A Grid-Based Interpolation Procedure for Turbulence Analysis in Riverine Settings

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INTRODUCTION

We introduce a methodology for a comprehensive characterization of river flows from transects surveyed at different times, over near coincident transects from acoustic Doppler current profiler (ADCP) data acquired from a moving vessel. This approach allows computing of time and spatial averages of ADCP velocities from which mean velocity, turbulence fluctuation, spectral power density and vorticity can be quantified. A case study with a data set from the Tanana River in Nenana, Alaska is presented.

AIMS

Provide a foundation for a comprehensive river characterization analysis, allowing for:

- improvements in our understanding of sediment transport, riverbed conditions, debris avoidance and fish studies.
- Study the relationships between eddy size and turbine size.

METHODS

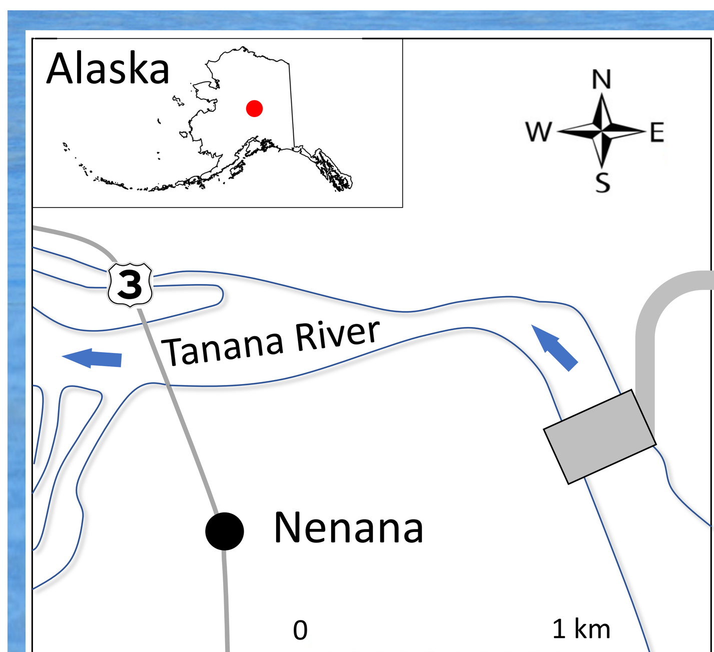

Fig. 1 Study area at Nenana, Alaska.

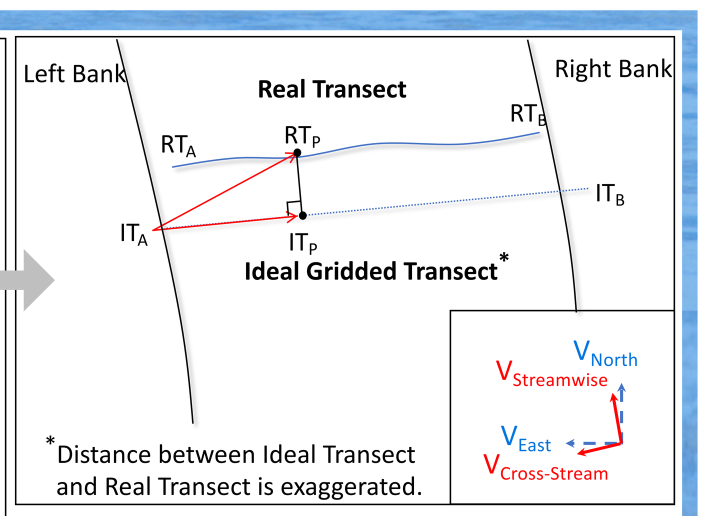

Fig. 2 Location of transects in Tanana River, showing rotation of East and North velocities (V) into streamwise and cross-stream horizontal flows that are projected onto a grid points on an ideal transect.

