

An intercomparison of 5 different current meters in a deep water, open ocean environment

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I work for the Rapid-MOC project and basically manage the mooring array in terms of where instruments are going etc

Responsible for the mooring designs we use

Why giving talk?

Introduction to Rapid-MOC project

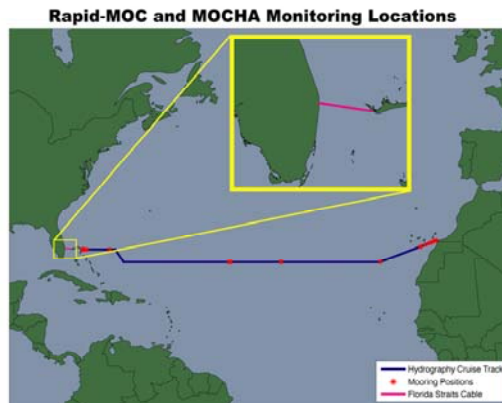
Project aim: To provide a 10 year time series of the Atlantic Meridional Overturning Circulation

Collaborative project between NOCS, RSMAS (University of Miami) and AOML (NOAA, Miami)

Atlantic array of moorings at 26 N, with winds measured by satellite and the Florida Straits flow from a disused telephone cable

Mooring array first deployed in 2004 and serviced annually

Array will continue to 2014 through funding of Rapid-WATCH project



Opportunity to test current meters as part of the Rapid-MOC project

Now many of you will have heard of the Rapid (or Rapid-MOC) array but for those that haven't

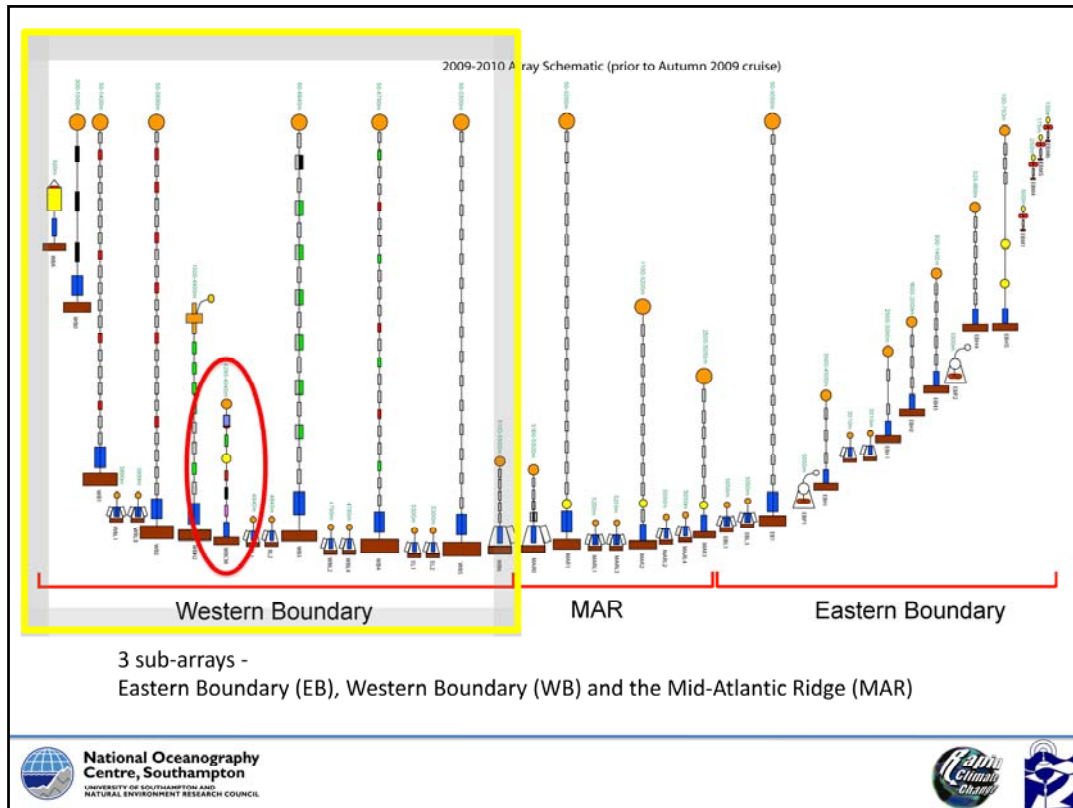
Project aims for 10 year timeseries of AMOC

By combining moored measurements at 26N with satellite derived winds

Most involved aspect is the mooring array at 26N

Regular service cruises since 2004 to both west and east

Took advantage of cruise to western boundary to compare some different current meters



Array divided into 3 sub arrays, EB, MAR and WB.

