

ANDRO: An Argo-based deep displacement atlas

Michel Ollitrault¹ & Jean-Philippe Rannou²

1 IFREMER Brest France michel.ollitrault@ifremer.fr

2 ALTRAN Ouest Brest France jean-philippe.rannou@altran.com

Argo float displacements

Since 2000, data from ~ 6000 **Argo** floats have been collected, worldwide, generating ~ 400000 profiles in the ocean main thermocline (between 2000m depth and the surface).

With their cycling periods of 10 days (generally), **Argo** floats subsurface displacements can also be used as a **direct** and **absolute** measure of the ocean mesoscale motions, at their drifting depths (1000m mostly).

Estimation of Argo deep displacements

We need reliable estimates of **Argo deep** displacements.

The **simplest** estimates use the first Argos fix from the present cycle and the last Argos fix from the previous cycle.

This was done by Lebedev et al. (2007) for their **YoMaHa'07** displacement/velocity file.

However, due to errors in the data processing and/or archiving several float cycles have missing or erroneous data, in the NetCDF public files.

YoMaHa'07 preserves some of the erroneous float cycles.

In particular **park pressures may be wrong**.

We have, over the last three years, almost fully corrected the AOML, Coriolis and JMA DAC data.

This was possible because we had access to the **original raw Argos** messages received.

ANDRO

We have created a displacement/velocity ASCII file (named **ANDRO** for **Argo** New Displacements Rannou Ollitrault) along the same lines and with the same format as **YoMaHa'07**, but with AOML, Coriolis and JMA DAC **corrected** data.

An Dro is a traditional celtic dance of Brittany (Vannes county), meaning a round, a turn, a swirl.

We are presently beginning to extend our procedure to the whole **Argo** data set, i.e. for all the other DACs, beginning with INCOIS.

AOML, Coriolis and JMA have kindly given us access to their Argos raw data files so that we have been able to do our own decoding. We hope this will also be possible for the other DACs.

All the errors detected and most corrections have been communicated, on a regular basis, to AOML Coriolis and JMA, so that they can progressively **update the NetCDF files**, if they think it is worth. We shall also proceed similarly with the other DACs.

Example of corrections done in 2007, on the Coriolis data set

- Check and correction of the correspondence between one ARGOS file and one float cycle ~ 6000 new or modified links (10% of total)
- Correction of time shifts for PROVOR, due to false day number determination
- Updating of the 25 different APEX formats.
- Check and correction of the version number for all the APEX floats
- Software updating for the APEX processing (still in progress at Coriolis)
- Check and correction of meta data (mainly REPETITION_RATE, CYCLE_TIME, PARKING_PRESSURE and DEEPEST_PRESSURE) e. g. 68 double missions created over a total of 753.

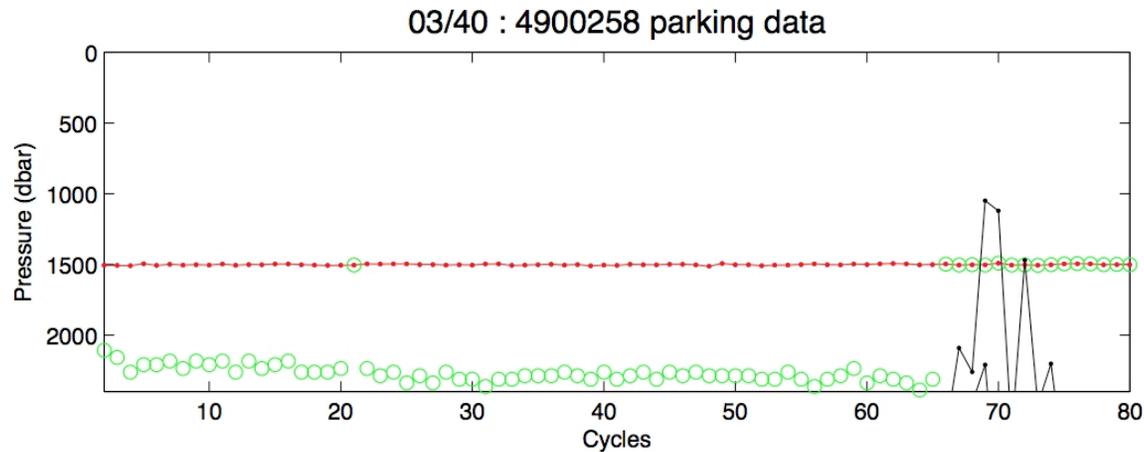
Similar checks were done in 2009 on the AOML and JMA Argos data set and results communicated back to the DACs

