

# 2nd Ocean Carbon from Space workshop

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## Retrieval of Mesozooplankton Carbon Biomass and DVM via the PSD: Implications of the PSD Slope

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# The Particle Size Distribution (PSD) From Space – Slope $\xi$



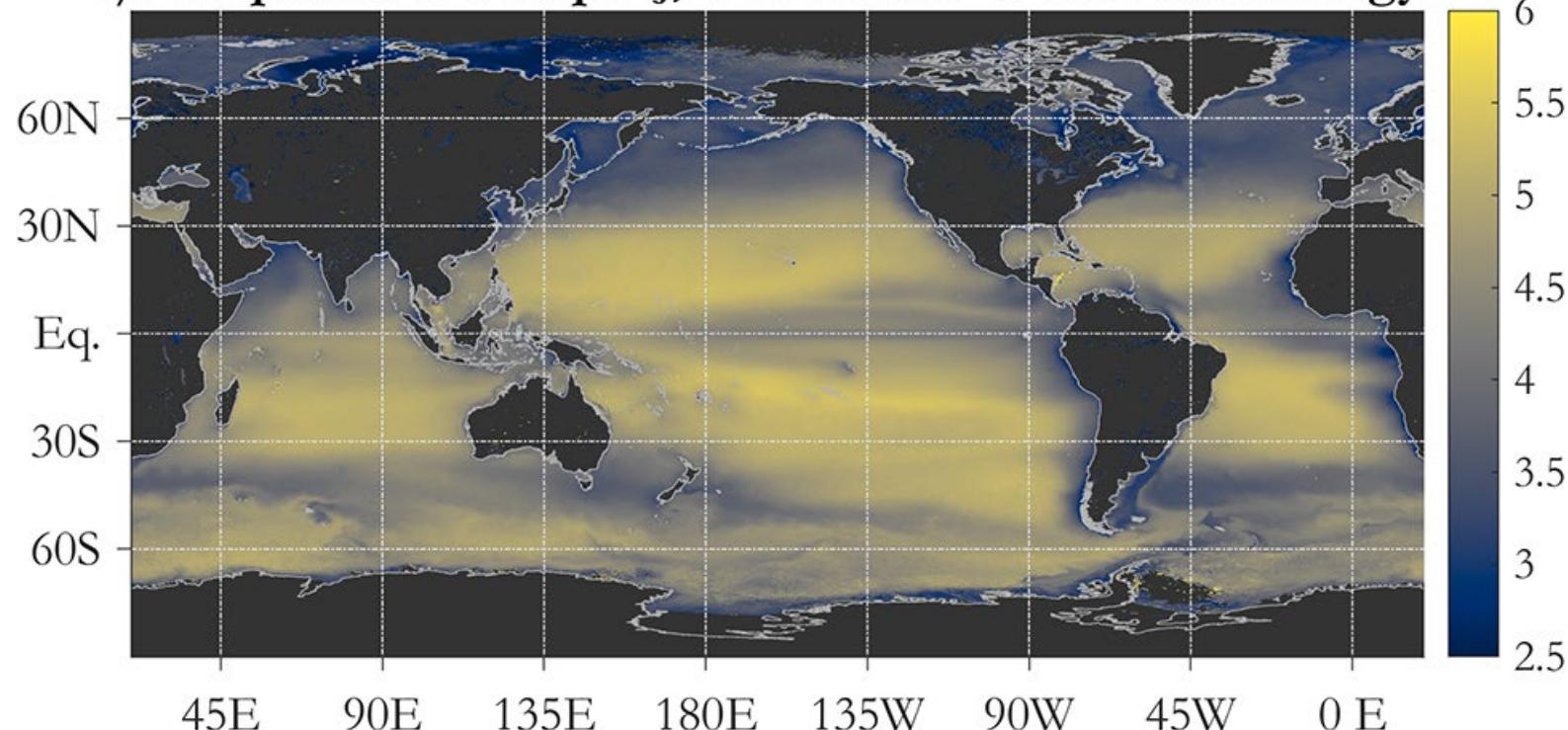
An assumed power-law PSD is modeled as follows:

$$\frac{dN_T}{dD} = N(D) = N_0 \left( \frac{D}{D_0} \right)^{-\xi}$$

$\xi$  is the slope of a differential number concentration PSD

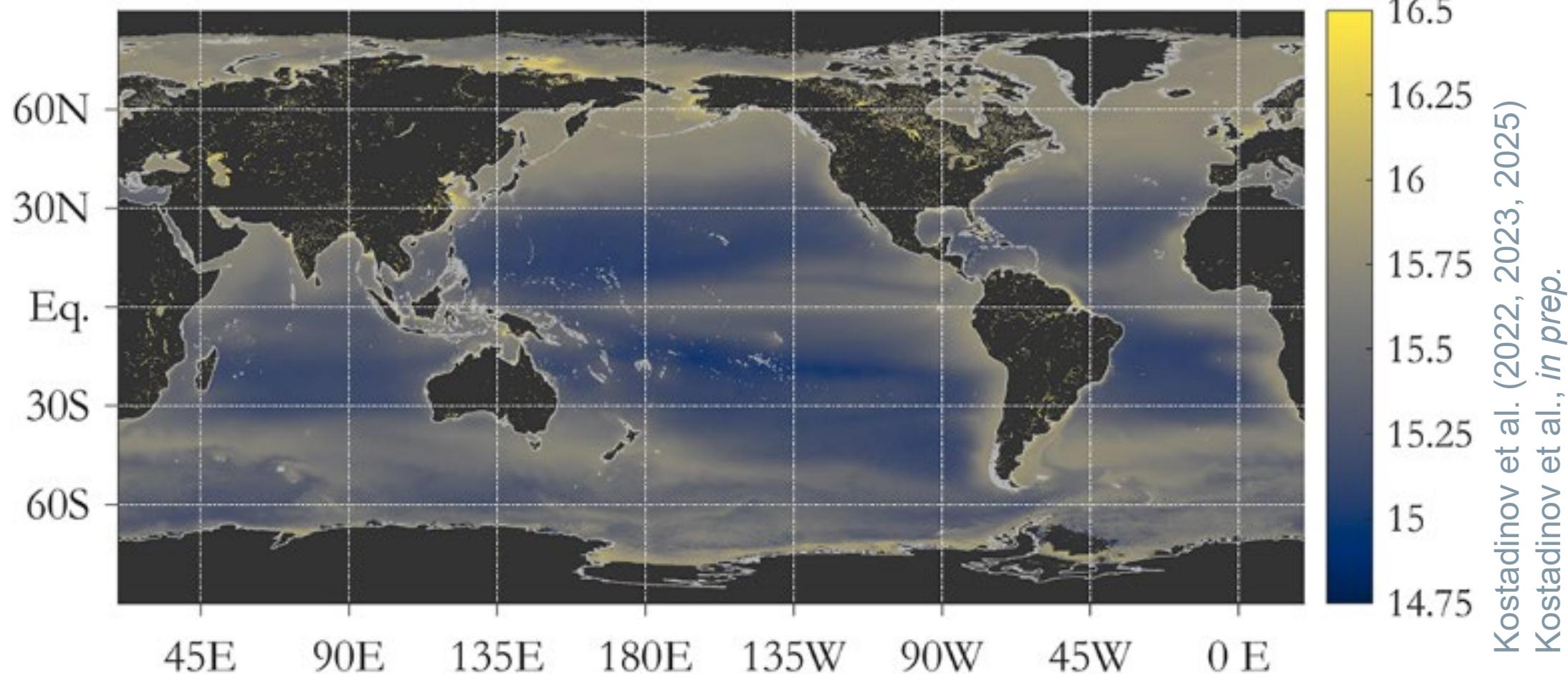
$\xi$  can be retrieved from space by using, for example, the spectral shape and magnitude of backscattering (Kostadinov et al., 2009, 2023). See also Roy et al. (2017)

