Product documentation :
Mixed Layer Depth (MLD) Climatology dataset

dr=0.03 kg/m3 ; reference-depth = 10m (v2023)

Product reference :
de Boyer montégut Clément (2023). Mixed layer depth climatology computed with a density threshold criterion of 0.03kg/m3 from 10 m depth value. SEANOE. https://doi.org/10.17882/91774
DOI :
https://doi.org/10.17882/91774
Institution :
This dataset is produced at LOPS laboratory (IFREMER, University of Brest, CNRS, IRD), Brest, France
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Abstract
The dataset made available here is the monthly climatology (i.e. 12 months) of ocean surface Mixed Layer Depth (MLD) over the global ocean, at 1 degree x 1 degree spatial resolution. The climatology is based on about 7.3 million casts/profiles of temperature and salinity measurements made at sea between January 1970 and December 2021. Those profiles data come from the ARGO program and from the NCEI-NOAA World Ocean Database (WOD, Boyer et al. 2018). The MLD is computed on each individual cast/profile using a threshold criterion. The depth of the mixed layer is defined as the shallowest depth where the surface potential density of the profile is superior to a reference value taken close to the surface added with the chosen threshold. Here we take a threshold value for the density of 0.03kg/m3, and a surface reference depth fixed at 10m (de Boyer Montégut et al., 2004). This mixed layer is by definition homogeneous in density (up to 0.03 kg/m3 variations) and can also be called an isopycnal layer. It is especially intended for validation of MLD fields of the Ocean General Circulation Models of the ocean sciences community (e.g. Tréguier et al., 2023). More information and some other related datasets can be found at : https://cerweb.ifremer.fr/mld (or https://www.umr-lops.fr/en/Data/MLD redirecting to previous page).

Data sources
The production of this MLD climatology relies on individual profile measurements of pressure/depth, temperature and salinity made at sea. Here, we use a total of about 7.3 millions hydrographic casts (Fig. 1). Those observations were obtained from several sources. Argo data (https://argo.ucsd.edu, https://www.ocean-ops.org) represent the majority of those casts, both in number and in spatial coverage, with about 30.1% of the total (i.e. ~2.2 million casts) form the years 2000's. All other profiles come from the NOAA-NCEI World Ocean Database (WOD, Boyer et al. 2018), namely, CTD data (13.5%), marine mammals data (APB, 7.6%), Ocean Station Data (OSD also called “bottle data”, 17.3%), Moored Buoy data (MRB, 4.0%), Gliders Data (GLD, 25.1%), Undulating Ocean Recorders (UOR, 1.1%), and Drifting Buoys (DRB, 1.3%). It should be noted that the percentages given above do not always represent the importance of each dataset. For exemple, gliders data have a high number of profiles, because of their way of taking measurements (high spatial density of profiles), but those are mostly located close to the shores. On the other hand, DRB is only a small percentage of all the data, but it encompasses the Ice Tethered Profilers which are essential to begin to have a more confident coverage of the MLD fields in the arctic Ocean. As a matter of fact, the geographical coverage of the data is nearly complete on the global scale, also thanks to the Argo data.

Methodology

The basic principles of the methodology used to produce this climatology is described in de Boyer Montégut et al. (2004). We compute the MLD from each individual hydrographic cast which has sufficient measurements of pressure or depth, temperature and salinity on the vertical. We only used quality controlled profiles and have also an outlier detection procedure. The MLD is diagnosed through a density threshold criterion of 0.03 kg/m3 increase from the reference value of surface potential density taken at 10 m depth. Based on all those MLD estimations, we then perform a mapping of those values on a monthly basis and at 1 degree x 1 degree resolution. The first basic mapping is done through an optimal interpolation (ordinary kriging) with correlation scales of 400 km along the x-axis (longitudes) and 300 km along the y-axis (latitudes). A second step is then performed as an extrapolation only, using the ordinary kriging as an exact interpolator (i.e. not changing already known values mapped in the 1st step), wih a correlation scale of 400 km. This last step enables to extrapolate somehow the MLD values in areas with few observations, especially in the Arctic Ocean, or in the Indonesian Throughflow. A field of the number of observations available per meshgrid and per month is given in the dataset, so that one can know to what extent some mapping was done in specific areas (if observations are present in that area, then we can have greater confidence in the result).

The final maps of the MLD climatology for each month are presented in the Appendix of this document.

