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ARPEGE/ALADIN : the galaxy

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This presentation describes :

- the data flow around ARPEGE/ALADIN software
- the multi-functionality of this software

ARPEGE = Action de Recherche Petite Echelle Grande Echelle
(at ECMWF : IFS = Integrated Forcasting System)
ALADIN = Aire Limitee Adaptation DYNamique

ARPEGE software => runs ARPEGE : the global model

ALADIN software + ARPEGE software => runs ARPEGE : the global model or ALADIN : the limited area model

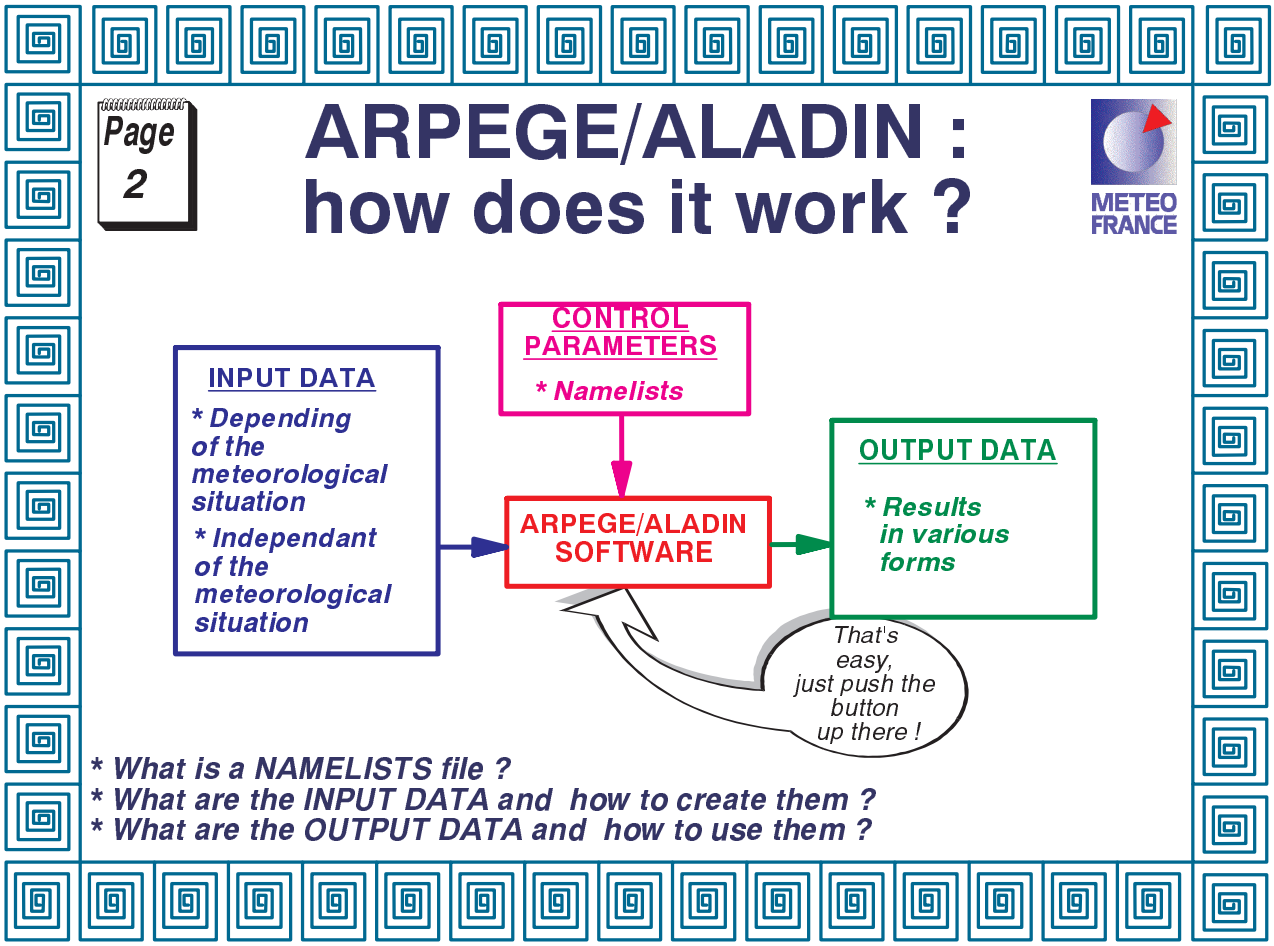
: ARPEGE & ALADIN work the same manner

This presentation is a very general one about the software Ifs/Arpege/Aladin.
It describes the dataflow environment around the software and its multi-functionality.

Meteo-France and ECMWF are developing together a software for a global model : the name is IFS (Integrated Forcasting System) at ECMWF, while it is called ARPEGE (Action de Recherche Petite Echelle - Grande Echelle) at Meteo-France, but the code is exactly the same.

Meteo-France and several other partners (the Aladin partners) are developing a limited area model named ALADIN (Aire Limitee Adaptation DYNamique, as suggested by Sylvie Malardel). This second software should be considered as a complement to the first one, as ALADIN is developed following the same scientific and technical spirit. Even more, you need the ARPEGE software in background when you want to run ALADIN.

Remark : the ALADIN software does not make the global model collapse : you can use the whole software ARPEGE/ALADIN just to run the global model ARPEGE.



To run the model, you need first some input data. It can be data depending from the meteorological situation, or other auxiliary data (like climatology, mathematical matrixes, etc.)
Then you will need to choose some parameters on yourself, in order to control what you really want to do. These parameters are written in a *Namelists file*.
As a result, you can get several outputs : the namelist file will tell the program what to write out.

In the next pages, we shall describe :

The Namelists file,
The input data
The output data

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What is the namelists file?

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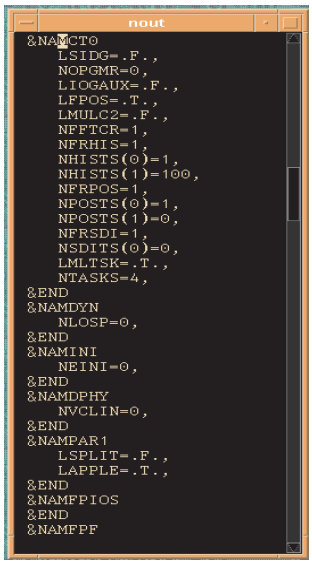
* The "post-command" of the software :

Enable choices for :
* technical options,
* scientific options,
* outputs,
* etc ...



Should the model be an aircraft, then the namelists file would be the cockpit : here you can define plenty of options to run the program.

