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A Note on the Correctness of Precipitation in the Danish Climate Model

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Abstract

The problem of exaggerated precipitation simulated by the atmospheric Danish climate model (DKCM) reported in a recent document is re-examined. The cause of the problem is addressed to as a post-processing error. It is shown that the characteristics of The problem of exaggerated precipitation simulated by the atmospheric Danish climate model (DKCM) reported in a recent document is re-examined. The cause of the problem is addressed to as a post-processing error. It is shown that the characteristics of the model precipitation after the error is corrected are realistic and of similar quality to that simulated by ARPEGE and ECHAM5.

Resumé

I en nylig rapport er det beskrevet, at den danske atmosfæriske klimamodel overdriver nedbøren. Problemet er undersøgt igen, og årsagen til de overdrevne nedbørmængder tilskrives en fejl i efterbehandlingen af modeldata. Det vises, at modellens nedbørkarakteristika efter rettelsen af fejlen er realistiske og af samme kvalitet som dem, der simuleres med klimamodellerne ARPEGE og ECHAM5.

1. Problems in precipitation reported in DKCM

In a recent document describing the atmospheric Danish climate model (DKCM), it was reported that the model simulated precipitation appeared to be too high (Yang, 2004). In table 1 it is listed the 30-year average of the global averaged annual mean daily precipitation simulated by DKCM, ARPEGE and ECHAM5 at resolution of T63 L31 (or equivalent in grid-point space for ECHAM5), as given in Yang (2004), and the correspondent global averaged annual mean daily evaporation of these simulations. Readers may refer to Yang (2004) for a detailed description of these simulations. For reference the observed precipitation given by Xie and Arkin (1997) is also listed in the table. It is clear that the precipitation simulated by DKCM is about 7 and 5% higher than that simulated by ARPEGE and ECHAM5, respectively. Globally speaking, the exaggerated precipitation in DKCM is not balanced by the evaporation. As shown in table 1, the global mean precipitation exceeds the global mean evaporation by more than 8% in DKCM, while global mean precipitations are closely balanced by the global mean evaporations in ARPEGE and ECHAM5.

Table 1. *Global averaged annual mean daily precipitation and evaporation simulated by ARPEGE, ECHAM5 and DKCM as given in the report by Yang (2004). The corrected value for DKCM after a bug-fix in post-processing is also listed in the right-most column. The observed global averaged annual mean daily precipitation given by Xie and Arkin's data set is also listed on the table. Unit: mm/day.*

Model	Xie-Arkin	ARPEGE	ECHAM5	DKCM (Yang, 2004)	DKCM (corrected)
Daily precipitation	2.59	3.06	3.11	3.28	3.09
Daily evaporation		2.97	3.11	3.02	3,02

On the other hand, it was pointed out in Yang (2004) that the precipitation patterns simulated by DKCM appeared to be broadly realistic. Some regional features of the precipitation distribution at the lower latitudes are perhaps better presented in DKCM than in the other models, particularly for the Indian monsoon (see fig. 10 in Yang, 2004). The most questionable feature of precipitation seen in DKCM is the broad precipitation over midlatitude oceans which extended to western part of the continents in the winter season. To further demonstrate the characteristics of precipitation distributions in the models, Fig. 1 plots the zonal distribution of the annual mean daily precipitations given by the DKCM (in orange), ARPEGE (in light blue), ECHAM5 (in dark blue) and the Xie and Arkin's data set (in black). It is evident that the zonal mean precipitation in DKCM is coincident with that in ARPEGE in area nearby the tropical precipitation maximum, and then follows closely that in ECHAM5 as moving to subtropics. However, the zonal mean precipitation of DKCM gradually departs from the other two models as moving to mid- and high latitudes, while the distributions of ARPEGE and ECHAM5 are very alike. The amount of zonal mean precipitation eventually becomes almost double of the precipitation in the other two models in high latitudes.

