

## simulation\_figure

November 24, 2020

```
[1]: %pylab inline
import sys

import numpy as np
import tensorflow as tf
import tensorflow_probability as tfp
import arviz as az

import matplotlib.pyplot as plt
from matplotlib import rcParams
import matplotlib.gridspec as gridspec

import matplotlib.font_manager as fm

from matplotlib import rc
rc('font',**{'family':'sans-serif','sans-serif':['Computer Modern Sans serif']})
## for Palatino and other serif fonts use:
#rc('font',**{'family':'serif','serif':['Palatino']})
#rc('text', usetex=True)
matplotlib.rcParams['text.usetex'] = True
matplotlib.rcParams['text.latex.unicode'] = True
sys.path.append('../')
from mederrata_spmf import PoissonMatrixFactorization
```

Populating the interactive namespace from numpy and matplotlib

/usr/local/lib/python3.7/site-packages/ipykernel\_launcher.py:21:

MatplotlibDeprecationWarning:

The text.latex.unicode rcparam was deprecated in Matplotlib 3.0 and will be removed in 3.2.

```
[2]: N = 50000
D_factor = 10
D_noise = 20
D = D_factor + D_noise
P = 3

V = np.abs(np.random.normal(1.5, 0.5, size=(P,D_factor)))
```

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Z = np.abs(np.random.normal(0, 1, size=(N,P)))

ZV = Z.dot(V)

X = np.zeros((N, D_factor+D_noise))
X = np.random.poisson(1.,size=(N,D_noise+D_factor))
X[:, ::3] = np.random.poisson(ZV*np.exp(ZV/np.mean(ZV)/10)+(ZV/np.mean(ZV)/
↪10)**2)
# Test taking in from tf.dataset, don't pre-batch
data_structured = tf.data.Dataset.from_tensor_slices(
    {
        'data': X,
        'indices': np.arange(N),
        'normalization': np.ones(N)
    })

data_structured = data_structured.batch(1000)

data_noise = tf.data.Dataset.from_tensor_slices(
    {
        'data': np.random.poisson(1.0, size=(N, D)),
        'indices': np.arange(N),
        'normalization': np.ones(N)
    })

data_noise = data_noise.batch(1000)

X_nonlinear = np.random.poisson(1.,size=(N,D_noise+D_factor))
X_nonlinear[:, ::3] = np.random.poisson(ZV*np.exp(-ZV/np.mean(ZV)/4.)+(ZV/np.
↪mean(ZV)/4.))**2)

data_nonlinear = tf.data.Dataset.from_tensor_slices(
    {
        'data': X_nonlinear,
        'indices': np.arange(N),
        'normalization': np.ones(N)
    })

data_nonlinear = data_nonlinear.batch(1000)

```

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[3]: # strategy = tf.distribute.MirroredStrategy()
strategy = None
factor = PoissonMatrixFactorization(
    data_structured, latent_dim=P, strategy=strategy,
    scale_rates=True, with_s=True,
    u_tau_scale=1.0/np.sqrt(D*N),
    dtype=tf.float64)

```

```

factor_noise = PoissonMatrixFactorization(
    data_noise, latent_dim=P, strategy=strategy,
    scale_rates=True, with_s=True,
    u_tau_scale=1.0/np.sqrt(D*N),
    dtype=tf.float64)

factor_nonlinear = PoissonMatrixFactorization(
    data_nonlinear, latent_dim=P, strategy=strategy,
    scale_rates=True, with_s=True,
    u_tau_scale=1.0/np.sqrt(D*N),
    dtype=tf.float64)

```

```

Feature dim: 30 -> Latent dim 3
Feature dim: 30 -> Latent dim 3
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[4]: losses = factor_noise.calibrate_advi(
    num_epochs=200, rel_tol=1e-4, learning_rate=.1)

```

```

WARNING: Logging before flag parsing goes to stderr.
W0604 09:11:03.165111 4458253760 deprecation.py:506] From
/usr/local/lib/python3.7/site-
packages/tensorflow/python/ops/resource_variable_ops.py:1817: calling
BaseResourceVariable.__init__ (from tensorflow.python.ops.resource_variable_ops)
with constraint is deprecated and will be removed in a future version.
Instructions for updating:
If using Keras pass *_constraint arguments to layers.

Initial loss: 46.31711849543949
Epoch 1: average-batch loss: 43.7410293952114 last batch loss:
43.042385896832336
Saved a checkpoint: ./tf_ckpts/chkpt-1
Epoch 2: average-batch loss: 42.52372213927176 last batch loss:
41.952291653026684
Saved a checkpoint: ./tf_ckpts/chkpt-2
Epoch 3: average-batch loss: 41.582225480914296 last batch loss:
41.0888366312795
Saved a checkpoint: ./tf_ckpts/chkpt-3
Epoch 4: average-batch loss: 40.8480151895427 last batch loss: 40.55134766730372
Saved a checkpoint: ./tf_ckpts/chkpt-4
Epoch 5: average-batch loss: 40.54365881577268 last batch loss:
40.411172955161916
Saved a checkpoint: ./tf_ckpts/chkpt-5
Epoch 6: average-batch loss: 40.43214223751251 last batch loss:
40.34313175380768
Saved a checkpoint: ./tf_ckpts/chkpt-6
Epoch 7: average-batch loss: 40.37050370200359 last batch loss:

```

40.273024932038055  
Saved a checkpoint: ./tf\_ckpts/chkpt-7  
Epoch 8: average-batch loss: 40.342723409471255 last batch loss:  
40.27076774237394  
Saved a checkpoint: ./tf\_ckpts/chkpt-8  
Epoch 9: average-batch loss: 40.32916126626243 last batch loss:  
40.292364637874975  
Saved a checkpoint: ./tf\_ckpts/chkpt-9  
Epoch 10: average-batch loss: 40.324502822708524 last batch loss:  
40.2611832673215  
Saved a checkpoint: ./tf\_ckpts/chkpt-10  
Epoch 11: average-batch loss: 40.31625113616794 last batch loss:  
40.263187956095024  
Saved a checkpoint: ./tf\_ckpts/chkpt-11  
Epoch 12: average-batch loss: 40.31757227883358 last batch loss:  
40.26816589386546  
Epoch 13: average-batch loss: 40.32032861014543 last batch loss:  
40.25569944947384  
We are in a loss plateau learning rate: 0.09000000000000001 loss:  
40.3542331170573  
Restoring from a checkpoint - loss: 40.35804688856251  
Epoch 14: average-batch loss: 40.315309450571405 last batch loss:  
40.25551451741229  
Saved a checkpoint: ./tf\_ckpts/chkpt-12  
Epoch 15: average-batch loss: 40.318508826939535 last batch loss:  
40.26747910626755  
Epoch 16: average-batch loss: 40.312061359040065 last batch loss:  
40.237294786228404  
Saved a checkpoint: ./tf\_ckpts/chkpt-13  
Epoch 17: average-batch loss: 40.3069971208062 last batch loss:  
40.25013286610486  
Saved a checkpoint: ./tf\_ckpts/chkpt-14  
Epoch 18: average-batch loss: 40.31816998913193 last batch loss:  
40.25855210813118  
We are in a loss plateau learning rate: 0.08100000000000002 loss:  
40.35806206627801  
Restoring from a checkpoint - loss: 40.36972945846287  
Epoch 19: average-batch loss: 40.314656763826044 last batch loss:  
40.24114986161297  
Epoch 20: average-batch loss: 40.31377568748963 last batch loss:  
40.252136369837125  
Epoch 21: average-batch loss: 40.31275755518176 last batch loss:  
40.25751685158035  
Epoch 22: average-batch loss: 40.31488090523727 last batch loss:  
40.31665932510191  
Epoch 23: average-batch loss: 40.316447183985495 last batch loss:  
40.24417568217497  
We are in a loss plateau learning rate: 0.0729 loss: 40.36362288129708

Restoring from a checkpoint - loss: 40.35773304828386  
 Epoch 24: average-batch loss: 40.319049253325325 last batch loss:  
 40.27477975581684  
 Epoch 25: average-batch loss: 40.314975309252056 last batch loss:  
 40.241180909969266  
 Epoch 26: average-batch loss: 40.313182111955 last batch loss: 40.24911813255544  
 Epoch 27: average-batch loss: 40.31605501868907 last batch loss:  
 40.256715210415805  
 Epoch 28: average-batch loss: 40.31575308671196 last batch loss:  
 40.23715132579596  
 Epoch 29: average-batch loss: 40.31090984219057 last batch loss:  
 40.27876307587368  
 Epoch 30: average-batch loss: 40.312839298821494 last batch loss:  
 40.26930476724554  
 Epoch 31: average-batch loss: 40.31067069722733 last batch loss:  
 40.2430117234137  
 Epoch 32: average-batch loss: 40.311943478055014 last batch loss:  
 40.27748101102052  
 Epoch 33: average-batch loss: 40.31563618533773 last batch loss:  
 40.2626826066216  
 We are in a loss plateau learning rate: 0.06561 loss: 40.356783709229006  
 Restoring from a checkpoint - loss: 40.357952812640896  
 Epoch 34: average-batch loss: 40.311277379818065 last batch loss:  
 40.238765458749704  
 Epoch 35: average-batch loss: 40.31025073804082 last batch loss:  
 40.25063785874379  
 Epoch 36: average-batch loss: 40.311708386419944 last batch loss:  
 40.253048085611894  
 Epoch 37: average-batch loss: 40.310360444090136 last batch loss:  
 40.244009466749176  
 Epoch 38: average-batch loss: 40.3143992247344 last batch loss:  
 40.26606488310181  
 We are in a loss plateau learning rate: 0.059049000000000001 loss:  
 40.37787764832081  
 Restoring from a checkpoint - loss: 40.3602849405381  
 Epoch 39: average-batch loss: 40.31509623695382 last batch loss:  
 40.280607159287314  
 Epoch 40: average-batch loss: 40.312468850590605 last batch loss:  
 40.25549553901391  
 Epoch 41: average-batch loss: 40.313472940072124 last batch loss:  
 40.260366026632994  
 Epoch 42: average-batch loss: 40.31691471250333 last batch loss:  
 40.266429109952675  
 Epoch 43: average-batch loss: 40.31845068751346 last batch loss:  
 40.241769901221105  
 We are in a loss plateau learning rate: 0.053144100000000001 loss:  
 40.36876336563457  
 Restoring from a checkpoint - loss: 40.353708905694496

