Construction and Validation of Gridded Data Sets of Global Surface Wind Field by Satellite Scatterometer

KEY WORDS: scatterometer, wind-stress products, validation

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1.Introduction

Ocean surface wind fields are very important in many applications, including weather and climate prediction, understanding air-sea various phenomenon and studying dynamical forcing of the ocean (e.g. Huddleston & Spencer, 2001; Liu, 2002; Bourassa *et al*, 2010) The satellite on microwave scatterometer provide high frequency and quality observations wind vector data and can be made uniformly over larger areas. Therefore, we are constructing, as a part of the J-OFURO data set (Kubota *et al*, 2002; Kutsuwada, 1999), using outputs from microwave scatterometer SeaWinds on board a single satellite QSCAT, vector gridded data sets, and have verified their reliabilities (Kasahara *et al*, 2003; Morimoto *et al*, 2006). The QSCAT satellite has broken down in operation in November 2009 and has stopped supplying the surface wind data for us. For gridded data sets covering about 10 years, we need to make re-verification for the reliabilities by comparison with in-situ measurements by moored buoys. In addition, validations should be made by inter-comparisons with other wind products such as numerical re-analysis ones. In the open ocean area in the mid- and high latitudes where there are few buoys, we try to validate the products through inter-comparison on the basis of J-OFURO data.

We are constructing the next J-OFURO gridded products of wind vectors using the Advanced Scatterometer (ASCAT)) on-board the Meteorological Operational (Metop) satellite launched by the European Space Agency (ESA), called ASCAT/J-OFUROpre, and also attempting to update QSCAT/J-OFURO v3 products which have been provided by the PO- DAAC/JPL(L2B12v3)

2.Data

Gridded products of surface wind/wind-stress vectors

1)**QSCAT/J-OFUROv2** Spatial resolution: 1°x 1°grid, Time resolution: daily monthly. (cover 60°N-80°S,1999/8-2009/10). Original swath data by the QSCAT/SeaWinds are delivered by the PO- DAAC/JPL(L2B12v2) since 2006. Construction procedures are in Kutsuwada (1998) and Kubota et al.(2002).

2)**QSCAT/IFREMER** Spatial resolution: 0.5°x 0.5°grid, Time resolution: one day. Products have been supplied by the Institut Francais de Recherche pourl'Exploitation de la Mer (IFREMER). Original swath data are delivered by the PO-DAAC/JPL (L2B12v2).

3)**NRA1** Spatial resolution: Gaussian grid, Time resolution: 6 hour. NWPM products which has been supplied by NCEP/ NCAR Reanalysis 1

4)**NRA2** Spatial resolution: Gaussian grid, Time resolution: 6 hour. NWPM products which has been supplied by NCEP/ DOE Reanalysis 2

Constructing the next J-OFURO gridded products of surface wind/wind-stress vectors

・**ASCAT25/J-OFUROpre** Spatial resolution: 1°x 1°grid, Time resolution: one day and monthly. (cover 60°N-80°S,2007/4-2012/12). Original swath data by the ASCAT are delivered by the PO- DAAC/JPL(preview L2B25) Construction procedures is in Kutsuwada (1998) and Kubota et al.(2002).

In-Situ Measurement (moored buoys) Data

We use time series of surface winds at TAO/TRITON, NDBC, KEO, and PIRATA buoys. These have been deployed by the NOAA/PMEL.
Winds by the buoy measurements are converted into 10m level and then daily-averaged wind stress is calculated using the procedure (LKB-3) depending upon atmospheric stability (Liu et al., 1979).