Processing done in 2008 and 2009, to produce our ASCII **ANDRO** file

- Regeneration of the most complete ARGOS data set from the DAC archived raw data
- Recovering of ARGOS fixes not found in NetCDF files
- PROVOR
 - Recovering of P,T, S measurements at drifting depth from ASCII decoded files
 - Correction of the remaining time shifts
 - **A new decoder is presently under development**
- APEX, SOLO and NINJA
 - Decoding anew of all the ARGOS raw message files
- Parking pressure for each cycle is given as:
 - Mean of P measurements at drifting depth, if they are available,
 - Otherwise, the one Parking pressure measured
 - Or, the Parking Pressure found in the meta file
- Visual validation of the Parking pressure
- Implementation of Nakamura, Ogita & Kobayashi test
- Exclusion of grounded cycles

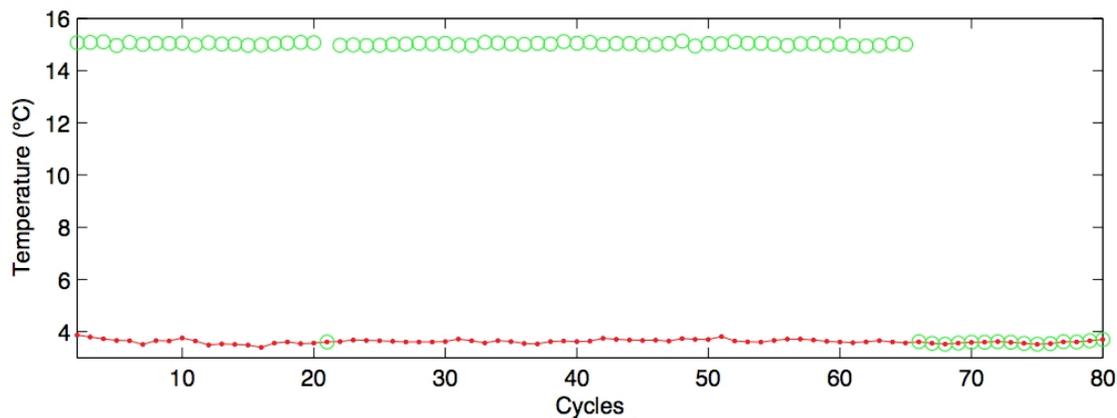
Example of an erroneous decoding

APEX (type 1.2) in the North-West Atlantic



As found in the NetCDF files before our work

After a new decoding of Argos raw data



ANDRO update

AOML, JMA & Coriolis data until January 1 2009:

- AOML: 2823 floats corresponding to ~270000 cycles (1428 SOLO, 1377 APEX, 16 ALACE & 2 PROVOR)
- JMA: 811 floats corresponding to ~75000 cycles (681 APEX, 93 PROVOR, 18 NINJA, 19 ALACE & misc.)
- Coriolis: 949 floats corresponding to ~70000 cycles (448 PROVOR, 449 APEX, 50 NEMO, 2 misc.)

These data represent 80% of the world Argo data set.

Presently, **ANDRO** contains 75% of the world Argo data set

Contents of the ANDRO file (January 15 2010)

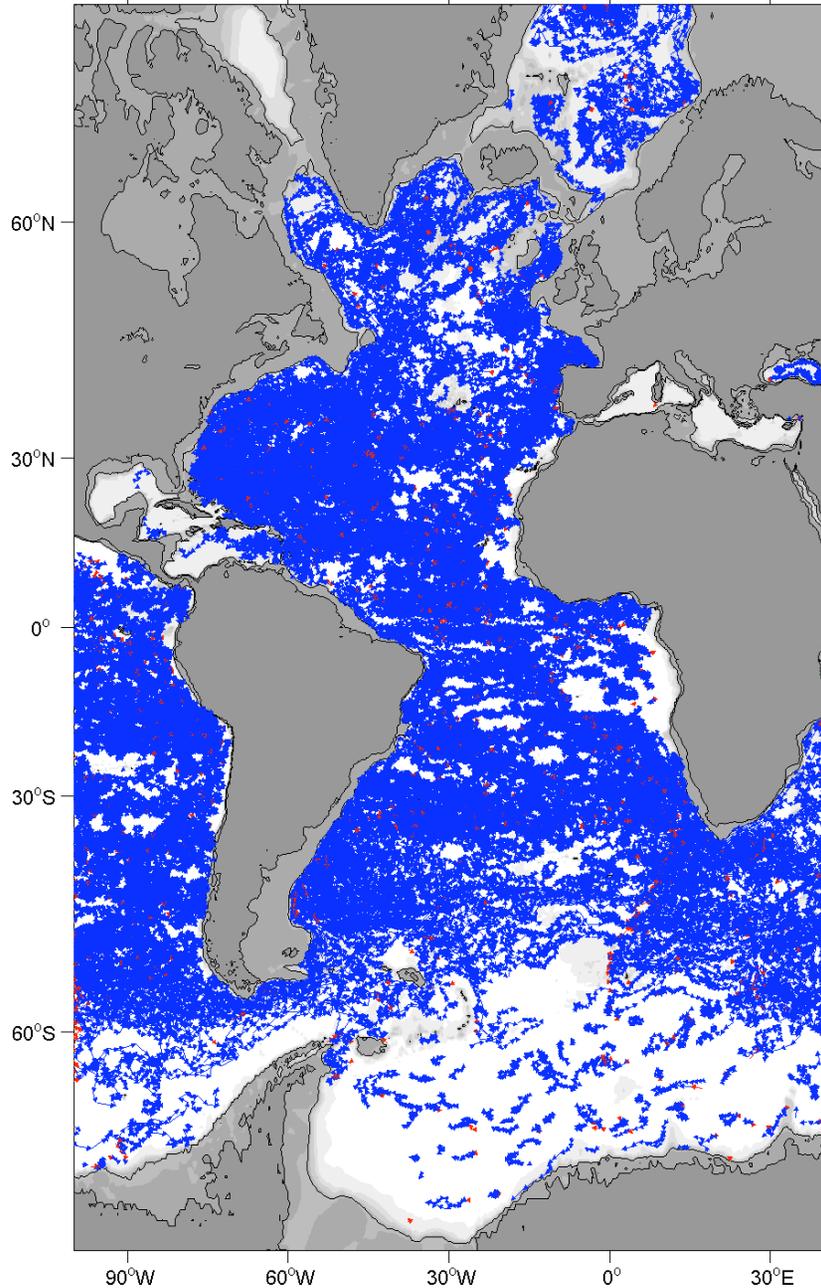
All Coriolis data covering the period July 11 1999 to April 7 2008

