ISAS products
Note on releases
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ABSTRACT:

The In Situ Analysis System (ISAS) was developed to produce gridded fields of temperature and salinity that preserve as much as possible the time and space sampling capabilities of the Argo network of profiling floats. ISAS is based on Optimal Interpolation method. Since the first global re-analysis performed in 2009, the system has been extended to accommodate all types of vertical profile as well as time series. ISAS gridded fields are entirely based on in-situ measurements. The system aims at monitoring the time evolution of ocean properties for climatic studies and allowing easy computation of climate indices. Delayed Mode (D) profiles are used a much as possible and extra visual check is carried out. **The ISAS procedure and products are described in *Gaillard et al.* (2016).** The present doi provides both analyzed **fields** and standardized profiles **data** used in interpolation.

PLEASE ACKNOWLEDGE:

ISAS temperature and salinity monthly gridded field products are made freely available by SNO Argo France at LOPS Laboratory (supported by UBO/CNRS/Ifremer/IRD) and IUEM Observatory (OSU IUEM/CNRS/INSU) at doi: https://doi.org/10.17882/52367

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HISTORY:

ISAS20_ARGO: The ISAS20_ARGO release is interpolated on 187 standard depth levels between 0-5500 m depth and 0.5°x0.5° global horizontal grid. ISAS20 use the version 8 of ISAS and updated statistics to produce the monthly analysis (Monthly Climatology and annual STD computed from WOA18A5B7). **ISAS20 gridded fields analyze the Argo and Deep-Argo temperature and salinity data alone between 2002-2020**.

ISAS17: The ISAS17 release is interpolated on 187 standard depth levels between 0-5500 m depth and 0.5°x0.5° global horizontal grid. ISAS17 use the version 8 of ISAS and updated statistics to produce the monthly analysis (Monthly Climatology and annual STD computed from WOA18A5D). **ISAS17 gridded fields analyze the Argo and Deep-Argo temperature and salinity profiles, and**

other in situ measurements between 2002-2017 to complete observations, including the higher latitudes (typically poleward of 60°S-N) where Argo sampling is sparse or not existent.

ISAS-SSS : The ISAS-SSS release is interpolated on 4 standard depth levels (1-3-5-10m depth) and 0.5°x0.5° global horizontal grid between 2002-2015. ISAS-SSS use the version 7 of ISAS and updated the statistics to produce the monthly analyses (Monthly Climatology computed from ISAS13 and annual STD computed from Argo dataset). ISAS-SSS gridded fields analyze the Argo and other in situ salinity data, including TSG from research and ship of opportunity from French SNO-SSS.
Previously available on :
Kolodziejczyk Nicolas, Prigent-Mazella Annaig, Gaillard Fabienne (2018). **ISAS-SSS: In situ Sea Surface Salinity gridded fields**. SEANOE. https://doi.org/10.17882/55600

ISAS15 : The ISAS15 release is interpolated on 152 standard depth levels between 0-2000 m depth and 0.5°x0.5° global horizontal grid between 2002-2015. ISAS15 use the version 7 of ISAS and updated statistics to produce the monthly analysis (Monthly Climatology computed from ISAS13 and annual STD computed from Argo dataset). ISAS15 gridded fields analyze the Argo temperature and salinity data alone in its ISAS15_ARGO configuration; or Argo plus other in situ measurements in its ISAS15 configuration.
Previously available on:
Kolodziejczyk Nicolas, Prigent-Mazella Annaig, Gaillard Fabienne (2017). **ISAS-15 temperature and salinity gridded fields**. SEANOE. https://doi.org/10.17882/52367

ISAS13 : The ISAS13 release is interpolated on 152 standard depth levels between 0-2000 m depth and 0.5°x0.5° global horizontal grid between 2002-2012. ISAS13 use the version 6 of ISAS and updated statistics to produce the monthly analysis (Monthly Climatology computed from ISAS11 and annual STD computed from Argo dataset). ISAS13 gridded fields analyze the Argo temperature and salinity data and other in situ measurements between 2002-2012.
Previously available on:
Gaillard Fabienne (2015). **ISAS-13 temperature and salinity gridded fields**. SEANOE. https://doi.org/10.17882/45945

