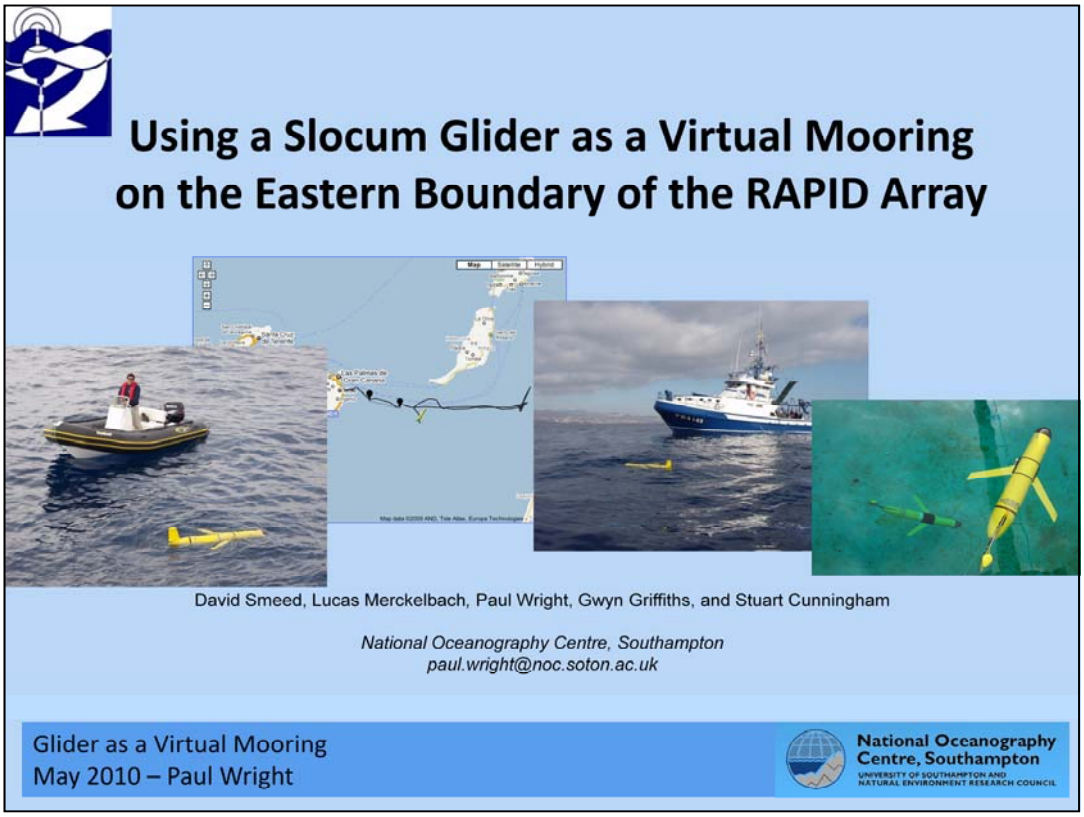
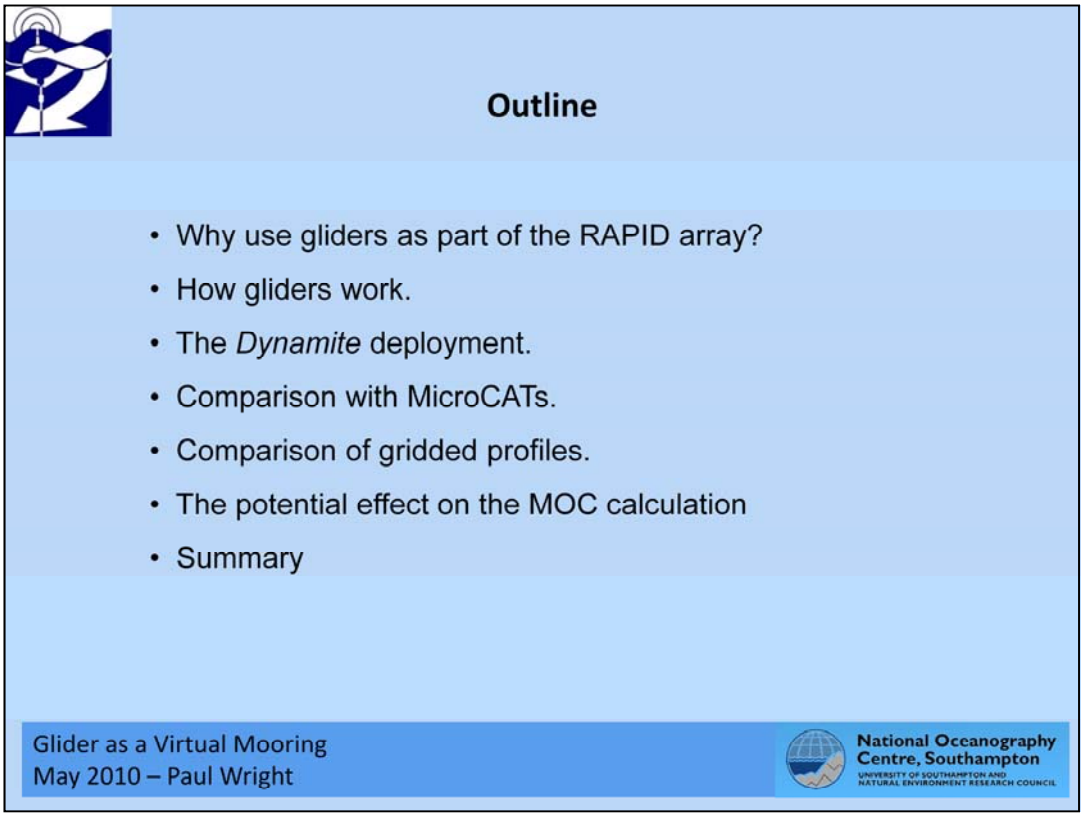


The PIs are DAS and SCU



The RAPID array measures the Meridional Overturning Circulation (MOC), which is the net northward transport of the warmer upper level water from the equatorial region to the poles.

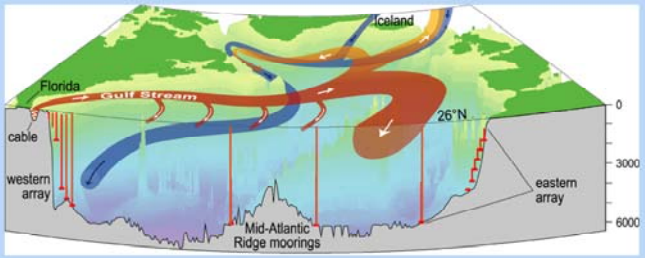
The size of the MOC is estimated to be about 17 Sv and it transports 1.3PW of heat northward (about ¼ of the global atmosphere/ocean heat transport required to balance the global heat budget).

Not sure if to include or not.

The RAPID-WATCH Project

Aim:

To provide a 10 year time series of the Atlantic Meridional Overturning Circulation (MOC) at 26.5° N.



- The RAPID array currently consists of 24 mooring and 16 landers.
- Measurements of the Florida Current, the Deep Western Boundary current and wind driven surface transports are also included.

Glider as a Virtual Mooring
May 2010 – Paul Wright

National Oceanography Centre, Southampton
University of Southampton and Natural Environment Research Council

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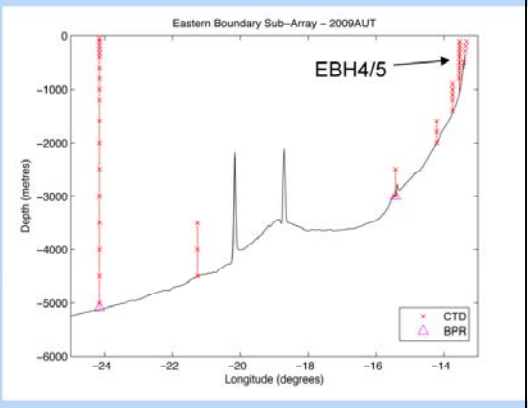
Why Use a Glider as a Mooring?

