Evaluating the performance of the CONCEPTS Global Ice Ocean Prediction System over the Grand Banks using ship based Doppler sonar velocity measurements

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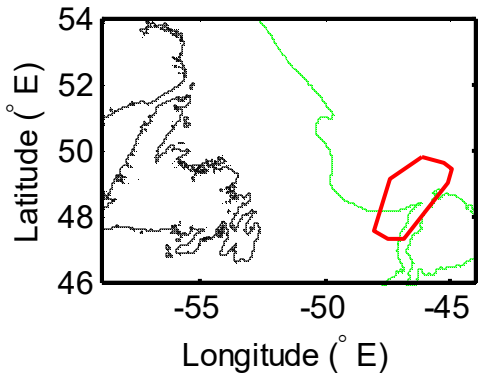
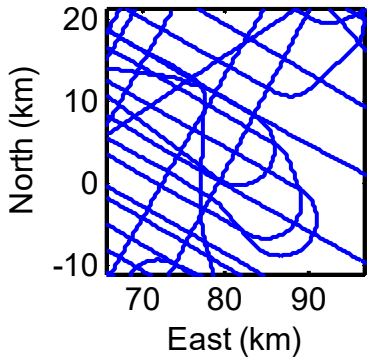
Motivation

- There is a need for oceanographic data to calibrate and validate ocean models
- In many areas of the ocean, such data is sparse or not available
- Seismic surveys collect water velocity measurements using Doppler sonar
- Critically, seismic surveys take place where operational ocean models could be of significant future value
- Can Doppler sonar velocity profiles be used to validate ocean models?

The Seismic Survey

Chevron 2011 North Grand Banks seismic survey
June 12 to August 17, 2011

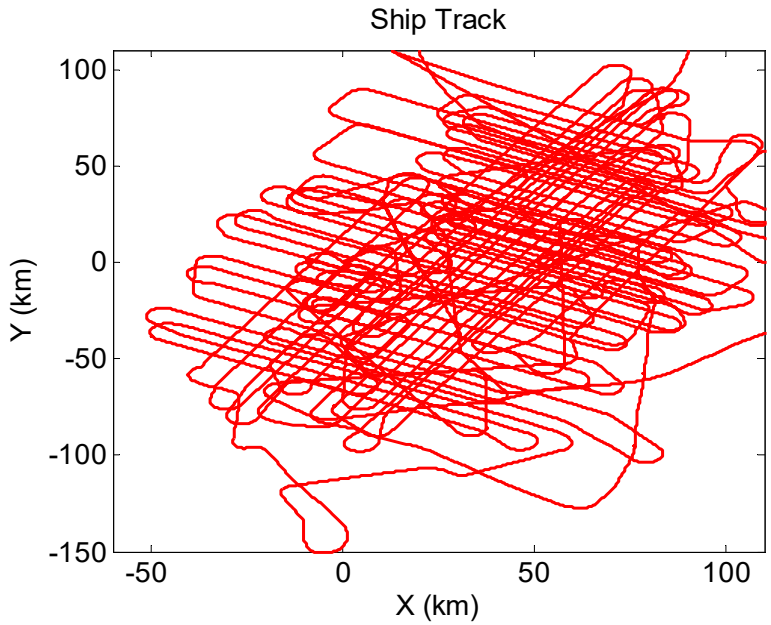




67 Days of data
32,000 km^2 area surveyed
12,000 km ship track

Water depth range from
100 m to 3000 m

Ship track includes
many repeat passes
of the same area



ADCP Data

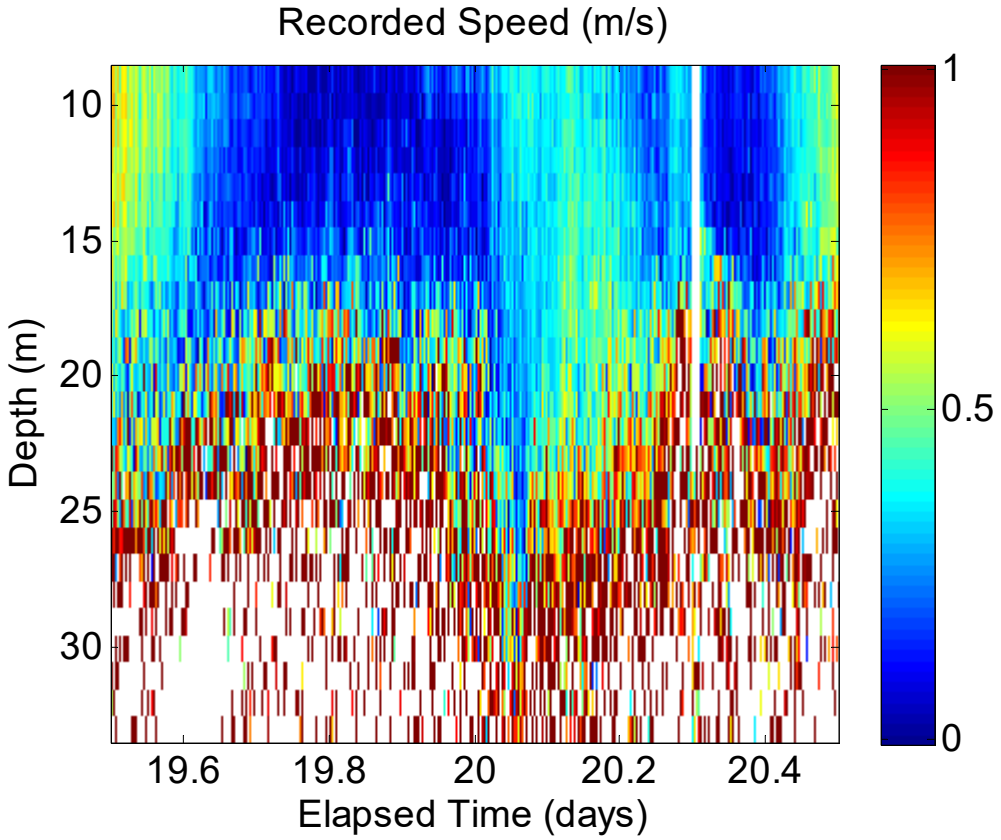
Nortek AWAC 600 kHz located at 8 m depth

