CONSORTIUM FOR SMALL SCALE MODELING

COSMO

Deutscher Wetterdienst

Wetter und Klima aus einer Hand

DWD

# Source Code Management
## (COSMO / INT2LM)

# Technical Test Suite

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COSMO-Model / INT2LM

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# Last Years Versions

| Version | Date | Contents (Highlights) | Results Changes |
|---|---|---|---|
| INT2LM 2.01 | 25.11.14 | • ICON to COSMO interpolation<br>• GRIB2 and grib_api | no |
| COSMO 5.01 | 28.11.14 | • COSMO-ICON microphysics<br>• Stoch. Perturbation of Physics Tend.<br>• POMPA contributions | numerical changes |
| COSMO 5.02 | 21.05.15 | • Revision of using MPI datatypes<br>• fix in computation of kflat | numerical changes |
| INT2LM 2.02 | 11.06.15 | • GRIB2 for centers ≠ DWD<br>• fix for computing PP when adjusting the reference atmosphere | numerical changes |
| COSMO 5.03 | ??.??.15 | • COSMO-ICON physics<br>• Further POMPA work | yes |

# COSMO-Model 5.1 and INT2LM 2.1

- Developments have been presented last year with the hope to have releases until end of September 2014.
- But things always take longer than you expect:
  - cross-checking by all contributors
  - testing
  - documentation
- New versions could only be released end of November 2014.

# Contents of COSMO 5.2

- Corrected computation of `kflat` for GRIB2 input:
  - `kflat` (height, where COSMO levels become flat) is not contained in GRIB2 meta data and has to be constructed when starting the model.
  - has erroneously been done in every subdomain without information on full domain and was not reproducible
- Revision of using MPI datatypes:
  - Boundary exchange is done for groups of variables. For each group an MPI datatype can be defined. But it is absolutely necessary that the memory layout of all variables in the group does not change during the simulation!
  - Due to some developments in the last time the proper association of the data types to the groups has been lost. Depending on the compiler, this could lead to erroneous message passing and wrong results!

# An Interesting Background Story

- On Sunday, Feb. 1st, 6 UTC, there was a crash of the COSMO-EU operational forecast run with the following error message (during output of hour 27)

```
GRIB_API ERROR:  grib_set: iDirectionIncrement Invalid grib id
*** Error in grib_clone: from outblock sample  -28
```

- grib cloning is done for every record of output (O($10^5$) per forecast)
- There is no error in GRIB_API, but the data structure (the sample), which should be cloned, was corrupted at that time: some other action destroyed the corresponding area of memory.
- Crashes with the same error message happened more often in the next months, but when restarting the model with a different processor configuration, the run could be completed without problems

# An Interesting Background Story (II)

- So we started an extensive debugging and model investigation:
  - array bound checking, NaN checking, etc.: showed no problems
  - tried different compiler options: reducing vectorization could cure some of the crashes
  - on Cray XC30: memory debugging with special library: indicated problems, but did not (always) point to the correct location
  - on Linux Workstation: using valgrind: indicated problems and could locate the exact location: very valuable!!!
- We could find and repair several problems:
  - using wrong MPI datatypes
  - using uninitialized variables
  - multiple allocation of a pointer in `mpe_io2.f90` without deallocation

# An Interesting Background Story (III)

- Some of the crashes could be cured with these fixes, but not all.
- Then we send an official bug report to Cray (mid of May)
- Beginning of August, a beta version was available, which cured the problem at least. The official release of this version is end of September!
- Estimated time to investigate that problem: 8-10 weeks!

# Contents of INT2LM 2.2

- Modifications of grib_api implementation for centers ≠ DWD:
- Bugfix in computing the pressure deviation when changing values of the reference atmosphere (`t0sl, p0sl, delta_t, h_scal`). It was only checked whether `irefatm` changed, but not whether these values changed.
- Determination of boundary layer height for ICON. A general procedure to calculate the boundary layer height for ICON has been implemented.
- Specification of the ICON representative grid distance as a scaling parameter for the radius of influence in the RBF-interpolation:
- Bugfix in computation of QV_S for partially and fully snow covered areas: use `t_g` and not `t_s`
- Bugfix in writing ready files for asynchronous IO: A missing synchronization between compute and I/O processors has been added.
- Some technical changes regarding treatment of ICON data.

