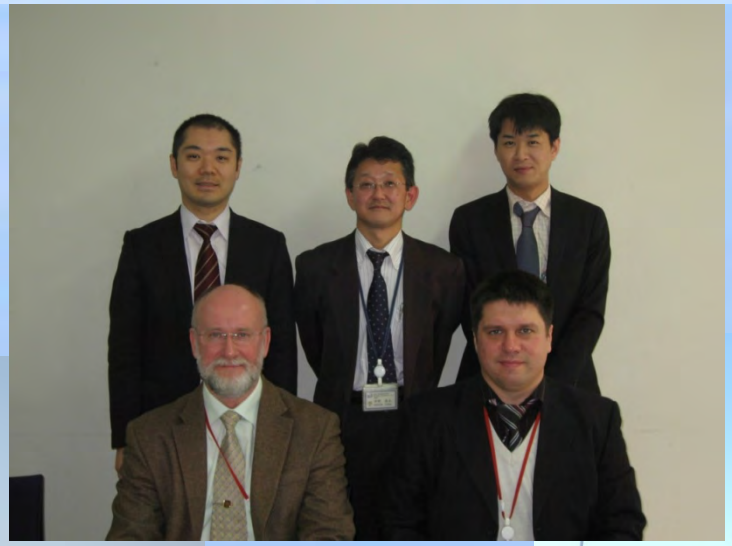
Procedures for correcting *in situ* CTD data and results obtained during the NEAR-GOOS Cross-Basin Climate Monitoring Section project



Dmitry Kaplunenko[1], Aleksander Lazaryuk[1, 2], Vyacheslav Lobanov[1], Sergey Sagalaev[1], Sho Hibino[3] and Toshiya Nakano[3]

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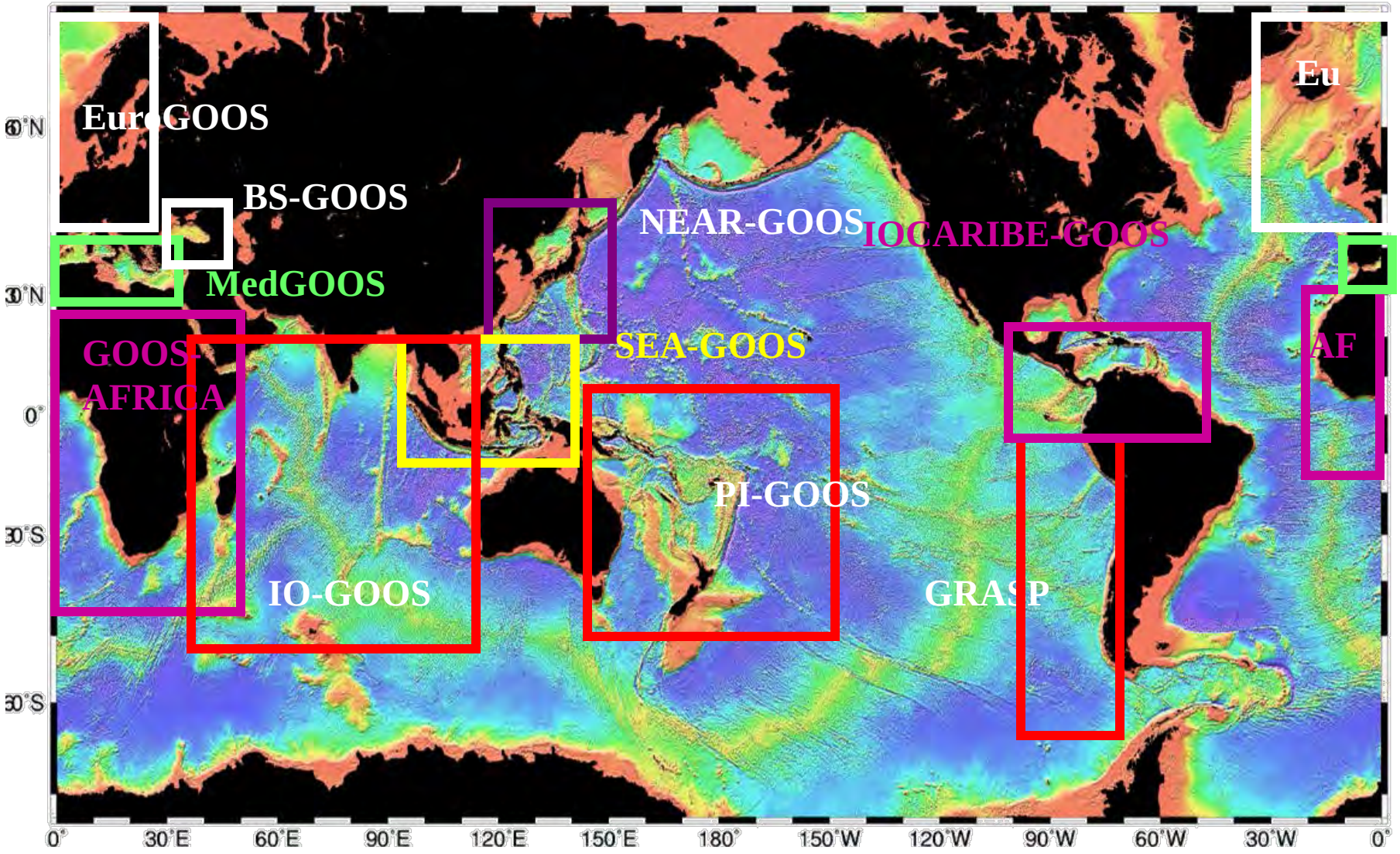
[3]Japan Meteorological Agency (JMA), Japan

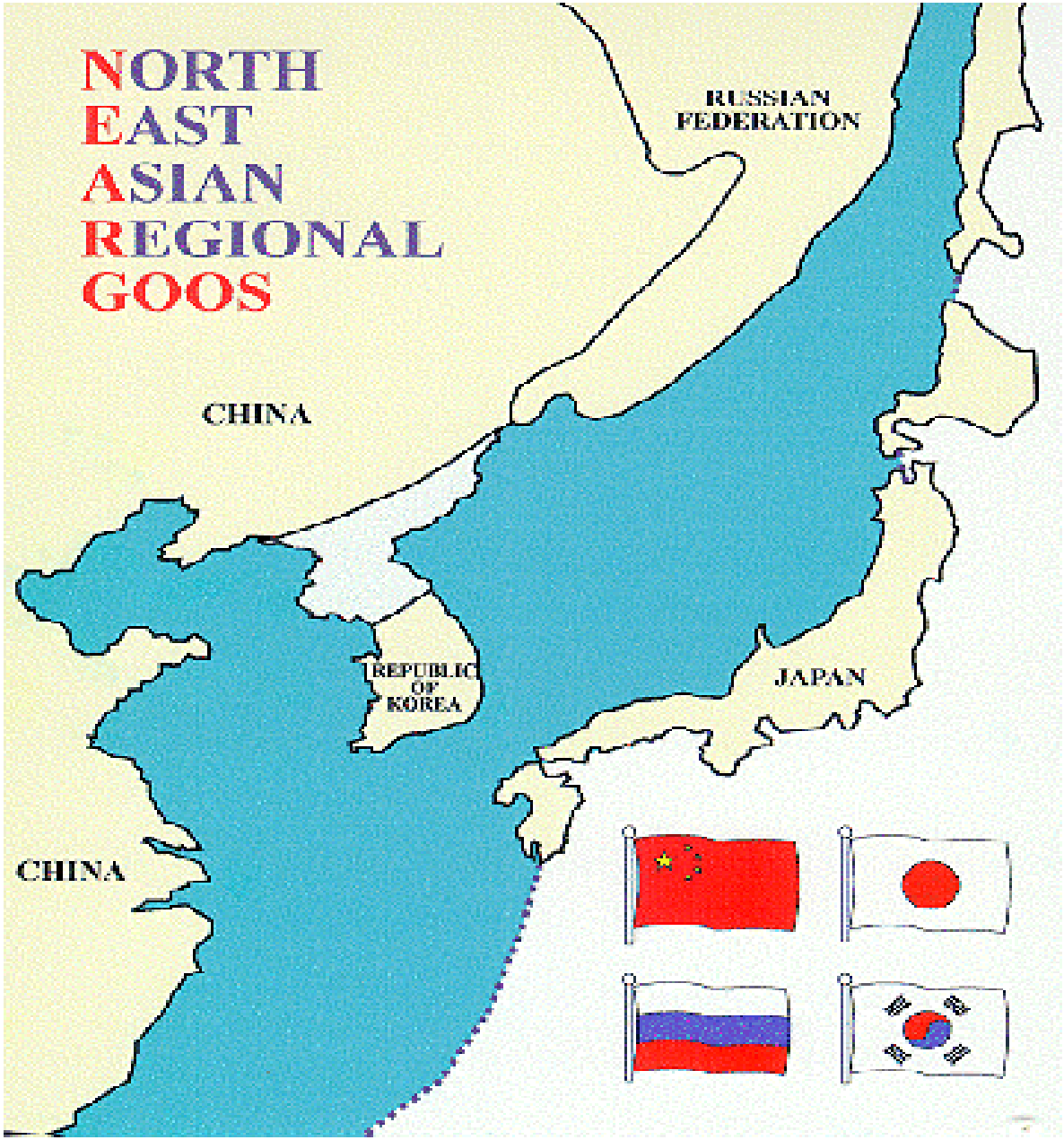
e-mail: dimkap@poi.dvo.ru

Contents

- NEAR-GOOS features
- Cross-Basin Climate Monitoring Section
- Precision of used sensors and data processing features
- JMA-POI data comparison
- Calibration results
- A hints on applying of calibrated data
- Conclusions

