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The co-variability of the characteristics of summer monsoon eddy activity in the South China Sea

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We have used the STORM simulation of a high-resolution (0.1° on average grid resolution; Zhang and von Storch, 2017) to derive a series of characteristics of the eddy activity (Zhang et al., 2018), namely regional mean of eddy intensity (EI), the mean eddy diameter (ED), the accumulated eddy number (N), the mean travel length (L) and the number of eddy points with over 90th percentile intensity (N90). The eddies are considered travelling objects, conneted through a track. Eddy points, on the other hand, are all points on all tracks.

Now, we want to study the co-variability of these 5 statistics, separately for anticyclonic (AE) and for cyclonic eddies (CE). We have formed "anomalies", i.e., subtracted the multi-year mean (1950-2010). Note that the EI of Anticyclonic eddies (AE) is positive while the EI of Cyclonic eddies (CE) is negative.

First, we examine the covariance matrix of the 10 seasonal statistics (see table). Sine the different variables go with different magnitudes and units, we have normalized them, with zero mean and standard deviation 1, the matrix is the symmetric **correlation matrix**.

The correlation measures the co-variability of two variables. EI co-varies with ED and the number of intense eddy points for AEs and CEs. Or, in plain words: **When the mean intensity of, say anticyclonic eddies, is higher, then the eddies tend to be larger in size, and there are more intense eddies**. Same with opposite sign, of course. The same for cyclonic eddies, but CEs and AEs do not co-vary in a noteworthily manner. On the other hand, the eddy number and the mean travel length show weak connection, and no noteworthy link to the intensity and size

In a second step, we examine the eigenvectors of the correlation matrix, i.e., the EOFs.

The figure 1 shows the first 4 EOF patterns of the eddy statistics. The first EOF shows the similar variability of the mean EI, the mean ED and the number of intense eddy points for both AEs and CEs. The three variables show opposite variability in AEs and CEs in the second EOF. The first two EOFs represent almost 47% of the total variance.

It may be that the two EOFs are degenerate, i.e., belong to the same eigenvalue, and may be rotated to two other orthogonal vectors, with one having noteworthy entries only for AEs and the other only for EIs.

The next two EOFs are connected with considerably less variance, namely together only 28%. EOFs 3 and 4 link the number of eddies, the number of intense eddies and the track length together. EOF2 combines the AEs and the CEs, and EOF4 describes opposite behavior in the two types of eddies. Again, the two EOFs may be again degenerate. **The story told by the EOF3 and 4 is that if there are more eddies, then there are also more intense eddies, and their tracks are longer**, and vice versa. **It appears plausible that along longer tracks, and more tracks, there are more intense points along these tracks than along shorter tracks.** However, this link is considerable weaker than the earlier identified link between intensity, size and number of intense events.

The links between the different seasonal eddy statistics seem to be plausible, but we are not aware of systematic studies, which discuss the dynamical background of such links.

Zhang M., and H. von Storch, 2017: Towards downscaling oceanic hydrodynamics - Suitability of a high-resolution OGCM for describing regional ocean variability in the South China Sea. *Oceanologia* 59, 166-176, DOI 10.1016/j.oceano.2017.01.001

Zhang M., H. von Storch, D. Wang, Chen X., and Li D., 2018: Statistics of travelling eddy variability in the South China Sea, 1950-2010 (manuscript, submitted)

Table 1 The correlation matrix of the 10 predictands

	EI_AE	EI_CE	ED_AE	ED_CE	N_AE	N_CE	L_AE	L_CE	N90_AE	N90_CE
EI_AE	1									
EI_CE	-0.03	1								
ED_AE	0.86	0.08	1							
ED_CE	0.06	-0.84	-0.05	1						
N_AE	0.04	-0.01	0.04	0.14	1					
N_CE	0.02	0.11	-0.03	-0.13	0.26	1				
L_AE	0.13	-0.07	0.16	0.05	0.39	0.09	1			
L_CE	0.17	-0.04	0.08	0.03	-0.22	0.09	-0.15	1		
N90_AE	0.62	-0.16	0.45	0.27	0.02	-0.06	0.05	0.22	1	
N90_CE	0.17	-0.49	0.07	0.41	-0.14	0.16	0.05	0.21	0.39	1