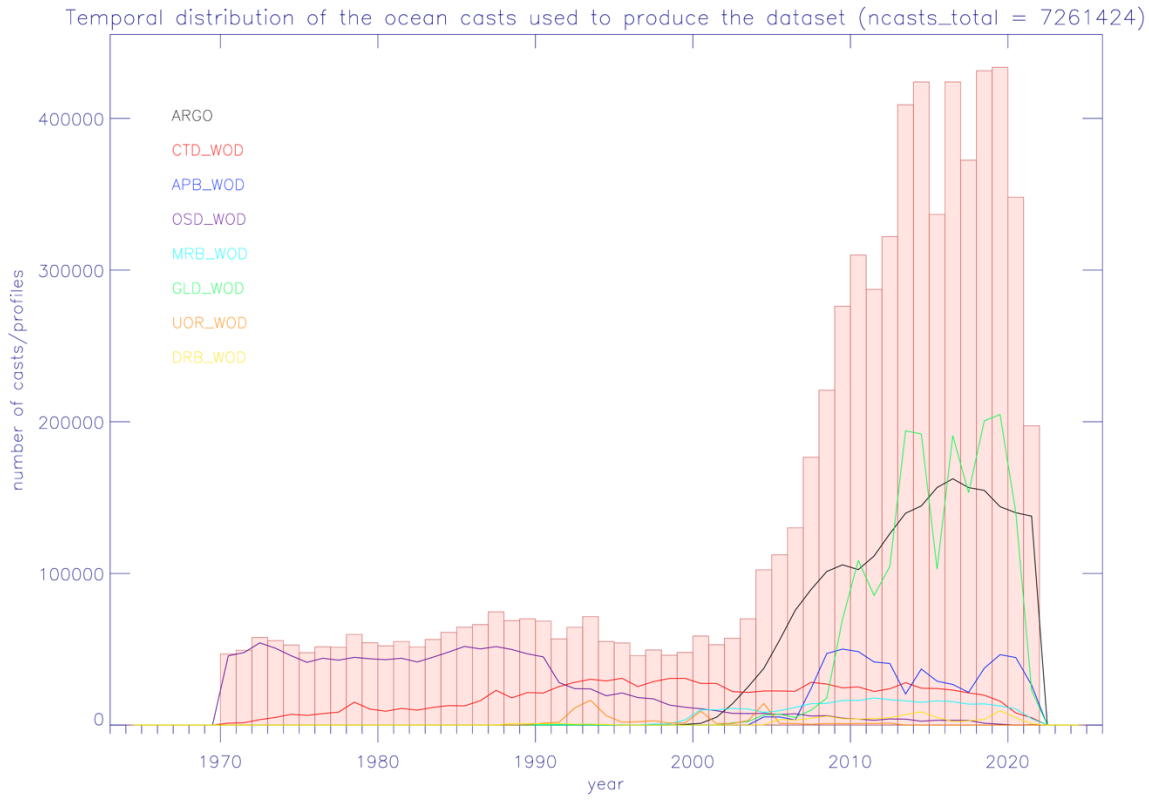


Figure 1. Temporal (yearly) distribution of all the ocean casts/profiles used to produce the MLD climatology presented here (histogram bars). Colored curves give the yearly distribution for each kind of dataset used.

Acknowledgements

The Argo data were collected and made freely available by the International Argo Program and the national programs that contribute to it. (https://argo.ucsd.edu, https://www.ocean-ops.org). The Argo Program is part of the Global Ocean Observing System. All other kind of casts/profiles comes from the World Ocean Database (WOD) at NOAA-NCEI.

References

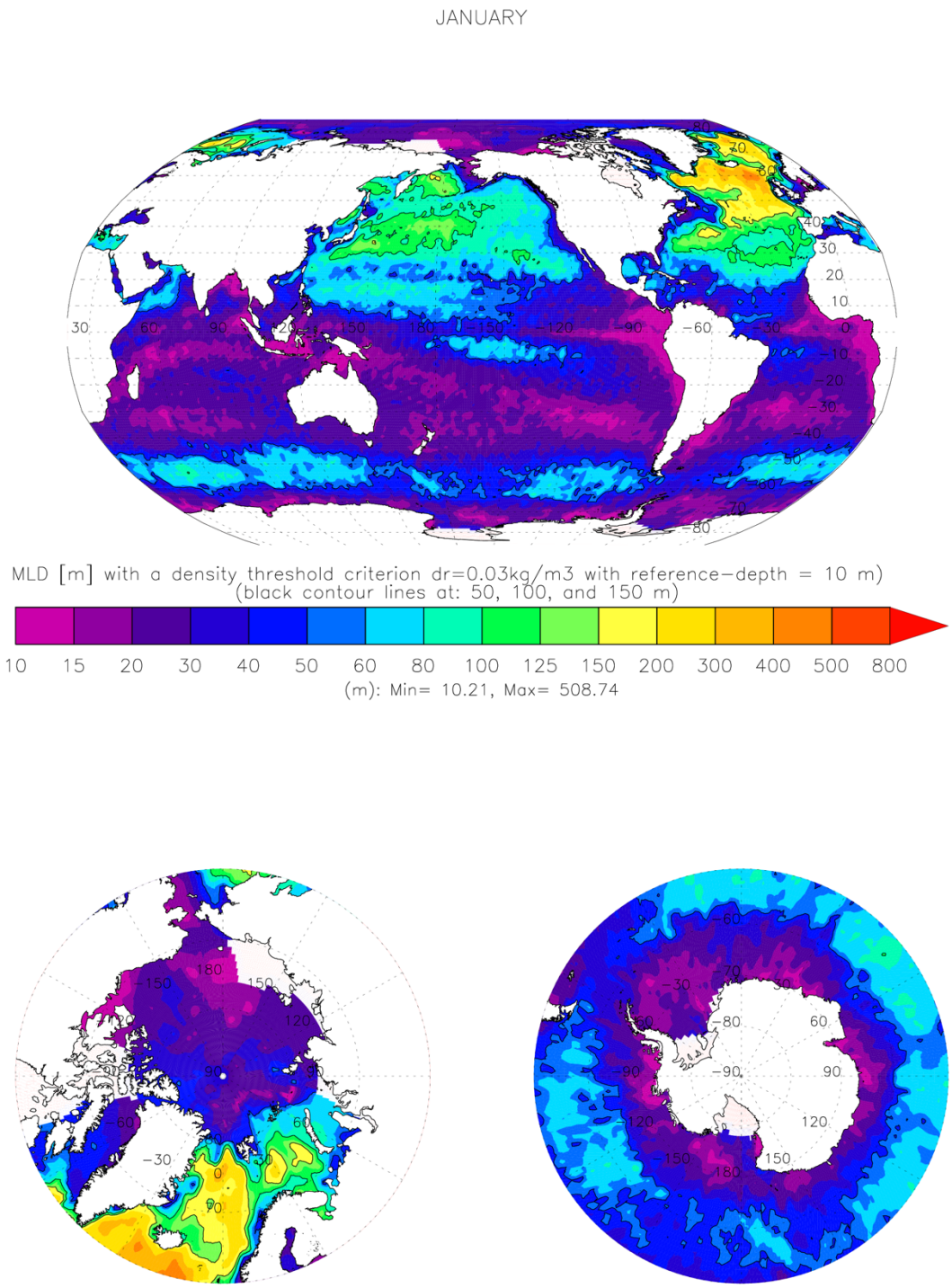
Boyer, T.P., O.K. Baranova, C. Coleman, H.E. Garcia, A. Grodsky, R.A. Locarnini, A.V. Mishonov, C.R. Paver, J.R. Reagan, D. Seidov, I.V. Smolyar, K.W. Weathers, M.M. Zweng (2018). World Ocean Database 2018. A. V. Mishonov, Technical Editor, NOAA Atlas NESDIS 87.

de Boyer Montégut, C., G. Madec, A. S. Fischer, A. Lazar, and D. Iudicone (2004), Mixed layer depth over the global ocean: An examination of profile data and a profile-based climatology, J. Geophys. Res., 109, C12003, doi:10.1029/2004JC002378.

