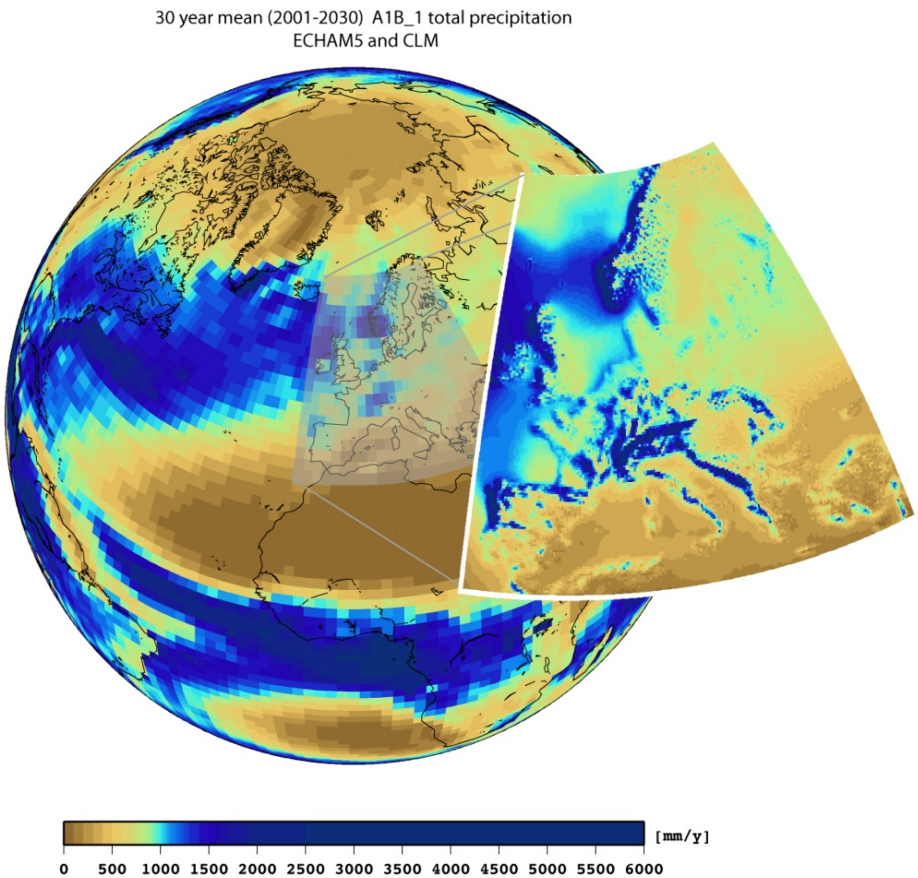
Achievements and Challenges in Developing and Maintaining COSMO-CLM (COSMO) as a Community RCM (NWP and environmental prediction model)



A.Will (BTU Cottbus)
and colleagues

WRF workshop, Boulder, 26-28 June 2012

History of the COSMO-CLM

Brandenburgische Technische Universität Cottbus

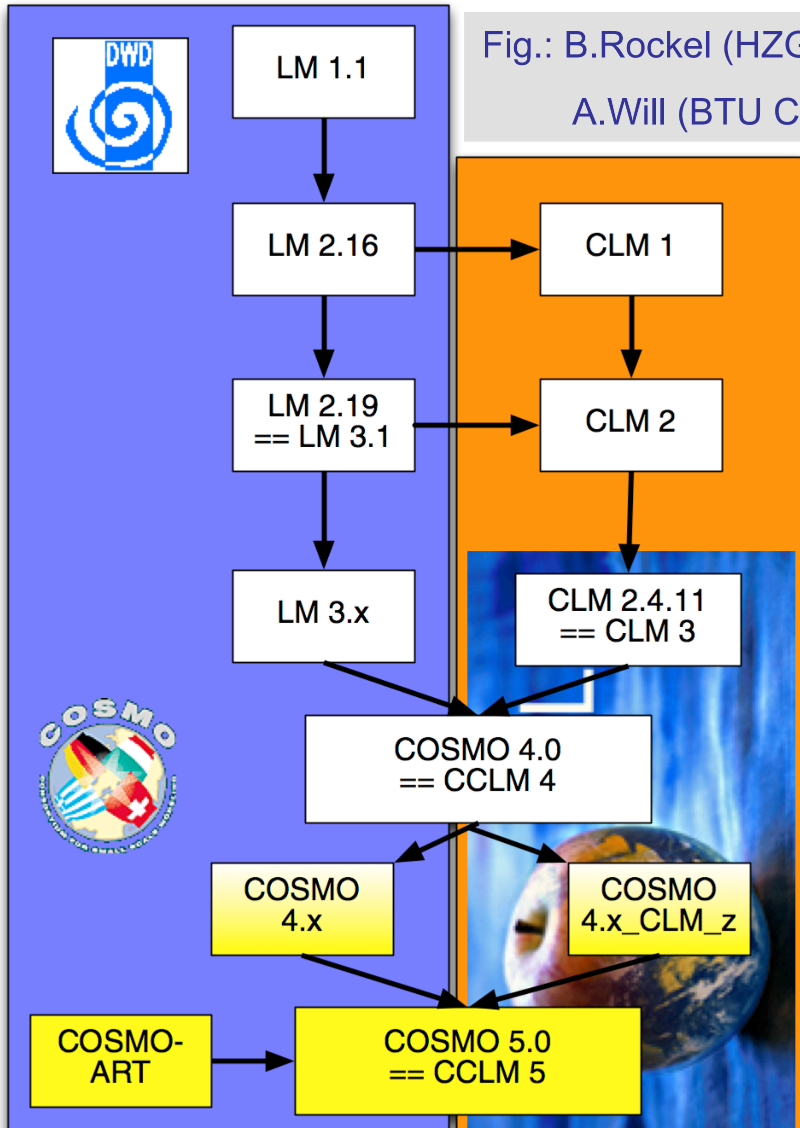


Fig.: B.Rockel (HZG), A.Will (BTU Cottbus)

