Comparison of COADS winds with SNMC climatology and measurements in the North Atlantic

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Recent climatological studies often indicate problems with the reliability of COADS winds connected with a number of different and yet poorly understood reasons. During the last years there has been considerable debate about the matter of long-term wind speed trends indicated by COADS (Ramage 1984, Peterson and Hasse 1987, Cardone et al. 1990, Lindau et al. 1990, Isemer and Hasse 1991), ranging from 0. 1 to 0. 5 m/s per decade with local maximums in tropics and in Norwegian Sea (Isemer and Lindau 1994, Isemer 1993). Reliability of these trends is still a matter of debate due to a number of reasons. As a result, Isemer (1995, this volume) has made a detailed and thorough comparison of COADS winds with measurements at fixed Ocean Weather Stations (OWS) and he has concluded that COADS wind trends in the North Atlantic are in disagreement with those taken at the OWS. These differences may at least be significantly reduced after accurate application of the Beaufort scale and careful consideration of individual sampling statistics. Changes with time of the relative role of anemometer measurements are considered as one of the possible reasons of unrealistically high COADS wind trends. This work discusses the use of additional independent data for the validation of COADS winds.

COADS has been used in the form of Monthly Summary Trimmed Groups (MSTG) taken from COADS Release 1 (Slutz et al. 1985). Monthly means of meteorological variables for 2° x 2° boxes for the North Atlantic Ocean were extracted from original COADS files during the period from 1950 to 1979. We also used COADS Release la which covers the period from 1980 to 1992. In order to compare COADS climatology with another one we used a completely different climatological data set, produced on the basis of individual marine reports by another community with the use of slightly different techniques of data processing. This second data set has been prepared during the last several years by the former Soviet National Meteorological Center (hereafter SNMC on the basis of individual marine reports for the period from 1957 to 1990 (Birman, et al. 1980 Birman et al. 1992). The source of original information appears to be close to those used in COADS. For the period from 1957 to 1969 this data set is based on updated archives of meteorological observations. Since 1970 original reports transmitted by voluntary observing fleet via radio are collected at SNMC. Actually the first release of this data set has been prepared in 1977 for the period from 1957 to 1971 with the extension until 1974 in 1980 (Birman et al, 1980). In 1992 a second data release became available (Birman et al. 1992). When second release has been created all data set was updated in order to use universal technique of data control and averaging. SNMC data set is organized in the form of monthly means and standard deviation of variables for 5° by 5° boxes over the North Atlantic from the equator to 75°N. Original reports were averaged for every box for the point with so-called “monthly mean coordinates” and then monthly means were re-interpolated to the centers of boxes. This data set contains in contrast with COADS two levels of cloudiness but does not include so-called derived variables (sea-air temperature and humidity differences and their products with wind speed) which are available from COADS MSTG. Comparison of the number of reports used in SNMC data set with those for COADS gives in general from 15 to 25 percent smaller values. At the same time, for about 20 percent of 10° × 10° boxes, which are mostly connected with the location of operational activity of former soviet scientific military and fishery fleets, the number of observations in SNMC data set is actually higher than in COADS. These boxes are mostly located around Norway and Greenland seas, North-West Atlantic and Tropical-East Atlantic. Data control procedures and the details of data processing and averaging are described in Birman et al. (1980, 1992). Figure 1 shows differences between zonal climatological seasonal cycle and annual means of scalar wind speed taken from COADS and SNHC data set for the period 1957-1979 (overlapping of two data sets). For scalar wind speed we found overestimation of COADS wind in relation to SNMC in the North-West Atlantic and high latitudes and higher SNMC winds in tropics and subtropics. The highest positive differences between SNMC and COADS winds are obtained in subtropical region and ranging from 0.3 to 0.6 m/s. Note that both COADS and SNMC data set used WMO (1970) Beaufort scale. Isemer and Hasse (1985, 1987) using Kaufeld (1981) correction of Beaufort scale obtained 2 m/s increases of climatological means in subtropics on the basis of Bunker’s data set. Recently Isemer and Lindau (personal communication) found these values to be too high. Calculations of wind trends from SNHC data set give trends which are approximately 50% lower than those obtained from COADS. Moreover, SNMC data set indicates considerable area in mid latitudes with negative or insignificant trends.

