Data Processing Report

Upper-ocean acoustic Doppler current profiler (**38kHz-ADCP**) underway measurements during **Maria S. Merian** cruise **MSM_104**

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1 Abstract

Upper-ocean velocities along the cruise track of Maria S. Merian cruise MSM_104 were continuously collected by a vessel-mounted Teledyne RD Instruments 38 kHz Ocean Surveyor ADCP.
The transducer was located at 6.0 m below the water line. The instrument was operated in broadband mode with 32 m bins and a blanking distance of 16.0 m, while 50 bins were recorded using a pulse of 1.65 s.
The ship's velocity was calculated from position fixes obtained by the Global Positioning System (GPS). Heading, pitch and roll data from the ship's gyro platforms and the navigation data were used by the data acquisition software VmDas internally to convert ADCP velocities into earth coordinates.
Accuracy of the ADCP velocities mainly depends on the quality of the position fixes and the ship's heading data. Further errors stem from a misalignment of the transducer with the ship's centerline.
Data post-processing included water track calibration of the misalignment angle (0.41° +/- 1.2721°) and scale factor (1.0045 +/- 0.0274) of the Ocean Surveyor signal. The average interval was set to 120 s.
Velocity quality flagging is based on following threshold criteria: abs(UC) or abs(VC) > 2.0 m/s, rms(UC_z) or rms(VC_z) > 0.3.

2 Sensor, configuration and deployment information

Sensor details	
Device	Teledyne RD Instruments Ocean Surveyor ADCP
Frequency	38 kHz
Transducer S/N*	1207
Sensor URN	`https://hdl.handle.net/10013/sensor.aef4e051-46f9-4999-921c-8c7914866078`
Transducer depth	6.0 m
Configuration details	
Operating mode	broadband
Number of cells	50
Bin length	32.0 m
Blanking distance	16.0 m
Pulse length	33.01 m
Ping interval	1.6500000000000001 s
Heading alignment	0.00°
Heading bias	0.00°
Deployment details	
Start Time	2021-11-23T08:02:00Z
End Time	2021-12-13T20:34:00Z
Minimum latitude	11.35°N
Maximum latitude	37.03°N
Minimum longitude	-22.98°E
Maximum longitude	-13.60°E
Minimum depth	54.00 m
Maximum depth	1622.00 m
ADCP/GPS positions*	
ADCP_x	-0.90 m
ADCP_y	3.80 m
GPS_x	0.00 m
GPS_y	0.00 m

* Position of ADCP and GPS antenna relative to the midship position. x positive/negative refers to starboard/portside and y positive/negative refers to ship's bow/ship's deck, respectively. A geometric compensation is applied to account for the different relative positions of transducer and GPS.

3 Processing details

ADCP raw data were acquired using the manufacturer's acquisition software VmDAS. VmDAS continuously merges the ADCP data stream with external data streams containing ship navigation and attitude information. VmDAS internally converts ADCP data from beam coordinates to Earth coordinates. All data are provided as single-ping ensembles in binary format (.pd0).

The binary raw data is converted and arranged in a data structure containing both measured variables and meta data. Next, raw data are checked for completeness, clock drift of the sensor PC and quality of navigational data.

Bins with percent good less than 25% are removed (for single-ping only percent good values of either 0 or 100 are possible). Potential bottom signals are identified by manual screening of the backscatter signal. If required, a mask is edited, marking all velocity data below the corresponding depth.

3.1 Water track calibration of misalignment angle and scale factor

Then, the ship velocities are determined from the GPS fixes for each single ping ensemble via central differences. A geometric compensation for the different positions of ADCP transducer and GPS antenna relative to the midship position is applied. Potential interferences originating from the parallel operation of other hydroacoustic instruments are removed before averaging pings to form 120 s ensemble averages. Following the water-track calibration of misalignment angle and scale factor, which is applied to the ensemble averages, the ship velocity is subtracted from the velocity measured by the ADCP to obtain ocean velocities.

As the velocity measured by an ADCP on a ship underway is usually dominated by the speed of the ship and not by the speed of the ocean currents, the velocity measurement is sensitive to small errors in measured speed and direction. Errors in measured speed cause errors in the estimation of the velocity component along the track, while errors in measured direction cause errors in the estimation of the cross-track component of the velocity.

Speed errors are minimized by a scale factor calibration, i.e. by determining and applying a small correction to the coefficient that multiplies the Doppler shift to yield the water velocity component along a beam. For Ocean Surveyor ADCPs, scale factors tend to cluster around 1.003, i.e. the estimate of Doppler shift is biased low by about 0.3%.

Direction errors are minimized by accurately determining the orientation of the transducer relative to the heading reference, i.e. the master heading sensor (usually the GPS).

