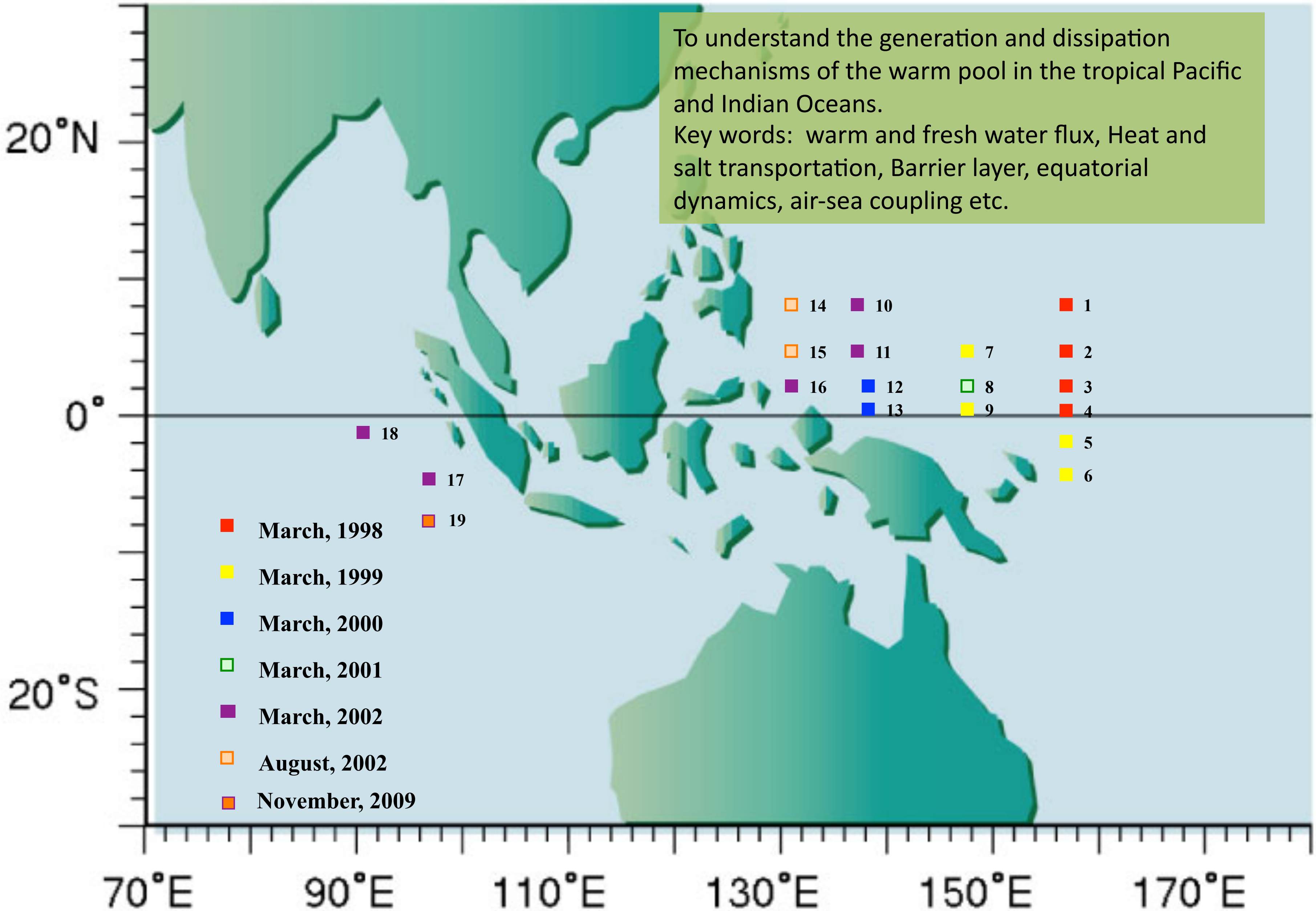
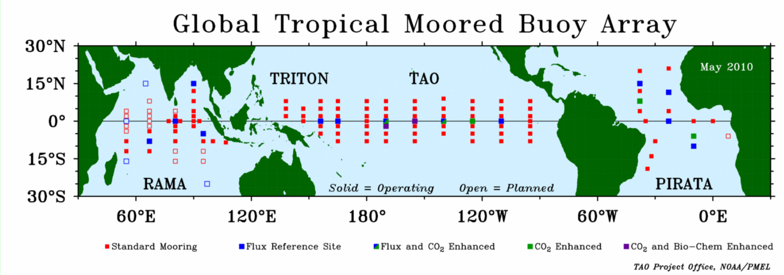
Current status of TRITON and m-TRITON buoy array and its data system

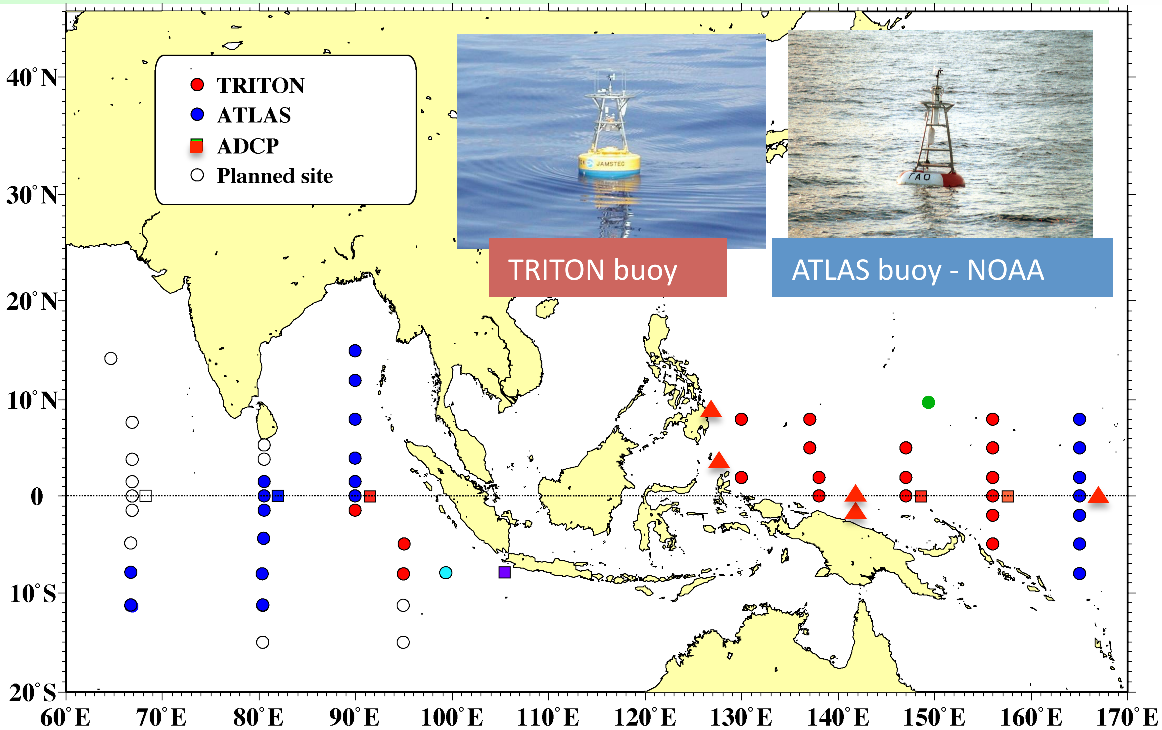
K. Ando and I. Ueki, JAMSTEC,
Yokosuka, Japan

TRITON buoy array in the tropical oceans



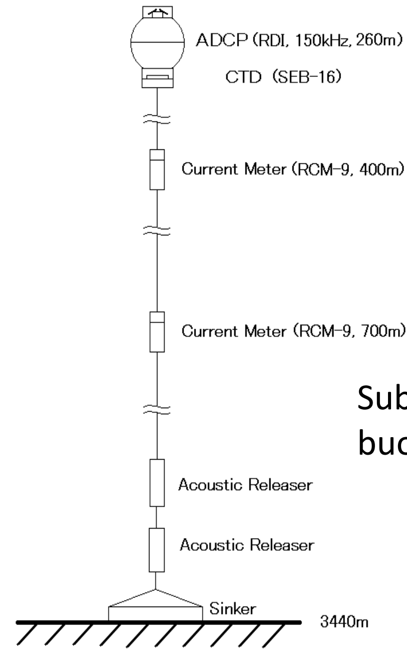
Past and Current Activities of JAMSTEC/TOCS/TRITON - Overall -



