12 Comparison of Flow Velocity Vectors Collected by Using RTK-GPS and Bottom-Tracking as a Reference on a Boat Mounted ADCP

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12.1. Introduction

The survey of current velocities in the ocean and riverine environment has been greatly improved with the appearance of acoustic Doppler current profilers (ADCPs) which became standard survey equipment for flow measurements in natural streams and artificial canals. ADCP is highly efficient and reliable instrument for flow measurements and is particularly useful for discharge measurement under different flow conditions that cannot be adequately measured by conventional current meters. Two of the most relevant advantages of ADCP application relative to traditional current meters are that ADCP measurements can be made in much less time, and that they provide three-dimensional velocity information [1, 8]. In hydrometry, their primary use is the measurement of river discharge and channel bed survey from a moving boat [19].

The acoustic Doppler current profiler (ADCP) is a device capable of making continuous current measurements at more than one depth from a moving ship. This instrument consists of four transducers set at an angle of 20° in a concave ("Janus") configuration, which transmits acoustic pulses and receives echoes from small particles such as zooplankton, sediments, or other solid particles. Using the Doppler frequency shift measured by the transducer, ADCP can compute the component of vector of the water's velocity along the beam direction and describe a profile of the current throughout the water column [6]. For measuring three velocity components ADCP utilizes four beams pointing in different directions [10]. The current and emerging applications of ADCPs have prompted the need for identifying sources of measurement errors, assessing the impact of these errors on the quality and reliability of the measurements, and developing good measurement practices. Estimates of total ADCP measurement uncertainty are necessary to properly report ADCP discharge data collected for the calibration of water control structures used for indirect real-time flow monitoring [9]. ADCPs mounted on moving vessels measure the velocity of the water relative to the velocity of the instrument. To obtain absolute water velocity, velocity of the instrument (boat speed and course) must be measured and subtracted from the measured relative water velocity:

$$\vec{v}_{water(ABS)} = \vec{v}_{water(REL)} - \vec{v}_{boat} \quad [\text{m/s}] \tag{1}$$

where: $v_{water\,(ABS)}$ – absolute water velocity [m/s],
$v_{water\,(REL)}$ – relative water velocity [m/s],
v_{boat} – ship speed [m/s].

Boat velocity v_{boat} can be acquired either by using the built-in bottom track option or by using external navigation data (GPS). Bottom track data can be used by ADCP to determine its velocity relative to the streambed using the Doppler Effect under assumption that the riverbed is motionless [17]. Apparent movement of the bottom measured this way equals negative vector of the boat velocity. This procedure is effective and convenient because there is no need for an external device (GPS), which could introduce an error [16].

12.2. Sources of Errors in Boat Speed Estimation

Flow currents deduced from shipboard ADCP data contain errors from three main sources: (a) the relative motion of water in relation to ADCP transducers, (b) the movement of the boat during transect and (c) instrument heading [11]. In this paper will be analyzed boat course and instrument heading, as well as their mutual interaction.

12.2.1. Influence of Sediment Transport on Measurements

Sediment transport is a fundamental aspect of natural river flows. The spatiotemporal distribution of bed material transport through a river reach determines river morphology. Sediment transport along and near the streambed can introduce bias in bottom track measurement method. If an ADCP is held stationary in a stream and the streambed is moving, the ADCP will interpret this condition as upstream movement of the ADCP. The underestimation of measured velocity and discharge by ADCP discharge measurements attributed to the movement of sediment near the streambed is an issue widely acknowledged by the scientific community [13]. Error in measured discharge using vessel-mounted ADCPs biased by bed load transport is referred to as moving bed error.

The integration of a global positioning system GPS to measure the speed of the boat has been shown to alleviate the errors associated with a moving bed. The method assumes that GPS provides an accurate and precise measure of boat speed. Errors in GPS are transferred directly as errors in absolute water velocity [18]. When GPS data is used as reference for boat speed it is determined from the difference between two GPS position fixes. This method produces boat speed vector between two measured position fixes. In this way calculated boat course actually represents boat's bearing between two points in given time interval Δt, and not course. Bottom track method measures instantaneous data of boat course and more accurately descripts boat movement. Boat speed and course acquired by bottom track is instantaneous and synchronized in time with related water velocity data. Boat speed and course acquired from GPS data are not synchronized with water velocity data. For given measurements 1 Hz RTK GPS was used so on three water velocity ensembles acquired through ADCP in 1 second comes one data on boat speed and course.

