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The neighbor enclosed area tracking algorithm and its application to cyclone merger in the midlatitudes

Masaru Inatsu, Shotarou Amada, and Yuya Satake
Dept of Natural History Sciences, Hokkaido University, Sapporo, Japan (inaz@mail.sci.hokudai.ac.jp)

The neighbor enclosed area tracking (NEAT) algorithm is proposed as an alternative method to conventional point-to-point cyclone tracking approaches. Most automated Lagrangian tracking algorithms contain three procedures: cyclone identification, cyclone tracking, and quantification of cyclone intensity and activity. The cyclone identification was simply based on a comparison of neighboring grid points; cyclone tracking mainly employed a near-neighbor point search to neighbor-time cyclone-center datasets; and cyclone intensity and activity are mainly quantified as cyclone track density, and other accompanying products such as genesis and lysis densities, mean lifetime, average moving vector, and mean growth rate can also be obtained in the final procedure. But a crucial problem in the above technique is its requirement of some complicated connecting conditions for near-neighbor tracking.

To overcome the problem, NEAT completes cyclone identification and cyclone tracking in a single process of equivalent labeling for spatiotemporally connected domains, i.e., if two spatially enclosed areas in a neighboring time frame overlap, they should be connected. NEAT enables us to count the genesis and tracks of individual cyclones as the conventional tracking. Moreover, NEAT has the ability to produce fruitful information on cyclone mergers and separations, cyclone shape, and material transport by individual eddies (the latter two features will be reported elsewhere).

There are many possible applications of NEAT to meteorology and oceanography, but now we focus on the situation, well-known by Japanese synopticians, that two cyclones pass respectively over the north and south of Japan and then they frequently merge and are rapidly deepened in the western Pacific. For the case, the southern cyclones tend to be stimulated just above the sea surface temperature front to the north of oceanic western boundary currents, while the northern cyclones, moving eastward along the polar front jet, are connected to potential vorticity disturbances in the upper troposphere. NEAT counts more than four merged cyclones there in the DJF season. Based on the NEAT statistics, these merged cyclones have a great growth rate with a statistical significance. Composite maps and backtracking from merged cyclones reveal two possible pathways in the north and south of Japan.