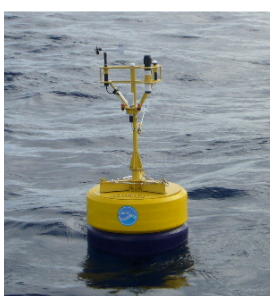


TRITON buoy

ATLAS buoy - NOAA



Subsurface ADCP buoy system



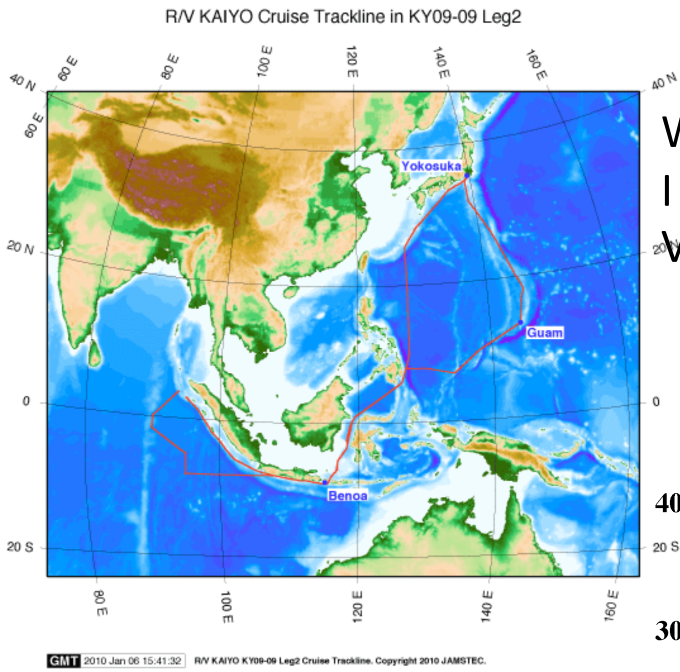
TRITON buoy (smaller) for Indian ocean

▲ ADCP mooring positions TOCS/JAMSTEC have moored in the past, but no longer exist.

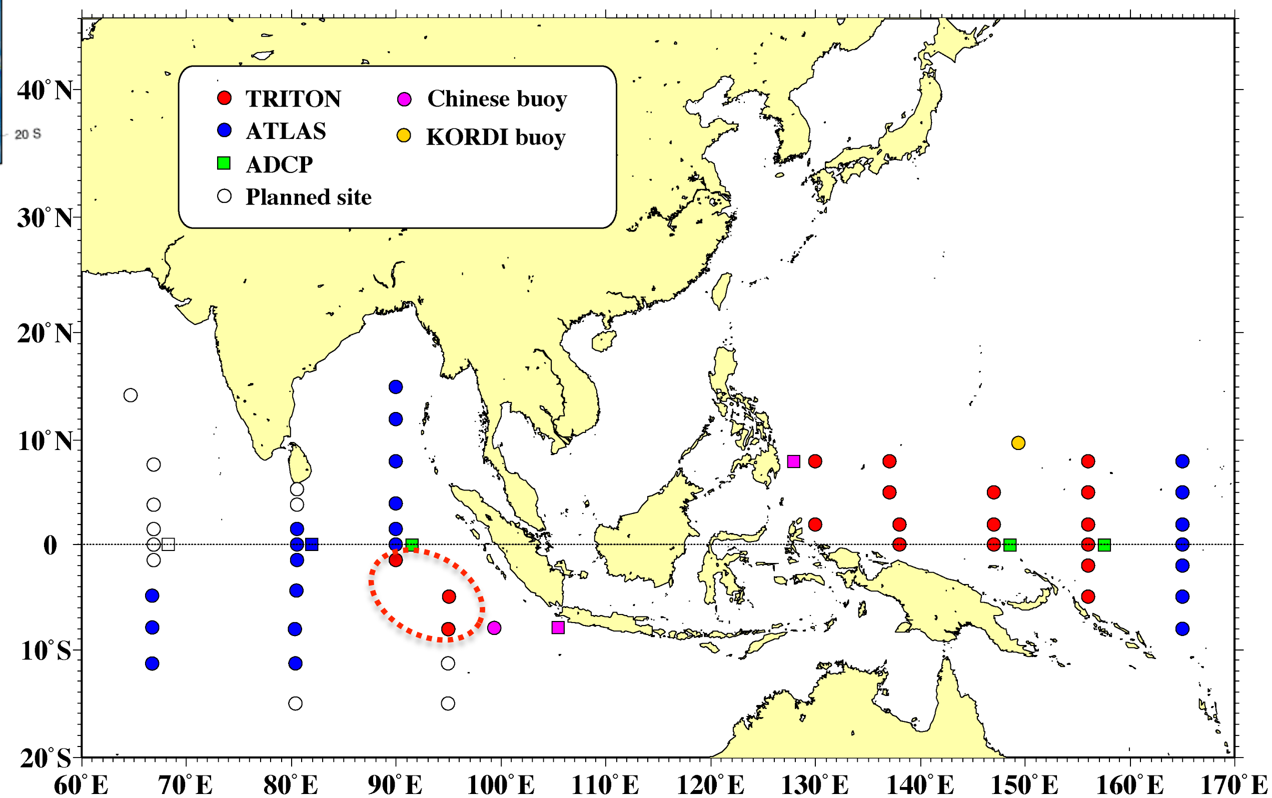
Data is available at http://www.jamstec.go.jp/iorgc/cgi-bin/database/v01/browse_list2.cgi?program=cvorp&group=IMOC

Other sites are maintained, buoys are active and data are available via Internet.

Indian Ocean Cruise in Nov. 2009



We had a lot of troubles
I had never experienced .
Very memorable cruise!!

