Temporal variability in bed elevation near Shoal E, Cape Canaveral shoals

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The increasing demand for sediments as source material for beach nourishment projects highlights the need to understand inner-shelf transport dynamics. At cape-related shoals, from where sedimentary materials are customarily extracted, the variability in particulate transport and related bedform evolution are not well understood **[1]**. To analyze bed elevation variability at a shoal adjacent to Cape Canaveral, Florida, two sets of upward- and downward-looking acoustic Doppler current profilers (ADCPs) were deployed in winter 2015-2016 at the inner swale of Shoal E, ~20 km south east of the cape tip at a depth of ~13 m, and at the edge of Southeast shoal ~5 m deep. Upward-looking-measured velocity profiles and suspended particle concentrations were used to quantify instantaneous temporal changes in bed elevation ($\partial z/\partial t$, in m/s) using a simplified version of the Exner equation **[2]**. Using mass conservation, temporal (deposition and entrainment) and spatial gradients in suspended sediment concentrations were calculated **[3]**, although neither bed-load fluxes nor spatial gradients in velocities were considered. Calculated values for instantaneous $\partial z/\partial t$ at the inner swale ranged from erosion at ~80x10^{-3} m/s to accretion at 80x10^{-3} m/s. Similarly, $\partial z/\partial t$ at the ridge ranged from erosion at ~50x10^{-3} m/s to accretion at 120x10^{-3} m/s. Most of the variability was found at subtidal (<1 cycle/day) and tidal (~2 cycles/day) periodicities. Values at the ridge suggest a total bed accretion of 30 x10^{-3} m during ~25 days of the experiment, which was 1 order of magnitude less than the average accretion of ~150x10^{-3} m in 37 days measured between July 28th and September 3rd. In addition to the fact that measurements were not performed simultaneously, the discrepancy between ADCP-derived and measured values of $\partial z/\partial t$ could be attributed to the underestimation of bed changes due to the exclusion of bed-load fluxes. Despite several uncertainties, these findings provide preliminary evidence regarding the role of seasonal and storm-driven subtidal flows in particulate transport at cape-associated shoals. Our methodology can be used to inform numerical models of sediment transport and morphological evolution along inner continental shelves.