# Developments for COSMO-Model 5.3

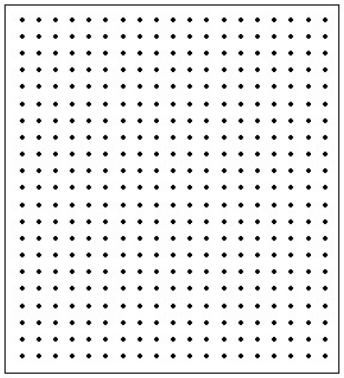
The Scientific Management Committee approved the following contributions for COSMO-Model 5.3:

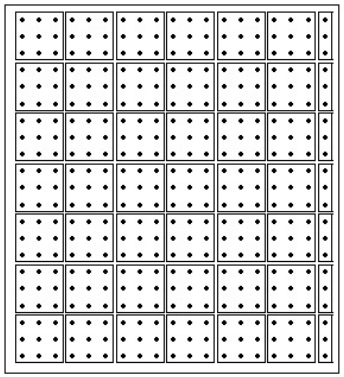
- Assimilation
  - feedback files and extended reading of scatterometer and AMDAR data
  - change of calling sequence of assimilation and relaxation (POMPA)
- Dynamics
  - Redesign of 3D diffusion to improve stability
  - Implement interface to C++ dynamical core and serialization (POMPA)
  - Implement possibility to switch on/off the Euler dynamics
  - Implement possibility to switch off the tracer advection
  - several bug fixes from POMPA

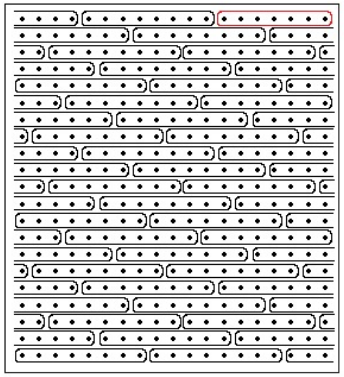
# Developments for COSMO-Model 5.3

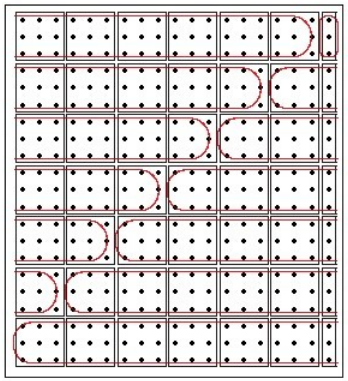
- COSMO-ICON Physics (contributions from POMPA)
  - Microphysics: implement possibility to run the microphysics at the beginning of the time loop
  - Radiation:
    - implement a blocked version of Ritter-Geleyn radiation and the corresponding interface
    - this version also supports the possibility to work on a coarser grid
  - Turbulence: a first version has been implemented, but is not activated yet
    - there is still a consolidation process between the current COSMO version and the modified ICON version. For that, much more tests have to be performed.
    - much time has been spent to investigate the changes for the ICON version (by introducing hard coded switches for all changes)