- Fairly high rate of mooring losses.
- Very long wait for data (up to 18 months)
- No idea until recovery if there has been a failure.
- Telemetry systems, to date, have not been successful.

The EBH4/5 site was chosen for the glider trials because:

- much of the seasonal variability of the MOC is due the upper layer of the eastern boundary
- weaker currents
- close to a convenient base
- 1000m depth



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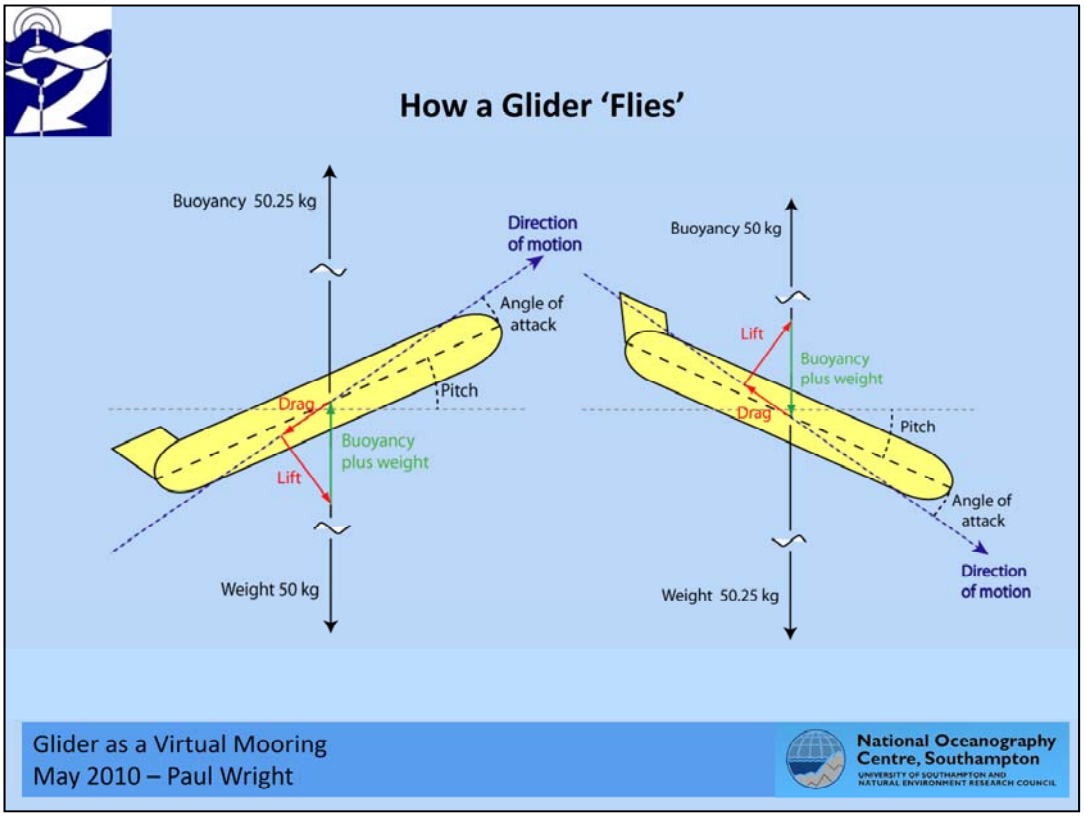
The RAPID array traverses the Atlantic at approximately 26N. The Western boundary is steep to, while the eastern boundary is more shelving. This has meant that the eastern sub-array needs to consist of a number of moorings.

Subsequent analysis by Chidichimo and Kanzow has shown that the offshore tall mooring at EB1 cannot act as a back up to the shallower moorings. This is due to upwelling and Ekman pumping. There is a large contribution to the seasonal variabilty from the eastern boundary, which may be related to the seasonal trade winds.

The majority of the variability occurs in the upper 1000m, making profiling by the deep glider a valuable contribution.

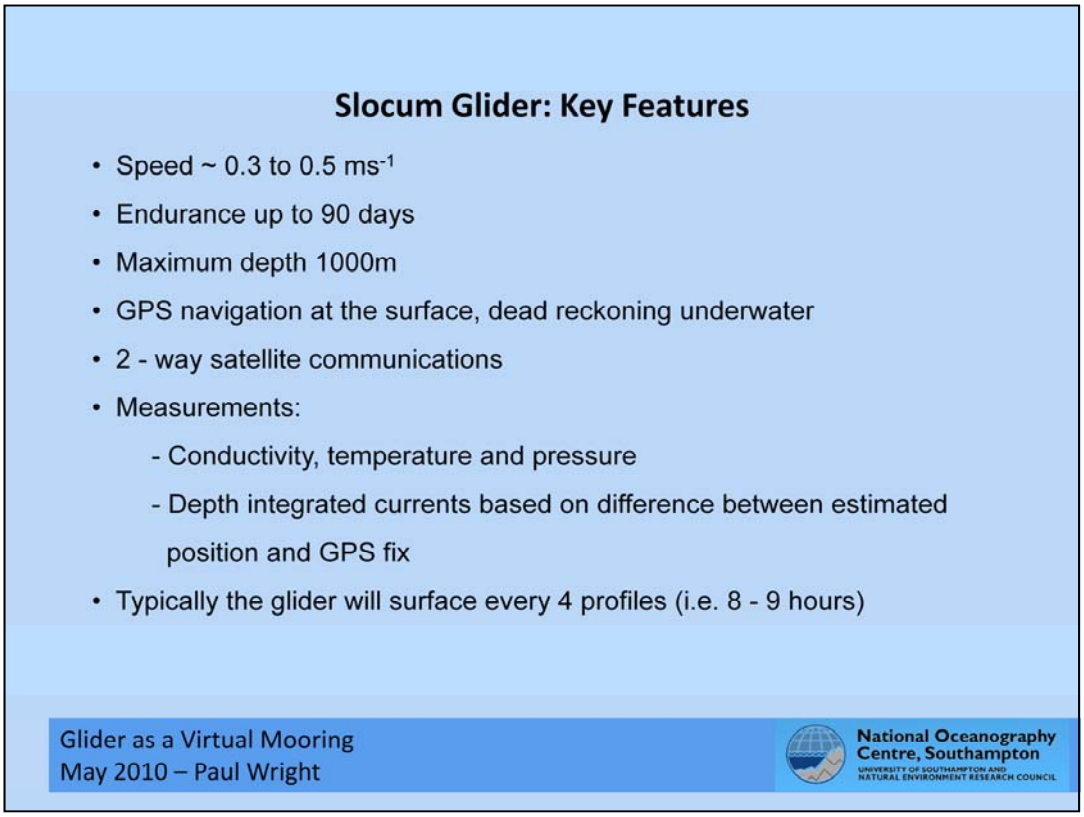
The eastern boundary was selected for 4 reasons:

- Weaker currents
- Convenient location
- Strong seasonal variability
- Relatively high rate of mooring loss due to fishing activity



A glider flies by changing buoyancy in the nose by moving +/- 270 cc of oil into/out of a bladder. As it sinks and rises the wings create a lift force that changes a small amount of the vertical motion into horizontal motion. The pitch can be fine tuned by moving the forward battery pack backwards and forewards.

A compass and a rudder mounted in the tail are used to steer the glider towards its next waypoint.



