The University of Reading

CloudNET: Model Conversion Software

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History

Date	***Initials***	***Description***
2004−03−31	AO	Version 5.0.

Contents

1 Introduction

This document describes the software for converting model output data files into netCDF datasets.

The software is available as a *gzip*ped *tar*file with a filename format similar to `cnconversion.tar.gz` or `cnconversion−X.Y.tar.gz` where X.Y is the version number. There is a `README` file which contains details on compiling and running the programs.

This document avoids many of the details that may change with new versions of the software so it is important to read the `README` file carefully.

1.1 Abbreviations

Table 1.1 is a list of abbreviations/mnemonics that I use in the rest of the document and in the software.

Abbreviation/ Mnemonic	***Meaning***
General	
MO	UK Met Office.
EC	ECMWF.
MF	Meteo−France.
KN	KNMI.
UMM	Unified Model−Mesoscale.
UMG	Unified Model−Global.
IFS	Integrated Forecast System.
ARP	ARPEGE is a global model centred on France with the grid spacings increasing as you move away from the centre. ALADIN is a LAM (Local Area Model) based on ARPEGE.
RAC	RACMO (Regional Atmospheric Climate Model).
HIR	HIRLAM (High Resolution Limited Area Model).
MOLTS	Model Output Time Series from UK Met Office global model runs.
Models	
MOUMM	UK Met Office Unified Model−Mesoscale.
MOUMG	UK Met Office Unified Model−Global.
ECIFS	ECMWF IFS.
MFARP	Meteo−France ARPEGE model.
KNHIR	KNMI HIRLAM.
KNRAC	KNMI RACMO.

Abbreviation/ Mnemonic	***Meaning***
File types	
VAR	File with variables on multiple levels.
FLX	File with flux variables in between levels.
SFC	File with surface variables.
Sites	
AB	Aberystwyth
CA	Cabauw
CH	Chilbolton
PA	Palaiseau

Table 1.1 Abbreviations.

2 Basic types of model output data

The model output data consists of three types of data

1. *Multi−level variables*. Sets of variables for different levels for a vertical profile through the atmosphere at a particular grid point and at a particular time. I refer to these as *var* data or files.
2. *Fluxes*. Sets of flux variables for the interfaces between levels. I refer to these as *flx* or *flux* data or files.
3. *Single−level variables*. Sets of variables for a single level. Single level variables can be for the surface, top of the atmosphere (TOA) or some other level defined either as height above the surface or a particular pressure. We are usually only interested in the surface variables. I refer to these as *sfc* data or files.

Each model output data file is usually for one particular grid point.

A profile is a record with variables for a particular time.

There are two times associated with model data: the initialization time of the model run; and the time for which a profile is valid, i.e. the forecast time.

3 Stages of conversion

Figure 3.1 shows the four stages for converting the model output files into the final netCDF dataset.

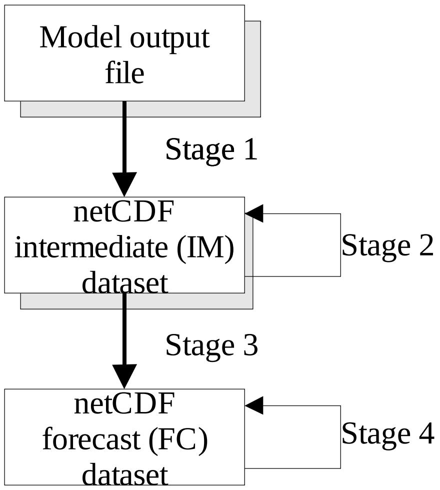

Figure 3.1 Conversion stages.

3.1 Stage 1

Convert the model output files (*var*, *flx* and *sfc*) into intermediate (IM[1]) netCDF datasets.

Model output files are available from several models in various (usually ASCII) formats. Therefore, each model output file requires specific processing which is done at stage 1. After stage 1, any processing on the data can be done using generic software rather than software written specifically for a particular model output format.

There will be a separate program for each data type (*var*, *flx* and *sfc*) for each model. (Note: an IM dataset is for one data type only, different data types must not be mixed in an IM dataset).

