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Comparison of low-level satellite winds and surface winds observed by research ships during summer MONEX-1979

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सार — ग्रीष्मकालीन मानसून प्रयोग (मॉनेक्स-1979) के दौरान सोवियत रूसी अनुसंधान जलयानों और गोज (I-O) उपग्रह द्वारा क्रमश: भूपृष्ठीय पवनों और उपग्रह-व्युत्पित निम्नतलीय मेघ संवहित पवनों को प्राप्त किया गया है। 6 बजे और 12 बजे ग्री० मा० स० के लिए जलयानों के स्थिर स्थानों पर प्रेक्षित पवनों का औसत निकाला गया है क्योंकि संयुक्त राज्य अमेरिका में विस्कोसिन विश्वविद्यालय के दल द्वारा व्युत्पित उपग्रह पवनें 0930 बजे से 1030 बजे ग्री०मा०स० प्रेक्षणों से सम्बन्धित थे। उपग्रही व्युत्पित निम्नतल मेघ संवहित पवनों और जलयानों से प्राप्त पवनों के बीच औसत दिशा और रफ्तार में अन्तर 19° और 1.3 मीटर प्रति सेकण्ड थे। पवन रफ्तार और पवन दिशा के लिए समंज्जित रेखीय समाश्रयण समीकरणों से कुल प्रसरण के 71% और 87% को स्पष्ट करते हैं। जबकि u और v संघटक के लिए रेखीय समाश्रयण समीकरण कुल प्रसरण के 86% और 49% का स्पष्टीकरण करते हैं। यद्यपि इन दो पवनों मापों के आपसी सम्बन्ध उपग्रह व्युत्पित निम्नतल मेघ संवहित पवनों से भूपृष्ठीय पवनों के पूर्वानुमान में 95% भरोसा सुनिश्चित करता है फिर भी और अधिक अध्ययन की आवश्यकता है क्योंकि हमारा अध्ययन सीमित आंकड़ों पर आधारित है और ग्रीष्मकालीन मानसून प्रयोग–1979 के दौरान स्थिर जलयानों के प्रेक्षणात्मक मंचों के क्षेत्रीय व्याप्ति तक प्रतिबन्धित है।

ABSTRACT. During summer MONEX-1979, surface winds and satellite-derived low-level cloud drift winds were obtained from Russian research ships and GOES (I-O) satellite respectively. The winds observed at the stationary positions of the ships were averaged for 06 and 12 GMT, since the satellite winds derived by the University of Wisconsin group in U.S.A. referred to 0930 - 1030 GMT observations. Average direction and speed differences between satellite-derived low-level cloud drift winds and ship winds were 19 deg. and 1.3 m/s. The fitted linear regression equations for wind speed and wind direction explain 71% and 87% of total variance whereas linear regression equations for u and v component explain 86% and 49% of total variance. Though the relationship between these two wind measurements assures 95% confidence in predicting surface winds from satellite-derived low-level cloud drift winds a further study is required as our study is based on the limited data and restricted areal coverage of observational platforms of stationary ships during summer MONEX-1979.

1. Introduction

The satellite derived low-level cloud drift winds are being routinely utilised in weather analysis over the ocean areas where the geostationary satellites are located. A number of investigators have compared satellite-derived low-level winds with the winds observed by ships or buoys (Halpern 1978, 1979; Wylie *et al.* 1981; Schott & Fernandez 1981). During FGGE 1979, geostationary satellite GOES-IO was positioned over the Indian Ocean for observing the atmospheric activities and this gave researchers their first opportunity to continuously view the monsoon circulation over the Indian Ocean. During summer MONEX period research ships recorded meteorological data at their stationary positions as well as during their cruises over the tropical Indian Ocean. In the present study we have used wind data derived from the GOES-IO satellite at low-level (Young *et al.* 1980) and compared them with the research ship wind observations.