12.2.2. True Earth and ADCP Coordinate System

Bottom tracking's biggest advantage over external devices is that many of its largest errors are matched by exactly the same errors in the current profile. These common-mode errors then cancel exactly when bottom track velocity is subtracted from the current profile data. Major common-mode errors include compass errors and velocity biases caused by beam pointing errors. This advantage arises from the fact that bottom tracking and current profiling use the same coordinate system. In contrast; boat's navigation and current profiling share no common-mode errors. Using GPS with ADCPs eliminates the effect of a moving bed on the velocity measurements but introduces several sources of potential error. Understanding how GPS operates and how it is used with ADCPs is important for collecting high-quality ADCP measurements when using GPS data as the boat-velocity reference.

The orientation of the ship fore relative to true North is needed to project the relative velocity components into geographic ones (Fig. 1). Any misalignment angle is known from installation and corroborated through compass calibration, because if not spurious current velocities will appear. ADCPs are equipped with internal tilt sensors to measure pitch and roll, and an internal compass to measure heading. Instrument heading errors propagate through the transformation from ship to true earth coordinates for data collected with ADCP. Compass errors due to incorrect magnetic declination do not effect ADCP discharge measurements by bottom tracking. However, errors in compass calibration bias ADCP discharge measurements by GPS tracking [9].

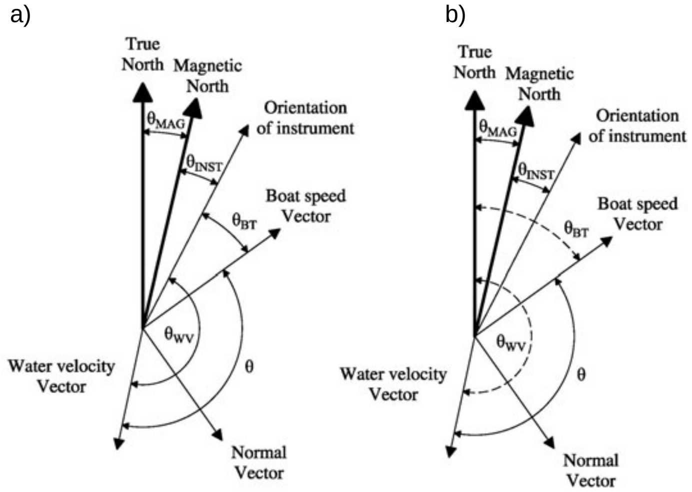

Fig. 1. Boat speed vectors reference by (a) bottom tracking and (b) GPS (adapted from Mueller, 2002)

When bottom tracking is used, the direction of the boat velocity vector as measured by bottom tracking (θ_{BT}) and water velocity vector (θ_{WV}) are referenced to the ADCP (Fig. 1a). The ADCP has an internal fluxgate compass to measure the orientation of the instrument (θ_{Inst}) relative to the magnetic north. The water velocity vector can be easily referenced to magnetic north by rotating the vector based on the measured θI_{nst} and to true north by again rotating the vector by a user-specified magnetic variation (θ_{Mag}). The magnitude of the water velocity is unaffected by any errors in the measurement of θI_{nst} or entry of θ_{Mag} when bottom tracking is used as the boat-velocity reference [14].

To compute the discharge, only the angle between the water velocity and the boat-velocity vectors is needed [19]:

$$Q = \int_0^T \int_0^D \left|\overrightarrow{v_w}\right| \left|\overrightarrow{v_b}\right| \sin\theta \cdot dzdt \tag{2}$$

where: Q – total discharge [m^3/s],
T – total time for which data were collected [s],
D – total depth [m],
$|\vec{v}_w|$ – semi-instantaneous water velocity vector [m/s],
$|\vec{v}_b|$ – boat speed vector [m/s],
θ – angle between the water velocity and boat speed vectors [°] (Fig. 1),
dz – vertical differential depth,
dt – differential time.

When GPS is used to determine the boat speed vector, this vector is referenced to true north as determined from the GPS data (Fig. 1b). The orientation of the instrument relative to true north must be determined to put the boat speed vector and the relative water velocity vector in the same coordinate system and allow for the computation of the water velocity vector and θ. The errors associated with θ_{Inst} can cause errors in the measured discharge that are proportional to the speed of the boat [14].