For comparisons with instrumental observations we also used COADS Release 1a as well as original COADS compressed marine reports (CMR) within some of the 10° × 10° boxes, located in the North-West Atlantic and data from the field experiments, taken for the period 1981-1991 under “SECTIONS” program. These data are taken continuous for the period of 10 years, if only within limited area (Lappo et al., 1989; Gulev et al., 1991, Gulev, 1994). All data were collected by six sister ships by professional meteorological teams. These are the same ships, which operated at OWS C from 1975 to 1990 (Isemer, 1993). Wind data consist exclusively of anemometer measurements. Anemometer level varied within the range from 26.6 meters to 27.6 meters. Temporal resolution is usually 3 hours, but for some cruises 1 hourly sampled data are available. Total number of cruises is 89, total number of reports is 46,800. The most interesting time series were obtained during NEUFOUEX-88 (Lappo et al., 1989) and ATLANTEX90 (Gulev et al., 1991) experiments. Both of these experiments, as well as the earlier experiment NEWFOUEX-84, were designed to study air-sea interaction processes in the Newfoundland basin during the periods from November 1987 until April 1988 and from December 1989 till May 1990 respectively. Ships, balloons, buoys and moorings were used to measure the atmospheric and oceanic structures and properties. Although the measurement program was designed primarily for the region 40°-48°N, 40°-48°W, voluntary meteorological observations were collected for a larger area. Figure 2 compares the number of instrumental measurements with the number of reports, indicated in COADS Release 1a for each calendar month. Most of instrumental data were collected during winter and spring, when the number of instrumental observations is from 35 to 55% of total COADS reports. It is difficult to check precisely how many of these data were included in COADS Release 1a, but approximate estimate is not higher than 20 to 25%.

In order to compare these data with COADS Release 1a climatology, all wind speed reports were averaged for individual months within 2° × 2° boxes, i.e. we made the same processing, as has been used to create COADS. Thus wind speed values were obtained for 2° × 2° boxes within the area 36°N-56°N, 36°W-56°W. Instrumental measurements indicate generally smaller wind speed within the range from 2 to 10 m/s and slightly higher values for strong winds. Thus, the angle of regression line is always smaller than 45 degrees (Fig. 3). In order to adjust instrumental measurements to COADS collection two procedures were followed. First, we can adjust all wind measurements to another anemometer reference level. This procedure changes the angle of the regression line but is not sufficient to adjust the fit to 45 degrees, even for such a small level as 5 meter which is clearly an underestimate of the mean height of anemometers in COADS collection. We also tried to take into account only those 2° × 2° boxes, which contain relatively high number of reports. Note here, that Weare and Strub (1981) found eleven observations to be needed for approximately unbiased intra monthly averaging. This procedure also increases the angle of the regression line, but again, not very much. Results of the use of these two procedures are presented in Fig. 4. If we take anemometer reference level of about 10 meters, and minimum monthly number of reports of 24, we obtain a regression of 0.7±0.02. Mean wind speed is from 0.3 to 0.8 m/s higher in COADS compared with instrumental measurements, adjusted to 10 meters anemometer level. Probability density functions, calculated from COADS/CMR collection for the period 1980-1989 for the same area indicate for most of the months a higher percentage of observations with smaller wind speed, and therefore bias of modal value.

For the consideration of seasonal cycle, we chose four 4° x 4° boxes with relatively high number of instrumental observations for every month. These boxes are located within the area 40°-48°N, 40o-48°W. Figure 5 shows an example of this comparison for 4-degree box number 3 (40°-44°N, 40°-44°W). If we consider unadjusted measurements, we can point out that COADS wind speed is higher during spring and summer, winter values are very close to each other in both data sets, although instrumental measurements slightly over predict COADS, and during autumn, instrumental measurements give higher values in compare with COADS. After adjustment of 10 meters anemometer reference level, instrumental measurements indicate significantly smaller winds for August, September and October only. During winter and spring COADS wind speed is from 0.7 to 1.3 m/s higher, and differences for November and December under predict the accuracy of sampling and intra-box averaging. Harmonic analyses of the curves in Fig. 5 indicate negative phase lag of about 12 days of COADS wind speed compared with research vessels measurements.

