Interannual ozone variability at the NCO-P WMO/GAW global station: influence of stratosphere-to-troposphere exchange

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Background

The **tropospheric ozone (O_3)** is an atmospheric key compound, being the third most important greenhouse gas. Acting as short-lived climate forcer, it can influence the oxidative capacity of the troposphere and affect the population health, the ecosystem integrity and the crop yields. A large part of the produced O_3 derives from anthropogenic emissions, although a not negligible contribution is provided by lightning and **stratosphere-to-troposphere exchange (STE)**. This latter process is a topic of ongoing research, especially for what concerns the quantification of where and how often the **stratospheric intrusions (SI)** take place.

Figure 1. The NCO-P measurement site.

South Asia and the Himalayas are a crucial zone for what concerns O_3 levels. For this reason, the **Nepal Climate Observatory-Pyramid (NCO-P)** WMO/GAW global station is operative since March 2006 in the high Khumbu Valley, Nepal, at 5079 m a.s.l. As previously investigated (Cristofanelli et al., 2010), NCO-P is strongly affected by SI events, thus the development of tools to assess and analyze the variability of such events is of particular importance, especially for what concerns the climatological perspective.

STE climatology and the steflux tool

In this study, the **STE climatology** presented in Škerlak et al. (2014) is used. This makes use of the ERA-Interim reanalysis dataset from the ECMWF, as well as a refined version of a well-developed Lagrangian methodology. Basically, it selects, from a large set of trajectories available each day, only the ones for which the tropopause (2 pvu/380 K) crossing occurs, according to a minimum residence time; then, following a 3-D labelling algorithm, it distinguishes between points of stratospheric or tropospheric nature.

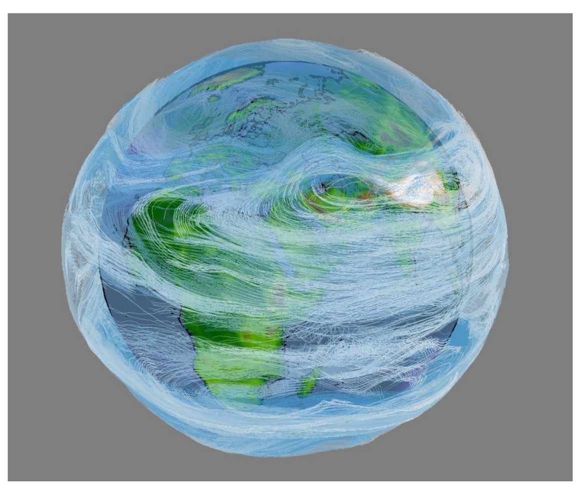

Figure 2. Visual example of the trajectories available each day.

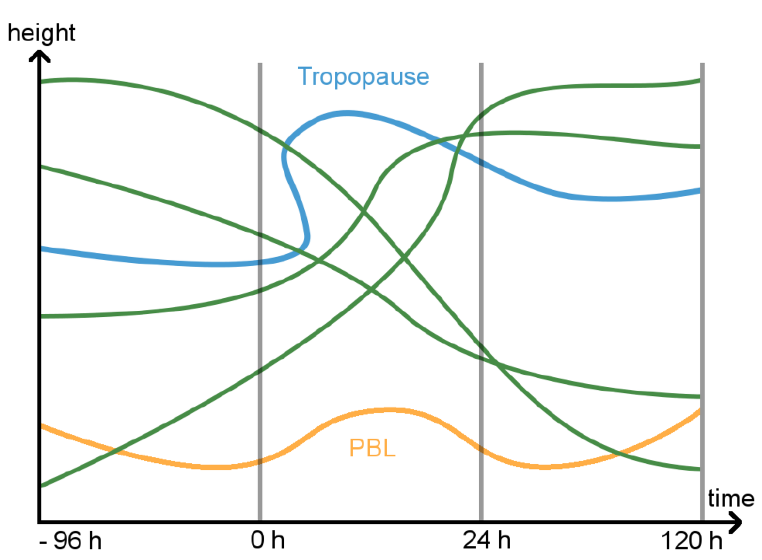

Figure 3. Methodology adopted for selecting ERA-Interim trajectories, adopted in Škerlak et al. (2014).