Epoch 44: average-batch loss: 40.318158737527476 last batch loss:  
40.24319998731415  
Epoch 45: average-batch loss: 40.318511865053495 last batch loss:  
40.25672000990405  
Epoch 46: average-batch loss: 40.31639434360291 last batch loss:  
40.25122926268056  
Epoch 47: average-batch loss: 40.313539488068194 last batch loss:  
40.255557205863845  
Epoch 48: average-batch loss: 40.31553466529627 last batch loss:  
40.25372491106888  
Epoch 49: average-batch loss: 40.31467045479144 last batch loss:  
40.239549178774006  
Epoch 50: average-batch loss: 40.31101044226907 last batch loss:  
40.24460616160383  
Epoch 51: average-batch loss: 40.31568316136772 last batch loss:  
40.266792018040576  
We are in a loss plateau learning rate: 0.04782969000000001 loss:  
40.35844025169808  
Restoring from a checkpoint - loss: 40.37330232430001  
Epoch 52: average-batch loss: 40.315553160935565 last batch loss:  
40.246858968843895  
Epoch 53: average-batch loss: 40.3124447524028 last batch loss:  
40.242048732513666  
Epoch 54: average-batch loss: 40.31075060281981 last batch loss:  
40.2499971253063  
Epoch 55: average-batch loss: 40.309677708288724 last batch loss:  
40.22542814223356  
Epoch 56: average-batch loss: 40.311954011107915 last batch loss:  
40.23219631087932  
We are in a loss plateau learning rate: 0.04304672100000001 loss:  
40.36086784151133  
Restoring from a checkpoint - loss: 40.36817877923919  
Epoch 57: average-batch loss: 40.31127544514213 last batch loss:  
40.24886835781467  
Epoch 58: average-batch loss: 40.30954694570147 last batch loss:  
40.24394299282481  
Epoch 59: average-batch loss: 40.313020331041606 last batch loss:  
40.2601513721178  
Epoch 60: average-batch loss: 40.312542451709284 last batch loss:  
40.252298180819736  
Epoch 61: average-batch loss: 40.31366590102423 last batch loss:  
40.251583245824065  
We are in a loss plateau learning rate: 0.03874204890000001 loss:  
40.3573532449526  
Restoring from a checkpoint - loss: 40.36246237756705  
Epoch 62: average-batch loss: 40.31327894621167 last batch loss:  
40.25111101391661  
Epoch 63: average-batch loss: 40.31236578822466 last batch loss:

40.26895197628445  
Epoch 64: average-batch loss: 40.31677801163617 last batch loss:  
40.26541091411296  
Epoch 65: average-batch loss: 40.3201573373843 last batch loss:  
40.24889760451085  
Epoch 66: average-batch loss: 40.31739898634148 last batch loss:  
40.262923858615345  
Epoch 67: average-batch loss: 40.31430465211733 last batch loss:  
40.2523827549853  
Epoch 68: average-batch loss: 40.30826343661409 last batch loss:  
40.23996691569377  
Epoch 69: average-batch loss: 40.310787204973536 last batch loss:  
40.25232157723873  
Epoch 70: average-batch loss: 40.312667683348096 last batch loss:  
40.256118053635376  
We are in a loss plateau learning rate: 0.03486784401000001 loss:  
40.358905980444455  
Restoring from a checkpoint - loss: 40.357635778338604  
Epoch 71: average-batch loss: 40.31402221712786 last batch loss:  
40.27775900545595  
Epoch 72: average-batch loss: 40.312447452211856 last batch loss:  
40.26092896105483  
Epoch 73: average-batch loss: 40.31354732570319 last batch loss:  
40.24411297975626  
Epoch 74: average-batch loss: 40.3140664159738 last batch loss:  
40.26156901666771  
Epoch 75: average-batch loss: 40.31490537509934 last batch loss:  
40.27837685547171  
We are in a loss plateau learning rate: 0.031381059609000006 loss:  
40.35501806581918  
Restoring from a checkpoint - loss: 40.35511720986122  
Epoch 76: average-batch loss: 40.32049584324178 last batch loss:  
40.25952540853716  
Epoch 77: average-batch loss: 40.321620220006665 last batch loss:  
40.25524283697703  
Epoch 78: average-batch loss: 40.31792328915354 last batch loss:  
40.267313386025705  
Epoch 79: average-batch loss: 40.31536330561132 last batch loss:  
40.2428864969236  
Epoch 80: average-batch loss: 40.308739449554345 last batch loss:  
40.26160661354793  
Epoch 81: average-batch loss: 40.31254434026423 last batch loss:  
40.2928373627872  
Epoch 82: average-batch loss: 40.31398621661139 last batch loss:  
40.24267448387266  
We are in a loss plateau learning rate: 0.028242953648100012 loss:  
40.348589856900205  
Restoring from a checkpoint - loss: 40.34734210702012

Epoch 83: average-batch loss: 40.31432036158623 last batch loss:  
40.240119344931216  
Epoch 84: average-batch loss: 40.31359029788203 last batch loss:  
40.261254285535976  
Epoch 85: average-batch loss: 40.31001851355683 last batch loss:  
40.2491673734911  
Epoch 86: average-batch loss: 40.31931174439211 last batch loss:  
40.24227015631254  
Epoch 87: average-batch loss: 40.315125013705405 last batch loss:  
40.25117551747005  
Epoch 88: average-batch loss: 40.31645853856624 last batch loss:  
40.24849584481001  
Epoch 89: average-batch loss: 40.318613049005116 last batch loss:  
40.25831805489947  
We are in a loss plateau learning rate: 0.02541865828329001 loss:  
40.34406322087014  
Restoring from a checkpoint - loss: 40.36461815589624  
Epoch 90: average-batch loss: 40.3115503917832 last batch loss: 40.2508372316452  
Epoch 91: average-batch loss: 40.309115320997726 last batch loss:  
40.240795702930015  
Epoch 92: average-batch loss: 40.31360801529079 last batch loss:  
40.26145019010428  
Epoch 93: average-batch loss: 40.31612113610267 last batch loss:  
40.25770648868005  
Epoch 94: average-batch loss: 40.31532200467066 last batch loss:  
40.24230537597818  
Epoch 95: average-batch loss: 40.317677771131514 last batch loss:  
40.2606428762501  
We are in a loss plateau learning rate: 0.02287679245496101 loss:  
40.362931052005344  
Restoring from a checkpoint - loss: 40.36482440089453  
Epoch 96: average-batch loss: 40.314080512001404 last batch loss:  
40.27326233566976  
Epoch 97: average-batch loss: 40.31336883824463 last batch loss:  
40.23121885001493  
Epoch 98: average-batch loss: 40.31783140849678 last batch loss:  
40.263651245972575  
Epoch 99: average-batch loss: 40.31026502250338 last batch loss:  
40.26851320123927  
Epoch 100: average-batch loss: 40.31422822679761 last batch loss:  
40.24326207682681  
Epoch 101: average-batch loss: 40.30895676469921 last batch loss:  
40.25306486433618  
Epoch 102: average-batch loss: 40.31038895457983 last batch loss:  
40.29560807027564  
Epoch 103: average-batch loss: 40.3137294916282 last batch loss:  
40.24557114785205  
We are in a loss plateau learning rate: 0.02058911320946491 loss:

40.36079722809003  
Restoring from a checkpoint - loss: 40.35918646779026  
Epoch 104: average-batch loss: 40.3146638825828 last batch loss: 40.27267381353326  
Epoch 105: average-batch loss: 40.314456858680934 last batch loss: 40.25662938589761  
Epoch 106: average-batch loss: 40.31268127971362 last batch loss: 40.23587975792065  
Epoch 107: average-batch loss: 40.31743910872382 last batch loss: 40.255075759490346  
Epoch 108: average-batch loss: 40.31463085789491 last batch loss: 40.27005925670267  
Epoch 109: average-batch loss: 40.31204270720695 last batch loss: 40.23057642142952  
Epoch 110: average-batch loss: 40.31468775875264 last batch loss: 40.25550973695337  
We are in a loss plateau learning rate: 0.018530201888518418 loss: 40.379396457862214  
Restoring from a checkpoint - loss: 40.362795917487816  
Epoch 111: average-batch loss: 40.31376837551691 last batch loss: 40.25633115613172  
Epoch 112: average-batch loss: 40.31619377890171 last batch loss: 40.24662528459542  
Epoch 113: average-batch loss: 40.30961044516378 last batch loss: 40.25084721932985  
Epoch 114: average-batch loss: 40.31187199637565 last batch loss: 40.25352836309899  
Epoch 115: average-batch loss: 40.3157522254764 last batch loss: 40.25128313329914  
We are in a loss plateau learning rate: 0.016677181699666577 loss: 40.36063538189017  
Restoring from a checkpoint - loss: 40.36538074658952  
Epoch 116: average-batch loss: 40.31357681358496 last batch loss: 40.26622800040993  
Epoch 117: average-batch loss: 40.312934433084955 last batch loss: 40.258627005661516  
Epoch 118: average-batch loss: 40.31080553517213 last batch loss: 40.240590556505076  
Epoch 119: average-batch loss: 40.311023884938805 last batch loss: 40.2419177019738  
Epoch 120: average-batch loss: 40.31023383733097 last batch loss: 40.242947157512816  
Epoch 121: average-batch loss: 40.309786144545576 last batch loss: 40.233111793807176  
Epoch 122: average-batch loss: 40.30766304550644 last batch loss: 40.25000154941631  
Epoch 123: average-batch loss: 40.313694043575445 last batch loss: 40.27077220923905

