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Kiyotaka SAKAIDA

1 Introduction

Various studies have been conducted on year-to-year variations of winter precipitation in Japan. Most have emphasized contrasts of variations between the Pacific and the Japan-Sea sides, indicating anti-phase of year-to-year variation curves in both regions. Asakura *et al*. (1961) presented a negative correlation between the two regions ; however the value was not high. They point out that the variations in the Japan-Sea side were not uniform, and that the San-in district was differed from the other regions on the Japan-Sea side.

The purpose of this paper is to investigate the regionality of winter precipitation variations in the Japan-Sea side region, with reference to circulation patterns in the Far East. The distribution of the amount of precipitation is regionally complicated by landform. In winter, the Japan-Sea coast is exposed to the northwestern monsoon with the mountain in the background. It is, therefore, considered that the distribution of the amount of precipitation in proximity to the Japan-Sea coast is not yet complicated by landform but correlates with circulation patterns in the Far East. Shitara (1980) selected stations located near the Japan-Sea coast in order to eliminate the landform effect and divided the region into winter climate types.

In this paper, the author also selects stations near the Japan-Sea coast in order to eliminate the landform effect, and investigates regional differences of year-to-year variation from the rather macro scale viewpoint.

2 Variability of winter precipitation

2.1. Japan as a whole

Regionality of winter precipitation variation is examined using principal component analyses. Data used in this paper are monthly precipitation from December to February at twenty three stations which have eighty years data series from 1901 to 1980. Monthly precipitation is transformed into cubic roots, to be normalized.

Fig. 1 shows distribution of eigen vectors for January precipitation and their time series. The first and second components account for 36.3 and 14.4 percent respectively.

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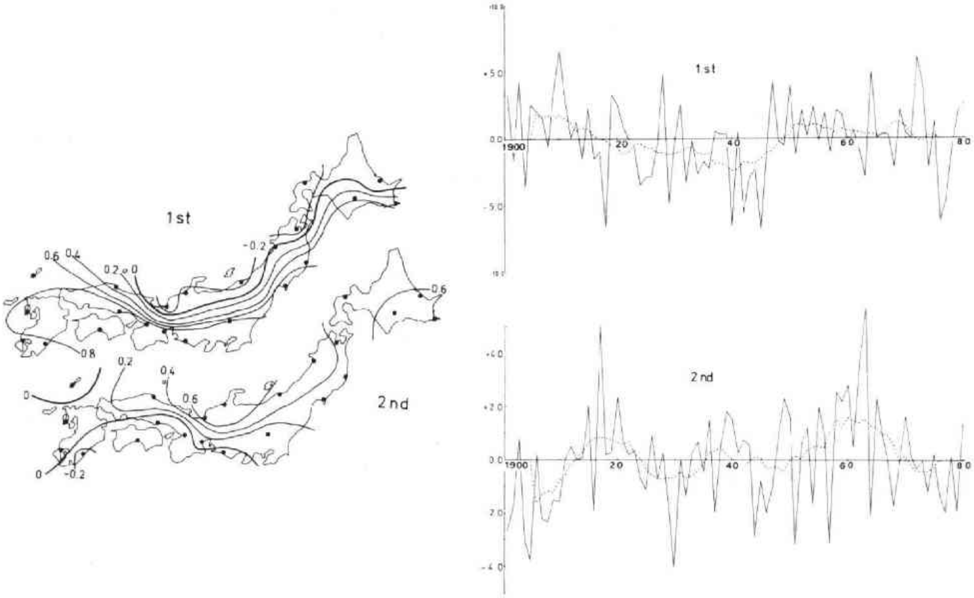


Fig. 1 Distribution of eigen vectors for January precipitation (left) and time series of the scores (right).
Dashed line indicates 11 year running mean.

