A non-interpolating semi-Lagrangian scheme for the continuity equation of the ECMWF forecast model.

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Area of Modelization

Spanish Meteorological Agency (AEMET)

Project 4: Formation in technical used in the dynamics of the numerical weather models.

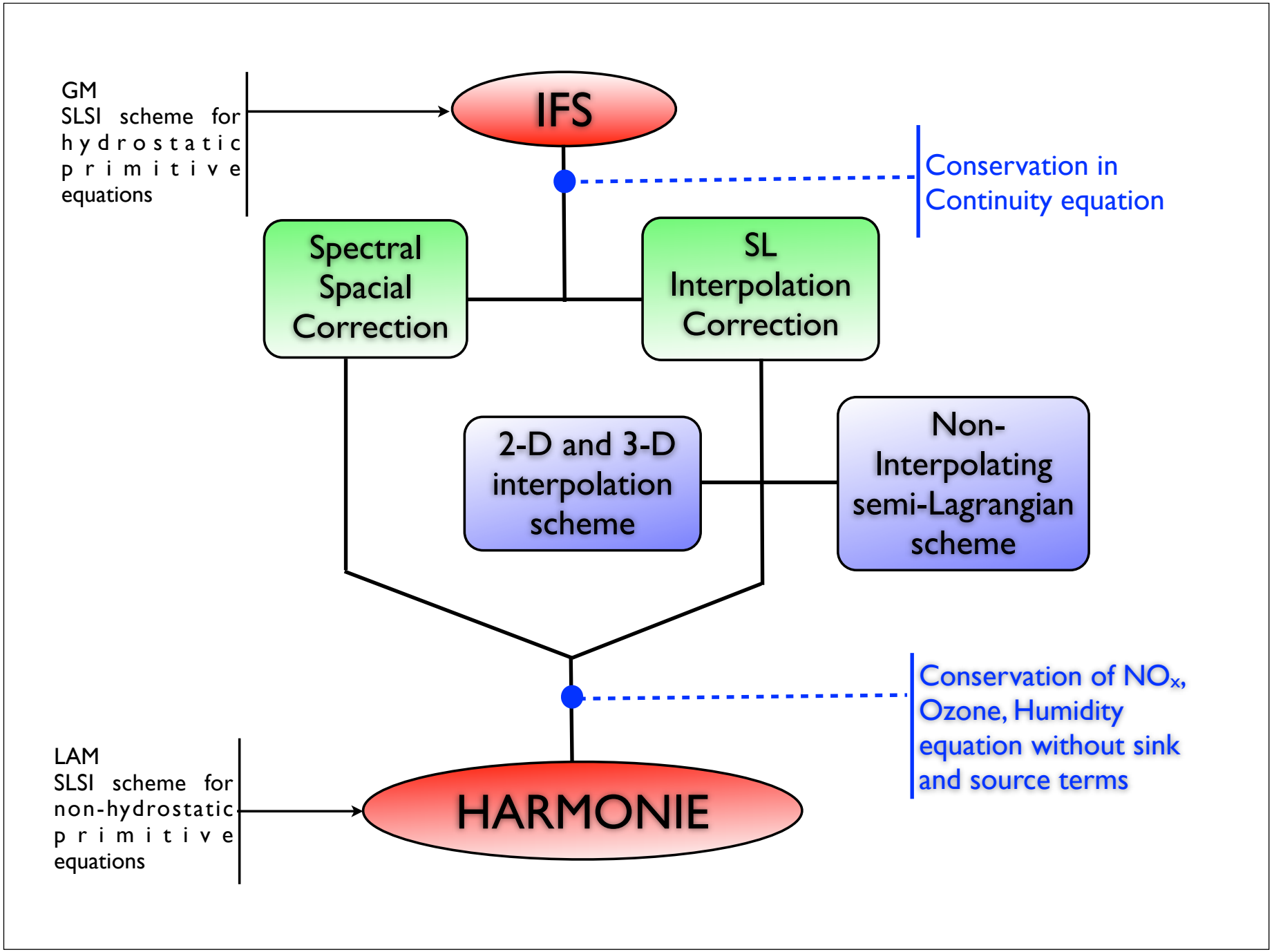
Outline

- Conclusions of previous works.

