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ACCURACY OF SPATIAL AND TEMPORAL AVERAGING OF ACOUSTIC DOPPLER CURRENT PROFILER (ADCP) MOVING BOAT MEASUREMENTS

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1. BACKGROUND

- Characterization of mean velocity and flow structures in rivers and tidal flow is crucial for the annual energy production estimation and structural design of MHK devices.
- ADCP moving vessel deployments provide 3D velocity data in a large spatial region, but the data are degraded by various factors, e.g. Doppler noise, large sampling volume, beam divergence
- Spatial and temporal averaging may improve data accuracy, but standard procedures are needed to quantify and correct errors

2. OBJECTIVE

To assess the accuracy of spatially-averaged ADCP moving vessel measurements against time-averaged ADCP fixed-vessel measurements.

3. DATA COLLECTION

ADCP moving vessel measurements (MV) and fixed vessel measurements (FV) were conducted in a 2.75 m wide and 1.8 m high straight channel.

- **Moving vessel measurements:**
  3 different horizontal bin sizes (y_{bin} : 8mm, 16mm and 32mm)
  1 vertical bin size (z_{bin} : 16mm)
  5 traverses were measured for each horizontal bin size
- **Fixed vessel measurements:**
  9 profiles -5 minutes data- at various distance across the channel
  1 vertical bin size (z_{bin} : 16mm)

Figure 3.1. ADCP and high resolution traversing system

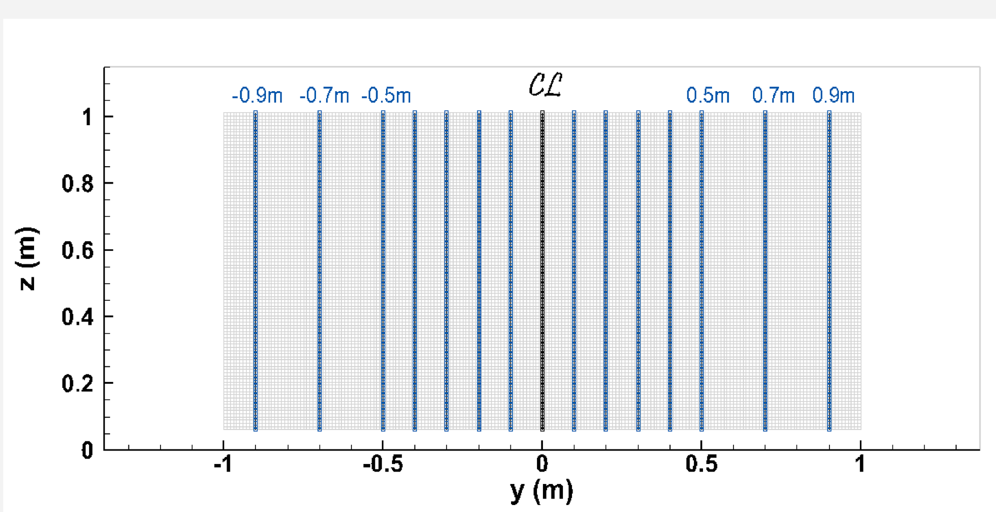


Figure 3.2. Measurement locations: Fixed vessel (blue and black lines); Moving vessel (grey region)

4. DATA POST-PROCESSING

Moving vessel measurements:

- 5 traverses were spatially and temporally averaged, as recommended by Szupiany et al.(2007)
- Distance weighted averaging with minimum distance smoothing was applied per Gunawan et al. (2010)
- Difference of discharge before and after averaging was compared for quality assessment

Fixed vessel measurements:

- Velocity data were post-processed using the Phase-Space Thresholding method (Goring and Nikora 2002), using the code outlined in Gunawan et al. (2011)