Table 1: *Summary of ISAS products configurations distributed since 2013.*

ISAS Release	**ISAS tool version**	**Depth range**	**z-levels**	**Time span since 2002**	**In situ data sources**	**First Guess**	**Correlation scales and weights** (L_1, T_1) (L_2, T_2) (w_1,w_2,w_{UR})*
ISAS13	v6	0-2000 m	152	2012	Argo doi: 2013-11	Monthly climatology ISAS11 (2004-2010)	(300km, 30days) (4*1st Rossby Radius, 20days) (1,2,6)
ISAS15	v7	0-2000 m	152	2015	Argo doi: 2016-02 ITP/MEOP/Tropical Moorings	Monthly climatology ISAS13 (2004-2012)	(300km, 30days) (6* 1st Rossby Radius, 20days) (1,2,8)
ISAS15_ARGO	v7	0-2000 m	152	2015	Argo doi:2016-02	Monthly climatology ISAS13 (2004-2012)	(300km, 30days) (6* 1st Rossby Radius, 20days) (1,2,8)
ISAS-SSS	V7	0-10 m	4	2015	Argo doi: 2016-02 ITP MEOP Tropical Moorings TSGs	Monthly climatology ISAS13 (2004-2012)	(300km, 30days) (6* 1st Rossby Radius, 20days) (1,2,8)
ISAS17	v8	0-5500 m	187	2017	Argo doi: 2019-01 ITP MEOP Tropical Moorings CTDs	Monthly climatology WOA18A5B7 (2005-2017)	(300km, 30days) (6* 1st Rossby Radius, 20days) (1,2,8)
ISAS20_ARGO	v8	0-5500 m	187	2020	Argo doi: 2021-03	Monthly climatologyWOA18A5B7 (2005-2017)	(300km, 30days) (6* 1st Rossby Radius, 20days) (1,2,8)

* *see Gaillard et al. (2016)*

DATA REFERENCES:

As described in table 1, we acknowledge Pis and data centers that freely provide quality controlled in situ data that have been included in the various ISAS configurations:

- **Argo doi** : Argo (2021). Argo float data and metadata from Global Data Assembly Centre (Argo GDAC). SEANOE. https://doi.org/10.17882/42182
- **MEOP (Marine Mammals Exploring the Oceans Pole to Pole)** : https://www.meop.net/
- **ITP (Ice Teethred Profilers)** : https://www2.whoi.edu/site/itp/
- **Tropical Mooring (Global Tropical Moored Buoy Array)** : https://www.pmel.noaa.gov/gtmba/
- **TSGs:**
  - **TSG from French Research Vessel :** https://doi.org/10.17882/3947
  - **TSG from French SNO-SSS (Merchant ships):** http://www.legos.obs-mip.fr/observations/sss

- **CTD casts:**
  - **CCHDO (Hydrological data)** : https://cchdo.ucsd.edu/
  - **ICES (International Council for the Exploration of the Sea)**: https://www.ices.dk/
  - **WHOI Beaufort Gyre Project:** https://www2.whoi.edu/site/beaufortgyre/data/data-overview/
  - **LOPS Laboratory Campaigns:** https://www.umr-lops.fr/Projets/Projets-actifs/OVIDE/Ovide-data

QUALITY METRICS:

Data coverage: ISAS is mainly designed for analyses of global Argo dataset. The Argo network has been deployed since the beginning of 2000's. The Argo design nominal target was a global ocean coverage with 3000 floats, Temperature-Salinity-Pressure, 0-2000 m, 60°S-N, 1 profile by 3°x3° by 10 days. Then, Argo network has been extended to marginal seas, higher latitudes, some regions such has western boundary current and equatorial band have been over-sampled, and new missions designed to reach deep ocean (2000 m depth-bottom) and measures Biogeochemical parameters. Today, around 4000 Argo floats are deployed over the global ocean (*Roemmich et al.*, 2019).