We considered also intra monthly high-order statistics from COADS Release la and research vessels collection for 1981-1991. Some recent studies (Zorita et al., 1992, von Storch et al., 1993) use such statistics as an important indicator of climate changes. For this consideration only boxes with the number of reports higher than 24 per month were chosen. COADS standard deviations are higher than those taken from research vessels collected during all months, and for most boxes. Typical difference is about 1 m/s, and appears to be considerable. We can note here, that our collection of instrumental measurements include 1 hourly and 3-hourly sampled data. Typical temporal resolution for voluntary observing ship reports in COADS is 6 hours. Thus instrumental measurements describe also dispersion of subsynoptic scale within the range of several hours. So, we expected even higher standard deviation of instrumental measurements compared with COADS. We repeated calculations of intra-monthly intra-box standard deviation with only those observations of research vessels, which are sampled on 00, 06, 12, and 1800 GMT. Results show a decrease in standard deviation of about 0.2 - 0.4 m/s. So, we can point out, that the higher standard deviation of wind speed from COADS, perhaps has another source, which is different from natural variability, and connected with higher random error of COADS winds.

As has been mentioned earlier, interannual variability of wind speed, and especially its long terni changes, is the key question of the reliability of COADS winds. It is rather difficult to use our collection of research vessels measurements for the comparison with interannual variations of COADS winds, due to the fact that even for the area with very high density of observations, not every month is complete with data. Nevertheless, we took some effort to check interannual variations, if only for a number of months, provided with relatively high number of measurements. Again, as before we took the same four $4° \times 4°$ boxes for our comparison. The main problem is that even for those individual months, when research vessels worked in this area, not each $2° \times 2°$ box within every $4° \times 4°$ box has data, or has enough of them to calculate monthly means. So, we first calculated $2° \times 2°$ monthly means for those boxes were it was possible. Then for each of these individual months the procedure of optimal interpolation has been made to obtain monthly means for those $2° \times 2°$ boxes, which are not complete with measurements. Of course, even after this procedure, we couldn't generate values for those months, when there was not one research vessel in the Newfoundland region. Then we removed from COADS Release 1a values for those boxes, which were missing from our collection of instrumental measurements. In this way we obtained another version of COADS for this particular area, which is of the same quality (in terms of data coverage), as research vessels data set. After that for this new version of COADS, the same procedure of optimal interpolation was applied. COADS indicates positive wind speed changes for most of the individual months, and most of the boxes. Upward trends are ranging from 0.3 to 0.9 m/s per decade. This is in agreement with the results of Diaz et al, (1995), this volume. Downward trends are obtained only for August. Re-interpolated version of COADS in 95% of cases supports with confidence these tendencies. On the other hand, data from a selected number of research vessels do not indicate any significant trends for any month, except in December. Fig. 6 gives remarkable examples of this disagreement for May. So we can point out that positive wind trends in COADS Release la are not supported by the homogeneous data of research vessels. Isemer (1995, this volume) comes to the same conclusion, comparing COADS Release 1a with OWS data.

It is interesting also to make a separate comparison for only those months and 2-degree boxes, which are very complete with data from research vessels. Most of these data were collected during special boundary layer experiments, carried out mostly during winter and spring of 1984, 1985, 1987, 1988 and 1990. Table 1 shows that the number of reports for certain boxes during these months sometimes is considerably higher in our research vessels collection, than in COADS Release 1a. On the other hand, we have to note that monthly means in COADS for these months are mostly determined by the contribution from research vessels. So, we shouldn't expect very remarkable differences. Nevertheless, even these 14 cases indicate higher wind speed from COADS in comparison with original sampled data and in comparison with wind, adjusted to a 10 meter level. Standard deviation, taken from COADS release Ia are also higher, although the difference here is not so remarkable, for the whole data set (4.5 m/s and 4.8 m/s respectively for research vessels and COADS).

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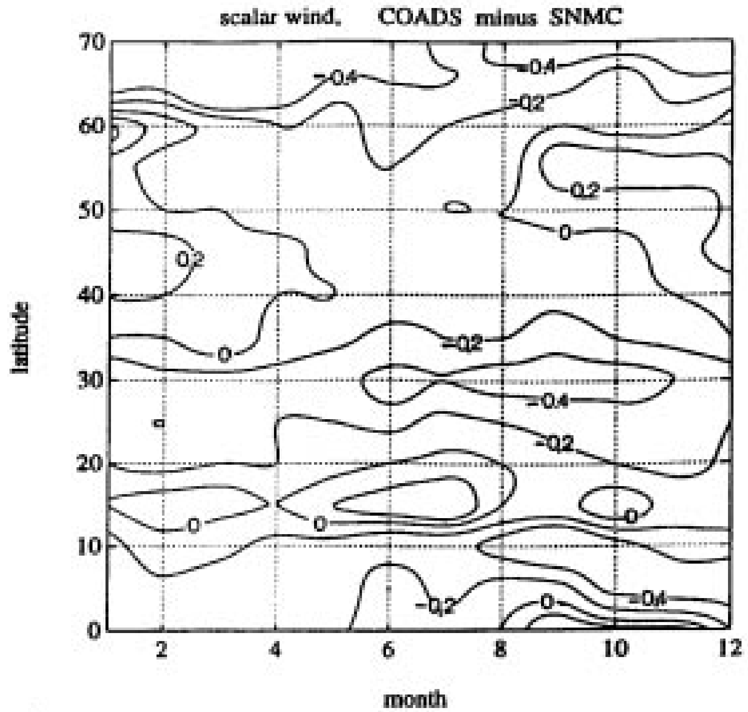
Table 1: Comparison of 2° × 2° monthly mean wind speed from COADS and research vessels measurements for some complete months.

