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Objective Classification of the Sea Level Pressure Distribution Pattern in East Asia: Analysis of the Cold Half of the Year

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As the first step in a series of statistical downscaling studies, an objective classification of the sea level pressure (SLP) distribution pattern in the East Asian region was conducted. Patterns classified by this method for the cold half of the year were characterized by referring to their group mean distribution patterns, prevailing seasons, and those obtained by traditional weather classification methods. On the basis of the time series of patterns obtained, the continuity of each pattern and transition between patterns were also investigated quantitatively depending on the probability. This method is based on multivariate analysis, in which a large number of parameters from the SLP field (distribution pattern) are integrated into a limited number of objective indices, and the distribution patterns are classified depending on the indices. First, SLP data at 00UTC for a period of 30 years (1979-2008) from the NCEP/NCAR dataset were analyzed using principal component analysis (PCA). Then, 10,958 days (distribution patterns) were classified into groups by cluster analysis in the six-dimensional space with the axes of the first six component scores of the PCA. Winter SLP distribution patterns in the East Asian region were classified into 12 groups (patterns). Each pattern was named according to the feature clarified. These patterns were mainly characterized as a strong winter pattern (three groups: Siberian high type, Aleutian low type, mixed type), weak winter pattern (three groups), cyclone pattern, anticyclone/cyclone pattern (two groups), anticyclone pattern (two groups), and others. Our method classified the strong winter pattern into three groups from the meteorological point of view. Through the use of the additionally calculated six-hourly time series of the patterns, the temporal continuity of each group was investigated. The group to which specific groups tend to shift was also clarified quantitatively. In the interannual variation of the frequency of each group, no increasing or decreasing trend was found, especially in those of the strong winter patterns. Our method enables the objective classification of the SLP distribution patterns according to the quantitative value. This will be helpful in evaluating climate change quantitatively from the frequency and intensity of each pattern when our method is applied to future SLP distribution patterns in the globally warming world.

Key words: weather classification, principal component analysis, cluster analysis, sea level pressure, statistical downscaling

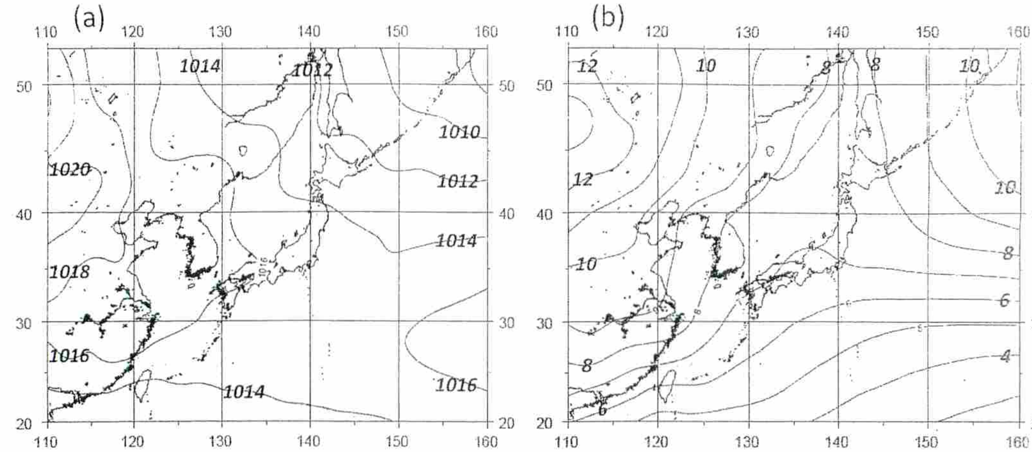

Fig. 1 (a) Mean and (b) standard deviation of sea level pressure (SLP) at 00UTC for 30 years (1979-2008) over the study area

Unit: hPa.

