ECMWFDATA V4.0 update
Final report of Consultant

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1 Introduction

There is high demand to run the trajectory models FLEXTRA, FLEXPART and HYSPLIT using ECMWF model fields as input. While most fields can be retrieved and interpolated with the ECMWF MARS software, some of them, especially the hybrid coordinate vertical velocity as well as some surface fluxes, need to be calculated or interpolated in time using the ECMWFDATA software.

Many major providers of gridded meteorological data have switched or are planning to switch from GRIB edition 1 to GRIB edition 2 as the default format for gridded data. This has become necessary because GRIB1 has limited capability in handling various satellite data formats as well as limited capability in handling multilevel data. In recent years an API (Application Programming Interface) for this format has been developed at ECMWF and other places. ECMWFDATA v3.0 and prior versions support only GRIB1 and thus an update has been requested to make the ECMWFDATA software compatible with GRIB2.

It also has been requested to check if ECMWFDATA can cope with the latest operational data (T1279 spectral resolution, corresponding to 15.6km gridpoint resolution).

This protocol documents the changes made to the ECMWFDATA software package during transition from version 3.0 to version 4.0, and the effects on data formats and sizes.

2 Changes in the software

2.1 New API in conversion programs

The three ECMWFDATA programs (CONVERT, FLXACC2 and CHECK) used the old GRIB API (GRIBEX), which is difficult to learn and has become old fashioned. The new GRIB-API (version 1.8.0 at the time of this report) is more intuitive and flexible. It contains FORTRAN and C interfaces as well as various utility programs that allow manipulation of GRIB files. It is quite well described at `http://nwmstest.ecmwf.int/products/data/software/grib_api.html` and its source code is freely available.

The FORTRAN source files have been updated to the new API. Change to the new API generally resulted in shorter, much more intuitive code particularly because the memory management is transparent and a lot of auxiliary arrays needed for the old API became unnecessary. Particularly the FLXACC2 program has been thoroughly revised and simplified.

The code changes have been such that both GRIB1 and GRIB2 formatted input files can be read. The programs mentioned above only convert the data content but do not attempt to convert the data format from GRIB1 into GRIB2. Conversion from GRIB1 and GRIB2 ist implemented using the standard open source GRIB conversion tools (grib_filter) that are installed at ECMWF but can be installed also locally. If GRIB2 is requested, data are compressed using JPEG packing. This reduces the file size compared to GRIB1 by 30-50%.

2.2 Modification of scripts

Introduction of the new GRIB API requires some modification of the scripts, though it was tried to keep them minimal and as transparent as possible.

A new parameter M_FORMAT has been added to the operational and on demand retrieval scripts. It can adopt values GRIB1 or GRIB2. If GRIB1 is chosen, the scripts are executed

Table 1: Essential surface parameters and need for multiplication with a conversion factor for proper transition to GRIB2.

Parameter name	Short name	GRIB1 ID	GRIB1 unit	GRIB2 ID	GRIB2 unit	NEED
Large Scale Precipitation	LSP	142	m	160142	$kgm^{-2}s^{-2}$	Y
Convective Precipitation	CP	143	m	160143	$kgm^{-2}s^{-2}$	Y
Surface Sensible Heat Flux	SSHF	146	W/m^2	146	W/m^2	N
Tendency of Surface Pressure	PTEN	158	Pa/s	None	None	?
Total Cloud Cover	TCC	164	0-1	228164	%	N
Surface Solar Radiation	SSR	176	W/m^2	176	W/m^2	N
East West Surface Stress	EWSS	180	N/m^2	None	None	?
North South Surface Stress	NSSS	181	N/m^2	None	None	?