NN	Month /year	number of reports (RV)	number of reports (COADS)	mean V (RV)	mean V_{adj} (RV)	mean V (COADS)	std (RV)	std (COADS)
1	1/84	78	167	11.5	10.0	11.1	3.6	4.2
2	11/85	187	74	12.1	11.0	12.8	4.2	4.4
3	12/85	240	142	12.9	11.8	12.0	5.6	5.5
4	3/86	131	143	12.9	11.6	13.2	5.1	5.4
5	2/87	84	49	10.2	8.9	12.3	4.1	6.0
6	3/87	490	69	12.8	11.6	13.3	5.2	5.1
7	3/88	455	143	11.2	9.8	10.4	4.9	4.9
8	3/88	489	148	12.4	11.2	11.6	5.1	5.4
9	3/88	107	75	9.5	8.6	12.2	4.8	4.0
10	3/88	530	539	12.9	11.6	12.5	5.2	5.7
11	4/90	399	93	8.2	7.0	8.6	4.0	4.4
12	4/90	338	82	10.7	9.6	10.8	4.0	3.9
13	4/90	470	143	8.3	7.5	8.6	3.2	3.8
14	10/90	208	45	11.7	10.7	9.9	4.0	3.8
mean		300	146	11.2	10.1	11.4	4.5	4.8

Figure 1: Comparison of zonal average seasonal cycle and zonal annual mean from COADS and SNMC climatologies.



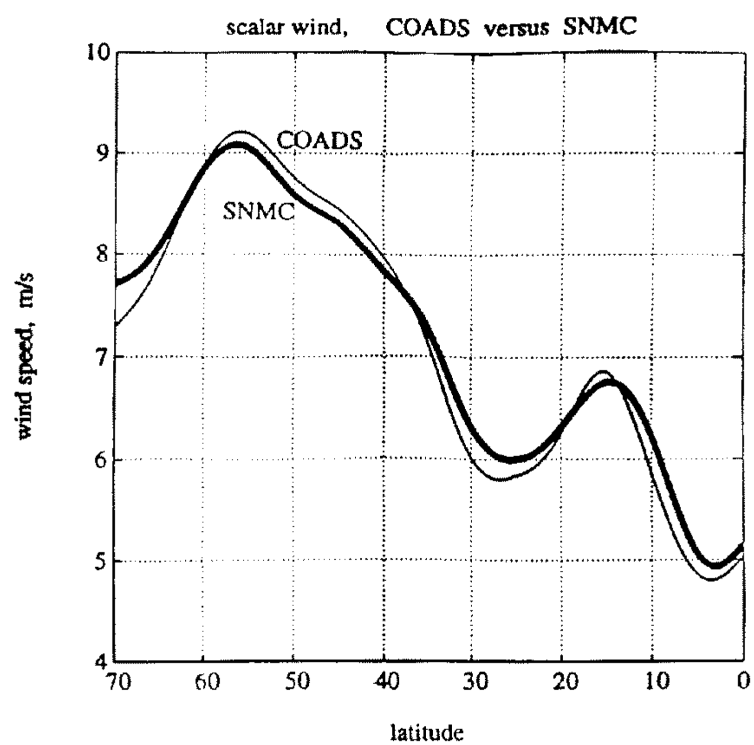


Figure 2: Seasonal distribution of the number of observations in COADS (white area) and in research vessels collection (black area).