Instrument was configured

1 m depth cells
40 depth cells (9 m – 49 m)
Average over 20 seconds

Data is clearly meaningless beyond depth of 15 m

Velocity < 15 depth is uniform … mixed layer



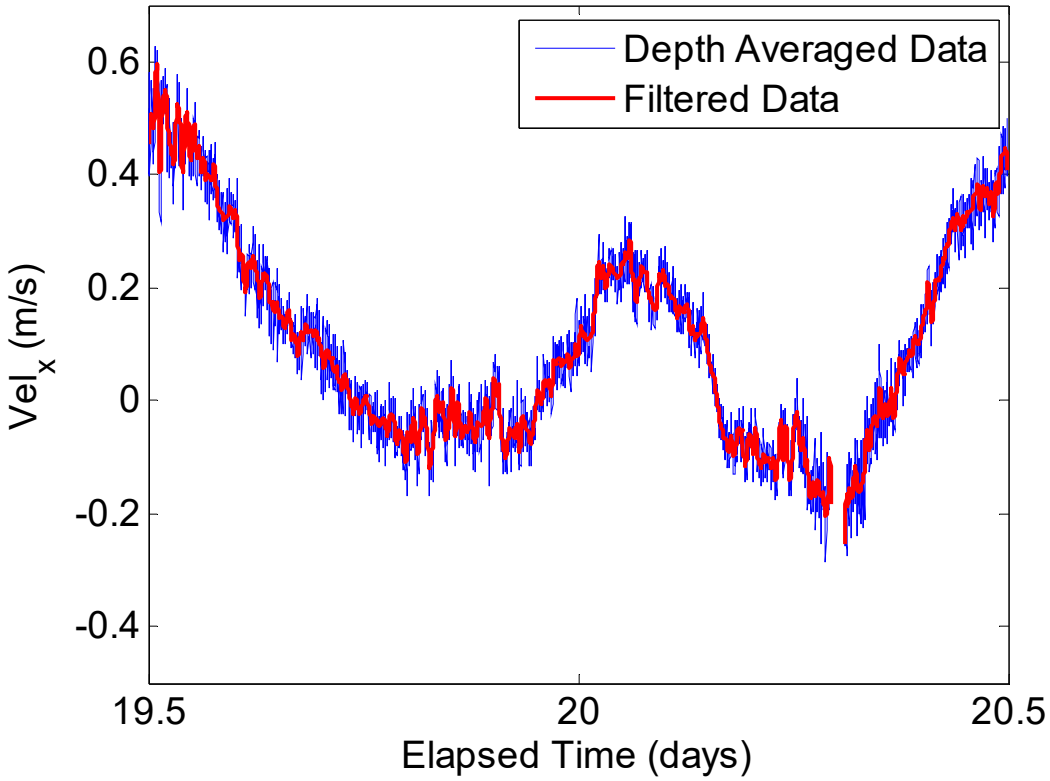
24 hour example of AWAC data

ADCP Data

Data were averaged in time and depth

All data in 8 – 15 m depth interval were averaged together (essentially creating a mixed layer velocity estimate)

Data were further low-pass filtered with 20 minute cut-off



ADCP Data

A common problem with ship mounted ADCP is that some fraction of the ship speed appears as a bias error in the water velocity measurements

$$\vec{V}_{\mathrm{m}} = \vec{V}_{\mathrm{t}} + \beta\,\vec{S} + \alpha\,\vec{T}$$

Where:

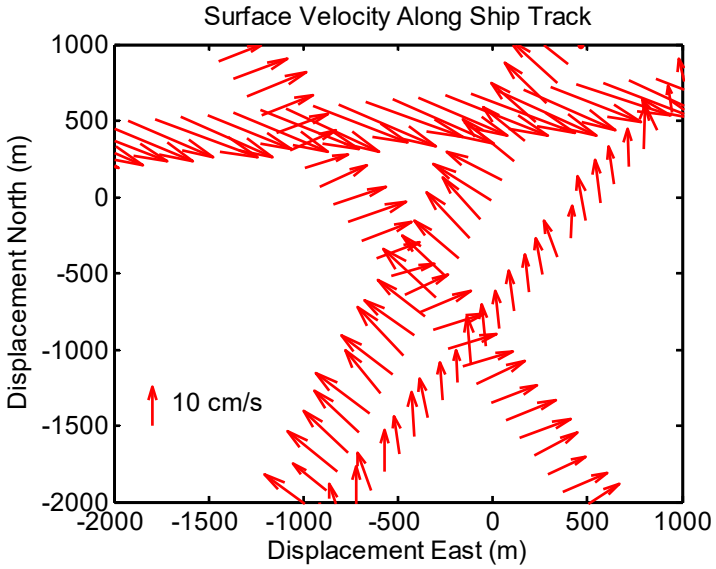
$\overrightarrow{V_{\mathrm{m}}}$ is the measured velocity of water

$\vec{V}_t$ is the true velocity of water

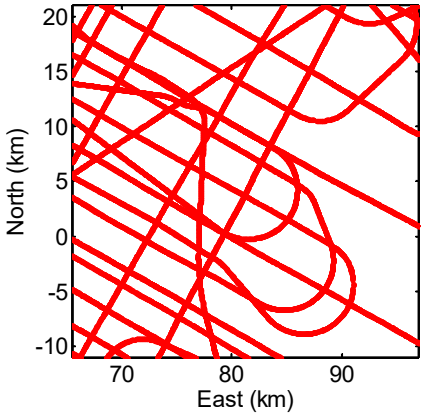
$\vec{S}$ is the ship velocity

$\vec{T}$ has magnitude $\left|\vec{S}\right|$ directed across the ship track

α and β are scaling factors



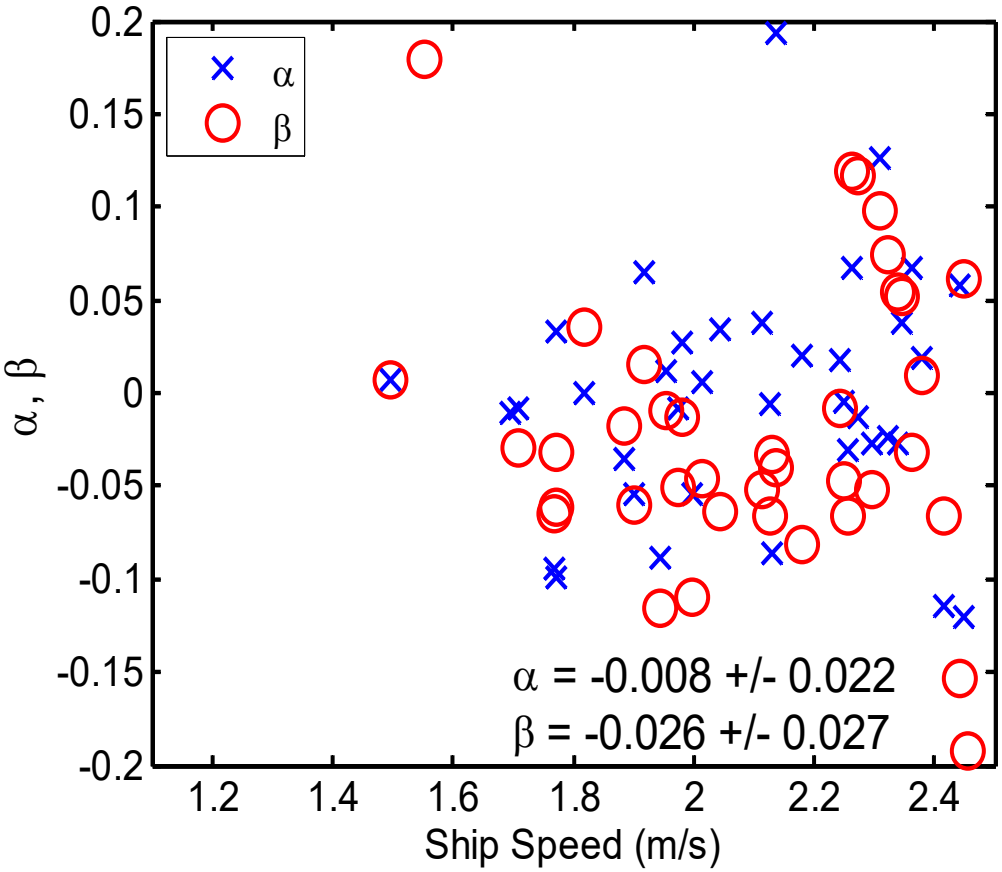
ADCP Data



Comparison of speeds is actually not so bad, maybe there is hope

α is not significantly different from 0.

