Data on frequency-wavenumber spectra of water waves from videos of the river surface: River Sheaf, UK, Feb-Jun 2019

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Introduction: This data set contains sequences of orthorectified images of the free surface of the River Sheaf, Sheffield, United Kingdom (Latitude: 53.373056° Longitude: -1.463913° (WGS 84)), recorded between February and June 2019, as well as their 3D space-time Fourier power spectrum, and gauging survey data of the stage and flow discharge. The data can be used to test video-based surface velocimetry algorithms in the absence of visible tracers.

Data types:

1. Rectified videos
2. Frequency-wavenumber spectra
3. Inversion Parameters
4. EA gauging survey data
5. Depth measurements

Location

River Sheaf, Sheffield, United Kingdom (Latitude: 53.373056° Longitude: -1.463913° (WGS 84)).

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Table 1: Hydraulic conditions

Measurement Time		Theoretical Stage-Discharge Curve	
Name	Date	D (m)	Q (m^3/s)
F1	02-02-2019	0.20	0.28
F2	21-03-2019	0.29	0.70
F3	08-03-2019	0.30	0.79
F4	08-02-2019	0.39	1.48
F5	12-06-2019	0.47	2.41
F6	12-03-2019	0.62	4.51

1. Rectified Videos

Videos of the free surface were recorded in 6 occasions between February and June 2019 (see Table 1). The camera (Hikvision DS-2CD2T42WD-I8 6mm IP) was installed on the left channel wall at a height of 4.5 m from the river bed, and looked upstream with an angle of approximately 30 degrees. The resolution was 1920×1080 pixels and the frame rate was 20 frames per second. Each video was recorded for approximately 5 minutes. The images were rectified to remove lens and geometry distortions. Intrinsic parameters of the camera lens (i.e. radial and tangential distortion coefficients, camera focal length, and image centre parameters), were determined using a 841×1189 mm checkerboard pattern and the Camera Calibrator App within Matlab 2017b. External parameters of the camera location were surveyed, whilst the view direction was optimized using surveyed ground control points within the camera field-of-view. Changes in water surface elevation over time were accounted for during the orthorectification process[1].

The rectified video frames in .png format can be found in the folder 'RectifiedVideos', for each flow condition. The frame rate was 20 frames per second. The spatial grid size was 0.20 m/pixel. Flow direction was from bottom right to top left.

2. Frequency-wavenumber spectra

The rectified image intensity of each sequence was detrended and normalized locally based on the standard deviation at each pixel. The sequence was split into a set of 10-second sub-sequences. A square portion of the images with size 300×300 pixels (6×6 m) with centre at the (525,558) pixel in the middle of the channel was extracted and Fourier transformed in the two spatial dimensions and in time. The squared modulus of the spectrum of each sub-sequence was averaged across all sub-sequences. The average spectrum I was normalized such that

$$2\pi \iiint I(k_1, k_2, f)\mathrm{d}k_1\mathrm{d}k_2\mathrm{d}f = 1, \tag{1}$$

where f is the frequency and k_1 and k_2 are the components of the wavenumber in the horizontal and vertical direction, respectively.

[1] Messerli & Grinsted (2015), Geoscientific Instrumentation, Methods and Data Systems

Table 2: Spectra

Structure name	Variable	Units
DataSpectrum.PowerSpectrum:	power spectra	non dim.
DataSpectrum.k1:	horiz. wavenumber component	rad/m
DataSpectrum.k2:	vert. wavenumber component	rad/m
DataSpectrum.f:	frequency	Hz

Table 3: Inversion Parameters

Structure name	Physical variable	Units
InversionParameters.MeasTime:	flow condition and date	non dim.
InversionParameters.U:	estimated flow speed at the surface	m/s
InversionParameters.d:	estimated water depth	m
InversionParameters.G:	optimization parameter	non dim.
InversionParameters.a:	estimated velocity index	non dim.
InversionParameters.Q:	estimated flow rate	m^3/s
InversionParameters.Q_a085:	estimated flow rate ($\alpha = 0.85$)	m^3/s

The frequency-wavenumber spectra can be found in the folder 'Spectra', for each flow conditions, in .mat format.

3. Inversion Parameters

The frequency-wavenumber spectra were analyzed by means of the procedure described in **Dolcetti, G., Hortobágyi, B., Perks, M., Tait, S.J. and Dervilis, N. (2020), Analysis of surface wave image spectrum to estimate river discharge (manuscript in preparation)** to provide an estimate of the surface speed of the flow U, water depth d, velocity index α, and river discharge Q. α is the ratio of the depth-averaged velocity to surface velocity. An additional estimate of the discharge obtained with $\alpha = 0.85$ is indicated as $Q_{0.85}$. The estimation is based on the maximization of an optimization parameter G.

The values of the inversion parameters calculated based on the present data set for each flow condition can be found in folder 'InversionParameters', in a single .mat file.

4. EQ gauging survey data

Gauging survey data was collected at various times starting from 1993 at a nearby gauging station operated by the UK Environment Agency. The gauging station is located approximately 25 m downstream of the measurement section. Data contains stage measured by a gauging apparatus and corresponding surveyed river discharge, and is time stamped. Measurements taken before 19-04-2011 were gauged with a standard metre device. Measurements from and including 19-04-2011 were obtained by means of an Acoustic Doppler Current Profiler (ADCP). The data is in .csv format, and can be found in the folder 'EA-GaugingSurvey'. Contains public sector information licensed under the Open Government Licence v3.0

5. Depth measurements

Additional measurements of the flow depth were performed in two separate occasions (18 November 2019, and 07 December 2019). The measurements were performed at 25 locations regularly distributed over an 8×8 m area that contained the video measurement section. The data in .mat format can be found in the folder 'DepthMeasurements'. The structure MeasDepth.Stage reports the stage measured by the gauging apparatus at the same times as the depth measurements. The structure MeasDepth.depth contains the corresponding 25 measurements of the flow depth. Units are meters.