Processing Irradiances, etc., to Get AOPs

One example: E_d to K_d

by
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who seldom gets to play with real data
and therefore must resort to HydroLight
to generate his "data"

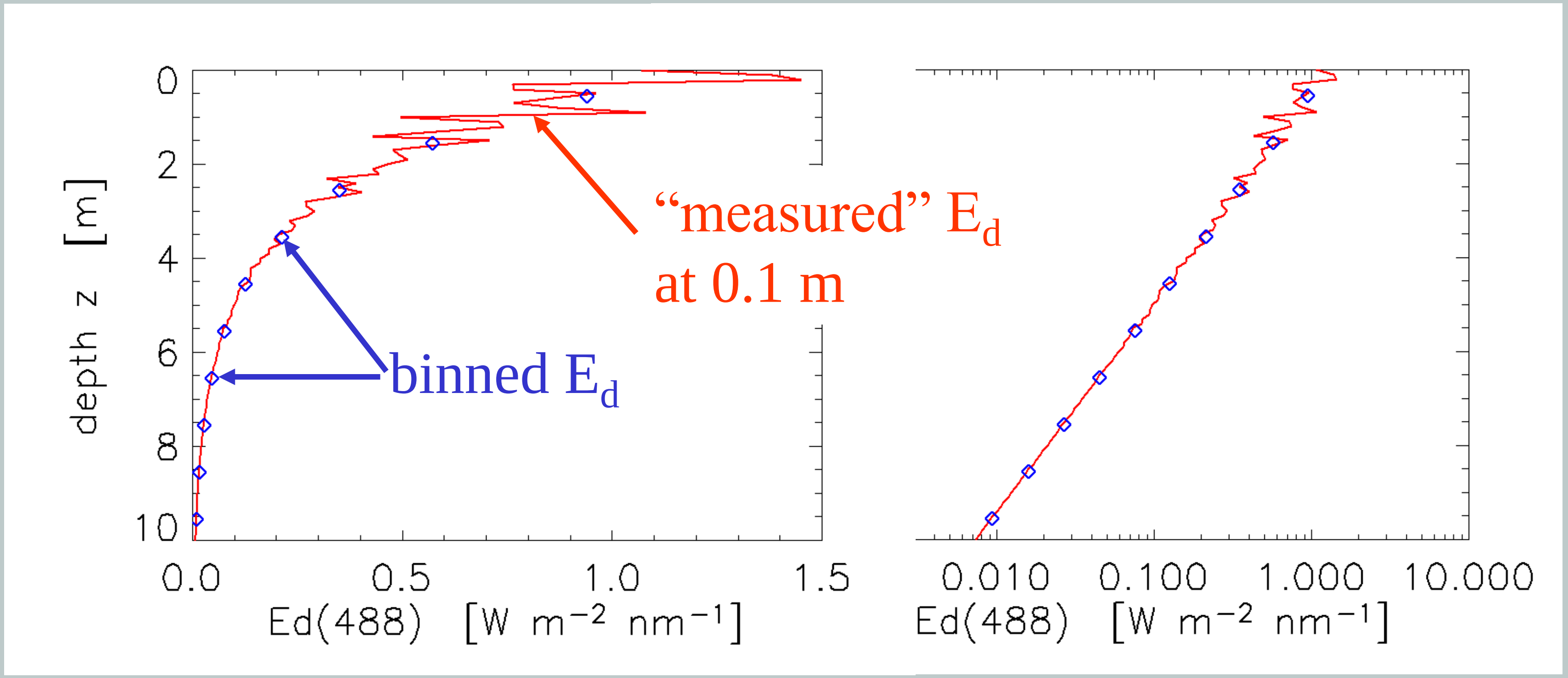
Maine 2007

PseudoData

I generated an $E_d(z)$ profile using HydroLight:

- Used ac9 data from the Maine 2004 class to get *a* and *b* at 488 nm: a(488) = 0.273 1/m, b = 2.415 1/m (after adding water)
- Used a Petzold phase function, sun at 40 deg, clear sky, wind = 3 m/s, etc
- Saved Ed at 0.1 m intervals from 0 to 10 m
- Added Gaussian random noise with std dev(z) = $0.25E_d(z)$ to simulate near-surface wave focusing effects
- Binned the noisy E_d values in 1 m bins (average of 10 Ed per depth bin)
- Used the binned E_d values to get K_d by 5 different methods
- Compared the 5 processing methods for noisy data with the "correct answer" as obtained from HydroLight for noise-free data