12.2.3. Compass Calibration

An error in the compass reading can be caused by distortion in the earth's magnetic field because of local objects on the boat, and displacement of the compass out of the horizontal position. The amount of distortion of the magnetic field by objects near a compass depends on the shape, material content, and proximity of the object to the compass. Objects that distort the magnetic field are commonly classified as hard iron and soft iron. Hard iron can be permanent magnets, and soft iron is material that, when placed in a magnetic field, will become magnetized. For ADCPs, hard iron and soft iron consist of the boat, instrument mount, objects on the boat, or structures near the measurement section such as bridges [15]. Errors associated with fluxgate-compass measurements caused by environmental conditions can be classified as one- and two-cycle errors. One-cycle errors are caused by permanent magnets and current-carrying conductors; two cycle errors are caused by iron and magnetically permeable material. ADCPs manufactured by TRDI for making discharge measurements from a moving boat have firmware routines to allow the calibration of the compasses in place to compensate for environmental conditions [14]. The result of the distortion of the magnetic field on compass heading is typically not constant and varies with heading. Compass errors caused by hard iron and soft iron vary with heading and can be modeled as sine and cosine curves. The general equation for compass error for a compass mounted on a boat is [15]:

$$\varepsilon = A + B\sin(\theta) + C\cos(\theta) + D\sin(2\theta) + E\cos(2\theta) \tag{3}$$

where: ε – compass error,
θ – compass heading [°],
A – coefficient that accounts for compass alignment,
B – coefficient that accounts for the fore-aft permanent magnetic field across the compass and a resultant asymmetrical vertical induced effect,
C – coefficient that accounts for the port-starboard permanent magnetic field across the compass, and a resultant asymmetrical vertical induced effect,
D – coefficient that accounts for symmetrical arrangements of horizontal soft iron and
E – coefficient that accounts for asymmetrical arrangements of horizontal soft iron [13].

A hypothetical compass error curve is shown in the following figure (Fig. 2).

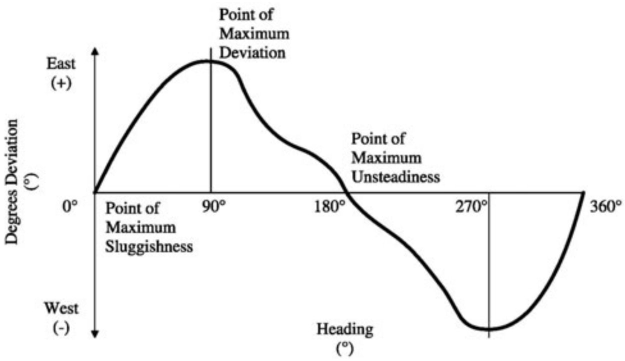

Fig. 2. Hypothetical uncompensated deviation curve as introduced by National Geospatial-Intelligence Agency [15]

Proper setup and calibration of the ADCP's internal compass, determination of the local magnetic variation, and a slow boat speed are critical to quality discharge measurements made by using GPS data as the boat speed reference.

12.2.4. Aim and Scope of This Paper

In this paper it will be analyzed survey data collected with ADCP on 5 independent measurements. The aim is to determine how much uncorrected or poorly corrected ADCP compass can influence discharge measurements. Analyses will include measurements in motionless riverbed conditions and during occurrence of moving riverbed.

12.3. Available Flow Measurements

Analyzed flow velocity measurements analyzed were collected on the Drava River on three locations: Nemetin, Osijek and Koprivnica. The average annual discharge of the Drava River is 522 m^3/s and the river width on given reach varies from 150 – 200 m [7, 12]. The ADCP used for discharge measurements is 1200 kHz broadband with transducer beams at angle of 20 degrees. For location Nemetin were conducted three measurements in year 2010: measurement *m*24 on April 30, *m*25 on July 19 and *m*26 on September 1 [2, 3, 4, 5]. Discharge was collected on 24 transects for each measurement under motionless riverbed conditions. For location Koprivnica was conducted one measurement, *m*01 on April 12, 2011. Discharge was collected on 7 transects under motionless riverbed conditions. For location Osijek was conducted one measurement, *m*02 on May 4, 2011. Discharge was collected on 6 transects under moving bottom conditions.

Flow velocity measurements *m*01, *m*24, *m*25 and *m*26 were conducted in conditions without moving bottom which could introduce bias in water velocity calculation [1]. On each location multiple transects were made to assure that wide angle of ADCP heading is covered. For location Nemetin measurements covered heading between 170 and 50°N (clockwise orientation). For location Koprivnica measurements covered heading between 200 and 310°N. For location Osijek measurements covered heading between 200 and 300°N. Measurements *m*24, *m*25 and *m*26 were conducted using uncorrected compass, while measurement *m*01 was conducted with corrected compass. Measurement *m*02 was conducted both with corrected and uncorrected compass.

