pf_experiments_plots

July 26, 2019

1 Particle Filter Experimental Results

This presents some of the results from the particle filter experiments. See pf_experiments_plots.py for more results. This script mainly produces the graphs that are used in the accompanying paper.

1.1 Initialisation

Read the requred libraries

```
In [1]: %matplotlib inline

        import os
        import re
        import math
        import numpy as np
        import matplotlib.pyplot as plt
        #plt.ioff() # Turn off interactive mode
        import pandas as pd
        import sys
        import warnings
        from scipy.interpolate import griddata # For interpolating across irregularly spaced g
        import pickle # For saving computationally-expensive operations

        # The following is to import the Particle Filter code
        # (mostly we just read results that were created previously, but sometimes it's  usefu
        # visualise additional experiments).
        import sys
        sys.path.append('../../stationsim')
        sys.path.append('../..')
        from stationsim.particle_filter import ParticleFilter
        from stationsim.stationsim_model import Model
        import time
        import multiprocessing
```

Configure the script

```
In [2]: # We need to tell the script which directory the results are in
```

```
# First try to get the directory of this .ipynb file
#root_dir = !echo %cd% # this might work under windows
root_dir = !pwd # under linux/mac # This works in linux/mac

# Now append the specific directory with results:
path = os.path.join(root_dir[0], "results","2/noise1")
print(f"Plotting results in directory: {path}")

# Need to set the number of particles and agents used in the experiments. These are se
# the experiments: ./run_pf.py
# Copy the lines near the top that set the number of particles and agents

# Lists of particles, agent numbers, and particle noise levels
num_par = list ( [1] + list(range(10, 50, 10)) + list(range(100, 501, 100)) + list(rang
num_age = [2, 5, 10, 15, 20, 30, 40, 50]

# Use log on y axis?
uselog = True

# Type of interpolation i.e. 'nearest' of 'linear' (see help(griddata))
interpolate_method = "nearest"
```

```
Plotting results in directory: /Users/nick/gp/dust/Projects/ABM_DA/experiments/pf_experiments/
```

1.2 Read the data

```
In [ ]: # From now on refer to the lists of agents and particles using different names (TODO:
        particles = num_par
        agents = num_age


        if not os.path.isdir(path):
            sys.exit("Directory '{}' does not exist".format(path))


        def is_duplicate(fname, files):
            """
            Sees if `fname` already exists in the `duplicates` list. Needs to strip off the in
            the file (these were added by the Particle Filter script to prevent overridding ex
            :param fname:
            :param duplicates:
            :return: True if this file exists already, false otherwise
            """
            regex = re.compile(r"(.*?)-\d*\.csv") # Find everthing before the numbers at the e
            fname_stripped = re.findall(regex, fname)[0]
            for f in files:
                if re.findall(regex, f)[0] == fname_stripped:
```

```
            return True # There is a duplicate
    return False # No duplicates found


files = []
duplicates = [] # List of diplicate files
# r=root, d=directories, f = files
for r, d, f in os.walk(path):
    for file in f:
        if '.csv' in file:
            fname = os.path.join(r, file)
            if is_duplicate(fname, files):
                duplicates.append(fname)
            else:
                files.append(fname)

if len(files) == 0:
    sys.exit("Found no files in {}, can't continue".format(path) )
elif len(duplicates) > 0:
    warnings.warn("Found {} duplicate files:\n\t{}".format(len(duplicates), "\n\t".joi
else:
    print("Found {} files".format(len(files)))


# Errors are a matrix of particles * agents. These are a tuple because the errors
# are calculated before and after resampling

def init_matrix():
    return ( np.zeros(shape=(len(particles),len(agents))), np.zeros(shape=(len(particle

min_mean_err = init_matrix()
max_mean_err = init_matrix()
ave_mean_err = init_matrix() # Mean of the mean errors
med_mean_err = init_matrix() # Median of the mean errors
min_abs_err  = init_matrix()
max_abs_err  = init_matrix()
ave_abs_err  = init_matrix() # Mean of the mean errors
med_abs_err  = init_matrix() # Median of the mean errors
min_var      = init_matrix()
max_var      = init_matrix()
ave_var      = init_matrix()
med_var      = init_matrix()

# Regular expressions to find the particle number and population total from json-forma
particle_num_re = re.compile(r".*?'number_of_particles': (\d*).*?")
agent_num_re = re.compile(r".*?'pop_total': (\d*).*?")

print("Reading files....",)
```

```
data_shape = None # Check each file has a consistent shape
for i, f in enumerate(files):

    file = open(f,"r").read()
    #data = pd.read_csv(f, header = 2).replace('on',np.nan)
    data = pd.read_csv(f, header=2).replace('on', np.nan)
    # Check that each file has a consistent shape
    if i==0:
        data_shape=data.shape
    if data.shape != data_shape:
        # If the columns are the same and there are only a few (20%) rows missing then
        if ( data_shape[1] == data.shape[1] ) and ( data.shape[0] > int(data_shape[0]
            warnings.warn("Current file shape ({}) does not match the previous one ({}
                                    str(data.shape), str(data_shape), f ))
        # Can exit if the shapes are too bad (turn this off for now)
        #else:
        #    sys.exit("Current file shape ({}) does not match the previous one ({}). C
        #            str(data.shape), str(data_shape), f  ))

    # Find the particle number and population total from json-formatted info at the st
    search = re.findall(particle_num_re, file)
    try:
        particle_num = int(search[0])
    except:
        sys.exit("Error: could not find the number of particles in the header for file
    search = re.findall(agent_num_re, file)
    try:
        agent_num = int(search[0])
    except:
        sys.exit("Error: could not find the number of agents in the header for file \n

    # Calculate the statstics before and after resampling
    for before in [0,1]:
        d = data[ data.loc[:,'Before_resample?'] == before] # Filter data

        data_mean =  d.mean() # Calculate the mean of all columns
        data_median = d.median() # and also sometimes use median

        min_mean_err[before][particles.index(particle_num),agents.index(agent_num)] = 
        max_mean_err[before][particles.index(particle_num),agents.index(agent_num)] = 
        ave_mean_err[before][particles.index(particle_num),agents.index(agent_num)] = 
        med_mean_err[before][particles.index(particle_num),agents.index(agent_num)] = 
        min_abs_err [before][particles.index(particle_num),agents.index(agent_num)] = 
        max_abs_err [before][particles.index(particle_num),agents.index(agent_num)] = 
        ave_abs_err [before][particles.index(particle_num),agents.index(agent_num)] = 
        med_abs_err [before][particles.index(particle_num),agents.index(agent_num)] = 
        min_var     [before][particles.index(particle_num),agents.index(agent_num)] = 
        max_var     [before][particles.index(particle_num),agents.index(agent_num)] = 
        ave_var     [before][particles.index(particle_num),agents.index(agent_num)] = c
        med_var     [before][particles.index(particle_num),agents.index(agent_num)] = c

# There will never be zero error, so replace 0s with NA
data[data == 0] = np.nan

print("...finished reading {} files".format(len(files)))
```