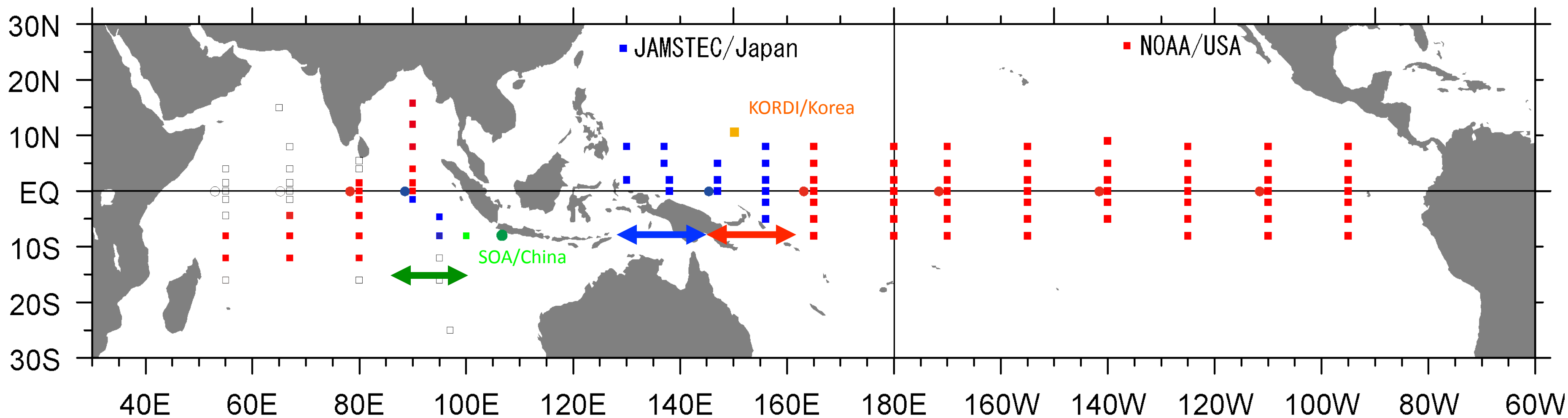


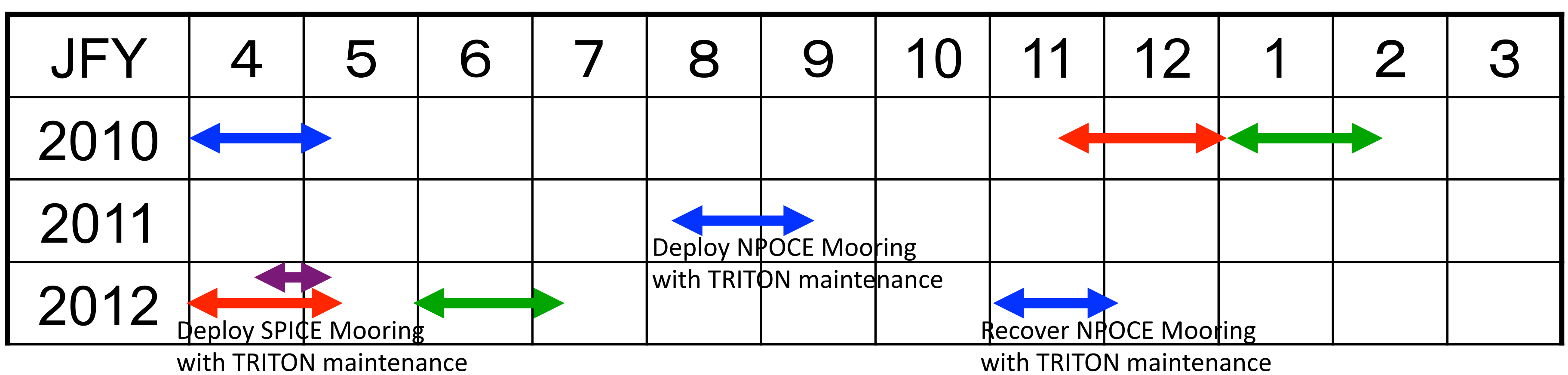
R/D 0-90E ADCP
R/D 1.5S90E m-TRITON
R/D 5S95E m-TRITON
D 8S95E m-TRITON

New Argos-3 systems at
1.5S90E and 8S95E sites

Current and Near-Future Research Activities

- Pacific Ocean TAO/TRITON & Indian Ocean RAMA -





The year is expressed by Japanese Financial Year (JFY) starting from April.
"March in JFY2010" is "March 2011"

Data return rate (real-time data)

Data return rates from 1999-2010 (real time data)

＊Yellow: 70%～80%, Pink: below 70%

Site No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	＊
Nominal latitude	8N	5N	2N	EQ	2S	5S	5N	2N	EQ	8N	5N	2N	EQ	8N	5N	2N	EQ	1.5S	Total
Nominal Longitude	156E	156E	156E	156E	156E	156E	147E	147E	147E	137E	137E	138E	138E	130E	130E	130E	95E	90E	
Total observation years	12年	12年	12年	11年	11年	12年	11年	10年	11年	10年	9年	11年	3年	9年	0年	3年	6年	6年	
WND	68%	67%	59%	75%	77%	64%	79%	75%	70%	74%	81%	55%	4%	24%	No met observations		30%	52%	63%
AT	82%	82%	79%	74%	81%	82%	83%	79%	83%	88%	90%	71%	4%	38%			42%	81%	74%
RH	82%	77%	76%	67%	81%	85%	80%	57%	77%	64%	80%	53%	4%	37%			42%	64%	67%
BAR	76%	84%	89%	75%	88%	94%	82%	82%	79%	90%	96%	69%	4%	38%			19%	80%	75%
RAN	81%	73%	72%	60%	78%	73%	76%	78%	62%	56%	79%	74%	4%	32%			11%	73%	65%
SWR	77%	87%	76%	70%	82%	90%	87%	77%	83%	80%	96%	68%	4%	30%			31%	83%	73%
CT-1.5m	77%	82%	92%	83%	94%	94%	78%	85%	76%	85%	80%	89%	78%	82%	Quiting	57%	82%	99%	84%
CT-25m	84%	82%	88%	80%	94%	94%	73%	85%	81%	83%	77%	84%	78%	75%		57%	83%	99%	83%
CT-50m	83%	82%	92%	82%	90%	90%	76%	71%	83%	81%	78%	79%	78%	90%		57%	83%	90%	83%
CT-75m	82%	82%	92%	73%	94%	94%	76%	79%	82%	85%	79%	74%	78%	89%		57%	83%	99%	83%
CT-100m	84%	74%	85%	69%	94%	93%	76%	85%	80%	85%	81%	76%	78%	90%		57%	57%	99%	82%
CT-125m	84%	82%	92%	71%	94%	87%	76%	85%	83%	85%	81%	83%	78%	90%		57%	83%	88%	84%
CT-150m	76%	77%	85%	75%	94%	94%	76%	85%	83%	85%	81%	83%	78%	90%		57%	83%	99%	83%
CT-200m	84%	82%	85%	74%	87%	94%	76%	85%	83%	77%	75%	83%	78%	89%		57%	70%	99%	82%
CT-250m	84%	82%	92%	73%	94%	94%	76%	85%	78%	76%	81%	83%	78%	81%		57%	83%	99%	83%
CT-500m	84%	82%	84%	66%	94%	82%	76%	77%	83%	85%	71%	83%	78%	91%		57%	83%	99%	82%
CTD300m	84%	80%	92%	75%	92%	94%	76%	77%	83%	85%	81%	72%	78%	91%		57%	83%	99%	83%
CTD750m	82%	82%	92%	73%	94%	94%	73%	85%	83%	85%	81%	83%	78%	91%		57%	83%	96%	84%
CRN	55%	62%	69%	55%	75%	63%	53%	69%	53%	53%	66%	50%	49%	49%		48%	41%	90%	60%
Total	79%	79%	83%	72%	88%	87%	76%	79%	78%	79%	81%	74%	53%	58%		39%	62%	89%	77%

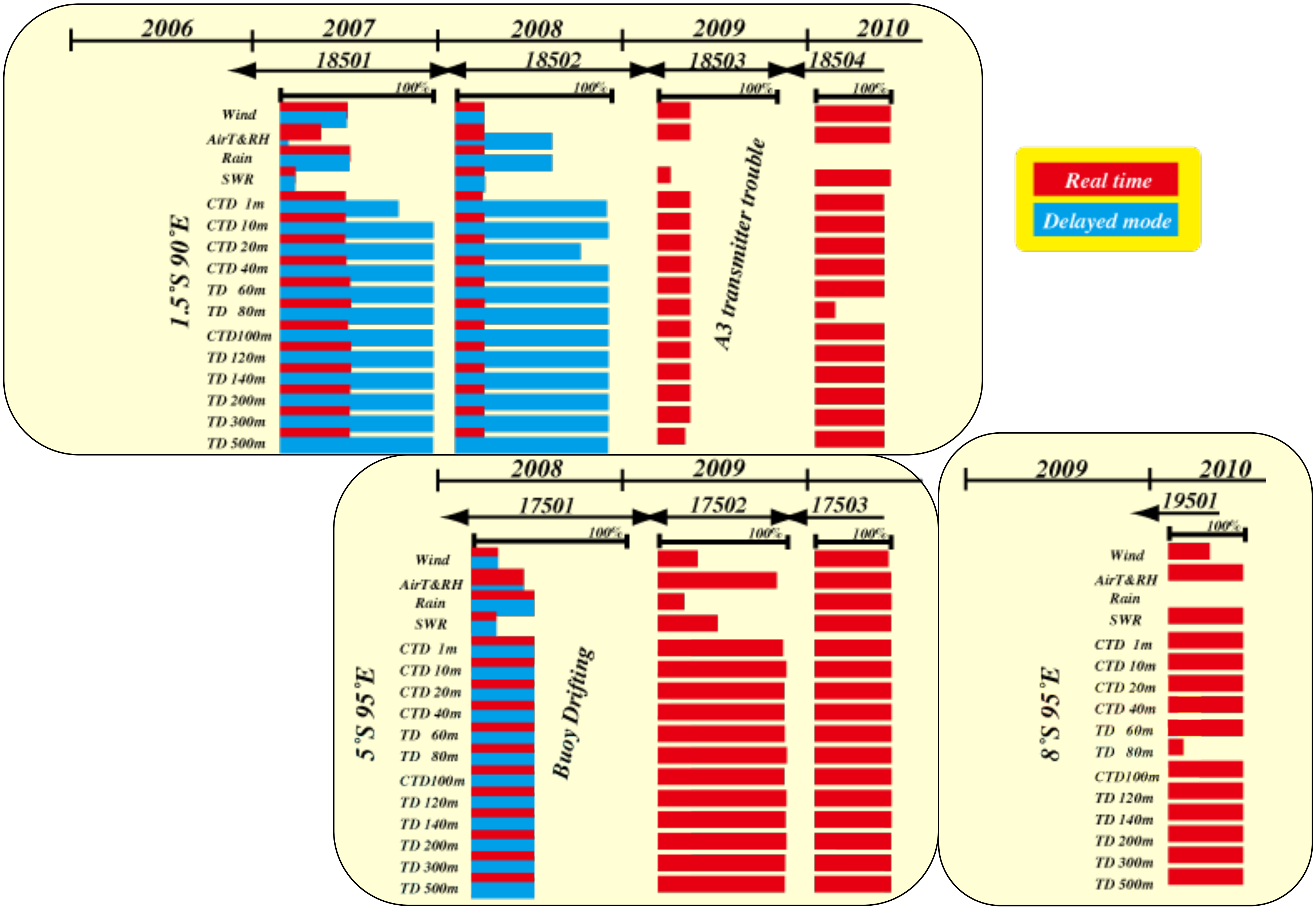
Data return rate (recover data)

