

# CFU (CUMULATED FLUXES) AND XFU (INSTANTANEOUS FLUXES) IN THE CYCLE 42 OF ARPEGE/IFS.

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## *Abstract:*

*This documentation describes some diagnostics done on the physical fluxes: CFU (cumulated fluxes) and XFU (instantaneous fluxes). Some algorithmic aspects and technical aspects (organigramme for example) are described.*

## *Résumé:*

*Cette documentation décrit certains diagnostics faits sur les flux issus de la physique: les CFU (flux cumulés) et les XFU (flux instantanés). On y aborde certains aspects algorithmiques et techniques (organigramme par exemple).*

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# 1 Introduction.

## 1.1 Purpose.

This documentation has to aim to describe the cumulated fluxes diagnostics (CFU) and the instantaneous fluxes diagnostics (XFU) in the cycle 42 of ARPEGE/IFS. These diagnostics can be used only at METEO-FRANCE with a non-lagged package of physics and ARPEGE files. The post-processing of CFU and XFU is not described in this documentation but in the FULL-POS documentation (IDFPOS).

## 1.2 Modifications since cycle 41.

none.

## 2 Algorithm.

\* **Instantaneous fluxes:** Fluxes computed in the physics are simply stored in a grid-point buffer **GFUBUF** (**YOMGFUB**) then written on a file.

\* **Cumulated fluxes:** The cumulated flux  $\bar{F}$  is computed from the instantaneous flux  $F(t)$  by the formula:

$$\bar{F} = \int_{t'=0}^{t'=t} F(t') dt \quad (1)$$

the discretisation of which is:

$$\bar{F} = \sum_{jstep=0}^{jstep=nstepcfu} F(t') \Delta t \quad (2)$$

where  $nstepcfu$  is the number of the timestep where CFU are requested and  $\Delta t$  is the timestep.

\* **Deep layer equations:** Fluxes stored in the code are “additive” ones: extensive quantities divided by a surface which is the projection of the true horizontal surface on a layer where the radius is the mean Earth radius.

## 3 Fluxes which can be diagnostiqued.

Cumulated fluxes and instantaneous fluxes are computed on model layers or interlayers when upper air ones; some fields are surface ones. They are grid-point fields and never converted to spectral ones. The CFU and XFU can be activated for fluxes, the physical parameterization which computes them is switched on; otherwise the code aborts.  $g$  is the gravity acceleration.

The list of available cumulated fluxes (CFU) can be found in module **PTRGFU**.

The list of available instantaneous fluxes (XFU) can be found in module **PTRXFU**.

## 4 Files containing CFU and XFU.

- They are ARPEGE files. No code is provided for GRIB files.
- When needed (FULL-POS for example) departure files are read on logical unit **NINISH**, **NINMSH**, **NFGISH**, **NINIGG**, **NPPPSH**, **NULUSR1** (CFU only), **NULUSR2** (XFU only) according to configuration (see **YOMLUN** and **SULUN** for definition of these logical units).
- If the variable **LFBDAP** is **.T.** in **NAMCT0** the CFU and XFU are written on the historic files (unit **NTRJSH**); otherwise the CFU are written on unit **NULUSR1** and the XFU are written on unit **NULUSR2**.

## 5 Organigramme.

### 5.1 Setup routines and call tree above STEPO.

\* **General architecture under CNT0:** Only features concerning CFU and XFU are mentioned.

```
CNT0 ->
* SUOYOMA ->
  - SUCTO
* SUOYOMB ->
  - SUIOS
  - SUCFU -> SUPPCFU
  - SUXFU -> SUPPXFU
* CNT1 ->
  - SU1YOM ->
    * SUINIF ->
      - SUGRCFU -> (organigramme not detailed)
      - SUGRXFU -> (organigramme not detailed)
  - CNT2 -> CNT3 -> CNT4 -> STEPO (see below call tree under STEPO).
```

### 5.2 Grid-point routines and output routines, call tree under STEPO.

\* **General architecture under STEPO:** Only features concerning CFU and XFU are mentioned.

```
STEPO ->
* Management of file reading/writing: IOPACK (see below call tree under IOPACK).
* Inverse spectral transforms: TRANSINVH
* Grid point computations SCAN2M -> GP_MODEL_HEAP or GP_MODEL_STACK -> GP_MODEL ->
  (see below call tree under GP_MODEL).
* Direct spectral transforms: TRANSDIRH
* Spectral computations: SPCM.
```

Transforms and spectral calculations are not involved for CFU and XFU.

\* **Architecture under IOPACK, WRFU, WRXFU:** Part 5 of **IOPACK** concerns partly CFU and XFU.

```
IOPACK ->
* [ WRMLPP if global model -> ] WRMLPPA ->
  - WRGRIDALL if LUSEWRGRIDALL=T -> (organigramme not detailed)
  - WRXFU if LUSEWRGRIDALL=F -> (organigramme not detailed)
  - WRFU if LUSEWRGRIDALL=F -> (organigramme not detailed)
* some other routines not used for CFU and XFU
```

This call tree is called when CFU and XFU are written on historic files.

