# The development of anelastic dynamical core for the future NWP model

**Damian Wojcik**, Marcin Kurowski,
Bogdan Rosa, Michal Ziemianski,
Zbigniew Piotrowski

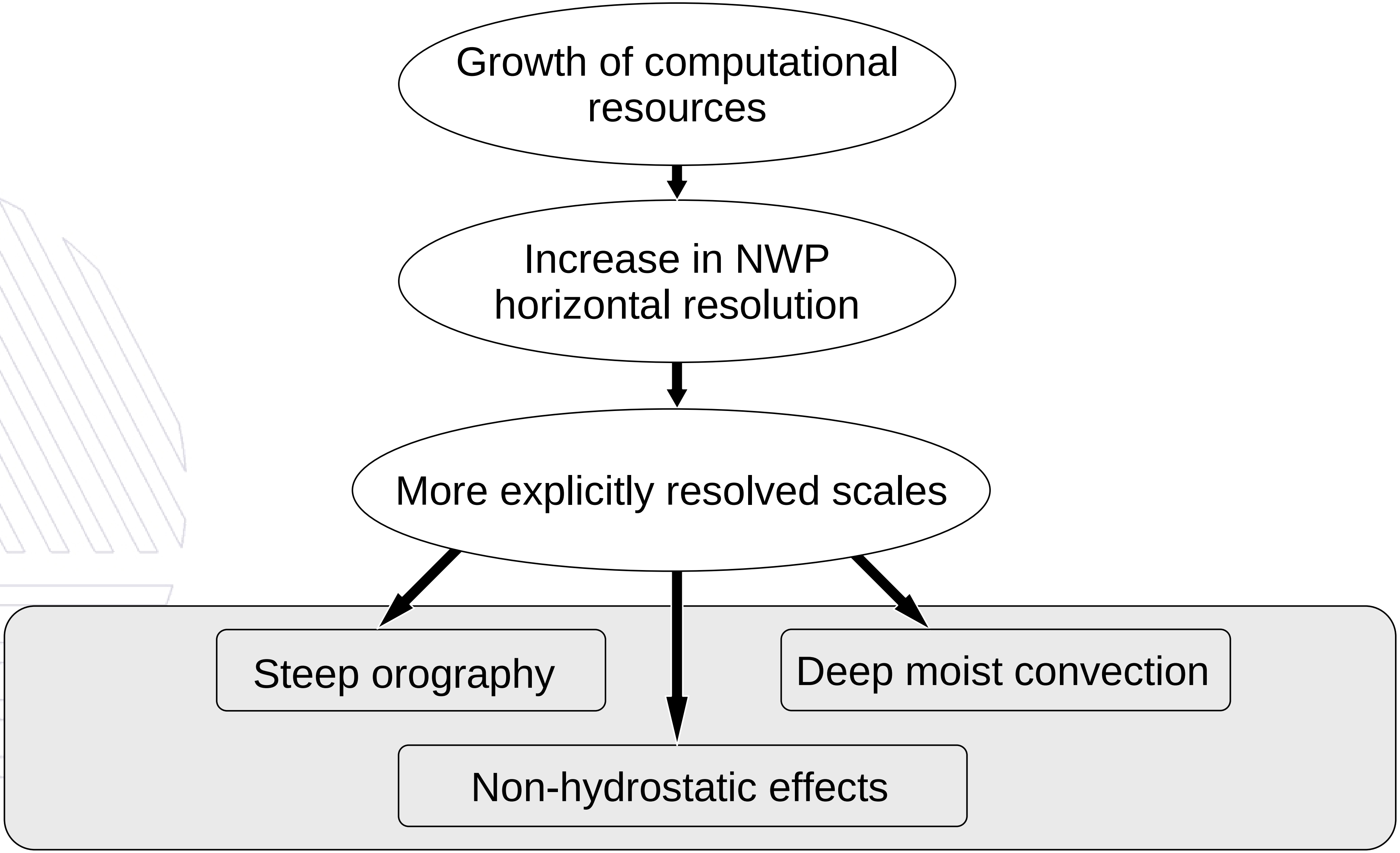
Institute of Meteorology and Water Management
National Research Institute
Warsaw, Poland

3rd International EULAG Workshop on Eulerian/Lagrangian methods for fluids.
27 June, 2012, Loughborough UK

# Outline

1. Motivation & CDC Project
2. Coupling of COSMO and EULAG
3. Project results
4. Summary

# Motivation


Growth of computational resources
Increase in NWP horizontal resolution
More explicitly resolved scales
Steep orography
Deep moist convection
Non-hydrostatic effects

# Conservative Dynamical Core Project

**COSMO (European Consortium for Small Scale Modeling)** decided to implement a conservative, accurate and computationally efficient dynamical core, based on finite volume discretization.

The anelastic dynamical fluid solver EULAG was chosen as a prospective dynamical core of a future operational COSMO model. The project include :

• idealized and semi-realistic tests of the EULAG
• coupling of EULAG with COSMO framework

# Coupling of EULAG with COSMO

# Coupling of EULAG with COSMO (1)

Main issues:

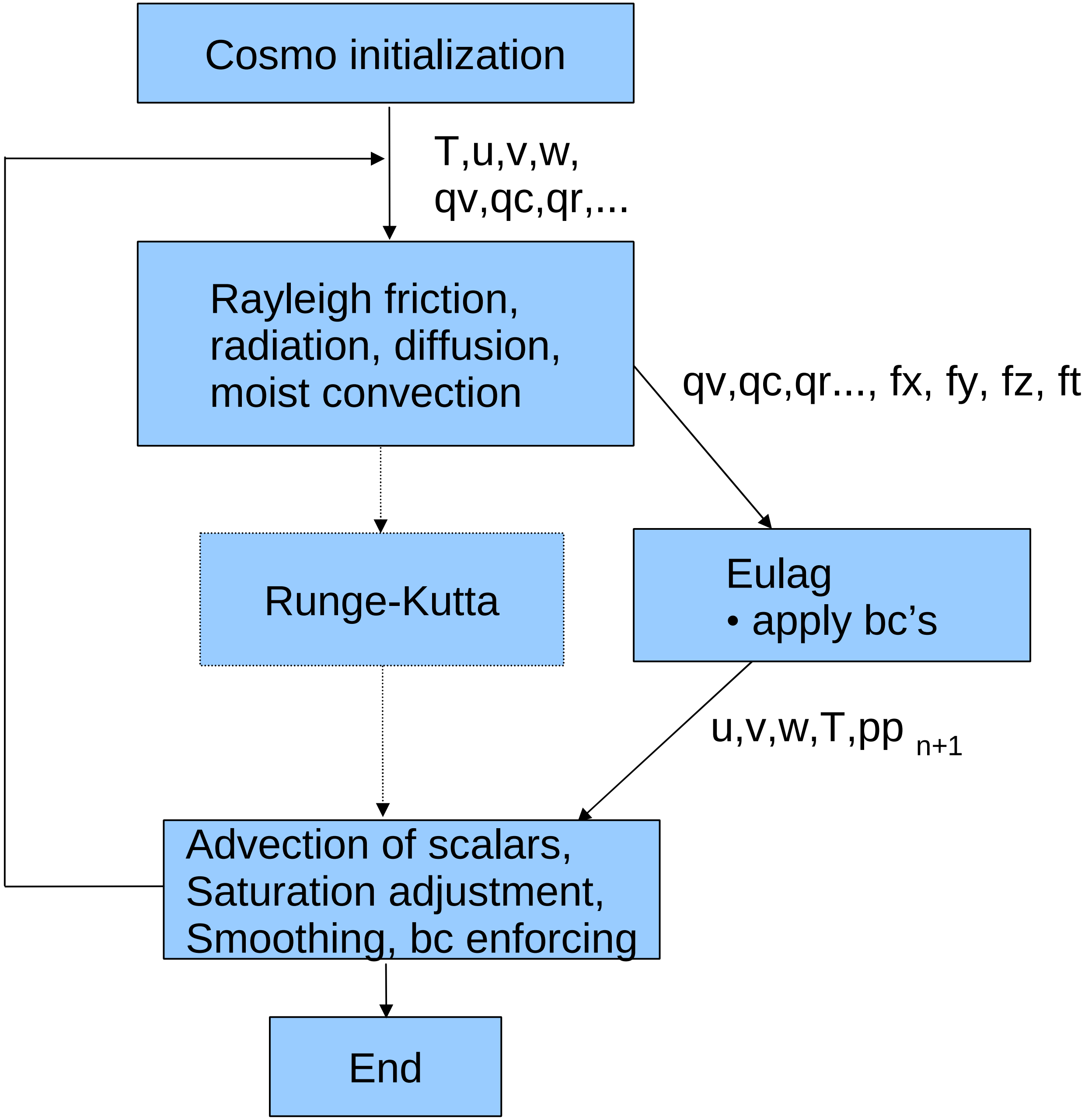
- Translation of EULAG (eulerian code), written in FORTRAN 77, to Fortran 90 and adaptation to COSMO standards (~ 48k code lines)
    - namelist
    - dynamic memory allocation
    - modular code structure
    - explicit variable typing
    - Makefile

- Verification of Fortran 90 EULAG version (idealized tests)