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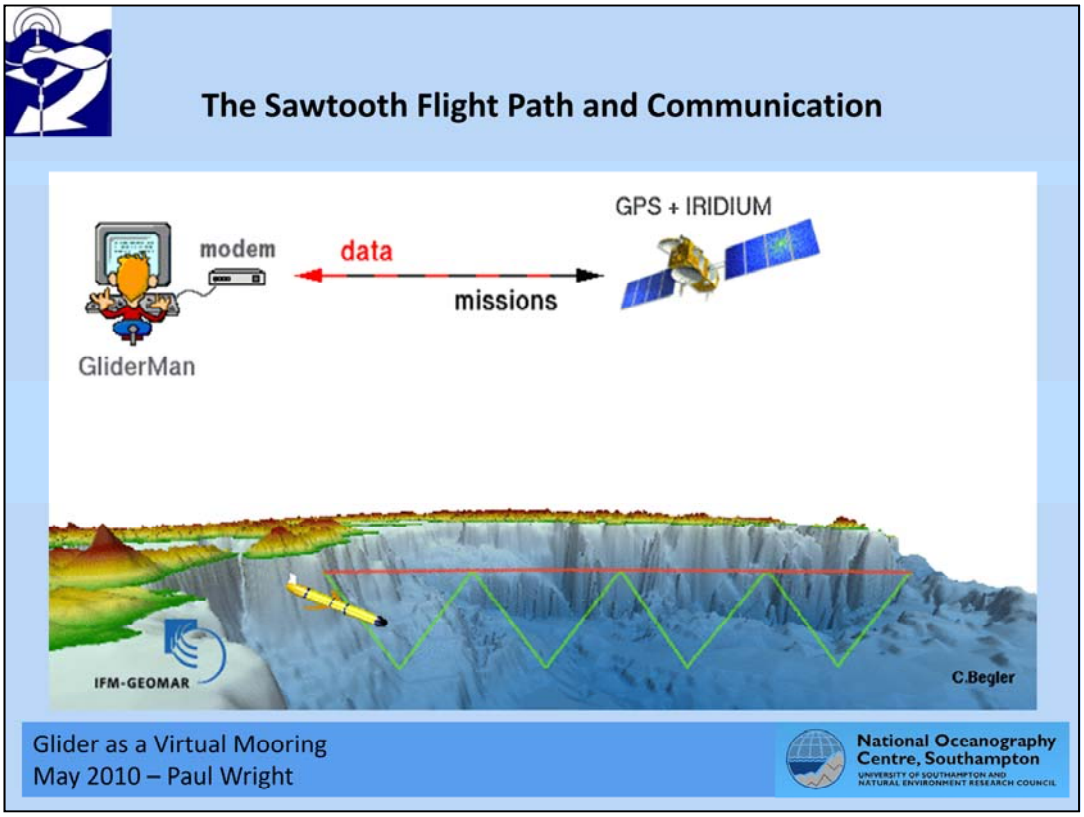
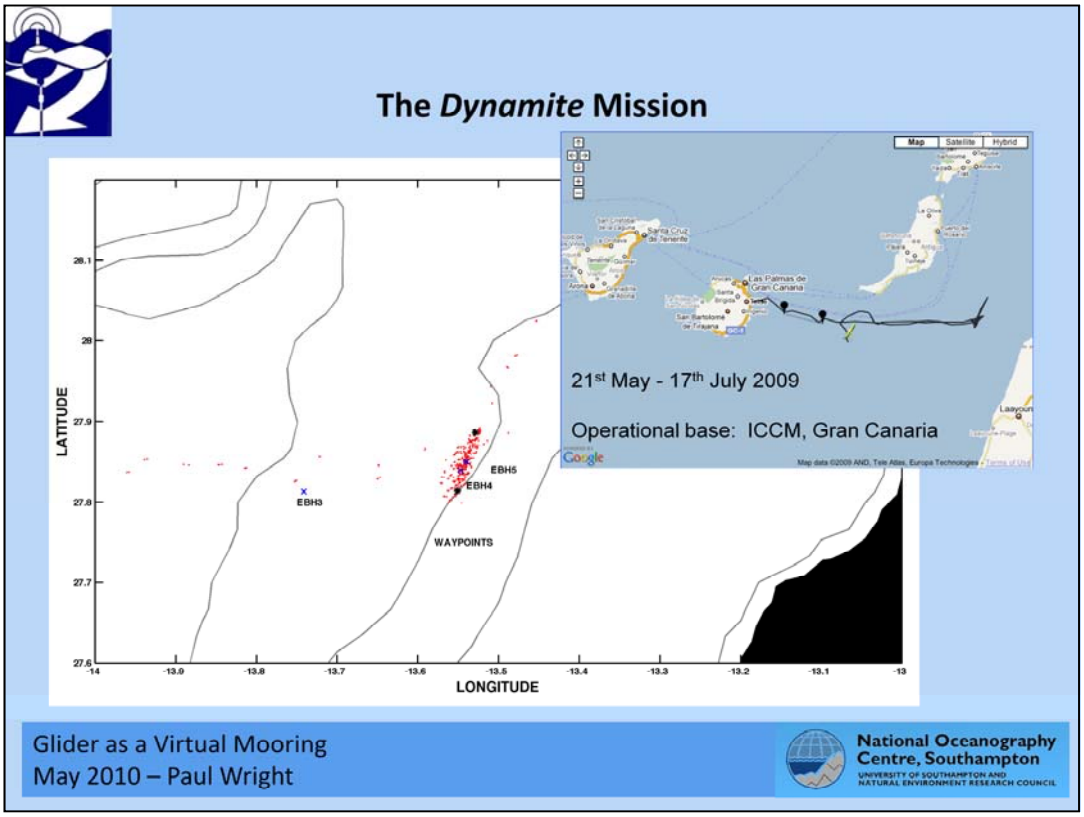


Due to the method of flying the glider describes a saw tooth like path. On surfacing the glider performs the following:

- fixes its position using GPS
- Connects with the Iridium network to transfer data and if required download new instructions
- If surfaced for a long time (3 hours) the Argos beacon can connect to a satellite.

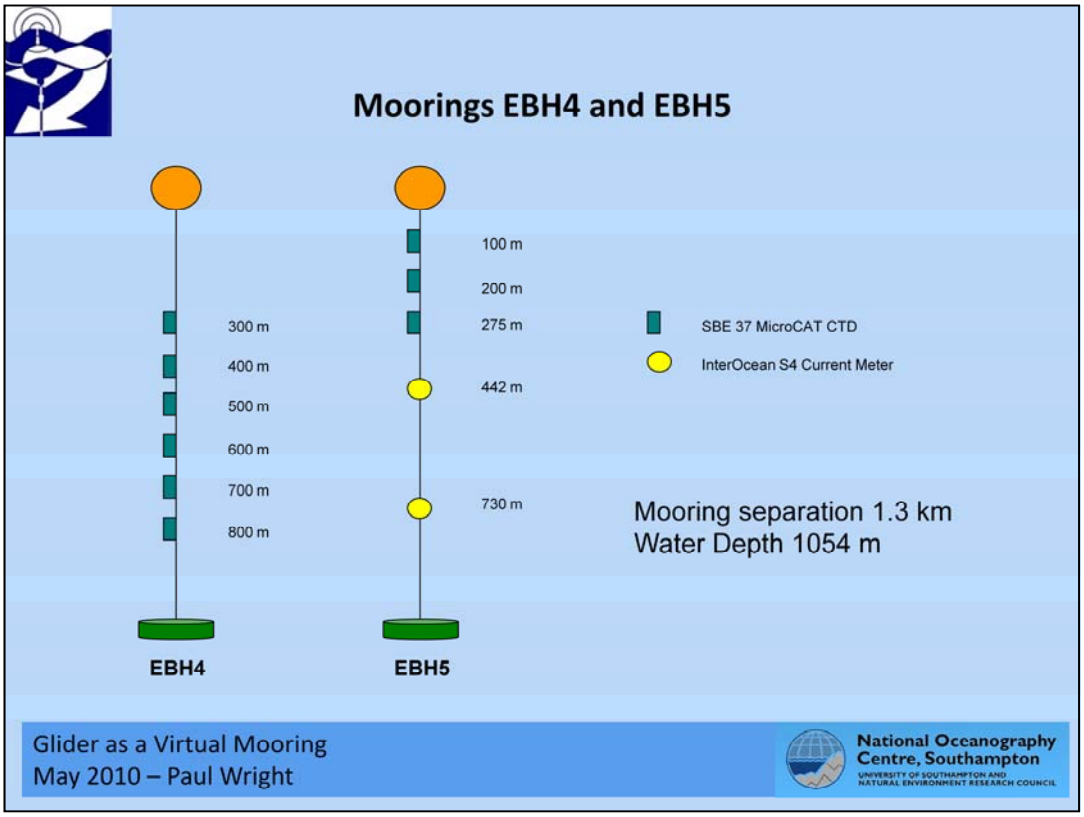


The chart above shows the inshore mooring locations and the GPS locations of the glider when she surfaced. The black stars are the waypoints used to constrain the glider around the EBH4/5 location. The glider rarely was > 4km from the moorings.

