validation_runs

March 25, 2019

```
In [1]: import ingestor, modeller, fitter
        import numpy as np
        from matplotlib import pyplot as plt

In [2]: plt.rc('text', usetex=True)
        plt.rc('font', family='serif')

In [3]: from importlib import reload

        reload(ingestor)
        reload(modeller)
        reload(fitter)

Out[3]: <module 'fitter' from '/media/dwu402/Data/wrap-mad/fitter.py'>

In [4]: context = ingestor.initialise_context()
        ingestor.read_run_file(context, "runs/mouse4.3.run")

In [5]: model = modeller.Model(context)

In [6]: solver = fitter.Fitter()
        solver.construct_objectives(context, model)

In [7]: solver.construct_problems()
        print(solver.solutions)

{}


In [8]: for rhoi in np.logspace(-3, 9, num=31):
            solver.solve(rhoi)

In [9]: solver.solutions

Out[9]: {'0.001': [      fun: 0.024380412583615972
           hess_inv: <9x9 LbfgsInvHessProduct with dtype=float64>
                jac: array([-9.95473641e-07,  4.60171174e-07, -3.78563317e-06,  4.40194962e-06,
                 -8.24609856e-06, -2.09672015e-05,  1.26333076e-05,  2.65451365e-06,
                 -1.48823914e-05])
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   message: b'CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH'
      nfev: 22
       nit: 1
    status: 0
   success: True
         x: array([3.00000000e-01, 1.00000000e+00, 7.00000000e-01, 2.00000000e+00,
       1.00000000e+00, 1.00000000e+00, 1.00000000e+00, 1.00000000e+00,
       1.00000003e-03])],
'0.0025118864315095794': [      fun: 0.0244033721634419
  hess_inv: <9x9 LbfgsInvHessProduct with dtype=float64>
       jac: array([-1.49201066e-06,  1.81047405e-06, -9.91341043e-07,  1.97517753e-06,
       -5.58708456e-06, -1.04167441e-05,  7.39205580e-06,  3.94426658e-07,
       -2.26169737e-06])
   message: b'CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH'
      nfev: 16
       nit: 1
    status: 0
   success: True
         x: array([3.00000000e-01, 1.00000000e+00, 7.00000000e-01, 2.00000000e+00,
       1.00000000e+00, 1.00000000e+00, 1.00000000e+00, 1.00000000e+00,
       1.00000002e-03])],
'0.006309573444801931': [      fun: 0.0244247079881888
  hess_inv: <9x9 LbfgsInvHessProduct with dtype=float64>
       jac: array([-9.29475141e-06,  1.21656298e-05, -5.22883281e-07,  1.35112463e-06,
       -5.22188405e-06, -2.03330204e-05,  1.47308827e-05, -4.01198808e-06,
       -2.94901056e-07])
   message: b'CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH'
      nfev: 19
       nit: 1
    status: 0
   success: True
         x: array([3.e-01, 1.e+00, 7.e-01, 2.e+00, 1.e+00, 1.e+00, 1.e+00, 1.e+00,
       1.e-03])],
'0.015848931924611142': [      fun: 0.024438026497777647
  hess_inv: <9x9 LbfgsInvHessProduct with dtype=float64>
       jac: array([ 7.00010044e-08,  5.75651149e-06,  3.61222353e-06,  2.88925346e-06,
       -7.73055501e-06, -4.76442013e-06,  1.74136127e-06,  4.43652209e-06,
        3.27501125e-05])
   message: b'CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL'
      nfev: 21
       nit: 14
    status: 0
   success: True
         x: array([0.        , 0.        , 2.07308963, 2.25116766, 0.96817756,
       6.02625311, 4.33460562, 2.52747574, 0.        ])],
'0.039810717055349734': [      fun: 0.024548367734489013
  hess_inv: <9x9 LbfgsInvHessProduct with dtype=float64>
       jac: array([ 9.63979661e-06,  4.35841744e-06, -6.79015579e-06,  3.91520298e-06,
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        -2.28668849e-06, -2.45304813e-06,  2.64105156e-07,  7.58923836e-06,
         1.01787869e-04])
   message: b'CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL'
      nfev: 19
       nit: 17
    status: 0
   success: True
         x: array([ 0.02265607,  0.        ,  2.02846154,  0.35223308,  0.17276806,
        13.12096767,  6.51070315,  2.19781235,  0.        ])],
'0.1': [      fun: 0.025031436423910564
  hess_inv: <9x9 LbfgsInvHessProduct with dtype=float64>
       jac: array([-2.20667913e-07,  4.05111576e-06, -6.92275078e-06,  9.17821777e-08,
         8.37410025e-06, -1.59803317e-07,  2.83448135e-07, -6.41772269e-06,
         7.19431689e-05])
   message: b'CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL'
      nfev: 30
       nit: 28
    status: 0
   success: True
         x: array([  0.        ,   0.        ,   2.04337038,  13.17449798,
          0.48717461, 100.        ,  11.85032935,   2.0107947 ,
          0.        ])],
'0.25118864315095824': [      fun: 0.027633066622827964
  hess_inv: <9x9 LbfgsInvHessProduct with dtype=float64>
