Max-Planck-Institut für Meteorologie
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Chemistry Climate Interactions After Large Volcanic Eruptions II
A New Analysis of Refractive Index

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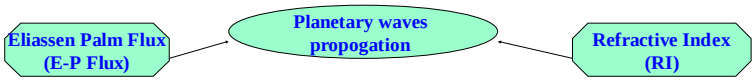
We propose a new kind of analysis of refractive index

- **Matsuno (1971) introduced the equation of the refractive index used widely for the study of planetary wave propagations. Planetary wave can only propagate when and where RI square is positive (Charney and Drazin, 1961).**
- **We are interested in the probability of planetary waves to propagate in meridional plane because this is correlated with different kinds of climate regimes**
- **We simply analyze the frequency of *negative* refractive index squared in meridional plane to assess where the planetary wave cannot propagate**

The propagation of planetary waves relates with different kinds of climate regimes and with the energy transported by them.In general, there are two main methods to illustrate the propagations of planetary waves.



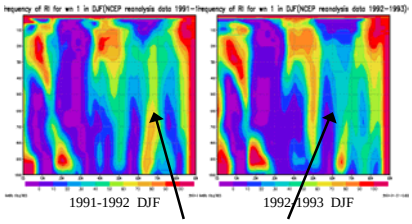
Mount Pinatubo volcanic eruption

The Mount Pinatubo eruption (June 15, 1991) injected amonts of material into lower stratosphere and thus influenced the Earth's radiative balance and the climate for a few years (Ingo Kirchner et al, 1999). It also had potential impact on the planetary wave propagation. Here planetary waves propagations is investigated by the EP flux and refractive index for observations (NCEP reanalysis) and model data.

NCEP reanalysis

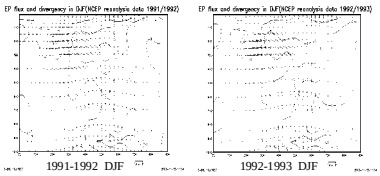
The data are from the National Centers for Enviromental Prediction-National Center for Atmospheric Research reanalysis. It has a horizontal resolution and extends from 1000 to 10 hpa with 17 vetical pressure levels.

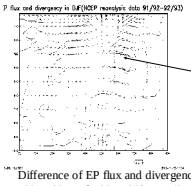
Frequency of negative RI squared for wave number 1 on meridional plane in DJF



The frequecies of negative RI square illustrate the possibility of upward transport of planetary wave in the winter after Pinatubo eruption. It also shows that the planetary waves can propagate more to higher midlatitude, they are blocked from the pole leading to a stronger polar vortex.

EP flux and divergency on meridional plane in DJF





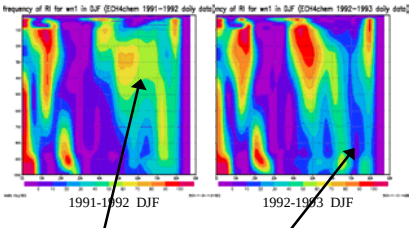
EP fluxes also shows higher possibility of planetary wave propagation in the 1992/1993 winter after the volcanic eruption.

Difference of EP flux and divergence between 1991-1992 and 1992-1993 DJF (91/92 minus 92/93)

ECH4-CHEM

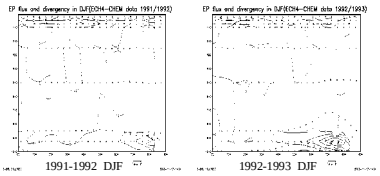
Model MAECHAM4/CHEM (Steil et al. 2003) + sulfur cycle vertical resolution:surface up to 0.01 hPa horizontal resolution T30 Pinatubo aerosol is a prognostic variable and interactive coupled with the radiation scheme

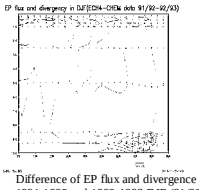
Frequency of negative RI squared for wave number 1 on meridional plane in DJF



In the first winter the frequencies of negative RI squared show that after the volcanic eruption are often blocked from entering the stratosphere while the planetary waves can propagate in very high latitudes from the surface in the second winter. This disturbance may result in a less strong polar vortex

EP flux and divergency on meridional plane in DJF





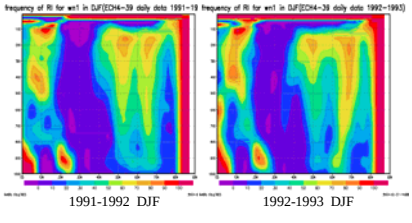
EP fluxes clearly illustrate the transport of planetary wave from surface. But obviously the transport does penetrate into higher altitudes.

Difference of EP flux and divergence between 1991-1992 and 1992-1993 DJF (91/92 minus 92/93)

ECH4-DLR39

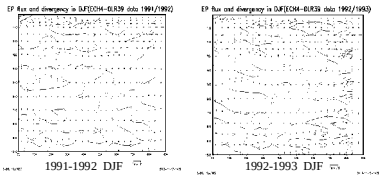
vertical resolution:surface up to 10 hPa: horizontal resolution T30 Pinatubo aerosol is prescribed, for the radiation calculation PADS (Stenchikov et al., 1998) and for the chemistry calculation SAGE surface area densities (Thomason et al, 1997) are used

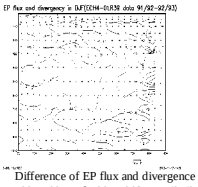
Frequency of negative RI squared for wave number 1 on meridional plane in DJF



The frequencies of negative RI square from the model with the volcanic eruption show in mid and high latitudes there is only a small chance for planetary wave propagation to the stratosphere, mainly in the second winter.

EP flux and divergency on meridional plane in DJF





There is even less EP flux in the DLR39 version of ECHAM4 and in the second winter a very strange vertical profile of EP fluxes divergence occurs.

Difference of EP flux and divergence between 1991-1992 and 1992-1993 DJF (91/92 minus 92/93)

Conclusion:

- **Frequency of negative RI squared is an efficient method to study the propagation of planetary wave and to evaluate models.**
- **The Mount Pinatubo volcanic eruption of 1991 had impact on the planetary wave propagation and the stronger stratospheric polar vortex in Northern Hemisphere winter. Models seem not to capture the planetary wave effects.**
- **Clear difference between the frequencies of negative RI squared of Re-analysis data and model which in part may explain the bias of model**

Reference:

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