- Coupling the dynamical core with the COSMO framework
    - dynamical variable conversion
    - common coordinate system
    - physical tendencies (currently 1st accuracy order)
    - boundary conditions

- Verification of the hybrid COSMO-EULAG model
    - idealized tests
    - semi-realistic testcase

# Coupling of EULAG with COSMO (2)



# Experiment results

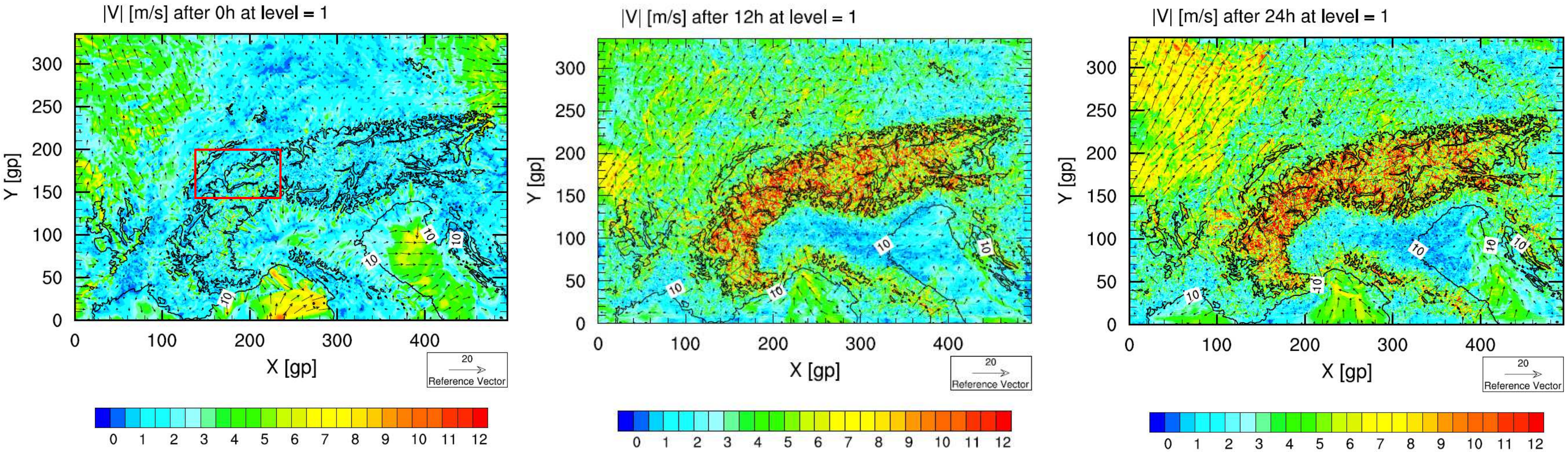
# Semi-realistic Alpine flows

## Setup overview :

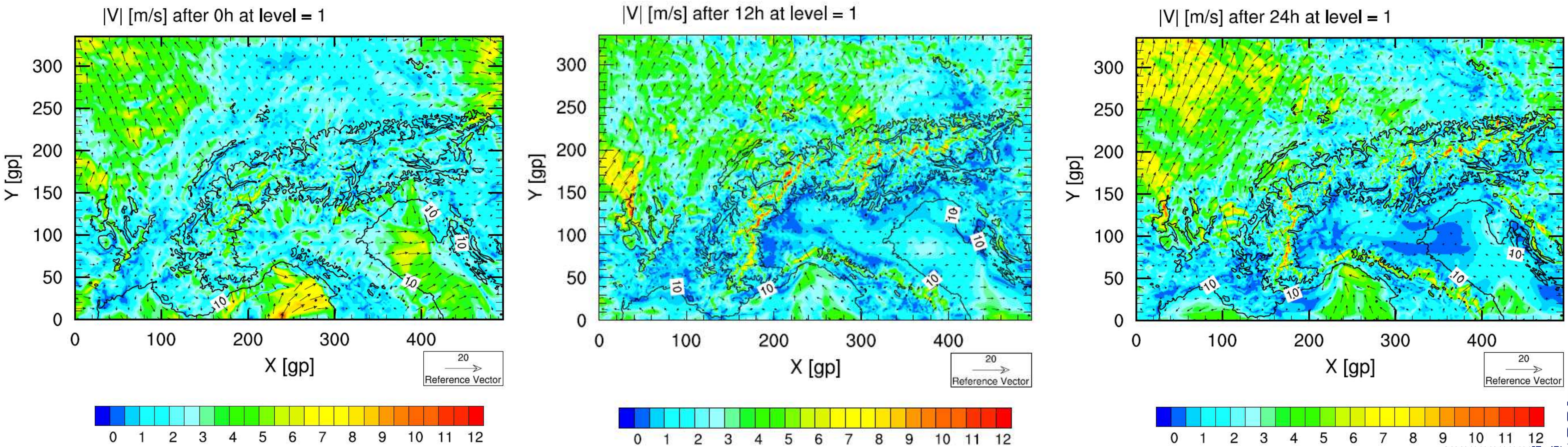
- Alpine domain 496x336x61 grid points with horizontal resolution of 2.2 km (similar to COSMO 2 of MeteoSwiss)
- Initial and boundary conditions and orography as for operational COSMO model for Switzerland
- TKE parameterization of sub-scale turbulence and friction (COSMO diffusion-turbulence model)
- Heat diffusion and fluxes turned off
- Dry run
- Simulation start at 00:00 UTC (midnight), 12 November 2009
- Results are compared with Runge-Kutta dynamical core
- Comparison after 12 and 24 hours of time integration

