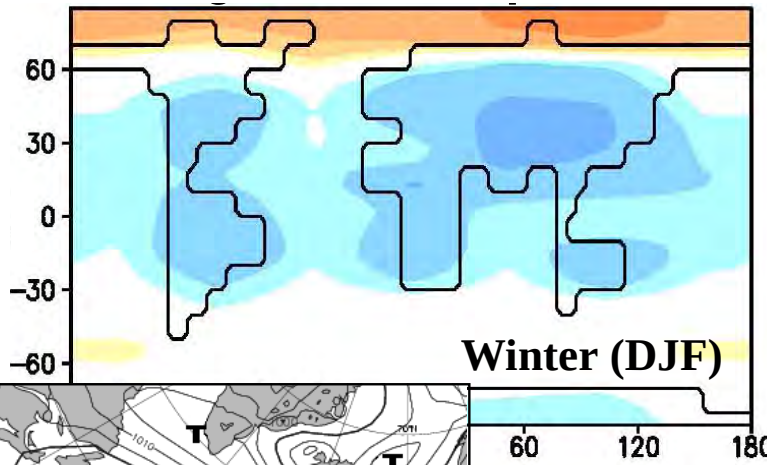
Multiple Scales in Fluid Dynamics and Meteorology

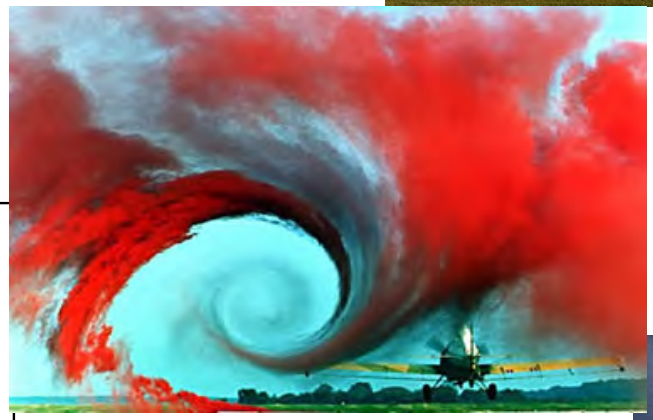
DFG-Priority Research Program 1276

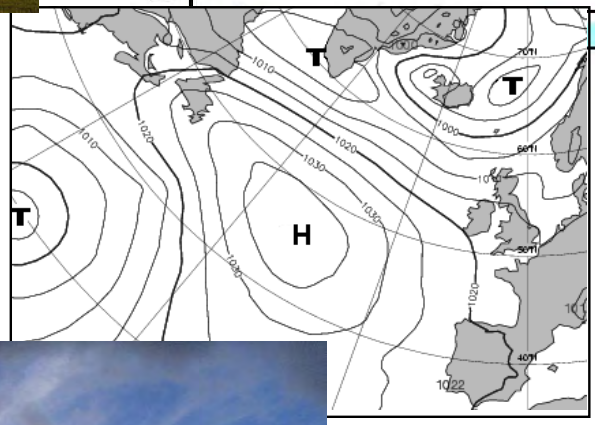
MetStröm

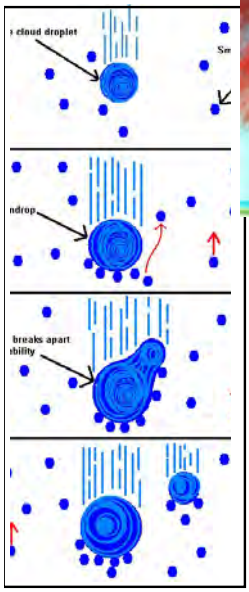
thanks to ...