β is just different from 0 (but not by much). (I have not applied this correction).



Model Data

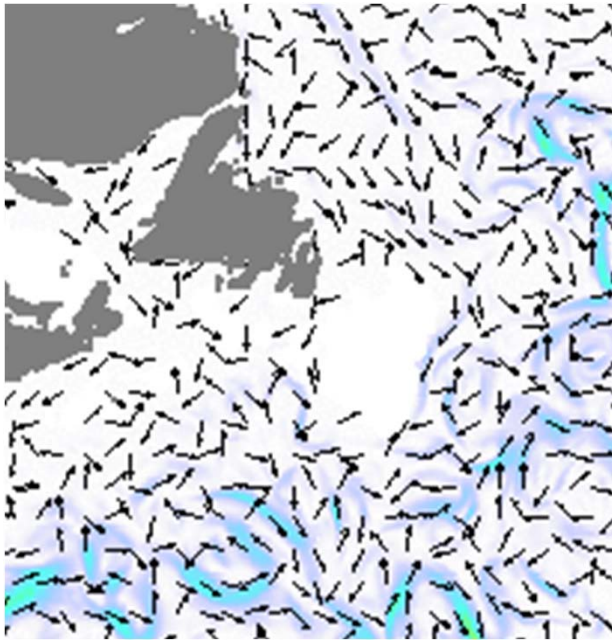
The Global Ice-Ocean Prediction System (GIOPS) Canadian Operational Network of Coupled Environmental Prediction Systems (CONCEPTS)

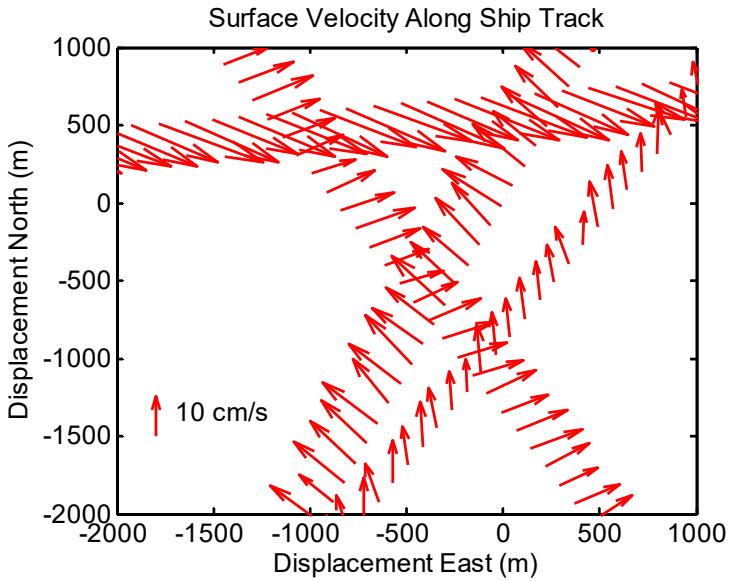
GIOPS 10 day forecast based on NEMO version 3.1 and CICE version 4.0.

Global ¼ degree resolution and 50 vertical levels

- Full model data was made available every three hours

Data and model compared by selecting model data that follows survey ship.



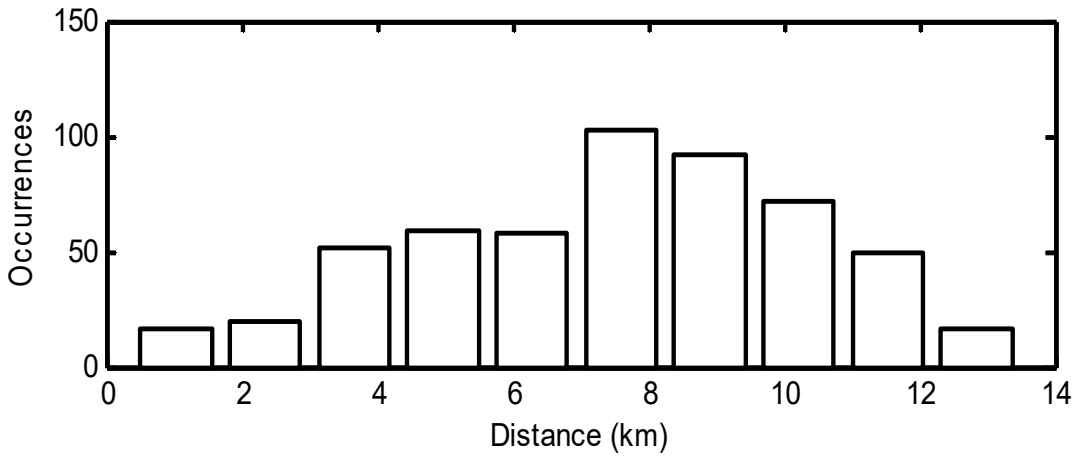


Comparison

ADCP data was filtered with a 3 hour low pass filter and sampled every three hours to match model output

Model data for comparison was selected based on closest model grid point to nominal sample location NO INTERPOLATION

Typical distance between model data and ADCP is 8 km (maximum is < 14 km).

