

# The difficult life of a cloud within NWP models

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With special thanks to Y. Seity,, F. Vana, S. Malardel, J.F. Geleyn,

Moist Processes in Future High Resolution  
NWP/Climate Models

SMHI, Norrköping, June 15-17 2009



**METEO FRANCE**  
Toujours un temps d'avance

## Outline

1. Clouds in NWP models: Which variables ? Cloud cover ? Is it resolution dependant ?
2. Clouds variable inside the time step, interactions between parametrization, example with AROME vs ALADIN/ARPEGE
3. Validation: 1D case BOMEX, ARM-Cumulus, etc ...
4. And after in 3D ?
5. Conclusion

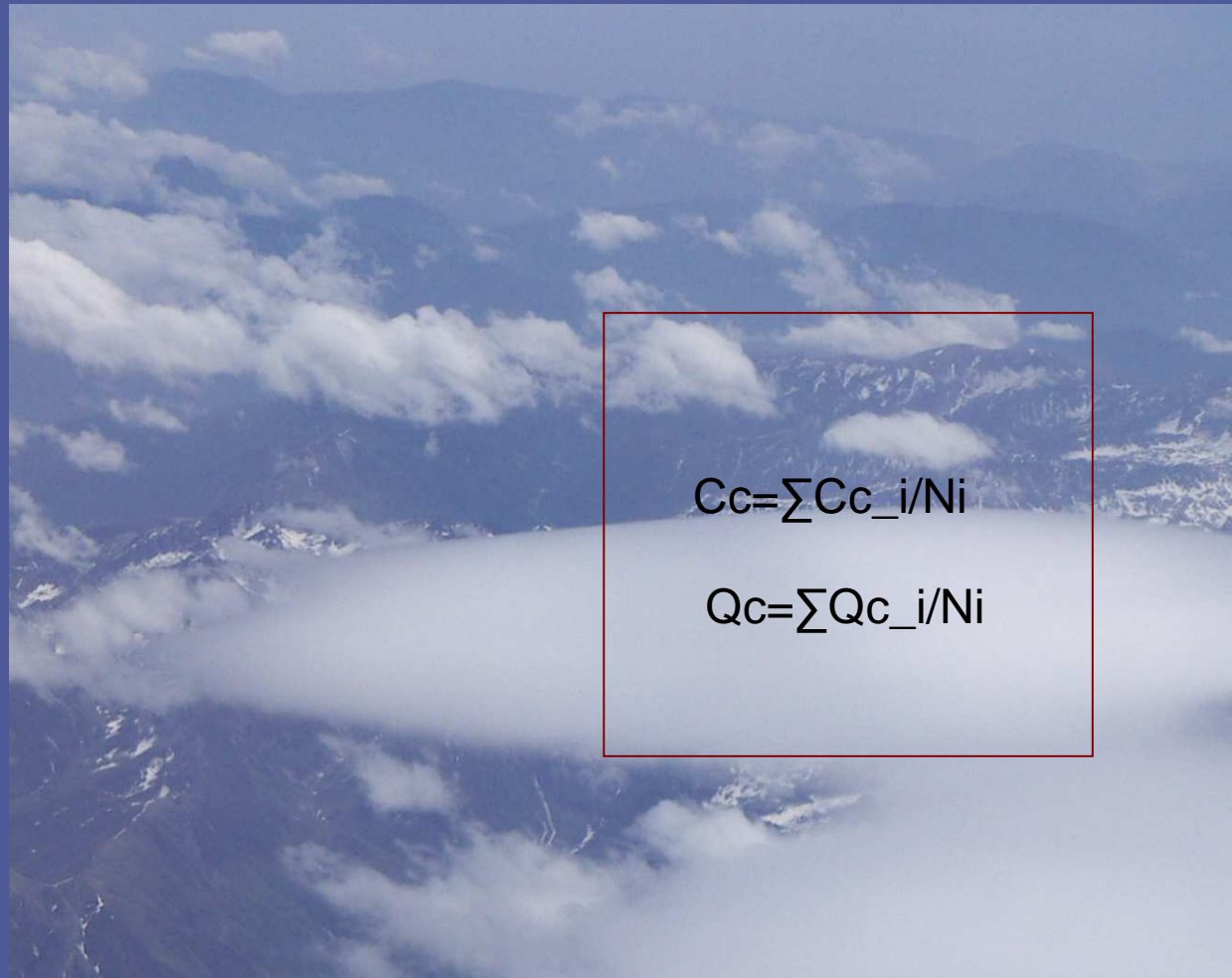
Which variables ?  
Cloud cover, cloud water, ice, mass flux.....

$$Q_{c\_incloud} = Q_c / C_c$$

$Q_c = x1$ $C_c = 0.3$	$Q_c = x2$ $C_c = 0.2$
$Q_c = x3$ $C_c = 1$	$Q_c = x3$ $C_c = 1$

$C_c \rightarrow 1$  or  $0$  for high resolution

Which variables ?  
Cloud cover, cloud water, ice ...



$$C_c = \sum C_{c\_i} / N_i$$

$$Q_c = \sum Q_{c\_i} / N_i$$

Is it true in our models ?

## AROME

$Q_c$

Adjustment

$Q_c, C_c$

Radiation

Surface

Shal. Convection

$P_{th\_tke\_shal}$

Turb. TKE

Micro-Physics

$Q_{c\_shal}$   
 $C_{c\_shal}$

## ARP/ALD

$Q_c$

Shal. Convection

$P_{th\_tke\_shal}$

Turb. TKE

$Q_{c\_shal}$   
 $C_{c\_shal}$

Adjustment

$Q_{c\_tot} = Q_c (pdf + shal + deep)$

Radiation

Surface

$Q_c = Q_c (pdf + Shal)$

Deep Conv.

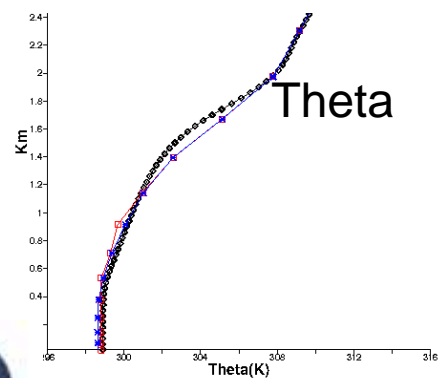
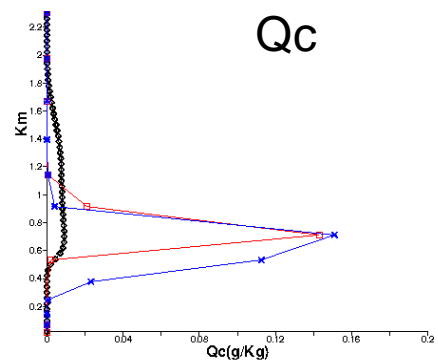
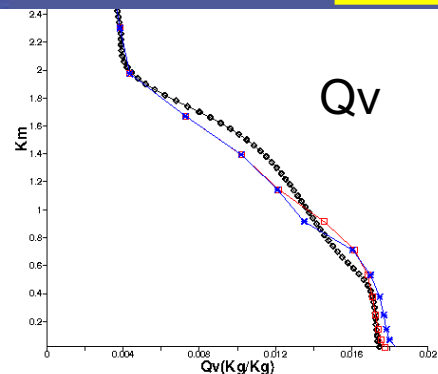
Micro-Physics

$Q_{c\_deep}$

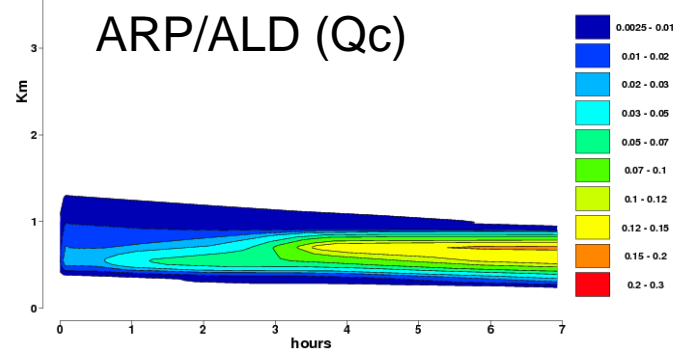
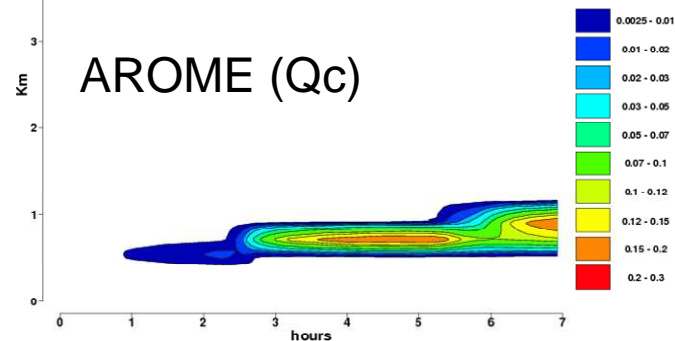


**METEO FRANCE**  
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# BOMEX : AROME and ARP/ALD without shallow convection scheme