Treguier, A.-M., C. de Boyer Montégut, A. Bozec, E. P. Chassignet, B. Fox-Kemper, A. McC. Hogg, D. Iovino, A. E. Kiss, J. Le Sommer, Y. Li, P. Lin, C. Lique, H. Liu, G. Serazin, D. Sidorenko, Q. Wang, X. Xu, and S. Yeager (2023). The mixed-layer depth in the Ocean Model Intercomparison Project (OMIP): impact of resolving mesoscale eddies. Geosci. Model Dev., 16, 3849–3872, https://doi.org/10.5194/gmd-16-3849-2023.

Appendix :

Maps of the MLD climatology for the 12 months of the year



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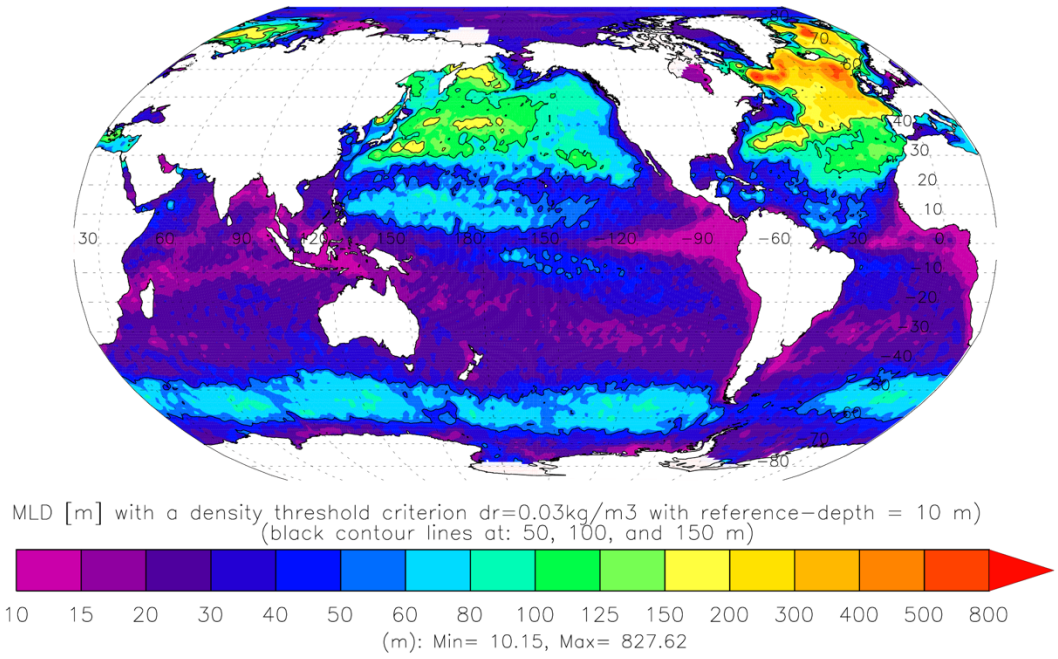
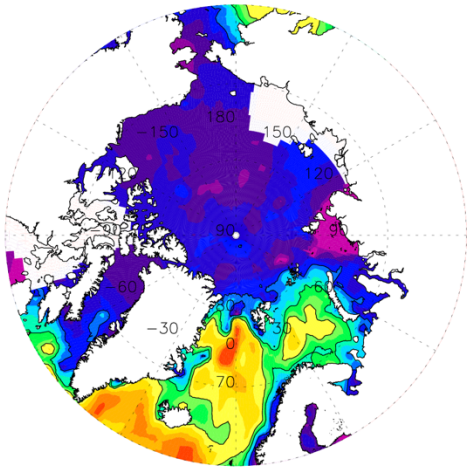
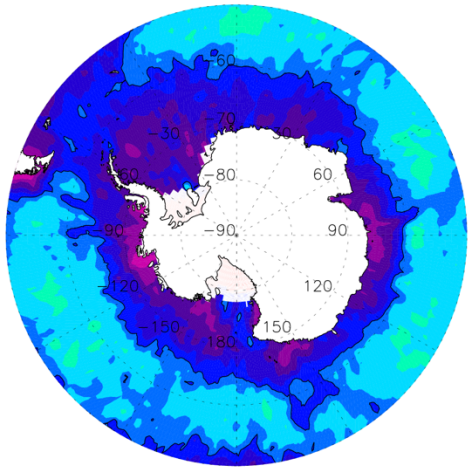

MLD [m] with a density threshold criterion dr=0.03kg/m3 with reference-depth = 10 m)
(black contour lines at: 50, 100, and 150 m)
10 15 20 30 40 50 60 80 100 125 150 200 300 400 500 800
(m): Min= 10.15, Max= 827.62