as in ECMWFDATAv3.0. The conversion programs CONVERT2, FLXACC2 and CHECK use the new GRIB API, but this is transparent on the script level. The model level data and a few other surface parameters, which comprise about 90% of the total data volume, are converted into GRIB2 after processing with CONVERT2. The following code in the retrieval scripts does the conversion:

```
ls -l ${INFILE}
cat >rule.filter<<EOF
if (shortName is "t" || shortName is "u" || shortName is "v" ||
shortName is "q" || shortName is "w" || shortName is "etadot" ||
shortName is "msl" || shortName is "sp" || shortName is
"10u" || shortName is "10v" || shortName is "2t" || shortName is "2d") {
  set edition=2;
    set packingType="grid_jpeg";
  write "[file]_2";
} else {
  write "[file]_2";
}
EOF

# Only conversion to GRIB2 is allowed, but no backward conversion
if [ ${M_FORMAT} == GRIB2 ] ; then
 grib_filter rule.filter ${INFILE}
 mv ${INFILE}_2 ${INFILE}
fi
ls -l ${INFILE}
```

At the time of finalization of this software package, the GRIB2 representation of several essential input surface parameters was still undefined. It was thus decided to leave these parameters in GRIB1 format, since conversion into GRIB2 would have required definition of local tables that would have become obsolete within months. The table below lists the GRIB1 and GRIB2 representation of the essential surface parameters needed for FLEXPART that are left in GRIB1. If additional surface parameters are requested using the ADDPAR parameter in the retrieval scripts, they will be left in GRIB1 unless the users add them to the shortName list in the code sequence above.

Besides the changes needed for GRIB2, also the load leveler queuing parameters in the script headers have been updated. On ecgate, the default queue has been set to *large*. This allows Gaussian grid conversion with resolutions up to T511 on ecgate. For scripts running on the HPC the memory requirements have been raised to cope with increased memory demand for T1279 calculations on the Gaussian grid. However, as is noted in the next section, these are needed only for the purpose of testing. If precalculated $\dot{\eta}$ fields from MARS are used, the HPC is not needed even with T1279.

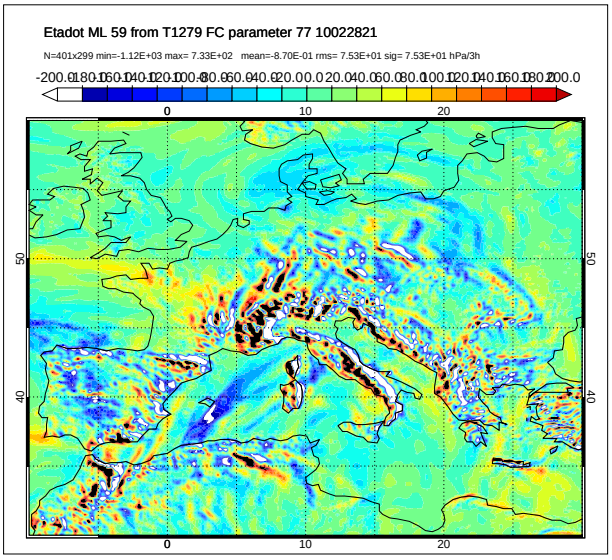

Figure 1: $\dot{\eta}(\partial p/\partial \eta)$ on 28 February 2010, 21 GMT, from T1279 9h forecasts and the horizontal winds using the Gaussian grid calculations built into the ECMWFDATA software

3 Results

This section describes the accuracy of the calculation of $\dot{\eta}$ using T1279 spectral resolution. Fig. 1 shows $\dot{\eta}$ for a case over Europe. Horizontal resolution used in this case over Europe is 0.1 degrees. The differences are quite small and show that CONVERT2 works reliably up to these high resolution.

However, it is unlikely that anybody will use the Gaussian grid calculation with this high resolution since $\dot{\eta}$ is stored operationally in MARS. The computational demand is substantial, 88 units on the HPC for one day of data (8 files). The calculation needs 21GB of memory and works on 32CPUs. Depending on the load of MARS, the execution of the script takes at least 2 hours. When $\dot{\eta}$ is retrieved from MARS instead, the computational demand is reduced to 10 units.

4 Conclusions and recommendations

The ECMWFDATA package has been updated to be compatible with future GRIB2 input and with high resolution data from the T1279 operational ECMWF model. The functionality of the previous package is kept.

The case of GRIB2 input from MARS had to be simulated since MARS still supported only GRIB1 at the time of writing this report. The scripts may be simplified as soon as GRIB2 input from MARS is available.