Dr. Walter Lachenmeier

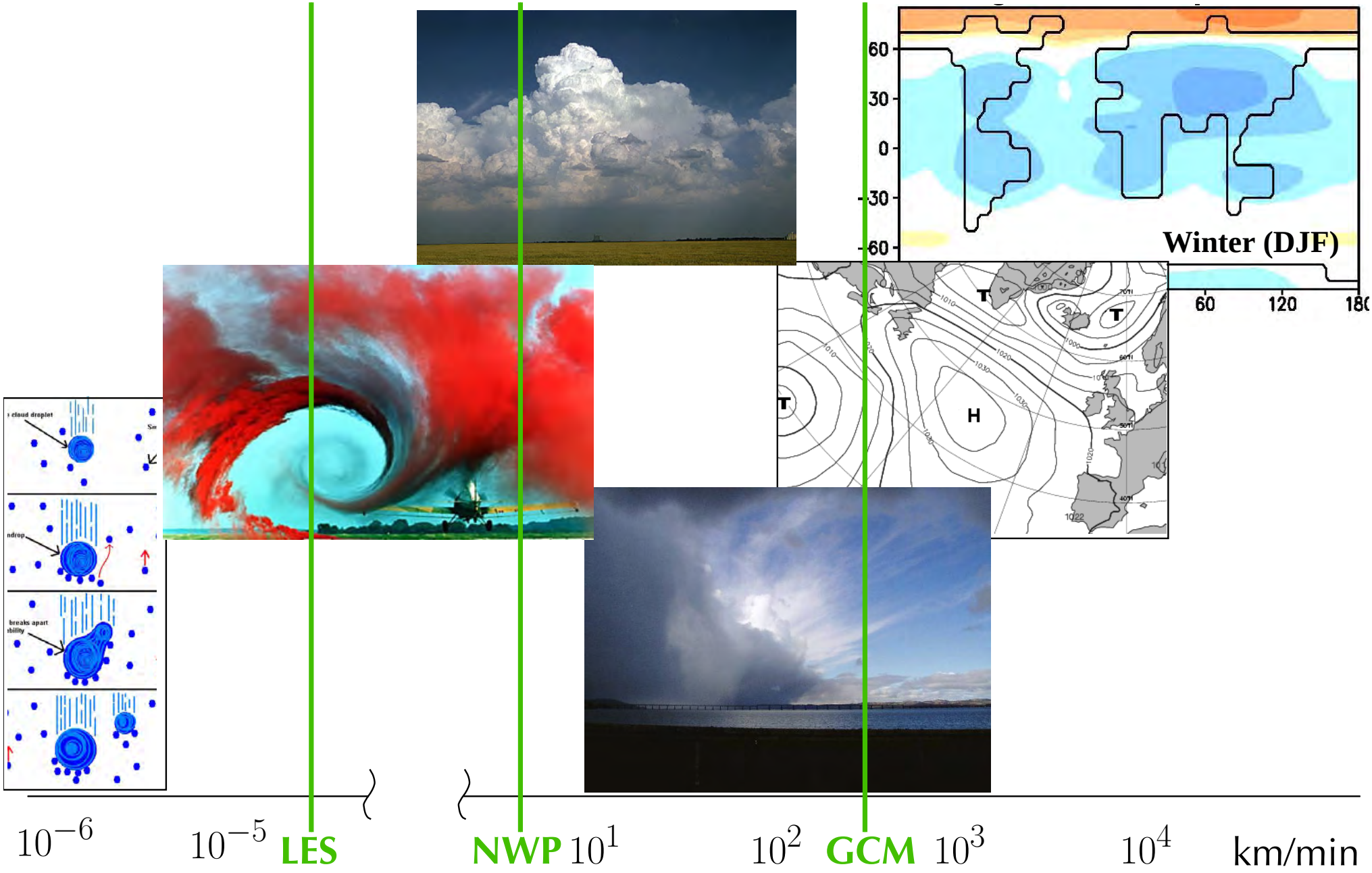




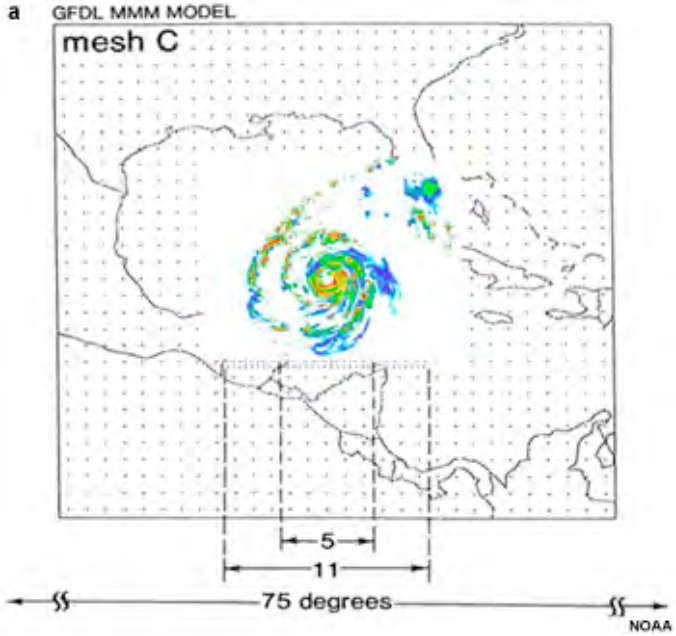




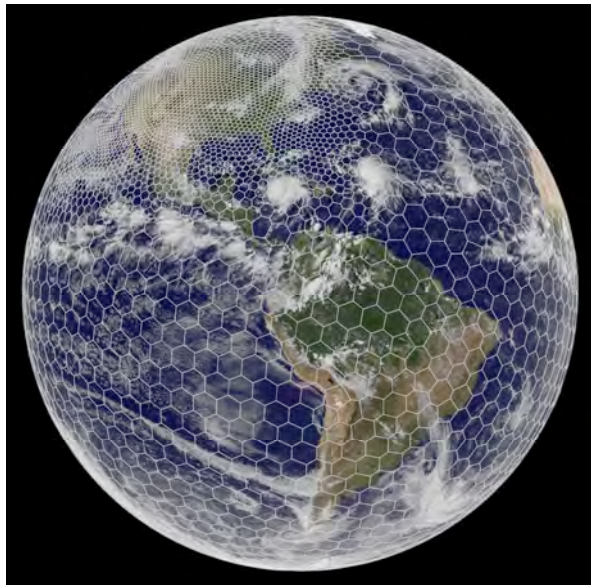
10^{-6} 10^{-5} 10^{1} 10^{2} 10^{3} 10^{4} km/min


Winter (DJF)
60
30
0
-30
-60
60
120
T
T
T
H
LES
NWP
GCM
10^{-6}
10^{-5}
10^{1}
10^{2}
10^{3}
10^{4}
km/min

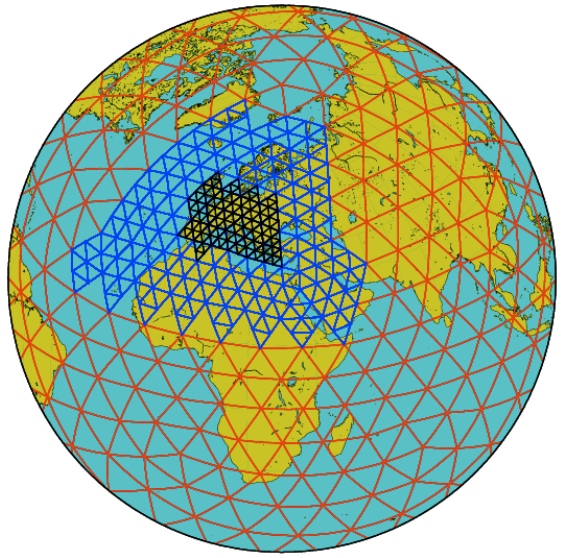
GFDL: Hurricane prediction model



NCAR: CAM-3/HOMME, MPAS, EULAG



DWD & MPI-HH: ICON



ECMWF: ...

ECMWF discusses a grid-based scheme for their next-generation forecast model

See **A. Arakawa's lecture** at their

Nonhydrostatic modelling workshop

Nov. 2010

A. Arakawa, ECMWF Nonhydrostatic Modelling Workshop:

WILLIAMSON, D. J. , 1999

For the upward branch of the Hadley circulations simulated by the NCAR CCM2 :

- When the resolutions are increased for both dynamics and parameterizations,

  → No sign of convergence;

- When the resolution is increased only for dynamics,

  → Convergence;

  However, the result is similar to that when the coarse resolution is used for both.