The first component which chiefly represents variations on the Pacific side has a slight negative value in the Japan-Sea side. The second component, on the other hand, represents that on the Japan-Sea side. The first and second components have no correlation with each other; therefore, the variability on both sides is not a simple negative link as in a seesaw. The Pacific side has a considerable amount of precipitation which is caused by passages of depressions along the southern coast of Japan. The first component, therefore, represents precipitation caused by depressions. Winter monsoon precipitation is expressed by the second component.

From the time series of the first component, two maxima around 1910 and in the 1950's are recognized. These maxima are found in summer precipitation curves as well. The second component has a twenty year periodicity with maxima around 1920, 1940 and 1960. This periodicity corresponds to snowfall fluctuations in the Japan-Sea side shown by Yamamoto (1972).

2.2. Japan-Sea coast

Shitara (1980) classified the Japan-Sea side region into three subregions taking notice of air temperature, the number of precipitation days and sea surface temperature of the Japan-Sea in winter. From the aspects of year-to-year variation, the

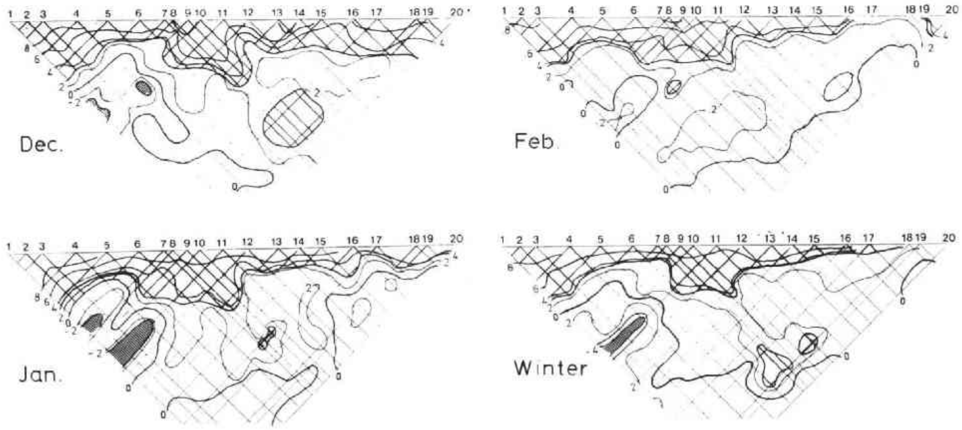


Fig. 2 Correlation coefficients of monthly amounts of precipitation between stations near the Japan-Sea coast.
Hatched area indicates a significant correlation (1% level of significance).

region can be classified into three or four subregions as well. Fig. 2 shows the correlation coefficients of monthly precipitation between twenty stations near the Japan-Sea coast. These twenty stations are located on a hypotenuse in proportion to their real distance. Correlation coefficients are plotted on intersections of each two stations and isopleths are drawn.

Fig. 2 indicates that four subregions are recognized from the viewpoint of homogeneity of year-to-year variation;

(a) San-in : from Hirado (1) to Hamada (4)
(b) Hokuriku : from Tsuruga (7) to Takada (11)
(c) Tohoku : from Sakata (13) to Akita (14)
(d) Hokkaido : from Esashi (16) to Suttsu (17).

Negative correlation between San-in and Hokuriku appears.

The above mentioned facts are common in December, January and February. As the season marches from December to February, correlation coefficients become smaller, especially those between Hokuriku and Hokkaido.

Correlation coefficients of the total amount of winter precipitation are lower than those for each month. This fact is a noteworthy problem when we investigate climatic changes during winter.

3 Variation of the circulation pattern

Winter precipitation in the Japan-Sea side is influenced by the intensity of the northwestern monsoon, the influence is , however, considerably different between subregions. Fig. 3 shows correlation coefficients between January precipitation in

