Untitled

Primary production

Photosynthetic available radiation (PAR) just bellow ice was derived from the total energy measured every 10 minutes over a period of 24 hours by the Polarstern weatherstation. Hourly PAR were then estimated by integrating measurements taken at each hour (n = 6). At each hour, PAR at different depths (2.1m, 5.0m, 10.0m, 15.0m, 30.0m, 50.0m) were estimated using an attenuation coefficient (kdPAR) of 0.15 m-1 (Christian Katlein, pers. comm.). Hourly primary production at each depth was then estimated using fitted photosynthetic parameters estimated from P vs E curves with the following equation (Platt et al., 1980):

EQUATION HERE

where x, y, z

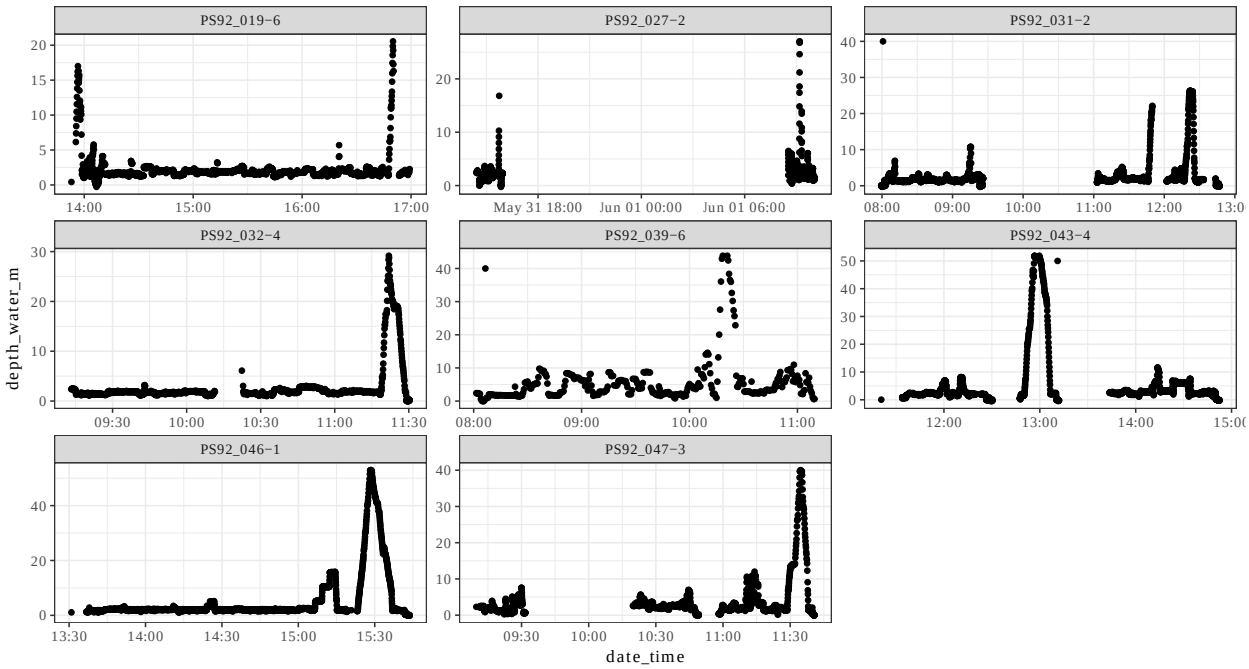
The non-linear fitting was done using the Levenberg-Marquardt algorithm from the minpack.lm R package (Timur2016). At each depth primary production was estimated using photosynthetic parameter and PAR estimates. Finally, daily primary production was calculated by integrating production over the depths.

Error estimation

A Monte-Carlo procedure has been used to propagate the incertitude of the fitted photosynthetic parameters on the estimate daily primary production. At each depth, a total of 10 000 simulations (i.e. P vs E curves) were performed by randomly sampling parameter values based a multivariate normal distribution of the fitted parameters. Using the generated curves, depth and daily integrated primary production rates were calculated as previously explained. The standard deviation of the 10 000 integrated daily primary production rates was then used as a measure of the uncertainty around the estimated value of primary production.