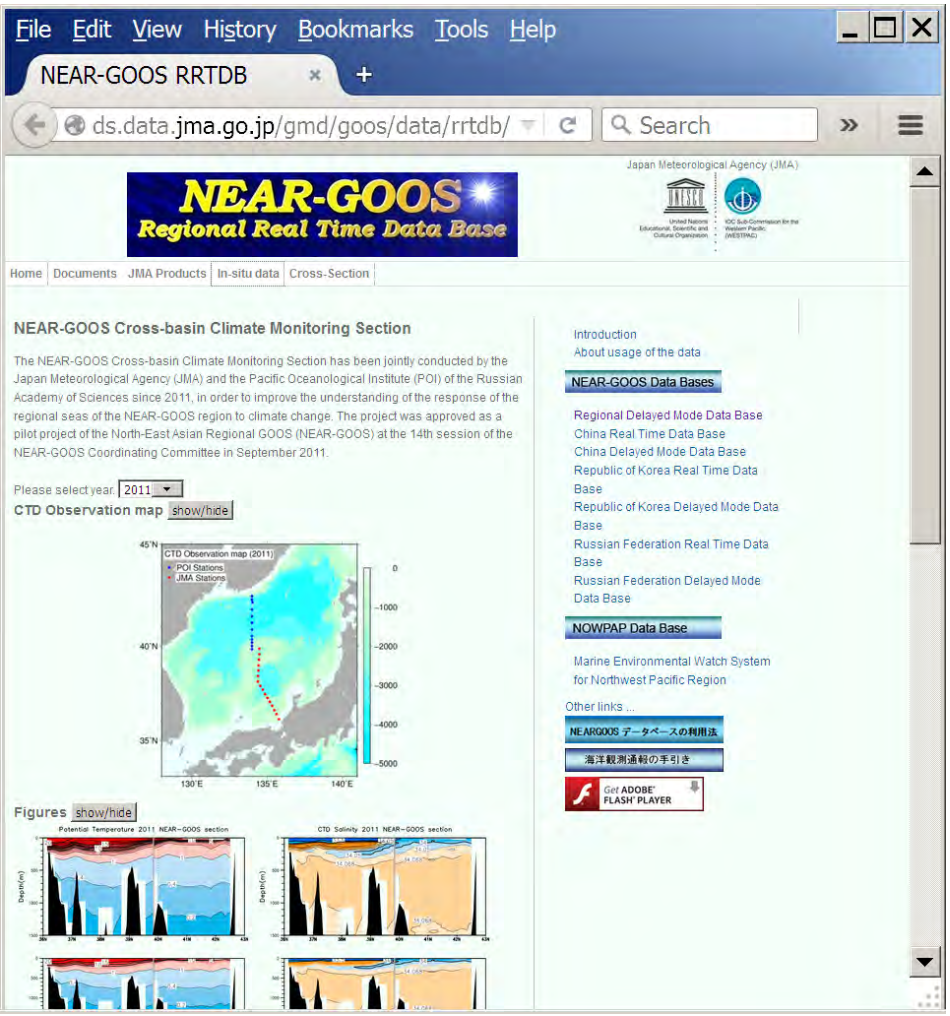
GOOS Regions




NORTH
EAST
ASIAN
REGIONAL
GOOS
RUSSIAN FEDERATION
CHINA
REPUBLIC OF KOREA
JAPAN
CHINA

NEAR-GOOS Pilot Project: Cross-Basin Climate Monitoring Section

http://ds.data.jma.go.jp/gmd/goos/data/rrtdb/cross-section/cross-section.html



Objectives for project:

- JES is semi-enclosed basin with the stable hydrographic structure e.g. cool deep water with the salinity and oxygene anomalies within the intermediate waters;
-The monitoring of these parameters gives a key for understanding of global warming the World Ocean;
- The main idea is to compare the temperature, salinity and oxygene observations made within the close locations which allow to suggest about data quality and compatibility of measurements made independently by the JMA and POI;

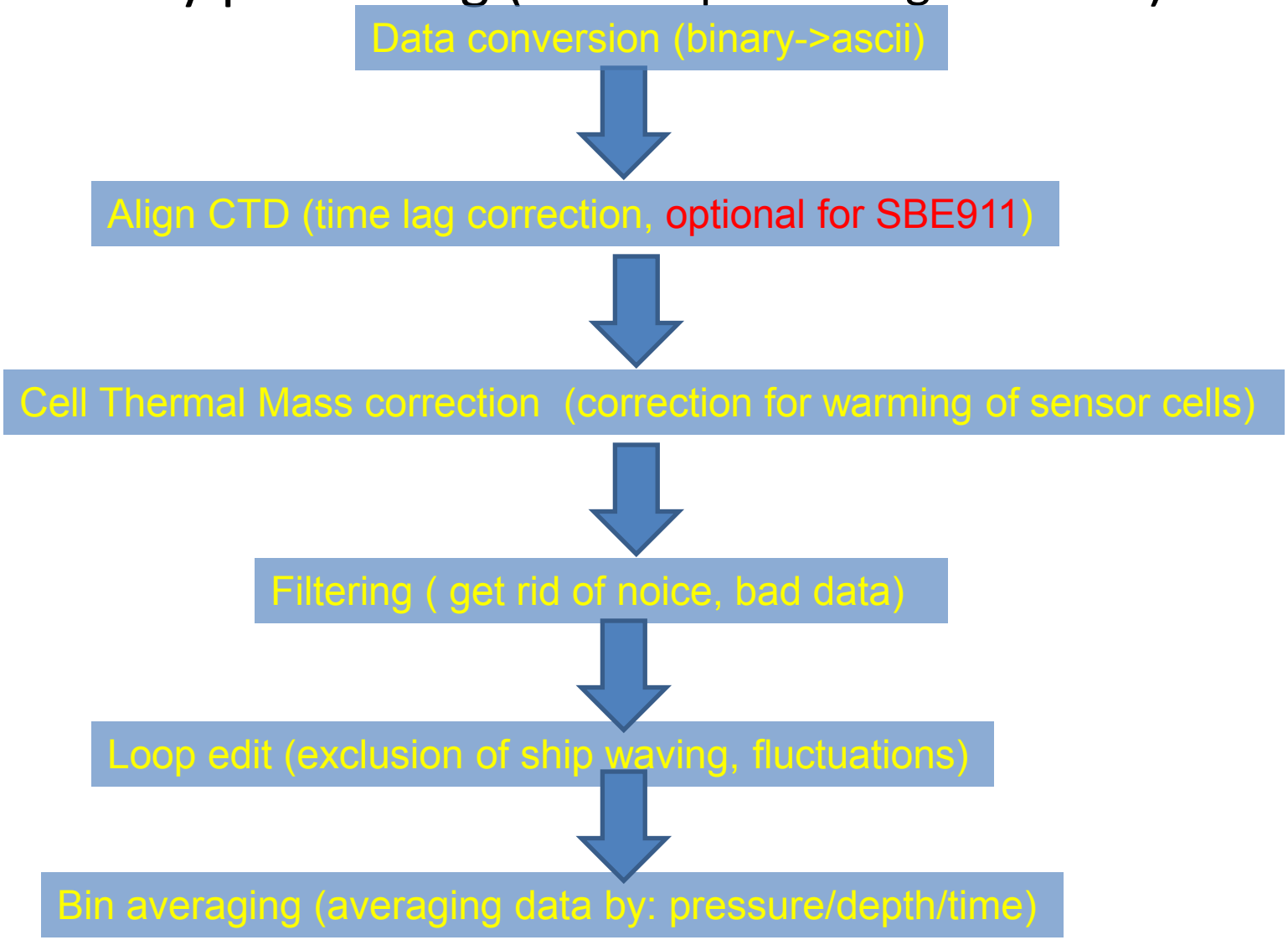
Accuracy of SBE sensors

	SBE-35	Temp. SBE-3+	Cond. SBE 4C	O_2 (SBE-43)	O_2 (RINKO-III)
Depth measure	to 6800 m	to 7000 m	to 7000 m	to 7000 m	To 7000
Initial accuracy	± **0.001** °C	0.001 °C	0.0003 S/m (0.001 psu)	2% saturation	±2%
Stability	0.001 °C per year	0.0002 °C/month	0.0003 S/m/mon. (0.001 psu/mon.)	0.5% per 1000 hours	±5% (1 month)
Range:	-5 to +35 °C	-5 to 35 °C	0 to 7 S/m	Until 120% surf. sat.	0-200%

• During the study of East Sea deep waters structure within long time it necessary to pay attention on basic characteristics of used sensors for CTD-unit.

