ekok_stereo

July 11, 2023

1 Ekofisk stereo video WDM test

Use WDM to estimate directional spectrum from Ekofisk stereo video data.

[1]:
```
# Imports
import os
import numpy as np
import pandas as pd
import xarray as xr
import matplotlib.pyplot as plt
from matplotlib import ticker, cm
# Interactive plots
%matplotlib widget
import cmocean
from pywdm import wdm
from roxsi_pyfuns import wave_spectra

# Read data
datadir = '/home/mikapm/Documents/EKOK'
# Read WAMOS spectrum
# fn_wamos = os.path.join(datadir, 'WAMOS_20200328_1520.nc')
# fn_wamos = os.path.join(datadir, 'WAMOS_20200211_1040.nc')
# fn_wamos = os.path.join(datadir, 'WAMOS_20191209_1240.nc')
# fn_wamos = os.path.join(datadir, 'WAMOS_20200104_0940.nc')
fn_wamos = os.path.join(datadir, 'WAMOS_20200413_0800.nc')
dsw = xr.open_dataset(fn_wamos)
dsw = dsw.rename({'__xarray_dataarray_variable__': 'WAMOS_spec'},)
# Read Ekofisk test stereo data
# fn_nc = os.path.join(datadir, 'xygrid_50cm_20200328_1520_plane_sub.nc')
# fn_nc = os.path.join(datadir, 'xygrid_50cm_20210406_1620_plane_sub.nc')
# fn_nc = os.path.join(datadir, 'xygrid_50cm_20200211_1040_plane_sub.nc')
# fn_nc = os.path.join(datadir, 'xygrid_50cm_20191209_1240_plane_sub.nc')
# fn_nc = os.path.join(datadir, 'xygrid_50cm_20200104_0940_plane_sub.nc')
fn_nc = os.path.join(datadir, 'xygrid_50cm_20200413_0800_plane_sub.nc')
ds = xr.open_dataset(fn_nc, decode_coords='all')
# Change sign of y coord
ds = ds.assign_coords(ym=ds.y * (-1))
# Just in case: make sure timestamps increase monotonically
```

```
ds = ds.sortby('time')
ds
```

[1]:
```
<xarray.Dataset>
Dimensions:  (time: 5159, x: 280, y: 300)
Coordinates:
  * time     (time) datetime64[ns] 2020-04-13T08:00:00.010648 … 2020-04-13T…
  * x        (x) float32 -70.0 -69.5 -69.0 -68.5 -68.0 … 68.0 68.5 69.0 69.5
  * y        (y) float32 -200.0 -199.5 -199.0 -198.5 … -52.0 -51.5 -51.0 -50.5
    ym       (y) float32 200.0 199.5 199.0 198.5 198.0 … 52.0 51.5 51.0 50.5
Data variables:
    xgrid    (x, y) float32 …
    ygrid    (x, y) float32 …
    eta      (time, x, y) float32 …
```

Pick array of grid cells in stereo field of view and calculate distances and angles.

[2]:
```
# x,y coordinates of square array
origin = (-5, 90) # x,y coordinates of array origin
sidelen = 10 # array half side length
# xpts = [origin[0]+sidelen, origin[0]-sidelen,
#         origin[0]-sidelen, origin[0]+sidelen]
# ypts = [origin[1]+sidelen, origin[1]+sidelen,
#         origin[1]-sidelen, origin[1]-sidelen]
xpts = [origin[0]+sidelen, origin[0],
        origin[0]-sidelen, origin[0]]
ypts = [origin[1], origin[1]+sidelen,
        origin[1], origin[1]-sidelen]

# Define A and R arrays for stereo array
# See figure below for visualization of array geometry.
# a_p1 = 45 # Angle from origin to p1 (see figure)
# a_p2 = 135
# a_p3 = 225
# a_p4 = 315
a_p1 = 0 # Angle from origin to p1 (see figure)
a_p2 = 90
a_p3 = 180
a_p4 = 270
# Angles from center
A = np.array([a_p1, a_p2, a_p3, a_p4]).astype(float)
# Convert angles to radians
A *= (np.pi / 180)
# Radius of array (m). i.e. Polar coordinates of the staffs
# o_l1 = np.sqrt(sidelen**2 + sidelen**2) # Distance from origin to p1 (see␣
↪plot)
# o_l2 = np.sqrt(sidelen**2 + sidelen**2)
```

