NortekUSA

www.nortekusa.com

True innovation makes a difference

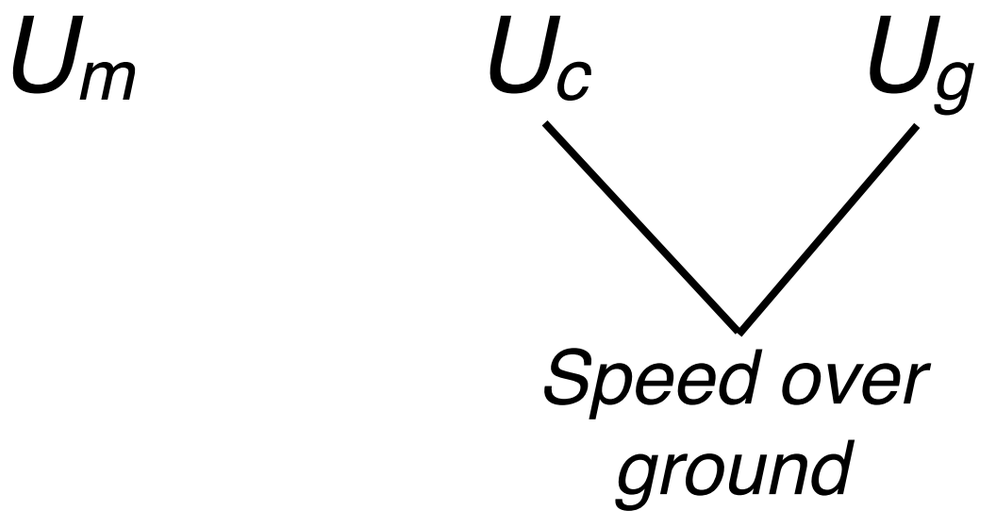
Processing Velocity Data from a Glider

Peter J. Rusello
Scientist
Nortek

What the AD2CP-Glider is Measuring

- A Doppler current profiler measures motion relative to the instrument.
- More specifically, the mono-static AD2CP-Glider measures relative radial motion along each of its acoustic beams.
  - Glider motion is implicitly measured.

$$u_{measured} = u_{current} - u_{glider}$$



A Fundamental Problem

Once underwater, there is no reliable, easily implemented way to obtain horizontal position information on the glider.

This means we don't know the glider velocity and can't determine the water velocity.

What we are faced with is a **localization** problem.

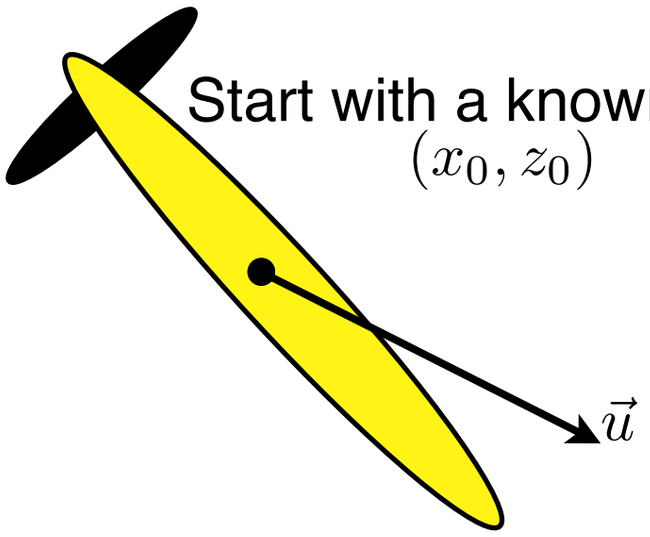
Goals of Data Processing

1. Position estimates
2. Obtain water velocity information
   (a) Velocity shear
   (b) Mixing coefficients and turbulent flow statistics
3. Uncertainty analysis

Position Estimates

- Vertical is relatively simple, we know where the free surface is.
  - Lots of options available to improve these estimates.
- Horizontal is hard:
  - GPS doesn't work underwater.
  - Acoustic baseline systems are slow and have limited range.
  - We only get information at the surface.

Dead Reckoning



Start with a known position
(x_0, z_0)

Obtain a velocity estimate $\vec{u}$

Time passes…

Some time later, estimate a new position
$(x_0 + \Delta t[\vec{u} \cdot e_x], z_0 + \Delta t[\vec{u} \cdot e_z])$