3.Result

3-1. Validation by Comparisons with In-situ Measurements by Moored buoys

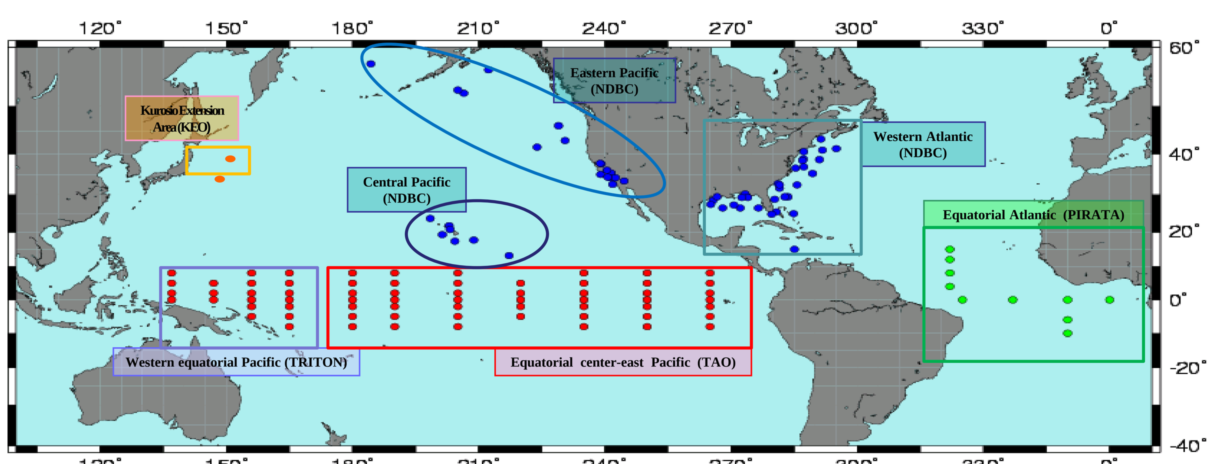


Fig. 1 Distributions of Moored buoys station.

Table 1 correlation coefficients between the wind products and Moored buoys data.

Correlation coefficient		all buoy data	Kuroshio Extension area (KEO)	Western equatorial Pacific (TRAITON)	Equatorial center-east Pacific (TAO)	Central Pacific (NDBC)	Eastern Pacific (NDBC)	Western Atlantic (NDBC)	Equatorial Atlantic (PIRATA)
Zonal wind	QSCAT/ J-OFUROv2	0.952	0.905	0.938	0.939	0.952	0.887	0.927	0.935
	QSCAT/ IFREMER	0.930	0.941	0.875	0.888	0.951	0.885	0.909	0.881
	NRA1	0.893	0.740	0.861	0.827	0.882	0.771	0.868	0.831
	NRA2	0.923	0.925	0.909	0.865	0.924	0.829	0.927	0.845
Meridional wind	QSCAT/ J-OFUROv2	0.932	0.884	0.886	0.941	0.873	0.935	0.916	0.971
	QSCAT/ IFREMER	0.924	0.933	0.859	0.938	0.889	0.906	0.918	0.969
	NRA1	0.829	0.744	0.781	0.753	0.778	0.821	0.863	0.902
	NRA2	0.884	0.935	0.814	0.799	0.829	0.897	0.925	0.902
Zonal wind Stress	QSCAT/ J-OFUROv2	0.924	0.888	0.933	0.938	0.950	0.883	0.895	0.950
	QSCAT/ IFREMER	0.844	0.917	0.701	0.747	0.928	0.885	0.832	0.767
	NRA1	0.799	0.560	0.805	0.782	0.835	0.707	0.795	0.742
	NRA2	0.904	0.910	0.897	0.833	0.929	0.868	0.923	0.836
Meridional wind Stress	QSCAT/ J-OFUROv2	0.908	0.813	0.876	0.939	0.869	0.917	0.884	0.968
	QSCAT/ IFREMER	0.891	0.789	0.769	0.907	0.879	0.905	0.871	0.948
	NRA1	0.753	0.454	0.748	0.747	0.783	0.758	0.756	0.813
	NRA2	0.899	0.847	0.829	0.807	0.873	0.911	0.913	0.877

Table 2 Mean Diffrence between the wind products and Moored buoys data.

