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Fimex

A library offering an abstract data-model for gridded data-formats

EGOWS-2014

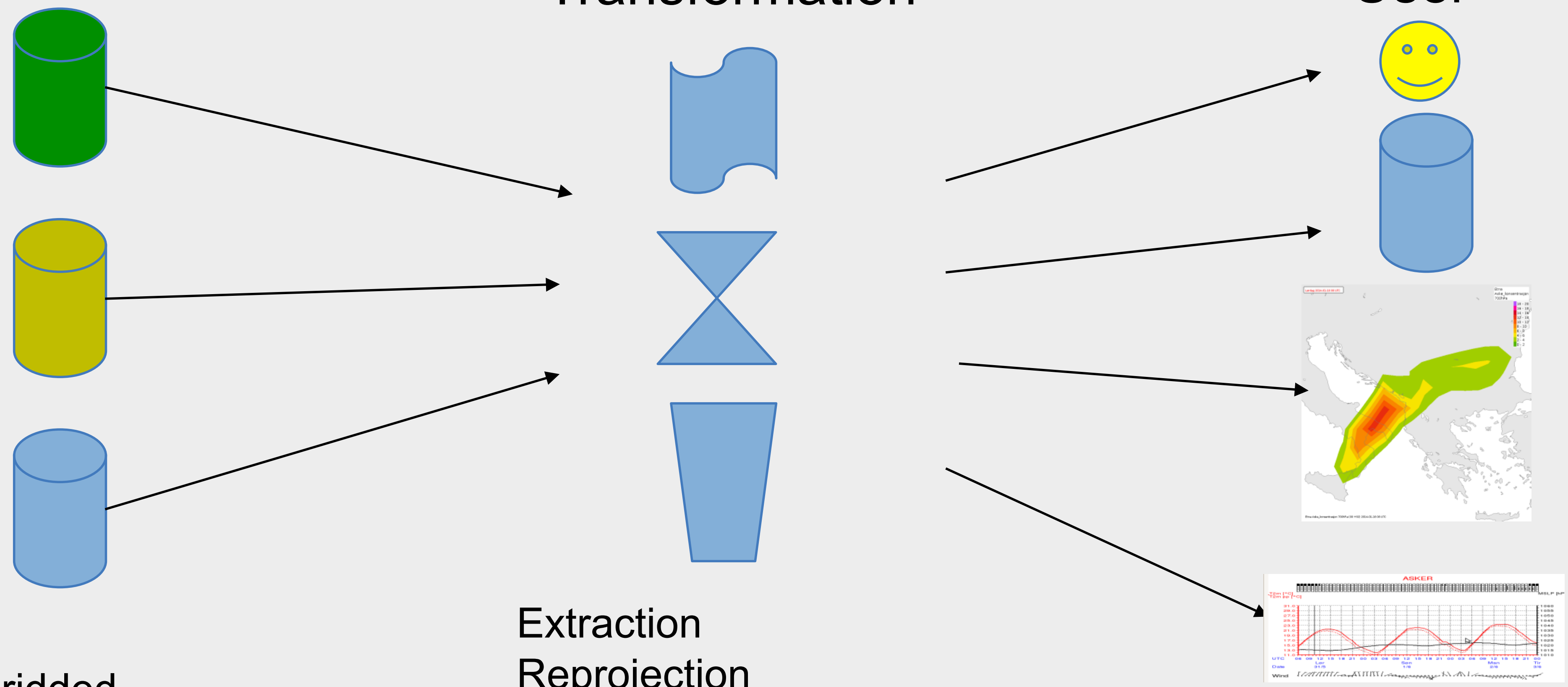
16-06-14

Data-Flow at Met. Institute

Data

Transformation

User



Extraction
Reprojection
Interpolation

gridded
different sources
different formats

require geo-reference
and other metadata

Data-Formats and Use-Metadata

- Grib 1 / Grib 2
- Netcdf 3/4 (HDF5)
- MetGM / STANAG 6022
- ProRAD
- Felt
- OpenDAP
- WCS?

