verify_unc_results

June 4, 2015

1 verify pyEMU results with the henry problem

```
In [2]: %pylab inline
        import os
        import numpy as np
        import pylab as ply
        import pyemu
        import pst_handler as phand
        import mat_handler as mhand
```

```
Populating the interactive namespace from numpy and matplotlib
```

instaniate `pyemu` object and drop prior info. Then reorder the jacobian and save as binary. This is needed because the pest utilities require strict order between the control file and jacobian

```
In [3]: la = pyemu.schur("pest.jco",verbose=False)
        la.drop_prior_information()
        jco_ord = la.jco.get(la.pst.obs_names,la.pst.par_names)
        ord_base = "pest_ord"
        jco_ord.to_binary(ord_base + ".jco")
```

extract and save the forecast sensitivity vectors

```
In [4]: pv_names = []
        predictions =  ["pd_ten", "c_obs10_2"]
        for pred in predictions:
            pv = jco_ord.extract(pred).T
            pv_name = pred + ".vec"
            pv.to_ascii(pv_name)
            pv_names.append(pv_name)
```

save the prior parameter covariance matrix as an uncertainty file

```
In [5]: prior_uncfile = "pest.unc"
        la.parcov.to_uncfile(prior_uncfile,covmat_file=None)
```

2 PRECUNC7

write a response file to feed `stdin` to `predunc7`

```
In [6]: post_mat = "post.cov"
        post_unc = "post.unc"
        args = [ord_base + ".pst","1.0",prior_uncfile,
```

```
                post_mat,post_unc,"1"]
        pd7_in = "predunc7.in"
        f = open(pd7_in,'w')
        f.write('\n'.join(args)+'\n')
        f.close()
        out = "pd7.out"
        pd7 = os.path.join("exe","i64predunc7.exe")
        os.system(pd7 + " <" + pd7_in + " >"+out)
        for line in open(out).readlines():
            print line,
```

```
PREDUNC7 Version 13.3. Watermark Numerical Computing.

 Enter name of PEST control file:  Enter observation reference variance:
 Enter name of prior parameter uncertainty file:
 Enter name for posterior parameter covariance matrix file:  Enter name for posterior parameter uncerta
 Use which version of linear predictive uncertainty equation:-
     if version optimized for small number of parameters   - enter 1
     if version optimized for small number of observations - enter 2
 Enter your choice:
 - reading PEST control file pest_ord.pst...
 - file pest_ord.pst read ok.

 - reading Jacobian matrix file pest_ord.jco...
 - file pest_ord.jco read ok.

 - reading parameter uncertainty file pest.unc...
 - parameter uncertainty file pest.unc read ok.
 - forming XtC-1(e)X matrix...
 - inverting prior C(p) matrix...
 - inverting [XtC-1(e)X + C-1(p)] matrix...
 - writing file post.cov...
 - file post.cov written ok.
 - writing file post.unc...
 - file post.unc written ok.
```

load the posterior matrix written by predunc7

In [7]:
```
post_pd7 = mhand.cov()
post_pd7.from_ascii(post_mat)

la_ord = pyemu.schur(jco="pest_ord.jco",predictions=predictions)
post_pyemu = la_ord.posterior_parameter
#post_pyemu = post_pyemu.get(post_pd7.row_names)
```

The cumulative difference between the two posterior matrices:

In [8]:
```
delta = (post_pd7 - post_pyemu).x
(post_pd7 - post_pyemu).to_ascii("delta.cov")
print delta.sum()
print delta.max(),delta.min()
```

```
1.70407837082e-06
4.97750649586e-08 -4.98772445567e-08
```

3 PREDUNC1

write a response file to feed `stdin`. Then run `predunc1` for each forecast

```
In [9]: args = [ord_base + ".pst", "1.0", prior_uncfile, None, "1"]
        pd1_in = "predunc1.in"
        pd1 = os.path.join("exe", "i64predunc1.exe")
        pd1_results = {}
        for pv_name in pv_names:
            args[3] = pv_name
            f = open(pd1_in, 'w')
            f.write('\n'.join(args) + '\n')
            f.close()
            out = "predunc1" + pv_name + ".out"
            os.system(pd1 + " <" + pd1_in + ">" + out)
            f = open(out,'r')
            for line in f:
                if "pre-cal " in line.lower():
                    pre_cal = float(line.strip().split()[-2])
                elif "post-cal " in line.lower():
                    post_cal = float(line.strip().split()[-2])
            f.close()
            pd1_results[pv_name.split('.')[0].lower()] = [pre_cal, post_cal]
```