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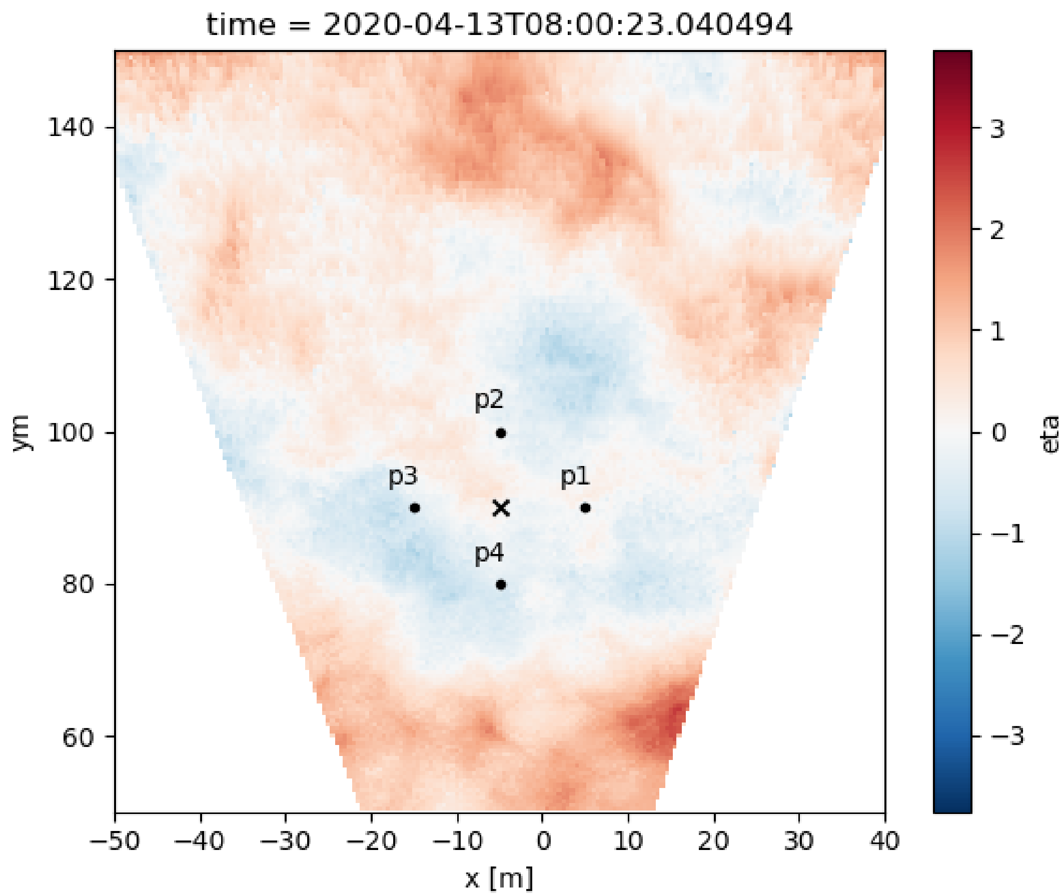
# o_l3 = np.sqrt(sidelen**2 + sidelen**2)
# o_l4 = np.sqrt(sidelen**2 + sidelen**2)
o_l1 = sidelen + 0 # Distance from origin to p1 (see plot)
o_l2 = sidelen + 0
o_l3 = sidelen + 0
o_l4 = sidelen + 0
R = np.array([o_l1, o_l2, o_l3, o_l4])
# Make virtual wave staff array (interpolate over NaNs)
arr = np.array([ds.eta.sel(x=xpts[0], y=-ypts[0], method='nearest').
 ↪interpolate_na(dim='time').bfill(
                    dim='time').ffill(dim='time').values.squeeze(),
                ds.eta.sel(x=xpts[1], y=-ypts[1], method='nearest').
 ↪interpolate_na(dim='time').bfill(
                    dim='time').ffill(dim='time').values.squeeze(),
                ds.eta.sel(x=xpts[2], y=-ypts[2], method='nearest').
 ↪interpolate_na(dim='time').bfill(
                    dim='time').ffill(dim='time').values.squeeze(),
                ds.eta.sel(x=xpts[3], y=-ypts[3], method='nearest').
 ↪interpolate_na(dim='time').bfill(
                    dim='time').ffill(dim='time').values.squeeze(),
               ])
# Check that array is even
if not (arr.shape[-1] % 2) == 0:
    arr = arr[:, :-1]
    # Time axis for plot
    t = ds.sel(x=xpts[0], y=ypts[0], method='nearest').
 ↪interpolate_na(dim='time').bfill(
            dim='time').ffill(dim='time').time.values[:-1]
else:
    t = ds.sel(x=xpts[0], y=ypts[0], method='nearest').
 ↪interpolate_na(dim='time').bfill(
            dim='time').ffill(dim='time').time.values