Mixture of self-logging CTDs, bottom pressure recorders and current meters

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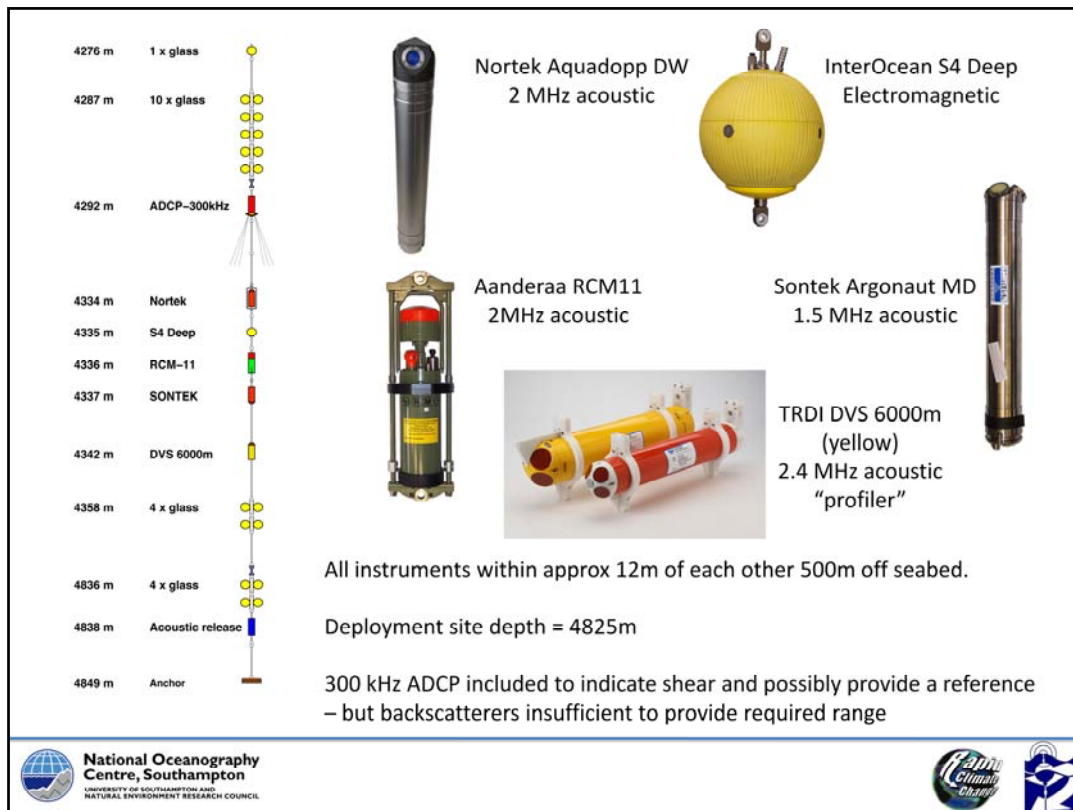
It is in the WB that current meters are used to directly measure the currents (current meters in green, red, cyan black and yellow)
(in what we call the western boundary wedge inshore of our primary density mooring)

So this was where I wanted to trial the current meters.

Previously trialled some in the eastern boundary where the currents are much weaker but not going to focus on those in this talk

The mooring used was this one **CLICK**
and was called WBCM

Deployed in Spring 2009 from the Ronald H. Brown and recovered in Autumn 2009 on the RRS Discovery



5 current meters plus ADCP

Approx 4300m deep in 4825m of water.

