Grouping the normal modes, a way to characterize tsunami sources in Japan Sea

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Satake and Shimazaki (1988) calculated the normal mode solutions of Japan Sea, qualitatively grouped the calculated modes into the whole Japan Sea modes and the regional modes, then discussed the properties of tsunami excitation of the 1963 Niigata earthquake and the 1983 Japan Sea earthquake.

We extended their method and obtained a high resolution normal mode solution of Japan Sea (Wu and Satake, 2015). We also characterized tsunami sources in Japan Sea, for the 60 potential submarine sources recently proposed by Japanese Ministry of Land, Infrastructure, Transport and Tourism.

In this study, we quantitatively grouped the normal mode solutions into basin-wide modes, regional modes and local modes, based on the eigenvectors, or water height distribution. We examined several statistical parameters, such as mean (first moment) or variance (second moment), and Kurtosis, which is the fourth moment divided by the square of the second moment. We finally selected Kurtosis to group the modes. We determined that the modes with Kurtosis < 35 as the basin-wide mode, those with Kurtosis > 350 as local modes, and those between as regional modes. Out of 6000 modes that we have calculated, 622 modes are grouped as basin-wide mode, 4953 modes are regional modes and 425 modes are local modes.

We then calculated the excitation weights of the 60 potential submarine faults. The average excitation weight is larger if the moment magnitude is larger or the source is located at shallower water depth. In order to examine the contribution from the above 3 groups, we compared the average weights of largest 425 modes, and found that those from the regional modes are the largest. For the regional modes, the faults located at shallower water depth generally have larger excitation weights. This indicates that the regional modes excited by an earthquake at shallow water depth is most powerful.

Finally, eigenfunctions of these regional modes with large average weight for the 60 faults show that they have large amplitude in wide shore areas, where these faults are located. This is in agreement with the obtained results and also reminds us to pay special attentions to the regional modes excited by potential sources at relatively shallower water depth.

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