\* **General architecture of SCAN2M:** SCAN2M →:

- Some memory transfers and pointer computations before grid-point computations.
- Comparison with observations (non-lagged part, then information communication between processors, then lagged part).
- Model grid-point computations (non-lagged part, then information communication between processors, then lagged part).
- Grid-point computations for analysis.

\* **General architecture concerning CFU and XFU in SCAN2M:**

```
SCAN2M -> GP_MODEL_HEAP or GP_MODEL_STACK -> GP_MODEL ->
* CPG_DRV -> CPG ->
  - non-lagged physics (MF_PHYS -> call tree not detailed)
  - CPG_DIA -> CPCFU and CPXFU (organigramme not detailed)
```

### 5.3 Action and brief description of each routine.

- Expression “full level” is synonym of “middle of layer”.
  - Expression “half level” is synonym of “interlayer”.
  - For meaning of [L5] see section “Sequences of calls of post-processing”.
  - Expression “DM-local” for a quantity means “local to the couple of processors (*proca,procb*)”: each processor has its own value for the quantity. Expression “DM-local computations” means that the computations are made independently in each processor on “DM-local” quantities, leading to results internal to each processor, which can be different from a processor to another one.
  - Expression “DM-global” for a quantity means that it has a unique value available in all the processors. Expression “DM-global computations” means that the computations are either made in one processor, then the results are dispatched in all the processors, or the same computations are made in all the processors, leading to the same results in all the processors.
  - In a routine description the mention “For distributed memory computations are DM-local” means that all calculations made by this routine are DM-local; the mention “For distributed memory computations are DM-global” means that all calculations made by this routine are DM-global; when no information is provided it means that a part of calculations are DM-local and the other part is DM-global.
  - Expression “main” processor currently refers to the processor number 1: (*proca,procb*)=(1,1).
- \* **Grid-point and spectral routines of directory “adiab”:**
- **CPG\_DRV**: driver for non lagged part of grid-point calculations.
  - **CPG**: non lagged part of grid-point calculations, including model dynamics, non lagged physics, diagnostics.
  - **CPG\_DIA**: part of the non lagged part grid-point calculations managing the diagnostics.
- \* **Control routines of directory “control”:**
- **CNT0**: controls integration job at level 0.
  - **CNT1**: controls integration job at level 1.
  - **CNT2**: controls integration job at level 2.
  - **CNT3**: controls integration job at level 3.
  - **CNT4**: controls integration job at level 4.
  - **SCAN2M**: interface for grid-point computations.
  - **GP\_MODEL**: part of the grid-point computations for model and some diagnostics (CFU,XFU,DDH).
  - **SPCM**: interface for spectral computations.
  - **STEPO**: control routine for one time integration step.
- \* **Routines of directory “dia”.**
- **CPCFU**: grid point calculations of the CFU fields.
  - **CPXFU**: grid point calculations of the XFU fields.
  - **WRFU**: routine to write CFU fields on an ARPEGE file.
  - **WRGRIDALL**: interface routine to write grid-point fields, called if **LUSEWRGRIDALL=T**.
  - **WRMLPP** and **WRMLPPA**: interface routines to write model-layer fields on an historic file.
  - **WRXFU**: routine to write XFU fields on an ARPEGE file.
- \* **Distributed memory environment routines (directory “parallel”):** See documentation (IDDM) about distributed memory features.
- \* **Set-up routines of directory “fullpos”:**
- **SUFPCFU**: initialises cumulated fluxes switches for FULL-POS: corrects the values of the **YOMCFU** variables in order to compute the CFU which are post-processed. For distributed memory computations are DM-global.
  - **SUFPCFU**: initialises instantaneous fluxes switches for FULL-POS: corrects the values of the **YOMXFU** variables in order to compute the XFU which are post-processed. For distributed memory computations are DM-global.

\* **Set-up routines of directory “setup”:**

- **SUCFU**: initialises the control of cumulated fluxes: reads **NAMCFU**, sets-up variables of **YOMCFU**, computes the **PTRGFU** pointers.
- **SUCTO**: routine to initialize level 0 control module.
- **SUGRCFU**: reads the cumulated fluxes on ARPEGE files.
- **SUGRXFU**: reads the instantaneous fluxes on ARPEGE files.
- **SUINIF**: interface routine for reading the departure files.
- **SUIOS**: sets-up **YOMIOS**.
- **SUXFU**: initialises the control of instantaneous fluxes: reads **NAMXFU**, sets-up variables of **YOMXFU**, computes the **PTRXFU** pointers.
- **SU0YOMA**: 0-level interface routine for set-up: first part.
- **SU0YOMB**: 0-level interface routine for set-up: second part.
- **SU1YOM**: 1-level interface routine for set-up.

\* **Routines of directory “transform”**. For more details see documentation (IDTS) about spectral transforms.

- **TRANSDIRH**: interface routine for direct spectral transforms.
- **TRANSINVH**: interface routine for inverse spectral transforms.

\* **Routines of directory “utility”**.