The namelists file presents itself as an editable ASCII file ; you will find inside plenty of Fortran namelists blocks : each one is, in principle, dedicated to a topic. For instance, NAMDFI is dedicated to the parameters related to the digital filters initialisation, while NAMDIM will setup general dimensionnings for the model dynamics.

Through the namelists file, you can decide yourself how to tune various parameters :

Scientific options (like : hydrostatic vs. non-hydrostatic model),

Technical options (like : Distributed memory model vs. Shared memory model)

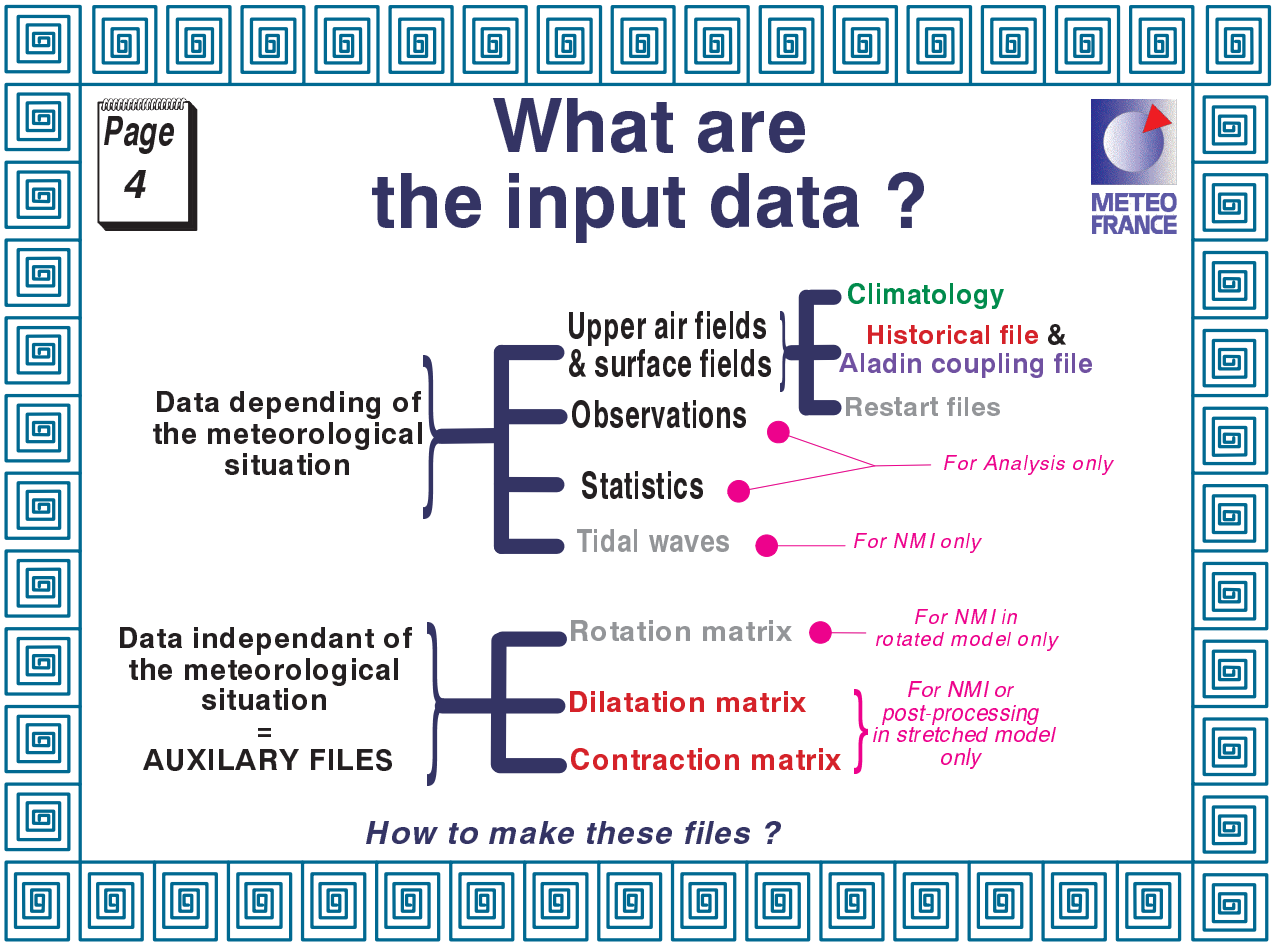
Custom choices (kind and frequency of outputs)

and much more ...

NOTICE : It is very important to understand the content of the namelists file you are using, otherwise you would not control what you are doing !! Learning the namelists parameters is an important investment for yourself.

The namelists file enables you to configurate the software according to what you want it to do.

The very first parameter you can learn right now is the configuration number : it is a integer in the namelist NAMCT0, named NCONF. The same configuration numbers apply for Arpege and Aladin, but traditionally, to distinguish the two model, the habit consists in talking about the configuration nnn for Arpege, and the configuration E-nnn for Aladin.



There are 2 kinds of input data :

First kind is the data depending of the meteorological situation. Usually this data is written on a file currently named initial conditions file, or historical file. It contains upper air fields (most of whom are represented as spectral coefficients since the model is spectral) and surface fields. In the case of Aladin, you may also need a set of coupling files (1 file per coupling range). Furthermore, in several cases, you may need some climatology data.

You may also need other data : observations and statistics to make the analysis of the situation ; tidal waves for the Normal Modes Initialisation.

As an alternative to the initial condition file, you may use the so-called "restart files" which are actually used only for very long climate runs or in case of a hardware crash in operations.