- A non-interpolating semi-Lagrangian scheme for the continuity equation (NI-SLCE).

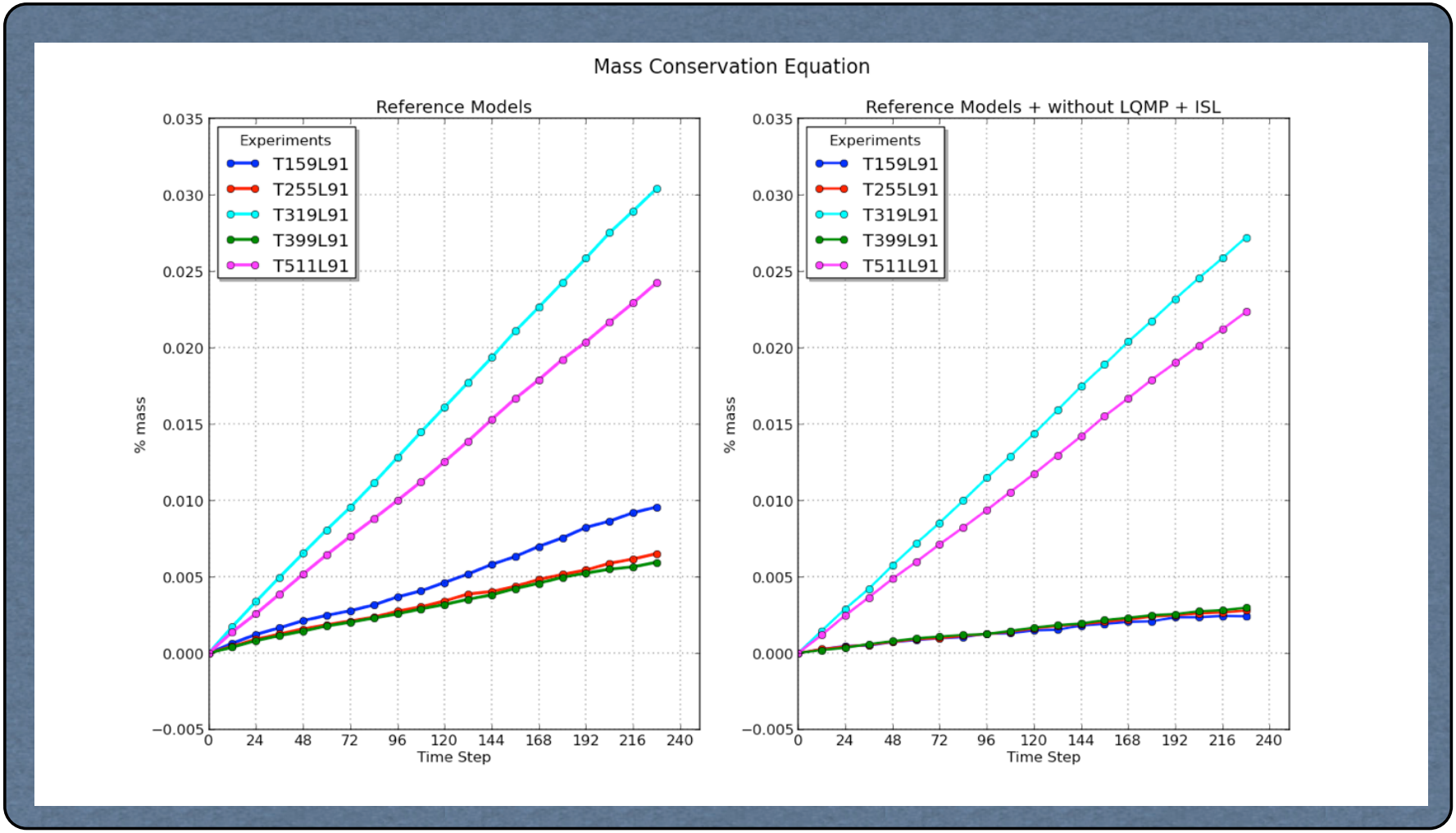
- Implementation of NI-SLCE in semi-Lagrangian semi-implicit (SLSI) scheme of the ECMWF Forecast Model.