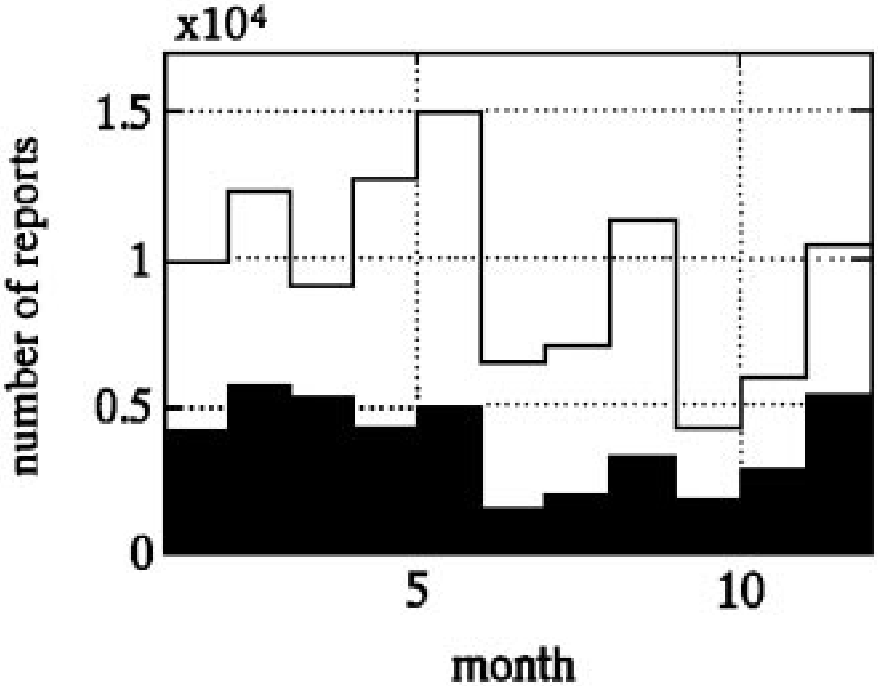


Figure 3: Comparison of COADS monthly mean for 2° by 2° boxes with research vessels monthly means for the period 1981-1991.

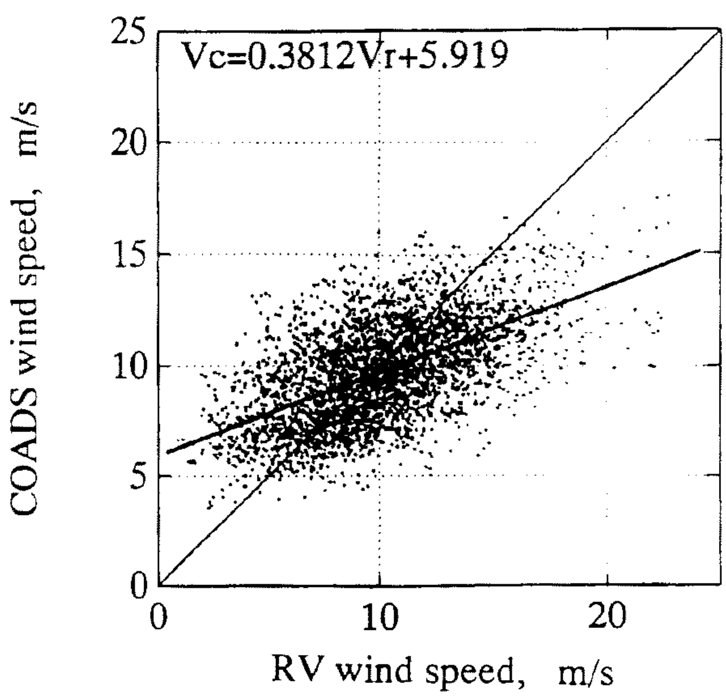


Figure 4: Dependence of regression line between COADS and research vessels wind speed on the anemometer reference level (left panel) and the minimum number of research vessels reports (right panel). Numbers indicate anemometer level and minimum number of reports respectively.