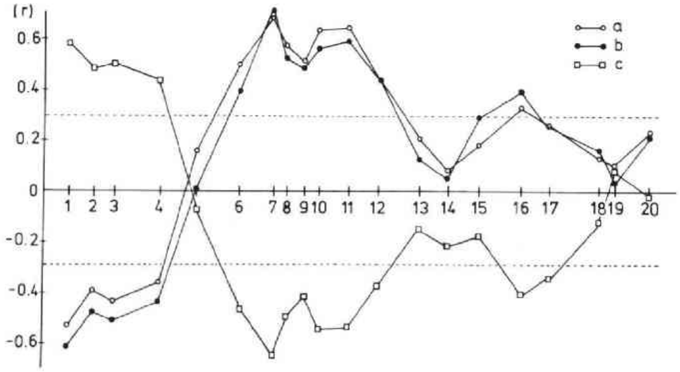


Fig. 3 Correlation coefficients between January precipitation and indices.
a : Surface pressure difference between Irkutsk and Nemuro, b : Surface pressure difference between Inchon and Ishinomaki, c : The first factor of air temperature variation (Sakaida 1980).

each station and three indices which represent an intensity of northwestern monsoon. The former two indices (a, b) represent surface pressure differences between stations on the Asian Continent and Japan. Index (c) is the value of the first factor of the temperature variation field in winter over the East Asia, representing temperatures in southwestern Japan, and signifies the variation in the upper westerlies between a meridional and a zonal pattern (Sakaida 1980). Fig. 3 indicates that heavy precipitation in Hokuriku occurs when the Far East Trough is deeper and pressure gradient

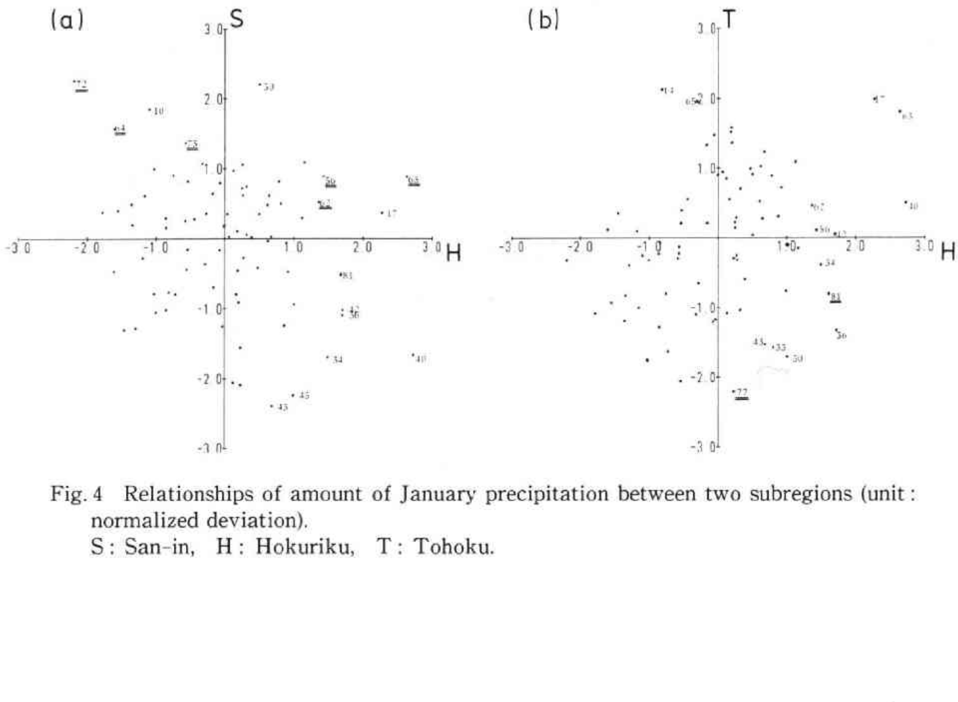


Fig. 4 Relationships of amount of January precipitation between two subregions (unit : normalized deviation).
S : San-in, H : Hokuriku, T : Tohoku.

around Japan increases. In contrast with Hokuriku, heavy precipitation in San-in occurs when the westerly pattern of the Far East is zonal and the pressure gradient decreases. The condition of heavy precipitation in Hokkaido is somewhat similar to that of Hokuriku, while Tohoku is considerably different from other subregions. Heavy precipitation in Tohoku is hardly related to pressure gradients or the first factor.