Second kind of data does not depend of the meteorological situation : 3 files can be needed :

1/ The rotation matrix file

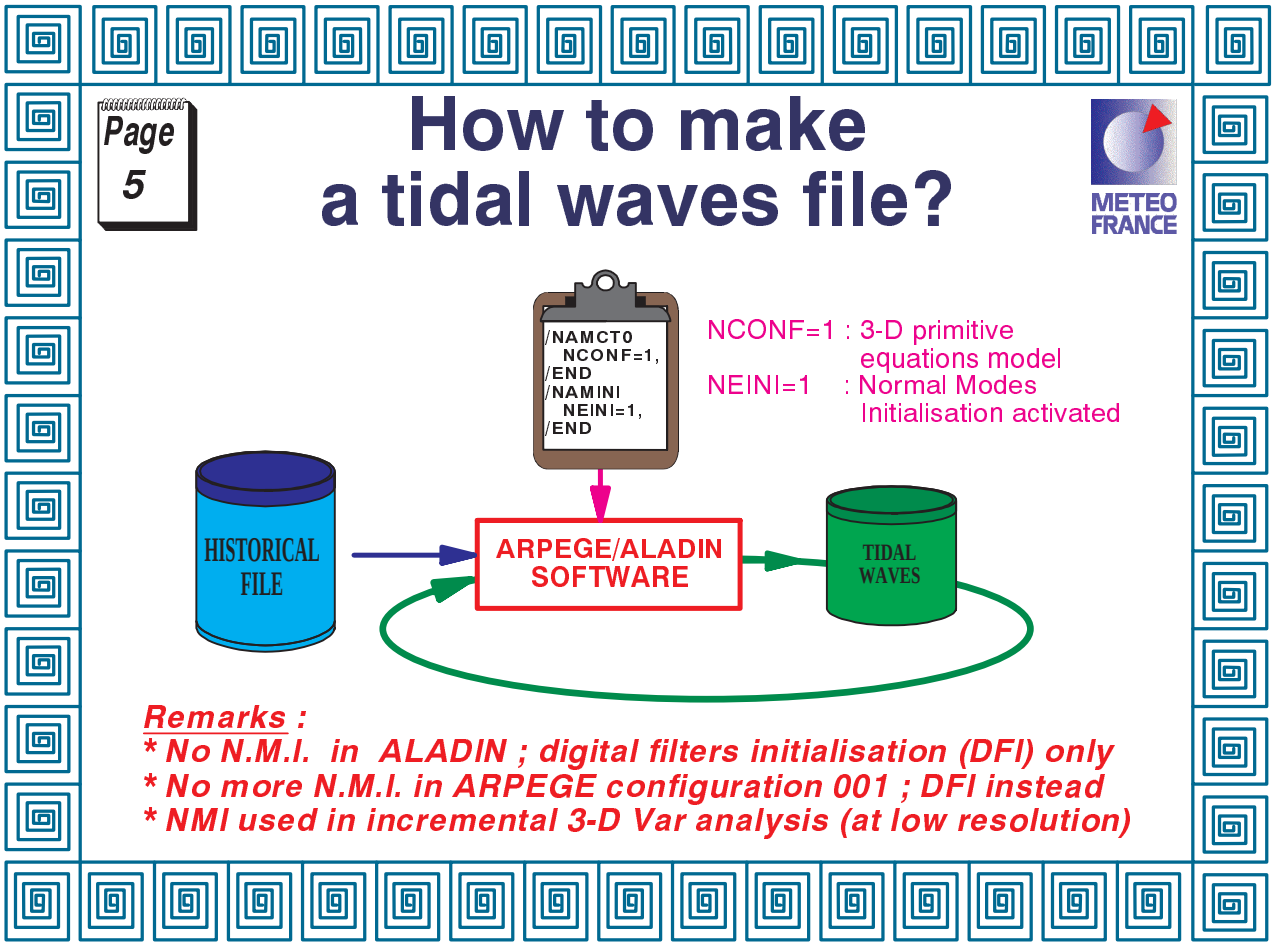
2/ The contraction matrix file

3/ The dilatation matrix file

The rotation matrix is used only for Normal Modes Initialisation when the pole of interest of the global model is not the geographical North pole.

The contraction and dilatation matrixes are used only for Normal Modes Initialisation and for the post-processing when the global model is stretched.

This presentation will now describe how to build all these files with Arpege/Aladin software, except the observations files.



The first time, the tidal wave file is automatically generated during the Normal Modes Initialisation, prior to the integration of the model. Then it can be re-used for the next forecast run.

Notices :

* Normal Modes Initialisation are not coded in Aladin ; Aladin is initialised by Digital Filters Initialisation.

* In operations, Normal Modes Initialisation are used in Arpege only during the 3D-Var incremental analysis (at low resolution, without rotation nor stretching). Arpege like Aladin is initialised by Digital Filters Initialisation.

* In 4D-Var analysis, the Digital Filters initialisation will be used instead of Normal Modes Initialization.

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How to make a historical file Arpege ?

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3 possibilities :

1/ Data extracted from MARS archive system at ECMWF
=> needs Arpege configuration 901

2/ From any file ARPEGE already existing
=> may need Arpege "Fullpos" (so-called configuration 927) if the geometry should be changed

3/ Data extracted from observations
=> needs :
Arpege configuration 131 (Variational) and
Arpege "Canari" : configuration 701 (OI analysis)

IMPORTANT NOTICE :
stretched/rotated ARPEGE model works with stretched/rotated ARPEGE files

There are 3 possible ways to make a historical file Arpege, according to the data you starts from :

1/ If you retrieve data from ECMWF Mars archive system, then you just have to feed the model with the GRIB data and you run the configuration
901 of Arpege : the program will generate a file Arpege with the same geometry as in the GRIB input data.
2/ If you have already a file Arpege, but you want to change any parameter of its geometry (like the spectral truncation), then you should run the
so-called configuration 927 : this is a special configuration of the post processing package ("Fullpos") of Arpege.
3/ Finally you can start from observations : then you will build your Arpege file thanks to 2 configurations of the software :
- The configuration 131 which is the variational analysis for upper air variables, - The configuration 701 ("CANARI") which is the optimal interpolation analysis for the surface variables.

NOTICE : when you run Arpege in stretched/rotated mode, you must have an input Arpege file with stretched/rotated data inside. As a consequence,
if you start from ECMWF Mars archive data and you want to run Arpege in stretched mode, you will have to run successively the configurations 901 then 927. If you start from observations and you want to run Arpege in stretched mode, then you will have to run the configurations 131 and 701 in
stretched mode.

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How to make ALADIN files ?

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3 possibilities :

1/ From any file ARPEGE

=> needs Arpege/Aladin "Fullpos" (so-called configuration E927)
(starting file & coupling files)

2/ From any file ALADIN

=> needs Arpege/Aladin "Fullpos" (so-called configuration EE927)
(to make an inner domain)
(starting file & coupling files)

3/ Data extracted from observations

=> needs Arpege/Aladin "Canari" configuration E701 (OI analysis)

There are 3 possible ways to make a historical file Aladin, according to the data you starts from :

1/ If you start from a file Arpege, then you should run the so-called configuration E927 : this is a special configuration of the post-processing package ("Fullpos") of Arpege/Aladin.

