COSMO Overview

Dmitrii Mironov

German Weather Service, Offenbach am Main, Germany

(dmitrii.mironov@dwd.de)

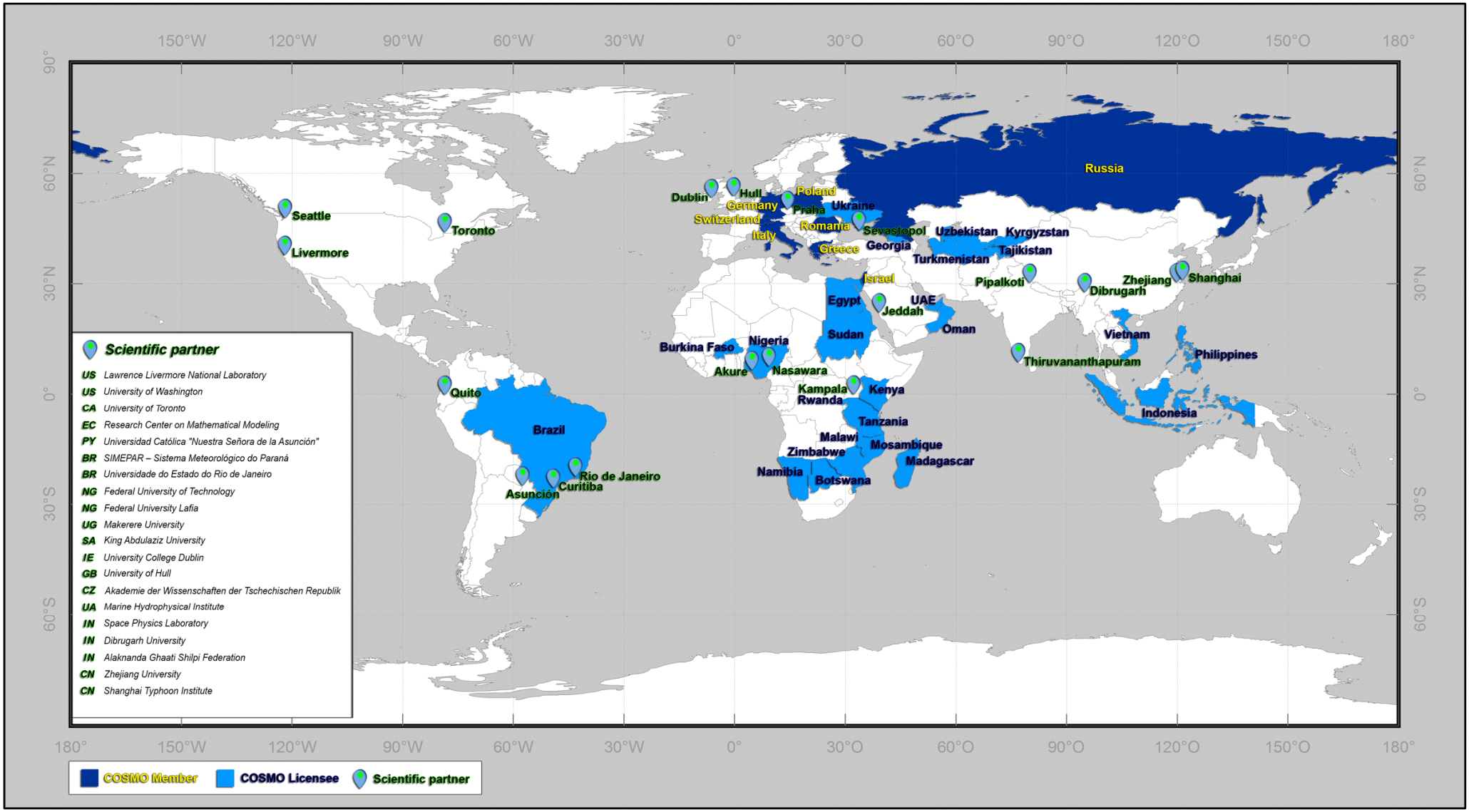
40th EWGLAM 25th SRNWP Workshop, 1-4 October Salzburg, Austria

