

TU_PRACUJE_DEMO_DKF_MV_FROM_PDF_TEST

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1 Orignalny kod

```
[1]: import pandas as pd
import torch
import torch.nn as nn
from torch.distributions import MultivariateNormal

[2]: class GatedTransition(nn.Module):
    def __init__(self, z_dim, hid_dim):
        super(GatedTransition, self).__init__()
        self.gate = nn.Sequential(nn.Linear(z_dim, hid_dim),
                                   nn.ReLU(),
                                   nn.Linear(hid_dim, z_dim),
                                   nn.Sigmoid())
        self.proposed_mean = nn.Sequential(nn.Linear(z_dim, hid_dim),
                                             nn.ReLU(),
                                             nn.Linear(hid_dim, z_dim))
        self.z_to_mu = nn.Linear(z_dim, z_dim)
        # modify the default initialization of z_to_mu
        # so that it starts out as the identity function
        self.z_to_mu.weight.data = torch.eye(z_dim)
        self.z_to_mu.bias.data = torch.zeros(z_dim)
        self.z_to_logvar = nn.Linear(z_dim, z_dim)
        self.relu = nn.ReLU()

    def forward(self, z_t_1):
        #
        gate = self.gate(z_t_1)
        proposed_mean = self.proposed_mean(z_t_1)
        mu = (1 - gate) * self.z_to_mu(z_t_1) + gate * proposed_mean
        logvar = self.z_to_logvar(self.relu(proposed_mean))
        # sampling
        eps = torch.randn(z_t_1.size())
        z_t = mu + eps * torch.exp(.5 * logvar)
        return z_t, mu, logvar
```

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[3]: class Combiner(nn.Module):
    # PostNet
    def __init__(self, z_dim, hid_dim):
        super(Combiner, self).__init__()
        self.z_dim = z_dim
        self.z_to_hidden = nn.Linear(z_dim, hid_dim)
        self.hidden_to_mu = nn.Linear(hid_dim, z_dim)
        self.hidden_to_logvar = nn.Linear(hid_dim, z_dim)
        self.tanh = nn.Tanh()
    def forward(self, z_t_1, h_rnn):
        # combine the rnn hidden state with a transformed version of z_t_1
        h_combined = 0.5 * (self.tanh(self.z_to_hidden(z_t_1)) + h_rnn)
        # use the combined hidden state
        # to compute the mean used to sample z_t
        mu = self.hidden_to_mu(h_combined)
        # use the combined hidden state
        # to compute the scale used to sample z_t
        logvar = self.hidden_to_logvar(h_combined)
        eps = torch.randn(z_t_1.size())
        z_t = mu + eps * torch.exp(.5 * logvar)
        return z_t, mu, logvar
```

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[4]: class Emitter(nn.Module):
    def __init__(self, z_dim, hid_dim, input_dim) -> None:
        super().__init__()
        self.input_dim = input_dim
        self.z_to_hidden = nn.Linear(z_dim, hid_dim)
        self.hidden_to_hidden = nn.Linear(hid_dim, hid_dim)
        self.hidden_to_input_mu = nn.Linear(hid_dim, input_dim)
        self.logvar = nn.Parameter(torch.ones(input_dim))
        self.relu = nn.ReLU()
    def forward(self, z_t):
        h1 = self.relu(self.z_to_hidden(z_t))
        h2 = self.relu(self.hidden_to_hidden(h1))
        mu = self.hidden_to_input_mu(h2)
        # return mu # x_t
        eps = torch.randn(z_t.size(0), self.input_dim)
        x_t = mu + eps * torch.exp(.5 * self.logvar)
        return x_t, mu, self.logvar
```

```
[5]: class DKF(nn.Module):
    # Structured Inference Networks
    # Current version ignores backward RNN outputs
    def __init__(self, input_dim, z_dim=50, trans_dim=30, emission_dim=30,
        rnn_dim=100, num_rnn_layers=1) -> None:
        super().__init__()
```

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self.input_dim = input_dim
self.z_dim = z_dim
self.trans_dim = trans_dim
self.emission_dim = emission_dim
self.rnn_dim = rnn_dim
self.num_rnn_layers = num_rnn_layers
self.trans = GatedTransition(z_dim, trans_dim)
self.emitter = Emitter(z_dim, emission_dim, input_dim)
self.combiner = Combiner(z_dim, rnn_dim)
self.z_0 = nn.Parameter(torch.zeros(z_dim))
self.z_q_0 = nn.Parameter(torch.zeros(z_dim))
self.h_0 = nn.Parameter(torch.zeros(1, 1, rnn_dim))
# corresponding learning 'l' in the original code
self.rnn = nn.RNN(input_size=input_dim,
    hidden_size=rnn_dim,
    nonlinearity="relu",
    batch_first=True,
    bidirectional=False,
    num_layers=num_rnn_layers)

def kl_div(self, mu1, logvar1, mu2=None, logvar2=None):
    if mu2 is None:
        mu2 = torch.zeros(1, device=mu1.device)
    if logvar2 is None:
        logvar2 = torch.zeros(1, device=mu1.device)
    return torch.sum(0.5 * (
        logvar2 - logvar1 + (torch.exp(logvar1) + (mu1 - mu2).pow(2))
        / torch.exp(logvar2) - torch.ones(1, device=mu1.device)
    ), 1)

def infer(self, x):
    batch_size, T_max, x_dim = x.size()
    h_0 = self.h_0.expand(1, batch_size, self.rnn_dim).contiguous()
    rnn_out, h_n = self.rnn(x, h_0)
    z_prev = self.z_q_0.expand(batch_size, self.z_q_0.size(0))
    kl_states = torch.zeros((batch_size, T_max))
    rec_losses = torch.zeros((batch_size, T_max))
    for t in range(T_max):
        # p(z_t/z_{t-1})
        z_prior, z_prior_mu, z_prior_logvar = self.trans(z_prev)
        # q(z_t/z_{t-1}, x_{t:T})
        z_t, z_mu, z_logvar = self.combiner(z_prev, rnn_out[:, t])
        # p(x_t/z_t)
        x_t, x_mu, x_logvar = self.emitter(z_t)
        # compute loss
        kl_states[:, t] = self.kl_div(
            z_mu, z_logvar, z_prior_mu, z_prior_logvar)

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        rec_losses[:, t] = nn.MSELoss(reduction='none')(
            x_t.contiguous().view(-1),
            # x_mu.contiguous().view(-1),
            x[:, t].contiguous().view(-1)
        ).view(batch_size, -1).mean(dim=1)
        z_prev = z_t
    return rec_losses.mean(), kl_states.mean()

def filter(self, x, num_sample=100):
    # Outputs
    x_hat = torch.zeros(x.size())
    x_025 = torch.zeros(x.size())
    x_975 = torch.zeros(x.size())
    # predictions
    batch_size, T_max, x_dim = x.size()
    assert batch_size == 1
    z_prev = self.z_0.expand(num_sample, self.z_0.size(0))
    h_0 = self.h_0.expand(1, 1, self.rnn_dim).contiguous()
    rnn_out, _ = self.rnn(x, h_0)
    rnn_out = rnn_out.expand(num_sample,
                             rnn_out.size(1), rnn_out.size(2))
    for t in range(T_max):
        # z_t: (num_sample, z_dim)
        z_t, z_mu, z_logvar = self.combiner(z_prev, rnn_out[:, t])
        x_t, x_mu, x_logvar = self.emitter(z_t)
        # x_hat[:, t] = x_mu
        x_covar = torch.diag(torch.sqrt(torch.exp(.5 * x_logvar)))
        x_samples = MultivariateNormal(
            x_mu, covariance_matrix=x_covar).sample()
        # # sampling z_t and computing quantiles
        # x_samples = MultivariateNormal(
        #     loc=x_mu, covariance_matrix=x_covar).sample_n(num_sample)
        x_hat[:, t] = x_samples.mean(0)
        x_025[:, t] = x_samples.quantile(0.025, 0)
        x_975[:, t] = x_samples.quantile(0.975, 0)
        # x_hat[:, t] = x_t.mean(0)
        # x_025[:, t] = x_t.quantile(0.025, 0)
        # x_975[:, t] = x_t.quantile(0.975, 0)
        z_prev = z_t
        # z_prev = z_mu
    return x_hat, x_025, x_975

def predict(self, x, pred_steps=1, num_sample=100):
    """ x should contain the prediction period
    """
    # Outputs
    x_hat = torch.zeros(x.size()) # predictions

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x_025 = torch.zeros(x.size())
x_975 = torch.zeros(x.size())
batch_size, T_max, x_dim = x.size()
assert batch_size == 1
z_prev = self.z_0.expand(num_sample, self.z_0.size(0))
h_0 = self.h_0.expand(1, 1, self.rnn_dim).contiguous()
rnn_out, _ = self.rnn(x[:, :T_max-pred_steps], h_0)
rnn_out = rnn_out.expand(num_sample,
    rnn_out.size(1), rnn_out.size(2))
for t in range(T_max - pred_steps):
    # z_t: (num_sample, z_dim)
    z_t, z_mu, z_logvar = self.combiner(z_prev, rnn_out[:, t])
    x_t, x_mu, x_logvar = self.emitter(z_t)
    x_covar = torch.diag(torch.sqrt(torch.exp(.5 * x_logvar)))
    x_samples = MultivariateNormal(
        x_mu, covariance_matrix=x_covar).sample()
    x_hat[:, t] = x_samples.mean(0)
    x_025[:, t] = x_samples.quantile(0.025, 0)
    x_975[:, t] = x_samples.quantile(0.975, 0)
    z_prev = z_mu
for t in range(T_max - pred_steps, T_max):
    rnn_out, _ = self.rnn(x[:, :t], h_0)
    rnn_out = rnn_out.expand(
        num_sample, rnn_out.size(1), rnn_out.size(2))
    z_t_1, z_mu, z_logvar = self.combiner(z_prev, rnn_out[:, -1])
    z_t, z_mu, z_logvar = self.trans(z_t_1)
    x_t, x_mu, x_logvar = self.emitter(z_t)
    x_covar = torch.diag(torch.sqrt(torch.exp(.5 * x_logvar)))
    x_samples = MultivariateNormal(
        x_mu, covariance_matrix=x_covar).sample()
    x_hat[:, t] = x_samples.mean(0)
    x_025[:, t] = x_samples.quantile(0.025, 0)
    x_975[:, t] = x_samples.quantile(0.975, 0)
return x_hat, x_025, x_975

def train_step(self, x, annealing_factor = 0.1):
    self.train()
    # self.rnn.train()
    rec_loss, kl_loss = self.infer(x)
    total_loss = rec_loss + annealing_factor * kl_loss
    self.optimizer.zero_grad()
    total_loss.backward()
    # nn.utils.clip_grad_norm_(self.parameters(), 5.)
    self.optimizer.step()
    return rec_loss.item(), kl_loss.item(), total_loss.item()

def validation_step(self, x, annealing_factor=0.1):

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self.eval()
rec_loss, kl_loss = self.infer(x)
total_loss = rec_loss + annealing_factor * kl_loss
return rec_loss.item(), kl_loss.item(), total_loss.item()

def fit(self, x, x_val=None, num_epochs=100, annealing_factor=0.1,
        verbose_step=1, eval_step=1, check_point_path=None,
        patience=20, learning_rate=0.01):

    self.optimizer = torch.optim.Adam(
        self.parameters(), lr=learning_rate)

    losses = []
    kl_losses = []
    rec_losses = []
    val_losses = []
    val_kl_losses = []
    val_rec_losses = []

    for epoch in range(num_epochs):
        try:
            res = self.train_step(x, annealing_factor=annealing_factor)
            losses.append(res[2])
            kl_losses.append(res[1])
            rec_losses.append(res[0])

            if epoch % verbose_step == verbose_step - 1:
                message = f'Epoch= {epoch+1}/{num_epochs}, '
                message += f'loss= {res[2]:.3f}, '
                message += f'mse= {res[0]:.3f}, '
                message += f'kld= {res[1]:.3f}'
                print(message)

            if x_val is not None:
                val_res = self.validation_step(x_val, annealing_factor)
                val_losses.append(val_res[2])
                val_kl_losses.append(val_res[1])
                val_rec_losses.append(val_res[0])

            if epoch % eval_step == eval_step - 1 and x_val is not None:
                message = f'\tval_loss= {val_res[2]:.3f}, '
                message += f'val_mse= {val_res[0]:.3f}, '
                message += f'val_kld= {val_res[1]:.3f}'
                print(message)

        except KeyboardInterrupt:
            break

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        history = {'loss': losses,
                   'kl_loss': kl_losses,
                   'rec_loss': rec_losses}

        if x_val is not None:
            history.update({'val_loss': val_losses,
                           'val_kl_loss': val_kl_losses,
                           'rec_loss': rec_losses})

        return history

    def save_model(self, filename):
        """ dkf.pth """
        torch.save(self.to('cpu').state_dict(), filename)

    def load_model(self, filename):
        self.load_state_dict(torch.load(filename))

    def get_config(self):
        return {
            'input_dim': self.input_dim,
            'z_dim': self.z_dim,
            'trans_dim': self.trans_dim,
            'emission_dim': self.emission_dim,
            'rnn_dim': self.rnn_dim,
            'num_rnn_layers': self.num_rnn_layers
        }

```

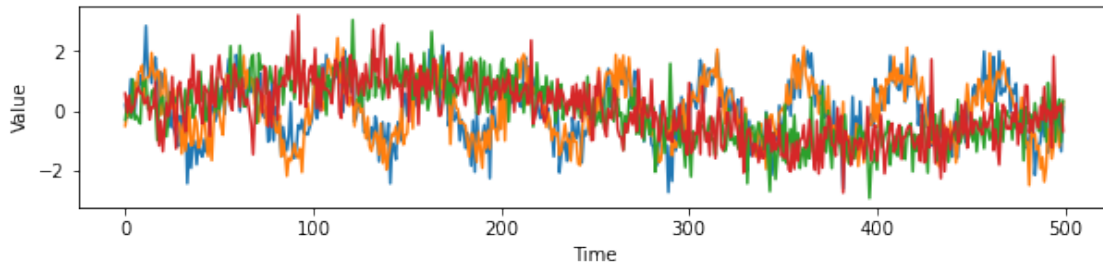
```

[6]: import matplotlib.pyplot as plt
import numpy as np
from sklearn.preprocessing import scale
# import warnings
# warnings.filterwarnings('ignore')
T = 500 # sequence length
observations = 2*np.sin(np.linspace(0, 20*np.pi, T))
interventions = 2*np.sin(np.linspace(0, 2*np.pi, T))
data = np.vstack([observations, observations*1.2, interventions,
                  interventions*0.85]).T
data += np.random.randn(*data.shape)
# data[:, 2:] = preprocessing.minmax_scale(data[:, 2:])
data = scale(data)

plt.figure(figsize=(10, 2))
plt.plot(data)
plt.xlabel('Time')
plt.ylabel('Value')

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plt.show()
```



```
[7]: x = torch.FloatTensor(data).reshape(1, *data.shape)
x_train = torch.FloatTensor(data[:400]).reshape(1, 400, data.shape[1])
#print(x_train)
x_val = torch.FloatTensor(data[400:450]).reshape(1, 50, data.shape[1])
#print(x_val)
```

```
[8]: dkf = DKF(input_dim=4, z_dim=20, rnn_dim=20, trans_dim=20, emission_dim=20)
```

```
[9]: history = dkf.fit(x_train, x_val, num_epochs=200, annealing_factor=0.1)
```

```
Epoch= 1/200, loss= 4.084, mse= 3.736, kld= 3.477
      val_loss= 4.590, val_mse= 4.325, val_kld= 2.652
Epoch= 2/200, loss= 4.058, mse= 3.796, kld= 2.614
      val_loss= 4.575, val_mse= 4.367, val_kld= 2.083
Epoch= 3/200, loss= 3.820, mse= 3.608, kld= 2.122
      val_loss= 3.912, val_mse= 3.744, val_kld= 1.682
Epoch= 4/200, loss= 3.814, mse= 3.641, kld= 1.726
      val_loss= 3.966, val_mse= 3.818, val_kld= 1.470
Epoch= 5/200, loss= 3.804, mse= 3.659, kld= 1.449
      val_loss= 4.335, val_mse= 4.211, val_kld= 1.247
Epoch= 6/200, loss= 3.963, mse= 3.844, kld= 1.190
      val_loss= 3.631, val_mse= 3.514, val_kld= 1.169
Epoch= 7/200, loss= 3.590, mse= 3.489, kld= 1.014
      val_loss= 3.990, val_mse= 3.879, val_kld= 1.111
Epoch= 8/200, loss= 3.828, mse= 3.736, kld= 0.929
      val_loss= 3.757, val_mse= 3.647, val_kld= 1.095
Epoch= 9/200, loss= 3.525, mse= 3.438, kld= 0.866
      val_loss= 3.588, val_mse= 3.472, val_kld= 1.167
Epoch= 10/200, loss= 3.519, mse= 3.433, kld= 0.867
      val_loss= 3.939, val_mse= 3.815, val_kld= 1.234
Epoch= 11/200, loss= 3.547, mse= 3.461, kld= 0.862
      val_loss= 3.372, val_mse= 3.261, val_kld= 1.114
Epoch= 12/200, loss= 3.642, mse= 3.560, kld= 0.824
      val_loss= 3.409, val_mse= 3.310, val_kld= 0.992
```


Epoch= 13/200, loss= 3.464, mse= 3.380, kld= 0.840
 val_loss= 3.624, val_mse= 3.506, val_kld= 1.182
 Epoch= 14/200, loss= 3.222, mse= 3.131, kld= 0.907
 val_loss= 3.883, val_mse= 3.769, val_kld= 1.144
 Epoch= 15/200, loss= 3.045, mse= 2.957, kld= 0.881
 val_loss= 3.655, val_mse= 3.553, val_kld= 1.026
 Epoch= 16/200, loss= 3.267, mse= 3.182, kld= 0.844
 val_loss= 2.956, val_mse= 2.871, val_kld= 0.856
 Epoch= 17/200, loss= 3.246, mse= 3.165, kld= 0.806
 val_loss= 3.262, val_mse= 3.152, val_kld= 1.100
 Epoch= 18/200, loss= 3.093, mse= 3.017, kld= 0.760
 val_loss= 3.020, val_mse= 2.939, val_kld= 0.813
 Epoch= 19/200, loss= 3.100, mse= 3.033, kld= 0.667
 val_loss= 3.292, val_mse= 3.217, val_kld= 0.745
 Epoch= 20/200, loss= 2.918, mse= 2.857, kld= 0.615
 val_loss= 3.130, val_mse= 3.049, val_kld= 0.814
 Epoch= 21/200, loss= 3.076, mse= 3.014, kld= 0.615
 val_loss= 3.304, val_mse= 3.251, val_kld= 0.538
 Epoch= 22/200, loss= 3.082, mse= 3.018, kld= 0.637
 val_loss= 3.278, val_mse= 3.209, val_kld= 0.696
 Epoch= 23/200, loss= 3.041, mse= 2.983, kld= 0.580
 val_loss= 3.076, val_mse= 3.011, val_kld= 0.652
 Epoch= 24/200, loss= 2.888, mse= 2.823, kld= 0.642
 val_loss= 3.077, val_mse= 2.998, val_kld= 0.799
 Epoch= 25/200, loss= 2.875, mse= 2.810, kld= 0.651
 val_loss= 2.521, val_mse= 2.436, val_kld= 0.849
 Epoch= 26/200, loss= 2.889, mse= 2.818, kld= 0.711
 val_loss= 2.993, val_mse= 2.894, val_kld= 0.987
 Epoch= 27/200, loss= 3.017, mse= 2.943, kld= 0.742
 val_loss= 3.020, val_mse= 2.946, val_kld= 0.732
 Epoch= 28/200, loss= 2.811, mse= 2.735, kld= 0.758
 val_loss= 3.093, val_mse= 3.027, val_kld= 0.662
 Epoch= 29/200, loss= 2.793, mse= 2.715, kld= 0.776
 val_loss= 2.914, val_mse= 2.846, val_kld= 0.679
 Epoch= 30/200, loss= 2.741, mse= 2.661, kld= 0.808
 val_loss= 3.039, val_mse= 2.950, val_kld= 0.888
 Epoch= 31/200, loss= 2.598, mse= 2.504, kld= 0.939
 val_loss= 3.107, val_mse= 3.011, val_kld= 0.958
 Epoch= 32/200, loss= 2.808, mse= 2.695, kld= 1.130
 val_loss= 2.532, val_mse= 2.412, val_kld= 1.207
 Epoch= 33/200, loss= 2.523, mse= 2.384, kld= 1.384
 val_loss= 2.400, val_mse= 2.260, val_kld= 1.405
 Epoch= 34/200, loss= 2.780, mse= 2.632, kld= 1.477
 val_loss= 2.858, val_mse= 2.688, val_kld= 1.701
 Epoch= 35/200, loss= 2.597, mse= 2.446, kld= 1.512
 val_loss= 2.504, val_mse= 2.355, val_kld= 1.488
 Epoch= 36/200, loss= 2.473, mse= 2.342, kld= 1.312
 val_loss= 2.354, val_mse= 2.225, val_kld= 1.282

Epoch= 37/200, loss= 2.390, mse= 2.271, kld= 1.185
val_loss= 2.559, val_mse= 2.468, val_kld= 0.908
Epoch= 38/200, loss= 2.442, mse= 2.331, kld= 1.109
val_loss= 2.786, val_mse= 2.678, val_kld= 1.082
Epoch= 39/200, loss= 2.343, mse= 2.237, kld= 1.058
val_loss= 2.779, val_mse= 2.667, val_kld= 1.116
Epoch= 40/200, loss= 2.315, mse= 2.210, kld= 1.051
val_loss= 2.282, val_mse= 2.149, val_kld= 1.333
Epoch= 41/200, loss= 2.292, mse= 2.180, kld= 1.120
val_loss= 2.420, val_mse= 2.313, val_kld= 1.066
Epoch= 42/200, loss= 2.402, mse= 2.294, kld= 1.083
val_loss= 2.295, val_mse= 2.194, val_kld= 1.005
Epoch= 43/200, loss= 2.406, mse= 2.297, kld= 1.091
val_loss= 2.355, val_mse= 2.263, val_kld= 0.927
Epoch= 44/200, loss= 2.306, mse= 2.203, kld= 1.032
val_loss= 2.221, val_mse= 2.137, val_kld= 0.837
Epoch= 45/200, loss= 2.237, mse= 2.137, kld= 0.999
val_loss= 2.413, val_mse= 2.294, val_kld= 1.185
Epoch= 46/200, loss= 2.258, mse= 2.150, kld= 1.081
val_loss= 2.318, val_mse= 2.202, val_kld= 1.156
Epoch= 47/200, loss= 2.232, mse= 2.125, kld= 1.063
val_loss= 1.799, val_mse= 1.689, val_kld= 1.106
Epoch= 48/200, loss= 2.226, mse= 2.116, kld= 1.104
val_loss= 2.170, val_mse= 2.040, val_kld= 1.306
Epoch= 49/200, loss= 2.256, mse= 2.143, kld= 1.131
val_loss= 2.157, val_mse= 2.020, val_kld= 1.370
Epoch= 50/200, loss= 2.128, mse= 2.008, kld= 1.194
val_loss= 2.183, val_mse= 2.070, val_kld= 1.133
Epoch= 51/200, loss= 2.258, mse= 2.141, kld= 1.171
val_loss= 1.977, val_mse= 1.844, val_kld= 1.329
Epoch= 52/200, loss= 2.238, mse= 2.122, kld= 1.154
val_loss= 1.876, val_mse= 1.758, val_kld= 1.181
Epoch= 53/200, loss= 2.120, mse= 1.999, kld= 1.210
val_loss= 1.993, val_mse= 1.870, val_kld= 1.222
Epoch= 54/200, loss= 2.247, mse= 2.126, kld= 1.210
val_loss= 1.864, val_mse= 1.754, val_kld= 1.101
Epoch= 55/200, loss= 2.098, mse= 1.985, kld= 1.131
val_loss= 2.247, val_mse= 2.129, val_kld= 1.184
Epoch= 56/200, loss= 2.098, mse= 1.992, kld= 1.059
val_loss= 2.098, val_mse= 1.982, val_kld= 1.160
Epoch= 57/200, loss= 2.059, mse= 1.955, kld= 1.043
val_loss= 2.011, val_mse= 1.899, val_kld= 1.124
Epoch= 58/200, loss= 2.011, mse= 1.913, kld= 0.976
val_loss= 1.816, val_mse= 1.719, val_kld= 0.966
Epoch= 59/200, loss= 2.167, mse= 2.063, kld= 1.040
val_loss= 1.953, val_mse= 1.848, val_kld= 1.056
Epoch= 60/200, loss= 2.026, mse= 1.929, kld= 0.978
val_loss= 2.334, val_mse= 2.229, val_kld= 1.055

Epoch= 61/200, loss= 2.033, mse= 1.939, kld= 0.936
val_loss= 2.161, val_mse= 2.043, val_kld= 1.188
Epoch= 62/200, loss= 1.986, mse= 1.889, kld= 0.966
val_loss= 2.245, val_mse= 2.132, val_kld= 1.130
Epoch= 63/200, loss= 2.023, mse= 1.927, kld= 0.965
val_loss= 1.971, val_mse= 1.841, val_kld= 1.293
Epoch= 64/200, loss= 1.982, mse= 1.875, kld= 1.075
val_loss= 2.063, val_mse= 1.972, val_kld= 0.908
Epoch= 65/200, loss= 2.056, mse= 1.948, kld= 1.082
val_loss= 2.242, val_mse= 2.131, val_kld= 1.116
Epoch= 66/200, loss= 1.895, mse= 1.791, kld= 1.045
val_loss= 1.776, val_mse= 1.673, val_kld= 1.022
Epoch= 67/200, loss= 2.055, mse= 1.961, kld= 0.936
val_loss= 1.907, val_mse= 1.780, val_kld= 1.268
Epoch= 68/200, loss= 1.817, mse= 1.720, kld= 0.973
val_loss= 1.970, val_mse= 1.861, val_kld= 1.087
Epoch= 69/200, loss= 1.966, mse= 1.870, kld= 0.966
val_loss= 1.951, val_mse= 1.831, val_kld= 1.204
Epoch= 70/200, loss= 1.848, mse= 1.747, kld= 1.013
val_loss= 1.703, val_mse= 1.604, val_kld= 0.993
Epoch= 71/200, loss= 1.907, mse= 1.812, kld= 0.940
val_loss= 1.972, val_mse= 1.849, val_kld= 1.237
Epoch= 72/200, loss= 1.920, mse= 1.829, kld= 0.907
val_loss= 2.042, val_mse= 1.936, val_kld= 1.052
Epoch= 73/200, loss= 1.920, mse= 1.820, kld= 1.001
val_loss= 1.875, val_mse= 1.769, val_kld= 1.063
Epoch= 74/200, loss= 1.921, mse= 1.821, kld= 1.005
val_loss= 1.832, val_mse= 1.730, val_kld= 1.018
Epoch= 75/200, loss= 1.935, mse= 1.835, kld= 0.997
val_loss= 1.719, val_mse= 1.627, val_kld= 0.923
Epoch= 76/200, loss= 1.846, mse= 1.748, kld= 0.982
val_loss= 1.932, val_mse= 1.837, val_kld= 0.944
Epoch= 77/200, loss= 1.916, mse= 1.817, kld= 0.993
val_loss= 1.916, val_mse= 1.813, val_kld= 1.024
Epoch= 78/200, loss= 1.756, mse= 1.657, kld= 0.984
val_loss= 2.166, val_mse= 2.046, val_kld= 1.192
Epoch= 79/200, loss= 1.801, mse= 1.706, kld= 0.948
val_loss= 1.884, val_mse= 1.774, val_kld= 1.095
Epoch= 80/200, loss= 1.805, mse= 1.707, kld= 0.985
val_loss= 1.700, val_mse= 1.588, val_kld= 1.120
Epoch= 81/200, loss= 1.814, mse= 1.719, kld= 0.947
val_loss= 1.773, val_mse= 1.669, val_kld= 1.043
Epoch= 82/200, loss= 1.729, mse= 1.630, kld= 0.988
val_loss= 1.628, val_mse= 1.533, val_kld= 0.954
Epoch= 83/200, loss= 1.748, mse= 1.640, kld= 1.072
val_loss= 1.978, val_mse= 1.862, val_kld= 1.155
Epoch= 84/200, loss= 1.725, mse= 1.619, kld= 1.064
val_loss= 1.835, val_mse= 1.716, val_kld= 1.190

Epoch= 85/200, loss= 1.828, mse= 1.726, kld= 1.015
val_loss= 1.750, val_mse= 1.657, val_kld= 0.935
Epoch= 86/200, loss= 1.776, mse= 1.678, kld= 0.979
val_loss= 1.777, val_mse= 1.683, val_kld= 0.939
Epoch= 87/200, loss= 1.788, mse= 1.691, kld= 0.969
val_loss= 1.559, val_mse= 1.443, val_kld= 1.162
Epoch= 88/200, loss= 1.678, mse= 1.580, kld= 0.981
val_loss= 1.765, val_mse= 1.665, val_kld= 0.992
Epoch= 89/200, loss= 1.684, mse= 1.589, kld= 0.951
val_loss= 1.580, val_mse= 1.478, val_kld= 1.024
Epoch= 90/200, loss= 1.708, mse= 1.610, kld= 0.986
val_loss= 1.601, val_mse= 1.494, val_kld= 1.073
Epoch= 91/200, loss= 1.632, mse= 1.538, kld= 0.943
val_loss= 1.544, val_mse= 1.434, val_kld= 1.096
Epoch= 92/200, loss= 1.718, mse= 1.629, kld= 0.887
val_loss= 1.371, val_mse= 1.269, val_kld= 1.020
Epoch= 93/200, loss= 1.613, mse= 1.525, kld= 0.884
val_loss= 1.673, val_mse= 1.591, val_kld= 0.819
Epoch= 94/200, loss= 1.681, mse= 1.592, kld= 0.888
val_loss= 1.553, val_mse= 1.480, val_kld= 0.729
Epoch= 95/200, loss= 1.623, mse= 1.538, kld= 0.846
val_loss= 1.791, val_mse= 1.683, val_kld= 1.081
Epoch= 96/200, loss= 1.682, mse= 1.588, kld= 0.939
val_loss= 1.763, val_mse= 1.671, val_kld= 0.924
Epoch= 97/200, loss= 1.572, mse= 1.484, kld= 0.881
val_loss= 1.839, val_mse= 1.741, val_kld= 0.978
Epoch= 98/200, loss= 1.522, mse= 1.433, kld= 0.892
val_loss= 1.568, val_mse= 1.475, val_kld= 0.931
Epoch= 99/200, loss= 1.493, mse= 1.408, kld= 0.849
val_loss= 1.542, val_mse= 1.446, val_kld= 0.955
Epoch= 100/200, loss= 1.606, mse= 1.515, kld= 0.908
val_loss= 1.737, val_mse= 1.647, val_kld= 0.895
Epoch= 101/200, loss= 1.672, mse= 1.582, kld= 0.899
val_loss= 1.604, val_mse= 1.518, val_kld= 0.862
Epoch= 102/200, loss= 1.559, mse= 1.473, kld= 0.868
val_loss= 1.383, val_mse= 1.292, val_kld= 0.904
Epoch= 103/200, loss= 1.624, mse= 1.539, kld= 0.847
val_loss= 1.477, val_mse= 1.386, val_kld= 0.905
Epoch= 104/200, loss= 1.536, mse= 1.459, kld= 0.765
val_loss= 1.280, val_mse= 1.198, val_kld= 0.824
Epoch= 105/200, loss= 1.537, mse= 1.454, kld= 0.829
val_loss= 1.729, val_mse= 1.643, val_kld= 0.861
Epoch= 106/200, loss= 1.524, mse= 1.437, kld= 0.865
val_loss= 1.637, val_mse= 1.546, val_kld= 0.918
Epoch= 107/200, loss= 1.605, mse= 1.518, kld= 0.863
val_loss= 1.355, val_mse= 1.277, val_kld= 0.774
Epoch= 108/200, loss= 1.512, mse= 1.422, kld= 0.899
val_loss= 1.531, val_mse= 1.432, val_kld= 0.988

Epoch= 109/200, loss= 1.499, mse= 1.412, kld= 0.861
val_loss= 1.624, val_mse= 1.537, val_kld= 0.871
Epoch= 110/200, loss= 1.465, mse= 1.374, kld= 0.918
val_loss= 1.566, val_mse= 1.489, val_kld= 0.773
Epoch= 111/200, loss= 1.486, mse= 1.399, kld= 0.869
val_loss= 1.580, val_mse= 1.494, val_kld= 0.855
Epoch= 112/200, loss= 1.405, mse= 1.318, kld= 0.866
val_loss= 1.536, val_mse= 1.444, val_kld= 0.924
Epoch= 113/200, loss= 1.526, mse= 1.441, kld= 0.857
val_loss= 1.433, val_mse= 1.351, val_kld= 0.824
Epoch= 114/200, loss= 1.478, mse= 1.396, kld= 0.827
val_loss= 1.722, val_mse= 1.620, val_kld= 1.025
Epoch= 115/200, loss= 1.491, mse= 1.408, kld= 0.832
val_loss= 1.517, val_mse= 1.435, val_kld= 0.822
Epoch= 116/200, loss= 1.510, mse= 1.426, kld= 0.842
val_loss= 1.573, val_mse= 1.490, val_kld= 0.826
Epoch= 117/200, loss= 1.449, mse= 1.365, kld= 0.843
val_loss= 1.390, val_mse= 1.306, val_kld= 0.838
Epoch= 118/200, loss= 1.458, mse= 1.371, kld= 0.872
val_loss= 1.502, val_mse= 1.422, val_kld= 0.796
Epoch= 119/200, loss= 1.424, mse= 1.336, kld= 0.881
val_loss= 1.423, val_mse= 1.326, val_kld= 0.969
Epoch= 120/200, loss= 1.386, mse= 1.294, kld= 0.926
val_loss= 1.388, val_mse= 1.287, val_kld= 1.014
Epoch= 121/200, loss= 1.492, mse= 1.407, kld= 0.849
val_loss= 1.303, val_mse= 1.220, val_kld= 0.829
Epoch= 122/200, loss= 1.496, mse= 1.412, kld= 0.837
val_loss= 1.406, val_mse= 1.315, val_kld= 0.915
Epoch= 123/200, loss= 1.429, mse= 1.347, kld= 0.823
val_loss= 1.629, val_mse= 1.538, val_kld= 0.912
Epoch= 124/200, loss= 1.470, mse= 1.391, kld= 0.789
val_loss= 1.484, val_mse= 1.395, val_kld= 0.889
Epoch= 125/200, loss= 1.382, mse= 1.296, kld= 0.853
val_loss= 1.373, val_mse= 1.282, val_kld= 0.914
Epoch= 126/200, loss= 1.303, mse= 1.217, kld= 0.868
val_loss= 1.569, val_mse= 1.469, val_kld= 0.992
Epoch= 127/200, loss= 1.425, mse= 1.335, kld= 0.901
val_loss= 1.503, val_mse= 1.408, val_kld= 0.954
Epoch= 128/200, loss= 1.394, mse= 1.304, kld= 0.899
val_loss= 1.305, val_mse= 1.227, val_kld= 0.788
Epoch= 129/200, loss= 1.451, mse= 1.367, kld= 0.840
val_loss= 1.449, val_mse= 1.369, val_kld= 0.801
Epoch= 130/200, loss= 1.437, mse= 1.349, kld= 0.880
val_loss= 1.464, val_mse= 1.369, val_kld= 0.953
Epoch= 131/200, loss= 1.378, mse= 1.298, kld= 0.801
val_loss= 1.220, val_mse= 1.134, val_kld= 0.864
Epoch= 132/200, loss= 1.438, mse= 1.349, kld= 0.891
val_loss= 1.649, val_mse= 1.560, val_kld= 0.890

Epoch= 133/200, loss= 1.404, mse= 1.309, kld= 0.951
 val_loss= 1.241, val_mse= 1.161, val_kld= 0.802
 Epoch= 134/200, loss= 1.413, mse= 1.322, kld= 0.914
 val_loss= 1.462, val_mse= 1.375, val_kld= 0.874
 Epoch= 135/200, loss= 1.299, mse= 1.212, kld= 0.865
 val_loss= 1.240, val_mse= 1.156, val_kld= 0.845
 Epoch= 136/200, loss= 1.302, mse= 1.211, kld= 0.912
 val_loss= 1.344, val_mse= 1.252, val_kld= 0.917
 Epoch= 137/200, loss= 1.254, mse= 1.170, kld= 0.843
 val_loss= 1.322, val_mse= 1.228, val_kld= 0.938
 Epoch= 138/200, loss= 1.294, mse= 1.202, kld= 0.920
 val_loss= 1.060, val_mse= 0.979, val_kld= 0.812
 Epoch= 139/200, loss= 1.339, mse= 1.250, kld= 0.892
 val_loss= 1.051, val_mse= 0.964, val_kld= 0.866
 Epoch= 140/200, loss= 1.356, mse= 1.263, kld= 0.930
 val_loss= 1.424, val_mse= 1.333, val_kld= 0.904
 Epoch= 141/200, loss= 1.391, mse= 1.304, kld= 0.874
 val_loss= 1.454, val_mse= 1.365, val_kld= 0.893
 Epoch= 142/200, loss= 1.279, mse= 1.189, kld= 0.894
 val_loss= 1.376, val_mse= 1.285, val_kld= 0.913
 Epoch= 143/200, loss= 1.280, mse= 1.197, kld= 0.829
 val_loss= 1.244, val_mse= 1.138, val_kld= 1.069
 Epoch= 144/200, loss= 1.387, mse= 1.297, kld= 0.905
 val_loss= 1.235, val_mse= 1.153, val_kld= 0.826
 Epoch= 145/200, loss= 1.315, mse= 1.225, kld= 0.898
 val_loss= 1.163, val_mse= 1.052, val_kld= 1.112
 Epoch= 146/200, loss= 1.235, mse= 1.149, kld= 0.857
 val_loss= 1.392, val_mse= 1.300, val_kld= 0.918
 Epoch= 147/200, loss= 1.271, mse= 1.187, kld= 0.845
 val_loss= 1.264, val_mse= 1.181, val_kld= 0.831
 Epoch= 148/200, loss= 1.261, mse= 1.175, kld= 0.860
 val_loss= 1.475, val_mse= 1.381, val_kld= 0.948
 Epoch= 149/200, loss= 1.338, mse= 1.250, kld= 0.879
 val_loss= 1.405, val_mse= 1.308, val_kld= 0.972
 Epoch= 150/200, loss= 1.191, mse= 1.108, kld= 0.834
 val_loss= 1.543, val_mse= 1.472, val_kld= 0.717
 Epoch= 151/200, loss= 1.270, mse= 1.181, kld= 0.890
 val_loss= 1.400, val_mse= 1.319, val_kld= 0.815
 Epoch= 152/200, loss= 1.256, mse= 1.175, kld= 0.811
 val_loss= 1.294, val_mse= 1.219, val_kld= 0.749
 Epoch= 153/200, loss= 1.325, mse= 1.241, kld= 0.836
 val_loss= 1.282, val_mse= 1.216, val_kld= 0.654
 Epoch= 154/200, loss= 1.227, mse= 1.147, kld= 0.798
 val_loss= 1.143, val_mse= 1.053, val_kld= 0.893
 Epoch= 155/200, loss= 1.253, mse= 1.170, kld= 0.835
 val_loss= 1.260, val_mse= 1.166, val_kld= 0.942
 Epoch= 156/200, loss= 1.237, mse= 1.155, kld= 0.825
 val_loss= 1.446, val_mse= 1.364, val_kld= 0.820

Epoch= 157/200, loss= 1.197, mse= 1.112, kld= 0.847
val_loss= 1.125, val_mse= 1.038, val_kld= 0.877
Epoch= 158/200, loss= 1.181, mse= 1.102, kld= 0.788
val_loss= 1.351, val_mse= 1.265, val_kld= 0.856
Epoch= 159/200, loss= 1.265, mse= 1.180, kld= 0.849
val_loss= 1.050, val_mse= 0.958, val_kld= 0.921
Epoch= 160/200, loss= 1.267, mse= 1.184, kld= 0.833
val_loss= 1.250, val_mse= 1.174, val_kld= 0.752
Epoch= 161/200, loss= 1.180, mse= 1.096, kld= 0.839
val_loss= 1.277, val_mse= 1.196, val_kld= 0.802
Epoch= 162/200, loss= 1.175, mse= 1.098, kld= 0.774
val_loss= 1.308, val_mse= 1.223, val_kld= 0.845
Epoch= 163/200, loss= 1.215, mse= 1.130, kld= 0.844
val_loss= 1.204, val_mse= 1.123, val_kld= 0.808
Epoch= 164/200, loss= 1.214, mse= 1.133, kld= 0.815
val_loss= 1.178, val_mse= 1.101, val_kld= 0.768
Epoch= 165/200, loss= 1.150, mse= 1.066, kld= 0.833
val_loss= 1.322, val_mse= 1.246, val_kld= 0.761
Epoch= 166/200, loss= 1.241, mse= 1.157, kld= 0.839
val_loss= 1.142, val_mse= 1.052, val_kld= 0.907
Epoch= 167/200, loss= 1.205, mse= 1.125, kld= 0.793
val_loss= 1.074, val_mse= 0.991, val_kld= 0.835
Epoch= 168/200, loss= 1.268, mse= 1.187, kld= 0.809
val_loss= 1.184, val_mse= 1.084, val_kld= 1.003
Epoch= 169/200, loss= 1.229, mse= 1.147, kld= 0.817
val_loss= 1.245, val_mse= 1.151, val_kld= 0.938
Epoch= 170/200, loss= 1.133, mse= 1.048, kld= 0.845
val_loss= 1.231, val_mse= 1.159, val_kld= 0.725
Epoch= 171/200, loss= 1.136, mse= 1.056, kld= 0.805
val_loss= 1.186, val_mse= 1.086, val_kld= 1.002
Epoch= 172/200, loss= 1.208, mse= 1.125, kld= 0.827
val_loss= 1.020, val_mse= 0.947, val_kld= 0.732
Epoch= 173/200, loss= 1.153, mse= 1.076, kld= 0.765
val_loss= 1.119, val_mse= 1.039, val_kld= 0.801
Epoch= 174/200, loss= 1.219, mse= 1.129, kld= 0.897
val_loss= 1.187, val_mse= 1.104, val_kld= 0.829
Epoch= 175/200, loss= 1.160, mse= 1.070, kld= 0.898
val_loss= 1.234, val_mse= 1.158, val_kld= 0.764
Epoch= 176/200, loss= 1.186, mse= 1.103, kld= 0.827
val_loss= 1.226, val_mse= 1.142, val_kld= 0.837
Epoch= 177/200, loss= 1.195, mse= 1.111, kld= 0.849
val_loss= 1.167, val_mse= 1.084, val_kld= 0.834
Epoch= 178/200, loss= 1.100, mse= 1.016, kld= 0.836
val_loss= 1.103, val_mse= 1.021, val_kld= 0.819
Epoch= 179/200, loss= 1.178, mse= 1.089, kld= 0.891
val_loss= 1.104, val_mse= 1.009, val_kld= 0.952
Epoch= 180/200, loss= 1.160, mse= 1.075, kld= 0.858
val_loss= 1.116, val_mse= 1.030, val_kld= 0.863

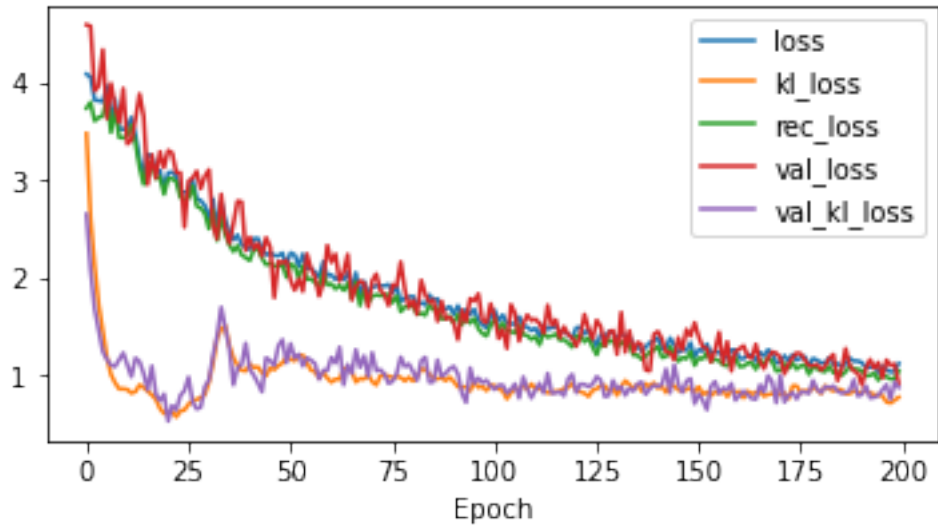
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Epoch= 181/200, loss= 1.133, mse= 1.051, kld= 0.820
      val_loss= 1.060, val_mse= 0.977, val_kld= 0.827
Epoch= 182/200, loss= 1.133, mse= 1.043, kld= 0.899
      val_loss= 1.102, val_mse= 1.013, val_kld= 0.891
Epoch= 183/200, loss= 1.185, mse= 1.099, kld= 0.865
      val_loss= 1.179, val_mse= 1.091, val_kld= 0.878
Epoch= 184/200, loss= 1.117, mse= 1.032, kld= 0.846
      val_loss= 1.219, val_mse= 1.129, val_kld= 0.896
Epoch= 185/200, loss= 1.127, mse= 1.040, kld= 0.865
      val_loss= 0.951, val_mse= 0.866, val_kld= 0.845
Epoch= 186/200, loss= 1.091, mse= 1.006, kld= 0.858
      val_loss= 1.065, val_mse= 0.983, val_kld= 0.822
Epoch= 187/200, loss= 1.126, mse= 1.044, kld= 0.817
      val_loss= 1.279, val_mse= 1.196, val_kld= 0.831
Epoch= 188/200, loss= 1.181, mse= 1.099, kld= 0.819
      val_loss= 1.105, val_mse= 1.020, val_kld= 0.847
Epoch= 189/200, loss= 1.152, mse= 1.067, kld= 0.847
      val_loss= 1.050, val_mse= 0.954, val_kld= 0.960
Epoch= 190/200, loss= 1.152, mse= 1.069, kld= 0.829
      val_loss= 1.027, val_mse= 0.947, val_kld= 0.794
Epoch= 191/200, loss= 1.135, mse= 1.051, kld= 0.840
      val_loss= 0.905, val_mse= 0.824, val_kld= 0.810
Epoch= 192/200, loss= 1.082, mse= 0.998, kld= 0.839
      val_loss= 1.084, val_mse= 0.994, val_kld= 0.896
Epoch= 193/200, loss= 1.087, mse= 1.004, kld= 0.828
      val_loss= 1.167, val_mse= 1.090, val_kld= 0.775
Epoch= 194/200, loss= 1.109, mse= 1.028, kld= 0.808
      val_loss= 1.075, val_mse= 0.997, val_kld= 0.780
Epoch= 195/200, loss= 1.035, mse= 0.955, kld= 0.805
      val_loss= 1.137, val_mse= 1.057, val_kld= 0.801
Epoch= 196/200, loss= 1.101, mse= 1.021, kld= 0.798
      val_loss= 0.977, val_mse= 0.892, val_kld= 0.856
Epoch= 197/200, loss= 1.064, mse= 0.990, kld= 0.733
      val_loss= 1.162, val_mse= 1.071, val_kld= 0.909
Epoch= 198/200, loss= 1.040, mse= 0.968, kld= 0.723
      val_loss= 1.106, val_mse= 1.030, val_kld= 0.762
Epoch= 199/200, loss= 1.047, mse= 0.972, kld= 0.753
      val_loss= 1.120, val_mse= 1.026, val_kld= 0.936
Epoch= 200/200, loss= 1.126, mse= 1.048, kld= 0.781
      val_loss= 0.926, val_mse= 0.838, val_kld= 0.881

```

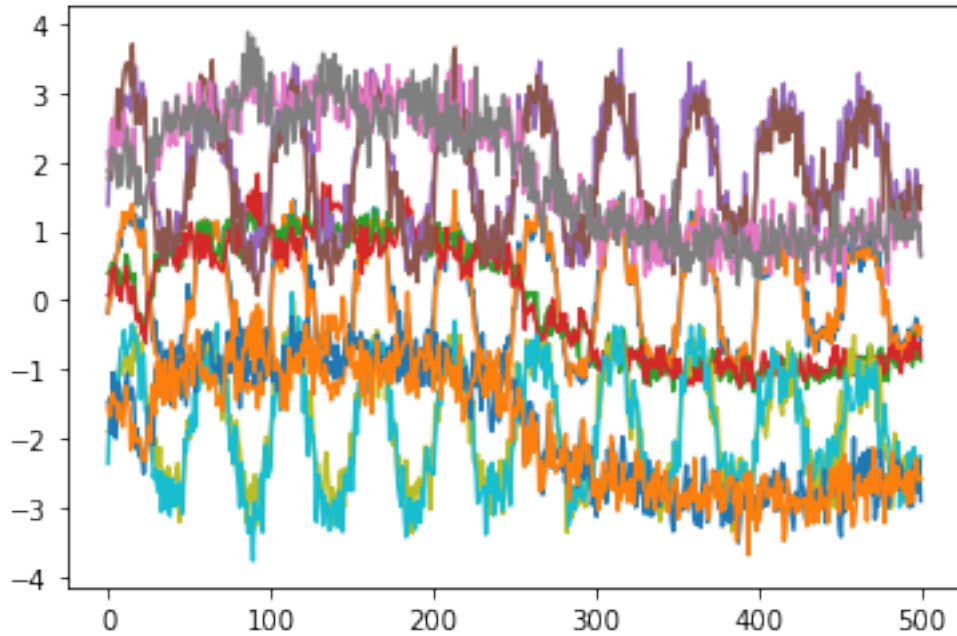
```
[10]: pd.DataFrame(history).plot(figsize=(6, 3), xlabel='Epoch')
```

```
[10]: <AxesSubplot:xlabel='Epoch'>
```

```
[11]: # x_hat = dkf.generate(x_train)
# x_hat, x_025, x_975 = dkf.filter(x_train)
x_hat, x_025, x_975 = dkf.predict(x, 100)
x_hat = x_hat.detach().numpy()[0]
x_025 = x_025.detach().numpy()[0]
x_975 = x_975.detach().numpy()[0]
plt.plot(x_hat)
plt.plot(x_975)
plt.plot(x_025)
```

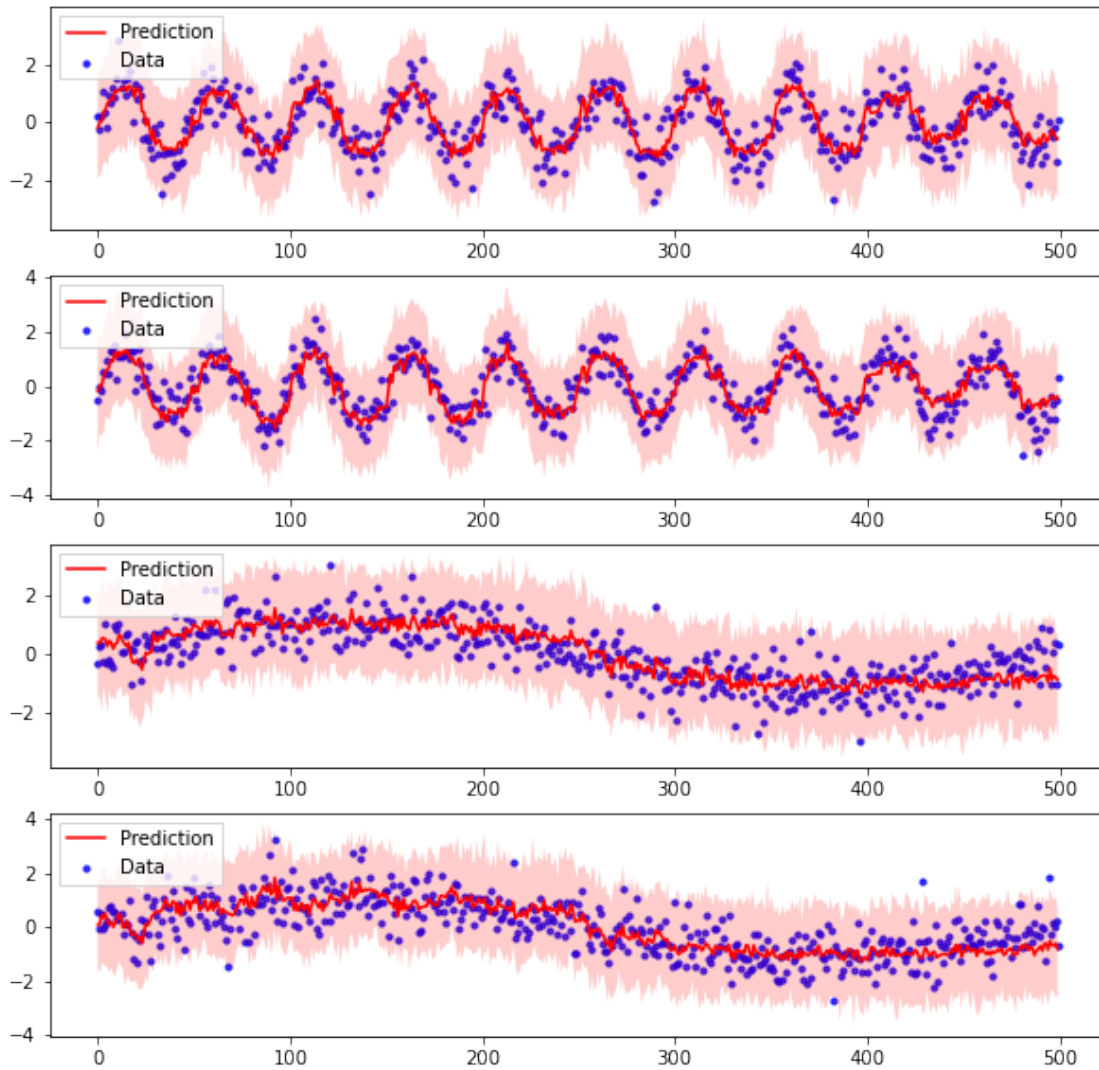
```
[11]: [<matplotlib.lines.Line2D at 0x7f8d5aeb92e0>,
<matplotlib.lines.Line2D at 0x7f8d5aeb93d0>,
<matplotlib.lines.Line2D at 0x7f8d5ae889a0>,
<matplotlib.lines.Line2D at 0x7f8d5aeb9520>]
```



```
[12]: fig, ax = plt.subplots(4, figsize=(10, 10))

for i, axi in enumerate(ax):
    axi.scatter(
        np.arange(data.shape[0]),
        data[:, i], s=10, alpha=0.8, label='Data', c='b')
    axi.plot(x_hat[:, i], label='Prediction', c='r')
    axi.fill_between(np.arange(x_hat.shape[0]), x_025[:, i], x_975[:, i],
                    facecolor='r', alpha=0.2)

    axi.legend(loc='upper left', fancybox=False)
plt.show()
```



2 Moja praca

2.1 Wczytanie danych

```
[14]: import matplotlib.pyplot as plt
import numpy as np
from sklearn import preprocessing
import torch
```

```
[15]: #FIRST on 10 000 workouts - train 9000, test 1000
data_endo = []
i = 0
```

```

#with gzip.open('endomondoHR.json.gz') as f:

with open('endomondoHR_proper.json') as f:
    for l in f:
        i += 1
        #print(i)
        data_endo.append(eval(l))
        if i == 10000:
            break
        #print(data[0])

```

2.2 Wstępne wykresy

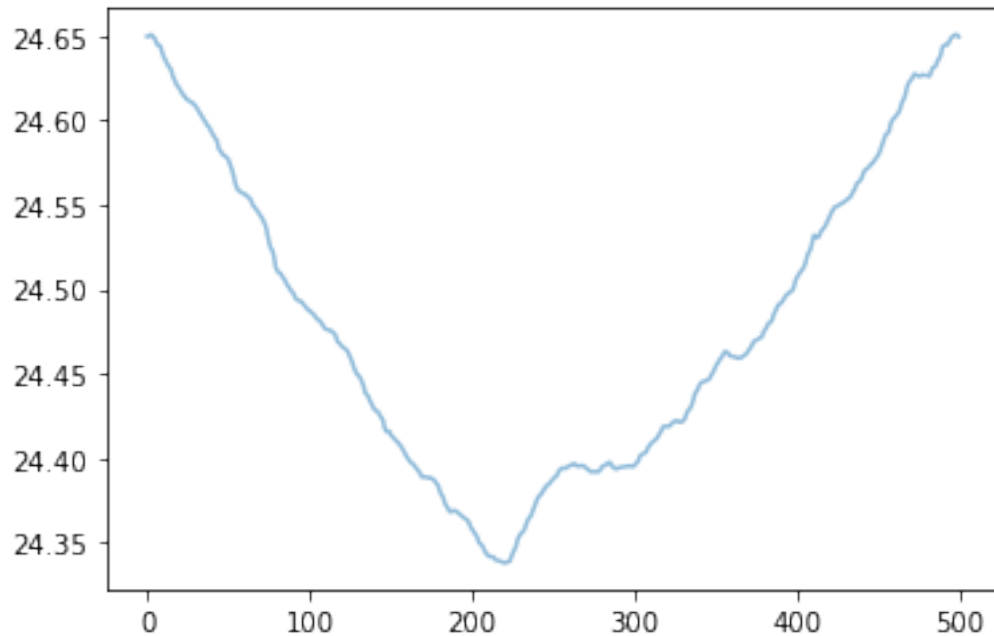
```

[16]: # Plot ithmeasurement x longitude

#print(data_endo[0].keys())
y=np.asarray(data_endo[0]['longitude'])
z=np.asarray(data_endo[0]['latitude'])
x =[]
#print(len(x))
data_t = []
for i in range(len(y)):
    x.append(i)
    data_t.append((x[i], y[i]))
#print(data_t)
data_t = np.asarray(data_t)
#colors = np.random.rand(N)
#area = (30 * np.random.rand(N))**2 # 0 to 15 point radii

plt.plot(x, y, alpha=0.5)
plt.show()
#print(y.shape)