ISAS takes benefit from the Argo global sampling using optimal correlation space and time scales to capture large space and time scales resolved by the Argo array, as well to compute reliable global indices. Along the OI analyzed fields, ISAS provide the percentage of a priori variance (PCTVAR), which is a parameters that depend on i) the data sampling and coverage, ii) the covariance scale (region of influence of the data), and iii) the error on the measurements. Thus, the PCTVAR provided by ISAS OI is a convenient metrics to measures the relative coverage of the Argo network. At a given space/time location in the OI fields, PCTVAR=100% indicates that no data are present at or in the neighbor and the T/S estimates is relaxed toward climatology. The Figure 1a shows the evolution of the number of profiles by month used in the global analysis between 2002-2020. The 20000 profiles/month (T/S) are reached during 2017. The associated global average PCTVAR for T/S shows a decrease from about 95% in 2002 to less than 80% in 2007 (Fig.1b), then it follows a slow decrease until 2020 (less than 70%). This illustrate that the Argo coverage has been improved significantly during the first years of global Argo program implementation, to reach the nominal coverage. Then, the coverage continues to slowly improved up to now (Fig. 1b). However, the PCTVAR global average hides inter-hemispheric asymmetric coverage during the first stage of implementation : while the Northern Hemisphere reaches a nominal coverage since 2003-2004, the Southern Hemisphere, reaches a nominal sampling around 2007 (Fig. 1c). **It is admitted that the nominal global coverage targeted by the Argo program was reached in 2007** (*Roemmich et al.*, 2019)**.** Before this period, the ISAS T/S estimates and deduced climate indices may be strongly relaxed towards first guess (climatology) and thus biased.

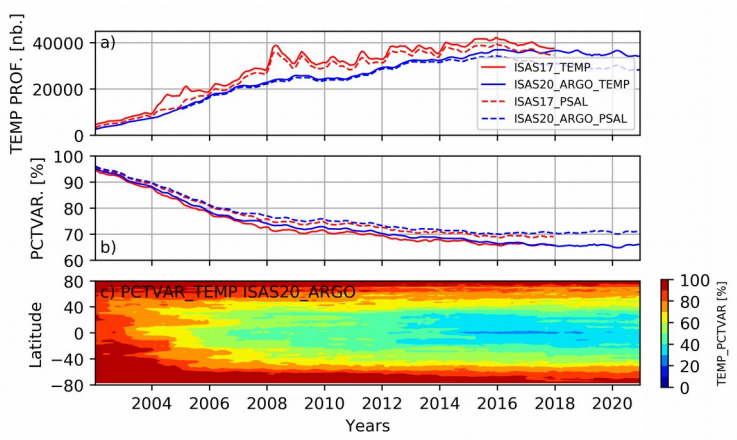

Figure 1: a) Number of temperature (solid) and salinity (dashed) profiles by month used in the global ISAS17 (red) and ISAS20_ARGO (blue) monthly analyses. b) Monthly global average percentage of a priori variance (PCTVAR) for temperature (solid) and salinity (dashed) parameters in the global ISAS17 (red) and ISAS20_ARGO (blue) analyses. Note that ISAS17 includes other than Argo T/S profiles (see Table 1), therefore a larger amount of profiles and a lower PCTVAR is observed in Figure 1a and d, respectively. c) Zonal average of the monthly percentage of a priori variance for temperature in the global ISAS20_ARGO (blue) analyses.

Data Quality Control: ISAS is mainly designed for analyses of Argo dataset. We acknowledge the high quality of the Argo temperature and salinity dataset made possible by the contribution of the Pis and Delayed (D) mode operators from Argo community and data centers. They provide Delayed D-mode Quality Controlled (QC) temperature and salinity profiles. Among other, they control and correct (when necessary) the practical salinity parameter, that is measured by conductivity cells known to experience drifts and fooling (*Wong et al.*, 2020). As this task necessitates high expertise of oceanic conditions and feed back from Argo float's profiles history, it can take few months to few years to complete the D mode QC on Argo dataset (Wong et al., 2020).