AOML data (all SOLO and 75% of APEX floats until December 31 2008)

JMA data (85% of APEX floats until December 31 2008)

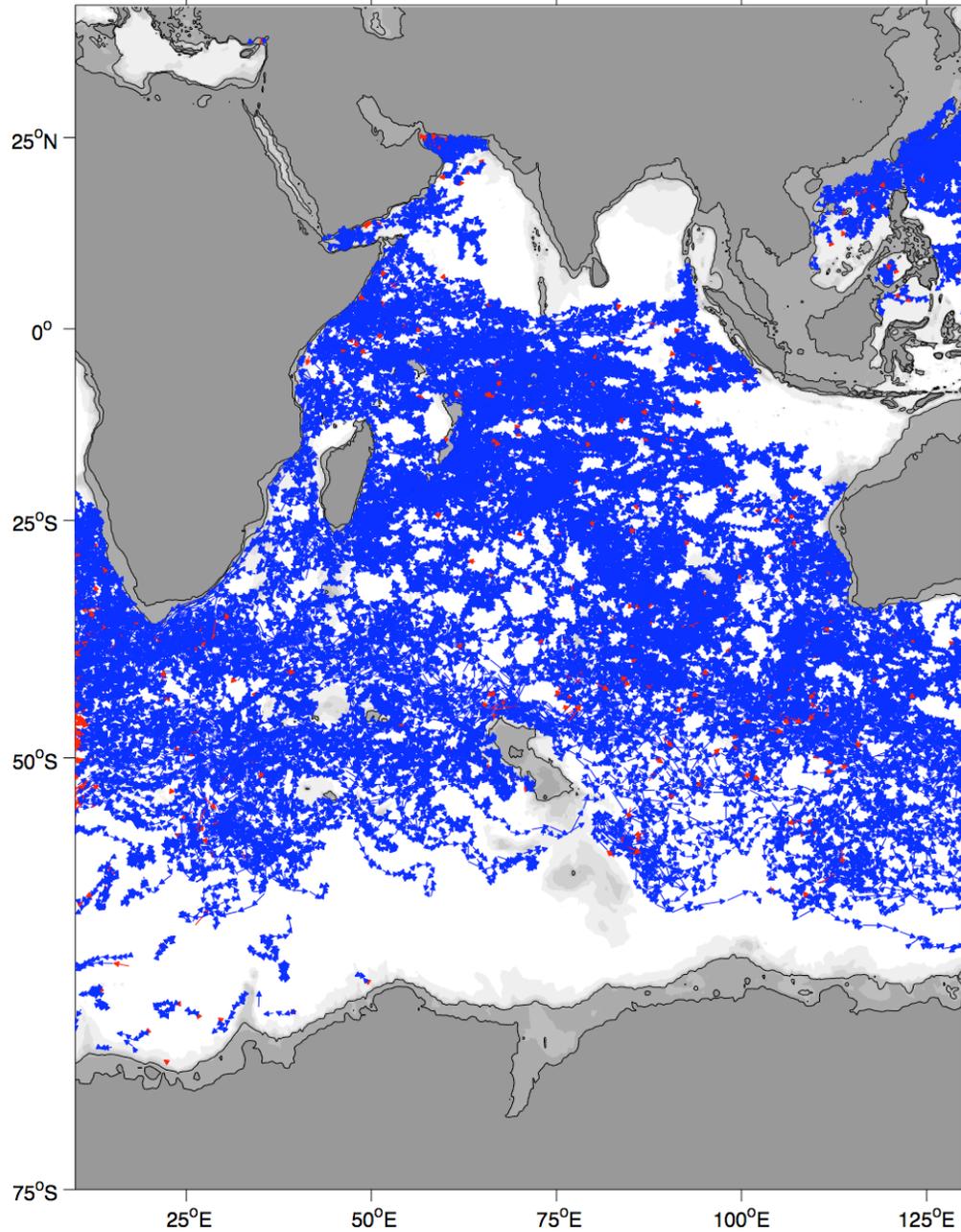
- Data span the period July 11 1999 to December 31 2008
- ASCII file, same format as YoMaHa'07 (updated '09)
- 3624 floats, 315820 displacements
 - 4 % at depths less than 250 dbar
 - 3 % between 250 and 750 dbar
 - 79 % between 750 and 1250 dbar
 - 10 % between 1250 and 1750 dbar
 - 3 % between 1750 and 2250 dbar
 - 1 % undefined

