ECMWF data sets as input for the ATM FLEXPART prepared by a new version of the flex_extract tool

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ABSTRACT

An open-source tool called flex_extract has been developed over many years, partly on behalf of the CTBTO/PTS, to retrieve and prepare meteorological data from the European Centre for Medium-Range Weather Forecasts (ECMWF) MARS archive for driving the Lagrangian particle transport model FLEXPART ([1],[3], [5],[6]) or the WRF model. These data fields describe the state of the atmosphere relevant for transport modelling.
Its functionality includes the generation and execution of MARS requests, calculation of the vertical winds for FLEXPART, and transformation to a latitude-longitude grid. Additionally, it disaggregates accumulated flux data, such as precipitation, in order to get the quasi-instantaneous fluxes which FLEXPART requires, and prepares the final FLEXPART input files.
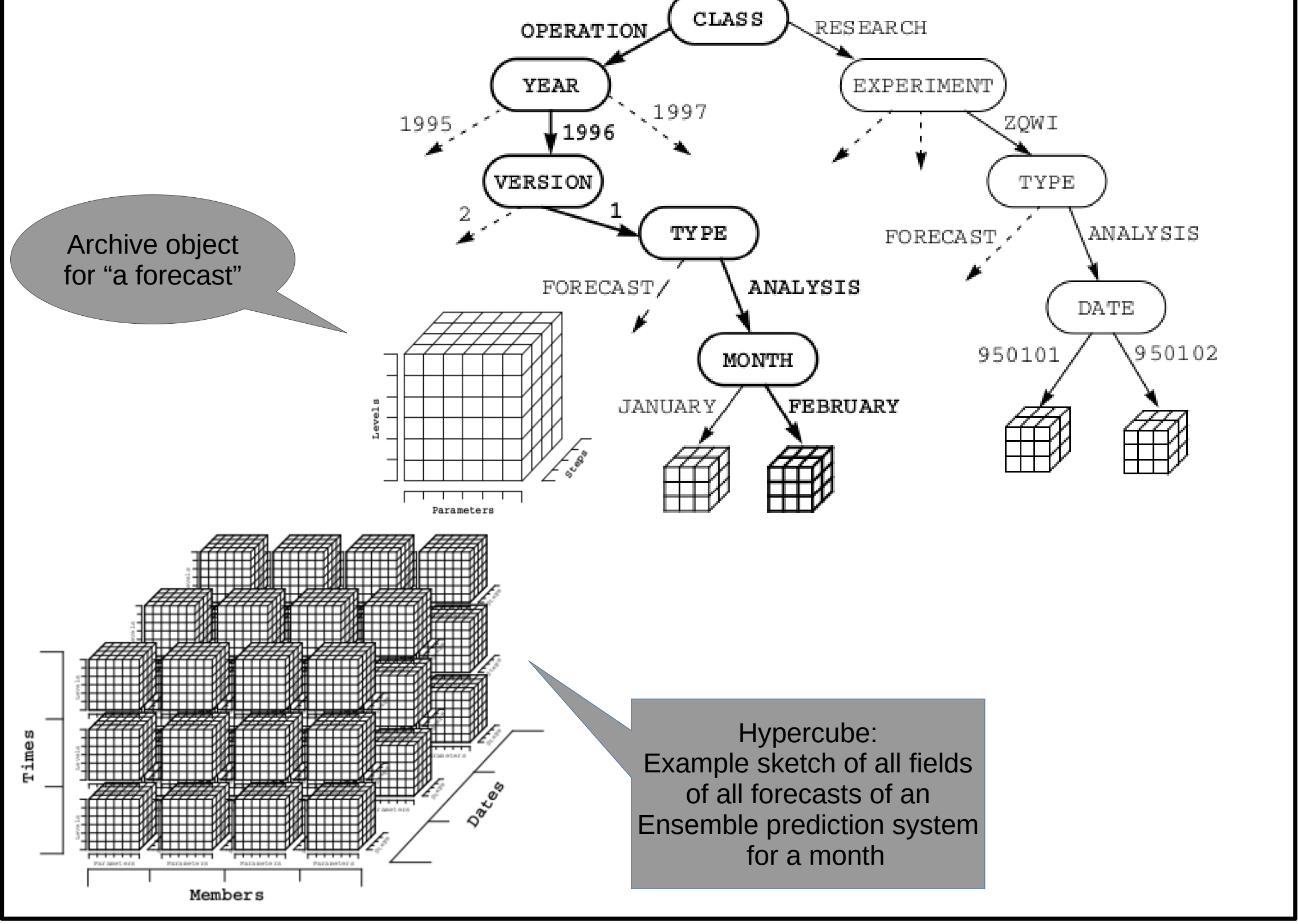
In 2018, several changes effected the ECMWF processing system, such as the replacement of grib_api by ecCodes, of emoslib by the new interpolation library MARS-MIR, and also in the Web API access. Furthermore, more data can now be accessed by non-member-state users. The latest reanalysis, ERA5, with many improvements compared to the previous ERA-Interim, is currently available from 1979 on.