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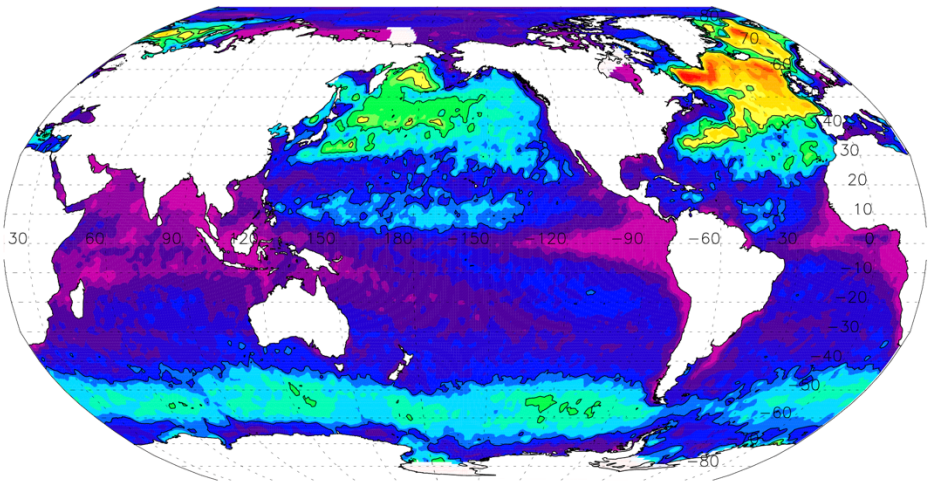

MLD [m] with a density threshold criterion dr=0.03kg/m3 with reference-depth = 10 m)
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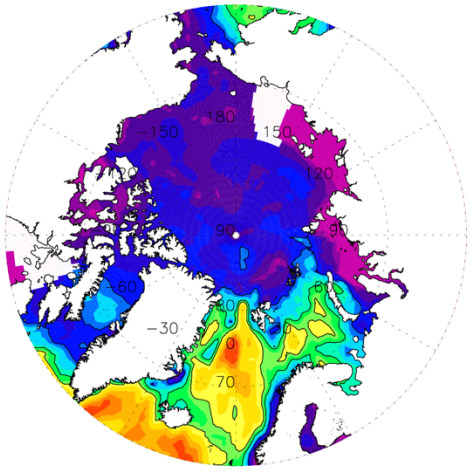

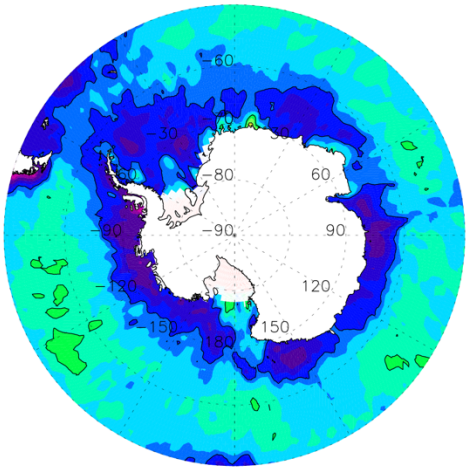

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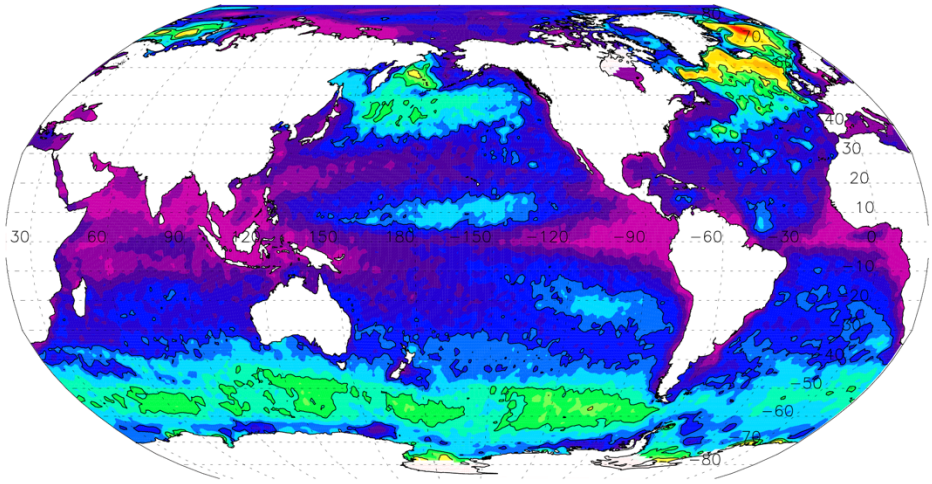

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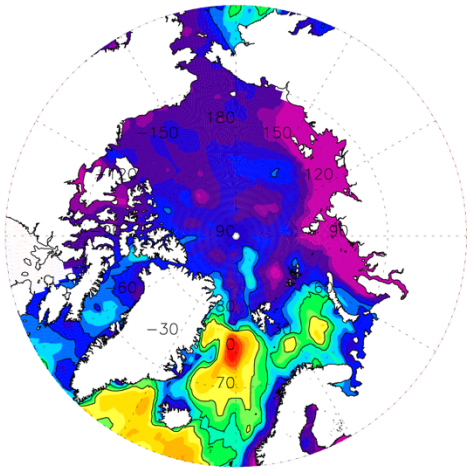
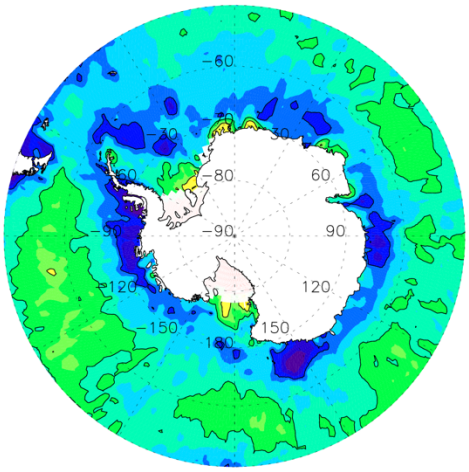
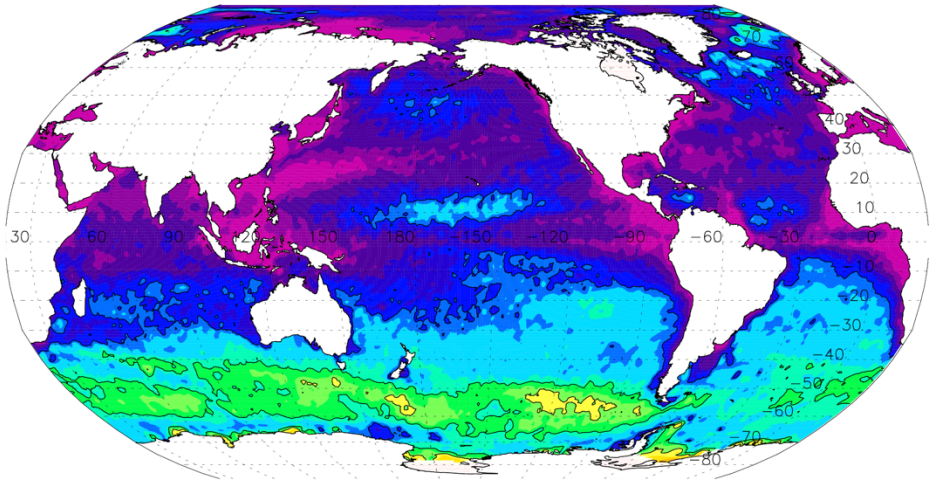
(black contour lines at: 50, 100, and 150 m)