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4 acoustic instruments and 1 electromagnetic

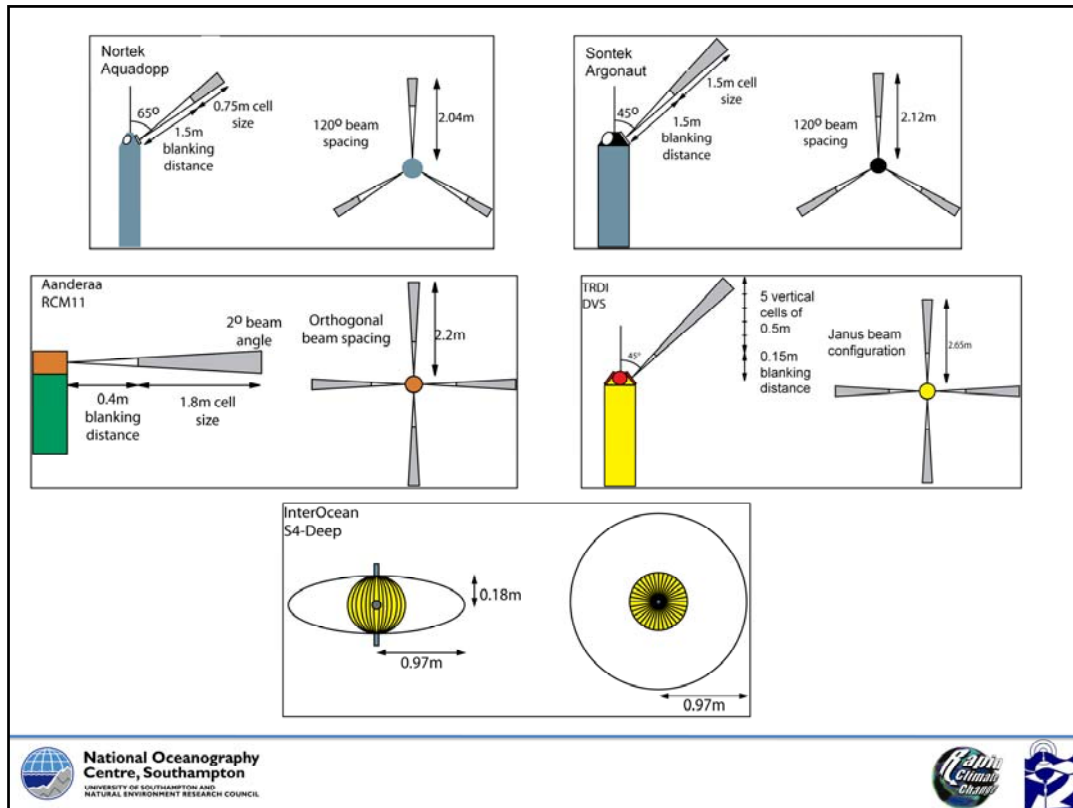
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All single point except for DVS which profiles 5 bins over about 3m, so still essentially single point for the moorings we deal with.

ADCP included for reference but not enough backscatterers



Nortek and Sontek very similar designs. Both have 3 beams. Only real difference is the beam angle of 65 for Nortek, and 45 for Sontek.