The bit to the NNE was to an earlier waypoint, from the Bellamite mission. Results showed that the differences between the MicroCATs and the glider increased as with horizontal distance, especially east to west.

The error to the ENE was likely to be related to a navigation error caused by software issues. (an abort led to a miscount of the number of yos, which seems to have caught out the current correction algorithm)

Note that the moorings and the glider lie almost along the 1000m contour line.

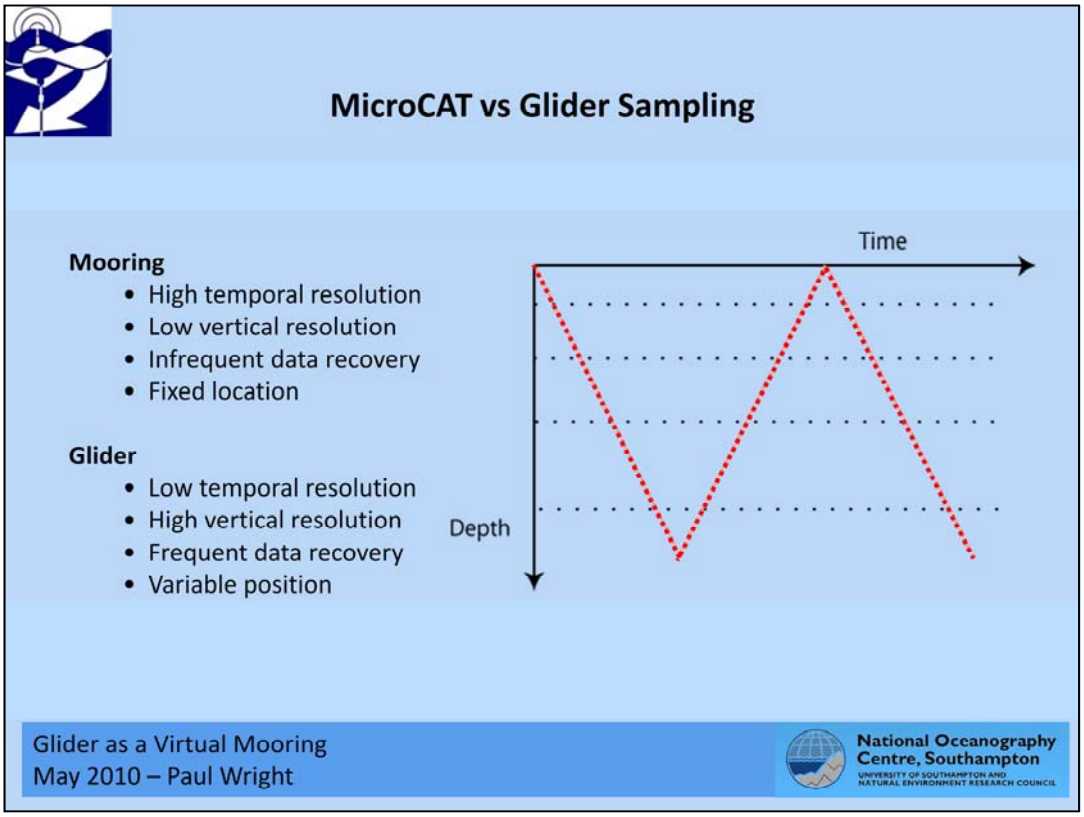


The two moorings EBH4 and EBH5 are now co-located.

There are two moorings rather than one combined one to reduce the risk of losses due to fishing activity. EBH5 was also loaded with 2 S4 current meters.

EBH4 had 6 MicroCAT CTD sensors

EBH5 had 3 MicroCATs and 2 S4 current meters

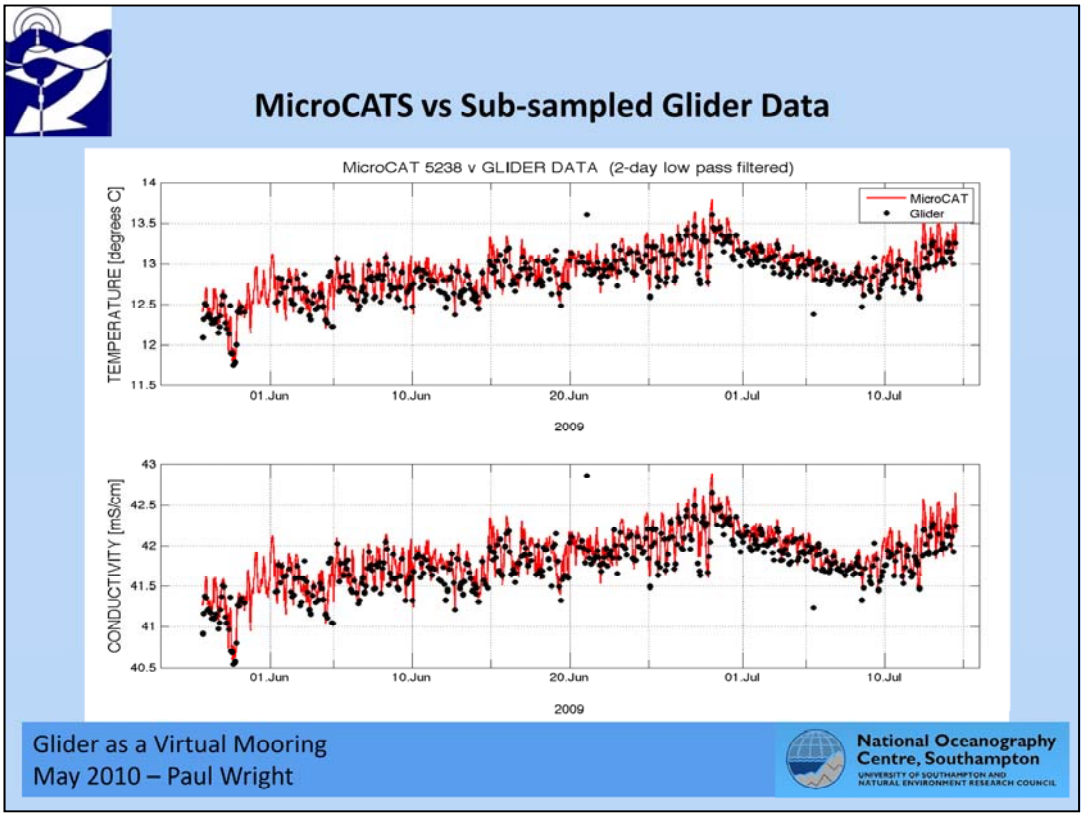


MicroCAT vs Glider Sampling

The two methods of sampling are quite different. The MicroCATs generally remain at a fixed pressure level and location and sample at regular 30 minute intervals. This enables excellent temporal resolution but as there are only 9 MicroCATs for 1000m depth the vertical resolution is very poor. In order to build a full depth profile interpolation based on the data and local climatology is required.

The glider however, samples far more frequently but over a range of depths. On average the glider take about 4.5 hours to complete a profile up and down at a depth rate of $0.38ms^{-1}$, i.e. approximately 5 profiles per day. The glider is most energy efficient when moving slowly (less oil to pump less often). The effect of this is that there is a very high vertical resolution at the expense of the temporal resolution.