       jac: array([ 1.02755095e-05,  3.92602473e-04, -4.34810985e-04,  3.35769341e-04,
        -1.89578801e-03, -3.07391129e-03,  6.31590132e-03,  6.76740953e-05,
        -4.52855378e-04])
   message: b'CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH'
      nfev: 37
       nit: 26
    status: 0
   success: True
         x: array([1.59017917e-03, 0.00000000e+00, 2.42271411e+00, 6.59662029e+00,
        1.70600575e+00, 2.62019894e+00, 1.51002629e+00, 3.13481749e+00,
        0.00000000e+00])],
'0.6309573444801936': [      fun: 0.032395461859291166
  hess_inv: <9x9 LbfgsInvHessProduct with dtype=float64>
       jac: array([-3.13610452e-04,  7.43665100e-05, -1.86816055e-03,  1.59555027e-03,
        -3.87528453e-03, -9.59200534e-03,  1.34406447e-02,  1.34150205e-03,
         1.62465197e-03])
   message: b'CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH'
      nfev: 108
       nit: 28
    status: 0
   success: True
         x: array([0.02571322, 0.12912826, 2.78579744, 9.8243031 , 2.87487168,
        2.69940481, 1.73011609, 3.80626908, 0.        ])],
'1.584893192461114': [      fun: 0.033383260719877045
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  hess_inv: <9x9 LbfgsInvHessProduct with dtype=float64>
       jac: array([-2.45863356e-04,  1.54556066e-04,  1.00704311e-05,  6.15573673e-05,
        -1.59284155e-05, -1.69670734e-04,  2.17428587e-04, -3.84920581e-05,
         7.36590815e-03])
   message: b'CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH'
      nfev: 121
       nit: 56
    status: 0
   success: True
         x: array([4.8415793 , 7.62318745, 0.6500189 , 6.44660889, 3.16343382,
        7.12750178, 6.59853544, 7.94891932, 0.        ])],
'3.981071705534973': [      fun: 0.081383886606366
  hess_inv: <9x9 LbfgsInvHessProduct with dtype=float64>
       jac: array([-8.04091461e-05,  2.36089406e-03,  2.89799943e-03, -1.44940438e-03,
         2.48092421e-03, -1.04647279e-04,  3.89541356e-03, -9.62113342e-05,
         1.93791341e-04])
   message: b'CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH'
      nfev: 28
       nit: 22
    status: 0
   success: True
         x: array([0.        , 0.        , 0.        , 3.93782917, 3.7058558 ,
        6.53469153, 0.1639838 , 2.64820963, 0.        ])],
'10.0': [      fun: 0.11659551773675354
  hess_inv: <9x9 LbfgsInvHessProduct with dtype=float64>
       jac: array([ 0.0015577 ,  0.00052261,  0.00431102,  0.00309955, -0.00589516,
        -0.00393452,  0.00335105, -0.0001108 ,  0.05017417])
   message: b'CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH'
      nfev: 205
       nit: 114
    status: 0
   success: True
         x: array([ 0.        ,  0.        ,  0.        , 92.03676676, 48.49627956,
       11.53778792, 13.80508639,  2.88788409,  0.        ])],
'25.11886431509582': [      fun: 0.23734009481259952
  hess_inv: <9x9 LbfgsInvHessProduct with dtype=float64>
       jac: array([ 0.0383218 , -0.04448113, -0.06276841, -0.06629281,  0.17414605,
        -0.0336714 ,  0.03870851,  0.001113  ,  0.02215383])
   message: b'CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH'
      nfev: 75
       nit: 10
    status: 0
   success: True
         x: array([0.73459336, 0.49029393, 1.42036535, 0.8716332 , 1.10257999,
        2.34152542, 2.0340173 , 1.18657005, 0.48931455])],
'63.09573444801943': [      fun: 0.5419226184222689
  hess_inv: <9x9 LbfgsInvHessProduct with dtype=float64>
       jac: array([-0.01428789,  0.00825008, -0.06291067,  0.34376497, -0.67530851,
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        0.15810603, -0.35183333, -0.00957186, -0.35570014])
   message: b'CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH'
      nfev: 13
       nit: 1
    status: 0
   success: True
         x: array([3.e-01, 1.e+00, 7.e-01, 2.e+00, 1.e+00, 1.e+00, 1.e+00, 1.e+00,
       1.e-03])],
'158.48931924611142': [      fun: 1.7126266980971563
  hess_inv: <9x9 LbfgsInvHessProduct with dtype=float64>
       jac: array([-1.11697339,  0.62366906, -3.75796828,  0.75690658, -0.39539502,
        0.98534532, -3.06166197,  0.3001869 , -0.60997705])
   message: b'CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH'
      nfev: 9
       nit: 1
    status: 0
   success: True
         x: array([3.e-01, 1.e+00, 7.e-01, 2.e+00, 1.e+00, 1.e+00, 1.e+00, 1.e+00,
       1.e-03])],
'398.1071705534977': [      fun: 0.2202633563728994
  hess_inv: <9x9 LbfgsInvHessProduct with dtype=float64>
       jac: array([ 1.02005065e-01,  9.53122827e-04,  4.31390138e-02,  6.65237762e-06,