12.4. Results and Discussion

In this paper are first shown results from measurements on location Nemetin. Results are shown for discharge measured on 24 transects in three independent measurements; *m*24, *m*25 and *m*26. Discharges are collected with uncorrected compass and are represented as relative ratio ΔQ_{REL} between discharge collected with GPS as boat reference (GGA) and one collected with bottom track as a boat reference (BT):

$$\Delta Q_{REL} = \frac{Q_{GGA} - Q_{BT}}{Q_{BT}} \cdot 100\,[\%] \tag{4}$$

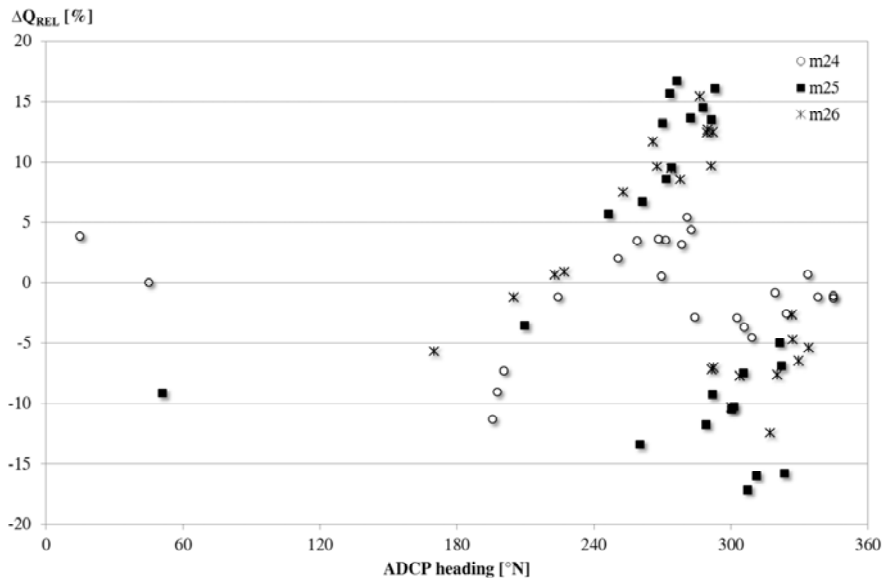

Fig. 3. Scatter plot of relative difference between measured discharges ΔQ_{REL} and instrument heading for location Nemetin

Measured discharge for measurement *m*24 varied from 408 to 457 m^3/s when BT was used as boat reference and from 383 to 465 m^3/s when GGA was used as boat reference; for measurement *m*25 varied from 391 to 448 m^3/s (BT) and from 349 to 509 m^3/s (GGA); for measurement *m*26 varied from 482 to 640 m^3/s (BT) and from 474 to 688 m^3/s (GGA). Below is given table (Tab. 1) with collected data from measurement *m*25. Data is averaged across cross-section and depth for each transect, and contains information about instrument heading, water velocity and direction, boat speed and course and discharge. Data is shown for both ship references, BT and GGA. Fig. 3 gives scatter plot of relative difference between measured discharges ΔQ_{REL} for all transects and all measurements on location Nemetin. Data is displayed in relation to ADCP heading.