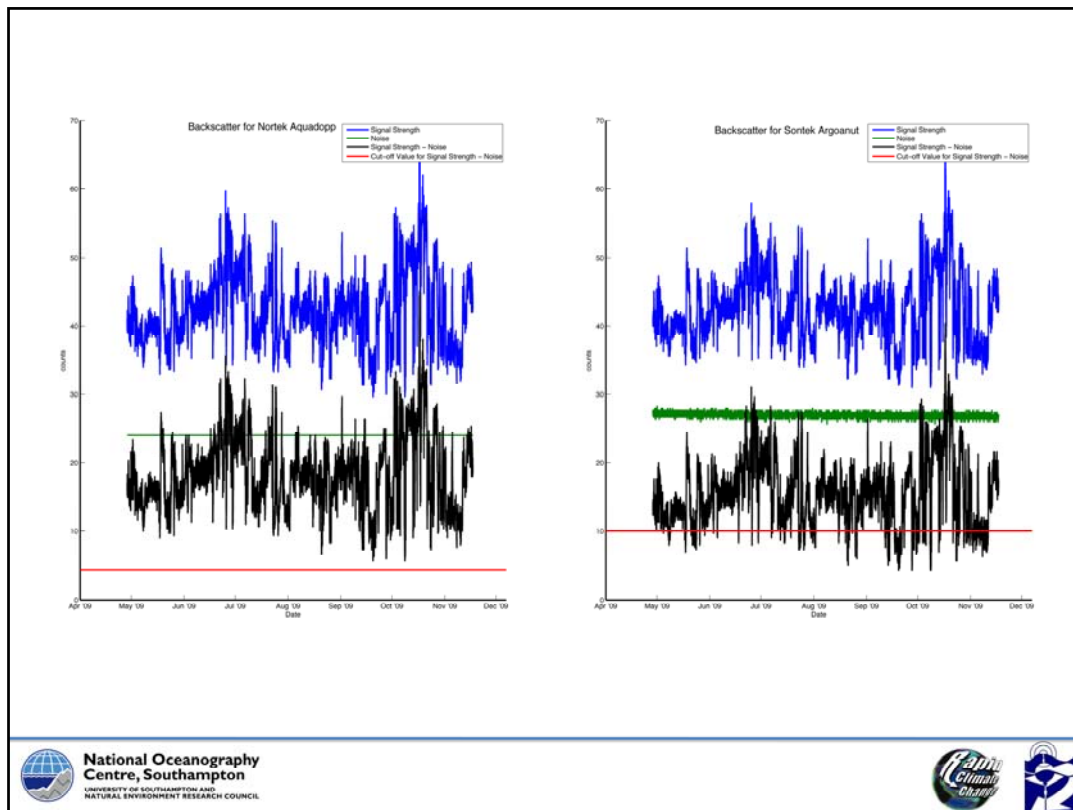
Cell size and blank are selectable for Sontek, only blank selectable for Nortek

RCM11 has 4 beams but only measures in a horizontal plane but this is corrected for tilt.

DVS has 4 beams and measures 5 bins. Cell size and blank both selectable

S4 – electromagnetic so influenced by any water flowing past it in the volume depicted by the black ellipse.

Acoustic instruments measurement area is away from the instrument itself and the mooring line, S4 will be influencing flow around it.



A check on the backscatter.

For the Nortek and the Sontek, the manufacturer's give a cut-off value for the allowable difference between the signal strength and the noise level. Above this level the data can be considered valid, although it's not definite that when it drops below it the data are invalid.

These are very similar instruments, and you can see this from the response.

Left = Nortek, Right = Sontek

Blue line = signal strength

Green line = noise.

Black = signal strength - noise

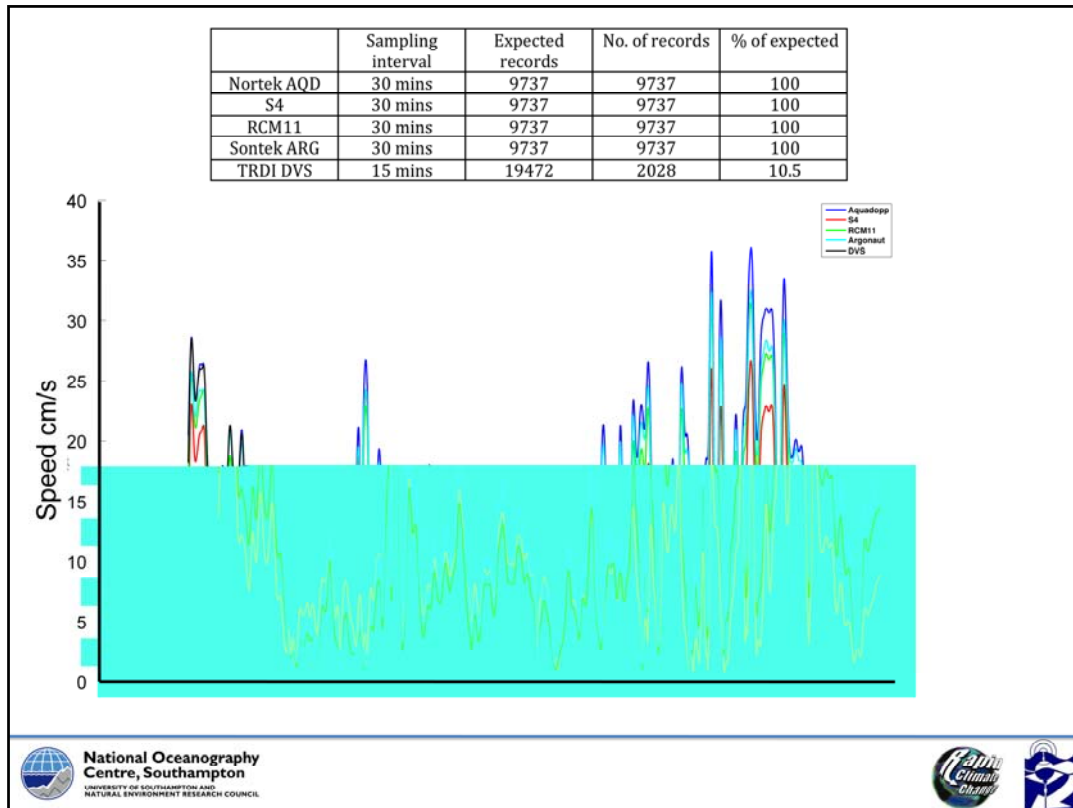
Red = manufacturer's stated allowable level