Noisy and Binned E_d



Now use the 10 binned E_d points to generate K_d in various ways

K_d by Method 1

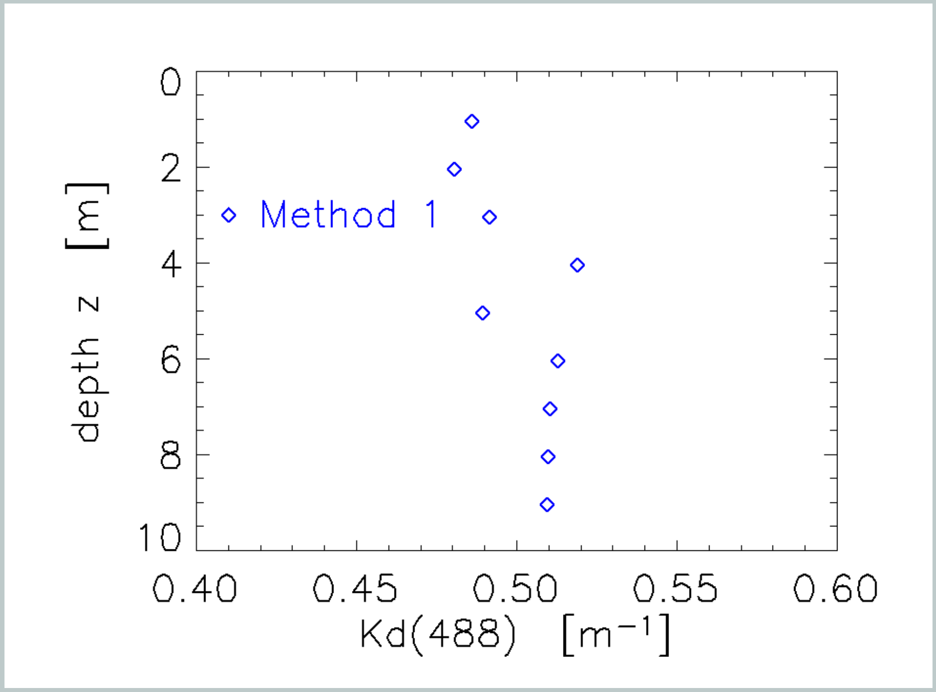
Use the definition of K_d

$$K_d(z) = -\frac{1}{E_d(z)}\frac{dE_d(z)}{dz}$$

which in finite-difference form becomes

$$K_d\left(0.5[z_{i+1}+z_i]\right) = -\frac{1}{0.5\,[E_d(z_i)+E_d(z_{i+1})]}\frac{E_d(z_{i+1})-E_d(z_i)}{z_{i+1}-z_i}$$

Note: For finite differences, I used the mid-point values between the depths of the binned values



