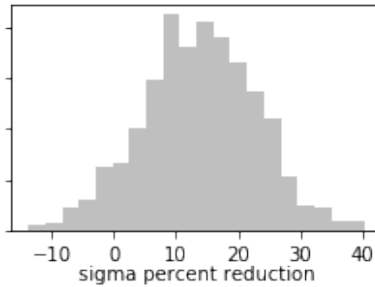
B) sigma change group:grstrt3, 705 entries
max: 32.0133, min: -12.8585



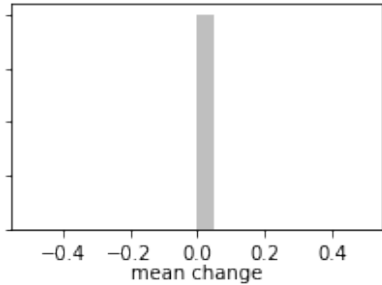
C) mean change group:grhk5, 705 entries
max: 0.362236, min: -0.375987



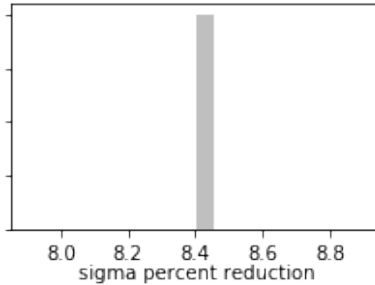
D) sigma change group:grhk5, 705 entries
max: 40.2772, min: -13.6757



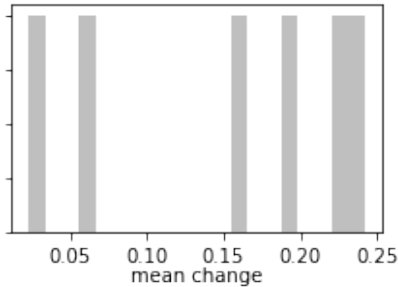
E) mean change group:strt6_cn, 1 entries
max:-0.00083552, min:-0.00083552



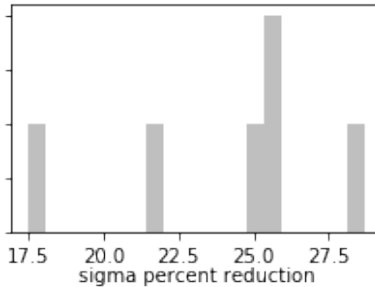
F) sigma change group:strt6_cn, 1 entries
max: 8.40444, min: 8.40444



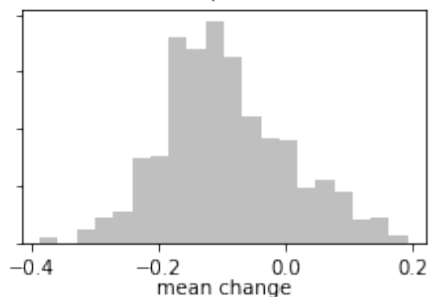
G) mean change group:welflux_k02, 6 entries
max: 0.242147, min: 0.02308



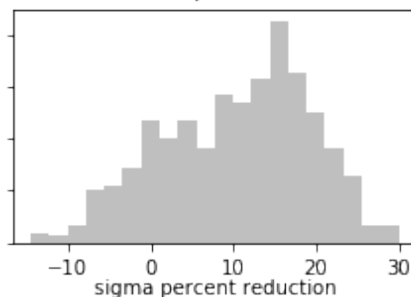
H) sigma change group:welflux_k02, 6 entries
max: 28.6957, min: 17.5033



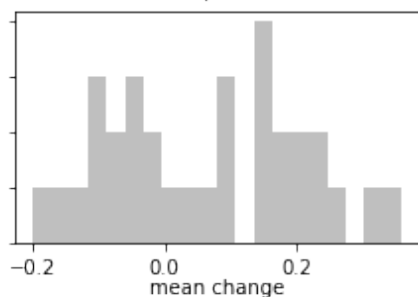
A) mean change group:grhk3, 705 entries
max: 0.192116, min: -0.385994



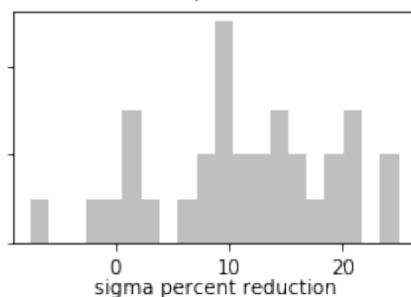
B) sigma change group:grhk3, 705 entries
max: 29.9566, min: -14.5106



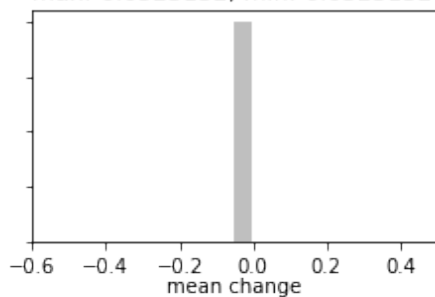
C) mean change group:pp_vka1, 32 entries
max: 0.358568, min: -0.199539



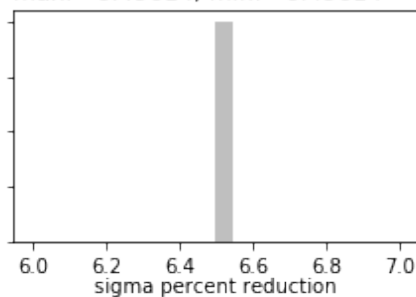
D) sigma change group:pp_vka1, 32 entries
max: 24.9157, min: -7.42191



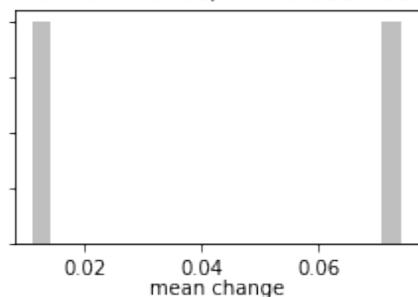
E) mean change group:ss7_cn, 1 entries
max:-0.0523132, min:-0.0523132



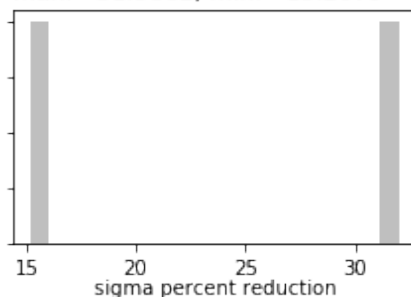
F) sigma change group:ss7_cn, 1 entries
max: 6.49614, min: 6.49614

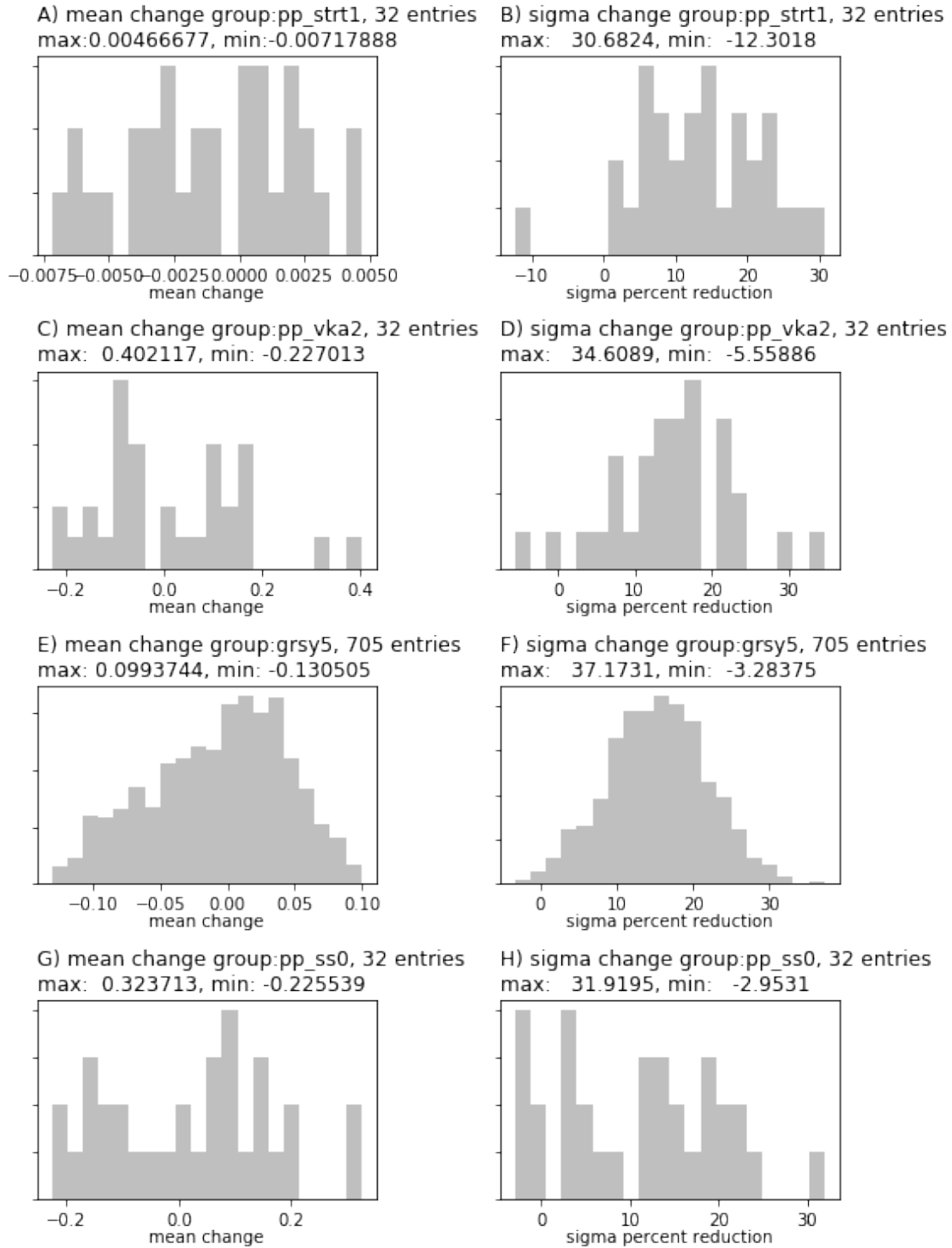


G) mean change group:welflux, 2 entries
max: 0.0740751, min: 0.0110752

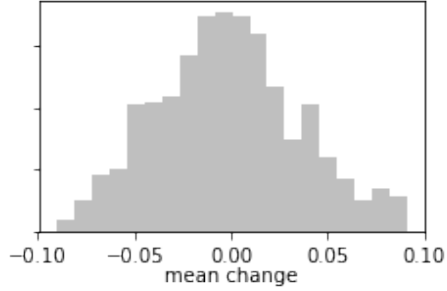


H) sigma change group:welflux, 2 entries
max: 31.9862, min: 15.2079

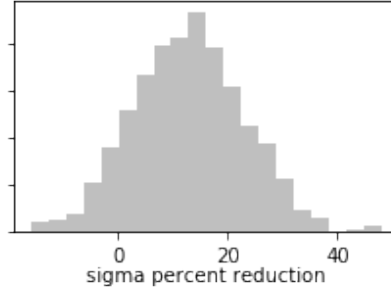




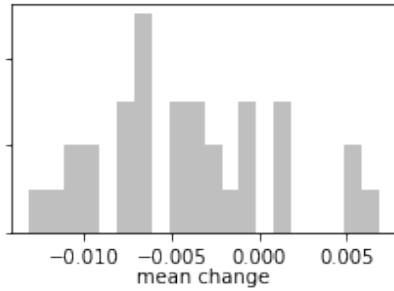
A) mean change group:grsy3, 705 entries
max: 0.0916073, min:-0.0905018



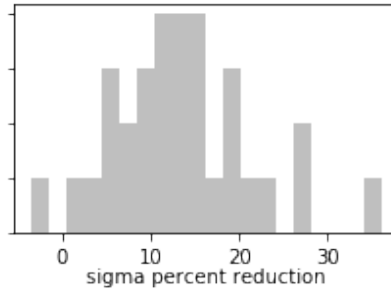
B) sigma change group:grsy3, 705 entries
max: 48.0864, min: -15.9649



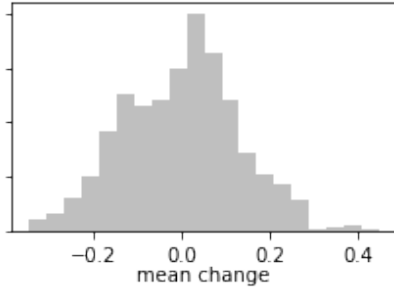
C) mean change group:pp_rech0, 32 entries
max:0.00692882, min:-0.013211



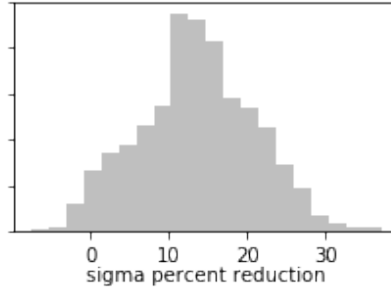
D) sigma change group:pp_rech0, 32 entries
max: 36.1962, min: -3.57398



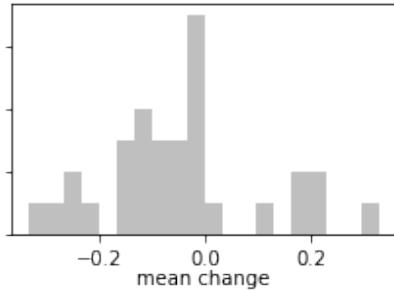
E) mean change group:grvka4, 705 entries
max: 0.450722, min:-0.350159



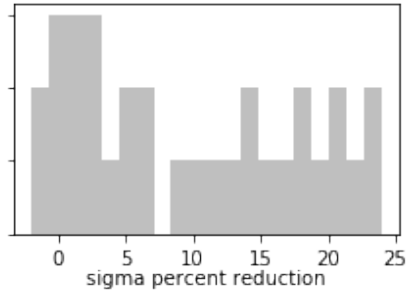
F) sigma change group:grvka4, 705 entries
max: 37.1495, min: -7.61896



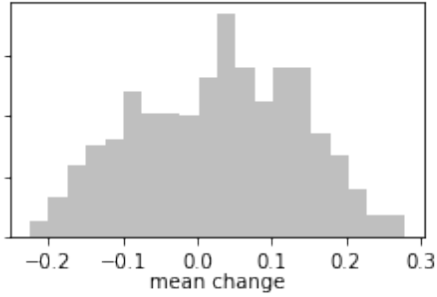
G) mean change group:pp_hk1, 32 entries
max: 0.32824, min:-0.333787



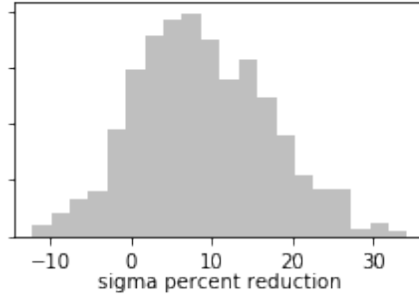
H) sigma change group:pp_hk1, 32 entries
max: 24.0101, min: -2.04698



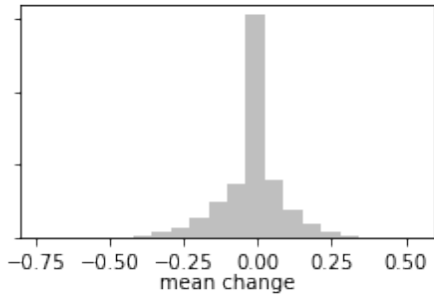
A) mean change group:grhk4, 705 entries
max: 0.279431, min: -0.2252



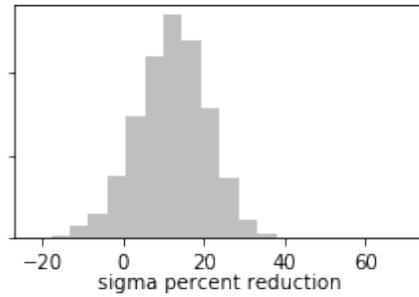
B) sigma change group:grhk4, 705 entries
max: 34.2756, min: -12.2028



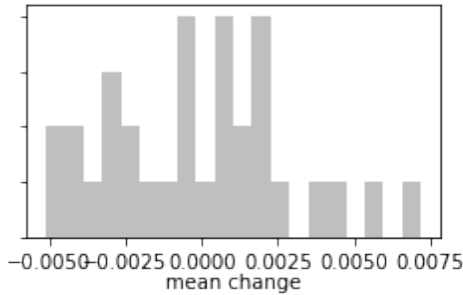
C) mean change group:all, 12605 entries
max: 0.531096, min: -0.737168



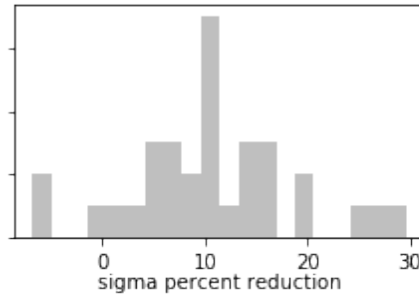
D) sigma change group:all, 12605 entries
max: 70.4514, min: -22.3415



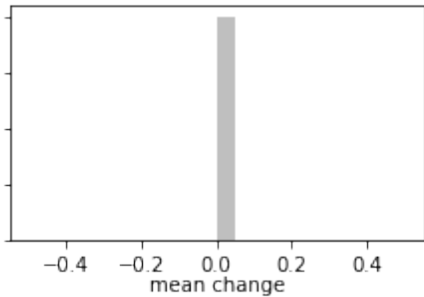
E) mean change group:pp_strt2, 32 entries
max:0.00720067, min:-0.00511891



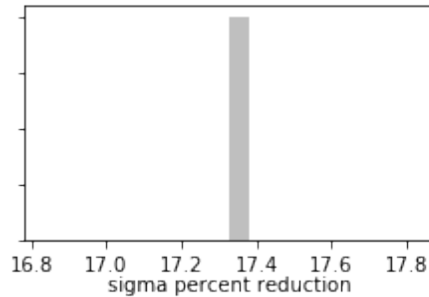
F) sigma change group:pp_strt2, 32 entries
max: 29.7992, min: -6.83996



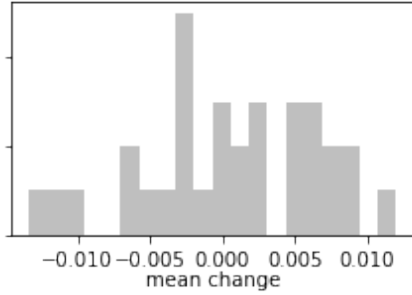
G) mean change group:strt7_cn, 1 entries
max:0.00210986, min:0.00210986



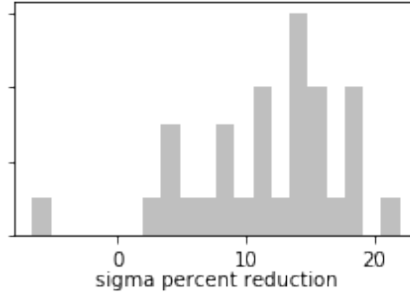
H) sigma change group:strt7_cn, 1 entries
max: 17.3286, min: 17.3286



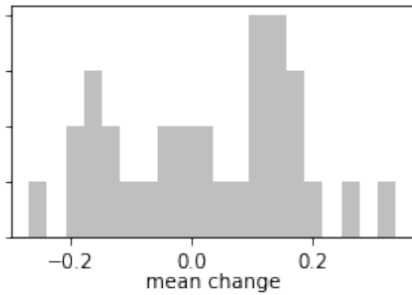
A) mean change group:pp_rech1, 32 entries
max: 0.0120034, min:-0.0133938



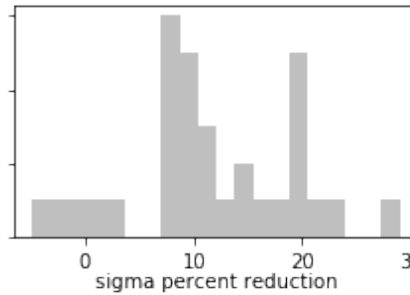
B) sigma change group:pp_rech1, 32 entries
max: 21.9726, min: -6.65121



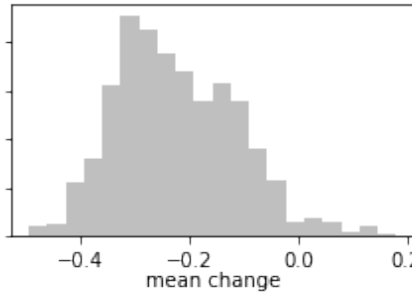
C) mean change group:pp_hk0, 32 entries
max: 0.339188, min: -0.269506



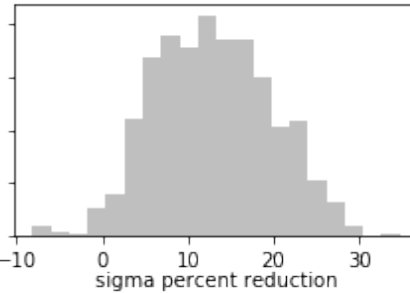
D) sigma change group:pp_hk0, 32 entries
max: 29.0031, min: -4.85968



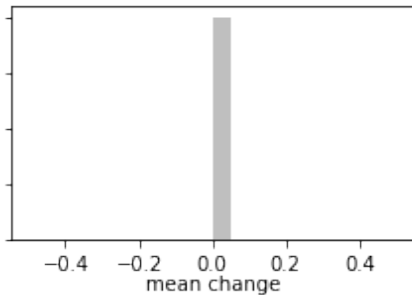
E) mean change group:grss5, 705 entries
max: 0.180068, min: -0.493738



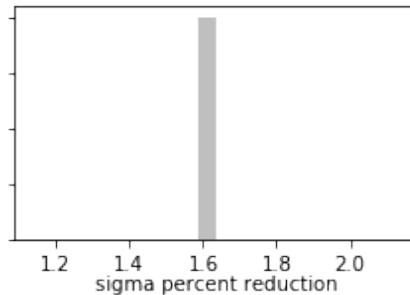
F) sigma change group:grss5, 705 entries
max: 34.8022, min: -8.15344



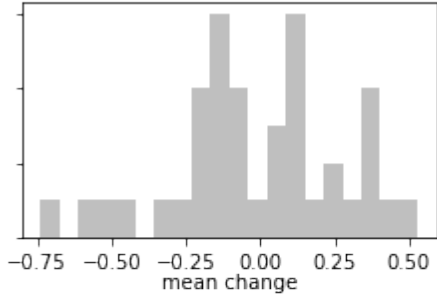
G) mean change group:strt8_cn, 1 entries
max:8.29921E-05, min:8.29921E-05



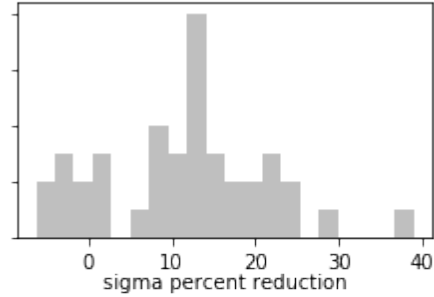
H) sigma change group:strt8_cn, 1 entries
max: 1.63602, min: 1.63602



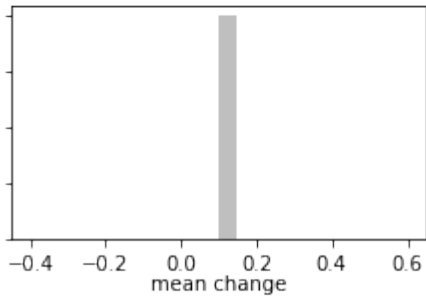
A) mean change group:strk, 40 entries
max: 0.531096, min: -0.737168



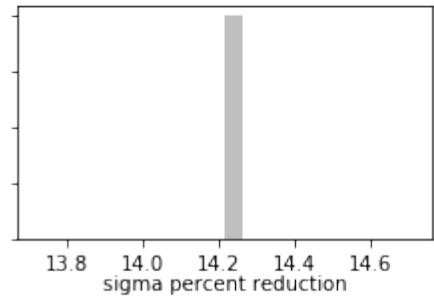
B) sigma change group:strk, 40 entries
max: 38.9038, min: -6.24839



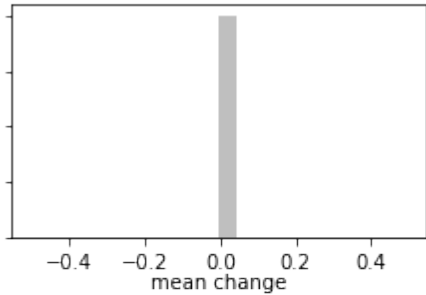
C) mean change group:ss8_cn, 1 entries
max: 0.0992234, min: 0.0992234



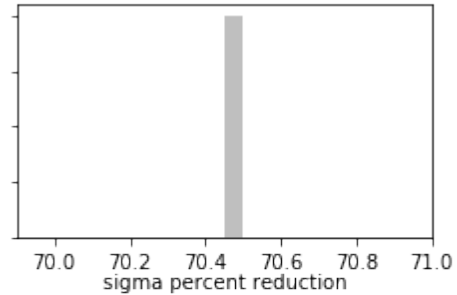
D) sigma change group:ss8_cn, 1 entries
max: 14.2162, min: 14.2162



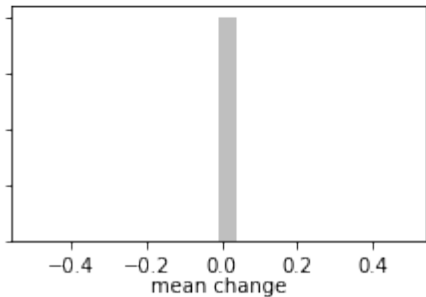
E) mean change group:flow, 1 entries
max:-0.00492203, min:-0.00492203



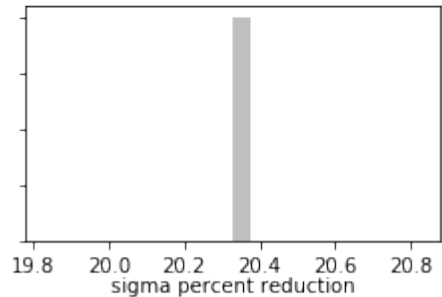
F) sigma change group:flow, 1 entries
max: 70.4514, min: 70.4514



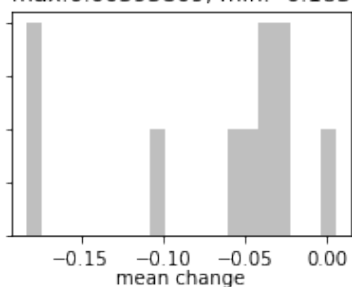
G) mean change group:rech4_cn, 1 entries
max:-0.00904351, min:-0.00904351



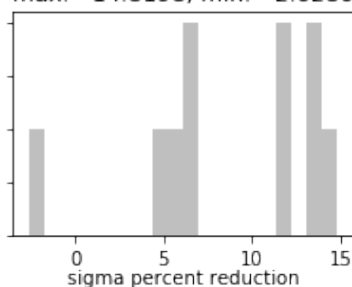
H) sigma change group:rech4_cn, 1 entries
max: 20.3283, min: 20.3283



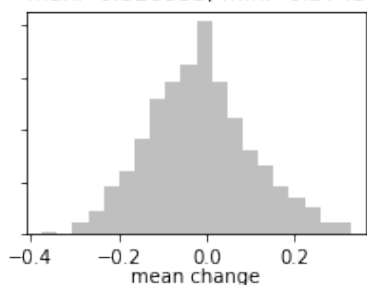
A) mean change group:drncond_k00, 10 entries
max:0.00595809, min: -0.183037



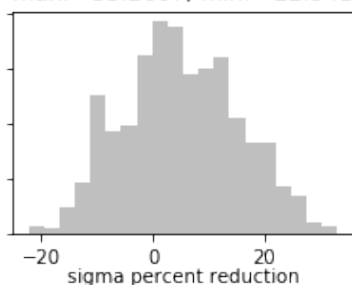
B) sigma change group:drncond_k00, 10 entries
max: 14.8198, min: -2.62803



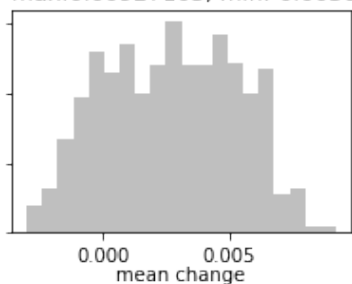
C) mean change group:grss3, 705 entries
max: 0.328935, min: -0.374376



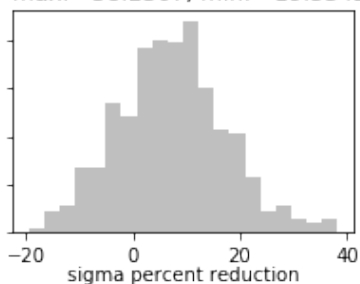
D) sigma change group:grss3, 705 entries
max: 33.2607, min: -22.3415



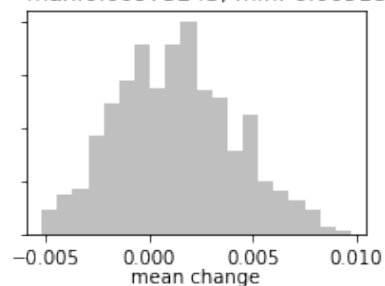
E) mean change group:grstrt5, 705 entries
max:0.00927105, min:-0.00304607



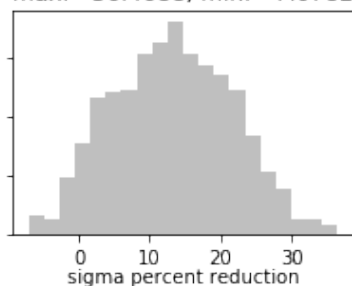
F) sigma change group:grstrt5, 705 entries
max: 38.2307, min: -19.5342



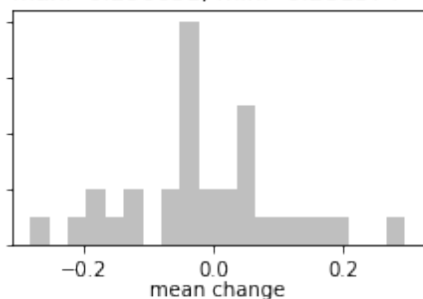
G) mean change group:grstrt4, 705 entries
max:0.00975243, min:-0.00518831



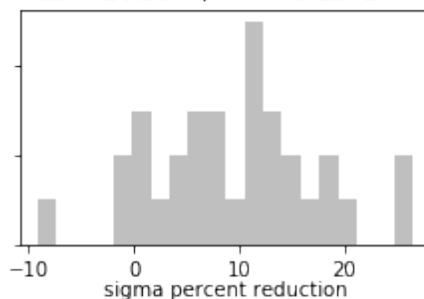
H) sigma change group:grstrt4, 705 entries
max: 36.4688, min: -7.07821



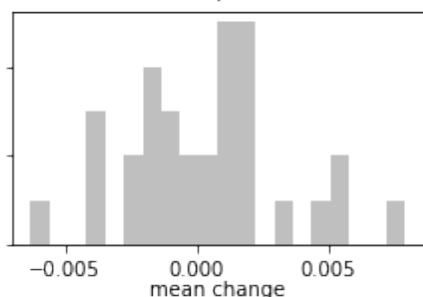
A) mean change group:pp_ss1, 32 entries
max: 0.296651, min: -0.281374



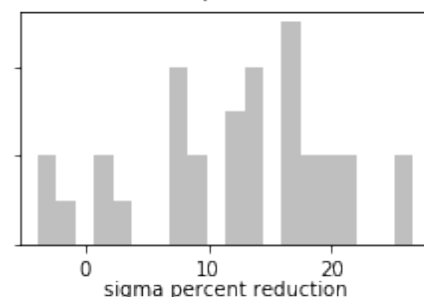
B) sigma change group:pp_ss1, 32 entries
max: 26.5644, min: -9.13414



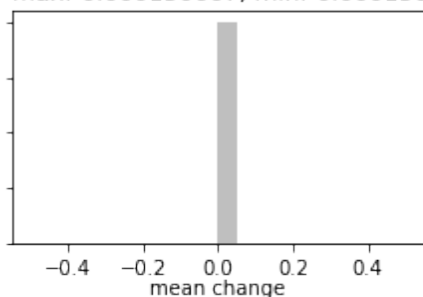
C) mean change group:pp_strt0, 32 entries
max:0.00791222, min:-0.00631947



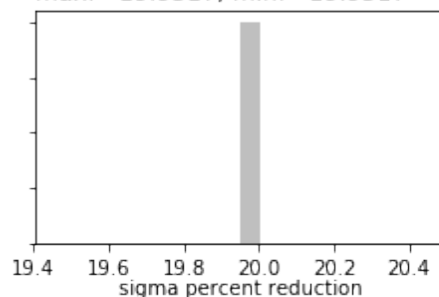
D) sigma change group:pp_strt0, 32 entries
max: 26.6317, min: -3.84395



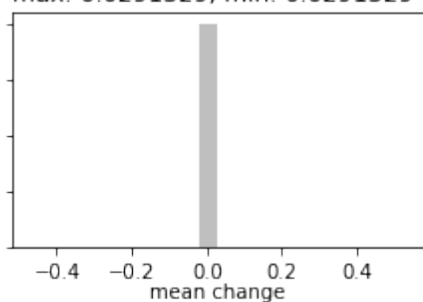
E) mean change group:rech5_cn, 1 entries
max:-0.000150667, min:-0.000150667