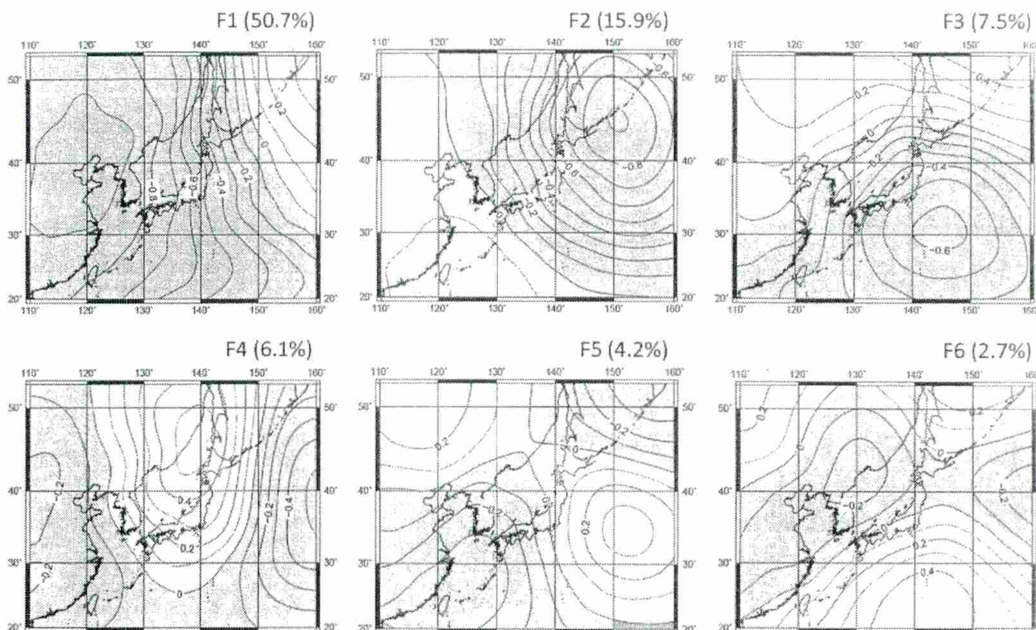

Fig. 2 First six factor loadings of principal components (PCs) for 30 years (1979-2008) in SLP reanalysis data (NCEP/NCAR) at 00UTC

Negative values are hatched. Numbers in parentheses denotes the proportion of each PC.

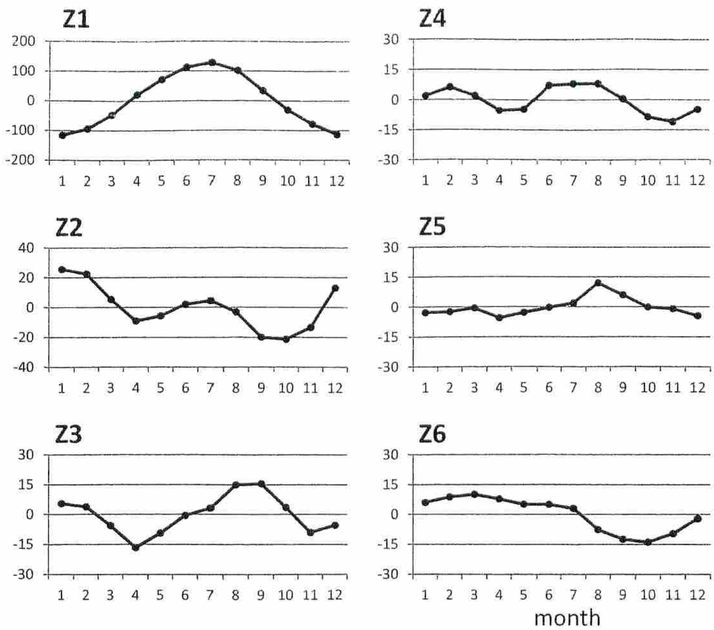

Fig. 3　Annual variation in Z-component scores of the principal components for SLP