He then raised a serious question:

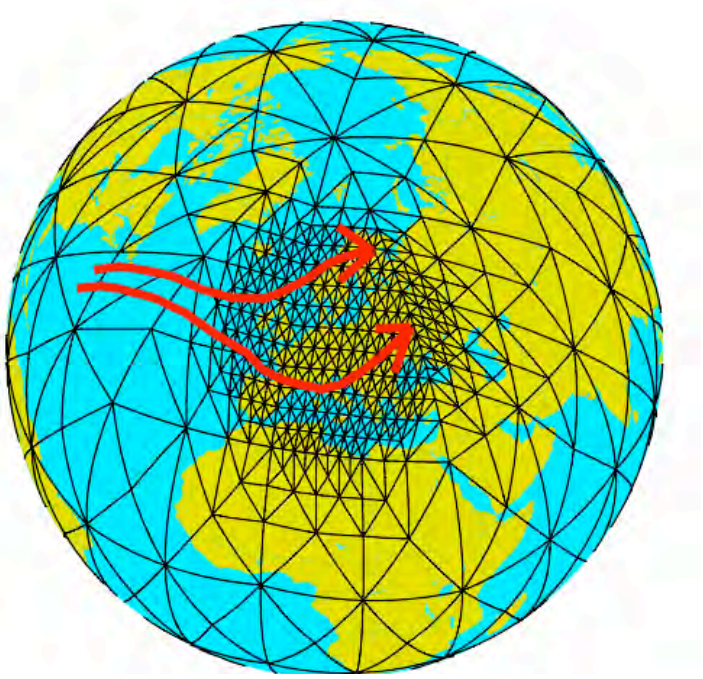
> *" . . . are the parameterizations correctly formulated ? . . .*
> *The parametrization should explicitly take into account*
> *the scale of the grid on which it is based. "*

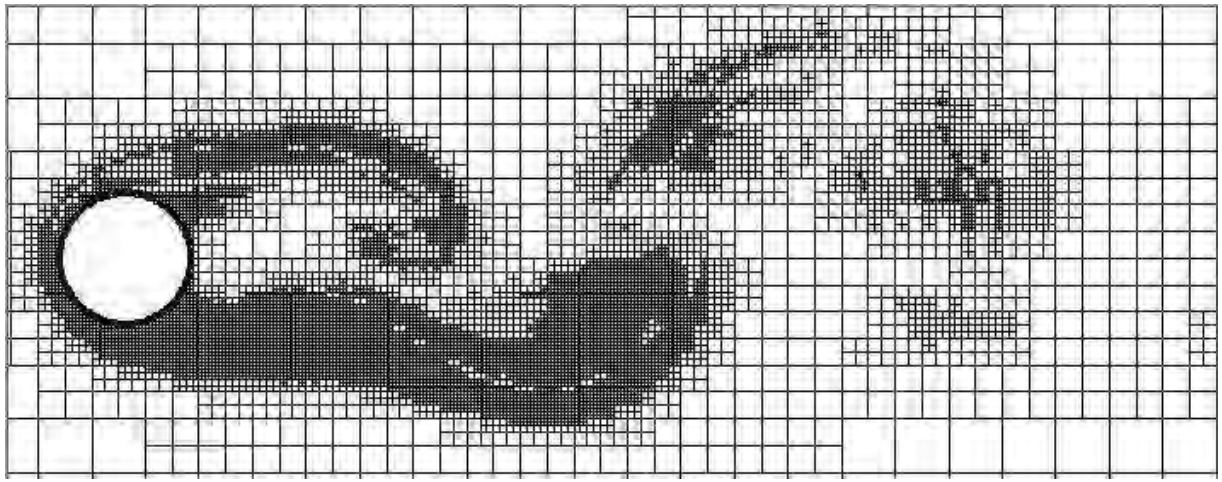
Similar questions are also raised by

Skamarock and Klemp (1993) and Buizza (2010).

http://www.ecmwf.int/newsevents/meetings/workshops/2010/Non_hydrostatic_Modelling/presentations/index.html

