In [1]:

```
import os

data_dir = './jena_climate'
fname = os.path.join(data_dir, 'jena_climate_2009_2016.csv')

f = open(fname)
data = f.read()
f.close()
lines = data.split('₩n')
header = lines[0].split(',')
lines = lines[1:]

print(header)
print(len(lines))
```

```
['"Date Time"', '"p (mbar)"', '"T (degC)"', '"Tpot (K)"', '"Tdew (degC)"', '"rh
(%)"', '"VPmax (mbar)"', '"VPact (mbar)"', '"VPdef (mbar)"', '"sh (g/kg)"', '"H2OC
(mmol/mol)"', '"rho (g/m**3)"', '"wv (m/s)"', '"max. wv (m/s)"', '"wd (deg)"']
420551
```

In [2]:

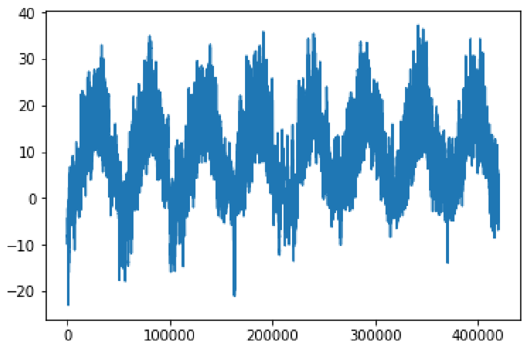
```
import numpy as np

float_data = np.zeros((len(lines), len(header) - 1))
for i, line in enumerate(lines):
    values = [float(x) for x in line.split(',')[1:]]
    float_data[i, :] = values
```

In [5]:

```
from matplotlib import  pyplot as plt

temp = float_data[:, 1]
plt.plot(range(len(temp)), temp)
```

Out[5]:

```
[<matplotlib.lines.Line2D at 0x255e747e898>]
```

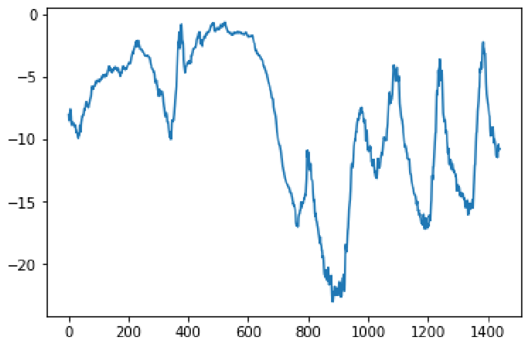


In [6]:

```
plt.plot(range(1440), temp[:1440])
```

Out[6]:

```
[<matplotlib.lines.Line2D at 0x255e7f334a8>]
```



In [3]:

```
mean = float_data[:200000].mean(axis=0)
float_data -= mean
std = float_data[:200000].std(axis=0)
float_data /= std
```

In [4]:

```
def generator(data, lookback, delay, min_index, max_index, shuffle=False, batch_size=128, step=6
):
    if max_index is None:
        max_index = len(data) - delay - 1
    i = min_index + lookback
    while 1:
        if shuffle:
            rows = np.random.randint(min_index + lookback, max_index, size=batch_size)
        else:
            if i + batch_size >= max_index:
                i = min_index + lookback
            rows = np.arange(i, min(i + batch_size, max_index))
            i += len(rows)

        samples = np.zeros((len(rows), lookback // step, data.shape[-1]))
        targets = np.zeros((len(rows),))
        for j, row in enumerate(rows):
            indices = range(rows[j] - lookback, rows[j], step)
            samples[j] = data[indices]
            targets[j] = data[rows[j] + delay][1]
        yield samples, targets
```

In [5]:

```
lookback = 1440
step = 6
delay = 144
batch_size = 128
train_gen = generator(float_data, lookback=lookback, delay=delay, min_index=0, max_index=200000,
shuffle=True, step=step,
                      batch_size=batch_size)

val_gen = generator(float_data, lookback=lookback, delay=delay, min_index=200001, max_index=3000
00, shuffle=True, step=step,
                      batch_size=batch_size)

test_gen = generator(float_data, lookback=lookback, delay=delay, min_index=300001, max_index=Non
e, shuffle=True, step=step,
                      batch_size=batch_size)

val_steps = (300000 - 200001 - lookback) // batch_size
test_steps = (len(float_data) - 300001 - lookback) // batch_size
```

In [21]:

```
def evaluate_naive_method():
    batch_maes = []
    for step in range(val_steps):
        samples, targets = next(val_gen)
        preds = samples[:, -1, 1]
        mae = np.mean(np.abs(preds - targets))
        batch_maes.append(mae)
    print(np.mean(batch_maes))

evaluate_naive_method()
```

0.28706624352615373

In [22]:

```
celsius_mae = 0.29 * std[1]
celsius_mae
```

Out[22]:

2.5672247338393395

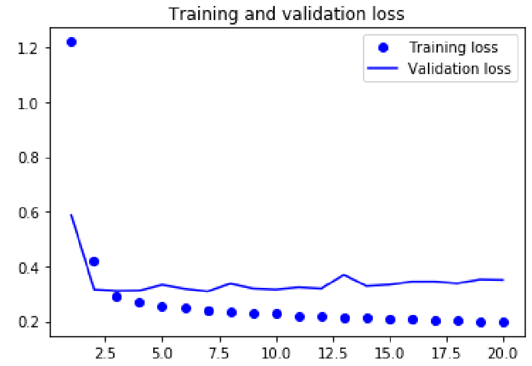
In [24]:

```
from keras.models import Sequential
from keras import layers
from keras.optimizers import RMSprop

model = Sequential()
model.add(layers.Flatten(input_shape=(lookback // step, float_data.shape[-1])))
model.add(layers.Dense(32, activation='relu'))
model.add(layers.Dense(1))
model.compile(optimizer=RMSprop(), loss='mae')


history = model.fit_generator(
    train_gen,
    steps_per_epoch=500,
    epochs=20,
    validation_data = val_gen,
    validation_steps = val_steps)
```

```
Epoch 1/20
500/500 [==============================] - 15s 31ms/step - loss: 1.2200 - val_loss: 0.5875
Epoch 2/20
500/500 [==============================] - 14s 27ms/step - loss: 0.4206 - val_loss: 0.3158
Epoch 3/20
500/500 [==============================] - 14s 27ms/step - loss: 0.2932 - val_loss: 0.3108
Epoch 4/20
500/500 [==============================] - 13s 27ms/step - loss: 0.2703 - val_loss: 0.3119
Epoch 5/20
500/500 [==============================] - 13s 27ms/step - loss: 0.2568 - val_loss: 0.3330
Epoch 6/20
500/500 [==============================] - 13s 27ms/step - loss: 0.2486 - val_loss: 0.3184
Epoch 7/20
500/500 [==============================] - 13s 27ms/step - loss: 0.2415 - val_loss: 0.3090
Epoch 8/20
500/500 [==============================] - 13s 27ms/step - loss: 0.2353 - val_loss: 0.3375
Epoch 9/20
500/500 [==============================] - 13s 27ms/step - loss: 0.2291 - val_loss: 0.3196
Epoch 10/20
500/500 [==============================] - 14s 27ms/step - loss: 0.2268 - val_loss: 0.3159
Epoch 11/20
500/500 [==============================] - 13s 27ms/step - loss: 0.2209 - val_loss: 0.3242
Epoch 12/20
500/500 [==============================] - 13s 27ms/step - loss: 0.2175 - val_loss: 0.3194
Epoch 13/20
500/500 [==============================] - 13s 27ms/step - loss: 0.2137 - val_loss: 0.3690
Epoch 14/20
500/500 [==============================] - 13s 27ms/step - loss: 0.2134 - val_loss: 0.3287
Epoch 15/20
500/500 [==============================] - 13s 27ms/step - loss: 0.2085 - val_loss: 0.3336
Epoch 16/20
500/500 [==============================] - 13s 27ms/step - loss: 0.2059 - val_loss: 0.3443
Epoch 17/20
500/500 [==============================] - 14s 28ms/step - loss: 0.2032 - val_loss: 0.3445
Epoch 18/20
500/500 [==============================] - 14s 27ms/step - loss: 0.2030 - val_loss: 0.3380
Epoch 19/20
500/500 [==============================] - 14s 27ms/step - loss: 0.1997 - val_loss: 0.3522
Epoch 20/20
500/500 [==============================] - 14s 27ms/step - loss: 0.1982 - val_loss: 0.3508
```

In [27]:

```
loss = history.history['loss']
val_loss = history.history['val_loss']

epochs = range(1, len(loss) + 1)

plt.plot(epochs, loss, 'bo', label='Training loss')
plt.plot(epochs, val_loss, 'b', label='Validation loss')
plt.title('Training and validation loss')
plt.legend()

plt.show()
```