```

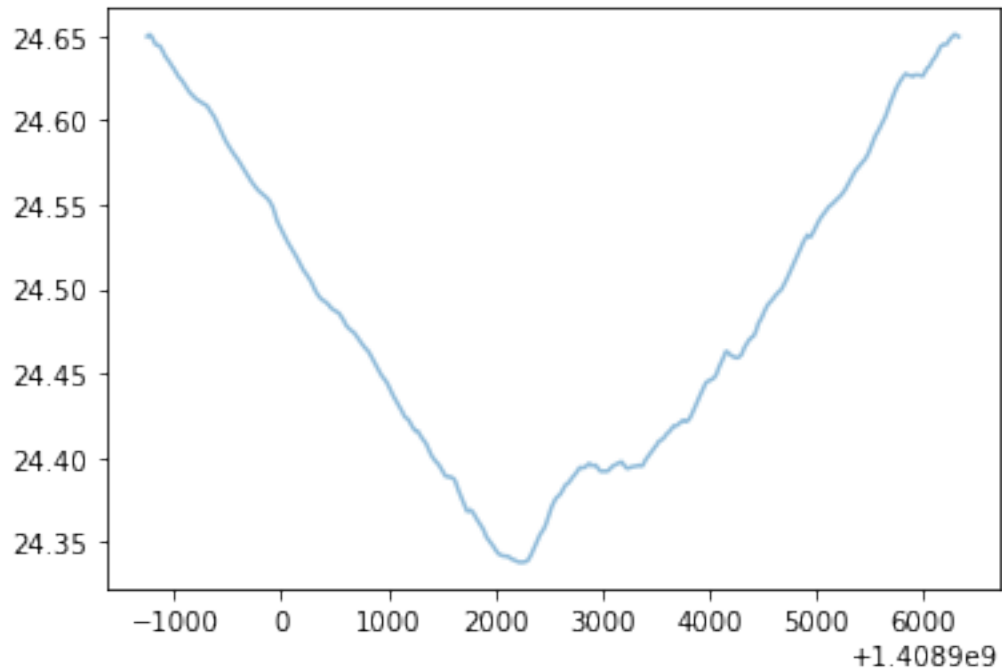


```
[17]: # Plot timestamp x longitude

#print(data_endo[0].keys())
y=np.asarray(data_endo[0]['longitude'])
z=np.asarray(data_endo[0]['latitude'])
x = []
#print(len(x))
data_t = []
for i in range(len(y)):
    x.append(i)
    data_t.append((x[i], y[i]))
#print(data_t)
data_t = np.asarray(data_t)
#colors = np.random.rand(N)
#area = (30 * np.random.rand(N))**2 # 0 to 15 point radii

x = np.asarray(data_endo[0]['timestamp'])

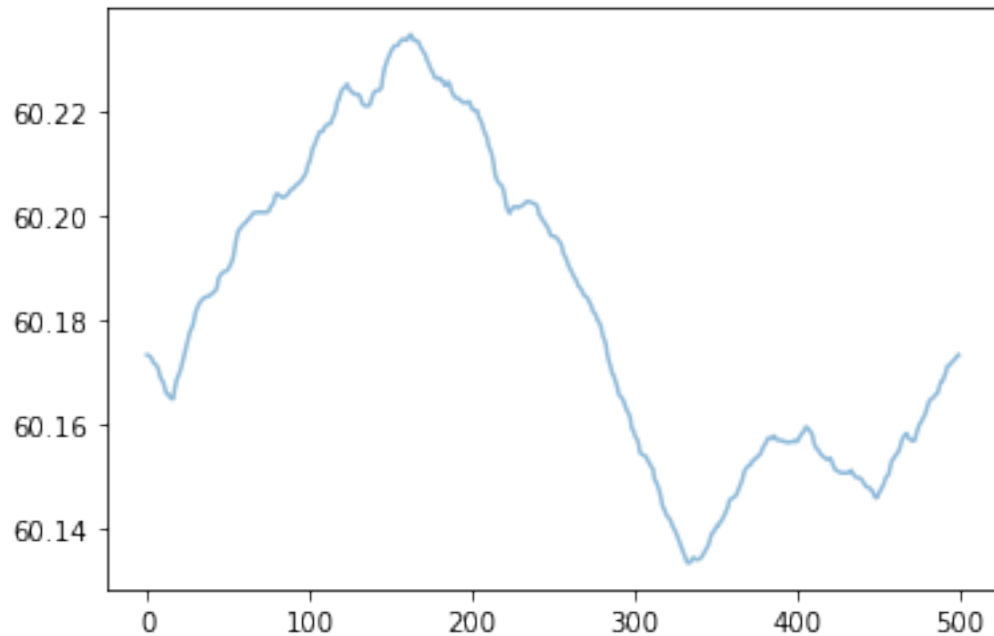
plt.plot(x, y, alpha=0.5)
plt.show()
#print(y.shape)
```



```
[18]: # Plot ithmeasurement x latitude

#print(data_endo[0].keys())
y=np.asarray(data_endo[0]['latitude'])
z=np.asarray(data_endo[0]['latitude'])
x =[]
#print(len(x))
data_t = []
for i in range(len(y)):
    x.append(i)
    data_t.append((x[i], y[i]))
#print(data_t)
data_t = np.asarray(data_t)
#colors = np.random.rand(N)
#area = (30 * np.random.rand(N))**2 # 0 to 15 point radii

plt.plot(x, y, alpha=0.5)
plt.show()
#print(y.shape)
```

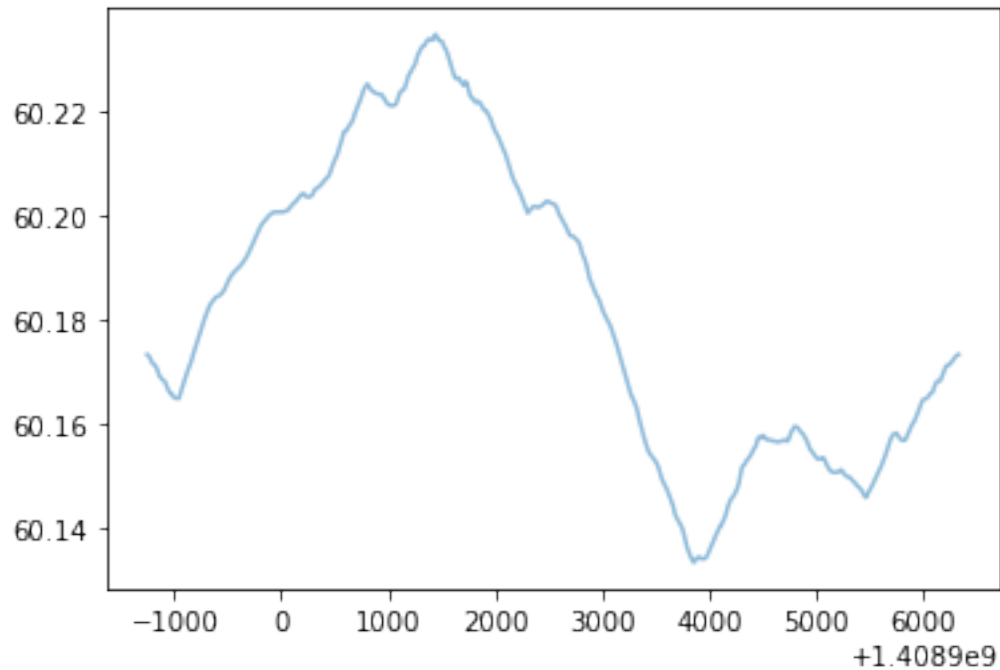


```
[19]: # Plot timestamp x latitude

#print(data_endo[0].keys())
y=np.asarray(data_endo[0]['latitude'])
z=np.asarray(data_endo[0]['latitude'])
x = []
#print(len(x))
data_t = []
for i in range(len(y)):
    x.append(i)
    data_t.append((x[i], y[i]))
#print(data_t)
data_t = np.asarray(data_t)
#colors = np.random.rand(N)
#area = (30 * np.random.rand(N))**2 # 0 to 15 point radii

x = np.asarray(data_endo[0]['timestamp'])

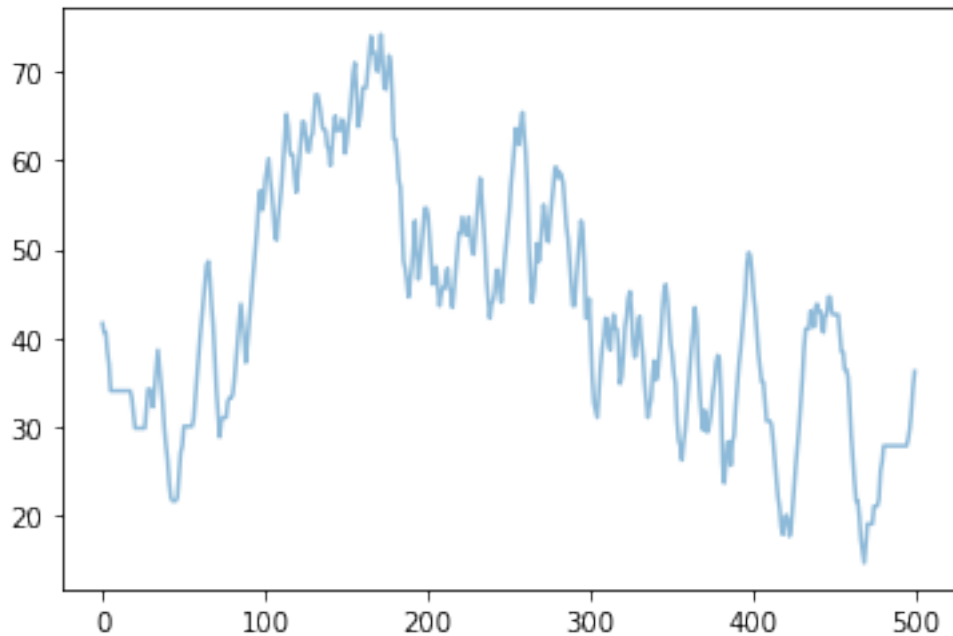
plt.plot(x, y, alpha=0.5)
plt.show()
#print(y.shape)
```



```
[20]: # Plot ithmeasurement x altitude

#print(data_endo[0].keys())
y=np.asarray(data_endo[0]['altitude'])
z=np.asarray(data_endo[0]['latitude'])
x = []
#print(len(x))
data_t = []
for i in range(len(y)):
    x.append(i)
    data_t.append((x[i], y[i]))
#print(data_t)
data_t = np.asarray(data_t)
#colors = np.random.rand(N)
#area = (30 * np.random.rand(N))**2 # 0 to 15 point radii

plt.plot(x, y, alpha=0.5)
plt.show()
#print(y.shape)
```

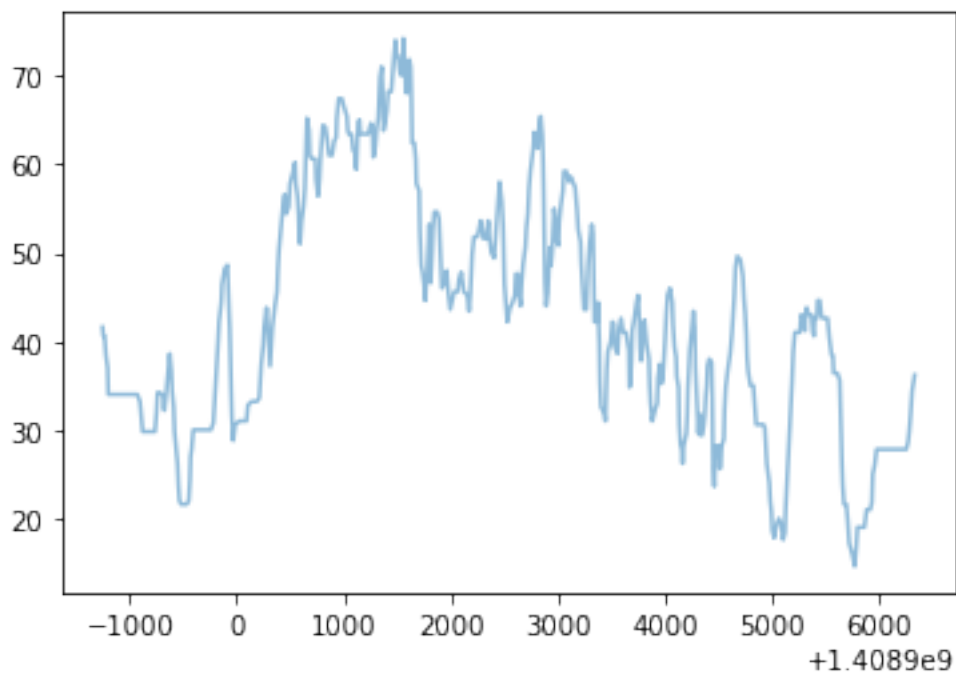



```
[21]: # Plot timestamp x altitude

#print(data_endo[0].keys())
y=np.asarray(data_endo[0]['altitude'])
z=np.asarray(data_endo[0]['latitude'])
x = []
#print(len(x))
data_t = []
for i in range(len(y)):
    x.append(i)
    data_t.append((x[i], y[i]))
#print(data_t)
data_t = np.asarray(data_t)
#colors = np.random.rand(N)
#area = (30 * np.random.rand(N))**2 # 0 to 15 point radii

x = np.asarray(data_endo[0]['timestamp'])

plt.plot(x, y, alpha=0.5)
plt.show()
#print(y.shape)
```



[22]: #####OK wykresy sie zgadzaja

[23]: ###TERAZ TRENUJEMY DLA 1 WORKOUTU LONGITUDE, TRAIN TO PIERWSZE 450 A VAL TO
 ↳ KOLEJNE 50

[]:

[]:

[]:

[]:

[]:

[]:

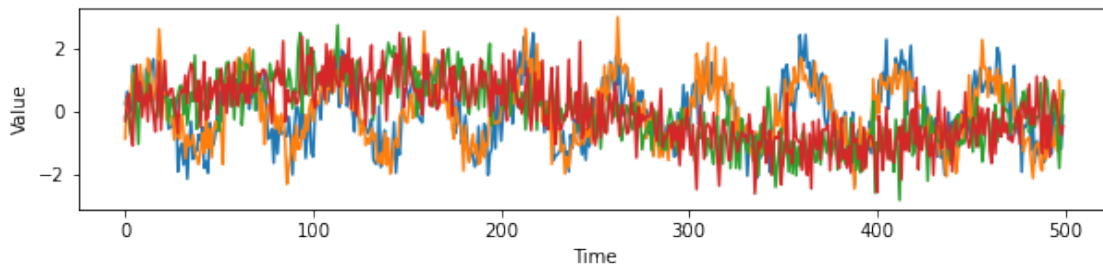
[]:

[]:

[24]: ##### ITHMEASUREMENT vs LONGITUDE

```
[25]: import matplotlib.pyplot as plt
import numpy as np
from sklearn.preprocessing import scale
# import warnings
# warnings.filterwarnings('ignore')
T = 500 # sequence length
observations = 2*np.sin(np.linspace(0, 20*np.pi, T))
interventions = 2*np.sin(np.linspace(0, 2*np.pi, T))
data = np.vstack([observations, observations*1.2, interventions,
                  interventions*0.85]).T
data += np.random.randn(*data.shape)
# data[:, 2:] = preprocessing.minmax_scale(data[:, 2:])
data = scale(data)

plt.figure(figsize=(10, 2))
plt.plot(data)
plt.xlabel('Time')
plt.ylabel('Value')
plt.show()
```



```
[26]: x = torch.FloatTensor(data).reshape(1, *data.shape)
#print(x)
x_train = torch.FloatTensor(data[:400]).reshape(1, 400, data.shape[1])
#print(x_train)
x_val = torch.FloatTensor(data[400:450]).reshape(1, 50, data.shape[1])
#print(x_val)
#print(data.shape[1])
```

```
[27]: # Plot ithmeasurement x longitude

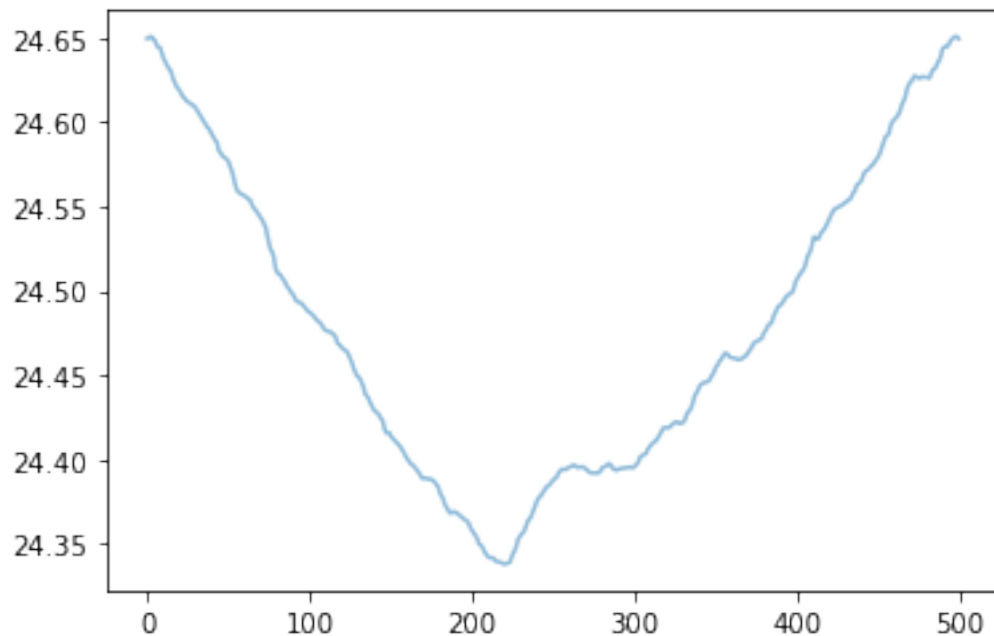
#print(data_endo[0].keys())
y=np.asarray(data_endo[0]['longitude'])
z=np.asarray(data_endo[0]['latitude'])
x = []
```

```

#print(len(x))
data_t = []
for i in range(len(y)):
    x.append(i)
    data_t.append((x[i], y[i]))
#print(data_t)
data_t = np.asarray(data_t)
#colors = np.random.rand(N)
#area = (30 * np.random.rand(N))**2 # 0 to 15 point radii

plt.plot(x, y, alpha=0.5)
plt.show()
#print(y.shape)

```



2.3 Trenowane dla 1 treningu po longitude

```

[28]: #x = torch.FloatTensor(data).reshape(1, *data.shape)
#x_train = torch.FloatTensor(data[:400]).reshape(1, 400, data.shape[1])
#x_val   = torch.FloatTensor(data[400:450]).reshape(1, 50, data.shape[1])

y_data = torch.FloatTensor(y).reshape(1, 500, 1)
#print(y_data)
y_train = torch.FloatTensor(y[:450]).reshape(1, 450, 1)
#print(y_train)

```

```
y_val = torch.FloatTensor(y[450:500]).reshape(1, 50, 1)
#print(y_val)
```

```
[29]: dkf = DKF(input_dim=1, z_dim=5, rnn_dim=5, trans_dim=5, emission_dim=5)
```

```
[30]: history = dkf.fit(y_train, y_val, num_epochs=200, annealing_factor=0.1)
```

```
Epoch= 1/200, loss= 602.290, mse= 601.823, kld= 4.672
        val_loss= 613.279, val_mse= 612.777, val_kld= 5.014
Epoch= 2/200, loss= 602.305, mse= 601.826, kld= 4.780
        val_loss= 593.956, val_mse= 593.469, val_kld= 4.863
Epoch= 3/200, loss= 597.139, mse= 596.652, kld= 4.876
        val_loss= 599.939, val_mse= 599.388, val_kld= 5.511
Epoch= 4/200, loss= 601.880, mse= 601.340, kld= 5.406
        val_loss= 597.171, val_mse= 596.568, val_kld= 6.030
Epoch= 5/200, loss= 591.181, mse= 590.550, kld= 6.318
        val_loss= 584.929, val_mse= 584.175, val_kld= 7.546
Epoch= 6/200, loss= 584.765, mse= 584.036, kld= 7.291
        val_loss= 597.986, val_mse= 597.130, val_kld= 8.559
Epoch= 7/200, loss= 585.687, mse= 584.818, kld= 8.692
        val_loss= 593.301, val_mse= 592.258, val_kld= 10.428
Epoch= 8/200, loss= 573.687, mse= 572.631, kld= 10.555
        val_loss= 557.416, val_mse= 556.030, val_kld= 13.855
Epoch= 9/200, loss= 569.449, mse= 568.163, kld= 12.863
        val_loss= 565.704, val_mse= 564.106, val_kld= 15.980
Epoch= 10/200, loss= 569.153, mse= 567.626, kld= 15.274
        val_loss= 555.728, val_mse= 553.848, val_kld= 18.802
Epoch= 11/200, loss= 548.458, mse= 546.531, kld= 19.268
        val_loss= 553.540, val_mse= 551.116, val_kld= 24.242
Epoch= 12/200, loss= 533.782, mse= 531.301, kld= 24.803
        val_loss= 525.920, val_mse= 522.740, val_kld= 31.799
Epoch= 13/200, loss= 531.722, mse= 528.828, kld= 28.939
        val_loss= 517.677, val_mse= 514.050, val_kld= 36.274
Epoch= 14/200, loss= 517.427, mse= 513.606, kld= 38.217
        val_loss= 492.004, val_mse= 486.746, val_kld= 52.576
Epoch= 15/200, loss= 493.947, mse= 489.115, kld= 48.320
        val_loss= 443.229, val_mse= 434.663, val_kld= 85.659
Epoch= 16/200, loss= 472.908, mse= 465.693, kld= 72.149
        val_loss= 431.285, val_mse= 420.237, val_kld= 110.480
Epoch= 17/200, loss= 446.261, mse= 437.548, kld= 87.128
        val_loss= 410.435, val_mse= 398.493, val_kld= 119.425
Epoch= 18/200, loss= 408.728, mse= 396.406, kld= 123.219
        val_loss= 404.892, val_mse= 385.446, val_kld= 194.459
Epoch= 19/200, loss= 375.436, mse= 354.284, kld= 211.521
        val_loss= 337.386, val_mse= 318.281, val_kld= 191.047
Epoch= 20/200, loss= 334.936, mse= 306.435, kld= 285.015
        val_loss= 296.008, val_mse= 269.013, val_kld= 269.948
```

Epoch= 21/200, loss= 306.298, mse= 262.320, kld= 439.782
val_loss= 252.860, val_mse= 226.142, val_kld= 267.186

Epoch= 22/200, loss= 255.851, mse= 224.112, kld= 317.383
val_loss= 179.885, val_mse= 150.981, val_kld= 289.034

Epoch= 23/200, loss= 211.697, mse= 183.442, kld= 282.549
val_loss= 189.111, val_mse= 150.433, val_kld= 386.779

Epoch= 24/200, loss= 188.366, mse= 161.684, kld= 266.819
val_loss= 213.458, val_mse= 187.694, val_kld= 257.639

Epoch= 25/200, loss= 184.532, mse= 157.431, kld= 271.010
val_loss= 150.587, val_mse= 115.950, val_kld= 346.373

Epoch= 26/200, loss= 158.499, mse= 132.529, kld= 259.696
val_loss= 156.752, val_mse= 136.802, val_kld= 199.500

Epoch= 27/200, loss= 141.033, mse= 119.906, kld= 211.267
val_loss= 109.466, val_mse= 91.971, val_kld= 174.954

Epoch= 28/200, loss= 116.163, mse= 100.284, kld= 158.786
val_loss= 114.811, val_mse= 102.318, val_kld= 124.928

Epoch= 29/200, loss= 104.629, mse= 93.021, kld= 116.076
val_loss= 102.988, val_mse= 94.486, val_kld= 85.027

Epoch= 30/200, loss= 83.159, mse= 74.175, kld= 89.838
val_loss= 61.239, val_mse= 55.184, val_kld= 60.557

Epoch= 31/200, loss= 73.958, mse= 67.728, kld= 62.301
val_loss= 71.399, val_mse= 66.718, val_kld= 46.806

Epoch= 32/200, loss= 64.010, mse= 59.359, kld= 46.514
val_loss= 38.797, val_mse= 35.686, val_kld= 31.107

Epoch= 33/200, loss= 49.386, mse= 45.922, kld= 34.636
val_loss= 41.928, val_mse= 39.374, val_kld= 25.546

Epoch= 34/200, loss= 37.365, mse= 34.849, kld= 25.167
val_loss= 39.367, val_mse= 37.468, val_kld= 18.987

Epoch= 35/200, loss= 27.621, mse= 25.745, kld= 18.764
val_loss= 21.384, val_mse= 19.897, val_kld= 14.873

Epoch= 36/200, loss= 21.258, mse= 19.848, kld= 14.100
val_loss= 21.177, val_mse= 19.944, val_kld= 12.333

Epoch= 37/200, loss= 16.230, mse= 15.136, kld= 10.934
val_loss= 17.934, val_mse= 17.004, val_kld= 9.306

Epoch= 38/200, loss= 13.717, mse= 12.853, kld= 8.640
val_loss= 11.609, val_mse= 10.867, val_kld= 7.426

Epoch= 39/200, loss= 12.576, mse= 11.886, kld= 6.899
val_loss= 15.154, val_mse= 14.472, val_kld= 6.826

Epoch= 40/200, loss= 12.057, mse= 11.482, kld= 5.747
val_loss= 15.001, val_mse= 14.423, val_kld= 5.778

Epoch= 41/200, loss= 11.966, mse= 11.482, kld= 4.845
val_loss= 14.098, val_mse= 13.582, val_kld= 5.158

Epoch= 42/200, loss= 9.760, mse= 9.326, kld= 4.334
val_loss= 9.457, val_mse= 8.977, val_kld= 4.801

Epoch= 43/200, loss= 8.533, mse= 8.124, kld= 4.088
val_loss= 6.006, val_mse= 5.541, val_kld= 4.648

Epoch= 44/200, loss= 8.106, mse= 7.719, kld= 3.869
val_loss= 6.103, val_mse= 5.656, val_kld= 4.461

Epoch= 45/200, loss= 6.085, mse= 5.700, kld= 3.843
val_loss= 5.636, val_mse= 5.183, val_kld= 4.530
Epoch= 46/200, loss= 5.458, mse= 5.076, kld= 3.818
val_loss= 6.736, val_mse= 6.279, val_kld= 4.564
Epoch= 47/200, loss= 5.409, mse= 5.023, kld= 3.859
val_loss= 7.353, val_mse= 6.881, val_kld= 4.725
Epoch= 48/200, loss= 5.630, mse= 5.238, kld= 3.919
val_loss= 7.869, val_mse= 7.419, val_kld= 4.500
Epoch= 49/200, loss= 5.782, mse= 5.382, kld= 3.999
val_loss= 4.612, val_mse= 4.145, val_kld= 4.670
Epoch= 50/200, loss= 5.737, mse= 5.335, kld= 4.026
val_loss= 6.041, val_mse= 5.554, val_kld= 4.867
Epoch= 51/200, loss= 5.543, mse= 5.133, kld= 4.097
val_loss= 6.821, val_mse= 6.325, val_kld= 4.955
Epoch= 52/200, loss= 5.081, mse= 4.669, kld= 4.118
val_loss= 5.470, val_mse= 4.980, val_kld= 4.898
Epoch= 53/200, loss= 3.827, mse= 3.402, kld= 4.246
val_loss= 3.965, val_mse= 3.475, val_kld= 4.902
Epoch= 54/200, loss= 4.180, mse= 3.755, kld= 4.248
val_loss= 3.965, val_mse= 3.470, val_kld= 4.944
Epoch= 55/200, loss= 3.572, mse= 3.144, kld= 4.275
val_loss= 6.531, val_mse= 6.037, val_kld= 4.933
Epoch= 56/200, loss= 3.814, mse= 3.381, kld= 4.334
val_loss= 6.044, val_mse= 5.535, val_kld= 5.084
Epoch= 57/200, loss= 3.924, mse= 3.496, kld= 4.277
val_loss= 4.442, val_mse= 3.941, val_kld= 5.001
Epoch= 58/200, loss= 4.138, mse= 3.712, kld= 4.264
val_loss= 3.266, val_mse= 2.767, val_kld= 4.985
Epoch= 59/200, loss= 3.965, mse= 3.541, kld= 4.240
val_loss= 3.366, val_mse= 2.881, val_kld= 4.853
Epoch= 60/200, loss= 3.487, mse= 3.066, kld= 4.207
val_loss= 3.451, val_mse= 2.961, val_kld= 4.903
Epoch= 61/200, loss= 3.429, mse= 3.019, kld= 4.097
val_loss= 3.473, val_mse= 2.994, val_kld= 4.793
Epoch= 62/200, loss= 2.854, mse= 2.450, kld= 4.046
val_loss= 2.859, val_mse= 2.394, val_kld= 4.650
Epoch= 63/200, loss= 3.234, mse= 2.835, kld= 3.996
val_loss= 4.106, val_mse= 3.626, val_kld= 4.799
Epoch= 64/200, loss= 3.095, mse= 2.704, kld= 3.907
val_loss= 3.103, val_mse= 2.632, val_kld= 4.709
Epoch= 65/200, loss= 3.515, mse= 3.129, kld= 3.858
val_loss= 3.430, val_mse= 2.967, val_kld= 4.625
Epoch= 66/200, loss= 2.895, mse= 2.514, kld= 3.805
val_loss= 3.547, val_mse= 3.092, val_kld= 4.552
Epoch= 67/200, loss= 3.268, mse= 2.889, kld= 3.787
val_loss= 2.603, val_mse= 2.155, val_kld= 4.487
Epoch= 68/200, loss= 3.377, mse= 3.004, kld= 3.728
val_loss= 3.306, val_mse= 2.859, val_kld= 4.474

Epoch= 69/200, loss= 2.586, mse= 2.221, kld= 3.644
val_loss= 2.062, val_mse= 1.617, val_kld= 4.451
Epoch= 70/200, loss= 2.522, mse= 2.160, kld= 3.617
val_loss= 2.782, val_mse= 2.334, val_kld= 4.477
Epoch= 71/200, loss= 2.822, mse= 2.463, kld= 3.590
val_loss= 3.488, val_mse= 3.045, val_kld= 4.430
Epoch= 72/200, loss= 2.718, mse= 2.363, kld= 3.547
val_loss= 2.789, val_mse= 2.350, val_kld= 4.391
Epoch= 73/200, loss= 2.516, mse= 2.164, kld= 3.516
val_loss= 3.098, val_mse= 2.658, val_kld= 4.398
Epoch= 74/200, loss= 2.537, mse= 2.189, kld= 3.471
val_loss= 2.446, val_mse= 2.012, val_kld= 4.342
Epoch= 75/200, loss= 2.530, mse= 2.189, kld= 3.408
val_loss= 3.153, val_mse= 2.725, val_kld= 4.282
Epoch= 76/200, loss= 2.553, mse= 2.214, kld= 3.387
val_loss= 2.690, val_mse= 2.259, val_kld= 4.302
Epoch= 77/200, loss= 2.376, mse= 2.046, kld= 3.293
val_loss= 3.452, val_mse= 3.020, val_kld= 4.316
Epoch= 78/200, loss= 2.288, mse= 1.962, kld= 3.265
val_loss= 2.613, val_mse= 2.187, val_kld= 4.254
Epoch= 79/200, loss= 2.132, mse= 1.809, kld= 3.226
val_loss= 3.165, val_mse= 2.740, val_kld= 4.249
Epoch= 80/200, loss= 2.230, mse= 1.911, kld= 3.184
val_loss= 2.303, val_mse= 1.885, val_kld= 4.181
Epoch= 81/200, loss= 2.368, mse= 2.054, kld= 3.144
val_loss= 2.432, val_mse= 2.006, val_kld= 4.256
Epoch= 82/200, loss= 2.387, mse= 2.076, kld= 3.108
val_loss= 1.986, val_mse= 1.566, val_kld= 4.205
Epoch= 83/200, loss= 2.464, mse= 2.156, kld= 3.078
val_loss= 2.844, val_mse= 2.428, val_kld= 4.164
Epoch= 84/200, loss= 2.277, mse= 1.971, kld= 3.055
val_loss= 1.925, val_mse= 1.507, val_kld= 4.186
Epoch= 85/200, loss= 2.340, mse= 2.036, kld= 3.049
val_loss= 2.120, val_mse= 1.704, val_kld= 4.153
Epoch= 86/200, loss= 2.333, mse= 2.030, kld= 3.026
val_loss= 2.170, val_mse= 1.756, val_kld= 4.142
Epoch= 87/200, loss= 2.017, mse= 1.719, kld= 2.983
val_loss= 2.505, val_mse= 2.099, val_kld= 4.061
Epoch= 88/200, loss= 2.088, mse= 1.791, kld= 2.975
val_loss= 2.219, val_mse= 1.809, val_kld= 4.101
Epoch= 89/200, loss= 2.040, mse= 1.747, kld= 2.930
val_loss= 1.500, val_mse= 1.088, val_kld= 4.112
Epoch= 90/200, loss= 1.925, mse= 1.633, kld= 2.917
val_loss= 2.289, val_mse= 1.883, val_kld= 4.060
Epoch= 91/200, loss= 1.912, mse= 1.619, kld= 2.934
val_loss= 1.997, val_mse= 1.582, val_kld= 4.145
Epoch= 92/200, loss= 1.861, mse= 1.576, kld= 2.848
val_loss= 2.009, val_mse= 1.597, val_kld= 4.119

Epoch= 93/200, loss= 1.915, mse= 1.633, kld= 2.824
val_loss= 1.842, val_mse= 1.439, val_kld= 4.031
Epoch= 94/200, loss= 2.049, mse= 1.764, kld= 2.848
val_loss= 2.210, val_mse= 1.808, val_kld= 4.022
Epoch= 95/200, loss= 1.921, mse= 1.644, kld= 2.769
val_loss= 1.866, val_mse= 1.464, val_kld= 4.017
Epoch= 96/200, loss= 1.689, mse= 1.414, kld= 2.751
val_loss= 1.740, val_mse= 1.347, val_kld= 3.931
Epoch= 97/200, loss= 2.002, mse= 1.727, kld= 2.749
val_loss= 1.737, val_mse= 1.347, val_kld= 3.900
Epoch= 98/200, loss= 1.924, mse= 1.652, kld= 2.719
val_loss= 1.778, val_mse= 1.386, val_kld= 3.922
Epoch= 99/200, loss= 1.916, mse= 1.650, kld= 2.658
val_loss= 2.950, val_mse= 2.555, val_kld= 3.951
Epoch= 100/200, loss= 1.947, mse= 1.679, kld= 2.682
val_loss= 1.531, val_mse= 1.141, val_kld= 3.896
Epoch= 101/200, loss= 1.806, mse= 1.541, kld= 2.653
val_loss= 2.480, val_mse= 2.093, val_kld= 3.870
Epoch= 102/200, loss= 1.957, mse= 1.694, kld= 2.635
val_loss= 2.274, val_mse= 1.890, val_kld= 3.839
Epoch= 103/200, loss= 1.684, mse= 1.426, kld= 2.584
val_loss= 2.029, val_mse= 1.644, val_kld= 3.852
Epoch= 104/200, loss= 1.788, mse= 1.529, kld= 2.595
val_loss= 1.864, val_mse= 1.481, val_kld= 3.831
Epoch= 105/200, loss= 1.770, mse= 1.512, kld= 2.585
val_loss= 1.611, val_mse= 1.231, val_kld= 3.803
Epoch= 106/200, loss= 1.730, mse= 1.476, kld= 2.549
val_loss= 2.008, val_mse= 1.635, val_kld= 3.730
Epoch= 107/200, loss= 1.628, mse= 1.374, kld= 2.543
val_loss= 1.919, val_mse= 1.538, val_kld= 3.817
Epoch= 108/200, loss= 1.766, mse= 1.509, kld= 2.566
val_loss= 1.755, val_mse= 1.386, val_kld= 3.689
Epoch= 109/200, loss= 1.727, mse= 1.474, kld= 2.529
val_loss= 1.351, val_mse= 0.973, val_kld= 3.772
Epoch= 110/200, loss= 1.870, mse= 1.615, kld= 2.551
val_loss= 1.950, val_mse= 1.571, val_kld= 3.785
Epoch= 111/200, loss= 1.734, mse= 1.483, kld= 2.509
val_loss= 1.643, val_mse= 1.269, val_kld= 3.736
Epoch= 112/200, loss= 1.812, mse= 1.560, kld= 2.521
val_loss= 1.982, val_mse= 1.610, val_kld= 3.721
Epoch= 113/200, loss= 1.723, mse= 1.474, kld= 2.491
val_loss= 1.825, val_mse= 1.455, val_kld= 3.703
Epoch= 114/200, loss= 1.667, mse= 1.417, kld= 2.499
val_loss= 1.749, val_mse= 1.376, val_kld= 3.732
Epoch= 115/200, loss= 1.805, mse= 1.558, kld= 2.475
val_loss= 2.315, val_mse= 1.943, val_kld= 3.720
Epoch= 116/200, loss= 1.536, mse= 1.287, kld= 2.490
val_loss= 1.628, val_mse= 1.258, val_kld= 3.701

Epoch= 117/200, loss= 1.593, mse= 1.346, kld= 2.468
 val_loss= 1.454, val_mse= 1.085, val_kld= 3.690
 Epoch= 118/200, loss= 1.641, mse= 1.399, kld= 2.419
 val_loss= 1.846, val_mse= 1.482, val_kld= 3.638
 Epoch= 119/200, loss= 1.670, mse= 1.426, kld= 2.434
 val_loss= 1.833, val_mse= 1.466, val_kld= 3.674
 Epoch= 120/200, loss= 1.727, mse= 1.488, kld= 2.391
 val_loss= 1.276, val_mse= 0.911, val_kld= 3.651
 Epoch= 121/200, loss= 1.579, mse= 1.342, kld= 2.376
 val_loss= 1.771, val_mse= 1.409, val_kld= 3.616
 Epoch= 122/200, loss= 1.552, mse= 1.314, kld= 2.376
 val_loss= 1.517, val_mse= 1.154, val_kld= 3.636
 Epoch= 123/200, loss= 1.635, mse= 1.398, kld= 2.366
 val_loss= 1.949, val_mse= 1.590, val_kld= 3.593
 Epoch= 124/200, loss= 1.537, mse= 1.302, kld= 2.354
 val_loss= 1.431, val_mse= 1.064, val_kld= 3.671
 Epoch= 125/200, loss= 1.604, mse= 1.368, kld= 2.360
 val_loss= 1.635, val_mse= 1.278, val_kld= 3.567
 Epoch= 126/200, loss= 1.449, mse= 1.217, kld= 2.320
 val_loss= 1.289, val_mse= 0.933, val_kld= 3.562
 Epoch= 127/200, loss= 1.429, mse= 1.195, kld= 2.339
 val_loss= 1.415, val_mse= 1.055, val_kld= 3.601
 Epoch= 128/200, loss= 1.571, mse= 1.340, kld= 2.310
 val_loss= 1.541, val_mse= 1.184, val_kld= 3.575
 Epoch= 129/200, loss= 1.312, mse= 1.085, kld= 2.266
 val_loss= 1.402, val_mse= 1.050, val_kld= 3.522
 Epoch= 130/200, loss= 1.511, mse= 1.285, kld= 2.263
 val_loss= 1.825, val_mse= 1.464, val_kld= 3.603
 Epoch= 131/200, loss= 1.563, mse= 1.338, kld= 2.256
 val_loss= 2.052, val_mse= 1.695, val_kld= 3.567
 Epoch= 132/200, loss= 1.440, mse= 1.213, kld= 2.273
 val_loss= 1.472, val_mse= 1.121, val_kld= 3.517
 Epoch= 133/200, loss= 1.535, mse= 1.311, kld= 2.239
 val_loss= 1.657, val_mse= 1.301, val_kld= 3.563
 Epoch= 134/200, loss= 1.470, mse= 1.245, kld= 2.253
 val_loss= 1.530, val_mse= 1.173, val_kld= 3.567
 Epoch= 135/200, loss= 1.439, mse= 1.218, kld= 2.210
 val_loss= 1.254, val_mse= 0.903, val_kld= 3.509
 Epoch= 136/200, loss= 1.483, mse= 1.260, kld= 2.225
 val_loss= 1.498, val_mse= 1.155, val_kld= 3.430
 Epoch= 137/200, loss= 1.461, mse= 1.241, kld= 2.196
 val_loss= 1.498, val_mse= 1.150, val_kld= 3.475
 Epoch= 138/200, loss= 1.504, mse= 1.283, kld= 2.211
 val_loss= 1.527, val_mse= 1.176, val_kld= 3.505
 Epoch= 139/200, loss= 1.379, mse= 1.158, kld= 2.202
 val_loss= 1.446, val_mse= 1.104, val_kld= 3.415
 Epoch= 140/200, loss= 1.414, mse= 1.198, kld= 2.157
 val_loss= 1.511, val_mse= 1.167, val_kld= 3.443

Epoch= 141/200, loss= 1.358, mse= 1.144, kld= 2.140
val_loss= 1.650, val_mse= 1.310, val_kld= 3.404
Epoch= 142/200, loss= 1.424, mse= 1.209, kld= 2.153
val_loss= 2.002, val_mse= 1.659, val_kld= 3.425
Epoch= 143/200, loss= 1.503, mse= 1.290, kld= 2.131
val_loss= 1.478, val_mse= 1.128, val_kld= 3.503
Epoch= 144/200, loss= 1.356, mse= 1.141, kld= 2.151
val_loss= 1.391, val_mse= 1.054, val_kld= 3.370
Epoch= 145/200, loss= 1.349, mse= 1.136, kld= 2.131
val_loss= 1.997, val_mse= 1.649, val_kld= 3.474
Epoch= 146/200, loss= 1.422, mse= 1.211, kld= 2.114
val_loss= 1.760, val_mse= 1.421, val_kld= 3.391
Epoch= 147/200, loss= 1.288, mse= 1.079, kld= 2.089
val_loss= 1.565, val_mse= 1.214, val_kld= 3.503
Epoch= 148/200, loss= 1.301, mse= 1.090, kld= 2.108
val_loss= 1.158, val_mse= 0.821, val_kld= 3.368
Epoch= 149/200, loss= 1.318, mse= 1.108, kld= 2.102
val_loss= 1.429, val_mse= 1.085, val_kld= 3.444
Epoch= 150/200, loss= 1.316, mse= 1.109, kld= 2.071
val_loss= 1.453, val_mse= 1.113, val_kld= 3.401
Epoch= 151/200, loss= 1.441, mse= 1.231, kld= 2.098
val_loss= 1.352, val_mse= 1.017, val_kld= 3.352
Epoch= 152/200, loss= 1.345, mse= 1.139, kld= 2.062
val_loss= 1.462, val_mse= 1.126, val_kld= 3.368
Epoch= 153/200, loss= 1.318, mse= 1.112, kld= 2.064
val_loss= 1.363, val_mse= 1.015, val_kld= 3.481
Epoch= 154/200, loss= 1.365, mse= 1.157, kld= 2.089
val_loss= 1.308, val_mse= 0.975, val_kld= 3.333
Epoch= 155/200, loss= 1.386, mse= 1.180, kld= 2.064
val_loss= 1.814, val_mse= 1.483, val_kld= 3.309
Epoch= 156/200, loss= 1.400, mse= 1.193, kld= 2.063
val_loss= 1.424, val_mse= 1.086, val_kld= 3.380
Epoch= 157/200, loss= 1.312, mse= 1.107, kld= 2.050
val_loss= 1.448, val_mse= 1.120, val_kld= 3.284
Epoch= 158/200, loss= 1.347, mse= 1.143, kld= 2.047
val_loss= 1.620, val_mse= 1.277, val_kld= 3.431
Epoch= 159/200, loss= 1.289, mse= 1.083, kld= 2.055
val_loss= 1.372, val_mse= 1.036, val_kld= 3.356
Epoch= 160/200, loss= 1.309, mse= 1.106, kld= 2.028
val_loss= 1.242, val_mse= 0.912, val_kld= 3.301
Epoch= 161/200, loss= 1.373, mse= 1.171, kld= 2.026
val_loss= 1.692, val_mse= 1.350, val_kld= 3.422
Epoch= 162/200, loss= 1.233, mse= 1.032, kld= 2.013
val_loss= 1.474, val_mse= 1.140, val_kld= 3.349
Epoch= 163/200, loss= 1.300, mse= 1.100, kld= 1.999
val_loss= 1.154, val_mse= 0.819, val_kld= 3.346
Epoch= 164/200, loss= 1.222, mse= 1.020, kld= 2.017
val_loss= 0.898, val_mse= 0.561, val_kld= 3.369

Epoch= 165/200, loss= 1.312, mse= 1.111, kld= 2.012
val_loss= 1.626, val_mse= 1.297, val_kld= 3.292
Epoch= 166/200, loss= 1.188, mse= 0.985, kld= 2.036
val_loss= 1.222, val_mse= 0.879, val_kld= 3.425
Epoch= 167/200, loss= 1.283, mse= 1.080, kld= 2.035
val_loss= 1.250, val_mse= 0.920, val_kld= 3.304
Epoch= 168/200, loss= 1.223, mse= 1.021, kld= 2.021
val_loss= 1.270, val_mse= 0.930, val_kld= 3.397
Epoch= 169/200, loss= 1.324, mse= 1.125, kld= 1.989
val_loss= 1.485, val_mse= 1.145, val_kld= 3.397
Epoch= 170/200, loss= 1.189, mse= 0.989, kld= 1.996
val_loss= 1.682, val_mse= 1.347, val_kld= 3.353
Epoch= 171/200, loss= 1.185, mse= 0.985, kld= 1.998
val_loss= 1.502, val_mse= 1.166, val_kld= 3.363
Epoch= 172/200, loss= 1.126, mse= 0.926, kld= 2.005
val_loss= 1.628, val_mse= 1.294, val_kld= 3.348
Epoch= 173/200, loss= 1.068, mse= 0.873, kld= 1.954
val_loss= 1.234, val_mse= 0.905, val_kld= 3.284
Epoch= 174/200, loss= 1.246, mse= 1.046, kld= 2.002
val_loss= 1.030, val_mse= 0.704, val_kld= 3.262
Epoch= 175/200, loss= 1.192, mse= 0.995, kld= 1.969
val_loss= 1.310, val_mse= 0.982, val_kld= 3.278
Epoch= 176/200, loss= 1.179, mse= 0.983, kld= 1.960
val_loss= 1.389, val_mse= 1.068, val_kld= 3.209
Epoch= 177/200, loss= 1.327, mse= 1.129, kld= 1.980
val_loss= 1.859, val_mse= 1.527, val_kld= 3.317
Epoch= 178/200, loss= 1.197, mse= 1.001, kld= 1.956
val_loss= 1.477, val_mse= 1.137, val_kld= 3.400
Epoch= 179/200, loss= 1.216, mse= 1.019, kld= 1.977
val_loss= 1.458, val_mse= 1.137, val_kld= 3.209
Epoch= 180/200, loss= 1.138, mse= 0.944, kld= 1.941
val_loss= 1.435, val_mse= 1.108, val_kld= 3.269
Epoch= 181/200, loss= 1.034, mse= 0.835, kld= 1.986
val_loss= 1.236, val_mse= 0.905, val_kld= 3.315
Epoch= 182/200, loss= 1.075, mse= 0.880, kld= 1.950
val_loss= 1.229, val_mse= 0.908, val_kld= 3.219
Epoch= 183/200, loss= 1.092, mse= 0.897, kld= 1.950
val_loss= 0.892, val_mse= 0.564, val_kld= 3.278
Epoch= 184/200, loss= 1.219, mse= 1.025, kld= 1.940
val_loss= 1.165, val_mse= 0.843, val_kld= 3.214
Epoch= 185/200, loss= 1.198, mse= 1.001, kld= 1.976
val_loss= 1.418, val_mse= 1.089, val_kld= 3.291
Epoch= 186/200, loss= 1.041, mse= 0.852, kld= 1.883
val_loss= 1.321, val_mse= 0.996, val_kld= 3.254
Epoch= 187/200, loss= 1.132, mse= 0.934, kld= 1.974
val_loss= 1.462, val_mse= 1.134, val_kld= 3.274
Epoch= 188/200, loss= 1.120, mse= 0.926, kld= 1.940
val_loss= 1.331, val_mse= 1.001, val_kld= 3.301

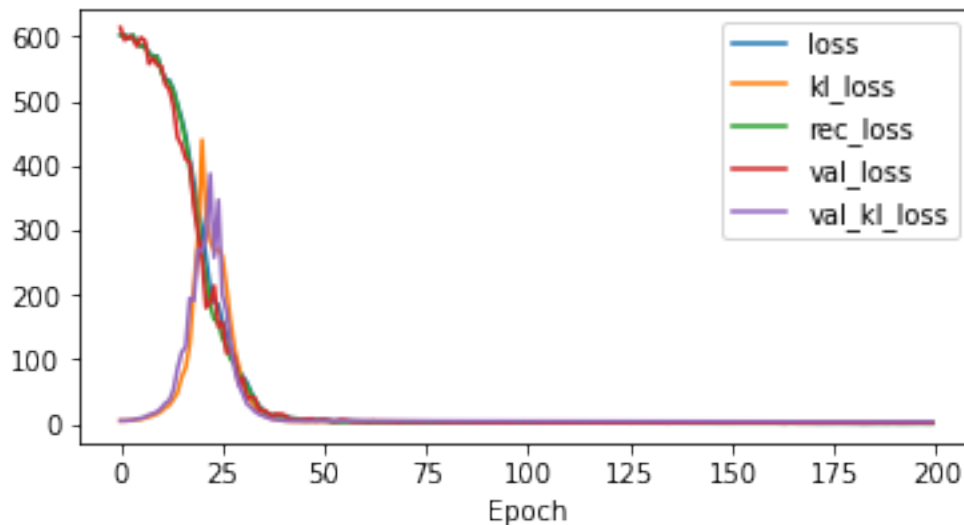
```

Epoch= 189/200, loss= 1.073, mse= 0.876, kld= 1.967
      val_loss= 1.038, val_mse= 0.716, val_kld= 3.227
Epoch= 190/200, loss= 1.068, mse= 0.878, kld= 1.895
      val_loss= 1.712, val_mse= 1.384, val_kld= 3.279
Epoch= 191/200, loss= 1.235, mse= 1.035, kld= 2.003
      val_loss= 1.238, val_mse= 0.905, val_kld= 3.330
Epoch= 192/200, loss= 1.087, mse= 0.899, kld= 1.883
      val_loss= 1.077, val_mse= 0.747, val_kld= 3.300
Epoch= 193/200, loss= 1.093, mse= 0.897, kld= 1.965
      val_loss= 1.096, val_mse= 0.775, val_kld= 3.203
Epoch= 194/200, loss= 1.099, mse= 0.911, kld= 1.879
      val_loss= 1.276, val_mse= 0.944, val_kld= 3.315
Epoch= 195/200, loss= 1.045, mse= 0.853, kld= 1.924
      val_loss= 1.133, val_mse= 0.813, val_kld= 3.196
Epoch= 196/200, loss= 1.095, mse= 0.909, kld= 1.854
      val_loss= 1.298, val_mse= 0.974, val_kld= 3.242
Epoch= 197/200, loss= 1.147, mse= 0.960, kld= 1.869
      val_loss= 1.895, val_mse= 1.575, val_kld= 3.203
Epoch= 198/200, loss= 1.136, mse= 0.951, kld= 1.852
      val_loss= 1.258, val_mse= 0.935, val_kld= 3.233
Epoch= 199/200, loss= 1.040, mse= 0.855, kld= 1.845
      val_loss= 1.297, val_mse= 0.976, val_kld= 3.210
Epoch= 200/200, loss= 1.124, mse= 0.935, kld= 1.890
      val_loss= 1.165, val_mse= 0.851, val_kld= 3.144

```

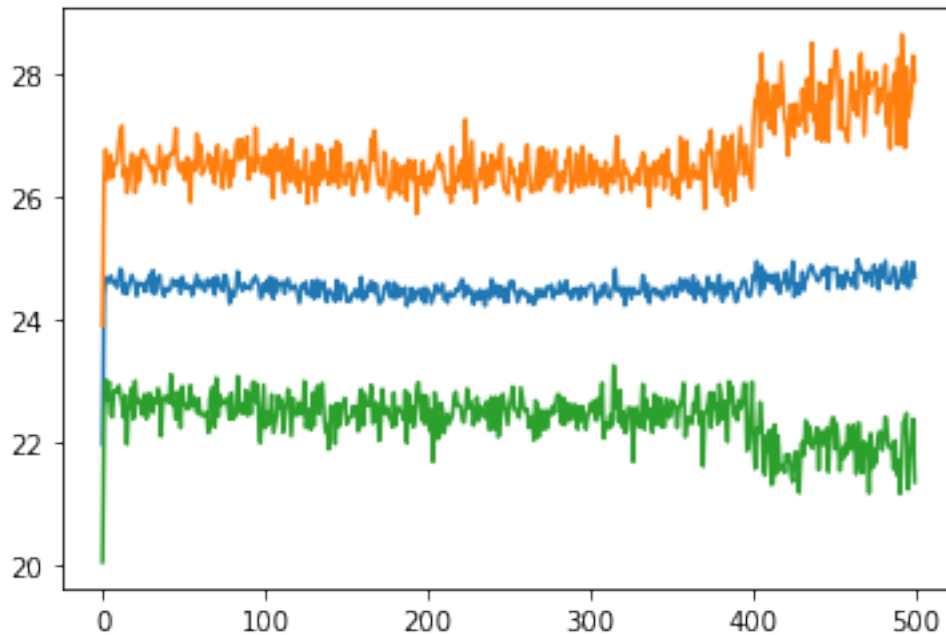
```
[31]: pd.DataFrame(history).plot(figsize=(6, 3), xlabel='Epoch')
```

```
[31]: <AxesSubplot:xlabel='Epoch'>
```



```
[32]: # x_hat = dkf.generate(x_train)
# x_hat, x_025, x_975 = dkf.filter(x_train)
x_hat, x_025, x_975 = dkf.predict(y_data, 100)
x_hat = x_hat.detach().numpy()[0]
x_025 = x_025.detach().numpy()[0]
x_975 = x_975.detach().numpy()[0]
plt.plot(x_hat)
plt.plot(x_975)
plt.plot(x_025)
```

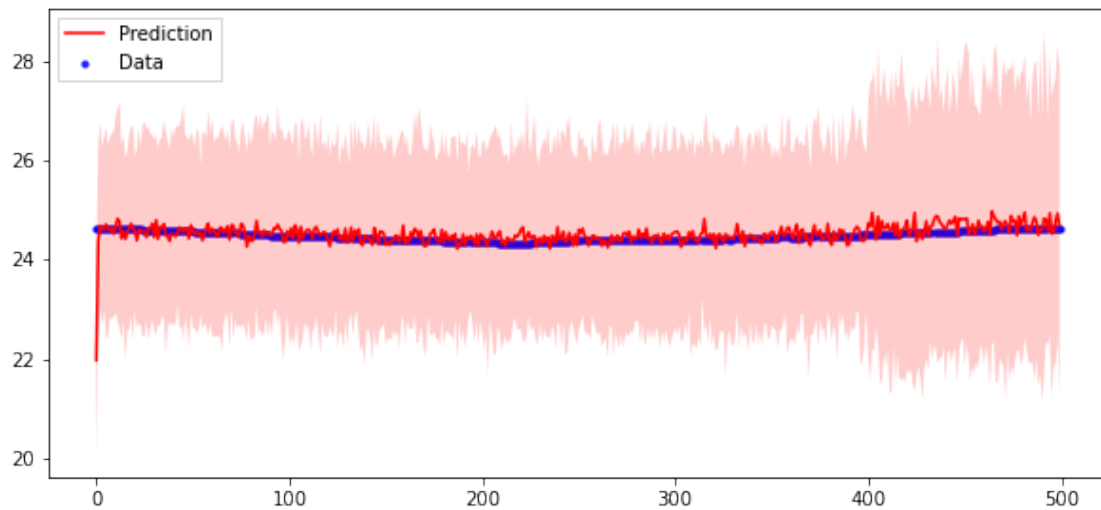
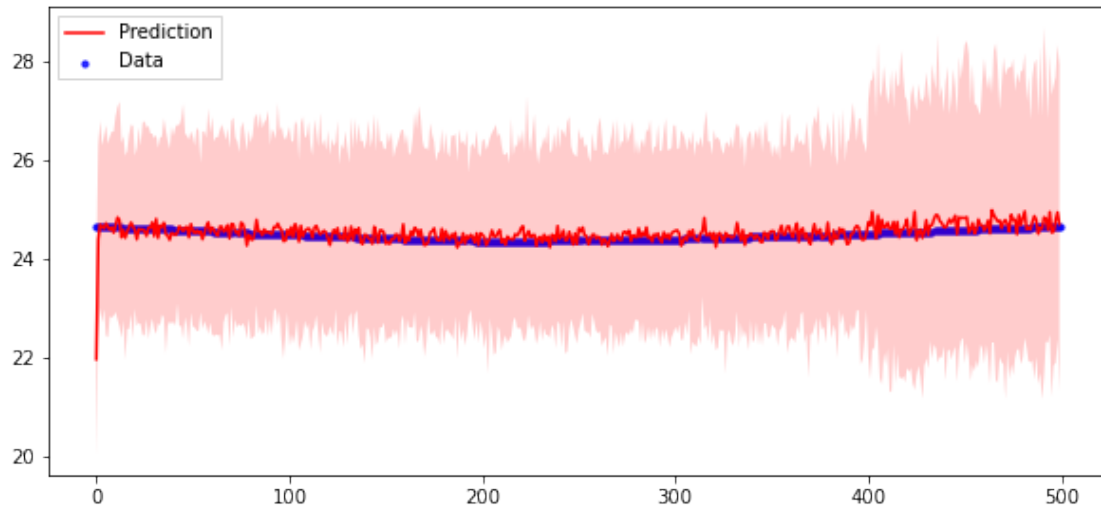
[32]: [<matplotlib.lines.Line2D at 0x7f8d090ed880>]



```
[33]: fig, ax = plt.subplots(2, figsize=(10, 10))

for i, axi in enumerate(ax):
    axi.scatter(
        np.arange(y.shape[0]),
        y[:, 0], s=10, alpha=0.8, label='Data', c='b')
    axi.plot(x_hat[:, 0], label='Prediction', c='r')
    axi.fill_between(np.arange(x_hat.shape[0]), x_025[:, 0], x_975[:, 0],
                    facecolor='r', alpha=0.2)

    axi.legend(loc='upper left', fancybox=False)
plt.show()
```