SBEDataProcessing : simple case

- Preliminary processing (SBEdataprocessing software.)

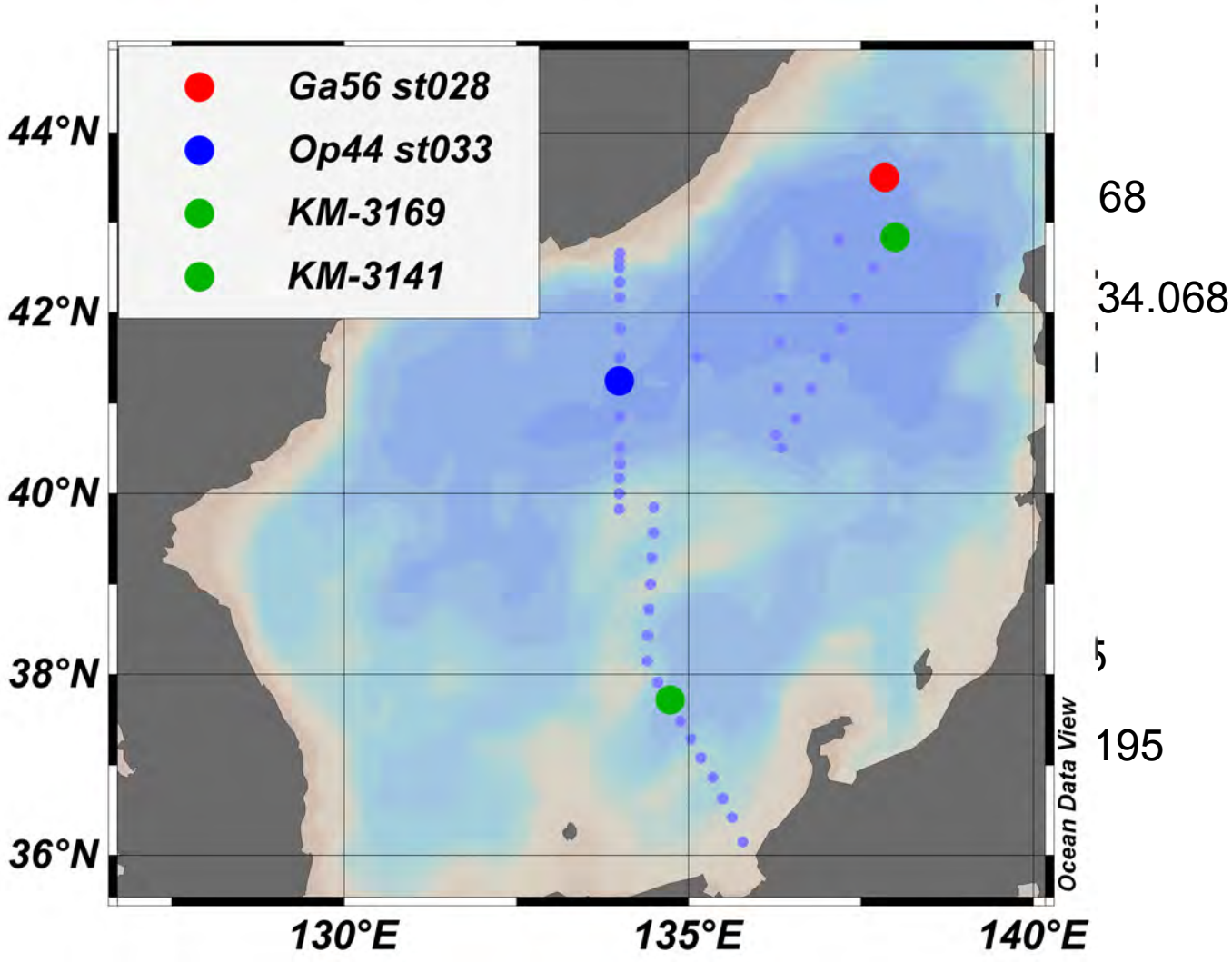


Data error assessment by NEAR-GOOS data

- Talley at al. 2004
- Cruise La58 R/V Akademik M.A. Lavrentyev", Ga56 R/V "Professor Gagarinsky", Op44 R/V "Akademik Oparin"
- R/V "Keifu Maru"
- Ga56 St028 – 19/Jun/12
- Op44 St033 – 24/Oct/12
- KM-3141 – 30/Oct/12
- KM-3169 – 4/Nov/12

Talley:

La58-s

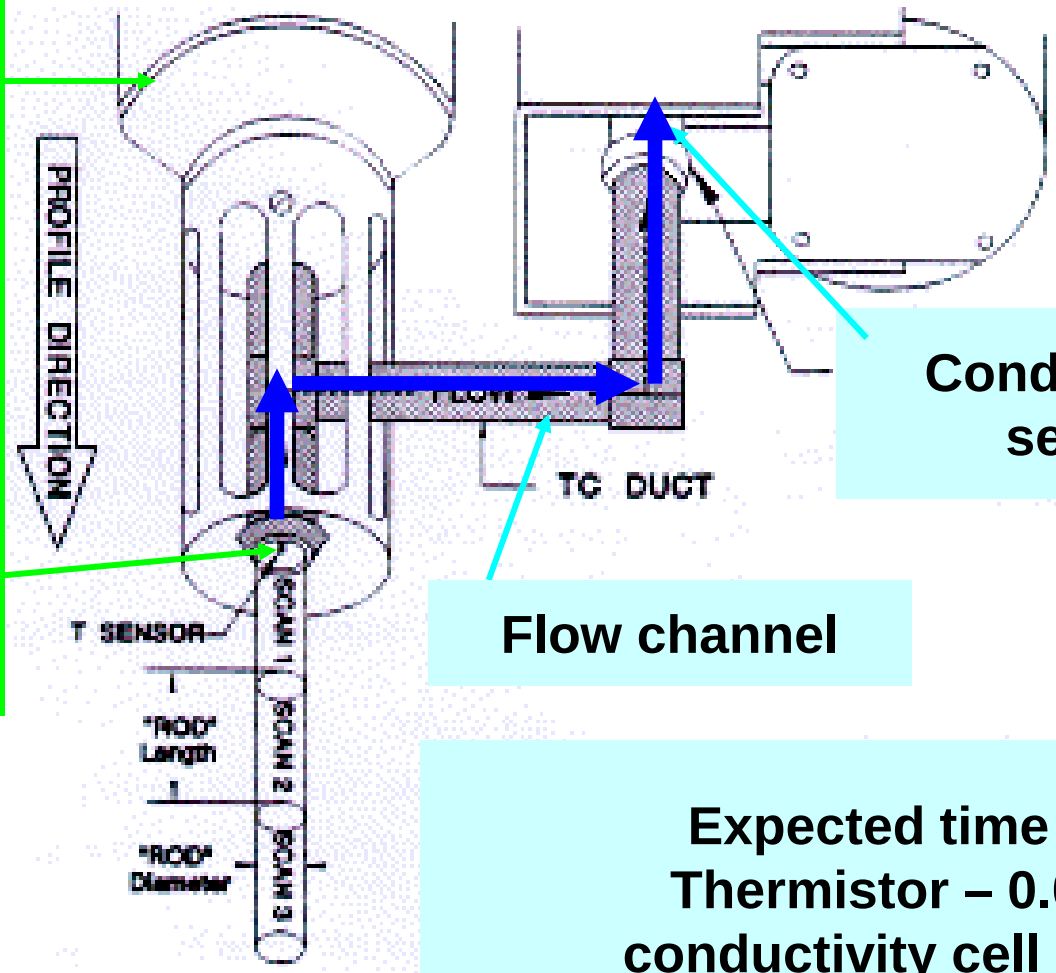


La58-st98 (raw): 196
(calibrated
1000m-bottom): 210

Temperature and conductivity sensors in SBE

Temperature Sensor

Thermistor



Conductivity sensor

Flow channel

Expected time lag for
Thermistor – 0.07 sec
conductivity cell – 0.06 sec
With a pump perfomanse 30 sm^3/sec
or 1 m/sec^2