# Horizontal velocity : 10m level

## EULAG

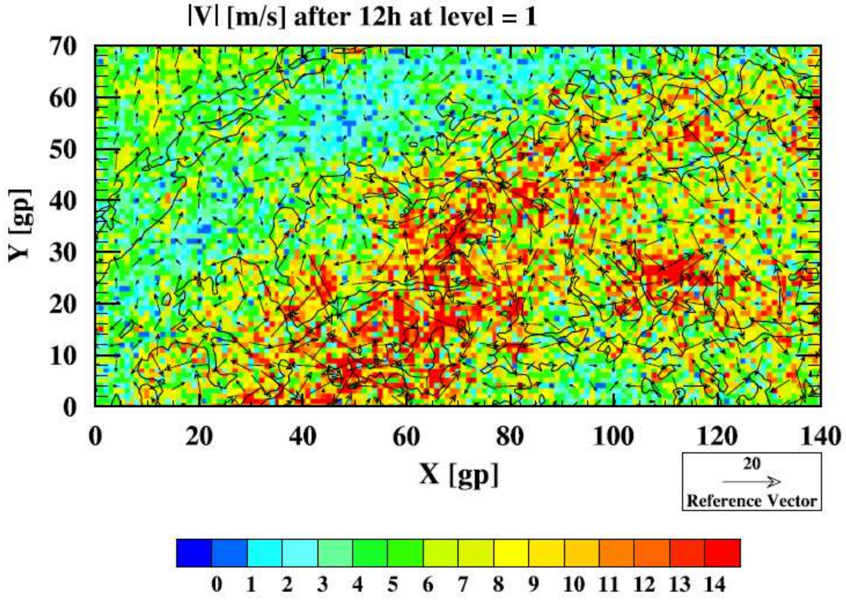


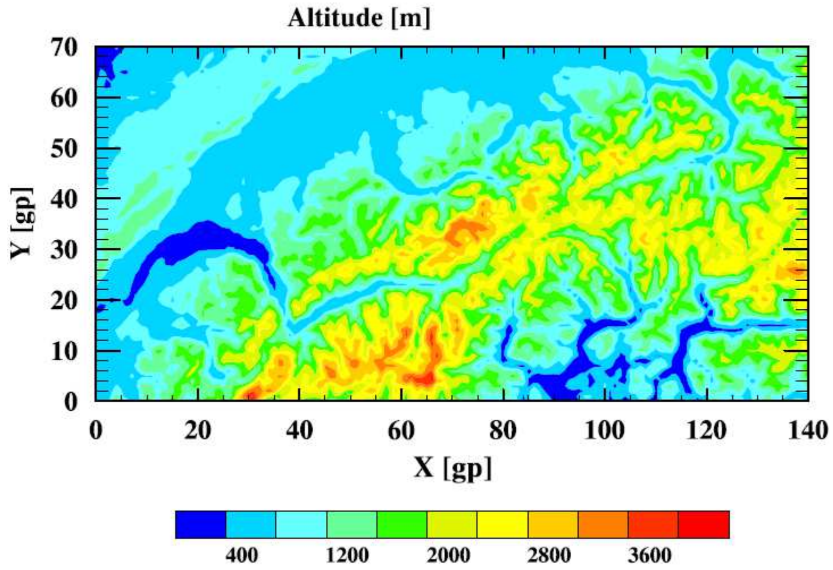

## COSMO R-K



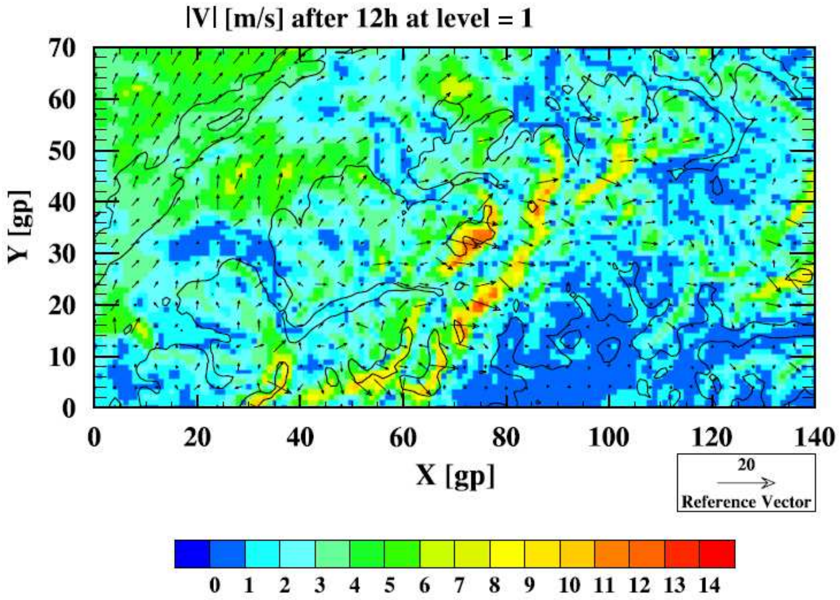
# Horizontal velocity : 10m level

EULAG

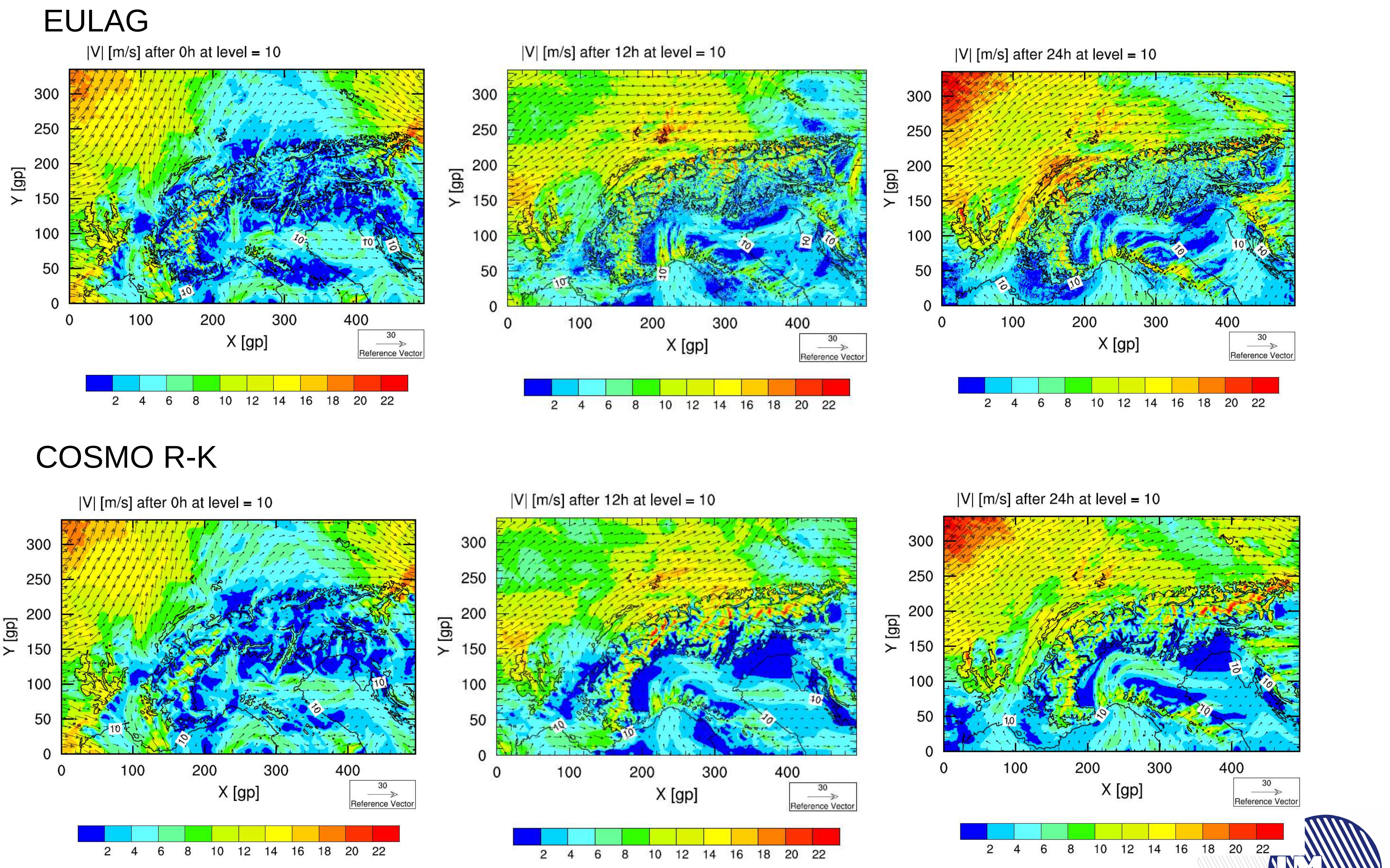



COSMO R-K

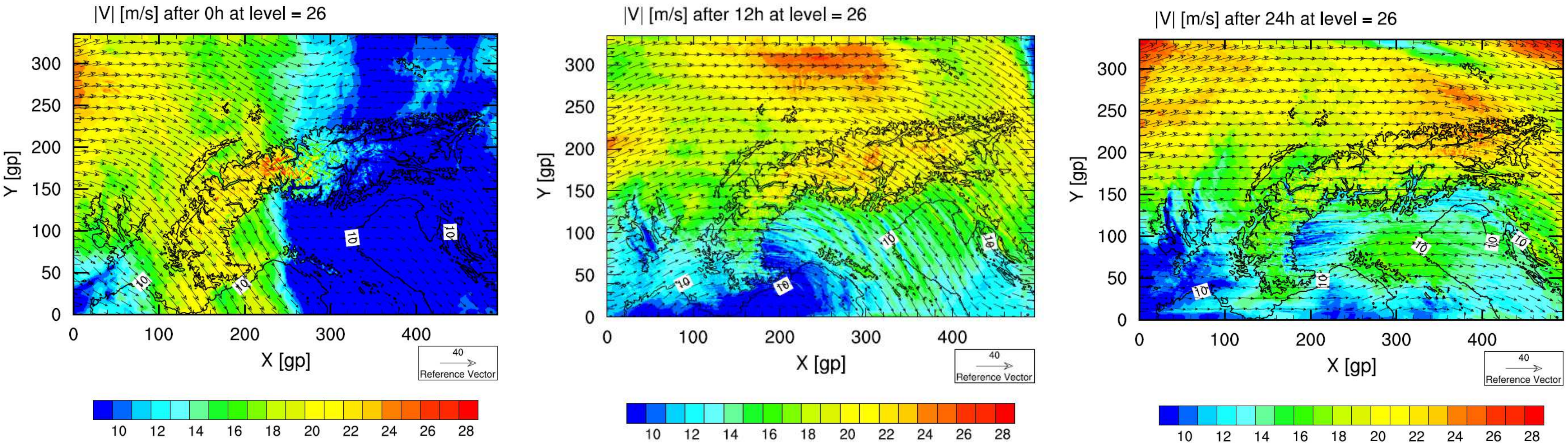


# Horizontal velocity : 500m level

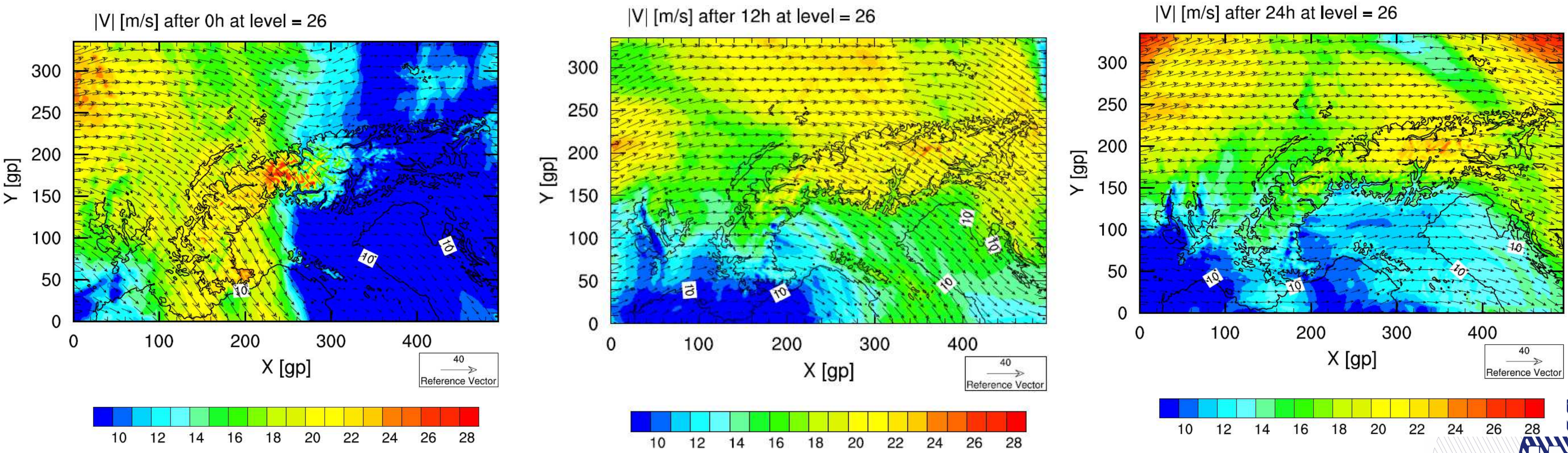


# Horizontal velocity : 4.5km level

## EULAG

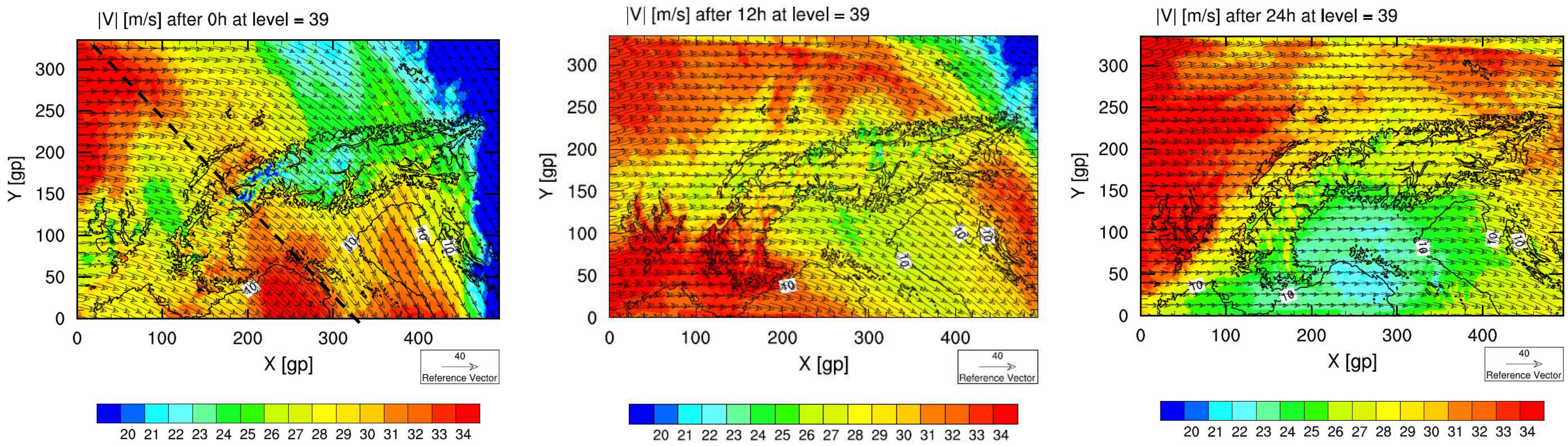



## COSMO R-K

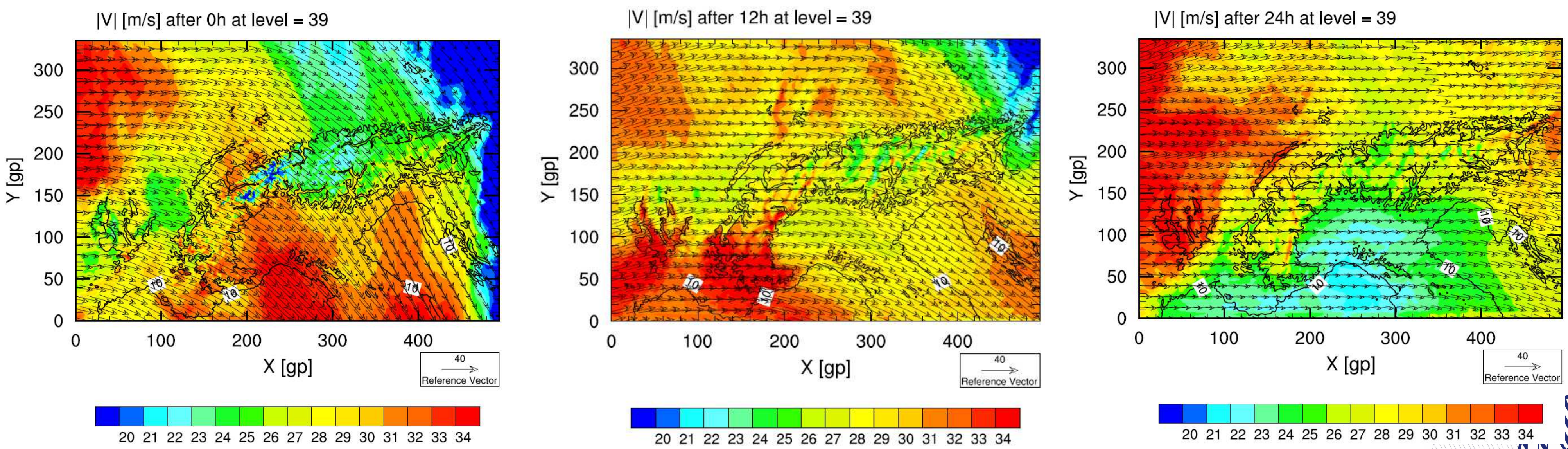


# Horizontal velocity : 10km level

EULAG

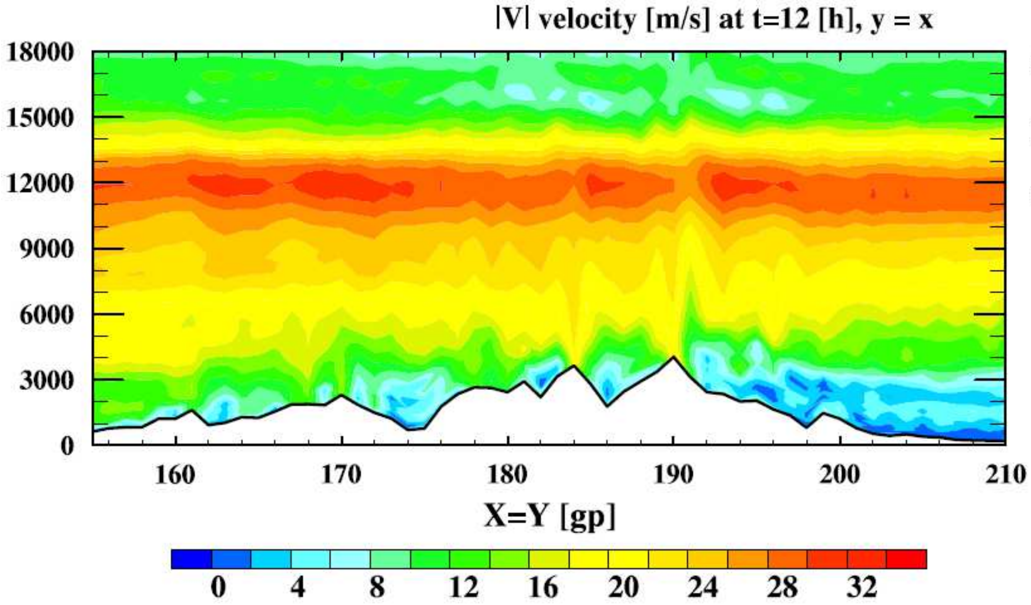


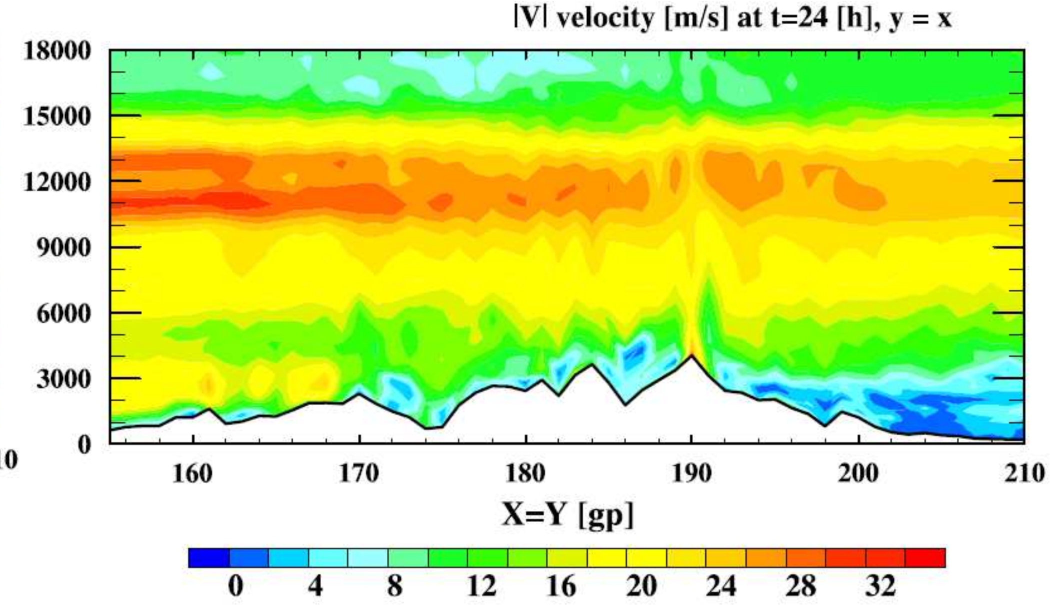

COSMO R-K



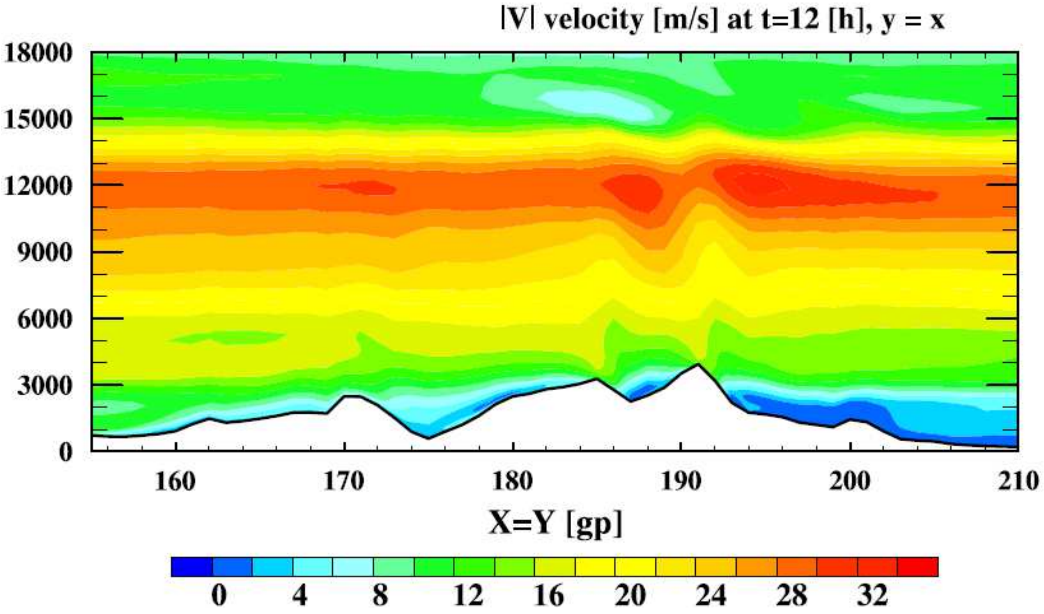
# Horizontal velocity : Mount Blanc

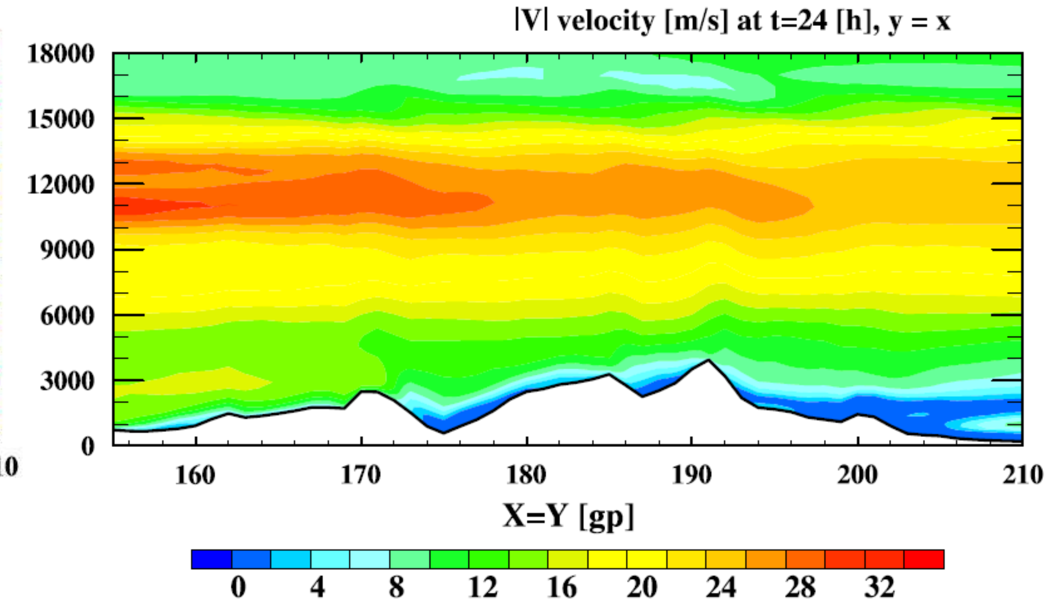
EULAG



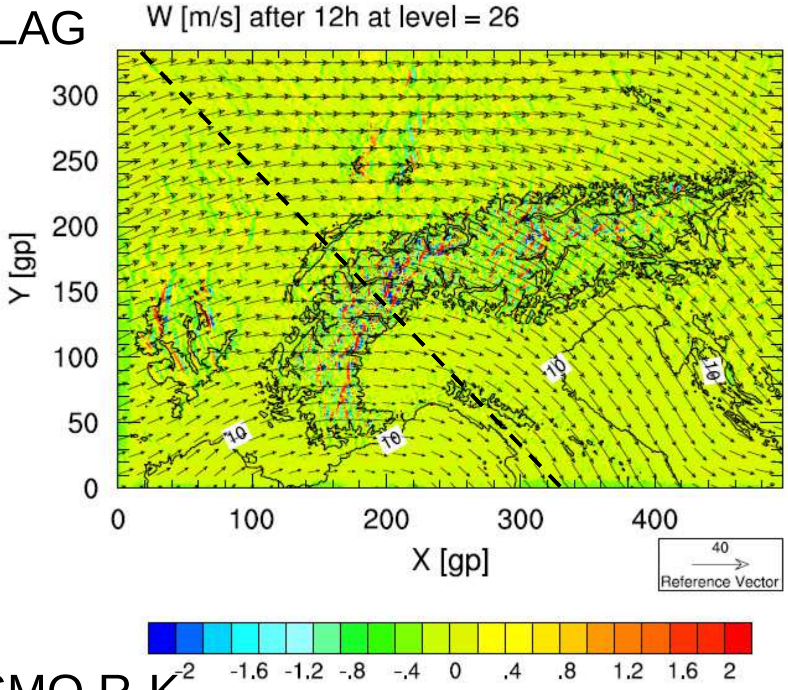

COSMO R-K

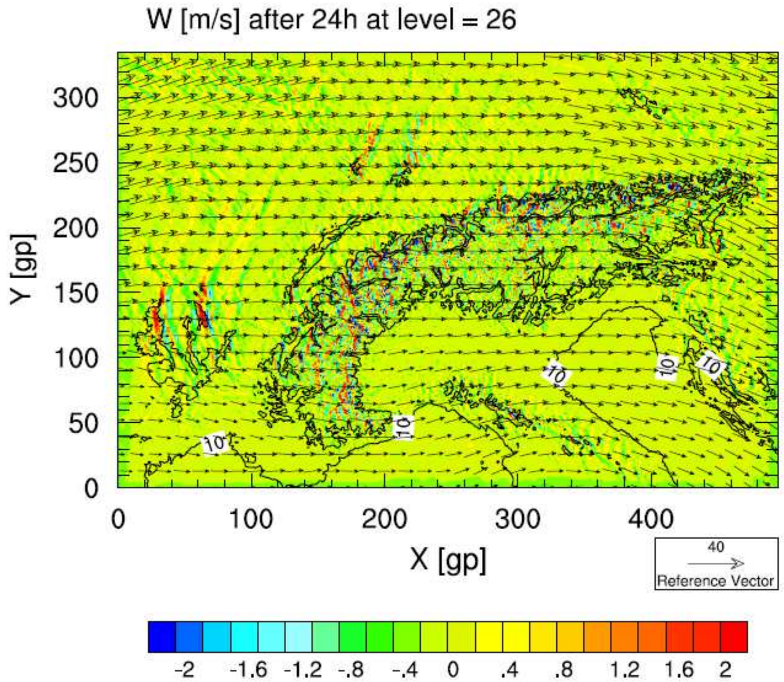


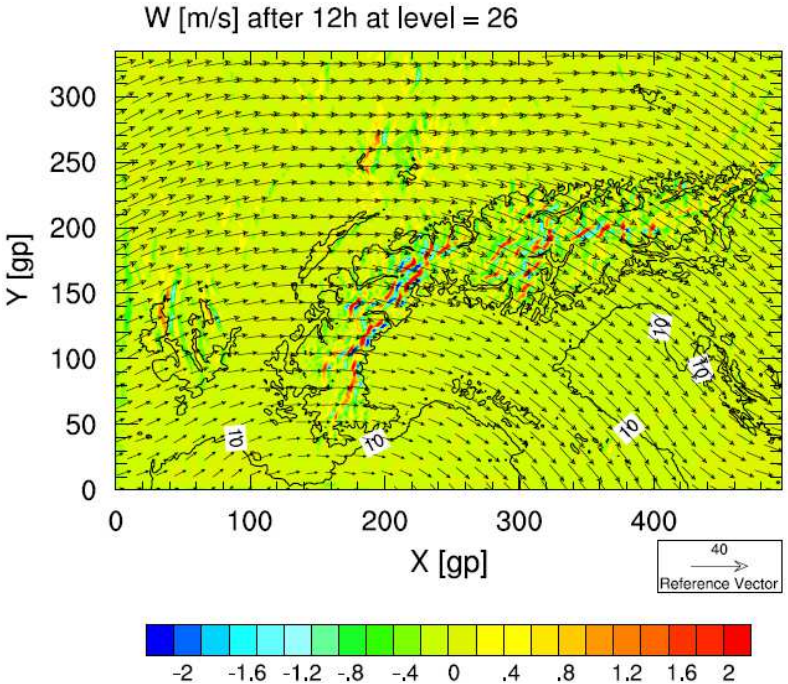
# Vertical velocity : 4.5km level

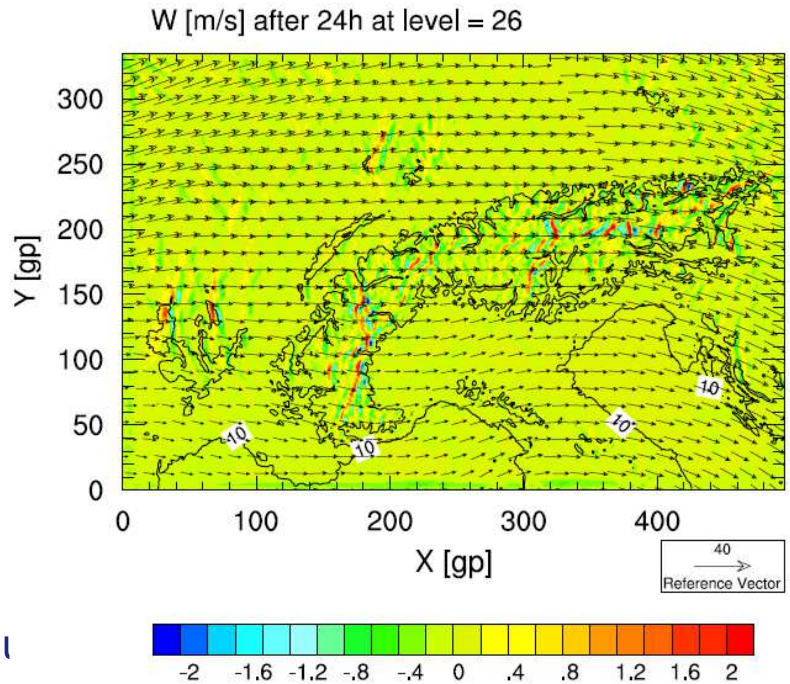
EULAG



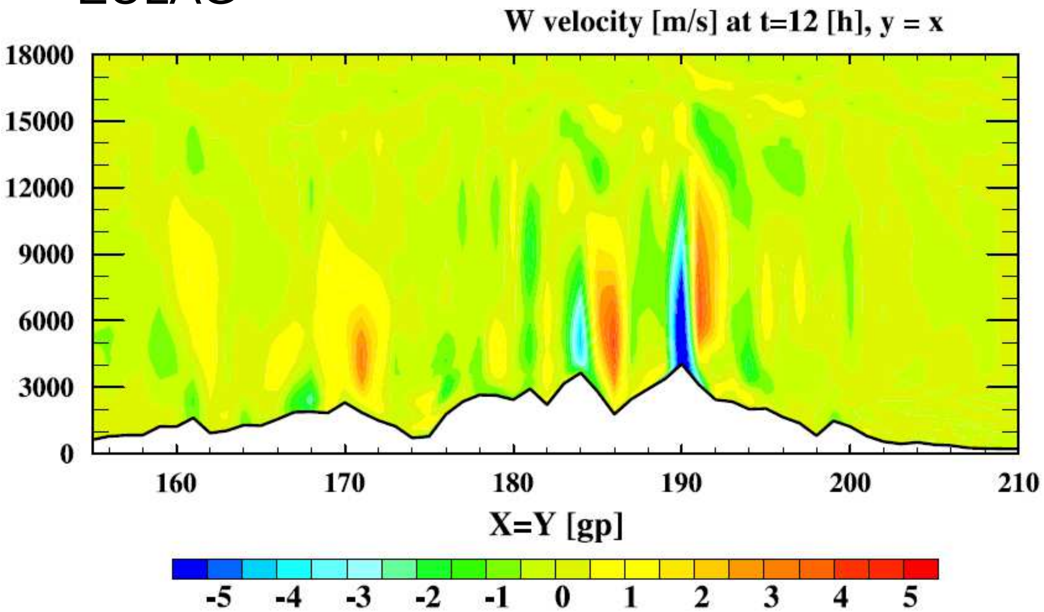

COSMO R-K

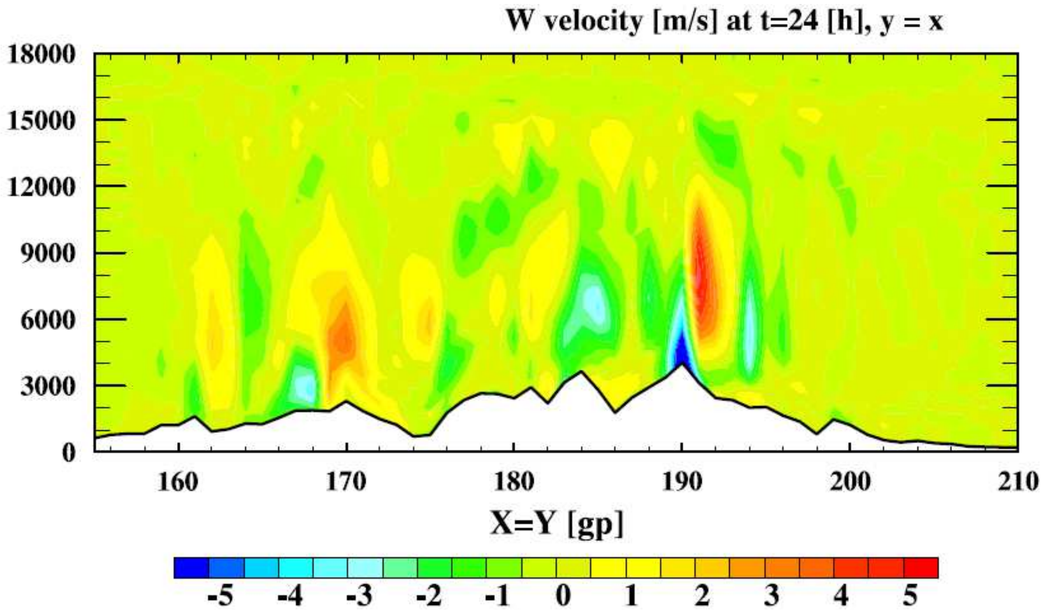


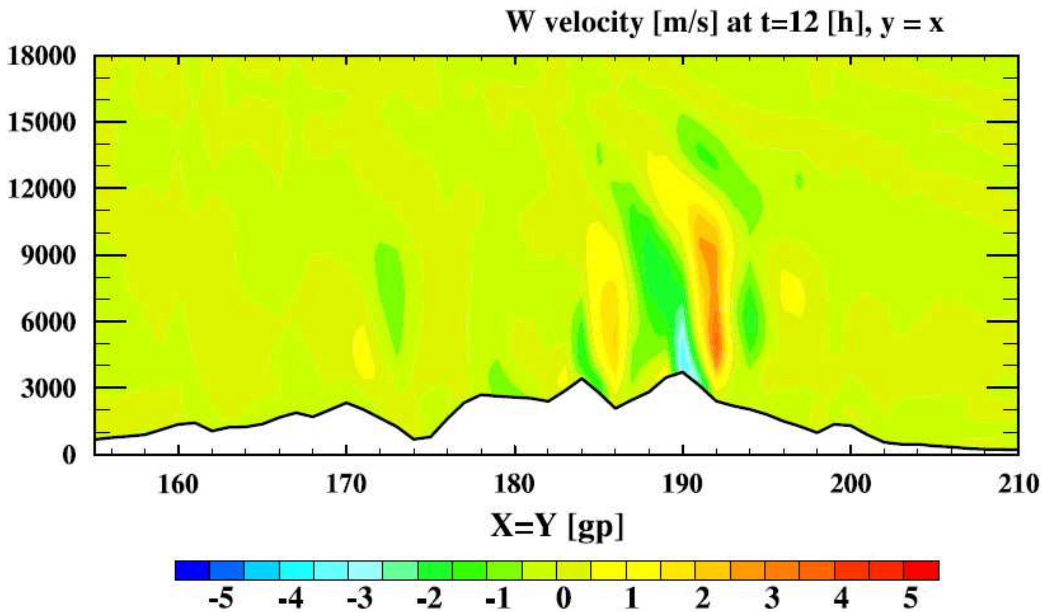
# Vertical velocity : Mount Blanc

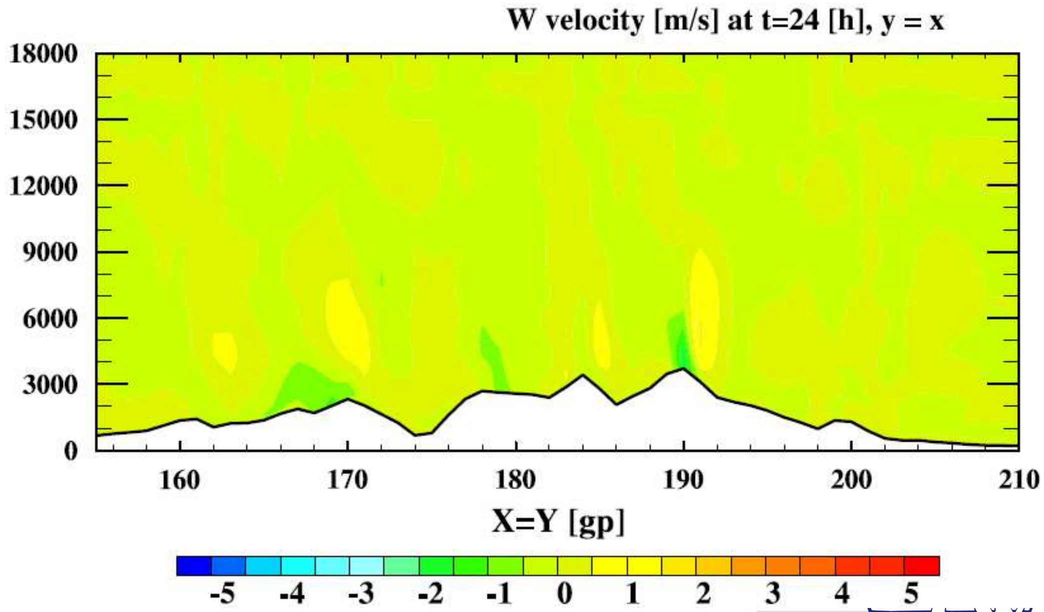
EULAG



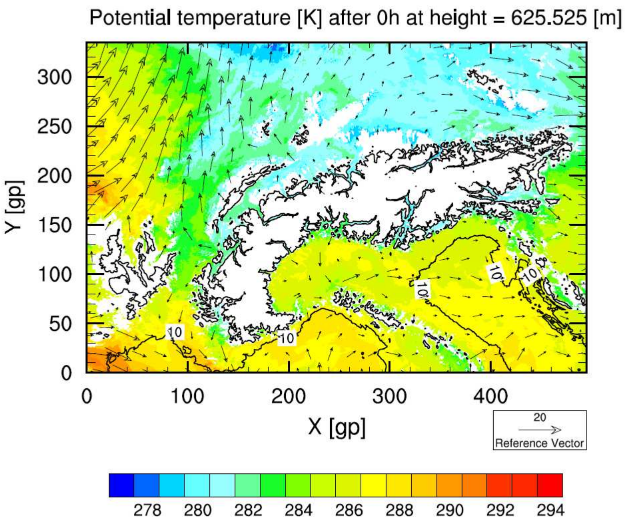

COSMO R-K

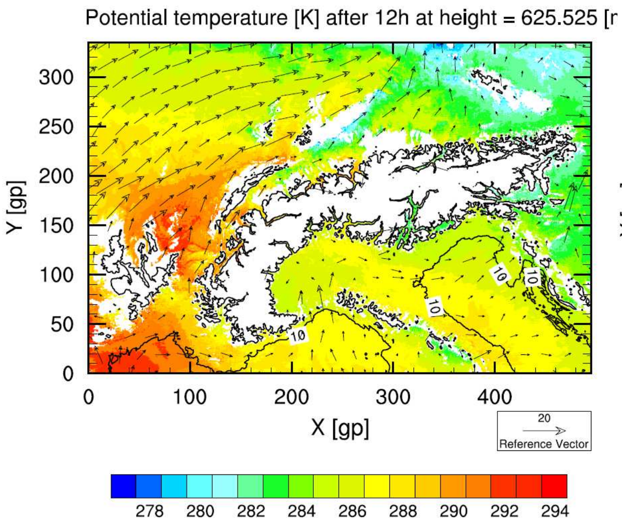


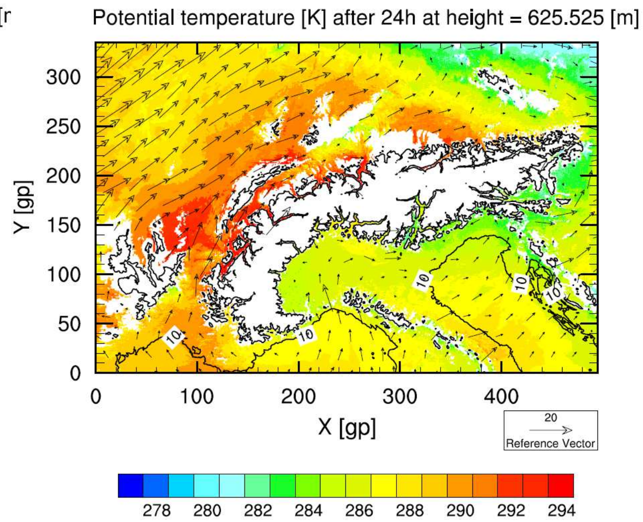



# Potential temperature : 626m height

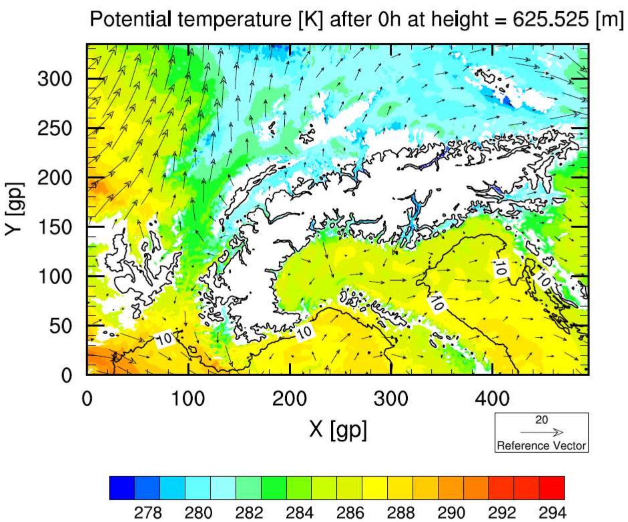
## EULAG

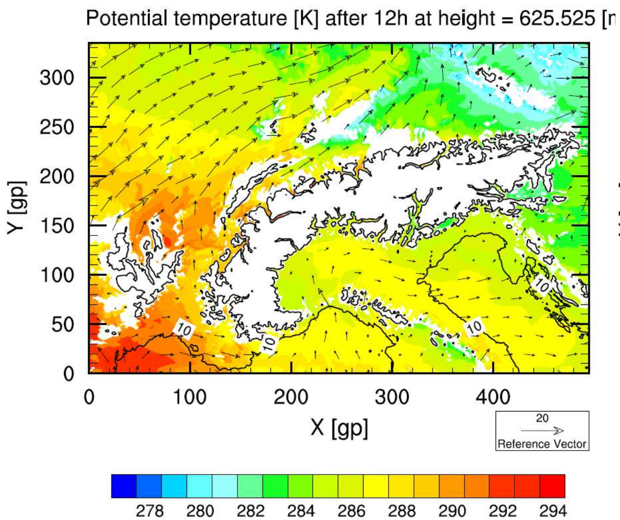


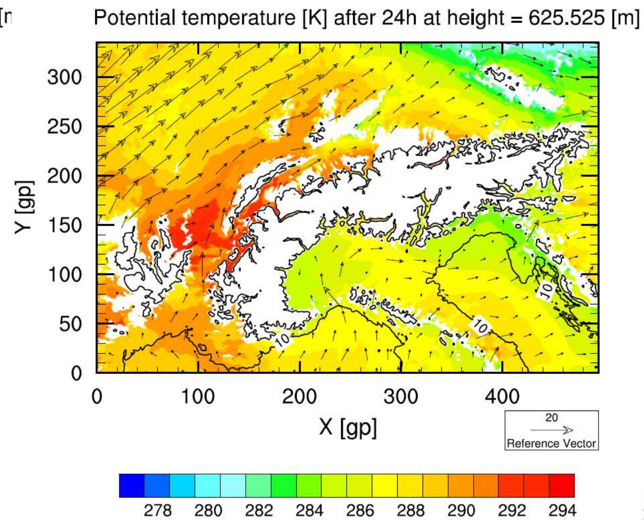




## COSMO R-K

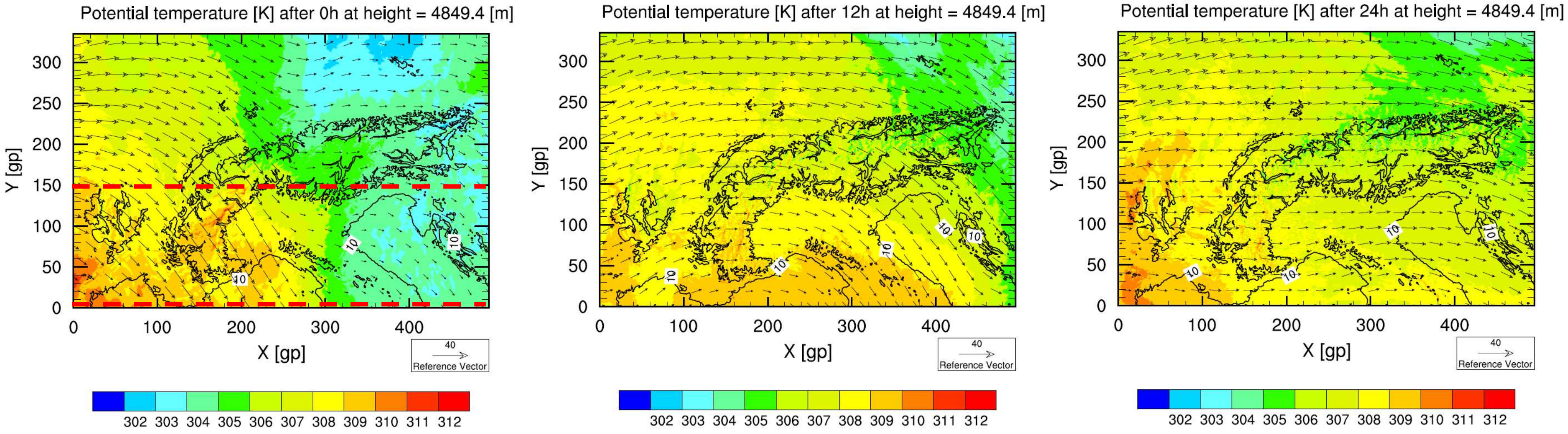


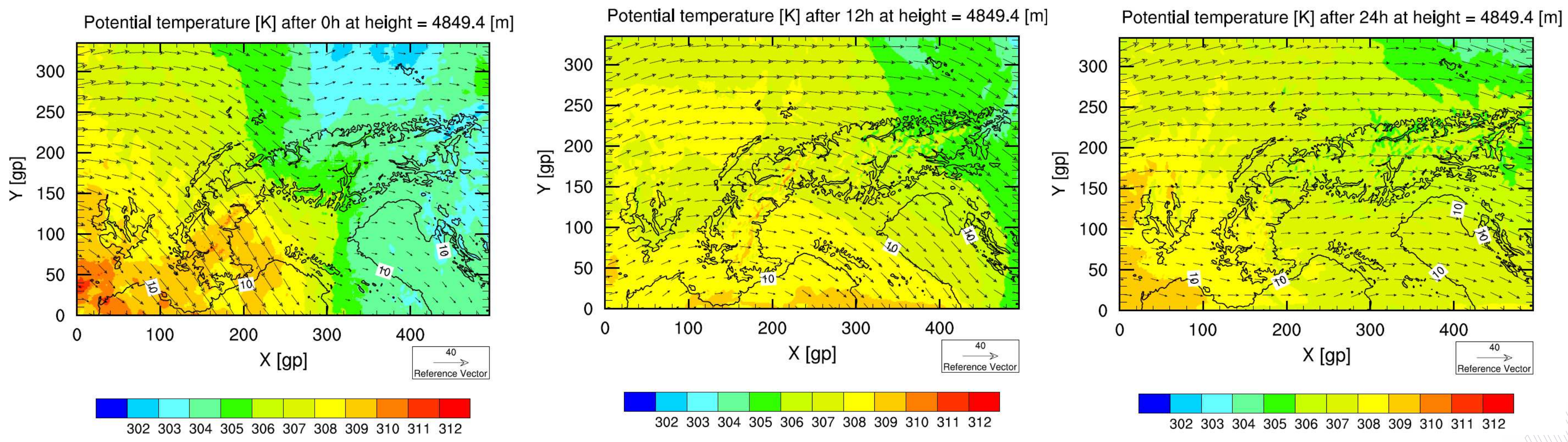



# Potential temperature : 4850m height

## EULAG

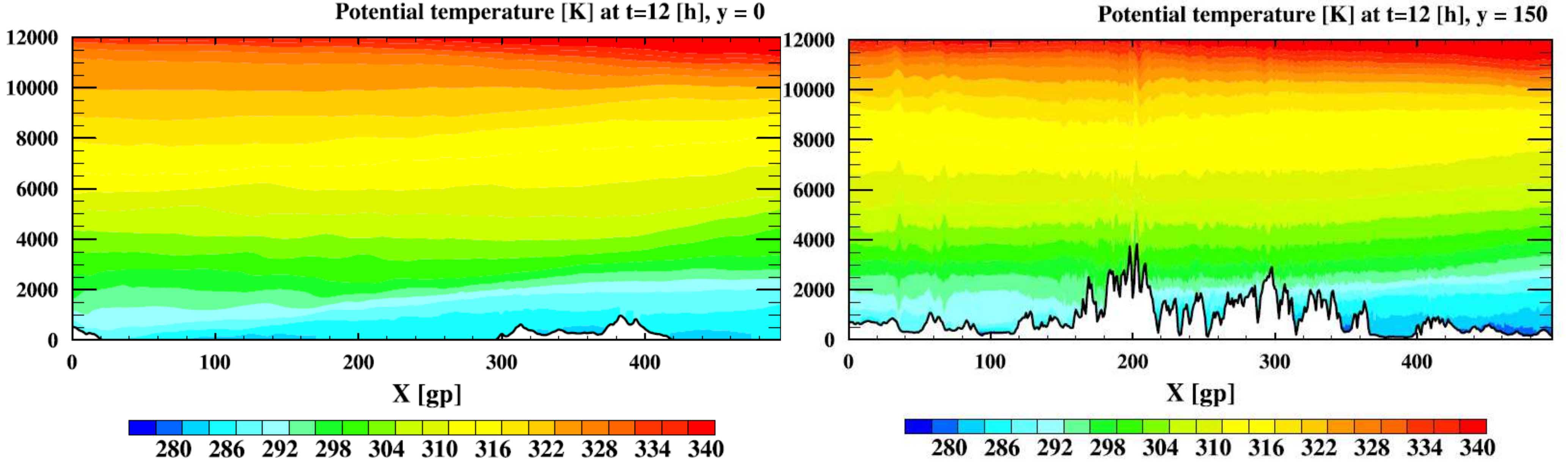



## COSMO R-K

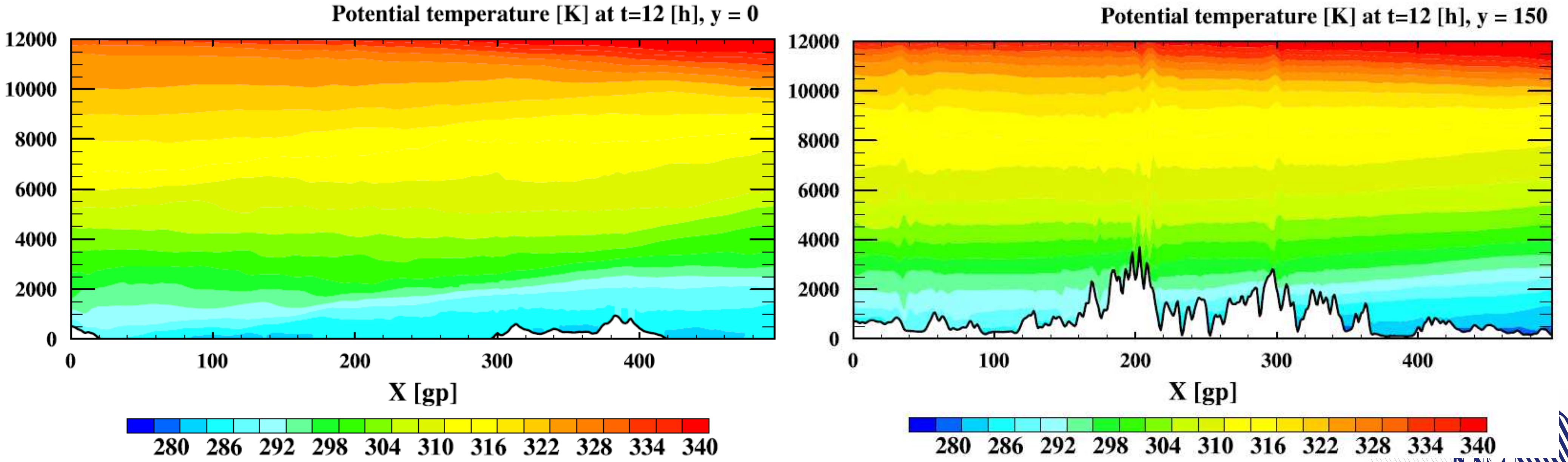


# Potential temperature

EULAG




COSMO R-K



# Summary

• EULAG is implemented into COSMO as anelastic dynamical core

• We completed first semi-realistic test for Alpine flow with COSMO parameterization of friction and turbulence

• No artificial smoothing was required to achieve stable solutions

• The solutions are generally similar to Runge-Kutta results and introduce more spatial variability, high wind speeds for higher mountain areas and higher amplitudes and spatial variability for orographic gravity waves

# Thank you !

IMGW 01-673 Warszawa, ul. Podleśna 61
Poland
tel.: + 48 22 56 94 361

damian.wojcik@imgw.pl
www.imgw.pl