VAREPS: technical description

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1 The new VAREPS: brief description

The rationale behind new Variable Resolution Ensemble Prediction System (VAREPS) is that during a numerical integration high-wave-number (i.e. small horizontal scales) are kept within a forecast range, in which the increased resolution has shown a positive impact on the forecast quality, and resolution is reduced when its impact is found to be smaller.

Technically, this can be achieved by running the first *leg* (leg-1) of the forecast with a higher resolution than the second *leg* (leg-2), e.g. spectral truncation T_L399 up to forecast day 10 and then T_L255 up to forecast day 15, thus using relatively more computing resources in the early forecast range than in the long forecast range. The computing resources ‘saved’ by reducing the horizontal resolution in the second half of the forecast range can be used not only to increase the resolution in the first half, but also to extend the ensemble forecast range. This approach to ensemble prediction is not new, since it has been used at the National Centers for Environmental Prediction (NCEP, Washington) since inception of their ensemble prediction system.

1.1 Planned operational configuration (under testing)

Each run of the current EPS (operational since 1 February 2006) includes 50 perturbed and 1 unperturbed (the ‘control’) 10-day forecasts run with a T_L399L62 resolution. This system will be upgraded to a 15-day VAREPS in Q2-2006.

Each run of the VAREPS configuration under operational testing will include 50 perturbed and 1 unperturbed 15-day forecasts run with a day-10 horizontal truncation (i.e. with 2 legs):

- **leg-1**: T_L399L62, from day 0 to day 10
- **leg-2**: T_L255L62, from day 9 to day 15

Between leg-1 and leg-2 there is a 24-hour overlap period: this has been introduced to reduce the impact on the forecast fields (especially on surface weather variables such as precipitation) of the horizontal truncation. It is worth mentioning that to further reduce the impact of the truncation the last steps of each leg can be run with an increasing horizontal diffusion: this allows to further reduce the impact of the resolution truncation.

Technically, once the ensemble initial conditions have been generated in the inigroup family, each single integration (families cf and pf) uses 5 key tasks:

- **getinileg** (to copy initial condition files, generated by task pert_ic, in the right work directory)
- **modelA** (to integrate from day 0 to day 10 at leg-1 resolution)
- **getvarepsdataB** (to retrieve leg-1 forecast fields)
- **intHtoL** (to generate leg-2 initial condition files, by interpolating the leg-1 forecast fields to the leg-2 resolution)
- **modelB** (to integrate from day 9 to day 15 at leg-2 resolution)

Scripts have been coded so that the old EPS can be run as a 1-leg VAREPS.

1.2 Initial condition and accumulated-field files for leg > 1

Consider a 2-leg VAREPS with a 9-day truncation (ie truncation at t+216h) and a 1-day overlap period (ie with a 240 hour forecast length). To start the leg-2 forecasts the following data are required (see Fig. 1):

- ICMSHxxINIT file with t+216h forecasts of upper-air spectral from leg-1
- ICMGGxxINUA file with t+216h forecasts of upper-air grid-point from leg-1
- ICMGGxxINIT file with t+216h forecasts of surface grid-pont from leg-1
- ICVEPxxINIT file with t+240h forecasts of surface accumulated-fields

This last file contains the leg-1 forecast accumulated fields, truncated at the leg-2 resolution: these fields are required to be able to have these fields accumulated from the beginning of the leg-1 forecast. Technically, these fields are read by the leg-2 forecast at the end of the overlap period (ie, in this case, after 24 hours, to re-set the leg-2 accumulated fields). These files are prepared by scripts GETVAREPSDATA.SMS and INTHTOL.SMS (see below).

Similarly, if a 3-leg VAREPS is run, the leg-3 forecasts read leg-2 forecasts of the accumulated fields to re-set them so that they contains variables accumulated from the beginning of the leg-1 forecast.