1142 floats in ANDRO atlas (750 < P <= 1250 dbar) (86163 disp.)



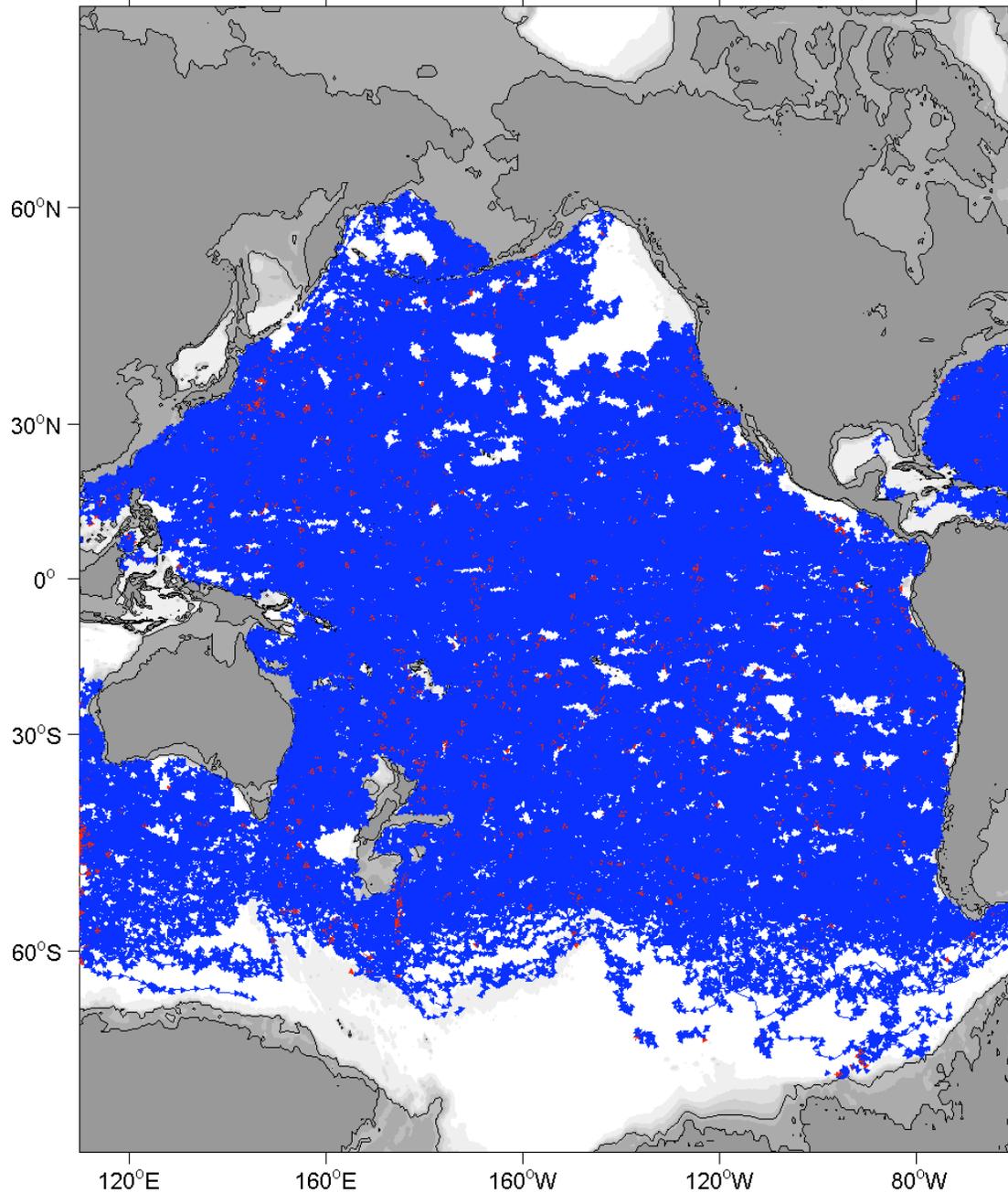
Present status of the
ANDRO atlas in the
Atlantic and for the
Layer [750, 1250[dbar

531 floats in ANDRO atlas (750 < P <= 1250 dbar) (35867 disp.)