Table 1

Data collected on measurement *m*25

Transect	Heading	Reference: BT					Reference: GGA					ΔQ_{REL}
		Q	Vel_{WATER}	Dir_{WATER}	Vel_{BOAT}	Crs_{BOAT}	Q	Vel_{WATER}	Dir_{WATER}	Vel_{BOAT}	Crs_{BOAT}	
	[°N]	[m^3/s]	[m/s]	[°N]	[m/s]	[°N]	[m^3/s]	[m/s]	[°N]	[m/s]	[°N]	[%]
0	260	442	0.75	139	1.00	39	383	0.68	140	1.00	35	–13
1	51	444	0.79	152	0.99	50	403	0.74	154	0.98	46	–9
2	293	433	0.77	155	0.93	255	503	0.87	156	0.94	248	16
3	273	436	0.62	158	1.09	246	504	0.70	162	1.08	241	16
4	291	448	0.79	152	0.83	251	509	0.88	153	0.83	244	13
5	288	443	0.81	145	0.90	248	507	0.91	146	0.90	242	14
6	276	394	0.87	125	0.89	242	460	0.98	127	0.88	231	17
7	282	431	0.83	138	0.82	239	489	0.93	139	0.82	233	14
8	305	424	0.83	137	0.86	48	393	0.79	139	0.86	46	–7
9	270	391	0.88	124	0.92	229	442	0.96	125	0.90	221	13
10	274	434	0.84	127	0.71	224	475	0.92	127	0.71	217	10
11	272	421	1.14	122	0.83	216	458	1.25	122	0.82	208	9
12	322	401	0.97	119	0.49	20	374	0.94	120	0.49	25	–7
13	321	412	0.92	118	0.53	32	392	0.89	118	0.52	20	–5
14	261	443	0.87	112	0.68	210	473	0.94	112	0.67	204	7
15	246	423	0.80	102	0.83	203	447	0.84	102	0.83	200	6
16	324	428	0.65	114	0.69	142	361	0.60	120	0.69	176	–16
17	311	427	0.68	100	0.65	306	359	0.62	103	0.65	326	–16
18	301	422	0.70	89	0.55	275	379	0.65	90	0.54	328	–10
19	307	421	0.69	92	0.78	334	349	0.61	95	0.78	340	–17
20	300	428	0.72	86	0.62	293	383	0.67	87	0.61	340	–10
21	210	420	0.78	72	0.73	160	405	0.76	72	0.73	162	–4
22	292	420	0.76	77	0.71	316	381	0.70	77	0.71	330	–9
23	289	423	0.70	69	0.80	330	373	0.63	71	0.80	326	–12

From given scatter plot (Fig. 3) it is visible that there is no unambiguous relation of discharge collected with GGA and BT as boat reference. For some transects Q_{GGA} is greater than Q_{BT}, and on some is smaller, and relative difference ΔQ_{REL} ranges between –20 and +20%. However, there is visible trend for heading under 230°N and over 290°N which shows that Q_{GGA} is smaller than Q_{BT}, and that for heading between 230°N and 290°N Q_{GGA} is greater than Q_{BT}.

As mentioned before, only difference between discharge calculation in relation to boat reference is in transformation between different coordinate systems. When bottom track option is used there is no need for transformations between coordinate systems as there is only one, which is oriented relative to ADCP beam configuration. When GPS is used as reference collected flow data, as well as boat speed data, are transformed into true earth (N–E) coordinate system. Boat speed is calculated and transformed from raw GPS data through Ellipsoid transformation, while flow velocity data are transformed into true earth coordinates through utilization of compass integrated in ADCP unit. Different values in discharges acquired by BT and GGA mode are result of different boat course measurement. Figure (Fig. 4) shows one spatial distribution of boat speed and course data collected on one transect from *m*25.

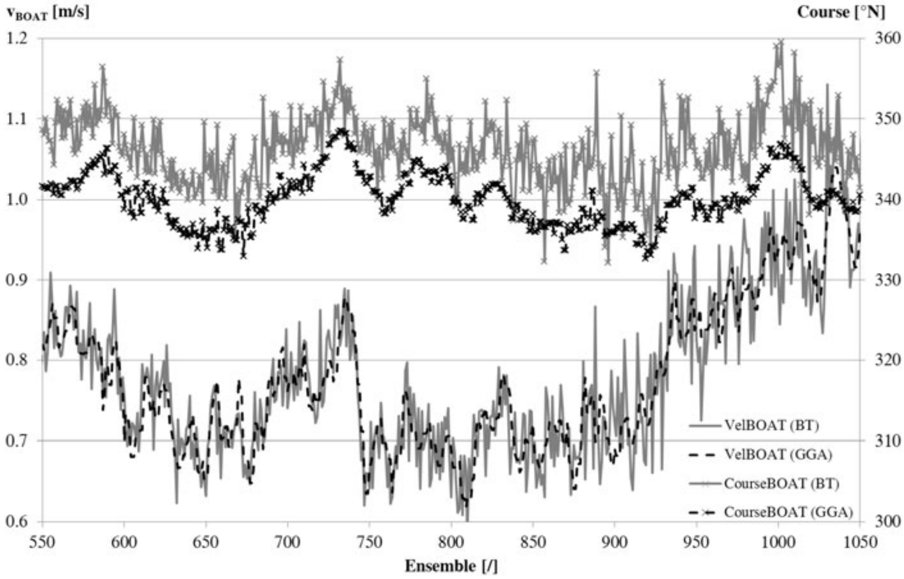

Fig. 4. Spatial distribution of boat speed and course data for transect 19 measured on *m*25