Data return rates from 1999 to 2008 (Data after recovery)

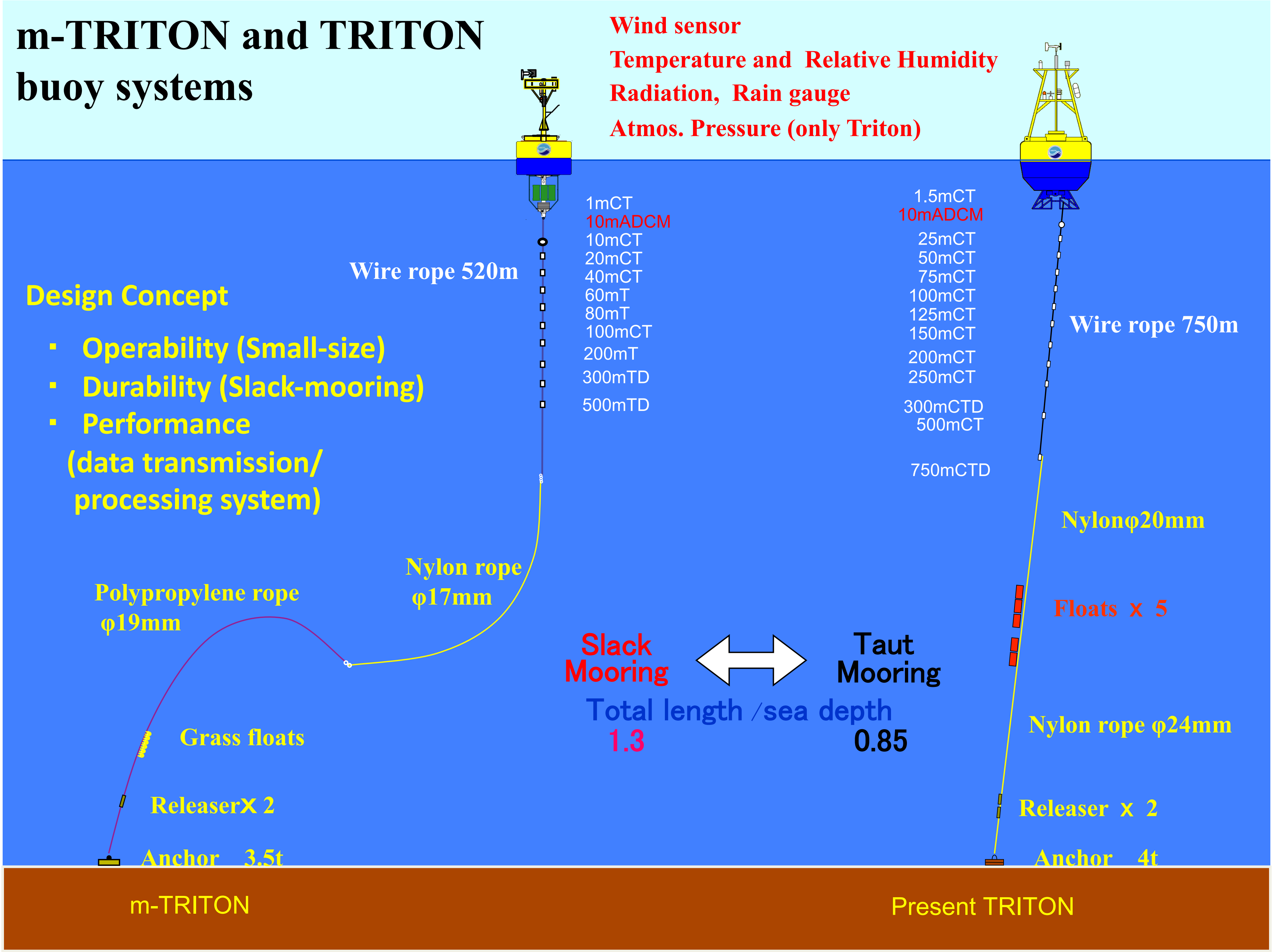
＊Yellow: 70%～80%, Pink: below 70%

Site number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	＊
Nominal Latitude	8N	5N	2N	EQ	2S	5S	5N	2N	EQ	8N	5N	2N	EQ	8N	5N	2N	EQ	1.5S	Total
Nominal Longitude	156E	156E	156E	156E	156E	156E	147E	147E	147E	137E	137E	138E	138E	130E	130E	130E	95E	90E	
WND	70%	64%	56%	79%	80%	65%	82%	72%	74%	73%	89%	52%	1%	6%	No Met Observations		30%	52%	59%
AT	91%	81%	79%	77%	79%	90%	91%	80%	88%	99%	88%	79%	1%	17%			50%	79%	72%
RH	90%	75%	76%	70%	79%	90%	88%	59%	81%	65%	75%	56%	1%	17%			43%	62%	64%
BAR	85%	88%	89%	79%	87%	100%	82%	80%	83%	98%	98%	73%	1%	17%			26%	79%	72%
RAN	90%	75%	69%	62%	80%	77%	79%	76%	66%	59%	85%	70%	1%	17%			7%	72%	62%
SWR	84%	91%	78%	73%	80%	95%	91%	84%	89%	87%	100%	75%	1%	17%			31%	79%	71%
CT-1.5m	76%	89%	94%	79%	96%	99%	91%	83%	85%	100%	91%	87%	84%	78%	Quiting	76%	90%	97%	88%
CT-25m	91%	90%	85%	86%	88%	91%	88%	79%	93%	79%	86%	95%	96%	67%		70%	81%	97%	87%
CT-50m	90%	90%	82%	82%	79%	93%	91%	68%	94%	80%	93%	82%	91%	98%		72%	90%	83%	86%
CT-75m	90%	94%	91%	72%	91%	94%	91%	78%	89%	98%	92%	96%	89%	93%		79%	90%	92%	89%
CT-100m	94%	93%	94%	88%	95%	95%	91%	84%	96%	98%	98%	91%	83%	98%		73%	64%	97%	91%
CT-125m	94%	95%	94%	84%	96%	99%	91%	84%	99%	100%	100%	99%	95%	98%		79%	90%	97%	94%
CT-150m	85%	88%	87%	88%	96%	100%	91%	84%	98%	100%	100%	99%	96%	98%		79%	90%	97%	92%
CT-200m	94%	89%	83%	87%	79%	99%	91%	84%	99%	90%	86%	99%	89%	100%		81%	78%	97%	90%
CT-250m	94%	92%	94%	86%	93%	100%	91%	82%	99%	100%	100%	99%	99%	100%		81%	90%	97%	94%
CT-500m	94%	94%	94%	79%	96%	87%	91%	76%	99%	100%	100%	99%	99%	100%		81%	90%	97%	92%
CTD300m	94%	84%	94%	88%	96%	100%	91%	84%	99%	100%	100%	95%	99%	93%		81%	90%	97%	93%
CTD750m	92%	92%	92%	86%	96%	100%	91%	84%	99%	100%	100%	99%	99%	100%		81%	90%	97%	94%
CRN	54%	67%	76%	62%	75%	64%	60%	71%	74%	95%	58%	51%	61%	49%		76%	31%	97%	66%
Total	87%	86%	85%	79%	87%	92%	88%	78%	90%	91%	92%	84%	62%	66%		53%	66%	87%	82%