As the data are generally 2-day low pass filtered and interpolated on to a 12 hour time grid for the MOC work, the reduced temporal resolution is not so much of an issue.

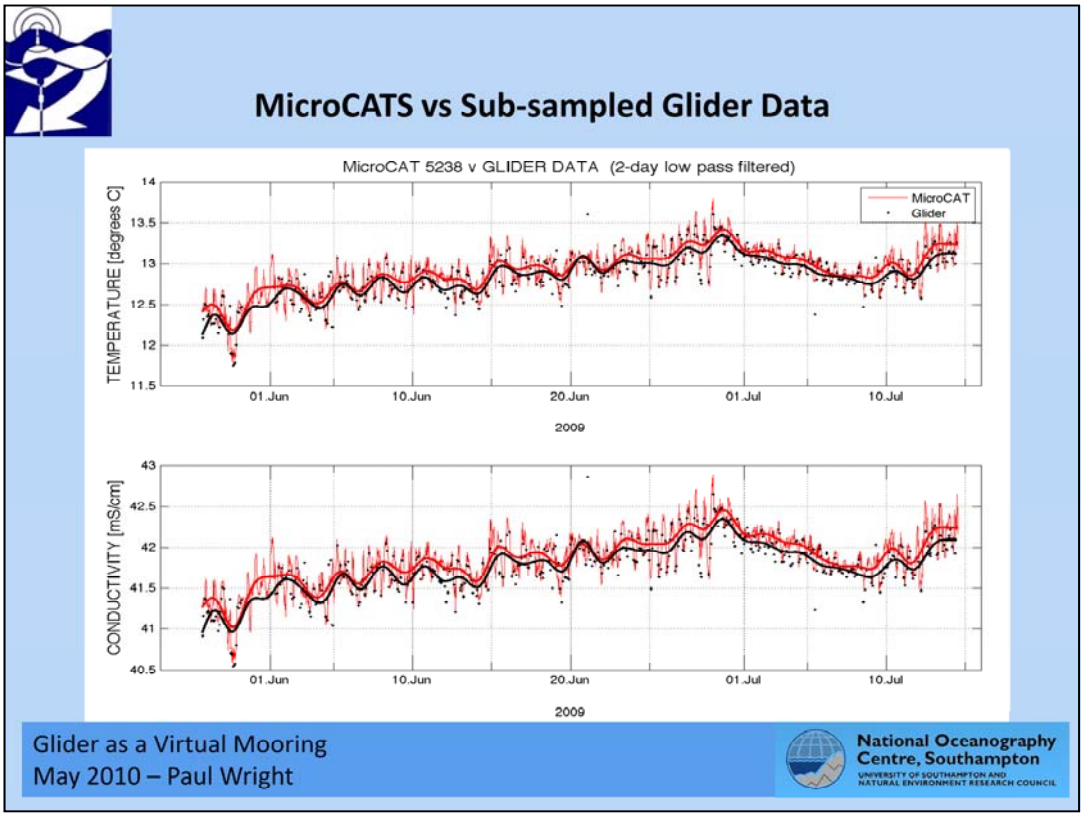


The moorings were successfully recovered in November 2009.

As a first comparison with the glider, the glider data was sub-sampled when the glider was within +/- 0.5dbar vertical depth and +/- 4km horizontal distance from each MicroCAT. The black dots highlight the reduced temporal resolution of the glider at any given pressure level. Despite this the 2-day low pass filtered time series agree very well indeed.

2-day low pass filter removes the tides.

Harmonic analysis was also used and yielded almost identical results, although less smooth than the filtering.



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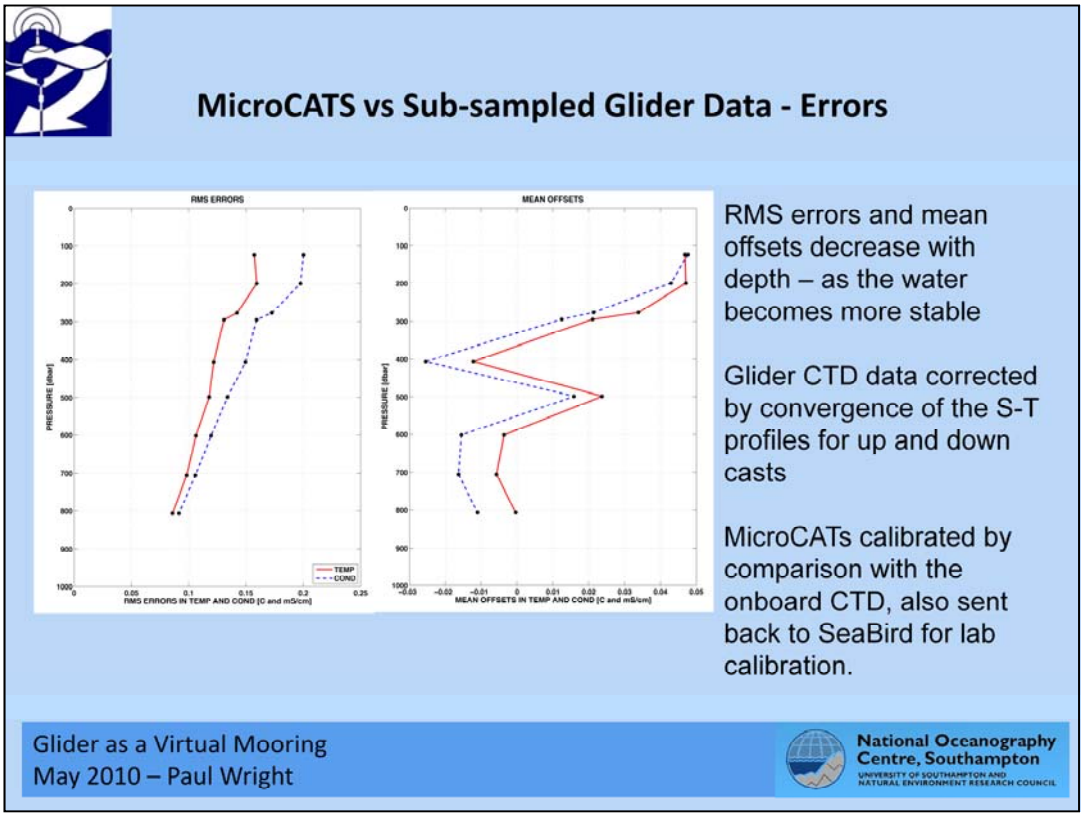

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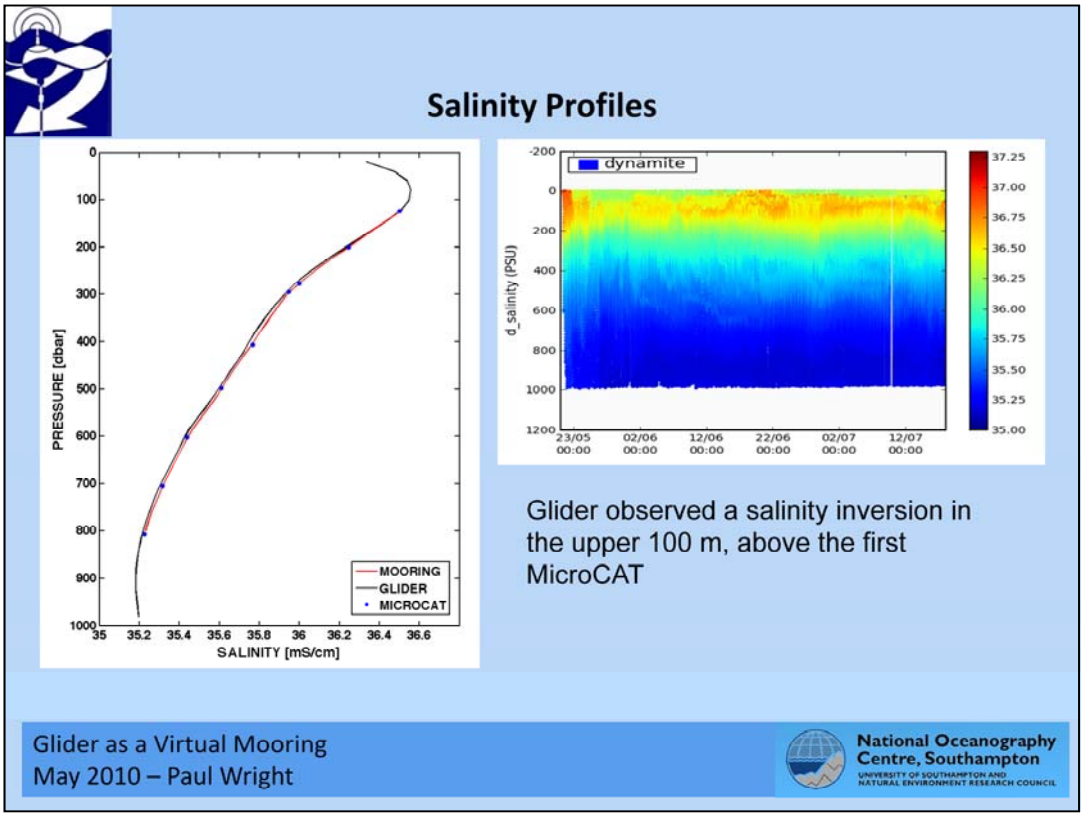