Present status of the
ANDRO atlas in the
Indian ocean and for the
Layer [750, 1250[dbar

2017 floats in ANDRO atlas (750 < P <= 1250 dbar) (164740 disp.)



Present status of the
ANDRO atlas in the
Pacific and for the
Layer [750, 1250[dbar

Comparison between ANDRO and YoMaHa'09

Comparison between the contents of ANDRO and YoMaHa'09
over the same period, that is from July 11 1999 to December 28 2008
and the same floats

(PROVOR and APEX from Coriolis, SOLO and 55% of the APEX from AOML)

Note that it is the updated YoMaHa'09 version dated January 3 2009
which has been used in this comparison.

Pressure interval (dbar)	P < 750	750<P<1250	1250<P<1750	1750<P<2250	total
ANDRO	18895	202517	21226	7537	250175
YoMaHa'09	13777	209539	22772	7336	253426

What are the differences and why?

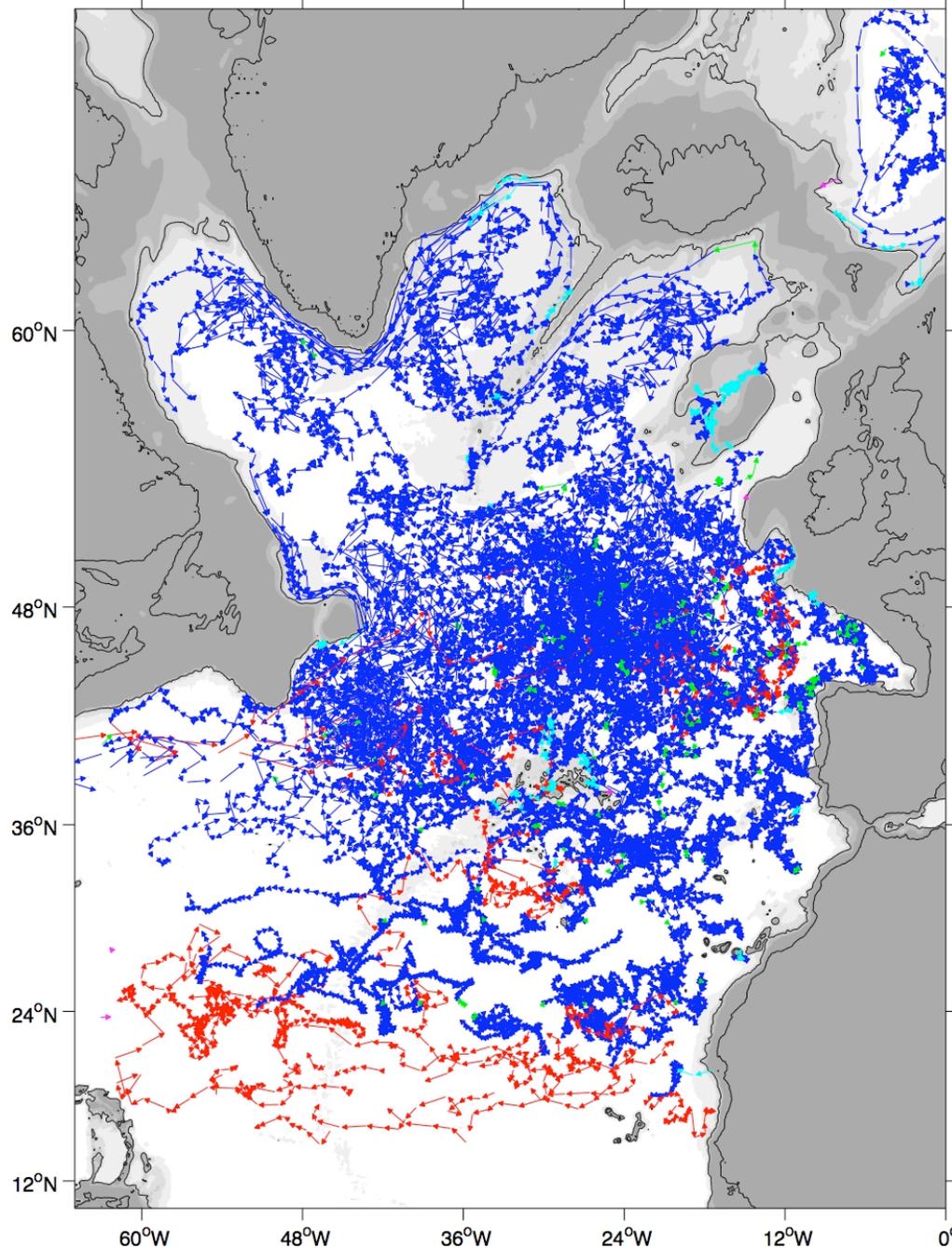
Between ANDRO and YoMaHa

The main difference between these two data sets is that **ANDRO** parking pressures are **measured** values (except for **29** floats).