2. Data used

2.1. *Satellite winds*

During summer MONEX-1979, Indian Ocean geostationary satellite GOES belonging to United States was specially brought to a new location at 58°E to watch the atmospheric activities over the Indian Ocean. This provided a good coverage of cloud wind tracers during summer monsoon months. GOES-IO measurements were ideal because they possessed both high spatial and high temporal resolution (1 km in visible, 8 km in infrared and half hourly sampling frequency). GOES-IO produced images of the earth and its cloud cover in the spectral bands 0.5-0.9 μm (visible) and 11-12 μm (infrared) respectively. Estimates of low-level wind fields deduced from cloud motions were extracted on McIDAS (Man computer Interactive Data Access System). From auto-correlation coefficient of satellite wind measurements, it was found that the correlation

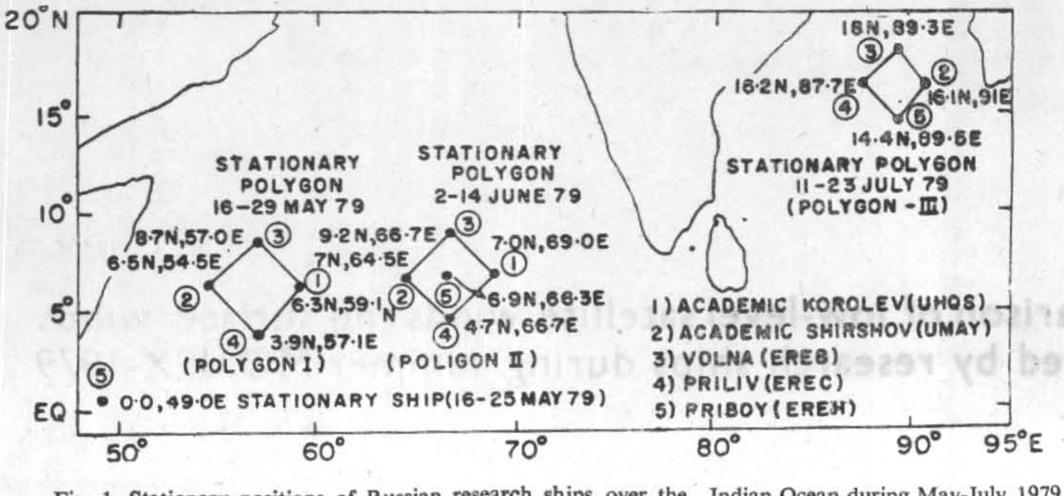

Fig. 1. Stationary positions of Russian research ships over the Indian Ocean during May-July 1979

TABLE 1

Ship	Standard deviation					Corr. coef.	
		Ship		Satellite		*u*	*v*
	N	*u* (m/s)	*v* (m/s)	*u* (m/s)	*v* (m/s)		
May 1979							
EREH	9	1.46	1.65	2.44	1.48	0.39	—0.29
EREB	13	3.35	2.07	3.87	3.02	0.57	0.61
EREC	13	2.86	1.97	4.04	1.98	0.82	—0.35
UMAY	13	2.66	1.53	4.16	2.02	0.85	0.25
June 1979							
EREH	13	2.54	3.85	4.18	3.77	0.70	0.54
EREB	13	2.79	2.27	4.34	2.26	0.94	0.74
EREC	13	4.51	1.88	4.42	2.82	0.95	0.45
UHQS	13	4.19	0.99	4.52	3.11	0.89	0.49
UMAY	13	4.22	2.45	4.48	3.59	0.80	0.12
July 1979							
EREH	13	1.86	2.25	2.79	2.17	0.73	—0.27
EREC	13	1.90	2.34	2.82	2.41	0.72	0.22
UHQS	13	2.35	1.46	3.02	2.78	0.95	0.40
UMAY	13	1.85	2.78	2.61	3.07	0.60	0.21
May-July 1979							
All ships	39	3.28	2.44	4.05	2.57	0.92	0.70

N=Number of observations

TABLE 2

Ship	Standard deviation					Corr. coef.	
		Ship		Satellite		Dir.	Sp.
	N	Dir. (°)	Sp. (m/s)	Dir. (°)	Sp. (m/s)	(°)	(m/s)
May 1979							
EREH	9	25.97	1.76	22.02	1.42	.70	—.02
EREB	13	59.89	1.73	41.19	2.75	.82	.84
EREC	13	40.42	2.08	42.47	2.59	.91	.47
UMAY	13	49.72	1.49	34.51	2.84	.91	.25
June 1979							
EREH	13	34.53	1.73	48.11	2.43	.68	.63
EREB	13	109.55	1.90	118.39	3.14	.98	.77
EREC	13	86.47	3.36	90.52	2.55	.98	.90
UHQS	13	92.37	3.56	90.97	3.07	.97	.85
UMAY	13	42.78	4.10	47.29	3.21	.80	.80
July 1979							
EREH	13	20.14	2.16	20.22	1.68	—.01	.70
EREC	13	20.83	1.38	20.36	2.13	.45	.69
UHQS	13	19.45	1.98	22.58	2.15	.82	.85
UMAY	13	19.36	2.49	28.19	1.98	.57	.58
May-July 1979							
All Ships	39	43.83	2.49	46.17	2.57	.93	.84