[34]: #####

[]:

[]:

[]:

[]:

[35]: #####

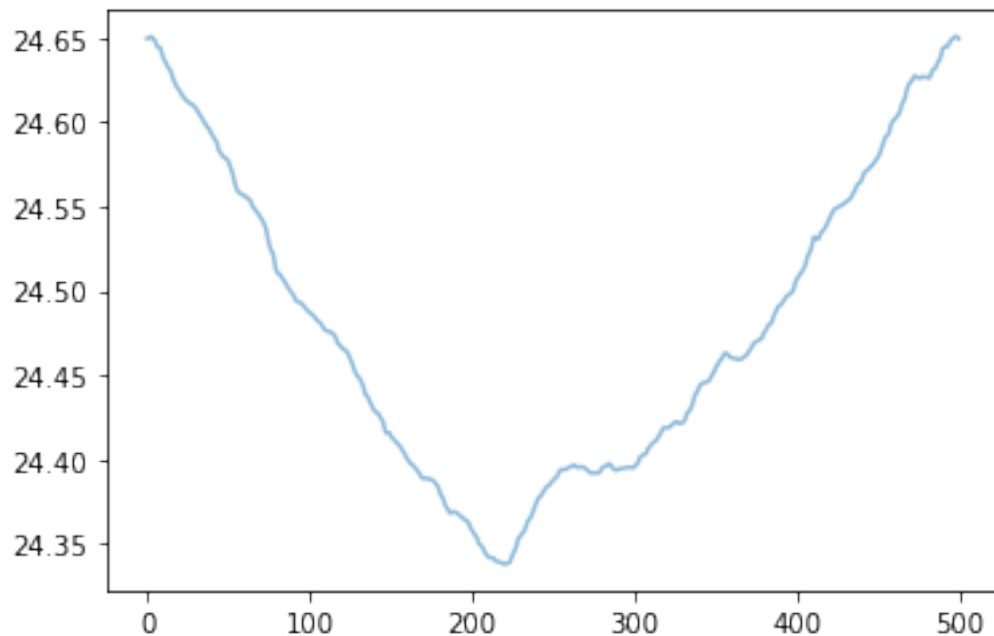
[36]: #TUTAJ TRENUJEMY DKF'a dla 1szego WORKOUTU 3 na RAZ LON LAT ALT

```
[37]: # Plot ithmeasurement x longitude
```

```
#print(data_endo[0].keys())
y=np.asarray(data_endo[0]['longitude'])
z=np.asarray(data_endo[0]['latitude'])
x = []
#print(len(x))
data_t = []
for i in range(len(y)):
    x.append(i)
    data_t.append((x[i], y[i]))
#print(data_t)
data_t = np.asarray(data_t)
#colors = np.random.rand(N)
#area = (30 * np.random.rand(N))**2 # 0 to 15 point radii

plt.plot(x, y, alpha=0.5)
plt.show()
#print(y.shape)
```

```
first_workout_data = np.vstack([np.asarray(data_endo[0]['longitude']), np.
    ↳asarray(data_endo[0]['latitude']), np.asarray(data_endo[0]['altitude'])]).T
print(first_workout_data.shape)
```



(500, 3)

2.4 Trenowanie dla pierwszego treningu po longitude, latitude i altitude

```
[38]: x = torch.FloatTensor(first_workout_data).reshape(1, *first_workout_data.shape)
      #print(x)
      x_train = torch.FloatTensor(first_workout_data[:450]).reshape(1, 450,
      ↪first_workout_data.shape[1])
      #print(x_train)
      x_val = torch.FloatTensor(first_workout_data[450:500]).reshape(1, 50,
      ↪first_workout_data.shape[1])
      #print(x_val)
```

```
[39]: dkf = DKF(input_dim=3, z_dim=15, rnn_dim=15, trans_dim=15, emission_dim=15)
```

```
[40]: history = dkf.fit(x_train, x_val, num_epochs=200, annealing_factor=0.1)
```

```
Epoch= 1/200, loss= 2135.828, mse= 2124.516, kld= 113.120
      val_loss= 1661.788, val_mse= 1658.344, val_kld= 34.435
Epoch= 2/200, loss= 2083.150, mse= 2076.909, kld= 62.406
      val_loss= 1604.040, val_mse= 1599.497, val_kld= 45.425
Epoch= 3/200, loss= 2002.598, mse= 1993.231, kld= 93.672
      val_loss= 1538.170, val_mse= 1531.325, val_kld= 68.454
Epoch= 4/200, loss= 1855.782, mse= 1804.994, kld= 507.883
      val_loss= 1487.258, val_mse= 1483.345, val_kld= 39.137
Epoch= 5/200, loss= 1789.791, mse= 1783.391, kld= 63.999
      val_loss= 1382.425, val_mse= 1379.060, val_kld= 33.649
Epoch= 6/200, loss= 1628.937, mse= 1624.718, kld= 42.186
      val_loss= 1206.423, val_mse= 1203.521, val_kld= 29.019
Epoch= 7/200, loss= 1368.593, mse= 1363.713, kld= 48.804
      val_loss= 932.989, val_mse= 928.364, val_kld= 46.250
Epoch= 8/200, loss= 984.407, mse= 878.437, kld= 1059.704
      val_loss= 764.817, val_mse= 761.530, val_kld= 32.865
Epoch= 9/200, loss= 785.207, mse= 737.106, kld= 481.017
      val_loss= 625.285, val_mse= 622.041, val_kld= 32.443
Epoch= 10/200, loss= 619.345, mse= 610.822, kld= 85.236
      val_loss= 498.440, val_mse= 495.775, val_kld= 26.652
Epoch= 11/200, loss= 417.217, mse= 413.766, kld= 34.511
      val_loss= 322.047, val_mse= 319.151, val_kld= 28.962
Epoch= 12/200, loss= 255.803, mse= 252.819, kld= 29.845
      val_loss= 219.583, val_mse= 216.712, val_kld= 28.706
Epoch= 13/200, loss= 172.392, mse= 169.473, kld= 29.192
      val_loss= 170.135, val_mse= 167.326, val_kld= 28.090
Epoch= 14/200, loss= 169.390, mse= 166.642, kld= 27.476
```

```

    val_loss= 159.342, val_mse= 156.605, val_kld= 27.370
Epoch= 15/200, loss= 150.465, mse= 147.925, kld= 25.408
    val_loss= 137.504, val_mse= 135.058, val_kld= 24.460
Epoch= 16/200, loss= 86.821, mse= 84.477, kld= 23.444
    val_loss= 141.011, val_mse= 138.753, val_kld= 22.572
Epoch= 17/200, loss= 57.023, mse= 54.855, kld= 21.677
    val_loss= 149.042, val_mse= 146.894, val_kld= 21.479
Epoch= 18/200, loss= 65.199, mse= 63.156, kld= 20.428
    val_loss= 173.945, val_mse= 171.927, val_kld= 20.179
Epoch= 19/200, loss= 85.352, mse= 83.402, kld= 19.499
    val_loss= 168.756, val_mse= 166.743, val_kld= 20.127
Epoch= 20/200, loss= 89.542, mse= 87.617, kld= 19.247
    val_loss= 152.578, val_mse= 150.584, val_kld= 19.937
Epoch= 21/200, loss= 81.751, mse= 79.808, kld= 19.426
    val_loss= 127.987, val_mse= 125.918, val_kld= 20.684
Epoch= 22/200, loss= 73.193, mse= 71.208, kld= 19.852
    val_loss= 116.534, val_mse= 114.445, val_kld= 20.891
Epoch= 23/200, loss= 76.559, mse= 74.535, kld= 20.245
    val_loss= 113.693, val_mse= 111.590, val_kld= 21.023
Epoch= 24/200, loss= 84.423, mse= 82.395, kld= 20.285
    val_loss= 101.839, val_mse= 99.732, val_kld= 21.069
Epoch= 25/200, loss= 79.663, mse= 77.661, kld= 20.026
    val_loss= 96.886, val_mse= 94.874, val_kld= 20.120
Epoch= 26/200, loss= 65.751, mse= 63.820, kld= 19.311
    val_loss= 98.964, val_mse= 96.978, val_kld= 19.860
Epoch= 27/200, loss= 58.488, mse= 56.618, kld= 18.698
    val_loss= 103.982, val_mse= 102.101, val_kld= 18.815
Epoch= 28/200, loss= 59.362, mse= 57.570, kld= 17.915
    val_loss= 106.182, val_mse= 104.324, val_kld= 18.586
Epoch= 29/200, loss= 57.094, mse= 55.354, kld= 17.401
    val_loss= 95.532, val_mse= 93.701, val_kld= 18.315
Epoch= 30/200, loss= 53.304, mse= 51.575, kld= 17.285
    val_loss= 87.352, val_mse= 85.504, val_kld= 18.474
Epoch= 31/200, loss= 47.872, mse= 46.158, kld= 17.139
    val_loss= 81.840, val_mse= 79.964, val_kld= 18.758
Epoch= 32/200, loss= 44.948, mse= 43.230, kld= 17.181
    val_loss= 79.488, val_mse= 77.628, val_kld= 18.593
Epoch= 33/200, loss= 47.327, mse= 45.645, kld= 16.816
    val_loss= 84.670, val_mse= 82.837, val_kld= 18.331
Epoch= 34/200, loss= 49.205, mse= 47.547, kld= 16.587
    val_loss= 84.940, val_mse= 83.121, val_kld= 18.191
Epoch= 35/200, loss= 47.806, mse= 46.217, kld= 15.889
    val_loss= 86.065, val_mse= 84.299, val_kld= 17.661
Epoch= 36/200, loss= 44.288, mse= 42.768, kld= 15.196
    val_loss= 90.305, val_mse= 88.609, val_kld= 16.961
Epoch= 37/200, loss= 44.927, mse= 43.433, kld= 14.947
    val_loss= 103.342, val_mse= 101.666, val_kld= 16.763
Epoch= 38/200, loss= 47.509, mse= 46.045, kld= 14.644

```

val_loss= 96.582, val_mse= 94.935, val_kld= 16.466
 Epoch= 39/200, loss= 47.998, mse= 46.563, kld= 14.348
 val_loss= 101.500, val_mse= 99.862, val_kld= 16.380
 Epoch= 40/200, loss= 47.057, mse= 45.662, kld= 13.950
 val_loss= 97.505, val_mse= 95.868, val_kld= 16.368
 Epoch= 41/200, loss= 44.125, mse= 42.741, kld= 13.845
 val_loss= 108.576, val_mse= 106.916, val_kld= 16.601
 Epoch= 42/200, loss= 45.314, mse= 43.943, kld= 13.710
 val_loss= 107.700, val_mse= 106.028, val_kld= 16.722
 Epoch= 43/200, loss= 46.003, mse= 44.637, kld= 13.660
 val_loss= 105.067, val_mse= 103.423, val_kld= 16.440
 Epoch= 44/200, loss= 45.213, mse= 43.861, kld= 13.516
 val_loss= 102.476, val_mse= 100.872, val_kld= 16.040
 Epoch= 45/200, loss= 44.038, mse= 42.741, kld= 12.973
 val_loss= 101.358, val_mse= 99.765, val_kld= 15.930
 Epoch= 46/200, loss= 43.586, mse= 42.323, kld= 12.622
 val_loss= 103.832, val_mse= 102.284, val_kld= 15.481
 Epoch= 47/200, loss= 42.113, mse= 40.897, kld= 12.155
 val_loss= 101.598, val_mse= 100.050, val_kld= 15.480
 Epoch= 48/200, loss= 43.974, mse= 42.763, kld= 12.113
 val_loss= 100.405, val_mse= 98.883, val_kld= 15.220
 Epoch= 49/200, loss= 42.490, mse= 41.316, kld= 11.742
 val_loss= 100.181, val_mse= 98.639, val_kld= 15.414
 Epoch= 50/200, loss= 40.844, mse= 39.686, kld= 11.585
 val_loss= 95.038, val_mse= 93.511, val_kld= 15.270
 Epoch= 51/200, loss= 41.958, mse= 40.819, kld= 11.394
 val_loss= 95.245, val_mse= 93.655, val_kld= 15.898
 Epoch= 52/200, loss= 42.112, mse= 40.963, kld= 11.496
 val_loss= 96.962, val_mse= 95.411, val_kld= 15.506
 Epoch= 53/200, loss= 41.225, mse= 40.121, kld= 11.042
 val_loss= 94.664, val_mse= 93.145, val_kld= 15.191
 Epoch= 54/200, loss= 41.845, mse= 40.756, kld= 10.886
 val_loss= 94.162, val_mse= 92.681, val_kld= 14.813
 Epoch= 55/200, loss= 41.504, mse= 40.441, kld= 10.629
 val_loss= 90.405, val_mse= 88.908, val_kld= 14.975
 Epoch= 56/200, loss= 41.338, mse= 40.300, kld= 10.380
 val_loss= 91.360, val_mse= 89.901, val_kld= 14.583
 Epoch= 57/200, loss= 42.423, mse= 41.418, kld= 10.042
 val_loss= 88.448, val_mse= 86.997, val_kld= 14.507
 Epoch= 58/200, loss= 41.909, mse= 40.891, kld= 10.185
 val_loss= 88.079, val_mse= 86.573, val_kld= 15.060
 Epoch= 59/200, loss= 41.373, mse= 40.348, kld= 10.250
 val_loss= 87.824, val_mse= 86.402, val_kld= 14.221
 Epoch= 60/200, loss= 41.333, mse= 40.340, kld= 9.933
 val_loss= 88.446, val_mse= 86.980, val_kld= 14.655
 Epoch= 61/200, loss= 41.461, mse= 40.478, kld= 9.835
 val_loss= 84.148, val_mse= 82.680, val_kld= 14.681
 Epoch= 62/200, loss= 40.878, mse= 39.906, kld= 9.728

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        val_loss= 86.079, val_mse= 84.628, val_kld= 14.506
Epoch= 63/200, loss= 41.035, mse= 40.066, kld= 9.690
        val_loss= 84.562, val_mse= 83.176, val_kld= 13.861
Epoch= 64/200, loss= 41.061, mse= 40.124, kld= 9.369
        val_loss= 85.768, val_mse= 84.356, val_kld= 14.128
Epoch= 65/200, loss= 40.792, mse= 39.862, kld= 9.294
        val_loss= 81.808, val_mse= 80.439, val_kld= 13.684
Epoch= 66/200, loss= 41.369, mse= 40.461, kld= 9.080
        val_loss= 84.622, val_mse= 83.227, val_kld= 13.952
Epoch= 67/200, loss= 40.975, mse= 40.068, kld= 9.064
        val_loss= 89.995, val_mse= 88.604, val_kld= 13.910
Epoch= 68/200, loss= 40.661, mse= 39.748, kld= 9.137
        val_loss= 89.304, val_mse= 87.934, val_kld= 13.704
Epoch= 69/200, loss= 40.537, mse= 39.639, kld= 8.973
        val_loss= 91.425, val_mse= 90.031, val_kld= 13.937
Epoch= 70/200, loss= 39.734, mse= 38.815, kld= 9.193
        val_loss= 90.977, val_mse= 89.625, val_kld= 13.523
Epoch= 71/200, loss= 40.449, mse= 39.561, kld= 8.876
        val_loss= 88.833, val_mse= 87.488, val_kld= 13.451
Epoch= 72/200, loss= 40.529, mse= 39.663, kld= 8.660
        val_loss= 92.291, val_mse= 90.970, val_kld= 13.211
Epoch= 73/200, loss= 39.816, mse= 38.948, kld= 8.674
        val_loss= 93.724, val_mse= 92.414, val_kld= 13.101
Epoch= 74/200, loss= 39.923, mse= 39.067, kld= 8.559
        val_loss= 94.353, val_mse= 93.033, val_kld= 13.202
Epoch= 75/200, loss= 40.367, mse= 39.511, kld= 8.564
        val_loss= 91.683, val_mse= 90.353, val_kld= 13.308
Epoch= 76/200, loss= 40.922, mse= 40.075, kld= 8.470
        val_loss= 92.561, val_mse= 91.267, val_kld= 12.943
Epoch= 77/200, loss= 39.477, mse= 38.646, kld= 8.310
        val_loss= 92.964, val_mse= 91.624, val_kld= 13.404
Epoch= 78/200, loss= 40.049, mse= 39.211, kld= 8.386
        val_loss= 91.984, val_mse= 90.703, val_kld= 12.813
Epoch= 79/200, loss= 40.025, mse= 39.200, kld= 8.246
        val_loss= 90.182, val_mse= 88.884, val_kld= 12.974
Epoch= 80/200, loss= 40.248, mse= 39.422, kld= 8.265
        val_loss= 91.144, val_mse= 89.862, val_kld= 12.825
Epoch= 81/200, loss= 40.120, mse= 39.308, kld= 8.120
        val_loss= 93.185, val_mse= 91.902, val_kld= 12.829
Epoch= 82/200, loss= 40.315, mse= 39.512, kld= 8.037
        val_loss= 87.906, val_mse= 86.631, val_kld= 12.755
Epoch= 83/200, loss= 39.882, mse= 39.089, kld= 7.930
        val_loss= 89.042, val_mse= 87.779, val_kld= 12.635
Epoch= 84/200, loss= 40.017, mse= 39.228, kld= 7.894
        val_loss= 89.639, val_mse= 88.367, val_kld= 12.720
Epoch= 85/200, loss= 40.405, mse= 39.628, kld= 7.776
        val_loss= 86.049, val_mse= 84.773, val_kld= 12.759
Epoch= 86/200, loss= 39.572, mse= 38.788, kld= 7.846

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    val_loss= 90.490, val_mse= 89.278, val_kld= 12.119
Epoch= 87/200, loss= 40.134, mse= 39.353, kld= 7.807
    val_loss= 92.157, val_mse= 90.922, val_kld= 12.346
Epoch= 88/200, loss= 39.481, mse= 38.709, kld= 7.726
    val_loss= 85.512, val_mse= 84.309, val_kld= 12.026
Epoch= 89/200, loss= 40.348, mse= 39.590, kld= 7.582
    val_loss= 87.716, val_mse= 86.554, val_kld= 11.617
Epoch= 90/200, loss= 40.233, mse= 39.492, kld= 7.416
    val_loss= 90.315, val_mse= 89.130, val_kld= 11.849
Epoch= 91/200, loss= 39.490, mse= 38.748, kld= 7.424
    val_loss= 88.150, val_mse= 86.960, val_kld= 11.907
Epoch= 92/200, loss= 39.774, mse= 39.031, kld= 7.432
    val_loss= 88.374, val_mse= 87.211, val_kld= 11.624
Epoch= 93/200, loss= 39.579, mse= 38.854, kld= 7.253
    val_loss= 90.899, val_mse= 89.683, val_kld= 12.164
Epoch= 94/200, loss= 40.240, mse= 39.512, kld= 7.282
    val_loss= 90.532, val_mse= 89.351, val_kld= 11.813
Epoch= 95/200, loss= 40.749, mse= 40.017, kld= 7.327
    val_loss= 87.167, val_mse= 85.978, val_kld= 11.891
Epoch= 96/200, loss= 39.474, mse= 38.762, kld= 7.117
    val_loss= 89.642, val_mse= 88.468, val_kld= 11.740
Epoch= 97/200, loss= 39.275, mse= 38.568, kld= 7.073
    val_loss= 86.512, val_mse= 85.392, val_kld= 11.200
Epoch= 98/200, loss= 39.928, mse= 39.226, kld= 7.023
    val_loss= 88.996, val_mse= 87.856, val_kld= 11.405
Epoch= 99/200, loss= 40.166, mse= 39.481, kld= 6.846
    val_loss= 90.964, val_mse= 89.827, val_kld= 11.364
Epoch= 100/200, loss= 39.573, mse= 38.890, kld= 6.827
    val_loss= 87.168, val_mse= 86.065, val_kld= 11.026
Epoch= 101/200, loss= 39.819, mse= 39.127, kld= 6.919
    val_loss= 90.524, val_mse= 89.424, val_kld= 11.000
Epoch= 102/200, loss= 40.279, mse= 39.601, kld= 6.784
    val_loss= 90.604, val_mse= 89.497, val_kld= 11.075
Epoch= 103/200, loss= 39.589, mse= 38.931, kld= 6.580
    val_loss= 90.041, val_mse= 88.951, val_kld= 10.897
Epoch= 104/200, loss= 39.398, mse= 38.741, kld= 6.575
    val_loss= 86.759, val_mse= 85.679, val_kld= 10.795
Epoch= 105/200, loss= 39.588, mse= 38.942, kld= 6.465
    val_loss= 90.415, val_mse= 89.312, val_kld= 11.030
Epoch= 106/200, loss= 38.487, mse= 37.846, kld= 6.412
    val_loss= 88.218, val_mse= 87.144, val_kld= 10.745
Epoch= 107/200, loss= 39.057, mse= 38.416, kld= 6.416
    val_loss= 87.206, val_mse= 86.163, val_kld= 10.430
Epoch= 108/200, loss= 39.496, mse= 38.864, kld= 6.316
    val_loss= 87.953, val_mse= 86.876, val_kld= 10.776
Epoch= 109/200, loss= 39.639, mse= 39.002, kld= 6.363
    val_loss= 89.423, val_mse= 88.356, val_kld= 10.662
Epoch= 110/200, loss= 39.391, mse= 38.772, kld= 6.189

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        val_loss= 90.433, val_mse= 89.373, val_kld= 10.599
Epoch= 111/200, loss= 39.346, mse= 38.729, kld= 6.166
        val_loss= 91.132, val_mse= 90.078, val_kld= 10.545
Epoch= 112/200, loss= 39.319, mse= 38.715, kld= 6.043
        val_loss= 90.682, val_mse= 89.640, val_kld= 10.422
Epoch= 113/200, loss= 39.188, mse= 38.582, kld= 6.064
        val_loss= 85.263, val_mse= 84.198, val_kld= 10.644
Epoch= 114/200, loss= 40.195, mse= 39.579, kld= 6.154
        val_loss= 90.813, val_mse= 89.790, val_kld= 10.231
Epoch= 115/200, loss= 39.764, mse= 39.170, kld= 5.938
        val_loss= 88.208, val_mse= 87.171, val_kld= 10.371
Epoch= 116/200, loss= 39.393, mse= 38.799, kld= 5.943
        val_loss= 88.059, val_mse= 87.057, val_kld= 10.020
Epoch= 117/200, loss= 38.781, mse= 38.182, kld= 5.992
        val_loss= 86.132, val_mse= 85.107, val_kld= 10.249
Epoch= 118/200, loss= 39.314, mse= 38.727, kld= 5.871
        val_loss= 86.883, val_mse= 85.835, val_kld= 10.480
Epoch= 119/200, loss= 39.702, mse= 39.115, kld= 5.875
        val_loss= 87.204, val_mse= 86.207, val_kld= 9.969
Epoch= 120/200, loss= 39.221, mse= 38.627, kld= 5.938
        val_loss= 87.097, val_mse= 86.065, val_kld= 10.323
Epoch= 121/200, loss= 39.450, mse= 38.881, kld= 5.691
        val_loss= 89.922, val_mse= 88.943, val_kld= 9.787
Epoch= 122/200, loss= 38.845, mse= 38.271, kld= 5.735
        val_loss= 90.300, val_mse= 89.291, val_kld= 10.098
Epoch= 123/200, loss= 39.926, mse= 39.370, kld= 5.560
        val_loss= 88.781, val_mse= 87.799, val_kld= 9.823
Epoch= 124/200, loss= 39.005, mse= 38.449, kld= 5.564
        val_loss= 87.449, val_mse= 86.479, val_kld= 9.704
Epoch= 125/200, loss= 38.999, mse= 38.446, kld= 5.532
        val_loss= 88.770, val_mse= 87.817, val_kld= 9.533
Epoch= 126/200, loss= 38.686, mse= 38.142, kld= 5.435
        val_loss= 87.356, val_mse= 86.416, val_kld= 9.397
Epoch= 127/200, loss= 39.189, mse= 38.646, kld= 5.431
        val_loss= 89.551, val_mse= 88.605, val_kld= 9.457
Epoch= 128/200, loss= 38.984, mse= 38.457, kld= 5.269
        val_loss= 88.410, val_mse= 87.447, val_kld= 9.623
Epoch= 129/200, loss= 39.421, mse= 38.882, kld= 5.391
        val_loss= 90.620, val_mse= 89.721, val_kld= 8.993
Epoch= 130/200, loss= 38.404, mse= 37.886, kld= 5.181
        val_loss= 85.973, val_mse= 85.048, val_kld= 9.248
Epoch= 131/200, loss= 39.078, mse= 38.554, kld= 5.237
        val_loss= 89.950, val_mse= 89.040, val_kld= 9.101
Epoch= 132/200, loss= 39.409, mse= 38.903, kld= 5.062
        val_loss= 89.931, val_mse= 89.012, val_kld= 9.188
Epoch= 133/200, loss= 39.335, mse= 38.832, kld= 5.032
        val_loss= 87.051, val_mse= 86.130, val_kld= 9.209
Epoch= 134/200, loss= 39.442, mse= 38.937, kld= 5.051

```

val_loss= 86.608, val_mse= 85.609, val_kld= 9.985
 Epoch= 135/200, loss= 38.243, mse= 37.729, kld= 5.135
 val_loss= 86.301, val_mse= 85.433, val_kld= 8.675
 Epoch= 136/200, loss= 38.383, mse= 37.884, kld= 4.991
 val_loss= 88.561, val_mse= 87.670, val_kld= 8.910
 Epoch= 137/200, loss= 39.296, mse= 38.797, kld= 4.992
 val_loss= 89.536, val_mse= 88.621, val_kld= 9.142
 Epoch= 138/200, loss= 38.581, mse= 38.081, kld= 5.002
 val_loss= 89.086, val_mse= 88.226, val_kld= 8.593
 Epoch= 139/200, loss= 39.170, mse= 38.680, kld= 4.901
 val_loss= 89.363, val_mse= 88.443, val_kld= 9.193
 Epoch= 140/200, loss= 39.269, mse= 38.777, kld= 4.919
 val_loss= 88.576, val_mse= 87.723, val_kld= 8.533
 Epoch= 141/200, loss= 39.013, mse= 38.513, kld= 4.999
 val_loss= 89.738, val_mse= 88.850, val_kld= 8.880
 Epoch= 142/200, loss= 38.951, mse= 38.457, kld= 4.944
 val_loss= 89.405, val_mse= 88.543, val_kld= 8.613
 Epoch= 143/200, loss= 38.451, mse= 37.957, kld= 4.941
 val_loss= 86.834, val_mse= 85.971, val_kld= 8.633
 Epoch= 144/200, loss= 38.763, mse= 38.278, kld= 4.854
 val_loss= 88.399, val_mse= 87.573, val_kld= 8.269
 Epoch= 145/200, loss= 38.855, mse= 38.370, kld= 4.851
 val_loss= 89.638, val_mse= 88.777, val_kld= 8.608
 Epoch= 146/200, loss= 38.869, mse= 38.380, kld= 4.892
 val_loss= 90.195, val_mse= 89.336, val_kld= 8.591
 Epoch= 147/200, loss= 39.259, mse= 38.759, kld= 4.993
 val_loss= 89.594, val_mse= 88.783, val_kld= 8.110
 Epoch= 148/200, loss= 38.860, mse= 38.378, kld= 4.819
 val_loss= 88.132, val_mse= 87.307, val_kld= 8.245
 Epoch= 149/200, loss= 38.466, mse= 37.993, kld= 4.733
 val_loss= 87.378, val_mse= 86.508, val_kld= 8.699
 Epoch= 150/200, loss= 39.116, mse= 38.637, kld= 4.784
 val_loss= 87.474, val_mse= 86.629, val_kld= 8.448
 Epoch= 151/200, loss= 38.858, mse= 38.374, kld= 4.842
 val_loss= 89.879, val_mse= 89.040, val_kld= 8.390
 Epoch= 152/200, loss= 39.032, mse= 38.556, kld= 4.763
 val_loss= 89.260, val_mse= 88.445, val_kld= 8.153
 Epoch= 153/200, loss= 38.817, mse= 38.324, kld= 4.932
 val_loss= 88.900, val_mse= 88.088, val_kld= 8.123
 Epoch= 154/200, loss= 38.719, mse= 38.244, kld= 4.755
 val_loss= 87.929, val_mse= 87.116, val_kld= 8.134
 Epoch= 155/200, loss= 37.987, mse= 37.515, kld= 4.726
 val_loss= 88.203, val_mse= 87.432, val_kld= 7.707
 Epoch= 156/200, loss= 39.036, mse= 38.567, kld= 4.695
 val_loss= 87.261, val_mse= 86.453, val_kld= 8.079
 Epoch= 157/200, loss= 38.983, mse= 38.512, kld= 4.712
 val_loss= 88.118, val_mse= 87.360, val_kld= 7.579
 Epoch= 158/200, loss= 39.098, mse= 38.614, kld= 4.839

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        val_loss= 91.286, val_mse= 90.537, val_kld= 7.492
Epoch= 159/200, loss= 38.755, mse= 38.290, kld= 4.652
        val_loss= 88.770, val_mse= 87.982, val_kld= 7.880
Epoch= 160/200, loss= 38.522, mse= 38.063, kld= 4.594
        val_loss= 89.625, val_mse= 88.893, val_kld= 7.315
Epoch= 161/200, loss= 38.264, mse= 37.793, kld= 4.708
        val_loss= 88.975, val_mse= 88.219, val_kld= 7.557
Epoch= 162/200, loss= 38.630, mse= 38.157, kld= 4.735
        val_loss= 88.473, val_mse= 87.709, val_kld= 7.636
Epoch= 163/200, loss= 38.925, mse= 38.468, kld= 4.572
        val_loss= 85.450, val_mse= 84.722, val_kld= 7.283
Epoch= 164/200, loss= 38.190, mse= 37.733, kld= 4.575
        val_loss= 88.052, val_mse= 87.281, val_kld= 7.709
Epoch= 165/200, loss= 38.473, mse= 38.010, kld= 4.633
        val_loss= 88.089, val_mse= 87.381, val_kld= 7.085
Epoch= 166/200, loss= 38.901, mse= 38.442, kld= 4.591
        val_loss= 88.746, val_mse= 88.039, val_kld= 7.069
Epoch= 167/200, loss= 38.713, mse= 38.252, kld= 4.611
        val_loss= 87.352, val_mse= 86.626, val_kld= 7.256
Epoch= 168/200, loss= 38.496, mse= 38.044, kld= 4.524
        val_loss= 88.602, val_mse= 87.868, val_kld= 7.340
Epoch= 169/200, loss= 38.452, mse= 37.995, kld= 4.572
        val_loss= 87.243, val_mse= 86.543, val_kld= 6.999
Epoch= 170/200, loss= 38.478, mse= 38.000, kld= 4.779
        val_loss= 89.494, val_mse= 88.742, val_kld= 7.523
Epoch= 171/200, loss= 38.306, mse= 37.828, kld= 4.781
        val_loss= 88.813, val_mse= 88.111, val_kld= 7.011
Epoch= 172/200, loss= 38.678, mse= 38.197, kld= 4.810
        val_loss= 87.563, val_mse= 86.834, val_kld= 7.297
Epoch= 173/200, loss= 38.722, mse= 38.268, kld= 4.534
        val_loss= 86.715, val_mse= 86.060, val_kld= 6.546
Epoch= 174/200, loss= 38.115, mse= 37.663, kld= 4.514
        val_loss= 88.462, val_mse= 87.759, val_kld= 7.035
Epoch= 175/200, loss= 38.717, mse= 38.254, kld= 4.624
        val_loss= 87.075, val_mse= 86.409, val_kld= 6.657
Epoch= 176/200, loss= 38.352, mse= 37.896, kld= 4.559
        val_loss= 87.941, val_mse= 87.260, val_kld= 6.802
Epoch= 177/200, loss= 38.528, mse= 38.069, kld= 4.598
        val_loss= 86.784, val_mse= 86.100, val_kld= 6.836
Epoch= 178/200, loss= 38.577, mse= 38.128, kld= 4.492
        val_loss= 89.003, val_mse= 88.365, val_kld= 6.376
Epoch= 179/200, loss= 38.504, mse= 38.076, kld= 4.282
        val_loss= 87.881, val_mse= 87.197, val_kld= 6.837
Epoch= 180/200, loss= 38.501, mse= 38.057, kld= 4.432
        val_loss= 88.454, val_mse= 87.810, val_kld= 6.440
Epoch= 181/200, loss= 38.928, mse= 38.496, kld= 4.321
        val_loss= 86.055, val_mse= 85.381, val_kld= 6.741
Epoch= 182/200, loss= 39.011, mse= 38.571, kld= 4.398

```



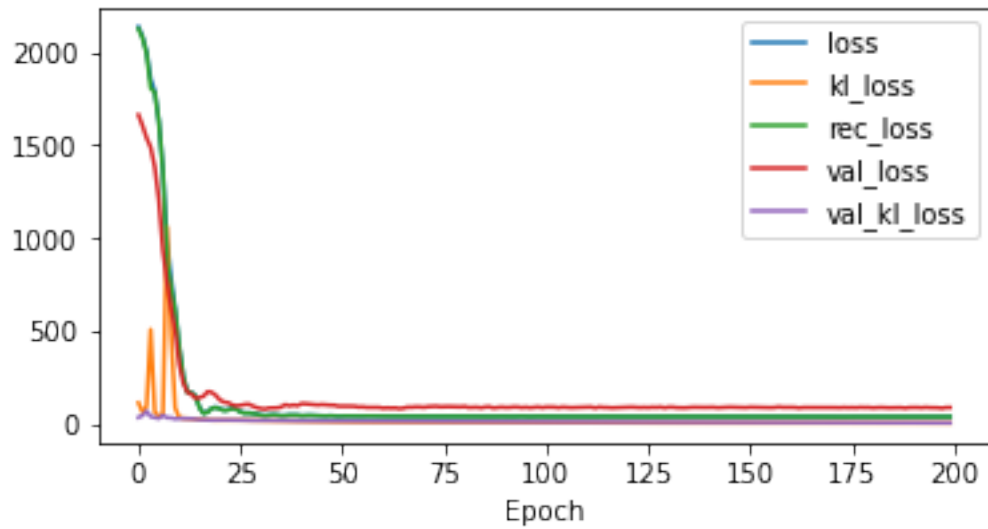
```

        val_loss= 87.869, val_mse= 87.228, val_kld= 6.410
Epoch= 183/200, loss= 39.048, mse= 38.616, kld= 4.316
        val_loss= 88.372, val_mse= 87.738, val_kld= 6.345
Epoch= 184/200, loss= 38.524, mse= 38.099, kld= 4.248
        val_loss= 87.234, val_mse= 86.635, val_kld= 5.987
Epoch= 185/200, loss= 38.606, mse= 38.166, kld= 4.393
        val_loss= 86.366, val_mse= 85.699, val_kld= 6.663
Epoch= 186/200, loss= 38.628, mse= 38.204, kld= 4.238
        val_loss= 86.990, val_mse= 86.350, val_kld= 6.392
Epoch= 187/200, loss= 38.885, mse= 38.460, kld= 4.250
        val_loss= 87.867, val_mse= 87.298, val_kld= 5.687
Epoch= 188/200, loss= 38.496, mse= 38.048, kld= 4.484
        val_loss= 87.384, val_mse= 86.772, val_kld= 6.119
Epoch= 189/200, loss= 38.523, mse= 38.067, kld= 4.558
        val_loss= 84.452, val_mse= 83.797, val_kld= 6.549
Epoch= 190/200, loss= 37.958, mse= 37.522, kld= 4.350
        val_loss= 87.794, val_mse= 87.189, val_kld= 6.050
Epoch= 191/200, loss= 38.795, mse= 38.372, kld= 4.232
        val_loss= 87.981, val_mse= 87.399, val_kld= 5.828
Epoch= 192/200, loss= 38.635, mse= 38.207, kld= 4.276
        val_loss= 88.091, val_mse= 87.530, val_kld= 5.611
Epoch= 193/200, loss= 38.014, mse= 37.583, kld= 4.309
        val_loss= 86.470, val_mse= 85.890, val_kld= 5.803
Epoch= 194/200, loss= 38.117, mse= 37.690, kld= 4.273
        val_loss= 88.875, val_mse= 88.295, val_kld= 5.800
Epoch= 195/200, loss= 38.231, mse= 37.802, kld= 4.293
        val_loss= 87.181, val_mse= 86.615, val_kld= 5.653
Epoch= 196/200, loss= 38.829, mse= 38.401, kld= 4.278
        val_loss= 87.500, val_mse= 86.866, val_kld= 6.334
Epoch= 197/200, loss= 38.281, mse= 37.865, kld= 4.170
        val_loss= 86.564, val_mse= 85.991, val_kld= 5.725
Epoch= 198/200, loss= 38.105, mse= 37.682, kld= 4.227
        val_loss= 83.678, val_mse= 83.114, val_kld= 5.639
Epoch= 199/200, loss= 38.431, mse= 38.015, kld= 4.164
        val_loss= 87.796, val_mse= 87.194, val_kld= 6.022
Epoch= 200/200, loss= 38.455, mse= 38.032, kld= 4.224
        val_loss= 87.723, val_mse= 87.156, val_kld= 5.666

```

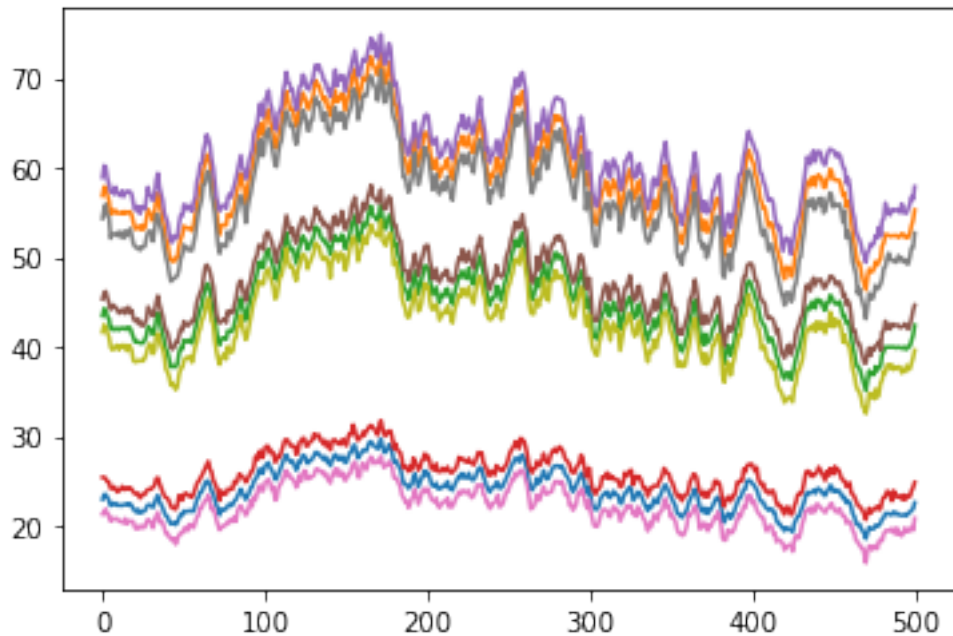
```
[41]: pd.DataFrame(history).plot(figsize=(6, 3), xlabel='Epoch')
```

```
[41]: <AxesSubplot:xlabel='Epoch'>
```



```
[42]: # x_hat = dkf.generate(x_train)
# x_hat, x_025, x_975 = dkf.filter(x_train)
x_hat, x_025, x_975 = dkf.predict(x, 100)
x_hat = x_hat.detach().numpy()[0]
x_025 = x_025.detach().numpy()[0]
x_975 = x_975.detach().numpy()[0]
plt.plot(x_hat)
plt.plot(x_975)
plt.plot(x_025)
```

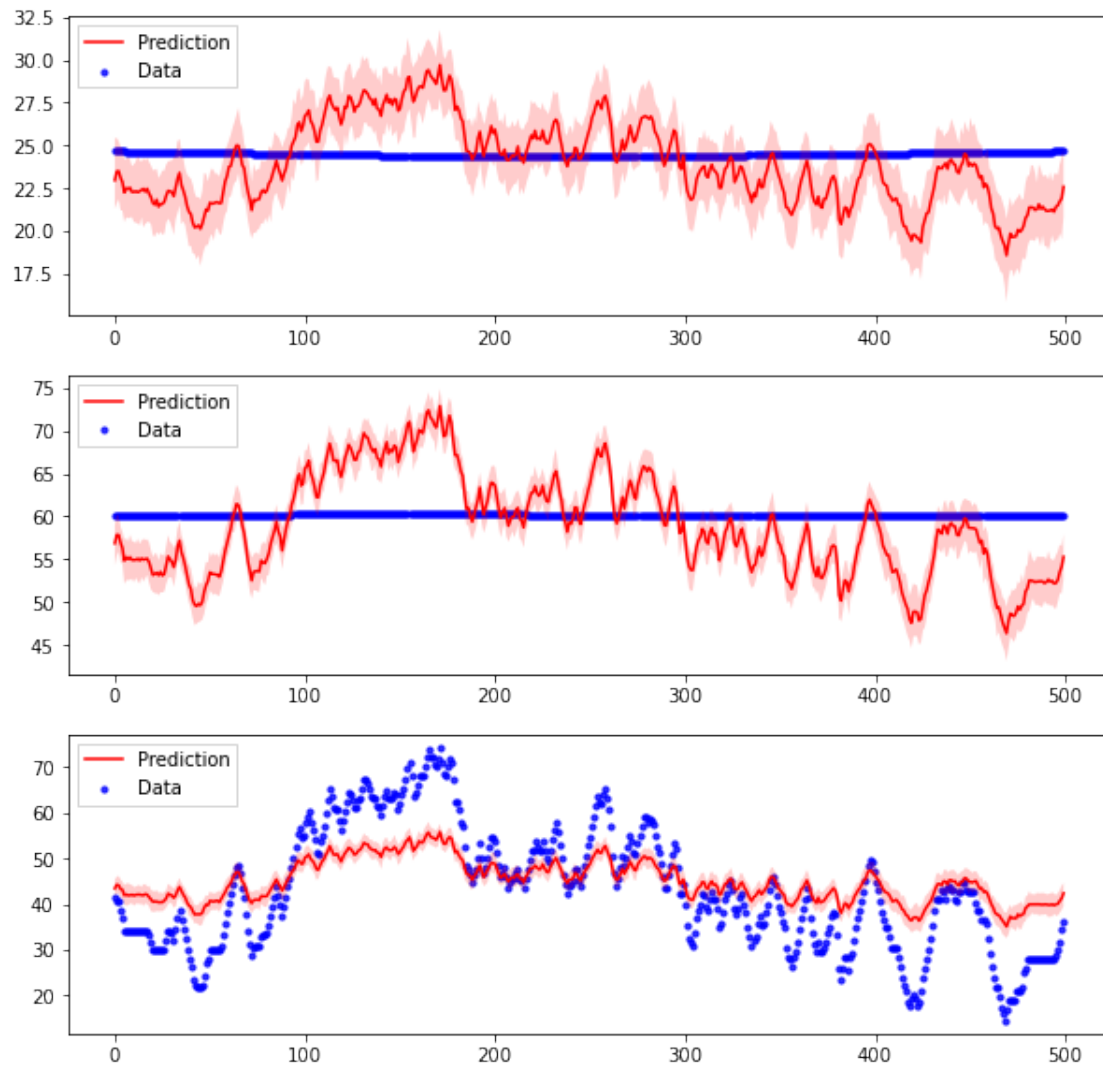
```
[42]: [<matplotlib.lines.Line2D at 0x7f8d585ddcd0>,
<matplotlib.lines.Line2D at 0x7f8d585ddd00>,
<matplotlib.lines.Line2D at 0x7f8d585ddc70>]
```



```
[43]: fig, ax = plt.subplots(3, figsize=(10, 10))

for i, axi in enumerate(ax):
    axi.scatter(
        np.arange(first_workout_data.shape[0]),
        first_workout_data[:, i], s=10, alpha=0.8, label='Data', c='b')
    axi.plot(x_hat[:, i], label='Prediction', c='r')
    axi.fill_between(np.arange(x_hat.shape[0]), x_025[:, i], x_975[:, i],
                     facecolor='r', alpha=0.2)

    axi.legend(loc='upper left', fancybox=False)
plt.show()
```



[44]: #####

[]:

[]:

[]:

[45]: #####

[46]: #TERAZ DKF DLA LONGITUDE DLA 3 PIERWSZYCH WORKOUTOW

2.5 Trenowanie dla 3 pierwszych treningow po longitude

```
[47]: longitude_three_data = np.vstack([np.asarray(data_endo[0]['longitude']), np.  
    ↪asarray(data_endo[1]['longitude']), np.asarray(data_endo[2]['longitude'])]).T  
    #print(first_workout_data.shape)
```

```
[48]: x = torch.FloatTensor(longitude_three_data).reshape(1, *longitude_three_data.  
    ↪shape)  
    #print(x)  
    x_train = torch.FloatTensor(longitude_three_data[:450]).reshape(1, 450, ↪  
    ↪longitude_three_data.shape[1])  
    #print(x_train)  
    x_val = torch.FloatTensor(longitude_three_data[450:500]).reshape(1, 50, ↪  
    ↪longitude_three_data.shape[1])  
    #print(x_val)
```

```
[49]: dkf = DKF(input_dim=3, z_dim=15, rnn_dim=15, trans_dim=15, emission_dim=15)
```

```
[50]: history = dkf.fit(x_train, x_val, num_epochs=200, annealing_factor=0.1)
```

```
Epoch= 1/200, loss= 608.611, mse= 607.615, kld= 9.954  
    val_loss= 606.587, val_mse= 606.012, val_kld= 5.748  
Epoch= 2/200, loss= 602.278, mse= 601.672, kld= 6.053  
    val_loss= 593.739, val_mse= 593.008, val_kld= 7.305  
Epoch= 3/200, loss= 593.585, mse= 592.899, kld= 6.860  
    val_loss= 581.522, val_mse= 580.547, val_kld= 9.752  
Epoch= 4/200, loss= 580.562, mse= 579.585, kld= 9.771  
    val_loss= 559.605, val_mse= 558.057, val_kld= 15.484  
Epoch= 5/200, loss= 551.979, mse= 550.521, kld= 14.585  
    val_loss= 520.882, val_mse= 518.164, val_kld= 27.177  
Epoch= 6/200, loss= 512.349, mse= 509.783, kld= 25.659  
    val_loss= 460.657, val_mse= 455.898, val_kld= 47.589  
Epoch= 7/200, loss= 449.991, mse= 445.293, kld= 46.986  
    val_loss= 383.284, val_mse= 374.130, val_kld= 91.536  
Epoch= 8/200, loss= 372.516, mse= 363.153, kld= 93.625  
    val_loss= 248.303, val_mse= 229.769, val_kld= 185.338  
Epoch= 9/200, loss= 237.407, mse= 219.582, kld= 178.248  
    val_loss= 6593.522, val_mse= 298.860, val_kld= 62946.625  
Epoch= 10/200, loss= 103269.008, mse= 370.854, kld= 1028981.562  
    val_loss= 142.490, val_mse= 125.155, val_kld= 173.356  
Epoch= 11/200, loss= 143.380, mse= 124.656, kld= 187.242  
    val_loss= 146.442, val_mse= 135.571, val_kld= 108.714  
Epoch= 12/200, loss= 140.320, mse= 129.848, kld= 104.722  
    val_loss= 131.633, val_mse= 124.349, val_kld= 72.840  
Epoch= 13/200, loss= 133.447, mse= 125.849, kld= 75.987  
    val_loss= 127.024, val_mse= 120.955, val_kld= 60.698  
Epoch= 14/200, loss= 119.765, mse= 113.623, kld= 61.421
```

```

        val_loss= 117.099, val_mse= 112.195, val_kld= 49.036
Epoch= 15/200, loss= 105.064, mse= 100.124, kld= 49.403
        val_loss= 85.539, val_mse= 81.094, val_kld= 44.449
Epoch= 16/200, loss= 83.972, mse= 79.662, kld= 43.108
        val_loss= 68.209, val_mse= 64.498, val_kld= 37.107
Epoch= 17/200, loss= 62.055, mse= 58.537, kld= 35.181
        val_loss= 51.499, val_mse= 48.291, val_kld= 32.076
Epoch= 18/200, loss= 46.978, mse= 43.954, kld= 30.239
        val_loss= 28.834, val_mse= 26.354, val_kld= 24.799
Epoch= 19/200, loss= 29.358, mse= 26.747, kld= 26.118
        val_loss= 17.774, val_mse= 15.465, val_kld= 23.085
Epoch= 20/200, loss= 21.401, mse= 19.191, kld= 22.099
        val_loss= 20.348, val_mse= 18.297, val_kld= 20.508
Epoch= 21/200, loss= 20.559, mse= 18.633, kld= 19.256
        val_loss= 22.786, val_mse= 20.935, val_kld= 18.508
Epoch= 22/200, loss= 27.890, mse= 26.117, kld= 17.728
        val_loss= 27.108, val_mse= 25.435, val_kld= 16.730
Epoch= 23/200, loss= 35.819, mse= 34.242, kld= 15.765
        val_loss= 34.601, val_mse= 33.237, val_kld= 13.640
Epoch= 24/200, loss= 35.487, mse= 34.069, kld= 14.185
        val_loss= 35.703, val_mse= 34.274, val_kld= 14.289
Epoch= 25/200, loss= 37.585, mse= 36.255, kld= 13.306
        val_loss= 39.292, val_mse= 38.013, val_kld= 12.784
Epoch= 26/200, loss= 31.655, mse= 30.432, kld= 12.237
        val_loss= 19.412, val_mse= 18.367, val_kld= 10.448
Epoch= 27/200, loss= 27.058, mse= 25.966, kld= 10.919
        val_loss= 26.547, val_mse= 25.393, val_kld= 11.535
Epoch= 28/200, loss= 25.146, mse= 24.103, kld= 10.426
        val_loss= 19.503, val_mse= 18.505, val_kld= 9.980
Epoch= 29/200, loss= 21.891, mse= 20.935, kld= 9.564
        val_loss= 21.823, val_mse= 20.917, val_kld= 9.054
Epoch= 30/200, loss= 22.825, mse= 21.921, kld= 9.035
        val_loss= 20.878, val_mse= 20.095, val_kld= 7.830
Epoch= 31/200, loss= 22.786, mse= 21.954, kld= 8.320
        val_loss= 29.191, val_mse= 28.407, val_kld= 7.844
Epoch= 32/200, loss= 23.058, mse= 22.290, kld= 7.680
        val_loss= 20.803, val_mse= 19.996, val_kld= 8.068
Epoch= 33/200, loss= 24.147, mse= 23.425, kld= 7.220
        val_loss= 23.791, val_mse= 23.113, val_kld= 6.776
Epoch= 34/200, loss= 24.725, mse= 24.061, kld= 6.644
        val_loss= 23.888, val_mse= 23.217, val_kld= 6.705
Epoch= 35/200, loss= 23.507, mse= 22.898, kld= 6.093
        val_loss= 23.096, val_mse= 22.449, val_kld= 6.474
Epoch= 36/200, loss= 24.107, mse= 23.506, kld= 6.013
        val_loss= 20.199, val_mse= 19.642, val_kld= 5.570
Epoch= 37/200, loss= 22.080, mse= 21.532, kld= 5.478
        val_loss= 24.531, val_mse= 23.984, val_kld= 5.477
Epoch= 38/200, loss= 21.270, mse= 20.749, kld= 5.208