By using this climatology as input, the **steflux** tool has been developed, in order to obtain a fast and reliable estimation of the SI occurring at a specific location, over a chosen time period.
As input, it is possible to select several parameters, such as coordinates and height (given as a specified pressure level, or PBL height) for the search location.

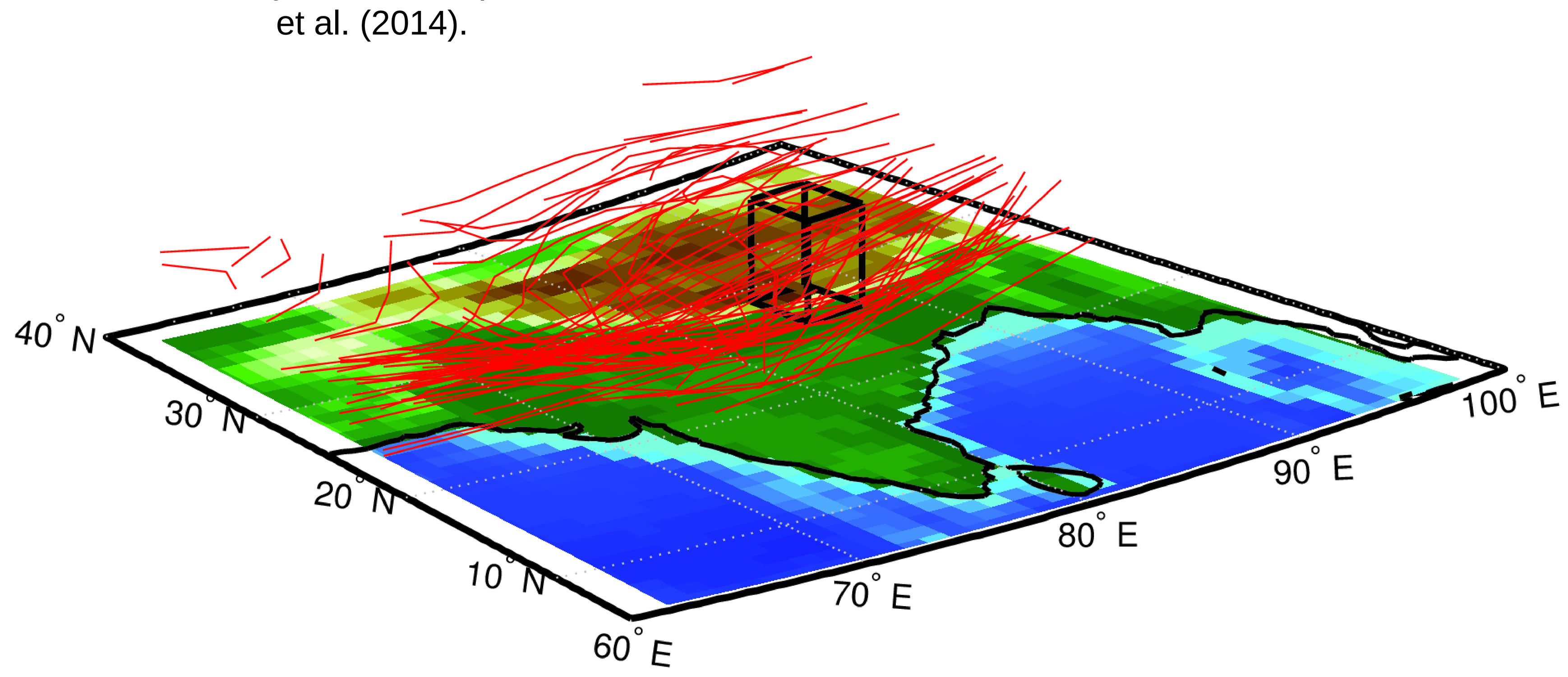

Figure 4. Conceptual scheme for the steflux tool. Red lines represent trajectories deriving from the STE climatology presented in Škerlak et al. (2014) .