N=Number of observations

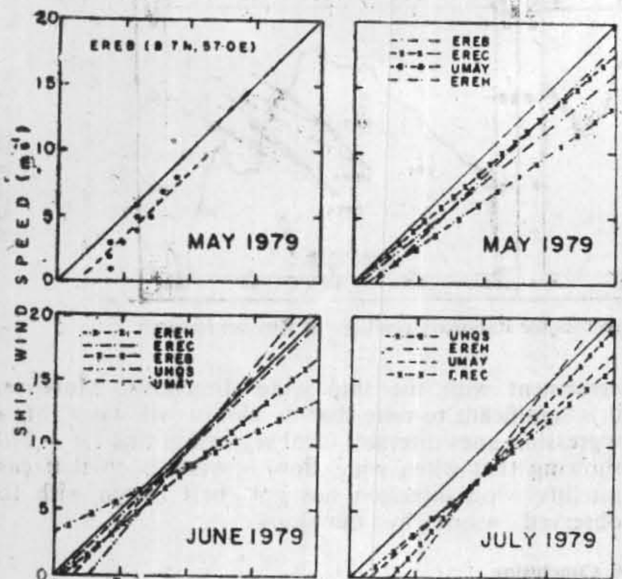

Fig. 2. Scatter diagram and linear regression lines (dashed lines) of each set of ships and satellite wind speed. Solid line represents ideal regression curve

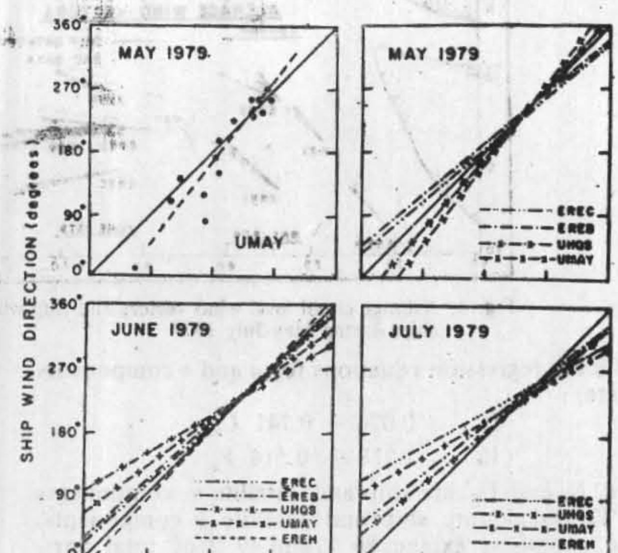

Fig. 3. Scatter diagram and linear regression lines (dashed lines) of each set of satellite and ship wind directions. Solid line represents ideal regression curve

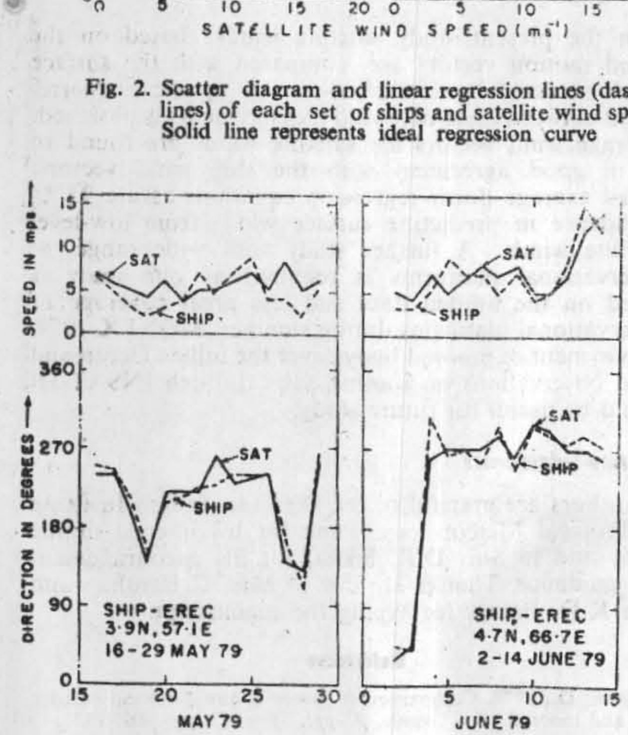

Fig. 4. Time series of ship winds and cloud level winds for ship EREC during May and June 1979

coefficient was significant within 5° square (Wylie and Hinton 1981). Therefore, on some occasions when the satellite winds were not observed exactly overhead the ships location, we have then derived the mean wind in a 5° quadrangle centring the ships position in that grid.

