Tropospheric circulation changes in response to a stratospheric zonal ozone anomaly - VARNAER

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Introduction

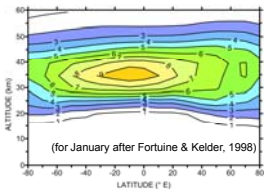
- The aim is to investigate the role of zonally asymmetric O3* in atmospheric circulation via the induced radiation perturbations with the focus on the impact on seasonal predictability of AO by NAM as function of altitude and leading times as well as the predicted period.
- Observed patterns of NAM and AO are diagnosed with ECMWF Reanalysis (ERA Interim 1979-2011, polar cap based > 65° N) and on NCEP reanalysis (1959-2002, EOF1 based, taken from M. Baldwin homepage).
- 40-year-model runs with GCM ECHAM5 were performed to reveal the one-way effects of prescribed O3* anomaly on the AO predictability by NAM from higher altitudes.

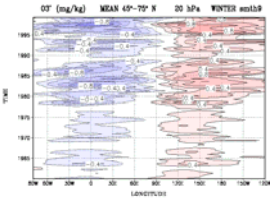
Results - Conclusion

- Pronounced influence of zonal asymmetries in ozone on poleward RWB events and on the appearance of SSW processes have been shown, in agreement with other studies, and are expected due to the higher induced stratospheric and tropospheric variability by stratospheric ozone anomaly in boreal extra-tropics.
- For the anomaly run we found a better agreement of the mean seasonal structure for low and high pass filtered NAM with the observation like ERA Interim.
- Insufficient model performance in describing the AO predictability skill, but for the anomaly run the predictability skill increases in midwinter in the middle stratosphere.
- We conclude that the consideration of the observed mean zonally asymmetric ozone structure in GCMs improves the model performance in describing the AO predictability by NAM of the middle stratosphere.

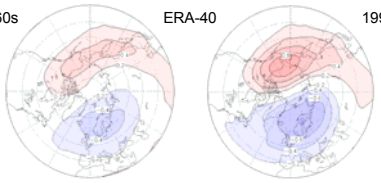
(1) Motivation: Zonal Ozone Anomaly O3* Impact on Poleward Rossby Wave Breaking (RWB-P2-index) Events

Control run [O3] - O3ZMO Anomaly run O3ZOA driven by O3* (months) winter(DJF) 20 hPa

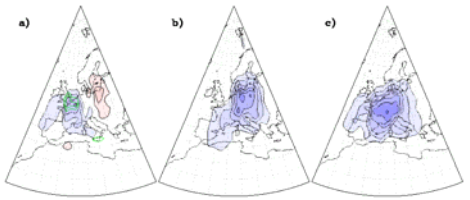




1960s ERA-40 1990s



Difference O3ZMO O3ZOA



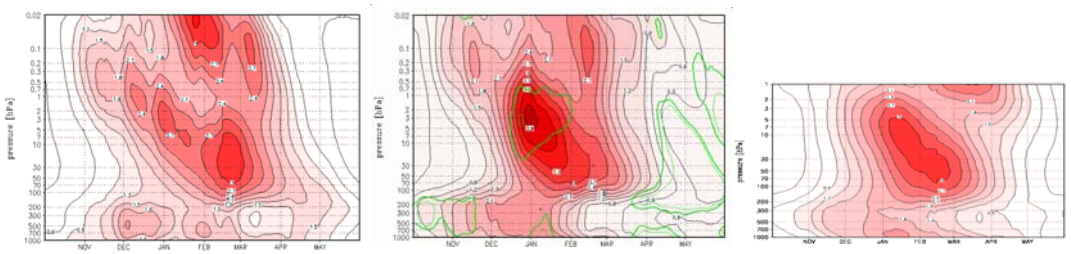
➔ Strong ozone wave (zonal ozone anomaly, dominant wave 1) in the 1980s and 1990s

➔ More P2 RWB events over western Europe in GCM run with zonally asymmetric ozone