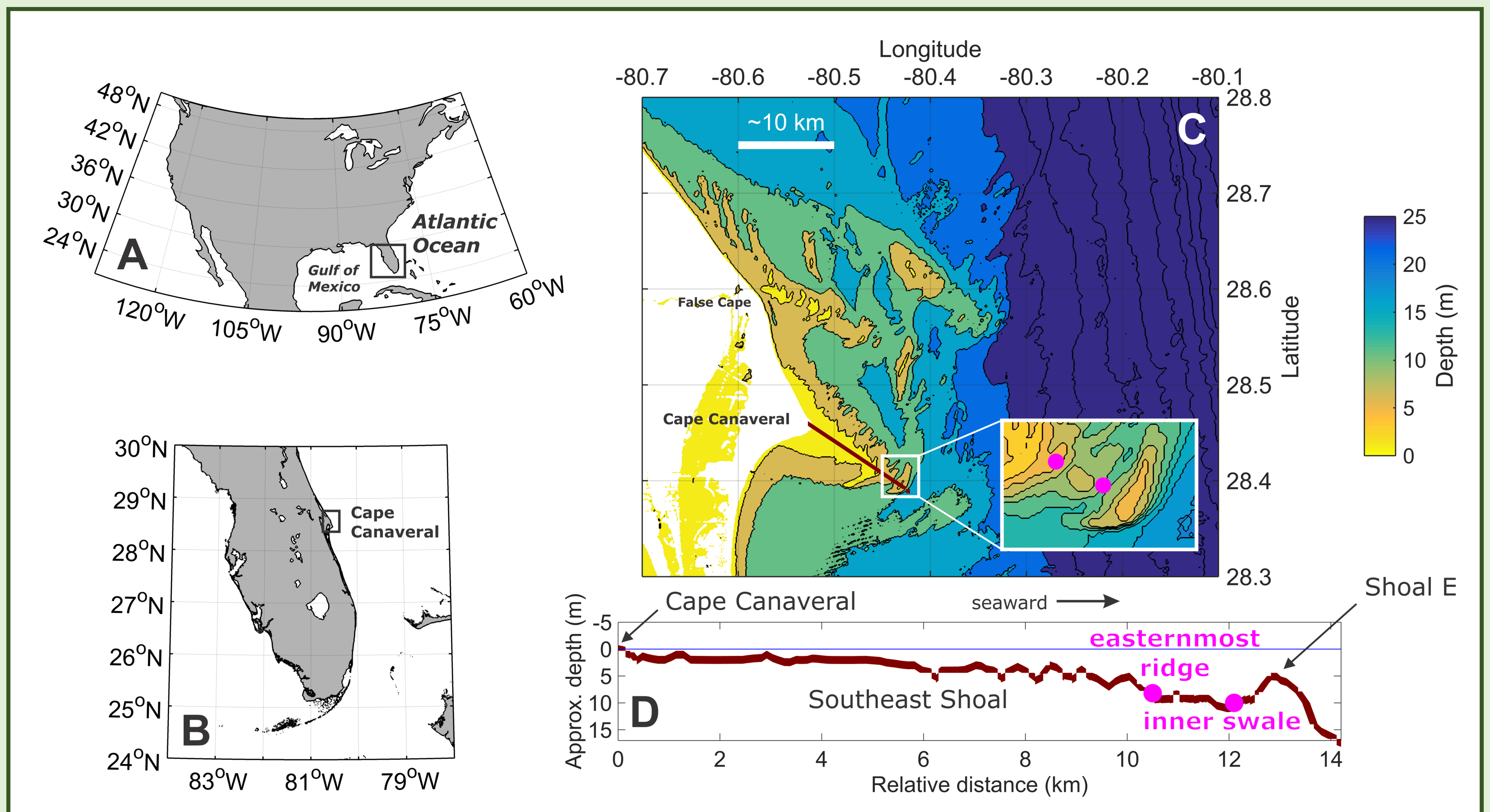

Fig. 1. Location of acoustic Doppler current profilers (ADCPs) at the shoals of Cape Canaveral. ***Black rectangles*** in **A** and **B** highlight the location of Florida in North America and Cape Canaveral in Florida Peninsula. The map in **C** shows the bathymetry off Cape Canaveral with an inset highlighting Shoal E. ***Magenta filled circles*** represent the approximate ADCP locations at the inner swale of Shoal E and the edge of Southeast shoal (easternmost ridge, water depths ~13 m and ~5 m). The ***brown line*** corresponds to an approximate bottom profile across Southeast shoal (**D**).