K_d by Method 2

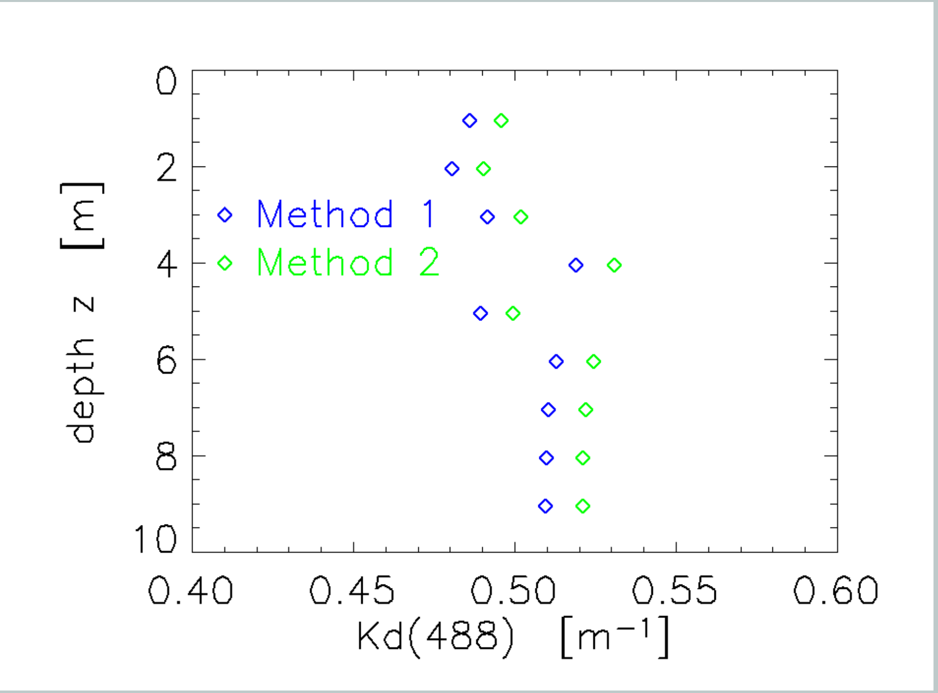
Rewrite the definition of K_d as

$$K_d(z) = -\frac{d \ln E_d(z)}{dz}$$

which in finite-difference form becomes

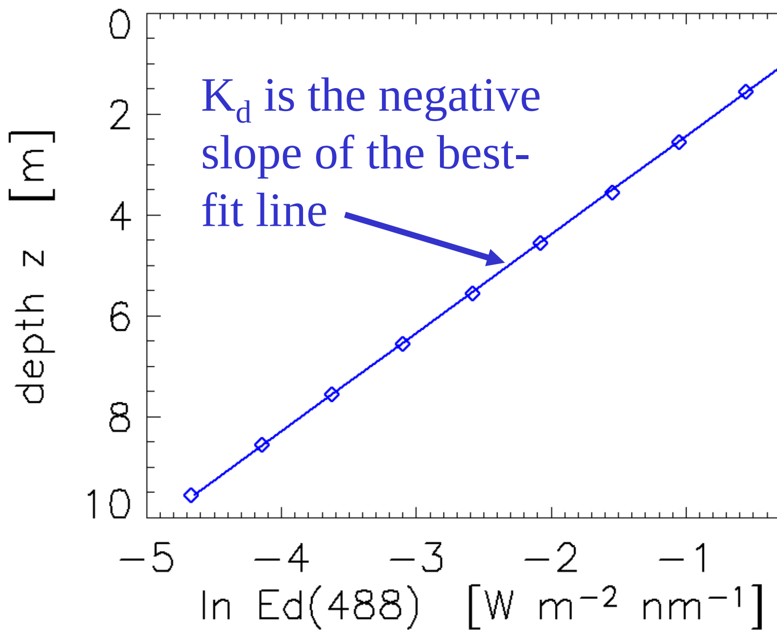
$$K_d\left(0.5[z_{i+1} + z_i]\right) = -\frac{\ln\left[E_d(z_{i+1}) / E_d(z_i)\right]}{z_{i+1} - z_i}$$

Note: Methods 1 and 2 are identical in terms of derivatives, but are different in terms of finite differences.