Sanity check:

```
In [4]: # Max error after resampling should be less than before resampling
        print(f"Max errors (mean) (before/after): {max_mean_err[0].max()} / {max_mean_err[1].ma
        assert max_mean_err[1].max() < max_mean_err[0].max()
        # Min error should not have gone up
        print(f"Min errors (before/after): {min_mean_err[0].max()} / {min_mean_err[1].max()}")
        assert min_mean_err[1].max() <= min_mean_err[0].max()
        # Average errors should mostly have gone down (wont always happen due to addition of pa
        false_count = 0
        total = 0
        for b,a in zip(ave_mean_err[0], ave_mean_err[1]):
            total += len(b)
            for i in range(len(b)):
                if b[i] < a[i]:
                    false_count += 1
        print(f"In {false_count} / {total} experiments resampling *increased* the mean error")
```

```
Max errors (mean) (before/after): 105.05834173855209 / 59.19515462293167
Min errors (before/after): 5.3279555391723585 / 5.3279555391723585
In 17 / 136 experiments resampling *increased* the mean error
```

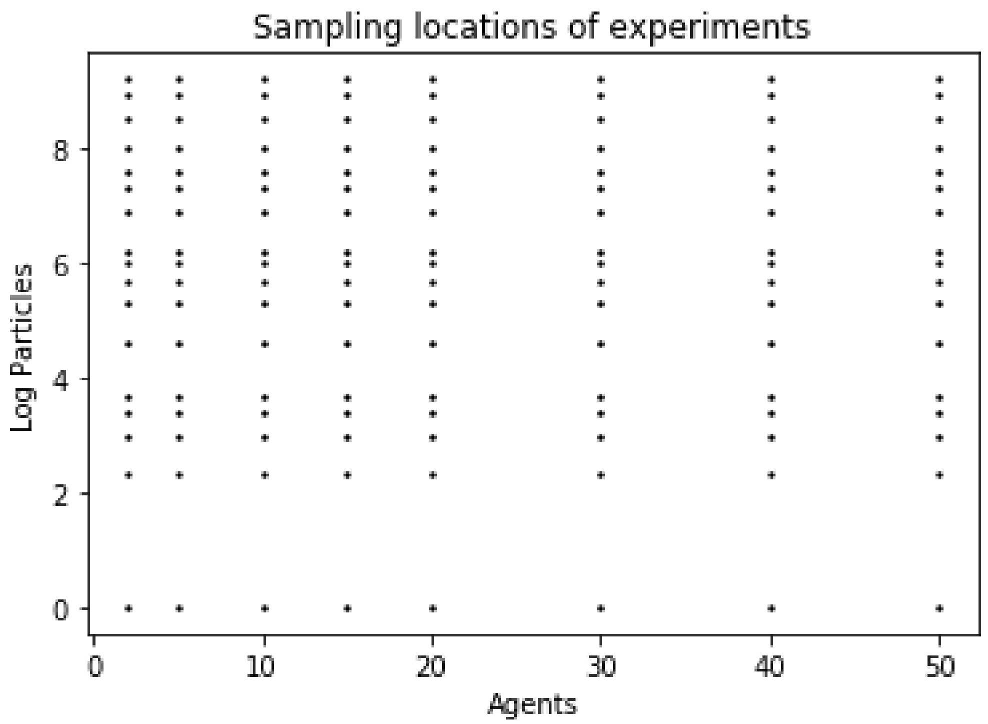
1.3 Plot the results

1.3.1 Sampling locations

Because the experiments are distributed across the agents/particles parameter space we need to create a grid and interpolate to show how the error varies

```
In [5]: # First plot all of the locations in the grids for which we have data (these are
        # not necessarily evenly spaced).
        # See here for instructions on how to do heatmap with irregularly spaced data:
        # https://scipy-cookbook.readthedocs.io/items/Matplotlib_Gridding_irregularly_spaced_da

        # Define the grid.
        # First need the points that the observations are taken at
        x, y = [], []
        for i in range(len(agents)):
            for j in range(len(particles)):
                x.append(agents[i])
                if uselog:
                    y.append(np.log(particles[j]))
                else:
                    y.append(particles[j])
        x = np.array(x)
        y = np.array(y)

        # Now the grid to interpolate over (used later)
        xi = np.linspace(0,max(agents)    ,100)
        yi = None
        if uselog:
            yi = np.geomspace(0.01,np.log(max(particles)),100)
        else:
            yi = np.linspace(0,max(particles),100)

        # Plot the point locations
        plt.figure(0)
        plt.scatter(x=x, y=y, marker='o',c='black',s=2)
        plt.xlabel('Agents')
        plt.ylabel('Log Particles' if uselog else 'Particles')
        plt.title("Sampling locations of experiments")
```

```
Out[5]: Text(0.5, 1.0, 'Sampling locations of experiments')
```



Also need plot definitions so it is easy to extract the required data

```
In [6]: # Define the plots so that they can be plotted in a loop
        plot_def = {
            "Min absolute error" : min_mean_err,
            "Max absolute error" : max_mean_err,
            "Avg absolute error" : ave_mean_err,
            "Median mean error":  med_mean_err,
            "Min absolute error"  : min_abs_err,
            "Max absolute error"  : max_abs_err,
            "Avg absolute error"  : ave_abs_err,
            "Median absolute error": med_abs_err,
            "Min variance"    : min_var,
            "Max variance"    : max_var,
            "Avg variance"   : ave_var,
            "Median variance"   : med_var
            }
```

