



Dynamics & Coupling

2005-2006 progress report

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CHMI

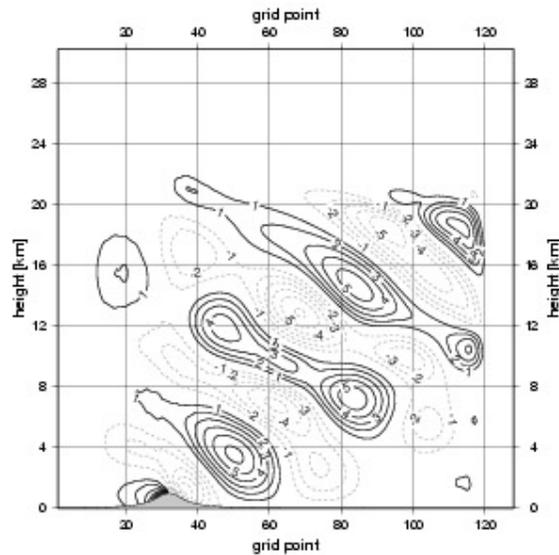


Diffusive chimney in NH dynamics

Work of: M. Vörös (Hu), R. Brožková (Cz) and F. Váňa (Cz)

```

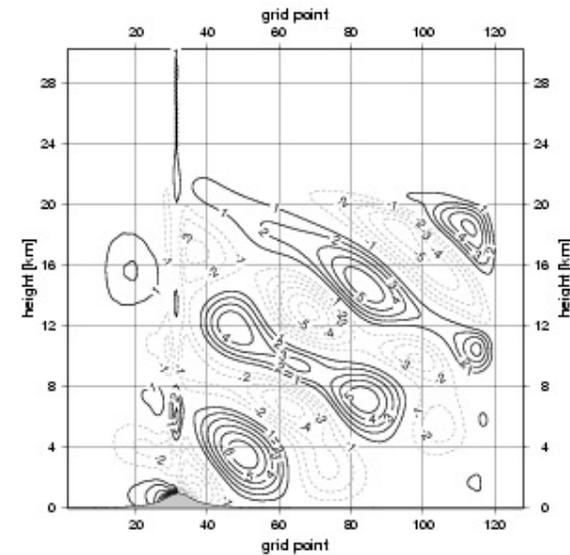
NLNH FLOW
NH vertical velocity [m/s], NSTEP = 40500
init_001_ILMRO2, agnes1, sigma-coordinate, regular z-levels
master_sl2st2_00_000
NH sl2t1, (HRO/AR, HVO/AR) = (2, 3), (ESTER = 3, LPC_FULL, LPC_DESC, LROBCC
TSTEP = 10.0 s
SIPR = 90000 Pa S1TR = 300 K S1TRA = 50 K
POO = 101325 Pa T00 = 293 K V00 = 10 m/s
RRR/AR = 0.01 1/s T_TROPO = 188 K
MOTR = 1000 m HEIGHT = 1000 m POSITION = 32
DELY = 300 m DELZ = 300 m
RESPORT = 30000 m REPORTP = 29500 m REPORTAD = 50 s
ROIR/O = 0 ROIR/OR = 0
ROIR/O = 0 ROIR/T = 0
    
```



min: -10.844
max: 9.476
step: 1.0

```

NLNH FLOW
NH vertical velocity [m/s], NSTEP = 40500
init_001_ILMRO2, agnes1, sigma-coordinate, regular z-levels
master_sl2st2_00_000
NH sl2t1, (HRO/AR, HVO/AR) = (2, 3), (ESTER = 3, LPC_FULL, LPC_DESC, LROBCC
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SIPR = 90000 Pa S1TR = 300 K S1TRA = 50 K
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RRR/AR = 0.01 1/s T_TROPO = 188 K
MOTR = 1000 m HEIGHT = 1000 m POSITION = 32
DELY = 300 m DELZ = 300 m
RESPORT = 30000 m REPORTP = 29500 m REPORTAD = 50 s
ROIR/O = 5 s ROIR/OR = 0
ROIR/O = 5 s ROIR/T = 0
    
```



min: -10.947
max: 9.5
step: 1.0

Fig. 7: NH sl2t1, d_3 + new BBC, no diffusion.

Fig. 8: NH sl2t1, d_3 + new BBC, diffusion.



Diffusive chimney in NH dynamics

BBC for the term $\frac{\partial \tilde{p}}{\partial \pi}$

$$\left(\frac{\partial \tilde{p}}{\partial \pi}\right)_S = \frac{\left[-\frac{RT}{p}\nabla p - \nabla\phi + \mathbf{v}\right]_S \cdot \nabla\phi_S + J_S - g\mathbf{w}_S}{g^2 + (\nabla\phi_S)^2}$$

$$J_S = \frac{\partial^2 \phi_S}{\partial x^2} u_S^2 + 2\frac{\partial^2 \phi_S}{\partial x \partial y} u_S v_S + \frac{\partial^2 \phi_S}{\partial y^2} v_S^2$$



Diffusive chimney in NH dynamics

BBC for the term $\frac{\partial \tilde{p}}{\partial \pi}$

$$\left(\frac{\partial \tilde{p}}{\partial \pi}\right)_S = \frac{\left[-\frac{RT}{p}\nabla p - \nabla\phi + \mathcal{V}\right]_S \cdot \nabla\phi_S + J_S - g\mathcal{W}_S}{g^2 + (\nabla\phi_S)^2}$$

$$J_S = \frac{\partial^2 \phi_S}{\partial x^2} u_S^2 + 2\frac{\partial^2 \phi_S}{\partial x \partial y} u_S v_S + \frac{\partial^2 \phi_S}{\partial y^2} v_S^2$$

Here \mathcal{V} and \mathcal{W} are the source terms of momentum containing coriolis, diabatic tendencies and **horizontal diffusion**.



Diffusive chimney in NH dynamics

Possible alternatives:



Diffusive chimney in NH dynamics

Possible alternatives:

- Switch off HD



Diffusive chimney in NH dynamics

Possible alternatives:

- Switch off HD
- Introduce extra spectral computation



Diffusive chimney in NH dynamics

Possible alternatives:

- Switch off HD
- Introduce extra spectral computation
- Use HD computed in GP space



Diffusive chimney in NH dynamics

Possible alternatives:

- Switch off HD
- Introduce extra spectral computation
- Use HD computed in GP space

Semi-**L**agrangian **H**orizontal **D**iffusion = way to control damping properties of the SL interpolation according to the flow deformation.

⇒ **SLHD solution for ALADIN NH dynamics?**



Diffusive chimney in NH dynamics

ALADIN 2TL SISL:

$$X_F^+ = \left(1 - \frac{\Delta t}{2} \mathcal{L}\right)^{-1} \left[\underbrace{\left(1 + \frac{\Delta t}{2} \mathcal{L}\right) X_O^- + \Delta t \mathcal{F}_O^- + \frac{\Delta t}{2} \mathcal{N}_O^*}_{SLHD} + \frac{\Delta t}{2} \mathcal{N}_F^* \right]$$

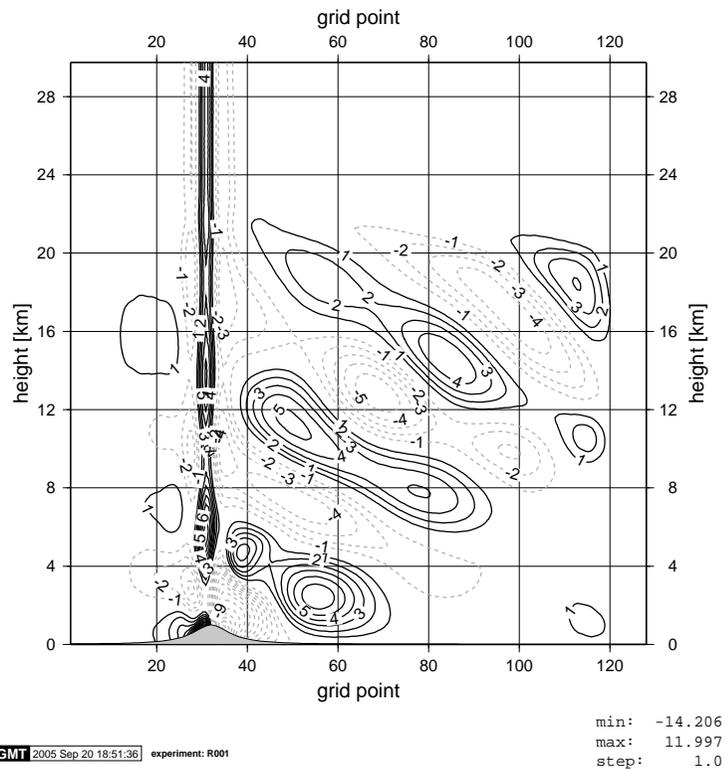
Extra spectral diffusion (= supporting diffusion) is needed for u , v and d (having ϕ_S in their \mathcal{N}).



Diffusive chimney in NH dynamics

Reference experiment #1
NH vertical velocity [m/s], NSTEP = +0500

A recreation of a 2D experiment of Jan Masek
Nonhydrostatic, nonlinear, Bell shaped mountain
Using diffusion - expecting a chimney



● Spectral diffusion



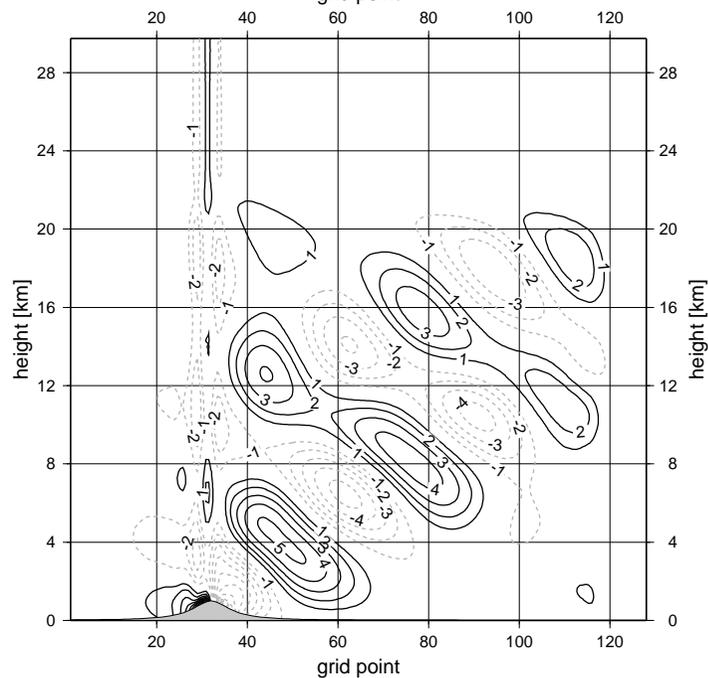
Diffusive chimney in NH dynamics

Reference experiment cy29 SLHD #1
NH vertical velocity [m/s], NSTEP = +0500

A recreation of a 2D experiment of Jan Masek
Nonhydrostatic, nonlinear, Bell shaped mountain
Using SLHD, normal diffusion strength, DiagBBC

```

LNHDYN=.T.      LTWOTL=.T.      NSITER=3
LPC_FULLL=.T.   LPC_NESC=.T.     LPC_OLD=.F.
LADV=.F.        LGWADV=.F.     LRDBBC=.T.
RRDXTAU=551.1352 RDAMPDIVS=1.  RDAMPVORS=5.
SIPR=90000.     SITR=300.      SITRA=50.
NVDVAR=3        NPDVAR=2        ND4SYS=1
REPONBT=20000.  REPONTAU=100.   REPONTP=29500.
NSPONGE=2       LSLHD_W=.T.     LSLHD_SVD=.T.
SLHDA0=0.25     SLHDB=4.         SLHDD00=6.5E-5  ZSLHDP1=1.7
ZSLHDP3=0.6     ALPHINT=0.15    GAMMAX0=0.15    SLHDKMAX n/a
RDAMPVORS=5.    RDAMPDIVS=1.    RDAMPVDS n/a    REXPDHS=6.
SLEVDHS=1.     SLEVDHS2 n/a
    
```



min: -11.865
max: 10.24
step: 1.0

GMT 2005 Oct 6 14:30:31 experiment: R016

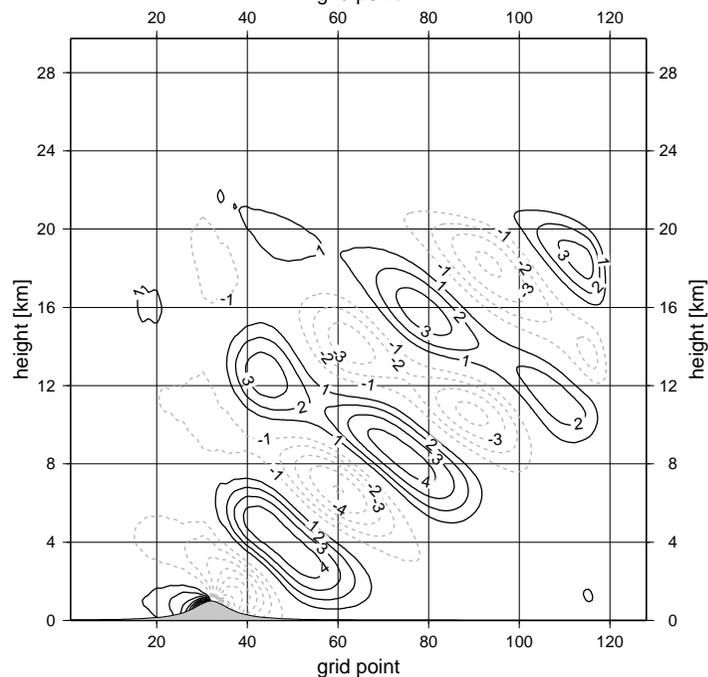


- Spectral diffusion
- Default SLHD

Diffusive chimney in NH dynamics

Reference experiment cy29 SLHD #2
NH vertical velocity [m/s], NSTEP = +0500

A recreation of a 2D experiment of Jan Masek
Nonhydrostatic, nonlinear, Bell shaped mountain
Using SLHD, no residual diffusion, diagBBC
LNHDYN=.T. LTWOTL=.T. NSITER=3
LPC_FULL=.T. LPC_NESC=.T. LPC_OLD=.F.
LADV=.F. LGWADV=.F. LRBBBC=.T.
RRDXTAU=0. RDAMPDIVS=1. RDAMPVORS=5.
SIPR=90000. SITR=300. SITRA=50.
NVDVAR=3 NPDVAR=2 ND4SYS=1
REPONBT=20000. REPONTAU=100. REPONTP=29500.
NSPONGE=2 LSLHD_W=.T. LSLHD_SVD=.T.
SLHDA0=0.25 SLHDB=4. SLHDD00=6.5E-5 ZSLHDP1=1.7
ZSLHDP3=0.6 ALPHINT=0.15 GAMMAX0=0.15 SLHDKMAX n/a
RDAMPVORS=5. RDAMPDIVS=1. RDAMPVDS n/a REXPDHS=6.
SLEVDHS=1. SLEVDHS2 n/a SLEVDHS3 n/a



min: -11.622
max: 9.802
step: 1.0

GMT 2006 Jan 3 14:21:34 experiment: R018



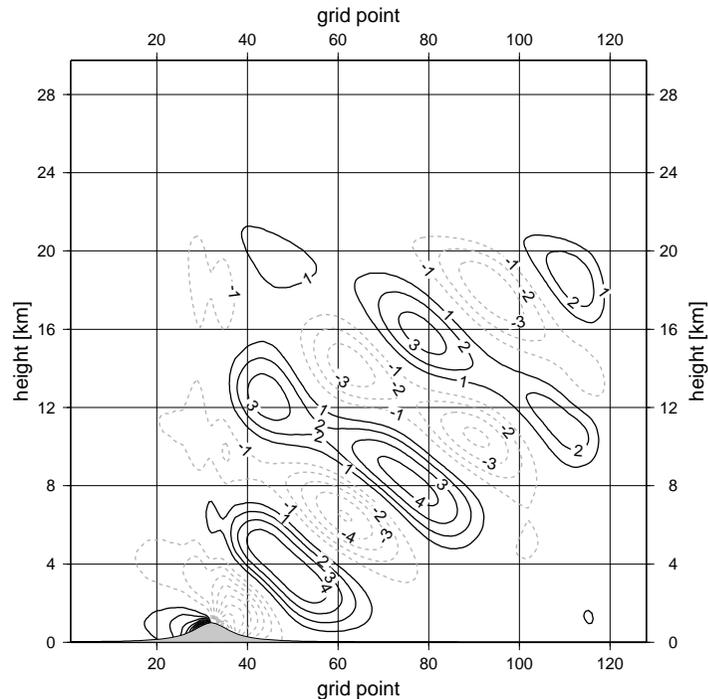
- Spectral diffusion
- Default SLHD
- Only GP part of SLHD

Diffusive chimney in NH dynamics

Reference experiment cy29 SLHD - Tuned RDAMPVDS
NH vertical velocity [m/s], NSTEP = +0500

```

Nonhydrostatic, nonlinear, Bell shaped mountain
Using SLHD, normal diffusion strength, DiagBBC
LNHDYN=.T.      LTWOTL=.T.      NSITER=3
LPC_FULLL=.T.   LPC_NESC=.T.     LPC_OLD=.F.
LADV=.F.        LGWADV=.F.     LRBBBC=.T.
RRDXTAU=551.1352 RDAMPDIVS=1.   RDAMPVORS=5.
SIPR=90000.     SITR=300.      SITRA=50.
NVDVAR=3        NPDVAR=2        ND4SYS=1
REPONBT=20000.  REPONTAU=100.   REPONTP=29500.
NSPONGE=2       LSLHD_W=.T.     LSLHD_SVD=.T.
SLHDA0=0.25     SLHDB=4.         SLHDD00=6.5E-5  ZSLHDP1=1.7
ZSLHDP3=0.6     ALPHINT=0.15     GAMMAX0=0.15    SLHDKMAX n/a
RDAMPVORS=5.    RDAMPDIVS=1.    RDAMPVDS=15.    REXPDHS=6.
SLEVDHS=1.      SLEVDHS2 n/a    SDRED=1.
    
```



min: -11.818
max: 10.151
step: 1.0

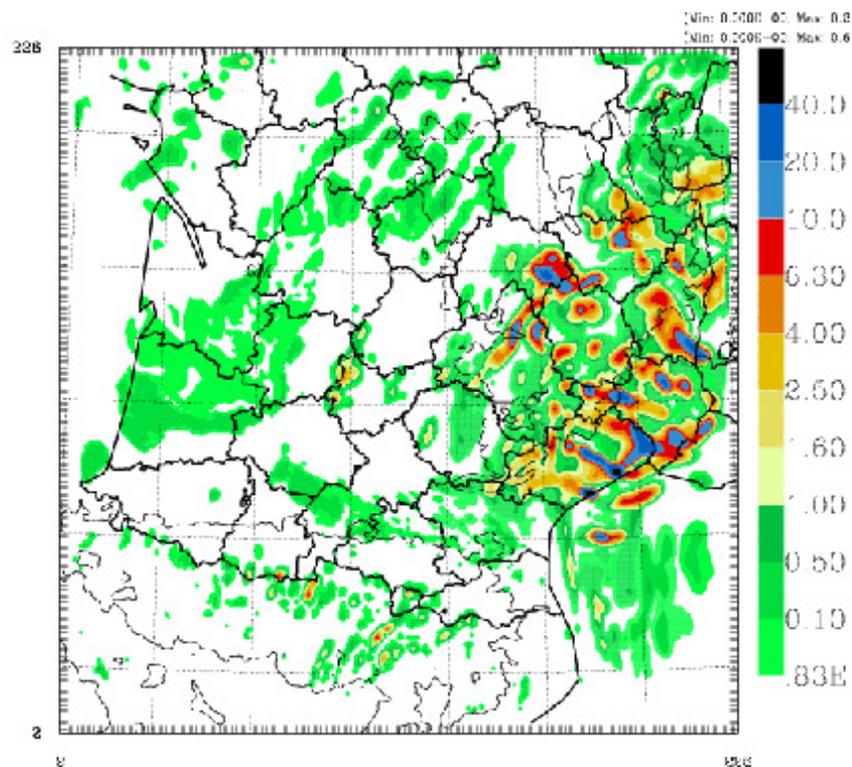
GMT 2006 Apr 3 10:00:04 experiment: R060



- Spectral diffusion
- Default SLHD
- Only GP part of SLHD
- New SLHD

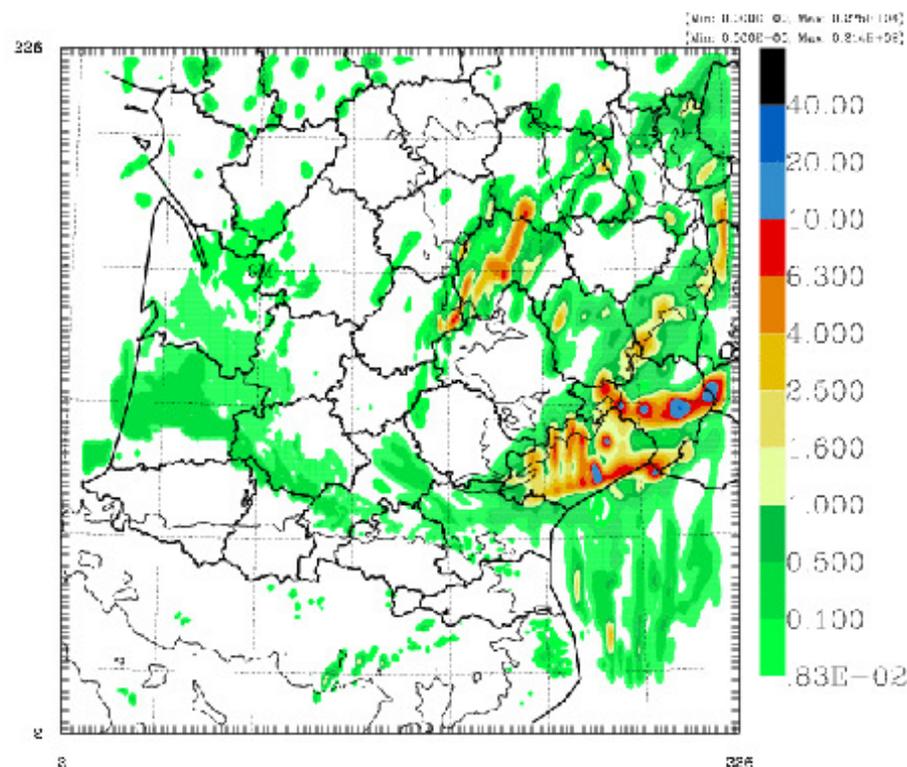
Diffusive chimney in NH dynamics

AROME instantaneous rainfalls 19-Oct-2005 00 UTC



INPR (0) + INPRS (0) + INPRD (0)
DATE MOD: 2005/10/18 08:59M 03 DATE CLR: 2005/10/18 08:59M 03
DATE EXP: 2005/10/18 21:59M 03 DATE ESC: 2005/10/18 08:59M 03 LAMBERT

AROME MIDPYR old diffusion



INPR (0) + INPRS (0) + INPRD (0)
DATE MOD: 2005/10/18 08:59M 03 DATE CLR: 2005/10/18 08:59M 03
DATE EXP: 2005/10/18 21:59M 03 DATE ESC: 2005/10/18 08:59M 03 LAMBERT

AROME MIDPYR LRDBBC+SLHD



Non-isothermal SI background



Work of: **J. Vivoda (Sk)**

$$T^*, T_a^* \Rightarrow T^*(\eta), T_a^*(\eta)$$



Non-isothermal SI background



Work of: **J. Vivoda (Sk)**

$$T^*, T_a^* \Rightarrow T^*(\eta), T_a^*(\eta)$$

System becomes more complicated:

- Non trivial setup for $T^*(\eta), T_a^*(\eta)$
- No analyze for optimal $T^*(\eta), T_a^*(\eta)$ setting (at the moment)
- Helmholtz solver becomes the two equations system





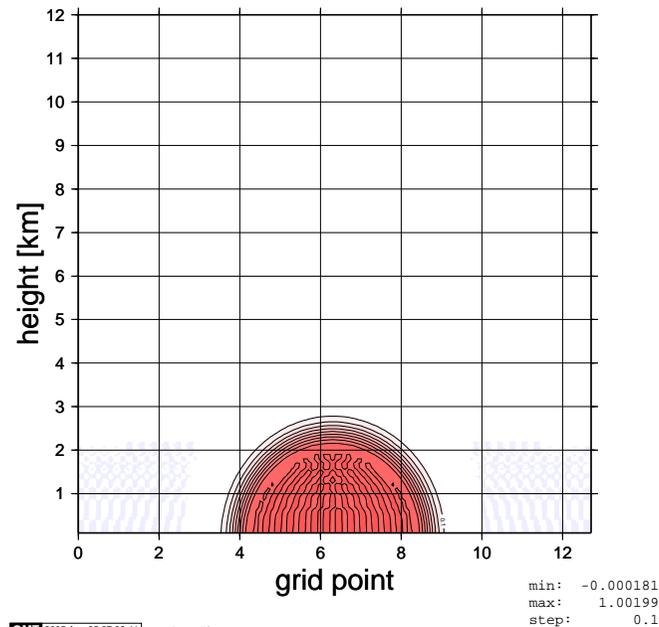
Non-isothermal SI background

2D explicit convection test

Explicit Convection Experiment
perturbation of potential temperature [K], NSTEP = +0000

```
NVDVAR=4      NPDVAR=2      LGWADV=.T.      ND4SYS = 1
XIDT =0.0     VESL=0.0     SITRA=100.     SITR=350.
SIPR=101325.  TSTEP=1      NDLNPR=1      NSITER=1
LSETTLS=.F.  LPC_XIDT=.F.  LPC_OLD =.F.   LPC_FULL=.T.
LPC_NOTR=.F. LPC_NESC=.T.  LNHDYN=.T.    LTWOTL=.T.
LSLAG=.T.     RCMSLP0=1.0    LSI_NONISOTHERMAL=.F.
```

no sponge
no lateral coupling
no Asseline filter
no diffusion



Initial state





Non-isothermal SI background

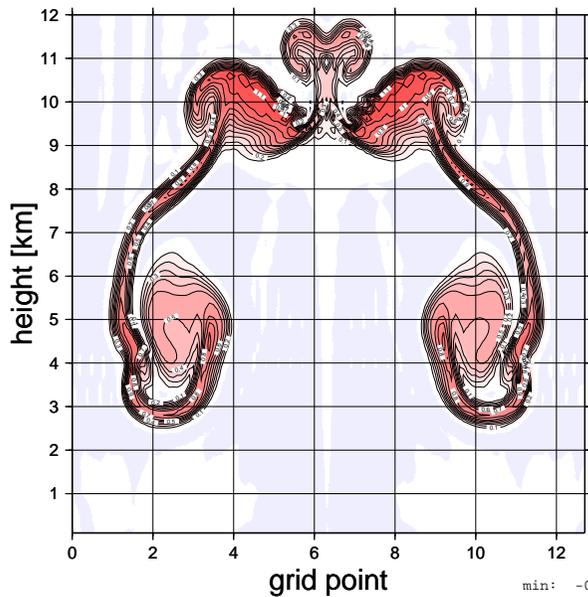
2D explicit convection test

Explicit Convection Experiment
perturbation of potential temperature [K], NSTEP = +4000

```

NVDVAR=4   NPDVAR=2   LGWADV=.T.   ND4SYS = 1
XIDT =0.0   VESL=0.0   SITRA=100.  SITR=350.
SIPR=101325. TSTEP=0.5   NDNLNR=1   NSITER=1
LSETTLS=.F. LPC_XIDT=.F. LPC_OLD =.F.  LPC_FULL=.T.
LPC_NOTR=.F. LPC_NESC=.T. LNHDYN=.T.  LTWOTL=.T.
LSLAG=.T.   RCMSLP0=1.0 LSI_NONISOTHERMAL=.F.
no sponge
no lateral coupling
no Asseline filter
no diffusion

```



GMT 2005 Aug 25 07:32:58 experiment: EC31

```

min: -0.113654
max:  1.2115
step:  0.1

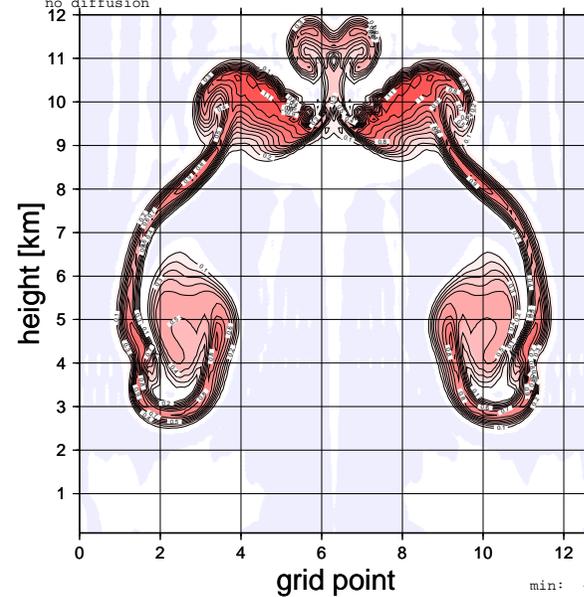
```

Explicit Convection Experiment
perturbation of potential temperature [K], NSTEP = +4000

```

NVDVAR=4   NPDVAR=2   LGWADV=.T.   ND4SYS = 1
XIDT =0.0   VESL=0.0   SITRA=100.  SITR=350.
SIPR=101325. TSTEP=0.5   NDNLNR=1   NSITER=1
LSETTLS=.F. LPC_XIDT=.F. LPC_OLD =.F.  LPC_FULL=.T.
LPC_NOTR=.F. LPC_NESC=.T. LNHDYN=.T.  LTWOTL=.T.
LSLAG=.T.   RCMSLP0=1.0 LSI_NONISOTHERMAL=.F.
no sponge
no lateral coupling
no Asseline filter
no diffusion

```



GMT 2005 Aug 25 07:33:01 experiment: EC33

```

min: -0.124471
max:  1.23164
step:  0.1

```

$$\Delta t = 0.5 \text{ s } (\Delta x = \Delta z = 100 \text{ m})$$





Non-isothermal SI background

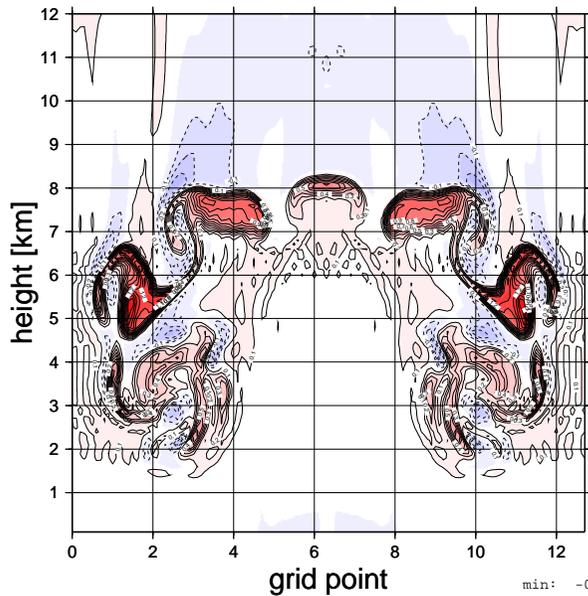
2D explicit convection test

Explicit Convection Experiment
perturbation of potential temperature [K], NSTEP = +0100

```

NVDVAR=4      NPDVAR=2      LGWADV=.T.      ND4SYS = 1
XIDT =0.0     VESL=0.0      SITRA=100.     SITR=350.
SIPR=101325.  TSTEP=20      NDLNPR=1      NSITER=1
LSETTLS=.F.   LPC_XIDT=.F.   LPC_OLD =.F.   LPC_FULL=.T.
LPC_NOTR=.F.  LPC_NESC=.T.         LNHDYN=.T.    LTWOTL=.T.
LSLAG=.T.     RCMSLP0=1.0    LSI_NONISOTHERMAL=.F.
no sponge
no lateral coupling
no Asseline filter
no diffusion

```



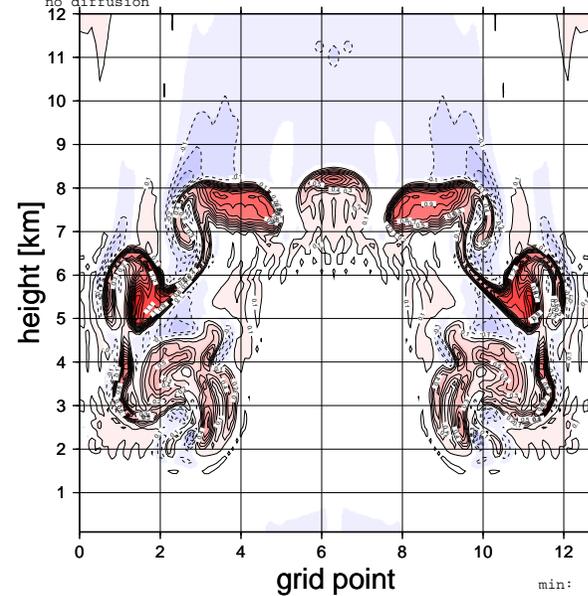
GMT 2005 Aug 25 07:32:52 experiment: EC21

Explicit Convection Experiment
perturbation of potential temperature [K], NSTEP = +0100

```

NVDVAR=4      NPDVAR=2      LGWADV=.T.      ND4SYS = 1
XIDT =0.0     VESL=0.0      SITRA=100.     SITR=350.
SIPR=101325.  TSTEP=20      NDLNPR=1      NSITER=1
LSETTLS=.F.   LPC_XIDT=.F.   LPC_OLD =.F.   LPC_FULL=.T.
LPC_NOTR=.F.  LPC_NESC=.T.         LNHDYN=.T.    LTWOTL=.T.
LSLAG=.T.     RCMSLP0=1.0    LSI_NONISOTHERMAL=.F.
no sponge
no lateral coupling
no Asseline filter
no diffusion

```



GMT 2005 Aug 25 07:32:55 experiment: EC23

$$\Delta t = 20. \text{ s } (\Delta x = \Delta z = 100 \text{ m})$$



Vertical Finite Element scheme



Work of: **J. Vivoda (Sk)**

- VFE scheme successfully implemented into the HY model (Untch and Hortal)



Vertical Finite Element scheme



Work of: **J. Vivoda (Sk)**

- VFE scheme successfully implemented into the HY model (Untch and Hortal)
- Is it extensible to the NH dynamics? (Bénard - compatibility and Vivoda - stability)



Vertical Finite Element scheme



Work of: **J. Vivoda (Sk)**

- VFE scheme successfully implemented into the HY model (Untch and Hortal)
- Is it extensible to the NH dynamics? (Bénard - compatibility and Vivoda - stability)
- The only non-local operations in the vertical are integrations in HY dynamics (SL version). In NH dynamics also derivatives plays important role (structure equation contains vertical laplacian).



Vertical Finite Element scheme



Work of: **J. Vivoda (Sk)**

- VFE scheme successfully implemented into the HY model (Untch and Hortal)
- Is it extensible to the NH dynamics? (Bénard - compatibility and Vivoda - stability)
- The only non-local operations in the vertical are integrations in HY dynamics (SL version). In NH dynamics also derivatives plays important role (structure equation contains vertical laplacian).
- First version of VFE implemented to the code → stable, efficient (2-3 % extra CPU) but (for the moment) noisy.



Vertical Finite Element scheme



Work of: **J. Vivoda (Sk)**

- VFE scheme successfully implemented into the HY model (Untch and Hortal)
- Is it extensible to the NH dynamics? (Bénard - compatibility and Vivoda - stability)
- The only non-local operations in the vertical are integrations in HY dynamics (SL version). In NH dynamics also derivatives plays important role (structure equation contains vertical laplacian).
- First version of VFE implemented to the code → stable, efficient (2-3 % extra CPU) but (for the moment) noisy.
- Plan to code a hybrid FE/FD system with interchangeable parts.





Vertical Finite Element scheme

NLNH02 test

perturbation of V-wind [m/s], NSTEP = +0500

```

TSTEP test: 5 2TL ICI NESC scheme NSITER=1
LVERTFE      =FALSE
LVFE_LAPL_FD =FALSE
LVFE_UVH_FD  =FALSE
LVFE_GW_FD   =FALSE
NVSCH        =3
NVDER        =3

```

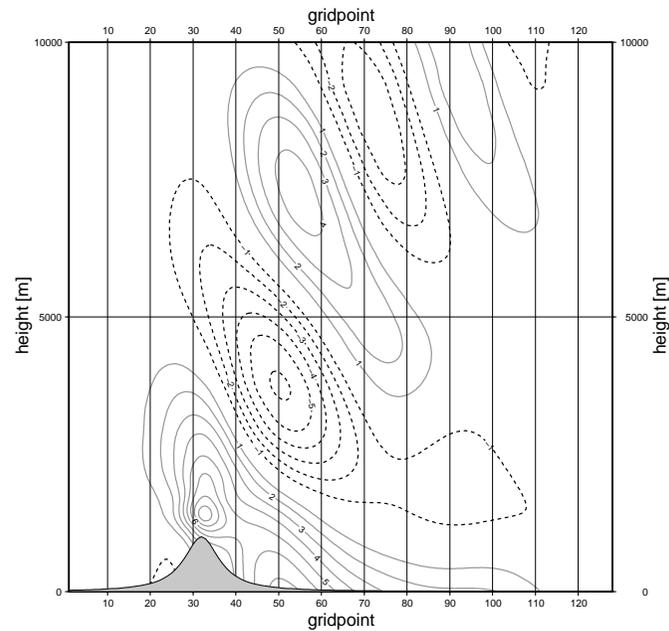
NLNH02 test

perturbation of V-wind [m/s], NSTEP = +0500

```

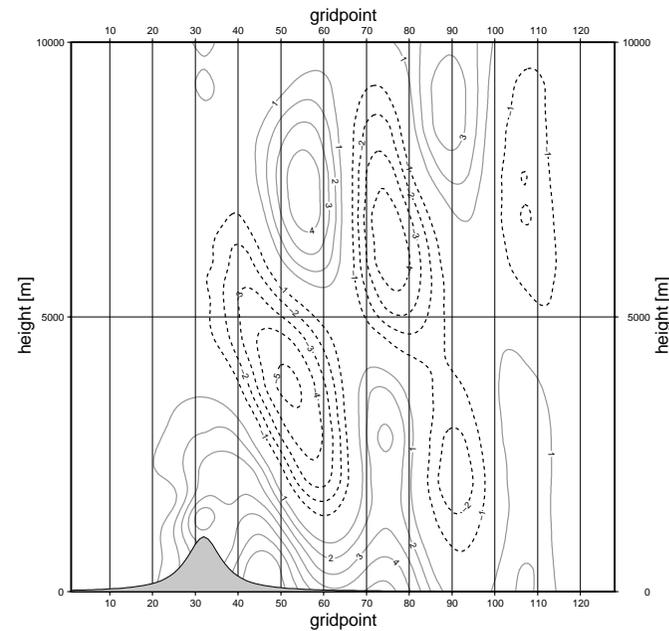
TSTEP test: 5 2TL ICI NESC scheme NSITER=1
LVERTFE      =TRUE
LVFE_LAPL_FD =FALSE
LVFE_UVH_FD  =FALSE
LVFE_GW_FD   =FALSE
NVSCH        =3
NVDER        =3

```



min: -6.1452
max: 8.6435
step: 1

GM 2006 Jul 4 11:30:31 experiment: VFE9



min: -5.2998
max: 7.7414
step: 1

GM 2006 Jun 22 08:23:15 experiment: VFE8

FD scheme versus full VFE



Vertical Finite Element scheme



NLNH02 test

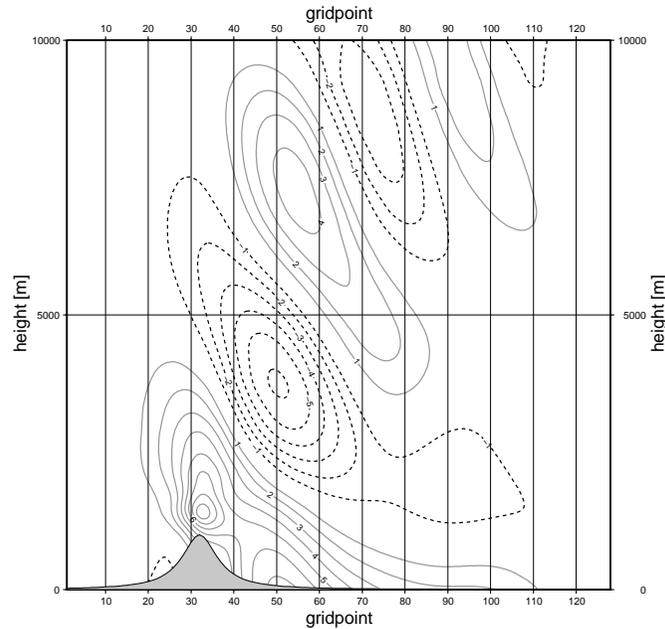
perturbation of V-wind [m/s], NSTEP = +0500

```
TSTEP test: 5 2TL ICI NESG scheme NSITER=1
LVERTFE      =FALSE
LVFE_LAPL_FD =FALSE
LVFE_UVH_FD  =FALSE
LVFE_GW_FD   =FALSE
NVSCH        =3
NVDER        =3
```

NLNH02 test

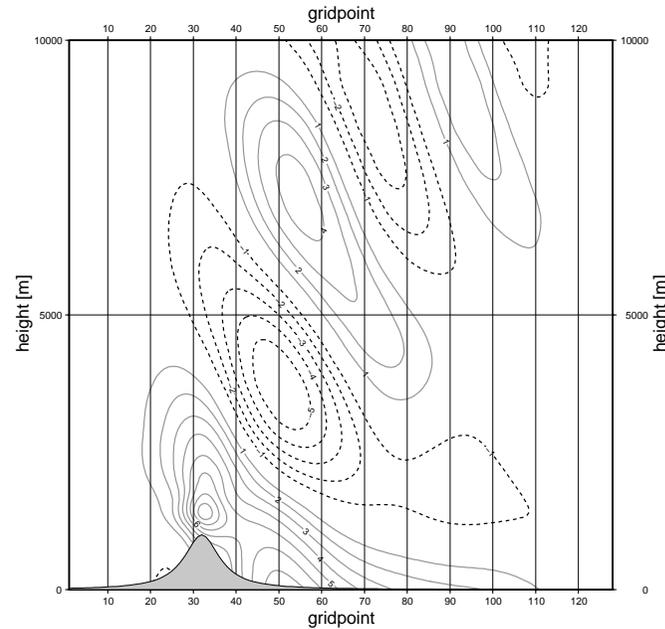
perturbation of V-wind [m/s], NSTEP = +0500

```
TSTEP test: 5 2TL ICI NESG scheme NSITER=1
LVERTFE      =TRUE
LVFE_LAPL_FD =TRUE
LVFE_LAPL_BC_FD =TRUE
LVFE_UVH_FD  =TRUE
LVFE_GW_FD   =TRUE
NVSCH        =3
NVDER        =3
```



GM 2006 Jul 4 11:30:31 experiment: VF09

min: -6.1452
max: 8.6435
step: 1



GM 2006 Jul 4 11:30:34 experiment: VF11

min: -5.9847
max: 8.7755
step: 1

FD scheme versus FD with VFE integral operators

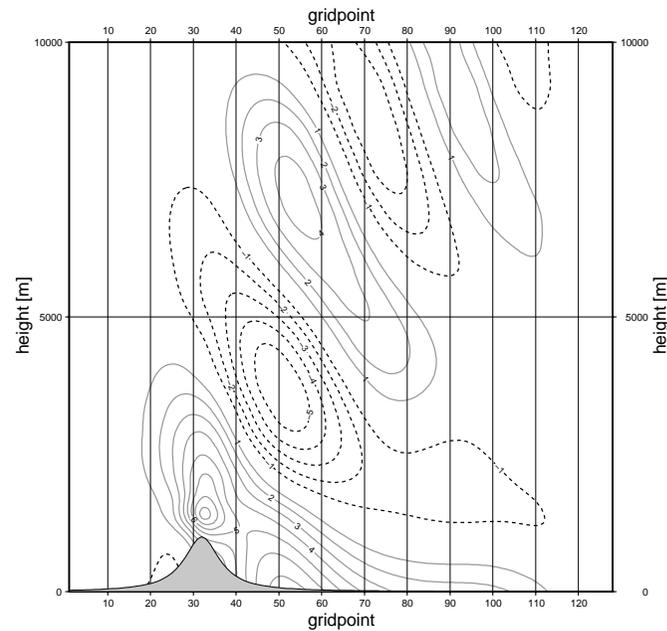
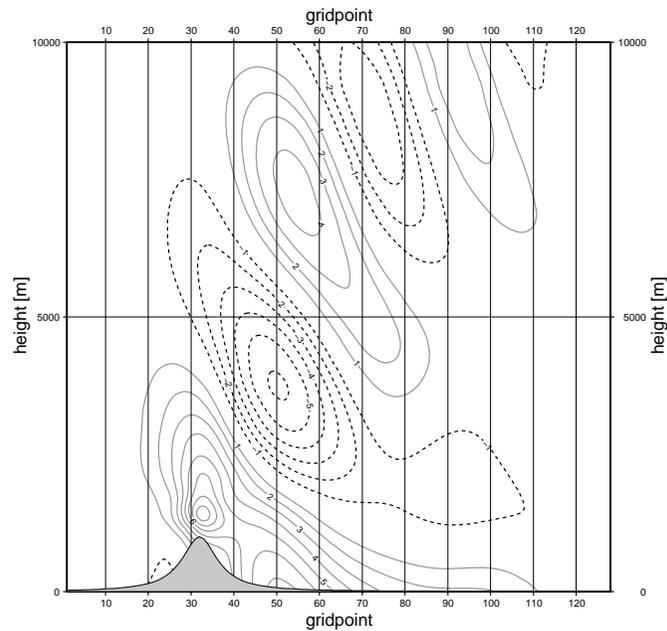


Vertical Finite Element scheme



NLNH02 test
 perturbation of V-wind [m/s], NSTEP = +0500
 TSTEP test: 5 2TL ICI NESC scheme NSITER=1
 LVERTFE =FALSE
 LVFE_LAPL_FD =FALSE
 LVFE_UVH_FD =FALSE
 LVFE_GW_FD =FALSE
 NVSCH =3
 NVDER =3

NLNH02 test
 perturbation of V-wind [m/s], NSTEP = +0500
 TSTEP test: 5 2TL ICI NESC scheme NSITER=1
 LVERTFE =TRUE
 LVFE_LAPL_FD =FALSE
 LVFE_LAPL_BC_FD =TRUE
 LVFE_UVH_FD =TRUE
 LVFE_GW_FD =TRUE
 NVSCH =3
 NVDER =3



GM 2006 Jul 4 11:30:31 experiment: VF09

min: -6.1452
 max: 8.6435
 step: 1

GM 2006 Jul 4 11:30:38 experiment: VF12

min: -5.8633
 max: 8.4249
 step: 1

FD scheme vs. FD with VFE integ. and laplacian oper.

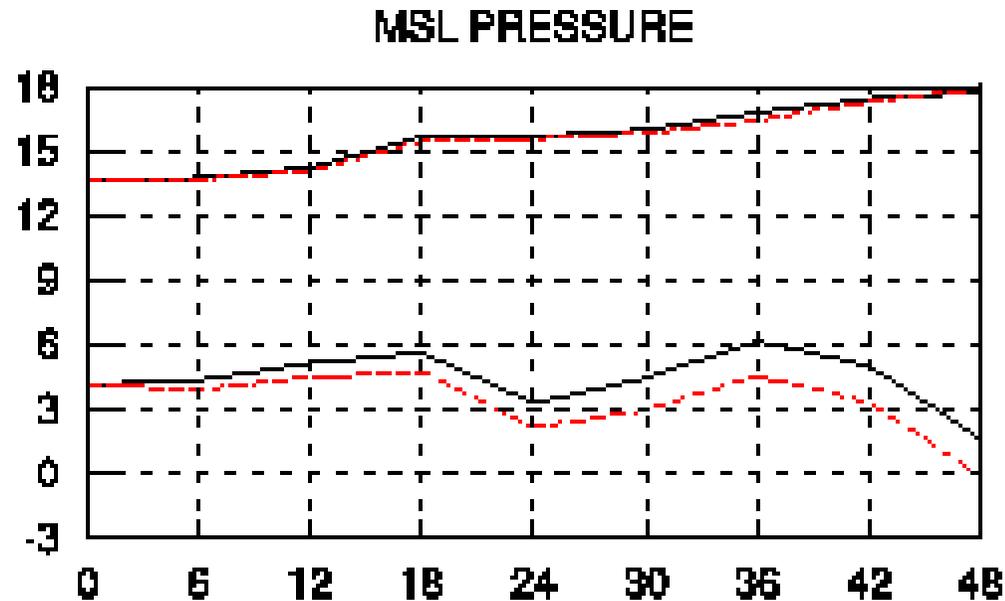


New interpolators for SL



Work of: **J. Mašek (Sk)** and **F. Váňa (Cz)**

Motivation: SLHD affects conservative properties of the model \Rightarrow need to an improvement of the SL interpolators accuracy.



MSL pressure RMSE and BIAS for 15 days of parallel run

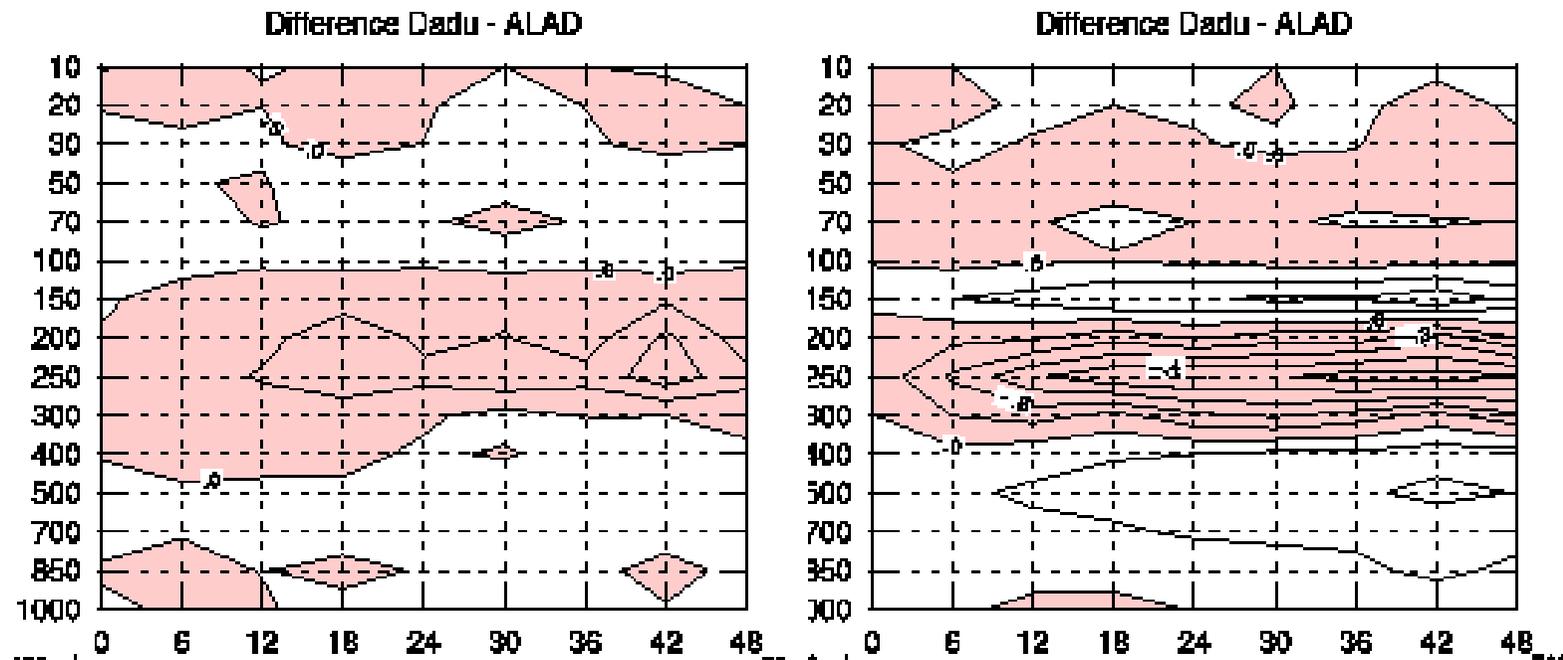




New interpolators for SL

Work of: **J. Mašek (Sk)** and **F. Váňa (Cz)**

Motivation: Performance of the local splines is not superior to the Lagrangian cubic interpolation in SL.



temperature RMSE and BIAS for 15 days of parallel run



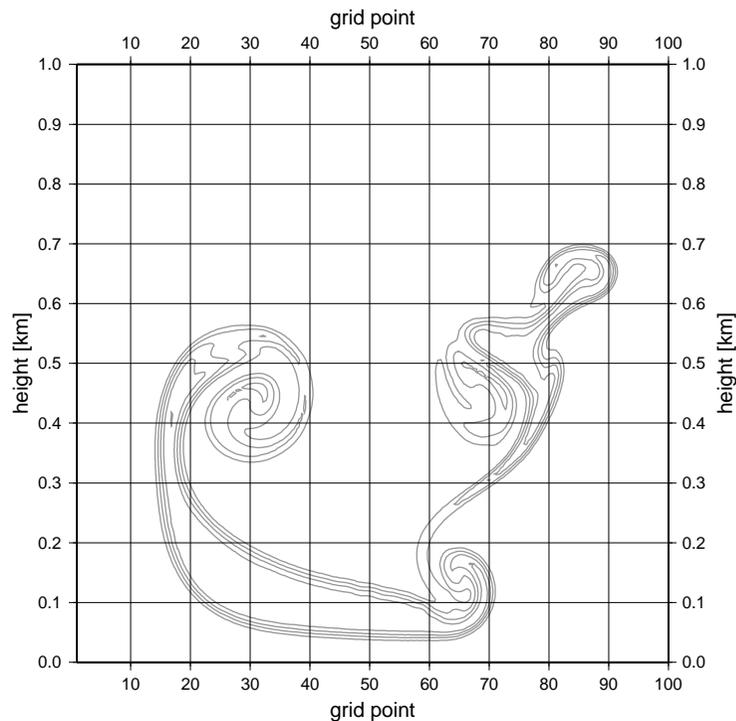


New interpolators for SL

WARM + COLD BUBBLE TEST
perturbation of potential temperature [K], NSTEP = +0120

```
init_102_wcb2_eta, eta-coordinate  
master_al29t2mx1_02_sx6, (A1, A2) = (-1/3, 1/2), .NOT.LQM  
NH sl2t1, (NPDVAR, NVDVAR) = (2, 3), NSITER = 1, LPC_FULL, LPC_NESC, LGWADV  
.NOT.LQM[x], .NOT.LQMH[x], LRSPLINE_[x], N[x]LAG = 3  
TSTEP = 5.0 s  
DELY = 10 m DELZ = 10 m  
P00 = 101325 Pa THETA00 = 300 K  
SIPR = 90000 Pa SITR = 350 K SITRA = 100 K  
RRDXTAU = 0
```

Bubble test, after 10 minutes



● Lagrangian cubic

GMT 2006 Aug 4 15:46:50 experiment: C000

min: -3.7963
max: 2.34
step: 0.12



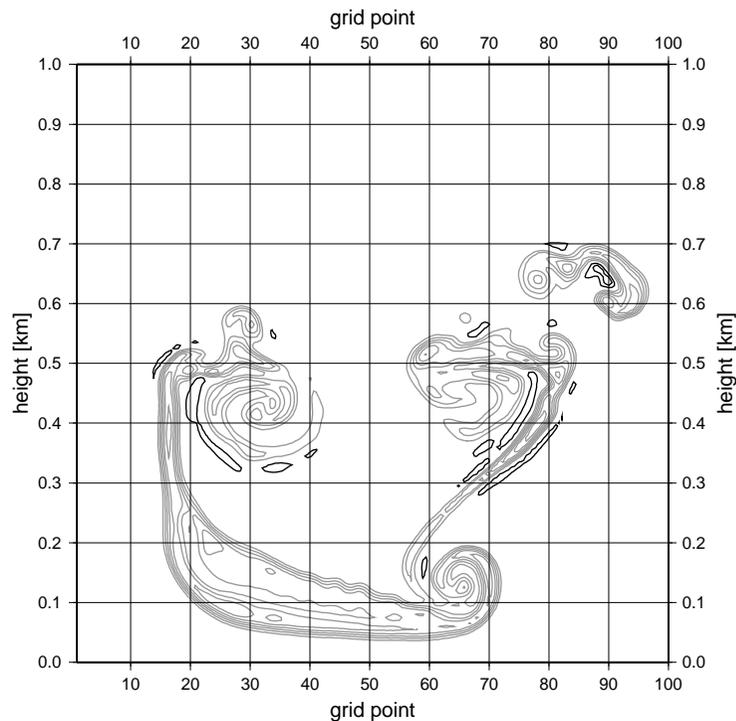


New interpolators for SL

WARM + COLD BUBBLE TEST
perturbation of potential temperature [K], NSTEP = +0120

```
init_102_wcb2_eta, eta-coordinate
master_al29t2mx1_02_sx6, (A1, A2) = (-7/15, 4/5), .NOT.LQM
NH sl2t1, (NPDVAR, NVDVAR) = (2, 3), NSITER = 1, LPC_FULL, LPC_NESC, LGWADV
.NOT.LQM[x], .NOT.LQMH[x], LRSPLINE_[x], N[x]LAG = 3
TSTEP = 5.0 s
DELY = 10 m DELZ = 10 m
P00 = 101325 Pa THETA00 = 300 K
SIPR = 90000 Pa SITR = 350 K SITRA = 100 K
RRDXTAU = 0
```

Bubble test, after 10 minutes



- Lagrangian cubic
- Splines

min: -9.616
max: 12.39
step: 0.12

GMT 2006 Aug 5 15:31:48 experiment: C004



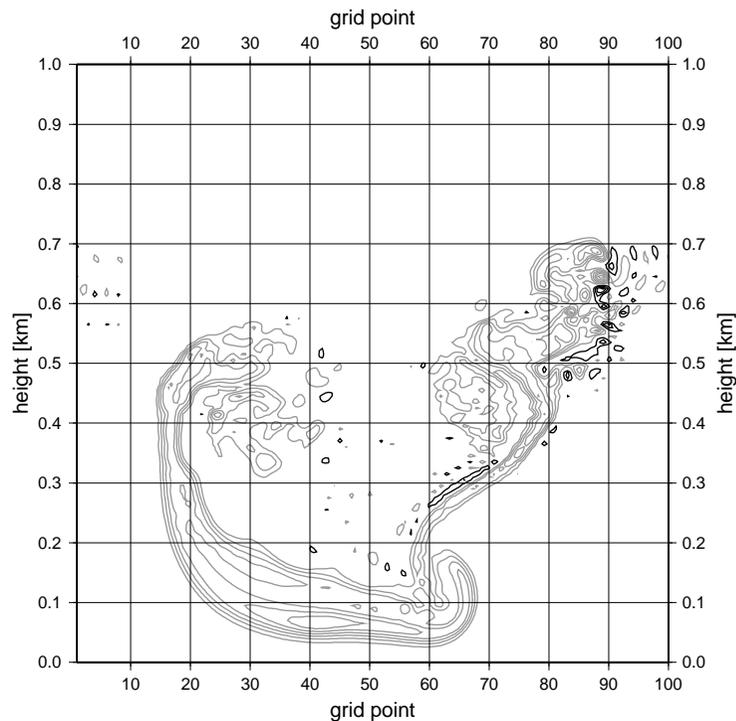
New interpolators for SL



WARM + COLD BUBBLE TEST
perturbation of potential temperature [K], NSTEP = +0600

```
init_102_wcb2_eta, eta-coordinate  
master_al29t2mx1_02_sx6  
NH euler, (NPDVAR, NVDVAR) = (2, 3), NSITER = 1, LPC_OLD  
TSTEP = 1.0 s  
DELY = 10 m DELZ = 10 m  
P00 = 101325 Pa THETA00 = 300 K  
SIPR = 90000 Pa SITR = 250 K SITRA = 250 K  
RRDXTAU = 0
```

Bubble test, after 10 minutes



- Lagrangian cubic
- Splines
- Eulerian adv.

min: -62.434
max: 16.339
step: 0.12

GMT 2006 Aug 4 20:05:50 experiment: C900



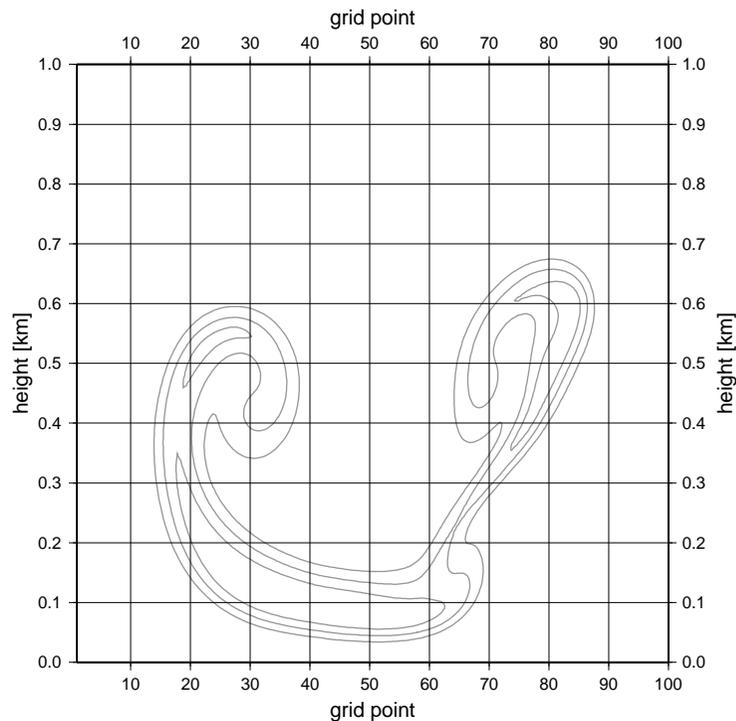
New interpolators for SL



WARM + COLD BUBBLE TEST
perturbation of potential temperature [K], NSTEP = +0120

```
init_102_wcb2_eta, eta-coordinate  
master_al29t2mx1_02_sx6, (A1, A2) = (0, 0), .NOT.LQM  
NH sl2t1, (NPDVAR, NVDVAR) = (2, 3), NSITER = 1, LPC_FULL, LPC_NESC, LGWADV  
.NOT.LQM[x], .NOT.LQMH[x], LRSPLINE_[x], N[x]LAG = 3  
TSTEP = 5.0 s  
DELY = 10 m DELZ = 10 m  
P00 = 101325 Pa THETA00 = 300 K  
SIPR = 90000 Pa SITR = 350 K SITRA = 100 K  
RRDXTAU = 0
```

Bubble test, after 10 minutes



- Lagrangian cubic
- Splines
- Eulerian adv.
- Linear

min: -10.645
max: 1.8519
step: 0.12

GMT 2006 Aug 4 18:46:16 experiment: C010



New interpolators for SL



Family of two parametric cubic interpolators

$$\begin{aligned} F(\mathbf{x}, \mathbf{y}) = & w_0(\mathbf{x})y_0 + w_1(\mathbf{x})y_1 \\ & + w_1(1 - \mathbf{x})y_2 + w_0(1 - \mathbf{x})y_3 \end{aligned}$$

where

$$w_0(\mathbf{x}) = a_1\mathbf{x} + a_2\mathbf{x}^2 - (a_1 + a_2)\mathbf{x}^3$$

$$w_1(\mathbf{x}) = 1 + (a_2 - 1)\mathbf{x} - (3a_1 + 4a_2)\mathbf{x}^2 + 3(a_1 + a_2)\mathbf{x}^3$$



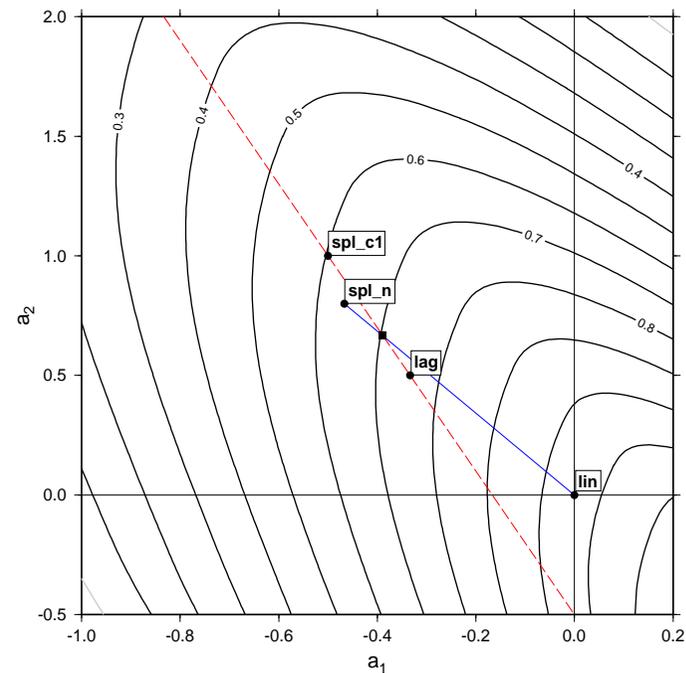
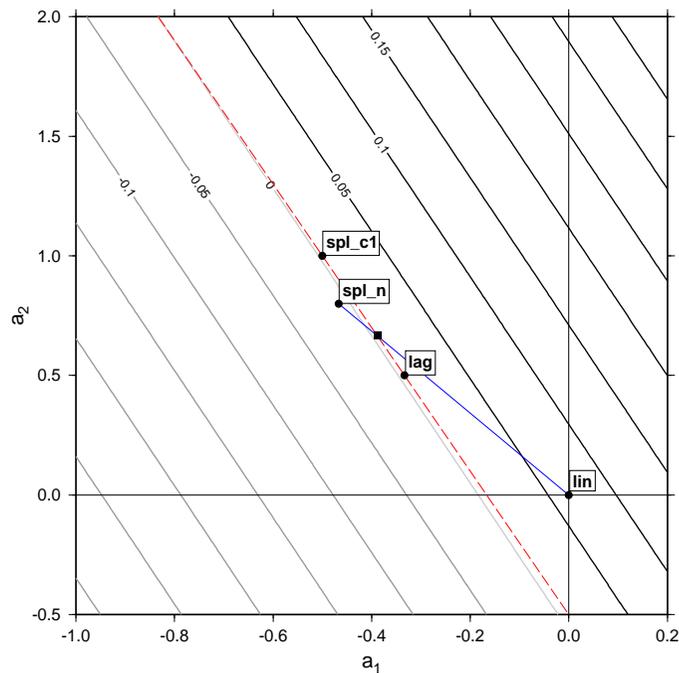


New interpolators for SL

Dimensionless damping rate

Damping factor for $N = 100, m = 10$

Damping factor for $N = 100, m = 40$



TL/AD of the ALADIN SL

Work of: F. Váňa (Cz)



TL/AD of the ALADIN SL



Work of: **F. Váňa (Cz)**

Convergence for the TL code:

$$\lim_{\epsilon \rightarrow 0} \frac{M(x + \epsilon \delta x) - M(x)}{\mathcal{M}'(\epsilon \delta x)}, \quad \epsilon = \epsilon_0 10^\lambda$$

	Eulerian advection $\Delta t=120s$	SL advection $\Delta t=450s$
$\lambda = 0$	RAT = 0.4922389696335498E+00	RAT = -.7944390364435365E+01
$\lambda = -1$	RAT = 0.9500193013364470E+00	RAT = -.4770497575992165E+00
$\lambda = -2$	RAT = 0.9950083001890732E+00	RAT = 0.6874108246125125E+00
$\lambda = -3$	RAT = 0.9995037024689268E+00	RAT = 0.9601433242017338E+00
$\lambda = -4$	RAT = 0.9999513959612562E+00	RAT = 0.9943026809878674E+00
$\lambda = -5$	RAT = 0.1000315146923774E+01	RAT = 0.9999531009073782E+00
$\lambda = -6$	RAT = 0.1001714189087304E+01	RAT = 0.1001665349367836E+01
$\lambda = -7$	RAT = 0.1007310357741422E+01	RAT = 0.1027349076274704E+01
$\lambda = -8$	RAT = 0.1119233730823803E+01	RAT = 0.8561242302289194E+00
$\lambda = -9$	RAT = 0.5596168654119013E+01	RAT = 0.4280621151144597E+01
$\lambda = -10$	RAT = 0.0000000000000000E+00	RAT = 0.0000000000000000E+00



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$\lambda = 0$	RAT = 0.9685219082957116E+00	RAT = 0.1094034387101322E+01
$\lambda = -1$	RAT = 0.9970618603595810E+00	RAT = 0.1008012195504008E+01
$\lambda = -2$	RAT = 0.9997073040468342E+00	RAT = 0.1002141025110223E+01
$\lambda = -3$	RAT = 0.9999707398884352E+00	RAT = 0.1000160788422592E+01
$\lambda = -4$	RAT = 0.9999970679271253E+00	RAT = 0.1000099605664519E+01
$\lambda = -5$	RAT = 0.9999995490240665E+00	RAT = 0.1000001139215519E+01
$\lambda = -6$	RAT = 0.9999987045356886E+00	RAT = 0.1000001847670018E+01
$\lambda = -7$	RAT = 0.9999936488857756E+00	RAT = 0.1000041939684409E+01
$\lambda = -8$	RAT = 0.9999533728917936E+00	RAT = 0.1000246087384355E+01
$\lambda = -9$	RAT = 0.9991377690586460E+00	RAT = 0.9994838411148169E+00
$\lambda = -10$	RAT = 0.9970808134568164E+00	RAT = 0.1032182685987080E+01



Physics-dynamics coupling



Work of: **R. Hamdi (Be) and P. Termonia (Be)**

- The way in which the physics is coupled to the dynamics has an influence on the stability and the accuracy



Physics-dynamics coupling



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- The way in which the physics is coupled to the dynamics has an influence on the stability and the accuracy
- Simple 1d model simulations using the framework proposed by Staniforth, Wood, Côté (2002) extended in a way to take into account the spectral nature of the models and the difference between the real atmosphere and the background of the linearisation.



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- Simple 1d model simulations using the framework proposed by Staniforth, Wood, Côté (2002) extended in a way to take into account the spectral nature of the models and the difference between the real atmosphere and the background of the linearisation.
- This study was restricted to explicit, semi implicit and implicit physics parameterizations (over-implicitness not treated).



Physics-dynamics coupling



Possibilities to organize a time step

- coupling of the physics parameterization before or after the explicit part of the dynamics



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- computing the physics parameterization in a parallel or a fractional manner



Physics-dynamics coupling

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- coupling of the physics to the dynamics at different positions (in space and time with respect to dyn.) on the SL trajectory
- computing the physics parameterization in a parallel or a fractional manner
- coupling the physics to the dynamics by updating the model state and using this for the dynamics, or computing the physics tendency and the dynamics tendencies separately and adding them to get the update, in other words to treat the physics/dynamics in a fractional or a sequential manner



Physics-dynamics coupling



A/A/A vs. SLAVEPP

	A/A/A	SLAVEPP
phys. before/after dyn. on SL traj.	before at t	computed after and averaged at $t + \Delta t$
parallel / sequential physics calls	parallel	sequential
parallel /sequential phys.- dyn. coupling	sequential	parallel



Physics-dynamics coupling



Results

- Always couple the physics to the air parcel along the SL trajectory. Otherwise the properties (stability and accuracy) depend on the advection.



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- In the A/A/A framework, coupling the physics *after* the dynamics gives a more accurate treatment of the steady state. This might be beneficial for climate simulations.
- If the physics were treated in a semi-implicit way (in the A/A/A context) we would have the same stability and also second-order accuracy as in the SLAVEPP approach. This is maybe not practical but nevertheless a nice surprise because it means that *(in the 1d model) one could get the same benefits of the time step reorganization, by an internal reorganization of the physics.*



Physics-dynamics coupling



Outcome for A/A/A

- If both forcing and diffusive processes are present, a SLAVEPP kind of time step becomes superior to the A/A/A one *IF* the diffusive processes are coupled *LAST*. This will also lead to a more accurate steady state and less climate drift.



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- There seems to be no better option with respect of phys-dyn coupling to increase the existing stability of the physics in the A/A/A framework.
- Publication with the detailed guidelines is in preparation (manuscript can be obtained from piet.termonia@oma.be)



Transparent LBCs in spec. models

Work of: F. Voitus (Fr) and P. Termonia (Be)

- LBCs *have* to be imposed in gridpoint space.



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- In a spectral model we are forced to address this question, but in a gridpoint model maintained in a huge collaboration with different kinds of researchers working together, this will have to be addressed too.



Transparent LBCs in spec. models

Different LBC scheme near the boundary



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- Proposal: rely on sub-stepping



Transparent LBCs in spec. models

First test in Shallow water model

- Inside the domain (crosses): SISL 2TL
Near the boundary to compute 3 points at $t + \Delta t$ (solid dots):
leapfrog Asselin or leapfrog trapezoidal by sub-stepping with
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- The problem is being replaced to data flow...: We need an
extra large stencil near the boundary (solid dots at t).