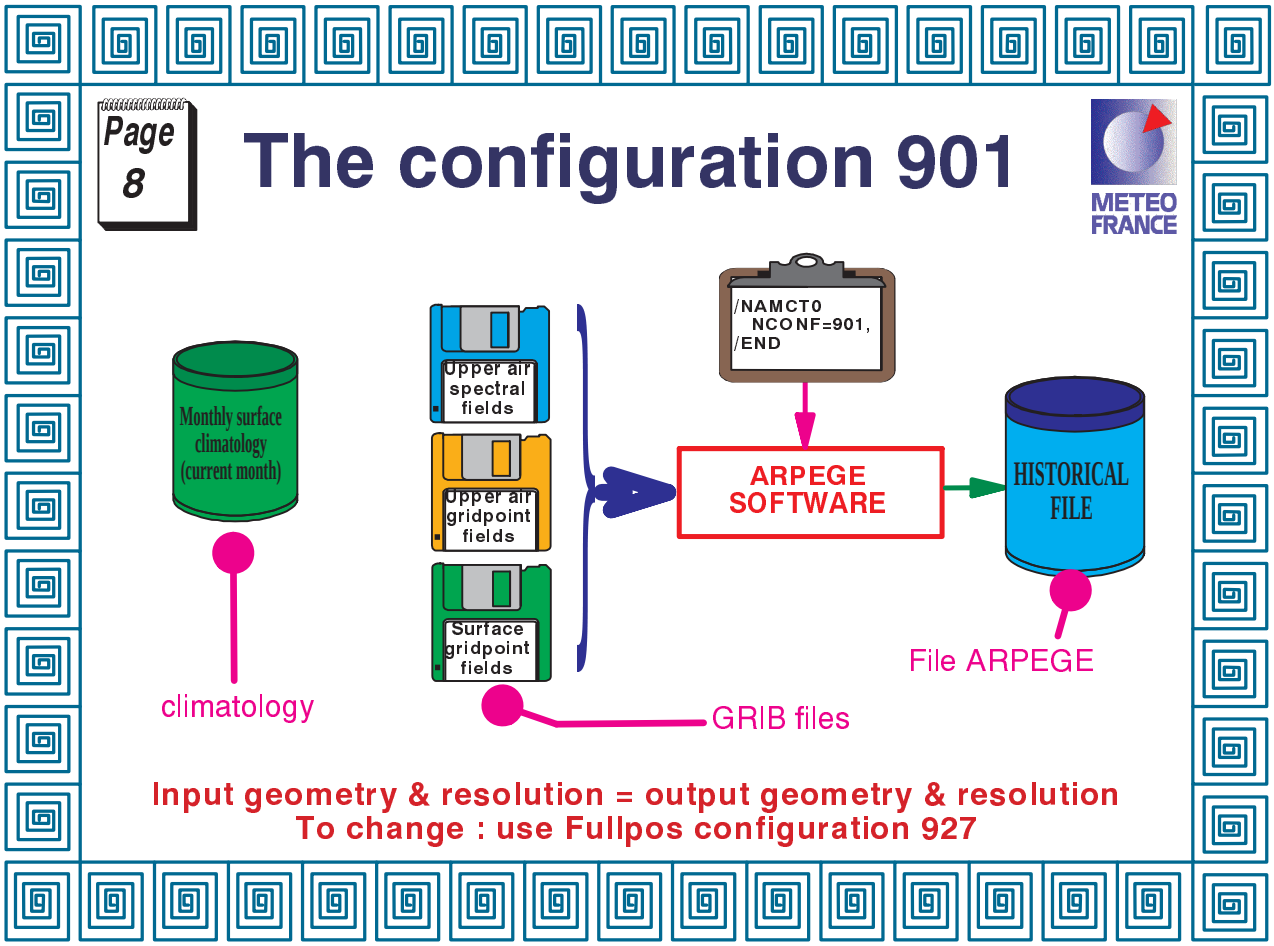
2/ If you start from a file Aladin, then you should run the so-called configuration EE927 : this is a special configuration of the post-processing package ("Fullpos") of Arpege/Aladin.

Note that your target domain Aladin must be completely inside the source domain Aladin !

3/ Finally you can start from observations : then you will build your Aladin file thanks to the configuration E701 ("CANARI" Aladin) which is the optimal interpolation analysis.

NOTICE :

- The configuration E131 (variational analysis for Aladin) is under development.



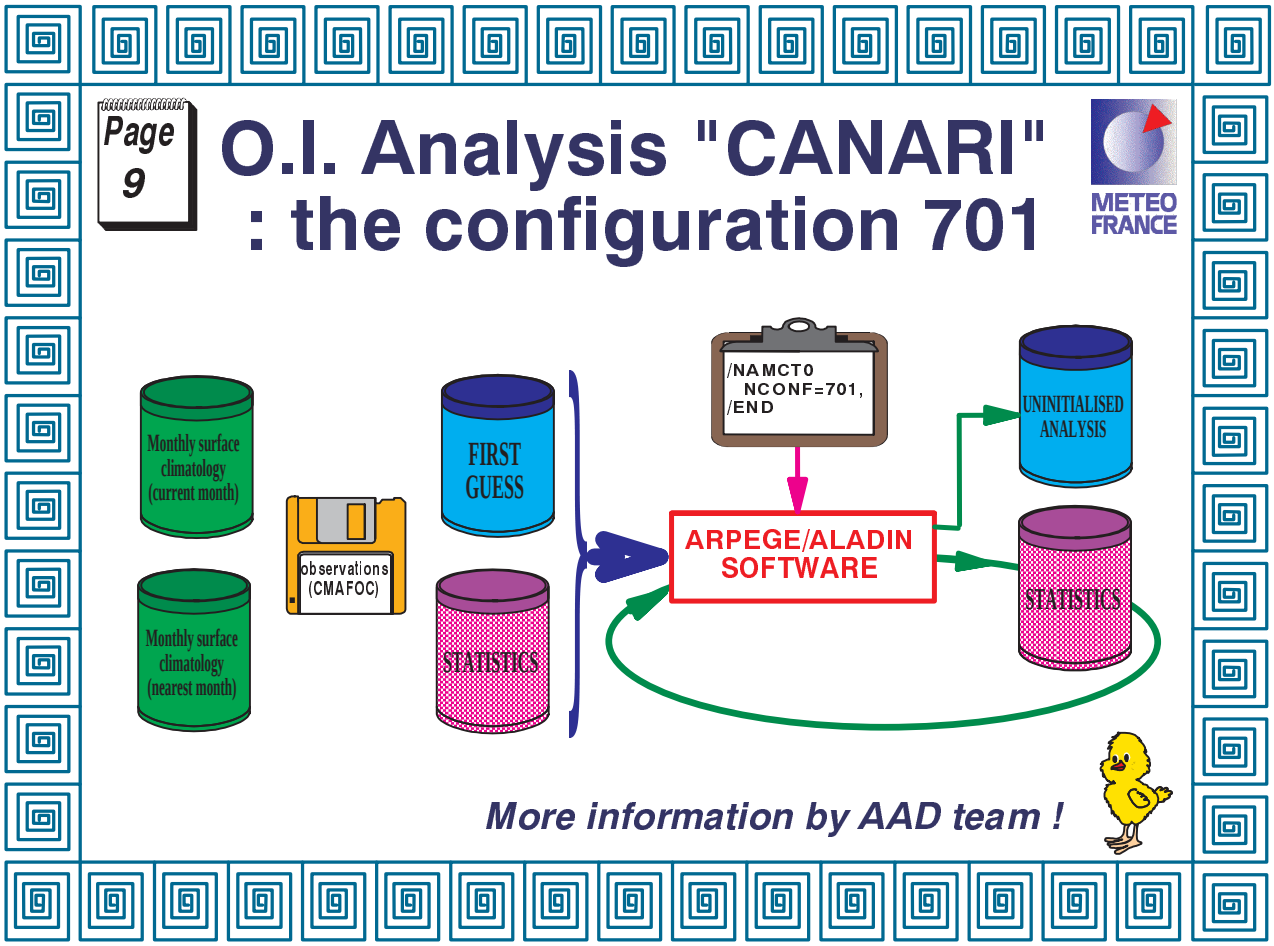
The configuration 901 is used when you want to run Arpege from ECMWF data.
For that you should retrieve data from MARS archive system. The input data will be a set of 3 GRIB files containing respectively :