Therefore, for a given Argo doi issue (i.e. the snapshot of Argo dataset at a given date, see Table 1), most recent profiles of temperature and salinity from Argo dataset is a mix of high quality D mode profiles and operational quality Real time (R, automatic QCs) and automatically adjusted profiles (A)(Fig.2). Thus, recent years of ISAS analyses, especially for salinity parameter should be regarded with caution.

For ISAS15_ARGO, ISAS17 and ISAS20_ARGO releases, the amount and ratio of delayed mode profiles and real time/adjusted profiles are depicted on Figure 2. First, it should be noted that ISAS17 includes other source of D data, such as Marine Mammals (MEOP), ITP or CTD casts for example, that complete the data coverage especially in high latitudes. Therefore the total amount of ISAS17 data is larger than the one in ARGO only configurations such as ISAS20_ARGO or ISAS15_ARGO (Fig. 2). Given the doi issue for Argo data used in ISAS15_ARGO (2016-02), D data represents less than 75% of the interpolated Argo data after 2012, and less 50% after 2014. For ISAS17 (ISAS20_ARGO), less than 75% of D mode data are used after 2014 (2018), and less than 50% after mid-2017 (in 2020). Despite the additional checks performed on Argo profiles along with ISAS procedures, this may have an impact on the quality of ISAS fields over these periods.

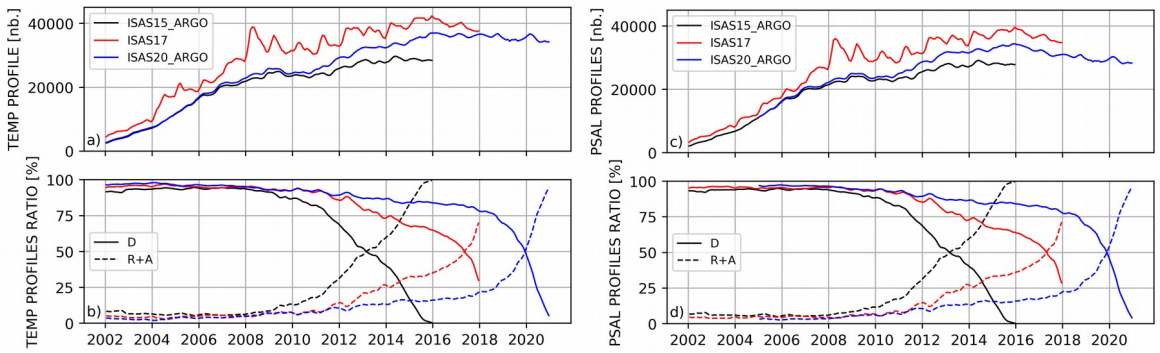

Figure 2: *Monthly number of a) temperature and c) salinity profiles used over 2002-2015 in ISAS15_ARGO (black); over 2002-2017 in ISAS17 (red) and over 2002-2020 ISAS20 (blue). Ratio (in %) of b) temperature and d) salinity Delayed Mode (solid) profiles and Real time and Adjusted in real time profiles used in ISAS15_ARGO (black); ISAS17 (red) and ISAS20 (blue).*

<u>WARNING ON FAST SALTY DRIFT (FSD)</u>:

Since 2015, Fast Salty Drift (FSD) on SeaBird Conductivity Cells (SBE41/41CP) have been reported on identified (and probably not yet identified) pool of SeaBird CTD sensors serial numbers larger than 6000 (*Wong et al.*, 2020). This salty drift is estimated to impacts about 25% of the Argo fleet (*Wong et al.*, 2020) and could be erratic and sever such as +0.01 pss-78 in few Argo cycles. On global average over 0-2000 m depth, it could correspond to an average drift around 0.001 pss-78/year. (Fig. 3).