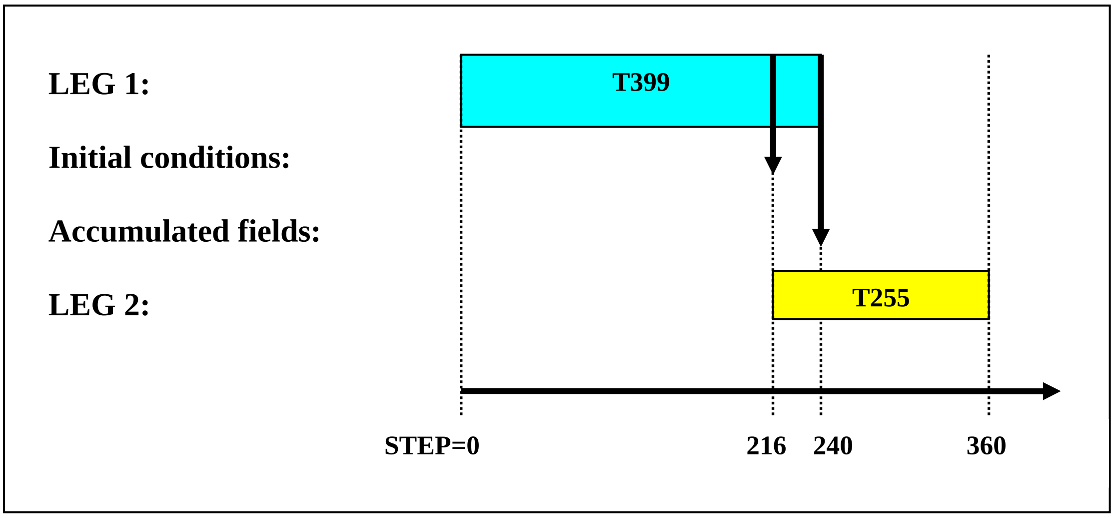

Figure 1. Schematic of the 2-leg VAREPS planned for operational implementation, with initial condition and accumulated-fields files.

1.3 ENFO and EFOV streams

During a VAREPS run with more than 1 leg, forecast data produced in the overlap period are written into a new EFOV stream, while the other forecasts are continuously written in the FDB (see Fig. 2).

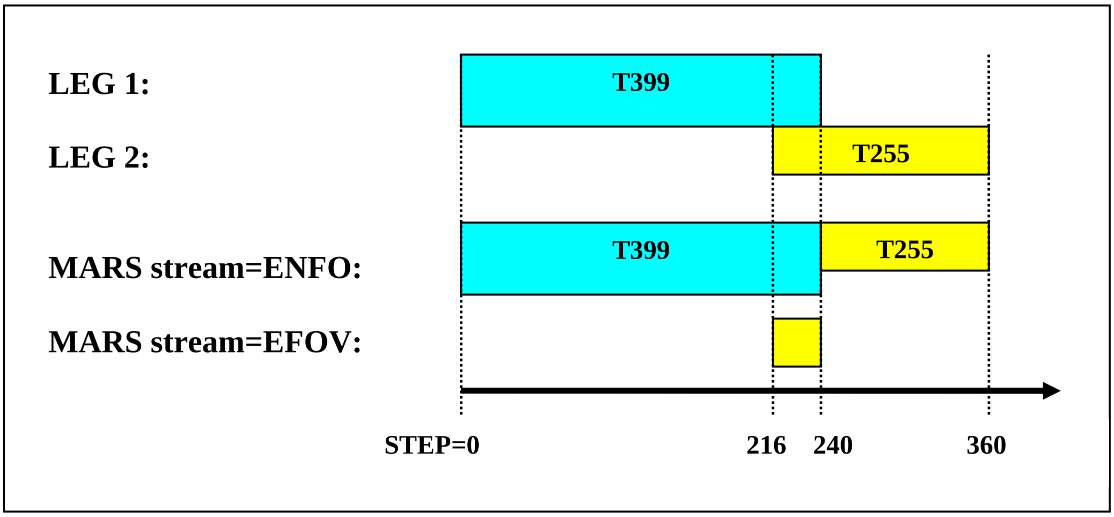

Figure 2. Schematic of the 2-leg VAREPS planned for operational implementation, with MARS data streams ENFO and EFOV.

In this case, for example, for each forecast:

- Stream ENFO contains forecasts from t=0 to t+360h:
  - Leg-1 T399 forecasts at T399 resolution from t=0 to t+240h
  - Leg-2 T255 forecasts at T255 resolution from the first post-processing step after t+240h to t+360h
- Stream EFOV contains forecasts valid for the overlap period:
  - Leg-2 T255 resolution at T255 resolution from t+216 to t+240h
  - Leg-1 T399 t+240h forecasts of the accumulated variables truncated at T255 resolution (ie the fields contained in file ICVEPxxxINIT (table 230)

1.4 Extra calibration/validation control forecasts (type=CV)

Following a request by some member states, two extra control forecasts will be run:

- T399-control (type=CV, NUMBER=1): T_L399L62, from day 0 to day 15
- T255-control (type=CV, NUMBER=2): T_L255L62, from day 0 to day 15

Thus, after the implementation of VAREPS, planned for Q2-2006, 51 VAREPS plus 2 calibration/validation forecasts will be run twice a-day (Fig. 3).

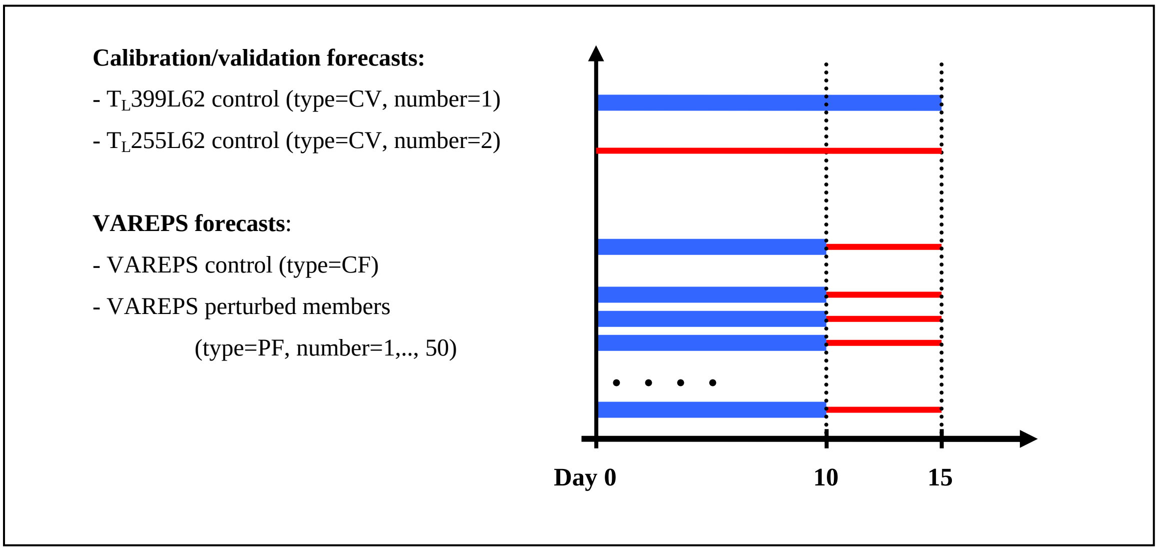

Figure 1. Schematic of VAREPS and calibration/validation forecasts that will be available after the operational implementation of VAREPS, planned for the second half of 2006.

2 Control variables (modules YOMVAREPS and NAMVAREPS)

Subroutine SUVAREPS (Call sequence: CNT0 > SU0YOMB > **SUVAREPS**) set the variables that control a VAREPS integration, after reading namelist NAMVAREPS.. These variables are contained in module YOMVAREPS.

To understand the meaning of the VAREPS control variables, consider the schematic of a 3-LEG system with an overlap period:

```
LEG1:    !--------------------------------!-------------------!
         ^                                ^                   ^
     NFCHO_TRUNC_INI              NFCHO_TRUNC            FCLENGTH
LEG2:                                     !-------------------!------------------------!-------------------!
                                          ^                   ^                        ^                   ^
 in hours ..                      NFCHO_TRUNC_INI       NFCLENGTH_INI            NFCHO_TRUNC          FCLENGTH
LEG3:                                                                                   !-------------------!----------------------!
                                                                                        ^                   ^                      ^
 in hours ..                                                                     NFCHO_TRUNC_INI      NFCLENGTH_INI           FCLENGTH
```

More esplicitly, for a 3-LEG system T399(0-10)+T255(9-15)+T159(14-21) with overlap:

```
LEG1:   !------------------------------!------------------!
        ^                              ^                  ^
        0                             216                240
LEG2:                                  !------------------!------------------------!------------------!
                                       ^                  ^                        ^                  ^
                                  216 (0+216)        240 (0+240)                  120                144
LEG3:                                                                              !------------------!---------------------!
                                                                                   ^                  ^                     ^
                                                                          336 (0+216+120)    360 (0+216+144)               168
```

In this case, the variables that control the initial time, the truncation time and the forecast length are:

LEG1 (0-10d):

- NFCHO_TRUNC_INI = 0
- NFCLENGTH_INI = 0
- NFCHO_TRUNC = 216
- FCLENGTH = 240

LEG2 (9d-15d):

- NFCHO_TRUNC_INI = 216 (=NFCHO_TRUNC_INI(LEG1)+NFCHO_TRUNC(LEG1) =0+216)
- NFCLENGTH_INI = 240 (=NFCHO_TRUNC_INI(LEG1)+FCLENGTH(LEG1) =0+240)
- NFCHO_TRUNC = 120
- FCLENGTH = 144

LEG3 (14d-21d):

- NFCHO_TRUNC_INI = 336 (NFCHO_TRUNC_INI(LEG2)+NFCHO_TRUNC(LEG2) =216+120)
- NFCLENGTH_INI = 360 (NFCHO_TRUNC_INI(LEG2)+FCLENGTH(LEG2) =216+144)
- NFCHO_TRUNC = 168
- FCLENGTH = 168

This is the full list of VAREPS control variables in YOMVAREPS:

- ***LVAREPS***: *.T. when running with variable resolution (controlled by namelist NAMVAREPS)*
- ***L_INC_HDIF***: *.T. to increase horizontal diffusion linearly from the default values of NRES_MA resolution to the default values of NRES_MB resolution (controlled by namelist NAMVAREPS)*

- ***NFCHO_TRUNC_INI****: forecast step used to define the ICs (ie NFCHO_TRUNC of previous VAREPS LEG) (controlled by namelist NAMVAREPS)*
- ***NFCLENGTH_INI****: length of the forecast of the previous VAREPS LEG (controlled by namelist NAMVAREPS)*
- NST_FCLENGTH_INI: NFCLENGTH_INI in number of time steps of current LEG
- ***NFCHO_TRUNC****: forecast hour when resolution is reduced from NRES_MA to NRES_MB (controlled by namelist NAMVAREPS)*
- NST_TRUNC: NFCHO_TRUNC in number of time steps of current LEG
- ***NFCHO_HDIF_TRANS****: number of hours during which hor-diff is increased (controlled by namelist NAMVAREPS)*
- NST_HDIF_TRANS: number of steps during which hor-diff is increased
- NST_HDIF_INI: initial time step when hor-diff is increased
- NAFVAREPSMAX: maximum number of accumulated fields to be re-set if VAREPS LEG gt 1
- NAFVAREPS: number of accumulated fields to be re-set if VAREPS LEG gt 1
- NAFVAREPSGC: grid codes of accumulated fields to be re-set
- NRES_MA: spectral truncation of first part of integration (model_A)
- NRES_MB: spectral truncation of second part of integration (model_B)
- ***HDIRVOR_MA****: initial hor diff model_A (controlled by namelist NAMVAREPS)*
- ***HDIRDIV_MA****: initial hor diff model_A (controlled by namelist NAMVAREPS)*
- ***HDIRT_MA****: initial hor diff model_A (controlled by namelist NAMVAREPS)*
- ***HDIRQ_MA****: initial hor diff model_A (controlled by namelist NAMVAREPS)*
- ***HDIRVOR_MB****: final hor diff model_B to which hdif-model_A tend to*
- ***HDIRDIV_MB****: final hor diff model_B to which hdif-model_A tend to (controlled by namelist NAMVAREPS)*
- ***HDIRT_MB****: final hor diff model_B to which hdif-model_A tend to (controlled by namelist NAMVAREPS)*
- ***HDIRQ_MB****: final hor diff model_B to which hdif-model_A tend to (controlled by namelist NAMVAREPS)*

3 Special changes for the wave model

Because of the lack of variability at high wave numbers, it is not necessary to match the horizontal resolution of the wave model with that of the atmospheric model. However it is known that increasing the wave model spectral resolution can be beneficial. For this reason, the T_L399 model is run with the wave model at 1 degree resolution as was the case before February 2006, but with an increased number of frequencies and directions, 30 and 24 respectively. For lower resolution legs, the number of frequencies and directions revert back to 25 and 12 and the horizontal resolution is kept at 1 degree. Note that technically both horizontal and spectral resolution can change for each leg.

In order to restart the wave model in the next leg, it is necessary to output the wind and the drag coefficient of the wave model but also the wave spectrum at each grid point. Wind and drag coefficient are standard output parameters of the wave model and are produced at all post processing time steps. Wave spectra are normally not output in the EPS runs as they constitute as large volume of data that is currently not disseminated. The necessary changes were made to insure that the wave spectra are written out at the beginning of the overlap period.

Due to the complexity of how the different legs overlap, it was decided to use the common part of GRIB header KSEC1 as passed to the wave model from the IFS when encoding the wave data. This is controlled by the wave model namelist variable LGRHDIFS=T. For all other configurations, we are not yet using that option even though it should work as well. Passing GRIB header information via the coupling interface has the advantage that no extra work is necessary in modifying the wave model namelists to input this information. Note however that the IFS and the wave model still do not share stream name.

3.1 WAEF and WEOV streams

The new overlap stream for wave data is WEOV. The correspondence between IFS and wave model streams is kept at script level in wave_find_stream and at code level in wstream_strg. Changes were made however to allow for both to have the same stream and to redefine the wave data with respect to a new wave level type. It is controlled by the namelist variable LNEWLVTP=T (see wam_input) but it is not used yet.

Archiving of the necessary fields was adapted accordingly, including the wave spectra at each overlaps.

The routine writing wave data to the FDB (fld2fdb) had to be adapted for the different new stream and type.

4 SMS structure

It is worth mentioning that the RD and the OD SMS structures are slightly different (Fig. 4), but they use the same scripts.

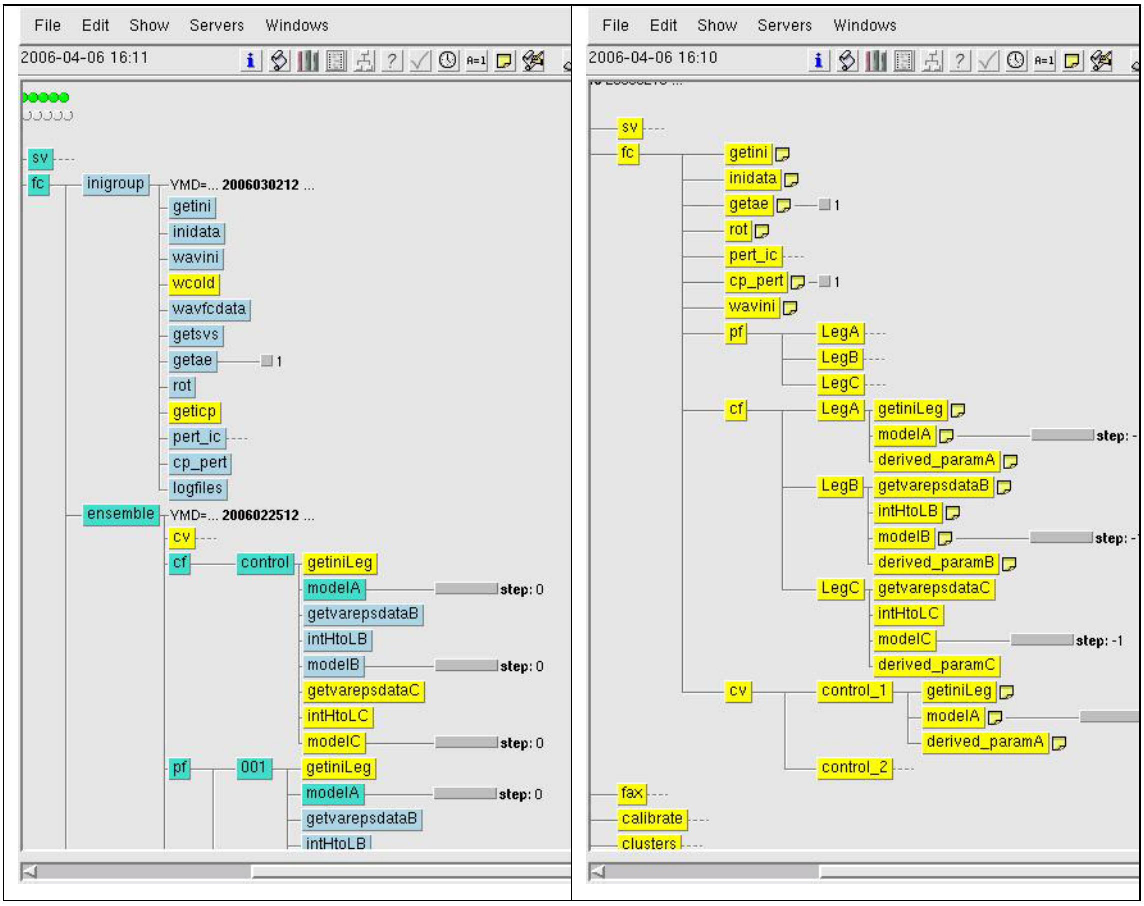

Figure 4. RD (left) and OD (right) SMS structures.

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