Gridpoint surface fields (like land-sea mask)
Spectral upper air fields & surface pressure & spectral orography
Gridpoint upper air fields (like humidity)

You will also need climatology data (out of a configuration 923) to complete data with "ISBA" surface data

The output will be a file Arpege of the same geometry as in the GRIB input files.

If you want to change this geometry, you should run the post-processing (Fullpos, as configuration 927)



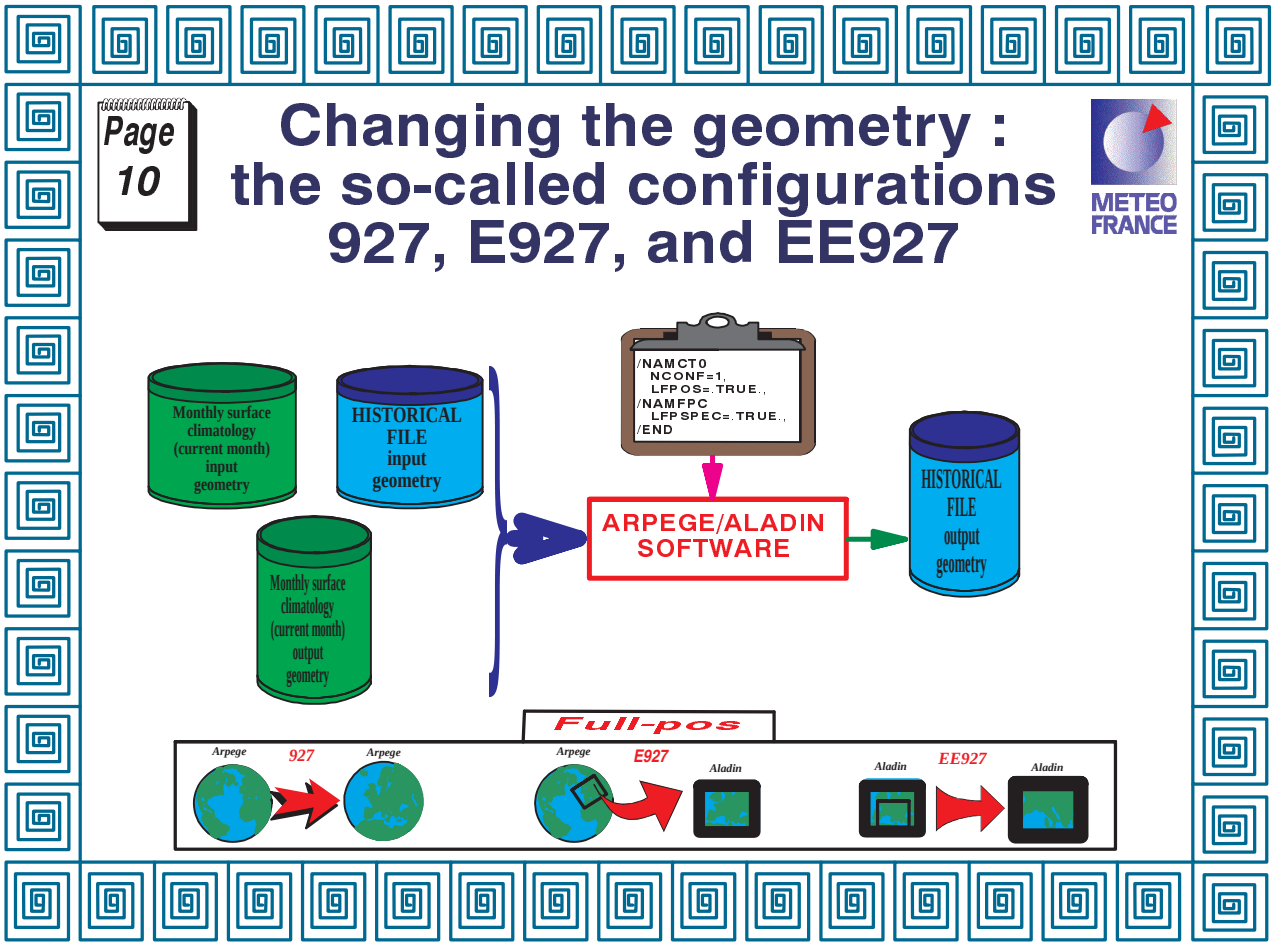
Optimal Interpolation analysis is nicknamed "CANARI".
To run it, you need several input data :

* monthly surface climatology of the current month and the nearest month, as 2 files Arpege/Aladin, made by the configuration 923 (Arpege) or E923 (Aladin)
* observation files, named "CMAFOC"
* the "first guess", as a historical file Arpege/Aladin (usually, it is the 6-hours previous forecast)
  statistics data ; if this data does not exist, it will be generated by the program itself, and this data could be re-used afterward.

In output, you will get an un-initialized analysis as a file Arpege/Aladin.