Advantage of Adaptivity: Meteorology



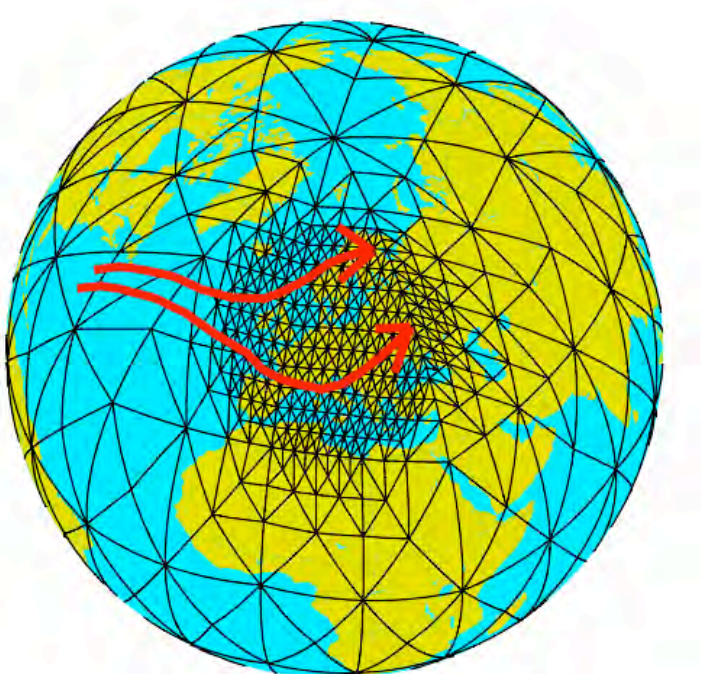


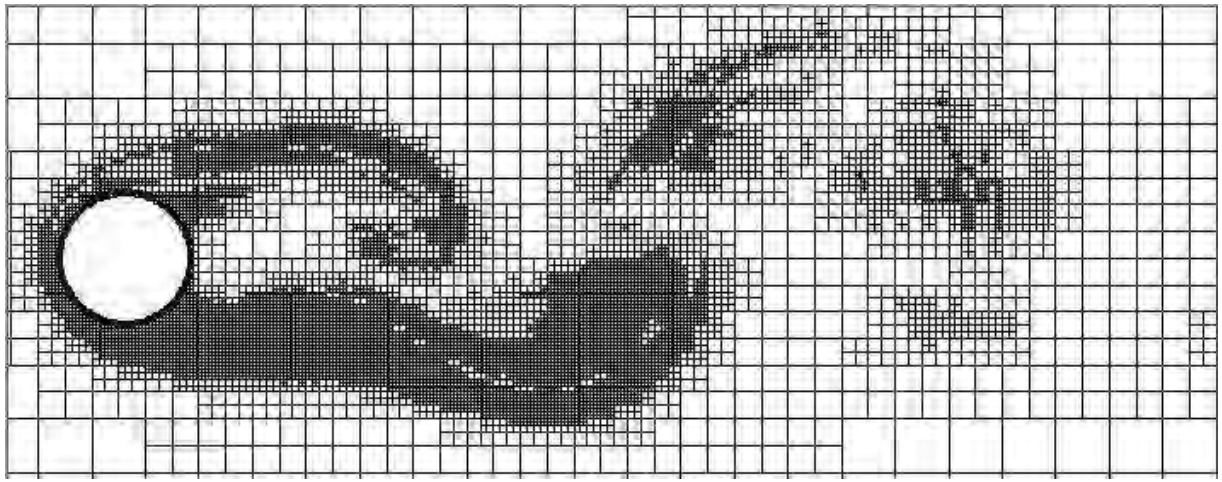
Adaptivity yields increased accuracy & efficiency

- in regions of interest
- in regions with strong, small-scale variability

by simplifying the closure task

Yet – Advantage of Adaptivity: Numerics





Adaptivity yields increased accuracy & efficiency

- for the entire solution
- for user-defined goal functions

by locally targeting the convergence corridor

Isaac Newton Institute for Mathematical Sciences

Multiscale Numerics for the Atmosphere and Ocean

22 August - 21 December 2012

Particular themes will include:

Adaptive simulation techniques

Adaptive meshes
Criteria for refinement
Mesh movement vs mesh refinement vs locally increasing polynomial order
Data assimilation and inverse problems on adaptive meshes

Numerical techniques

Closures accurate over a wide range of resolutions
Discretisations suited to the atmosphere and ocean
Solution of equation sets appropriate for the local mesh resolution
Preservation of balance, conservation, monotonicity, accuracy and high curvature under adaptation
Spurious wave reflection and refraction from mesh inhomogeneity

Computing techniques

Algorithims with sufficient computational efficiency and parallelism
Mapping numerical schemes to emerging massively parallel computer architectures

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Challenges set for the MetStröm–Program

- Understanding of the relevant multiscale physical processes
- Understanding of under-resolved numerics

- Numerics-compatible Parameterizations
- Parameterization-compatible Numerics

- Concepts for the control of Grid- and Model-Adaptivity

- Check against observations („the truth“)

- **Preferentially Meteorological Applications**

Thanks again for coming

and

We hope you will enjoy the conference

Deutsche
Forschungsgemeinschaft

MetStröm DFG