In some cases, the model output file may need some preprocessing before being converted. For example, the ECMWF model produces several types of surface files, which can be merged together before converting to an IM dataset.

See section 4 for more details.

3.2 Stage 2

Perform any neccessary processing on the IM datasets.

It may be neccessary to process IM datasets before they can be merged into an FC dataset. For example, the forecast times for the Meteo−France *var* data are not regular and need to be converted before the IM datasets are merged in stage 3.

1The use of the mnemonics IM and FC are for simplifying the discussion in the rest of this document and do not have any kind of external or *official* meaning.

3.3 Stage 3

Merge several IM datasets into a forecast (FC) netCDF dataset.

There is only one program for stage 3 that performs only one task and that is to read several IM datasets and create a new FC dataset.

An FC dataset may contain:

- level parameters;
- flux parameters in between the levels;
- surface parameters including surface fluxes.

A dataset contains the forecasts for a particular period, usually 24 hours, and the forecasts are at regular time intervals within that period, usually every hour.

3.4 Stage 4

Perform any neccessary processing on the FC dataset.

At this stage, an FC dataset contains all the relevant data that can be extracted from a models' output files.

For some models, it may be neccessary to calculate parameters that are required but are not available in the model output files.

Some examples are:

- the height of the surface;
- height of each model level above the surface;
- total cloud cover;
- relative humidity;
- vertical wind;
- microwave propagation parameters.

4 Conventions for IM datasets

I describe here the dimensions, variables and attributes that are used in the IM datasets.

These datasets can only contain one set of data, either *var, flx* or *sfc* data.

The emphasis for IM datasets is for ease of processing, not neccessarily for human−readability.

These are the basic definitions, other definitions may be added by software.

4.1 Filename format

The conventions for the filenames for IM datasets is as follows

```
<model>_<file_type>_YYYYMMDD_HHMM_<site>.nc
```

Where <model>, <file_type> and <site> are given in table 1.1.

`YYYYMMDD_HHMM` is the date/time of the first forecast in the dataset.

4.2 Dimensions

The dimensions are listed in table 4.1.

Dimension	***Description***
time	Number of profiles. Can be UNLIMITED.
level	Number of levels per profile. =1 for *sfc* files, >0 for *var* and *flx* data.

Table 4.1 Dimensions for IM datasets.

4.3 Variables

The variables are listed in table 4.2.

Variable	***Type***	***Units***	***Description***
latitude	float	degrees_N	Latitude of the model grid point.
longitude	float	degrees_E	Longitude of the model grid point.
time(time)	int	minutes since initialization	The time of each profile since the initialization time.
Model variables are not listed here, see the README file with the software.			

Table 4.2 Variables for IM datasets.

All variables must be in the correct units.

They must not be given any attributes.

There is no level variable. The number of levels is given in the level dimension. Levels do not have to be in the correct order at this stage. Level ordering can be done at stage 4. It is essential though that the different file types from the same model use the same level order.

No calculated variables. All calculated data should be done by generic software that can operate on any IM dataset in stage 2.

Use −999 for missing value.

4.4 Global attributes

The global attributes are listed in table 4.3.

Global attribute	***Type***	***Description***
site	int	Site for the model grid point: 0=CH; 1=CA; 2=PA; 3=AB.

Global attribute	***Type***	***Description***
institute	int	Institute the model is from: 0=MO; 1=EC; 2=MF; 3=KN.
model	int	The model itself: 0=MOUMM; 1=MOUMG; 2=ECIFS; 3=MFARP; 4=KNHIR; 5=KNRAC.
file_type	int	The type of data stored in the file: 0=VAR; 1=FLX; 2=SFC.
initialization	int	Initialization date and time. Minutes since 1960.
utc_offset	int	Minutes offset from UTC.

Table 4.3 Global attributes for IM datasets.

5 Conventions for FC datasets

The FC datasets conform to the CF−1.0 conventions.

5.1 Filename format

The conventions for the filenames for FC datasets is as follows

<model>_YYYYMMDD_HHMM_<site>.nc

Where <model> is as given in table 1.1 and <site> is the full site name in lower case letters. `YYYYMMDD_HHMM` is the date/time of the first forecast in the dataset.