ADCP measurements were processed through the following algorithm and results interpreted:

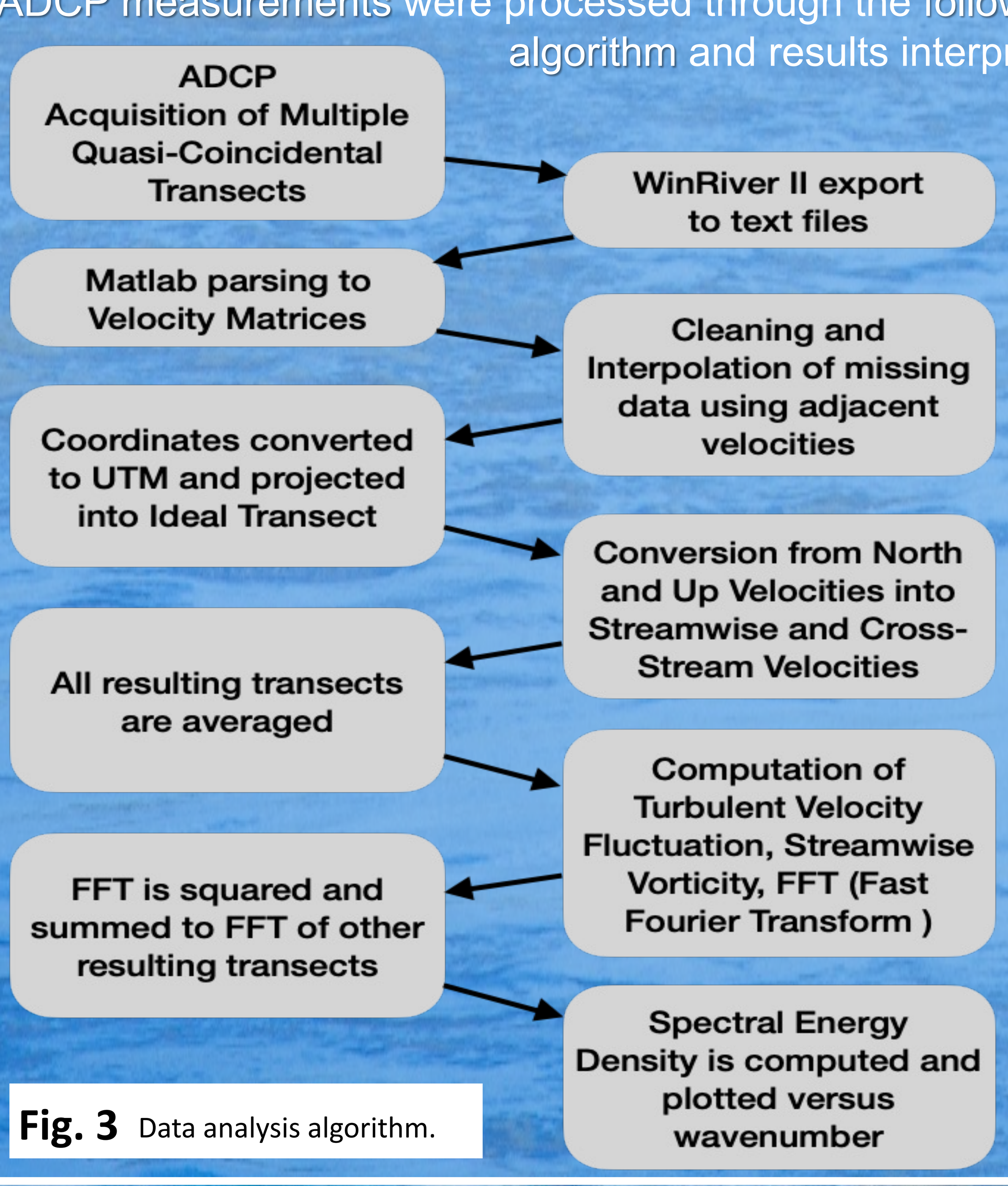

Fig. 3 Data analysis algorithm.

RESULTS

Streamwise and cross-stream velocities and streamwise vorticity for the ideal transect, are shown with turbulent fluctuations computed from a measured transect in Fig. 4.

To validate the ADCP-derived spectra and turbulence size, estimates we compare ADCP to ADV data. Fig. 5 shows spectral density for the ideal gridded transects from ADCP data, while Fig. 6 displays the spectral energy density from fixed ADV measurements. The integral length scale of the streamwise velocity was calculated as 1.45 m following El-Gabry et al. (2014) for ADV data, which indicates good agreement with the largest eddy size of 1.39 m from ADCP data. **The integral length scale indicates the largest eddy size in the turbulent fluid.**

