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Typhoon secondary eyewall formation and replacement cycle in association with increased low-level inner-core diabatic cooling

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The role of increased inner-core diabatic cooling in typhoon secondary eyewall formation (SEF) and eyewall replacement cycle (ERC) is examined using idealized numerical simulation in WRF model. The experiment with the low-level inner-core (i.e. the annulus between 40- and 80-km radii) diabatic cooling increased by 30% (C30) is characterized by the low-entropy air and downward motion in the inner-core region whereas the convergence and active convective updrafts in the outer-core region. In collaboration with the favorable dynamic ambient conditions and unbalanced boundary layer dynamics induced by the outer rainband, the concentric convective ring is triggered and contracts inward to replace the inner eyewall. Subsequently, the deep-tropospheric radial outflows driven by the strong outward-directed agradient force give rise to a largely outward-tilted eyewall, eventually forming a large-eyed storm. The sensitivity of SEF and ERC to the strength and radial location of low-level cooling is further investigated. The results show that the only 20% increase (C20) or 10-km radially-inward shift (C30-IN) of the low-level inner-core cooling hardly produce a pronounced SEF and ERC due to the lack of an evident moat region. In contrast, both the 40% increase (C40) and 10-km radially-outward shift (C30-OUT) of low-level cooling lead to the active outer rainbands occurring at a larger radius. In the former case, due to the weak inner-core radial inflow and deep-layer outer radial outflows associated with the massive secondary tangential wind maximum, the concentric eyewall shrinks slowly with a large outward slope, directly creating a large-eyed structure. In the latter case, the concentric eyewall forms late due to the low inertial stability at a large radius, but experiences an expeditious contraction because of the strong radial inflow.