Fig. 4 shows greater fluctuations in both boat speed and course acquired with bottom track method. Average boat speed for given transects is approximately the same when BT and GGA are used as reference. However, there are significant differences between boat course along the transect. Influence of compass error due to non-existing calibration is visible through difference in boat course, $Course_{BOAT}$ (*BT*) and $Course_{BOAT}$ (*GGA*), which is 6.2°, averaged for given transect. Since boat course collected via BT is influenced by lack of compass calibration, data about boat course collected this way are not accurate. Magnitude of boat speed data projected in true earth coordinates is directly affected by erroneous boat course data. Although boat speed calculated from bottom tracking and GPS have same magnitude, different boat course significantly influences calculation of absolute water velocity and discharge, respectively (Tab. 1).

In order to quantify error introduced by compass miscalibration results are shown for measurement *m*01 on location Koprivnica. Flow measurements were conducted on 14 transects after compass calibration was conducted. Procedure used was “Method 3” outlined in WinRiver User’s Guide [20] which uses Rio Grande’s built-in function for one-cycle deviation errors correction of internal flux-gate compass. Hydrologic and hydraulic conditions on given location prevented successful implementation of compass calibration procedure. Namely, water velocity magnitude was over 2.5 m/s on area near to the concave bank, and extremely low depths were present on 30% of river (under 1m). These conditions resulted in high values of standard deviation of instrument’s pitch and roll, which are unsatisfactory. Average pitch during calibration procedure was 1.60° with pitch standard deviation of 0.68°. Average roll during calibration procedure was 4.84° with roll standard deviation of 1.40°. RD Instruments recommend that standard deviation of pitch and roll should be lower than 1° [20]. Results of measurement *m*01 are given in Tab. 2.

Table 2

Data collected on measurement *m*01

Transect	Heading	Reference: BT					Reference: GGA					ΔQ_{REL}
		Q	Vel_{WATER}	Dir_{WATER}	Vel_{BOAT}	Crs_{BOAT}	Q	Vel_{WATER}	Dir_{WATER}	Vel_{BOAT}	Crs_{BOAT}	
	[°N]	[m³/s]	[m/s]	[°N]	[m/s]	[°N]	[m³/s]	[m/s]	[°N]	[m/s]	[°N]	[%]
1	263	407	1.21	149	1.00	62	409	1.25	148	1.06	64	1
2	282	387	1.35	145	0.96	239	372	1.32	145	0.95	240	–4
3	286	386	1.24	154	1.07	59	396	1.26	153	1.08	60	3
4	285	400	1.41	153	1.12	240	390	1.38	153	1.12	242	–3
5	281	357	1.32	158	1.26	250	349	1.29	159	1.28	251	–2
6	214	345	1.16	158	0.99	64	348	1.20	158	1.05	70	1
7	289	373	1.53	164	1.39	245	363	1.49	165	1.38	247	–3
8	218	389	1.49	163	0.84	64	393	1.50	162	0.86	65	1
9	308	396	1.38	165	0.82	266	387	1.35	164	0.81	268	–2
10	249	394	1.57	168	0.77	75	399	1.59	168	0.78	78	1
11	293	392	1.37	167	1.24	250	373	1.32	167	1.22	253	–5
12	198	411	1.39	162	0.96	68	414	1.41	162	0.96	73	1
13	298	385	1.62	161	1.09	244	375	1.58	161	1.10	245	–3
14	270	387	1.66	159	0.85	76	395	1.67	160	0.86	77	2

Fig. 5 gives scatter plot of relative difference between measured discharges ΔQ_{REL} for all transects and all measurements on location Koprivnica. Data is displayed in relation to ADCP heading.

Fig. 5 shows significant improvement of correlation between Q_{BT} and Q_{GGA}. Maximum relative difference is less than ±5%. There is no consistency in discharge difference, and for one heading Q_{GGA} can be both greater and lower than Q_{BT}. Results show that miscalibration of compass still significantly influences discharge measurements. In order to quantify error introduced by compass miscalibration, or lack of it, on location Osijek were conducted flow measurements on 6 transects before and after compass calibration. When compass calibration was conducted, results for compass correction obtained were: One Cycle K = 0.029 and One Cycle Offset = 65.807°. Average pitch during calibration procedure was 5.02° with pitch standard deviation of 0.43°. Average roll during calibration procedure was –1.78° with roll standard deviation of 0.65°. These values fall in range of recommend values by RD Instruments. Results of measurement *m*02 are given in Tab. 3.