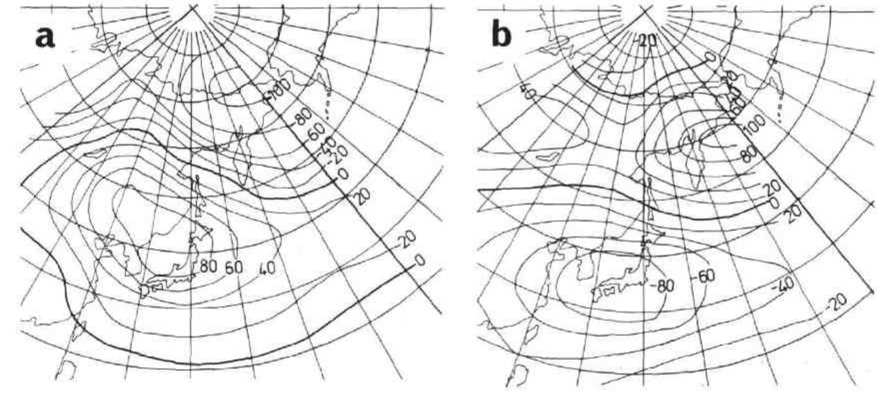
Fig. 4 shows the relationship of the amount of January precipitation between Hokuriku and San-in (a), and Hokuriku and Tohoku (b). In the former case, dots are scattered homogeneously in all quadrants. In the latter case there is a blank in the second quadrant. In order to clarify the circulation patterns of years when the precipitation pattern is typical, years are selected as follows:

a-type: excessive in San-in, and deficient in Hokuriku; 1964, 1972, 1973

b-type: excessive in Hokuriku, and deficient in San-in; 1956, 1962, 1963

c-type: excessive in Hokuriku, and deficient in Tohoku; 1977, 1981.

Fig. 5 shows composite 500 mb height anomaly maps of each type. The a-type



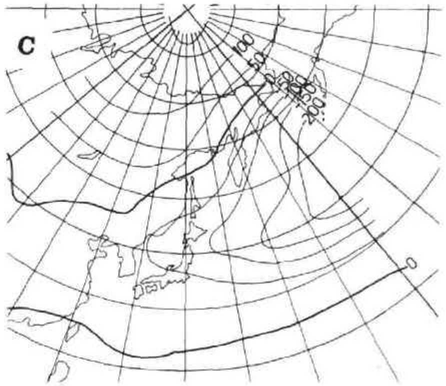


Fig. 5 Composite maps of 500 mb height anomaly. (unit: m)
(a): a-type (1964, 1972, 1973),
(b): b-type (1956, 1962, 1963),
(c): c-type (1977, 1981).

and the b-type indicate reverse patterns in the 500 mb height anomaly maps. In the a-type, the Far Eastern Trough is weak, an axis of the westerlies is oriented northward, which is the typical pattern in the case of mild winters in Japan (Asakura *et al.* 1966). Precipitation in San-in is correlates with that of the Pacific side of Japan (Fig. 1). Heavy precipitation in San-in is caused by depression passing along the Japanese Islands (Tasaka 1980) in accordance with a northward shift of the axis of the westerlies. The b-type shows a severe winter pattern. Low temperature in the western Japan and heavy precipitation in Hokuriku are frequently synchronous. The type c shows a large negative anomaly to the east of Japan, that is, the east-trough type. As a reverse type to type c is rarely seen, it shall be assumed that stations in the Japan-Sea coast of the Tohoku district have heavy precipitation in the case of a west-trough type, and low precipitation in the case of an east-trough type. It seems to support the assumption that those stations have heavy precipitation just before a passage of a Japan-Sea Low (Tasaka 1980), which is tend to be active under a west-trough type.