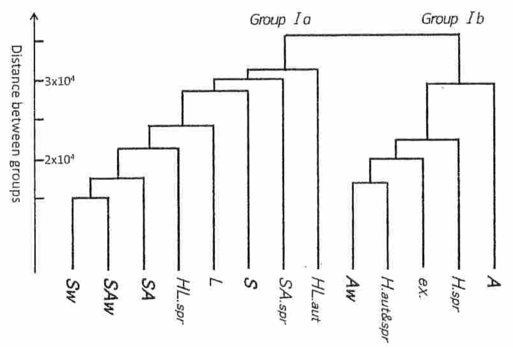

Fig. 4　Dendrogram of clusters (SLP distribution patterns) for the cold season

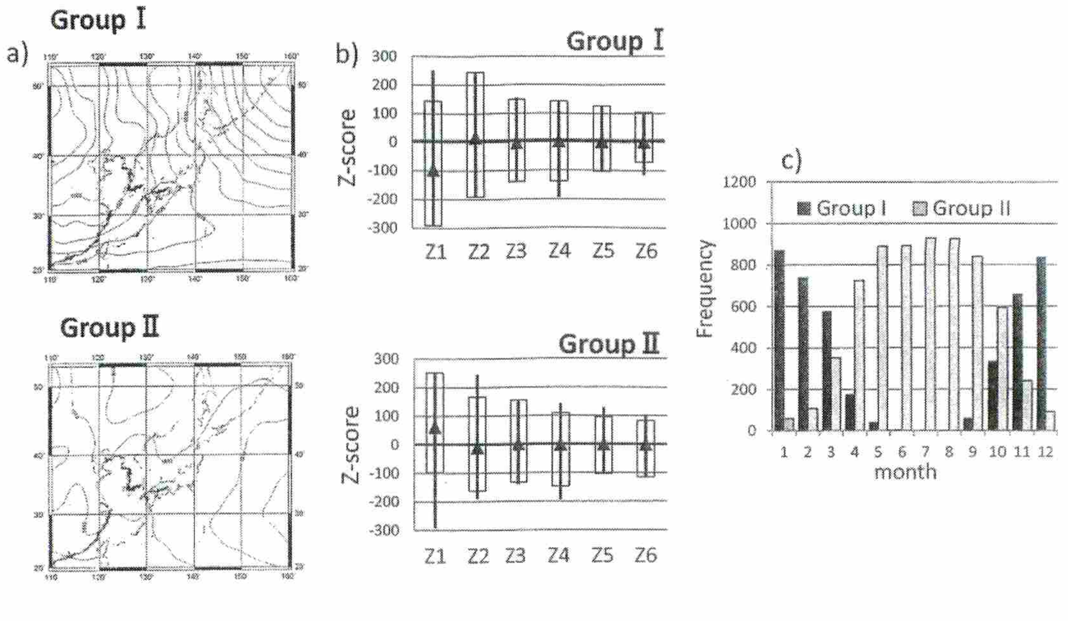

Fig. 5 Comparison between group I and group II
a) Group mean SLP patterns synthesized from the first six *Z*-components, b) group mean *Z*-component scores for the first six PCs (▲) with the maximum and minimum value within groups (box plot) and data range for all data (bar), and c) seasonal variation in the frequency.