Overall Goals

- **Convection-permitting high-resolution weather forecast**

- **Ensemble prediction and nowcasting, incl. ensemble data assimilation**

COSMO in a Nutshell



COSMO in a Nutshell (cont'd)

Consortium members (national services)

- Germany (DWD) Deutscher Wetterdienst
- Greece (HNMS) Hellenic National Meteorological Service
- Israel (IMS) Israel Meteorological Service
- Italy (ReMet) Aeronautica Militare-Reparto per la Meteorologia
- Poland (IMGW) Institute of Meteorology and Water Management
- Romania (NMA) National Meteorological Administration
- Russia (RHM) Federal Service for Hydrometeorology and Environmental Monitoring
- Switzerland (MCH) MeteoSchweiz

COSMO in a Nutshell (cont'd)

Consortium members

Regional and military services

- Germany (ZGeoBw) Zentrum für GeoInformationswesen der Bundeswehr
- Italy (CIRA) Centro Italiano Ricerche Aerospaziali
- Italy (ARPAE) Agenzia Regionale per la Prevenzione, l´ Ambiente e l´Energia Emilia Romagna
- Italy (ARPA) Piemonte Agenzia Regionale per la Protezione Ambientale Piemonte

Academic Communities

- CLM Climate Limited-Area Modeling
- COSMO ART COSMO Aerosols and Reactive Trace gases

COSMO in a Nutshell (cont'd)

Working Groups

- WG1 Data assimilation (Christoph Schraff)
- WG2 Numerical aspects (Michael Baldauf)
- WG3a Physical aspects, Upper Air (Matthias Raschendorfer)
- WG3b Physical aspects, Soil and Surface (Jean-Marie Bettems)
- WG4 Interpretation and Applications (Anastasia Bundel)
- WG5 Verification and case studies (Flora Gofa)
- WG6 Reference Version and Implementation (Massimo Milelli)
- WG7 Predictability and Ensemble Methods (Chiara Marsigli)

COSMO in a Nutshell (cont'd)

A number of **Priority Projects** (PP) and **Priority Tasks** (PT)

Governing bodies

- Steering Committee (STC)
- Scientific Management Committee (SMC)
- Technical Advisory Group (TAG)

Data Assimilation

PP KENDA-O (Christoph Schraff)

- PP is aimed at further improving and extending the data assimilation system and using observations within the framework of the KENDA-LETKF in view of better convective-scale deterministic and ensemble forecasts, particularly of quantities related to cloud and precipitation. PP also paves the way towards the use of NWP for nowcasting, as far as data assimilation capabilities are concerned. For this purpose, a main focus is to include the use of high-resolution frequent observations into KENDA, particularly remote sensing data and observations related to the boundary layer, humidity, cloud and precipitation, as well as the surface.

Numerical Aspects, Dycores

Development of dynamical cores with improved conservation properties.

- COSMO-D2 is operational at DWD since May 2018 (ca. 2 km horizontal mesh size, 65 levels in the vertical, etc., c/o Michael Baldauf)
- PP CDIC (Michal Baldauf, PP recently completed). Comparison of COSMO and ICON dycores via a number of idealized tests.
- PPs CELO (Bogdan Rosa, PP recently completed), EX-CELO (Zbigniew Piotrowski) and CEL-ACCEL (Zbigniew Piotrowski). Development and operationalization of COSMO-EULAG. COSMO-EULAG is pre-operational at IMGW since June 2018.

More in the talk of Michael Baldauf on Tu

Physics

Development of parameterizations; more intimate coupling of turbulence, microphysics, radiation and soil (including ocean and lakes) parameterization schemes.

- PT ConSAT (Matthias Raschendorfer) “Consolidation of the Surface-to-Atmosphere Transfer scheme”.
- PP T2(RC)2 (Harel Muskatel) “Testing and Tuning of Revised Cloud Radiation Coupling”. The main goal is to improve the current cloud-radiation-coupling (incl. implementation and testing of new ice and water droplets optical properties into ICON-RRTM, implementation and testing of ICON-ART and CAMS prognostic aerosols, improved parameterization of shallow cumuli)

Physics (cont'd)

- Mire parameterization. Developed by Alla Yurova, successfully tested through numerical experiments (neutral results), being implemented into COSMO (ICON), operationalization expected.
- PT AEVUS (Paola Mercogliano). Evaluation and verification of the performance of the urban parameterization code TERRA_URB, optimization of model parameters.
- PT SAINT (Sascha Bellaire). Validation, further development (as needed), and providing a production-ready version of multi-layer snow parameterization scheme for COSMO and ICON.
- PT TERRA Nova (Yiftach Ziv). Comprehensive testing of the (most recent version of) soil parameterization scheme TERRA.
- PT CIAO (Andrea Montani). Testing the IFS (Bechtold) convection scheme within COSMO, particularly in the ensemble mode

Physics (cont'd)

Further efforts within the framework of WG3ab

- Comparison of TERRA and CLM (Community Land Model)
- Seasonal cycle of phenology
- Snow analysis and data assimilation
- TERRA stand alone (externalized soil module)
- EXTPAR (COSMO software for generation of external parameter fields)
- Parameterizations of microphysics, turbulence, canopy…

More at the COSMO web site

Verification

Development and efficient use of spatial verification methods for ensemble and deterministic forecasts (particularly important for high-resolution forecasts).

- WG5: verification of operational forecasts, incl. common verification plots, verification reports, test suite, etc.
- PP INSPECT (Anastasia Bundel, Flora Gofa, PP recently completed). PP summarizes the experience of applying spatial verification methods to COSMO forecast systems at very high resolution (1-3 km) and provides guidance as to which methods are best suited to particular applications.

Model Calibration

A practicable objective multivariate calibration method build on a quadratic meta-model (in essence, find optimal values of disposable model parameters) is developed and successfully applied for the calibration of the COSMO-2 model (PPs CALMO and CALMO-MAX, Antigoni Voudouri).

- Critical issue: find a compromise between the computational cost of the method (need to perform many model runs) and the quality of the calibration. CALMO-MAX is expected to provide a permanent COSMO framework for objective model calibration.

EPS, Perturbation Methods, Model Error

Maintenance and improvement of EPSs, methodologies for initial and boundary perturbations, model error description, product interpretation and verification, post-processing

PPs SPRED and APSU (**Chiara Marsigli**).

- Application/development of model perturbation methodologies (incl. SPPT, stochastic pattern generator, new EM model of model error)
- Revision of parameter perturbation set-up (incl. surface/soil perturbations)
- Post-processing methods for convection-permitting ensembles (to improve spread-skill relationship)
- Better use of the KENDA analyses to initialize the CP ensembles and perturb boundary conditions

Performance on Massively Parallel Architectures

Performance on the massively parallel (e.g. GPU-based) computer architectures is high on the COSMO agenda.

- PP POMPA (Xavier Lapillonne, PP recently completed). GPU-capable version of COSMO is developed, tested, and brought into operational use.
- New PP IMPACT (Carlos Osuna). Building on the experience and know-how of PP POMPA, the aim of PP IMPACT is to adapt the ICON model to run on various architectures such as x86 multicore CPUs and GPU accelerators, focusing in the LAM mode for NWP applications.

WG4: Interpretation and Applications

- The destiny of COSMO WG4 was unclear for some time…
- COSMO decided to keep the working group
- Anastasia Bundel is the current WG co-ordinator (deputy Andrzej Mazur)

More in the talk of Anastasia Bundel on Th

COSMO in Transition

Transition from limited-area NWP model (LAM) COSMO to LAM version of (the global NWP model) ICON

- Efforts will no longer go into the development of COSMO model, focus is on ICON
- PP C2I (Daniel Rieger is the project leader) is launched to ensure a smooth transition from COSMO to ICON-LAM; at the end of PP C2I, each participating institution is free to choose when ICON-LAM replaces the COSMO model in their operational forecasting system)
- Numerous tricky issues… (details in Daniel's talk on Tu)

In March 2022, all COSMO members should be able to perform deterministic forecast with ICON-LAM.

COSMO Publications

COSMO Newsletters, COSMO Technical Reports

- No problem with Technical Reports (willingly written, quite widely used)
- Low interest to write even short notes to COSMO Newsletters (that decreases further in spite of efforts of COSMO people)
- A few suggestions as to how to remedy the situation, no really good solution so far

How should we behave in the brave new world

of Hirsch Index and Impact Factors?

COSMO NWP Test Suite

New set-up of test runs: series of forecasts, where **the soil variable run freely and are not reinitialized**

- Lateral b.c. from HRES ECMWF, i.c. for soil from ICON-EU
- Test periods: July 2017 and December 2017
- DP (new COSMO model version vs. reference version): 72-hr forecasts with 7 km horizontal mesh size, 48-hr forecasts with 2.8 km mesh size
- SP (new model version only): 72-hr forecasts with 7 km horizontal mesh size

Work in progress

- Perform hindcast runs (one continuous run driven by later b.c. from the analysis)
- Introduce FSS and possibly other scores

Thank you for your kind attention!

40th EWGLAM 25th SRNWP Workshop, 1-4 October Salzburg, Austria

■ ■ ■

Support Activities (WG6)

WG6 (Massimo Milelli)

- Source code management (implementation, release of new versions, testing, documentation)
- User support
  - Support of new COSMO users during the implementation phase
  - Support of new COSMO users in setting up their operational COSMO applications
  - Training of new scientific users during the annual COSMO-CLM User Training
  - Training of new operational COSMO users
  - Further activities to facilitate installation and use of the COSMO-model and the INT2LM (developing a FAQ page; implementation of standardized error messages, etc.)
- NWP test suite
- Web page administration (content management, technical work)
- COSMO Newsletter and COSMO Technical Reports

Status Report for KENDA-O (+ WG1)

Deutscher Wetterdienst

- Task 1: further development of LETKF scheme (conventional obs)
  - MCH: Claire Merker (2-y) on developing regional static B matrix
  - COMET: KENDA slightly worse than COMET-LETKF on 7km (investigation ceased?), now focusing on KENDA for 2.2 km
  - discrepancies betw. DWD and MeteoSwiss KENDA results understood
    (due to different QC in verification; QC in LETKF adjusted, not yet in official code)

- Task 2: extended use of obs: ongoing work, highlights:
  - radar radial winds in parallel suite for testing; DA of reflectivity also promising
  - MCH: new project (1-2 FTE > 01/19) for Doppler wind lidar + MW radiometer

- Task 3: soil moisture analysis using satellite SM data: fellowship ends 12/18 !
  (no clear benefit yet, will continue tests in parallel suite, with little (!) FTE in 2019)

- Task 4: adaptation to ICON-LAM → (ambitious) main milestones:
  - 12/18: consolidated ICON-LAM LETKF
    (still possible despite delay in implementing obs operators in ICON;
    very preliminary(!) tests with MEC-based LETKF for ICON-LAM look ok)
  - 03/19: 3DVAR + EnVar technically available (a first version already exists!)
  - 12/19: parallel suite at DWD; risk: A. Rhodin has left DWD end 03/18

■ ■ ■

Outline

- **COSMO in a nutshell**
- **Work in progress**
- **Issues**