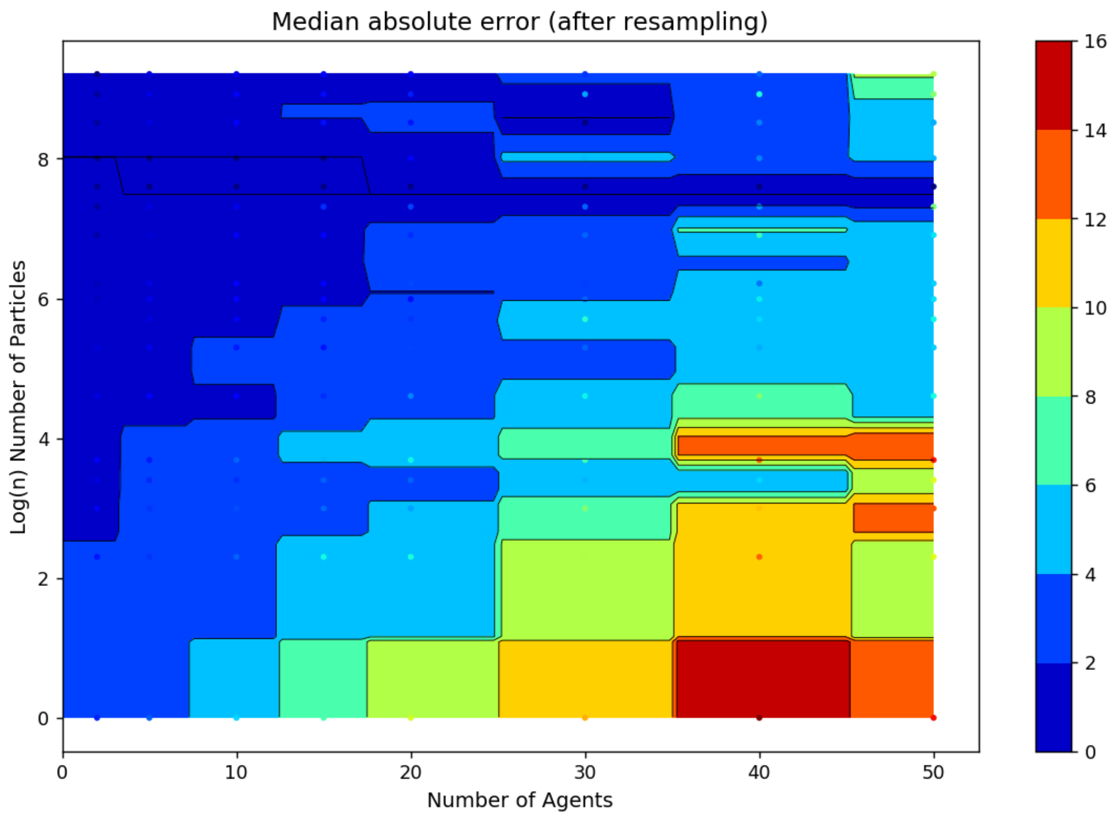
And some functions / other parameters that are consistent across all plots:

```
In [7]: # Some things that are consistent across all the plots
        _xlabel = 'Number of Agents'
        _ylabel = lambda x: 'Log(n) Number of Particles' if x else 'Number of Particles'

        # Font sizes (from https://stackoverflow.com/questions/3899980/how-to-change-the-font-
        SMALL_SIZE = 10
        MEDIUM_SIZE = 11
        BIGGER_SIZE = 13
        plt.rc('font', size=SMALL_SIZE)          # controls default text sizes
        plt.rc('axes', titlesize=SMALL_SIZE)     # fontsize of the axes title
        plt.rc('axes', labelsize=MEDIUM_SIZE)    # fontsize of the x and y labels
        plt.rc('xtick', labelsize=SMALL_SIZE)    # fontsize of the tick labels
        plt.rc('ytick', labelsize=SMALL_SIZE)    # fontsize of the tick labels
        plt.rc('legend', fontsize=SMALL_SIZE)    # legend fontsize
        plt.rc('figure', titlesize=BIGGER_SIZE)  # fontsize of the figure title
        plt.rc('axes', titlesize=BIGGER_SIZE)    # fontsize of the figure title (when using ax

        def make_z(d):
            """Calculate the value of the statistic being visualised (e.g. mean_error) as a lo
            z = []
            for i in range(len(agents)):
                for j in range(len(particles)):
                    z.append(d[j,i])
            assert len(x) == len(y) and len(x) == len(z)
            return np.array(z)

        def make_zi(z):
            """Grid the data"""
            return griddata(points=(x, y),
                   values=z,
                      xi=(xi[None,:], yi[:,None]),
                      method=interpolate_method)
```

1.3.2 Headline Plot: Median error after resampling

The headline: how the error changes with number of particles v.s. number of agents.

```
In [8]: # Title and array
        title = "Median absolute error"
        d = plot_def[title][1] # Index 1 for the array created *after* resampling

        # Calculate the value of the error statistic as a long list
        z = make_z(d)

        # Turn that into a grid
        zi = make_zi(z)

        fig = plt.figure(num=None, figsize=(11, 7), dpi=128, facecolor='w', edgecolor='k')
        ax = fig.add_subplot(111)
        cs1 = plt.contour( xi,yi,zi,8,linewidths=0.5,colors='k')
        cs2 = plt.contourf(xi,yi,zi,8,cmap=plt.cm.jet)
        plt.colorbar() # draw colorbar
        #plt.scatter(x,y,marker='o',c=[cs2.get_cmap()(val) for val in z], s=2)
        plt.scatter(x,y,marker='o',c=z, cmap=cs2.get_cmap(), s=5)
        plt.xlabel(_xlabel)
        plt.ylabel(_ylabel(uselog))
        # Make the numbers not logged
        #locs, labels = plt.yticks() # So that numbers are not logged
        #plt.yticks(locs, [math.exp(int(x.get_text())) if int(x.get_text().replace("'",'')) > 
        plt.title(title+" (after resampling)")
        #plt.show()
        plt.savefig("figs_for_pf_paper/median_abs_error.pdf", bbox_inches="tight")
        del(z, d, zi) # tidy up
```