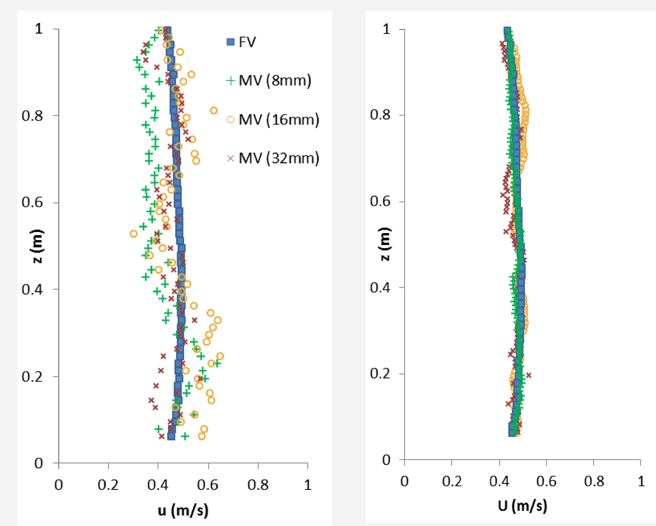
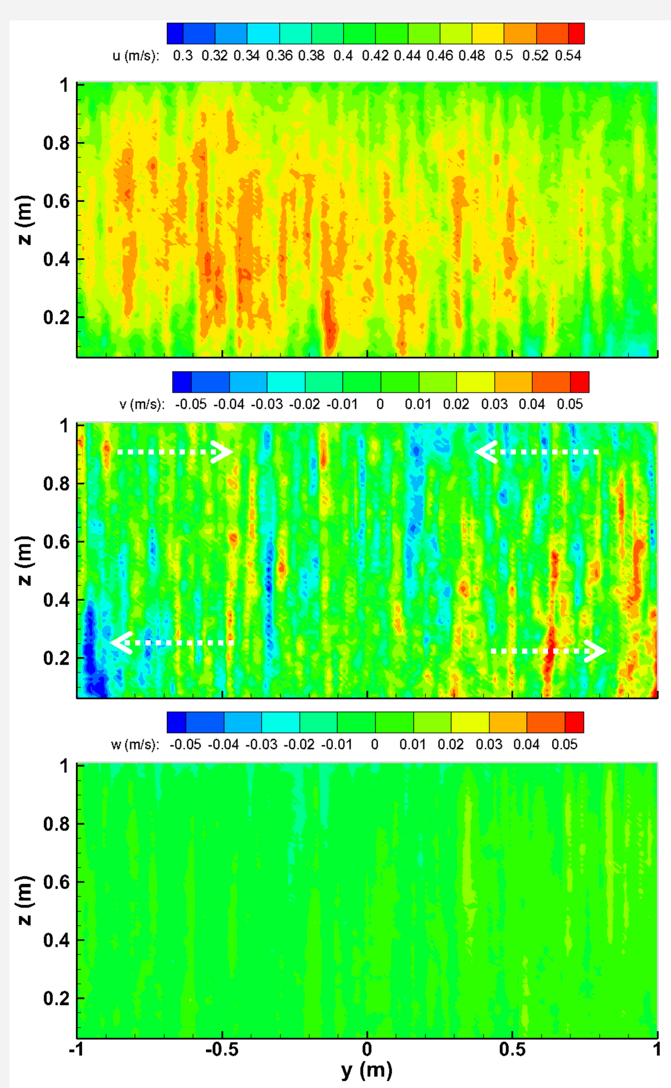


Figure 4.1. Left : Raw MV data Vs. FV data; Right : Spatially and temporally averaged MV data Vs. FV data

5. RESULTS

5.1. Mean velocity contours



Streamwise velocity

- High velocity core is slightly shifted to the left of the channel centerline
- Discharge before and after averaging differs by 0.58%

Lateral velocity

- Reynolds stress driven secondary flow may be inferred from the figure

Vertical velocity

- W is in the order of 1% of U
- W distribution varies less than V distribution

Figure 5.1. Spatial and temporally averaged MV data for bin size 8mm x 16mm (looking downstream)

5.2. Velocity profiles

- Velocity profiles from spatially and temporally averaged moving-vessel measurements (STMV) were assessed against the velocity profiles obtained from fixed-vessel measurements
- In general, decreasing the MV bin size increases the accuracy of the spatially and temporally averaged velocity