Acknowledgments

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Results

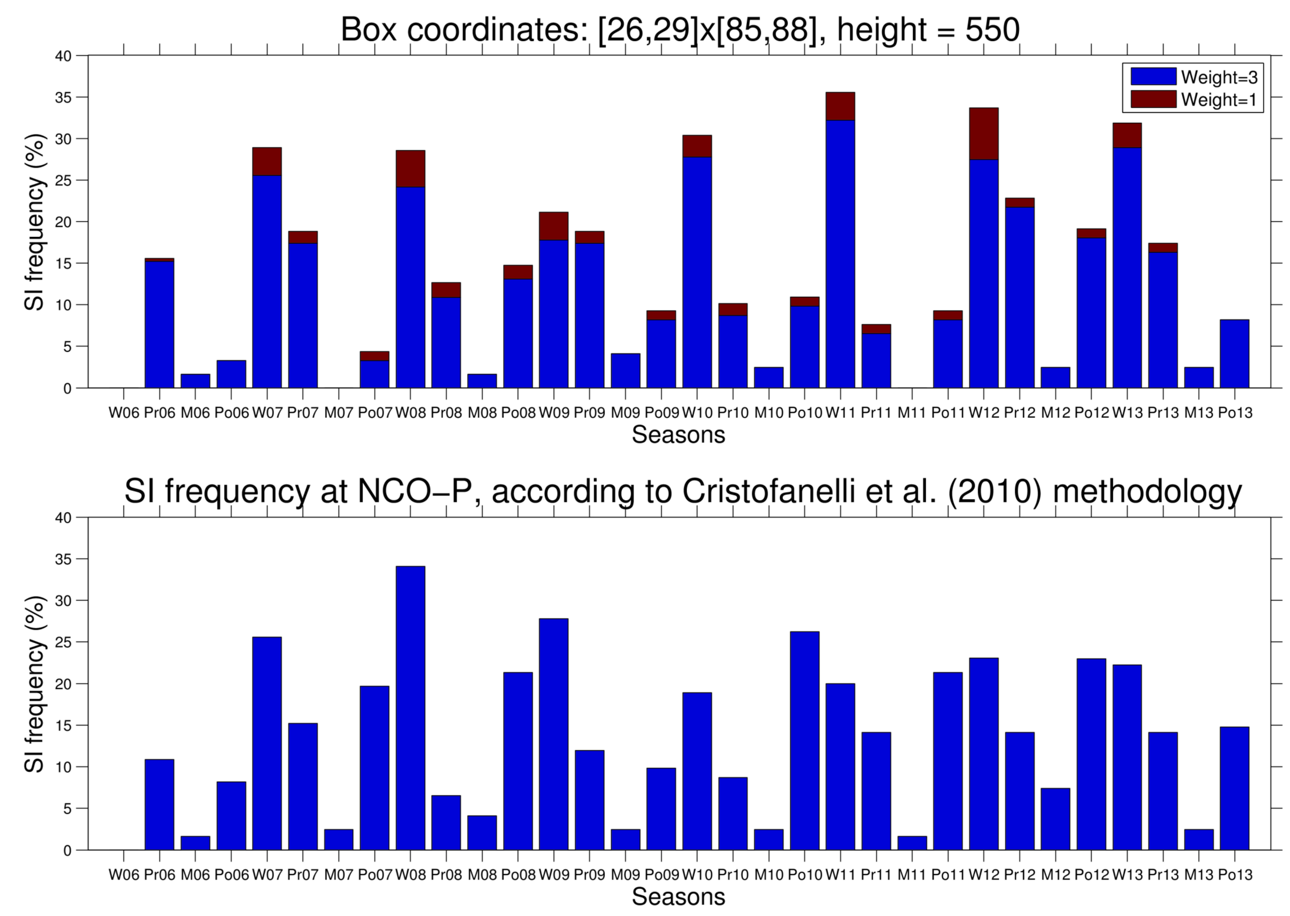

Figure 5. SI frequency seasonal graph for the steflux tool operating in the [26,29]x[85,88] box with a top pressure surface of 550 hPa (upper plot) and for the analysis shown in Cristofanelli et al., 2010 (bottom plot), for the period March 2006 – December 2013.
Abbreviations for the seasons are the following:
W = winter,
Pr = pre-monsoon,
M = monsoon and
Po = post-monsoon.

The output of the steflux tool on a specific time window (Mar 2006 – Dec 2013) has been compared with a well-developed method for identifying SI events, giving an overall correspondence (**r=0.75**), also in terms of the annual variation, with **winter** and **pre-monsoon** months as the most