Pre-operational COSMO-EULAG 2.8 km over Poland and high-resolution runs

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May 29th, 2018

This event is sponsored by the **"Numerical Weather Prediction for Sustainable Europe"** project, financed by the European fund within the **Smart Growth Operational Programme 2014–2020**, Measure 4.4. "Boosting human potential in R&D sector", through the **First Team 1/2016** award of **Foundation for Polish Science.**

COSMO Consortium

"The Consortium for Small-scale Modeling (COSMO) was formed in October 1998. Its general goal is to develop, improve and maintain a non-hydrostatic limited-area atmospheric model, to be used both for operational and for research applications by the members of the consortium. Moreover, within a licence agreement, the COSMO model may be used for operational and research applications by other national (hydro-)meteorological services, universities and research institutes. "

Members: Germany, Switzerland, Italy, Greece, Poland, Romania, Russia, Israel. **Note that there are lots of mountains in these countries !**

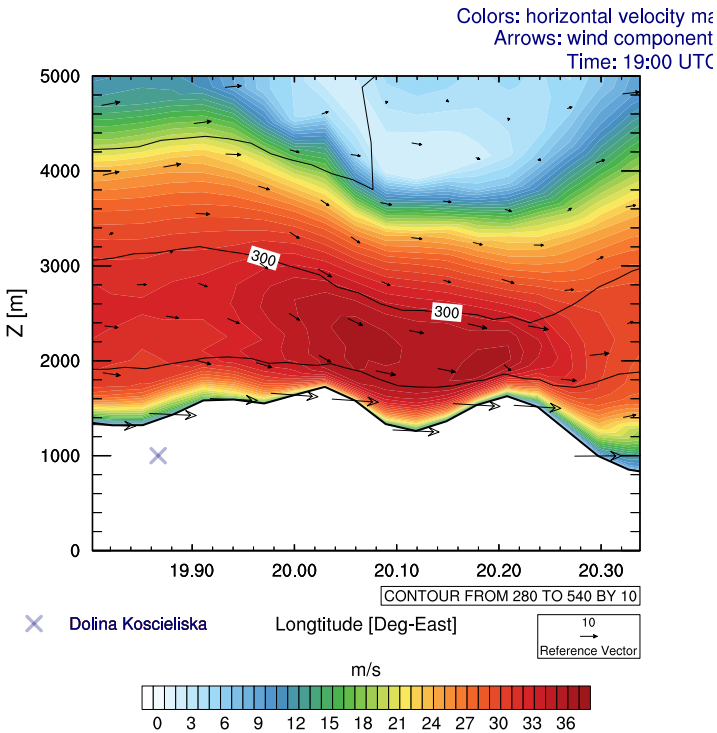
Motivation: addressing the need for high-resolution numerical weather prediction for the Alpine countries.

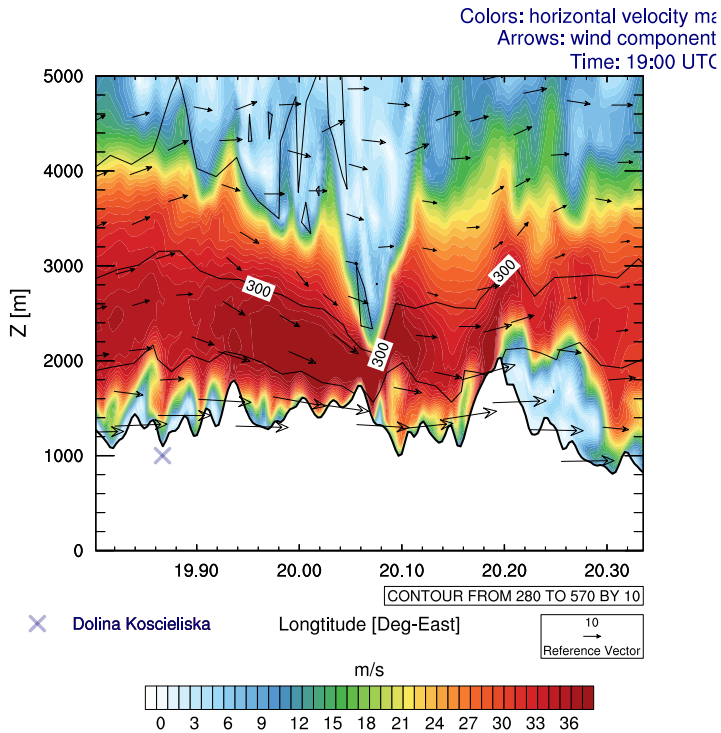
Motivation: accurate research tools and precipitation forecasts for Carpathians.

Kościeliska valley in Tatra National Park, Poland

Operational (2 km) and research resolution (200 m) - Foehn of 25.12.2013 19 UTC

At current operational resolutions (left panel), we are far from representing real topography and interaction of the flow with Earth's surface in operational weather prediction.





Bits of recent of history of COSMO-EULAG development.

- EULAG components became a subject of the "Energy-efficient Scalable Algorithms for Weather Prediction at Exascale" project led by ECMWF. Independently, EULAG components gained proof-of-concept ports to GPU and Xeon Phi.
- The road of EULAG dynamical core to the official COSMO trunk is coming to an end within the CELO priority project of COSMO
- In turn, new COSMO priority projects, EX-CELO and CEL-ACCEL address the future needs of integration on GPUs, ensemble data assimilation and detailed understanding of momentum and heat transport in the boundary layer.

Adaptation of fluid model EULAG to graphics processing unit architecture, Rojek et al., Concurrency and Computation: Practice and Experience 27

PROPOZE team

- **dr. Zbigniew Piotrowski** - numerical methods and computational optimizations, surface to atmosphere transport
- **dr. Marcin Polkowski** - code refactoring and auxiliary Python developments
- **Adam Ryczkowski**(programmer) - porting of the EULAG dynamical core to GPU using Domain Specific Language GridTools of MeteoSwiss
- **Farnoush Ataei**(Phd student) - data processing, investigations into application of EULAG diffusion in COSMO

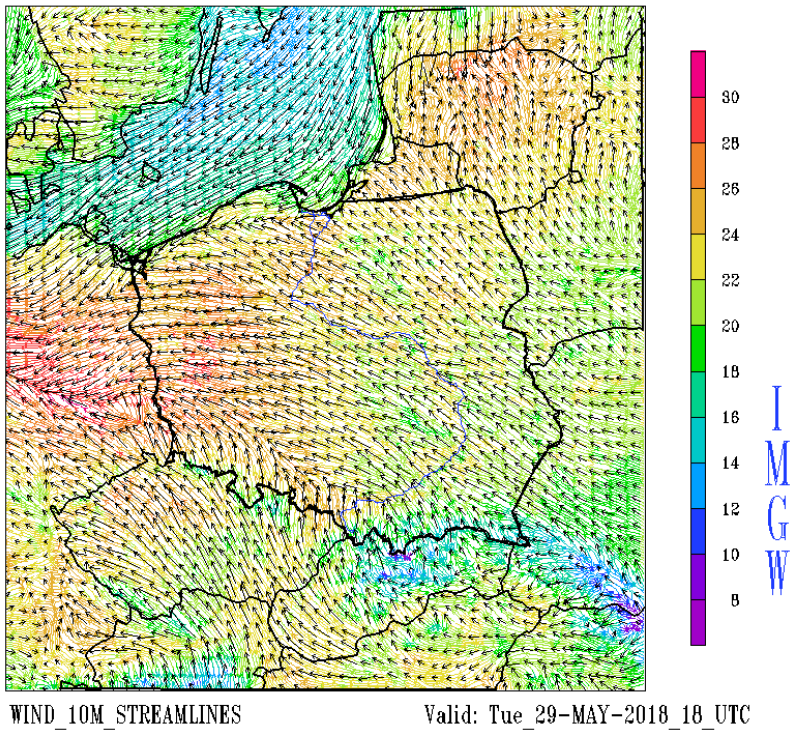
Maing goals of PROPOZE

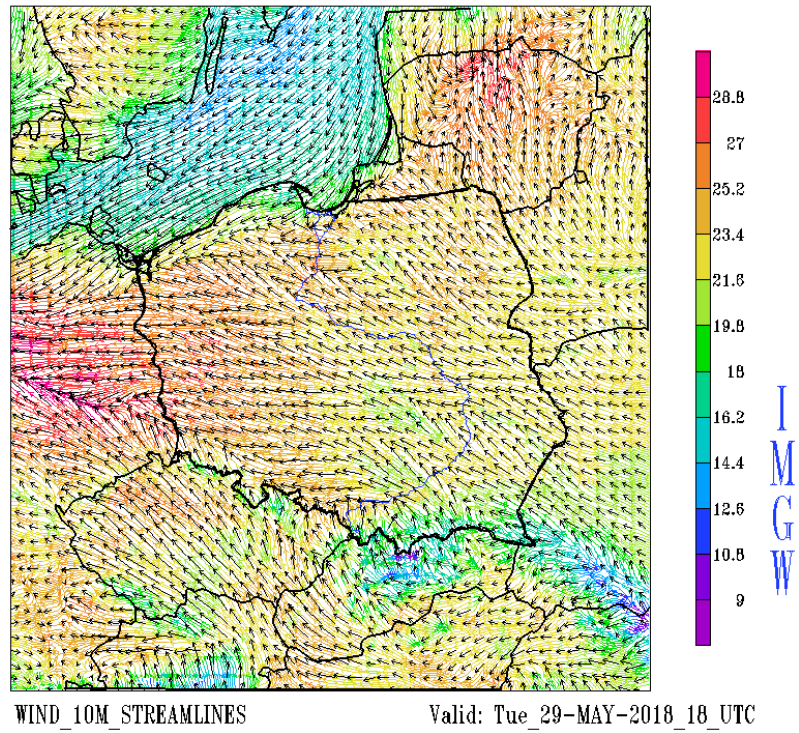
- To provide deep understanding and correct EULAG-world implementation of subgridscale turbulence and surface-to-atmosphere transfer in COSMO-EULAG framework (currently relying fully on legacy COSMO implementation
- To provide GridTools C++ port of EULAG dynamical core, for possible operational use at MeteoSwiss and other COSMO Countries with GPU hardware
- To provide competitive computational performance, overcoming limitations of the fully explicit Eulerian advection.
- To investigate data assimilation issues for COSMO-EULAG.
- To exchange experiences and maintain link to the ECMWF developments.

Pre-operational runs of COSMO-EULAG over Poland

- 4 runs of COSMO 2.8 km a day.
- Subcycling of the whole dynamics permits for the same (or larger) timesteps as the RK core.
- Computational efficiency is very close to the operational RK core
- Integration is usually stable, but there are exceptions due to (probably) implementation bugs and coupling inconsistencies. Especially during the second day of the 12 UTC runs !
- Overall forecasting scores are comparable, with the tendency for a bit worse scores for wind speed in COSMO-EULAG in the cold months.
- This may stem from the fact that current implementation relies on the legacy COSMO implicit vertical diffusion, not fully consistent with the EULAG dynamical core (e.g. diffuses T instead of θ)
- Uses nudging data assimilation.

Model domain and the COSMO-EULAG and Runge-Kutta forecast for 18 UTC today





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- Maximizing the potential of COSMO-EULAG with fully-correct formulation of subgridscale turbulence(i.e. proper coordinate transformation) and diffusion operators is a major task and will be further pursued within PROPOZE. Currently, application of EULAG diffusion operator provides far less friction - deeper integration with (rather undocumented in this respect) COSMO framework is needed.

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- Disruptive change within COSMO Consortium from COSMO to ICON is on the horizon - thinking forward towards adaptation of ATLAS-based horizontally unstructured formulation in the mid-term perspective.
- Overall, COSMO-EULAG appears to be a success, but still lots of work is needed to polish the details