# Combined effects of the deformation and nonlinearities during the crossing of a westerly jet by a surface cyclone.

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Many winter storms reaching Western Europe quickly grow as they cross the jet-stream axis from South to North as revealed for example by the FASTEX campaign (Joly and coauthors, 1999). Riviere and Joly (2006) have suggested that these zones where cyclones cross the mid-latitude jet and regenerate depend in large part on the horizontal deformation field of the large-scale jet. Moreover, the energy budget of a particular cyclone (POI17 of FASTEX) shows a rapid development just after the jet-crossing phase that can be linked with barotropic and baroclinic interactions.

We re-examine this problem of the development of a surface cyclone during the jet-crossing phase within the idealized framework of the two-layer quasi-geostrophic model. Our objectives are to recreate and understand Riviere and Joly's results about preferential crossing zones and about the energy budget of the POI17 case. Gilet et al (2009) have already emphasized the key role played by the nonlinearities and more specifically the nonlinear beta drift during the jet-crossing phase but have reduced their investigations to purely zonal flows. In that simple context, barotropic interaction and horizontal deformation effects are weak and far from the observed behaviour of the POI17. In our study, the evolution of a surface cyclone embedded in a more complex basic flow (a meandering westerly jet) is analyzed.

We show that due to the horizontal inhomogeneities of the basic flow, a preferential crossing zone exists. This zone is collocated with the "saddle" point of a new diagnostic, called hereafter effective deformation, that depends on the horizontal deformation tensor of the basic flow. We examine in more details the combined effects of the effective deformation and the nonlinearities. Different simpler numerical experiments using a barotropic version of the model are presented to explain why the cyclones tend to cross the jet near the saddle point and how it is dependent on both the beta drift and the deformation effects.