(m): Min= 10.03, Max= 1205.85

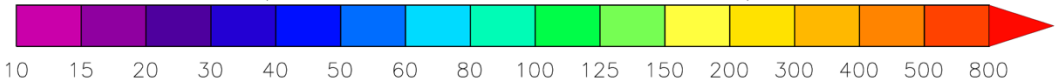




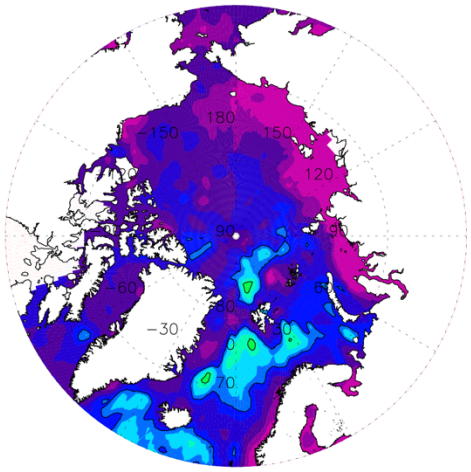
MAY

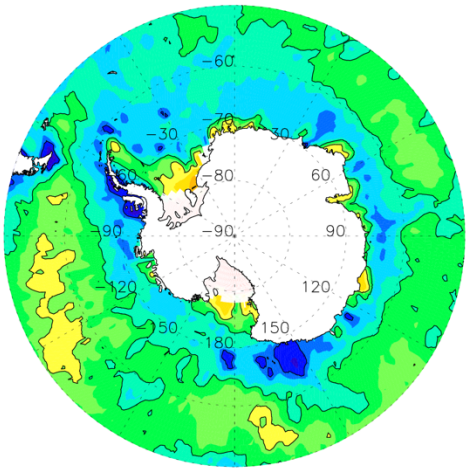


MLD [m] with a density threshold criterion dr=0.03kg/m3 with reference-depth = 10 m)
(black contour lines at: 50, 100, and 150 m)



(m): Min= 10.05, Max= 398.96





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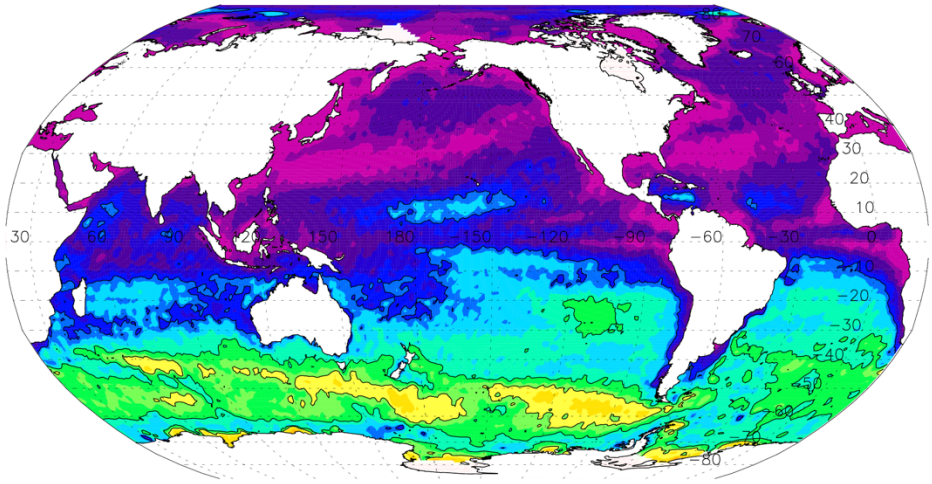