Many floats have apparently grounded during part of their lives. **3260** corresponding cycles have been excluded in **ANDRO**.

A few floats have also transmitted bad pressure measurements, mainly because of ill functioning of their pressure transducer. For **2451** cycles where the temperature does not indicate clearly that the float is at the surface, we have defaulted the parking pressure in **ANDRO**.

Comparison ANDRO / YoMaHa'07 ($1250 < P \leq 1750$ dbar)



In blue common displacements

In magenta, YoMaHa'09
displacements found outside
the layer [1250, 1750] dbar

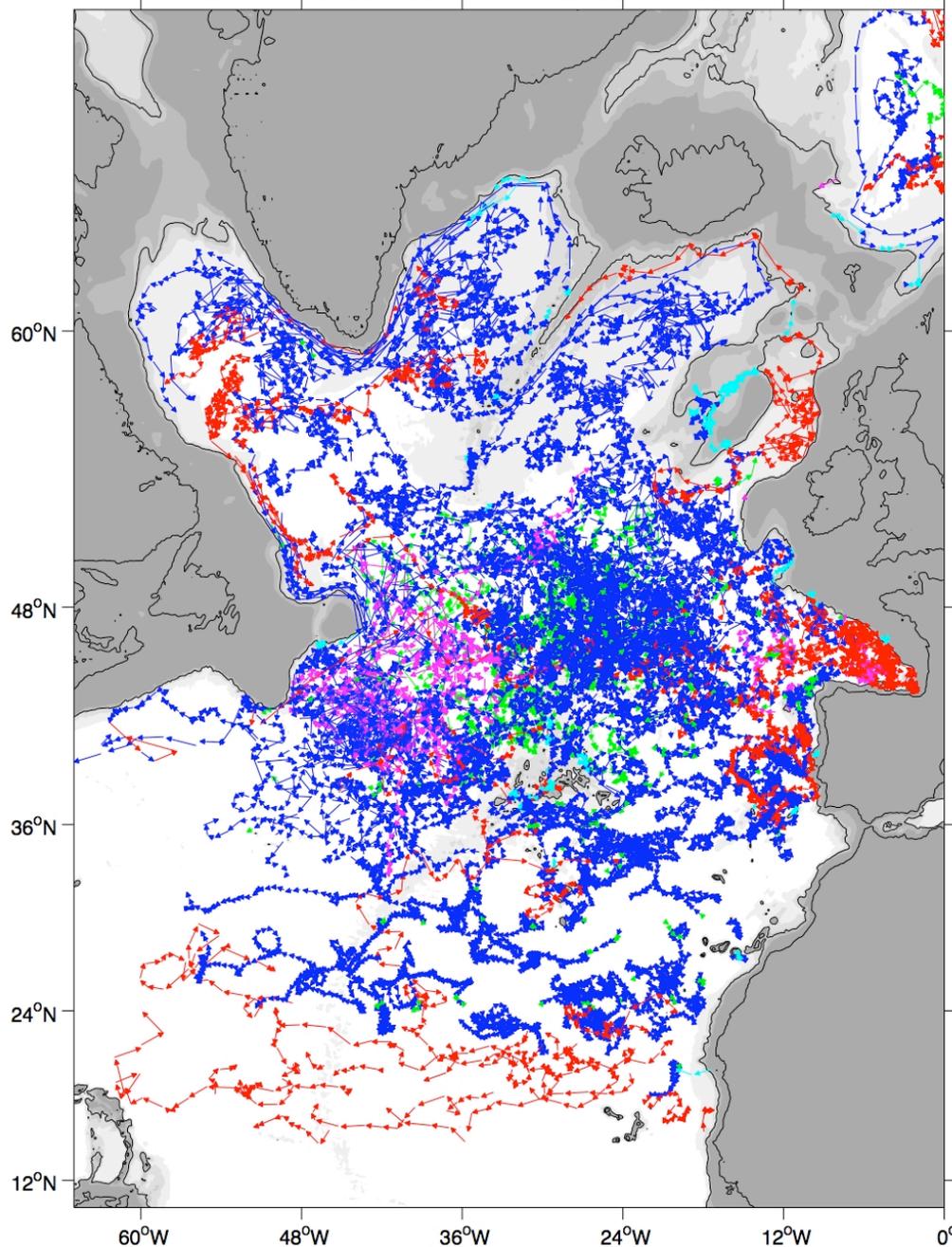
In green ANDRO added
displacements

In red, YoMaHa'09
displacements found in this
layer, erroneously

In cyan, YoMaHa'07
displacements not in ANDRO

Here it is the updated
2009 version of the
YoMaHa atlas which is
compared

Comparaison ANDRO/YoMaHa (1250 < P <= 1750 dbar)