These FSD are reported and treated in priority by Argo Pis and DMQC operators (see: https://argo.ucsd.edu/fast-salty-drifters-documented-by-dmqc-operators/). The AST and ADMT Argo community work closely with SeaBird to address this issue. SeaBird have modified their CTD since 2018. Although, FSD are expected to still occurs in the currents Argo salinity profiles, improvements are expected.

Meanwhile, the ratio of D mode profiles could be sensitive to determine the quality of the analyses salinity fields. Especially when computing global budget based on salinity (global salinity average, freshwater content, halosteric sea level, see Fig. 3). **ISAS17 and ISAS20_ARGO are impacted by the FSD.**

In <u>ISAS20 salinity</u> products, we adopt the following strategy:

- We have removed the WMO floats affected by FSD as identified by Argo Pis and DMQC operators (see: https://argo.ucsd.edu/fast-salty-drifters-documented-by-dmqc-operators/).
- We use the most recent (as possible) issued Argo doi (2021-03 for ISAS20) to maximize the D mode profiles in our analyses salinity fields.
- We provide (Fig 3) the global salinity average time series (over 60°N-S, 0-2000 m depth) and monthly D mode profile ratio to advise the user on the period of global salinity budget discrepancy. **It is recommended to not use ISAS20 data after 2016 for global integral budgets using <u>salinity</u>.**
- No adjustment, other than those performed by the Argo Pis and DMQC operators (*Wong et al.*, 2020), have been performed on salinity profiles.

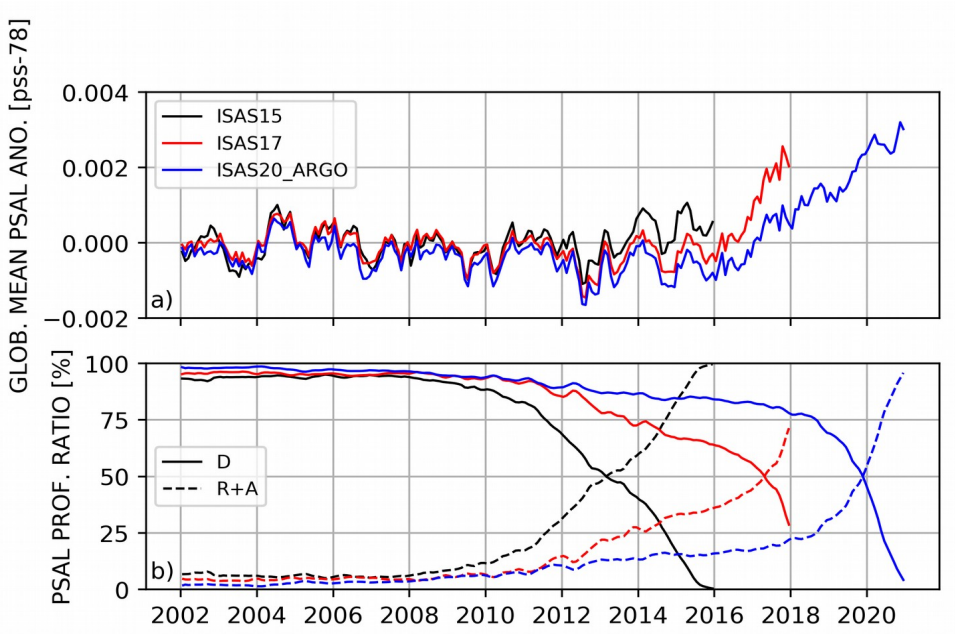

Figure 3: a) Monthly global (0-2000 m depth; 60°S-60°N) averaged salinity (in pss-78) anomaly (relative to 2002-2012) over the period 2002-2015 fore ISAS15_ARGO (black), 2002-2017 in ISAS17 (red); and 2002-2020 in ISAS20_ARGO (blue). b) *Ratio (in %) of salinity Delayed Mode (solid) profiles and Real time and Adjusted in real time profiles used in ISAS15 (black); ISAS17 (red) and ISAS20_ARGO (blue).*

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