The diversity of data sets, the possible combinations of MARS request settings and ways of accessing MARS can be confusing for less experienced users. Therefore, an overview of the available ECMWF data sets and the ways how they can be accessed with the latest version of flex_extract is presented.

MARS archive

MARS is the ECMWF's Meteorological Archival and Retrieval System. The data in this system are meteorological fields and observation data, the smallest addressable object. Additionally, metadata describe the place where the data is stored.

The single fields are grouped together into logical entities, such as "a forecast", also called archive object. To address these fields or objects the metadata or attributes are organised in a tree fashion, such as this one for an operational analysis in february 1996:

Archive object for "a forecast"

Hypercube: Example sketch of all fields of all forecasts of an Ensemble prediction system for a month

Program flow

Flex_extract is used by first specifying the parameters in a CONTROL file and by defining some parameters in the "run.sh" script. Afterwards the "run.sh" script is started:
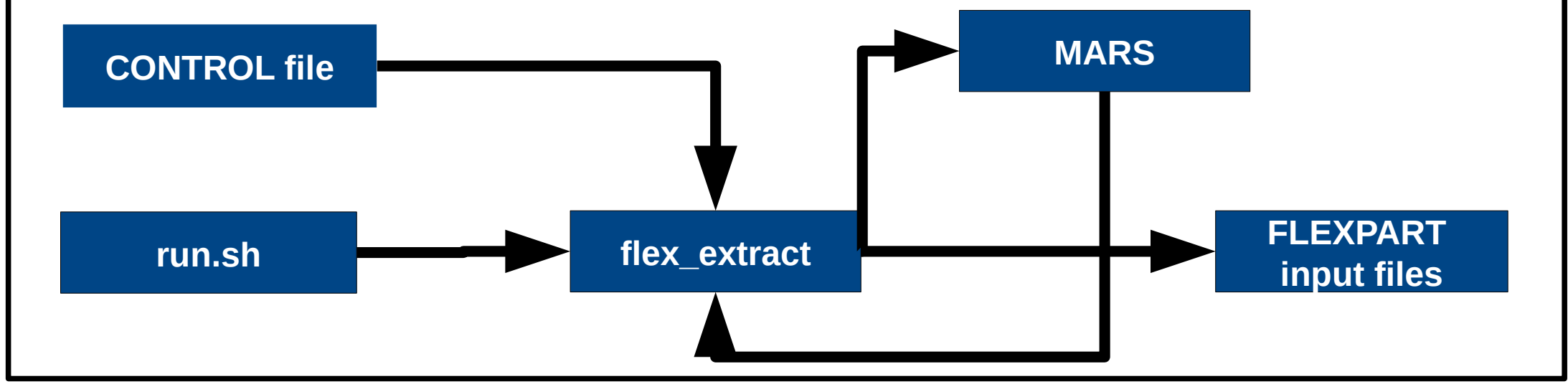
FLEXPART parameters retrieved with flex_extract

FLEXPART needs specific meteorological fields which are extracted with flex_extract in any case. However, with the additional keyword "*ADDPAR*" the user can extract more 2D fields, with the only limit that they are not allowed to be accumulated fields.

	Parameters
Model level	U, V, T, Q, ETADOT, (CIWC+CLWC=QC)
Surface level	LNSP, MSL, 10u, 10v, 2T, 2D, SD, TCC, SR, Z, SDOR, LSM
Flux data	LSP, CP, SSHF, EWSS, NSSS

Access modes with flex_extract

Member state user
Full access to ECMWF data in MARS. Registration through Computing Representative.