        -8.81999149e-06, -1.05943149e-04,  3.03746052e-03,  2.01529137e-06,
         8.11125246e-04])
   message: b'CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL'
      nfev: 100
       nit: 74
    status: 0
   success: True
         x: array([  0.        ,   0.        ,   0.        ,   1.19043596,
         0.60818631, 100.        ,   0.        ,   4.79602492,
         0.        ])],
'1000.0': [      fun: 0.5331571639261616
  hess_inv: <9x9 LbfgsInvHessProduct with dtype=float64>
       jac: array([-0.44011411,  0.40329745, -0.31896729, -0.32023578,  1.01484215,
        -0.33972759,  0.03724525,  0.0178111 ,  0.03004021])
   message: b'CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH'
      nfev: 46
       nit: 15
    status: 0
   success: True
         x: array([0.48378271, 0.75239156, 1.00495573, 1.65720397, 0.99250495,
       1.31471113, 1.49956997, 1.0159564 , 0.7826698 ])],
'2511.886431509582': [      fun: 0.2908837113544197
  hess_inv: <9x9 LbfgsInvHessProduct with dtype=float64>
       jac: array([ 0.01423672, -0.01914859, -0.00460876, -0.08281285,  0.16988423,
        -0.00137508,  0.00232168, -0.00068715, -0.01426714])
   message: b'CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH'
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      nfev: 101
       nit: 35
    status: 0
   success: True
         x: array([0.5786771 , 0.        , 4.91400721, 0.        , 0.12361767,
       6.92949322, 5.7710018 , 1.0713397 , 0.77617093])],
'6309.573444801943': [      fun: 4.52133116356414
  hess_inv: <9x9 LbfgsInvHessProduct with dtype=float64>
       jac: array([ -0.89421277,   0.96932528,  -1.10060303,  20.19796726,
        -38.83529455, -15.46193238,  13.61360514,   0.27630133,
         -5.44070997])
   message: b'CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH'
      nfev: 13
       nit: 1
    status: 0
   success: True
         x: array([3.e-01, 1.e+00, 7.e-01, 2.e+00, 1.e+00, 1.e+00, 1.e+00, 1.e+00,
       1.e-03])],
'15848.93192461114': [      fun: 0.34886905124273543
  hess_inv: <9x9 LbfgsInvHessProduct with dtype=float64>
       jac: array([-9.58153328e-07, -8.64108007e-08,  7.36584400e-06, -1.17787042e-06,
        -6.06698440e-04,  1.12443215e-03, -3.65570280e-02, -7.51061416e-06,
        -5.39469153e-04])
   message: b'CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH'
      nfev: 107
       nit: 29
    status: 0
   success: True
         x: array([1.46496696e+00, 4.60845632e+01, 1.00000000e+02, 7.65750425e-02,
       0.00000000e+00, 4.27150488e+01, 4.98221867e-01, 9.91312727e+01,
       9.43482361e+01])],
'39810.71705534977': [      fun: 5.525819985314521
  hess_inv: <9x9 LbfgsInvHessProduct with dtype=float64>
       jac: array([ -0.97660071,   1.07884269,  -0.71781098,  36.03149592,
        -72.31328858, -38.27314602,  37.79983024,   0.2742951 ,
        -11.72768176])
   message: b'CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH'
      nfev: 18
       nit: 1
    status: 0
   success: True
         x: array([3.e-01, 1.e+00, 7.e-01, 2.e+00, 1.e+00, 1.e+00, 1.e+00, 1.e+00,
       1.e-03])],
'100000.0': [      fun: 4.310199619298702
  hess_inv: <9x9 LbfgsInvHessProduct with dtype=float64>
       jac: array([-13.80684136,   5.93633831,  -6.10338952,  -2.24870079,
          8.65720575,  -3.05413245,   6.46774325,  -2.0015123 ,
        -0.84304102])
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   message: b'CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH'
      nfev: 60
       nit: 3
    status: 0
   success: True
         x: array([0.36611713, 0.99241885, 0.73582688, 1.99209613, 1.08615299,
       1.07554898, 0.91742604, 1.04899766, 0.03630869])],
'251188.6431509582': [      fun: 5.608842781717838
  hess_inv: <9x9 LbfgsInvHessProduct with dtype=float64>
       jac: array([ -0.63146147,   0.69393503,  -0.33941175,  34.55931334,
        -68.67190378, -35.2512121 ,  34.6990354 ,   0.16378955,
        -11.69300362])
   message: b'CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH'
      nfev: 92
       nit: 1
    status: 0
   success: True
         x: array([3.e-01, 1.e+00, 7.e-01, 2.e+00, 1.e+00, 1.e+00, 1.e+00, 1.e+00,
       1.e-03])],
'630957.3444801943': [      fun: 4.317897235777234
  hess_inv: <9x9 LbfgsInvHessProduct with dtype=float64>
       jac: array([-14.26469746,   6.27314671, -10.03393611,  -2.67866133,
         11.6133819 ,  -4.265811  ,   8.43170499,  -2.33794762,
         -1.25522228])
   message: b'CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH'
      nfev: 51
       nit: 3
    status: 0