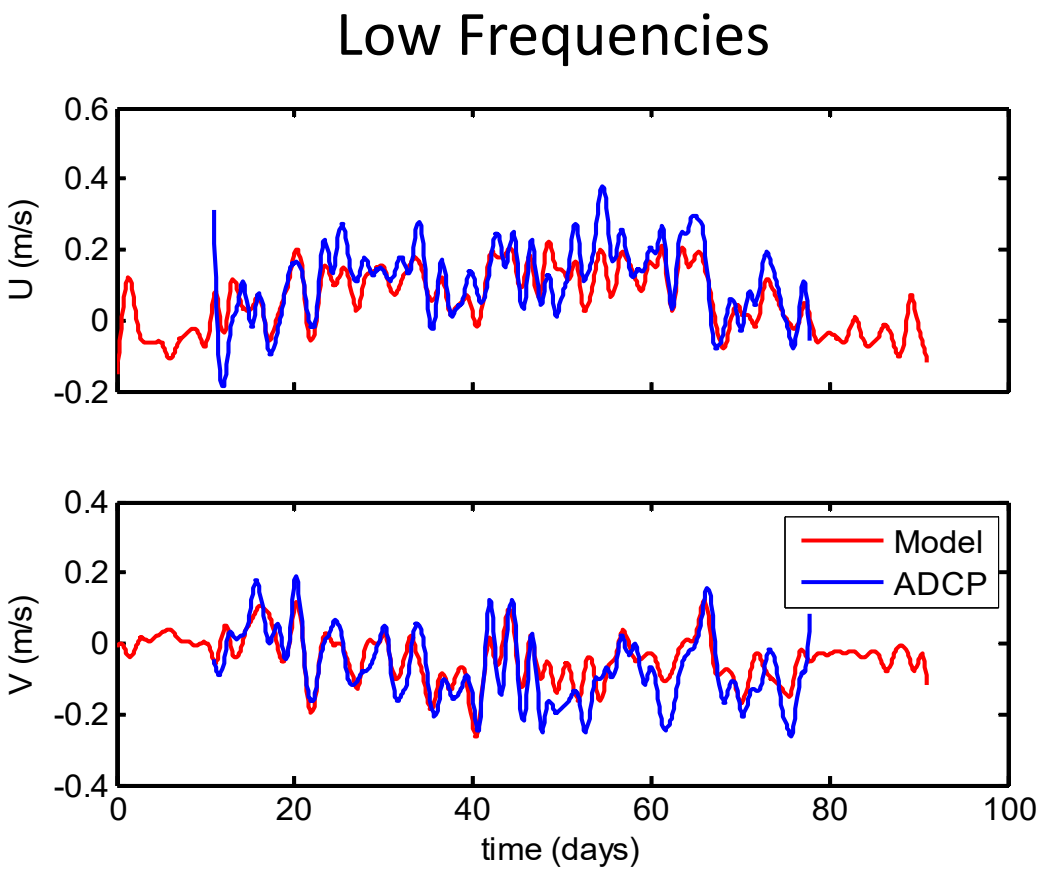


Time Series Comparison

Model output was averaged over 8 –16 m depth to match ADCP. All data low-pass filtered with 48 hour cut-off

I was gobsmacked by this figure!

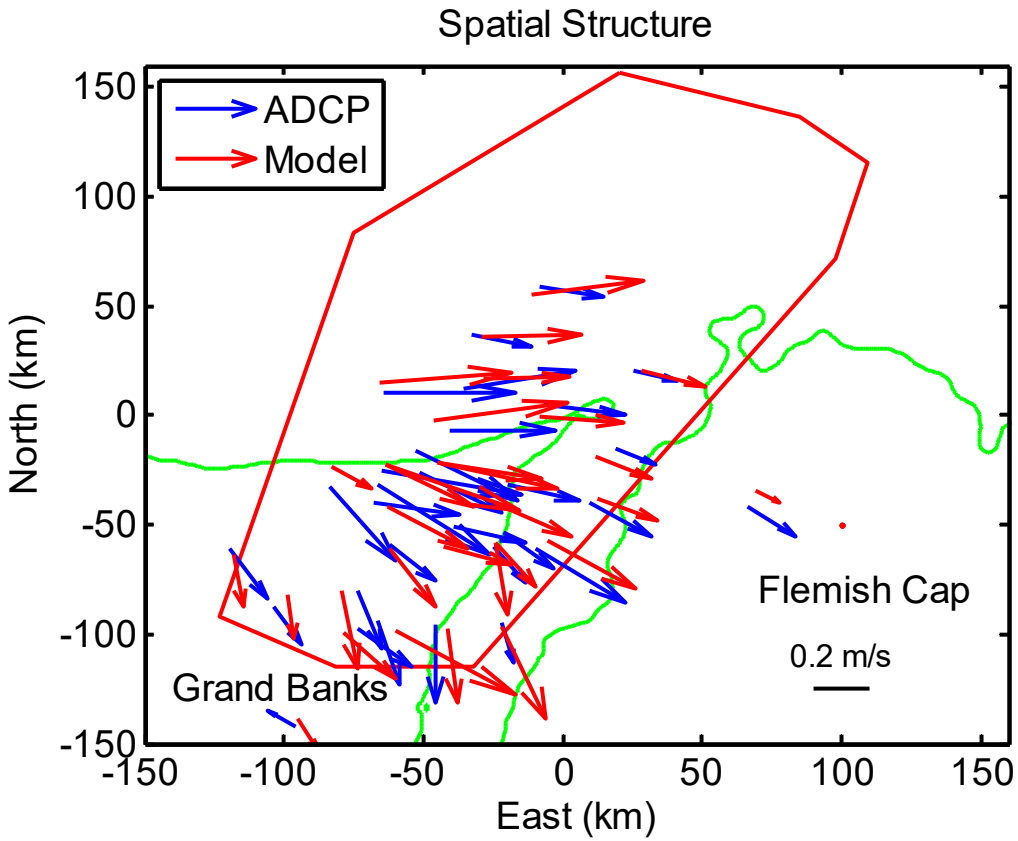
"I didn't think it would work"
Fraser Davidson, 2014.