Estimation of KdPAR

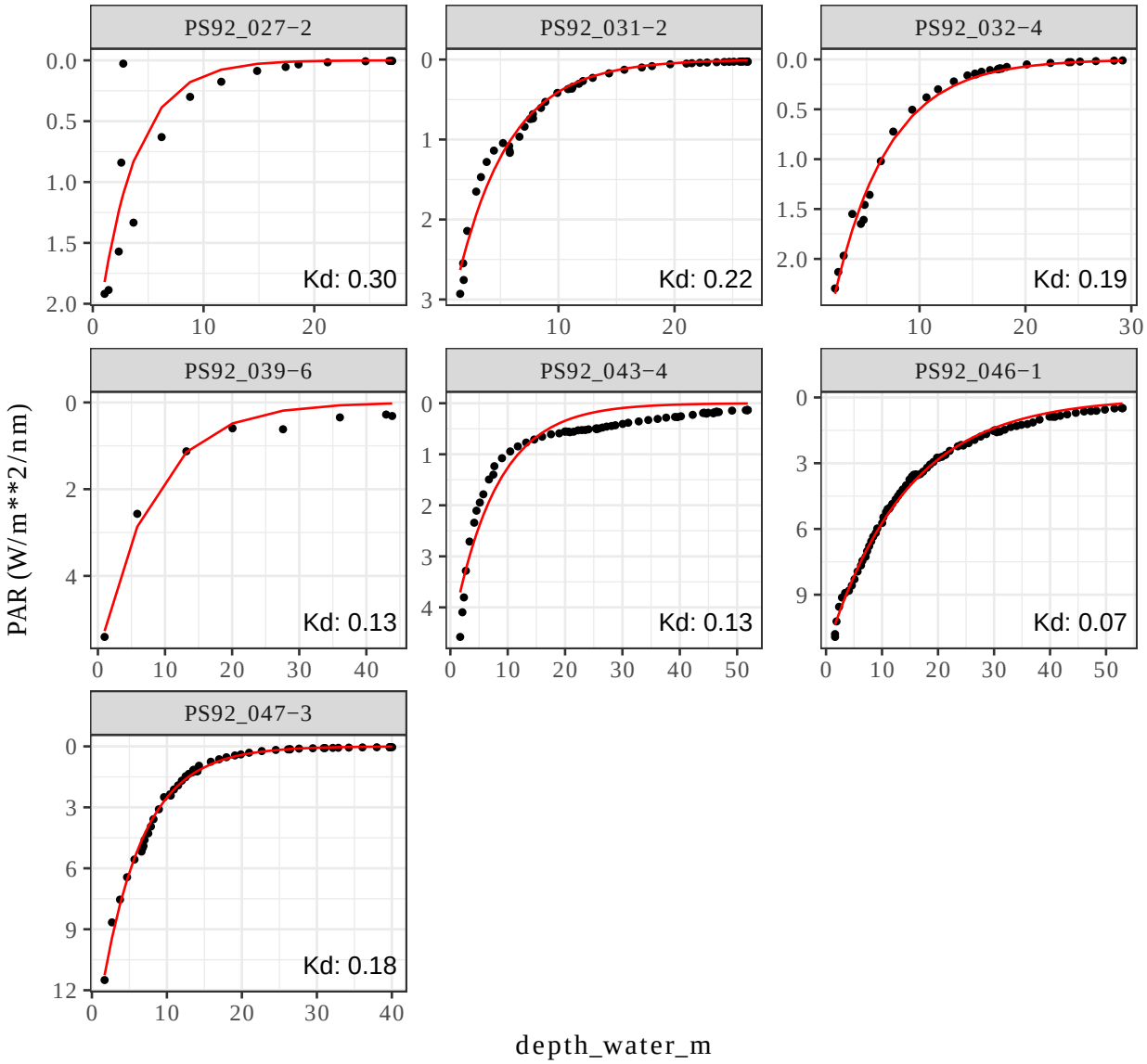
Estimations been done on irradiance measured by the ROV using files containing `rov_irrad` in their name. At each station, the ROV made a vertical profile. We extracted the profile data visually by exploring the graphics of depth as a function of time.