a) PSD power-law slope  $\xi$ , OCCCIv6.0 overall climatology

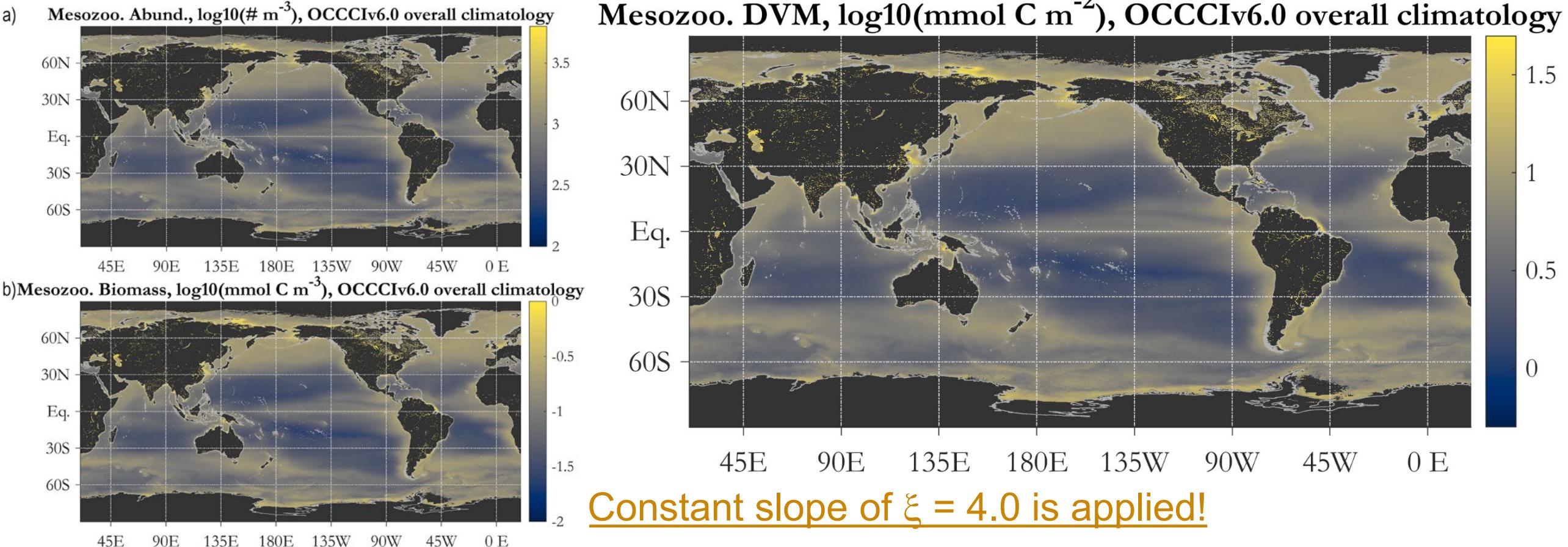


Kostadinov et al. (2022, 2023, 2025)  
Kostadinov et al., *in prep.*

## c) Tuned $\log_{10}(N_0, \text{m}^{-4})$ , OCCCIv6.0 overall climatology



# Extrapolation of the PSD to Mesozooplankton Biomass and DVM



Constant slope of  $\xi = 4.0$  is applied!