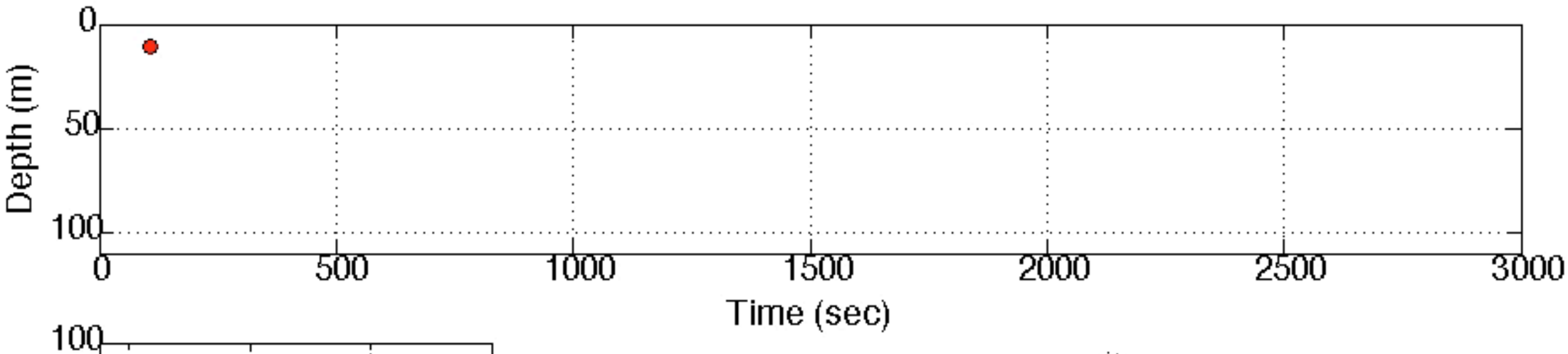
Continue on in this manner, updating position and velocity until a new position fix is obtained.