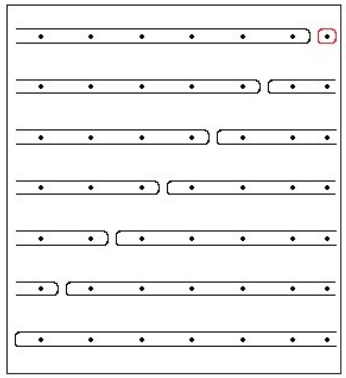
# Blocked Radiation and a Coarse Grid







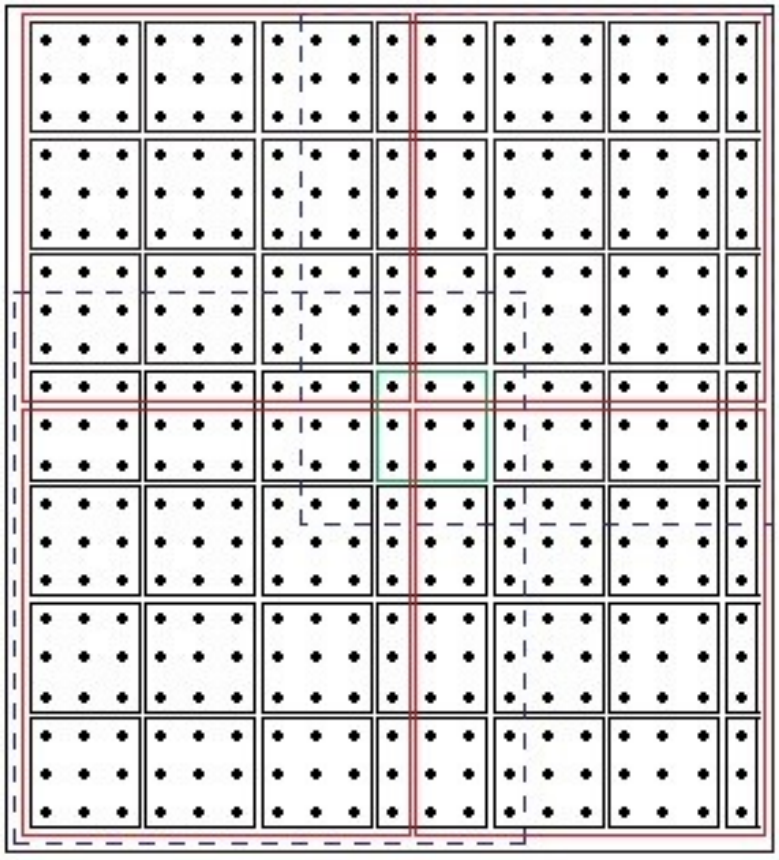




Blocking for the usual COSMO grid

And blocking for the coarse radiation grid

# Blocked Radiation, Coarse Grid and Parallelization



Try, not to get confused!

# Developments for COSMO-Model 5.3

- Technical Changes
  - Modification of grib_api implementation for centers other than DWD
  - Computation of pure diabatic temperature tendencies (new output variable `TTENS_DIAB`)
  - Computation of Lightning Potential Index (LPI) after Lynn et al. (2010) (new output variable `LPI`)

# Plans for the next Version(s)

- Assimilation
  - Removal of AOF interface
  - Radar operator (but still to be decided)
  - Code Re-Factoring (POMPA)
  - Work on LHN (POMPA, improvement of communications)
- Dynamics
  - Integration of new boundary condition module src_lbc.f90
  - Code Re-Factoring of Fortran dynamical core

# Plans for the next Version(s)

- COSMO-ICON Physics
  - Turbulence
  - Surface schemes: src_soil_multlay, src_seaice, src_flake
  - Remove src_soil (old 2/3 layer soil model)
  - SSO scheme: src_sso
  - Convection (if time allows)
  - Microphysics, Radiation: „wrap-up“
- Further POMPA work
  - OpenACC and GPU utilities

# Changes to the COSMO Standards

- Chapter 4: Included link to C++ Style Guide
- Chapter 2, Appendix D: Changes for CLM
- Chapter 6: Added section about COSMO-ICON coordination

The development, maintenance and quality control of contributions to this COSMO-ICON physics therefore needs coordination between the two groups.

➔Development: The development for special packages shall be coordinated by the Responsible CodeOwner of the package.

➔Quality Control: Contributions that shall enter the official code have to be tested in both systems, ICONand COSMO, and have to pass all corresponding tests.

➔Conflicts: Conflicting contributions can be implemented with namelist switches and / or ifdefs.It is recommended to keep such implementations to a minimum.

# The Technical Test Suite

- It checks the technical correctness of modifications to the COSMO-Model.

- It does tests, all developers should do, when implementing modifications:
  - Are results still reproducible (8x8 tasks have to give the same results as 7x9+1 tasks)?
  - Does the restart still work properly?
  - Are results within rounding errors compared to a reference simulation?

- The technical test suite does these tests as a „turn-key system“.

- Of course it has to be installed and prepared, before you can turn the key.

# The Technical Test Suite

- Installation requirements: Python 2.6 with several standard modules installed. If it runs on the compute nodes of a parallel computer, Python must be available on these compute nodes.
- Preparation:
  - You have to provide necessary input data (binary data, observation data, namelist input) and reference output for all tests using a reference binary.
  - The different tests that should be run are defined in an xml input file: `testlist.xml`. A short list of xml-tags is defined to describe the tests.
- Running the tests:
  - For each test a set of so-called „checkers“ are called and return one of the following results: MATCH, OK, FAILED, CRASH.
  - Users are encouraged to develop, document and share their own checker scripts, which can be distributed with future versions of the testsuite.

# Using the Technical Test Suite

- In the future, we will provide the technical test suite together with the COSMO-Model source code.
- Two sets of tests are defined: `testlist_mch.xml` and `testlist_dwd.xml`
- A script is provided to get the binary data to run these tests from a MCH ftp-server (get_data.sh), so really everybody can run these tests.
- Users are encouraged to develop their own tests.


Thank you
very much
for your
attention