High Resolution Modelling with the IFS

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ECMWF

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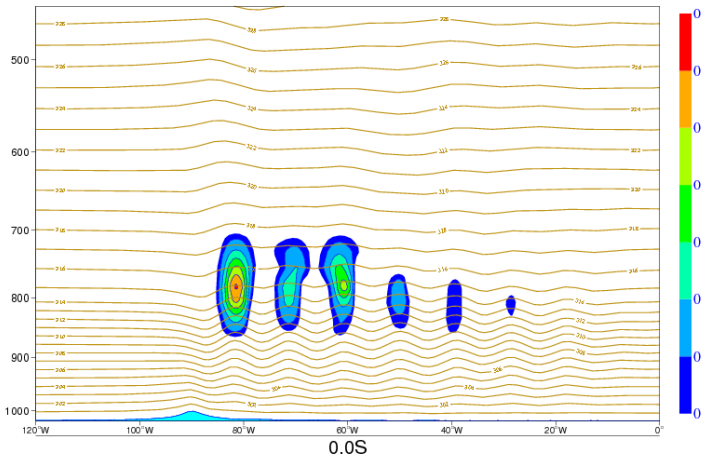
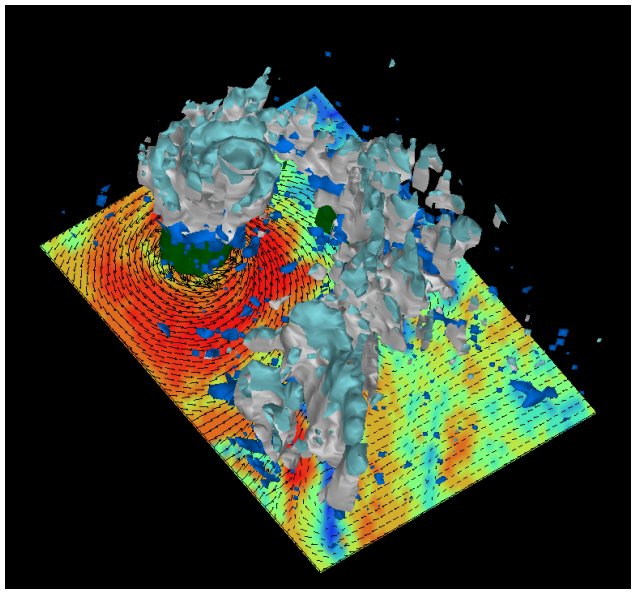
News from the small planet





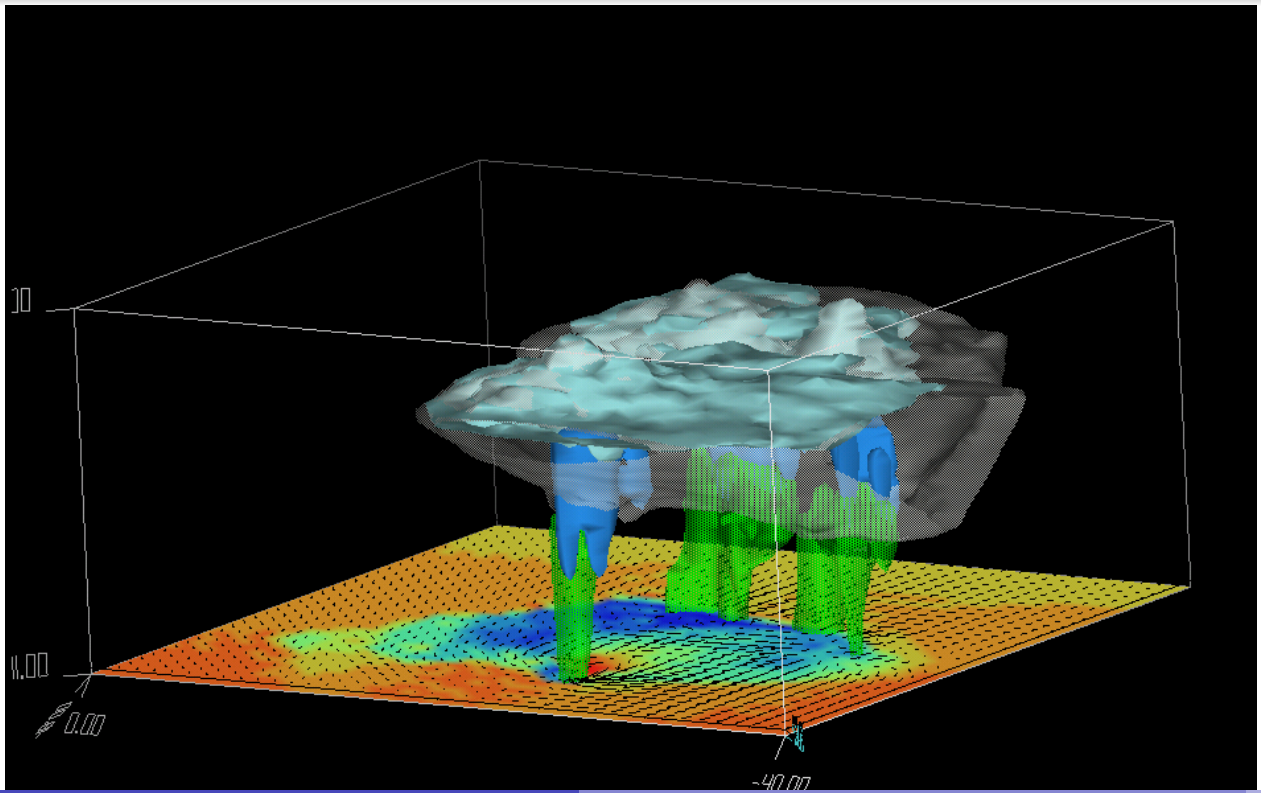
Test cases

- Moist orographic waves (Used in Meso-NH for high order advection tests)
- Tropical Cyclones (Reed and Jablonowski, 2011)
- Splitting storms (Weisman and Klemp, 1982, 1984)

NH dynamics and prognostic microphysics in the IFS

Is the current IFS able to simulate deep convective systems?

At 1 km and 3 km resolutions, the development of split storms in unidirectional and rotational wind shear environment simulated with the IFS is qualitatively in good agreement with the original results of Weisman and Klemp (1982, 1984) and with more recent results obtained with the mesoscale models AROME and Meso-NH (Verrelle, 2011).



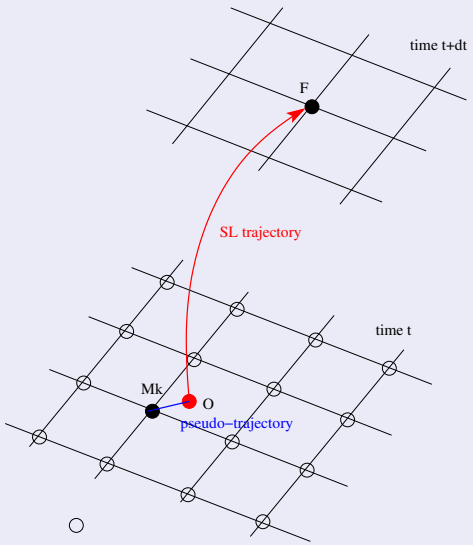
For more details, visit my poster

Eulerian transport scheme for interpolations in a semi-Lagrangian transport scheme

Problem: reconstruction of a field ψ at departure point O knowing only values at neighbouring grid points M_i using an Eulerian algorithm (Smolarkiewicz and Pudykiewicz, 1992)

Interpolation methods used for Arbitrary Lagrangian Eulerian (ALE, unstructured grid)) codes in the industry, aerospace and military applications

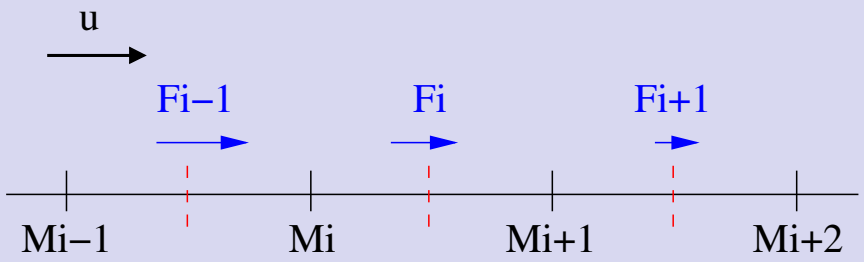
- move the depature points O to their nearest grid point M_k using the MPDATA formalism.
- displacement of the fluid at constant real time t along "pseudo-trajectories" from O to M_k at a constant pseudo-velocity equal to the distance between O and M_k divided by a pseudo-time unit.



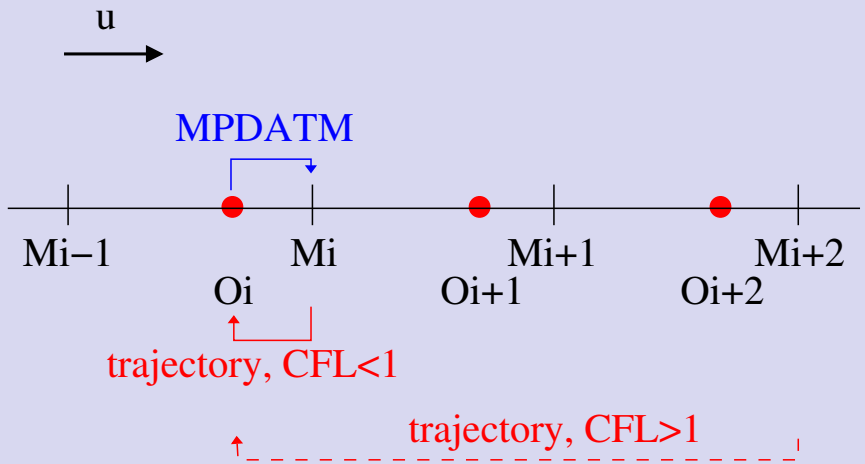
MPDATA for SL interpolations

1D transport - Constant wind advection - CFL<1

Eulerian-Flux Form



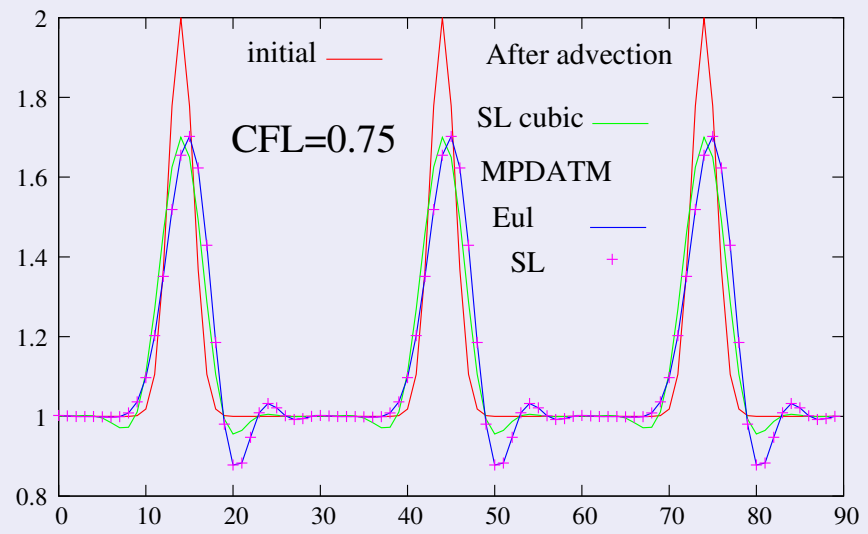
SL with Eulerian interpolation



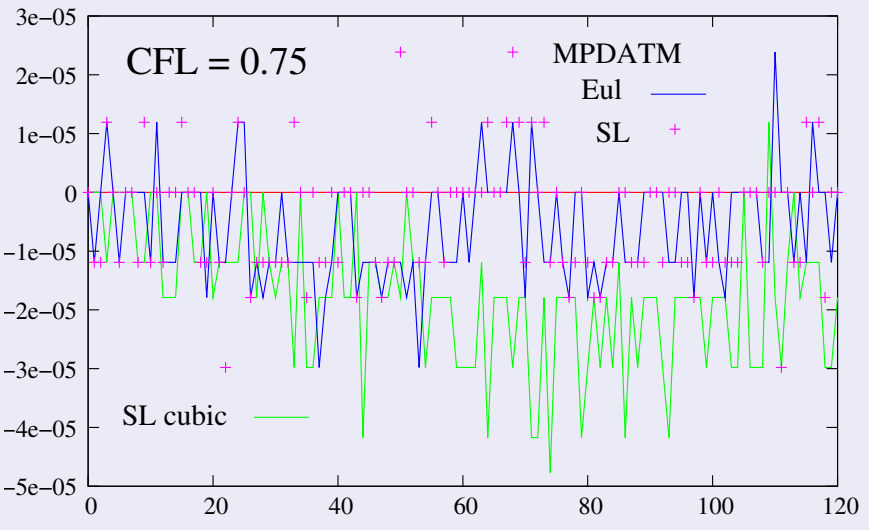
- The pseudo-displacement is always less than Δx: CFL<1
- MPDATA formalism is equivalent to a Taylor expansion in space and pseudo-time around the nearest grid point at departure time.
- Order 1 expansion is equivalent to linear interpolation (donor scheme).

1D transport - Constant wind advection - no filter

Shape



Total mass evolution



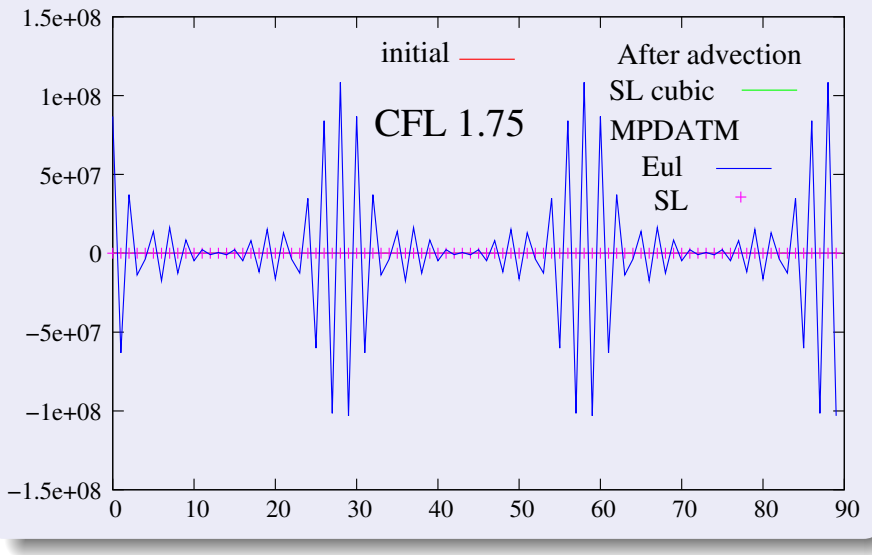
CFL< 1

Without monotonous filter,

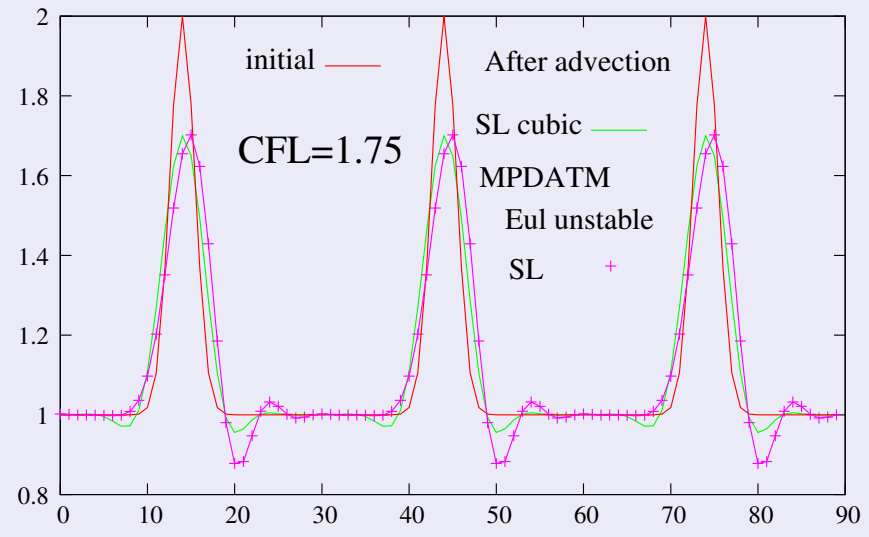
- Eulerian MPDATM $=$ SL with MPDATM interpolation
- Undershoot/overshoot but global conservation with all methods

1D transport - Constant wind advection - no filter

Shape



Shape

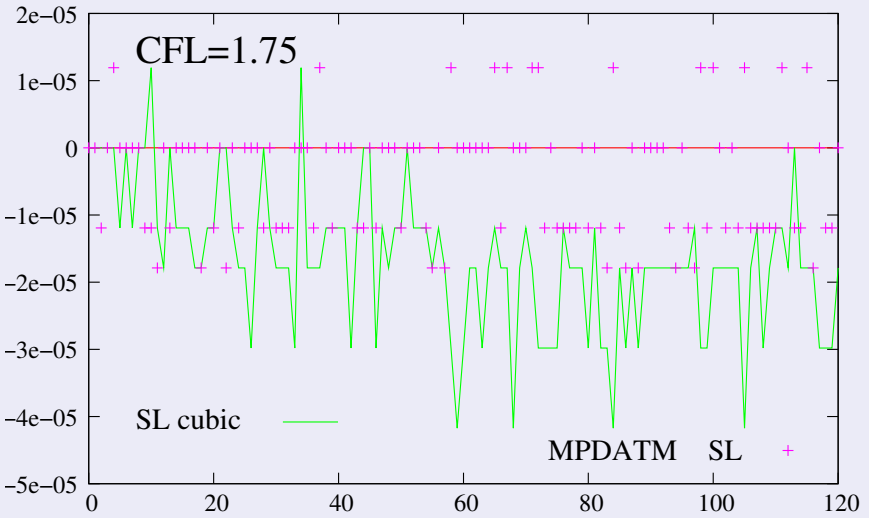


CFL> 1

Without monotonous filter,

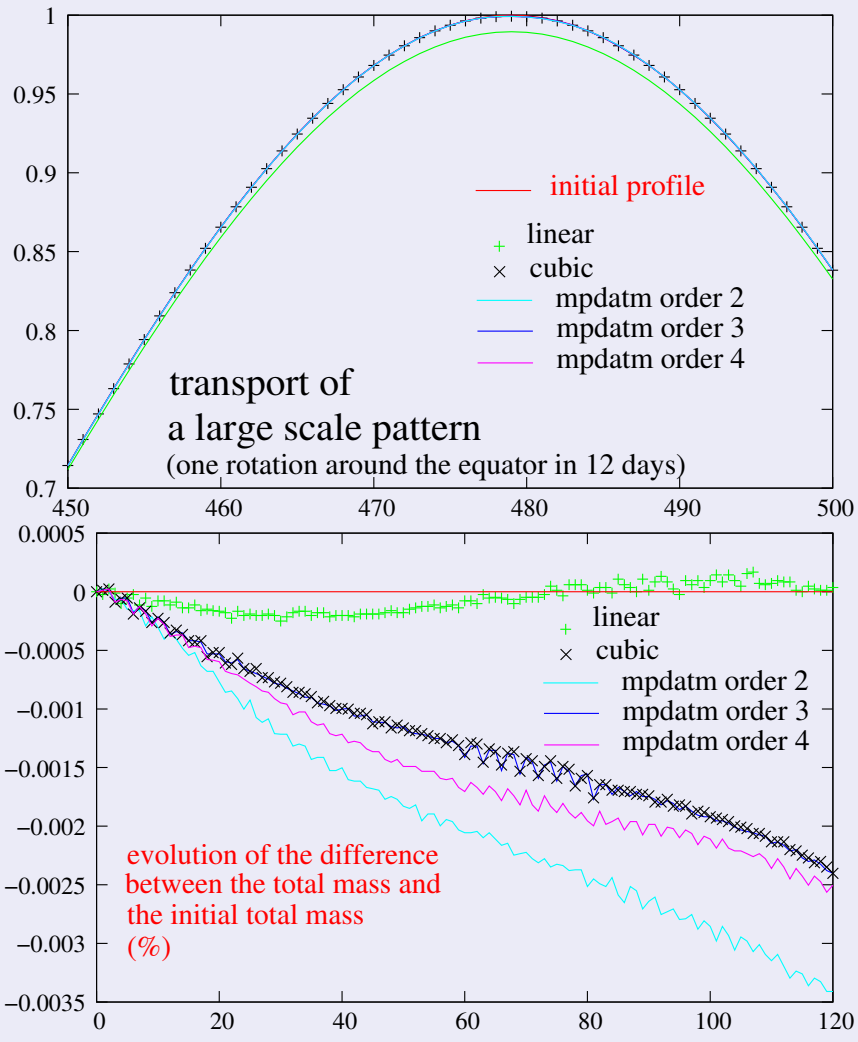
- Eulerian MPDATM is unstable for CFL> 1
- SL scheme gives the same results with CFL= 0.75 and CFL= 1.75, CFL= 2.75 ...

Total mass evolution

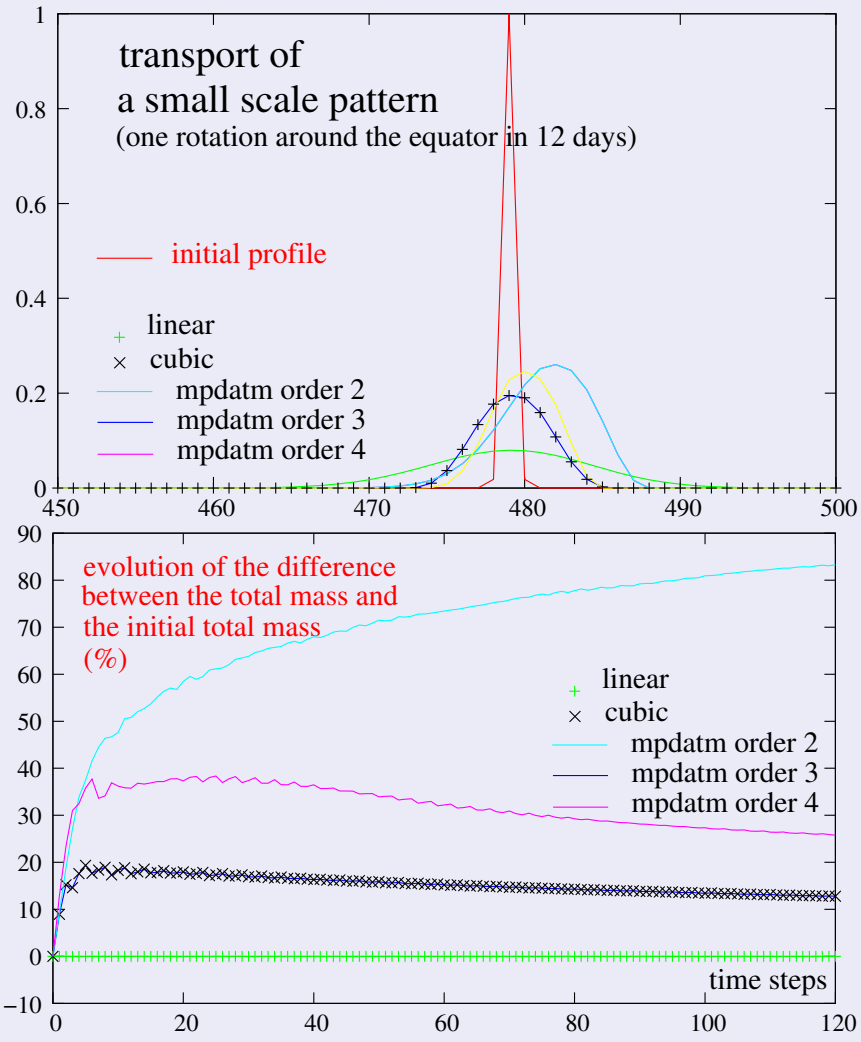


1D transport - Constant wind advection - Simple min/max filter

Well resolved shape



Poorly resolved shape

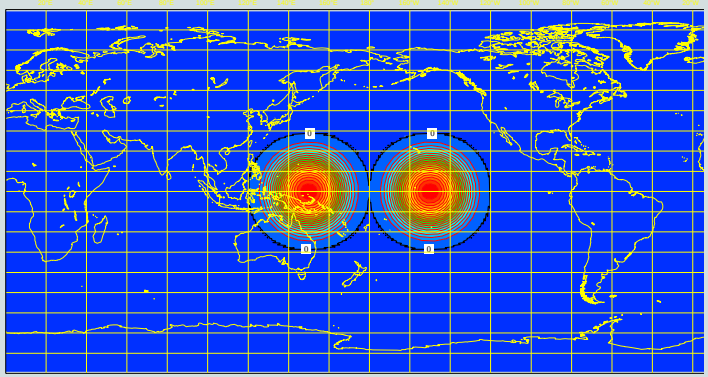


MPDATA for SL interpolations: First implementation in the IFS

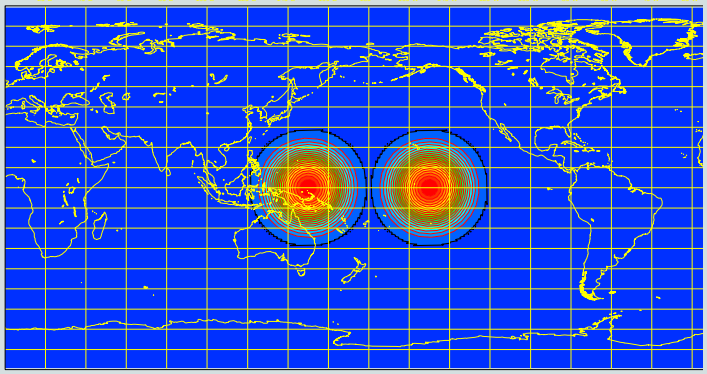
2D advection of a well resolved Gaussian shape

- second order
- monotonous filter: min/max of two nearest grid point (LQM type)
- solid body rotation

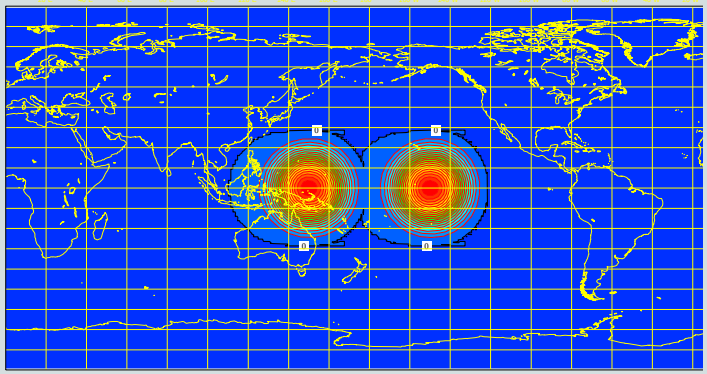
Cubic+min/max filter



Initial field

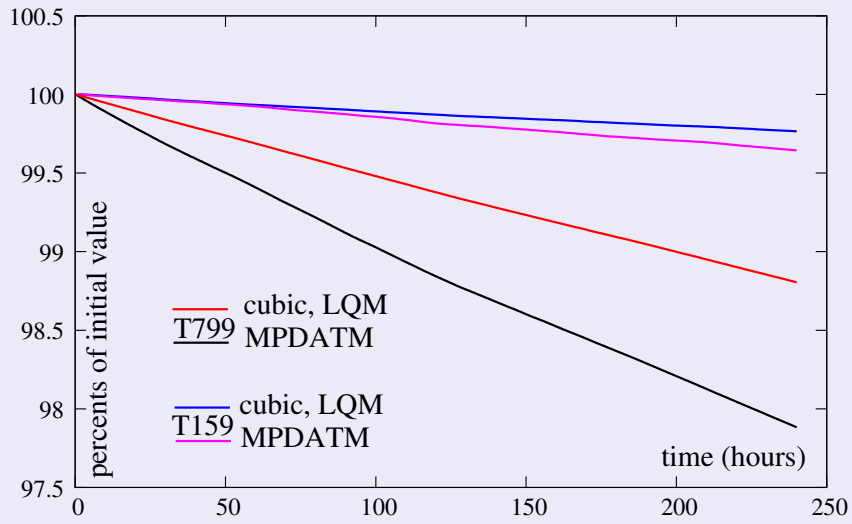


MPDATM+min/max filter

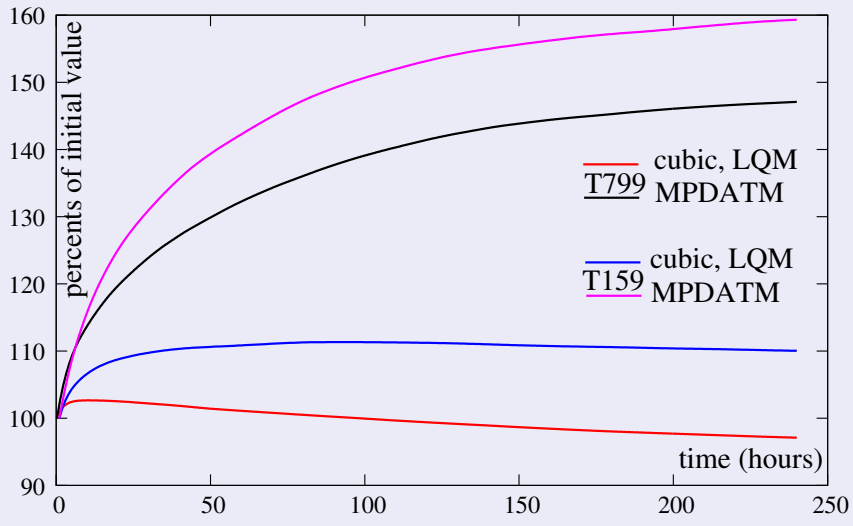


3D adiabatic transport

Total mass O_3
10 day evolution
no chemistry
adiabatic
no diffusion scheme

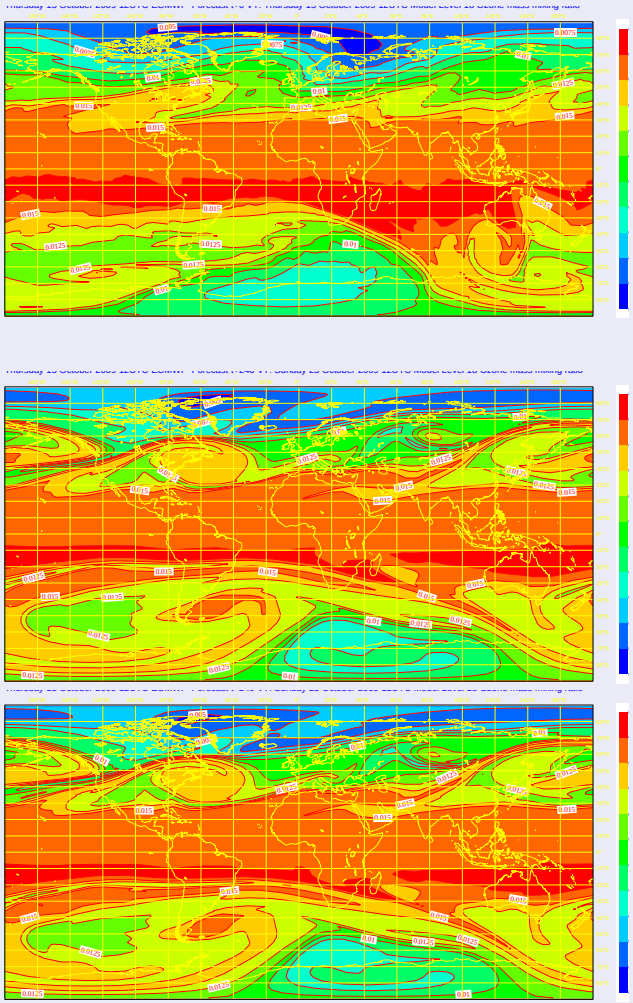


Total mass cloud content
10 day evolution
adiabatic
no diffusion scheme

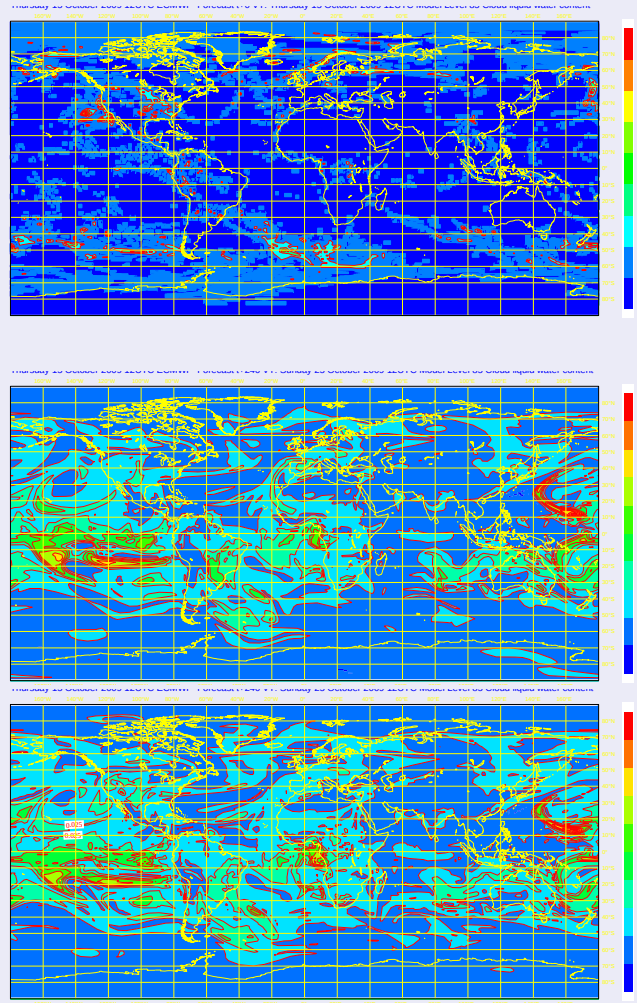


3D adiabatic transport

O_3:
large scale structures at day 0
day 10 - Cubic and MPDATA



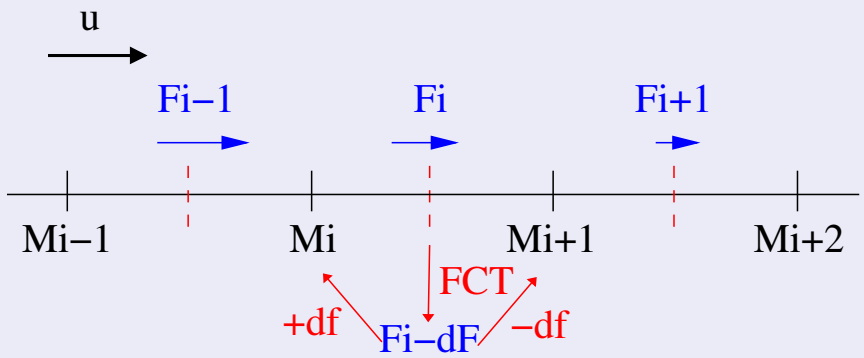
Cloud content:
very spotty at day 0
day 10 - Cubic and MPDATA



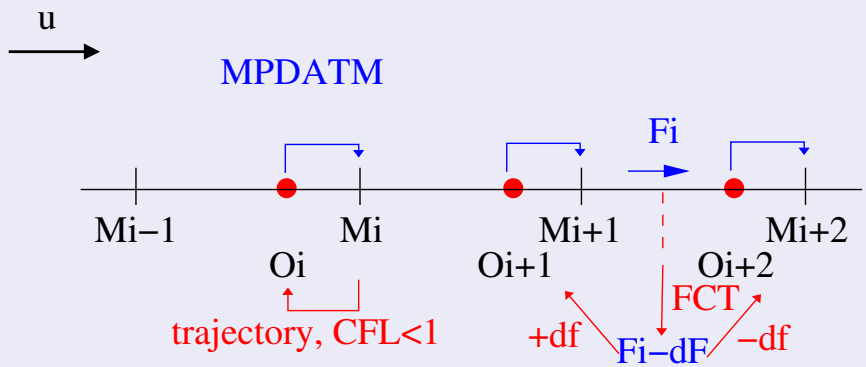
Flux Corrected Transport

Eulerian FCT

Flux limitation with respect to what is available at the grid point upstream



SL FCT



1D transport - Constant wind advection - FCT

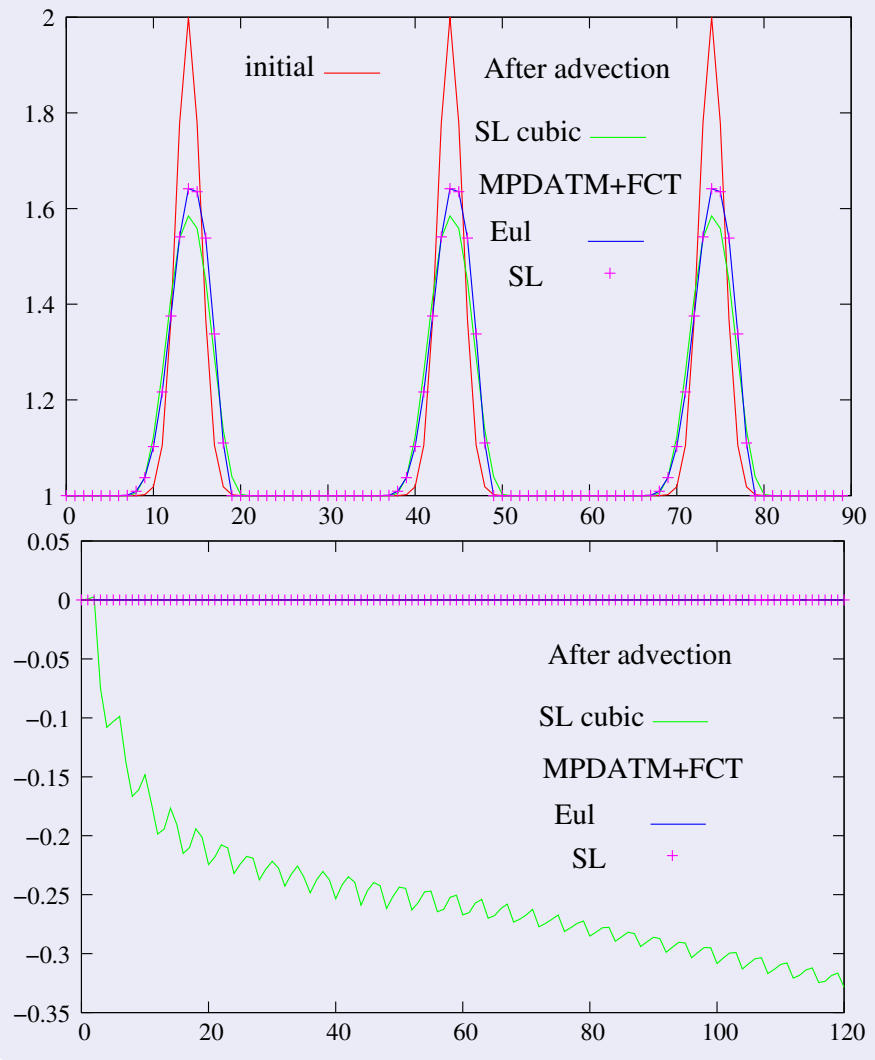
For 1D advection with constant wind,

Eulerian MPDATM+FCT

=

SL MPDATM with FCT

$\Rightarrow$ perfect conservation



Summary

- MPDATA formalism has been introduced in the IFS as a new interpolation method for the SL.
- Results with the 2nd order MPDATM scheme without monotonous filter or with a simple monotonous filter are generally equivalent or worse than cubic without or with the same filter.

- For 1D advection with constant wind, MPDATM Eulerian with FCT = SL with MPDATM interpolation and FCT: good shape conservation, perfect conservation
- FCT control the computation for the all "unstructured" grid of departure points: generalisation to real atmospheric flows? feasibility in the IFS?