swarmtoolkit_demo

November 16, 2016

1 Demo

Some examples below are shown to showcase some of the functionality of `swarmtoolkit`.

1) *Basic functionality*

- Help
- Extract parameter from file(s)
- Modify parameter
- Quick introspection
- Plot parameter(s)
- Unzip file and extract contents

2) *FTP-server*

- Download file(s) from ftp server and extract contents
- Filter ftp-server vs. interactive selection

3) *Delay of parameter*

- Shift a parameter wrt. time
- Align two parameters wrt. time

4) *Visualization*

5) *Spherical harmonics*

6) *Miscellaneous*

- Fourier transform
- Read sp3 files
- EFI provisional
- Parameter

1.1 Basic functionality

```
In [1]: %matplotlib inline
        import swarmtoolkit as st
        import numpy as np
        import matplotlib.pyplot as plt
```

```
  File "/home/mikaelt/Documents/mypackages_py/swtools_root/swarmtoolkit/swa
    PdP = np.zeros((3,nmax+1,mmax+1))
                                     ^
IndentationError: unindent does not match any outer indentation level
```

1.1.1 Help

```
In [ ]: #using the built-in help function:
        #help(st.getCDFparams)

In [ ]: #if using ipython or the jupyter notebook you can also use:
        #st.getCDFlist?

In [ ]: #to find names of functions in the jupyter notebook one can tab(to auto-com
        #st. #tab to find avalable functions and submodules

In [ ]: #change this to target your sample data directory
        sample_loc = "sample_files/"

        #cleanup of directory:
        import os
        with open(os.path.join(sample_loc,'sample_files.txt'),'r') as f:
            samplefiles=[line.strip() for line in f]
            for fn in os.listdir(sample_loc):
                if fn not in samplefiles:
                    f_del = os.path.join(sample_loc,fn)
                    if os.path.isfile(f_del):
                        print('Removing {}'.format(f_del))
                        os.remove(f_del)
```

1.1.2 Extract parameter from file(s)

```
In [ ]: #check content of directory:
        %ls sample_files/

In [ ]: #a cdf file with the EEF product
        filepath_EEF_1 = os.path.join(sample_loc,'SW_OPER_EEFATMS_2F_20151101T00203
        filepath_EEF_2 = os.path.join(sample_loc,'SW_OPER_EEFATMS_2F_20151101T23450

        #get EEF and timestamp parameter from file
        EEF_1v,EEF_1t,EEF_1lon,EEF_1lat = st.getCDFparams(
            filepath_EEF_1,'EEF','Timestamp','longitude','latitude')
        print('Parameter: {}, units: {}\nValues:\n{}'
              .format(EEF_1v.name,EEF_1v.unit,EEF_1v.values),end='\n\n')
        print('Parameter: {}, units: {}\n(some) Values:\n{}'
              .format(EEF_1t.name,EEF_1t.unit,EEF_1t.values[::3]))
```

```
In [ ]: #Filepaths could also be fetched using:
        filepaths=st.getCDFlist(sample_loc) #get list of cdf files in given path

        #extract data from both files, concatenate output
        EEF_v = st.getCDFparams(filepaths,'EEF')
        print('Parameter: {}, units: {}\nValues:\n{}'
              .format(EEF_v.name,EEF_v.unit,EEF_v.values),end='\n\n')
```

These functions by default do not evaluate zip files unless there are no cdf files available or the keyword argument `includezip=True` is passed. If `getCDFparams` is passed with `cat=False`, values will be a list of `numpy.ndarrays`.

```
In [ ]: EEF_v_no_cat,EEF_t_no_cat = st.getCDFparams(filepaths,'EEF','Timestamp',cat
        print(EEF_v_no_cat.values[0],'\n\n',EEF_v_no_cat.values[1])
```

1.1.3 Modify parameter

The `values`-attribute is a `numpy.ndarray`, and can thus be freely manipulated.

```
In [ ]: from numpy import sqrt,sin,log

        #mathematical operations performed on the EEF array
        derived_value=log(sqrt(sin(1/EEF_v.values)+1.5))**5
        print(derived_value,sum(derived_value))

        #cut of last value:
        EEF_v_no_cat.values[1] = EEF_v_no_cat.values[1][:len(EEF_v_no_cat.values[0]
        EEF_t_no_cat.values[1] = EEF_t_no_cat.values[1][:len(EEF_t_no_cat.values[0]
        print(len(EEF_v_no_cat.values[1]))
```