```

```

    val_loss= 24.839, val_mse= 24.273, val_kld= 5.664
Epoch= 39/200, loss= 19.523, mse= 19.030, kld= 4.927
    val_loss= 16.357, val_mse= 15.861, val_kld= 4.957
Epoch= 40/200, loss= 17.373, mse= 16.887, kld= 4.862
    val_loss= 16.786, val_mse= 16.212, val_kld= 5.733
Epoch= 41/200, loss= 20.603, mse= 20.150, kld= 4.531
    val_loss= 13.577, val_mse= 13.169, val_kld= 4.080
Epoch= 42/200, loss= 18.743, mse= 18.307, kld= 4.357
    val_loss= 16.331, val_mse= 15.891, val_kld= 4.402
Epoch= 43/200, loss= 19.159, mse= 18.732, kld= 4.268
    val_loss= 23.991, val_mse= 23.539, val_kld= 4.523
Epoch= 44/200, loss= 18.602, mse= 18.214, kld= 3.880
    val_loss= 21.325, val_mse= 20.904, val_kld= 4.214
Epoch= 45/200, loss= 17.885, mse= 17.520, kld= 3.648
    val_loss= 18.896, val_mse= 18.496, val_kld= 3.993
Epoch= 46/200, loss= 17.131, mse= 16.779, kld= 3.519
    val_loss= 11.955, val_mse= 11.600, val_kld= 3.547
Epoch= 47/200, loss= 20.494, mse= 20.150, kld= 3.439
    val_loss= 26.294, val_mse= 25.941, val_kld= 3.529
Epoch= 48/200, loss= 18.531, mse= 18.212, kld= 3.193
    val_loss= 18.102, val_mse= 17.778, val_kld= 3.238
Epoch= 49/200, loss= 18.242, mse= 17.921, kld= 3.213
    val_loss= 17.282, val_mse= 16.962, val_kld= 3.200
Epoch= 50/200, loss= 15.762, mse= 15.452, kld= 3.096
    val_loss= 14.798, val_mse= 14.501, val_kld= 2.967
Epoch= 51/200, loss= 15.929, mse= 15.619, kld= 3.103
    val_loss= 14.766, val_mse= 14.493, val_kld= 2.732
Epoch= 52/200, loss= 15.121, mse= 14.836, kld= 2.858
    val_loss= 15.862, val_mse= 15.551, val_kld= 3.108
Epoch= 53/200, loss= 15.572, mse= 15.301, kld= 2.705
    val_loss= 17.317, val_mse= 17.015, val_kld= 3.014
Epoch= 54/200, loss= 17.033, mse= 16.770, kld= 2.629
    val_loss= 23.943, val_mse= 23.665, val_kld= 2.783
Epoch= 55/200, loss= 14.657, mse= 14.406, kld= 2.501
    val_loss= 13.888, val_mse= 13.607, val_kld= 2.803
Epoch= 56/200, loss= 18.302, mse= 18.045, kld= 2.576
    val_loss= 16.973, val_mse= 16.692, val_kld= 2.814
Epoch= 57/200, loss= 15.895, mse= 15.641, kld= 2.535
    val_loss= 17.329, val_mse= 17.062, val_kld= 2.672
Epoch= 58/200, loss= 16.180, mse= 15.936, kld= 2.443
    val_loss= 18.789, val_mse= 18.546, val_kld= 2.432
Epoch= 59/200, loss= 15.880, mse= 15.628, kld= 2.524
    val_loss= 13.780, val_mse= 13.535, val_kld= 2.445
Epoch= 60/200, loss= 15.106, mse= 14.885, kld= 2.214
    val_loss= 16.208, val_mse= 15.967, val_kld= 2.415
Epoch= 61/200, loss= 13.458, mse= 13.237, kld= 2.213
    val_loss= 14.462, val_mse= 14.230, val_kld= 2.320
Epoch= 62/200, loss= 16.681, mse= 16.458, kld= 2.228

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    val_loss= 16.097, val_mse= 15.856, val_kld= 2.411
Epoch= 63/200, loss= 14.787, mse= 14.565, kld= 2.222
    val_loss= 20.450, val_mse= 20.179, val_kld= 2.708
Epoch= 64/200, loss= 13.866, mse= 13.651, kld= 2.151
    val_loss= 16.171, val_mse= 15.923, val_kld= 2.484
Epoch= 65/200, loss= 13.906, mse= 13.698, kld= 2.078
    val_loss= 18.225, val_mse= 17.985, val_kld= 2.399
Epoch= 66/200, loss= 15.072, mse= 14.861, kld= 2.109
    val_loss= 14.312, val_mse= 14.098, val_kld= 2.141
Epoch= 67/200, loss= 14.523, mse= 14.314, kld= 2.094
    val_loss= 14.321, val_mse= 14.092, val_kld= 2.291
Epoch= 68/200, loss= 14.312, mse= 14.105, kld= 2.074
    val_loss= 16.368, val_mse= 16.152, val_kld= 2.166
Epoch= 69/200, loss= 13.765, mse= 13.562, kld= 2.031
    val_loss= 19.452, val_mse= 19.225, val_kld= 2.268
Epoch= 70/200, loss= 13.639, mse= 13.440, kld= 1.990
    val_loss= 12.168, val_mse= 11.932, val_kld= 2.361
Epoch= 71/200, loss= 14.629, mse= 14.427, kld= 2.016
    val_loss= 17.625, val_mse= 17.407, val_kld= 2.185
Epoch= 72/200, loss= 13.733, mse= 13.533, kld= 1.997
    val_loss= 13.455, val_mse= 13.238, val_kld= 2.163
Epoch= 73/200, loss= 11.978, mse= 11.788, kld= 1.893
    val_loss= 12.201, val_mse= 11.990, val_kld= 2.111
Epoch= 74/200, loss= 11.946, mse= 11.755, kld= 1.910
    val_loss= 14.401, val_mse= 14.179, val_kld= 2.219
Epoch= 75/200, loss= 11.741, mse= 11.556, kld= 1.858
    val_loss= 11.905, val_mse= 11.702, val_kld= 2.033
Epoch= 76/200, loss= 13.580, mse= 13.393, kld= 1.872
    val_loss= 13.033, val_mse= 12.841, val_kld= 1.917
Epoch= 77/200, loss= 11.537, mse= 11.353, kld= 1.838
    val_loss= 12.777, val_mse= 12.572, val_kld= 2.052
Epoch= 78/200, loss= 12.596, mse= 12.413, kld= 1.833
    val_loss= 13.880, val_mse= 13.682, val_kld= 1.979
Epoch= 79/200, loss= 12.841, mse= 12.652, kld= 1.889
    val_loss= 11.708, val_mse= 11.500, val_kld= 2.085
Epoch= 80/200, loss= 11.640, mse= 11.463, kld= 1.774
    val_loss= 10.666, val_mse= 10.482, val_kld= 1.839
Epoch= 81/200, loss= 11.037, mse= 10.863, kld= 1.743
    val_loss= 11.022, val_mse= 10.826, val_kld= 1.957
Epoch= 82/200, loss= 11.978, mse= 11.795, kld= 1.828
    val_loss= 15.178, val_mse= 14.977, val_kld= 2.013
Epoch= 83/200, loss= 11.239, mse= 11.060, kld= 1.790
    val_loss= 11.652, val_mse= 11.469, val_kld= 1.832
Epoch= 84/200, loss= 12.032, mse= 11.857, kld= 1.759
    val_loss= 12.586, val_mse= 12.393, val_kld= 1.928
Epoch= 85/200, loss= 10.936, mse= 10.767, kld= 1.688
    val_loss= 9.980, val_mse= 9.794, val_kld= 1.863
Epoch= 86/200, loss= 11.369, mse= 11.197, kld= 1.725

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        val_loss= 8.310, val_mse= 8.125, val_kld= 1.856
Epoch= 87/200, loss= 11.400, mse= 11.221, kld= 1.789
        val_loss= 10.418, val_mse= 10.216, val_kld= 2.022
Epoch= 88/200, loss= 10.494, mse= 10.324, kld= 1.699
        val_loss= 9.203, val_mse= 9.018, val_kld= 1.855
Epoch= 89/200, loss= 11.327, mse= 11.156, kld= 1.711
        val_loss= 6.934, val_mse= 6.761, val_kld= 1.734
Epoch= 90/200, loss= 11.575, mse= 11.400, kld= 1.752
        val_loss= 10.065, val_mse= 9.890, val_kld= 1.751
Epoch= 91/200, loss= 10.600, mse= 10.430, kld= 1.695
        val_loss= 10.342, val_mse= 10.149, val_kld= 1.930
Epoch= 92/200, loss= 10.015, mse= 9.848, kld= 1.678
        val_loss= 11.976, val_mse= 11.782, val_kld= 1.948
Epoch= 93/200, loss= 10.752, mse= 10.585, kld= 1.662
        val_loss= 11.539, val_mse= 11.359, val_kld= 1.808
Epoch= 94/200, loss= 10.018, mse= 9.847, kld= 1.706
        val_loss= 10.614, val_mse= 10.443, val_kld= 1.713
Epoch= 95/200, loss= 10.273, mse= 10.107, kld= 1.660
        val_loss= 7.643, val_mse= 7.468, val_kld= 1.746
Epoch= 96/200, loss= 11.129, mse= 10.956, kld= 1.724
        val_loss= 11.503, val_mse= 11.316, val_kld= 1.877
Epoch= 97/200, loss= 10.462, mse= 10.296, kld= 1.663
        val_loss= 9.858, val_mse= 9.685, val_kld= 1.732
Epoch= 98/200, loss= 10.681, mse= 10.515, kld= 1.666
        val_loss= 8.839, val_mse= 8.661, val_kld= 1.773
Epoch= 99/200, loss= 9.357, mse= 9.192, kld= 1.655
        val_loss= 10.067, val_mse= 9.893, val_kld= 1.743
Epoch= 100/200, loss= 9.880, mse= 9.715, kld= 1.656
        val_loss= 12.846, val_mse= 12.643, val_kld= 2.030
Epoch= 101/200, loss= 9.849, mse= 9.684, kld= 1.656
        val_loss= 7.742, val_mse= 7.574, val_kld= 1.674
Epoch= 102/200, loss= 9.328, mse= 9.167, kld= 1.606
        val_loss= 12.680, val_mse= 12.493, val_kld= 1.872
Epoch= 103/200, loss= 10.225, mse= 10.063, kld= 1.624
        val_loss= 10.408, val_mse= 10.223, val_kld= 1.845
Epoch= 104/200, loss= 9.693, mse= 9.526, kld= 1.672
        val_loss= 13.090, val_mse= 12.887, val_kld= 2.032
Epoch= 105/200, loss= 9.527, mse= 9.367, kld= 1.597
        val_loss= 7.638, val_mse= 7.470, val_kld= 1.687
Epoch= 106/200, loss= 9.821, mse= 9.663, kld= 1.583
        val_loss= 8.008, val_mse= 7.827, val_kld= 1.810
Epoch= 107/200, loss= 9.249, mse= 9.093, kld= 1.559
        val_loss= 7.515, val_mse= 7.345, val_kld= 1.699
Epoch= 108/200, loss= 9.316, mse= 9.158, kld= 1.582
        val_loss= 8.646, val_mse= 8.467, val_kld= 1.788
Epoch= 109/200, loss= 9.703, mse= 9.548, kld= 1.550
        val_loss= 9.394, val_mse= 9.211, val_kld= 1.834
Epoch= 110/200, loss= 9.028, mse= 8.870, kld= 1.582

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        val_loss= 9.156, val_mse= 8.975, val_kld= 1.810
Epoch= 111/200, loss= 8.544, mse= 8.387, kld= 1.570
        val_loss= 8.927, val_mse= 8.760, val_kld= 1.669
Epoch= 112/200, loss= 8.621, mse= 8.461, kld= 1.595
        val_loss= 14.551, val_mse= 14.355, val_kld= 1.961
Epoch= 113/200, loss= 8.494, mse= 8.335, kld= 1.591
        val_loss= 7.114, val_mse= 6.953, val_kld= 1.612
Epoch= 114/200, loss= 9.197, mse= 9.038, kld= 1.584
        val_loss= 9.424, val_mse= 9.237, val_kld= 1.872
Epoch= 115/200, loss= 7.776, mse= 7.623, kld= 1.537
        val_loss= 8.317, val_mse= 8.147, val_kld= 1.703
Epoch= 116/200, loss= 7.502, mse= 7.353, kld= 1.491
        val_loss= 8.580, val_mse= 8.414, val_kld= 1.660
Epoch= 117/200, loss= 8.569, mse= 8.411, kld= 1.574
        val_loss= 7.615, val_mse= 7.452, val_kld= 1.634
Epoch= 118/200, loss= 8.482, mse= 8.331, kld= 1.515
        val_loss= 10.579, val_mse= 10.398, val_kld= 1.809
Epoch= 119/200, loss= 8.314, mse= 8.163, kld= 1.518
        val_loss= 7.726, val_mse= 7.570, val_kld= 1.554
Epoch= 120/200, loss= 8.213, mse= 8.061, kld= 1.519
        val_loss= 9.018, val_mse= 8.855, val_kld= 1.626
Epoch= 121/200, loss= 8.030, mse= 7.882, kld= 1.483
        val_loss= 9.052, val_mse= 8.870, val_kld= 1.820
Epoch= 122/200, loss= 7.768, mse= 7.618, kld= 1.497
        val_loss= 7.078, val_mse= 6.912, val_kld= 1.654
Epoch= 123/200, loss= 7.990, mse= 7.842, kld= 1.474
        val_loss= 8.049, val_mse= 7.881, val_kld= 1.684
Epoch= 124/200, loss= 7.993, mse= 7.845, kld= 1.474
        val_loss= 6.899, val_mse= 6.732, val_kld= 1.671
Epoch= 125/200, loss= 7.889, mse= 7.739, kld= 1.497
        val_loss= 5.439, val_mse= 5.285, val_kld= 1.538
Epoch= 126/200, loss= 7.108, mse= 6.965, kld= 1.430
        val_loss= 7.065, val_mse= 6.892, val_kld= 1.737
Epoch= 127/200, loss= 7.010, mse= 6.871, kld= 1.394
        val_loss= 7.990, val_mse= 7.819, val_kld= 1.709
Epoch= 128/200, loss= 7.787, mse= 7.637, kld= 1.499
        val_loss= 6.819, val_mse= 6.657, val_kld= 1.616
Epoch= 129/200, loss= 8.321, mse= 8.177, kld= 1.439
        val_loss= 8.529, val_mse= 8.362, val_kld= 1.672
Epoch= 130/200, loss= 6.644, mse= 6.500, kld= 1.445
        val_loss= 7.144, val_mse= 6.982, val_kld= 1.623
Epoch= 131/200, loss= 7.403, mse= 7.261, kld= 1.420
        val_loss= 7.189, val_mse= 7.015, val_kld= 1.746
Epoch= 132/200, loss= 7.169, mse= 7.024, kld= 1.445
        val_loss= 9.505, val_mse= 9.309, val_kld= 1.966
Epoch= 133/200, loss= 7.095, mse= 6.952, kld= 1.430
        val_loss= 6.537, val_mse= 6.365, val_kld= 1.713
Epoch= 134/200, loss= 7.470, mse= 7.324, kld= 1.464

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        val_loss= 6.517, val_mse= 6.351, val_kld= 1.662
Epoch= 135/200, loss= 7.508, mse= 7.362, kld= 1.458
        val_loss= 8.635, val_mse= 8.461, val_kld= 1.739
Epoch= 136/200, loss= 7.119, mse= 6.973, kld= 1.461
        val_loss= 7.791, val_mse= 7.630, val_kld= 1.606
Epoch= 137/200, loss= 6.513, mse= 6.376, kld= 1.370
        val_loss= 8.785, val_mse= 8.610, val_kld= 1.751
Epoch= 138/200, loss= 7.421, mse= 7.277, kld= 1.442
        val_loss= 5.912, val_mse= 5.756, val_kld= 1.561
Epoch= 139/200, loss= 7.031, mse= 6.890, kld= 1.406
        val_loss= 5.745, val_mse= 5.576, val_kld= 1.695
Epoch= 140/200, loss= 6.763, mse= 6.624, kld= 1.397
        val_loss= 6.470, val_mse= 6.316, val_kld= 1.540
Epoch= 141/200, loss= 6.760, mse= 6.619, kld= 1.413
        val_loss= 7.287, val_mse= 7.121, val_kld= 1.660
Epoch= 142/200, loss= 6.482, mse= 6.342, kld= 1.395
        val_loss= 7.550, val_mse= 7.396, val_kld= 1.536
Epoch= 143/200, loss= 6.231, mse= 6.092, kld= 1.391
        val_loss= 7.628, val_mse= 7.466, val_kld= 1.616
Epoch= 144/200, loss= 6.459, mse= 6.316, kld= 1.428
        val_loss= 6.120, val_mse= 5.945, val_kld= 1.753
Epoch= 145/200, loss= 6.595, mse= 6.458, kld= 1.376
        val_loss= 6.065, val_mse= 5.896, val_kld= 1.691
Epoch= 146/200, loss= 6.884, mse= 6.748, kld= 1.368
        val_loss= 7.424, val_mse= 7.256, val_kld= 1.672
Epoch= 147/200, loss= 7.462, mse= 7.316, kld= 1.457
        val_loss= 5.219, val_mse= 5.058, val_kld= 1.611
Epoch= 148/200, loss= 6.753, mse= 6.614, kld= 1.390
        val_loss= 5.685, val_mse= 5.528, val_kld= 1.572
Epoch= 149/200, loss= 6.241, mse= 6.099, kld= 1.421
        val_loss= 6.439, val_mse= 6.275, val_kld= 1.646
Epoch= 150/200, loss= 5.894, mse= 5.754, kld= 1.397
        val_loss= 8.052, val_mse= 7.895, val_kld= 1.574
Epoch= 151/200, loss= 5.993, mse= 5.857, kld= 1.359
        val_loss= 7.147, val_mse= 6.979, val_kld= 1.681
Epoch= 152/200, loss= 5.844, mse= 5.712, kld= 1.321
        val_loss= 6.358, val_mse= 6.196, val_kld= 1.623
Epoch= 153/200, loss= 6.174, mse= 6.035, kld= 1.383
        val_loss= 5.972, val_mse= 5.811, val_kld= 1.616
Epoch= 154/200, loss= 6.538, mse= 6.399, kld= 1.383
        val_loss= 6.738, val_mse= 6.580, val_kld= 1.583
Epoch= 155/200, loss= 6.280, mse= 6.142, kld= 1.371
        val_loss= 8.196, val_mse= 8.028, val_kld= 1.683
Epoch= 156/200, loss= 6.122, mse= 5.988, kld= 1.344
        val_loss= 7.443, val_mse= 7.266, val_kld= 1.767
Epoch= 157/200, loss= 5.948, mse= 5.815, kld= 1.337
        val_loss= 7.844, val_mse= 7.675, val_kld= 1.690
Epoch= 158/200, loss= 5.667, mse= 5.533, kld= 1.337

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        val_loss= 8.407, val_mse= 8.227, val_kld= 1.797
Epoch= 159/200, loss= 5.866, mse= 5.727, kld= 1.389
        val_loss= 5.315, val_mse= 5.161, val_kld= 1.547
Epoch= 160/200, loss= 5.400, mse= 5.266, kld= 1.338
        val_loss= 6.417, val_mse= 6.245, val_kld= 1.717
Epoch= 161/200, loss= 6.241, mse= 6.104, kld= 1.365
        val_loss= 4.969, val_mse= 4.830, val_kld= 1.390
Epoch= 162/200, loss= 6.544, mse= 6.404, kld= 1.399
        val_loss= 4.733, val_mse= 4.569, val_kld= 1.642
Epoch= 163/200, loss= 5.569, mse= 5.437, kld= 1.314
        val_loss= 6.017, val_mse= 5.849, val_kld= 1.680
Epoch= 164/200, loss= 5.629, mse= 5.493, kld= 1.362
        val_loss= 5.686, val_mse= 5.529, val_kld= 1.566
Epoch= 165/200, loss= 5.351, mse= 5.220, kld= 1.318
        val_loss= 5.584, val_mse= 5.426, val_kld= 1.575
Epoch= 166/200, loss= 5.758, mse= 5.622, kld= 1.360
        val_loss= 4.996, val_mse= 4.835, val_kld= 1.607
Epoch= 167/200, loss= 5.109, mse= 4.980, kld= 1.284
        val_loss= 5.581, val_mse= 5.429, val_kld= 1.519
Epoch= 168/200, loss= 5.454, mse= 5.321, kld= 1.329
        val_loss= 4.823, val_mse= 4.669, val_kld= 1.540
Epoch= 169/200, loss= 5.478, mse= 5.344, kld= 1.343
        val_loss= 5.520, val_mse= 5.355, val_kld= 1.651
Epoch= 170/200, loss= 4.809, mse= 4.679, kld= 1.297
        val_loss= 5.596, val_mse= 5.425, val_kld= 1.711
Epoch= 171/200, loss= 5.251, mse= 5.119, kld= 1.320
        val_loss= 6.651, val_mse= 6.479, val_kld= 1.718
Epoch= 172/200, loss= 5.711, mse= 5.580, kld= 1.308
        val_loss= 7.080, val_mse= 6.906, val_kld= 1.746
Epoch= 173/200, loss= 5.245, mse= 5.111, kld= 1.334
        val_loss= 6.667, val_mse= 6.497, val_kld= 1.707
Epoch= 174/200, loss= 5.172, mse= 5.037, kld= 1.352
        val_loss= 4.551, val_mse= 4.404, val_kld= 1.470
Epoch= 175/200, loss= 5.457, mse= 5.332, kld= 1.246
        val_loss= 4.497, val_mse= 4.348, val_kld= 1.489
Epoch= 176/200, loss= 4.945, mse= 4.814, kld= 1.308
        val_loss= 5.675, val_mse= 5.512, val_kld= 1.625
Epoch= 177/200, loss= 5.059, mse= 4.927, kld= 1.316
        val_loss= 5.703, val_mse= 5.543, val_kld= 1.596
Epoch= 178/200, loss= 5.090, mse= 4.959, kld= 1.307
        val_loss= 5.125, val_mse= 4.970, val_kld= 1.549
Epoch= 179/200, loss= 5.227, mse= 5.093, kld= 1.340
        val_loss= 5.406, val_mse= 5.251, val_kld= 1.545
Epoch= 180/200, loss= 4.602, mse= 4.471, kld= 1.305
        val_loss= 5.075, val_mse= 4.919, val_kld= 1.563
Epoch= 181/200, loss= 4.700, mse= 4.571, kld= 1.283
        val_loss= 7.730, val_mse= 7.571, val_kld= 1.594
Epoch= 182/200, loss= 4.898, mse= 4.767, kld= 1.310

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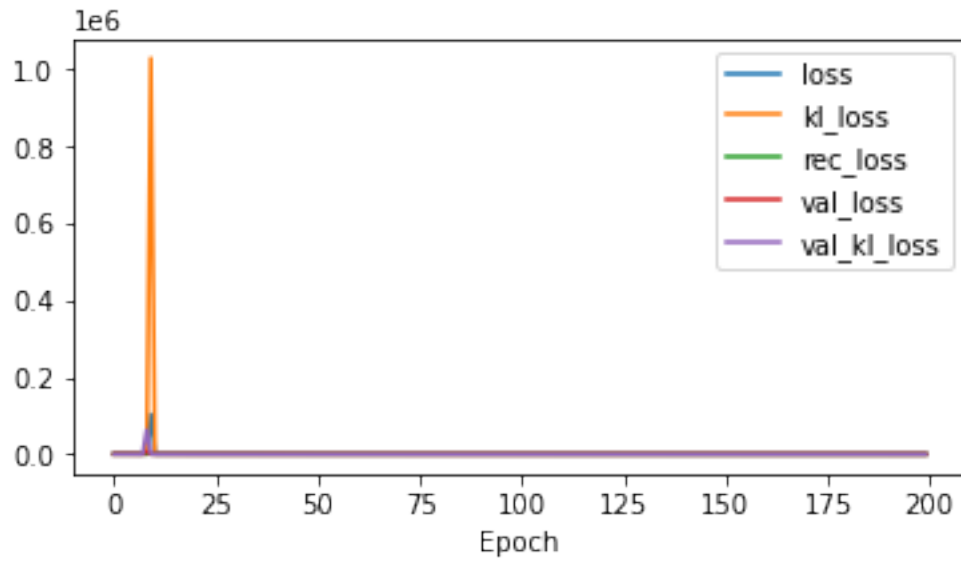
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        val_loss= 4.867, val_mse= 4.706, val_kld= 1.618
Epoch= 183/200, loss= 4.737, mse= 4.609, kld= 1.280
        val_loss= 4.665, val_mse= 4.507, val_kld= 1.581
Epoch= 184/200, loss= 4.541, mse= 4.412, kld= 1.294
        val_loss= 6.521, val_mse= 6.352, val_kld= 1.690
Epoch= 185/200, loss= 4.982, mse= 4.852, kld= 1.297
        val_loss= 3.855, val_mse= 3.706, val_kld= 1.490
Epoch= 186/200, loss= 4.840, mse= 4.713, kld= 1.276
        val_loss= 4.881, val_mse= 4.715, val_kld= 1.657
Epoch= 187/200, loss= 4.772, mse= 4.640, kld= 1.317
        val_loss= 3.934, val_mse= 3.776, val_kld= 1.582
Epoch= 188/200, loss= 4.722, mse= 4.591, kld= 1.305
        val_loss= 6.657, val_mse= 6.484, val_kld= 1.734
Epoch= 189/200, loss= 4.720, mse= 4.590, kld= 1.302
        val_loss= 4.289, val_mse= 4.136, val_kld= 1.526
Epoch= 190/200, loss= 4.789, mse= 4.660, kld= 1.297
        val_loss= 4.398, val_mse= 4.238, val_kld= 1.605
Epoch= 191/200, loss= 4.563, mse= 4.438, kld= 1.247
        val_loss= 4.280, val_mse= 4.122, val_kld= 1.587
Epoch= 192/200, loss= 4.545, mse= 4.415, kld= 1.299
        val_loss= 4.488, val_mse= 4.334, val_kld= 1.539
Epoch= 193/200, loss= 4.693, mse= 4.559, kld= 1.335
        val_loss= 3.611, val_mse= 3.450, val_kld= 1.610
Epoch= 194/200, loss= 4.468, mse= 4.342, kld= 1.262
        val_loss= 6.164, val_mse= 6.000, val_kld= 1.644
Epoch= 195/200, loss= 4.487, mse= 4.359, kld= 1.277
        val_loss= 5.389, val_mse= 5.234, val_kld= 1.553
Epoch= 196/200, loss= 4.309, mse= 4.181, kld= 1.280
        val_loss= 5.174, val_mse= 4.988, val_kld= 1.865
Epoch= 197/200, loss= 4.467, mse= 4.338, kld= 1.288
        val_loss= 3.904, val_mse= 3.733, val_kld= 1.701
Epoch= 198/200, loss= 4.397, mse= 4.268, kld= 1.285
        val_loss= 5.053, val_mse= 4.896, val_kld= 1.563
Epoch= 199/200, loss= 4.318, mse= 4.187, kld= 1.311
        val_loss= 3.736, val_mse= 3.586, val_kld= 1.501
Epoch= 200/200, loss= 4.136, mse= 4.011, kld= 1.253
        val_loss= 4.540, val_mse= 4.388, val_kld= 1.519

```

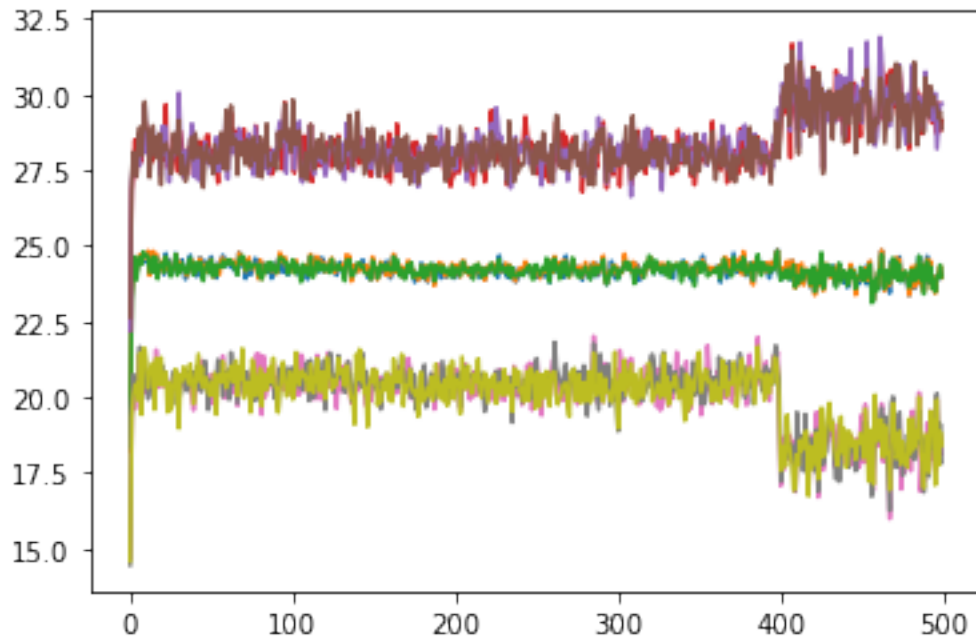
```
[51]: pd.DataFrame(history).plot(figsize=(6, 3), xlabel='Epoch')
```

```
[51]: <AxesSubplot:xlabel='Epoch'>
```



```
[52]: # x_hat = dkf.generate(x_train)
# x_hat, x_025, x_975 = dkf.filter(x_train)
x_hat, x_025, x_975 = dkf.predict(x, 100)
x_hat = x_hat.detach().numpy()[0]
x_025 = x_025.detach().numpy()[0]
x_975 = x_975.detach().numpy()[0]
plt.plot(x_hat)
plt.plot(x_975)
plt.plot(x_025)
```

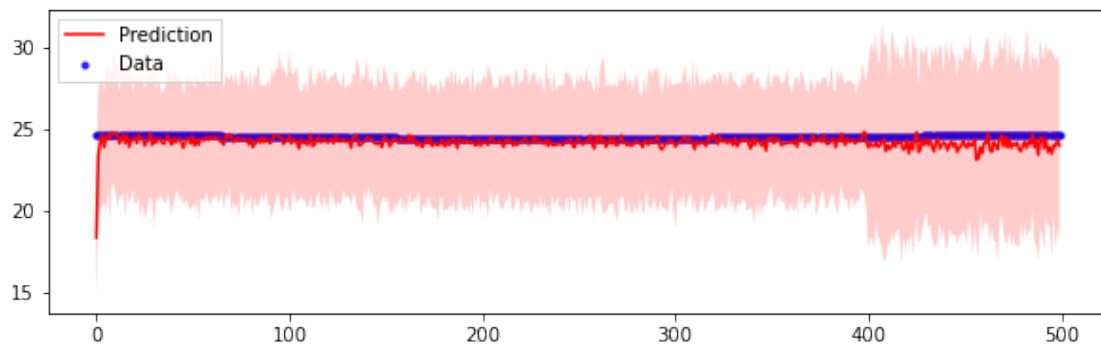
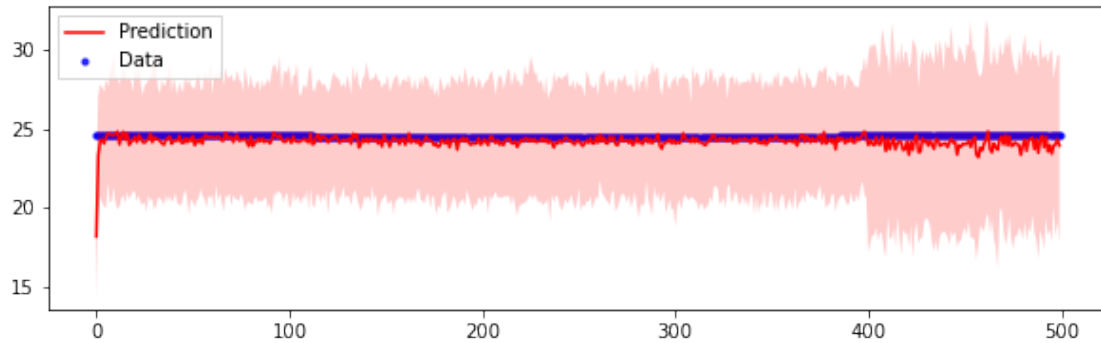
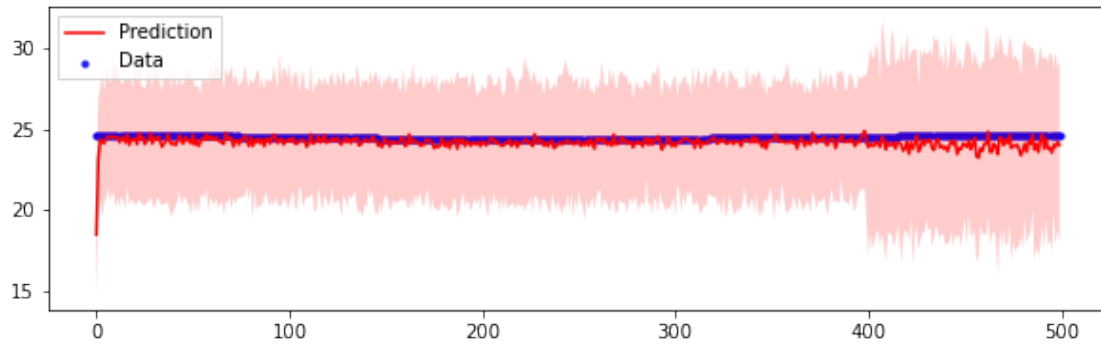
```
[52]: [<matplotlib.lines.Line2D at 0x7f8d06c310a0>,
<matplotlib.lines.Line2D at 0x7f8d06c31190>,
<matplotlib.lines.Line2D at 0x7f8d06c31250>]
```



```
[53]: fig, ax = plt.subplots(3, figsize=(10, 10))

for i, axi in enumerate(ax):
    axi.scatter(
        np.arange(longitude_three_data.shape[0]),
        longitude_three_data[:, i], s=10, alpha=0.8, label='Data', c='b')
    axi.plot(x_hat[:, i], label='Prediction', c='r')
    axi.fill_between(np.arange(x_hat.shape[0]), x_025[:, i], x_975[:, i],
                    facecolor='r', alpha=0.2)

    axi.legend(loc='upper left', fancybox=False)
plt.show()
```



[54]: #####

[]:

[]:

[]:

[55]: #####

[56]: #TUTAJ DKF PO ALTITUDE DLA 5 WORKOUTOW

2.6 Trenowane dla 5 pierwszych treningow po altitude

```
[57]: data = np.vstack([np.asarray(data_endo[0]['altitude']), np.  
    ↪asarray(data_endo[1]['altitude']),  
        np.asarray(data_endo[2]['altitude']), np.  
    ↪asarray(data_endo[3]['altitude']),  
        np.asarray(data_endo[4]['altitude'])]).T  
#print(data.shape)
```

```
[58]: x = torch.FloatTensor(data).reshape(1, *data.shape)  
#print(x)  
x_train = torch.FloatTensor(data[:450]).reshape(1, 450, data.shape[1])  
#print(x_train)  
x_val    = torch.FloatTensor(data[450:500]).reshape(1, 50, data.shape[1])  
#print(x_val)
```

```
[59]: dkf = DKF(input_dim=5, z_dim=25, rnn_dim=25, trans_dim=25, emission_dim=25)
```

```
[60]: history = dkf.fit(x_train, x_val, num_epochs=200, annealing_factor=0.1)
```

```
Epoch= 1/200, loss= 2005.400, mse= 1966.889, kld= 385.108  
    val_loss= 825.362, val_mse= 823.245, val_kld= 21.167  
Epoch= 2/200, loss= 1930.631, mse= 1925.754, kld= 48.773  
    val_loss= 811.823, val_mse= 810.357, val_kld= 14.658  
Epoch= 3/200, loss= 1885.502, mse= 1882.524, kld= 29.778  
    val_loss= 782.201, val_mse= 780.429, val_kld= 17.719  
Epoch= 4/200, loss= 1818.449, mse= 1814.650, kld= 37.991  
    val_loss= 710.922, val_mse= 708.096, val_kld= 28.259  
Epoch= 5/200, loss= 1683.341, mse= 1675.457, kld= 78.840  
    val_loss= 621.273, val_mse= 616.852, val_kld= 44.211  
Epoch= 6/200, loss= 1449.555, mse= 1433.891, kld= 156.641  
    val_loss= 436.460, val_mse= 431.211, val_kld= 52.493  
Epoch= 7/200, loss= 1070.056, mse= 1051.350, kld= 187.056  
    val_loss= 211.947, val_mse= 206.966, val_kld= 49.810  
Epoch= 8/200, loss= 548.084, mse= 521.347, kld= 267.373  
    val_loss= 67.649, val_mse= 61.811, val_kld= 58.373  
Epoch= 9/200, loss= 216.366, mse= 202.954, kld= 134.127  
    val_loss= 269.140, val_mse= 262.882, val_kld= 62.581  
Epoch= 10/200, loss= 653.094, mse= 644.512, kld= 85.824  
    val_loss= 155.168, val_mse= 149.459, val_kld= 57.093  
Epoch= 11/200, loss= 361.795, mse= 354.540, kld= 72.545  
    val_loss= 47.575, val_mse= 42.151, val_kld= 54.243  
Epoch= 12/200, loss= 131.617, mse= 124.496, kld= 71.214  
    val_loss= 45.970, val_mse= 40.844, val_kld= 51.256  
Epoch= 13/200, loss= 142.253, mse= 135.422, kld= 68.318  
    val_loss= 73.313, val_mse= 68.413, val_kld= 48.995  
Epoch= 14/200, loss= 219.903, mse= 213.369, kld= 65.340
```

```

    val_loss= 98.192, val_mse= 93.405, val_kld= 47.870
Epoch= 15/200, loss= 268.588, mse= 262.233, kld= 63.554
    val_loss= 90.651, val_mse= 85.768, val_kld= 48.831
Epoch= 16/200, loss= 260.219, mse= 253.852, kld= 63.675
    val_loss= 69.159, val_mse= 64.018, val_kld= 51.410
Epoch= 17/200, loss= 207.800, mse= 201.182, kld= 66.188
    val_loss= 45.252, val_mse= 39.950, val_kld= 53.018
Epoch= 18/200, loss= 138.760, mse= 131.944, kld= 68.159
    val_loss= 34.002, val_mse= 28.439, val_kld= 55.629
Epoch= 19/200, loss= 102.795, mse= 95.731, kld= 70.638
    val_loss= 61.902, val_mse= 56.046, val_kld= 58.556
Epoch= 20/200, loss= 139.393, mse= 132.118, kld= 72.748
    val_loss= 94.800, val_mse= 88.917, val_kld= 58.832
Epoch= 21/200, loss= 190.233, mse= 183.023, kld= 72.102
    val_loss= 82.703, val_mse= 76.946, val_kld= 57.577
Epoch= 22/200, loss= 180.115, mse= 173.194, kld= 69.210
    val_loss= 57.554, val_mse= 52.128, val_kld= 54.258
Epoch= 23/200, loss= 131.491, mse= 125.110, kld= 63.807
    val_loss= 38.171, val_mse= 33.098, val_kld= 50.723
Epoch= 24/200, loss= 102.839, mse= 96.887, kld= 59.522
    val_loss= 32.777, val_mse= 28.018, val_kld= 47.584
Epoch= 25/200, loss= 104.217, mse= 98.643, kld= 55.748
    val_loss= 32.478, val_mse= 28.127, val_kld= 43.509
Epoch= 26/200, loss= 118.212, mse= 113.109, kld= 51.028
    val_loss= 34.936, val_mse= 30.836, val_kld= 41.001
Epoch= 27/200, loss= 126.832, mse= 122.041, kld= 47.915
    val_loss= 30.181, val_mse= 26.154, val_kld= 40.264
Epoch= 28/200, loss= 123.220, mse= 118.563, kld= 46.573
    val_loss= 26.673, val_mse= 22.702, val_kld= 39.710
Epoch= 29/200, loss= 107.479, mse= 102.904, kld= 45.748
    val_loss= 24.662, val_mse= 20.635, val_kld= 40.265
Epoch= 30/200, loss= 90.712, mse= 86.111, kld= 46.010
    val_loss= 25.305, val_mse= 21.283, val_kld= 40.225
Epoch= 31/200, loss= 83.312, mse= 78.716, kld= 45.962
    val_loss= 34.557, val_mse= 30.513, val_kld= 40.438
Epoch= 32/200, loss= 91.734, mse= 87.162, kld= 45.719
    val_loss= 41.692, val_mse= 37.540, val_kld= 41.527
Epoch= 33/200, loss= 100.333, mse= 95.874, kld= 44.590
    val_loss= 45.285, val_mse= 41.174, val_kld= 41.102
Epoch= 34/200, loss= 102.704, mse= 98.407, kld= 42.972
    val_loss= 38.374, val_mse= 34.404, val_kld= 39.705
Epoch= 35/200, loss= 94.622, mse= 90.429, kld= 41.932
    val_loss= 29.039, val_mse= 25.150, val_kld= 38.894
Epoch= 36/200, loss= 85.561, mse= 81.545, kld= 40.157
    val_loss= 24.171, val_mse= 20.355, val_kld= 38.166
Epoch= 37/200, loss= 85.608, mse= 81.710, kld= 38.974
    val_loss= 23.478, val_mse= 19.932, val_kld= 35.458
Epoch= 38/200, loss= 89.131, mse= 85.473, kld= 36.583

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    val_loss= 23.685, val_mse= 20.267, val_kld= 34.179
Epoch= 39/200, loss= 95.182, mse= 91.732, kld= 34.496
    val_loss= 24.249, val_mse= 20.925, val_kld= 33.240
Epoch= 40/200, loss= 96.217, mse= 92.880, kld= 33.370
    val_loss= 21.305, val_mse= 17.990, val_kld= 33.146
Epoch= 41/200, loss= 90.344, mse= 86.999, kld= 33.444
    val_loss= 24.251, val_mse= 21.014, val_kld= 32.369
Epoch= 42/200, loss= 85.483, mse= 82.141, kld= 33.419
    val_loss= 23.204, val_mse= 19.936, val_kld= 32.675
Epoch= 43/200, loss= 83.313, mse= 80.020, kld= 32.932
    val_loss= 29.867, val_mse= 26.604, val_kld= 32.634
Epoch= 44/200, loss= 85.063, mse= 81.821, kld= 32.419
    val_loss= 33.922, val_mse= 30.624, val_kld= 32.987
Epoch= 45/200, loss= 88.148, mse= 84.953, kld= 31.945
    val_loss= 33.280, val_mse= 29.969, val_kld= 33.104
Epoch= 46/200, loss= 87.244, mse= 84.069, kld= 31.743
    val_loss= 30.058, val_mse= 26.796, val_kld= 32.626
Epoch= 47/200, loss= 84.349, mse= 81.273, kld= 30.761
    val_loss= 25.503, val_mse= 22.352, val_kld= 31.505
Epoch= 48/200, loss= 81.003, mse= 78.010, kld= 29.937
    val_loss= 21.875, val_mse= 18.873, val_kld= 30.019
Epoch= 49/200, loss= 81.321, mse= 78.447, kld= 28.743
    val_loss= 21.032, val_mse= 18.117, val_kld= 29.144
Epoch= 50/200, loss= 83.105, mse= 80.297, kld= 28.080
    val_loss= 21.067, val_mse= 18.170, val_kld= 28.974
Epoch= 51/200, loss= 83.815, mse= 81.063, kld= 27.516
    val_loss= 21.526, val_mse= 18.660, val_kld= 28.662
Epoch= 52/200, loss= 83.073, mse= 80.336, kld= 27.367
    val_loss= 22.439, val_mse= 19.548, val_kld= 28.906
Epoch= 53/200, loss= 81.492, mse= 78.784, kld= 27.079
    val_loss= 23.183, val_mse= 20.315, val_kld= 28.683
Epoch= 54/200, loss= 80.794, mse= 78.122, kld= 26.723
    val_loss= 29.012, val_mse= 26.142, val_kld= 28.702
Epoch= 55/200, loss= 81.237, mse= 78.561, kld= 26.761
    val_loss= 30.090, val_mse= 27.282, val_kld= 28.072
Epoch= 56/200, loss= 82.589, mse= 79.971, kld= 26.177
    val_loss= 28.388, val_mse= 25.570, val_kld= 28.184
Epoch= 57/200, loss= 82.600, mse= 80.033, kld= 25.665
    val_loss= 27.876, val_mse= 25.027, val_kld= 28.491
Epoch= 58/200, loss= 81.673, mse= 79.158, kld= 25.152
    val_loss= 25.577, val_mse= 22.784, val_kld= 27.927
Epoch= 59/200, loss= 80.055, mse= 77.593, kld= 24.619
    val_loss= 23.848, val_mse= 21.151, val_kld= 26.964
Epoch= 60/200, loss= 80.451, mse= 78.055, kld= 23.961
    val_loss= 22.017, val_mse= 19.368, val_kld= 26.495
Epoch= 61/200, loss= 80.745, mse= 78.423, kld= 23.215
    val_loss= 21.273, val_mse= 18.706, val_kld= 25.675
Epoch= 62/200, loss= 80.801, mse= 78.520, kld= 22.806

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        val_loss= 23.276, val_mse= 20.675, val_kld= 26.004
Epoch= 63/200, loss= 80.744, mse= 78.489, kld= 22.553
        val_loss= 23.716, val_mse= 21.167, val_kld= 25.490
Epoch= 64/200, loss= 79.856, mse= 77.620, kld= 22.361
        val_loss= 26.312, val_mse= 23.780, val_kld= 25.318
Epoch= 65/200, loss= 79.439, mse= 77.229, kld= 22.099
        val_loss= 25.835, val_mse= 23.305, val_kld= 25.301
Epoch= 66/200, loss= 79.553, mse= 77.398, kld= 21.548
        val_loss= 26.955, val_mse= 24.385, val_kld= 25.703
Epoch= 67/200, loss= 79.681, mse= 77.520, kld= 21.609
        val_loss= 27.348, val_mse= 24.776, val_kld= 25.716
Epoch= 68/200, loss= 80.086, mse= 77.946, kld= 21.400
        val_loss= 24.652, val_mse= 22.084, val_kld= 25.684
Epoch= 69/200, loss= 78.739, mse= 76.635, kld= 21.039
        val_loss= 23.550, val_mse= 20.958, val_kld= 25.915
Epoch= 70/200, loss= 79.110, mse= 77.023, kld= 20.864
        val_loss= 22.936, val_mse= 20.414, val_kld= 25.225
Epoch= 71/200, loss= 78.846, mse= 76.764, kld= 20.819
        val_loss= 21.841, val_mse= 19.349, val_kld= 24.917
Epoch= 72/200, loss= 80.231, mse= 78.199, kld= 20.318
        val_loss= 22.448, val_mse= 19.991, val_kld= 24.569
Epoch= 73/200, loss= 80.039, mse= 78.028, kld= 20.107
        val_loss= 22.479, val_mse= 20.056, val_kld= 24.229
Epoch= 74/200, loss= 78.667, mse= 76.701, kld= 19.658
        val_loss= 21.905, val_mse= 19.514, val_kld= 23.914
Epoch= 75/200, loss= 79.051, mse= 77.113, kld= 19.381
        val_loss= 25.357, val_mse= 23.007, val_kld= 23.494
Epoch= 76/200, loss= 78.773, mse= 76.839, kld= 19.347
        val_loss= 26.266, val_mse= 23.882, val_kld= 23.834
Epoch= 77/200, loss= 79.005, mse= 77.119, kld= 18.860
        val_loss= 24.165, val_mse= 21.815, val_kld= 23.497
Epoch= 78/200, loss= 78.949, mse= 77.074, kld= 18.750
        val_loss= 23.772, val_mse= 21.466, val_kld= 23.063
Epoch= 79/200, loss= 79.192, mse= 77.371, kld= 18.205
        val_loss= 22.453, val_mse= 20.137, val_kld= 23.152
Epoch= 80/200, loss= 79.168, mse= 77.385, kld= 17.825
        val_loss= 23.002, val_mse= 20.686, val_kld= 23.155
Epoch= 81/200, loss= 78.794, mse= 77.043, kld= 17.505
        val_loss= 22.902, val_mse= 20.602, val_kld= 23.000
Epoch= 82/200, loss= 77.897, mse= 76.158, kld= 17.390
        val_loss= 21.911, val_mse= 19.594, val_kld= 23.175
Epoch= 83/200, loss= 78.607, mse= 76.891, kld= 17.158
        val_loss= 21.230, val_mse= 19.043, val_kld= 21.876
Epoch= 84/200, loss= 78.828, mse= 77.126, kld= 17.019
        val_loss= 24.352, val_mse= 22.164, val_kld= 21.880
Epoch= 85/200, loss= 78.294, mse= 76.613, kld= 16.809
        val_loss= 24.177, val_mse= 21.978, val_kld= 21.991
Epoch= 86/200, loss= 77.814, mse= 76.185, kld= 16.287

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        val_loss= 23.110, val_mse= 20.887, val_kld= 22.228
Epoch= 87/200, loss= 77.546, mse= 75.927, kld= 16.199
        val_loss= 22.618, val_mse= 20.359, val_kld= 22.588
Epoch= 88/200, loss= 77.646, mse= 76.050, kld= 15.958
        val_loss= 23.629, val_mse= 21.471, val_kld= 21.587
Epoch= 89/200, loss= 77.650, mse= 76.090, kld= 15.606
        val_loss= 24.795, val_mse= 22.634, val_kld= 21.608
Epoch= 90/200, loss= 78.360, mse= 76.815, kld= 15.452
        val_loss= 22.650, val_mse= 20.507, val_kld= 21.422
Epoch= 91/200, loss= 78.211, mse= 76.726, kld= 14.855
        val_loss= 22.514, val_mse= 20.451, val_kld= 20.635
Epoch= 92/200, loss= 77.954, mse= 76.486, kld= 14.681
        val_loss= 22.445, val_mse= 20.436, val_kld= 20.083
Epoch= 93/200, loss= 77.766, mse= 76.323, kld= 14.425
        val_loss= 21.188, val_mse= 19.220, val_kld= 19.686
Epoch= 94/200, loss= 77.077, mse= 75.651, kld= 14.258
        val_loss= 21.922, val_mse= 19.930, val_kld= 19.922
Epoch= 95/200, loss= 77.866, mse= 76.463, kld= 14.033
        val_loss= 24.607, val_mse= 22.691, val_kld= 19.160
Epoch= 96/200, loss= 77.468, mse= 76.087, kld= 13.802
        val_loss= 22.392, val_mse= 20.424, val_kld= 19.681
Epoch= 97/200, loss= 77.381, mse= 76.008, kld= 13.736
        val_loss= 23.875, val_mse= 21.905, val_kld= 19.695
Epoch= 98/200, loss= 77.800, mse= 76.455, kld= 13.452
        val_loss= 21.908, val_mse= 20.057, val_kld= 18.516
Epoch= 99/200, loss= 77.651, mse= 76.254, kld= 13.971
        val_loss= 21.513, val_mse= 19.635, val_kld= 18.776
Epoch= 100/200, loss= 77.951, mse= 76.609, kld= 13.427
        val_loss= 21.510, val_mse= 19.649, val_kld= 18.614
Epoch= 101/200, loss= 77.092, mse= 75.800, kld= 12.920
        val_loss= 22.425, val_mse= 20.599, val_kld= 18.265
Epoch= 102/200, loss= 78.161, mse= 76.856, kld= 13.052
        val_loss= 22.479, val_mse= 20.537, val_kld= 19.425
Epoch= 103/200, loss= 77.008, mse= 75.694, kld= 13.144
        val_loss= 21.965, val_mse= 20.143, val_kld= 18.212
Epoch= 104/200, loss= 77.568, mse= 76.304, kld= 12.646
        val_loss= 22.230, val_mse= 20.408, val_kld= 18.227
Epoch= 105/200, loss= 76.962, mse= 75.683, kld= 12.792
        val_loss= 21.983, val_mse= 20.172, val_kld= 18.107
Epoch= 106/200, loss= 77.136, mse= 75.893, kld= 12.432
        val_loss= 21.393, val_mse= 19.637, val_kld= 17.559
Epoch= 107/200, loss= 77.031, mse= 75.733, kld= 12.984
        val_loss= 22.306, val_mse= 20.554, val_kld= 17.527
Epoch= 108/200, loss= 76.706, mse= 75.425, kld= 12.807
        val_loss= 22.721, val_mse= 21.001, val_kld= 17.203
Epoch= 109/200, loss= 76.979, mse= 75.754, kld= 12.249
        val_loss= 21.836, val_mse= 20.125, val_kld= 17.112
Epoch= 110/200, loss= 77.120, mse= 75.875, kld= 12.449

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    val_loss= 21.441, val_mse= 19.691, val_kld= 17.502
Epoch= 111/200, loss= 77.252, mse= 76.058, kld= 11.944
    val_loss= 21.206, val_mse= 19.511, val_kld= 16.947
Epoch= 112/200, loss= 76.387, mse= 75.169, kld= 12.178
    val_loss= 20.869, val_mse= 19.172, val_kld= 16.970
Epoch= 113/200, loss= 77.314, mse= 76.107, kld= 12.065
    val_loss= 21.087, val_mse= 19.402, val_kld= 16.846
Epoch= 114/200, loss= 76.691, mse= 75.510, kld= 11.811
    val_loss= 21.194, val_mse= 19.545, val_kld= 16.486
Epoch= 115/200, loss= 77.398, mse= 76.258, kld= 11.398
    val_loss= 20.610, val_mse= 18.937, val_kld= 16.735
Epoch= 116/200, loss= 76.874, mse= 75.691, kld= 11.830
    val_loss= 21.099, val_mse= 19.438, val_kld= 16.609
Epoch= 117/200, loss= 77.256, mse= 76.063, kld= 11.933
    val_loss= 20.235, val_mse= 18.601, val_kld= 16.345
Epoch= 118/200, loss= 76.840, mse= 75.689, kld= 11.512
    val_loss= 21.517, val_mse= 19.884, val_kld= 16.324
Epoch= 119/200, loss= 76.669, mse= 75.494, kld= 11.747
    val_loss= 21.180, val_mse= 19.594, val_kld= 15.865
Epoch= 120/200, loss= 76.415, mse= 75.226, kld= 11.892
    val_loss= 20.305, val_mse= 18.718, val_kld= 15.873
Epoch= 121/200, loss= 76.544, mse= 75.387, kld= 11.565
    val_loss= 20.692, val_mse= 19.125, val_kld= 15.661
Epoch= 122/200, loss= 76.580, mse= 75.440, kld= 11.397
    val_loss= 21.044, val_mse= 19.485, val_kld= 15.593
Epoch= 123/200, loss= 76.668, mse= 75.550, kld= 11.178
    val_loss= 21.688, val_mse= 20.159, val_kld= 15.281
Epoch= 124/200, loss= 76.390, mse= 75.277, kld= 11.131
    val_loss= 20.898, val_mse= 19.373, val_kld= 15.246
Epoch= 125/200, loss= 76.126, mse= 75.036, kld= 10.904
    val_loss= 21.616, val_mse= 20.073, val_kld= 15.429
Epoch= 126/200, loss= 76.499, mse= 75.394, kld= 11.049
    val_loss= 21.167, val_mse= 19.706, val_kld= 14.612
Epoch= 127/200, loss= 77.174, mse= 76.045, kld= 11.287
    val_loss= 20.070, val_mse= 18.519, val_kld= 15.519
Epoch= 128/200, loss= 77.326, mse= 76.100, kld= 12.260
    val_loss= 21.185, val_mse= 19.679, val_kld= 15.065
Epoch= 129/200, loss= 76.668, mse= 75.448, kld= 12.206
    val_loss= 20.583, val_mse= 19.097, val_kld= 14.858
Epoch= 130/200, loss= 77.040, mse= 75.936, kld= 11.033
    val_loss= 20.206, val_mse= 18.790, val_kld= 14.159
Epoch= 131/200, loss= 76.420, mse= 75.349, kld= 10.710
    val_loss= 20.332, val_mse= 18.854, val_kld= 14.776
Epoch= 132/200, loss= 76.352, mse= 75.271, kld= 10.813
    val_loss= 20.917, val_mse= 19.458, val_kld= 14.582
Epoch= 133/200, loss= 76.547, mse= 75.488, kld= 10.585
    val_loss= 22.165, val_mse= 20.757, val_kld= 14.084
Epoch= 134/200, loss= 76.859, mse= 75.804, kld= 10.552

```

```

    val_loss= 20.259, val_mse= 18.845, val_kld= 14.140
Epoch= 135/200, loss= 76.871, mse= 75.706, kld= 11.648
    val_loss= 20.728, val_mse= 19.245, val_kld= 14.834
Epoch= 136/200, loss= 76.831, mse= 75.528, kld= 13.031
    val_loss= 21.645, val_mse= 20.258, val_kld= 13.875
Epoch= 137/200, loss= 76.148, mse= 75.067, kld= 10.817
    val_loss= 21.243, val_mse= 19.854, val_kld= 13.891
Epoch= 138/200, loss= 76.900, mse= 75.685, kld= 12.155
    val_loss= 20.773, val_mse= 19.441, val_kld= 13.320
Epoch= 139/200, loss= 76.270, mse= 75.238, kld= 10.313
    val_loss= 20.117, val_mse= 18.737, val_kld= 13.794
Epoch= 140/200, loss= 76.216, mse= 75.128, kld= 10.877
    val_loss= 19.892, val_mse= 18.552, val_kld= 13.396
Epoch= 141/200, loss= 75.942, mse= 74.880, kld= 10.618
    val_loss= 20.936, val_mse= 19.607, val_kld= 13.294
Epoch= 142/200, loss= 76.586, mse= 75.550, kld= 10.356
    val_loss= 19.922, val_mse= 18.574, val_kld= 13.478
Epoch= 143/200, loss= 75.664, mse= 74.635, kld= 10.293
    val_loss= 19.336, val_mse= 18.023, val_kld= 13.129
Epoch= 144/200, loss= 75.919, mse= 74.910, kld= 10.088
    val_loss= 21.518, val_mse= 20.252, val_kld= 12.656
Epoch= 145/200, loss= 77.008, mse= 76.013, kld= 9.949
    val_loss= 20.970, val_mse= 19.646, val_kld= 13.234
Epoch= 146/200, loss= 75.719, mse= 74.722, kld= 9.967
    val_loss= 20.169, val_mse= 18.907, val_kld= 12.620
Epoch= 147/200, loss= 76.256, mse= 75.287, kld= 9.690
    val_loss= 19.499, val_mse= 18.239, val_kld= 12.602
Epoch= 148/200, loss= 75.505, mse= 74.543, kld= 9.619
    val_loss= 20.213, val_mse= 18.966, val_kld= 12.477
Epoch= 149/200, loss= 75.513, mse= 74.541, kld= 9.720
    val_loss= 20.541, val_mse= 19.346, val_kld= 11.954
Epoch= 150/200, loss= 75.845, mse= 74.860, kld= 9.844
    val_loss= 20.166, val_mse= 18.976, val_kld= 11.903
Epoch= 151/200, loss= 75.356, mse= 74.420, kld= 9.360
    val_loss= 19.547, val_mse= 18.288, val_kld= 12.588
Epoch= 152/200, loss= 76.088, mse= 75.152, kld= 9.358
    val_loss= 20.074, val_mse= 18.878, val_kld= 11.961
Epoch= 153/200, loss= 75.822, mse= 74.887, kld= 9.352
    val_loss= 19.506, val_mse= 18.250, val_kld= 12.563
Epoch= 154/200, loss= 75.886, mse= 74.912, kld= 9.740
    val_loss= 19.499, val_mse= 18.362, val_kld= 11.373
Epoch= 155/200, loss= 75.729, mse= 74.724, kld= 10.051
    val_loss= 19.928, val_mse= 18.731, val_kld= 11.969
Epoch= 156/200, loss= 76.175, mse= 75.115, kld= 10.601
    val_loss= 20.615, val_mse= 19.465, val_kld= 11.496
Epoch= 157/200, loss= 76.549, mse= 75.545, kld= 10.044
    val_loss= 19.786, val_mse= 18.614, val_kld= 11.727
Epoch= 158/200, loss= 75.862, mse= 74.960, kld= 9.024

