Lowered ADCPs in Subpolar North Atlantic

Teledyne RDI ADCPs Aid Overturning Studies

OVERVIEW

Stimulated by findings from improved observations, there is now intense interest in how deep currents take part in the global climate system. Especially important are the changing heat and CO2 content of the deep ocean.

To measure deep currents, scientists worldwide attach compact Acoustic Doppler Current Profilers (ADCPs) to hydrographic packages. These packages are routinely lowered to the seabed to catch water samples and to measure water properties.

Vertical profiles of water current velocity and shear show how water moves and mixes. They help describe how water properties change and disperse. These properties include heat and energy as well as organisms, nutrients, chemicals, debris, and pollutants.

For studying deep currents, scientists want velocity profiles to have long reach yet keep a fine-scale view of how currents change with depth. This data type has revealed ocean facets from internal waves to jets, eddies, and undercurrents. This information is used widely, from scientific discovery to operations aboard offshore rigs.

Products: Self-Contained ADCP: 150, 300 kHz

Application:
Observing Overturning Currents

Project:
Defining volume flux of subpolar part of meridional overturning circulation (MOC)

Companies:
International OSNAP program
GEOMAR Kiel, Germany

Data Collection Date:
Projects from 1997 and 2014 are ongoing

Location:
50°-60°N, subpolar North Atlantic

Dual Teledyne RDI ADCPs (colored yellow for high-pressure rating) are attached to a hydrographic package.

Photo: T. Wasilewski (IFM Hamburg). https://goo.gl/q7XGKK

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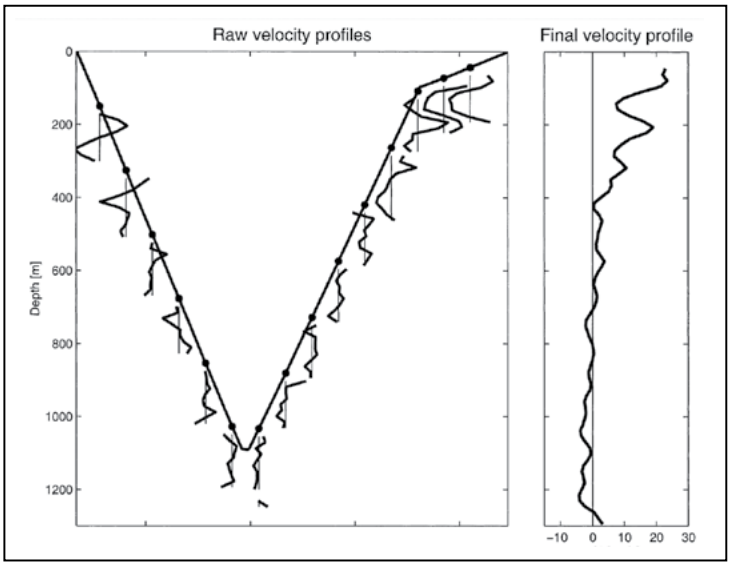
Over several years, a handful of experts adapted ADCPs to provide a full-depth profiling method that was more economical, easier to use, and available to a wider audience than prior methods. They devised the lowered ADCP (LADCP) method and processing (https://goo.gl/1TGXBn).

Key input came from staff at the University of Hawaii and Lamont Doherty Geological Observatory in USA and IFM Kiel in Germany.

The LADCP has spread to be a standard technique used worldwide by the ocean research community. They have used it to lift the veil on deep currents. And after three decades of gathering data, full-depth LADCP velocity profiles span the global ocean.



ADCP profiles are stitched together to form a full-depth profile. Speed (cm/s).

Credit: M. Visbeck (GEOMAR, 2002). https://goo.gl/kftcJ3

Here we look at some results from studies at high northern latitudes, where scientists are exploring the overturning circulation in the subpolar North Atlantic.

SOLUTION: LOWERED ADCPS

Deep current profiling measures below the acoustic range of ship-mounted profilers. Attached to a lowered hydrographic package, compact self-contained ADCPs pass through the water column. During descent and ascent, the ADCP continues to measure current profiles with ranges to 100 m. Later these short segments—with their fine-scale vertical resolution—are stitched together to produce a full-depth profile.

Careful processing of LADCP data incorporates various inputs. Current profiles from ship-mounted ADCPs are used to validate LADCP profiles where they overlap. Corrections are made for ship's drift and the varying attitude and motions of the lowered package. Near the bottom of the cast, acoustic echoes scattered by the seabed reveal the ADCP's motion. Often, dual ADCPs are used—looking up and down.

One key advantage of the LADCP method is that it does not add to ship time and running costs; the velocity profile is completed during scheduled hydro casts. Specialized technicians are not required, although successfully operating the LADCP entails training and diligence. The ADCP's compass should be calibrated carefully.

Adding ADCPs to hydro casts caused a sea change. Deep current profiling was available to a much larger community. Data collection was regular and widespread. And supplementary information about deep currents informed other studies, such as tracer measurements.

HIGHLIGHTS:

- Current profiles with ranges to 100 m are stitched together to produce a full-depth LADCP profile
- Corrections are made for ship's drift and the varying attitude and motions of the lowered package
- The LADCP method avoids adding to ship time and running cost
- LADCP results about deep currents are used to complement other current measurement methods and to supplement other scientific work

Extensive collections of these full-depth measurements are available. And accumulating LADCP sections from many cruises opened the door to statistical descriptions.

