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Diabatic processes and the evolution of two contrasting extratropical cyclones

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Extratropical cyclones are typically weaker and less frequent in summer as a result of differences in the background state flow and diabatic processes with respect to other seasons. Two extratropical cyclones were observed in summer 2012 with a research aircraft during the DIAMET (DIAbatic influences on Mesoscale structure in ExTratropical storms) field campaign. The first cyclone deepened only down to 995 hPa; the second cyclone deepened down to 978 hPa and formed a potential vorticity (PV) tower, a frequent signature of intense cyclones. The cyclones were analyzed through numerical simulations incorporating tracers for the effects of diabatic processes on potential temperature and PV.

It was found that the observed maximum vapor flux in the stronger cyclone was twice as strong as in the weaker cyclone; the water vapor mass flow along the warm conveyor belt of the stronger cyclone was over half that typical in winter even though the flow was weaker. Did the greater water transport and latent heat release associated with condensation result in the greater circulation in the PV tower case?

A cyclone-centred integral framework is introduced relating the tracers with cross-isentropic mass transport and circulation around the cyclone. It is shown that the circulation increases much more slowly than the amplitude of the diabatically-generated PV tower at its centre. This effect is explained using the PV impermeability theorem and the influence of diabatic heating on circulation around a cyclone is shown to scale with Rossby number. The implication is that the stronger a cyclone becomes (larger Rossby number), the stronger the influence of latent heating on circulation.