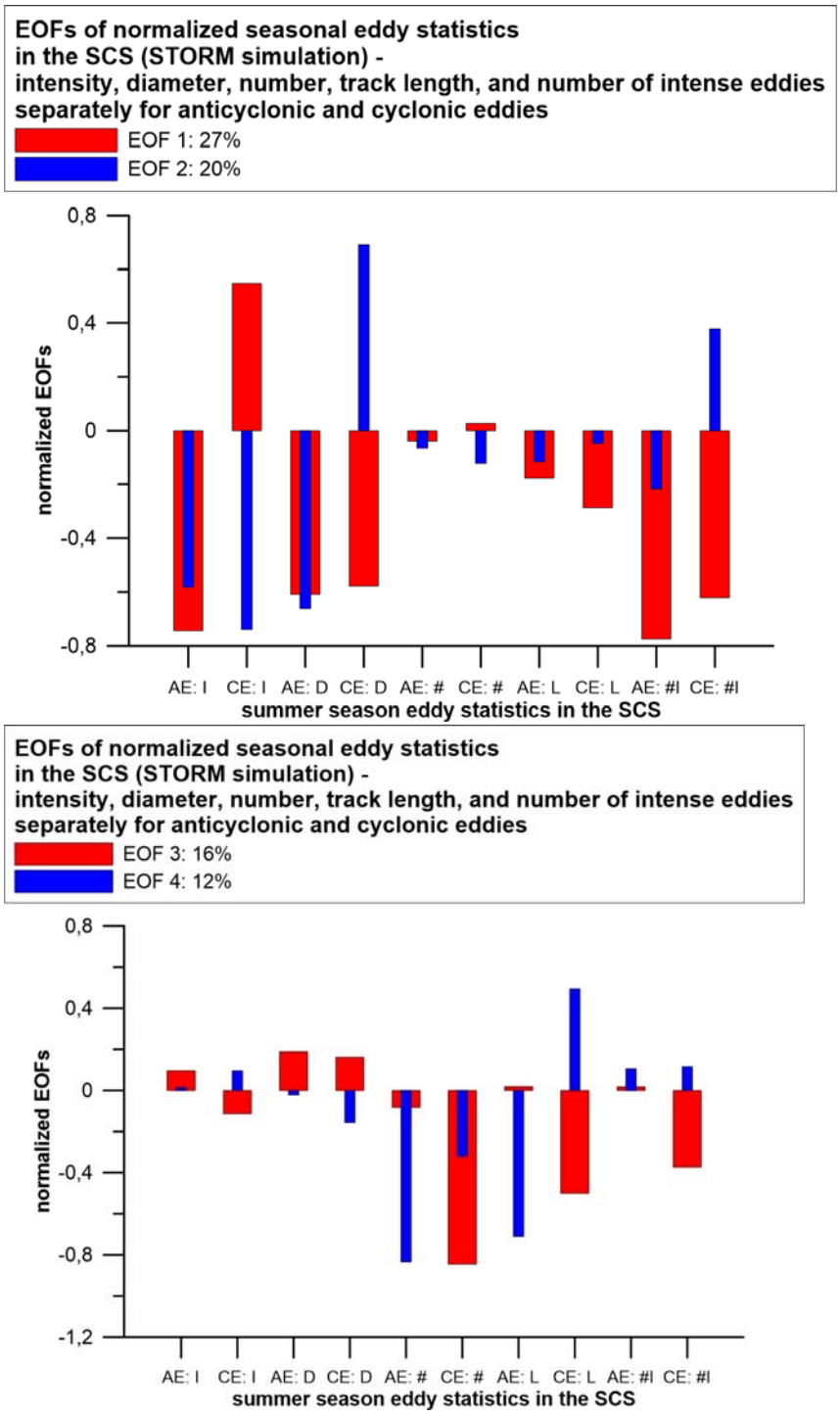

Figure: The first 4 EOF patterns of the eddy statistics