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Atmospheric Chemistry and Physics Discussions

# *Interactive comment on* "The spring 2011 final stratospheric warming above Eureka: anomalous dynamics and chemistry" *by* C. Adams et al.

**C. Adams et al.**

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RESPONSE TO REFEREE 2: Anonymous

Thank you for your comments. They have especially improved our discussion of the FrIAC observed above Eureka in 2011. Below we address the recommended changes point-by-point.

MAJOR COMMENTS:

*The authors discuss the evolution and the persistence of the FrIAC, in particular the narrowing of the low-latitude intrusion, in relation to the time-theta cross-section of equivalent latitude above Eureka (Fig 3b) (p20049, line 17). It is unclear to me that the layer of air with a low-latitude origin near 600K has much to do with the FrIAC. Maps*



*(Fig 5l, for example) indicate that the intrusion originates from a different longitude sector than the intrusion leading to the FrIAC (Fig 6l).*

This will be addressed by identifying that 600 K is below the FrIAC throughout the paper. Therefore, we will restructure the discussion in Sect. 3.3 and, in the abstract, we will change:

"Ozone isolated within this frozen-in anticyclone (FrIAC) in the middle stratosphere was depleted due to reactions with the enhanced NOx. Ozone loss was calculated using the passive tracer technique, with passive ozone profiles from the Lagrangian Chemistry and Transport Model, ATLAS. At 600 K, ozone losses between 1 December 2010 and 20 May 2011 reached 4.2 ppmv (58%) and 4.4 ppmv (61%), when calculated using GMI and OSIRIS ozone profiles, respectively."

to

"Ozone isolated within this frozen-in anticyclone (FrIAC) in the middle stratosphere was lost due to reactions with the enhanced NOx. Below the FrIAC (from the tropopause to 700 K), NOx driven ozone loss above Eureka was larger than in previous years, according to GMI monthly average ozone loss rates. Using the passive tracer technique, with passive ozone profiles from the Lagrangian Chemistry and Transport Model, ATLAS, ozone losses since 1 December 2010 were calculated at 600 K. In the air mass that was above Eureka on 20 May 2011, ozone losses reached 4.2 parts per million by volume (ppmv) (58%) and 4.4 ppmv (61%), when calculated using GMI and OSIRIS ozone profiles, respectively."

*The apparent narrowing of the FrIAC vertical extension, as seen above Eureka, ought also to be related to the vertical tilting of the anticyclone, as discussed for example in Allen et al. (ACP, 2011). From the discussion, it seems that the authors focused on the descent of ozone. These points have to be clarified.*

We will clarify the language, in order to ensure that we are not implying that ozone is descending through the atmosphere. It does not appear that the anticyclone has tilted during this period. Polar maps of $N_2O$ are shown in Fig. 1 at 850 K (left panels) and at 1150 K (right panels). On the 18 April (top panels), the low ozone values extend to high altitudes, while and on 18 May (bottom panels), the altitude range of low ozone values had narrowed to lower altitudes only. During both of these periods, the centre of the FrIAC (indicated by high $N_2O$) is at approximately the same latitude/longitude at 850 K and 1150 K, suggesting that the narrowing of the low ozone values is not caused by the tilting of the FrIAC. We will add the following text to the paper:

"Examination of $N_2O$ polar maps at 850 K and 1150 K (not shown here) indicates that the FrIAC has weakened but has not tilted during this period."

*While the authors comment that the FrIAC lasted until the end of May, there is little satellite based observational or modeling evidence of this in the figures. Some maps of GMI $N_2O$ at the altitude of the FriAC (850K) into the end of May would have been a strong addition to the paper. Or was the model unable to reproduce the long duration of the FrIAC event?*

GMI reproduces the FrIAC in $N_2O$ fields throughout the April/May period of interest. In order to clarify this, we have replaced the maps shown on 16 April with maps on 30 May in Fig. 7.

*Sub-sections 3.4 and 3.5 are very short, and are very thin on new science. It seems to me that the material briefly presented there (and in figures 9, 10) does not deserve full sub-sections. The occurrence of an ozone mini-hole or a vortex remnant passing above Eureka could be briefly mentioned somewhere else in the manuscript, with little need of supporting figures.*

We have integrated sections 3.4 and 3.5 into a single section titled "Other phenomena affecting ozone columns above Eureka." We have elected to keep the figures showing the ozone mini-hole and the vortex fragment because it is interesting to see how these events, which both occur below the FrIAC, affect the short-term ozone total column



variability above Eureka.

MINOR COMMENTS:

*1) A more precise indication of the lowest equivalent latitudes found in the FrIAC would have been useful: e.g. how close to the equator is the air mass origin?*

The minimum EqL above Eureka was 19° at 850 K observed on 16 April. We will add the following to the text in Sect. 3.1

"A minimum equivalent latitude of 19° was observed at 850 K on 16 April."

*2) In the conclusions, p20052, it is mentioned "transport over Eureka from mid-latitudes in an anticyclone". Should it be from low-latitudes?*

We will correct this in the text.

*3) Spell DMPs in the heading of section 2.4*

We will change the section heading as recommended.

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Interactive comment on Atmos. Chem. Phys. Discuss., 12, 20033, 2012.

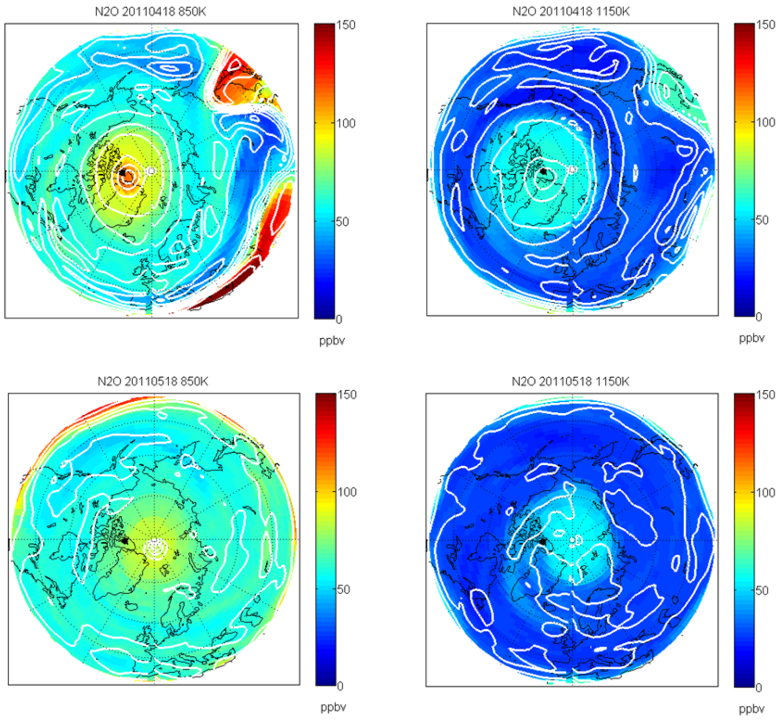


**Fig. 1.** Polar maps of N2O at (left panels) 850 K and (right panels) 1150 K for 18 April (top panels) and 18 May (bottom panels). PV contours are shown in white.