

Impact of horizontal diffusion, radiation and
cloudiness parametrization on fog
forecasting in valleys

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Introduction

- In December 2004, fog and low stratus were absent from the initial conditions (although there was humidity)
- And failed to develop during the model forecast
- Resulting in wrong 2m temperature and cloudiness forecast.
- Various model parametrizations were tested in order to forecast the fog and low stratus using the same initial conditions.

Parametrization schemes

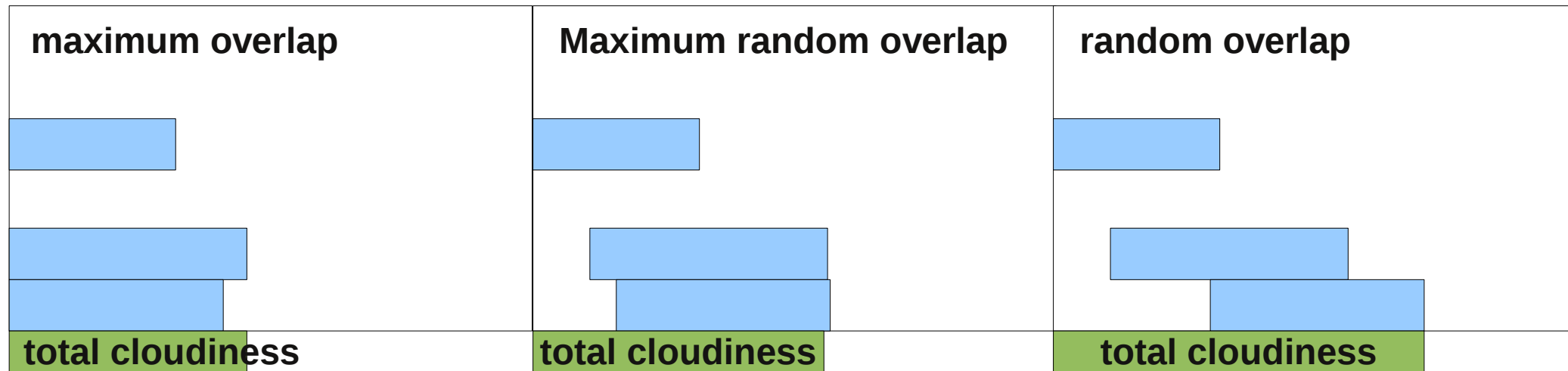
- Radiation

- Operational – Ritter and Geleyn (1990) based on Geleyn and Hollingsworth (1979)
- NER – net exchange rate
- FMR – Morcrette (1989)
- RRTM – rapid radiative transfer model Mlawer et al (1997)

- Cloud diagnosing formulas

- Operational (as in Arpege) $N_S = \alpha \sqrt{\frac{q_{cs}}{q_{sat}}}$
- and Xu-Randall (1996) $N_S = RH^p (1 - e^{-\alpha q_{cs}})$

- Cloud overlap assumptions

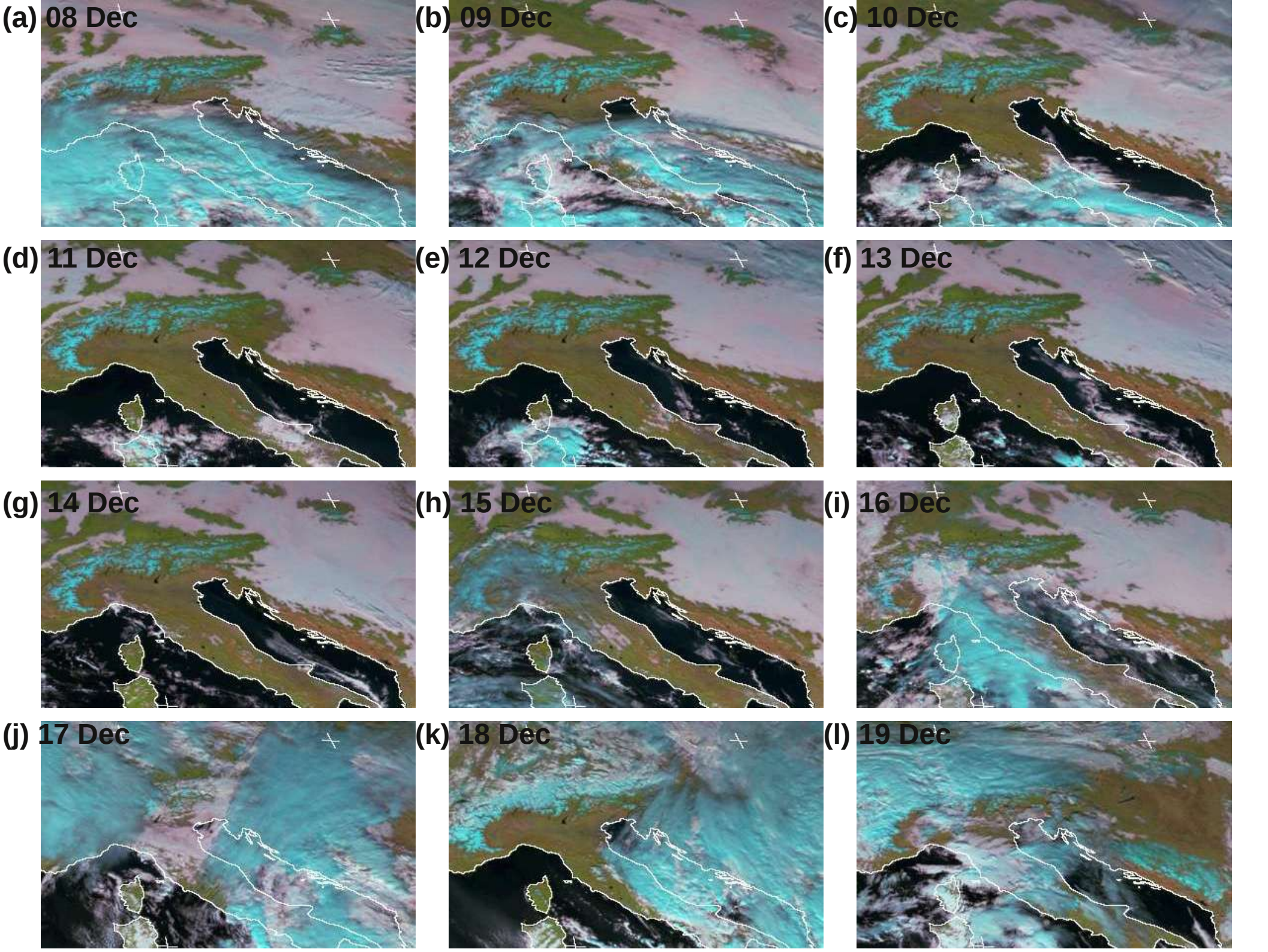


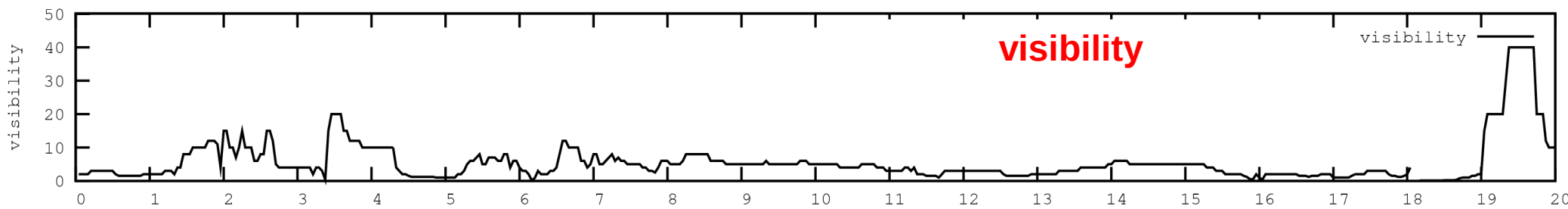
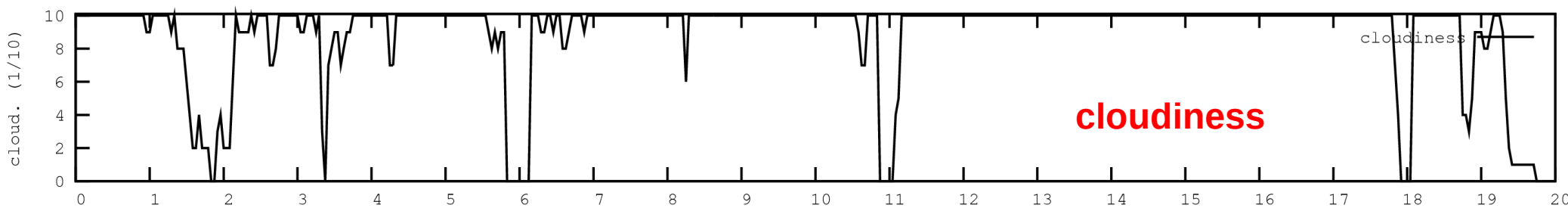
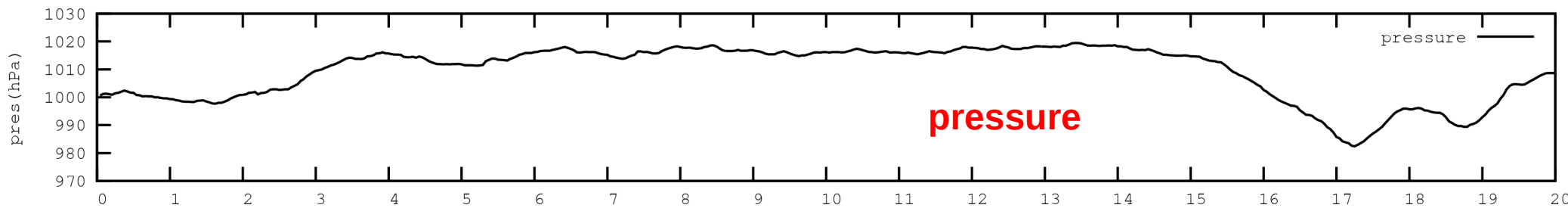
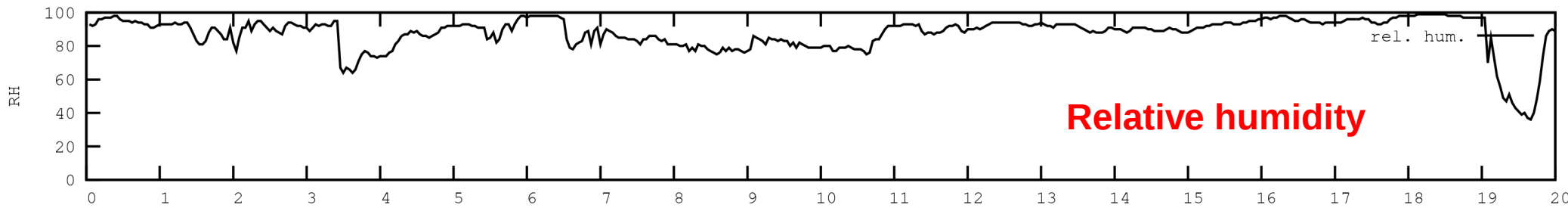
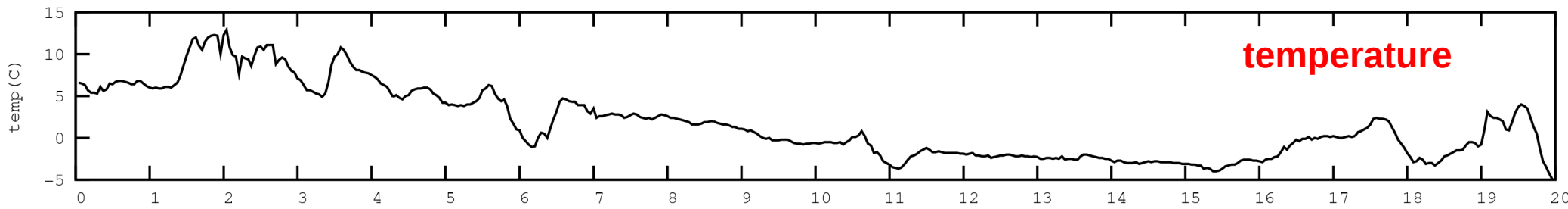
- Prognostic TKE
- Prognostic cloud water and ice, rain and snow

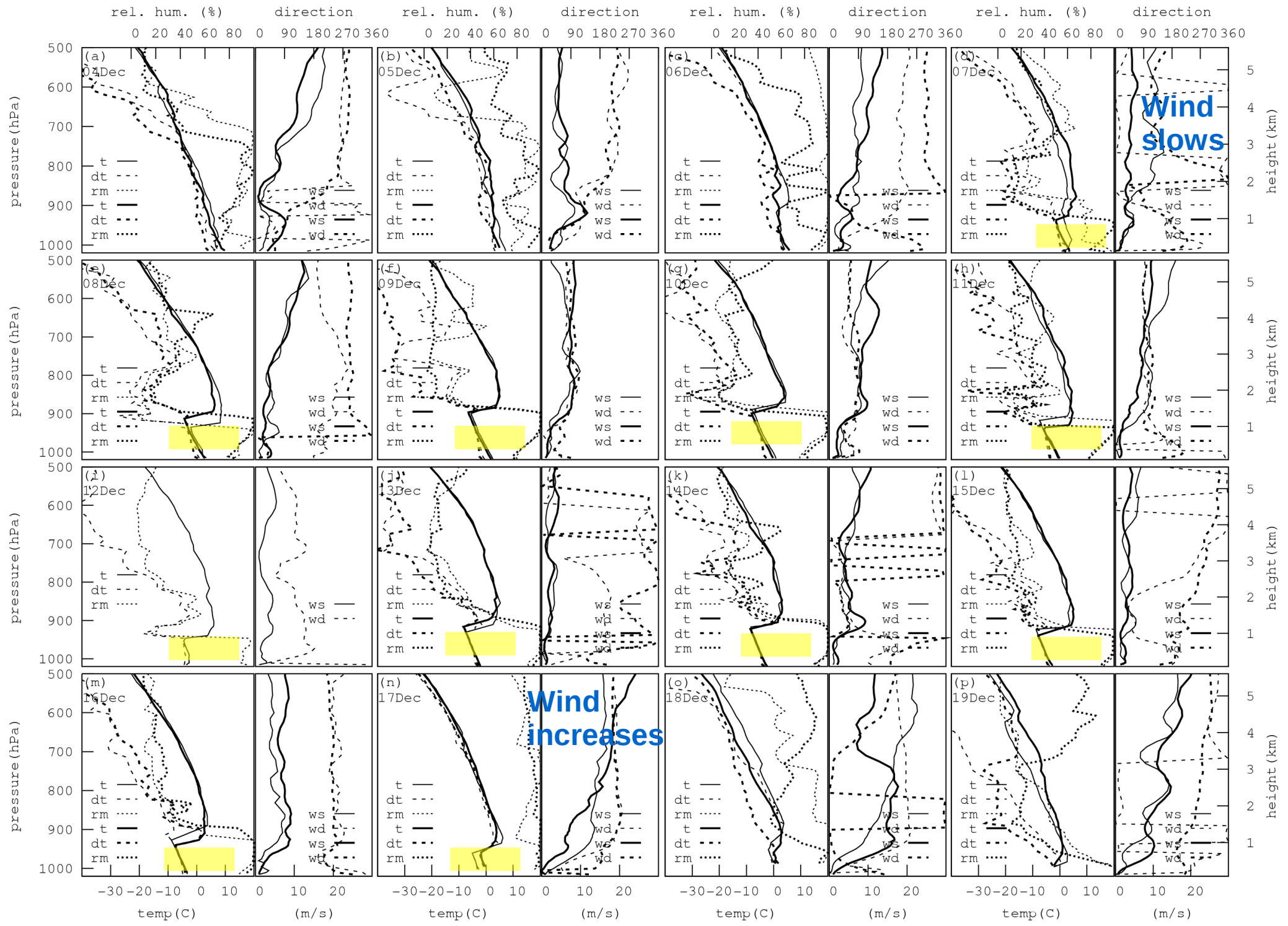
$$q_{cs} = q_{cmax} \left(1 - e^{-\beta \frac{q - r_c q_{sat}}{q_{cmax}}} \right)$$

$$q_{cs} = q_{cmax} \left(1 - e^{-\beta \frac{q + q_l + q_i - r_c q_{sat}}{q_{cmax}}} \right)$$

- Horizontal diffusion (SLHD)
- Higher resolution in vertical and horizontal ...



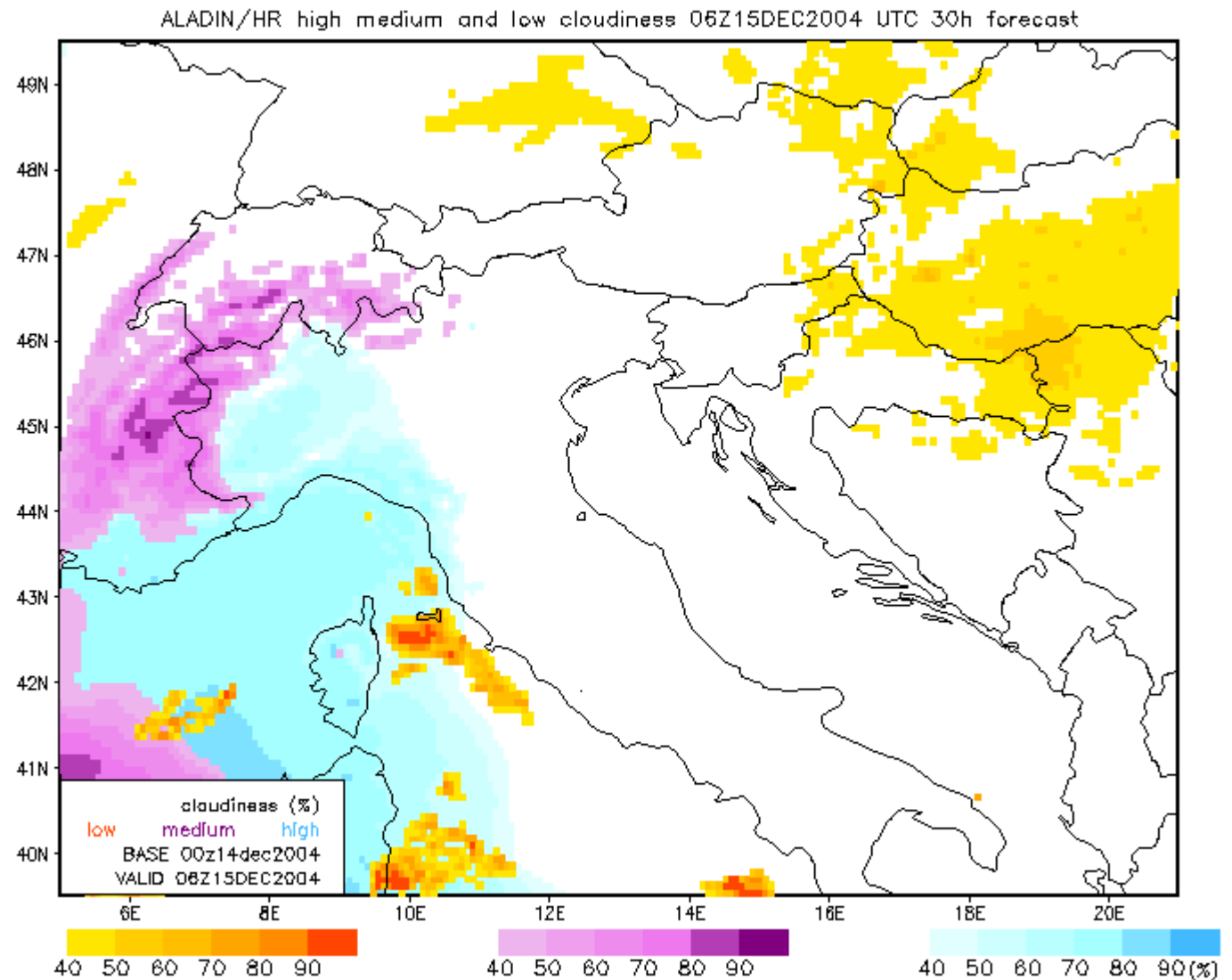




experiment	cloud scheme	overlap	horizontal diffusion	radiation scheme	prognostic TKE	prognostic condensate	Cloudiness figure
oper	oper	random	numerical	RG90	no	no	No
exp1	Xu-Randall	random	numerical	RG90	no	no	6a
exp2	Xu-Randall	maximum	numerical	RG90	no	no	No
exp3	Xu-Randall	random	numerical	RG90NER	no	no	6b
exp4	Xu-Randall	random	numerical	FMR 3h	no	no	No
exp5	Xu-Randall	random	numerical	FMR 1h	no	no	6c
exp6	Xu-Randall	random	numerical	RRTM 3h	no	no	No
exp7	Xu-Randall	random	numerical	RRTM 1h	no	no	6d
exp8	Xu-Randall	random	SLHD	RG90	no	no	6e
exp9	Xu-Randall	random	SLHD	RG90	yes	no	No
exp10	Xu-Randall	random	SLHD	RG90	yes	yes	6f
exp11	Xu-Randall	random	SLHD	RG90	yes	yes	Envelope orography
exp12	Xu-Randall	random	SLHD	RG90	yes	yes	73 levels

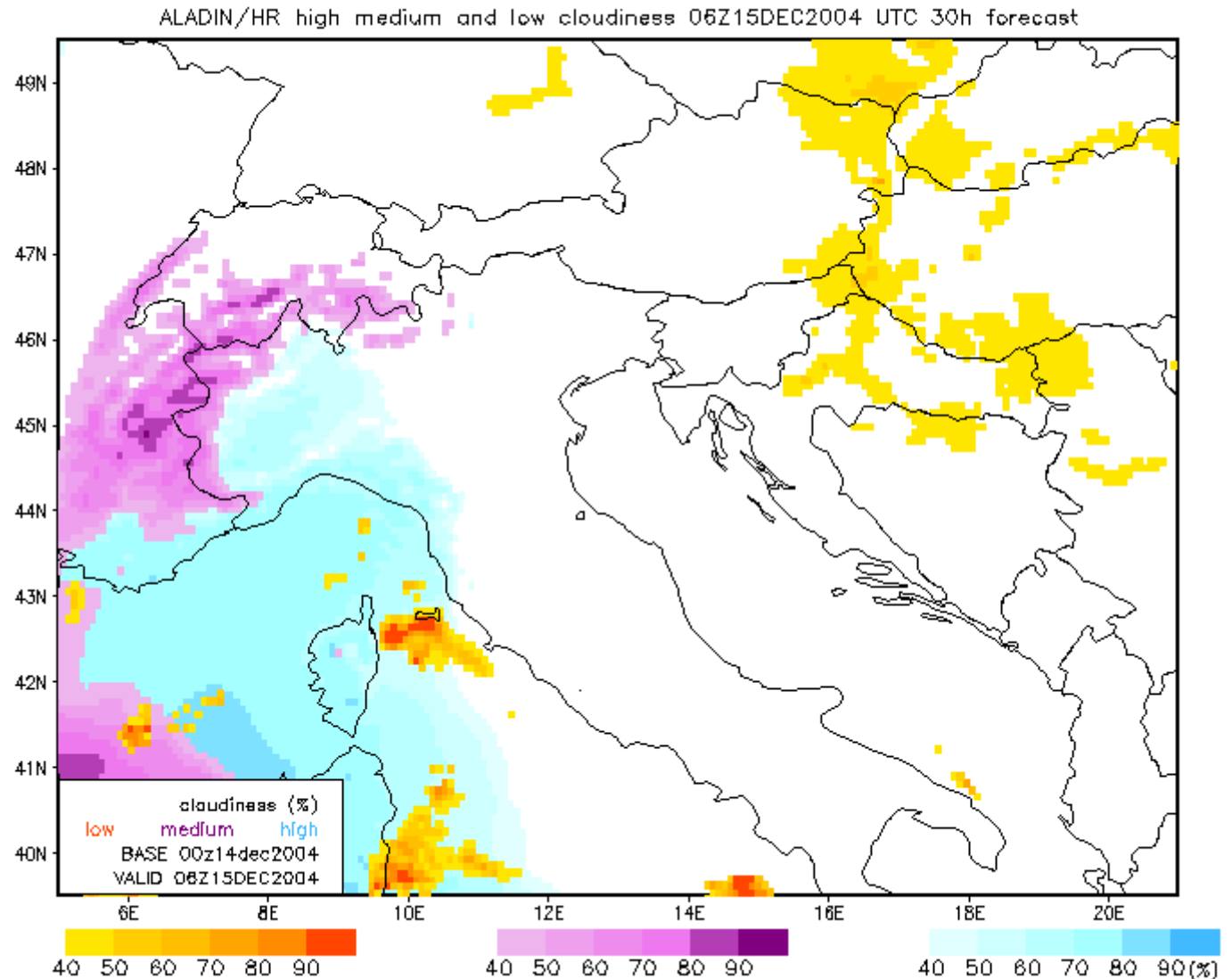
Operational cloudiness forecast

- RG90 radiation
- Random overlap
- No prog. Cond no TKE
- 8 km resolution
- 37 levels in the vertical



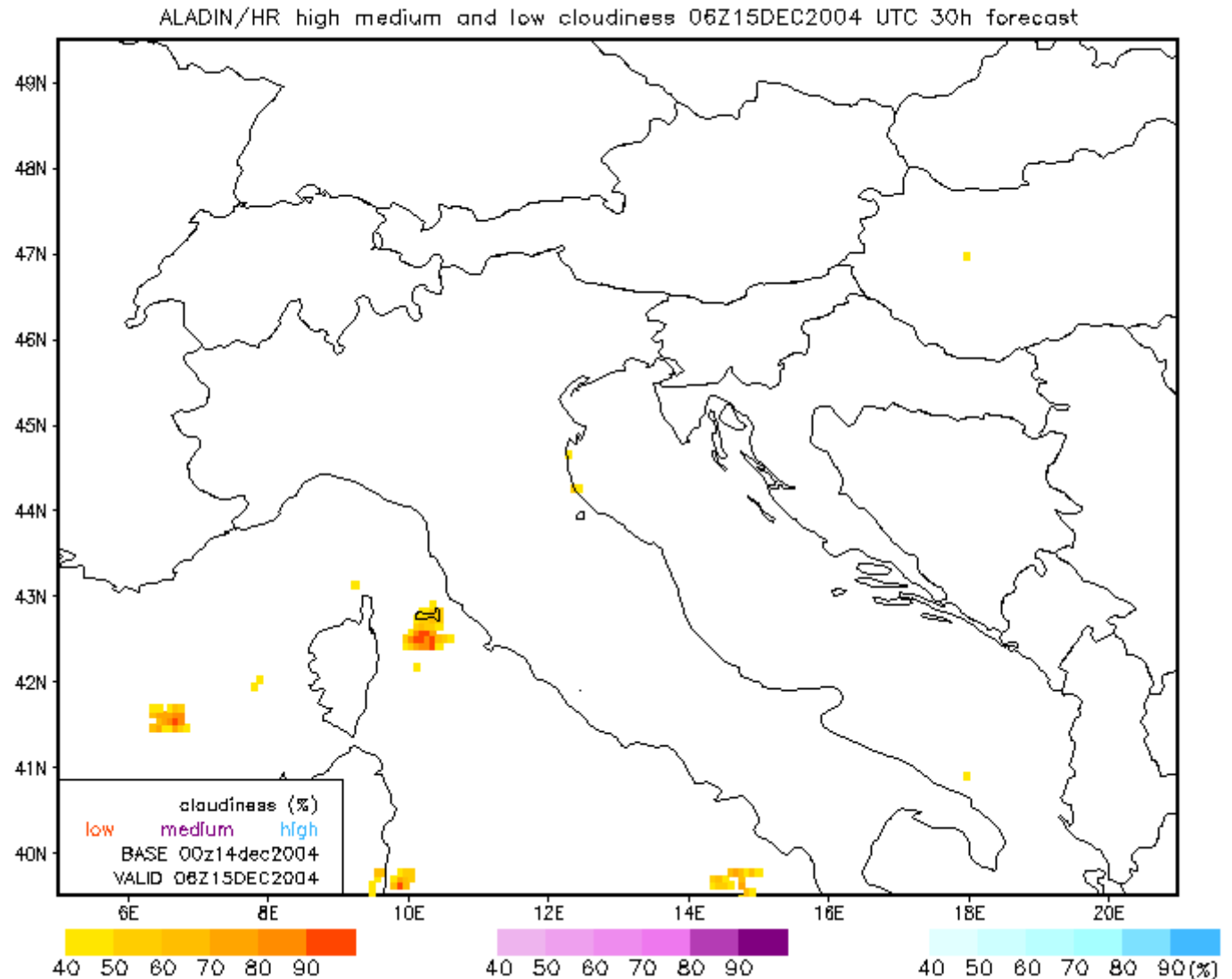
Net exchange rate (radiation)

- **RG90+NER**
radiation
- Random overlap
- No prog.
Cond no TKE
- 8 km resolution
- 37 levels in the vertical

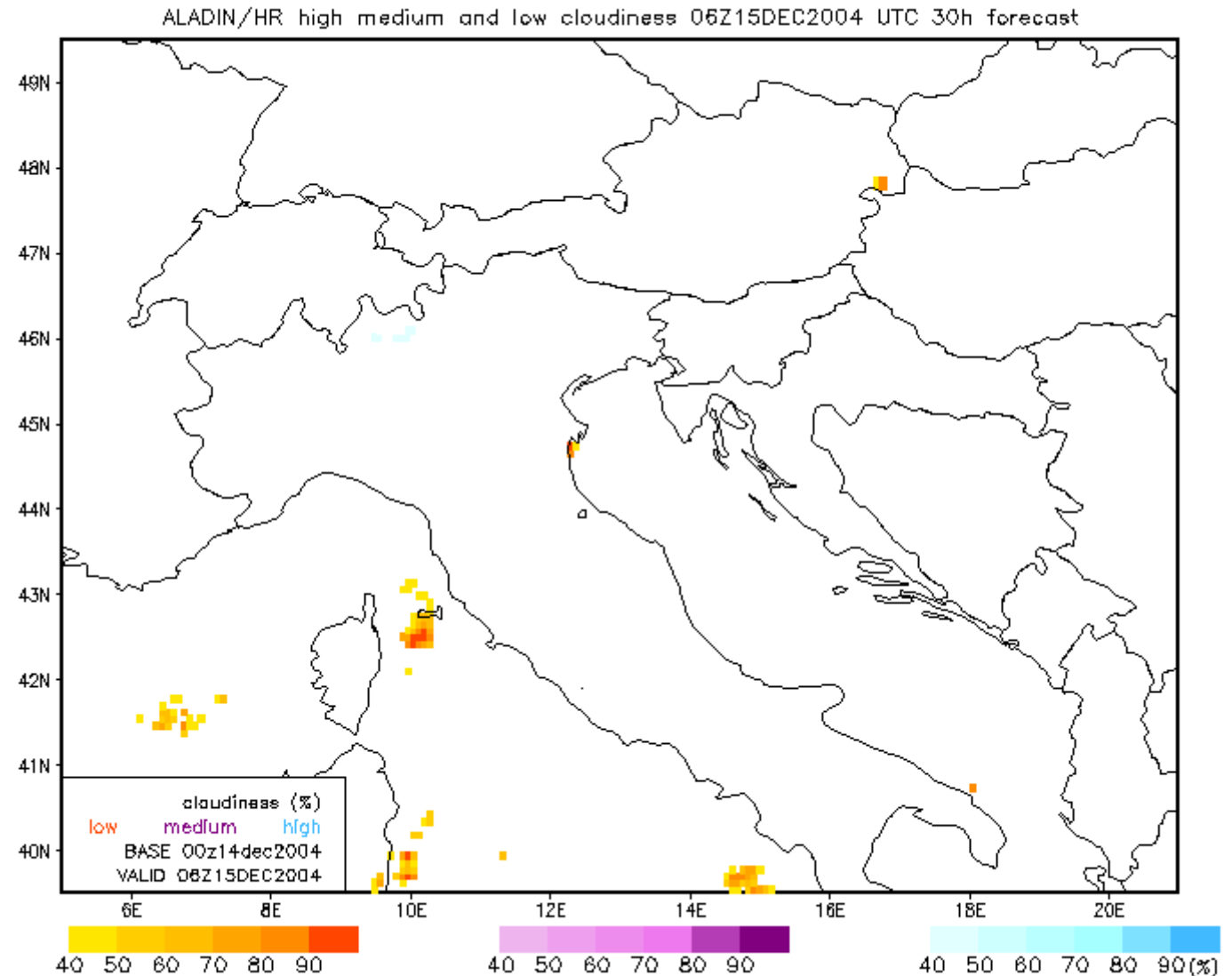


Random maximum overlap

- **RG90+NER**
radiation
- **Random**
maximum
overlap
- No prog.
Cond no TKE
- 8 km
resolution
- 37 levels in
the vertical

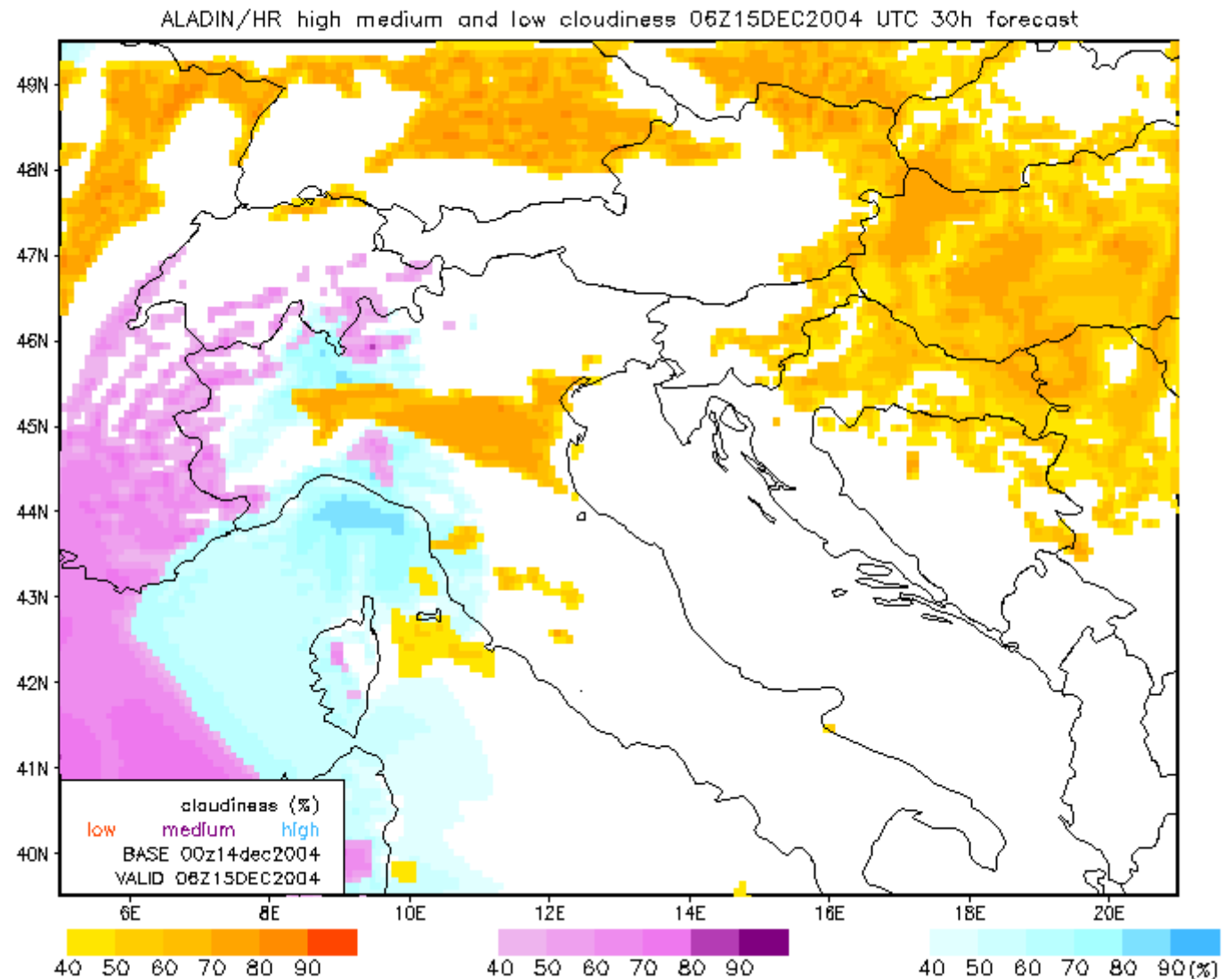


New critical relative humidity profile



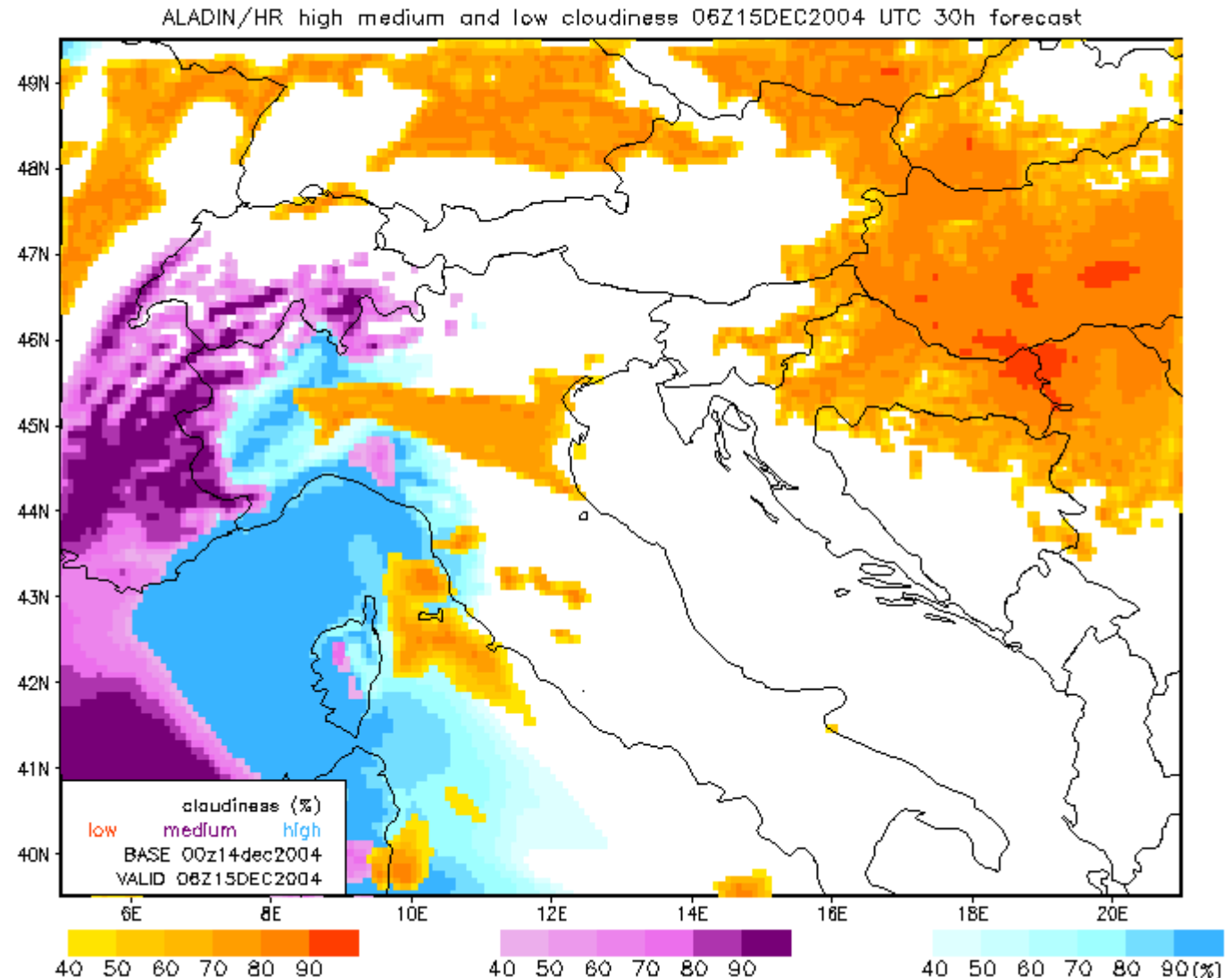
New cloud diagnosing scheme

- RG90 radiation
- Random maximum overlap
- Xu-Randall cloud scheme
- No prog. Cond no TKE



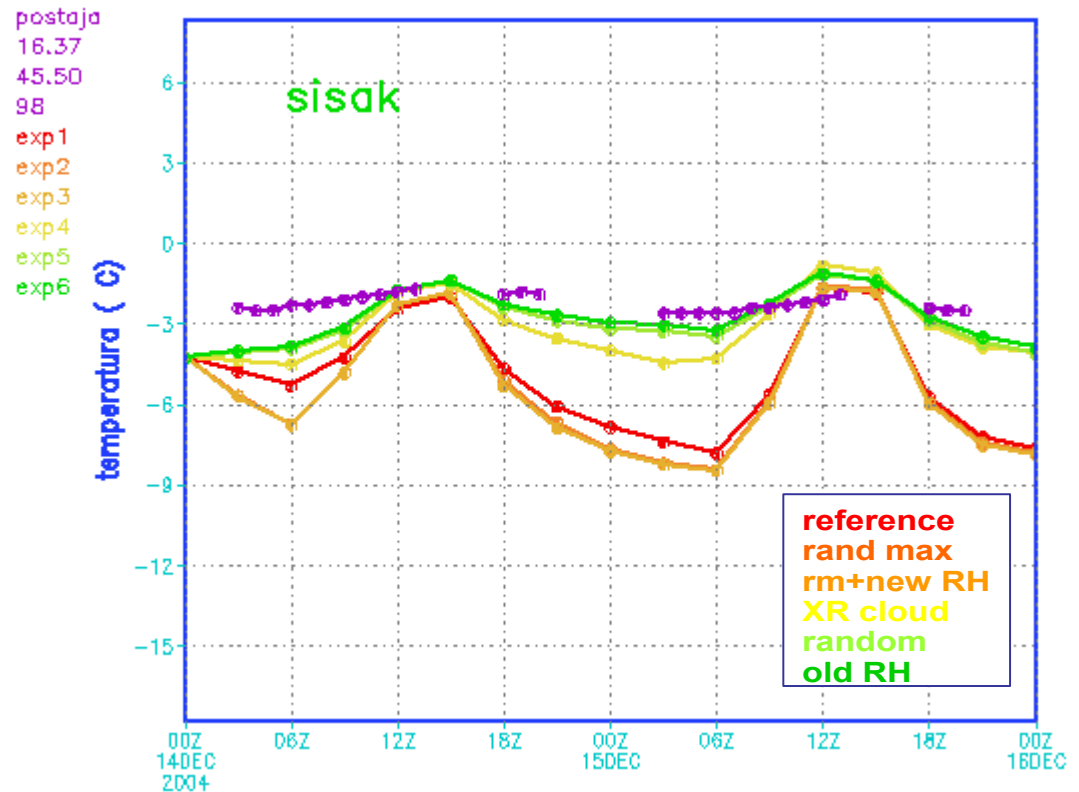
Return to random overlap

- RG90 radiation
- Random overlap
- Xu-Randall cloud scheme
- No prog. Cond no TKE
- Numerical horizontal diffusion



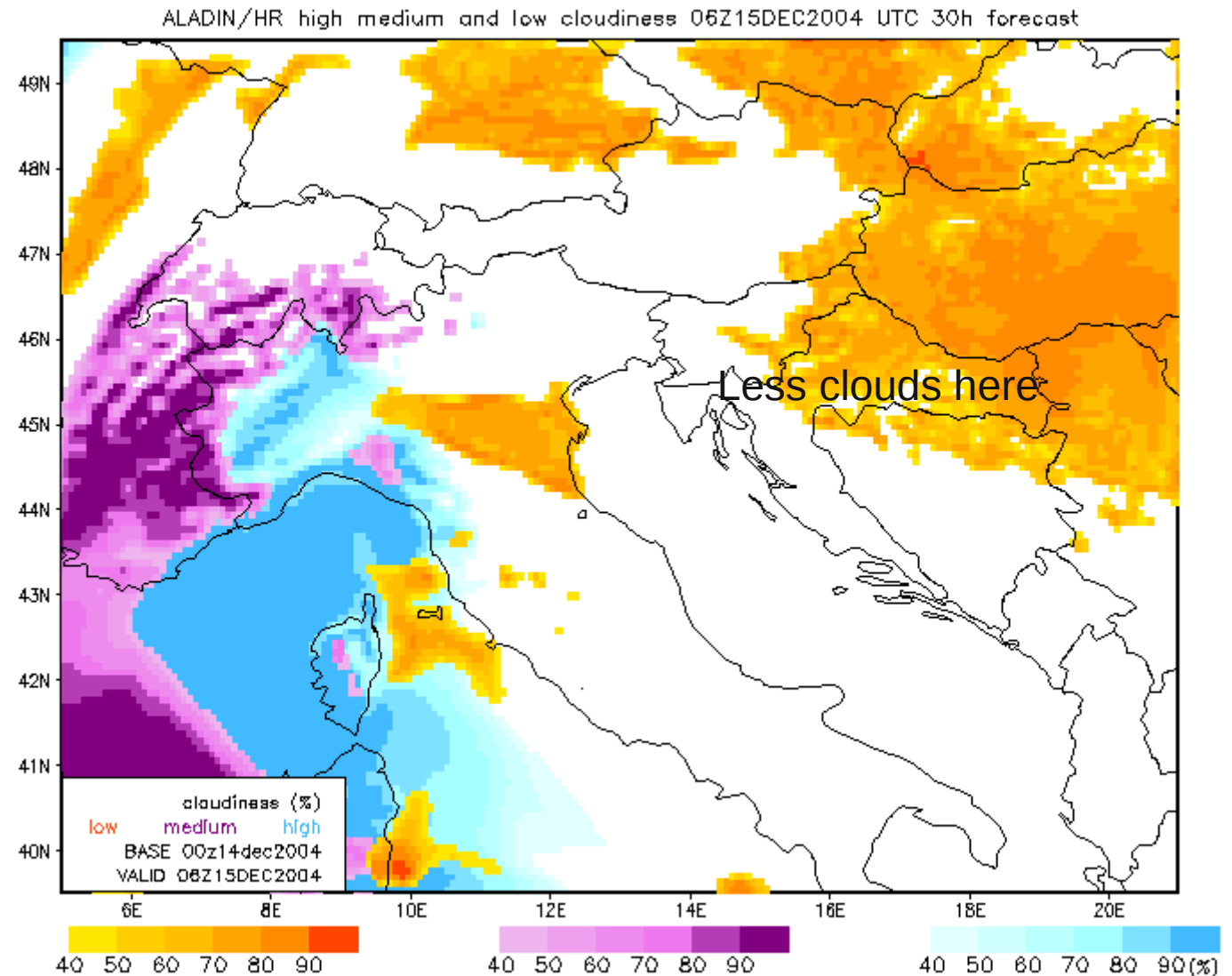
RG90 radiation scheme

- With
- old critical relative humidity profile,
- random overlap and
- Xu-Randall cloud diagnosing scheme



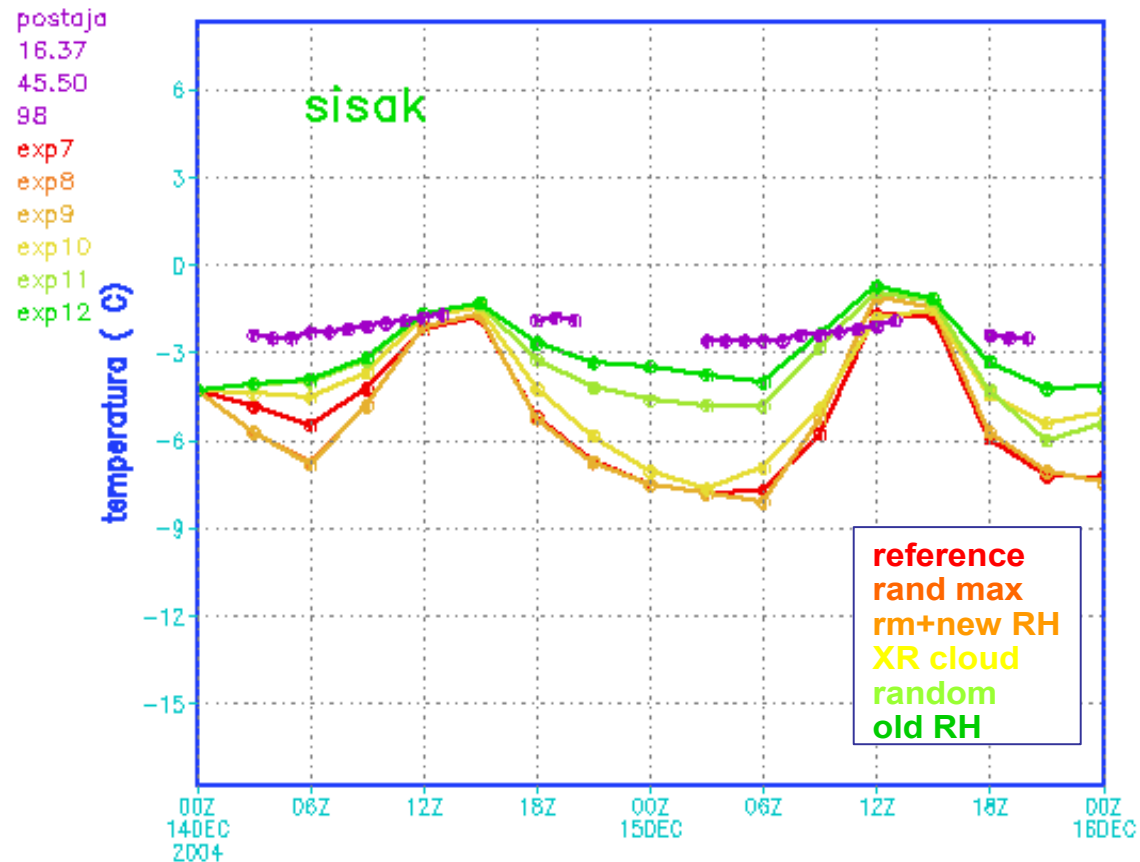
Net Exchange rate

- **RG90+NER** radiation
- Random overlap
- **Xu-Randall** cloud scheme
- No prog.
Cond no TKE
- Numerical horizontal diffusion



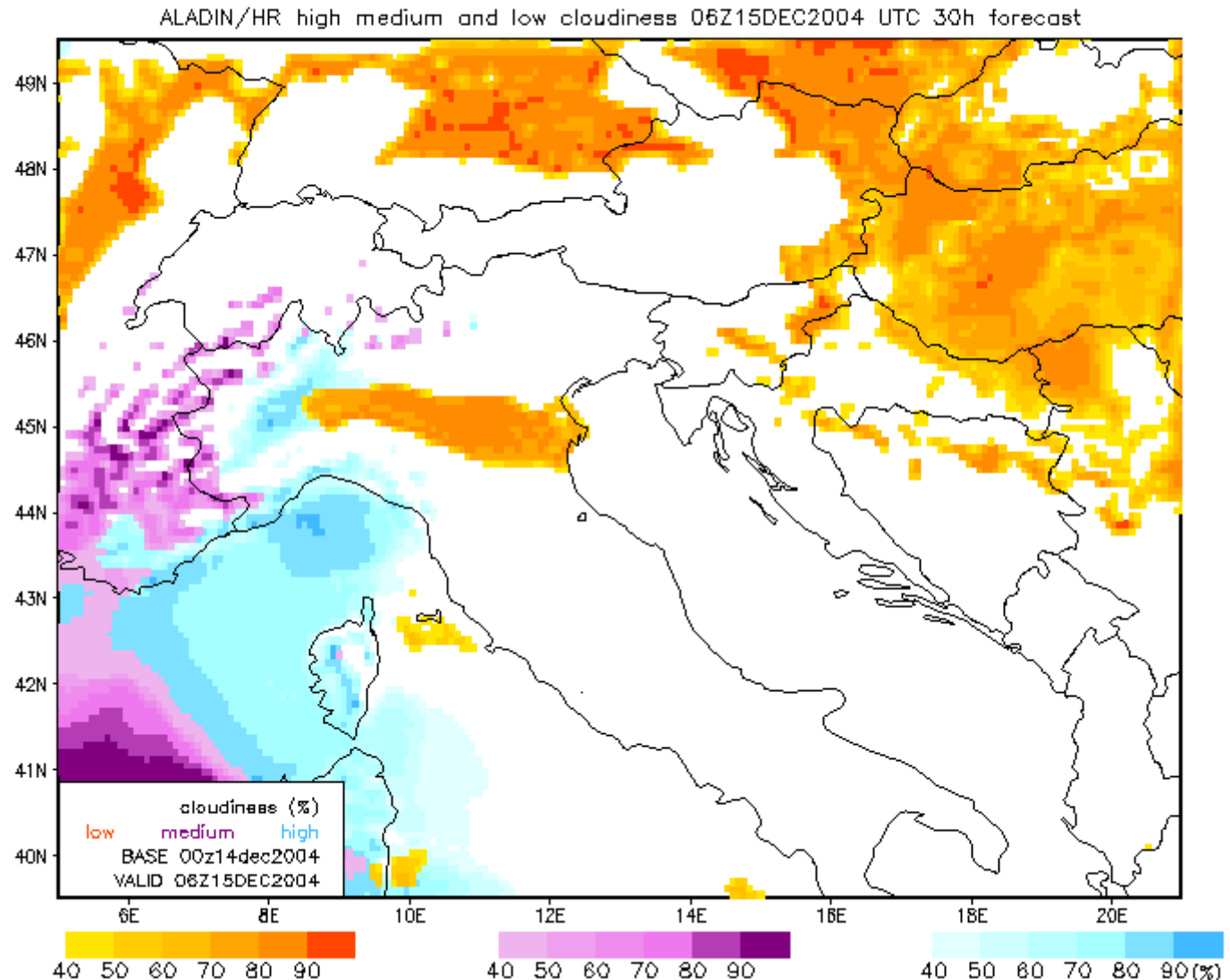
RG90 + NER

- With
- old critical relative humidity profile,
- random overlap and
- Xu-Randall cloud diagnosing scheme



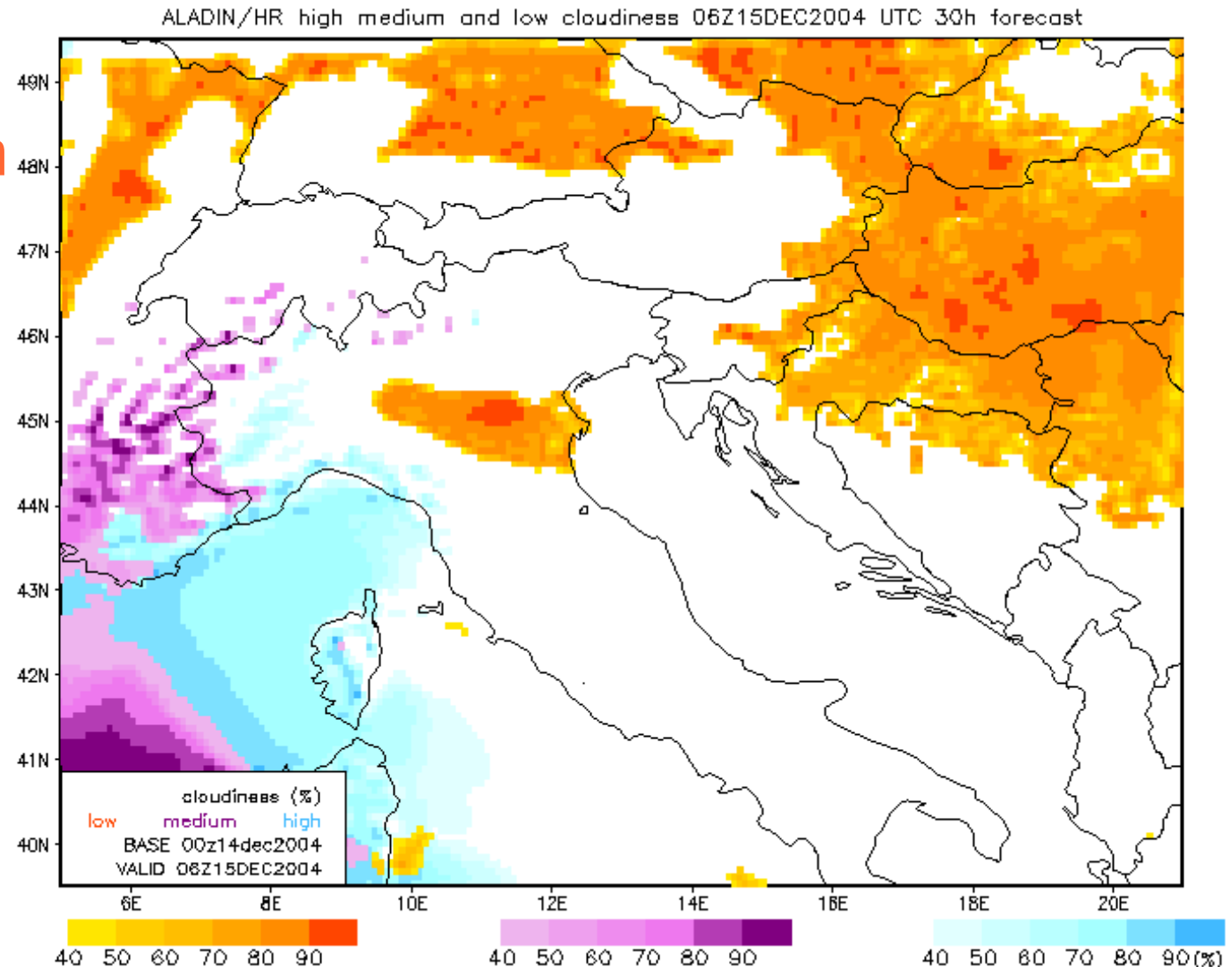
Morcrette (1989) 3 hourly

- FMR radiative transfer coefs computed with 3 hour interval
- Random overlap
- Xu-Randall cloud scheme
- No prog. Cond no TKE
- NHD



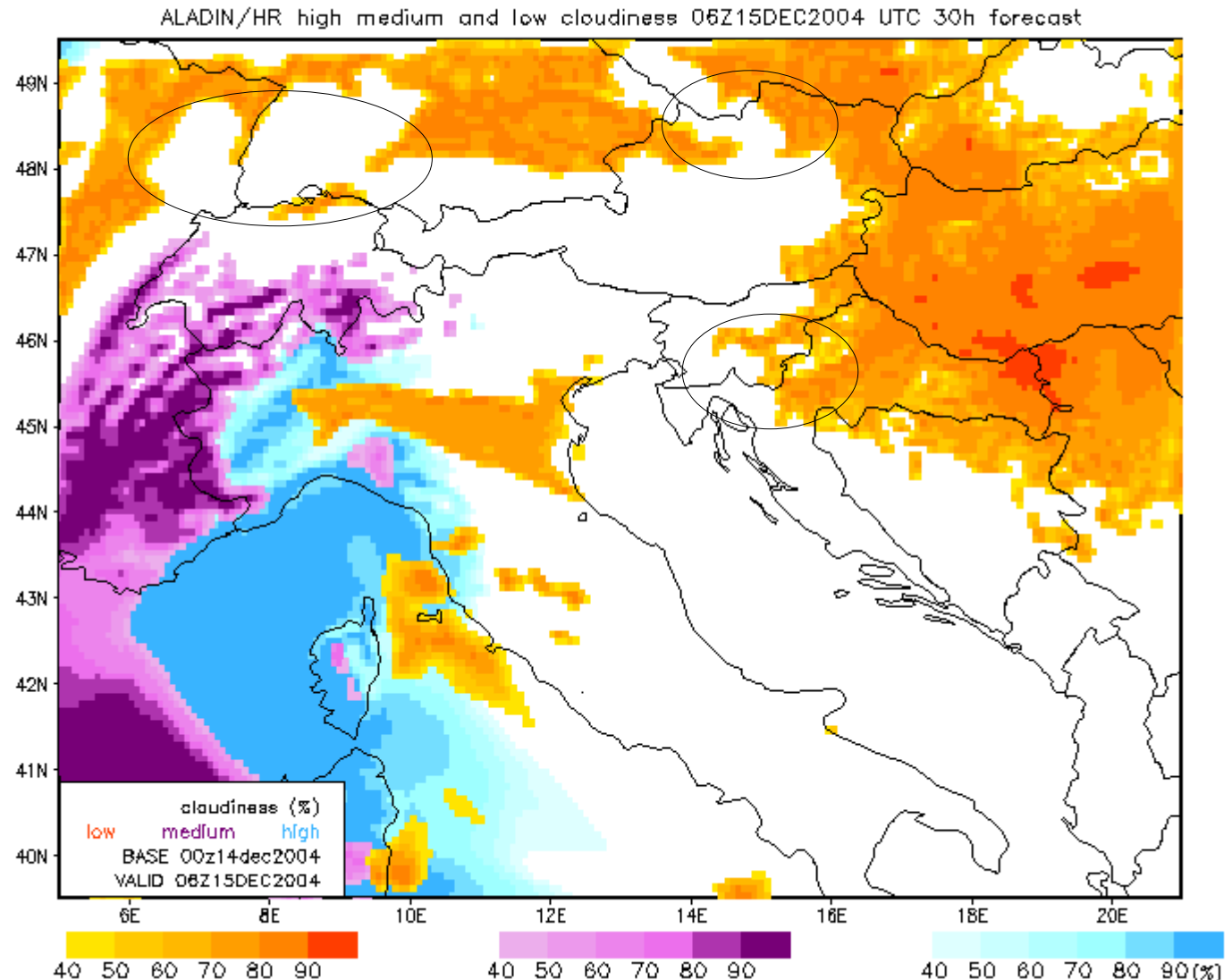
Morcrette (1989) 1 hourly

- FMR radiative transfer coefs computed with 3 hour interval
- Random overlap
- Xu-Randall cloud scheme
- No prog. Cond no TKE
- NHD



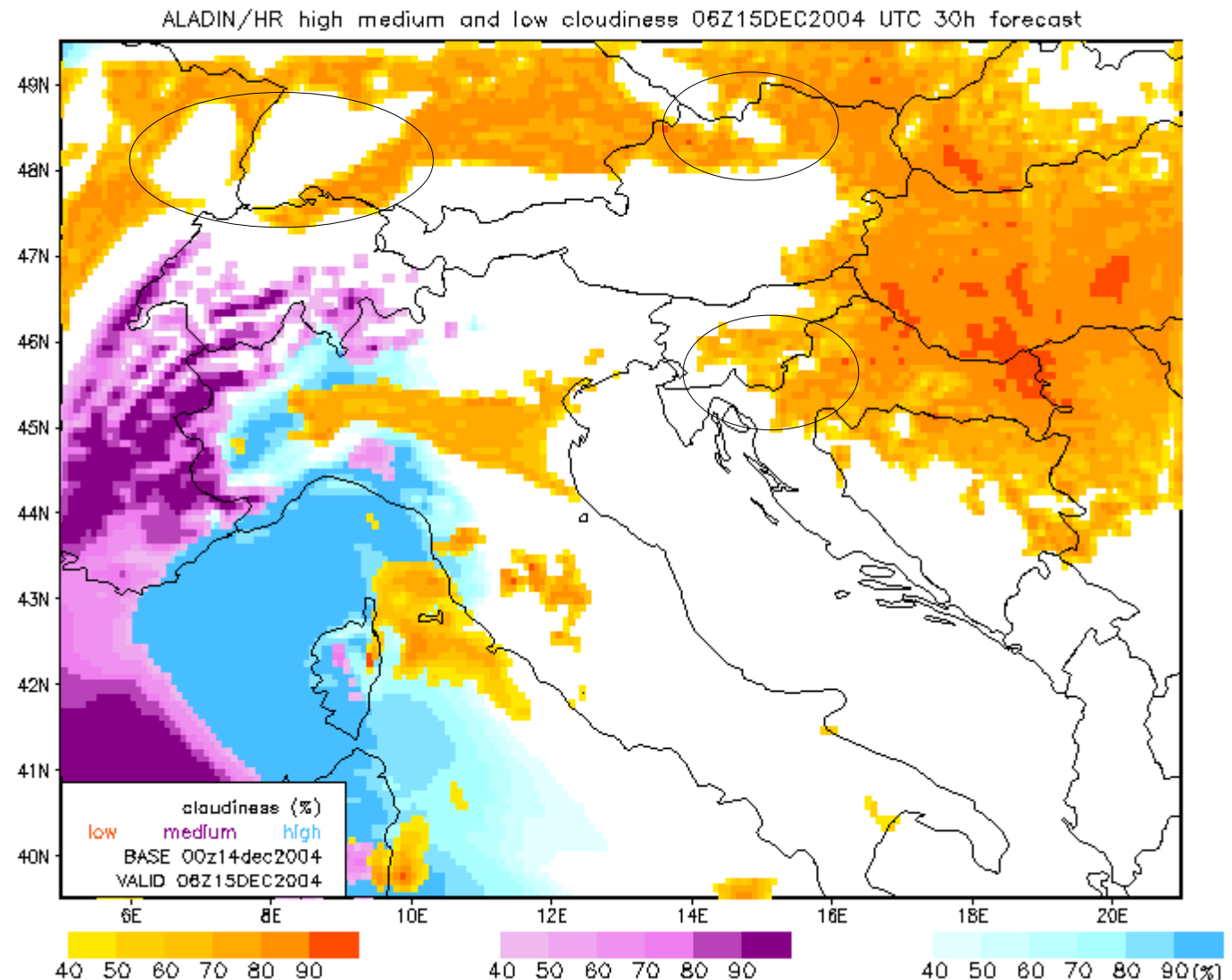
Return to random overlap

- RG90 radiation
- Random overlap
- Xu-Randall cloud scheme
- No prog. Cond no TKE
- Numerical horizontal diffusion

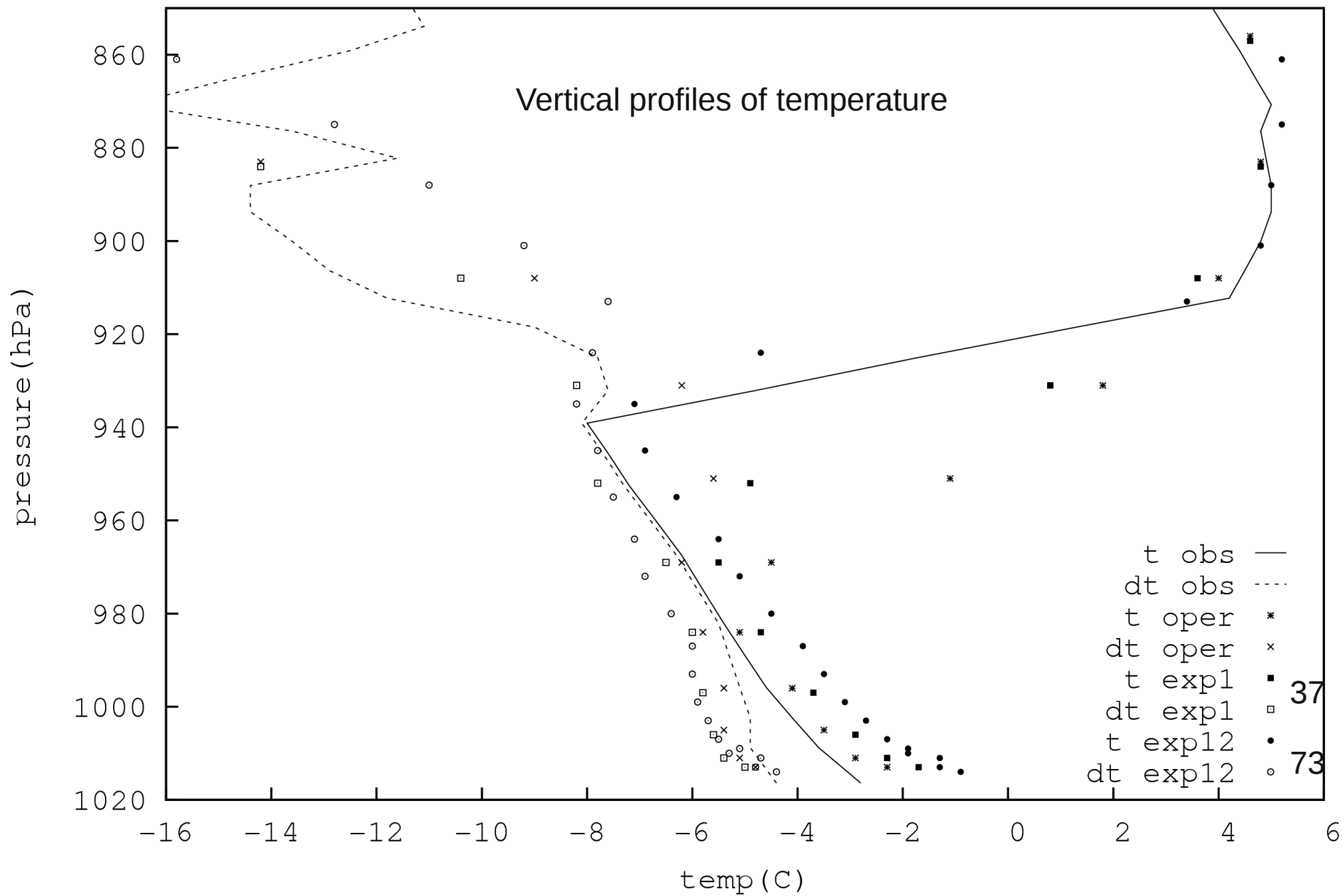


Semi-Lagrangian horizontal diffusion

- RG90 radiation
- Random overlap
- Xu-Randall cloud scheme
- No prog. Cond no TKE
- SLHD



Temperature and dewpoint 12 UTC 15th December 2004



Summary

- Cloud diagnosing schemes and overlap assumptions were more important than more sophisticated radiation schemes, introduction of prognostic microphysics and TKE.
- More realistic orography representation and more physical horizontal diffusion significantly improve the forecast of 2 m temperature and low clouds in areas with variable orography.



fog