Results show that for uncorrected compass there is no strong correlation between Q_{BT} and Q_{GGA}. For headings between 200 and 210°N Q_{GGA} is greater than Q_{BT} and for headings between 290 and 310°N Q_{GGA} is smaller than Q_{BT} (Fig. 6). These results are very similar to those collected at location Nemetin. When compass correction was applied, for all transects measured discharge Q_{GGA} was greater than Q_{BT}. For averaged values of all transects this difference was 5%. This positive difference in discharge is expected for moving bottom conditions as moving bottom introduces bias that reflects itself in apparent upstream movement of the boat. Results show that discharge measurements are less dispersed after compass calibration, i.e. standard deviation of ΔQ between Q_{GGA} and Q_{BT} was reduced from 9.7 to 8.2 m^3/s (Tab. 3).

Table 3

Data collected on measurement *m*02

Compass	Transect	ADCP	Reference: BT					Reference: GGA					ΔQ_{REL}
		Heading	Q	Vel_{WATER}	Dir_{WATER}	Vel_{BOAT}	Crs_{BOAT}	Q	Vel_{WATER}	Dir_{WATER}	Vel_{BOAT}	Crs_{BOAT}	
		[°N]	[m^3/s]	[m/s]	[°N]	[m/s]	[°N]	[m^3/s]	[m/s]	[°N]	[m/s]	[°N]	[%]
Uncorrected	1	199	393	0.93	61	1.17	166	396	0.94	61	1.17	166	1
	2	297	381	0.86	65	1.20	343	373	0.86	64	1.21	343	–2
	3	303	382	0.82	73	1.12	276	376	0.81	74	1.12	271	–1
	4	202	379	0.79	74	1.01	164	383	0.80	74	1.01	164	1
	5	306	394	0.80	80	1.26	340	371	0.78	80	1.26	339	–6
	6	207	387	0.78	81	1.03	168	386	0.80	79	1.02	167	0
Corrected	1	207	400	0.94	64	0.93	171	414	1.01	64	0.91	171	3
	2	292	392	0.92	63	1.16	340	400	0.96	63	1.16	341	2
	3	300	371	0.80	76	1.08	320	391	0.84	74	1.08	307	5
	4	205	385	0.81	74	0.99	167	411	0.87	75	1.00	163	7
	5	302	382	0.75	76	0.94	331	394	0.78	78	0.93	324	3
	6	216	389	0.81	82	0.94	181	418	0.88	82	0.94	177	7

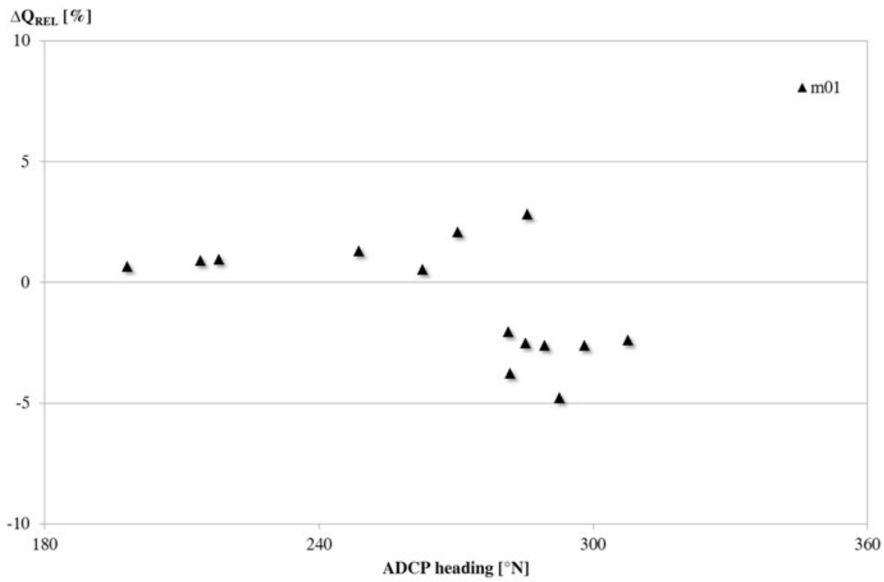

Fig. 5. Scatter plot of relative difference between measured discharges ΔQ_{REL} and instrument heading for location Koprivnica

Next figure (Fig. 7) shows one spatial distribution of boat speed and course data collected on one transect after compass calibration. There is visible better coincidence between boat courses from bottom track and GPS than between ones from uncorrected compass measurements (Fig. 3). This coincidence is greater in areas pertaining to left and right riverbanks than in middle area of river transect. This is another indicator that there is occurrence of moving bottom on given location, which introduces bias in bottom tracking operation.