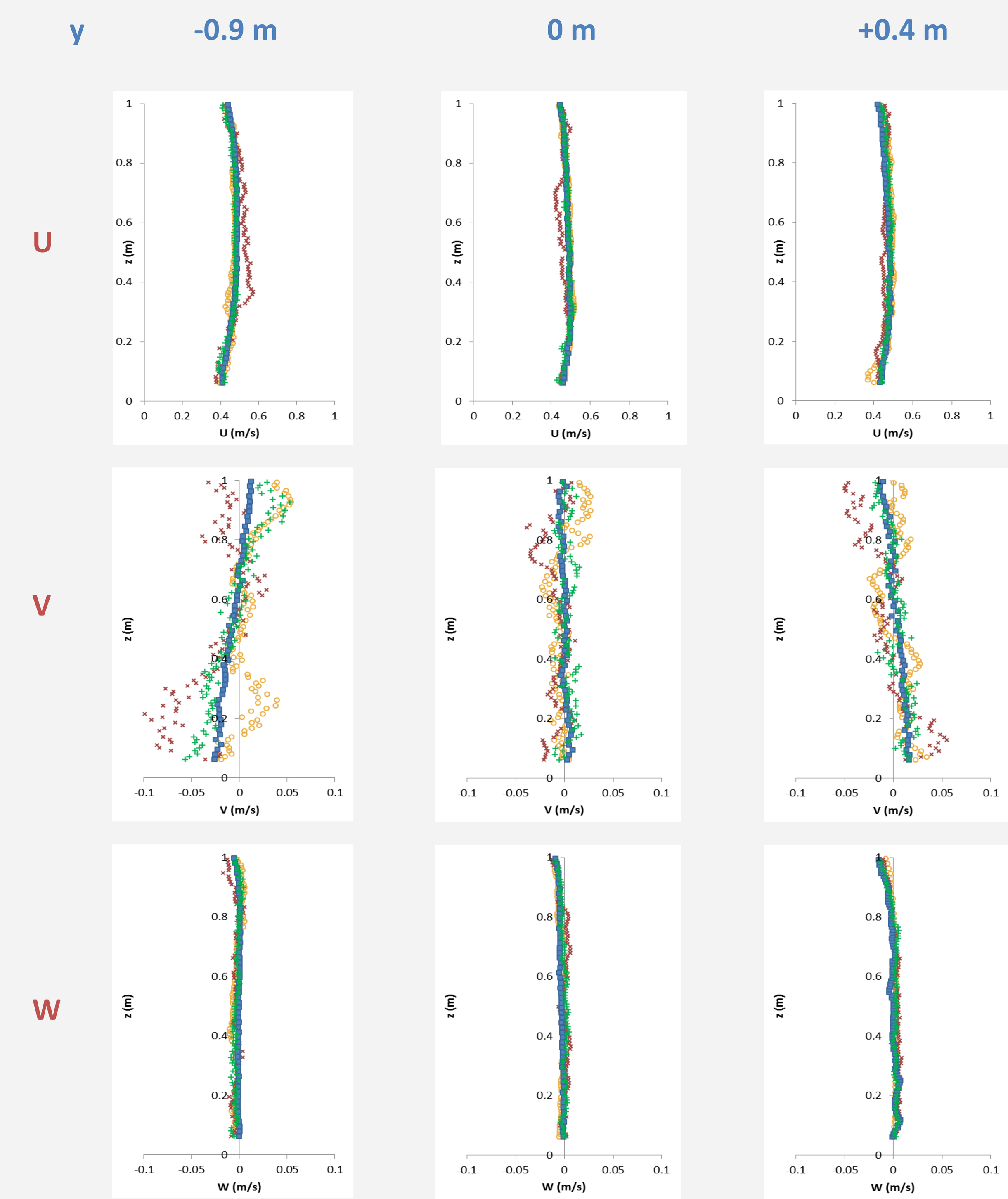


Figure 5.2. Comparison of U, V and W profiles at three locations across the channel