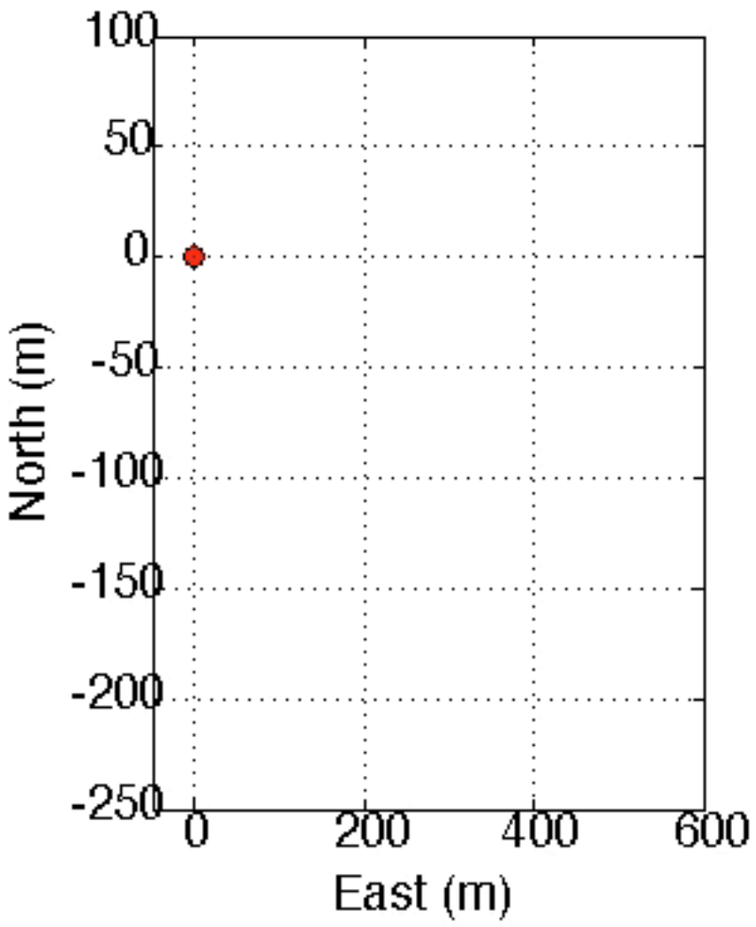
NortekUSA

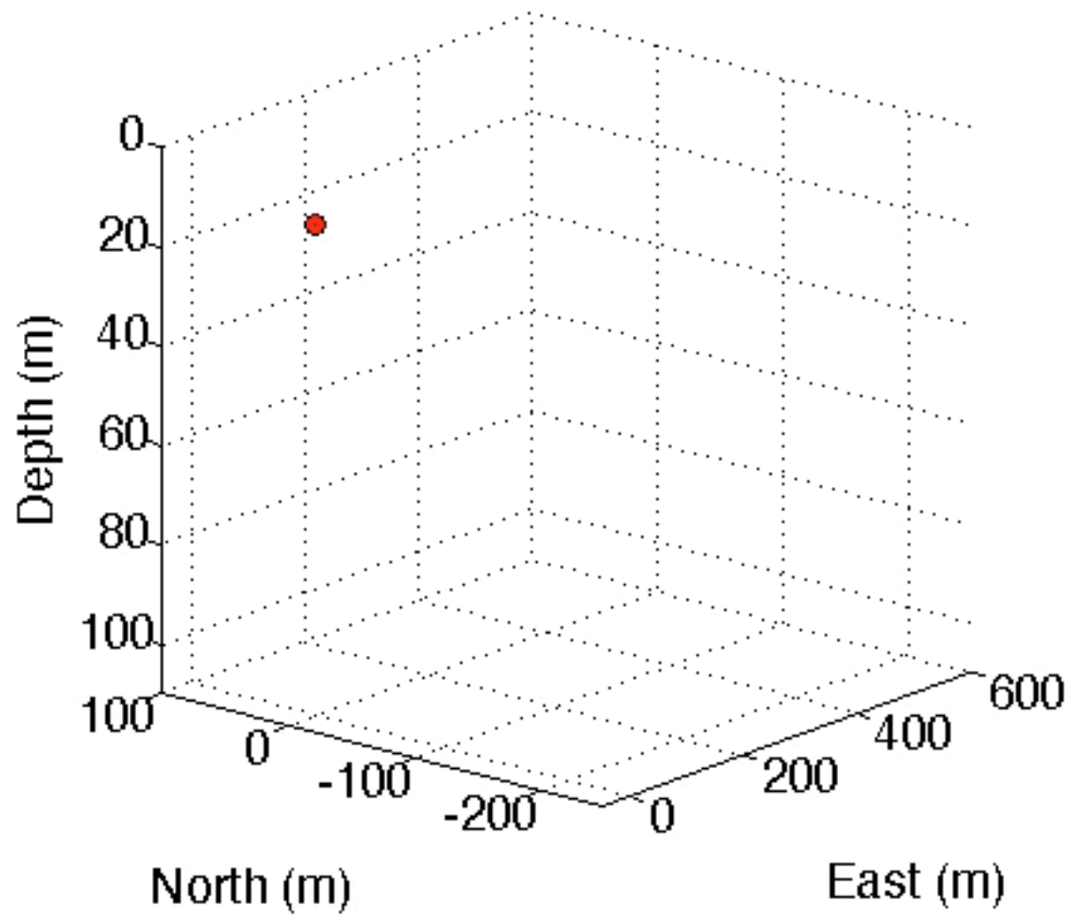
www.nortekusa.com

Dead Reckoning