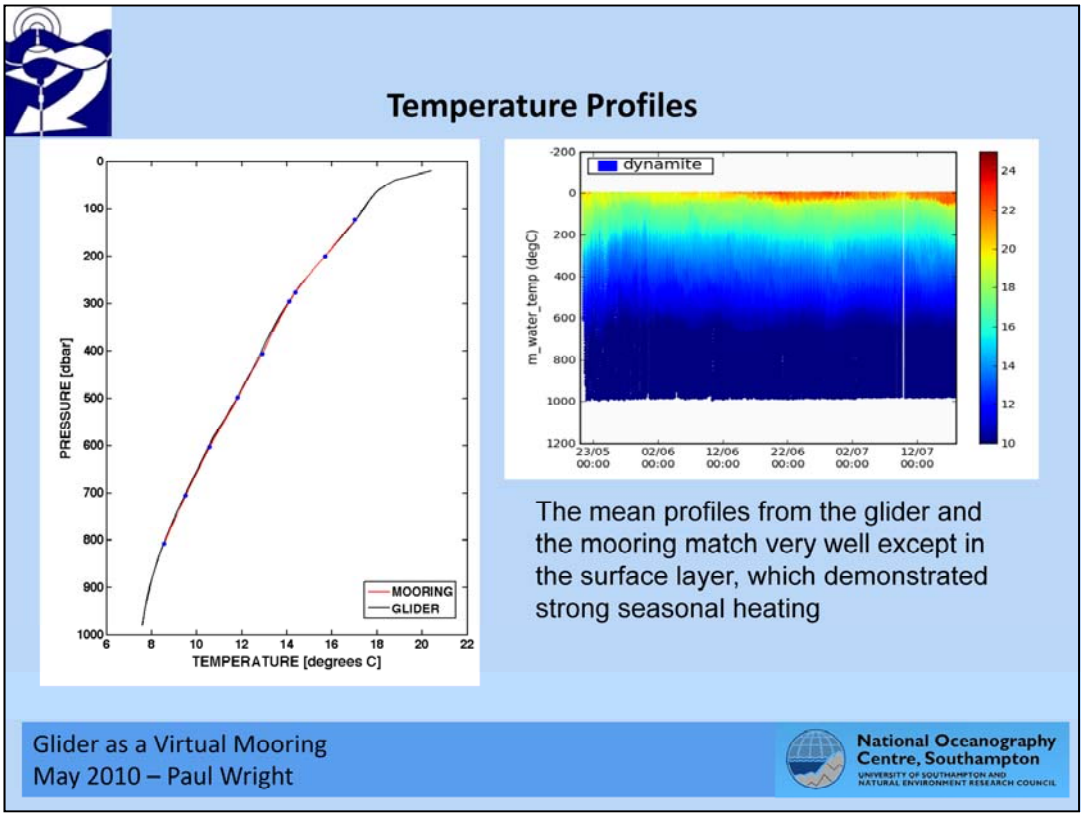
Gridded Products

For the MOC work the data must be gridded onto a 12-hour 20-dbar grid.

These require different techniques, the mooring data uses a vertical interpolation technique based on the climatological ds/dp and dT/dp data as there are only 9 data points for the 1000 m depth range. The glider data is far more detailed – especially as it is full depth. Although the surface layer tends to get lost in the gridding.

For the profiles above the black dots show the mean MicroCAT data and the red curve the mean mooring profiles. They have been extrapolated, for demonstration purposes, to the surface, while the glider data are actual observations. Notice the salinity inversion, which the mooring does not capture at all.

The salinity inversion at the surface is clearly shown in both the mean profiles and the raw glider data from the web site.



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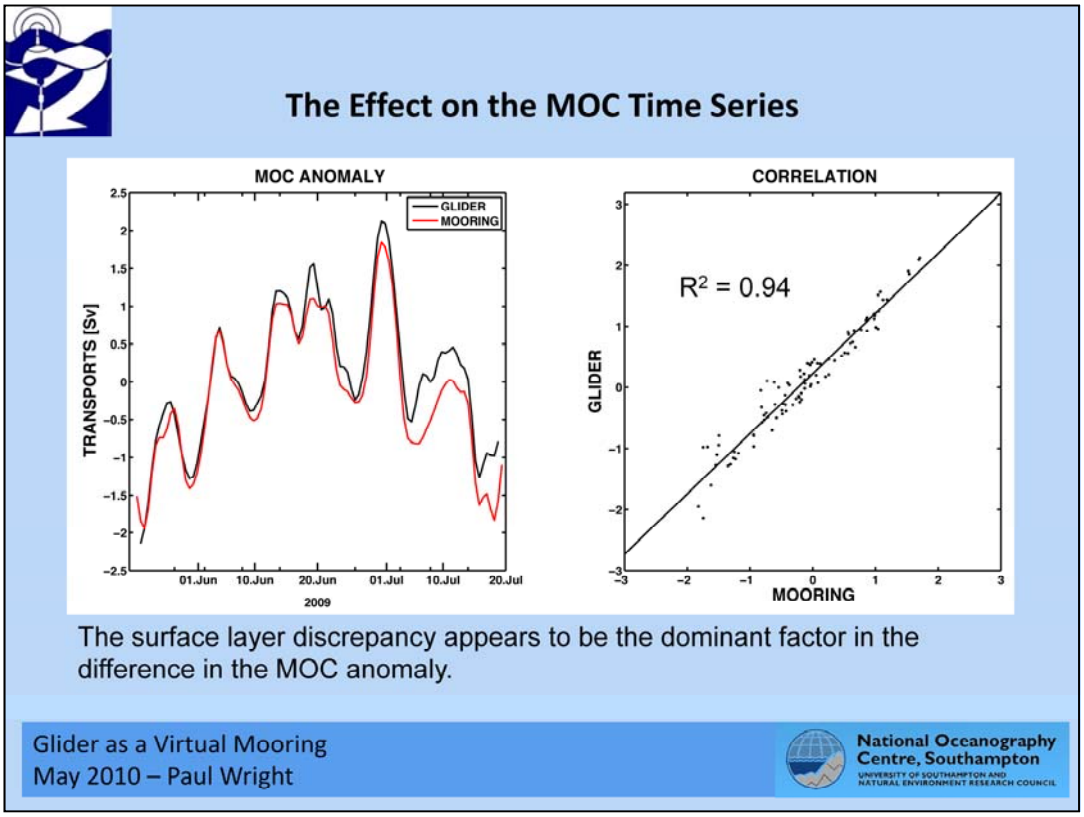