In short, LADCPs provide a unique and developing view for studying the global ocean—from large-scale circulation to small-scale mixing.

RESULTS: LONG-TERM SECTIONS

On the western side of the subpolar North Atlantic is the Labrador Sea. Located between Labrador and Greenland, this is another source for North Atlantic Deep Water in the lower limb of the meridional overturning circulation (MOC).

Since 1997, German researchers have had an ocean observatory installed at 53°N. It is located downstream from deep water formation. Their goal has been to closely monitor water transports at all levels—from surface to seabed. The observatory comprises current meter moorings and recurring shipboard sections.

These shipboard sections were made using both ship-mounted and lowered ADCPs, and were installed during 13 cruises over a 17-year period (1996–2014). Hydrographic packages carrying ADCPs were lowered to the seabed. Data from 150 LADCP stations supplement the moorings to describe flow from the Labrador Sea.

The researchers identified three significant advantages to using LADCPs. (1) Much-improved spatial resolution across the section: 12–15 stations cf. 3–5 moorings. Improved understanding of spatial scales underpins more accurate transport calculations from moored data. (2) Better definition of the inner and outer edges of the boundary current. (3) A view of the strength and extent of recirculating currents seaward of the undercurrent edge.

HIGHLIGHTS:

- For two decades, German researchers have closely monitored currents at all levels in the Labrador Sea off Canada
- During 13 cruises from 1996–2014, 150 LADCP stations were made along the same transect to complement time series at current meter moorings
- Improved understanding of spatial scales underpins more accurate transport calculations from moored data
- The volume of deep water exported southward across 53°N is a similar amount to transport through the Florida Straits
- OSNAP's focus is ocean-wide transport of heat and freshwater as part of the global climate system
- Results merge currents from the density field with a deep reference velocity from LADCP data
- LADCP data are particularly valuable in narrow boundary currents and undercurrents

Hydrographic package with dual Teledyne RDI ADCPs (yellow) in action off Greenland.

Credit: C. Nobre (WHOI).
https://goo.gl/HJLq5m

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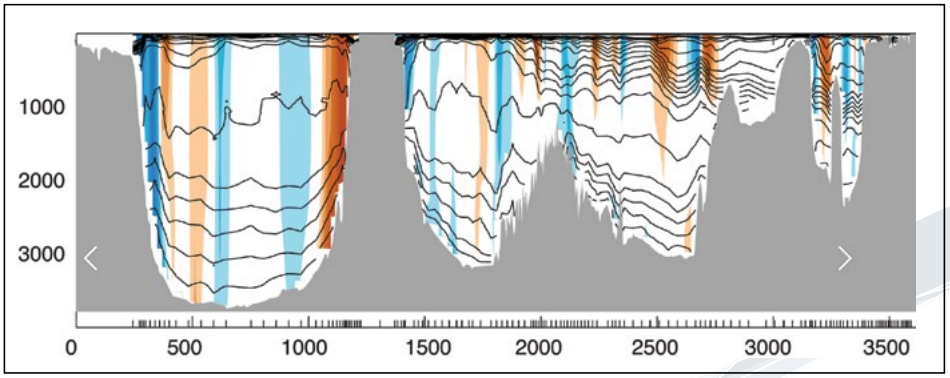
The researchers observed that the boundary current was 120 km wide and that its spatial structure was stable. The volume of deep water exported southward was 30 million cubic meters per second. For comparison, a similar volume is transported northward through the Florida Straits to supply the Gulf Stream.



Ocean-wide section of north/south currents in Subpolar N. Atlantic in 2016. Currents: North (red), South (blue). Units: Depth (m), Distance (km).

Credit: Holliday et al. (2018) https://goo.gl/3YAE8X

Strong currents were seen at various levels. In particular, the LADCP data showed a high-speed core near the deep-sea floor. Its waters had originated in the Nordic Seas.

RESULTS: OCEAN-WIDE SECTIONS

An ongoing multi-year, international research initiative is titled *Overturning in the Subpolar N. Atlantic Program* (OSNAP). Working across the width of the Atlantic at high northern latitudes, OSNAP includes many researchers with prior programs in the region. Their joint focus is ocean-wide transport of heat and freshwater as part of the global climate system.

A recent report described two crossings of a composite ocean-wide hydrographic section, observed in 2014 and 2016. The sections span several basins that show strong boundary currents. Results for the deep velocity field merged currents from the density field with a deep reference velocity from LADCP data.

The researchers noted that the LADCP data are particularly valuable in narrow boundary currents and undercurrents. Accurately measuring these features relies on high horizontal resolution; they tend to be underestimated and underresolved by satellite-based options. In fact, the report quantified this discrepancy for the combined transport of deep undercurrents around the subpolar gyre.

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www.teledynemarine.com/rdi
14020 Stowe Drive, Poway, CA 92064 USA
Tel. +1-858-842-2600 • Email: rdisales@teledyne.com
Les Nertieres 5 Avenue Hector Pintus 06610 La Gaude France
Tel. +33-49-211-0930 • Email: rdie@teledyne.com