In blue common displacements

In magenta, YoMaHa'07 displacements found outside the layer [1250, 1750] dbar

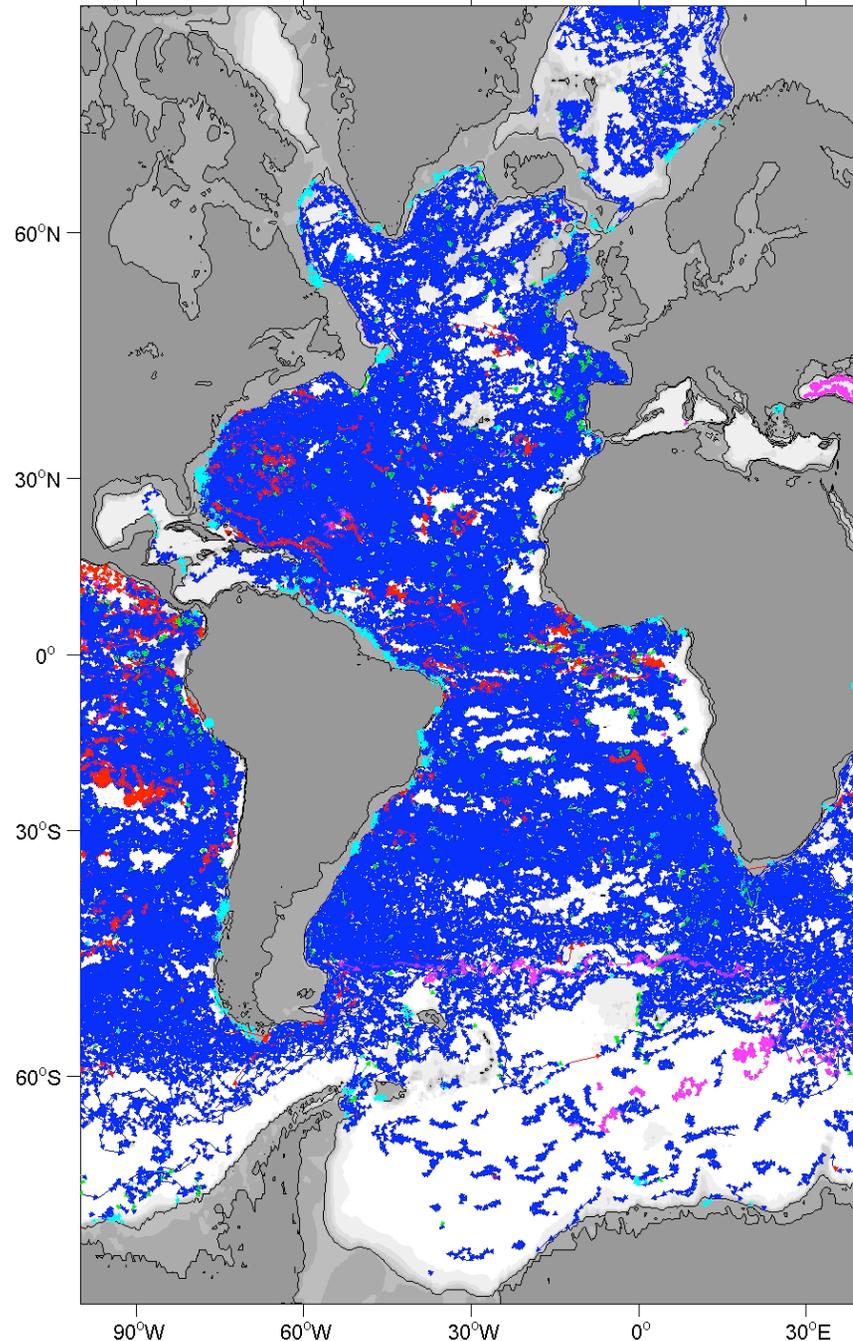
In green ANDRO added displacements

In red, YoMaHa'07 displacements found in this layer, erroneously

In cian, YoMaHa'07 displacements not in ANDRO

Here it is the original 2007 version of the YoMaHa atlas which is compared

Comparison ANDRO / YoMaHa'07 (750 < P <= 1250 dbar)