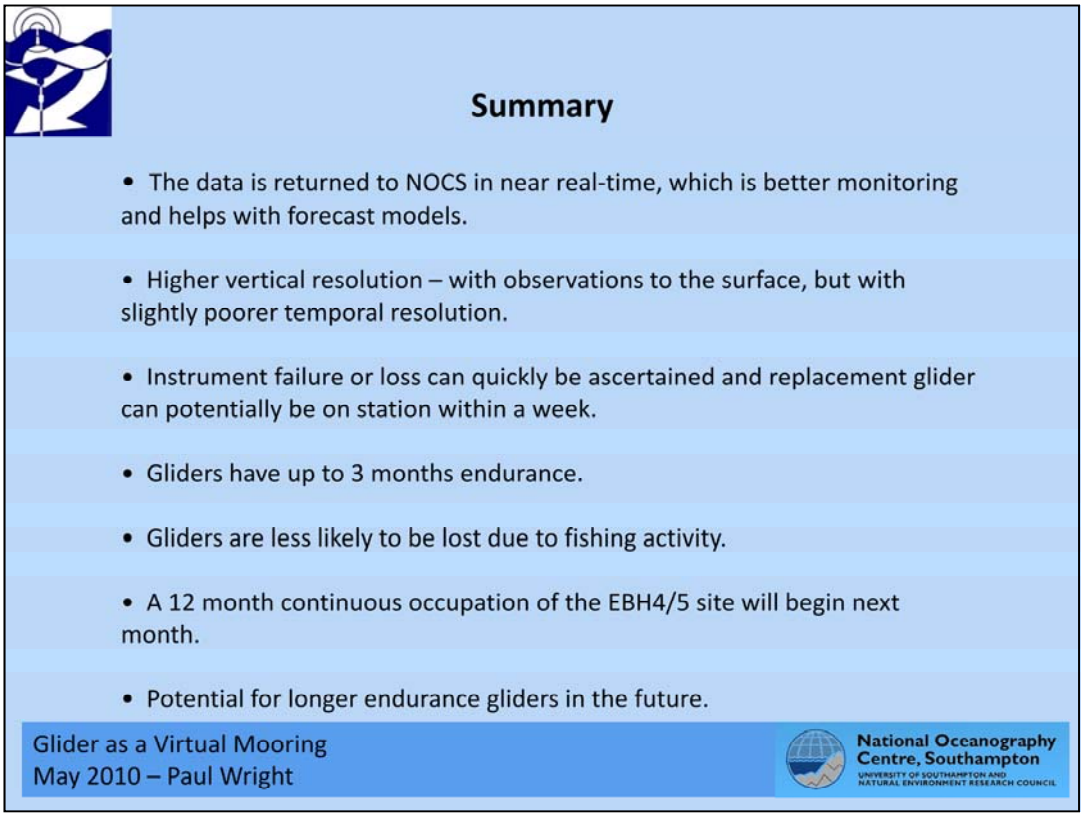
The Effect on the Final MOC Calculation

This is all well and good but how would substituting the glider data at EBH4/5 for the mooring data affect the overall MOC time series?

Surprisingly, quite a bit. The lower salinity and higher SST mean that the surface layer density is much lower than that 'inferred' by the mooring. This is especially noticeable as the SST increased as the summer went on.

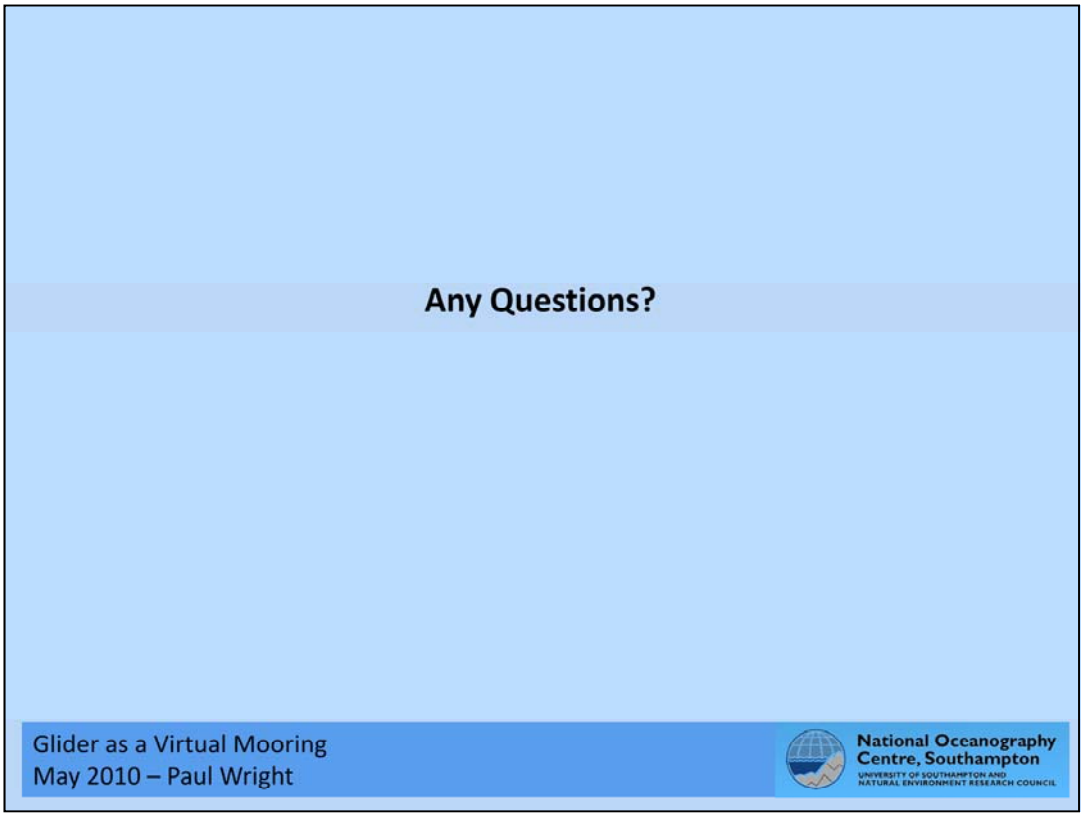
Conclusion: as the glider uses full depth observations it is likely to yield better S and T profiles than the single mooring at EBH4/5, despite the poorer temporal resolution. Although how much the MOC is affected by small scale filaments is debateable. The surface layer tends to be dominated by the Ekman and Florida Current transports.

FOLLOWING slice is a possible replacement. It shows the MOC as calculated between WB2 and the eastern boundary with the glider data substituted for the mooring data. It therefore also includes the Florida Current and the Ekman transports. It is 10-day low pass filtered.