- **IOPACK**: interface for writing data on ARPEGE, ALADIN or GRIB files.

## 6 Sequences of calls.

Cumulated fluxes and instantaneous fluxes are computed on model layers or interlayers when upper air ones; some fields are surface ones. CFU and XFU grid-point part calls a special sequence for **STEPO**. A sequence is defined by nine letters (or zeros) [L1][L2][L3][L4][L5][L6][L7][L8][L9] (variable **CLCONF** in routine **control/CNT4** and **CDCONF** in routine **control/STEPO**).

- L1 controls the file reading/writing.
- L2+L3 controls the inverse transforms.
- L4 controls the grid-point computations for dynamics and physics.
- L5 controls the grid-point computations for some diagnostics.
- L6 controls the grid-point computations for assimilation.
- L7 controls the coupling in LAM models.
- L8 controls the direct transforms.
- L9 controls the spectral computations.

For example a model integration time-step is defined by the sequence [L1]AAA00AAA. Additional sequences can be performed by calls to **SCAN2M** under routines other than **STEPO**. The sequence called for CFU and XFU is [L1]AAX00000.

## 7 Some distributed memory features.

The total number of processors involved in the A-level parallelisation is **NPRGPNS**. The total number of processors involved in the B-level parallelisation is **NPRGPEW**. One processor treats **NGPTOT** points (a part of the Gaussian grid points). The total amount of grid-points for all the processors is **NGPTOTG**. The maximum value of **NGPTOT** is **NGPTOTMX**. In the grid-point space there is a subdivision of the current processor grid-points into  $\text{NGPBLKS} = \text{int}[(\text{NGPTOT} + \text{NPROMA} - 1) / \text{NPROMA}]$  packets of length **NPROMA** (the useful number of values in each packet is lower or equal than **NPROMA**). These packets do not contain neither extra-longitudes nor extra-polar latitudes data. A **NPROMA**-packet does not always contain a set of complete latitudes. One 2D field has **NGPTOTG** points divided into **NPRGPNS\*NPRGPEW** sets of **NGPTOT** points treated by each processor. **NGPTOT** does not take account of the extra-longitudes and the extra-polar latitudes. All these variables take account of the reduced Gaussian grid. It is assumed and hardcoded that there are one western extra-longitude and two eastern extra-longitudes. The DM-global longitude  $j_{lon} = 1$  is always the “Greenwich” meridian of the computational sphere. All the vertical levels and the variables corresponding to a same grid-point are treated by the same processor.

## 8 Pointer, module and namelist variables to be known.

These modules are auto-documented so description of each variable is provided in the code source. We can recall here the most important variables to know for each module:

- **PTRGFU** (contains the pointers relative to the CFU).
- **PTRXFU** (contains the pointers relative to the XFU).
- **YOMCFU** (contains variables relative to the CFU, in particular contains keys switching on cumulated fluxes). Some of them are in namelist **NAMCFU**.
- **YOMXFU** (contains variables relative to the XFU, in particular contains keys switching on instantaneous fluxes). Some of them are in namelist **NAMXFU**.
- **YOMGFUB** (contains buffer GFUBUF for CFU).
- **YOMXFUB** (contains buffer XFUBUF for XFU).
- **YOMCT0** (0-level control).
- **YOMCT1** (1-level control). In particular N1CFU and N1XFU. Some of them are in namelist **NAMCT1**.
- **YOMDIM**, **YOMDIMV** and **YOMDIMF** (dimensioning): most of variables. Some of these variables are in namelist **NAMDIM**.
- **YOMLUN** (logical units).
- **YOMMP0** and **YOMMP** (distributed memory environment, see documentation (IDDM) for more details).
- **YOMOPH**. In particular LINC and LTIMEP0. Some of them are in namelist **NAMOPH**.
- **TYPE\_FLUXES** (defines descriptors of families of model fluxes).
- **PARFPOS**, **YOM4FPOS**, **YOMAFN**, **YOMFP4**, **YOMFPC** for applications doing post-processing on CFU and XFU (see FULL-POS documentation (IDFPOS)).

## 9 References.

### 9.1 Some internal notes and other ARPEGE notes.

- (TDECDYN) 2014: IFS technical documentation (CY40R1). Part III: dynamics and numerical procedures. Available at “<http://old.ecmwf.int/research/ifsdocs/>”.
- (TDECTEC) 2014: IFS technical documentation (CY40R1). Part VI: technical and computational procedures. Available at “<http://old.ecmwf.int/research/ifsdocs/>”.
- (IDBAS) Yessad, K., 2015: Basics about ARPEGE/IFS, ALADIN and AROME in the cycle 42 of ARPEGE/IFS (internal note).
- (IDFPOS) Yessad, K., 2015: FULL-POS in the cycle 42 of ARPEGE/IFS (internal note).
- (IDDM) Yessad, K., 2015: Distributed memory features in the cycle 42 of ARPEGE/IFS (internal note).
- (IDEUL) Yessad, K., 2015: Integration of the model equations, and Eulerian dynamics, in the cycle 42 of ARPEGE/IFS (internal note).