- New conclusions.


GM
SLSI scheme for hydrostatic primitive equations
IFS
Conservation in Continuity equation
Spectral Spacial Correction
SL Interpolation Correction
2-D and 3-D interpolation scheme
Non-Interpolating semi-Lagrangian scheme
Conservation of NOx, Ozone, Humidity equation without sink and source terms
LAM
SLSI scheme for non-hydrostatic primitive equations
HARMONIE

Conclusions of previous works

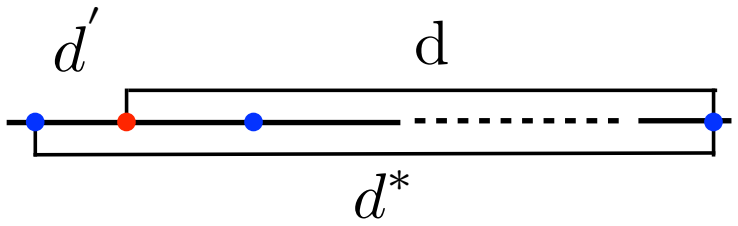
Why should we use a NI-SLCE scheme to calculate the value of the fields at the departure point of the semi-Lagrangian trajectory?



SL scheme

$$\frac{dX}{dt} = RHS \longrightarrow X^{A,+} = X^{D,0} + RHS^{D,0}$$

NI-SL scheme



$$v = v^{'} + v^{*}$$

$$\frac{\partial X}{\partial t} + (v^{'} + v^{*})\frac{\partial X}{\partial x} = RHS \longrightarrow \frac{D^{*}X}{Dt} + v^{'}\frac{\partial X}{\partial x} = RHS$$

$$X^{A,+} = \left\{ X - d\frac{\partial X}{\partial x} \right\}^{*,0} + RHS^{*,0}$$

A non-interpolating SL scheme for the continuity equation

NI-SLCE

Temporal discretization

Non-interpolating semi-Lagrangian semi-implicit time integration scheme (only for the continuity equation).