1.1.4 Quick introspection

of parameter names One can quickly look at the parameter names of a cdf file (or several files simultaneously):

```
In [ ]: st.getCDFparamlist(filepaths)
```

Only one file will be shown for every unique product (based on filename).

of parameter values `param_peek` can be used to get a quick idea of the content within either a parameter in a file or an array. Note that it behaves differently depending on the dimension of the values. This only works if the parameter is represented by floats (eg. not `datetime.datetime` objects)

```
In [ ]: #from filename
        st.param_peek(filepath_EEF_1,'EEF')

In [ ]: EEF_v_no_cat() #The value array can be accessed also by calling the paramet

In [ ]: #15x2 array
        a=np.column_stack((EEF_v_no_cat.values[0][:-1],EEF_v_no_cat.values[1]))
        st.param_peek(a,axis=1)
```

of discontinuities in values

```
In [ ]: #find jumps in values:

        #jump larger than difference between 25th and 75 percentile
        jumps_pcnt=st.where_diff(a[:,0])

        #relative difference of 50%
        jumps_rtol=st.where_diff(a[:,0],rtol=0.5)

        #absolute difference
        jumps_atol=st.where_diff(a[:,0],atol=0.0004)

        #abs_tol ∩ rel_tol
        jumps_comb=st.where_diff(a[:,0],atol=0.0004,rtol=0.5)

        print(jumps_pcnt,a[jumps_pcnt,0])
        print(jumps_rtol,a[jumps_rtol,0])
        print(jumps_atol,a[jumps_atol,0])
        print(jumps_comb,a[jumps_comb,0])
```

1.1.5 Plot parameter(s)

```
In [ ]: fig,ax=st.plot(EEF_t_no_cat.values[0],EEF_v_no_cat.values[0],
                                  EEF_t_no_cat.values[1],EEF_v_no_cat.values[1],
                                  legends=[EEF_1v.name+'1',EEF_1v.name+'2'])

In [ ]: #plot EEF(t) and longitude(t) with own unique y-axis
        fig,ax1=st.plot(EEF_1t.values,EEF_1v.values,
                                   legends=[EEF_1v.name],lhide=True)
        ax2=st.plot_twinx(EEF_1t.values,EEF_1lon.values,ax=ax1,
                                 legends=[EEF_1lon.name])

In [ ]: #plot EEF(t) and longitude(t) with own unique y-axis and legend position:
        fig,ax1=st.plot(EEF_1t.values,EEF_1v.values,
                                   legends=[EEF_1v.name,'a'],lloc='lower left')
        ax2=st.plot_twinx(EEF_1t.values,EEF_1lon.values,ax=ax1,
                                 legends=[EEF_1lon.name],lall=False)
```

1.1.6 Unzip file and extract contents

To unzip a cdf file and extract parameter from file, simply use the same syntax as for a normal file. Additionally, one can store the cdf temporarily by specifying `temp=True`:

```
In [ ]: #include zipfile in search for cdf files- unzip it in temporary storage,
        #then filter files based on satelite and within time range based on filenam
        filepaths_w_zip=st.getCDFlist(sample_loc,includezip=True,temp=True,
                                              sat='A',start_t='20150901',end_t='201510

In [ ]: filepaths_w_zip
```

```
In [ ]: EEF_zip=st.getCDFparams(
            os.path.join(sample_loc,'SW_OPER_EEFATMS_2F_20150924T010219_20150924T22
            'EEF',temp=True)
```

1.2 FTP-server

1.2.1 Download file(s) from ftp server and extract contents

Extracting from ftp server follows same syntax. output location is by default the current working directory, by may be specified. `filter_param` will ensure that only folders where the parameter is presumed to be will be checked (as of `swarmtoolkit 1.0.2` only main `MAG`, `EFI`, `IBI`, `FAC`, `TEC` and `EEF` products are supported for filtering, and only for the dissemination server `swarm-diss.eo.esa.int`):