5.2 Dimensions

The dimensions that may be present in a FC dataset are given in table 5.1.

Dimension	***Description***
time	Number of profiles.
level	Number of model levels per profile.
flux_level	Number of flux levels per profile. This will be one greater than the *level* dimension. The flux levels are the half levels in between the model levels. They are for the fluxes on the interfaces between model levels.
frequency	For the microwave propagation parameters.

Table 5.1 Dimensions for FC datasets.

5.3 Variables

Table 5.2 gives the variables that may be defined in FC datasets.

Variable	***Type***	***Units***	***Description***
time(time)	float	hours since 00:00.	The time of each profile since midnight.

Variable	***Type***	***Units***	***Description***
forecast_time(time)	float	hours	Hours since the model was initialised.
level(level)	short		The model level number. Top of the atmosphere is numbered 1.
flux_level(flux_level)	short		The flux level number. Top of the atmosphere is numbered 1.
frequency(frequency)	float	GHz	The frequencies for the microwave propagation parameters.
latitude	float	degrees_N	Latitude of the model grid point.
longitude	float	degrees_E	Longitude of the model grid point.
horizontal_resolution	float	km	The horizontal resolution of the model at the grid point.
Model variables are not listed here, see the README file with the software.			

Table 5.2. Variables for FC datasets.

5.4 Global attributes

The global attributes that may be present in an FC dataset are all CF−1.0 conforming attributes: Conventions, title, location, source, institute, initialization_time, and history.

6 References

CloudNET website: http://www.met.rdg.ac.uk/~radar/cloudnet/

CLIWA−NET website: http://www.knmi.nl/samenw/cliwa−net/

ECMWF website: http://www.ecmwf.int/

Appendix A. Calculating the height of each level in a profile

The height of a level, if not given explicitly, can be calculated using the pressure, temperature and specific humidity.

If n is the number of levels with the level numbers running from $0 \ldots n-1$ and level 0 being the lowest in the atmosphere (closest to the surface) then the height of the lowest level $H[0]$, in metres, is

$$H[0]=\frac{R_G}{g}\left(\frac{1}{\sigma_0}-1\right)\frac{T[0]}{(1+\epsilon_f Q[0])}$$

the height for each level above level 0 is

$$H[i]=H[i-1]+\frac{R_G}{g}\frac{(P[i-1]-P[i])(T[i]+T[i-1])}{(P[i]+P[i-1])(1+\epsilon_f(Q[i-1]+Q[i])/2)} \quad , \quad i=1\ldots n\text{-}$$

where $R_G=287$ is the gas constant, $g=9.87\,\mathrm{m\ s^{-2}}$ is the acceleration due to gravity, $\sigma_0=\frac{P[0]}{P_{surface}}=0.998812\,[\text{default}]$ is the ratio of the pressure of the first level above the surface to the pressure at the surface, T is the absolute temperature in K, Q is the specific humidity, $\epsilon_f=1-\frac{1}{\epsilon}$, $\epsilon=\frac{R}{R_v}=0.622$ where R is the gas constant for a perfect gas and R_v is the gas constant for water vapour.

Appendix B. Calculating the relative humidity

The relative humidity can be calculated using the following technique.

The Goff−Gratch formula for saturated vapour pressure is

$$\begin{aligned}\mathrm{SVP} = 10 \wedge (& 10.79574(1-T_0/T) - 5.028\log_{10}(T/T_0) \\ & +1.50475\times10^{-4}(1-10^{-8.2969(T/T_0-1)}) \\ & +0.42873\times10^{-3}(10^{4.76955(1-T_0/T)}) + 0.78614 + 2)\end{aligned}$$

where $T_0 = 273.16\,\mathrm{K}$ and $223 \leq T \leq 373$.

For ice $223 < T < 273$

$$\mathrm{SVP}_{\mathrm{ice}} = 611\exp\left(\frac{21.874(T-T_0)}{(T-7.66)}\right)\ .$$

Mixing ratio is

$$\text{mixing ratio} = 0.62198\left(\frac{\mathrm{SVP}}{P-\mathrm{SVP}}\right)$$

The relative humidity is calculated using the mixing ratio from the model divided by the mixing ratio as calculated above.