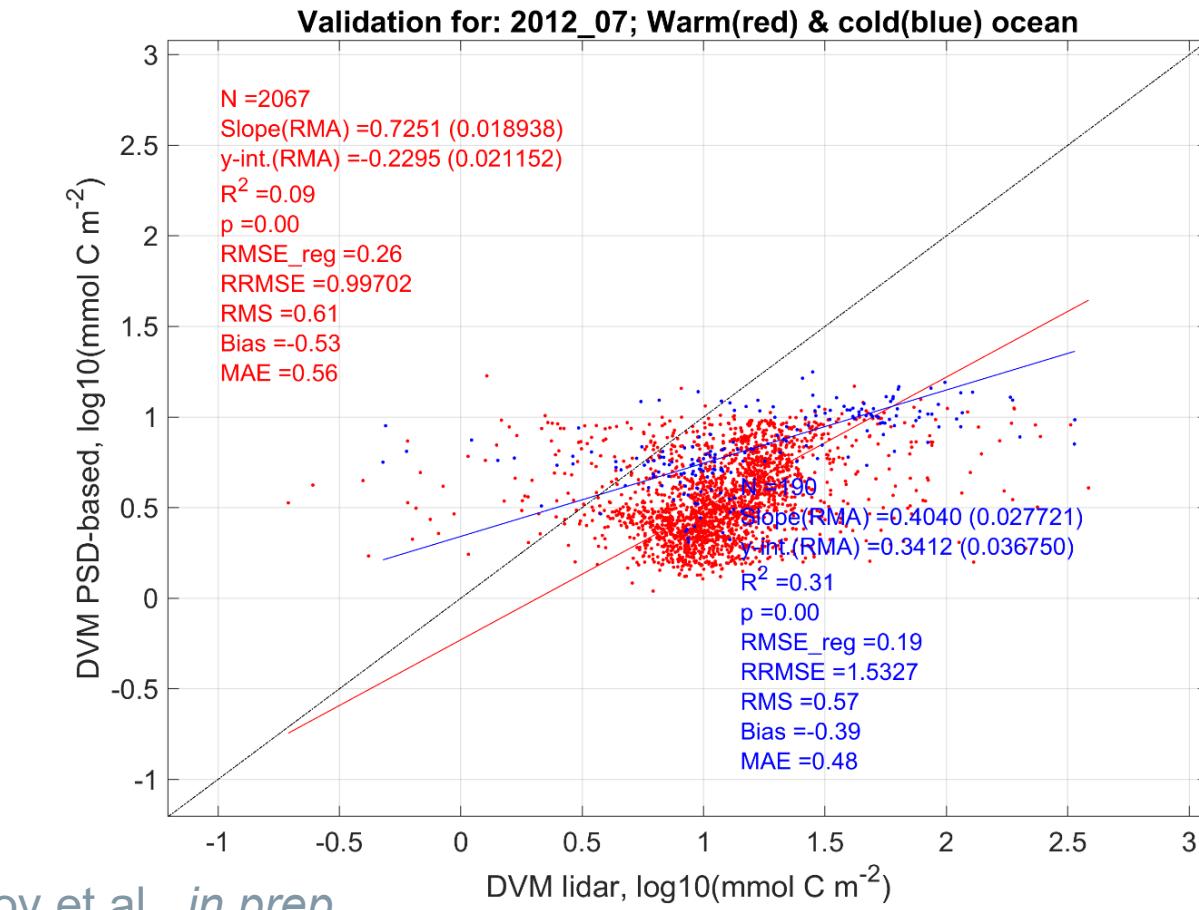
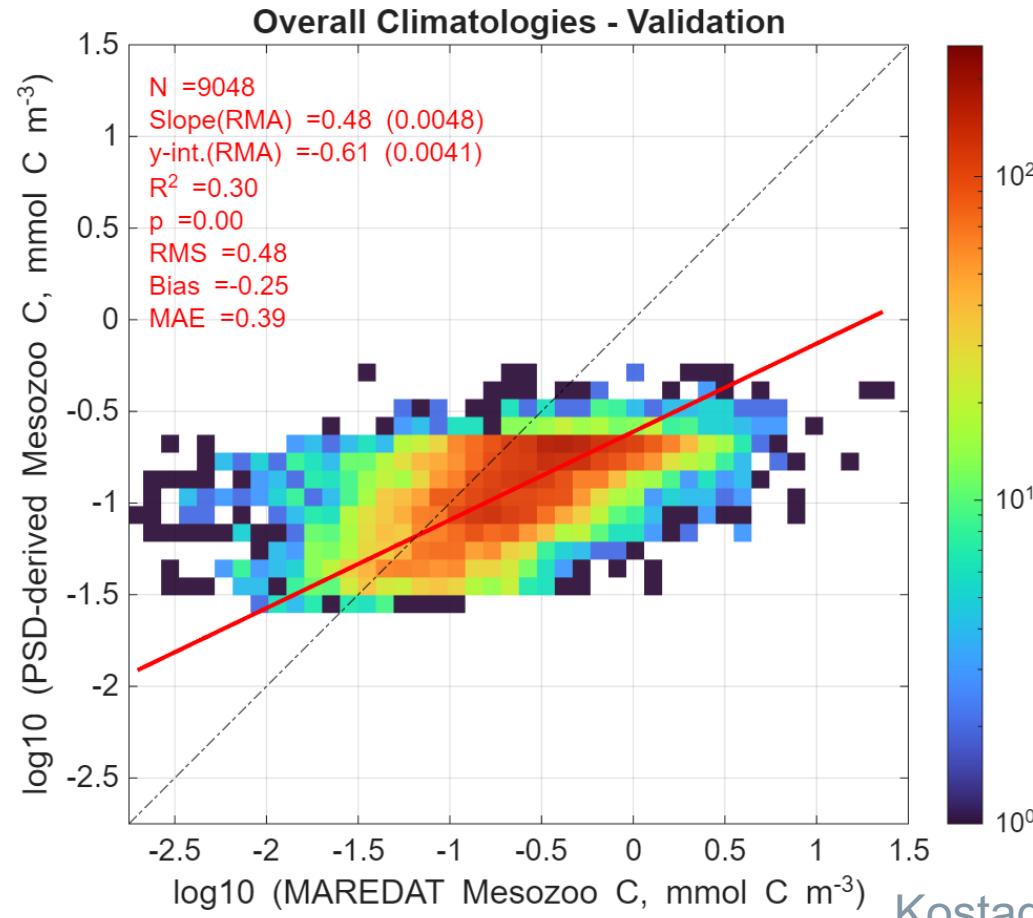
The tuned  $N_o$  parameter is used, tuning as in Kostadinov et al. (2023)