Data return of m-TRITON in the Indian Ocean (since 2007 until 30 Jun. 2010)

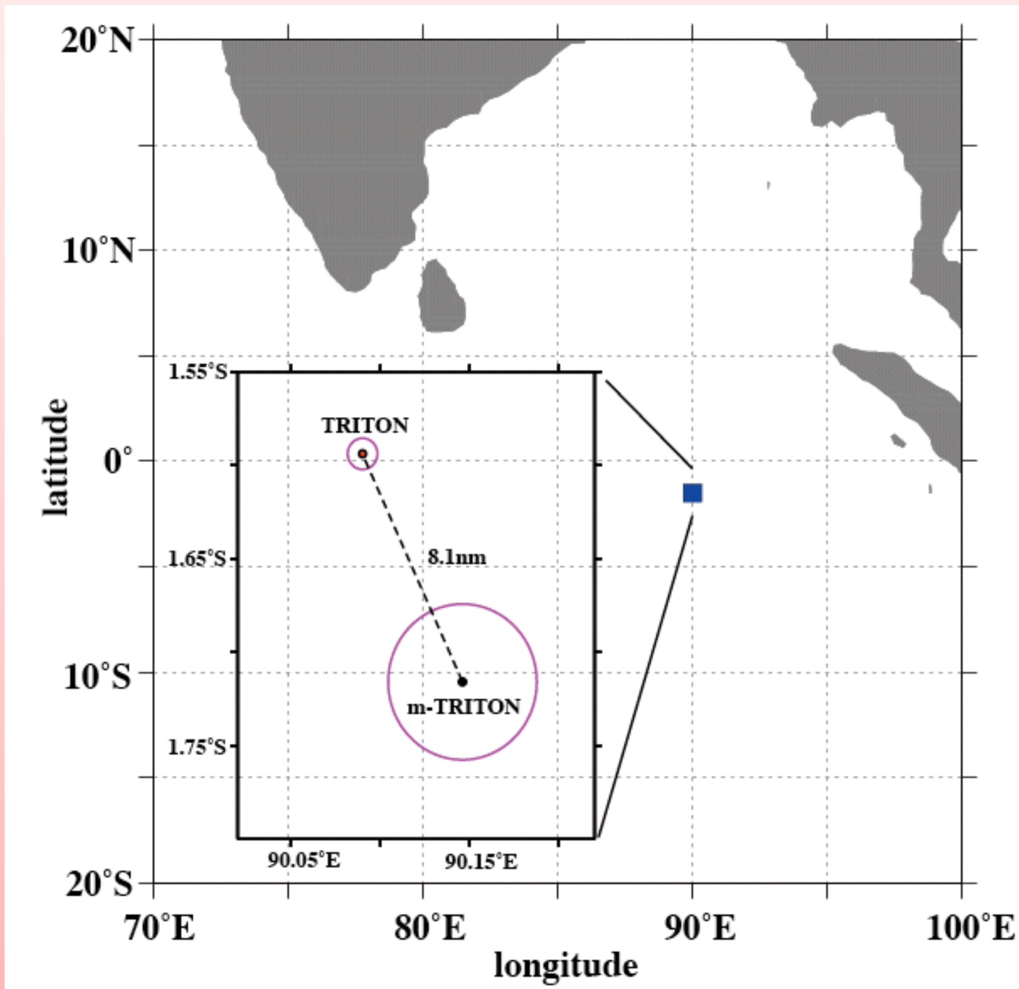


m-TRITON and TRITON buoy systems



A multi-national effort and data consistency

RAMA is being built by a multi-national effort, and various kind of moorings will be used. Therefore, consistency in data quality among different mooring methods is crucial for utilization of buoy array data.



The field experiment at 1.5˚S 90˚E from Dec. 2006 to Feb. 2008.

Behavior of m-TRITON mooring

Although the slack-line mooring method has the advantage of downsizing of the total mooring system, it also a disadvantage that underwater sensors installed on the mooring line can move vertically a large distance according to the larger inclination of the mooring line as compared to that in the case of the taut-line method.

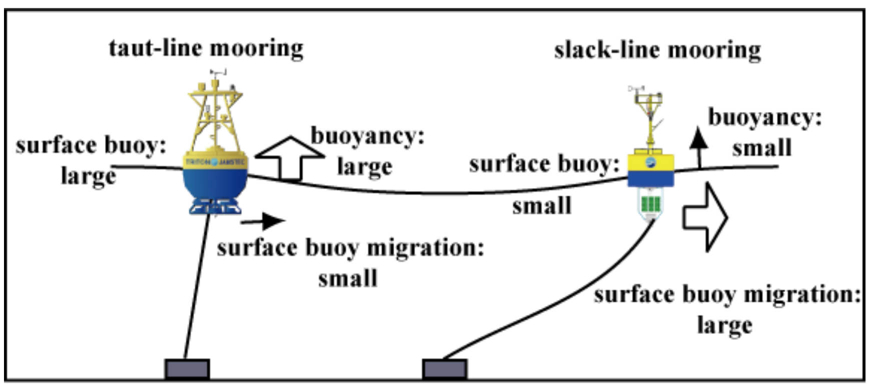
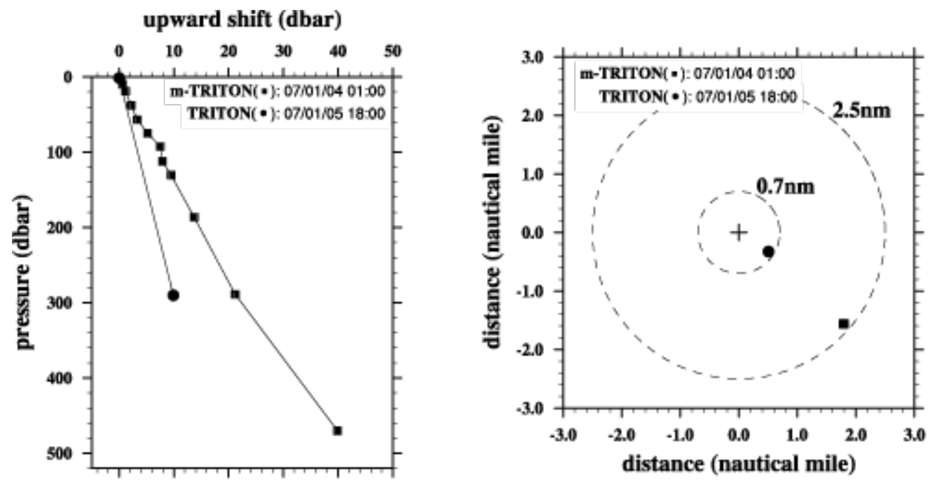


Figure: Schematic diagram of difference between taut-line (left) and slack-line (right) mooring. Note that the shape of mooring lines for both buoy are not to scale, to emphasize difference of concept.