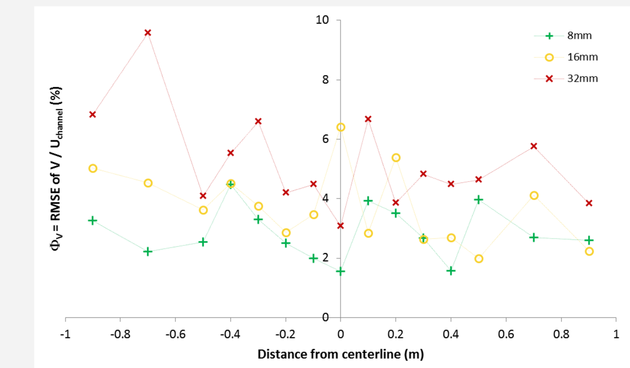
5.3. Root mean squared error (RMSE)

$$RMSE_{U_i} = \sqrt{\frac{\sum_{j=1}^{j=n}(U_{ij} - \hat{U}_{ij})}{n}}$$

$\hat{U}_{ij}$ = Velocity component i at depth j (FV)

U_{ij} = Velocity component i at depth j (MV)

- Normalized RMSE (Φ) values for all three STMV cases are less than 10% (Fig.. 5.3.)
- Accuracies of STMV from data with y_{bin}/z_{bin} :value = 1 are within 4.3% for all velocity components (Table 5.1)
- Accuracies of STMV improved by 23-26% for y_{bin}/z_{bin} :value = 0.5
- Accuracies of STMV U and V decreased by 40-46% for y_{bin}/z_{bin} :value = 2; for STMV W, the accuracy only decreased by 7%



$$\Phi_{U_i} = \frac{RMSE_{U_i}}{U_{Channel}}$$

$U_{Channel}$ = Mean streamwise velocity of the ADCP transect area in Fig. 3.2

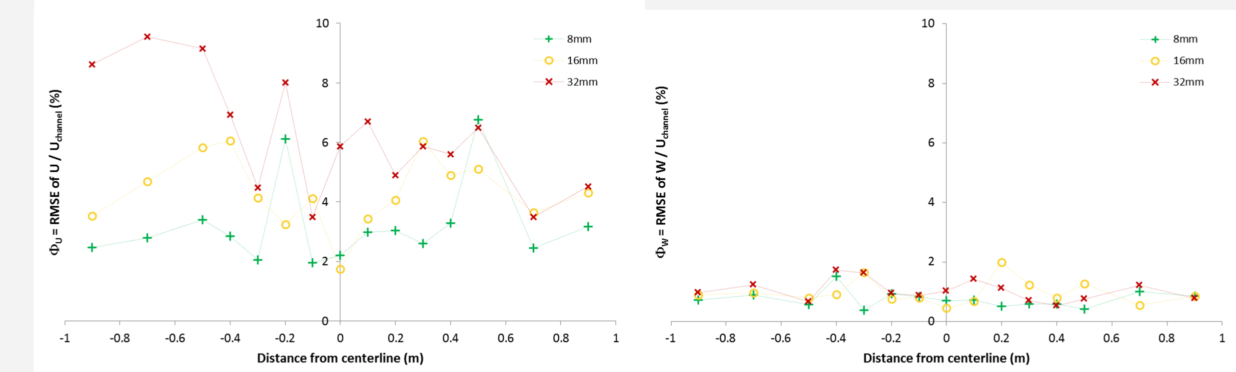


Figure 5.3. Normalized RMSE values at various locations across the channel

y_{bin} =	8mm	16mm	32mm
Φ_U	3.2	4.3	6.2
Φ_V	2.9	3.7	5.2
Φ_W	0.7	1.0	1.0

Table 5.1. Average of normalized RMSE values (in percent)

6. SUMMARY

- Decreasing vessel speed increases the size horizontal bin size and increase the accuracy of STMV
- In order to obtain an accuracy within 5%, y_{bin} should be equal to z_{bin} (i.e. vessel speed x ADCP sampling frequency = z_{bin})

7. REFERENCES

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8. ACKNOWLEDGEMENTS

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9. POINT OF CONTACT

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