# Plot array on top of sample grid for visualization
fig, ax = plt.subplots(figsize=(6,5))
ds.isel(time=100).eta.plot(ax=ax, x='x', y='ym')
for i, (xp, yp) in enumerate(zip(xpts, ypts)):
    ax.scatter(xp, yp, color='k', marker='.')
    # Name points p1-p4
    ax.annotate(f'p{i+1:0d}', xy=(xp-3, yp+3), )
# Mark origin w/ x
ax.scatter(origin[0], origin[1], color='k', marker='x')
# Crop limits
ax.set_ylim([50, 150])
ax.set_xlim([-50, 40])
plt.tight_layout()
```

```
plt.show()
```

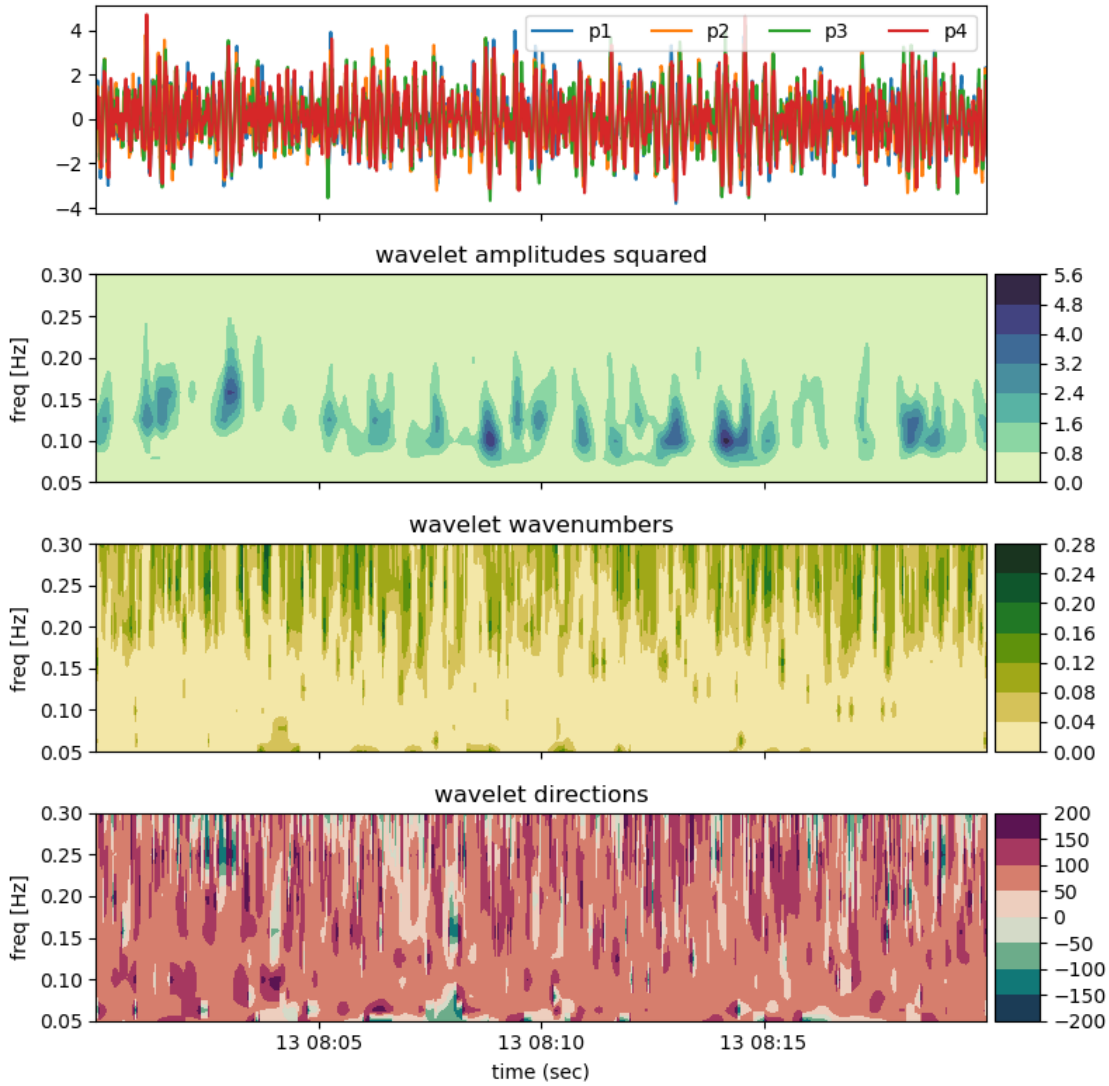


Estimate WDM spectrum and make example plot.

[3]:
```
# Initialize WDM class using default parameters
WDM = wdm.WaveletDirectionalMethod(A, R, lf=0.05, hf=0.8, nv=3)
# Run WDM algorithm
Amp, K, Th, freqs = WDM.wdm_kth(arr.T)
# Get f-theta and f spectra
res = 10
dse = WDM.spec_fth(Amp, Th*(180/np.pi), freqs, res=res, ang_offset=21)