We are in a loss plateau learning rate: 0.015009463529699918 loss:  
40.35330707625844  
Restoring from a checkpoint - loss: 40.35649911017776  
Epoch 124: average-batch loss: 40.31045685683197 last batch loss:  
40.24542303313264  
Epoch 125: average-batch loss: 40.31320140367407 last batch loss:  
40.25696546554309  
Epoch 126: average-batch loss: 40.316671671390665 last batch loss:  
40.26019417331993  
Epoch 127: average-batch loss: 40.315748670646826 last batch loss:  
40.24591296862467  
Epoch 128: average-batch loss: 40.317606387355966 last batch loss:  
40.27207692005575  
We are in a loss plateau learning rate: 0.013508517176729929 loss:  
40.34173634455952  
Restoring from a checkpoint - loss: 40.38020600308881  
Epoch 129: average-batch loss: 40.3155105282528 last batch loss:  
40.266319047740346  
Epoch 130: average-batch loss: 40.315600735987985 last batch loss:  
40.23912382903667  
Epoch 131: average-batch loss: 40.31298308983354 last batch loss:  
40.258297196267705  
Epoch 132: average-batch loss: 40.31051439434886 last batch loss:  
40.255743489194664  
Epoch 133: average-batch loss: 40.31383690580715 last batch loss:  
40.25256503132904  
We are in a loss plateau learning rate: 0.012157665459056936 loss:  
40.3526192813182  
Restoring from a checkpoint - loss: 40.36175035227806  
Epoch 134: average-batch loss: 40.311003804086624 last batch loss:  
40.282459312996615  
Epoch 135: average-batch loss: 40.31408507780259 last batch loss:  
40.256998828568875  
Epoch 136: average-batch loss: 40.314474715116624 last batch loss:  
40.23770134941089  
Epoch 137: average-batch loss: 40.31325457471018 last batch loss:  
40.256123297882894  
Epoch 138: average-batch loss: 40.3118495343104 last batch loss:  
40.26614211901841  
Epoch 139: average-batch loss: 40.30968769337849 last batch loss:  
40.22505248169586  
Epoch 140: average-batch loss: 40.31563461068611 last batch loss:  
40.24954599583068  
We are in a loss plateau learning rate: 0.010941898913151242 loss:  
40.3567770555648  
Restoring from a checkpoint - loss: 40.37823656823585  
Epoch 141: average-batch loss: 40.31234311223658 last batch loss:  
40.26089137685575

Epoch 142: average-batch loss: 40.31199104975651 last batch loss: 40.243831824949815  
Epoch 143: average-batch loss: 40.30618903076279 last batch loss: 40.25024102111653  
Saved a checkpoint: ./tf\_ckpts/chkpt-15  
Epoch 144: average-batch loss: 40.30801140707822 last batch loss: 40.265122523579485  
Epoch 145: average-batch loss: 40.31308671695384 last batch loss: 40.22913007062229  
We are in a loss plateau learning rate: 0.00984770902183612 loss: 40.34851749641173  
Restoring from a checkpoint - loss: 40.34851528093881  
Epoch 146: average-batch loss: 40.309193491703134 last batch loss: 40.25836745774177  
Epoch 147: average-batch loss: 40.317703506357894 last batch loss: 40.26164853783824  
Epoch 148: average-batch loss: 40.31590029894211 last batch loss: 40.24348806745942  
Epoch 149: average-batch loss: 40.30935653409368 last batch loss: 40.24981482269517  
Epoch 150: average-batch loss: 40.31497381499557 last batch loss: 40.27039916609391  
Epoch 151: average-batch loss: 40.31437248065376 last batch loss: 40.242305156493124  
Epoch 152: average-batch loss: 40.311550120160916 last batch loss: 40.26098494340612  
Epoch 153: average-batch loss: 40.3147775794977 last batch loss: 40.26537111360466  
We are in a loss plateau learning rate: 0.008862938119652507 loss: 40.366239374124476  
Restoring from a checkpoint - loss: 40.3649857092609  
Epoch 154: average-batch loss: 40.31280814618549 last batch loss: 40.253419615257776  
Epoch 155: average-batch loss: 40.3186957092687 last batch loss: 40.2784030262875  
Epoch 156: average-batch loss: 40.31658391413802 last batch loss: 40.26675322175352  
Epoch 157: average-batch loss: 40.312181618098386 last batch loss: 40.232666294233944  
Epoch 158: average-batch loss: 40.308453528418916 last batch loss: 40.25009366435455  
Epoch 159: average-batch loss: 40.31611342122856 last batch loss: 40.269292785358395  
We are in a loss plateau learning rate: 0.007976644307687256 loss: 40.363010988470485  
Restoring from a checkpoint - loss: 40.36480235844436  
Epoch 160: average-batch loss: 40.31540182404827 last batch loss: 40.252243298658634

Epoch 161: average-batch loss: 40.31767802665194 last batch loss: 40.26517490797475  
Epoch 162: average-batch loss: 40.309983339164404 last batch loss: 40.25266583110049  
Epoch 163: average-batch loss: 40.31228842921752 last batch loss: 40.23470310688186  
Epoch 164: average-batch loss: 40.31213373915335 last batch loss: 40.24067804493226  
Epoch 165: average-batch loss: 40.3134304927436 last batch loss: 40.253414473595946  
We are in a loss plateau learning rate: 0.00717897987691853 loss: 40.373593353654144  
Restoring from a checkpoint - loss: 40.35017736668298  
Epoch 166: average-batch loss: 40.31432025592184 last batch loss: 40.23622858693165  
Epoch 167: average-batch loss: 40.31414037631848 last batch loss: 40.24019442813776  
Epoch 168: average-batch loss: 40.313731909420795 last batch loss: 40.25768822565389  
Epoch 169: average-batch loss: 40.31412039572831 last batch loss: 40.23943953556016  
Epoch 170: average-batch loss: 40.30983748429897 last batch loss: 40.26572249315661  
Epoch 171: average-batch loss: 40.311370300067686 last batch loss: 40.278550219087045  
Epoch 172: average-batch loss: 40.31282406088495 last batch loss: 40.247358181366835  
We have reset 25 times so quitting

```
[5]: waic = factor_noise.waic()
      print(waic)
```

```
{'waic': 353932.84494931763, 'se': 1811.8601142166967, 'lppd':
-37825.634589802445, 'pwaic': 139140.78788485637}
```

```
[6]: losses = factor.calibrate_advi(
      num_epochs=200, rel_tol=1e-4, learning_rate=.1)
```

Initial loss: 60.68973508624056  
Epoch 1: average-batch loss: 56.3720230987765 last batch loss: 55.22081383717899  
Saved a checkpoint: ./tf\_ckpts/chkpt-1  
Epoch 2: average-batch loss: 55.082912448534145 last batch loss: 54.162403801960714  
Saved a checkpoint: ./tf\_ckpts/chkpt-2  
Epoch 3: average-batch loss: 54.15355712297716 last batch loss: 53.31761765792192  
Saved a checkpoint: ./tf\_ckpts/chkpt-3  
Epoch 4: average-batch loss: 53.403993550009666 last batch loss:

52.59896178977851  
Saved a checkpoint: ./tf\_ckpts/chkpt-4  
Epoch 5: average-batch loss: 52.979769210149215 last batch loss:  
52.23694692800408  
Saved a checkpoint: ./tf\_ckpts/chkpt-5  
Epoch 6: average-batch loss: inf last batch loss: 50.489294432202925  
Got NaN, restoring a checkpoint  
We are in a loss plateau learning rate: 0.08100000000000002 loss:  
52.61801519404851  
Restoring from a checkpoint - loss: 52.653317391166404  
Epoch 7: average-batch loss: 52.207079565926804 last batch loss:  
51.11457552850712  
Saved a checkpoint: ./tf\_ckpts/chkpt-6  
Epoch 8: average-batch loss: 50.63999583439122 last batch loss:  
49.87894576994419  
Saved a checkpoint: ./tf\_ckpts/chkpt-7  
Epoch 9: average-batch loss: 49.10950751138291 last batch loss: 48.3145864538665  
Saved a checkpoint: ./tf\_ckpts/chkpt-8  
Epoch 10: average-batch loss: 48.41871957969979 last batch loss:  
48.06275979412896  
Saved a checkpoint: ./tf\_ckpts/chkpt-9  
Epoch 11: average-batch loss: 48.124935264382245 last batch loss:  
47.92444534482841  
Saved a checkpoint: ./tf\_ckpts/chkpt-10  
Epoch 12: average-batch loss: 47.8387483886198 last batch loss:  
47.54598323484583  
Saved a checkpoint: ./tf\_ckpts/chkpt-11  
Epoch 13: average-batch loss: 47.63158355260927 last batch loss:  
47.406248276370775  
Saved a checkpoint: ./tf\_ckpts/chkpt-12  
Epoch 14: average-batch loss: 47.552417815314655 last batch loss:  
47.338874273717686  
Saved a checkpoint: ./tf\_ckpts/chkpt-13  
Epoch 15: average-batch loss: 47.522006108303 last batch loss: 47.35113607547721  
Saved a checkpoint: ./tf\_ckpts/chkpt-14  
Epoch 16: average-batch loss: 47.48796579718822 last batch loss:  
47.40833705536867  
Saved a checkpoint: ./tf\_ckpts/chkpt-15  
Epoch 17: average-batch loss: 47.47144157036161 last batch loss:  
47.27227011456655  
Saved a checkpoint: ./tf\_ckpts/chkpt-16  
Epoch 18: average-batch loss: 47.46099261816438 last batch loss:  
47.30926791098044  
Saved a checkpoint: ./tf\_ckpts/chkpt-17  
Epoch 19: average-batch loss: 47.450009309158304 last batch loss:  
47.29792462397202  
Saved a checkpoint: ./tf\_ckpts/chkpt-18  
Epoch 20: average-batch loss: 47.443506506337414 last batch loss:

47.31828795780614  
 Saved a checkpoint: ./tf\_ckpts/chkpt-19  
 Epoch 21: average-batch loss: 47.436780067206826 last batch loss: 47.28161863061407  
 Saved a checkpoint: ./tf\_ckpts/chkpt-20  
 Epoch 22: average-batch loss: 47.42356518108662 last batch loss: 47.275543105202836  
 Saved a checkpoint: ./tf\_ckpts/chkpt-21  
 Epoch 23: average-batch loss: 47.40905143475697 last batch loss: 47.26612976679065  
 Saved a checkpoint: ./tf\_ckpts/chkpt-22  
 Epoch 24: average-batch loss: 47.39999130379585 last batch loss: 47.25440451439634  
 Saved a checkpoint: ./tf\_ckpts/chkpt-23  
 Epoch 25: average-batch loss: 47.388157148092226 last batch loss: 47.298793744506504  
 Saved a checkpoint: ./tf\_ckpts/chkpt-24  
 Epoch 26: average-batch loss: 47.3810319288741 last batch loss: 47.23181065091319  
 Saved a checkpoint: ./tf\_ckpts/chkpt-25  
 Epoch 27: average-batch loss: 47.375435883572294 last batch loss: 47.26329681246791  
 Saved a checkpoint: ./tf\_ckpts/chkpt-26  
 Epoch 28: average-batch loss: 47.37187647619015 last batch loss: 47.24345358671395  
 Saved a checkpoint: ./tf\_ckpts/chkpt-27  
 Epoch 29: average-batch loss: 47.36680438442809 last batch loss: 47.24699248394022  
 Saved a checkpoint: ./tf\_ckpts/chkpt-28  
 Epoch 30: average-batch loss: 47.370830177022924 last batch loss: 47.24731798212649  
 Epoch 31: average-batch loss: 47.36289043559822 last batch loss: 47.248297432411654  
 Saved a checkpoint: ./tf\_ckpts/chkpt-29  
 Epoch 32: average-batch loss: 47.34842899829022 last batch loss: 47.27842815024899  
 Saved a checkpoint: ./tf\_ckpts/chkpt-30  
 Epoch 33: average-batch loss: 47.3477464696143 last batch loss: 47.2443081705245  
 Saved a checkpoint: ./tf\_ckpts/chkpt-31  
 Epoch 34: average-batch loss: 47.34721750664046 last batch loss: 47.2362191941786  
 Saved a checkpoint: ./tf\_ckpts/chkpt-32  
 Epoch 35: average-batch loss: 47.351951543841516 last batch loss: 47.21581484854231  
 We are in a loss plateau learning rate: 0.0729 loss: 47.15495956132456  
 Restoring from a checkpoint - loss: 47.145489278357516  
 Epoch 36: average-batch loss: 47.344511313112505 last batch loss: 47.22439197650844