(2) Variance of Low - and High Pass Filtered NAM (Polar Cap Based > 65 N) Not Smoothed

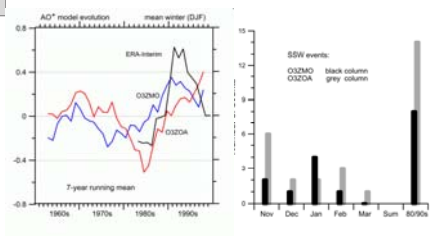
--- low pass variance or inter-annual variability ---

control run O3ZMO **anomaly run O3ZOA** **ERA-Interim 1979-2011**



➔ + comparable inter-annual variance structure between ECHAM5 model runs and ERA Interim observation
+ significant changes and better agreement in the upper stratosphere for O3ZOA run in midwinter, green lines sign.

AO evolution & SSW events

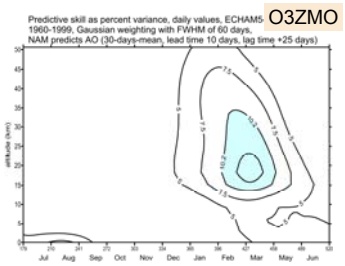


➔ + AO minimum from mid-1980s causing weaker AO+ and in connection weaker NAO+ patterns
+ significant more major SSWs for 1980-99 period

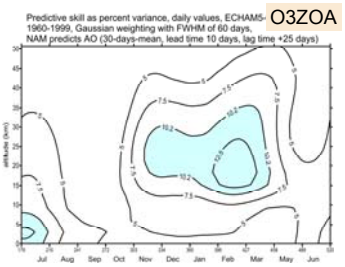
(3) Predictability of AO From NAM of Higher Altitudes – Significant in Ice Blue Areas - Gaussian Smoothed

control run NAM ECHAM5 model (polar cap based > 65° N) O3* **anomaly run**

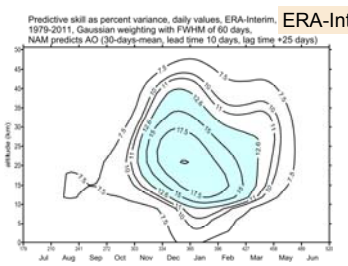
ERA-Interim (polar cap based) **observation** NAM from Baldwin et al. 2003 (EOF, NCEP rea)



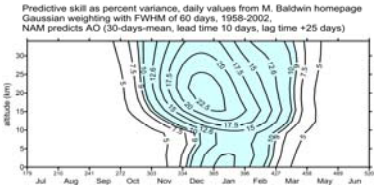
O3ZMO



O3ZOA



ERA-Interim



EOF_NCEP

➔ + less NAM predictability in ECHAM5 model runs in comparison to ERA Interim and NCEP reanalysis
+ improvement by zonally asymmetric ozone O3* (**anomaly run**) in the middle stratosphere in midwinter
+ significant increase as known from observation

➔ + less NAM predictability for ERA Interim (1979-2011) than for NCEP reanalysis (1958-2002)
+ similar significant Gaussian smoothed structure in the middle stratosphere
+ weaker tropospheric predictability in midwinter

Methodology:

+ performing a sensitivity study and comparing two GCM-ECHAM5 runs (T42, $H_{top} \approx 80$km) (Roeckner et al. 2002, Manzini et al., *J. Cli.*, 2006)
+ runtime interval was 40 years with same AMIP SST (1960-1999) and different ozone
  - first: **control run O3ZMO** with mean zonally symmetric ozone of the 1990s
  - second: **anomaly run O3ZOA** with added zonally asymmetric ozone O3*
    ~ based on ECMWF reanalysis ERA-40 ozone fields of the 1960 – 1999 period
    ~ using O3* field only north of 30° N and between 500 and 1 hPa layer
+ different diagnoses: RWB, number of SSW, NAM variance and predictability of AO by NAM (p)

Related references of our group:

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