Nortek = always above it despite this region being low in backscatters

Sontek drops below it occasionally, but is generally above the cut-off.

RCM11 doesn't have a cut off specified

DVS uses beam correlation and percent good pings as quality flags. For the short period that it worked, all the data were valid using these criteria.



So what did we actually get for currents?

7 month deployment from April 2009 to November 2009.

All instruments collected full records except the DVS which stopped logging after 21 days.

This was one of the first deep units produced by RDI who are still working on diagnosing the problem.

They think it's something to do with a chip state getting stuck and blocking out the whole system whilst draining the battery

Their request to use twice the sampling rate and battery should still have been sufficient for a year's deployment.

Current speeds were highly variable, and reached up to 35-40cm/s (this is 2 day filtered time series)

	Mean Speed (and STD) cm/s	Mean Direction (and STD) degrees
Nortek AQD	10.7 (8.1)	200.8 (56.2)
S4	7.1 (5.6)	192.2 (60.0)
RCM11	8.7 (7.0)	204.6 (56.7)
Sontek ARG	10.2 (7.4)	205.0 (57.2)
TRDI DVS	n/a	n/a

Not significantly different at 95% level.

Stated accuracies	Speed	Compass
Nortek AQD	1% \pm 0.5cm/s	\pm 2.0°
S4	2% \pm 1cm/s	\pm 2.0°
RCM11	1% \pm 0.15cm/s	\pm 5.0°
Sontek ARG	1% \pm 0.5cm/s	\pm 2.0°
TRDI DVS	1% \pm 0.15cm/s	\pm 2.0°



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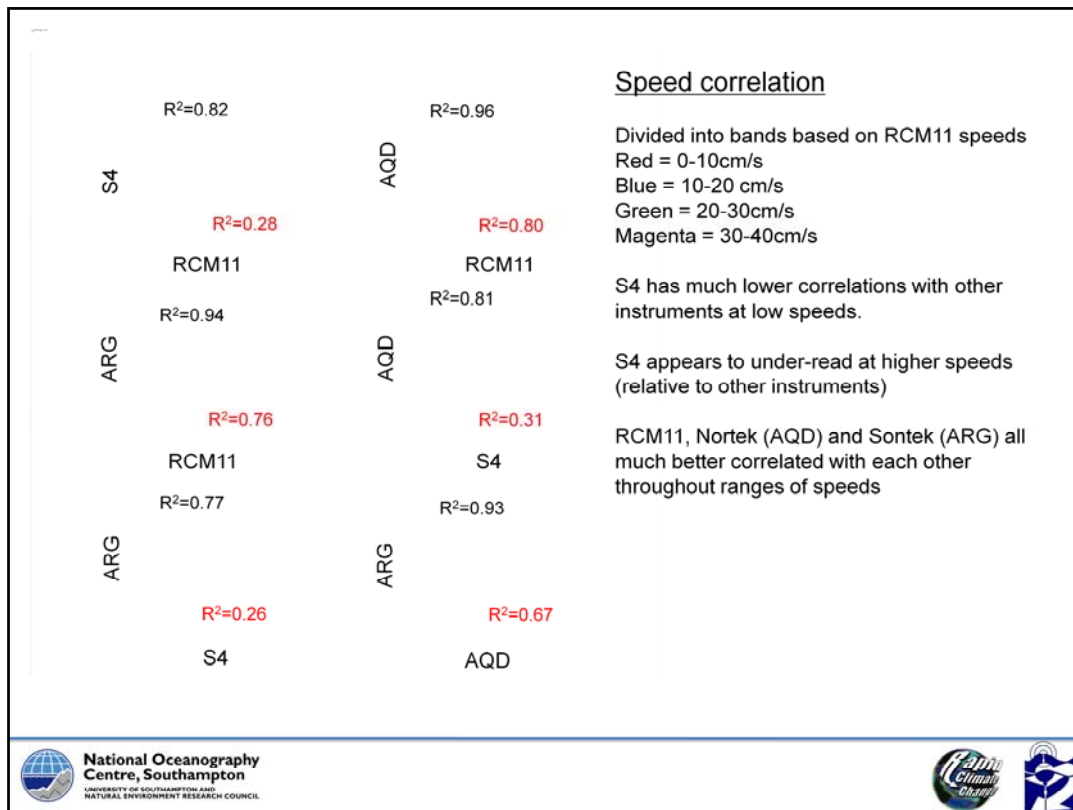