True innovation makes a difference





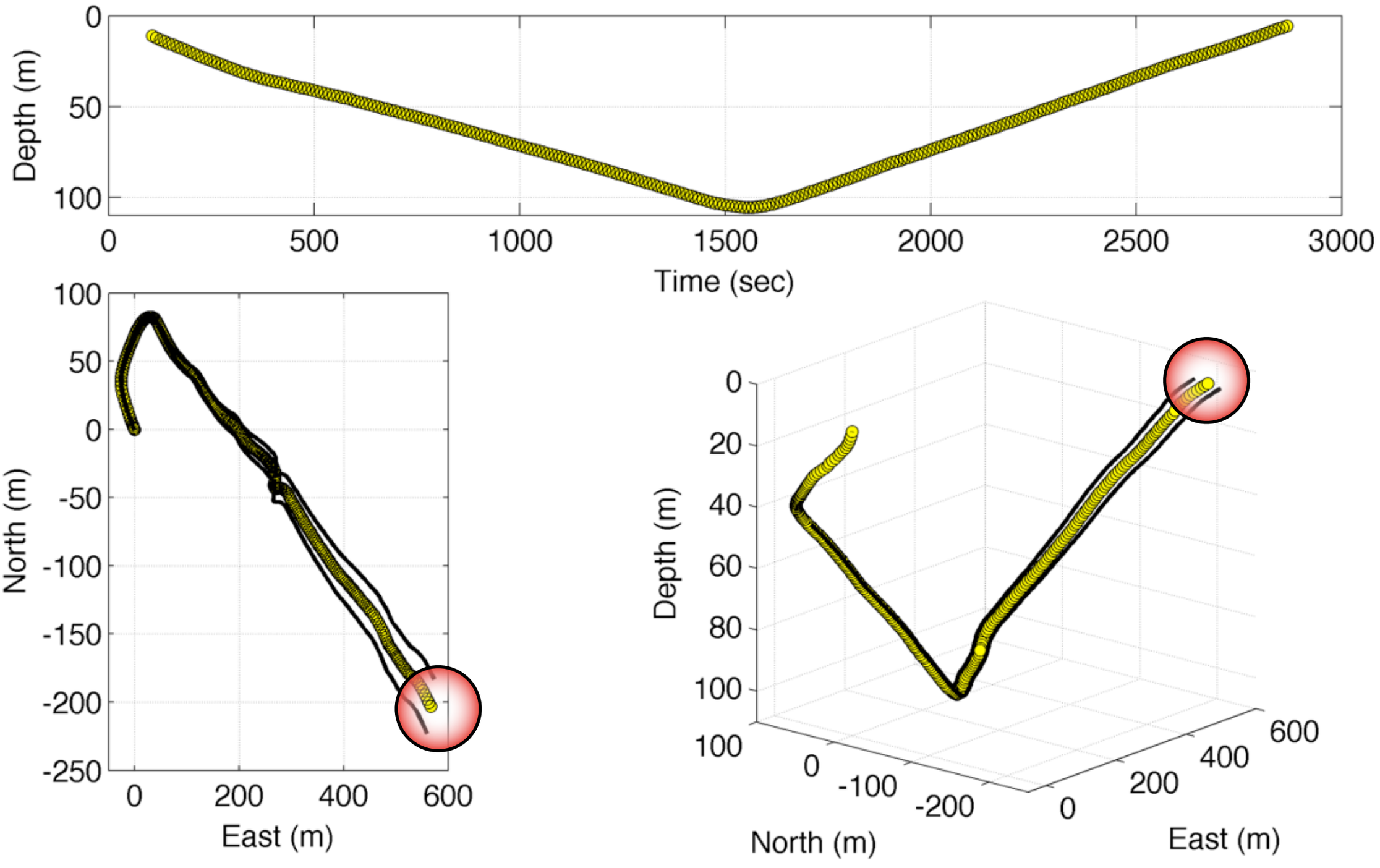


NortekUSA

www.nortekusa.com

Where does the glider end up?