NOTE: If experiencing difficulties connecting to the dissemination server from a secure ESA network, the problem may be resolved by adding `use_passive_mode=False` and possibly also temporarily deactivating your firewall.

```
In [ ]: url,user,pw='swarm-diss.eo.esa.int/','myuser','mypw'
        #get files with parameter 'n'(ie. EFI product) from satellite B,
        #within two days after 1.9.2015, download to current directory

        #st.getCDFparams(url+'Level1b/','n',user=user,pw=pw,outloc=sample_loc,
        #                      filter_param=True,sat='B',start_t='20150901',duratio
```

1.2.2 Filter ftp-server vs. interactive selection

In the above example no interaction is needed, as everything is specified. If not all filters are used, the user can select files/directories interactively:

```
In [ ]: #look for products from satellite B  with parameter 'timestamp'
        #st.getCDFparams(url,'Timestamp',user=user,pw=pw,outloc=sample_loc,sat='B'
```

1.3 Delay of parameter

1.3.1 Shift a parameter wrt. time

```
In [ ]: #shift a parameter with respect to itself 10000s(for illustration purposes)
        eef1,eef2,eeft1,eeft2=st.shift_param(
            EEF_1v.values,EEF_1v.values,EEF_1t.values,EEF_1t.values,delta_t=3000,k=
        fig,ax=st.plot(eeft1,eef1,eeft2,eef2,legends=['shifted','original'])
```

It is also possible to make the function shift into a best fit using `auto=True`.

```
In [ ]: #Shift to best fit (which should shift eef1 back to initial position), and
        #find the "unknown" shift assumed to be +-10000s from present position.
        #`ext=0` due to large errors, so the solver starts to try to extrapolate
        #otherwise
        eef1_,eef2_,eeft1_,eeft2_=st.shift_param(eef1,eef2,eeft1,eeft2,
                                                 dt_lim=[-10000,10000],
                                                 auto=True,ext=0)
```

Here due to using very few points(EEF has ~15 values/day) the error is large, and interpolation poor, and a warning is shown; but the original value was approximately regained. More detailed output can be gained from `v=2` and `show=True`:

```
In [ ]: eef1_,eef2_,eeft1_,eeft2_=st.shift_param(
            eef1,eef2,eeft1,eeft2,dt_lim=[-10000,10000],
            auto=True,ext=0,v=2,show=True)

In [ ]: #best fit:
        st.plot(eeft1_,eef1_,eeft2_,eef2_,legends=['shift to best fit','original'])
```

1.3.2 Align two parameters wrt. time

If we want to plot to parameters with different frequencies together(downsample one of them), we can use `align_param`:

```
In [ ]: #plot shifted values, where one has half the frequency of the other:
        eef1_a,eef2_a,eeft=st.align_param(eef1[::2],eef2,eeft1[::2],eeft2)
        st.plot(eeft,eef1_a,eeft,eef2_a)

        #one could use plot_align(eef1[::2],eef2,eeft1[::2],eeft2)
        #if not interested in the output values(only the visualization)
```