   success: True
         x: array([0.36603371, 0.99183793, 0.7378561 , 1.9920578 , 1.08884712,
       1.07629622, 0.91664076, 1.04933126, 0.03681048])],
'1584893.1924611174': [      fun: 0.8047103792315696
  hess_inv: <9x9 LbfgsInvHessProduct with dtype=float64>
       jac: array([ 4.21360046e-06,  5.17085215e-08,  1.15455451e-06, -1.47051658e-07,
        -8.56158937e-06,  6.74350970e-07,  9.92915347e-03,  1.95952504e-07,
         9.47467212e-07])
   message: b'CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL'
      nfev: 68
       nit: 44
    status: 0
   success: True
         x: array([ 0.77082245, 73.99076609, 99.99982058,  3.19188483,  0.72390078,
         2.16717774,  0.        , 63.63267887, 99.99984873])],
'3981071.7055349858': [      fun: 9.413737464235533
  hess_inv: <9x9 LbfgsInvHessProduct with dtype=float64>
       jac: array([ -0.15471806,   0.14411707,   0.03558107,  -3.1839143 ,
         16.12740315,  20.97360717, -24.89283959,  -0.1926991 ,
         13.382032  ])
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   message: b'CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH'
      nfev: 48
       nit: 1
    status: 0
   success: True
         x: array([3.e-01, 1.e+00, 7.e-01, 2.e+00, 1.e+00, 1.e+00, 1.e+00, 1.e+00,
       1.e-03])],
'10000000.0': [      fun: 6.573853781865785
  hess_inv: <9x9 LbfgsInvHessProduct with dtype=float64>
       jac: array([ 2.49775499e-07, -1.07783992e-13, -1.32801179e-06, -8.25173657e-18,
        1.87674814e-05, -2.96521051e-05,  4.89283233e+00, -8.28881589e-07,
       -1.15004600e-05])
   message: b'CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH'
      nfev: 10
       nit: 2
    status: 0
   success: True
         x: array([1.17864472e+01, 0.00000000e+00, 1.38016230e-07, 1.71504936e+00,
       4.55082281e+00, 2.13600789e+00, 0.00000000e+00, 3.51180395e+00,
       1.84574275e+00])],
'25118864.315095823': [      fun: 9.324599193666817
  hess_inv: <9x9 LbfgsInvHessProduct with dtype=float64>
       jac: array([-12.02970959,   1.3984476 ,  42.01315212,   8.21363729,
       -39.72854683,   3.4668683 ,  -4.09479275,   2.28368274,
         1.80383979])
   message: b'CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH'
      nfev: 40
       nit: 1
    status: 0
   success: True
         x: array([3.e-01, 1.e+00, 7.e-01, 2.e+00, 1.e+00, 1.e+00, 1.e+00, 1.e+00,
       1.e-03])],
'63095734.44801943': [      fun: 6.573904474391823
  hess_inv: <9x9 LbfgsInvHessProduct with dtype=float64>
       jac: array([ 3.81420100e-08, -2.59926039e-15, -2.03027835e-07, -3.21946723e-20,
        2.92661136e-06, -4.68266550e-06,  4.89310587e+00, -1.28437371e-07,
       -1.81615905e-06])
   message: b'CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL'
      nfev: 2
       nit: 1
    status: 0
   success: True
         x: array([11.88171101,  0.        ,  0.        ,  1.7389175 ,  4.50780486,
       2.08906509,  0.        ,  3.48861411,  1.80136528])],
'158489319.24611175': [      fun: 9.834154074458391
  hess_inv: <9x9 LbfgsInvHessProduct with dtype=float64>
       jac: array([ -5.53938601,  -0.88095399,  43.71260352,   8.7684714 ,
       -43.67107666,   4.97374453,  -8.12779747,   3.56602544,
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        1.98117714])
   message: b'CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH'
      nfev: 88
       nit: 1
    status: 0
   success: True
         x: array([3.e-01, 1.e+00, 7.e-01, 2.e+00, 1.e+00, 1.e+00, 1.e+00, 1.e+00,
       1.e-03])],
'398107170.55349857': [      fun: 6.573912338030069
 hess_inv: <9x9 LbfgsInvHessProduct with dtype=float64>
      jac: array([ 5.88882617e-09, -6.37014897e-17, -3.14970144e-08, -1.28492010e-22,
        4.62596204e-07, -7.43313333e-07,  4.89314830e+00, -2.00205158e-08,
       -2.88292158e-07])
   message: b'CONVERGENCE: NORM_OF_PROJECTED_GRADIENT_<=_PGTOL'
      nfev: 2
       nit: 1
    status: 0
   success: True
         x: array([11.96641858,  0.        ,  0.        ,  1.75182946,  4.48036017,
        2.0670886 ,  0.        ,  3.47993429,  1.78128027])],
'1000000000.0': [      fun: 11.175582550484712
 hess_inv: <9x9 LbfgsInvHessProduct with dtype=float64>
      jac: array([-24.47149082,   7.92764309,  34.40111149,   3.56260487,
       -30.12775371,   3.00971271,  -8.00196421,   5.01279634,
         1.00576393])
   message: b'CONVERGENCE: REL_REDUCTION_OF_F_<=_FACTR*EPSMCH'
      nfev: 81
       nit: 1
    status: 0
   success: True
         x: array([3.e-01, 1.e+00, 7.e-01, 2.e+00, 1.e+00, 1.e+00, 1.e+00, 1.e+00,
       1.e-03])]}
```

