DCMIP 2012 Results

GEM-LatLon *versus* GEM-YinYang

Environment Canada

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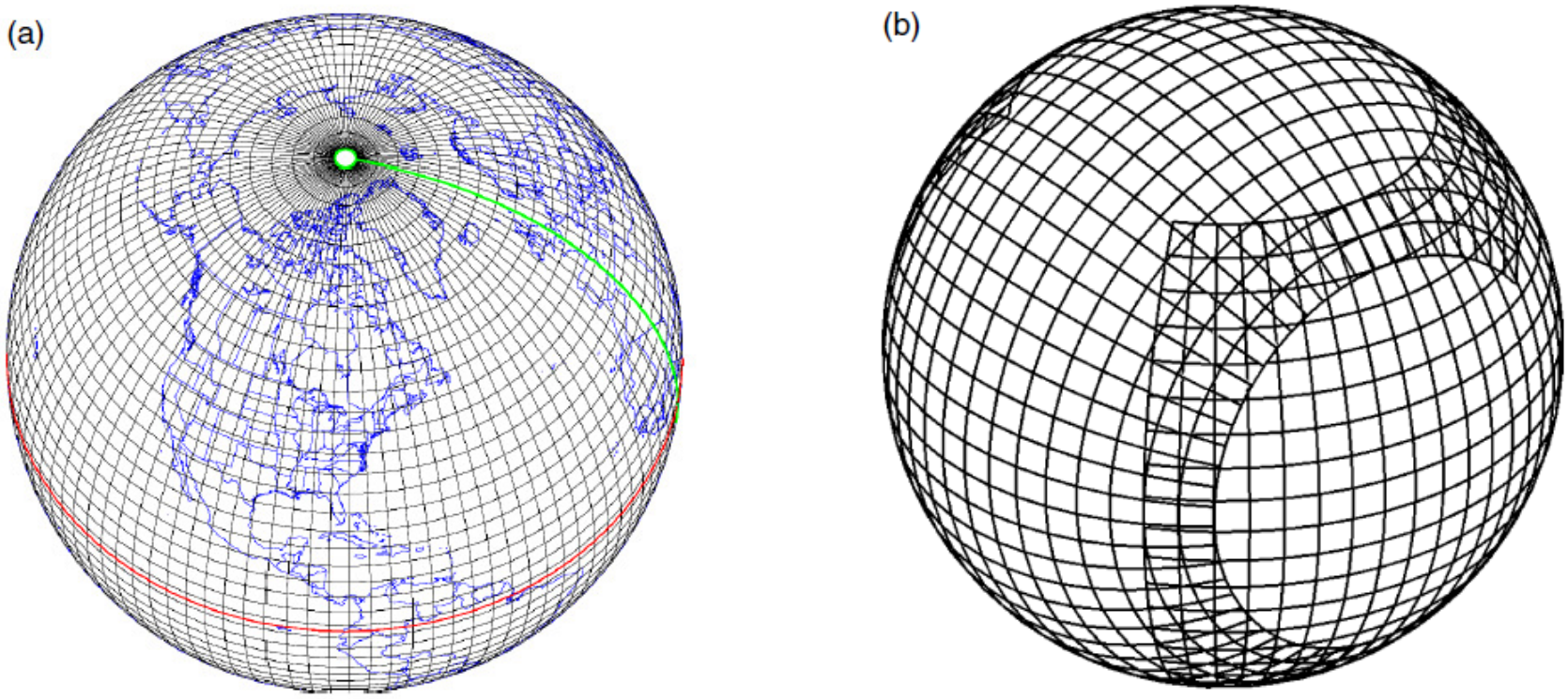
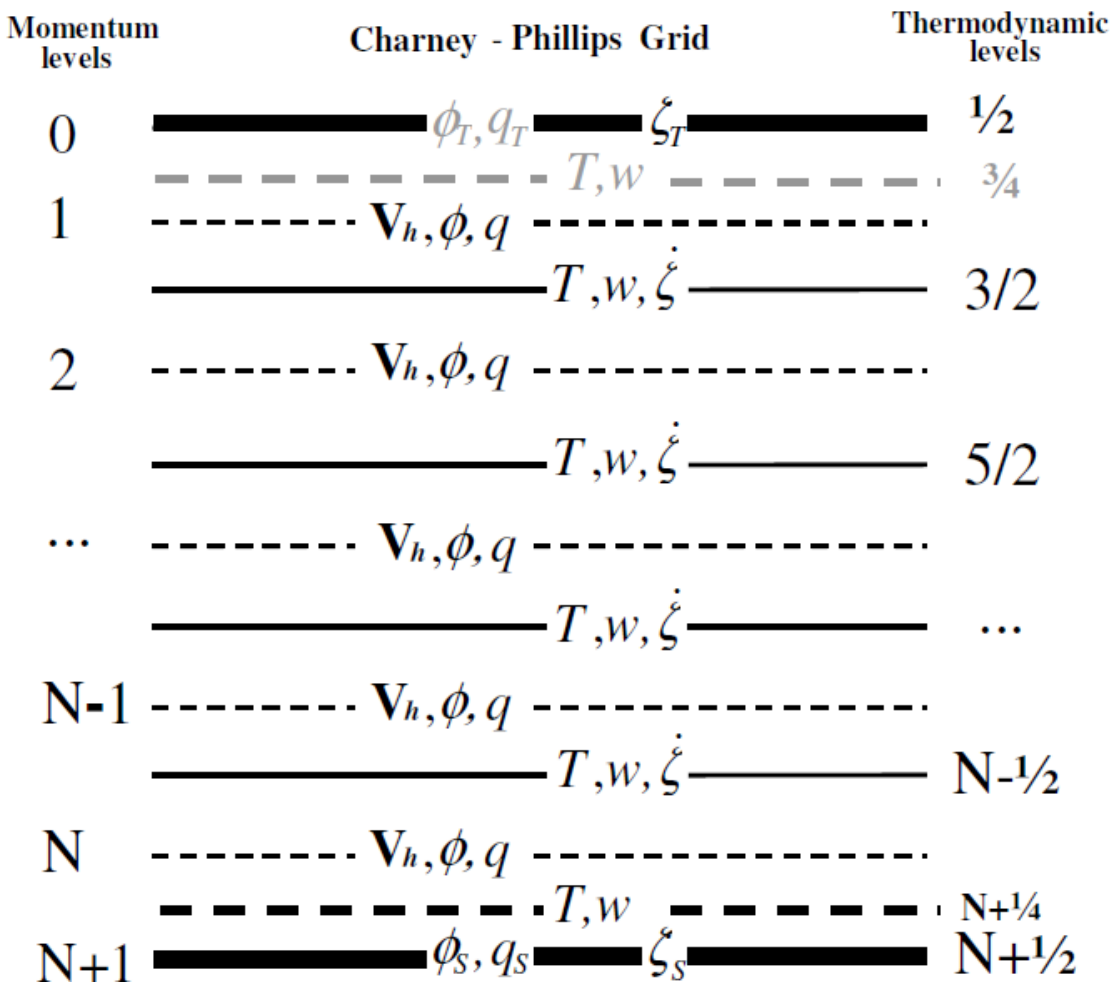


LL

YY

Horizontal computational grids



Vertical Charney-Phillips grid

$$\ln p_T = \zeta_T \le \zeta \le \zeta_S = \ln 10^5 : \ln \boldsymbol{\pi}\text{-like } \textit{model} \text{ levels}$$

$$\ln \pi = A + Bs = \zeta + B \ln(\pi_s / 10^5)$$

$$A = \zeta; \qquad B = \lambda^r; \qquad 0 < r = r_{\max} - (r_{\max} - r_{\min})\lambda < 200; \;\; \lambda = \frac{\zeta - \zeta_T}{\zeta_S - \zeta_T}$$

Terrain-following vertical coordinate of the log-hydrostatic-pressure type

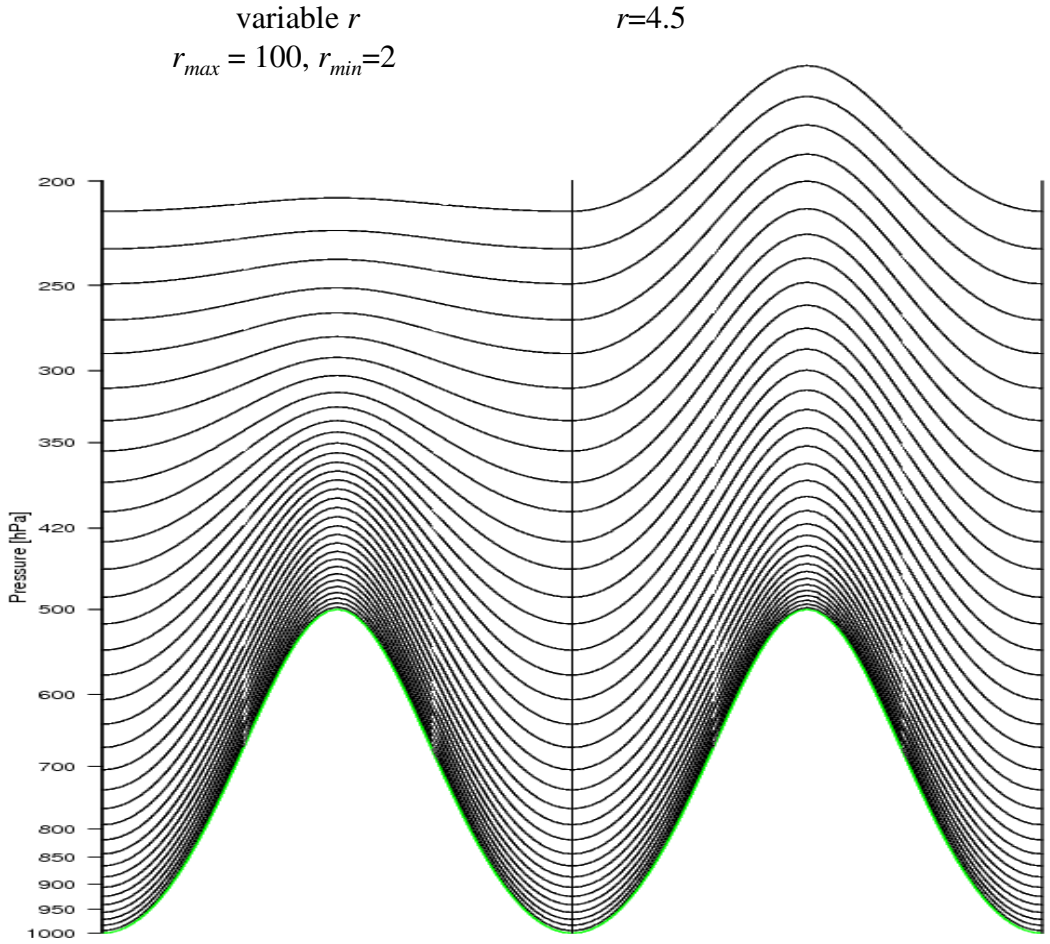


Figure 5. GEM4 with variable r (r_{max}=100, r_{min}=2) compared to GEM4 with constant r=4.5 **below 200 hPa**.

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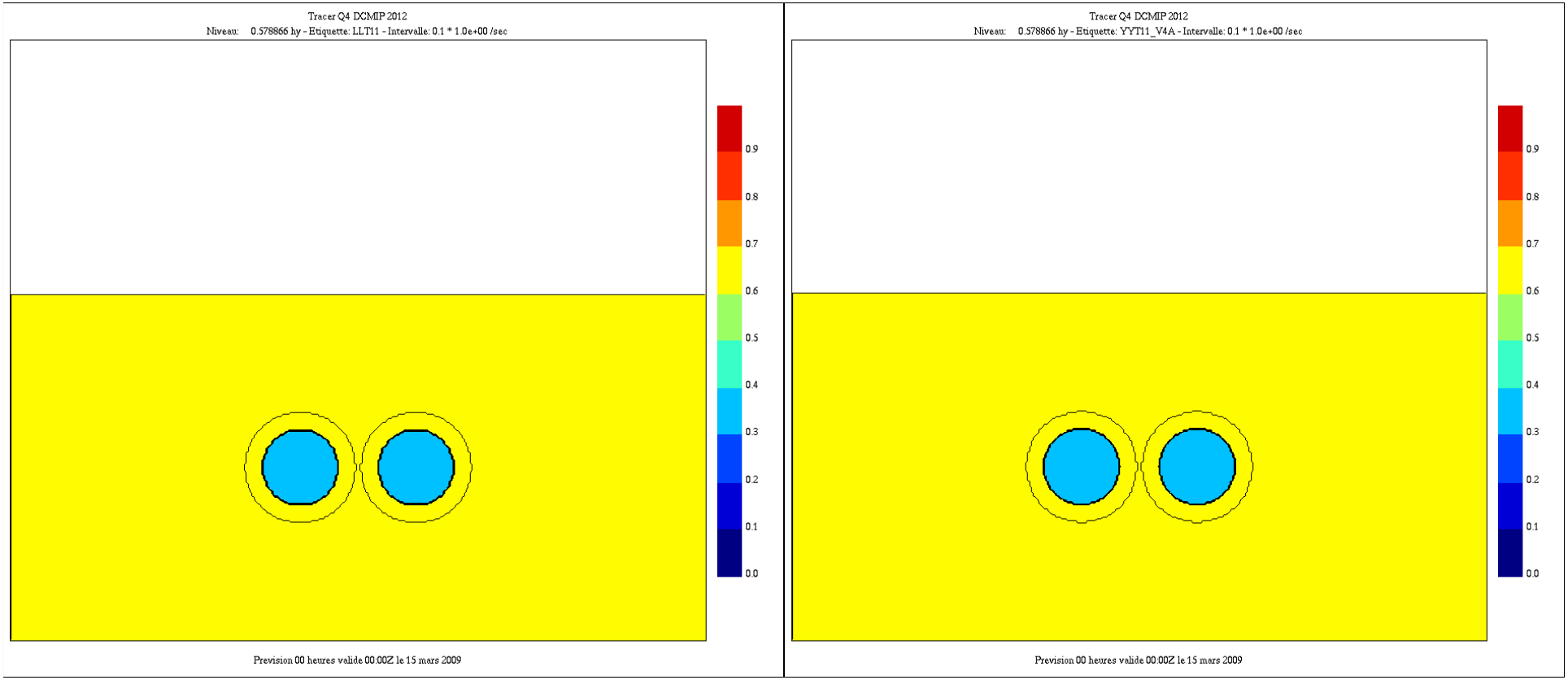
T11 (3D Deformation Flow)

RUN for 12 days

[1 deg - Dz=200m Top=12km L60]: DT = 3600 sec

- Traditional non-conservative semi-Lagrangian scheme
  with Bermejo and Staniforth (1992) fixer
- The fixer is also applied to interpolations between Yin &Yang

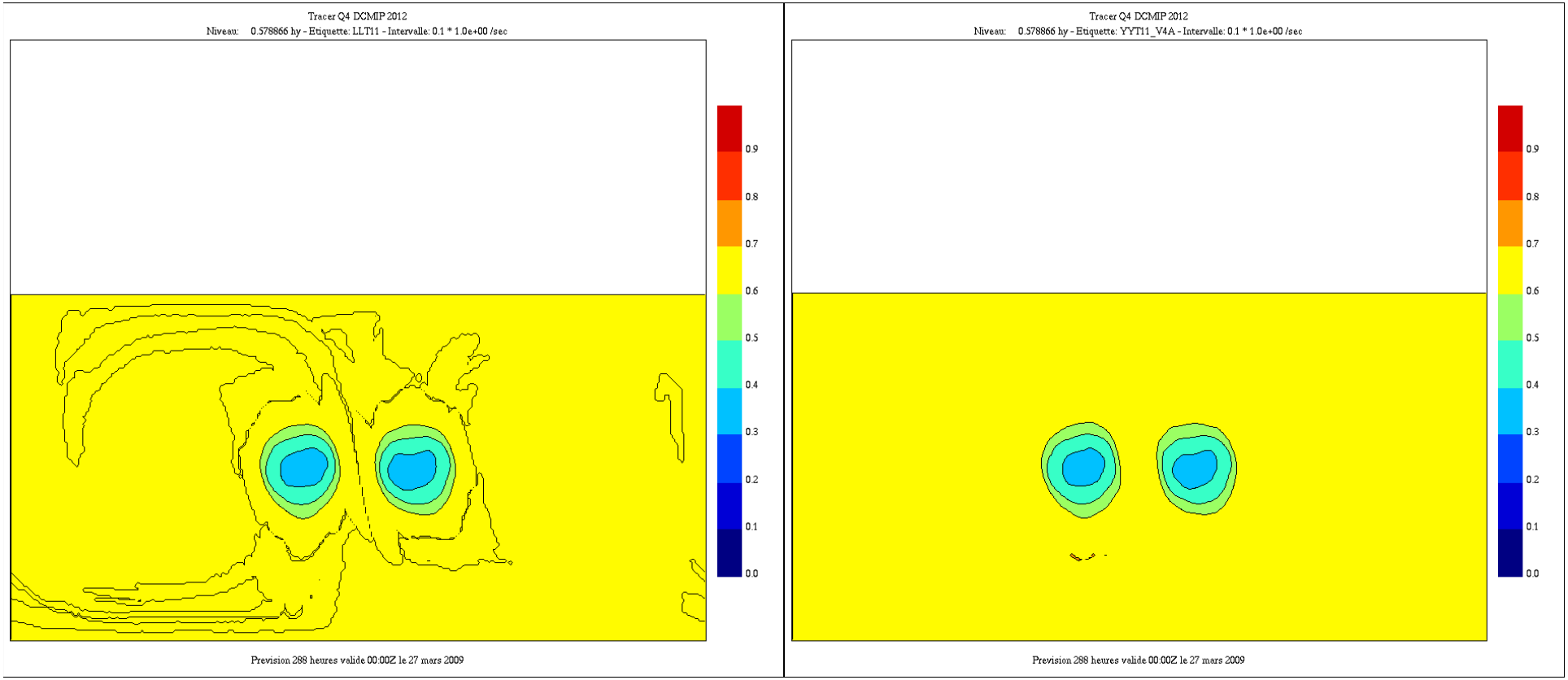


LL YY

Plot Lat_Lon hyb_t = .578866 close to z=4900 m

Q4

t= 0

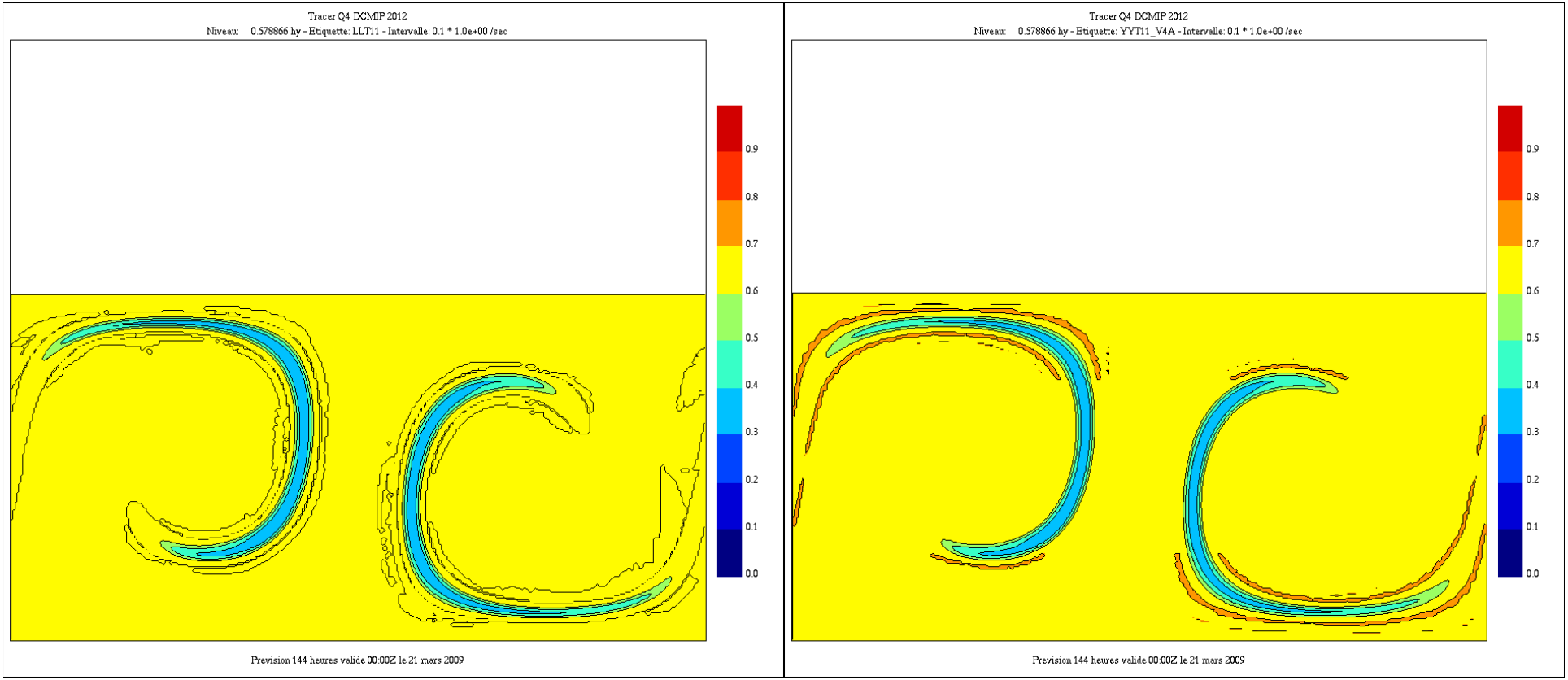


LL YY

Plot Lat_Lon hyb_t = .578866 close to z=4900 m

Q4

t= 12 days



LL YY

Plot Lat_Lon hyb_t = .578866 close to z=4900 m

Q4

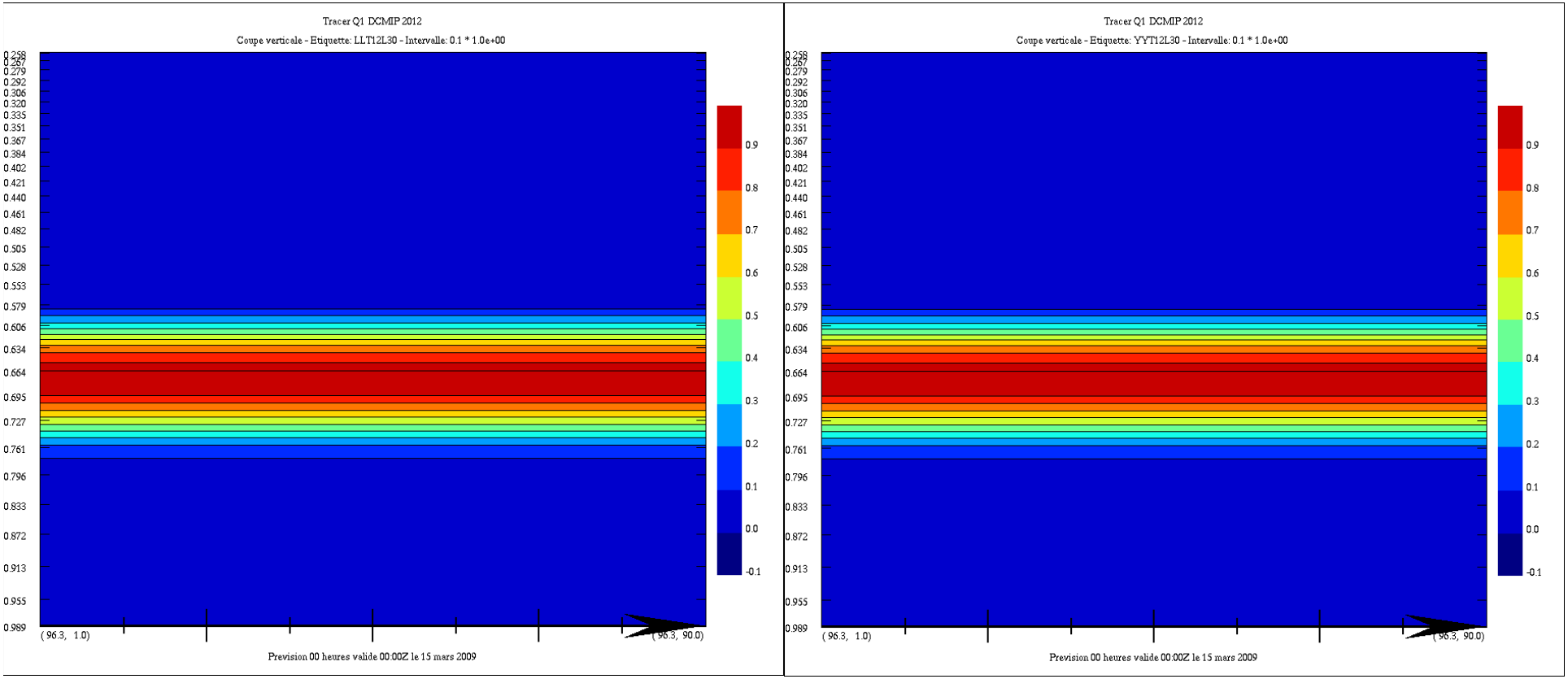
t= 6 days

Tracer		L1	L2	Linf
Q1	**LL**	0.2914849	0.2177525	0.3074692
	YY	0.3143167	0.2275852	0.3072484
Q2	**LL**	0.1139193E-02	0.1079737E-01	0.2921945
	YY	0.1135893E-02	0.1085525E-01	0.2913662
Q3	**LL**	0.3239649E-01	0.2763509	0.7635567
	YY	0.3097074E-01	0.2728861	0.8056100
Q4	**LL**	0.1535967E-02	0.1488639E-01	0.3864071
	YY	0.1476286E-02	0.1460091E-01	0.3920970

T12 (Hadley-like Meridional Circulation)

RUN for 24 hrs

[2 deg - Dz=400m Top=12km L30]: DT = 3600 sec
[1 deg - Dz=200m Top=12km L60]: DT = 3600 sec
[.5 deg - Dz=100m Top=12km L120]: DT = 3600 sec

