Improving the computation of screen level fields (temperature, moisture)

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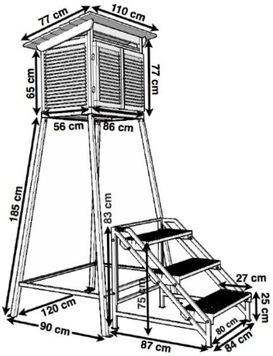
Introduction

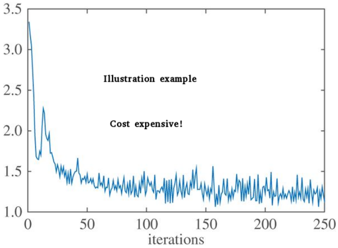
- At current ALARO res. the height of the lowest model level z_L is about 10m above surface, so T_{2m} (RH_{2m}) must be obtained by interpolation between z_L and surface .
- In 1988 J.F. Geleyn proposed interpolation method, but in strongly stable conditions has cold bias.
- In 2009 L. Kullmann proposed more realistic formula based on Arctic Ocean Experiment (warm bias).
- End of 2014, provisional fix was implemented at CHMI based on mix of Geleyn and Kullmann (oscillations).



The interpolation technique: Monin-Obukhov theory

- Both interpolations are based on Monin-Obukhov similarity theory
- Monin-Obukhov equations are:

$$\frac{\partial u}{\partial z} = \frac{u_*}{\kappa(z+z_{0D})}\varphi_D\left(\frac{z+z_{0D}}{L}\right),$$
$$\frac{\partial s}{\partial z} = \frac{s_*}{\kappa(z+z_{0H})}\varphi_H\left(\frac{z+z_{0H}}{L}\right),$$
$$L = \frac{\tilde{s}u_*^2}{g\kappa s_*},$$



- No analytic solution of these eq. for arbitrary φ_D, φ_H.
- It leads to cost expensive iterative numerical computations.

Stability functions in stable case

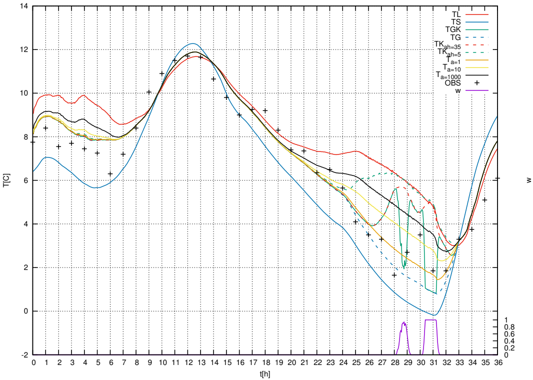
- 1988 Geleyn
  $\varphi_H(\xi) = 1 + \alpha_G \xi$, $\int dz \implies s_G(z)$, where α_G is elimination paramater determined by consistancy conditions at z_L, Oversimplified $\varphi_H(\xi) \implies$ cold bias in strongly stable conditions (clear-sky nights)
- 2009 Kullmann motivited by experiments: $\varphi_H(\xi) = 1 + a_K \frac{\alpha_K \xi}{1+\alpha_K \xi}$, $\int dz \implies s_K(z, a_K)$, α_K is elimination paramater. Experiments recommended $a_K \approx 5$, but Kullmann set this as tuning parameter. (Warm bias also for big a_K)
- 2014 CHMI mixed solution
  $s(z)_{mix} = w \cdot s_G(z) + (1 - w) \cdot s_K(z)$ where $w = w(C_H)$ function of heat surface exchange coefficient - getting from model. Oscillate rapidly.

New interpolation formula

- We have found that also pure Kullmann solution oscillated
- Problem is also in strongly stable conditions
- We proposed $\varphi_H(\xi) = 1 + \alpha \frac{\xi}{1+a\xi}$ instead of Kullmann $\varphi_H(\xi) = 1 + a_K \frac{\alpha_K \xi}{1+\alpha_K \xi}$
- Difference: elimination parameter α is before fraction. Tuning parameter a is in denominator.

Results: Prague 23th December 2015 from 00UTC

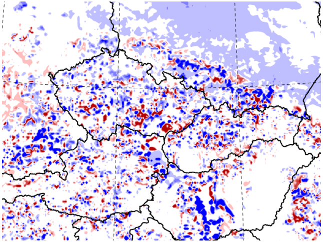
- To detect oscillations we needed one run (not statistical sample)
- Clear sky conditions (stable case)
- Obs temperature lying between surface and at the lowest model level
- Our new interpolation is smooth for all $a = 1$, $a = 10$ $a = 1000$ and without any oscillations



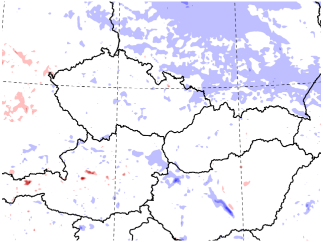
Temperatures for Prague 23th December 2015 from 00UTC

Results: Spatial behavior 24th December 2015

- We compared also spatial behavior
- We subtracted T_{2m} for forecast on 2UTC and 3UTC
- Temp deviation more then $3-4K$ in neighboring gridboxes
- Our interpolation is also without oscillations



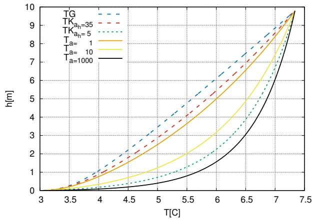
Reference



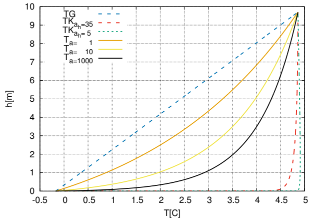
New formula

Results: Temperature profiles Prague 24th December 2015

- weak stable conditions (near neutral) Geleyn (red) Kullmann (blue) profiles similar
- stronger stable conditions Kullmann becomes vertically constant with a sharp gradient near the surface.
- Our solution is without this undesirable gradient



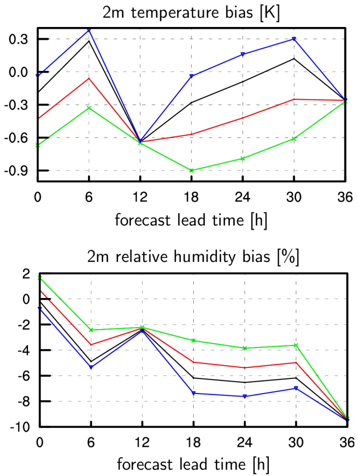
25hours after 0UTC near neutral conditions



31hours after 0UTC strong stable conditions

Results VERAL (stations 23-24th December 2015)

- Robust verification containing other stations is provided by VERAL scores
- Geleyn solution is coldest
- Reference mixed is nearly unbiased
- New solution $a = 1$ slighty colder
- Relative humidity lines are in reversed order



Green: Pure Geleyn, Black: Mixed reference, Red: New solution $a = 1$, Blue: New solution $a = 10$

Namelist modification

- In new modset of cy40t1bf05, the interpolation routine ACTKECLS is called only from TOUCANS, i.e. when there is LCOEFKSURF=.T. in namelist &NAMPHY.
- New interpolation is activated by setting:
  &NAMPHY1
  LCLS_HS=.T., (default .F.)
  ACLS_HS=1., (default 1,for reduce cold bias recommended $1 \lesssim$ ACLS_HS $\lesssim 3$. Values $\gtrsim 3$ can shift bias artificially, because $T(z_L)$ and $\tilde{T}$ can be shifted by biased model.)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UP
AND
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YOUR ATTENTION