# Plot time series and wavelet amplitudes^2, wavenumbers and directions
fig, axes = plt.subplots(figsize=(8,8), nrows=4, sharex=True)
ims = {} # dict for images for colorbars
# Plot array time series on top
for i in range(4):
    axes[0].plot(t, arr[i], label=f'p{i+1:0d}')
```

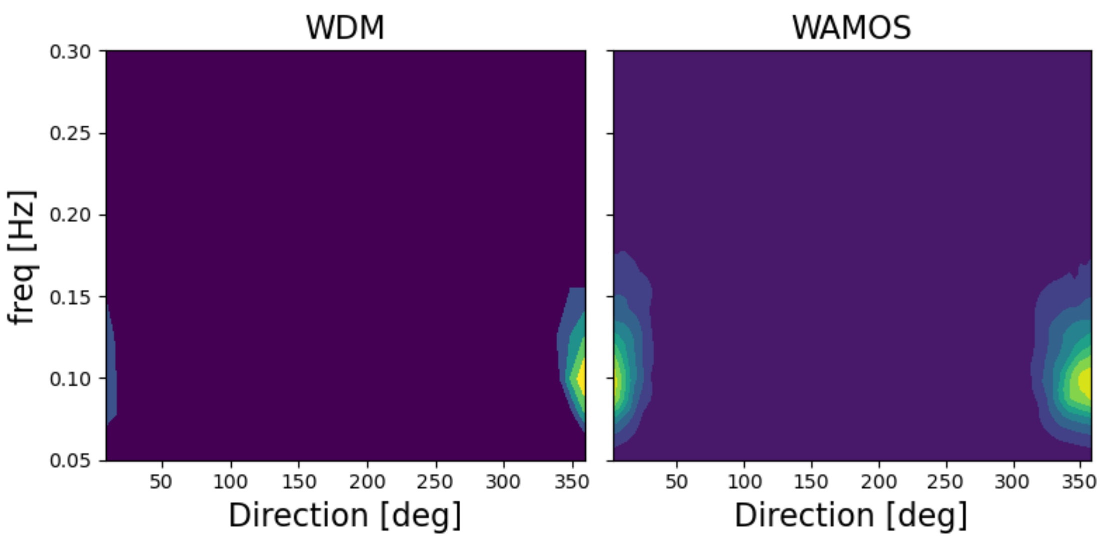
```
axes[0].set_xlabel(None)
axes[0].set_title(None)
axes[0].legend(loc='upper right', ncol=4)
# Row 2: Wavelet amplitudes ^ 2
ims['1'] = axes[1].contourf(t, freqs, Amp**2, cmap=cmocean.cm.deep)
axes[1].set_title('wavelet amplitudes squared')
axes[1].set_ylabel('freq [Hz]')
# Row 3: Wavelet wavenumbers
ims['2'] = axes[2].contourf(t, freqs, K, cmap=cmocean.cm.speed)
axes[2].set_ylabel('freq [Hz]')
axes[2].set_title('wavelet wavenumbers')
# Row 4: Wavelet directions
ims['3'] = axes[3].contourf(t, freqs, np.rad2deg(Th), cmap=cmocean.cm.curl)
axes[3].set_ylabel('freq [Hz]')
axes[3].set_xlabel('time (sec)')
axes[3].set_title('wavelet directions')
# Colorbars
for i,ax in enumerate(axes[1:]):