True innovation makes a difference



Depth Averaged Currents

- With a few assumptions, we can obtain an estimate of the depth averaged velocity over the glider's operating depth range.
- Most gliders already include this type of processing by utilizing a hydrodynamic model to estimate glider velocity.

The Mean Velocity Profile

- Processing attempts to estimate the glider velocity, the water velocity, or both to obtain absolute, earth referenced velocities.
- There are two basic methods available for global processing:

1. Integration of shear profiles

Shear Processing

- Originally developed in the late 1980s and early 1990s for processing lowered ADCP datasets.
- This processing technique removes platform motion by differentiation and integration of measured velocities.

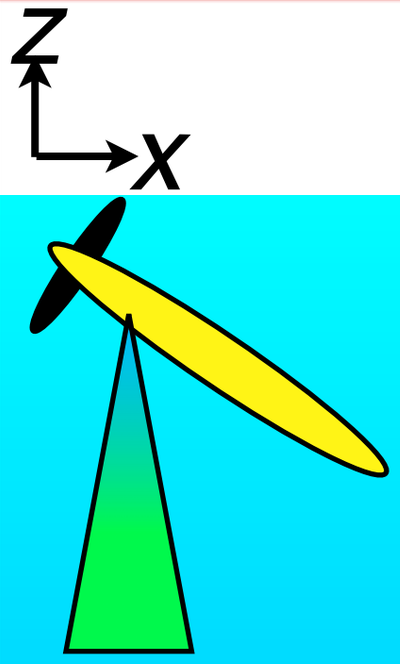
Firing, E., and Gordon R. (1990). Deep ocean acoustic Doppler profiling. Proc. IEEE Fourth Working Conf. on Current Measurements, Clinton, MD, Current Measurement Technology Committee of the Ocean Engineering Society, 192–201.

Fischer, J., & Visbeck, M. (1993). Deep velocity profiling with self-contained ADCP's. Journal Of Atmospheric And Oceanic Technology, 10(5), 764–773.