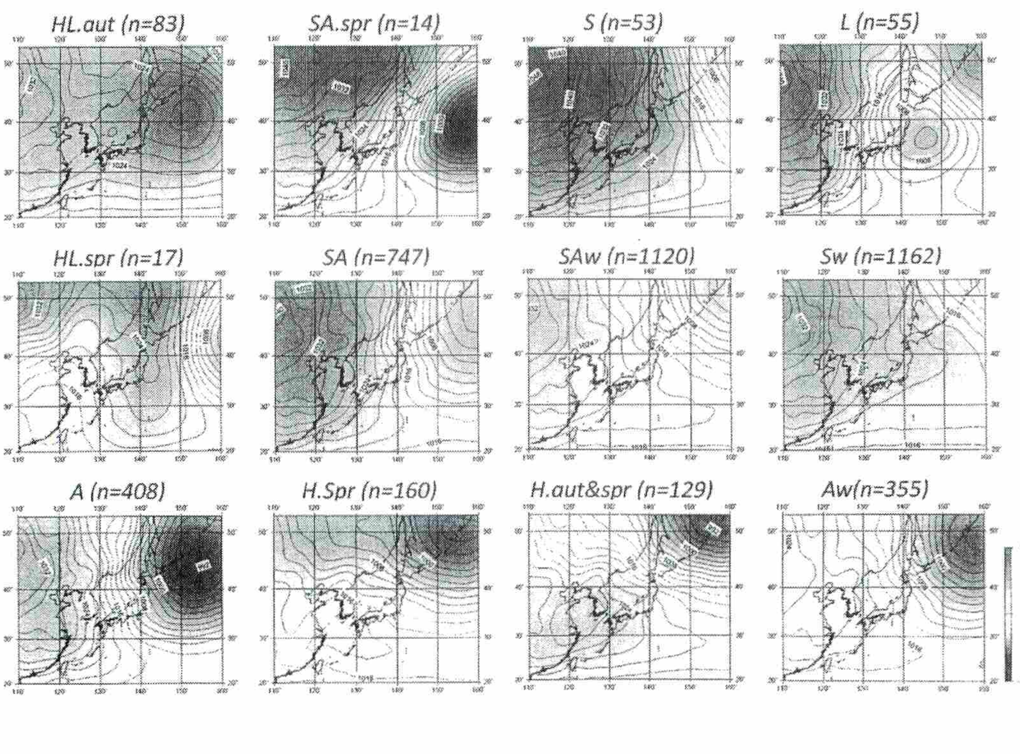

Fig. 6 Mean SLP distribution pattern of each group synthesized from the first six *Z*-components
Contour interval, 4 hPa. Color represents deviation from the 30-year mean.

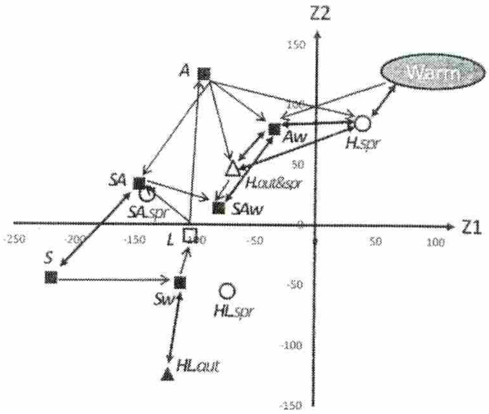

Fig. 7　Central position of each group projected on the $Z1$–$Z2$ plane

Symbols correspond to the groups prevailing in winter (□), spring (○), and autumn (△). Open symbols denote that higher-order PCs (>$Z3$) dominate in the group. Arrows and thick two-way arrows indicate a tendency for transition between groups. See the text (Section III-5) for details.