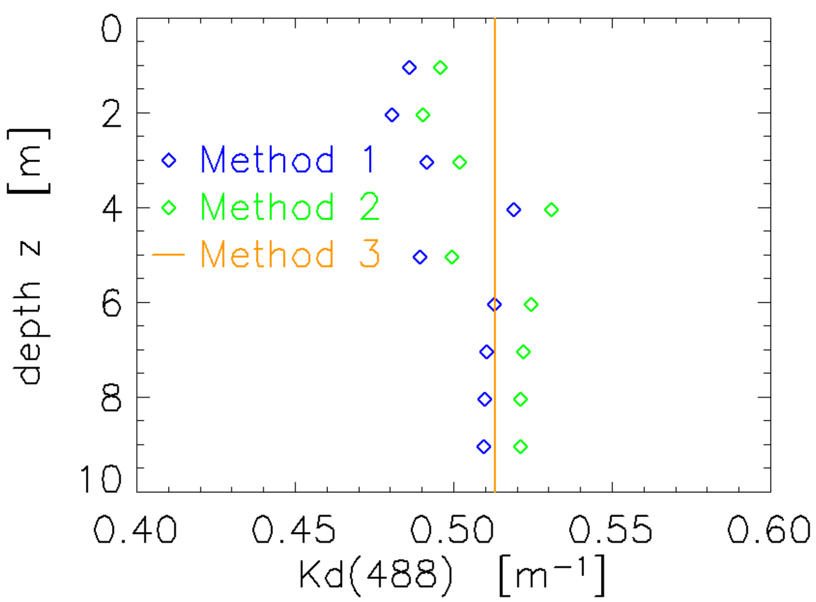


K_d by Method 3

Do a linear least squares fit to ln $E_d(z)$ vs z to get K_d = - slope



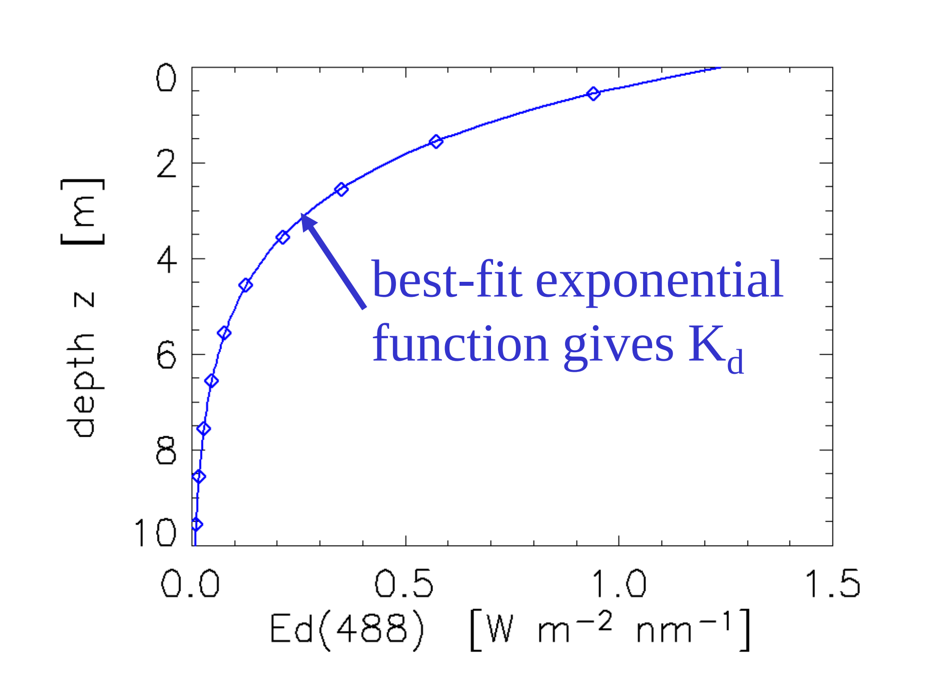
Note: this assumes that K_d is independent of z



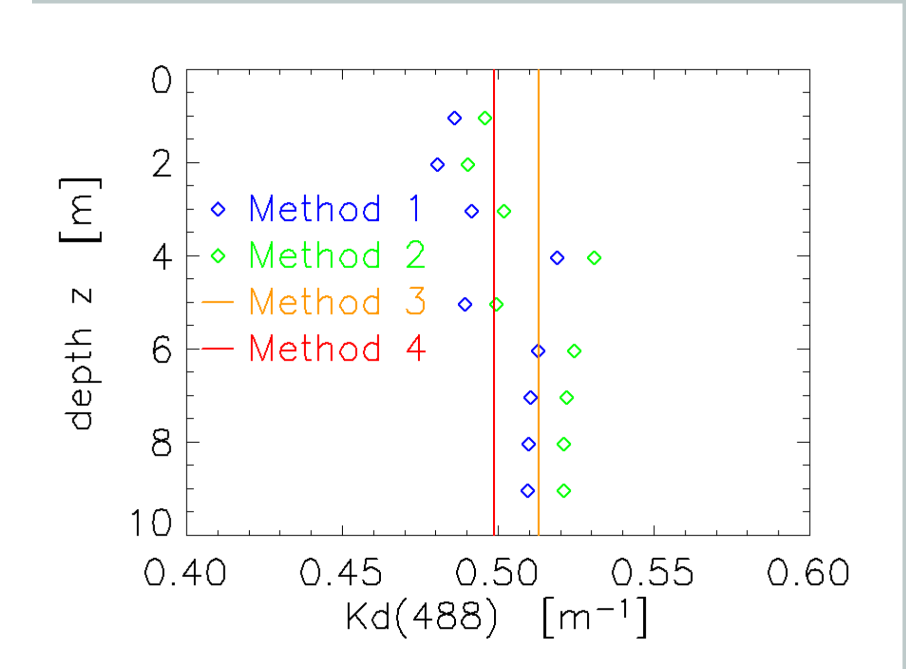
Note: you could weight the Ed(z) differently at different depths, and get a different best fit.