1.3.3 Visualising Individual PF instances

What does that error actually mean in practice? Take a snaphsot of a high- and low- error PF implementation while it's running to give an idea about how close it gets to the 'real' system

```
In [9]: # These are the basic parameter settings required.
        # We will chance the number of particles and agents to see what the experiments are li

        model_params = {
            'width': 200,
            'height': 100,
            'pop_total': 10, # IMPORTANT: number of agents
            'speed_min': .1,
            'separation': 2,
            'batch_iterations': 4000,  # Only relevant in batch() mode
            'do_history': False,
            'do_print': False,
        }
        # Model(model_params).batch() # Runs the model as normal (one run)

        filter_params = {
```

```
        'number_of_particles': 10, #IMPORTANT: number of particles
        'number_of_runs': 1,  # Number of times to run each particle filter configuration
        'resample_window': 100,
        'multi_step': True,  # Whether to predict() repeatedly until the sampling window i
        'particle_std': 1.0, # Noise added to particles
        'model_std': 1.0, # Observation noise
        'agents_to_visualise': 10,
        'do_save': True,
        'plot_save': False,
        'do_ani': True, # Do the animation (generatea plot at each data assimilation windo
        'show_ani': False, # Don't actually show the animation. They can be extracted late
    }
```

10 agents, 10 particles, First two windows This shows that with only a few agents there is very little stochasticity, so even with only 10 particles the system is easy to estimate.

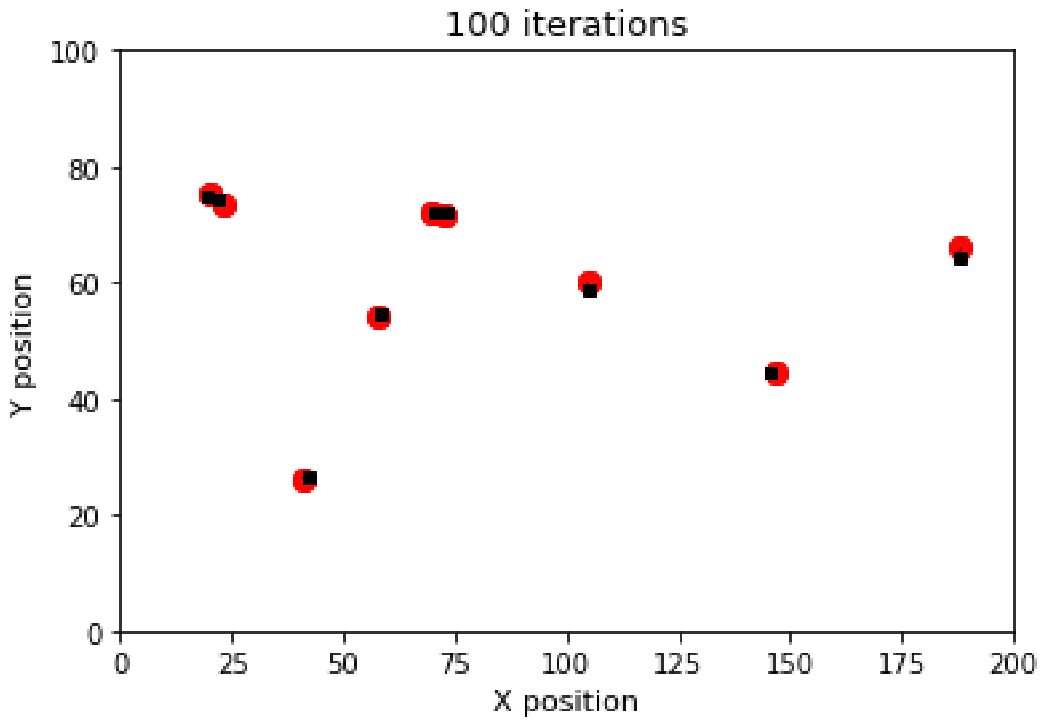
```
In [10]: # Temporarily turn off plotting (the 'show_ani' should stop plots being displayed,
         # but doesn't work for some reason)
         %matplotlib auto

         model_params['pop_total'] = 10
         filter_params['number_of_particles'] = 10
         pf = ParticleFilter(Model, model_params, filter_params, numcores = int(multiprocessin
         result = pf.step() # Run the particle filter

         # For some reason the pool doesn't always kill it's child processes (notebook problem
         pf.pool.close()

         # Turn on inline plotting again
         %matplotlib inline
```

```
Using matplotlib backend: MacOSX
BadKeyWarning: batch_iterations is not a model parameter.
Running filter with 10 particles and 1 runs (on 16 cores) with 10 agents.
Starting particle filter step()
Animating window
        Finished window 1, step 100 (took 0.74s)
Animating window
        Finished window 2, step 200 (took 0.49s)
Animating window
        Finished window 3, step 300 (took 0.36s)
Animating window
        Finished window 4, step 400 (took 0.25s)
Animating window
        Finished window 5, step 500 (took 0.2s)
Animating window
        Finished window 6, step 600 (took 0.18s)
Animating window
```

```
        Finished window 7, step 700 (took 0.25s)
Animating window
        Finished window 8, step 800 (took 0.17s)
Animating window
        Finished window 9, step 900 (took 0.05s)
```

```
In [11]: pf.animation[0]
```

Out[11]:



```
In [12]: #pf.animation[1]
```

If we want to re-save the images (don't necessarily want to do this if I was happy with the preivous ones they vary slightly each time the model runs.

```
In [13]: pf.animation[0].savefig("figs_for_pf_paper/ani-10agents-10particles-window100.pdf", bl
         #pf.animation[1].savefig("figs_for_pf_paper/ani-10agents-10particles-window200.pdf", 
```

50 agents, 10 particles, First three windows With 50 agents and still only 10 particles we start to see some agents being very poorly simulated. There are examples of XXXX (no particles correctly simulating an agent)