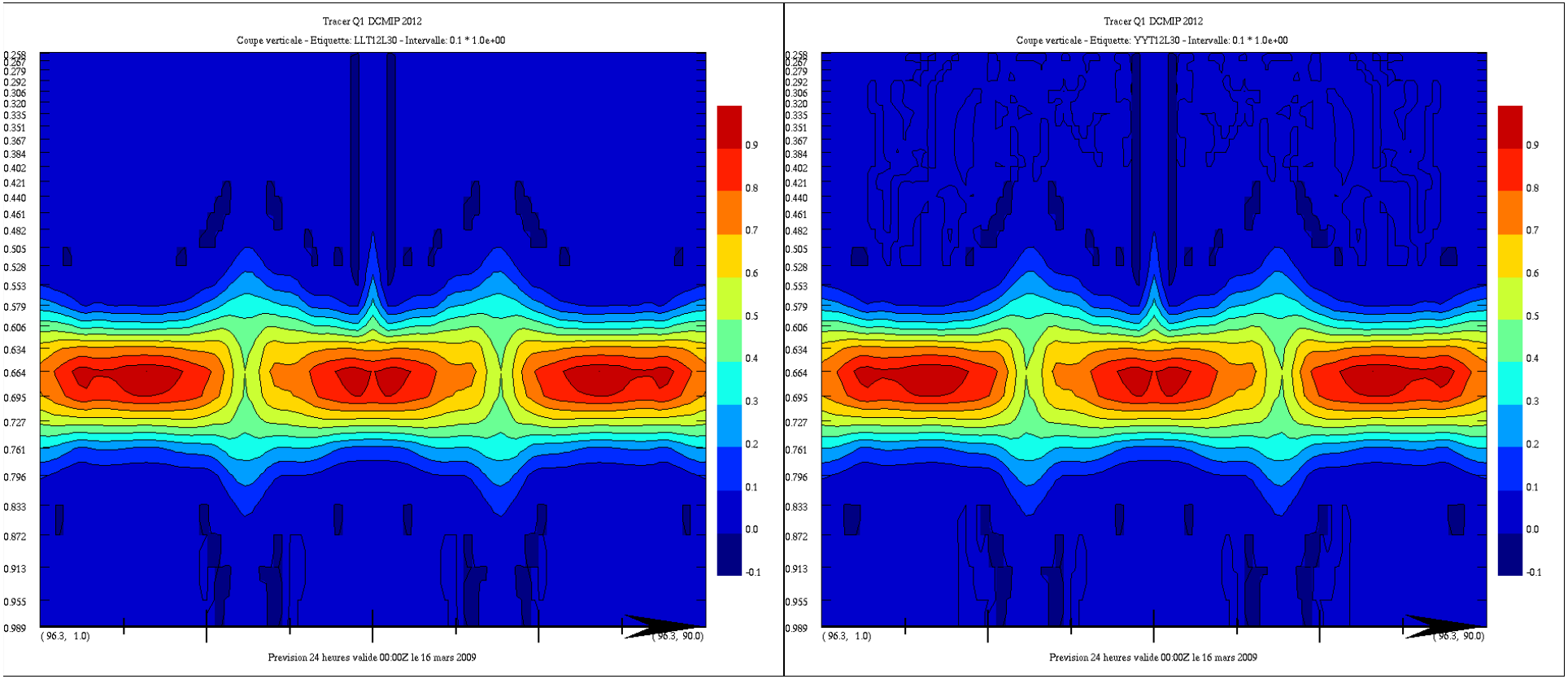


LL 2 deg, L30 YY

Plot Lat_Height along Lon=180 deg

Q1

t=0

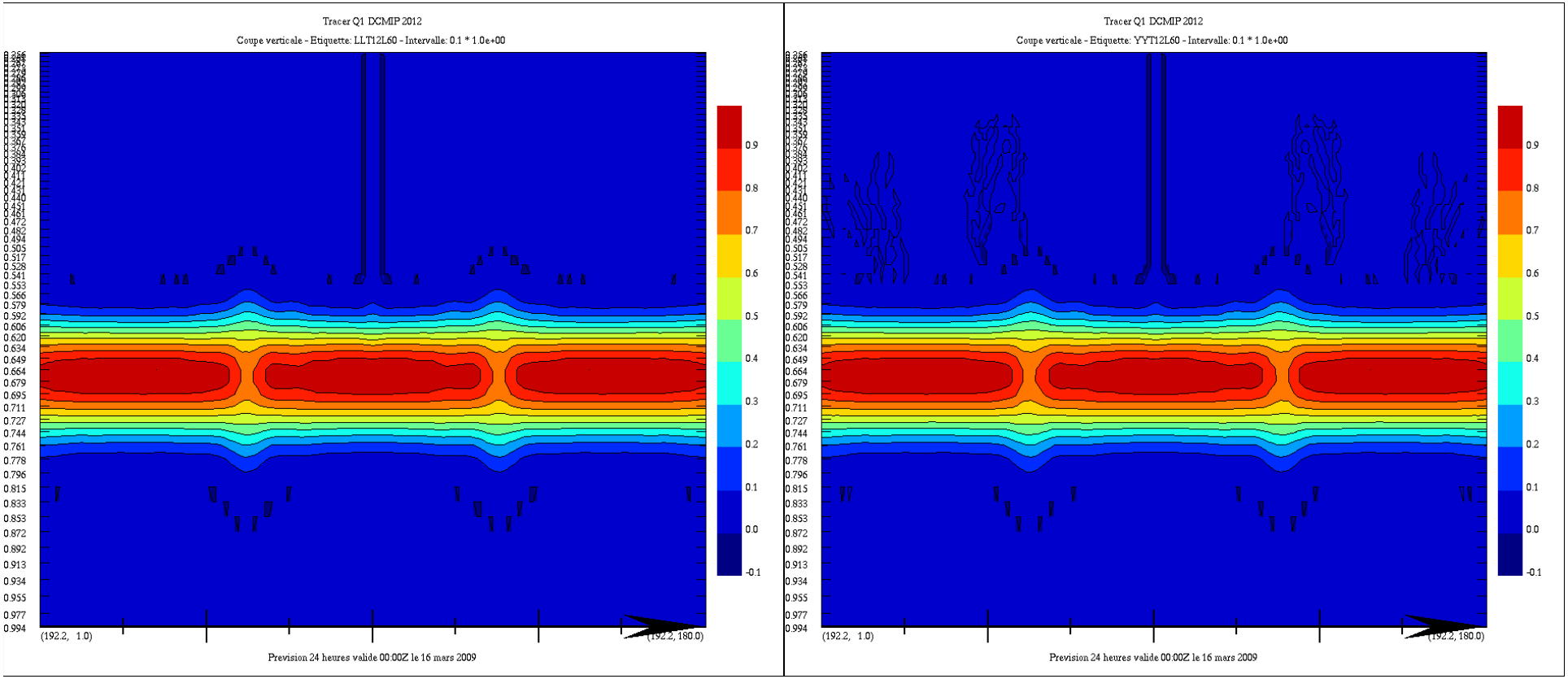


LL 2 deg, L30 YY

Plot Lat_Height along Lon=180 deg

Q1

t=24 hrs

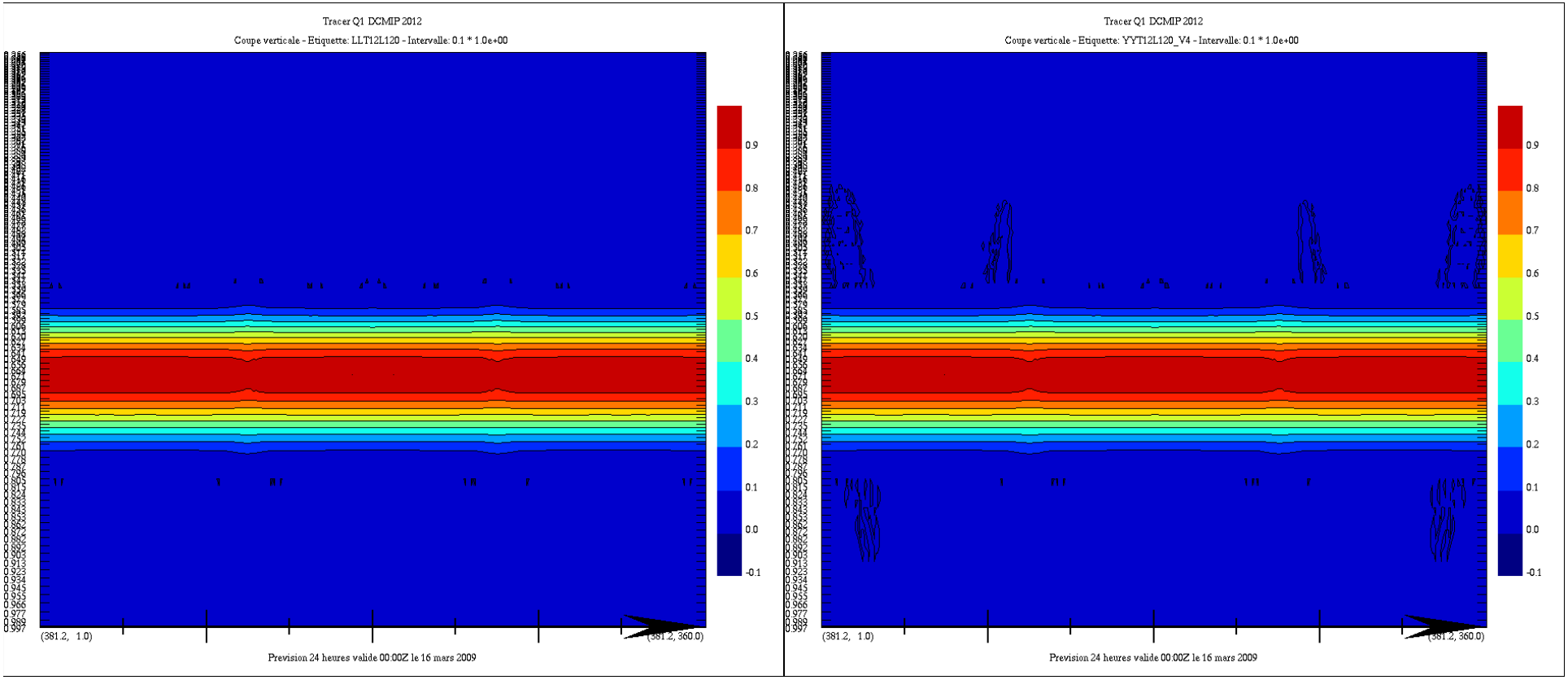


LL 1 deg, L60 YY

Plot Lat_Height along Lon=180 deg

Q1

t=24 hrs

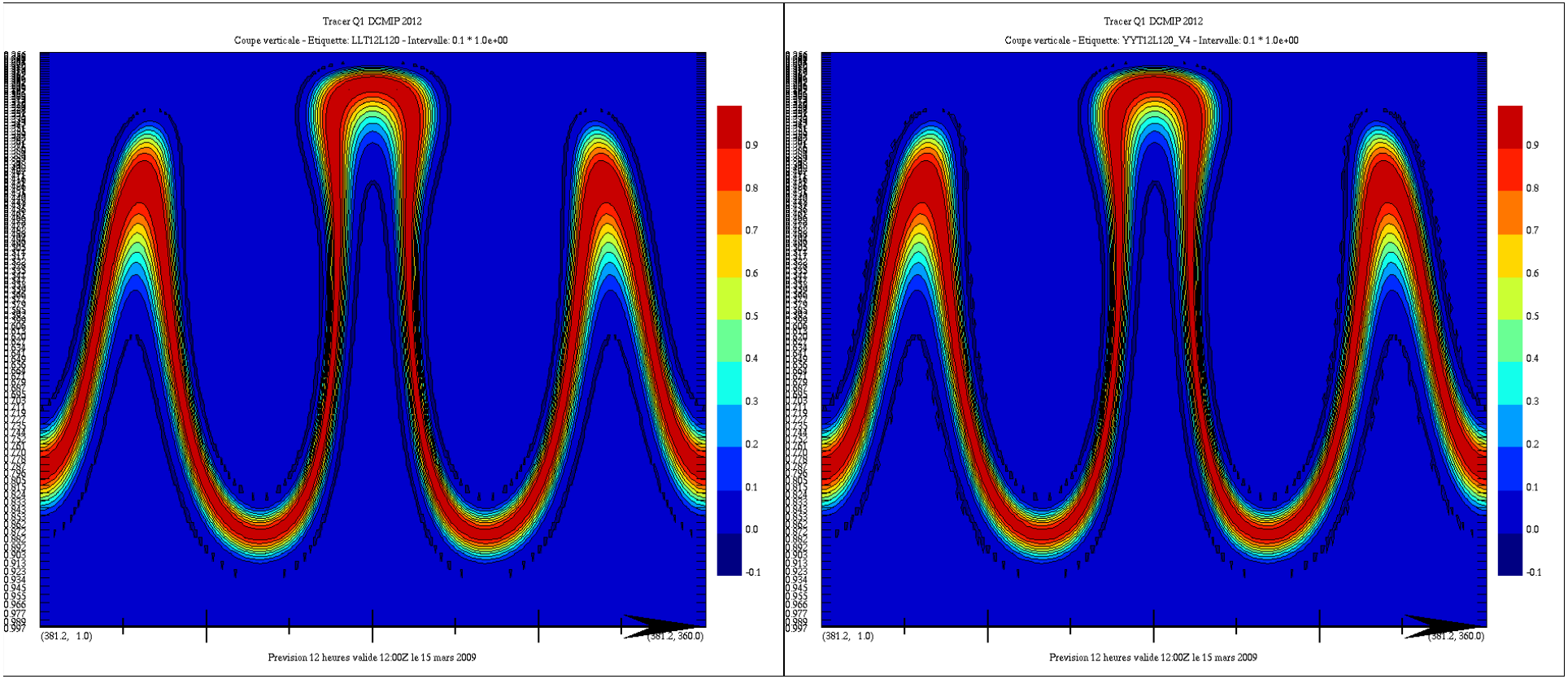


LL 0.5 deg, L120 YY

Plot Lat_Height along Lon=180 deg

Q1

t=24 hrs



LL 0.5 deg, L120 YY

Plot Lat_Height along Lon=180 deg

Q1

t=12 hrs

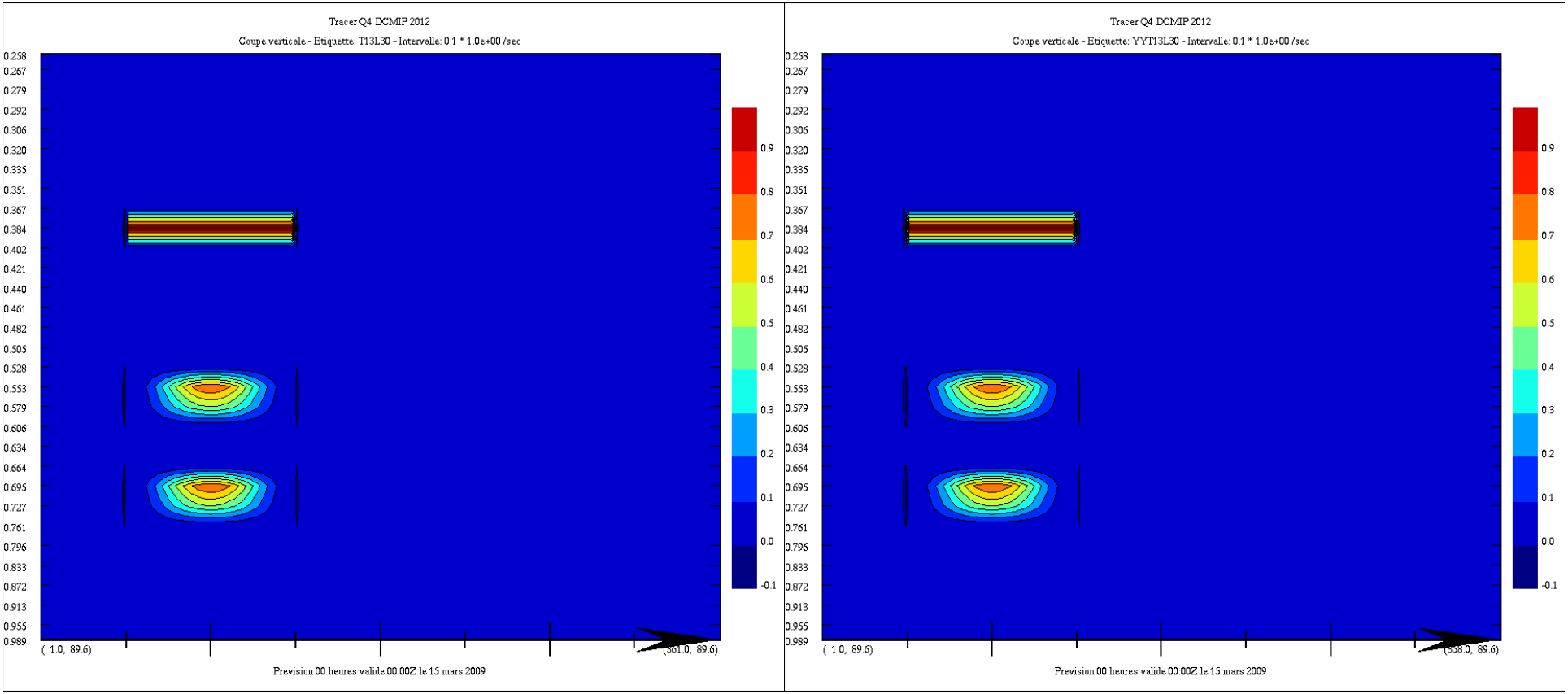
Tracer Q1		L1	L2	Linf
2 deg, L30	**LL**	0.2601217	0.2505390	0.4901941
	YY	0.2664702	0.2542443	0.4936417
1 deg, L60	**LL**	0.6039249E-01	0.7934086E-01	0.2161520
	YY	0.6191024E-01	0.8090493E-01	0.2251573
0.5 deg, L120	**LL**	0.7640922E-02	0.1282917E-01	0.5716013E-01
	YY	0.7819027E-02	0.1312023E-01	0.5868130E-01

Errors decrease with increasing resolution

T13 (Horizontal advection of thin cloud-like tracers in the presence of orography)

RUN for 12 days

[1 deg - Dz=400m Top=12km L30]: DT= 3600 sec
[1 deg - Dz=200m Top=12km L60]: DT= 3600 sec
[1 deg - Dz=100m Top=12km L120]: DT= 3600 sec

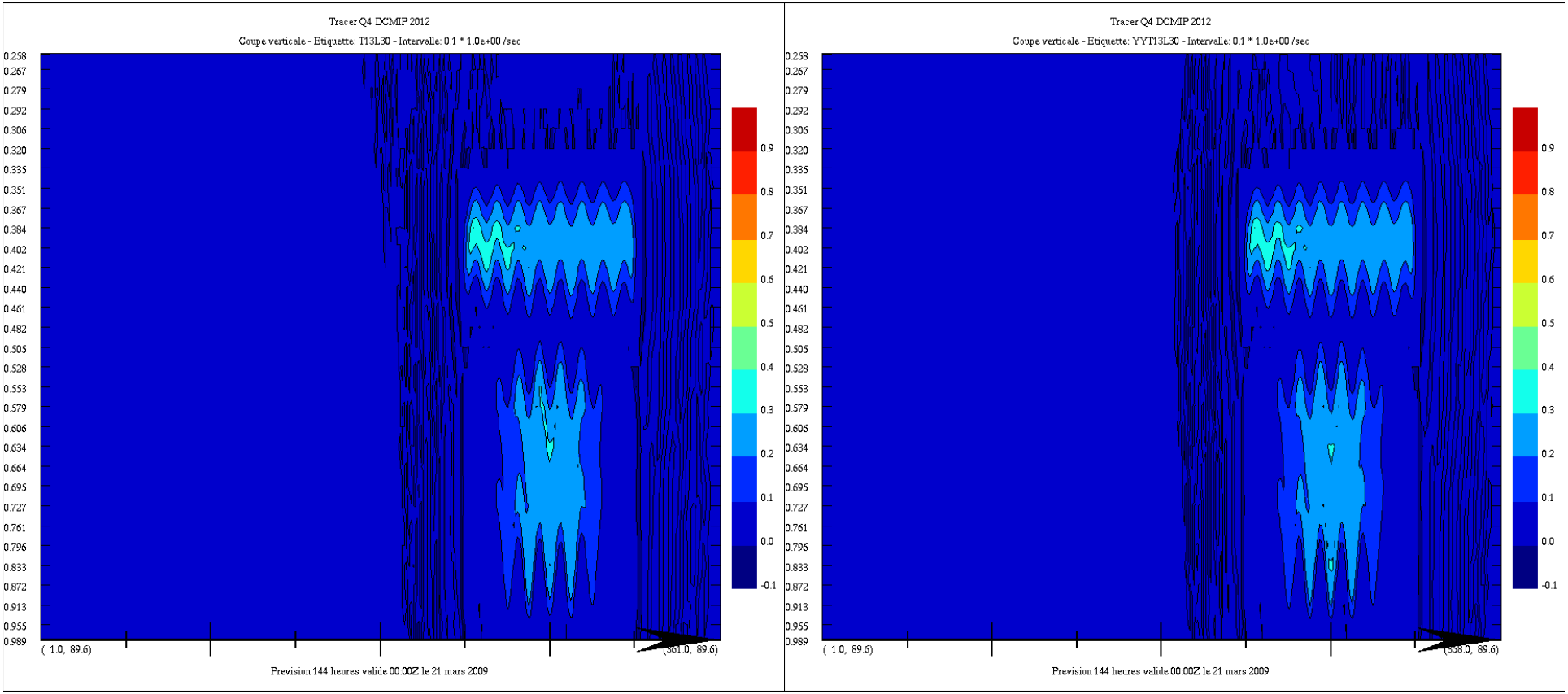


LL 1 deg, L30 YY

Plot Lon_Height at Eq.

Q4

t=0

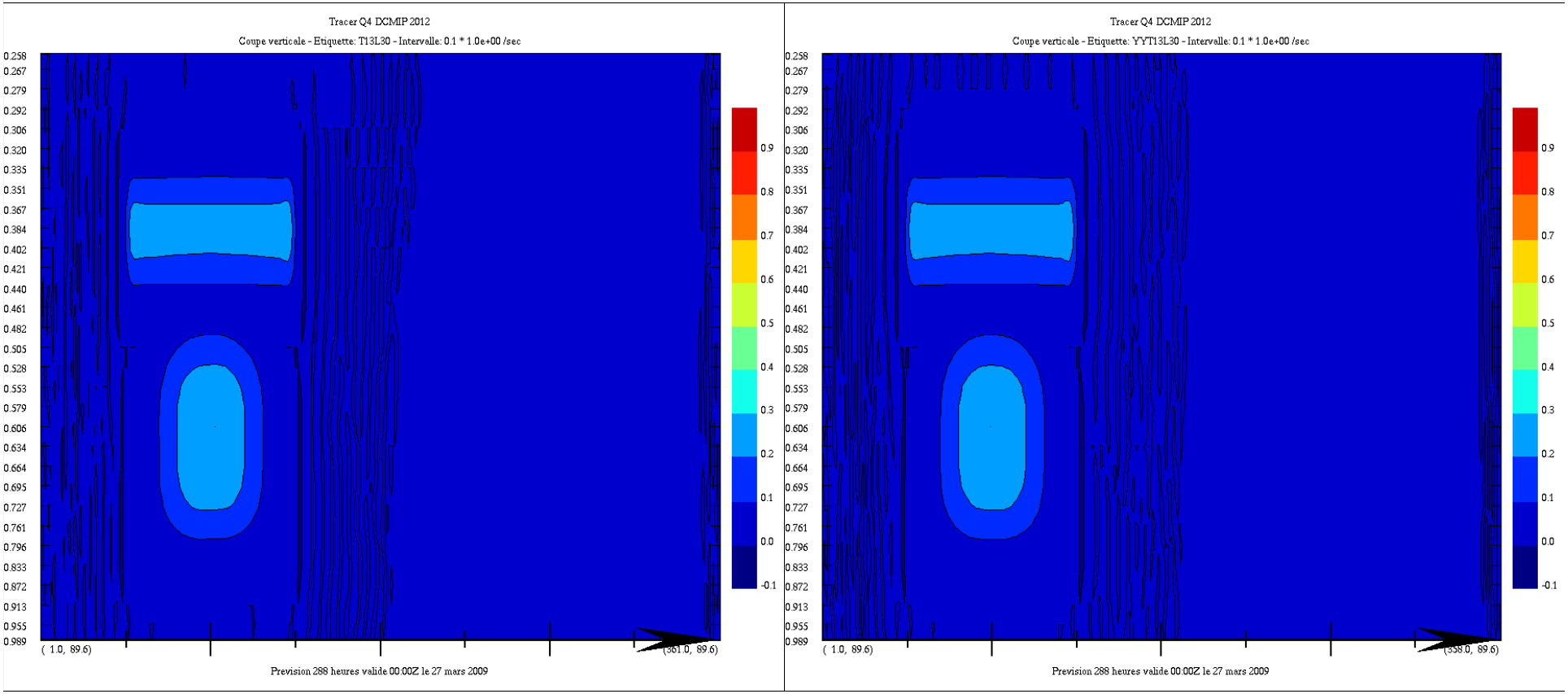


LL 1 deg, L30 YY

Plot Lon_Height at Eq.

Q4

t=6 days

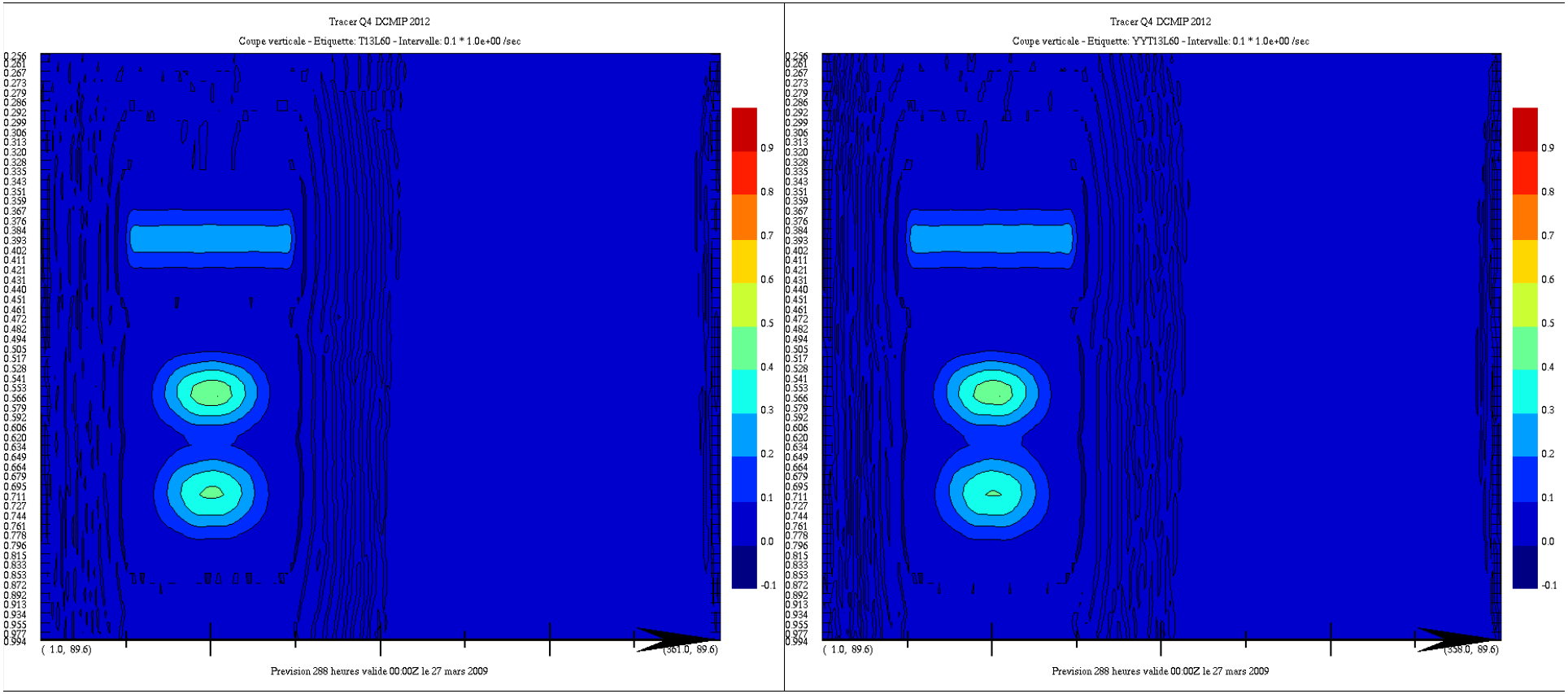


LL 1 deg, L30 YY

Plot Lon_Height at Eq.

Q4

t=12 days

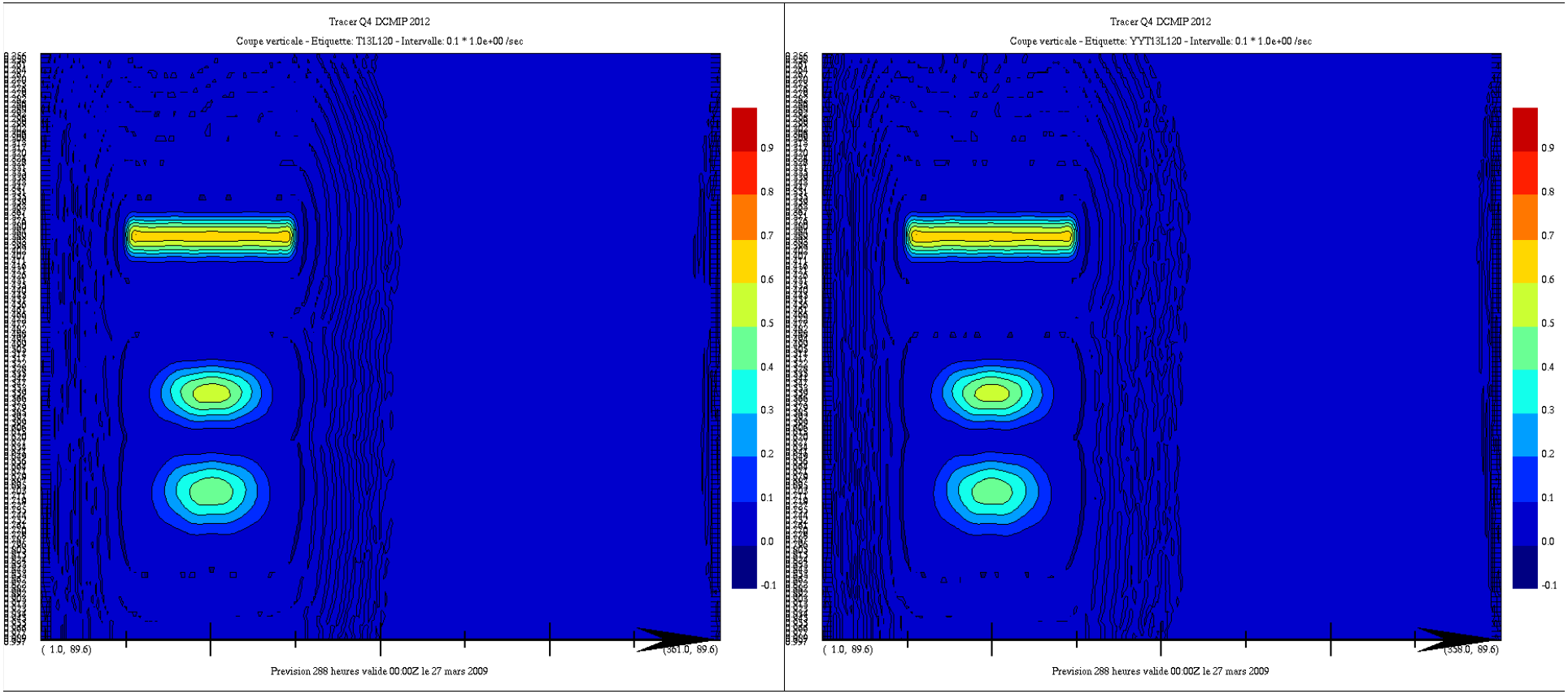


LL 1 deg, L60 YY

Plot Lon_Height at Eq.

Q4

t=12 days



LL 1 deg, L120 YY

Plot Lon_Height at Eq.

Q4

t=12 days

Tracer Q4		L1	L2	Linf
1 deg, L30	**LL**	1.4335157	0.8217909	0.8688315
	YY	1.4653047	0.8328240	0.9496743
1 deg, L60	**LL**	1.2008981	0.7467500	0.8789407
	YY	1.2535632	0.7843578	0.9508272
1 deg, L120	**LL**	0.8262327	0.5525821	0.7180120
	YY	0.8557260	0.5635907	0.7696477

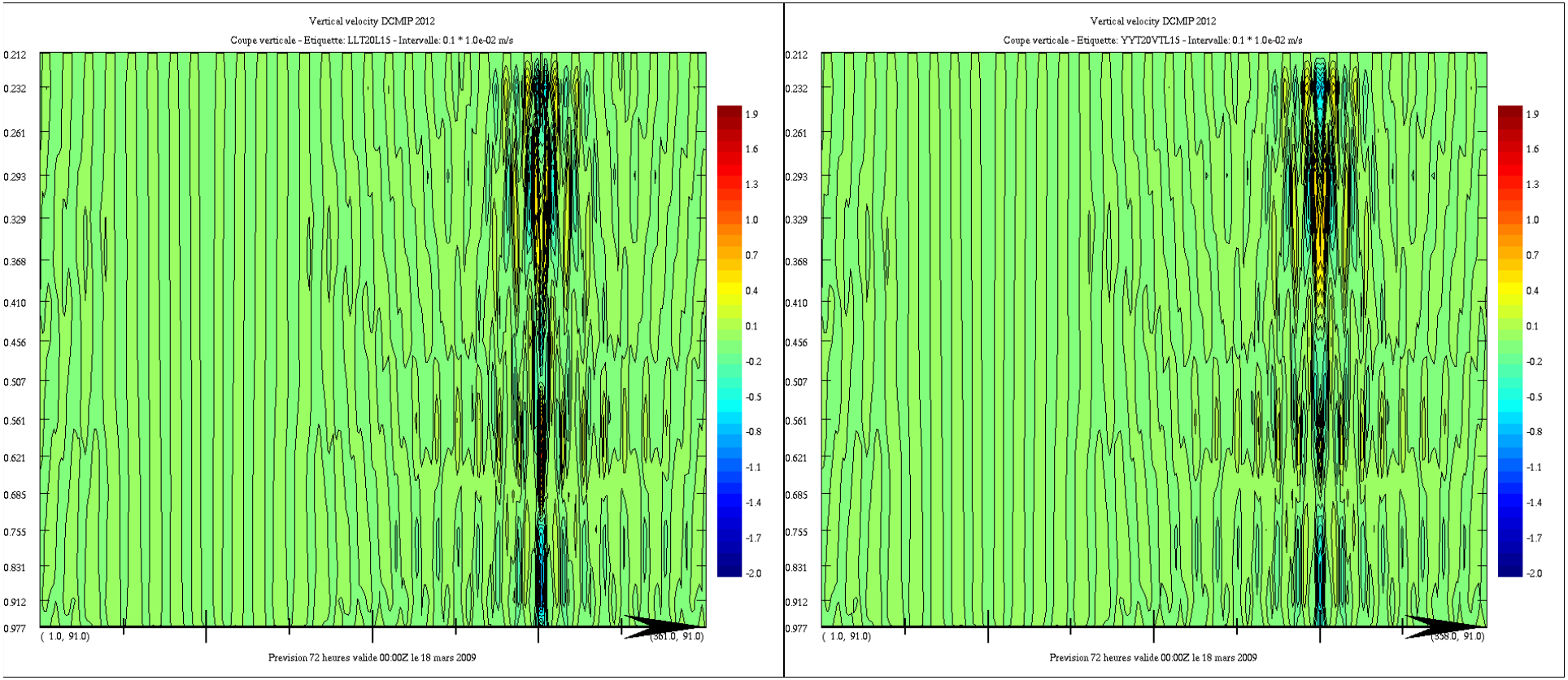
Errors decrease with increasing resolution

T20 (Steady-State Atmosphere at Rest in the presence of Orography) (OPTIONAL)

RUN for 6 days

[1. deg - Dz=800m Top=12km L15]: DT=1800 sec
[1. deg - Dz=400m Top=12km L30]: DT=1800 sec

2D Del(6) Diffusion (2 Delta-x removal ratio of 4% per timestep)

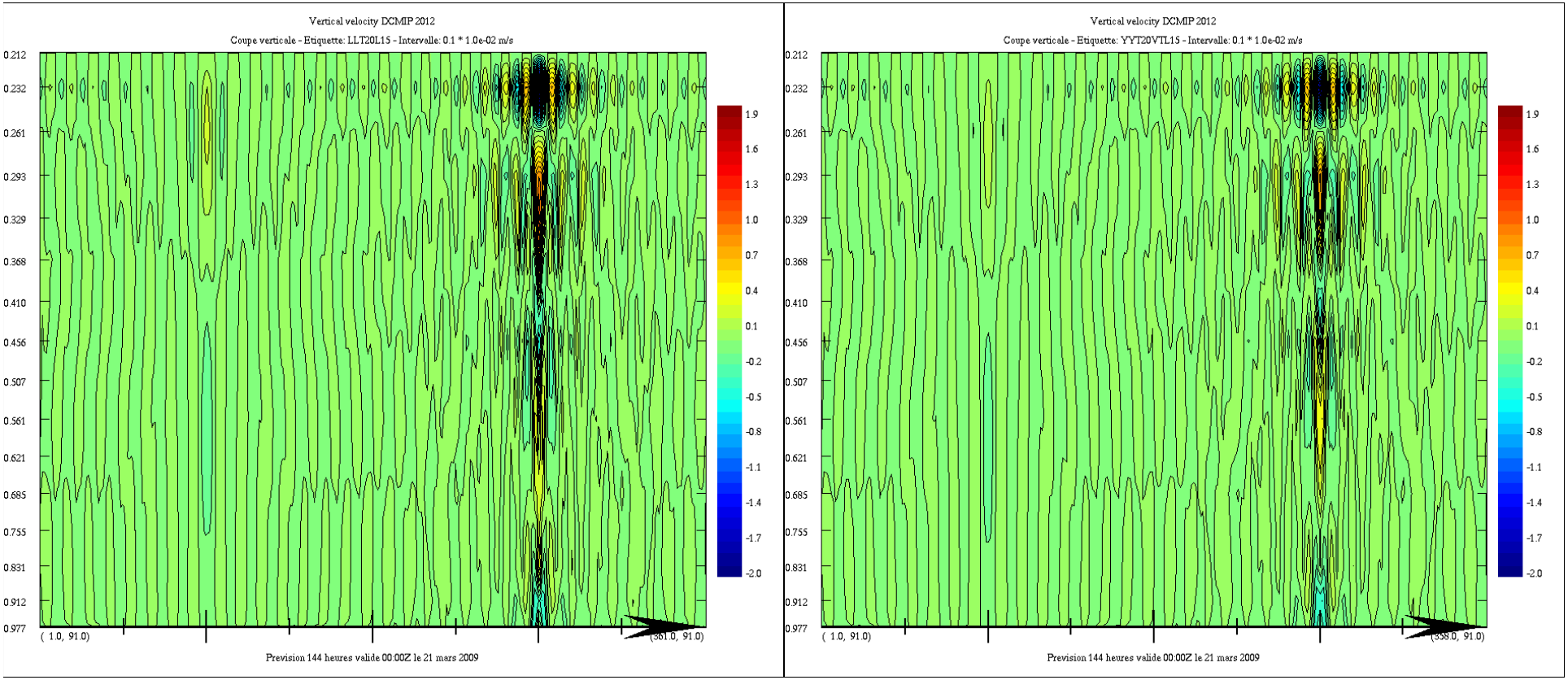


LL 1 deg, L15 YY

Plot Lon_Height at Eq.

Dz/Dt

t=3 days



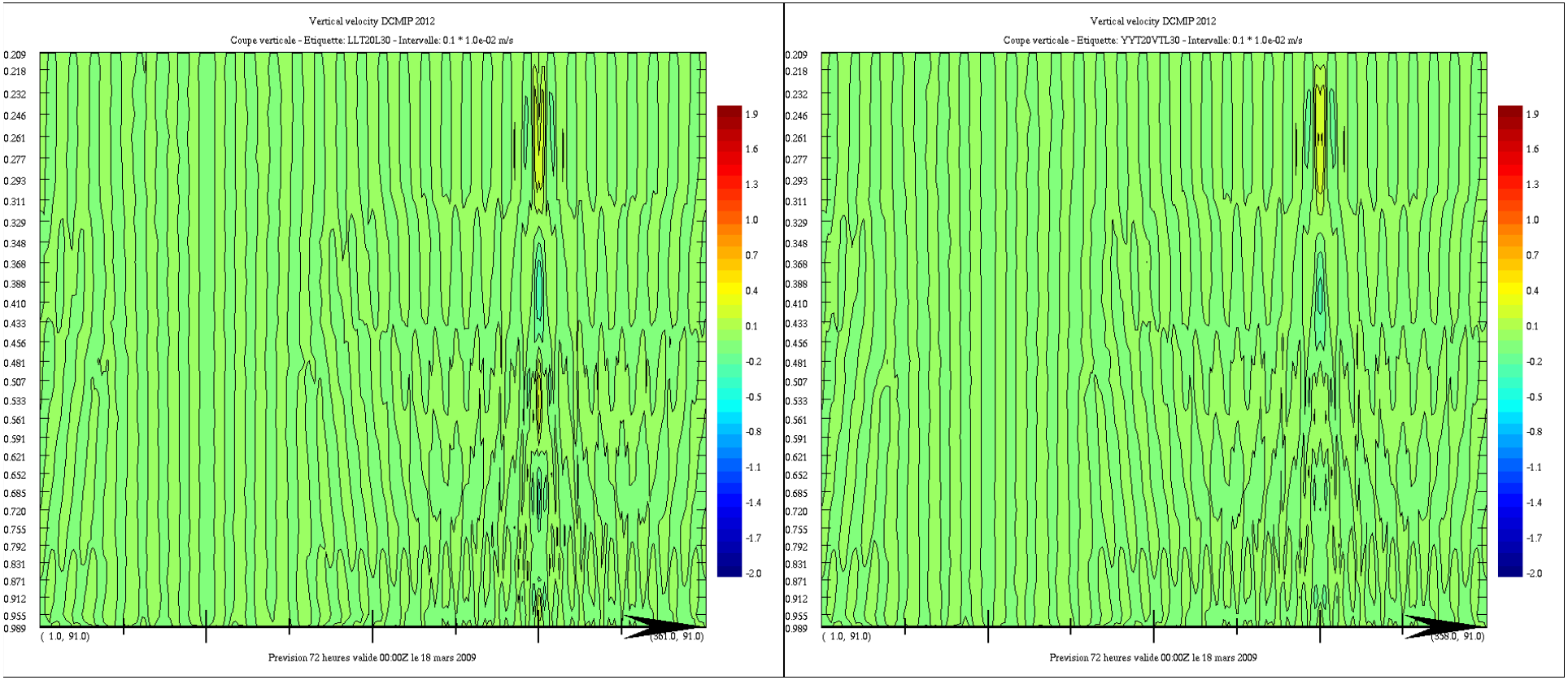
LL 1 deg, L15 YY

- *The noise moves along the vertical*
- *Presence of the noise in sections far from mountain*

Plot Lon_Height at Eq.

Dz/Dt

t=6 days

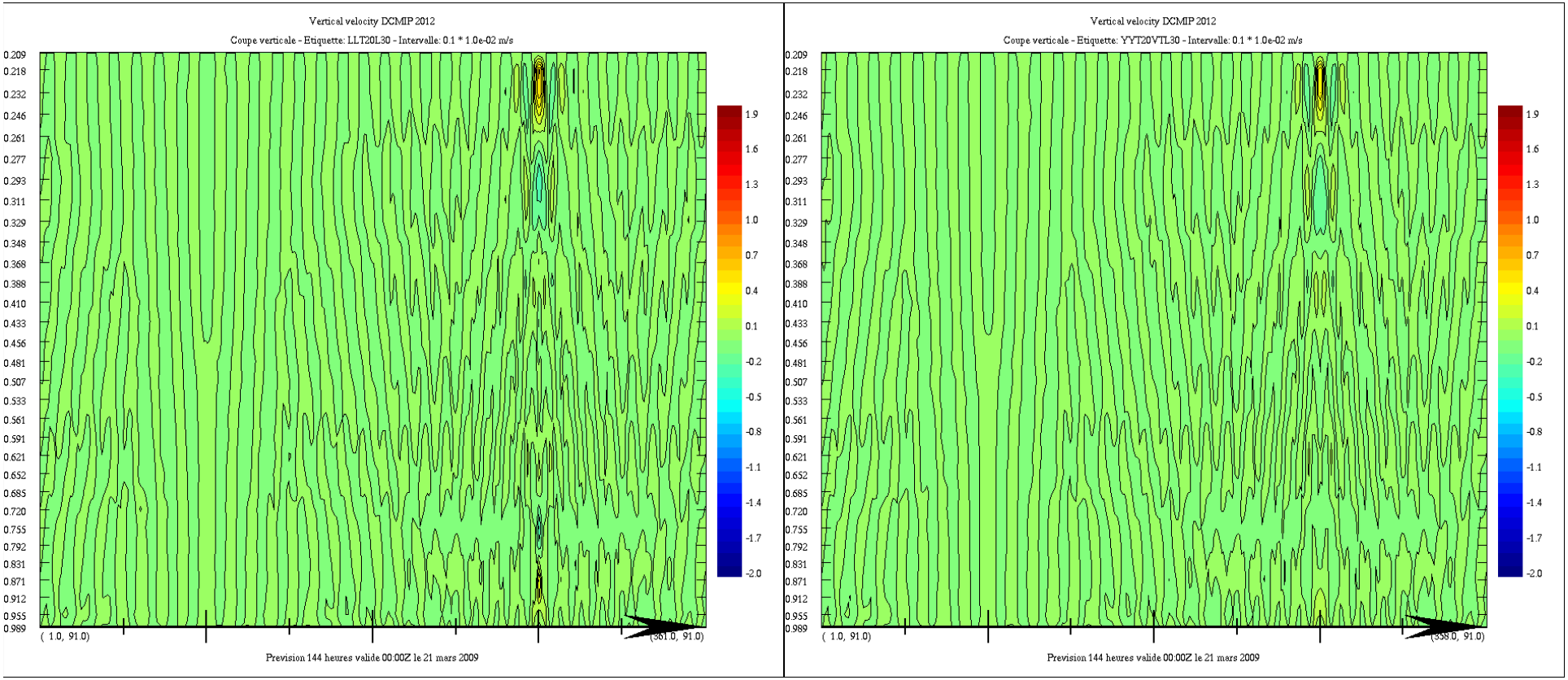


LL 1 deg, L30 YY

Plot Lon_Height at Eq.

Dz/Dt

t=3 days



LL 1 deg, L30 YY

Less intense with resolution

Plot Lon_Height at Eq.

Dz/Dt

t=6 days

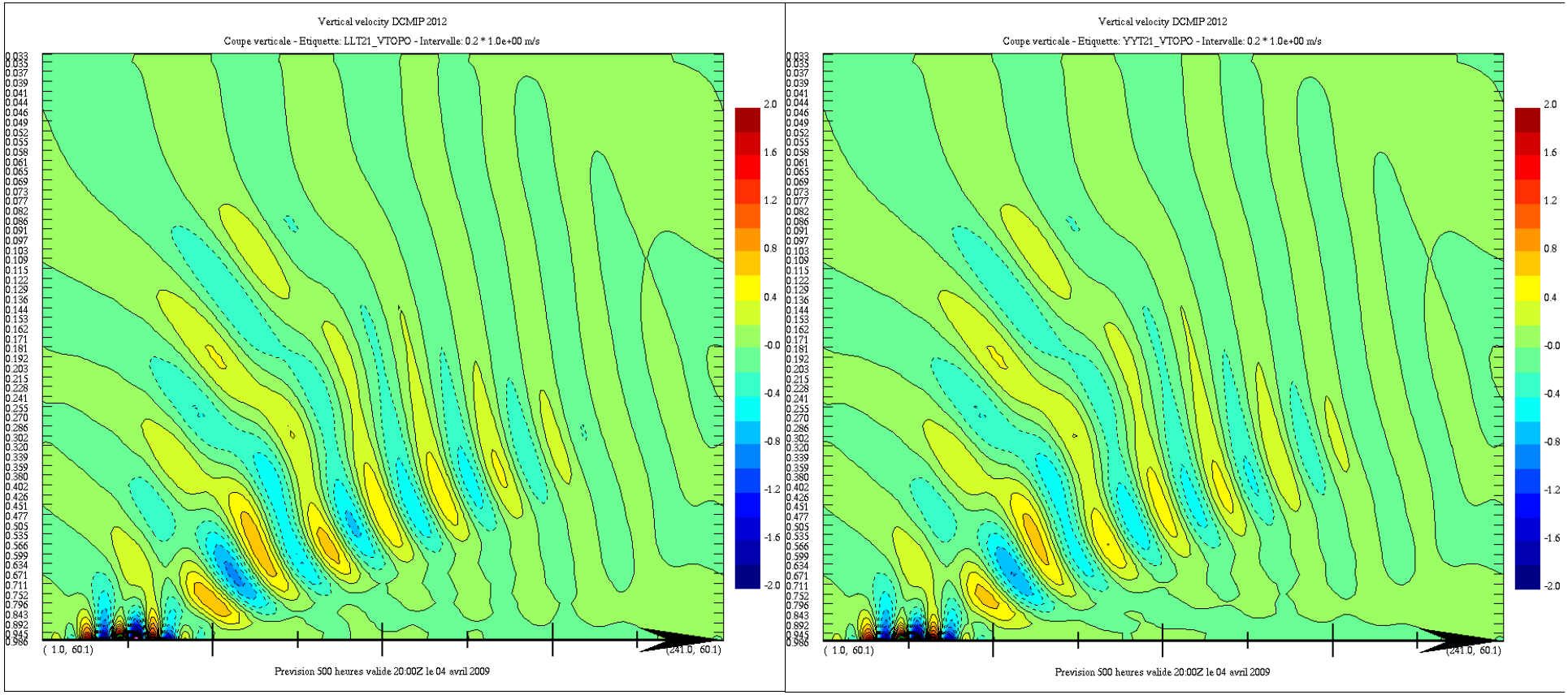
T21-T22
(Non-Hydrostatic mountain waves over a Schaer-Type mountain)

RUN for 2 hrs

[1.5 deg - Dz=500m Top=30km L60]:
DT = 2500/X sec = 2500/500 sec = 5 sec

2D Del(6) Diffusion (2 Delta-x removal ratio of 4% per timestep)

Rayleigh friction absorbing layer



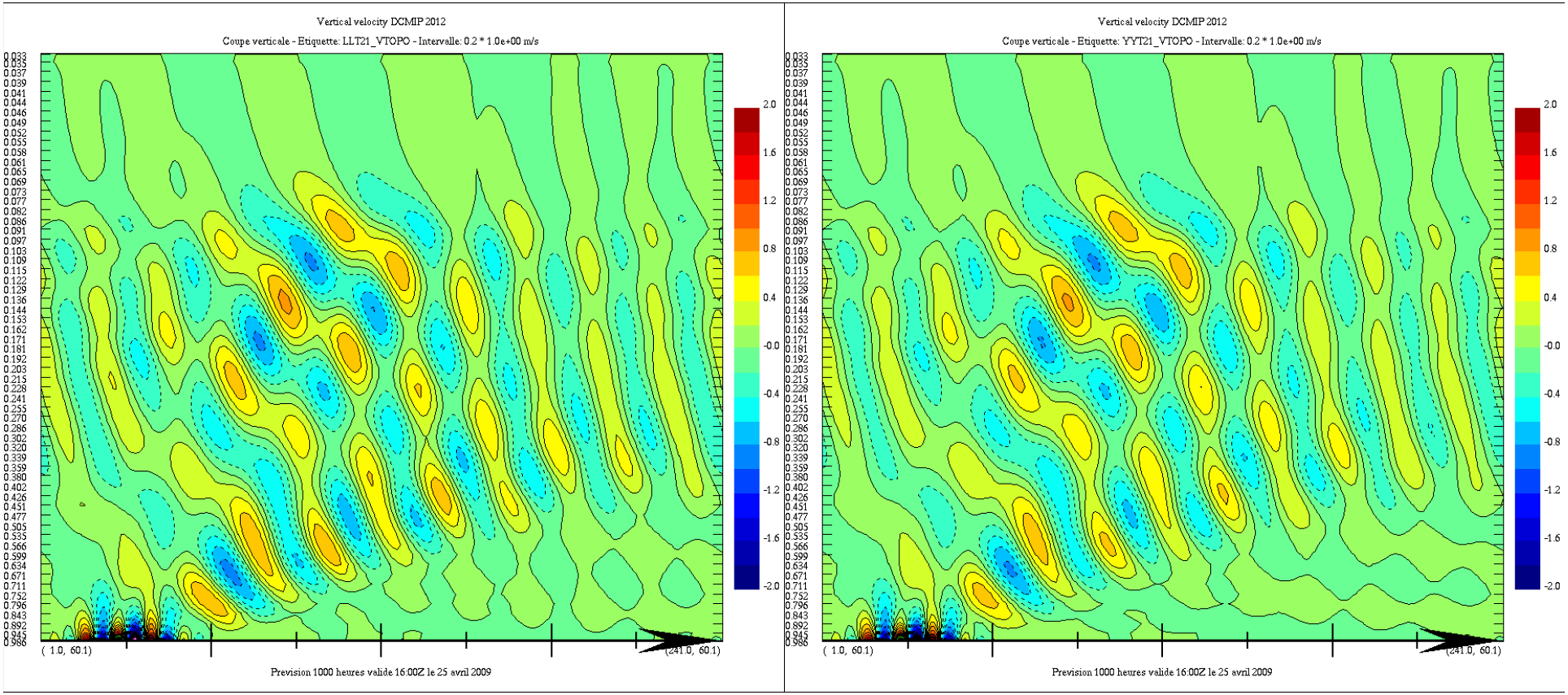
LL Case T21 : without vertical wind shear YY

Yin-Yang slightly less intense

Plot Lon_Height at Eq.

Dz/Dt

t=3600 sec



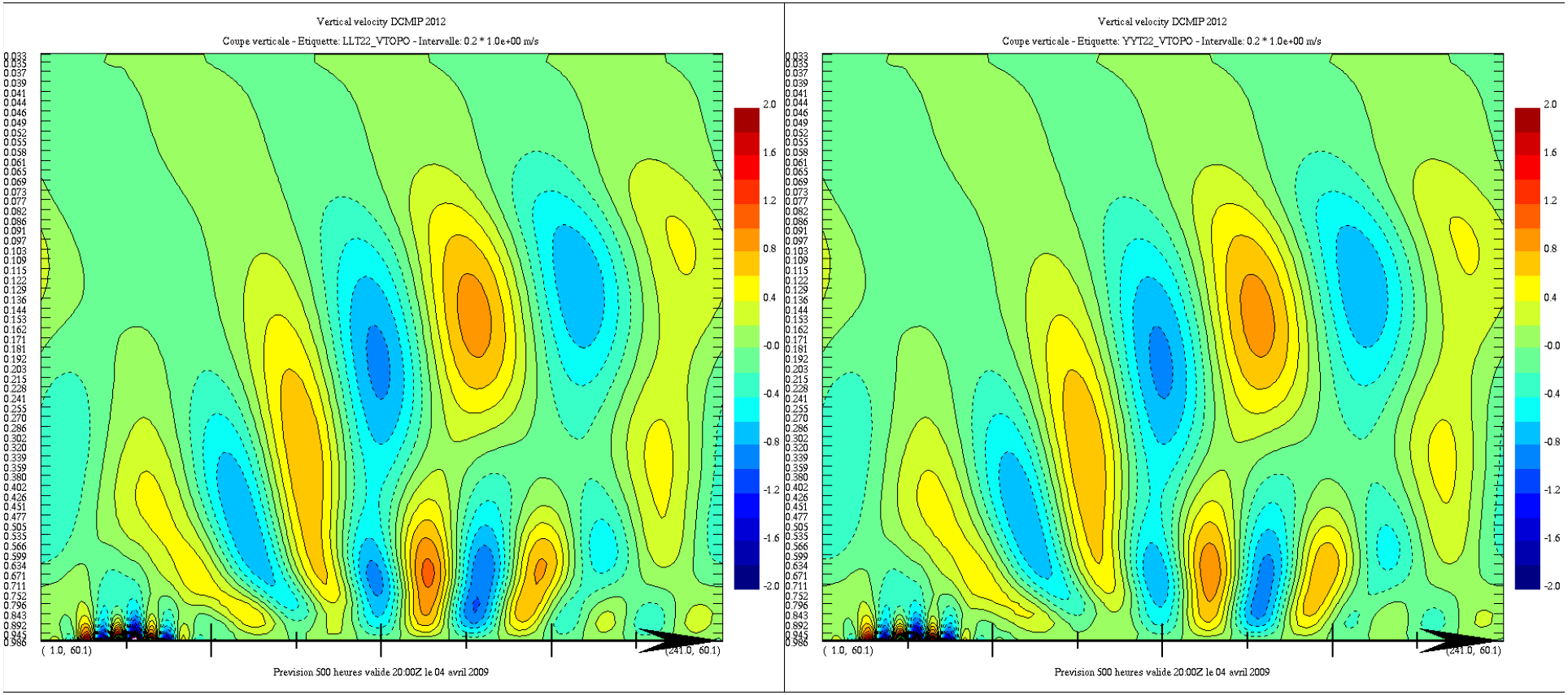
LL Case T21 : without vertical wind shear YY

Yin-Yang slightly less intense

Plot Lon_Height at Eq.

Dz/Dt

t=7200 sec



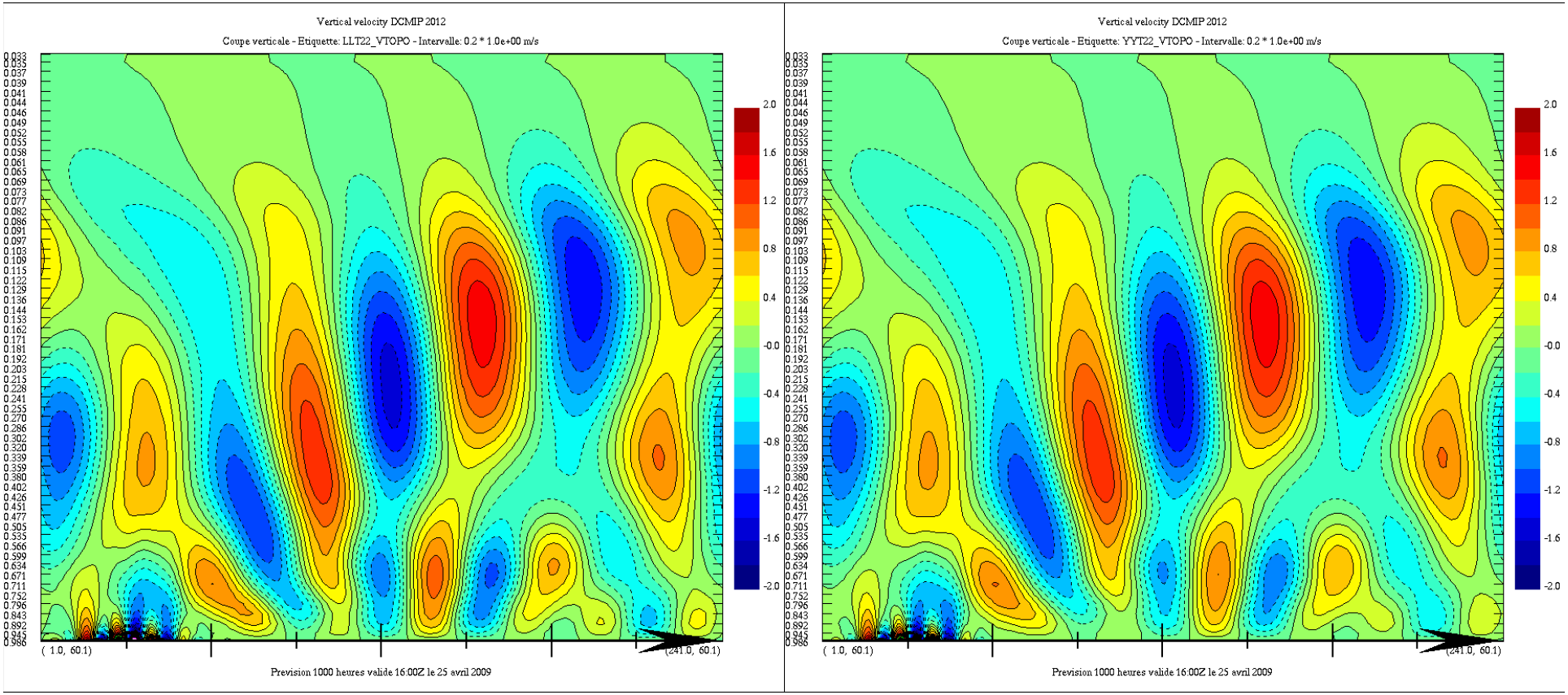
LL Case T22 : with vertical wind shear YY

Yin-Yang slightly less intense

Plot Lon_Height at Eq.

Dz/Dt

t=3600 sec



LL Case T22 : with vertical wind shear YY

The contours are more intense

Plot Lon_Height at Eq.

Dz/Dt

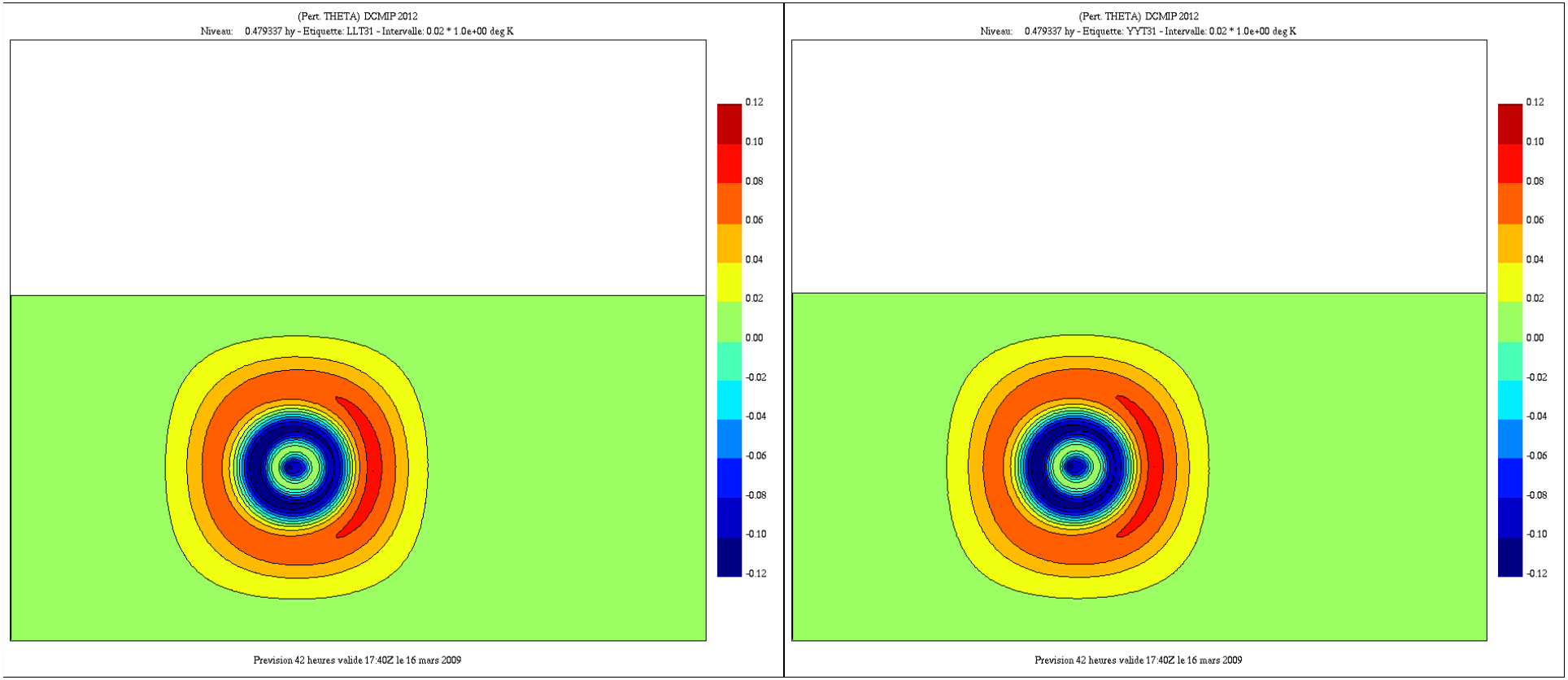
t=7200 sec

T31 (Non-hydrostatic Gravity Waves)

RUN for 1 hr

[1.125 deg - Dz=1000m Top=10km N=.01 L10]:
DT = 3125/X sec = 3125/125 sec = 25 sec

2D Del(6) Diffusion (2 Delta-x removal ratio of 4% per timestep)

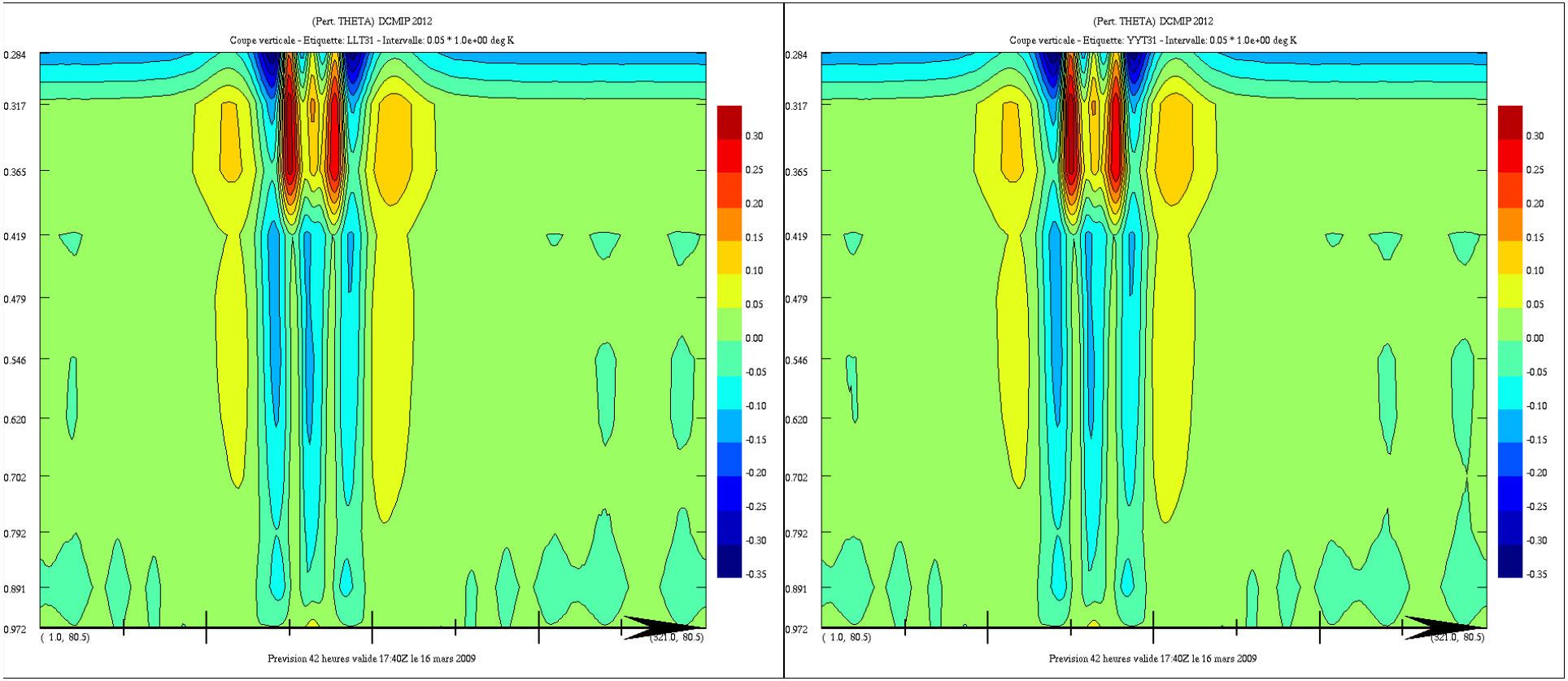


LL YY

Plot Lat_Lon nearest p=512.09 hPa (hyb_t=4.79337E-01)

Pert. Potential Temp.

t=1200 sec

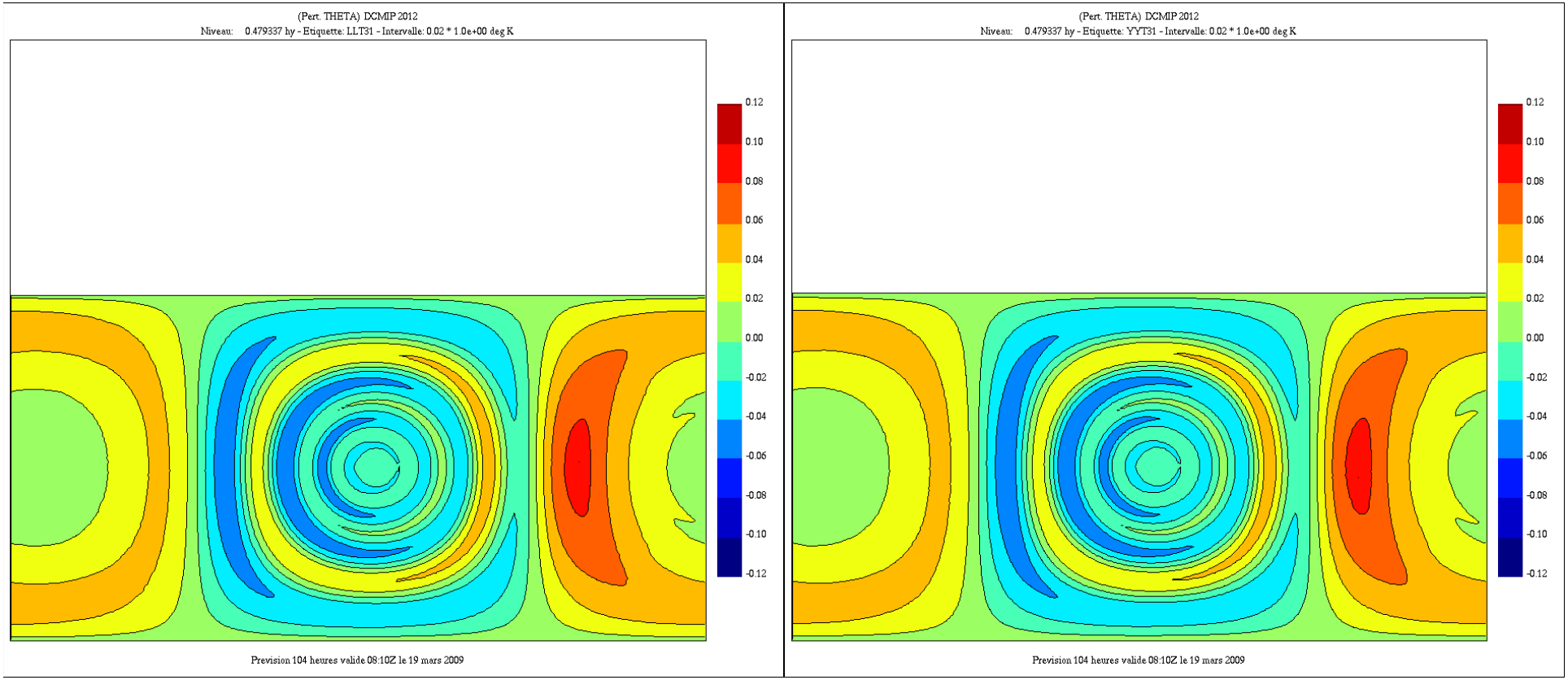


LL YY

Plot Lon_Height at Eq.

Pert. Potential Temp.

t=1200 sec

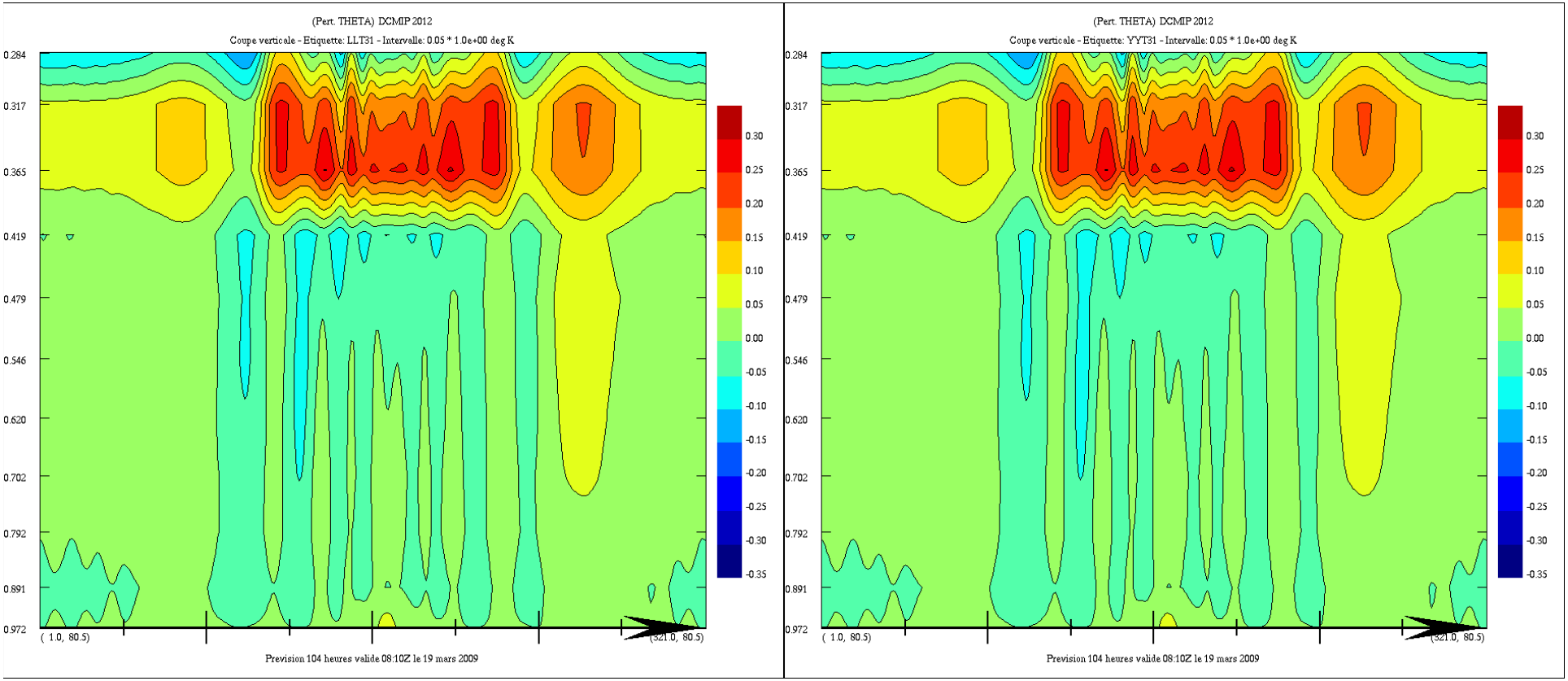


LL YY

Plot Lat_Lon nearest p=512.09 hPa (hyb_t=4.79337E-01)

Pert. Potential Temp.

t=3000 sec



LL YY

The wave is more intense near the top of the model.
The initial perturbation was maximum near 500 hPa.

Plot Lon_Height at Eq.

Pert. Potential Temp.

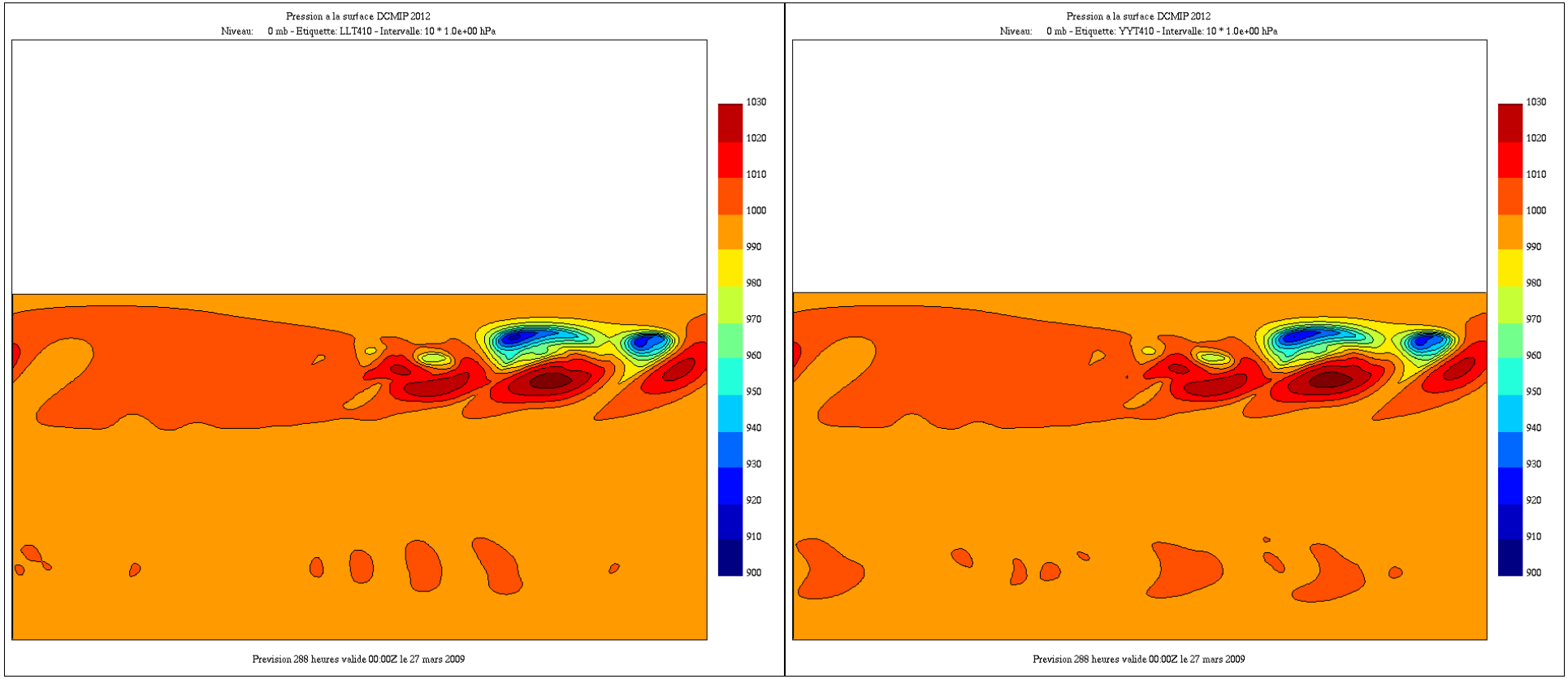
t=3000 sec

T41X (Dry Baroclinic Instability on a Small Planet with Dynamic Tracers)

RUN for 30 days

[1 deg - Levels eta L30]: DT = 1800/X sec

2D Del(6) Diffusion (2 Delta-x removal ratio of 4% per timestep)



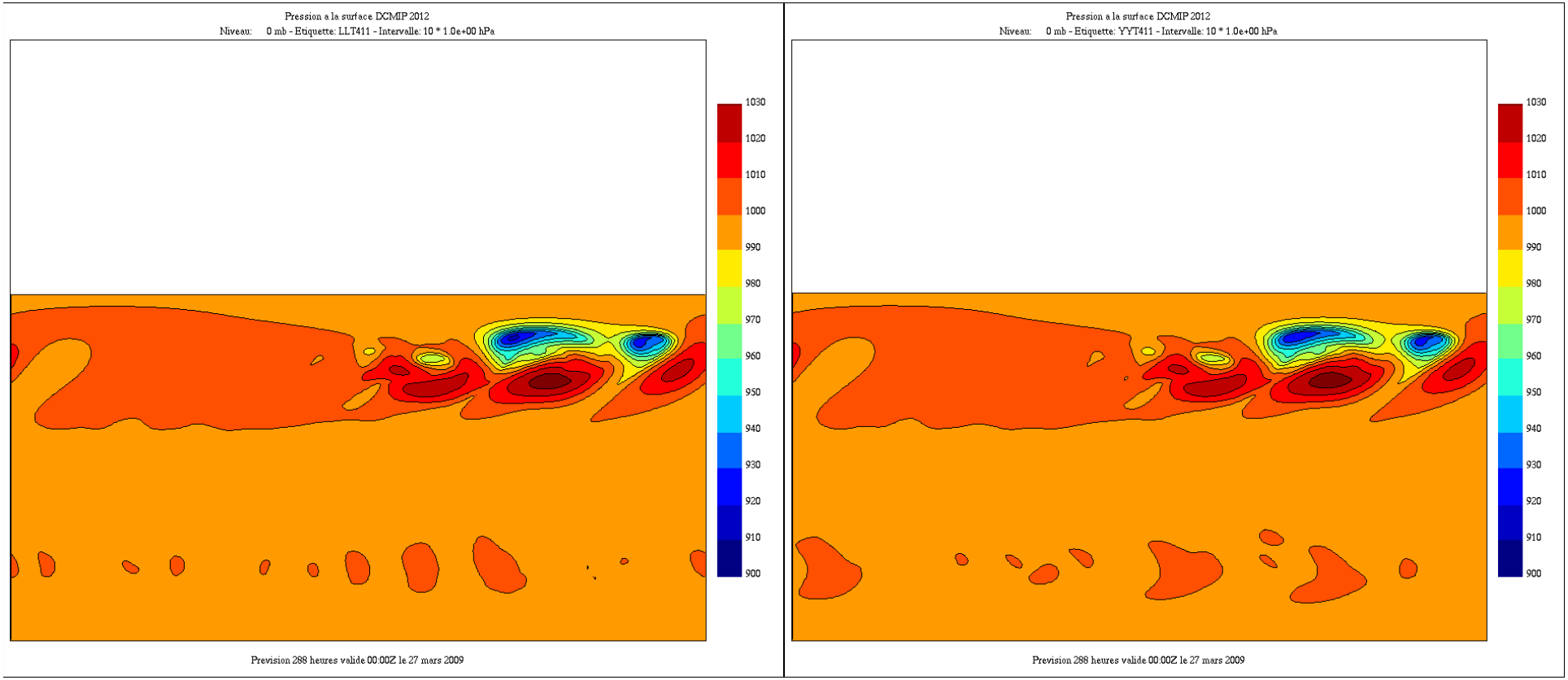
LL Case T410 YY

Scaling Factor X=1

Plot Lat_Lon

Surface pressure

t=12 days



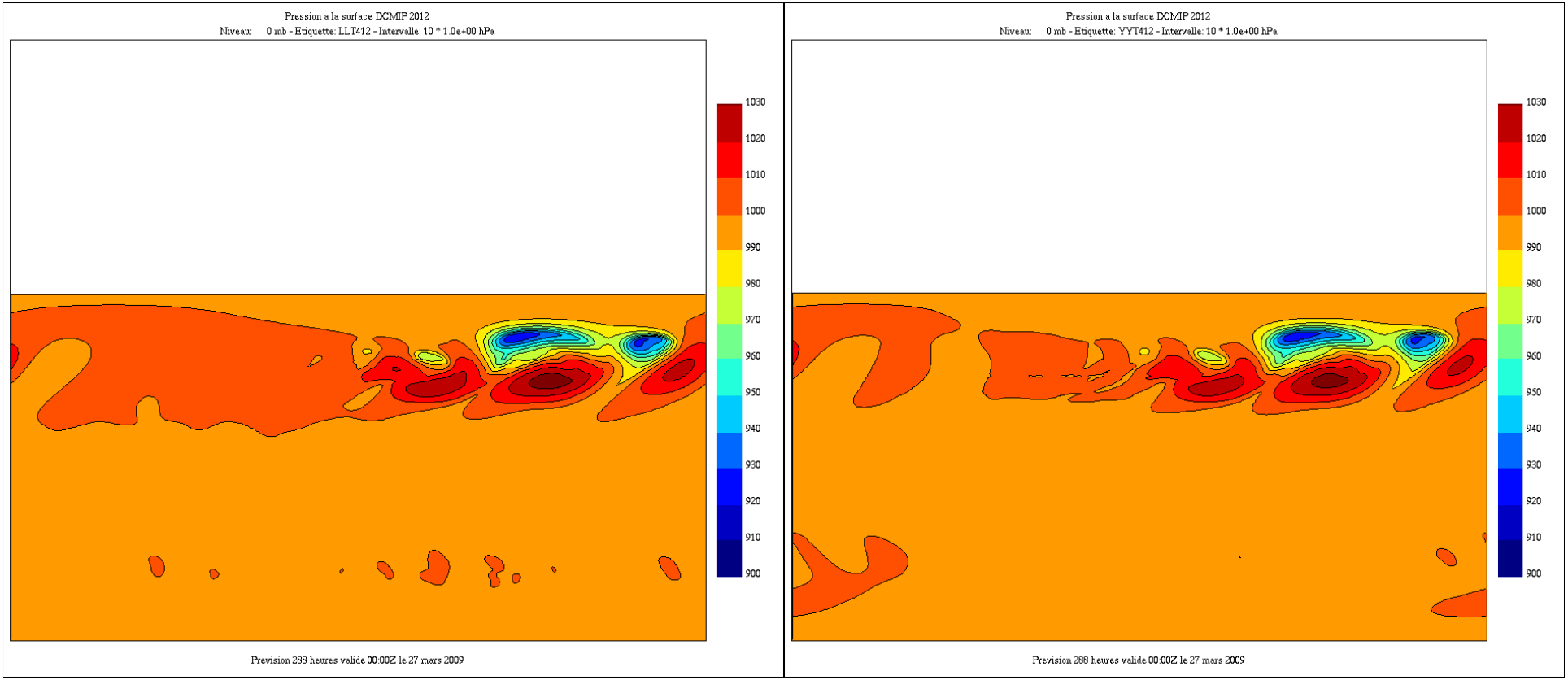
LL Case T411 YY

Scaling Factor X=10

Plot Lat_Lon

Surface pressure

t=12 days



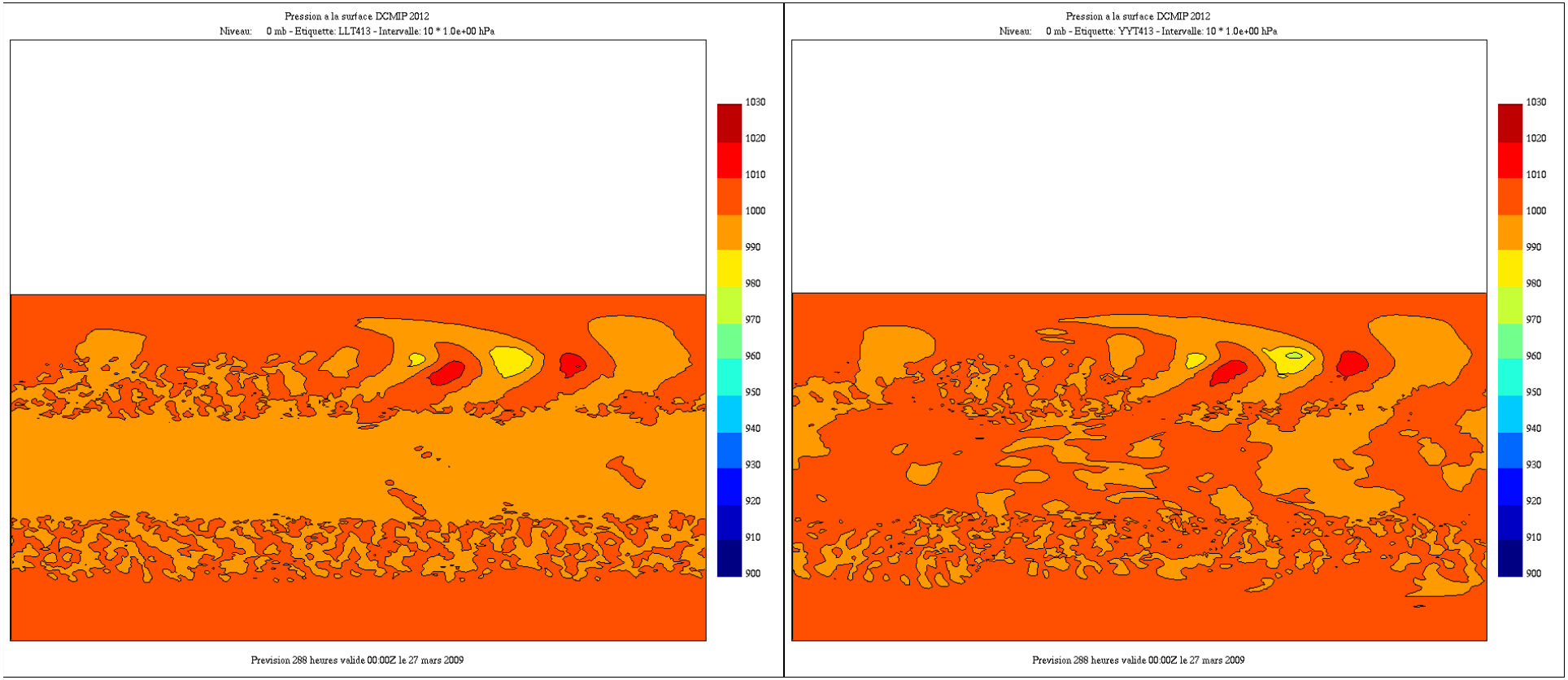
LL Case T412 YY

Scaling Factor X=100

Plot Lat_Lon

Surface pressure

t=12 days



LL Case T413 YY

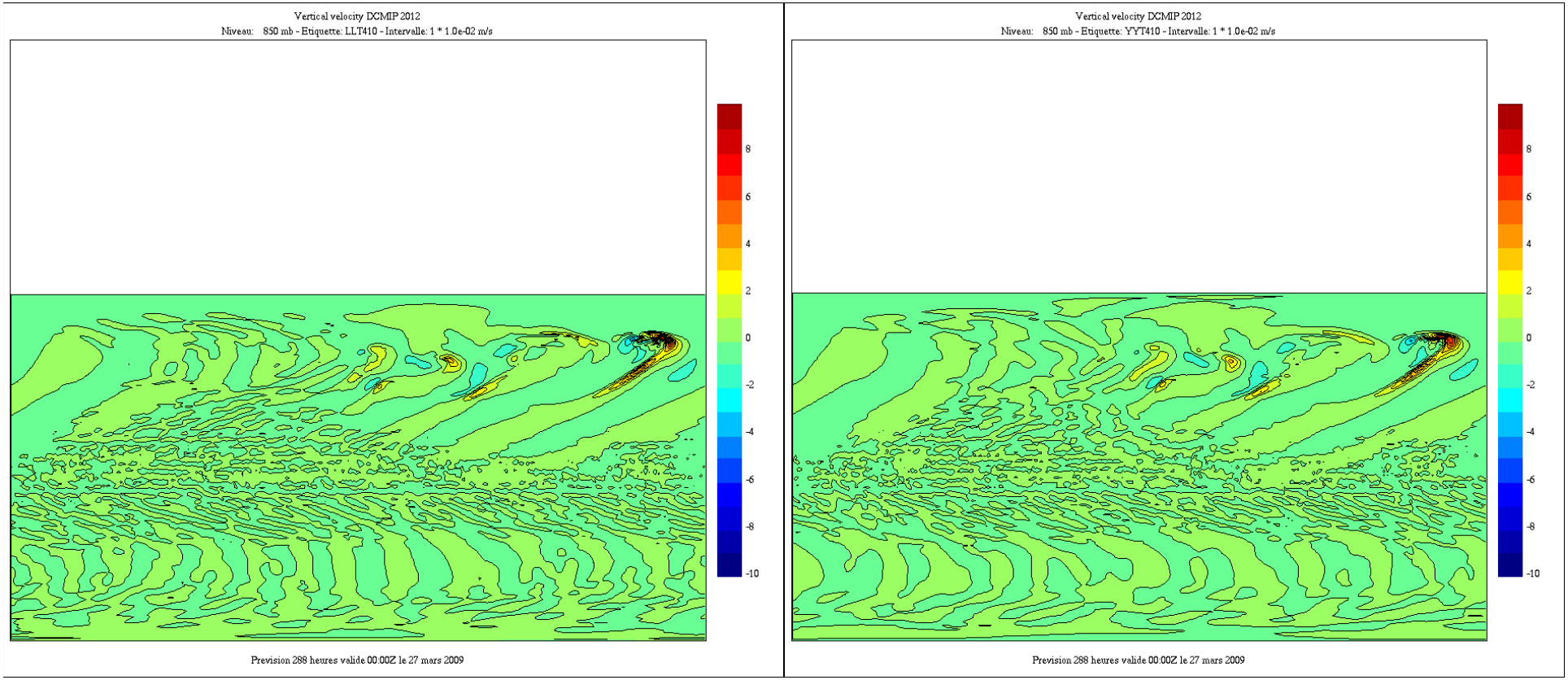
Scaling Factor X=1000

T413 loses intensity

Plot Lat_Lon

Surface pressure

t=12 days



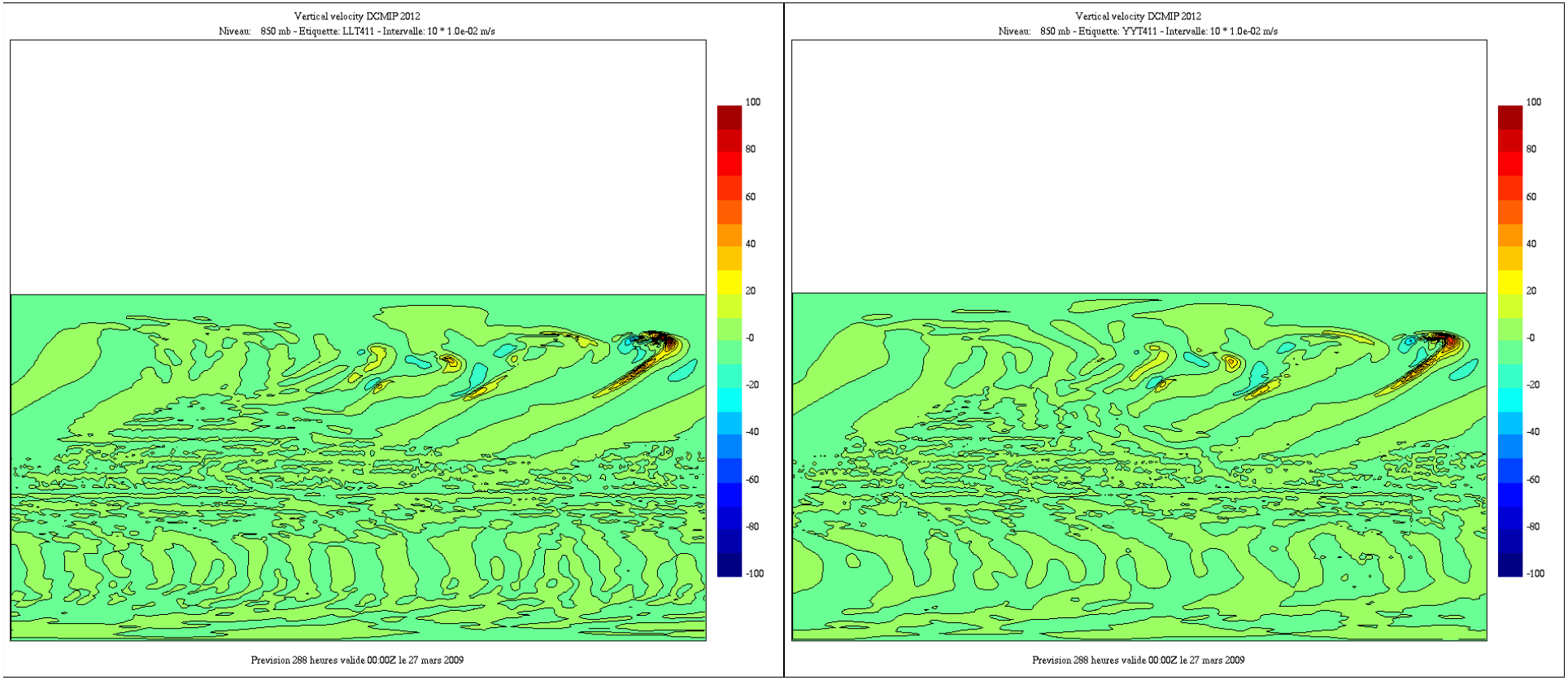
LL Case T410 YY

Scaling Factor X=1

Plot Lat_Lon 850hPa

Dz/Dt

t=12 days



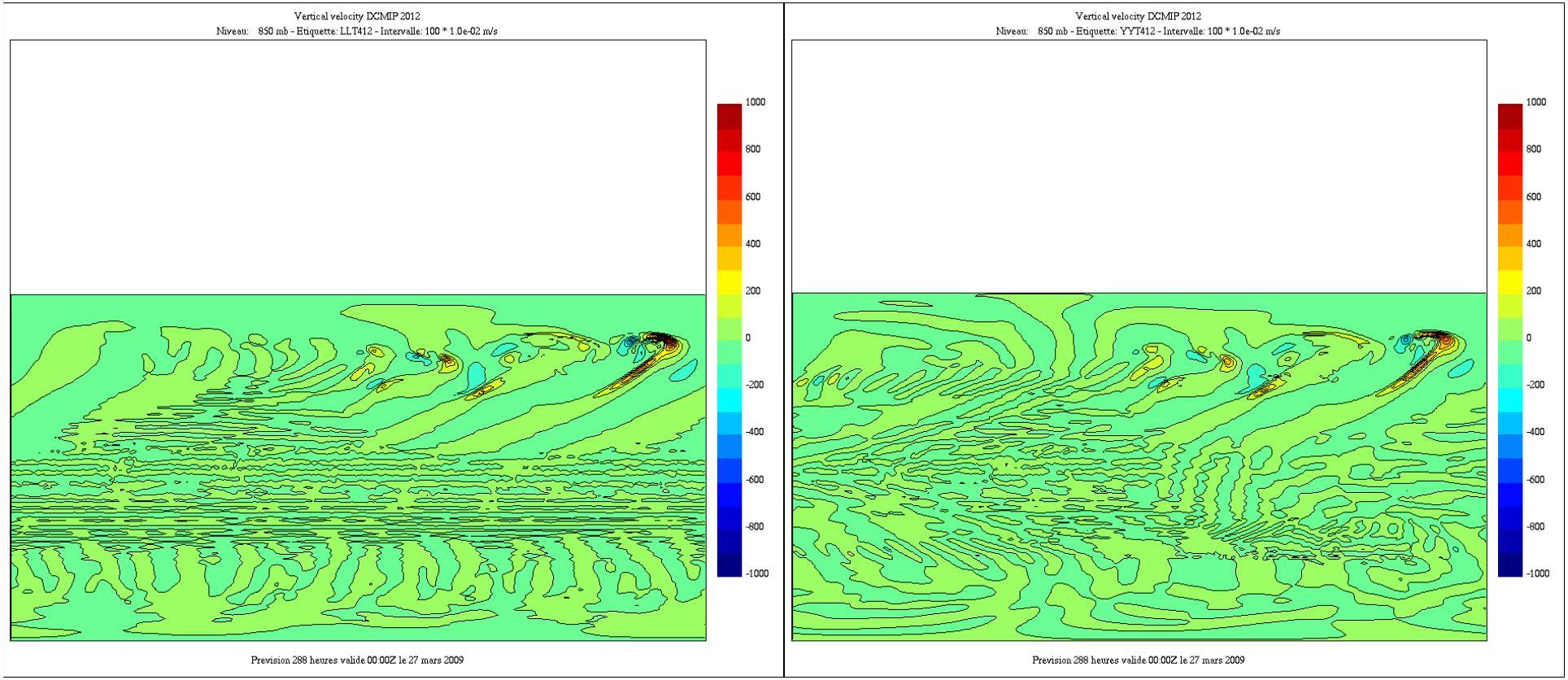
LL Case T411 YY

Scaling Factor X=10

Plot Lat_Lon 850hPa

Dz/Dt

t=12 days



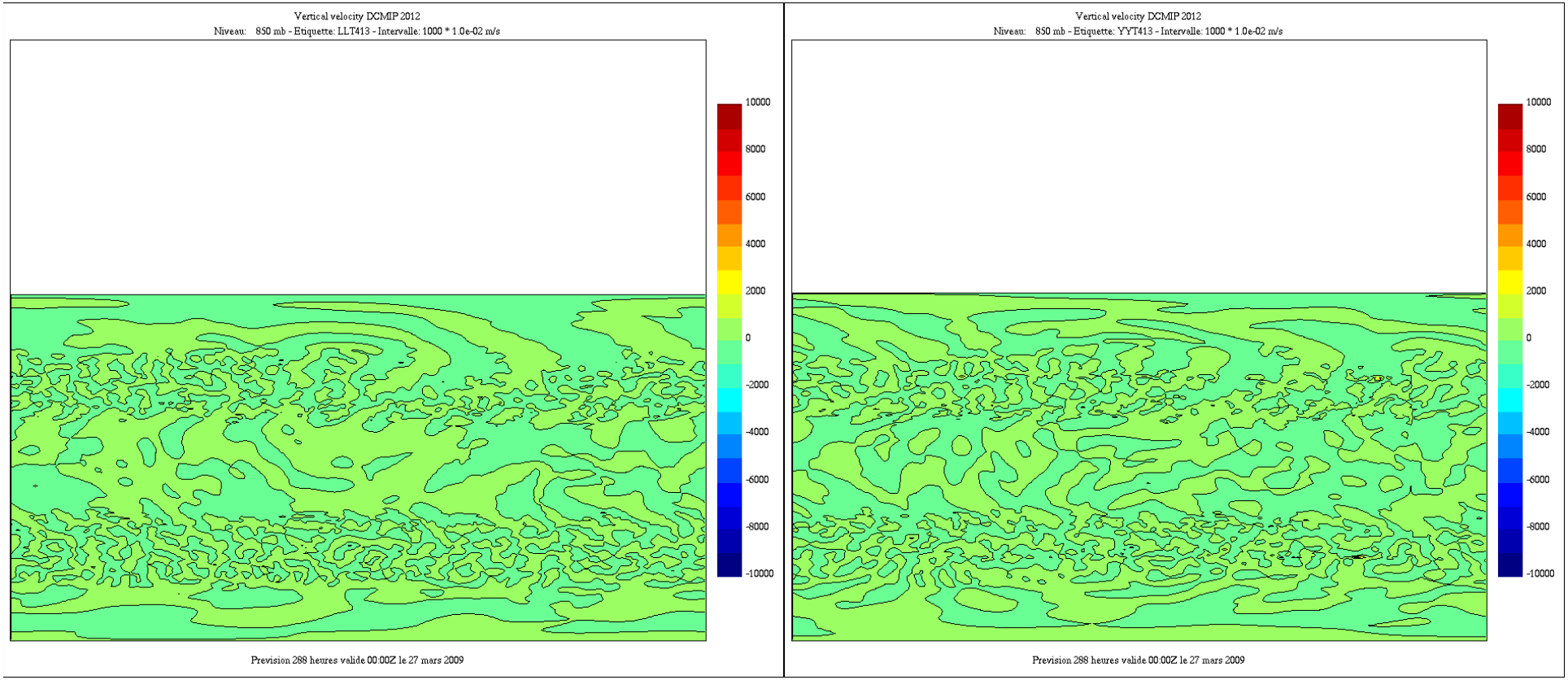
LL Case T412 YY

Scaling Factor X=100

Plot Lat_Lon 850hPa

Dz/Dt

t=12 days



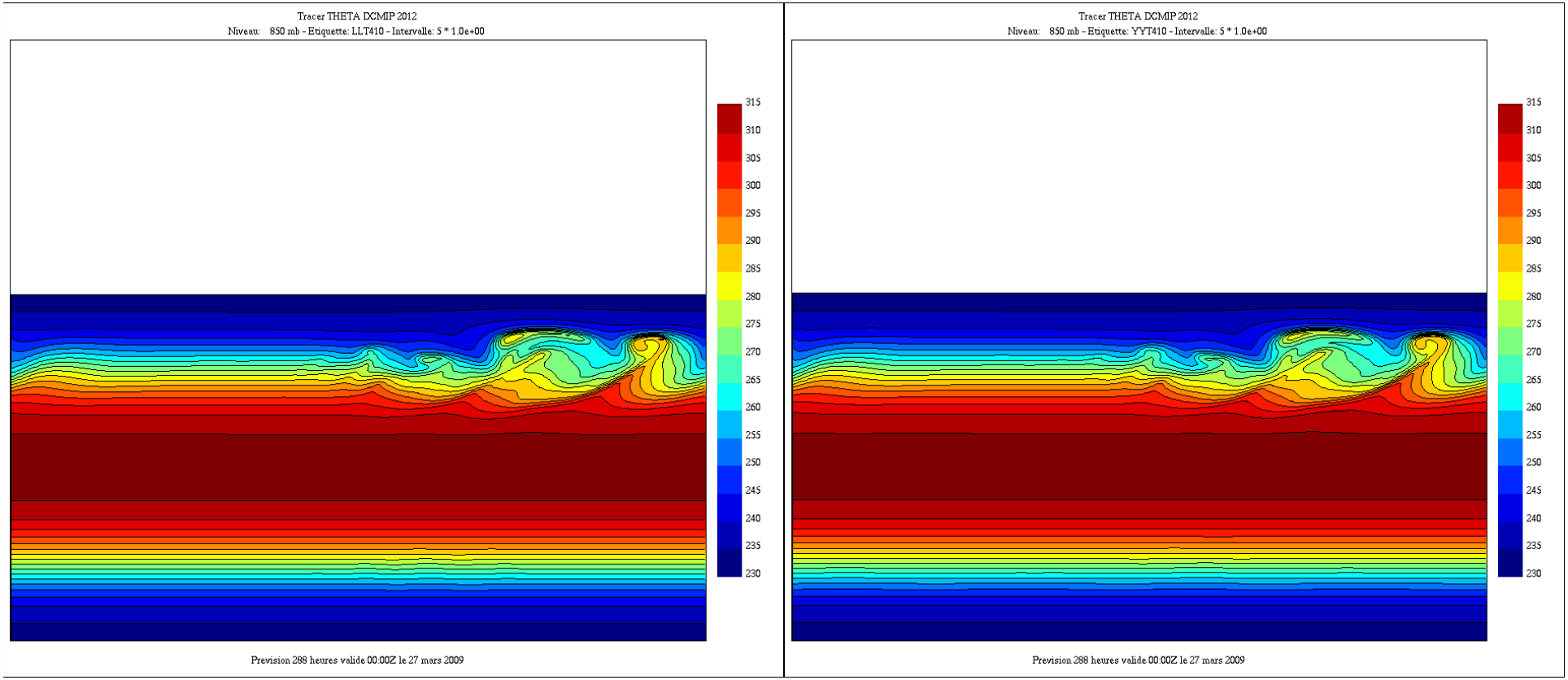
LL Case T413 YY

Scaling Factor X=1000

Plot Lat_Lon 850hPa

Dz/Dt

t=12 days



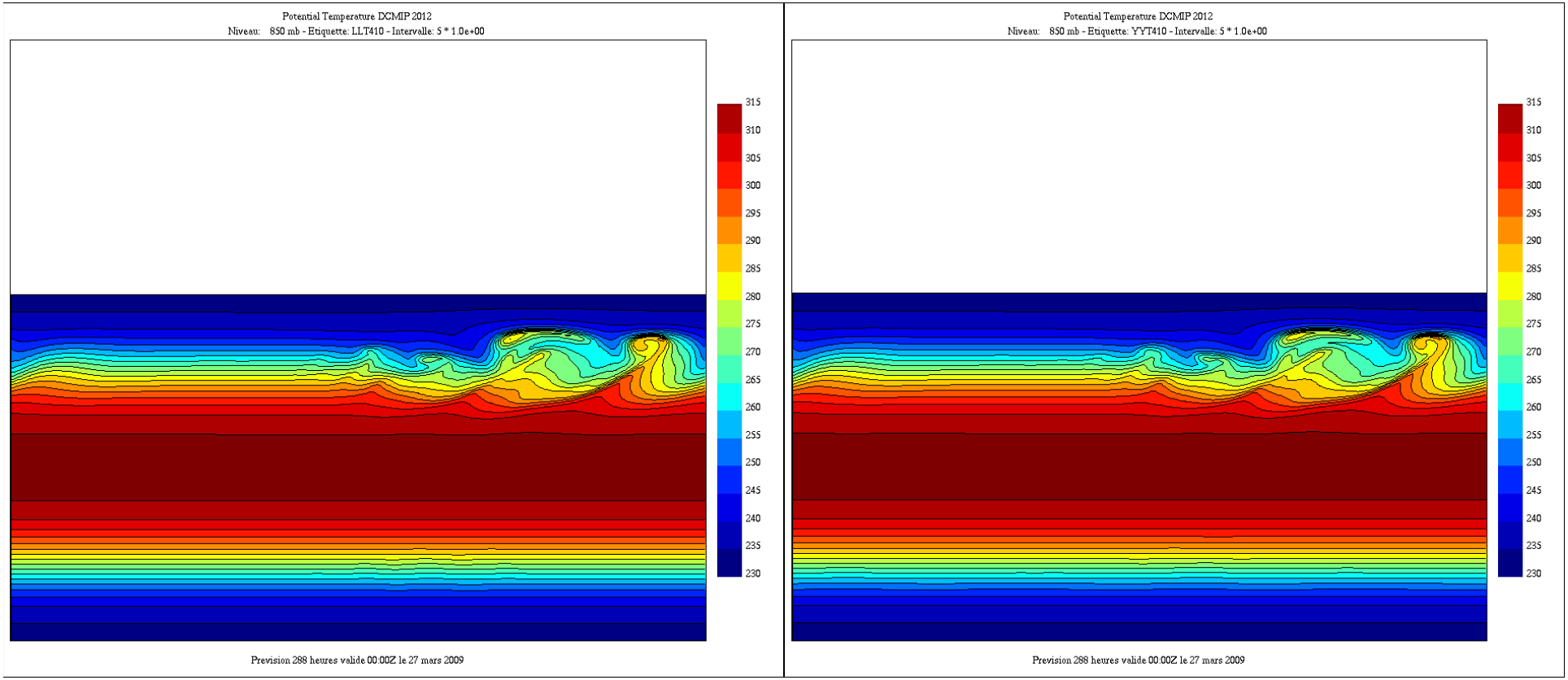
LL Case T410 YY

Scaling Factor X=1

Plot Lat_Lon 850hPa

Tracer Q1

t=12 days



LL Case T410 YY

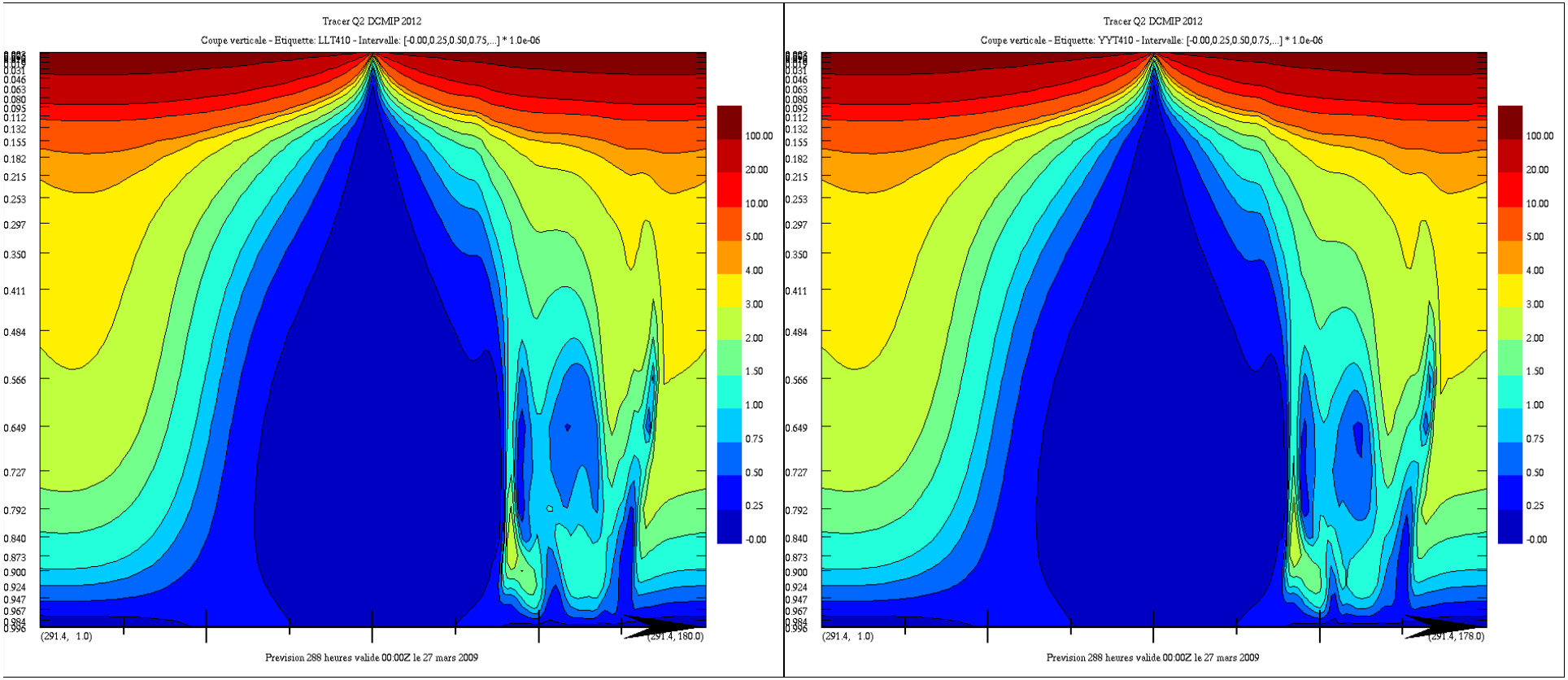
Scaling Factor X=1

Plot Lat_Lon 850hPa

Potential Temperature

t=12 days

- *Tracer Q1 and GEM's potential temperature have the same pattern*
- *Differences between Tracer Q1 and GEM's Potential Temperature very small*



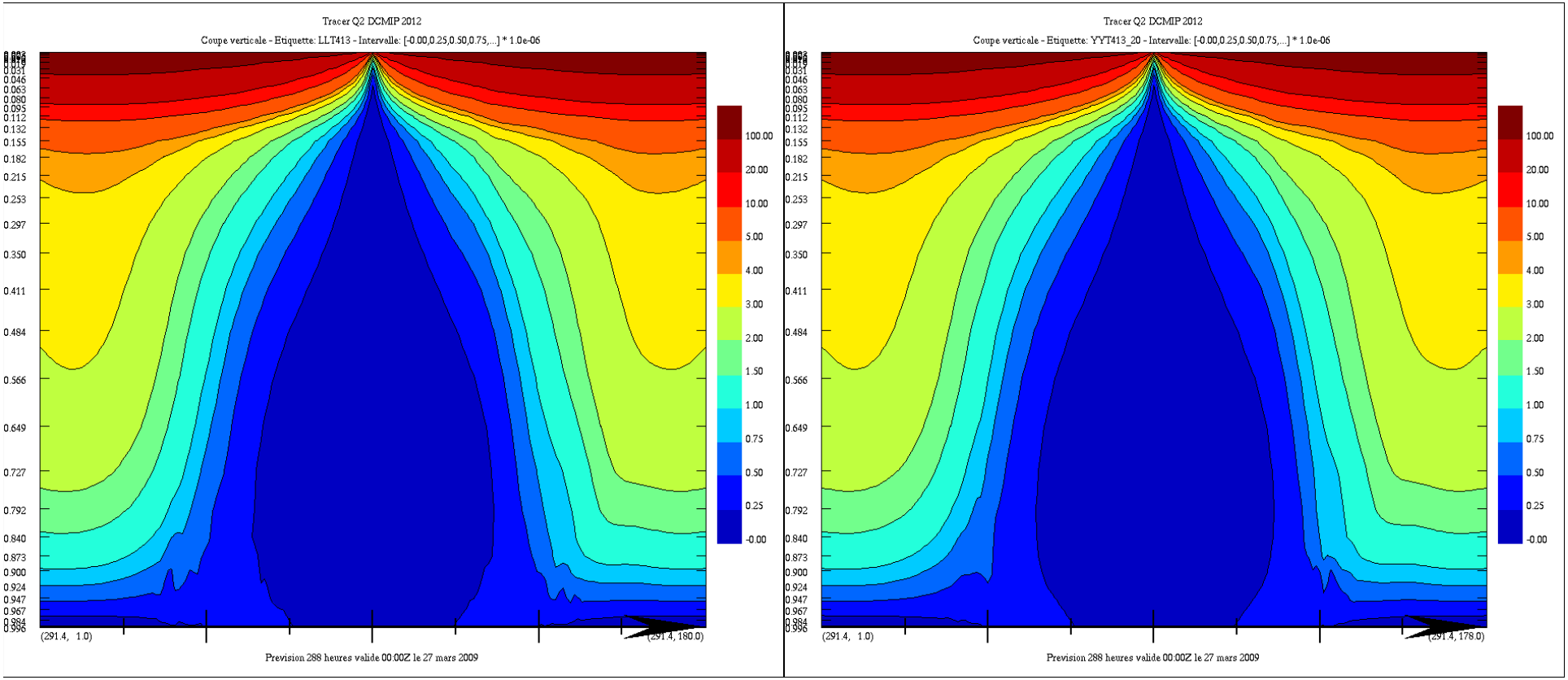
LL Case T410 YY

Scaling Factor X=1

Plot Lat_Height at Lon=290 deg

Tracer Q2=Abs(Equivalent Potential Vorticity)

t=12 days



LL Case T413 YY

Scaling Factor X=1000

Small EPV deformation with the smallest planet

Plot Lat_Height at Lon=290 deg

Tracer Q2=Abs(Equivalent Potential Vorticity)

t=12 days

T42 (Moist Variant of the Baroclinic Wave Test with Large-Scale Condensation)

RUN for 15 days

[1 deg - Levels eta L30]: DT = 1800 sec
[.5 deg - Levels eta L30]: DT = 900 sec

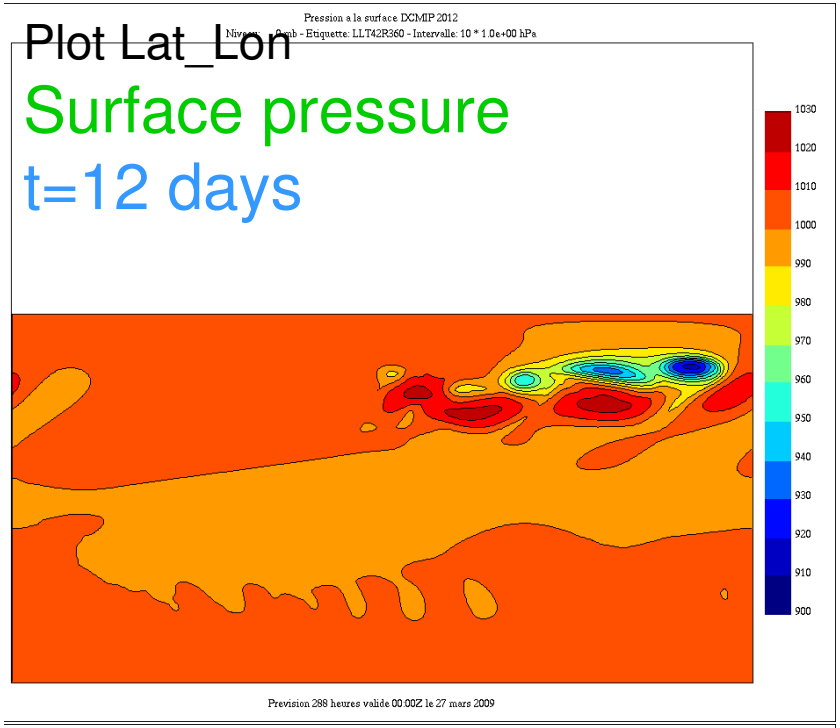
2D Del(6) Diffusion (2 Delta-x removal ratio of 4% per timestep)

Off-centering Epsilon = .1

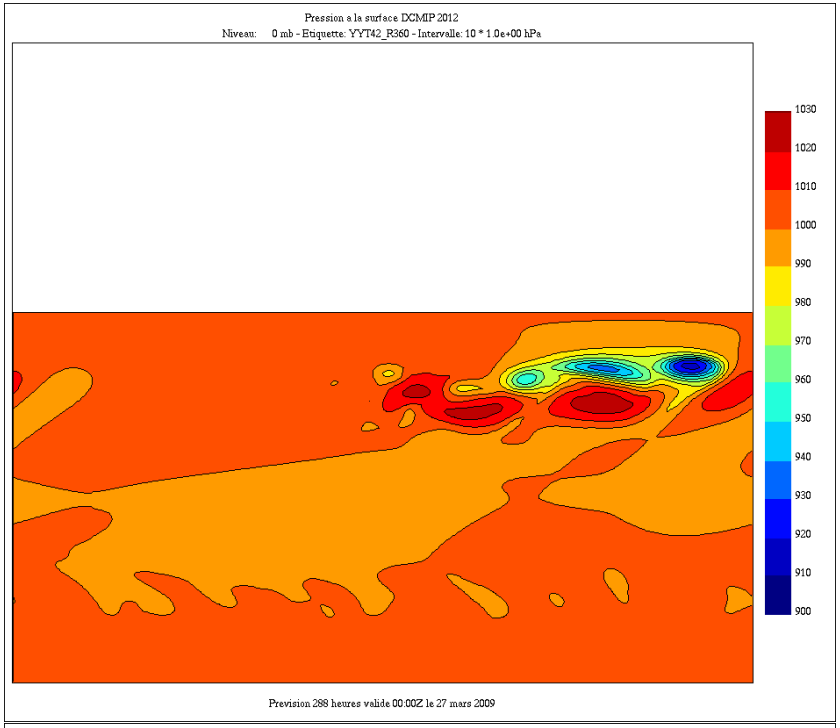
Plot Lat_Lon

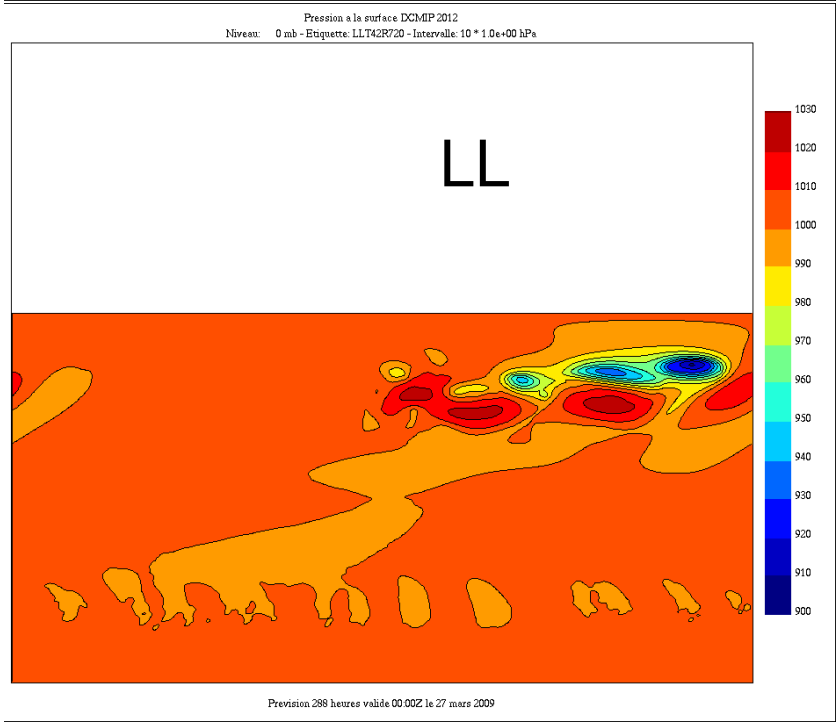
Surface pressure

t=12 days

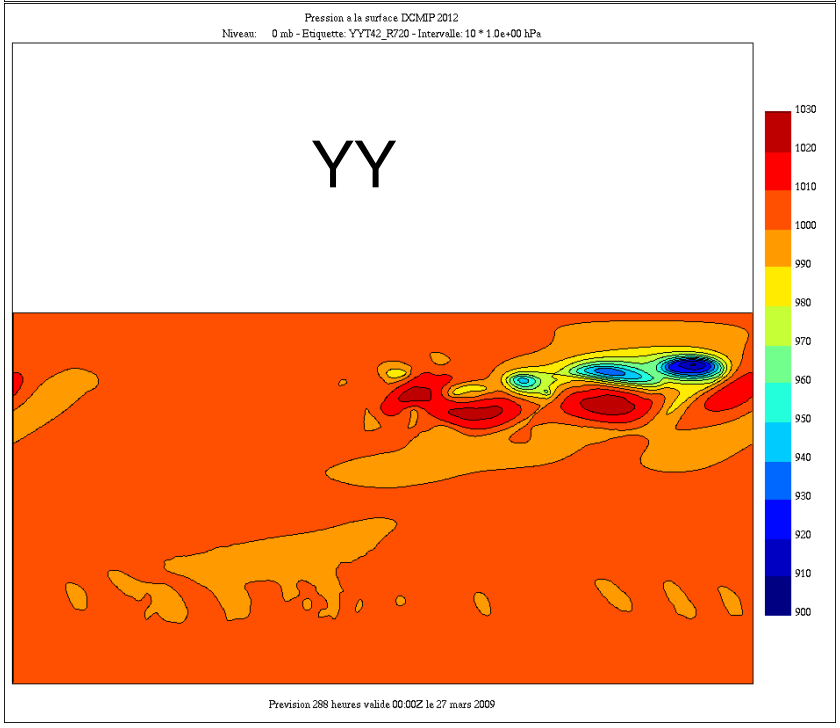


1 deg





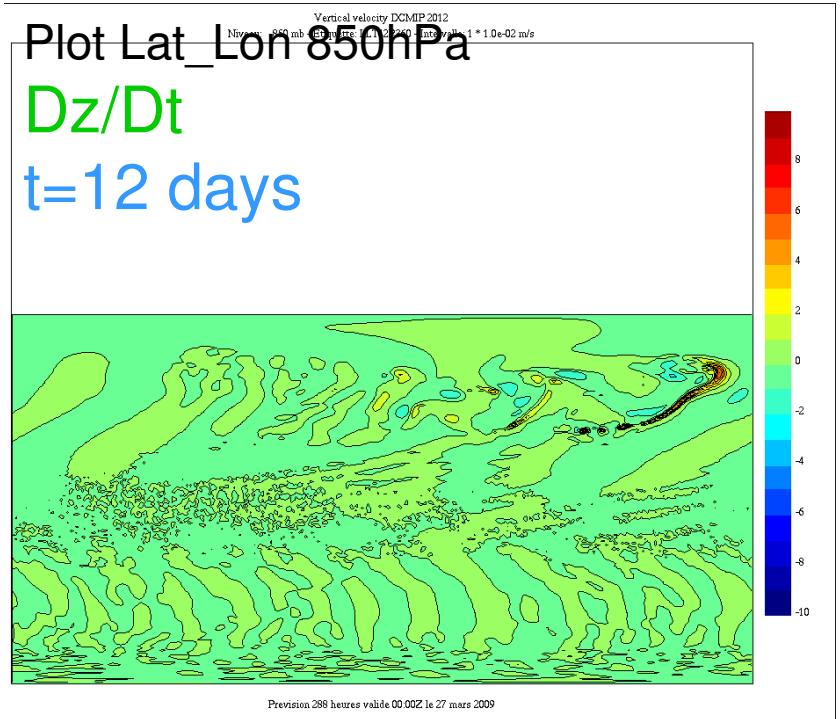
0.5 deg



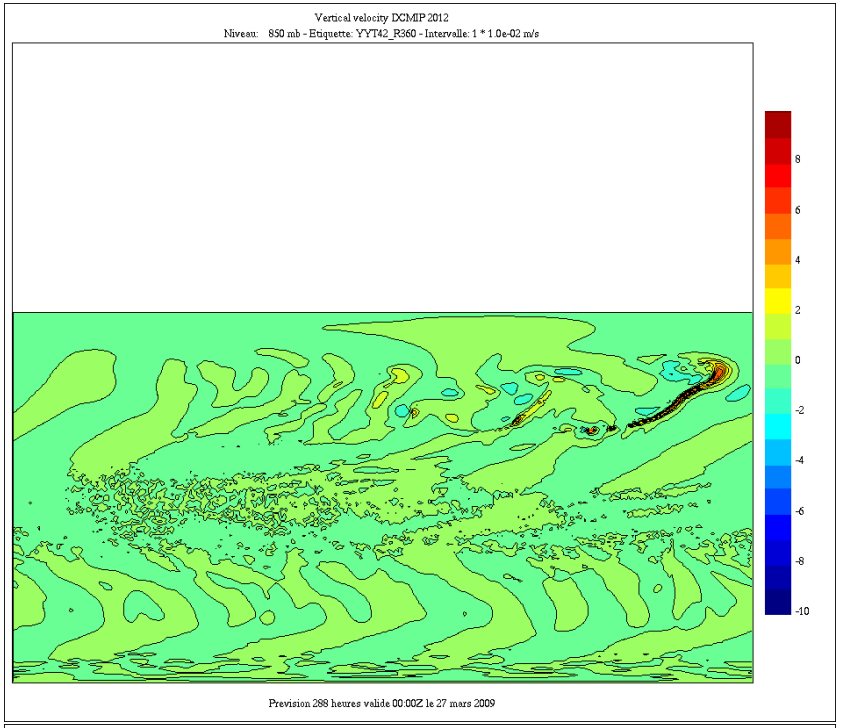
Plot Lat_Lon 850hPa

Dz/Dt

t=12 days

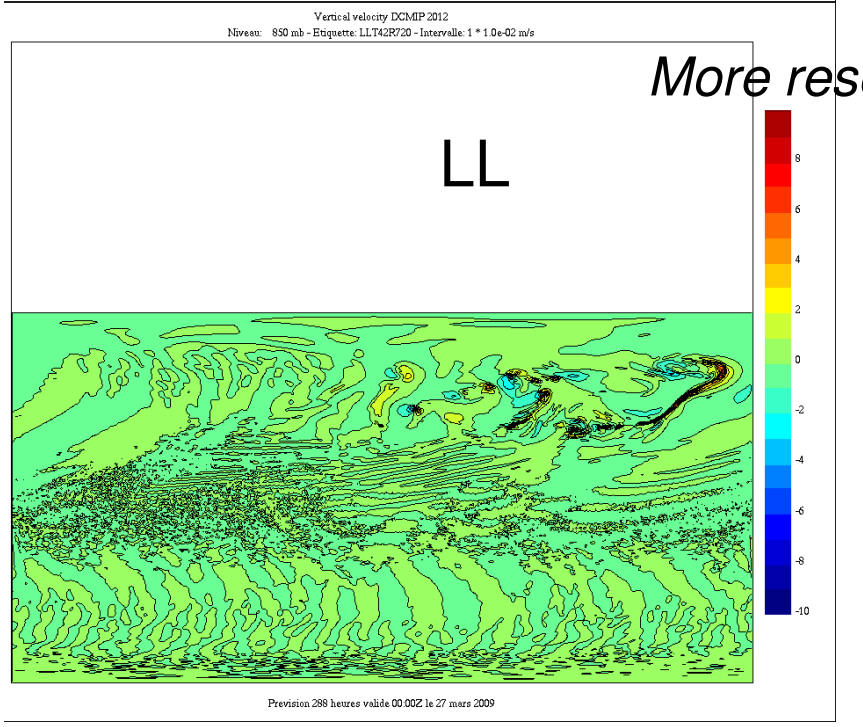


1 deg



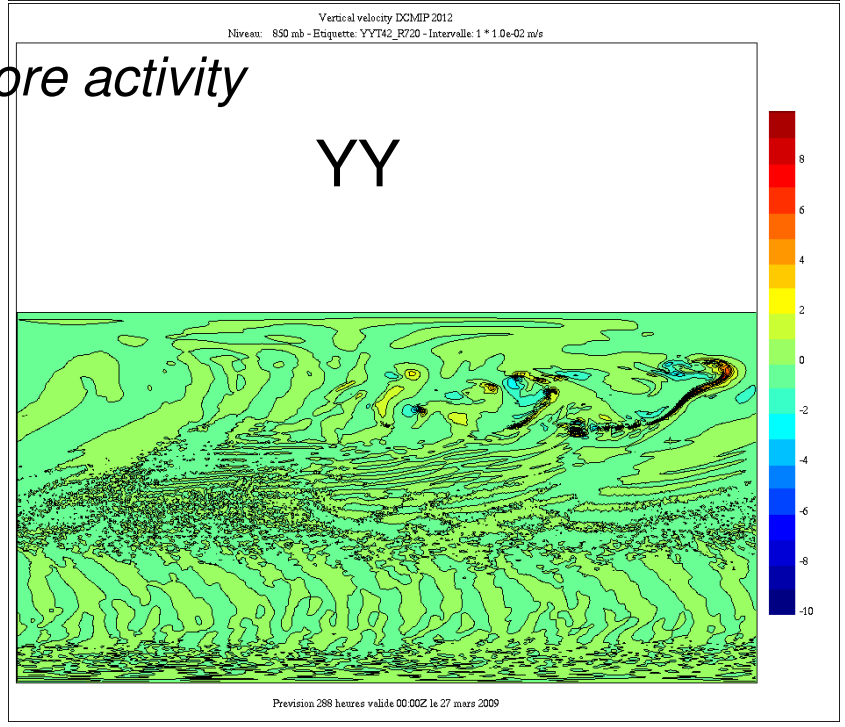
More resolution more activity

LL



0.5 deg

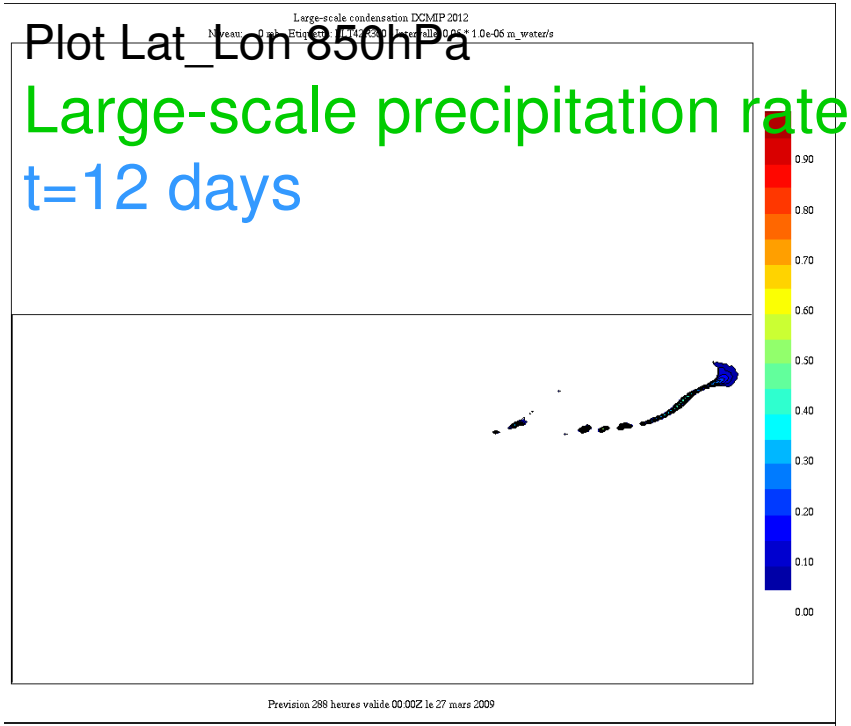
YY



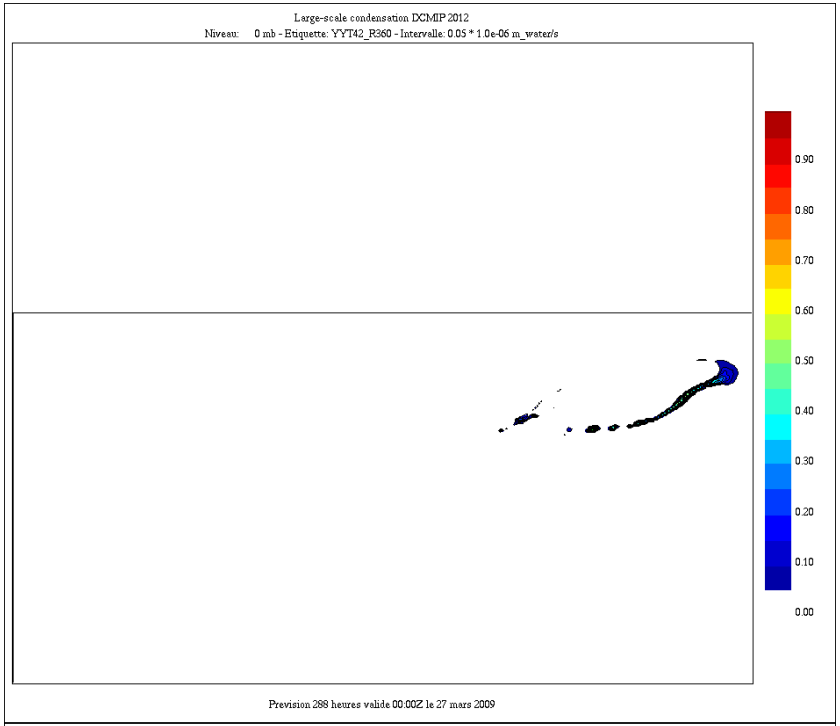
Plot Lat_Lon 850hPa

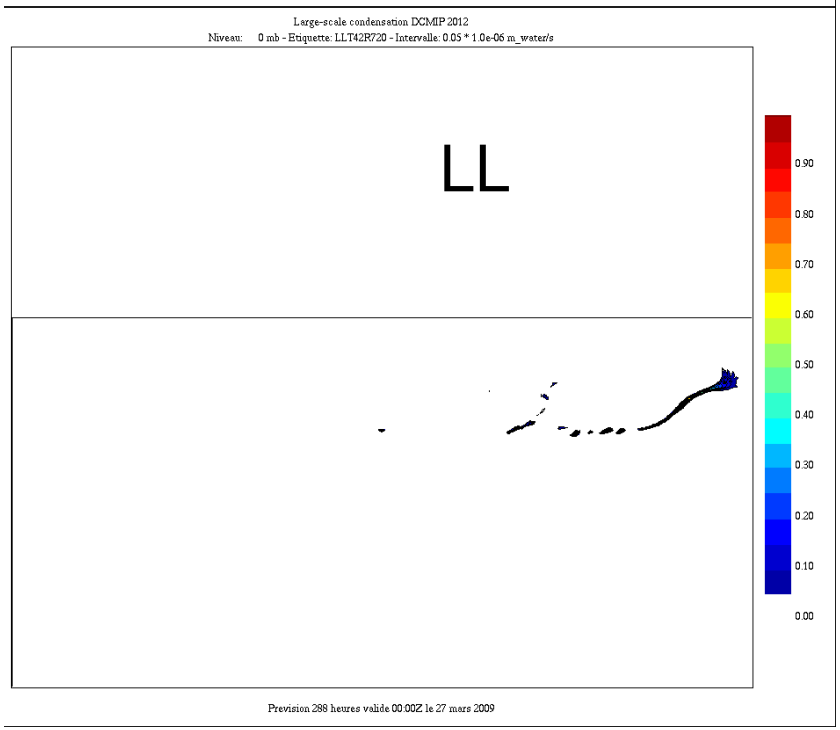
Large-scale precipitation rate

t=12 days

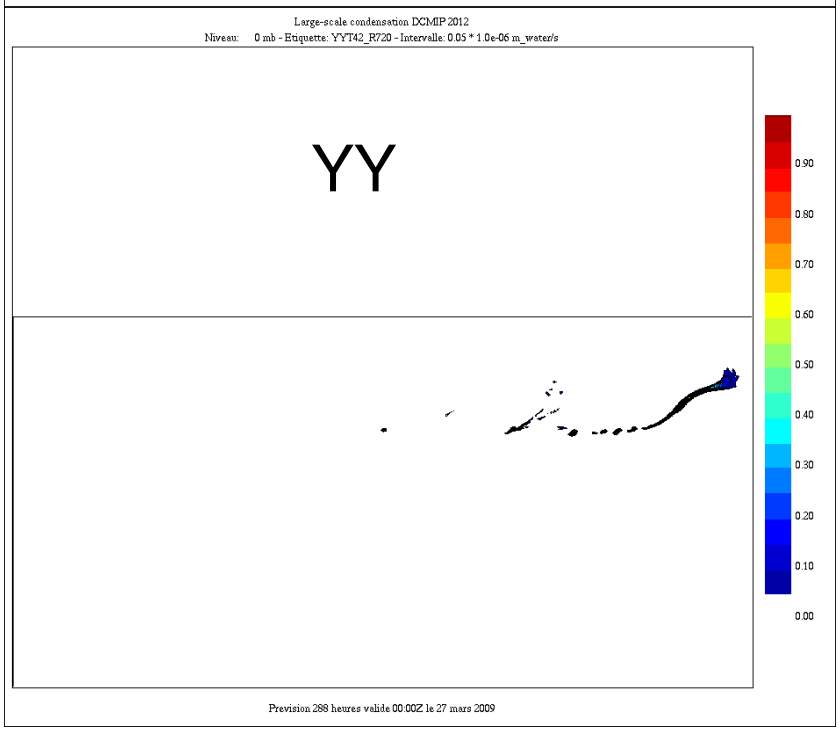


1 deg





0.5 deg



T43 (Moist Variant of the Baroclinic Wave Test, driven by Simple-Physics) (OPTIONAL)

RUN for 15 days

[1 deg - Levels eta L30]: DT = 1800 sec
[.5 deg - Levels eta L30]: DT = 900 sec

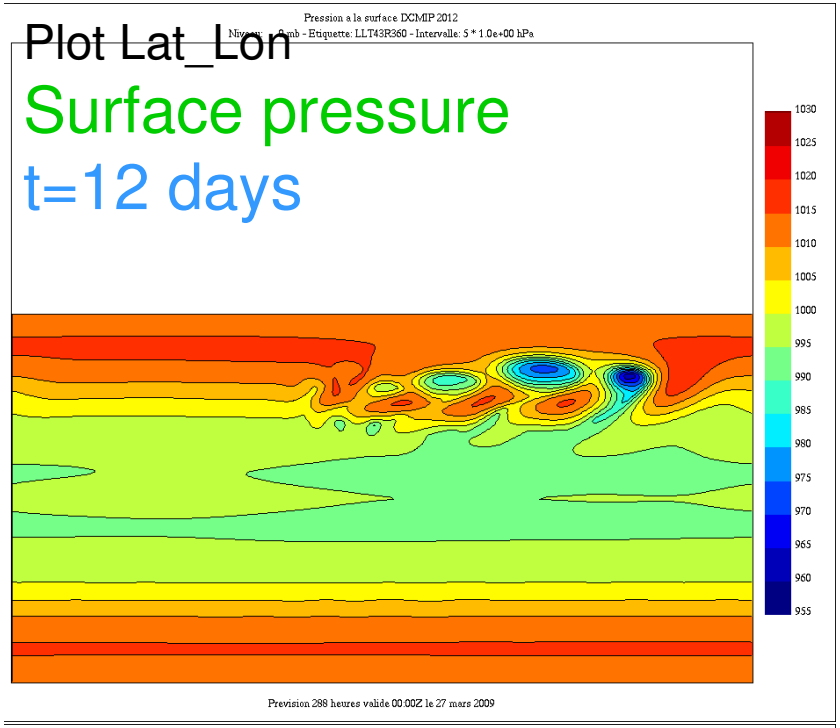
2D Del(6) Diffusion (2 Delta-x removal ratio of 4% per timestep)

Off-centering Epsilon = .1

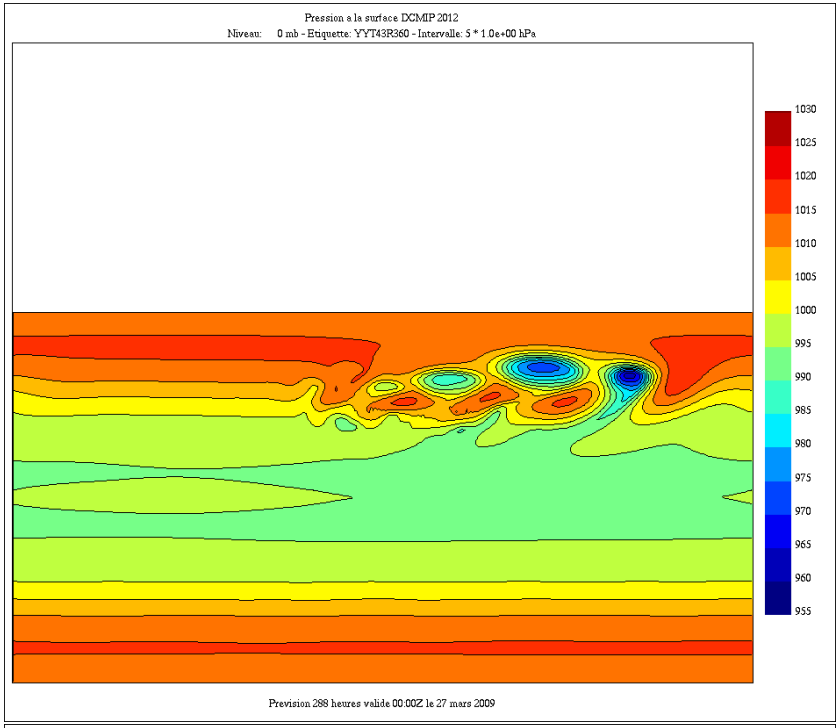
Plot Lat_Lon

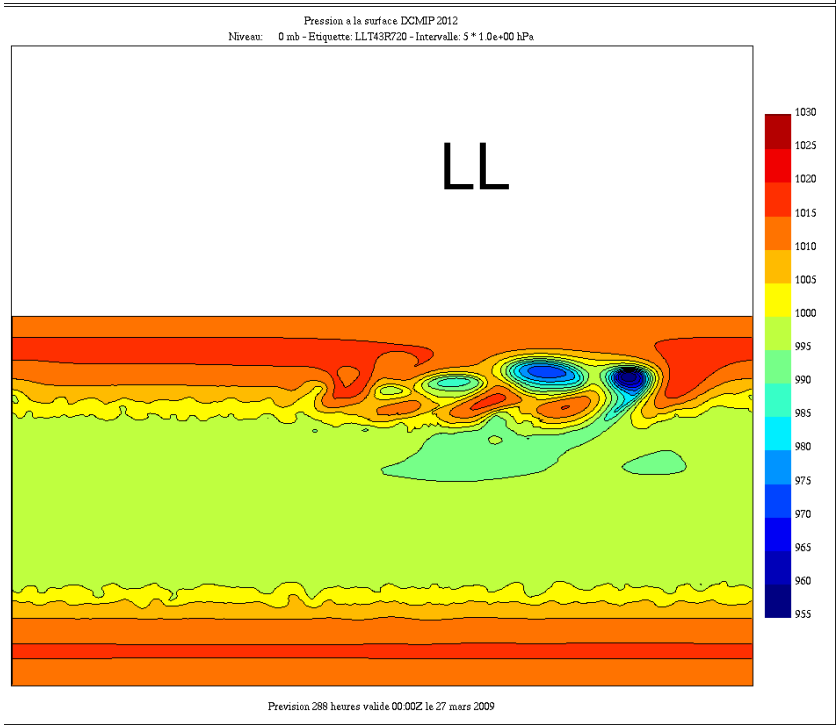
Surface pressure

t=12 days

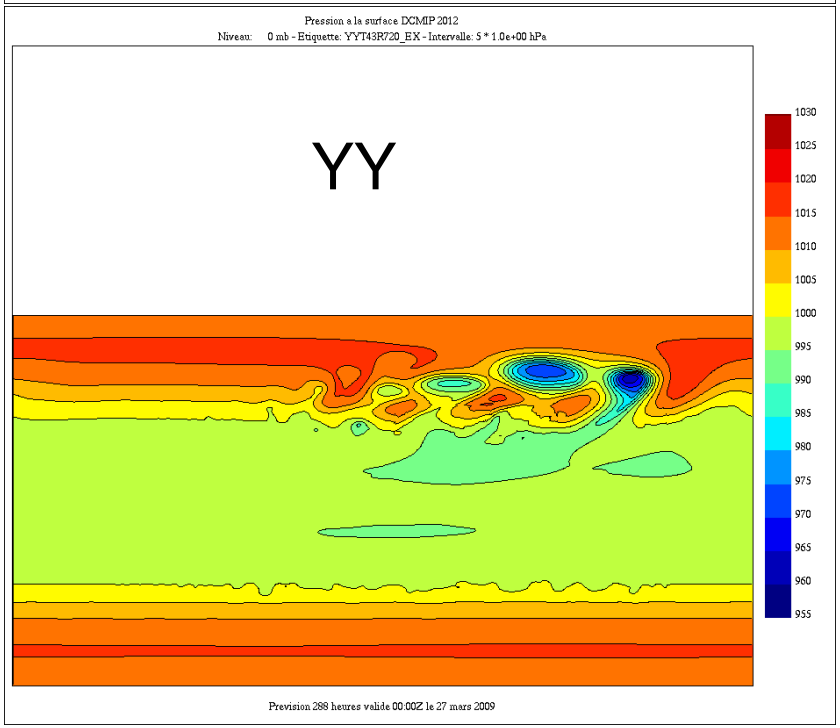


1 deg





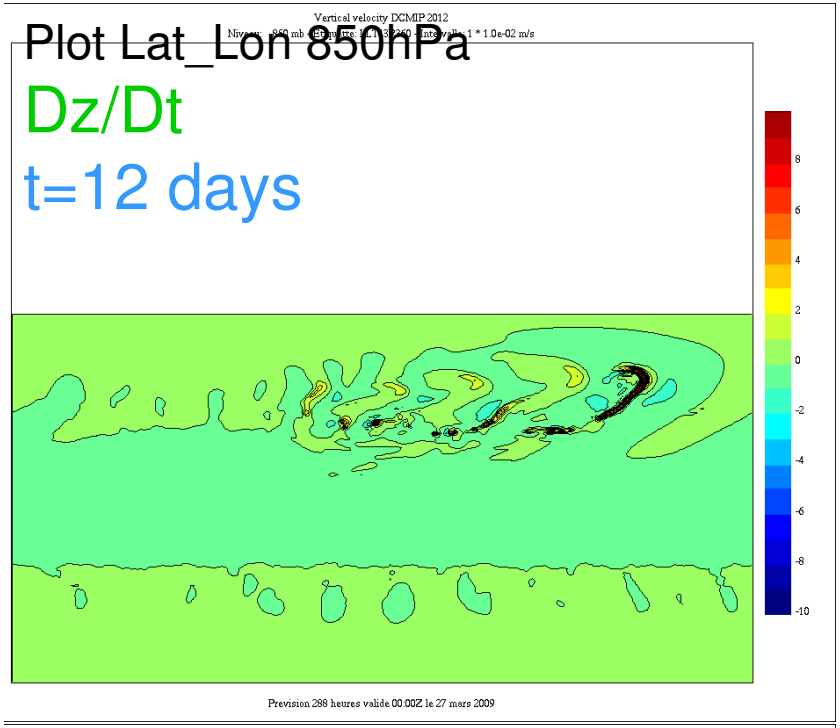
0.5 deg



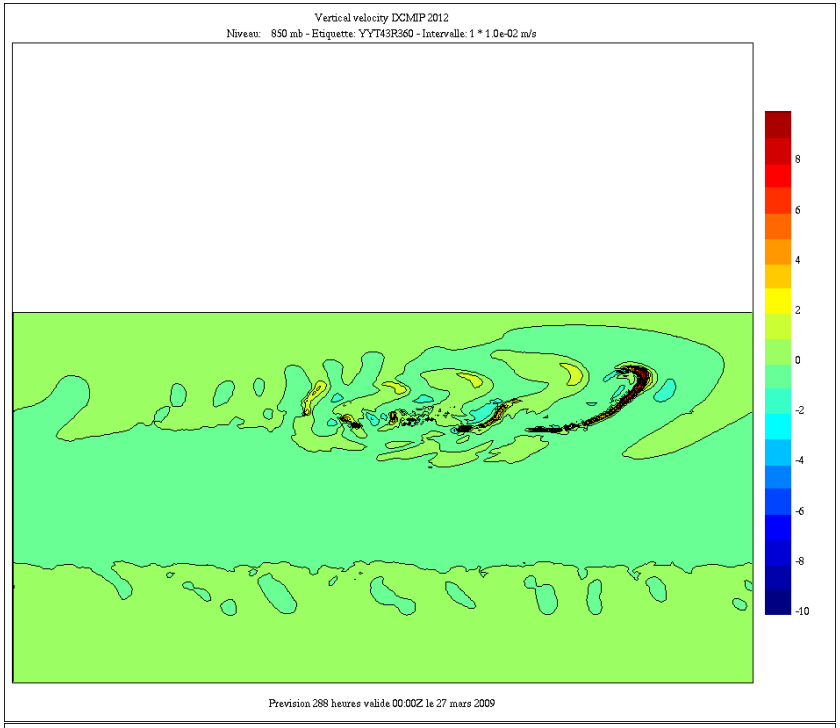
Plot Lat_Lon 850hPa

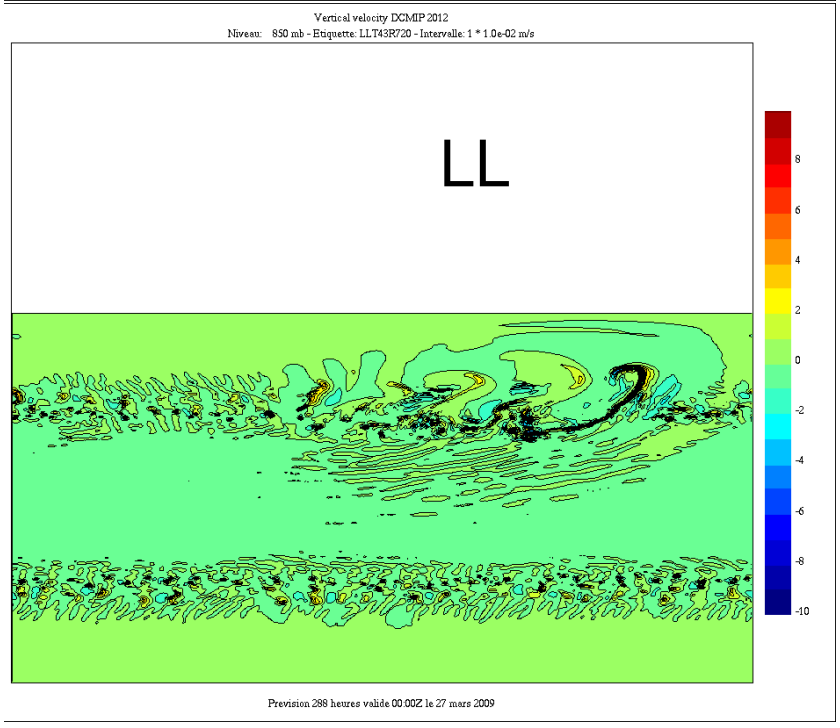
Dz/Dt

t=12 days

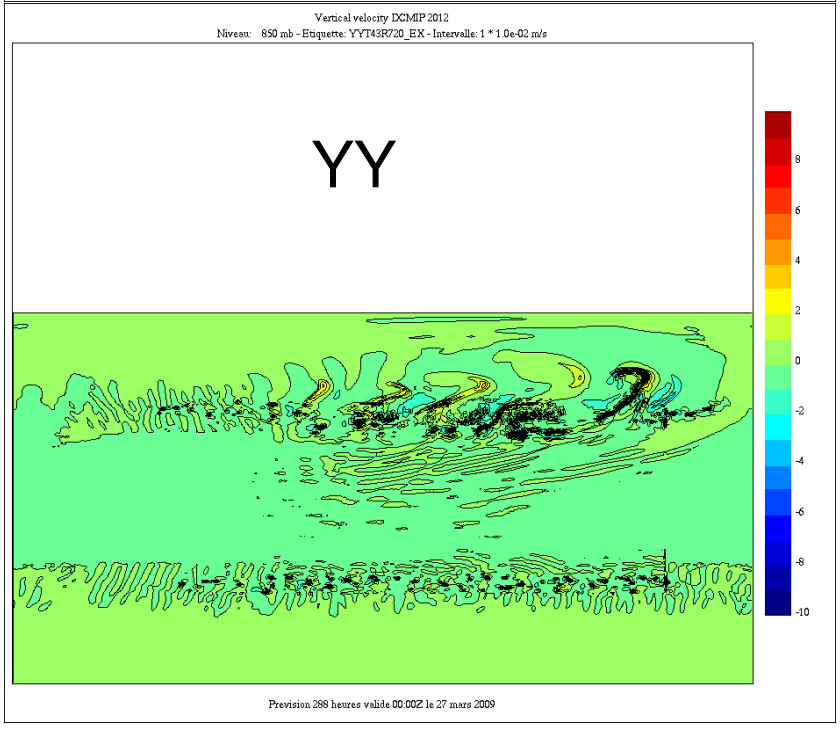


1 deg





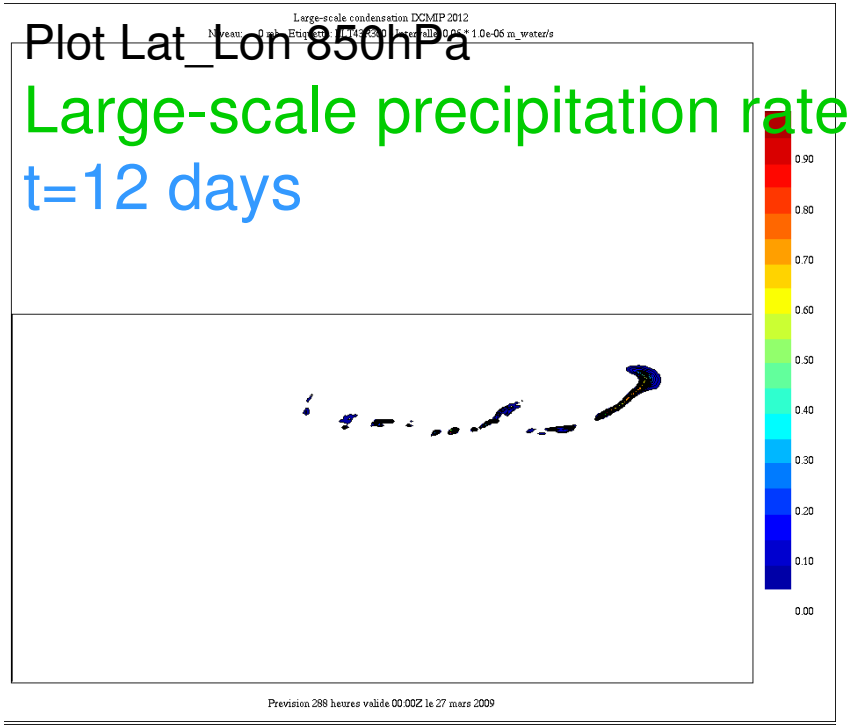
0.5 deg



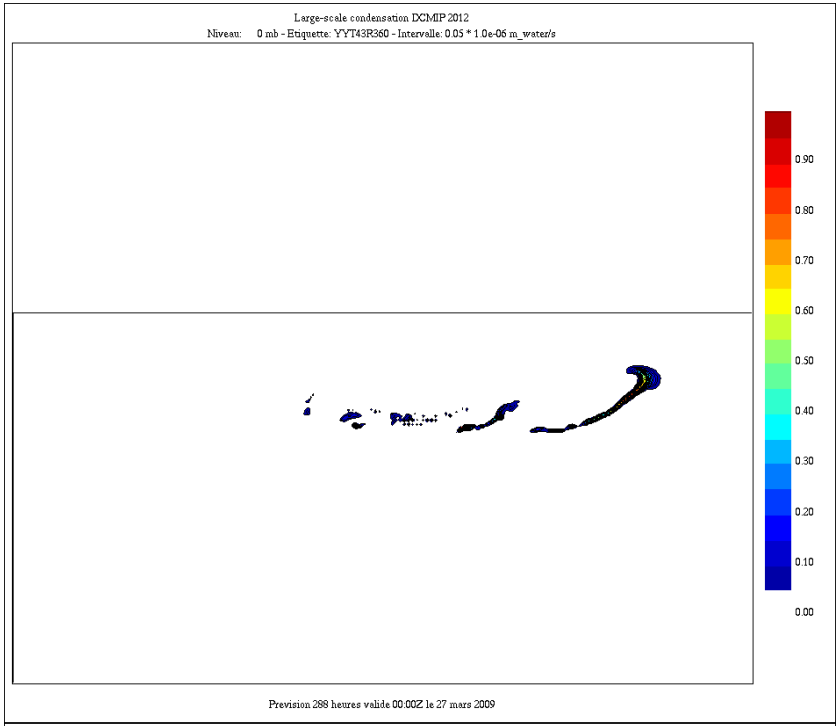
Plot Lat_Lon 850hPa

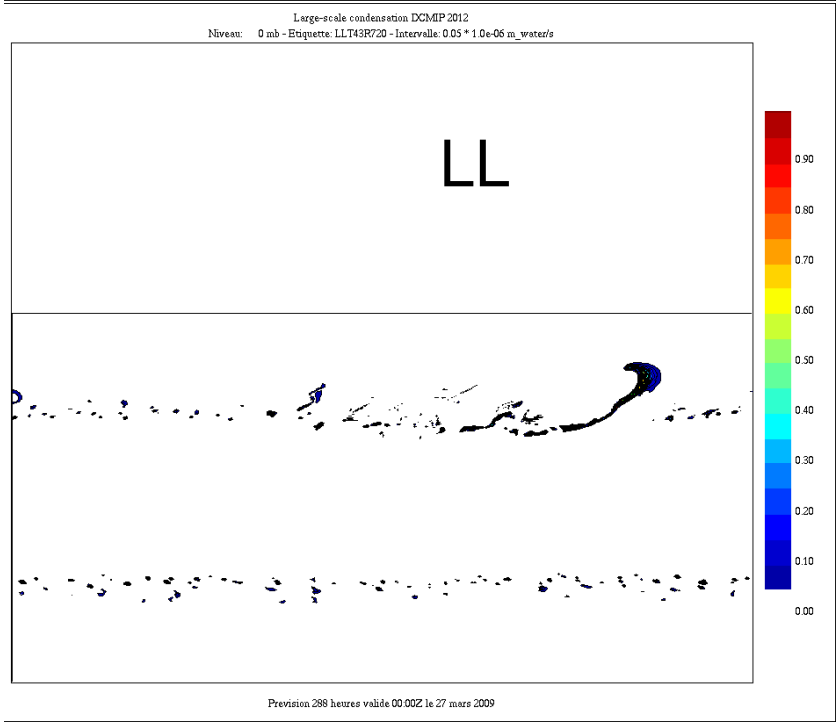
Large-scale precipitation rate

t=12 days

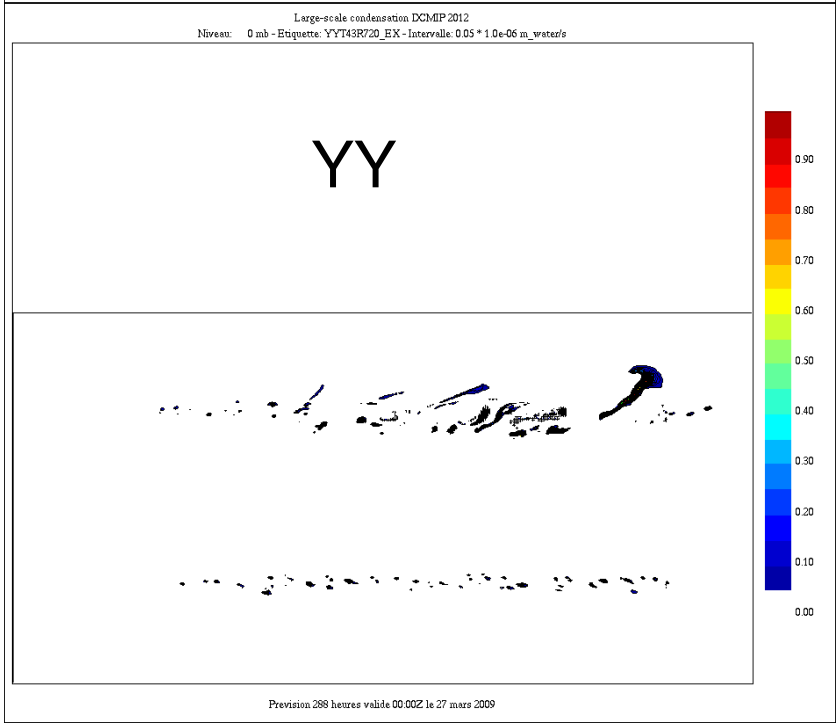


1 deg





0.5 deg



T51 **(Idealized Tropical Cyclone experiments coupling to the Simple-Physics Physical Parameterizations)**

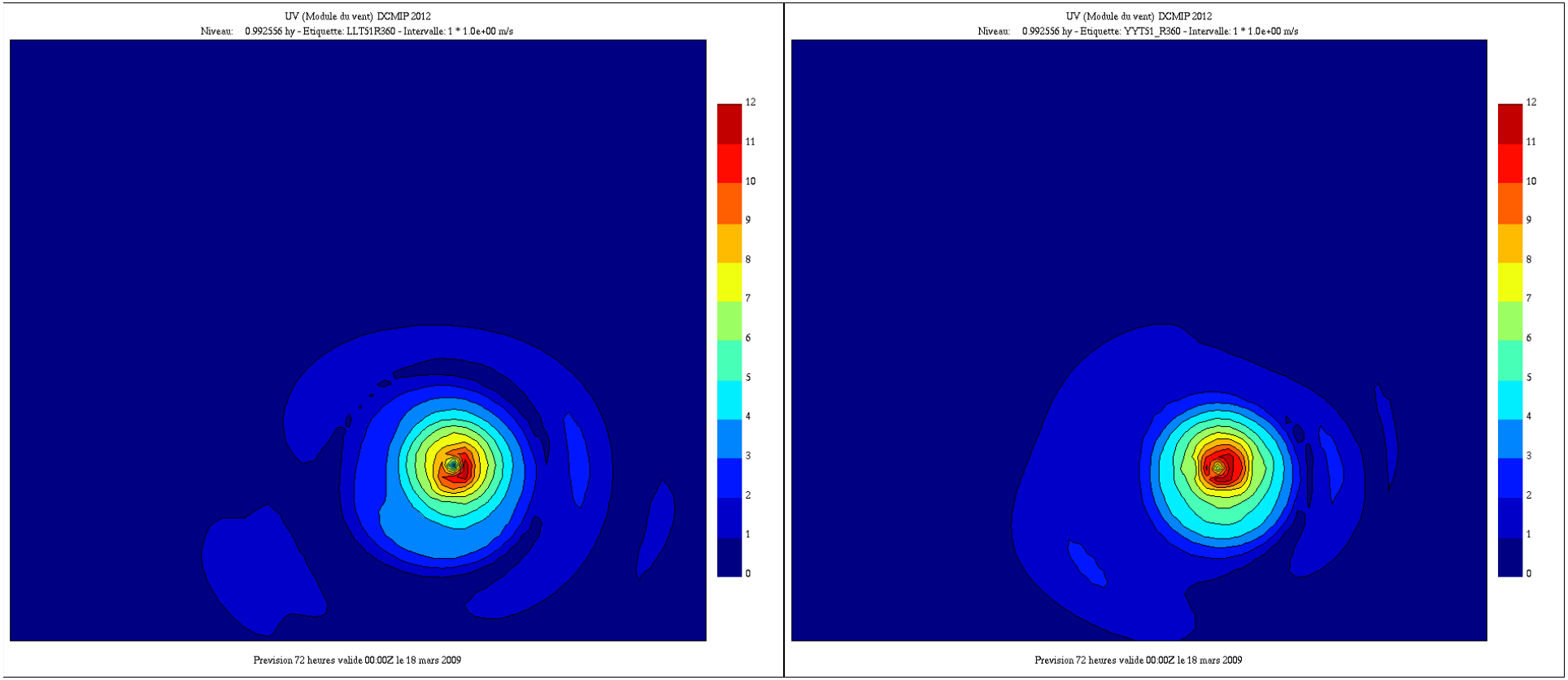
RUN for 10 days

[1 deg - Levels eta L30]: DT = 1800 sec
[.5 deg - Levels eta L30]: DT = 900 sec
[.25 deg - Levels eta L30]: DT = 450 sec

2D Del(6) Diffusion (2 Delta-x removal ratio of 4% per timestep)

Off-centering Epsilon = .1

Sponge layer 3 top levels C=.38*10**6 m**2/sec

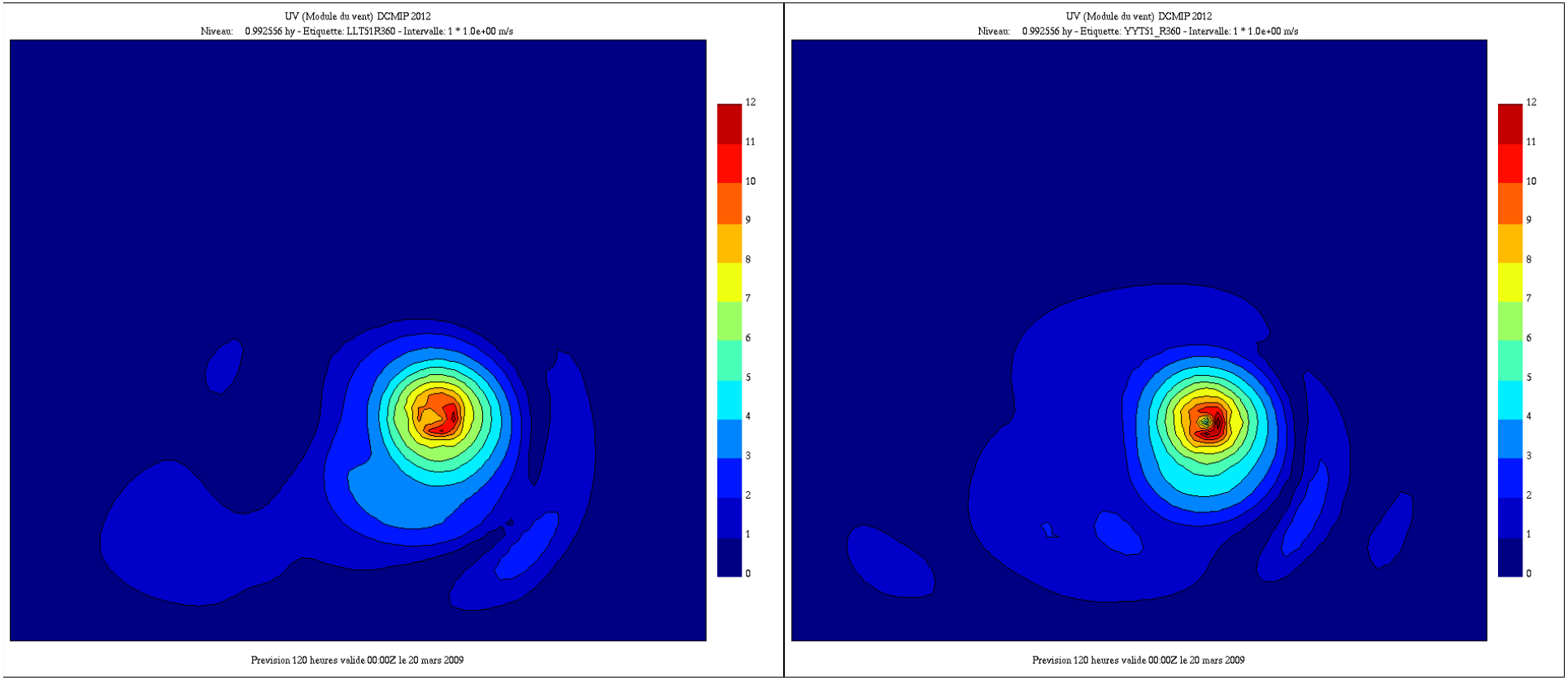


LL 1 deg YY

Plot Lat_Lon Lower Level

Wind Speed

t=3 days

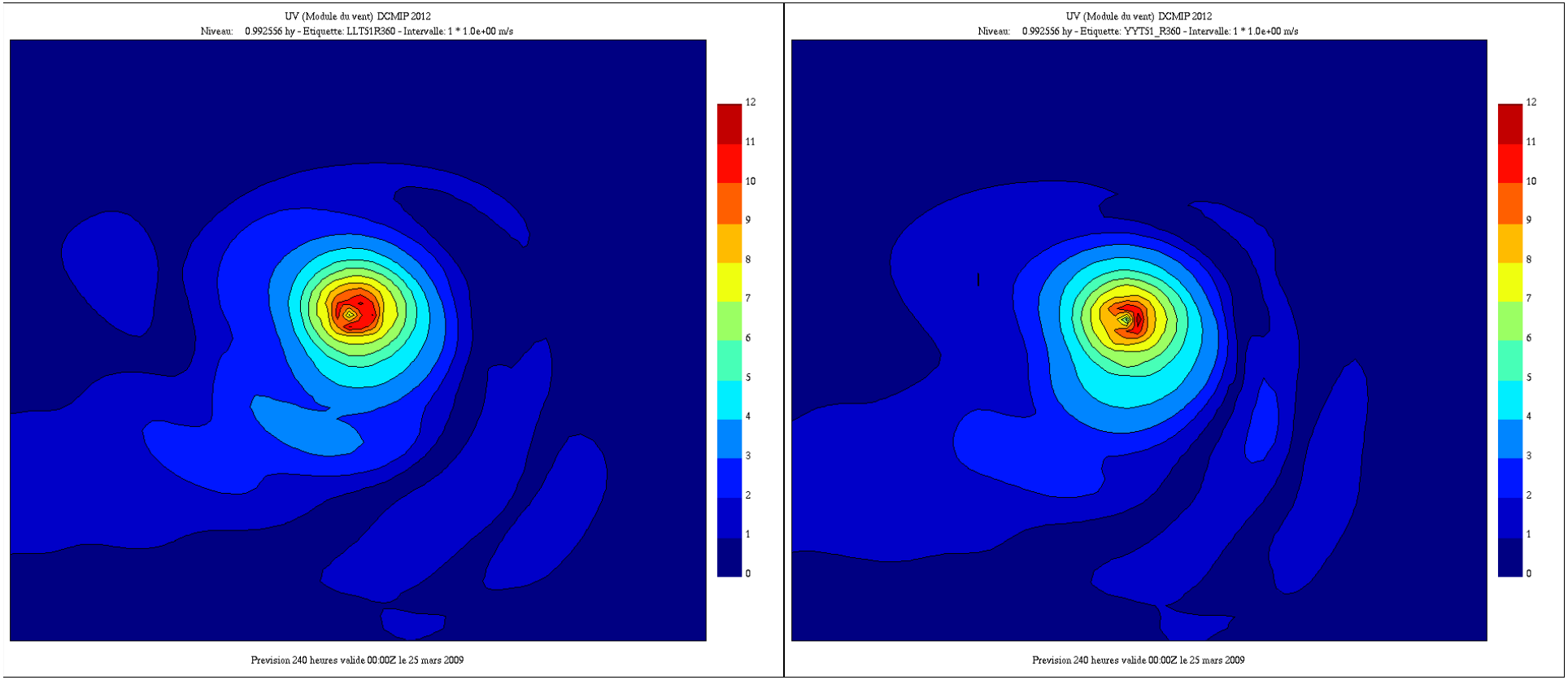


LL 1 deg YY

Plot Lat_Lon Lower Level

Wind Speed

t=5 days

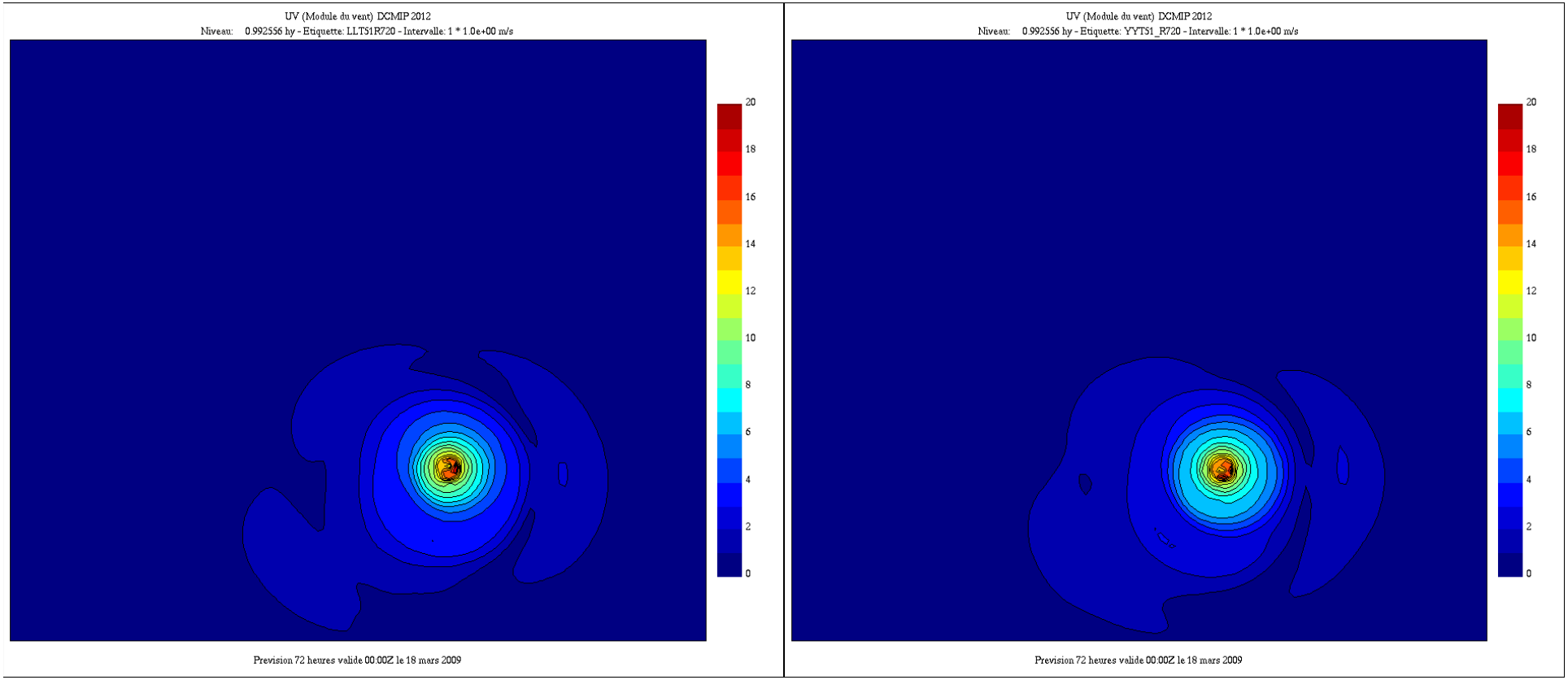


LL 1 deg YY

Plot Lat_Lon Lower Level

Wind Speed

t=10 days

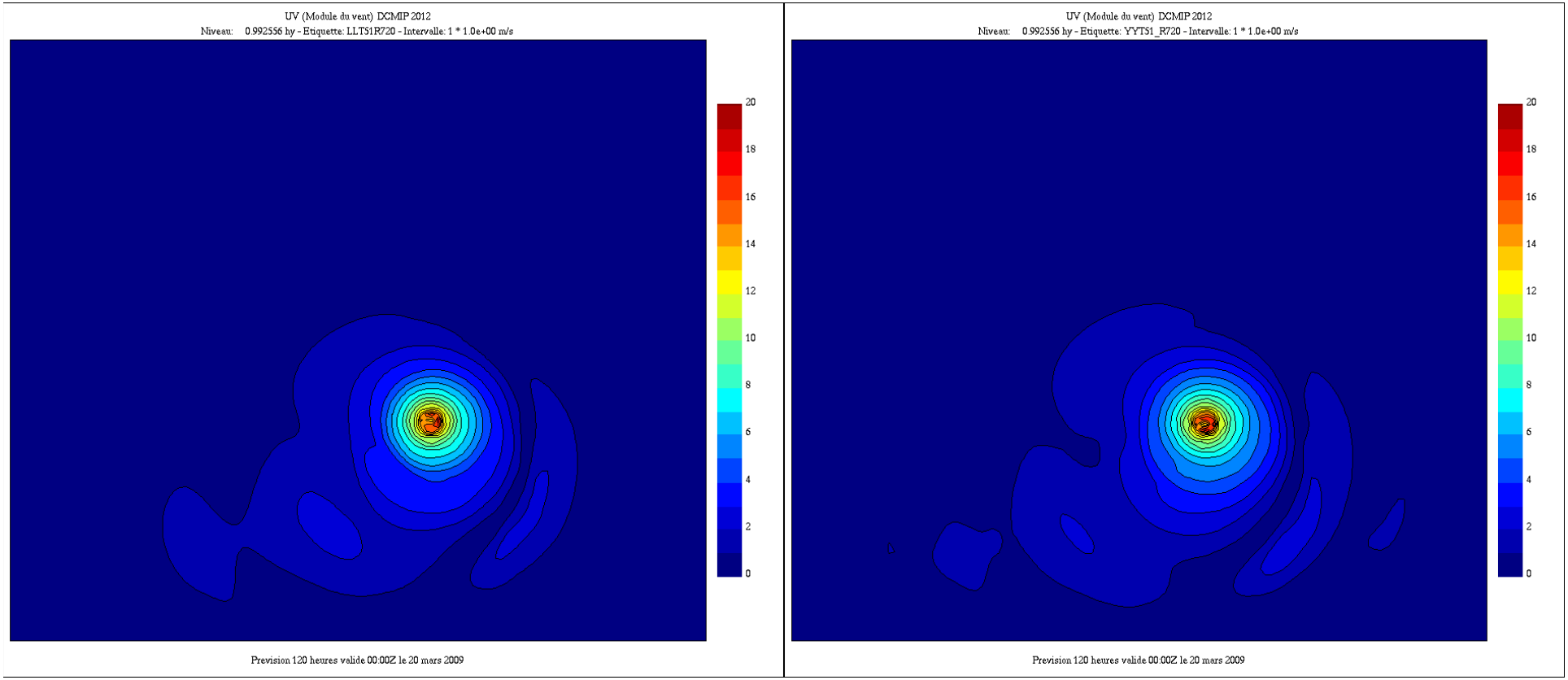


LL 0.5 deg YY

Plot Lat_Lon Lower Level

Wind Speed

t=3 days

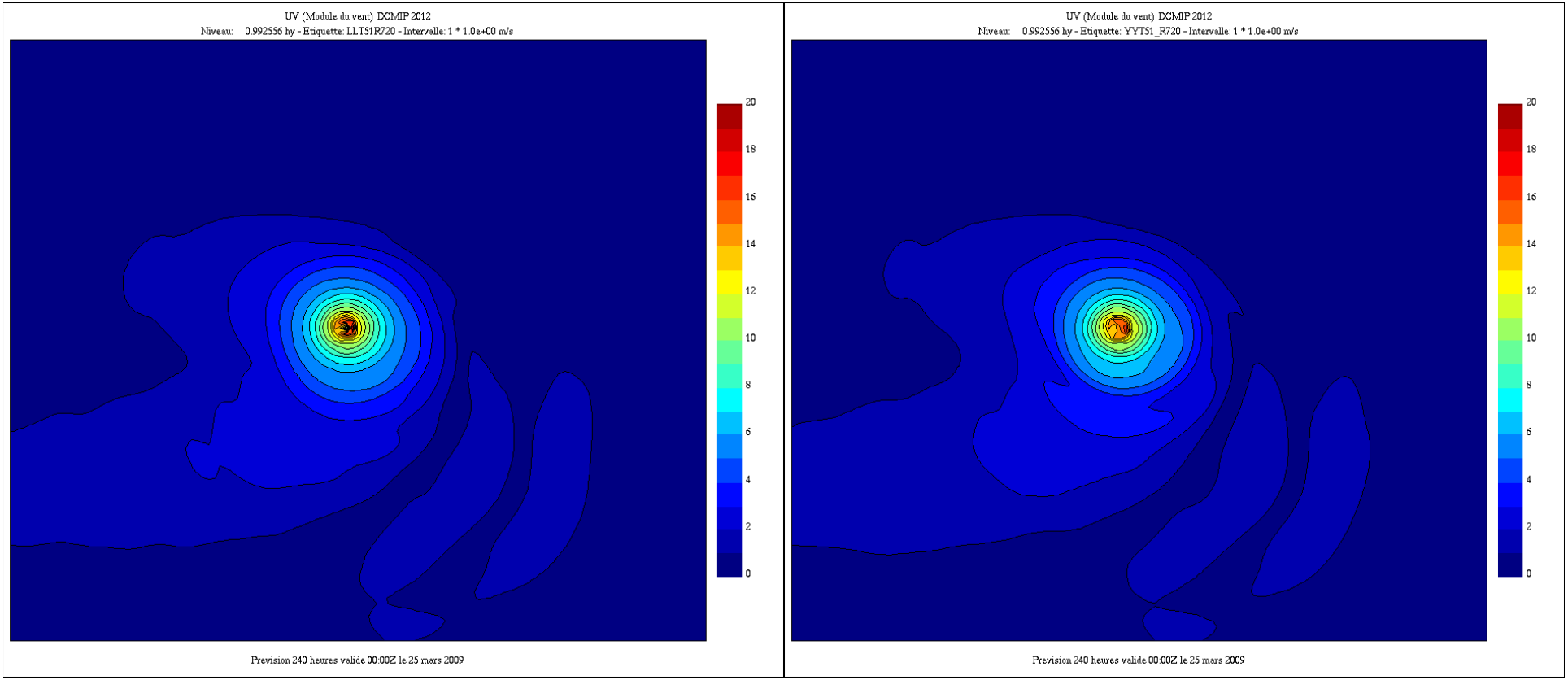


LL 0.5 deg YY

Plot Lat_Lon Lower Level

Wind Speed

t=5 days

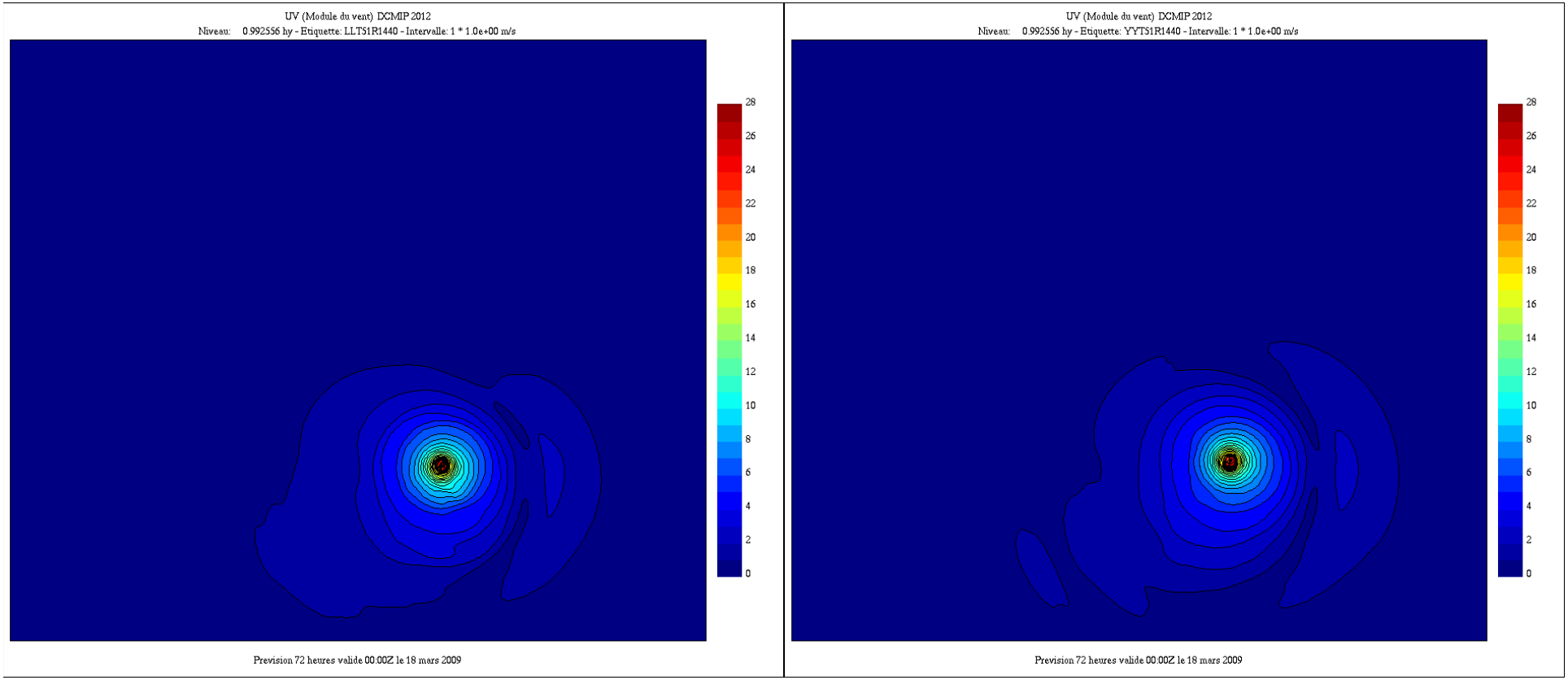


LL 0.5 deg YY

Plot Lat_Lon Lower Level

Wind Speed

t=10 days

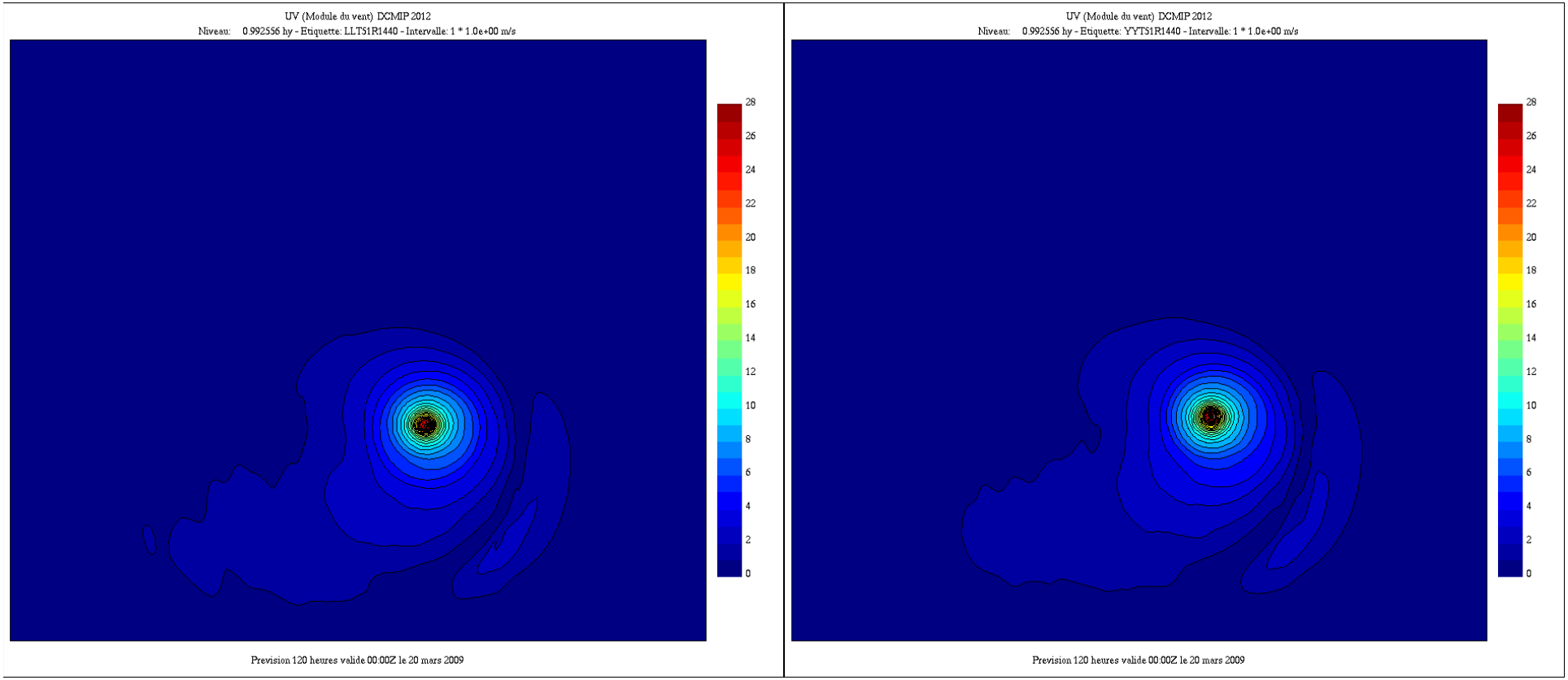


LL 0.25 deg YY

Plot Lat_Lon Lower Level

Wind Speed

t=3 days

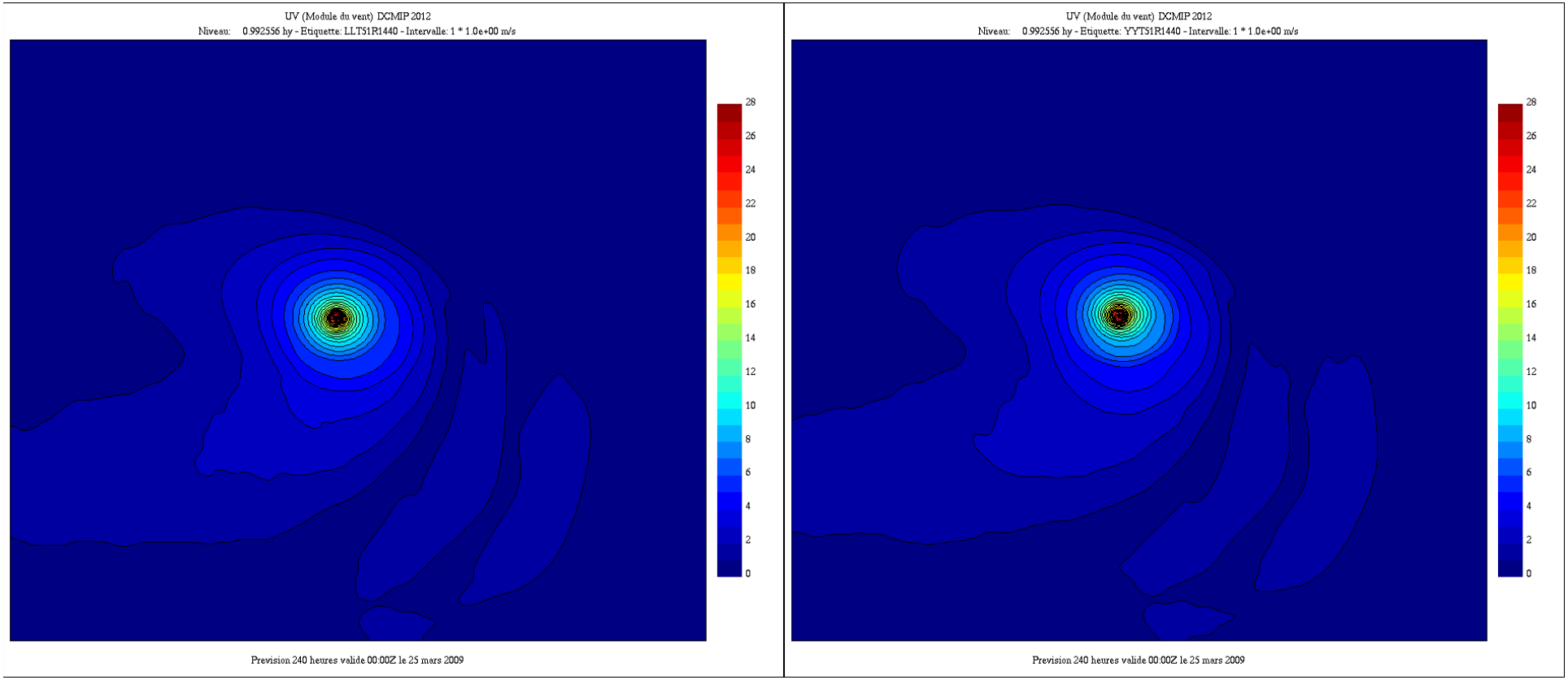


LL 0.25 deg YY

Plot Lat_Lon Lower Level

Wind Speed

t=5 days



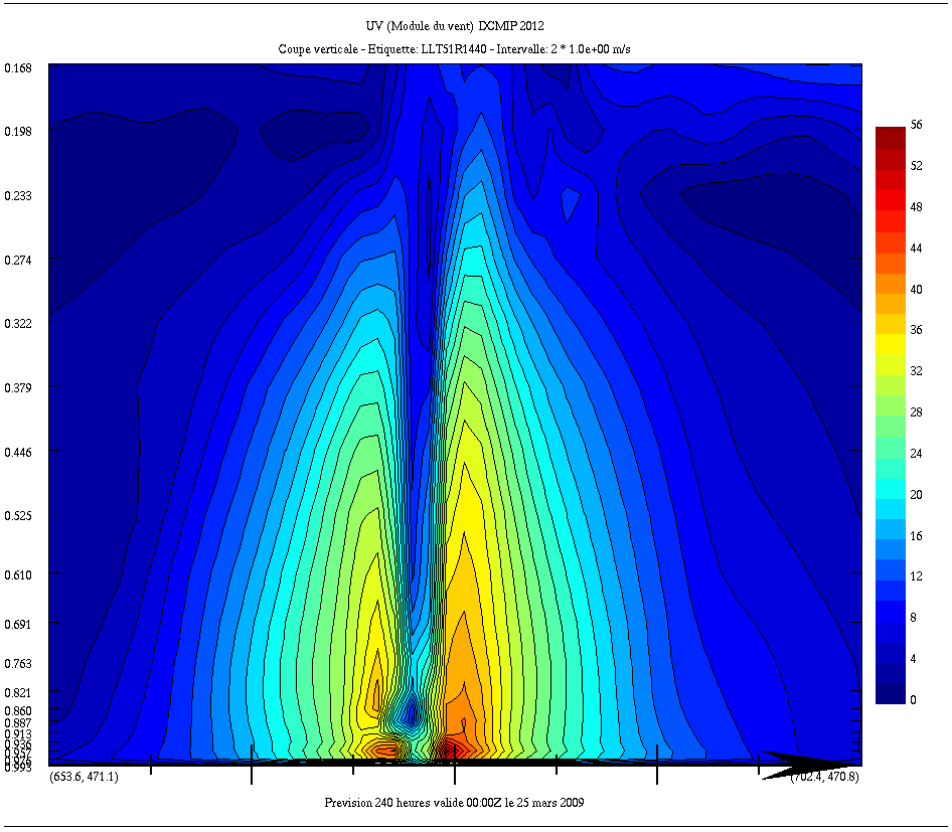
LL 0.25 deg YY

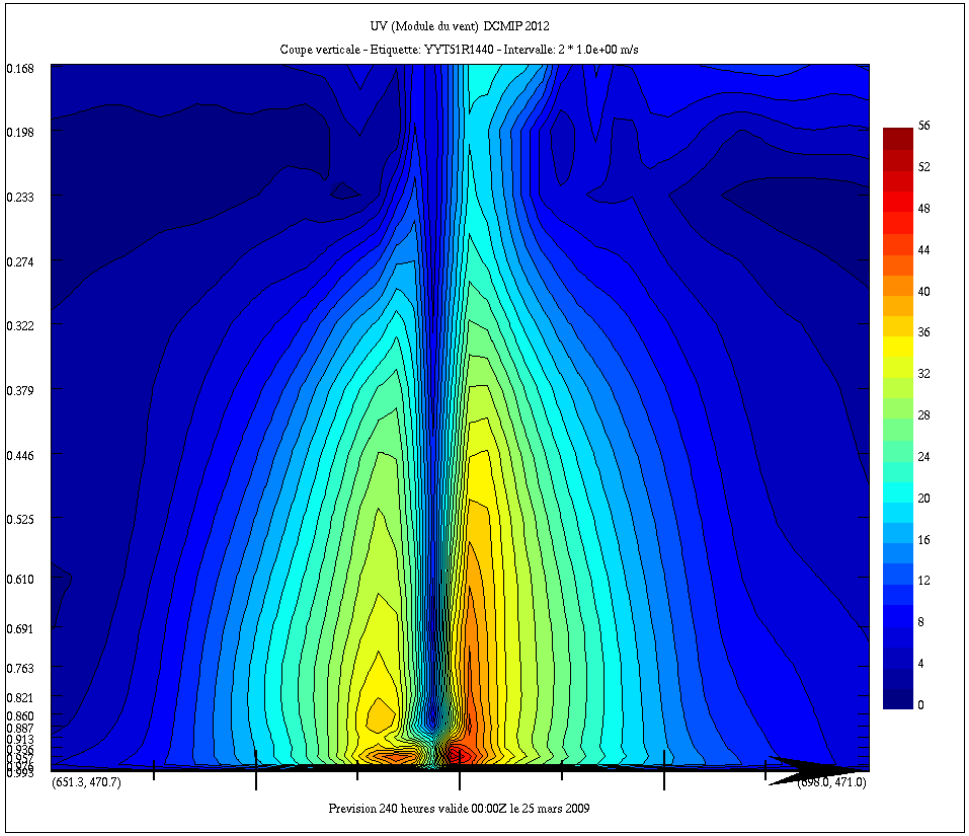
- *The intensity increases with the resolution*
- *The cyclone is more concentrated in space with the resolution*

Plot Lat_Lon Lower Level

Wind Speed

t=10 days





LL 0.25 deg YY

Plot Lon_ Height Through the center latitude of the vortex

Wind Speed

t=10 days

T52
(Idealized Tropical Cyclone experiments using GEM's Full Physics Aqua-Planet Mode with SST=302.15 K)
(OPTIONAL)

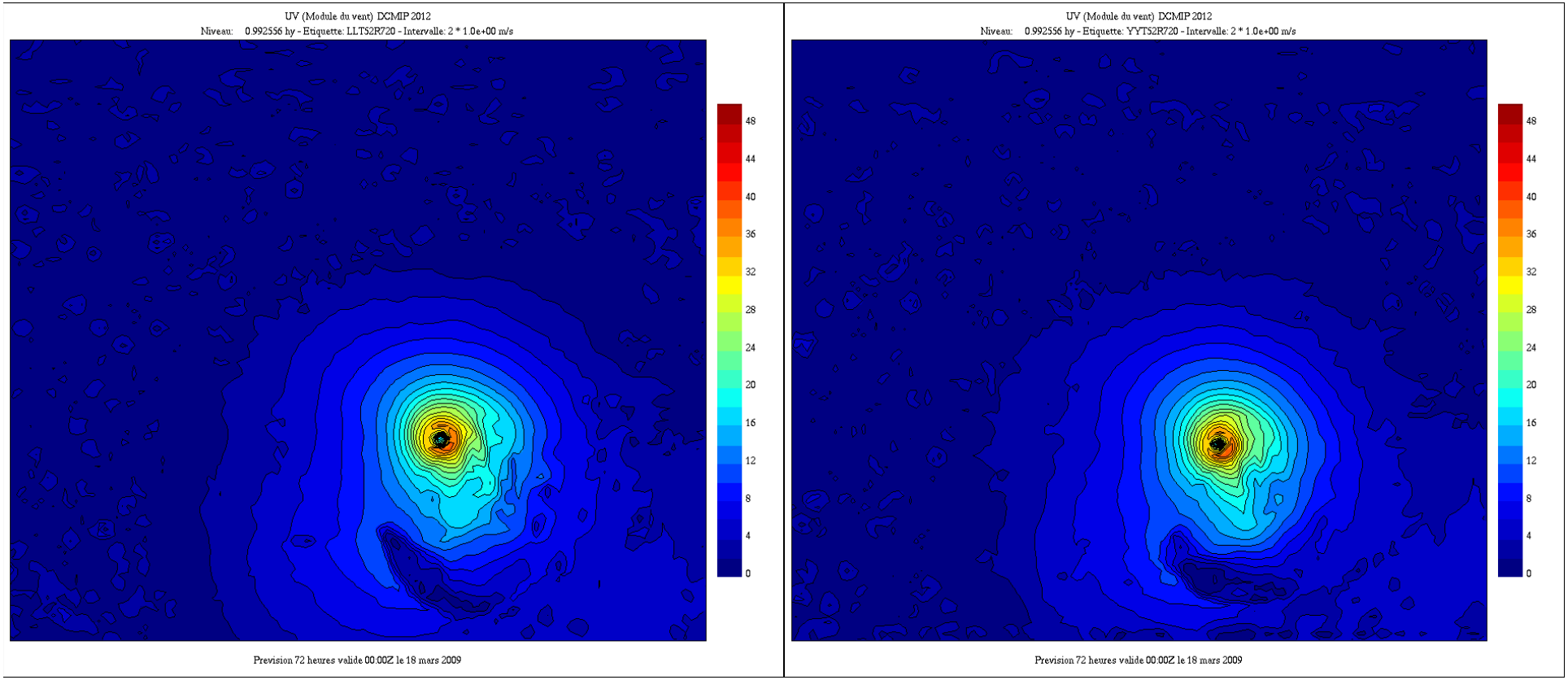
RUN for 10 days

[.5 deg - Levels eta L30] + DT=900 sec

2D Del(6) Diffusion (2 Delta-x removal ratio of 4% per timestep)

Off-centering Epsilon = .1

Sponge layer 3 top levels C=.38*10**6 m**2/sec

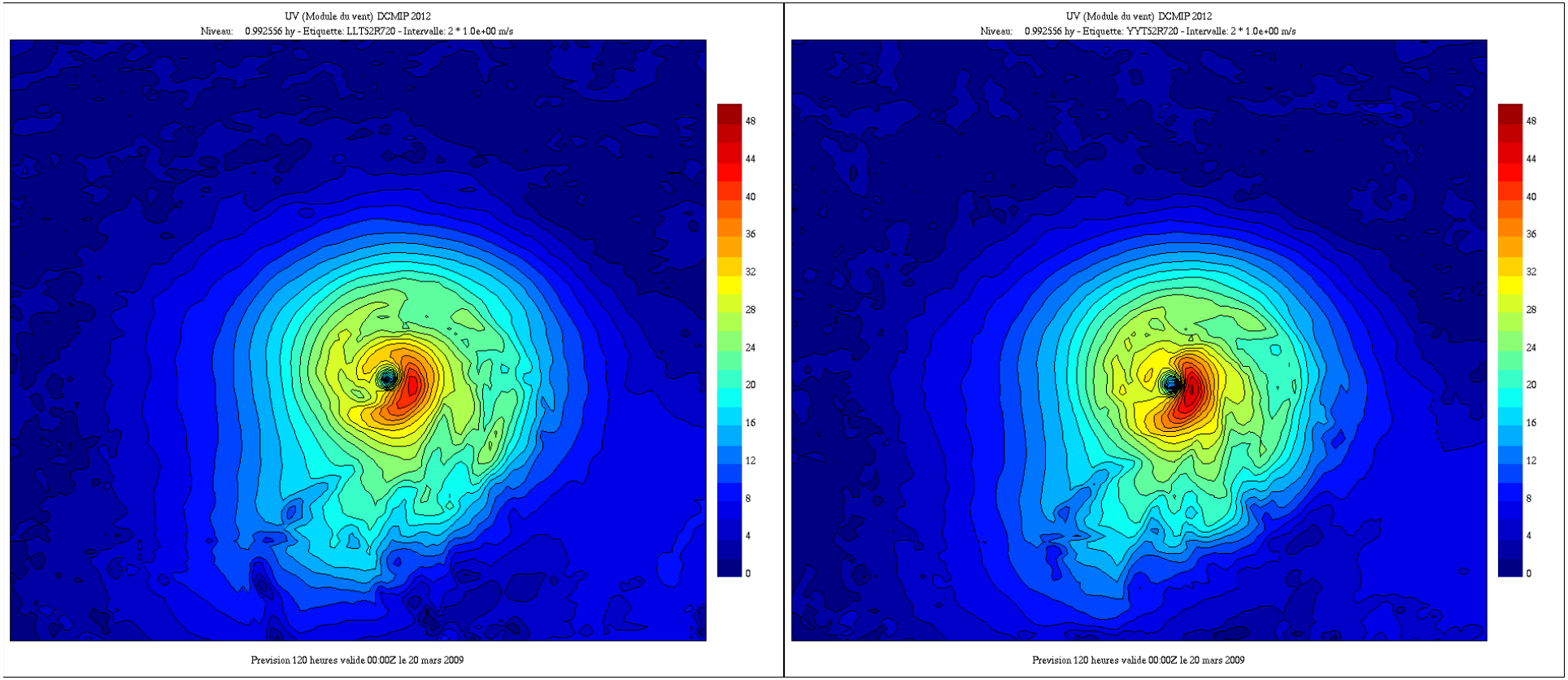


LL 0.5 deg YY

Plot Lat_Lon Lower Level

Wind Speed

t=3 days



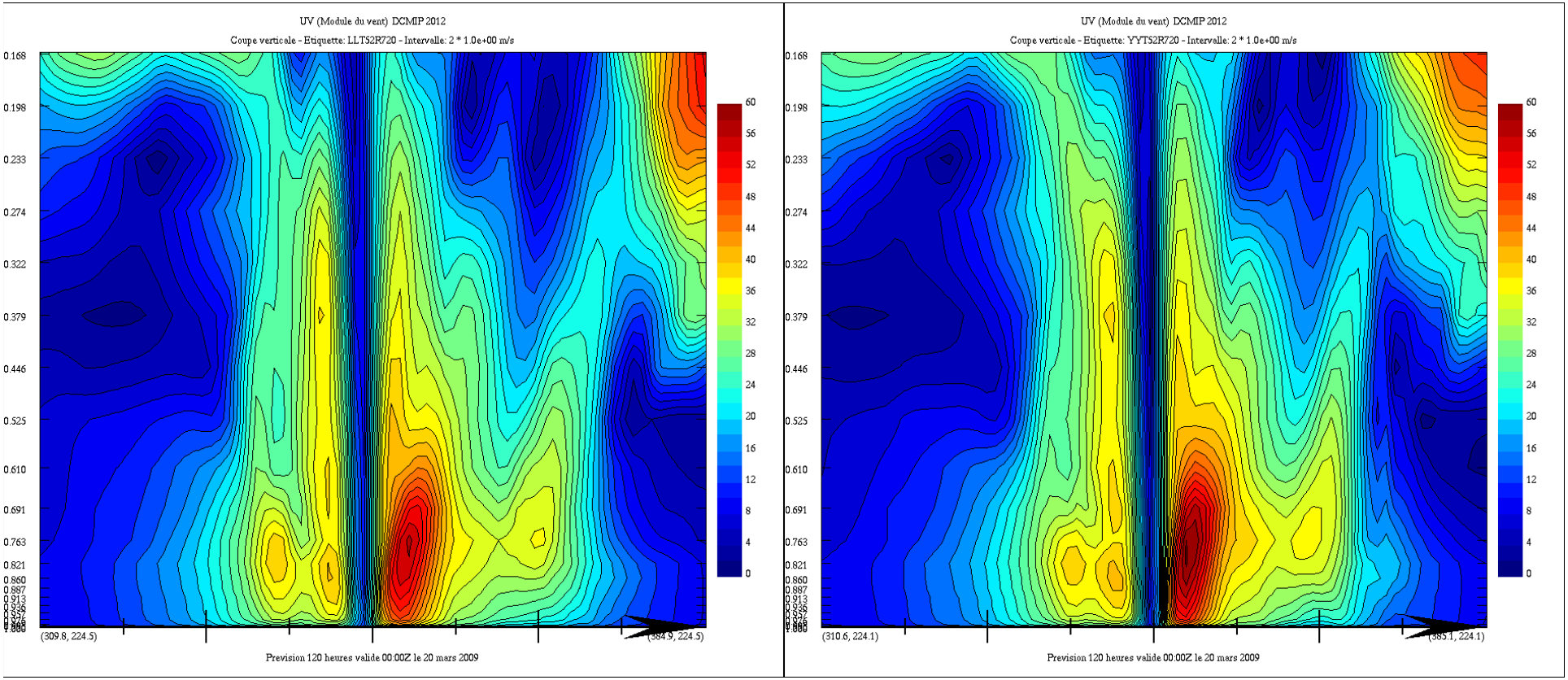
LL 0.5 deg YY

By contrast to simplified physics, here for the same space resolution, we see expansion of the cyclone over time

Plot Lat_Lon Lower Level

Wind Speed

t=5 days



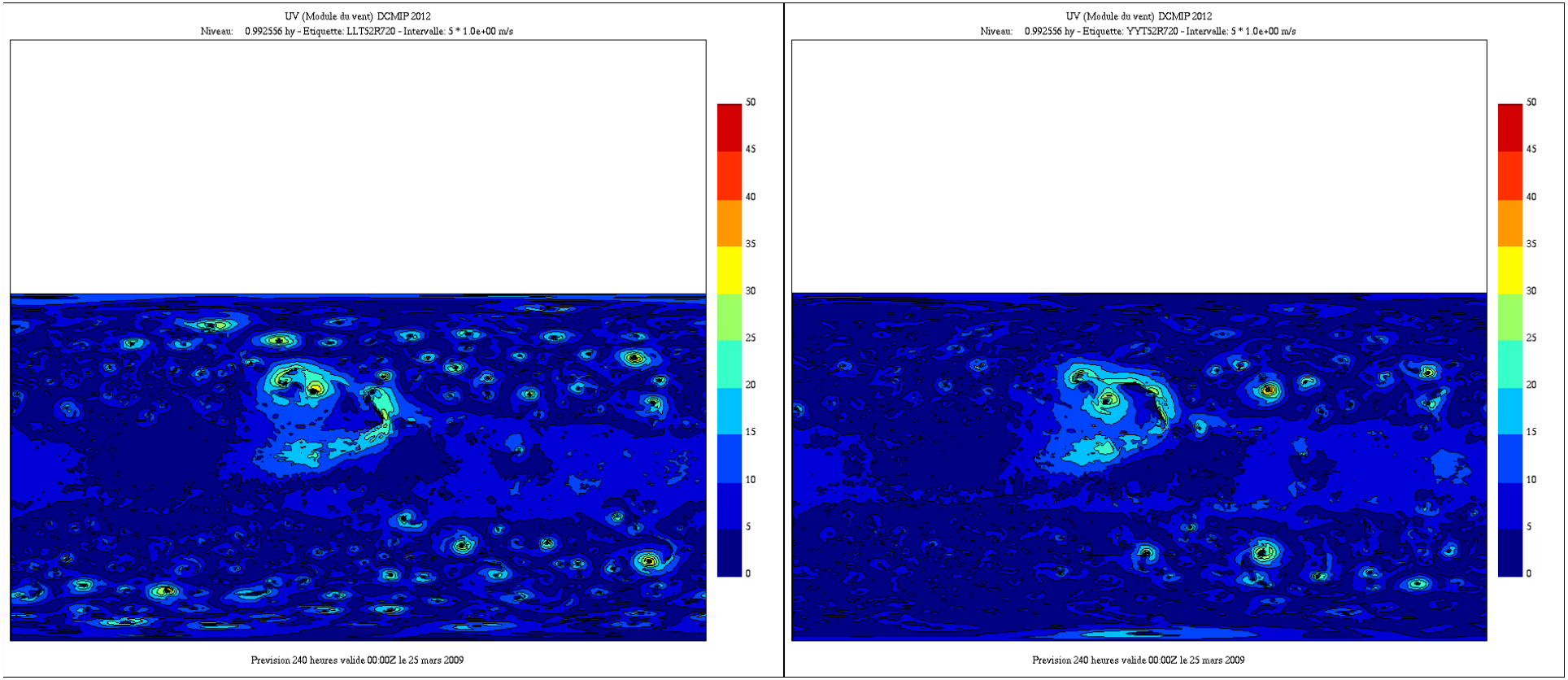
LL 0.5 deg YY

Eye of the cyclone is clearly defined with Full Physics

Plot Lon_ Height Through the center latitude of the vortex

Wind Speed

t=5 days



LL 0.5 deg YY

Appearance of several small cyclones

Plot Lat_Lon Lower Level

Wind Speed

t=10 days

END