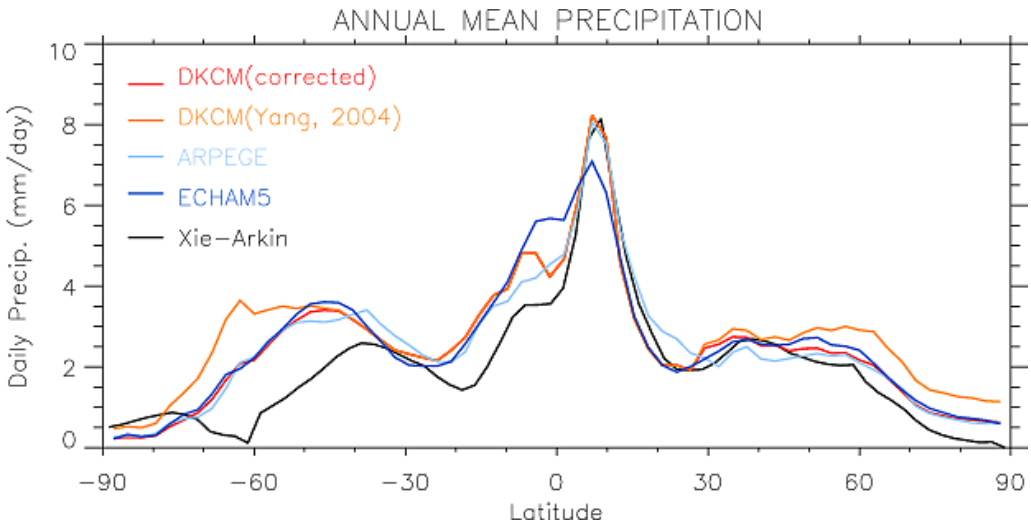

Fig. 1. *Zonal distributions of annual mean daily precipitations simulated by different models. The light blue line is for ARPEGE, Dark blue for ECHAM5, orange for DKCM as reported in Yang (2004) and red for DKCM after the bug-fix described in section 2. The observed zonal averaged annual mean daily precipitation given by Xie and Arkin data set is also plotted in black.*

2. The corrected precipitation simulated in DKCM

In Yang (2004) several possible causes for the overestimation of precipitation in DKCM was speculated. The possible explanations include the use of a non-conservative semi-Lagrangian advection scheme for humidity and cloud water, the spectral harmonic representation for positive definite humidity, and *etc*. However, these possibilities can't explain why the non-closed hydrological cycle does not appear in ARPEGE which dynamical core is the same as that of DKCM. In particular, they can't explain why the exaggerate precipitation in DKCM only occurs at mid- and high latitudes.

Since the work of Yang (2004), a series of investigations were made to address the problem. Different parts of the model were also carefully examined. It was then found that the amount of snow fall in DKCM was double-counted when post-processing the model simulation. It is thus obvious that the precipitation amount is exaggerated only in mid- and high latitudes where there are snow falls. Indeed, when this bug in the post-processing was corrected, the zonal distribution of the annual mean precipitation of DKCM, as shown by the red line in Fig. 1, is very similar to those of ARPEGE and ECHAM5 in the mid- and high latitudes, while its distribution in low latitudes remains the same as in Yang (2004). The global averaged annual mean daily precipitation after the bug fix, as given in the right column in table 1, reduced to 3.09 mm/day, which falls in between the amounts given by ARPEGE and ECHAM5. This corrected global averaged precipitation is now reasonably balanced by the global mean evaporation, as in ARPEGE.

The geographical distributions of the DKCM simulated precipitation after bug-fix together with those simulated by ARPEGE and ECHAM5 as well as that given by Xie and Arkin (1997) are shown in Fig. 2 for northern winter (DJF) and in Fig. 3 for northern summer (JJA). These figures may be compared to Figures 9 and 10 in Yang (2004) where the distributions for questionable precipitation are shown. As expected, the distributions for DKCM in low latitudes are unchanged by the bug-fix. However, the distributions for DKCM in mid- and high latitudes are now much more realistic in comparison with that for Xie and Arkin's data set. In particular, the patterns and amount of precipitation simulated in DKCM appear to match very well that in Xie and Arkin over

North Atlantic, North Pacific, Europe and North America in winter time.

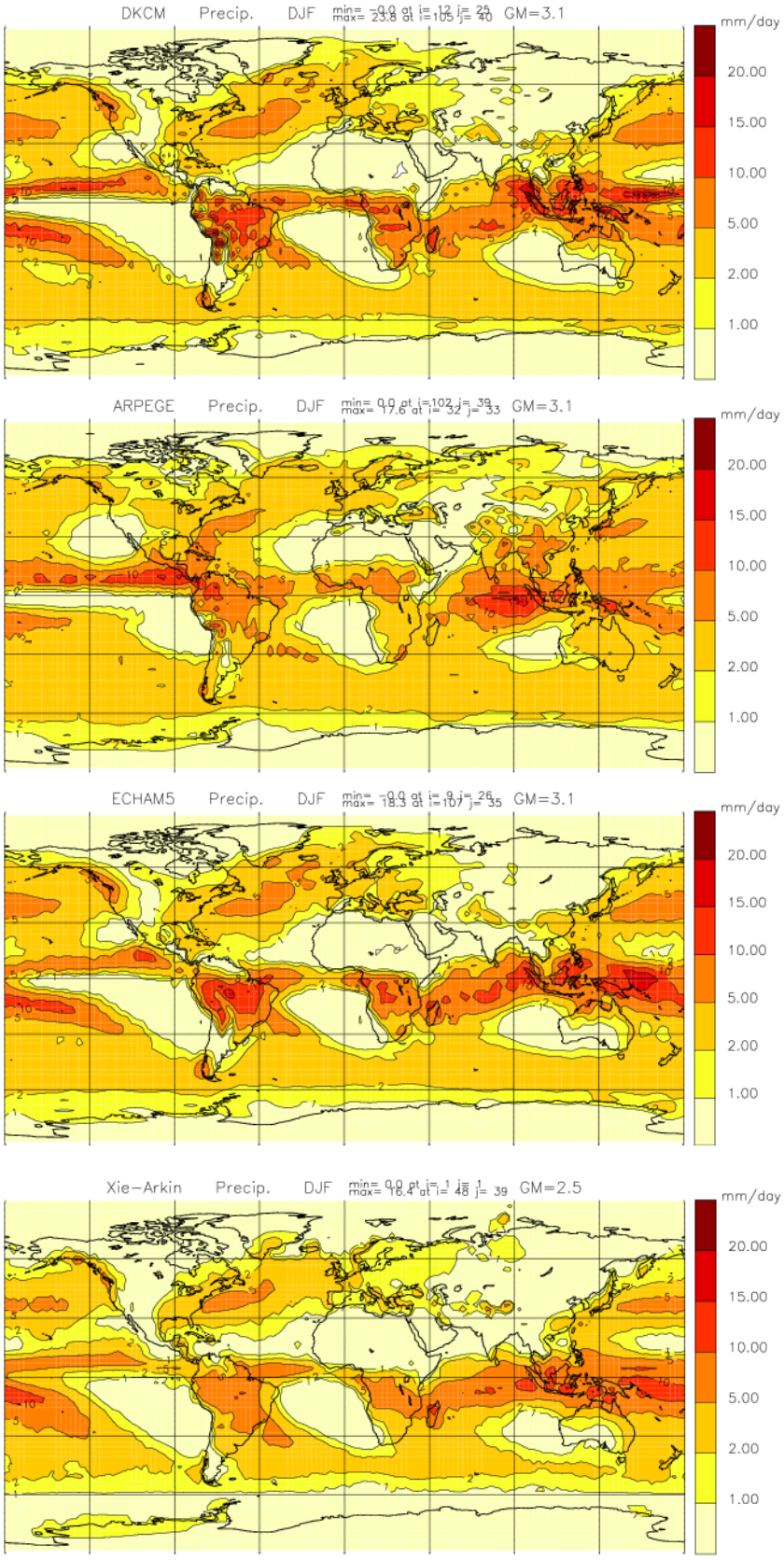

Fig. 2. *Seasonal mean precipitation for Northern winter (DJF) for the three models as well as for the Xie and Arkin data set, respectively. From top to bottom: DKCM after the bug fix, ARPEGE, ECHAM5 and the xie and Arkin data set. Unit: mm/day.*

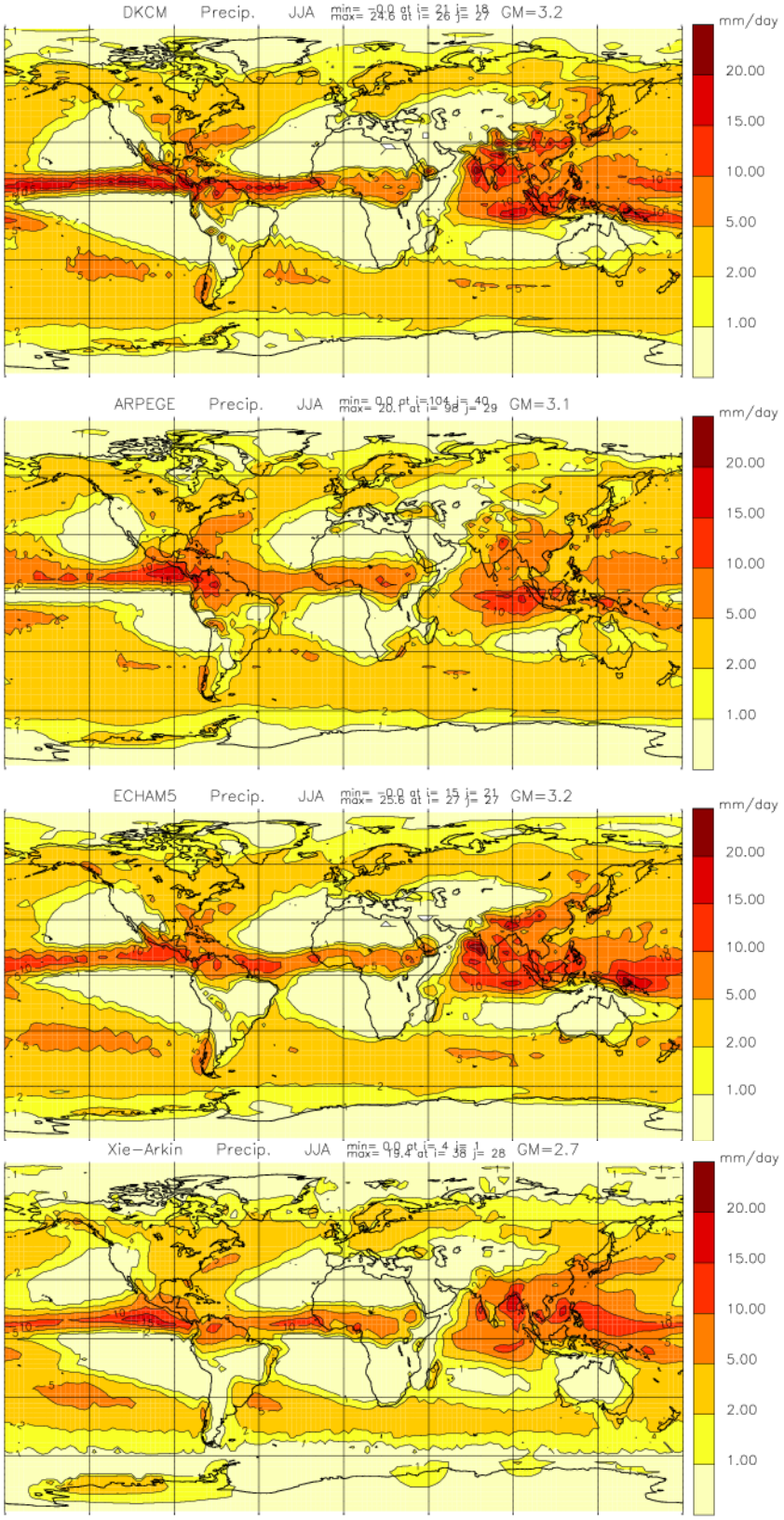

Fig. 3 *As Fig. 9 but for northern summer (JJA).*

3. Conclusion

In this note, the problem of exaggerated precipitation simulated by DKCM as reported in Yang 2004 is re-examined. The cause of the problem is addressed to as a post-processing error. The characteristics of the model precipitation after the error is corrected are then presented. It is shown now that, generally speaking, the amount and the geographic patterns of the precipitation simulated in DKCM are realistic and of similar quality to that simulated by ARPEGE and ECHAM5.

References

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