Example of surface buoy position and associated upward shifts of each underwater sensors in a case of declined condition

The statistical values for the observed pressure of each underwater sensor revealed that effects of slack-line mooring appeared below 80 m and cannot be ignored especially in a deeper layer. In the case of the deepest sensor installed at 510 m, the mean observed pressure is 503.6 dbar with a standard deviation of 7.9 dbar, and the maximum upward shift indicates approximately 55 dbar.

Data evaluation: 1) the virtual test using historical CTD casts

The virtual test for temperature:

1. CTD temperature data at observed levels, which were defined by observed pressure of 14-month mooring.
2. Reconstructed standard level temperature data from the observed mooring pressure data using the Akima-spline method.
3. Compared reconstructed data with the CTD data at observed pressure at each nominal standard levels of mooring.

This procedure was done for 15 historical CTD casts observed near buoys.

Standard level (m)	Temperature at standard level (°C)	Pressure (dbar)	OE (°C) mean	OE (°C) S. D.	RE (°C) mean	RE (°C) S.D.
10	29.10	9.60	0.00	0.00	0.00	0.00
20	29.11	19.48	0.00	0.01	0.00	0.01
40	29.08	39.32	0.00	0.01	0.00	0.01
60	28.94	58.69	0.02	0.04	0.00	0.03
80	27.41	77.37	0.29	0.42	0.08	0.21
100	25.27	98.12	0.27	0.34	-0.08	0.27
120	18.64	117.44	0.87	0.98	0.34	0.76
140	16.32	137.04	0.18	0.16	-0.05	0.20
200	13.15	195.87	0.15	0.12	0.06	0.12
300	11.33	303.41	-0.04	0.03	0.00	0.04
500	9.60	495.64	0.02	0.02	-0.01	0.02

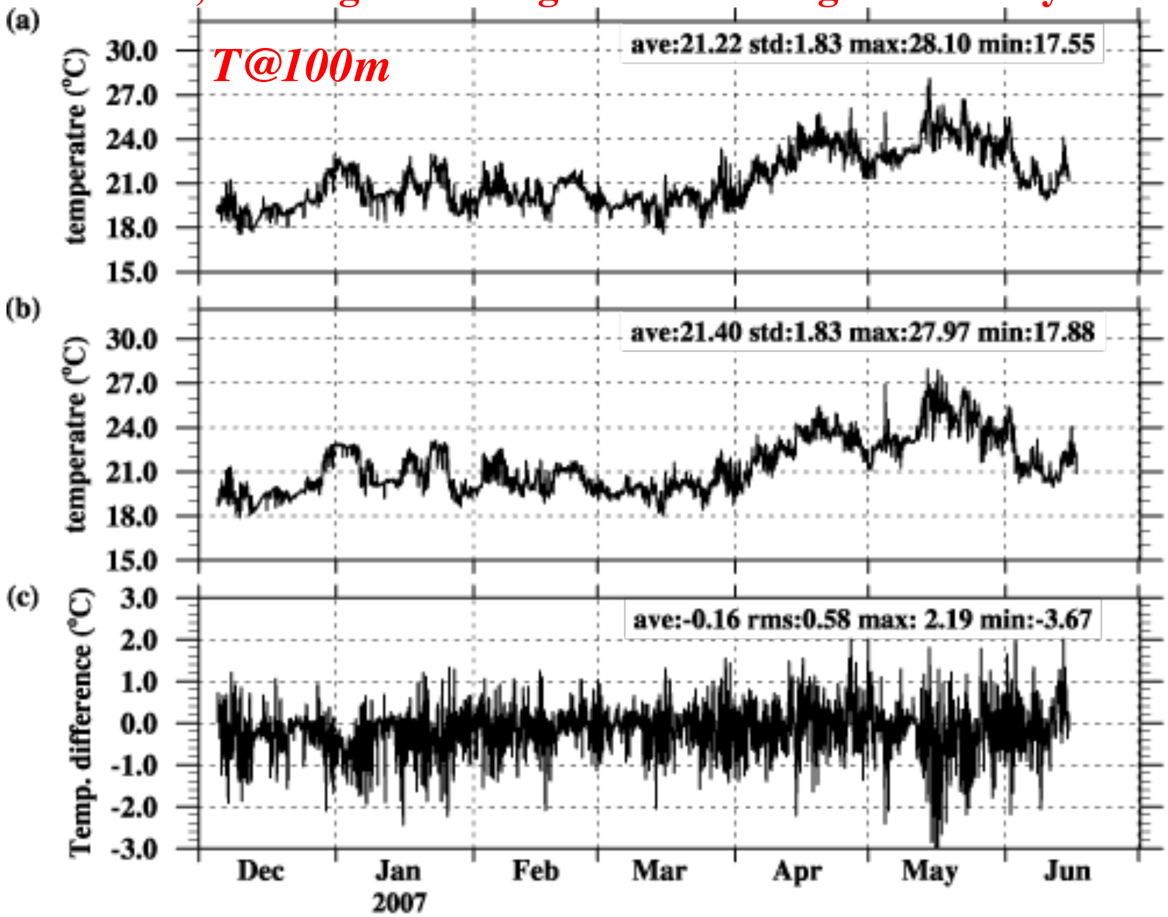
OE: original error with no consideration of vertical shift

RE: reconstruct error caused by reconstruction method

The mean value of the RE at each level is smaller than that of OE.

Data evaluation: 2) comparison between two types of mooring system

This depth is corresponded to the thermocline layer on average; therefore, has large vertical gradient and high variability.



Time series of temperature observed with (a) m-TRITON, (b) TRITON mooring at 100 m, and (c) its difference (m-TRITON minus TRITON)

The both buoy captured same feature except short-time variability and oceanic response against wind forcing. The temp. diff. is produced by the diff. in the mooring points

The m-TRITON temperature was relatively lower than the TRITON temperature until the end of Feb. 2007 and then the difference decreased until the beginning of Apr. 2007.

The amplitude of the difference increased after the beginning of Apr. 2007.

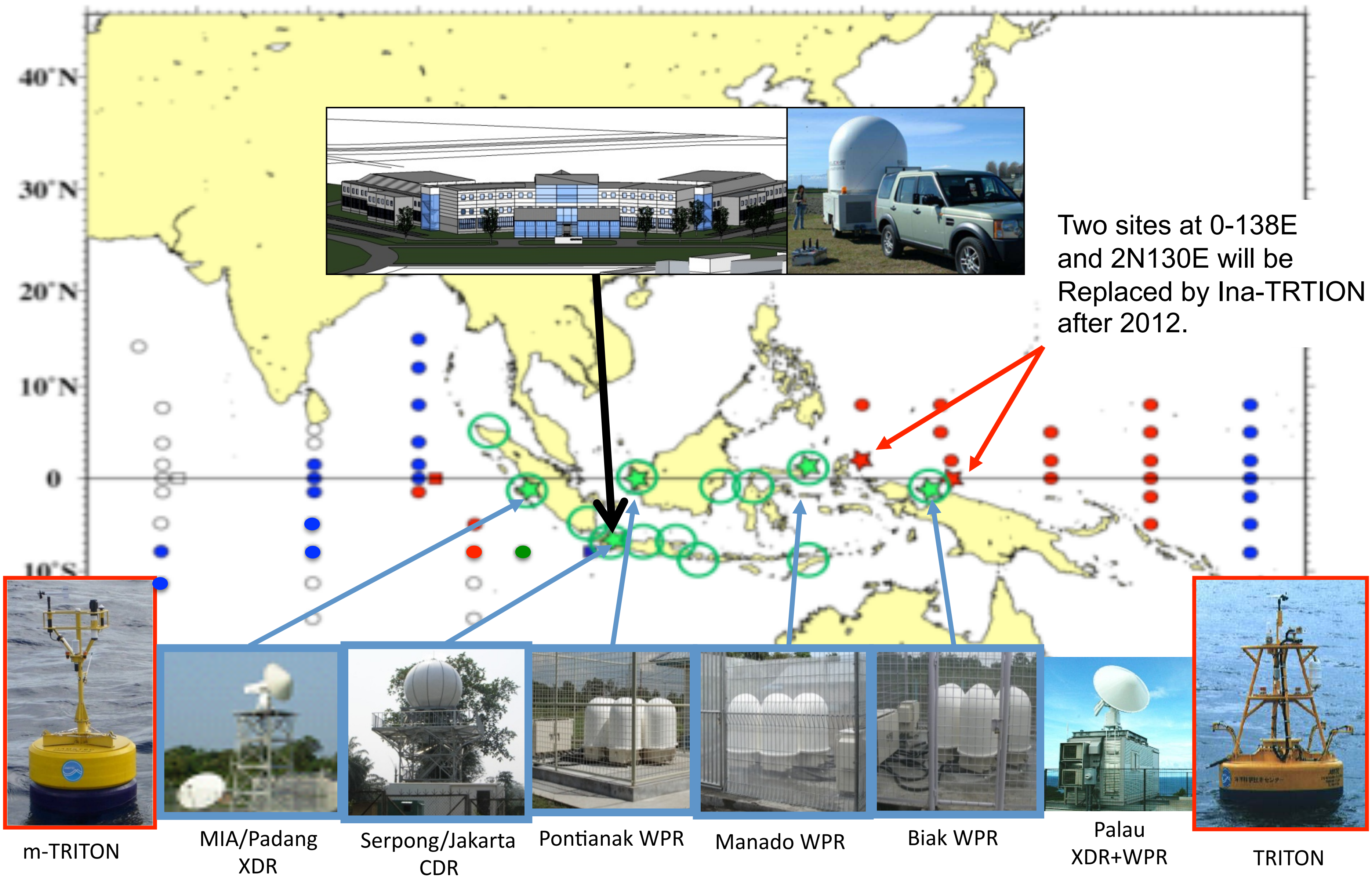
The mean difference and RMS diff. were -0.16 ˚C and 0.58 ˚C.