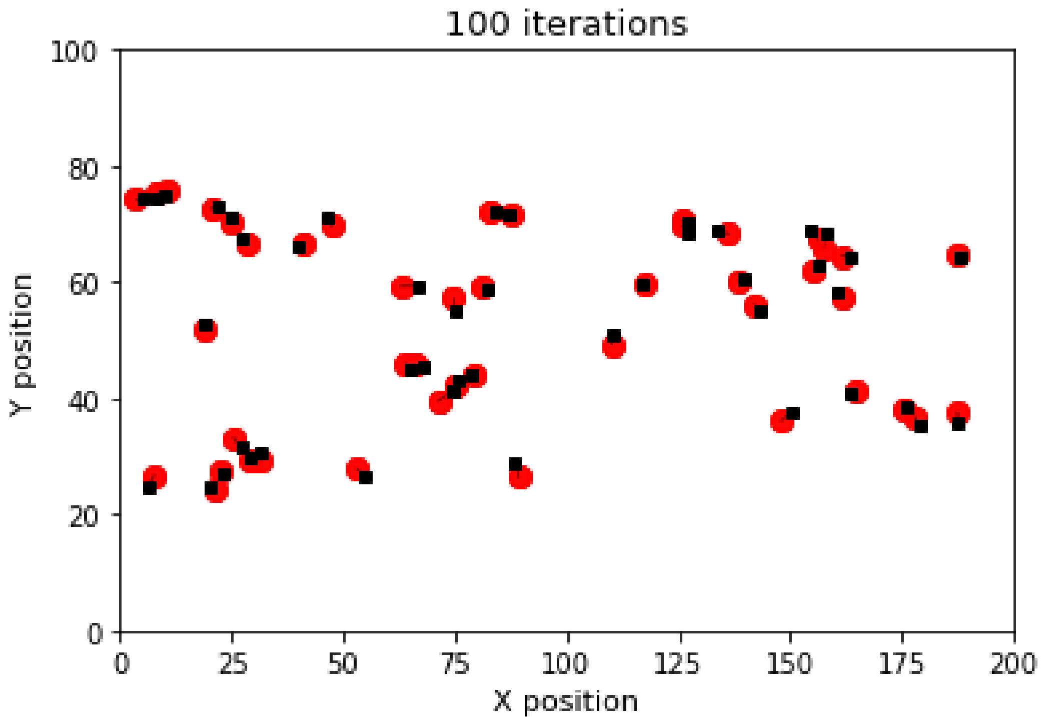
```
In [14]: # Temporarily turn off plotting (the 'show_ani' should stop plots being displayed,
         # but doesn't work for some reason)
         %matplotlib auto

         N = 50
         NP = 10
         model_params['pop_total'] = N
         filter_params['number_of_particles'] = NP
         filter_params['agents_to_visualise'] = N
         pf = ParticleFilter(Model, model_params, filter_params, numcores = int(multiprocessin
         result = pf.step() # Run the particle filter

         # For some reason the pool doesn't always kill it's child processes (notebook problem
         pf.pool.close()

         # Turn on inline plotting again
         %matplotlib inline
```

```
Using matplotlib backend: MacOSX
BadKeyWarning: batch_iterations is not a model parameter.
Running filter with 10 particles and 1 runs (on 16 cores) with 50 agents.
Starting particle filter step()
Animating window
        Finished window 1, step 100 (took 3.6s)
Animating window
        Finished window 2, step 200 (took 2.03s)
Animating window
        Finished window 3, step 300 (took 1.24s)
Animating window
        Finished window 4, step 400 (took 0.98s)
Animating window
        Finished window 5, step 500 (took 0.81s)
Animating window
        Finished window 6, step 600 (took 0.65s)
Animating window
        Finished window 7, step 700 (took 0.48s)
Animating window
        Finished window 8, step 800 (took 0.38s)
Animating window
        Finished window 9, step 900 (took 0.33s)
Animating window
        Finished window 10, step 1000 (took 0.31s)
Animating window
        Finished window 11, step 1100 (took 0.3s)
Animating window
        Finished window 12, step 1200 (took 0.4s)
Animating window
        Finished window 13, step 1300 (took 0.3s)
```

```
Animating window
        Finished window 14, step 1400 (took 0.31s)
Animating window
        Finished window 15, step 1500 (took 0.23s)
Animating window
        Finished window 16, step 1600 (took 0.19s)
Animating window
        Finished window 17, step 1700 (took 0.14s)
Animating window
        Finished window 18, step 1800 (took 0.12s)
Animating window
        Finished window 19, step 1900 (took 0.1s)
Animating window
        Finished window 20, step 2000 (took 0.03s)
```

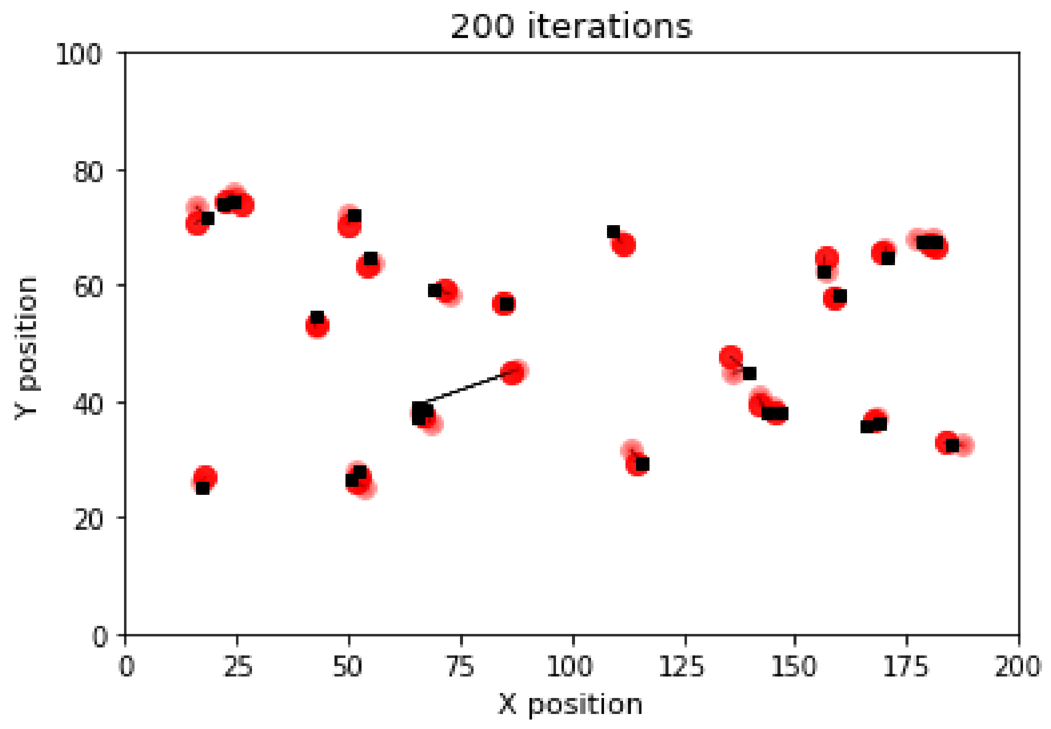
```
In [15]: pf.animation[0]
```

```
Out[15]:
```