For the determination of scale factor and misalignment angle, water-track calibration is used, taking advantage of ship maneuvers (acceleration/deceleration, turns) in deep water. The underlying assumption is that within a small region and a short time interval, currents are constant so that any changes in absolute currents arise from non-perfect elimination of the ship's speed over ground. The resulting error is large at fast ship speeds and small during station work. During the calibration, the misalignment angle and scale factor are determined, for which the differences between on-station and underway measurements close to the station location are smallest in a least squares sense for all calibration points.

Calibration results are documented in Figure 1. The final estimates for misalignment angle and scale factor were applied to the velocity data:

	Mean value	Standard deviation
Misalignment angle	0.4101°	1.2721°
Scale factor	1.0045	0.0274

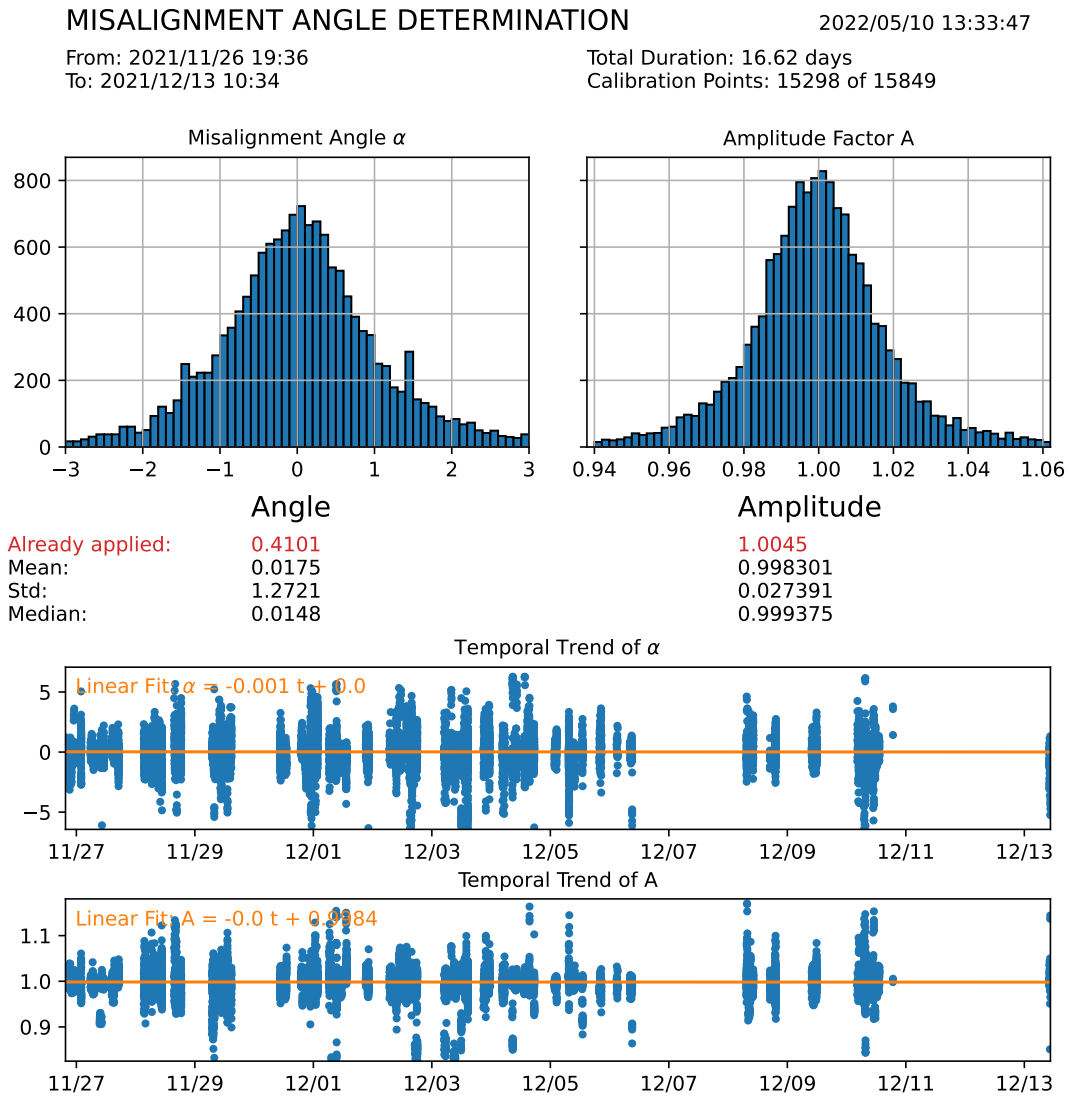

Figure 1: Top: Histograms showing results from misalignment angle (left) and scale factor (right) determination. Bottom: Temporal trend of misalignment angle (upper panel) and scale factor (lower panel).

3.2 Quality control and flags

Velocity quality flagging is based on following threshold criteria: abs(UC) or abs(VC) > 2.0 m/s, rms(UC_z) or rms(VC_z) > 0.3.