Saved a checkpoint: ./tf\_ckpts/chkpt-33  
 Epoch 37: average-batch loss: 47.346470318127075 last batch loss: 47.25912725119658  
 Epoch 38: average-batch loss: 47.34596380194026 last batch loss: 47.23748744353062  
 Epoch 39: average-batch loss: 47.34901063331131 last batch loss: 47.23264164814837  
 Epoch 40: average-batch loss: 47.34471103300497 last batch loss: 47.24376731706898  
 Epoch 41: average-batch loss: 47.3624684127824 last batch loss: 47.242182655336286  
 We are in a loss plateau learning rate: 0.06561 loss: 47.175036101273214  
 Restoring from a checkpoint - loss: 47.24516261598802  
 Epoch 42: average-batch loss: 47.346812709081036 last batch loss: 47.22959944100569  
 Epoch 43: average-batch loss: 47.348393986292784 last batch loss: 47.264770148110564  
 Epoch 44: average-batch loss: 47.33957176427047 last batch loss: 47.24398340758466  
 Saved a checkpoint: ./tf\_ckpts/chkpt-34  
 Epoch 45: average-batch loss: 47.34071902397049 last batch loss: 47.19774486044382  
 Epoch 46: average-batch loss: 47.34284906518194 last batch loss: 47.26161685232471  
 We are in a loss plateau learning rate: 0.059049000000000001 loss: 47.147484022162374  
 Restoring from a checkpoint - loss: 47.13836797181588  
 Epoch 47: average-batch loss: 47.34746240725568 last batch loss: 47.19804286965973  
 Epoch 48: average-batch loss: 47.33924744127609 last batch loss: 47.21920089771847  
 Saved a checkpoint: ./tf\_ckpts/chkpt-35  
 Epoch 49: average-batch loss: 47.343647794206824 last batch loss: 47.24385971459855  
 Epoch 50: average-batch loss: 47.33759858912108 last batch loss: 47.20171688711792  
 Saved a checkpoint: ./tf\_ckpts/chkpt-36  
 Epoch 51: average-batch loss: 47.338386535435276 last batch loss: 47.201820979615086  
 Epoch 52: average-batch loss: 47.33820415379792 last batch loss: 47.24331642832771  
 Epoch 53: average-batch loss: 47.34625031807454 last batch loss: 47.21863928720876  
 We are in a loss plateau learning rate: 0.053144100000000001 loss: 47.18894981735236  
 Restoring from a checkpoint - loss: 47.21894422414894  
 Epoch 54: average-batch loss: 47.33992492664137 last batch loss: 47.20857914133155

Epoch 55: average-batch loss: 47.34544244700228 last batch loss:  
47.24907564382831  
Epoch 56: average-batch loss: 47.327507320222495 last batch loss:  
47.20430817232907  
Saved a checkpoint: ./tf\_ckpts/chkpt-37  
Epoch 57: average-batch loss: 47.327170941567935 last batch loss:  
47.23607218951751  
Saved a checkpoint: ./tf\_ckpts/chkpt-38  
Epoch 58: average-batch loss: 47.33768853401373 last batch loss:  
47.2642999420518  
We are in a loss plateau learning rate: 0.04782969000000001 loss:  
47.162298779095195  
Restoring from a checkpoint - loss: 47.17562219018908  
Epoch 59: average-batch loss: 47.33622790515828 last batch loss:  
47.22056439293924  
Epoch 60: average-batch loss: 47.3537504134913 last batch loss:  
47.22426137681109  
Epoch 61: average-batch loss: 47.336793668312545 last batch loss:  
47.27356112419565  
Epoch 62: average-batch loss: 47.3374542082463 last batch loss:  
47.220444527636324  
Epoch 63: average-batch loss: 47.333617079421586 last batch loss:  
47.235692405943034  
Epoch 64: average-batch loss: 47.33809638535645 last batch loss:  
47.22754699018565  
We are in a loss plateau learning rate: 0.04304672100000001 loss:  
47.16843890381348  
Restoring from a checkpoint - loss: 47.17343863567404  
Epoch 65: average-batch loss: 47.347517984291834 last batch loss:  
47.207033556958066  
Epoch 66: average-batch loss: 47.3352382088192 last batch loss:  
47.256972884820705  
Epoch 67: average-batch loss: 47.333598809970056 last batch loss:  
47.20968805990571  
Epoch 68: average-batch loss: 47.339468538483786 last batch loss:  
47.2214007662104  
Epoch 69: average-batch loss: 47.32693087530134 last batch loss:  
47.19752911042511  
Saved a checkpoint: ./tf\_ckpts/chkpt-39  
Epoch 70: average-batch loss: 47.32759735684912 last batch loss:  
47.24607962387546  
Epoch 71: average-batch loss: 47.325732149146596 last batch loss:  
47.20396944395074  
Saved a checkpoint: ./tf\_ckpts/chkpt-40  
Epoch 72: average-batch loss: 47.32409782042782 last batch loss:  
47.22619835778565  
Saved a checkpoint: ./tf\_ckpts/chkpt-41  
Epoch 73: average-batch loss: 47.330717529277734 last batch loss:

47.20236654744645  
We are in a loss plateau learning rate: 0.03874204890000001 loss:  
47.13687881386963  
Restoring from a checkpoint - loss: 47.16396824104601  
Epoch 74: average-batch loss: 47.33219775331197 last batch loss:  
47.24533380639455  
Epoch 75: average-batch loss: 47.32721372004748 last batch loss:  
47.246863852328595  
Epoch 76: average-batch loss: 47.32563677234275 last batch loss:  
47.26066173859507  
Epoch 77: average-batch loss: 47.32726585250423 last batch loss: 47.177729538914  
Epoch 78: average-batch loss: 47.33614308515839 last batch loss:  
47.239051286600095  
We are in a loss plateau learning rate: 0.03486784401000001 loss:  
47.16786246206105  
Restoring from a checkpoint - loss: 47.188438139282304  
Epoch 79: average-batch loss: 47.338756461649 last batch loss: 47.19782766573829  
Epoch 80: average-batch loss: 47.336603490751706 last batch loss:  
47.21618788011382  
Epoch 81: average-batch loss: 47.332662763222686 last batch loss:  
47.20334009045098  
Epoch 82: average-batch loss: 47.32323493220513 last batch loss:  
47.19062283552262  
Saved a checkpoint: ./tf\_ckpts/chkpt-42  
Epoch 83: average-batch loss: 47.328648893235304 last batch loss:  
47.19839168372504  
Epoch 84: average-batch loss: 47.32644384896661 last batch loss:  
47.20115060067175  
Epoch 85: average-batch loss: 47.323451968639375 last batch loss:  
47.225327597651365  
Epoch 86: average-batch loss: 47.32909984148734 last batch loss:  
47.224786579817554  
We are in a loss plateau learning rate: 0.031381059609000006 loss:  
47.178559700443294  
Restoring from a checkpoint - loss: 47.19446093129392  
Epoch 87: average-batch loss: 47.338118793160426 last batch loss:  
47.23551195464266  
Epoch 88: average-batch loss: 47.32263755817623 last batch loss:  
47.23518946585957  
Saved a checkpoint: ./tf\_ckpts/chkpt-43  
Epoch 89: average-batch loss: 47.33144307401702 last batch loss:  
47.21680449943353  
Epoch 90: average-batch loss: 47.34426157573872 last batch loss:  
47.216775589543175  
Epoch 91: average-batch loss: 47.32265703711557 last batch loss:  
47.22490536519654  
Epoch 92: average-batch loss: 47.326227635182185 last batch loss:  
47.18416170437762

Epoch 93: average-batch loss: 47.32563847858201 last batch loss:  
47.21798193698212  
Epoch 94: average-batch loss: 47.32758279898362 last batch loss:  
47.21420192028013  
We are in a loss plateau learning rate: 0.028242953648100012 loss:  
47.14556986445314  
Restoring from a checkpoint - loss: 47.15524527794372  
Epoch 95: average-batch loss: 47.325190824189825 last batch loss:  
47.229628053731155  
Epoch 96: average-batch loss: 47.324190734632346 last batch loss:  
47.20204215776624  
Epoch 97: average-batch loss: 47.31415520025123 last batch loss:  
47.22094507452441  
Saved a checkpoint: ./tf\_ckpts/chkpt-44  
Epoch 98: average-batch loss: 47.32073347553608 last batch loss:  
47.1879503421463  
Epoch 99: average-batch loss: 47.3255963906192 last batch loss:  
47.21726022990354  
We are in a loss plateau learning rate: 0.02541865828329001 loss:  
47.167557535235495  
Restoring from a checkpoint - loss: 47.16478663517301  
Epoch 100: average-batch loss: 47.32340809212405 last batch loss:  
47.215988801944924  
Epoch 101: average-batch loss: 47.31736274303462 last batch loss:  
47.20291603442821  
Epoch 102: average-batch loss: 47.334974698436525 last batch loss:  
47.22512652098645  
Epoch 103: average-batch loss: 47.326392370877414 last batch loss:  
47.19322151638057  
Epoch 104: average-batch loss: 47.32377908883434 last batch loss:  
47.19936817016976  
Epoch 105: average-batch loss: 47.340890314081896 last batch loss:  
47.2187410802644  
We are in a loss plateau learning rate: 0.02287679245496101 loss:  
47.155250907265824  
Restoring from a checkpoint - loss: 47.17147644862766  
Epoch 106: average-batch loss: 47.34384534623041 last batch loss:  
47.25352467747347  
Epoch 107: average-batch loss: 47.31955329959721 last batch loss:  
47.197701602819286  
Epoch 108: average-batch loss: 47.32713335721892 last batch loss:  
47.20042231070645  
Epoch 109: average-batch loss: 47.32095658965604 last batch loss:  
47.18966254474341  
Epoch 110: average-batch loss: 47.33046199706814 last batch loss:  
47.2195654222511  
We are in a loss plateau learning rate: 0.02058911320946491 loss:  
47.17240936659731

