The generation mechanism of instability wave along convergent cloud band

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When the winter pressure pattern grows stronger around Japan Islands, cloud streaks appear over the Japan Sea. In the east of Korea Peninsula over the western Japan Sea, strikingly broad cloud band is formed, which is called Convergent Cloud Band. Along this Convergent Cloud Band,meso alpha and beta scale vortex disturbances often appear. Meso scale disturbances grow rapidly and often cause heavy snowfall especially in Hokuriku District and San-in District along the Coast of Japan Sea. For this reason many studies were conducted until now. Previous studies about the generation mechanism of meso scale disturbances showed that meso beta scale disturbance was caused by barotropic instability and meso alpah scale disturbance was caused by baroclinic instability.

However, the linear stability problems in these studies include only one of these instabilities. Therefore we cannot discuss disturbances with which scale dominant.

In this study, we investigate the mechanism of the generation of meso-scale disturbances along Japan-Sea Polar-Airmass Convergence Zone by calculating the linear stability of a basic flow with a frontal structure under quasi-geostrophic system which includes both barotropic and baroclinic instabilities.

The linear stability analysis revealed the results as follows: Both meso alpha scale and meso beta scale disturbances exist in the same a basic field.

The meso beta scale disturbance has local maximum of amplitude in the region where the horizontal shear is large. The structure of this disturbance shows that barotropic instability is the dominant generation mechanism.

The meso alpha scale disturbance has a large amplitude on frontal surface where the basic field has positive potential vorticity gradient and on the ground surface with potential temperature gradient. The structure of this disturbance indicates that it is caused by baroclinic instability.

Energy conversion of disturbances is also consistent with the dominant generation mechanism of the meso scale disturbances revealed by their structures.

We also investigate the dependences of the stability in the basic field features by changing the following parameters.

1.Thickness of the frontal transition layer

2.Potential temperature gradient on the ground surface

3.Stability of the atmosphere

When the basic field has a thick frontal transition layer, meso alpha scale disturbance caused by baroclinic instability dominates. Under this condition, horizontal shear is so weak that barotropic instability waves do not grow in the basic field. In other words, sharpness of the shear around frontal surface in the basic field is one of the important physical factors for deciding the scale of disturbance.

The growth rates of the disturbances are not influenced by horizontal potential temperature gradient on the ground surface, but the structure of the meso alpha scale disturbances are changed. If horizontal potential temperature gradient on the ground surface is small, the meso alpha scale disturbance has large amplitude in two regions: On upper frontal surface and lower frontal surface where the basic field has opposite horizontal potential vorticity gradient. This structure shows that , there is a resonance caused by waves which exist on upper frontal surface and lower frontal surface, which generates baroclinic instability wave.

When the basic field has a small stability of atmosphere, meso alpha scale disturbance caused by baroclinic instability dominates. Since vertical relation of atmosphere is strong, disturbances, situated in the vertically position, interact each other.

In this study, we obtained the following results. Both meso alpha scale instability mode and meso beta scale instability mode exist in the same basic field. Meso alpha scale disturbance dominates in basic fields where frontal transition layer is thick and stability of atmosphere is small.