

# REQUEST FOR A SPECIAL PROJECT 2012–2014

**MEMBER STATE:** Germany

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**Project Title:**  
The global circulation in various coordinate systems

If this is a continuation of an existing project, please state the computer project account assigned previously.	SP _____
Starting year: <small>(Each project will have a well defined duration, up to a maximum of 3 years, agreed at the beginning of the project.)</small>	
Would you accept support for 1 year only, if necessary?	YES <input type="checkbox"/> NO <input checked="" type="checkbox"/>

<b>Computer resources required for 2012-2014:</b> <small>(The maximum project duration is 3 years, therefore a continuation project cannot request resources for 2014.)</small>	<b>2012</b>	<b>2013</b>	<b>2014</b>
High Performance Computing Facility (units)	500	500	500
Data storage capacity (total archive volume) (gigabytes)	10	10	10

An electronic copy of this form **must be sent** via e-mail to: *special\_projects@ecmwf.int*

Electronic copy of the form sent on (please specify date): 18 March 2011

*Continue overleaf*

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<sup>1</sup> The Principal Investigator will act as contact person for this Special Project and, in particular, will be asked to register the project, provide an annual progress report of the project's activities, etc.

**Principal Investigator:** Klaus P. Hoinka and Joseph Egger

**Project Title:** The global circulation in various coordinate systems

## Extended abstract

*It is expected that Special Projects requesting large amounts of computing resources (500,000 SBU or more) should provide a more detailed abstract/project description (3-5 pages) including a scientific plan, a justification of the computer resources requested and the technical characteristics of the code to be used. The Scientific Advisory Committee and the Technical Advisory Committee review the scientific and technical aspects of each Special Project application. The review process takes into account the resources available, the quality of the scientific and technical proposals, the use of ECMWF software and data infrastructure, and their relevance to ECMWF's objectives. - Descriptions of all accepted projects will be published on the ECMWF website.*

Traditionally, the global mean circulation of the atmosphere is analyzed in pressure coordinates and closely related other coordinate systems. A dramatic change occurs with a shift to isentropic coordinate systems (e.g. Johnson 1989). The distinct Hadley and Ferrel cells are replaced by hemispheric cells. There is still a lively debate how to reconcile and exploit these differing results. It is planned to extend these approaches by analyzing the global circulation in coordinate systems which have not been used so far but appear to be promising. Potential vorticity (PV) is a variable which has been extensively used during the last 30 years in case studies. Hoskins (1991) discussed the general circulation in terms of PV dynamics. Stan and Randall (2007) looked into the problems of PV-coordinates and derived the prognostic equations for barotropic and also baroclinic atmospheres with PV as a meridional coordinate. So far, however, no attempt has been made to derive the basic characteristics of the general circulation on the basis the ERA data or a similar reanalysis set. We just do not know which mean mass circulation to expect and how the global angular momentum transports look like in this coordinate system. We expect to find similarly exciting results as for isentropic coordinates. On the other hand, PV is a more complicated variable than potential temperature. This makes the analysis more difficult. It is planned in this project to derive the mass circulation and the angular momentum balance for every season on the basis of ERA40 data. As a by-product we will obtain mean fields of  $dPV/dt$ . A further step would be to introduce potential temperature as a vertical coordinate in addition to PV as a meridional one. This is a rather attractive idea, because all advections in the meridional plane are then 'forced' and most of the basic characteristics of the zonal mean circulation in these coordinates can be estimated when this forcing is known. This opens the possibility for a new interpretation of this mean circulation. This work will begun after the work on PV-coordinates has been completed.

Another, perhaps less ambitious, choice are angular momentum coordinates where latitude as the meridional coordinate is replaced by angular momentum. There is some arbitrariness which must be exposed to tests. One may use specific momentum, but also momentum per unit volume as a coordinate. In any case, this will allow us to incorporate the surface torques directly into the equations of the analysis scheme. The well known problem of the meridional propagation of angular momentum anomalies (Egger et al. 2007) away from mountains will be seen in a new light when turning to these coordinates. As a first step it is planned to derive the mean mass circulation as well as the potential temperature balance in these coordinates using again ERA analyses. Angular momentum coordinates have, however, the disadvantage that they can at best used on a hemispheric basis. Investigations of this system will begin only after work on (PV/Theta)-coordinates has been completed.

We will also look into the situations treated earlier by us. How does the atmosphere react to sources of angular momentum at the surface? New aspects may come up by discussing such problems in angular

momentum coordinates. There are, however, limitations because of the enhanced complexity of the interpretation. For example, mountains are not locally fixed in (PV)-coordinates so that the consideration of mountain torque events is more complicated than in standard coordinates. It is the same with angular momentum coordinates but problems may be less severe because angular momentum contours are less mobile than PV-contours.

Egger, J., K. Weickmann and K.P. Hoinka, 2007: Angular momentum in the global circulation. *Rev. Geophys.*, 45, R64007, 1-25.

Hoskins, B., 1991: Towards a PV-Theta view of the general circulation. *Tellus* 43 AB, 27-35.

Johnson, D., 1989: The forcing and maintenance of global monsoonal circulations: An isentropic analysis. *Adv. Geophys.*, 31, 43-329.

Stan, C, and D. Randall, 2007: Potential vorticity as meridional coordinate. *JAS*, 64, 621-633.