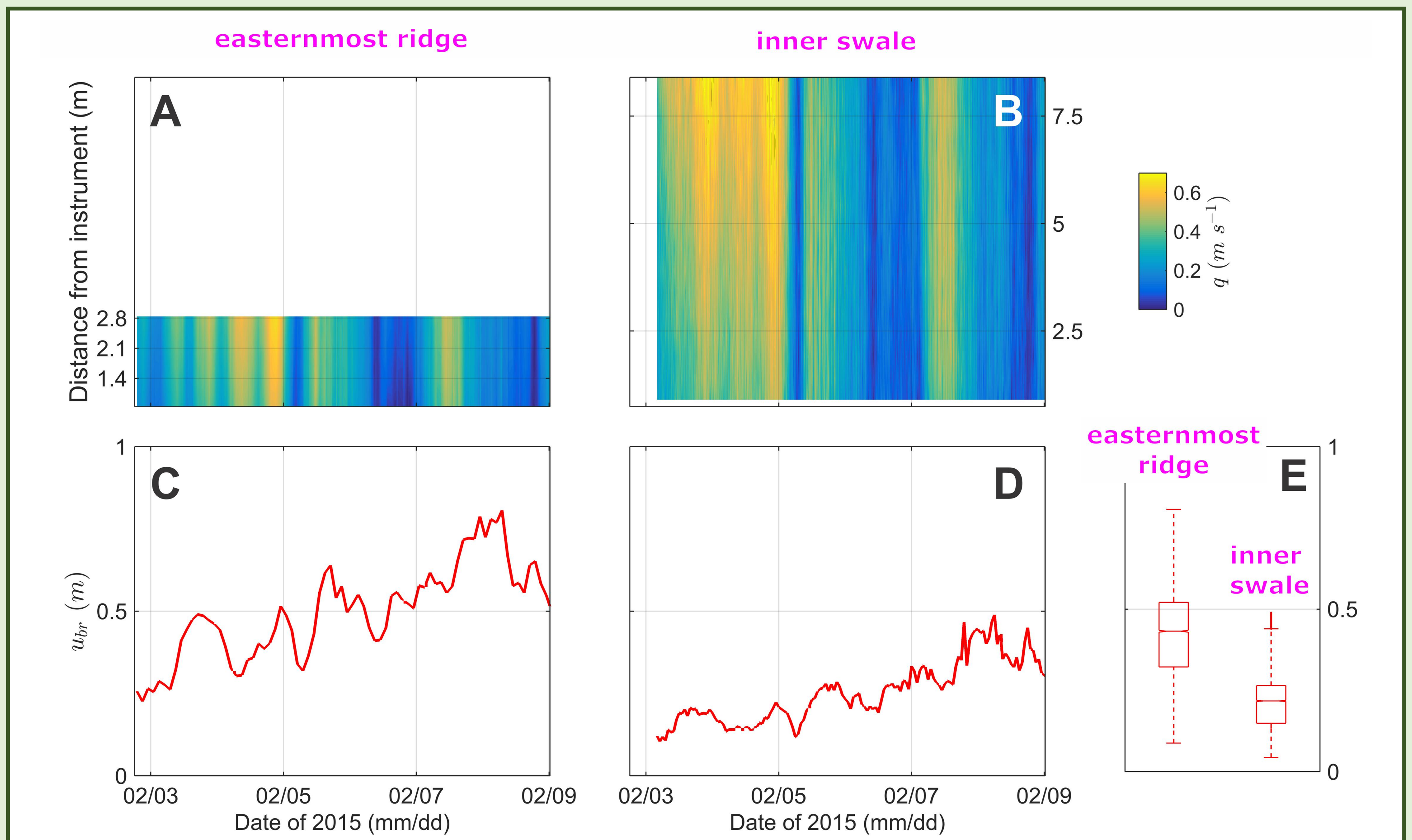

Fig. 2. (**A** and **B**) Profiles of speed from the upward-looking ADCPs, q, at the inner swale and easternmost ridge suggest water motions vary at tidal and subtidal periodicities. (**C** and **D**) Significant bottom orbital velocities **[4]**, u_{br}, as measured by the upward-looking ADCPs. (E) The comparison of u_{br} suggests waves had more potential to modify the bed at the easternmost ridge.