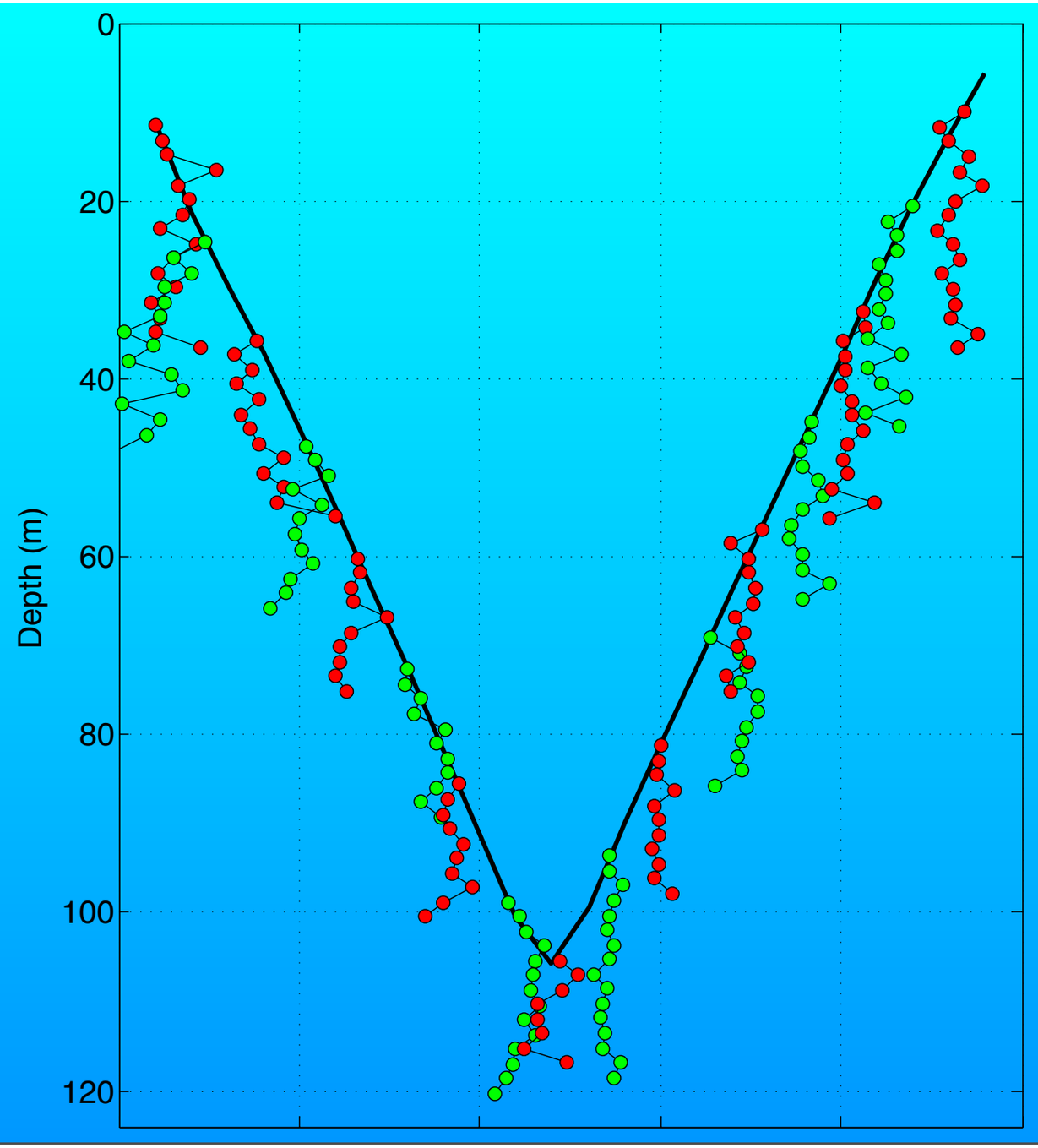
Shear Processing

www.nortekusa.com

True innovation makes a difference



Measured Velocities

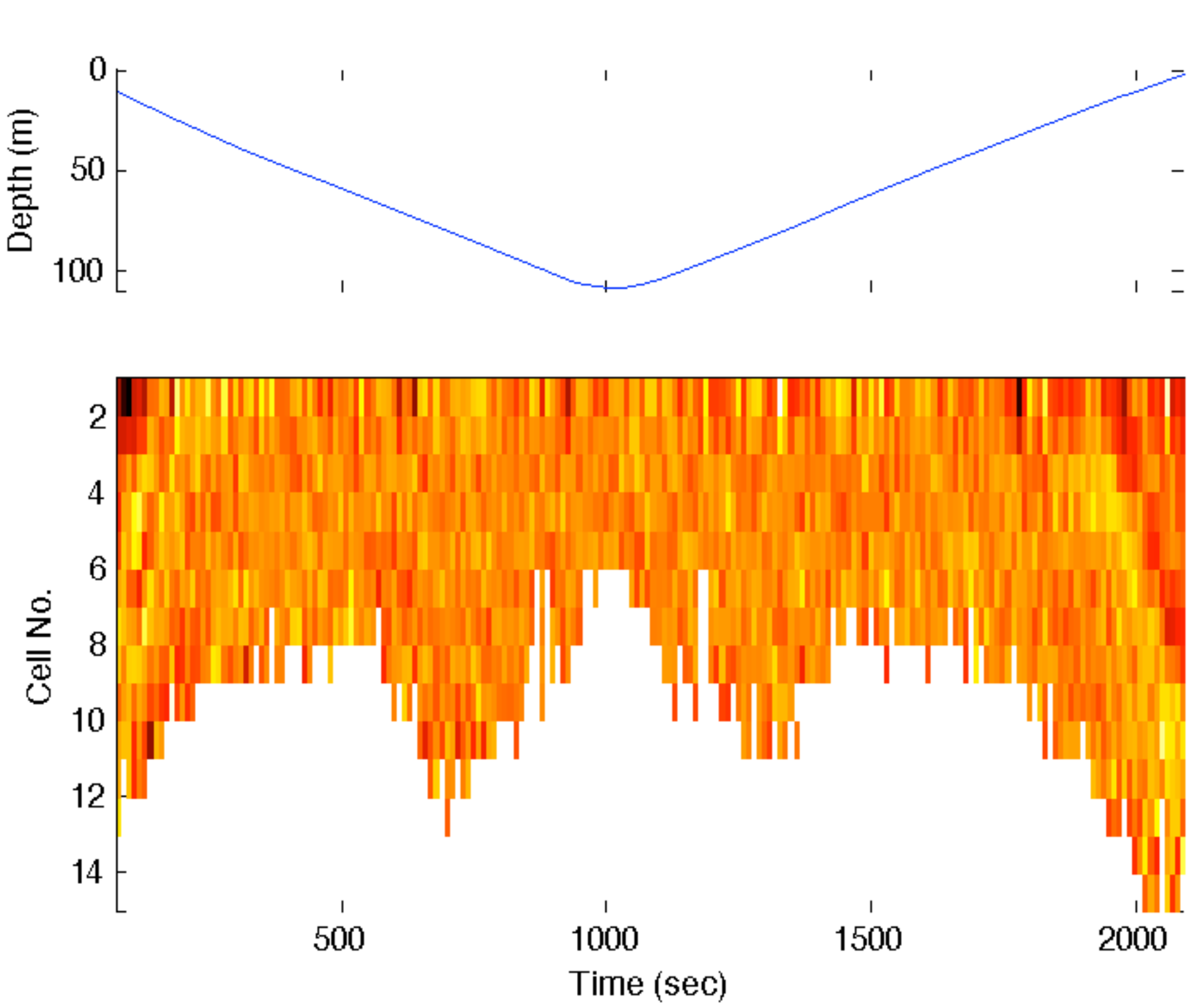


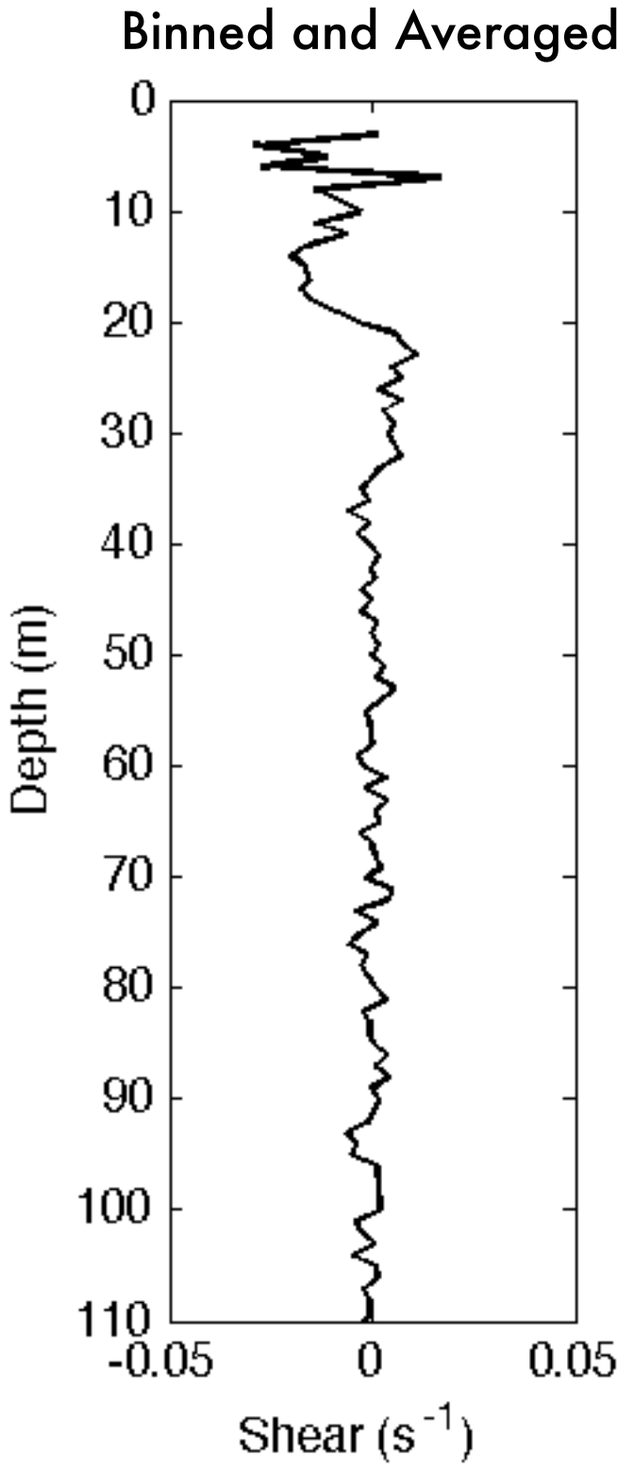
NortekUSA

www.nortekusa.com

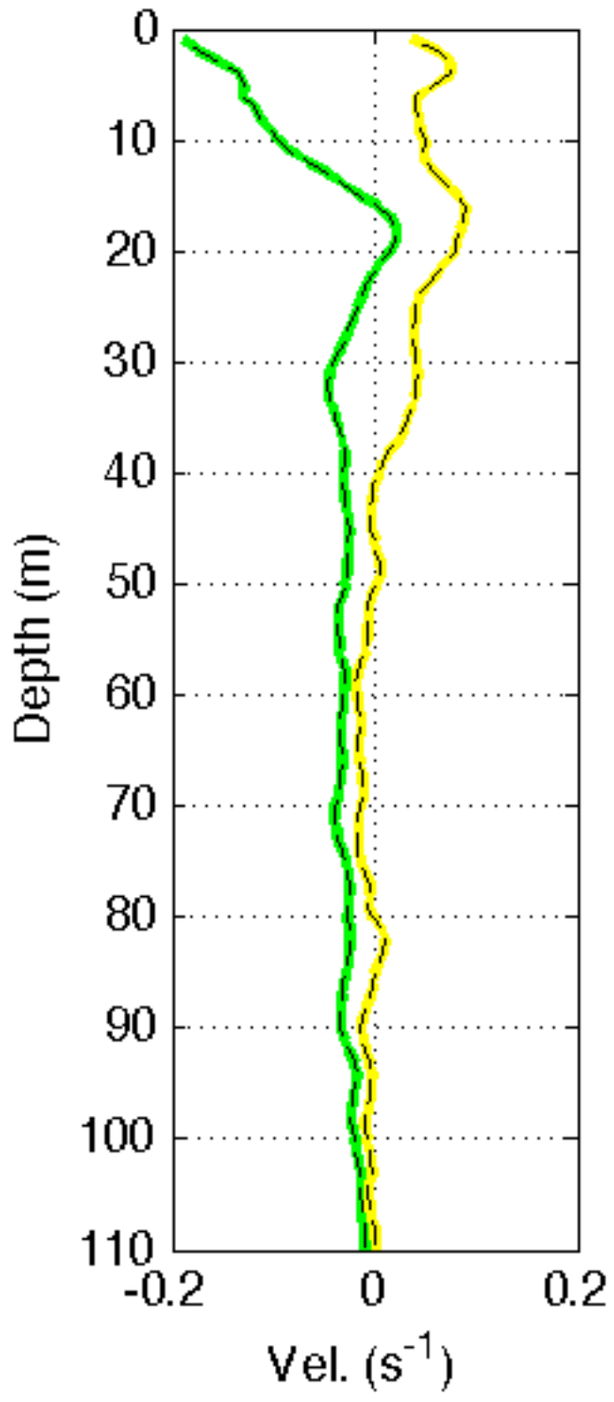
Shear Profiles

True innovation makes a difference





The Integrated Velocity Profile



- The integration moves from the bottom up.
- There is an unknown integration constant.
  - This is obtained from depth averaged current estimates.
- Need to estimate two things accurately:
  - The mean shear profile.
  - The depth averaged current.

Linear Least Squares

- Model the system as:

$$U_m(z_i) = -U_g(z_0) + U_c(z_i)$$

- For each measurement U_m, we have this equation, providing
  - n glider velocities
  - at most $n * n_{cells}$ measurements of water velocity

