Incremental Digital-Filtering Initialization of GME in Vertical Mode Space

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Since October 4, 1999 an incremental digital filtering initialization (IDFI, Lynch, 1997) is applied during the data assimilation of the operational icosahedral-hexagonal grid point model GME (Majewski et al., 2002). The IDFI should only work on the analysis increments, thus the balanced first guess of the model should not be altered at all but IDFI should modify the analysed fields only in those regions where observations have disrupted this balance.

The IDFI consists of the following three steps

- A DFI (Digital Filtering Initialization) is performed on the 6-hour first guess fields → $(FG)_{DFI}$. The DFI consists of a 3-h adiabatic backward integration of GME, followed by a 3-h diabatic forward one.
- A DFI is performed on the analysed fields → $(ANA)_{DFI} = (FG)_{DFI} + (INCR)_{DFI}$, where INCR is the analysis increment. In regions without any observations the analysis increment vanishes.
- The incrementally initialized analysis is defined as $(ANA)_{IDFI} = FG + (ANA)_{DFI} - (FG)_{DFI} = FG + (INCR)_{DFI}$.

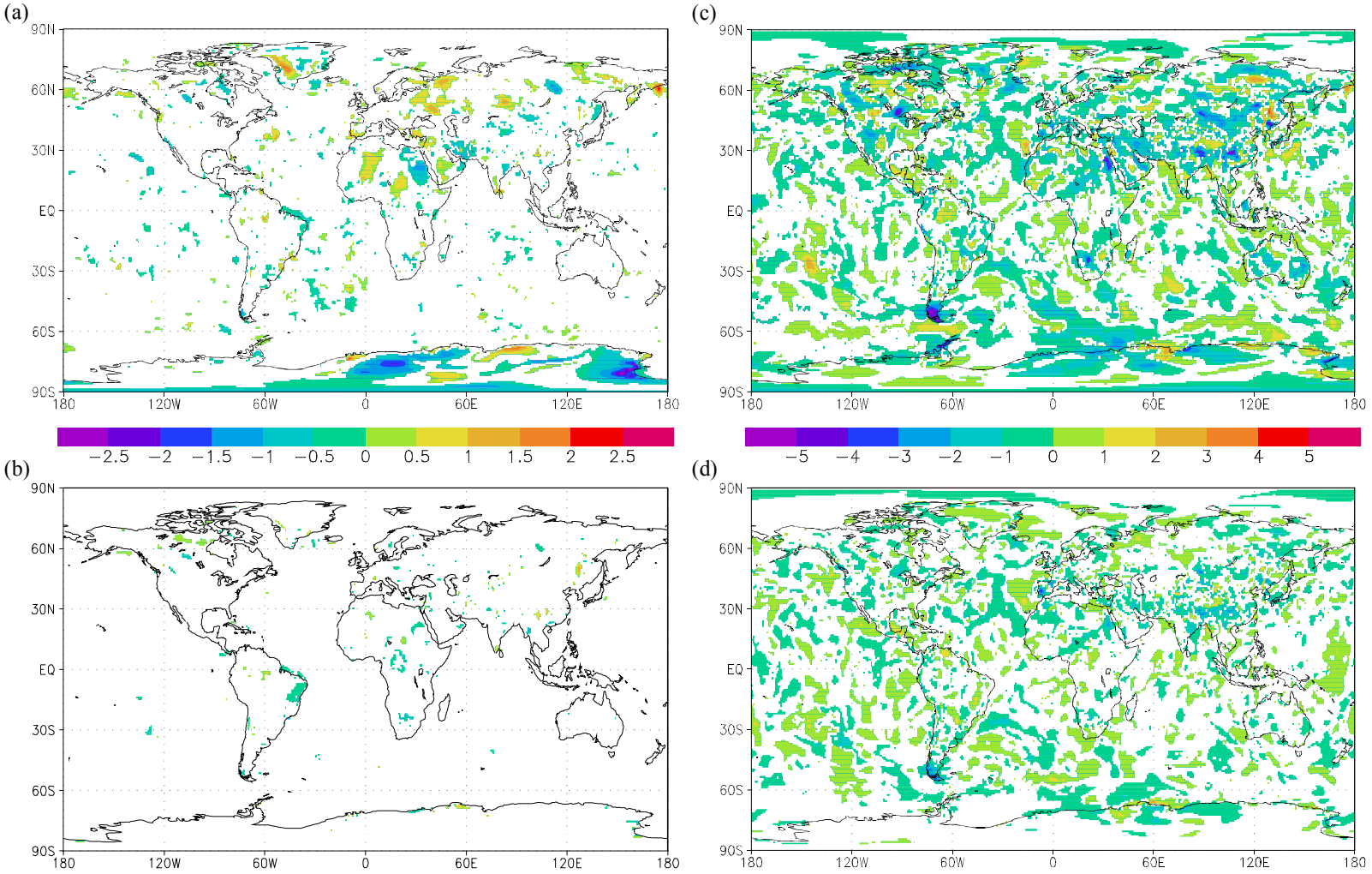
Thus in regions without observations the balanced FG of GME should not be altered.

But even though IDFI is quite effective in removing the initial noise from the forecast, the impact of the initialization on the analysed fields seems to be unreasonably large in some data sparse areas like the oceanic boundary layer or the free atmosphere in convectively unstable situations. The modification of the analysed fields by the IDFI in these regions are mostly due to physical processes like turbulence or convection in the 3-h diabatic forward step of the filtering procedure. If data lead to a modified vertical stability compared to the first guess fields, convective and turbulent processes may be different between the steps $(FG)_{DFI}$ and $(ANA)_{DFI}$. Thus $(INCR)_{DFI} = (ANA)_{DFI} - (FG)_{DFI}$ will not only reflect the changes of the analysis which are necessary to control noise in the forecast but also changes due to the adaptation of the model atmosphere to the modified stratification.

To further restrict the impact of IDFI on the analysed fields to noise control alone, the filtering, i.e. the steps $(ANA)_{DFI}$ and $(FG)_{DFI}$ is performed in vertical mode space. Only the external mode plus the first nine internal ones are filtered, all higher internal modes which represent e.g. boundary layer processes are taken unchanged from the analysed values. Moreover, relative humidity and cloud liquid water are reset to their analysed values, too, to reduce the impact of IDFI on the hydrological cycle. This modified IDFI scheme has the same properties regarding noise control as the original one but the impact on fields like temperature at 850 hPa and low level winds (Fig. 1 a, b, c and d) is smaller. Since June 12, 2001 the IDFI in vertical mode space is used operationally.

Lynch, P., 1997: The Dolph-Chebyshev window: A simple optimal filter. Mon. Wea. Rev., 125, 655-660.

Majewski, D., D. Liermann, P. Prohl, B. Ritter, M. Buchhold, T. Hanisch, G. Paul, W. Wergen and J. Baumgardner, 2002: The operational global icosahedral-hexagonal grid point model GME: Description and high resolution tests. Mon. Wea. Rev., to appear.



Difference between initialized and uninitialized analyses at 12 UTC on 30 April 01.

(a) Temperature (K) 850 hPa, full IDFI.

(b) Same as a), but IDFI in vertical mode space, first 10 modes filtered

(c) Wind speed (m/s) at 1000 hPa, full IDFI.

(d) Same as c), but IDFI in vertical mode space, first 10 modes filtered