QC flag	Meaning
0	unknown
1	good_data
2	probably_good_data
3	potentially_correctable_bad_data
4	bad_data
5	*not_used*
6	*not_used*
7	nominal_value
8	interpolated_value
9	missing_value

Processing toolbox information

DAM ADCP Toolbox (Version 2.2, Python), using the following scripts:

- os_settings.py
- os_read_enx.py
- os_edit_bottom.py
- os_watertrack.py

List of ENX files used

OS38NBMSM104009_000000
OS38NBMSM104010_000000
OS38NBMSM104010_000001
OS38NBMSM104010_000002
OS38NBMSM104010_000003
OS38NBMSM104010_000004
OS38NBMSM104010_000005
OS38NBMSM104011_000000
OS38NBMSM104012_000000
OS38NBMSM104012_000001
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OS38NBMSM104012_000003
OS38NBMSM104012_000004
OS38NBMSM104012_000005
OS38NBMSM104012_000006

OS38NBMSM104012_000007
OS38NBMSM104012_000008
OS38NBMSM104012_000009
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OS38NBMSM104013_000003
OS38NBMSM104013_000004
OS38NBMSM104013_000005
OS38NBMSM104013_000006
OS38NBMSM104013_000007
OS38NBMSM104013_000008
OS38NBMSM104013_000009

ADCP data coverage

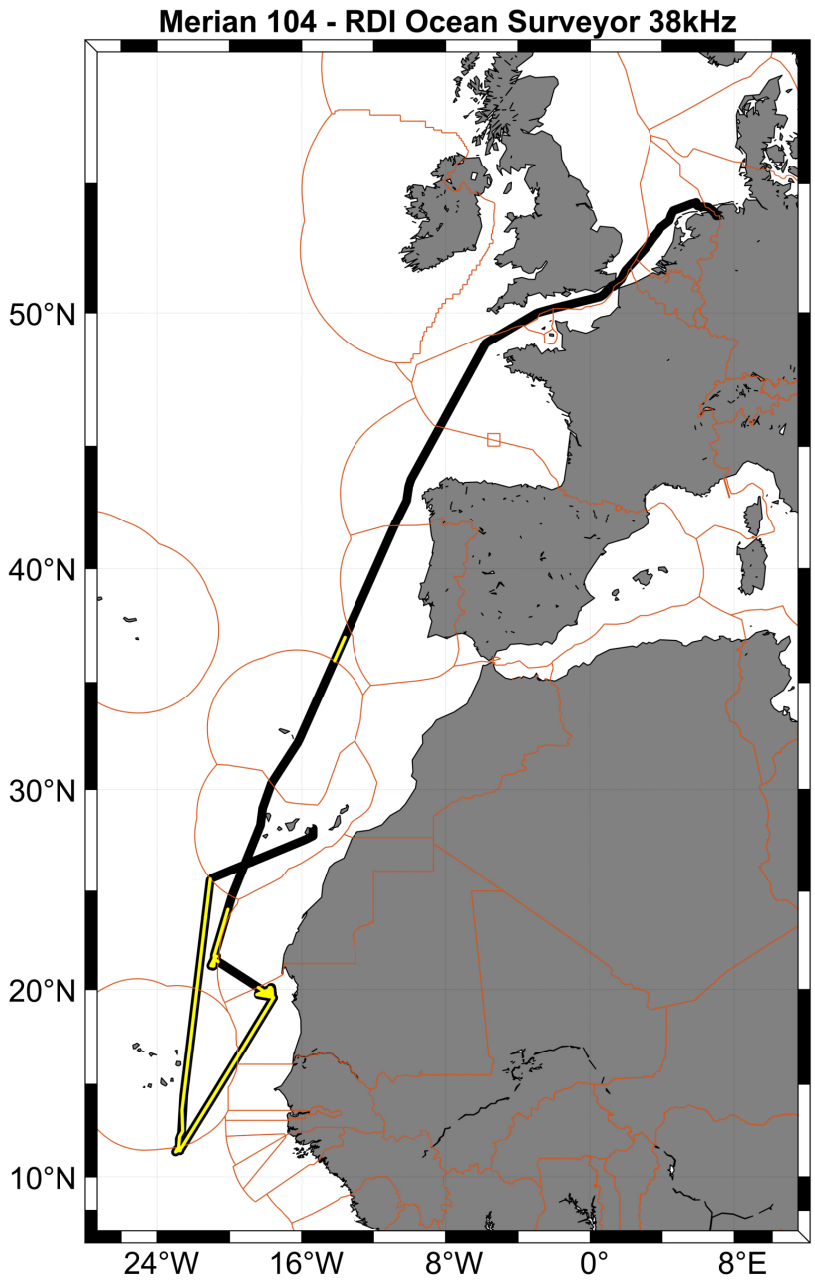

Figure 2: ADCP measurements (yellow dots) along cruise track (black line). EEZs are marked by red lines.