(Time series takes moving ADCP data and matches to nearest available model data position)

Time Series Comparison

2 – day low pass filter
Vector plotted every 2 days

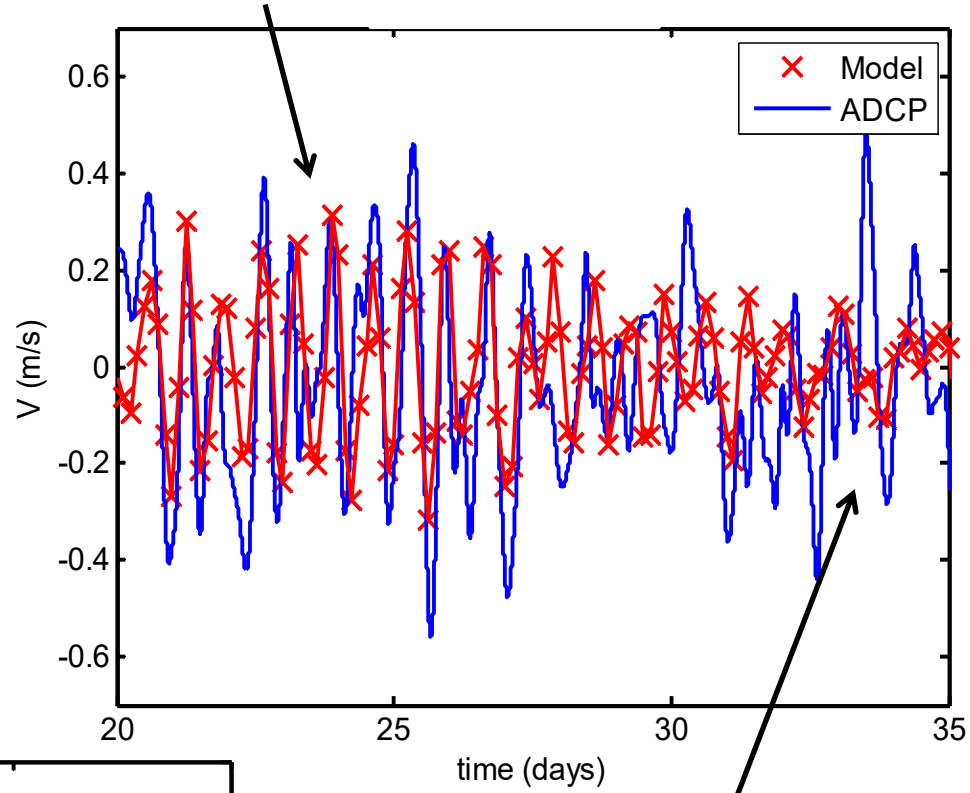


Model resolution

Time Series Comparison

High Frequencies

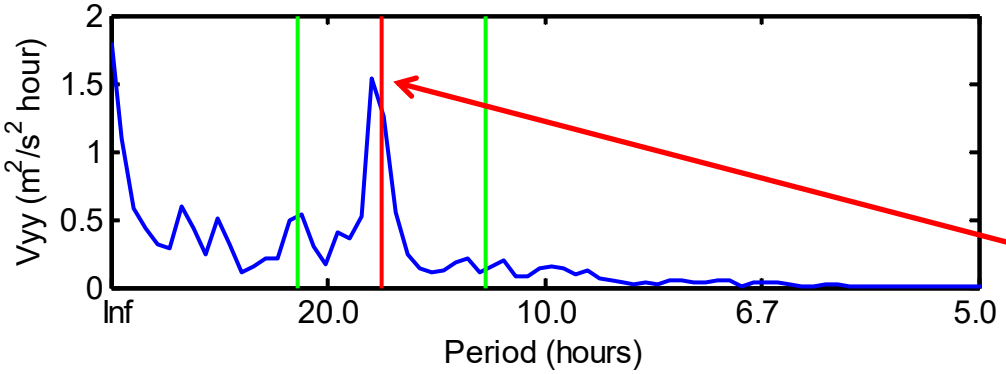
Sometimes it's really good



Filtered data with 3-48 hour pass-band

"Oscillation" is real inertial current captured by model!