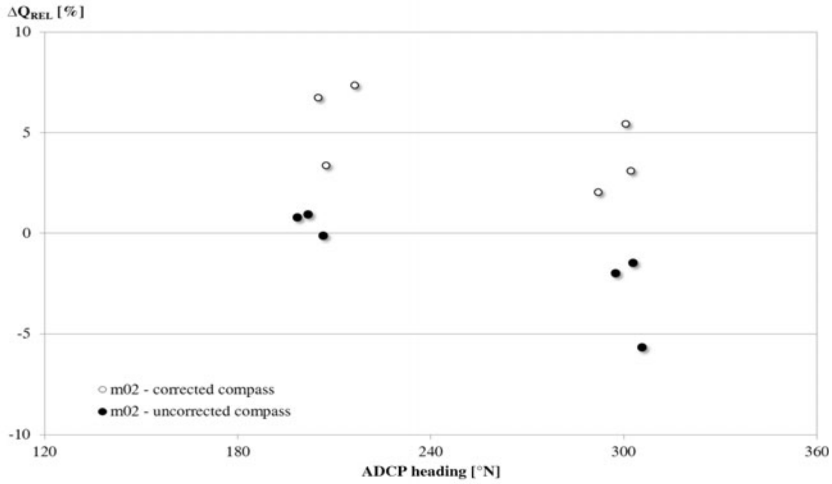

Fig. 6. Scatter plot of relative difference between measured discharges ΔQ_{REL} and instrument heading for location Osijek

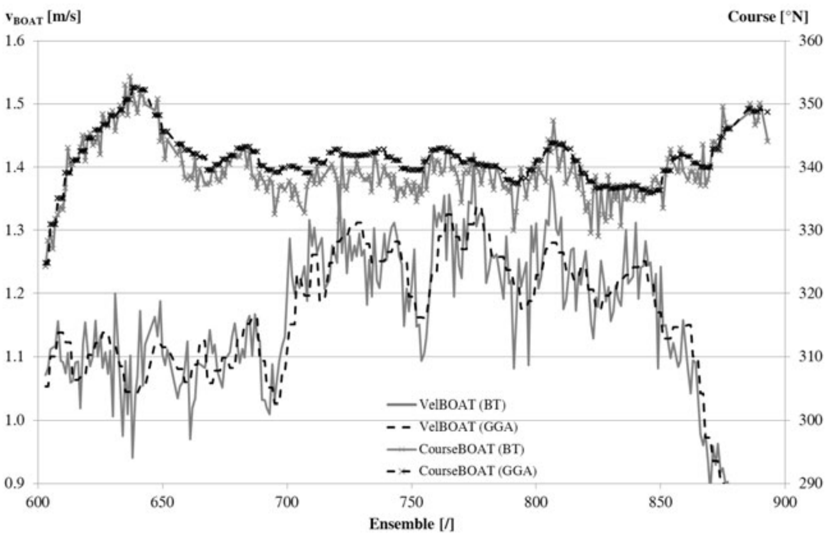

Fig. 7. Spatial distribution of boat speed and course data for transect 1 measured on *m*02

12.5. Conclusion

When conducting discharge measurements by using ADCP the best practice is to use built-in methods for boat speed reference. When measurements are made in natural watercourse there is often possibility of sediment movement on riverbed, i.e. occurrence of moving bottom. When moving bottom occurs ADCP's bottom tracking feature is biased and boat speed acquired with it is not accurate. In this case external device must be used for boat speed calculation, and most frequently used are GPS units. When external unit is used for boat speed and course, its data must be paired with appurtenant relative water velocity data from ADCP. This is done by water velocity data transformation into true earth coordinates which is done with ADCP's internal flux-gate compass information.

In order to acquire correct data from compass it must be calibrated on given location and boat mounting. In areas where there is no possibility of conducting correct compass calibration error up to ± 20 % can be introduced in discharge measurement. Even if there is no moving bottom on given location and compass calibration is not necessary for correct data acquisition, it is useful to properly calibrate compass so absolute water velocity data can be correctly displayed in true earth coordinate system on orthophoto images, for example.

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