The Transregional Collaborative Research Center TR32 and its participating Rhenish Institute for Environmental Research at the University of Cologne, Germany, invite applications for

**PhD Graduate Research Assistantship**

In the frame of the TR32, *Patterns in Soil-Vegetation-Atmosphere Systems: Monitoring, Modelling, and Data* (www.tr32.de) the Rhenish Institute for Environmental Research at the University of Cologne (RIU) is seeking two suitable candidates to carry out research in atmospheric-hydrological inverse modelling, leading to the award of a PhD degree in the subproject (D3)

**CO2 and water flux estimation by 4-dimensional variational assimilation of in situ and remote sensing data**

**Project description**

The work involves research and development in the areas of data assimilation using the Weather Research and Forecasting (WRF) model, the Common Land Model (CLM), and the EURAD-IM transport model, together with their existing tangent-linear and adjoint model derivatives.

As part of Transregio 32, the sub-project D3 (CO2 and water flux estimation by 4-dimensional variational assimilation of in situ and remote sensing data) involves research and development in the areas of data assimilation using the Weather Research and Forecasting (WRF) model, the Common Land Model (CLM), and the EURAD-IM transport model, together with existing tangent-linear and adjoint model derivatives. Two key areas of active research in locally refined Numerical Weather Prediction (NWP), soil data assimilation and transport modelling include:

1) four-dimensional variational data assimilation, which deals with the specification of the analysis, initial state, or surface flux values, from which a numerical forecast starts; and
2) transport modelling of CO2 of both anthropogenic and biogenic components.

They are closely related, as both deal with the inherent difficulty of specifying the current state of the atmosphere, fluxes of energy, humidity and CO2 from and to the surface, due to limitations in the quality and availability of observational data. Finally, in an NWP context, the main goal of data assimilation is to provide the single best estimate of the initial state and fluxes by combining observations and model forecasts, both of which contain errors. The system will be coupled, with the WRF-CLM coupling to provide biogenic CO2 sinks and sources for transport modelling.

The successful candidate will investigate the application of such techniques to data assimilation and CO2 transport modelling. This will provide the candidates with an ideal opportunity to participate in the development of state-of-the-art methods of analysing
biogenic tracer fluxes and data assimilation, with calculations performed on Europe's most powerful scientific compute platforms, hosted by the research centre Jülich. The work is funded by the German Science Foundation.

The central goal of the project is to study the influence of subsurface hydrodynamics on patterns and structures of the mass and energy balance at the land surface and the lower atmosphere. Subsurface hydrodynamics may be expressed through the presence of a dynamic free water table that may be hydraulically connected to land surface processes such as evapotranspiration via the shallow vadose zone. This results in a non-linear two way feedback between subsurface hydrodynamics and the mass and energy balance at the land surface, which reciprocally impacts weather generating processes of the atmosphere. Commonly, the effect of a moving free water table on land surface and atmospheric processes is neglected, which may result in wrong analyses results and predictions. The proposed project closes this gap by developing a modelling platform covering the domain from the deeper subsurface into the atmosphere in cooperation with the central modelling project, Z4, and other project sections of the TR32. The model will be setup over the larger Rur catchment and informed and validated by in situ and remotely sensed data of the TR32, in addition to a plethora of data sources that exist for the region of interest. In case of data scarcity, especially for the shallow subsurface domain, stochastic techniques will be used to close information gaps. Simulations will be performed at high spatial and temporal resolution over multiple years. Thus, variability in parameters, state variables and fluxes will be resolved over three orders of magnitude in the space and time domains.

The simulation results will be used in conjunction with various commonly applied and more sophisticated statistical approaches for pattern recognition. Since physics based simulation approaches will be used commensurate with measured data, we expect to identify and explain patterns and structures of two-way feedback between subsurface hydrodynamics and the land surface and the atmosphere.

Applicants
Applicants should have a first class or second class (division 1) honours degree, or equivalent, in meteorology, mathematics, geophysics, or physics. Given its nature, this project will require a strong mathematical background. In addition, programming experience in Fortran95 and/or C and familiarity with UNIX or Linux operating systems is highly desirable.

We offer a competitive position (75% TV‐L E13, that is ¾ of a full scientist position) with 3 years duration, excellent benefits, a productive, interdisciplinary working atmosphere including comprehensive supervision. PhD students will be part of the newly established Graduate School of the TR32. The successful applicants will enrol for the degree of PhD at Cologne University.

The supervisor of this sub-project is Hendrik Elbern, Research Centre Jülich and RIU. The candidates will have access to excellent computing facilities, appropriate Linux- or UNIX-based systems for model development and execution. At RIU successful candidates will work alongside a team of Postdocs, PhD students and graduate students carrying out research and
development in advanced chemical and meteorological data assimilation. Along with their other 21 fellow PhD students of the other sub-projects, successful applicants will join the Integrated Research Training Group, which will train and guide in the transdisciplinary framework of TR32.

Equal employment opportunity: Selection for these positions will be based solely on merit without regard to gender, religion, national origin, political affiliation, marital or family status or other differences. Among equally qualified candidates, handicapped candidates will be given preference.

Interested individuals are invited to send electronically a CV, contact information of two references, and academic transcripts to Hendrik Elbern (he@eurad.uni-koeln.de, Rheinisches Institut für Umweltforschung an der Universität zu Köln, Aachener Straße 209, D-50931 Köln, Germany). The position is expected to be filled during coming months. Review of applications will begin immediately and continue until the position has been filled.