Spacial discretization

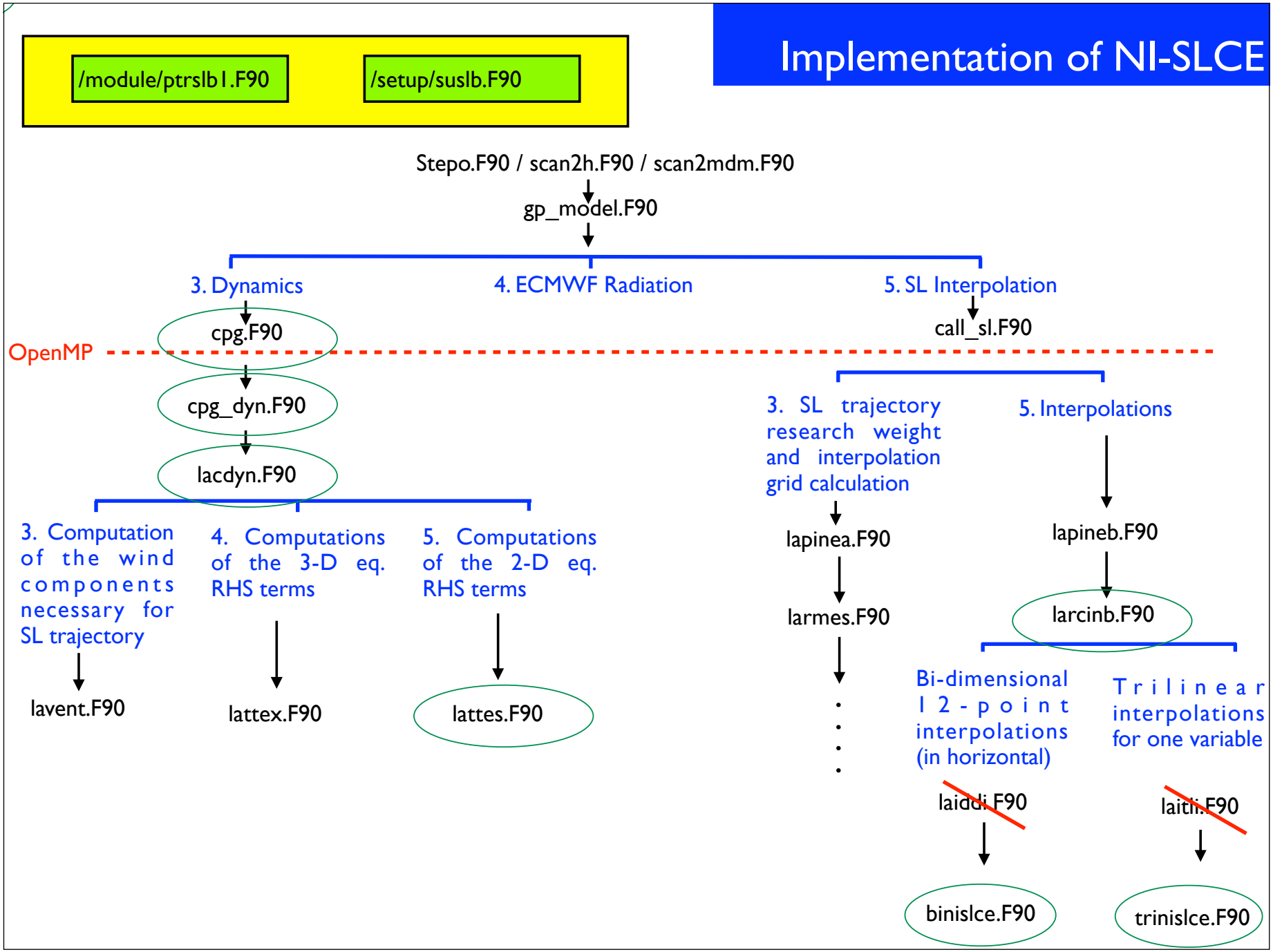
Spectral in the horizontal (spherical harmonics).

Pseudo-spectral (finite-element) vertical representation (cubic B-spline).

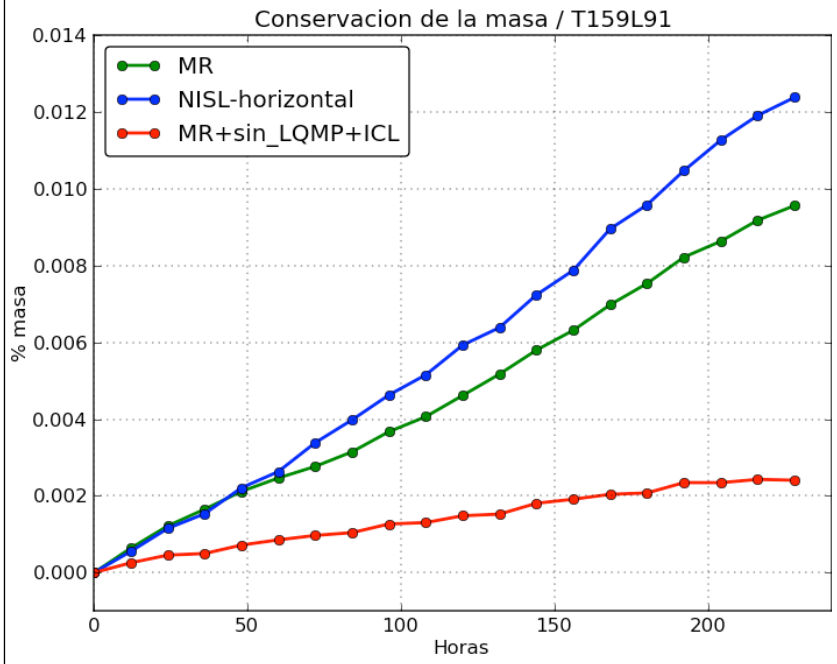
$$Lnp_{sup}^{A,+} = \underbrace{\{Lnp_{sup} - d\nabla Lnp_{sup}\}^{*,0}}_{\mathbf{A}} + \underbrace{\{N.L. + L.\}^{*,0}}_{\mathbf{B}} + \underbrace{\{L.\}^{A,+}}_{\mathbf{C}}$$

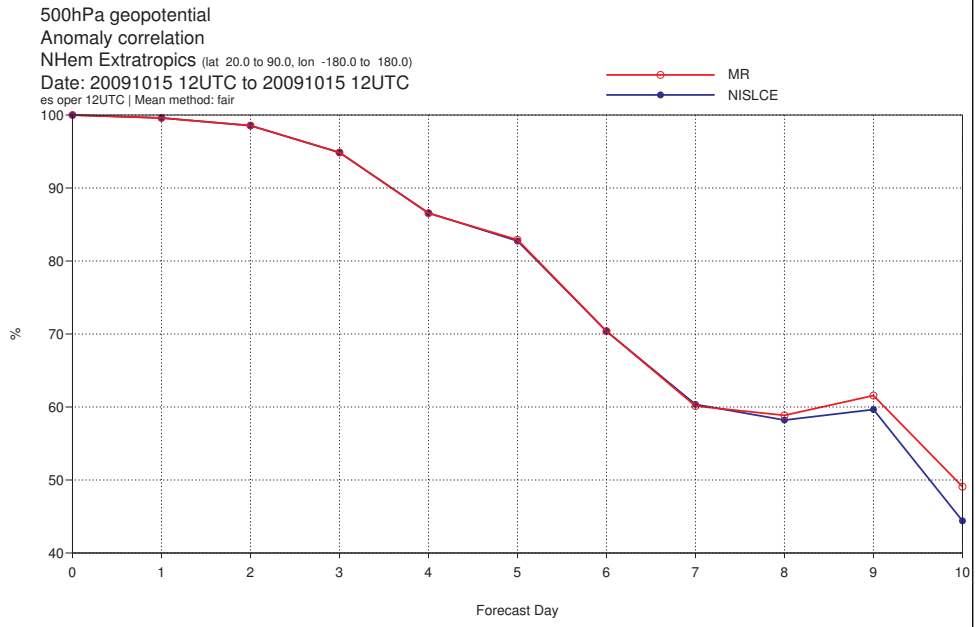
$$Lnp_{sup}^{A,+} + \{L.\}^{A,+} = \underbrace{\{Lnp_{sup} - d\nabla Lnp_{sup}\}^{*,0}}_{\mathbf{I}} + \underbrace{\{N.L. + L.\}^{*,0}}_{\mathbf{2}}$$

Implementation of NI-SLCE

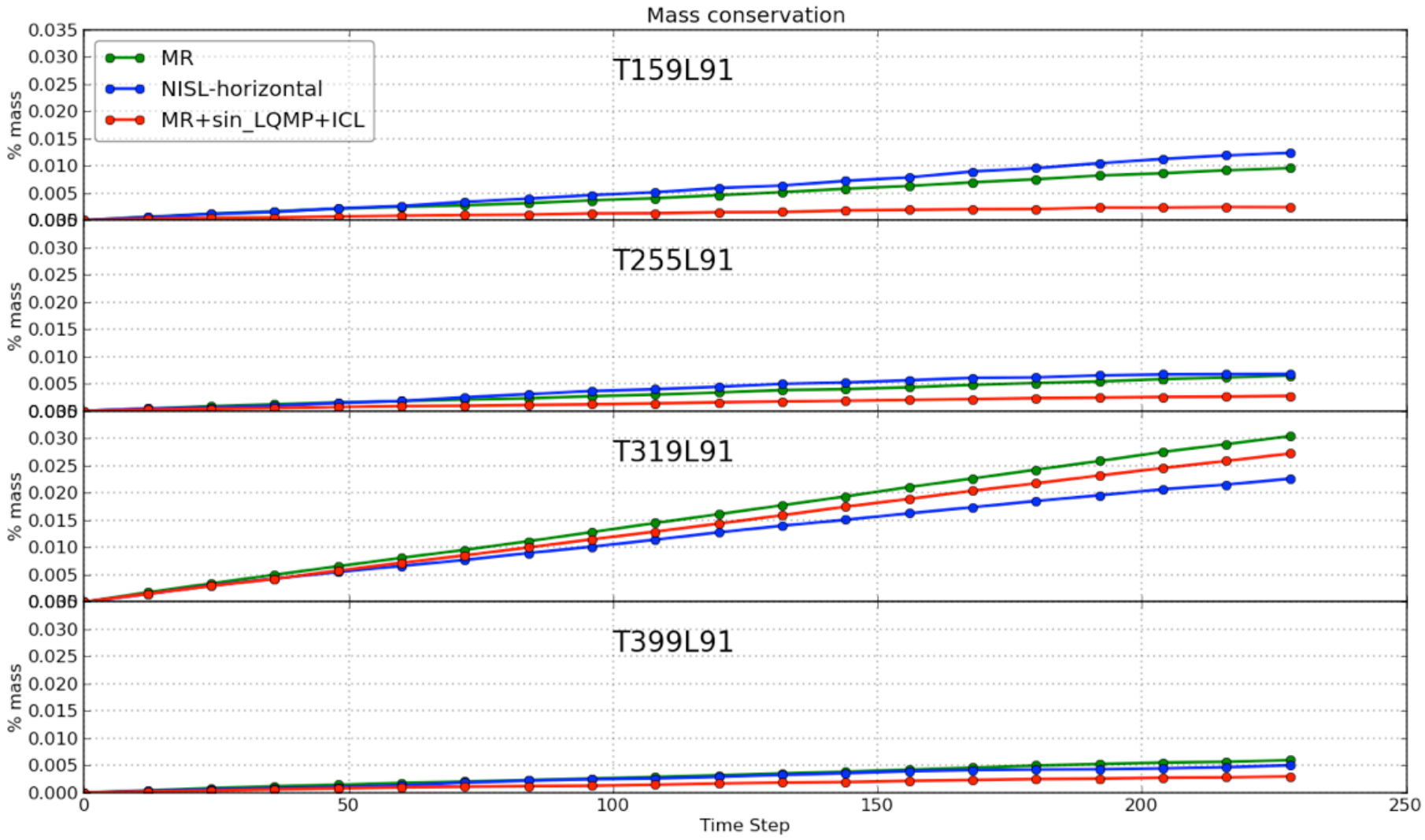


Results

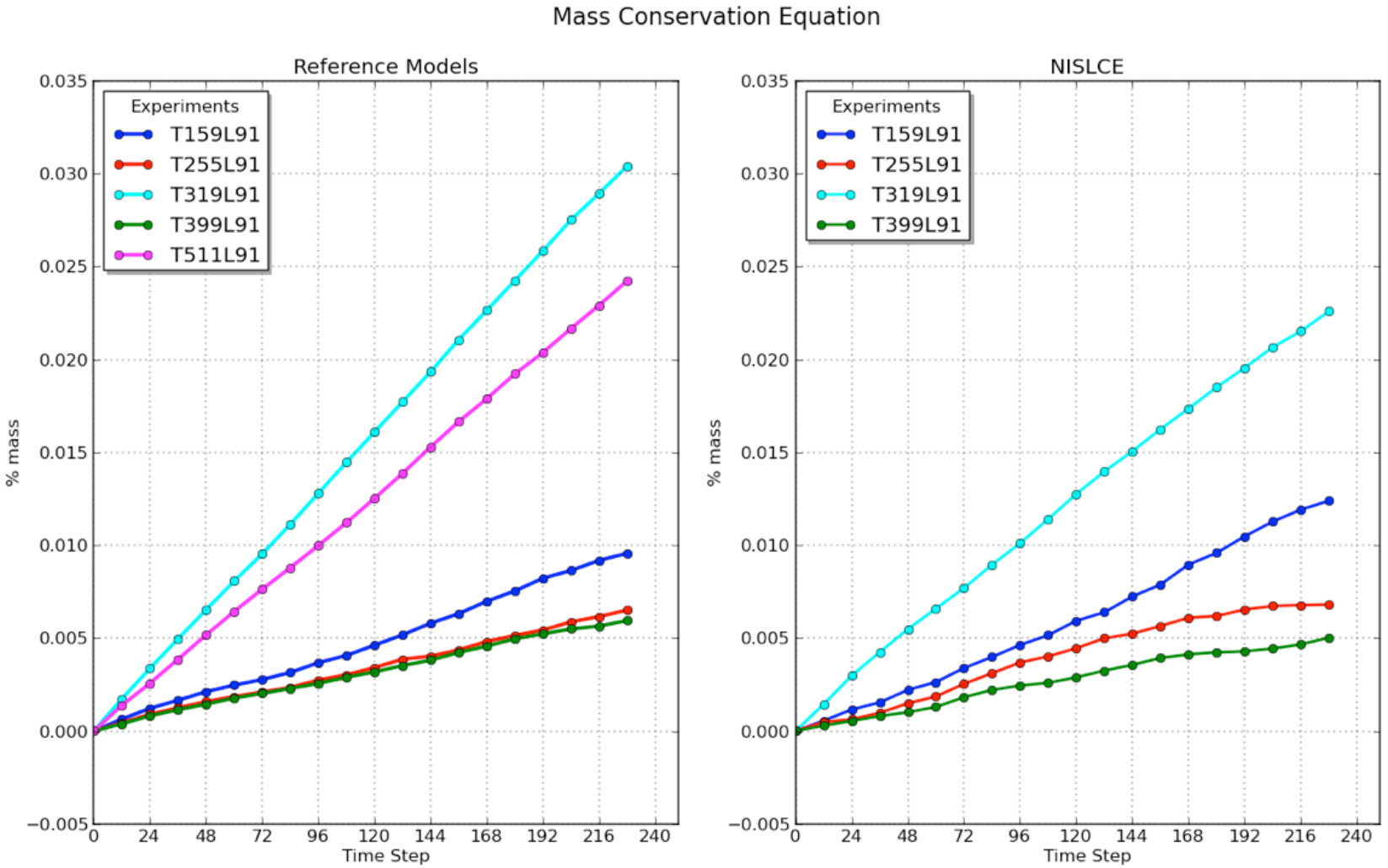

Conservacion de la masa / T159L91
MR
NISL-horizontal
MR+sin_LQMP+ICL
% masa
Horas
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
0
50
100
150
200


500hPa geopotential
Anomaly correlation
NHem Extratropics (lat 20.0 to 90.0, lon -180.0 to 180.0)
Date: 20091015 12UTC to 20091015 12UTC
es oper 12UTC | Mean method: fair
MR
NISLCE
%
Forecast Day
100
90
80
70
60
50
40
0
1
2
3
4
5
6
7
8
9
10

Results


Mass conservation
MR
NISL-horizontal
MR+sin_LQMP+ICL
T159L91
T255L91
T319L91
T399L91
% mass
Time Step
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
0
50
100
150
200
250

Results


Mass Conservation Equation
Reference Models
NISLCE
Experiments
T159L91
T255L91
T319L91
T399L91
T511L91
% mass
Time Step
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
−0.005
0
24
48
72
96
120
144
168
192
216
240

Conclusions

- The NI-SLCE in the horizontal scheme does not improve the conservation of the mass in the continuity equation.

- It is better to continue using interpolation methods to calculate the value of the field at the departure point of the semi-Lagrangian trajectory.