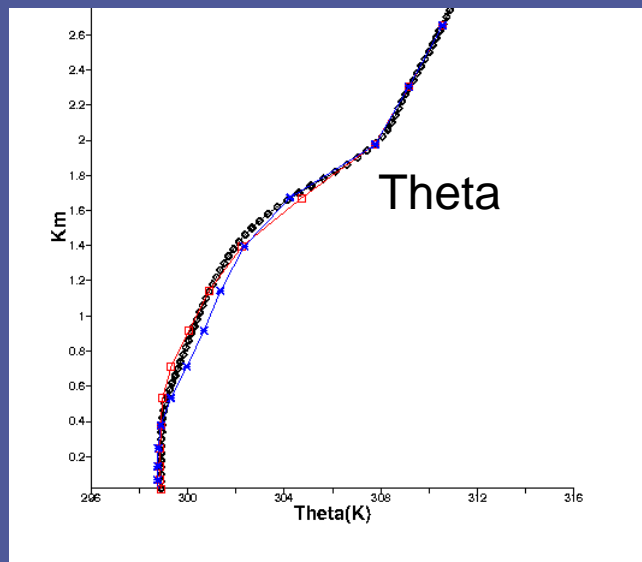
Black=LES  
Blue =AROME  
Red=ARP/ALD



Main difference between ALADIN and AROME is the PDF function for clouds

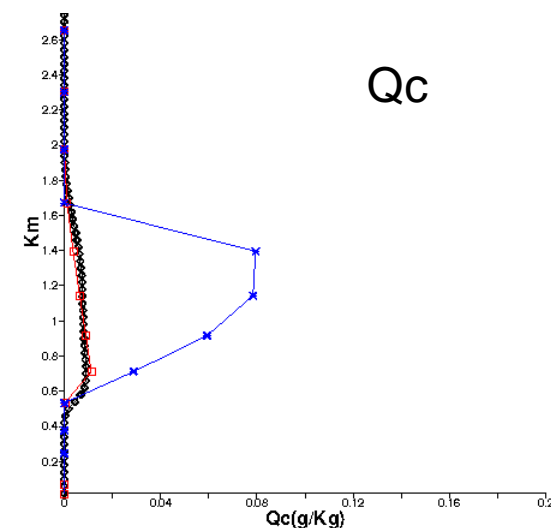
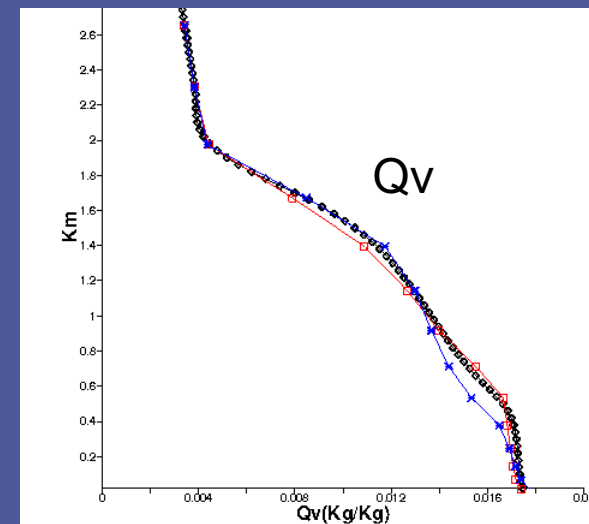
# BOMEX :

AROME (60s) with EDKF Pergaud et al submitted  
ALADIN/ARPEGE (300s) with KFB (Bechtold et al.2001)



Black=LES  
Red =AROME  
Blue=ARP/ALD

AROME with EDKF → good agreement with LES  
ARP/ALD with KFB → QI is overestimated due to some tunings necessary in the tropics !



NCE

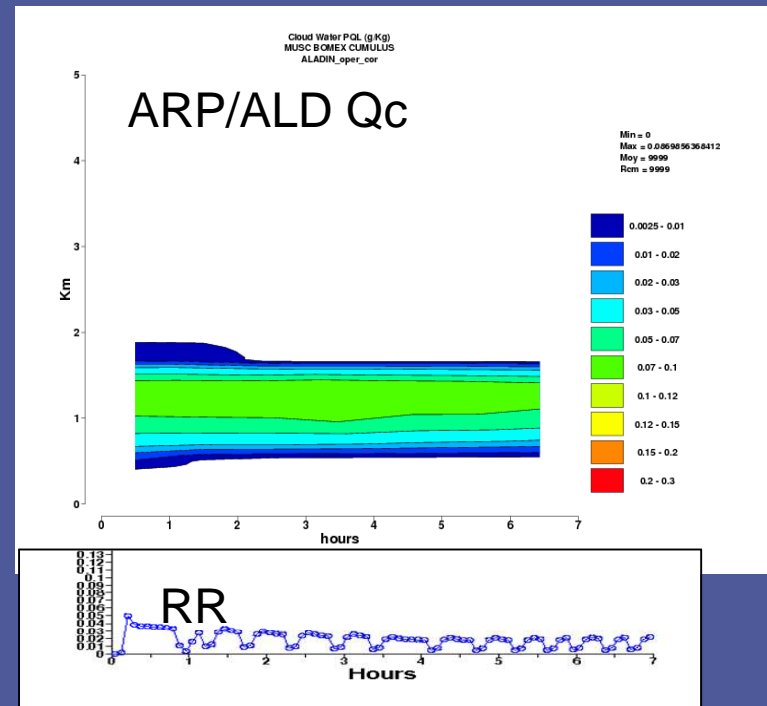
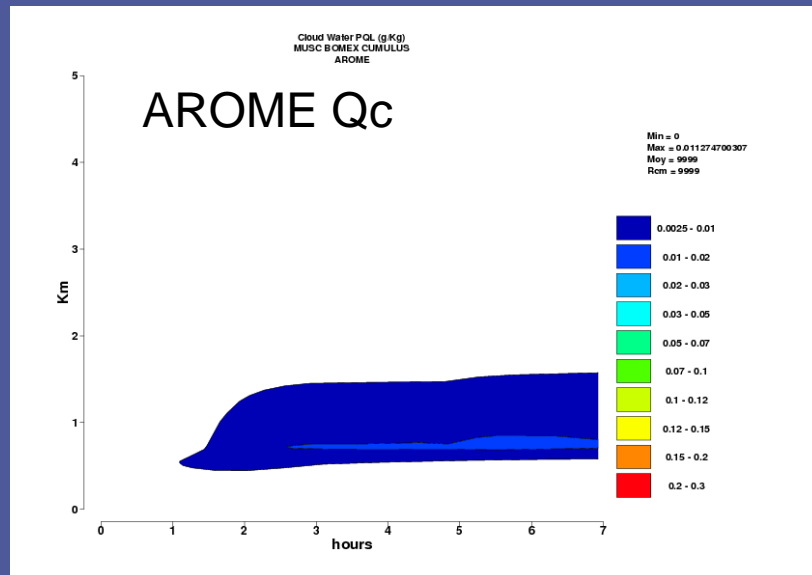
toujours un temps d'avance





# BOMEX

AROME with EDKF Pergaud et al submitted  
ALADIN/ARPEGE with KFB (Bechtold et al.2001)



Threshold for autoconversion in ARP/ALD is probably too small for cumulus and too much Qc\_shall so ...



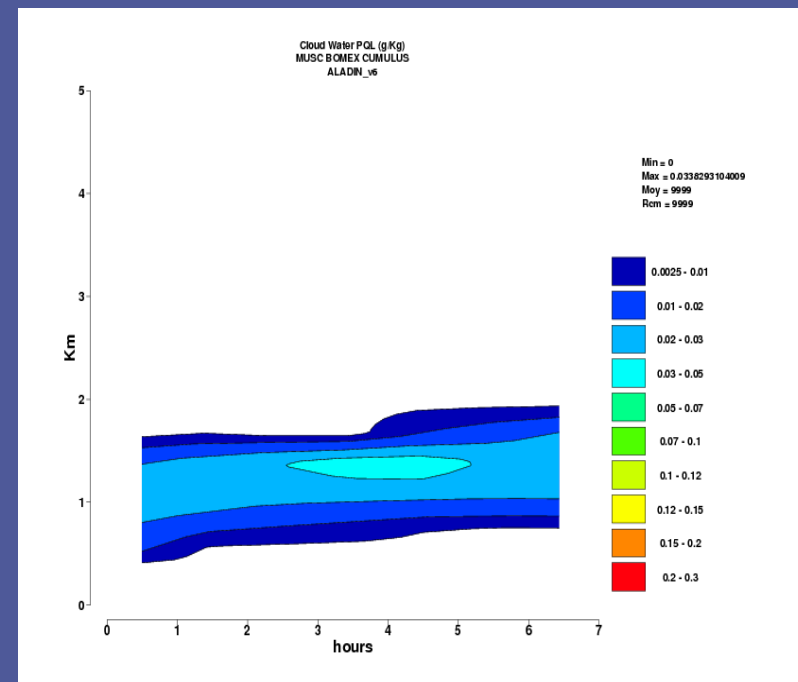
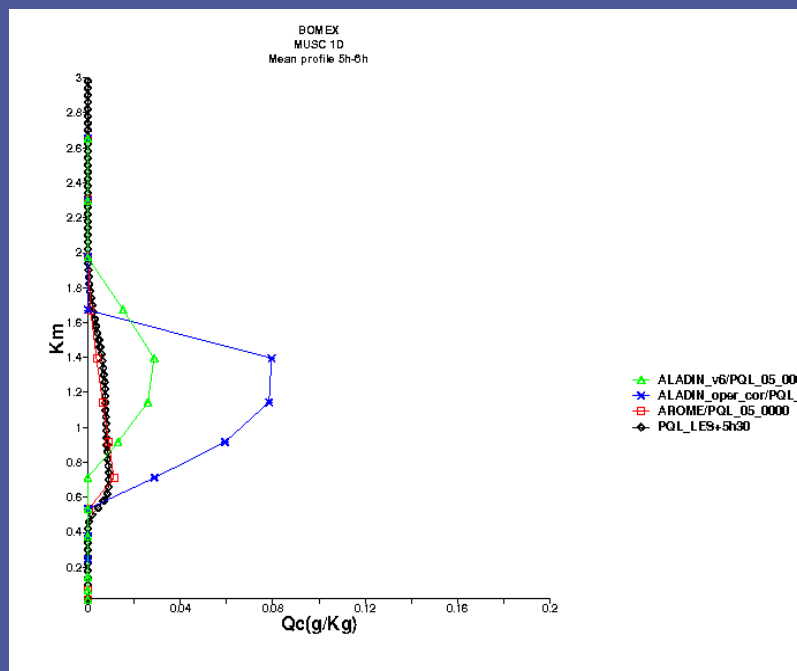
# BOMEX

## ARP/ALD with shallow convection scheme

With less  $qc_{\text{shall}}$  and for autoconversion  
two threshold :

$2E-4$  for  $qc_{\text{pdf}}$

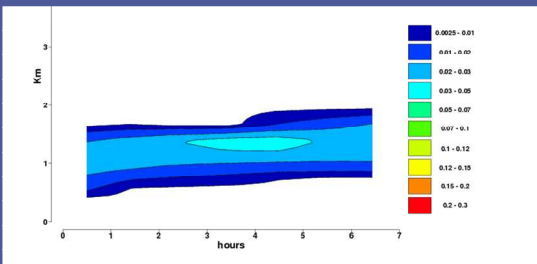
$4E-4$  for  $qc_{\text{shal}}$  (similar to AROME value)



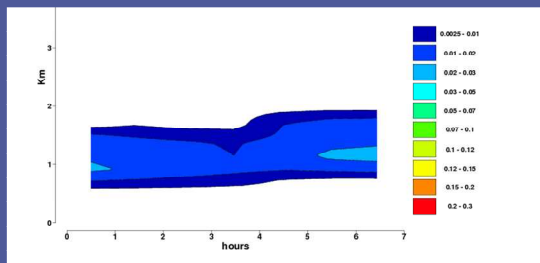
# Cloud water BOMEX

ARP/ALD

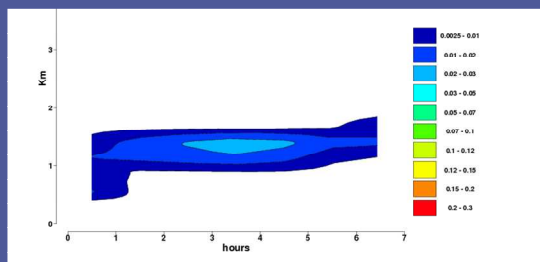
Qc\_pro



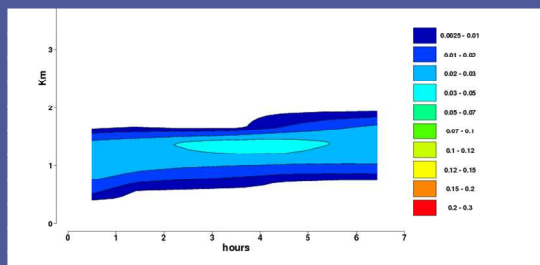
Qc\_shal



Qc\_pdf

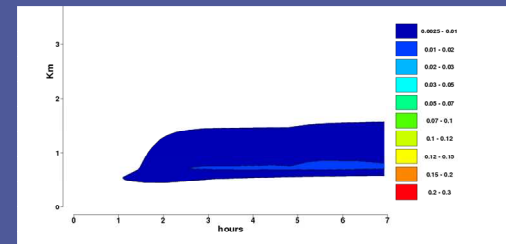


Qc\_Rad

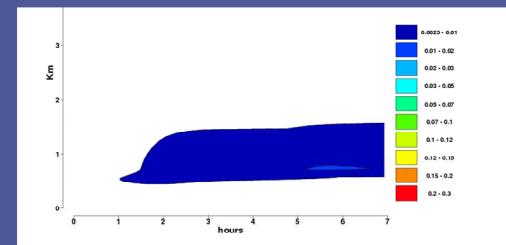


AROME(oper)

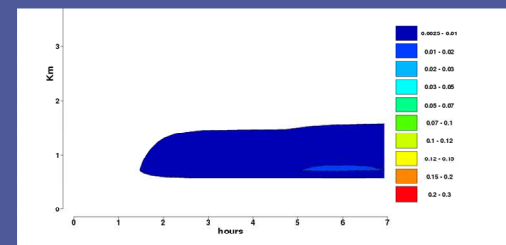
Qc\_pro



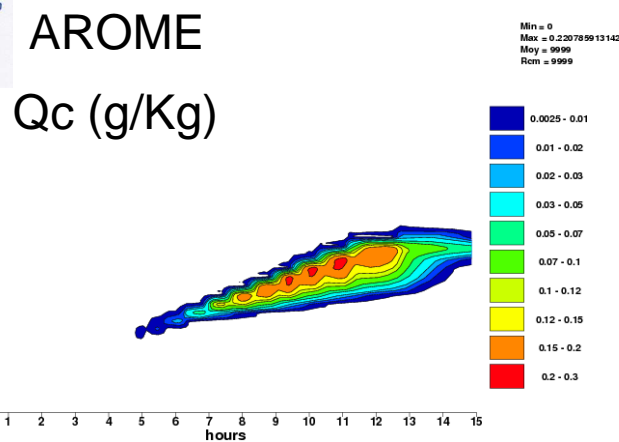
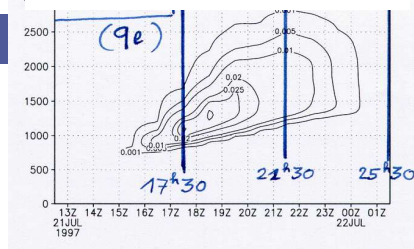
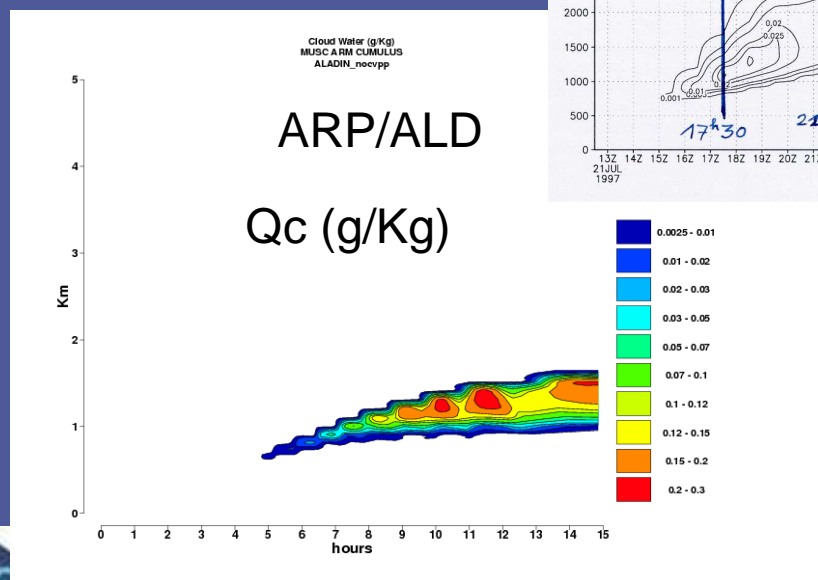
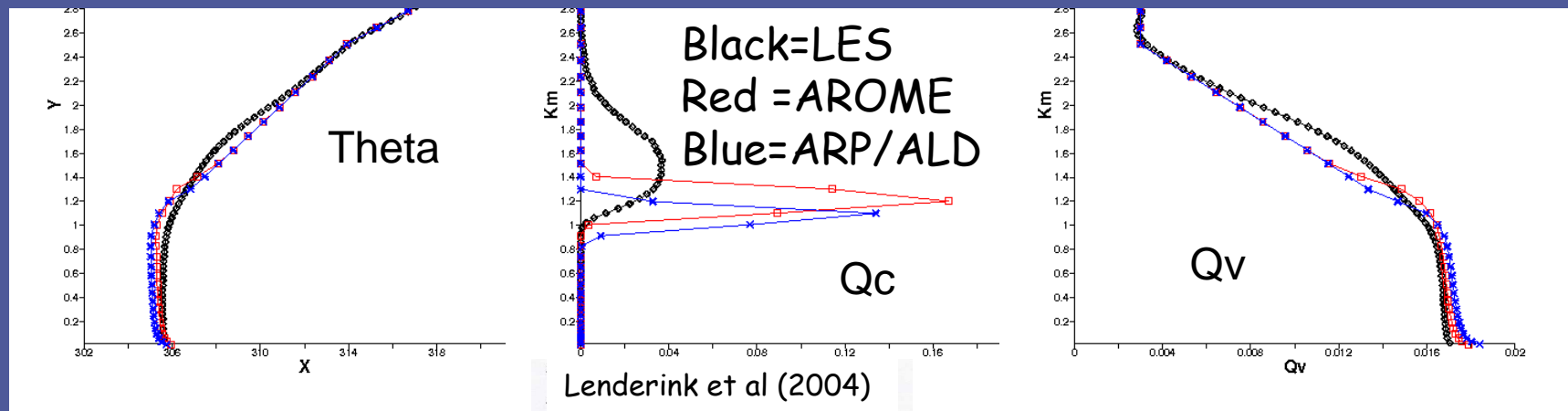
Qc\_Rad



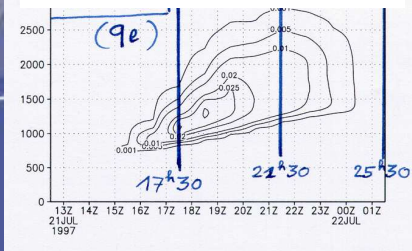
Qc\_shal



# EUROCS / ARMCU AROME and ARP/ALD without shallow convection

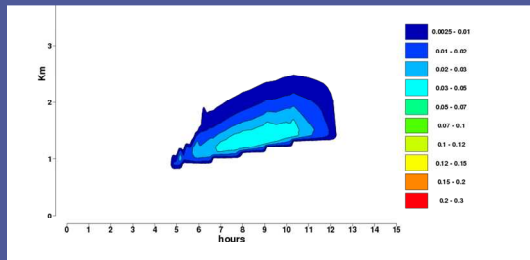


Lenderink et al (2004)

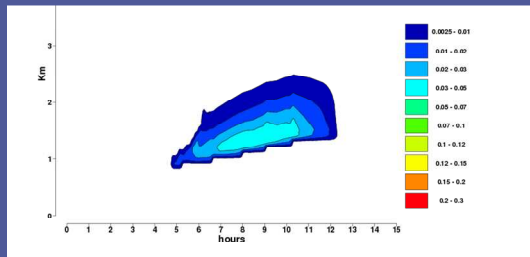


AROME with EDKF

Qc\_shal



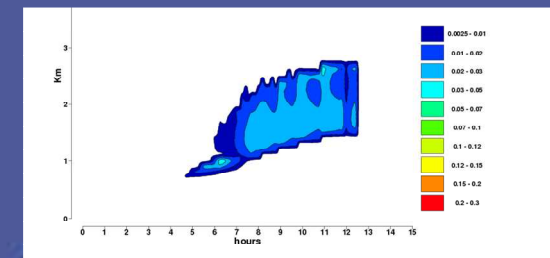
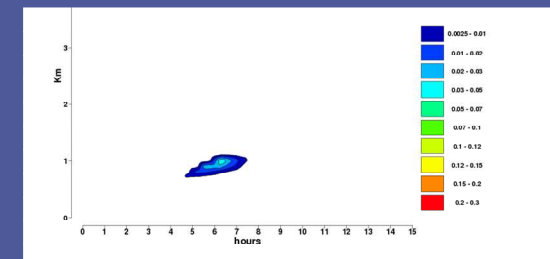
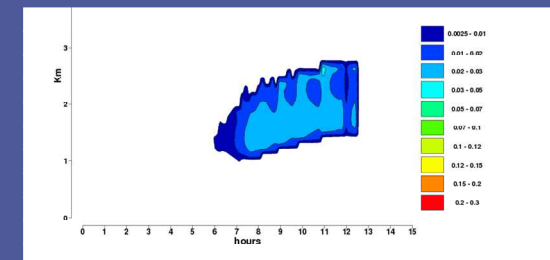
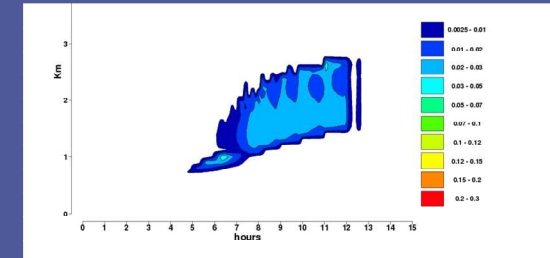
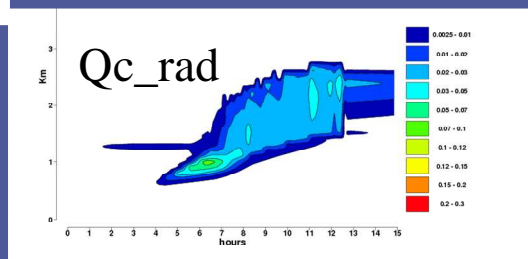
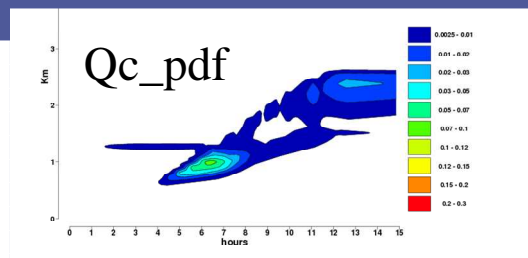
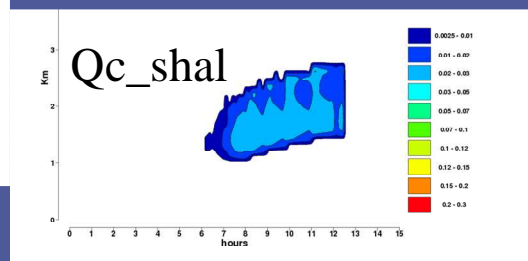
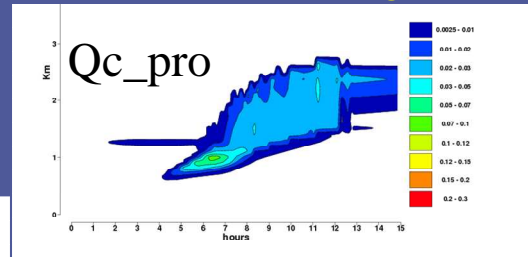
Qc\_Rad



EUROCS/ARMCU

ARP/ALD modified from  
BOMEX tunings

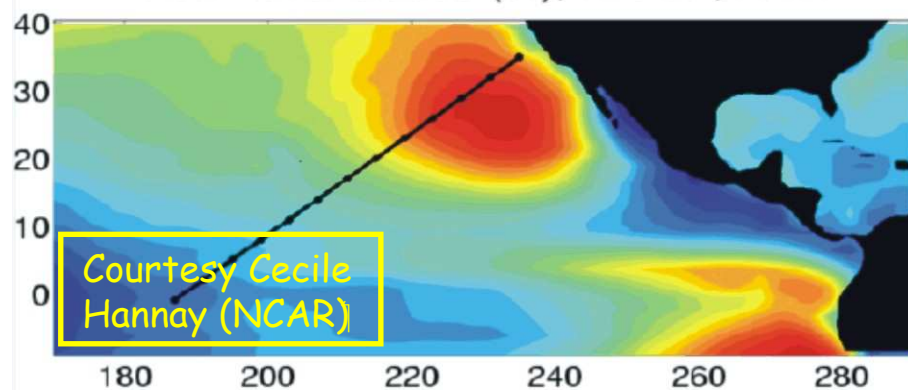
= + pdf modified via Hucr



# GPCI : Gewex Pacific Cross-section Intercomparison

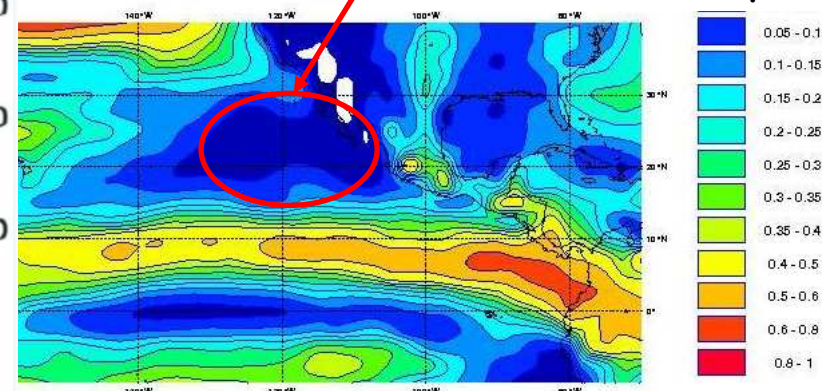
Less than 10%

Low-level clouds (%), ISCCP, ANN

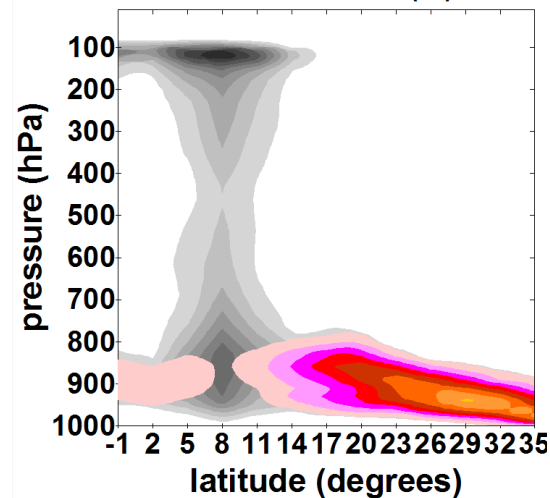


ARPEGE oper LOW-LEVEL CLOUD

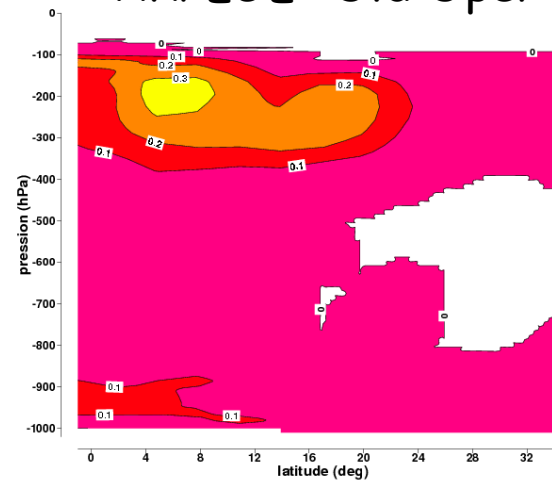
ARPEGE -Old Oper



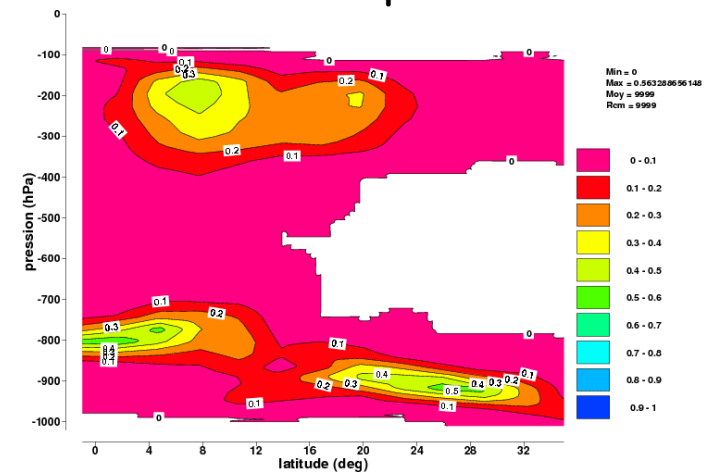
ERA-40  
cloud cover (%)



ARPEGE -Old Oper



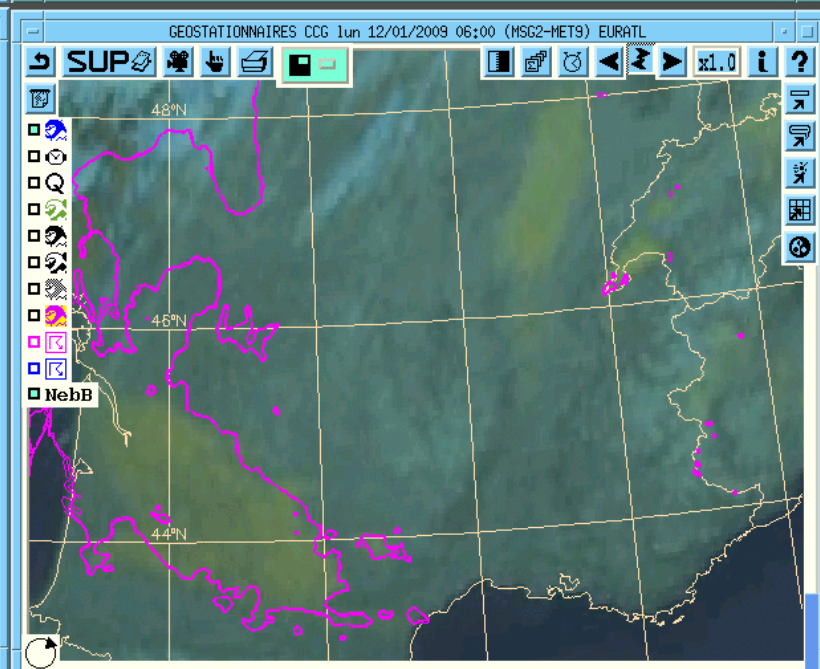
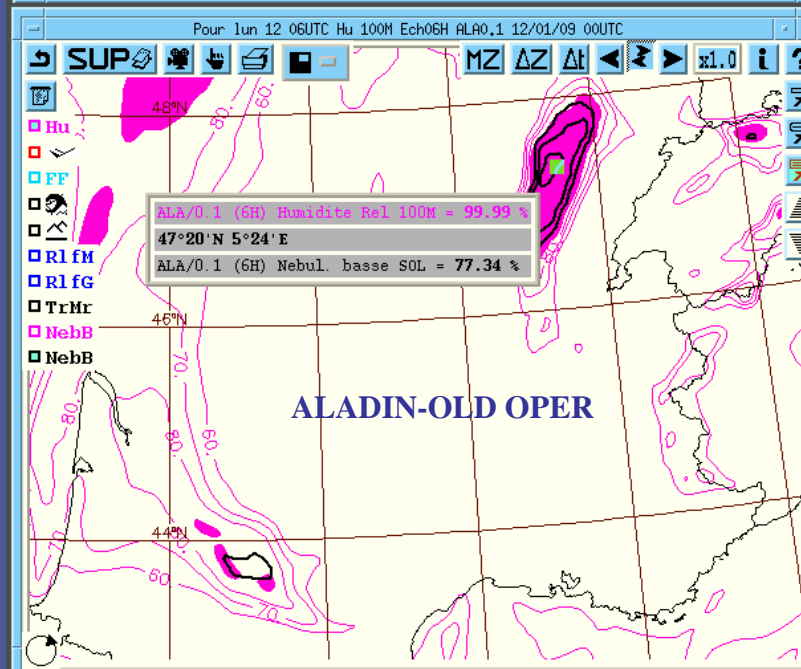
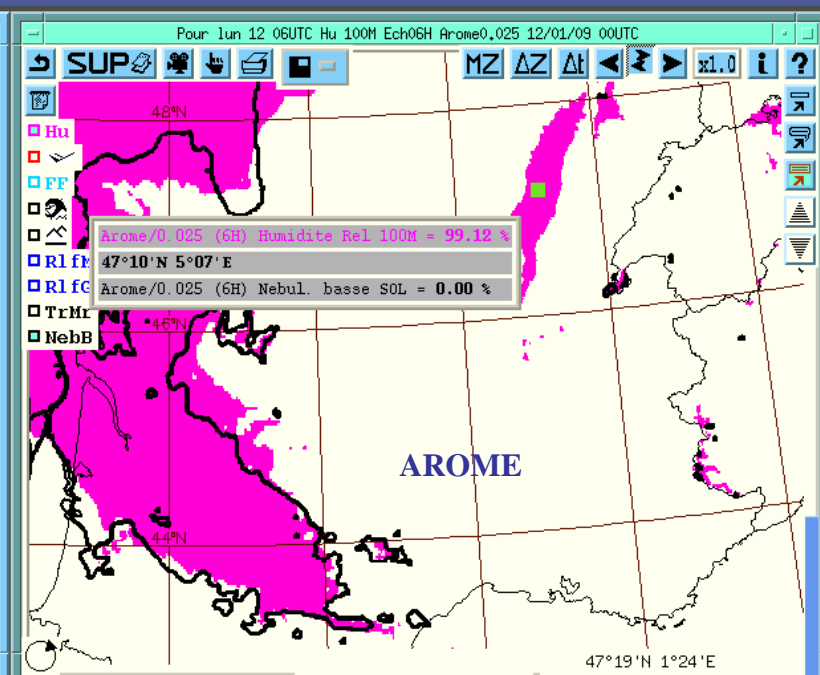
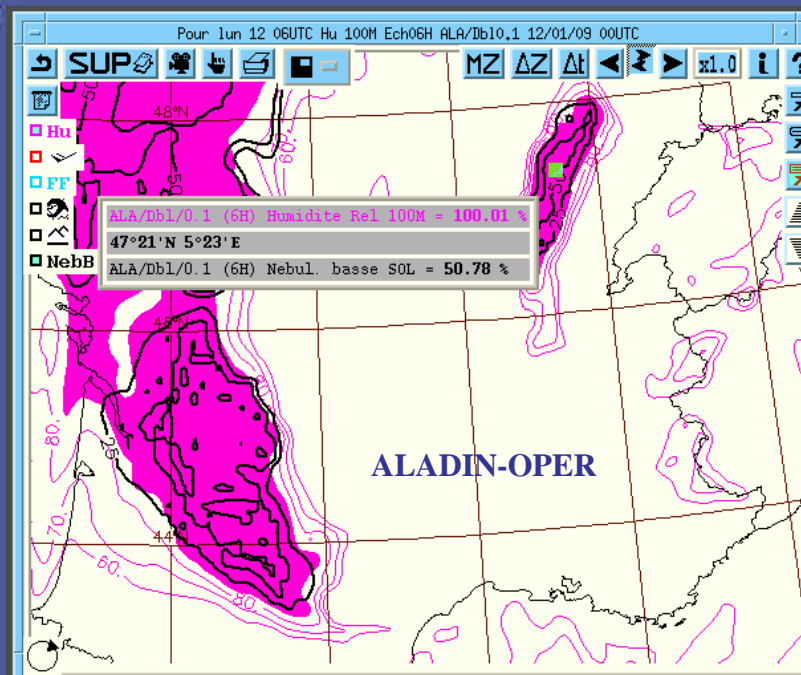
ARPEGE -Oper





# Fog over south west 12/01/2009

Hu=pink  
at 100m  
Black  
line=cloud  
cover



# Models at 2.5Km

AROME= 4 versions :

- with SLHD on qc,qi,qr,qs,qg = 62UY
- without SLHD = 63AB
- with SLHD only on ql,qi = 63BA
- with SLHD on T,qv,ql,qi = 63BL

ALADIN= (without deep convection) 2 versions :

- no SLHD = 73WK
- SLHD only on Ql,Qi,Qr,Qs = 73X4

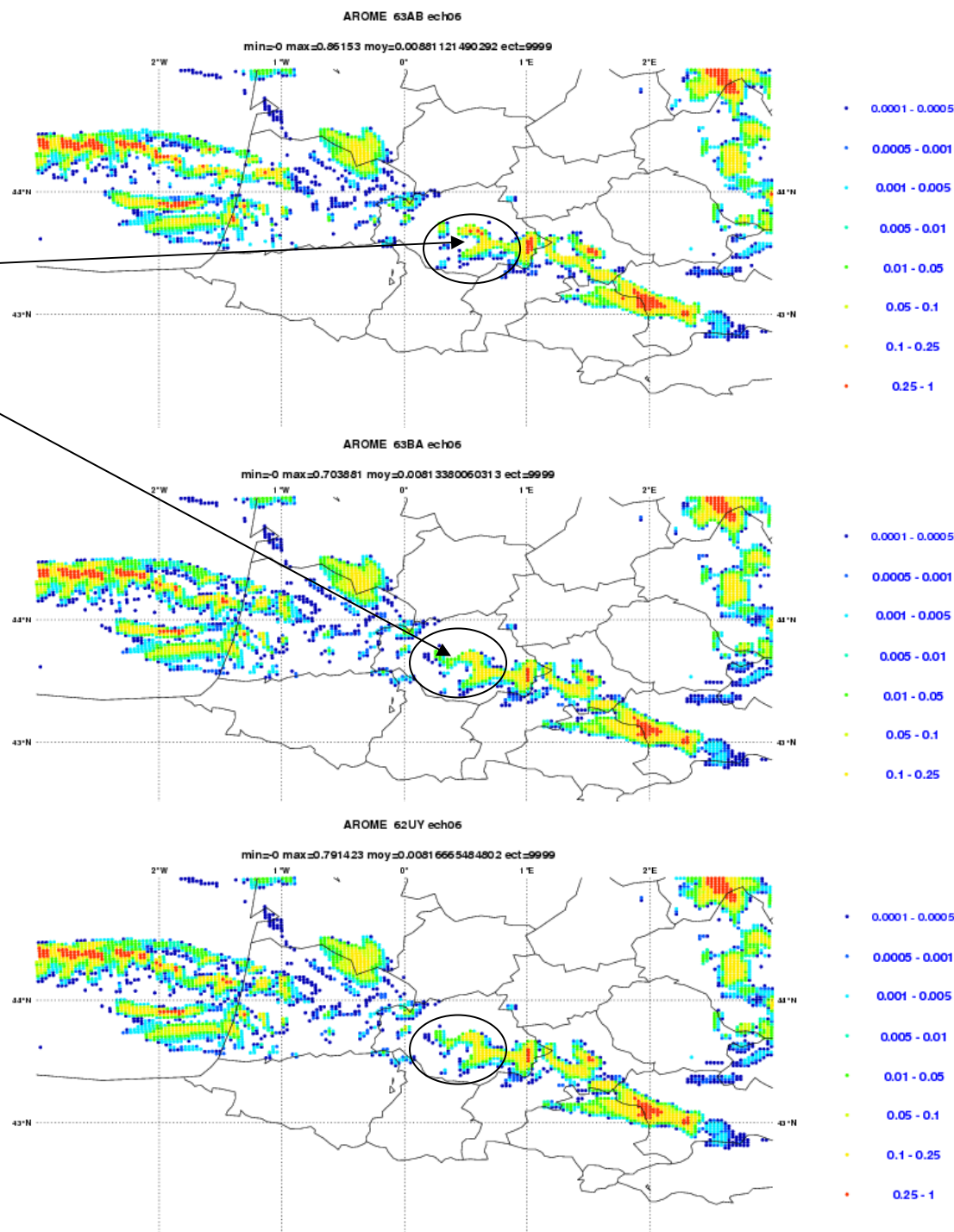
ALARO-0 physics = 2 versions

- with 3MT and no SLHD = 73XH
- with 3MT and SLHD on T,Qv,Ql,Qi = 747D



$Q_c > 0.25 \text{g/Kg}$   
 $\text{BOMEX} = 0.05 \text{g/kg}$   
 $Q_c \leq 0.15 \text{g/Kg}$

AROME  
 Qc Level 35



No SLHD

SLHD  
 qc,qi

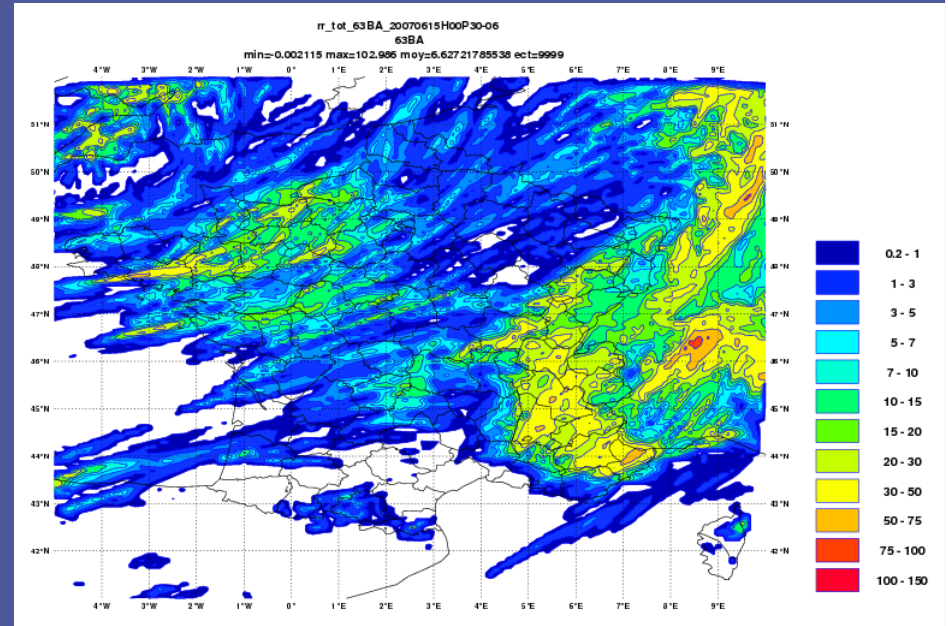
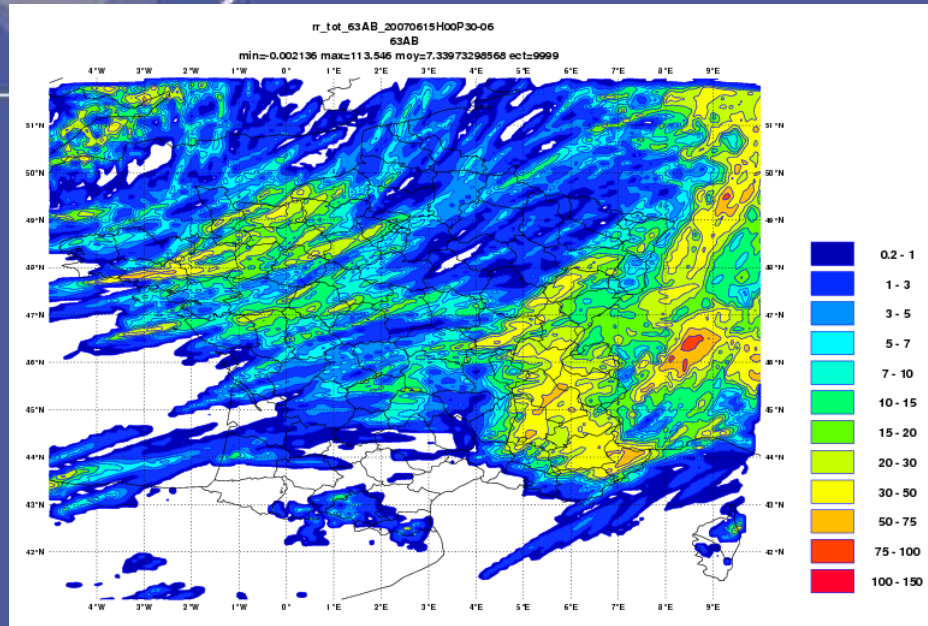
SLHD  
 qc,qi,q<sub>r</sub>,  
 q<sub>s</sub>,q<sub>g</sub>

**EO FRANCE**  
 un temps d'avance

AROME no SLHD

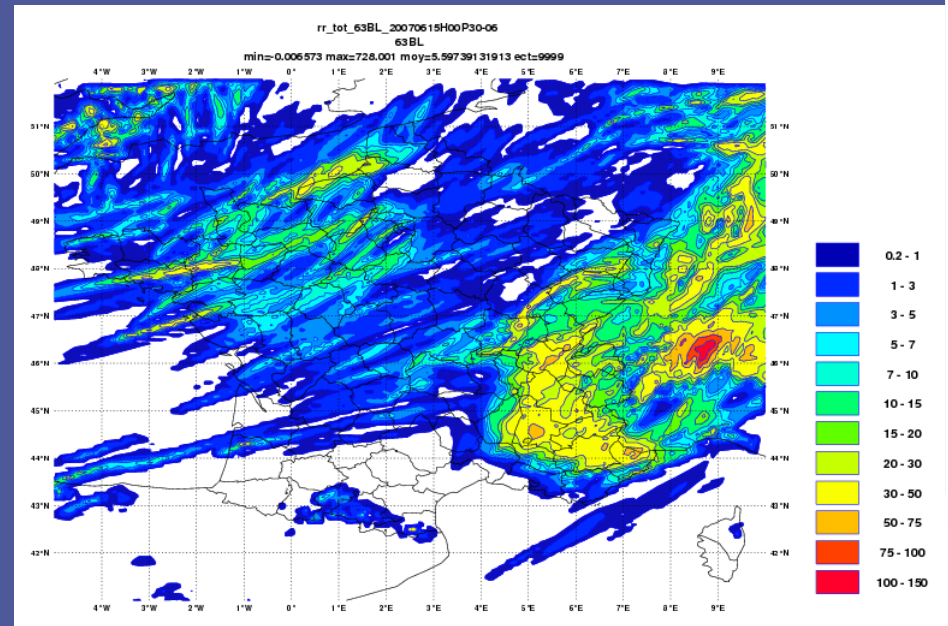
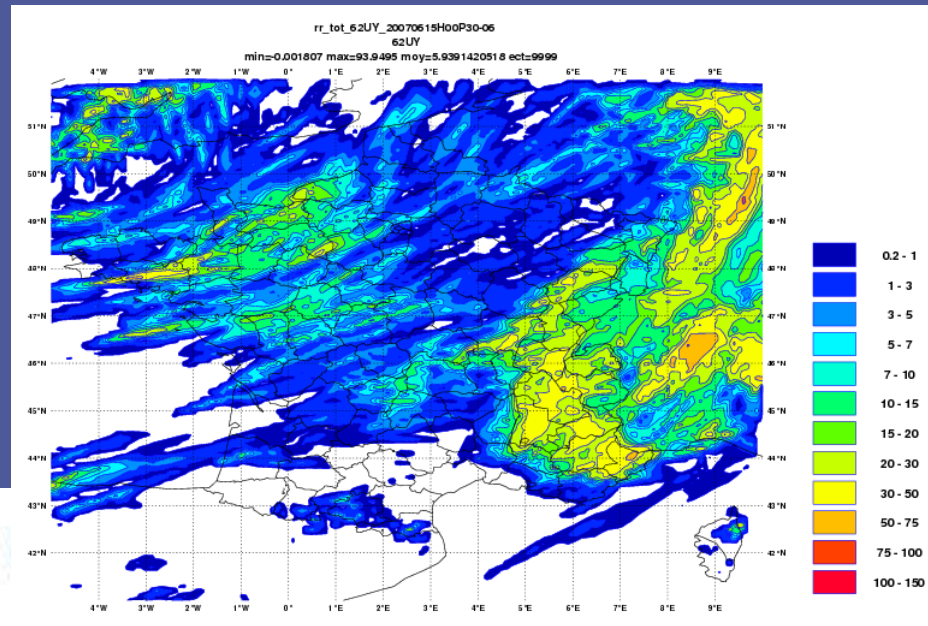
24h precipitation

AROME SLHD on ql,ql



AROME SLHD 5hyd

AROME SLHD T,qv,ql,qi

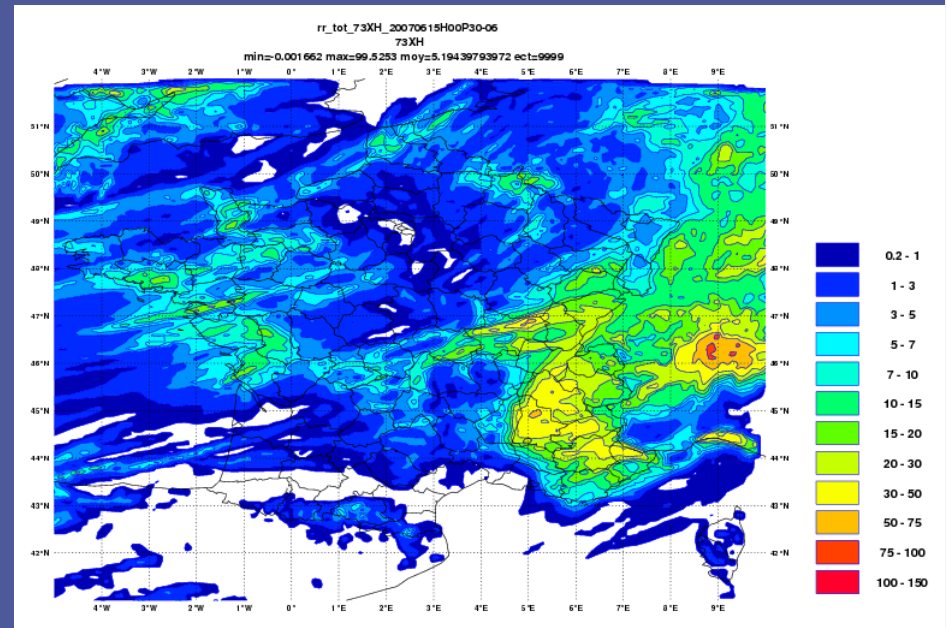
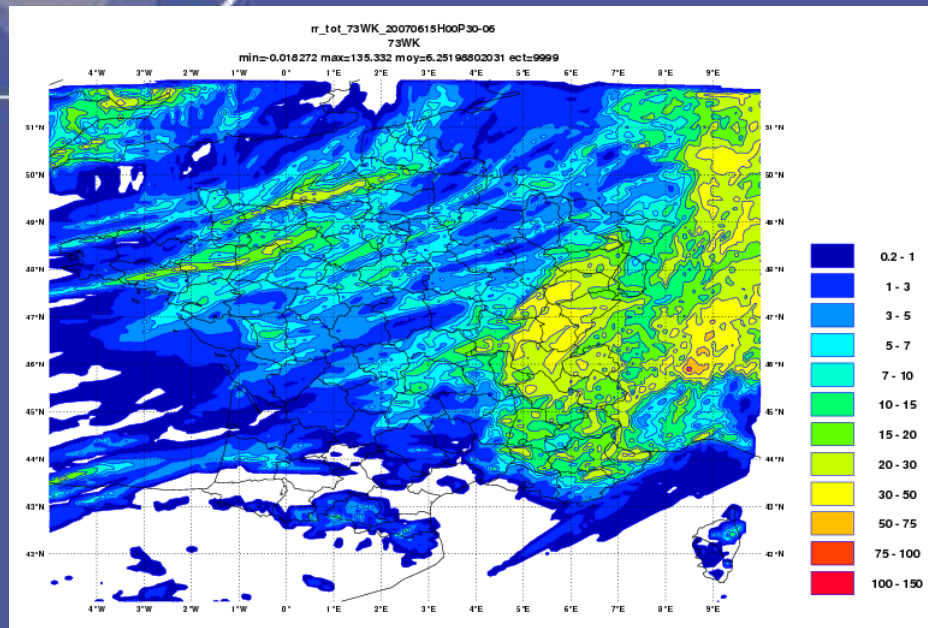




ALD phys. 2.5km no SLHD

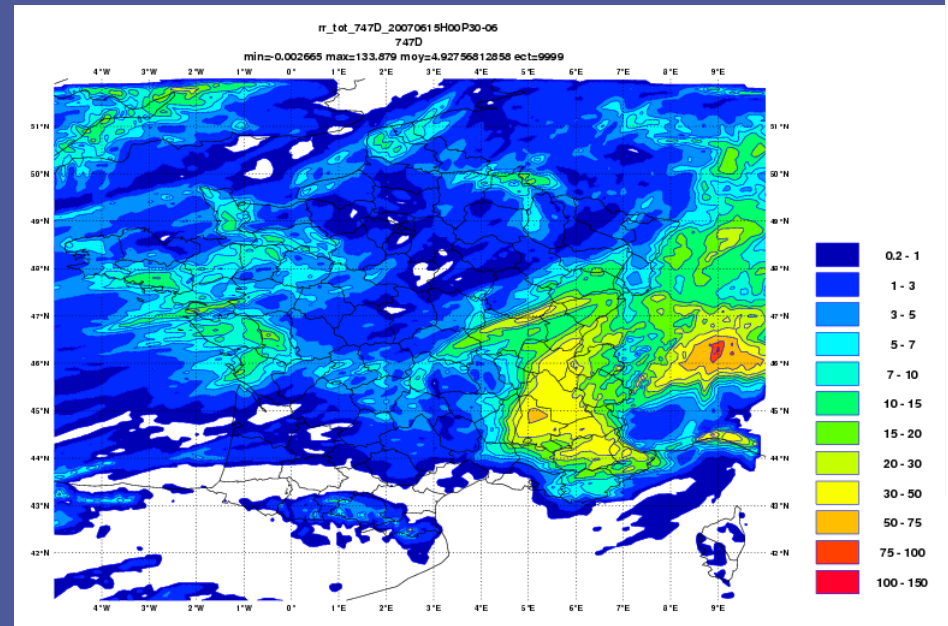
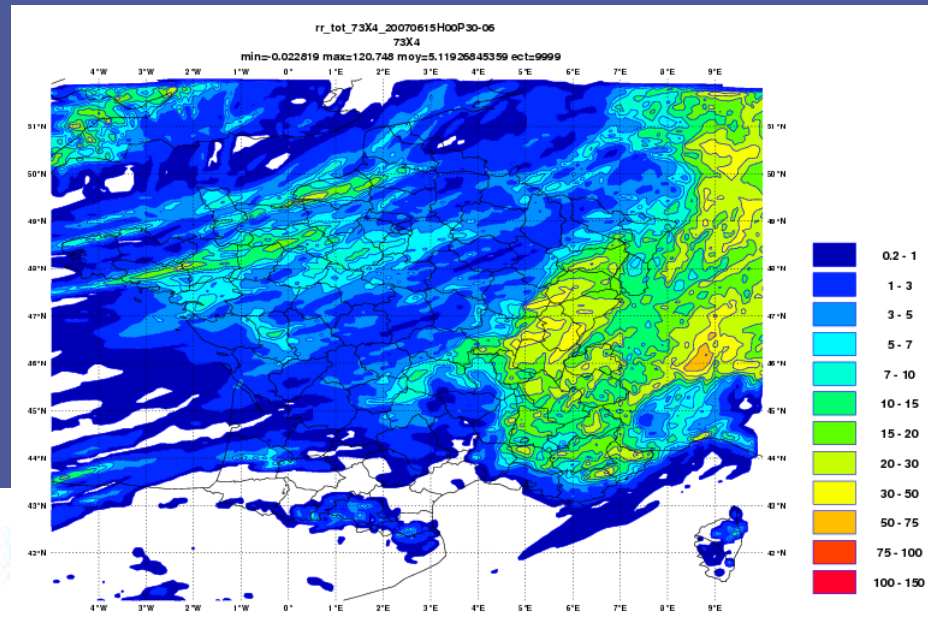
24h precipitation

ALARO phys. 2.5Km no SLHD

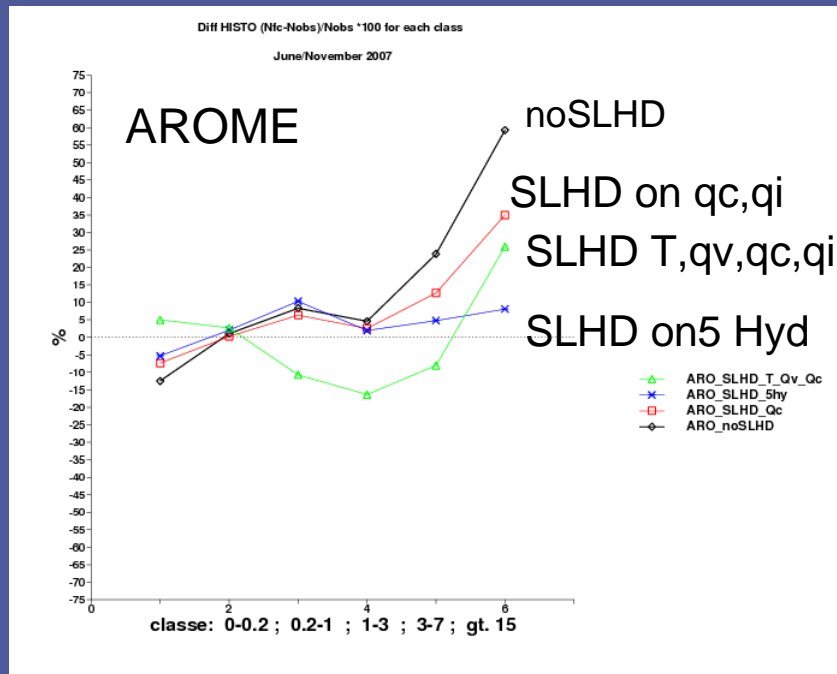


ALD phys. 2.5Km SLHD qc,qi,qv,qs

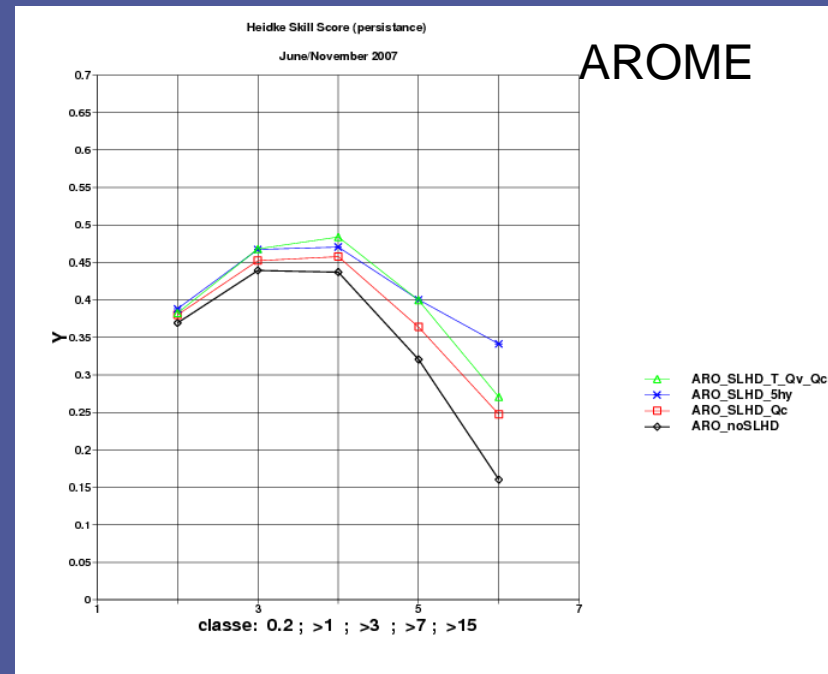
ALARO phys. 2.5Km SLHD T,qv,qc,qi



# Experiment 2.5 Km AROME Domain June and November 2007

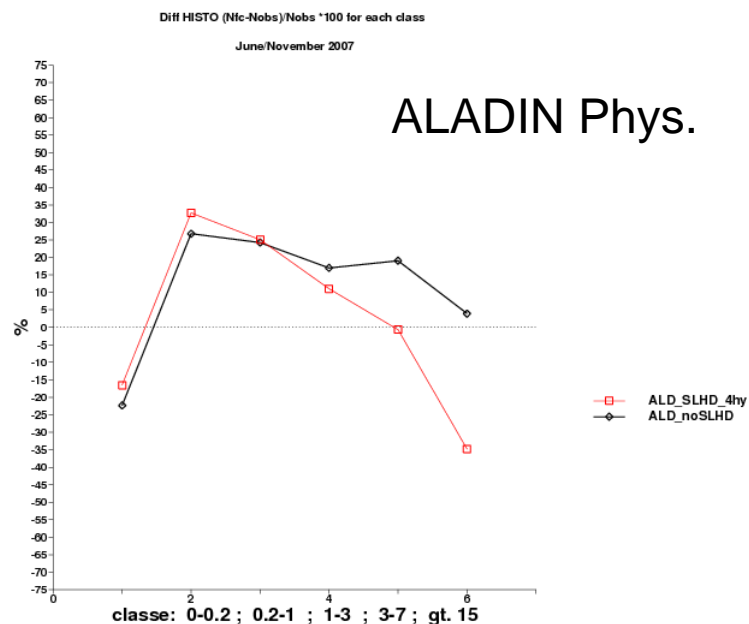


Frequency bias

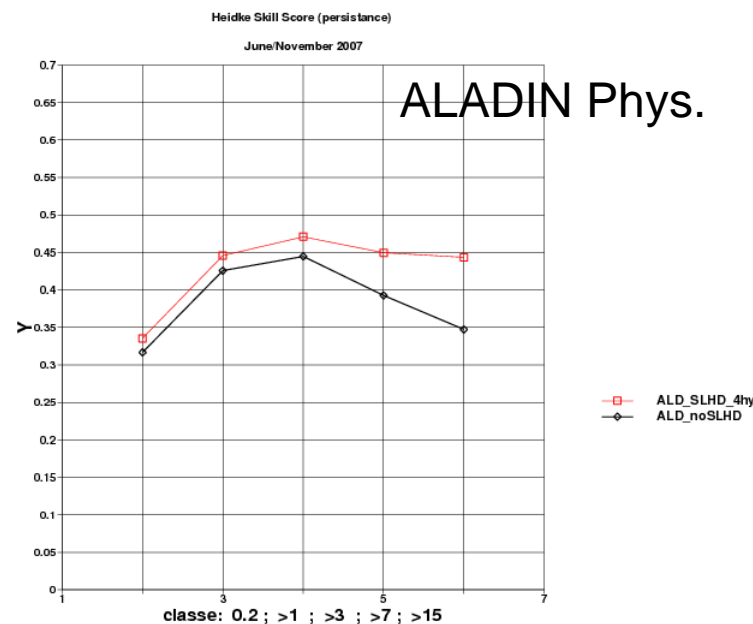


Heidke Skill Score

# Experiment 2.5 Km AROME Domain June and November 2007

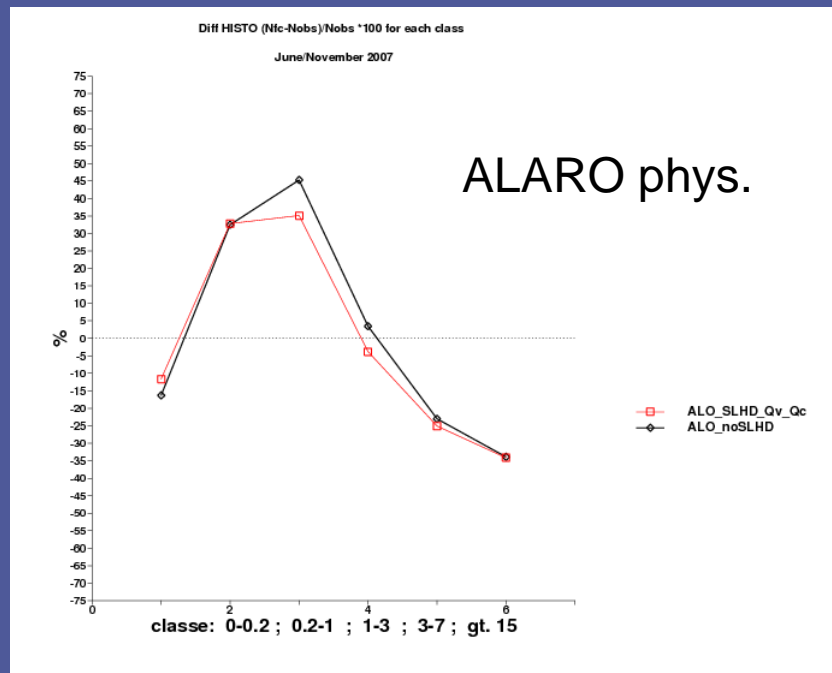


Frequency bias

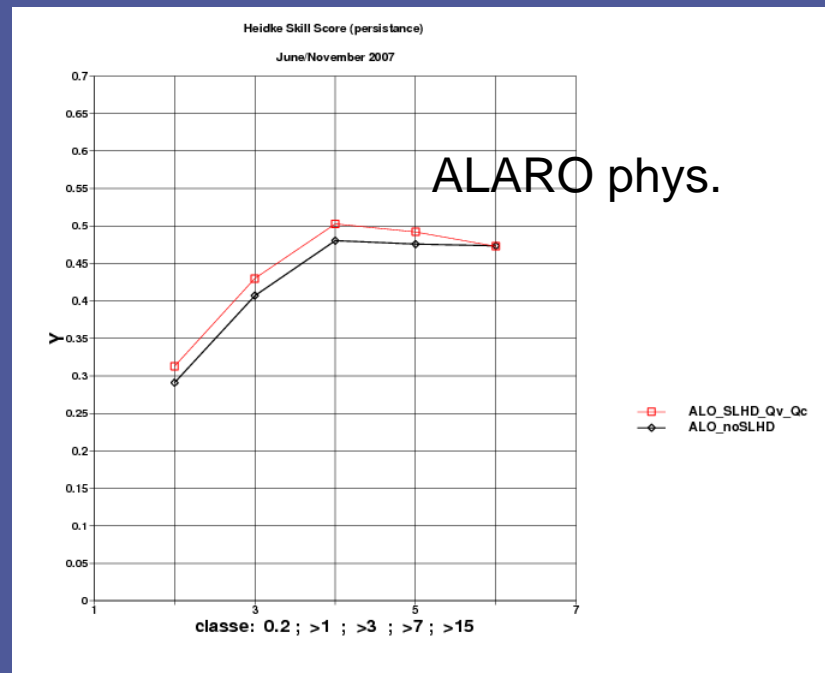


Heidke Skill Score

## Experiment 2.5 Km AROME Domain June and November 2007



Frequency bias



Heidke Skill Score

Smaller impact of SLHD in ALARO00 why ?

# QUESTIONS ?

- Can we apply SLHD on hydrometeor ? SLHD on  $Q_v$  ? SLHD on  $Q_t$  and adjustment ?
- Is it still useful to work with 1D model to develop new parameterization for micro-physics, shallow convection if the dynamics, hor.diff and SLHD have more impact than physics at high resolution ?
- Or shall we develop parametrization with specific constraint from the type of the dynamics or the type of the model ? Interoperability ?
- But despite of all this problem and "strange" tunings models are still in progress !