2.2. *Ship winds*

In the present study we have utilised data received from stationary positions of Russian research ships in the polygon formation (Fig. 1) which were located at 6.3°N, 59.1°E (UHQS); 6.5°N, 54.5°E (UMAY), 8.7°N, 57.0°E (EREB), *3.9°N, 57.1°E (EREC)* for the period 16-29 May 1979; 7.0°N, 69.0°E (UHQS), 7.0°N, 64.5°E (UMAY), 9.2°N, 66.7°E (EREB), 4.7°N, 66.7°E(EREC), 6.9°N, 66.3°E (EREH) for the period 2-14 June 1979 and 18.0°N, 89.5°E (UHQS), 16.1°N, 91.0°E (UMAY), 16.2N, 87.7°E (EREC), 14.4°N, 89.5°E (EREH) for the period of 11-23 July 1979. Apart from these polygon formation one Russian research ship EREH (00, 49.0°E) was stationary over the equator for the period 16-25 May and the data recorded by that ship were also used in the study. The surface winds (at the deck level, *i.e.*, ~10 m a.s.l.) at ship locations were averaged for 0600 GMT and 1200 GMT since the satellite winds derived by the University of Wisconsin group (Young *et al.* 1980) referred to 0930 - 1030 GMT observations.

3. Comparison of satellite and ship wind measurements

To compare satellite and ship wind measurements, average u and v components for both ship and satellite winds were computed. These average u and v components were used to calculate vector-averaged speed (s) and direction (θ), *i.e.*, $s=(u^2+v^2)^{\frac{1}{2}}$ and $\theta=\tan^{-1}u/v$. Correlation coefficients between these two wind measurements for u, v components (Table 1) as well as for wind direction and wind speed (Table 2) were computed. Linear regression equations were computed for each stationary position of Russian research ship for wind direction and wind speed separately (Figs. 2 and 3). Also, the average linear regression equations for wind direction and wind speed as well as for u and v components were computed. For an intercomparison of ship and cloud-level winds, time series of speeds and directions for the ship EREC during May and June is displayed in Fig. 4 and mean cloud-level wind vectors and ship wind vectors are displayed in Fig. 5.

4. Results

The following are the major results of the study :

(*i*) Linear regression equations for the total data set in respect of wind speed and wind direction are

$$V_s = 0.12+0.793\ V_g \quad (1)$$

$$\theta_s = 16+0.9\ \theta_g \quad (2)$$

where, V_s and V_g are ship and satellite wind speeds and θ_s and θ_g are ship and satellite wind directions. These equations explain 71% and 87% of total variance in wind speed and wind direction respectively.

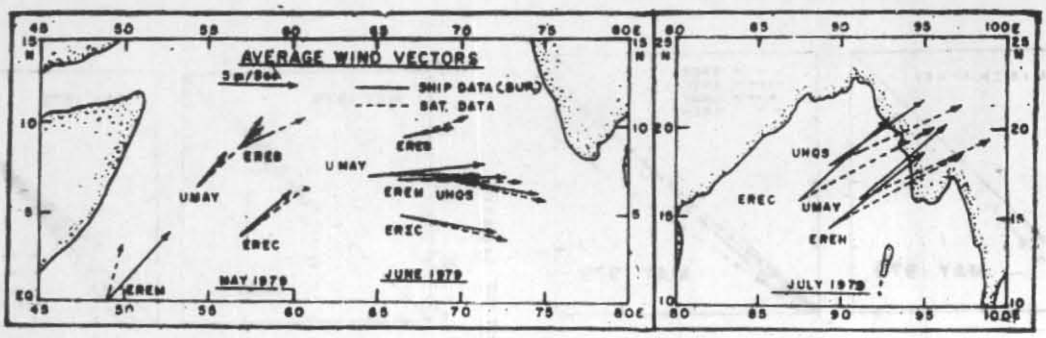

Fig. 5. Average cloud level wind vectors and ship wind vectors for stationary positions of Russian research ships during May-July 1979

(*ii*) Linear regression equations for *u* and *v* components are :

$$U_s = 0.074 + 0.741 \; U_g$$
$$V_s = 1.218 + 0.514 \; V_g$$

where, U_s and U_g are ship and satellite *u* components and V_s and V_g are ship and satellite *v* components. These equations explain 86 % and 49 % of total variance in *u* and *v* component respectively.

