Continuous Data Assimilation for the IFS

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Early Delivery 4D-Var configuration

Since 2004, ECMWF has used an “Early Delivery” configuration of incremental 4D-Var (Haseler, 2004). In this configuration the medium range forecast is provided by an Early Delivery analysis produced with a 6-hour assimilation window and a tight observation cut-off time. Late arriving observations are then assimilated in a 12-hour “delayed cut-off” assimilation window which provides an improved background for the next Early Delivery cycle.

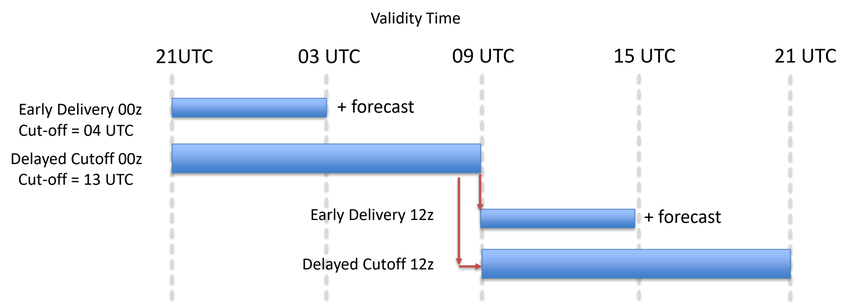

Fig.1. Schematic illustration of the Early Delivery configuration of 4D-Var

Continuous DA configuration

Over the years various continuous data assimilation concepts have been proposed (Jarvinen et al 1996, Pires et al 1996, Gautier et al 2007). These configurations decouple the start time of the assimilation computations from the data cut-off time, i.e. data assimilation can begin before all of the observations have arrived. A variation of this concept is presented here.

There are three main components of the new configuration enabled with Continuous DA:

- recently arrived observations are introduced at each outer loop,
- the assimilation window is extended from 6 hours to 8 hours (so that all available observations can be assimilated)
- the number of outer loop iterations is increased from 3 to 4 (possible due to the later cutoff time).

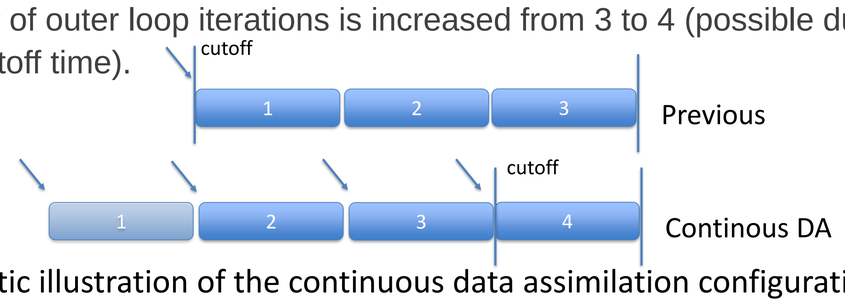

Fig.2. Schematic illustration of the continuous data assimilation configuration. Arrows indicate input observations. Boxes represent outer loops of 4D-Var.

More observations and improved forecasts

Overall around 15% more observations are assimilated in the Early Delivery analysis (e.g. Fig 3). Forecast improvements of around 2% at day 3 are seen for many variables (Fig 4). This corresponds to around 2 hours gain in forecast skill. Fig. 5 shows the contributions from the different components implemented with Continuous DA.

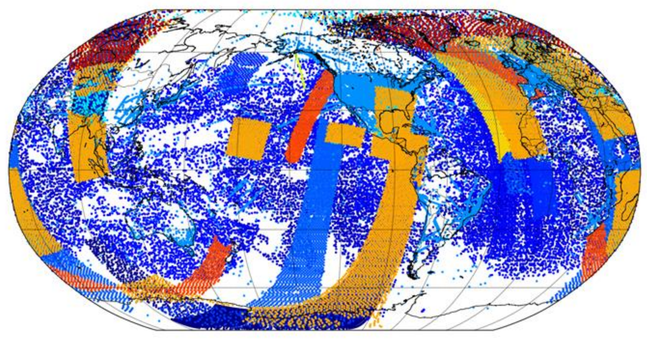

Fig.3. Example of the extra observations assimilated in a single cycle. Different colours represent different observation types.

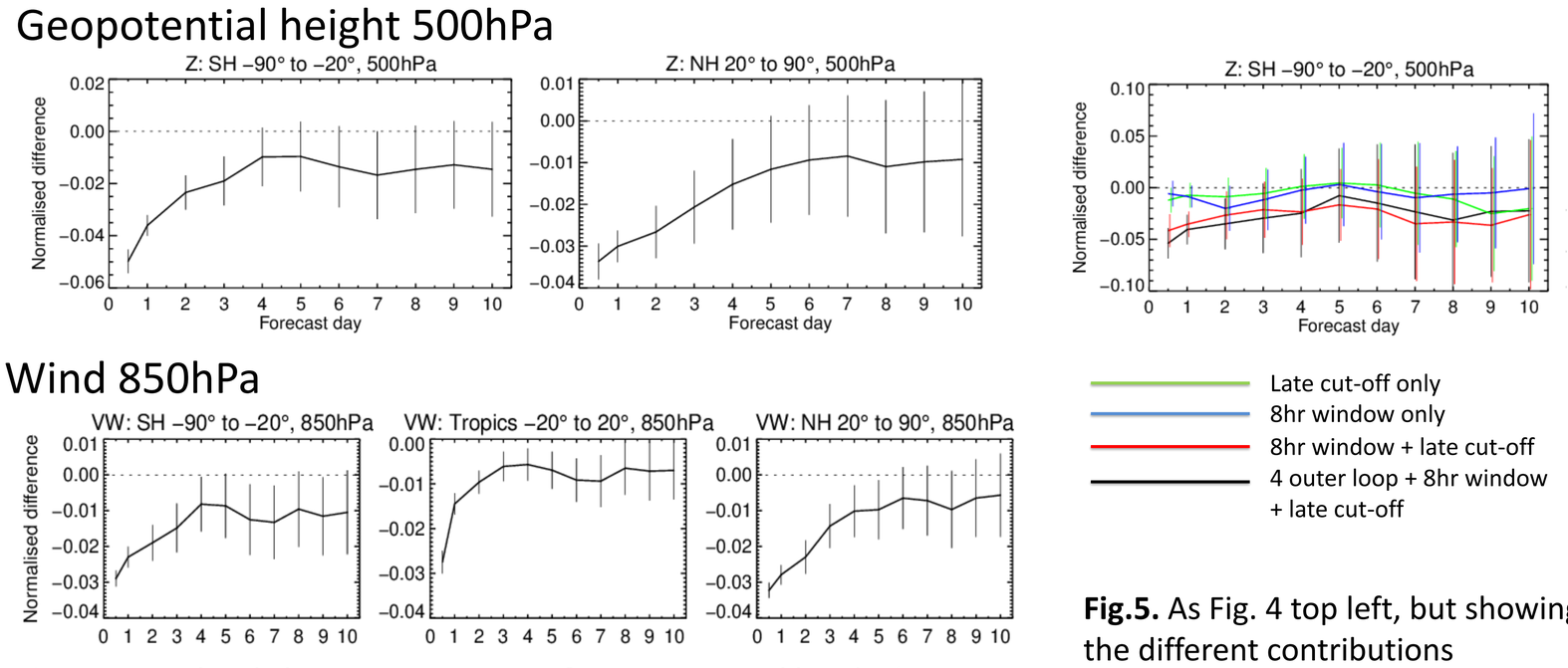

Fig.4. Normalised change in RMS error for geopotential height (upper panel) and vector wind (lower panel) over a 6-month period.

Fig.5. As Fig. 4 top left, but showing the different contributions implemented in Continuous DA, for a shorter period of 26 days.

Observation Timeliness

The majority of the extra observations assimilated are very low latency observations at the end of the assimilation windows. Here, an increasing proportion of data comes from DBNet (Fig. 5).

DBNet and aircraft data have among the lowest timeliness, and these observations hence make up most of the data for the last populated ½ hour of the assimilation window (requiring latency of 25 min or better, Fig. 6). These end-of-window observations are especially valuable for NWP applications. Improving the timeliness of other observations will help improve the coverage at the end of the window.

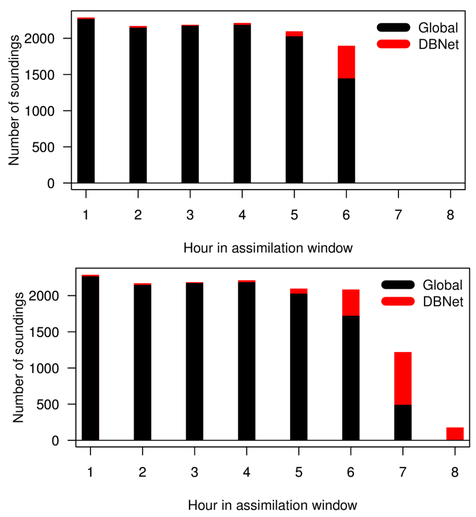

Fig.5. Number of assimilated NOAA-19 AMSU-A soundings in each hour of the early-delivery assimilation window for the control (top) and Continuous DA (bottom).

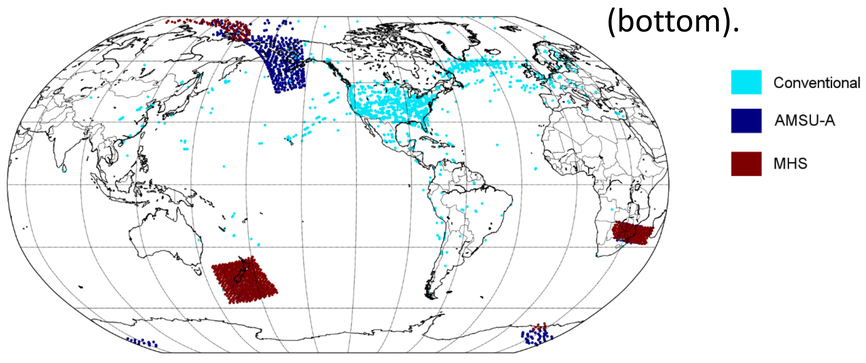

Fig.6. Example of assimilated observations made between 04:00 and 04:25UTC with a data cut-off time of 04:25UTC.

Summary

A new continuous data assimilation configuration of 4D-Var has been introduced at ECMWF. It allows around 15% more observations to be assimilated in ECMWF’s Early Delivery analysis. The majority of these observations are valuable end-of-window observations.

The new configuration also allows more complex, but more costly, data assimilation configurations to be accommodated within the operational schedule.

The forecast improvements coming from this upgrade correspond to a gain in forecast skill of around 2 hours.

Continuous data assimilation was implemented into operations in cycle 46r1 on June 11th, 2019.

References

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