Public user
Limited access to reanalysis data in MARS through Web API. Registration on ECMWF website.

Modes	Description
1.Remote	Installation and execution on ECMWF server; member state user account
2.Gateway	Installation and execution on local gateway server; Job scripts send by ecaccess to ECMWF server; member state user account
3.Local member	Installation and execution on local machine; member state user account
4.Local public	Installation and execution on local machine; registration as public user; acceptance of each dataset licenses needed

Datasets accessible through flex_extract

Member state user
- Operational
- ERA-Interim
- CERA-20C
- ERA5

Public user
- ERA-Interim
- CERA-20C
- ERA5

Table1: List of most important specifications and differences in the available datasets.

	Operational	ERA-Interim	ERA5	CERA-20C
Period	12/1985 - ongoing	01/1979-12/2018	01/1979-12/2018	09/1901-12/2010
Streams	oper/elda/enfo	oper	oper/enda	enda
Types	AN/FC/4V/PF(1992-2019)/CF(1992-2019)/CV (2006-2016) – only for enfo)	AN/FC/4V	AN/FC/4V	AN/FC
FC base time	0/12 UTC	0/12 UTC	06/18 UTC	18 UTC
Max. time resolution	1-hourly AN/FC mix	3-hourly AN/FC mix (6-hourly AN for public user)	1-hourly AN	1-hourly AN
Highest resolution	~0.1°	0.75° (80km)	0.28125° (31km)	~1.25° (125km)
Levels	137 (starting from 25/06/2013; less levels before, see docu)	60	137	91
Ensemble members	11 (enda); 26 (elda, upto 50 with sythesized doubles); 50 (enfo, since 1996)	-	10 (3-hourly)	10 (3-hourly)
Eta- coordinate vertical velocity	yes	No, only reduced gaussian grid	yes	yes

Not all meteorological fields and time steps are available for public users. This is taken into account in the sample CONTROL files according to the datasets.