Additional calibration of SBE

GO-SHIP Repeat Hydrography Manual: A Collection of Expert Reports and Guidelines

IOCCP Report No. 14

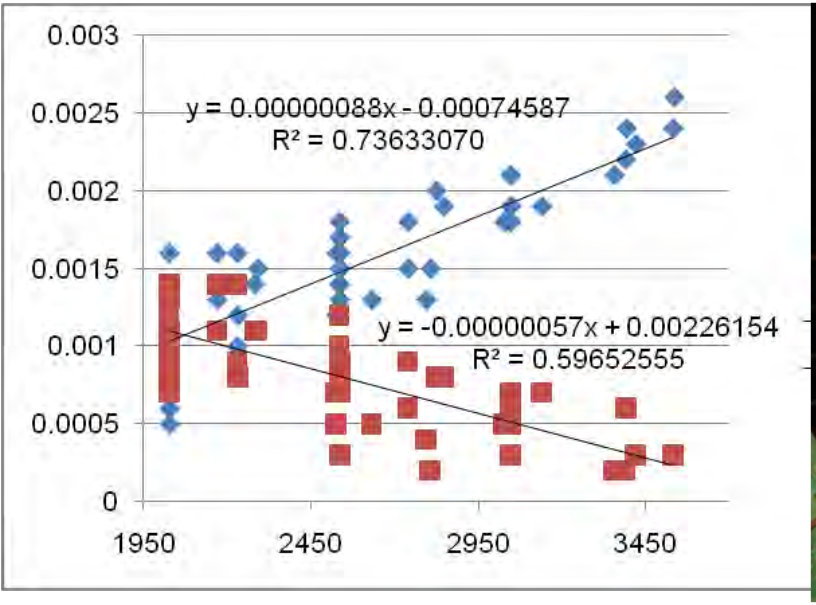
ICPO Publication Series No. 134

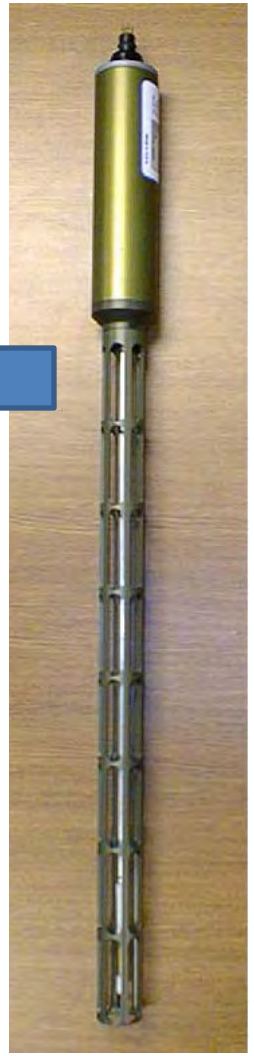
Version 1, 2010

Temperature measurements

La66-2014

[WHP-P9(2010) cruise report. JMA]





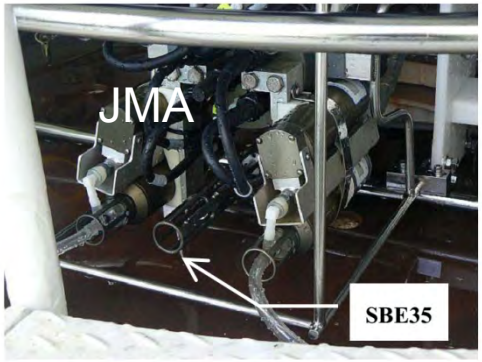
SBE35

Each SBE-sensor is individual. Its deformation can be corrected at depths more than 2000 m by the calibration using SBE-35 (platinum thermometer).

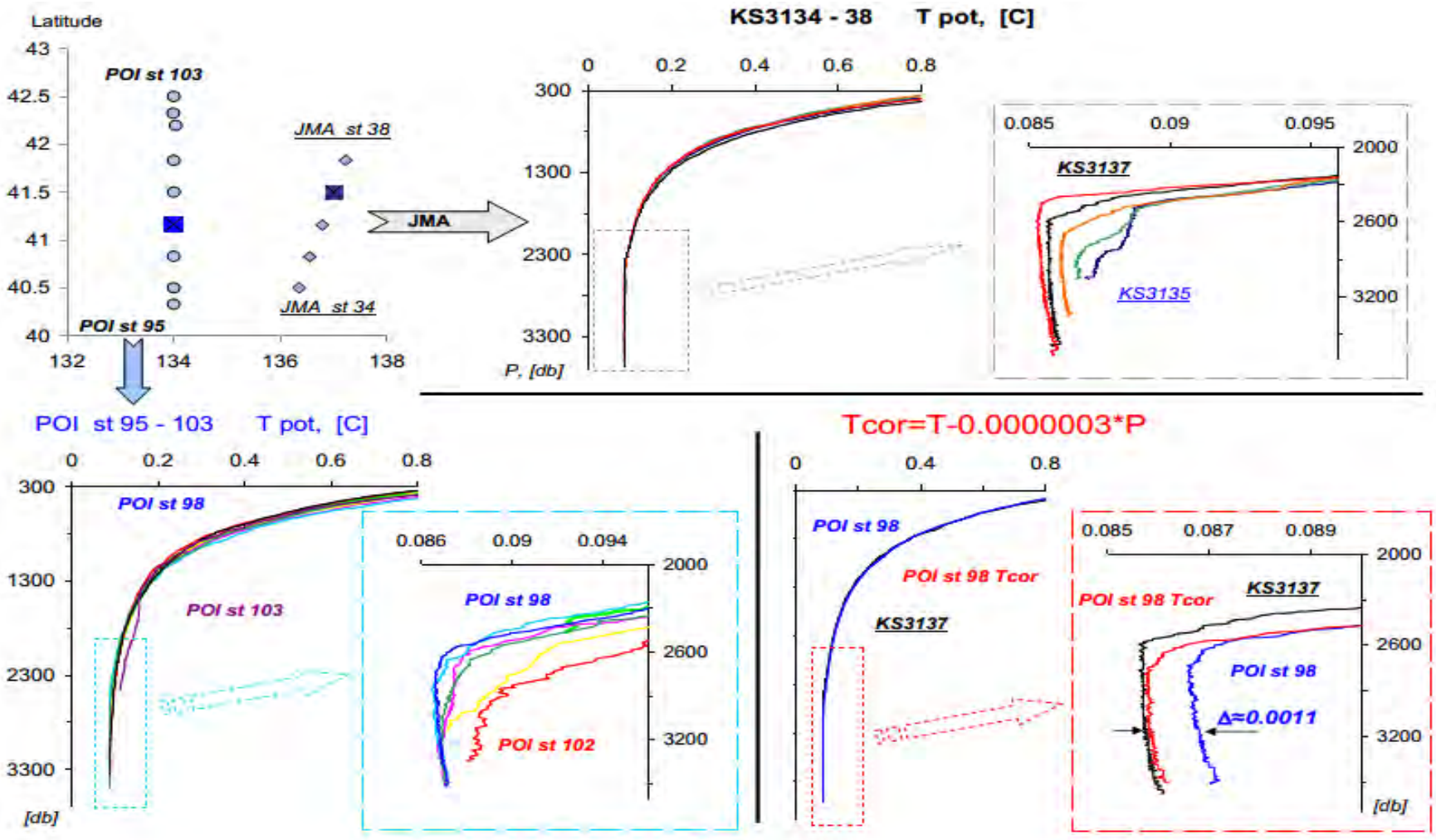
Usual calibration formula for this case:

$$T_{cal} = T_{raw} - (C_0 + C_1 \times P)$$

- We used second sensors set (POI) for analysis due to the problem with the 1st one