GRU를 사용한 모델을 훈련하고 평가하기

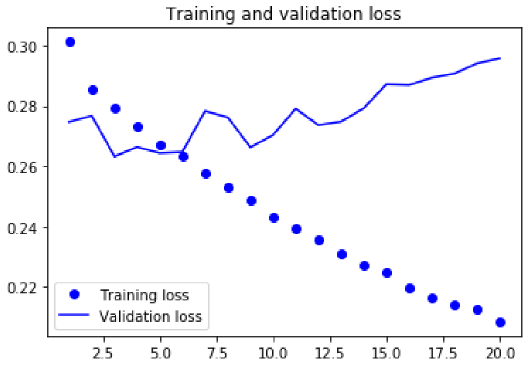
In [30]:

```
model = Sequential()
model.add(layers.GRU(32, input_shape=(None, float_data.shape[-1])))
model.add(layers.Dense(1))

model.compile(optimizer=RMSprop(), loss='mae')
history = model.fit_generator(
    train_gen,
    steps_per_epoch=500,
    epochs=20,
    validation_data = val_gen,
    validation_steps = val_steps)
```

```
Epoch 1/20
500/500 [==============================] - 176s 352ms/step - loss: 0.3013 - val_lo
ss: 0.2747
Epoch 2/20
500/500 [==============================] - 172s 344ms/step - loss: 0.2854 - val_lo
ss: 0.2768
Epoch 3/20
500/500 [==============================] - 176s 352ms/step - loss: 0.2795 - val_lo
ss: 0.2632
Epoch 4/20
500/500 [==============================] - 172s 344ms/step - loss: 0.2734 - val_lo
ss: 0.2664
Epoch 5/20
500/500 [==============================] - 171s 342ms/step - loss: 0.2671 - val_lo
ss: 0.2644
Epoch 6/20
500/500 [==============================] - 173s 346ms/step - loss: 0.2635 - val_lo
ss: 0.2647
Epoch 7/20
500/500 [==============================] - 173s 346ms/step - loss: 0.2577 - val_lo
ss: 0.2783
Epoch 8/20
500/500 [==============================] - 172s 343ms/step - loss: 0.2530 - val_lo
ss: 0.2762
Epoch 9/20
500/500 [==============================] - 172s 344ms/step - loss: 0.2486 - val_lo
ss: 0.2663
Epoch 10/20
500/500 [==============================] - 172s 345ms/step - loss: 0.2433 - val_lo
ss: 0.2704
Epoch 11/20
500/500 [==============================] - 174s 348ms/step - loss: 0.2395 - val_lo
ss: 0.2791
Epoch 12/20
500/500 [==============================] - 174s 349ms/step - loss: 0.2356 - val_lo
ss: 0.2737
Epoch 13/20
500/500 [==============================] - 173s 347ms/step - loss: 0.2307 - val_lo
ss: 0.2748
Epoch 14/20
500/500 [==============================] - 172s 344ms/step - loss: 0.2270 - val_lo
ss: 0.2792
Epoch 15/20
500/500 [==============================] - 170s 340ms/step - loss: 0.2247 - val_lo
ss: 0.2872
Epoch 16/20
500/500 [==============================] - 170s 341ms/step - loss: 0.2196 - val_lo
ss: 0.2870
Epoch 17/20
500/500 [==============================] - 169s 338ms/step - loss: 0.2163 - val_lo
ss: 0.2894
Epoch 18/20
500/500 [==============================] - 169s 339ms/step - loss: 0.2142 - val_lo
ss: 0.2907
Epoch 19/20
500/500 [==============================] - 170s 340ms/step - loss: 0.2126 - val_lo
ss: 0.2941
Epoch 20/20
500/500 [==============================] - 171s 342ms/step - loss: 0.2084 - val_lo
ss: 0.2958
```

In [31]:

```
loss = history.history['loss']
val_loss = history.history['val_loss']

epochs = range(1, len(loss) + 1)

plt.plot(epochs, loss, 'bo', label='Training loss')
plt.plot(epochs, val_loss, 'b', label='Validation loss')
plt.title('Training and validation loss')
plt.legend()

plt.show()
```



드롭아웃 규제된 GRU

In [32]:

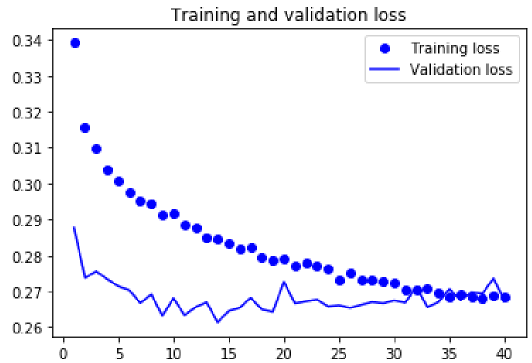
```
model = Sequential()
model.add(layers.GRU(32, dropout=0.2, recurrent_dropout=0.2, input_shape=(None, float_data.shape
[-1])))
model.add(layers.Dense(1))

model.compile(optimizer=RMSprop(), loss='mae')
history = model.fit_generator(
    train_gen,
    steps_per_epoch=500,
    epochs=40,
    validation_data = val_gen,
    validation_steps = val_steps)
```

```
WARNING:tensorflow:From C:₩ProgramData₩Anaconda3₩lib₩site-packages₩keras₩backend₩t
ensorflow_backend.py:3445: calling dropout (from tensorflow.python.ops.nn_ops) wit
h keep_prob is deprecated and will be removed in a future version.
Instructions for updating:
Please use `rate` instead of `keep_prob`. Rate should be set to `rate = 1 - keep_p
rob`.
Epoch 1/40
500/500 [==============================] - 195s 390ms/step - loss: 0.3392 - val_lo
ss: 0.2877
Epoch 2/40
500/500 [==============================] - 192s 384ms/step - loss: 0.3157 - val_lo
ss: 0.2738
Epoch 3/40
500/500 [==============================] - 193s 386ms/step - loss: 0.3098 - val_lo
ss: 0.2756
Epoch 4/40
500/500 [==============================] - 193s 385ms/step - loss: 0.3037 - val_lo
ss: 0.2734
Epoch 5/40
500/500 [==============================] - 194s 388ms/step - loss: 0.3009 - val_lo
ss: 0.2714
Epoch 6/40
500/500 [==============================] - 191s 382ms/step - loss: 0.2977 - val_lo
ss: 0.2704
Epoch 7/40
500/500 [==============================] - 191s 382ms/step - loss: 0.2954 - val_lo
ss: 0.2668
Epoch 8/40
500/500 [==============================] - 194s 387ms/step - loss: 0.2945 - val_lo
ss: 0.2692
Epoch 9/40
500/500 [==============================] - 193s 385ms/step - loss: 0.2914 - val_lo
ss: 0.2631
Epoch 10/40
500/500 [==============================] - 193s 386ms/step - loss: 0.2919 - val_lo
ss: 0.2681
Epoch 11/40
500/500 [==============================] - 194s 388ms/step - loss: 0.2887 - val_lo
ss: 0.2633
Epoch 12/40
500/500 [==============================] - 192s 384ms/step - loss: 0.2878 - val_lo
ss: 0.2656
Epoch 13/40
500/500 [==============================] - 193s 386ms/step - loss: 0.2852 - val_lo
ss: 0.2670
Epoch 14/40
500/500 [==============================] - 193s 385ms/step - loss: 0.2846 - val_lo
ss: 0.2614
Epoch 15/40
500/500 [==============================] - 194s 388ms/step - loss: 0.2833 - val_lo
ss: 0.2645
Epoch 16/40
500/500 [==============================] - 192s 384ms/step - loss: 0.2817 - val_lo
ss: 0.2654
Epoch 17/40
500/500 [==============================] - 191s 382ms/step - loss: 0.2823 - val_lo
ss: 0.2682
Epoch 18/40
500/500 [==============================] - 193s 386ms/step - loss: 0.2793 - val_lo
ss: 0.2650
Epoch 19/40
500/500 [==============================] - 195s 390ms/step - loss: 0.2788 - val_lo
ss: 0.2643
Epoch 20/40
500/500 [==============================] - 194s 388ms/step - loss: 0.2793 - val_lo
ss: 0.2726
Epoch 21/40
500/500 [==============================] - 194s 387ms/step - loss: 0.2772 - val_lo
ss: 0.2666
Epoch 22/40
500/500 [==============================] - 192s 385ms/step - loss: 0.2778 - val_lo
ss: 0.2672
Epoch 23/40
500/500 [==============================] - 193s 385ms/step - loss: 0.2772 - val_lo
ss: 0.2677
Epoch 24/40
500/500 [==============================] - 193s 387ms/step - loss: 0.2762 - val_lo
ss: 0.2658
Epoch 25/40
500/500 [==============================] - 193s 385ms/step - loss: 0.2732 - val_lo
ss: 0.2661
Epoch 26/40
500/500 [==============================] - 192s 385ms/step - loss: 0.2752 - val_lo
ss: 0.2654
Epoch 27/40
500/500 [==============================] - 200s 400ms/step - loss: 0.2733 - val_lo
ss: 0.2662
Epoch 28/40
500/500 [==============================] - 198s 396ms/step - loss: 0.2730 - val_lo
ss: 0.2670
Epoch 29/40
500/500 [==============================] - 192s 383ms/step - loss: 0.2726 - val_lo
ss: 0.2667
Epoch 30/40
500/500 [==============================] - 192s 384ms/step - loss: 0.2724 - val_lo
ss: 0.2675
Epoch 31/40
500/500 [==============================] - 193s 386ms/step - loss: 0.2706 - val_lo
ss: 0.2669
Epoch 32/40
500/500 [==============================] - 194s 388ms/step - loss: 0.2703 - val_lo
ss: 0.2714
Epoch 33/40
500/500 [==============================] - 194s 387ms/step - loss: 0.2707 - val_lo
ss: 0.2656
Epoch 34/40
500/500 [==============================] - 191s 381ms/step - loss: 0.2696 - val_lo
ss: 0.2670
Epoch 35/40
500/500 [==============================] - 190s 380ms/step - loss: 0.2686 - val_lo
ss: 0.2707
Epoch 36/40
500/500 [==============================] - 194s 387ms/step - loss: 0.2691 - val_lo
ss: 0.2675
Epoch 37/40
500/500 [==============================] - 194s 388ms/step - loss: 0.2685 - val_lo
ss: 0.2698
Epoch 38/40
500/500 [==============================] - 192s 385ms/step - loss: 0.2680 - val_lo
ss: 0.2694
Epoch 39/40
500/500 [==============================] - 193s 386ms/step - loss: 0.2689 - val_lo
```

```
ss: 0.2736
Epoch 40/40
500/500 [==============================] - 194s 387ms/step - loss: 0.2683 - val_lo
ss: 0.2672
```

In [33]:

```
loss = history.history['loss']
val_loss = history.history['val_loss']

epochs = range(1, len(loss) + 1)

plt.plot(epochs, loss, 'bo', label='Training loss')
plt.plot(epochs, val_loss, 'b', label='Validation loss')
plt.title('Training and validation loss')
plt.legend()

plt.show()
```



드롭아웃 규제 및 스태킹(stacking, 적재)한 GRU 모델

In [6]:

```
from keras.models import Sequential
from keras import layers
from keras.optimizers import RMSprop

model = Sequential()
model.add(layers.GRU(32, dropout=0.1, recurrent_dropout=0.5, return_sequences=True, input_shape=
(None, float_data.shape[-1])))
model.add(layers.GRU(64, activation='relu', dropout=0.1, recurrent_dropout=0.5))
model.add(layers.Dense(1))

model.compile(optimizer=RMSprop(), loss='mae')
history = model.fit_generator(
    train_gen,
    steps_per_epoch=500,
    epochs=40,
    validation_data = val_gen,
    validation_steps = val_steps)
```