Restoring from a checkpoint - loss: 47.15187964664377  
Epoch 111: average-batch loss: 47.33507014821705 last batch loss: 47.20526140422582  
Epoch 112: average-batch loss: 47.33087169101434 last batch loss: 47.2043762864475  
Epoch 113: average-batch loss: 47.33312777115335 last batch loss: 47.205413821891604  
Epoch 114: average-batch loss: 47.318711698422575 last batch loss: 47.20687473188315  
Epoch 115: average-batch loss: 47.32338406303447 last batch loss: 47.20418823720967  
Epoch 116: average-batch loss: 47.323238709612745 last batch loss: 47.19029072934063  
Epoch 117: average-batch loss: 47.32363752138728 last batch loss: 47.20113432185697  
We are in a loss plateau learning rate: 0.018530201888518418 loss: 47.155168155008155  
Restoring from a checkpoint - loss: 47.14383976013677  
Epoch 118: average-batch loss: 47.3217337542446 last batch loss: 47.23555993705651  
Epoch 119: average-batch loss: 47.32183904323386 last batch loss: 47.19599508248945  
Epoch 120: average-batch loss: 47.3213853285382 last batch loss: 47.23869694329196  
Epoch 121: average-batch loss: 47.322075962690235 last batch loss: 47.24162486943067  
Epoch 122: average-batch loss: 47.3241439877287 last batch loss: 47.206380810556325  
We are in a loss plateau learning rate: 0.016677181699666577 loss: 47.1418728348788  
Restoring from a checkpoint - loss: 47.13910223443964  
Epoch 123: average-batch loss: 47.325579061680465 last batch loss: 47.216880019955546  
Epoch 124: average-batch loss: 47.32424074603438 last batch loss: 47.21577020256429  
Epoch 125: average-batch loss: 47.31992506192414 last batch loss: 47.22018717597902  
Epoch 126: average-batch loss: 47.32430597232507 last batch loss: 47.203236665116414  
Epoch 127: average-batch loss: 47.32515284901455 last batch loss: 47.229509310884126  
We are in a loss plateau learning rate: 0.015009463529699918 loss: 47.155975345664615  
Restoring from a checkpoint - loss: 47.18010656011705  
Epoch 128: average-batch loss: 47.325656851512605 last batch loss: 47.188564889757295  
Epoch 129: average-batch loss: 47.32105337207409 last batch loss: 47.203880547328254

Epoch 130: average-batch loss: 47.31989842892095 last batch loss: 47.21914031013087  
Epoch 131: average-batch loss: 47.32683981112242 last batch loss: 47.20627948014173  
Epoch 132: average-batch loss: 47.32884875690616 last batch loss: 47.20935637263634  
We are in a loss plateau learning rate: 0.013508517176729929 loss: 47.159068564819734  
Restoring from a checkpoint - loss: 47.18555501366129  
Epoch 133: average-batch loss: 47.31745833917801 last batch loss: 47.205802439664204  
Epoch 134: average-batch loss: 47.321575020248154 last batch loss: 47.192472521771485  
Epoch 135: average-batch loss: 47.326963221467764 last batch loss: 47.225129157150576  
Epoch 136: average-batch loss: 47.32698477349395 last batch loss: 47.215323161918015  
Epoch 137: average-batch loss: 47.32356284971374 last batch loss: 47.18105269998105  
Epoch 138: average-batch loss: 47.32367988127271 last batch loss: 47.21655337506081  
Epoch 139: average-batch loss: 47.324653125779584 last batch loss: 47.27049704605024  
We are in a loss plateau learning rate: 0.012157665459056936 loss: 47.15778829683135  
Restoring from a checkpoint - loss: 47.13612038801483  
Epoch 140: average-batch loss: 47.31608282997373 last batch loss: 47.19689071635526  
Epoch 141: average-batch loss: 47.32704424679945 last batch loss: 47.23090781694822  
Epoch 142: average-batch loss: 47.35002319840799 last batch loss: 47.29674049769555  
Epoch 143: average-batch loss: 47.33209044397387 last batch loss: 47.206270513977664  
Epoch 144: average-batch loss: 47.32932112220016 last batch loss: 47.23985780086594  
Epoch 145: average-batch loss: 47.338725378729315 last batch loss: 47.231115450551  
We are in a loss plateau learning rate: 0.010941898913151242 loss: 47.13844776540554  
Restoring from a checkpoint - loss: 47.146791067554574  
Epoch 146: average-batch loss: 47.32951279124454 last batch loss: 47.215776998667  
Epoch 147: average-batch loss: 47.350958359692314 last batch loss: 47.2323458931215  
Epoch 148: average-batch loss: 47.32783407685025 last batch loss: 47.19978890459356  
Epoch 149: average-batch loss: 47.32673020366864 last batch loss:

47.19648386795307  
Epoch 150: average-batch loss: 47.334510565533236 last batch loss: 47.21694818518671  
We are in a loss plateau learning rate: 0.00984770902183612 loss: 47.17972454584809  
Restoring from a checkpoint - loss: 47.155766861638796  
Epoch 151: average-batch loss: 47.32358623423341 last batch loss: 47.22125508805814  
Epoch 152: average-batch loss: 47.33192238284032 last batch loss: 47.22458686713809  
Epoch 153: average-batch loss: 47.32350733259439 last batch loss: 47.20250465946038  
Epoch 154: average-batch loss: 47.328756134594684 last batch loss: 47.238249827842004  
Epoch 155: average-batch loss: 47.327701908288276 last batch loss: 47.209207185541864  
Epoch 156: average-batch loss: 47.32617133834002 last batch loss: 47.20035625251179  
Epoch 157: average-batch loss: 47.3210233535215 last batch loss: 47.19625780855157  
Epoch 158: average-batch loss: 47.330320888315555 last batch loss: 47.22268511523727  
We are in a loss plateau learning rate: 0.008862938119652507 loss: 47.17867306029102  
Restoring from a checkpoint - loss: 47.15766807962001  
Epoch 159: average-batch loss: 47.323815424458864 last batch loss: 47.21674714084194  
Epoch 160: average-batch loss: 47.32693285128522 last batch loss: 47.217201002582584  
Epoch 161: average-batch loss: 47.33346753315073 last batch loss: 47.21521443167863  
Epoch 162: average-batch loss: 47.326773740208765 last batch loss: 47.21484805731934  
Epoch 163: average-batch loss: 47.335742812699245 last batch loss: 47.234047085901544  
We are in a loss plateau learning rate: 0.007976644307687256 loss: 47.134976878144926  
Restoring from a checkpoint - loss: 47.14390683099616  
Epoch 164: average-batch loss: 47.32225443383144 last batch loss: 47.21611430138973  
Epoch 165: average-batch loss: 47.32052660824564 last batch loss: 47.21599254838767  
Epoch 166: average-batch loss: 47.32142028439803 last batch loss: 47.28354165744919  
Epoch 167: average-batch loss: 47.32361507727931 last batch loss: 47.23768349993394  
Epoch 168: average-batch loss: 47.32380958784477 last batch loss: 47.188659319998045

We are in a loss plateau learning rate: 0.00717897987691853 loss:  
 47.16165719425512  
 Restoring from a checkpoint - loss: 47.16451163590707  
 Epoch 169: average-batch loss: 47.31978533626555 last batch loss:  
 47.242338369745326  
 Epoch 170: average-batch loss: 47.32588783877297 last batch loss:  
 47.19333221224989  
 Epoch 171: average-batch loss: 47.323787536199426 last batch loss:  
 47.21133203921988  
 Epoch 172: average-batch loss: 47.32887635551424 last batch loss:  
 47.220996379900186  
 Epoch 173: average-batch loss: 47.33164886979041 last batch loss:  
 47.20705801897227  
 We are in a loss plateau learning rate: 0.006461081889226678 loss:  
 47.30286184624535  
 Restoring from a checkpoint - loss: 47.29704844159921  
 Epoch 174: average-batch loss: 47.32947550813609 last batch loss:  
 47.21747691988641  
 Epoch 175: average-batch loss: 47.330136670609136 last batch loss:  
 47.212378796269874  
 Epoch 176: average-batch loss: 47.316946872023784 last batch loss:  
 47.19812044963006  
 Epoch 177: average-batch loss: 47.32868103665129 last batch loss:  
 47.18725060608993  
 Epoch 178: average-batch loss: 47.32130895639921 last batch loss:  
 47.19656178549989  
 Epoch 179: average-batch loss: 47.33134874669782 last batch loss:  
 47.18721404502957  
 We have reset 25 times so quitting

```
[7]: losses = factor_nonlinear.calibrate_advi(
      num_epochs=200, rel_tol=1e-4, learning_rate=.1)
```

Initial loss: 54.6392703125668  
 Epoch 1: average-batch loss: 51.14601513363424 last batch loss:  
 50.239704978423966  
 Saved a checkpoint: ./tf\_ckpts/chkpt-1  
 Epoch 2: average-batch loss: 49.89042928301294 last batch loss:  
 49.17429576970631  
 Saved a checkpoint: ./tf\_ckpts/chkpt-2  
 Epoch 3: average-batch loss: 48.95978751104007 last batch loss:  
 48.30918832688681  
 Saved a checkpoint: ./tf\_ckpts/chkpt-3  
 Epoch 4: average-batch loss: 48.22607947172859 last batch loss:  
 47.780640145405776  
 Saved a checkpoint: ./tf\_ckpts/chkpt-4  
 Epoch 5: average-batch loss: inf last batch loss: 47.574680546370786  
 Got NaN, restoring a checkpoint

