The implementation of the sweep interpolation in the semi-Lagrangian scheme of the ACCORD system

Report from the stay at CHMI, Prague, 03.11-28.11.2025

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January 30, 2026

1 Introduction

The sweep interpolation method as described and demonstrated by Mortezazadeh and Wang is motivated by its ability to reduce both dissipation and dispersion errors, which is particularly critical near sharp gradients. Even though it is a 4th-order semi-Lagrangian scheme it achieves a high-order accuracy at the computational cost of a 3rd-order method by alternating backward and forward interpolations. Theoretical explanation of the method can be found in [1] and [2].

The purpose of this stay was to understand how the sweep interpolation works and to implement it in the LAM code, as well as to test the quality of the new method.

2 Implementation

The code modification was done based on the operational version of CY48t3mas available at CHMI in Prague on lada: /home2/mma010/pack/cy48t3mas_op1.02.NEC400DPMPI226.x and may be found on lada: /local/mma277/pack/CY48t3mas_sweep.01.NEC400DPMPI226.x. We implemented the sweep interpolation method in the LAM code by phasing Filip Váňa's original implementation done in the global IFS to cy48t3mas available in Prague and by adapting it to the local model geometry.

Since interpolation weights in the limited area model use plane geometry while the global model employs spherical coordinates, we had to implement corresponding modifications to the LAM code. We introduced a new logical key $LSWEEP$ as a global switch activating sweep weights computation. We added new conditional cases in the routine elascaw.F90 that compute quadratic horizontal and vertical weights required for sweep interpolation when $LSWEEP = .T.$. List of the modified routines can be found in Appendix 4.

3 Experiment

To evaluate the results we conducted a test on the classical Robert's rising thermal bubble. We define it do be a sharp edged 2-dimensional bubble with perturbed temperature: +1K in the centre of bubble and wind speed of 0m/s (no advection) in the field of constant potential temperature of 300K. The experiment was carried out on a domain of 256 gridpoints, 200 vertical levels with meridional grid spacing and vertical spacing of half levels both set to 10m.

We compared the solutions of the sweep interpolation with reference solutions using quadratic and cubic interpolators on Figures 1 - 4.

4 Conclusion

The sweep interpolation method produces results visually very similar to both quadratic and cubic reference solutions, making it difficult to draw definitive conclusions about its relative performance. However, the close agreement with both established interpolators suggests the method successfully captures the essential dynamics of the rising thermal bubble. Thus the method is promising and additional testing across varying parameters and a 3-dimensional test cases is necessary to further validate the sweep interpolation method for atmospheric modelling applications.

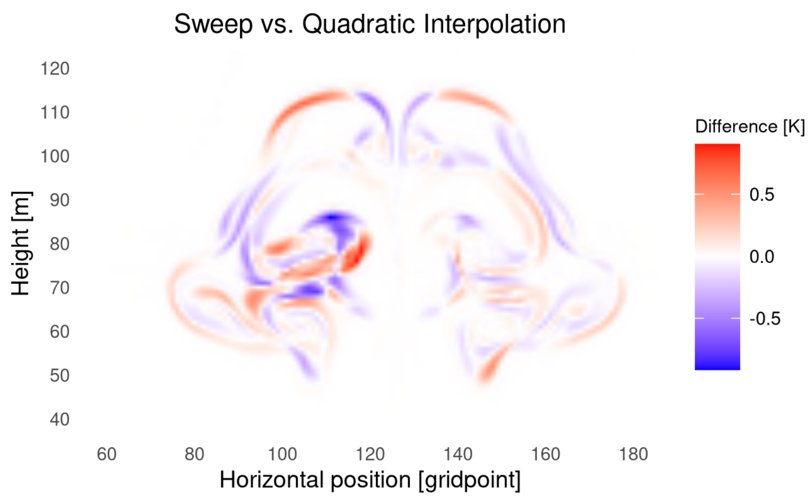


Figure 1: Bubble test: difference between sweep and quadratic Lagrange interpolation of perturbation of potential temperature after 7 minutes.

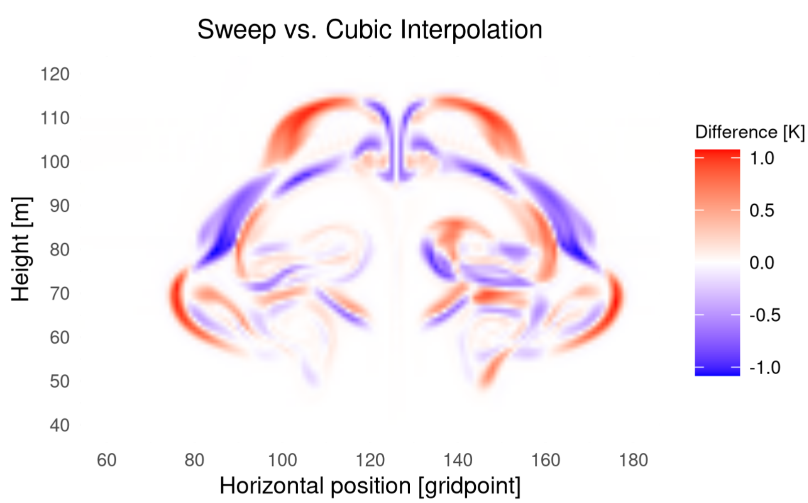
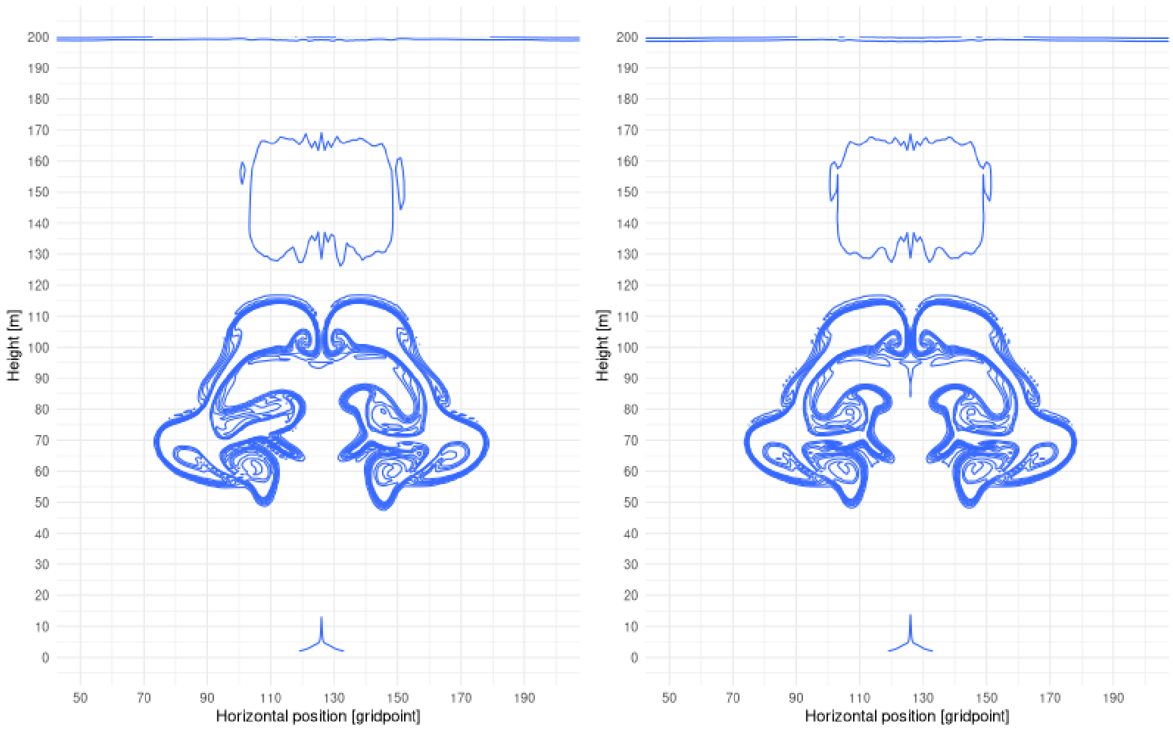
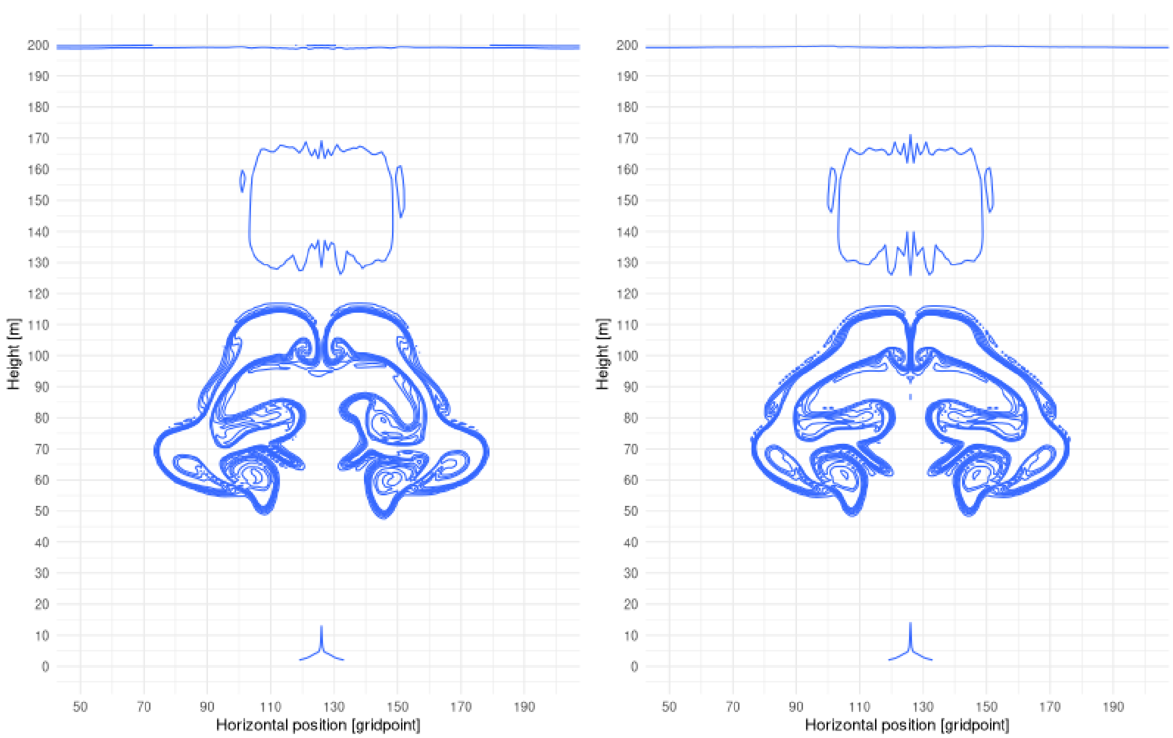


Figure 2: Bubble test: difference between sweep and cubic Lagrange interpolation of perturbation of potential temperature after 7 minutes.



(a) (b)

Figure 3: Bubble test: perturbation of potential temperature after 7 minutes - (a) sweep interpolation, (b) quadratic interpolation.



(a) (b)

Figure 4: Bubble test: perturbation of potential temperature after 7 minutes - (a) sweep interpolation, (b) cubic interpolation.

References

[1] Mortezazadeh, M., & Wang, L. L., 2017: *A high-order backward forward sweep interpolating algorithm for semi-Lagrangian method*, International Journal for Numerical Methods in Fluids, 84(10), 584–597.

[2] Mortezazadeh, M., Cossette, J.-F., Dastoor, A., de Grandpré, J., Ivanova, I., and Qaddouri, A., 2024: *Sweep interpolation: a cost-effective semi-Lagrangian scheme in the Global Environmental Multiscale model*, Geosci. Model Dev., 17, 335–346.

Appendix A

List of modified routines:

aladin/interpol/elascaw.F90
arpifs/adiab/larcina.F90
arpifs/adiab/larcinha.F90
arpifs/oops/interpolator_ad_mod.F90
arpifs/oops/interpolator_mod.F90
arpifs/op_obs/slintad.F90
arpifs/op_obs/slint.F90