And solve the system of equations

$$\mathbf{A}\vec{x} = \vec{b}$$

Design Matrix

Water & Glider Velocities

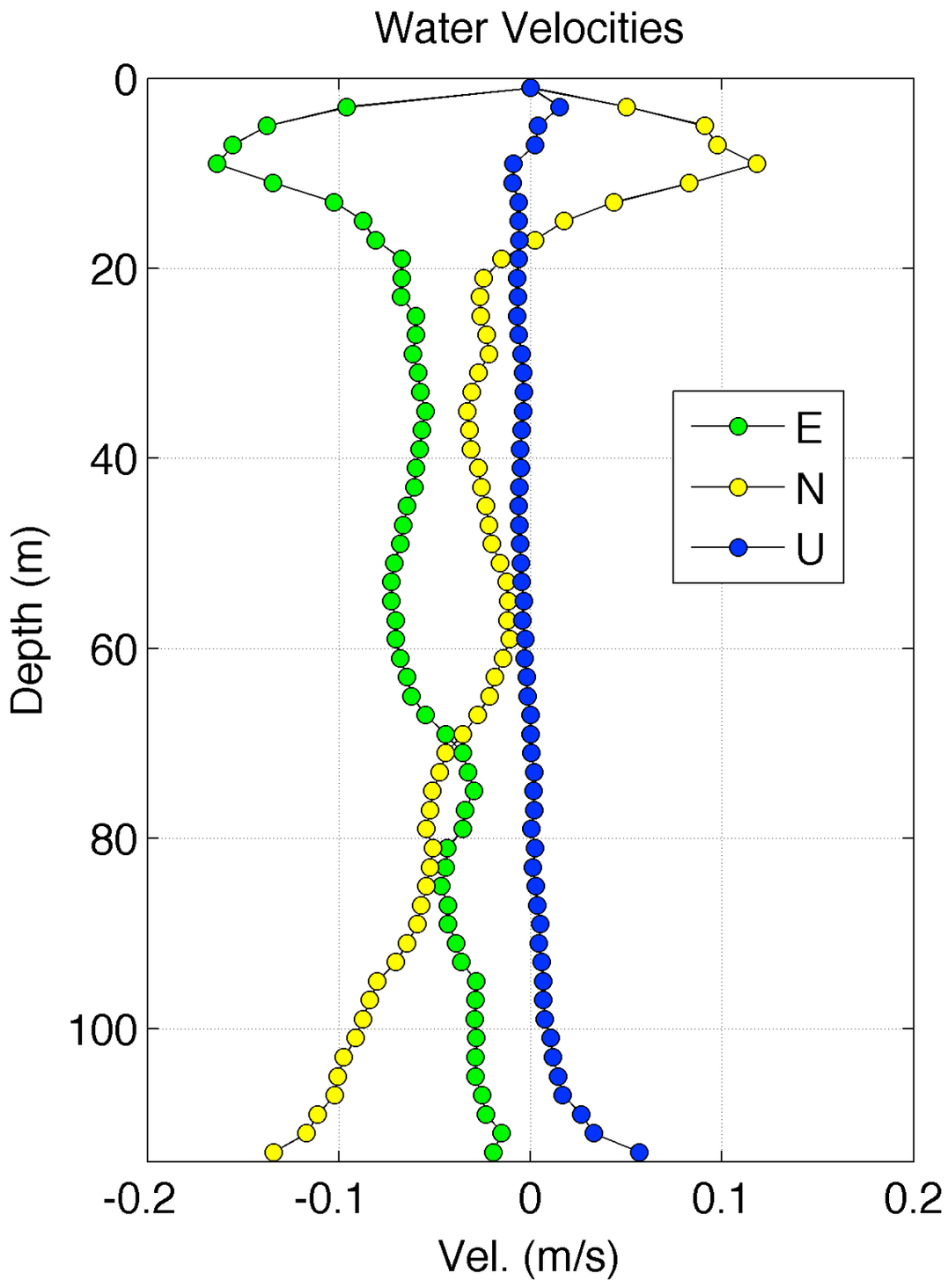
Observations

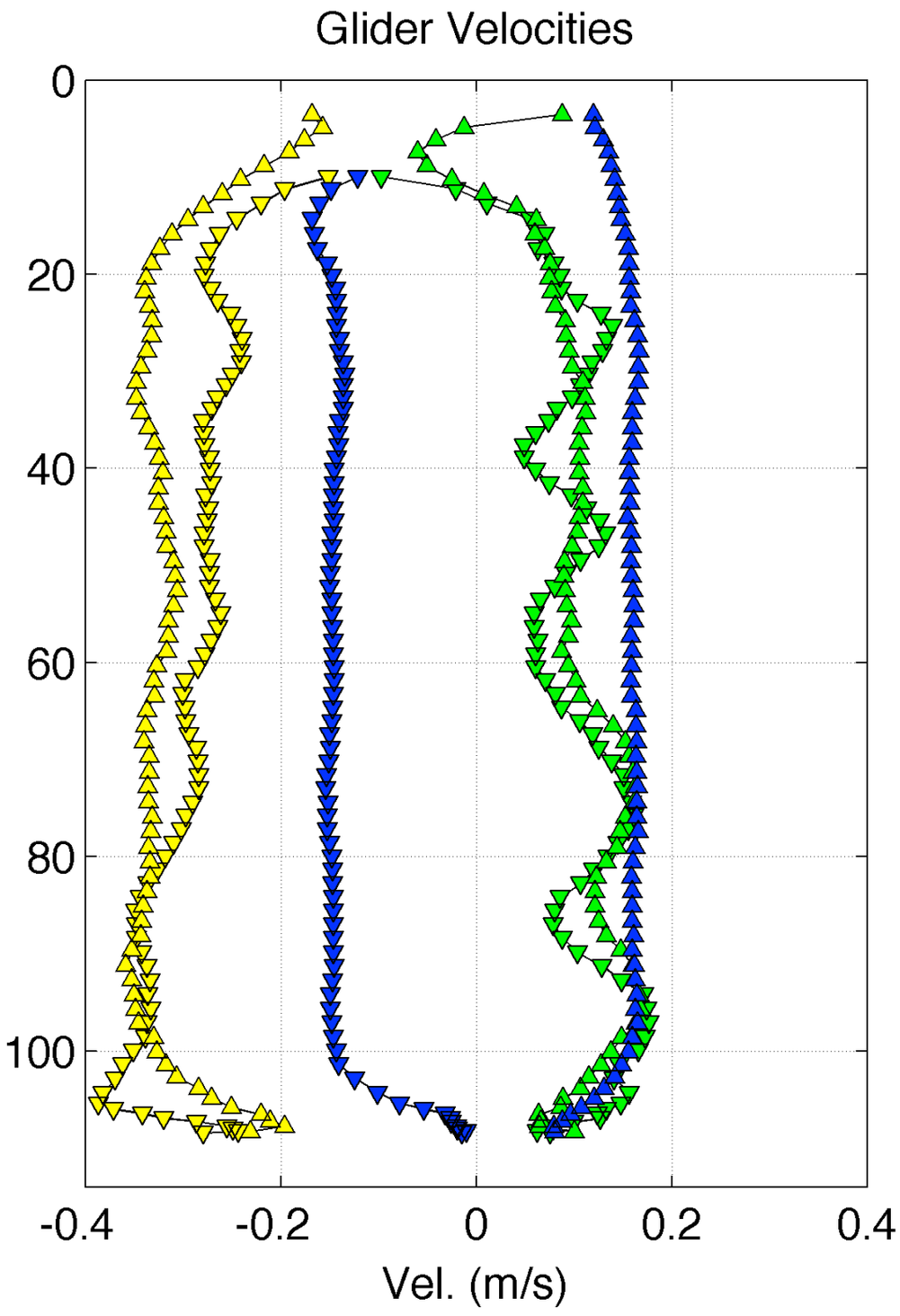
NortekUSA

www.nortekusa.com

The Solution

True innovation makes a difference





Summary of GLS Solution

- Provides estimates of both water and glider velocities.
- It's fairly simple to incorporate additional information.
  - Actually, we need to to avoid trivial solutions.
- Lots of options in formulating the problem.
  - More work needed to understand the impact of these options.
    - Weighting function
    - Profile resolution
    - Number of observations/profile length
    - Profile overlap
    - Constraints on velocity and acceleration

Questions?