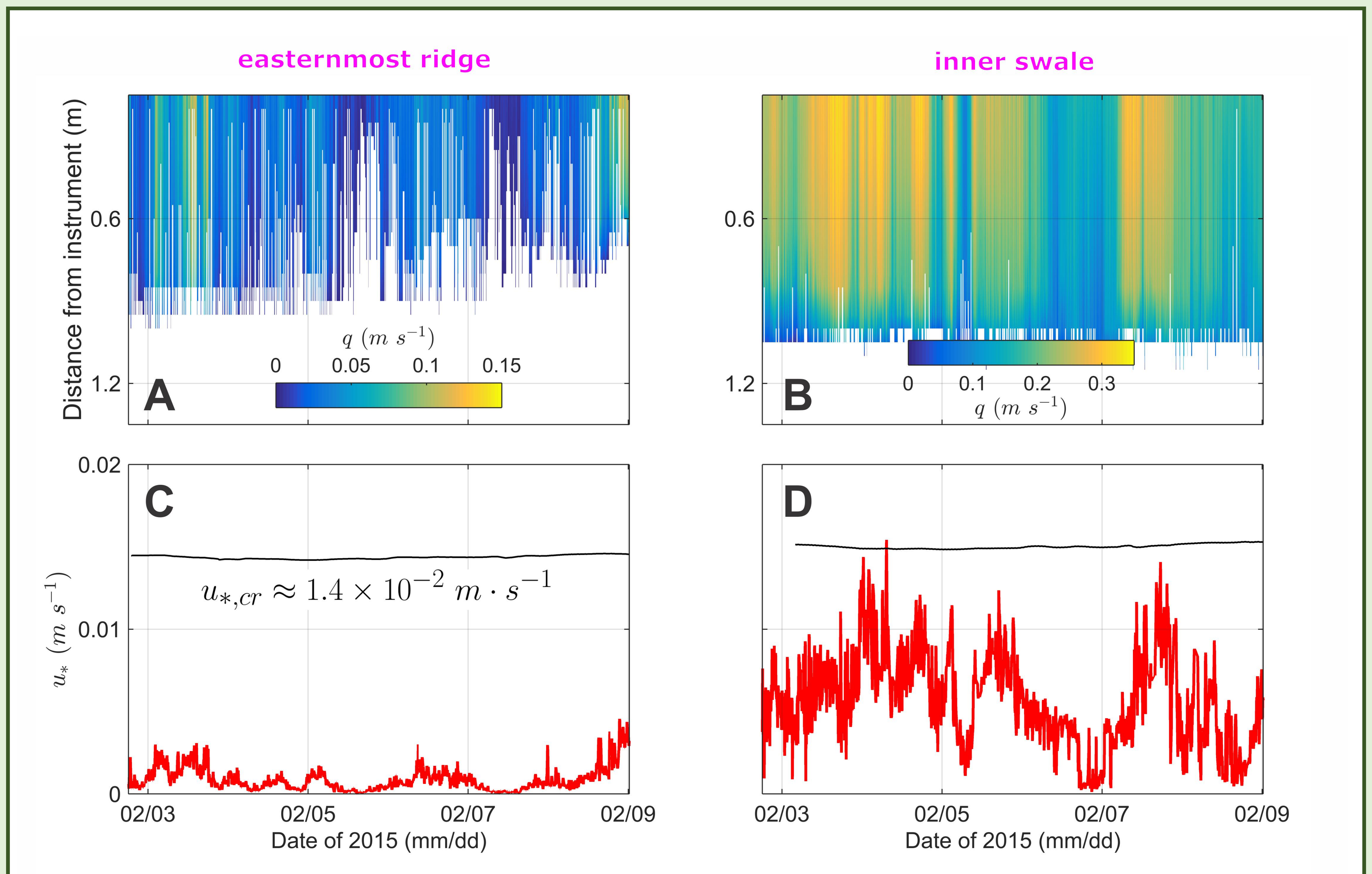

Fig. 3. (**A** and **B**) Profiles of speed from downward-looking ADCPs, q, at the inner swale and easternmost ridge suggest water motions vary at tidal and subtidal periodicities, as in the upward-looking data. However, most of ridge data were discarded. (**C** and **D**) Shear velocities, u_* (calculated using the law-of-the-wall **[5]**) and critical shear velocities for siliciclastic sand with d_{50}=0.250 mm **[6, 7]** suggest shear stresses did not exceed the motion threshold at both locations.