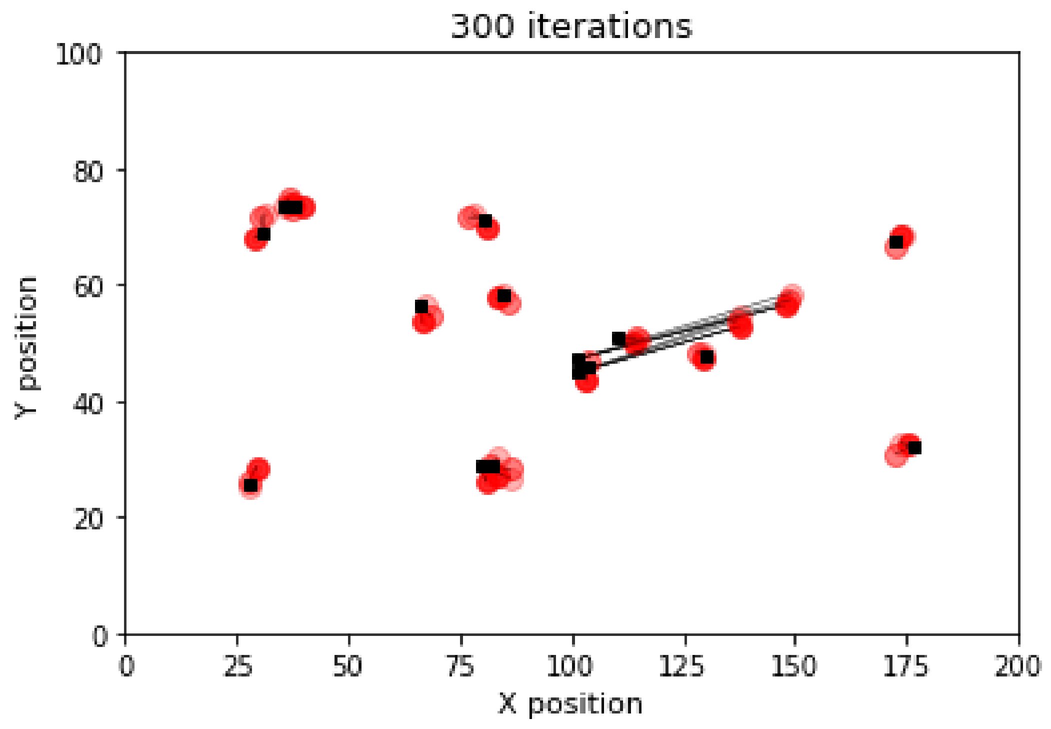


```
In [16]: pf.animation[1]
```

```
Out[16]:
```



```
In [17]: pf.animation[2]

   Out[17]:
```



If we want to re-save the images the uncomment below (don't necessarily want to do this if I was happy with the preivous ones they vary slightly each time the model runs).

```
In [18]: #pf.animation[0].savefig(f"figs_for_pf_paper/ani-{N}agents-{NP}particles-window100.pd
         #pf.animation[1].savefig(f"figs_for_pf_paper/ani-{N}agents-{NP}particles-window200.pd
         #pf.animation[2].savefig(f"figs_for_pf_paper/ani-{N}agents-{NP}particles-window300.pd
```

```
In [ ]:
```

50 agents, 5000 particles, First three windows Now with many more particles ..... XXXX HERE

```
In [19]: %%script false



         # Temporarily turn off plotting (the 'show_ani' should stop plots being displayed,
         # but doesn't work for some reason)
         %matplotlib auto

         N = 50
         NP = 5000

         # Try to load the complete particle filter results from a pickled file. If none are a
         pf = None
         pickle_file = f"./pickles/{N}agents_{NP}particles.pickle"

         try:
             with open(pickle_file, 'rb') as f:
                 pf = pickle.load(f)
                 print(f"Loaded previous PF run from file {pickle_file}")
         except FileNotFoundError as e:
             print("Could not load previously-run PF from file. Re-running code (go and make a
             pf = None # (not sure this is necessary)

         if pf == None:

             model_params['pop_total'] = N
             filter_params['number_of_particles'] = NP
             filter_params['agents_to_visualise'] = N
             pf = ParticleFilter(Model, model_params, filter_params, numcores = int(multiproce
             result = pf.step() # Run the particle filter

             # For some reason the pool doesn't always kill it's child processes (notebook prol
             pf.pool.close()

             pf.pool = None # This is necessary to allow pickling
```

```
            # Save the particle filter object as a pickle file
            with open(pickle_file, 'wb') as f:
                pickle.dump(pf, f)

        # Turn on inline plotting again
        %matplotlib inline
```

```
In [20]: %%script false
         pf.animation[0]
```

```
In [21]: %%script false
         pf.animation[1]
```

```
In [22]: %%script false
         pf.animation[2]
```

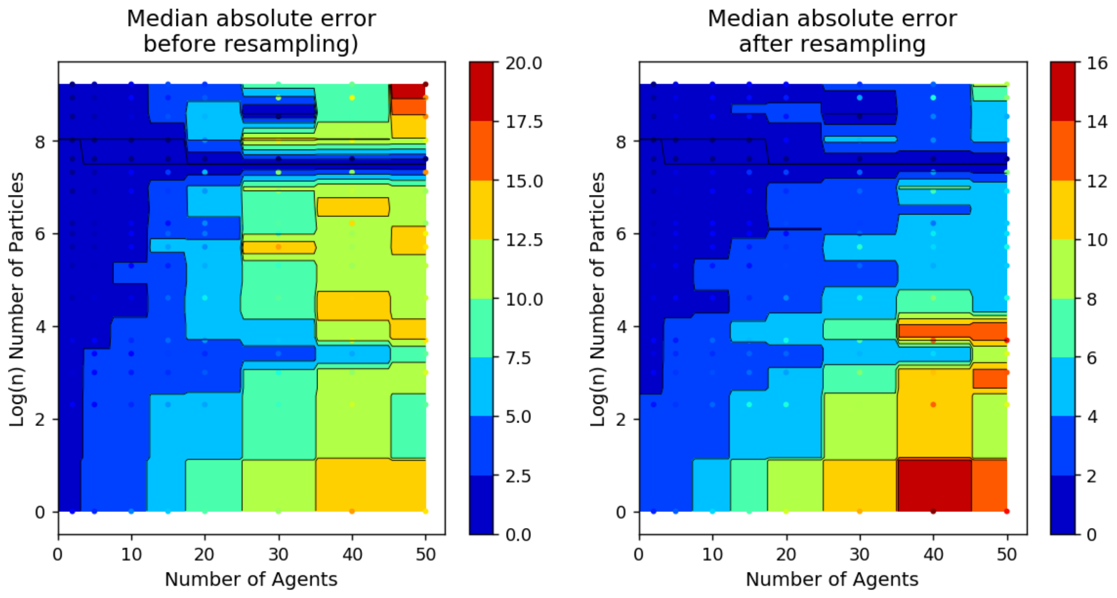
```
In [23]: %%script false
         pf.animation[0].savefig(f"figs_for_pf_paper/ani-{N}agents-{NP}particles-window100.pdf
         pf.animation[1].savefig(f"figs_for_pf_paper/ani-{N}agents-{NP}particles-window200.pdf
         pf.animation[2].savefig(f"figs_for_pf_paper/ani-{N}agents-{NP}particles-window300.pdf
```