```

```

        val_loss= 20.183, val_mse= 19.066, val_kld= 11.172
Epoch= 159/200, loss= 75.560, mse= 74.604, kld= 9.559
        val_loss= 20.810, val_mse= 19.699, val_kld= 11.110
Epoch= 160/200, loss= 75.681, mse= 74.759, kld= 9.222
        val_loss= 20.001, val_mse= 18.919, val_kld= 10.817
Epoch= 161/200, loss= 75.699, mse= 74.803, kld= 8.964
        val_loss= 19.189, val_mse= 18.104, val_kld= 10.852
Epoch= 162/200, loss= 75.365, mse= 74.453, kld= 9.121
        val_loss= 20.011, val_mse= 18.933, val_kld= 10.779
Epoch= 163/200, loss= 75.564, mse= 74.663, kld= 9.011
        val_loss= 19.590, val_mse= 18.537, val_kld= 10.537
Epoch= 164/200, loss= 75.325, mse= 74.424, kld= 9.012
        val_loss= 19.569, val_mse= 18.511, val_kld= 10.580
Epoch= 165/200, loss= 75.708, mse= 74.826, kld= 8.819
        val_loss= 19.928, val_mse= 18.857, val_kld= 10.713
Epoch= 166/200, loss= 75.458, mse= 74.556, kld= 9.019
        val_loss= 18.804, val_mse= 17.780, val_kld= 10.233
Epoch= 167/200, loss= 75.643, mse= 74.773, kld= 8.701
        val_loss= 19.142, val_mse= 18.149, val_kld= 9.937
Epoch= 168/200, loss= 75.700, mse= 74.834, kld= 8.664
        val_loss= 19.099, val_mse= 18.093, val_kld= 10.058
Epoch= 169/200, loss= 75.007, mse= 74.162, kld= 8.450
        val_loss= 19.134, val_mse= 18.123, val_kld= 10.114
Epoch= 170/200, loss= 75.239, mse= 74.386, kld= 8.526
        val_loss= 18.093, val_mse= 17.126, val_kld= 9.671
Epoch= 171/200, loss= 75.744, mse= 74.900, kld= 8.439
        val_loss= 19.828, val_mse= 18.861, val_kld= 9.665
Epoch= 172/200, loss= 75.495, mse= 74.634, kld= 8.616
        val_loss= 19.001, val_mse= 18.031, val_kld= 9.696
Epoch= 173/200, loss= 74.840, mse= 73.998, kld= 8.418
        val_loss= 20.208, val_mse= 19.185, val_kld= 10.232
Epoch= 174/200, loss= 75.568, mse= 74.704, kld= 8.635
        val_loss= 20.094, val_mse= 19.129, val_kld= 9.651
Epoch= 175/200, loss= 75.284, mse= 74.426, kld= 8.574
        val_loss= 18.752, val_mse= 17.796, val_kld= 9.559
Epoch= 176/200, loss= 75.941, mse= 75.071, kld= 8.705
        val_loss= 18.944, val_mse= 17.927, val_kld= 10.173
Epoch= 177/200, loss= 75.970, mse= 75.095, kld= 8.752
        val_loss= 19.041, val_mse= 18.082, val_kld= 9.591
Epoch= 178/200, loss= 75.279, mse= 74.464, kld= 8.154
        val_loss= 20.039, val_mse= 19.135, val_kld= 9.034
Epoch= 179/200, loss= 75.382, mse= 74.567, kld= 8.142
        val_loss= 20.278, val_mse= 19.326, val_kld= 9.519
Epoch= 180/200, loss= 75.468, mse= 74.624, kld= 8.439
        val_loss= 20.122, val_mse= 19.192, val_kld= 9.305
Epoch= 181/200, loss= 74.864, mse= 74.046, kld= 8.176
        val_loss= 19.270, val_mse= 18.327, val_kld= 9.430
Epoch= 182/200, loss= 74.889, mse= 74.064, kld= 8.247

```



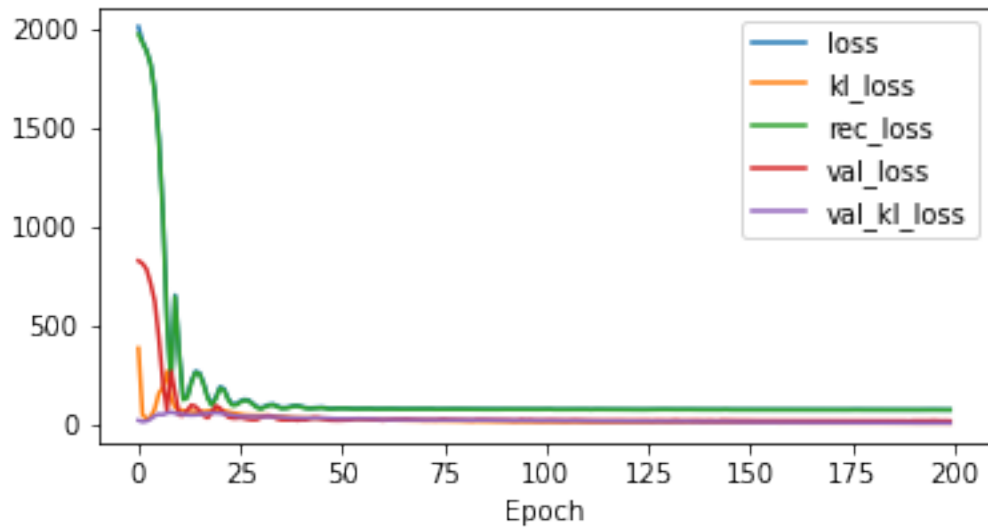
```

        val_loss= 18.292, val_mse= 17.395, val_kld= 8.973
Epoch= 183/200, loss= 75.319, mse= 74.492, kld= 8.265
        val_loss= 18.508, val_mse= 17.563, val_kld= 9.452
Epoch= 184/200, loss= 75.047, mse= 74.225, kld= 8.213
        val_loss= 18.370, val_mse= 17.494, val_kld= 8.754
Epoch= 185/200, loss= 75.468, mse= 74.650, kld= 8.181
        val_loss= 18.323, val_mse= 17.413, val_kld= 9.094
Epoch= 186/200, loss= 74.875, mse= 74.076, kld= 7.989
        val_loss= 18.331, val_mse= 17.414, val_kld= 9.163
Epoch= 187/200, loss= 75.229, mse= 74.435, kld= 7.949
        val_loss= 18.702, val_mse= 17.825, val_kld= 8.771
Epoch= 188/200, loss= 75.058, mse= 74.267, kld= 7.915
        val_loss= 20.156, val_mse= 19.273, val_kld= 8.831
Epoch= 189/200, loss= 74.701, mse= 73.894, kld= 8.070
        val_loss= 18.615, val_mse= 17.735, val_kld= 8.803
Epoch= 190/200, loss= 74.954, mse= 74.163, kld= 7.907
        val_loss= 17.615, val_mse= 16.725, val_kld= 8.909
Epoch= 191/200, loss= 75.014, mse= 74.236, kld= 7.774
        val_loss= 19.126, val_mse= 18.317, val_kld= 8.081
Epoch= 192/200, loss= 74.835, mse= 74.020, kld= 8.147
        val_loss= 18.738, val_mse= 17.906, val_kld= 8.320
Epoch= 193/200, loss= 75.123, mse= 74.336, kld= 7.871
        val_loss= 18.653, val_mse= 17.797, val_kld= 8.552
Epoch= 194/200, loss= 75.615, mse= 74.830, kld= 7.849
        val_loss= 18.541, val_mse= 17.692, val_kld= 8.488
Epoch= 195/200, loss= 74.701, mse= 73.908, kld= 7.920
        val_loss= 19.027, val_mse= 18.187, val_kld= 8.396
Epoch= 196/200, loss= 75.389, mse= 74.617, kld= 7.721
        val_loss= 20.178, val_mse= 19.315, val_kld= 8.632
Epoch= 197/200, loss= 74.746, mse= 73.978, kld= 7.679
        val_loss= 18.507, val_mse= 17.648, val_kld= 8.595
Epoch= 198/200, loss= 74.365, mse= 73.581, kld= 7.832
        val_loss= 18.295, val_mse= 17.405, val_kld= 8.893
Epoch= 199/200, loss= 74.778, mse= 73.995, kld= 7.828
        val_loss= 19.020, val_mse= 18.175, val_kld= 8.453
Epoch= 200/200, loss= 74.692, mse= 73.937, kld= 7.544
        val_loss= 17.991, val_mse= 17.173, val_kld= 8.180

```

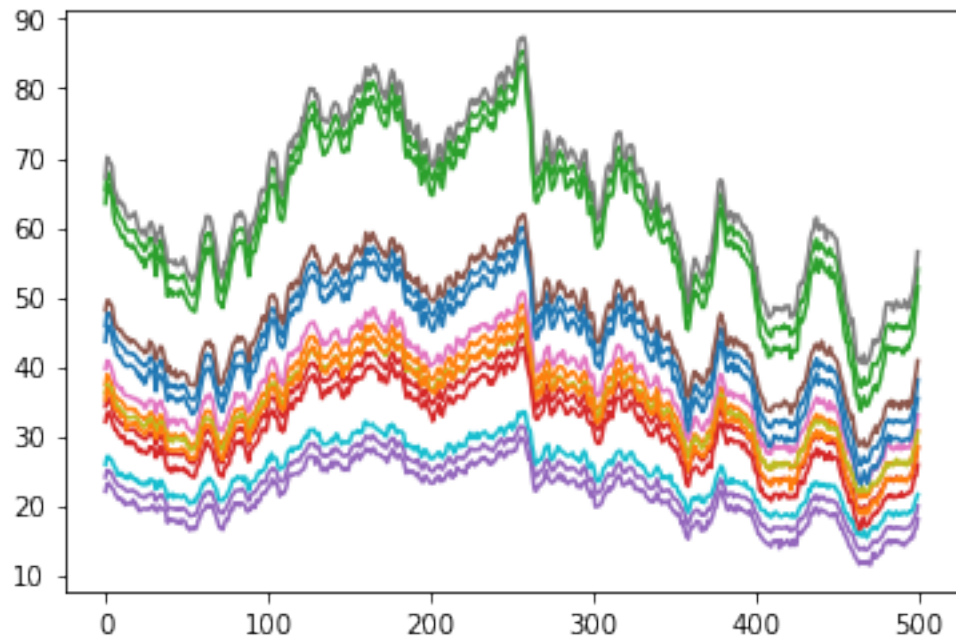
```
[61]: pd.DataFrame(history).plot(figsize=(6, 3), xlabel='Epoch')
```

```
[61]: <AxesSubplot:xlabel='Epoch'>
```



```
[62]: # x_hat = dkf.generate(x_train)
# x_hat, x_025, x_975 = dkf.filter(x_train)
x_hat, x_025, x_975 = dkf.predict(x, 100)
x_hat = x_hat.detach().numpy()[0]
x_025 = x_025.detach().numpy()[0]
x_975 = x_975.detach().numpy()[0]
plt.plot(x_hat)
plt.plot(x_975)
plt.plot(x_025)
```

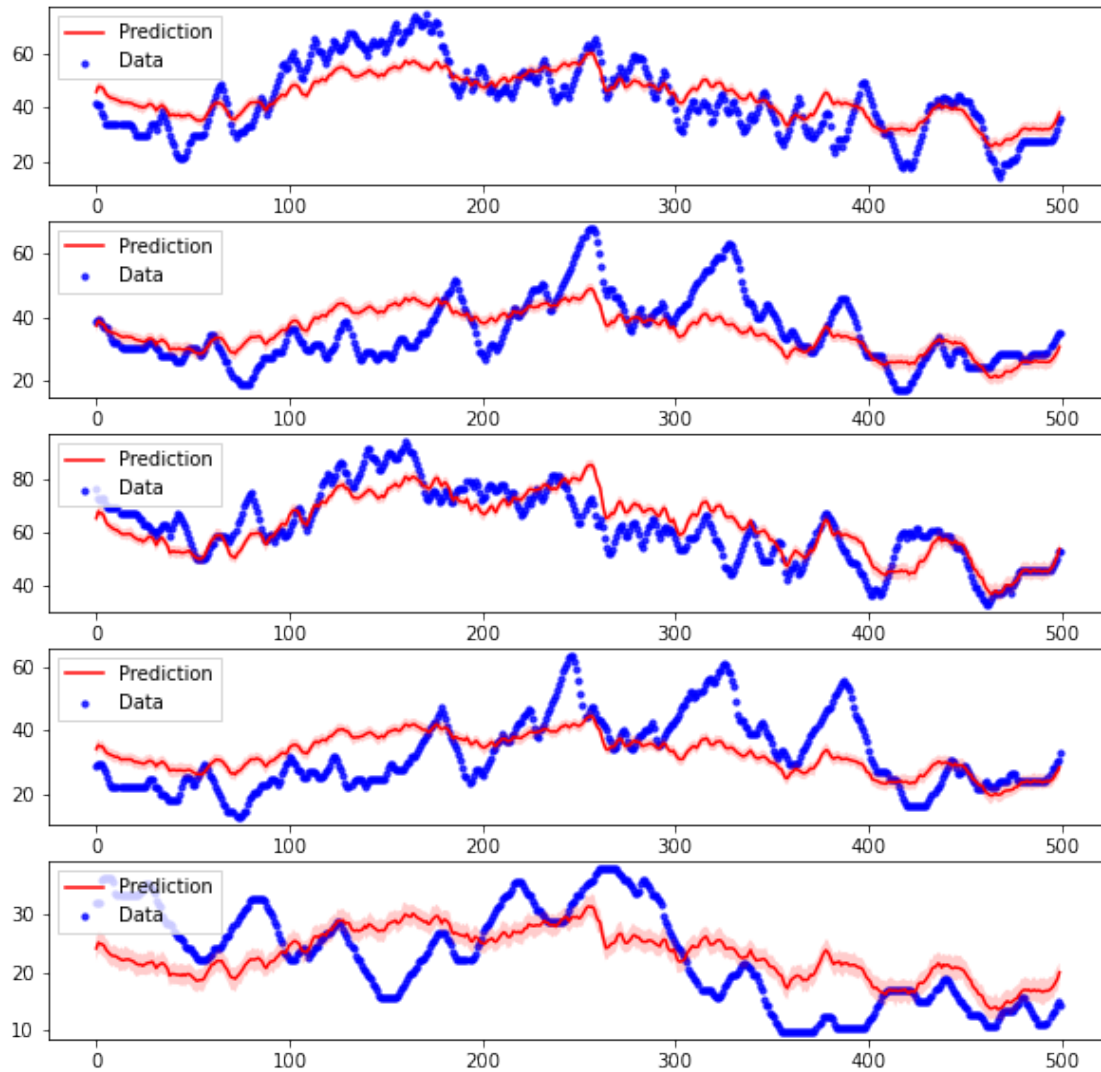
```
[62]: [<matplotlib.lines.Line2D at 0x7f8d5865c640>,
<matplotlib.lines.Line2D at 0x7f8d0cd22d00>,
<matplotlib.lines.Line2D at 0x7f8d0cd22a90>,
<matplotlib.lines.Line2D at 0x7f8d0cd22ee0>,
<matplotlib.lines.Line2D at 0x7f8d0cd22f40>]
```



```
[63]: fig, ax = plt.subplots(5, figsize=(10, 10))

for i, axi in enumerate(ax):
    axi.scatter(
        np.arange(data.shape[0]),
        data[:, i], s=10, alpha=0.8, label='Data', c='b')
    axi.plot(x_hat[:, i], label='Prediction', c='r')
    axi.fill_between(np.arange(x_hat.shape[0]), x_025[:, i], x_975[:, i],
                     facecolor='r', alpha=0.2)

    axi.legend(loc='upper left', fancybox=False)
plt.show()
```



[]:

[]:

[]:

[]:

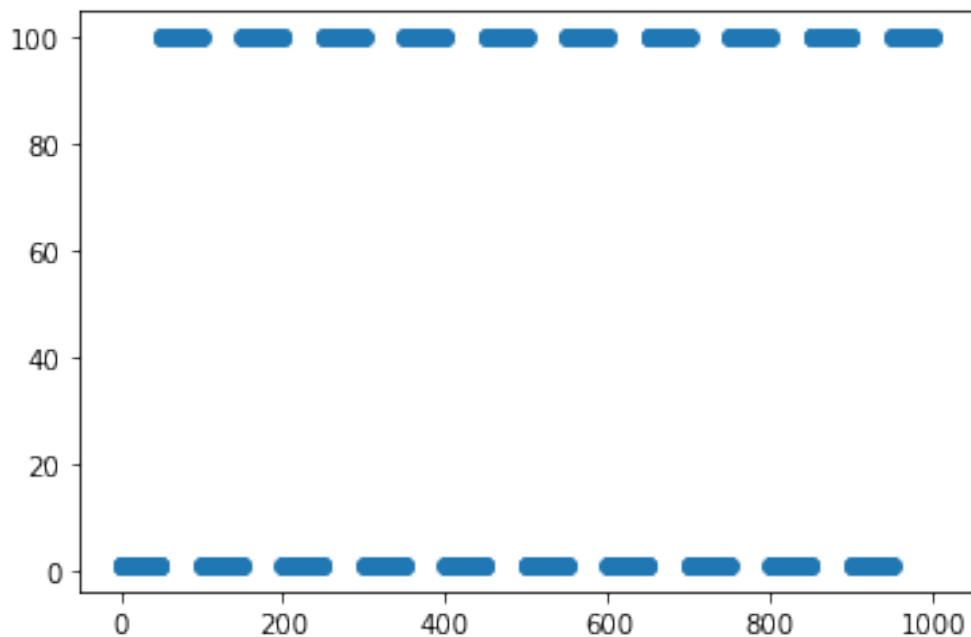
[]:

[64]: #####

[130]: *#Preparing test synthetic datasets - each 1000 measurements*

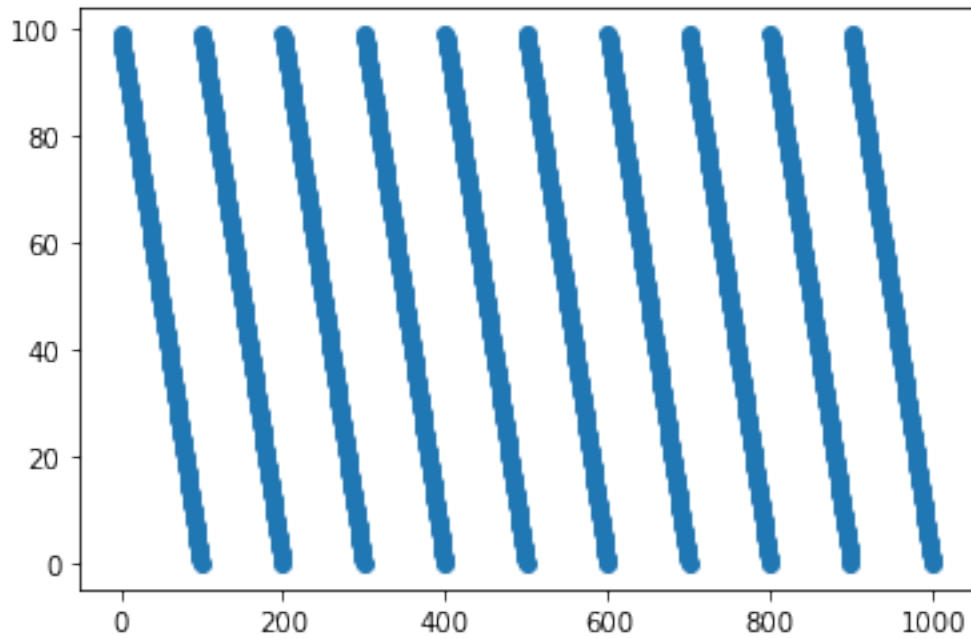
3 Przygotowanie danych syntetycznych

```
[66]: #Dataset 1 - binary a bunch of 1's then a bunch of 100's
data_bin = []
while len(data_bin)<1000:
    data_bin.extend([1 for i in range(50)])
    data_bin.extend([100 for i in range(50)])
data_bin = np.asarray(data_bin[:1000])
#print(data_bin)
plt.scatter(range(len(data_bin)),data_bin)
plt.show()
```



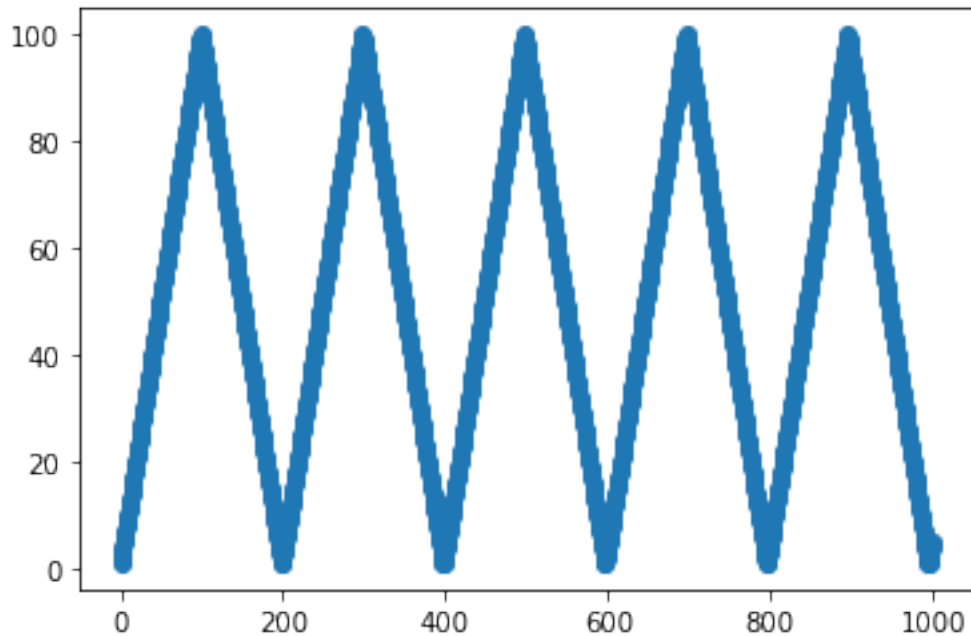
```
[67]: #Dataset 2 - Decreasing from 100 to 1 in a loop
data_spike = []
while len(data_spike)<1000:
    data_spike.extend([-i + 100 for i in range(1, 101)])

data_spike = np.asarray(data_spike[:1000])
#print(data_spike)
plt.scatter(range(len(data_spike)), data_spike)
plt.show()
```



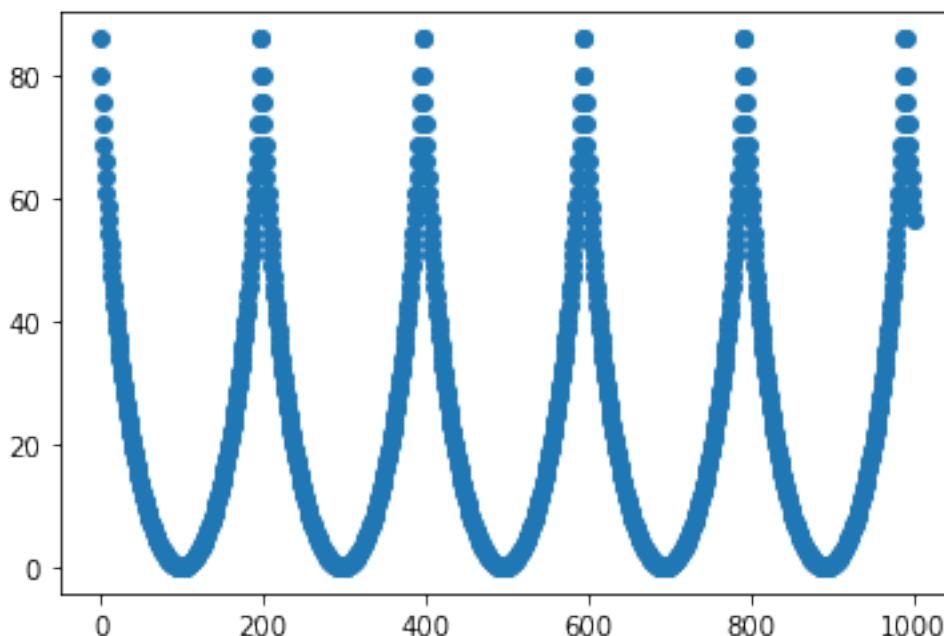
```
[68]: #Dataset 3 - Growing from 1 to 100 then from 100 to 1
```

```
[69]: data_alt = []  
while len(data_alt)<1000:  
    data_alt.extend([i for i in range(1,100)])  
    data_alt.extend([i for i in range(100,0,-1)])  
  
data_alt = np.asarray(data_alt[:1000])  
#print(data_alt)  
plt.scatter(range(len(data_alt)), data_alt)  
plt.show()
```



```
[70]: #Dataset 4 - Lower half of a circle
data_circle = []
while len(data_circle)<1000:
    data_circle.extend([-np.sqrt(100 ** 2 - i ** 2) + 100 for i in
↪range(99,0,-1)])
    data_circle.extend([-np.sqrt(100 ** 2 - i ** 2) + 100 for i in
↪range(1,100)])

data_circle = np.asarray(data_circle[:1000])
#print(data_circle)
#print(len(data_circle))
plt.scatter(range(len(data_circle)), data_circle)
plt.show()
```



```
[71]: data = np.vstack([data_bin, data_spike, data_alt, data_circle]).T
      #print(data.shape)
```

```
[72]: x = torch.FloatTensor(data).reshape(1, *data.shape)
      #print(x)
      x_train = torch.FloatTensor(data[:600]).reshape(1, 600, data.shape[1])
      #print(x_train)
      x_val = torch.FloatTensor(data[600:800]).reshape(1, 200, data.shape[1])
      #print(x_val)
```

3.1 Trenowanie dla danych syntetycznych

```
[73]: dkf = DKF(input_dim=4, z_dim=20, rnn_dim=20, trans_dim=20, emission_dim=20)
```

```
[74]: history = dkf.fit(x_train, x_val, num_epochs=200, annealing_factor=0.2)
```

```
Epoch= 1/200, loss= 9781.516, mse= 3065.445, kld= 33580.348
        val_loss= 3113.489, val_mse= 3046.729, val_kld= 333.801
Epoch= 2/200, loss= 3147.812, mse= 3079.981, kld= 339.159
        val_loss= 3074.664, val_mse= 3038.626, val_kld= 180.193
Epoch= 3/200, loss= 3083.398, mse= 3046.969, kld= 182.148
        val_loss= 3013.500, val_mse= 2973.494, val_kld= 200.031
Epoch= 4/200, loss= 3017.760, mse= 2977.804, kld= 199.781
        val_loss= 2929.241, val_mse= 2881.523, val_kld= 238.591
Epoch= 5/200, loss= 2931.472, mse= 2881.846, kld= 248.131
```



```

    val_loss= 2796.022, val_mse= 2732.863, val_kld= 315.797
Epoch= 6/200, loss= 2791.465, mse= 2725.806, kld= 328.294
    val_loss= 2524.583, val_mse= 2434.120, val_kld= 452.314
Epoch= 7/200, loss= 2578.042, mse= 2480.326, kld= 488.581
    val_loss= 2222.888, val_mse= 2094.419, val_kld= 642.341
Epoch= 8/200, loss= 2252.187, mse= 2113.523, kld= 693.315
    val_loss= 752501.438, val_mse= 2134.756, val_kld= 3751833.500
Epoch= 9/200, loss= 3248.151, mse= 2166.432, kld= 5408.598
    val_loss= 1834.054, val_mse= 1756.477, val_kld= 387.885
Epoch= 10/200, loss= 1889.561, mse= 1793.688, kld= 479.361
    val_loss= 1794.586, val_mse= 1734.027, val_kld= 302.797
Epoch= 11/200, loss= 1823.752, mse= 1763.612, kld= 300.699
    val_loss= 1695.430, val_mse= 1647.575, val_kld= 239.276
Epoch= 12/200, loss= 1713.494, mse= 1666.691, kld= 234.017
    val_loss= 1562.417, val_mse= 1527.780, val_kld= 173.185
Epoch= 13/200, loss= 1569.668, mse= 1530.943, kld= 193.624
    val_loss= 1350.310, val_mse= 1318.206, val_kld= 160.519
Epoch= 14/200, loss= 1398.597, mse= 1366.866, kld= 158.654
    val_loss= 1207.979, val_mse= 1183.382, val_kld= 122.985
Epoch= 15/200, loss= 1275.873, mse= 1249.615, kld= 131.289
    val_loss= 1179.710, val_mse= 1158.302, val_kld= 107.044
Epoch= 16/200, loss= 1203.621, mse= 1182.285, kld= 106.676
    val_loss= 1241.900, val_mse= 1225.604, val_kld= 81.480
Epoch= 17/200, loss= 1264.467, mse= 1247.093, kld= 86.866
    val_loss= 1263.678, val_mse= 1250.026, val_kld= 68.259
Epoch= 18/200, loss= 1275.180, mse= 1261.748, kld= 67.161
    val_loss= 1185.140, val_mse= 1174.499, val_kld= 53.203
Epoch= 19/200, loss= 1225.213, mse= 1214.082, kld= 55.652
    val_loss= 1096.767, val_mse= 1087.891, val_kld= 44.384
Epoch= 20/200, loss= 1105.800, mse= 1096.857, kld= 44.717
    val_loss= 1054.040, val_mse= 1046.304, val_kld= 38.676
Epoch= 21/200, loss= 1049.060, mse= 1041.245, kld= 39.073
    val_loss= 1049.947, val_mse= 1043.020, val_kld= 34.634
Epoch= 22/200, loss= 1053.647, mse= 1046.609, kld= 35.188
    val_loss= 1076.654, val_mse= 1070.149, val_kld= 32.527
Epoch= 23/200, loss= 1081.990, mse= 1075.524, kld= 32.330
    val_loss= 1098.739, val_mse= 1092.655, val_kld= 30.420
Epoch= 24/200, loss= 1099.284, mse= 1093.078, kld= 31.030
    val_loss= 1101.066, val_mse= 1095.197, val_kld= 29.346
Epoch= 25/200, loss= 1109.846, mse= 1103.964, kld= 29.411
    val_loss= 1084.229, val_mse= 1078.452, val_kld= 28.886
Epoch= 26/200, loss= 1093.050, mse= 1087.251, kld= 28.995
    val_loss= 1051.872, val_mse= 1046.080, val_kld= 28.962
Epoch= 27/200, loss= 1062.590, mse= 1056.796, kld= 28.973
    val_loss= 1040.798, val_mse= 1034.905, val_kld= 29.469
Epoch= 28/200, loss= 1041.640, mse= 1035.778, kld= 29.307
    val_loss= 1034.451, val_mse= 1028.526, val_kld= 29.624
Epoch= 29/200, loss= 1033.416, mse= 1027.517, kld= 29.491

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val_loss= 1031.508, val_mse= 1025.512, val_kld= 29.981
 Epoch= 30/200, loss= 1040.789, mse= 1034.779, kld= 30.051
 val_loss= 1036.195, val_mse= 1030.095, val_kld= 30.500
 Epoch= 31/200, loss= 1038.708, mse= 1032.633, kld= 30.377
 val_loss= 1018.198, val_mse= 1012.016, val_kld= 30.908
 Epoch= 32/200, loss= 1035.397, mse= 1029.255, kld= 30.708
 val_loss= 1019.557, val_mse= 1013.428, val_kld= 30.647
 Epoch= 33/200, loss= 1017.226, mse= 1011.100, kld= 30.626
 val_loss= 997.793, val_mse= 991.720, val_kld= 30.370
 Epoch= 34/200, loss= 996.688, mse= 990.568, kld= 30.600
 val_loss= 966.560, val_mse= 960.480, val_kld= 30.399
 Epoch= 35/200, loss= 981.198, mse= 975.134, kld= 30.323
 val_loss= 962.867, val_mse= 956.831, val_kld= 30.180
 Epoch= 36/200, loss= 982.293, mse= 976.259, kld= 30.172
 val_loss= 967.430, val_mse= 961.428, val_kld= 30.011
 Epoch= 37/200, loss= 971.917, mse= 965.885, kld= 30.160
 val_loss= 961.226, val_mse= 955.208, val_kld= 30.087
 Epoch= 38/200, loss= 961.753, mse= 955.738, kld= 30.074
 val_loss= 954.108, val_mse= 948.037, val_kld= 30.357
 Epoch= 39/200, loss= 950.208, mse= 944.155, kld= 30.266
 val_loss= 929.278, val_mse= 923.217, val_kld= 30.308
 Epoch= 40/200, loss= 925.924, mse= 919.812, kld= 30.559
 val_loss= 882.359, val_mse= 876.146, val_kld= 31.066
 Epoch= 41/200, loss= 892.388, mse= 886.205, kld= 30.919
 val_loss= 871.124, val_mse= 864.893, val_kld= 31.153
 Epoch= 42/200, loss= 870.290, mse= 864.023, kld= 31.336
 val_loss= 832.078, val_mse= 825.741, val_kld= 31.686
 Epoch= 43/200, loss= 845.655, mse= 839.299, kld= 31.783
 val_loss= 802.318, val_mse= 795.898, val_kld= 32.100
 Epoch= 44/200, loss= 819.223, mse= 812.801, kld= 32.106
 val_loss= 782.186, val_mse= 775.729, val_kld= 32.285
 Epoch= 45/200, loss= 779.278, mse= 772.809, kld= 32.348
 val_loss= 727.954, val_mse= 721.453, val_kld= 32.506
 Epoch= 46/200, loss= 733.905, mse= 727.408, kld= 32.483
 val_loss= 689.536, val_mse= 683.023, val_kld= 32.565
 Epoch= 47/200, loss= 672.553, mse= 666.037, kld= 32.579
 val_loss= 633.943, val_mse= 627.415, val_kld= 32.637
 Epoch= 48/200, loss= 621.684, mse= 615.142, kld= 32.713
 val_loss= 561.604, val_mse= 555.040, val_kld= 32.823
 Epoch= 49/200, loss= 566.647, mse= 560.075, kld= 32.861
 val_loss= 528.845, val_mse= 522.259, val_kld= 32.928
 Epoch= 50/200, loss= 510.716, mse= 504.086, kld= 33.149
 val_loss= 467.004, val_mse= 460.332, val_kld= 33.357
 Epoch= 51/200, loss= 453.483, mse= 446.803, kld= 33.400
 val_loss= 419.284, val_mse= 412.528, val_kld= 33.780
 Epoch= 52/200, loss= 402.791, mse= 396.034, kld= 33.785
 val_loss= 383.306, val_mse= 376.488, val_kld= 34.090
 Epoch= 53/200, loss= 376.621, mse= 369.773, kld= 34.242

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    val_loss= 364.440, val_mse= 357.550, val_kld= 34.449
Epoch= 54/200, loss= 363.183, mse= 356.265, kld= 34.586
    val_loss= 368.620, val_mse= 361.657, val_kld= 34.817
Epoch= 55/200, loss= 370.774, mse= 363.775, kld= 34.993
    val_loss= 383.798, val_mse= 376.779, val_kld= 35.094
Epoch= 56/200, loss= 389.587, mse= 382.553, kld= 35.167
    val_loss= 393.340, val_mse= 386.349, val_kld= 34.952
Epoch= 57/200, loss= 406.774, mse= 399.754, kld= 35.101
    val_loss= 402.672, val_mse= 395.712, val_kld= 34.804
Epoch= 58/200, loss= 412.388, mse= 405.386, kld= 35.014
    val_loss= 399.485, val_mse= 392.605, val_kld= 34.402
Epoch= 59/200, loss= 408.270, mse= 401.332, kld= 34.689
    val_loss= 389.003, val_mse= 382.184, val_kld= 34.091
Epoch= 60/200, loss= 395.551, mse= 388.685, kld= 34.328
    val_loss= 377.700, val_mse= 370.980, val_kld= 33.603
Epoch= 61/200, loss= 384.300, mse= 377.520, kld= 33.903
    val_loss= 367.391, val_mse= 360.739, val_kld= 33.264
Epoch= 62/200, loss= 370.979, mse= 364.284, kld= 33.476
    val_loss= 355.431, val_mse= 348.824, val_kld= 33.034
Epoch= 63/200, loss= 358.253, mse= 351.613, kld= 33.198
    val_loss= 346.680, val_mse= 340.111, val_kld= 32.843
Epoch= 64/200, loss= 353.117, mse= 346.512, kld= 33.023
    val_loss= 341.404, val_mse= 334.879, val_kld= 32.626
Epoch= 65/200, loss= 343.209, mse= 336.622, kld= 32.934
    val_loss= 339.097, val_mse= 332.582, val_kld= 32.575
Epoch= 66/200, loss= 344.584, mse= 338.008, kld= 32.881
    val_loss= 341.642, val_mse= 335.124, val_kld= 32.586
Epoch= 67/200, loss= 346.519, mse= 339.966, kld= 32.765
    val_loss= 348.187, val_mse= 341.674, val_kld= 32.566
Epoch= 68/200, loss= 350.709, mse= 344.186, kld= 32.615
    val_loss= 343.734, val_mse= 337.247, val_kld= 32.437
Epoch= 69/200, loss= 349.530, mse= 343.036, kld= 32.472
    val_loss= 346.042, val_mse= 339.613, val_kld= 32.146
Epoch= 70/200, loss= 347.531, mse= 341.066, kld= 32.325
    val_loss= 342.386, val_mse= 336.023, val_kld= 31.818
Epoch= 71/200, loss= 343.687, mse= 337.285, kld= 32.009
    val_loss= 340.340, val_mse= 334.012, val_kld= 31.638
Epoch= 72/200, loss= 342.537, mse= 336.183, kld= 31.770
    val_loss= 335.995, val_mse= 329.692, val_kld= 31.515
Epoch= 73/200, loss= 336.930, mse= 330.612, kld= 31.587
    val_loss= 331.864, val_mse= 325.641, val_kld= 31.117
Epoch= 74/200, loss= 334.865, mse= 328.571, kld= 31.468
    val_loss= 331.916, val_mse= 325.674, val_kld= 31.213
Epoch= 75/200, loss= 331.617, mse= 325.333, kld= 31.420
    val_loss= 329.764, val_mse= 323.530, val_kld= 31.171
Epoch= 76/200, loss= 328.126, mse= 321.858, kld= 31.342
    val_loss= 320.006, val_mse= 313.769, val_kld= 31.186
Epoch= 77/200, loss= 323.934, mse= 317.681, kld= 31.263

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    val_loss= 318.210, val_mse= 312.015, val_kld= 30.975
Epoch= 78/200, loss= 319.474, mse= 313.210, kld= 31.320
    val_loss= 311.381, val_mse= 305.150, val_kld= 31.151
Epoch= 79/200, loss= 317.767, mse= 311.527, kld= 31.196
    val_loss= 306.711, val_mse= 300.509, val_kld= 31.009
Epoch= 80/200, loss= 314.621, mse= 308.371, kld= 31.251
    val_loss= 306.933, val_mse= 300.743, val_kld= 30.950
Epoch= 81/200, loss= 310.337, mse= 304.093, kld= 31.217
    val_loss= 304.414, val_mse= 298.241, val_kld= 30.864
Epoch= 82/200, loss= 307.639, mse= 301.416, kld= 31.117
    val_loss= 296.834, val_mse= 290.685, val_kld= 30.749
Epoch= 83/200, loss= 303.832, mse= 297.637, kld= 30.975
    val_loss= 296.268, val_mse= 290.151, val_kld= 30.585
Epoch= 84/200, loss= 299.663, mse= 293.510, kld= 30.764
    val_loss= 292.608, val_mse= 286.508, val_kld= 30.501
Epoch= 85/200, loss= 295.781, mse= 289.642, kld= 30.696
    val_loss= 282.997, val_mse= 276.938, val_kld= 30.295
Epoch= 86/200, loss= 290.535, mse= 284.440, kld= 30.479
    val_loss= 283.195, val_mse= 277.167, val_kld= 30.137
Epoch= 87/200, loss= 284.779, mse= 278.698, kld= 30.407
    val_loss= 273.699, val_mse= 267.675, val_kld= 30.122
Epoch= 88/200, loss= 279.502, mse= 273.435, kld= 30.339
    val_loss= 270.570, val_mse= 264.589, val_kld= 29.906
Epoch= 89/200, loss= 275.286, mse= 269.218, kld= 30.341
    val_loss= 265.297, val_mse= 259.289, val_kld= 30.042
Epoch= 90/200, loss= 267.304, mse= 261.256, kld= 30.241
    val_loss= 261.048, val_mse= 255.050, val_kld= 29.990
Epoch= 91/200, loss= 265.536, mse= 259.493, kld= 30.214
    val_loss= 249.366, val_mse= 243.393, val_kld= 29.865
Epoch= 92/200, loss= 258.808, mse= 252.782, kld= 30.130
    val_loss= 252.549, val_mse= 246.588, val_kld= 29.804
Epoch= 93/200, loss= 253.121, mse= 247.105, kld= 30.084
    val_loss= 242.211, val_mse= 236.264, val_kld= 29.737
Epoch= 94/200, loss= 248.825, mse= 242.821, kld= 30.022
    val_loss= 233.026, val_mse= 227.128, val_kld= 29.492
Epoch= 95/200, loss= 240.562, mse= 234.559, kld= 30.011
    val_loss= 225.811, val_mse= 219.861, val_kld= 29.751
Epoch= 96/200, loss= 235.637, mse= 229.672, kld= 29.823
    val_loss= 219.781, val_mse= 213.864, val_kld= 29.585
Epoch= 97/200, loss= 228.094, mse= 222.096, kld= 29.986
    val_loss= 209.820, val_mse= 203.900, val_kld= 29.599
Epoch= 98/200, loss= 221.881, mse= 215.910, kld= 29.855
    val_loss= 204.958, val_mse= 199.054, val_kld= 29.520
Epoch= 99/200, loss= 213.130, mse= 207.143, kld= 29.934
    val_loss= 198.764, val_mse= 192.807, val_kld= 29.786
Epoch= 100/200, loss= 208.855, mse= 202.862, kld= 29.968
    val_loss= 188.220, val_mse= 182.262, val_kld= 29.789
Epoch= 101/200, loss= 199.361, mse= 193.356, kld= 30.028

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        val_loss= 186.766, val_mse= 180.808, val_kld= 29.792
Epoch= 102/200, loss= 192.794, mse= 186.773, kld= 30.105
        val_loss= 174.482, val_mse= 168.508, val_kld= 29.872
Epoch= 103/200, loss= 185.856, mse= 179.837, kld= 30.096
        val_loss= 168.276, val_mse= 162.303, val_kld= 29.864
Epoch= 104/200, loss= 179.573, mse= 173.523, kld= 30.248
        val_loss= 160.903, val_mse= 154.938, val_kld= 29.824
Epoch= 105/200, loss= 172.601, mse= 166.565, kld= 30.177
        val_loss= 155.638, val_mse= 149.653, val_kld= 29.922
Epoch= 106/200, loss= 167.507, mse= 161.469, kld= 30.190
        val_loss= 146.980, val_mse= 140.975, val_kld= 30.022
Epoch= 107/200, loss= 161.276, mse= 155.216, kld= 30.298
        val_loss= 141.908, val_mse= 135.930, val_kld= 29.889
Epoch= 108/200, loss= 154.936, mse= 148.853, kld= 30.412
        val_loss= 136.079, val_mse= 130.057, val_kld= 30.107
Epoch= 109/200, loss= 148.255, mse= 142.154, kld= 30.506
        val_loss= 129.327, val_mse= 123.288, val_kld= 30.197
Epoch= 110/200, loss= 141.639, mse= 135.539, kld= 30.500
        val_loss= 123.123, val_mse= 117.111, val_kld= 30.062
Epoch= 111/200, loss= 135.526, mse= 129.432, kld= 30.473
        val_loss= 118.737, val_mse= 112.734, val_kld= 30.017
Epoch= 112/200, loss= 128.158, mse= 122.076, kld= 30.411
        val_loss= 111.581, val_mse= 105.535, val_kld= 30.229
Epoch= 113/200, loss= 122.899, mse= 116.807, kld= 30.458
        val_loss= 108.468, val_mse= 102.438, val_kld= 30.154
Epoch= 114/200, loss= 115.632, mse= 109.524, kld= 30.539
        val_loss= 102.817, val_mse= 96.754, val_kld= 30.316
Epoch= 115/200, loss= 112.156, mse= 106.043, kld= 30.562
        val_loss= 97.678, val_mse= 91.649, val_kld= 30.141
Epoch= 116/200, loss= 106.431, mse= 100.324, kld= 30.534
        val_loss= 93.459, val_mse= 87.417, val_kld= 30.211
Epoch= 117/200, loss= 102.341, mse= 96.223, kld= 30.589
        val_loss= 89.641, val_mse= 83.606, val_kld= 30.176
Epoch= 118/200, loss= 96.604, mse= 90.492, kld= 30.559
        val_loss= 88.370, val_mse= 82.284, val_kld= 30.432
Epoch= 119/200, loss= 91.817, mse= 85.696, kld= 30.605
        val_loss= 82.072, val_mse= 76.029, val_kld= 30.219
Epoch= 120/200, loss= 90.007, mse= 83.890, kld= 30.587
        val_loss= 81.594, val_mse= 75.546, val_kld= 30.237
Epoch= 121/200, loss= 87.269, mse= 81.132, kld= 30.685
        val_loss= 76.595, val_mse= 70.554, val_kld= 30.206
Epoch= 122/200, loss= 83.626, mse= 77.503, kld= 30.616
        val_loss= 75.217, val_mse= 69.121, val_kld= 30.478
Epoch= 123/200, loss= 80.072, mse= 73.932, kld= 30.699
        val_loss= 74.483, val_mse= 68.402, val_kld= 30.405
Epoch= 124/200, loss= 77.080, mse= 70.939, kld= 30.701
        val_loss= 71.301, val_mse= 65.240, val_kld= 30.302
Epoch= 125/200, loss= 74.515, mse= 68.384, kld= 30.653

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        val_loss= 69.435, val_mse= 63.366, val_kld= 30.346
Epoch= 126/200, loss= 72.562, mse= 66.425, kld= 30.687
        val_loss= 68.485, val_mse= 62.406, val_kld= 30.397
Epoch= 127/200, loss= 68.967, mse= 62.844, kld= 30.613
        val_loss= 64.569, val_mse= 58.514, val_kld= 30.274
Epoch= 128/200, loss= 66.971, mse= 60.853, kld= 30.586
        val_loss= 61.732, val_mse= 55.695, val_kld= 30.185
Epoch= 129/200, loss= 66.285, mse= 60.162, kld= 30.615
        val_loss= 60.574, val_mse= 54.539, val_kld= 30.171
Epoch= 130/200, loss= 62.980, mse= 56.863, kld= 30.583
        val_loss= 58.871, val_mse= 52.851, val_kld= 30.103
Epoch= 131/200, loss= 60.454, mse= 54.350, kld= 30.522
        val_loss= 56.206, val_mse= 50.171, val_kld= 30.177
Epoch= 132/200, loss= 57.951, mse= 51.885, kld= 30.331
        val_loss= 55.046, val_mse= 49.059, val_kld= 29.939
Epoch= 133/200, loss= 56.948, mse= 50.887, kld= 30.305
        val_loss= 53.285, val_mse= 47.284, val_kld= 30.006
Epoch= 134/200, loss= 53.965, mse= 47.899, kld= 30.327
        val_loss= 51.250, val_mse= 45.293, val_kld= 29.787
Epoch= 135/200, loss= 52.754, mse= 46.736, kld= 30.092
        val_loss= 52.248, val_mse= 46.278, val_kld= 29.851
Epoch= 136/200, loss= 52.052, mse= 46.049, kld= 30.013
        val_loss= 52.369, val_mse= 46.411, val_kld= 29.793
Epoch= 137/200, loss= 50.487, mse= 44.492, kld= 29.978
        val_loss= 50.451, val_mse= 44.521, val_kld= 29.649
Epoch= 138/200, loss= 49.862, mse= 43.895, kld= 29.839
        val_loss= 50.001, val_mse= 44.095, val_kld= 29.528
Epoch= 139/200, loss= 49.913, mse= 43.951, kld= 29.809
        val_loss= 49.187, val_mse= 43.312, val_kld= 29.374
Epoch= 140/200, loss= 48.564, mse= 42.618, kld= 29.730
        val_loss= 49.382, val_mse= 43.498, val_kld= 29.418
Epoch= 141/200, loss= 48.304, mse= 42.367, kld= 29.685
        val_loss= 50.583, val_mse= 44.714, val_kld= 29.342
Epoch= 142/200, loss= 48.133, mse= 42.207, kld= 29.630
        val_loss= 49.340, val_mse= 43.481, val_kld= 29.294
Epoch= 143/200, loss= 46.180, mse= 40.278, kld= 29.513
        val_loss= 48.977, val_mse= 43.136, val_kld= 29.203
Epoch= 144/200, loss= 48.660, mse= 42.774, kld= 29.431
        val_loss= 49.673, val_mse= 43.857, val_kld= 29.080
Epoch= 145/200, loss= 46.522, mse= 40.671, kld= 29.255
        val_loss= 47.780, val_mse= 41.988, val_kld= 28.960
Epoch= 146/200, loss= 46.949, mse= 41.099, kld= 29.250
        val_loss= 48.415, val_mse= 42.649, val_kld= 28.829
Epoch= 147/200, loss= 46.529, mse= 40.692, kld= 29.186
        val_loss= 49.577, val_mse= 43.803, val_kld= 28.871
Epoch= 148/200, loss= 47.107, mse= 41.291, kld= 29.076
        val_loss= 48.823, val_mse= 43.082, val_kld= 28.708
Epoch= 149/200, loss= 46.454, mse= 40.643, kld= 29.057

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        val_loss= 48.186, val_mse= 42.460, val_kld= 28.627
Epoch= 150/200, loss= 45.775, mse= 40.008, kld= 28.836
        val_loss= 46.253, val_mse= 40.555, val_kld= 28.490
Epoch= 151/200, loss= 46.028, mse= 40.271, kld= 28.786
        val_loss= 46.906, val_mse= 41.226, val_kld= 28.398
Epoch= 152/200, loss= 46.526, mse= 40.789, kld= 28.685
        val_loss= 49.276, val_mse= 43.602, val_kld= 28.370
Epoch= 153/200, loss= 46.500, mse= 40.807, kld= 28.467
        val_loss= 46.734, val_mse= 41.101, val_kld= 28.166
Epoch= 154/200, loss= 44.734, mse= 39.051, kld= 28.415
        val_loss= 46.185, val_mse= 40.576, val_kld= 28.043
Epoch= 155/200, loss= 44.408, mse= 38.752, kld= 28.275
        val_loss= 46.844, val_mse= 41.270, val_kld= 27.872
Epoch= 156/200, loss= 44.737, mse= 39.103, kld= 28.170
        val_loss= 46.101, val_mse= 40.545, val_kld= 27.777
Epoch= 157/200, loss= 45.039, mse= 39.422, kld= 28.088
        val_loss= 46.972, val_mse= 41.455, val_kld= 27.581
Epoch= 158/200, loss= 45.775, mse= 40.185, kld= 27.950
        val_loss= 46.590, val_mse= 41.064, val_kld= 27.627
Epoch= 159/200, loss= 44.395, mse= 38.847, kld= 27.737
        val_loss= 45.260, val_mse= 39.770, val_kld= 27.453
Epoch= 160/200, loss= 44.407, mse= 38.883, kld= 27.621
        val_loss= 45.817, val_mse= 40.375, val_kld= 27.212
Epoch= 161/200, loss= 43.509, mse= 38.001, kld= 27.539
        val_loss= 43.849, val_mse= 38.416, val_kld= 27.164
Epoch= 162/200, loss= 43.602, mse= 38.101, kld= 27.507
        val_loss= 44.773, val_mse= 39.382, val_kld= 26.954
Epoch= 163/200, loss= 43.978, mse= 38.509, kld= 27.348
        val_loss= 44.885, val_mse= 39.488, val_kld= 26.986
Epoch= 164/200, loss= 42.938, mse= 37.489, kld= 27.248
        val_loss= 45.006, val_mse= 39.628, val_kld= 26.893
Epoch= 165/200, loss= 43.804, mse= 38.365, kld= 27.192
        val_loss= 46.437, val_mse= 41.051, val_kld= 26.931
Epoch= 166/200, loss= 42.981, mse= 37.582, kld= 26.994
        val_loss= 44.717, val_mse= 39.387, val_kld= 26.647
Epoch= 167/200, loss= 42.675, mse= 37.285, kld= 26.950
        val_loss= 43.315, val_mse= 37.989, val_kld= 26.632
Epoch= 168/200, loss= 42.968, mse= 37.594, kld= 26.868
        val_loss= 44.256, val_mse= 38.942, val_kld= 26.571
Epoch= 169/200, loss= 43.249, mse= 37.903, kld= 26.730
        val_loss= 43.065, val_mse= 37.786, val_kld= 26.395
Epoch= 170/200, loss= 42.848, mse= 37.501, kld= 26.736
        val_loss= 43.137, val_mse= 37.857, val_kld= 26.398
Epoch= 171/200, loss= 42.168, mse= 36.860, kld= 26.539
        val_loss= 44.140, val_mse= 38.895, val_kld= 26.227
Epoch= 172/200, loss= 42.437, mse= 37.123, kld= 26.568
        val_loss= 43.046, val_mse= 37.807, val_kld= 26.198
Epoch= 173/200, loss= 42.417, mse= 37.129, kld= 26.442

```

```

    val_loss= 43.923, val_mse= 38.669, val_kld= 26.268
Epoch= 174/200, loss= 42.403, mse= 37.131, kld= 26.360
    val_loss= 41.807, val_mse= 36.604, val_kld= 26.019
Epoch= 175/200, loss= 42.104, mse= 36.840, kld= 26.324
    val_loss= 43.630, val_mse= 38.416, val_kld= 26.071
Epoch= 176/200, loss= 41.340, mse= 36.093, kld= 26.233
    val_loss= 42.106, val_mse= 36.909, val_kld= 25.981
Epoch= 177/200, loss= 41.528, mse= 36.262, kld= 26.331
    val_loss= 42.052, val_mse= 36.875, val_kld= 25.885
Epoch= 178/200, loss= 41.107, mse= 35.880, kld= 26.136
    val_loss= 43.316, val_mse= 38.147, val_kld= 25.845
Epoch= 179/200, loss= 41.864, mse= 36.652, kld= 26.065
    val_loss= 42.657, val_mse= 37.476, val_kld= 25.903
Epoch= 180/200, loss= 41.061, mse= 35.837, kld= 26.120
    val_loss= 42.473, val_mse= 37.326, val_kld= 25.735
Epoch= 181/200, loss= 40.182, mse= 34.988, kld= 25.970
    val_loss= 41.553, val_mse= 36.445, val_kld= 25.537
Epoch= 182/200, loss= 40.269, mse= 35.085, kld= 25.922
    val_loss= 41.324, val_mse= 36.200, val_kld= 25.621
Epoch= 183/200, loss= 39.841, mse= 34.682, kld= 25.794
    val_loss= 41.266, val_mse= 36.151, val_kld= 25.575
Epoch= 184/200, loss= 40.598, mse= 35.434, kld= 25.817
    val_loss= 41.865, val_mse= 36.773, val_kld= 25.457
Epoch= 185/200, loss= 40.492, mse= 35.330, kld= 25.810
    val_loss= 40.408, val_mse= 35.343, val_kld= 25.325
Epoch= 186/200, loss= 39.543, mse= 34.414, kld= 25.644
    val_loss= 40.583, val_mse= 35.501, val_kld= 25.406
Epoch= 187/200, loss= 39.731, mse= 34.584, kld= 25.735
    val_loss= 41.463, val_mse= 36.387, val_kld= 25.378
Epoch= 188/200, loss= 40.127, mse= 34.996, kld= 25.657
    val_loss= 39.867, val_mse= 34.814, val_kld= 25.264
Epoch= 189/200, loss= 39.356, mse= 34.249, kld= 25.535
    val_loss= 40.148, val_mse= 35.085, val_kld= 25.316
Epoch= 190/200, loss= 38.745, mse= 33.659, kld= 25.431
    val_loss= 39.260, val_mse= 34.242, val_kld= 25.087
Epoch= 191/200, loss= 38.622, mse= 33.564, kld= 25.290
    val_loss= 39.875, val_mse= 34.858, val_kld= 25.083
Epoch= 192/200, loss= 38.518, mse= 33.453, kld= 25.327
    val_loss= 39.408, val_mse= 34.403, val_kld= 25.028
Epoch= 193/200, loss= 38.122, mse= 33.065, kld= 25.285
    val_loss= 39.197, val_mse= 34.226, val_kld= 24.854
Epoch= 194/200, loss= 38.041, mse= 32.993, kld= 25.238
    val_loss= 39.012, val_mse= 34.043, val_kld= 24.849
Epoch= 195/200, loss= 38.256, mse= 33.206, kld= 25.249
    val_loss= 39.365, val_mse= 34.402, val_kld= 24.817
Epoch= 196/200, loss= 38.257, mse= 33.244, kld= 25.063
    val_loss= 38.924, val_mse= 33.975, val_kld= 24.746
Epoch= 197/200, loss= 37.711, mse= 32.706, kld= 25.024

```



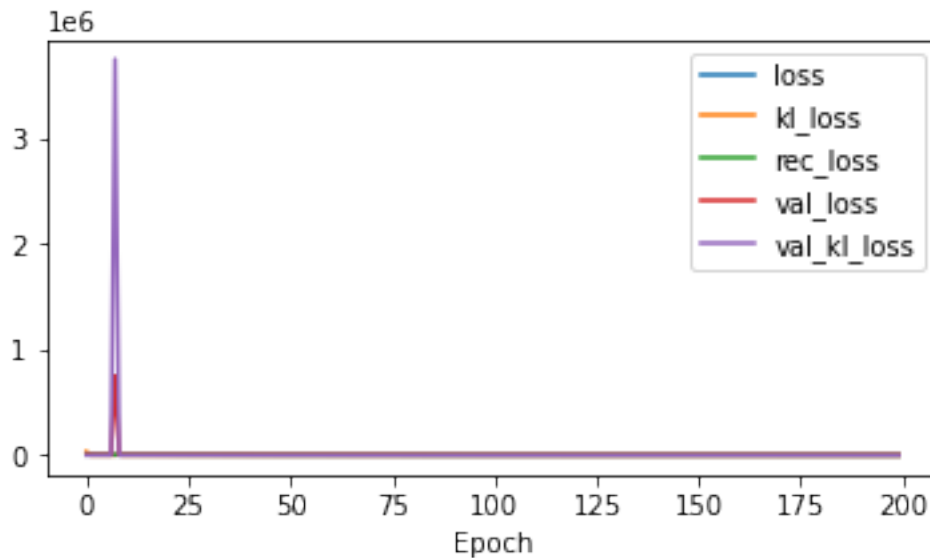
```

        val_loss= 38.433, val_mse= 33.500, val_kld= 24.666
Epoch= 198/200, loss= 37.632, mse= 32.619, kld= 25.065
        val_loss= 38.693, val_mse= 33.751, val_kld= 24.711
Epoch= 199/200, loss= 36.531, mse= 31.526, kld= 25.025
        val_loss= 37.696, val_mse= 32.780, val_kld= 24.581
Epoch= 200/200, loss= 36.895, mse= 31.921, kld= 24.873
        val_loss= 38.102, val_mse= 33.172, val_kld= 24.651