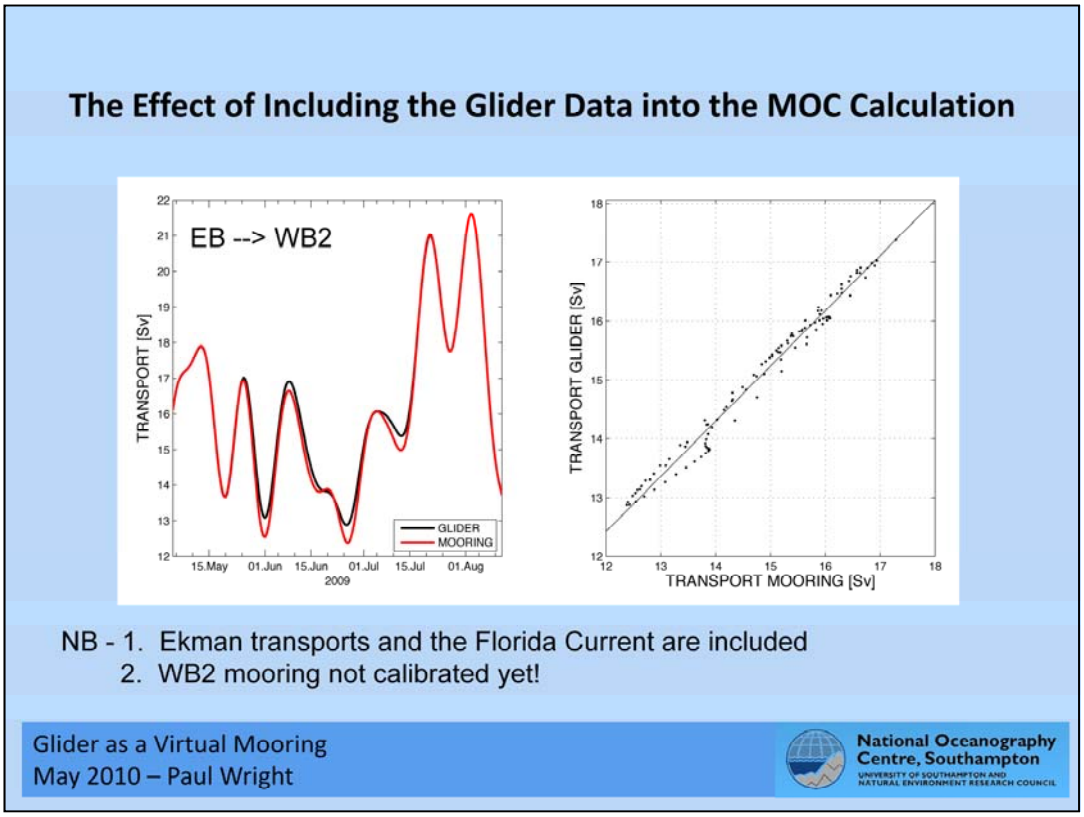
Gliders can do the job! Although RAPID is also investigating a telemetry system for the key mooring.

The western boundary cannot use gliders as they currently stand due to the stronger currents.



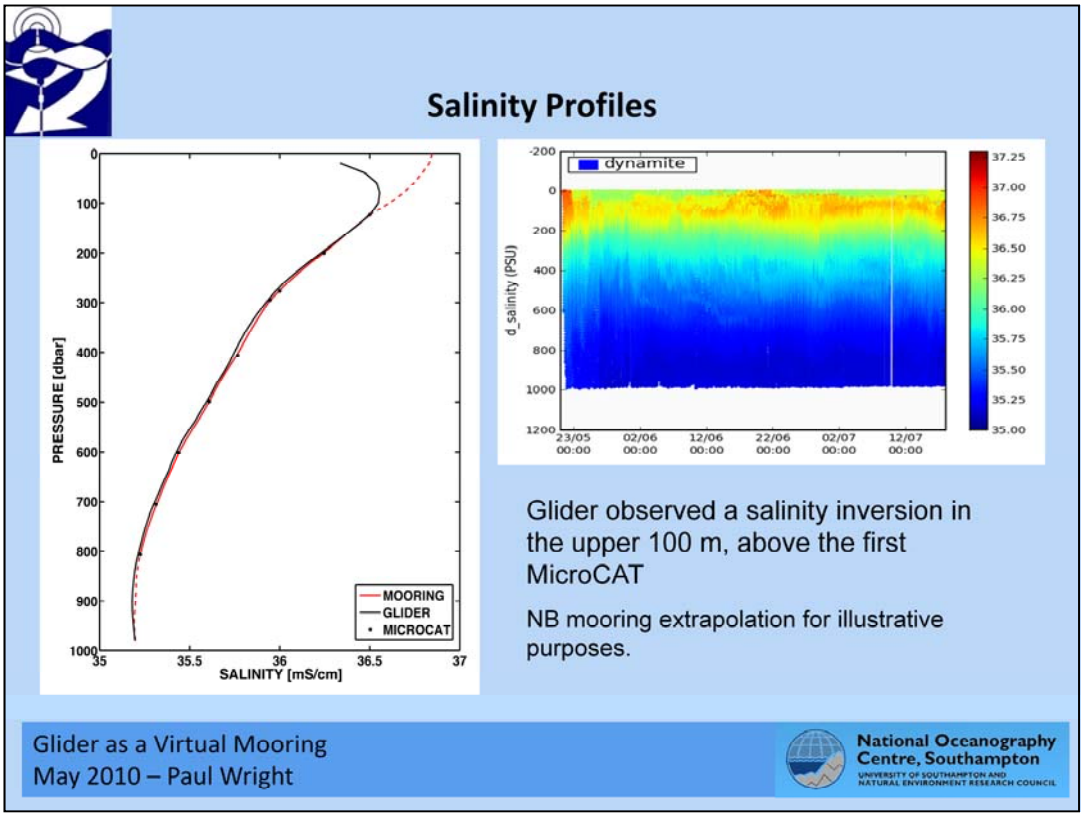
Need to check on figures

Is this necessary? May just use final figures?



MOC time series based on mid-ocean transport between WB2 and the eastern boundary, Ekman transport and the Florida Current. The glider data has been substituted for the upper 1000m of the eastern boundary for the period of the Dynamite deployment. The correlation between the two time series is shown on the right.

The surface layer effects of the salinity inversion and the SST rise is masked to a degree by the Ekman and Florida Current transports.



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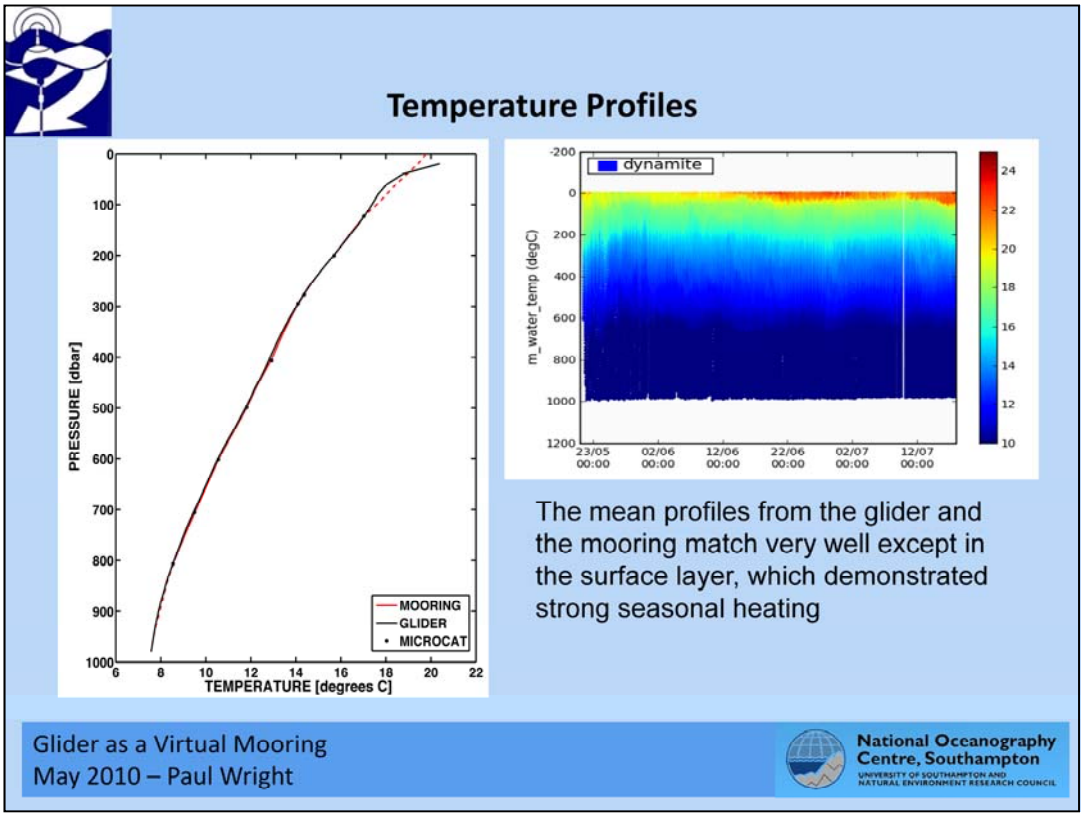

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