1.3.4 Impact of Resampling

Plots that show how resampling reduced the error of the population of particles

```
In [24]: # Title and array
         title = "Median absolute error"
         d0 = plot_def[title][0] # Index 1 for the array created *beforer* resampling
         d1 = plot_def[title][1] # Index 1 for the array created *after* resampling

         # Calculate the value of the error statistic as a long list
         z0 = make_z(d0)
         z1 = make_z(d1)

         # Turn that into a grid
         zi0 = make_zi(z0)
         zi1 = make_zi(z1)

         fig = plt.figure(num=None, figsize=(11, 5), dpi=128, facecolor='w', edgecolor='k')

         ax0 = plt.subplot(121) #nrows, ncols, index,
         cs1 = plt.contour( xi,yi,zi0,8,linewidths=0.5,colors='k')
         cs2 = plt.contourf(xi,yi,zi0,8,cmap=plt.cm.jet)
         plt.colorbar() # draw colorbar
         plt.scatter(x,y,marker='o',c=z0, cmap=cs2.get_cmap(), s=5)
         plt.xlabel(_xlabel)
         plt.ylabel(_ylabel(uselog))
         plt.title(f"{title}\nbefore resampling)")
```

```
ax1 = plt.subplot(122) #nrows, ncols, index,
cs1 = plt.contour( xi,yi,zi1,8,linewidths=0.5,colors='k')
cs2 = plt.contourf(xi,yi,zi1,8,cmap=plt.cm.jet)
plt.colorbar() # draw colorbar
plt.scatter(x,y,marker='o',c=z1, cmap=cs2.get_cmap(), s=5)
plt.xlabel(_xlabel)
plt.ylabel(_ylabel(uselog))
plt.title(f"{title}\nafter resampling")

#plt.show()
plt.savefig("figs_for_pf_paper/resampling.pdf", bbox_inches="tight")
```



1.3.5 Impact of Noise

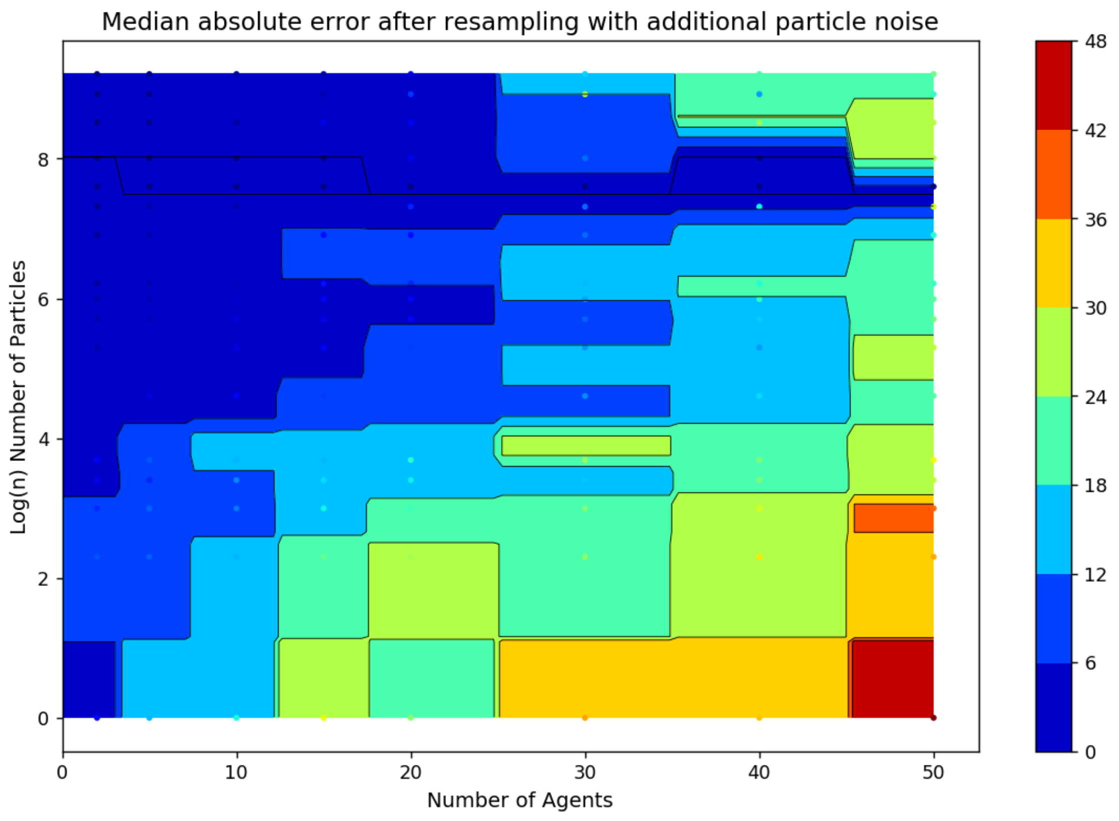
Plots that show the impact of changing the amount of particle noise from $\sigma_p = 1$ to $\sigma_p = 2$