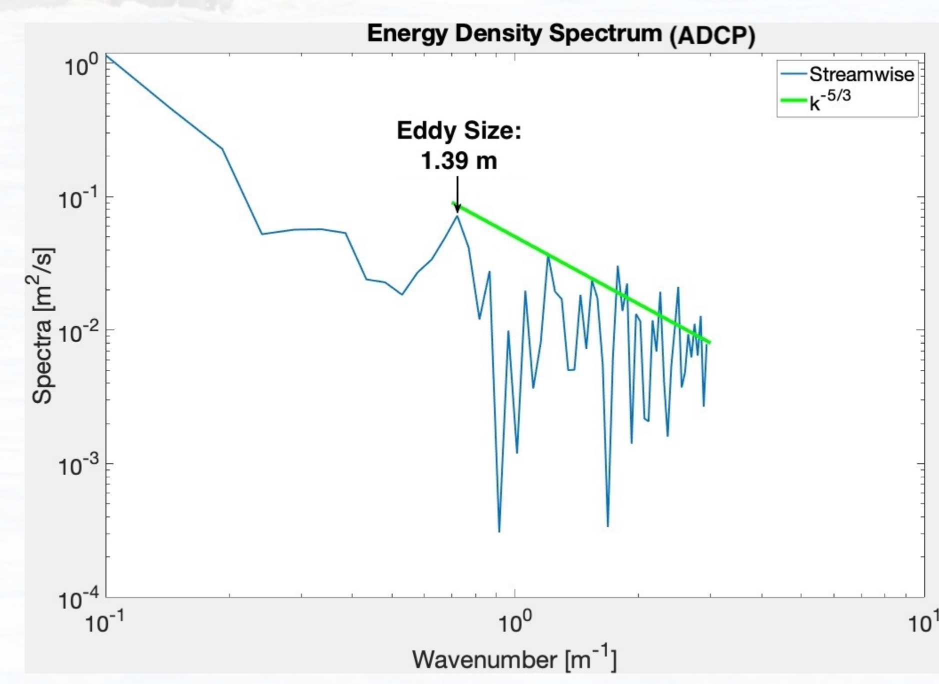

Fig. 5 Spectral energy density for ideal transect from gridded ADCP data.

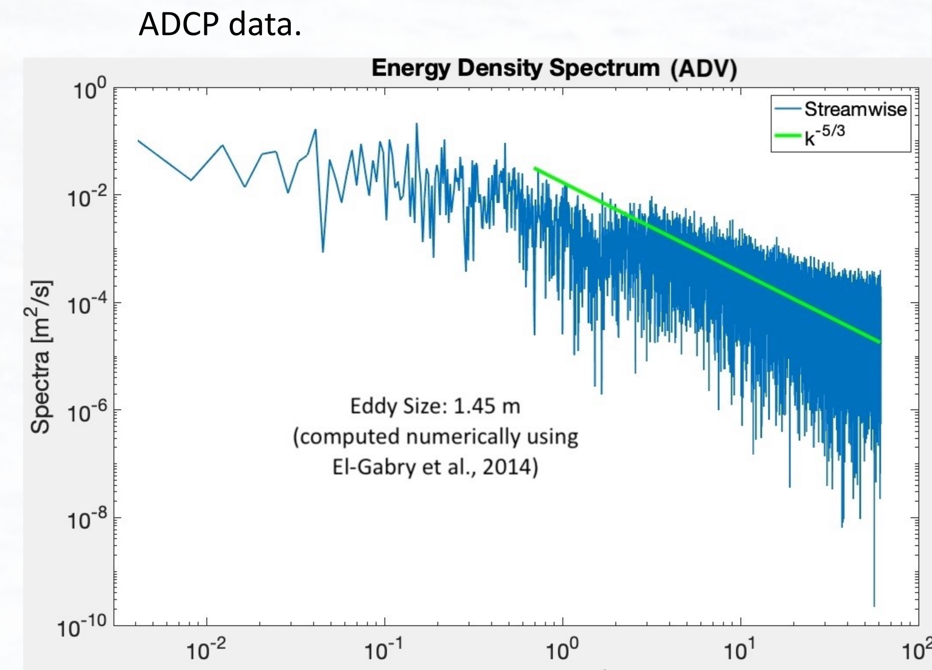

Fig. 6 Spectral energy density from measured ADV data.