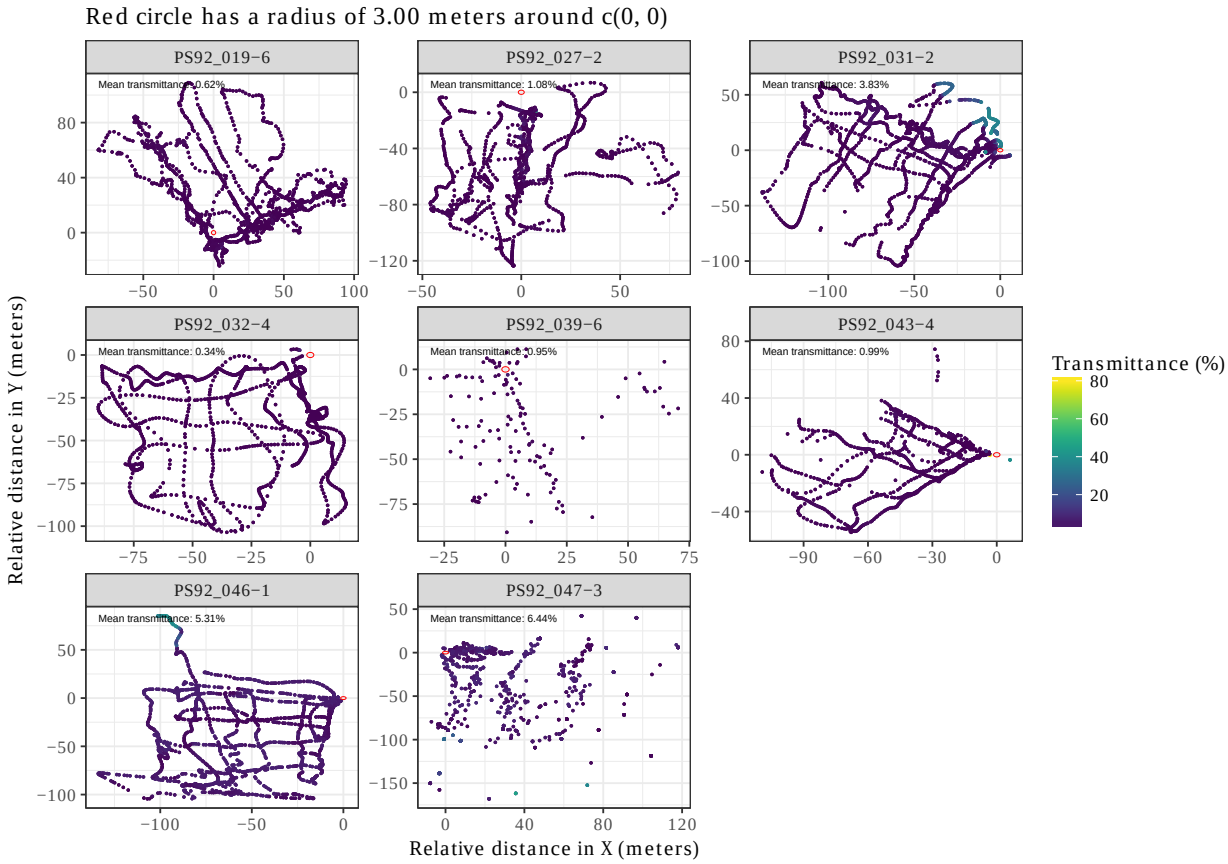
Then, PAR has been calculated by integrating irradiance data between 400 and 700 nm. Finally, KdPAR has been calculated using the following equation:

$$\mathrm{PAR} = a \times e^{-\mathrm{kd} \times \mathrm{depth}}$$

Irradiance data were not converted to umol m−2 sec−1 since only used calculate Kd



Ice transmittance



To remove the effect of ice hole where the ROV was deployed, we excluded measurements in a radius of 3 meters around the coordinates. This correspond to the red circles in the previous figure. We also conserved observations between 0.7 and 3 meters to avoid including transmittance measured a high depths.

References

Plat, T., C.L. Gallegos and W.G. Harrison (1980). Photoinhibition o photosynthesis in natural assemblages of marine phytoplankton. J. Mar. Res. 38:687-701.

Timur V. Elzhov, Katharine M. Mullen, Andrej-Nikolai Spiess and Ben Bolker (2016). minpack.lm: R Interface to the Levenberg-Marquardt Nonlinear Least-Squares Algorithm Found in MINPACK, Plus Support for Bounds. R package version 1.2-1. https://CRAN.R-project.org/package=minpack.lm