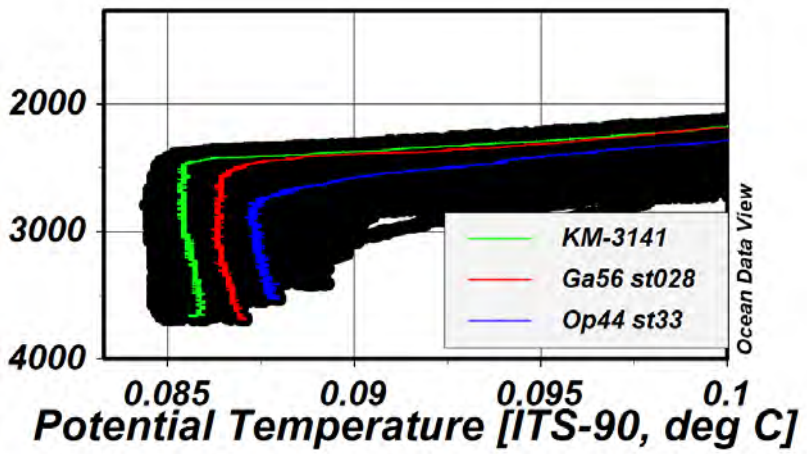
Temperature Correction: without SBE35



Calibration based on PM-Line section, the data from R/V “Keifu Maru” have been Compared with La-58 data (close locations), the SBE35 was not installed

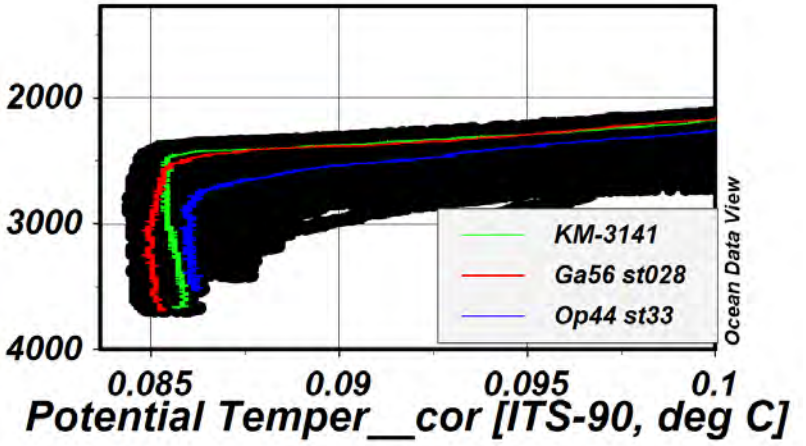
Temperature correction: with SBE35

unCalibrated Theta



Ga56 and Op44 data before correction
KM3141 – corrected data for reference

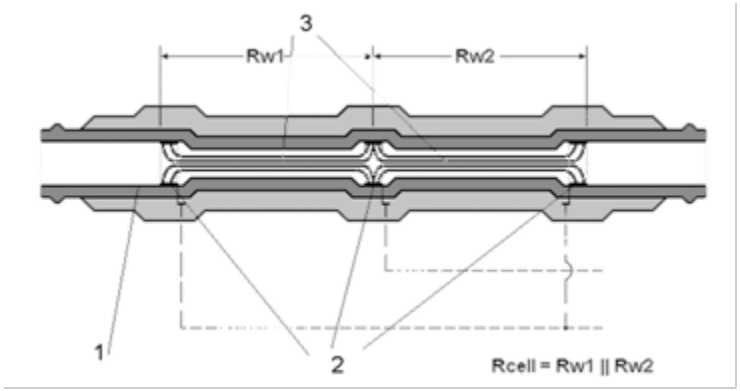
Calibrated Theta



Ga56 and Op44 data after correction
KM3141 – corrected data for reference

- Correction of temperature on sensitivity to pressure may cause change of T value on +- 0.003 C which may be important during the study of climatic changes

Salinity correction



SBE 4C – conductivity sensor

- to obtain high accuracy it is not enough a standard SBE-processing procedures
- it is necessary to consider pressure effect for SBE conductivity sensor by calibration with data from sampling bottles (together with SBE 35 measurements)

- Correction may be defined using the following formula:

$$C_{cal} = C - \left(\sum_{i=0}^{I} c_i \times C^i + \sum_{j=1}^{J} p_j \times P^j \right), \quad I = J = 2$$

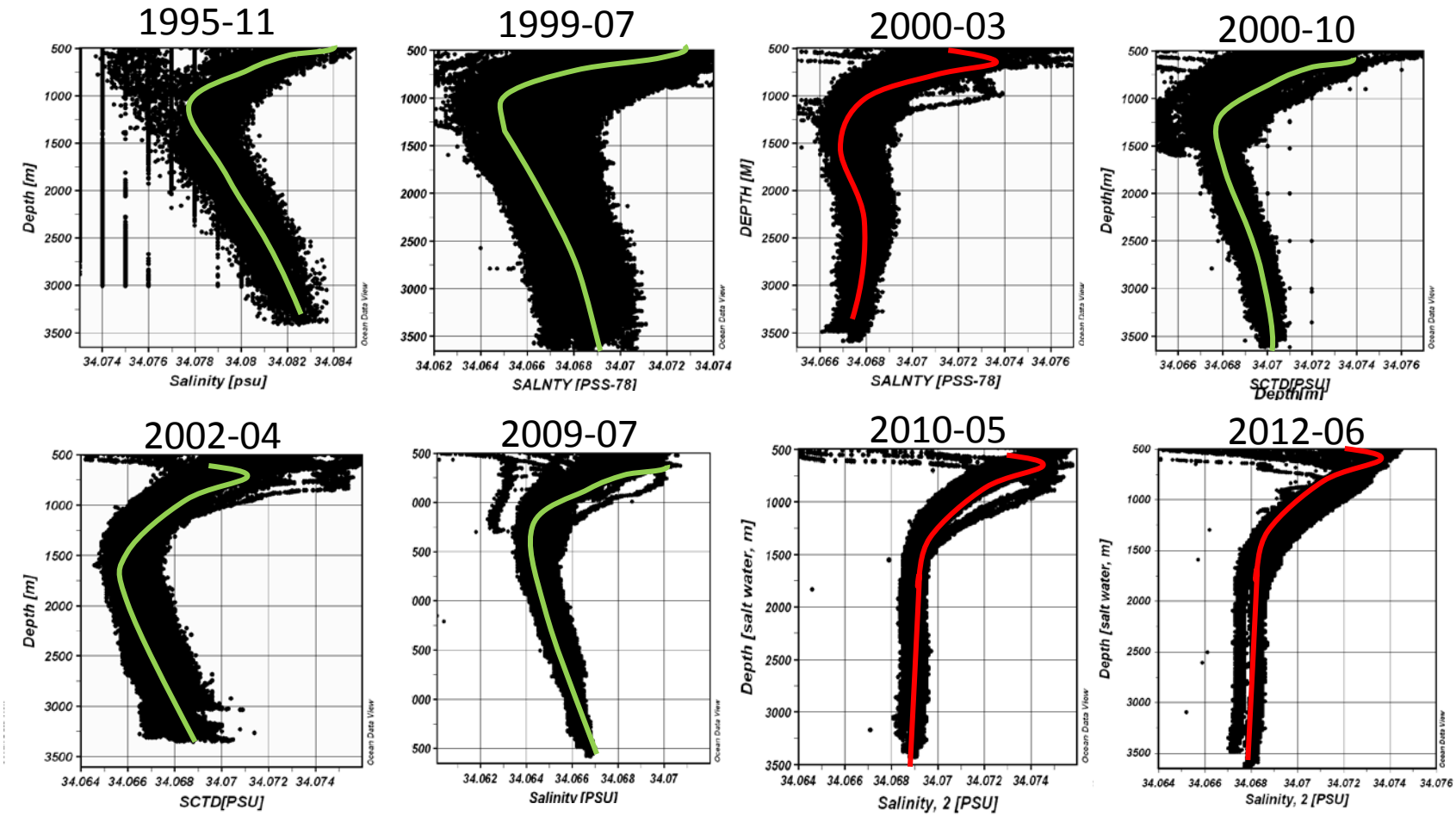
The GO-SHIP Repeat Hydrography Manual: A Collection of Expert Reports and Guidelines

IOCCP Report No. 14, ICPO Publication Series No. 134, Version 1, 2010

NOTES ON CTD/O2 DATA ACQUISITION AND PROCESSING USING SEA-BIRD HARDWARE AND SOFTWARE (AS AVAILABLE)

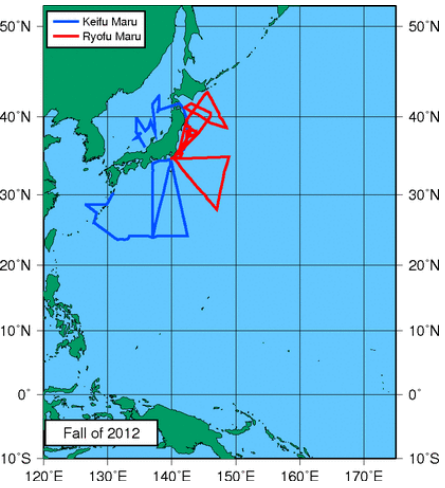
K.E. McTaggart, G.C. Johnson, M.C. Johnson, F.M. Delahoyde, and J.H. Swift