1.4 Visualization

Visualize on the globe

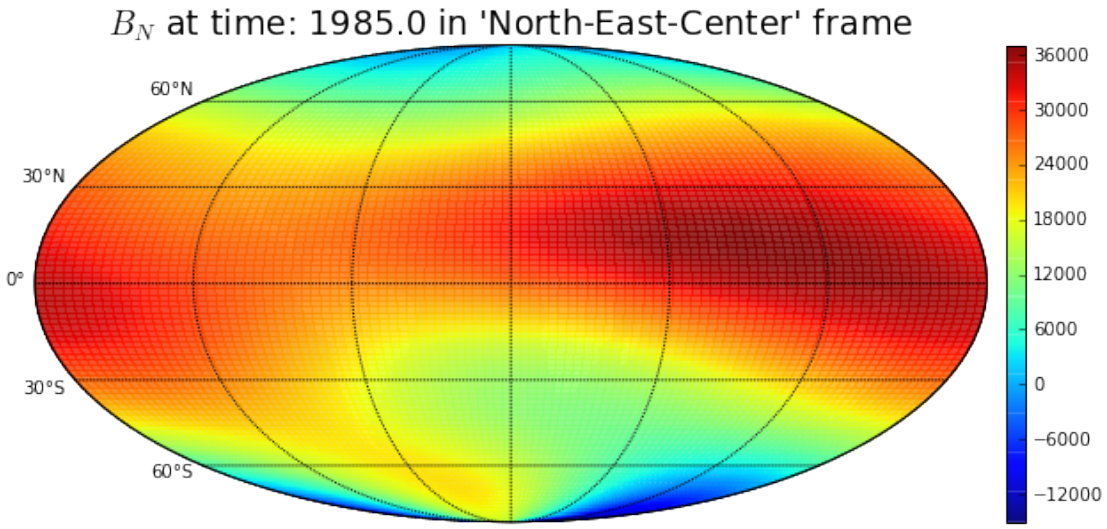
```
In [ ]: #plain scatter plot with no background
        fig,ax=st.plot_scatter(EEF_1lon.values,EEF_1lat.values,EEF_1v.values,
                               s=300,figsize=(12,12))
        ax.set_xlim([-180,180])

In [ ]: #scatter on hammer projection centered on longitude=90
        st.plot_geo(EEF_1lat.values,EEF_1lon.values,EEF_1v.values,
                    s=300,projection='hammer',lon_0=90,figsize=(12,12))

In [ ]: #Orthographic projection centered on (50° N,10° E) using dark map,
        #no colorbar and a figure size of 12x12 inches
        st.plot_geo(EEF_1lat.values,EEF_1lon.values,EEF_1v.values,
                    s=1500,lon_0=10,lat_0=50,projection='ortho',
                    dark_map=True,cbar=False,figsize=(12,12))

In [ ]: #need 2d array for colormesh, so here I just stack the EEF values on top o
        #essentially losing the latitude information.
        EEF_band=np.column_stack([EEF_1v.values]*15).T
        #colormesh on South-Polar Azimuthal Equidistant projection,
        #with the equator as bounding latitude
        st.plot_geo(EEF_1lat.values,EEF_1lon.values,EEF_band,
                    ptype='colormesh',latlon=True,projection='spaeqd',bounding
```

1.5 Spherical harmonics

```
In [ ]: lon,lat=np.linspace(0,360,101),np.linspace(-90,90,101)