We are in a loss plateau learning rate: 0.081000000000000002 loss:  
47.95131362219337  
Restoring from a checkpoint - loss: 47.92805659391549  
Epoch 6: average-batch loss: 47.915695496963096 last batch loss:  
47.628084664272755  
Saved a checkpoint: ./tf\_ckpts/chkpt-5  
Epoch 7: average-batch loss: 47.782115551386326 last batch loss:  
47.441653876132825  
Saved a checkpoint: ./tf\_ckpts/chkpt-6  
Epoch 8: average-batch loss: 47.36983078034264 last batch loss:  
46.87659964285793  
Saved a checkpoint: ./tf\_ckpts/chkpt-7  
Epoch 9: average-batch loss: 46.505913857749036 last batch loss:  
45.84347276088438  
Saved a checkpoint: ./tf\_ckpts/chkpt-8  
Epoch 10: average-batch loss: 45.964402168017735 last batch loss:  
45.67475975839573  
Saved a checkpoint: ./tf\_ckpts/chkpt-9  
Epoch 11: average-batch loss: 45.84349368535068 last batch loss:  
45.60204571195199  
Saved a checkpoint: ./tf\_ckpts/chkpt-10  
Epoch 12: average-batch loss: 45.787880433005505 last batch loss:  
45.58519641529285  
Saved a checkpoint: ./tf\_ckpts/chkpt-11  
Epoch 13: average-batch loss: 45.731785908342744 last batch loss:  
45.570304711720276  
Saved a checkpoint: ./tf\_ckpts/chkpt-12  
Epoch 14: average-batch loss: 45.70730956937596 last batch loss:  
45.53202938777572  
Saved a checkpoint: ./tf\_ckpts/chkpt-13  
Epoch 15: average-batch loss: 45.69441192235976 last batch loss:  
45.55156001864737  
Saved a checkpoint: ./tf\_ckpts/chkpt-14  
Epoch 16: average-batch loss: 45.696471408429325 last batch loss:  
45.51750633326975  
Epoch 17: average-batch loss: 45.654554801908674 last batch loss:  
45.48876634497153  
Saved a checkpoint: ./tf\_ckpts/chkpt-15  
Epoch 18: average-batch loss: 45.64253588904079 last batch loss:  
45.50392694873573  
Saved a checkpoint: ./tf\_ckpts/chkpt-16  
Epoch 19: average-batch loss: 45.639650591018935 last batch loss:  
45.60736738761993  
Saved a checkpoint: ./tf\_ckpts/chkpt-17  
Epoch 20: average-batch loss: 45.63756130765908 last batch loss:  
45.46351811954646  
Saved a checkpoint: ./tf\_ckpts/chkpt-18  
Epoch 21: average-batch loss: 45.616282277487606 last batch loss:

45.48597449054403  
 Saved a checkpoint: ./tf\_ckpts/chkpt-19  
 Epoch 22: average-batch loss: 45.623490073868304 last batch loss:  
 45.4770718239019  
 Epoch 23: average-batch loss: 45.6155900705779 last batch loss:  
 45.47134572778488  
 Saved a checkpoint: ./tf\_ckpts/chkpt-20  
 Epoch 24: average-batch loss: 45.61412941334247 last batch loss:  
 45.48523787933976  
 Saved a checkpoint: ./tf\_ckpts/chkpt-21  
 Epoch 25: average-batch loss: 45.6117840900876 last batch loss:  
 45.481586205171524  
 Saved a checkpoint: ./tf\_ckpts/chkpt-22  
 Epoch 26: average-batch loss: 45.60812774209508 last batch loss:  
 45.48403070909591  
 Saved a checkpoint: ./tf\_ckpts/chkpt-23  
 Epoch 27: average-batch loss: 45.60872295715302 last batch loss:  
 45.4818357420911  
 Epoch 28: average-batch loss: 45.61651459586317 last batch loss:  
 45.49698954966119  
 We are in a loss plateau learning rate: 0.0729 loss: 45.481863416741554  
 Restoring from a checkpoint - loss: 45.47335111170108  
 Epoch 29: average-batch loss: 45.61187092825164 last batch loss:  
 45.457026253755515  
 Epoch 30: average-batch loss: 45.60486752522554 last batch loss:  
 45.47751504283195  
 Saved a checkpoint: ./tf\_ckpts/chkpt-24  
 Epoch 31: average-batch loss: 45.61492328825612 last batch loss:  
 45.48315630121775  
 Epoch 32: average-batch loss: 45.61154200850538 last batch loss:  
 45.471068544670025  
 Epoch 33: average-batch loss: 45.61901146461079 last batch loss:  
 45.46829309247945  
 We are in a loss plateau learning rate: 0.06561 loss: 45.512834395209474  
 Restoring from a checkpoint - loss: 45.51354778756816  
 Epoch 34: average-batch loss: 45.61111389609296 last batch loss:  
 45.489287348341584  
 Epoch 35: average-batch loss: 45.60443096401181 last batch loss:  
 45.50548825122654  
 Saved a checkpoint: ./tf\_ckpts/chkpt-25  
 Epoch 36: average-batch loss: 45.604523813464766 last batch loss:  
 45.44322299535187  
 Epoch 37: average-batch loss: 45.61738481377578 last batch loss:  
 45.49866974859348  
 Epoch 38: average-batch loss: 45.60667084471301 last batch loss:  
 45.457906831423344  
 Epoch 39: average-batch loss: 45.60142120427076 last batch loss:  
 45.48774297794543

Saved a checkpoint: ./tf\_ckpts/chkpt-26  
Epoch 40: average-batch loss: 45.60338459308857 last batch loss: 45.49555096565993  
Epoch 41: average-batch loss: 45.605148595856015 last batch loss: 45.486060634828476  
We are in a loss plateau learning rate: 0.05904900000000001 loss: 45.457126371514974  
Restoring from a checkpoint - loss: 45.46509987104918  
Epoch 42: average-batch loss: 45.60048019124761 last batch loss: 45.44857971981736  
Saved a checkpoint: ./tf\_ckpts/chkpt-27  
Epoch 43: average-batch loss: 45.6053629453131 last batch loss: 45.472937544779604  
Epoch 44: average-batch loss: 45.60388760430454 last batch loss: 45.457697611754554  
Epoch 45: average-batch loss: 45.60739342264047 last batch loss: 45.472116357875855  
Epoch 46: average-batch loss: 45.610275616395484 last batch loss: 45.4761713984572  
We are in a loss plateau learning rate: 0.053144100000000001 loss: 45.45989855839544  
Restoring from a checkpoint - loss: 45.465900145262644  
Epoch 47: average-batch loss: 45.60432632401925 last batch loss: 45.453966925643314  
Epoch 48: average-batch loss: 45.60221970655514 last batch loss: 45.492916948021644  
Epoch 49: average-batch loss: 45.59939549097476 last batch loss: 45.464090912540776  
Saved a checkpoint: ./tf\_ckpts/chkpt-28  
Epoch 50: average-batch loss: 45.61081906090951 last batch loss: 45.448279288054735  
Epoch 51: average-batch loss: 45.60245340550049 last batch loss: 45.45867442328142  
Epoch 52: average-batch loss: 45.60891608886073 last batch loss: 45.496082418621185  
Epoch 53: average-batch loss: 45.607912829660584 last batch loss: 45.4674344112137  
Epoch 54: average-batch loss: 45.61705680025309 last batch loss: 45.4851161890564  
We are in a loss plateau learning rate: 0.047829690000000001 loss: 45.50224382662  
Restoring from a checkpoint - loss: 45.47343757930159  
Epoch 55: average-batch loss: 45.62396169906138 last batch loss: 45.47732547403464  
Epoch 56: average-batch loss: 45.61477863805128 last batch loss: 45.46715142317875  
Epoch 57: average-batch loss: 45.6151364815879 last batch loss: 45.500687879571124  
Epoch 58: average-batch loss: 45.614591425012115 last batch loss:

45.502885631957675  
Epoch 59: average-batch loss: 45.6018400352492 last batch loss:  
45.45427683267964  
Epoch 60: average-batch loss: 45.5991460628728 last batch loss:  
45.48295995121497  
Saved a checkpoint: ./tf\_ckpts/chkpt-29  
Epoch 61: average-batch loss: 45.608143574699845 last batch loss:  
45.49386150073771  
We are in a loss plateau learning rate: 0.04304672100000001 loss:  
45.480042555171224  
Restoring from a checkpoint - loss: 45.45048634265506  
Epoch 62: average-batch loss: 45.60067358258946 last batch loss:  
45.455858567730644  
Epoch 63: average-batch loss: 45.60385474144757 last batch loss:  
45.46767861874642  
Epoch 64: average-batch loss: 45.60231718232009 last batch loss:  
45.49922549582657  
Epoch 65: average-batch loss: 45.59762296464774 last batch loss:  
45.45890453433009  
Saved a checkpoint: ./tf\_ckpts/chkpt-30  
Epoch 66: average-batch loss: 45.606435388065435 last batch loss:  
45.46977804445899  
We are in a loss plateau learning rate: 0.03874204890000001 loss:  
45.48363061097619  
Restoring from a checkpoint - loss: 45.49228750422222  
Epoch 67: average-batch loss: 45.6074423284243 last batch loss:  
45.53106804849746  
Epoch 68: average-batch loss: 45.60287024829868 last batch loss:  
45.46143160374307  
Epoch 69: average-batch loss: 45.598618223620996 last batch loss:  
45.461013172153805  
Epoch 70: average-batch loss: 45.59992096611109 last batch loss:  
45.48776998188305  
Epoch 71: average-batch loss: 45.60257255525533 last batch loss:  
45.47372169789323  
We are in a loss plateau learning rate: 0.03486784401000001 loss:  
45.493167723728035  
Restoring from a checkpoint - loss: 45.47728834532782  
Epoch 72: average-batch loss: 45.603977286139596 last batch loss:  
45.49761428033806  
Epoch 73: average-batch loss: 45.60488988713442 last batch loss:  
45.4677384741601  
Epoch 74: average-batch loss: 45.60603743611438 last batch loss:  
45.48596283152084  
Epoch 75: average-batch loss: 45.613562720048385 last batch loss:  
45.45361415225539  
Epoch 76: average-batch loss: 45.60353726113015 last batch loss:  
45.484326327345826