Note that the configuration 701 is still used in operations beacause there is not yet any variational tool to analyse the surface fields.

Refer to ADD team for more information !



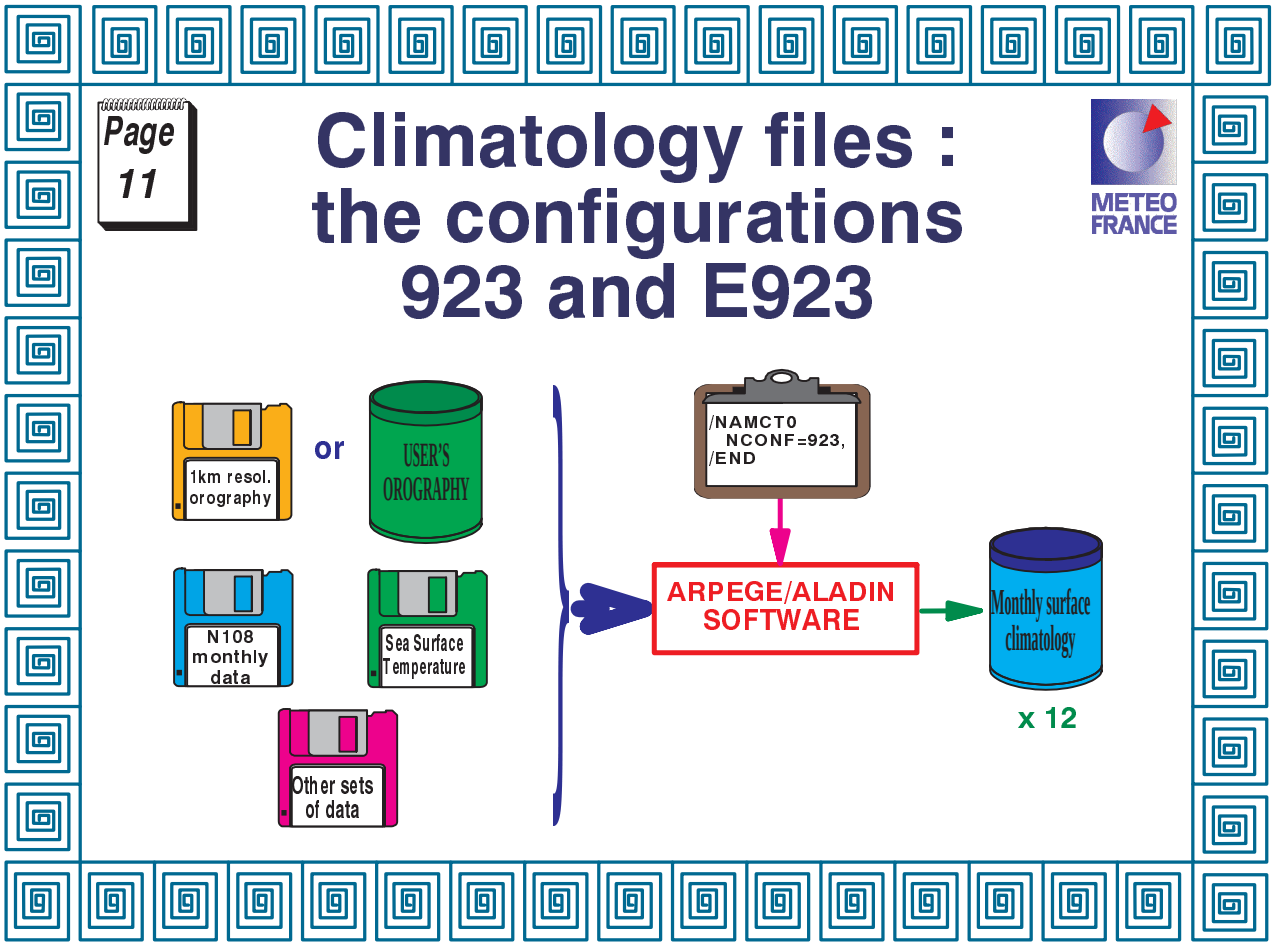
To change the geometry of your input file, you should use the family of the so-called configuration 927 :

configuration 927 is to transform a file Arpege to a file Arpege,
configuration E927 is to transform a file Arpege to a file Aladin,
configuration EE927 is to transform a file Aladin to a file Aladin

This so-called configurations are actually active inside the configuration 1 (3D primitive equations model) and consist in a particular configuration of the post-processing namelists (ref. : Fullpos)

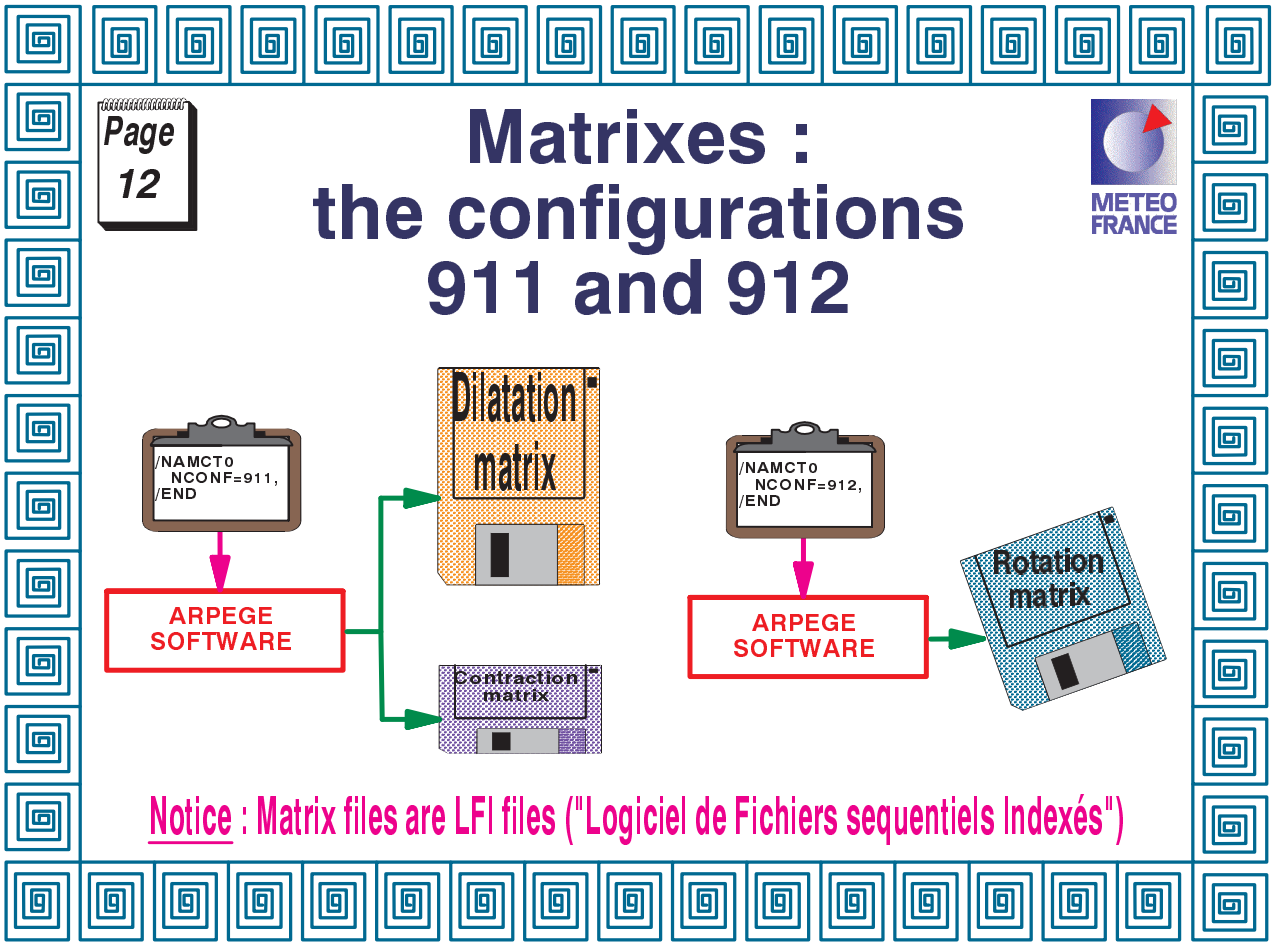
In input, you will generally need two climatology files (generated by the configuration 923 or E923) :