        shc_fn=os.path.join(sample_loc+'IGRF12.shc')
        Bnec=st.get_Bnec(shc_fn,lat,lon,h=100)
        dBnec=st.get_Bnec(shc_fn,lat,lon,h=100,dB=True)
```

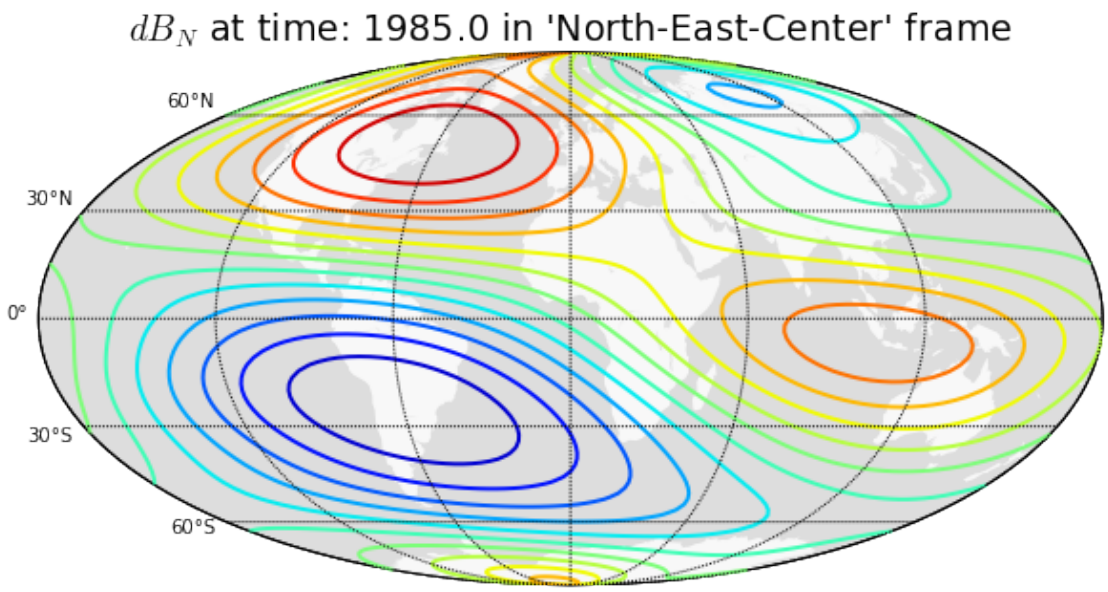
```
In [34]: time_idx=17
         dim_idx=0
         print("Number of time values: {}, Dimensions in B(fixed): {},\n"
               .format(*Bnec.shape[:2]) +
               "Number of latitude values: {}, Number of longitude values: {}"
               .format(*Bnec.shape[2:]))
         fig,m=st.plot_geo(lat,lon,Bnec[time_idx][dim_idx],
                           ptype='colormesh',latlon=True,figsize=(10,10),proje

         #can read data from shc file using `read_shc`:
         plt.title("$B_{}$ at time: {} in 'North-East-Center' frame"
                   .format('NEC'[dim_idx],st.read_shc(shc_fn)[-1][time_idx]),fontsi
         plt.show()
```

```
Number of time values: 25, Dimensions in B(fixed): 3,
Number of latitude values: 101, Number of longitude values: 101
```




```
In [35]: #same for its derivative
         fig,m=st.plot_geo(lat,lon,dBnec[time_idx][dim_idx],
                           ptype='contour',latlon=True,figsize=(10,10),
                           linewidths=2,cbar=False)
         plt.title("$dB_{}$ at time: {} in 'North-East-Center' frame"
```

```
                .format('NEC'[dim_idx],st.read_shc(shc_fn)[-1][time_idx]),fontsi
plt.show()
```