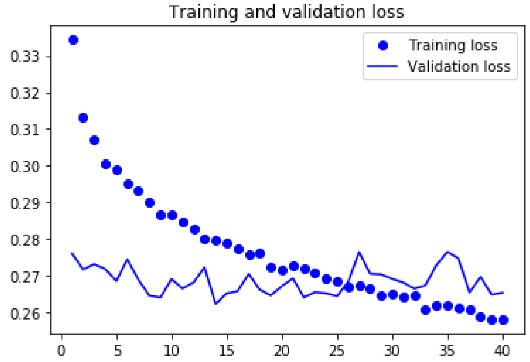
```
Using TensorFlow backend.
```

```
WARNING:tensorflow:From C:₩ProgramData₩Anaconda3₩lib₩site-packages₩tensorflow₩pyth
on₩framework₩op_def_library.py:263: colocate_with (from tensorflow.python.framewor
k.ops) is deprecated and will be removed in a future version.
Instructions for updating:
Colocations handled automatically by placer.
WARNING:tensorflow:From C:₩ProgramData₩Anaconda3₩lib₩site-packages₩keras₩backend₩t
ensorflow_backend.py:3445: calling dropout (from tensorflow.python.ops.nn_ops) wit
h keep_prob is deprecated and will be removed in a future version.
Instructions for updating:
Please use `rate` instead of `keep_prob`. Rate should be set to `rate = 1 - keep_p
rob`.
WARNING:tensorflow:From C:₩ProgramData₩Anaconda3₩lib₩site-packages₩tensorflow₩pyth
on₩ops₩math_ops.py:3066: to_int32 (from tensorflow.python.ops.math_ops) is depreca
ted and will be removed in a future version.
Instructions for updating:
Use tf.cast instead.
Epoch 1/40
500/500 [==============================] - 384s 768ms/step - loss: 0.3344 - val_lo
ss: 0.2760
Epoch 2/40
500/500 [==============================] - 381s 762ms/step - loss: 0.3134 - val_lo
ss: 0.2717
Epoch 3/40
500/500 [==============================] - 384s 768ms/step - loss: 0.3072 - val_lo
ss: 0.2731
Epoch 4/40
500/500 [==============================] - 387s 773ms/step - loss: 0.3005 - val_lo
ss: 0.2718
Epoch 5/40
500/500 [==============================] - 389s 778ms/step - loss: 0.2988 - val_lo
ss: 0.2686
Epoch 6/40
500/500 [==============================] - 388s 775ms/step - loss: 0.2953 - val_lo
ss: 0.2745
Epoch 7/40
500/500 [==============================] - 385s 770ms/step - loss: 0.2930 - val_lo
ss: 0.2689
Epoch 8/40
500/500 [==============================] - 388s 776ms/step - loss: 0.2902 - val_lo
ss: 0.2645
Epoch 9/40
500/500 [==============================] - 387s 774ms/step - loss: 0.2868 - val_lo
ss: 0.2641
Epoch 10/40
500/500 [==============================] - 388s 777ms/step - loss: 0.2866 - val_lo
ss: 0.2691
Epoch 11/40
500/500 [==============================] - 387s 774ms/step - loss: 0.2848 - val_lo
ss: 0.2665
Epoch 12/40
500/500 [==============================] - 388s 776ms/step - loss: 0.2827 - val_lo
ss: 0.2681
Epoch 13/40
500/500 [==============================] - 385s 770ms/step - loss: 0.2800 - val_lo
ss: 0.2723
Epoch 14/40
500/500 [==============================] - 387s 774ms/step - loss: 0.2798 - val_lo
ss: 0.2623
Epoch 15/40
500/500 [==============================] - 385s 771ms/step - loss: 0.2789 - val_lo
ss: 0.2652
```

```
Epoch 16/40
500/500 [==============================] - 386s 773ms/step - loss: 0.2772 - val_lo
ss: 0.2658
Epoch 17/40
500/500 [==============================] - 389s 777ms/step - loss: 0.2757 - val_lo
ss: 0.2705
Epoch 18/40
500/500 [==============================] - 383s 766ms/step - loss: 0.2764 - val_lo
ss: 0.2662
Epoch 19/40
500/500 [==============================] - 387s 774ms/step - loss: 0.2725 - val_lo
ss: 0.2646
Epoch 20/40
500/500 [==============================] - 381s 763ms/step - loss: 0.2717 - val_lo
ss: 0.2672
Epoch 21/40
500/500 [==============================] - 377s 755ms/step - loss: 0.2729 - val_lo
ss: 0.2692
Epoch 22/40
500/500 [==============================] - 376s 752ms/step - loss: 0.2719 - val_lo
ss: 0.2641
Epoch 23/40
500/500 [==============================] - 384s 768ms/step - loss: 0.2709 - val_lo
ss: 0.2655
Epoch 24/40
500/500 [==============================] - 384s 768ms/step - loss: 0.2692 - val_lo
ss: 0.2652
Epoch 25/40
500/500 [==============================] - 385s 770ms/step - loss: 0.2684 - val_lo
ss: 0.2644
Epoch 26/40
500/500 [==============================] - 381s 762ms/step - loss: 0.2670 - val_lo
ss: 0.2683
Epoch 27/40
500/500 [==============================] - 382s 764ms/step - loss: 0.2675 - val_lo
ss: 0.2765
Epoch 28/40
500/500 [==============================] - 381s 761ms/step - loss: 0.2667 - val_lo
ss: 0.2706
Epoch 29/40
500/500 [==============================] - 381s 763ms/step - loss: 0.2647 - val_lo
ss: 0.2703
Epoch 30/40
500/500 [==============================] - 383s 767ms/step - loss: 0.2649 - val_lo
ss: 0.2691
Epoch 31/40
500/500 [==============================] - 386s 773ms/step - loss: 0.2643 - val_lo
ss: 0.2681
Epoch 32/40
500/500 [==============================] - 387s 774ms/step - loss: 0.2646 - val_lo
ss: 0.2665
Epoch 33/40
500/500 [==============================] - 384s 769ms/step - loss: 0.2608 - val_lo
ss: 0.2674
Epoch 34/40
500/500 [==============================] - 378s 757ms/step - loss: 0.2620 - val_lo
ss: 0.2729
Epoch 35/40
500/500 [==============================] - 384s 768ms/step - loss: 0.2618 - val_lo
ss: 0.2765
Epoch 36/40
500/500 [==============================] - 380s 760ms/step - loss: 0.2611 - val_lo
ss: 0.2747
Epoch 37/40
500/500 [==============================] - 381s 762ms/step - loss: 0.2607 - val_lo
ss: 0.2655
Epoch 38/40
500/500 [==============================] - 375s 751ms/step - loss: 0.2590 - val_lo
ss: 0.2697
Epoch 39/40
500/500 [==============================] - 373s 745ms/step - loss: 0.2581 - val_lo
ss: 0.2648
Epoch 40/40
500/500 [==============================] - 376s 752ms/step - loss: 0.2582 - val_lo
ss: 0.2654
```

