Title: Potential Vorticity Index

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Investigators:

Albert Barcilon and Hengyi Weng
Geophysical Fluid Dynamics Institute
Florida State University
Tallahassee, FL 32306-3017

(904) 644-5594

I. Significant Accomplishments in the Past Year

Potential vorticity (PV) is a significant dynamical tracer which could be linked to ozone measurements from satellite and, therefore, could be a NASA measured quantity.

1. We have accomplished the first part of the research supported by NASA grant NAG 8-760, and written up a paper entitled "Potential Vorticity Index Vacillation In The 78 - 79 Winter: Its Relation To Teleconnection Patterns", which was recently accepted by *Quart. J. Roy. Meteor. Soc.*

   Based on ECMWF FGGE IIIb data set in the 78 - 79 winter, we define a PV index, $I(Q)$, as a measure of the zonally averaged, mid-latitude PV gradient on the 300K isentropic surface in the Northern Hemisphere, and study the evolution of that index and its relation to teleconnection patterns of 500mb geopotential height anomaly.

   The time series studies of the PV index and other indices indicate that in the time domain there is a dominant period of about 14 days, at which the PV index and the eddy index exhibit a strong signal in their spectra and have good coherence. Such a strong signal in the 14-16 day periodicity, which has been previously observed by many authors in the tropospheric and stratospheric circulation, is not obvious in the time series of our parallel study using the zonal wind index as defined by Kidson (1985).

   The cross-correlation coefficients between the PV index and 500mb geopotential height anomaly, at each grid point in the Northern Hemisphere, bring out some major teleconnection patterns summarized by Wallace and Gutzler (1981): the North Atlantic Oscillation, the North Pacific Oscillation, and the Pacific/North American patterns. The existence and the phase relation of these patterns with the PV index cycle are seen from daily 500mb geopotential height maps during this period. Each pattern has two stages, corresponding to high and low PV index periods, separated by a time difference of a few days. The Scandinavian highs, including those over the Norwegian Sea, tend to occur *at* or a few days *after* the minimum of the PV index, while the Greenland highs and the northern Pacific highs tend to form *at* or a few days *before* the maxima of the PV index. It seems that the large scale highs in Northern Hemisphere in the 78 - 79 winter occur preferentially during the transition period from low PV index to high PV index. They occur

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mostly in an orderly fashion: Scandinavian high → Greenland high → Pacific high; this picture points to planetary waves propagating westward. Scandinavia and the Norwegian Sea may be a key area which affects global flow changes. The composite maps show that, in general, high and low index periods correspond to relatively "wavy" and "zonal" flows in mid-latitudes, respectively, especially over Atlantic and Europe. A similar study between the zonal wind index and the geopotential height anomalies does not reflect as many of the teleconnection patterns as the PV index does, even though the zonal wind index and the geopotential height anomalies are on the same pressure surface (500mb).

Based on our limited data analyses and the comparison with climatological studies by other authors, we have shown that the zonally-averaged isentropic gradient of PV may be a better index of the global circulation in the Northern Hemisphere winter and may reflect the existence of teleconnections between large active centers, as well as the transition from one stage of the teleconnection pattern to another.

2. We have obtained the main results for the second part of the research, which focuses on temporal and spatial variation of blocking and cyclogenesis in the 78 - 79 winter and its relation to *global* and *local* PV gradients, $I(Q)$ and $\delta(Q)$, respectively.

   We have performed complex EOF analyses, using the same FGGE data set for the 78 - 79 winter, for a representative high-latitude-band and mid-latitude-band geopotential height anomalies at 500mb, Φ_H and Φ_M, and PV gradient at 300K, $\delta(Q)$, at each longitude for the 3-month period.

II. Focus of Current Research and Plans for the Next Year

1. Complete the second part of the research:

(1) Do Fourier analyses for first three EOFs of Φ_H, Φ_M and $\delta(Q)$ at given latitude bands, and find the dominant wavenumbers and frequencies which are responsible for these EOFs.

(2) Compare the results from EOF and Fourier analyses. The comparisons will be used to explore the relations of blocking and cyclogensis with local and global PV gradients.

(3) Study the time dependence of the local PV gradients and relate it to the PV index vacillation cycles observed and described by WB (1991). Infer dynamical explanations for the features observed in that PV index cycle.

(4) Write-up the second part of the research and submit it for publication in the Fall 1991.

2. Pursue a similar research for the FGGE winter in the Southern Hemisphere. The comparison between the results for two hemispheres for this particular winter will help understand the difference in global circulations between these two hemi-

spheres. Since the grant NAG 8-760 will be terminated in March 1992, the research of the Southern Hemisphere is subject to the continuation of funding.

III. Papers and Presentations Supported by NASA grant NAG 8-760

1. Weng, H.-Y. and A. Barcilon, 1990: Potential vorticity index and its relation to blocking and cyclogenesis. *XV General Assembly of European Geophysical Society, 23 - 27 April, 1990.*
2. Weng, H.-Y. and A. Barcilon, 1991: Potential vorticity index vacillation in the 78 - 79 winter: its relation to teleconnection patterns. Accepted by *Quart. J. Roy. Meteor. Soc.*
3. Whitaker, J. and A. Barcilon, 1991: Type B cyclogenesis in a zonally varying flow. Submitted to *J. Atmos. Sci.*
4. Whitaker, J. and A. Barcilon, 1991: On the genesis of mobile troughs in the upper westerlies. Submitted to *J. Atmos. Sci.*
5. Weng, H.-Y. and A. Barcilon, 1991: Temporal and spatial variation of blocking and cyclogenesis in the 78 - 79 winter. (in preparation)
6. A. Barcilon gave talks about PV index in seminars at NCAR and on the role of PV in explosive cyclogenesis at University of California at Davis.

References

Kidson, J.W., 1985: Index cycles in the Northern Hemisphere during the Global Weather Experiment. *Mon. Wea. Rev.*, **113**, 607 – 623.

Wallace, J.M. and D. S. Gutzler, 1981: Teleconnections in the geopotential height field during the Northern Hemisphere winter. *Mon. Wea. Rev.*, **109**, 784 – 812.