Mesozooplankton Data set and Code Available at Kostadinov et al. (2025):

<https://doi.org/10.5281/zenodo.15307007>

# Validation and Intercomparison

Validation against MAREDAT in-situ data (Moriarty and O'Brien, 2013) (left);  
and comparison against lidar-derived DVM data of Behrenfeld et al. (2019) (right)



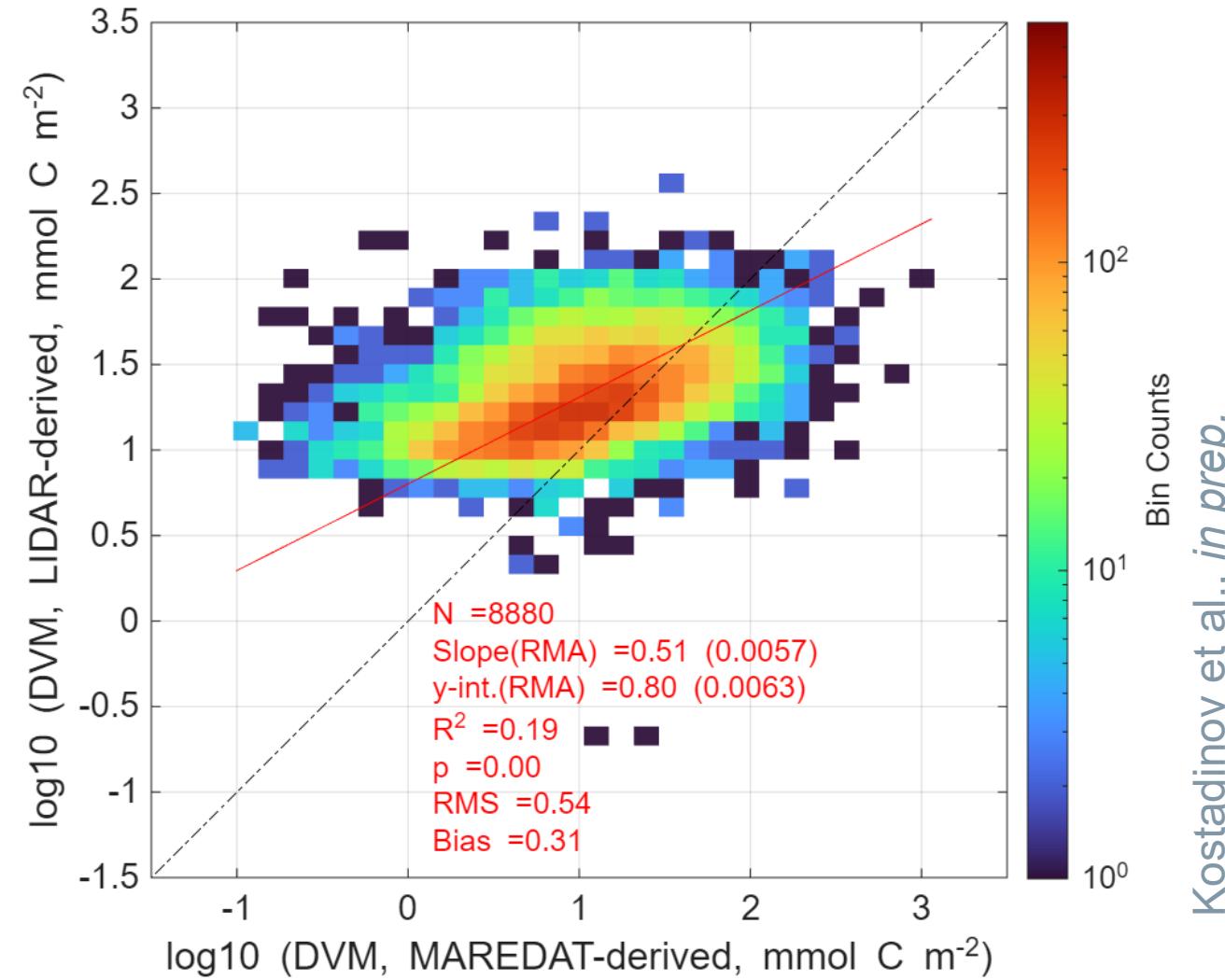
Kostadinov et al., *in prep.*

# MAREDAT to lidar-based DVM Intercomparison

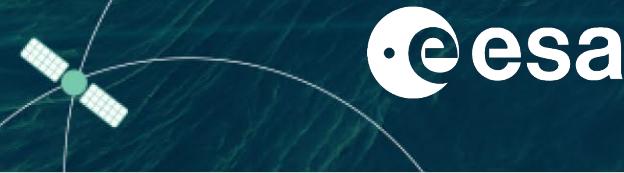
MAREDAT data are from Moriarty and O'Brien (2013); O'Brien and Moriarty (2012)

Lidar data are from Behrenfeld et al. (2019)

Biomass conversions on this slide and elsewhere in this work are from Wiebe et al. (1975) and Wiebe (1988), as also cited in O'Brien and Moriarty (2013).



# Significance of the Constant PSD Slope of 4.0



Algorithm is based on ecosystem prediction, not on ocean color being directly sensitive to mesozooplankton!

Thus time lags are expected and being investigated (confirmed at BATS).

Remarkably, mesozooplankton variable retrieval works reasonably well when the PSD slope is **fixed globally to a CONSTANT value of  $\xi = 4.0$** . This leaves the  $N_o$  scaling parameter of the PSD to control the retrievals, as size range is fixed (0.2 to 20 mm diameter).  $N_o$  was tuned *a-priori* to lead to reasonable global POC and Chl (and phyto C?) retrievals (Kostadinov et al., 2023), but *it is NOT tuned for mesozooplankton variables*.

This slope of 4.0 means equal biomass in even logarithmically spaced size bins, the so-called Sheldon Hypothesis (Sheldon et al., 1972). This slope is also equivalent to the -1.0 slope illustrated in Hatton et al. (2021) (body mass vs. bin-integrated abundance), or a slope of ~0.0 for body mass vs. bin-integrated biomass. See also Tekwa et al. (2023).

Importantly, when biomass size spectra are measured over many orders of magnitude of size ( $> 7$ ), the slopes converge to  $\sim -1.0$  for the normalized biomass size spectrum (NBSS) (Atkinson et al., 2021; C. Serra Pompei, pers. comm.), which is also equivalent to our slope of 4.0 used here!

# Knowledge Gaps and Priorities for Next Steps



## Knowledge Gaps

Separating phyto C from bulk POC in *in-situ* measurements and satellite products.

Better constraint of the biological pump magnitude (and its expected changes), ideally from space.

Better submicron particle characterization and better characterization of the particle assemblages overall. Often, we assume biogenic (and covariates) origin of the PSD, but the bulk PSD is actually measured!

Detailed process-based understanding of the spectral degrees of freedom for a given water type.

## Priorities for Next Steps

Include Hyperspectral Ocean Color Data in Algorithms, attempting to retrieve more variables at once, with a mechanistic, first-principles-based approach.

More global measurements of the PSD (bulk and particle-type specific) would be immensely useful for further algorithm development and process understanding.

More global measurements of phyto C (and ideally other undersampled pools of C in the ocean)

Curated and processed data repositories (one-stop shop ideally) and data compilations should be further maintained and developed.

Uncertainty characterization.

# Thank You!