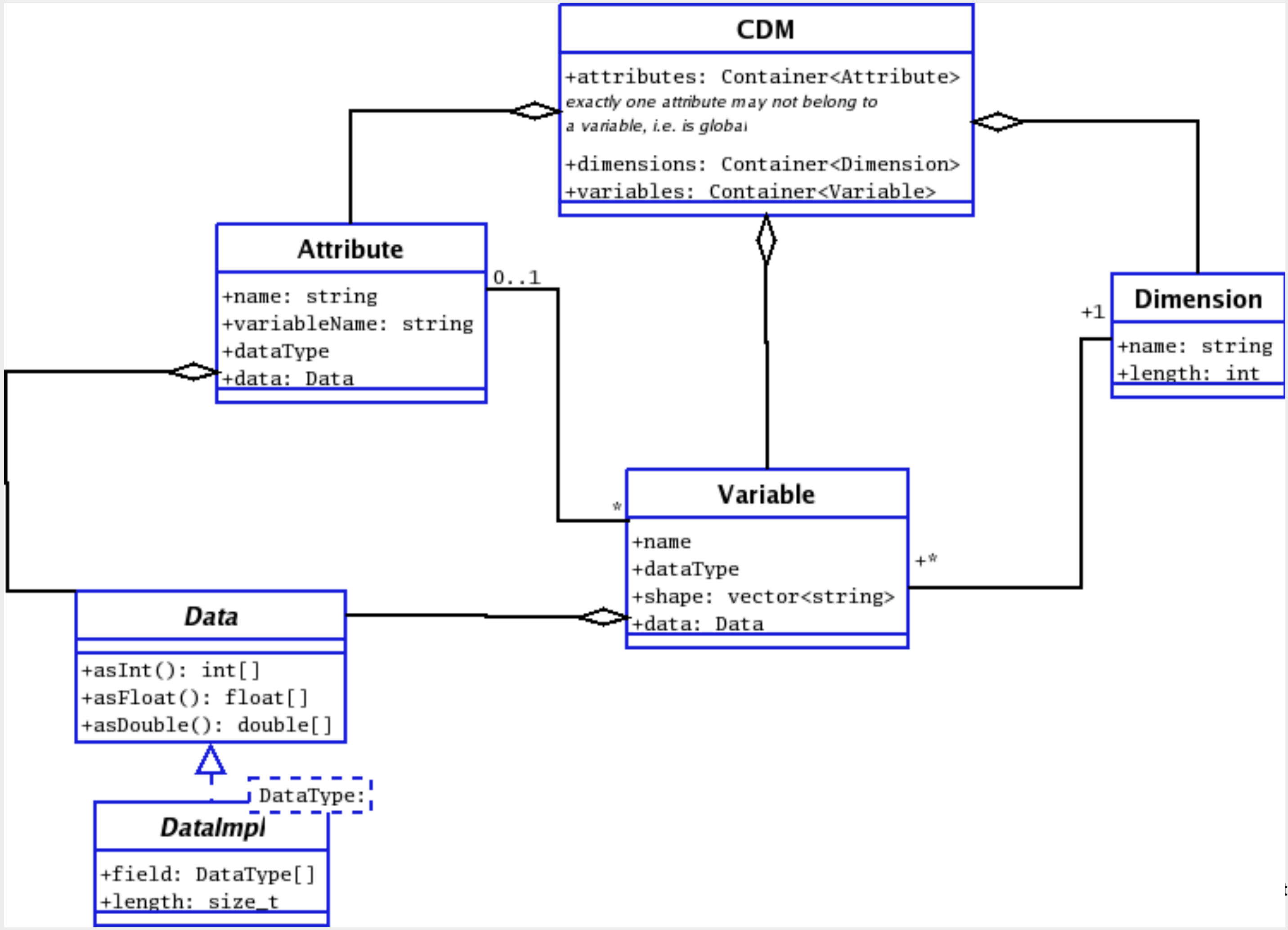
- GRIB-API (common-keys for grib1 and grib2)
- Convention on Climate and Forecast (CF)
- WRF-Convention
- Proj4 projection description / WKT

What does Fimex?