Epoch 77: average-batch loss: 45.602685126947584 last batch loss:  
45.44778091362455  
Epoch 78: average-batch loss: 45.59444889044656 last batch loss:  
45.51264444588749  
Saved a checkpoint: ./tf\_ckpts/chkpt-31  
Epoch 79: average-batch loss: 45.595722130295265 last batch loss:  
45.467500317631  
Epoch 80: average-batch loss: 45.60164356504046 last batch loss:  
45.46547350604335  
We are in a loss plateau learning rate: 0.031381059609000006 loss:  
45.45053241870449  
Restoring from a checkpoint - loss: 45.450511060932996  
Epoch 81: average-batch loss: 45.600754500615324 last batch loss:  
45.486654001390946  
Epoch 82: average-batch loss: 45.5979193754902 last batch loss:  
45.46918360174884  
Epoch 83: average-batch loss: 45.60021365855052 last batch loss:  
45.48107128350639  
Epoch 84: average-batch loss: 45.59968959297168 last batch loss:  
45.48497267955096  
Epoch 85: average-batch loss: 45.612727349197506 last batch loss:  
45.47655286548337  
We are in a loss plateau learning rate: 0.028242953648100012 loss:  
45.47229452601989  
Restoring from a checkpoint - loss: 45.48086354371816  
Epoch 86: average-batch loss: 45.59885933090436 last batch loss:  
45.44118921212909  
Epoch 87: average-batch loss: 45.60545954057862 last batch loss:  
45.47403700689497  
Epoch 88: average-batch loss: 45.596447456969074 last batch loss:  
45.45229228240063  
Epoch 89: average-batch loss: 45.5982070996314 last batch loss:  
45.46211540012603  
Epoch 90: average-batch loss: 45.5984614774944 last batch loss:  
45.49721247244664  
We are in a loss plateau learning rate: 0.02541865828329001 loss:  
45.496051987222636  
Restoring from a checkpoint - loss: 45.45842835962199  
Epoch 91: average-batch loss: 45.60157183898945 last batch loss:  
45.49104689693625  
Epoch 92: average-batch loss: 45.5979917078671 last batch loss:  
45.477239095084805  
Epoch 93: average-batch loss: 45.604067411778225 last batch loss:  
45.489323986780654  
Epoch 94: average-batch loss: 45.595707744395995 last batch loss:  
45.4524502066382  
Epoch 95: average-batch loss: 45.5984329119096 last batch loss:  
45.466010563903865

Epoch 96: average-batch loss: 45.6024677208297 last batch loss:  
45.47974821721809  
We are in a loss plateau learning rate: 0.02287679245496101 loss:  
45.46967258918608  
Restoring from a checkpoint - loss: 45.46240348563664  
Epoch 97: average-batch loss: 45.59588856108578 last batch loss:  
45.47268918372611  
Epoch 98: average-batch loss: 45.59954058958297 last batch loss:  
45.45771851342079  
Epoch 99: average-batch loss: 45.60159621522349 last batch loss:  
45.47230762081022  
Epoch 100: average-batch loss: 45.60047211060588 last batch loss:  
45.49461292558286  
Epoch 101: average-batch loss: 45.6002357574292 last batch loss:  
45.45008118033628  
Epoch 102: average-batch loss: 45.6114450704965 last batch loss:  
45.470569858266636  
We are in a loss plateau learning rate: 0.02058911320946491 loss:  
45.487456263498665  
Restoring from a checkpoint - loss: 45.4577710350345  
Epoch 103: average-batch loss: 45.604076798347094 last batch loss:  
45.47203953038619  
Epoch 104: average-batch loss: 45.59615608470154 last batch loss:  
45.46524938407174  
Epoch 105: average-batch loss: 45.59723334909904 last batch loss:  
45.4871398799303  
Epoch 106: average-batch loss: 45.602967516542584 last batch loss:  
45.51463733907644  
Epoch 107: average-batch loss: 45.601951830802 last batch loss:  
45.52361223495519  
Epoch 108: average-batch loss: 45.59990889061351 last batch loss:  
45.488736046762234  
Epoch 109: average-batch loss: 45.59995258897981 last batch loss:  
45.488016272167336  
Epoch 110: average-batch loss: 45.60264297788905 last batch loss:  
45.46537236288082  
We are in a loss plateau learning rate: 0.018530201888518418 loss:  
45.47589772396837  
Restoring from a checkpoint - loss: 45.469384182381816  
Epoch 111: average-batch loss: 45.600001144450225 last batch loss:  
45.498352103547745  
Epoch 112: average-batch loss: 45.5963236467027 last batch loss:  
45.45295856729773  
Epoch 113: average-batch loss: 45.59520449474484 last batch loss:  
45.47941238061636  
Epoch 114: average-batch loss: 45.59650728424295 last batch loss:  
45.44204747144293  
Epoch 115: average-batch loss: 45.59694004835358 last batch loss:

45.472058729404395  
We are in a loss plateau learning rate: 0.016677181699666577 loss:  
45.45640500425825  
Restoring from a checkpoint - loss: 45.44543359440775  
Epoch 116: average-batch loss: 45.592279569328056 last batch loss:  
45.47049486527265  
Saved a checkpoint: ./tf\_ckpts/chkpt-32  
Epoch 117: average-batch loss: 45.60161114227961 last batch loss:  
45.474174528197835  
Epoch 118: average-batch loss: 45.601913646645954 last batch loss:  
45.46624950736609  
Epoch 119: average-batch loss: 45.59580083011815 last batch loss:  
45.46922568362055  
Epoch 120: average-batch loss: 45.59474714195092 last batch loss:  
45.460750705010796  
Epoch 121: average-batch loss: 45.60110945913175 last batch loss:  
45.512070192393786  
We are in a loss plateau learning rate: 0.015009463529699918 loss:  
45.44960021822574  
Restoring from a checkpoint - loss: 45.453045572907484  
Epoch 122: average-batch loss: 45.59294365173021 last batch loss:  
45.47066473575456  
Epoch 123: average-batch loss: 45.59003403540053 last batch loss:  
45.454295957928856  
Saved a checkpoint: ./tf\_ckpts/chkpt-33  
Epoch 124: average-batch loss: 45.59542048603082 last batch loss:  
45.492165812050516  
Epoch 125: average-batch loss: 45.599370339040654 last batch loss:  
45.480044478555364  
Epoch 126: average-batch loss: 45.59770950102549 last batch loss:  
45.4646140082763  
Epoch 127: average-batch loss: 45.60793124540749 last batch loss:  
45.4636523973461  
We are in a loss plateau learning rate: 0.013508517176729929 loss:  
45.4648182239623  
Restoring from a checkpoint - loss: 45.448231079248714  
Epoch 128: average-batch loss: 45.59855978696857 last batch loss:  
45.45895216975791  
Epoch 129: average-batch loss: 45.59708581231263 last batch loss:  
45.46239012809971  
Epoch 130: average-batch loss: 45.59292098360934 last batch loss:  
45.49678569228147  
Epoch 131: average-batch loss: 45.609647615487454 last batch loss:  
45.46812723980198  
Epoch 132: average-batch loss: 45.60286501994301 last batch loss:  
45.48956195548345  
Epoch 133: average-batch loss: 45.594250043264644 last batch loss:  
45.463038332924704

Epoch 134: average-batch loss: 45.59143497756467 last batch loss: 45.44719664873898  
Epoch 135: average-batch loss: 45.59570230616218 last batch loss: 45.48530062693593  
We are in a loss plateau learning rate: 0.012157665459056936 loss: 45.497987448297  
Restoring from a checkpoint - loss: 45.457777215146244  
Epoch 136: average-batch loss: 45.59384713691713 last batch loss: 45.45874819044119  
Epoch 137: average-batch loss: 45.598220634502624 last batch loss: 45.497376083766476  
Epoch 138: average-batch loss: 45.59702338539952 last batch loss: 45.47012573987118  
Epoch 139: average-batch loss: 45.59373198423993 last batch loss: 45.4441152726814  
Epoch 140: average-batch loss: 45.5958271652865 last batch loss: 45.4641271176651  
Epoch 141: average-batch loss: 45.59359252788745 last batch loss: 45.4903039353185  
Epoch 142: average-batch loss: 45.597509429425514 last batch loss: 45.47734997888671  
We are in a loss plateau learning rate: 0.010941898913151242 loss: 45.46047966360862  
Restoring from a checkpoint - loss: 45.45563373959223  
Epoch 143: average-batch loss: 45.60303271206581 last batch loss: 45.45501298505957  
Epoch 144: average-batch loss: 45.591556367886895 last batch loss: 45.47436428683826  
Epoch 145: average-batch loss: 45.606500766704315 last batch loss: 45.55979453919943  
Epoch 146: average-batch loss: 45.596626758566465 last batch loss: 45.45212053698031  
Epoch 147: average-batch loss: 45.5912700959509 last batch loss: 45.462383764823194  
Epoch 148: average-batch loss: 45.601173560074166 last batch loss: 45.4650444670846  
We are in a loss plateau learning rate: 0.00984770902183612 loss: 45.47098341830852  
Restoring from a checkpoint - loss: 45.455686555439534  
Epoch 149: average-batch loss: 45.59856504750246 last batch loss: 45.44234434697601  
Epoch 150: average-batch loss: 45.59520777057076 last batch loss: 45.462448820935094  
Epoch 151: average-batch loss: 45.59851891889459 last batch loss: 45.523273219549274  
Epoch 152: average-batch loss: 45.59716541902576 last batch loss: 45.44613884628001  
Epoch 153: average-batch loss: 45.59599352864102 last batch loss:

45.45954276710261  
Epoch 154: average-batch loss: 45.5996657078885 last batch loss:  
45.47882392983274  
We are in a loss plateau learning rate: 0.008862938119652507 loss:  
45.46161790466939  
Restoring from a checkpoint - loss: 45.455196341123  
Epoch 155: average-batch loss: 45.594074625495274 last batch loss:  
45.45844261449238  
Epoch 156: average-batch loss: 45.59811817297973 last batch loss:  
45.50565560578467  
Epoch 157: average-batch loss: 45.59800354683506 last batch loss:  
45.46767308478814  
Epoch 158: average-batch loss: 45.59578441104508 last batch loss:  
45.46176670486485  
Epoch 159: average-batch loss: 45.59486568179733 last batch loss:  
45.467466513513344  
Epoch 160: average-batch loss: 45.60568238164349 last batch loss:  
45.48499362743417  
We are in a loss plateau learning rate: 0.007976644307687256 loss:  
45.47565644950465  
Restoring from a checkpoint - loss: 45.47234782845974  
Epoch 161: average-batch loss: 45.58702569456489 last batch loss:  
45.459666997328526  
Saved a checkpoint: ./tf\_ckpts/chkpt-34  
Epoch 162: average-batch loss: 45.59787252152707 last batch loss:  
45.486885380840945  
Epoch 163: average-batch loss: 45.595485974863 last batch loss:  
45.48340620471529  
Epoch 164: average-batch loss: 45.595445086778355 last batch loss:  
45.466035875658314  
Epoch 165: average-batch loss: 45.593334412466646 last batch loss:  
45.484131723302696  
Epoch 166: average-batch loss: 45.59414140021558 last batch loss:  
45.50160196395078  
Epoch 167: average-batch loss: 45.59269929325959 last batch loss:  
45.45294507613129  
Epoch 168: average-batch loss: 45.59339758864056 last batch loss:  
45.44780336734506  
Epoch 169: average-batch loss: 45.59796768797533 last batch loss:  
45.495394264681835  
We are in a loss plateau learning rate: 0.00717897987691853 loss:  
45.472805218837834  
Restoring from a checkpoint - loss: 45.46009368396526  
Epoch 170: average-batch loss: 45.594430250162716 last batch loss:  
45.49693887420059  
Epoch 171: average-batch loss: 45.59237634051108 last batch loss:  
45.456705956500784  
Epoch 172: average-batch loss: 45.594675853915035 last batch loss:

45.449838411049264  
Epoch 173: average-batch loss: 45.5881770369681 last batch loss:  
45.507536920944254  
Epoch 174: average-batch loss: 45.58861849025665 last batch loss:  
45.45540935070964  
Epoch 175: average-batch loss: 45.593172302104286 last batch loss:  
45.4524820608663  
We are in a loss plateau learning rate: 0.006461081889226678 loss:  
45.449845208247304  
Restoring from a checkpoint - loss: 45.494468237048736  
Epoch 176: average-batch loss: 45.59346767645248 last batch loss:  
45.46472167027451  
Epoch 177: average-batch loss: 45.594843542404895 last batch loss:  
45.452803756285384  
Epoch 178: average-batch loss: 45.59235304419255 last batch loss:  
45.46806627746948  
Epoch 179: average-batch loss: 45.59849100556392 last batch loss:  
45.442873920645795  
Epoch 180: average-batch loss: 45.597036573942496 last batch loss:  
45.452306772857995  
Epoch 181: average-batch loss: 45.59411593314003 last batch loss:  
45.49063356394543  
Epoch 182: average-batch loss: 45.59264514524319 last batch loss:  
45.47943604460497  
Epoch 183: average-batch loss: 45.58998678687076 last batch loss:  
45.481883474358824  
Epoch 184: average-batch loss: 45.59313535678578 last batch loss:  
45.46382805275777  
We have reset 25 times so quitting

```
[8]: surrogate_samples = factor.surrogate_distribution.sample(1000)
if 's' in surrogate_samples.keys():
    weights = surrogate_samples['s']/tf.
    ↪reduce_sum(surrogate_samples['s'],-2,keepdims=True)
    intercept_data_structured = az.convert_to_inference_data(
        {
            r"":
                (tf.squeeze(surrogate_samples['w'])*weights[:,-1,:]*factor.
    ↪column_norm_factor).numpy().T})
else:
    intercept_data_structured = az.convert_to_inference_data(
        {
            r"":
                (tf.squeeze(surrogate_samples['w'])*factor.column_norm_factor).
    ↪numpy().T})

surrogate_samples = factor_noise.surrogate_distribution.sample(1000)
```

```

if 's' in surrogate_samples.keys():
    weights = surrogate_samples['s']/tf.
    ↪reduce_sum(surrogate_samples['s'],-2,keepdims=True)
    intercept_data_noise = az.convert_to_inference_data(
        {
            r"":
                (tf.squeeze(surrogate_samples['w'])*weights[:,-1,:
    ↪]*factor_noise.column_norm_factor).numpy().T})
else:
    intercept_data_noise = az.convert_to_inference_data(
        {
            r"":
                (tf.squeeze(surrogate_samples['w'])*factor_noise.
    ↪column_norm_factor).numpy().T})

surrogate_samples = factor_nonlinear.surrogate_distribution.sample(1000)
if 's' in surrogate_samples.keys():
    weights = surrogate_samples['s']/tf.
    ↪reduce_sum(surrogate_samples['s'],-2,keepdims=True)
    intercept_data_nonlinear = az.convert_to_inference_data(
        {
            r"":
                (tf.squeeze(surrogate_samples['w'])*weights[:,-1,:
    ↪]*factor_nonlinear.column_norm_factor).numpy().T})
else:
    intercept_data_nonlinear = az.convert_to_inference_data(
        {
            r"":
                (tf.squeeze(surrogate_samples['w'])*factor_nonlinear.
    ↪column_norm_factor).numpy().T})

```

```

[9]: fig = plt.figure(constrained_layout=False, figsize=(20,7.5))
gs = fig.add_gridspec(3, 3, height_ratios=(0.08, 6.5, 0.3))
ax = []

ax += [fig.add_subplot(gs[0,0])]
txt = ax[-1].text(0,0,"a) Poisson($1$) noise", clip_on=False, fontsize=20)
ax[-1].axis('off')

ax += [fig.add_subplot(gs[0,1])]
txt = ax[-1].text(0,0,"b) Linearly structured", clip_on=False, fontsize=20)
ax[-1].axis('off')

ax += [fig.add_subplot(gs[0,2])]
txt = ax[-1].text(0,0,"c) Nonlinearly structured", clip_on=False, fontsize=20)
ax[-1].axis('off')

```

```

gs0 = gs[1, 0].subgridspec(1,2, width_ratios=[1,3])
ax+= [fig.add_subplot(gs0[0, 0])]
pcm = ax[-1].imshow(factor_noise.encoding_matrix().numpy()[::-1,:], vmin=0,
    ↪vmax=0.1, cmap="Blues")
ax[-1].set_title(r"$\mathbf{A}=(\alpha_{ik})$")
ax[-1].set_xticks(range(P))
ax[-1].set_yticks(range(D))
ax[-1].set_ylabel(r"$d$")
ax[-1].set_xlabel(r"$p$")
ax[-1].grid(which='minor', color='g', linestyle='-', linewidth=2)
#fig.colorbar(pcm, ax=ax[-1], location='left', shrink=0.5)
#ax[-1].set_title("a) Noise factorization", fontsize=20)

ax+= [fig.add_subplot(gs0[0, 1])]
az.plot_forest(intercept_data_noise, ax=ax[-1])
ax[-1].set_title(r"background feature rate $\phi_i$")
ax[-1].set_ylim((-0.014,.466))
ax[-1].axvline(1.0, linestyle='dashed', color="black")

#

gs1 = gs[1, 1].subgridspec(1,2, width_ratios=[1,3])
ax = []
ax+= [fig.add_subplot(gs1[0, 0])]

pcm = ax[-1].imshow(factor.encoding_matrix().numpy()[::-1,:], vmin=0, vmax=0.1,
    ↪cmap="Blues")
ax[-1].set_title(r"$\mathbf{A}=(\alpha_{ik})$")

ax[-1].set_xticks(range(P))
ax[-1].set_yticks(range(D))
ax[-1].set_ylabel(r"$d$")
ax[-1].set_xlabel(r"$p$")
#fig.colorbar(pcm, ax=ax[-1], location='left', shrink=0.5)
ax+= [fig.add_subplot(gs1[0, 1])]
az.plot_forest(intercept_data_structured, ax=ax[-1])
ax[-1].set_title(r"background feature rate $\phi_i$")
ax[-1].set_ylim((-0.014,.466))
ax[-1].axvline(1.0, linestyle='dashed', color="black")

gs2 = gs[1, 2].subgridspec(1,2, width_ratios=[1,3])
ax = []
ax+= [fig.add_subplot(gs2[0, 0])]
pcm = ax[-1].imshow(factor_nonlinear.encoding_matrix().numpy()[::-1,:], vmin=0,
    ↪vmax=0.1, cmap="Blues")

```

```

ax[-1].set_title(r"$\mathbf{A}=(\alpha_{ik})$")

ax[-1].set_xticks(range(P))
ax[-1].set_yticks(range(D))
ax[-1].set_ylabel(r"$d$")
ax[-1].set_xlabel(r"$p$")
#fig.colorbar(pcm, ax=ax[-1], location='left', shrink=0.5)
#ax[-1].set_title("a) Noise factorization", fontsize=20)

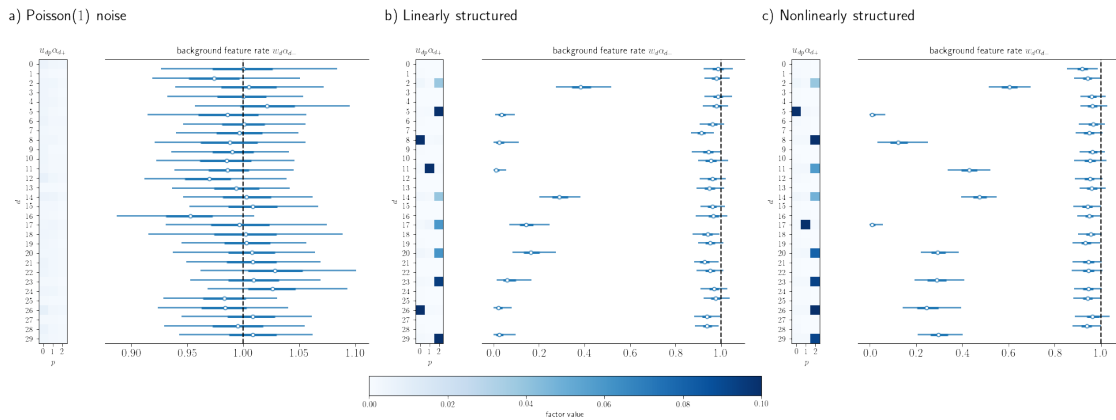
ax+= [fig.add_subplot(gs2[0, 1])]
az.plot_forest(intercept_data_nonlinear, ax=ax[-1])
#ax[-1].set_xlabel("background rate")
ax[-1].set_ylim((-0.014,.466))
ax[-1].set_title(r"background feature rate $\phi_i$")
ax[-1].axvline(1.0, linestyle='dashed', color="black")

# colorbar

ax += [fig.add_subplot(gs[2, :])]
ax[-1].set_axis_off()
fig.colorbar(pcm, ax=ax[-1], orientation="horizontal", fraction=1.5,
    label="factor value")

plt.tight_layout()
#plt.savefig('simulations_sepmf.pdf', bbox_inches='tight')

```



[ ]:

[ ]: