Report on status of tool support for high resolution data in the CF and FAIR contexts

Milestone 8.1

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1 About

Reporting on progress towards supporting high resolution grids in CF conventions and data FAIRness.

2 Executive summary

The Climate Forecast conventions (CF) provide a data model for the layout of weather and climate data in storage. Recent work has prepared the way for supporting finite element grids in CF via incorporation of UGRID into the CF data model. This task takes that conventions support and demonstrates that it is implementable by implementing full support for ICON, FESOM, LFRic as well as the DestinE generic state vector HEALPix mesh in the python implementation of the CF data model (cfdm) and a science library which builds upon that data model (cf-python). Part of this is to support an existing proposed CF extension for HEALPix through the CF process.

Metadata conventions, and tools that understand them, are a key requirement towards achieving FAIR datasets – mainly impacting the "I" (interoperability) aspect. This is particularly the case for complex grids of the types already mentioned. The structures of these grids are often not intuitive for the casual reader, but the CF conventions and cf-python infrastructure provides a guaranteed correct interpretation when using the data in analysis workflows, particularly when combined with datasets on other grids. This will be the case for the lifetime of the data (which is usually many years, or even decades), and future interoperability will only be achieved if the data have been encoded according to accepted metadata conventions, and the tools still exist that leverage those conventions.

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3 HEALPix grids

3.1 CF conventions

A proposal to introduce HEALPix (Hierarchical Equal Area isoLatitude Pixelisation of a sphere) grids to the CF conventions was initiated in March 2023, with little progress for over a year. As part of EXPECT, process of completing this proposal was undertaken. This has been successful, with HEALPix grids being accepted for inclusion into CF-1.13 (released in December 2025). This conclusion was reached by 23 contributors making ~325 posts on GitHub in two issues and a pull request:

- https://github.com/cf-convention/cf-conventions/issues/433
- https://github.com/cf-convention/vocabularies/issues/290
- https://github.com/cf-convention/cf-conventions/pull/605

3.2 Python implementation

The implementation of HEALPix grids is a two stage process. First it has to be implemented in cfdm, the CF data model reference implementation (https://ncas-cms.github.io/cfdm), which includes the ability to read and write HEALPix datasets; and then in cf-python, the science library built on cfdm that adds useful functionality, such as statistical reductions, regridding, etc. (https://ncas-cms.github.io/cf-python).

3.2.1 cfdm

The cfdm HEALPix implementation is complete, and will be in the next release (January 2026): https://github.com/NCAS-CMS/cfdm/issues/370

3.2.2 cf-python

The cf-python HEALPix implementation is complete, and will be in the next release (January 2026): https://github.com/NCAS-CMS/cf-python/issues/909

4 UGRID support

4.1 Python implementation

UGRID support has been in cfdm and cf-python for some time, with the exception of being able to write UGRID datasets to disk. However, this has now been added to cfdm (and inherited by cf-python) in the next releases (January 2026): https://github.com/NCAS-CMS/cfdm/issues/271

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4.2 CF-compliance

Checking if UGRID datasets are CF-compliant is a complicated task, for which there are no readily available software libraries. Work towards allowing `cfdm` to check this is underway. Coding has not yet begun, but the design process is complete, and a CF-compliance data model has been written, which will guarantee that all aspects are checked, and will greatly facilitate the coding (**figure 1**): https://github.com/NCAS-CMS/cfdm/issues/365

5 Repositories and documentation

This section collates the publicly available, and open source, documentation and code repositories of the software and standards described in this document.

5.1 cfdm

- **Documentation**: https://ncas-cms.github.io/cfdm
- **Source**: https://github.com/NCAS-CMS/cfdm

5.2 cf-python

- **Documentation**: https://ncas-cms.github.io/cf-python
- **Source**: https://github.com/NCAS-CMS/cf-python

5.3 CF conventions

- **Documentation**: https://cfconventions.org
- **Source**: https://github.com/cf-convention/cf-conventions

5.4 UGRID

- **Documentation**: https://ugrid-conventions.github.io/ugrid-conventions
- **Source**: https://github.com/ugrid-conventions/ugrid-conventions

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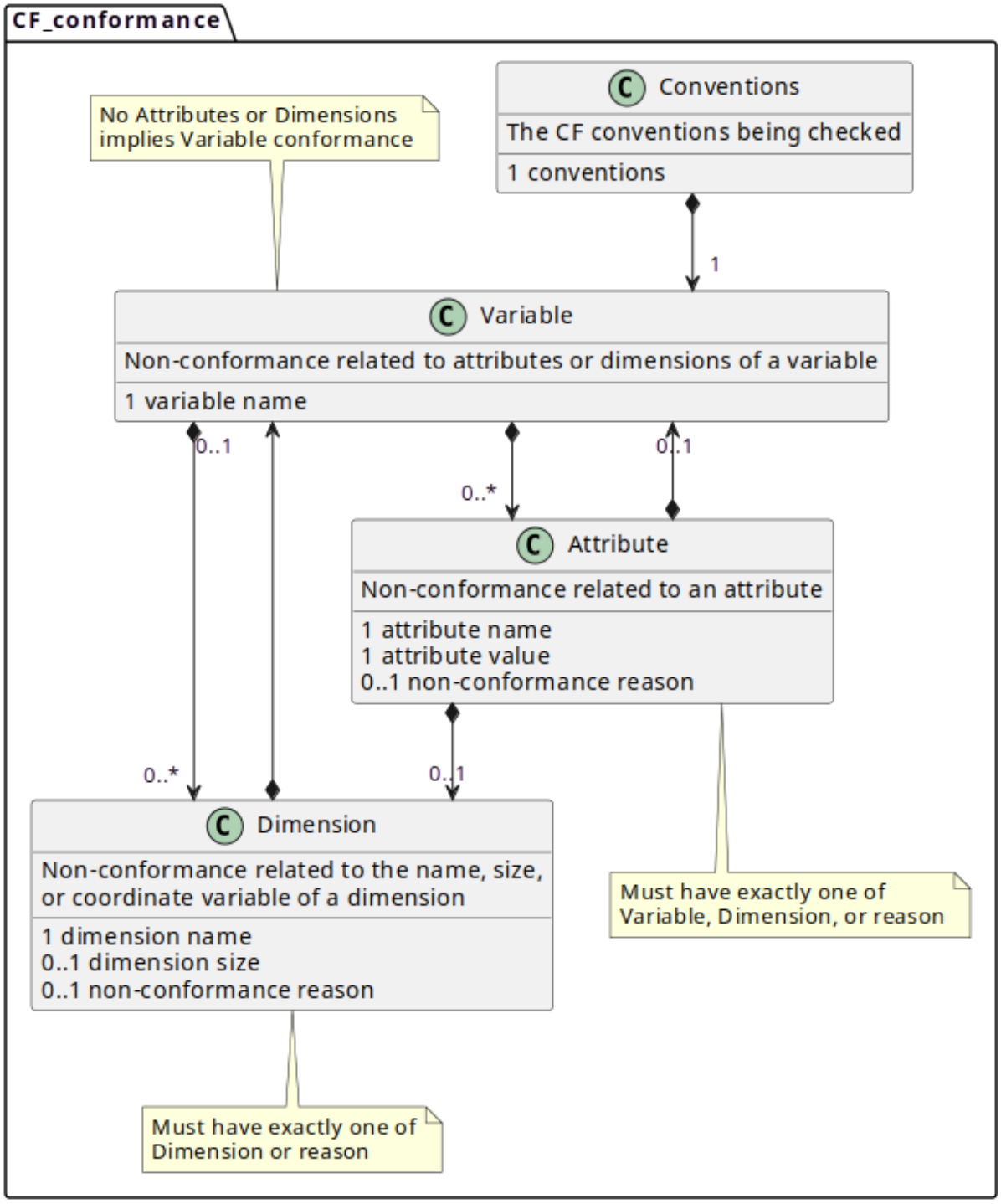

Figure 1: The new CF-compliance data model

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