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Challenges for a new 1km non–hydrostatic model over the Alpine area

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Setup of the COSMO-1 model

(ww.cosmo-model.org)

Model Equations

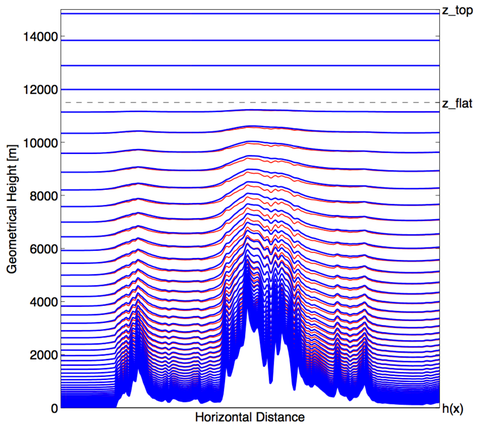
•Non-hydrostatic, full compressible hydro-thermodynamical equations in advection form
•Subtraction of a hydrostatic basic state (exponential profile with asymptotic isothermal stratosphere atmosphere) at rest

Prognostic Variables

•pressure, 3 wind components, temperature, specific humidity, cloud water, cloud ice, graupel, rain, snow, turbulent kinetic energy (TKE)

Coordinate System

•Arakawa-C, rotated lat/lon horizontal grid
•Generalized terrain-following SLEVE2 (after Leuenberger et al. 2010) height-based vertical levels, Lorenz staggering
•80 levels
(quadratic distribution)



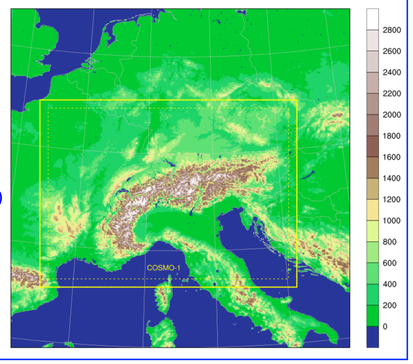
SLEVE2
Δz_{min} = 15.6 m

Gal-Chen
Δz_{min} = 13.1 m

Domain (yellow)

$\Delta\lambda = \Delta\phi = 0.01°$

1062 × 774
= (2^5×3×11+6) x (2^8×3+6)



Relaxation zone
(stippled) of 30 grid points

References

Baldauf, M., 2012: Development of a new fast waves solver for the Runge-Kutta scheme, *COSMO/CLM User Seminar*, Offenbach 6-8 March, Germany, [available online at http://www.dwd.de].
Baldauf, M., G. Zängl, 2012: Horizontal nonlinear Smagorinsky diffusion. *COSMO newsletter*, **12**, 3-7, [available online at http://www.cosmo-model.org].
Leuenberger, D., M. Koller, O. Fuhrer, and C. Schär, 2010: A generalization of the SLEVE vertical coordinate. *Mon. Wea. Rev.*, **138**, 3683–3689.

Dynamics

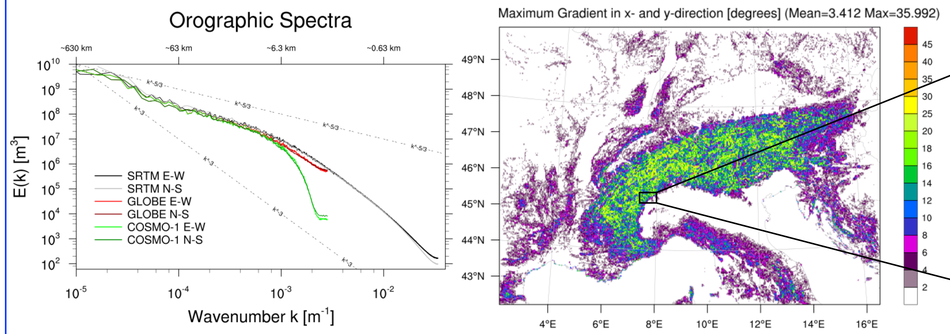
- Split-explicit 3rd-order Runge-Kutta time-discretization (Δt = 10 seconds) with explicit 5th-order advection in the horizontal direction and 2nd-order implicit vertical advection
- Rayleigh damping in upper layers
- 2D divergence damping
- Horizontal non-linear Smagorinsky diffusion (Baldauf et al. 2012)

Related questions

- Is Δt=10s too close to Courant–Friedrichs–Lewy (CFL) criteria? but the CFL is below the theoretical limit (1.42*CFL)
- Is a Radiative Upper Boundary Conditions (RUBC) necessary?
- What would be the impact of a 3D divergence damping?
- Would a Smagorinsky-Lilly turbulence closure be better?

