# PUMA

Version May 2005

**Principal Investigators**
Klaus Fraedrich (Fraedrich@dkrz.de)
Edilbert Kirk (E.Kirk@gmx.de)
Frank Lunkeit (Lunkeit@dkrz.de)

Download Address: http://www.mi.uni-hamburg.de/puma

Meteorologisches Institut
Universität Hamburg
Bundesstr. 55
D-20146 Hamburg
Germany

## A Scope of the model

**PUMA** (**P**ortable **U**niversity **M**odel of the **A**tmosphere) is a very fast dynamical core of an atmospheric model. It can be used to run simulations on long time scales and inexpensive hardware. The priorities in development were set to speed, easy handling, portability and well documented coding. The compatibility of PUMA to the Planet Simulator and ECHAM makes it an ideal tool to teach modelling to junior scientist and students. An interactive mode with a GUI (**G**raphical **U**ser **I**nterface) can be used to view atmospheric fields while changing model parameters on the fly. This is especially useful for teaching, debugging and tuning of parameterizations.

## B Model components

**Atmosphere**

PUMA is a spectral model with triangular truncation. It solves the Primitive Equations on σ-coordinates in the vertical. Possible horizontal resolutions are T21, T31, T42, and T85. The vertical resolution is an arbitrary number of levels. The parameterisations are Rayleigh friction and Newtonian cooling.

**Miscellaneous**

PUMA is a model of the atmosphere and is usually run without orography as an "Aqua Planet". It is however possible to include orography (realistic or synthetic) in the model. Due to its small code size of less than 4000 FORTRAN lines (without GUI and MPI) PUMA is an ideal teaching tool for courses in atmospheric modeling. An adjoint version of PUMA is under development.

## C Limitations

The model has the typical problems of all spectral models, like the Gibbs phenomenon. It simulates the dry atmosphere with only few necessary parameterisations like Rayleigh friction and Newtonian cooling. There are no moist processes and no boundary layer.

## D Performance

Due to the high portability PUMA can be run on a wide range of computers ranging from mainframes to PC's. It is fully parallelized and can be run on as many CPUs as latitudes (32 for the standard T21 resolution). On a PC with a single Pentium-IV Processor at 3GHz PUMA in standard configuration runs one year of simulation in 2 minutes wall clock time. Using a PC with two CPUs speeds up the program by a factor 1.8 - 1.9 using about 1 minute per simulation year.

## E Applications

Simulation of stormtracks.
Lagrangian tracers.
Stochastic forcing.
Synchronization experiments.
Maximum entropy production.
Stratosphere–troposphere interaction.

## F References


Bagliani, M., Fraedrich, K., von Hardenberg, J., Lunkeit, F., Provencale, A., 2000: Lagrangian tracer homogenization and dispersion in a simplified atmospheric GCM. Il Nuovo Cimento, 23C, 433-448.

Blessing, S., Fraedrich, K., Lunkeit, F., 2004: The Climate in Historical Times. Towards a Synthesis of Holocene Proxy Data and Climate Models. Miller, H., Negendank, J.F.W., Flöser, G., von Storch, H., Fischer, H., Lohmann, G., Kumke, T. (eds.). GKSS School of Environmental Research, Springer-Verlag, 383-396.

Fraedrich, K., Kirk, E., Lunkeit, F., 1998: Portable University Model of the Atmosphere. DKRZ Report, 16 (http://www.mad.zmaw.de/Pingo/reports/ReportNo.16.pdf).

Fraedrich, K., Kirk, E., Luksch, U., Lunkeit, F., 2003: Ein Zirkulationsmodell für Forschung und Lehre. Promet, 29, 34-48.

Fraedrich, K., Kirk, E., Luksch, U., Lunkeit, F., 2005: The Portable University Model of the Atmosphere (PUMA): Storm track dynamics and low frequency variability. Meteorol. Z., 14.

Franzke, C., Fraedrich, K., Lunkeit, F., 2000: Low frequency variability in a simplified atmospheric global circulation model: Storm track induced 'spatial resonance'. Q. J. R. Meteorol. Soc., 126, 2691-2708.

Franzke, C., Fraedrich, K., Lunkeit, F., 2001: Teleconnections and low frequency variability in idealised experiments with two storm tracks. Q. J. R. Meterol. Soc., 127, 1321-1339.

Frisius, T., Lunkeit, F., Fraedrich, K., James, I.A., 1998: Storm-track organization and variability in a simplified atmospheric global circulation model (SGCM). Q. J. R. Meteorol. Soc., 124, 1019-1043.

Grieger, B., Segschneider, J., Keller, H.U., Rodin, A.V., Lunkeit, F., Kirk, E., Fraedrich, K., 2003: Simulating Titan's tropospheric circulation with the Portable University Model of the Atmosphere. Advances in Space Research. In press.

James, P.M., Fraedrich, K., James, I.N., 1994: Wave-zonal flow interaction and ultra-low frequency variability in a simplified general circulation model. Q. J. R. Meteorol. Soc., 120, 1045-1067.

Kleidon, A., Fraedrich, K., Kunz, T., Lunkeit, F., 2003: The atmospheric circulation and states of maximum entropy production. Geophys. Res. Letters, 30, 23, 9-(1-4).

Lunkeit, F., Bauer, S.E., Fraedrich, K., 1998: Storm tracks in a warmer climate: Sensitivity studies with a simplified global circulation model. Clim. Dyn., 14, 813-826.

Lunkeit, F., 2001: Synchronization experiments with an atmospheric global circulation model. Chaos, 11, 47-51.

Müller, W., Blender, R., Fraedrich, K., 2002: Low frequency variability in idealised GCM experiments with circumpolar and localised storm tracks. Nonlinear Processes Geophys., 9, 37-49.

Pérez-Munuzuri, V., Lorenzo, M.,N., Montero, P., Fraedrich, K., Kirk, E., Lunkeit, F., 2004: Spatio-temporal stochastic forcing of an ensemble of global circulation models. Nonlinear Processes Geophys., 10, 453-46.

Stenzel, O.J., von Storch, J.-S., 2004: On the effect of the thermal forcing on the global AAM circulation. Climate Dynamics, 22, 415-427.

von Hardenberg, J., Fraedrich, K., Lunkeit, F., Provenzale, A., 2000: Transient chaotic mixing during a baroclinic life cycle. Chaos, 10, 122-134.

Walter, K., Luksch, U., Fraedrich, K., 2001: A response climatology of idealised midlatitude SST anomaly experiments with and without stormtrack. J. Climate, 14, 467-484.