- Extension of NetCDF C-API to support additional data-formats
  - NetCDF 3/4, OpenDAP, HDF4
  - Felt / Grib + tables (configurations)
  - MetGM, NcML, WDB, ProRAD
- Library to simplify interpretation of data (Use-Metedata/ Conventions/CoordinateSystems)
- Libraries to modify data
  - Re-projection/interpolation (time/horizontal/vertikal)
  - Merging of files
  - Extraction/subsetting of data
  - Accumulation/deaccumulation
  - Theta -> temp, ...
- And a command-line tool «fimex» for easy access to the functionality

Data Model

- Fimex is a C++ implementation of Unidatas NetCDF-JAVA *Common Data Model (CDM-1)*

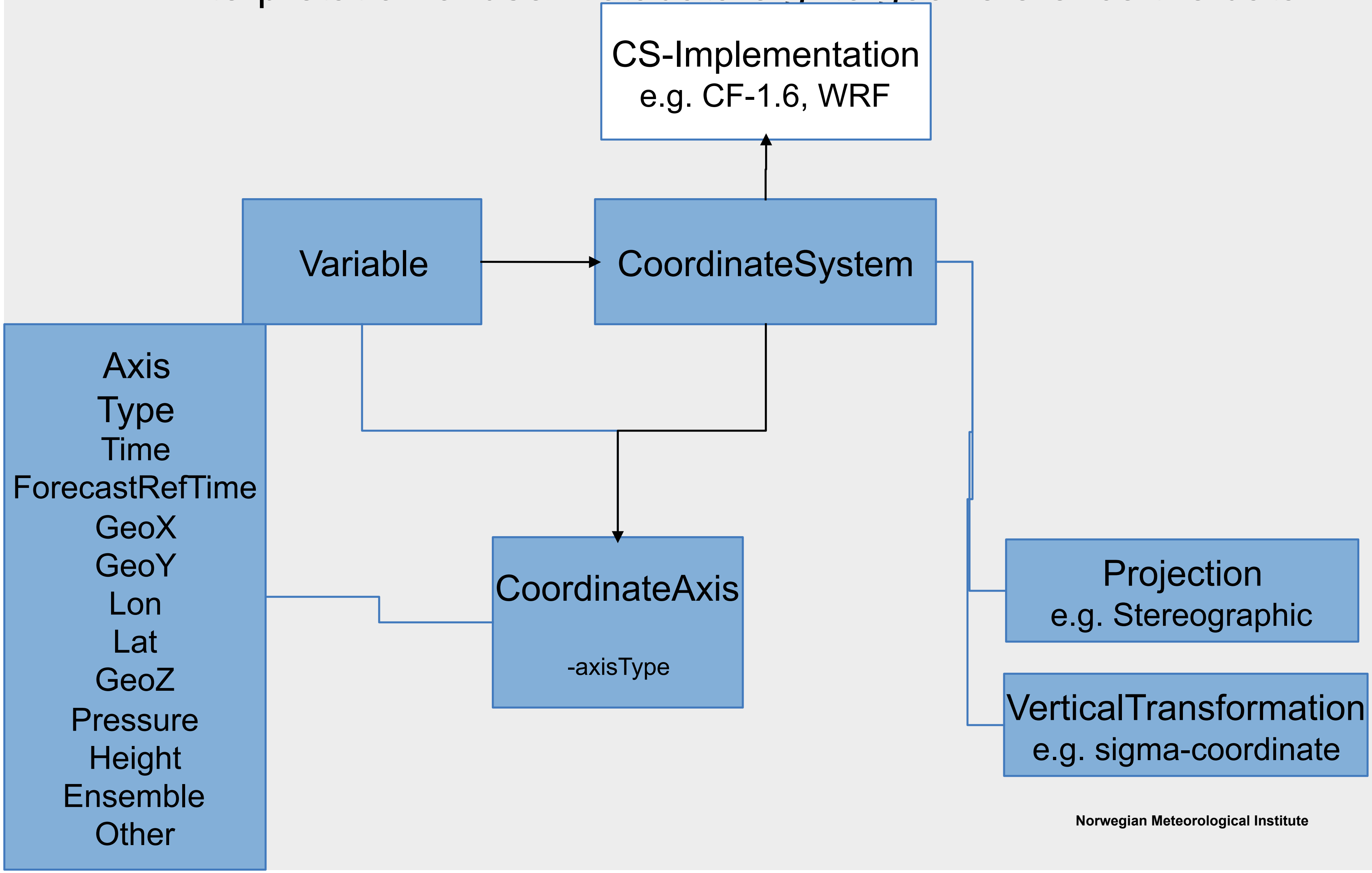


Restrictions by CDM-1

- Data is multi-dimensional with *fixed* dimension
  - Lower resolution in upper layers not possible
  - Lower resolution in later time-steps not possible
- NetCDF-4 features only partly implemented
  - No groups / no shared dimensions
  - No user-defined data-types (unsigned datatypes ok)

Coordinate-System

- Interpretation of use-metadata e.g. to geo-reference the data



Example: Interpolation and Extraction

Examples (fimex config-file (-c option))

```
[input]
file = arome_00.grb
config = aromeGribReader.xml

[output]
file = arome_00.nc

[extract]
selectVariables = x_wind_10m
selectVariables = y_wind_10m
```

```
[interpolate]
method = bilinear
projString = +proj=utm +zone=33 +ellps=WGS84
xAxisValues=0,500,...,x;relativeStart=0
yAxisValues=0,500,...,x;relativeStart=0
xAxisUnit = m
yAxisUnit = m
```

Examples (fimex command-line)

```
fimex --input.file=arome_00.grb --
input.config=aromeGribReader.xml --
output.file=arome_00.nc
--extract.selectVariables=x_wind_10m --
extract.selectVariables=y_wind_10m ...
```