In [9]:

```python
from matplotlib import pyplot as plt

loss = history.history['loss']
val_loss = history.history['val_loss']

epochs = range(1, len(loss) + 1)

plt.plot(epochs, loss, 'bo', label='Training loss')
plt.plot(epochs, val_loss, 'b', label='Validation loss')
plt.title('Training and validation loss')
plt.legend()

plt.show()
```



거꾸로 된 시퀀스 사용한 LSTM

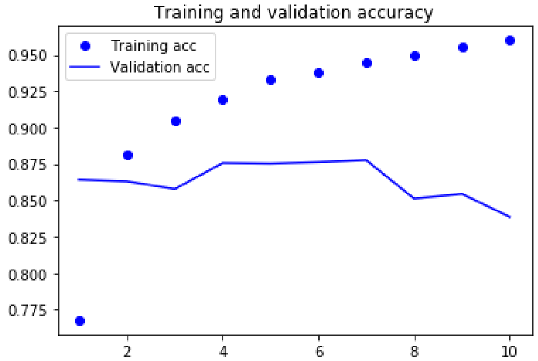
In [13]:

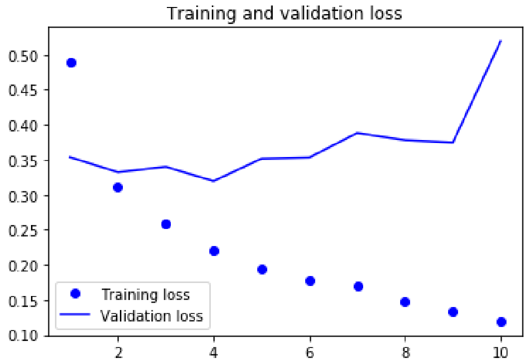
```
from keras.datasets import imdb
from keras.preprocessing import sequence

max_features = 10000
maxlen = 500

(x_train, y_train), (x_test, y_test) = imdb.load_data(num_words = max_features)

x_train = [x[::-1] for x in x_train]
x_test = [x[::-1] for x in x_test]

x_train = sequence.pad_sequences(x_train, maxlen=maxlen)
x_test = sequence.pad_sequences(x_test, maxlen=maxlen)

model = Sequential()
model.add(layers.Embedding(max_features, 128))
model.add(layers.LSTM(32))
model.add(layers.Dense(1, activation='sigmoid'))

model.compile(optimizer=RMSprop(), loss='binary_crossentropy', metrics=['acc'])
history = model.fit(
    x_train, y_train,
    epochs=10,
    batch_size = 128,
    validation_split = 0.2)
```

```
Train on 20000 samples, validate on 5000 samples
Epoch 1/10
20000/20000 [==============================] - 121s 6ms/step - loss: 0.4890 - acc:
0.7677 - val_loss: 0.3535 - val_acc: 0.8642
Epoch 2/10
20000/20000 [==============================] - 120s 6ms/step - loss: 0.3113 - acc:
0.8811 - val_loss: 0.3322 - val_acc: 0.8630
Epoch 3/10
20000/20000 [==============================] - 120s 6ms/step - loss: 0.2588 - acc:
0.9046 - val_loss: 0.3399 - val_acc: 0.8578
Epoch 4/10
20000/20000 [==============================] - 119s 6ms/step - loss: 0.2204 - acc:
0.9191 - val_loss: 0.3195 - val_acc: 0.8756
Epoch 5/10
20000/20000 [==============================] - 118s 6ms/step - loss: 0.1947 - acc:
0.9326 - val_loss: 0.3515 - val_acc: 0.8752
Epoch 6/10
20000/20000 [==============================] - 119s 6ms/step - loss: 0.1772 - acc:
0.9376 - val_loss: 0.3531 - val_acc: 0.8762
Epoch 7/10
20000/20000 [==============================] - 118s 6ms/step - loss: 0.1692 - acc:
0.9443 - val_loss: 0.3882 - val_acc: 0.8776
Epoch 8/10
20000/20000 [==============================] - 119s 6ms/step - loss: 0.1469 - acc:
0.9500 - val_loss: 0.3779 - val_acc: 0.8512
Epoch 9/10
20000/20000 [==============================] - 119s 6ms/step - loss: 0.1343 - acc:
0.9553 - val_loss: 0.3745 - val_acc: 0.8544
Epoch 10/10
20000/20000 [==============================] - 119s 6ms/step - loss: 0.1196 - acc:
0.9601 - val_loss: 0.5192 - val_acc: 0.8386
```