0.1 Validation

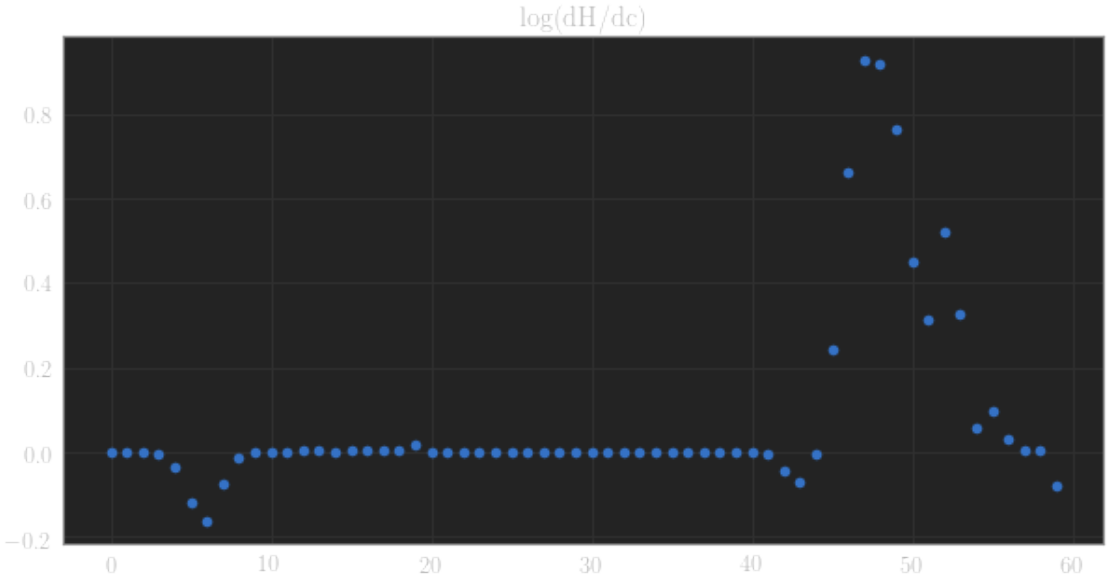
```
In [10]: ## Validation of the outer jacobian
         ca = fitter.ca
         dHdc = ca.hcat([ca.gradient(solver._inner_objective._obj_1, ci) for ci in model.cs]).re
         d2Jdc2 = ca.hcat([ca.jacobian(solver._inner_objective.inner_jacobian, ci) for ci in mod
         dJ2dcdp = ca.hcat([ca.jacobian(solver._inner_objective.inner_jacobian, pi) for pi in mo

In [11]: dHdc_fn = ca.Function("dhdcfn", solver._inner_objective.input_list, [dHdc])
         d2Jdc2_fn = ca.Function("d2jdc2", solver._inner_objective.input_list, [d2Jdc2])
         dJ2dcdp_fn = ca.Function("d2jdcdp", solver._inner_objective.input_list, [dJ2dcdp])

In [12]: in_arg = [model.observation_times, *fitter.argsplit(solver.problems[0].cache.recent, 3)

In [13]: dhdc_eval = dHdc_fn(*in_arg)
         d2jdc2_eval = d2Jdc2_fn(*in_arg)
```

```
dj2dcdp_eval = dJ2dcdp_fn(*in_arg)
```

In [14]:
```
import numpy as np
def numerical_log(matrix):
    return np.log(np.fabs(np.array(matrix))+1e-16)

import matplotlib.pyplot as plt
plt.rcParams['figure.figsize'] = [10, 5]
```

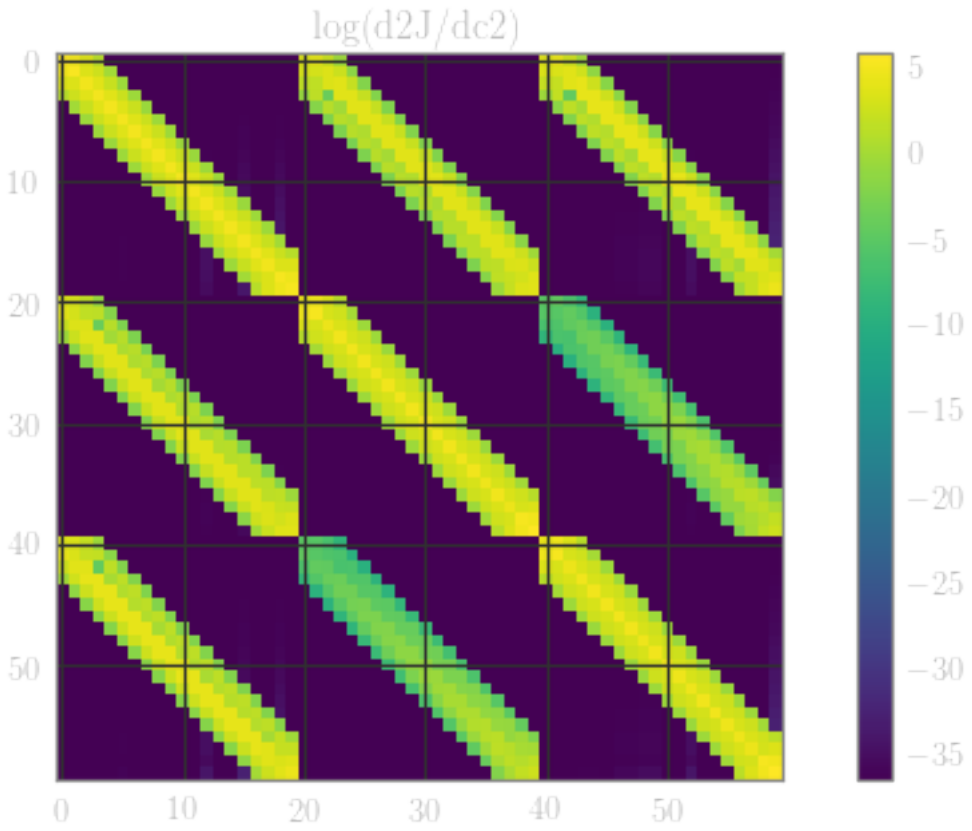
In [15]:
```
plt.plot(np.array(dhdc_eval).reshape(-1,), 'o')
plt.title("log(dH/dc)")
```

