Developments on the snow parameterization in ARPEGE

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In the NWP ARPEGE model, the snow cover fraction (P_{sn}) is a simple function of the snow quantity, represented by its equivalent water content (W_n): $P_{sn} = W_n/(W_n + 10)$. The snow fraction is crucial for the computation of the total surface albedo, owing to the fact that it is a combination of the initial surface albedo (~ 0.15) and the snow albedo ($\alpha_{sn} \sim 0.7$). [VB99] have decreased the cold bias on the boreal forest present in the ECMWF model with the use of the forest albedo instead of the snow albedo. The current modification goes further, with a snow cover fraction on vegetation part function of the leaf area index but also of the snow age. A prognostic equation for the snow albedo will be added to parametrize the ageing process on the albedo as proposed by [DRM95].

In ARPEGE, the general bias over the snow cover areas is positive, but on the forests in the Northern America a cold bias appears. It is clearly linked with the boreal forest with a Leaf Area Index (LAI) greater than 3.5. Therefore the idea of considering the albedo of the vegetation to reduce the cold bias on the forests seems to be justified. In addition, a prognostic equation for the snow albedo will afford the possibility to increase the albedo up to 0.85 with fresh snow instead of 0.7 (as presently fixed in operations), and consequently reduce the warm bias. To take into account the snow below the canopy in forests, fallen from the leaves, a relative snow cover fraction on the vegetation was introduced (P_{sn}^{veg}). P_{sn}^{veg} should be smaller than the equivalent over bareground (P_{sn}^{bg}) and we assume $P_{sn}^{veg} = P_{sn}^{bg} * F$. F is a decreasing function of both the Leaf Area Index and the snow age. For low vegetation ($LAI < 3$) F is equal to 1 and for forest ($LAI \geq 3$) the function F may decrease down to 0.15.

- $F(Lai, \alpha_{sn}) = 1$ for $LAI < 3$
- $F(Lai, \alpha_{sn}) = 1 - \frac{LAI}{K_{lai}} \cdot \frac{\alpha_1 - max(\alpha_0, \alpha_{sn})}{\alpha_1 - \alpha_0}$ for $LAI > 3$, $\alpha_1 = 0.87$, $\alpha_0 = 0.84$, $K_{lai} = 7$

The parameter α_0 was tuned to 0.84 so as to obtain a maximum impact between 6 hours and 30 hours after the latest snow fall (more details in [BEBS02]). After a snow fall, the function F could be closed to 1 also for a LAI greater than 3 (fresh snow can remain on the leaves), but [BB97] have shown that the maximum for the forest albedo is rarely larger than 0.3 for conifer and 0.35 for aspen.

A modification on a snow scheme with a new prognostic variable must be tested along a complete winter season, in order to achieve validation during the accumulation and the melting periods of the snow. The validation was made with the 3DVAR for the winter 2000/2001. Scores against SYNOP and TEMP observations were computed. The SYNOP scores on North 20° and EUROPE are roughly equivalent or slightly better than the current scheme. Over Northern America, the improvement is more significant for March and becomes negligible for April (Fig: 1). Scores against TEMP are slightly improved: around 1mgp at 72h for the geopotential over Europe (Fig: 2).

The new scheme improves the 2m temperature over boreal forests in spring and the introduction of the prognostic snow albedo reduces the warm bias over Antarctica. The impact in upper air is also positive but only after one month assimilation cycle !

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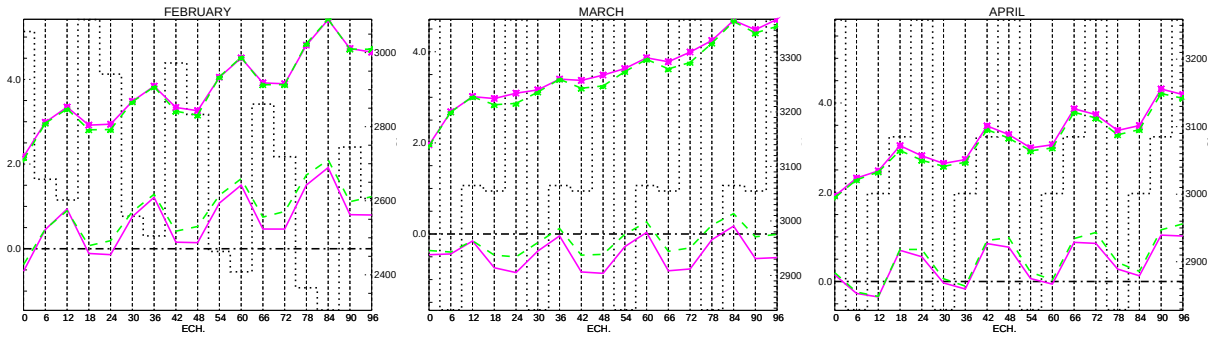

Figure 1: Bias and Rms against SYNOP for T_{2m} over Northern America. Full line: Ref. Dashed line: New.

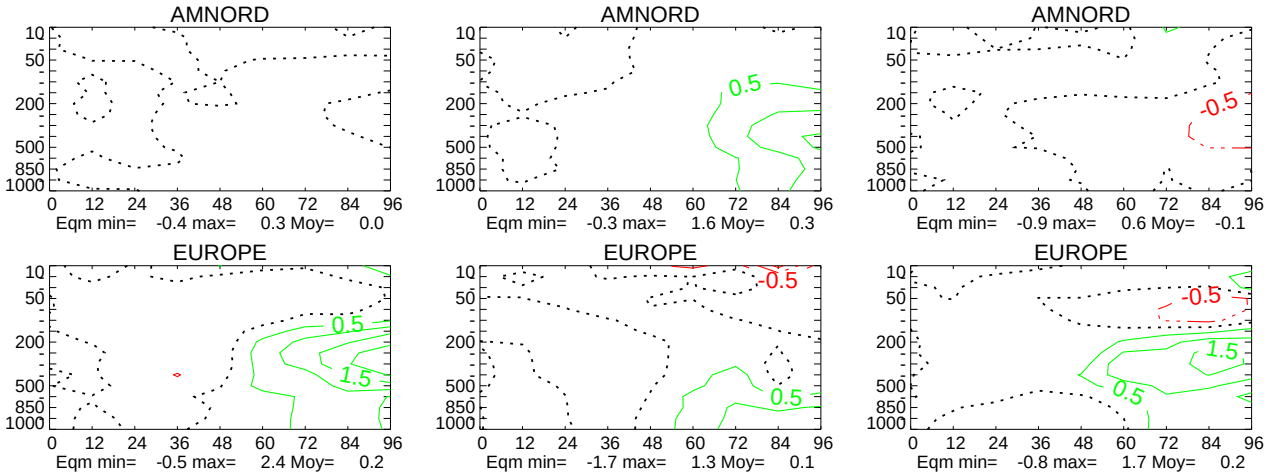

Figure 2: Scores against TEMP. Difference of rms between the reference and the new scheme. X-axis: forecast length. Y-axis: Pressure. Full line: improvement. Dotted line: neutral; Dashed line: deterioration. Left: January. Middle: February. Right: March.

References

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