Fieldextra (WG4)

COSMO software, pre- and post-processing

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Latest release 13.4.0 (01.04.2021)

https://github.com/COSMO-ORG/fieldextra

1998 ...

- **Swiss Model** : hydrostatic, determinist, 125x125 grid size, 20 levels, dx=14km, dt=240s
- **Cray J90 cluster** at ETHZ, SMP cluster: 30’ for 24h forecast
- **UNICOS 9.0**, with restricted set of tools (C, fortran, sh, csh)

- The Swiss Model popularity is increasing, *tool to generate products out of the model output* required
- Decision to (1) use a *single Fortran program* for all applications, (2) use *flat files* as database, (3) generate products *concurrently* to the model run.

- **May 1998, fieldextra is born!**

2021 …

- **COSMO-1E**: non-hydrostatic, EPS 11 members, 1170x786 grid size, 80 levels, dx=1.1km, dt=10s
- **Cray CS-Storm** at CSCS, GPU compute nodes : 30’ for 24h forecast

- **Fieldextra still here, 23 years later, used for production by many centers, and for many models**
- Single *Fortran 2003* application, about 200k lines of code
- Operations controlled by user specified *namelist*
- *Actively developed*, 2-3 releases each year
- Fieldextra is the *official COSMO Consortium Software* for model post-processing

Why fieldextra?

- **Designed for *automated production***
- Systematic use of meta-data for *automatic error detection* (product consistency)
- Consequent handling of *missing values* (data, meta-data)
- Understand *specificities of target models* (GME, IFS, COSMO, ICON)
- Focus on *robustness* (fault tolerant)
- Focus on *performance*, in particular for large problems (memory footprint, time to solution)
- *Versatility* (from simple single file operation to full set of products generation in real time production)
- … also *quick implementation* of new features as new needs arise …

Design

- ***Import*** and ***export*** GRIB 1, GRIB 2, NetCDF (CF), ASCII specific format
- Rich set of primitive operators, which can be arbitrarily combined (***toolbox*** )
- Code ***optimization***
  - *Read input once*, produce as many products as defined
  - *Shared memory nested parallelism* (OpenMP)
    - concurrent import
    - concurrent production of output
    - parallel computation of operators used for each output
- Rich ***diagnostic*** (support code debugging, problem optimization)

Quality control

- Fieldextra development is mainly done by *JM. Bettems (SCA)* and *P. Baumann*, both at MCH
- Fieldextra development is *hosted on GitHub*, and includes full version control and code review
- A extensive *regression suite* is used for testing any new developments; they include
  - short tests, also available in deployed installations (cookbook),
  - tests reflecting usage of fieldextra by different COSMO members (MCH, DWD, ITAF),
  - exhaustive tests using MCH operational usage, but only available on development platform at CSCS.
- *CI / CD* (continuous integration, continuous deployment) is partly implemented, using Jenkins @CSCS
  - daily and weekly plans to test the head of the develop branch
  - weekly deployment of the head of the develop branch if tests have passed

Some use cases

- Explore content of file (R&D) (*)
- Transform between different formats (R&D) (*)
- Extract meteograms at specified geographical locations (model validation)
- Compute probability fields (EPS post-processing)
- Interpolate tracer defined on an ‘arbitrary’ 3D grid, in NetCDF, onto COSMO-1E grid, in GRIB 2 (boundary conditions)
- Upscaling COSMO-1E analysis onto COSMO-2E grid (initial conditions) (*)
- COSMO-1E product generation (near real time production)

(*) Parameterized application (*fx tools*): minimal set of arguments, automatic namelist generation

Some use cases

- ***Small live demo if time permit***

ICON specific

- Interpolation ***on import*** from the triangular grid to any regular grid is available in the current production release (13.4.0)
- A release 14.0.0 which will ***fully support the triangular grid*** is planned before the end of this year
- Many features are *already available* in the *head of the develop branch*, and we encourage you to test these
  - NetCDF import/export, GRIB 2 import/export, BLK_TABLE (ASCII format) import/export, data subset defined by geog. locations, merging/comparing fields under some conditions, lateral smoothing of fields, grins, fxclone, fxfilter, fxconvert ...
  - All features not depending on the horizontal grid are still available: ASCII export, EPS operators, vertical operators (e.g. vertical interpolation), meteorological operators not using differential operators (e.g. compute RELHUM), ...
- The features *we are currently working on*, and that we hope having ready in October:
  - full support of HORIZON and FR_LUC (additional dimension which is not spatio-temporal), support all possible interpolations (currently only regular ↔ regular and unstructured → regular are implemented), support products mixing multiple subgrid (e.g. VN and T)
- The table summarizing the *state of the developments* is available on GitHub, at https://github.com/orgs/COSMO-ORG/projects/8

Documentation

- *Starting point* available at the fieldextra GitHub master page
  (https://github.com/COSMO-ORG/fieldextra)
- Management overview and *basic introduction* (recommended!)
  (https://github.com/COSMO-ORG/fieldextra/blob/develop/documentation/0_Overview.pdf,
  https://github.com/COSMO-ORG/fieldextra/blob/develop/documentation/1_FirstContact.pdf)
- Rich set of *commented examples* … including input and reference results (tell us if you need more)!
  (in installed package, in subdirectory ./cookbook)
- Systematic and extensive *documentation of usage and of all features*
  (in installed package, in ./documentation/README.user)

Documentation

- Summary of *features introduced in each release*
  (https://github.com/COSMO-ORG/fieldextra-wiki/wiki/History)
- *Detailed history* of modifications
  (in installed package, in ./admin/HISTORY)
- *Backward compatibility* is not always guaranteed, the required modification of namelists, the modifications of resources, the modifications of output format are all documented
  (in installed package, in ./compatibility)
- *Planning* is organized and documented in GitHub milestones & issues
  (in https://github.com/COSMO-ORG/fieldextra/milestones)

Access

- Full self-contained package of official release on ***COSMO web site***, includes all libraries & regression (https://www.cosmo-model.org/content/support/software/default.htm)
- Official releases and *stable* head of develop branch installed at ***CSCS*** (Tsa & Daint) and at ***ECMWF*** (at cscs in /project/s83c/fieldextra, at cca in /perm/ms/ch/ch7/projects/fieldextra/)
- Code base in ***GitHub***, requires independent access to support libraries (https://github.com/COSMO-ORG/fieldextra)
  - Official releases in branch *master*, stable head of develop in branch *develop_tested*
  - Branch *develop_tested* supports *automatic deployment* of the latest stable state of the developments, for a quick access to the latest features and bug fixes!

Thank you for your attention !

Questions, comments, wishes ?

This is now the opportunity to express yourself!