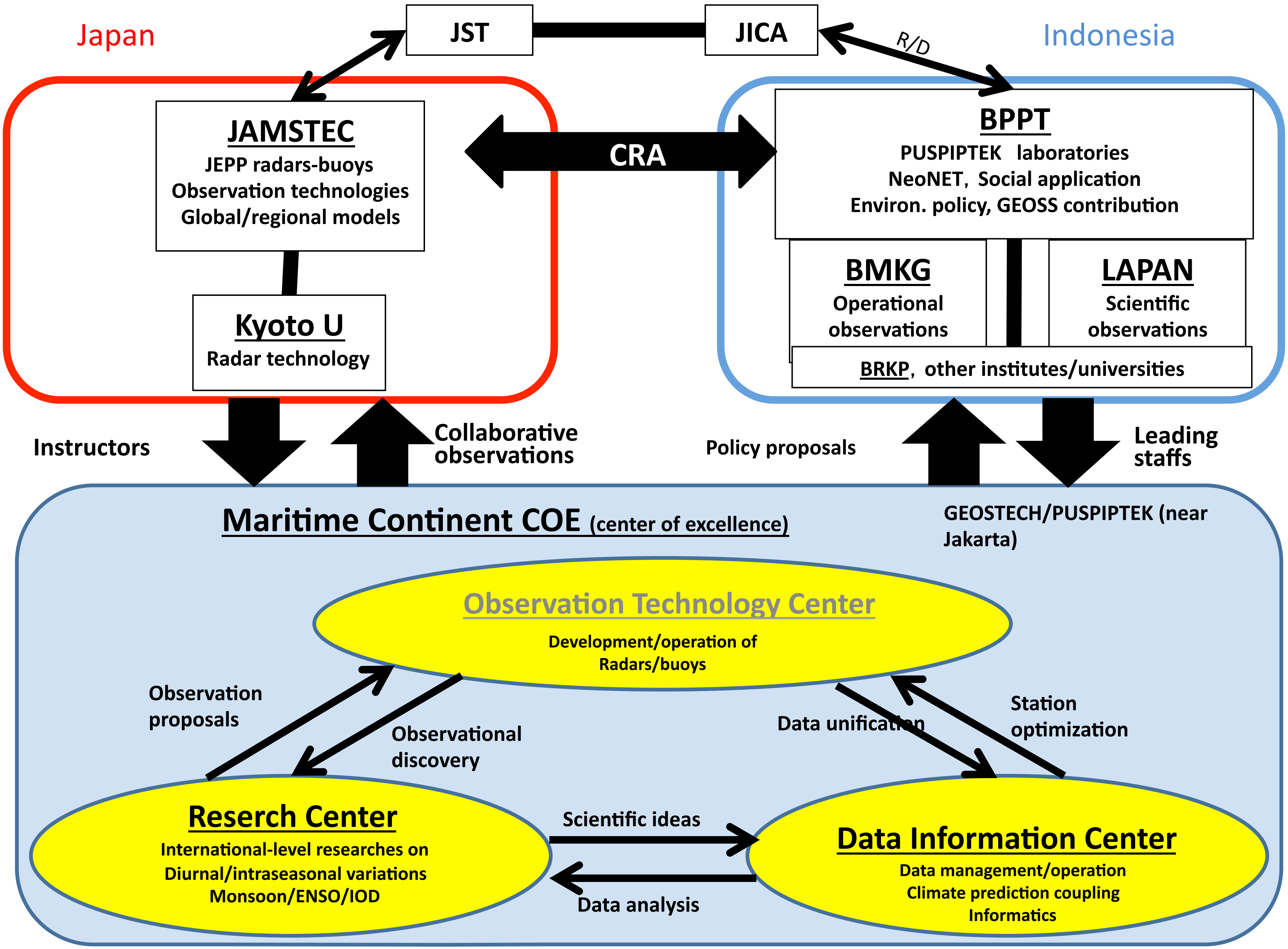
The RMS difference decreases if we take low-passed filter. It was suggested that the relatively large RMS difference is caused by phase lag against short time-scale variability between the both mooring site.

Climate Variability Study and Societal Application through Indonesia-Japan "Maritime Continent COE"

- Radar-Buoy Network Optimization for Rainfall Prediction

A Scientific & Technology Research Partnership for Sustainable Development (**SATREPS-MCCOE**)





Japan
JST
JICA
R/D
Indonesia
JAMSTEC
JEPP radars-buoys
Observation technologies
Global/regional models
CRA
BPPT
PUSPIPTEK laboratories
NeoNET, Social application
Environ. policy, GEOSS contribution
BMKG
Operational observations
LAPAN
Scientific observations
BRKP, other institutes/universities
Kyoto U
Radar technology
Instructors
Collaborative observations
Policy proposals
Leading staffs
Maritime Continent COE (center of excellence)
GEOSTECH/PUSPIPTEK (near Jakarta)
Observation Technology Center
Development/operation of Radars/buoys
Observation proposals
Observational discovery
Data unification
Station optimization
Reserch Center
International-level researches on
Diurnal/intraseasonal variations
Monsoon/ENSO/IOD
Scientific ideas
Data analysis
Data Information Center
Data management/operation
Climate prediction coupling
Informatics

Climate Variability Study and Societal Application through Indonesia-Japan "Maritime Continent COE"
- Radar-Buoy Network Optimization for Rainfall Prediction

A Scientific & Technology Research Partnership for Sustainable Development (**SATREPS-MCCOE**)