Sorry, this is disgusging. To plot the more noisy scenarios we need to re-read the data stored in a different directory (`noise2`) so I've just copied data reading the code from above (without the warnings)

```
In [25]: path = os.path.join(root_dir[0], "results","2/noise2")
         print(f"Plotting results in directory: {path}")


         files = []
         duplicates = [] # List of diplicate files
         # r=root, d=directories, f = files
         for r, d, f in os.walk(path):
             for file in f:
                 if '.csv' in file:
```

```
            fname = os.path.join(r, file)
            if is_duplicate(fname, files):
                duplicates.append(fname)
            else:
                files.append(fname)

if len(files) == 0:
    sys.exit("Found no files in {}, can't continue".format(path) )
elif len(duplicates) > 0:
    warnings.warn("Found {} duplicate files:\n\t{}".format(len(duplicates), "\n\t".joi
else:
    print("Found {} files".format(len(files)))


# Errors are a matrix of particles * agents. These are a tuple because the errors
# are calculated before and after resampling

def init_matrix():
    return ( np.zeros(shape=(len(particles),len(agents))), np.zeros(shape=(len(particl

min_mean_err = init_matrix()
max_mean_err = init_matrix()
ave_mean_err = init_matrix() # Mean of the mean errors
med_mean_err = init_matrix() # Median of the mean errors
min_abs_err  = init_matrix()
max_abs_err  = init_matrix()
ave_abs_err  = init_matrix() # Mean of the mean errors
med_abs_err  = init_matrix() # Median of the mean errors
min_var      = init_matrix()
max_var      = init_matrix()
ave_var      = init_matrix()
med_var      = init_matrix()

# Regular expressions to find the particle number and population total from json-form
particle_num_re = re.compile(r".*?'number_of_particles': (\d*).*?")
agent_num_re = re.compile(r".*?'pop_total': (\d*).*?")

print("Reading files....",)
data_shape = None # Check each file has a consistent shape
for i, f in enumerate(files):

    file = open(f,"r").read()
    #data = pd.read_csv(f, header = 2).replace('on',np.nan)
    data = pd.read_csv(f, header=2).replace('on', np.nan)
    # Check that each file has a consistent shape
    # Filter by whether errors are before or after (NOW DONE LATER, THIS CAN GO)
    #data = data[ data.loc[:,'Before_resample?'] == before]
    # Find the particle number and population total from json-formatted info at the s
    search = re.findall(particle_num_re, file)
    try:
        particle_num = int(search[0])
    except:
        sys.exit("Error: could not find the number of particles in the header for file
    search = re.findall(agent_num_re, file)
    try:
        agent_num = int(search[0])
    except:
        sys.exit("Error: could not find the number of agents in the header for file \r

    # Calculate the statstics before and after resampling
    for before in [0,1]:
        d = data[ data.loc[:,'Before_resample?'] == before] # Filter data

        data_mean =  d.mean() # Calculate the mean of all columns
        data_median = d.median() # and also sometimes use median

        min_mean_err[before][particles.index(particle_num),agents.index(agent_num)] =
        max_mean_err[before][particles.index(particle_num),agents.index(agent_num)] =
        ave_mean_err[before][particles.index(particle_num),agents.index(agent_num)] =
        med_mean_err[before][particles.index(particle_num),agents.index(agent_num)] =
        min_abs_err [before][particles.index(particle_num),agents.index(agent_num)] =
        max_abs_err [before][particles.index(particle_num),agents.index(agent_num)] =
        ave_abs_err [before][particles.index(particle_num),agents.index(agent_num)] =
        med_abs_err [before][particles.index(particle_num),agents.index(agent_num)] =
        min_var     [before][particles.index(particle_num),agents.index(agent_num)] =
        max_var     [before][particles.index(particle_num),agents.index(agent_num)] =
        ave_var     [before][particles.index(particle_num),agents.index(agent_num)] =
        med_var     [before][particles.index(particle_num),agents.index(agent_num)] =

# There will never be zero error, so replace 0s with NA
data[data == 0] = np.nan

print("...finished reading {} files".format(len(files)))

# Define the plots so that they can be plotted in a loop
plot_def = {
    "Min absolute error" : min_mean_err,
    "Max absolute error" : max_mean_err,
    "Avg absolute error" : ave_mean_err,
    "Median mean error":  med_mean_err,
    "Min absolute error"  : min_abs_err,
    "Max absolute error"  : max_abs_err,
    "Avg absolute error"  : ave_abs_err,
    "Median absolute error": med_abs_err,
    "Min variance"    : min_var,
             "Max variance"   : max_var,
             "Avg variance"  : ave_var,
             "Median variance"  : med_var
             }

Plotting results in directory: /Users/nick/gp/dust/Projects/ABM_DA/experiments/pf_experiments/
Reading files...


/Users/nick/anaconda/envs/py35/lib/python3.6/site-packages/ipykernel_launcher.py:20: UserWarnin
        /Users/nick/gp/dust/Projects/ABM_DA/experiments/pf_experiments/results/2/noise2/pf_par
        /Users/nick/gp/dust/Projects/ABM_DA/experiments/pf_experiments/results/2/noise2/pf_par


...finished reading 124 files
```

```
In [26]: title = "Median absolute error"
         d = plot_def[title][1] # Index 1 for the array created *after* resampling

         # Calculate the value of the error statistic as a long list
         z = make_z(d)

         # Turn that into a grid
         zi = make_zi(z)

         fig = plt.figure(num=None, figsize=(11, 7), dpi=128, facecolor='w', edgecolor='k')
         ax = fig.add_subplot(111)
         cs1 = plt.contour( xi,yi,zi,8,linewidths=0.5,colors='k')
         cs2 = plt.contourf(xi,yi,zi,8,cmap=plt.cm.jet)
         plt.colorbar() # draw colorbar
         plt.scatter(x,y,marker='o',c=z, cmap=cs2.get_cmap(), s=5)
         plt.xlabel(_xlabel)
         plt.ylabel(_ylabel(uselog))
         plt.title(title+" after resampling with additional particle noise")
         plt.savefig("figs_for_pf_paper/median_abs_error-noise2_0.pdf", bbox_inches="tight")
         del(z, d, zi) # tidy up
```


Median absolute error after resampling with additional particle noise
Log(n) Number of Particles
Number of Agents
0
2
4
6
8
0
10
20
30
40
50
0
6
12
18
24
30
36
42
48