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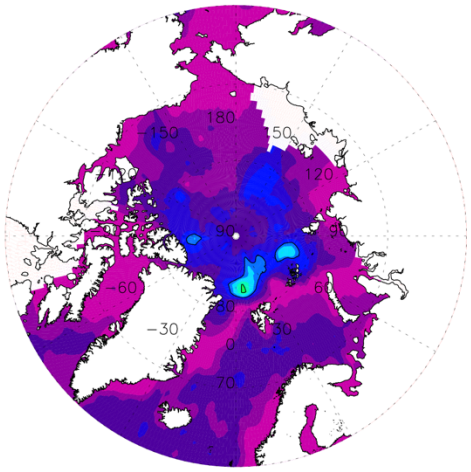
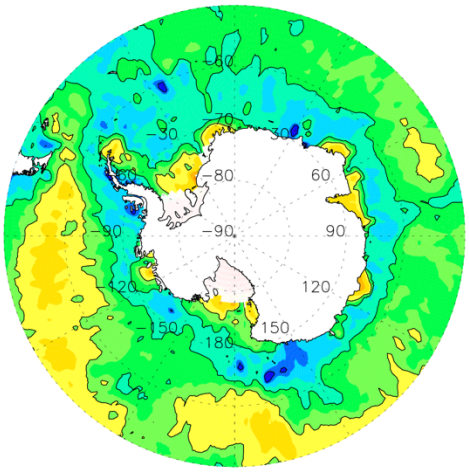
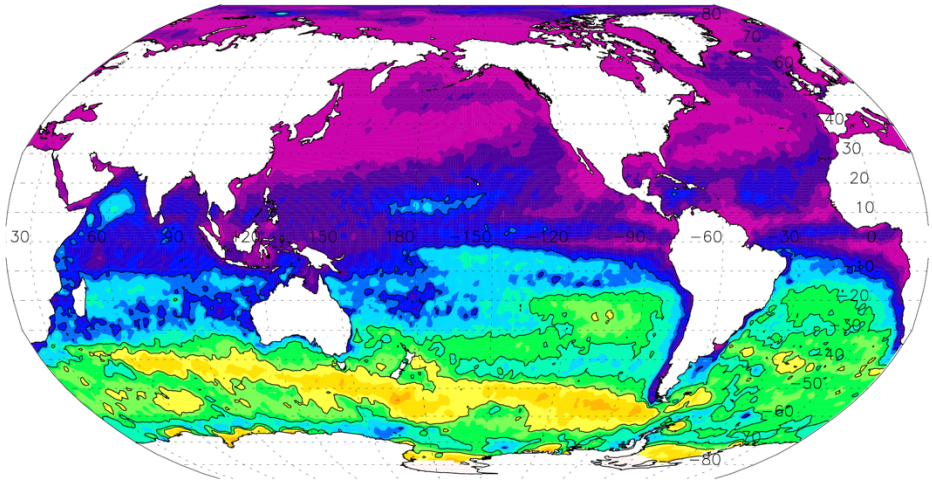
(m): Min= 10.10, Max= 433.14



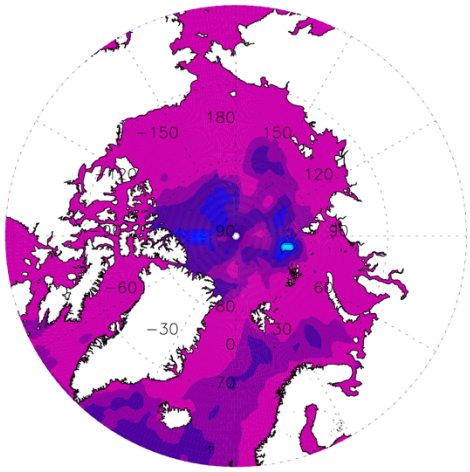


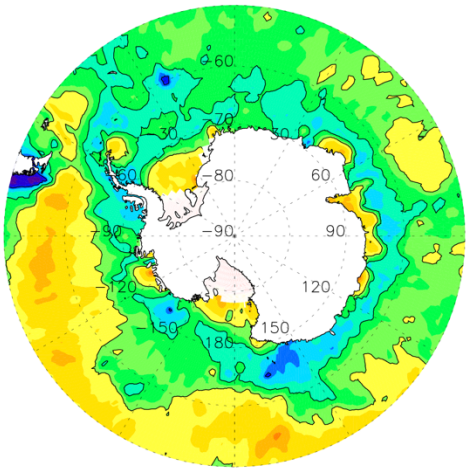
JULY



MLD [m] with a density threshold criterion dr=0.03kg/m3 with reference-depth = 10 m)
(black contour lines at: 50, 100, and 150 m)

(m): Min= 10.02, Max= 507.75





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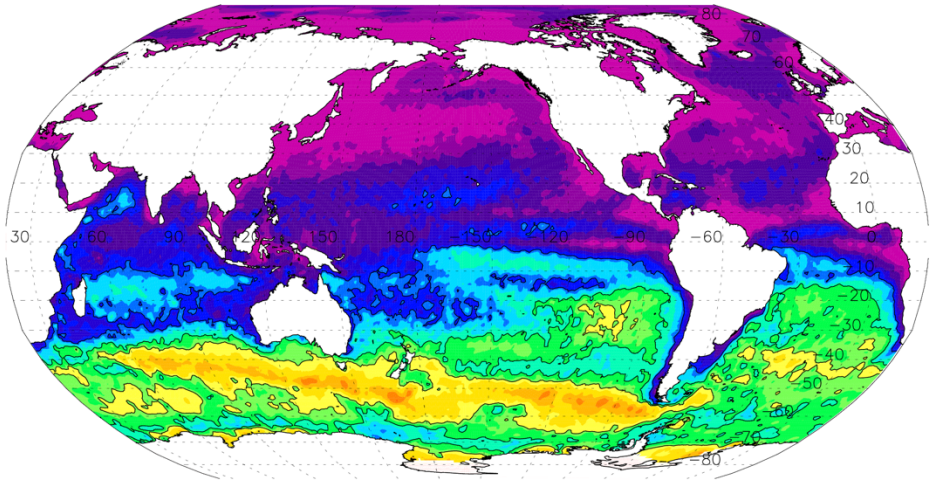
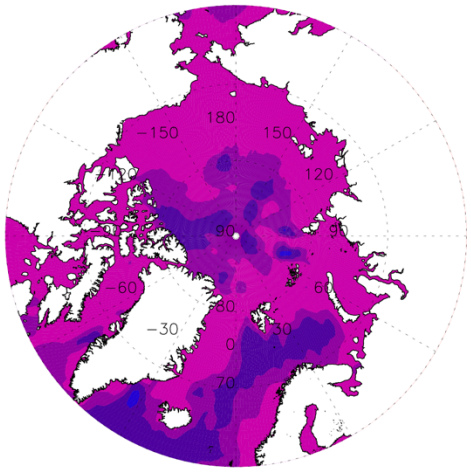
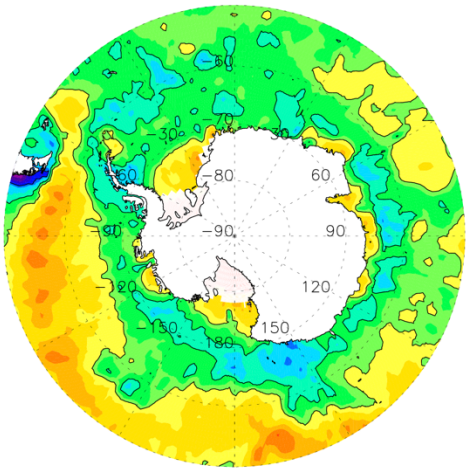


