# Testing the New Semi-Lagrangian Horizontal Diffusion Scheme

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# Outline

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- Two schemes – many cases
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# Introduction

- Numerical horizontal diffusion is applied along model level that follows orography, so it is not purely horizontal.
- Significance of physical diffusion increases with horizontal resolution,
- in situations with strong horizontal wind shear and statically stable situations,
- is more pronounced in cyclogenetic areas like Adriatic Sea.
- Near orography model levels are more tilted, "horizontal" diffusion acts more along the vertical.
- Horizontal mixing occurs between "valleys" and "mountaintops"- cloud forming on mountaintop instead of fog in the valley.

# Methods

- Operational model: 4th order numerical diffusion scheme

- Experimental model: Semi-Lagrangian Horizontal Diffusion (SLHD) uses local physical properties of the flow to control the amount of interpolation used in the Semi-Lagrangian advection scheme.
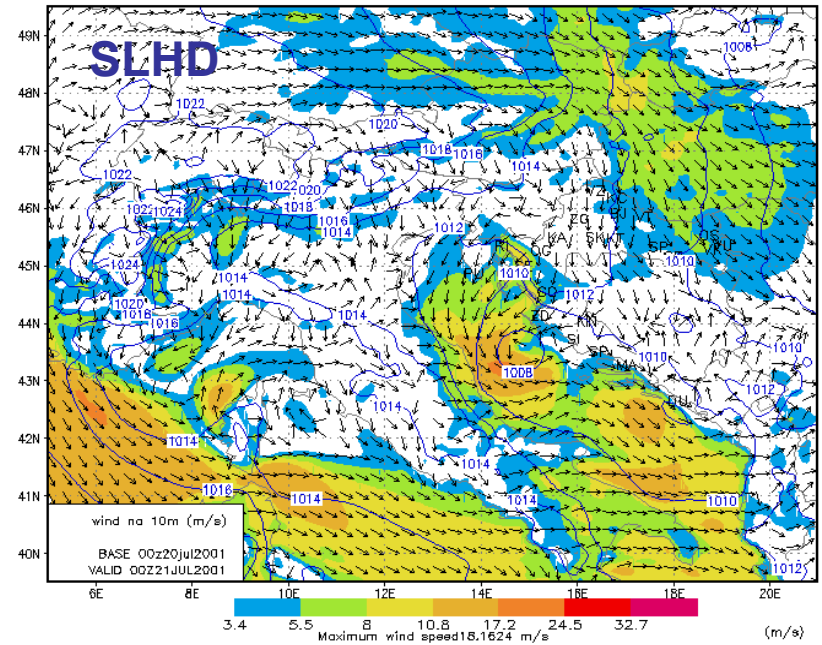
# Adriatic cyclone (1)

- 20th and 21st July 2001, intense cyclone in the Adriatic

- Operational 00 UTC run 24 h forecast starting 20th July 2001 overestimates the strength of the cyclone

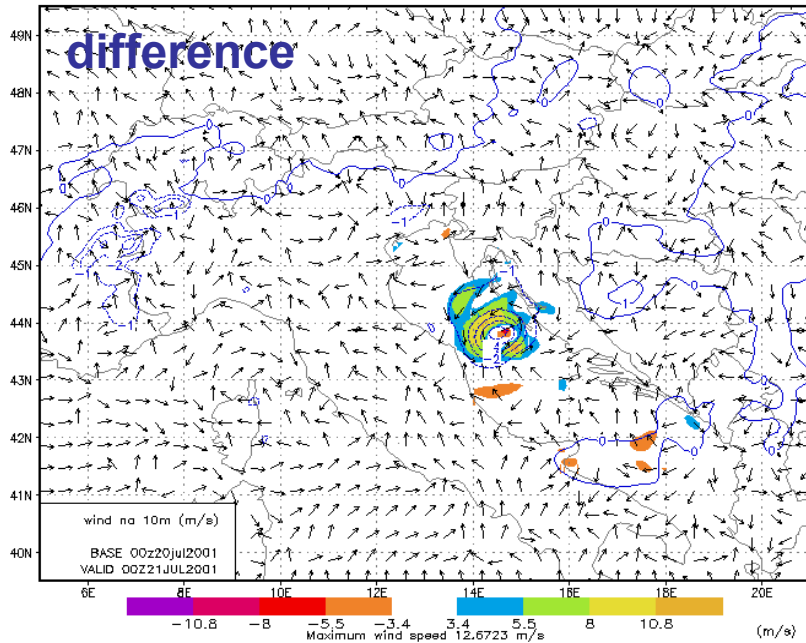- SLHD reduces cyclone intensity at sea level and at 850 hPa

ALADIN/HR wind 00Z21JUL2001 UTC 24h forecast
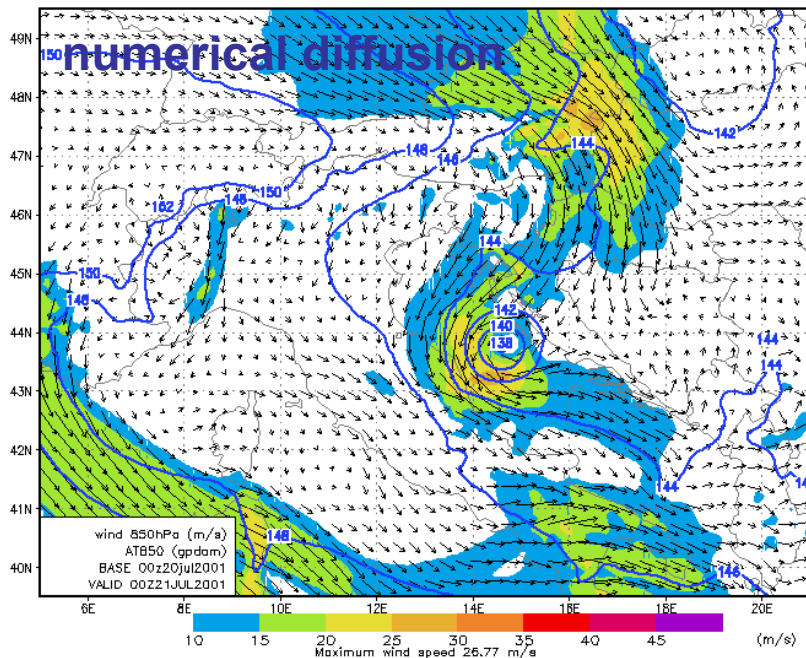
numerical diffusion
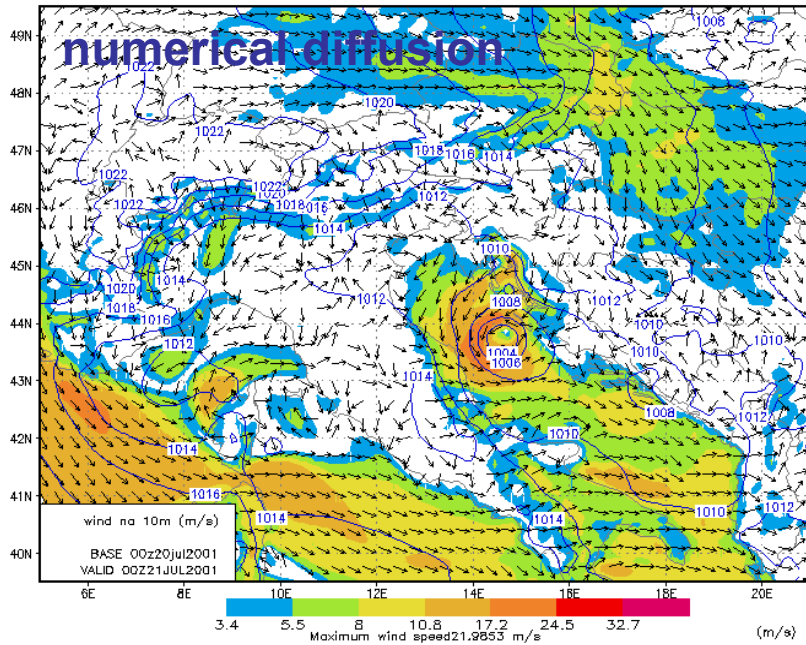
New ALADIN/HR wind 00Z21JUL2001 UTC 24h forecast

SLHD

Difference ALADIN/HR wind 00Z21JUL2001 UTC 24h forecast
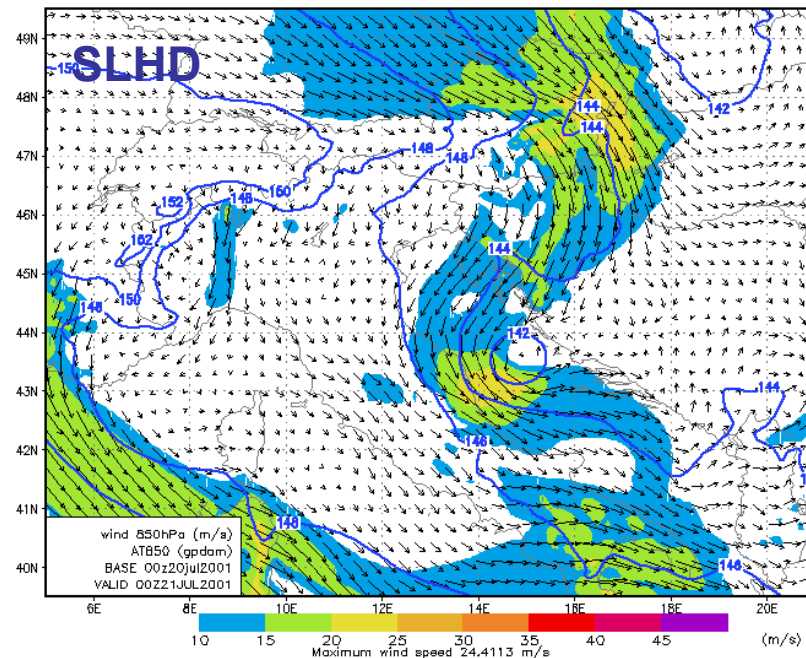
difference

Mean sea level pressure and 10 m wind obtained with numerical diffusion (top left), SLHD (top) and their difference (left), 24 hour forecast starting from 00 UTC 20th July 2001.
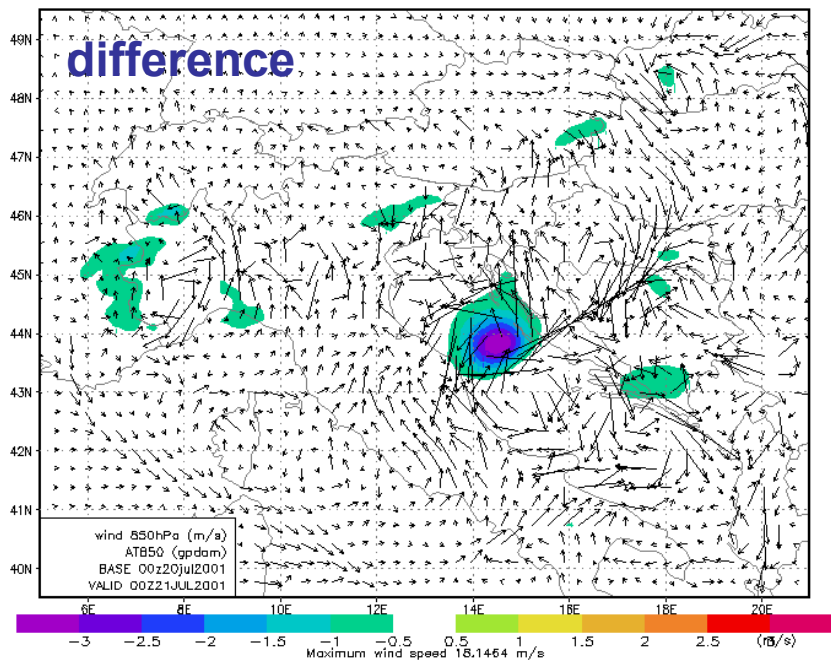
ALADIN/HRn8 wind + Z 850hPa 00Z21JUL2001 UTC 24h forecast

numerical diffusion



New ALADIN/HRn8 wind + Z 850hPa 00Z21JUL2001 UTC 24h forecast

SLHD



Difference ALADIN/HR wind + Z 850hPa u 00Z21JUL2001 UTC 24h forecast

difference

AT850 and wind obtained with numerical diffusion (top left), SLHD (top) and their difference (left), 24 hour forecast starting from 00 UTC 20th July 2001.
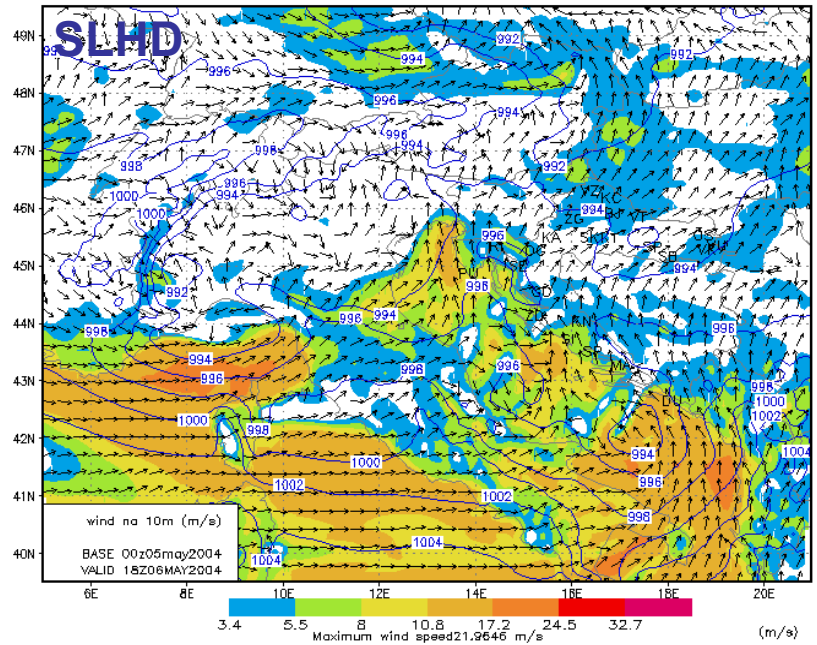
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# Adriatic cyclone (2)

- 6th May 2004, a small but intensive cyclone develops in the Adriatic

- Intensity is predicted well but the position is more to the northwest

- SLHD shifted the system in the northwestern direction leaving intensity untouched
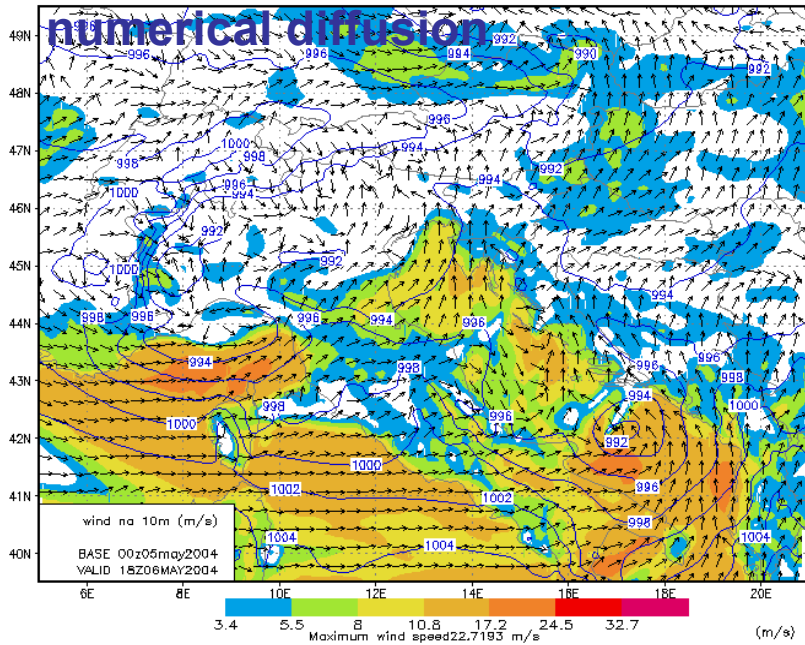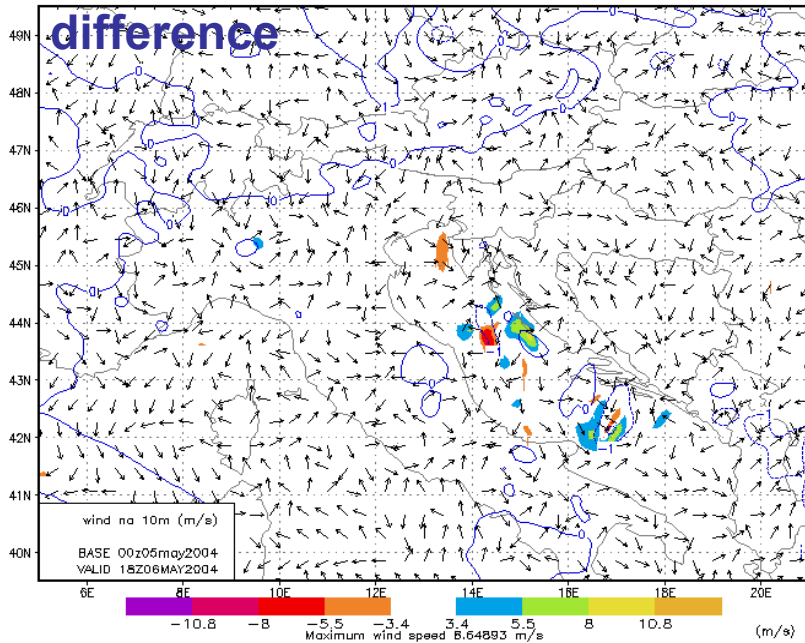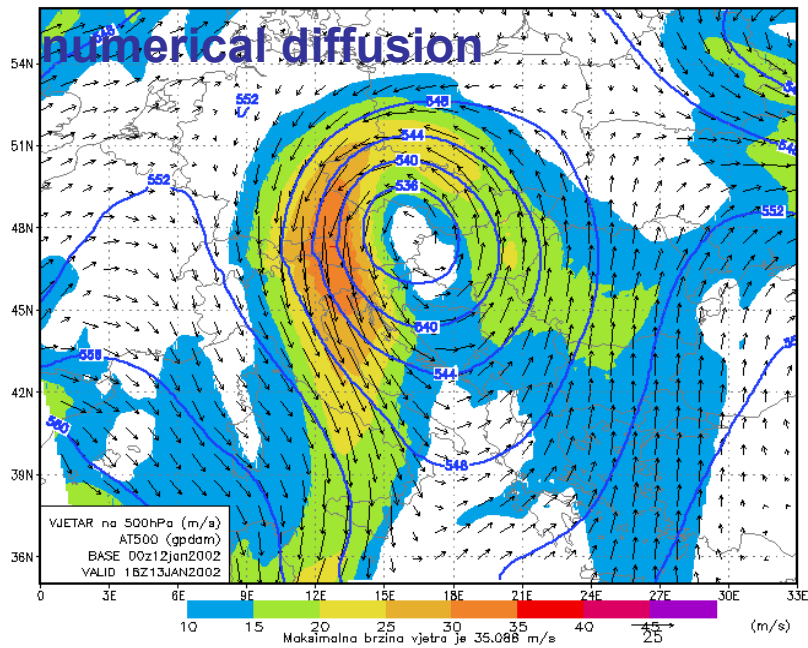
Mean sea level pressure and 10 m wind obtained with numerical diffusion (top left), SLHD (top) and their difference (left), 42 hour forecast starting from 00 UTC 5th May 2004.

# Upper level cyclone

- 13th January 2002, an intense cyclone in upper troposphere over Central Europe. Lower level geopotential does not show gradients

- When SLHD is used, cyclone's center shifts northeast, but the cyclone intensity does not change

- In the absence of large gradients of horizontal wind and far from an orographic obstacle, SLHD acts similarly to classical numerical diffusion
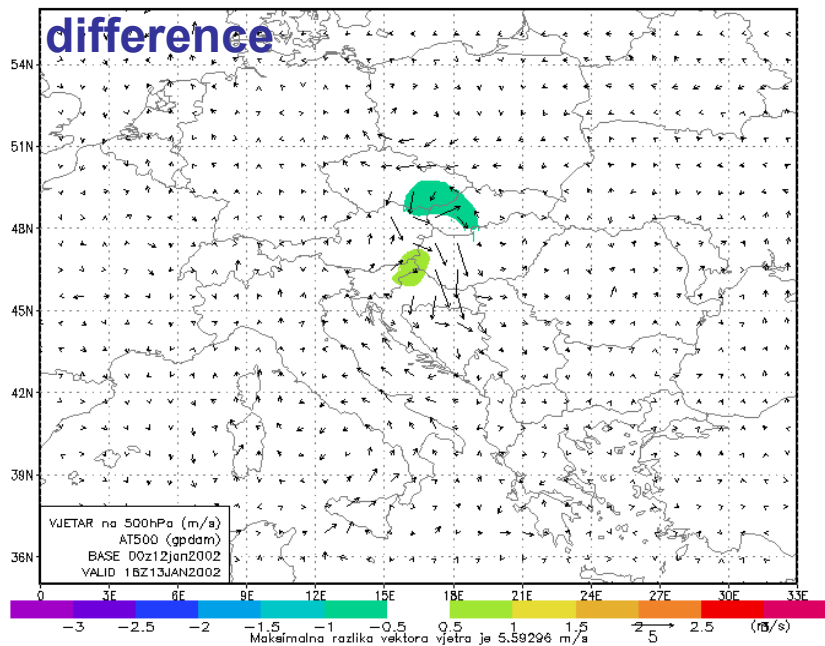
ALADIN/LACE VJETAR + Z na 500hPa u 18Z13JAN2002 UTC 42h forecast

**numerical diffusion**



Novi ALADIN/LACE VJETAR + Z na 500hPa u 18Z13JAN2002 UTC 42h forecast
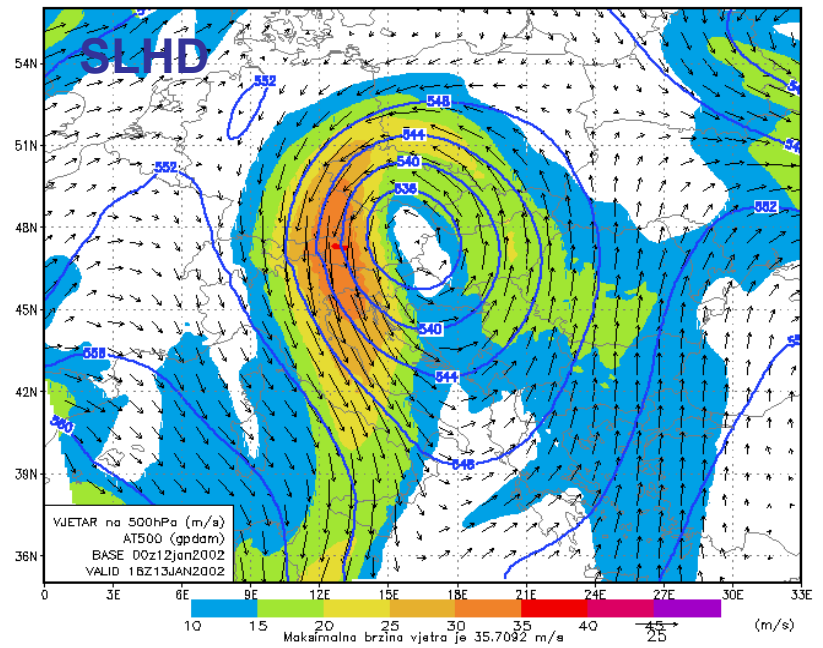
**SLHD**



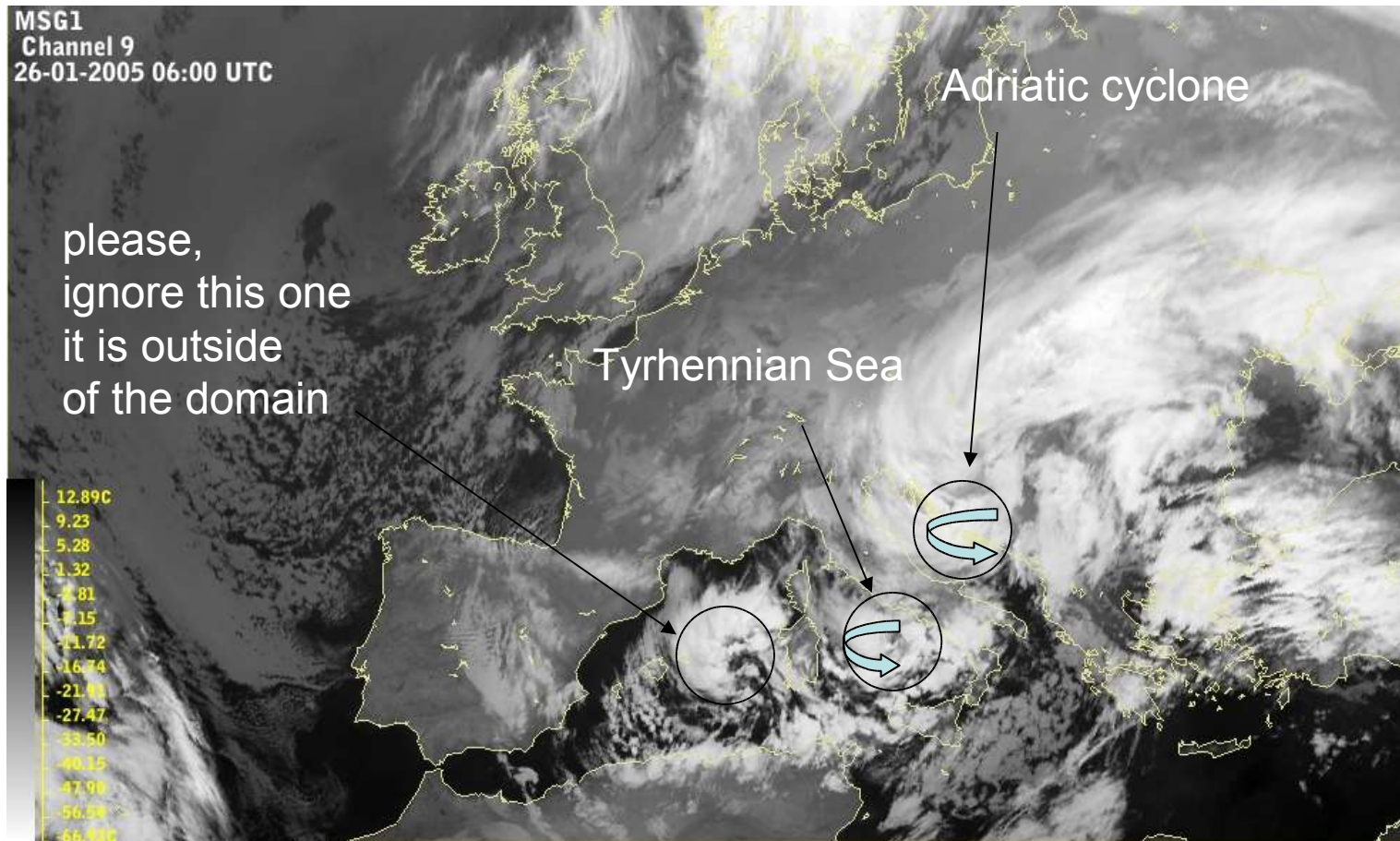ALADIN/LACE VJETAR + Z na 500hPa u 18Z13JAN2002 UTC 42h forecast

**difference**

AT500 and wind obtained with numerical diffusion (top left), SLHD (top) and their difference (left), 42 hour forecast starting from 00 UTC 12th January 2002.

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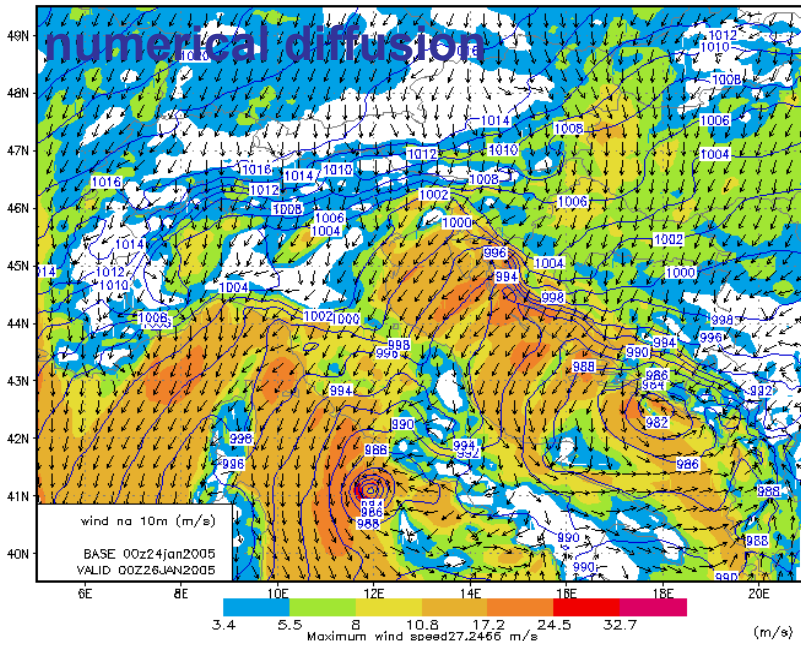
# Twin cyclones

- 24th January 2005, 00 UTC run produces twin cyclones

- The strength of the Tyrrheinan sea cyclone is overestimated

- Using SLHD, Tyrrhenian cyclone weakens and moves southwest and the Adriatic cyclone shifts inland.
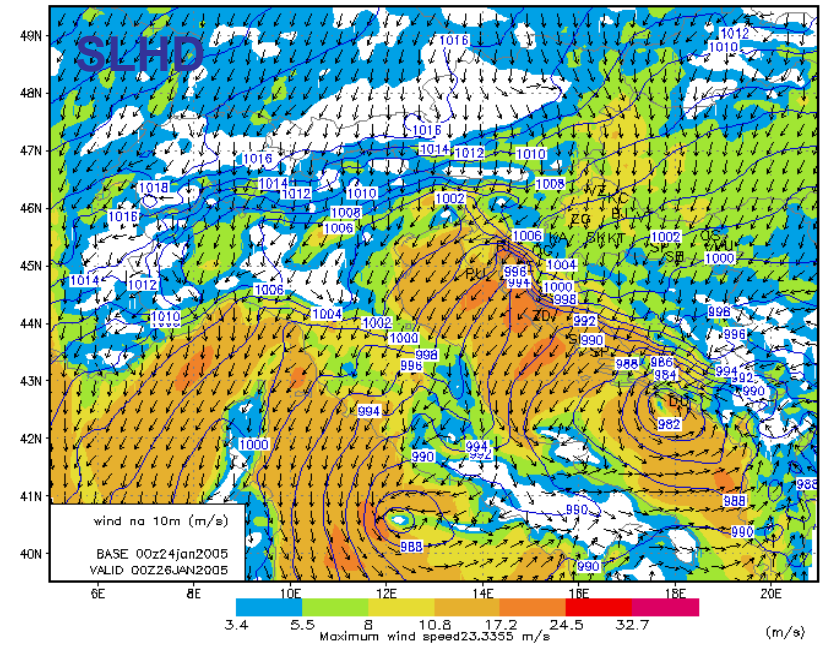
# Twin cyclones



- Meteosat-8 infra-red image for January 26th 2005, 06 UTC.
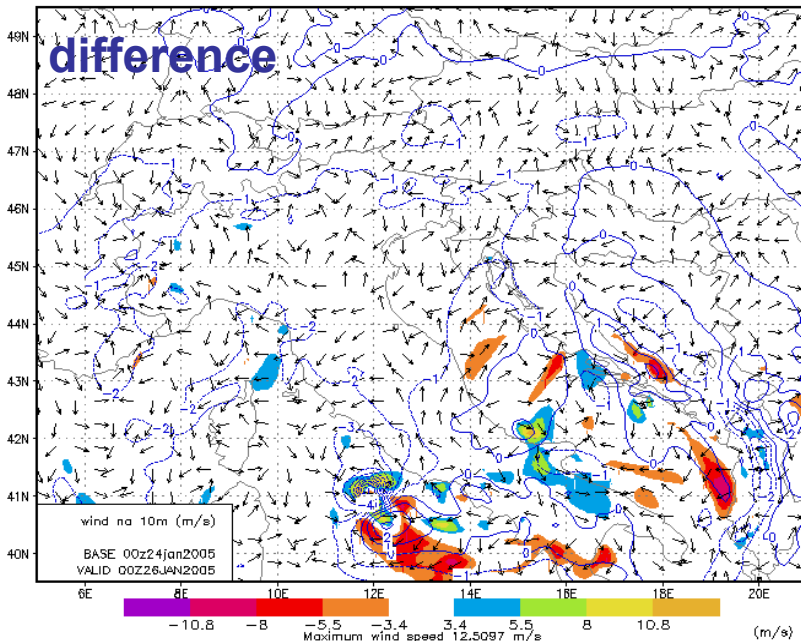- Cyclones over Tyrhennian and Adriatic Sea.
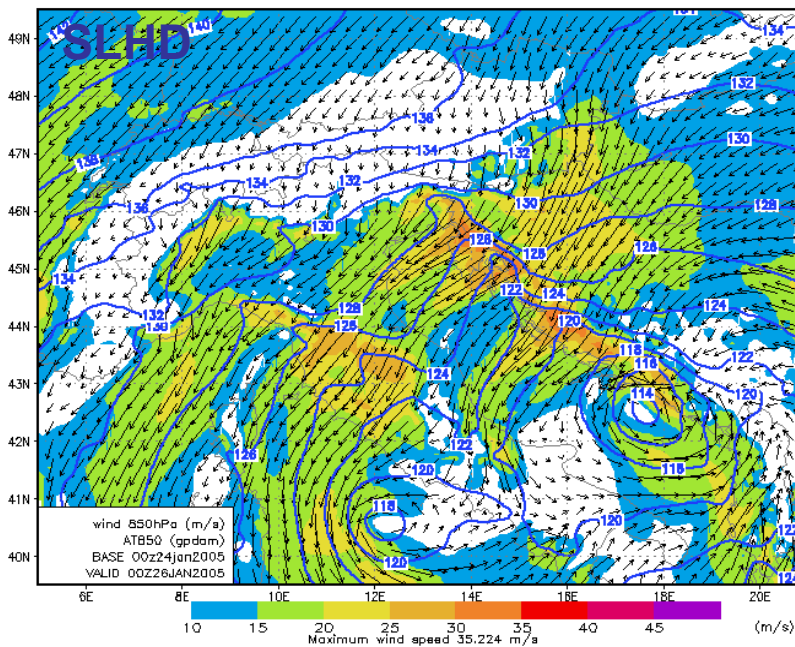
10m wind and mean sea level pressure obtained with numerical diffusion (top left), SLHD (top) and their difference (left), 48 hour forecast starting from 00 UTC 24th January 2005.
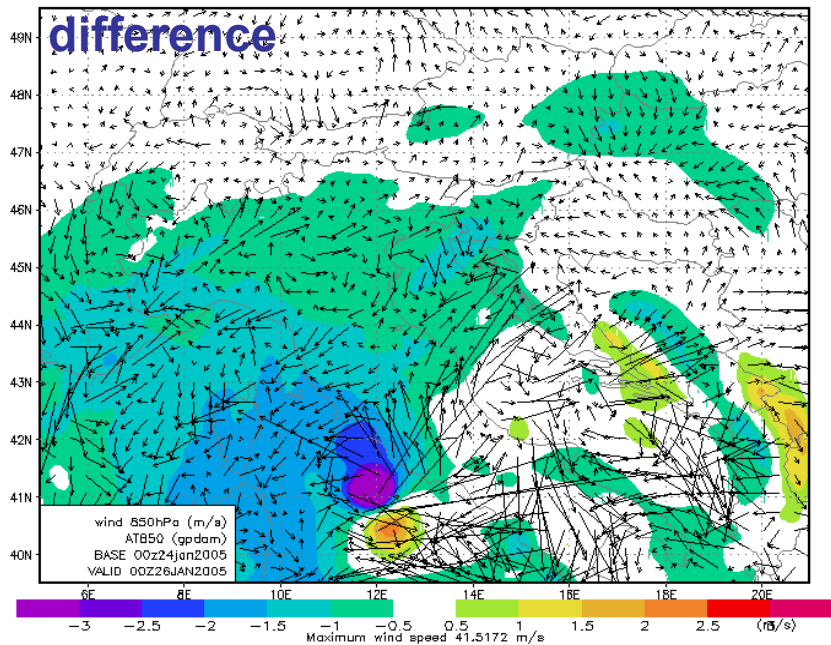
ALADIN/HRn8 wind + Z 850hPa 00Z26JAN2005 UTC 48h forecast

numerical diffusion

New ALADIN/HRn8 wind + Z 850hPa 00Z26JAN2005 UTC 48h forecast
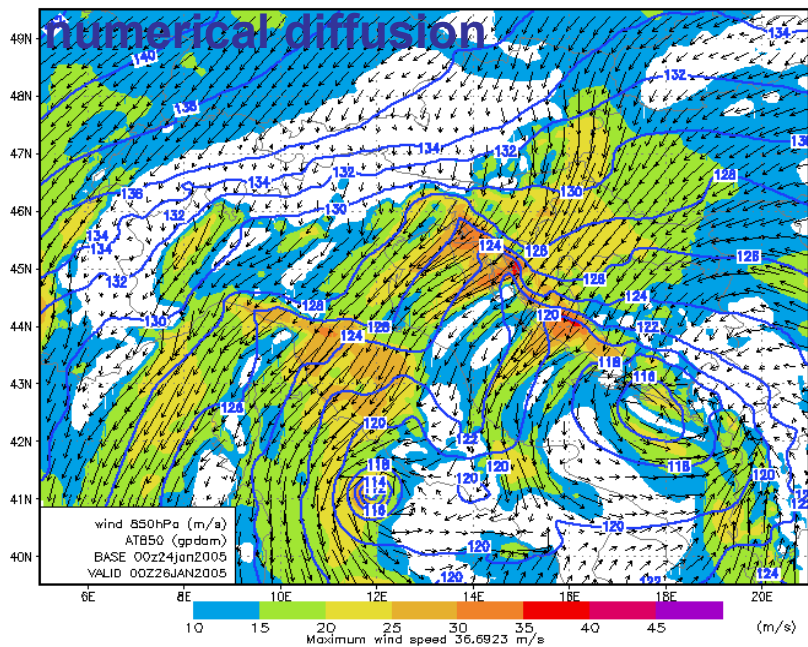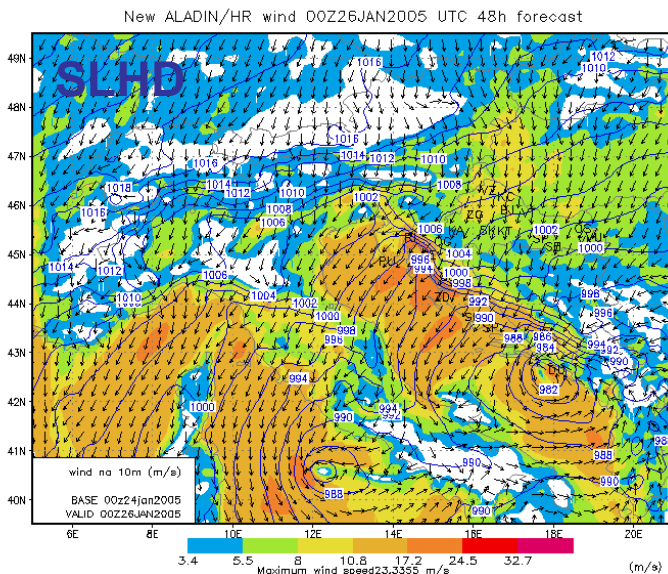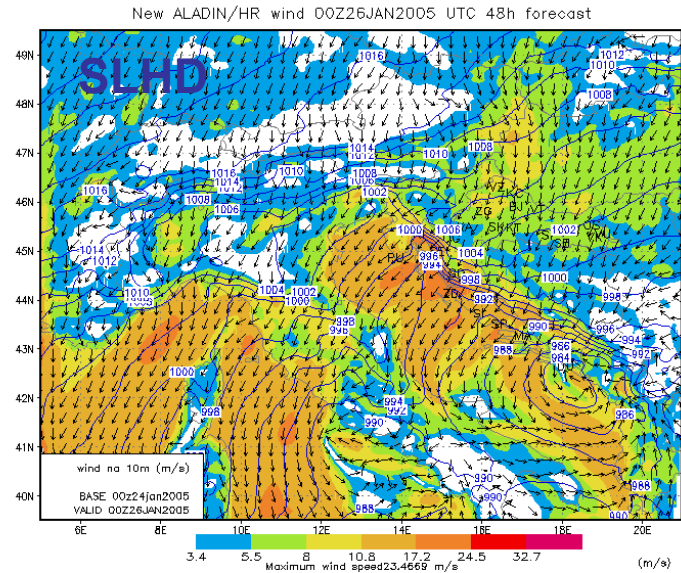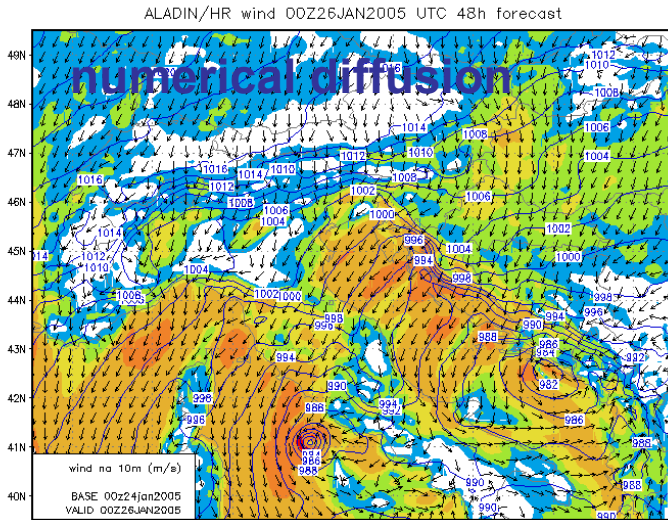
SLHD

Difference ALADIN/HR wind + Z 850hPa u 00Z26JAN2005 UTC 48h forecast

difference

AT850 and wind obtained with numerical diffusion (top left), SLHD (top) and their difference (left), 48 hour forecast starting from 00 UTC 24th January 2005.

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# Coupling ploblem



ALADIN/HR wind 00Z26JAN2005 UTC 48h forecast — **numerical diffusion**



New ALADIN/HR wind 00Z26JAN2005 UTC 48h forecast — **SLHD**



New ALADIN/HR wind 00Z26JAN2005 UTC 48h forecast — **SLHD**

10m wind numerical coupled to numerical diffusion (top left), SLHD coupled to numerical diffusion (top) and SLHD coupled to SLHD (left).
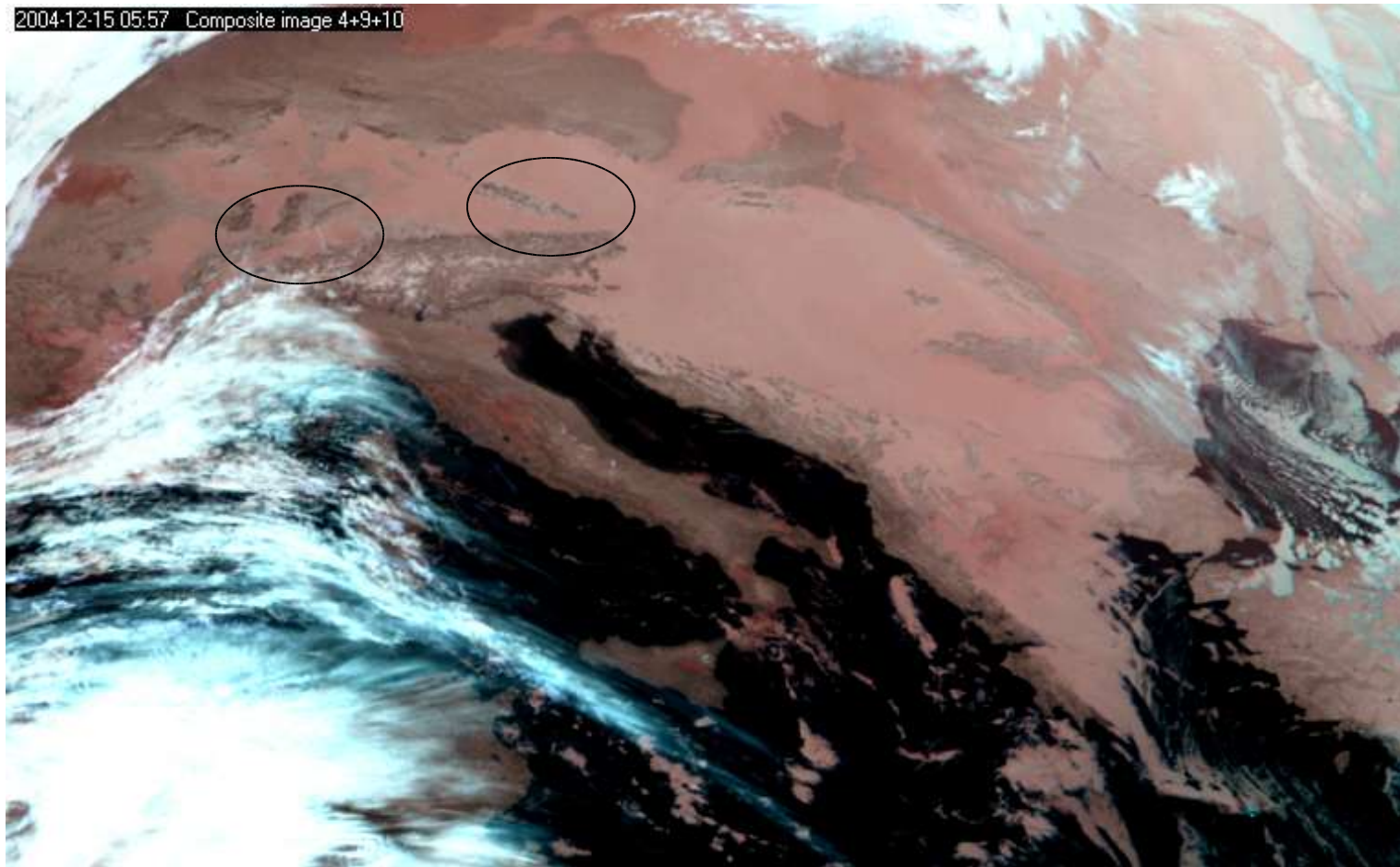
a, 6-10 June 2005

# Fog case

- 15th February 2004, Central Europe is under anticyclone and most of the valleys are covered in fog

- SLHD increases the amount of fog in Alpine valleys (border between Switzerland and Germany, and in Danube valley in Austria)

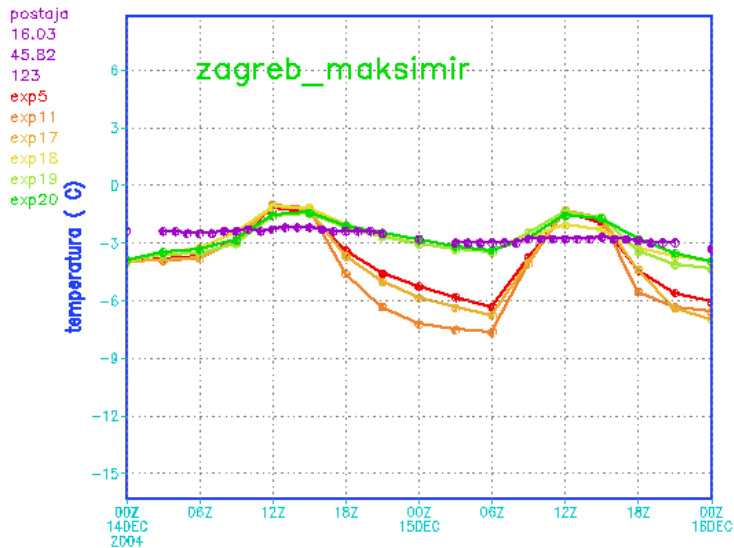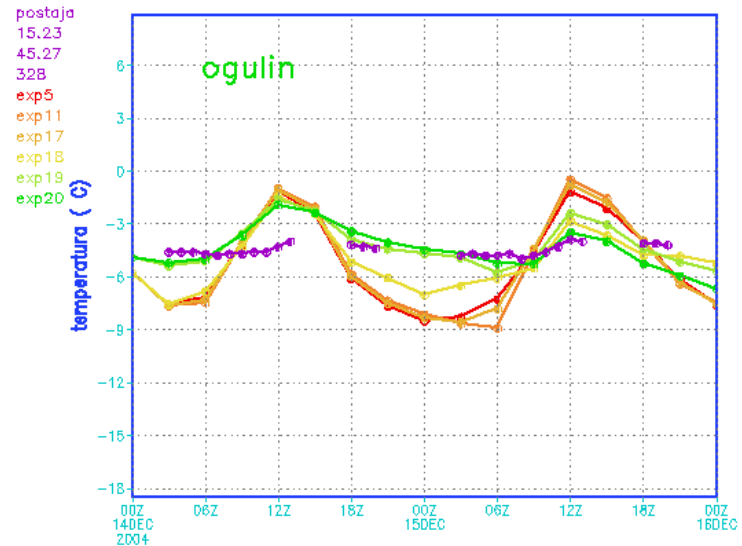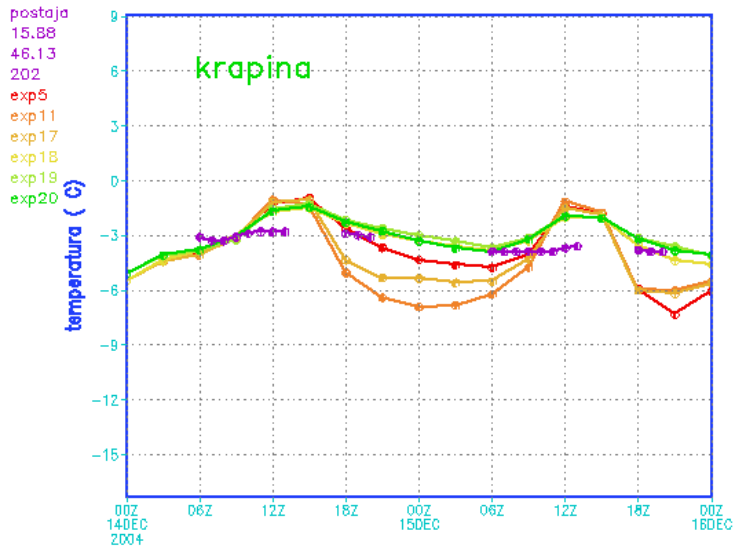- SLHD reduces mixing between valleys and the air above

# Fog case



2004-12-15 05:57  Composite image 4+9+10

- Meteosat-8 RBG composite of channels 3.9, 10.8 and 12.0 μm for December 15th 2004, 06 UTC.

# Fog case
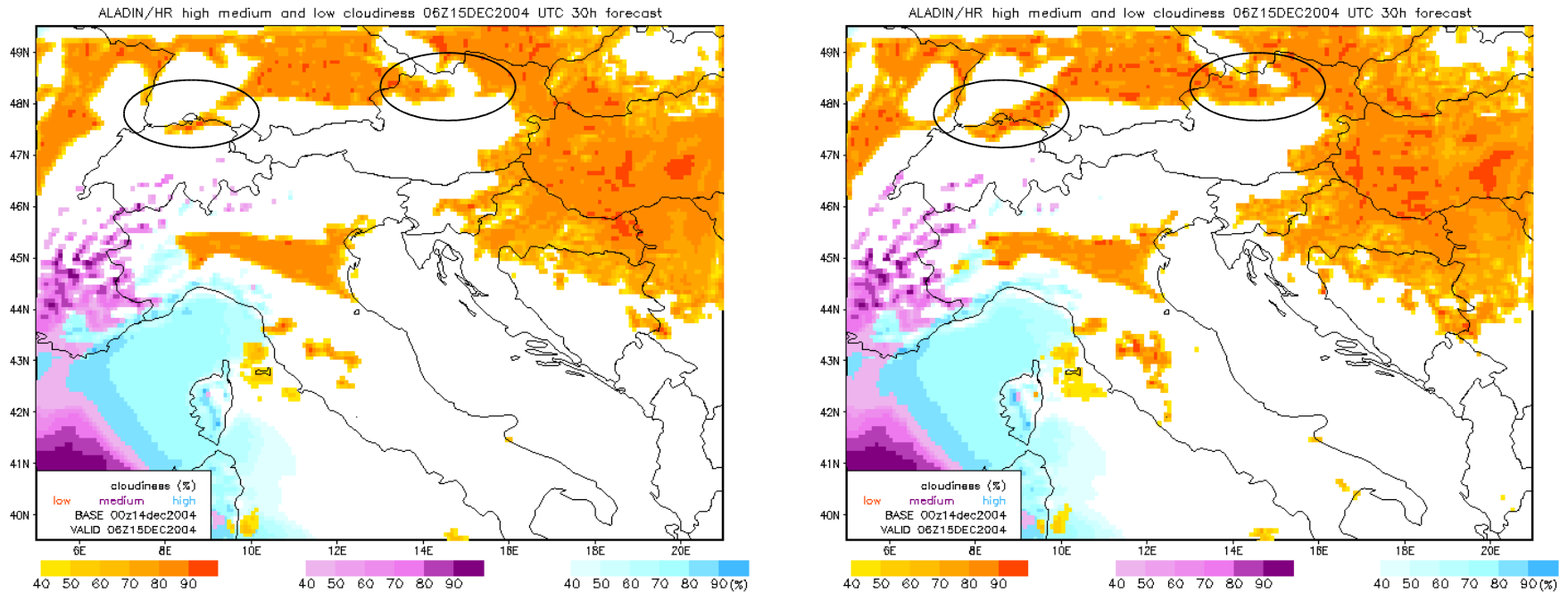


- Low, medium and high cloudiness, numerical diffusion (left) and SLHD (right), 30 hour forecast starting from 00 UTC 14th December 2004.

# Comparison to data



Comparison of the modelled 2m temperature evolution for 00 UTC run on 14th December 2004 measured data from synoptic station

*va*, 6-10 June 2005

**reference**
**NER**
**LRAUTOEV**
**SLHD**
**mean orog**
**SLHD+m.o.**

# Summary

- Semi-Lagrangian Horizontal Diffusion (SLHD) shows beneficial impact on the
  - reduction of the overestimated cyclone intensity,
  - correction of cyclone position while not altering a good intensity prediction,
  - improvement of fog forecast in the valleys in an anticyclone