New interpolation formula in stable situation for the calculation of diagnostic fields at measurement height

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with supervision of

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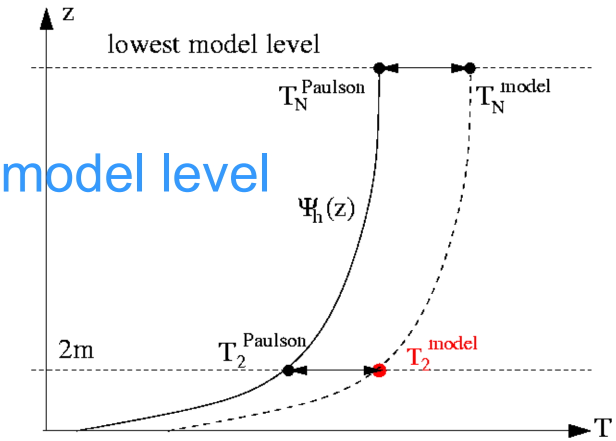
Outline

- Description and of the current diagnostic formulas
  - Paulson, Geleyn88, Canopy
- New interpolation formula
  - determination of the new formula
  - comparison with Geleyn88 and Canopy
- Application in DA
  - Use the new formula as the TL/AD version of Canopy
- Conclusion

Description of current diagnostic schemes in SURFEX



- **Paulson scheme**
  - fixed function, extrapolation from lowest model level

    → Ts inconsistency
- **Geleyn88 scheme**
  - fixed function with one parameter, interpolation between surface, lowest model level

    → underestimation of T2m in stable situation
- **Canopy scheme** (V. Masson)
  - 6 SBL levels between lowest model level & surface, solving prognostic equation (1d) with LS forcing + turbulence + drag

    → T2m is prognostic (TL/AD problem)

New interpolation formula

$$\frac{\partial s}{\partial z}=\frac{s_*}{\kappa}\frac{1}{z+z_{0H}}\varphi_h\left(\frac{z+z_{0H}}{L}\right)$$

neutral

stable/unstable

$$s(z)-s(0)=\frac{s_*}{\kappa}\left\{\ln\left(\frac{z+z_{0H}}{z_{0H}}\right)-\Psi_h\left(\frac{z+z_{0H}}{L}\right)+\Psi_h\left(\frac{z_{0H}}{L}\right)\right\}$$

$$\Psi\left(\xi=\frac{z}{L}\right)\equiv\int\frac{1-\varphi(\xi)}{\xi}d\xi$$

- use prescribed Ψ function (like in Paulson scheme)
- use the interpolation technique (JFG88)

  Ψ(αξ) contains **α parameter** → determine α from s(z_N)

$$s(z_N)-s(0)=\underbrace{\frac{s_*}{\kappa}}_{\frac{s(z_N)-s(0)}{b_H}}\left\{\underbrace{\ln\left(\frac{z_N+z_{0H}}{z_{0H}}\right)-\Psi_h\left(\frac{z_N+z_{0H}}{L}\right)+\Psi_h\left(\frac{z_{0H}}{L}\right)}_{b_n}\right\}$$

$$\Psi_h\left(\alpha\frac{z_N+z_{0H}}{L}\right)-\Psi_h\left(\alpha\frac{z_{0H}}{L}\right)=b_n-b_H \quad\Longrightarrow\quad \frac{\alpha}{L}=f\left(b_H,b_n\right)$$

New interpolation formula

Geleyn88 function:

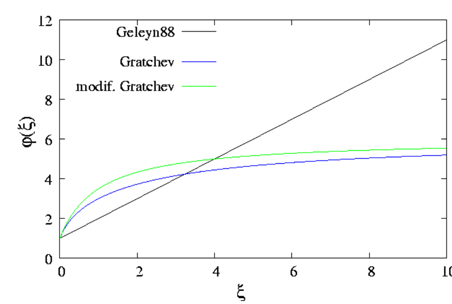
$$\varphi_h(\xi) = 1 + \alpha\xi \quad \Longrightarrow \quad \Psi_h\left(\frac{z+z_{0H}}{L}\right) - \Psi_h\left(\frac{z_{0H}}{L}\right) \boxed{= -\frac{z}{z_N}\left(b_H - b_n\right)}$$

Gratchev et al. function (proposed for stable condition):

$$\varphi_h(\xi) = 1 + a_h\xi\,\frac{1+\xi}{1+c_h\xi+\xi^2}$$

where a_h=5, c_h=3 → Ψ too complicated...

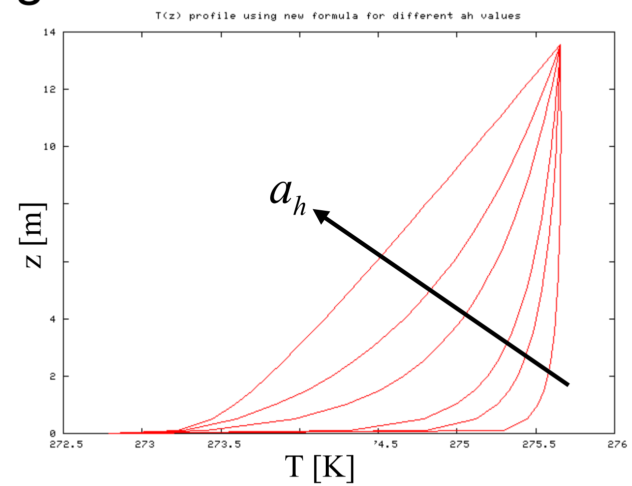
simplified function (c_h=2): $\varphi_h(\xi) = 1 + a_h\,\dfrac{\alpha\xi}{1+\alpha\xi}$



$$\Psi_h\left(\frac{z+z_{0H}}{L}\right) - \Psi_h\left(\frac{z_{0H}}{L}\right) \boxed{= -a_h \ln\left[1 + \frac{z}{z_N}\left(e^{\frac{b_H-b_n}{a_h}} - 1\right)\right]} \xrightarrow[a_h\to\infty]{} -\frac{z}{z_N}\left(b_H - b_n\right)$$

New interpolation formula (2)

- The Gratchev formula for wind is too complicated
  → use original formula which already gives good results
- New formula has a tuning parameter (a_h)
  → determines the shape of the profile

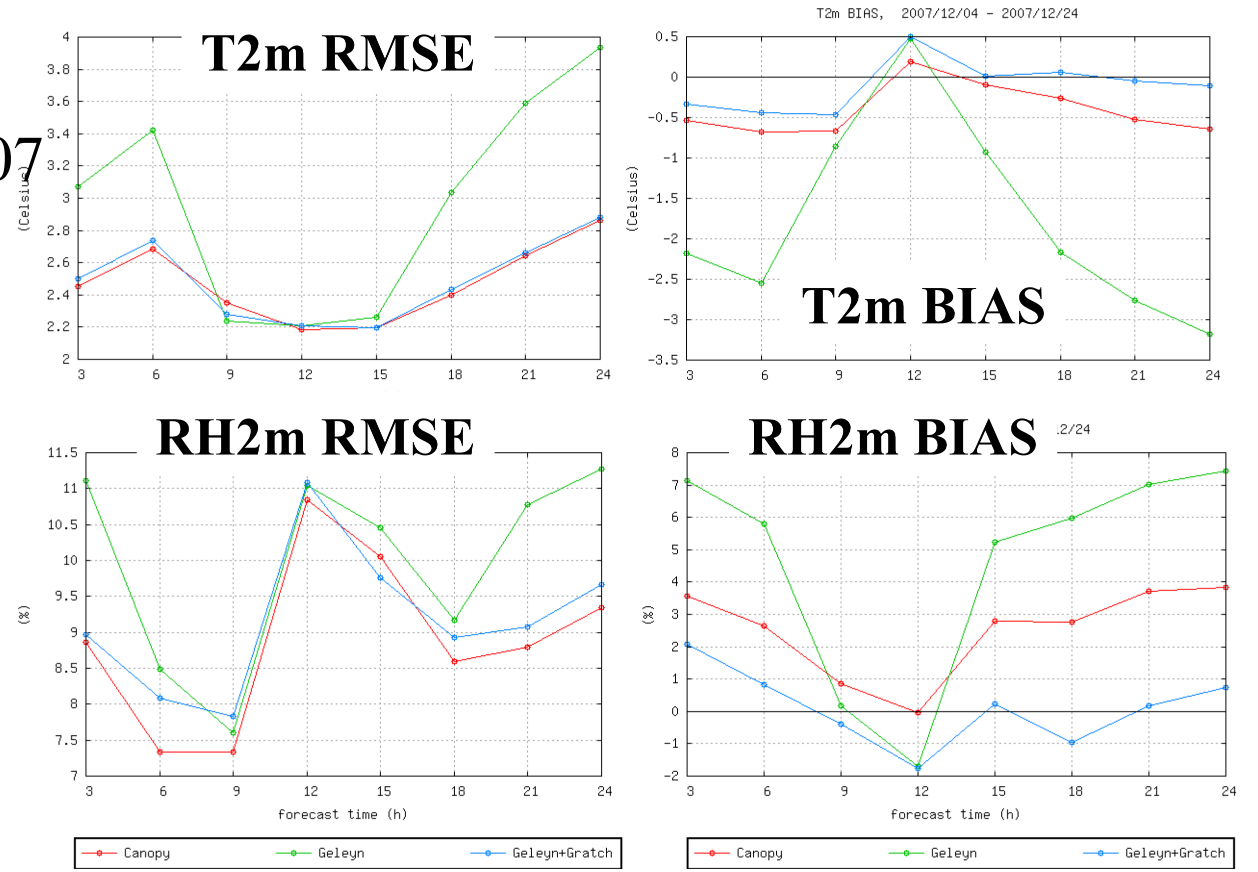


- Determination of a_h by fitting to observations
  → big variance: $a_h \in [2,20]$
  → use the proposed value a_h=5

Comparison of new/old formula

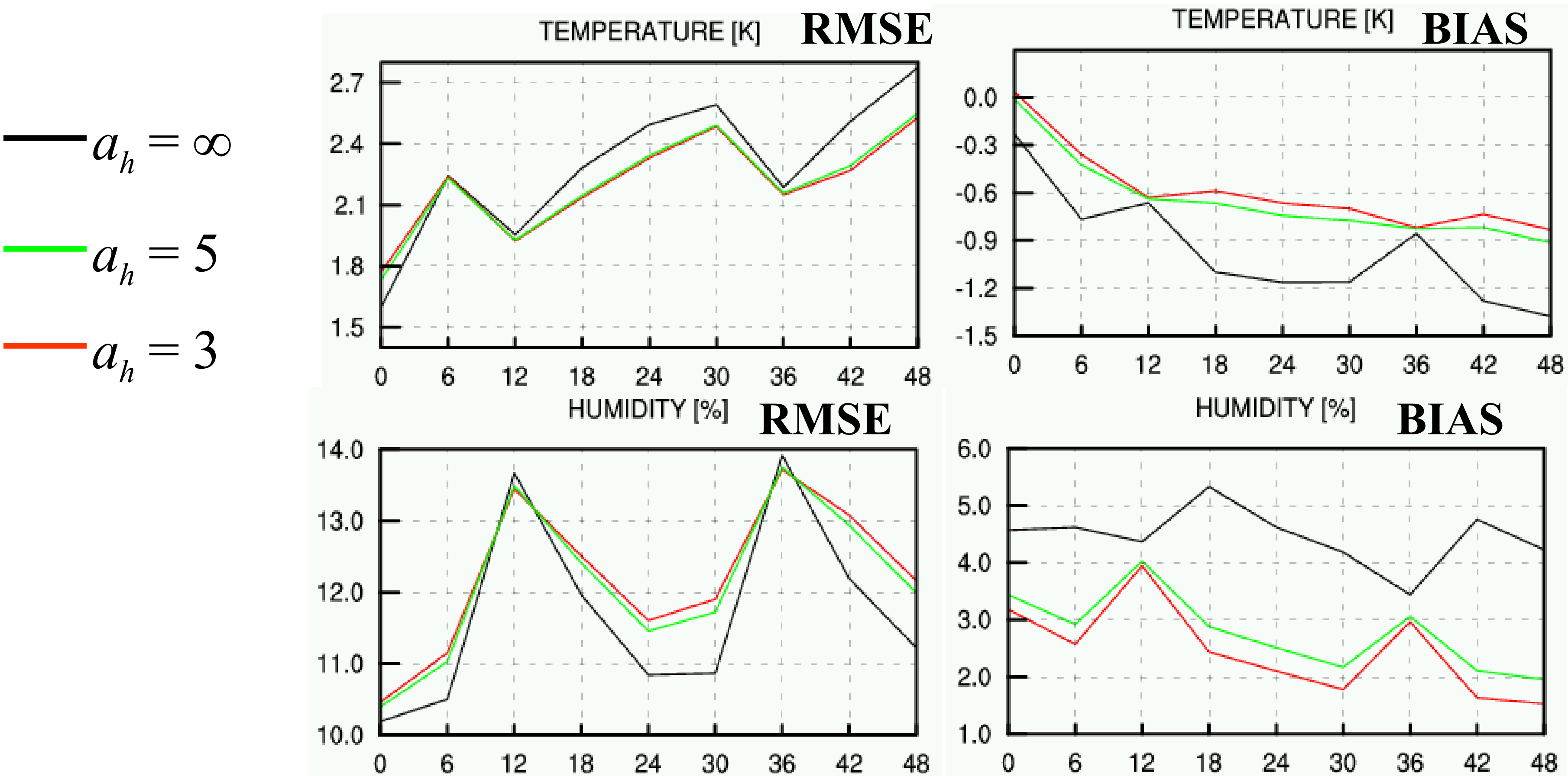
AROME forecast
04/12/2007-24/12/2007
only nature tile

Canopy
Geleyn88
New form.



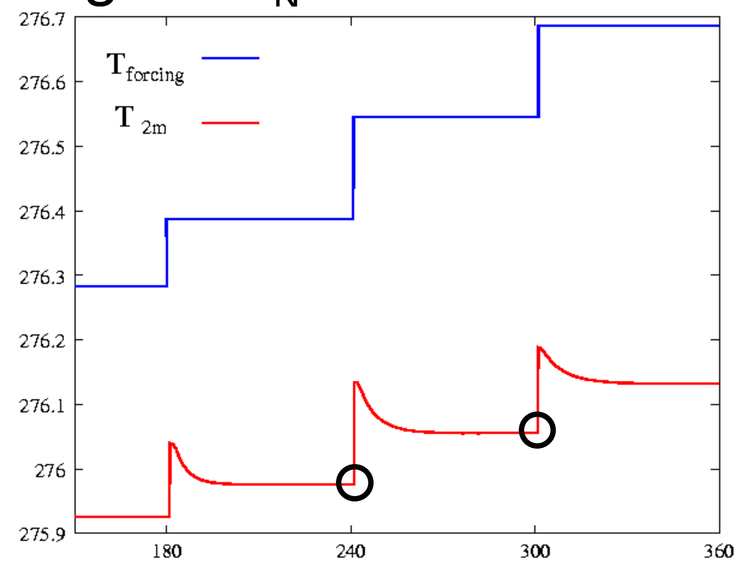
New formula gives similar results as Canopy

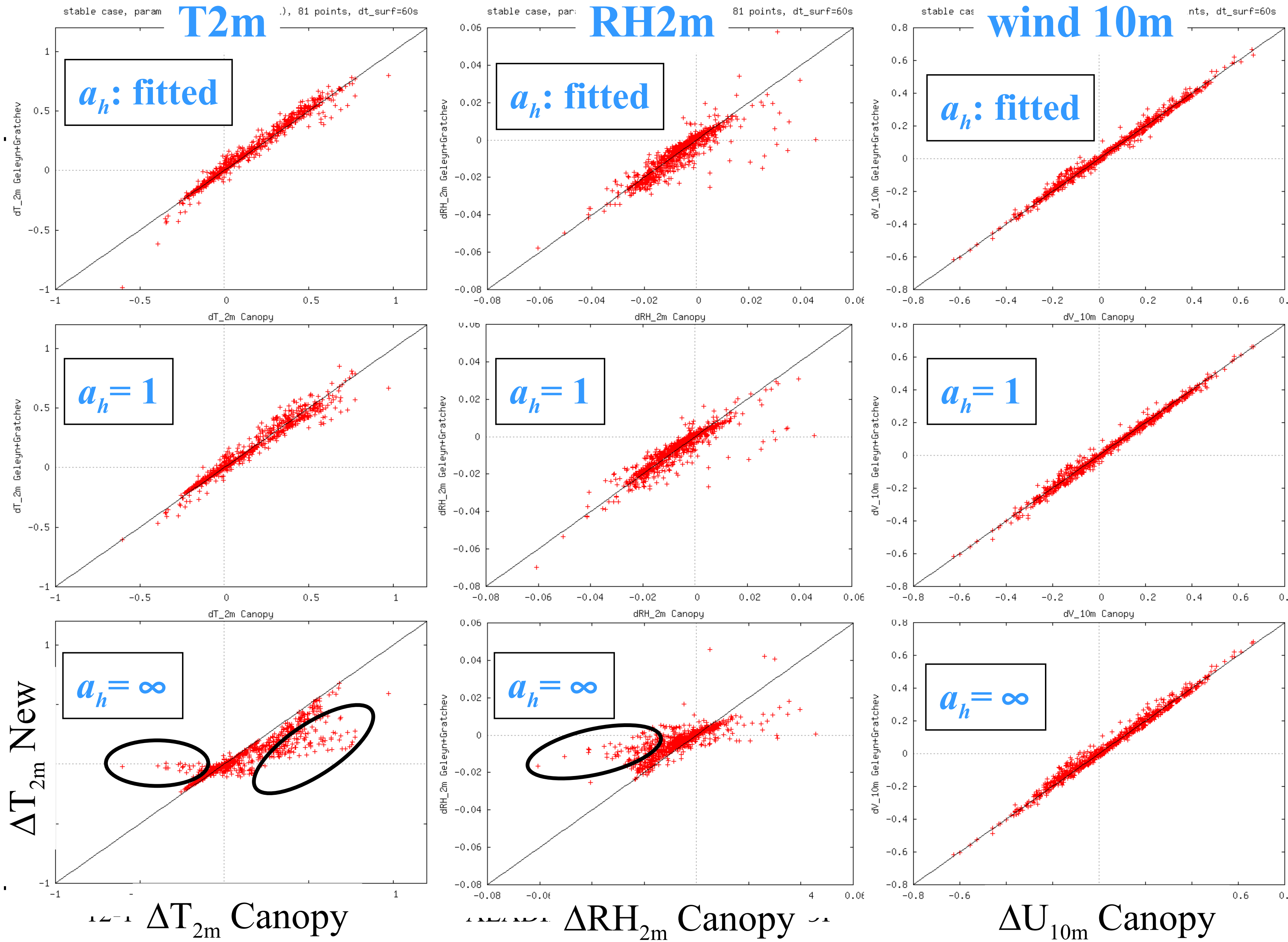
Tested in ALADIN (by Alena Trojakova)



Testing the TL/AD of Canopy

- Check if new formula is able to describe the TL of Canopy
- Canopy scheme is prognostic → change in T_N does not cause immediate change in T_{2m}
  - Checking the speed of relaxation
- Offline Surfex run
  - random perturbation of forcing fields
  - keep forcing fields constant for relaxation period
  - surface fields are kept constant
  - Compare TL of new formula with the change in Canopy field: $T(t_2\text{-}1)\text{-}T(t_1\text{-}1)$
  - determine a_h by fitting to Canopy profile





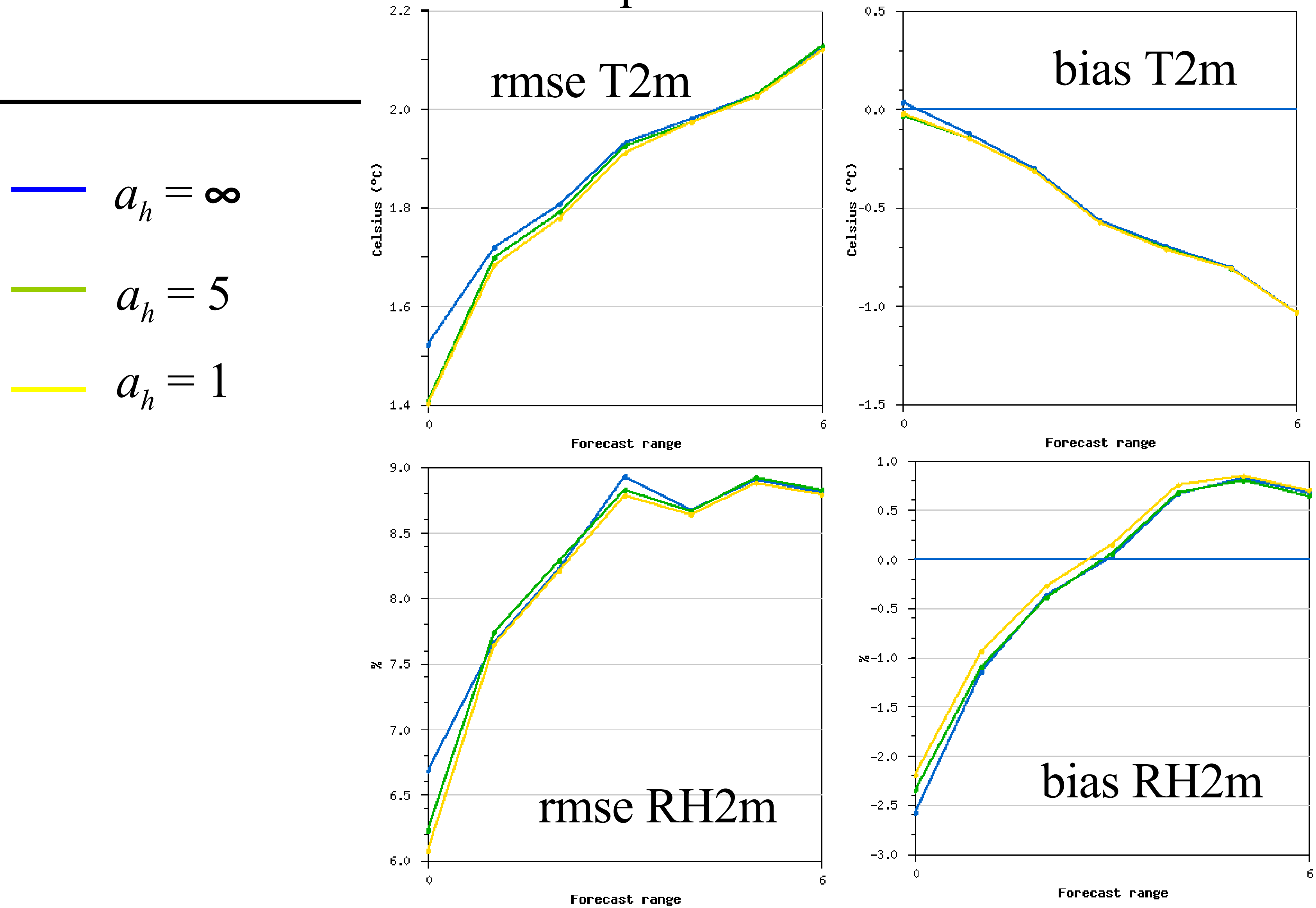
T2m
RH2m
wind 10m
stable case, param
.), 81 points, dt_surf=60s
stable case, par
81 points, dt_surf=60s
stable cas
nts, dt_surf=60s
a_h: fitted
a_h= 1
a_h= ∞
dT_2m Geleyn+Gratchev
dT_2m Canopy
dRH_2m Geleyn+Gratchev
dRH_2m Canopy
dV_10m Geleyn+Gratchev
dV_10m Canopy
ΔT2m New
ΔT2m Canopy
ΔRH2m Canopy
ΔU10m Canopy

AROME 3dVar test

- Comparing results using TL/AD of old (G88) and new formula
- 6h assimilation cycling
- Observations: TEMP, AIREP, AMSU-A, AMSU-B, SYNOP (T2, RH2, U10)
- direct obs. operator is the Canopy scheme (from guess)
- Ensemble B matrix

- Small differences on average, disappears after few hours

time period: 05/12/2007 – 22/12/2007



Conclusion

- Determination of new interpolation formula
- The new formula gives similar result as Canopy or Paulson in stable case
- TL of new formula approximates well the TL of Canopy
- Using TL/AD of new formula in assimilation has small impact compared to the old one