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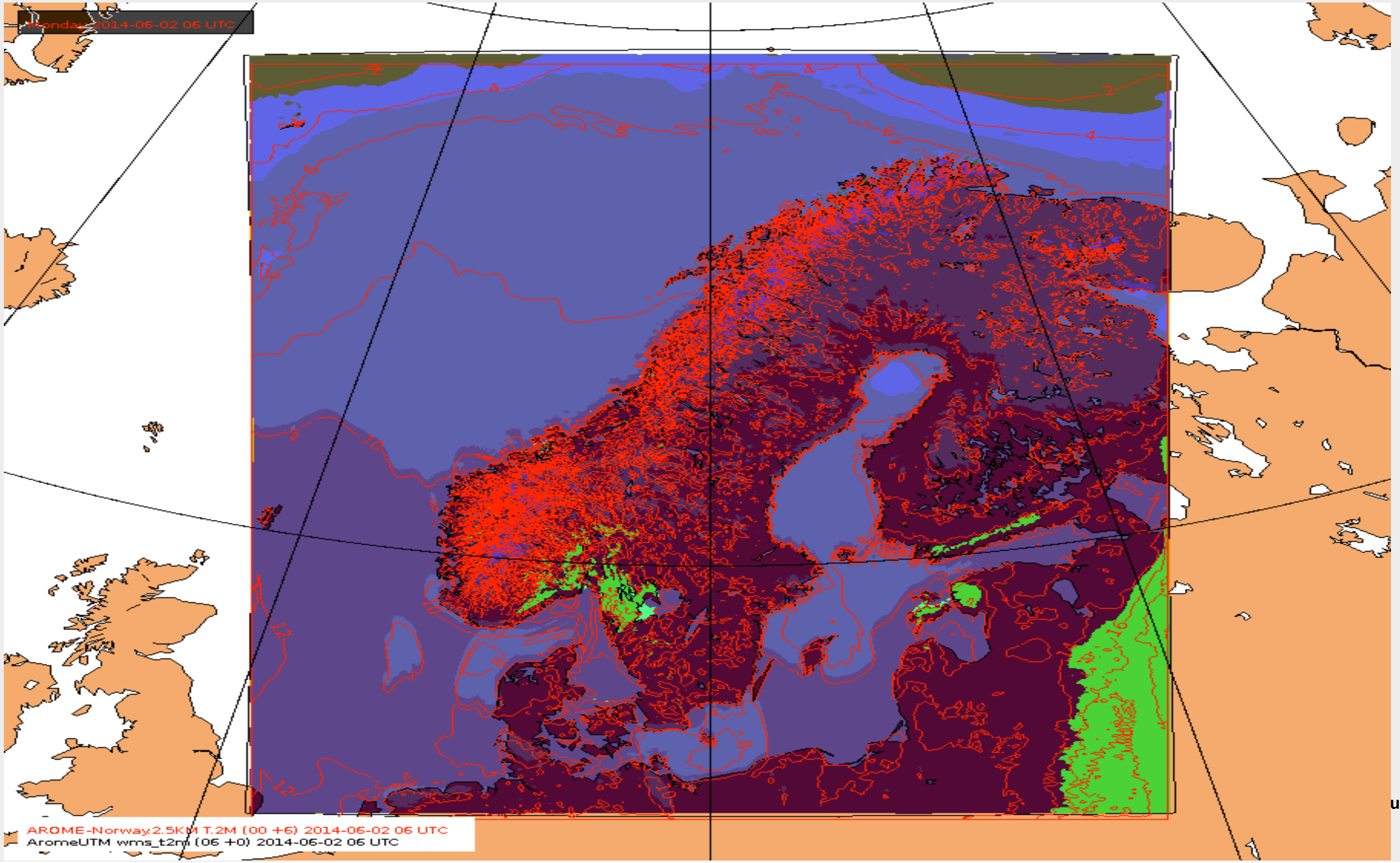
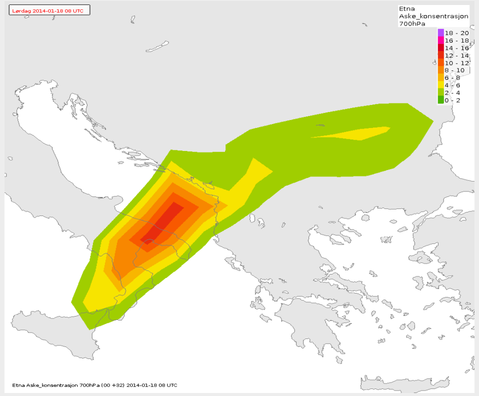
Example: Interpolation and Extraction

- Requirements:
  - Input Coordinate System with horizontal axes
  - Description of new horizontal layout, either:
    - Proj-Projection + axes (in degree or m)
      - `proj -lp`
  - Projection Methods
    - nearestneighbor, bilinear, bicubic
      - Require input rectangular grid with named projection
      - Allow interpolation, also from vectors (continuous data)
      - Generally fastest methods
    - coord_nearestneighbor, coord_kdtree