Out[15]:
```
Text(0.5, 1.0, 'log(dH/dc)')
```

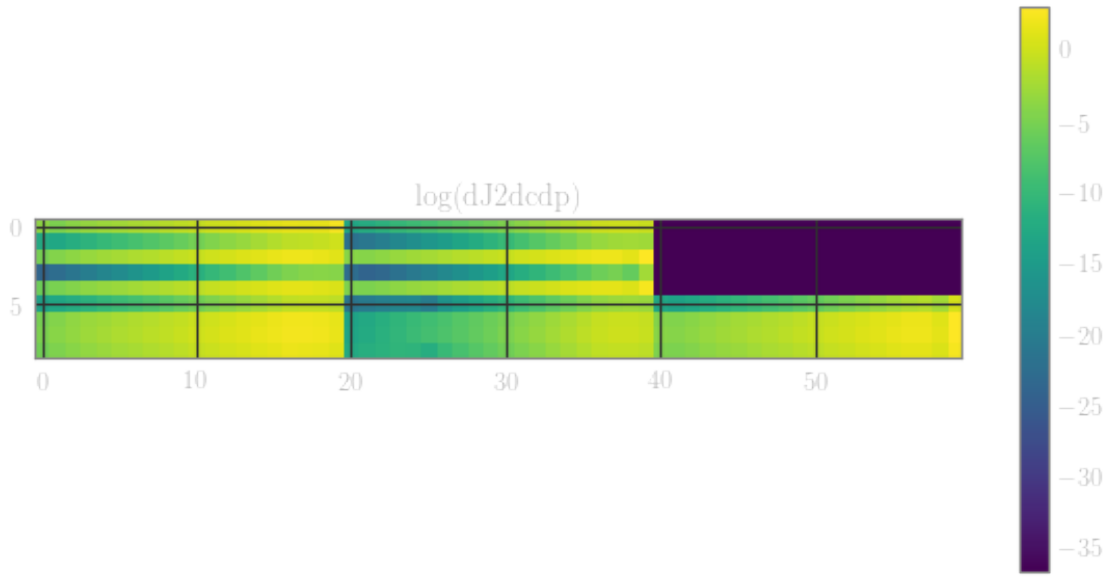


In [16]:
```
plt.imshow(numerical_log(d2jdc2_eval))
plt.colorbar()
plt.title("log(d2J/dc2)")
```

Out[16]:
```
Text(0.5, 1.0, 'log(d2J/dc2)')
```

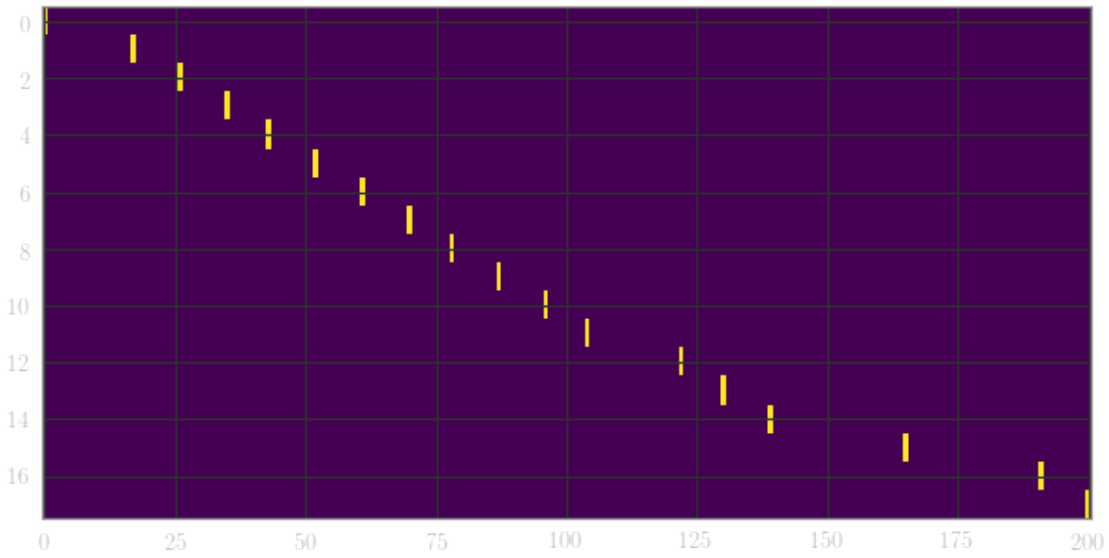



```
In [17]: plt.imshow(numerical_log(dj2dcdp_eval).T)
         plt.colorbar()
         plt.title("log(dJ2dcdp)")

Out[17]: Text(0.5, 1.0, 'log(dJ2dcdp)')
```



