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DIFFERENCES OF SOUTH CHINA SEA SUMMER MONSOON DERIVED BY NCEP AND ECMWF REANALYSIS DATA

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1 INTRODUCTION

Due to long-term time series and many elements, reanalysis data of National Centers for Environmental Prediction (NCEP) and European Center for Medium-Range Weather Forecasts (ECMWF) are widely used in present climate studies. Even so, there are discrepancies between NCEP and ECMWF reanalysis. Some climate fields may be better reproduced by NCEP than by ECMWF. On the other hand, ECMWF may describe some climate characteristics more realistically than NCEP. Xu et al.[1] pointed out that NCEP data are of uncertainty when used for studying long-term trends of climate change. By comparing temperatures and pressures from NCEP and observation, it can be seen that NCEP data show higher reliability in the east and lower-latitudes of China than in its west and higher latitudes, NCEP temperature is of more reality than pressure and NCEP data after 1979 are closer to the observations than before. Yang et al.[2] also revealed some serious problems of NCEP data in the north of subtropical Asia. Regional differences of NCEP data in representation are also explored by other studies[3-4]. As for seasonal variability, NCEP simulates relatively real conditions of Chinese summer and annual mean but winter data are relatively bad, as in comparisons of NCEP data wity China surface station observations by Zhao et al.[5] Moreover, Trenberth and Stepaniak[6] showed that ECMWF data had better energy budgets than NCEP data for pure pressure coordinates are adopted by ECMWF. Renfrew et al.[7] compared NCEP data to ECMWF data in terms of surface fluxes and the results indicate that the time series of surface sensible and latent heating fluxes from ECMWF are 13% and 10% larger than the observations and those from NCEP would be 51% and 27% larger than the observations, respectively. So, Renfrew et al. suggested that it be more appropriate to drive ocean models by ECMWF data. Based on comparisons of multiple elements by some scientists, it seems that ECMWF data are better than NCEP data on global, hemispheric and regional scales. Whereas, reanalysis have big errors in some regions in contrast to observations, especially the variables related to humidity[8]. Since that, researchers should compare the two sets of data and select a better one according to specific problems.

To study monsoon using the reanalysis, it is also vary important to choose data. Better data will reproduce monsoon circulations more accurately and help us understand the characteristics of monsoon on multiple temporal and spatial scales. Annamalai et al.[9] compared some differences between NCEP and ECMWF data in monsoon regions as followings. For climatological seasonal variability, ECMWF data are closer to observations in rainfall and diabatic heating, and NCEP data have some large errors of dry anomalies due to underestimated rainfall over the tropical ocean; the differences of the two datasets are also in precipitation on the interannual scale, which will be responsible for the discrepancy of strong and weak monsoon if the monsoon indices are defined by

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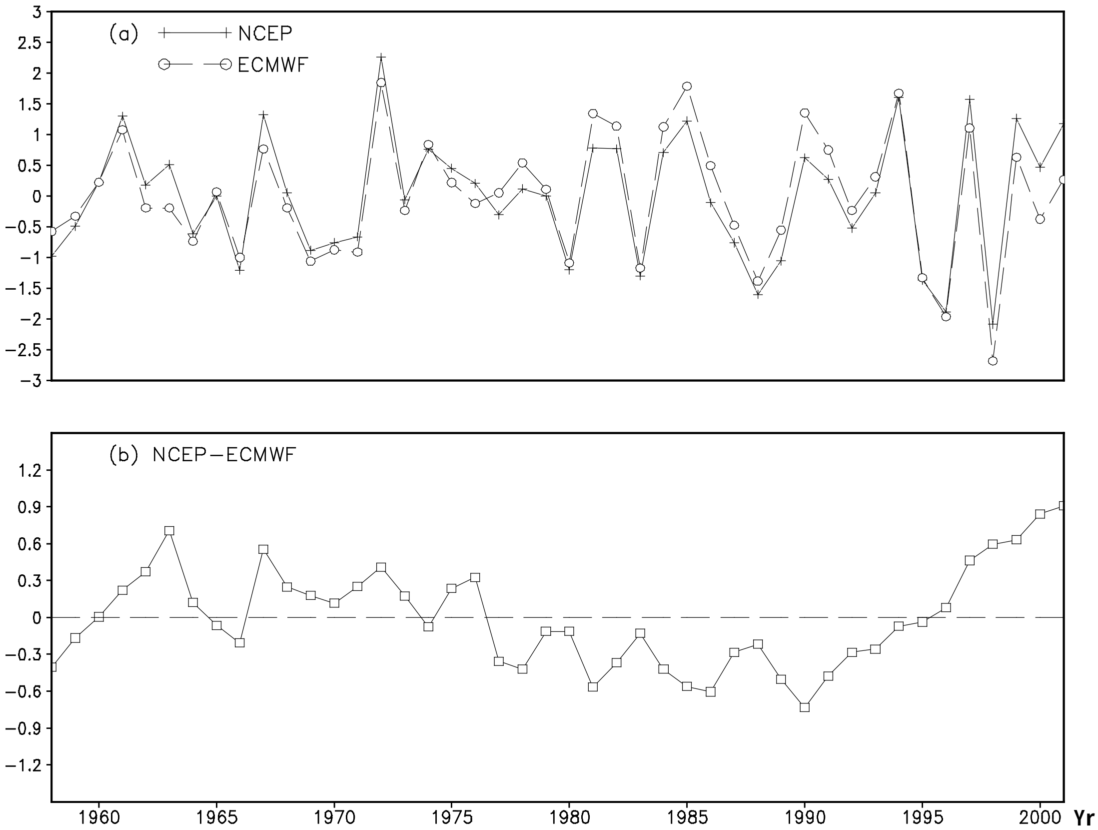