monthly surface climatology in the geometry of the source file
monthly surface climatology in the geometry of the target file



The configuration 923 and E923 are used to create monthly climatology fields, respectively for Arpege and Aladin.
The output is a set of 12 files (1 per month) Arpege or Aladin.
The input is a set of various data, coming from various databases or from the user itself.

Actually, to get all the needed fields for each month, you have to run 6 times this configuration (with a tiny modification in the namelist)



Making matrixes, you do not need any data in input but the namelist.
The same configuration 911 creates the contraction and dilatation matrixes as two files in "LFI" format ("Logiciel de fichiers séquentiels indexés"), while a special configuration 912 creates the rotation matrix.
Note that the configuration 912 is less and less used, since the Digital Filter Initialization is currently replacing the Normal Modes Initialization in rotated mode.

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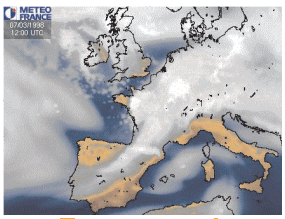
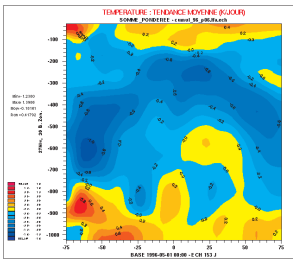
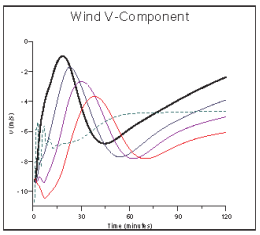
Available output data



Forecasted satellite pictures

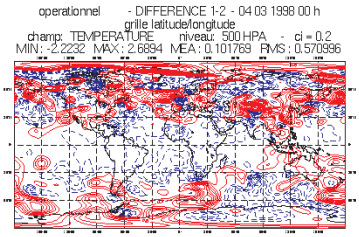


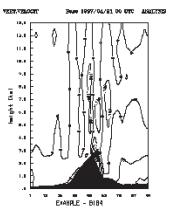
Diagnostics on horizontal domains 'DDH'



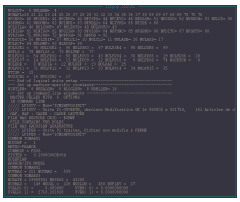
Punctual evolution diagnostics 'EVOL'

Restart files

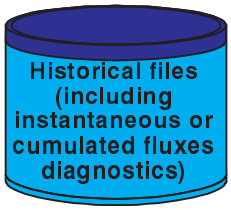




Post-processing files 'FULLPOS'



Listing



'ICMSH' file

You can work on various output data :