1996	1. Beta LM Version
1998	1. official LM Version
1999	LM operational
1999	Start of CLM development at PIK
2000	One-year simulation (Brasilien, PIK)
2002	
2004	First climate simulation (EU Project PRUDENCE, GKSS)
2005	Community Model Status in Germany
2006	Consortial runs for the 21st century
2007	Unified model version for weather and climate
2008-2011	Further developments and model consolidation
2012	Unified model version for weather, climate, aerosols and chemistry

Physics and dynamics of the COSMO-CLM

COSMO-CLM

b-tu Brandenburgische Technische Universität Cottbus

- **Model Physics**
  - Nonhydrostatic, hydro-thermodynamic equations in u,v,w,T`,p`,$q_{x,}$(x=v,c,I,r,s,g)
  - Multi-layer soil model with ice (t_so,w_so)
  - 1 and Multi-layer snow model
  - 1 and 2 moment microphysics
  - Lake model
  - Prognostic precipitation for qr,qs,qg
  - TKE / 3D turbulence and subgrid-scale orography scheme
  - Tile approach
- **Numerics**:
  - time splitting fast waves/slow modes
  - Staggered grid, terrain following
    - Leapfrog 3rd order
    - hor. RK 3rd ord., vert. 3rd ord. implicit
- **Numerics (continued)**
  - hor: 2nd ord CD, 2nd (to 6th) ord. adv.
  - Vert: 2nd ord. for stretched grid
  - EULAG ad dynamical core
  - 3rd to 6th order horizontal discretisation
- **Forcing**
  - Initialisation at all grid points
  - Model state (u,v,w,T,q and pp) prescribed at lateral and upper boundary
  - Prescribed: Solar TOA, SSTs, Aerosols
  - Prescribed monthly vegetation and GHG
  - Documentation
- **Coupling**
  - Community Land Model
  - Ocean: NEMO, TRIMNP/CICE
  - Chemistry and aerosol scheme ART
  - ECHAM6 in preparation

Standards of COSMO-CLM

- **I/O**
  - GRIB1, GRIB2 (GRIB-API)
  - NetCDF (asynchronous)

- **COSMO standards for source code development**
  - Implementation rules
  - Management process
  - Developers guide
  - Testing
  - Reporting
  - Documentation
  - Version status (development, test, released)
  - Technical test suite

- **Documentation**
  - F90 programming standard
  - Internal documentation of the method
  - Model Changes documentation
  - Scientific documentation of model physics, dynamics and numerics
  - Implementation documentation

Data flow in COSMO-CLM

Brandenburgische Technische Universität Cottbus

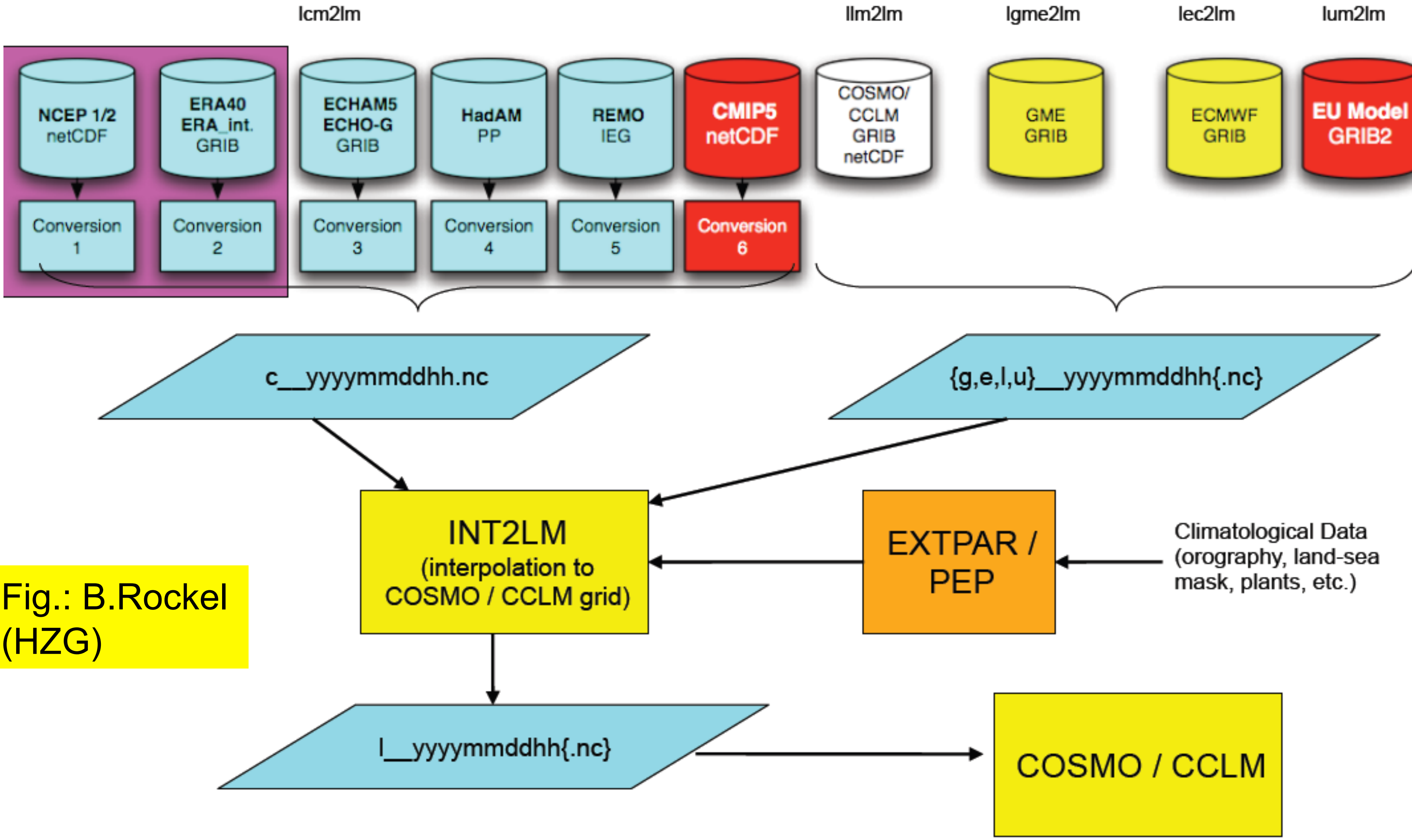


Fig.: B.Rockel (HZG)

