# *Summary*

# *Nudging of 2-m Humidity Observations*

*Christoph Schraff, DWD*

**The assimilation of 2-m humidity data caused large amounts of spurious precipitation in some cases during the preoperational phase until October 1999. The worst case was at 9 - 10 September 1999. At that time, these data were spread vertically to several model layers by using a Gaussian vertical correlation function in height differences between the lowest model level and the target model level. The e-folding decay height and hence the vertical extent of strong influence was between 300 m and 400 m. As a result of the problems observed, the influence of the 2-m humidity data was limited to the lowest model level ever since. This cured the problems, e.g. in today's operational version, however at the cost of hardly making use of these observations any more.**

**In order to make better use of 2-m humidity data, they must be allowed to influence several model layers, yet in a selective way. 3 modifications have been implemented and applied together with the original Gaussian vertical radius of influence in an experimental version:**

- **An additional stability-dependent vertical weight.**

  **Reason: If the stability in the model is large then observations at 2 m are not considered representative for the atmospheric state further above.**

- **A quality weight depending on the 2-m temperature observation increment.**

  **Reason: If the thermal structure of the model differs strongly from the true (i.e. observed) one, it may be potentially harmful to adjust only (relative or specific ?) humidity.**

- **Adjustment of the model's 2-m humidity to the observed specific humidity rather than relative humidity (without modifying the assimilation of upper-air observations).**

  **Reason: Specific humidity is a conserved quantity except for turbulent fluxes and processes of phase change. If e.g. after a perfect simulation of the daytime PBL, the 2-m model temperature drops too slowly in the evening due to insufficient vertical resolution or other reasons, then nudging of relative humidity would lead to an adjustment of specific humidity instead of temperature. The correct analysis of relative humidity at 2 m is not considered as important for a realistic initial state of cloudiness as the correct analysis of upper-air relative humidity.**

**In whatever way the influence of 2-m humidity data is enhanced, the minimum requirement is a satisfactory simulation for the 9 - 10 September 1999. Therefore, the impact of the 3 modifications is tested for this case, and the results are positive.**

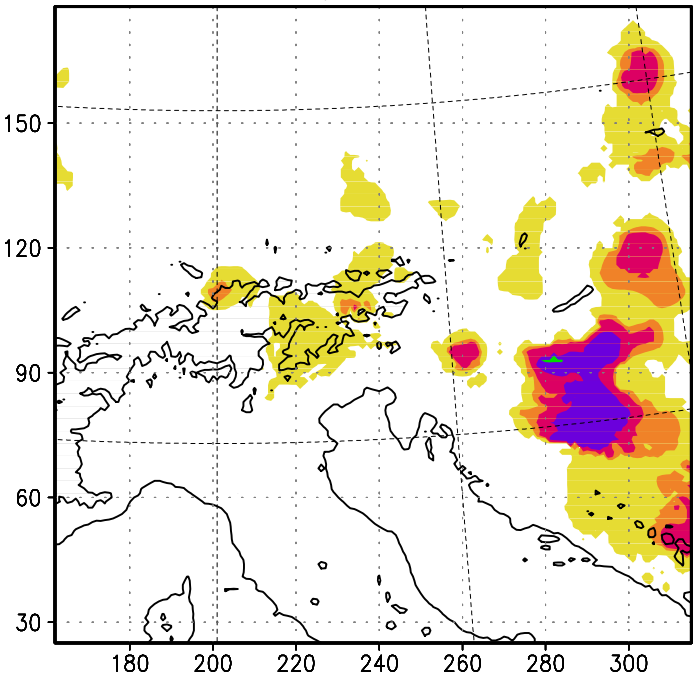
**A clear positive impact has also been found for the prediction of low stratus in a parallel assimilation cycle and forecast experiment for 19 - 23 December 2000 (not shown).**

**Consequence: These ideas and modifications may partly complement the new scheme developed by ARPA-SMR (Davide Cesari, W.P. 1.3) for the use of screen-level observations.**

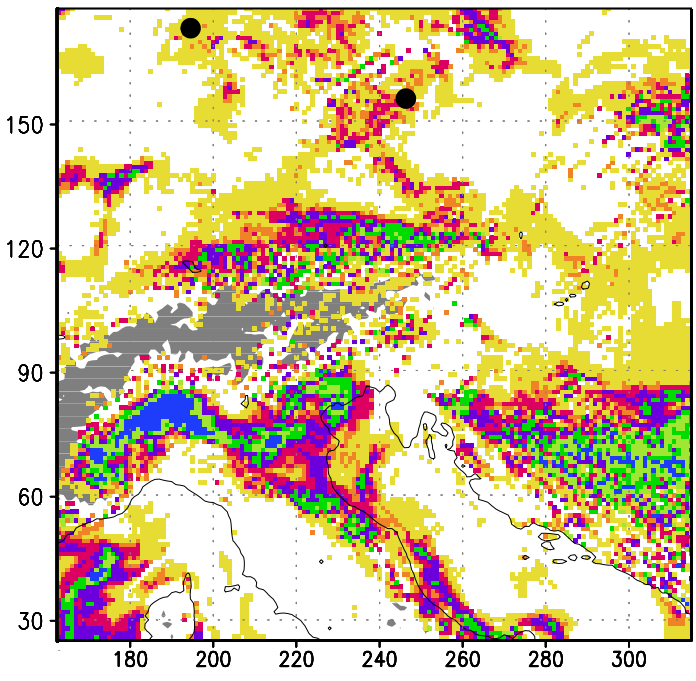
# *24-hour precipitation of LM assimilation cycles*

## *valid for 10 September 1999, 6 UTC*

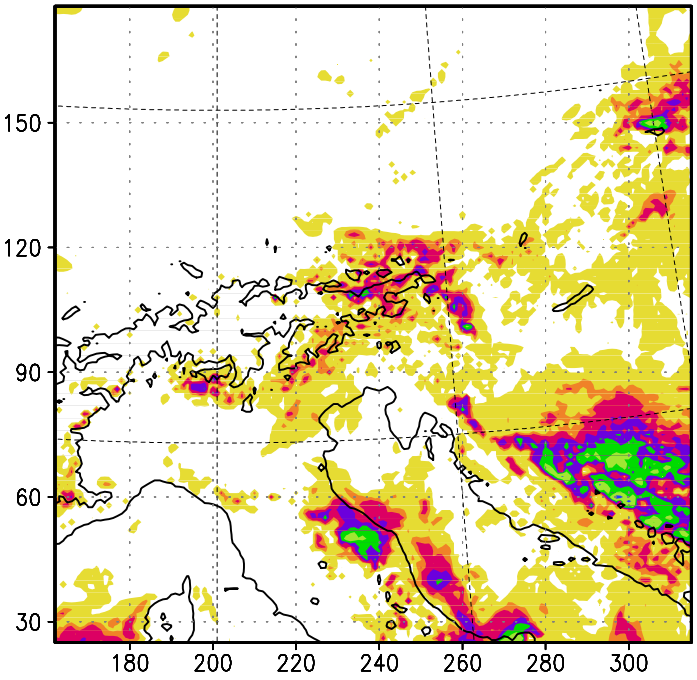
verifying analysis
using SYNOP observations



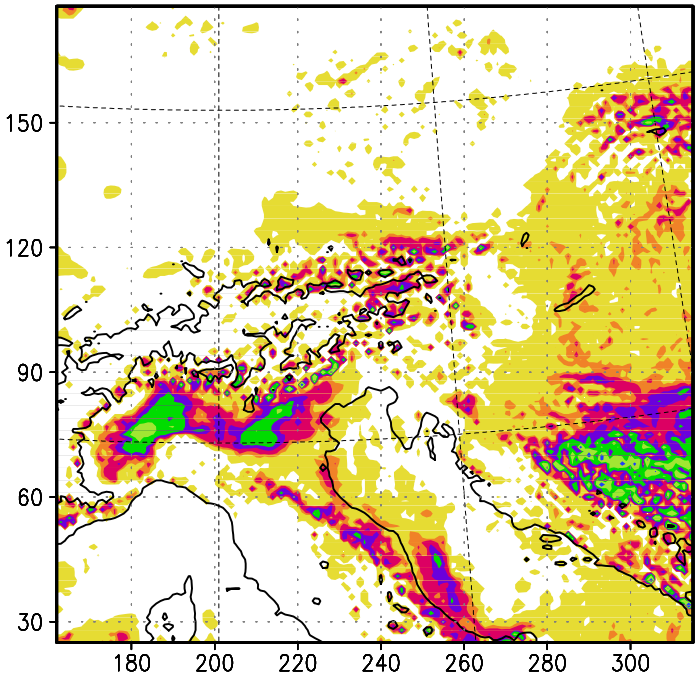

pre-operational version of 09-1999 with
horizontal spreading of $\Delta f_{2m}$

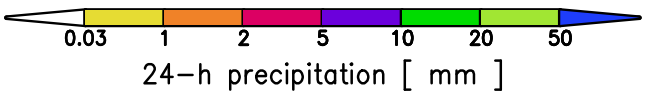



operational version of 05-2002 with
spreading $\Delta f_{2m}$ to lowest model level only




LM version of 03-2001 with TKE,
spreading $\Delta f_{2m}$ vertically & along $\sigma$-levels



# Nudging of 2-m Humidity Observations

## Current Status

- ⋆ **observation increments in terms of relative humidity :** $\Delta f_{2m}$
- ⋆ **spreading confined to lowest model level only, using a non-isotropic lateral correlation function**

## Refinements Tested

- ⋆ **stability-dependent vertical weight :**

  $$w_z^{\Theta} = e^{-\left(\frac{\Theta(k) - \min(\Theta(k_s), \Theta_{2m})}{\Theta_c}\right)^2}, \qquad \Theta_c = 1K$$

  **(additionally to the standard height-dependent weight)**

- ⋆ **quality weight assigned to increment :**

  $$\epsilon = e^{-\left(\frac{\Delta T_{2m}}{T_c}\right)^2}, \qquad T_c = 5K$$

- ⋆ **observation increments in terms of specific humidity :** $\Delta q_{v\,2m}$

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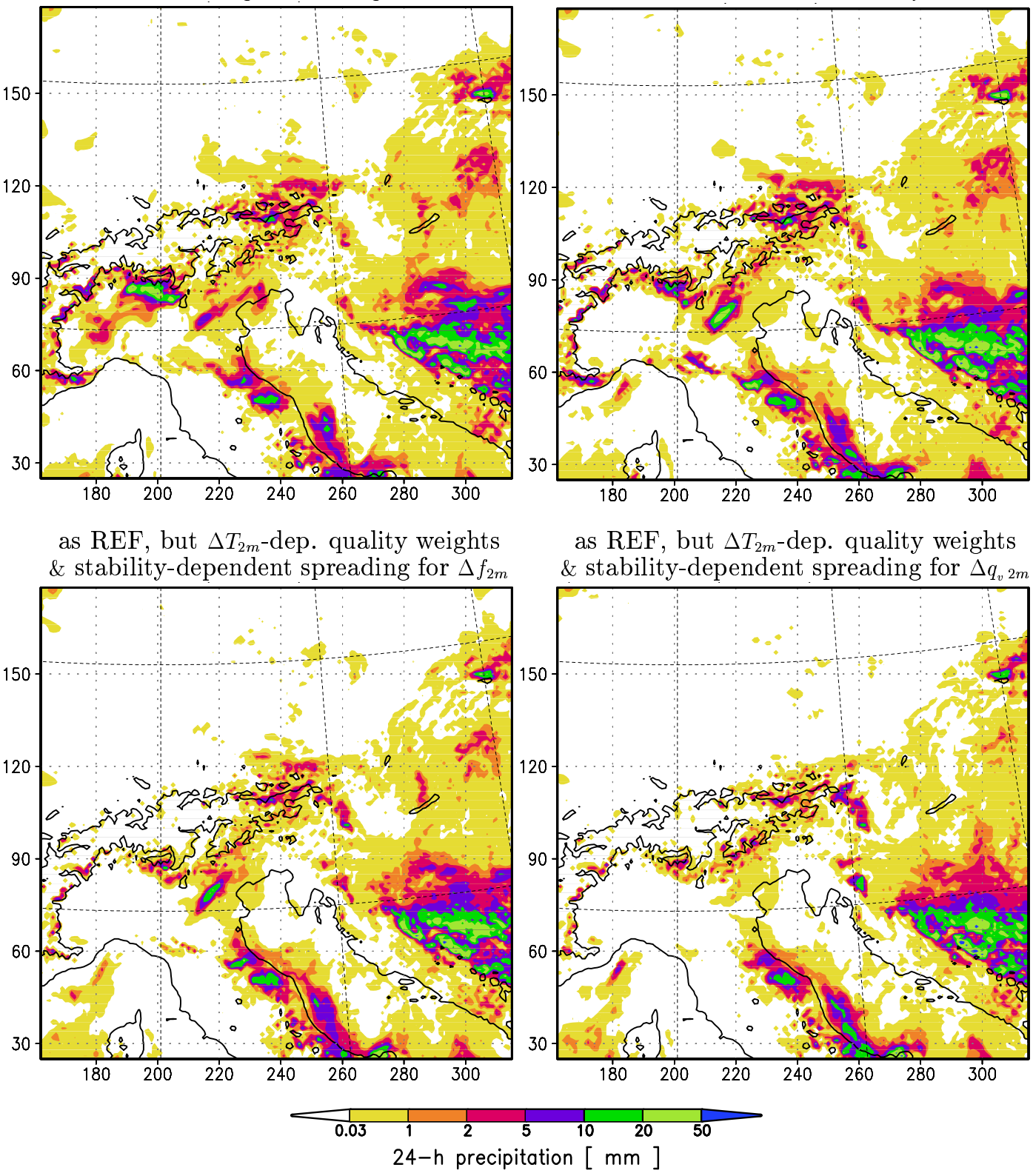
## *valid for 10 September 1999, 6 UTC*

'REF': opr. LM of 05-2002, but spreading $\Delta f_{2m}$ along $\sigma$-levels

as REF, but spreading of $\Delta f_{2m}$ dependent on stability

as REF, but $\Delta T_{2m}$-dep. quality weights & stability-dependent spreading for $\Delta f_{2m}$

as REF, but $\Delta T_{2m}$-dep. quality weights & stability-dependent spreading for $\Delta q_{v\,2m}$



# *24-hour precipitation of LM assimilation cycles*

## *valid for 10 September 1999, 6 UTC*