active in terms of SI occurrences. This makes steflux a confident tool to evaluate SI from a climatological perspective. Moreover, the synoptic-scale fields for several meteorological parameters have been analyzed, according to the different timing between the tropopause crossing and the first box crossing. This permitted, for example, to indicate a clear link between the exchange locations and the **potential vorticity streamers**.

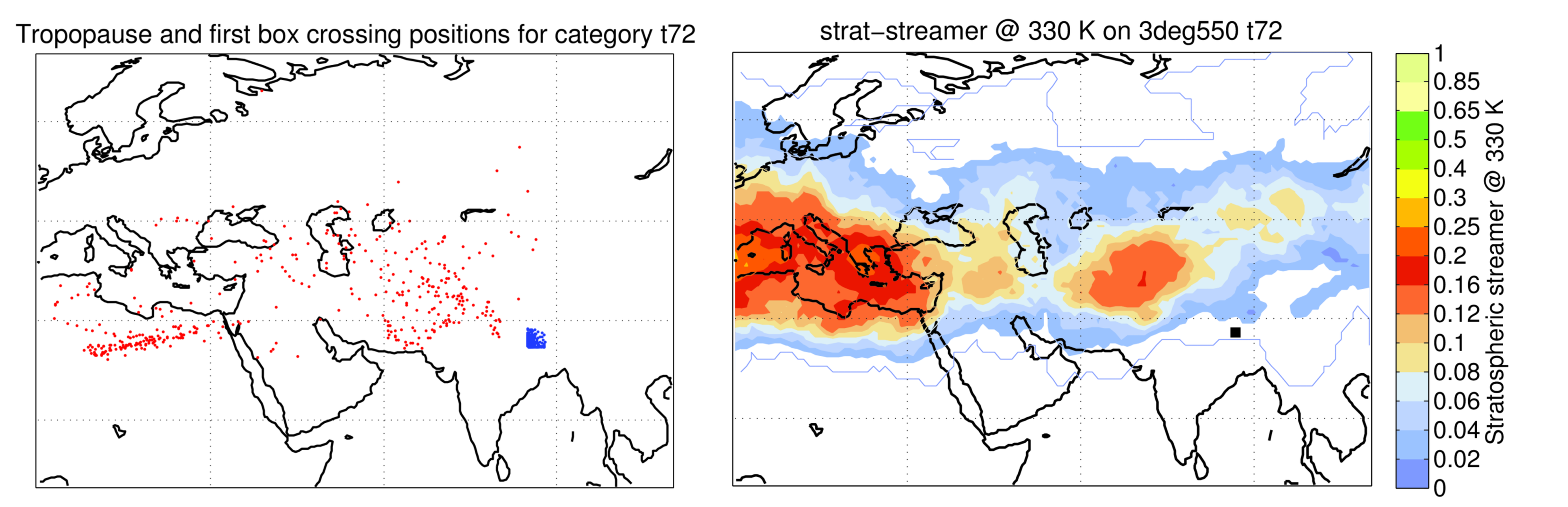

Figure 6. On the left, tropopause (red dots) and first box (blue) crossing locations for category t72, i.e. presenting a timing 48h<t<72h between the tropopause crossing and the first box crossing; on the right, the stratospheric streamer composite (at the 330 K isentropic surface) for the days shown by red dots.