In blue common displacements

In magenta, YoMaHa'07 displacements found outside the layer [750, 1250] dbar

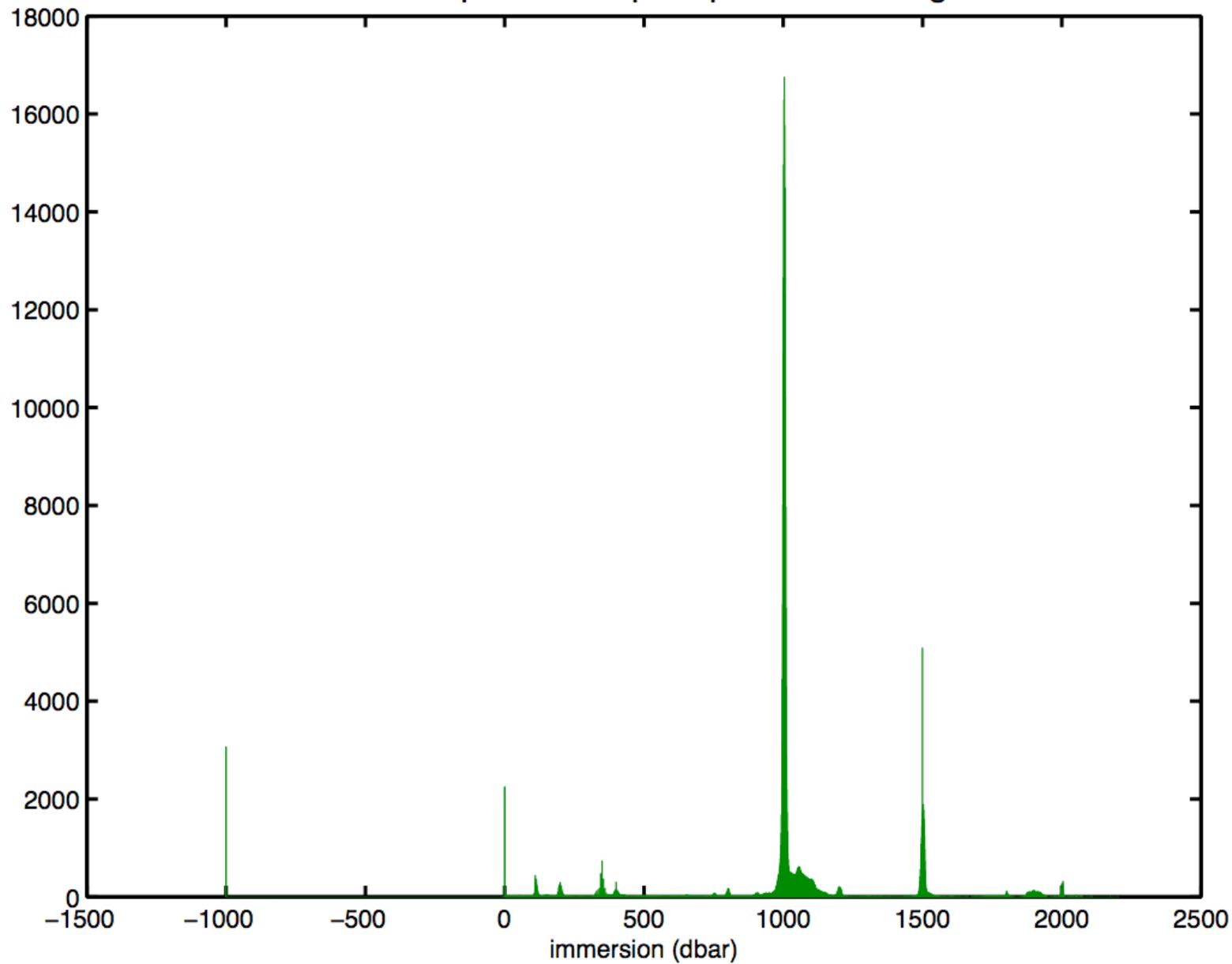
In green ANDRO added displacements

In red, YoMaHa'07 displacements found in this layer, erroneously

In cyan, YoMaHa'07 displacements not in ANDRO

Pressure distribution in ANDRO

ANDRO displacement park pressure histogram



CONCLUSION and FUTURE

- Generally, instruments (PROVOR, APEX and SOLO) give very good data as far as subsurface displacements are concerned.
- A better version of ANDRO is possible with estimates of actual diving and surfacing positions: this needs to get the surfacing and diving times and then to extrapolate the corresponding positions from the actual Argos locations (for example using a least square fit of a uniform velocity and a circular inertial motion, see Park et al., 2004).
- **Argo** subsurface displacements are an unprecedented data base of **direct** and **absolute** measurements of the ocean circulation (but one needs their **exact** drifting depths).
- Deep (depth greater than 2000 m) and bottom water displacements remain **unknown**
- **ANDRO** extended worldwide, i. e. to all the **Argo** DACs, should be completed by the end of 2010 (with data until January 1 2009).

Thank you

We acknowledge the continual
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this project