

Computation of accumulated fields in VAREPS

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On 1 February 2006, the EPS resolution was increased to T399L62, with T42L62 singular vectors. The EPS wave model spectral resolution was increased to 30 frequencies and 24 directions respectively without any change to its horizontal resolution. This change is the first of a three-phase upgrading process that will lead to the implementation of the ECMWF Variable Resolution Ensemble Prediction System (VAREPS):

- ◆ *Phase 1 (February 2006)*: resolution increase of the 10-day EPS from T255L40 to T399L62.
- ◆ *Phase 2 (planned for the second half of 2006)*: extension of the forecast range to 15 days using the VAREPS system, with T399L62(d0-10) and T255L62(d10-15).
- ◆ *Phase 3 (planned for 2007)*: weekly extension of VAREPS to one month, with a T255L62 atmospheric resolution and ocean coupling introduced at day 10 (the precise configuration of this final stage of VAREPS is still to be finalized).

The resolution upgrade and the VAREPS system are described in detail in the Summer 2006 issue of the ECMWF Newsletter, available from the ECMWF website:

<http://www.ecmwf.int/publications/newsletters/>

This note describes the technical details of how to compute accumulated fields across the truncation step.

Key VAREPS technical characteristics

Technically, each VAREPS member will be generated by a two-leg forecast:

- ◆ *leg-1*: T399L62, from day 0 to day 10
- ◆ *leg-2*: T255L62, from day 9 to day 15

The horizontal resolution of the wave model stays unchanged (~110 km), however *leg-1* is now run with the same spectral resolution as the deterministic forecast (30 frequencies and 24 directions). The second leg reverts to 25 frequencies and 12 directions.

Leg-2 initial conditions – Each *leg-2* forecast starts from a *leg-1* day-9 forecast, interpolated to the T255L62 resolution (in other words, the *leg-2* initial state is defined by a truncated *leg-1* forecast instead of analysis fields for all the state-vector variables). The 24-hour overlap period has been introduced to

reduce the impact on the fields that are more sensitive to the truncation from high to low resolution (e.g. convective and large scale precipitation). High-resolution wave spectra are smoothed to the lower spectral resolution of the second leg.

Accumulated fields – Accumulated fields are accumulated from the start of the *leg-1* forecast. In the *leg-2* forecast, to accumulate from the start of *leg-1*, once the *leg-2* forecast reaches the end of the overlap period (24-hour, i.e. day-10 if counted from the beginning of the *leg-1* forecast), the accumulated fields are overwritten by the *leg-1* 10-day forecast fields interpolated onto the T255 reduced Gaussian grid.

FDB and MARS streams ENFO and EFOV – In the Field Data Base (FDB) and the Meteorological Archival and Retrieval System (MARS), *leg-1* forecasts from day 0 to day 10, and *leg-2* forecasts from day 10 to day 15 are written in the MARS stream ENFO (Ensemble Forecast stream), while *leg-2* forecasts from day 9 to day 10 are written in the new MARS stream EFOV (Ensemble Forecast OVERalp stream). The *leg-1* day-10 forecast fields interpolated onto the T255 reduced Gaussian grid are archived in the EFOV overlap stream, so that they can be retrieved if needed (e.g. to correctly compute accumulated fields across the truncation forecast step, see below). Similarly, ensemble wave fields are written in, respectively, streams WAEF and WEOV.

This set-up ensures that only users interested in using VAREPS forecasts for accumulated fields after forecast day 10 need to take care when constructing fields accumulated between two forecast steps that include the truncation step.

Computation of accumulated fields across the truncation forecast step

Let us introduce the following variables:

- ◆ t : forecast step ($0 \leq t \leq 360$ h)
- ◆ $AF(t)$: the accumulated field (accumulated from the start of the forecast) in the FDB/MARS stream ENFO
- ◆ $INTERP_{255}[AF(t)]$: the interpolation of $AF(t)$ on the T255 reduced Gaussian grid
- ◆ $INTERP_{UG}[AF(t)]$: the interpolation of $AF(t)$ on the user's grid
- ◆ $AF_{255}(t)$: the $AF(t)$ field interpolated on the T255 reduced Gaussian grid:

$$AF_{255}(t) = INTERP_{255}[AF(t)]$$
- ◆ $AF_{UG}(t)$: the $AF(t)$ field interpolated on the user's grid (e.g. the T255 reduced Gaussian grid, or a regular lat/long grid): $AF_{UG}(t) = INTERP_{UG}[AF(t)]$

- ◆ $AFvar(t_{TR})$: the *leg-1* accumulated field interpolated on the T255 Gaussian grid retrieved from *stream = EFOV*
- ◆ $AF_{UG}(t_1, t_2)$: the field accumulated between forecast steps t_1 and t_2 on the user's grid

Let us compute $AF_{UG}(t_1, t_2)$ for all forecast intervals (t_1, t_2) .

If the forecast interval (t_1, t_2) includes the truncation step t_{TR} , $t_1 \leq t_{TR} \leq t_2$ and the user's grid is different from the T255 reduced Gaussian grid, the fields archived in the overlap stream should be used to compute correctly $AF_{UG}(t_1, t_2)$, as discussed below. This procedure is necessary because the *leg-2* day-10 forecasts (i.e. after 24-hour integration) of the accumulated fields are re-set to be equal to the T399L62 ones interpolated onto the T255 reduced Gaussian grid.

Computation of accumulated fields on any grid using data in the overlap stream EFOV

The correct way to compute accumulated fields in the forecast interval (t_1, t_2) is to retrieve fields $AF(t)$ from stream ENFO and $AFvar(t_{TR})$ from stream EFOV on the user's grid, and then compute $AF_{UG}(t_1, t_2)$ as follows:

- | | |
|--|--|
| <p>(a) If $t_1 < t_2 \leq t_{TR}$:</p> $AF_{UG}(t_1, t_2) = INTERP_{UG}[AF(t_2)] - INTERP_{UG}[AF(t_1)]$ | |
| <p>(b) If $t_1 < t_{TR} < t_2$:</p> $AF_{UG}(t_1, t_2) = \{INTERP_{UG}[AF(t_2)] - INTERP_{UG}[AFvar(t_{TR})]\} \\ + \{INTERP_{UG}[AF(t_{TR})] - INTERP_{UG}[AF(t_1)]\}$ | |
| <p>(c) If $t_{TR} = t_1 < t_2$:</p> $AF_{UG}(t_1, t_2) = INTERP_{UG}[AF(t_2)] - INTERP_{UG}[AFvar(t_{TR})]$ | |
| <p>(d) If $t_{TR} < t_1 < t_2$:</p> $AF_{UG}(t_1, t_2) = INTERP_{UG}[AF(t_2)] - INTERP_{UG}[AF(t_1)]$ | |

Since in (b) and (c) the fields read in *leg-2* to re-set the accumulated fields are explicitly used, this method guarantees that correct accumulated fields are computed.

Computation of accumulated fields on T255 reduced Gaussian grid

Suppose that a user wants the VAREPS accumulated fields $AF(t)$ on the T255 reduced Gaussian grid. In this case, if the interpolation is done using the same software that was used to generate $AFvar(t_{TR})$ ¹,

$$AF_{UG}(t) = AF_{255}(t) = INTERP_{255}[AF(t)]$$

and for $t = t_{TR}$

$$AF_{UG}(t_{TR}) = AF_{255}(t_{TR}) = INTERP_{255}[AF(t_{TR})] = AFvar(t_{TR})$$

Thus, the field $AFvar(t_{TR})$ would not be required, and for all (t_1, t_2) :

$$AF_{UG}(t_1, t_2) = AF_{255}(t_2) - AF_{255}(t_1) = INTERP_{255}[AF(t_2)] - INTERP_{255}[AF(t_1)]$$

Computation of accumulated fields after interpolation to T255 reduced Gaussian grid

Suppose that someone wants the VAREPS accumulated fields on a grid that is different from the T255 reduced Gaussian grid (e.g. a regular latitude–longitude grid of 1°), but also wants to avoid the extraction of the interpolated $AFvar(t_{TR})$ from the overlap stream. This could be achieved by applying a two-step interpolation procedure.

First, interpolate all fields on the T255 reduced Gaussian grid [i.e. compute $AF_{255}(t)$] using the same interpolation software¹ used to generate the interpolated $AFvar(t_{TR})$. As discussed above, this would guarantee that $AFvar(t_{TR})$ would not be required.

Then, apply a second interpolation procedure to interpolate the $AF_{255}(t)$ fields from the T255 reduced Gaussian grid to the user's grid.

Thus, for all (t_1, t_2) :

$$\begin{aligned} AF_{UG}(t_1, t_2) &= INTERP_{UG}[AF_{255}(t_2)] - INTERP_{UG}[AF_{255}(t_1)] \\ &= INTERP_{UG}[INTERP_{255}[AF(t_2)]] - INTERP_{UG}[INTERP_{255}[AF(t_1)]] \end{aligned}$$

Use of VAREPS forecasts at a single-point location

It is worth stressing the fact that since the two VAREPS legs are run with different resolution, the corresponding forecast fields are generated using a different model which is based, for example, on a different reduced Gaussian grid in physical space, and different land-sea mask and orography. Users should be aware of this, especially when generating a time-series of VAREPS products for a single location that crosses the truncation forecast step (e.g. when generating a time series of a variable, or an EPS-gram), and develop interpolation procedures that take these changes into account.

¹ The interpolation may be different for two reasons: either because the user does not use the interpolation software used by ECMWF to generate $AFvar(t_{TR})$, or because the user uses a different version of the ECMWF interpolation software. If this approach is followed, the user should check that the correct interpolation software is used.