Mean Difference		all buoy data	Kuroshio Extension area (KEO)	Western equatorial Pacific (TRAITON)	Equatorial center-east Pacific (TAO)	Central Pacific (NDBC)	Eastern Pacific (NDBC)	Western Atlantic (NDBC)	Equatorial Atlantic (PIRATA)
Zonal wind	QSCAT/ J-OFUROv2	-0.02	0.07	-0.42	-0.02	0.18	0.10	0.01	0.09
	QSCAT/ IFREMER	-0.14	0.03	-0.42	-0.25	-0.03	-0.02	0.06	-0.09
	NRA1	0.34	0.26	0.11	0.74	0.86	-0.15	0.17	-0.20
	NRA2	0.17	0.67	-0.11	0.29	0.35	0.06	0.36	-0.45
Meridional wind	QSCAT/ J-OFUROv2	-0.17	-0.16	-0.10	0.09	-0.09	-0.97	-0.23	0.09
	QSCAT/ IFREMER	-0.20	-0.14	-0.10	0.11	-0.12	-1.26	-0.14	0.12
	NRA1	-0.26	0.68	0.22	-0.55	-0.19	0.02	-0.24	-0.14
	NRA2	-0.08	0.41	0.27	0.15	-0.45	-0.34	-0.45	0.03
Zonal wind Stress	QSCAT/ J-OFUROv2	-0.002	0.001	-0.004	0.004	0.010	-0.002	0.000	0.005
	QSCAT/ IFREMER	-0.021	0.056	-0.006	-0.006	-0.003	0.000	-0.001	-0.005
	NRA1	-0.021	0.119	-0.002	0.014	0.017	-0.005	0.003	-0.002
	NRA2	-0.021	0.060	-0.001	0.008	0.014	-0.005	0.007	-0.006
Meridional wind Stress	QSCAT/ J-OFUROv2	-0.002	0.000	-0.001	0.000	0.001	-0.012	-0.001	0.001
	QSCAT/ IFREMER	-0.003	0.002	-0.002	0.001	-0.003	-0.019	0.000	0.001
	NRA1	-0.003	0.006	0.000	-0.007	0.000	0.003	-0.003	-0.005
	NRA2	0.000	0.017	0.002	0.000	0.000	0.001	-0.002	-0.001

First, in order to examine the reliabilities of all the wind products, we calculate correlation coefficients and man difference between time series of the zonal and meridional wind and wind stress components by in-situ measurements at moored buoys and those at their closest grid points in the wind products. The statistics of each wind products tend to depend on region, even if in-situ buoy measurement data distribute inhomogeneously in space (as shown Kasahara *et al*, 2003; Morimoto *et al*, 2006) Therefore, we were re-calculated correlation coefficients and mean difference for each region shown in Fig. 1 (Table 1, 2) Table 1 shown that as shown correlation for all buoy data, the QSCAT/J-OFUROv2 product has higher correlation than the others in many regions. And these values are not so different among regions. On the other hand, mean differences are different among regions (table 2)

3-2. Re-examination of Reliability of NWPM Products

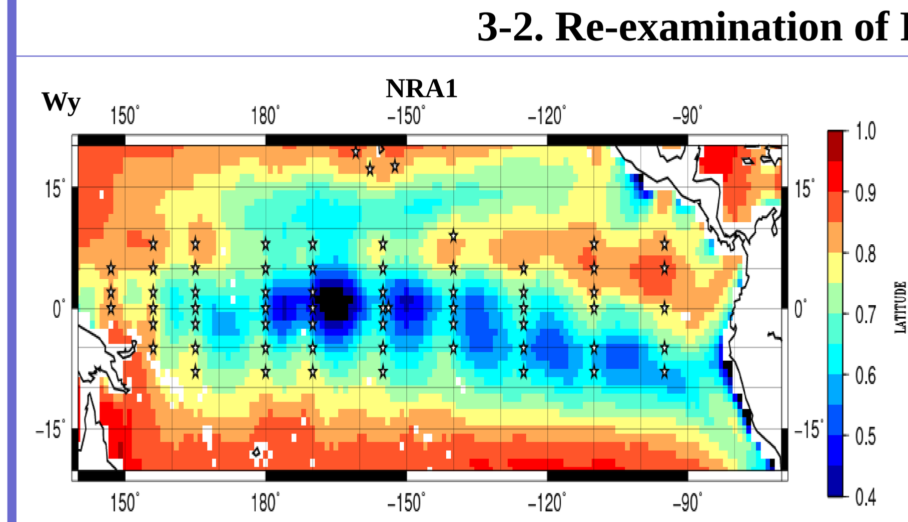


Fig. 2 Zoom-up figures of correlation coefficients of the zonal and meridional components in the NRA-1 products with the QSCAT/J-OFUROv2 ones (color). Buoy stations (Fig.1) are also over-plotted (open star).