State what means are

Stated specs cannot account for apparent differences

But when testing the significance of these it was found that none of them are significantly different

When comparing just the shortened time series, only the mean speed measured by the S4 and DVS are significantly different



So next thing I started to do was to do correlation plots

Plots of speed correlations separated into ranges based on the RCM11 speed values.

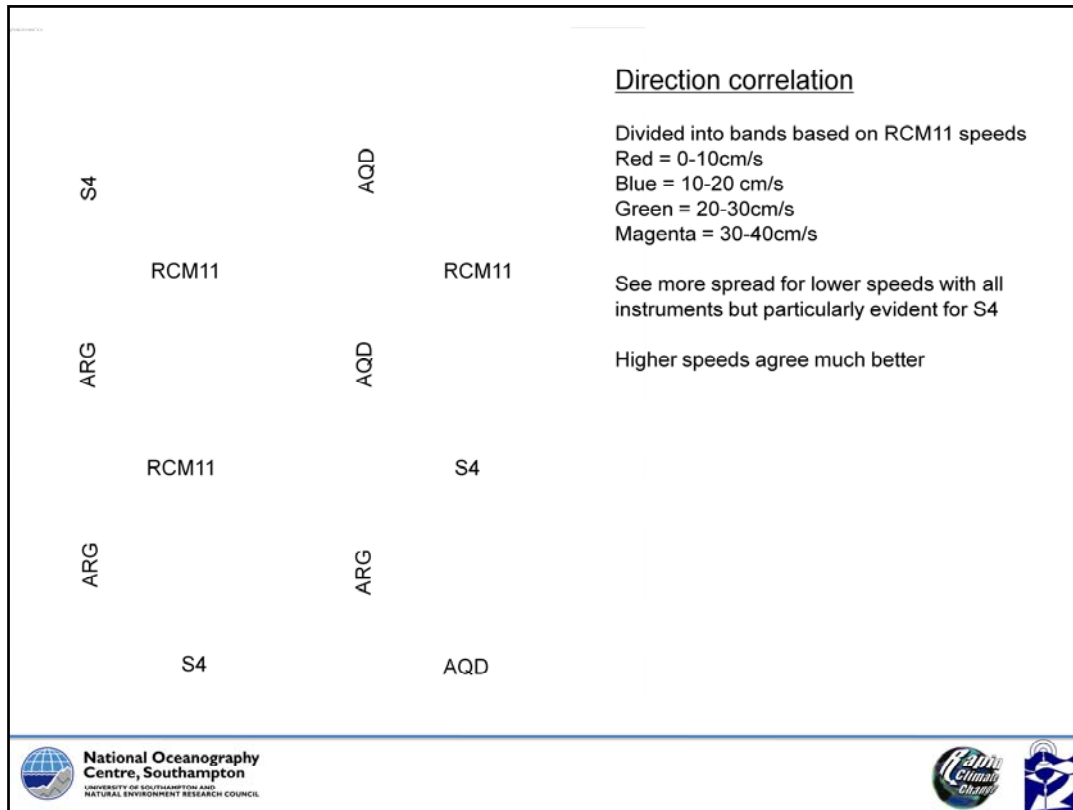
Could have divided them up using any one as the reference, but the RCM11 has been the workhorse of the Rapid-MOC array so using this one.

