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Interactive comment on "Using Satellite Measurements of N$_2$O to remove dynamical variability from HCl measurements" *by* Richard Stolarski et al.

Anonymous Referee #1

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This manuscript introduces a method aiming at accounting for (correcting for) the real variability observed in time series of stratospheric tracers. More specifically, simultaneous measurements of hydrogen chloride (HCl, the main reservoir of stratospheric chlorine) and nitrous oxide (a long-lived source of nitrogen) are used in conjunction, so that the variability of stratospheric N2O is used to remove the one of HCl, assuming they have the same origins, here circulation and transport. The ultimate aim is to determine HCl trends unaffected by atmospheric variability, useful for the verification of the effectiveness of the Montreal Protocol in the stratosphere.

It is claimed that this method is more appropriate than those using proxies for repre-

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Discussion paper

senting multiyear dynamical variabilities resulting from, e.g., the QBO, ENSO. In the present case, the implementation of the method to simultaneous measurements of HCl and N2O by the Aura/MLS instrument results in the determination of significant HCl decreases in the lower stratosphere over the 2004-2016 time period (about 13 years) which are in agreement with the evolution of total organic chlorine at the surface, when accounting for the mean age of stratospheric air. In contrast, direct HCl trends are mostly not significant over this decadal time scale.

One can foresee that the method presented in this study will be used in future trend evaluations, for HCl, but also for other target gases relevant to ozone depletion and recovery, when trying to reconcile tropospheric and stratospheric trends,... provided that simultaneous measurements of tracers with similar response to atmospheric dynamical variability or other influences are available.

Therefore, I recommend publication of this study, after consideration of the suggestions indicated below.

Major comments

In order to allow precise implementations of this approach or replication of the method in future studies, it would be good to have available a description on how the "time-series regression" is actually performed (by simple ratio-ing or more elaborated ways). I believe this would not be possible with the current version of the text.

Another aspect which is not described is the evaluation of the uncertainties affecting the various trends. It is stated in caption of Fig. 2 that "the 2σ uncertainty in that fit includes consideration of auto-correlation in the time series". Various approaches have been used in recent papers such as to account for auto-correlation in the data sets, particularly for studies of ozone recovery. But we do not know how the uncertainty ranges were determined in the present instance, while visual inspection of the HCl and N2O time series suggests that auto-correlation might be quite significant. It would be good to know how the authors accounted for auto-correlation. A brief description of the

statistical evaluation of the confidence intervals should be added. A citation might be relevant if the current method has been used before.

Specific comments and remarks

There is a mismatch between the main text and the captions for Fig. 2 and 3. It is indicated in the text that anomalies or deviations are shown. But it looks like the captions correctly state that deseasonalized time series are shown for HCl and N2O. Several portions of the main body text need to be amended accordingly, or the captions and figures 2 and 3 updated.

Minor comments or typos

-Page 1/line 30: suggest changing to "... a few years for them to reach..."

-Page 1/line 37: Jungfraujoch is misspelt

-Page 1/line 38: suggest changing to "...from in situ surface measurements..."

-Page 2/line 14: might be good to indicate why N2O is a relevant target for this purpose (and/or add a reference)

-Page 3/line 1: I don't think that there is a comparison between the N2O products from MLS, only the drift as a function of altitude is given

-Page 4/line 24: "deseasonalized" is misspelt

-Page 5/line3-line5: this sentence needs to be reworded

-Page 5/line 16: "HCl anomaly time series as in Figures 2 and 3"; true if Fig. 2 and 3 are updated accordingly

-Page 6/line28-30: a good reference is needed here, to introduce the concept of age of air, and showing that a 3 years delay is appropriate

-Page 7/figure 5: perhaps provide approximate altitude information on the right scale?

C3

-Page 7/line 23: suggest replacing "showed" by 'reported"

-Page 7/line 24: suggest replacing "linear trend" by "linear decrease"

-Page 8/line 36: [Carpenter and Reimann, 2014] instead of 2015

-Page 9/line 8: 2014 instead of 2015

C4