organize the `pyemu` results into a structure for comparison

```
In [10]: pyemu_results = {}
         for pname in la_ord.prior_prediction.keys():
             pyemu_results[pname] = [np.sqrt(la_ord.prior_prediction[pname]),
                                     np.sqrt(la_ord.posterior_prediction[pname])]
```

compare the results:

```
In [11]: f = open("predunc1_textable.dat",'w')
         for pname in pd1_results.keys():
             print pname
             f.write(pname+"&{0:6.5f}&{1:6.5}&{2:6.5f}&{3:6.5f}\\\n"\
                     .format(pd1_results[pname][0],pyemu_results[pname][0],
                             pd1_results[pname][1],pyemu_results[pname][1]))
             print "prior",pname,pd1_results[pname][0],pyemu_results[pname][0]
             print "post",pname,pd1_results[pname][1],pyemu_results[pname][1]
         f.close()
```

```
c_obs10_2
prior c_obs10_2 0.1509421 0.150942104963
post c_obs10_2 0.089084382 0.0890843823278
pd_ten
prior pd_ten 0.4716172 0.471617160877
post pd_ten 0.2267402 0.226740171374
```

3.1 PREDVAR1b

write the nessecary files to run `predvar1b`

In [12]:
```
f = open("pred_list.dat",'w')
out_files = []
for pv in pv_names:
    out_name = pv+".predvar1b.out"
    out_files.append(out_name)
    f.write(pv+" "+out_name+"\n")
f.close()
args = ["pest_ord.pst","1.0","pest.unc","pred_list.dat"]
for i in xrange(36):
    args.append(str(i))
args.append('')
args.append("n")
args.append("y")
f = open("predvar1b.in", 'w')
f.write('\n'.join(args) + '\n')
f.close()

os.system("predvar1b.exe <predvar1b.in")
```

Out[12]: 0

In [13]:
```
pv1b_results = {}
for out_file in out_files:
    pred_name = out_file.split('.')[0]
    f = open(out_file,'r')
    for _ in xrange(3):
        f.readline()
    arr = np.loadtxt(f)
    pv1b_results[pred_name] = arr
```

now for pyemu

In [14]:
```
la_ord_errvar = pyemu.errvar(jco="pest_ord.jco",
                             predictions=predictions,
                             omitted_parameters="mult1",
                             verbose=False)
df = la_ord_errvar.get_errvar_dataframe(np.arange(36))
df
```

Out[14]:

	first		second		third
	c_obs10_2	pd_ten	c_obs10_2	pd_ten	c_obs10_2
0	0.015706	0.076700	0.000000e+00	0.000000e+00	7.077577e-03
1	0.006040	0.046811	8.323523e-04	2.573705e-03	1.155533e-01
2	0.005905	0.045945	9.201068e-04	3.138167e-03	7.724431e-02
3	0.004850	0.042798	4.135876e-03	1.273156e-02	2.939249e-02
4	0.004582	0.037457	5.612732e-03	4.213813e-02	3.411090e-02
5	0.004233	0.031039	8.756785e-03	9.996844e-02	4.180124e-02
6	0.004156	0.031010	9.697704e-03	1.003232e-01	3.803914e-02
7	0.004155	0.030849	9.728439e-03	1.032245e-01	3.804302e-02
8	0.004084	0.029342	1.123436e-02	1.354974e-01	4.117493e-02
9	0.004084	0.029109	1.123444e-02	1.422348e-01	4.117309e-02
10	0.004084	0.028689	1.124962e-02	1.547092e-01	4.127345e-02
11	0.004083	0.027723	1.127209e-02	1.870549e-01	4.113856e-02
12	0.004044	0.027693	1.373466e-02	1.889087e-01	4.167552e-02
13	0.003870	0.027380	2.509977e-02	2.094440e-01	3.828531e-02