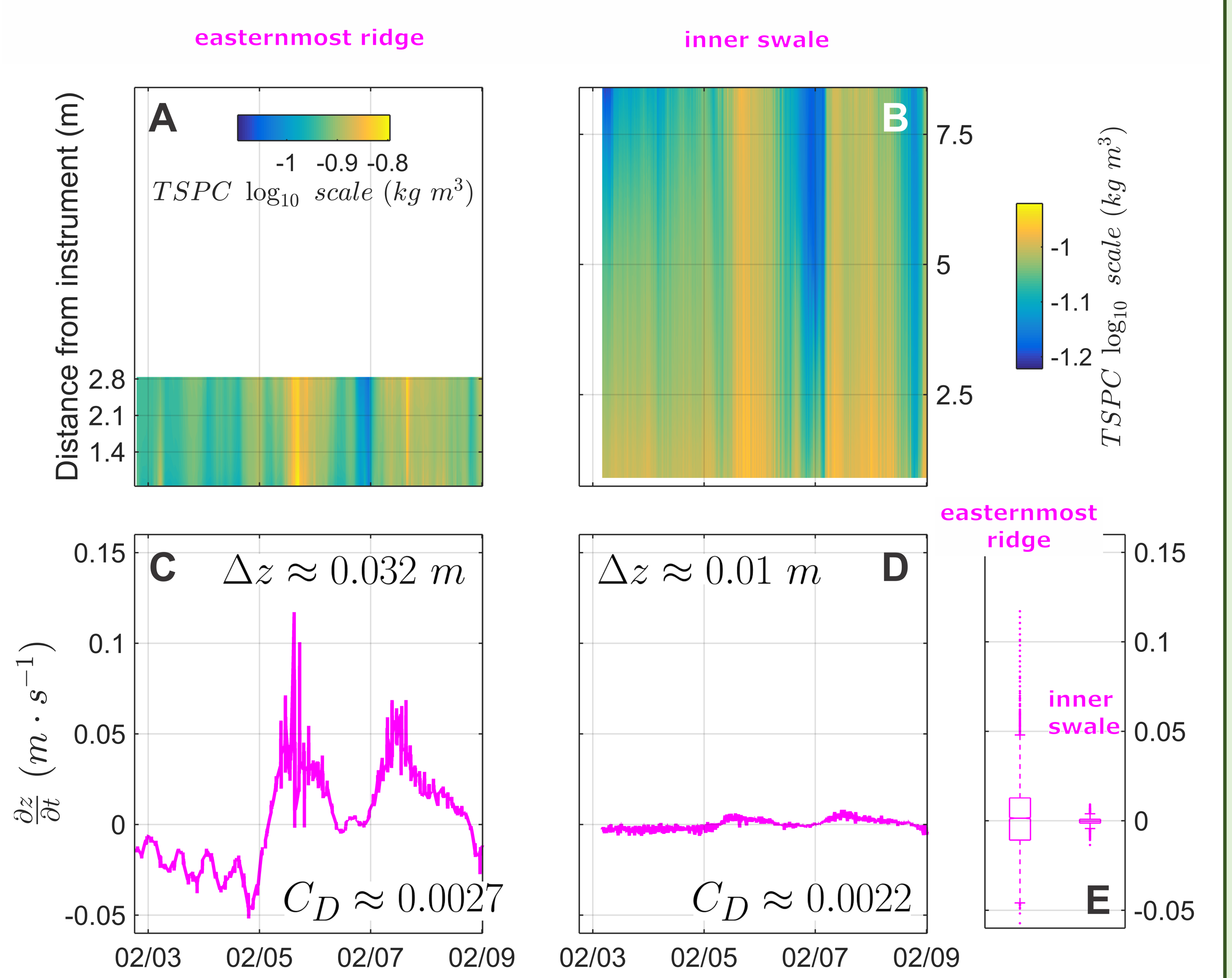

Fig. 4. (**A** and **B**) Profiles of total suspended particle concentration, *TSPC*, from upward-looking ADCPs **[8, 9]**, at the inner swale and easternmost ridge suggest water motions vary at tidal and subtidal periodicities. (**C** and **D**) Bed elevation changes from the local and advective terms, $\partial z/\partial t$ **[2, 3]** show tidal and subtidal variability at the ridge. Total bed changes, Δz, were ~3 and 1 cm at the ridge and inner swale, respectively. Drag coefficients, C_D were practically equal. The comparison of bed changes (**E**) suggest more variability at the ridge bottom, with mean values practically equal and close to zero.

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References: **[1]** McNinch & Luettich Jr (2000) *Cont. Shelf Res. 20*; **[2]** Paola & Voller (2005) *J. Geophys. Res. 110, F04014*; **[3]** Soulsby (1997) *Dynamics of Marine Sands*, ThomasTelford; **[4]** Wiberg & Sherwood (2008) *Comput. Geosci. 34*; **[5]** Sherwood *et al*. (2006) *Cont. Shelf Res. 26*; **[6]** Cao *et al*. (2006) *J. Hydraul. Eng.-ASCE 132*; **[7]** Jaeger *et al*. (2011) University of Florida NASA-IHA Annual Report; **[8]** Urick (1984) *Principles of Underwater Sound, 3rd Ed.*, McGraw-Hill; **[9]** Kim *et al*. (2004) *University of South Carolina Tech. Rep. CPSD #04-01*.