    cax = axes[i+1].inset_axes([1.01, 0.00, 0.05, 1.0], transform=axes[i+1].
 ↪transAxes)
    fig.colorbar(ims[f'{i+1:0d}'], cax=cax, orientation='vertical')
# x-lims
for ax in axes[1:]:
    ax.set_ylim([0.05, 0.3])
plt.tight_layout()
plt.show()
# plt.close()
```



Plot frequency-directional spectra.

[4]:
```
fig, axes = plt.subplots(figsize=(8,4), ncols=2, sharey=True)
# WDM spec
# axes[0].contourf(dirs, freqs, Efd,)# locator=ticker.LogLocator(), cmap=cm.
↪PuBu_r)
dse.Efth.plot.contourf(ax=axes[0], add_colorbar=False)
axes[0].set_title('WDM', fontsize=16)
axes[0].set_ylabel('freq [Hz]', fontsize=16)
axes[0].set_xlabel('Direction [deg]', fontsize=16)
# WAMOS spec
axes[1].contourf(dsw.direction.data, dsw.freq, dsw.WAMOS_spec.T,)#␣
↪locator=ticker.LogLocator(), cmap=cm.PuBu_r)
```

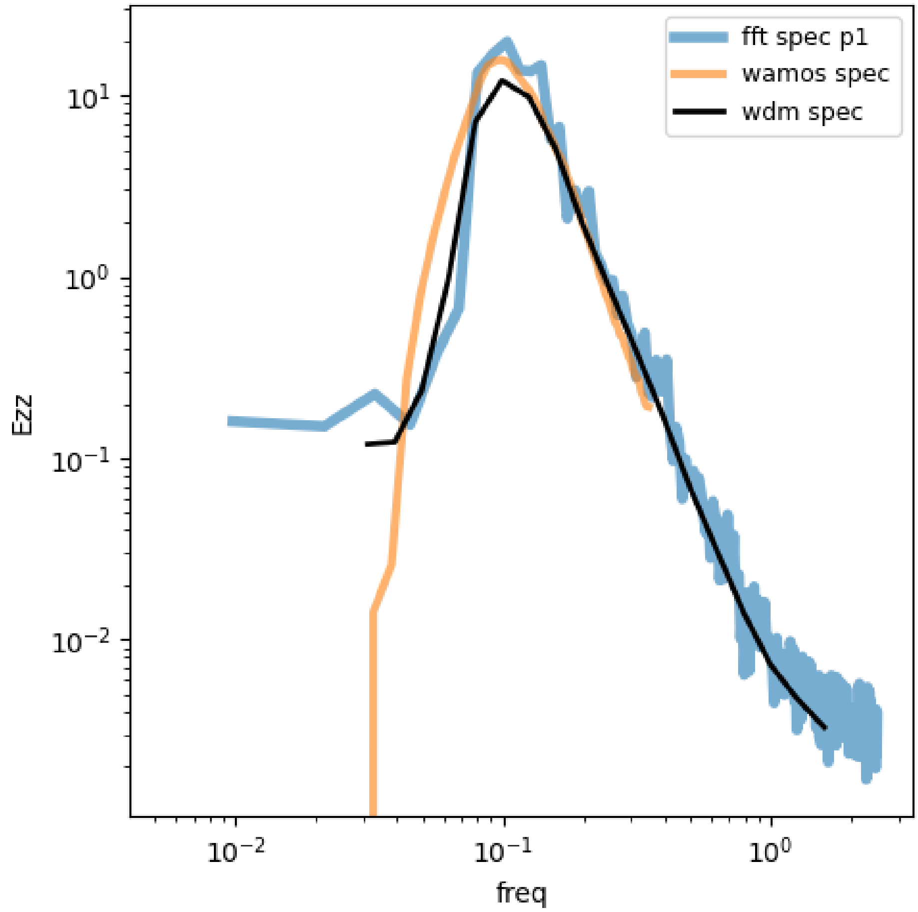
```
# axes[1].set_xlim([100, 200])
axes[1].set_ylim([0.05, 0.3])
axes[1].set_title('WAMOS', fontsize=16)
axes[1].set_xlabel('Direction [deg]', fontsize=16)
plt.tight_layout()
plt.show()
```



Plot frequency spectra (sanity check).

[5]:
```