In [18]:
```
H_num = solver._inner_objective.generate_collocation_matrix(context['datasets'][0], mod
plt.imshow(H_num, aspect='auto')
```

Out[18]: <matplotlib.image.AxesImage at 0x7fb97f5d56a0>



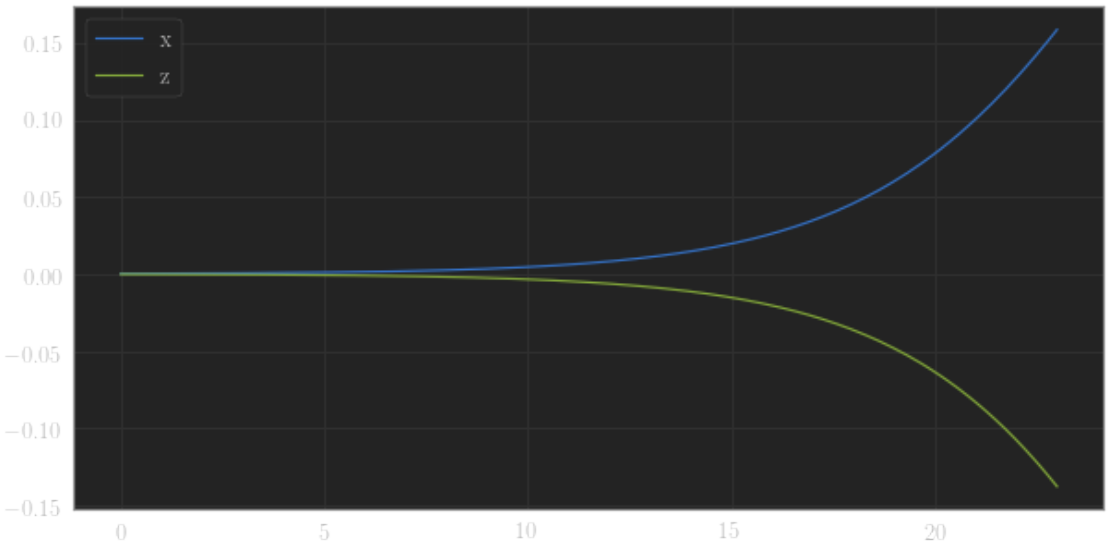
In [19]:
```
# create and profile calls

obj_fn, obj_jac = solver._inner_objective.create_objective_functions(model, context['da
```

```
        c_test = np.array(solver.problems[0].cache.recent)

        %timeit obj_fn(c_test, [0.3, 1, 0.7, 2, 1, 1, 1,1 , 1e-4], rho=1000)
```

```
34.3 ms ś 222 ţs per loop (mean ś std. dev. of 7 runs, 10 loops each)
```

```
In [20]: getx = ca.Function("getx", [model.ts, *model.cs], model.xs)
```

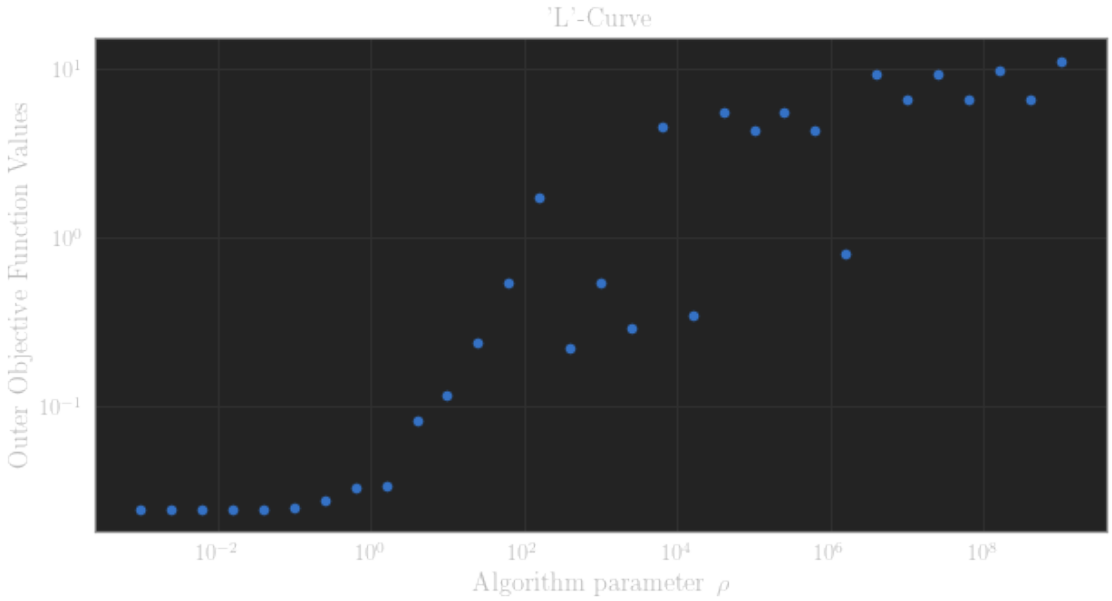
```
In [21]: xs = np.array([np.array(i) for i in getx(model.observation_times, *fitter.argsplit(solv
         plt.plot(model.observation_times, np.hstack([xs[0], xs[2]]))
         plt.legend("xz")

         iv = [xs[i][0].item() for i in range(3)]
```