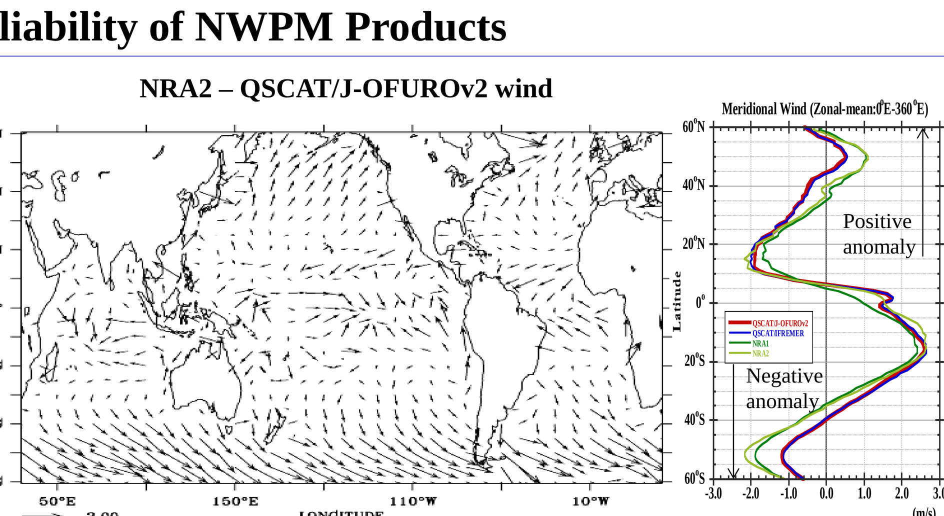


Fig. 3 Distributions of mean differences from NRA2 to QSCAT/J-OFUROv2 wind vector for mean from 31-aug-1999 to 31-jul-2009.

Next, in order to examine whether there are any discrepancies among the different wind products in world-wide areas including no in-situ measurement regions, we calculate statistical values between the QSCATJ-OFUROv2 product and other three ones: QSCAT/IFREMER and NWPM (NRA-1 and 2) products.
We have found two following noticeable results. First, we found striped features in the tropical regions for the NWPM products. In our validations by comparisons with buoy measurements, the NWPM products have relatively low correlations in the tropical regions (table 1) On the other hand, the inter-comparisons reveal that the NWPM products have lower correlations with the QSCAT/J-OFUROv2 one in the central-eastern parts of the tropical Pacific and Atlantic Oceans, where meridionally striped features are found in the correlation (and RMSD) distributions. When we overlap the buoy station maps shown above (fig. 2), we find that the NWPM products have relatively high correlations along the meridians around the buoy locations and lower in the regions between them, producing meridionally striped features. Our results suggest that the NWPM products have relatively low reliabilities in the tropical regions, even if they have been assimilated by buoy measurement data.
Second, in the distributions of MD for the meridional winds, we can see positive and negative anomalies in the mid- and high regions of the northern and southern hemispheres, for the NWPM products (Fig. 3). These mean that the NWPMs have poleward wind anomalies in in high latitudinal regions, compared with our QSCAT/J-OFUROv2 one.