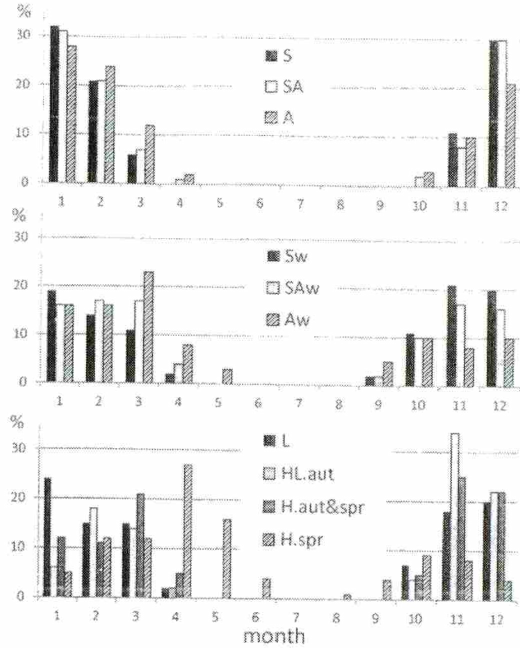

Fig. 8　Monthly frequency of each group

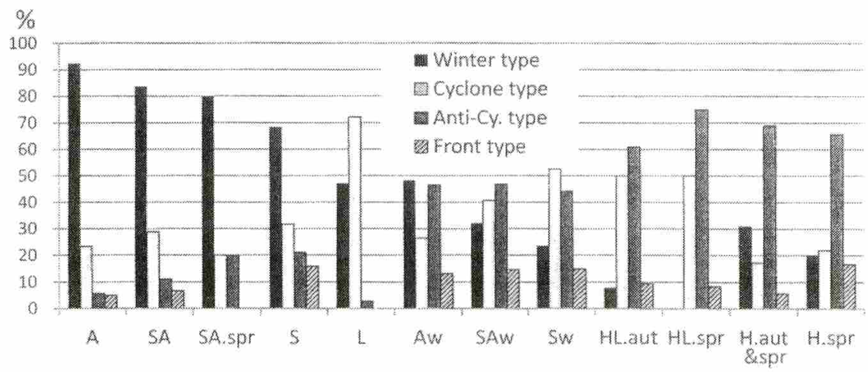

Fig. 9　Correspondence between groups with those of the traditional Yoshino-Kai classification

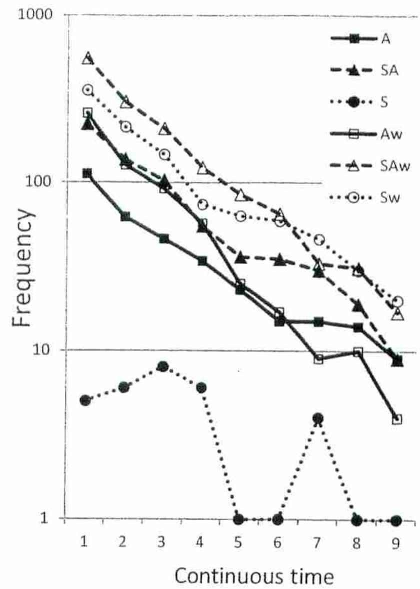

Fig. 10　Continuity of each group depending on the frequency for any continuous days

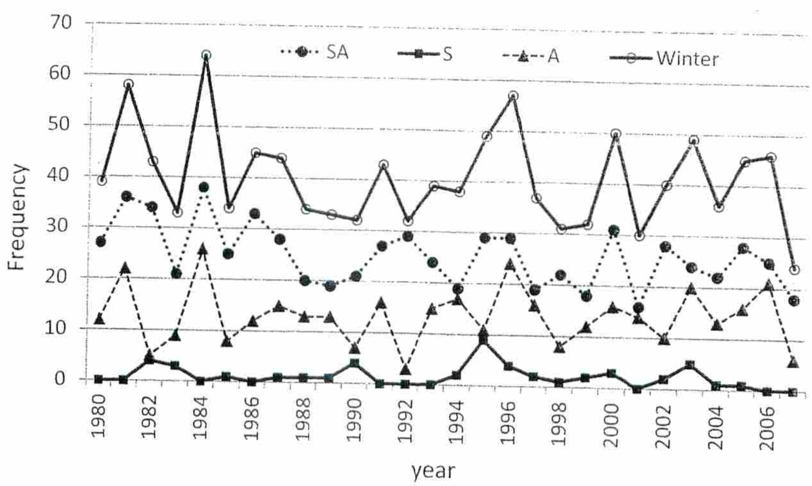

Fig. 11　Interannual variation in the frequency of three typical winter groups

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