Decadal NAO Variability or Anthropogenic Trend?

Ozone Trends in the North Atlantic European Region

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DYNAMICAL INFLUENCE ON OZONE

Variability in the North Atlantic Oscillation (NAO) index correlates with variability in the tropopause pressure over Europe.
Trends in tropopause pressure contribute to ozone trends.

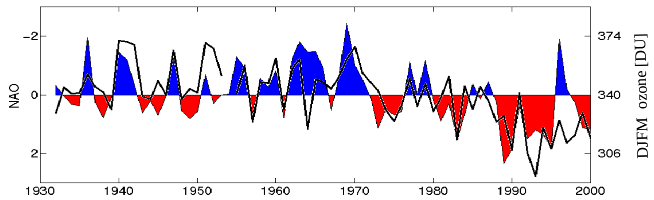

Fig. 1 The total winter ozone of Arosa (black) shows long-term variability similar to the NAO index (colored). Negative phases (blue) prevailed until 1970, then positive phases (red) became increasingly frequent until the mid-nineties. The tropopause pressure is a key quantity in understanding this decadal variability in total ozone (Fig. 2).

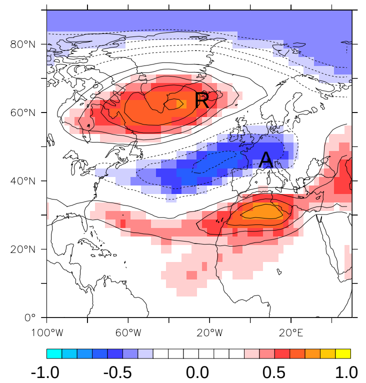

Fig. 2
Correlation map of NAO index with tropopause pressure based on NCEP-Reanalysis data (DJFM mean). Note the negative correlation over Arosa (A) and the positive one over Reykjavik (R).

TOTAL OZONE TRENDS

New anthropogenic total ozone trends

trend 1970-1996, based on model Eq. (1).

winter	old (without *NAO*)	revised
Swiss *trend*	-3.2 ± 0.6 %	-2.4 ± 0.5 %
Iceland *trend*	not significant (0 %)	-3.8 ± 1.4 %

Paper: *Appenzeller, C., Weiss, A. K., Staehelin, J. : North Atlantic Oscillation modulates total ozone winter trends. GRL* ***27*** *(8) 1131-1134, 2000.*

Paper: *Weiss, A. K., Staehelin, J., Appenzeller, C., Harris, N. R. P: Chemical and dynamical contributions to ozone profile trends of the Payerne (Switzerland) balloon soundings. submitted to JGR 2000.*

SUMMARY

- Decadal NAO variability can substantially mask or enhance the man-made impact on the ozone layer.
- At Arosa the revised total ozone winter trend is reduced by 25%. At Reykjavik the trend is enhanced (as expected from 2D chemistry models).
- In Switzerland half of the observed lower stratospheric winter ozone trend is due to decadal climate variability.

INFLUENCES ON THE OZONE PROFILE

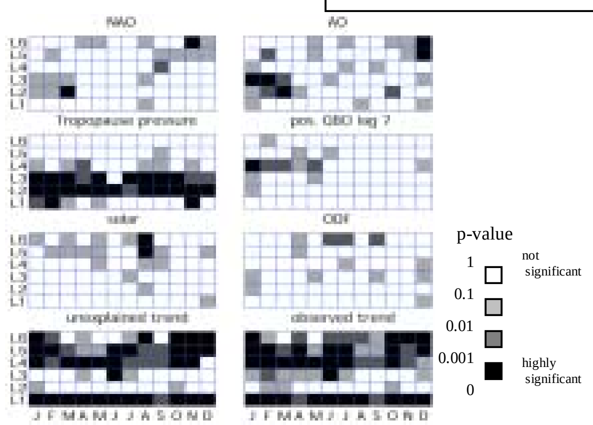

Fig. 3 Influences of explanatory variables on the Swiss ozone profiles, based on the model Eq.(1), monthly data. See Fig.4 for Layer definitions.

Trend analysis performed with stepwise linear regression:

$$O_3' = c_1\, dyn + c_2 ODF + c_3\, sun + c_4\, QBO + trend + \varepsilon \qquad \textbf{(Eq.1)}$$

where *dyn* is NAO, AO or tropopause pressure

Ozone profile trend estimates considering dynamics:

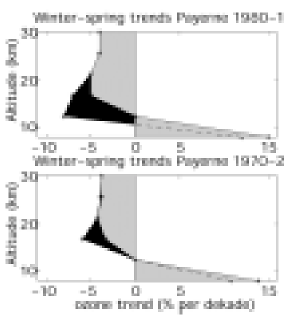

Fig. 4 Payerne sounding trends (top), comparable to the SPARC/IOC/GAW report [1998], and from 1970 to most recent data (bottom).
The observed trends can partly be explained by **dynamical change** (**black area**). The remaining **unexplained trend** (**grey area**) is attributed to anthropogenic ozone depletion. The layers L1 - L6 are indicated by the symbols (*).