      - Work with any data with known latitude/longitude coordinates
      - Find closest point in input, require extend of input cell (distanceOfInterest)

- forward_max, forward_mean, forward_median, forward_sum
  - Translate input lat/lon to output-grid
  - Very fast, but might leave holes
  - Mass-conservative, best when reducing resolution


Monday 2014-06-02 06 UTC
AROME-Norway2.5KM T.2M (00 +6) 2014-06-02 06 UTC
AromeUTM wms_t2m (06 +0) 2014-06-02 06 UTC

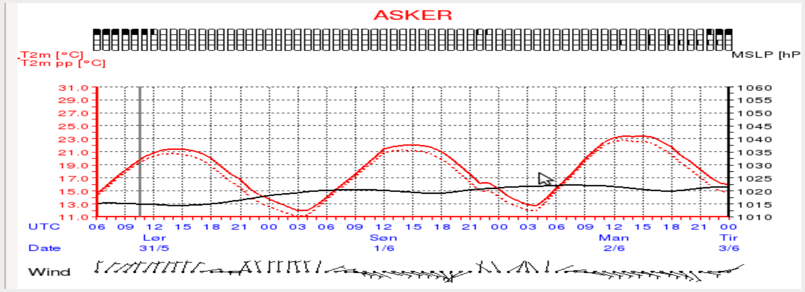
Library in different programs



- Diana setup-files:

```
m=model t=fimex format=netcdf
f=/disk1/file.nc config=my_config.ncml
```