In [14]:

```
import matplotlib.pyplot as plt

acc = history.history['acc']
val_acc = history.history['val_acc']
loss = history.history['loss']
val_loss = history.history['val_loss']

epochs = range(1, len(acc) + 1)

plt.plot(epochs, acc, 'bo', label='Training acc')
plt.plot(epochs, val_acc, 'b', label='Validation acc')
plt.title('Training and validation accuracy')
plt.legend()

plt.figure()

plt.plot(epochs, loss, 'bo', label='Training loss')
plt.plot(epochs, val_loss, 'b', label='Validation loss')
plt.title('Training and validation loss')
plt.legend()

plt.show()
```





양방향 LSTM

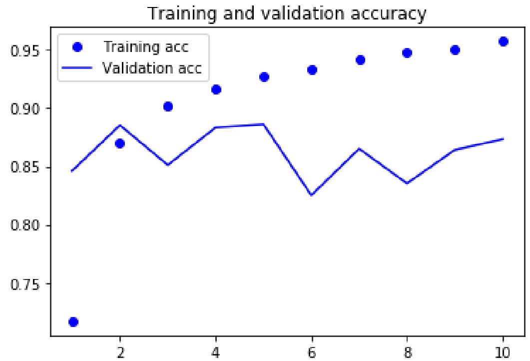
In [16]:

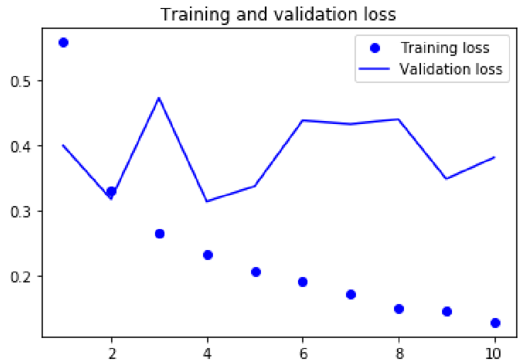
```
model = Sequential()
model.add(layers.Embedding(max_features, 32))
model.add(layers.Bidirectional(layers.LSTM(32)))
model.add(layers.Dense(1, activation='sigmoid'))

model.compile(optimizer=RMSprop(), loss='binary_crossentropy', metrics=['acc'])
history = model.fit(
    x_train, y_train,
    epochs=10,
    batch_size = 128,
    validation_split = 0.2)
```

```
Train on 20000 samples, validate on 5000 samples
Epoch 1/10
20000/20000 [==============================] - 230s 12ms/step - loss: 0.5586 - ac
c: 0.7169 - val_loss: 0.3998 - val_acc: 0.8460
Epoch 2/10
20000/20000 [==============================] - 226s 11ms/step - loss: 0.3303 - ac
c: 0.8706 - val_loss: 0.3175 - val_acc: 0.8852
Epoch 3/10
20000/20000 [==============================] - 228s 11ms/step - loss: 0.2645 - ac
c: 0.9020 - val_loss: 0.4729 - val_acc: 0.8510
Epoch 4/10
20000/20000 [==============================] - 224s 11ms/step - loss: 0.2325 - ac
c: 0.9158 - val_loss: 0.3140 - val_acc: 0.8832
Epoch 5/10
20000/20000 [==============================] - 227s 11ms/step - loss: 0.2064 - ac
c: 0.9271 - val_loss: 0.3373 - val_acc: 0.8860
Epoch 6/10
20000/20000 [==============================] - 228s 11ms/step - loss: 0.1909 - ac
c: 0.9331 - val_loss: 0.4382 - val_acc: 0.8250
Epoch 7/10
20000/20000 [==============================] - 233s 12ms/step - loss: 0.1714 - ac
c: 0.9421 - val_loss: 0.4327 - val_acc: 0.8650
Epoch 8/10
20000/20000 [==============================] - 226s 11ms/step - loss: 0.1501 - ac
c: 0.9476 - val_loss: 0.4402 - val_acc: 0.8352
Epoch 9/10
20000/20000 [==============================] - 226s 11ms/step - loss: 0.1458 - ac
c: 0.9503 - val_loss: 0.3486 - val_acc: 0.8640
Epoch 10/10
20000/20000 [==============================] - 226s 11ms/step - loss: 0.1285 - ac
c: 0.9574 - val_loss: 0.3815 - val_acc: 0.8732
```

In [17]:

```
import matplotlib.pyplot as plt

acc = history.history['acc']
val_acc = history.history['val_acc']
loss = history.history['loss']
val_loss = history.history['val_loss']

epochs = range(1, len(acc) + 1)

plt.plot(epochs, acc, 'bo', label='Training acc')
plt.plot(epochs, val_acc, 'b', label='Validation acc')
plt.title('Training and validation accuracy')
plt.legend()

plt.figure()

plt.plot(epochs, loss, 'bo', label='Training loss')
plt.plot(epochs, val_loss, 'b', label='Validation loss')
plt.title('Training and validation loss')
plt.legend()

plt.show()
```