More detailed precipitation maps are made using data of auxiliary stations in order to clarify the distribution including inland regions. Fig. 6 shows the distribution with more than 500 mm of precipitation in years of above normal in Tohoku (A) and below normal in Tohoku (B) corresponding with excessive precipitation years in Hokuriku. Hatched areas indicate where more than 500 mm of precipitation occurred in January once or three times in five years. In the years of (A), an area with heavy precipitation extends northward in proximity to the coast. In the years of (B), on the

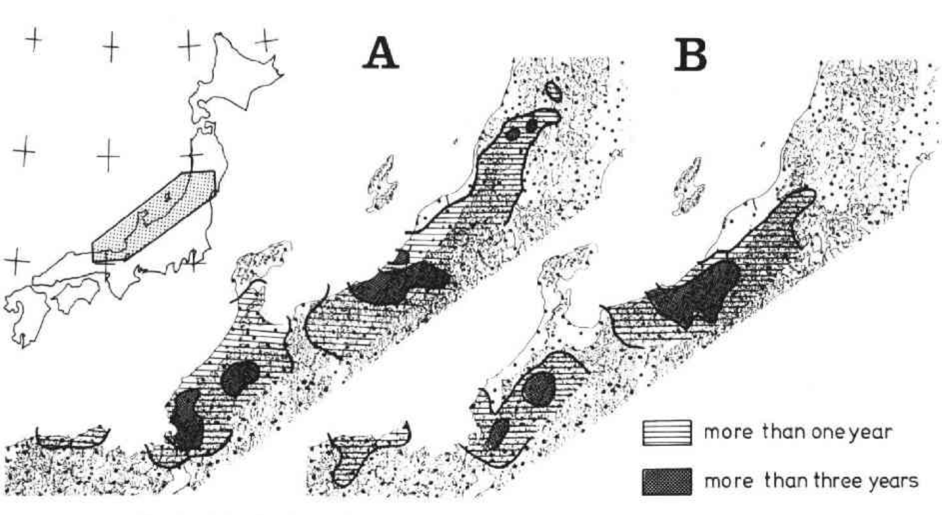


Fig. 6 Distribution of area with more than 500 mm precipitation.
A: Years of above normal in Tohoku (1917, 22, 40, 62, 63).
B: Years of below normal in Tohoku (1934, 36, 43, 45, 77).