MLD [m] with a density threshold criterion dr=0.03kg/m3 with reference-depth = 10 m)
(black contour lines at: 50, 100, and 150 m)

(m): Min= 10.02, Max= 509.33





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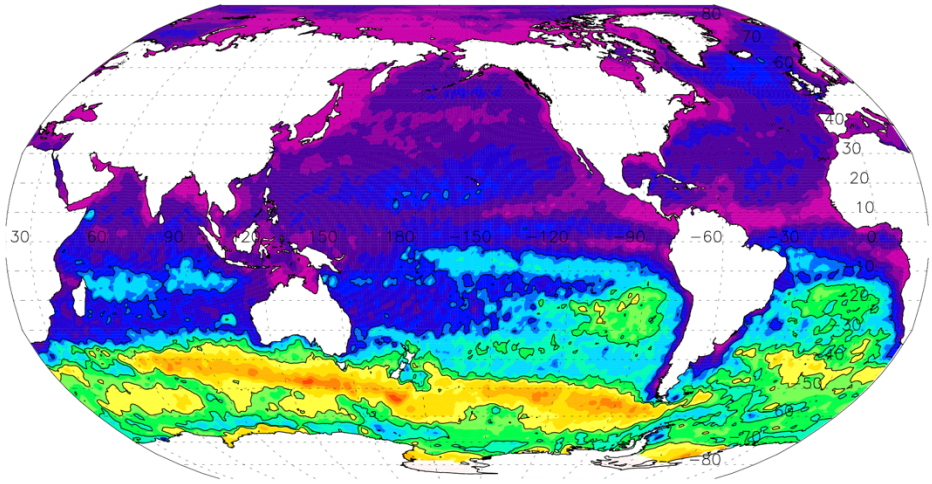

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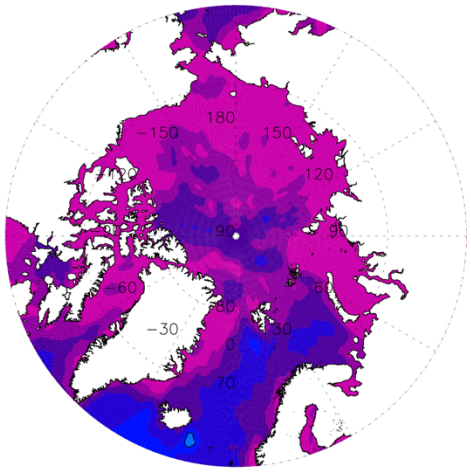
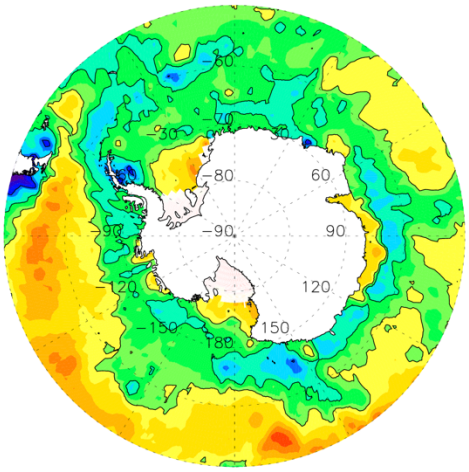
(m): Min= 10.02, Max= 569.50





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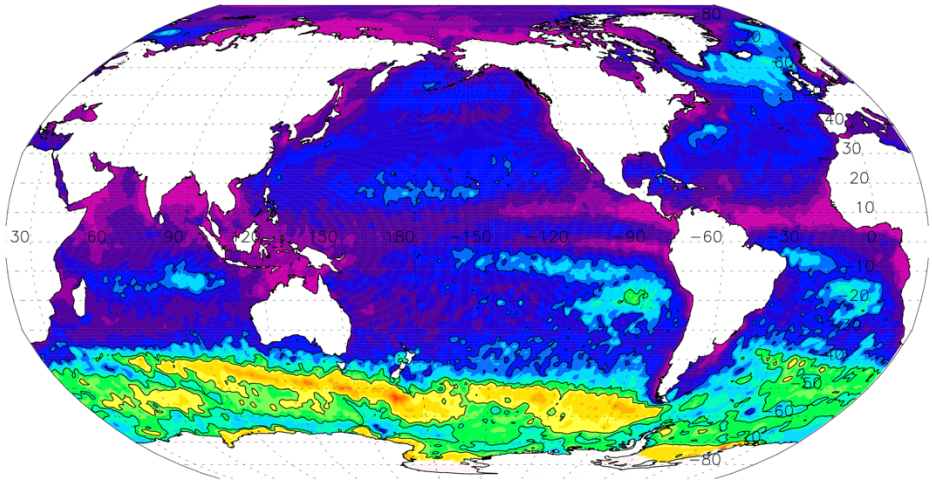