```

```
[75]: pd.DataFrame(history).plot(figsize=(6, 3), xlabel='Epoch')
```

```
[75]: <AxesSubplot:xlabel='Epoch'>
```



```

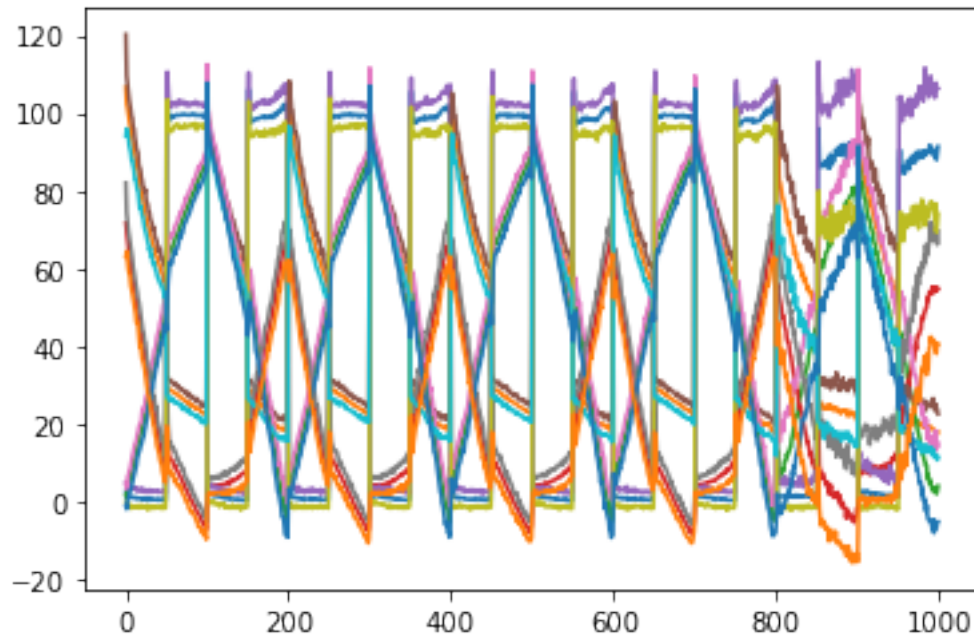
[76]: # x_hat = dkf.generate(x_train)
      # x_hat, x_025, x_975 = dkf.filter(x_train)
      x_hat, x_025, x_975 = dkf.predict(x, 200)
      x_hat = x_hat.detach().numpy()[0]
      x_025 = x_025.detach().numpy()[0]
      x_975 = x_975.detach().numpy()[0]
      plt.plot(x_hat)
      plt.plot(x_975)
      plt.plot(x_025)

```

```

[76]: [<matplotlib.lines.Line2D at 0x7f8d06b3f8e0>,
      <matplotlib.lines.Line2D at 0x7f8d58615d30>,
      <matplotlib.lines.Line2D at 0x7f8d06a1feb0>,
      <matplotlib.lines.Line2D at 0x7f8d58615b80>]

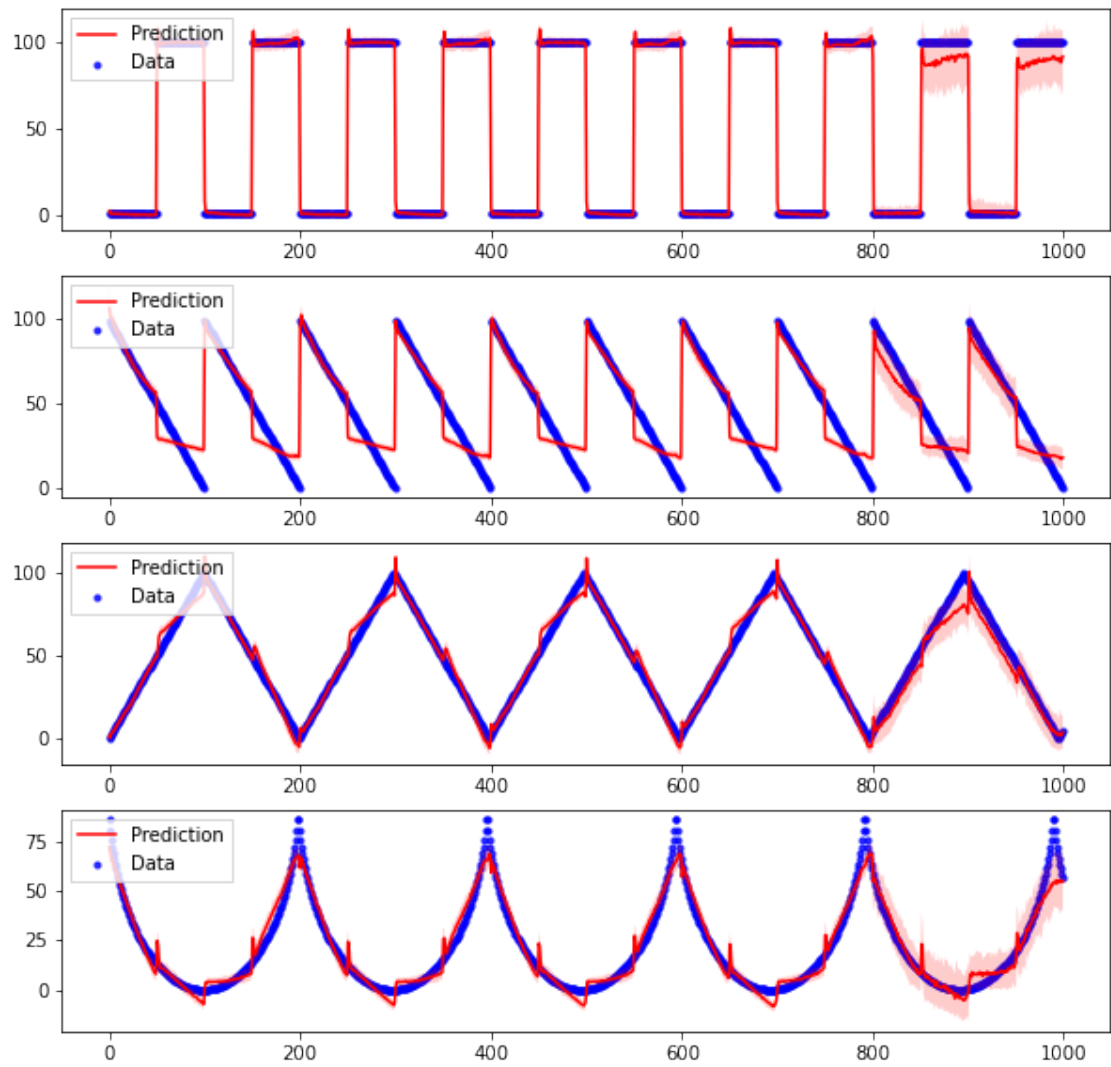
```



```
[77]: fig, ax = plt.subplots(4, figsize=(10, 10))

for i, axi in enumerate(ax):
    axi.scatter(
        np.arange(data.shape[0]),
        data[:, i], s=10, alpha=0.8, label='Data', c='b')
    axi.plot(x_hat[:, i], label='Prediction', c='r')
    axi.fill_between(np.arange(x_hat.shape[0]), x_025[:, i], x_975[:, i],
                     facecolor='r', alpha=0.2)

    axi.legend(loc='upper left', fancybox=False)
plt.show()
```



[78]: #####

[]:

[]:

[]:

[]:

4 Przesunięcie i normalizacja danych

4.1 Trenowanie dla pierwszych 5 treningów po przesunięciu w płaszczyźnie longitude x latitude

```
[79]: #5 Workoutow, gdzie zbijamy longitude i latitude w przesunięcie
```

```
def translation(i):
    lon = np.asarray(data_endo[i]['longitude'])
    lat = np.asarray(data_endo[i]['latitude'])
    tra = np.sqrt(np.power(lon, 2) + np.power(lat, 2))
    return tra

data = np.vstack([translation(i) for i in range(5)]).T
#print(data.shape)
```

```
[80]: x = torch.FloatTensor(data).reshape(1, *data.shape)
      #print(x)
      x_train = torch.FloatTensor(data[:400]).reshape(1, 400, data.shape[1])
      #print(x_train)
      x_val = torch.FloatTensor(data[400:450]).reshape(1, 50, data.shape[1])
      #print(x_val)
```

```
[85]: dkf = DKF(input_dim=5, z_dim=25, rnn_dim=25, trans_dim=25, emission_dim=25)
```

```
[86]: history = dkf.fit(x_train, x_val, num_epochs=200, annealing_factor=0.2)
```

```
Epoch= 1/200, loss= 4216.039, mse= 4191.806, kld= 121.161
      val_loss= 4088.448, val_mse= 4065.533, val_kld= 114.571
Epoch= 2/200, loss= 4086.384, mse= 4063.202, kld= 115.910
      val_loss= 3810.938, val_mse= 3772.804, val_kld= 190.670
Epoch= 3/200, loss= 3791.244, mse= 3753.598, kld= 188.231
      val_loss= 3238.750, val_mse= 3204.529, val_kld= 171.102
Epoch= 4/200, loss= 3220.132, mse= 3186.787, kld= 166.726
      val_loss= 2226.942, val_mse= 2200.832, val_kld= 130.553
Epoch= 5/200, loss= 2204.635, mse= 2180.047, kld= 122.943
      val_loss= 890.374, val_mse= 855.860, val_kld= 172.568
Epoch= 6/200, loss= 841.280, mse= 812.472, kld= 144.041
      val_loss= 1124.537, val_mse= 1077.920, val_kld= 233.089
Epoch= 7/200, loss= 1148.478, mse= 1111.739, kld= 183.693
      val_loss= 652.439, val_mse= 619.773, val_kld= 163.332
Epoch= 8/200, loss= 682.817, mse= 657.085, kld= 128.657
      val_loss= 157.692, val_mse= 137.954, val_kld= 98.688
Epoch= 9/200, loss= 125.743, mse= 110.380, kld= 76.813
      val_loss= 219.133, val_mse= 201.652, val_kld= 87.405
```

Epoch= 10/200, loss= 180.624, mse= 166.476, kld= 70.741
 val_loss= 350.054, val_mse= 333.548, val_kld= 82.529
 Epoch= 11/200, loss= 313.026, mse= 299.542, kld= 67.419
 val_loss= 348.522, val_mse= 332.503, val_kld= 80.095
 Epoch= 12/200, loss= 317.016, mse= 304.014, kld= 65.010
 val_loss= 249.268, val_mse= 233.358, val_kld= 79.551
 Epoch= 13/200, loss= 218.619, mse= 205.707, kld= 64.562
 val_loss= 171.720, val_mse= 155.370, val_kld= 81.750
 Epoch= 14/200, loss= 142.890, mse= 129.913, kld= 64.886
 val_loss= 219.140, val_mse= 201.799, val_kld= 86.703
 Epoch= 15/200, loss= 208.575, mse= 194.889, kld= 68.430
 val_loss= 318.935, val_mse= 301.308, val_kld= 88.136
 Epoch= 16/200, loss= 316.804, mse= 302.876, kld= 69.638
 val_loss= 283.613, val_mse= 265.994, val_kld= 88.098
 Epoch= 17/200, loss= 275.716, mse= 261.695, kld= 70.104
 val_loss= 176.612, val_mse= 159.894, val_kld= 83.591
 Epoch= 18/200, loss= 163.217, mse= 149.846, kld= 66.856
 val_loss= 137.769, val_mse= 122.531, val_kld= 76.190
 Epoch= 19/200, loss= 117.088, mse= 104.995, kld= 60.470
 val_loss= 157.118, val_mse= 142.802, val_kld= 71.582
 Epoch= 20/200, loss= 133.311, mse= 121.954, kld= 56.782
 val_loss= 176.141, val_mse= 162.640, val_kld= 67.506
 Epoch= 21/200, loss= 148.907, mse= 138.246, kld= 53.305
 val_loss= 148.170, val_mse= 135.212, val_kld= 64.790
 Epoch= 22/200, loss= 125.987, mse= 115.927, kld= 50.298
 val_loss= 88.144, val_mse= 75.375, val_kld= 63.844
 Epoch= 23/200, loss= 72.159, mse= 62.411, kld= 48.740
 val_loss= 49.730, val_mse= 36.881, val_kld= 64.247
 Epoch= 24/200, loss= 32.632, mse= 23.048, kld= 47.919
 val_loss= 51.342, val_mse= 38.720, val_kld= 63.111
 Epoch= 25/200, loss= 38.182, mse= 28.980, kld= 46.009
 val_loss= 78.703, val_mse= 66.306, val_kld= 61.986
 Epoch= 26/200, loss= 70.470, mse= 61.652, kld= 44.092
 val_loss= 76.373, val_mse= 64.232, val_kld= 60.705
 Epoch= 27/200, loss= 73.438, mse= 64.904, kld= 42.672
 val_loss= 51.141, val_mse= 39.828, val_kld= 56.564
 Epoch= 28/200, loss= 44.343, mse= 36.664, kld= 38.399
 val_loss= 39.176, val_mse= 28.654, val_kld= 52.611
 Epoch= 29/200, loss= 26.390, mse= 19.334, kld= 35.281
 val_loss= 51.214, val_mse= 41.162, val_kld= 50.260
 Epoch= 30/200, loss= 34.756, mse= 28.065, kld= 33.456
 val_loss= 72.628, val_mse= 63.054, val_kld= 47.872
 Epoch= 31/200, loss= 52.337, mse= 46.071, kld= 31.328
 val_loss= 72.632, val_mse= 63.121, val_kld= 47.556
 Epoch= 32/200, loss= 55.731, mse= 49.434, kld= 31.484
 val_loss= 55.304, val_mse= 45.646, val_kld= 48.293
 Epoch= 33/200, loss= 44.615, mse= 38.333, kld= 31.412
 val_loss= 41.563, val_mse= 31.904, val_kld= 48.297

Epoch= 34/200, loss= 29.883, mse= 23.631, kld= 31.259
val_loss= 38.803, val_mse= 29.137, val_kld= 48.335
Epoch= 35/200, loss= 26.828, mse= 20.672, kld= 30.778
val_loss= 43.730, val_mse= 34.149, val_kld= 47.904
Epoch= 36/200, loss= 36.481, mse= 30.318, kld= 30.815
val_loss= 46.188, val_mse= 36.606, val_kld= 47.909
Epoch= 37/200, loss= 38.643, mse= 32.738, kld= 29.526
val_loss= 38.500, val_mse= 28.885, val_kld= 48.077
Epoch= 38/200, loss= 28.470, mse= 22.580, kld= 29.451
val_loss= 25.963, val_mse= 17.026, val_kld= 44.688
Epoch= 39/200, loss= 17.017, mse= 11.510, kld= 27.534
val_loss= 26.135, val_mse= 17.944, val_kld= 40.952
Epoch= 40/200, loss= 16.021, mse= 11.083, kld= 24.689
val_loss= 30.088, val_mse= 22.153, val_kld= 39.676
Epoch= 41/200, loss= 19.668, mse= 14.954, kld= 23.567
val_loss= 33.577, val_mse= 25.658, val_kld= 39.596
Epoch= 42/200, loss= 20.883, mse= 16.255, kld= 23.144
val_loss= 25.214, val_mse= 17.739, val_kld= 37.373
Epoch= 43/200, loss= 15.852, mse= 11.605, kld= 21.239
val_loss= 20.219, val_mse= 12.697, val_kld= 37.609
Epoch= 44/200, loss= 10.291, mse= 6.033, kld= 21.292
val_loss= 19.940, val_mse= 12.499, val_kld= 37.208
Epoch= 45/200, loss= 10.695, mse= 6.593, kld= 20.506
val_loss= 22.187, val_mse= 15.080, val_kld= 35.534
Epoch= 46/200, loss= 15.944, mse= 11.980, kld= 19.820
val_loss= 23.258, val_mse= 16.378, val_kld= 34.404
Epoch= 47/200, loss= 16.269, mse= 12.520, kld= 18.745
val_loss= 19.894, val_mse= 13.222, val_kld= 33.359
Epoch= 48/200, loss= 12.483, mse= 8.910, kld= 17.866
val_loss= 18.384, val_mse= 12.009, val_kld= 31.878
Epoch= 49/200, loss= 9.978, mse= 6.508, kld= 17.353
val_loss= 19.487, val_mse= 13.306, val_kld= 30.907
Epoch= 50/200, loss= 11.063, mse= 7.811, kld= 16.260
val_loss= 22.648, val_mse= 16.800, val_kld= 29.242
Epoch= 51/200, loss= 13.700, mse= 10.505, kld= 15.976
val_loss= 19.940, val_mse= 14.297, val_kld= 28.214
Epoch= 52/200, loss= 12.540, mse= 9.513, kld= 15.131
val_loss= 15.401, val_mse= 9.995, val_kld= 27.032
Epoch= 53/200, loss= 9.382, mse= 6.369, kld= 15.062
val_loss= 13.113, val_mse= 7.821, val_kld= 26.461
Epoch= 54/200, loss= 8.071, mse= 5.142, kld= 14.645
val_loss= 15.307, val_mse= 10.110, val_kld= 25.986
Epoch= 55/200, loss= 8.468, mse= 5.690, kld= 13.893
val_loss= 14.981, val_mse= 9.900, val_kld= 25.401
Epoch= 56/200, loss= 9.071, mse= 6.291, kld= 13.899
val_loss= 13.945, val_mse= 9.025, val_kld= 24.603
Epoch= 57/200, loss= 8.258, mse= 5.539, kld= 13.593
val_loss= 11.791, val_mse= 7.229, val_kld= 22.809

Epoch= 58/200, loss= 5.879, mse= 3.286, kld= 12.965
val_loss= 11.806, val_mse= 7.521, val_kld= 21.427
Epoch= 59/200, loss= 6.182, mse= 3.746, kld= 12.181
val_loss= 12.735, val_mse= 8.717, val_kld= 20.089
Epoch= 60/200, loss= 6.653, mse= 4.231, kld= 12.107
val_loss= 11.221, val_mse= 7.335, val_kld= 19.429
Epoch= 61/200, loss= 7.121, mse= 4.819, kld= 11.507
val_loss= 11.994, val_mse= 8.329, val_kld= 18.322
Epoch= 62/200, loss= 6.367, mse= 4.162, kld= 11.027
val_loss= 8.592, val_mse= 5.174, val_kld= 17.087
Epoch= 63/200, loss= 5.576, mse= 3.354, kld= 11.107
val_loss= 9.432, val_mse= 6.129, val_kld= 16.515
Epoch= 64/200, loss= 5.898, mse= 3.728, kld= 10.852
val_loss= 9.007, val_mse= 5.759, val_kld= 16.240
Epoch= 65/200, loss= 6.449, mse= 4.264, kld= 10.927
val_loss= 9.043, val_mse= 5.882, val_kld= 15.801
Epoch= 66/200, loss= 5.952, mse= 3.791, kld= 10.805
val_loss= 8.300, val_mse= 5.255, val_kld= 15.226
Epoch= 67/200, loss= 5.434, mse= 3.307, kld= 10.637
val_loss= 7.568, val_mse= 4.572, val_kld= 14.982
Epoch= 68/200, loss= 5.199, mse= 3.108, kld= 10.457
val_loss= 8.120, val_mse= 5.212, val_kld= 14.541
Epoch= 69/200, loss= 5.474, mse= 3.389, kld= 10.427
val_loss= 8.278, val_mse= 5.496, val_kld= 13.914
Epoch= 70/200, loss= 5.464, mse= 3.404, kld= 10.303
val_loss= 7.994, val_mse= 5.315, val_kld= 13.393
Epoch= 71/200, loss= 4.933, mse= 2.922, kld= 10.053
val_loss= 7.218, val_mse= 4.542, val_kld= 13.383
Epoch= 72/200, loss= 4.629, mse= 2.627, kld= 10.010
val_loss= 6.547, val_mse= 3.957, val_kld= 12.951
Epoch= 73/200, loss= 4.520, mse= 2.566, kld= 9.769
val_loss= 6.993, val_mse= 4.491, val_kld= 12.511
Epoch= 74/200, loss= 5.056, mse= 3.105, kld= 9.755
val_loss= 6.336, val_mse= 3.849, val_kld= 12.438
Epoch= 75/200, loss= 4.670, mse= 2.783, kld= 9.436
val_loss= 6.182, val_mse= 3.777, val_kld= 12.026
Epoch= 76/200, loss= 4.212, mse= 2.359, kld= 9.269
val_loss= 6.189, val_mse= 3.945, val_kld= 11.219
Epoch= 77/200, loss= 4.301, mse= 2.493, kld= 9.038
val_loss= 6.004, val_mse= 3.723, val_kld= 11.406
Epoch= 78/200, loss= 4.471, mse= 2.692, kld= 8.895
val_loss= 5.628, val_mse= 3.464, val_kld= 10.822
Epoch= 79/200, loss= 4.239, mse= 2.476, kld= 8.813
val_loss= 5.929, val_mse= 3.707, val_kld= 11.109
Epoch= 80/200, loss= 3.961, mse= 2.241, kld= 8.601
val_loss= 5.368, val_mse= 3.131, val_kld= 11.183
Epoch= 81/200, loss= 3.897, mse= 2.161, kld= 8.679
val_loss= 5.111, val_mse= 2.919, val_kld= 10.959

Epoch= 82/200, loss= 4.186, mse= 2.458, kld= 8.640
 val_loss= 4.992, val_mse= 2.916, val_kld= 10.382
 Epoch= 83/200, loss= 4.011, mse= 2.345, kld= 8.330
 val_loss= 5.010, val_mse= 2.865, val_kld= 10.724
 Epoch= 84/200, loss= 3.829, mse= 2.161, kld= 8.339
 val_loss= 5.724, val_mse= 3.521, val_kld= 11.012
 Epoch= 85/200, loss= 3.714, mse= 2.077, kld= 8.182
 val_loss= 5.059, val_mse= 2.847, val_kld= 11.060
 Epoch= 86/200, loss= 3.760, mse= 2.107, kld= 8.263
 val_loss= 4.892, val_mse= 2.751, val_kld= 10.708
 Epoch= 87/200, loss= 3.801, mse= 2.182, kld= 8.094
 val_loss= 5.046, val_mse= 2.996, val_kld= 10.249
 Epoch= 88/200, loss= 3.664, mse= 2.072, kld= 7.960
 val_loss= 4.823, val_mse= 2.767, val_kld= 10.280
 Epoch= 89/200, loss= 3.698, mse= 2.077, kld= 8.102
 val_loss= 4.870, val_mse= 2.760, val_kld= 10.549
 Epoch= 90/200, loss= 3.588, mse= 1.974, kld= 8.066
 val_loss= 4.311, val_mse= 2.226, val_kld= 10.421
 Epoch= 91/200, loss= 3.664, mse= 2.060, kld= 8.018
 val_loss= 4.101, val_mse= 2.146, val_kld= 9.776
 Epoch= 92/200, loss= 3.551, mse= 1.967, kld= 7.921
 val_loss= 4.399, val_mse= 2.335, val_kld= 10.318
 Epoch= 93/200, loss= 3.562, mse= 1.968, kld= 7.969
 val_loss= 4.356, val_mse= 2.347, val_kld= 10.046
 Epoch= 94/200, loss= 3.511, mse= 1.974, kld= 7.685
 val_loss= 4.539, val_mse= 2.520, val_kld= 10.095
 Epoch= 95/200, loss= 3.548, mse= 2.034, kld= 7.570
 val_loss= 4.205, val_mse= 2.239, val_kld= 9.827
 Epoch= 96/200, loss= 3.421, mse= 1.920, kld= 7.504
 val_loss= 4.215, val_mse= 2.168, val_kld= 10.231
 Epoch= 97/200, loss= 3.487, mse= 1.962, kld= 7.629
 val_loss= 3.915, val_mse= 1.838, val_kld= 10.385
 Epoch= 98/200, loss= 3.342, mse= 1.849, kld= 7.462
 val_loss= 3.964, val_mse= 2.052, val_kld= 9.560
 Epoch= 99/200, loss= 3.336, mse= 1.834, kld= 7.513
 val_loss= 3.768, val_mse= 1.892, val_kld= 9.381
 Epoch= 100/200, loss= 3.319, mse= 1.849, kld= 7.348
 val_loss= 4.199, val_mse= 2.352, val_kld= 9.238
 Epoch= 101/200, loss= 3.365, mse= 1.875, kld= 7.451
 val_loss= 4.074, val_mse= 2.088, val_kld= 9.925
 Epoch= 102/200, loss= 3.449, mse= 1.966, kld= 7.416
 val_loss= 3.771, val_mse= 1.812, val_kld= 9.798
 Epoch= 103/200, loss= 3.257, mse= 1.824, kld= 7.163
 val_loss= 3.456, val_mse= 1.561, val_kld= 9.479
 Epoch= 104/200, loss= 3.238, mse= 1.773, kld= 7.323
 val_loss= 3.386, val_mse= 1.498, val_kld= 9.439
 Epoch= 105/200, loss= 3.349, mse= 1.883, kld= 7.327
 val_loss= 3.511, val_mse= 1.544, val_kld= 9.833

Epoch= 106/200, loss= 3.106, mse= 1.651, kld= 7.274
 val_loss= 3.625, val_mse= 1.785, val_kld= 9.199
 Epoch= 107/200, loss= 3.227, mse= 1.791, kld= 7.181
 val_loss= 3.557, val_mse= 1.708, val_kld= 9.246
 Epoch= 108/200, loss= 3.190, mse= 1.767, kld= 7.115
 val_loss= 3.584, val_mse= 1.743, val_kld= 9.204
 Epoch= 109/200, loss= 3.214, mse= 1.812, kld= 7.010
 val_loss= 3.517, val_mse= 1.738, val_kld= 8.894
 Epoch= 110/200, loss= 3.183, mse= 1.769, kld= 7.074
 val_loss= 3.472, val_mse= 1.732, val_kld= 8.701
 Epoch= 111/200, loss= 3.070, mse= 1.702, kld= 6.841
 val_loss= 3.628, val_mse= 1.876, val_kld= 8.758
 Epoch= 112/200, loss= 3.022, mse= 1.682, kld= 6.698
 val_loss= 3.385, val_mse= 1.624, val_kld= 8.803
 Epoch= 113/200, loss= 3.054, mse= 1.687, kld= 6.832
 val_loss= 3.175, val_mse= 1.491, val_kld= 8.422
 Epoch= 114/200, loss= 2.950, mse= 1.624, kld= 6.627
 val_loss= 3.386, val_mse= 1.616, val_kld= 8.850
 Epoch= 115/200, loss= 2.960, mse= 1.645, kld= 6.578
 val_loss= 3.067, val_mse= 1.328, val_kld= 8.696
 Epoch= 116/200, loss= 3.251, mse= 1.915, kld= 6.677
 val_loss= 3.270, val_mse= 1.542, val_kld= 8.641
 Epoch= 117/200, loss= 3.033, mse= 1.682, kld= 6.756
 val_loss= 3.490, val_mse= 1.736, val_kld= 8.767
 Epoch= 118/200, loss= 2.937, mse= 1.635, kld= 6.510
 val_loss= 3.842, val_mse= 2.011, val_kld= 9.155
 Epoch= 119/200, loss= 2.897, mse= 1.579, kld= 6.590
 val_loss= 3.229, val_mse= 1.514, val_kld= 8.576
 Epoch= 120/200, loss= 2.974, mse= 1.664, kld= 6.548
 val_loss= 3.266, val_mse= 1.516, val_kld= 8.750
 Epoch= 121/200, loss= 3.044, mse= 1.696, kld= 6.743
 val_loss= 3.579, val_mse= 1.846, val_kld= 8.666
 Epoch= 122/200, loss= 2.933, mse= 1.635, kld= 6.490
 val_loss= 3.265, val_mse= 1.568, val_kld= 8.483
 Epoch= 123/200, loss= 2.948, mse= 1.651, kld= 6.485
 val_loss= 3.286, val_mse= 1.602, val_kld= 8.417
 Epoch= 124/200, loss= 2.971, mse= 1.690, kld= 6.404
 val_loss= 3.261, val_mse= 1.594, val_kld= 8.337
 Epoch= 125/200, loss= 2.853, mse= 1.592, kld= 6.306
 val_loss= 3.201, val_mse= 1.519, val_kld= 8.413
 Epoch= 126/200, loss= 2.874, mse= 1.631, kld= 6.215
 val_loss= 3.230, val_mse= 1.534, val_kld= 8.483
 Epoch= 127/200, loss= 2.879, mse= 1.625, kld= 6.269
 val_loss= 3.134, val_mse= 1.553, val_kld= 7.903
 Epoch= 128/200, loss= 2.763, mse= 1.552, kld= 6.057
 val_loss= 2.923, val_mse= 1.276, val_kld= 8.234
 Epoch= 129/200, loss= 2.820, mse= 1.574, kld= 6.234
 val_loss= 3.319, val_mse= 1.743, val_kld= 7.876

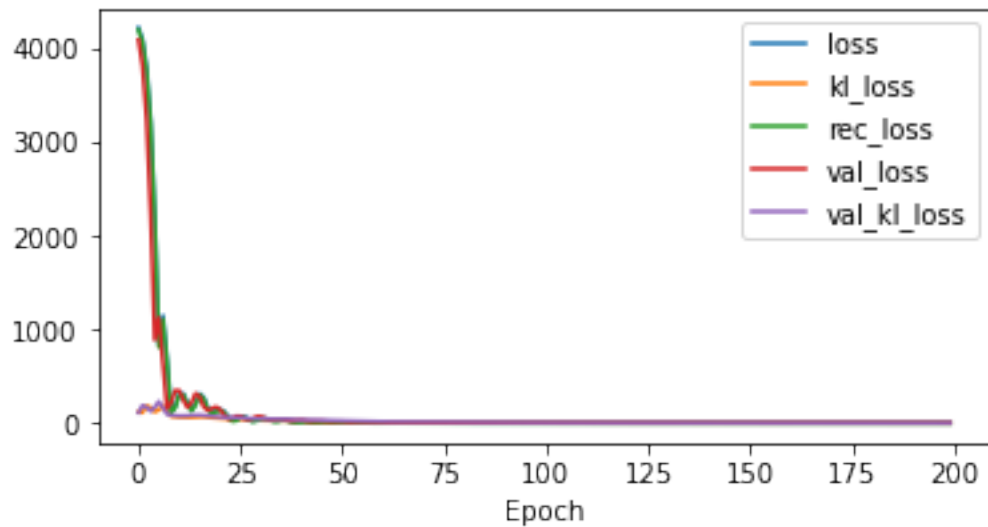
Epoch= 130/200, loss= 2.734, mse= 1.516, kld= 6.090
 val_loss= 2.972, val_mse= 1.380, val_kld= 7.960
 Epoch= 131/200, loss= 2.733, mse= 1.485, kld= 6.238
 val_loss= 3.034, val_mse= 1.366, val_kld= 8.340
 Epoch= 132/200, loss= 2.738, mse= 1.499, kld= 6.192
 val_loss= 3.378, val_mse= 1.652, val_kld= 8.629
 Epoch= 133/200, loss= 2.608, mse= 1.408, kld= 6.000
 val_loss= 3.033, val_mse= 1.490, val_kld= 7.712
 Epoch= 134/200, loss= 2.820, mse= 1.590, kld= 6.151
 val_loss= 3.446, val_mse= 1.823, val_kld= 8.118
 Epoch= 135/200, loss= 2.681, mse= 1.468, kld= 6.061
 val_loss= 2.929, val_mse= 1.393, val_kld= 7.677
 Epoch= 136/200, loss= 2.737, mse= 1.537, kld= 5.996
 val_loss= 2.824, val_mse= 1.293, val_kld= 7.657
 Epoch= 137/200, loss= 2.745, mse= 1.562, kld= 5.915
 val_loss= 2.866, val_mse= 1.262, val_kld= 8.020
 Epoch= 138/200, loss= 2.561, mse= 1.379, kld= 5.909
 val_loss= 3.153, val_mse= 1.553, val_kld= 7.998
 Epoch= 139/200, loss= 2.629, mse= 1.442, kld= 5.931
 val_loss= 2.919, val_mse= 1.374, val_kld= 7.726
 Epoch= 140/200, loss= 2.656, mse= 1.485, kld= 5.853
 val_loss= 2.977, val_mse= 1.443, val_kld= 7.668
 Epoch= 141/200, loss= 2.702, mse= 1.526, kld= 5.880
 val_loss= 3.308, val_mse= 1.721, val_kld= 7.937
 Epoch= 142/200, loss= 2.707, mse= 1.514, kld= 5.968
 val_loss= 3.235, val_mse= 1.664, val_kld= 7.853
 Epoch= 143/200, loss= 2.658, mse= 1.447, kld= 6.054
 val_loss= 2.847, val_mse= 1.277, val_kld= 7.851
 Epoch= 144/200, loss= 2.534, mse= 1.347, kld= 5.932
 val_loss= 2.849, val_mse= 1.256, val_kld= 7.967
 Epoch= 145/200, loss= 2.467, mse= 1.300, kld= 5.840
 val_loss= 2.785, val_mse= 1.265, val_kld= 7.602
 Epoch= 146/200, loss= 2.620, mse= 1.405, kld= 6.076
 val_loss= 3.065, val_mse= 1.554, val_kld= 7.553
 Epoch= 147/200, loss= 2.514, mse= 1.353, kld= 5.808
 val_loss= 2.830, val_mse= 1.279, val_kld= 7.757
 Epoch= 148/200, loss= 2.576, mse= 1.384, kld= 5.961
 val_loss= 2.978, val_mse= 1.368, val_kld= 8.048
 Epoch= 149/200, loss= 2.475, mse= 1.320, kld= 5.773
 val_loss= 2.794, val_mse= 1.243, val_kld= 7.759
 Epoch= 150/200, loss= 2.575, mse= 1.424, kld= 5.753
 val_loss= 2.951, val_mse= 1.382, val_kld= 7.845
 Epoch= 151/200, loss= 2.534, mse= 1.388, kld= 5.733
 val_loss= 2.817, val_mse= 1.292, val_kld= 7.625
 Epoch= 152/200, loss= 2.562, mse= 1.426, kld= 5.682
 val_loss= 2.963, val_mse= 1.499, val_kld= 7.320
 Epoch= 153/200, loss= 2.535, mse= 1.412, kld= 5.614
 val_loss= 2.862, val_mse= 1.323, val_kld= 7.696

Epoch= 154/200, loss= 2.582, mse= 1.421, kld= 5.808
 val_loss= 2.801, val_mse= 1.300, val_kld= 7.503
 Epoch= 155/200, loss= 2.498, mse= 1.346, kld= 5.760
 val_loss= 2.722, val_mse= 1.152, val_kld= 7.850
 Epoch= 156/200, loss= 2.481, mse= 1.344, kld= 5.689
 val_loss= 3.016, val_mse= 1.471, val_kld= 7.728
 Epoch= 157/200, loss= 2.458, mse= 1.331, kld= 5.634
 val_loss= 2.651, val_mse= 1.165, val_kld= 7.430
 Epoch= 158/200, loss= 2.477, mse= 1.323, kld= 5.770
 val_loss= 2.829, val_mse= 1.308, val_kld= 7.601
 Epoch= 159/200, loss= 2.422, mse= 1.294, kld= 5.637
 val_loss= 2.716, val_mse= 1.218, val_kld= 7.490
 Epoch= 160/200, loss= 2.477, mse= 1.352, kld= 5.623
 val_loss= 2.910, val_mse= 1.393, val_kld= 7.582
 Epoch= 161/200, loss= 2.342, mse= 1.202, kld= 5.701
 val_loss= 2.836, val_mse= 1.348, val_kld= 7.442
 Epoch= 162/200, loss= 2.389, mse= 1.260, kld= 5.648
 val_loss= 2.989, val_mse= 1.526, val_kld= 7.313
 Epoch= 163/200, loss= 2.373, mse= 1.265, kld= 5.541
 val_loss= 2.715, val_mse= 1.242, val_kld= 7.366
 Epoch= 164/200, loss= 2.475, mse= 1.340, kld= 5.675
 val_loss= 2.684, val_mse= 1.188, val_kld= 7.482
 Epoch= 165/200, loss= 2.476, mse= 1.361, kld= 5.576
 val_loss= 2.852, val_mse= 1.381, val_kld= 7.355
 Epoch= 166/200, loss= 2.474, mse= 1.332, kld= 5.710
 val_loss= 2.820, val_mse= 1.222, val_kld= 7.989
 Epoch= 167/200, loss= 2.384, mse= 1.214, kld= 5.846
 val_loss= 2.844, val_mse= 1.384, val_kld= 7.304
 Epoch= 168/200, loss= 2.430, mse= 1.310, kld= 5.598
 val_loss= 2.768, val_mse= 1.236, val_kld= 7.655
 Epoch= 169/200, loss= 2.395, mse= 1.262, kld= 5.663
 val_loss= 2.693, val_mse= 1.249, val_kld= 7.219
 Epoch= 170/200, loss= 2.372, mse= 1.209, kld= 5.814
 val_loss= 2.764, val_mse= 1.274, val_kld= 7.453
 Epoch= 171/200, loss= 2.393, mse= 1.278, kld= 5.573
 val_loss= 2.806, val_mse= 1.263, val_kld= 7.715
 Epoch= 172/200, loss= 2.388, mse= 1.248, kld= 5.702
 val_loss= 2.808, val_mse= 1.366, val_kld= 7.208
 Epoch= 173/200, loss= 2.325, mse= 1.234, kld= 5.457
 val_loss= 2.801, val_mse= 1.272, val_kld= 7.645
 Epoch= 174/200, loss= 2.364, mse= 1.248, kld= 5.578
 val_loss= 2.614, val_mse= 1.155, val_kld= 7.295
 Epoch= 175/200, loss= 2.354, mse= 1.236, kld= 5.589
 val_loss= 2.583, val_mse= 1.167, val_kld= 7.079
 Epoch= 176/200, loss= 2.309, mse= 1.213, kld= 5.478
 val_loss= 2.785, val_mse= 1.309, val_kld= 7.378
 Epoch= 177/200, loss= 2.341, mse= 1.241, kld= 5.503
 val_loss= 2.452, val_mse= 1.117, val_kld= 6.671

Epoch= 178/200, loss= 2.331, mse= 1.264, kld= 5.336
 val_loss= 2.817, val_mse= 1.388, val_kld= 7.149
 Epoch= 179/200, loss= 2.298, mse= 1.191, kld= 5.534
 val_loss= 2.842, val_mse= 1.325, val_kld= 7.585
 Epoch= 180/200, loss= 2.237, mse= 1.165, kld= 5.363
 val_loss= 2.573, val_mse= 1.147, val_kld= 7.134
 Epoch= 181/200, loss= 2.277, mse= 1.205, kld= 5.360
 val_loss= 2.503, val_mse= 1.112, val_kld= 6.954
 Epoch= 182/200, loss= 2.268, mse= 1.198, kld= 5.351
 val_loss= 2.433, val_mse= 1.019, val_kld= 7.070
 Epoch= 183/200, loss= 2.244, mse= 1.165, kld= 5.395
 val_loss= 2.683, val_mse= 1.255, val_kld= 7.140
 Epoch= 184/200, loss= 2.248, mse= 1.211, kld= 5.185
 val_loss= 2.557, val_mse= 1.161, val_kld= 6.977
 Epoch= 185/200, loss= 2.242, mse= 1.179, kld= 5.314
 val_loss= 2.618, val_mse= 1.175, val_kld= 7.217
 Epoch= 186/200, loss= 2.214, mse= 1.145, kld= 5.345
 val_loss= 2.681, val_mse= 1.216, val_kld= 7.328
 Epoch= 187/200, loss= 2.195, mse= 1.131, kld= 5.317
 val_loss= 2.553, val_mse= 1.148, val_kld= 7.025
 Epoch= 188/200, loss= 2.135, mse= 1.090, kld= 5.222
 val_loss= 2.523, val_mse= 1.100, val_kld= 7.119
 Epoch= 189/200, loss= 2.218, mse= 1.167, kld= 5.255
 val_loss= 2.715, val_mse= 1.273, val_kld= 7.210
 Epoch= 190/200, loss= 2.190, mse= 1.119, kld= 5.358
 val_loss= 2.705, val_mse= 1.276, val_kld= 7.143
 Epoch= 191/200, loss= 2.129, mse= 1.096, kld= 5.165
 val_loss= 2.530, val_mse= 1.074, val_kld= 7.277
 Epoch= 192/200, loss= 2.131, mse= 1.067, kld= 5.319
 val_loss= 2.701, val_mse= 1.246, val_kld= 7.272
 Epoch= 193/200, loss= 2.179, mse= 1.116, kld= 5.315
 val_loss= 2.552, val_mse= 1.115, val_kld= 7.184
 Epoch= 194/200, loss= 2.211, mse= 1.122, kld= 5.444
 val_loss= 2.788, val_mse= 1.267, val_kld= 7.602
 Epoch= 195/200, loss= 2.201, mse= 1.111, kld= 5.452
 val_loss= 2.403, val_mse= 1.050, val_kld= 6.766
 Epoch= 196/200, loss= 2.064, mse= 1.061, kld= 5.012
 val_loss= 2.446, val_mse= 1.061, val_kld= 6.922
 Epoch= 197/200, loss= 2.030, mse= 1.007, kld= 5.113
 val_loss= 2.467, val_mse= 1.065, val_kld= 7.008
 Epoch= 198/200, loss= 2.146, mse= 1.094, kld= 5.257
 val_loss= 2.851, val_mse= 1.434, val_kld= 7.087
 Epoch= 199/200, loss= 2.172, mse= 1.091, kld= 5.404
 val_loss= 2.418, val_mse= 0.974, val_kld= 7.222
 Epoch= 200/200, loss= 2.328, mse= 1.159, kld= 5.847
 val_loss= 2.726, val_mse= 1.003, val_kld= 8.615

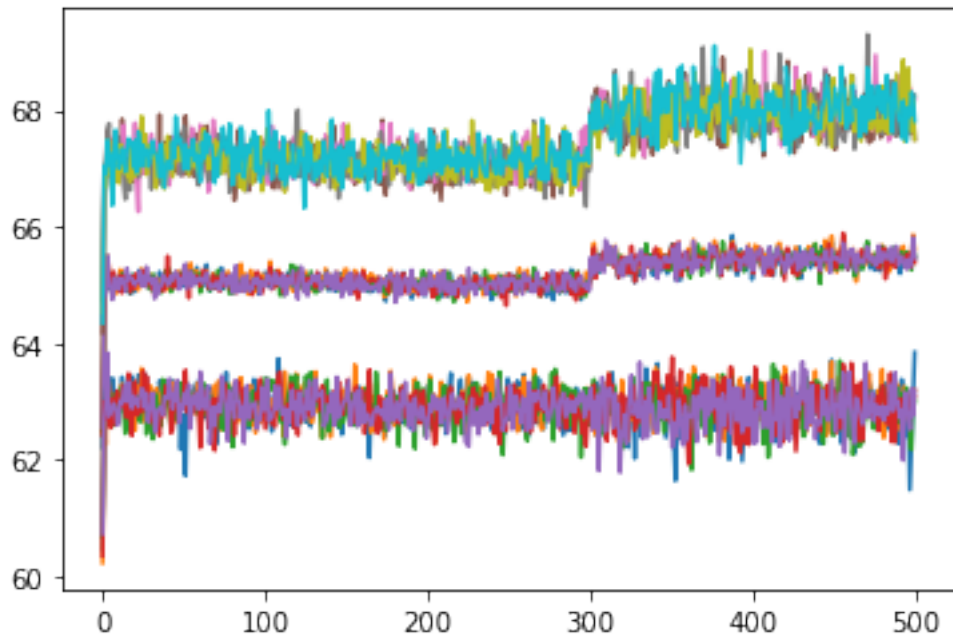
```
[87]: pd.DataFrame(history).plot(figsize=(6, 3), xlabel='Epoch')
```

```
[87]: <AxesSubplot:xlabel='Epoch'>
```



```
[88]: # x_hat = dkf.generate(x_train)
# x_hat, x_025, x_975 = dkf.filter(x_train)
x_hat, x_025, x_975 = dkf.predict(x, 200)
x_hat = x_hat.detach().numpy()[0]
x_025 = x_025.detach().numpy()[0]
x_975 = x_975.detach().numpy()[0]
plt.plot(x_hat)
plt.plot(x_975)
plt.plot(x_025)
```

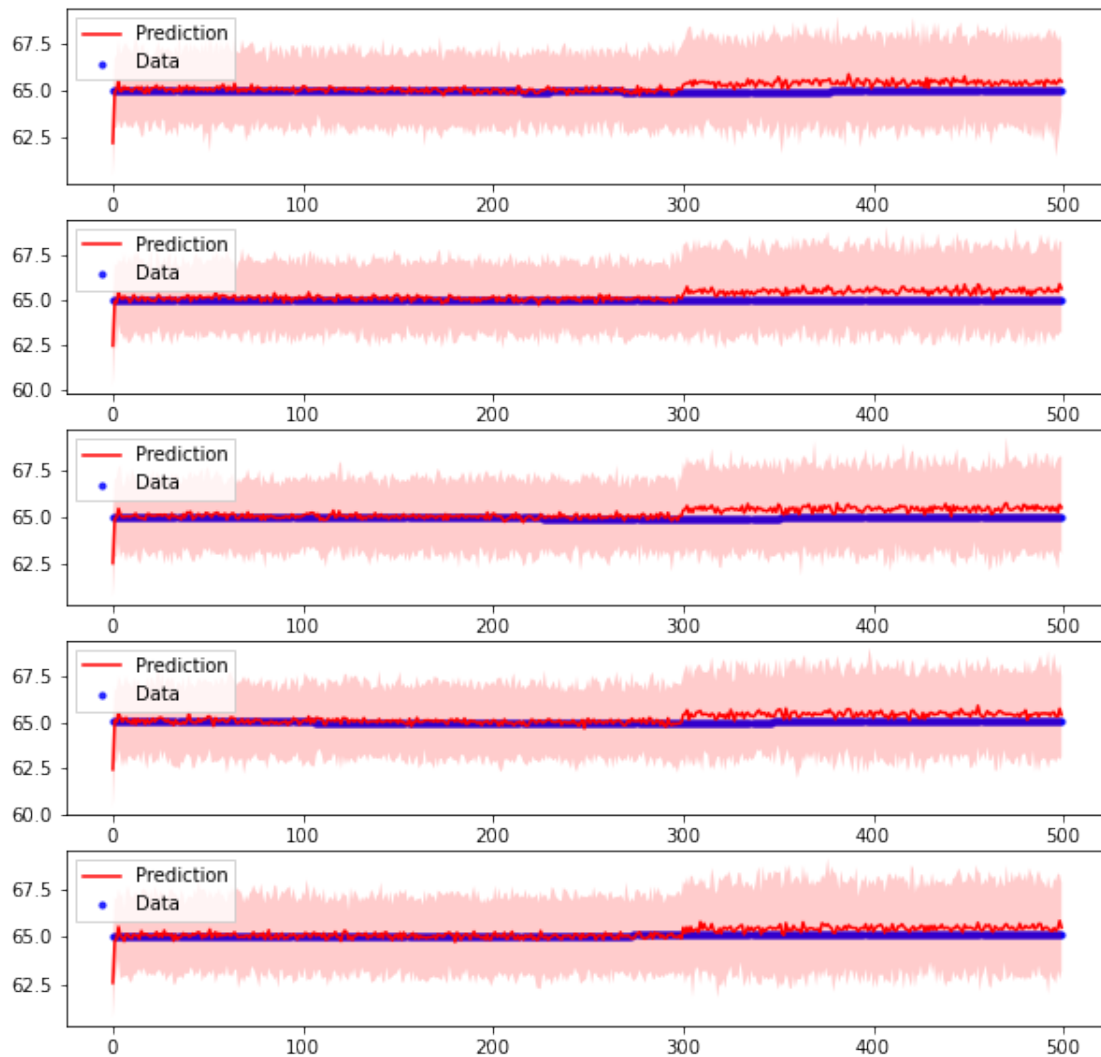
```
[88]: [<matplotlib.lines.Line2D at 0x7f8d585c5d60>,
<matplotlib.lines.Line2D at 0x7f8d58331250>,
<matplotlib.lines.Line2D at 0x7f8d583319a0>,
<matplotlib.lines.Line2D at 0x7f8d5864a160>,
<matplotlib.lines.Line2D at 0x7f8d5864a820>]
```



```
[89]: fig, ax = plt.subplots(5, figsize=(10, 10))

for i, axi in enumerate(ax):
    axi.scatter(
        np.arange(data.shape[0]),
        data[:, i], s=10, alpha=0.8, label='Data', c='b')
    axi.plot(x_hat[:, i], label='Prediction', c='r')
    axi.fill_between(np.arange(x_hat.shape[0]), x_025[:, i], x_975[:, i],
                    facecolor='r', alpha=0.2)

    axi.legend(loc='upper left', fancybox=False)
plt.show()
```