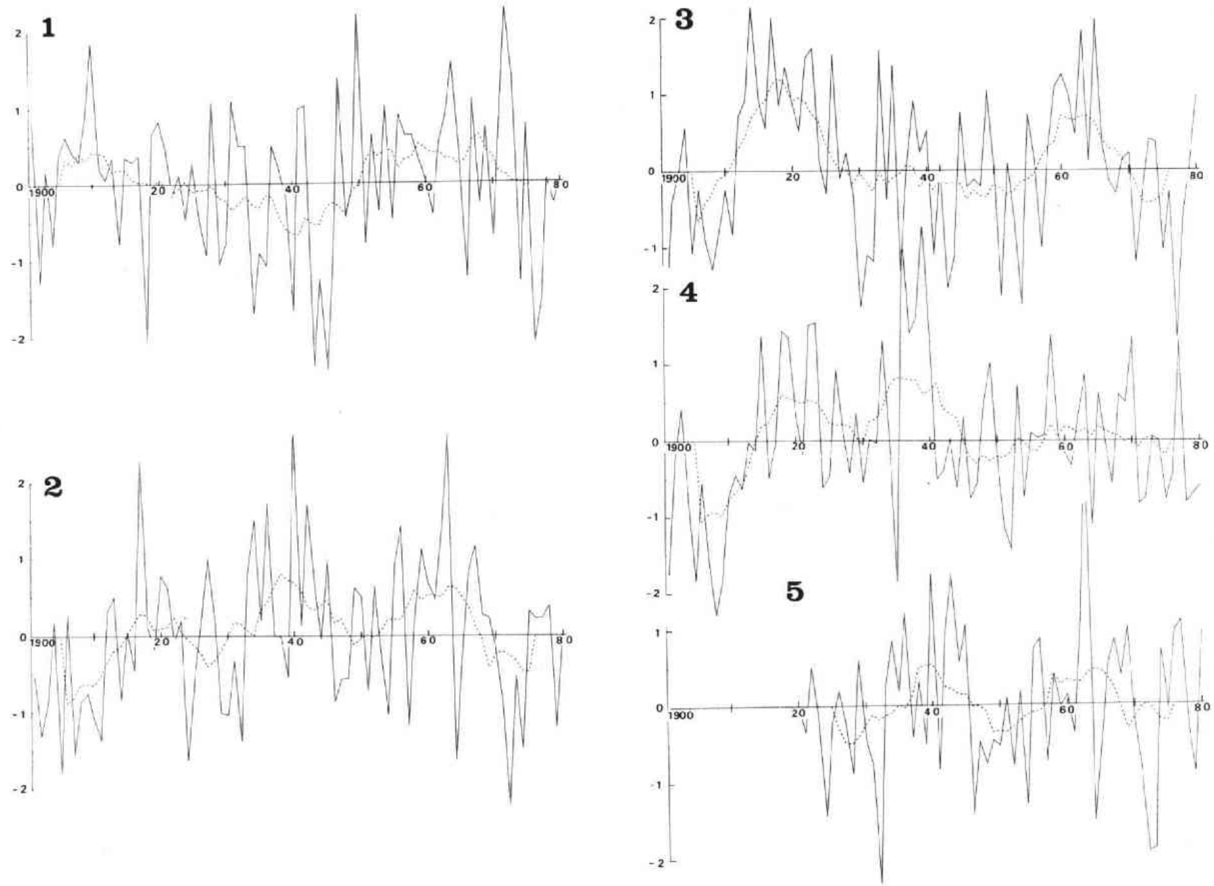


Fig. 7 Secular changes of January precipitation (1-4) and winter monsoon index (5).
Dashed line indicates 11 year running mean.
1. San-in, 2. Hokuriku, 3: Tohoku, 4: Hokkaido, 5: surface pressure difference between Irkutsk and Nemuro.

other hand, heavy precipitation located inland. These types seem to correspond with the two functions describing the variation of winter precipitation in Niigata Prefecture (Akiyama 1981).

4 Secular changes

Fig. 7 shows secular changes of January precipitation in the four subregions and the winter monsoon index represented by surface pressure differences between Irkutsk (52°16′N, 104°21′E) and Nemuro (43°20′N, 145°35′E). The curve of 11-year running mean in San-in is similar to the first component in Fig. 3. This indicates that San-in has characteristics of the Pacific side of Japan from the aspect of secular changes. Hokuriku has a twenty year periodicity with maxima around 1920, 1940 and 1960, corresponding with the winter monsoon index. Tohoku and Hokkaido are generally accordant to the twenty year periodicity, though the former lacks a peak around 1940, while the latter lacks a peak around 1960. That is, the c-type in Fig. 5 has occurred frequently around 1940. It is assumed that the Far East Trough deepened, winter monsoon strengthened, and the Japan-Sea Low occurred infrequently under the east-trough type around 1940. Precipitation in San-in is little then; therefore, the Pacific Coast Lows were also fewer during that time period. These tendencies are recognized in the case of December, February, and the winter-total precipitation more or less.

5 Concluding remarks

The regional difference of winter precipitation variation in the Japan-Sea side was investigated using data of stations located near the Japan-Sea coast. Results are summarized as follows:

(1) The Japan-Sea coast is classified into four subregions; San-in, Hokuriku, Tohoku and Hokkaido, from the aspect of year-to-year variations.

(2) Variation in San-in correlates more with that of the Pacific side than that of the Japan-Sea side. Heavy precipitation in San-in is related to mild winters in western Japan.

(3) Heavy precipitation in Hokuriku is followed by a severe winter in western Japan. This is a cycle with a ca. twenty year periodicity.

(4) Variations in Tohoku correlate in some degree with that of Hokuriku. These are, moreover, influenced by location of the Far East Trough.

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