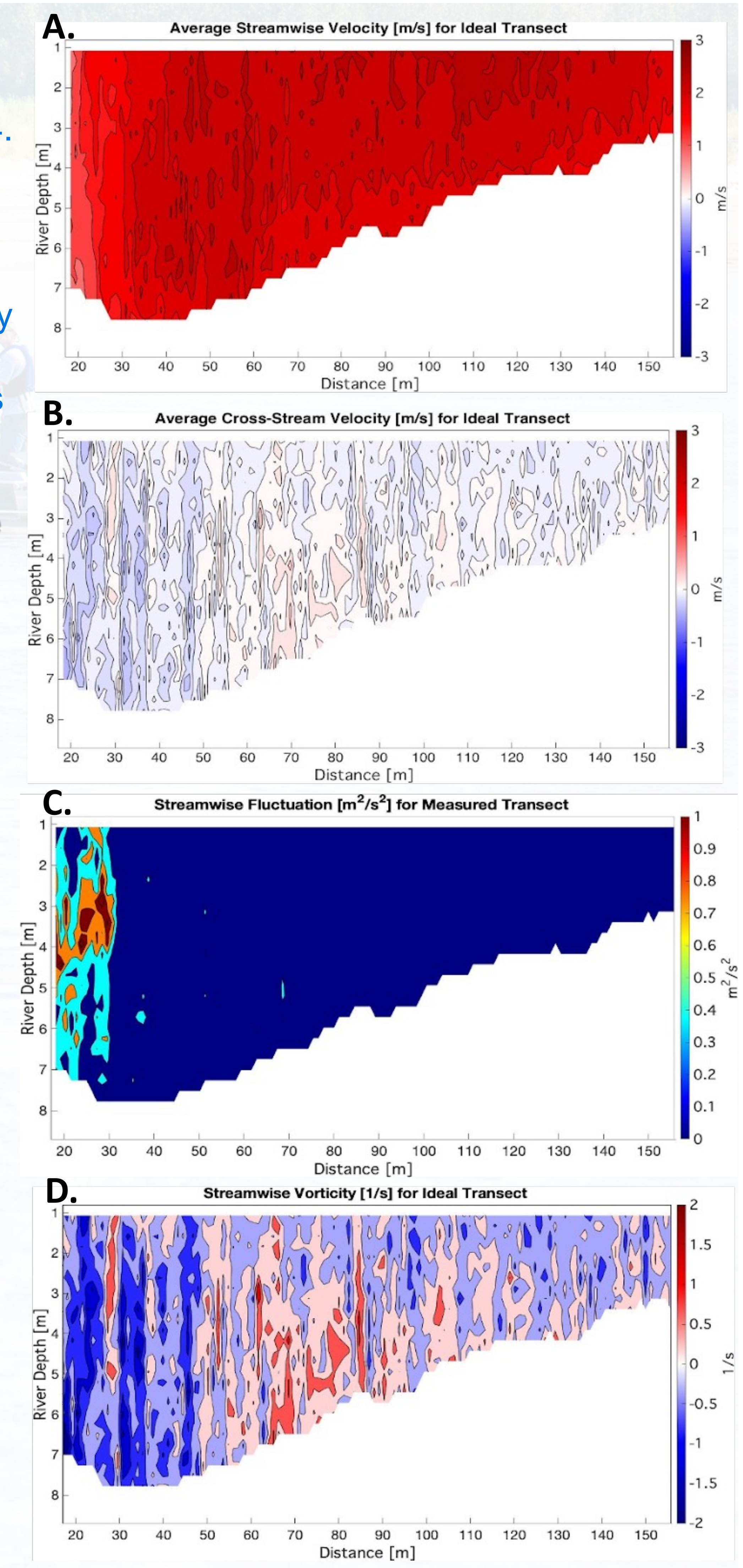

Fig. 4 **A)** Average streamwise and **B)** cross-stream velocities for the ideal transect; **C)** streamwise turbulence fluctuation computed from one measured transect and **D)** streamwise vorticity for the ideal transect.

CONCLUSIONS

This process provides the computation of time and spatial averages of ADCP velocities from where mean velocity, turbulence fluctuations, spectral power density and vorticity can be quantified. It also provides the foundation of a comprehensive river characterization analysis which allows for improvements in our understanding of sediment transport and riverbed conditions (Johnson et al., 2013), strategies for debris avoidance (Johnson et al., 2015a, Johnson et al., 2015b, Kasper et al., 2015), and fish studies (Bradley et al., 2015). The use of wavenumber instead of frequency enables the study of relationships between eddy size and turbine size.

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