14	0.003397	0.023741	5.647082e-02	4.508064e-01	2.912006e-02
15	0.003397	0.023106	5.648180e-02	4.973744e-01	2.909730e-02
16	0.003397	0.022881	5.654890e-02	5.176496e-01	2.918142e-02
17	0.003395	0.022858	5.673687e-02	5.202939e-01	2.930732e-02
18	0.003021	0.022763	1.240355e-01	5.373727e-01	2.907968e-02
19	0.002723	0.022762	3.052508e+00	5.493474e-01	3.142555e-02
20	0.002716	0.022580	4.771325e+01	1.123392e+03	2.520051e-02
21	0.002714	0.022526	6.754794e+01	1.881534e+03	2.583911e-02
22	0.002700	0.022522	3.533209e+02	1.958512e+03	2.141976e-02
23	0.002695	0.022522	5.097773e+02	1.959862e+03	2.053177e-02
24	0.002693	0.022217	6.125413e+02	1.771097e+04	1.952132e-02
25	0.002685	0.014189	2.167707e+03	1.588460e+06	2.133588e-02
26	0.002672	0.013960	4.329719e+05	9.693323e+06	2.360649e-02
27	0.002652	0.013455	7.992996e+10	2.007430e+12	1.542328e-02
28	0.002650	0.006844	1.799184e+18	6.562896e+21	1.150392e+14
29	0.002650	0.006784	1.054631e+20	2.058308e+22	7.271745e+16
30	0.002519	0.004777	9.475104e+24	4.984723e+25	7.113472e+26
31	0.002496	0.004774	2.922553e+26	1.015110e+26	4.483415e+27
32	0.002348	0.004633	3.540864e+27	3.594508e+27	5.481805e+25
33	0.002208	0.004505	6.190564e+27	9.009335e+27	4.192711e+29
34	0.002155	0.004487	1.507685e+28	1.103374e+28	6.278009e+28
35	0.002011	0.004336	9.173505e+27	8.916057e+27	4.114380e+26

	pd_ten
0	1.457226e-01
1	1.324554e-01
2	2.716444e-01
3	4.971922e-01
4	4.173139e-01
5	5.340010e-01
6	5.255830e-01
7	5.257229e-01
8	5.798819e-01
9	5.818767e-01
10	5.711167e-01
11	5.522239e-01
12	5.539267e-01
13	5.710230e-01
14	6.807260e-01
15	6.879139e-01
16	6.950367e-01
17	6.927365e-01
18	6.921780e-01
19	6.928959e-01
20	8.561705e-01
21	8.334545e-01
22	8.198732e-01
23	8.203889e-01
24	9.024169e-01
25	5.597574e-01
26	6.100087e-01
27	7.536910e-01
28	2.887622e+17

```
29  9.515040e+18
30  3.767866e+27
31  6.497523e+26
32  2.539297e+26
33  7.026078e+29
34  1.427545e+29
35  3.259060e+28
```