R-squared values shown are for the whole timeseries – not divided up into ranges.

S4 lower correlations at low speeds – as can be seen from the spread in the red and to a degree the blue points on these plots.

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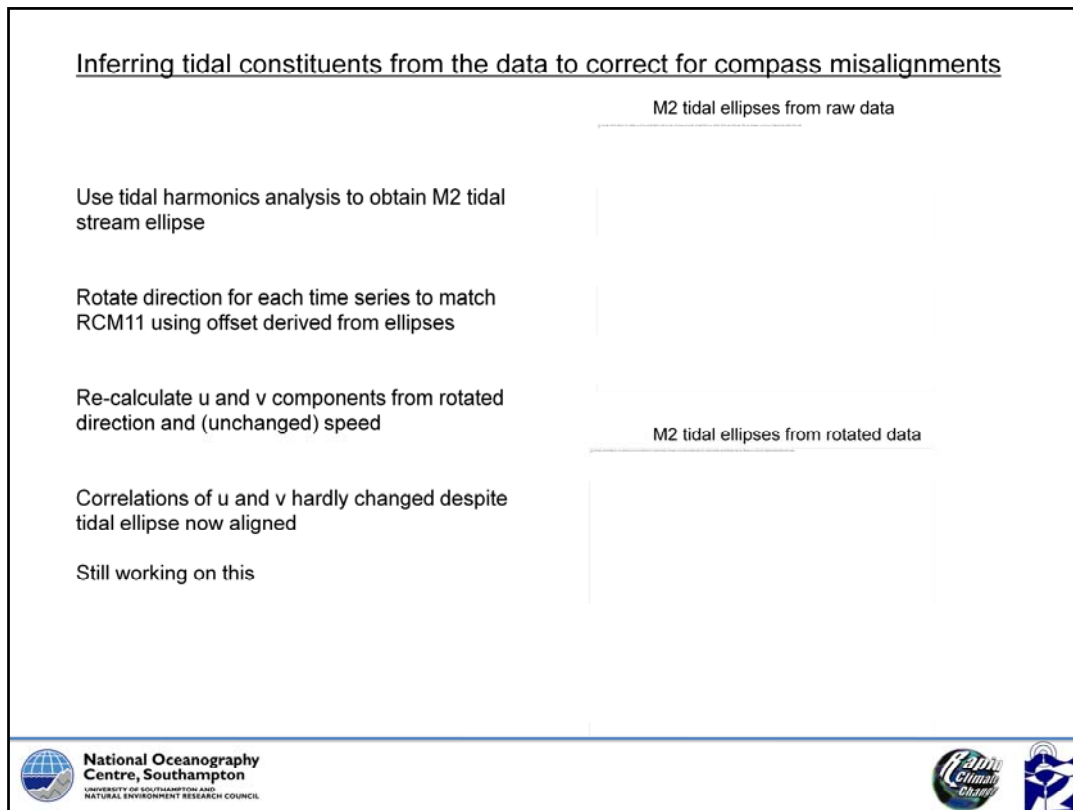
If just look at the correlations from these lower speeds get the R-squared value in red. ()



Now for direction:

again divided into ranges based on the speed measured by the RCM11.

More spread for lower speeds for the S4 but can see for each instrument that the current direction agrees better with higher speeds and is much more scattered at low speeds.



Used tidal harmonics to infer M2 tidal ellipse

As seen in upper figure

Tried to correct for any compass offset

Rotated data using the offset from the M2 major axes

Summary

7 month deployment gave good data set for comparison

No significant differences when looking at mean of whole time series

But S4 not well correlated with other instruments at low current speeds

Aanderaa RCM11, Nortek Aquadopp and Sontek Argonaut all behave very similarly
but need more work to understand apparent differences in means

TRDI DVS had short record but allows some comparison.
Agrees with the RCM11, Aquadopp and Argonaut (all acoustic current meters)

Caveat:

**Cannot say which instrument is “correct” in intercomparison tests as no reference, but
allows comparison at location where likely to be used**

The End

<http://www.noc.soton.ac.uk/rpdmoc>

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Thank you for listening and any questions

Prices of current meters:

Nortek = £8.5k

Seaguard = £11k

DVS = £9.7k

Sontek = ?