Mysterious Deep Salinity Minimum



- Due to polynomial equation of second order sometimes slope and curl is not correctly obtained for intermediate and deep waters of JES

Salinity correction



JMA data of cruises of R/V “Keifu Maru” (blue line on map):

http://www.data.kishou.go.jp/kaiyou/db/vessel_obs/data-report/html/ship/ship_e.php

- During the cruise the Laboratory Salinometer was available onboard, which allowed one to make a calibration;

Laboratory Salinometer
Autosal 8400B

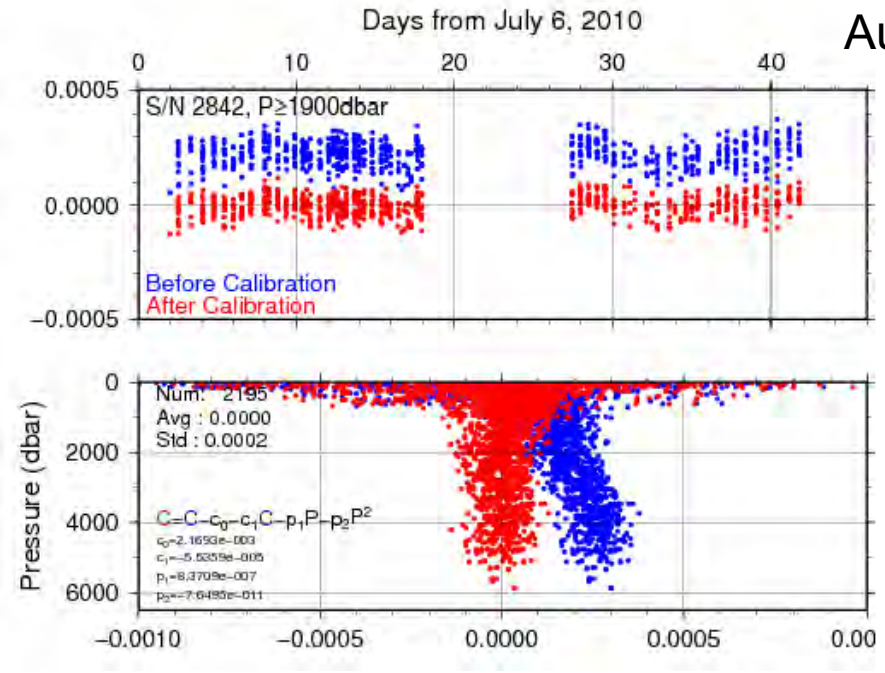


Table C.1.2. Conductivity Calibration Coefficient Summary.

S/N	Num	c_0(mS/m)	c_1	c_2(mS/m)	Stations
			p_1(mS/dbar)	p_2(mS/m/dbar^2)	
3670	1274	1.5107e–3	–7.4144e–5	0.0000e–0	Stn. 1 – 67
			6.6856e–7	–8.3866e–11	
3670	308	2.2680e-3	–8.0696e–5	0.0000e · 0	Stn. 68 – 83,
			–1.2437e–8	0.5038e–11	Stn. 105 – 107
3670	608	1.0048e-3	–7.6991e–5	0.0000e–0	Stn. 84 – 104,
			3.9031e–7	–4.2466e–11	Stn. 108 – 124
2849	2195	2.1693e-3	–5.5359e–5	0.0000e–0	Stn. 1 124
			8.3709e 7	7.6495e 11	

Salinity correction

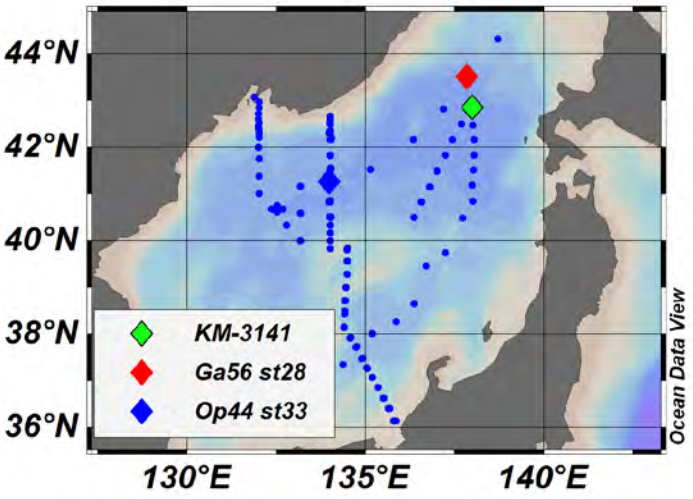
Ga56 and Op44 data before correction

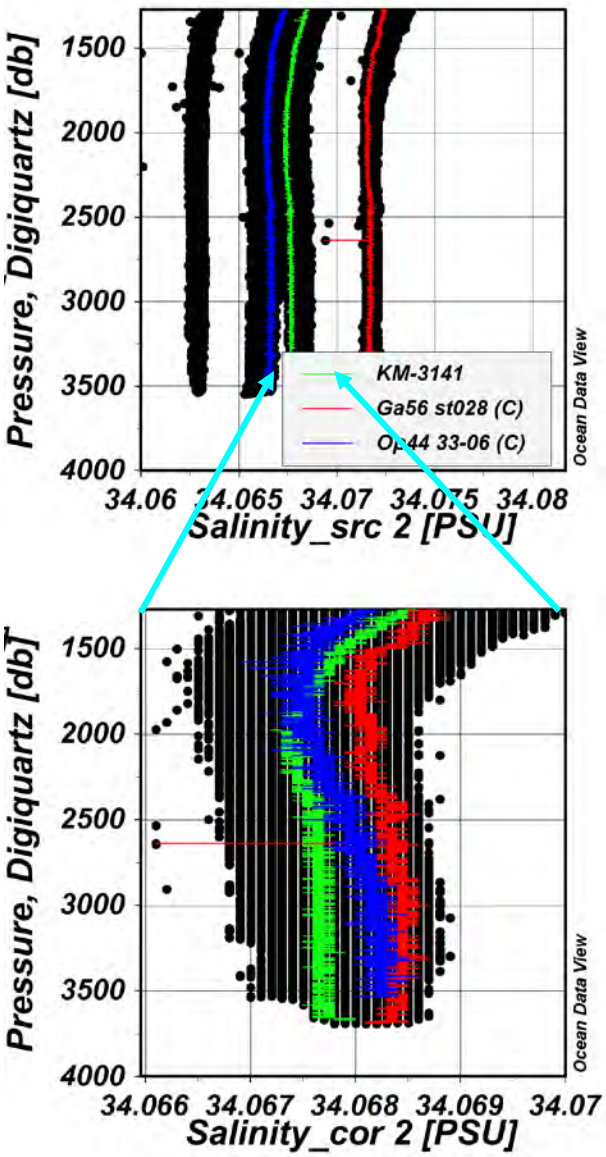
KM3141 – corrected data for reference

Ga56 and Op44 data after correction

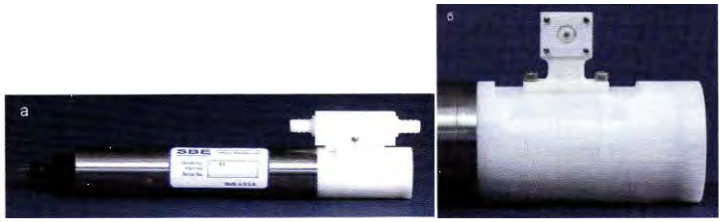
KM3141 – corrected data for reference

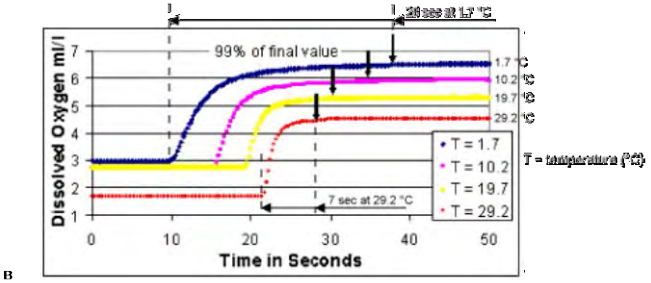
Temporal drift of conductivity sensor is shown for 127 calendar (36 operated) days





Dissolved Oxygen Measurements





SBE 43 – O_2 sensor
with polarographic membrane

Ref: Gordon, Garcia

Ref: Uchida et al.