Parameters controlling flex_extract

Flex_extract uses so-called "CONTROL" files to specify the parameters for controlling the program flow and to generate the MARS request. Some parameters in these CONTROL files are specific for the MARS requests, others control internals of flex_extract. The parameters are described in detail in the documentation.
An example of a CONTROL file for the extraction of a single day from the CERA-20C dataset is shown below:
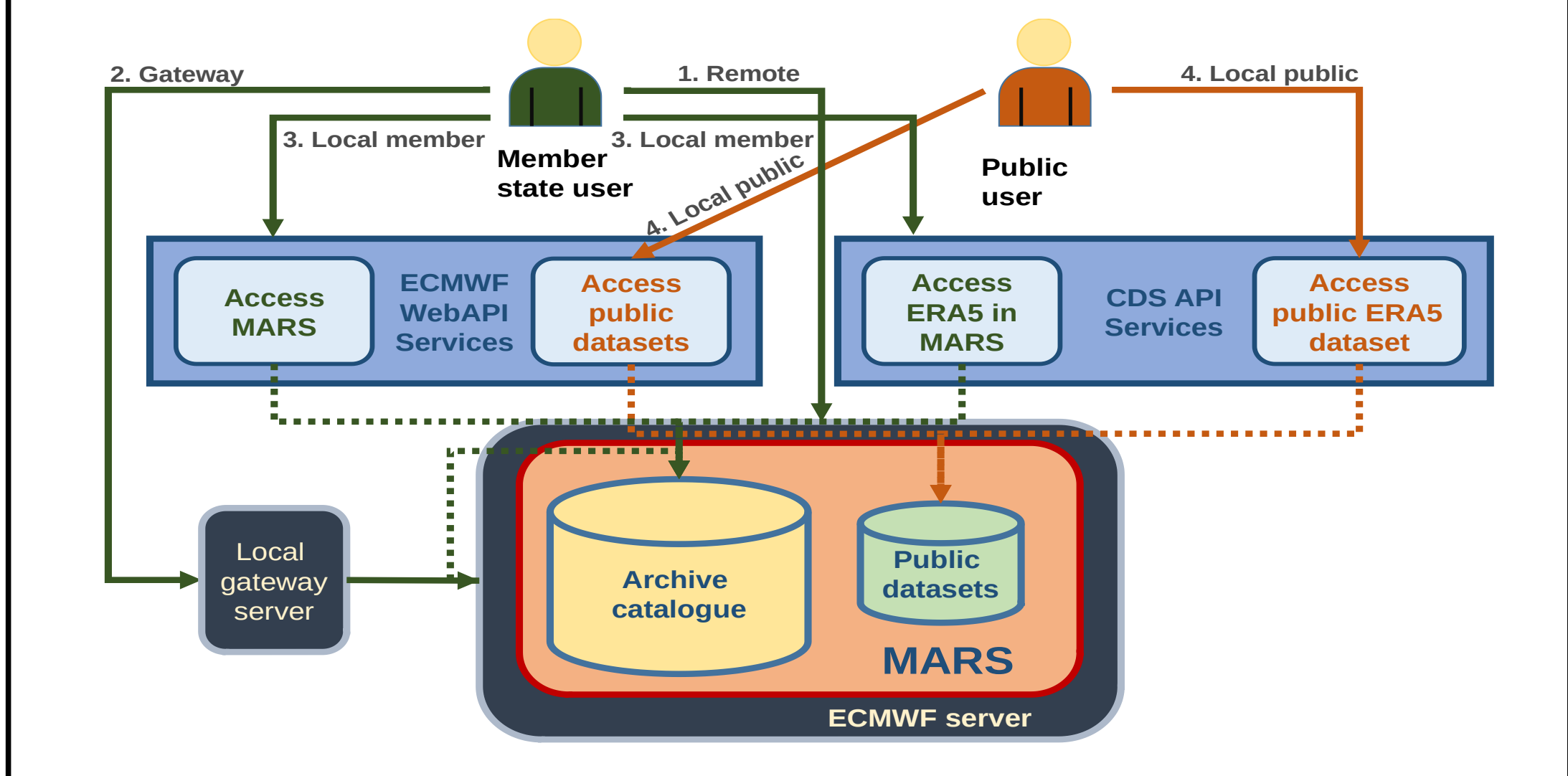
```
START_DATE 20000908
DTIME 3
TYPE AN AN AN AN AN AN AN AN
TIME 00 03 06 09 12 15 18 21
STEP 00 00 00 00 00 00 00 00
ACCTYPE FC
ACCTIME 18
ACCMAXSTEP 24
CLASS EP
DATASET cera20c
STREAM ENDA
NUMBER 0
GRID 1.
LEFT -179.
LOWER -90.
UPPER 90.
RIGHT 180.
LEVELIST 1/to/91
RESOL 106
ETA 1
CWC 1
PREFIX CEpub
```

This would result in 8 FLEXPART input files, one per time step:

CEpub00090800
CEpub00090803
CEpub00090806
CEpub00090809
CEpub00090812
CEpub00090815
CEpub00090818
CEpub00090821

A public dataset is explicitly requested by using the additional keyword "**DATASET**".

MARS access for availability check

It might be useful or necessary to check for availability of data in ECMWF's MARS. Public users can use a web mask to check on data or list available data at https://apps.ecmwf.int/datasets/.
Member state users can check availability of data online at https://apps.ecmwf.int/mars-catalogue/.

On ECMWF servers there are more possibilities to work with MARS:
- **retrieve** – extract data by specifying the MARS keywords
- **compute** – performs mathematical operations on GRIB files
- **list** – checks if data specifying from MARS request is available
- **read** – just reads data from GRIB files for manipulation
- **write** – writes selected data into files

How to get flex_extract

Since it is not yet officially released, it can currently be cloned from the dev branch of the git repository on https://flexpart.eu for testing purposes. An extensive online documentation is currently in process and will soon be available on https://flexpart.eu along with the software package .

Support

- **FLEXPART's community website and ticket system**: https://flexpart.eu
- **flex_extract information:** https://www.flexpart.eu/wiki/FpInputMetEcmwf
- **Git repository:** https://www.flexpart.eu/browser/flex_extract.git
- **Mailing list:** flexpart[at]lists.univie.ac.at

REFERENCES

[1] Anonymous (2019): The official FLEXPART web site, https://www.flexpart.eu/

[2] MARS user documentation. https://confluence.ecmwf.int/display/UDOC/MARS+user+documentation, Accessed: 19.06.2019

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PUTTING AN END TO NUCLEAR EXPLOSIONS