3.3. Inter-comparisons QSCAT/J-OFUROv2 and pre making J-OFUROs Wind Products

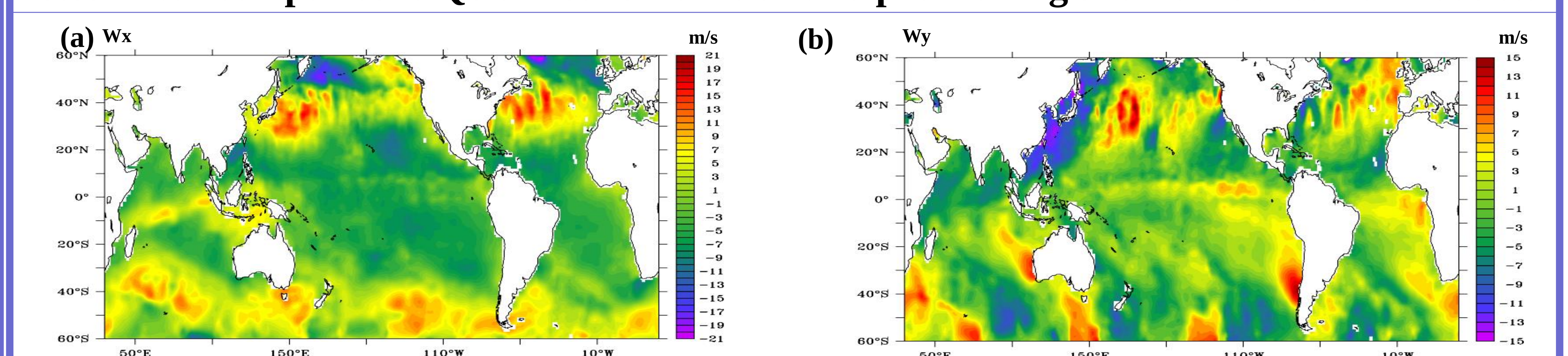


Fig. 4 Distributions of mean wind speed for 2008 of ASCAT25/J-OFUROpre wind data set. (a) Zonal Wind speed (b) Meridional Wind Speed

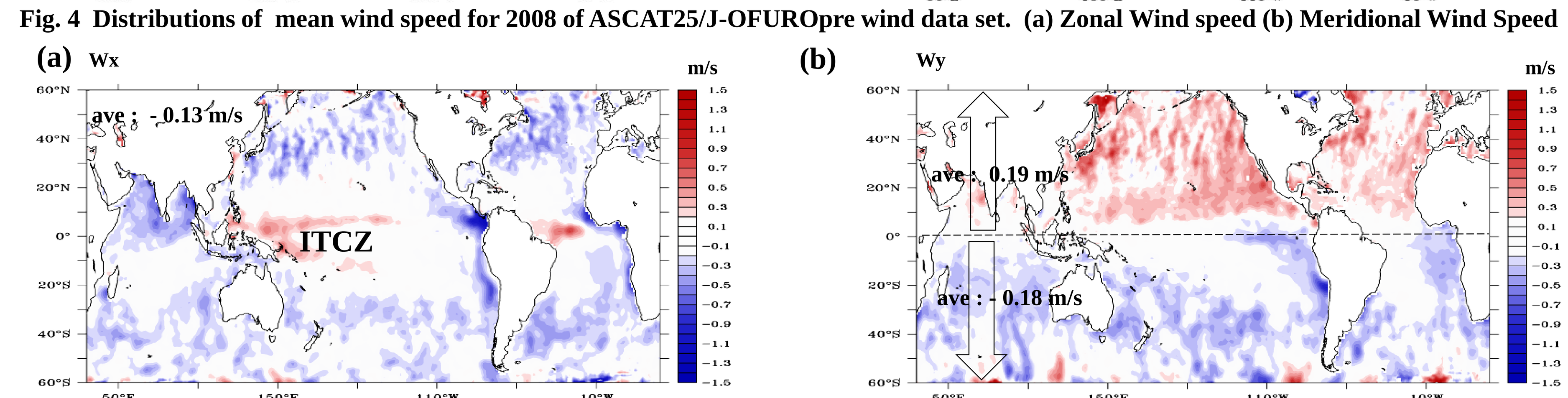


Fig. 5 Distributions of mean differences from ASCAT25/J-OFUROpre to QSCAT/J-OFUROv2 for 2008. (a) Zonal Wind (b) Meridional wind