(*iii*) Wind directions as obtained from satellite data are in good agreement with those observed by the ships. Satellite-derived wind speeds are somewhat stronger (about 1-2 mps) than the winds reported by the ships.

(*iv*) Average direction and speed differences between satellite and ship wind vectors are found to be 19° and 1.3 ms^{-1}.

(*v*) For the sequences of stationary ship positions the satellite winds fluctuate more (as measured by standard deviation) than ship winds.

(*vi*) On an averge correlation coefficients between satellite and ship wind measurements have been found to be statistically significant.

5. Discussion

Halpern (1978, 1979) compared cloud-level winds with the surface winds over the equatorial Pacific, and Wylie *et al.* (1981) over the Pacific and the Atlantic Oceans. They found that these two wind measurements were not well correlated. Schott and Fernandez-Partagas (1981), on the basis of their study over the western Indian Ocean, observed significant correlation between these two wind measurements. Our study agrees well with the study of Schott and Fernandez-Partagas with a significant correlation between satellite and ship wind measurements for even other parts of Indian Ocean. Larger standard deviation observed in majority of the cases for satellite winds (Tables 1 and 2) may be attributed to several differences in the procedures of observations between satellite and ship wind measurements. During summer monsoon months low-level winds over the Indian Ocean are generally stronger at the height of 1-1.5 km in the lower troposphere. Fig. 2 shows that satellite-derived winds are stronger than the surface winds observed by the ships. It is obvious because satellite-derived winds at low-level pertain to about 900 mb (~1 km) while surface winds observed by ships to few tens of metres (~10 m, *i.e.,* deck level of ship) above sea-level. Fig. 3 shows that computed linear regression lines slightly fluctuate from ideal regression line (solid line) indicating that satellite wind directions are in good agreement with the ship wind directions. Moreover, it is significant to note that in almost all cases linear regression lines intersect ideal regression line at ~270° showing that when wind flow is westerly in that case satellite wind direction has got best match with the observed winds by the ships.

6. Conclusion

In the present study satellite winds based on the cloud motion vectors are compared with the surface winds observed by research ships. A significant correlation between these two wind measurements is observed. Average wind vectors for satellite winds are found to be in good agreement with the ship wind vectors. Fitted average linear regression equations assure 95 % confidence in predicting surface winds from low-level satellite winds. A further study with wide range of observational platforms is required as our study is based on the limited data and less areal coverage of observational platforms during summer MONEX-1979. Deployment of moored buoys over the Indian Ocean and wind observations on routine basis through INSAT-1B would be useful for future study.

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References

Halpern, D., 1978, Comparison of low-level cloud motion vectors and moored buoy winds, *J. appl. Met.*, **17**, pp. 1866-1871.

Halpern, D., 1979, Surface wind measurements and low-level cloud motion vectors near the Intertropial Convergence Zone in the Central Pacific Ocean from November 1977 to March 1978, *Mon. Weath. Rev.*, **107**, pp. 1523-1534.

Maddox, R.A., and Vander Haar, T.H., 1979, Covariance analysis of satellite-derived meso-scale wind fields, *J. appl. Met.*, **18**, pp. 1327-1334.

Schott and Fernandez-Partagas, 1981, The onset of the summer monsoon during the FGGE 1979 Experiment Off the East African Coast : A comparison of wind data collected by different means, *J. geophys. Res.*, **86**, pp. 4173-4180.

Wylie, D.P., Hinton, B.B. and Millette, K.L., 1981, A comparison of three satellite-based methods for estimating surface winds over oceans, *J. appl. Met.*, **20**, pp. 439-449.

Wylie, D. P. and Hinton, B.B., 1981, Some statistical characteristics of cloud motion winds measured over Indian Ocean during the summer monsoon, *Mon. Weath. Rev.*, **109**, pp. 1810-1812.

Young, J.A., Virji, D.P., Wylie and Cecil Lo, 1980, 'Summer Monsoon Windsets from Geostationary satellite Data", Space Science and Engineering Centre, Madison.