fig, ax = plt.subplots(figsize=(5,5))
# Regular FFT spectra
for i in range(1):
    dss = wave_spectra.spec_uvz(arr[i], fs=5)
    dss.Ezz.plot(ax=ax, label='fft spec p{}'.format(i+1), lw=4, alpha=0.6)
# WAMOS frequency spectrum
dth = np.deg2rad(dsw.direction[1] - dsw.direction[0]) # dir. res.
ax.loglog(dsw.freq, dsw.WAMOS_spec.sum(axis=0)*dth, label='wamos spec', lw=3,␣
↪alpha=0.6)
# WDM spectrum
ax.loglog(dse.freq, dse.Efth.integrate(coord='direction'), label='wdm spec',␣
↪color='k', lw=2)

ax.legend(fontsize=9)
plt.tight_layout()
plt.show()
```




```
[6]: # Print spectral dataset
dse
```

```
[6]: <xarray.Dataset>
Dimensions:    (freq: 18, direction: 36)
Coordinates:
  * freq       (freq) float64 0.03125 0.03937 0.04961 0.0625 … 1.0 1.26 1.587
  * direction  (direction) int64 9 19 29 39 49 59 69 … 309 319 329 339 349 359
Data variables:
    Efth       (freq, direction) float64 0.0002277 0.0002317 … 1.522e-05
    Hm0        float64 4.148
    fp         float64 0.09921
    mdir       float64 358.2
    dspr       float64 24.54
```