Consortium for Small-Scale Modelling

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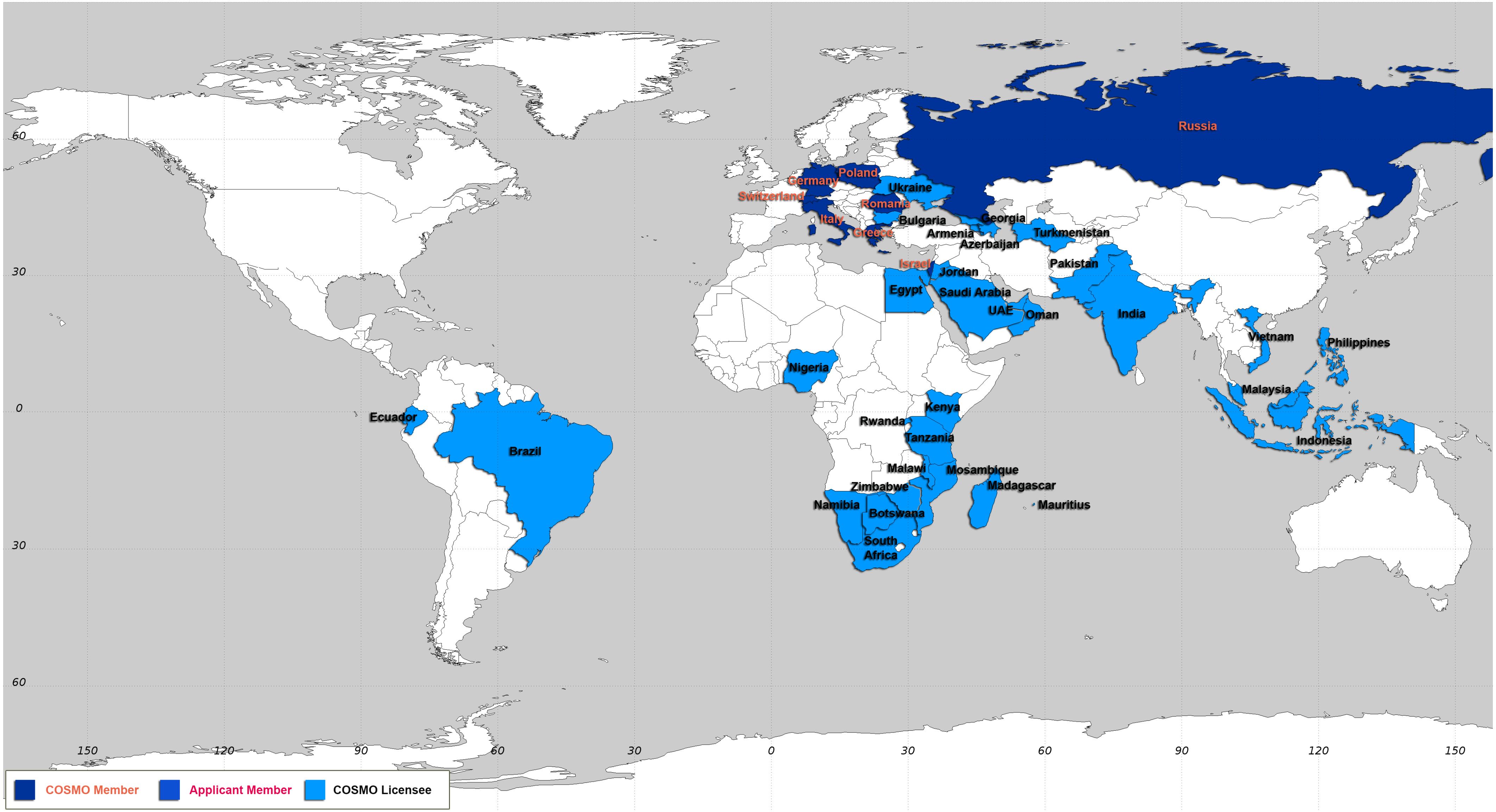
COSMO Governance: General:

- The Israel Meteorological Service (IMS) successfully terminated its applicantion period to the COSMO consortium and will become its member, soon

- A strategy review is planned during current COSMO year to decide on optimum use of consortium resorces within a new package of priority projects and tasks

- An increase of number of COSMO licensees (see the map)

COSMO users in 2017



COSMO Governance: Elections

- In September 2016 COSMO Steering Committee elected:

  → Andrzej Wyszogrodzki (IMGW) as the Steering Committee Chair for 2017 and 2018

  → Dmitrii Mironov (DWD) as the Scientific Project Manager for 2017 - 2020

COSMO model:
Strategy

- COSMO implements the overall strategy of harmonization with global ICON model (November 2013):

  → first, unification of COSMO and ICON physics packages (expected in the official code in Q1 2017)

  → development of ICON-LAM (ongoing)

  → if successful, slow transition from COSMO to ICON modelling framework in time horizon of 2020

- Scientific strategy: COSMO Science Plan (April 2015):

  → focus on short-term convective-scale EPS applications

COSMO model: Dynamical core

- Runge-Kutta (Wicker and Skamarock 2002) is default with additional options: leapfrog (Skamarock and Klemp 1992) and semi-implicit (Thomas et al. 2000)
- ICON-LAM:

  → currently, pre-tested for a set of idealized test cases within a dedicated priority project

  → available for COSMO partners in Q1 2017

  → later, coordinated testing by all partners
- EULAG (compressible dycore):

  → work on its operationalization as a backup and for potential use in some (EPS?) applications

ICON dynamical core

Equations system and solver

- Fully compressible nonhydrostatic vector invariant form, shallow atmosphere approximation

$$\partial_t v_n + (\zeta + f)\, v_t + \partial_n K + w\, \partial_z v_n = -c_{pd}\theta_v \partial_n \pi \quad \text{Edge normal velocity}$$

$$\partial_t w + \vec{v}_h \cdot \nabla w + w\, \partial_z w = -c_{pd}\theta_v \partial_z \pi - g \quad \text{Vertical velocity}$$

$$\partial_t \rho + \nabla \cdot (\vec{v}\rho) = 0 \quad \text{Full air density}$$

$$\partial_t (\rho\theta_v) + \nabla \cdot (\vec{v}\rho\theta_v) = 0 \quad \text{Virtual potential temperature}$$

$(v_n,\ w,\ \rho,\ \theta_v$: prognostic variables$)$

Additional prognostic variables for q_v, q_c, q_i, q_r, q_s and TKE)

Solver:

- Finite volume/finite difference discretization (mostly 2nd order)
- Two-time level predictor-corrector time integration
- Vertically implicit (vertical sound-wave propagation)
- Fully explicit time integration in the horizontal (at sound wave time step; not split explicit!)
- Mass conserving

COSMO model: Physics

Physical Process in COSMO			Method		Authors
Local Parameterizations of atmospheric source terms	Radiation Transport		δ two-stream; revised optical cloud properties		Ritter and Geleyn (1992) Blahak (->)
	Microphysics		1-moment; 3 prognostic ice phases; prognostic rain and snow		Doms (2004) Seiffert (2010)
			optionally 2-moment version		
	any other not yet considered process (e.g. SSO driven thermal circulations or horizontally propagating GW)				
Grid-scale Parameterizations of sub-grid scale atmospheric processes (dependent on horizontal resolution)	Convection	deep shallow	2-class (updraft-downdraft) mass-flux equations with moisture convergence closure and simplified microphysics		Tiedke (1989), update by Bechthold et al. (2008) optionally
	Sub-grid Scale Orography (SSO) effects		orographic blocking and breaking of vertically propagating Gravity Waves (GW)		Lott and Miller (1997)
	Quasi-Isotropic Turbulence		2-nd order closure; progn. TKE with addit. scale-interaction terms (STIC); horizont. BL-approx. with opt. 3D-extensions; turb. sat.- adjustm.		Raschendorfer (2001,->)
	Surface-to-Atmosphere Transfer and Roughness Layer effects		transfer resistances based on constant **turbulent**/laminar diffusion fluxes normal to roughness-covering surfaces; separate heat budget of roughness elements (shading)	not yet tiled	Raschendorfer (2001,->)
Modelling the Non-atmospheric part below the surface	Vertical Heat and Water Transport of the Soil including Vegetation and a Snow-cover		s.- layer snow; m.- layer soil; freezing of soil water; resistances for vapor from stomata of leaves and soil pores; moisture and root mass dep. conduct.; coupled with roughness-layer concept		Heise and Schrodin (2002), Schulz (2016, ->), Helmert (->), Raschendorfer (->)
			optional m.-layer snow		Maschulskaya (->)
	Heat Transport and Phase Change of Lakes		s.-layer with an assumed shape function of temperature profiles; including freezing of lake water and a possible snow-cover		Mironov (2008)
	Heat Transport and Amount of Sea Ice				

COSMO model: Physics (atmosphere): main developments

- turbulence and SAT:

  → interaction of subgrid-scale circulations with turbulence

  → vertically resolved roughness layer
- clouds and radiation:

  → subgrid-scale clouds, their interactions with radiation

  → aerosol (forecasted instead of climatological?)
- generally:

  → convection initiation with consistent representation of interactions of grid- and subgrid-scale processes

  → statistical hyperparameterizations

COSMO model:
Physics (surface): main developments

- TERRA:
  → implementation of canopy layer
  → implementation of urban and mire effects (soon)
  → implementation of tiles
- work toward common snow model
- further development od extpar (web generator of physiographic parameters): available at http://www.clm-community.eu/index.php?menuid=221&reporeid=260 and maintained by COSMO CLM (Climate Limited-area Modelling) Community

COSMO model: Architectures

- Standard default support for CPU HPC architectures
- Support for GPU architectures expected at the official code by Q1 2017 (and already used at MeteoSwiss):

  → strong optimization for C++ dycore with GPU/CPU capabilities using object oriented stencil library STELLA (potentially GRIDTool)

  → use of Open ACC directives for porting the remaining part of the code (esp. physics)
- Single precision model version available (work on radiation ongoing) for research and operationally oriented applications (especially of EPS type)

COSMO model:
Code management:

- The development of COSMO code requires coordination and quality assurance involving COSMO/ICON, CPU/GPU, COSMO/CLM/ART aspects:

  → well defined (and still developing!) formal standards of the code management (procedures, responsibilities, …)

  → Scientific Management Committee for code approvals with representation of all ‘stake-holders’

  → Source Code Administrators and Technical Advisory Committee (e.g. coordination between COSMO software)

  → good working cooperation on developers’ level

  → support for distributed development (evaluation of GitHub)

COSMO system: Data assimilation

- Currently, nudging is the default DA system
- Recently, LETKF KENDA DA system was developed for the consortium to support convective-scale applications:

  → implemented operationally at MeteoSwiss for EPS applications at 2.2 km grid (May 2016)

  → implemented pre-operationally at DWD (May 2016), operational implementation expected soon (by Q1 2017)

  → implementation at COMET expected soon
- Discussion on further developments is starting (e.g. hybrid methods as in global ICON?)

COSMO system:
COSMO software:

Additional, officially maintained (and evolving) software:

- Preprocessing tool: int2lm
- Postprocessing tool: fieldextra
- Verification tool: VERSUS, with conditional verification capability

  → evaluation of DWD Rfdbk (R Interface to Feedback Files) as potential common software
- Data assimilation software: DACE (Data Assimilation Coding Environment): official software in 2017

  → for both LETKF KENDA and DWD global EnVar

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COSMO applications: EPS configurations:

- Convection-parameterized COSMO-LEPS at 7km grid is the common consortium system (by ARPAE-SIMC)

  → extension to 20 members (single precision,Q4 2016)
- Convection-permitting systems:

  → COSMO DE EPS: at DWD, 40 members, 2.8 km grid, 27/45 h, 8 runs/day, operational since 2012

  → COSMO-E, at MeteoSwiss, 21 members, 2.2 km grid, 120 h, 2 runs/day, operational since May 2016

  → further implementations expected soon in Italy, at IMGW and RHM; at DWD 2.2 km COSMO-D expected in 2018

COSMO applications: deterministic configurations:

- Convection-parameterized COSMO at 7km grid (and 14 km at RHM) operational at all partners, except DWD
- Convection-permitting systems:

  → COSMO-1, at MeteoSwiss, 1.1 km grid, 33 h, 8/day, operational since May 2016

  → COSMO with 2.2 km grid at HNMS (2/day) and RHM

  → COSMO with 2.8 km grid at DWD (8/day), COMET, IMGW (4/day), NMA (4/day), IMS (4/day)

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Please, note further COSMO presentations during the meeting:

→ Christoph Schraff on recent KENDA developments

→ Michael Baldauf on dynamical core and numerics

→ Philippe Steiner on PP POMPA project results

→ Chiara Marsigli on ensembles in COSMO

→ Detlev Majewski on seamless nowcasting/very short range forecasting

→ Matthias Raschendorfer on both physics developments

→ Pierre Eckert on INCA with COSMO-1

→ Andrzej Wyszogrodzki on nowcasting at IMGW

→ Flora Gofa on verification activities

→ Inna Rozinkina on snow analysis at RHM

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COSMO

Thank you!