Rinko III – O_2 sensor
with optical sensor

$$O_2 = S_{oc} \cdot \left(V + V_{off} + \tau_{20} \cdot e^{(D_1 \cdot p + D_2 \cdot (T-20))} \cdot dV/dt\right)$$
$$\cdot O_{sat} \cdot (1 + A \cdot T + B \cdot T^2 + C \cdot T^3) \cdot e^{[(E \cdot p)/(273.15+T)]}$$

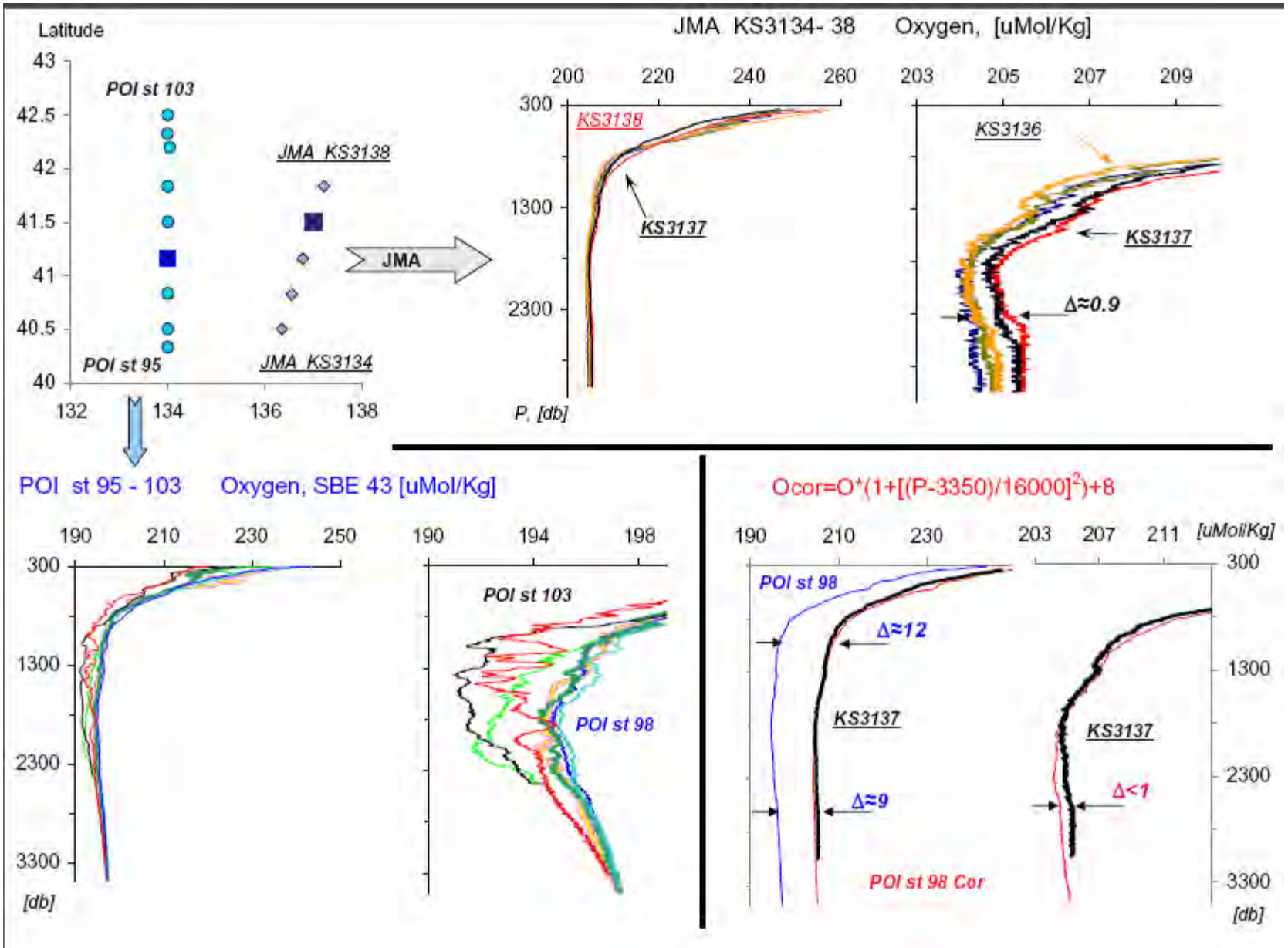
$$P_0 = 1.0 + c_4 \times t$$
$$P_c = c_5 + c_6 \times v + c_7 \times T + c_8 \times T \times v$$
$$K_{sv} = c_1 + c_2 \times t + c_3 \times t^2$$
$$coef = (1.0 + c_9 \times P/1000)^{1/3}$$
$$[O_2] = \{(P_0/P_c - 1.0)/K_{sv} \times coef\}$$

Owens, W. B., and R. C. Millard Jr., 1985: A new algorithm for CTD oxygen calibration. J. Physical Oceanography., 15, 621-631.

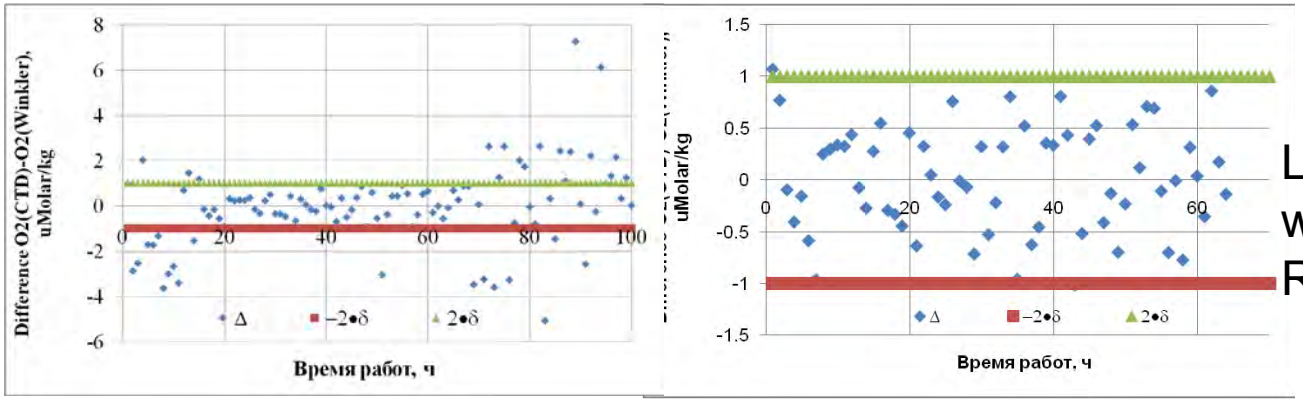
Garcia and Gordon (1992) "Oxygen solubility in seawater: Better fitting equations", Limnology & Oceanography, vol 37(6), p1307-1312.

Uchida, H., T. Kawano, I. Kaneko, and M. Fukasawa (2008): In –situ calibration of optode-based oxygen sensors. J. Atmos. Oceanic Technol., 25, 2271-2281.

DO correction: no samples

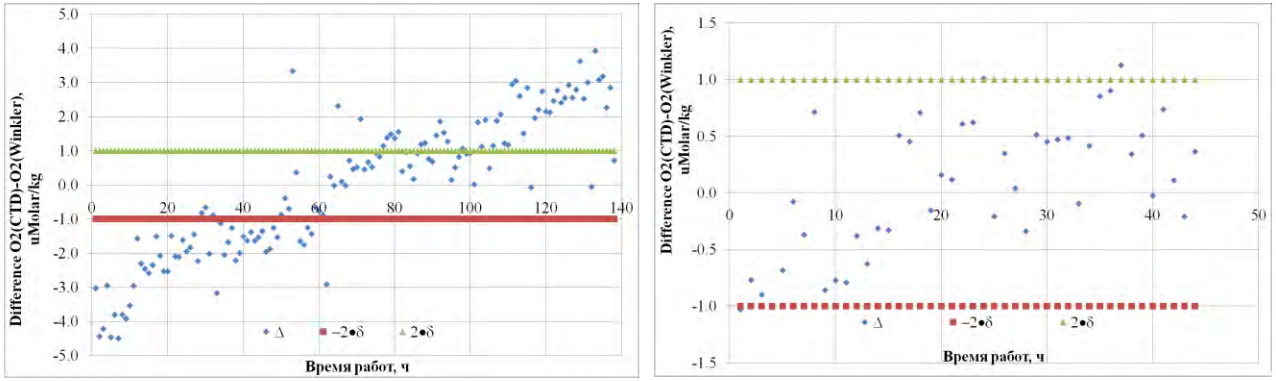


Optical (Rinko)/ Membrane (SBE43) correction



(a) (b)