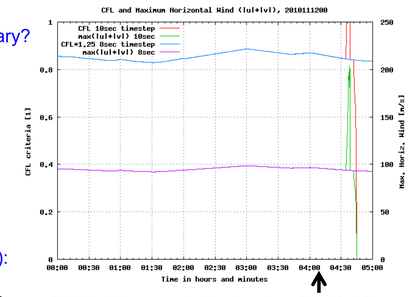
Stability

- Orographic filtering removes from original 1km GLOBE data all 4Δx waves and locally 750m steps



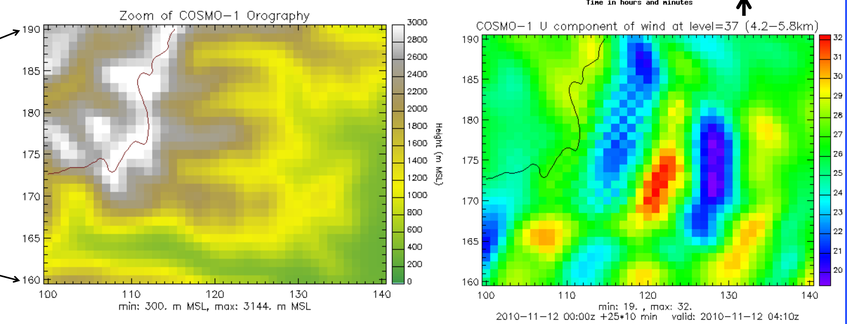
- The new fast waves solver (Baldauf 2012) seems to be able to cope with slopes below 47°
- Maximum slope of orography does not exceed 36°

Storm Carmen (12.11.2010) needs 8s



- CFL criteria and maximum horizontal wind for 2 runs with 10 and 8s time step (overlap) during the first 5 hours:

- Zoom NW of Torino (near French/Italian border):



- The model level slopes in this area do not exceed 27°
- The waves in the mid-troposphere (here from the NW) have a check pattern which do not depend on the choice of Rayleigh damping, diffusion or advection scheme used (other problem!)

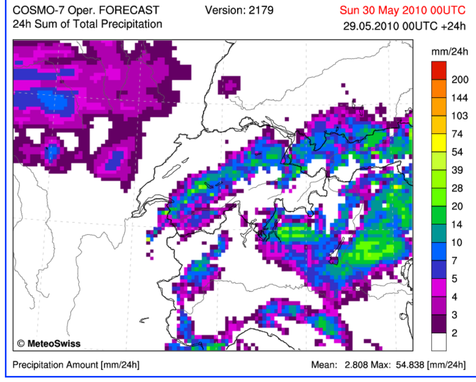
Physics

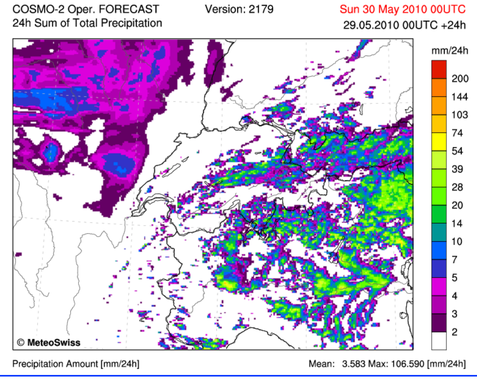
- Explicit deep convection **BUT** reduced Tiedtke (1989) scheme for shallow convection
- Bulk microphysics for atmospheric water content
- Turbulence: Prognostic TKE closure at level 2.5 including effects from subgrid-scale condensation and from thermal circulations
- Radiation: Ritter and Geleyn (1992) with a calling frequency (0.1h) Aerosol climatology (Tanre et al. 1984)
- NO Subgrid-Scale Orography scheme by Lott and Miller (1997)
- Multilayer soil module coupled to the Surface layer scheme (based on TKE) including a laminar-turbulent roughness layer

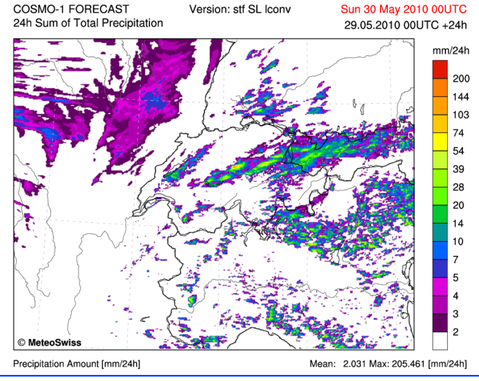
- Should be coupled to the turbulent scheme (see below)
- Would a 2-moment scheme perform better?
- Which parameterization?
  1D TKE **.OR.** 1D TKE + horizontal TKE advection **.OR.** 3D LES
- Could be replaced by Tegen (1997)
- Use Community Land Model CLM?

Benefits

- Higher resolution compared to operational (7 and 2km) has a potential for a better topographic forcing







- Non-linear scale interactions limited to Convection (case below) and/or Stratocumulus clouds?