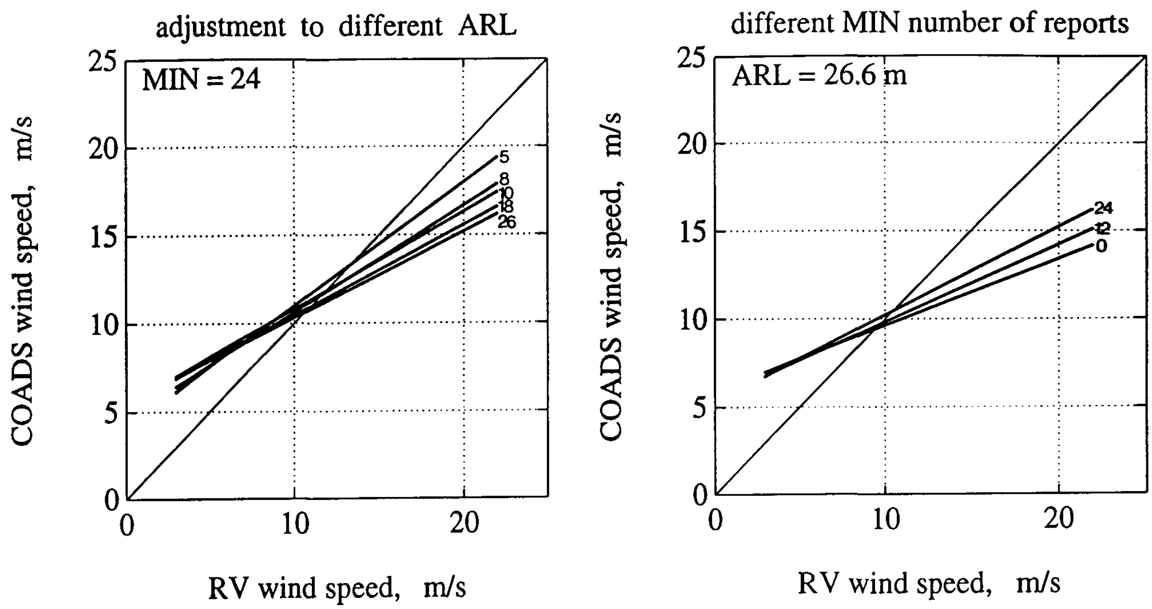


Figure 5: Seasonal march of wind speed, taken from COADS (dashed line) and from research vessels collection before (thin line) and after (bold line) adjustment of 10 meters anemometer level.

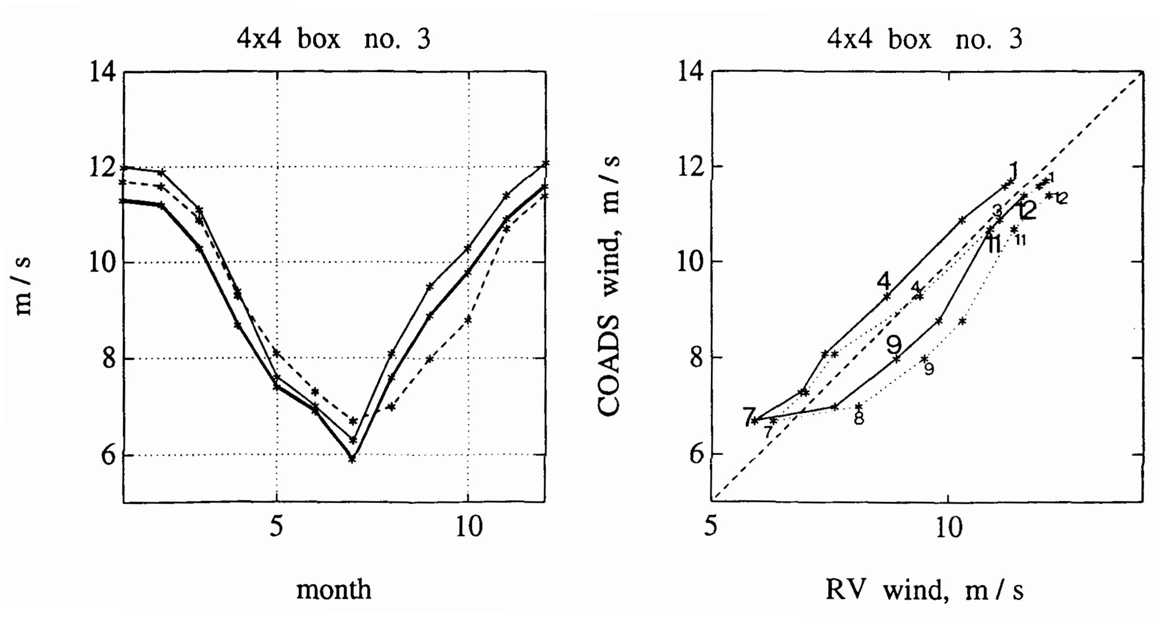


Figure 6: Interannual variability of May values of wind speed, taken from original COADS (dashed line), COADS, adjusted research vessels data coverage (crosses), and from research vessels collection (black points).