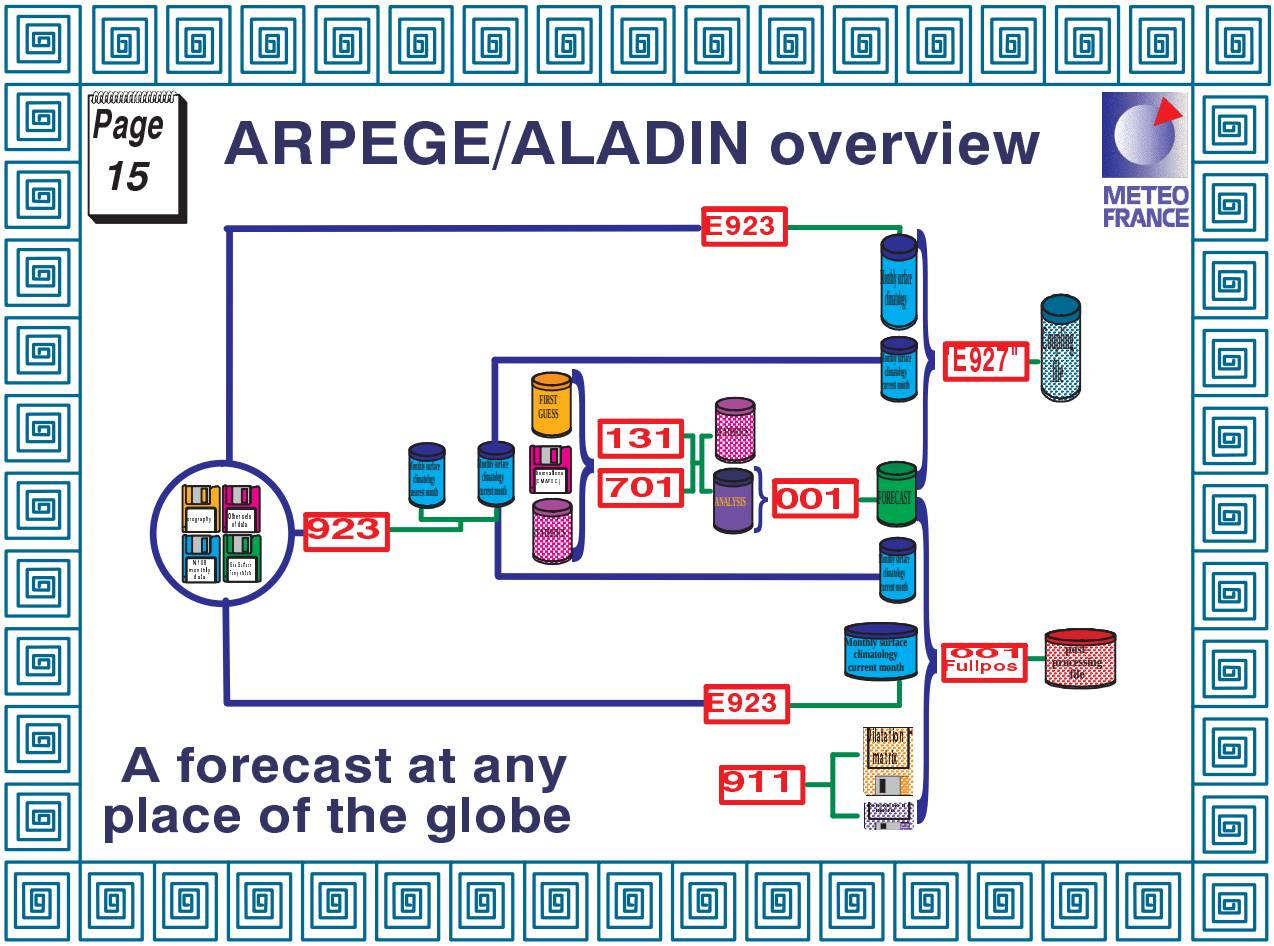
* The very first one is the listing ! It is very informative to do debugging or validations. Do not neglect it !!
* More ordinary outputs are the post-processing files (out of "Fullpos" package) which enable to plot horizontal fields or cross sections
* The "DDH" (Diagnostics par Domaines Horizontaux) enable to control the behaviour of the model after averaging the data on a horizontal domains. This is intensively used for physics studies.
* Punctual diagnostics enable to study the evolution at a single model point during the time integration
* Forecasted satellite pictures is not used for studies but for the media.
* Restart files should not be read !!! They contain a copy of the memory buffers in order to restart the model from the last restart point in case of hardware crash in operations.
* Last but not least : the historical files contains all data produced by the model in their native form : spectral coefficients for dynamic fields, gridpoints (on the possibly reduced and rotated sphere if model is Arpege) for surface fields and fluxes.

... What else ?

```
   1 : 3-D PRIMITIVE EQUATION MODEL

 101 : 4-D VAR WITH 3-D P.E. MODEL
 111 : 4-D VAR WITH 3-D P.E. TANGENT-LINEAR MODEL
 121 : 4-D VAR WITH SHALLOW-WATER MODEL
 122 : 4-D VAR WITH VORTICITY EQUATION MODEL
 123 : 4-D VAR WITH LINEAR GRAVITY WAVE MODEL
 131 : INCREMENTAL 4-D VAR
 151 : 3-D VAR

 201 : SHALLOW-WATER MODEL
 202 : VORTICITY EQUATION MODEL
 203 : LINEAR GRAVITY WAVE MODEL

 301 : KALMAN FILTER WITH 3-D P.E. MODEL
 321 : KALMAN FILTER WITH SHALLOW-WATER MODEL
 322 : KALMAN FILTER WITH VORTICITY EQUATION MODEL
 323 : KALMAN FILTER WITH LINEAR GRAVITY WAVE MODEL
 351 : LOCAL PREDICTABILITY WITH 3-D P.E. MODEL
 371 : LOCAL PREDICTABILITY WITH SHALLOW-WATER MODEL
 372 : LOCAL PREDICTABILITY WITH VORTICITY EQUATION MODEL
 373 : LOCAL PREDICTABILITY WITH LINEAR GRAVITY WAVE MODEL

 401 : TEST OF ADJOINT WITH 3-D P.E. MODEL
 421 : TEST OF ADJOINT WITH SHALLOW-WATER MODEL
 422 : TEST OF ADJOINT WITH VORTICITY EQUATION MODEL
 423 : TEST OF ADJOINT WITH LINEAR GRAVITY WAVE MODEL

 501 : TEST OF TANGENT LINEAR WITH 3-D P.E. MODEL
 521 : TEST OF TANGENT LINEAR WITH SHALLOW-WATER MODEL
 522 : TEST OF TANGENT LINEAR WITH VORTICITY EQUATION MODEL
 523 : TEST OF TANGENT LINEAR WITH LINEAR GRAVITY WAVE MODEL

 6xx : EIGENVALUE/VECTOR SOLVER (currently 601,621,622,623).

 701 : OPTIMAL INTERPOLATION WITH *CANARI*

 801 : SENSITIVITY WITH 3-D P.E. MODEL
 821 : SENSITIVITY WITH SHALLOW-WATER MODEL

 9xx : SET UP INITIAL CONDITIONS (CPREP1, currently 901,902,921,922).
 911 : INITIALISATION OF DILATATION MATRIXES FOR SPECTRAL TRANSFORMATIONS.
 912 : INITIALISATION OF ROTATION MATRIXES FOR SPECTRAL TRANSFORMATIONS.
 923 : INITIALISATION OF CLIMATICAL FIELDS
 926 : CHANGE OF GEOMETRY
 927 : CHANGE OF GEOMETRY USING FULL-POS.
 951 : DIFFERENCE BETWEEN 2 MODEL STATES (CPREP2)
 952 : COMPUTE WIND AND GRIDPOINT FIELDS (CPREP3)
 953 : COMPUTE GRIDPOINT GRADIENT FIELDS (CPREPAD)
```


The main configurations have been described. But there are more of them !
Without giving too much details, let us just say that :

* configurations 1** deal with variational analysis
* configurations 2** deal with the shallow water model
* configurations 3** deal with kalman filter
* configurations 4** control the validity of the adjoint of the model
* configurations 5** control the validity of the tangeant linear model
* configurations 6** deal with singular vectors
* configurations 8** deal with sensitivity model
* configurations 9** deal with the preparation of initial conditions or diagnostics.



To close this presentation, here is a simplified overview of what should be done to run a forecast at any place of the globe with Arpege, and preparing data to run Aladin.

As you can see, the operation is conplex and involved several configurations of the same software Arpege/Aladin.