K_d by Method 4

Do a nonlinear least squares fit to $E_d(z) = E_d(0) \exp(-K_d z)$



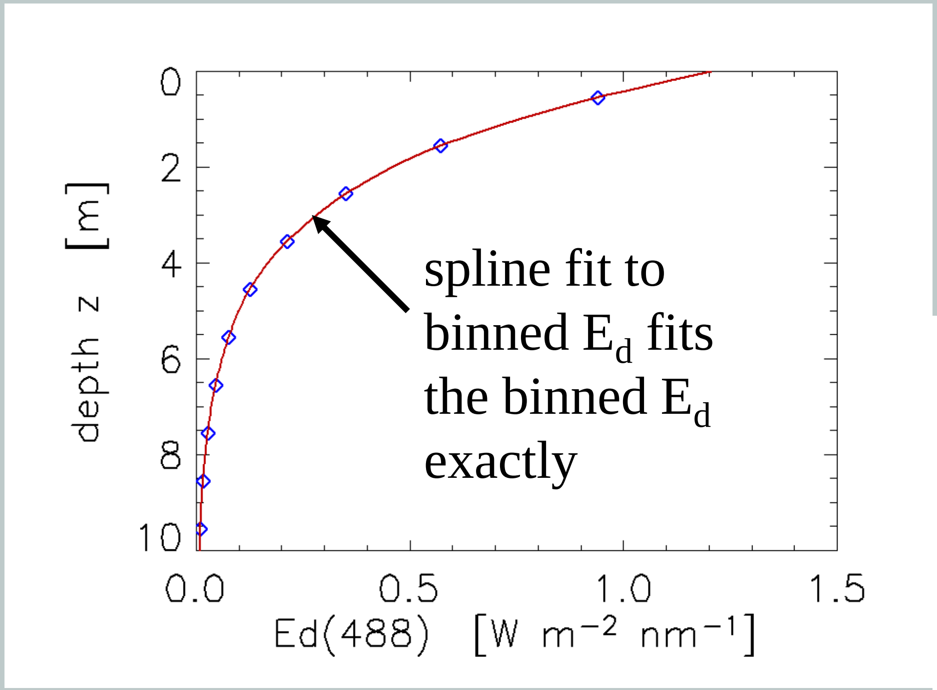
Note: this assumes that K_d is independent of z

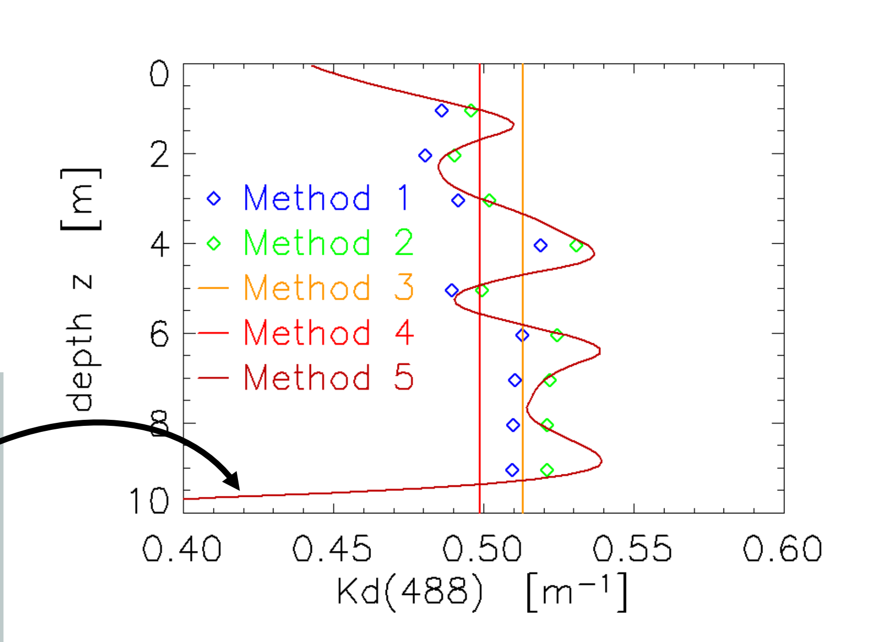


Note: fitting to the data (E_d) and the log of the data give different results.