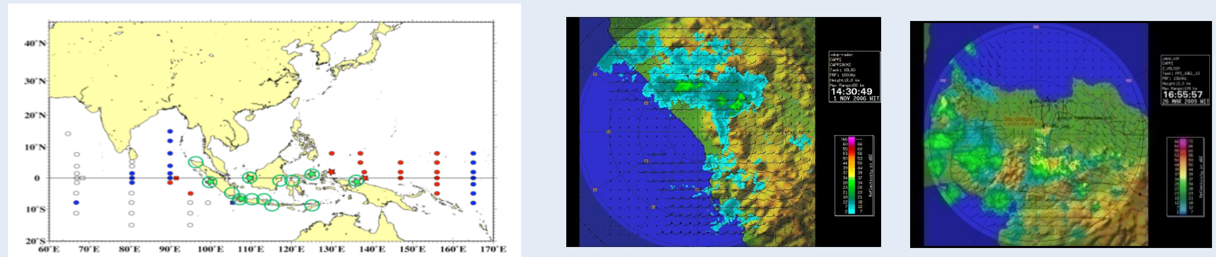
Obs. Center Facility

Radar NW operations

Buoy NW maintenance

Contribution to GEO

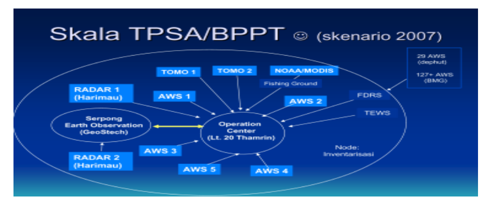
Data Center Facility



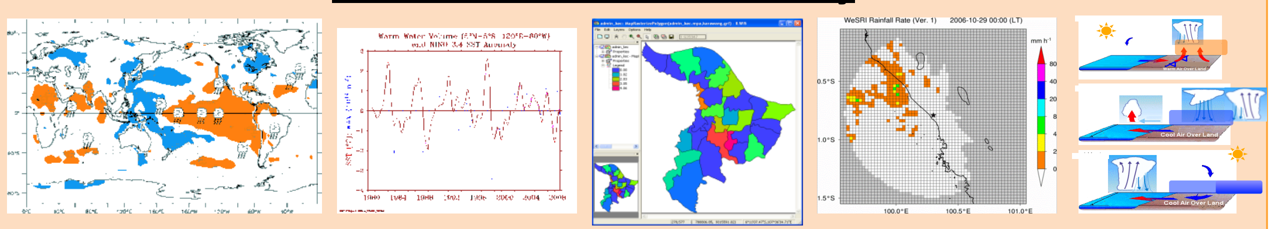
Data application (domestic/international, scientific/social)

"Maritime Continent COE"

Data network (NEONET)

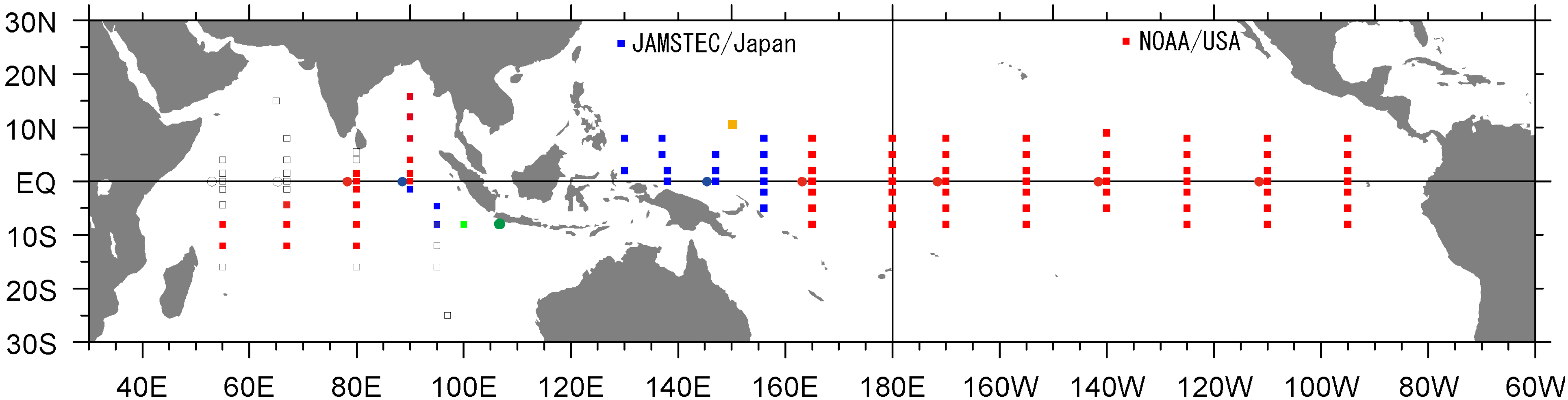


Research Center Facility



Contribution to international scientific community / domestic policy

Future of TAO/TRITON



RAMA: Multinational efforts by China, French, India, Indonesia, Japan, South Africa and US

The first Resource Forum under CLIVAR and GOOS for maintaining and developing RAMA will be discussed in the next July

TAO/TRITON: Substantially, maintained only by the efforts of Japan and US

TAO/TRITON: Asian countries like China, Korea and Indonesia are strongly expected (by myself) to participate to this Pacific buoy array.

Issues associated with the TAO/TRITON array

- The Pacific array (TAO/TRITON) has not had practical multi-national coordination body to share resources (ship-time and buoy).
- Asian countries such as China, Korea and Indonesia, have been interesting to buoy observations.
- Need better coordination to maintain and develop the Pacific array, including from logistical issues to scientific review processes.

  --- TIP should, but better to have something intergovernmental in future

Proposed meetings of (or related to) TIP

- Buoy technology information exchange workshop (maybe half-day)

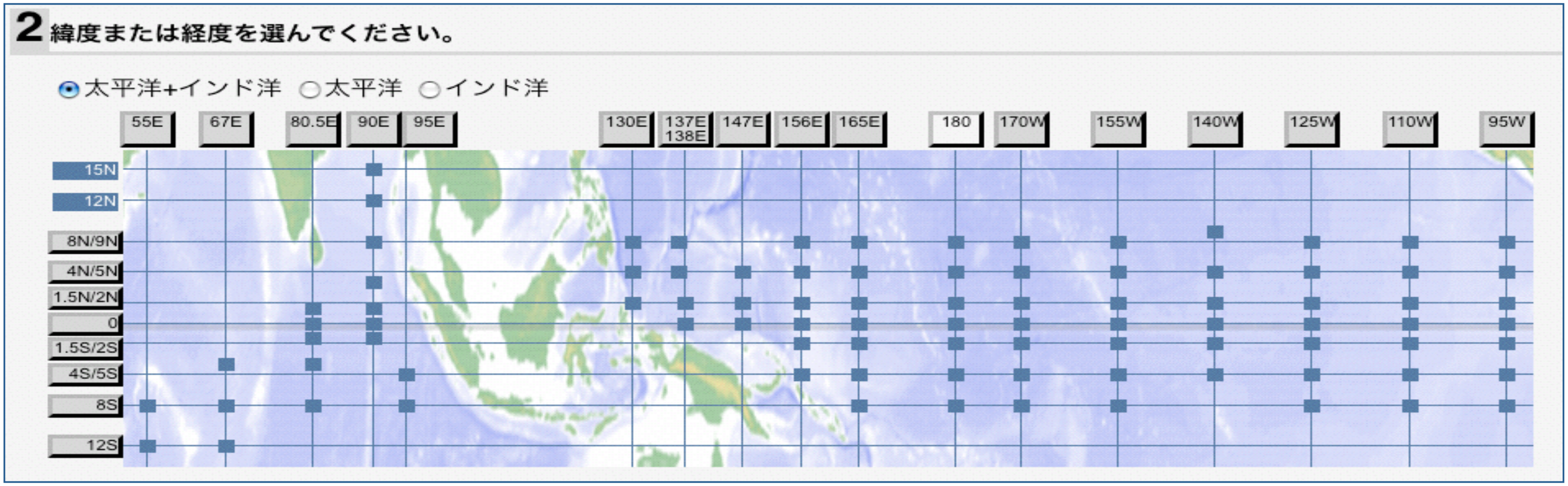
  Place and time: Busan Korea in March 2011

  During the IOC/WESTPAC sympo, Dongchull and I will convey the workshop. The purpose is to exchange buoy technology and technology information, and promote buoy business to other WESTPAC countries.

- International symposium on the Indo-Pacific buoy arrays in Jakarta in 2012 autumn.

  Hosted by BPPT buoy team. BPPT/JAMSTEC will deploy the Indonesian surface buoy (Ina-TRITON) in April 2012 at 0-138E (Indonesian EEZ), which is already a part of TAO/TRITON.

Data Integration of RAMA and TAO/TRITON



New data display system in Japanese (under construction)