Fig.1 South China Sea summer monsoon indices from NCEP and ECMWF (a) and their difference (b), with long-term trends removed. unit: m/s.

the two datasets; though differences also appear in interannual wind, they are more consistent than the precipitation. For example, the dynamic monsoon indices from large scale wind shear (DMI, defined by zonal wind differences at 850 hPa and 200 hPa over the region of 5 – 20 °N, 40 – 110°E[10]) agree with each other well.

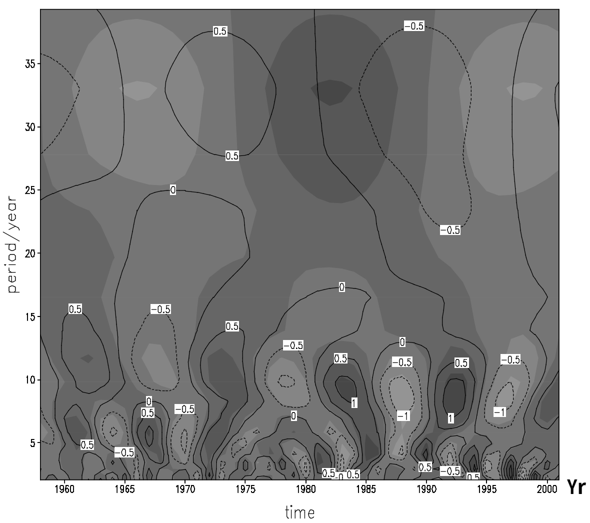

Fig.2 Wavelet analysis of SCSSM indices from ECMWF and NCEP. Interdecadal periods, affected by edge, are valuable by combining Fig.1.

Due to the lack of observation stations in the South China Sea (SCS), the reanalysis are often used to study SCS summer monsoon (SCSSM). Comparisons by Annamalai et al.[9] emphasize on the South Asia monsoon region and the period of 1979 – 1995, in this paper the SCSSM differences by NCEP and ECMWF data are explored on interannual and interdecadal scales and long-term trends. Then compare them to the data from Xisha sounding station and 1998 SCS monsoon experiment (SCSMEX) for temporal and spatial variations, respectively. The results will help us select a better set of data (especially in lower tropospheric wind) in studying SCSSM.

2 DATASETS

The monthly mean zonal winds u and meridional winds v with period of 1958 – 2001 from NCEP and ECMWF, u and v sounding observations of 1958～1998 from Xisha sounding station and limited area assimilation data from 1998 SCSMEX, all at 850 hPa, are used in this paper. Mean u and v time series in SCS

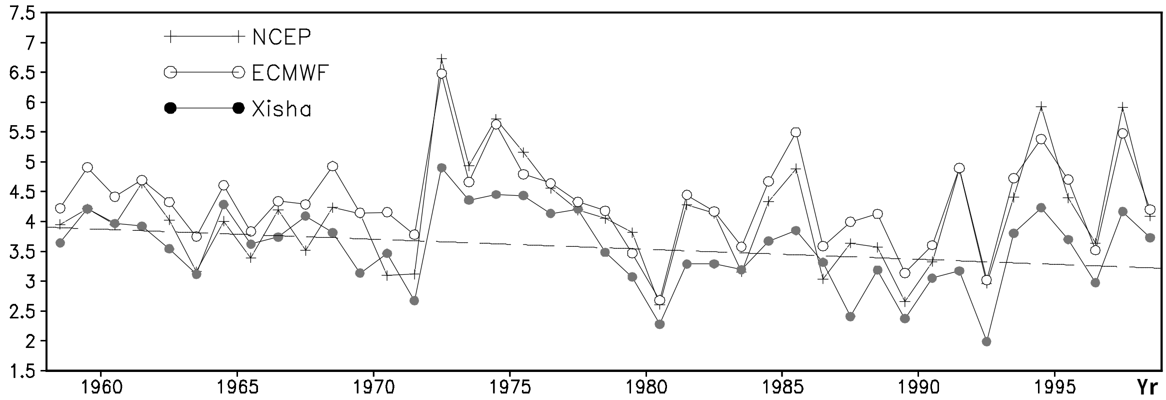

Fig.3 Comparison of southwesterlies at 850 hPa from NCEP and ECMWF to the sounding data in Xisha. Specifically, NCEP and ECMWF data are averaged around Xisha by four grids (110 – 112.5 °E, 15 – 17.5 °N), unit: m/s. The dash line represents linear trend of the southwesterly at 850 hPa in Xisha.