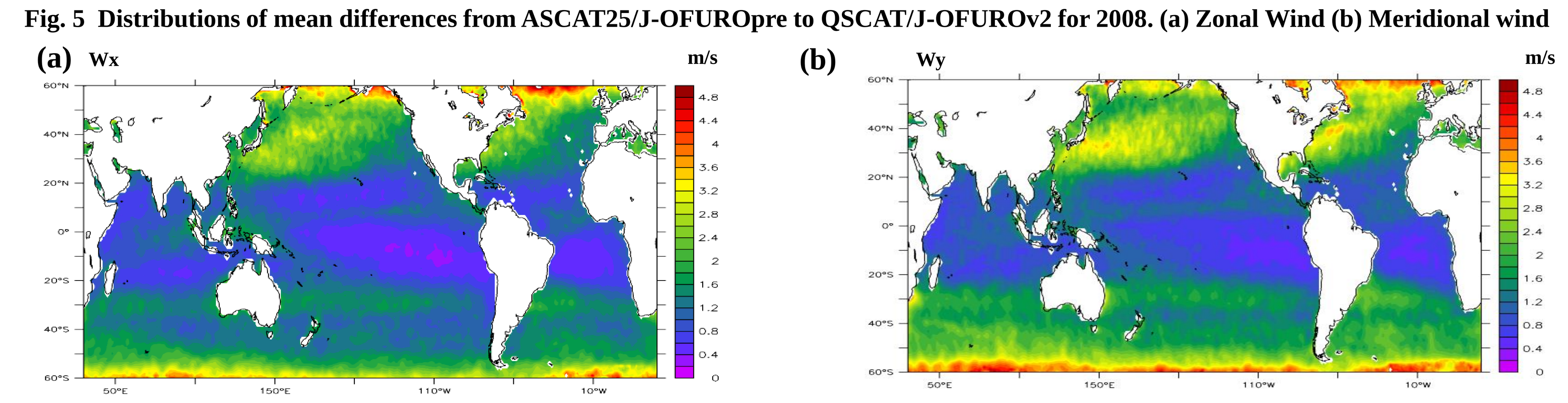


Fig. 6 Distributions of RMS differences between ASCAT25/J-OFUROpre and QSCAT/J-OFUROv2 for 2008. (a) Zonal Wind speed (b) Meridional Wind Speed

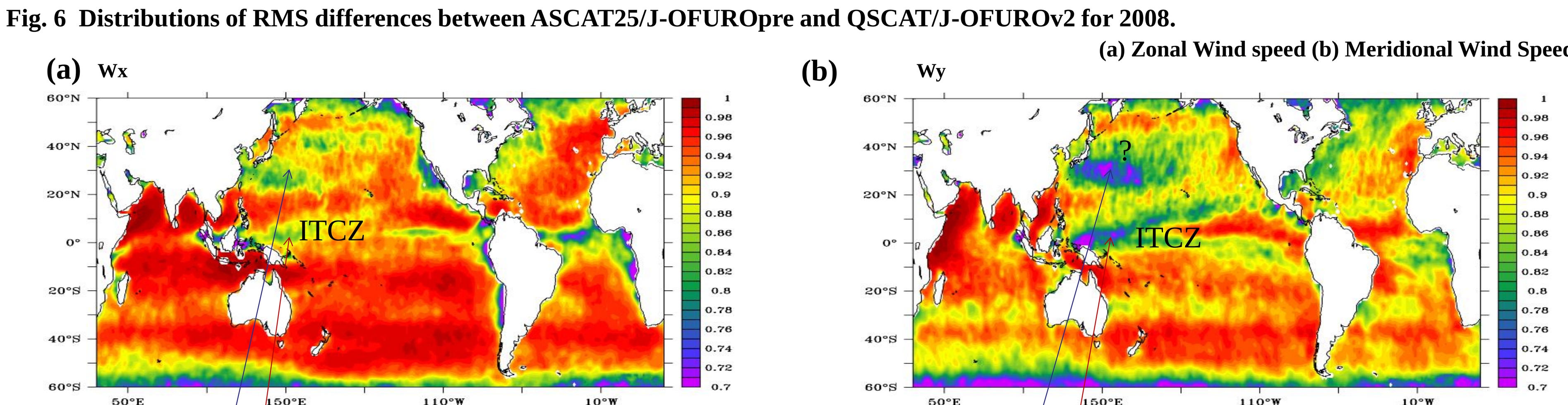
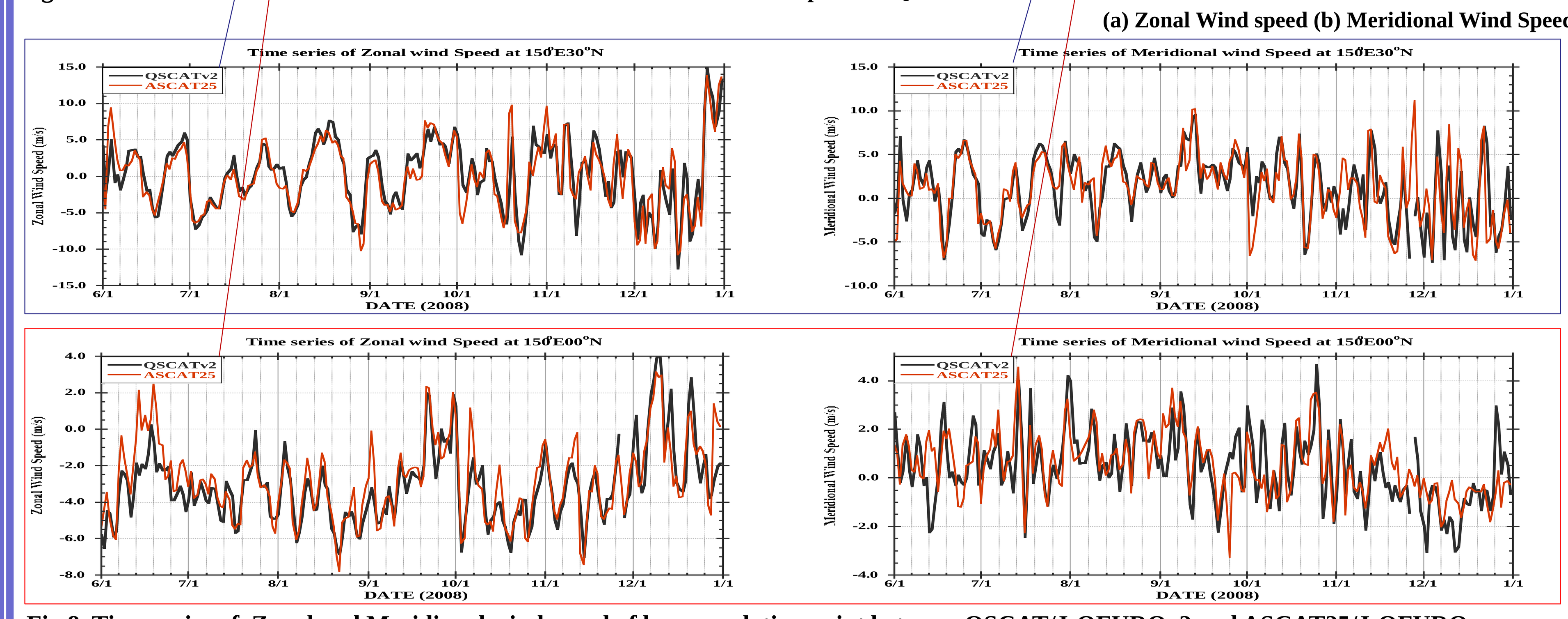