- Tseries:



```
DataFile=/disk1/file.nc
DataDescription=AROME-PP
DataType=netcdf
DataConfig=my_config.ncml
```

- R:

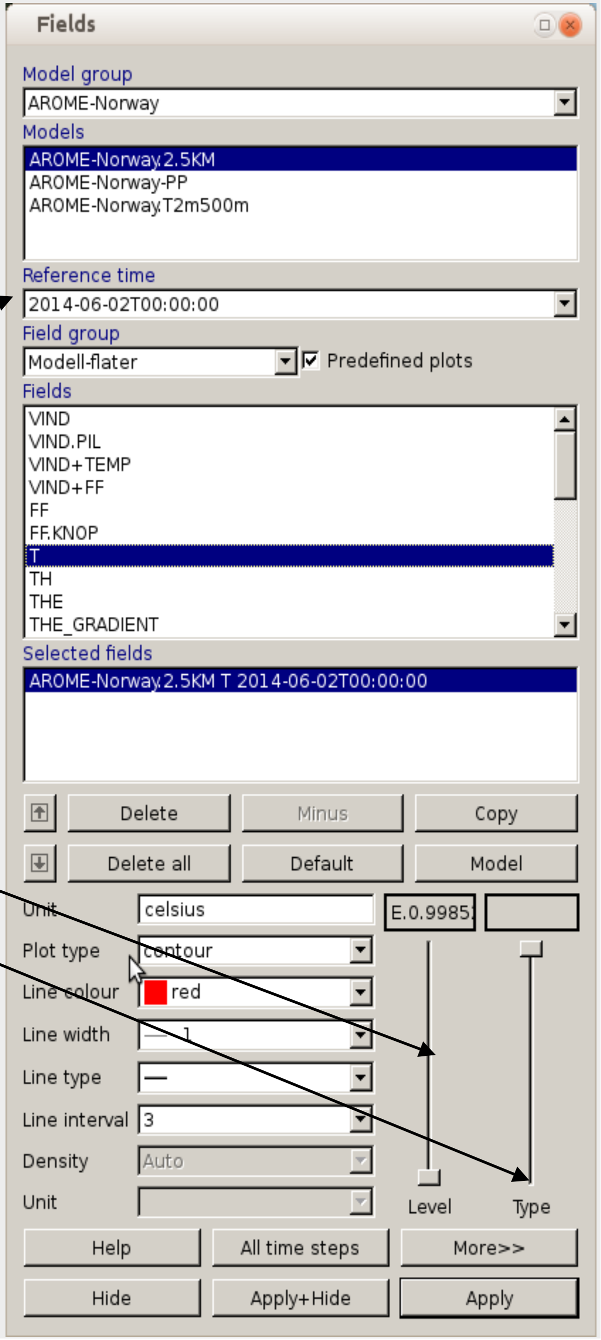
```
io = mifi.reader.new(«netcdf»,
·                          «/disk1/file.nc»,
·                          «my_config.ncml»);
```

- Fortran:

```
ierr=fio%open(input_file,config_file,set_filetype(filetype))
· IF ( ierr /= 0 ) CALL error(«Can't open file»)
```

6-D Coordinate-System

- No requirement in Fimex, but often used for practical reasons
- 3 selectable
  - forecast_reference_time
  - layer
  - additional (e.g. ensemble, percentile)
- 3 implicit
  - X
  - Y
  - Time



