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Variations in the timing of the stratospheric final warmings and its dynamical effects on spring tropospheric conditions over Europe

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A large number of studies have shown that the stratospheric final warmings (SFWs) are relevant processes in the springtime stratosphere, since the occurrence of these events after winter season means an abrupt change in the stratospheric circulation. Some of these studies indicate that the variation in the timing of the SFWs is very large, what in turn leads changes in some stratospheric aspects such as the polar ozone content and in the developing of the vortex breakup. Other works have related inter-decadal changes in the spring onset affecting certain surface variables to variations in the persistence of the polar vortex.

As a contribution to the study of the stratosphere-troposphere coupling, in the present work we analyze the impact of the interanual variability in the timing of the SFWs on the troposphere during the springtime over Europe. For it, using ERA40 data, firstly we identify the date of the vortex breakup in the period of 1958-1999, in such a way that we have considered two sets: those years when the polar vortex breaks up very early, in March ('early SFWs' hereafter); and those ones in which the breakup is very late, that is, in May ('late SFWs' hereafter).

From composite analyses, we have found differences in certain atmospheric fields at tropospheric levels over the North Atlantic region between April-months under "early SFW" and "late SFW". These differences appear more significant when, in addition, the stratospheric polar vortex is extremely anomalous during April. For instance, concerning the 500-hPa geopotential field (Z500), a tripole pattern is found for "early SFWs", in such a way that Z500 anomalies are positive at high latitudes and Azores

Islands, and negative in front of the western French coast. Similar structure is obtained for “late SFWs” but with opposite sign in the anomalies and a northward shift of the antinodes. This is consistent to the corresponding 500-hPa zonal wind patterns. These anomalous atmospheric conditions in the troposphere explain that the monthly precipitation in April of the “early SFWs” is more than normal in the South of France and in the Northwest of Italy, and less than normal in the North of Europe. The opposite occurs in the “late SFWs”.

Results from an additional analysis of the transient eddy energy at 500 hPa in April give evidences that the “early SFWs” seem to be related to a southward shift of the storm tracks crossing Europe. This could explain the anomalous rainfall pattern above mentioned, providing a dynamical link between precipitation and atmospheric variability in the North Atlantic area.

Briefly, this study constitutes a contribution which supports that the variations in the persistence of the stratospheric vortex in springtime seem to have some impact on the troposphere over Europe, affecting in turn climate conditions at surface.