Fig. 7 Distributions of correlation coefficients between ASCAT25/J-OFUROpre and QSCAT/J-OFUROv2 for 2008. (a) Zonal Wind speed (b) Meridional Wind Speed



Fig,8 Time series of Zonal and Meridional wind speed of low correlation point between QSCAT/J-OFUROv2 and ASCAT25/J-OFUROpre. (a) Zonal wind at 150°E30°N (b) Meridional wind at 150°E30°N (c) Zonal wind at 150°E00°N (d) meridional wind at 150°E00°N

We are constructing the next J-OFURO gridded products of ASCAT25/J-OFUROpre products. In order to make long-term time series, we need to examine whether there are any discrepancies between the two products by the QSCAT and ASCAT data. We calculate statistical values between the QSCAT/ J-OFUROv2 product and ASCAT25/J-OFUROpre product. Spatial distributions of mean differences (MD) (Fig. 5), root-mean-square differences (RMSD) (Fig.6) and the correlation coefficients (Fig.7) are shown for the zonal and meridional wind components.

4. Summary

In this study, we have made validation for gridded products of surface wind vector data using comparisons with in-situ buoy measurements and inter-comparisons among different products. The QSCAT/J-OFURO product has higher reliability than the others in many regions.
Inter-comparisons have revealed that there are large discrepancies between the QSCAT/J-OFURO and NRA-1 and 2 products, showing meridionally-dependent features. These involve that the NWPMs have pole-ward wind anomalies in the almost entire regions except the tropical areas. The NRA-1 and 2 reanalysis products have both relatively lower reliabilities in the tropical Pacific region, even if they have been assimilated into the data measured at many moored TAO buoys.
Comparison between the QSCAT and ASCAT products has exhibited that there are relatively large discrepancies with lower correlations in some regions such as the northwestern Pacific and western tropical Pacific.