La 64 – steps of choice with 2sigma criteria for RINKO III

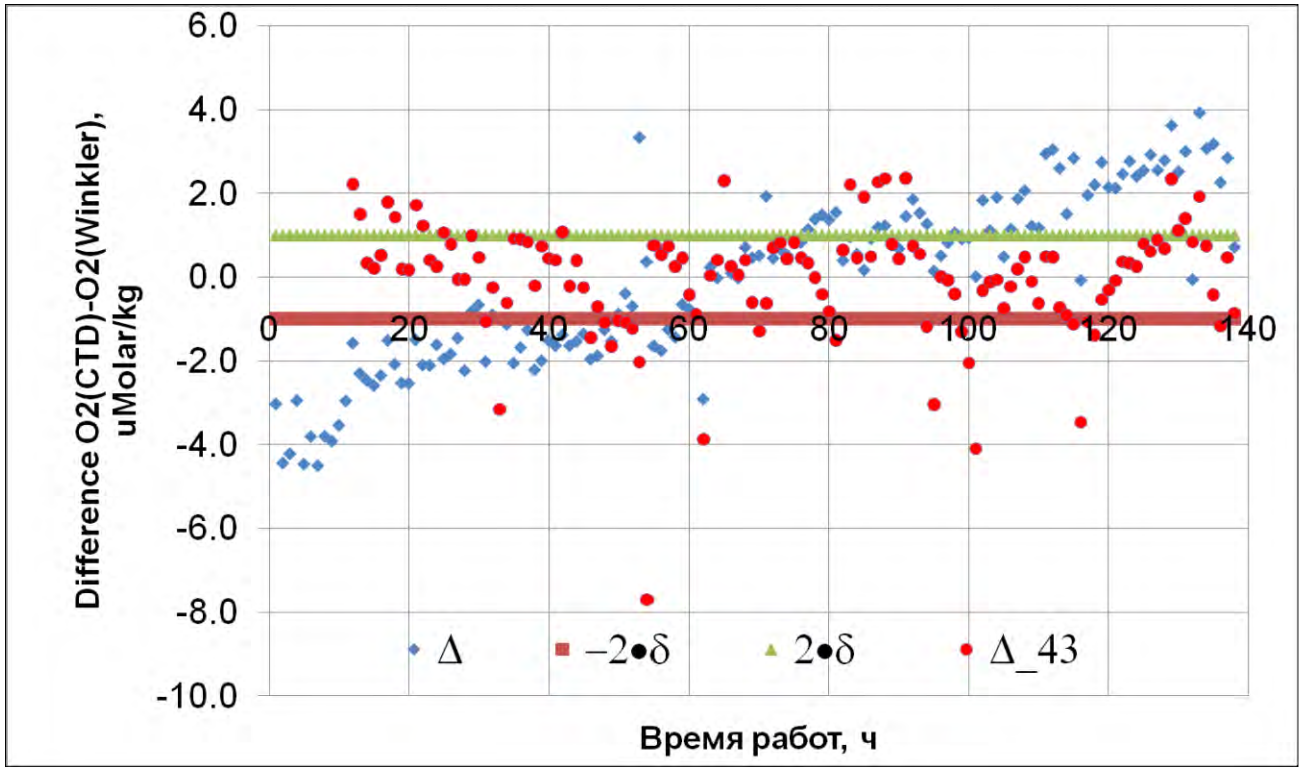


(a) (b)

La 66 – steps of choice with 2sigma criteria for RINKO III

The analysis showed different behavior of sensor during two different cruises

Optical (Rinko)/ Membrane (SBE43) correction

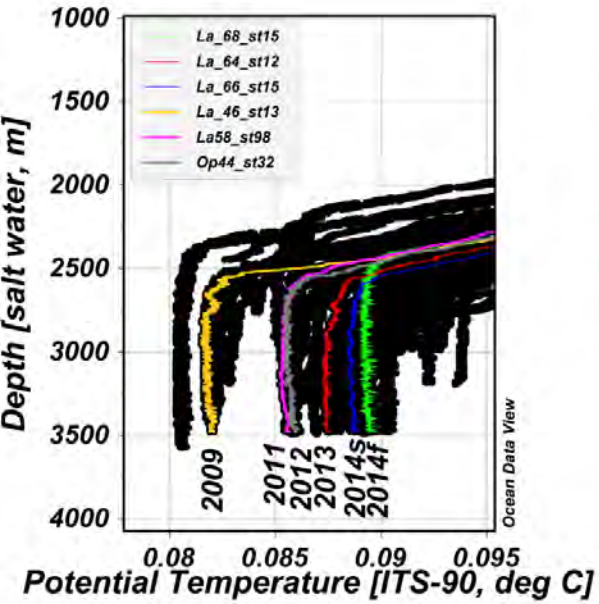


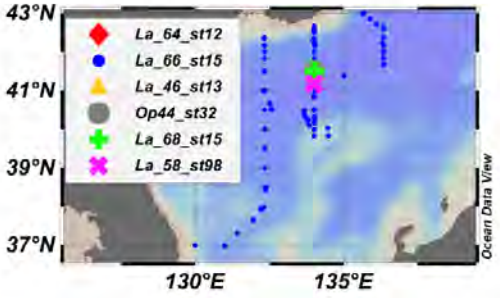
Comparatively with the SBE43 RinkoIII has a temporal drift which is not similar for different cruises

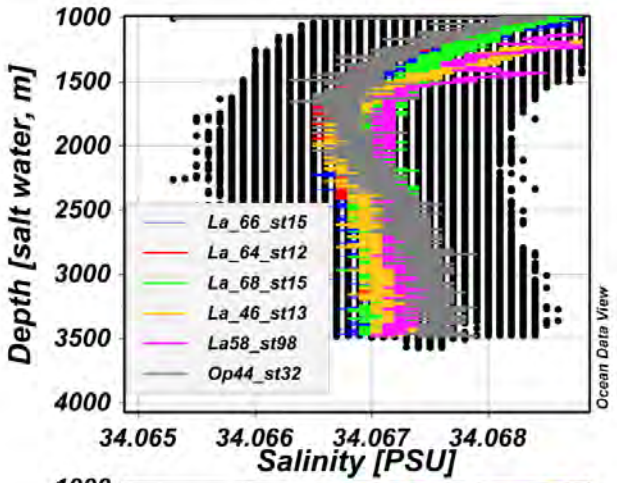
This cause us to use only 30% of obtained data for calibration in the La66 cruise

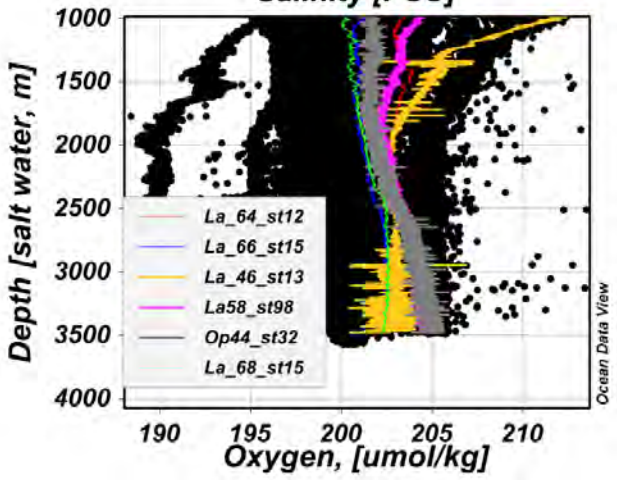
According with this the RinkoIII sensors needs to be inspected and controlled during the further cruises

Calibrated data comparison (2009-2014)









Finally were defined:
-Temperature corrected in the same manner for the last 5 years essentially increases;
- The temperature growth is not regular from year to year;
- The salinity minimum is stable within the frames of instrument sensitivity;
- The oxygen in the deep layer has some variations and now is lower than 3 years before, but rather oscillate than increases;

Conclusions

1. To identify interannual and spatial variations of deep and bottom water parameters in the JES an accuracy of +- 0.001 is required for temperature and salinity.
2. T, S and dissolved oxygen intercalibration and correction of data is important.
3. Calibration of SBE43 and RINKO-III DO-sensors is available by samples analysis (Winkler chemical method) and by comparison of POI and JMA data.
4. Optical sensor (RINKO-III) sensor has some peculiarities which need to take into account during the oxygen calibration.
5. Continuation of NEAR-GOOS Cross-Basin Section will provide reliable data on deep and bottom water response of the sea to climate changes.


謝謝!
Thank you for your attention!
СПАСИБО!