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Numerical simulations on winter cold damage to citrus fruits by using the WRF model.

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In Japan, a strong cold surge in winter often causes damage of citrus fruits cultured in open field, and it leads to reduce the yield. In general, many citrus varieties are known as being vulnerable to sub-zero temperature conditions. The past cold attacks have caused freeze damages to citrus fruits and physiological disorder of citrus rind and afflicted the Japanese citrus farmer. Since, in Japan, many citrus orchards are locally spread and scattered on the slope sides of hills and mountains, it is difficult to know how the cold surge affects the orchard fruits. Hence, we will consider the application of a highly-resolved meteorological model to quantitatively assess the cold damage of citrus fruits.

In this study, the Weather Research and Forecasting Model (WRF Ver. 3.8.1) was used to simulate an experience of sub-zero temperature due to a strong cold surge coming in January 15-16, 2011. A calculating domain included the west region of Ehime Prefecture in Japan at which a citrus cold damage has been reported actually (Ehime Pref., 2012). This domain was resolved spatially at 500-m squares of two domains (the other was resolved at 1500 m). Although actual temperatures at some locations were being observed by the Japan Meteorological Agency (the observatory is called the AMeDAS), every site was located at lowland near the coast. Simulated meteorological elements were compared with observed those prior to assessing cold damage risk of citrus fruits. In addition, a relationship between recorded hours of sub-zero temperature and citrus yields was analyzed from using the actual past data.

First, we simulated highly-resolved maps projecting the sub-zero temperature duration as a risk factor contributing to citrus physiological disorders. From the simulated map, a large difference in this duration was found between the AMeDAS lowlands and orchard slope-lands. For example, in the south-west region of Ehime Prefecture, while the temperature duration of less than -1 ºC was simulated for 8 hours at a model grid including the AMeDAS station (name specified as Misyo), the duration was found for 12 to 15 hours at nearby slope-land grids including citrus orchards. This region is famous for citrus cultivations of “Kawachi-bankan” (Citrus Maxima) which has a low tolerance for cold environment. In fact, from our statistical analysis, the more past annual yield of Kawachi-bankan decreased gradually, the longer observed temperature duration of less than -2 ºC was. Next, we developed a highly-resolved risk map for reducing yield, by using that relation. The map showed the higher risk reducing yield (the modal class from -8 to -10%) on the slope orchard than the risk (the modal class from 0 to -2%) on plain and seashore around AMeDAS.