(105 – 120 °E，5 – 20 °N) averaged from June to August are obtained. The u and v of sounding averaged through summer as well. SCSMEX limited area assimilation data cover an area at 70 – 150 °E, 10 °S – 40 °N. The SCSSM index is defined as mean southeasterly over SCS region from June to August [11-13].

$$I_m = (\overline{u_{850}} + \overline{v_{850}}) / \sqrt{2}$$

where $\overline{u_{850}}$ and $\overline{v_{850}}$ represent mean zonal wind and meridional wind at 850 hPa over SCS.

3 RESULTS

The computed trend coefficients from NCEP and ECMWF during the period of 1958 – 2001 are -0.272 and 0.003, respectively. It is obvious that SCSSM indices from NCEP tend to decrease sharply but that from ECMWF do not have significant long-term trends.

With long-term trends removed, the SCSSM indices from NCEP and ECMWF data are compared on interannual and interdecadal scales. The strong interannual variability of SCSSM indices is shown in Fig.1a. It indicates that SCSSM indices derived from NCEP and ECMWF data are rather consistent, though slight differences, induced by different interdecadal variabilities, exist in amplitudes. Fig.1b shows that the difference of the two series has an around 36-yr period. During 1960 – 1976, almost all the NCEP SCSSM indices with long-term trends removed are larger than that of ECMWF but are reversed during 1977 – 1995. The wavelet analysis results in Fig.2 indicates that they behave as in-phase on interannual scale, but the variations do not synchronize on periods larger than 15-yr. The 44-yr data will be responsible for the unreliable interdecadal periods (in particular for the above 25-yr periods) due to edge effects of wavelet analysis, but the about 30-yr period can be taken as reference. The difference mentioned above may be one of the main discrepancies.

There are relatively long-term sounding observations only at Xisha in the South China Sea, locating at 112 °20’E, 16 °50’N. For the comparisons, NCEP and ECMWF data are averaged around Xisha by four grids (110 – 112.5 °E，15 – 17.5 °N). It is shown in Fig.3 that southwesterly of Xisha at 850 hPa tends to decrease with a coefficient of -0.31. But both the trends of southwesterlies mean around Xisha from NCEP and ECMWF are not clear and the trend coefficients are close to zero. Further study indicates that meridional wind decreases will mainly attribute to the southwesterly trend for Xisha. By comparing, the results suggest that the NCEP meridional wind around Xisha correlates better with the observations than the ECMWF data, and the correlations coefficients are 0.726 and 0.653, separately.

Both the NCEP and ECMWF data agree well with the Xisha observations on the interannual scale after the departure of long-term trends. Considering the consistence of variation on the interannual scale, differences of two sets of reanalysis data and Xisha observations lie in interdecadal variabilities. Euclidean distance (as follows) is used to measure which correlates to the data of Xisha better.

$$D_{ij} = \sqrt{\sum_{k=1}^{41} ({}_iI_{\mathrm{ID}}^k - {}_jI_{\mathrm{ID}}^k)^2}$$

Then, $D_{\text{NCEP-Xisha}}$=3.35 m/s and $D_{\text{ECMWF-Xisha}}$=2.52 m/s. Thus, ECMWF data seem to be closer to the observations on the interdecadal scale.

Tab.1 shows that the NCEP data are closer to the SCSMEX data not only over SCS but also over the region covered by the SCSMEX data. Moreover, compared to the SCSMEX data, the NCEP data have more real meridional wind and zonal winds of two reanalysis datasets SCSMEX have few differences, especially over the region with SCSMEX data.

Tab.1 Spatial Similarity of the NCEP and ECMWF Data to the SCSMEX Data of 1998

Similarity coefficient with SCSMEX data		South China Sea (105 – 120°E, 5 – 20 °N)	Region covered by SCSMEX data (70 – 150 °E, 10 °S – 40 °N)
NCEP	*U*	0.924	0.963
	V	0.838	0.861
ECMWF	*U*	0.869	0.947
	V	0.731	0.686

4 SUMMARY

The SCSSM intensity indices (defined by mean southwesterly at 850 hPa from June to August in the region of 105 – 120 °E, 5 – 20 °N) from the NCEP and ECMWF data are compared on multiple time scales. Temporal and spatial differences from the observations of Xisha sounding station and SCSMEX are explored, respectively. The results indicate that SCSSM denoted by the lower tropospheric winds from NCEP data have better trend than that from ECMWF data and the ECMWF reanalysis reproduce better interdecadal variation. Both the NCEP and ECMWF data agree well with the observation on the interannual scale. As for spatial distribution, SCSSM from the NCEP data is more similar to the observations than that from the ECMWF data. Of cause, the comparisons in the paper are not sufficient due to the lack of observations. In spite of this, the work will, to some extent, help us select reanalysis data (especially for the lower tropospheric winds) in SCSSM research.

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