Validation dataset

Method shown in Cristofanelli et al. (2010), developed to assess the influence of SI to the O_3 variability at NCO-P. It makes the combined use of different *in situ* measurements (such as O_3, P and RH), satellite observations (total column O_3 retrieved by OMI product, TCO) and modelling back-trajectory outputs (by using LAGRANTO model, see Sprenger et al., 2015). Basically, a specific day was considered as influenced by SI if at least one of the following criteria was satisfied:

- Significant variations of daily P value and presence of back-trajectories with PV>1.6 pvu
- Significant daily TCO increases and presence of back-trajectories with PV>1.6 pvu
- Significant variations of daily P values and significant TCO daily increases
- Presence of RH<60% and significant negative correlation O_3-RH and daily O_3 maximum higher than the seasonal value and significant variation of daily P, PV or TCO values

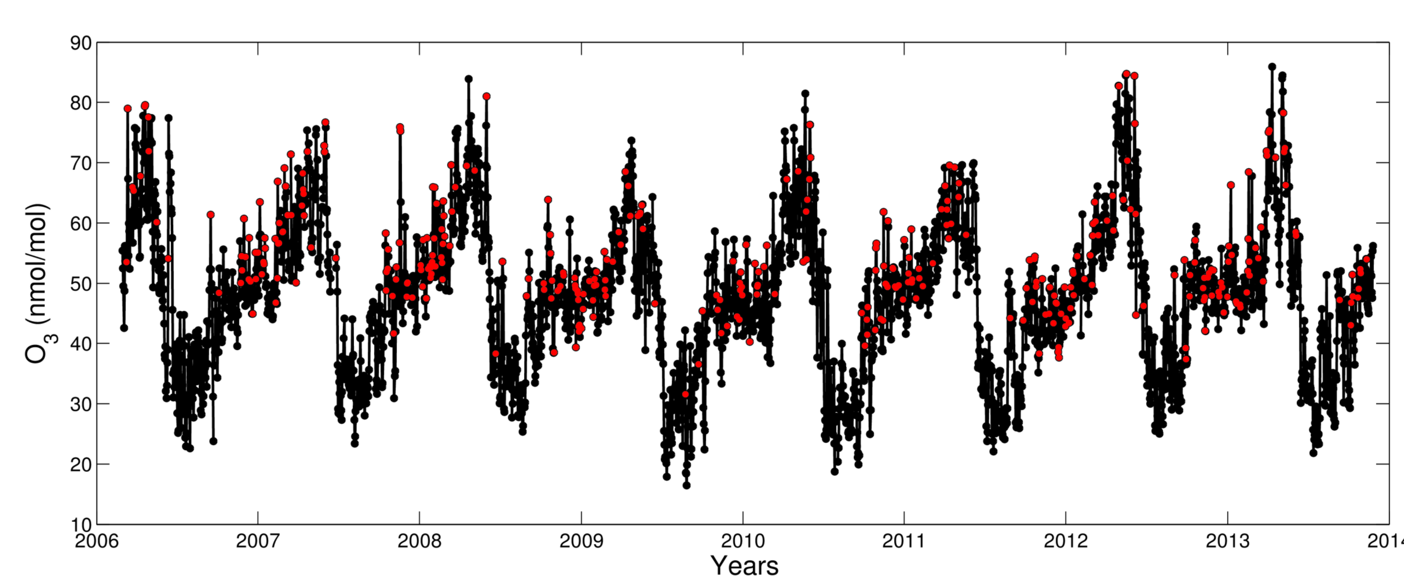

Figure 7. Daily average values of O_3 values collected at NCO-P. Red dots indicate days affected by SI, as defined by the four criteria presented in Cristofanelli et al. (2010).

References

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