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Is tropopause folding promoting or suppressing deep convection? First results from TROSIAD

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The occurrence, timing, and location of deep, moist convection remains a problem for operational weather forecasting, despite the rapid development of the numerical weather prediction models and implementation of new observational techniques. One impediment to better forecasting of deep convection is the role played by tropopause folds. How deep convection is modulated by tropopause folding, which brings stratospheric air into the troposphere, is not well understood. Three ingredients are required for deep moist, convection– moisture, instability, and lift–and all three ingredients associated with tropopause folds can either promote or suppress convection. For example, the dry air associated with the descent of upper-tropospheric air may limit the vertical development of buoyant thermals, yet this dry air may also create potential instability.

The purpose of the research project TROSIAD is to assess the importance for convection forecasting of correctly representing tropopause folds in numerical weather forecasting models and to disentangle the conflicting paradigms that tropopause folds both promote and suppress convection. The work plan of the project involves the analysis of existing data from the Mesosphere–Stratosphere–Troposphere (MST) Radar at Aberystwyth, UK, which can measure both tropopause folds and convection, a number of cases studies from measurement campaigns, and numerical modelling experiments. The project begins with building 5-year (2006–2010) climatologies of radar data, and wind-profiling data to determine the relationship between tropopause folds and deep moist convection.

Using data from Met Office NIMROD radar network, a climatology of all convective storms with the track in study region was developed. To be included in the climatology, a convective storm must persist for at least 30 minutes with a maximum radar reflectivity greater than 30 dBZ. A total of 663 convective storms were identified.

A climatology of the tropopause folds over Wales was developed based on the MST radar data. Tropopause folds can be identified in the wind speed plots, coinciding with maxima in wind shear and echo power. A total of 231 tropopause folds events were identified.

By combining the severe-storm and tropopause-fold climatologies 76 convective storms were associated with tropopause folds. About half of these cases (42%) were observed on the western side of an upper level trough, a region in which the convection is in generally considered as being suppressed. As an exemplification of entangled effects of tropopause folds on convection, two case studies are presented. The first event took place on 24 May 2006, when a cold front has passed over the UK, and convection was associated with moist air moving north-eastward over Wales, and becoming instable when the tropopause due to the presence of dry air in the tropopause fold above. In the second case on 2 December 2006, again associated with the passage of a cold front, the tropopause fold reached a lower attitude in comparison with the first case, suppressing convection.

We also studied the morphology of the storms associated with tropopause folds, and we found that 51% of the cases are associated with multicellular convective lines, 25% are isolated cells, and 24% are multicellular clusters.