K_d by Method 5

Do a spline fit to $E_d(z)$ to generate $E_d(z)$ at 0.1 m resolution, then take derivative of the spline $E_d(z)$ using Method 2

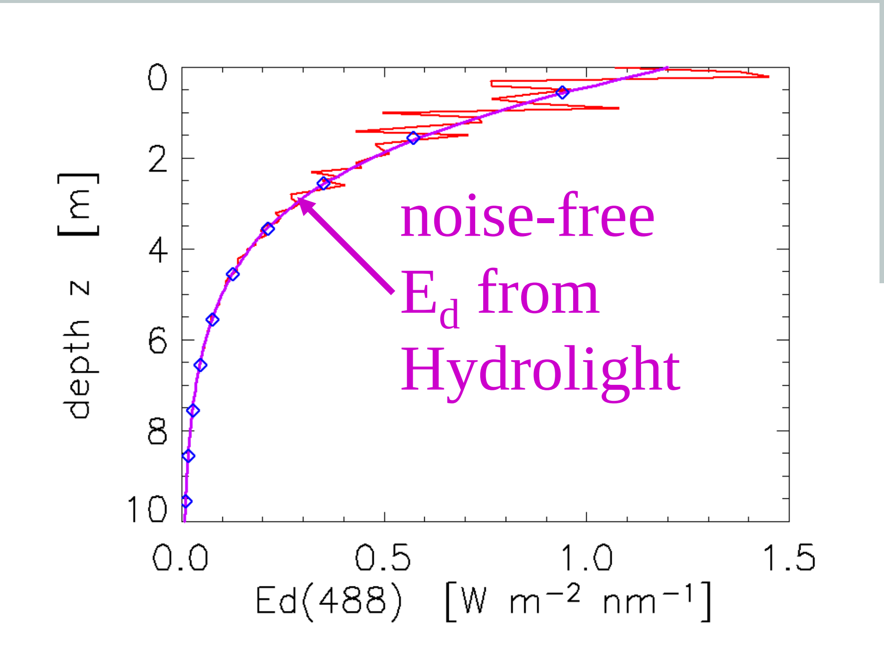


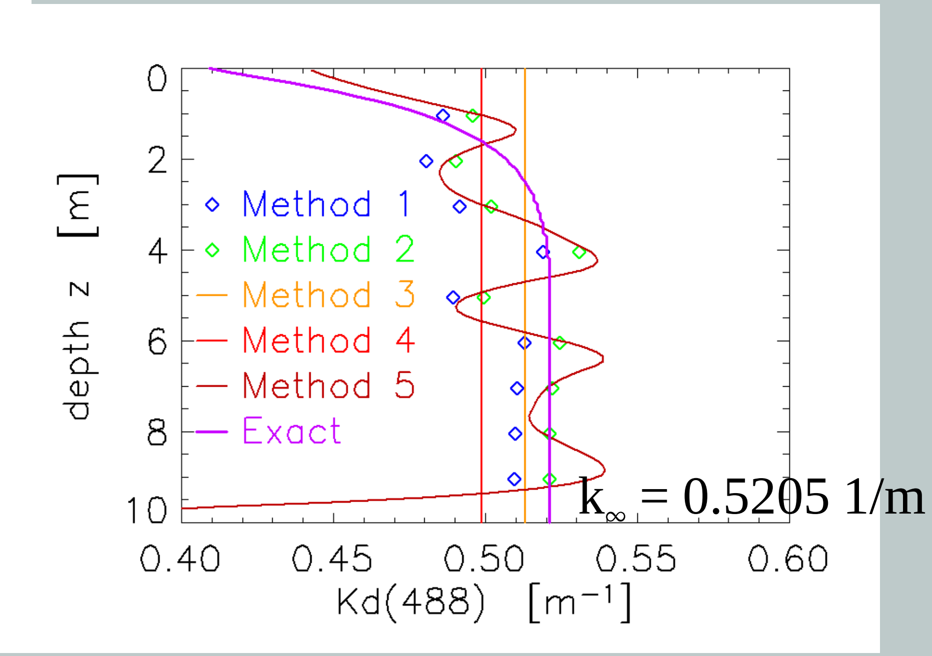


Note: extrapolating splines outside the data range usually leads to grief

$E_d(z)$ and $K_d(z)$ from HydroLight

The noise-free HydroLight $E_d(z)$, and $K_d(z)$ from Method 2 with dz = 0.01 m





Note: none of the 5 methods gave good K_d values very near the surface due to the noise in the data (wave focussing)

Lessons Learned

What you end up with (for K_d or any other AOP) depends not just on your data, but also on how you process the data.

There is no “right” way to process data, although some ways are usually better than others, depending on the particular data set.

Data binning, smoothing, function fitting, filtering, etc. are all useful for noise reduction and squeezing information out of data sets, but a lot of care and experience are required to make sure you don’t end up worse off than when you started.