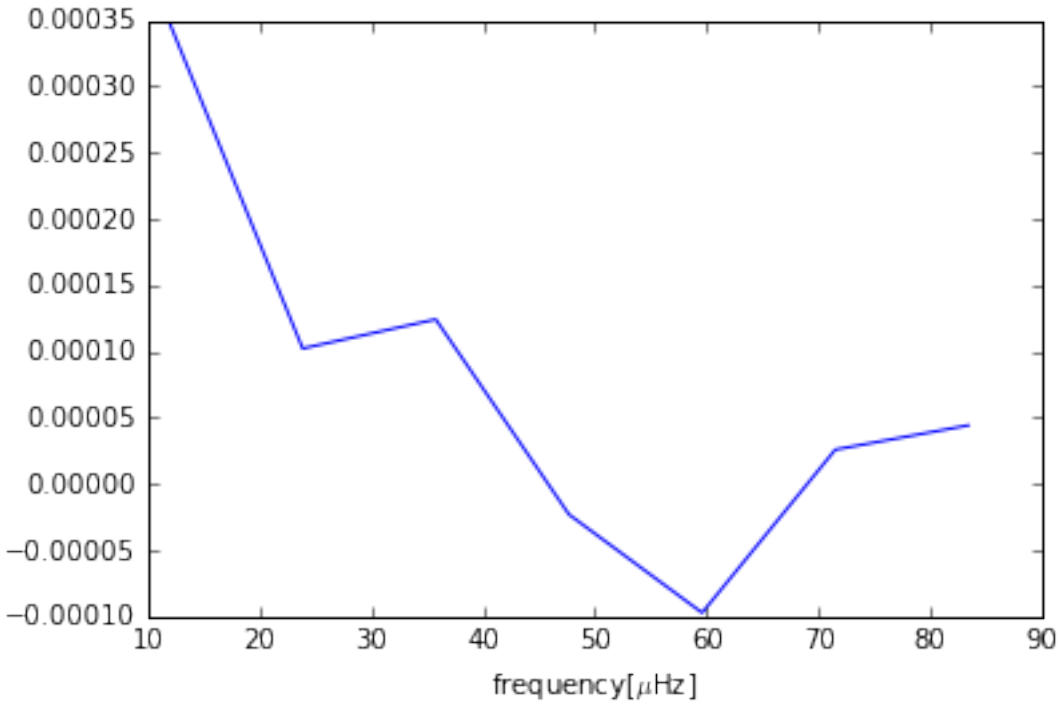


1.6 Miscellaneous

1.6.1 Fourier transform

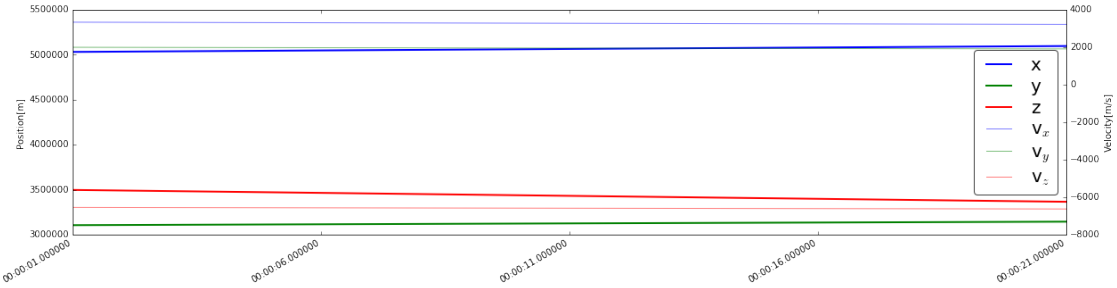
Fourier transforms can be performed on data:

```
In [36]: #Note that the input should have a fixed frequency
         #unitary fourier transform off EEF values
         fEEF,EEF_freq=st.fourier_transform(EEF_1v.values,EEF_1t.values,
                                                 norm='ortho')
         positive_freq=np.where(EEF_freq>0)
         fig,ax=st.plot_basic(EEF_freq[positive_freq]*1e6,fEEF[positive_freq])
         ax.set_xlabel('frequency[$\mu$Hz]')
         plt.show()
```



1.6.2 Read sp3 files

```
In [37]: #x,y,z,t,header=st.read_sp3('sample_kin.txt',doctype=1)#read kinetic sp3 f
         x,y,z,vx,vy,vz,dt,t,header=st.read_sp3(sample_loc+'sample_rd.txt')
         fig,ax=st.plot_basic(t,x,t,y,t,z,legends=['x','y','z'],
                                  figsize=(20,5),lhide=True,lw=2)
         ax2=st.plot_twinx(t,vx,t,vy,t,vz,legends=['v$_x$','v$_y$','v$_z$'],
                           lfontsize=20,lbox=True,alpha=0.5,colors=['b','g','r
         ax2.set_ylabel('Velocity[m/s]')
         ax.set_ylabel('Position[m]')
         plt.show()
```



1.6.3 EFI provisional

Read the provisional EFI ascii files

```
In [38]: #if no parameter specified, a dictionary of all parameters are returned
         out=st.read_EFI_prov_txt(
             os.path.join(sample_loc,'SW_PREL_EFIA_LP_1B_20150720T000000_20150720T2
         print("Parameters available in provisional ascii file:\n\t"+'\n\t'.join(ou
         print("first 5 values:",out['n'][:5])

Parameters available in provisional ascii file:
        longitude
        latitude
        radius
        u_sc
        flag
        n
        t_elec
        timestamp
first 5 values: [ 163151.  162957.  163151.  162957.]
```

1.6.4 Parameter

When a parameter is returned from `st.extract_parameter` or `st.getCDFparams`, it is an instance of the `Parameter` class.

```
In [39]: EEF_1v

Out[39]: Parameter EEF V/m
         array([ 0.00075635,  0.00079489,  0.00089461,  0.00053112,  0.00052239,
                 0.00046283,  0.00051985,  0.00052364,  0.0001264 ,  0.00014414,
                 0.00047001,  0.0003849 ,  0.00022549,  0.00032556,  0.00060109])

In [40]: #the instance has a `values`,`name` and `unit` attribute.
         EEF_1v.values,EEF_1v.name,EEF_1v.unit

Out[40]: (array([ 0.00075635,  0.00079489,  0.00089461,  0.00053112,  0.00052239,
                  0.00046283,  0.00051985,  0.00052364,  0.0001264 ,  0.00014414,
                  0.00047001,  0.0003849 ,  0.00022549,  0.00032556,  0.00060109]),
          'EEF',
          'V/m')

In [41]: #values can be accessed directly:
         print(EEF_1v[:4])
         #calling is shorthand for `.values`:
         print(EEF_1v())

[ 0.00075635  0.00079489  0.00089461  0.00053112]
[ 0.00075635  0.00079489  0.00089461  0.00053112  0.00052239  0.00046283
```

```
0.00051985  0.00052364  0.0001264   0.00014414  0.00047001  0.0003849
0.00022549  0.00032556  0.00060109]
```