Other times not so good



16 hour inertial period
(spectral analysis from ADCP data)

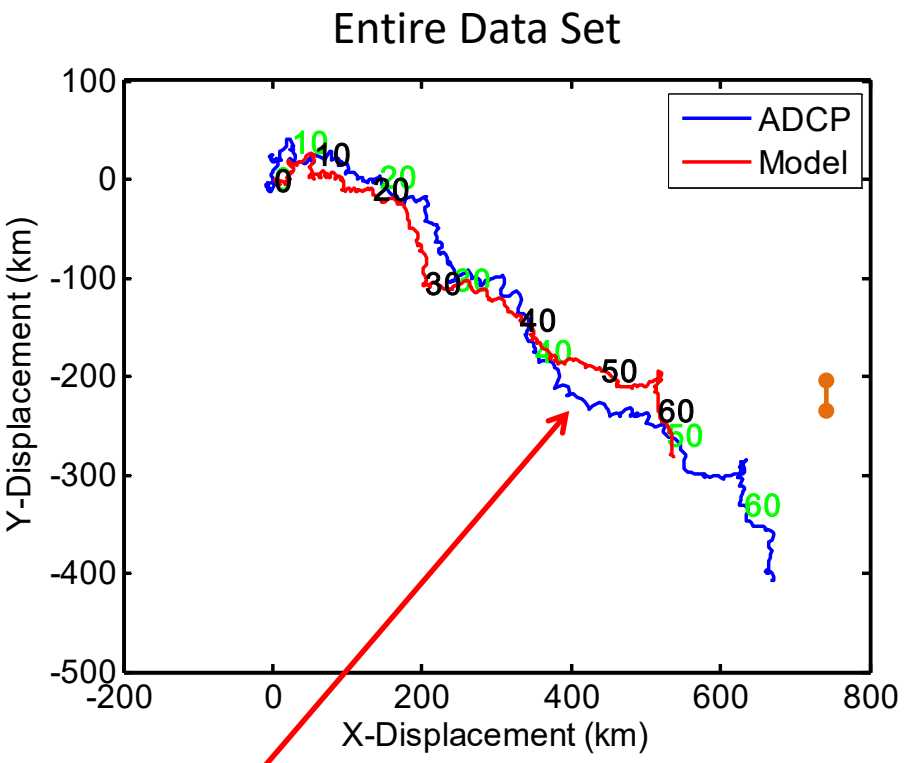
From Survey Ship Logs

25 June 2011 The weather steadily improved during the day with very good conditions present by the end of the reporting period. This good weather was utilized in a line change in the afternoon to address problem areas at the very front of STR3 and STR7 that could only be repaired in good weather conditions. Currents have been increasingly noticeable in the past several days. Currents were present over one knot for extended periods during the day which slowed the acquisition rate somewhat.

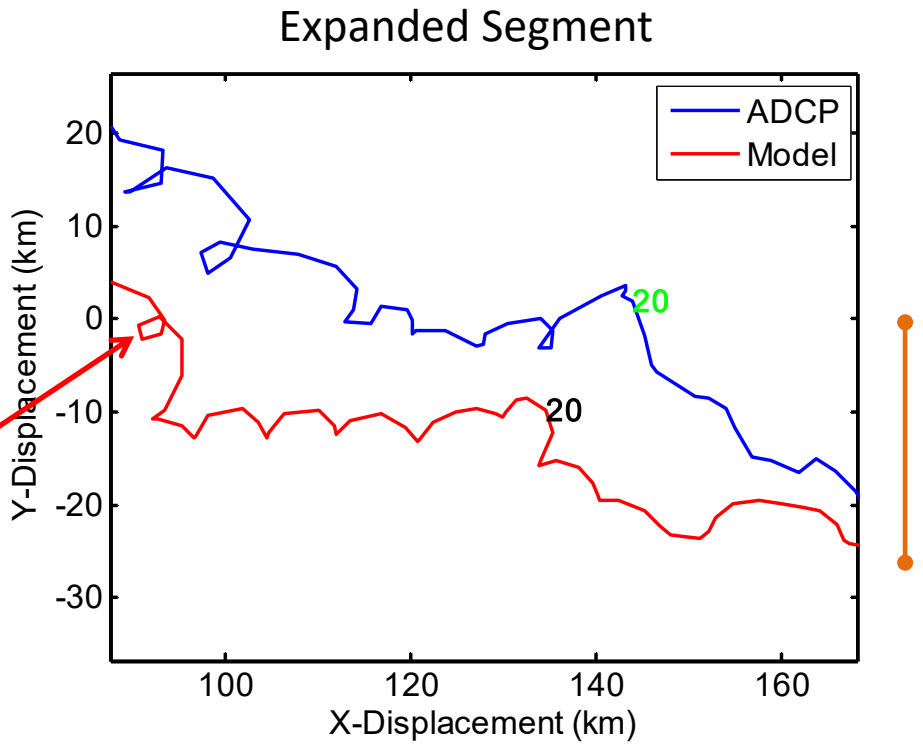
Sequence 013	Wind: NE 8 knots	Positioning
GB11-6920P1-013	Swell: NE 2.0 m	Sp 5898Current change causing feather to change from +6 expected to
Date: 25 Jun 2011		be negative. Vessel driving to stbd .3VC. Steer point @ DC -88
Dir 116.0°	SOL Noise: 9.5 µBar	Sp 5840Steer point stabilized and coming stbd. Currently at DC -71
FGSP:5886	EOL Noise: 5.81 µBar	Sp 5746Steer point steady at DC 0
LGSP:3518		Sp 5639decreased range exclude start [m] to 425 & max iterations to 2
		d/t IPM lagging
		Sp 5016strange currents causing vessel to move back and forth.
		monowings a bit unstable. qfins having trouble keeping depth
		Sp 4996bridge taking over and keeping a CMG of 116
		Sp 4866currents increasing from .3 to 1.1+
		Sp 4823failures in positioning d/t high Q fin steering & currents.
		Sp 4641vessel back in seistrack