양방향 GRU

In [19]:

```
model = Sequential()
model.add(layers.Bidirectional(layers.GRU(32), input_shape=(None, float_data.shape[-1])))
model.add(layers.Dense(1))

model.compile(optimizer=RMSprop(), loss='mae')
history = model.fit_generator(
    train_gen,
    steps_per_epoch=500,
    epochs=40,
    validation_data = val_gen,
    validation_steps = val_steps)
```

```
Epoch 1/40
500/500 [==============================] - 322s 645ms/step - loss: 0.2928 - val_lo
ss: 0.2860
Epoch 2/40
500/500 [==============================] - 353s 707ms/step - loss: 0.2757 - val_lo
ss: 0.2725
Epoch 3/40
500/500 [==============================] - 516s 1s/step - loss: 0.2654 - val_loss:
0.2773
Epoch 4/40
500/500 [==============================] - 517s 1s/step - loss: 0.2617 - val_loss:
0.2696
Epoch 5/40
500/500 [==============================] - 516s 1s/step - loss: 0.2560 - val_loss:
0.2705
Epoch 6/40
500/500 [==============================] - 517s 1s/step - loss: 0.2505 - val_loss:
0.2904
Epoch 7/40
500/500 [==============================] - 517s 1s/step - loss: 0.2443 - val_loss:
0.2851
Epoch 8/40
500/500 [==============================] - 517s 1s/step - loss: 0.2377 - val_loss:
0.2811
Epoch 9/40
500/500 [==============================] - 516s 1s/step - loss: 0.2319 - val_loss:
0.2917
Epoch 10/40
500/500 [==============================] - 516s 1s/step - loss: 0.2256 - val_loss:
0.2877
Epoch 11/40
500/500 [==============================] - 517s 1s/step - loss: 0.2209 - val_loss:
0.2970
Epoch 12/40
500/500 [==============================] - 517s 1s/step - loss: 0.2151 - val_loss:
0.3061
Epoch 13/40
500/500 [==============================] - 517s 1s/step - loss: 0.2104 - val_loss:
0.3042
Epoch 14/40
500/500 [==============================] - 517s 1s/step - loss: 0.2058 - val_loss:
0.3077
Epoch 15/40
500/500 [==============================] - 518s 1s/step - loss: 0.2019 - val_loss:
0.3154
Epoch 16/40
500/500 [==============================] - 517s 1s/step - loss: 0.1962 - val_loss:
0.3123
Epoch 17/40
500/500 [==============================] - 516s 1s/step - loss: 0.1926 - val_loss:
0.3218
Epoch 18/40
500/500 [==============================] - 516s 1s/step - loss: 0.1865 - val_loss:
0.3204
Epoch 19/40
500/500 [==============================] - 517s 1s/step - loss: 0.1836 - val_loss:
0.3272
Epoch 20/40
500/500 [==============================] - 518s 1s/step - loss: 0.1808 - val_loss:
0.3267
Epoch 21/40
```

```
500/500 [==============================] - 517s 1s/step - loss: 0.1766 - val_loss: 0.3284
Epoch 22/40
500/500 [==============================] - 517s 1s/step - loss: 0.1750 - val_loss: 0.3291
Epoch 23/40
500/500 [==============================] - 516s 1s/step - loss: 0.1713 - val_loss: 0.3325
Epoch 24/40
500/500 [==============================] - 516s 1s/step - loss: 0.1687 - val_loss: 0.3292
Epoch 25/40
500/500 [==============================] - 517s 1s/step - loss: 0.1664 - val_loss: 0.3273
Epoch 26/40
500/500 [==============================] - 518s 1s/step - loss: 0.1635 - val_loss: 0.3320
Epoch 27/40
500/500 [==============================] - 516s 1s/step - loss: 0.1613 - val_loss: 0.3284
Epoch 28/40
500/500 [==============================] - 516s 1s/step - loss: 0.1595 - val_loss: 0.3346
Epoch 29/40
500/500 [==============================] - 516s 1s/step - loss: 0.1563 - val_loss: 0.3312
Epoch 30/40
500/500 [==============================] - 516s 1s/step - loss: 0.1547 - val_loss: 0.3368
Epoch 31/40
500/500 [==============================] - 516s 1s/step - loss: 0.1522 - val_loss: 0.3374
Epoch 32/40
500/500 [==============================] - 515s 1s/step - loss: 0.1516 - val_loss: 0.3442
Epoch 33/40
500/500 [==============================] - 516s 1s/step - loss: 0.1497 - val_loss: 0.3402
Epoch 34/40
500/500 [==============================] - 516s 1s/step - loss: 0.1487 - val_loss: 0.3440
Epoch 35/40
500/500 [==============================] - 518s 1s/step - loss: 0.1464 - val_loss: 0.3477
Epoch 36/40
500/500 [==============================] - 518s 1s/step - loss: 0.1450 - val_loss: 0.3421
Epoch 37/40
500/500 [==============================] - 518s 1s/step - loss: 0.1445 - val_loss: 0.3455
Epoch 38/40
500/500 [==============================] - 517s 1s/step - loss: 0.1422 - val_loss: 0.3465
Epoch 39/40
500/500 [==============================] - 516s 1s/step - loss: 0.1419 - val_loss: 0.3474
Epoch 40/40
500/500 [==============================] - 517s 1s/step - loss: 0.1407 - val_loss: 0.3423
```

In [20]:

```
loss = history.history['loss']
val_loss = history.history['val_loss']

epochs = range(1, len(loss) + 1)

plt.plot(epochs, loss, 'bo', label='Training loss')
plt.plot(epochs, val_loss, 'b', label='Validation loss')
plt.title('Training and validation loss')
plt.legend()

plt.show()
```