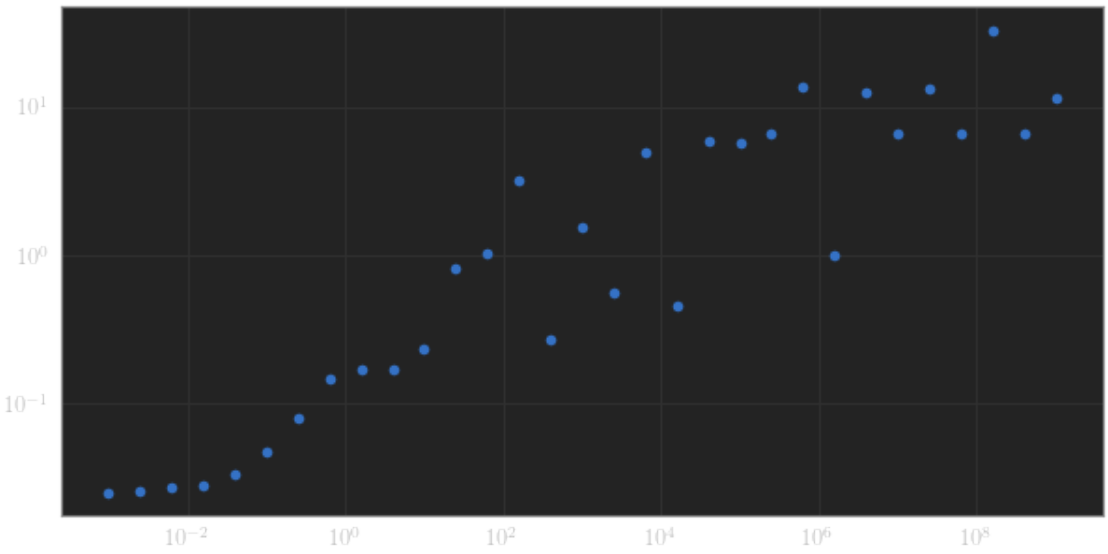

```
In [22]: from scipy import integrate

         sol = integrate.solve_ivp(lambda t, y: context['model'](t, y, [0.92255063, 0.55098101,
                  2.21360157, 2.85341497, 1.13601111, 0.55253756]), [0, 24], iv)

         sol.y[2]
```

```
Out[22]: array([-1.68393743e-04, -1.55477248e-04, -1.97366133e-04, -3.43618069e-04,
                -7.48114499e-04, -2.18439382e-03, -8.62825984e-03, -2.36758019e-02,
                -5.88842534e-02, -1.47887789e-01, -3.77710334e-01, -1.00923944e+00,
                -5.36165767e+00, -3.99792748e+01, -5.16282656e+02, -5.75382747e+03,
                -4.08190501e+04, -1.93135665e+05, -8.71960662e+05, -4.87640830e+06,
                -5.78240064e+06])
```

```
In [23]: outer_evals = {r:v[0].fun for r, v in solver.solutions.items()}

         outer_list = np.array([[float(key), value] for key, value in outer_evals.items()])

In [24]: plt.loglog(*outer_list.T, 'o')
         plt.xlabel(r"Algorithm parameter $\rho$ ")
         plt.ylabel(r"Outer Objective Function Values")
         plt.title("'L'-Curve")

Out[24]: Text(0.5, 1.0, "'L'-Curve")
```




```
In [25]: def gen_key(sol_key, solution):
             return "y".join(map(str,solution.x)) + "r" + sol_key

In [26]: inner_evals = dict()
         for soli in solver.solutions:
             key = gen_key(soli, solver.solutions[soli][0])
             inner_evals[soli] = solver.problems[0].cache.results[key]


In [27]: new_list = []
         for key in inner_evals.keys():
             new_list.append((float(key), inner_evals[key].fun))
         new_list = np.array(new_list)
         plt.loglog(*np.array(new_list).T, 'o')

Out[27]: [<matplotlib.lines.Line2D at 0x7fb97f45a400>]
```




```
In [28]: diff_field_value = [[okey, (ivalue-ovalue)/(ikey)] for (ikey, ivalue), (okey, ovalue) i

In [29]: plt.loglog(*np.array(diff_field_value).T, 'o')

Out[29]: [<matplotlib.lines.Line2D at 0x7fb97f39e5c0>]
```