PREDICTABLE currents caused disruption to seismic data acquisition!

Drift Track Comparison



For some reason, model falls behind at between days 40 and 50



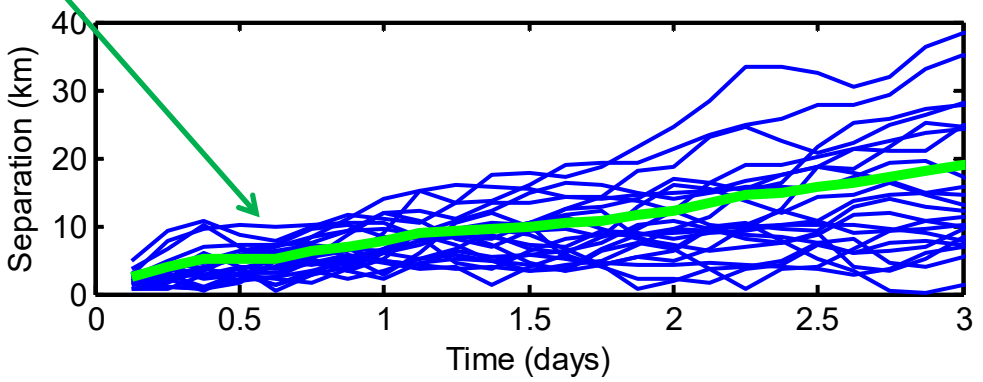
3-hour samples just captures inertial oscillations

Model resolution

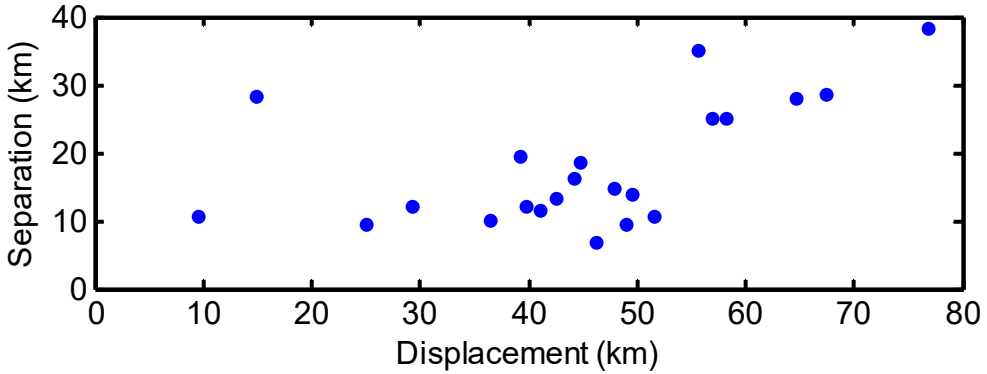
Drift Track Comparison

RMS drift track separation is 8 km after 1 day

Drift track separation dependence on time



Drift track separation dependence on displacement



(RMS separation of tracks from adjacent model grid points after 1 day is 4 km)

Conclusions

- Seismic survey ADCP provides quality data
- Comparison with ocean prediction model is "better than expected":
  - ➢ Captures overall low frequency structures
  - ➢ High frequency captures inertial oscillations
- Drift track separation 8 km in 1 day
- Huge potential if deeper profiles available
- Yes, ADCP (from seismic surveys) can be used to validate ocean models

Acknowledgment

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Questions

Jinshan

Fraser

Len