Tropospheric Dispersive Phase Anomalies during Heavy Rain Detected by L-band InSAR and Their Interpretation

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The split-spectrum method (SSM) can largely isolate and correct for the ionospheric contribution in the L-band interferometric synthetic aperture radar (InSAR). The standard SSM is performed on the assumption of only the first-order ionospheric dispersive effect, which is proportional to the total electron content (TEC). It is also known that during extreme atmospheric events, either originated from the ionosphere or in the troposphere, other dispersive effects do exist and potentially provide new insights into the dynamics of the atmosphere, but there have been few detection reports of such signals by InSAR. We apply L-band InSAR into heavy rain cases and examine the applicability and limitation of the standard SSM. Since no events such as earthquakes to cause surface deformation took place, the non-dispersive component is apparently attributable to the large amount of water vapor associated with heavy rain, whereas there are spotty anomalies in the dispersive component that are closely correlated with the heavy rain area. The ionosonde and Global Navigation Satellite System (GNSS) rate of total electron content index (ROTI) map both show little anomalies during the heavy rain, which suggests few ionospheric disturbances. Therefore, we interpret that the spotty anomalies in the dispersive component of the standard SSM during heavy rain are originated not in the ionosphere but the troposphere. While we can consider two physical mechanisms, one is runaway electron avalanche and the other is the dispersive effect due to rain, comparison with the observations from the ground-based lightning detection network and rain gauge data, we conclude that the rain dispersive effect is spatiotemporally favorable. We further propose a formulation to examine if another dispersive phase than the first-order TEC effect is present and apply it to the heavy rain cases as well as two extreme ionospheric sporadic-E events. Our formulation successfully isolates the presence of another dispersive phase during heavy rain that is in positive correlation with the local rain rate. In comparison with other dispersive phases during Sporadic-E episodes, the dispersive heavy rain phases seem to have the same order of magnitude with the ionospheric higher-order effects.

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