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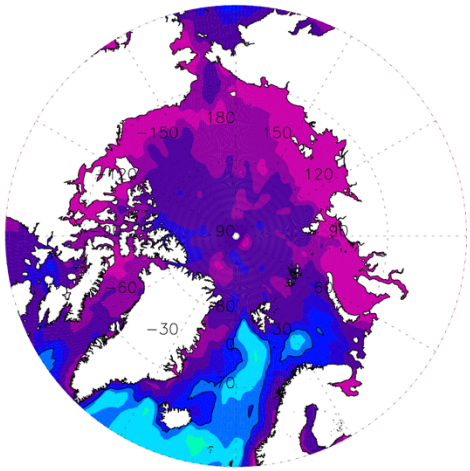
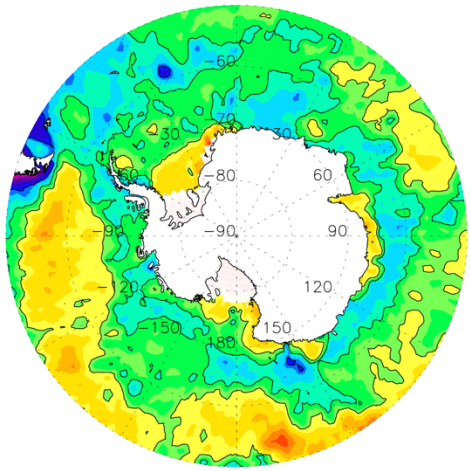
(m): Min= 10.01, Max= 553.29





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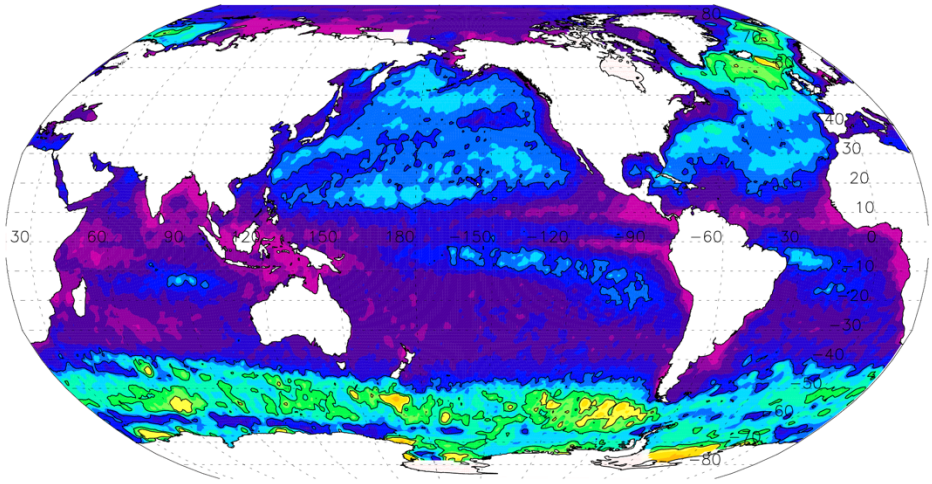

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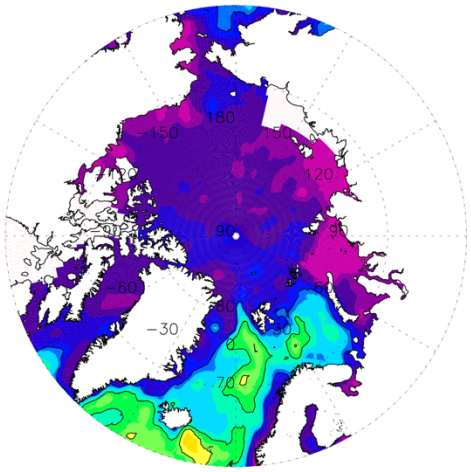
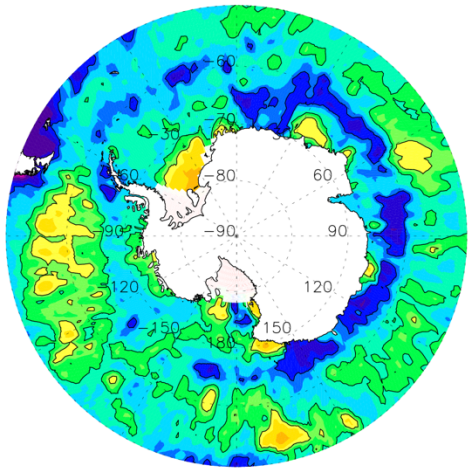
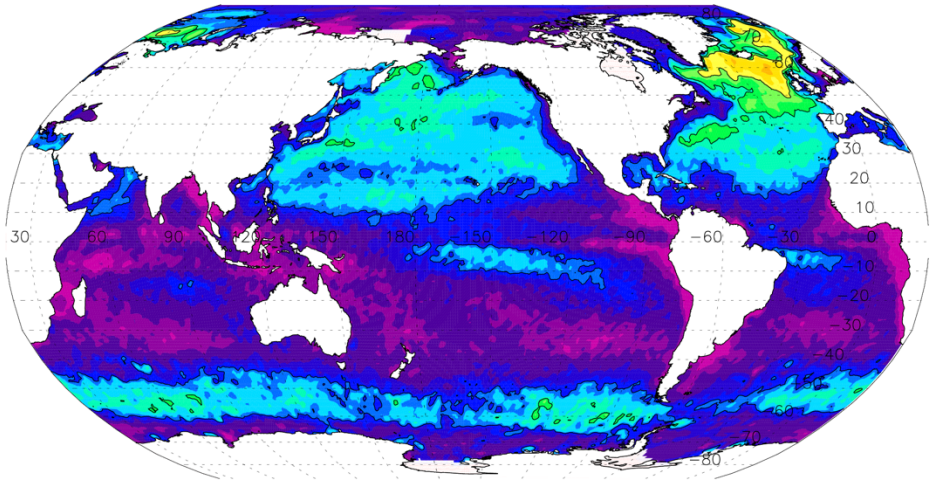




DECEMBER



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(black contour lines at: 50, 100, and 150 m)

(m): Min= 10.12, Max= 348.35