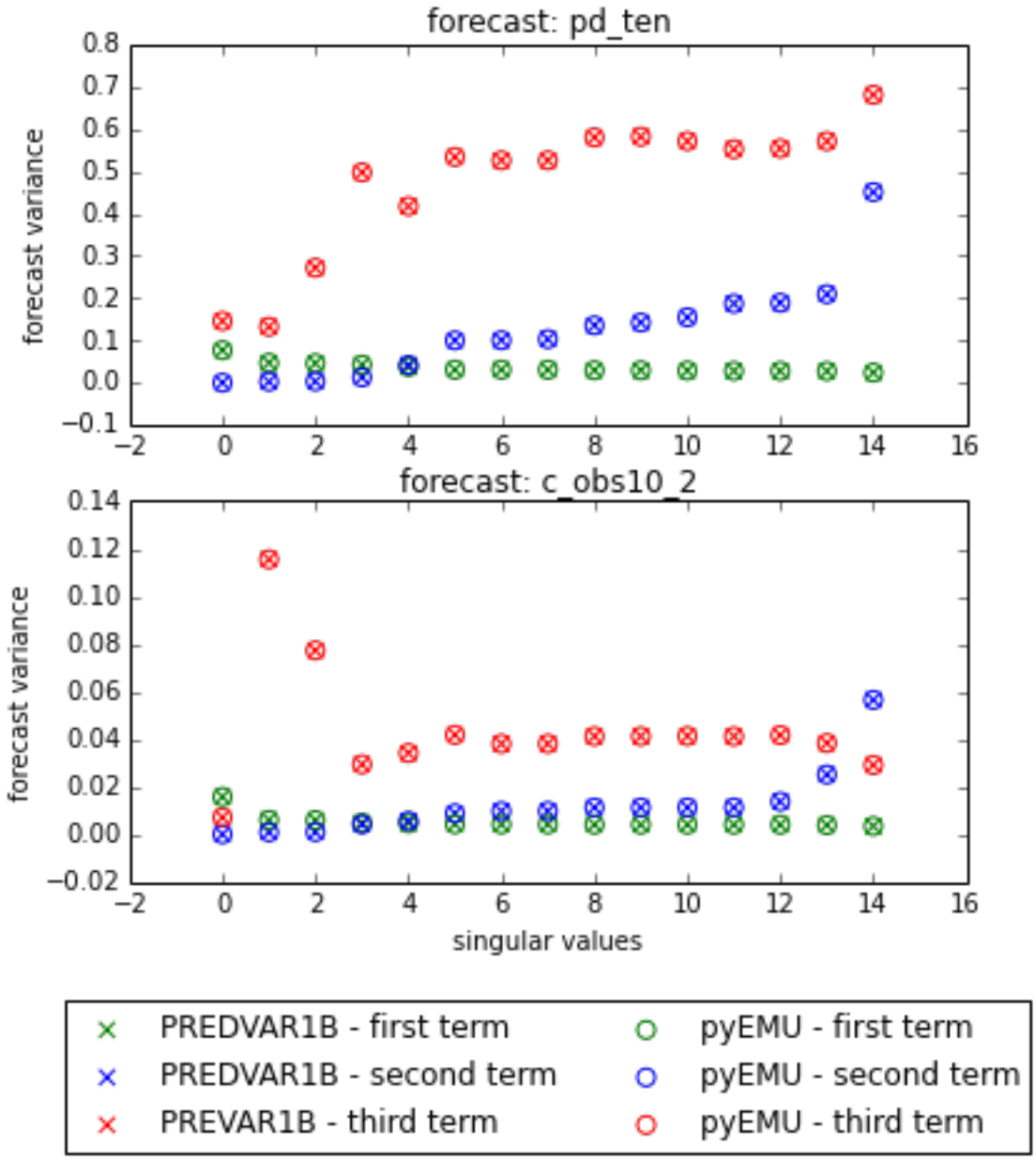
generate some plots to verify

```
In [15]: fig = plt.figure(figsize=(6,6))
         max_idx = 15
         idx = np.arange(max_idx)
         for ipred,pred in enumerate(predictions):
             arr = pv1b_results[pred][:max_idx,:]
             first = df[("first", pred)][:max_idx]
             second = df[("second", pred)][:max_idx]
             third = df[("third", pred)][:max_idx]
             ax = plt.subplot(len(predictions),1,ipred+1)
             #ax.plot(arr[:,1],color='b',dashes=(6,6),lw=4,alpha=0.5)
             #ax.plot(first,color='b')
             #ax.plot(arr[:,2],color='g',dashes=(6,4),lw=4,alpha=0.5)
             #ax.plot(second,color='g')
             #ax.plot(arr[:,3],color='r',dashes=(6,4),lw=4,alpha=0.5)
             #ax.plot(third,color='r')

             ax.scatter(idx,arr[:,1],marker='x',s=40,color='g',
                        label="PREDVAR1B - first term")
             ax.scatter(idx,arr[:,2],marker='x',s=40,color='b',
                        label="PREDVAR1B - second term")
             ax.scatter(idx,arr[:,3],marker='x',s=40,color='r',
                        label="PREVAR1B - third term")
             ax.scatter(idx,first,marker='o',facecolor='none',
                        s=50,color='g',label='pyEMU - first term')

             ax.scatter(idx,second,marker='o',facecolor='none',
                        s=50,color='b',label="pyEMU - second term")

             ax.scatter(idx,third,marker='o',facecolor='none',
                        s=50,color='r',label="pyEMU - third term")
             ax.set_ylabel("forecast variance")
             ax.set_title("forecast: " + pred)
             if ipred == len(predictions) -1:
                 ax.legend(loc="lower center",bbox_to_anchor=(0.5,-0.75),
                           scatterpoints=1,ncol=2)
                 ax.set_xlabel("singular values")
             #break
         plt.savefig("predvar1b_ver.eps")
```


forecast: pd_ten
forecast variance
forecast: c_obs10_2
forecast variance
singular values
PREDVAR1B - first term
PREDVAR1B - second term
PREVAR1B - third term
pyEMU - first term
pyEMU - second term
pyEMU - third term