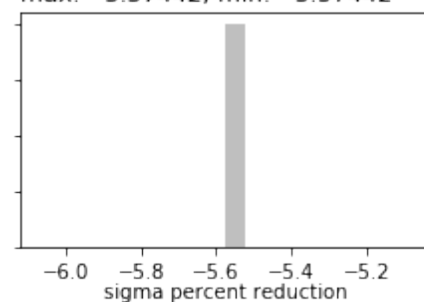
F) sigma change group:rech5_cn, 1 entries
max: 19.9517, min: 19.9517



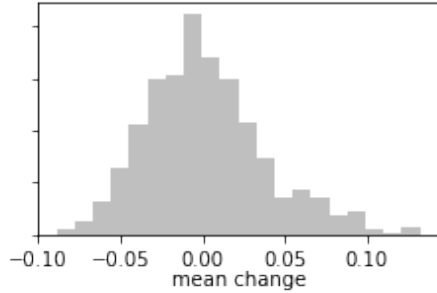
G) mean change group:vka7_cn, 1 entries
max: 0.0291329, min: 0.0291329



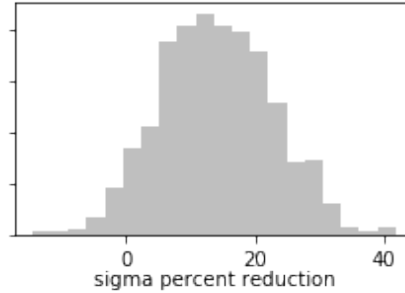
H) sigma change group:vka7_cn, 1 entries
max: -5.57442, min: -5.57442



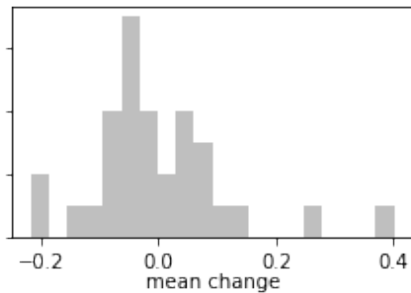
A) mean change group:grsy4, 705 entries
max: 0.132499, min:-0.0889423



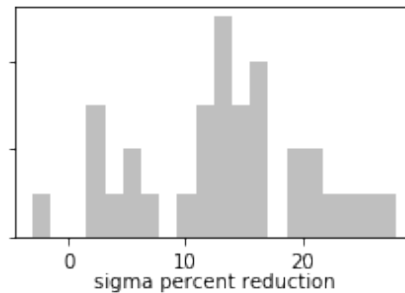
B) sigma change group:grsy4, 705 entries
max: 41.7008, min: -14.4243



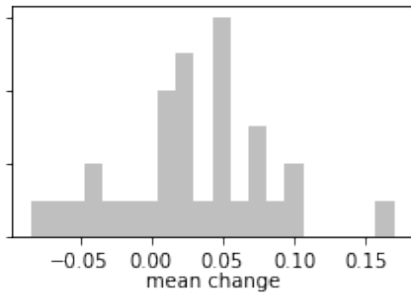
C) mean change group:pp_vka0, 32 entries
max: 0.400708, min:-0.217889



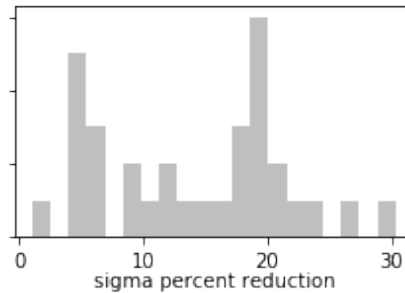
D) sigma change group:pp_vka0, 32 entries
max: 28, min: -3.14785



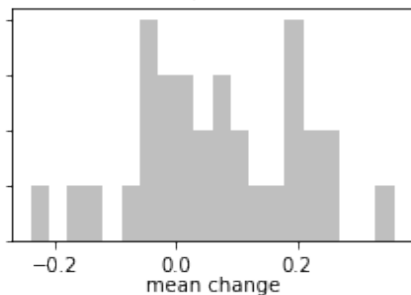
E) mean change group:pp_sy2, 32 entries
max: 0.170206, min:-0.0845847



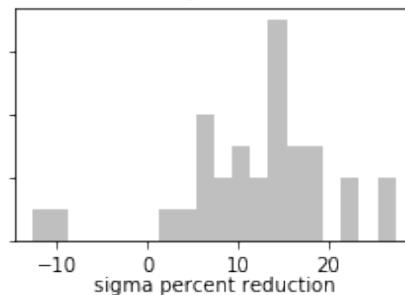
F) sigma change group:pp_sy2, 32 entries
max: 30.3024, min: 1.05086



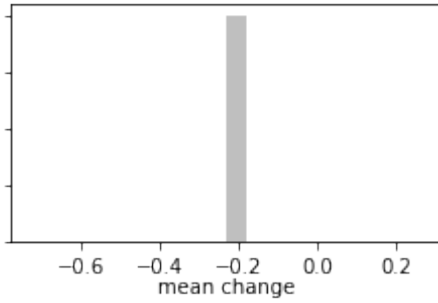
G) mean change group:pp_ss2, 32 entries
max: 0.35944, min:-0.239333



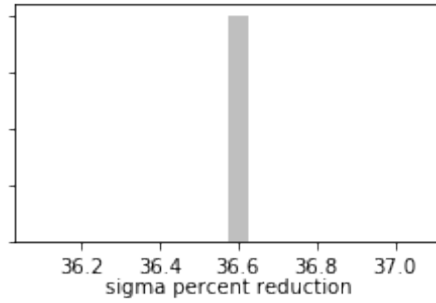
H) sigma change group:pp_ss2, 32 entries
max: 27.469, min: -12.7665



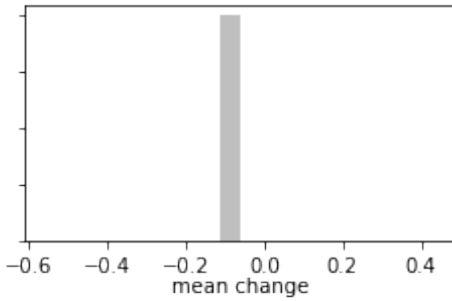
A) mean change group:hk8_cn, 1 entries
max: -0.232458, min: -0.232458



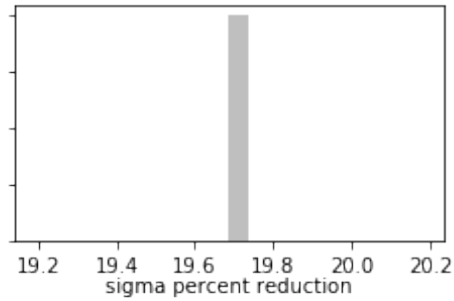
B) sigma change group:hk8_cn, 1 entries
max: 36.5773, min: 36.5773



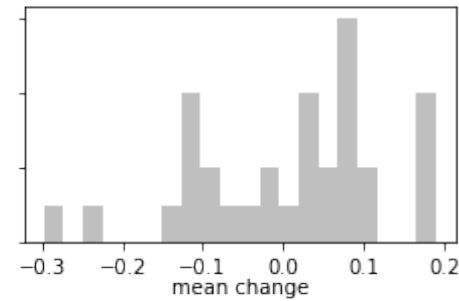
C) mean change group:sy6_cn, 1 entries
max: -0.062336, min: -0.062336



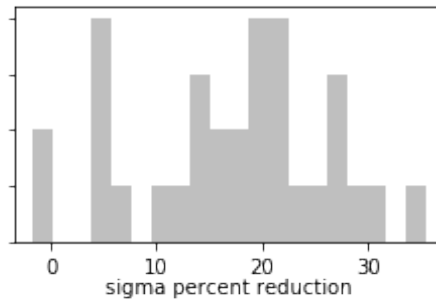
D) sigma change group:sy6_cn, 1 entries
max: 19.6873, min: 19.6873



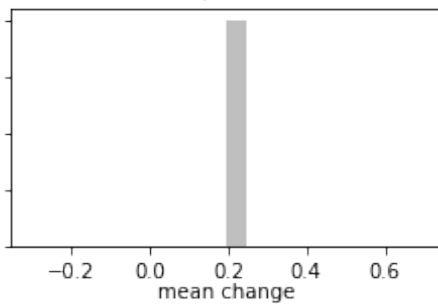
E) mean change group:pp_hk2, 32 entries
max: 0.189467, min: -0.297735



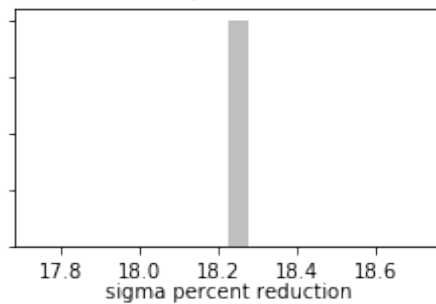
F) sigma change group:pp_hk2, 32 entries
max: 35.3836, min: -1.68303



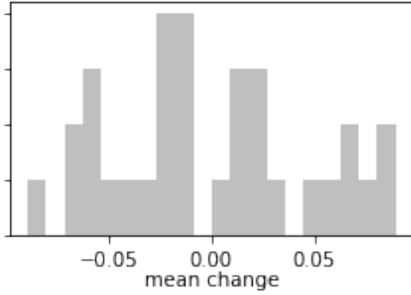
G) mean change group:hk6_cn, 1 entries
max: 0.194413, min: 0.194413



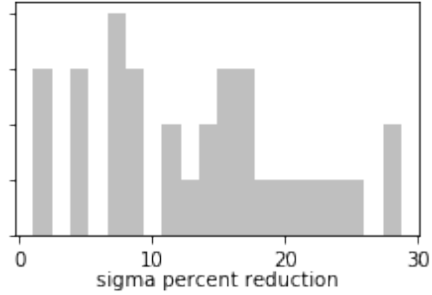
H) sigma change group:hk6_cn, 1 entries
max: 18.227, min: 18.227



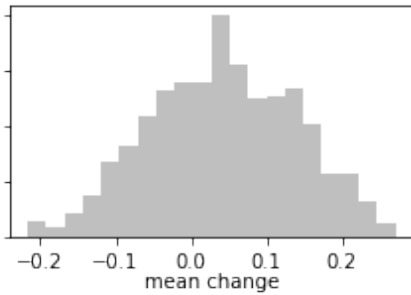
A) mean change group:pp_sy0, 32 entries
max: 0.0895291, min:-0.0891005



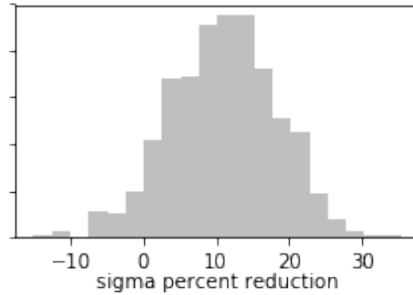
B) sigma change group:pp_sy0, 32 entries
max: 28.7608, min: 1.06458



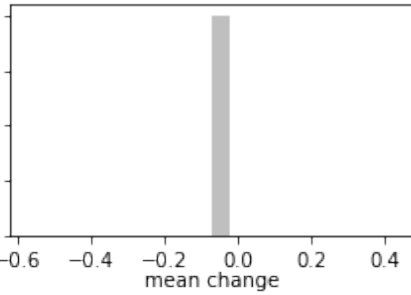
C) mean change group:grvka5, 705 entries
max: 0.270865, min: -0.216877



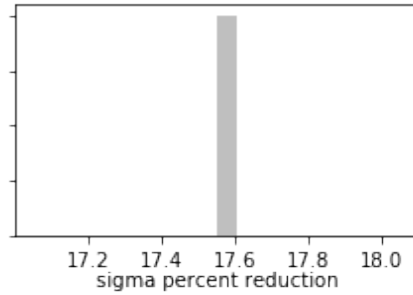
D) sigma change group:grvka5, 705 entries
max: 35.3615, min: -15.0333



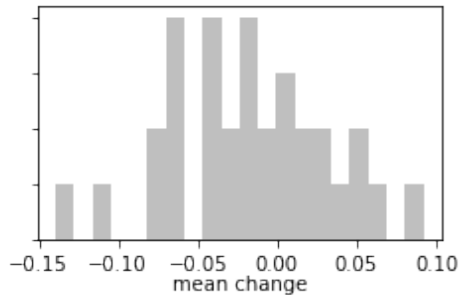
E) mean change group:hk7_cn, 1 entries
max:-0.0727548, min:-0.0727548



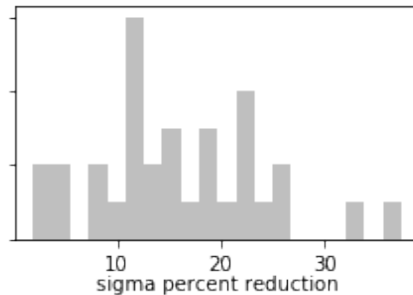
F) sigma change group:hk7_cn, 1 entries
max: 17.5538, min: 17.5538



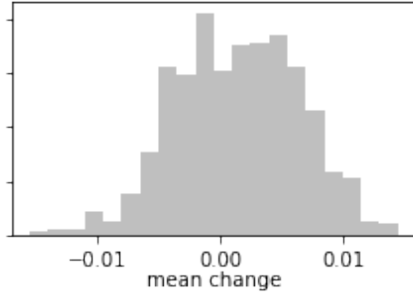
G) mean change group:pp_sy1, 32 entries
max: 0.0919632, min: -0.139343



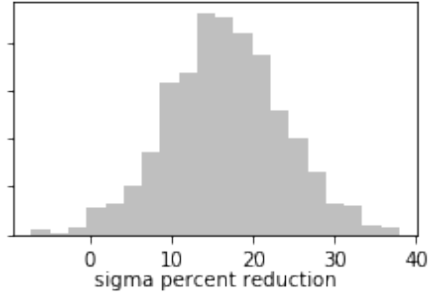
H) sigma change group:pp_sy1, 32 entries
max: 37.3755, min: 1.98049



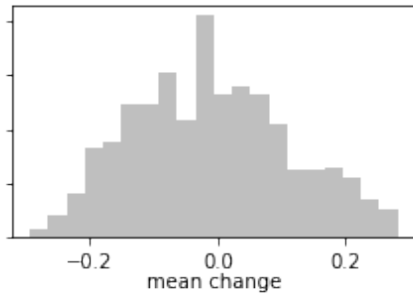
A) mean change group:grrech3, 705 entries
max: 0.0144108, min:-0.0155037



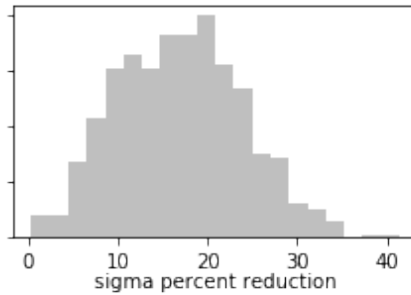
B) sigma change group:grrech3, 705 entries
max: 37.9391, min: -7.13929



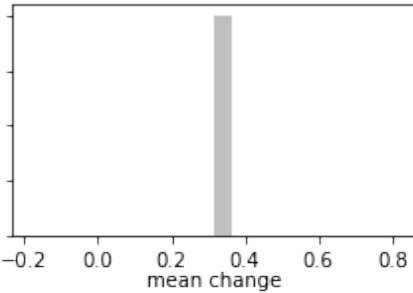
C) mean change group:grvka3, 705 entries
max: 0.281656, min: -0.293625



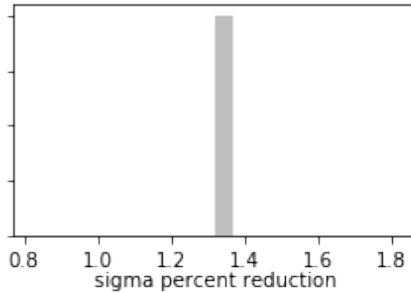
D) sigma change group:grvka3, 705 entries
max: 41.3873, min: 0.337299



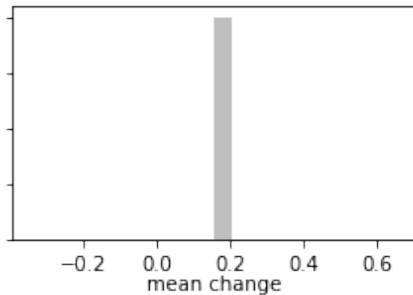
E) mean change group:vka8_cn, 1 entries
max: 0.314932, min: 0.314932



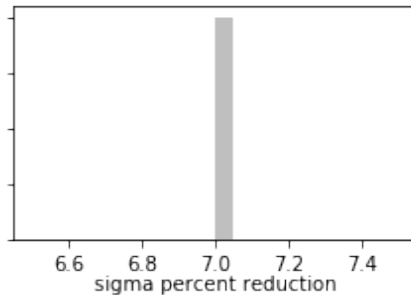
F) sigma change group:vka8_cn, 1 entries
max: 1.32071, min: 1.32071



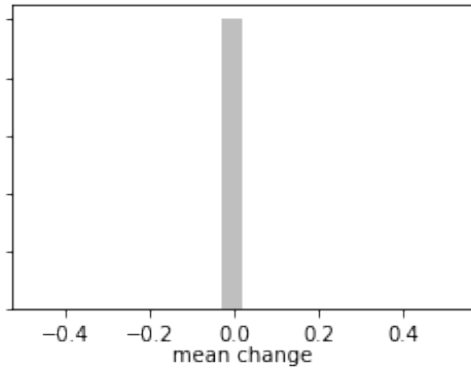
G) mean change group:vka6_cn, 1 entries
max: 0.156557, min: 0.156557



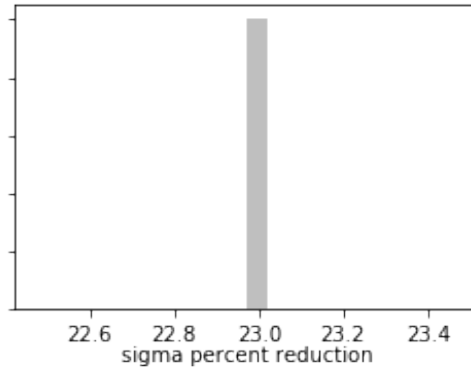
H) sigma change group:vka6_cn, 1 entries
max: 6.99983, min: 6.99983



A) mean change group:sy8_cn, 1 entries
max: 0.0205511, min: 0.0205511



B) sigma change group:sy8_cn, 1 entries
max: 22.9708, min: 22.9708



Those are some pretty extreme variance reductions, considering we are conditioning 10K+ pars on 13 water levels and one flux. This is a well-known issue with low-rank ensemble method

("ensemble collapse"). This is over come with localization...

1.0.2 PESTPP-IES with simple temporal localization

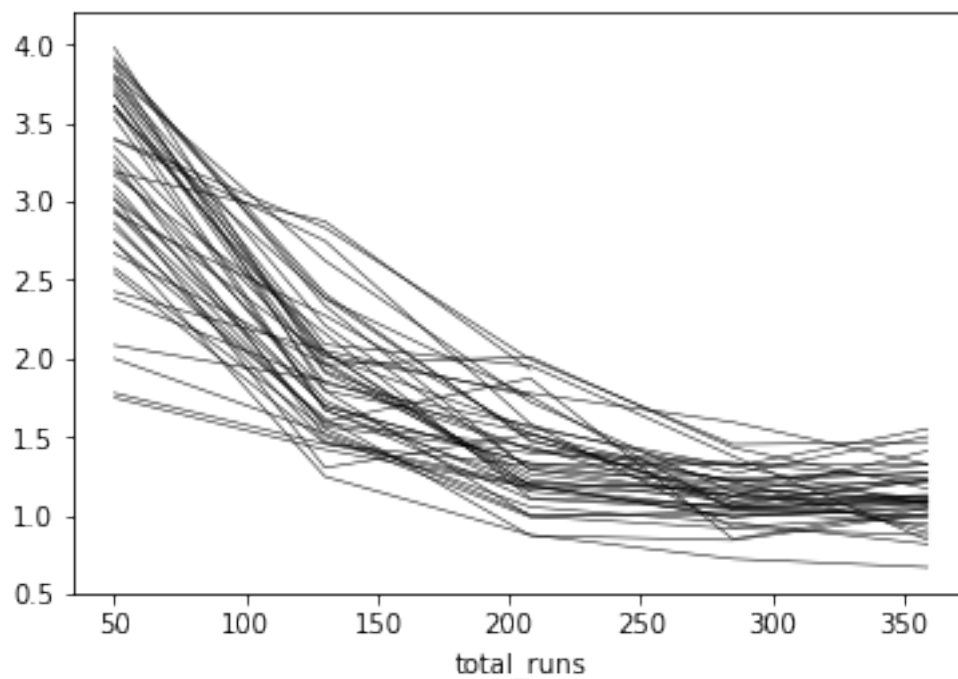
Now let's add some localization. The obvious stuff is temporal - scenario parameters can't influence historic observations (and the inverse is true) so let's tell PESTPP-IES about this:

```
In [12]: par = pst.parameter_data
         #parameter groups for future recharge
         scen_groups = ["grrech3", "pp_rech1", "rech5_cn"]
         scen_pars = par.loc[par.pargp.apply(lambda x: x in scen_groups), "parname"].tolist()
         scen_pars.append("welflux_001")

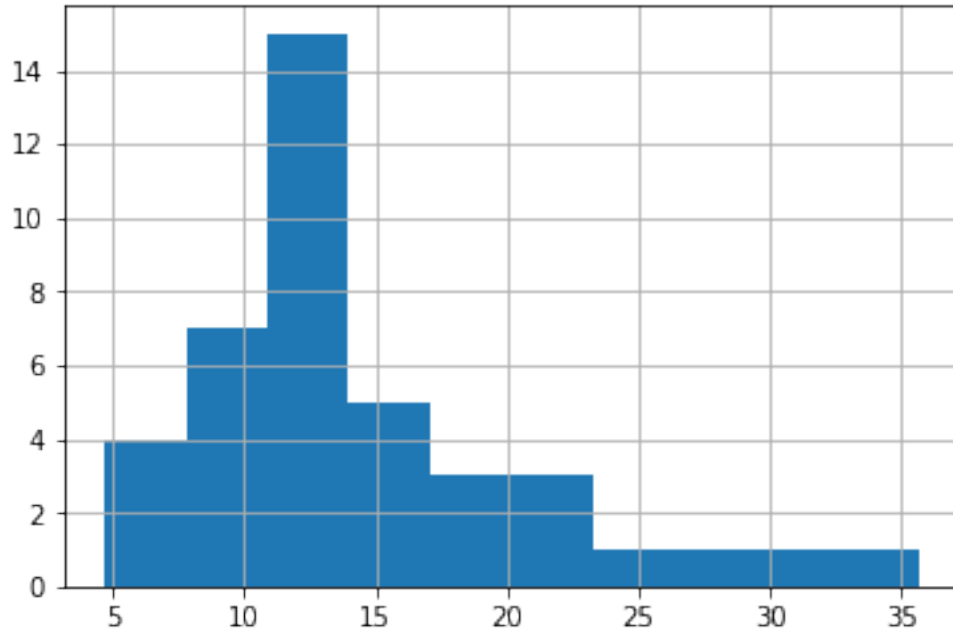
In [13]: loc = pyemu.Matrix.from_names(pst.nnz_obs_names, pst.par_groups).to_dataframe()
         loc.loc[:, :] = 1.0
         loc.loc[:, scen_groups] = 0.0
         pyemu.Matrix.from_dataframe(loc).to_ascii(os.path.join(t_d, "loc.mat"))

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

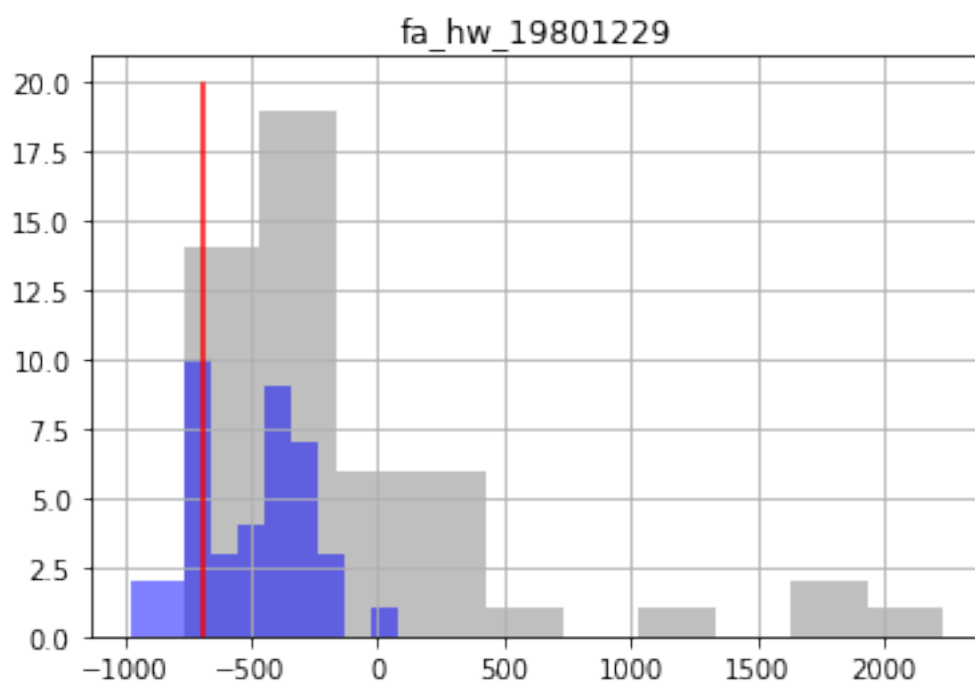
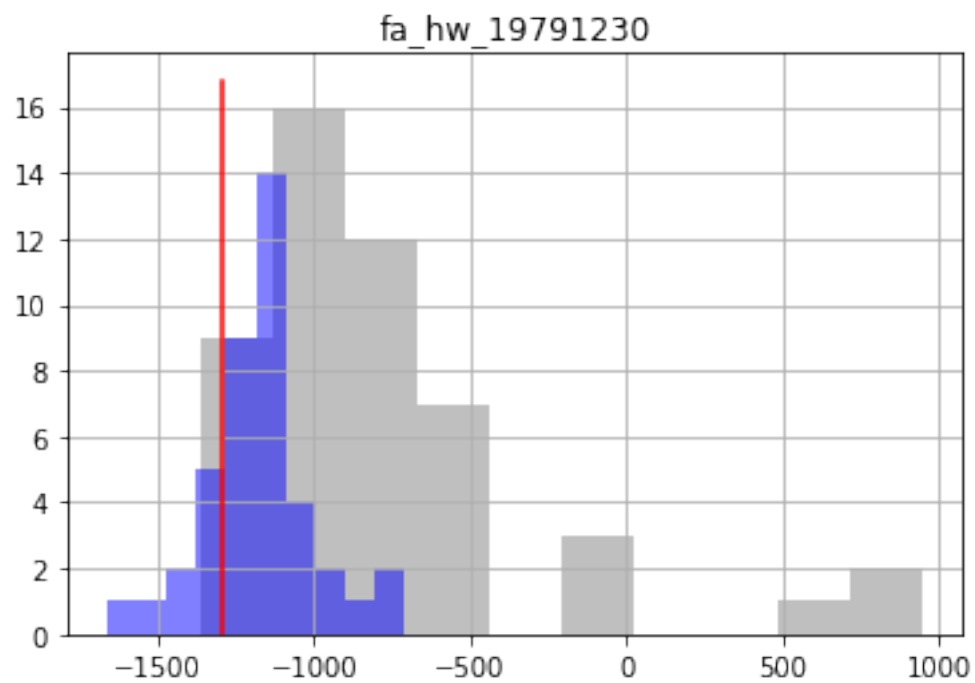
In [15]: phi = pd.read_csv(os.path.join(m_d, "freyberg_ies.phi.actual.csv"), index_col=0)
         phi.index = phi.total_runs
         phi.iloc[:, 6:].apply(np.log10).plot(legend=False, lw=0.5, color='k')
         plt.show()
         phi.iloc[-1, 6:].hist()
```

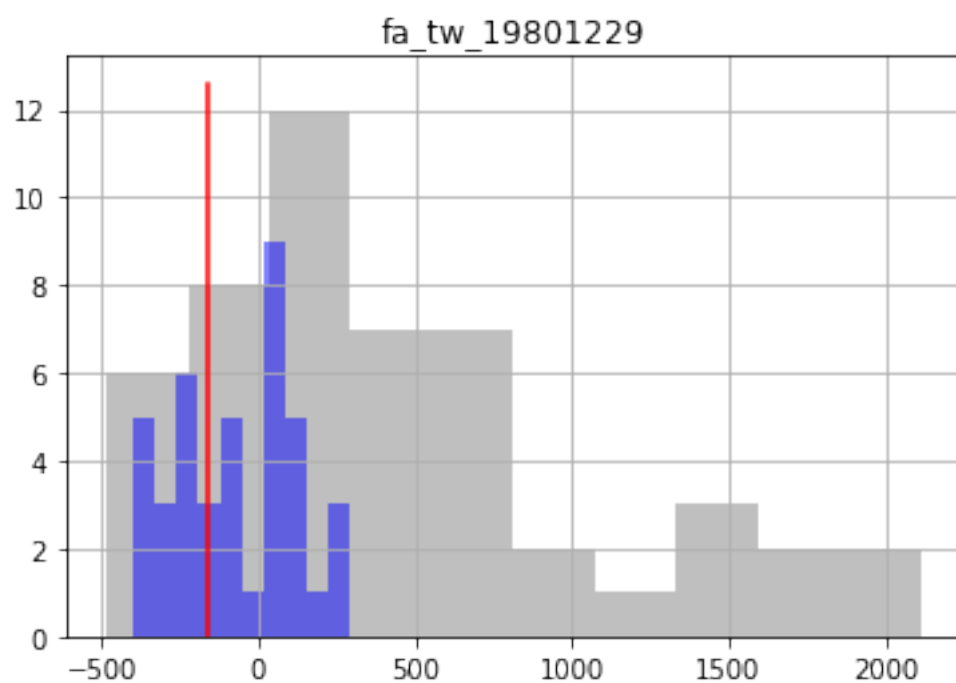
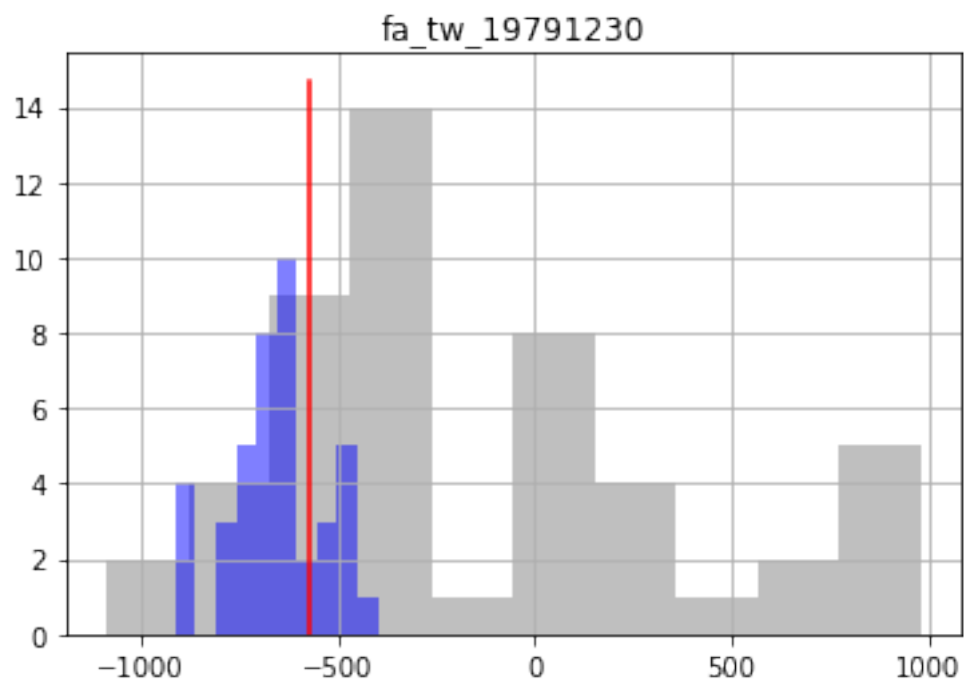