Fields

Model group: AROME-Norway

Models:
AROME-Norway.2.5KM
AROME-Norway-PP
AROME-Norway.T2m500m

Reference time: 2014-06-02T00:00:00

Field group: Modell-flater ☑ Predefined plots

Fields:
VIND
VIND.PIL
VIND+TEMP
VIND+FF
FF
FF.KNOP
T
TH
THE
THE_GRADIENT

Selected fields:
AROME-Norway.2.5KM T 2014-06-02T00:00:00

Unit: celsius | E.0.9985

Plot type: contour

Line colour: 🟥 red

Line width: 1

Line type: —

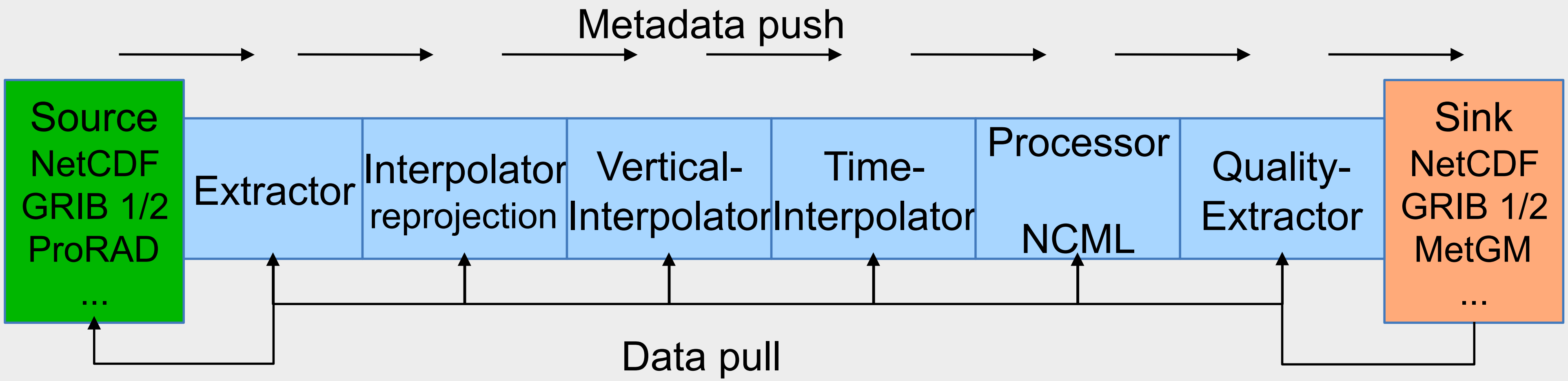
Line interval: 3

Density: Auto

Unit:

Programming philosophy

- Modules have the same set of basic functions
  - Push metadata
  - Pull data (only required data is read/transfered)
- Modules are compeletely independent from each other
- Order of modules can be changed
- Modules can be used more than once



Metadata push

Source NetCDF GRIB 1/2 ProRAD ...

Extractor

Interpolator reprojection

Vertical-Interpolator

Time-Interpolator

Processor NCML

Quality-Extractor

Sink NetCDF GRIB 1/2 MetGM ...

Data pull

Merge = 2 Sources + Interpolator

Performance considerations

- Many fimex-operations are fast, bottlenecks are often
  - IO (disk / network performance)
  - Netcdf4 build-in compression (default gzip -3)

  -> do as many operations as possible in one fimex call
- CPU-bottlenecks might be avoided by parallelization, e.g.
  - -n 4 (4 CPU support) (only for fimex-operations, not IO or compression) (OpenMP based)
  - Parallel fimex-tasks to many files, join files at the end
- It is possible to fill a file with information e.g. along the unlimited (time) dimension
  - --output.fillFile
  - Output file is already readable after first data-arrive

Requirements / Information

- Programming equirements
  - c99/c++03 compiler
  - Libxml2 >= 2.5.0
  - boost library >= 1.32
  - Proj-4 >= 4.4.9
  - udunits >= 2.1.x
- Optional:
  - Netcdf / opendap (>= 3.6)
  - Grib-api (>= 1.4)
  - Psql
  - Log4cpp / openmp
  - Fortran2003 compiler
  - R (>= 2.14)
- More info: https://fimex.met.no/

bildet
«Set
ure

og

Bildet kan ikke vises. Datamaskinen har kanskje ikke nok minne til å åpne bildet, eller bildet kan være skadet. Start datamaskinen på nytt, og åpne deretter filen på nytt. Hvis rød x fortsatt vises, må du kanskje slette bildet og deretter sette det inn på nytt.

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