[]: #####

4.2 Trenowane dla znormalizowanych latitude i longitude

```
[90]: #Normalizacja dla 2D - latitude i longitude

def NormalizeData(data):
    return 100*(data - np.min(data)) / (np.max(data) - np.min(data))

norm_long = NormalizeData(np.asarray(data_endo[0]['longitude']))
norm_lat = NormalizeData(np.asarray(data_endo[0]['latitude']))
#norm_alt = NormalizeData(np.asarray(data_endo[0]['altitude']))
```

```
data = np.vstack([norm_long, norm_lat]).T
#print(data.shape)
```

```
[91]: x = torch.FloatTensor(data).reshape(1, *data.shape)
      #print(x)
      x_train = torch.FloatTensor(data[:400]).reshape(1, 400, data.shape[1])
      #print(x_train)
      x_val = torch.FloatTensor(data[400:450]).reshape(1, 50, data.shape[1])
      #print(x_val)
```

```
[92]: dkf = DKF(input_dim=2, z_dim=10, rnn_dim=10, trans_dim=10, emission_dim=10)
```

```
[93]: history = dkf.fit(x_train, x_val, num_epochs=200, annealing_factor=0.1)
```

```
Epoch= 1/200, loss= 3807.126, mse= 2935.846, kld= 8712.804
      val_loss= 2409.694, val_mse= 2399.504, val_kld= 101.893
Epoch= 2/200, loss= 2948.892, mse= 2944.320, kld= 45.729
      val_loss= 2400.162, val_mse= 2395.637, val_kld= 45.247
Epoch= 3/200, loss= 2930.590, mse= 2926.911, kld= 36.790
      val_loss= 2373.984, val_mse= 2370.500, val_kld= 34.835
Epoch= 4/200, loss= 2926.578, mse= 2922.917, kld= 36.612
      val_loss= 2388.612, val_mse= 2385.838, val_kld= 27.743
Epoch= 5/200, loss= 2898.389, mse= 2894.486, kld= 39.031
      val_loss= 2348.069, val_mse= 2345.375, val_kld= 26.932
Epoch= 6/200, loss= 2883.536, mse= 2879.411, kld= 41.256
      val_loss= 2338.518, val_mse= 2335.853, val_kld= 26.648
Epoch= 7/200, loss= 2853.299, mse= 2848.437, kld= 48.618
      val_loss= 2295.796, val_mse= 2292.956, val_kld= 28.407
Epoch= 8/200, loss= 2809.452, mse= 2803.538, kld= 59.139
      val_loss= 2259.435, val_mse= 2256.462, val_kld= 29.737
Epoch= 9/200, loss= 2760.859, mse= 2753.680, kld= 71.791
      val_loss= 2216.229, val_mse= 2212.847, val_kld= 33.825
Epoch= 10/200, loss= 2674.403, mse= 2665.285, kld= 91.172
      val_loss= 2171.665, val_mse= 2167.720, val_kld= 39.454
Epoch= 11/200, loss= 2611.594, mse= 2598.901, kld= 126.925
      val_loss= 2098.388, val_mse= 2093.674, val_kld= 47.137
Epoch= 12/200, loss= 2461.216, mse= 2439.431, kld= 217.841
      val_loss= 2003.991, val_mse= 1997.857, val_kld= 61.333
Epoch= 13/200, loss= 3561.820, mse= 2321.883, kld= 12399.370
      val_loss= 1935.045, val_mse= 1930.192, val_kld= 48.527
Epoch= 14/200, loss= 2341.185, mse= 2280.984, kld= 602.011
      val_loss= 1831.053, val_mse= 1827.115, val_kld= 39.386
Epoch= 15/200, loss= 2196.934, mse= 2186.243, kld= 106.915
      val_loss= 1783.058, val_mse= 1779.727, val_kld= 33.306
Epoch= 16/200, loss= 2205.962, mse= 2197.805, kld= 81.569
      val_loss= 1675.868, val_mse= 1672.870, val_kld= 29.983
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Epoch= 17/200, loss= 2152.149, mse= 2146.212, kld= 59.370
 val_loss= 1571.212, val_mse= 1568.405, val_kld= 28.071
 Epoch= 18/200, loss= 2036.141, mse= 2031.109, kld= 50.314
 val_loss= 1441.144, val_mse= 1438.600, val_kld= 25.438
 Epoch= 19/200, loss= 1915.557, mse= 1911.494, kld= 40.632
 val_loss= 1303.679, val_mse= 1301.227, val_kld= 24.521
 Epoch= 20/200, loss= 1808.847, mse= 1805.430, kld= 34.168
 val_loss= 1166.860, val_mse= 1164.550, val_kld= 23.097
 Epoch= 21/200, loss= 1625.681, mse= 1622.787, kld= 28.943
 val_loss= 1016.403, val_mse= 1014.223, val_kld= 21.809
 Epoch= 22/200, loss= 1423.833, mse= 1421.502, kld= 23.310
 val_loss= 904.104, val_mse= 901.960, val_kld= 21.444
 Epoch= 23/200, loss= 1308.242, mse= 1306.054, kld= 21.876
 val_loss= 753.880, val_mse= 751.833, val_kld= 20.473
 Epoch= 24/200, loss= 1118.179, mse= 1116.227, kld= 19.524
 val_loss= 641.830, val_mse= 639.815, val_kld= 20.152
 Epoch= 25/200, loss= 908.550, mse= 906.821, kld= 17.295
 val_loss= 531.914, val_mse= 529.947, val_kld= 19.668
 Epoch= 26/200, loss= 791.916, mse= 790.314, kld= 16.024
 val_loss= 525.723, val_mse= 523.762, val_kld= 19.615
 Epoch= 27/200, loss= 696.665, mse= 695.158, kld= 15.066
 val_loss= 568.867, val_mse= 566.922, val_kld= 19.454
 Epoch= 28/200, loss= 655.564, mse= 654.177, kld= 13.865
 val_loss= 705.316, val_mse= 703.478, val_kld= 18.379
 Epoch= 29/200, loss= 690.427, mse= 689.027, kld= 13.992
 val_loss= 899.099, val_mse= 897.297, val_kld= 18.022
 Epoch= 30/200, loss= 757.396, mse= 756.056, kld= 13.403
 val_loss= 1030.031, val_mse= 1028.216, val_kld= 18.149
 Epoch= 31/200, loss= 792.261, mse= 790.996, kld= 12.653
 val_loss= 1151.707, val_mse= 1149.913, val_kld= 17.935
 Epoch= 32/200, loss= 784.287, mse= 783.057, kld= 12.295
 val_loss= 1140.617, val_mse= 1138.854, val_kld= 17.634
 Epoch= 33/200, loss= 765.402, mse= 764.259, kld= 11.429
 val_loss= 1096.933, val_mse= 1095.201, val_kld= 17.320
 Epoch= 34/200, loss= 645.194, mse= 644.044, kld= 11.501
 val_loss= 1029.424, val_mse= 1027.737, val_kld= 16.871
 Epoch= 35/200, loss= 609.814, mse= 608.707, kld= 11.078
 val_loss= 964.723, val_mse= 963.061, val_kld= 16.619
 Epoch= 36/200, loss= 548.804, mse= 547.729, kld= 10.753
 val_loss= 936.291, val_mse= 934.647, val_kld= 16.438
 Epoch= 37/200, loss= 513.810, mse= 512.740, kld= 10.708
 val_loss= 936.066, val_mse= 934.439, val_kld= 16.278
 Epoch= 38/200, loss= 503.549, mse= 502.508, kld= 10.409
 val_loss= 952.177, val_mse= 950.547, val_kld= 16.303
 Epoch= 39/200, loss= 510.744, mse= 509.707, kld= 10.371
 val_loss= 939.852, val_mse= 938.268, val_kld= 15.839
 Epoch= 40/200, loss= 517.102, mse= 516.087, kld= 10.155
 val_loss= 961.618, val_mse= 960.025, val_kld= 15.929

Epoch= 41/200, loss= 534.204, mse= 533.195, kld= 10.090
val_loss= 997.312, val_mse= 995.719, val_kld= 15.932
Epoch= 42/200, loss= 529.958, mse= 528.973, kld= 9.855
val_loss= 1003.968, val_mse= 1002.388, val_kld= 15.797
Epoch= 43/200, loss= 526.766, mse= 525.771, kld= 9.945
val_loss= 1014.079, val_mse= 1012.512, val_kld= 15.665
Epoch= 44/200, loss= 521.931, mse= 520.940, kld= 9.907
val_loss= 1037.890, val_mse= 1036.323, val_kld= 15.676
Epoch= 45/200, loss= 510.746, mse= 509.762, kld= 9.843
val_loss= 1048.502, val_mse= 1046.938, val_kld= 15.641
Epoch= 46/200, loss= 488.888, mse= 487.901, kld= 9.865
val_loss= 1044.962, val_mse= 1043.392, val_kld= 15.704
Epoch= 47/200, loss= 474.075, mse= 473.088, kld= 9.872
val_loss= 1075.260, val_mse= 1073.707, val_kld= 15.531
Epoch= 48/200, loss= 451.130, mse= 450.151, kld= 9.790
val_loss= 1050.455, val_mse= 1048.889, val_kld= 15.661
Epoch= 49/200, loss= 439.522, mse= 438.538, kld= 9.839
val_loss= 1055.449, val_mse= 1053.893, val_kld= 15.553
Epoch= 50/200, loss= 435.874, mse= 434.894, kld= 9.799
val_loss= 1034.733, val_mse= 1033.170, val_kld= 15.631
Epoch= 51/200, loss= 436.302, mse= 435.316, kld= 9.867
val_loss= 1046.013, val_mse= 1044.427, val_kld= 15.863
Epoch= 52/200, loss= 439.961, mse= 438.967, kld= 9.939
val_loss= 1009.147, val_mse= 1007.569, val_kld= 15.774
Epoch= 53/200, loss= 443.208, mse= 442.213, kld= 9.942
val_loss= 974.870, val_mse= 973.315, val_kld= 15.551
Epoch= 54/200, loss= 433.108, mse= 432.114, kld= 9.941
val_loss= 954.268, val_mse= 952.716, val_kld= 15.512
Epoch= 55/200, loss= 436.171, mse= 435.188, kld= 9.822
val_loss= 963.885, val_mse= 962.320, val_kld= 15.652
Epoch= 56/200, loss= 415.840, mse= 414.862, kld= 9.788
val_loss= 922.193, val_mse= 920.620, val_kld= 15.725
Epoch= 57/200, loss= 406.520, mse= 405.545, kld= 9.746
val_loss= 900.661, val_mse= 899.072, val_kld= 15.891
Epoch= 58/200, loss= 396.200, mse= 395.207, kld= 9.937
val_loss= 874.707, val_mse= 873.125, val_kld= 15.819
Epoch= 59/200, loss= 393.036, mse= 392.059, kld= 9.776
val_loss= 866.887, val_mse= 865.301, val_kld= 15.869
Epoch= 60/200, loss= 391.706, mse= 390.716, kld= 9.897
val_loss= 847.216, val_mse= 845.620, val_kld= 15.962
Epoch= 61/200, loss= 385.444, mse= 384.448, kld= 9.960
val_loss= 835.736, val_mse= 834.134, val_kld= 16.020
Epoch= 62/200, loss= 380.960, mse= 379.992, kld= 9.681
val_loss= 810.840, val_mse= 809.223, val_kld= 16.166
Epoch= 63/200, loss= 371.722, mse= 370.739, kld= 9.837
val_loss= 781.474, val_mse= 779.862, val_kld= 16.115
Epoch= 64/200, loss= 366.086, mse= 365.103, kld= 9.825
val_loss= 746.766, val_mse= 745.128, val_kld= 16.387

Epoch= 65/200, loss= 355.304, mse= 354.310, kld= 9.940
val_loss= 703.533, val_mse= 701.884, val_kld= 16.485
Epoch= 66/200, loss= 337.476, mse= 336.482, kld= 9.943
val_loss= 678.158, val_mse= 676.508, val_kld= 16.503
Epoch= 67/200, loss= 326.848, mse= 325.835, kld= 10.121
val_loss= 631.196, val_mse= 629.547, val_kld= 16.484
Epoch= 68/200, loss= 308.159, mse= 307.159, kld= 10.002
val_loss= 609.093, val_mse= 607.420, val_kld= 16.735
Epoch= 69/200, loss= 298.604, mse= 297.599, kld= 10.053
val_loss= 581.366, val_mse= 579.659, val_kld= 17.071
Epoch= 70/200, loss= 283.432, mse= 282.418, kld= 10.141
val_loss= 515.430, val_mse= 513.752, val_kld= 16.774
Epoch= 71/200, loss= 271.781, mse= 270.757, kld= 10.238
val_loss= 489.681, val_mse= 487.980, val_kld= 17.013
Epoch= 72/200, loss= 257.577, mse= 256.549, kld= 10.285
val_loss= 465.404, val_mse= 463.692, val_kld= 17.126
Epoch= 73/200, loss= 240.727, mse= 239.699, kld= 10.281
val_loss= 422.197, val_mse= 420.460, val_kld= 17.362
Epoch= 74/200, loss= 222.320, mse= 221.239, kld= 10.806
val_loss= 394.966, val_mse= 393.261, val_kld= 17.044
Epoch= 75/200, loss= 204.540, mse= 203.513, kld= 10.278
val_loss= 370.232, val_mse= 368.512, val_kld= 17.203
Epoch= 76/200, loss= 182.650, mse= 181.614, kld= 10.359
val_loss= 318.354, val_mse= 316.614, val_kld= 17.400
Epoch= 77/200, loss= 165.792, mse= 164.755, kld= 10.368
val_loss= 282.536, val_mse= 280.768, val_kld= 17.682
Epoch= 78/200, loss= 150.682, mse= 149.651, kld= 10.309
val_loss= 250.445, val_mse= 248.651, val_kld= 17.934
Epoch= 79/200, loss= 131.333, mse= 130.295, kld= 10.379
val_loss= 214.562, val_mse= 212.814, val_kld= 17.480
Epoch= 80/200, loss= 121.832, mse= 120.798, kld= 10.338
val_loss= 196.608, val_mse= 194.815, val_kld= 17.923
Epoch= 81/200, loss= 100.860, mse= 99.817, kld= 10.423
val_loss= 164.336, val_mse= 162.591, val_kld= 17.449
Epoch= 82/200, loss= 94.502, mse= 93.450, kld= 10.525
val_loss= 152.995, val_mse= 151.182, val_kld= 18.131
Epoch= 83/200, loss= 79.011, mse= 77.957, kld= 10.539
val_loss= 137.328, val_mse= 135.481, val_kld= 18.477
Epoch= 84/200, loss= 68.041, mse= 66.932, kld= 11.092
val_loss= 137.601, val_mse= 135.741, val_kld= 18.601
Epoch= 85/200, loss= 61.980, mse= 60.917, kld= 10.631
val_loss= 132.145, val_mse= 130.258, val_kld= 18.868
Epoch= 86/200, loss= 52.623, mse= 51.550, kld= 10.739
val_loss= 138.665, val_mse= 136.704, val_kld= 19.619
Epoch= 87/200, loss= 47.110, mse= 46.052, kld= 10.582
val_loss= 129.040, val_mse= 127.096, val_kld= 19.440
Epoch= 88/200, loss= 44.456, mse= 43.381, kld= 10.753
val_loss= 122.125, val_mse= 120.133, val_kld= 19.915

Epoch= 89/200, loss= 42.775, mse= 41.694, kld= 10.803
 val_loss= 119.105, val_mse= 117.118, val_kld= 19.868

Epoch= 90/200, loss= 45.643, mse= 44.537, kld= 11.065
 val_loss= 115.538, val_mse= 113.558, val_kld= 19.794

Epoch= 91/200, loss= 42.478, mse= 41.402, kld= 10.767
 val_loss= 103.507, val_mse= 101.616, val_kld= 18.913

Epoch= 92/200, loss= 45.273, mse= 44.190, kld= 10.834
 val_loss= 100.617, val_mse= 98.688, val_kld= 19.292

Epoch= 93/200, loss= 45.115, mse= 44.033, kld= 10.821
 val_loss= 85.578, val_mse= 83.665, val_kld= 19.131

Epoch= 94/200, loss= 45.314, mse= 44.234, kld= 10.793
 val_loss= 79.822, val_mse= 77.950, val_kld= 18.715

Epoch= 95/200, loss= 47.072, mse= 45.978, kld= 10.940
 val_loss= 67.292, val_mse= 65.459, val_kld= 18.332

Epoch= 96/200, loss= 44.677, mse= 43.590, kld= 10.862
 val_loss= 65.519, val_mse= 63.702, val_kld= 18.160

Epoch= 97/200, loss= 42.202, mse= 41.120, kld= 10.815
 val_loss= 58.933, val_mse= 57.128, val_kld= 18.054

Epoch= 98/200, loss= 37.898, mse= 36.794, kld= 11.046
 val_loss= 53.964, val_mse= 52.126, val_kld= 18.385

Epoch= 99/200, loss= 35.393, mse= 34.303, kld= 10.899
 val_loss= 53.563, val_mse= 51.770, val_kld= 17.922

Epoch= 100/200, loss= 30.921, mse= 29.847, kld= 10.742
 val_loss= 57.908, val_mse= 56.150, val_kld= 17.582

Epoch= 101/200, loss= 29.592, mse= 28.488, kld= 11.036
 val_loss= 58.847, val_mse= 57.103, val_kld= 17.445

Epoch= 102/200, loss= 26.856, mse= 25.764, kld= 10.923
 val_loss= 59.873, val_mse= 58.126, val_kld= 17.466

Epoch= 103/200, loss= 25.219, mse= 24.140, kld= 10.787
 val_loss= 60.634, val_mse= 58.883, val_kld= 17.511

Epoch= 104/200, loss= 25.680, mse= 24.478, kld= 12.020
 val_loss= 60.680, val_mse= 58.979, val_kld= 17.007

Epoch= 105/200, loss= 23.957, mse= 22.855, kld= 11.015
 val_loss= 56.984, val_mse= 55.265, val_kld= 17.187

Epoch= 106/200, loss= 22.033, mse= 20.941, kld= 10.921
 val_loss= 54.930, val_mse= 53.228, val_kld= 17.015

Epoch= 107/200, loss= 21.786, mse= 20.695, kld= 10.918
 val_loss= 58.795, val_mse= 57.092, val_kld= 17.033

Epoch= 108/200, loss= 20.224, mse= 19.145, kld= 10.785
 val_loss= 49.114, val_mse= 47.421, val_kld= 16.932

Epoch= 109/200, loss= 19.051, mse= 17.972, kld= 10.791
 val_loss= 46.242, val_mse= 44.573, val_kld= 16.690

Epoch= 110/200, loss= 19.946, mse= 18.848, kld= 10.986
 val_loss= 39.567, val_mse= 37.894, val_kld= 16.732

Epoch= 111/200, loss= 18.914, mse= 17.816, kld= 10.984
 val_loss= 33.557, val_mse= 31.899, val_kld= 16.578

Epoch= 112/200, loss= 18.876, mse= 17.801, kld= 10.743
 val_loss= 31.557, val_mse= 29.895, val_kld= 16.622

Epoch= 113/200, loss= 17.961, mse= 16.883, kld= 10.775
 val_loss= 26.809, val_mse= 25.148, val_kld= 16.618
 Epoch= 114/200, loss= 17.320, mse= 16.262, kld= 10.588
 val_loss= 29.027, val_mse= 27.349, val_kld= 16.775
 Epoch= 115/200, loss= 16.799, mse= 15.732, kld= 10.676
 val_loss= 23.909, val_mse= 22.225, val_kld= 16.832
 Epoch= 116/200, loss= 16.590, mse= 15.535, kld= 10.555
 val_loss= 24.747, val_mse= 23.094, val_kld= 16.528
 Epoch= 117/200, loss= 16.058, mse= 14.997, kld= 10.607
 val_loss= 23.668, val_mse= 22.015, val_kld= 16.527
 Epoch= 118/200, loss= 16.778, mse= 15.725, kld= 10.525
 val_loss= 22.196, val_mse= 20.514, val_kld= 16.818
 Epoch= 119/200, loss= 15.926, mse= 14.859, kld= 10.668
 val_loss= 21.413, val_mse= 19.735, val_kld= 16.786
 Epoch= 120/200, loss= 15.003, mse= 13.941, kld= 10.618
 val_loss= 22.766, val_mse= 21.089, val_kld= 16.769
 Epoch= 121/200, loss= 15.816, mse= 14.735, kld= 10.806
 val_loss= 22.078, val_mse= 20.392, val_kld= 16.864
 Epoch= 122/200, loss= 15.338, mse= 14.276, kld= 10.622
 val_loss= 24.868, val_mse= 23.145, val_kld= 17.237
 Epoch= 123/200, loss= 14.466, mse= 13.403, kld= 10.622
 val_loss= 21.787, val_mse= 20.087, val_kld= 16.996
 Epoch= 124/200, loss= 14.500, mse= 13.438, kld= 10.620
 val_loss= 21.164, val_mse= 19.450, val_kld= 17.141
 Epoch= 125/200, loss= 14.368, mse= 13.266, kld= 11.021
 val_loss= 22.249, val_mse= 20.531, val_kld= 17.178
 Epoch= 126/200, loss= 13.733, mse= 12.666, kld= 10.667
 val_loss= 19.994, val_mse= 18.333, val_kld= 16.609
 Epoch= 127/200, loss= 14.101, mse= 13.026, kld= 10.747
 val_loss= 21.082, val_mse= 19.349, val_kld= 17.331
 Epoch= 128/200, loss= 13.030, mse= 11.967, kld= 10.634
 val_loss= 22.952, val_mse= 21.228, val_kld= 17.237
 Epoch= 129/200, loss= 12.374, mse= 11.321, kld= 10.529
 val_loss= 18.369, val_mse= 16.661, val_kld= 17.083
 Epoch= 130/200, loss= 11.934, mse= 10.863, kld= 10.709
 val_loss= 19.796, val_mse= 18.047, val_kld= 17.491
 Epoch= 131/200, loss= 11.901, mse= 10.836, kld= 10.653
 val_loss= 19.177, val_mse= 17.428, val_kld= 17.492
 Epoch= 132/200, loss= 11.745, mse= 10.676, kld= 10.692
 val_loss= 17.605, val_mse= 15.902, val_kld= 17.027
 Epoch= 133/200, loss= 12.690, mse= 11.615, kld= 10.759
 val_loss= 15.545, val_mse= 13.823, val_kld= 17.223
 Epoch= 134/200, loss= 11.525, mse= 10.454, kld= 10.712
 val_loss= 18.831, val_mse= 17.060, val_kld= 17.710
 Epoch= 135/200, loss= 12.189, mse= 11.121, kld= 10.682
 val_loss= 15.960, val_mse= 14.230, val_kld= 17.294
 Epoch= 136/200, loss= 11.307, mse= 10.238, kld= 10.688
 val_loss= 16.119, val_mse= 14.400, val_kld= 17.190

Epoch= 137/200, loss= 11.296, mse= 10.229, kld= 10.675
val_loss= 15.437, val_mse= 13.666, val_kld= 17.714
Epoch= 138/200, loss= 10.752, mse= 9.683, kld= 10.687
val_loss= 13.956, val_mse= 12.209, val_kld= 17.466
Epoch= 139/200, loss= 11.261, mse= 10.187, kld= 10.736
val_loss= 14.189, val_mse= 12.509, val_kld= 16.792
Epoch= 140/200, loss= 10.305, mse= 9.238, kld= 10.666
val_loss= 12.836, val_mse= 11.069, val_kld= 17.669
Epoch= 141/200, loss= 9.597, mse= 8.529, kld= 10.682
val_loss= 13.031, val_mse= 11.308, val_kld= 17.235
Epoch= 142/200, loss= 10.659, mse= 9.587, kld= 10.725
val_loss= 11.833, val_mse= 10.098, val_kld= 17.347
Epoch= 143/200, loss= 10.190, mse= 9.123, kld= 10.667
val_loss= 9.762, val_mse= 8.020, val_kld= 17.418
Epoch= 144/200, loss= 9.864, mse= 8.799, kld= 10.656
val_loss= 11.211, val_mse= 9.435, val_kld= 17.764
Epoch= 145/200, loss= 10.230, mse= 9.165, kld= 10.652
val_loss= 9.707, val_mse= 8.043, val_kld= 16.646
Epoch= 146/200, loss= 10.083, mse= 9.000, kld= 10.822
val_loss= 8.735, val_mse= 6.992, val_kld= 17.427
Epoch= 147/200, loss= 11.010, mse= 9.925, kld= 10.850
val_loss= 9.278, val_mse= 7.570, val_kld= 17.085
Epoch= 148/200, loss= 10.311, mse= 9.199, kld= 11.120
val_loss= 8.541, val_mse= 6.863, val_kld= 16.777
Epoch= 149/200, loss= 9.090, mse= 8.017, kld= 10.727
val_loss= 8.753, val_mse= 7.021, val_kld= 17.318
Epoch= 150/200, loss= 9.830, mse= 8.773, kld= 10.572
val_loss= 8.837, val_mse= 7.104, val_kld= 17.330
Epoch= 151/200, loss= 9.587, mse= 8.513, kld= 10.742
val_loss= 9.134, val_mse= 7.433, val_kld= 17.013
Epoch= 152/200, loss= 9.392, mse= 8.331, kld= 10.611
val_loss= 7.523, val_mse= 5.823, val_kld= 17.000
Epoch= 153/200, loss= 8.512, mse= 7.451, kld= 10.604
val_loss= 8.665, val_mse= 6.990, val_kld= 16.749
Epoch= 154/200, loss= 9.669, mse= 8.613, kld= 10.559
val_loss= 8.059, val_mse= 6.353, val_kld= 17.061
Epoch= 155/200, loss= 9.916, mse= 8.744, kld= 11.720
val_loss= 8.772, val_mse= 7.070, val_kld= 17.023
Epoch= 156/200, loss= 9.127, mse= 8.065, kld= 10.612
val_loss= 7.987, val_mse= 6.296, val_kld= 16.912
Epoch= 157/200, loss= 9.596, mse= 8.537, kld= 10.591
val_loss= 8.352, val_mse= 6.655, val_kld= 16.976
Epoch= 158/200, loss= 9.364, mse= 8.301, kld= 10.630
val_loss= 9.121, val_mse= 7.381, val_kld= 17.404
Epoch= 159/200, loss= 8.767, mse= 7.717, kld= 10.495
val_loss= 8.568, val_mse= 6.892, val_kld= 16.765
Epoch= 160/200, loss= 9.487, mse= 8.417, kld= 10.707
val_loss= 9.481, val_mse= 7.794, val_kld= 16.869

Epoch= 161/200, loss= 8.504, mse= 7.459, kld= 10.448
val_loss= 8.019, val_mse= 6.303, val_kld= 17.165
Epoch= 162/200, loss= 8.441, mse= 7.391, kld= 10.495
val_loss= 9.318, val_mse= 7.626, val_kld= 16.917
Epoch= 163/200, loss= 8.747, mse= 7.705, kld= 10.418
val_loss= 7.626, val_mse= 5.910, val_kld= 17.160
Epoch= 164/200, loss= 9.131, mse= 8.080, kld= 10.519
val_loss= 9.444, val_mse= 7.683, val_kld= 17.617
Epoch= 165/200, loss= 8.745, mse= 7.688, kld= 10.568
val_loss= 8.174, val_mse= 6.510, val_kld= 16.645
Epoch= 166/200, loss= 8.180, mse= 7.130, kld= 10.498
val_loss= 8.622, val_mse= 6.940, val_kld= 16.824
Epoch= 167/200, loss= 8.052, mse= 7.007, kld= 10.441
val_loss= 7.951, val_mse= 6.205, val_kld= 17.457
Epoch= 168/200, loss= 8.206, mse= 7.149, kld= 10.576
val_loss= 7.511, val_mse= 5.855, val_kld= 16.569
Epoch= 169/200, loss= 8.536, mse= 7.492, kld= 10.435
val_loss= 8.084, val_mse= 6.434, val_kld= 16.502
Epoch= 170/200, loss= 8.241, mse= 7.175, kld= 10.668
val_loss= 8.629, val_mse= 6.880, val_kld= 17.489
Epoch= 171/200, loss= 8.330, mse= 7.278, kld= 10.517
val_loss= 8.891, val_mse= 7.204, val_kld= 16.864
Epoch= 172/200, loss= 7.633, mse= 6.579, kld= 10.545
val_loss= 8.157, val_mse= 6.538, val_kld= 16.187
Epoch= 173/200, loss= 8.233, mse= 7.184, kld= 10.492
val_loss= 7.605, val_mse= 5.870, val_kld= 17.345
Epoch= 174/200, loss= 7.995, mse= 6.954, kld= 10.410
val_loss= 7.384, val_mse= 5.663, val_kld= 17.215
Epoch= 175/200, loss= 7.932, mse= 6.887, kld= 10.451
val_loss= 8.163, val_mse= 6.511, val_kld= 16.520
Epoch= 176/200, loss= 8.072, mse= 6.995, kld= 10.768
val_loss= 7.171, val_mse= 5.501, val_kld= 16.697
Epoch= 177/200, loss= 7.800, mse= 6.775, kld= 10.249
val_loss= 8.214, val_mse= 6.540, val_kld= 16.735
Epoch= 178/200, loss= 7.528, mse= 6.494, kld= 10.334
val_loss= 7.513, val_mse= 5.810, val_kld= 17.034
Epoch= 179/200, loss= 7.594, mse= 6.564, kld= 10.306
val_loss= 7.639, val_mse= 5.951, val_kld= 16.876
Epoch= 180/200, loss= 7.833, mse= 6.805, kld= 10.287
val_loss= 7.042, val_mse= 5.402, val_kld= 16.392
Epoch= 181/200, loss= 7.531, mse= 6.517, kld= 10.142
val_loss= 8.577, val_mse= 6.917, val_kld= 16.601
Epoch= 182/200, loss= 7.566, mse= 6.545, kld= 10.211
val_loss= 7.321, val_mse= 5.588, val_kld= 17.335
Epoch= 183/200, loss= 7.813, mse= 6.777, kld= 10.355
val_loss= 6.660, val_mse= 5.010, val_kld= 16.508
Epoch= 184/200, loss= 7.632, mse= 6.614, kld= 10.183
val_loss= 6.694, val_mse= 5.064, val_kld= 16.295

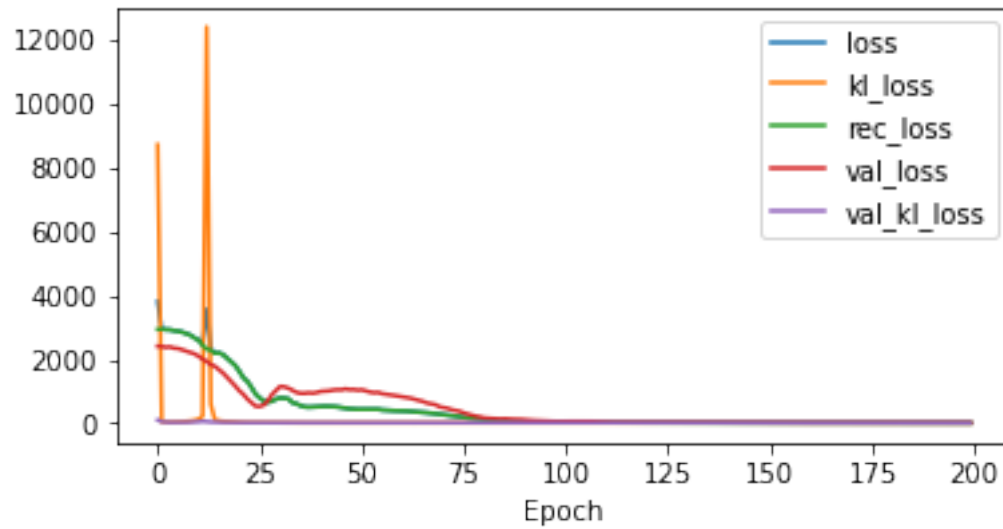
```

Epoch= 185/200, loss= 7.230, mse= 6.209, kld= 10.204
      val_loss= 6.523, val_mse= 4.819, val_kld= 17.046
Epoch= 186/200, loss= 7.254, mse= 6.220, kld= 10.343
      val_loss= 6.062, val_mse= 4.359, val_kld= 17.030
Epoch= 187/200, loss= 7.294, mse= 6.263, kld= 10.303
      val_loss= 6.223, val_mse= 4.570, val_kld= 16.532
Epoch= 188/200, loss= 6.728, mse= 5.714, kld= 10.141
      val_loss= 5.898, val_mse= 4.246, val_kld= 16.517
Epoch= 189/200, loss= 7.582, mse= 6.555, kld= 10.265
      val_loss= 5.618, val_mse= 3.932, val_kld= 16.863
Epoch= 190/200, loss= 6.886, mse= 5.864, kld= 10.223
      val_loss= 6.765, val_mse= 5.084, val_kld= 16.812
Epoch= 191/200, loss= 6.596, mse= 5.584, kld= 10.118
      val_loss= 6.192, val_mse= 4.542, val_kld= 16.502
Epoch= 192/200, loss= 6.956, mse= 5.940, kld= 10.162
      val_loss= 7.246, val_mse= 5.591, val_kld= 16.545
Epoch= 193/200, loss= 7.013, mse= 5.998, kld= 10.150
      val_loss= 6.525, val_mse= 4.819, val_kld= 17.058
Epoch= 194/200, loss= 6.786, mse= 5.770, kld= 10.160
      val_loss= 6.501, val_mse= 4.806, val_kld= 16.946
Epoch= 195/200, loss= 6.971, mse= 5.917, kld= 10.543
      val_loss= 7.577, val_mse= 5.899, val_kld= 16.782
Epoch= 196/200, loss= 7.725, mse= 6.721, kld= 10.041
      val_loss= 6.278, val_mse= 4.593, val_kld= 16.843
Epoch= 197/200, loss= 6.272, mse= 5.263, kld= 10.092
      val_loss= 7.133, val_mse= 5.448, val_kld= 16.853
Epoch= 198/200, loss= 7.098, mse= 6.054, kld= 10.439
      val_loss= 6.602, val_mse= 4.923, val_kld= 16.789
Epoch= 199/200, loss= 7.415, mse= 6.367, kld= 10.485
      val_loss= 6.057, val_mse= 4.384, val_kld= 16.733
Epoch= 200/200, loss= 6.993, mse= 5.989, kld= 10.038
      val_loss= 5.834, val_mse= 4.200, val_kld= 16.341

```

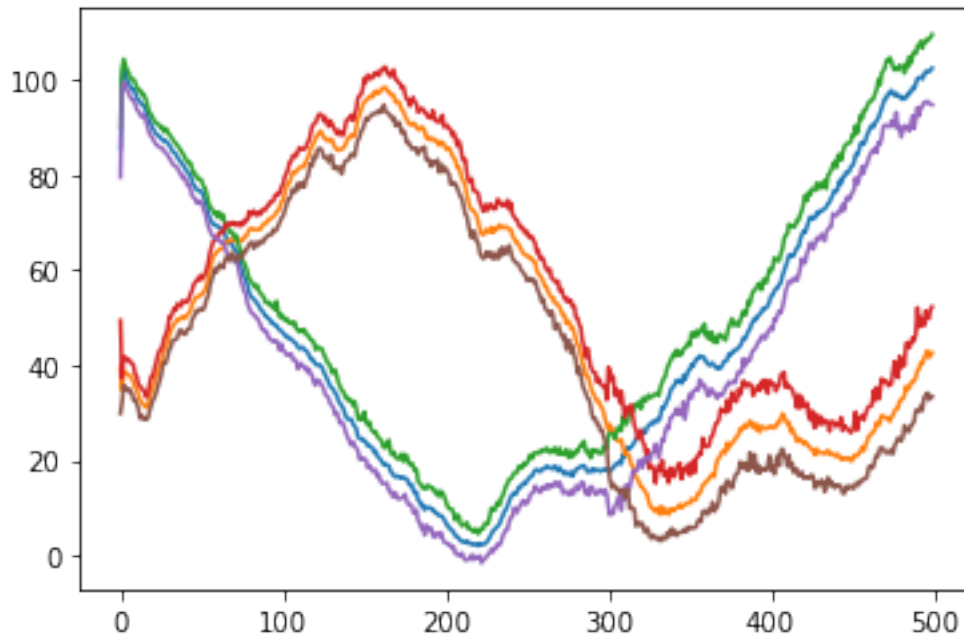
```
[94]: pd.DataFrame(history).plot(figsize=(6, 3), xlabel='Epoch')
```

```
[94]: <AxesSubplot:xlabel='Epoch'>
```

```
[95]: # x_hat = dkf.generate(x_train)
# x_hat, x_025, x_975 = dkf.filter(x_train)
x_hat, x_025, x_975 = dkf.predict(x, 200)
x_hat = x_hat.detach().numpy()[0]
x_025 = x_025.detach().numpy()[0]
x_975 = x_975.detach().numpy()[0]
plt.plot(x_hat)
plt.plot(x_975)
plt.plot(x_025)
```

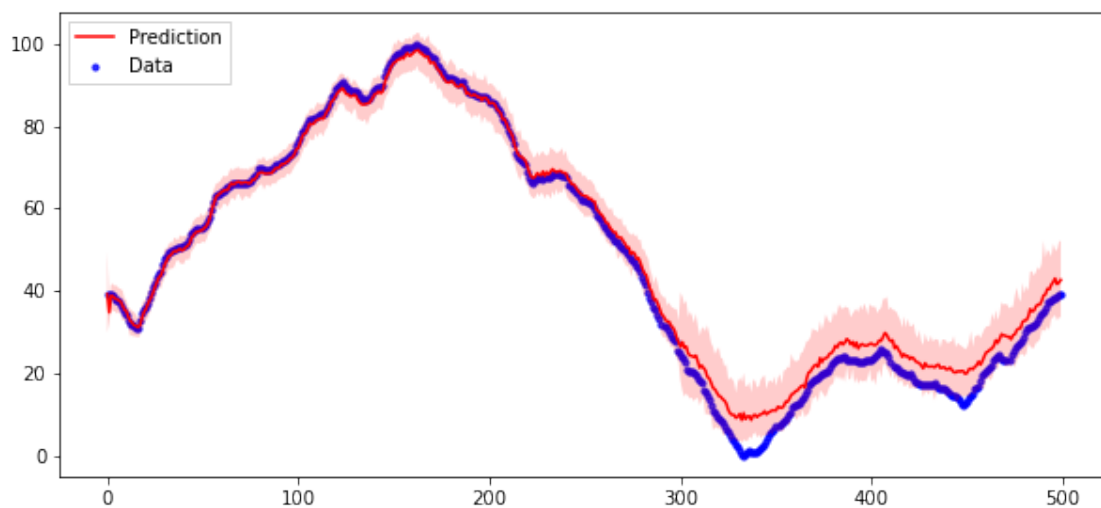
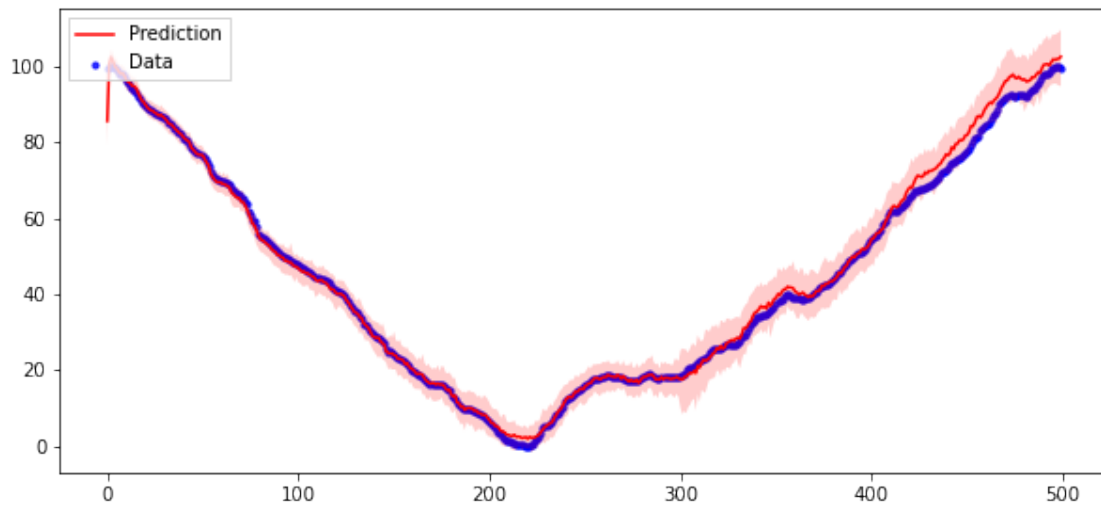
```
[95]: [<matplotlib.lines.Line2D at 0x7f8d5861d670>,
<matplotlib.lines.Line2D at 0x7f8d5861d7f0>]
```



```
[96]: fig, ax = plt.subplots(2, figsize=(10, 10))

for i, axi in enumerate(ax):
    axi.scatter(
        np.arange(data.shape[0]),
        data[:, i], s=10, alpha=0.8, label='Data', c='b')
    axi.plot(x_hat[:, i], label='Prediction', c='r')
    axi.fill_between(np.arange(x_hat.shape[0]), x_025[:, i], x_975[:, i],
                    facecolor='r', alpha=0.2)

    axi.legend(loc='upper left', fancybox=False)
plt.show()
```



```
[97]: #Normalizacja dla 3D - latitude, longitude i altitude
```

4.3 Trenowanie dla znormalizowanych danych latitude, longitude, altitude

```
[105]: def NormalizeData(data):
        return 100*(data - np.min(data)) / (np.max(data) - np.min(data))

norm_long = NormalizeData(np.asarray(data_endo[0]['longitude']))
norm_lat  = NormalizeData(np.asarray(data_endo[0]['latitude']))
norm_alt  = NormalizeData(np.asarray(data_endo[0]['altitude']))

data = np.vstack([norm_long, norm_lat, norm_alt]).T
#print(data.shape)
```

```
[112]: x = torch.FloatTensor(data).reshape(1, *data.shape)
        #print(x)
        x_train = torch.FloatTensor(data[:400]).reshape(1, 400, data.shape[1])
        #print(x_train)
        x_val = torch.FloatTensor(data[400:450]).reshape(1, 50, data.shape[1])
        #print(x_val)

[113]: dkf = DKF(input_dim=3, z_dim=15, rnn_dim=15, trans_dim=15, emission_dim=15)

[114]: history = dkf.fit(x_train, x_val, num_epochs=200, annealing_factor=0.15)
```

```
Epoch= 1/200, loss= 4221.733, mse= 3018.567, kld= 8021.112
        val_loss= 2020.732, val_mse= 2006.235, val_kld= 96.650
Epoch= 2/200, loss= 3014.642, mse= 3002.156, kld= 83.235
        val_loss= 1990.798, val_mse= 1981.331, val_kld= 63.111
Epoch= 3/200, loss= 2992.583, mse= 2986.338, kld= 41.633
        val_loss= 1969.912, val_mse= 1962.406, val_kld= 50.037
Epoch= 4/200, loss= 2989.960, mse= 2985.093, kld= 32.449
        val_loss= 1966.978, val_mse= 1960.112, val_kld= 45.770
Epoch= 5/200, loss= 2951.449, mse= 2947.028, kld= 29.470
        val_loss= 1919.699, val_mse= 1913.929, val_kld= 38.466
Epoch= 6/200, loss= 2926.813, mse= 2922.271, kld= 30.279
        val_loss= 1872.975, val_mse= 1867.310, val_kld= 37.763
Epoch= 7/200, loss= 2871.569, mse= 2866.552, kld= 33.446
        val_loss= 1825.710, val_mse= 1820.282, val_kld= 36.189
Epoch= 8/200, loss= 2802.319, mse= 2796.976, kld= 35.619
        val_loss= 1743.551, val_mse= 1738.099, val_kld= 36.345
Epoch= 9/200, loss= 2692.185, mse= 2686.415, kld= 38.465
        val_loss= 1641.502, val_mse= 1636.979, val_kld= 30.156
Epoch= 10/200, loss= 2551.989, mse= 2545.842, kld= 40.980
        val_loss= 1534.633, val_mse= 1530.214, val_kld= 29.463
Epoch= 11/200, loss= 2389.610, mse= 2383.010, kld= 44.004
        val_loss= 1447.020, val_mse= 1442.659, val_kld= 29.070
Epoch= 12/200, loss= 2179.684, mse= 2173.472, kld= 41.413
        val_loss= 1268.141, val_mse= 1264.405, val_kld= 24.912
Epoch= 13/200, loss= 1909.279, mse= 1900.505, kld= 58.495
        val_loss= 1107.033, val_mse= 1103.180, val_kld= 25.690
Epoch= 14/200, loss= 1555.403, mse= 1517.383, kld= 253.469
        val_loss= 880.038, val_mse= 876.531, val_kld= 23.385
Epoch= 15/200, loss= 1267.431, mse= 1256.539, kld= 72.609
        val_loss= 732.988, val_mse= 729.417, val_kld= 23.805
Epoch= 16/200, loss= 941.465, mse= 932.695, kld= 58.467
        val_loss= 718.709, val_mse= 715.029, val_kld= 24.527
Epoch= 17/200, loss= 826.752, mse= 812.888, kld= 92.424
        val_loss= 833.431, val_mse= 829.845, val_kld= 23.906
Epoch= 18/200, loss= 717.448, mse= 712.950, kld= 29.985
        val_loss= 965.533, val_mse= 961.400, val_kld= 27.551
```

Epoch= 19/200, loss= 807.436, mse= 803.364, kld= 27.144
 val_loss= 1149.530, val_mse= 1145.556, val_kld= 26.494
 Epoch= 20/200, loss= 707.743, mse= 703.875, kld= 25.785
 val_loss= 1146.065, val_mse= 1142.298, val_kld= 25.115
 Epoch= 21/200, loss= 617.650, mse= 613.885, kld= 25.104
 val_loss= 1021.682, val_mse= 1018.096, val_kld= 23.905
 Epoch= 22/200, loss= 562.872, mse= 559.311, kld= 23.742
 val_loss= 917.320, val_mse= 913.856, val_kld= 23.093
 Epoch= 23/200, loss= 493.851, mse= 490.453, kld= 22.658
 val_loss= 871.392, val_mse= 868.105, val_kld= 21.913
 Epoch= 24/200, loss= 481.968, mse= 478.699, kld= 21.793
 val_loss= 839.225, val_mse= 836.057, val_kld= 21.124
 Epoch= 25/200, loss= 494.431, mse= 491.316, kld= 20.763
 val_loss= 827.168, val_mse= 824.102, val_kld= 20.444
 Epoch= 26/200, loss= 510.971, mse= 507.960, kld= 20.075
 val_loss= 836.003, val_mse= 832.999, val_kld= 20.028
 Epoch= 27/200, loss= 520.787, mse= 517.843, kld= 19.629
 val_loss= 862.432, val_mse= 859.414, val_kld= 20.122
 Epoch= 28/200, loss= 514.935, mse= 512.015, kld= 19.470
 val_loss= 899.480, val_mse= 896.459, val_kld= 20.140
 Epoch= 29/200, loss= 498.296, mse= 495.384, kld= 19.408
 val_loss= 873.007, val_mse= 869.885, val_kld= 20.811
 Epoch= 30/200, loss= 476.605, mse= 473.666, kld= 19.591
 val_loss= 913.526, val_mse= 910.423, val_kld= 20.691
 Epoch= 31/200, loss= 463.270, mse= 460.304, kld= 19.777
 val_loss= 954.075, val_mse= 951.031, val_kld= 20.289
 Epoch= 32/200, loss= 452.369, mse= 449.387, kld= 19.882
 val_loss= 983.737, val_mse= 980.709, val_kld= 20.190
 Epoch= 33/200, loss= 452.757, mse= 449.788, kld= 19.791
 val_loss= 971.103, val_mse= 968.088, val_kld= 20.098
 Epoch= 34/200, loss= 456.665, mse= 453.734, kld= 19.541
 val_loss= 930.348, val_mse= 927.364, val_kld= 19.893
 Epoch= 35/200, loss= 449.465, mse= 446.580, kld= 19.234
 val_loss= 879.587, val_mse= 876.642, val_kld= 19.633
 Epoch= 36/200, loss= 440.694, mse= 437.832, kld= 19.077
 val_loss= 827.142, val_mse= 824.265, val_kld= 19.182
 Epoch= 37/200, loss= 426.860, mse= 424.027, kld= 18.883
 val_loss= 789.336, val_mse= 786.541, val_kld= 18.634
 Epoch= 38/200, loss= 425.334, mse= 422.571, kld= 18.419
 val_loss= 760.210, val_mse= 757.439, val_kld= 18.473
 Epoch= 39/200, loss= 424.527, mse= 421.853, kld= 17.826
 val_loss= 758.294, val_mse= 755.543, val_kld= 18.337
 Epoch= 40/200, loss= 426.264, mse= 423.634, kld= 17.536
 val_loss= 753.554, val_mse= 750.746, val_kld= 18.718
 Epoch= 41/200, loss= 426.095, mse= 423.514, kld= 17.207
 val_loss= 776.167, val_mse= 773.435, val_kld= 18.214
 Epoch= 42/200, loss= 424.927, mse= 422.363, kld= 17.093
 val_loss= 769.284, val_mse= 766.600, val_kld= 17.894

Epoch= 43/200, loss= 415.719, mse= 413.169, kld= 16.996
val_loss= 765.272, val_mse= 762.619, val_kld= 17.685
Epoch= 44/200, loss= 407.585, mse= 405.056, kld= 16.857
val_loss= 770.797, val_mse= 768.231, val_kld= 17.111
Epoch= 45/200, loss= 403.421, mse= 400.923, kld= 16.650
val_loss= 785.850, val_mse= 783.231, val_kld= 17.458
Epoch= 46/200, loss= 396.098, mse= 393.612, kld= 16.572
val_loss= 785.683, val_mse= 783.139, val_kld= 16.959
Epoch= 47/200, loss= 397.247, mse= 394.758, kld= 16.590
val_loss= 785.133, val_mse= 782.594, val_kld= 16.925
Epoch= 48/200, loss= 392.905, mse= 390.459, kld= 16.310
val_loss= 786.943, val_mse= 784.411, val_kld= 16.881
Epoch= 49/200, loss= 386.040, mse= 383.635, kld= 16.034
val_loss= 774.661, val_mse= 772.154, val_kld= 16.711
Epoch= 50/200, loss= 377.331, mse= 374.969, kld= 15.745
val_loss= 779.951, val_mse= 777.446, val_kld= 16.700
Epoch= 51/200, loss= 364.644, mse= 362.293, kld= 15.670
val_loss= 759.121, val_mse= 756.657, val_kld= 16.426
Epoch= 52/200, loss= 356.564, mse= 354.237, kld= 15.515
val_loss= 751.412, val_mse= 748.938, val_kld= 16.495
Epoch= 53/200, loss= 354.839, mse= 352.541, kld= 15.315
val_loss= 735.360, val_mse= 732.903, val_kld= 16.383
Epoch= 54/200, loss= 344.110, mse= 341.814, kld= 15.307
val_loss= 725.601, val_mse= 723.124, val_kld= 16.510
Epoch= 55/200, loss= 333.035, mse= 330.757, kld= 15.188
val_loss= 688.355, val_mse= 685.897, val_kld= 16.389
Epoch= 56/200, loss= 317.851, mse= 315.559, kld= 15.280
val_loss= 671.367, val_mse= 668.864, val_kld= 16.688
Epoch= 57/200, loss= 300.927, mse= 298.642, kld= 15.237
val_loss= 642.577, val_mse= 640.010, val_kld= 17.112
Epoch= 58/200, loss= 289.087, mse= 286.781, kld= 15.373
val_loss= 601.258, val_mse= 598.614, val_kld= 17.624
Epoch= 59/200, loss= 270.141, mse= 267.831, kld= 15.403
val_loss= 563.860, val_mse= 561.247, val_kld= 17.419
Epoch= 60/200, loss= 252.588, mse= 250.256, kld= 15.546
val_loss= 519.216, val_mse= 516.549, val_kld= 17.780
Epoch= 61/200, loss= 228.587, mse= 226.264, kld= 15.491
val_loss= 482.419, val_mse= 479.715, val_kld= 18.027
Epoch= 62/200, loss= 208.703, mse= 206.381, kld= 15.483
val_loss= 440.397, val_mse= 437.676, val_kld= 18.139
Epoch= 63/200, loss= 188.026, mse= 185.708, kld= 15.452
val_loss= 406.773, val_mse= 403.988, val_kld= 18.571
Epoch= 64/200, loss= 165.370, mse= 163.022, kld= 15.649
val_loss= 370.120, val_mse= 367.307, val_kld= 18.755
Epoch= 65/200, loss= 150.111, mse= 147.763, kld= 15.656
val_loss= 323.426, val_mse= 320.584, val_kld= 18.942
Epoch= 66/200, loss= 136.467, mse= 134.087, kld= 15.867
val_loss= 296.629, val_mse= 293.846, val_kld= 18.556

Epoch= 67/200, loss= 125.526, mse= 123.140, kld= 15.903
val_loss= 268.301, val_mse= 265.439, val_kld= 19.087
Epoch= 68/200, loss= 119.361, mse= 116.977, kld= 15.890
val_loss= 243.051, val_mse= 240.221, val_kld= 18.870
Epoch= 69/200, loss= 114.046, mse= 111.663, kld= 15.883
val_loss= 230.603, val_mse= 227.750, val_kld= 19.022
Epoch= 70/200, loss= 117.017, mse= 114.631, kld= 15.901
val_loss= 208.057, val_mse= 205.223, val_kld= 18.890
Epoch= 71/200, loss= 122.861, mse= 120.509, kld= 15.675
val_loss= 204.466, val_mse= 201.718, val_kld= 18.321
Epoch= 72/200, loss= 125.401, mse= 123.056, kld= 15.627
val_loss= 189.541, val_mse= 186.803, val_kld= 18.256
Epoch= 73/200, loss= 127.807, mse= 125.511, kld= 15.304
val_loss= 186.001, val_mse= 183.335, val_kld= 17.767
Epoch= 74/200, loss= 126.437, mse= 124.173, kld= 15.095
val_loss= 176.521, val_mse= 173.862, val_kld= 17.732
Epoch= 75/200, loss= 123.517, mse= 121.280, kld= 14.915
val_loss= 171.863, val_mse= 169.242, val_kld= 17.475
Epoch= 76/200, loss= 117.094, mse= 114.891, kld= 14.688
val_loss= 162.471, val_mse= 159.902, val_kld= 17.128
Epoch= 77/200, loss= 110.911, mse= 108.741, kld= 14.467
val_loss= 160.149, val_mse= 157.566, val_kld= 17.221
Epoch= 78/200, loss= 104.048, mse= 101.903, kld= 14.299
val_loss= 169.963, val_mse= 167.430, val_kld= 16.887
Epoch= 79/200, loss= 101.542, mse= 99.417, kld= 14.168
val_loss= 171.630, val_mse= 169.113, val_kld= 16.780
Epoch= 80/200, loss= 99.180, mse= 97.055, kld= 14.165
val_loss= 162.902, val_mse= 160.392, val_kld= 16.730
Epoch= 81/200, loss= 97.805, mse= 95.702, kld= 14.017
val_loss= 161.341, val_mse= 158.889, val_kld= 16.344
Epoch= 82/200, loss= 97.124, mse= 95.037, kld= 13.916
val_loss= 156.191, val_mse= 153.763, val_kld= 16.188
Epoch= 83/200, loss= 96.924, mse= 94.860, kld= 13.761
val_loss= 152.549, val_mse= 150.133, val_kld= 16.103
Epoch= 84/200, loss= 97.845, mse= 95.794, kld= 13.671
val_loss= 150.115, val_mse= 147.727, val_kld= 15.919
Epoch= 85/200, loss= 97.053, mse= 95.024, kld= 13.531
val_loss= 151.856, val_mse= 149.488, val_kld= 15.787
Epoch= 86/200, loss= 94.500, mse= 92.486, kld= 13.426
val_loss= 149.107, val_mse= 146.800, val_kld= 15.380
Epoch= 87/200, loss= 93.830, mse= 91.843, kld= 13.248
val_loss= 141.444, val_mse= 139.185, val_kld= 15.059
Epoch= 88/200, loss= 93.582, mse= 91.610, kld= 13.149
val_loss= 143.852, val_mse= 141.620, val_kld= 14.879
Epoch= 89/200, loss= 91.465, mse= 89.506, kld= 13.059
val_loss= 131.767, val_mse= 129.501, val_kld= 15.107
Epoch= 90/200, loss= 91.084, mse= 89.150, kld= 12.892
val_loss= 127.706, val_mse= 125.451, val_kld= 15.031

Epoch= 91/200, loss= 90.695, mse= 88.773, kld= 12.813
val_loss= 124.455, val_mse= 122.276, val_kld= 14.529
Epoch= 92/200, loss= 90.025, mse= 88.113, kld= 12.748
val_loss= 117.983, val_mse= 115.803, val_kld= 14.537
Epoch= 93/200, loss= 90.083, mse= 88.185, kld= 12.653
val_loss= 117.428, val_mse= 115.244, val_kld= 14.559
Epoch= 94/200, loss= 88.153, mse= 86.275, kld= 12.522
val_loss= 117.747, val_mse= 115.593, val_kld= 14.362
Epoch= 95/200, loss= 86.284, mse= 84.405, kld= 12.528
val_loss= 113.230, val_mse= 111.101, val_kld= 14.194
Epoch= 96/200, loss= 86.105, mse= 84.254, kld= 12.342
val_loss= 113.055, val_mse= 110.893, val_kld= 14.410
Epoch= 97/200, loss= 84.382, mse= 82.533, kld= 12.324
val_loss= 119.720, val_mse= 117.627, val_kld= 13.958
Epoch= 98/200, loss= 85.969, mse= 84.102, kld= 12.448
val_loss= 115.710, val_mse= 113.551, val_kld= 14.396
Epoch= 99/200, loss= 85.241, mse= 83.355, kld= 12.574
val_loss= 113.613, val_mse= 111.461, val_kld= 14.344
Epoch= 100/200, loss= 85.725, mse= 83.867, kld= 12.389
val_loss= 120.968, val_mse= 118.848, val_kld= 14.135
Epoch= 101/200, loss= 85.883, mse= 84.085, kld= 11.986
val_loss= 117.841, val_mse= 115.684, val_kld= 14.379
Epoch= 102/200, loss= 85.078, mse= 83.269, kld= 12.064
val_loss= 119.209, val_mse= 117.117, val_kld= 13.947
Epoch= 103/200, loss= 85.578, mse= 83.776, kld= 12.011
val_loss= 114.102, val_mse= 112.029, val_kld= 13.815
Epoch= 104/200, loss= 84.973, mse= 83.211, kld= 11.750
val_loss= 114.648, val_mse= 112.573, val_kld= 13.835
Epoch= 105/200, loss= 83.981, mse= 82.223, kld= 11.724
val_loss= 111.619, val_mse= 109.594, val_kld= 13.503
Epoch= 106/200, loss= 84.711, mse= 82.952, kld= 11.722
val_loss= 109.057, val_mse= 107.056, val_kld= 13.342
Epoch= 107/200, loss= 82.838, mse= 81.071, kld= 11.775
val_loss= 108.179, val_mse= 106.090, val_kld= 13.928
Epoch= 108/200, loss= 81.210, mse= 79.443, kld= 11.781
val_loss= 110.916, val_mse= 108.893, val_kld= 13.485
Epoch= 109/200, loss= 82.156, mse= 80.411, kld= 11.630
val_loss= 109.158, val_mse= 107.163, val_kld= 13.299
Epoch= 110/200, loss= 82.281, mse= 80.572, kld= 11.392
val_loss= 109.968, val_mse= 107.961, val_kld= 13.379
Epoch= 111/200, loss= 81.377, mse= 79.686, kld= 11.272
val_loss= 108.834, val_mse= 106.841, val_kld= 13.283
Epoch= 112/200, loss= 82.431, mse= 80.780, kld= 11.005
val_loss= 108.224, val_mse= 106.277, val_kld= 12.979
Epoch= 113/200, loss= 82.006, mse= 80.299, kld= 11.379
val_loss= 106.849, val_mse= 104.853, val_kld= 13.308
Epoch= 114/200, loss= 81.809, mse= 80.149, kld= 11.066
val_loss= 103.515, val_mse= 101.523, val_kld= 13.280

Epoch= 115/200, loss= 82.500, mse= 80.880, kld= 10.799
 val_loss= 109.050, val_mse= 107.159, val_kld= 12.612
 Epoch= 116/200, loss= 80.755, mse= 79.071, kld= 11.223
 val_loss= 105.586, val_mse= 103.631, val_kld= 13.034
 Epoch= 117/200, loss= 80.815, mse= 79.165, kld= 11.002
 val_loss= 105.013, val_mse= 103.114, val_kld= 12.660
 Epoch= 118/200, loss= 80.853, mse= 79.180, kld= 11.159
 val_loss= 107.492, val_mse= 105.578, val_kld= 12.762
 Epoch= 119/200, loss= 80.449, mse= 78.770, kld= 11.191
 val_loss= 104.753, val_mse= 102.843, val_kld= 12.738
 Epoch= 120/200, loss= 80.723, mse= 79.107, kld= 10.775
 val_loss= 107.881, val_mse= 105.952, val_kld= 12.864
 Epoch= 121/200, loss= 81.156, mse= 79.497, kld= 11.060
 val_loss= 100.454, val_mse= 98.529, val_kld= 12.831
 Epoch= 122/200, loss= 80.972, mse= 79.261, kld= 11.407
 val_loss= 104.652, val_mse= 102.697, val_kld= 13.030
 Epoch= 123/200, loss= 78.759, mse= 77.104, kld= 11.035
 val_loss= 101.951, val_mse= 100.036, val_kld= 12.769
 Epoch= 124/200, loss= 81.279, mse= 79.669, kld= 10.735
 val_loss= 106.425, val_mse= 104.461, val_kld= 13.091
 Epoch= 125/200, loss= 80.308, mse= 78.669, kld= 10.930
 val_loss= 105.751, val_mse= 103.823, val_kld= 12.855
 Epoch= 126/200, loss= 80.507, mse= 78.906, kld= 10.669
 val_loss= 108.418, val_mse= 106.551, val_kld= 12.443
 Epoch= 127/200, loss= 79.863, mse= 78.282, kld= 10.539
 val_loss= 101.971, val_mse= 100.077, val_kld= 12.621
 Epoch= 128/200, loss= 80.550, mse= 78.946, kld= 10.691
 val_loss= 105.222, val_mse= 103.309, val_kld= 12.748
 Epoch= 129/200, loss= 79.200, mse= 77.615, kld= 10.569
 val_loss= 103.369, val_mse= 101.489, val_kld= 12.532
 Epoch= 130/200, loss= 79.576, mse= 77.995, kld= 10.541
 val_loss= 103.463, val_mse= 101.545, val_kld= 12.782
 Epoch= 131/200, loss= 78.594, mse= 77.034, kld= 10.406
 val_loss= 101.793, val_mse= 99.895, val_kld= 12.652
 Epoch= 132/200, loss= 78.081, mse= 76.513, kld= 10.455
 val_loss= 104.203, val_mse= 102.324, val_kld= 12.529
 Epoch= 133/200, loss= 79.432, mse= 77.847, kld= 10.565
 val_loss= 103.754, val_mse= 101.888, val_kld= 12.441
 Epoch= 134/200, loss= 78.803, mse= 77.230, kld= 10.490
 val_loss= 104.507, val_mse= 102.610, val_kld= 12.642
 Epoch= 135/200, loss= 77.666, mse= 76.117, kld= 10.327
 val_loss= 106.055, val_mse= 104.215, val_kld= 12.267
 Epoch= 136/200, loss= 79.100, mse= 77.541, kld= 10.395
 val_loss= 102.046, val_mse= 100.221, val_kld= 12.170
 Epoch= 137/200, loss= 78.460, mse= 76.910, kld= 10.334
 val_loss= 104.158, val_mse= 102.294, val_kld= 12.427
 Epoch= 138/200, loss= 77.325, mse= 75.697, kld= 10.851
 val_loss= 104.206, val_mse= 102.284, val_kld= 12.812

Epoch= 139/200, loss= 78.391, mse= 76.803, kld= 10.588
 val_loss= 103.305, val_mse= 101.446, val_kld= 12.393
 Epoch= 140/200, loss= 77.577, mse= 75.981, kld= 10.641
 val_loss= 108.386, val_mse= 106.520, val_kld= 12.443
 Epoch= 141/200, loss= 77.685, mse= 76.011, kld= 11.164
 val_loss= 102.460, val_mse= 100.637, val_kld= 12.151
 Epoch= 142/200, loss= 77.892, mse= 76.272, kld= 10.800
 val_loss= 106.899, val_mse= 105.022, val_kld= 12.513
 Epoch= 143/200, loss= 78.288, mse= 76.727, kld= 10.408
 val_loss= 100.849, val_mse= 99.055, val_kld= 11.956
 Epoch= 144/200, loss= 76.935, mse= 75.415, kld= 10.139
 val_loss= 100.662, val_mse= 98.843, val_kld= 12.127
 Epoch= 145/200, loss= 76.868, mse= 75.271, kld= 10.643
 val_loss= 102.688, val_mse= 100.923, val_kld= 11.773
 Epoch= 146/200, loss= 76.973, mse= 75.446, kld= 10.180
 val_loss= 101.504, val_mse= 99.641, val_kld= 12.423
 Epoch= 147/200, loss= 77.345, mse= 75.818, kld= 10.178
 val_loss= 102.989, val_mse= 101.159, val_kld= 12.202
 Epoch= 148/200, loss= 76.367, mse= 74.831, kld= 10.241
 val_loss= 102.444, val_mse= 100.641, val_kld= 12.021
 Epoch= 149/200, loss= 75.429, mse= 73.910, kld= 10.123
 val_loss= 103.408, val_mse= 101.659, val_kld= 11.661
 Epoch= 150/200, loss= 76.338, mse= 74.830, kld= 10.054
 val_loss= 104.344, val_mse= 102.535, val_kld= 12.059
 Epoch= 151/200, loss= 74.188, mse= 72.701, kld= 9.913
 val_loss= 100.155, val_mse= 98.366, val_kld= 11.925
 Epoch= 152/200, loss= 75.578, mse= 74.097, kld= 9.875
 val_loss= 103.966, val_mse= 102.247, val_kld= 11.460
 Epoch= 153/200, loss= 76.061, mse= 74.591, kld= 9.799
 val_loss= 102.834, val_mse= 101.091, val_kld= 11.624
 Epoch= 154/200, loss= 75.409, mse= 73.908, kld= 10.002
 val_loss= 98.665, val_mse= 96.942, val_kld= 11.490
 Epoch= 155/200, loss= 76.278, mse= 74.796, kld= 9.877
 val_loss= 98.572, val_mse= 96.895, val_kld= 11.178
 Epoch= 156/200, loss= 75.091, mse= 73.622, kld= 9.793
 val_loss= 102.468, val_mse= 100.730, val_kld= 11.588
 Epoch= 157/200, loss= 74.602, mse= 73.153, kld= 9.664
 val_loss= 101.684, val_mse= 100.007, val_kld= 11.182
 Epoch= 158/200, loss= 74.528, mse= 73.058, kld= 9.802
 val_loss= 100.117, val_mse= 98.478, val_kld= 10.926
 Epoch= 159/200, loss= 74.323, mse= 72.870, kld= 9.689
 val_loss= 98.467, val_mse= 96.771, val_kld= 11.309
 Epoch= 160/200, loss= 73.446, mse= 71.979, kld= 9.781
 val_loss= 102.302, val_mse= 100.598, val_kld= 11.365
 Epoch= 161/200, loss= 73.827, mse= 72.409, kld= 9.451
 val_loss= 98.143, val_mse= 96.489, val_kld= 11.029
 Epoch= 162/200, loss= 73.810, mse= 72.365, kld= 9.635
 val_loss= 102.191, val_mse= 100.526, val_kld= 11.105

Epoch= 163/200, loss= 72.489, mse= 71.046, kld= 9.624
 val_loss= 99.519, val_mse= 97.873, val_kld= 10.969
 Epoch= 164/200, loss= 72.524, mse= 71.088, kld= 9.573
 val_loss= 99.116, val_mse= 97.490, val_kld= 10.842
 Epoch= 165/200, loss= 71.590, mse= 70.151, kld= 9.595
 val_loss= 96.727, val_mse= 95.118, val_kld= 10.730
 Epoch= 166/200, loss= 72.132, mse= 70.682, kld= 9.669
 val_loss= 96.769, val_mse= 95.132, val_kld= 10.909
 Epoch= 167/200, loss= 71.634, mse= 70.228, kld= 9.375
 val_loss= 97.347, val_mse= 95.713, val_kld= 10.890
 Epoch= 168/200, loss= 71.940, mse= 70.534, kld= 9.371
 val_loss= 97.683, val_mse= 96.087, val_kld= 10.641
 Epoch= 169/200, loss= 71.100, mse= 69.651, kld= 9.660
 val_loss= 93.245, val_mse= 91.626, val_kld= 10.788
 Epoch= 170/200, loss= 70.119, mse= 68.707, kld= 9.416
 val_loss= 95.795, val_mse= 94.188, val_kld= 10.715
 Epoch= 171/200, loss= 69.385, mse= 67.960, kld= 9.504
 val_loss= 96.530, val_mse= 94.896, val_kld= 10.897
 Epoch= 172/200, loss= 69.171, mse= 67.752, kld= 9.459
 val_loss= 97.551, val_mse= 95.905, val_kld= 10.977
 Epoch= 173/200, loss= 69.693, mse= 68.278, kld= 9.435
 val_loss= 96.379, val_mse= 94.747, val_kld= 10.886
 Epoch= 174/200, loss= 67.656, mse= 66.247, kld= 9.393
 val_loss= 94.110, val_mse= 92.512, val_kld= 10.650
 Epoch= 175/200, loss= 67.764, mse= 66.360, kld= 9.359
 val_loss= 93.732, val_mse= 92.112, val_kld= 10.798
 Epoch= 176/200, loss= 66.193, mse= 64.783, kld= 9.403
 val_loss= 93.743, val_mse= 92.114, val_kld= 10.864
 Epoch= 177/200, loss= 66.373, mse= 64.977, kld= 9.303
 val_loss= 93.647, val_mse= 92.042, val_kld= 10.705
 Epoch= 178/200, loss= 65.514, mse= 64.100, kld= 9.424
 val_loss= 92.547, val_mse= 90.960, val_kld= 10.579
 Epoch= 179/200, loss= 64.096, mse= 62.693, kld= 9.355
 val_loss= 91.613, val_mse= 89.961, val_kld= 11.011
 Epoch= 180/200, loss= 64.436, mse= 63.012, kld= 9.498
 val_loss= 93.251, val_mse= 91.665, val_kld= 10.572
 Epoch= 181/200, loss= 63.804, mse= 62.395, kld= 9.391
 val_loss= 89.405, val_mse= 87.757, val_kld= 10.988
 Epoch= 182/200, loss= 62.401, mse= 60.995, kld= 9.374
 val_loss= 87.688, val_mse= 86.081, val_kld= 10.709
 Epoch= 183/200, loss= 60.450, mse= 59.055, kld= 9.302
 val_loss= 85.424, val_mse= 83.864, val_kld= 10.402
 Epoch= 184/200, loss= 60.571, mse= 59.163, kld= 9.389
 val_loss= 81.794, val_mse= 80.189, val_kld= 10.699
 Epoch= 185/200, loss= 59.789, mse= 58.375, kld= 9.425
 val_loss= 83.673, val_mse= 82.074, val_kld= 10.666
 Epoch= 186/200, loss= 59.141, mse= 57.742, kld= 9.326
 val_loss= 83.684, val_mse= 82.034, val_kld= 11.001

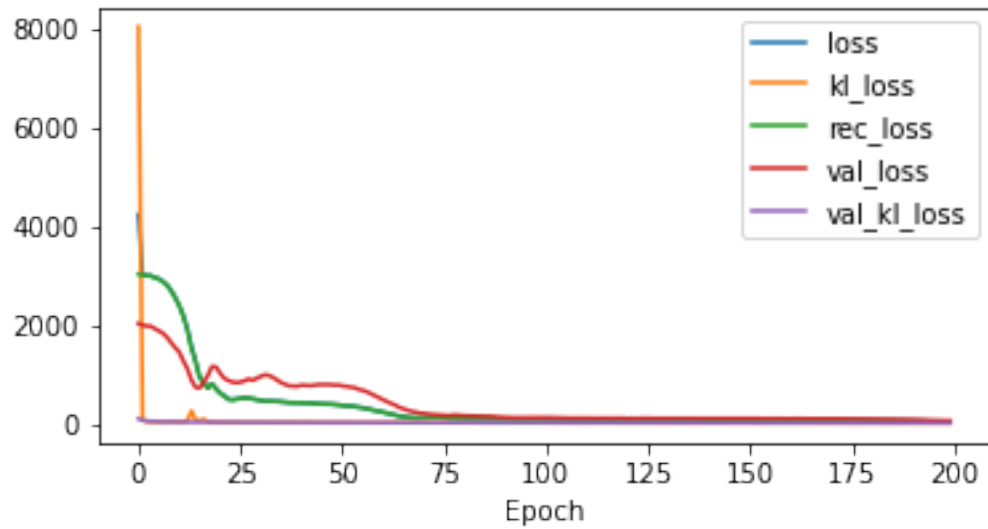
```