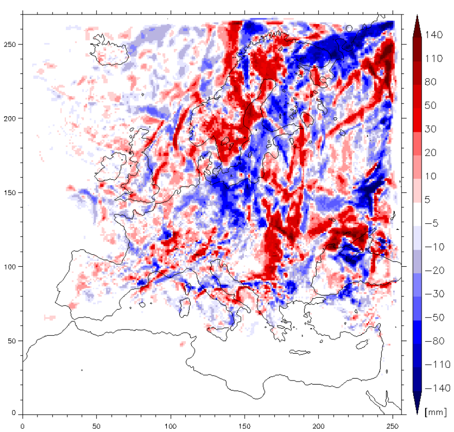
2 Quality of COSMO-CLM

2.1 Convergence properties

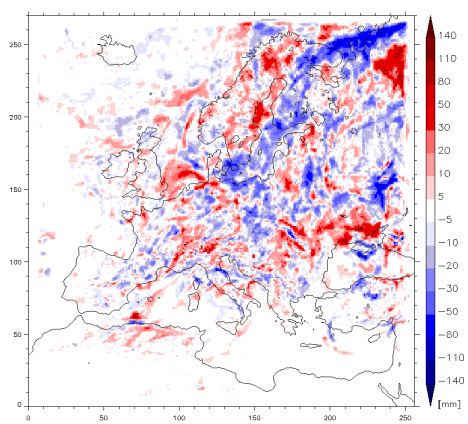
Small Disturbance of Boundary Conditions Once in a Month

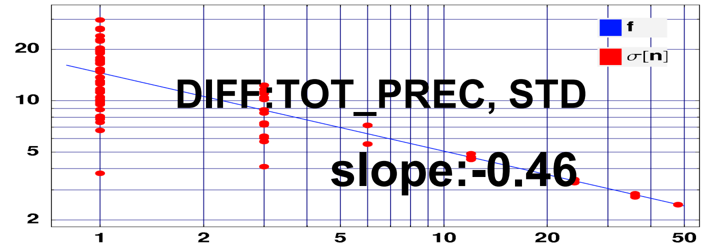
Δ TOT_PREC

7.1981

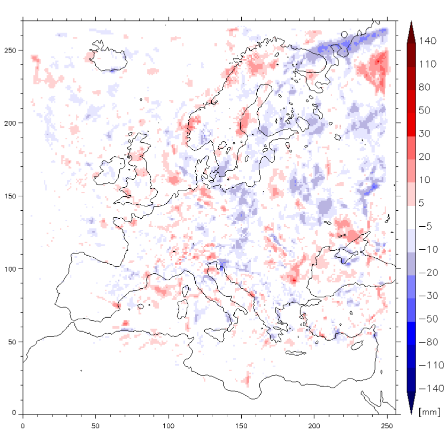


JJA 1981

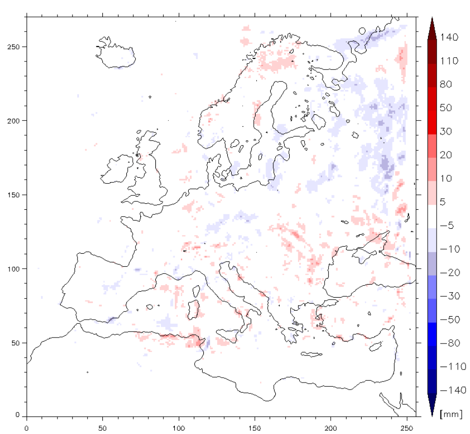




1981



1979-1981



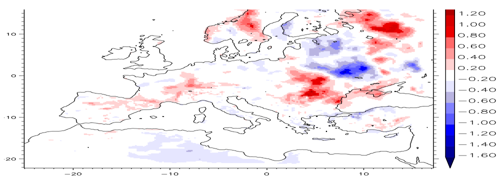
Simulated time: 79-83
Run1: clm4 eval
Run2: clm4 eval + small dist. of B.C. once in a month

Result:
Convergence of1/√N and thus stoachastic disturbance.

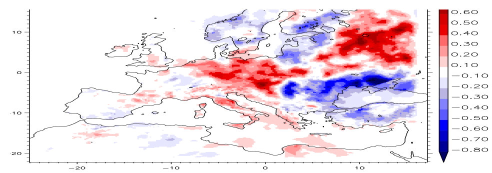
Small Disturbance of Boundary Conditions Once in a Month

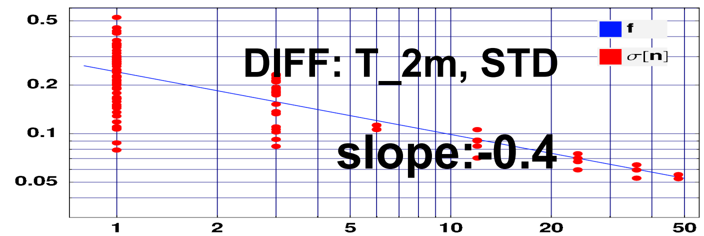
Δ T_2M

7.1981

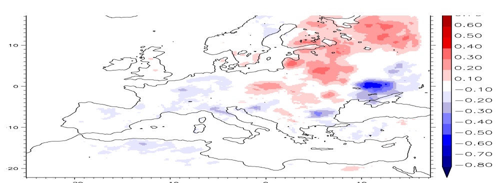


JJA 1981

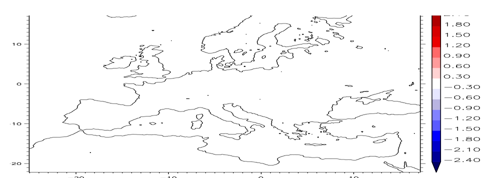




1982



1979-1981



Result:

Convergence of1/(√N-0.1) and thus stoachastic disturbance with memory effect.
Same result for other energetic variables.
Memory: soil water content.

Uncertainties of the initial conditions of the driving model (DTL)

Difference of COSMO-CLM simulation results with different ECHAM5 IBCs

Fig.: Klaus Keuler, BTU Cottbus

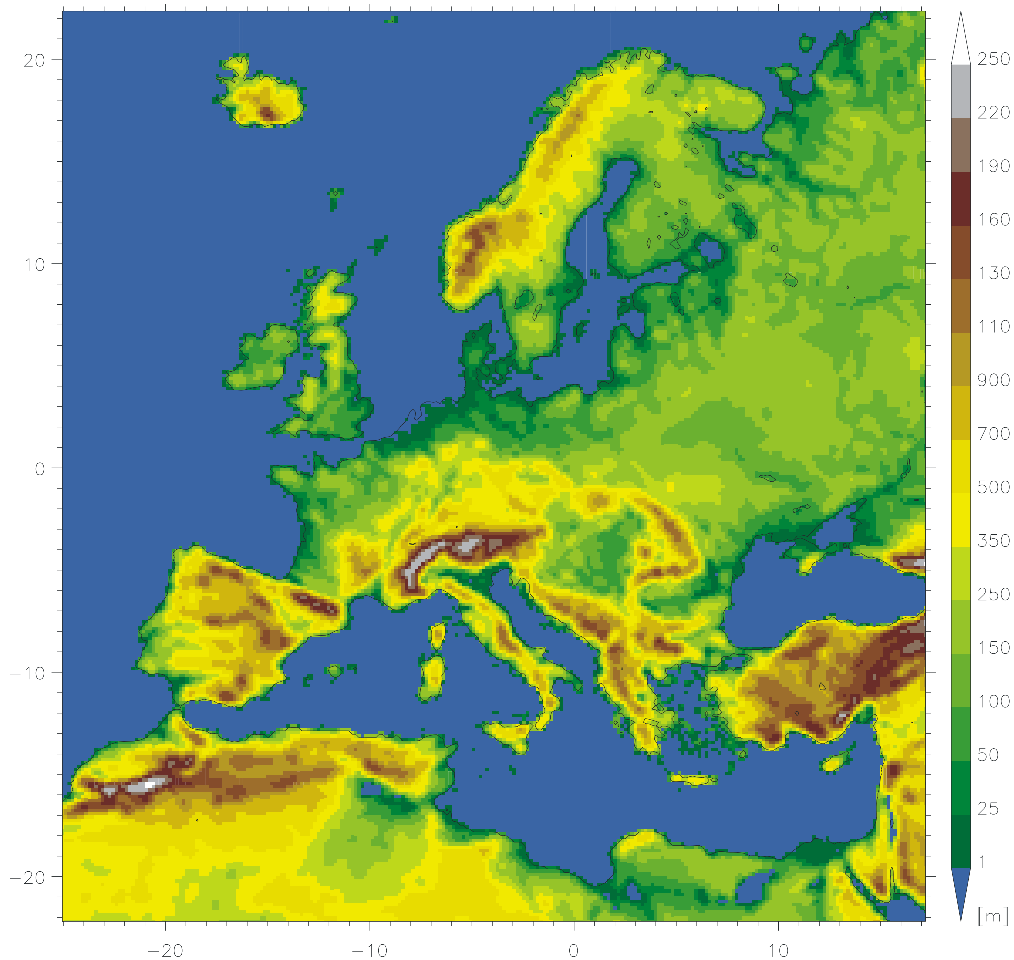
2.2. COSMO-CLM
Evaluation results over Europe

K.S. Radtke, K. Keuler

BTU Cottbus, Chair of Environmental Meteorology

Brandenburgische
Technische Universität
Cottbus

Model Domain for Standard Evaluation



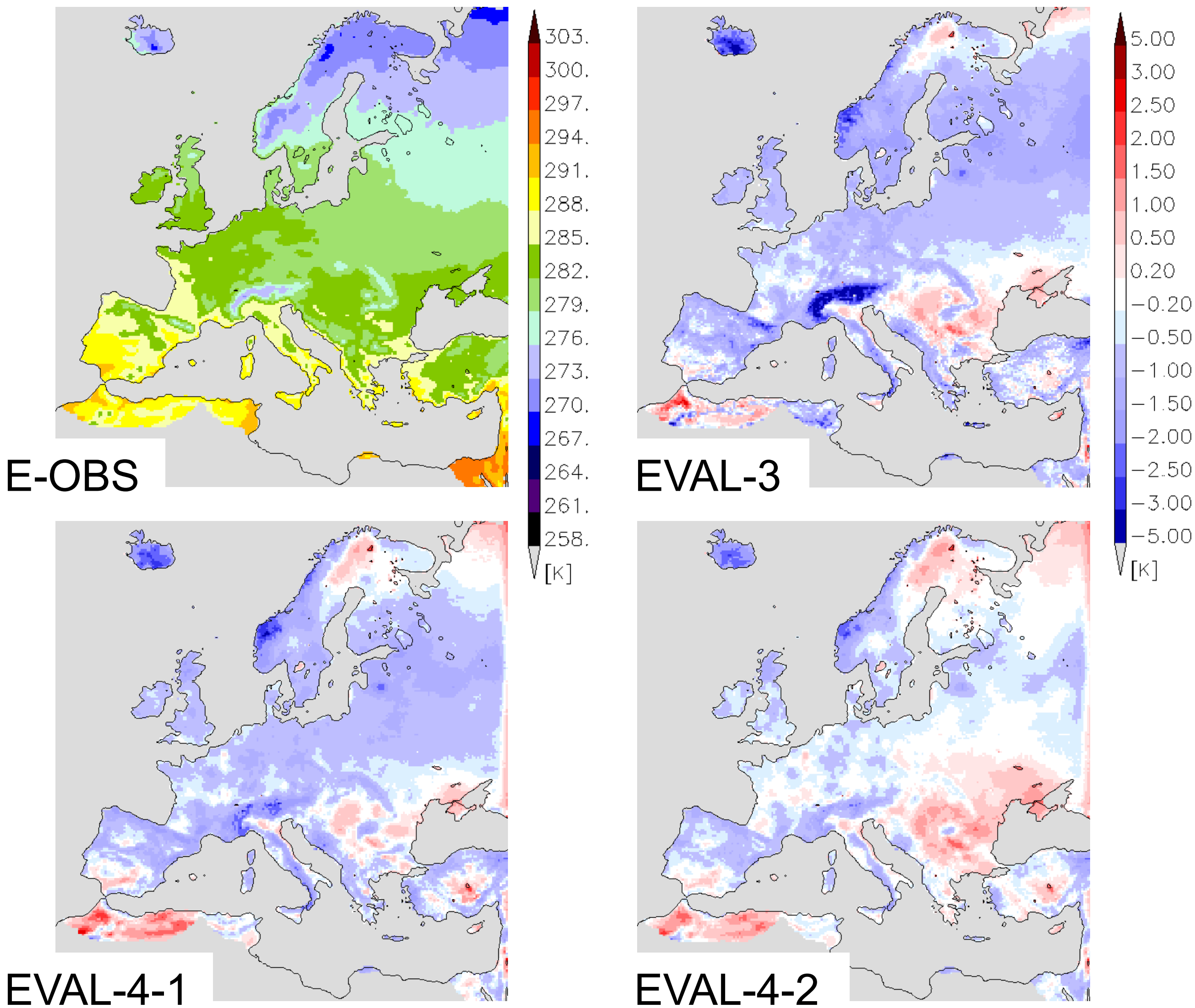
257x271 grid boxes
0.165º resolution

Rotated Pole:
(-162, 39.25)

Forcing:
ERA-40, 1981-2000

Brandenburgische Technische Universität Cottbus

2m Air Temperature, Annual Mean



ME:

EVAL-3: -0.79K

EVAL-4-1: -0.76K

EVAL-4-2: -0.32K

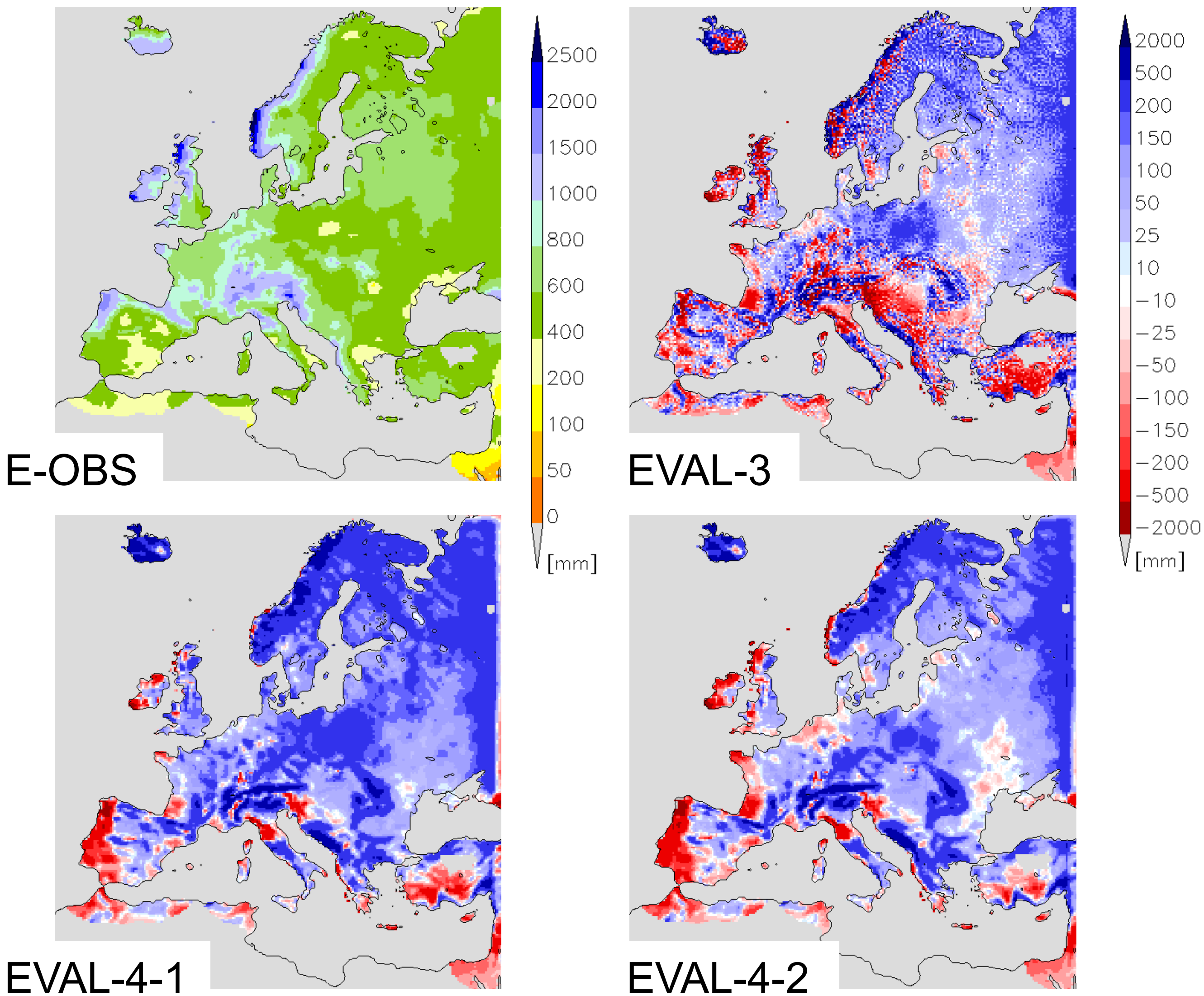
MD:

EVAL-3: -0.57K

EVAL-4-1: -0.52K

EVAL-4-2: -0.05K

Total Precipitation, Annual Sum



ME:

EVAL-3: +65mm

EVAL-4-1: +154mm

EVAL-4-2: +97mm

MD:

EVAL-3: +64mm

EVAL-4-1: +130mm

EVAL-4-2: +131mm

2. Climate and NWP mode

Brandenburgische Technische Universität Cottbus

DWD-KU Project in cooperation with BTU

	CCLM-NWP	COSMO-EU (NWP)	CCLM-Climate
COSMO Quellcode	COSMO4.8-CLM13	COSMO4.21	COSMO4.8-CLM13
Period	01.01.2010 – 31.12.2011		
Forcing	GME Forecast	GME Forecast	GME Analysis.
Domain	EU - IPCC Gebiet	COSMO-EU	EU - IPCC Gebiet
Resolution	12 km (011°)	7 km (0.0625°)	12 km (011°)
Forecast time	96h	78h	—
Configuration	IPCC-AR5	COSMO-EU	IPCC-AR5
Data-Assimilation	✓		✗
Soil moisture analysis	✓		✗
Initialisation of the soil	at init. time	sometimes	at initial time

3. CLM Community

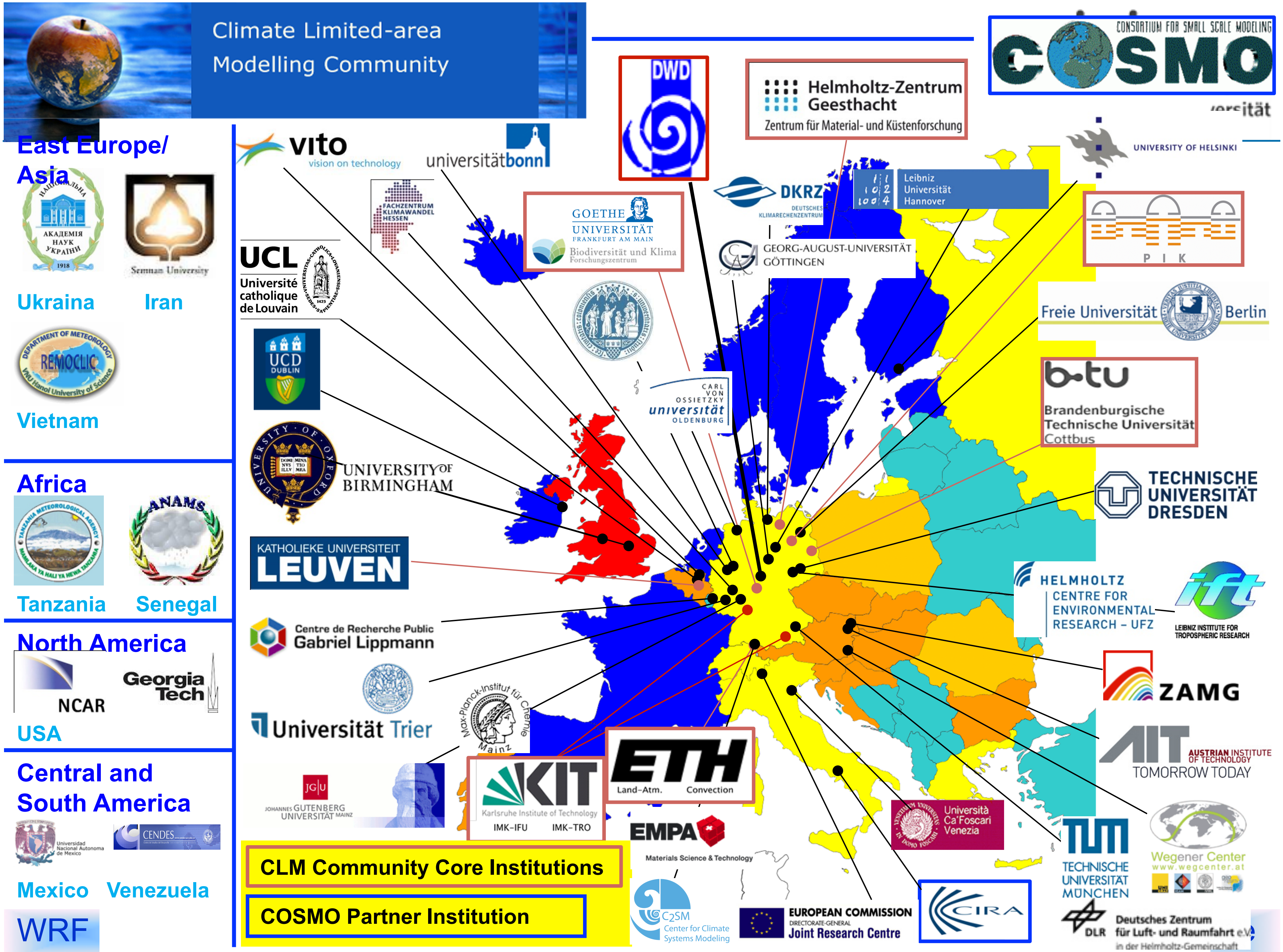
3. CLM Community: Agreement

The CLM Community is an open, international, network of scientists who signed the CLM Community agreement.

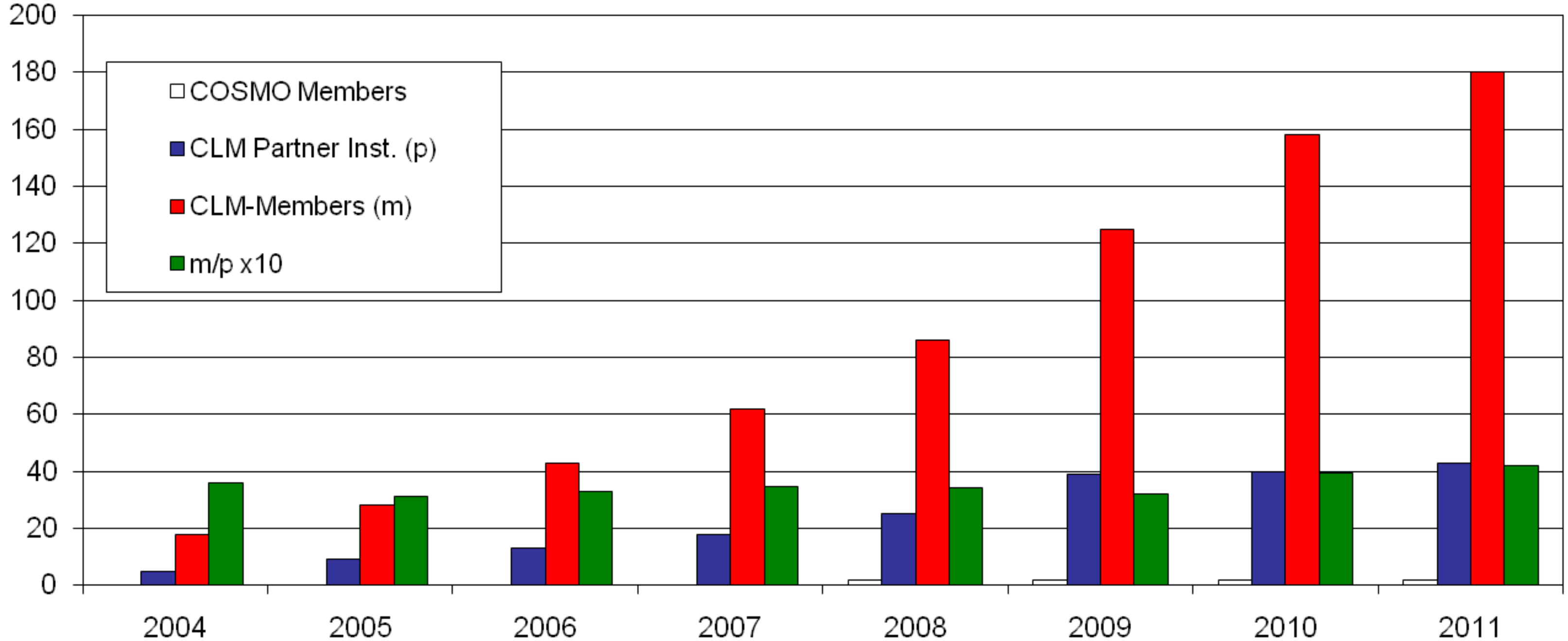
The CLM Community Agreement specifies:
- acceptance of the rules of good scientific practice of the DFG
- free exchange of results
- restriction to scientific use of the COSMO model
- contribution to the aims of the CLM Community

Aims of the CLM Community:
- Quantification and Reduction of Model Uncertainties
- Efficient Use of Computational Ressources
- Preparation and Conduction of Consortial Scenario Runs

www.clm-community.eu


Climate Limited-area Modelling Community
East Europe/ Asia
Ukraina
Iran
Vietnam
Africa
Tanzania
Senegal
North America
NCAR
Georgia Tech
USA
Central and South America
Mexico
Venezuela
WRF
vito
vision on technology
universitätbonn
FACHZENTRUM KLIMAWANDEL HESSEN
UCL
Université catholique de Louvain
UCD DUBLIN
UNIVERSITY OF BIRMINGHAM
KATHOLIEKE UNIVERSITEIT LEUVEN
Centre de Recherche Public Gabriel Lippmann
Universität Trier
Max-Planck-Institut für Chemie Mainz
JOHANNES GUTENBERG UNIVERSITÄT MAINZ
DWD
GOETHE UNIVERSITÄT FRANKFURT AM MAIN
Biodiversität und Klima Forschungszentrum
CARL VON OSSIETZKY universität OLDENBURG
Helmholtz-Zentrum Geesthacht
Zentrum für Material- und Küstenforschung
DKRZ
DEUTSCHES KLIMARECHENZENTRUM
Leibniz Universität Hannover
GEORG-AUGUST-UNIVERSITÄT GÖTTINGEN
CONSORTIUM FOR SMALL SCALE MODELING
COSMO
UNIVERSITY OF HELSINKI
P I K
Freie Universität Berlin
Brandenburgische Technische Universität Cottbus
TECHNISCHE UNIVERSITÄT DRESDEN
HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ
ift
LEIBNIZ INSTITUTE FOR TROPOSPHERIC RESEARCH
ZAMG
AIT AUSTRIAN INSTITUTE OF TECHNOLOGY
TOMORROW TODAY
Wegener Center
www.wegcenter.at
TECHNISCHE UNIVERSITÄT MÜNCHEN
DLR
Deutsches Zentrum für Luft- und Raumfahrt e.V.
in der Helmholtz-Gemeinschaft
Università Ca'Foscari Venezia
CIRA
EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre
C2SM
Center for Climate Systems Modeling
EMPA
Materials Science & Technology
ETH
Land-Atm.
Convection
KIT
Karlsruhe Institute of Technology
IMK-IFU
IMK-TRO
CLM Community Core Institutions
COSMO Partner Institution

CLM Community: Development



Core Institutions of the CLM-Community (2011):

Brandenburgische Technische Universität Cottbus

GOETHE UNIVERSITÄT FRANKFURT AM MAIN

ETH Land-Atm. Convection

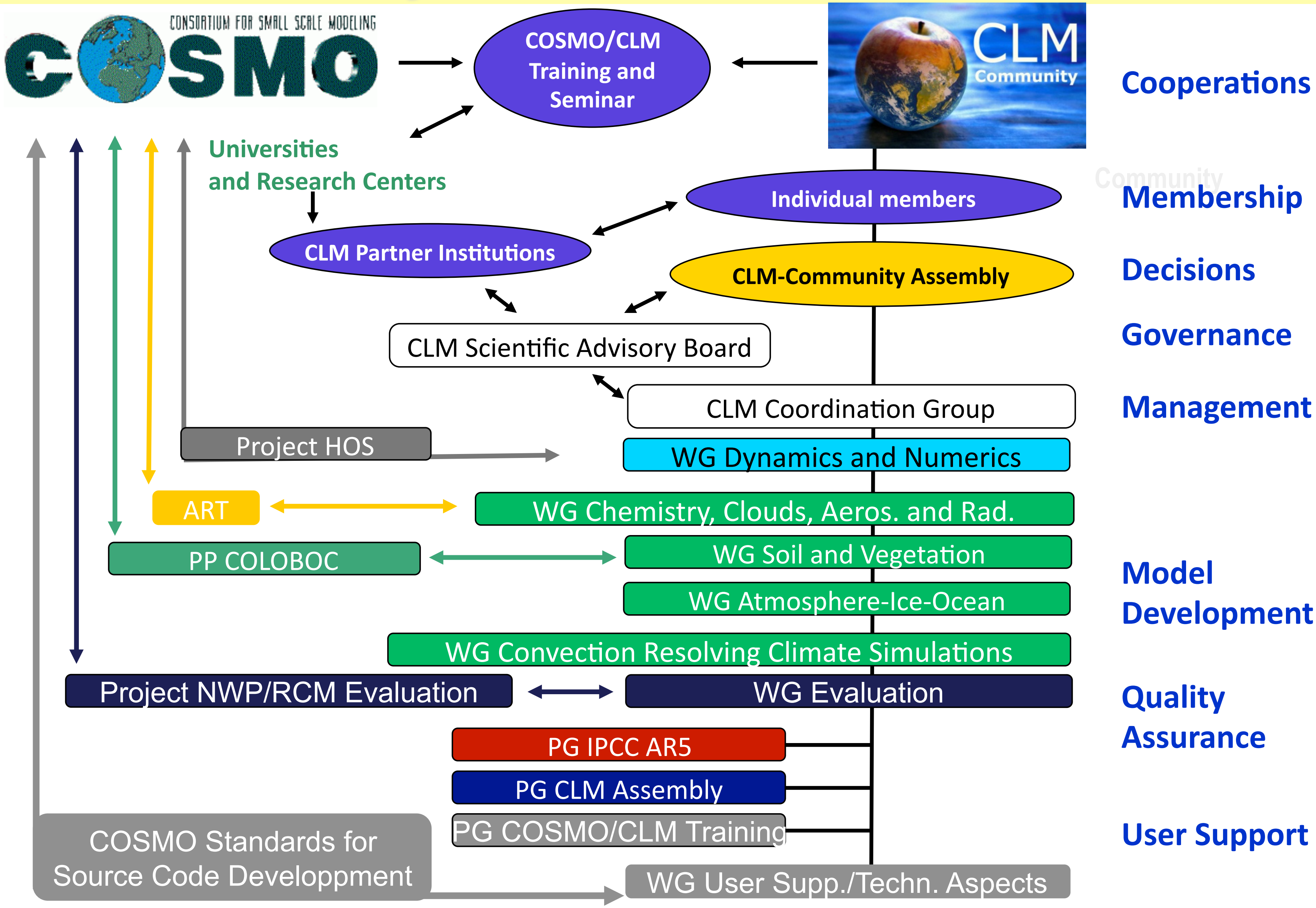
DWD

KIT Karlsruhe Institute of Technology IMK-IFU IMK-TRO

P I K

Helmholtz-Zentrum Geesthacht Zentrum für Material- und Küstenforschung

CLM-Community network



Challenges of Modelling and the CLM Community approach

COSMO-CLM

b-tu Brandenburgische Technische Universität Cottbus

Prerequisites of a community

- willingness of the members to spend resources for community tasks
- organised communication

Challenges of community model development

1. how we bridge

- **institutional interests**
  - individual membership and bottom up decisions: one member one vote
- **weather and climate community**
  - unified model version,
  - common standards and community structure
  - common standards of source code development,
  - representatives in management board

4. Challenges of Modelling and the CLM Community approach

2. how to implement individual developments in a community model version
- standards of source code development
- personal resources for code maintenance

3. how we systematically develop the model
- independent model evaluation
- community measures of model evaluation
- community standards of model development
  - technical test suite
  - scientific documentation
  - process documentation
  - coding standards

4. Management and User support
- only positively evaluated configurations and model versions are released to all members
- namelist tool
- research topic and simulation browser
- coordination office
- regular meetings and training

Summary

If you want to be fast, go alone,

if you want to get far go together!