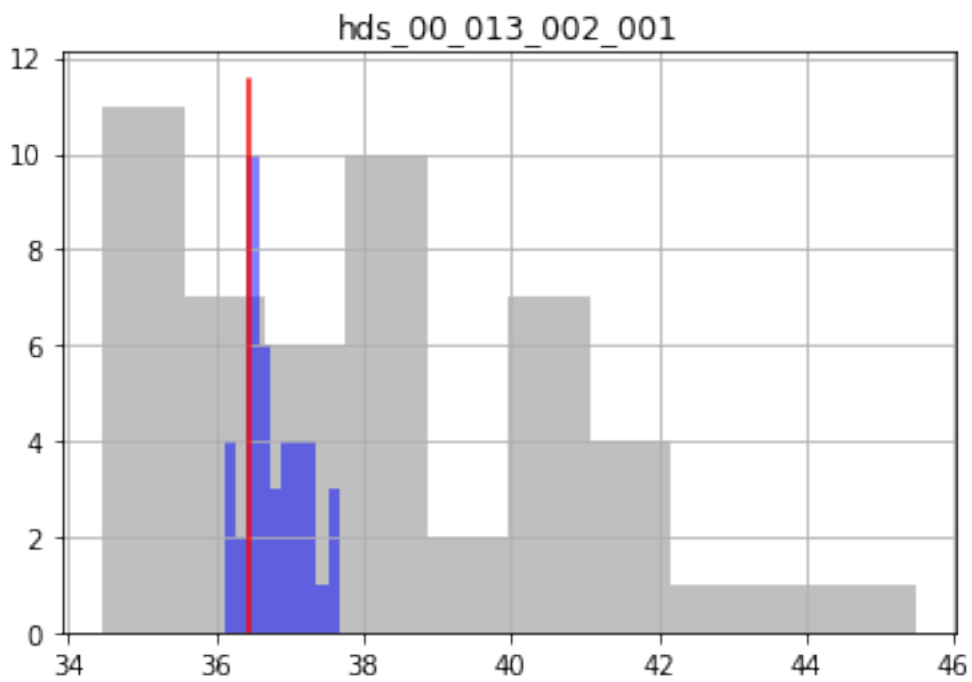
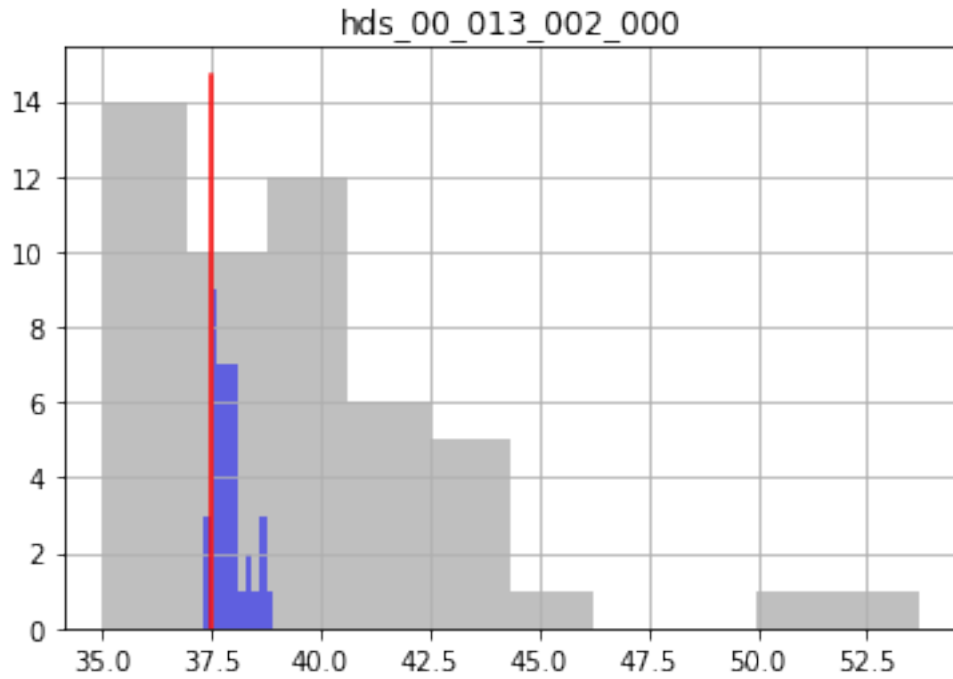
Out[15]: <matplotlib.axes._subplots.AxesSubplot at 0x1822350b38>



```
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)

```

(50, 12605) (41, 12605)

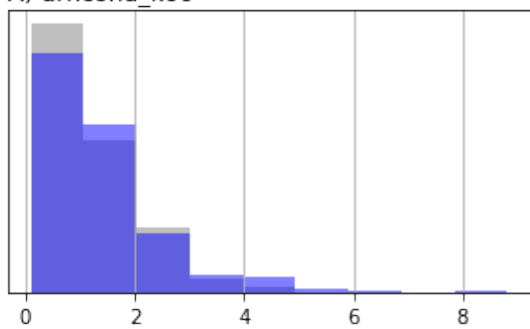
```

Out[17]: [<Figure size 576x756 with 0 Axes>,
<Figure size 576x756 with 8 Axes>,
<Figure size 576x756 with 8 Axes>,
<Figure size 576x756 with 8 Axes>,
<Figure size 576x756 with 8 Axes>,
<Figure size 576x756 with 8 Axes>,
<Figure size 576x756 with 8 Axes>,
<Figure size 576x756 with 8 Axes>,
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<Figure size 576x756 with 8 Axes>,
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<Figure size 576x756 with 8 Axes>,
<Figure size 576x756 with 8 Axes>,
<Figure size 576x756 with 8 Axes>]

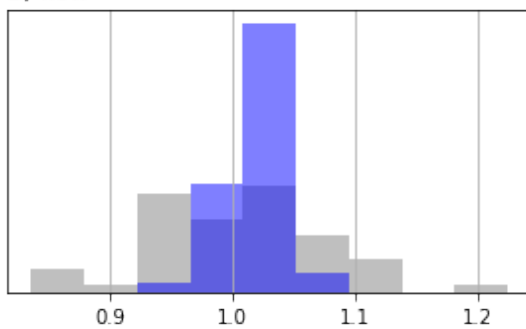
```

<Figure size 576x756 with 0 Axes>

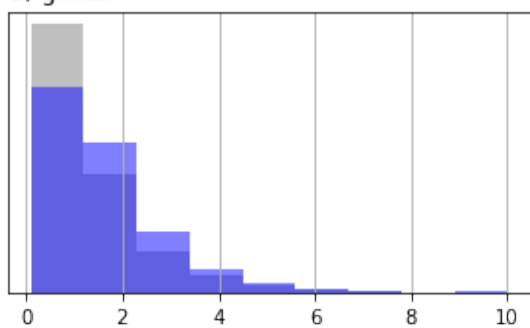
A) `drncond_k00`



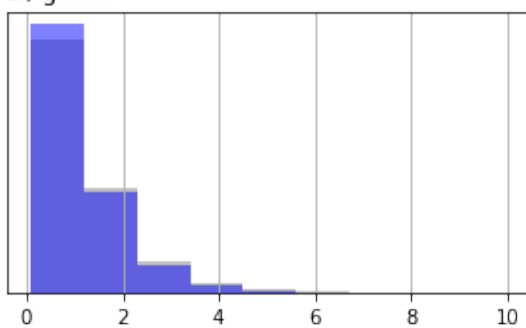
B) `flow`



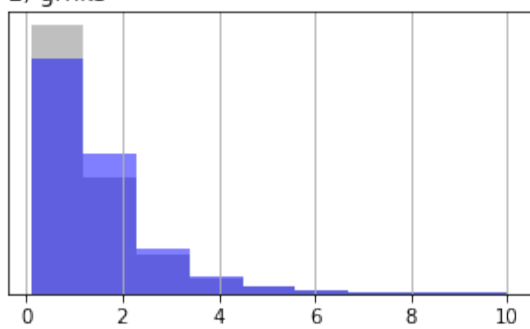
C) `grhk3`



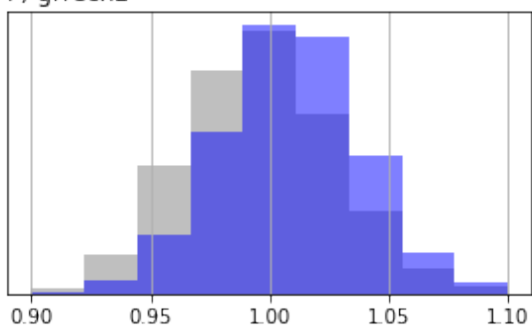
D) `grhk4`



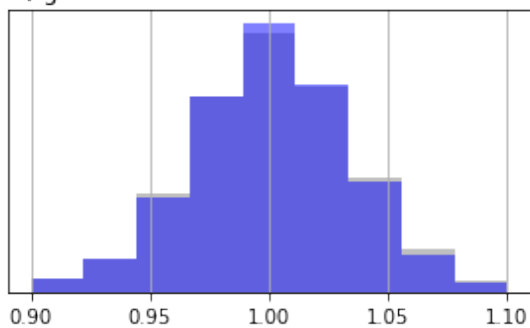
E) `grhk5`



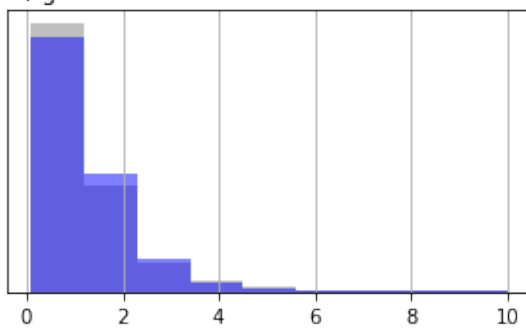
F) `grrech2`



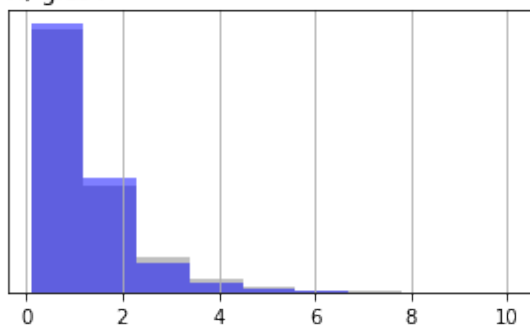
G) `grrech3`



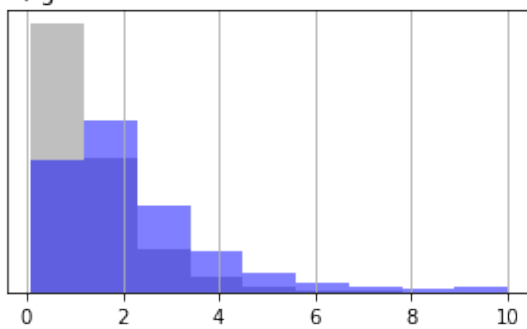
H) `grss3`



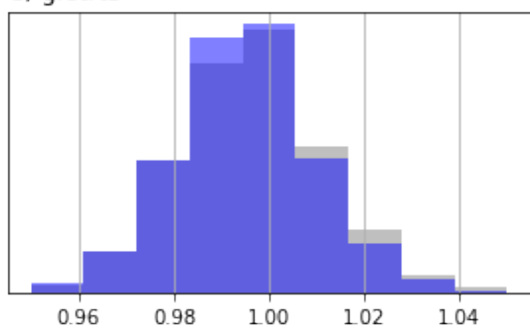
A) grss4



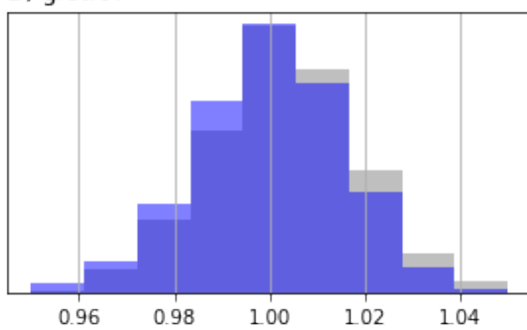
B) grss5



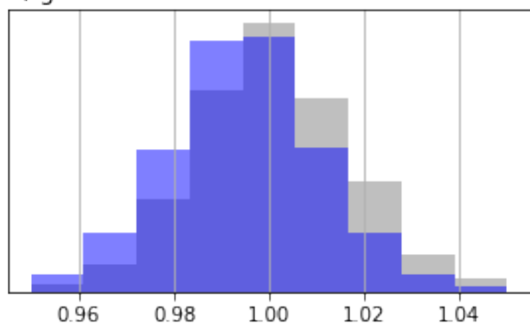
C) grstrt3



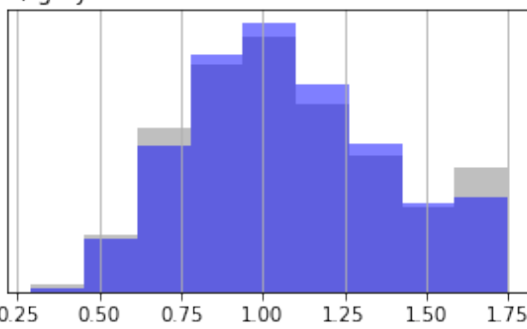
D) grstrt4



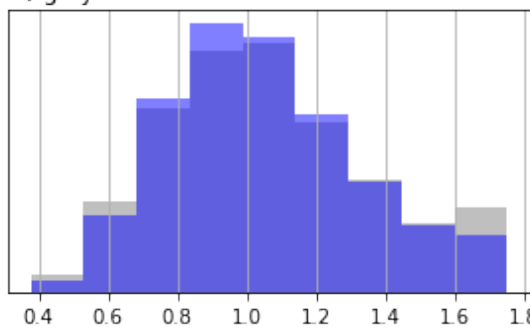
E) grstrt5



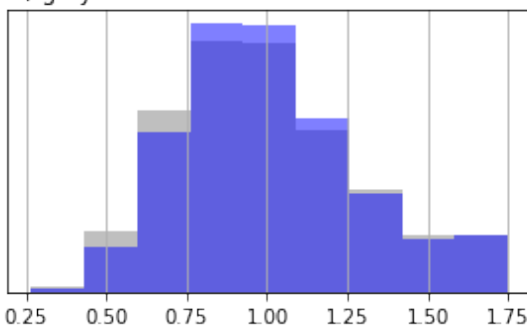
F) grsy3



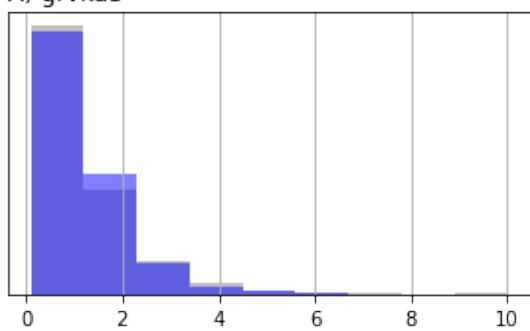
G) grsy4



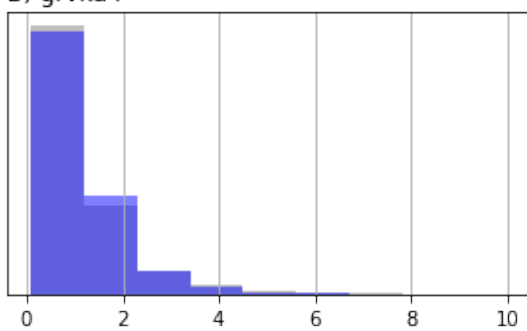
H) grsy5



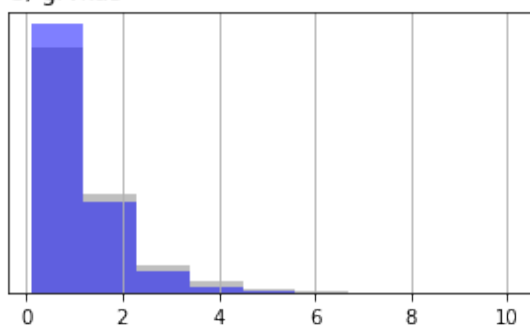
A) grvka3



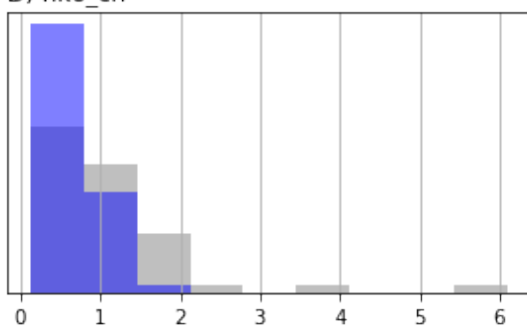
B) grvka4



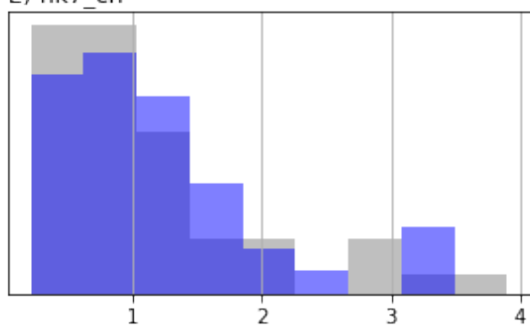
C) grvka5



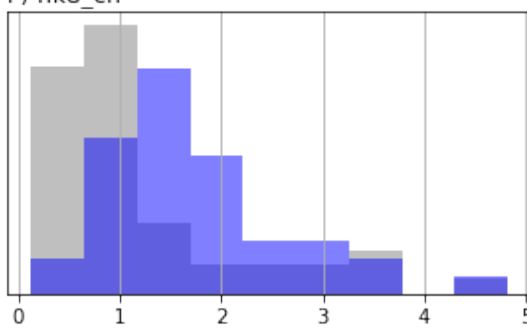
D) hk6_cn



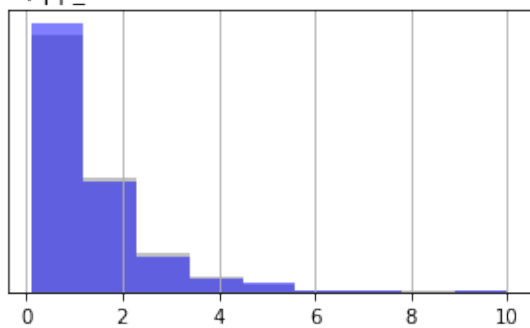
E) hk7_cn



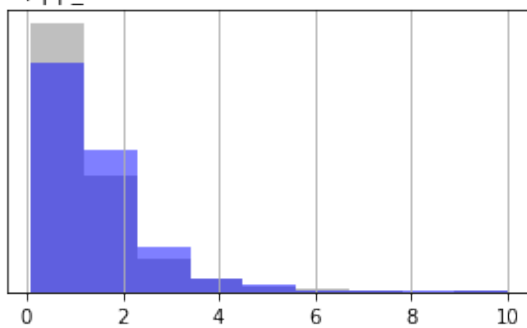
F) hk8_cn



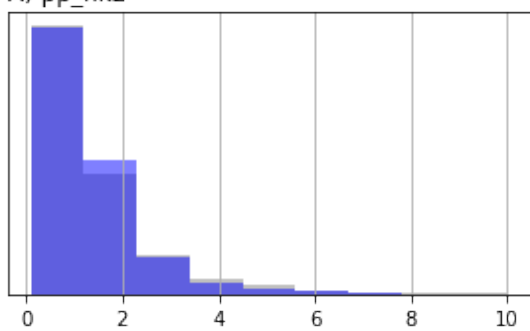
G) pp_hk0



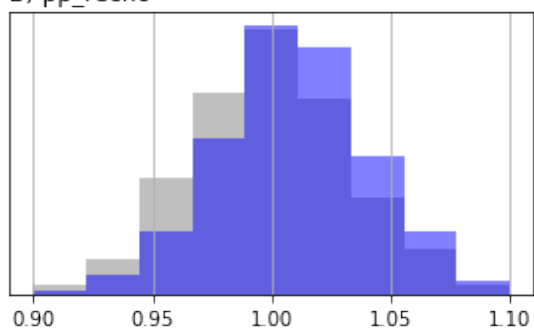
H) pp_hk1



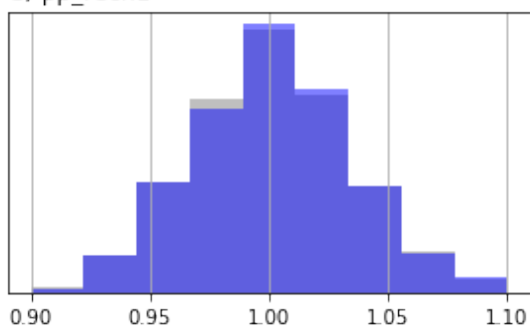
A) pp_hk2



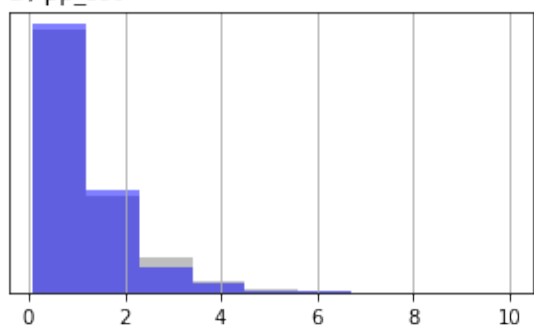
B) pp_rech0



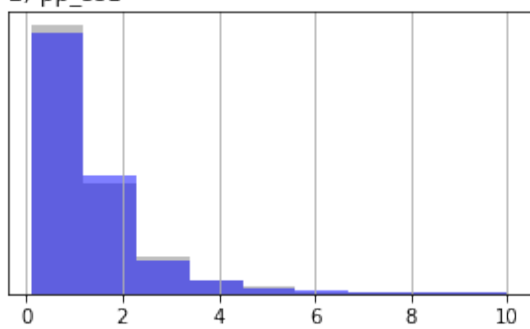
C) pp_rech1



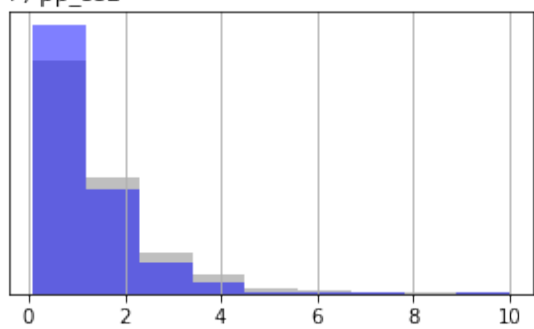
D) pp_ss0



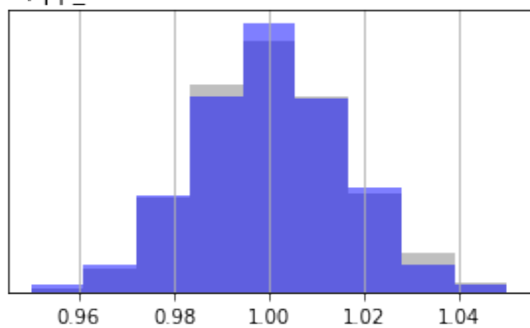
E) pp_ss1



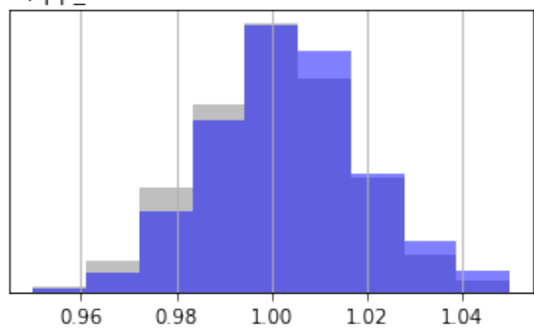
F) pp_ss2



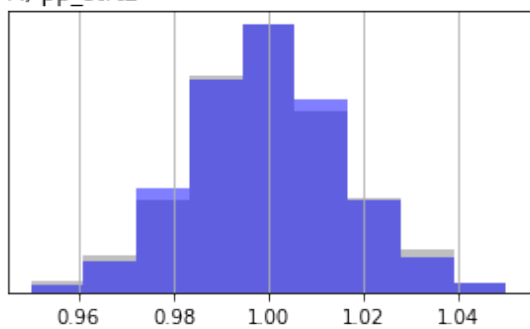
G) pp_strt0



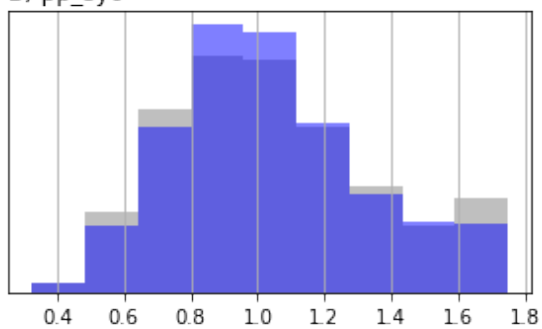
H) pp_strt1



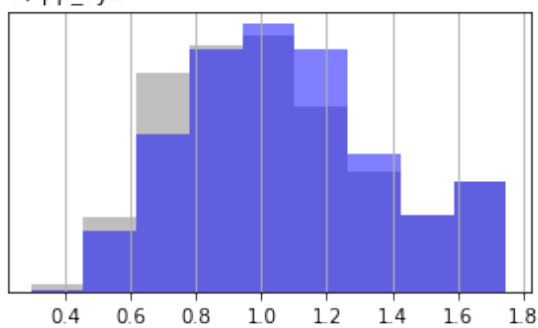
A) pp_strt2



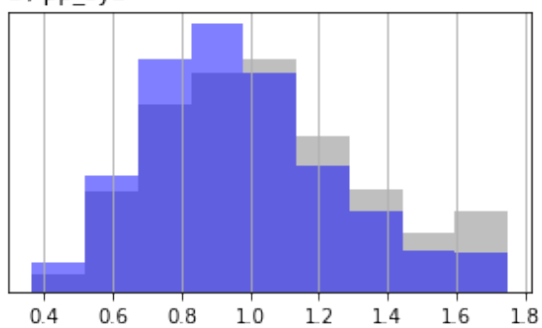
B) pp_sy0



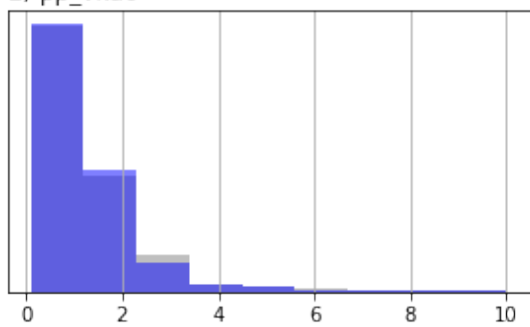
C) pp_sy1



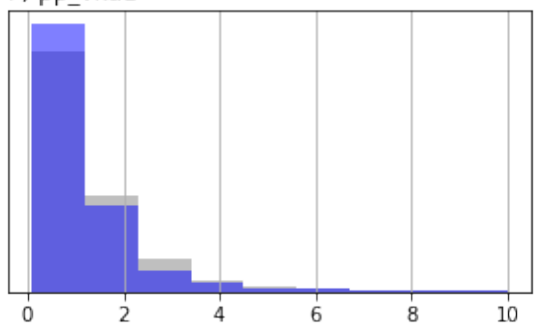
D) pp_sy2



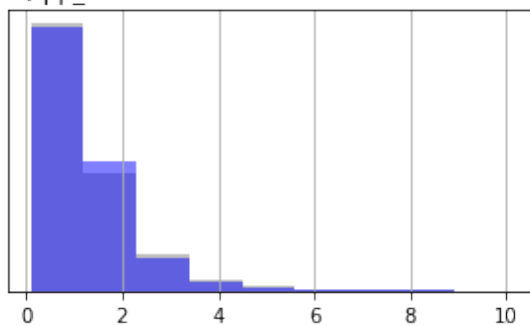
E) pp_vka0



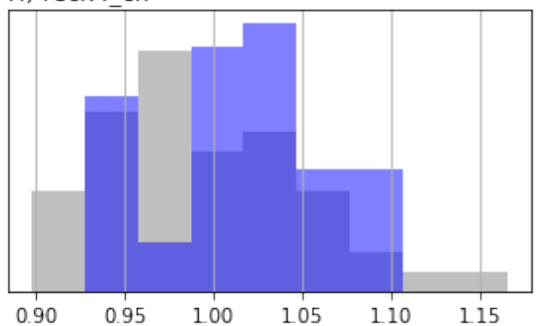
F) pp_vka1

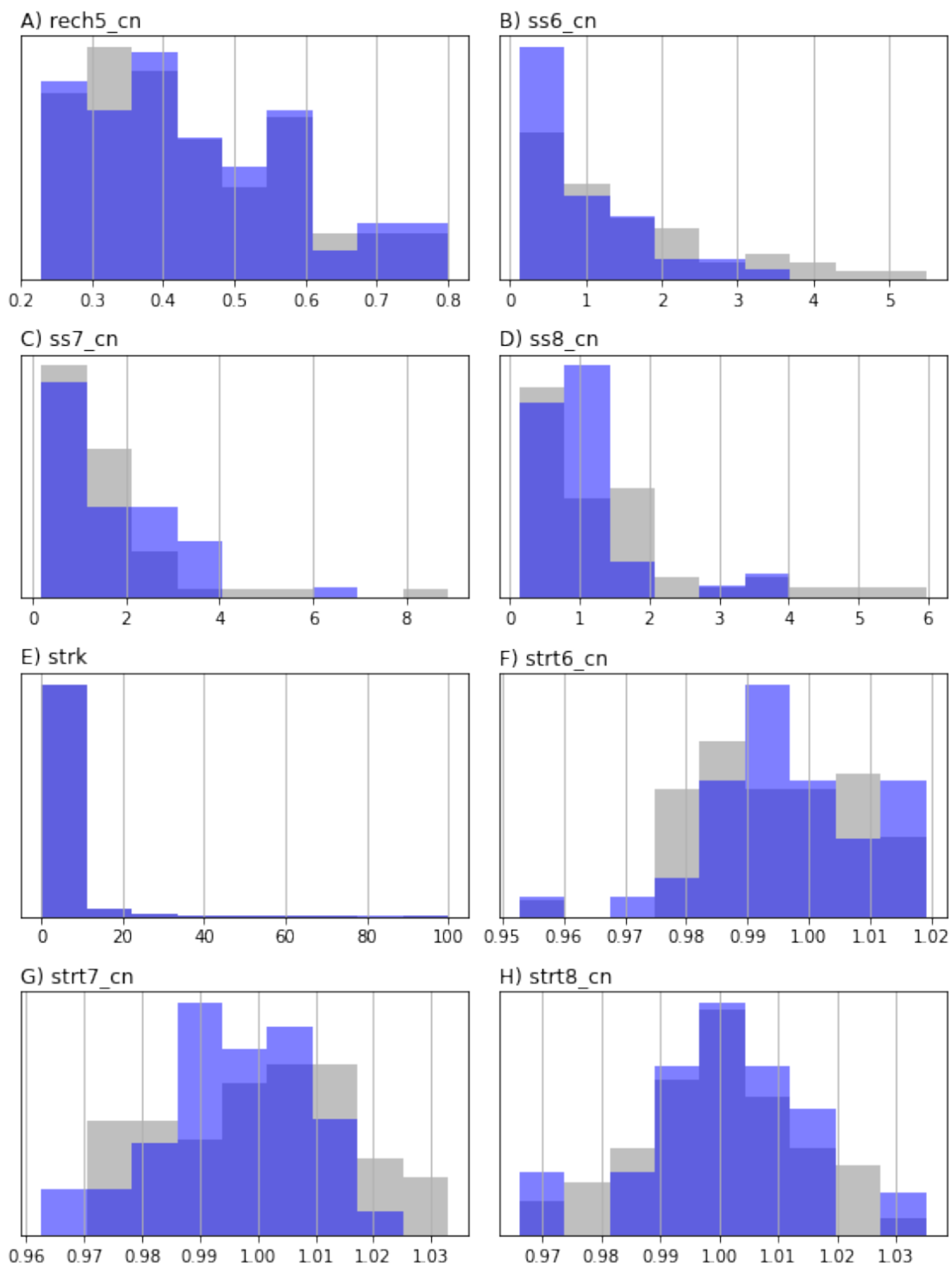


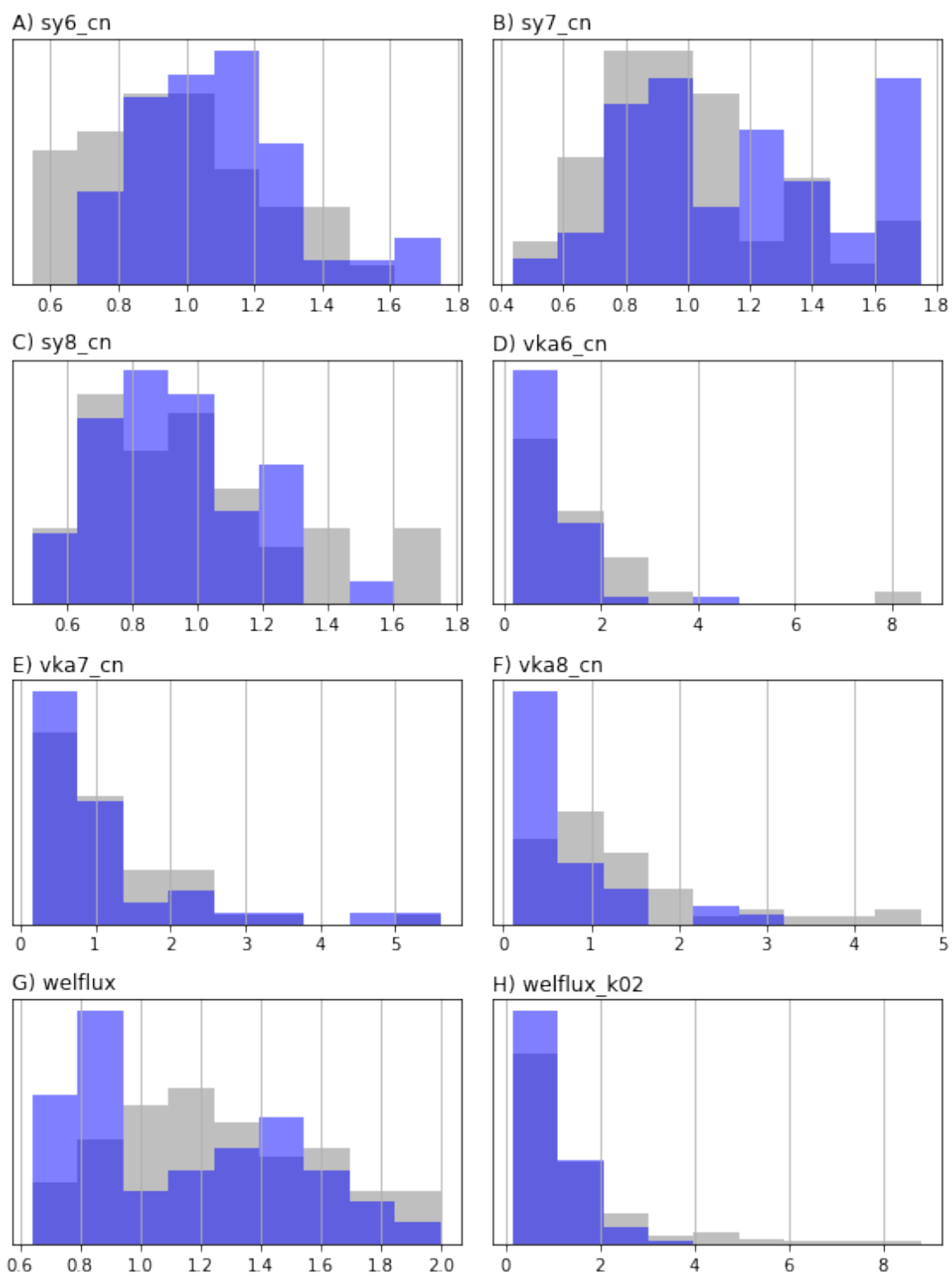
G) pp_vka2



H) rech4_cn

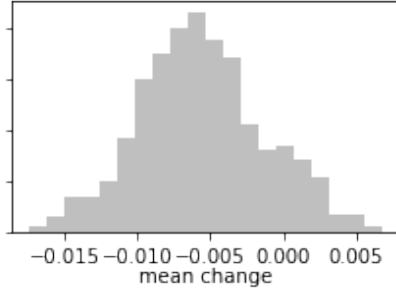




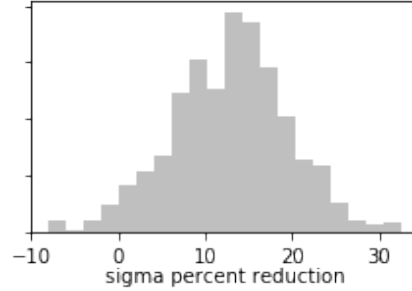


<Figure size 576x756 with 0 Axes>

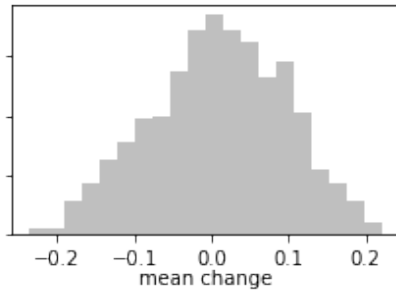
A) mean change group:grrech2, 705 entries
max:0.00677122, min:-0.0174453



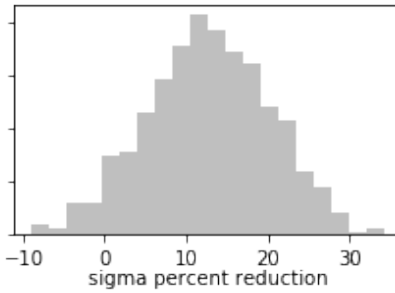
B) sigma change group:grrech2, 705 entries
max: 32.6074, min: -8.07086



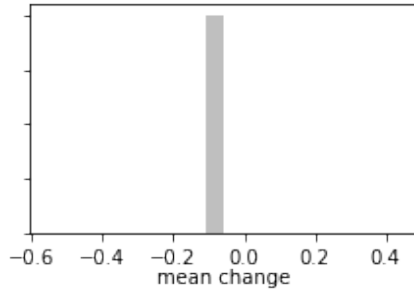
C) mean change group:grss4, 705 entries
max: 0.221286, min: -0.237682



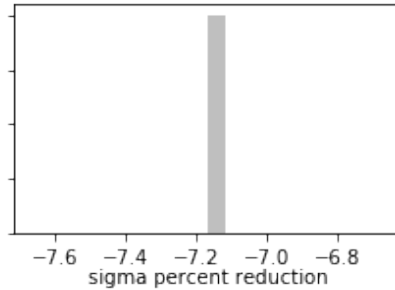
D) sigma change group:grss4, 705 entries
max: 34.3904, min: -9.04958



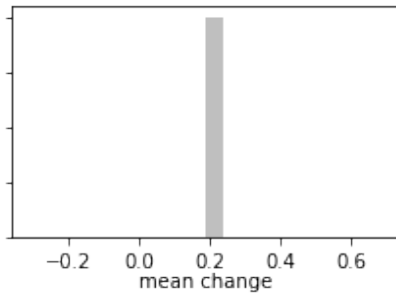
E) mean change group:sy7_cn, 1 entries
max:-0.0593125, min:-0.0593125



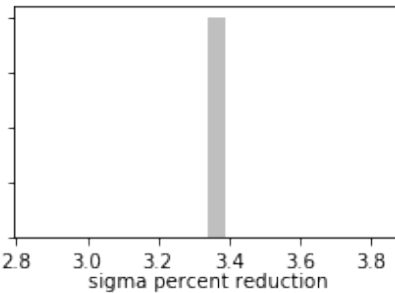
F) sigma change group:sy7_cn, 1 entries
max: -7.16653, min: -7.16653



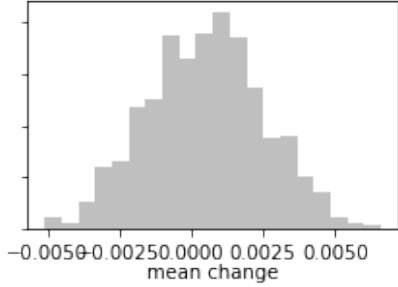
G) mean change group:ss6_cn, 1 entries
max: 0.18629, min: 0.18629



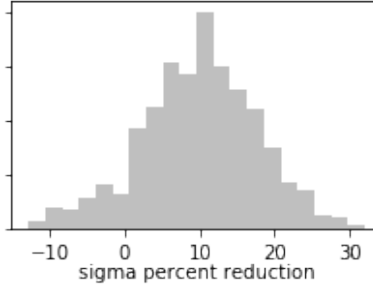
H) sigma change group:ss6_cn, 1 entries
max: 3.341, min: 3.341



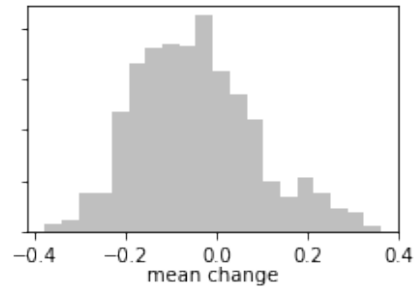
A) mean change group:grstrt3, 705 entries
max:0.00659681, min:-0.00510234



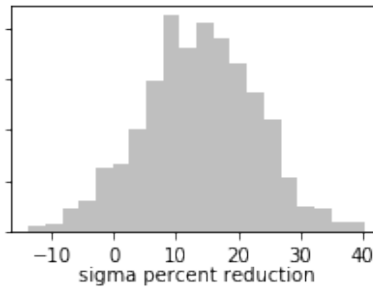
B) sigma change group:grstrt3, 705 entries
max: 32.0133, min: -12.8585



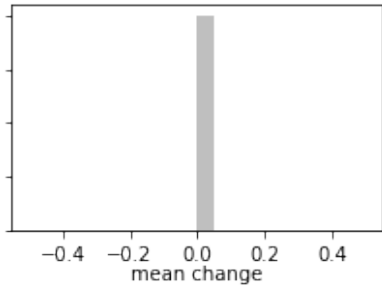
C) mean change group:grhk5, 705 entries
max: 0.362236, min: -0.375987



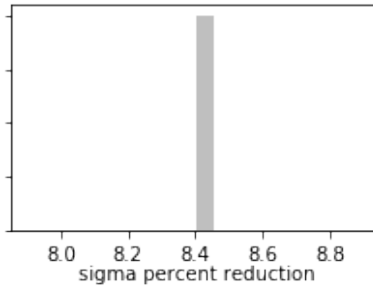
D) sigma change group:grhk5, 705 entries
max: 40.2772, min: -13.6757



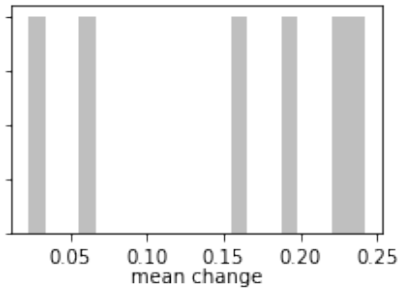
E) mean change group:strt6_cn, 1 entries
max:-0.00083552, min:-0.00083552



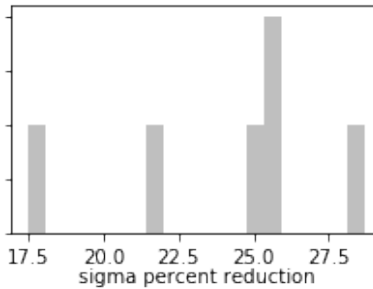
F) sigma change group:strt6_cn, 1 entries
max: 8.40444, min: 8.40444



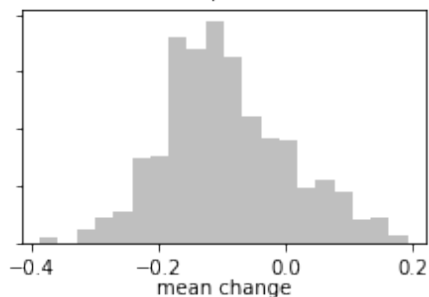
G) mean change group:welflux_k02, 6 entries
max: 0.242147, min: 0.02308



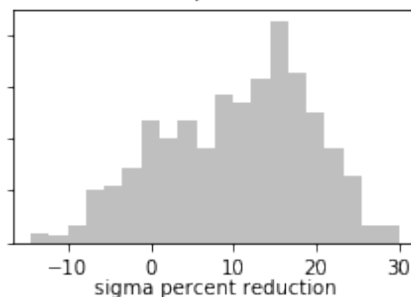
H) sigma change group:welflux_k02, 6 entries
max: 28.6957, min: 17.5033



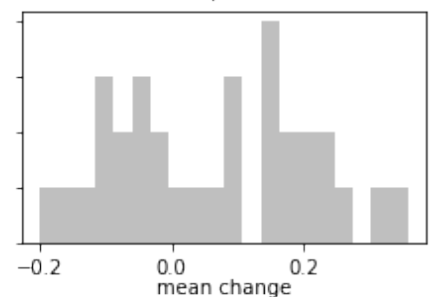
A) mean change group:grhk3, 705 entries
max: 0.192116, min: -0.385994



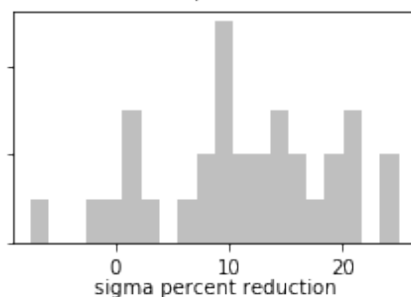
B) sigma change group:grhk3, 705 entries
max: 29.9566, min: -14.5106



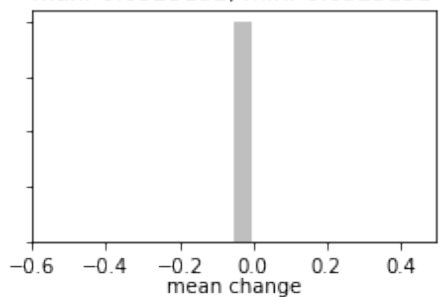
C) mean change group:pp_vka1, 32 entries
max: 0.358568, min: -0.199539



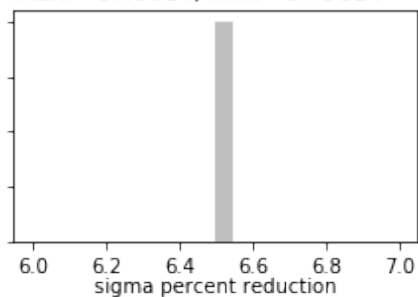
D) sigma change group:pp_vka1, 32 entries
max: 24.9157, min: -7.42191



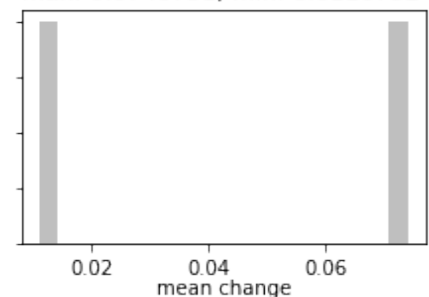
E) mean change group:ss7_cn, 1 entries
max:-0.0523132, min:-0.0523132



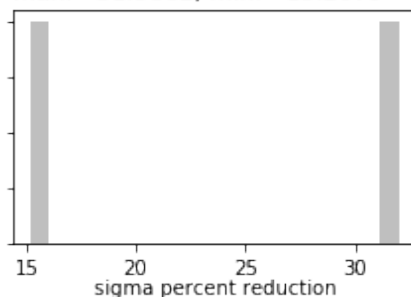
F) sigma change group:ss7_cn, 1 entries
max: 6.49614, min: 6.49614

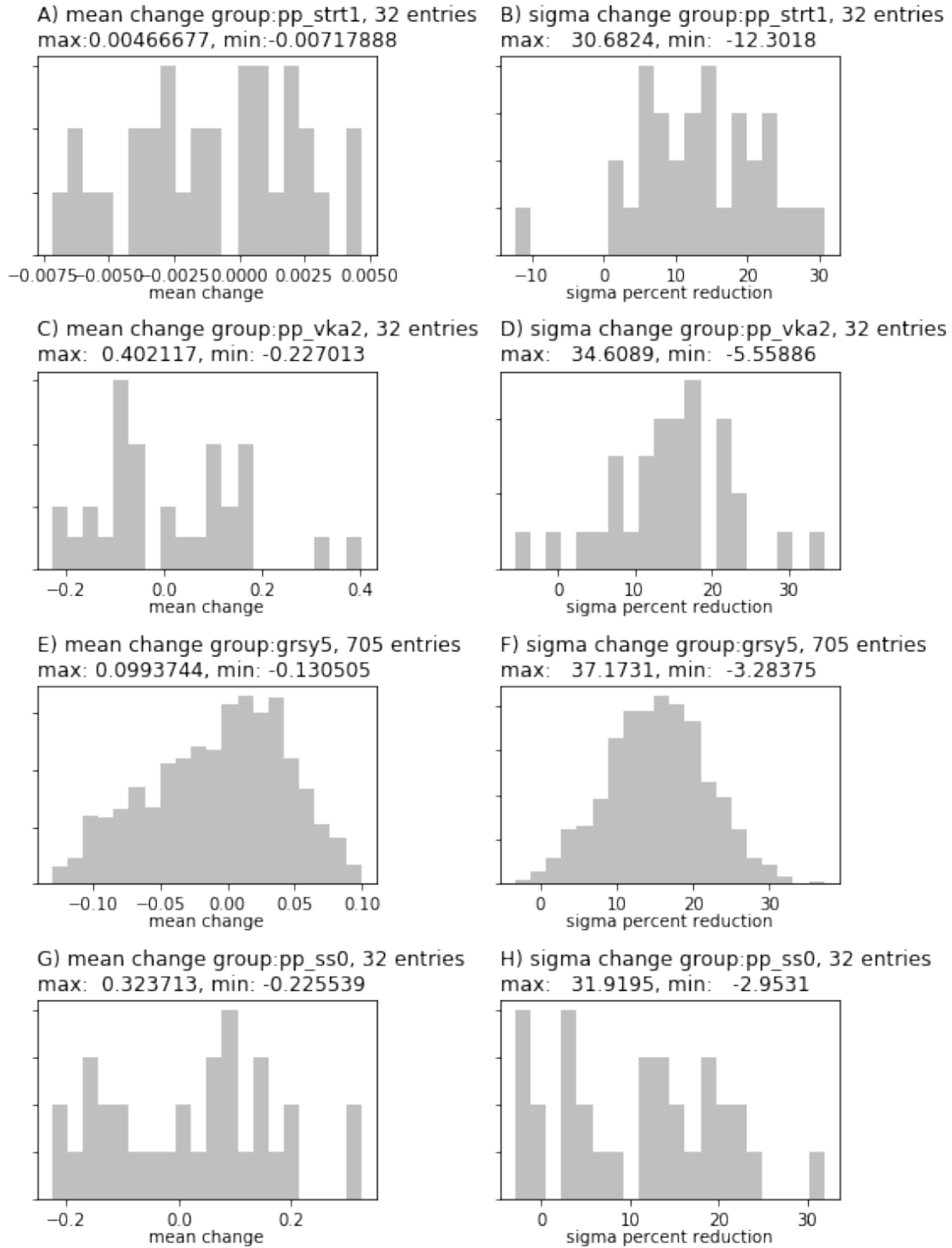


G) mean change group:welflux, 2 entries
max: 0.0740751, min: 0.0110752

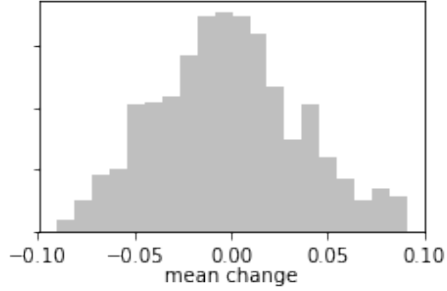


H) sigma change group:welflux, 2 entries
max: 31.9862, min: 15.2079

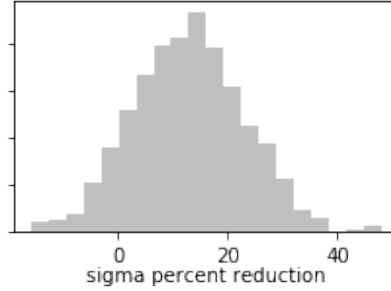




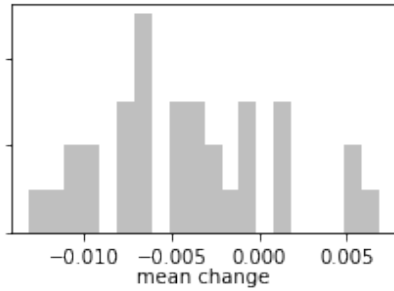
A) mean change group:grsy3, 705 entries
max: 0.0916073, min:-0.0905018



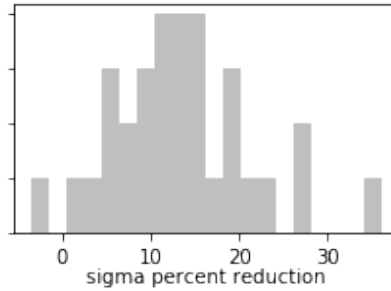
B) sigma change group:grsy3, 705 entries
max: 48.0864, min: -15.9649



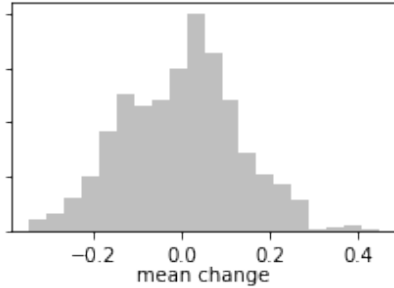
C) mean change group:pp_rech0, 32 entries
max:0.00692882, min:-0.013211



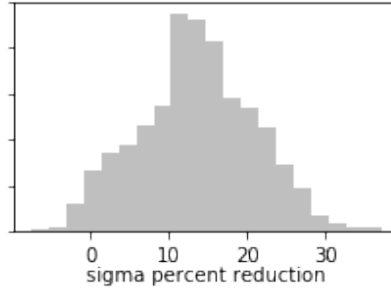
D) sigma change group:pp_rech0, 32 entries
max: 36.1962, min: -3.57398



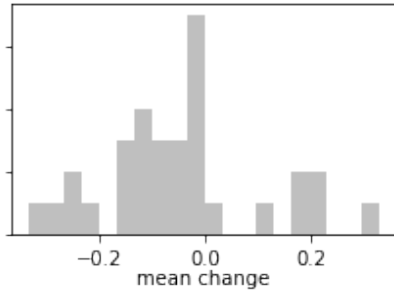
E) mean change group:grvka4, 705 entries
max: 0.450722, min:-0.350159



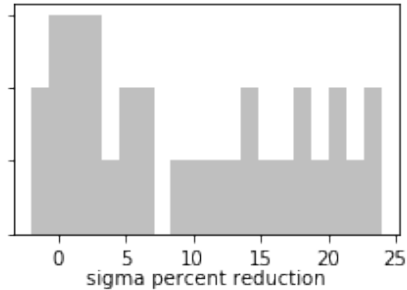
F) sigma change group:grvka4, 705 entries
max: 37.1495, min: -7.61896



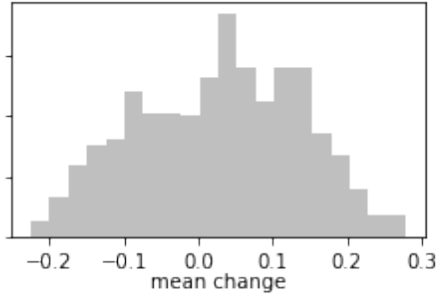
G) mean change group:pp_hk1, 32 entries
max: 0.32824, min:-0.333787



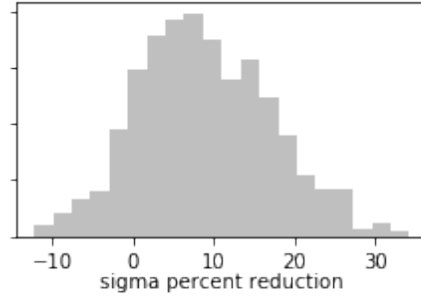
H) sigma change group:pp_hk1, 32 entries
max: 24.0101, min: -2.04698



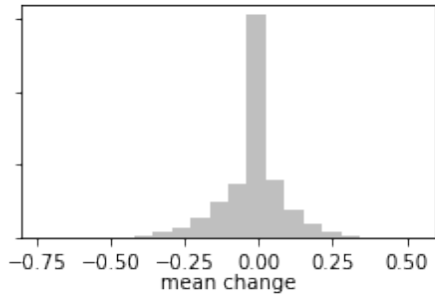
A) mean change group:grhk4, 705 entries
max: 0.279431, min: -0.2252



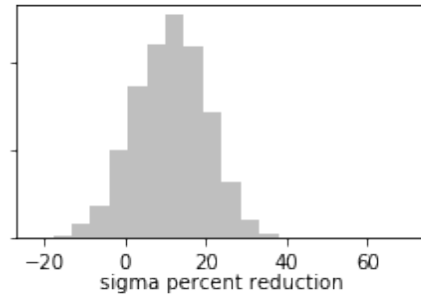
B) sigma change group:grhk4, 705 entries
max: 34.2756, min: -12.2028



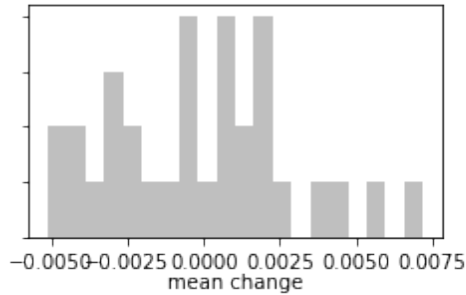
C) mean change group:all, 12605 entries
max: 0.531096, min: -0.737168



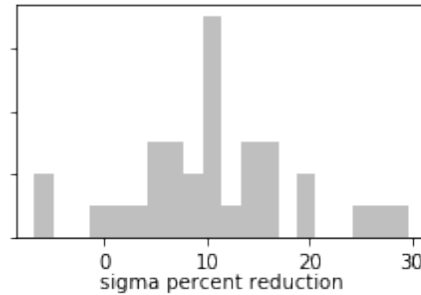
D) sigma change group:all, 12605 entries
max: 70.4514, min: -22.3415



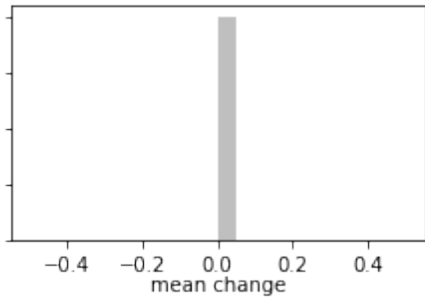
E) mean change group:pp_strt2, 32 entries
max:0.00720067, min:-0.00511891



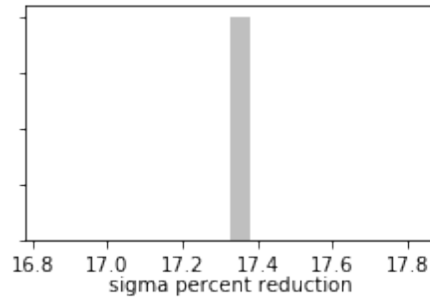
F) sigma change group:pp_strt2, 32 entries
max: 29.7992, min: -6.83996



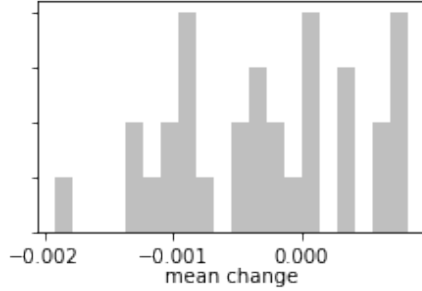
G) mean change group:strt7_cn, 1 entries
max:0.00210986, min:0.00210986



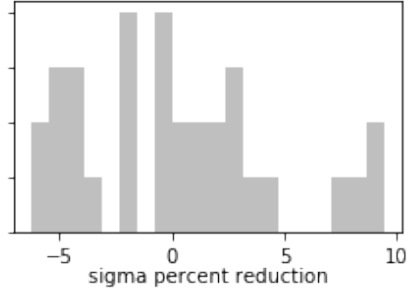
H) sigma change group:strt7_cn, 1 entries
max: 17.3286, min: 17.3286



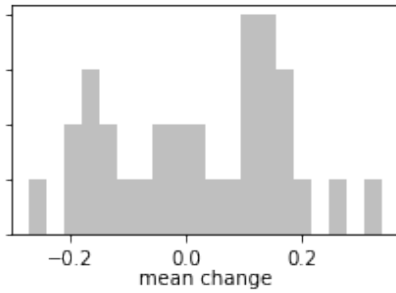
A) mean change group:pp_rech1, 32 entries
max:0.000835525, min:-0.00191626



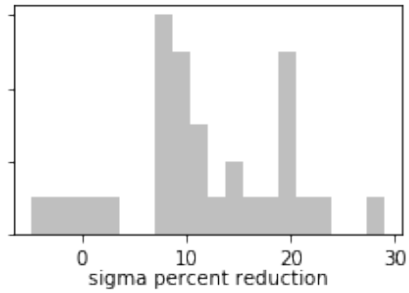
B) sigma change group:pp_rech1, 32 entries
max: 9.45948, min: -6.24516



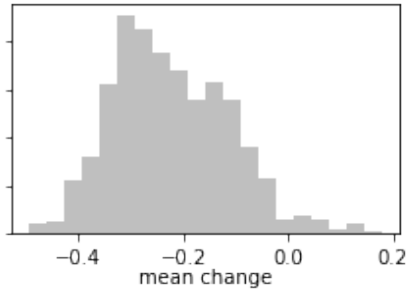
C) mean change group:pp_hk0, 32 entries
max: 0.339188, min: -0.269506



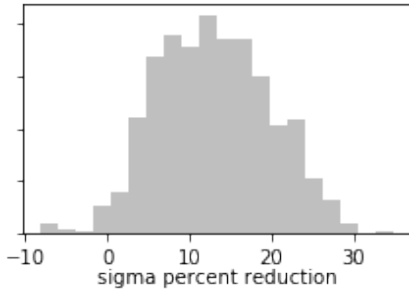
D) sigma change group:pp_hk0, 32 entries
max: 29.0031, min: -4.85968



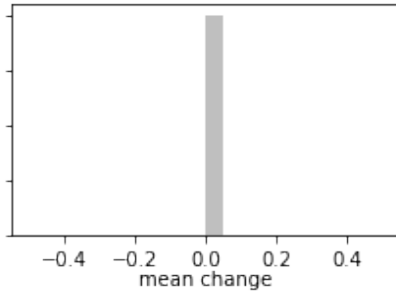
E) mean change group:grss5, 705 entries
max: 0.180068, min: -0.493738



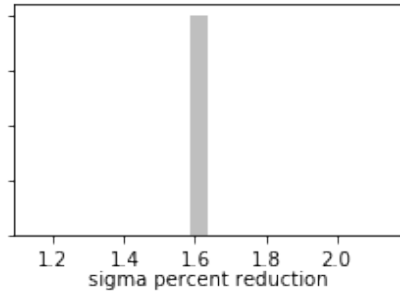
F) sigma change group:grss5, 705 entries
max: 34.8022, min: -8.15344



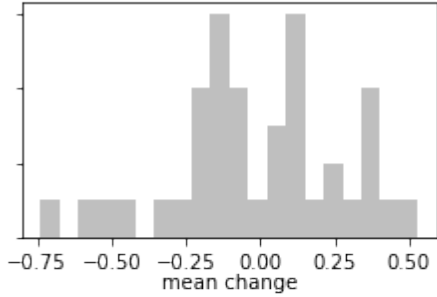
G) mean change group:strt8_cn, 1 entries
max:8.29921E-05, min:8.29921E-05



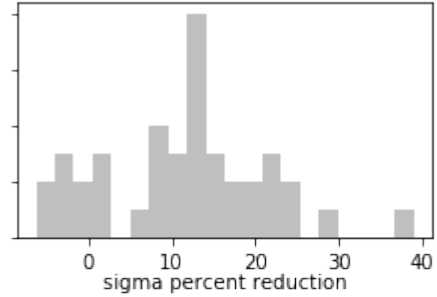
H) sigma change group:strt8_cn, 1 entries
max: 1.63602, min: 1.63602



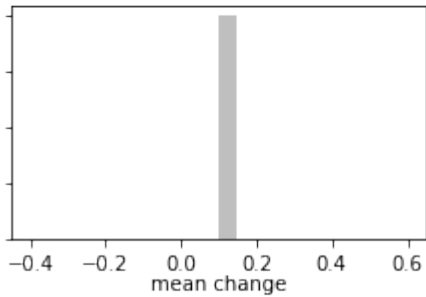
A) mean change group:strk, 40 entries
max: 0.531096, min: -0.737168



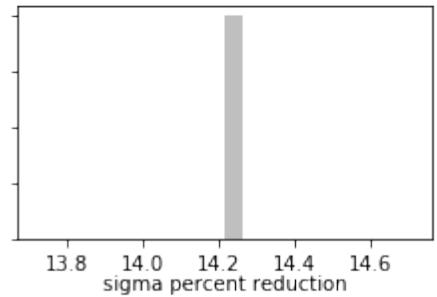
B) sigma change group:strk, 40 entries
max: 38.9038, min: -6.24839



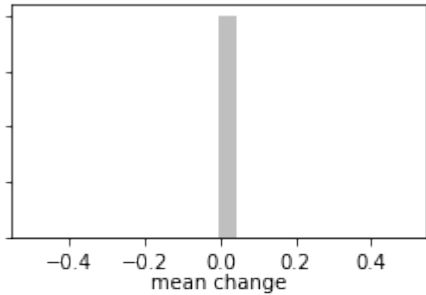
C) mean change group:ss8_cn, 1 entries
max: 0.0992234, min: 0.0992234



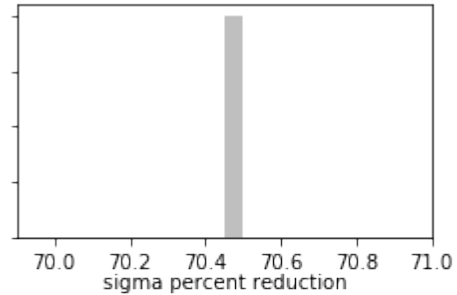
D) sigma change group:ss8_cn, 1 entries
max: 14.2162, min: 14.2162



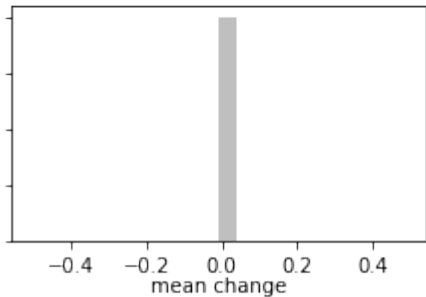
E) mean change group:flow, 1 entries
max:-0.00492203, min:-0.00492203



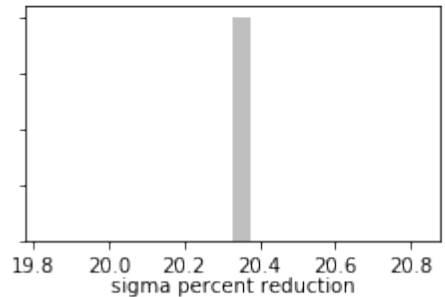
F) sigma change group:flow, 1 entries
max: 70.4514, min: 70.4514



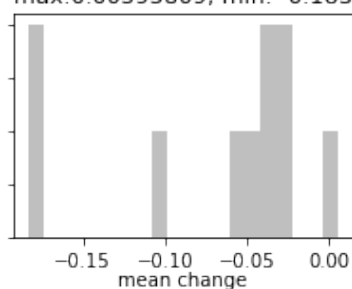
G) mean change group:rech4_cn, 1 entries
max:-0.00904351, min:-0.00904351



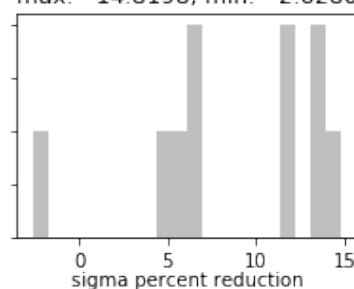
H) sigma change group:rech4_cn, 1 entries
max: 20.3283, min: 20.3283



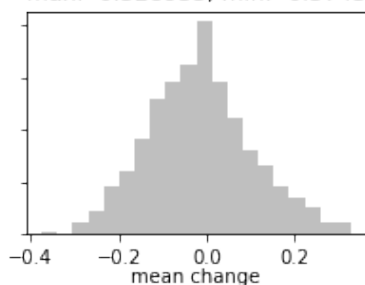
A) mean change group:drncond_k00, 10 entries
max:0.00595809, min: -0.183037



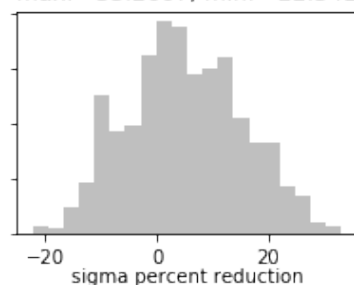
B) sigma change group:drncond_k00, 10 entries
max: 14.8198, min: -2.62803



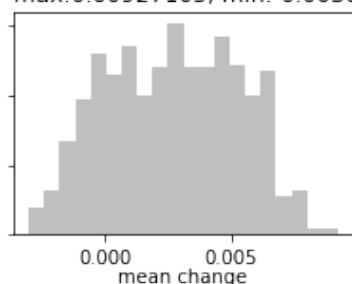
C) mean change group:grss3, 705 entries
max: 0.328935, min: -0.374376



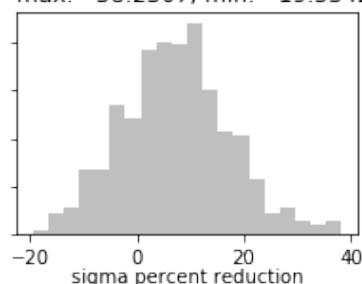
D) sigma change group:grss3, 705 entries
max: 33.2607, min: -22.3415



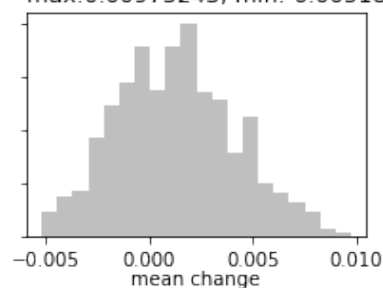
E) mean change group:grstrt5, 705 entries
max:0.00927105, min:-0.00304607



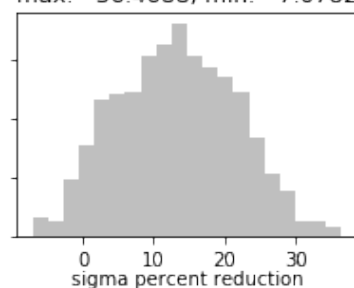
F) sigma change group:grstrt5, 705 entries
max: 38.2307, min: -19.5342



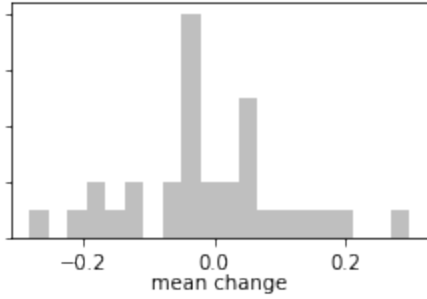
G) mean change group:grstrt4, 705 entries
max:0.00975243, min:-0.00518831



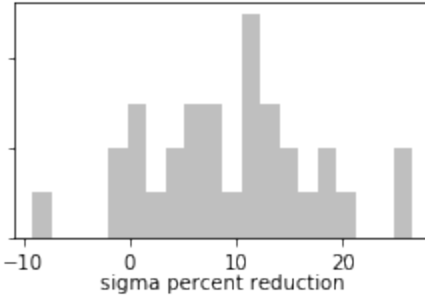
H) sigma change group:grstrt4, 705 entries
max: 36.4688, min: -7.07821



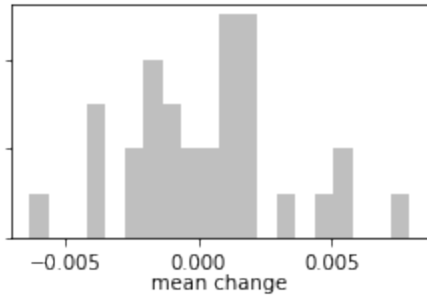
A) mean change group:pp_ss1, 32 entries
max: 0.296651, min: -0.281374



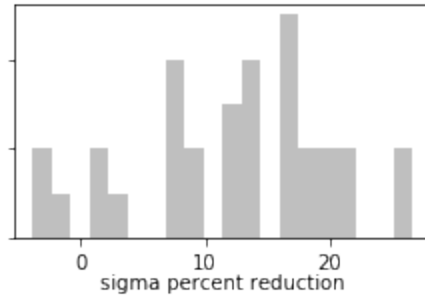
B) sigma change group:pp_ss1, 32 entries
max: 26.5644, min: -9.13414



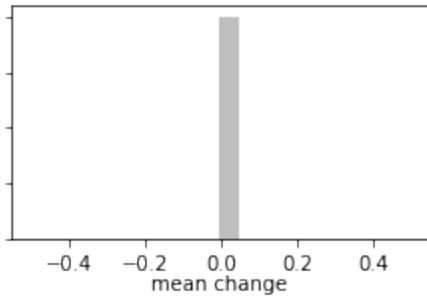
C) mean change group:pp_strt0, 32 entries
max:0.00791222, min:-0.00631947



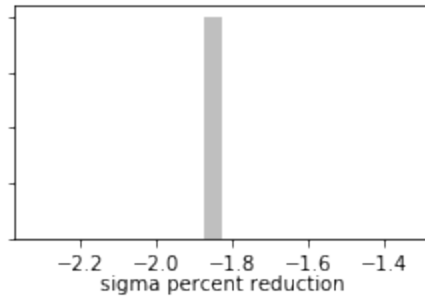
D) sigma change group:pp_strt0, 32 entries
max: 26.6317, min: -3.84395



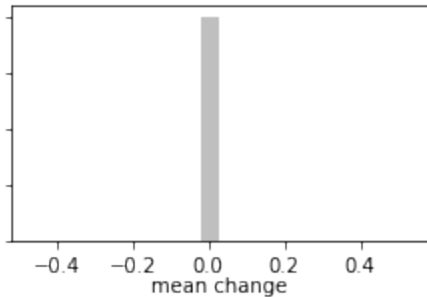
E) mean change group:rech5_cn, 1 entries
max:-0.00521245, min:-0.00521245



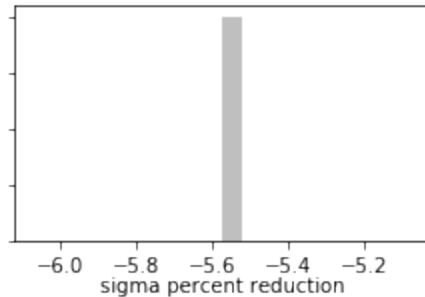
F) sigma change group:rech5_cn, 1 entries
max: -1.82507, min: -1.82507



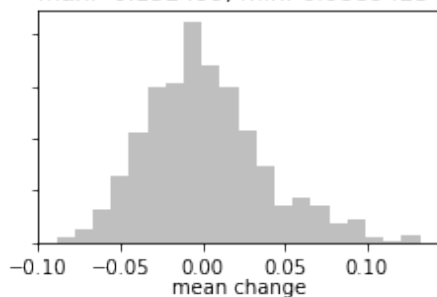
G) mean change group:vka7_cn, 1 entries
max: 0.0291329, min: 0.0291329



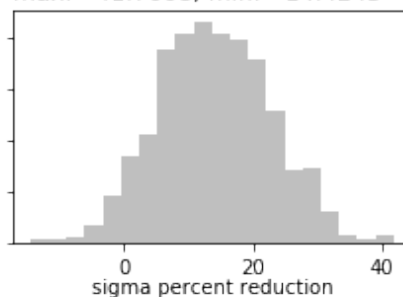
H) sigma change group:vka7_cn, 1 entries
max: -5.57442, min: -5.57442



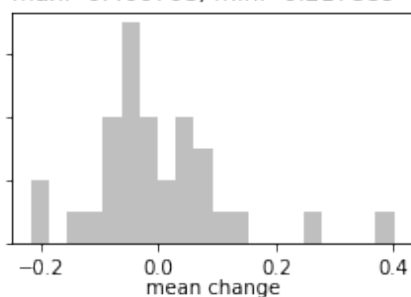
A) mean change group:grsy4, 705 entries
max: 0.132499, min:-0.0889423



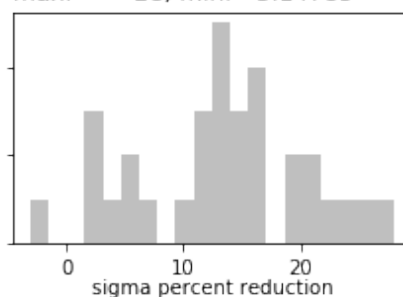
B) sigma change group:grsy4, 705 entries
max: 41.7008, min: -14.4243



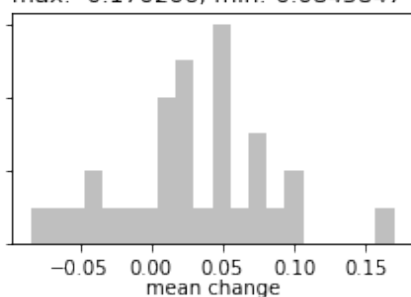
C) mean change group:pp_vka0, 32 entries
max: 0.400708, min: -0.217889



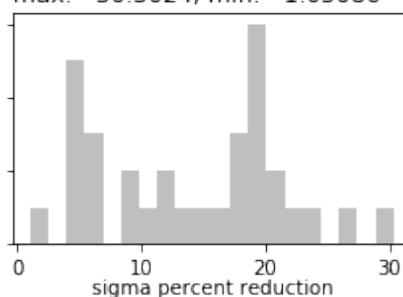
D) sigma change group:pp_vka0, 32 entries
max: 28, min: -3.14785



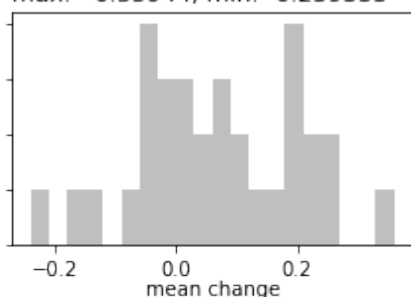
E) mean change group:pp_sy2, 32 entries
max: 0.170206, min:-0.0845847



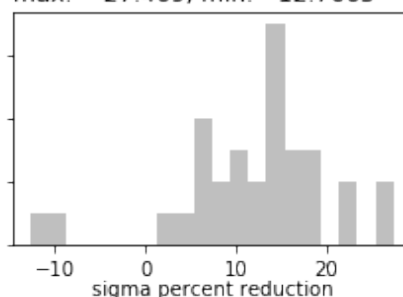
F) sigma change group:pp_sy2, 32 entries
max: 30.3024, min: 1.05086



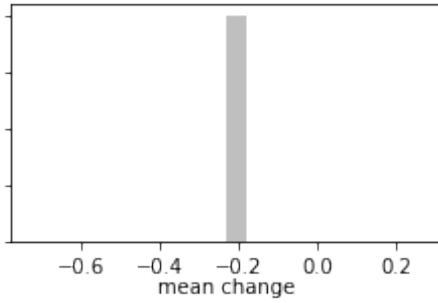
G) mean change group:pp_ss2, 32 entries
max: 0.35944, min: -0.239333



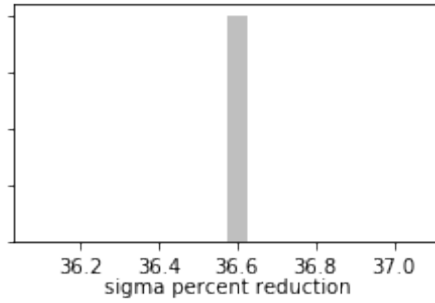
H) sigma change group:pp_ss2, 32 entries
max: 27.469, min: -12.7665



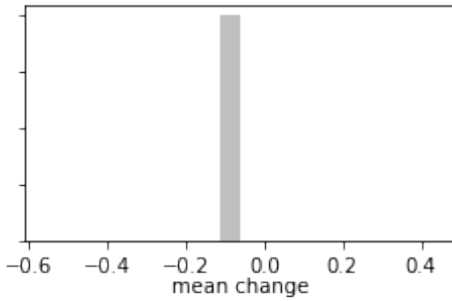
A) mean change group:hk8_cn, 1 entries
max: -0.232458, min: -0.232458



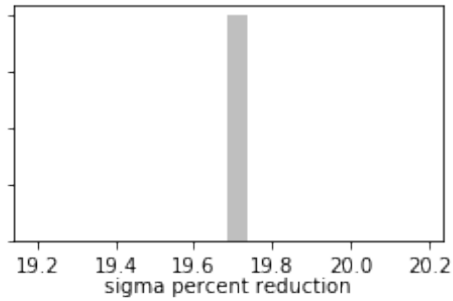
B) sigma change group:hk8_cn, 1 entries
max: 36.5773, min: 36.5773



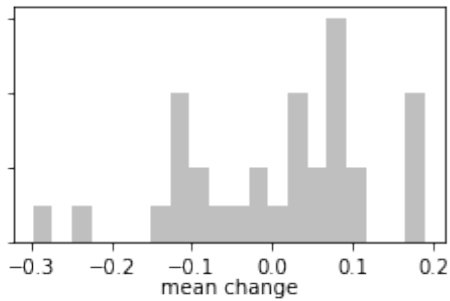
C) mean change group:sy6_cn, 1 entries
max: -0.062336, min: -0.062336



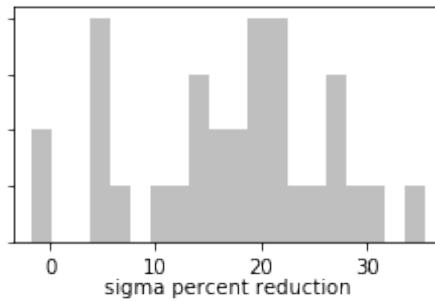
D) sigma change group:sy6_cn, 1 entries
max: 19.6873, min: 19.6873



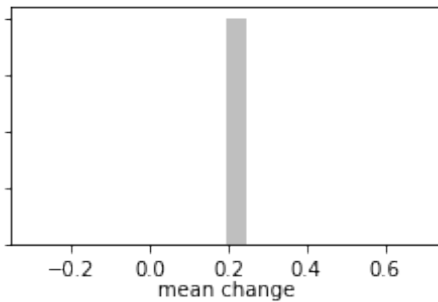
E) mean change group:pp_hk2, 32 entries
max: 0.189467, min: -0.297735



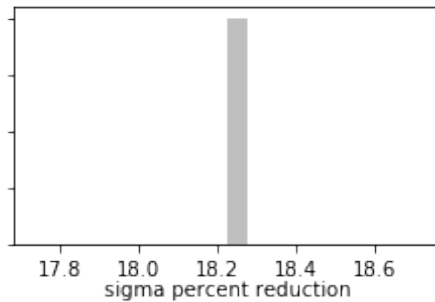
F) sigma change group:pp_hk2, 32 entries
max: 35.3836, min: -1.68303



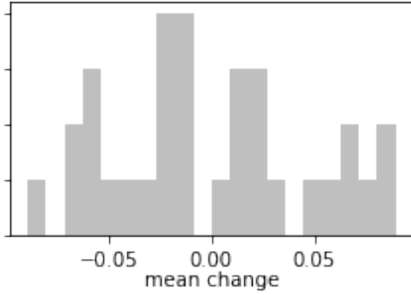
G) mean change group:hk6_cn, 1 entries
max: 0.194413, min: 0.194413



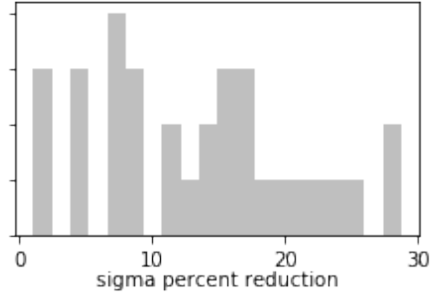
H) sigma change group:hk6_cn, 1 entries
max: 18.227, min: 18.227



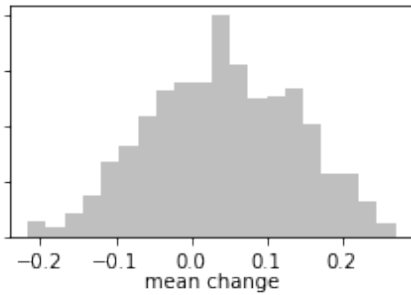
A) mean change group:pp_sy0, 32 entries
max: 0.0895291, min:-0.0891005



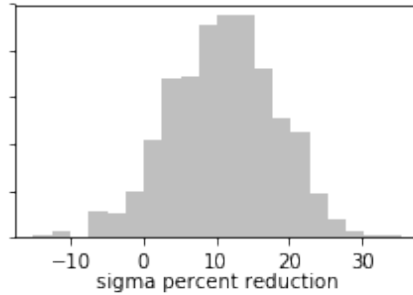
B) sigma change group:pp_sy0, 32 entries
max: 28.7608, min: 1.06458



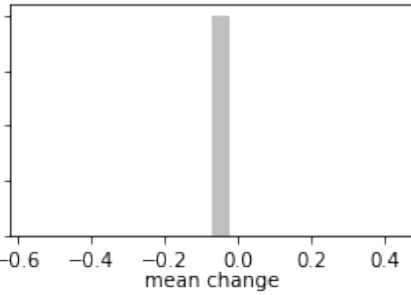
C) mean change group:grvka5, 705 entries
max: 0.270865, min: -0.216877



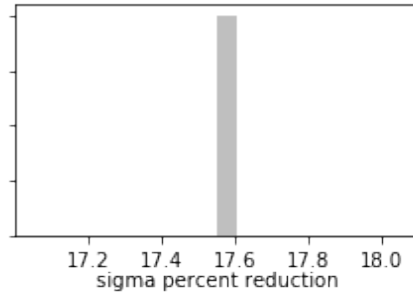
D) sigma change group:grvka5, 705 entries
max: 35.3615, min: -15.0333



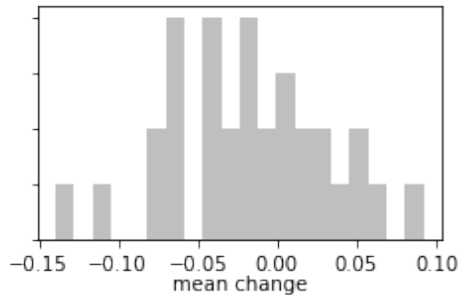
E) mean change group:hk7_cn, 1 entries
max:-0.0727548, min:-0.0727548



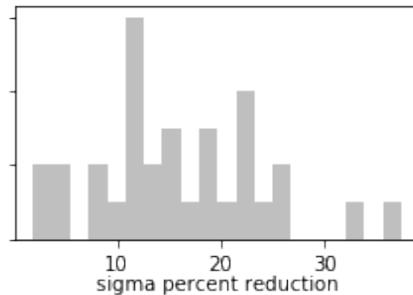
F) sigma change group:hk7_cn, 1 entries
max: 17.5538, min: 17.5538



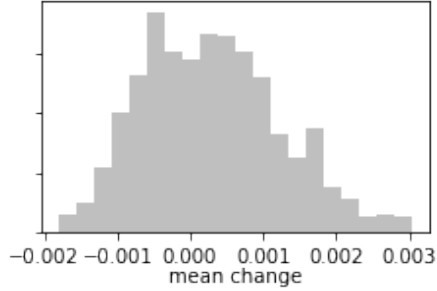
G) mean change group:pp_sy1, 32 entries
max: 0.0919632, min: -0.139343



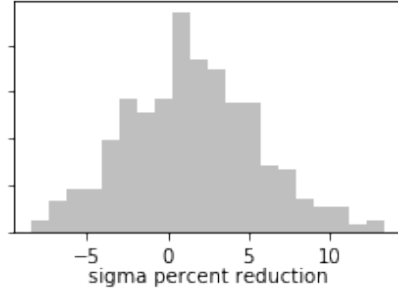
H) sigma change group:pp_sy1, 32 entries
max: 37.3755, min: 1.98049



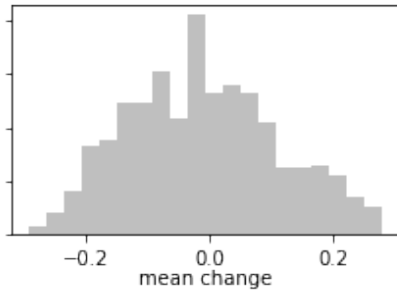
A) mean change group:grrech3, 705 entries
max:0.00305174, min:-0.00180138



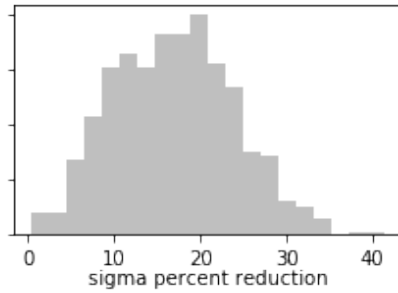
B) sigma change group:grrech3, 705 entries
max: 13.4091, min: -8.45338



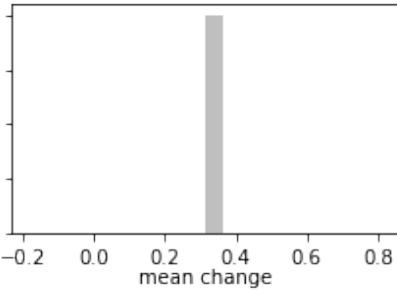
C) mean change group:grvka3, 705 entries
max: 0.281656, min: -0.293625



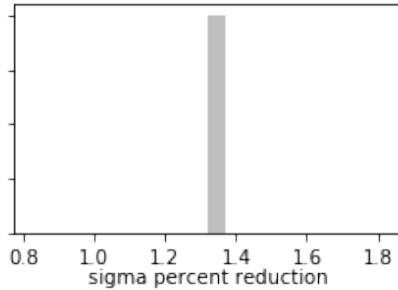
D) sigma change group:grvka3, 705 entries
max: 41.3873, min: 0.337299



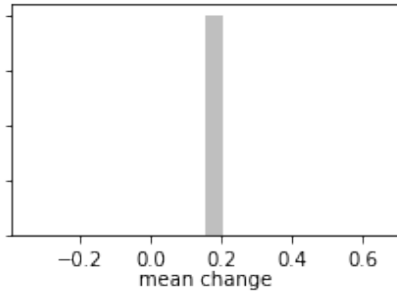
E) mean change group:vka8_cn, 1 entries
max: 0.314932, min: 0.314932



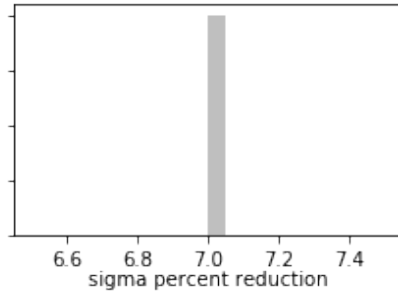
F) sigma change group:vka8_cn, 1 entries
max: 1.32071, min: 1.32071



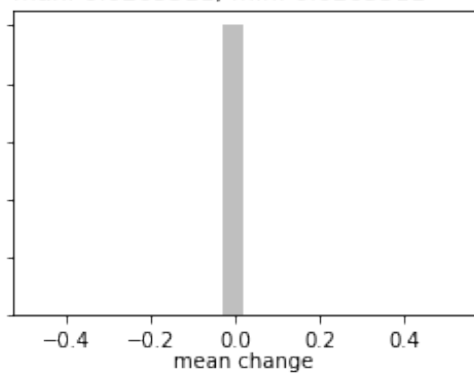
G) mean change group:vka6_cn, 1 entries
max: 0.156557, min: 0.156557



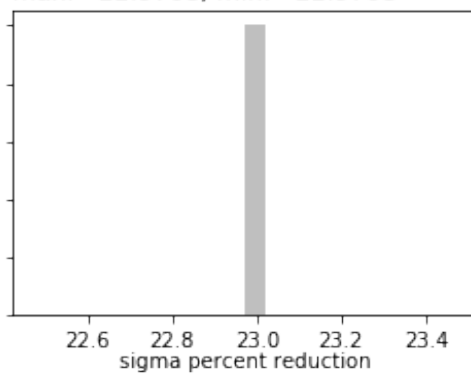
H) sigma change group:vka6_cn, 1 entries
max: 6.99983, min: 6.99983



A) mean change group:sy8_cn, 1 entries
max: 0.0205511, min: 0.0205511



B) sigma change group:sy8_cn, 1 entries
max: 22.9708, min: 22.9708



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),:].copy()
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()
```

```
In [20]: loc = pyemu.Matrix.from_names(pst.nnz_obs_names,pst.par_names).to_dataframe()
```

```
loc.loc[:, :] = 1.0
```

```
loc_dist = 5000.0
```

```
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, "parnme"]
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, "parnme"]
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[:, scen_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_binary(os.path.join(t_d,"loc.jcb"))
          pst.pestpp_options["ies_localizer"] = "loc.jcb"
          pst.write(os.path.join(t_d,"freyberg_ies.pst"))

```

```

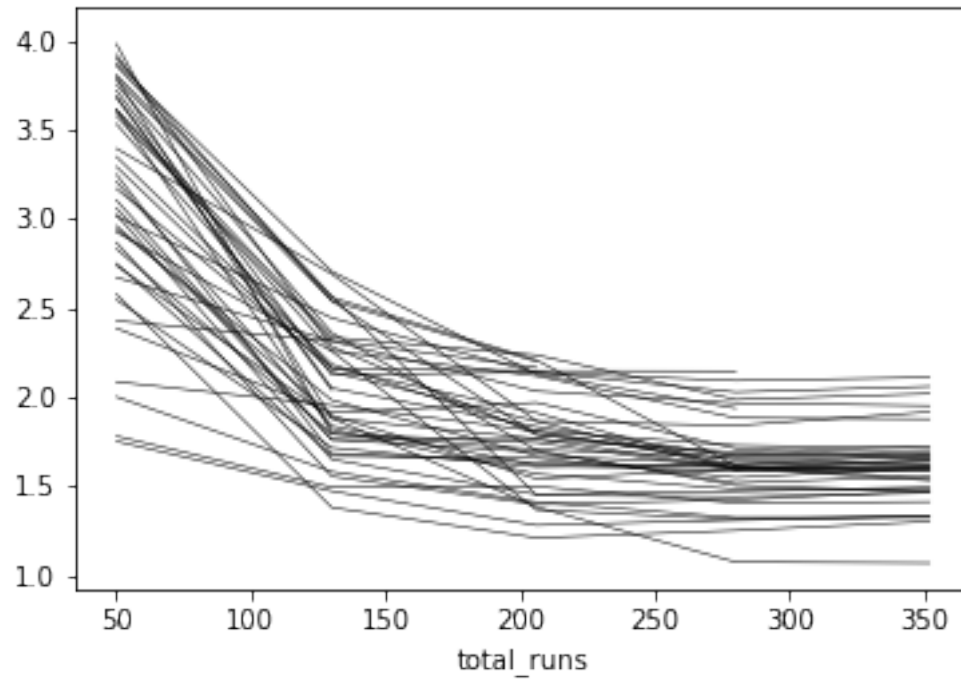
In [22]: pyemu.os_utils.start_slaves(t_d,"pestpp-ies","freyberg_ies.pst",num_slaves=20,master_

```

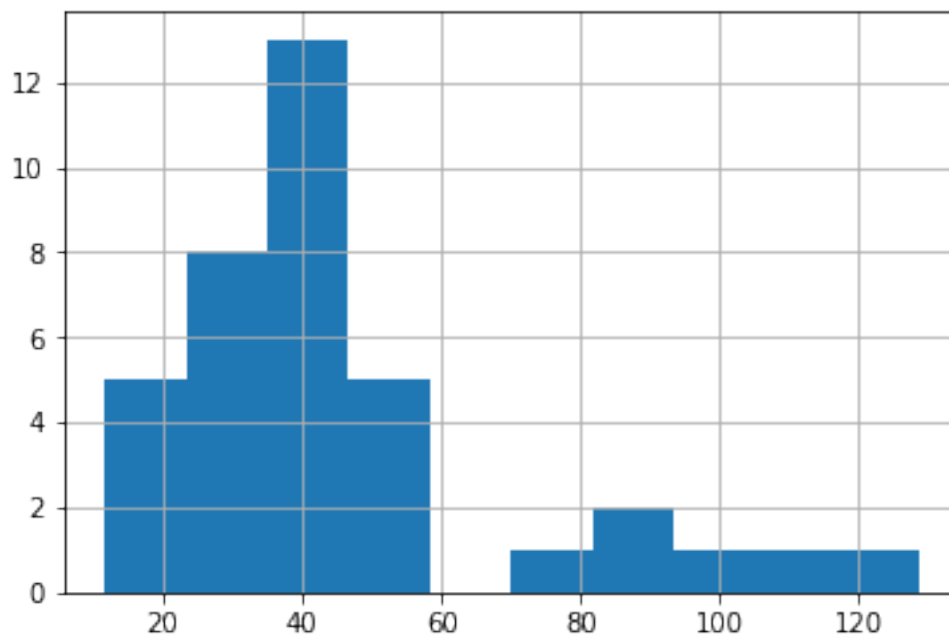
```

In [23]: phi = pd.read_csv(os.path.join(m_d,"freyberg_ies.physical.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()

```



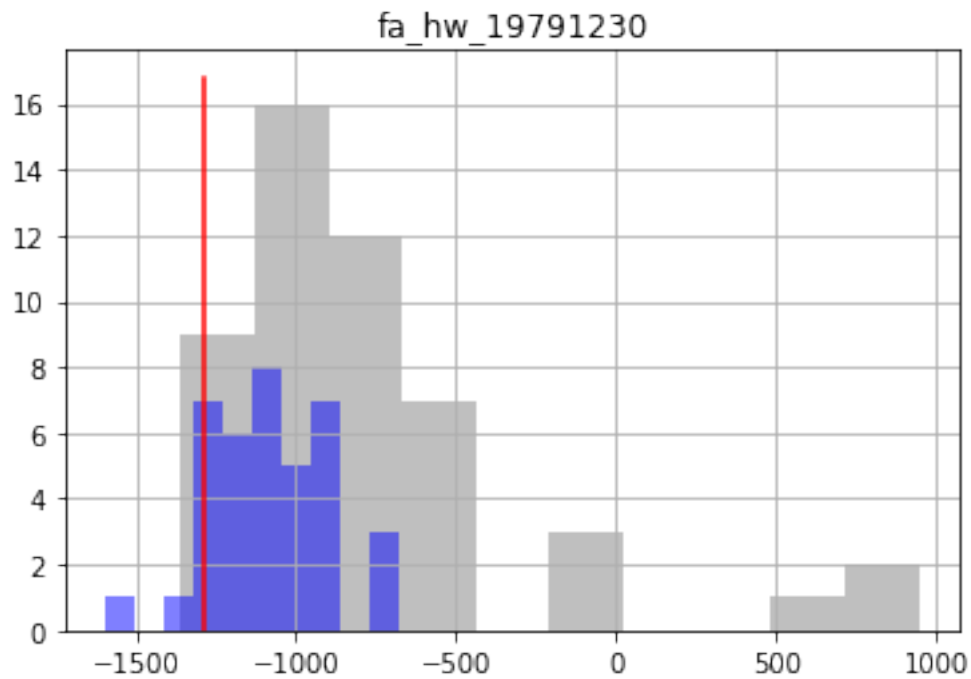
Out[23]: <matplotlib.axes._subplots.AxesSubplot at 0x1827ff8d68>

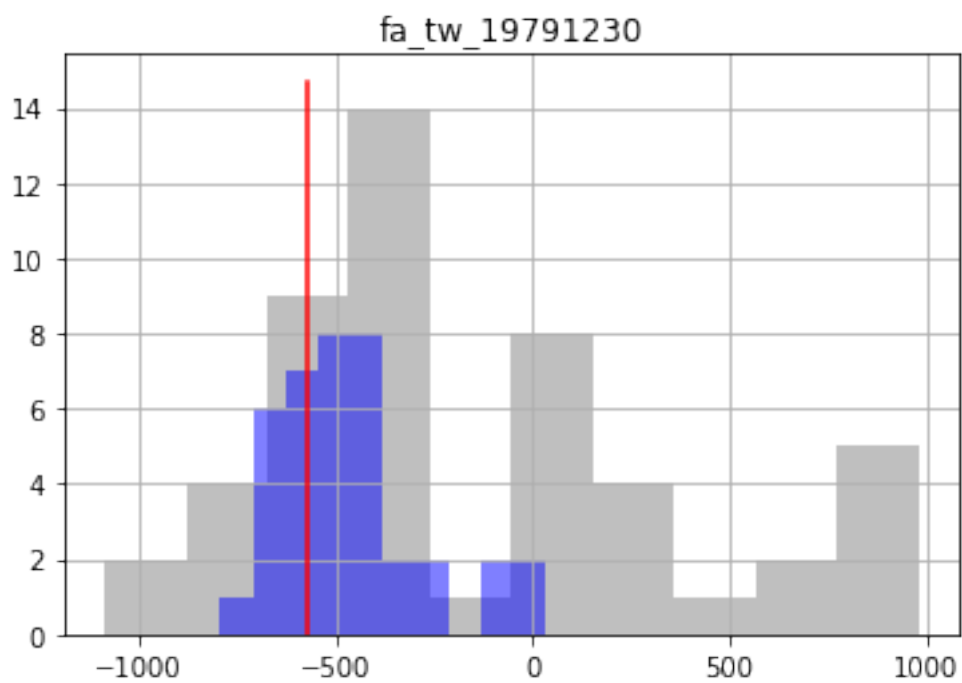
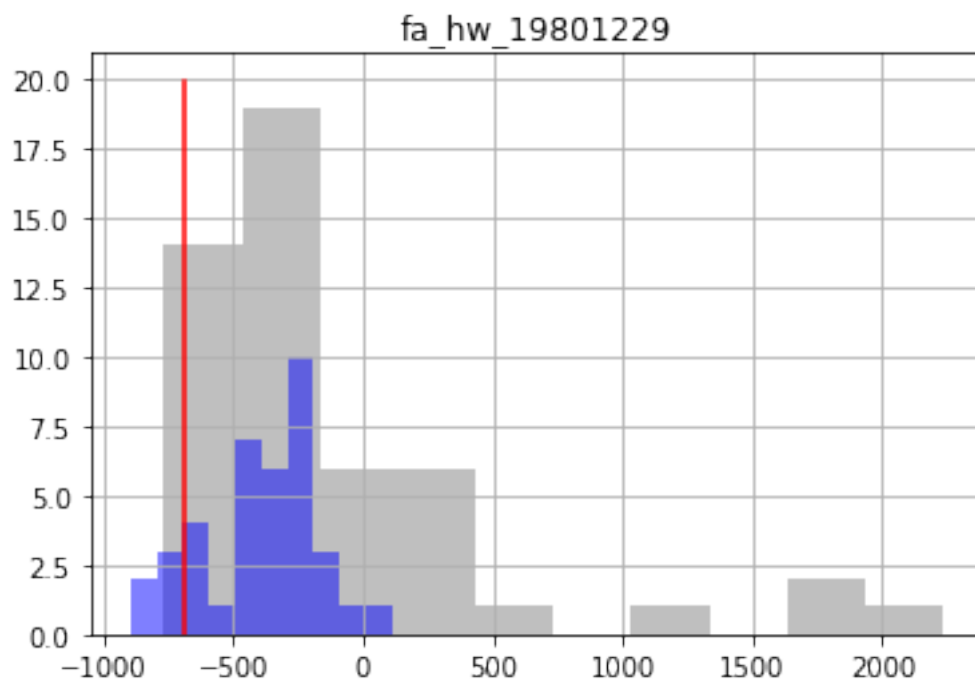


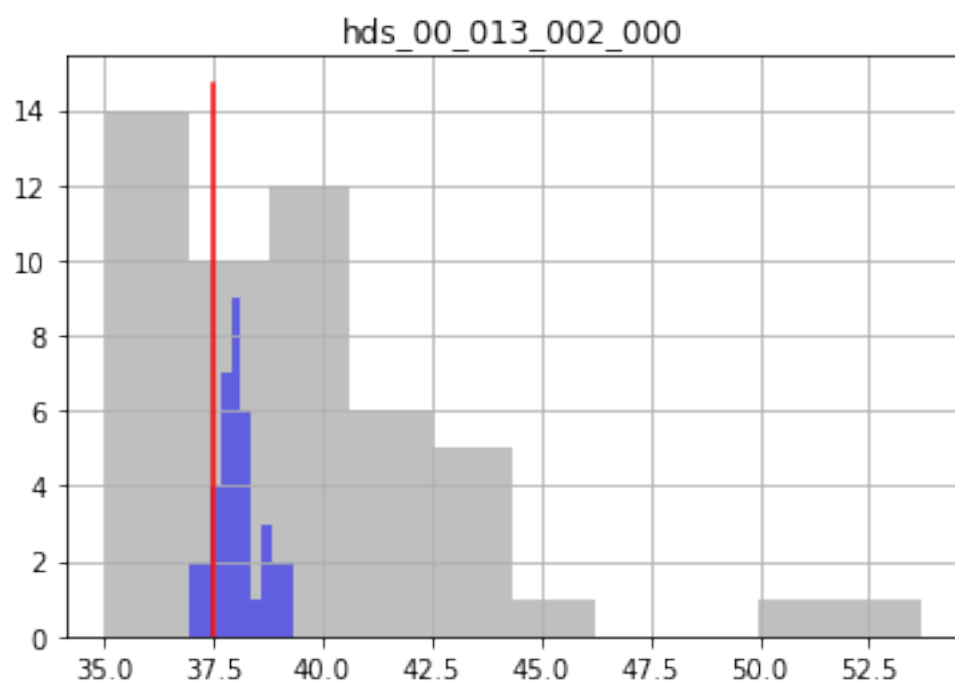
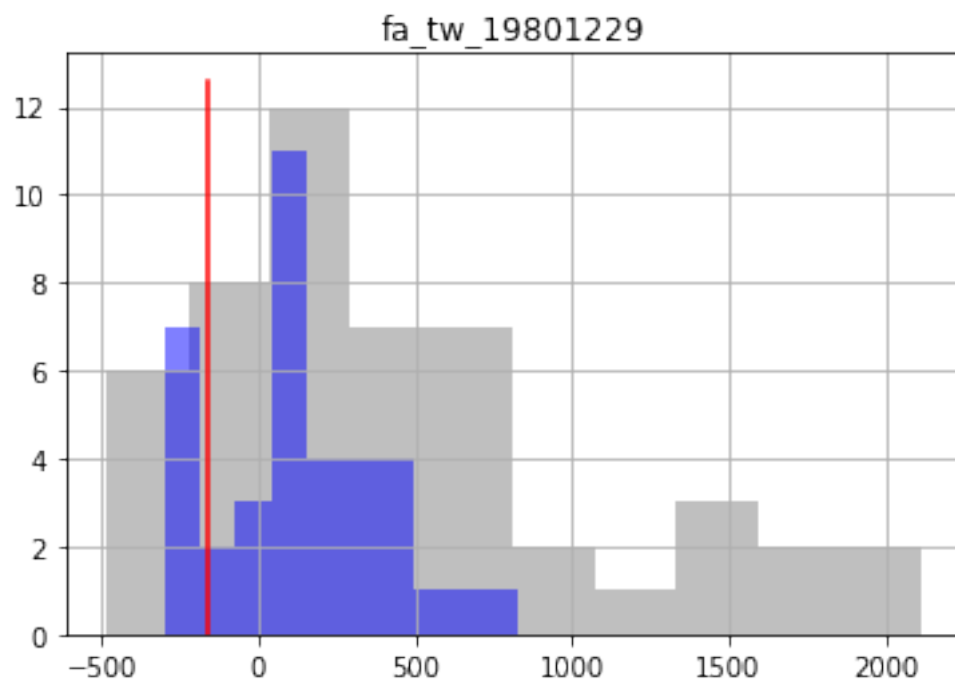
```

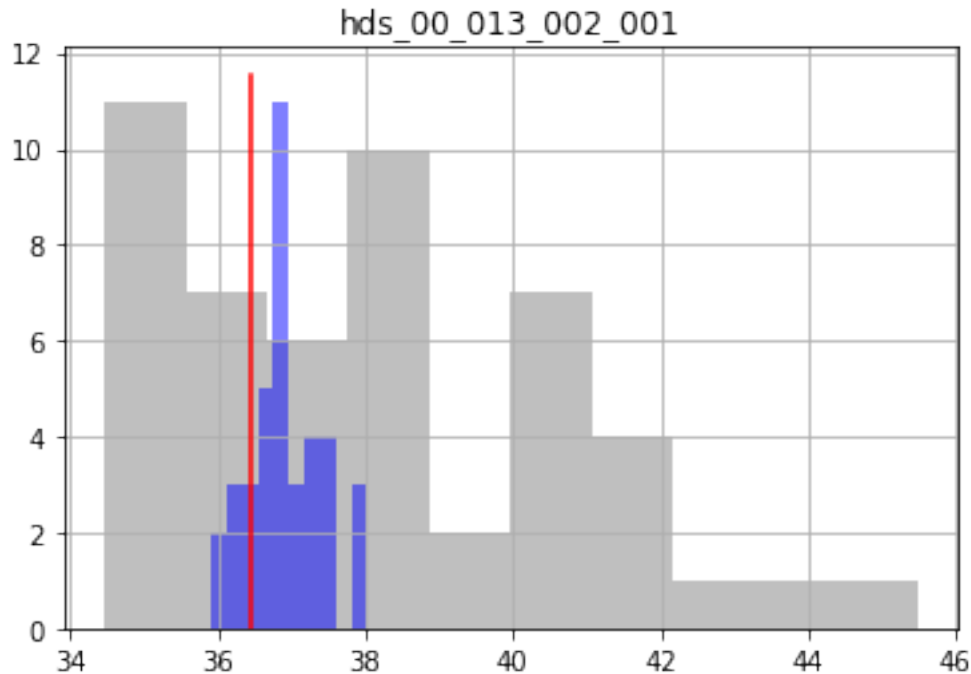
In [24]: oe_pr = pd.read_csv(os.path.join(m_d,"freyberg_ies.0.obs.csv"),index_col=0)
oe_pt = pd.read_csv(os.path.join(m_d,"freyberg_ies.{0}.obs.csv".format(pst.control_da
obs = pst.observation_data
fnames = pst.pestpp_options["forecasts"].split(",")
for forecast in fnames:
    ax = plt.subplot(111)
    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()

```







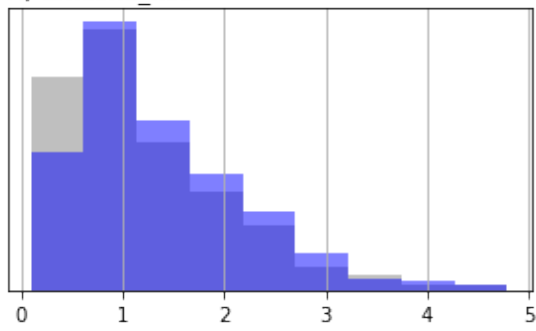


```
In [25]: pe_pr = pd.read_csv(os.path.join(m_d,"freyberg_ies.0.par.csv"),index_col=0)
pe_pt = pd.read_csv(os.path.join(m_d,"freyberg_ies.{0}.par.csv".format(pst.control_da
par = pst.parameter_data
pdict = par.groupby("pargp").groups
pyemu.plot_utils.ensemble_helper({"0.5":pe_pr,"b":pe_pt},plot_cols=pdict)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

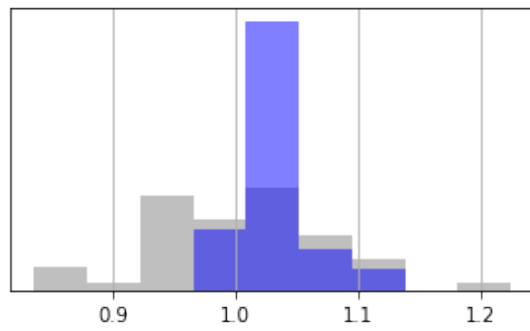
```
Out[25]: [<Figure size 576x756 with 0 Axes>,
<Figure size 576x756 with 8 Axes>,
<Figure size 576x756 with 8 Axes>,
<Figure size 576x756 with 8 Axes>,
<Figure size 576x756 with 8 Axes>,
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<Figure size 576x756 with 8 Axes>,
<Figure size 576x756 with 8 Axes>]
```

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

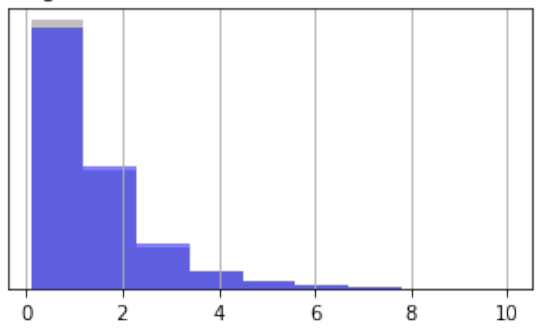
A) drncond_k00



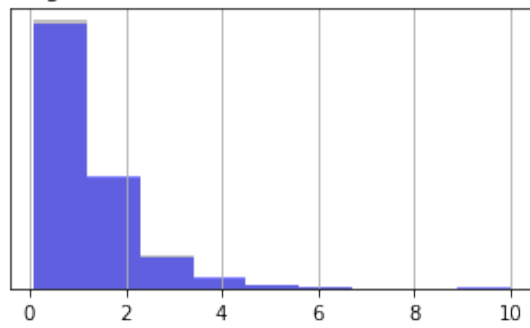
B) flow



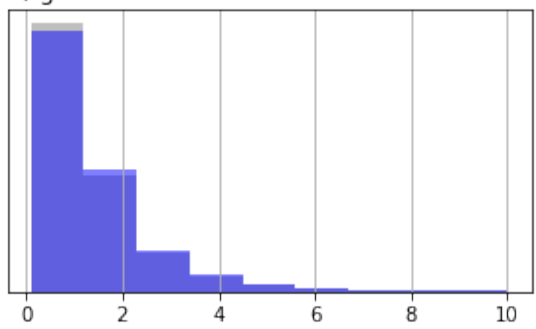
C) grhk3



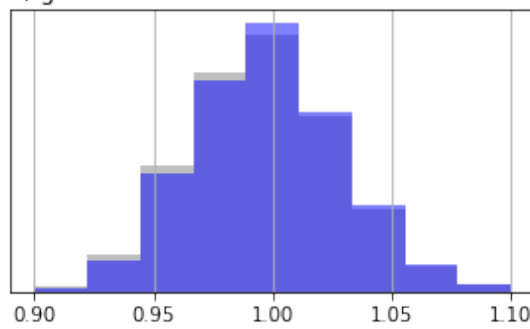
D) grhk4



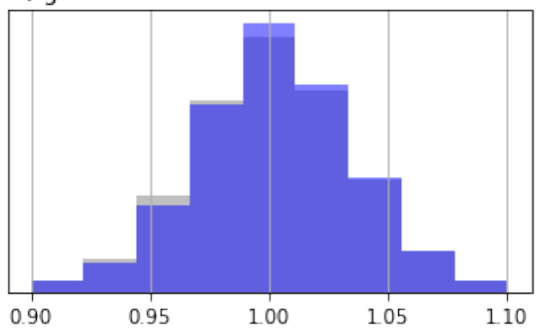
E) grhk5



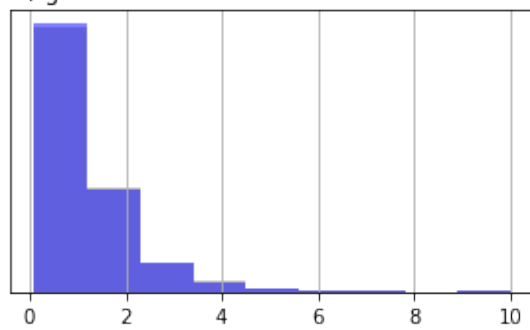
F) grrech2



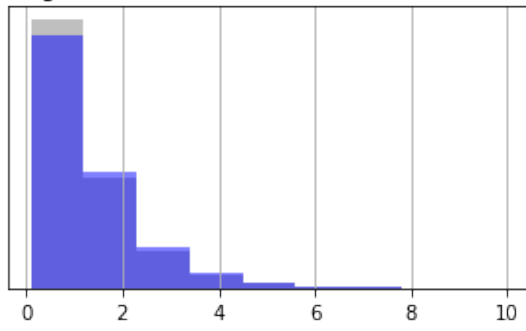
G) grrech3



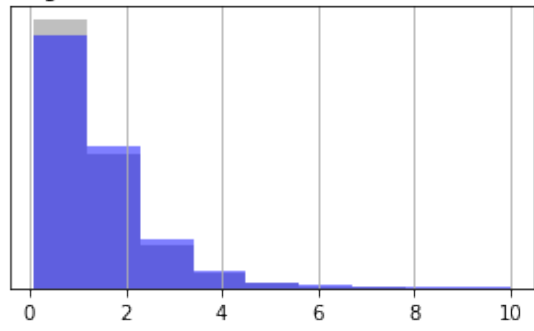
H) grss3



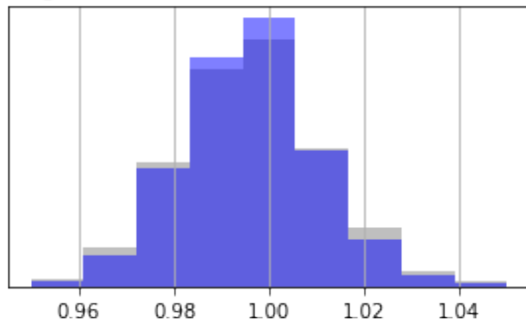
A) grss4



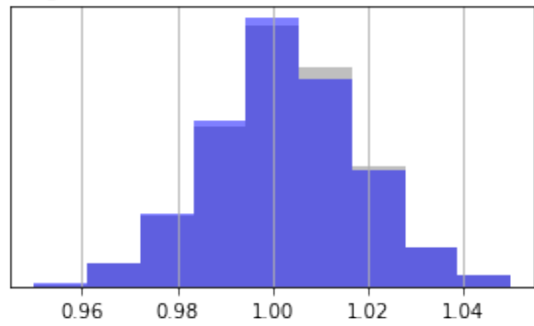
B) grss5



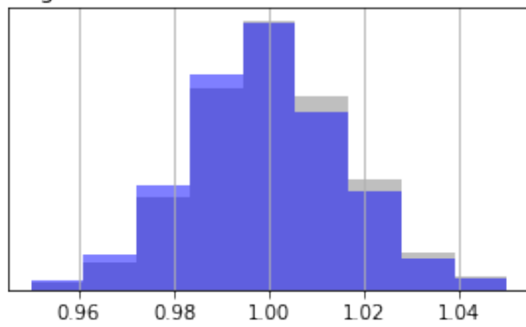
C) grstrt3



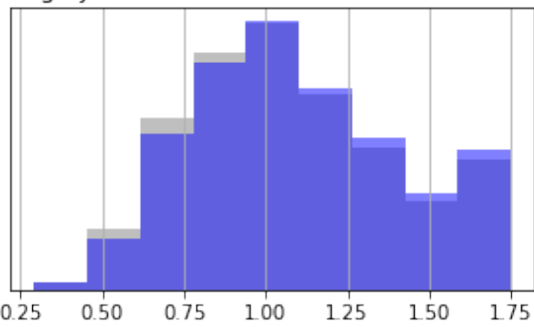
D) grstrt4



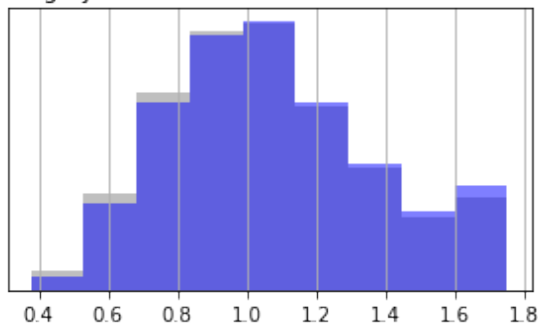
E) grstrt5



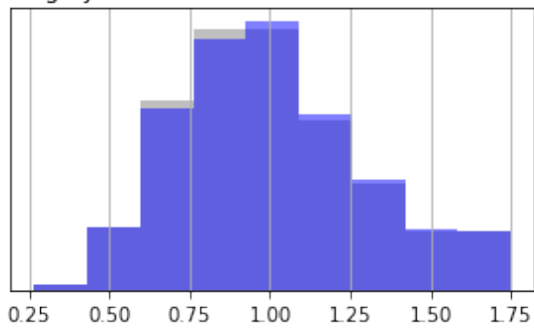
F) grsy3



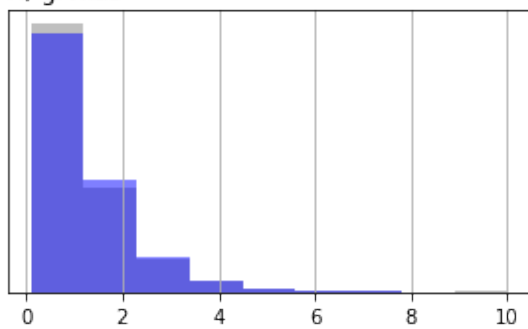
G) grsy4



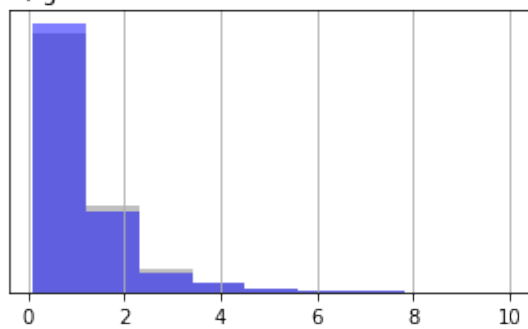
H) grsy5



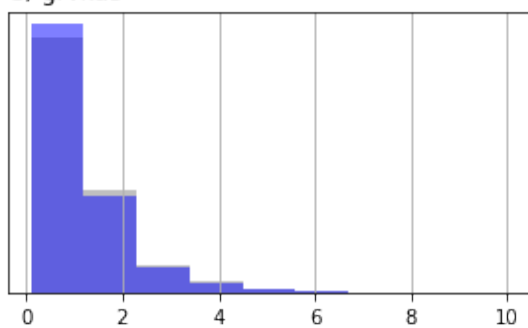
A) grvka3



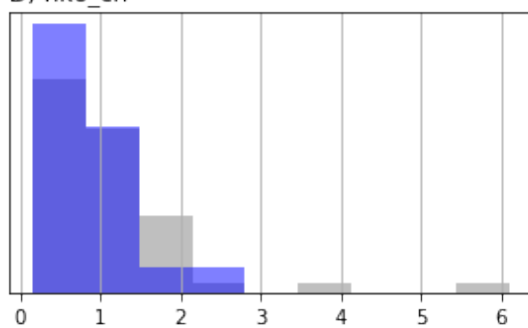
B) grvka4



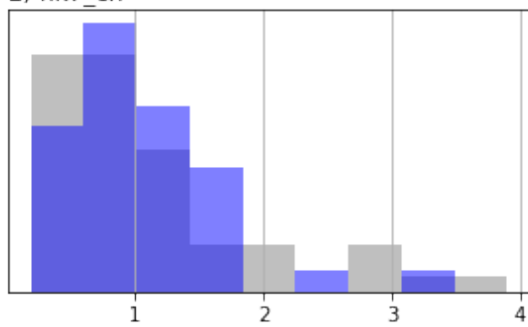
C) grvka5



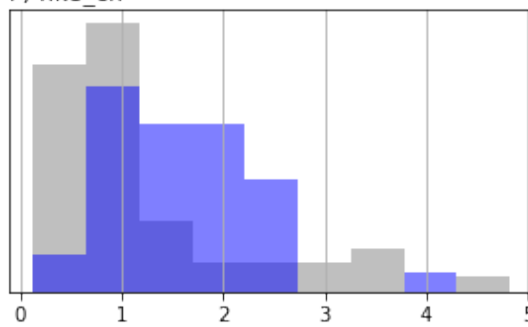
D) hk6_cn



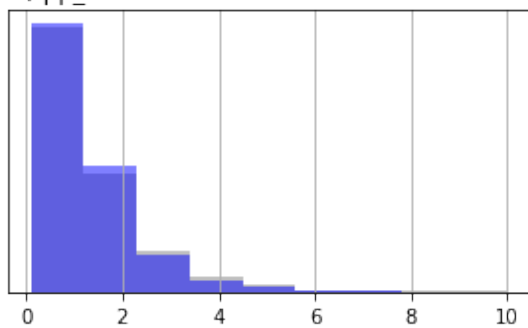
E) hk7_cn



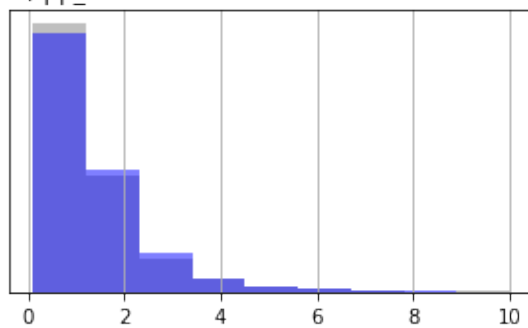
F) hk8_cn



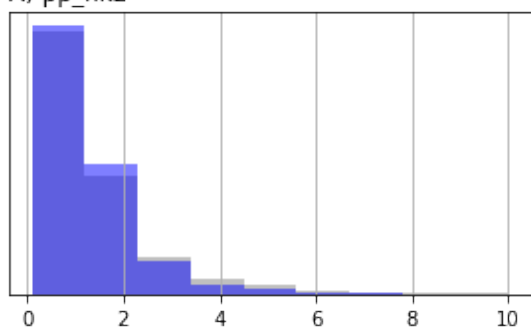
G) pp_hk0



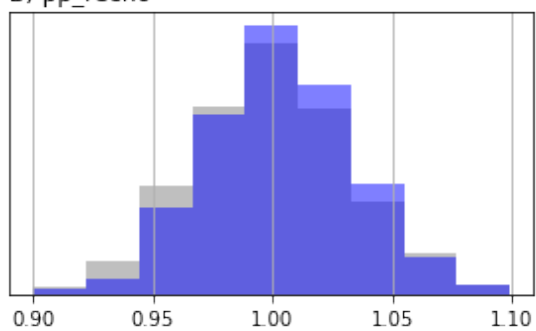
H) pp_hk1



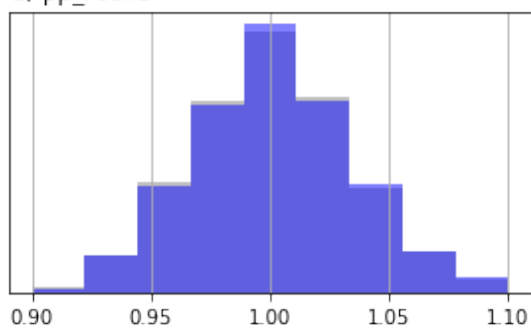
A) pp_hk2



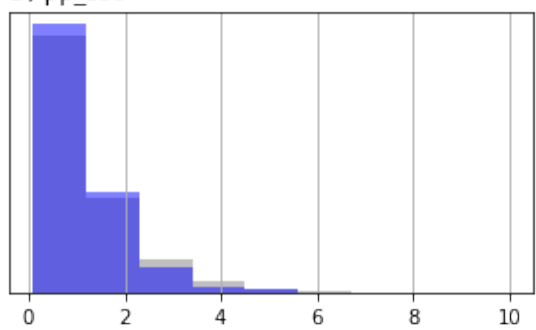
B) pp_rech0



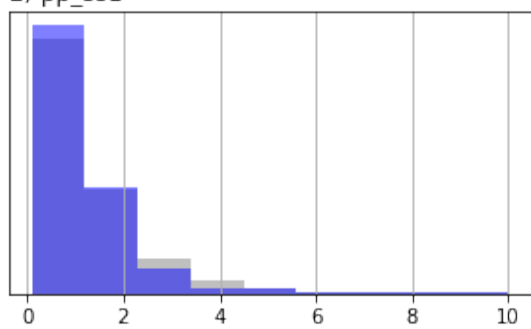
C) pp_rech1



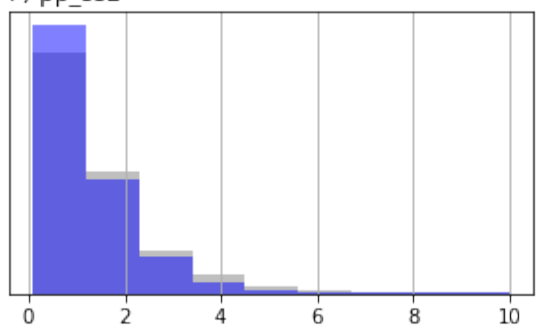
D) pp_ss0



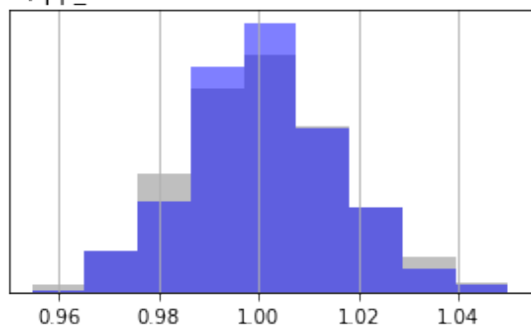
E) pp_ss1



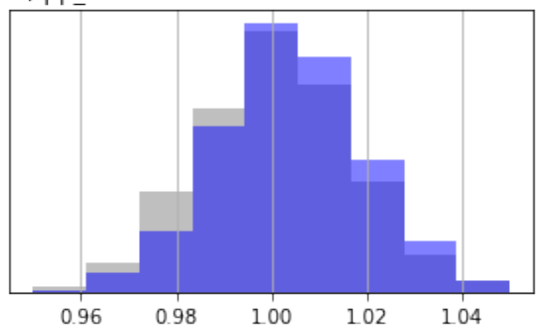
F) pp_ss2



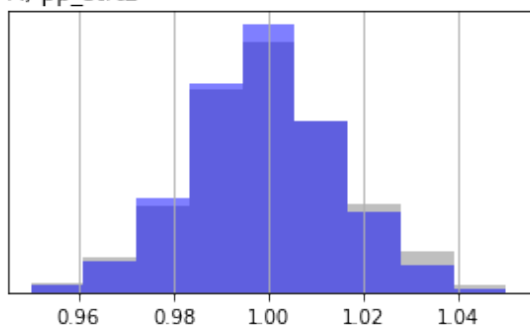
G) pp_strt0



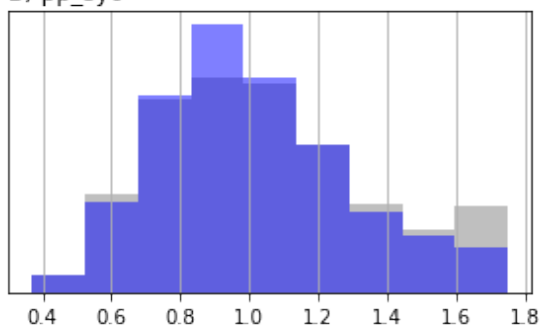
H) pp_strt1



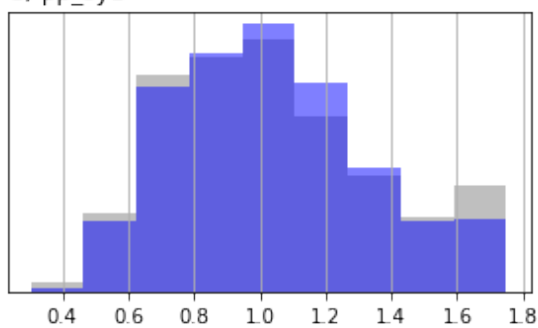
A) pp_strt2



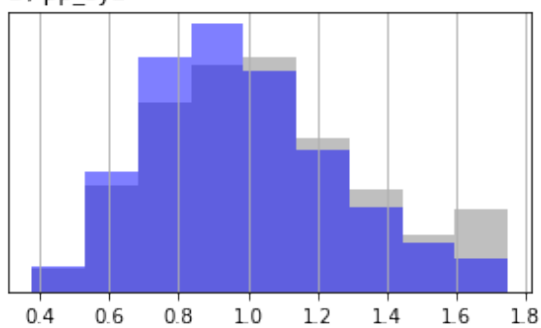
B) pp_sy0



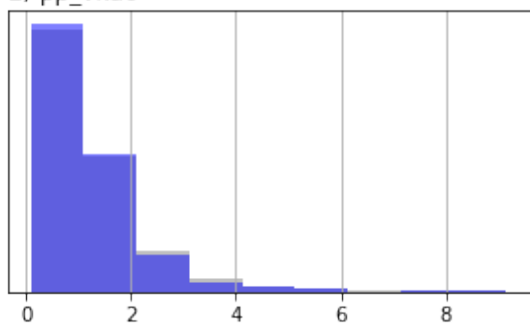
C) pp_sy1



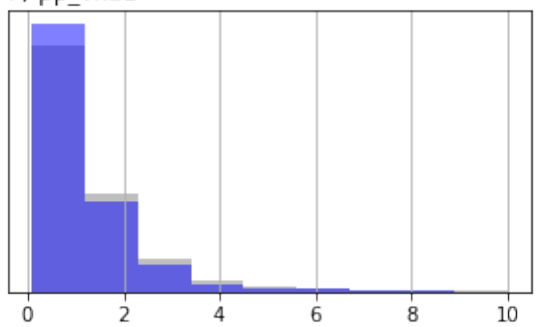
D) pp_sy2



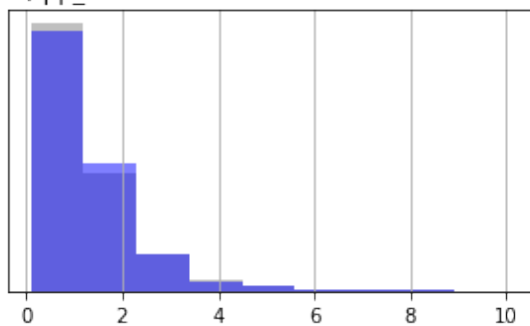
E) pp_vka0



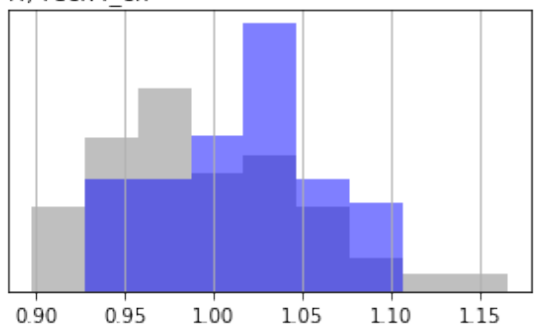
F) pp_vka1

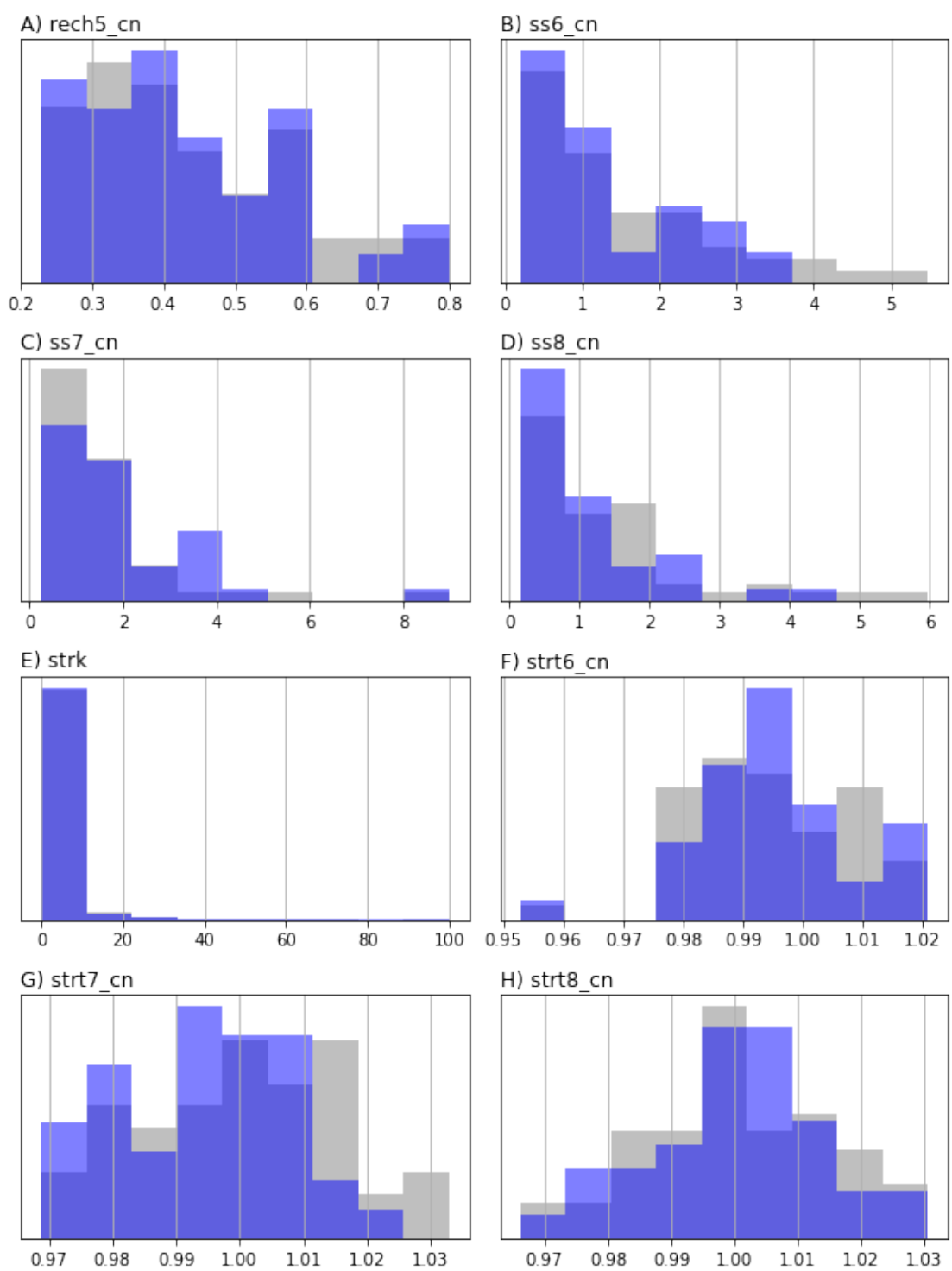


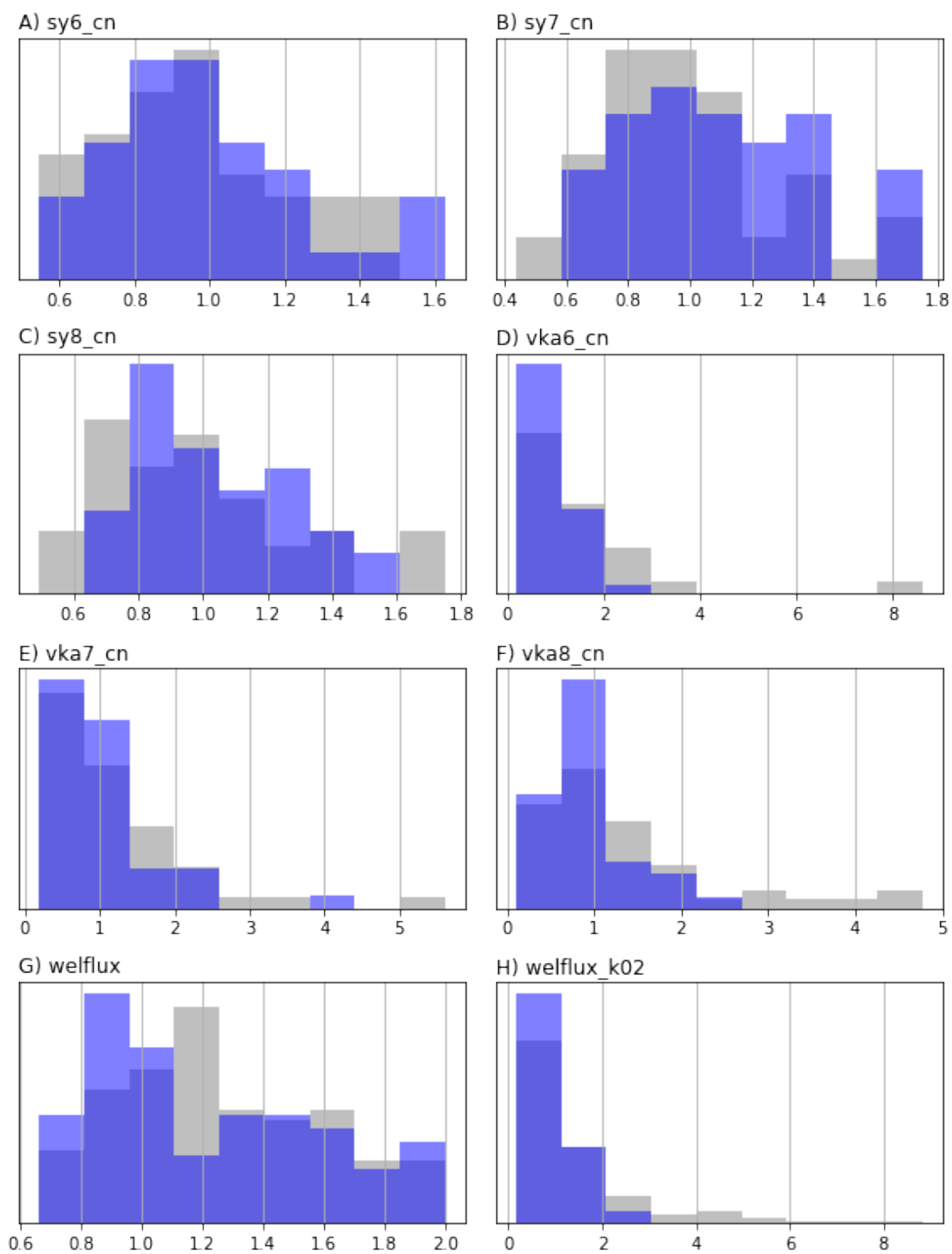
G) pp_vka2



H) rech4_cn

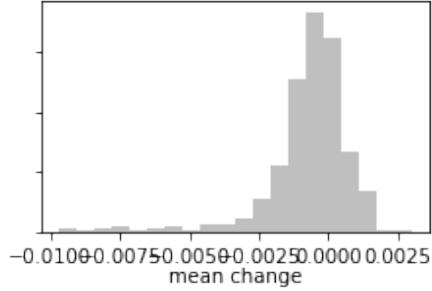




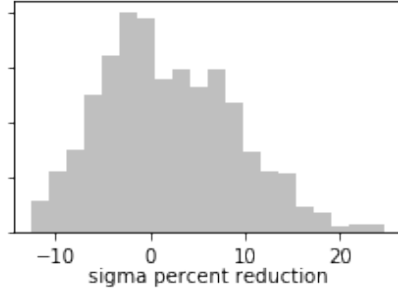


<Figure size 576x756 with 0 Axes>

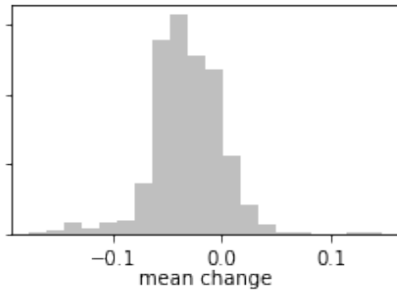
A) mean change group:grrech2, 705 entries
max:0.00302335, min:-0.00971583



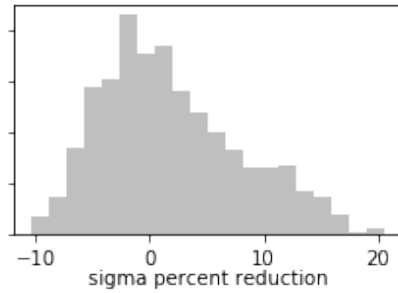
B) sigma change group:grrech2, 705 entries
max: 24.778, min: -12.6281



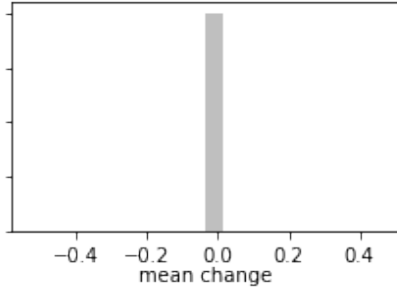
C) mean change group:grss4, 705 entries
max: 0.147577, min: -0.177083



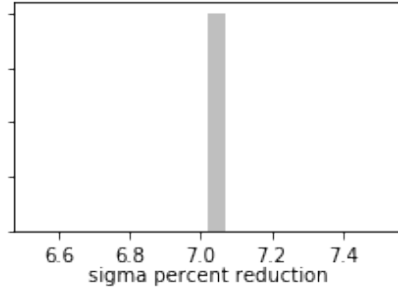
D) sigma change group:grss4, 705 entries
max: 20.5698, min: -10.3781



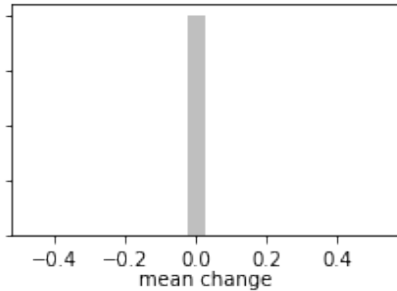
E) mean change group:sy7_cn, 1 entries
max:-0.0350417, min:-0.0350417



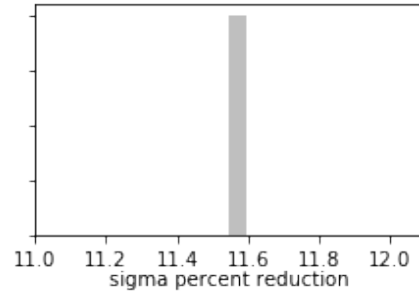
F) sigma change group:sy7_cn, 1 entries
max: 7.02012, min: 7.02012



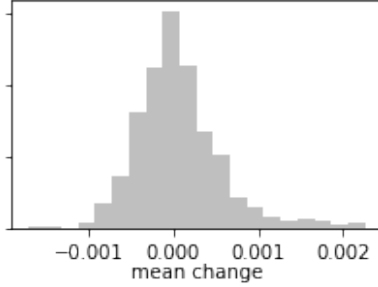
G) mean change group:ss6_cn, 1 entries
max: 0.0285179, min: 0.0285179



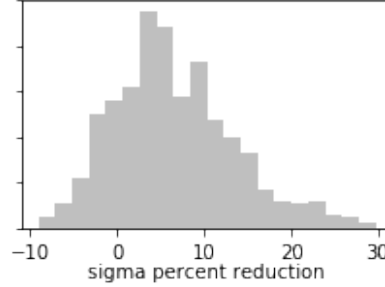
H) sigma change group:ss6_cn, 1 entries
max: 11.5466, min: 11.5466



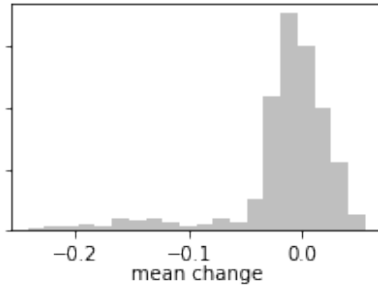
A) mean change group:grstrt3, 705 entries
max:0.00225637, min:-0.00171701



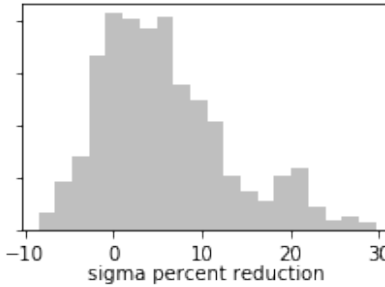
B) sigma change group:grstrt3, 705 entries
max: 29.7127, min: -9.05963



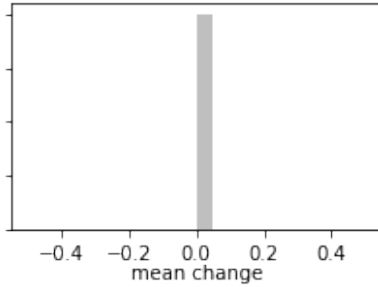
C) mean change group:grhk5, 705 entries
max: 0.0547712, min: -0.241452



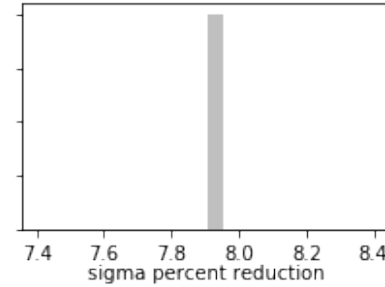
D) sigma change group:grhk5, 705 entries
max: 29.6732, min: -8.50304



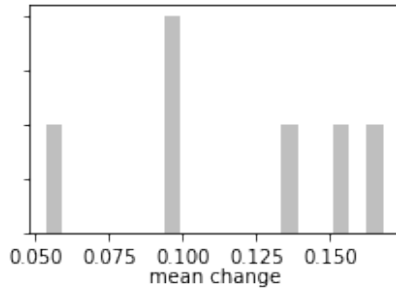
E) mean change group:strt6_cn, 1 entries
max:-0.000283884, min:-0.000283884



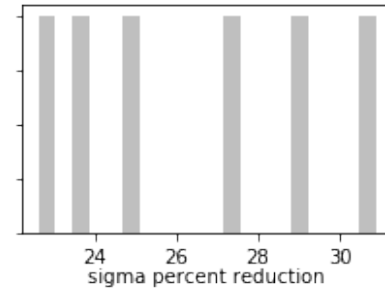
F) sigma change group:strt6_cn, 1 entries
max: 7.90583, min: 7.90583



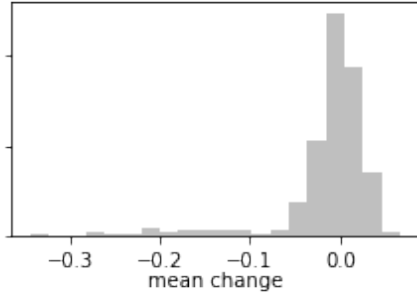
G) mean change group:welflux_k02, 6 entries
max: 0.168111, min: 0.0534904



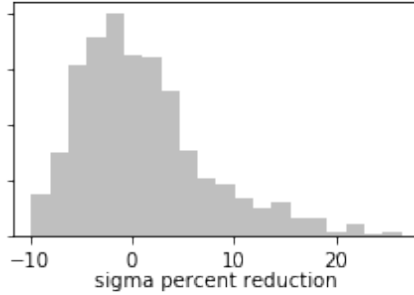
H) sigma change group:welflux_k02, 6 entries
max: 30.8842, min: 22.6126



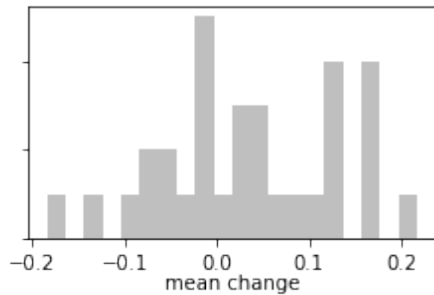
A) mean change group:grhk3, 705 entries
max: 0.0661048, min: -0.343395



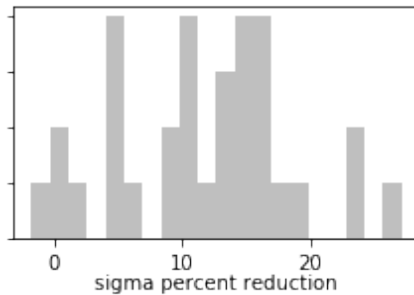
B) sigma change group:grhk3, 705 entries
max: 26.4128, min: -9.86168



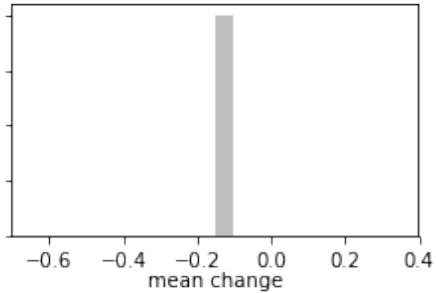
C) mean change group:pp_vka1, 32 entries
max: 0.217116, min: -0.183945



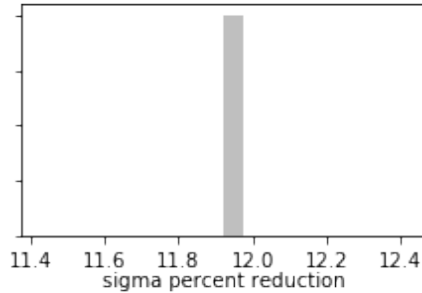
D) sigma change group:pp_vka1, 32 entries
max: 27.1555, min: -1.80198



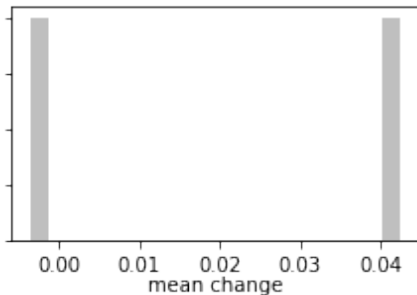
E) mean change group:ss7_cn, 1 entries
max: -0.15123, min: -0.15123



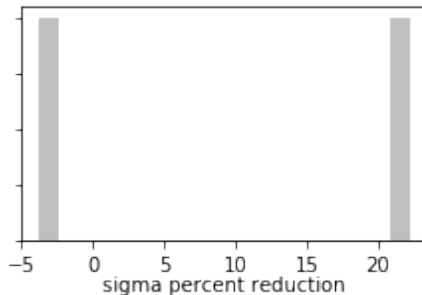
F) sigma change group:ss7_cn, 1 entries
max: 11.9243, min: 11.9243



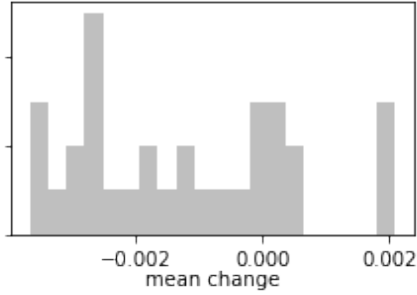
G) mean change group:welflux, 2 entries
max: 0.0424552, min: -0.0036149



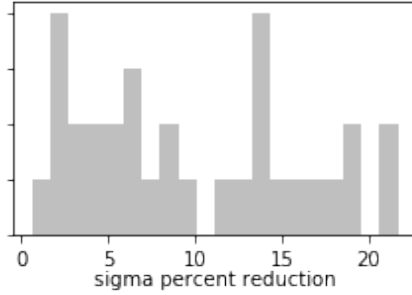
H) sigma change group:welflux, 2 entries
max: 22.1804, min: -3.75034



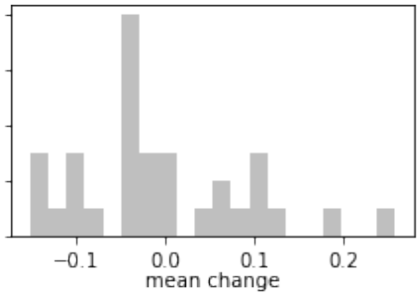
A) mean change group:pp_strt1, 32 entries
max:0.00210103, min:-0.00368758



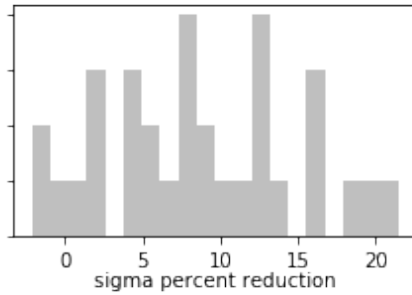
B) sigma change group:pp_strt1, 32 entries
max: 21.6916, min: 0.62952



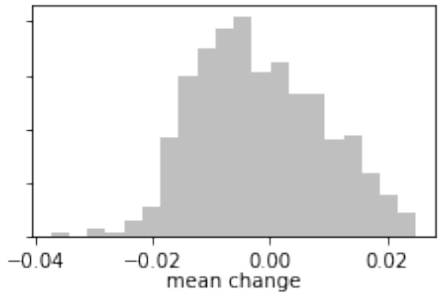
C) mean change group:pp_vka2, 32 entries
max: 0.257463, min: -0.151164



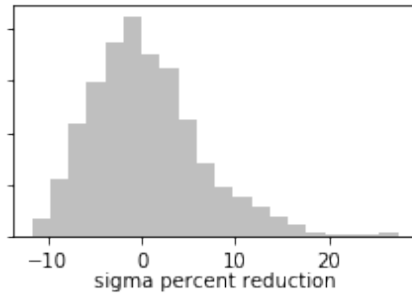
D) sigma change group:pp_vka2, 32 entries
max: 21.4367, min: -2.13637



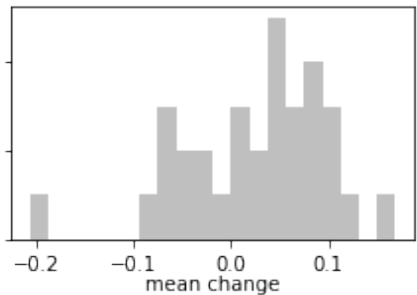
E) mean change group:grsy5, 705 entries
max: 0.0250653, min:-0.0375598



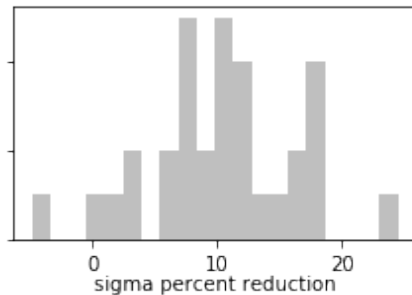
F) sigma change group:grsy5, 705 entries
max: 27.3573, min: -11.695



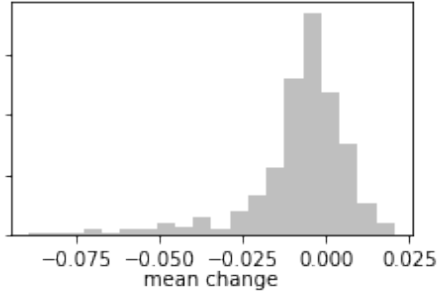
G) mean change group:pp_ss0, 32 entries
max: 0.168654, min: -0.206783



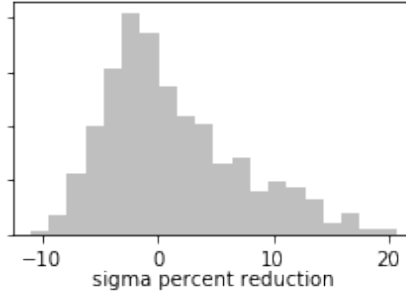
H) sigma change group:pp_ss0, 32 entries
max: 24.5161, min: -4.84539



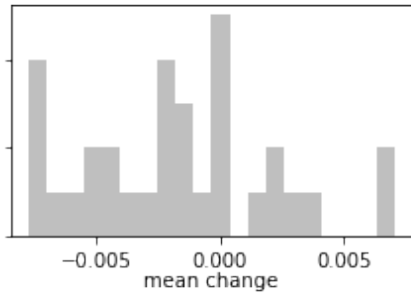
A) mean change group:grsy3, 705 entries
max: 0.0205445, min:-0.0891775



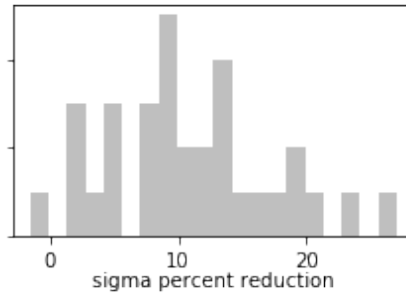
B) sigma change group:grsy3, 705 entries
max: 20.6583, min: -10.989



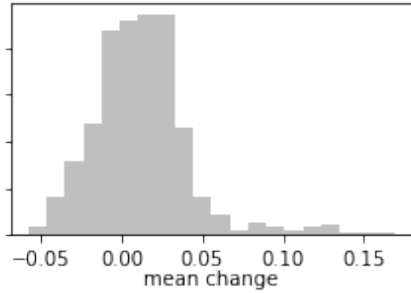
C) mean change group:pp_rech0, 32 entries
max:0.00705668, min:-0.00773195



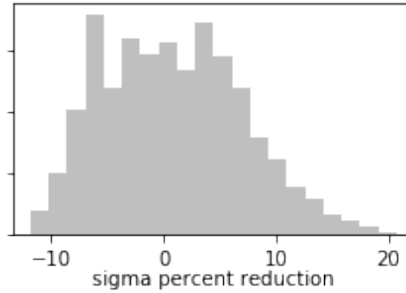
D) sigma change group:pp_rech0, 32 entries
max: 27.0414, min: -1.5393



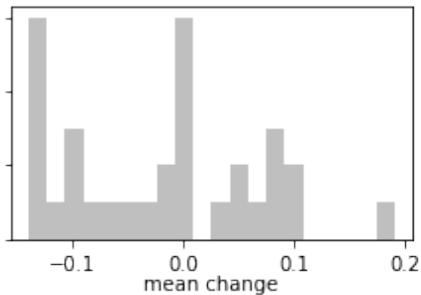
E) mean change group:grvka4, 705 entries
max: 0.169029, min:-0.0574925



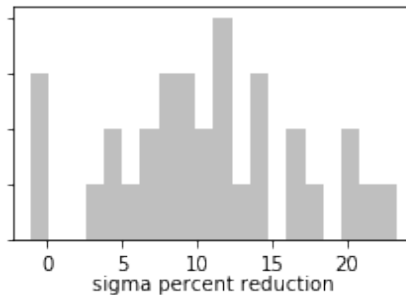
F) sigma change group:grvka4, 705 entries
max: 20.7197, min: -11.8252



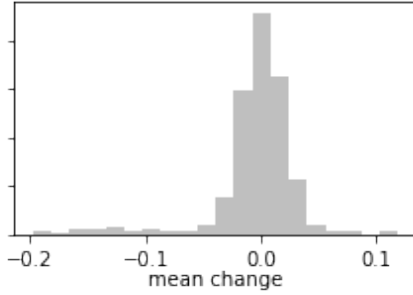
G) mean change group:pp_hk1, 32 entries
max: 0.190804, min: -0.139622



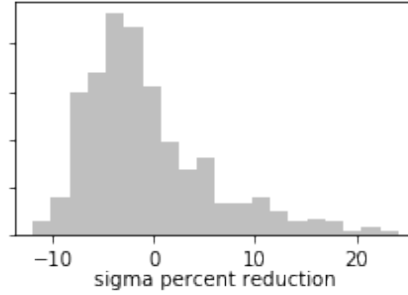
H) sigma change group:pp_hk1, 32 entries
max: 23.2842, min: -1.12566



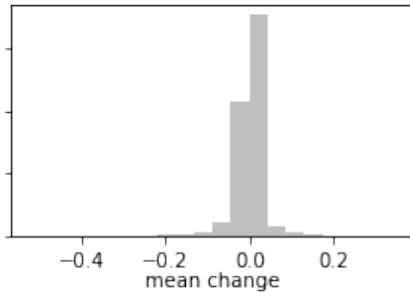
A) mean change group:grhk4, 705 entries
max: 0.119103, min: -0.19731



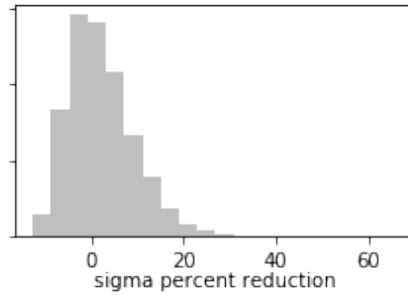
B) sigma change group:grhk4, 705 entries
max: 24.1535, min: -11.9614



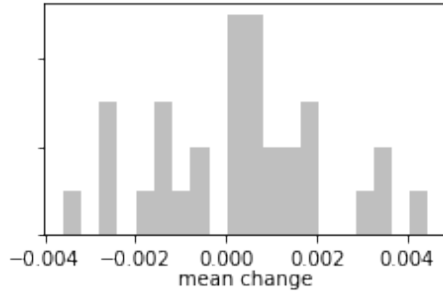
C) mean change group:all, 12605 entries
max: 0.346506, min: -0.52407



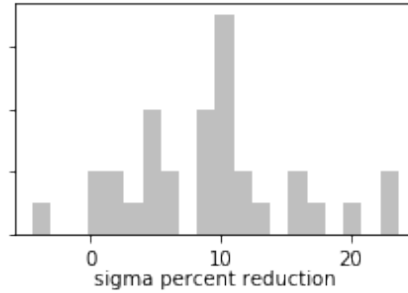
D) sigma change group:all, 12605 entries
max: 66.494, min: -12.6281



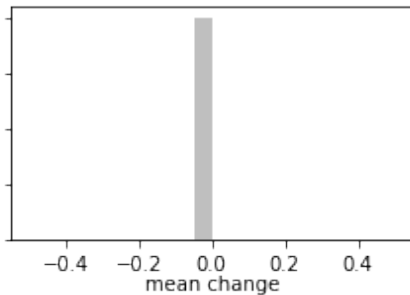
E) mean change group:pp_strt2, 32 entries
max:0.00445734, min:-0.00359962



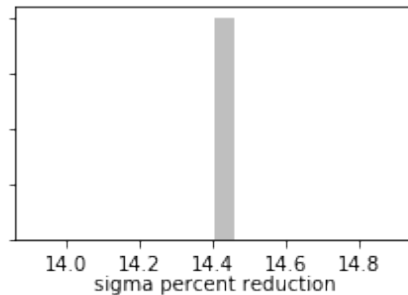
F) sigma change group:pp_strt2, 32 entries
max: 23.6757, min: -4.41567



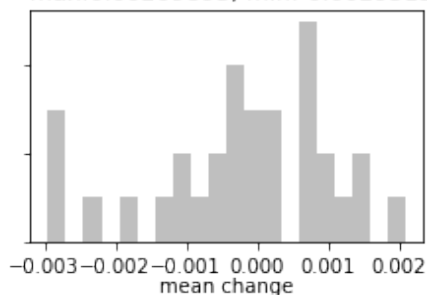
G) mean change group:strt7_cn, 1 entries
max:0.00272632, min:0.00272632



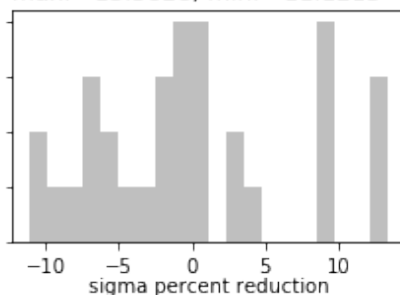
H) sigma change group:strt7_cn, 1 entries
max: 14.4073, min: 14.4073



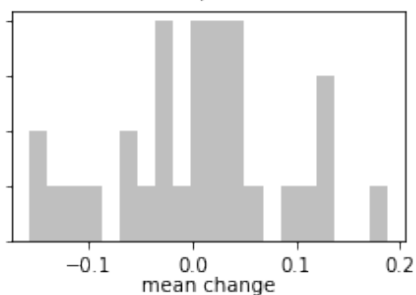
A) mean change group:pp_rech1, 32 entries
max:0.00209893, min:-0.00295134



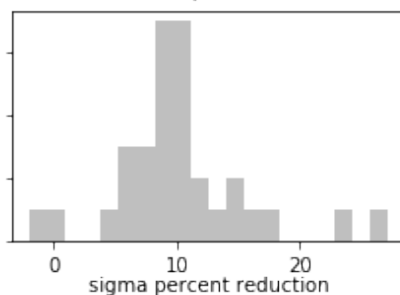
B) sigma change group:pp_rech1, 32 entries
max: 13.3828, min: -11.1213



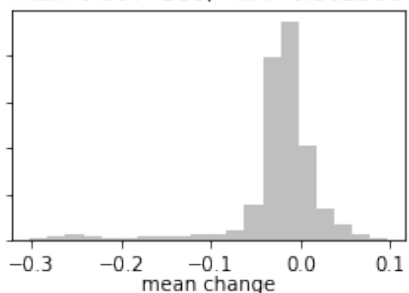
C) mean change group:pp_hk0, 32 entries
max: 0.188215, min: -0.156902



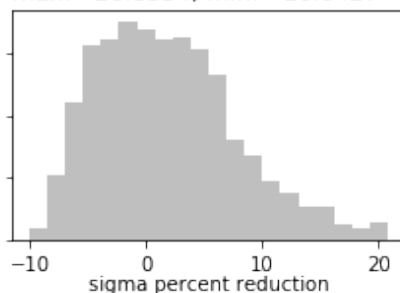
D) sigma change group:pp_hk0, 32 entries
max: 27.1982, min: -1.98689



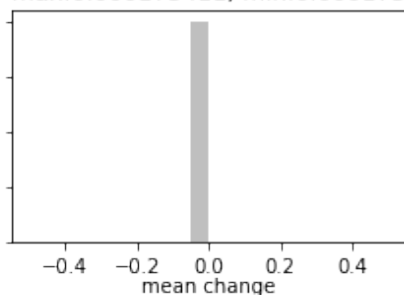
E) mean change group:grss5, 705 entries
max: 0.0977288, min: -0.302366



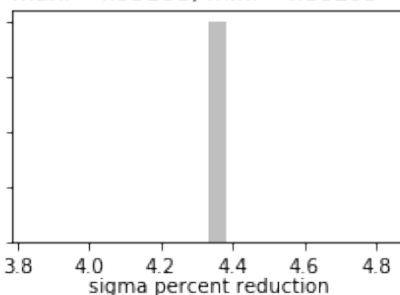
F) sigma change group:grss5, 705 entries
max: 20.8354, min: -10.0427



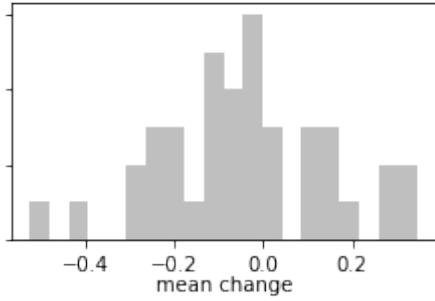
G) mean change group:strt8_cn, 1 entries
max:0.000175411, min:0.000175411



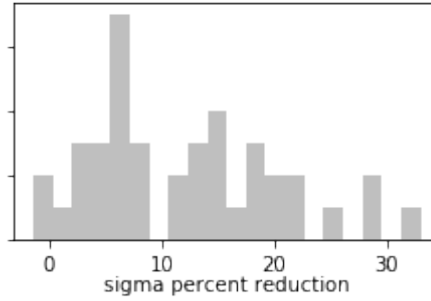
H) sigma change group:strt8_cn, 1 entries
max: 4.33293, min: 4.33293



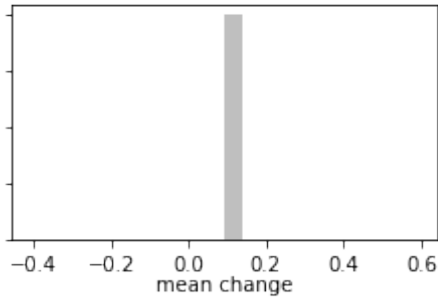
A) mean change group:strk, 40 entries
max: 0.346506, min: -0.52407



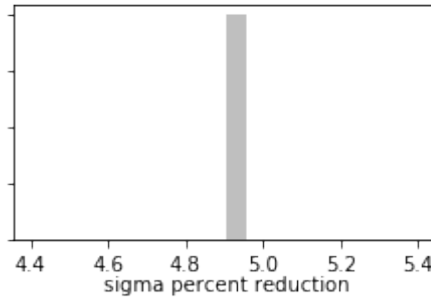
B) sigma change group:strk, 40 entries
max: 33.0266, min: -1.41909



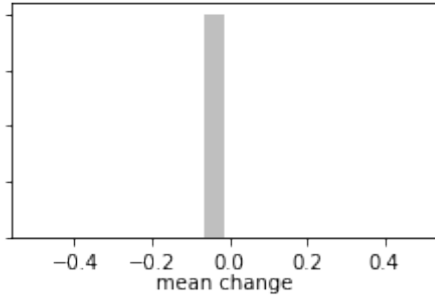
C) mean change group:ss8_cn, 1 entries
max: 0.0902138, min: 0.0902138



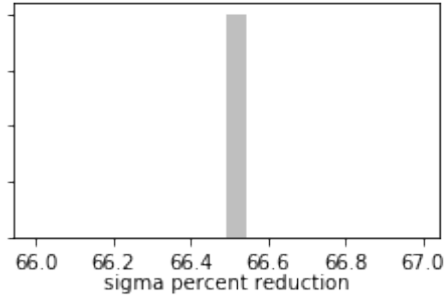
D) sigma change group:ss8_cn, 1 entries
max: 4.90551, min: 4.90551



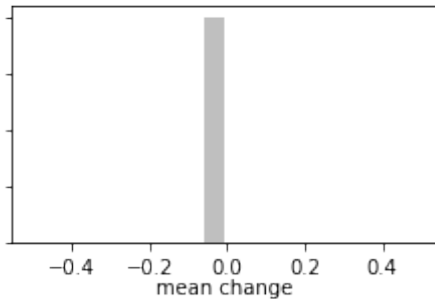
E) mean change group:flow, 1 entries
max: -0.015025, min: -0.015025



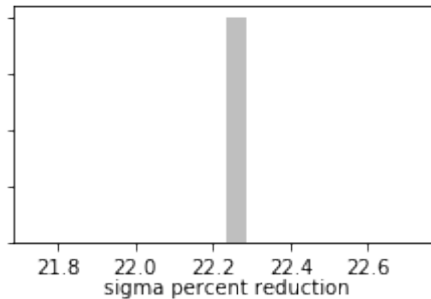
F) sigma change group:flow, 1 entries
max: 66.494, min: 66.494



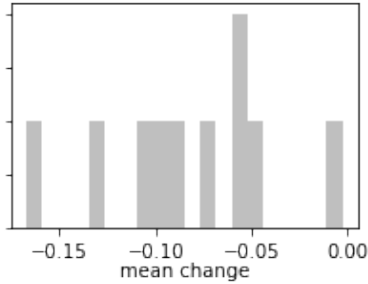
G) mean change group:rech4_cn, 1 entries
max:-0.00940592, min:-0.00940592



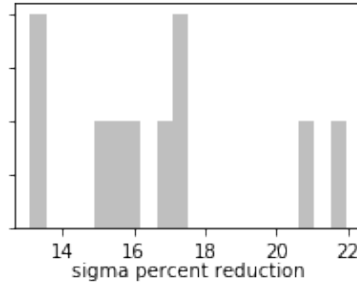
H) sigma change group:rech4_cn, 1 entries
max: 22.2353, min: 22.2353



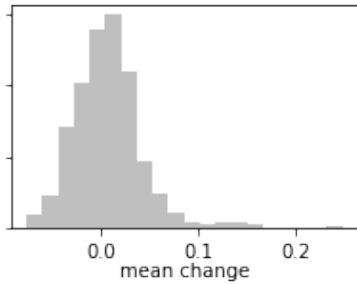
A) mean change group:drncond_k00, 10 entries
max:-0.00278286, min:-0.167367



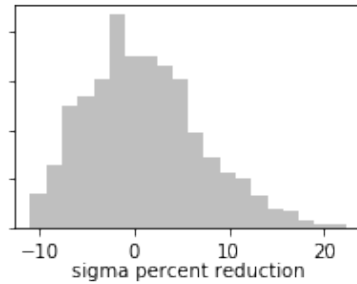
B) sigma change group:drncond_k00, 10 entries
max: 21.9658, min: 13.0997



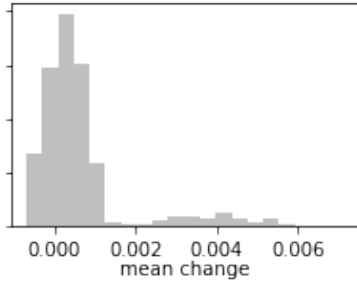
C) mean change group:grss3, 705 entries
max: 0.247133, min:-0.0770737



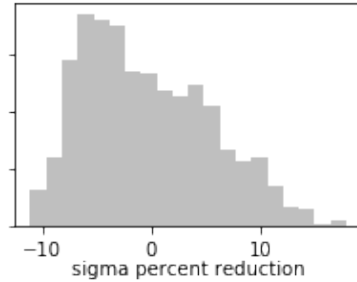
D) sigma change group:grss3, 705 entries
max: 22.3987, min: -11.0038



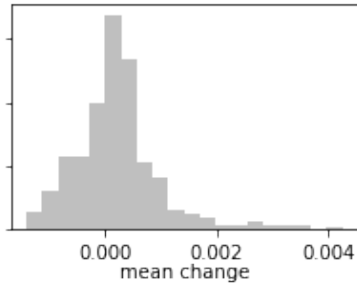
E) mean change group:grstrt5, 705 entries
max: 0.0070988, min:-0.000706506



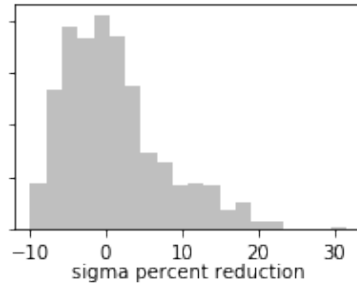
F) sigma change group:grstrt5, 705 entries
max: 17.7635, min: -11.0645



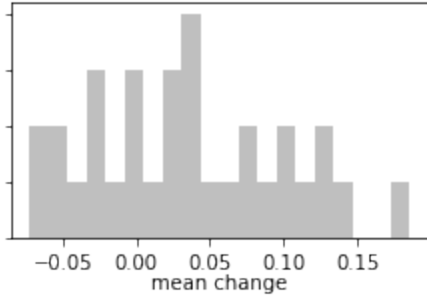
G) mean change group:grstrt4, 705 entries
max:0.00424293, min:-0.00141493



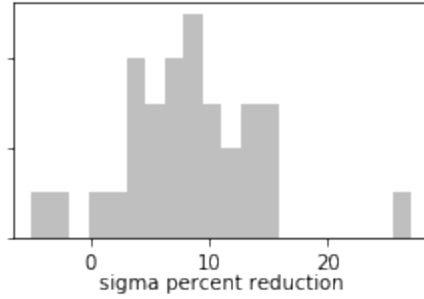
H) sigma change group:grstrt4, 705 entries
max: 31.4917, min: -9.89303



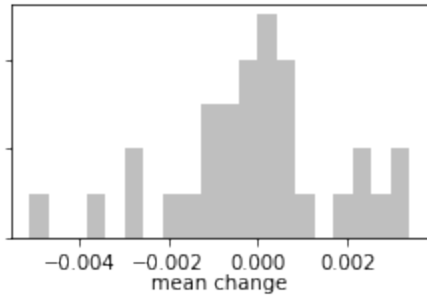
A) mean change group:pp_ss1, 32 entries
max: 0.185547, min:-0.0724362



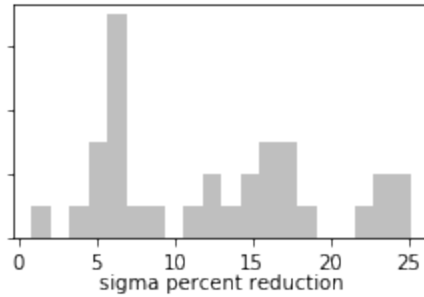
B) sigma change group:pp_ss1, 32 entries
max: 27.0817, min: -5.01221



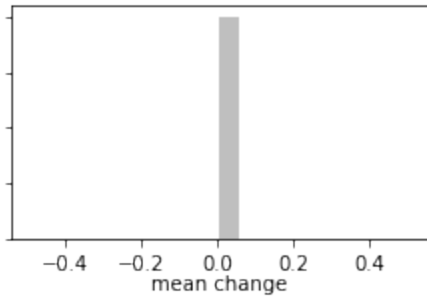
C) mean change group:pp_strt0, 32 entries
max:0.00339293, min:-0.00509914



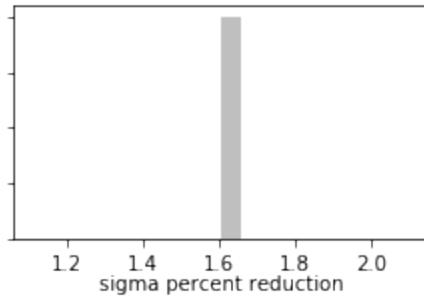
D) sigma change group:pp_strt0, 32 entries
max: 25.2233, min: 0.806239



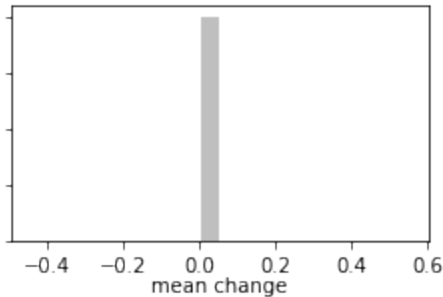
E) mean change group:rech5_cn, 1 entries
max:0.00415297, min:0.00415297



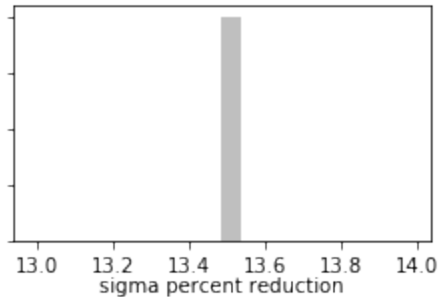
F) sigma change group:rech5_cn, 1 entries
max: 1.6067, min: 1.6067



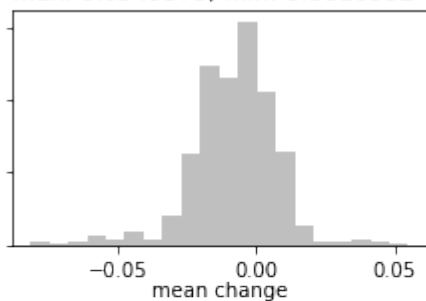
G) mean change group:vka7_cn, 1 entries
max: 0.0516391, min: 0.0516391



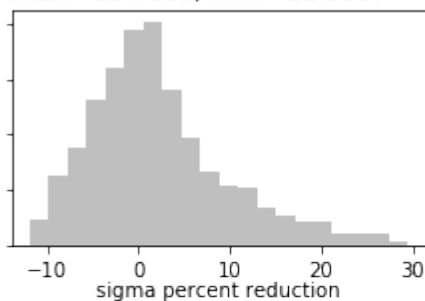
H) sigma change group:vka7_cn, 1 entries
max: 13.4865, min: 13.4865



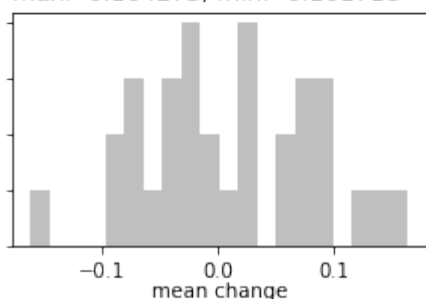
A) mean change group:grsy4, 705 entries
max: 0.0549575, min:-0.0816992



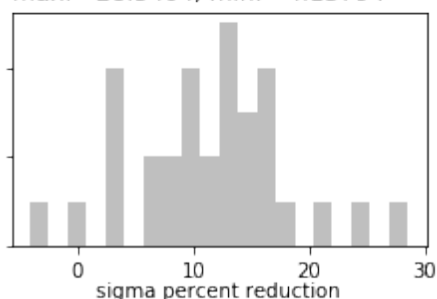
B) sigma change group:grsy4, 705 entries
max: 29.4659, min: -11.8687



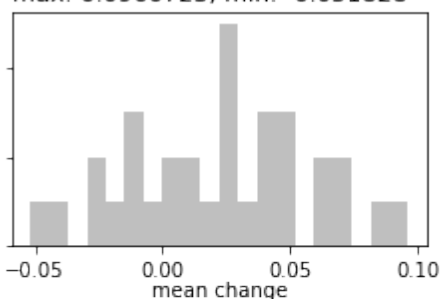
C) mean change group:pp_vka0, 32 entries
max: 0.164275, min:-0.161718



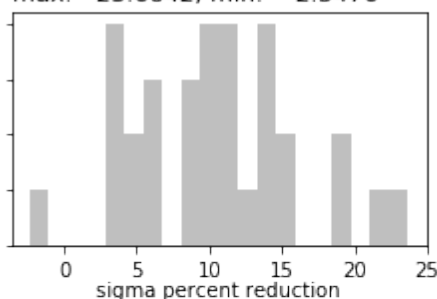
D) sigma change group:pp_vka0, 32 entries
max: 28.5404, min: -4.13794



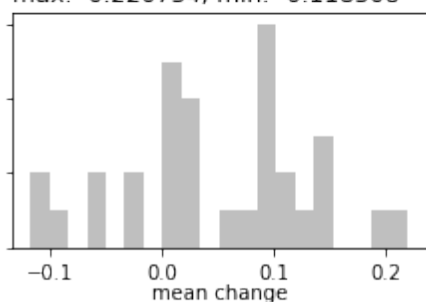
E) mean change group:pp_sy2, 32 entries
max: 0.0960723, min:-0.051828



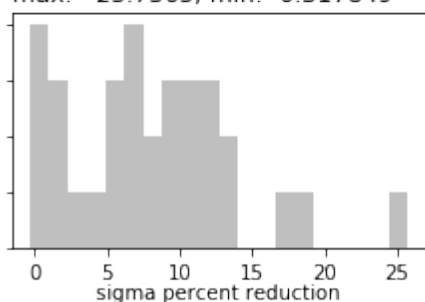
F) sigma change group:pp_sy2, 32 entries
max: 23.6842, min: -2.3476



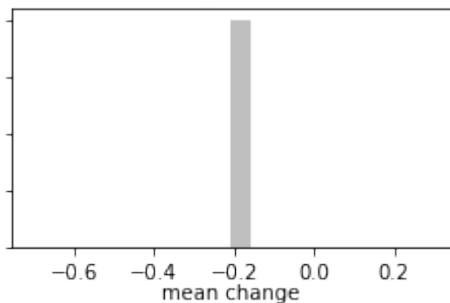
G) mean change group:pp_ss2, 32 entries
max: 0.220754, min:-0.118508



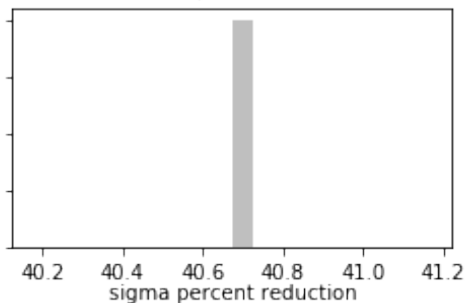
H) sigma change group:pp_ss2, 32 entries
max: 25.7365, min: -0.317849



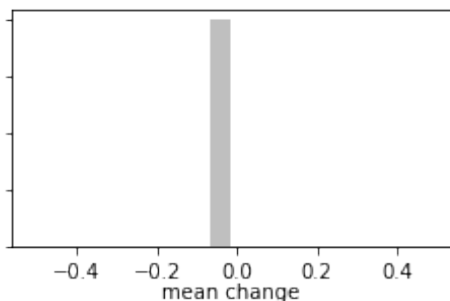
A) mean change group:hk8_cn, 1 entries
max: -0.208784, min: -0.208784



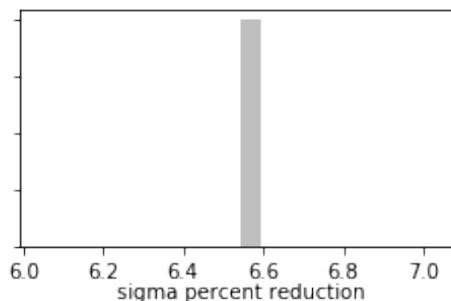
B) sigma change group:hk8_cn, 1 entries
max: 40.6743, min: 40.6743



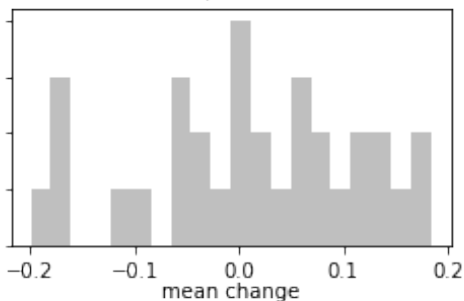
C) mean change group:sy6_cn, 1 entries
max: -0.0151409, min: -0.0151409



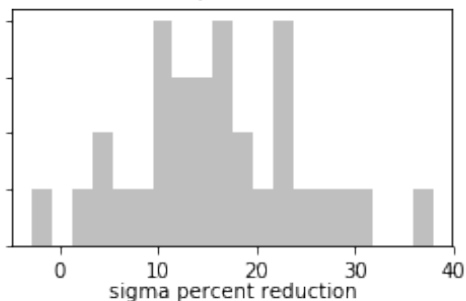
D) sigma change group:sy6_cn, 1 entries
max: 6.54331, min: 6.54331



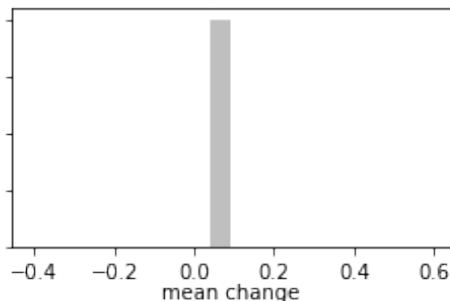
E) mean change group:pp_hk2, 32 entries
max: 0.183924, min: -0.199322



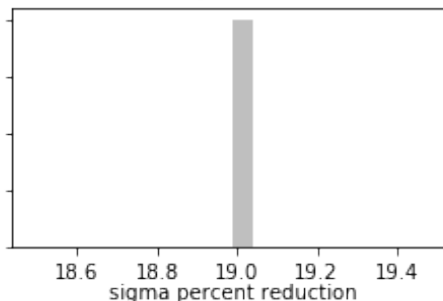
F) sigma change group:pp_hk2, 32 entries
max: 37.8669, min: -2.77673



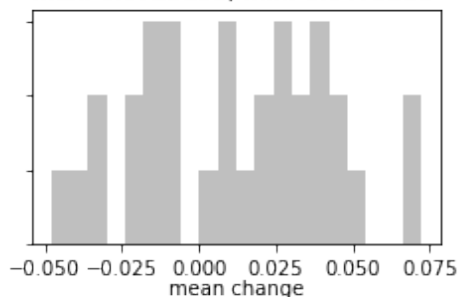
G) mean change group:hk6_cn, 1 entries
max: 0.0921041, min: 0.0921041



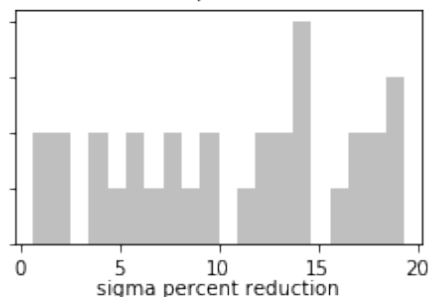
H) sigma change group:hk6_cn, 1 entries
max: 18.9889, min: 18.9889



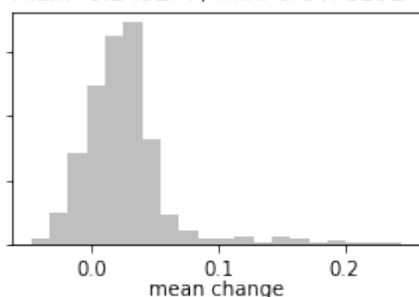
A) mean change group:pp_sy0, 32 entries
max: 0.0723193, min:-0.0479218



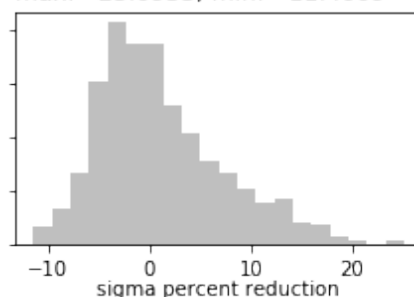
B) sigma change group:pp_sy0, 32 entries
max: 19.3094, min: 0.679423



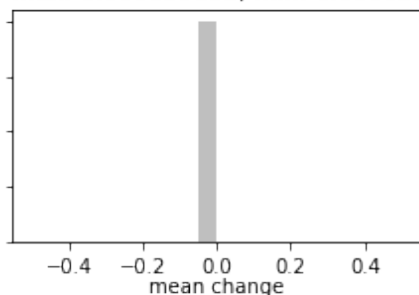
C) mean change group:grvka5, 705 entries
max: 0.245277, min:-0.0478291



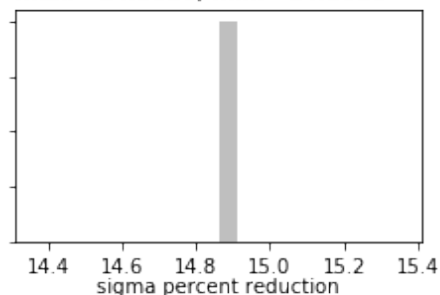
D) sigma change group:grvka5, 705 entries
max: 25.0933, min: -11.4009



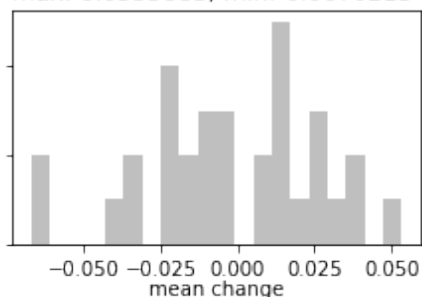
E) mean change group:hk7_cn, 1 entries
max:-0.000639895, min:-0.000639895



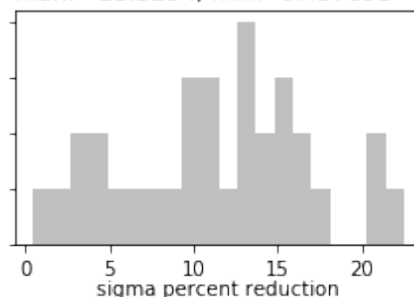
F) sigma change group:hk7_cn, 1 entries
max: 14.8616, min: 14.8616



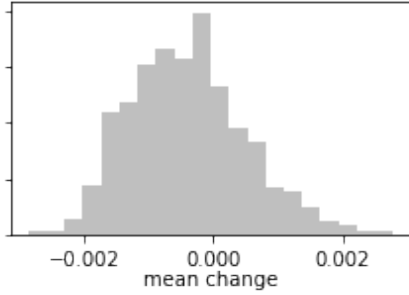
G) mean change group:pp_sy1, 32 entries
max: 0.0533883, min:-0.0670213



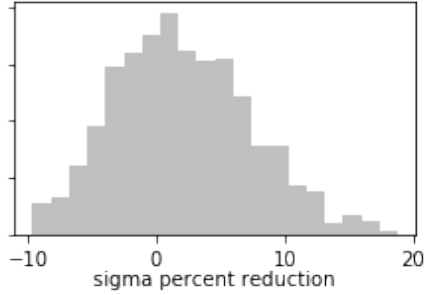
H) sigma change group:pp_sy1, 32 entries
max: 22.5234, min: 0.457852



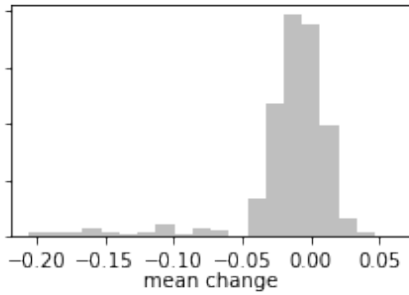
A) mean change group:grrech3, 705 entries
max:0.00279212, min:-0.00287502



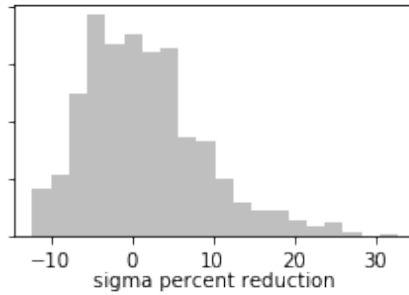
B) sigma change group:grrech3, 705 entries
max: 18.7929, min: -9.61534



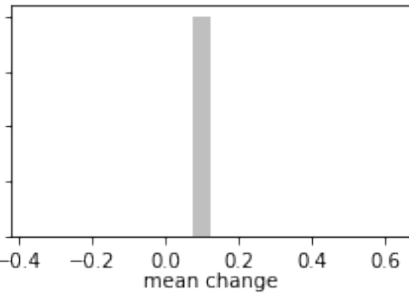
C) mean change group:grvka3, 705 entries
max: 0.0604757, min: -0.206051



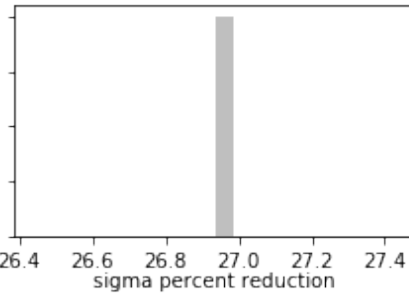
D) sigma change group:grvka3, 705 entries
max: 32.7534, min: -12.2282



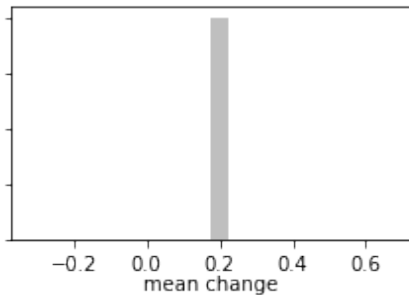
E) mean change group:vka8_cn, 1 entries
max: 0.124516, min: 0.124516



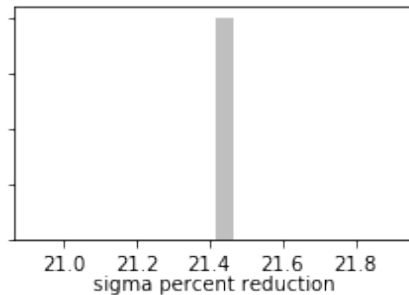
F) sigma change group:vka8_cn, 1 entries
max: 26.9355, min: 26.9355



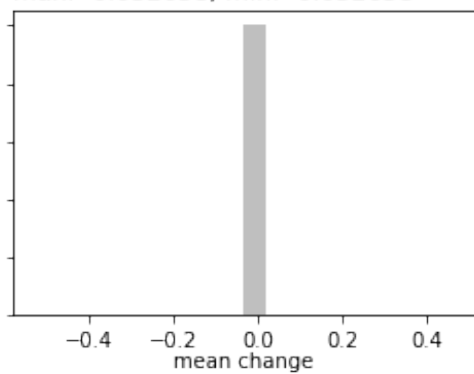
G) mean change group:vka6_cn, 1 entries
max: 0.175631, min: 0.175631



H) sigma change group:vka6_cn, 1 entries
max: 21.4155, min: 21.4155



A) mean change group:sy8_cn, 1 entries
max: -0.032658, min: -0.032658



B) sigma change group:sy8_cn, 1 entries
max: 29.5972, min: 29.5972