Epoch= 187/200, loss= 56.506, mse= 55.116, kld= 9.264
      val_loss= 83.098, val_mse= 81.524, val_kld= 10.493
Epoch= 188/200, loss= 55.914, mse= 54.512, kld= 9.347
      val_loss= 80.928, val_mse= 79.343, val_kld= 10.572
Epoch= 189/200, loss= 53.459, mse= 52.057, kld= 9.345
      val_loss= 80.135, val_mse= 78.561, val_kld= 10.491
Epoch= 190/200, loss= 53.595, mse= 52.203, kld= 9.277
      val_loss= 78.631, val_mse= 77.028, val_kld= 10.683
Epoch= 191/200, loss= 50.878, mse= 49.463, kld= 9.435
      val_loss= 75.446, val_mse= 73.800, val_kld= 10.971
Epoch= 192/200, loss= 49.957, mse= 48.533, kld= 9.496
      val_loss= 75.797, val_mse= 74.256, val_kld= 10.268
Epoch= 193/200, loss= 48.464, mse= 47.071, kld= 9.289
      val_loss= 71.009, val_mse= 69.464, val_kld= 10.303
Epoch= 194/200, loss= 45.606, mse= 44.200, kld= 9.374
      val_loss= 69.689, val_mse= 68.069, val_kld= 10.800
Epoch= 195/200, loss= 44.057, mse= 42.643, kld= 9.430
      val_loss= 68.618, val_mse= 67.004, val_kld= 10.765
Epoch= 196/200, loss= 41.201, mse= 39.759, kld= 9.611
      val_loss= 66.857, val_mse= 65.278, val_kld= 10.525
Epoch= 197/200, loss= 41.097, mse= 39.671, kld= 9.506
      val_loss= 65.431, val_mse= 63.811, val_kld= 10.801
Epoch= 198/200, loss= 38.664, mse= 37.220, kld= 9.630
      val_loss= 61.072, val_mse= 59.518, val_kld= 10.362
Epoch= 199/200, loss= 36.283, mse= 34.858, kld= 9.497
      val_loss= 57.684, val_mse= 56.088, val_kld= 10.643
Epoch= 200/200, loss= 34.514, mse= 33.103, kld= 9.407
      val_loss= 57.441, val_mse= 55.871, val_kld= 10.466

```

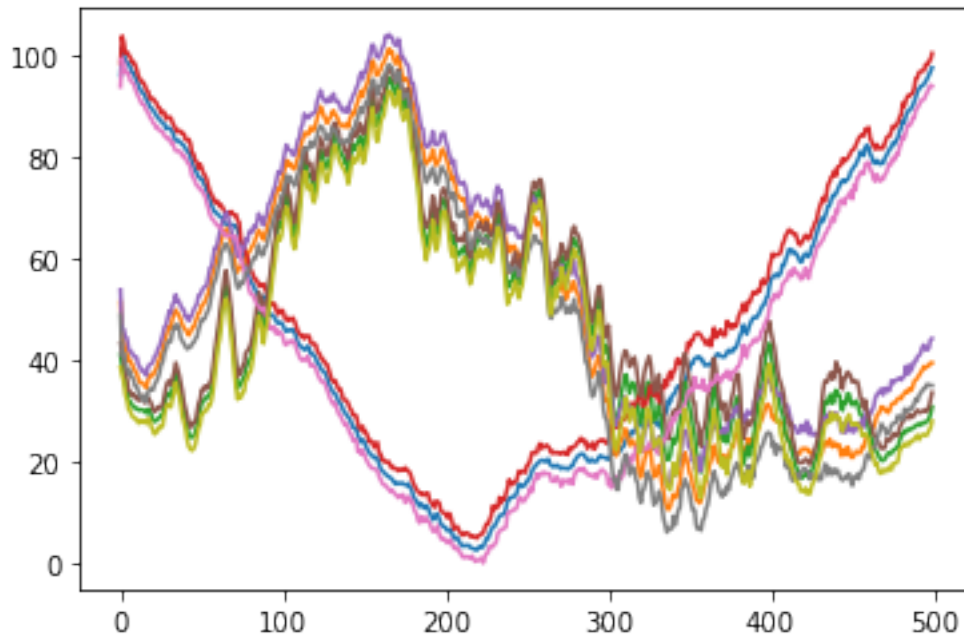
```
[115]: pd.DataFrame(history).plot(figsize=(6, 3), xlabel='Epoch')
```

```
[115]: <AxesSubplot:xlabel='Epoch'>
```



```
[116]: # x_hat = dkf.generate(x_train)
# x_hat, x_025, x_975 = dkf.filter(x_train)
x_hat, x_025, x_975 = dkf.predict(x, 200)
x_hat = x_hat.detach().numpy()[0]
x_025 = x_025.detach().numpy()[0]
x_975 = x_975.detach().numpy()[0]
plt.plot(x_hat)
plt.plot(x_975)
plt.plot(x_025)
```

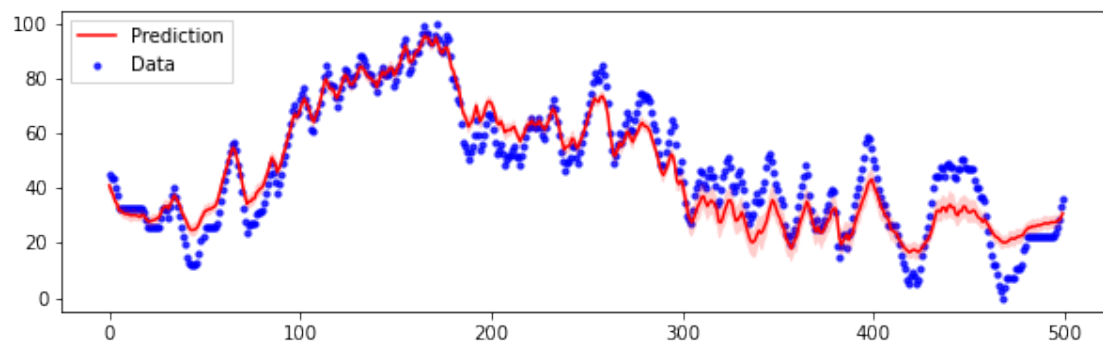
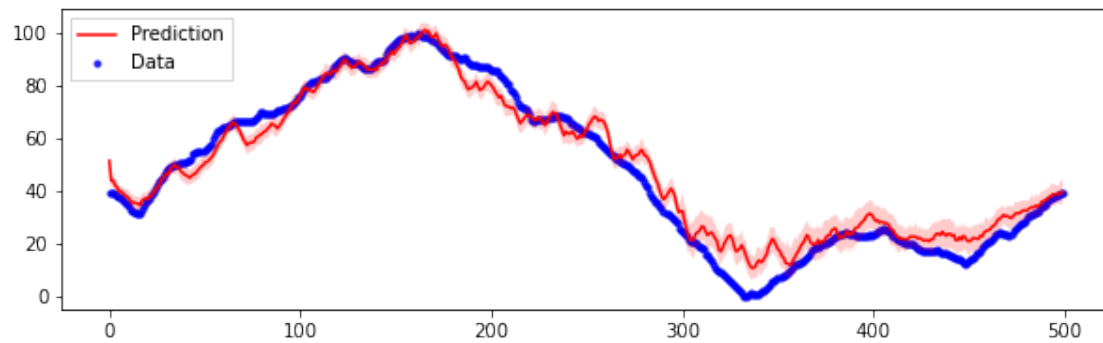
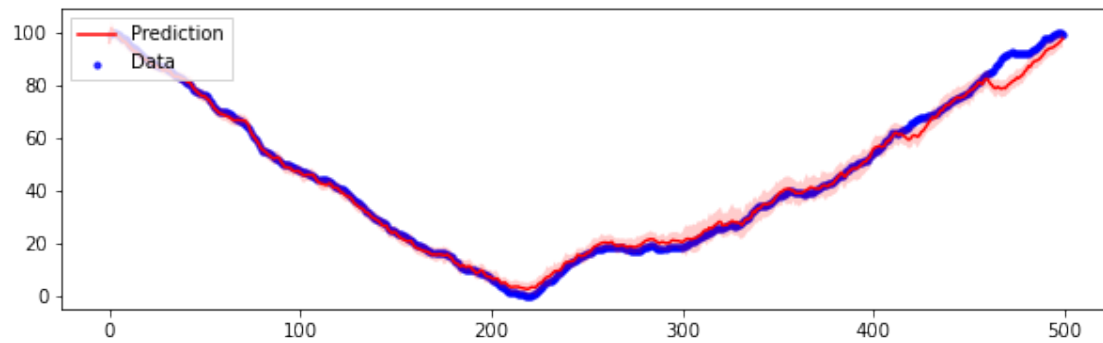
```
[116]: [<matplotlib.lines.Line2D at 0x7f8d06719520>,
<matplotlib.lines.Line2D at 0x7f8d06719a60>,
<matplotlib.lines.Line2D at 0x7f8d06719c10>]
```



```
[117]: fig, ax = plt.subplots(3, figsize=(10, 10))

for i, axi in enumerate(ax):
    axi.scatter(
        np.arange(data.shape[0]),
        data[:, i], s=10, alpha=0.8, label='Data', c='b')
    axi.plot(x_hat[:, i], label='Prediction', c='r')
    axi.fill_between(np.arange(x_hat.shape[0]), x_025[:, i], x_975[:, i],
                    facecolor='r', alpha=0.2)

    axi.legend(loc='upper left', fancybox=False)
plt.show()
```



```
[ ]: #####
```

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[ ]:
```

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[ ]:
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```
[ ]:
```

```
[ ]: #5 Workoutow ze znormalizowanym altitude
```

4.4 5 treningow z znormalizowanych altitude

```
[118]: def NormalizeData(data):  
        return 100*(data - np.min(data)) / (np.max(data) - np.min(data))  
  
data = np.vstack([NormalizeData(np.asarray(data_endo[i]['altitude'])) for i in_  
→range(5)]).T  
#print(data.shape)
```

```
[119]: x = torch.FloatTensor(data).reshape(1, *data.shape)  
#print(x)  
x_train = torch.FloatTensor(data[:400]).reshape(1, 400, data.shape[1])  
#print(x_train)  
x_val    = torch.FloatTensor(data[400:450]).reshape(1, 50, data.shape[1])  
#print(x_val)
```

```
[124]: dkf = DKF(input_dim=5, z_dim=25, rnn_dim=25, trans_dim=25, emission_dim=25)
```

```
[125]: history = dkf.fit(x_train, x_val, num_epochs=200, annealing_factor=0.15)
```

```
Epoch= 1/200, loss= 2976.399, mse= 2937.448, kld= 259.675  
        val_loss= 792.484, val_mse= 790.710, val_kld= 11.825  
Epoch= 2/200, loss= 2915.403, mse= 2908.163, kld= 48.270  
        val_loss= 768.934, val_mse= 767.336, val_kld= 10.651  
Epoch= 3/200, loss= 2859.369, mse= 2853.604, kld= 38.435  
        val_loss= 745.941, val_mse= 743.911, val_kld= 13.531  
Epoch= 4/200, loss= 2752.967, mse= 2744.765, kld= 54.675  
        val_loss= 677.029, val_mse= 674.284, val_kld= 18.305  
Epoch= 5/200, loss= 2543.289, mse= 2531.938, kld= 75.668  
        val_loss= 562.338, val_mse= 557.872, val_kld= 29.775  
Epoch= 6/200, loss= 2176.268, mse= 2137.145, kld= 260.823  
        val_loss= 403.796, val_mse= 395.637, val_kld= 54.388  
Epoch= 7/200, loss= 4852.684, mse= 1578.551, kld= 21827.553  
        val_loss= 338.001, val_mse= 332.757, val_kld= 34.965  
Epoch= 8/200, loss= 1444.489, mse= 1428.133, kld= 109.038  
        val_loss= 298.545, val_mse= 294.196, val_kld= 28.996  
Epoch= 9/200, loss= 1259.006, mse= 1246.854, kld= 81.016  
        val_loss= 252.960, val_mse= 248.900, val_kld= 27.066  
Epoch= 10/200, loss= 1089.720, mse= 1080.169, kld= 63.679  
        val_loss= 235.327, val_mse= 231.422, val_kld= 26.034  
Epoch= 11/200, loss= 979.330, mse= 970.714, kld= 57.436  
        val_loss= 263.414, val_mse= 259.619, val_kld= 25.302  
Epoch= 12/200, loss= 999.024, mse= 990.643, kld= 55.872  
        val_loss= 269.267, val_mse= 265.632, val_kld= 24.230  
Epoch= 13/200, loss= 957.409, mse= 950.239, kld= 47.797  
        val_loss= 246.819, val_mse= 243.515, val_kld= 22.031  
Epoch= 14/200, loss= 838.724, mse= 832.397, kld= 42.178
```



```

        val_loss= 207.781, val_mse= 204.775, val_kld= 20.043
Epoch= 15/200, loss= 741.657, mse= 736.027, kld= 37.537
        val_loss= 169.365, val_mse= 166.484, val_kld= 19.212
Epoch= 16/200, loss= 670.320, mse= 665.183, kld= 34.246
        val_loss= 153.770, val_mse= 151.061, val_kld= 18.065
Epoch= 17/200, loss= 628.108, mse= 623.297, kld= 32.071
        val_loss= 150.097, val_mse= 147.459, val_kld= 17.591
Epoch= 18/200, loss= 603.810, mse= 599.149, kld= 31.079
        val_loss= 133.449, val_mse= 130.824, val_kld= 17.496
Epoch= 19/200, loss= 568.475, mse= 563.871, kld= 30.696
        val_loss= 128.116, val_mse= 125.522, val_kld= 17.298
Epoch= 20/200, loss= 515.588, mse= 510.936, kld= 31.013
        val_loss= 132.086, val_mse= 129.372, val_kld= 18.094
Epoch= 21/200, loss= 473.052, mse= 468.297, kld= 31.704
        val_loss= 139.212, val_mse= 136.445, val_kld= 18.448
Epoch= 22/200, loss= 451.525, mse= 446.680, kld= 32.304
        val_loss= 151.337, val_mse= 148.527, val_kld= 18.737
Epoch= 23/200, loss= 444.687, mse= 439.742, kld= 32.966
        val_loss= 163.059, val_mse= 160.182, val_kld= 19.180
Epoch= 24/200, loss= 446.050, mse= 441.033, kld= 33.446
        val_loss= 161.423, val_mse= 158.537, val_kld= 19.237
Epoch= 25/200, loss= 425.068, mse= 420.050, kld= 33.453
        val_loss= 145.450, val_mse= 142.607, val_kld= 18.956
Epoch= 26/200, loss= 403.449, mse= 398.526, kld= 32.820
        val_loss= 137.839, val_mse= 135.111, val_kld= 18.183
Epoch= 27/200, loss= 396.567, mse= 391.784, kld= 31.886
        val_loss= 135.772, val_mse= 133.071, val_kld= 18.006
Epoch= 28/200, loss= 399.056, mse= 394.351, kld= 31.368
        val_loss= 137.217, val_mse= 134.569, val_kld= 17.657
Epoch= 29/200, loss= 410.586, mse= 405.958, kld= 30.854
        val_loss= 144.300, val_mse= 141.677, val_kld= 17.486
Epoch= 30/200, loss= 410.566, mse= 405.987, kld= 30.524
        val_loss= 150.465, val_mse= 147.813, val_kld= 17.678
Epoch= 31/200, loss= 403.575, mse= 399.025, kld= 30.333
        val_loss= 160.112, val_mse= 157.497, val_kld= 17.438
Epoch= 32/200, loss= 397.382, mse= 392.821, kld= 30.411
        val_loss= 161.547, val_mse= 158.941, val_kld= 17.378
Epoch= 33/200, loss= 398.083, mse= 393.548, kld= 30.234
        val_loss= 172.716, val_mse= 170.152, val_kld= 17.096
Epoch= 34/200, loss= 400.661, mse= 396.159, kld= 30.014
        val_loss= 175.737, val_mse= 173.184, val_kld= 17.017
Epoch= 35/200, loss= 402.326, mse= 397.894, kld= 29.546
        val_loss= 171.730, val_mse= 169.227, val_kld= 16.680
Epoch= 36/200, loss= 397.692, mse= 393.344, kld= 28.991
        val_loss= 163.769, val_mse= 161.305, val_kld= 16.425
Epoch= 37/200, loss= 389.483, mse= 385.249, kld= 28.222
        val_loss= 154.506, val_mse= 152.155, val_kld= 15.674
Epoch= 38/200, loss= 384.480, mse= 380.378, kld= 27.347

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    val_loss= 152.838, val_mse= 150.563, val_kld= 15.168
Epoch= 39/200, loss= 383.799, mse= 379.790, kld= 26.723
    val_loss= 148.003, val_mse= 145.753, val_kld= 14.999
Epoch= 40/200, loss= 382.308, mse= 378.419, kld= 25.928
    val_loss= 151.377, val_mse= 149.194, val_kld= 14.553
Epoch= 41/200, loss= 373.935, mse= 370.109, kld= 25.510
    val_loss= 142.744, val_mse= 140.552, val_kld= 14.609
Epoch= 42/200, loss= 373.253, mse= 369.501, kld= 25.012
    val_loss= 140.365, val_mse= 138.257, val_kld= 14.054
Epoch= 43/200, loss= 370.362, mse= 366.683, kld= 24.526
    val_loss= 143.828, val_mse= 141.701, val_kld= 14.181
Epoch= 44/200, loss= 371.188, mse= 367.625, kld= 23.752
    val_loss= 140.619, val_mse= 138.579, val_kld= 13.602
Epoch= 45/200, loss= 370.027, mse= 366.540, kld= 23.250
    val_loss= 141.955, val_mse= 139.981, val_kld= 13.156
Epoch= 46/200, loss= 372.106, mse= 368.713, kld= 22.622
    val_loss= 139.644, val_mse= 137.668, val_kld= 13.171
Epoch= 47/200, loss= 369.727, mse= 366.417, kld= 22.067
    val_loss= 132.524, val_mse= 130.621, val_kld= 12.685
Epoch= 48/200, loss= 368.759, mse= 365.566, kld= 21.288
    val_loss= 132.324, val_mse= 130.463, val_kld= 12.405
Epoch= 49/200, loss= 368.249, mse= 365.139, kld= 20.732
    val_loss= 129.582, val_mse= 127.728, val_kld= 12.359
Epoch= 50/200, loss= 368.040, mse= 364.989, kld= 20.342
    val_loss= 125.562, val_mse= 123.766, val_kld= 11.974
Epoch= 51/200, loss= 370.631, mse= 367.663, kld= 19.786
    val_loss= 122.060, val_mse= 120.283, val_kld= 11.844
Epoch= 52/200, loss= 368.560, mse= 365.606, kld= 19.694
    val_loss= 127.704, val_mse= 125.881, val_kld= 12.156
Epoch= 53/200, loss= 366.525, mse= 363.635, kld= 19.271
    val_loss= 127.749, val_mse= 125.978, val_kld= 11.806
Epoch= 54/200, loss= 367.448, mse= 364.623, kld= 18.835
    val_loss= 131.691, val_mse= 129.917, val_kld= 11.825
Epoch= 55/200, loss= 367.252, mse= 364.484, kld= 18.453
    val_loss= 129.807, val_mse= 128.161, val_kld= 10.971
Epoch= 56/200, loss= 367.831, mse= 365.142, kld= 17.932
    val_loss= 123.441, val_mse= 121.711, val_kld= 11.533
Epoch= 57/200, loss= 364.245, mse= 361.613, kld= 17.548
    val_loss= 126.735, val_mse= 125.084, val_kld= 11.005
Epoch= 58/200, loss= 368.471, mse= 365.904, kld= 17.117
    val_loss= 125.201, val_mse= 123.593, val_kld= 10.721
Epoch= 59/200, loss= 368.093, mse= 365.580, kld= 16.751
    val_loss= 127.678, val_mse= 126.048, val_kld= 10.867
Epoch= 60/200, loss= 366.129, mse= 363.644, kld= 16.569
    val_loss= 127.911, val_mse= 126.325, val_kld= 10.569
Epoch= 61/200, loss= 363.047, mse= 360.608, kld= 16.256
    val_loss= 129.065, val_mse= 127.535, val_kld= 10.202
Epoch= 62/200, loss= 365.663, mse= 363.272, kld= 15.944

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val_loss= 134.464, val_mse= 132.903, val_kld= 10.408
 Epoch= 63/200, loss= 363.923, mse= 361.545, kld= 15.852
 val_loss= 132.415, val_mse= 130.926, val_kld= 9.925
 Epoch= 64/200, loss= 364.968, mse= 362.650, kld= 15.453
 val_loss= 131.321, val_mse= 129.781, val_kld= 10.268
 Epoch= 65/200, loss= 362.059, mse= 359.773, kld= 15.241
 val_loss= 132.010, val_mse= 130.445, val_kld= 10.437
 Epoch= 66/200, loss= 363.764, mse= 361.496, kld= 15.125
 val_loss= 131.382, val_mse= 129.951, val_kld= 9.535
 Epoch= 67/200, loss= 364.000, mse= 361.763, kld= 14.916
 val_loss= 134.181, val_mse= 132.748, val_kld= 9.556
 Epoch= 68/200, loss= 362.125, mse= 359.903, kld= 14.816
 val_loss= 136.126, val_mse= 134.567, val_kld= 10.396
 Epoch= 69/200, loss= 361.051, mse= 358.881, kld= 14.467
 val_loss= 133.860, val_mse= 132.456, val_kld= 9.362
 Epoch= 70/200, loss= 362.870, mse= 360.758, kld= 14.080
 val_loss= 131.449, val_mse= 130.121, val_kld= 8.851
 Epoch= 71/200, loss= 362.275, mse= 360.161, kld= 14.090
 val_loss= 133.057, val_mse= 131.719, val_kld= 8.919
 Epoch= 72/200, loss= 363.027, mse= 360.961, kld= 13.770
 val_loss= 129.671, val_mse= 128.280, val_kld= 9.275
 Epoch= 73/200, loss= 360.474, mse= 358.362, kld= 14.076
 val_loss= 130.533, val_mse= 129.172, val_kld= 9.075
 Epoch= 74/200, loss= 361.915, mse= 359.894, kld= 13.479
 val_loss= 136.885, val_mse= 135.509, val_kld= 9.174
 Epoch= 75/200, loss= 359.586, mse= 357.576, kld= 13.403
 val_loss= 132.135, val_mse= 130.784, val_kld= 9.006
 Epoch= 76/200, loss= 362.002, mse= 360.014, kld= 13.255
 val_loss= 135.351, val_mse= 133.970, val_kld= 9.207
 Epoch= 77/200, loss= 359.707, mse= 357.749, kld= 13.055
 val_loss= 129.117, val_mse= 127.764, val_kld= 9.019
 Epoch= 78/200, loss= 360.481, mse= 358.529, kld= 13.013
 val_loss= 131.170, val_mse= 129.888, val_kld= 8.549
 Epoch= 79/200, loss= 360.630, mse= 358.752, kld= 12.523
 val_loss= 134.540, val_mse= 133.152, val_kld= 9.251
 Epoch= 80/200, loss= 360.055, mse= 358.131, kld= 12.828
 val_loss= 130.306, val_mse= 129.018, val_kld= 8.589
 Epoch= 81/200, loss= 360.475, mse= 358.599, kld= 12.511
 val_loss= 136.522, val_mse= 135.255, val_kld= 8.445
 Epoch= 82/200, loss= 359.160, mse= 357.292, kld= 12.456
 val_loss= 130.395, val_mse= 129.117, val_kld= 8.515
 Epoch= 83/200, loss= 361.141, mse= 359.292, kld= 12.331
 val_loss= 129.775, val_mse= 128.525, val_kld= 8.333
 Epoch= 84/200, loss= 359.625, mse= 357.827, kld= 11.984
 val_loss= 127.228, val_mse= 125.984, val_kld= 8.294
 Epoch= 85/200, loss= 360.370, mse= 358.546, kld= 12.164
 val_loss= 127.648, val_mse= 126.410, val_kld= 8.254
 Epoch= 86/200, loss= 358.130, mse= 356.328, kld= 12.013

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        val_loss= 127.091, val_mse= 125.840, val_kld= 8.337
Epoch= 87/200, loss= 357.329, mse= 355.592, kld= 11.577
        val_loss= 131.561, val_mse= 130.315, val_kld= 8.309
Epoch= 88/200, loss= 358.182, mse= 356.405, kld= 11.847
        val_loss= 128.108, val_mse= 126.827, val_kld= 8.543
Epoch= 89/200, loss= 358.074, mse= 356.337, kld= 11.586
        val_loss= 128.636, val_mse= 127.468, val_kld= 7.787
Epoch= 90/200, loss= 358.291, mse= 356.534, kld= 11.715
        val_loss= 131.446, val_mse= 130.243, val_kld= 8.023
Epoch= 91/200, loss= 358.550, mse= 356.822, kld= 11.519
        val_loss= 129.595, val_mse= 128.395, val_kld= 8.004
Epoch= 92/200, loss= 357.593, mse= 355.902, kld= 11.273
        val_loss= 128.864, val_mse= 127.704, val_kld= 7.732
Epoch= 93/200, loss= 359.286, mse= 357.591, kld= 11.299
        val_loss= 127.776, val_mse= 126.581, val_kld= 7.967
Epoch= 94/200, loss= 357.973, mse= 356.260, kld= 11.420
        val_loss= 123.729, val_mse= 122.625, val_kld= 7.357
Epoch= 95/200, loss= 357.200, mse= 355.478, kld= 11.479
        val_loss= 125.739, val_mse= 124.569, val_kld= 7.802
Epoch= 96/200, loss= 357.745, mse= 355.873, kld= 12.480
        val_loss= 127.512, val_mse= 126.417, val_kld= 7.300
Epoch= 97/200, loss= 358.516, mse= 356.764, kld= 11.683
        val_loss= 128.800, val_mse= 127.643, val_kld= 7.713
Epoch= 98/200, loss= 355.613, mse= 353.847, kld= 11.779
        val_loss= 130.292, val_mse= 129.198, val_kld= 7.299
Epoch= 99/200, loss= 357.344, mse= 355.652, kld= 11.279
        val_loss= 127.732, val_mse= 126.607, val_kld= 7.501
Epoch= 100/200, loss= 357.113, mse= 355.341, kld= 11.812
        val_loss= 128.540, val_mse= 127.374, val_kld= 7.775
Epoch= 101/200, loss= 356.063, mse= 354.303, kld= 11.732
        val_loss= 124.981, val_mse= 123.836, val_kld= 7.636
Epoch= 102/200, loss= 355.915, mse= 354.245, kld= 11.133
        val_loss= 127.334, val_mse= 126.236, val_kld= 7.320
Epoch= 103/200, loss= 355.578, mse= 353.879, kld= 11.325
        val_loss= 126.488, val_mse= 125.274, val_kld= 8.094
Epoch= 104/200, loss= 353.365, mse= 351.647, kld= 11.452
        val_loss= 127.587, val_mse= 126.441, val_kld= 7.641
Epoch= 105/200, loss= 353.644, mse= 351.989, kld= 11.033
        val_loss= 131.242, val_mse= 130.063, val_kld= 7.857
Epoch= 106/200, loss= 352.884, mse= 351.226, kld= 11.050
        val_loss= 128.008, val_mse= 126.926, val_kld= 7.213
Epoch= 107/200, loss= 354.685, mse= 352.983, kld= 11.347
        val_loss= 122.659, val_mse= 121.477, val_kld= 7.879
Epoch= 108/200, loss= 353.225, mse= 351.525, kld= 11.339
        val_loss= 128.298, val_mse= 127.125, val_kld= 7.823
Epoch= 109/200, loss= 353.444, mse= 351.755, kld= 11.257
        val_loss= 128.052, val_mse= 126.943, val_kld= 7.393
Epoch= 110/200, loss= 354.346, mse= 352.721, kld= 10.837

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        val_loss= 129.108, val_mse= 127.951, val_kld= 7.714
Epoch= 111/200, loss= 353.205, mse= 351.512, kld= 11.289
        val_loss= 126.864, val_mse= 125.797, val_kld= 7.113
Epoch= 112/200, loss= 351.835, mse= 350.161, kld= 11.161
        val_loss= 128.548, val_mse= 127.431, val_kld= 7.448
Epoch= 113/200, loss= 350.307, mse= 348.692, kld= 10.767
        val_loss= 127.195, val_mse= 126.095, val_kld= 7.337
Epoch= 114/200, loss= 350.293, mse= 348.672, kld= 10.805
        val_loss= 123.781, val_mse= 122.676, val_kld= 7.368
Epoch= 115/200, loss= 350.311, mse= 348.682, kld= 10.861
        val_loss= 127.391, val_mse= 126.296, val_kld= 7.297
Epoch= 116/200, loss= 348.797, mse= 347.173, kld= 10.827
        val_loss= 126.810, val_mse= 125.650, val_kld= 7.737
Epoch= 117/200, loss= 350.475, mse= 348.875, kld= 10.670
        val_loss= 126.507, val_mse= 125.390, val_kld= 7.442
Epoch= 118/200, loss= 347.065, mse= 345.396, kld= 11.130
        val_loss= 124.749, val_mse= 123.636, val_kld= 7.418
Epoch= 119/200, loss= 345.485, mse= 343.833, kld= 11.010
        val_loss= 127.809, val_mse= 126.697, val_kld= 7.408
Epoch= 120/200, loss= 345.347, mse= 343.779, kld= 10.453
        val_loss= 125.217, val_mse= 124.150, val_kld= 7.109
Epoch= 121/200, loss= 342.114, mse= 340.550, kld= 10.426
        val_loss= 126.507, val_mse= 125.401, val_kld= 7.379
Epoch= 122/200, loss= 343.169, mse= 341.563, kld= 10.706
        val_loss= 122.892, val_mse= 121.775, val_kld= 7.446
Epoch= 123/200, loss= 340.989, mse= 339.372, kld= 10.783
        val_loss= 124.154, val_mse= 123.055, val_kld= 7.328
Epoch= 124/200, loss= 340.047, mse= 338.473, kld= 10.494
        val_loss= 124.818, val_mse= 123.706, val_kld= 7.411
Epoch= 125/200, loss= 338.911, mse= 337.317, kld= 10.626
        val_loss= 124.600, val_mse= 123.499, val_kld= 7.339
Epoch= 126/200, loss= 338.355, mse= 336.819, kld= 10.238
        val_loss= 124.772, val_mse= 123.732, val_kld= 6.933
Epoch= 127/200, loss= 335.264, mse= 333.673, kld= 10.606
        val_loss= 124.586, val_mse= 123.512, val_kld= 7.158
Epoch= 128/200, loss= 334.991, mse= 333.442, kld= 10.326
        val_loss= 125.365, val_mse= 124.276, val_kld= 7.265
Epoch= 129/200, loss= 332.551, mse= 331.000, kld= 10.337
        val_loss= 123.424, val_mse= 122.414, val_kld= 6.731
Epoch= 130/200, loss= 330.719, mse= 329.155, kld= 10.431
        val_loss= 125.973, val_mse= 124.878, val_kld= 7.299
Epoch= 131/200, loss= 330.290, mse= 328.695, kld= 10.633
        val_loss= 122.045, val_mse= 120.941, val_kld= 7.359
Epoch= 132/200, loss= 325.597, mse= 324.047, kld= 10.332
        val_loss= 123.296, val_mse= 122.200, val_kld= 7.310
Epoch= 133/200, loss= 324.132, mse= 322.469, kld= 11.093
        val_loss= 120.462, val_mse= 119.395, val_kld= 7.109
Epoch= 134/200, loss= 320.831, mse= 319.210, kld= 10.810

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        val_loss= 120.465, val_mse= 119.407, val_kld= 7.054
Epoch= 135/200, loss= 317.600, mse= 315.956, kld= 10.958
        val_loss= 122.470, val_mse= 121.409, val_kld= 7.067
Epoch= 136/200, loss= 312.632, mse= 311.047, kld= 10.571
        val_loss= 119.380, val_mse= 118.273, val_kld= 7.379
Epoch= 137/200, loss= 310.231, mse= 308.616, kld= 10.767
        val_loss= 117.885, val_mse= 116.870, val_kld= 6.769
Epoch= 138/200, loss= 306.066, mse= 304.475, kld= 10.606
        val_loss= 118.900, val_mse= 117.808, val_kld= 7.283
Epoch= 139/200, loss= 302.246, mse= 300.622, kld= 10.828
        val_loss= 116.608, val_mse= 115.540, val_kld= 7.118
Epoch= 140/200, loss= 297.266, mse= 295.658, kld= 10.717
        val_loss= 121.326, val_mse= 120.176, val_kld= 7.666
Epoch= 141/200, loss= 291.709, mse= 290.133, kld= 10.505
        val_loss= 120.689, val_mse= 119.614, val_kld= 7.167
Epoch= 142/200, loss= 288.428, mse= 286.792, kld= 10.911
        val_loss= 119.994, val_mse= 118.962, val_kld= 6.879
Epoch= 143/200, loss= 282.601, mse= 281.022, kld= 10.529
        val_loss= 113.826, val_mse= 112.660, val_kld= 7.775
Epoch= 144/200, loss= 276.749, mse= 275.137, kld= 10.747
        val_loss= 115.493, val_mse= 114.337, val_kld= 7.712
Epoch= 145/200, loss= 270.130, mse= 268.468, kld= 11.079
        val_loss= 114.097, val_mse= 113.001, val_kld= 7.306
Epoch= 146/200, loss= 264.872, mse= 263.218, kld= 11.027
        val_loss= 116.306, val_mse= 115.196, val_kld= 7.400
Epoch= 147/200, loss= 260.081, mse= 258.396, kld= 11.232
        val_loss= 114.118, val_mse= 112.978, val_kld= 7.598
Epoch= 148/200, loss= 251.393, mse= 249.762, kld= 10.874
        val_loss= 111.329, val_mse= 110.171, val_kld= 7.719
Epoch= 149/200, loss= 244.555, mse= 242.901, kld= 11.026
        val_loss= 109.501, val_mse= 108.329, val_kld= 7.817
Epoch= 150/200, loss= 239.637, mse= 237.995, kld= 10.946
        val_loss= 107.398, val_mse= 106.270, val_kld= 7.521
Epoch= 151/200, loss= 232.170, mse= 230.507, kld= 11.088
        val_loss= 106.919, val_mse= 105.749, val_kld= 7.801
Epoch= 152/200, loss= 226.951, mse= 225.228, kld= 11.486
        val_loss= 109.260, val_mse= 108.083, val_kld= 7.850
Epoch= 153/200, loss= 220.912, mse= 219.215, kld= 11.313
        val_loss= 111.217, val_mse= 110.091, val_kld= 7.511
Epoch= 154/200, loss= 215.169, mse= 213.443, kld= 11.503
        val_loss= 102.933, val_mse= 101.792, val_kld= 7.611
Epoch= 155/200, loss= 209.604, mse= 207.893, kld= 11.408
        val_loss= 106.285, val_mse= 105.158, val_kld= 7.516
Epoch= 156/200, loss= 204.654, mse= 202.815, kld= 12.258
        val_loss= 104.061, val_mse= 102.863, val_kld= 7.987
Epoch= 157/200, loss= 202.406, mse= 200.608, kld= 11.990
        val_loss= 104.145, val_mse= 102.957, val_kld= 7.922
Epoch= 158/200, loss= 195.969, mse= 194.223, kld= 11.637

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        val_loss= 102.470, val_mse= 101.248, val_kld= 8.149
Epoch= 159/200, loss= 193.337, mse= 191.540, kld= 11.977
        val_loss= 101.938, val_mse= 100.747, val_kld= 7.941
Epoch= 160/200, loss= 190.443, mse= 188.706, kld= 11.577
        val_loss= 103.443, val_mse= 102.200, val_kld= 8.283
Epoch= 161/200, loss= 189.817, mse= 188.032, kld= 11.902
        val_loss= 104.382, val_mse= 103.177, val_kld= 8.033
Epoch= 162/200, loss= 184.890, mse= 183.121, kld= 11.790
        val_loss= 100.478, val_mse= 99.242, val_kld= 8.237
Epoch= 163/200, loss= 186.651, mse= 184.825, kld= 12.176
        val_loss= 99.765, val_mse= 98.510, val_kld= 8.366
Epoch= 164/200, loss= 184.327, mse= 182.476, kld= 12.339
        val_loss= 99.719, val_mse= 98.503, val_kld= 8.107
Epoch= 165/200, loss= 184.785, mse= 182.925, kld= 12.400
        val_loss= 102.542, val_mse= 101.311, val_kld= 8.211
Epoch= 166/200, loss= 182.598, mse= 180.655, kld= 12.955
        val_loss= 101.970, val_mse= 100.719, val_kld= 8.338
Epoch= 167/200, loss= 182.651, mse= 180.569, kld= 13.881
        val_loss= 98.964, val_mse= 97.700, val_kld= 8.425
Epoch= 168/200, loss= 180.293, mse= 178.351, kld= 12.951
        val_loss= 98.057, val_mse= 96.702, val_kld= 9.030
Epoch= 169/200, loss= 179.230, mse= 177.292, kld= 12.914
        val_loss= 95.835, val_mse= 94.474, val_kld= 9.078
Epoch= 170/200, loss= 178.607, mse= 176.681, kld= 12.838
        val_loss= 97.283, val_mse= 95.965, val_kld= 8.790
Epoch= 171/200, loss= 177.984, mse= 176.042, kld= 12.941
        val_loss= 96.270, val_mse= 94.958, val_kld= 8.741
Epoch= 172/200, loss= 178.416, mse= 176.479, kld= 12.914
        val_loss= 97.391, val_mse= 96.085, val_kld= 8.706
Epoch= 173/200, loss= 176.596, mse= 174.679, kld= 12.779
        val_loss= 91.694, val_mse= 90.450, val_kld= 8.296
Epoch= 174/200, loss= 177.544, mse= 175.663, kld= 12.537
        val_loss= 94.701, val_mse= 93.433, val_kld= 8.457
Epoch= 175/200, loss= 177.677, mse= 175.781, kld= 12.639
        val_loss= 93.815, val_mse= 92.506, val_kld= 8.724
Epoch= 176/200, loss= 176.557, mse= 174.673, kld= 12.556
        val_loss= 93.202, val_mse= 91.909, val_kld= 8.619
Epoch= 177/200, loss= 174.250, mse= 172.211, kld= 13.592
        val_loss= 95.901, val_mse= 94.590, val_kld= 8.739
Epoch= 178/200, loss= 174.375, mse= 172.230, kld= 14.300
        val_loss= 94.642, val_mse= 93.328, val_kld= 8.758
Epoch= 179/200, loss= 173.981, mse= 171.929, kld= 13.676
        val_loss= 94.770, val_mse= 93.452, val_kld= 8.783
Epoch= 180/200, loss= 172.615, mse= 170.679, kld= 12.905
        val_loss= 95.291, val_mse= 94.004, val_kld= 8.578
Epoch= 181/200, loss= 173.371, mse= 171.399, kld= 13.147
        val_loss= 95.588, val_mse= 94.263, val_kld= 8.838
Epoch= 182/200, loss= 172.465, mse= 170.520, kld= 12.966

```

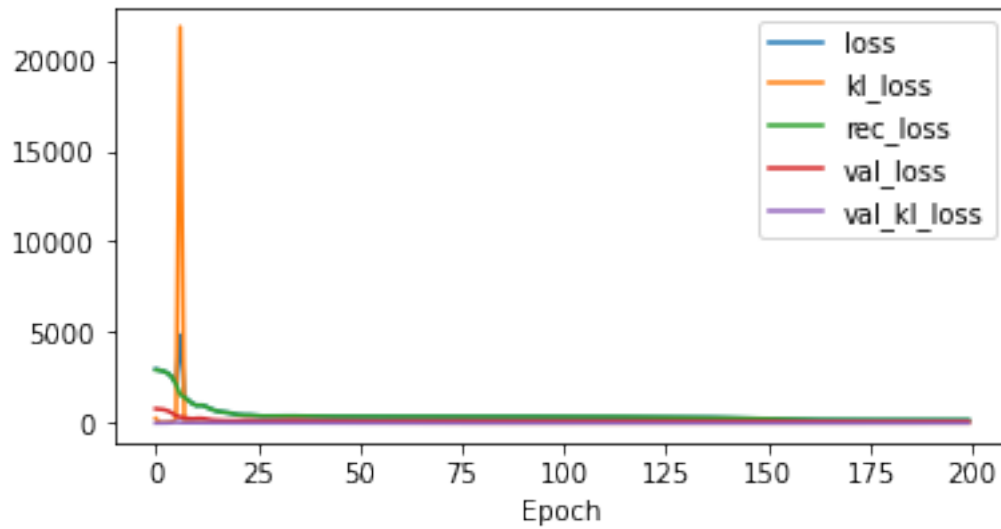
```

        val_loss= 94.603, val_mse= 93.242, val_kld= 9.073
Epoch= 183/200, loss= 171.862, mse= 169.959, kld= 12.690
        val_loss= 94.719, val_mse= 93.427, val_kld= 8.610
Epoch= 184/200, loss= 171.330, mse= 169.459, kld= 12.472
        val_loss= 95.182, val_mse= 93.918, val_kld= 8.425
Epoch= 185/200, loss= 170.955, mse= 169.057, kld= 12.653
        val_loss= 92.907, val_mse= 91.626, val_kld= 8.542
Epoch= 186/200, loss= 170.461, mse= 168.555, kld= 12.712
        val_loss= 96.864, val_mse= 95.512, val_kld= 9.009
Epoch= 187/200, loss= 170.207, mse= 168.028, kld= 14.523
        val_loss= 97.933, val_mse= 96.541, val_kld= 9.277
Epoch= 188/200, loss= 170.439, mse= 167.605, kld= 18.894
        val_loss= 96.696, val_mse= 95.299, val_kld= 9.319
Epoch= 189/200, loss= 170.690, mse= 168.259, kld= 16.207
        val_loss= 95.057, val_mse= 93.615, val_kld= 9.616
Epoch= 190/200, loss= 169.903, mse= 167.777, kld= 14.175
        val_loss= 99.369, val_mse= 97.888, val_kld= 9.877
Epoch= 191/200, loss= 168.381, mse= 166.179, kld= 14.681
        val_loss= 95.422, val_mse= 93.932, val_kld= 9.932
Epoch= 192/200, loss= 168.796, mse= 166.518, kld= 15.190
        val_loss= 95.424, val_mse= 93.901, val_kld= 10.155
Epoch= 193/200, loss= 168.410, mse= 166.204, kld= 14.705
        val_loss= 94.561, val_mse= 93.073, val_kld= 9.917
Epoch= 194/200, loss= 167.906, mse= 165.803, kld= 14.018
        val_loss= 95.180, val_mse= 93.691, val_kld= 9.927
Epoch= 195/200, loss= 167.611, mse= 165.533, kld= 13.857
        val_loss= 94.342, val_mse= 92.863, val_kld= 9.861
Epoch= 196/200, loss= 168.198, mse= 166.158, kld= 13.603
        val_loss= 95.438, val_mse= 93.941, val_kld= 9.980
Epoch= 197/200, loss= 167.486, mse= 165.436, kld= 13.668
        val_loss= 97.391, val_mse= 95.795, val_kld= 10.640
Epoch= 198/200, loss= 167.852, mse= 165.635, kld= 14.781
        val_loss= 99.435, val_mse= 97.852, val_kld= 10.550
Epoch= 199/200, loss= 166.851, mse= 164.360, kld= 16.607
        val_loss= 96.111, val_mse= 94.437, val_kld= 11.157
Epoch= 200/200, loss= 166.750, mse= 164.329, kld= 16.140
        val_loss= 99.557, val_mse= 97.979, val_kld= 10.521

```

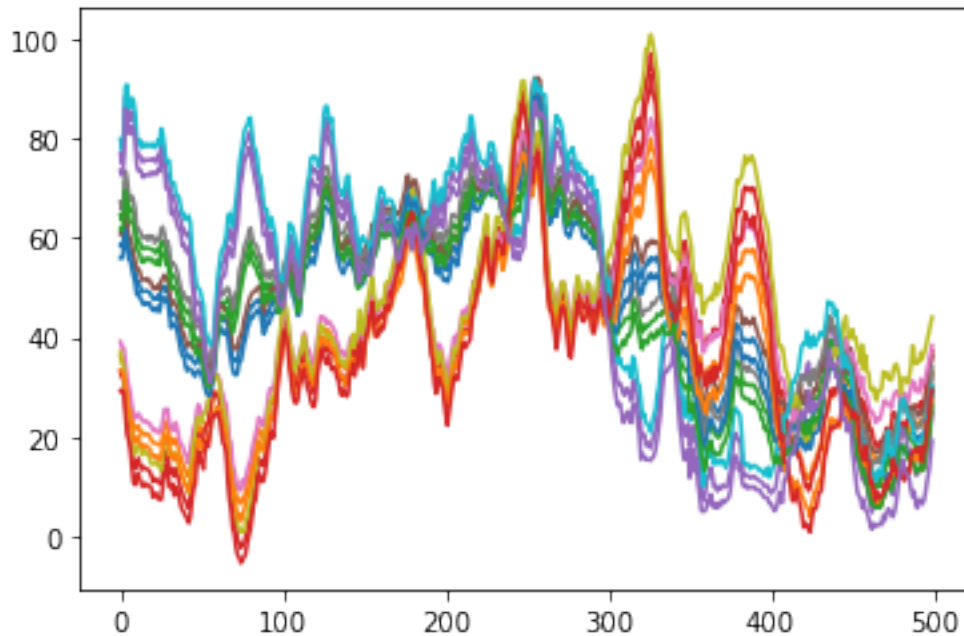
```
[127]: pd.DataFrame(history).plot(figsize=(6, 3), xlabel='Epoch')
```

```
[127]: <AxesSubplot:xlabel='Epoch'>
```

```
[128]: # x_hat = dkf.generate(x_train)
# x_hat, x_025, x_975 = dkf.filter(x_train)
x_hat, x_025, x_975 = dkf.predict(x, 200)
x_hat = x_hat.detach().numpy()[0]
x_025 = x_025.detach().numpy()[0]
x_975 = x_975.detach().numpy()[0]
plt.plot(x_hat)
plt.plot(x_975)
plt.plot(x_025)
```

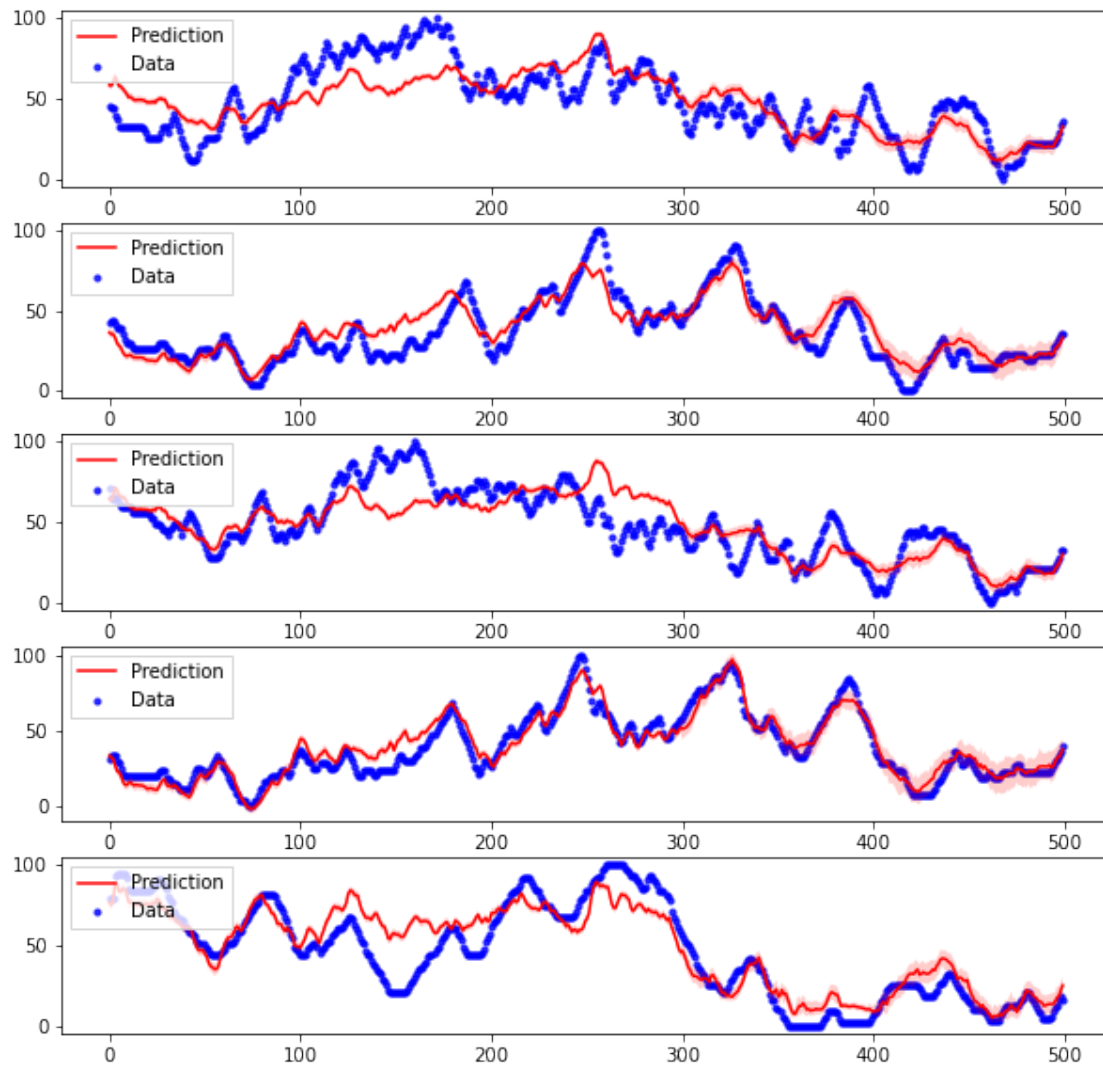
```
[128]: [<matplotlib.lines.Line2D at 0x7f8d066a38b0>,
<matplotlib.lines.Line2D at 0x7f8d064dc970>,
<matplotlib.lines.Line2D at 0x7f8d064dca30>,
<matplotlib.lines.Line2D at 0x7f8d064dcaf0>,
<matplotlib.lines.Line2D at 0x7f8d064dcbb0>]
```



```
[129]: fig, ax = plt.subplots(5, figsize=(10, 10))

for i, axi in enumerate(ax):
    axi.scatter(
        np.arange(data.shape[0]),
        data[:, i], s=10, alpha=0.8, label='Data', c='b')
    axi.plot(x_hat[:, i], label='Prediction', c='r')
    axi.fill_between(np.arange(x_hat.shape[0]), x_025[:, i], x_975[:, i],
                     facecolor='r', alpha=0.2)

    axi.legend(loc='upper left', fancybox=False)
plt.show()
```



[]: